Upgrading the Pacific Highway

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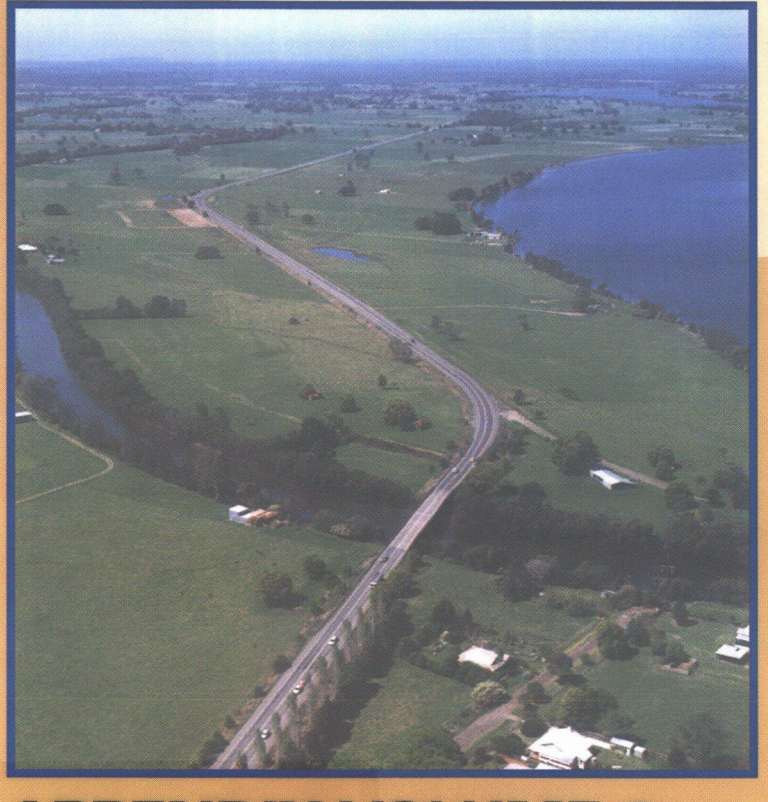
COMMONWEALTH DEPARTMENT OF TRANSPORT AND REGIONAL SERVICES

REVIEW OF ENVIRONMENTAL FACTORS

PACIFIC HIGHWAY UPGRADE
TAREE BYPASS TO COOPERNOOK BYPASS



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1998

Prepared by

Connell Wagner

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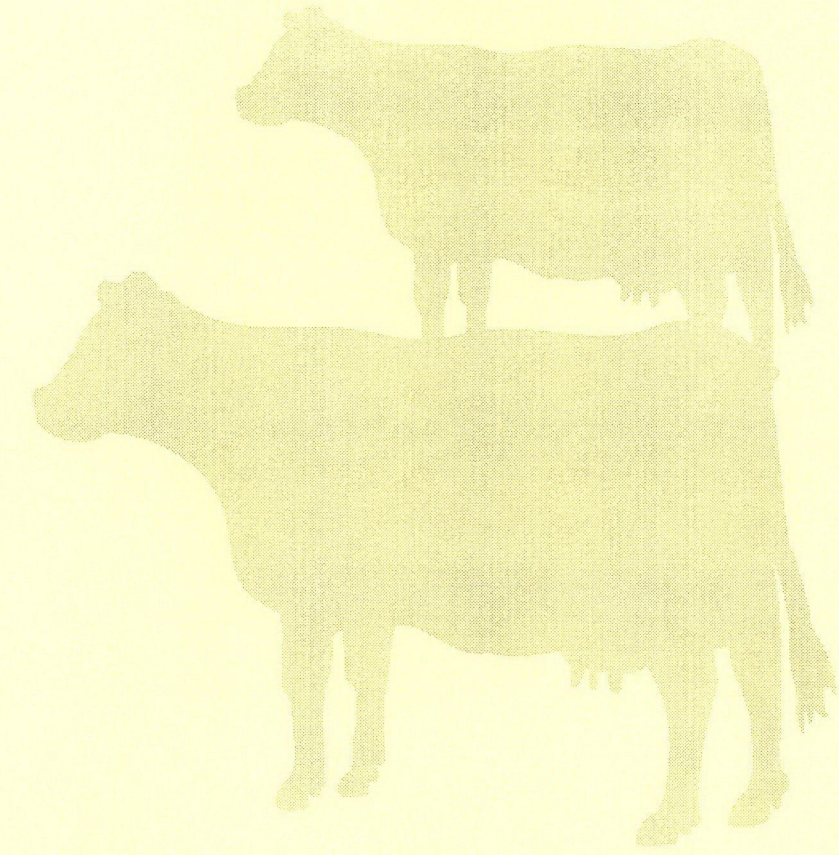

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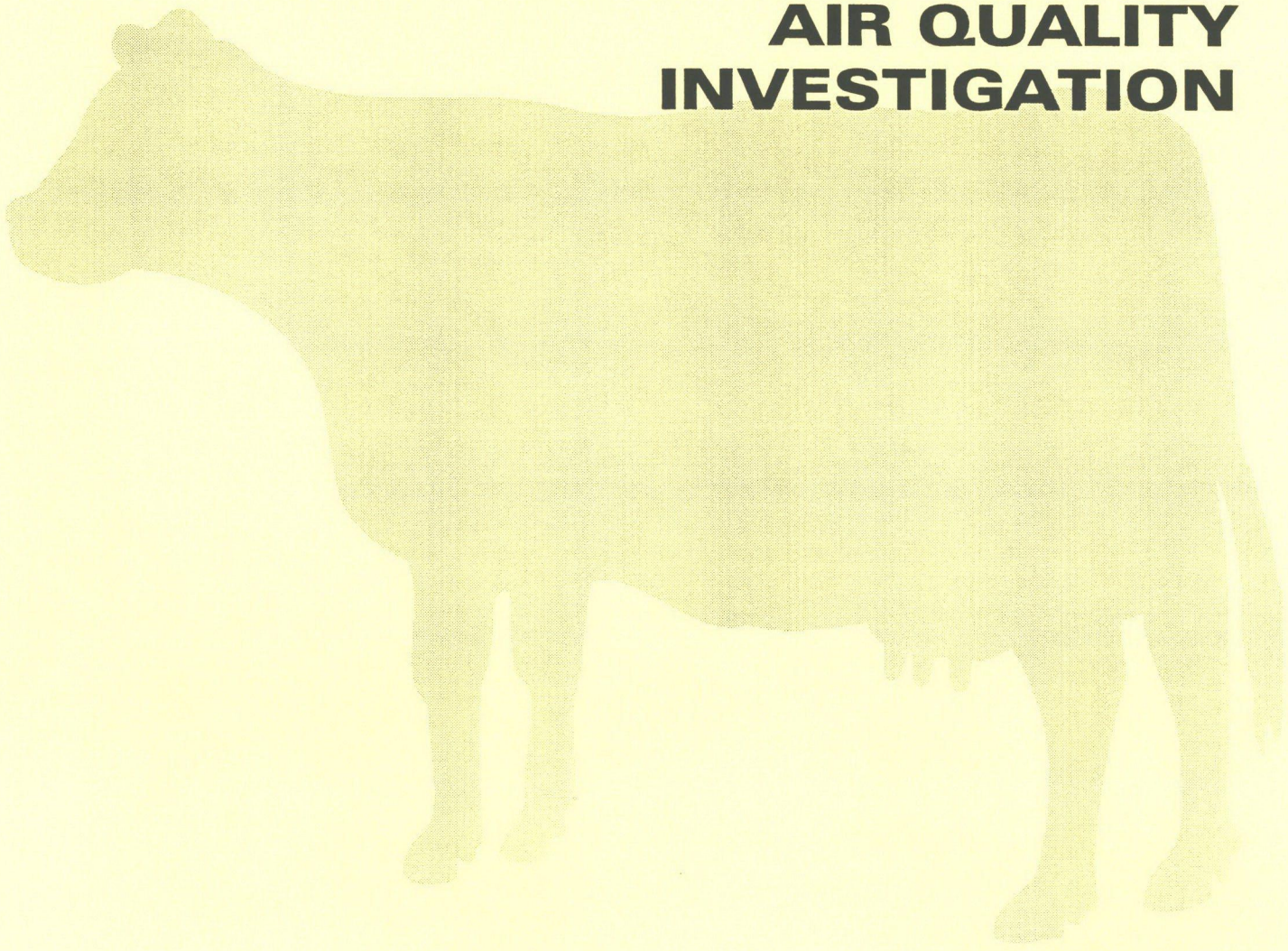
AIR QUALITY INVESTIGATION



AIR QUALITY ASSESSMENT
PROPOSED UPGRADE OF THE PACIFIC HIGHWAY, TAREE TO COOPERNOOK

2 November, 1998

Prepared
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by

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1 INTRODUCTION

This report has been prepared by Holmes Air Sciences for Connell Wagner, and its purpose is to assess the air quality impacts of the proposed upgrade to the Pacific Highway between the northern end of the Taree Bypass at Cundletown and the southern end of the Coopernook Bypass.

The assessment of the impacts of motor vehicle emissions along the proposal is based on the use of a computer model to determine the dispersion of emissions and to predict ground-level concentrations of the various exhaust components in the area close to the road. The assessment has been carried out for the years 2001 and 2011 (the first and tenth years of operation). In the first year of operation (2001) the primary pollutants of concern are carbon monoxide, hydrocarbons, nitrogen oxides, particulate matter and lead. It has been assumed that by 2011, the tenth year of operation, lead will no longer be a significant emission.

2 PROJECT DESCRITION

The proposal includes the operation of a dual carriageway between Taree and Coopernook. This section is the first part of a two stage project that extends from the northern tie-in of the Taree Bypass to Moorland (approximately 31.2 km north of Taree). **Figure 1** shows the proposal schematically. Each of the 4 lanes will be 3.5 m wide and separated by a median strip of width 9 m. The shoulder width is expected to be 2.5 m, as shown in **Figure 2**.

The proposed upgrade of this section of the highway is part of the Pacific Highway Upgrading Program, which is a joint NSW State/Commonwealth Government initiative. The Program has committed some $2.2 billion, over 10 years, for upgrading the Pacific Highway between Hexham and the Queensland border.

3 AIR QUALITY CRITERIA

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

The National Environment Protection Council of Australia (NEPC) has determined a new set of air quality standards for adoption at a national level, which are part of the National Environment Protection Measures (NEPM). These are currently being considered by Federal Parliament and are likely to be adopted. In its recent publication "Action for Air" (**EPA, 1998**), the NSW EPA has proposed new air quality goals for particulate matter and nitrogen dioxide as interim goals, some of which are consistent with the draft NEPM standards, pending the adoption of the measure.

Table 1 lists the EPA's air quality goals for New South Wales including the historical goals and new interim goals. Not all of these are major emissions from motor vehicles. The basis of these air quality goals and the safety margins which they provide are outlined in the following.

Table 1 - NSW Air Quality Goals		
Pollutant	Standard*	Agency
Carbon monoxide	87 ppm or 108 mg/m^3 (15-minute maximum)	WHO
	25 ppm or 31 mg/m^3 (1-hour maximum)	WHO
	9 ppm or 10 mg/m^3 (8-hour maximum)	NHMRC, NEPM
Nitrogen dioxide	0.16 ppm or 320 µg/m^3 (1-hour maximum)	NHMRC
	0.05 ppm or 103 µg/m^3 (annual mean)	US EPA
	0.12 ppm or 245 µg/m^3 (1-hour maximum)	NEPM
	0.125 ppm or 256 µg/m^3 (1-hour maximum)	NSW EPA interim
	0.11ppm or 200 µg/m^3 (1-hour maximum)	WHO, NSW EPA long-term reporting goal
	0.03 ppm or 60 µg/m^3 (annual mean)	NEPM, NSW EPA interim
Total suspended particulate matter (TSP)	90 µg/m^3 (annual mean)	NHMRC
Particulate matter < 10 µm (PM_{10})	50 µg/m^3 (annual mean)	US EPA
	30 µg/m^3 (annual mean)	NSW EPA Interim
	150 µg/m^3 (24-hour maximum)	US EPA
	50 µg/m^3 (24-hour maximum)	NEPM, NSW EPA interim
Lead	1.5 µg/m^3 (90-day average)	NHMRC
	0.5 µg/m^3 (annual average)	NEPM
Ozone	0.10 ppm or 200 µg/m^3 (1-hour maximum)	NHMRC, NEPM,
	0.08 ppm or 150 µg/m^3 (4-hour maximum)	NSW EPA
	0.08 ppm or 150 µg/m^3 (1-hour maximum)	NSW EPA long term reporting goal**
	0.06 ppm or 120 µg/m^3 (4-hour average)	
Sulphur dioxide	0.25 ppm or 700 µg/m^3 (10-minute maximum)	NHMRC and
	0.20 ppm or 570 µg/m^3 (1-hour maximum)	NEPM
	0.08 ppm or 225 µg/m^3 (24-hour maximum)	NEPM
	0.02 ppm or 60 µg/m^3 (annual mean)	NHMRC and NEPM

* *all concentration units have been converted at 0°C*
** *based on WHO goals*

3.1 Carbon Monoxide

Carbon monoxide can be harmful to humans because its affinity for haemoglobin is more than 200 times greater than that of oxygen. When it is inhaled it is taken up by the blood and therefore reduces the capacity of the blood to transport oxygen. This process is reversible and reducing the exposure will lead to the establishment of a new equilibrium with a period of three hours being the approximate time required to reach 50% of the equilibrium value.

Symptoms of carbon monoxide intoxication are lassitude and headaches, however these are generally not reported until the concentrations of carboxyhaemoglobin in the blood are in excess of 10% of saturation. This is approximately the equilibrium value achieved with an ambient atmospheric concentration of 70 mg/m^3 for a person engaged in light activity. However, there is evidence that there is a risk for individuals with cardiovascular disease when the carboxyhaemoglobin concentration reaches 4% and the WHO recommends that ambient concentrations be kept to values which would protect individuals from exceeding the 4% level.

The 15-minute, 1-hour and 8-hour goals noted by the EPA provide a significant margin for safety, however this is appropriate for this type of guideline, which is designed to protect a wide range of people in the community including the very young and elderly.

3.2 Oxides of Nitrogen

Nitrogen oxides (NO_x) emitted by motor vehicles are comprised mainly of nitric oxide (NO, approximately 95% at the point of emission) and nitrogen dioxide (NO_2, approximately 5% at the point of emission). Nitric oxide is much less harmful to humans than nitrogen dioxide and is not generally considered a pollutant with health impacts at the concentrations normally found in urban environments. Concern with nitric oxide relates to its transformation to nitrogen dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported to have an effect on respiratory function although the evidence concerning effects has been mixed and conflicting. The EPA has not set any air quality goals for nitric oxide, however it has set 1-hour and annual average goals for nitrogen dioxide. It has adopted as an interim goal the draft NEPM standard of 0.125 ppm or 256 μg/m^3. The NEPM standard has been revised downwards to 0.12 ppm and it is likely that the EPA will adopt this new level once the measure has been approved. It will also adopt the WHO 1-hour goal of 200 μg/m^3 as a long-term reporting goal.

3.3 Hydrocarbons

Hydrocarbons alone do not generally pose a problem at the concentrations commonly experienced. However, some hydrocarbons such as benzene are known to have an adverse effect on human health (see later), but the effects are thought to occur at concentrations higher than the levels of exposure found at roadsides from traffic emissions. Hydrocarbons do play a significant role in photochemical smog formation and until recently the air quality standards adopted by the US EPA for non-methane hydrocarbons have been applied in NSW. However it has been recognised that this goal does not distinguish the reactive species which are involved in smog formation from the total hydrocarbon concentration and this air quality goal has been abandoned by the US EPA and the NSW EPA.

There is growing concern about the amount of benzene released in motor vehicle emissions, especially in Europe where fuel has a higher benzene and aromatic content than in Australia. At present NSW has no ambient air quality goals for benzene. The Victorian EPA currently has a limit of 0.10 mg/m^3 (0.033 ppm) (3-minute average). Many in the scientific community hold the view that there is no safe limit for benzene. The WHO specifies a risk factor for developing leukaemia of 4×10^{-6} for a lifetime exposure to 1 μg/m^3. The United Kingdom has an annual average ambient benzene goal of 5 parts per billion (ppb) or 16 μg/m^3 to be achieved by 2005. The 5 ppb goal is based on the "No Observable Adverse Effect Level" from the findings of the UK Expert Panel on Air Quality Standards that the risk of leukaemia in workers would not be detectable when the average working lifetime exposure to benzene was less than 500 ppb. Two safety factors of 10 were then applied to derive the goal of 5 ppb. The Australian draft air quality goal for benzene is 5 ppb (16 μg/m^3).

3.4 *Particulate Matter*

The presence of particulate matter in the atmosphere can have an adverse effect on health and amenity. The health effects of particles are largely related to the extent to which they can penetrate the respiratory tract. Larger particles, that is those greater than 10 μm, generally adhere to the mucus in the nose, mouth, pharynx and larger bronchi and from there are removed by either swallowing or expectorating. Finer particles can enter bronchial and pulmonary regions of the respiratory tract, with increased deposition during mouth breathing which increases during exercise. The very fine particles can be deposited in the pulmonary region and it is these which are of particular concern.

The health effects of particulate matter are further complicated by the chemical nature of the particles and by the possibility of synergistic effects with other air pollutants such as sulphur dioxide.

Much of the recent concern over the health effects of fine particulate matter is based on investigations carried out in the US, with the view to quantifying the health risks associated with both long-term and short-term exposure to airborne particulate matter. The study is colloquially referred to as "The Six Cities Study" from the original work by **Dockery and others (1993)**, which determined a relationship between fine particulate matter (defined as particles smaller than 2.5 μm in diameter) in the air and mortality in six US cities.

The basic findings of the Six Cities Study is that there is an increase in mortality with increasing concentrations of fine particulate matter. The conclusions appear to be robust and have been supported by subsequent studies and as far as can be determined are not confounded by other known variables. The mechanism is still unknown.

These findings have not yet been fully evaluated by the scientific community and new Australian standards are currently being evaluated by NEPC. The US EPA has not changed its PM_{10} (particles less than 10 μm in diameter) goal but has introduced new goals for very fine particles ($PM_{2.5}$) with a 24-hour limit of 65 $\mu g/m^3$ and an annual limit of 15 $\mu g/m^3$. The NSW EPA has historically noted the US EPA 24-hour air quality standard of 150 $\mu g/m^3$ and annual average standard of 50 $\mu g/m^3$ for PM_{10}. It will now adopt the NEPM 24-hour standard of 50 $\mu g/m^3$ as an interim goal and reference an annual average of 30 $\mu g/m^3$ as a long-term reporting goal.

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

3.5 *Lead*

Lead is a cumulative poison which exerts its toxic effects on the kidneys, blood and central nervous system. It is now generally agreed, that while the effects are not readily discernible on an individual basis, on a population basis, lead exposure in young children can lead to an IQ deficit of between 2 to 3 points for each 10 μg/dL increment in blood lead (**EPA, 1993**). As environmental lead has emerged as a public health issue, governments in Australia have developed strategies to reduce the levels of lead exposure.

It has been estimated (**ABS, 1992**) that about 90% of the lead in air arises from motor vehicle emissions, apart from areas where there are significant local lead industries. However ingestion, rather than inhalation is the more significant route of lead intake for young children who absorb lead very efficiently, up to 50% of ingested lead compared to 10-15% in adults.

Most ingested lead is from contaminated soil and dust which children take in through exploratory hand to mouth activities. Some measures to reduce lead intake through ingestion include washing of children's hands and faces before meals, regular washing of outside toys and planting grass or ground cover on exposed areas of soil in the yard.

The NHMRC goal for lead is 1.5 $\mu g/m^3$ (90-day average). The NEPM draft standard is 0.5 $\mu g/m^3$ on an annual basis. Since the introduction of unleaded petrol there has been a steady and unambiguous decline in lead emissions (**VEPA, 1991**) and in the low concentration of lead in the air in urban environment, clearly demonstrating the effectiveness of this strategy. EPA monitoring data in NSW shows the same trend. From 1986 when unleaded petrol was introduced to 1991, the lead levels in air have been reduced by a factor of two in suburban Sydney, so that ambient levels are now about one third of the NHMRC goal (see **Figure 3**).

In 2001, the first year of opening of the proposal, about 15% of the fleet will still be using leaded petrol. By 2011 lead will no longer be a significant emission from motor vehicles, and has therefore not been assessed for that year.

3.6 Ozone

Ozone is a powerful oxidant, formed in the atmosphere in the presence of sunlight, nitrogen oxides and reactive hydrocarbons. It is not a primary emission from motor vehicles, but a regional pollutant, being a major component of photochemical smog. Because of its highly reactive nature, ozone can combine with virtually all classes of biologically active molecules including enzymes, proteins and lipids. Cellular membranes are a target for ozone which has also been reported to have an irritant effect on the respiratory system. The NSW EPA air quality goal for ozone is 200 $\mu g/m^3$ (0.10 ppm) for a 1-hour maximum. In addition, the EPA now notes a four hour ozone goal of 150 $\mu g/m^3$ (0.08 ppm). The EPA is also using as long term reporting goals a 1-hour maximum ozone goal of 0.08 ppm and a 4-hour average of 0.06 ppm (120 $\mu g/m^3$).

3.7 Sulphur Dioxide

Sulphur dioxide is an acid gas which can have harmful effects on the respiratory system as well as on vegetation and building materials. It is however a minor component of motor vehicle emissions, due to the low sulphur content of Australian petrol, and has not been assessed quantitatively in this study. For example the Metropolitan Air Quality Study (MAQS) estimates that for the 1992 fleet, average SO_2 emissions under arterial travel conditions are 0.065 g/km compared to emissions of nitrogen oxides of 2.33 g/km for the same conditions. In addition transient emissions of above average levels of odorous sulphur compounds such as hydrogen sulphide and carbonyl sulphide (which may be smelt at concentrations as low as 5 ppb) have been noted from vehicles fitted with catalytic converters. While these compounds may produce a local short term nuisance, they do not represent significant emissions under normal running conditions.

4 DISPERSION METEOROLOGY AND AIR QUALITY ISSUES

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

4.1 Meteorology

4.1.1 Wind data for Taree

The closest meteorological monitoring station with data which can be considered as representative of the meteorological conditions along the route is at Taree radio station. **Figures 4a**, **4b** and **4c** present 9 am and 3 pm seasonal and annual wind rose diagrams compiled from this data. On an annual basis at 9 am the winds exhibit a strong northwest to southwest (anti-clockwise) component. This is also the case for autumn and winter. These winds are also common in spring and summer but there is also a significant contribution from the northeast sector.

In the afternoon on an annual basis, the winds tend to blow from the eastern quadrant in all seasons, indicating the direction of the seabreeze. This can be seen also in summer, autumn and spring. Calm conditions are less prevalent at 3 pm (10.6% compared with 26.7% at 9am), which is typical of an exposed coastal location.

When the 9 am and 3 pm data are combined, it can be seen that on an annual basis winds are quite evenly distributed although there is little contribution from the north or south. This pattern is evident in both autumn and spring whereas summer and winter exhibit winds from the eastern and western sectors respectively.

4.1.2 Temperature, Humidity and Rainfall

Table 2 presents the temperature, humidity and rainfall data for Taree (**Bureau of Meteorology, 1996**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean and median monthly rainfall and the average number of raindays per month.

The annual average maximum and minimum temperatures experienced are 24.1°C and 11.9°C respectively. On average, January is the hottest month with an average maximum temperature of 28.9°C. July is the coldest month, with an average minimum temperature of 5.8°C.

The annual average humidity reading from 29 years of data collected at 9 am is 73%, and at 3 pm is 57%. The month with the highest humidity on average is February with a 9 am average of 79%, and the lowest are August and September with 3 pm averages of 50%.

Rainfall data collected over 110 years show that March is the wettest month, with an average rainfall of 149 mm over 12 days. The average annual rainfall is 1178 mm with an average of 111 raindays.

Table 2 - Temperature, humidity and rainfall data for Taree Radio Station (2RE)

(Station Number 060030 Latitude 31 Deg 54 Min S Longitude 152 Deg 29 Min E Elevation 5.0 m)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Temperatures (C) and Relative Humidity (%) (29 years of record)													
Dry-bulb	23.2	22.4	21.7	18.8	15.1	12.4	11.2	12.7	16.2	19.5	21.0	22.8	18.1
Wet-bulb	20.2	20.1	19.2	16.3	13.2	10.6	9.2	10.1	12.9	15.7	17.3	19.1	15.3
Humidity	75	79	78	76	78	78	76	70	66	65	66	69	73
3 pm Mean Temperatures (C) and Mean Relative Humidity (%) (29 Years of record)													
Dry-bulb	27.3	27.1	25.8	23.6	20.6	18.1	17.7	19.0	21.0	22.5	24.6	26.3	22.8
Wet-bulb	22.0	21.9	20.6	18.4	16.0	13.7	12.8	13.4	15.1	17.3	18.9	20.6	17.5
Humidity	61	61	61	58	60	59	53	50	50	57	55	57	57
Daily Maximum Temperature (C) (29 Years of record)													
Mean	28.9	28.5	27.1	24.7	21.4	19.0	18.4	19.8	22.4	24.8	26.7	28.3	24.1
Daily Minimum Temperature (C) (29 Years of record)													
Mean	17.4	17.5	15.9	12.8	9.8	7.3	5.8	6.4	8.5	11.4	14.0	16.3	11.9
Rainfall (mm) (110 Years of record)													
Mean	123	138	149	117	96	99	74	62	61	75	80	103	1178
Median	98	99	121	75	64	71	47	36	43	59	62	82	1120
Raindays (Number) (110 Years of record)													
Mean	10	11	12	10	9	9	7	7	7	9	9	10	111

*Source : **Bureau of Meteorology (1996)** - (www.bom.gov.au)*

4.2 *Air quality Issues*

4.2.1 *Vehicle emissions and photochemical smog*

Apart from local air quality impacts, motor vehicle emissions have the potential to contribute significantly to photochemical smog in an urban environment. Photochemical smog is formed by the reaction between nitrogen oxides and reactive hydrocarbons in the presence of sunlight. Models for the formation of photochemical smog envisage hydrocarbon emissions mostly from motor cars, facilities for the storage of hydrocarbons or spray painting operations and so on, mixing with nitrogen oxides from either industrial sources or from motor cars. The mixture of pollution from these sources then reacts photochemically to form photochemical smog comprising mainly ozone, but also including other oxidants. At sufficient concentrations the smog can affect the eyes and respiratory system and can adversely affect plants and materials.

Photochemical smog is often a concern on the fringes of large cities as parcels of smog-laden air can travel to areas remote from the source. However in the Taree area there are unlikely to be any regional air quality problems associated with vehicle emissions. The most important air quality issue associated with the proposed road development would be the local impacts at kerbside and nearby residences from specific emissions from vehicles.

4.2.2 *Conversion of nitric oxide to nitrogen dioxide*

As discussed previously there are no ambient air quality goals for nitric oxide, the major nitrogen oxide emission from motor vehicles. Nitric oxide is however converted to nitrogen dioxide and its rate of conversion is dependent on the presence of oxidising agents. The issue here is the rate at which NO converts to NO_2. Analysis of the EPA's NO_x monitoring data reveals that the percentage of NO_2 in the air is inversely proportional to the total NO_x concentration. **Figure 5** presents a plot of the mean total NO_x (calculated from the mean NO_2 concentration and the mean total NO_x concentration, in ppm) against the mean nitrogen oxide concentration recorded at five sites in Sydney, namely Earlwood, Eagle Vale, Lidcombe, Kensington and Rozelle, from 1988 to 1992.

The trend in the graph shows an inverse correlation between total NO_x concentration and percentage of NO_2. Average percentages of NO_2 in the EPA monitoring data range from 5 to 50%, with a mean value of about 30%. These data however, are mostly collected at some distance from roads and while they demonstrate the inverse correlation between total NO_x concentrations and NO_2 concentrations, they do not necessarily reflect the proportion of NO_2 which will be present close to roadways.

Monitoring data collected by the RTA in Sydney (**RTA, 1997**) indicate that close to the roadways, NO_2 would make up from 5 to 20% by weight of the total NO_x. A conservative value of 15% by weight at 0-10 m from the roadway and 20% by weight at 25 - 50 m from the roadway has been used in the impact assessment presented in **Section 8**. Although this information is drawn from measurements made in Sydney, the chemical processes involved in the conversion of NO to NO_2 will still be relevant for the current study area between Taree and Coopernook.

4.3 *Existing Air Quality*

Site-specific air quality monitoring has not been carried out for this study. Several environmental assessments of roadways have been carried out in this general region. From a review of these studies the assessment of the Pacific Highway upgrade near Bulahdelah (**Nigel Holmes & Associates, 1993**) contains the only air quality monitoring data, comprising roadside measurements of carbon monoxide.

Bulahdelah is south of Taree and is similar in landuse to Coopernook. The monitoring data collected for the Bulahdelah study us therefore considered to be reasonably representative of the current study area. The results indicated that in general, hourly concentrations of carbon monoxide in this type of environment ranged from 0.3 – 14.2 ppm (0.3 – 16.4 mg/m^3), which is well below the EPA goal of 31 μg/m^3. Other factors such as bushfires may contribute more significantly to air pollution in rural areas than motor vehicle emissions.

5 METHODS FOR ASSESSING IMPACTS

The Caline4 dispersion model has been used to estimate the concentration of oxides of nitrogen, carbon monoxide, hydrocarbons, particulate matter and lead, that are likely to be produced in the vicinity of the highway.

This model is an upgrade of Caline3 the most recent US EPA approved model, and is a steady state Gaussian model which can determine concentrations at receptor locations downwind of "at grade", "fill", "bridges" and "cut section" highways located in relatively uncomplicated terrain. The model is applicable for any wind direction, highway orientation and receptor location.

It is neither feasible nor necessary within the scope of this study to assess air quality at every sensitive receptor along each section of road, taking account of terrain, road grade and distance of receptor from the road, although it is technically possible to do so. This very detailed approach is warranted for model validation which has already been carried out in Sydney for Caline4 (**Williams and others, 1994**) for the RTA.

The approach in this report has been to identify worst case conditions which comprise 1-hour peak hour traffic flow, combined with the poorest dispersion conditions, equivalent to atmospheric inversions with very light winds. The traffic flow has been assumed to be constant (at peak levels) along the route, and although this is clearly a simplification, it is a reasonable approximation to what could happen in practice. Two cases have been studied here – the Annual Average Daily Traffic (AADT) and the Maximum Daily Traffic Year (MDTY).

The position of the receptor with respect to the road is also a factor when determining "worst-case" conditions along a roadway. Distances of 0 m, 10 m, 20 m 30 m and 50 m have been used here. Traffic numbers in each direction were obtained from measurements carried out over two weeks in October/November 1997, and extrapolated to the years 2001 and 2011.

6 METHODS FOR ESTIMATING EMISSIONS

This section provides a brief description of the methods used to calculate the major emissions from vehicles, namely nitrogen oxides, carbon monoxide, hydrocarbons and particulate matter. This information is required as input to the dispersion models used to predict ground-level concentrations of the various pollutants.

An estimation of these emissions has been made by **Pengilley (1989)** and US EPA emission factors (**US EPA, 1985**). These data have been used in previous roadway studies, however a comprehensive emissions inventory which relates vehicle emissions to different travel conditions in NSW has now been prepared for the Metropolitan Air Quality Study (MAQS) (**Carnovale & Tilly 1995**). These emission rates have been combined with traffic flow data to determine air quality impacts for peak traffic flow. **Appendix A** provides a detailed description of the calculation of vehicle emissions.

The emissions from vehicles were determined for previous studies from these relationships (**Nigel Holmes & Associates, 1992, 1994**). The emissions inventory prepared for MAQS takes a different approach. Although similar principles apply in terms of the relationship between speed and emissions, the roads are divided into different categories and emissions from the mix of traffic on that type of road is determined. These categories are described as follows:

Freeway/Highway	Major roads with relatively high average speeds (say in excess of 40 km/h), low congestion levels (say less than 5% idle time) and low proportion of heavy duty vehicles.
Arterial	Major roads with moderate average speeds (say 20-40 km/h), moderate congestion levels (say 20% idle time) and low proportion of heavy duty vehicles (say less than 7% of total fleet vehicle kilometres travelled (VKT)).
Commercial-Arterial	Major roads with moderate average speeds and congestion levels and moderate proportions of heavy duty vehicles (say greater than 7% of total fleet VKT).
Commercial-Highway	Major roads with relatively high average speeds, low congestion levels and moderate proportions of heavy duty vehicles.
Residential/Minor	Secondary roads with moderate average speeds, negligible levels of congestion and a very low proportion of heavy duty vehicles (say one half the arterial road level).

The proposed upgrade section has been classified as freeway/highway with varying percentages of the fleet being heavy vehicles during peak times. Emission rates for different vehicle categories have been determined. This is presented in more detail in the discussion and tables in **Appendix A.**

6.1 Carbon Monoxide

The way in which vehicle emissions vary with speed is fundamental to the understanding of the analysis presented in this report. The relationship between speed and carbon monoxide emission is shown in **Figure 6** where the estimated CO emission rates in the years 1988 and 2000 are presented for light duty petrol vehicles (hot start). It is assumed that approximately 30% and 96% of cars are fitted with catalytic converters in 1988 and 2000 respectively. At present about 70% of the fleet are fitted with catalytic converters and so the year 2000 assumption of 96% is likely to be an overestimate. For cars without catalytic converters, there is a marked decrease of emissions with speed. Fitting cars with catalytic converters reduces the overall emissions and again the same pattern of decreasing emission rate with speed is observed.

6.2 Oxides of Nitrogen

Oxides of nitrogen emissions show a different trend with speed from carbon monoxide and this is illustrated in **Figure 7**. As in the case of carbon monoxide, catalytic converters reduce the overall NO_x emission rate, however the trend with increasing speed is reversed, that is NO_x increases with increasing speed, although the effect is more gradual.

As for carbon monoxide, while the same trend remains, these emission factors have been replaced by those determined for MAQS (see **Appendix A**).

6.3 Hydrocarbons

Hydrocarbon emissions vary with speed in a similar way to carbon monoxide and have been determined for MAQS in the same way (see **Appendix A**).

6.4 Particulate Matter

Particulate matter emission rates for the different years are presented in **Appendix A.** These comprise exhaust emissions as well as emissions from tyre and brake wear.

6.5 Lead

Lead emission rates for 2001 only are presented in **Appendix A.** It has been assumed that in 2001, 85% of light vehicles will use unleaded petrol, and by 2011 this will have increased to 100%. Heavy duty diesel vehicles do not contribute to lead emissions from the vehicle fleet.

7 ESTIMATED EMISSIONS

Emission rates during the hour of peak traffic flow for the two scenarios (2001 and 2011) are estimated for both the AADT and the MDTY from the total traffic volume and the emission rate per vehicle. Details of assumptions relating to the percentages of heavy vehicles, petrol and diesel fuelled, are presented in **Appendix A.** The estimated peak hour traffic volumes for 2001 and 2011 are summarised in **Table 3.**

Table 3 - Estimated peak hour traffic volumes

Roadway Section	2001		2011	
AADT	Northbound	Southbound	Northbound	Southbound
Taree to Coopernook	372	456	487	598
MDTY	Northbound	Southbound	Northbound	Southbound
Taree to Coopernook	741	910	970	1192

Emission estimates are presented in detail in **Appendix A** and are summarised in **Table 4.**

Table 4 - Estimated peak hour traffic emissions - (kg/km/hour)

Roadway Section		Carbon Monoxide	Nitrogen Oxides	Hydrocarbons	Particulate Matter	Lead
2001 – AADT						
Taree to Coopernook	Northbound	4.01	1.12	0.37	0.05	0.0011
	Southbound	4.95	1.43	0.46	0.06	0.0013
2001 – MDTY						
Taree to Coopernook	Northbound	7.99	2.24	0.74	0.10	0.0021
	Southbound	9.88	2.86	0.92	0.13	0.0026
2011 – AADT						
Taree to Coopernook	Northbound	4.15	1.37	0.39	0.06	
	Southbound	5.15	1.76	0.49	0.09	
2011 - MDTY						
Taree to Coopernook	Northbound	8.27	2.74	0.77	0.13	
	Southbound	10.16	3.36	0.95	0.16	

8 PREDICTION AND ASSESSMENT OF IMPACTS

8.1 Operational impacts

This section assesses the air quality impacts of the proposal by comparing the predicted ground-level concentrations of roadway emissions with air quality goals or other air quality criteria where specified goals are not available. Predictions have been made for peak hour flows.

Table 5 presents the maximum predicted 1-hour average increase in ground-level concentrations of carbon monoxide, hydrocarbons, nitrogen oxides, nitrogen dioxide, particulate matter and lead, at 0 m, 10 m, 20 m, 30 m and 50 m from the roadway edge. Predictions at 30 m and 50 m have been made to assess impacts at any nearby residences. Assuming a wind speed of 1.0 m/s and that F-class stability conditions occur, the model has been set to determine the worst-case wind angle.

The exact relationship will vary with roadway configuration, but typically, concentrations at 10 m from the roadway edge are approximately 55% of concentrations at the kerbside, and around 35% at 30 m. This will not be the case for NO_2 however, since the NO in the exhaust emission will be oxidised to NO_2 over time. That is, as the exhaust plume disperses and the overall NO_x concentration decreases, the percentage of NO_2 will increase. Monitoring data collected by the RTA in the vicinity of freeways and arterial roads (**RTA, 1997**), indicate that the concentration of NO_2 remains fairly constant over a distance of 60 m from the road. In other words the increase in NO_2 concentration due to oxidation of NO is offset by the dilution due to dispersion.

Carbon Monoxide

It can be seen from **Table 5** that the predicted 1-hour carbon monoxide concentration 10 m from the road for the MDTY is 3.0 mg/m^3 in both 2001 and 2011. This is well below the EPA's 1-hour goal of 31 mg/m^3 and levels at 30 m and 50 m are even lower. Levels at kerbside are also below the 1-hour EPA goal.

The average "background" level of carbon monoxide, that is carbon monoxide which is due to all other sources apart from the road, is likely to be of the order of 2 to 5 mg/m^3. However, monitoring data from a similar study near Bulahdelah (**Nigel Holmes & Associates, 1993**) indicate that the maximum 1-hour average background concentration could be as high as 14.2 mg/m^3 (see **Section 4.3**). Adding this to the maximum predicted increase of 3.0 mg/m^3 at 10 m from the kerb, gives a maximum concentration of 17.2 mg/m^3 in 2001 and 2011. This is still less than the goal of 31 mg/m^3.

Nitrogen Dioxide

Estimating nitrogen dioxide concentrations is more complicated than estimating carbon monoxide concentrations. As discussed previously, nitrogen oxides are initially emitted as a mixture of nitric oxide and other oxides of nitrogen, which are oxidised to nitrogen dioxide. At the point of emission the mixture is generally about 5% nitrogen dioxide by mass. However, while the maximum concentrations of <u>total</u> oxides of nitrogen generally occur during peak hour, this is not necessarily the case for nitrogen dioxide. An extensive monitoring program undertaken by the RTA indicates that during peak hour the percentage NO_2 at 10 m from the roadway edge is likely to be about 5%. The conversion rate from NO to NO_2 at other times of the day may be significantly higher than this although the total NO_x levels may be significantly lower than peak hour levels. It is necessary therefore to assume some intermediate value for a worst-case assessment.

Data from the RTA program indicate that at 10 m from the roadway a conversion rate of 15% by weight is still conservative but more realistic than the 20% assumed in previous EIS studies. At

distances of 30-60 m from the kerbside the 20% conversion rate appears to be appropriate. There are no monitoring data for the kerbside location in the present study, but it is considered that a 10% conversion rate is likely to still be conservative.

Taking this into consideration, the highest predicted 1-hour nitrogen dioxide concentration 10 m from the road for the MDTY in 2001 is 138 $\mu g/m^3$, and 157 $\mu g/m^3$ in 2011, both of which are below the 1-hour interim goal of 256 $\mu g/m^3$ and long-term reporting goal of 200 $\mu g/m^3$. Concentrations at 50 m from the roadway are predicted to be 54 $\mu g/m^3$ and 64 $\mu g/m^3$ in 2001 and 2011 respectively. These predictions do not take into account background concentrations which are likely to be in the range of 30 - 50 $\mu g/m^3$.

It should be noted that predictions do not take into account fully the benefits of three-way catalytic converters which are fitted to all new (fuel-injected) petrol-fuelled passenger vehicles in Australia and which substantially reduce NO_x emissions. Nor (more significantly) do they take account of controls on diesel vehicles which are being implemented through new design rule ADR-70.

Table 5 – Predicted increase in 1-hour average ground-level concentrations of vehicle emissions at various distances from the roadway edge

	Distance from kerb (m)	Carbon Monoxide (mg/m^3)	Nitrogen Oxides ($\mu g/m^3$)	Nitrogen Dioxide* ($\mu g/m^3$)	Hydrocarbons (mg/m^3)	Particulate Matter ($\mu g/m^3$)	Lead ($\mu g/m^3$)
2001 – AADT							
Taree to Coopernook	0	3.0	910	91	0.28	39.1	0.81
	10	1.7	517	77	0.16	21.9	0.46
	20	1.3	406	81	0.12	17.3	0.35
	30	1.1	344	69	0.10	13.8	0.35
	50	0.9	271	54	0.08	11.5	0.23
2001 – MDTY							
Taree to Coopernook	0	5.5	1673	167	0.51	71.3	1.50
	10	3.0	923	138	0.28	39.1	0.81
	20	2.4	726	145	0.22	29.9	0.58
	30	2.0	615	123	0.19	25.3	0.58
	50	1.6	480	96	0.14	19.6	0.46
2011 – AADT							
Taree to Coopernook	0	3.0	1095	109	0.28	49.5	
	10	1.7	603	90	0.16	27.6	
	20	1.3	480	96	0.12	21.9	
	30	1.1	406	81	0.11	18.4	
	50	0.9	320	64	0.08	13.8	
2011 – MDTY							
Taree to Coopernook	0	5.4	1919	192	0.51	84.0	
	10	3.0	1046	157	0.27	46.0	
	20	2.3	824	165	0.22	35.7	
	30	2.0	701	140	0.18	29.9	
	50	1.5	541	108	0.14	24.2	

** Assumed to be 10% by weight of total nitrogen oxides at the kerbside, 15% at 10 m and 20% at 20 m, 30 m and 50 m from the roadway edge, (**RTA, 1997**).*

Hydrocarbons

Hydrocarbon concentrations are no longer specified in the EPA's air quality goals. This is largely due to the fact that a simple hydrocarbon concentration goal is now recognised as not being useful for the purposes of assessing health impacts or identifying the need for air quality management requirements. More detailed information on specific hydrocarbons is required. As previously noted, hydrocarbons, in particular those associated with motor vehicles, are a common contaminant of urban atmospheres and have been for many years. Emission controls on Australian cars and equivalents since 1978 have resulted in a considerable reduction in both evaporative and exhaust emissions of hydrocarbons.

One of the components of hydrocarbons that has become a concern in the community is benzene, which is a known carcinogen (**WHO 1987**). **Appendix B** (data from **Nelson and Quigley, 1982**) shows an analysis of the hydrocarbon content of fuel and exhaust. It can be seen that benzene is a component of petrol comprising approximately 2.6%. It can also be seen that the percentage benzene (by mass) in vehicle exhausts was approximately 5% (note these data relate to leaded petrol, but there has not been any substantial change in the benzene content with the introduction of unleaded petrol).

The current understanding of long-term health risks is that they are a function of average lifetime exposure levels. For example WHO estimated that the risk of developing leukemia with a lifetime exposure to ambient concentrations of 1 $\mu g/m^3$ of benzene is $4x10^{-6}$. This is referred to as a unit risk estimate.

Levels of benzene can range from 3 $\mu g/m^3$ in a rural environment to up to 160 $\mu g/m^3$ in an urban environment (higher close to service stations and storage tanks) with typical levels of about 20 $\mu g/m^3$ in residential areas. Most people would be exposed to much higher levels on occasions, for example when filling their car with petrol or in a smoke-filled indoor environment. The daily intake from ambient air in an urban environment is estimated to range from 30 to 300 $\mu g/m^3$ and smoking one pack of cigarettes per day can add approximately 600 mg to this intake.

From **Table 5** the predicted maximum 1-hour increase in total hydrocarbons is of the order of 0.28 mg/m^3 in 2001 and 0.27 mg/m^3 in 2011 for the MDTY and at 10 m from the roadway. Assuming a 5% benzene composition in the exhaust the benzene concentration at 10 m from the roadway edge would be approximately 0.014 mg/m^3 or 14 $\mu g/m^3$ (1-hour average), under unfavourable dispersion and with peak traffic flows. This is below the proposed UK goal of 16 $\mu g/m^3$ (the UK goal however is an annual average). Concentrations of total hydrocarbons are of course substantially lower at the locations of residences 50 m from the road, 0.14 mg/m^3 (7 $\mu g/m^3$ benzene) being the maximum predicted in both 2001 and 2011. It is nevertheless recognised that there may be no safe limit for benzene, but the risks to a particular individual over a lifetime is small, and on a population and individual basis could be offset by lower risks through safer roads, although to an undetermined extent.

Particulate Matter and Lead

The predicted levels of PM_{10} are for 1-hour averaging periods, while the air quality goal refers to a 24-hour period. Comparing these is therefore a conservative approach (that is an over-prediction) as the maximum predicted 1-hour average will always be higher than the predicted 24-hour average. However, the actual relationship is dependent on hourly variations in traffic flow and meteorological conditions. An empirical averaging time correction factor of 0.24 has been suggested by **Katestone Scientific (1995)** to convert 1-hour predictions to 24 hour averages. This factor will obviously vary with site, and cannot be regarded as rigorous.

However in the absence of detailed meteorological data it provides some estimate of the likely differences between 1-hour and 24-hour averages.

Kerbside levels are not predicted to exceed the historical 24-hour PM_{10} goal of 150 $\mu g/m^3$. In 2001 the highest 1-hour concentration at kerbside for the MDTY is predicted to be 71.3 $\mu g/m^3$, increasing to 84.0 $\mu g/m^3$ in 2011. Using the correction factor of 0.24, the 24-hour concentrations are likely to be of the order of 17 $\mu g/m^3$ (2001) and 20 $\mu g/m^3$ (2011). These levels are below both the historical and interim 24-hour NSW EPA goals. Background PM_{10} concentrations would have to be of the order of 30 $\mu g/m^3$ or more to cause exceedances of the 50 $\mu g/m^3$ level (the EPA interim goal), which is unlikely in the area between Taree and Coopernook.

The highest predicted increase in PM_{10} at 10 m from the proposed road is of the order of 9 $\mu g/m^3$ in 2001 and 11 $\mu g/m^3$ in 2011, when the conversion factor is used, which are both less than the historical and interim NSW EPA 24-hour goals.

Using the conversion factor, all predicted increases in PM_{10} more than 10 m away from the road are less than 50 $\mu g/m^3$, even under the worst-case dispersion conditions combined with peak traffic flow. Concentrations over a year would be substantially less and concentrations at sites further removed from the road would again be reduced. Similarly, the NHMRC 90 $\mu g/m^3$ annual average for TSP (which is still retained by the NSW EPA) is unlikely to be exceeded as is the proposed annual PM_{10} goal of 30 $\mu g/m^3$.

Lead impacts have also been assessed for 2001, assuming that about 15% of vehicles will still be using leaded petrol. It should be noted that the lead goal applies to a 90-day average, and the predicted level is for a "worst-case" 1-hour period. However, none of the predicted values at 10 m exceed the 90-day average of 1.5 $\mu g/m^3$. These are short term predictions and are therefore likely to remain even further below the long term goals since "worst-case" conditions are unlikely to prevail for any significant period of time. The Ghinni Ghinni School currently lies about 70 m from the Pacific Highway and at this distance would not be affected by roadway lead emissions. This distance will increase to 90 m for the proposed roadway.

8.2 Construction impacts

Dust would be generated from earthworks associated with the construction of the upgraded Pacific Highway. The total amount of dust generated would depend on the silt and moisture content of the soil, the types of operations being carried out, exposed area, frequency of water spraying and speed of machinery.

Estimates of dust emissions from construction operations can be made using emission factors developed by the **SPCC (1983)** and the **US EPA (1981)**. These emission factors relate the amount of dust generated by different types of equipment and operations associated with construction work. The most likely equipment to be used in the project includes back hoes, rollers, excavators, pavers, concrete trucks, jackhammers and haul trucks. The major sources of dust would be the dozers, excavators, scrapers, trucks and wind erosion during construction. An estimate of the amount of dust generated by each operation per day is summarised below. It should be noted that the emission estimates relate to an area which would impact individual residences, not emissions from the entire length of the roads.

- Dust from loading of material by excavator to trucks assuming dust is generated at the rate of 0.01 kg/t and that 50 x 15 cubic metre trucks loads are removed in a ten-hour day, making a total of approximately 750 m^3 or approximately 1125 t of material removed per day gives a total dust generation of 11.25 kg/day.

- Dust from trucks travelling on the unsealed road surface assuming a 400 m round trip distance, five movements per hour and 2 kg of dust/vehicle/km (after taking account of dust suppression by watering of the trafficked areas) would generate 40 kg during a ten-hour working shift.
- Dust from wind erosion from an exposed area of 200 m long by 30 m wide (the exposed area may be greater than this but the area which could contribute significant amounts of dust to a particular residence would be unlikely to be larger) assuming an erosion rate of 0.4 kg/ha/hour gives a total of 2.4 kg in ten hours.

Thus the total dust generated in a ten-hour working day could be as high as approximately 50-60 kg. On a hot, dry, windy day (worst case emission conditions with respect to dust) the amount of dust from wind erosion could be much higher, and should be controlled using water sprays. It is possible that under some extreme wind conditions, construction activities would be stopped or relocated to areas removed from sensitive receptors.

The appropriate air quality goal for determining impacts from construction work is the EPA 24-hour goal for PM_{10} of 150 $\mu g/m^3$ (formerly noted by the NSW EPA). This is approximately equivalent to the former EPA 24-hour goal of 260 $\mu g/m^3$ for total suspended particulate matter (TSP). It is still useful to refer to this goal as many historical measurements are for TSP. The US EPA PM_{10} goal is considered to be appropriate in this instance as the emitted dust is of crustal origin and is likely to contain only a small fraction of $PM_{2.5}$ which is the particulate fraction of concern. When assessing particulate emissions from combustion processes (such as roadway emissions) which have high $PM_{2.5}$ content, the more stringent PM_{10} goal of 50 $\mu g/m^3$ is appropriate.

Previous dispersion modelling studies (**Stephenson, 1991**) indicate that high levels of dust generation associated with road construction work, can result in short-term dust impacts. That is exceedances of the 24-hour air quality goal for TSP, out to 600 m or more under "worst-case" dispersion conditions and out to 300 m for typical conditions.

In addition to the goals for ambient dust concentrations it is appropriate to consider goals for dust deposition during the construction period. The EPA consider that residential areas begin to experience dust related nuisance impacts when annual average dust (insoluble solids) deposition levels exceed 4 g/m^2/month, and that dust impacts would be at unacceptable levels when they reached 10 g/m^2/month (**SPCC 1983**). In the early 1990s the EPA (**Dean et al., 1990**) refined these criteria. They are now expressed in terms of an acceptable increase in dust deposition over the existing background. For example, in residential areas with annual average deposition levels of between 0 and 2 g/m^2/month, an increase of up to 2 g/m^2/month would be permitted before it is considered that a significant degradation of air quality has occurred. **Table 6** shows the maximum acceptable increase in dust deposition over the existing dust levels.

Table 6- EPA criteria for dust fallout

Existing dust fallout level (g/m^2/month)	Maximum acceptable increase over existing fallout levels (g/m^2/month)	
	Residential	Other
2	2	2
3	1	2
4	0	1

Existing deposition levels in the Taree / Coopernook area are likely to be of the order of 1-2 g/m^2/month. Therefore an increase of 2 g/m^2/month could occur before there was a perceptible degradation in air quality. It is recommended that deposition monitors be installed during construction in order to determine levels at any sensitive receptors.

Concerns regarding the palatability of nearby pastures for grazing animals could potentially be raised for the period during construction of the roadway. In the course of feeding these animals inevitably disturb the surface and create localised dust which settles on the pasture they feed on. Further, it is known that grazing cattle ingest the roots of pasture and typically ingest of the order of 1 kg of soil per day. The question of palatability has been investigated in a study undertaken by **Andrews and Sriskandrajah (1992)**. They undertook two field trials in an attempt to test if the feed intake of dairy cows was affected by contamination of the feed with coal mine dust. There was found to be no statistical significance between dust intake and milk production.

The tests suggest that dust from construction of the proposed bypass is unlikely to affect grazing animals. This deduction of course is based on an extrapolation from a test with one type of dairy cow and one type of feed. However, when considered with other factors such as the likely micro-level of dust deposition level expected on pastures due to the movement of stock and the way in which dairy cattle feed, it would seem unlikely that deposition levels adjacent to the construction operations would affect grazing animals.

As construction is likely to continue for at least one year, it is important that exposed areas be stabilised as quickly as possible and that appropriate dust suppression methods be used to keep dust impacts to a minimum. It is recommended that monitoring be carried out during the construction phase of the project to assess compliance with EPA goals. A minimum of three monitors would be required, ideally at the closest residences or other sensitive receptors.

8.3 Batch Plants

If the established ready mixed concrete and asphalt suppliers in the region are not able to provide fully the quantity of the materials required for construction of the roadway, batching plants would need to be constructed on site. Establishing one (or more) batch plants would require separate environmental assessments and approaches. This aspect is discussed here to ensure that the outlined project Environmental Management Plan includes relevant matters in this regard.

8.4 Greenhouse Issues

The temperature of the earth's atmosphere is determined by the balance between incoming solar radiation and the loss of heat energy by radiation from the earth and atmosphere to outer space. This balance is in turn affected by a complex set of processes, acting on a global scale, which control the way in which heat is transported around the earth by winds and ocean currents, and by the quantities of energy that are reflected and absorbed by the earth's surface. While the broad principles of the way in which these processes work to control the temperature of the earth's atmosphere are understood, the details, which may well be very important in determining the final temperature that is achieved at the earth's surface, are still the subject of scientific research.

One of the important factors in determining the amount of radiant energy absorbed in the atmosphere is the concentration of carbon dioxide. Changes in this concentration are likely to cause changes in the temperature of the earth's atmosphere near the earth's surface. Increases in carbon dioxide concentration are expected to cause increases in temperature.

Australia is signatory to the "International Frame-work Convention on Climate Change" (Rio Convention), which commits Australia to programs of monitoring and reporting on greenhouse gas emissions. A target of the Rio Convention is that signatory countries should attempt to reduce greenhouse gas emissions to the levels that applied in 1990. At the recent Kyoto meeting (1997) the convention agreed that Australia would be allowed to reduce their emissions to 5% above the 1990 level by 2010.

The RTA is committed to ensuring that its environmental goals and policies are consistent with those outlined in the 1992 Intergovernmental Agreement on the Environment. This agreement addresses a number of globally important environmental issues including the greenhouse effect. This commitment is facilitated through the RTA's environmental vision which addresses greenhouse gas emissions and also energy consumption.

Approximately 21% of NSW's total carbon dioxide emissions are estimated to come from the transport sector (**EPA, 1995**). At a broad level, the RTA has been involved in and implemented several strategic initiatives to address the issue of road transport related greenhouse gas emissions. These are:

- National Greenhouse Response Strategy

  This strategy was adopted by the Council of Australian Governments in 1992 and aims to contribute to the national commitment to the National Strategy for Ecologically Sustainable Development. The RTA contributed to the development of this strategy and is the NSW representative on the Transport Working Group for the development of a greenhouse gas emissions inventory. With respect to transport, the response strategies include reducing fuel consumption in motorised transport; improving the technical and economic efficiency of operation of the road network and traffic management; and to encourage the use of bicycles. This proposal contributes to these initiatives.

- RTA Greenhouse Reduction Plan

  The RTA has prepared a plan at a strategic level to address and provide policy in relation to greenhouse gas emissions resulting from its activities. A greenhouse emissions inventory of RTA activities has been carried out (**Beer and others, 1996**) and the findings incorporated into the RTA Greenhouse Inventory.

Emissions of carbon dioxide from motor vehicles are directly proportional to fuel consumption. They cannot be reduced by emission control technologies except where they result in an improvement in fuel consumption. RTA programs that encourage better vehicle maintenance and hence better fuel economy will be beneficial.

The RTA also continues to engage in other strategies to encourage the tightening of vehicle emissions standards. These include;

- working with the EPA to implement the State's Motor Vehicle Maintenance Program for lowering emissions, and on the introduction of vehicle emissions testing;
- enhancing the State's vehicle emissions enforcement resources; and,
- continuing its role on ACVEN (Advisory Committee on Vehicle Emissions and Noise) to encourage the early implementation of more stringent Australian Design Rules, including the revision of ADR-37/0X to tighten current light vehicle emission standards. A revision of ADR-70, is also in progress. This will also contribute to controlling emissions from diesel vehicles, which will be particularly important for NO_x and particulate matter emissions (**RTA, 1995**).

In terms of the construction of the proposal, the new route is likely to result in better traffic flow and hence better fuel economy and therefore reduced greenhouse emissions.

9 CONCLUSIONS

This study has assessed air quality impacts along the proposed route for the Pacific Highway upgrade between the northern end of the Taree Bypass and Coopernook.

The results of the assessment conclude that:

1. Due to the present emission controls on motor vehicles and the projected traffic conditions for 2001 and 2011, the EPA's carbon monoxide 1-hour goals are not expected to be exceeded during the operation of the upgrade.
2. The PM_{10} annual and 24-hour maximum air quality goals, are not likely to be exceeded at any nearby residences. This is also the case for the 90-day lead goal which is not exceeded even in the short-term.
3. The predicted increases in concentration of nitrogen dioxide indicate that the EPA's interim goal would not be exceeded at any distance from the roadway.
4. Predicted concentrations of benzene (and other pollutants) are not at levels which should pose health effects. However it is recognised that there may be no safe level for exposure to benzene.
5. The assessment has assumed a traffic growth of 30% over 10 years. If this were to double as a result of the cumulative effects of upgrades along the length of the Pacific Highway, it is expected that air quality would still be within acceptable limits.

As discussed earlier, the introduction of catalytic converters has resulted in a substantial reduction in carbon monoxide and hydrocarbon emissions from motor vehicles. This is also true for nitrogen oxides, as all new fuel-injected passenger vehicles are fitted with three-way catalytic converters which reduce nitrogen oxide emissions. However the increased speed on upgraded roads results in increased nitrogen oxide emissions and this has offset to some extent the gains from the improved technology. Nevertheless the proposed roadway is predicted to result in nitrogen dioxide levels which are substantially below the air quality goal.

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APPENDIX A
EMISSION CALCULATIONS

VEHICLE EMISSIONS FACTORS

The emissions from vehicles on NSW roads were assumed to all fit into three classes:

1. Light duty petrol vehicles (LDPV)
2. Heavy duty petrol vehicles (HDPV)
3. Heavy duty diesel vehicles (HDDV)

These classes of vehicles account for more than 99% of all vehicle kilometres travelled on NSW roads (**Pengilley 1989**). The following assumptions were made regarding the vehicles in the years 2001 and 2011;

Year 2001

- 85% of passenger vehicles were assumed to be fitted with catalytic converters.
- Between Taree and Coopernook, 10% of the northbound vehicles and 11% of the southbound vehicles were assumed to be heavy duty for both the AADT and MDTY.
- Of the heavy vehicles category, 90% are considered to be HDDV and 10% are considered to be HDPV for all sections.

Year 2011

- 100% of passenger vehicles were assumed to be fitted with catalytic converters
- The percentages of heavy vehicles along the section was assumed to be the same as for 2001, as was the composition of diesel and petrol vehicles in the heavy duty fleet.

The emissions of CO, NO_x, hydrocarbons and particulate matter were taken from estimates in the Sydney Metropolitan Air Quality Study (MAQS) (**Carnovale & Tilly, 1995**). It was assumed that traffic on the roadway was in freeway/highway travel mode. It was also assumed that the deterioration of catalytic converters was as in the 1992 MAQS estimates of passenger vehicle emission rates.

The emission of particulate matter from vehicles is made up of lead salts, organic and sulphate components. The total emissions comprise exhaust emission plus airborne brake wear particulate emission and airborne tyre wear particulate emissions. In the case of passenger vehicles, the PM_{10} fraction comprises 74% of the total particulate exhaust emissions. The PM_{10} fraction of HDDV and HDPV particulate exhaust emissions is 100% and 64% respectively. Brake and tyre emissions are assumed to be essentially all PM_{10}.

Calculation of vehicle emission rates

Details of emission calculations for the route sections during peak hours for 2001 and 2011 are presented in the following tables.

Emission rates for CO, NO_x, hydrocarbons and particulate matter corresponding to a given section of the route are presented for each class of vehicle and expressed as g/km/vehicle. The total emissions (tot CO etc.) during the peak period have been calculated by multiplying the emission rate by the total number of vehicles estimated to be using the road in the one hour peak period. These values are expressed as g/km/h. Finally these values have been converted to kg/km/h and g/vehicle mile (the latter is used as input to the model).

Estimated emissions for the proposed roadway in 2001												
AADT												
Section	Taree to Coopernook-Northbound											
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		**372.00**									PM10	
total heavy		37.20										
LDPV		334.80	10.08	1.73	0.78	0.021	0.0028	3374.78	579.20	261.14	7.03	0.9374
HDDV		33.48	7.11	15.72	2.58	1.150		238.04	526.31	86.38	38.50	
HDPV		3.72	107.09	4.59	5.82	0.081	0.0322	398.37	17.07	21.65	0.30	0.1198
Brake & Tyre						0.009					3.35	
Total kg/km/h								4.01	1.12	0.37	0.05	0.0011
g/v-mi								17.25	4.83	1.59	0.21	0.0045
Section	Taree to Coopernook -Southbound											
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		**456.00**									PM10	
total heavy		50.16										
LDPV		405.84	10.08	1.73	0.78	0.021	0.0028	4090.87	702.10	316.56	8.52	1.1364
HDDV		45.14	7.11	15.72	2.58	1.150		320.97	709.66	116.47	51.92	
HDPV		5.02	107.09	4.59	5.82	0.081	0.0322	537.16	23.02	29.19	0.41	0.1615
Brake & Tyre						0.009					4.10	
Total kg/km/h								4.95	1.43	0.46	0.06	0.0013
g/v-mi								17.36	5.03	1.62	0.23	0.0046
Maximum Daily Traffic Year												
Section	Taree to Coopernook-Northbound											
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		**741.00**									PM10	
total heavy		74.10										
LDPV		666.90	10.08	1.73	0.78	0.021	0.0028	6722.35	1153.74	520.18	14.00	1.8673
HDDV		66.69	7.11	15.72	2.58	1.150		474.17	1048.37	172.06	76.69	
HDPV		7.41	107.09	4.59	5.82	0.081	0.0322	793.54	34.01	43.13	0.60	0.2386
Brake & Tyre						0.009					6.67	
Total kg/km/h								7.99	2.24	0.74	0.10	0.0021
g/v-mi								17.25	4.83	1.59	0.21	0.0045
Section	Taree to Coopernook -Southbound											
Freeway			Emission rate g/km/vehicle					Total emissions g/km/h				
Vehicle		Number	CO	NOx	HC	PM10	Pb	totCO	tot NOx	tot HC	tot	tot Pb
total no		**910.00**									PM10	
total heavy		100.10										
LDPV		809.90	10.08	1.73	0.78	0.021	0.0028	8163.79	1401.13	631.72	17.01	2.2677
HDDV		90.09	7.11	15.72	2.58	1.150		640.54	1416.21	232.43	103.60	
HDPV		10.01	107.09	4.59	5.82	0.081	0.0322	1071.97	45.95	58.26	0.81	0.3223
Brake & Tyre						0.009					8.19	
Total kg/km/h								9.88	2.86	0.92	0.13	0.0026
g/v-mi								17.36	5.03	1.62	0.23	0.0046

Estimated emissions for the proposed roadway in 2011									
AADT									
Section	Taree to Coopernook-Northbound								
Freeway		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no	**487.00**								PM10
total heavy	48.70								
LDPV	438.30	7.57	1.51	0.56	0.021	3317.93	661.83	245.45	9.20
HDDV	43.83	7.11	15.72	2.58	1.150	311.63	689.01	113.08	50.40
HDPV	4.87	107.09	4.59	5.82	0.081	521.53	22.35	28.34	0.39
Brake & Tyre					0.009				4.38
Total kg/km/h						4.15	1.37	0.39	0.06
g/v-mi						13.64	4.51	1.27	0.21
Section	Taree to Coopernook-Southbound								
Freeway		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no	**598.00**								PM10
total heavy	65.78								
LDPV	532.22	7.57	1.51	0.56	0.021	4028.91	803.65	298.04	11.18
HDDV	59.20	7.11	15.72	2.58	1.150	420.93	930.66	152.74	68.08
HDPV	6.58	107.09	4.59	5.82	0.081	704.44	30.19	38.28	0.53
Brake & Tyre					0.009				5.38
Total kg/km/h						5.15	1.76	0.49	0.09
g/v-mi						13.79	4.72	1.31	0.23
Maximum Daily Traffic Year									
Section	Taree to Coopernook-Northbound								
Freeway		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no	**970.00**								PM10
total heavy	97.00								
LDPV	873.00	7.57	1.51	0.56	0.021	6608.61	1318.23	488.88	18.33
HDDV	87.30	7.11	15.72	2.58	1.150	620.70	1372.36	225.23	100.40
HDPV	9.70	107.09	4.59	5.82	0.081	1038.77	44.52	56.45	0.79
Brake & Tyre					0.009				8.73
Total kg/km/h						8.27	2.74	0.77	0.13
g/v-mi						13.64	4.51	1.27	0.21
Section	Taree to Coopernook-Southbound								
Freeway		Emission rate g/km/vehicle				Total emissions g/km/h			
Vehicle	Number	CO	NOx	HC	PM10	totCO	tot NOx	tot HC	tot
total no	**1192.00**								PM10
total heavy	119.20								
LDPV	1072.80	7.57	1.51	0.56	0.021	8121.10	1619.93	600.77	22.53
HDDV	107.28	7.11	15.72	2.58	1.150	762.76	1686.44	276.78	123.37
HDPV	11.92	107.09	4.59	5.82	0.081	1276.51	54.71	69.37	0.97
Brake & Tyre					0.009				10.73
Total kg/km/h						10.16	3.36	0.95	0.16
g/v-mi						13.64	4.51	1.27	0.21

APPENDIX B
HYDROCARBON ANALYSIS OF VEHICLE EXHAUST, PETROL AND PETROL VAPOUR

HYDROCARBON COMPOSITION OF VEHICLE EXHAUST, PETROL AND PETROL VAPOUR

Hydrocarbon	Exhaust Average	Exhaust SD	Petrol Average	Petrol SD	Petrol Vapour
ethane	1.4	0.5			
ethylene	11.2	3.2			
acetylene	8.7	2.7			
propane	0.1	0.1	0.1	0.1	1.5
propylene	5.0	1.6			
methylacetylene	0.4	0.3			
n-butane	2.1	0.6	2.9	0.4	18.7
i-butane	1.0	0.3	1.2	0.3	11.1
1-butene	0.9	0.3	0.2	0.1	1.6
i-butene	1.4	0.6			
trans-2-butene	0.6	0.4	0.6	0.1	3.7
cis-2-butene	0.5	0.2	0.5	0.1	2.9
n-pentane	3.0	0.7	6.0	0.6	10.7
i-pentane	4.8	0.9	10.6	0.5	25.4
cyclopentane	0.4	0.1	0.5	0.1	0.6
1-pentene	0.2	0.1	0.3	0.1	0.7
trans-2-pentene	0.3	0.2	0.8	0.1	1.5
cis-2-pentene	0.3	0.2	0.5	0.1	0.9
2-methyl-1-butene	0.3	0.2	0.6	0.1	1.3
2-methyl-2-butene	0.5	0.2	1.6	0.2	2.6
n-hexane	1.9	0.4	3.5	0.3	1.9
2-methylpentane	2.3	0.4	4.9	0.2	3.5
3-methylpentane	1.6	0.3	3.2	0.1	2.2
2,2-dimethylbutane	0.3	0.2	0.5	0.1	0.6
2,3-dimethylbutane	0.6	0.1	1.3	0.1	1.1
methylcyclopentane	1.0	0.2	1.9	0.1	0.9
cyclohexane	0.6	0.2	0.8	0.1	0.3
1-hexene	0.3	0.2	0.4	0.1	0.3
other C_6 olefins	0.7	0.2	1.6	0.1	1.0
benzene	5.0	0.7	2.6	0.2	0.9
n-heptane	0.8	0.2	1.6	0.1	0.3
2-methylhexane	1.5	0.3	2.9	0.1	0.7
3-methylhexane	1.2	0.3	2.3	0.1	0.5
2,4-dimethylpentane	0.3	0.1	0.7	0.1	0.2
methylcyclohexane	0.6	0.2	1.1	0.2	0.2
other C_7 cycloalkanes	0.3	0.2	0.6	0.1	0.1
toluene	10.2	0.9	9.6	0.6	1.0
n-octane	0.4	0.1	0.7	0.1	
2,2,4-trimethylpentane	1.0	0.4	2.1	0.5	0.4
other C_8 alkanes	3.2	0.7	7.1	0.6	0.6
ethylbenzene	1.9	0.2	1.6	0.1	0.1
m, p-xylenes	6.5	0.9	6.5	0.4	0.2
o-xylene	2.5	0.4	2.3	0.2	0.1
n-nonane	0.2	0.1	0.3	0.1	
other C_9 alkanes	1.7	0.4	2.1	0.3	
n-propylbenzene	0.4	0.1	0.4	0.1	
i-propylbenzene	0.2	0.1	0.2	0.1	
1,2,4-trimethylbenzene	1.9	0.3	1.8	0.2	
1,3,5-trimethylbenzene	0.7	0.1	0.7	0.1	
m, p-ethyltoluenes	2.0	0.3	1.8	0.2	
o-ethyltoluene	0.6	0.2	0.5	O.1	
n-decane	0.4	0.1	0.4	0.1	
other C_{10} alkanes & aromatics	0.9	0.4	1.2	0.3	
C_{11} and C_{12} alkanes & aromatics	3.6	1.1	4.2	0.7	
	100.40		99.80		100.30

Source: **Nelson & Quigley (1982)**

FIGURES

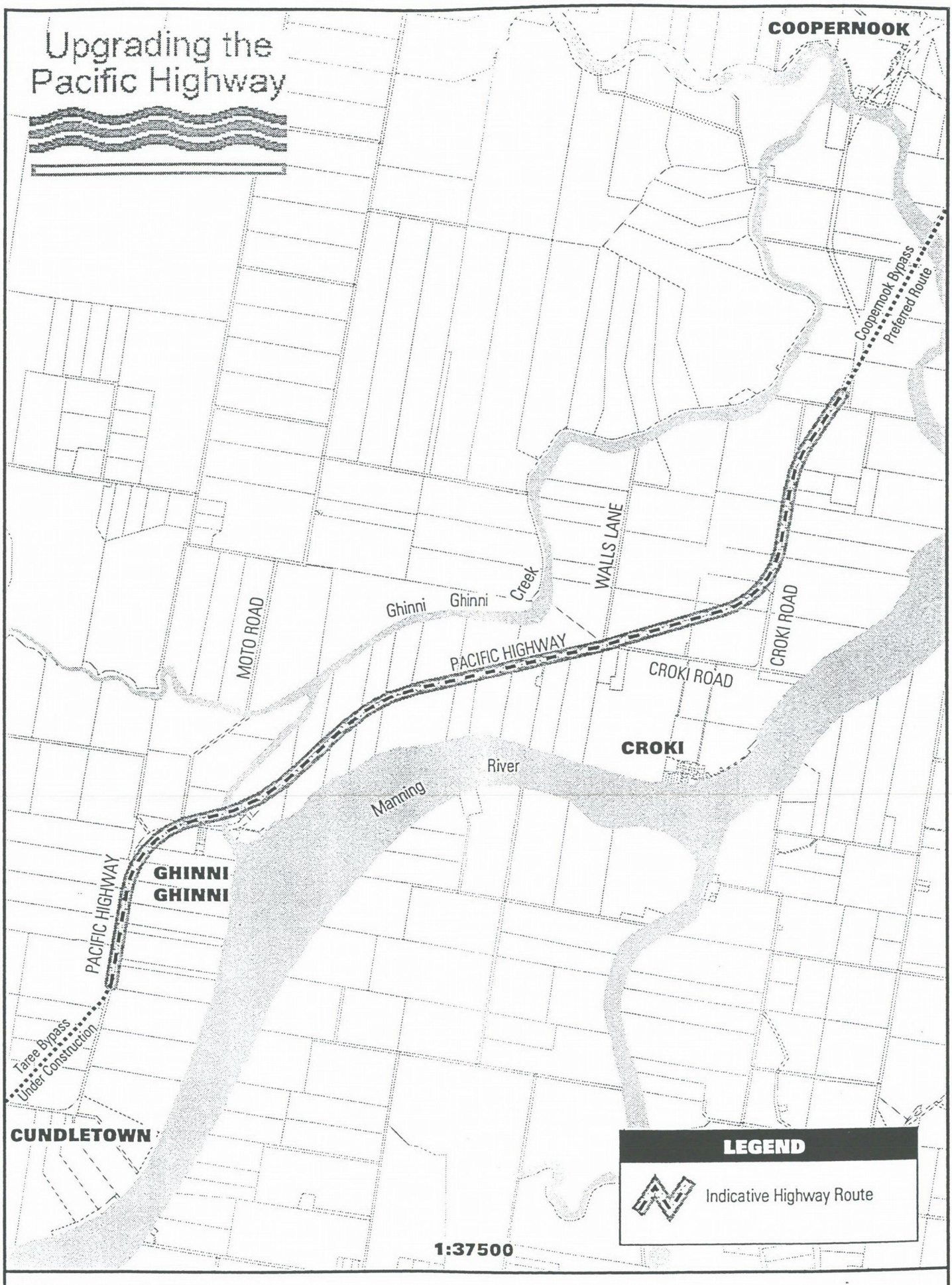
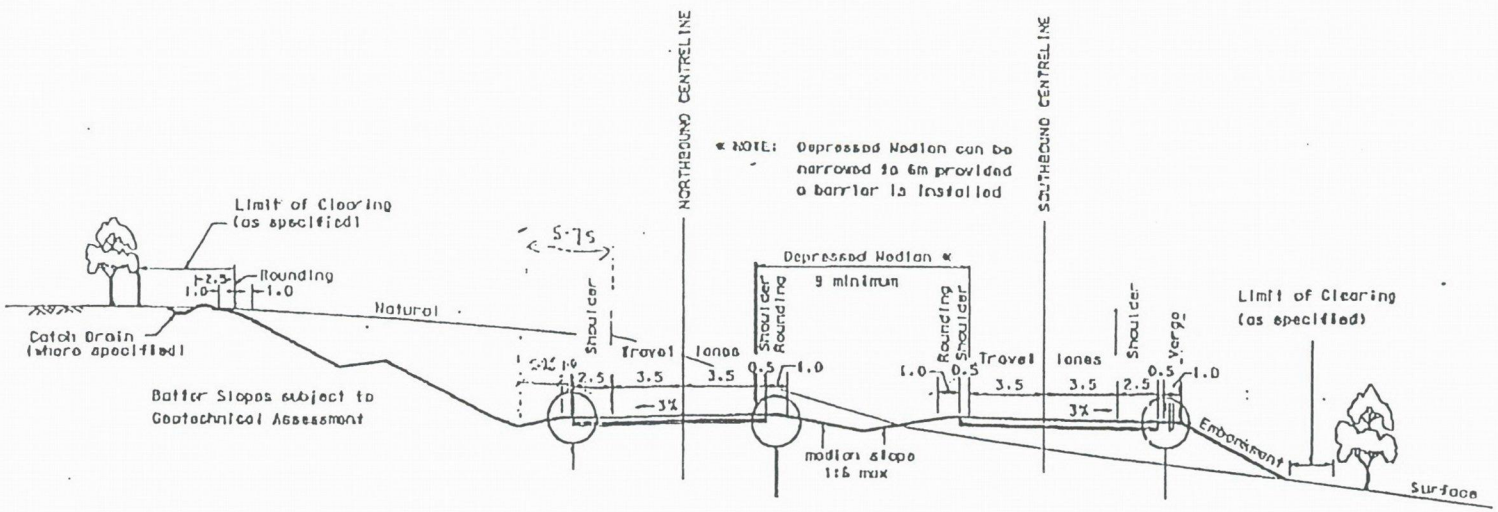

Upgrading the Pacific Highway
COOPERNOOK
Coopernook Bypass Preferred Route
WALLS LANE
Ghinni Ghinni Creek
MOTO ROAD
PACIFIC HIGHWAY
CROKI ROAD
CROKI ROAD
CROKI
River
Manning
GHINNI GHINNI
PACIFIC HIGHWAY
Taree Bypass Under Construction
CUNDLETOWN
LEGEND
Indicative Highway Route
1:37500
PACIFIC HIGHWAY UPGRADE
TAREE BYPASS TO COOPERNOOK BYPASS
N
PREFERRED CORRIDOR
TAREE TO COOPERNOOK

FIGURE 1



TYPICAL ROADWAY CROSS-SECTION

FIGURE 2

LEAD LEVELS - SYDNEY SUBURBS
(Monthly averages - Rozelle and Lane Cove)

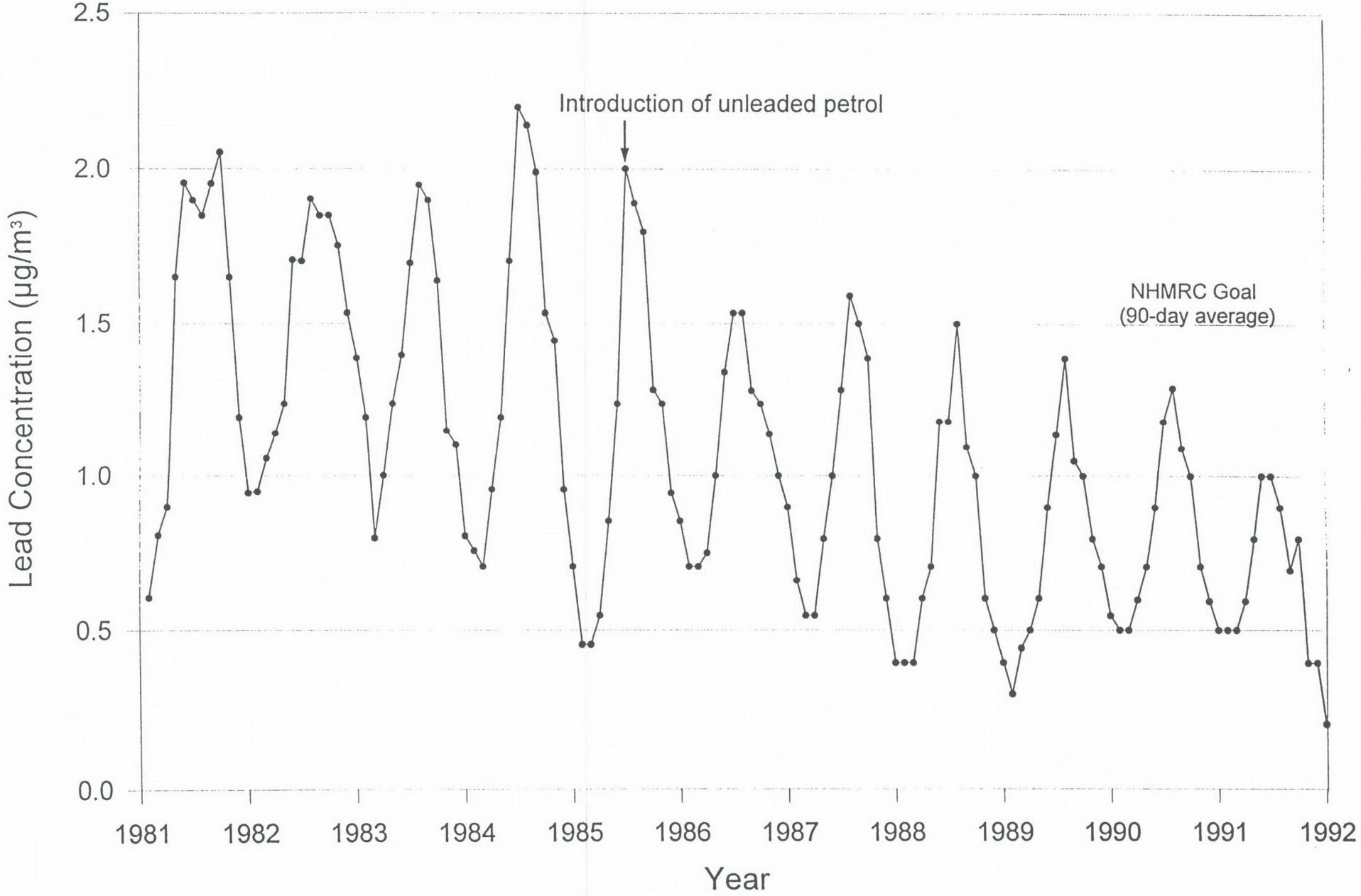
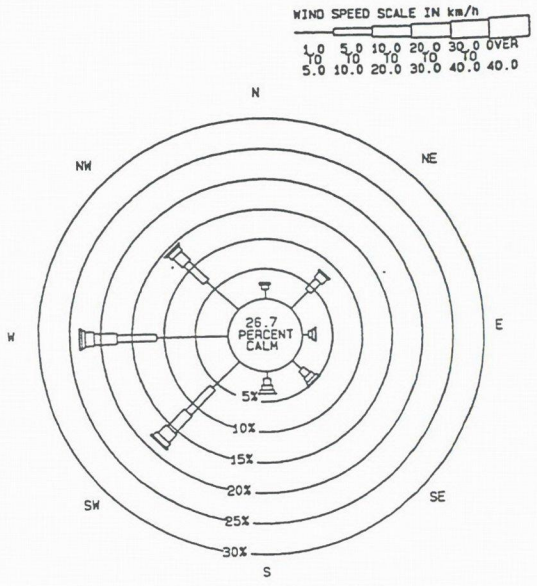
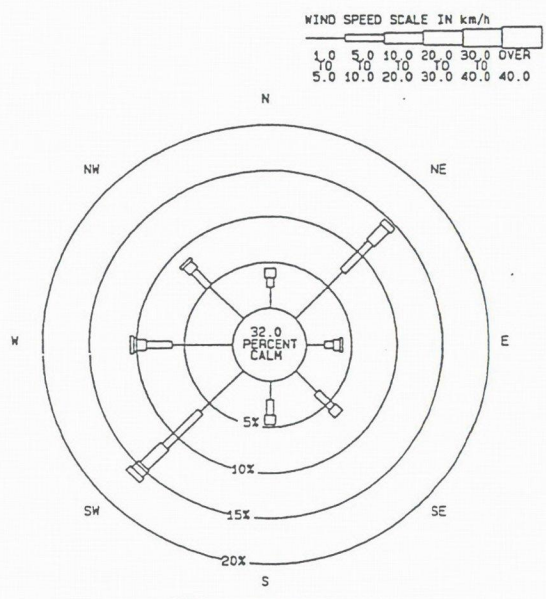


FIGURE 3

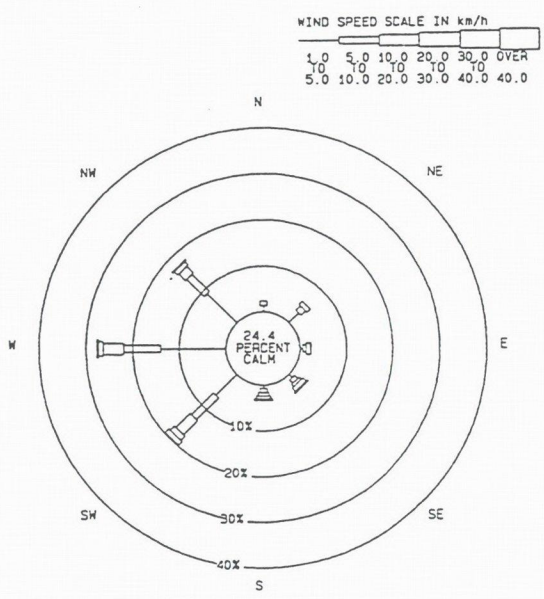
ANNUAL AND SEASONAL WINDROSES FOR TAREE RADIO STATION 9AM



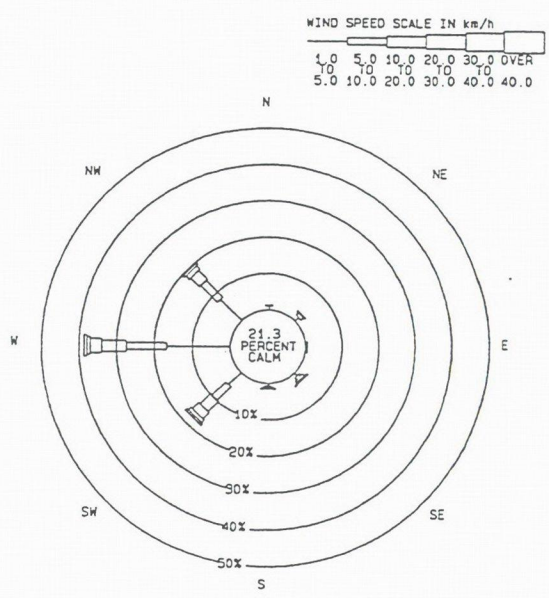
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am - Annual



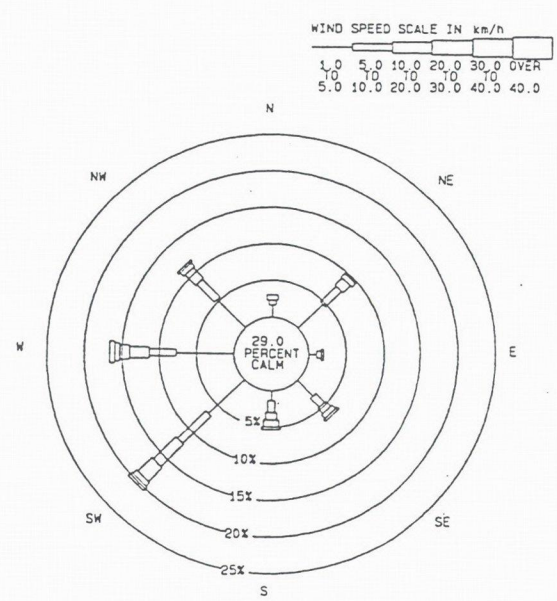
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am - Summer



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am - Autumn



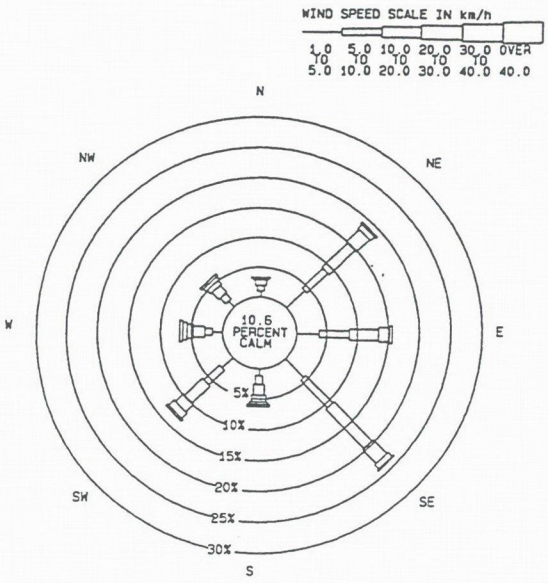
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am - Winter



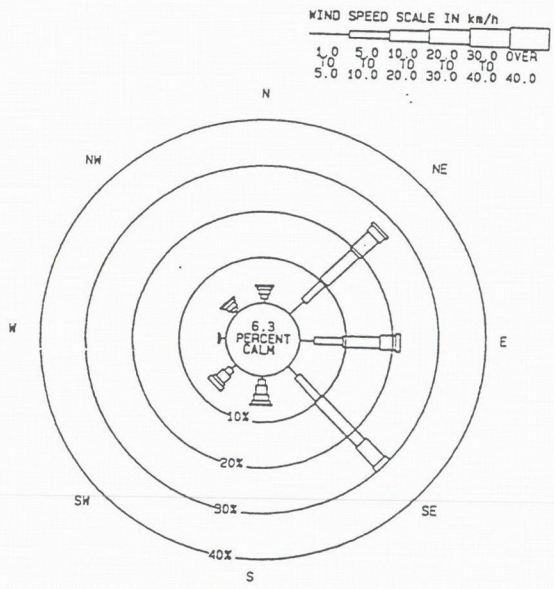
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am - Spring

FIGURE 4a

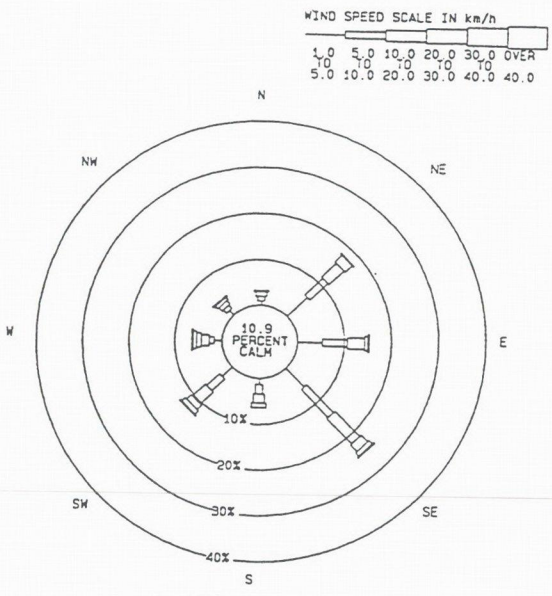
ANNUAL AND SEASONAL WINDROSES FOR TAREE RADIO STATION 3PM



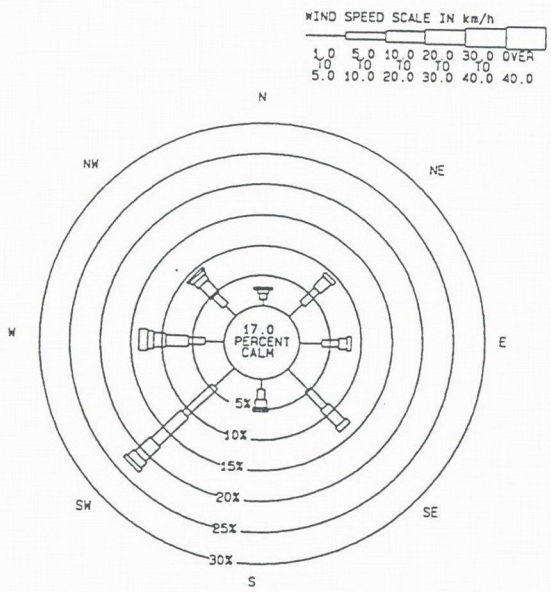
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 3pm - Annual



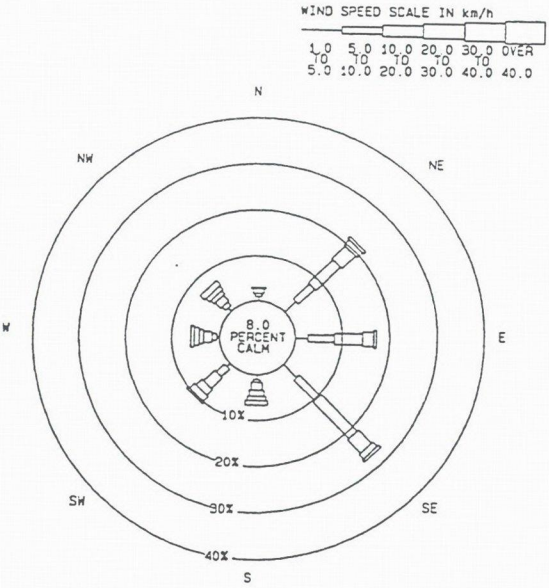
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 3pm - Summer



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 3pm - Autumn



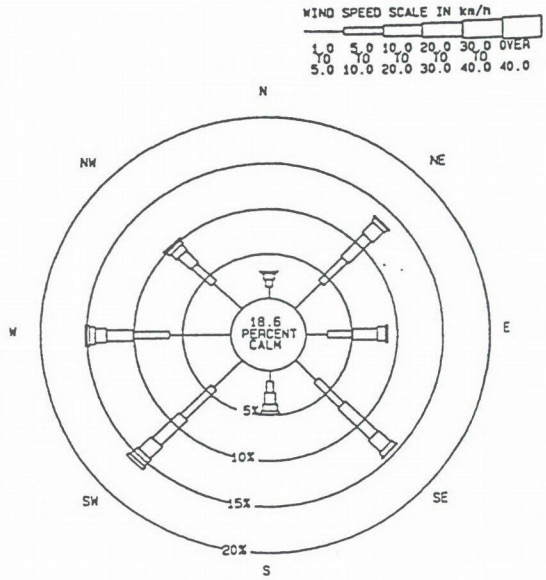
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 3pm - Winter



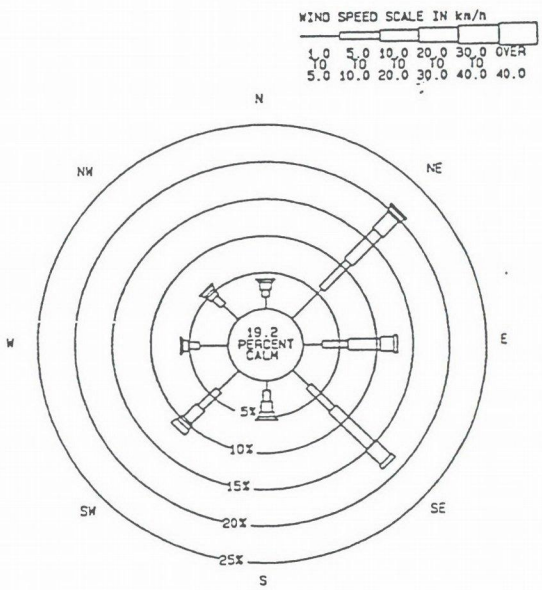
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 3pm - Spring

FIGURE 4b

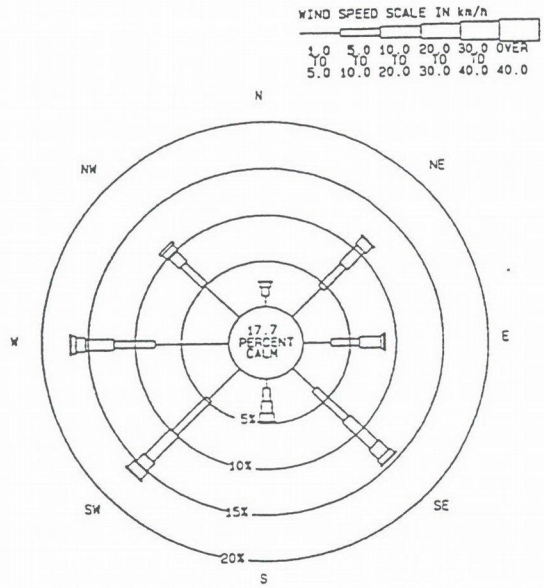
ANNUAL AND SEASONAL WINDROSES FOR TAREE RADIO STATION 9AM & 3PM COMBINED



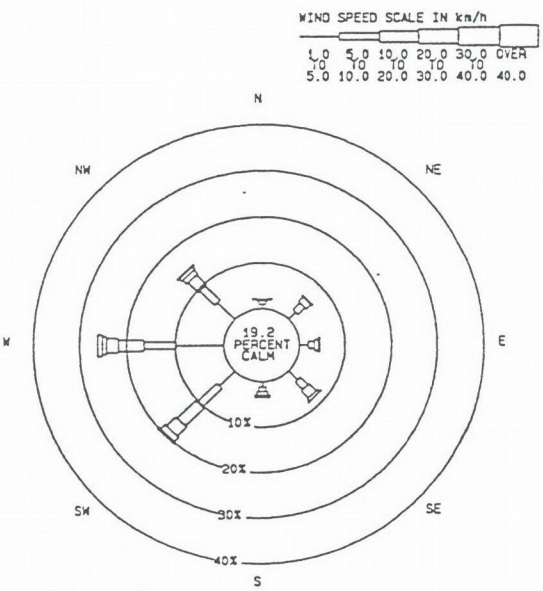
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am & 3pm - Annual



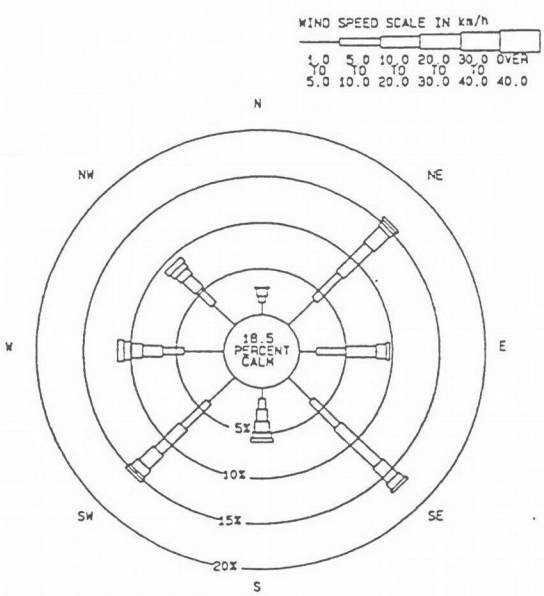
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am & 3pm - Summer



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am & 3pm - Autumn



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am & 3pm - Winter



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Taree Radio Station 9am & 3pm - Spring

FIGURE 4c

Correlation between % NO_2 and total NO_x
EPA monitoring data

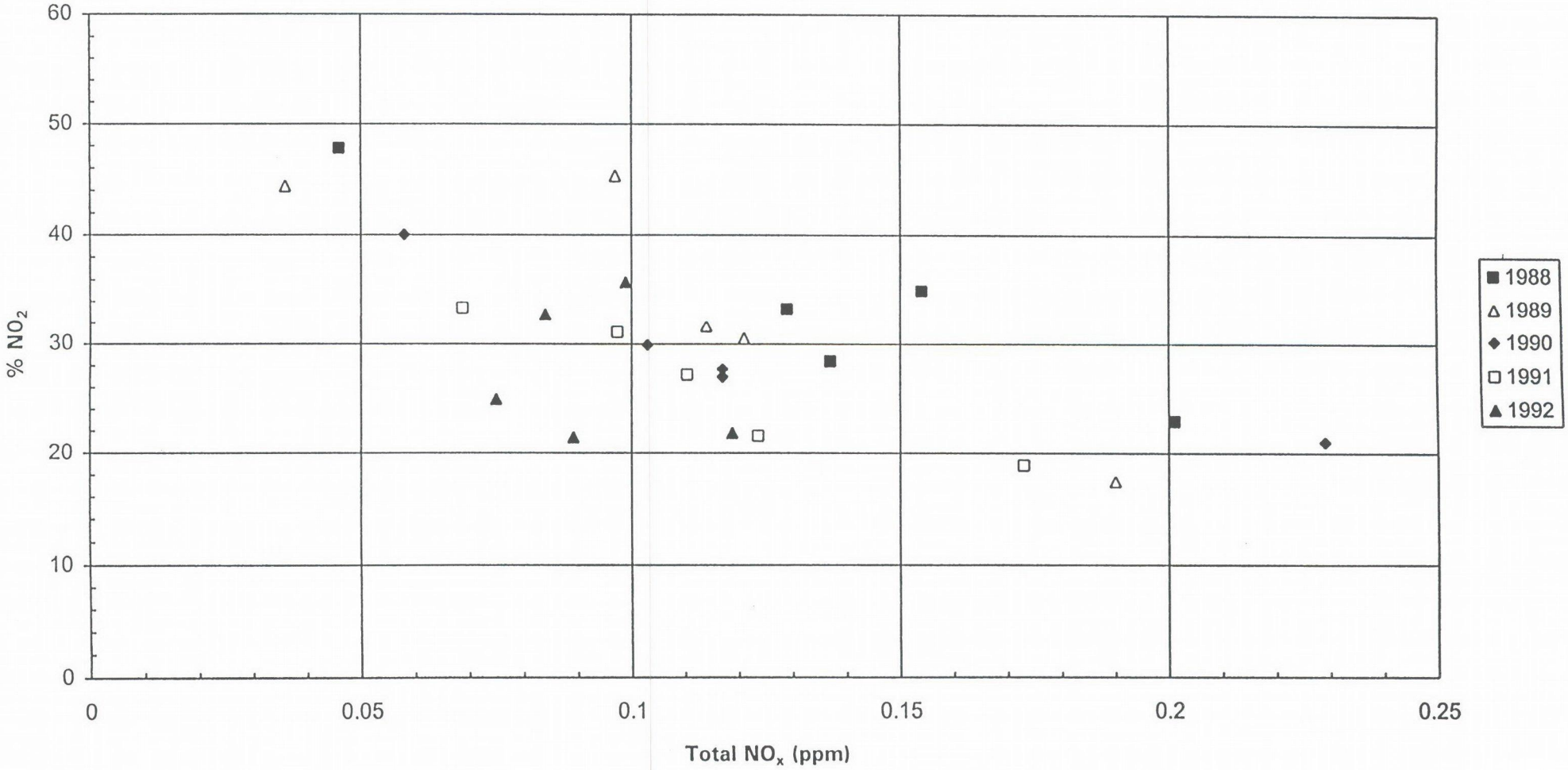


FIGURE 5

EMISSION RATE OF CO vs SPEED FOR LIGHT DUTY PETROL VEHICLES - YEARS 1988 AND 2000

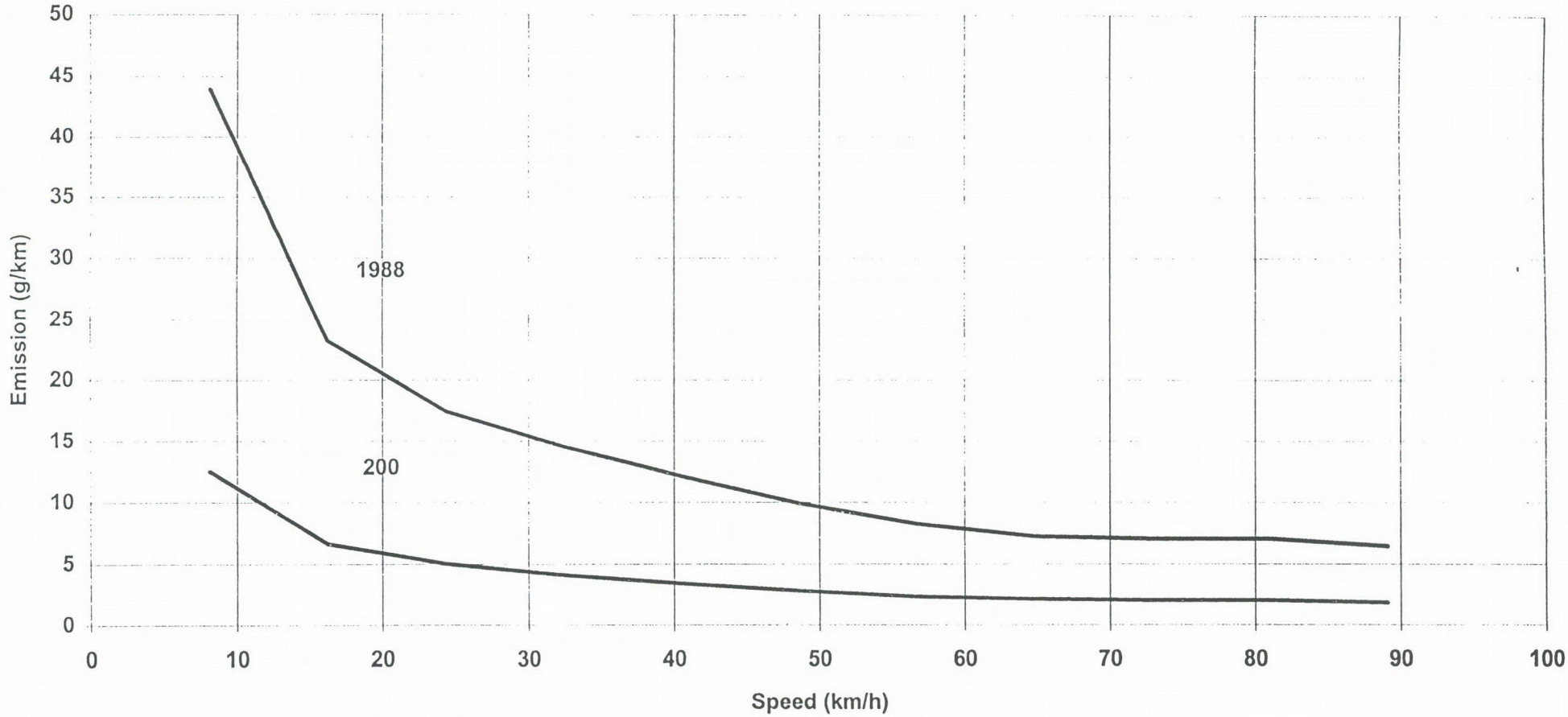


FIGURE 6

EMISSION RATE OF NO_x vs SPEED FOR LIGHT DUTY PETROL VEHICLES - YEARS 1988 AND 2000

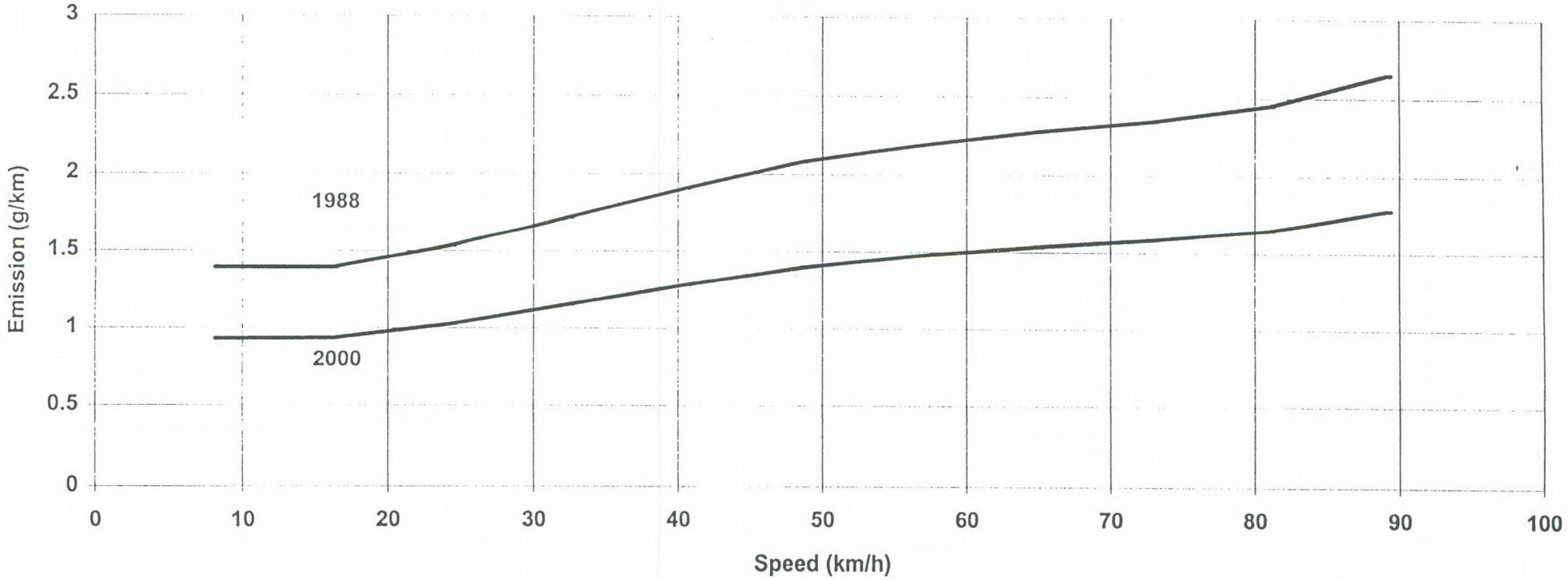
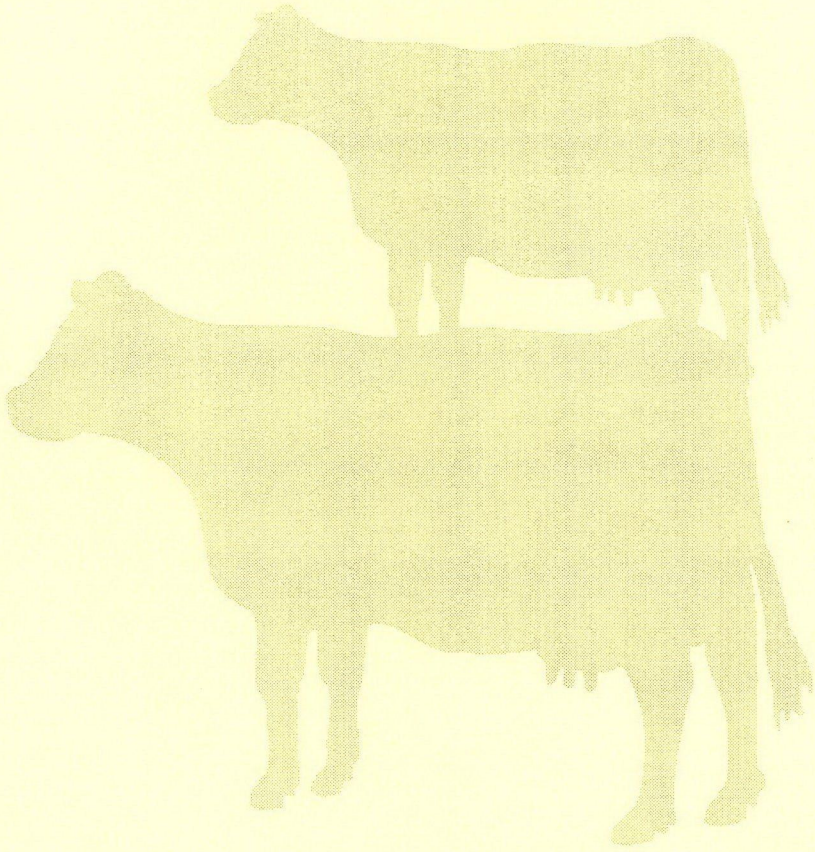


FIGURE 7



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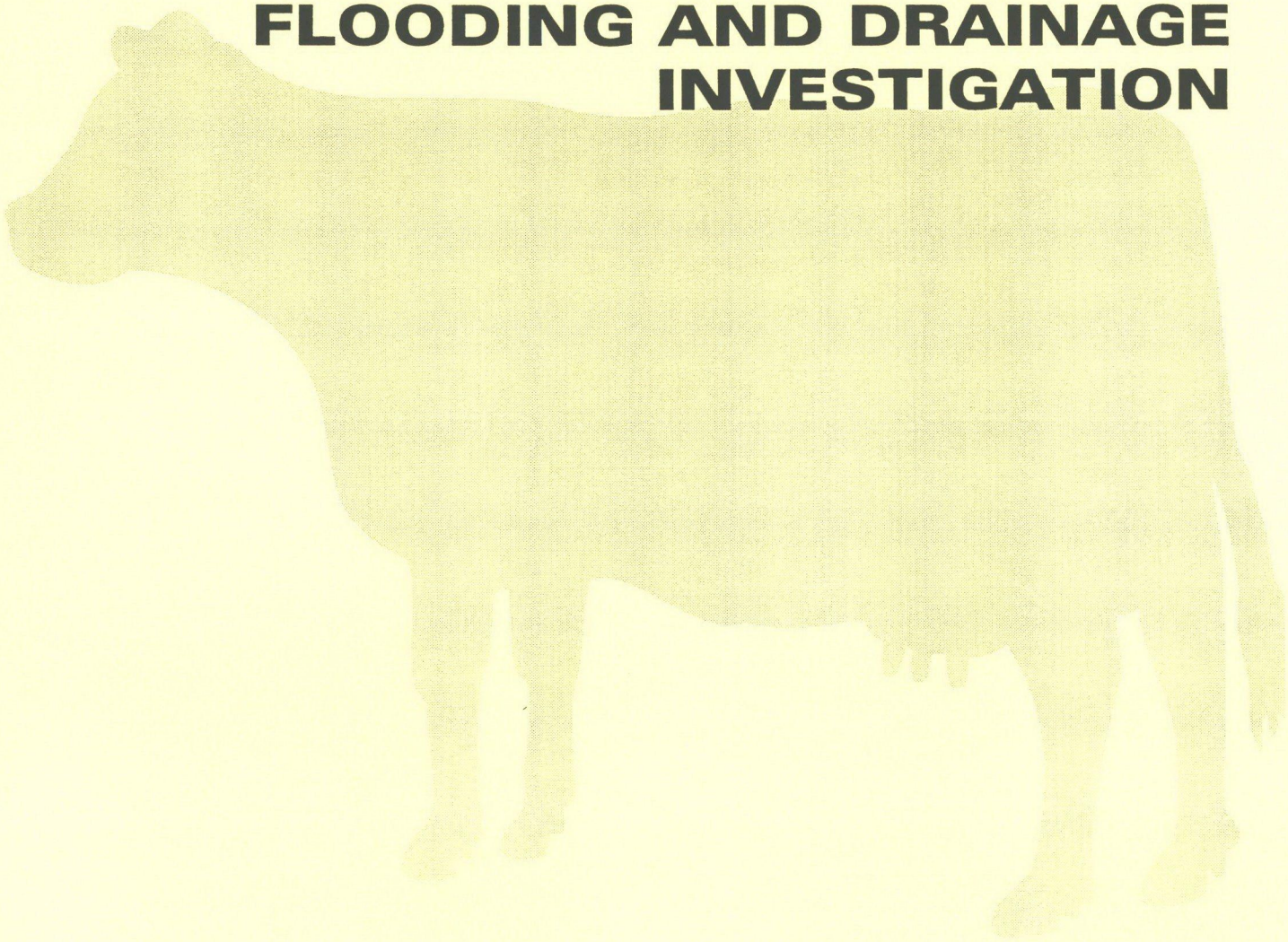
FLOODING AND DRAINAGE INVESTIGATION



CUNDLETOWN TO COOPERNOOK R.E.F.

HYDROLOGY, FLOODING AND DRAINAGE WORKING PAPER

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Original Date of Issue:	8/9/98
Project Manager:	Greg Rogencamp
Library Ref:	N0237.R1.1

Title:	Cundletown to Coopernook REF - Hydrology, Flooding and Drainage (Draft)
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Synopsis: This document forms the working paper for the assessment of the hydrology, flooding and drainage impacts associated with the proposed upgrade of the Pacific Highway between the Taree Bypass and the proposed Coopernook Bypass for the REF which is being prepared by Connell Wagner.

REVISION/CHECKING HISTORY

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EXECUTIVE SUMMARY

Existing Flooding and Drainage Characteristics

Existing Flooding Behaviour

The Manning River catchment has an area of approximately 8,100 km^2 (upstream of the junction of the Manning and Lansdowne Rivers). Manning River floods dominate the flooding behaviour of the study area and in these flood events the peak flow in the Manning River can be in the order of 15,000 m^3/s. This type of flooding is often combined with elevated ocean levels ('storm tides').

The floodplains to the north of the existing Pacific Highway have the potential to store a significant volume of floodwater. There are large areas of low-lying land to the west of the town of Coopernook and on the Moto floodplain (see Figure 2.1).

The rising flood levels in the Manning River result in flood waters filling these low areas through back-up of Ghinni Ghinni Creek and the Lansdowne River. In large flood events, the Pacific Highway is overtopped and floodwaters flow from the Manning River across the highway and onto the floodplains.

Existing Drainage Network

The existing local drainage network for the study area contains a number of agricultural drains which pass under the existing Pacific Highway. Most commonly, these drains cross under the highway as 450mm diameter pipes (or a number of barrels of these size pipes).

These drains play an important role in draining the agricultural areas of the study area. They allow runoff from local rainfall on the area to drain from the land as well as draining the floodplain in the final stages of the recession of larger flood events. It is recognised that maintenance of adequate drainage is essential for the continued operation of the agricultural enterprises in the study area.

Numerical Modelling

A numerical model of the Manning River system was developed by WBM Oceanics Australia (then trading as Oceanics) as part of the Manning River Flood Study (PWD, 1991). The model has two parts; a hydrologic model and a hydraulic model. The models aim to simulate the flooding characteristics and behaviour of the Manning River system and floodplains over the duration of a flood event.

In order to assess the impacts to flooding of the proposed bypass, three 'design' flood events were considered.

100 Year ARI Manning River Flood: This flood is the 1% AEP flood for the entire Manning River combined with the 1% AEP ocean levels. This flood was chosen to assess the performance of the bypass when it is overtopped. The proposed bypass is to be trafficable in floods up to the '20 year Manning River flood' (see below).

50 Year ARI Manning River Flood: This flood is the 2% AEP flood for the entire Manning River combined with the 2% AEP ocean levels.

20 Year ARI Manning River Flood: This flood is the 5% AEP flood for the entire Manning River combined with the 5% AEP ocean levels. This flood was chosen to produce the design road levels for the proposed upgrade.

Details of Proposed Bypass

Design Level

The road is to be constructed such that at least one lane (in either direction) is trafficable in a 5% AEP flood event. The existing highway is below this level. For a significant length of the proposed upgrade, two additional lanes will be constructed to supplement the existing Pacific Highway. Both of these additional lanes will be trafficable in a 5% AEP flood event (ie. the whole lane width is above the peak 5% AEP flood level). Hence, during a flood, the northbound traffic may need to be diverted onto the southbound carriageway (and vice versa at the southern end of the proposed upgrade).

The existing 5% AEP flood level varies from 2.7 mAHD (at the upstream end) to 2.3 mAHD (at the downstream end).

Required Waterway Openings

The numerical model was used in an iterative manner to assess the design requirements and associated impacts of the proposed bypass. The required waterway openings under the proposed upgrade are detailed in Table A. These waterway openings are sufficient to ensure that there will be negligible impacts to flood levels (ie. less than 100mm). As well, the times of inundation experience only minor increases (ie. lass than 2 hours over a number of days), if any at all.

The chainages indicated are approximate and will need to be confirmed at the detailed design stage of the project.

Table A - Required Waterway Openings

Approximate Chainages (m)	Details
11,500	4 RCBC's[1] 2.4m wide, 1.2m high at invert level of 0.9 mAHD
12,200 to 12,280	Bridge over Ghinni Ghinni Creek
14,100	5 RCBC's 2.4m wide, 0.9m high at invert level of 1.5 mAHD
16,350	2 RCBC's 2.4m wide, 0.9m high at invert level of 0.4 mAHD

Notes: 1 - RCBC = Reinforced Concrete Box Culvert

It was also assumed that the abutments of the bridge over the Ghinni Ghinni Creek would be close to the creek banks. Final bridge details would include sufficient width for an access road on either or both banks. This would only improve the hydraulic performance and efficiency of the structure.

As well, there are a number of small culvert crossings of the existing Pacific Highway (mostly with 450mm diameter pipes). It is proposed that these crossing be replicated in the proposed upgrade.

Impacts to Flooding and Drainage Characteristics

The flooding impacts of the proposed bypass can be assessed by considering the changes to:

- flood levels, including peak flood levels;
- times of inundation of the floodplain; and
- flows and velocities.

It was assumed in the flooding assessments that the waterway openings, as described above, will be constructed. These waterway openings were determined by considering the impacts to flood levels and limiting these impacts to a maximum increase of 100mm.

This magnitude of increase is considered to be negligible in relation to the existing depths of inundation on the floodplain of 2 to 3m. It can also be considered negligible in relation to other common occurrences during flooding including boat and wind waves that can result in flood level increases of similar magnitudes.

Impacts to Flood Levels

The predicted impacts of the completed bypass on peak flood levels are less than 100mm and can be considered to be negligible. These impacts are presented on Figures 4.2 to 4.4 for the three flood events considered.

Impact to Frequency of Floor Level Inundation

The impacts described above will result in increases to the frequency of flood inundation of 17 residential structures in the vicinity of the proposed highway upgrade for the 100 year ARI flood. However, the majority of these houses will experience an increase of 10mm or less and all impacts are less than 30mm. The impacts on inundated structures for all three flood events considered are presented in Table B.

Table B - Impacts to House Floor Levels

Impact (mm)	Number of Houses Impacted		
	100 year ARI Flood	50 year ARI Flood	20 year ARI Flood
10mm	11		
20mm	5	5	
30mm	1	1	1
40mm		2	
50mm			
60mm		2	
Total	**17**	**10**	**1**

Impacts to Recession of Floods

The numerical modelling indicates that the proposed upgrade of the Pacific Highway will have a negligible (ie. less than 1%) impact on the rate of flood water recession. The model is most accurate in simulating the major overland floodpaths such as flow over levee banks, across the floodplain and over the Pacific Highway. These major flowpaths convey large flows durting the flood event (ie. 100's of cubic metres per second).

The model is less accurate in simulating the minor flows (ie. 10's of cubic metres per second) from the floodplain through culverts in river / creek levees. However, for these

minor flows, the rate of floodwater recession is dominated by the size of culverts through embankments such as levees and the highway embankments.

For a significant length of this highway upgrade, a new carriageway is proposed to be constructed to compliment the existing carriageway. It is proposed that the existing crossings of drains under the Pacific Highway will be replicated under the new carriageway. Hence, as it is these drainage crossings that dominate the rate of flood recession, the rates of flood recession will be similar to that experienced at present.

Impacts to Flood Velocities and Bank Erosion

The numerical computer modelling of the flooding impacts associated with the highway upgrade is also able to assess the impacts to river velocities. Table B presents the impacts to peak flood velocities and flows in Ghinni Ghinni Creek for the three flood events considered.

Table C - Impacts to Ghinni Ghinni Ck Flows and Velocities

Flood Event	Existing Case		Upgrade Case	
	Peak Velocity (m/s)	Peak Flow (m^3/s)	Peak Velocity (m/s)	Peak Flow (m^3/s)
100 year ARI Flood	1.3	280	1.8	400
50 year ARI Flood	1.3	270	1.8	380
20 year ARI Flood	1.3	250	1.6	330

It is apparent from the results in Table C that the upgrade will result in increases in flood velocities of up to 38%. These increases in velocity occur in the mouth of Ghinni Ghinni Creek and specifically through the bridge opening.

This impact in flood flow and velocity is limited to flood events greater than the 15 year ARI flood event. Hence, the frequency of occurrence of these increased velocities is not common.

During these larger flood events, the velocities will not be increased for flooding levels lower than 2.0 mAHD. At these higher flood levels, the banks of Ghinni Ghinni Creek to the north of the Pacific Highway are overtopped. The additional flow through Ghinni Ghinni Creek and onto the floodplain in this area is distributed over long lengths of creek bank. Hence, there are no increases to the velocities in Ghinni Ghinni Creek north of the Pacific Highway.

Given the above, these increases in flood velocity have the potential to increase the erosion potential through the mouth of Ghinni Ghinni Creek for large flood events (ie. greater than the 15 year ARI flood event). This could result in increased erosion of the creek bed and banks at this location.

It is recommended that bank protection works (eg. rock protection) be constructed within the road reserve as part of the construction of the new bridge to protect the bridge abutments against potential erosion of creek banks. Further, it is recommended that the bridge piers associated with the former and existing Pacific Highway bridges over Ghinni Ghinni Creek be removed to bed level to improve the hydraulic efficiency of this section of creek and

assist in the mitigation of these increased velocities.

Flood Access to Croki

It is proposed as part of this Pacific Highway upgrade to close the intersection of Croki Road North with the Pacific Highway. This may result in the flood free access to the Pacific Highway from Croki to be closed earlier than in the existing situation. This impact is dependant on the location of the lowest points along Croki Road (North and South).

If the location of the first cutting of Croki Road is on Croki Road South, then the reduced flood access could be avoided by installation of a flood access gate on the closed section of Croki Road North.

Impacts to Drainage Network

The existing local drainage network for the study area contains a number of agricultural drains which pass under the existing Pacific Highway. Most commonly, these drains cross under the highway as 450mm diameter pipes (or a number of barrels of these size pipes).

These drains play an important role in draining the agricultural areas of the study area. They allow runoff from local rainfall on the area to drain from the land as well as draining the floodplain in the final stages of the recession of larger flood events. It is recognised that maintenance of adequate drainage is essential for the continued operation of the agricultural enterprises in the study area to minimise pasture damage following flood peaks.

For a significant length of this highway upgrade, a new carriageway is proposed to be constructed to compliment the existing carriageway. Hence, the existing crossings of drains under the Pacific Highway will be replicated and extended under the new carriageway. All drainage crossings of the existing Pacific Highway will be maintained by increasing the length of pipe to convey water under the additional carriageway.

There are not any locations where there is a need to completely re-route any drains within the study area. However, there are a number of locations where the new additional carriageway will be constructed over a drain running alongside the existing carriageway. It is recommended in these locations that a drain of similar size be constructed alongside the new additional carriageway and provide appropriate linkages with other field drains.

More detailed investigations into the proposed alterations to the local drainage network should be carried out at the detailed design stage of the project.

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1 INTRODUCTION

The RTA has commissioned Connell Wagner and a team of sub-consultants to prepare an Review of Environmental Factors (REF) for a proposed upgrade of the Pacific Highway between the Taree Bypass near Cundletown and the proposed Coopernook Bypass.

WBM Oceanics Australia was commissioned by Connell Wagner on behalf of the RTA to assess the impacts of the proposed road construction on the flooding and drainage characteristics of the study area.

This document is the working paper for the flooding and drainage impact assessment of the proposed works.

2 FLOODING CHARACTERISTICS

2.1 General Flooding Behaviour

The proposed highway upgrade route crosses the floodplain of the Manning River. In order to assess the impacts associated with the proposed route on flooding, it is necessary to understand the general flooding behaviour of the Manning River system and, more specifically, this part of the floodplain. A locality map showing the route location and other general features is shown in Figure 2.1.

2.1.1 Catchments

The Manning River catchment has an area of approximately 8,100 km^2 (upstream of the study area). The major tributaries include the Barnard, Nowendoc, Rowleys, and Barrington (or Gloucester) Rivers. It is bounded by the Hunter River and Karuah River catchments to the south, the Great Dividing Range to the west and the Macleay River and Hastings River catchments to the north.

The northern part of the study area crosses the southern floodplain of the Lansdowne River. The catchment of the Lansdowne River is approximately 200 km^2 (upstream of the proposed bypass). Hence, this catchment comprises 2.5 % of the Manning River catchment.

Manning River floods dominate the flooding behaviour of the study area.

2.1.2 Manning River Floods

In a flood dominated by Manning River flooding, the peak flow in the Manning River can be in the order of 15,000 m^3/s. This type of flooding is often combined with elevated ocean levels ('storm tides').

The floodplains to the north of the existing Pacific Highway store a significant volume of floodwater during flood events. There are large areas of low-lying land to the west of the town of Coopernook and on the Moto floodplain (see Figure 2.1).

The rising flood levels in the Manning River result in flood waters filling these low areas through back-up of Ghinni Ghinni Creek and the Lansdowne River. In large flood events (ie. those greater than the 1 in 10 year ARI flood) , the Pacific Highway is overtopped over a long length and significant volumes of floodwater flow from the Manning River across the highway and onto the floodplains.

The approximate extent of this overtopping is shown on Figure 2.2 for a 20 year ARI flood (see Section 2.5 for an explanation of this flood event). The duration of overtopping is dependant on the height of a specific section of highway. However, most of the highway is at a level of approximately 2.0 mAHD and would be inundated for up to 24 hours.

2.2 Flood Model

2.2.1 Description

A numerical model of the Manning River system was developed by WBM Oceanics

Australia (then trading as Oceanics) as part of the Manning River Flood Study (PWD, 1991). This model was further refined as part of flooding investigation associated with the Coopernook Traffic Relief Route (WBM Oceanics Australia, 1992 and 1997).

The model has two parts; a hydrologic model (using RORB) and a hydraulic model (using ESTRY). The models aim to simulate the flooding characteristics and behaviour of the Manning River system and floodplains over the duration of a flood event.

The **hydrologic** model simulates the process of rainfall on the catchment becoming flow in a river. The hydrologic model is made up of a number of sub-catchments which are represented by parameters such as the area, length, vegetation cover and steepness of each sub-catchment. The inputs to the hydrological model are rainfall patterns (over the duration of the flood event). The rainfall patterns are factored to account for antecedent catchment conditions. The outputs of the hydrological model are flows over the duration of the flood event. The model can be used with different rainfall intensities over different parts of the catchment (eg. large flood in Lansdowne River catchment with a small flood in the Manning River catchment).

The **hydraulic** model (see Figure 2.3) uses as input the flows from the hydrologic model as well as the variations in ocean water levels (over the duration of the flood event). The hydraulic model simulates the relationships between flows and water levels in the rivers and creeks and on the floodplain. The hydraulic model represents over 350 flowpaths with parameters such as the size (width and area of flow), slope and roughness of the waterway. There are over 40 flowpaths within the study area represented in the model. It also simulates the capacity of over 170 storage areas on the floodplain.

Hence, using rainfall as input into the hydrologic model and in conjunction with the hydraulic model, the models can reproduce flood level behaviour anywhere on the floodplain or in the river system.

2.2.2 *Calibration*

The performance of the models was tested by simulating the behaviour of some historical flood events for which adequate rainfall and flood level records exist. The average recurrence interval of the March 1978 flood event is estimated to be approximately 75 years. It was the largest of the flood events chosen to be simulated by the models. For this event there were only two inputs into the models:

- rainfall records from the Manning River catchment; and
- ocean water levels during the flood event.

Based on this input data, the model 'predicted' peak flood levels along the river as shown in Figure 2.4. For comparison, the recorded peak flood levels at a number of locations are also plotted on this figure.

Further, there were two locations, Taree and Wingham, where flood levels were recorded over the duration of the flood event. The comparison between these recorded levels and the 'predicted' flood levels from the model are shown on Figure 2.5.

The conclusion drawn from the calibration and verification exercises was that the models can accurately calculate flood levels based only on rainfall data as input (as well as ocean water levels).

2.3 Rainfall

Records of daily rainfall totals in the Manning River catchment have been kept for over 100 years. Pluviographic records (ie. records of the variation of rainfall over short durations) have been kept for over 30 years.

The Bureau of Meteorology used these records and standard statistical methods to derive representative rainfall totals for 'design' rainfall events. These 'design' rainfall events are based on selected average recurrence intervals (ARI's) such as 100 years. Hence, for example, the 100 year ARI rainfall total for Taree is 300mm in 24 hours with a peak intensity of 46 mm/hr. The rainfall total for this flood event is significantly higher in the upper parts of the catchment.

In deriving the design flood inputs for the design flood event simulations, average antecedent catchment conditions were assumed.

2.4 Ocean Water Levels

A study of elevated ocean water levels associated with significant meteorological events (eg. cyclones and east-coast tropical lows) was carried out as part of the Manning River Flood Study by AWACS (1989). This study considered the probability of elevated ocean water levels due to low pressure systems and wave forces.

A product of this study was a set of water level profiles over the duration of a flood event for various probabilities of recurrence. These profiles have been used in the model to simulate the effects on flooding in the Manning River of elevated and varying (due to tidal variation) ocean water levels.

2.5 Flood Events Considered

A design flood event is a flood event with a defined probability of exceedance. Hence, the probability of a flood occurring that is greater than the 1% AEP (Annual Exceedance Probability) flood event is 1% or 1 in 100.

This flood is sometimes referred to as the '100 year flood' as there is an average chance that a flood greater than this flood will occur only once every 100 years. However, this is only an average probability and it is possible for two floods larger than the 100 year flood to occur in any 100 year period.

In order to assess the impacts to flooding of the proposed bypass, three 'design' flood events were considered.

100 Year ARI Manning River Flood: This flood is the 1% AEP flood for the entire Manning River combined with the 1% AEP ocean levels. This flood was chosen to assess the performance of the bypass when it is overtopped. The proposed bypass is to be trafficable in floods up to the '20 year Manning River flood' (see below).

50 Year ARI Manning River Flood: This flood is the 2% AEP flood for the entire Manning River combined with the 2% AEP ocean levels.

20 Year ARI Manning River Flood: This flood is the 5% AEP flood for the entire Manning River combined with the 5% AEP ocean levels. This flood was chosen to produce

the design road levels for the proposed upgrade.

Other flood events were also considered including a flood event in which a large flood (eg. a 100 year ARI flood) occurs in the Lansdowne River catchment and a smaller flood (eg. a 20 year AIR flood event) occurs in the Manning River catchment. However, it was found that the flow paths over the Pacific Highway did not play a significant role in this type of flood as the majority of floodwater flowed in the Lansdowne River or Ghinni Ghinni Creek to the Manning River. Hence, this flood event was not considered in any further detail.

2.6 Existing Flooding Levels

The existing flood levels in the study area are presented on Figures 2.6 to 2.11 for the three design flood events described above. For these Manning River flood events, the influence of the elevated ocean water levels result in a very flat flood gradient.

2.7 Assumptions for Existing Conditions

This section of Pacific Highway upgrade forms another component of the roadworks associated with improving the flood immunity of the Pacific Highway across the Manning River floodplain. It will supplement the Taree Traffic Relief Route and the Coopernook Traffic Relief Route.

The assessment of the impacts of these previous projects on the flooding characteristics of the Manning River has been carried out using the same techniques and hydrodynamic model.

However, importantly, this section will be the final section required to produce a crossing of the entire Manning River floodplain with a '1 in 20 year' flood immunity. Hence, for this flooding assessment, the 'existing conditions' case assumed that the Taree and Coopernook Traffic Relief Routes are not constructed.

Further, the design case (ie. that scenario with the upgraded Pacific Highway) assumes that the entire Pacific Highway across the Manning River floodplain is upgraded (ie. the Taree and Coopernook Traffic Relief Routes are constructed).

This approach has been adopted to allow a cumulative assessment of the impacts of the three projects.

A previous assessment of the floodway openings required for this proposed upgrade was carried out as part of the studies into the proposed Coopernook Bypass. However, there were a number of conservative assumptions made in this assessment which indicated a large length of culverts would be required to minimise impacts to flooding.



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Figure 2-1 - Study Area



Figure 2-2 - Length of Pacific Highway Inundated in 1 in 20 year Flood

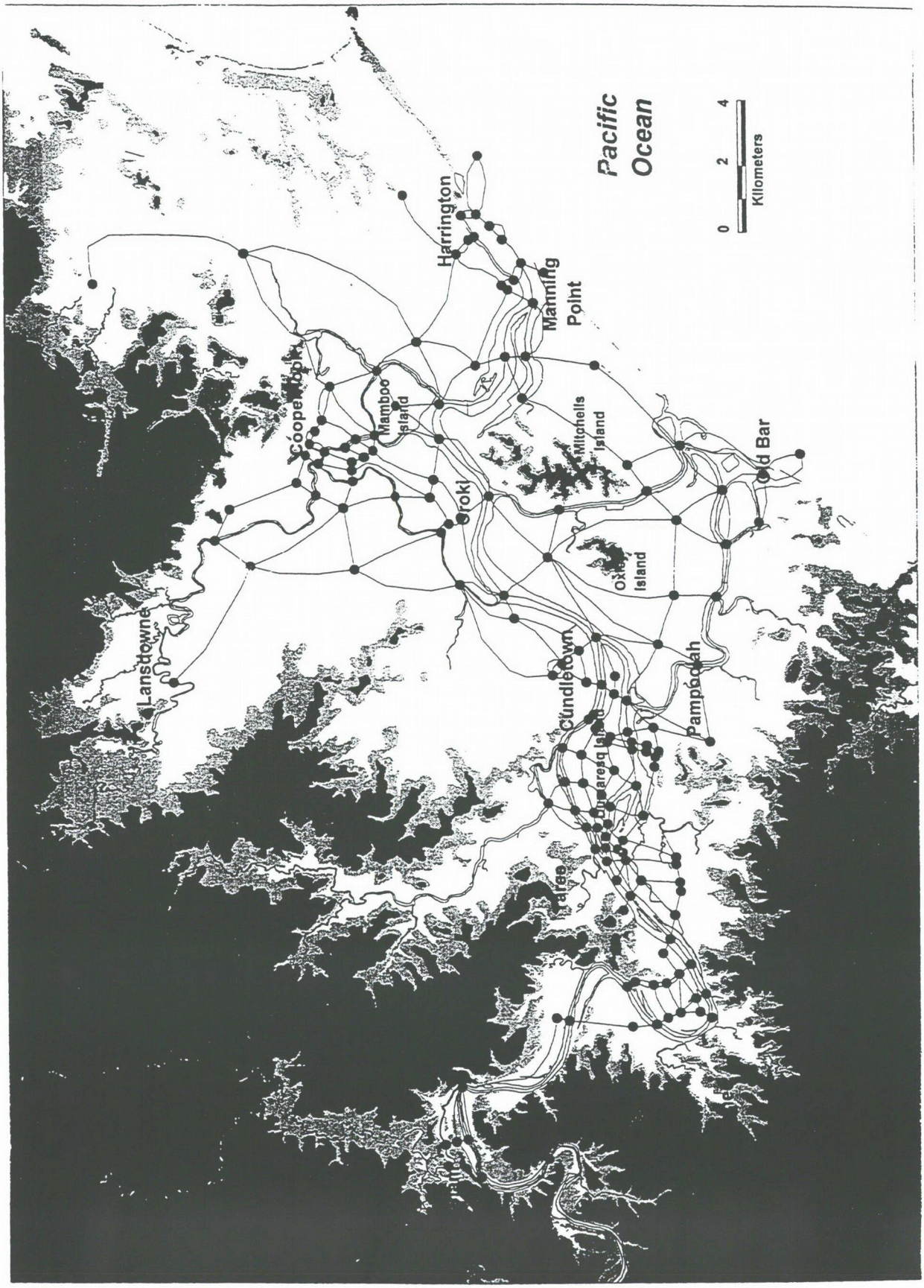


Figure 2-3 - Manning River Flood Model Network

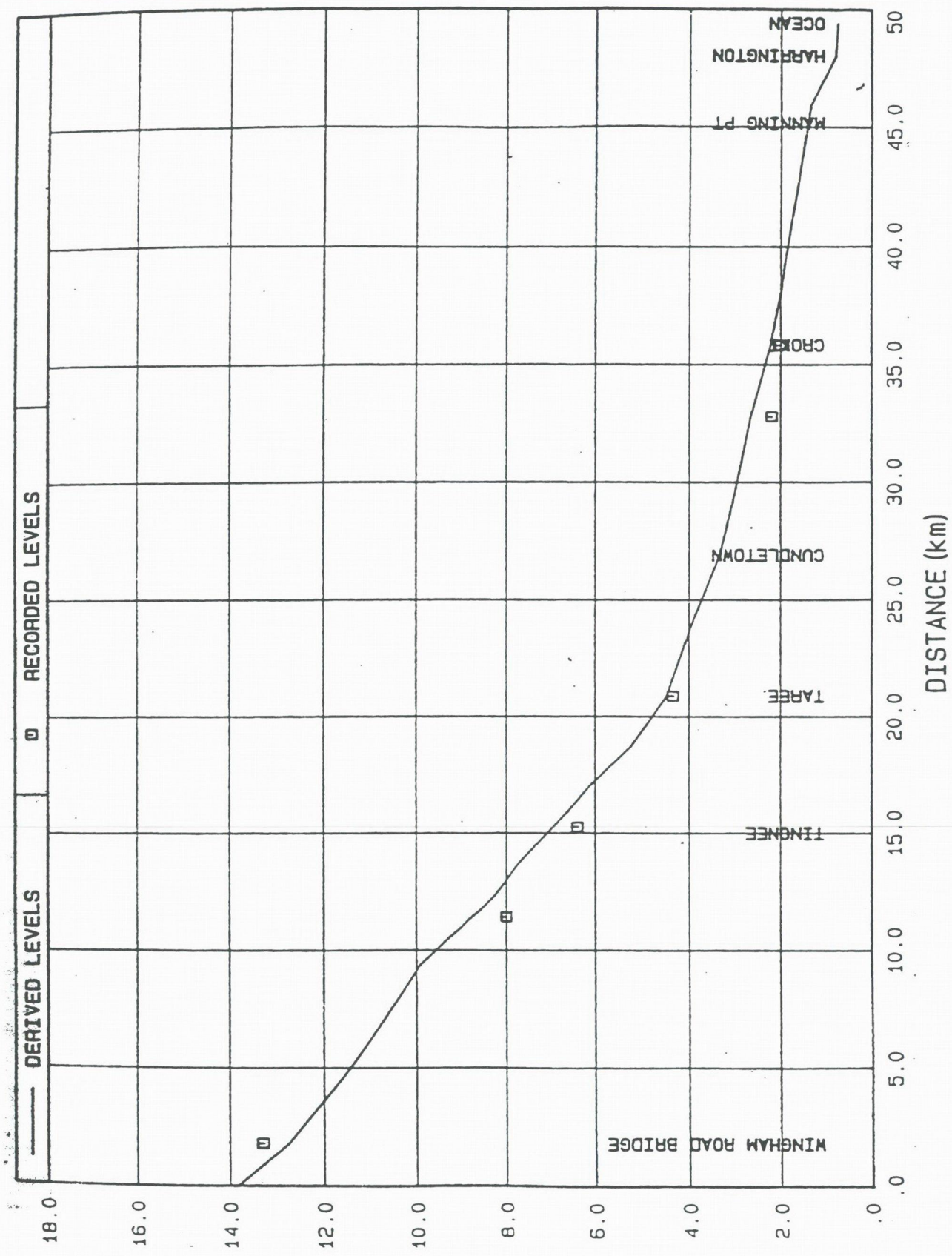
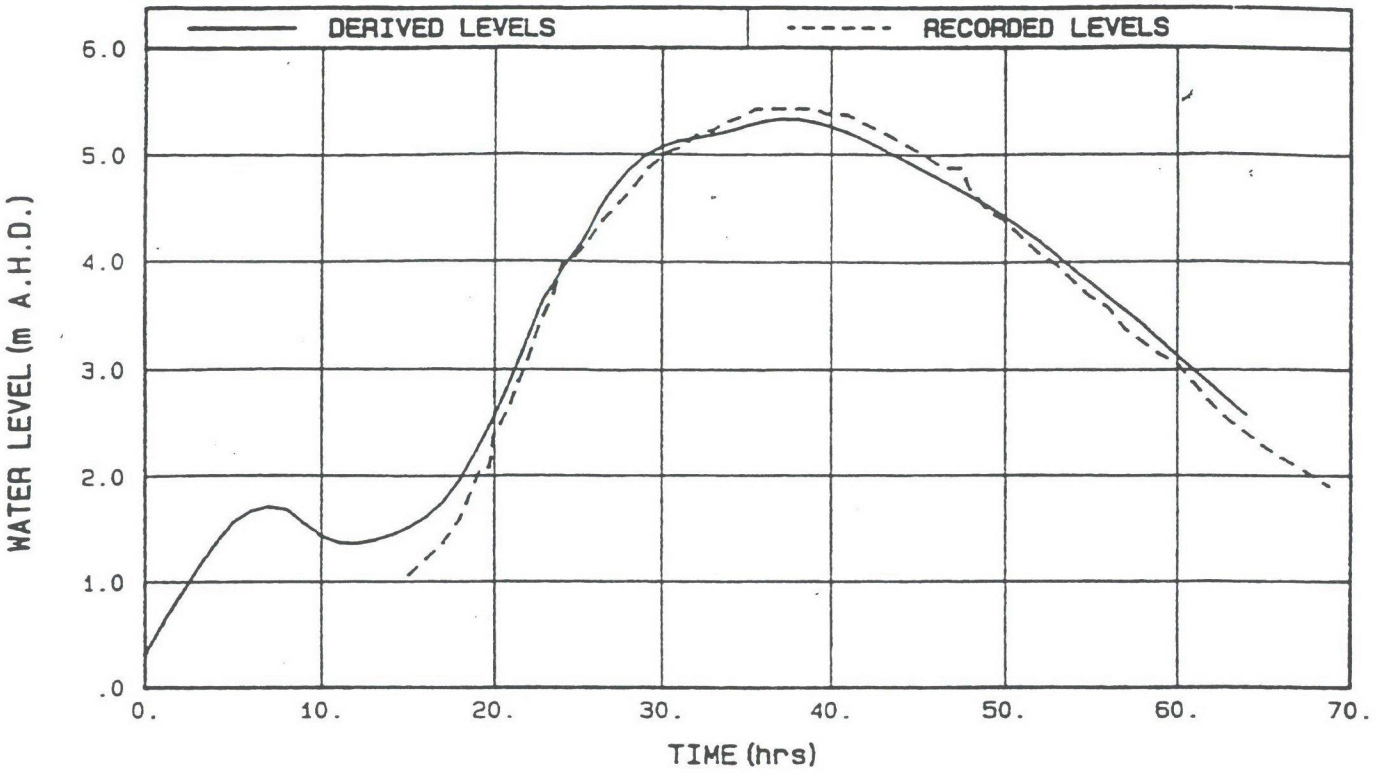
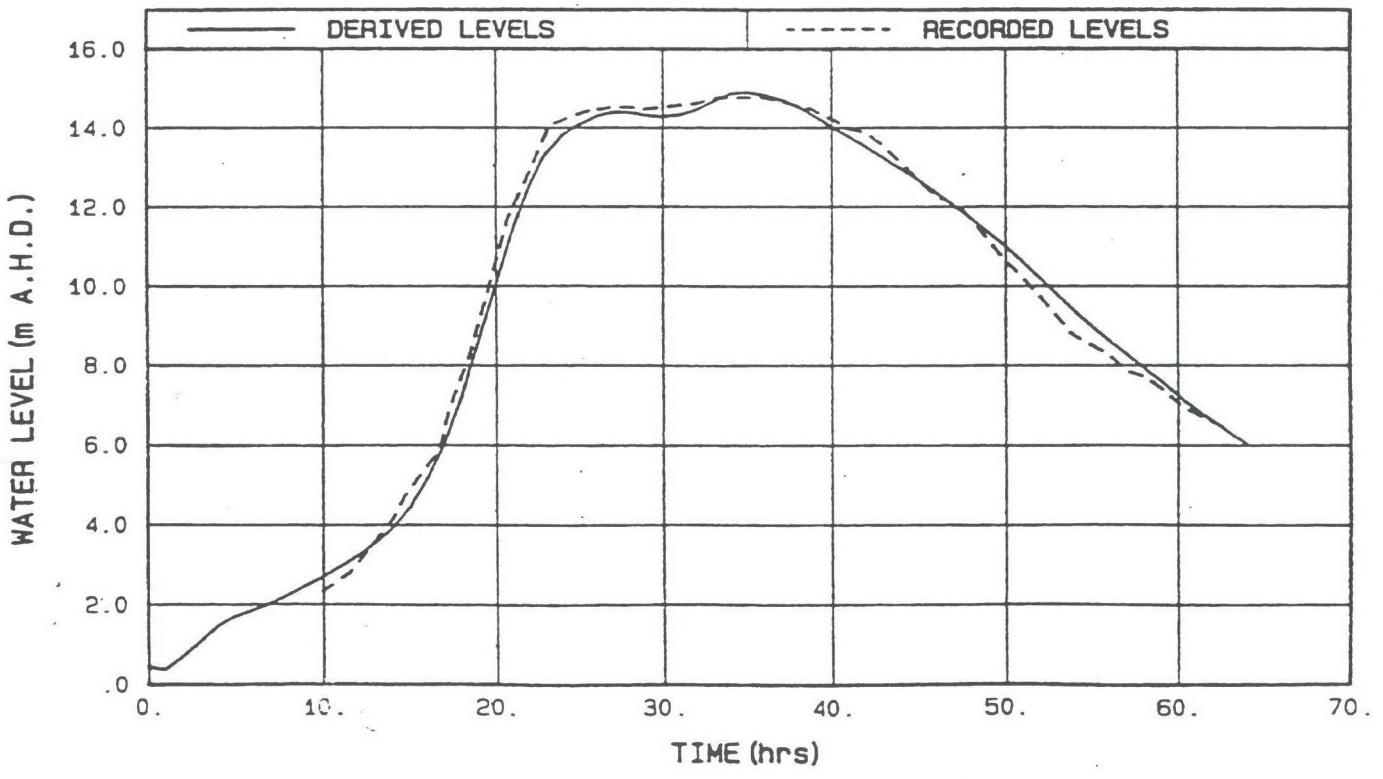


Figure 2-4 - Comparison of Peak Flood Levels for 1978 Flood



TAREE STAGE HYDROGRAPHS-MARCH 1978 FLOOD



WINGHAM STAGE HYDROGRAPHS-MARCH 1978 FLOOD

Figure 2-5 - Comparison of Flood Levels at Wingham and Taree for 1978 Flood

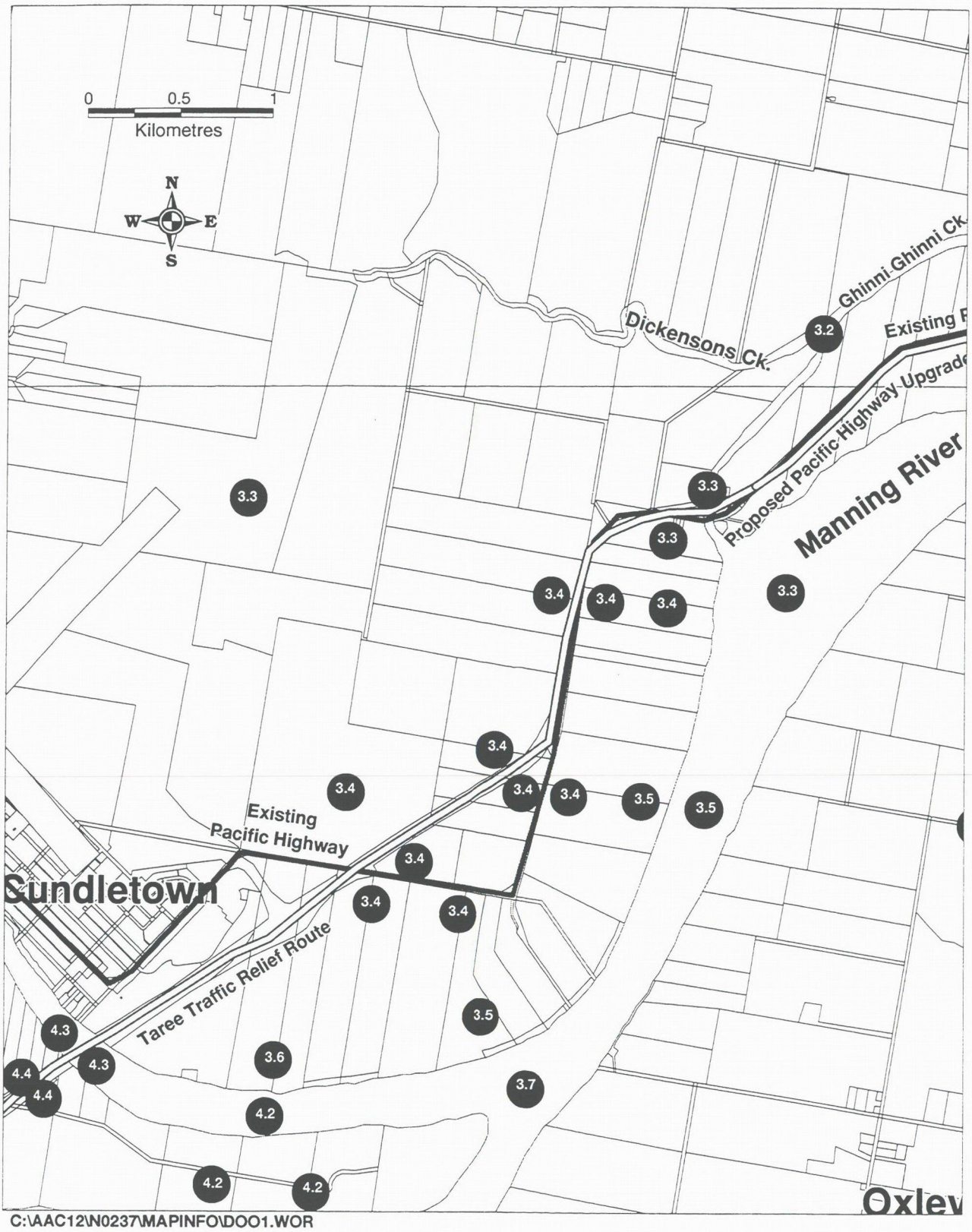


Figure 2-6 - Peak Flood Levels (mAHD): 100 Year ARI Manning River Flood Section A

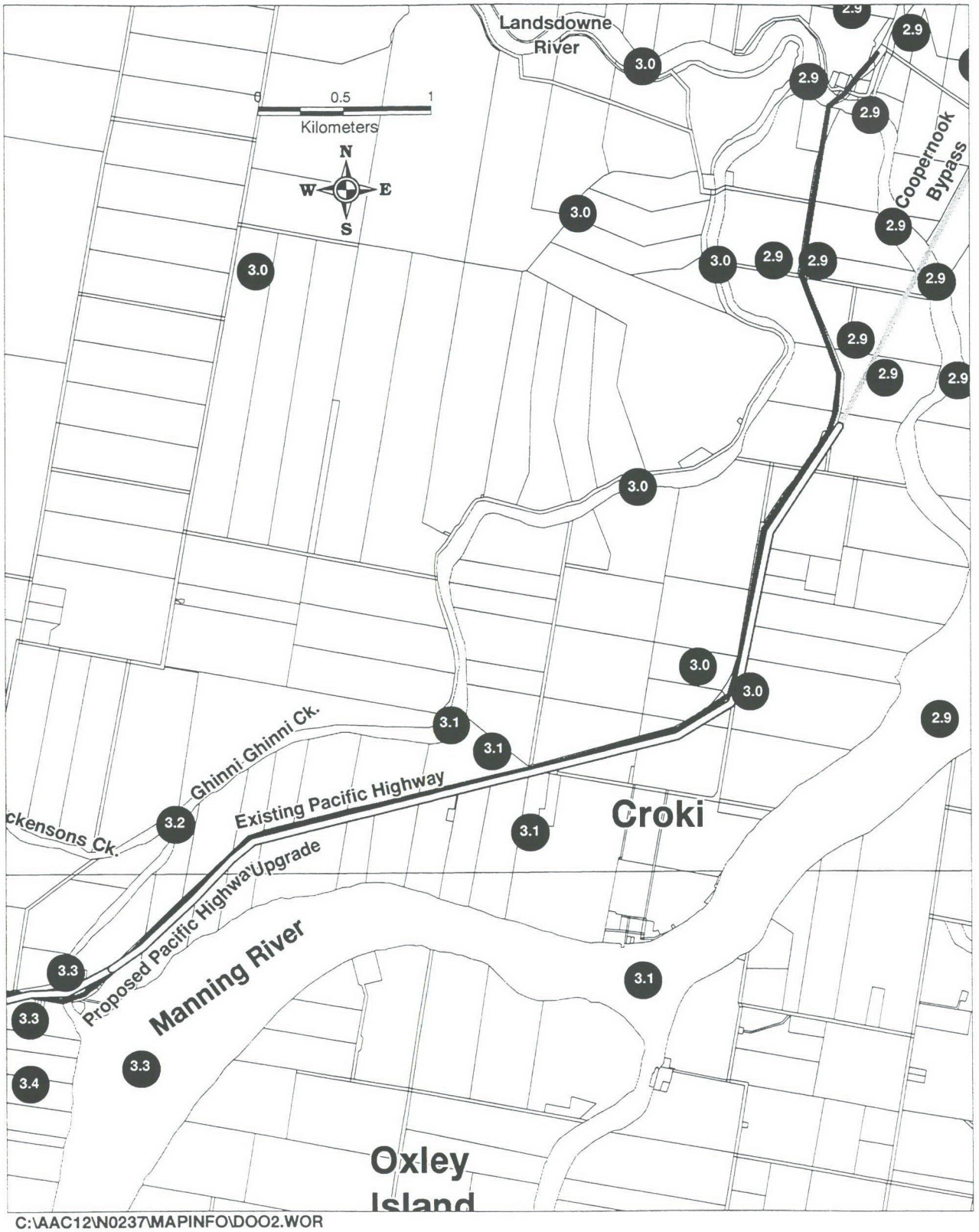


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Figure 2-7 - Peak Flood Levels (mAHD): 100 Year ARI Manning River Flood Section B

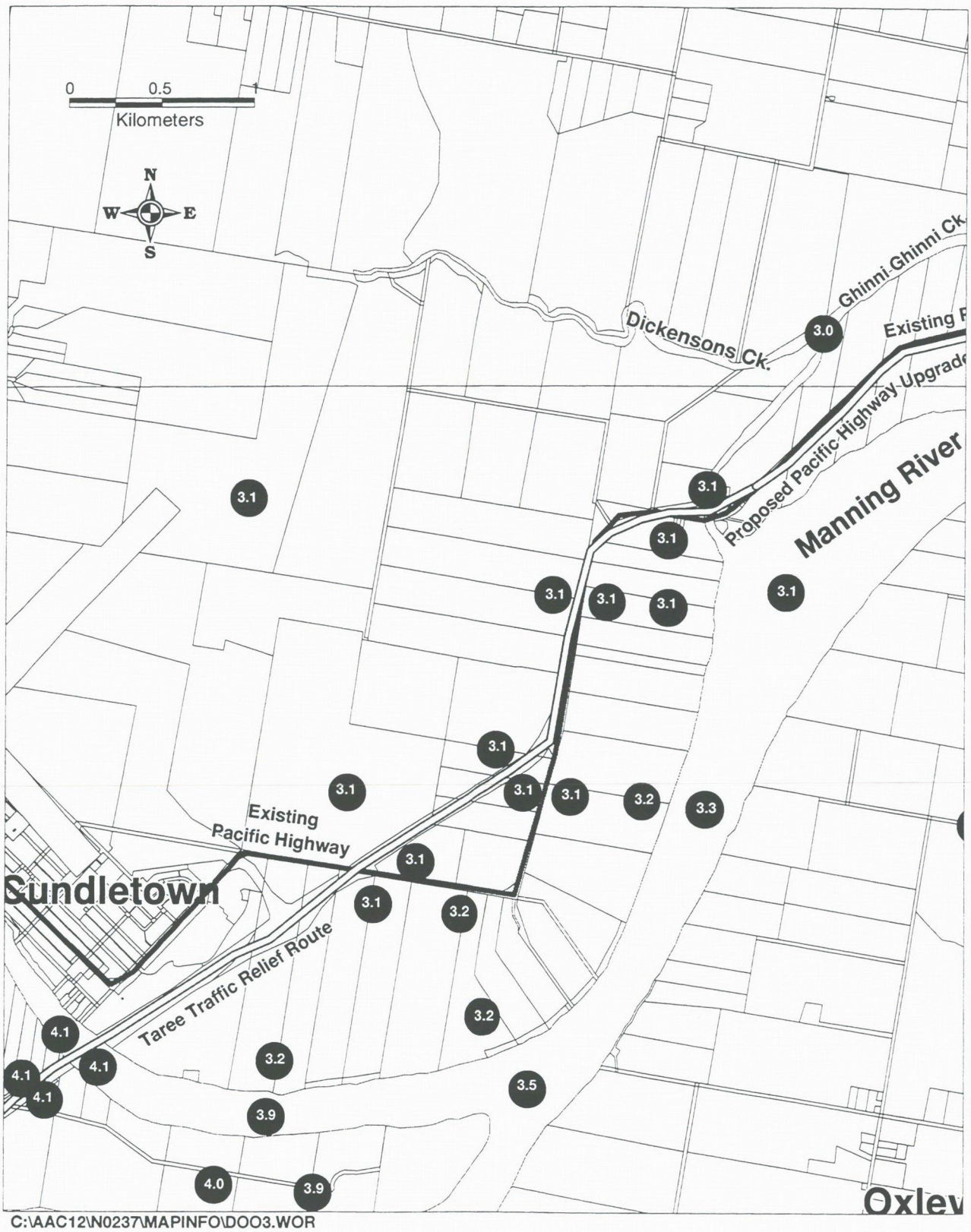

Figure 2-8 - Peak Flood Levels (mAHD): 50 Year ARI Manning River Flood Section A

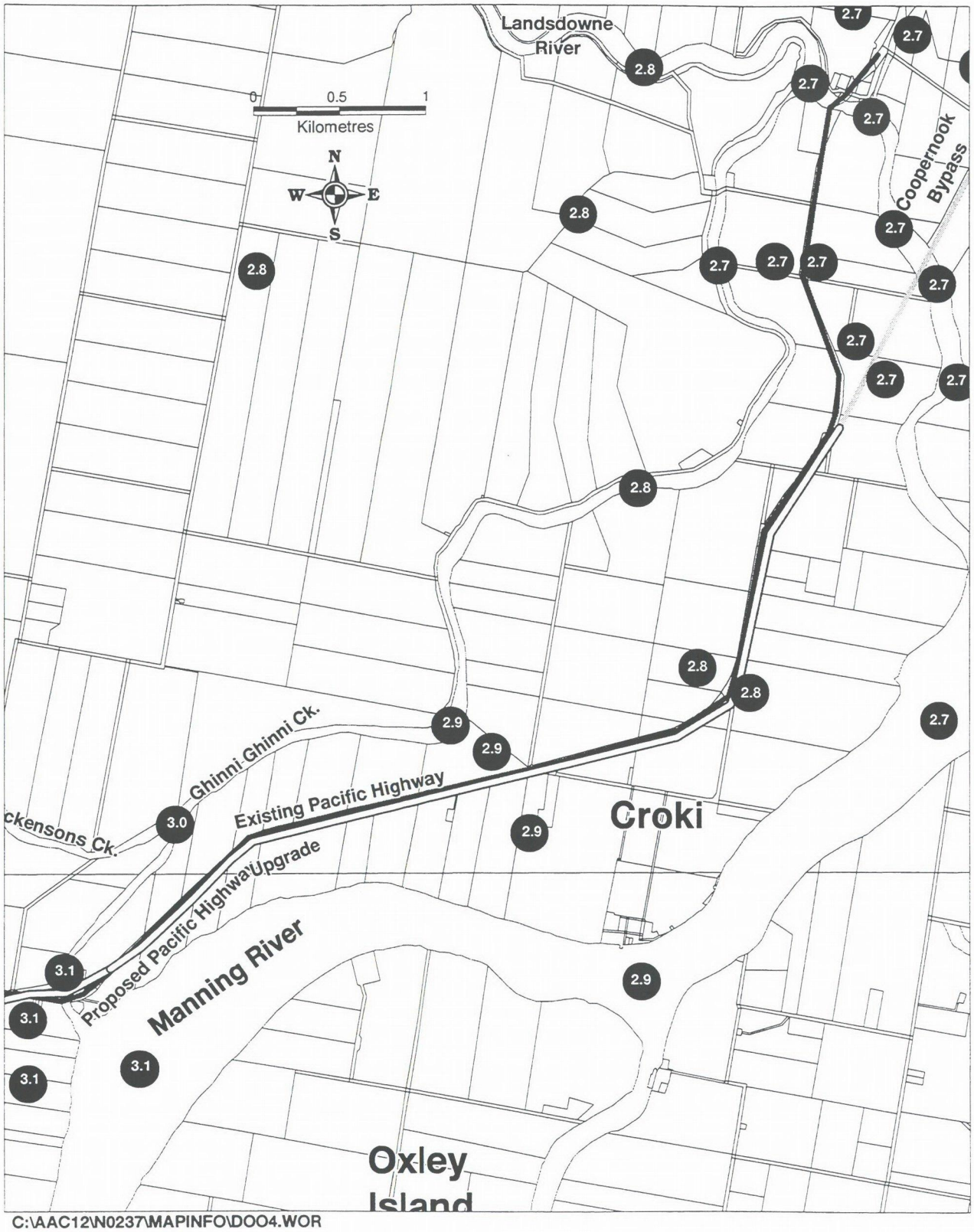

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Figure 2-9 - Peak Flood Levels (mAHD): 50 Year ARI Manning River Flood Section B

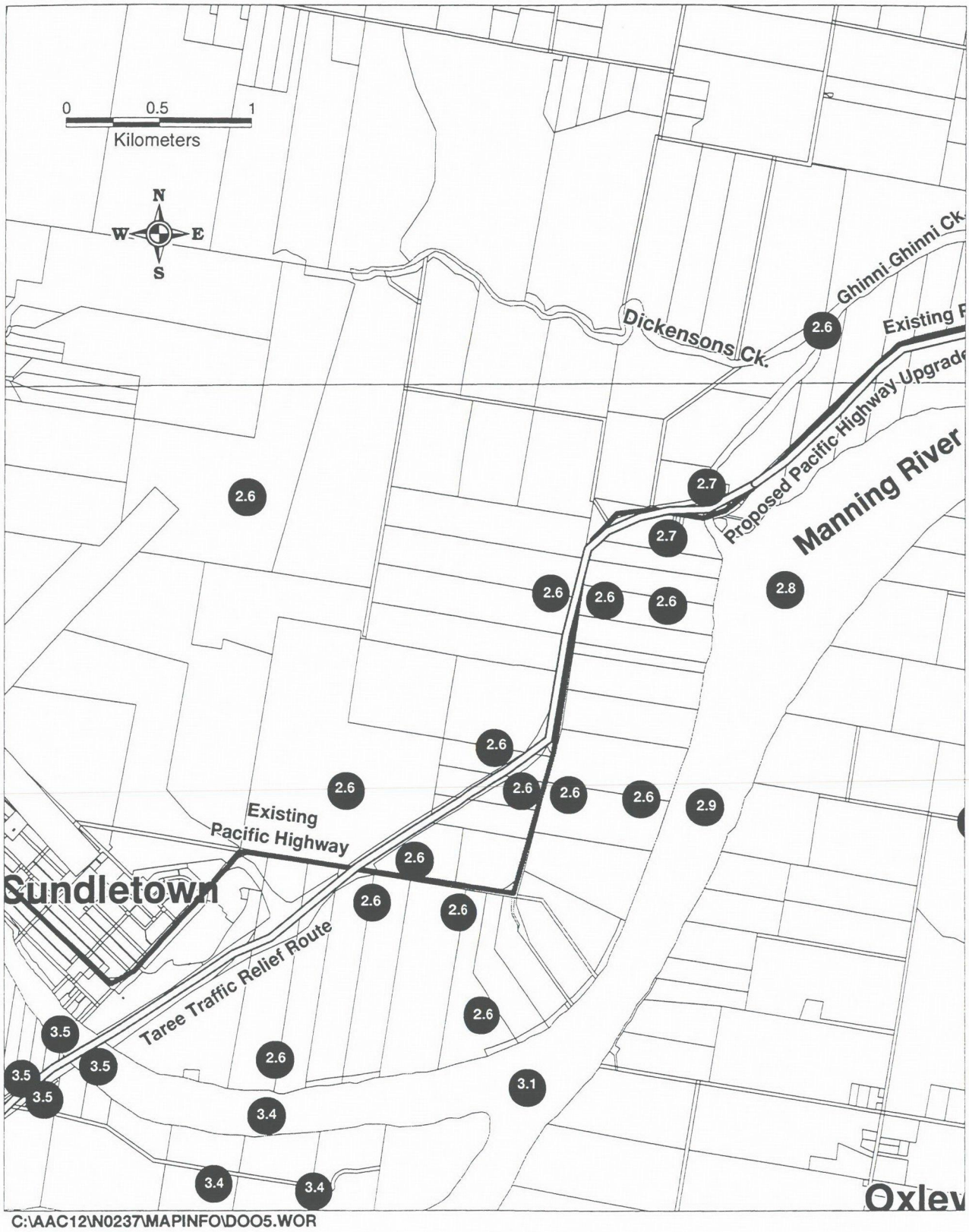

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Figure 2-10 - Peak Flood Levels (mAHD): 20 Year ARI Manning River Flood Section A



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Figure 2-11 - Peak Flood Levels (mAHD): 20 Year ARI Manning River Flood Section B

3 DETAILS OF UPGRADE

3.1 Level of Upgrade

The road is to be constructed such that at least one lane (in either direction) is trafficable in a 5% AEP flood event. The existing highway is below this level. For a significant length of the proposed upgrade, two additional lanes will be constructed to supplement the existing Pacific Highway. Both of these additional lanes will be trafficable in a 5% AEP flood event (ie. the whole lane width is above the peak 5% AEP flood level). Hence, during a flood, the northbound traffic may need to be diverted onto the southbound carriageway (and vice versa at the southern end of the proposed upgrade).

The existing 5% AEP flood level varies from 2.7 mAHD (at the upstream end) to 2.3 mAHD (at the downstream end). The extent of overtopping of the existing Pacific highway is shown in Figure 2.2.

Details of the cross-section of the proposed upgrade can be found in Connell Wagner's REF Section 5.

3.2 Required Waterway Openings

The numerical model was used in an iterative manner to assess the design requirements and associated impacts of the proposed bypass. The required waterway openings under the proposed upgrade are detailed in Table 3-1. These waterway openings are sufficient to ensure that there will be negligible impacts to flood levels (ie. less than 100mm). As well, the times of inundation experience only minor increases (ie. lass than 2 hours over a number of days), if any at all.

The chainages indicated are approximate and will need to be confirmed at the detailed design stage of the project.

Table 3-1 - Required Waterway Openings

Approximate Chainages (m)	Details
11,500	4 RCBC's[1] 2.4m wide, 1.2m high at invert level of 0.9 mAHD
12,200 to 12,280	Bridge over Ghinni Ghinni Creek
14,100	5 RCBC's 2.4m wide, 0.9m high at invert level of 1.5 mAHD
16,350	2 RCBC's 2.4m wide, 0.9m high at invert level of 0.4 mAHD

Notes: 1 - RCBC = Reinforced Concrete Box Culvert

It was also assumed that the abutments of the bridge over the Ghinni Ghinni Creek would be close to the creek banks. Final bridge details would include sufficient width for an access road on either or both banks at near natural surface levels. This would only improve the hydraulic performance and efficiency of the structure by providing additional waterway capacity.

As well, there are a number of small culvert crossings of the existing Pacific Highway (mostly with 450mm diameter pipes). It is recommended that these crossing be replicated in the proposed upgrade.

4 IMPACTS OF UPGRADE TO FLOODING

4.1 Approach to Quantifying Impacts

The flooding impacts of the proposed bypass have been assessed by using the numerical model to predict the changes to:

- flood levels, including peak flood levels;
- times of inundation of the floodplain; and
- flows and velocities.

This section presents these impacts of the upgrade for the three design flood events considered. It was assumed that the waterway openings as described in Section 3.2 will be constructed. These waterway openings were determined by considering the impacts to flood levels and limiting these impacts to a maximum increase of 100mm.

This magnitude of increase is considered to be negligible in relation to the existing depths of inundation on the floodplain of 2 to 3m. It can also be considered negligible in relation to other common occurrences during flooding including boat and wind waves that can result in flood level increases of similar magnitudes.

4.2 Impacts to Flood Levels

The predicted impacts of the bypass on peak flood levels are less than 100mm. These impacts are presented on Figures 4.1 to 4.6 for the three flood events considered.

4.3 Impact to Frequency of Floor Level Inundation

There are a number of residential structures in the vicinity of the proposed highway upgrade. These floor levels need to be considered in conjunction with the predicted flood levels of the three flood events. The floor levels of houses in the study area, provided by Greater Taree City Council, were measured as part of the Manning River Floodplain Management Study.

The impacts described above will result in increases to the frequency of flood inundation of 17 of these structures for the 100 year ARI flood. However, the majority of these houses will experience an increase of 10mm or less and all impacts are less than 30mm. The impacts on inundated structures for all three flood events considered are presented in Table 4-1.

Table 4-1 Impacts to House Floor Levels

Impact (mm)	Number of Houses Impacted		
	100 year ARI Flood	50 year ARI Flood	20 year ARI Flood
10mm	11		
20mm	5	5	
30mm	1	1	1
40mm		2	
50mm			
60mm		2	
Total	**17**	**10**	**1**

4.4 Impacts to Recession of Floods

4.4.1 General Considerations

It is important to recognise the different stages of flow from the floodplain during the recession of a flood. A brief description of the dominant characteristics is presented below.

Following the peak of the flood, the floodwaters flow from the floodplain to the river over the natural and artificial levees along the river banks. When floodwaters are significantly higher than these levees (eg. greater than 0.5m), the flow from the floodplain is relatively unimpeded and the floodplain levels are only marginally higher (eg. 10mm) than the river levels. The rates of recession of both the floodplain and the river are the same.

As the flood levels fall closer to the level of the levees, they act as a weir and impede flow from the floodplain to the river. This creates a small difference (eg. 50mm) in flood levels between the floodplain and the river and, hence, a slower rate of recession on the floodplain. However, due to the significant length of levee (100's of metres) relative to the volume of water draining from the floodplain in this situation, this difference in rates of recession is very small (eg. 0.5m/day compared with 0.49 m/day).

Once flood levels on the floodplain fall below the top of the levees, the flow to the river is dominated by structures such as flap-gated (or tide-gated) drainage culverts. The difference between floodplain flood levels and river flood levels increases as more head difference is required to drain the floodplain at the same rate as the river level is falling.

Finally, as the river levels recede to a level at which tidal variations occur, the flow from the floodplain is dominated by the timing of the tidal variations (ie. more outflow at low tide and possibly no outflow at high tide), the size and number of flap-gated culverts and the agricultural drainage network of the floodplain.

4.4.2 Detailed Considerations

The numerical modelling indicates that the proposed upgrade of the Pacific Highway will have a negligible (ie. less than 1%) impact on the rate of flood water recession. The model is most accurate in simulating the major overland floodpaths such as flow over levee banks, across the floodplain and over the Pacific Highway. These major flowpaths convey large flows durting the flood event (ie. 100's of cubic metres per second).

The model is less accurate in simulating the minor flows (ie. 10's of cubic metres per second) from the floodplain through culverts in river / creek levees. However, for these minor flows, the rate of floodwater recession is dominated by the size of culverts through embankments such as levees and the highway embankments.

For a significant length of this highway upgrade, a new carriageway is proposed to be constructed to compliment the existing carriageway. It is proposed that the existing crossings of drains under the Pacific Highway will be replicated under the new carriageway. Hence, as it is these drainage crossings that dominate the rate of flood recession, the rates of flood recession will be similar to that experienced at present.

4.5 Impacts to Times of Flood Inundation

The proposed upgrade will have a minor impact on the length of time that agricultural land is

inundated by floodwaters. The magnitude of this impact varies for different levels of flooding and different locations. However, the impacts are in the order of an additional 1 hour over a 24 hour period of inundation (ie. approximately 4%).

This impact is best illustrated by considering the plot of flood levels over the duration of the 1 in 20 year flood event as presented in Figure 4.7. As discussed previously, the rate of flood recession below flood levels of approximately 2.0 mAHD will not be altered as it is dominated by flowpaths over creek banks and levees as well as low flow pipes.

4.6 Impacts to Flood Velocities and Bank Erosion

The numerical computer modelling of the flooding impacts associated with the highway upgrade is also able to assess the impacts to river velocities. Table 4.1 presents the impacts to peak flood velocities and flows in the mouth of Ghinni Ghinni Creek (through the bridge) for the three flood events considered. The velocities in Ghinni Ghinni Creek for the 100 year ARI flood are shown in Figure 4.8.

Table 4-2 Impacts to Ghinni Ghinni Ck Flows and Velocities

Flood Event	Existing Case		Upgrade Case	
	Peak Velocity (m/s)	Peak Flow (m^3/s)	Peak Velocity (m/s)	Peak Flow (m^3/s)
100 year ARI Flood	1.3	280	1.8	400
50 year ARI Flood	1.3	270	1.8	380
20 year ARI Flood	1.3	250	1.6	330

It is apparent from the results in Table 4.1 that the upgrade will result in increases in flood velocities of up to 38%. These increases in velocity occur in the mouth of Ghinni Ghinni Creek and specifically through the bridge opening.

This impact in flood flow and velocity is limited to flood events greater than the 15 year ARI flood event. Hence, the frequency of occurrence of these increased velocities is not common.

During these larger flood events, the velocities will not be increased for flooding levels lower than 2.0 mAHD. At these higher flood levels, the banks of Ghinni Ghinni Creek to the north of the Pacific Highway are overtopped. The additional flow through Ghinni Ghinni Creek and onto the floodplain in this area is distributed over long lengths of creek bank. Hence, there are no increases to the velocities in Ghinni Ghinni Creek north of the Pacific Highway.

Given the above, these increases in flood velocity have the potential to increase the erosion potential through the mouth of Ghinni Ghinni Creek for large flood events (ie. greater than the 15 year ARI flood event). This could result in increased erosion of the creek bed and banks at this location.

It is recommended that bank protection works (eg. rock protection) be constructed within the road reserve as part of the construction of the new bridge to protect the bridge abutments against potential erosion of creek banks. Further, it is recommended that the bridge piers

associated with the former and existing Pacific Highway bridges over Ghinni Ghinni Creek be removed to bed level to improve the hydraulic efficiency of this section of creek and assist in the mitigation of these increased velocities.

4.7 Flood Access to Croki

It is proposed as part of this Pacific Highway upgrade to close the intersection of Croki Road North with the Pacific Highway. This may result in the flood free access to the Pacific Highway from Croki to be closed earlier than in the existing situation. This impact is dependant on the location of the lowest points along Croki Road (North and South).

If the location of the first cutting of Croki Road is on Croki Road South, then the reduced flood access could be avoided by installation of a flood access gate on the closed section of Croki Road North.

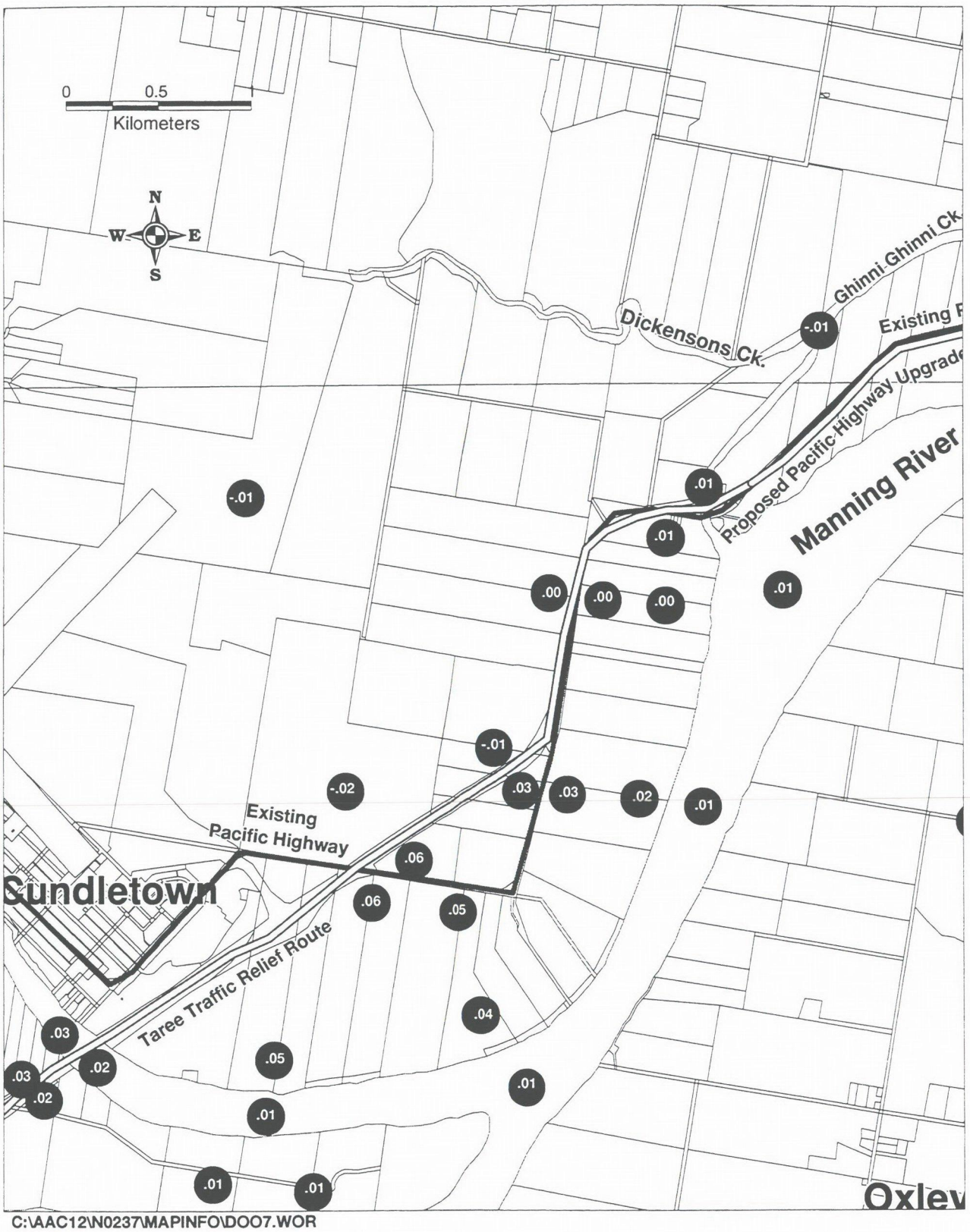

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Figure 4-1 Impacts to Peak Flood Levels (m): 100 Year Manning River Flood Section A

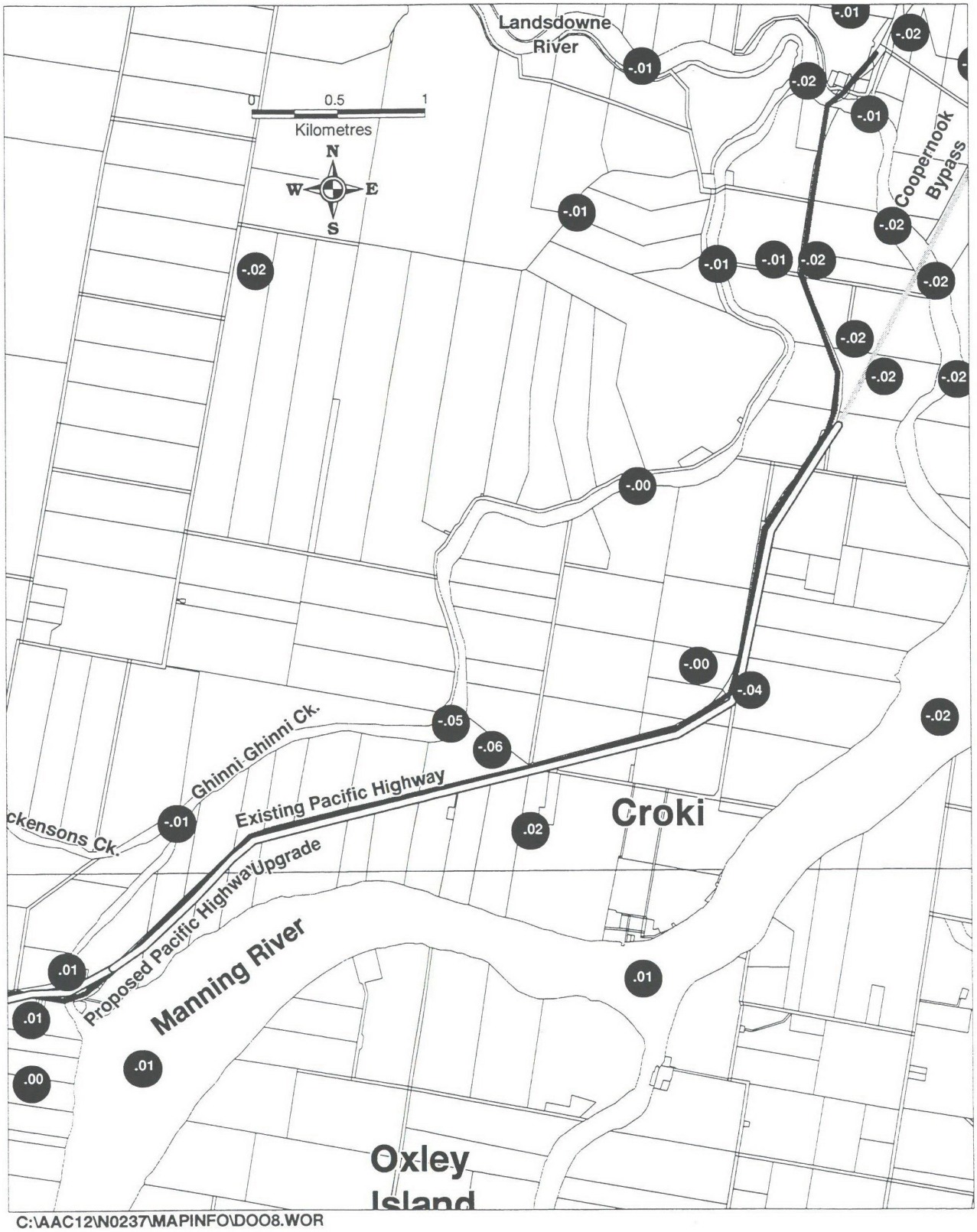

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Figure 4-2 Impacts to Peak Flood Levels (m): 100 Year Manning River Flood Section B

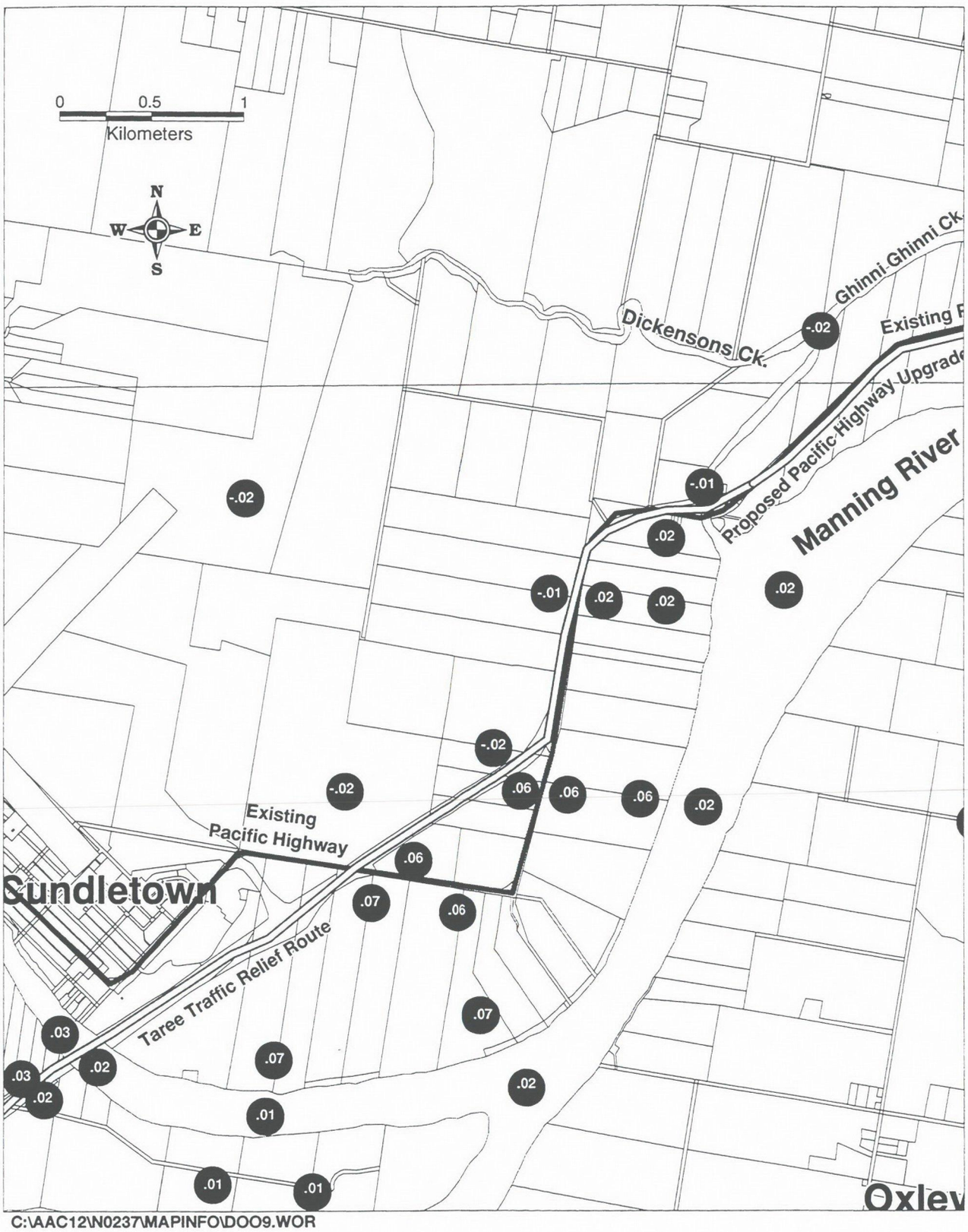

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Figure 4-3 - Impacts to Peak Flood Levels (m): 50 Year Manning River Flood Section A



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Figure 4-4 Impacts to Peak Flood Levels (m): 50 Year Manning River Flood Section B

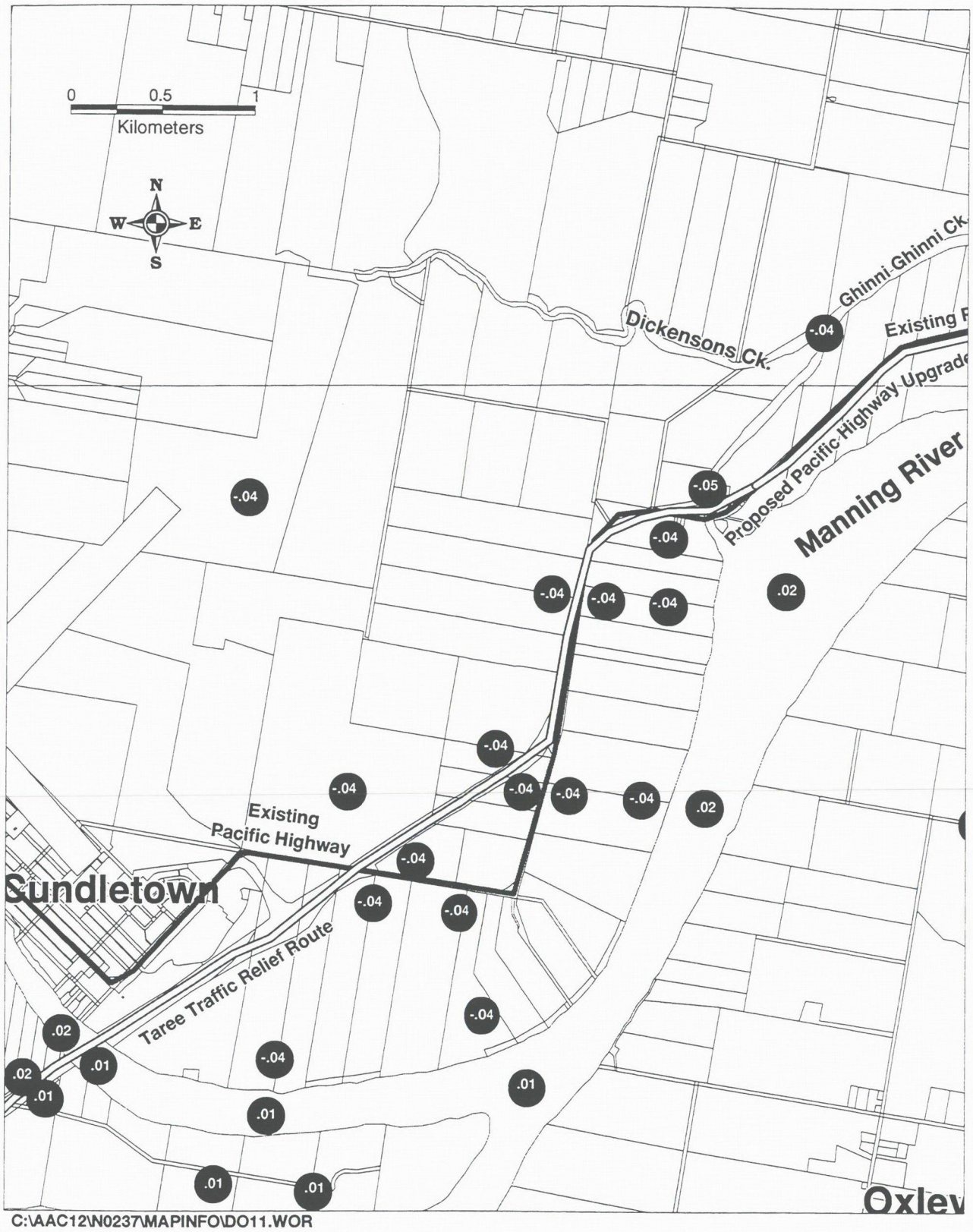

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Figure 4-5 - Impacts to Peak Flood Levels (m): 20 Year Manning River Flood Section A

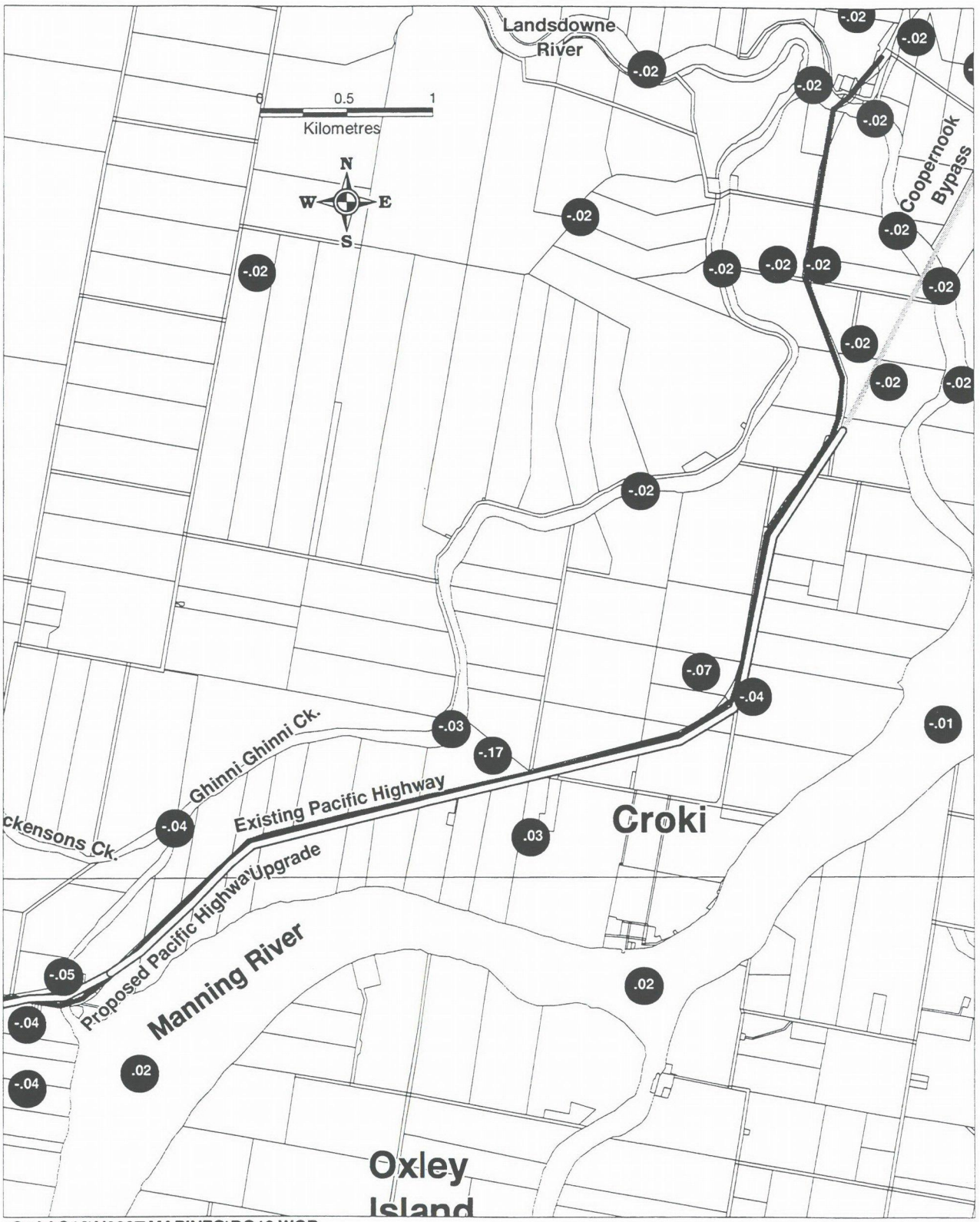

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Figure 4-6 Impacts to Peak Flood Levels (m): 20 Year Manning River Flood Section B

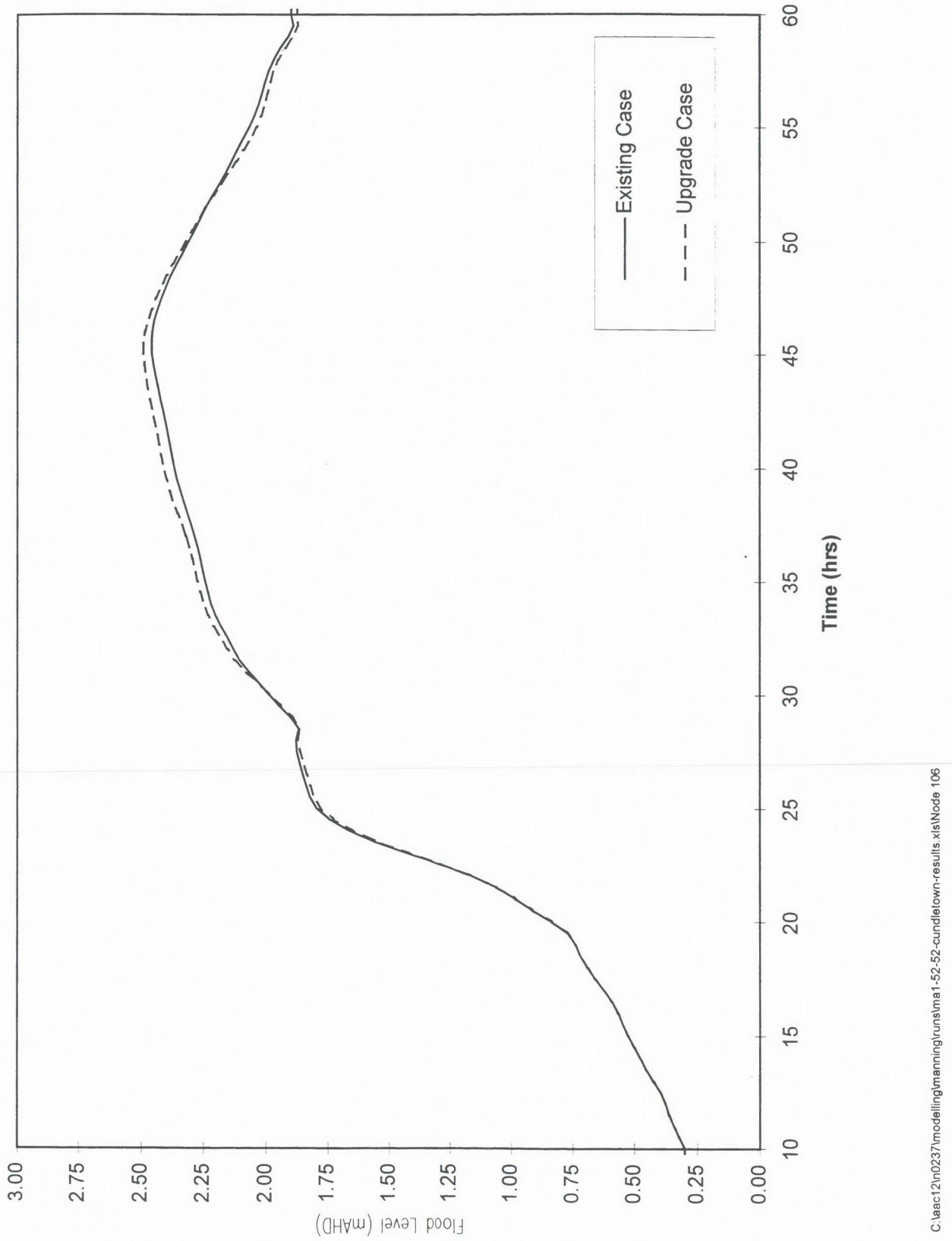

Figure 4-7 - Impacts Times of Inundation : 20 Year Manning River Flood

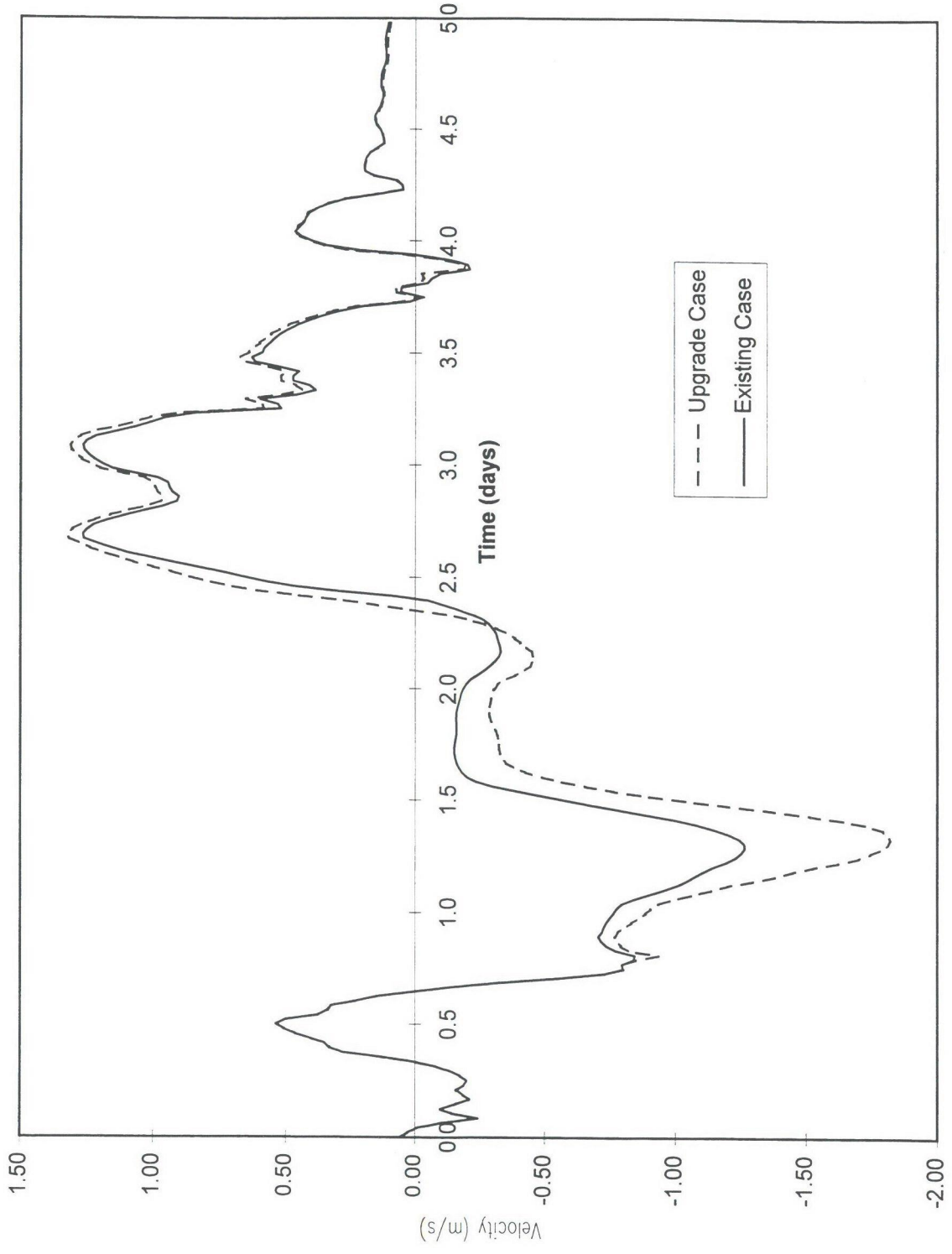

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Figure 4-8 - Impacts to Ghinni Ghinni Creek Velocities : 100 Year Manning River Flood

5 LOCAL DRAINAGE NETWORK

The existing local drainage network for the study area contains a number of agricultural drains which pass under the existing Pacific Highway. Most commonly, these drains cross under the highway as 450mm diameter pipes (or a number of barrels of these size pipes). There are also some drains which run along the existing Pacific Highway.

These drains play an important role in draining the agricultural areas of the study area. They allow runoff from local rainfall on the area to drain from the land as well as draining the floodplain in the final stages of the recession of larger flood events. It is recognised that maintenance of adequate drainage is essential for the continued operation of the agricultural enterprises in the study area to minimise pasture damage following flood peaks.

For a significant length of this highway upgrade, a new carriageway is proposed to be constructed to compliment the existing carriageway. Hence, the existing crossings of drains under the Pacific Highway will be replicated and extended under the new carriageway. All drainage crossings of the existing Pacific Highway will be maintained by increasing the length of pipe to convey water under the additional carriageway.

There are not any locations where there is a need to completely re-route any drains within the study area. However, there are a number of locations where the new additional carriageway will be constructed over a drain running alongside the existing carriageway. It is recommended in these locations that a drain of similar size be constructed alongside the new additional carriageway and provide appropriate linkages with other field drains.

The issue of disturbance and possible oxidisation of Potential Acid Sulfate Soils (PASS) will need to be considered with regard to excavation of these proposed drains. Soil excavated as part of these drains may require some treatment during construction to minimise the potential of acid sulphate runoff. There are two specific locations (from CH15,880m to CH15,980m and from CH17,080m to CH17,240m) that will require treatment.

More detailed investigations into the proposed alterations to the local drainage network should be carried out at the detailed design stage of the project.

6 REFERENCES

Australian Water and Coastal Studies - AWACS (1989) *Elevated Ocean Levels - Manning River Entrances* Report No. 89/05

Public Works Department (1991) *Manning River Flood Study* Report No. 90029

WBM Oceanics Australia (1992) *Pacific Highway Upgrading at Coopernook- Hydraulic Investigation* Report No. 6610C

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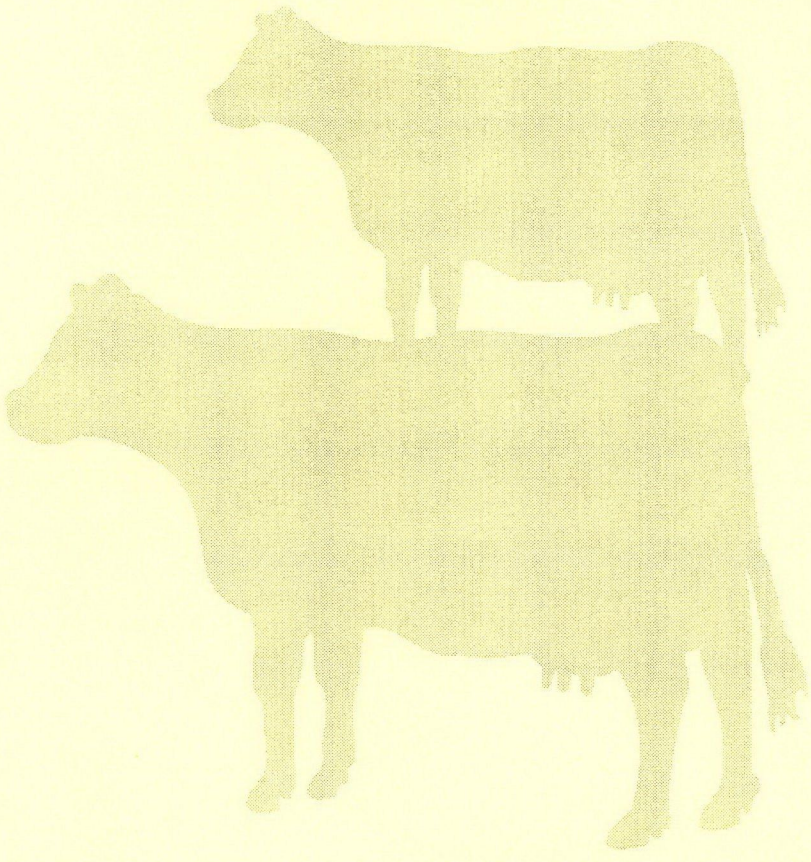

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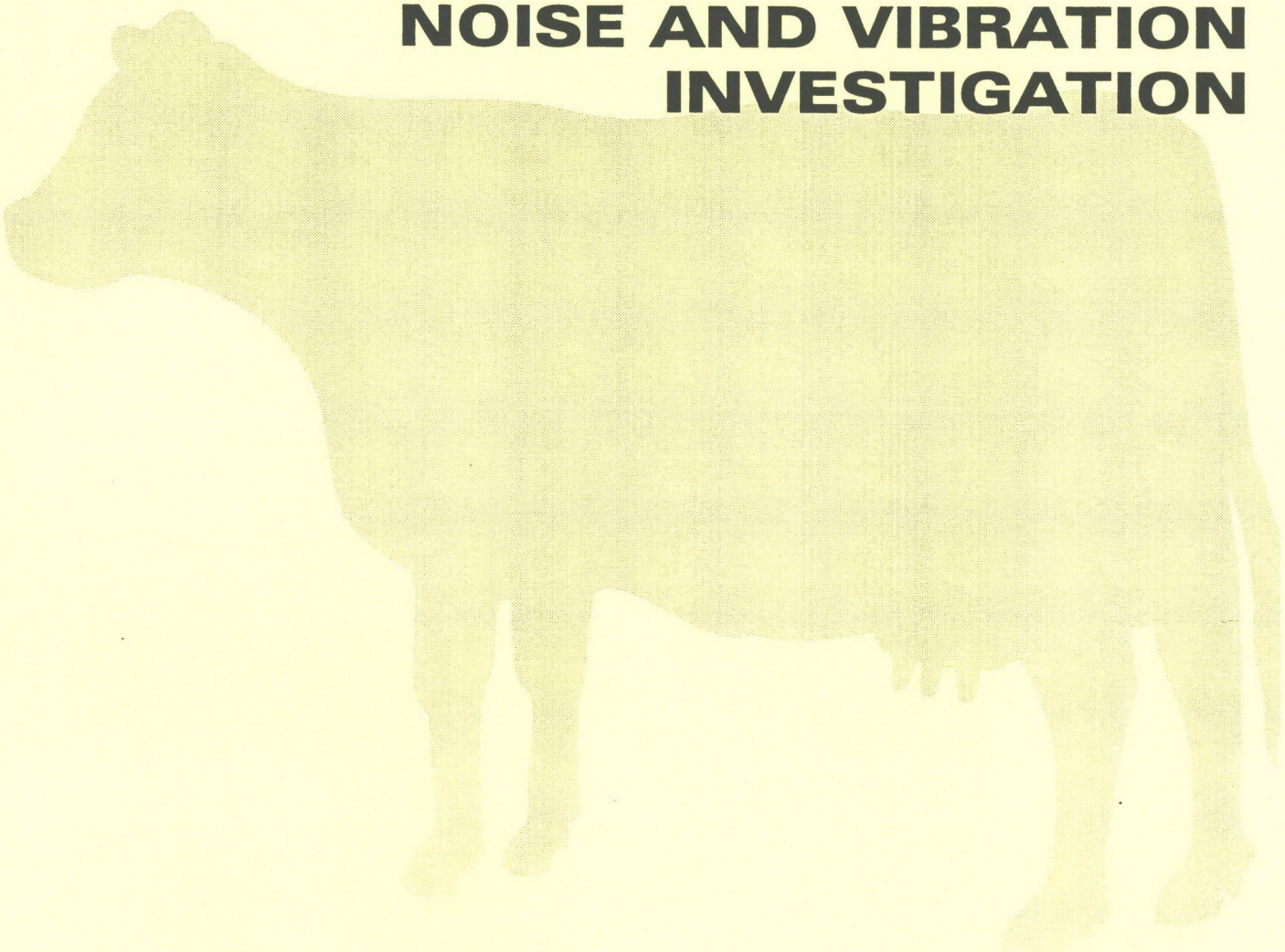
NOISE AND VIBRATION INVESTIGATION



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NOISE IMPACT ASSESSMENT
PACIFIC HIGHWAY REDEVELOPMENT
GHINNI GHINNI

28.4796.R1:GA104
Revision 01

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October 1998

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1.0 INTRODUCTION

The Road and Traffic Authority (RTA) propose to redevelop the Pacific Highway at Ghinni Ghinni (Appendix 1). The proposed road works involve adjustments to the existing road alignment and could result in a number of rural/ residential properties and the Ghinni Ghinni Public School being affected by road traffic noise and construction noise and vibration.

Atkins Acoustics was commissioned by Connell Wagner Pty Limited on behalf of the Roads and Traffic Authority to conduct a noise and vibration impact assessment for the operation and construction of the proposal.

The main aims of the assessment, were;

- to measure the existing ambient noise levels in the Ghinni Ghinni study area;
- to predict the likely changes to the existing noise levels at the opening (nominally 2001), five (5) years and ten (10) years post opening (nominally 2006 and 2011),
- to assess the predicted traffic noise levels in accordance with goals referenced in the NSW Draft Government Environmental Criteria for Road Traffic Noise;
- where the traffic noise levels exceed the recommended assessment goals, consider ameliorative noise control options to reduce the traffic noise to satisfy the goals;
- to assess potential noise and vibration impacts during the construction of the proposal in accordance with the recommendations of the NSW Environment Protection Authority, Environmental Noise Control Manual; and
- to report on the results, findings and recommendations from the noise and vibration investigations and assessment

2.0 THE PROPOSAL

The proposal is for the construction of approximately seven point five (7.5) kilometres of dual carriageway between chainages 10535 and 17980 to improve the road carrying capacity and safety of the existing highway. The road works involve adjustments to the existing carriageway, the realignment of bends, the construction of a new carriageway, the construction of a new road bridge over Ghinni Ghinni Creek and the provision of vehicular access to private properties from the highway. Appendices 1 and 2 identify the study area and the proposed road alignment.

The proposal involves adjustments to the existing road alignment, earthworks, the import of fill material to the site by road truck, the formation and compaction of a road based, the construction of a concrete sub-based and the surfacing of the road with a dense graded asphaltic concrete (DGAC) or an equivalent low noise road surface.

2.1 Traffic Projections

The traffic volumes adopted considered for the noise assessment (Table 1) were established from traffic counts and growth projections prepared by Connell Wagner.

Table 1: Projected Future AADT Traffic Flows

Traffic Flow 1997		Traffic Flow 2001	Traffic Flow 2006	Traffic Flow 2011
AADT	% H.V.	AADT	AADT	AADT
9363	16	10524	12155	13786

2.2 Sensitive Development

From site inspections a number of rural/residential properties and the Ghinni Ghinni Public School were identified as potentially being affected by road traffic noise from the proposal and construction noise and vibration during the development of the road. For the purpose of the noise assessment these properties are represented by four (4) reference residential properties and the Ghinni Ghinni Public School. Noise levels were measured at the five (5) locations to quantify the existing ambient noise levels and assess the predicted future traffic noise levels.

3.0 METHODOLOGY

The findings and recommendations presented in this report are based on site inspections, the existing ambient noise levels (Appendix 3), the existing and projected traffic flows, the proposed road alignment (Appendix 2) and the predicted road traffic noise levels.

3.1 Existing Noise Level Measurements

The existing ambient noise levels were measured and recorded at five (5) reference locations during August 1998. The locations are shown in Appendix 1, and described with approximate chainage distances from north to south and off-set distances from the existing road alignment in Table 2.

Table 2: Reference Measurement Locations

Reference Location	Description	Measurement Orientation	Chainage (metres)	Off-set (metres)
R1	Kennedy Residence	Building Facade	16480	$80^{(west)}$
R2	Young Residence	Building Facade	14950	$140^{(east)}$
R3	Ghinni Ghinni School	North Boundary	12020	$75^{(east)}$
R4	Moy Residence	Building Facade	11570	$90^{(west)}$
R5	Ruprecht Residence	Building Facade	10930	$100^{(east)}$

3.2 Instrumentation

The instrumentation selected for the noise measurements comprised Tonin Technology, Environmental Noise Data Loggers. Each noise logger was installed with the meter set to A-weighting, fast response, and a fifteen (15) minute sampling period. The reference level for each logger was checked prior to and after the measurements with a NATA Calibrated (Certificate No 1766), Sound Level Calibrator Type 4230, Serial No. 597264. and remained within $\pm$ 0.5dB(A).

3.3 Traffic Noise Descriptors

The traffic noise levels presented in the report are assessed as A-weighted energy equivalent continuous (constant) sound levels. From the energy equivalent sound levels,

the $L_{Aeq,15hour}$ (the energy equivalent fifteen (15) hour level for the period 7.00am to 10.00pm), the $L_{Aeq,\ 9hour}$ (the equivalent level for the period 10.00pm to 7.00am), and the $L_{Aeq,\ 24hour}$ (the equivalent level over twenty four (24) hours) levels are determined.

3.4 Road Traffic Noise Predictions

The traffic noise predictions presented in the report are been based on the UK Department of Transport [1988], "The Calculation of Road Traffic Noise" (CORTN) traffic noise model, and modelled with the Environmental Noise Model (ENM). The CORTN model considers vehicle numbers, vehicle speed, percentage of heavy vehicles, the road alignment and the road surface. ENM considers distance attenuation, screening effects from barriers, topographical features of the area, ground absorption, the height of the noise source above the finished road level and the height of the noise receiver.

4.0 ASSESSMENT OF PE-CONSTRUCTION CONDITIONS

4.1 Preamble

The Ghinni Ghinni study area (Appendix 1) is exposed to traffic noise from the existing highway traffic, local domestic and farming activities and natural elements (wind, etc). To quantify the level of pre-development noise experienced in the area, audit noise monitoring was undertaken during August 1998. During the first stage of the noise monitoring heavy rain periods were recorded, hence the results of the noise measurements recorded during this period have not been considered in the assessment.

4.2 Existing Ambient Noise Environment

From the noise monitoring (Appendix 3), the existing ambient $L_{Aeq,\ 15hour,}$, $L_{Aeq,\ 9hour}$, $L_{Aeq,\ 24hour}$ and L_{Amax} noise levels were determined. Table 3 presents a summary of the existing noise levels.

Table 3: Existing Ambient Noise Levels
dB(A) re 20 x 10^{-6} Pa

Date	Sound Pressure Levels dB(A) re: 20x10^{-6} Pa			
	$L_{Aeq,15\ hour}$	$L_{Aeq,9\ hour}$	$L_{Aeq,24\ hour}$	L_{Amax}
Location 1: Kennedy Residence				
Monday 17.8.'98	-	61.3	-	73-78
Tuesday 18.8.'98	62.8	61.7	62.4	73-78
Wednesday 19.8.'98	62.2	61.1	61.9	73-81
Thursday 20.8.'98	63.3	62.8	62.7	72-81
Friday 21.8.'98	63.7	60.1	63.3	74-80
Saturday 22.8.'98	62.0	55.5	61.3	70-80
Sunday 23.8.'98	62.8	58.7	61.2	70-80
Monday 24.8.'98	62.2	60.9	60.6	70-81
Tuesday 25.8.'98	-	-	-	
Location 2: Young Residence				
Monday 17.8.'98	-	57.5	-	67-72
Tuesday 18.8.'98	59.4	59.5	59.0	67-73
Wednesday 19.8.'98	56.6	58.4	57.7	69-75
Thursday 20.8.'98	60.7	59.5	60.1	69-75
Friday 21.8.'98	63.4	59.9	62.2	69-75
Saturday 22.8.'98	62.8	54.5	62.3	68-75
Sunday 23.8.'98	64.6	59.7	62.8	62-75
Monday 24.8.'98	61.1	59.9	60.8	69-75
Tuesday 25.8.'98	-	-	-	

Table 3: Existing Ambient Noise Levels (Cont'd.)
dB(A) re 20 x 10^{-6} Pa

Date	Sound Pressure Levels dB(A) re: 20x10^{-6} Pa			
	$L_{Aeq,15\ hour}$	$L_{Aeq,9\ hour}$	$L_{Aeq,24\ hour}$	L_{Amax}
Location 3: Ghinni Ghinni School*				
Monday 17.8.98	-	58.7	-	70-73
Tuesday 18.8.98	61.3	60.0	60.6	70-74
Wednesday 19.8.98	61.2	59.8	60.7	70-75
Thursday 20.8.98	61.9	60.3	61.3	70-75
Friday 21.8.98	63.8	59.3	62.8	70-74
Saturday 22.8.98	61.6	54.0	60.7	70-73
Sunday 23.8.98	60.3	57.8	58.9	65-73
Monday 24.8.98	60.8	60.2	60.1	70-74
Tuesday 25.8.98	-	-	-	-
Location 4: Moy Residence				
Monday 17.8.98	-	58.8	-	70-74
Tuesday 18.8.98	61.0	59.9	60.5	70-74
Wednesday 19.8.98	60.4	56.8	60.0	70-75
Thursday 20.8.98	60.9	61.1	60.1	68-73
Friday 21.8.98	61.3	57.7	61.1	70-76
Saturday 22.8.98	59.5	55.0	58.8	68-74
Sunday 23.8.98	61.0	56.2	59.5	64-75
Monday 24.8.98	59.8	58.2	58.2	67-75
Tuesday 25.8.98	-	-	-	-
Location 5: Reprecht Residence				
Monday 17.8.98	-	61.0	-	64-75
Tuesday 18.8.98	61.4	62.7	61.6	66-76
Wednesday 19.8.98	60.0	65.4	61.5	70-78
Thursday 20.8.98	62.2	62.8	63.8	72-78
Friday 21.8.98	64.4	61.4	63.2	71-79
Saturday 22.8.98	64.5	58.1	63.8	67-76
Sunday 23.8.98	64.2	62.6	62.6	64-75
Monday 24.8.98	63.9	62.8	63.6	71-77
Tuesday 25.8.98	-	-	-	-

* Facade correction not included

4.3 Existing Traffic Flows

Traffic counts conducted during the noise survey period (August '98) confirmed the daytime (7.00am-10.00pm) and night-time (10.00pm-7.00am) traffic flows and heavy vehicle content. Table 4 presents a summary of the data recorded during the traffic survey period.

Table 4: August '98 Traffic Counts

Date	Daytime (15 hour) Traffic Counts					Night-time (9 hour) Traffic Counts				
	Southbound		Northbound		Total	Southbound		Northbound		Total
	cars	trucks	cars	trucks		cars	trucks	cars	trucks	
17.8.98	-	-	-	-	-	234	295	197	254	980
18.8.98	3275	544	3084	522	7425	188	287	275	297	1047
19.8.98	3491	549	3269	553	7862	246	306	258	263	1073
20.8.98	3698	476	3380	530	8084	256	304	346	296	1202
21.8.98	4303	442	4260	515	9520	319	106	537	244	1206
22.8.98	3793	233	3853	229	8108	199	68	226	58	551
23.8.98	4645	343	3528	240	8756	223	183	218	91	715
24.8.98	3788	456	2608	558	8410	243	318	241	268	1070
25.8.98	3353	630	3161	590	7734	186	310	237	269	1002

The traffic counts (Table 4) confirmed that the weekday daytime $_{(15\ hour)}$ percentage of heavy vehicles was 16%, the night-time $_{(9\ hour)}$ percentage was 54%. For the weekend period, the heavy vehicle percentages were 6% daytime $_{(15\ hour)}$ and 30% night-time $_{(9\ hour)}$.

5.0 TRAFFIC NOISE ASSESSMENT GOALS

The NSW, EPA, Draft Environment Criteria for Road Traffic Noise (ECRTN) recommends procedures for the assessing road traffic noise. In presenting these goals, it is recognised that there will be situations where planning strategies are not feasible and solutions to mitigate traffic noise are not always practical.

5.1 Assessment Goals

For the redevelopment of existing highway/freeways/arterial roads, the Draft ECRTN recommends base line traffic noise assessment goals for residential properties of $L_{Aeq,\ 15\ hour}$ 60dB(A) and $L_{Aeq,\ 9\ hour}$ 55dB(A). Where the existing ambient noise levels exceed the base line goals, it is recommended that the traffic noise resulting from the proposal should not increase the existing noise levels by more than 2dB(A), and that noise control options be considered to reduce the traffic noise to the base line goals where practical.

For schools, the recommended goal for assessing traffic noise in classrooms is $L_{Aeq,\ 1\ hour}$ 45dB(A). The equivalent external level (based on an open window facade noise reduction of 10dB(A)) to satisfy the internal goal is $L_{Aeq,\ 1\ hour}$ 55dB(A). For outdoor school playground areas, the recommended traffic noise assessment goal is $L_{Aeq,\ 1\ hour}$ 55dB(A),

For the assessment of road traffic noise at residential dwellings, the noise is assessed to a point one (1.0) metre from the building facade which is the most exposed to the traffic noise and a height of one point five (1.5) metres above the floor level.

For the evaluation of the Draft ECRTN noise goals for the Ghinni Ghinni proposal, the noise assessment has considered the projected traffic volumes and predicted noise levels for the opening of the proposal, five (5) and the ten (10) years after the opening (nominally 2001, 2006 and 2011).

5.2 Recommended Project Assessment Goals

For assessing the traffic noise predictions, the five (5) reference locations identified earlier in this report (Appendix 1) have been considered to establish noise assessment goals. Table 5 presents a summary of the existing ambient levels and the recommended assessment goals for each location.

Table 5: Traffic Noise Assessment Goals

Location	Sound Pressure Levels dB(A) re: 10^{-6} Pa.					
	Existing 1998		Baseline Assessment Goals		Assessment Goals	
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
R1	64	60	60	55	66	62
R2	63	60	60	55	65	62
R3*	62	-	55	-	55	-
R4	61	58	60	55	63	60
R5	64	61	60	55	66	63

* $L_{Aeq,\ 1hour}$ external noise levels.

6.0 TRAFFIC NOISE PREDICTIONS

Factors that affect road traffic noise include vehicle numbers, vehicle types, percentage heavy vehicles, vehicle speed, the vertical and horizontal road alignment, road surfaces, the distance to the noise receiver, noise source heights, local topography, building facade reflections, the presence of road cuttings and shielding from man made structures. From the above factors the following details have been considered for the Ghinni Ghinni noise assessment.

6.1 Road Alignment

The conceptual road alignments shown in Appendix 2.

6.2 Traffic Volumes

The existing and projected traffic volumes summarised in Chapter 2.

6.3 Traffic Speed

An average traffic speed of 100km/h.

6.4 Building Facade Correction

A building facade correction of plus 2.5dB(A).

6.5 Road Surfaces

The assessment has considered that the road will be surfaced with dense graded asphaltic concrete (DGAC) or an equivalent low noise road surface.

Noise investigations [(Roads & Transport Research '95)] conducted for various road surfaces have shown that a dense graded asphaltic surface will be 2 to 4dB(A) quieter than a chip sealed surface and approximately 1dB(A) quieter than a hessian dragged concrete surface. The existing road is surfaced with a chip sealed asphalt.

6.6 Noise Source Heights

The noise source heights adopted for the noise modelling were point five (0.5) of a metre for cars, one point five (1.5) metres trucks and three point six (3.6) metres for truck exhausts.

6.7 Validation

To validate the noise modelling the noise levels measured at the Young residence (Location 2) were evaluated against predicted levels. The findings confirmed that the measured levels were 2dB(A) lower than the predicted levels, indicating that the noise predictions are marginally conservative.

6.8 Predicted Traffic Noise Levels

In accordance with the assessment procedures discussed earlier, the noise modelling considered the projected traffic volumes for the years 2001, 2006 and 2011. Table 6 presents a summary of the project assessment goals and the predicted post development traffic noise levels without allowances for additional noise mitigation control.

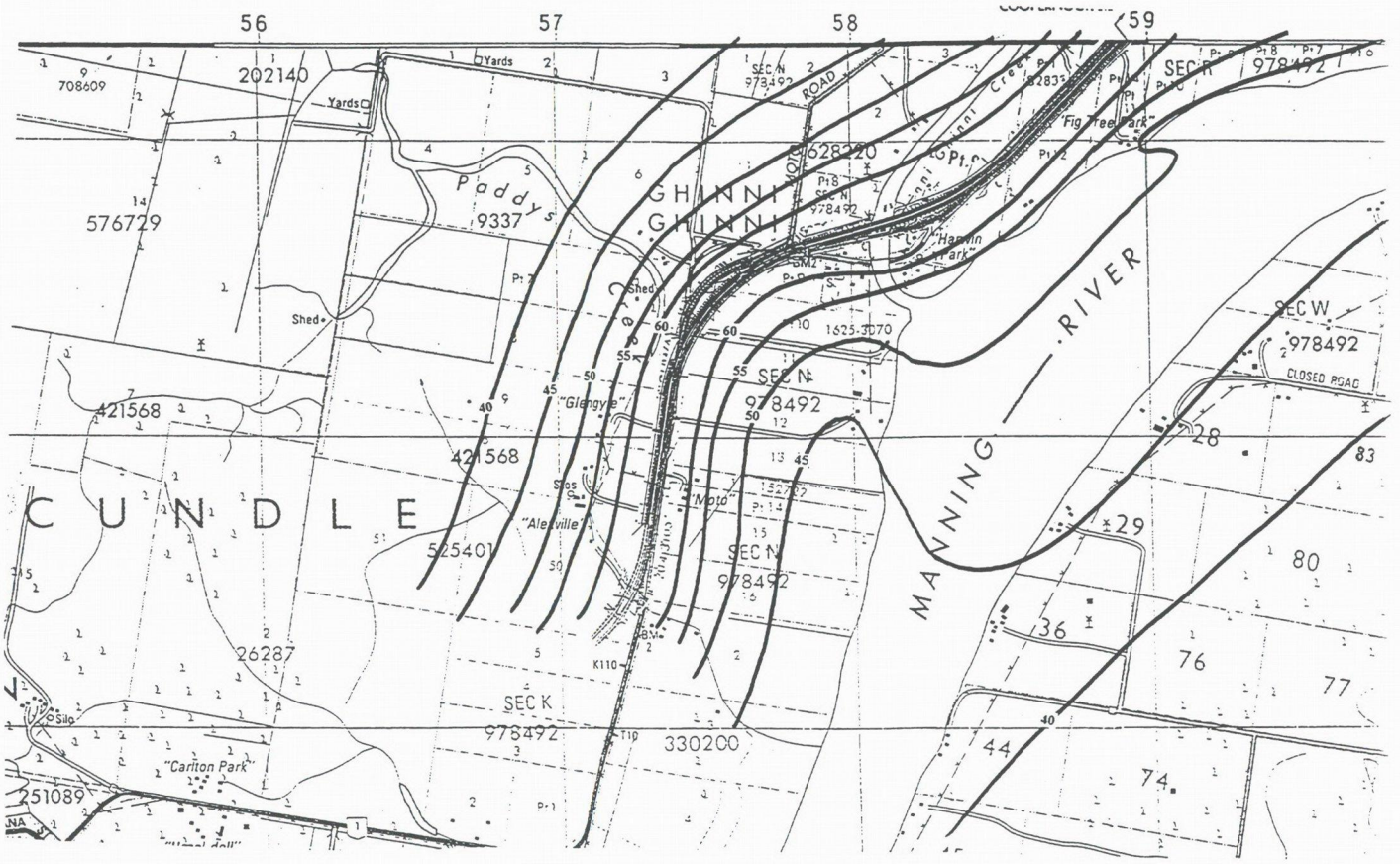
Table 6: Predicted Post Development Traffic Noise Levels
dB re: 20 x 10^{-6} Pa

Location	Project Assessment Goals		Post Development 2001		Post Development 2006		Post Development 2011	
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
R1	66	62	61.8	58.8	62.0	59.0	62.5	59.5
R2	65	62	62.6	59.6	62.8	59.8	63.3	60.3
R3*	55	-	58.4	-	58.6	-	59.1	-
R4	63	60	57.7	54.7	57.9	54.9	58.4	55.4
R5	66	63	61.6	58.6	61.8	58.8	62.3	59.3

* $L_{Aeq,\ 1hour}$ external noise levels.

For descriptive purposes traffic noise contour plots for the year 2001 ($L_{Aeq,\ 15hour}$ and $L_{Aeq,\ 9hours}$) are presented in Figures 1-4.

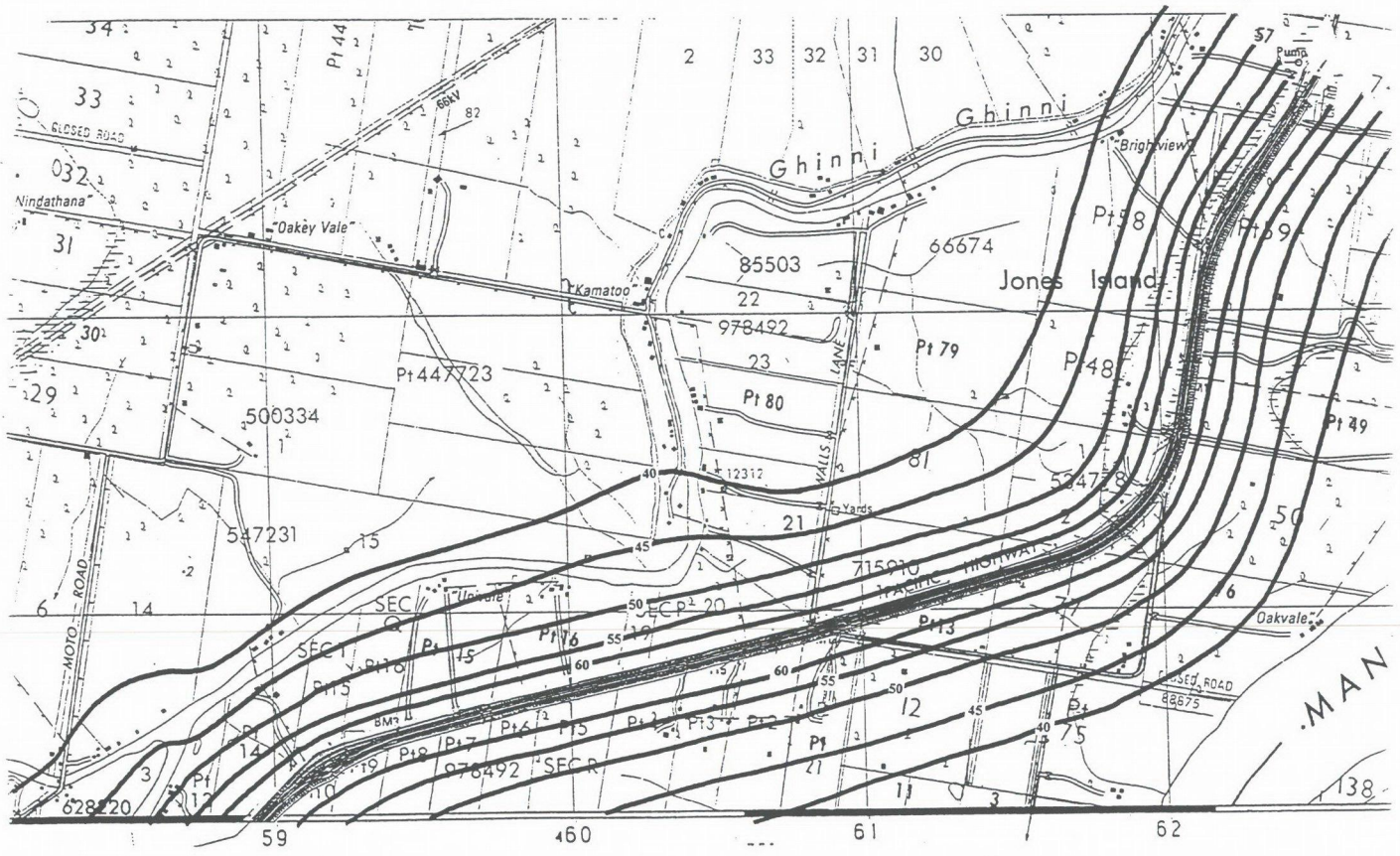
Figure 1: $L_{Aeq,\ 15hour}$ (2001) Traffic Noise Contour Plot



NOTES:

1. The $L_{Aeq,\ 15\ hour}$ (2001) traffic noise contour plot without additional noise controls.
2. The contours are for neutral weather conditions
3. Contours are for descriptive purposes.

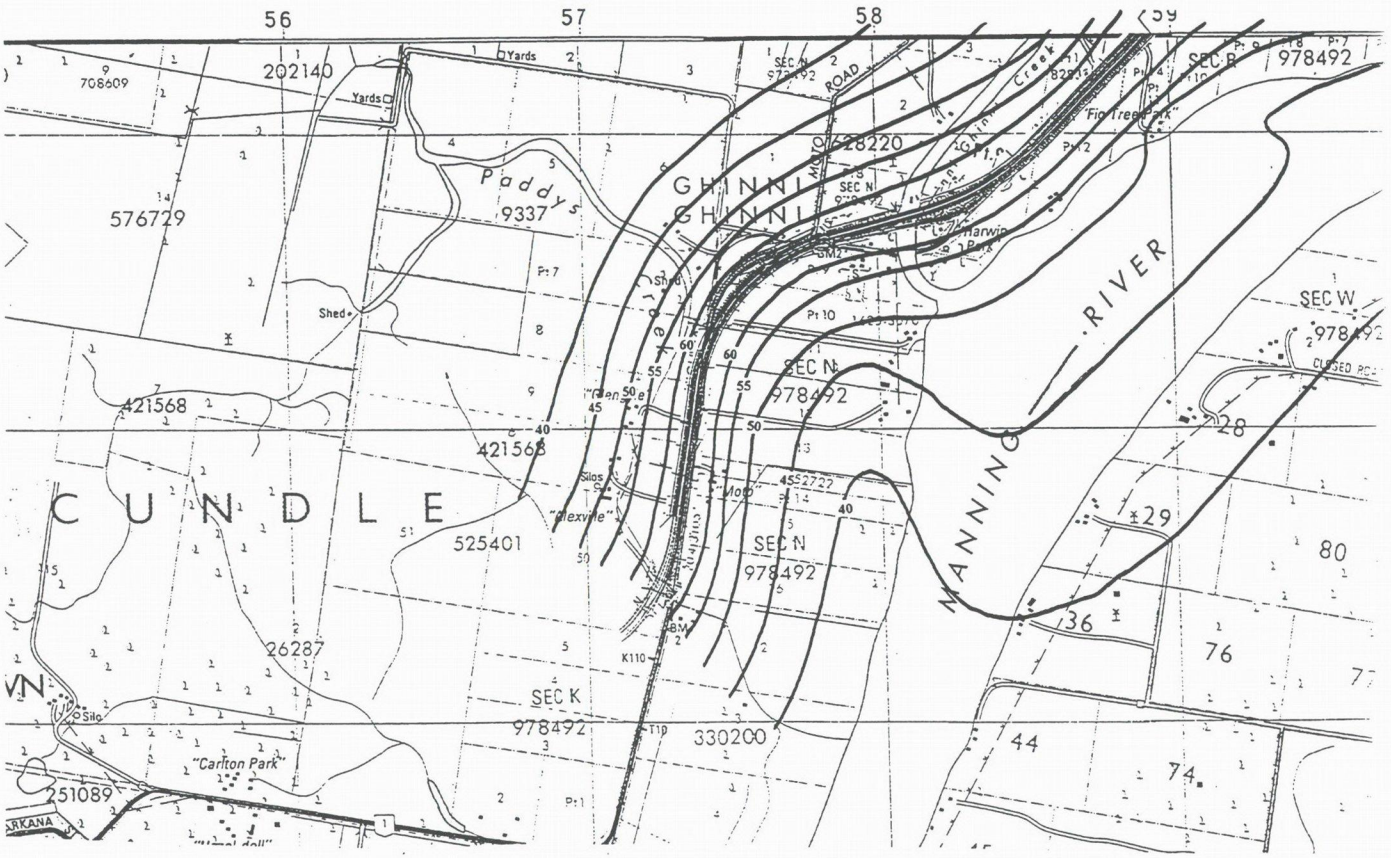
Figure 2: $L_{Aeq,\ 15hour}$ (2001) Traffic Noise Contour Plot



NOTES:

1. The $L_{Aeq,\ 15\ hour}$ (2001) traffic noise contour plot without additional noise controls.
2. The contours are for neutral weather conditions
3. Contours are for descriptive purposes.

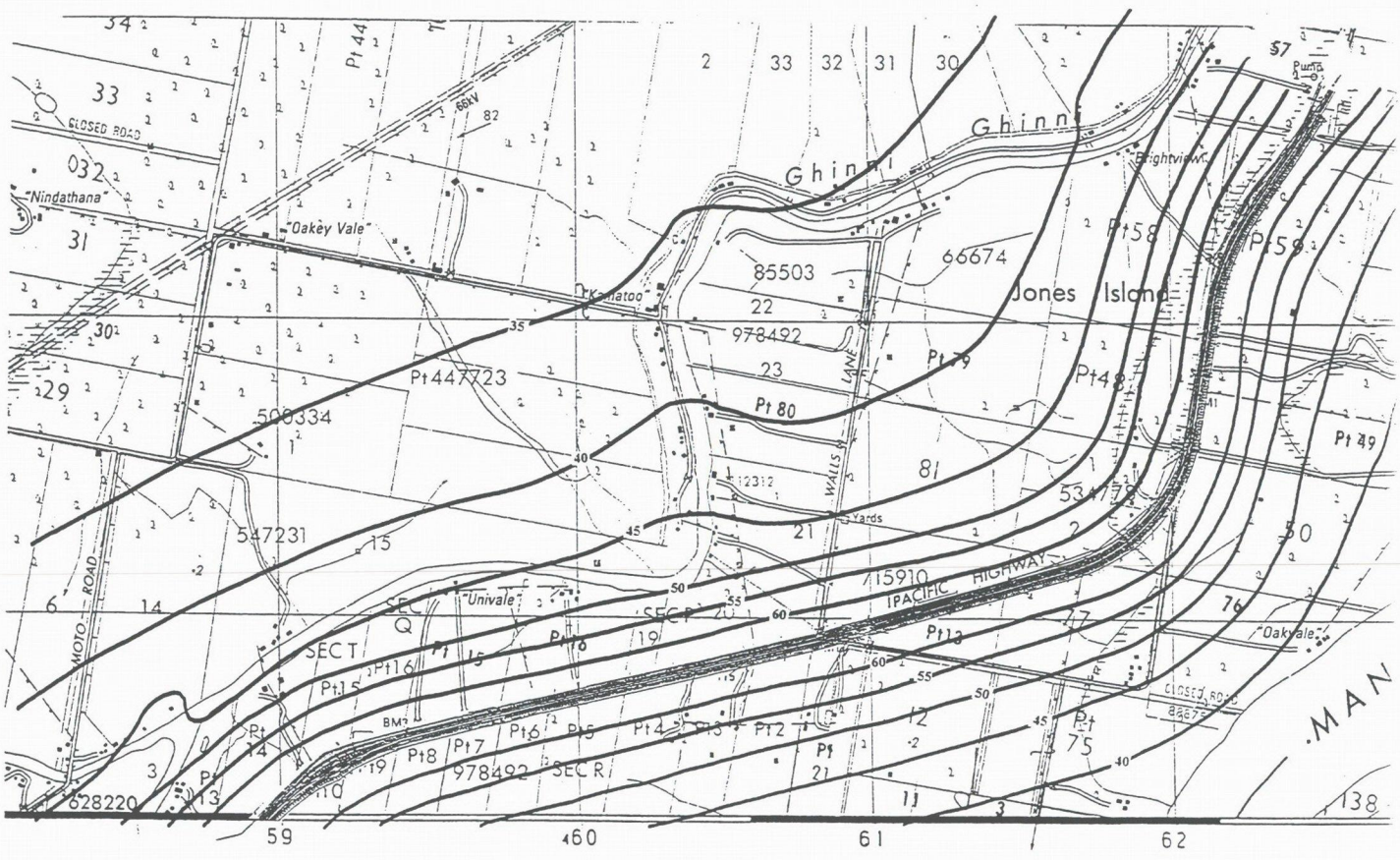
Figure 3: $L_{Aeq, 9hour}$ (2001) Traffic Noise Contour Plot



NOTES:

1. The $L_{Aeq, 9 hour}$ (2001) traffic noise contour plot without additional noise controls.
2. The contours are for neutral weather conditions
3. Contours are for descriptive purposes.

Figure 4: $L_{Aeq,\ 9hour}$ (2001) Traffic Noise Contour Plot



NOTES:

1. The $L_{Aeq,\ 9\ hour}$ (2001) traffic noise contour plot without additional noise controls.
2. The contours are for neutral weather conditions
3. Contours are for descriptive purposes.

7.0 ASSESSMENT

Considering the proposed road alignment and the recommended road surfacing (DGAC), the noise modelling has shown that without additional noise mitigation control, the post development $L_{Aeq,\ 15\ hour}$ and $L_{Aeq,\ 9\ hour}$ traffic noise levels for the opening of the road (2001) satisfy the recommended residential assessment goals, ie., the existing ambient noise levels do not increase by more than 2dB(A).

The noise investigations and modelling have also shown that the existing ($L_{Aeq,1\ hour}$ 62dB(A)) and post development noise levels ($L_{Aeq,\ 1\ hour}$ 58.4dB(A)) at the Ghinni Ghinni Public School exceed the recommended external traffic noise assessment goal $L_{Aeq,\ 1\ hour}$ 55dB(A). However, the proposal will result in a reduction in traffic noise exposure and an improvement to the existing acoustic environment at the school.

In regard to the projected traffic growth rates for the periods five (5) and ten (10) years post opening, the assessment has shown that the post opening $^{(2001)}$ traffic noise will increase by 0.2dB(A) and 0.5dB(A), respectively. Considering the increases to the post opening traffic noise, the assessment has shown that the resultant noise levels from the five (5) and ten (10) year traffic growth projections satisfy the recommended assessment goals (existing ambient plus 2dB(A)).

Reviewing the existing and predicted post development traffic noise levels (Table 7) in regard to the base line noise goals of $L_{Aeq,\ 15\ hour}$ 60dB(A) and $L_{Aeq,\ 9\ hour}$ 55dB(A), the assessment has shown that both the daytime and nigh-time goals will be exceeded at the opening of the proposal. Therefore, in accordance with the recommended assessment procedures additional ameliorative noise controls options have been considered.

Table 7: Summary Post Development Traffic Noise Levels
dB re: 20 x 10^{-6} Pa

Location	Existing Noise Levels		Baseline Assessment Goals		Post Development 2001		Post Development 2006		Post Development 2011	
	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$	$L_{Aeq,15hr}$	$L_{Aeq,9hr}$
R1	64	60	60	55	61.8	58.8	62.0	59.0	62.5	59.5
R2	63	60	60	55	62.6	59.6	62.8	59.8	63.3	60.3
R3*	62	-	55	-	58.4	-	58.6	-	59.1	-
R4	61	58	60	55	57.7	54.7	57.9	54.9	58.4	55.4
R5	64	61	60	55	61.6	58.6	61.8	58.8	62.3	59.3

* $L_{Aeq,\ 1hour}$ external noise levels.

In regard to the identified base line noise goal exceedances, the following section of the report discusses a number of options that could be considered to reduce the traffic noise.

7.1 Conceptual Ameliorative Noise Control Options

Reviewing the predicted traffic noise levels for the opening, five (5) and ten (10) years after the opening of the proposal, five (5) areas have been identified where additional noise controls are required to satisfy the base line traffic noise goals.

The following section of the report presents a details of noise controls that could be considered for project to satisfy the base line goals, providing they can be shown to be practical and cost effective.

7.1.1 Opening of the Proposal

For the projected traffic conditions at the opening (2001) of the proposal, in addition to the dense graded asphaltic concrete road surface, the following noise control options could be considered for inclusion in the project to satisfied the night-time $L_{Aeq,\ 9\ hour}$ 55dB(A) assessment goal. By default if the night-time goals are satisfied the daytime goals will be satisfied.

Acoustic Barriers

Acoustic barriers can be constructed in the form of precast concrete panels, masonry walls, timber panel walls and/or earth mounding. The effectiveness of a

barrier in terms of noise reduction, is dependent on the location and the height of the noise source, the receiver, and the barrier.

Considering the distance separations between the road and the residential dwellings, the following noise control barriers are required to satisfy the base line assessment goals for the opening of the proposal. Appendix 4 identifies the location of the proposed barriers.

Chainage 10840 - 11050 (eastern road carriageway) ..... 1 - 1½ metres
Chainage 11970 - 12850 (eastern road carriageway) ..... 1 - 1½ metres
Chainage 13450 - 13720 (eastern road carriageway) ..... 1 - 1½ metres
Chainage 14850 - 15150 (eastern road carriageway) ..... 1 - 1½ metres
Chainage 16350 - 16850 (western road carriageway) ..... 1 - 1½ metres

Treatment to Individual Dwellings

An alternative to noise control barriers and where practical noise controls could be incorporated into individual dwellings. The treatments that could be considered include external court yard walls, upgrading walls/glazing, acoustic seals around door and window openings, sealing off exposed wall vents and mechanical ventilation. It is noted that these treatments would provide no benefit to the outdoor acoustic amenity.

7.1.2 5 years After Opening

The noise modelling has shown that the traffic noise five (5) years post opening would increase by 0.2dB(A). The additional noise reduction required for the project to satisfy the base line assessment goals considering this increase, could be accommodated by the noise controls recommended for the proposed opening (Section 7.1.1) ie., barriers and/or treatments to individual dwellings.

7.1.3 10 years After Opening

The predicted increase to the traffic noise ten (10) years post opening would be in the order of 0.7dB(A). The additional noise controls required for the

project to satisfy the assessment goals considering this increase, could also be accommodated by the controls recommended for the opening (Section 7.1.1) ie., barriers and/or treatments to individual dwellings.

7.2 Summary

A number of practical constraints have been identified and considered in the evaluation of the noise control options for the project, they include access to private properties from the highway, flood impedance and visual impacts.

Considering the constraints on the use of noise control barriers and that the noise modelling has shown that proposal will not result in traffic noise levels that exceed the recommended assessment goal for redeveloped highway/freeways/arterial roads, ie., the existing noise levels by more than 2dB(A), it is recommended that no additional noise controls be incorporated into the project.

Considering that the existing traffic noise levels at the Ghinni Ghinni Public School exceed the recommended assessment goal of $L_{Aeq,\ 1\ hour}$ 55dB(A) and that the proposal will result in the existing levels reducing, it is recommended that no additional noise controls be considered for the school.

Reviewing the findings of the noise assessment it is recommended that following the opening of the road, post construction noise monitoring be undertaken to confirm that the project assessment goals have been satisfied.

7.3 Future Planning

The local Council has a role in ensuring that road traffic noise is considered when determining rezoning development and building applications under the provisions of the Environmental Planning and Assessment Act, 1979, and Local Government Act, 1993. It is therefore recommended that the local Council consider planning strategies for future land zoning and development adjacent to the highway.

7.4 Site Observations

Discussions with residents exposed to the existing highway traffic noise, have identified an issue associated with truck noise and in particular engine brakes. It appears that the study area is subjected to localised fog conditions which give rise to trucks drivers applying engine brakes to reduce speed. To assist in reducing excessive noise from trucks braking it is recommended that the area be sign posted to warn drivers of potential fog conditions and that the road alignment be better identified. In addition the proposed road alignment and improvements to the road surface the proposal will reduce the need for truck drivers to apply engine brakes.

7.5 Future Development in Traffic Noise Control

As part of the Government long term plan to reduce road traffic noise, strategies that are being considered include controlling noise emissions from individual vehicles, developing programs to monitor and control noisy vehicles, controlling noise from trucks and engine brakes. The effective implementation of these plans will assist in further reductions to road traffic noise.

8.0 CONSTRUCTION NOISE AND VIBRATION

8.1 Overview

The proposal at present is conceptual and no final plan or road contractor have been established. Similarly no final road construction program or construction techniques have been determined. The final details will be established when the proposal is approved and a contractor has been engaged. However, it is understood that the envisaged construction activities would be based on normal road design and construction procedures, ie., site preparation, bridge construction, sub-base preparation, and asphalt laying. To evaluate the likely level of noise and vibration envisaged during the construction, the following activities and plant schedules have been considered.

8.1.1 Preliminary Site Works

The preliminary site works would involve the relocation of services and access adjustments to local roads. At this time it is envisaged that trucks, a dozer, a grader and an excavator would be used to excavate and move materials during the site works.

8.1.2 Earthworks

The main construction activities envisage during the earthworks phase of the project will involve filling and compaction. During this phase of the project, dozers, scrapers, excavators, graders and compactors would be used to spread, level and compact the fill material to form the road base.

8.1.3 Sub-base Preparation

Following the earthworks, the road sub-base would be prepared by a fleet of trucks and concrete laying machines.

8.1.4 Road Surfacing

The laying of the asphalt surface would be carried out by asphalt laying machines and a fleet of trucks and rollers.

8.1.5 Bridge Construction

It is assumed that the Ghinni Ghinni Creek bridge would be constructed with prefabricated bridge structures supported on driven or bored piled concrete foundations and pre-cast concrete decks. During the construction of bridge, it is envisaged that the main plant and equipment would consist of a pile driver, trucks, cranes and compressors.

8.1.6 Construction Schedule

Table 8 presents a summary of the likely construction plant and construction schedules.

Table 8: Operations and Equipment for Site Preparation/Construction

Operation	Plant Type	No. Required (Av max)
Preliminary Site Works	Grader Dozer Excavator 25T trucks	1 1 1 2
Earthworks	25T trucks Excavator Scrapers Dozers Compactors	3 1 2 1 2
Sub-base Preparation/ Road Surfacing	Concrete/asphalt trucks Trucks Rollers	3 3 2
Bridge Construction	Pile Driver Cranes Trucks Generator Compressor	1 2 2 1 1

8.1.7 Construction Compounds

The location of construction compound sites for the establishment of material, plant and stockpile sites would be identified and carried out by the construction contractor. These areas are normally located within the road reservation, or by prior agreement with individual property owner on private property.

8.2 Construction Hours

To minimise noise impacts during construction, the activities would generally be restricted to between 7.00am and 6.00pm., Monday to Friday, and 8.00am to 1.00pm on Saturday. With prior approval from the EPA and Council and notification to residents construction outside these hours could be undertaken provided the construction noise did not give rise to an unreasonable nuisance or disturbance to the occupiers of nearby residential dwellings.

8.3 Construction Plant and Equipment Noise Levels

For the modelling and assessment of the range of noise levels for the envisaged construction activities, the sound power levels summarised in Table 9 have been established from data presented in Australian Standard AS2436-1981 and previous studies conducted by Atkins Acoustics and modelled with ENM.

Table 9: Construction Plant and Equipment Sound Power Levels
L_{A10} re: 10^{-12} Watts

Plant Description	Plant Type	Sound Power Level
Dozer	Caterpillar D7, D9	113
Front End Loader	Wheeled	110
Scraper	Caterpillar 651	110
Grader	Caterpillar 16	110
Compactor	Caterpillar 825	110
Vibratory Roller	10-12 tonne	110
Water Cart		106
Excavator	Kato 750	107
Pile driver		120
Truck		106

Table 9: Construction Plant and Equipment Sound Power Levels. Cont'd.
L_{A10} re: 10^{-12} Watts

Plant Description	Plant Type	Sound Power Level
Crane	truck mounted	110
Compressor	600 CFM	100
Backhoe		108
Grader	Caterpillar	106
Spreader	asphalt, concrete	95
Tip Truck		106
Concrete Paver		115
Concrete Truck		108
Concrete Pump		109
Concrete Vibrators		105

8.4 Ground Vibration from Construction Activities

As part of the road construction it will be necessary to use plant and equipment that will generate ground vibration. To evaluate the possible effects of ground vibration from the construction activities, the following vibration levels established from similar assessments have been considered.

Table 10: Construction Plant Vibration Levels

Plant Description	Vibration Levels mm/sec	
	5 metres	20 metres
Dozer	2	0.2
Pile Driver	10	4
Vibrating Compactor	20	2

8.5 Assessment Criteria

For the evaluation of the noise and vibration impact during the construction of the road, the following assessment goals recommended in the EPA, ENCM have been considered.

8.5.1 Noise

i **Construction periods of 4 weeks and under**

The $L_{A10,15min}$ noise level from the construction activities should not exceed the background level by more than 20dB(A).

ii **Construction periods greater than 4 weeks and less than 26 weeks**

The $L_{A10,15min}$ noise level from the construction activities should not exceed the background noise level by more than 10dB(A).

iii **Construction periods greater than 26 weeks**

The $L_{A10,15min}$ noise level from the construction activities should not exceed the background noise level by more than 5dB(A).

From the ambient noise survey results, the lowest repeatable daytime (0700-1800 hours) background (L_{A90}) noise levels at the measurement locations ranged between 37-40dB(A). A summary of the measured daytime background noise levels and construction noise assessment criteria are presented in Table 11.

Table 11: Background Daytime Noise Levels and Assessment Criteria
dB re: 20 x 10^{-6} Pa

Reference Location	Sound Pressure Level dB(A) re: $20x10^{-6}$ Pa			
	Range Background $L_{A90,15min}$	Short Term Construction $L_{A10,15min}$	Medium Term Construction $L_{A10,15min}$	Long Term Construction $L_{A10,15min}$
R1	40-55	60	50	45
R2	38-55	58	48	43
R3	38-55	58	48	43
R4	38-58	58	48	43
R5	37-55	57	47	42

For assessing noise from the permanent construction sites/compounds, the $L_{A10,15min}$ levels emitted from the site activities should not exceed that background level by more than 5dB(A), when assessed at the facade of a residential dwelling.

8.5.2 Mobile and Construction Plant Ground Vibration

(i) EPA Human Comfort and Disturbance

The EPA's Noise Control Manual (Chapter 174) recommends criteria for assessing vibration in buildings. The EPA base their criteria on weighted curves developed in the British Standard BS6472, and recommend that the vibration levels measured on the floor of a residence should not exceed the base Curve 60 (approx. 8mm/sec); where the levels are less than Curve 60 (approx 8mm/sec) and exceed Curve 2 (approx. 0.3mm/sec) it is recommended that the construction activities be restricted to between 7.00am and 6.00pm Monday to Friday, 7.00am and 1.00pm Saturday.

(ii) British Standard Effects on Building Occupants

British Standard BS6472[1992] provides guidelines for assessing potential disturbance to persons exposed to continuous and intermittent vibration in buildings. The vibration levels referenced in the standard that may give rise to "adverse comment" are shown in Table 12 For comparison purposes continuous vibration is normally felt at about 0.15mm/sec and becomes "noticeable" at approximately 1mm/sec.

Table 12: Vibration Levels for Assessing Human Comfort
(Ref: British Standard BS6472)

Type of Space Occupancy	Time of Day	Vibration Levels mm/sec			
		Continuous Vibration		Intermittent Vibration and Impulsive Vibration Excitation with Several Occurrences per day	
		Vert.	*Hor.*	*Vert.*	*Hor.*
Residential	Day Night	0.3 to 0.66 0.2	0.8 to 1.6 0.6	8.4 to 12.6 2.8	24 to 36 8

(iii) Effects on Structures - DIN 4150

German Standard DIN 4150 - Part 3:1986 provides guidelines for evaluating the effects of vibration on structures. The values recommended in the standard (maximum levels measured in any direction at the building foundation) are summarised in Table 13.

Table 13: Structural Damage - Safe Limits for Building Vibration
Reference: German Standard DIN4150

Type of Structure	Vibration Velocity mm/sec		
	Frequency		
	Less than 10Hz	*10Hz to 50Hz*	*50Hz to 100Hz*
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20

As the buildings in the vicinity of the proposal would be classified as residential structures, a vibration level of 5mm/sec has been recommended for assessing the potential for structural damage from the construction activities. It should be noted that the standard states that this level is a "safe limit", up to which no damage due to vibration effects has been observed for the particular class of building. "Damage" is defined by DIN 4150 to include minor non-structural superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls.

(iv) Effects on Building Contents

The threshold for visible movement of susceptible building contents (eg. plants, hanging pictures, etc) is approximately 0.5mm/sec; the audible rattling of loose objects (eg. crockery) generally does not occur until levels of about 0.9mm/sec.

8.6 Construction Noise Levels at Exposed Properties

Considering the envisaged construction scenarios described earlier, the range of noise levels has been predicted for each reference location. It is noted that the predicted noise levels represent the worst case scenario, that is when the construction activities are in close proximity to the referenced receiver. As the intensity of the construction activities decrease or the activities are more distant or shielded from the referenced location the associated noise levels will also decrease.

Table 14 presents a summary of the range of construction noise levels predicted for the worst case scenario, ie. adjacent to the referenced location.

Table 14: Range of Noise Levels from Construction Activities
L_{A10} re: 20 x 10^{-6} Pa

Reference Location	Sound Pressure Levels dB(A) re: 20 x 10^{-6} Pa					
	Site Preparation	Earthworks	Bridge Construction		Sub-base Preparation	Road Surfacing
			Piling	Erection		
R1	66	68	15	2	63	65
R2	63	65	24	10	60	62
R3	61	63	65	55	58	60
R4	65	67	47	35	62	64
R5	62	64	40	24	59	61

8.6.1 Assessment of Noise from Construction Activities

The modelling has shown that noise emissions from the construction activities immediately adjacent to an exposed location exceed both the short term and medium term construction criteria. From our experience, we confirm that as a result of the type of plant and equipment required to construct the road, other than plant selection, there is little opportunity to reduce the construction noise. To minimise potential noise impacts during the road construction, it is recommended that the plant and equipment be selected and operated with appropriate mufflers and noise controls, and where practical work practices and plant selection be considered so as to minimise noise impacts.

8.7 Predicted Ground Vibration from Construction Plant

Plant and equipment envisaged for the road construction will give rise to ground vibration. Table 15 presents a summary of the predicted vibration levels that could be generated by that plant.

Table 15: Typical Plant Vibration Levels

velocity (mm/sec)

Plant Description	Vibration Levels mm/sec	
	20 metres	40 metres
Dozer	0.2	0.02
Pile Driver	10	4
Compactor	2	0.3

8.7.1 Assessment of Ground Vibration from Construction Activities

The main sources of ground vibration from the construction activities will be associated with the pile driver and compactors. Typical ground vibration levels from pile drivers can range up to 10mm/sec at a distance of twenty (20) metres, at distances greater than forty (40) metres the levels will generally be below 4mm/sec. For compactors, vibration levels can range up to 2mm/sec at a distance of twenty (20) metres, at distances greater than forty (40) metres the levels will generally be below 0.3mm/sec.

As a result of the distance between the construction activities the residential buildings and the school, it is unlikely that the construction plant and equipment activities will give rise to vibration levels that exceed the structural damage criterion for residential buildings of 5mm/sec.

As a result of the shallow water table in the study area, to ensure that ground vibration levels from the construction activities are within acceptable limits and comply with the limits set, it is recommended that the ground vibration be

monitored during any pile driving within fifty (50) metres and vibration compaction within twenty (20) metres of any residential building or sensitive structure.

8.8 Recommendations

To control construction noise and vibration during the road construction, in consultation with the EPA and Council it is recommended that as part of the construction contractors undertaking an "Environmental Management Plan" (EMP) be prepared to address the issues of noise and vibration. As part of the "EMP", the following issues should be considered;

- the establishment of a construction noise and vibration control plan,
- the selection of plant and equipment where practical on acoustic performance,
- the use of the plant and equipment to minimise potential noise and vibration impacts,
- the implementation of a monitoring program to ensure that the construction noise and vibration is controlled and that the best possible practices are being implemented,
- the preparation of dilapidation reports on sensitive structures within sixty (60) metres of any road construction activity, and
- to implementation of an information program to inform the local residents of the construction program and time periods when noise and vibration levels could exceed the recommended assessment guidelines.

9.0 SUMMARY

This report presents the results and findings of a noise and vibration assessment for the proposed redevelopment of the Pacific Highway at Ghinni Ghinni. The assessment has identified a number of sensitive locations which include Ghinni Ghinni Public School and a number of rural/residential residences that are and will be exposed to road traffic noise, and construction noise and vibration during the road construction. For the purpose of the assessment these properties have been represented by four (4) residential locations and the Ghinni Ghinni Public School. Noise levels were measured at the five (5) locations to quantify the existing ambient noise levels and assess the predicted future traffic noise levels, and construction noise and vibration.

For the assessment of road traffic noise from the redevelopment of existing highway/freeways/arterial roads, the NSW EPA, Draft ECRTN recommended base line assessment goals for residential dwellings are $L_{Aeq,\ 15\ hour}$ 60dB(A) and $L_{Aeq,\ 9\ hour}$ 55dB(A). Where the existing noise levels exceed the base line goals, it is recommended that the traffic noise from the proposal not increase the existing noise levels by more than 2dB(A), and that consideration be given to reducing the noise levels to satisfy the base line goals where practical.

For existing schools, the recommended goal for assessing traffic noise in classrooms is $L_{Aeq,\ 1\ hour}$ 45dB(A). The equivalent external level (based on an open window facade noise reduction of 10dB(A)) to satisfy the internal goal is $L_{Aeq,\ 1\ hour}$ 55dB(A). For outdoor school playground areas, the recommended traffic noise assessment goal is $L_{Aeq,\ 1\ hour}$ 55dB(A).

Considering the conceptual road alignment with the replacement of the existing chip seal road surface with dense graded asphaltic concrete or an equivalent road surface, the assessment has shown that without additional noise mitigation, the post development (2001) $L_{Aeq,15\ hour}$ and $L_{Aeq,9\ hour}$ traffic noise levels satisfy the recommended residential

assessment goal, ie., the existing levels plus 2dB(A).

In regard to the projected traffic growth rates for the assessment periods five (5) and ten (10) years post opening, the traffic noise levels (Table 7) predicted for the opening (2001) could increase by 0.2dB(A) and 0.7dB(A), respectively. The resultant traffic noise levels considering the projected traffic growth for the five (5) and ten (10) post opening years, satisfy the recommended assessment goal. ie., the existing levels plus 2dB(A).

Reviewing the existing and predicted post construction traffic noise levels (Table 7) at the referenced residential locations in regard to the base line noise goals of $L_{Aeq,\ 15\ hour}$ 60dB(A) and $L_{Aeq,\ 9\ hour}$ 55dB(A), the assessment has shown that both the daytime and nigh-time goals will be exceeded at the opening of the proposal.

Considering the predicted post construction traffic noise levels in regard to the recommended assessment procedures, i.e., where the existing or predicted future traffic noise levels exceed the base line goals, five (5) areas have been identified where traffic noise levels exceed the recommended base line assessment goals, if no additional ameliorative noise controls are incorporated into the project. Chapter 7 presents recommendations that have been considered for the project to satisfy the base line assessment goals.

A number of practical constraints have been considered in the evaluation of the noise control options for the project, they include access to private properties from the highway, flood impedance and visual impacts. Considering the constraints on the noise control options and that the noise modelling has shown that proposal will not result in traffic noise levels that exceed the recommended assessment goal for redeveloped highway/freeways/arterial roads, ie., the existing noise levels by more than 2dB(A), it is recommended that no additional noise controls be incorporated into the project.

Considering that the existing traffic noise levels at the Ghinni Ghinni Public School

exceed the recommended assessment goal of $L_{Aeq,\ 1\ hour}$ 55dB(A) and that the proposal will result in the existing reducing, it is recommended that no additional noise controls be considered for the school.

Reviewing the findings of the noise assessment it is recommended that following the opening of the road, post construction noise monitoring be undertaken to confirm that the project assessment goals have been satisfied.

From the site investigation it has been established that the existing highway is subjected to localised fog which give rise to trucks drivers applying engine brakes to reduce speed. The application of the engine brakes has been identified as a source of noise compliant. To assist in reducing noise from trucks braking it is recommended that the area be sign posted to warn drivers of potential fog conditions and that the road alignment be better identified. In addition the proposed road alignment will assist in an improvement to the existing road conditions and the need for truck drivers to apply engine brakes.

As part of the NSW Government long term plan to reduce road traffic noise, strategies that are being considered include controlling noise emissions from individual vehicles, developing programs to monitor and control noisy vehicles, and the control of noise from trucks and engine brakes. The progressive and effective implementation of these plans will assist in further reductions to road traffic noise in the Ghinni Ghinni area.

In terms of future planning the local Council has a role in ensuring that road traffic noise is considered when determining rezoning development and building applications under the provisions of the Environmental Planning and Assessment Act, 1979, and Local Government Act, 1993. It is recommended that the local Council consider planning strategies for future residential development adjacent to the proposal.

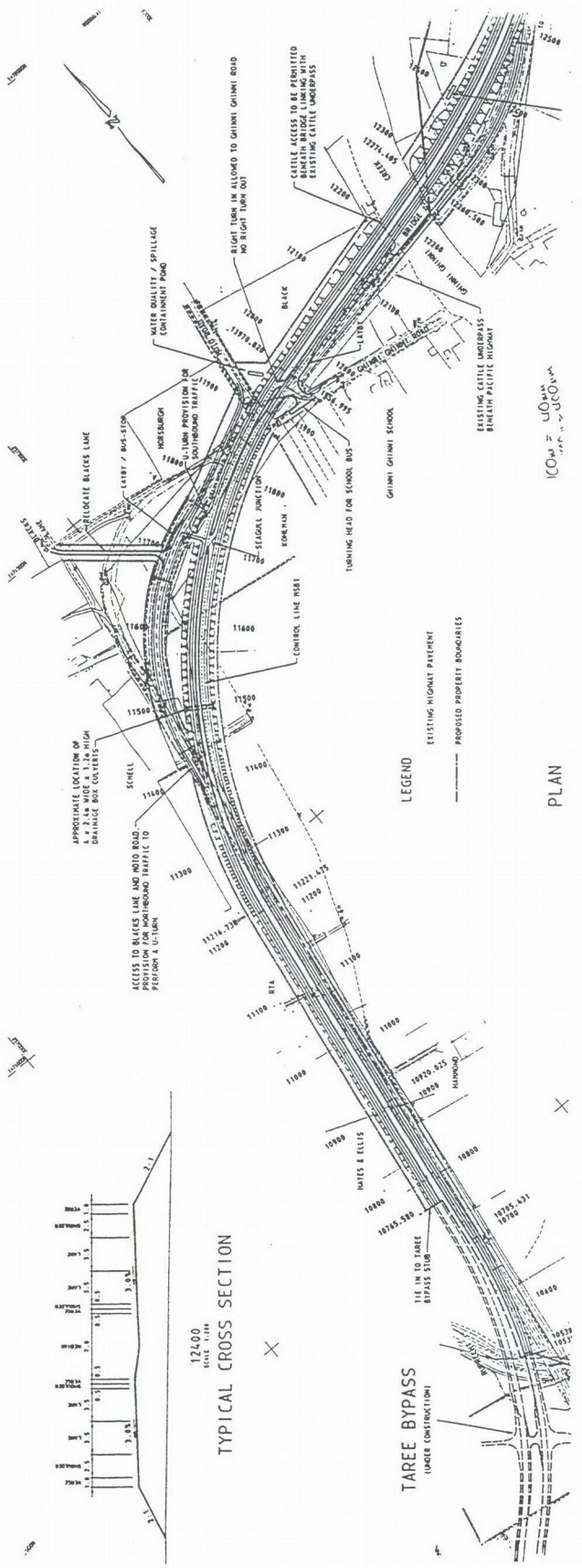
At this time the redevelopment proposal is conceptual and no final plan or road contractor have been established. Similarly no final road construction program or

construction techniques have been determined. The final construction details will be established when the proposal is approved and a contractor engaged. However, it is understood that the construction activities would be based on normal road design and construction procedures, ie., site preparation, bridge construction, sub-base preparation, and asphalt laying. The assessment has shown that during the construction of the proposal there could be localised adverse noise and vibration impacts where the earthworks and the road construction activities take place adjacent to sensitive development. Noise and vibration impacts from these activities, can be minimised through planning, programming and consultation with the occupiers of the affected properties. To ensure that construction noise and vibration impacts are minimised during the road construction, it is recommended that as part of the construction contractors undertakings, an "Environmental Management Plan" be prepared to address and control construction noise and vibration.

APPENDIX 1: STUDY AREA and REFERENCE ASSESSMENT LOCATIONS



APPENDIX 2: PROPOSED ROAD ALIGNMENT



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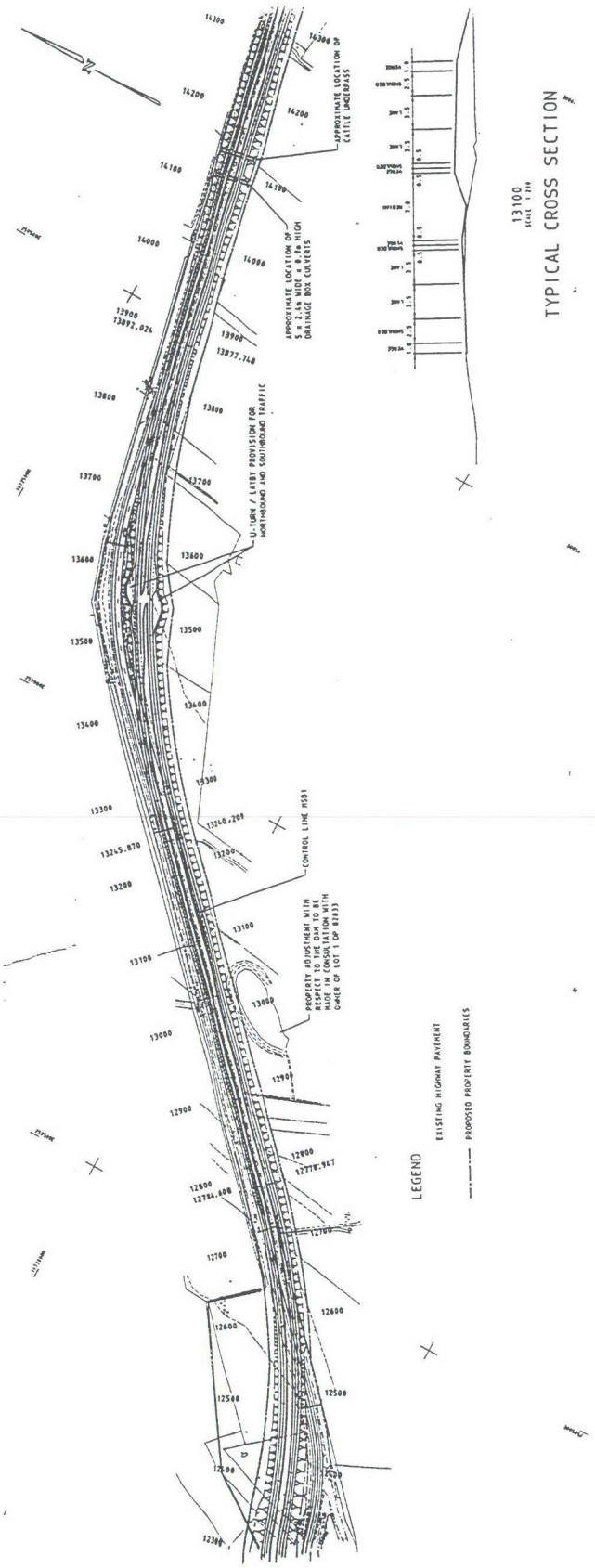

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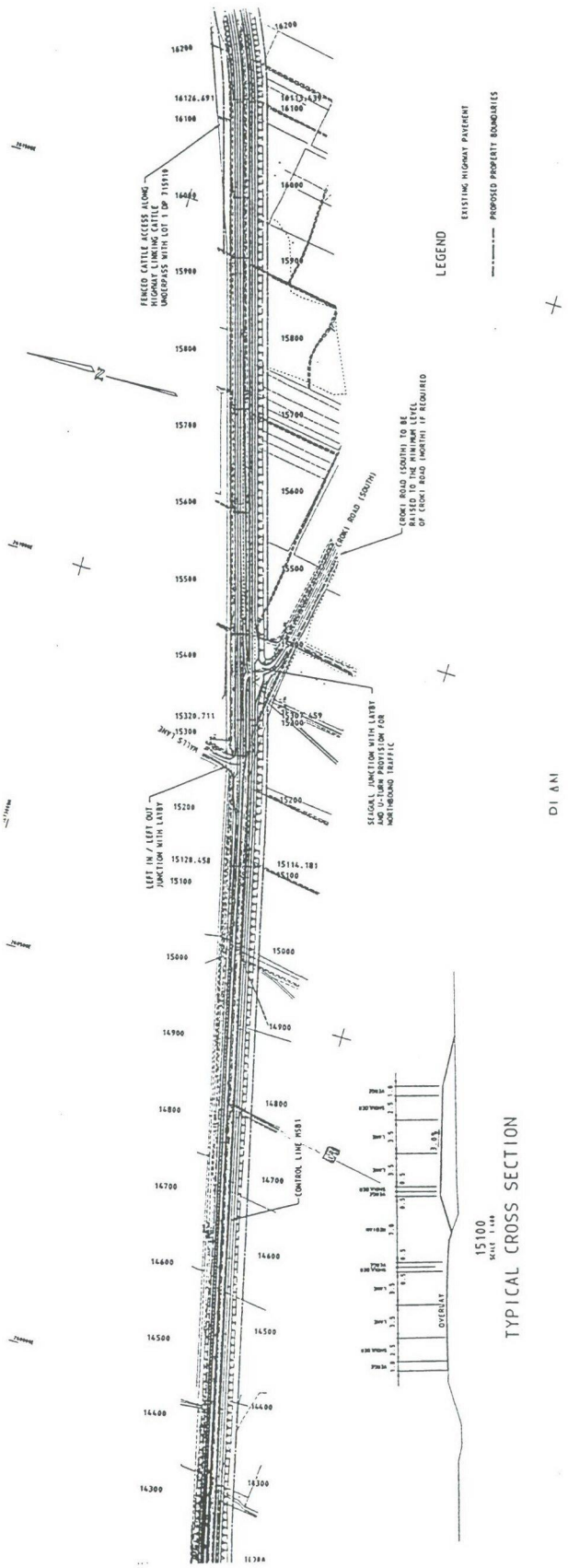

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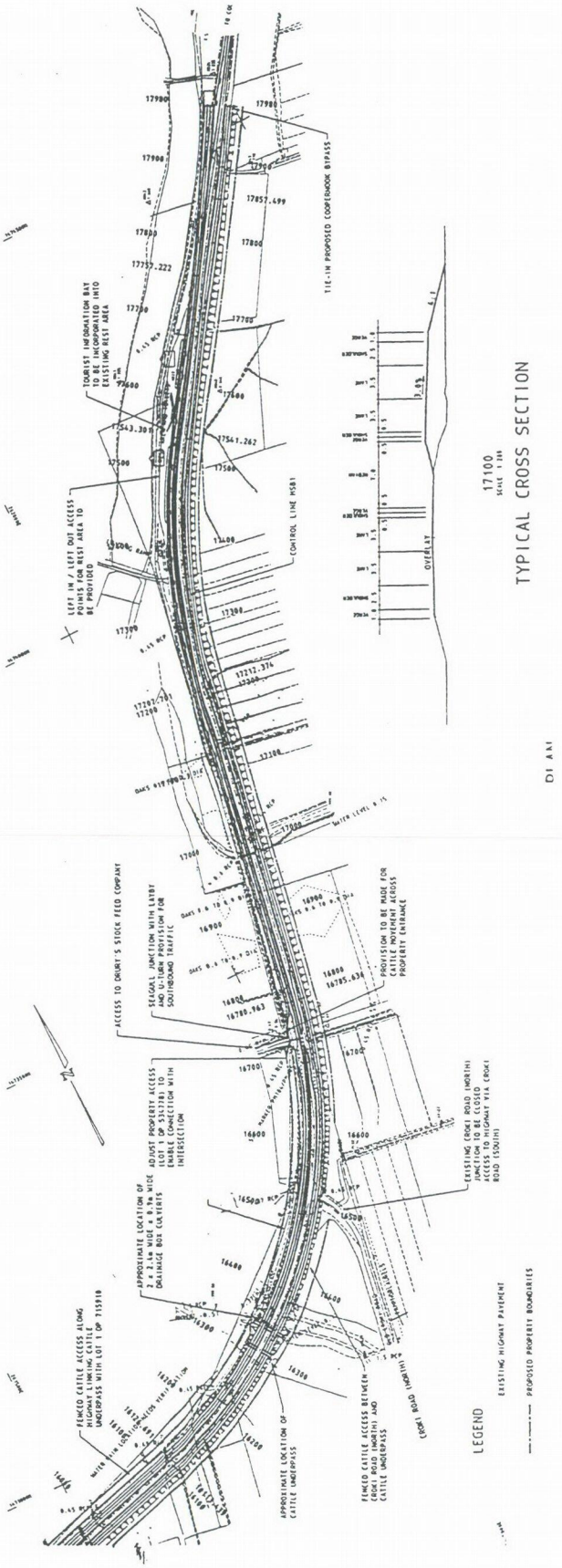
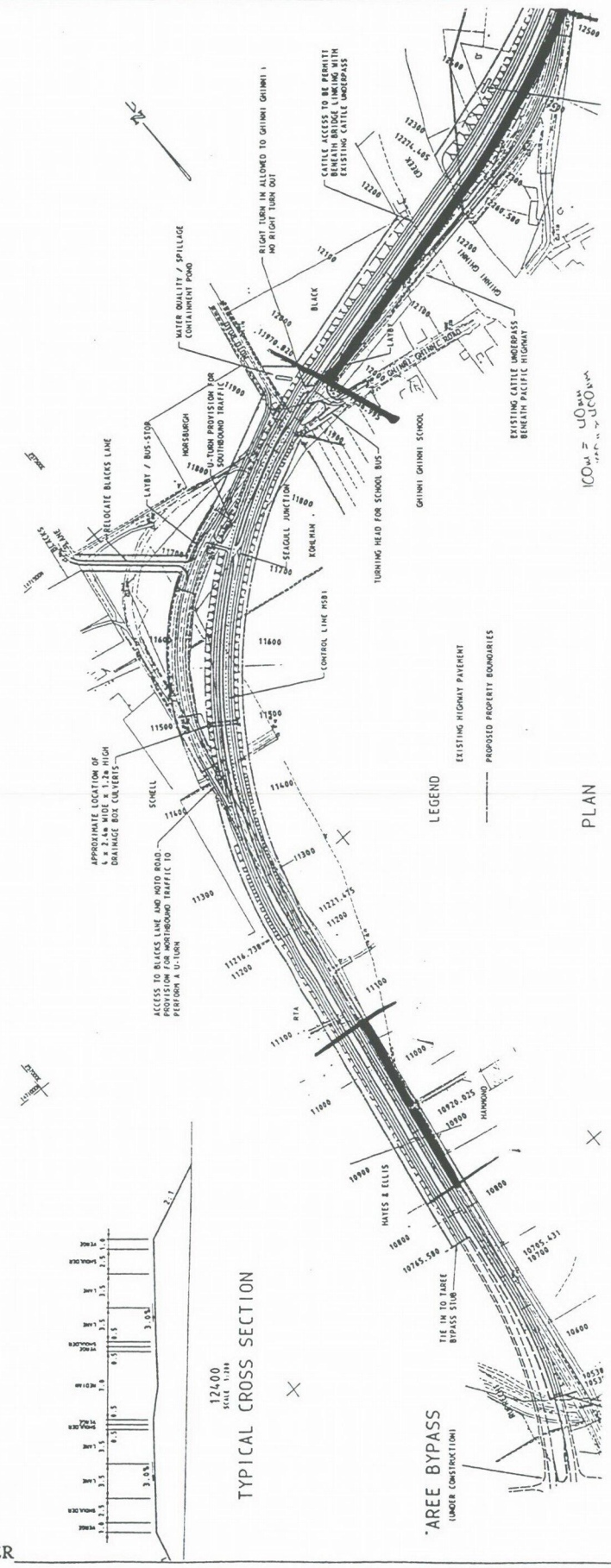


APPENDIX 3: EXISTING AMBIENT NOISE MEASUREMENTS

APPENDIX 4: BARRIER NOISE CONTROL OPTIONS



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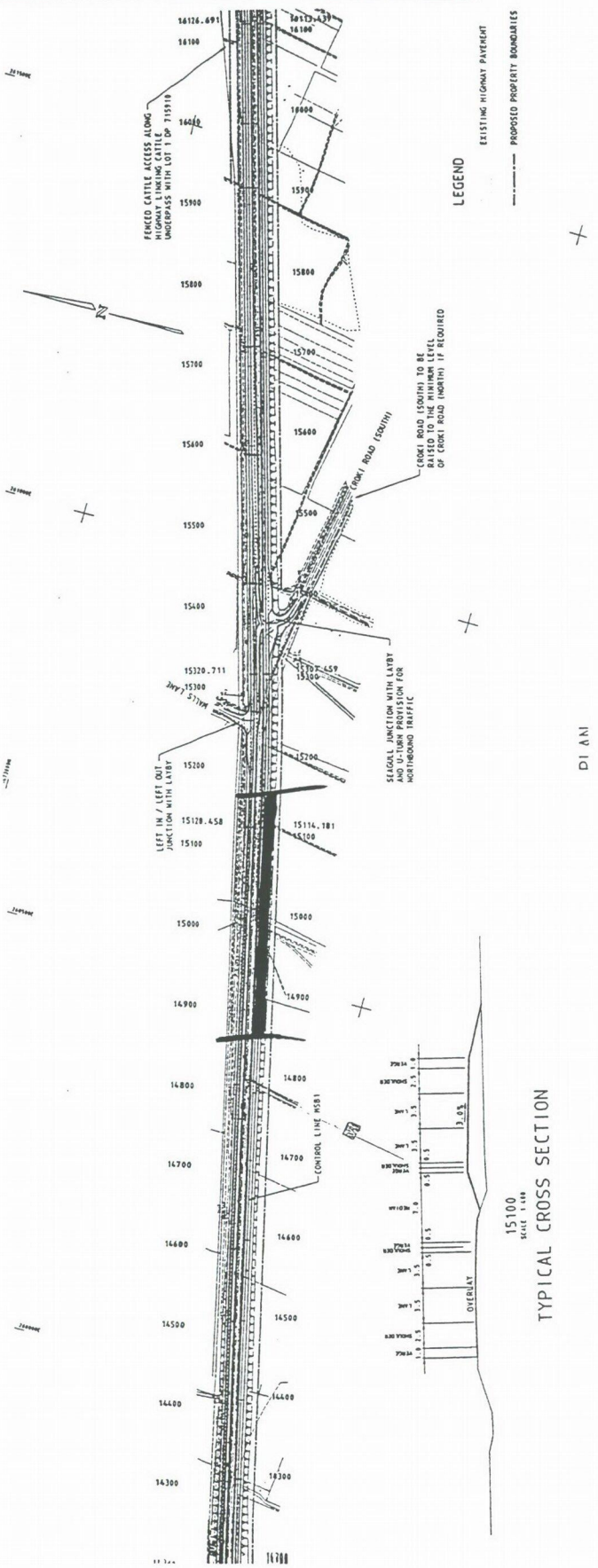

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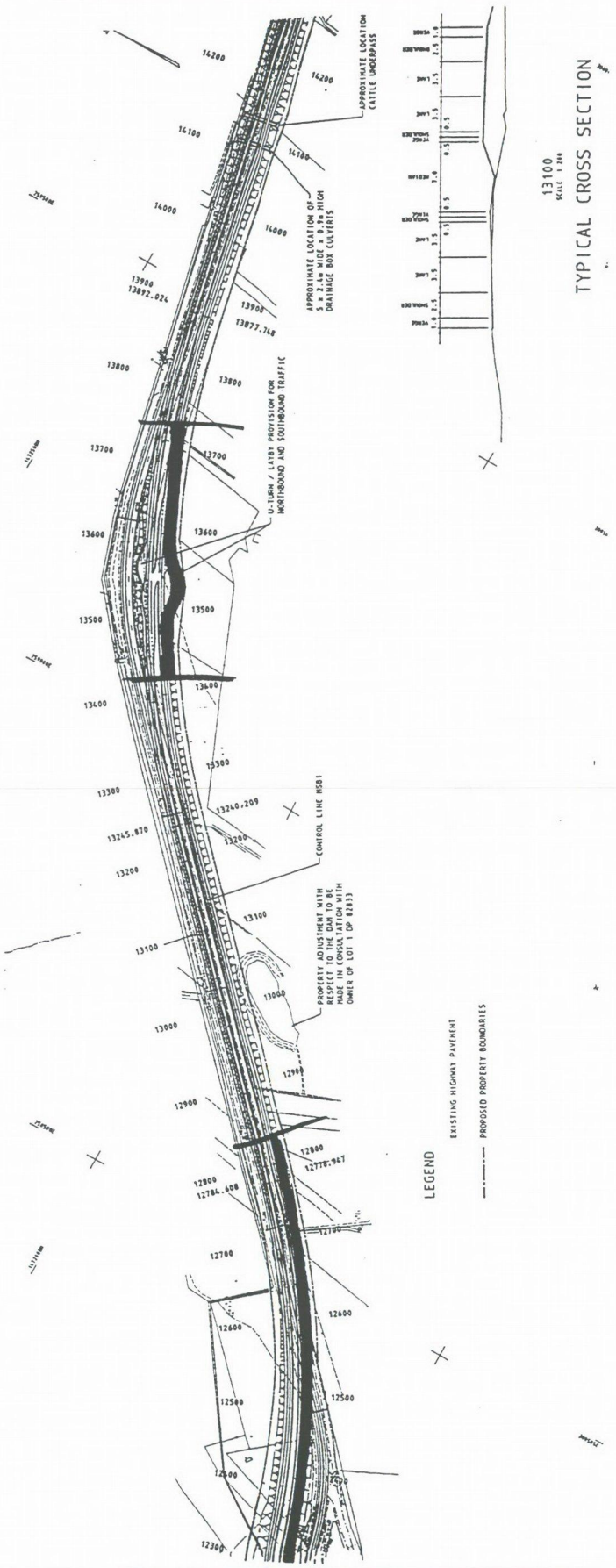

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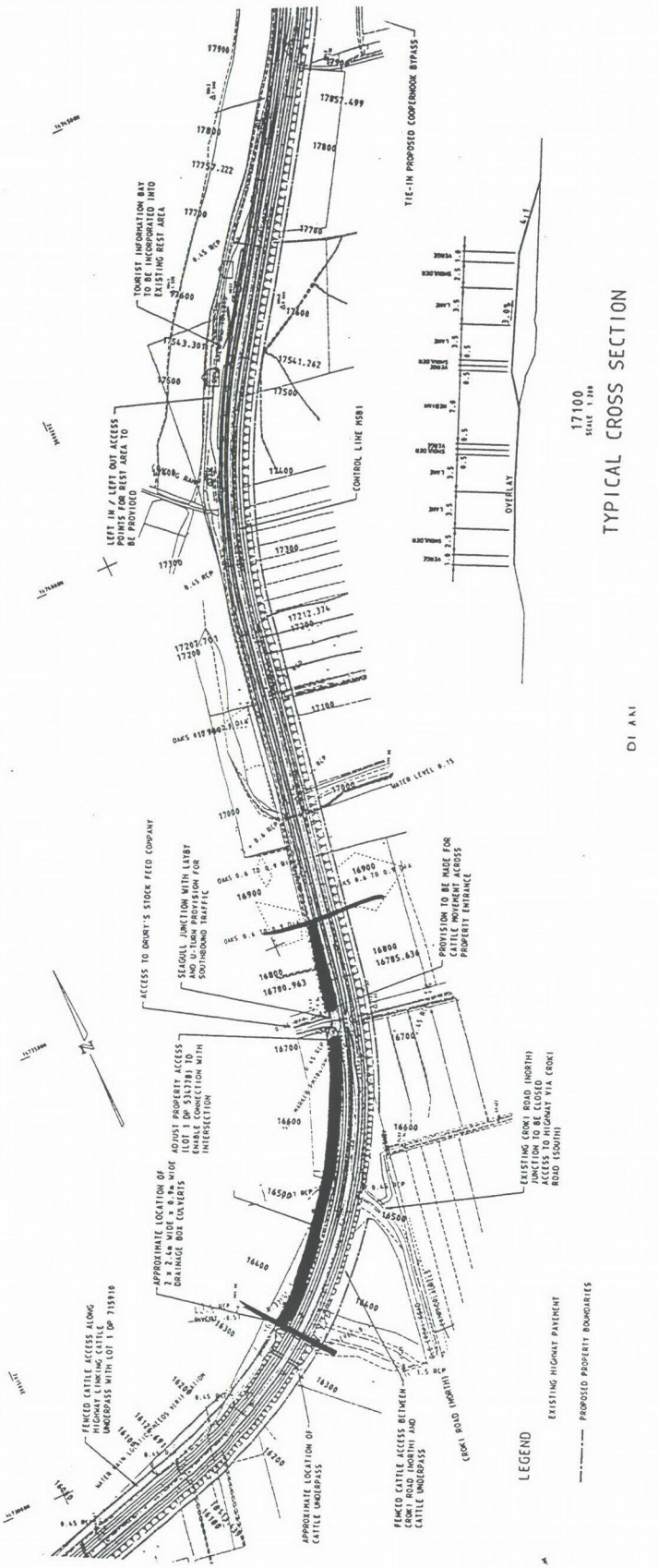
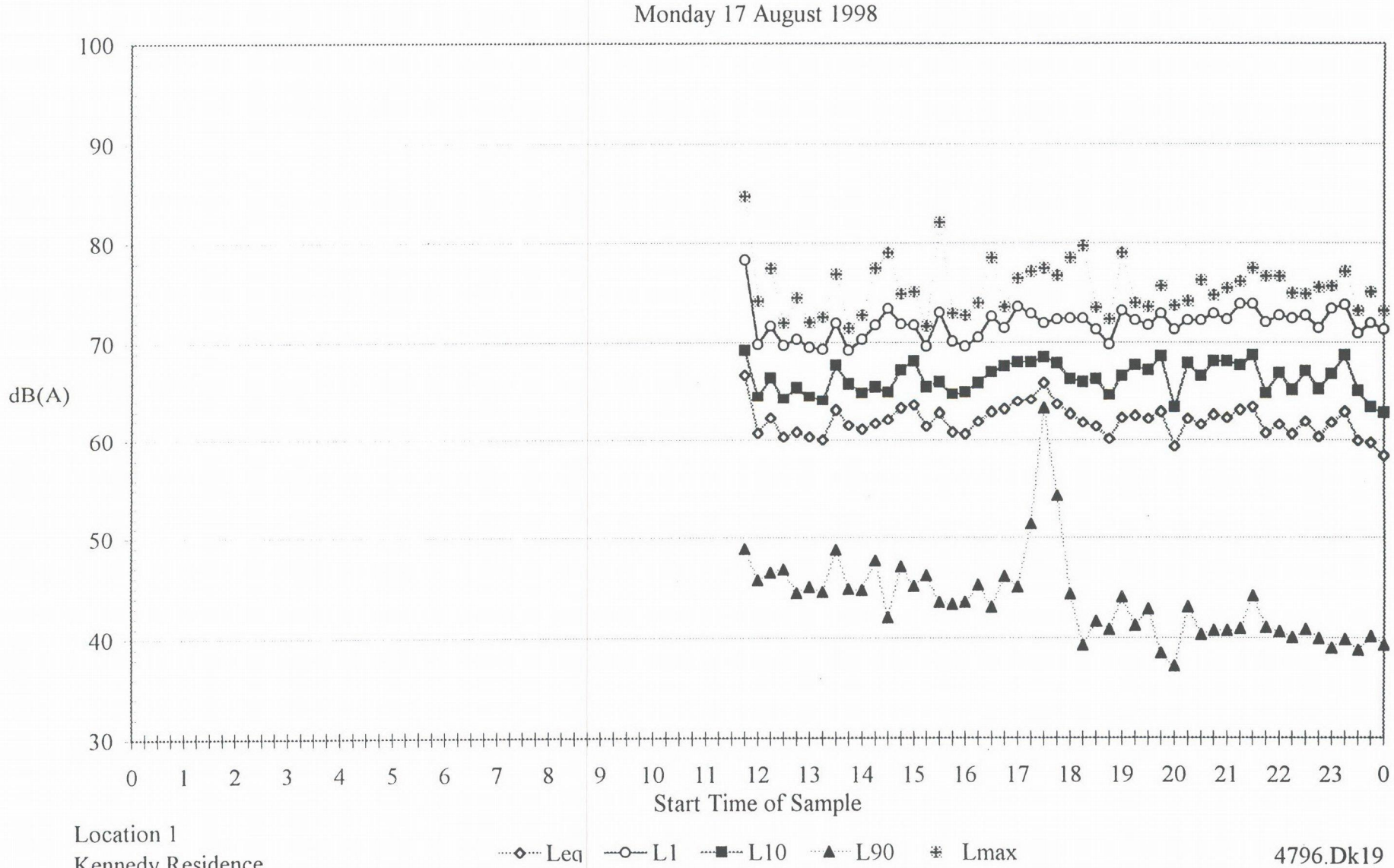


Ambient Sound Pressure Levels



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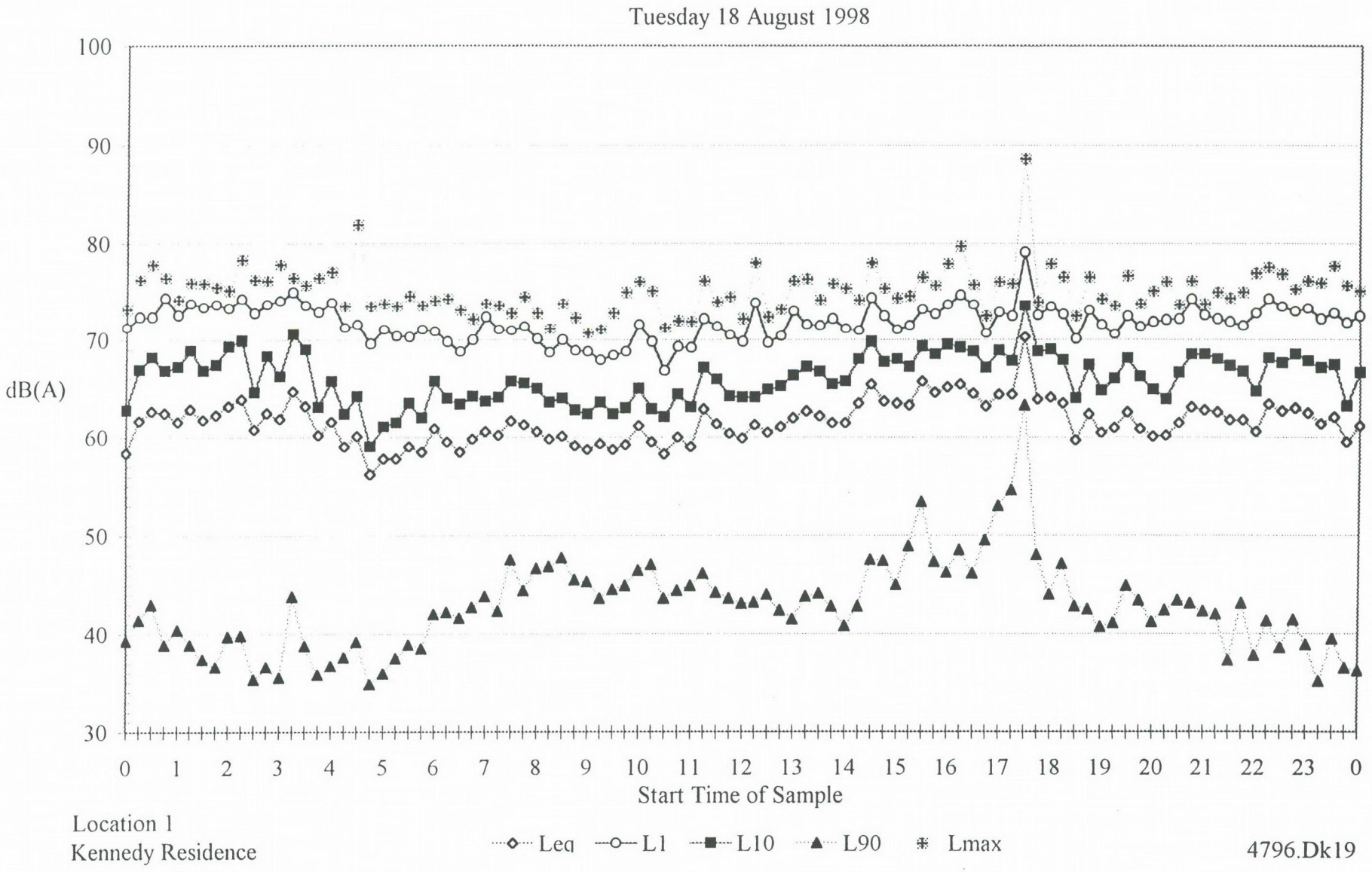

Location 1
Kennedy Residence

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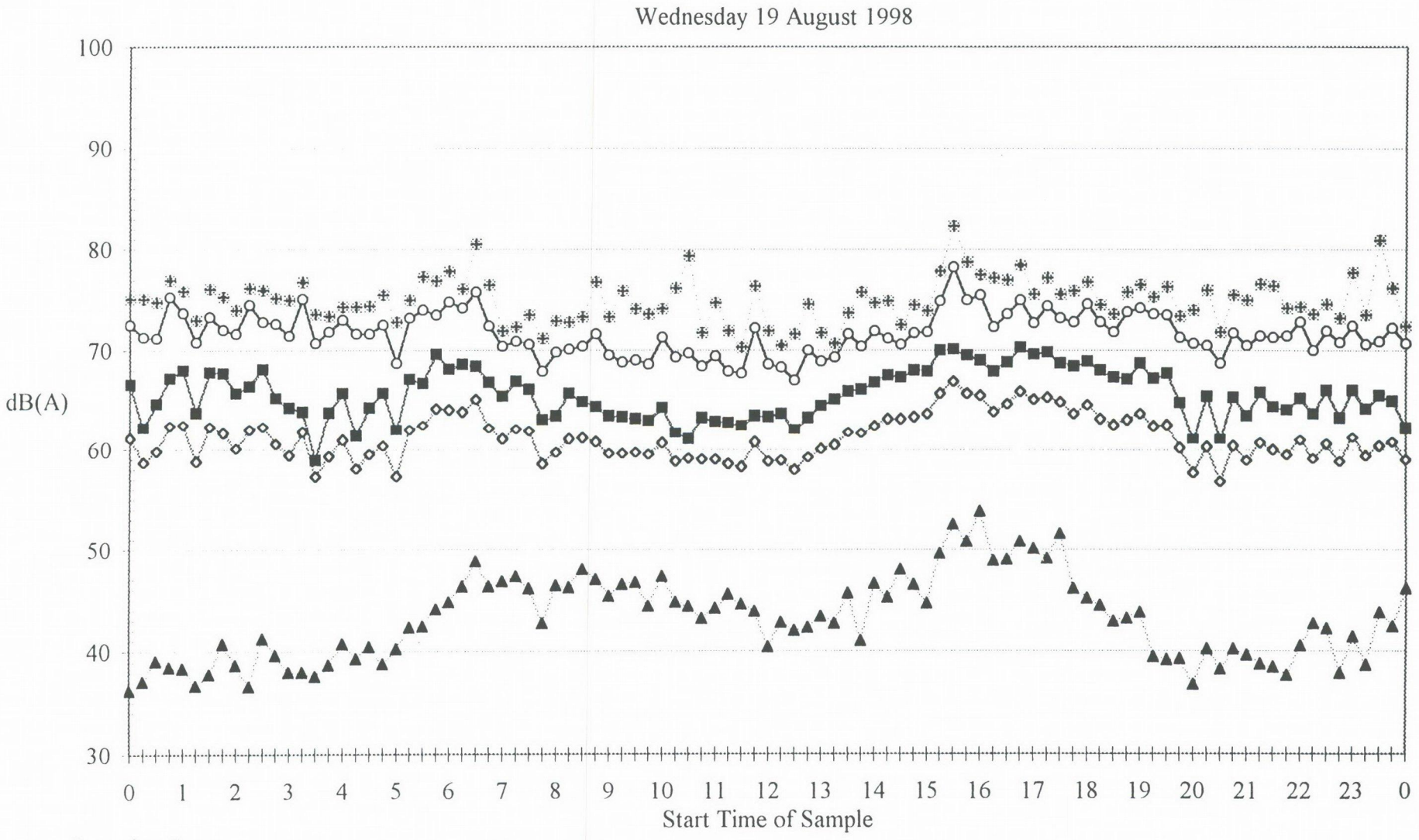

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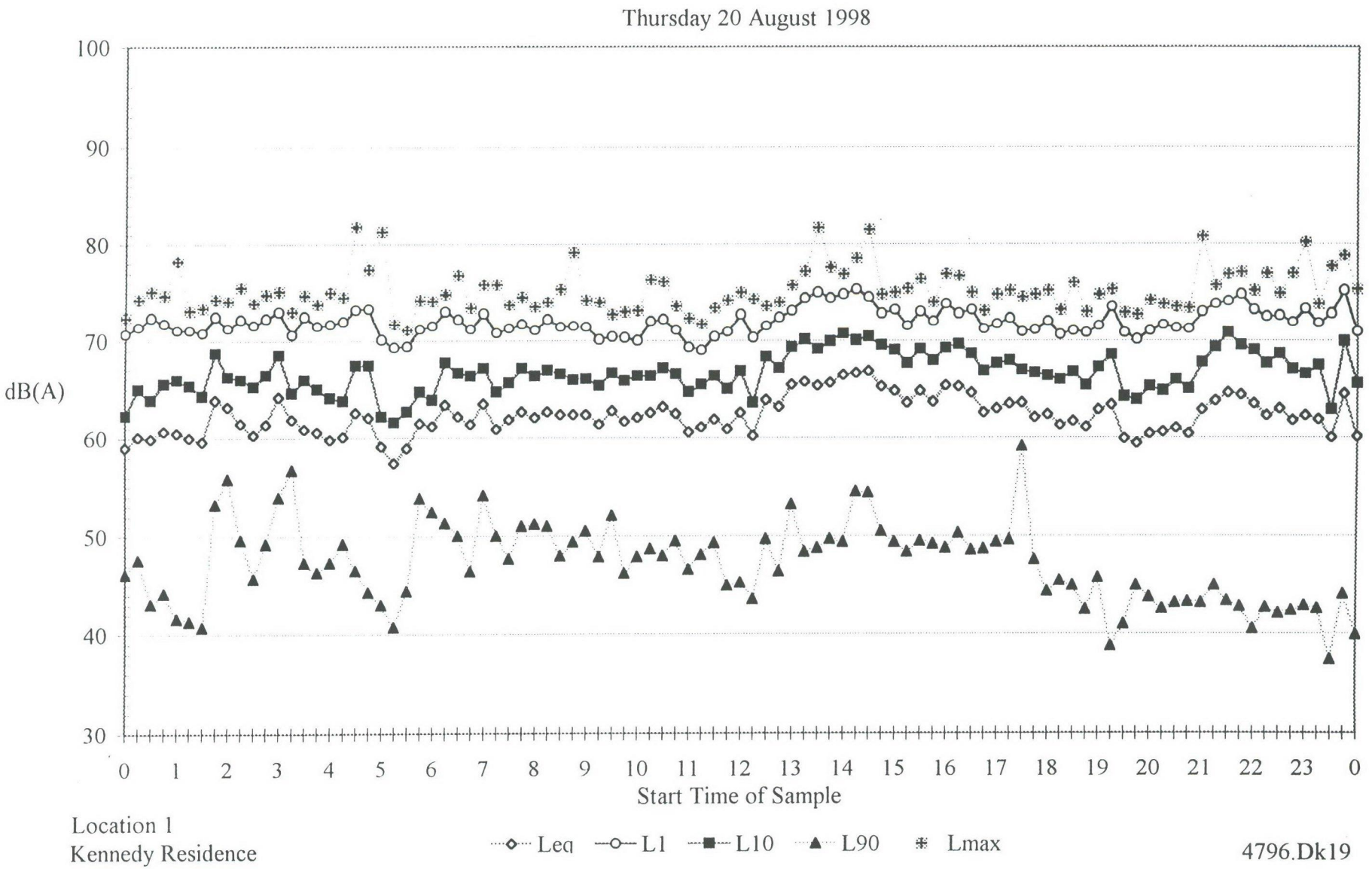

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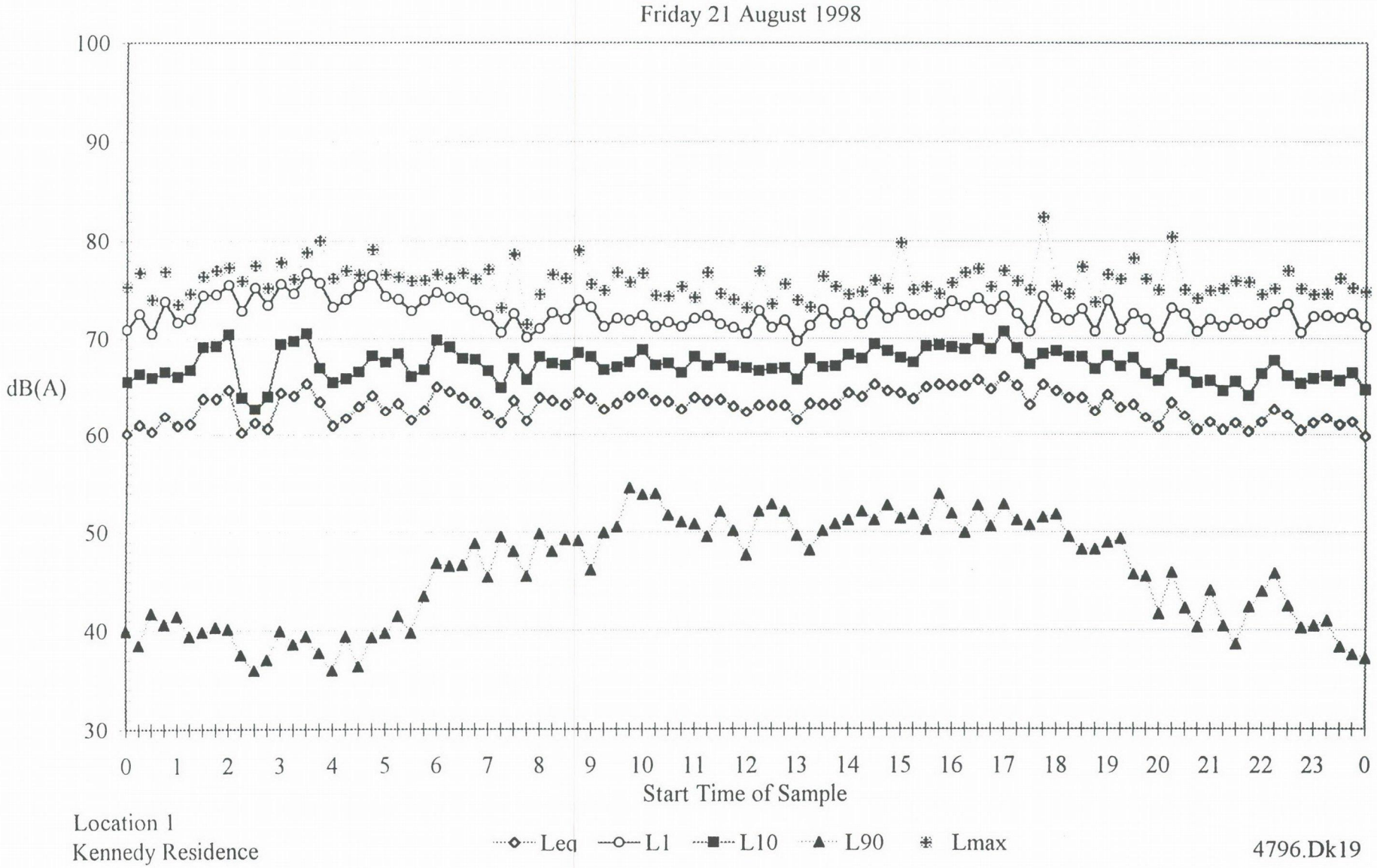

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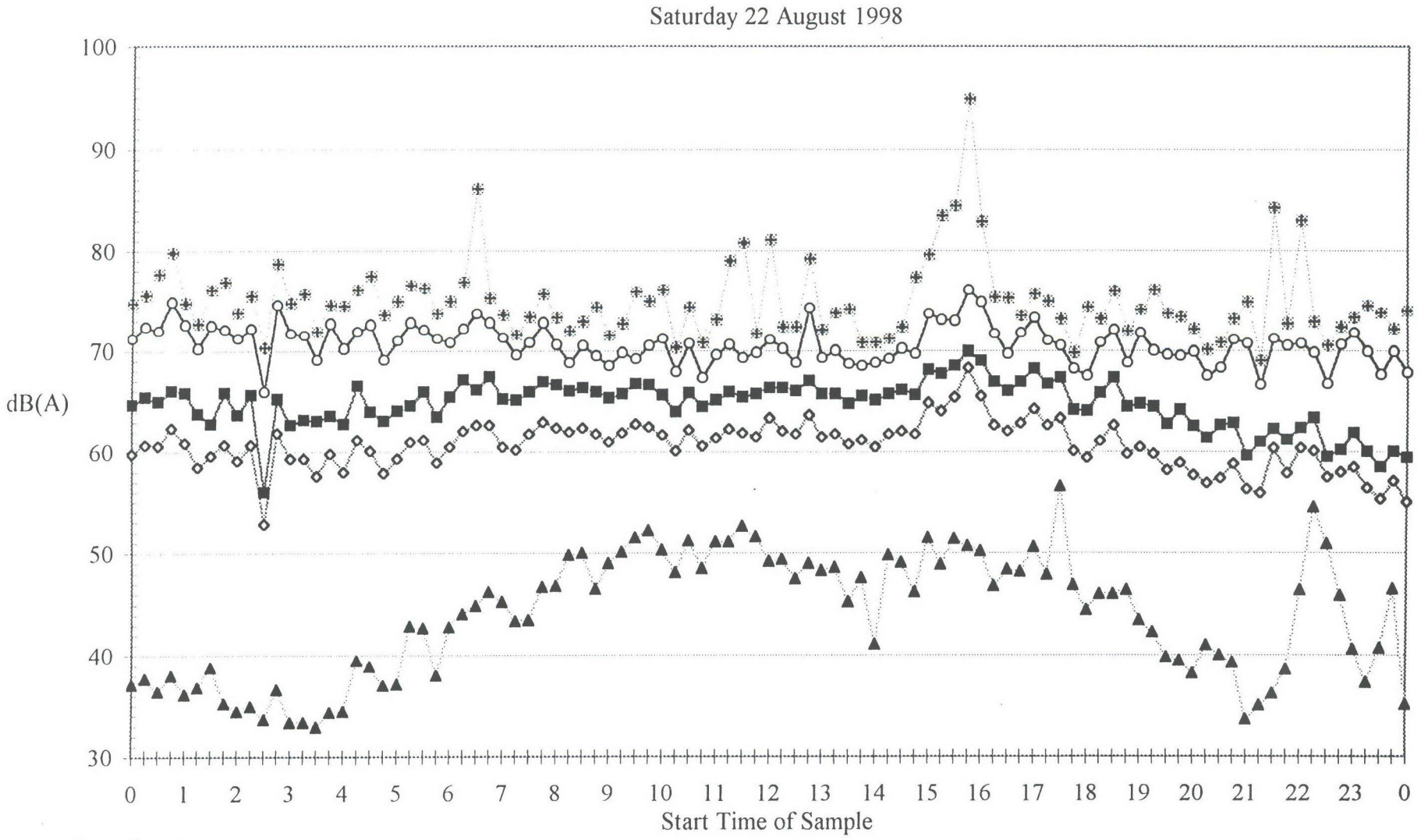

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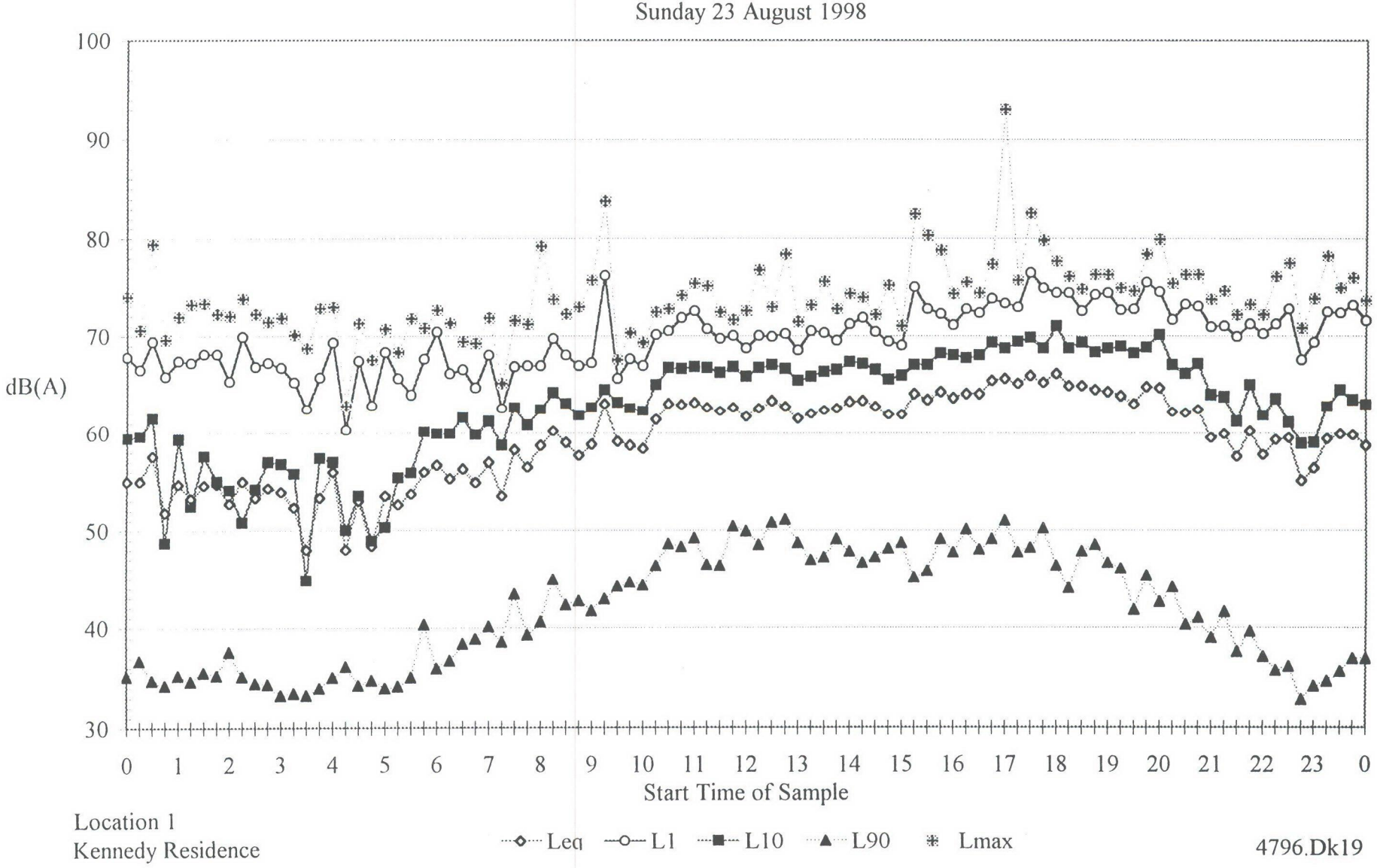

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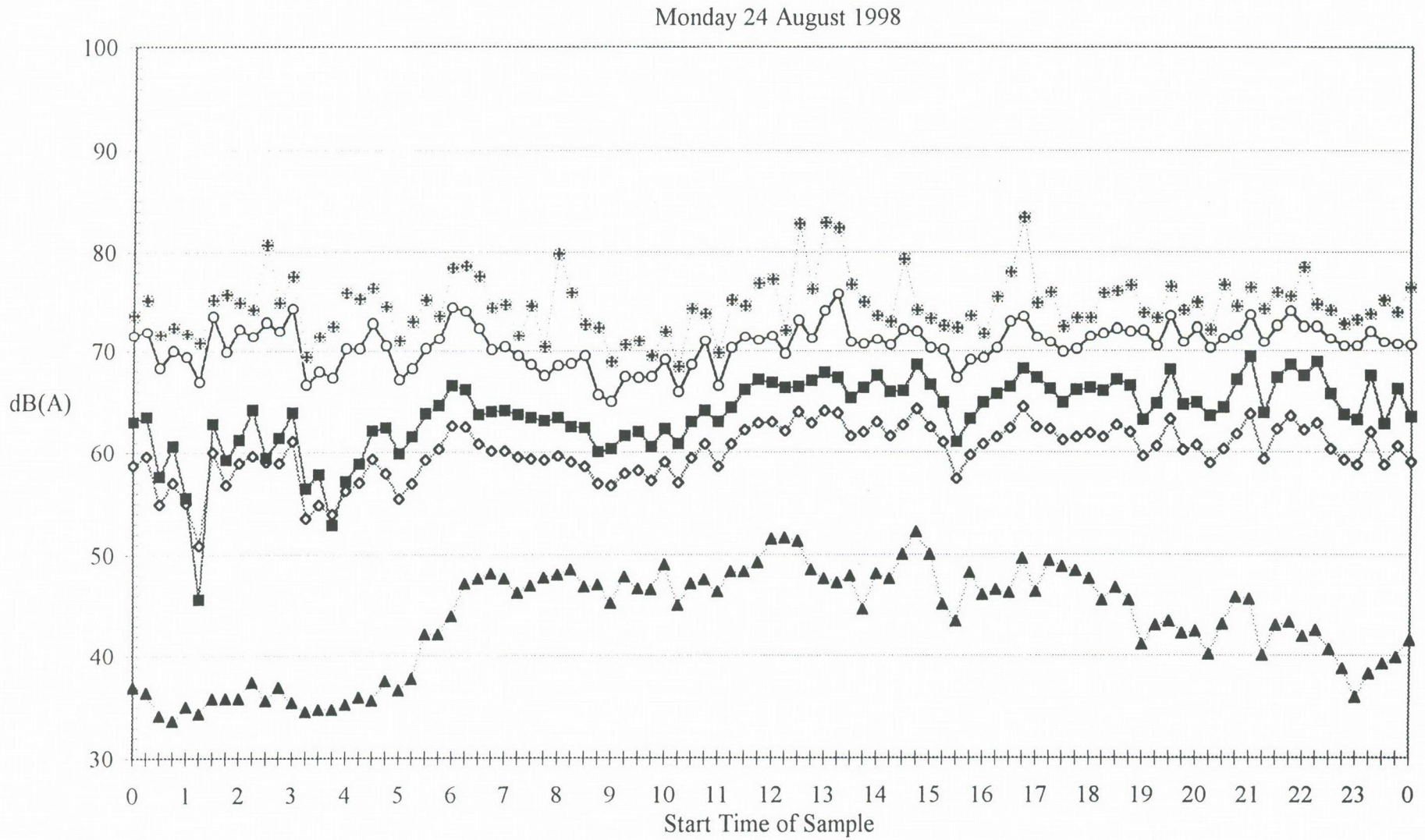

Location 1
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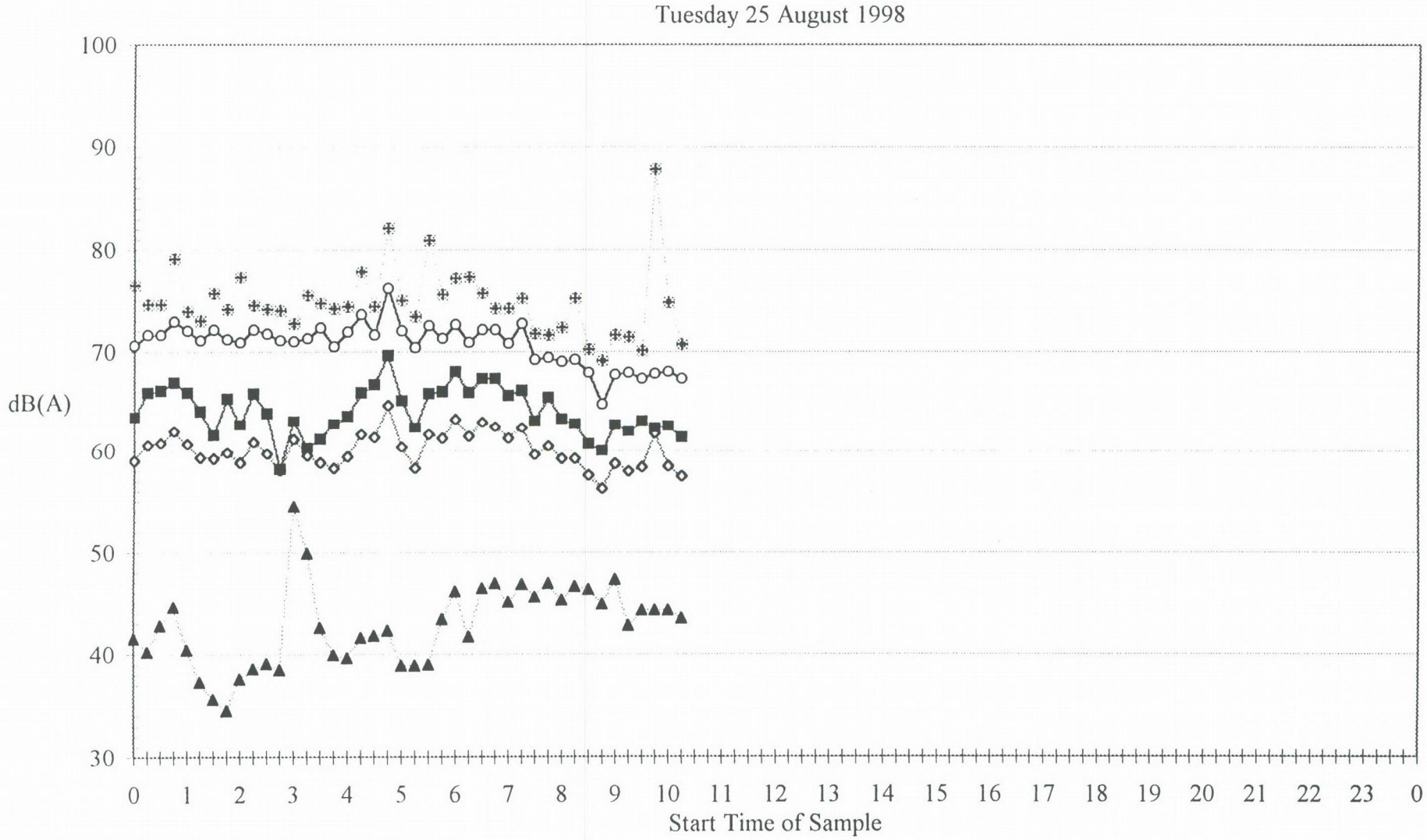

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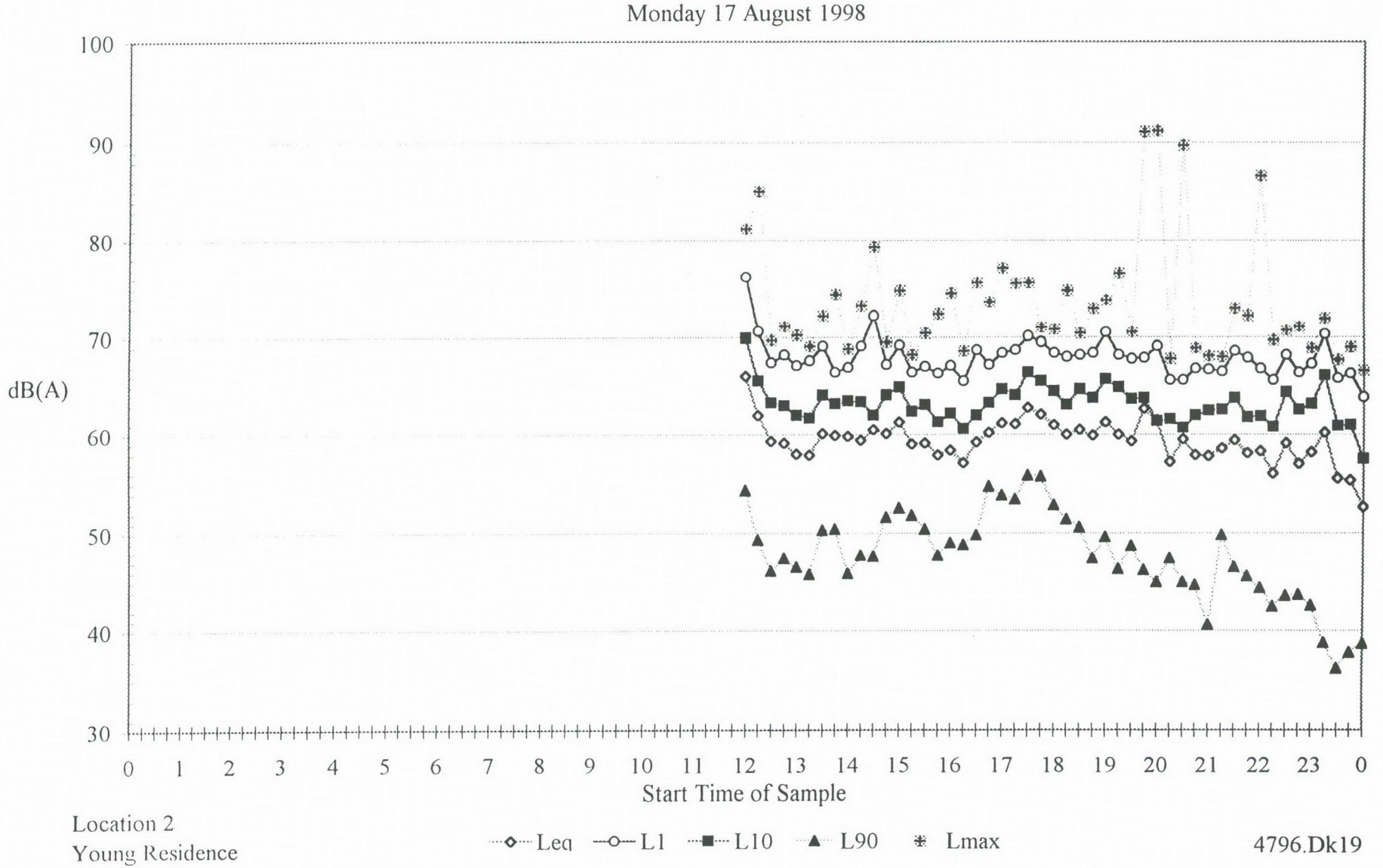

Location 2
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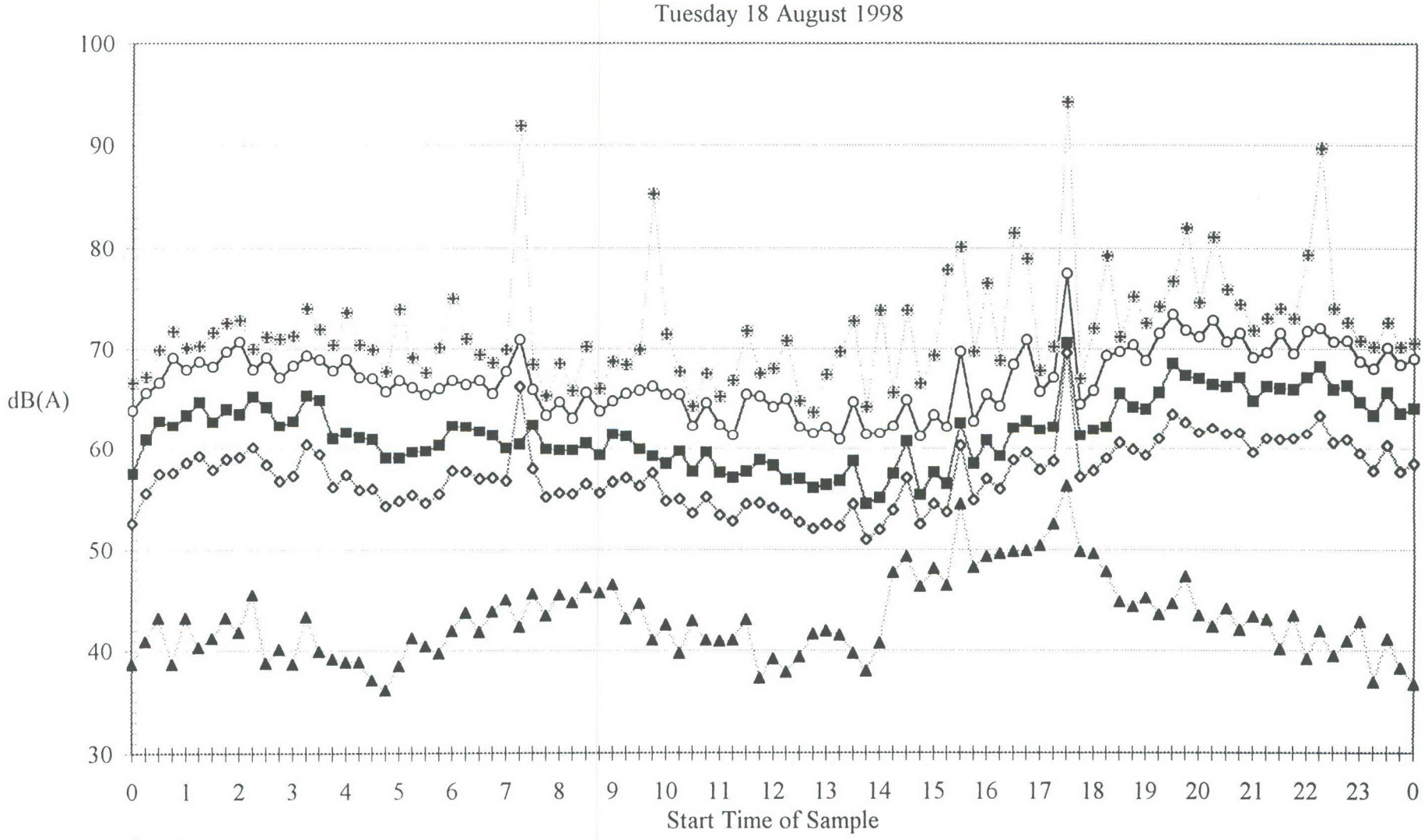
Ambient Sound Pressue Levels



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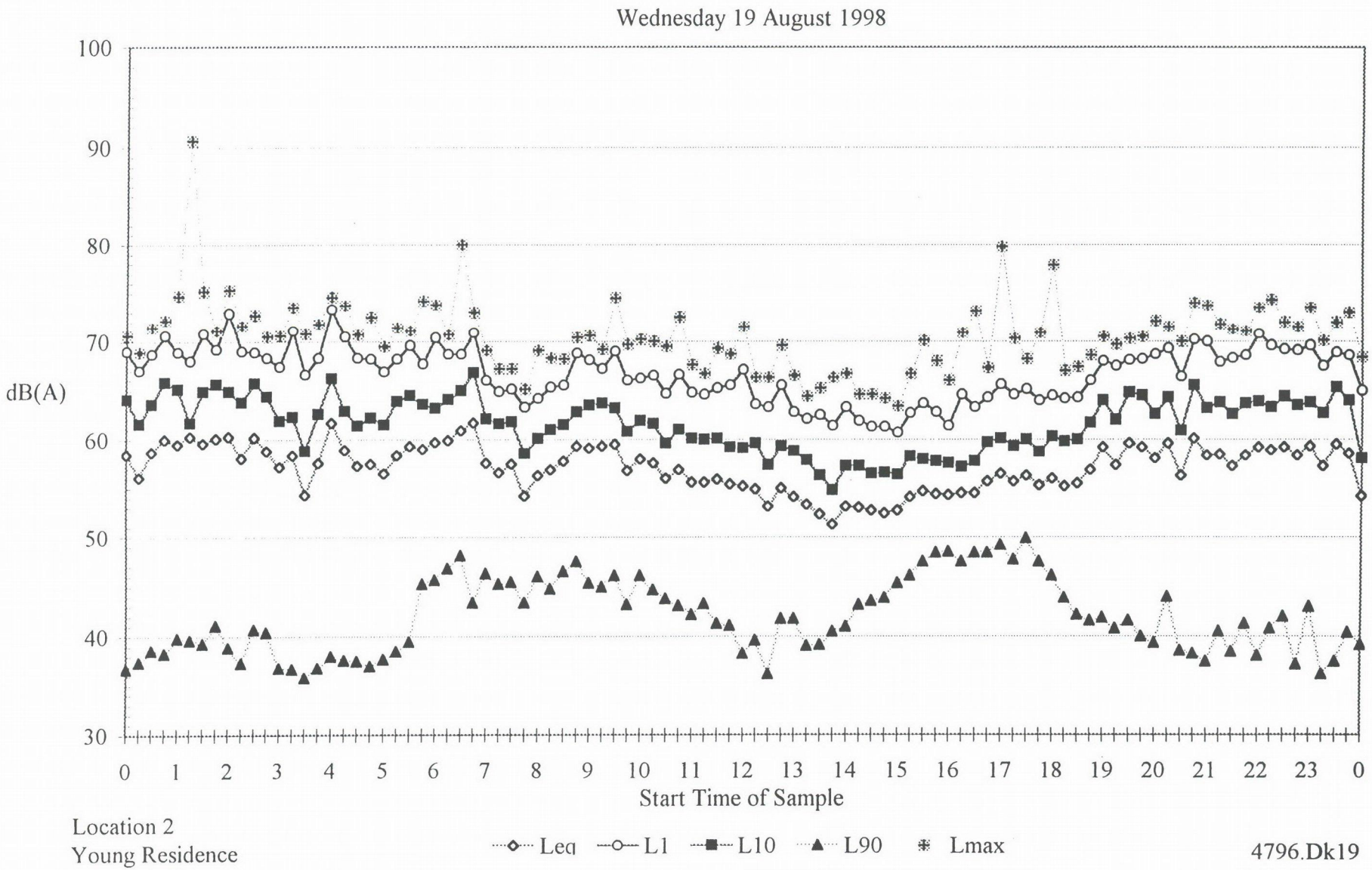

Location 2
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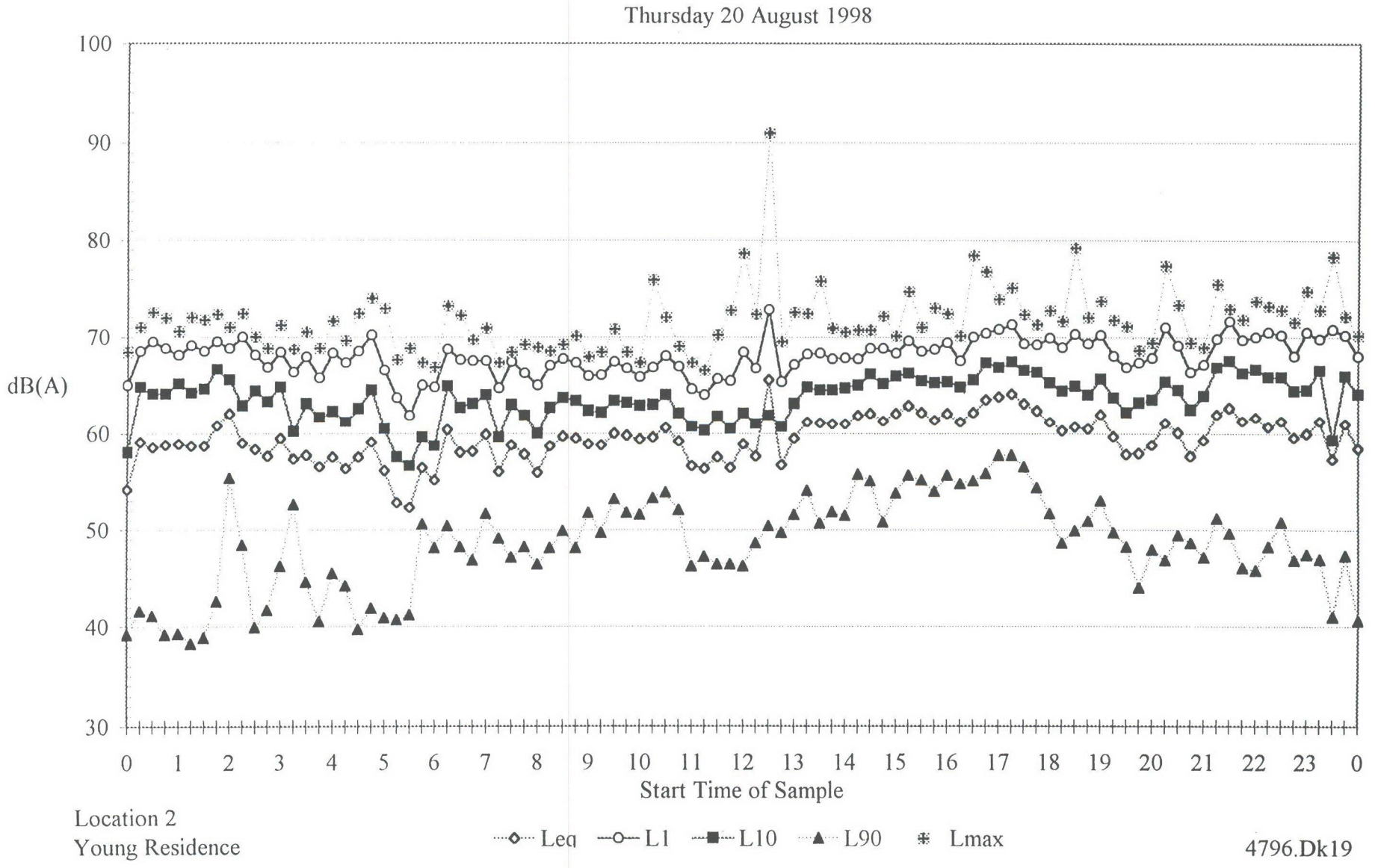

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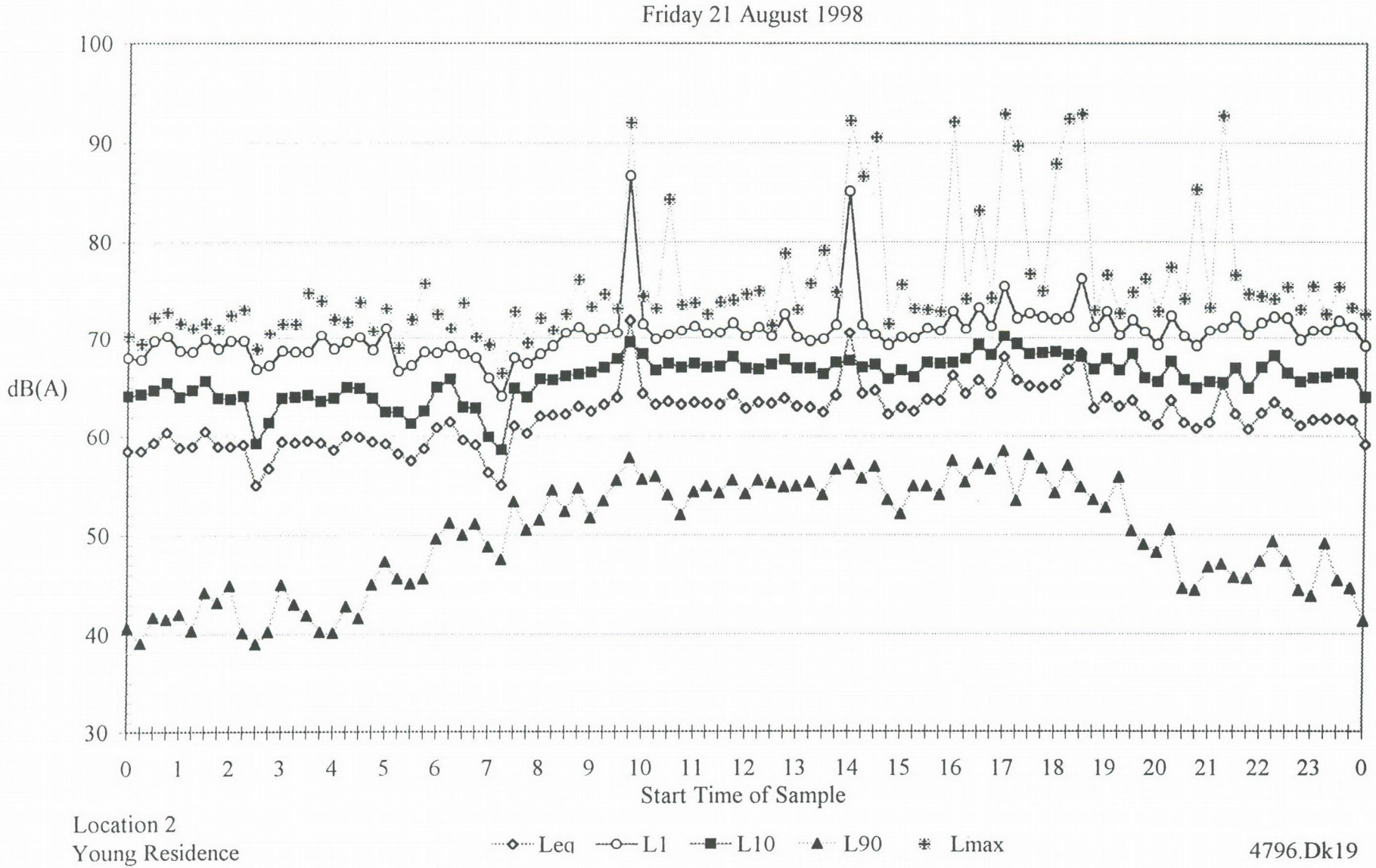

Location 2
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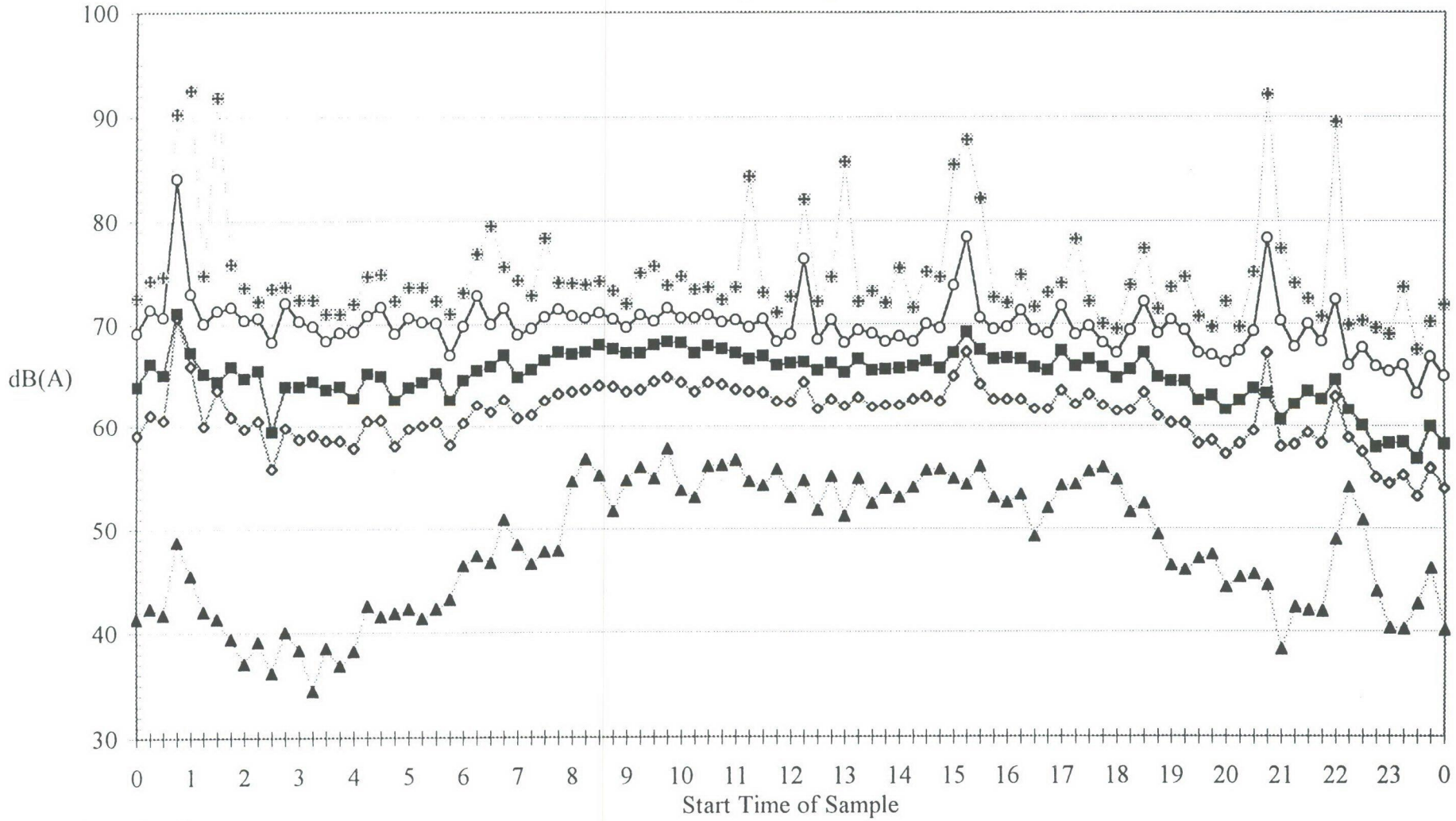
Ambient Sound Pressure Levels

Saturday 22 August 1998



Location 2
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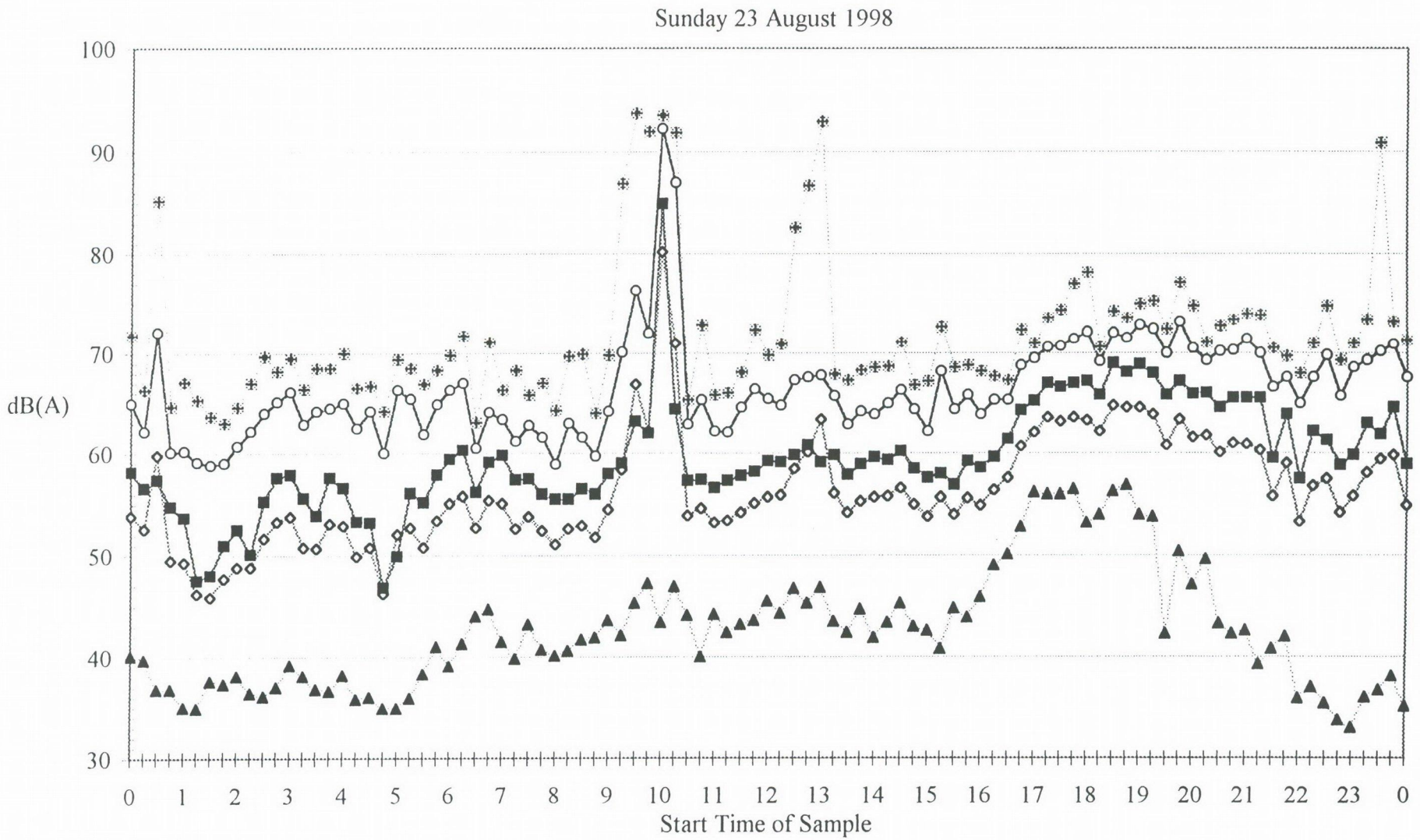
Ambient Sound Pressure Levels



Location 2
Young Residence

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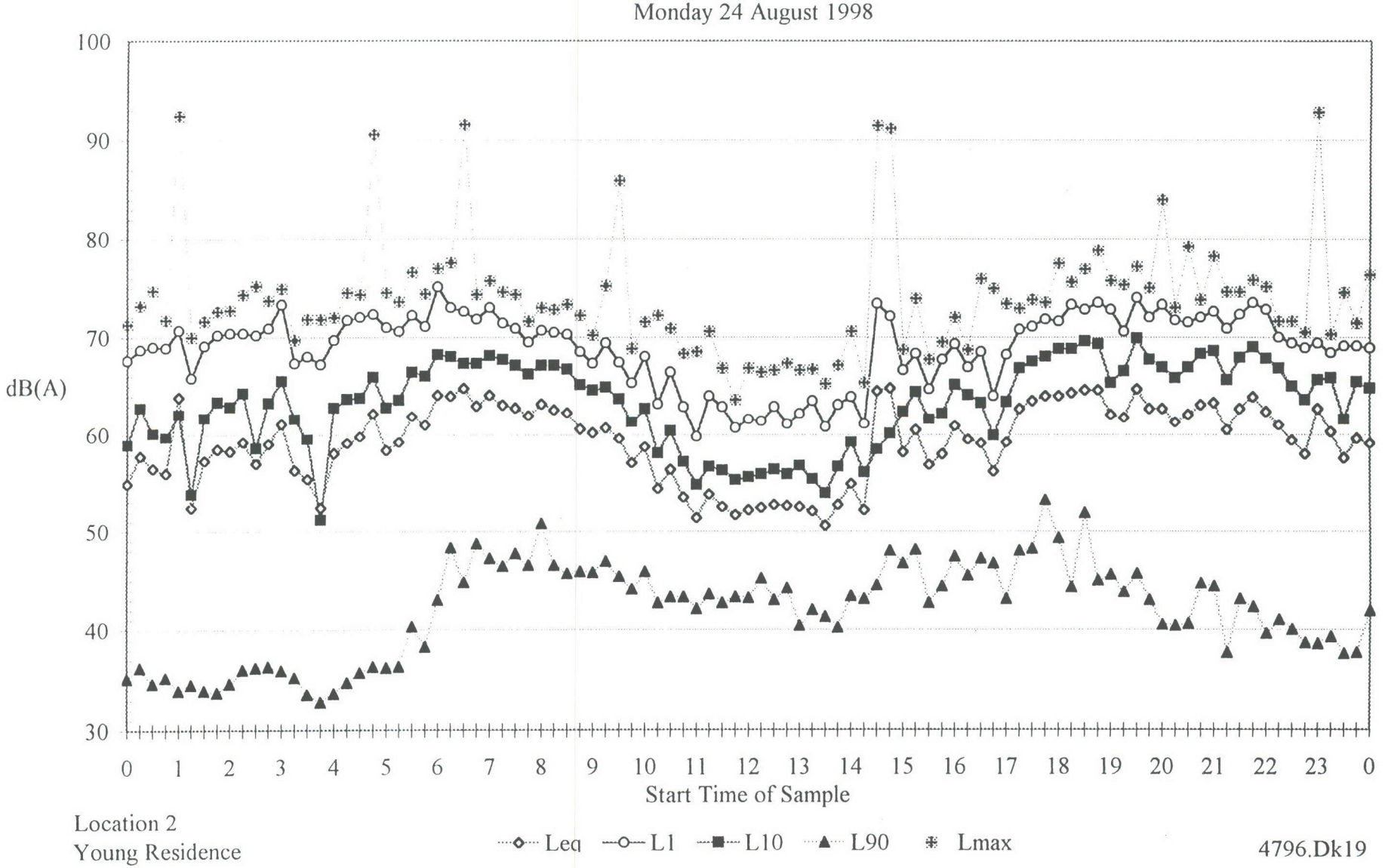
Ambient Sound Pressure Levels



Location 2
Young Residence

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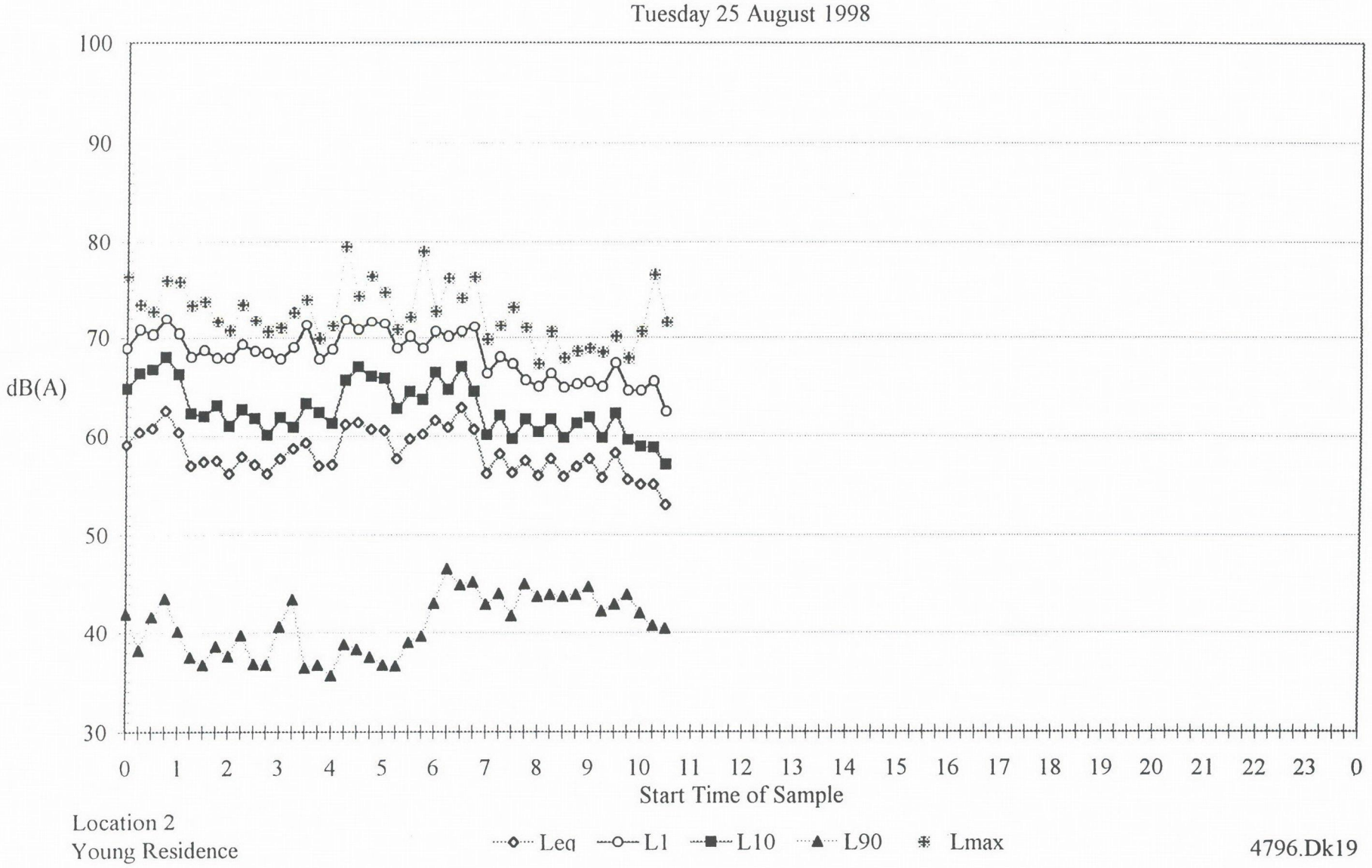
Ambient Sound Pressure Levels



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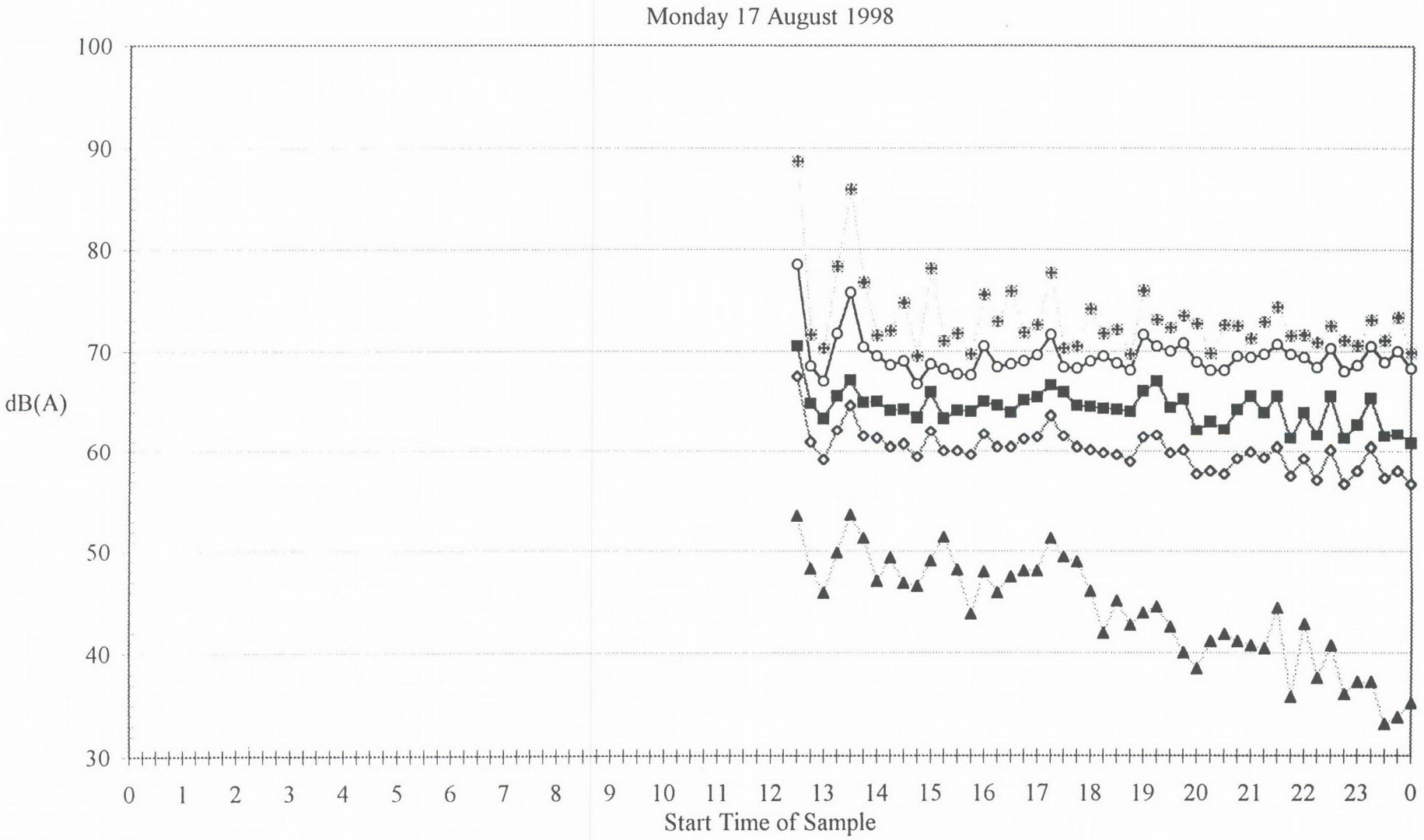
Ambient Sound Pressure Levels



Location 3
Ghinni Ghinni School

4796.Dk19

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Ambient Sound Pressue Levels

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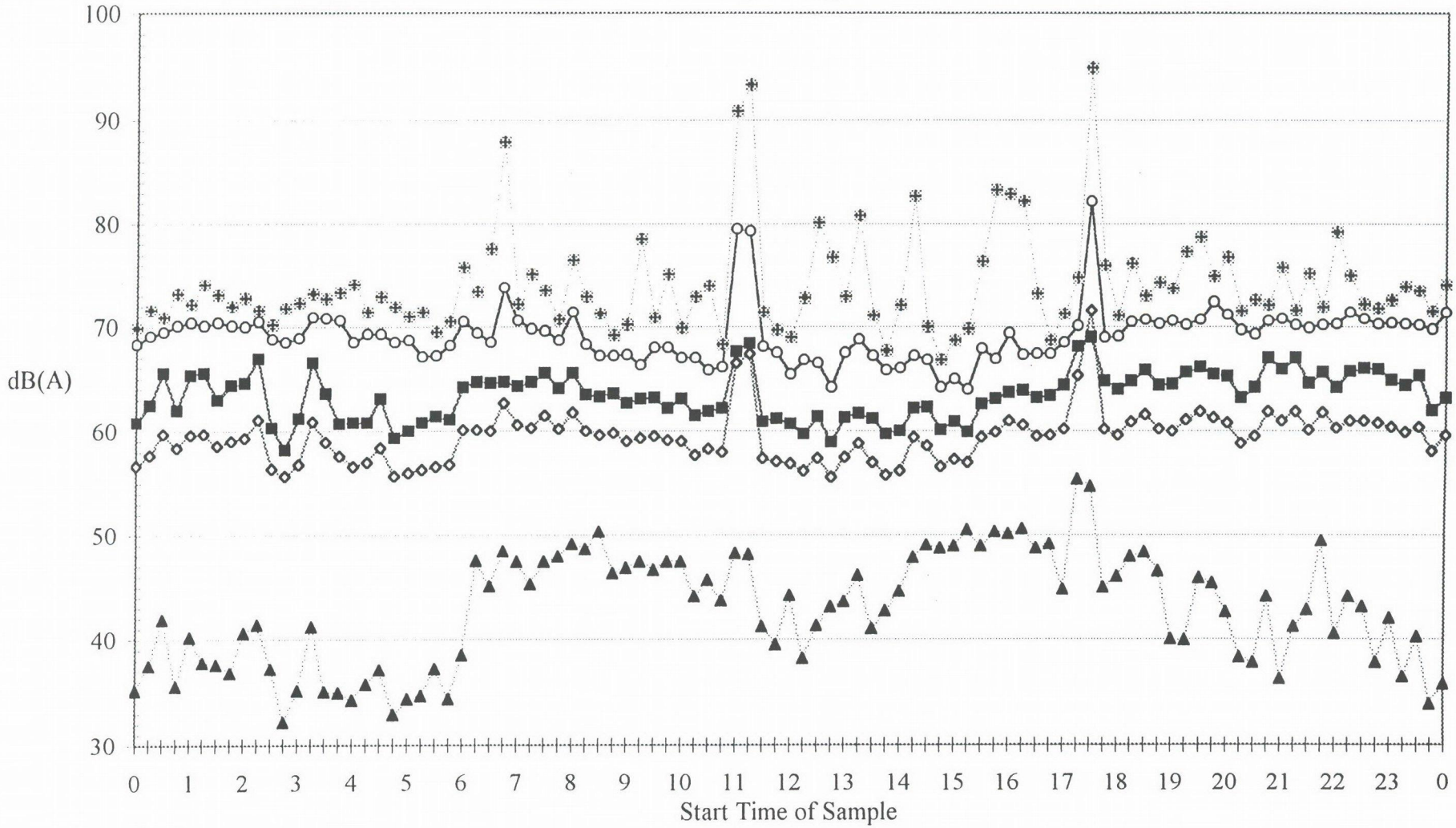

Location 3
Ghinni Ghinni School

4796.Dk19

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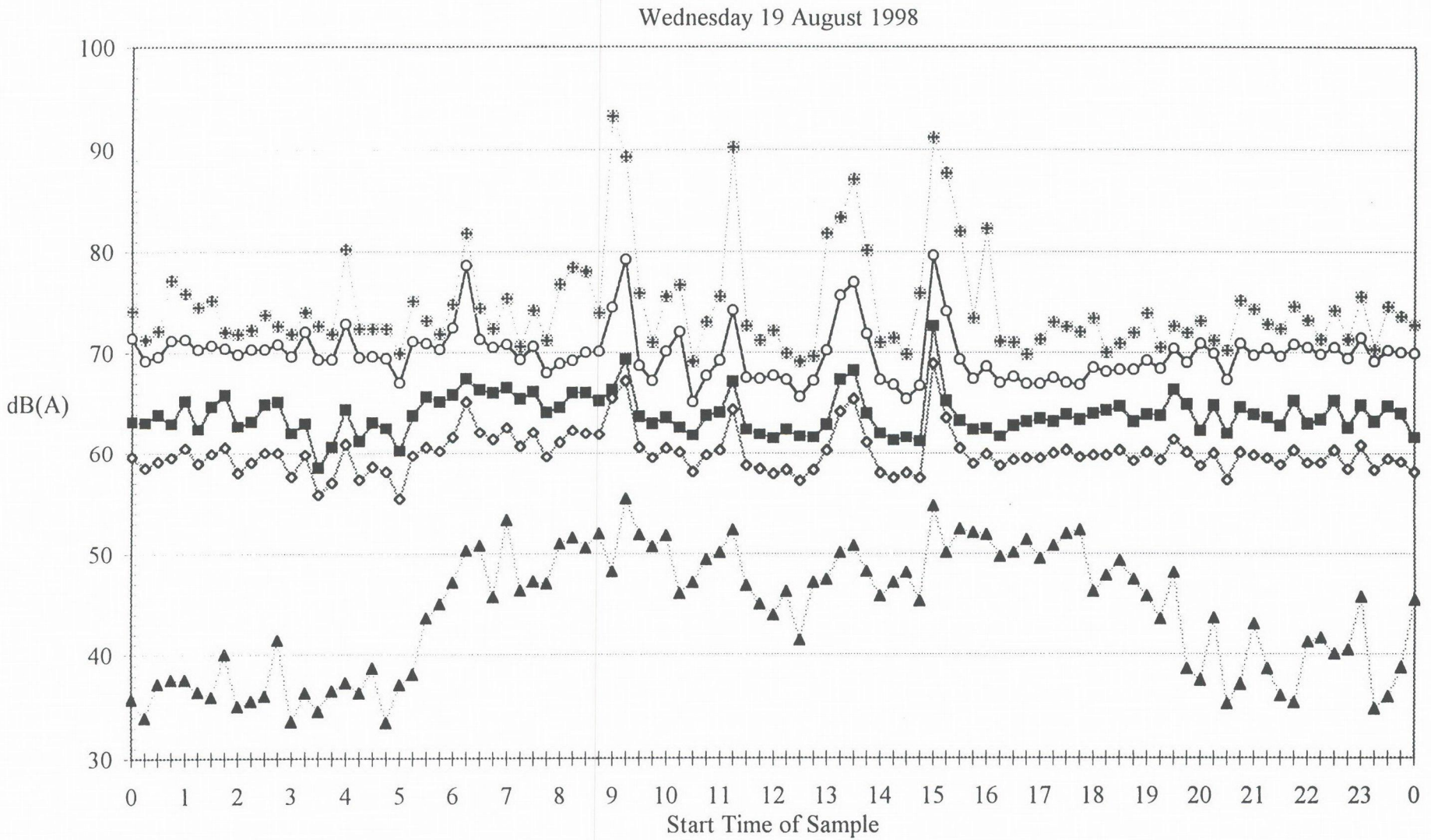
Ambient Sound Pressure Levels



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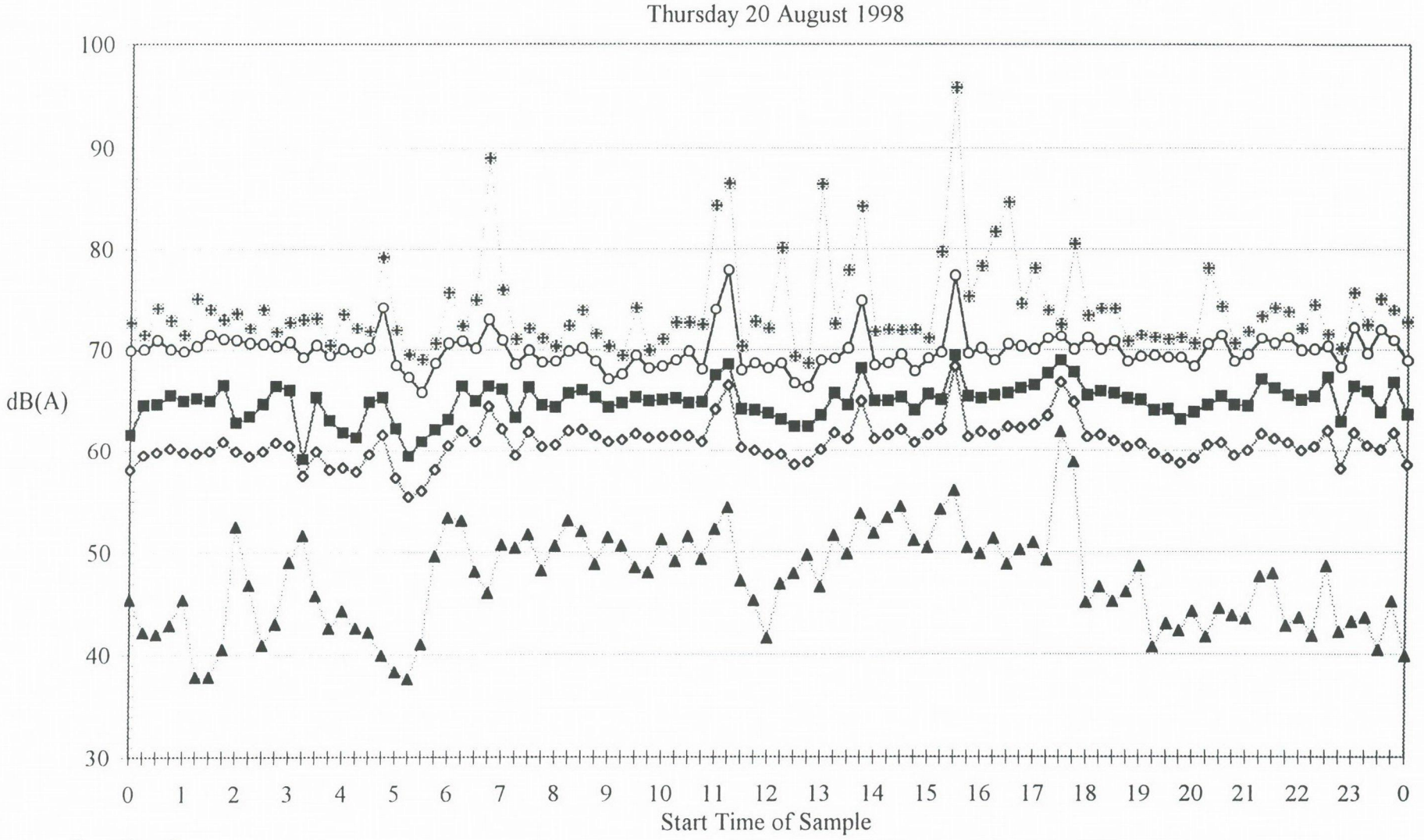

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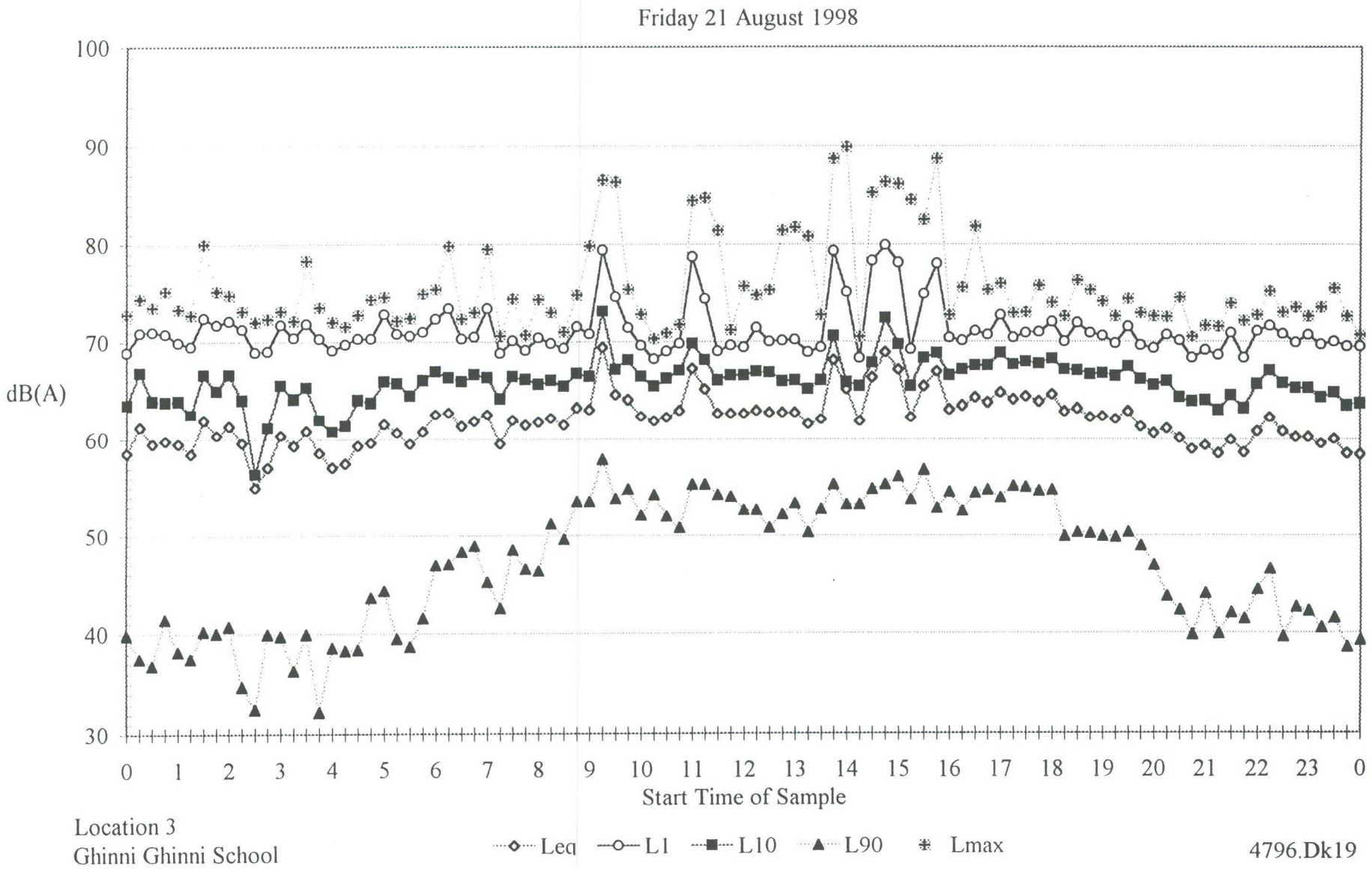

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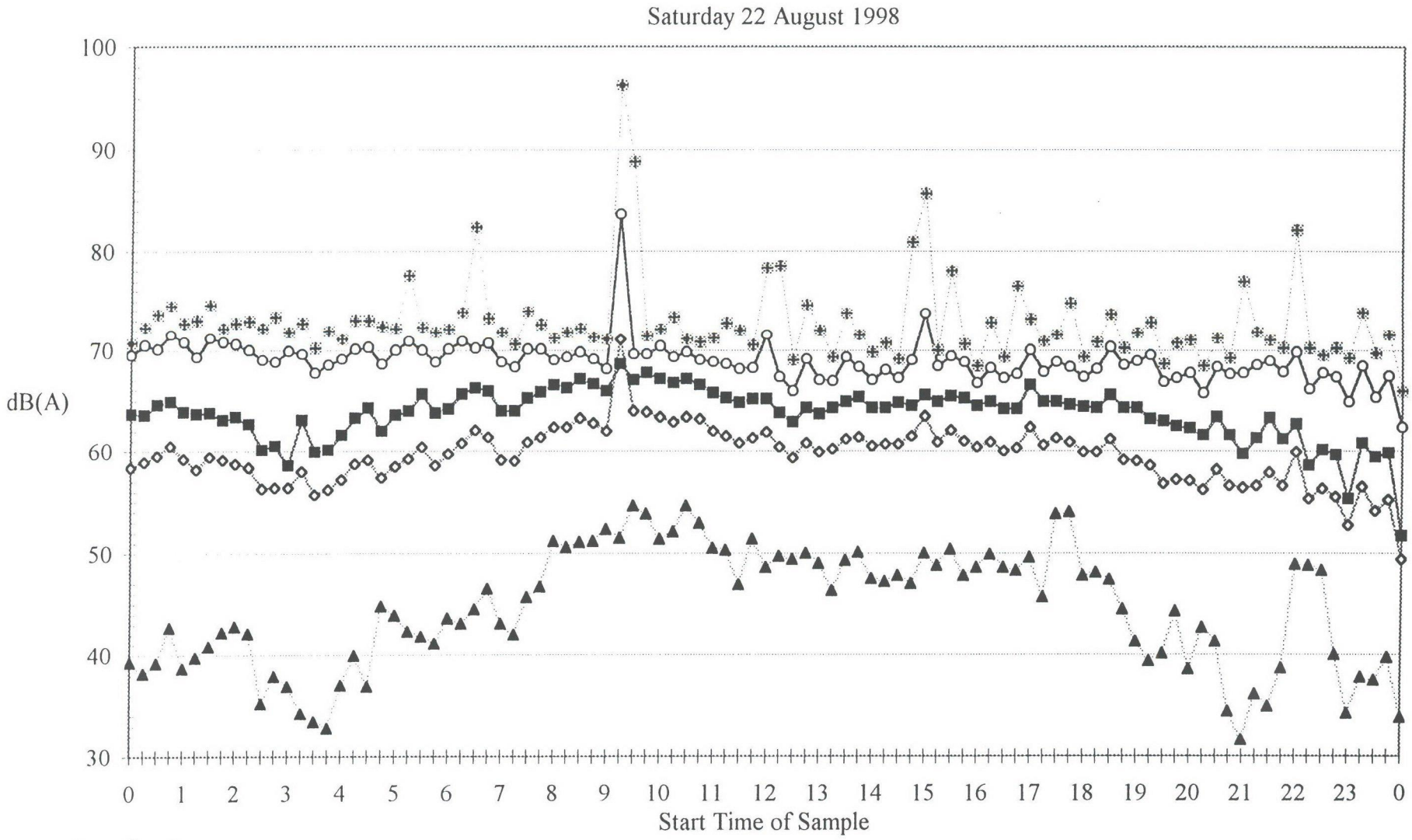

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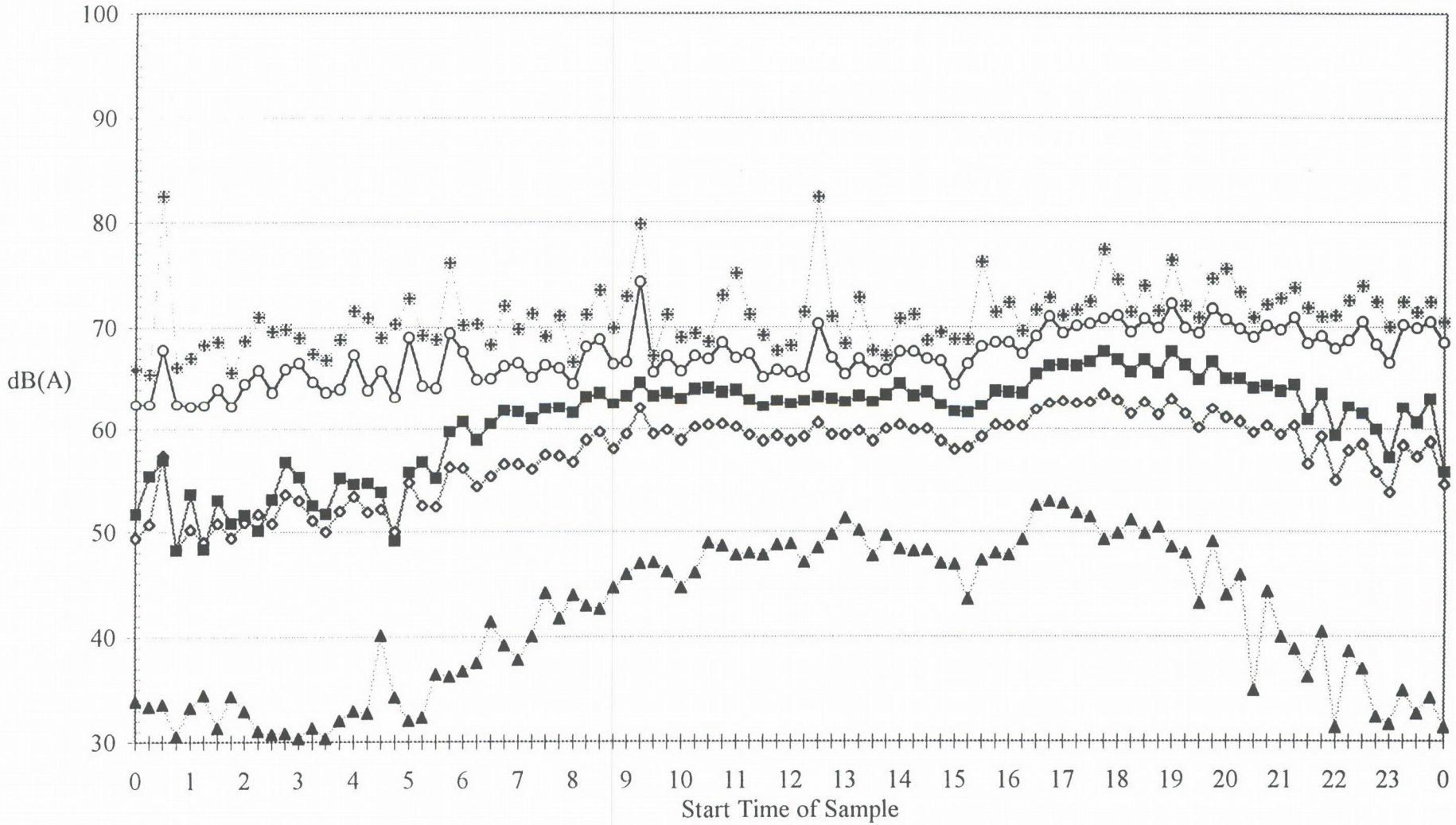

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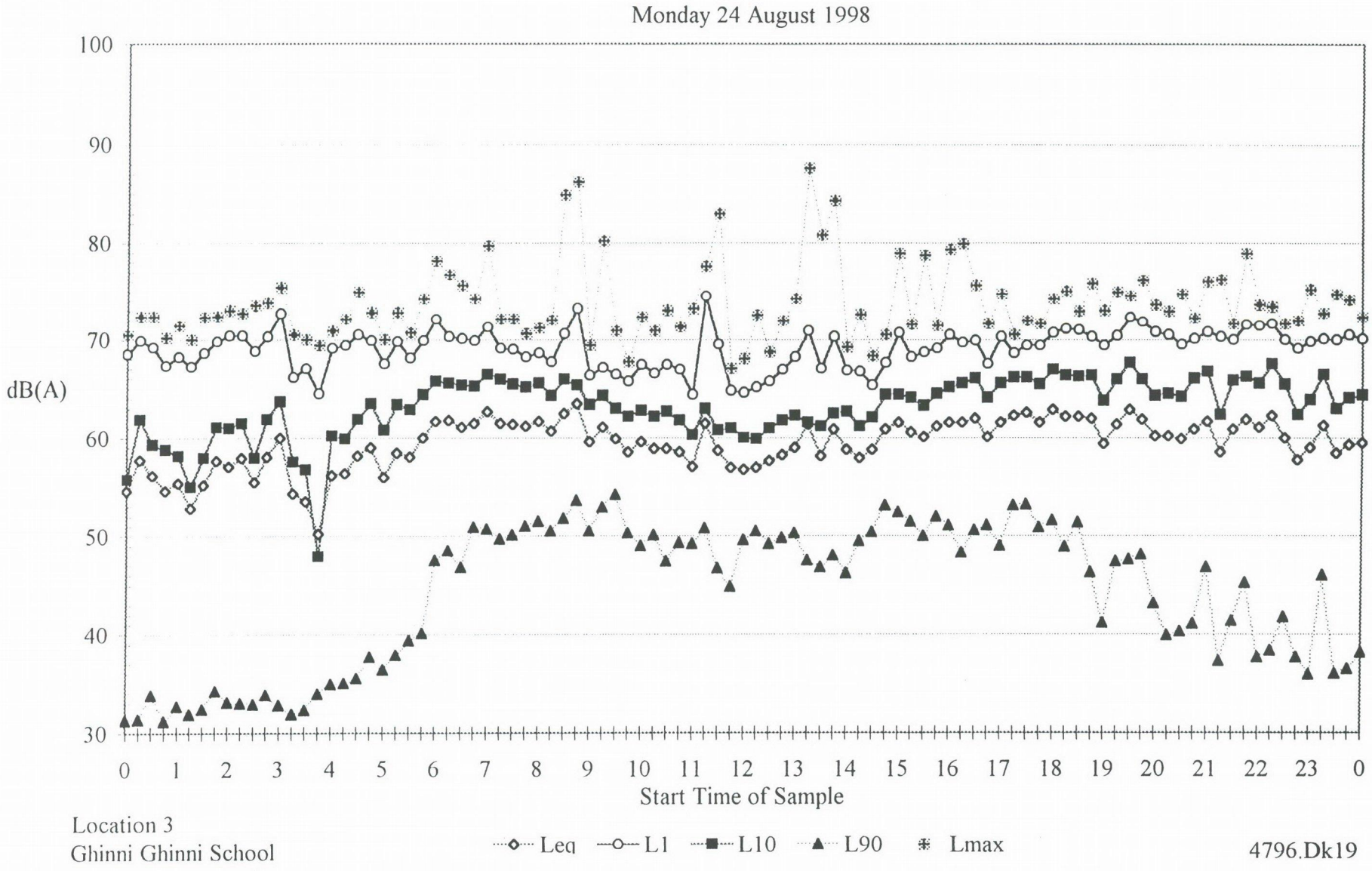

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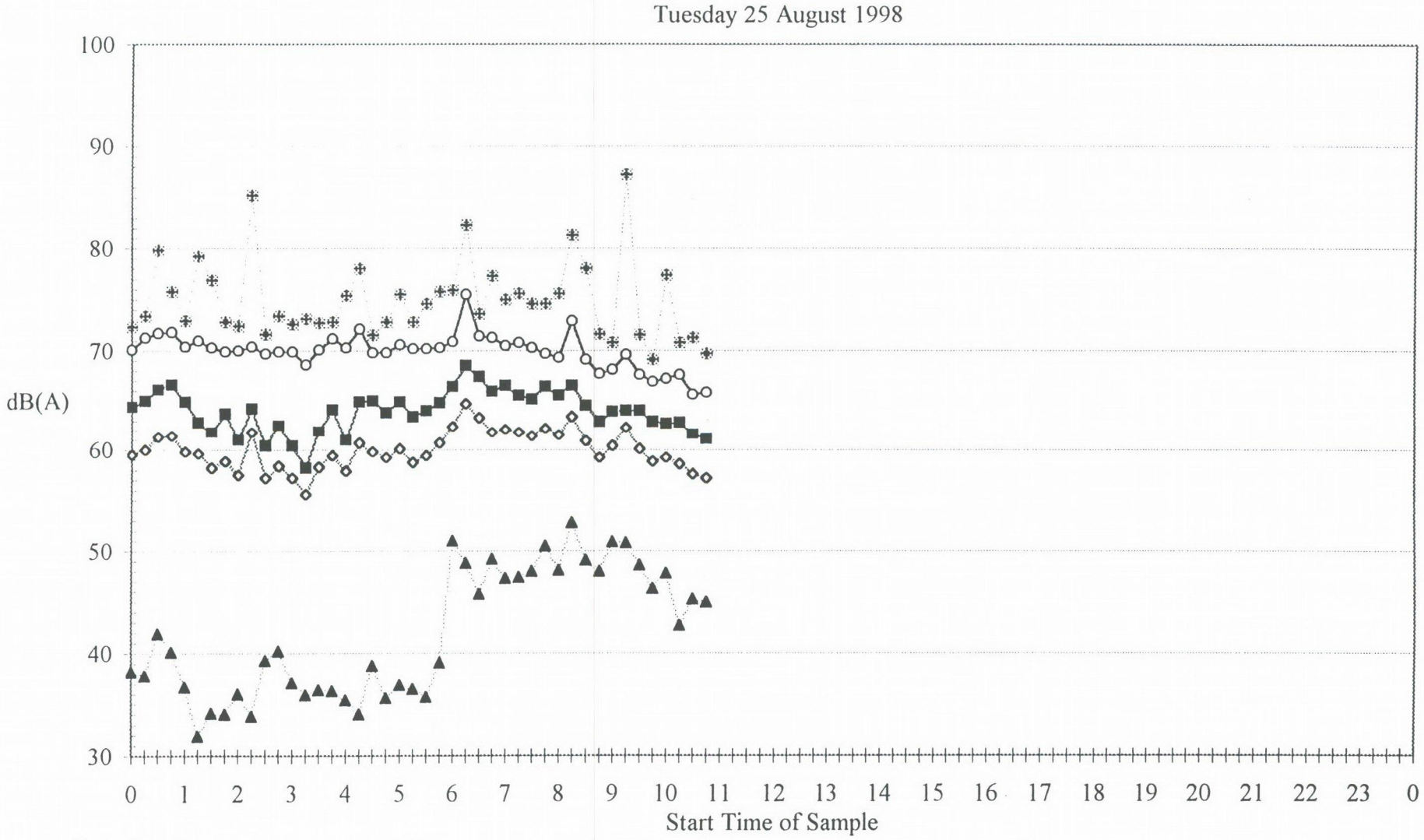

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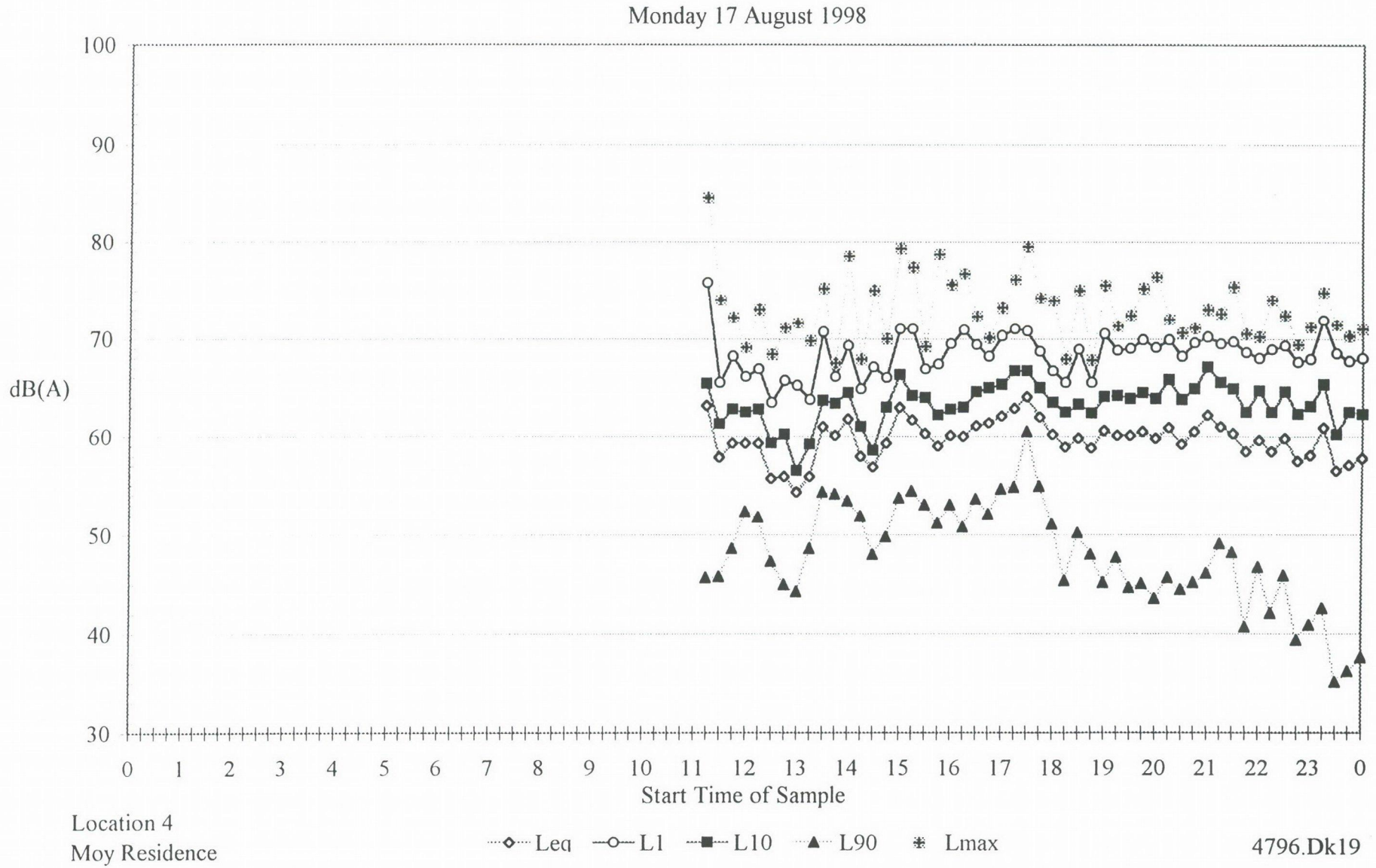

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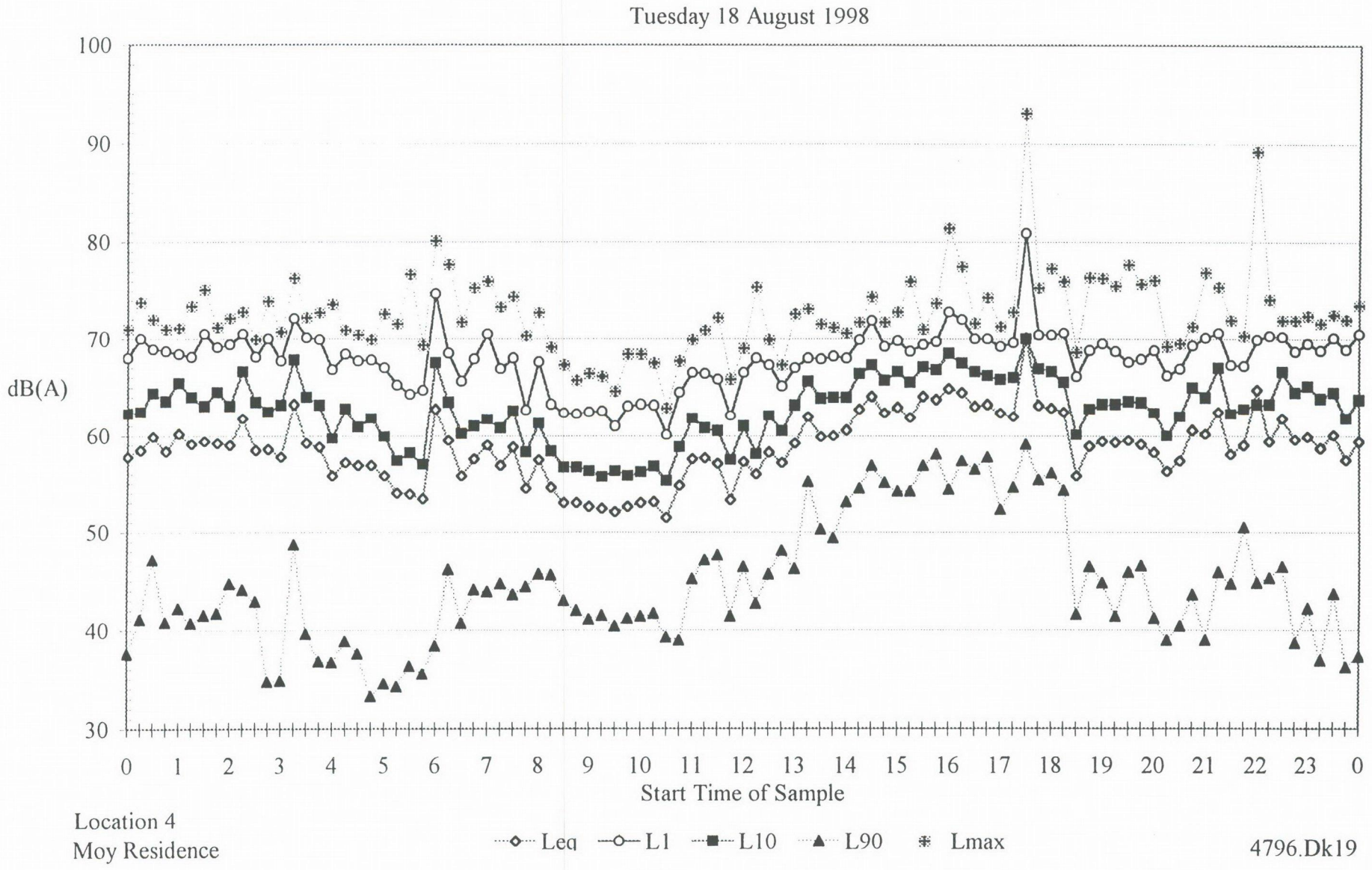

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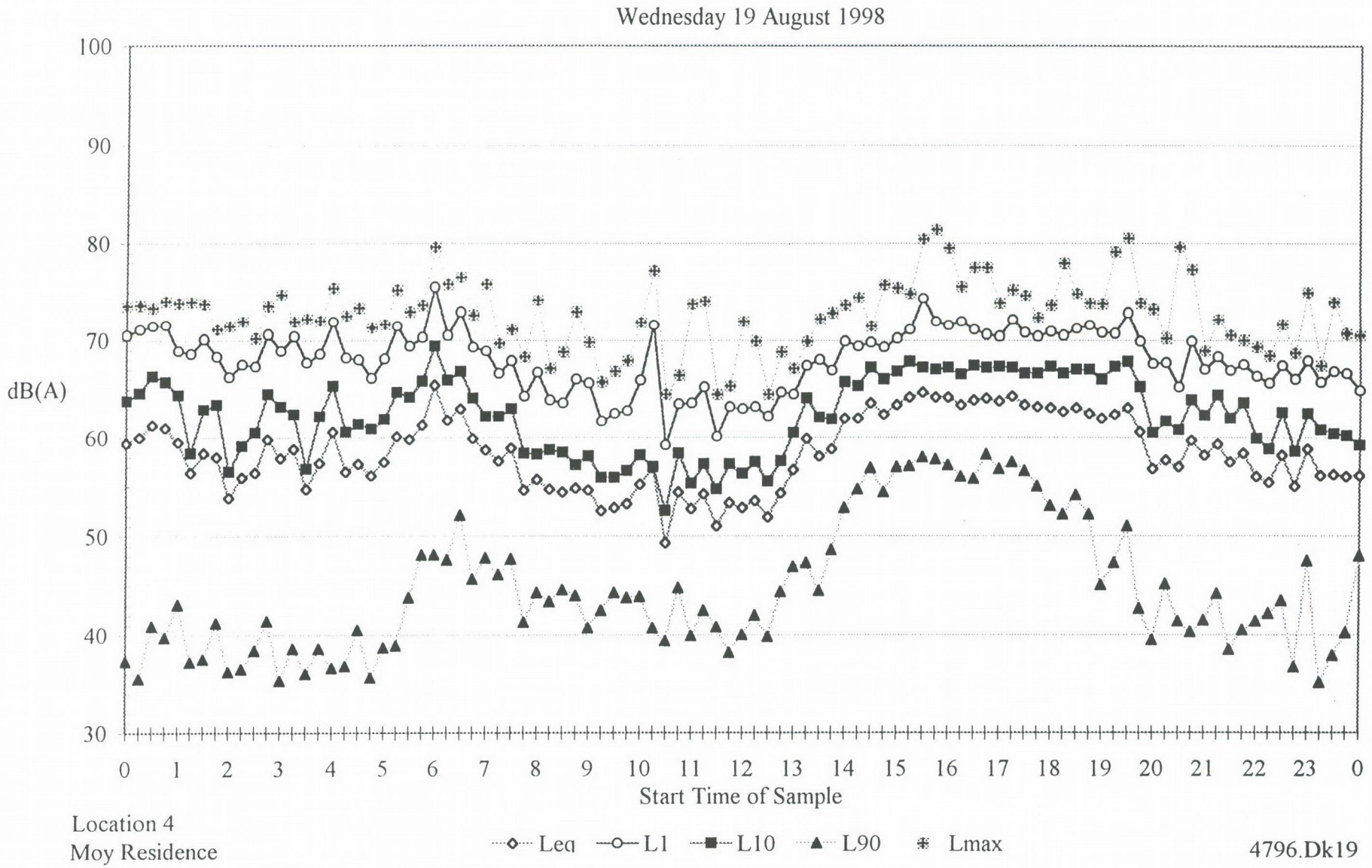

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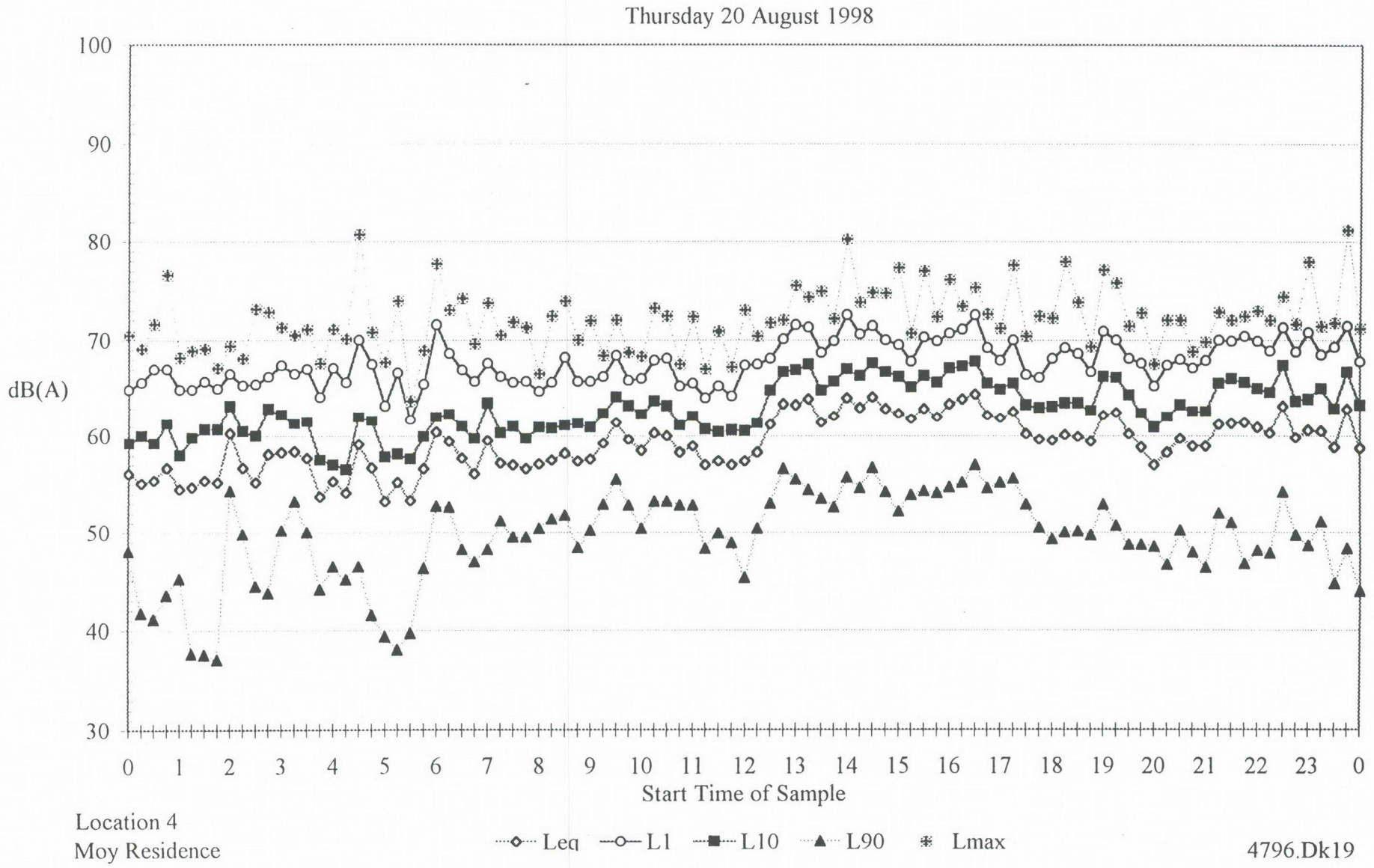

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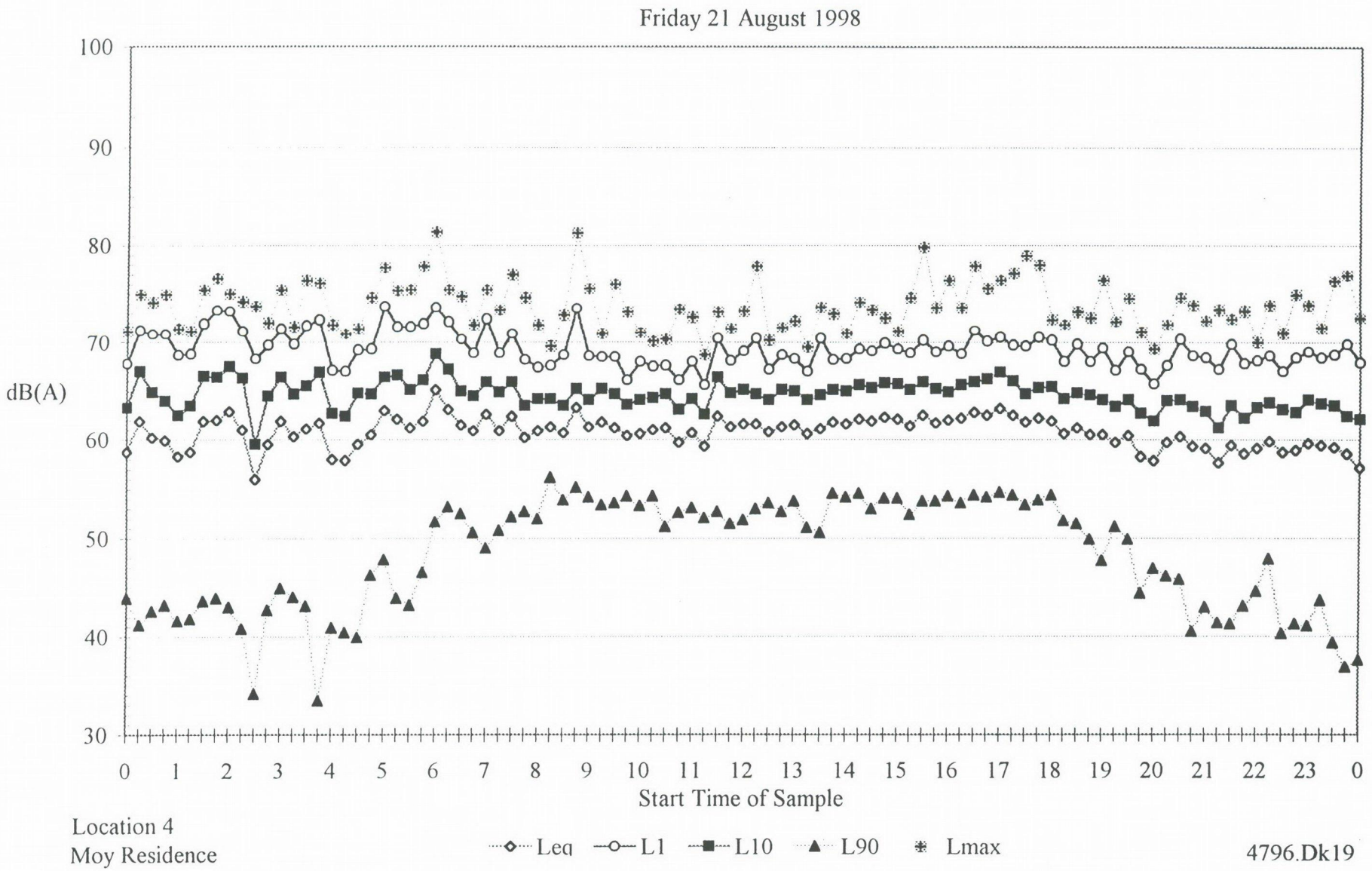

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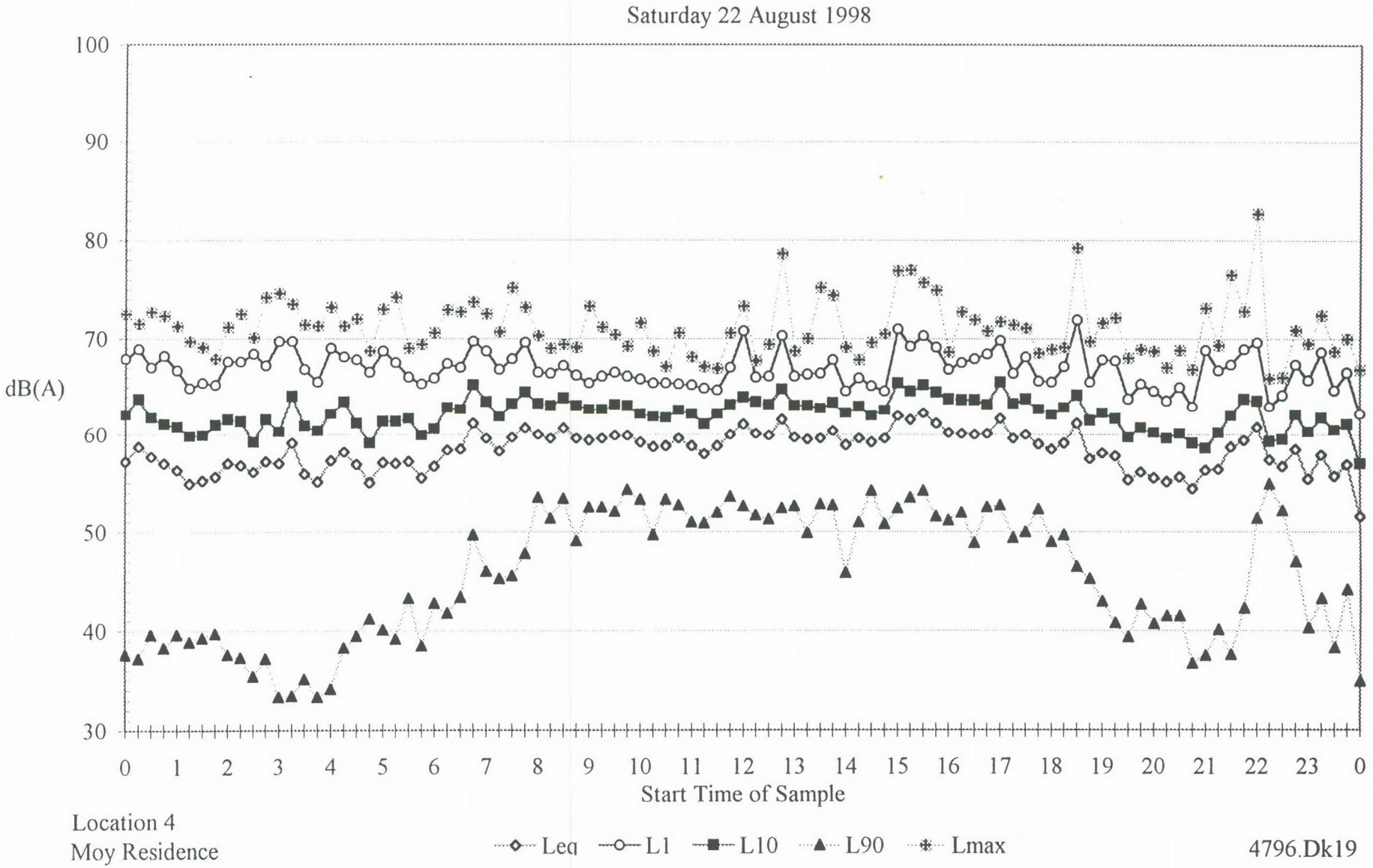

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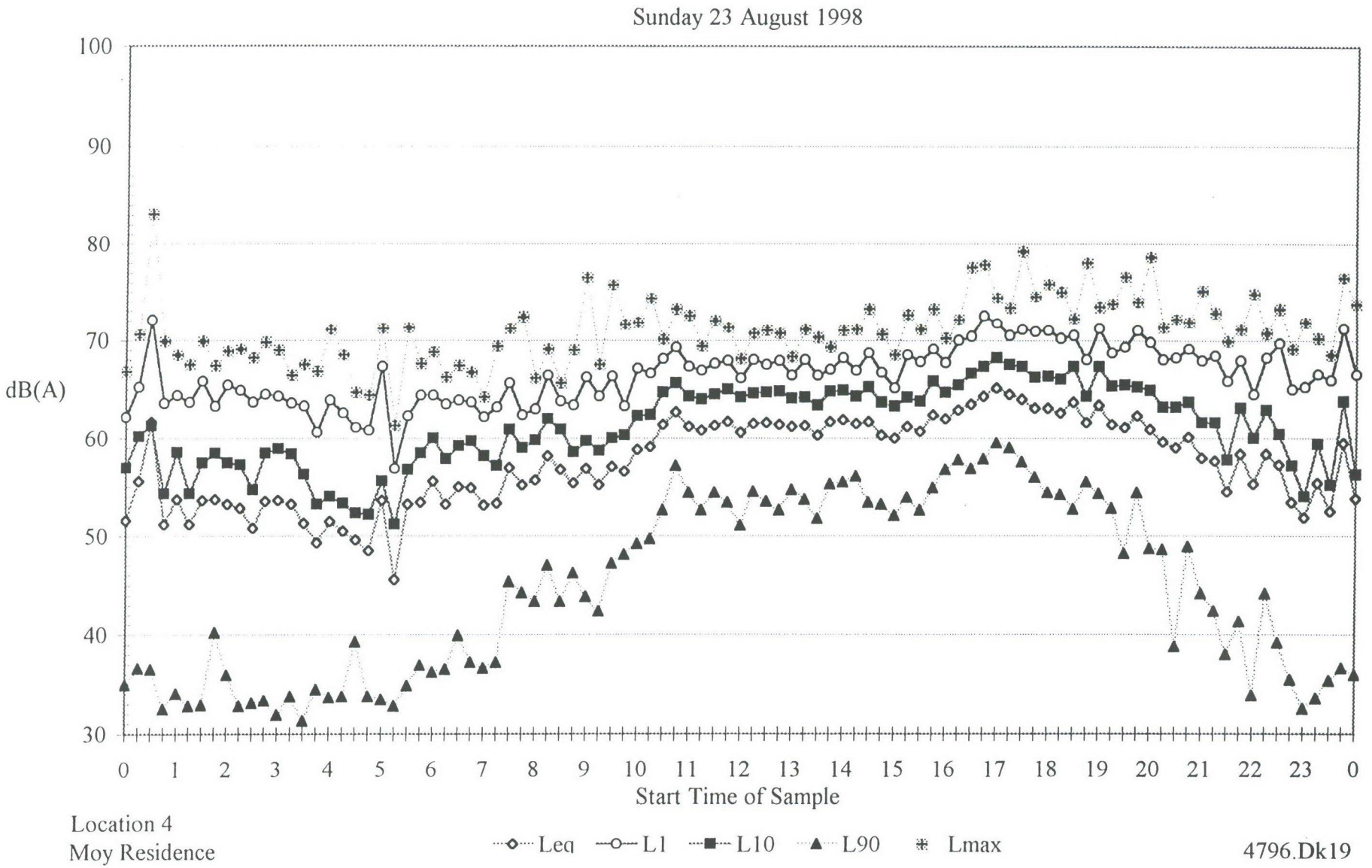

Location 4
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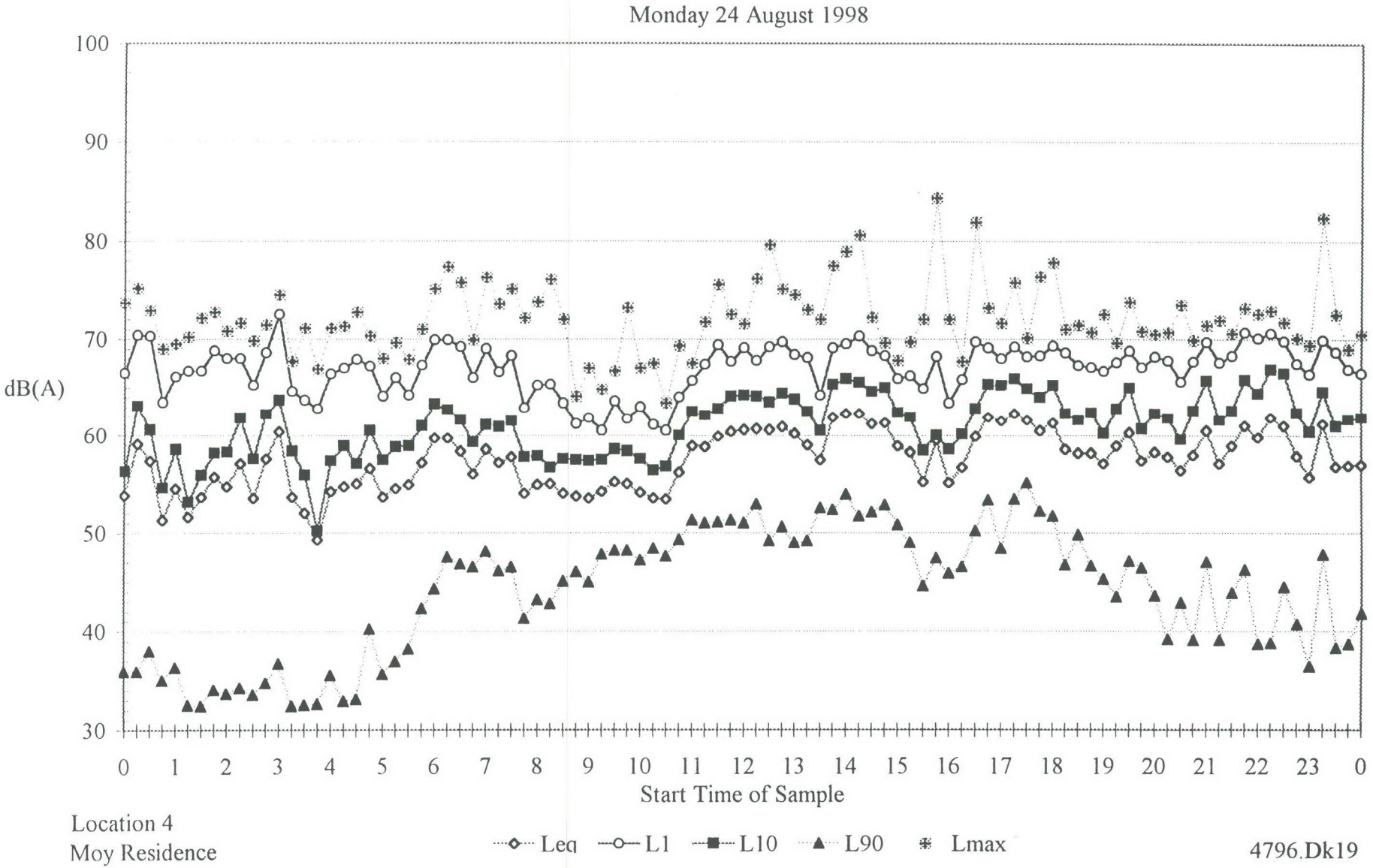

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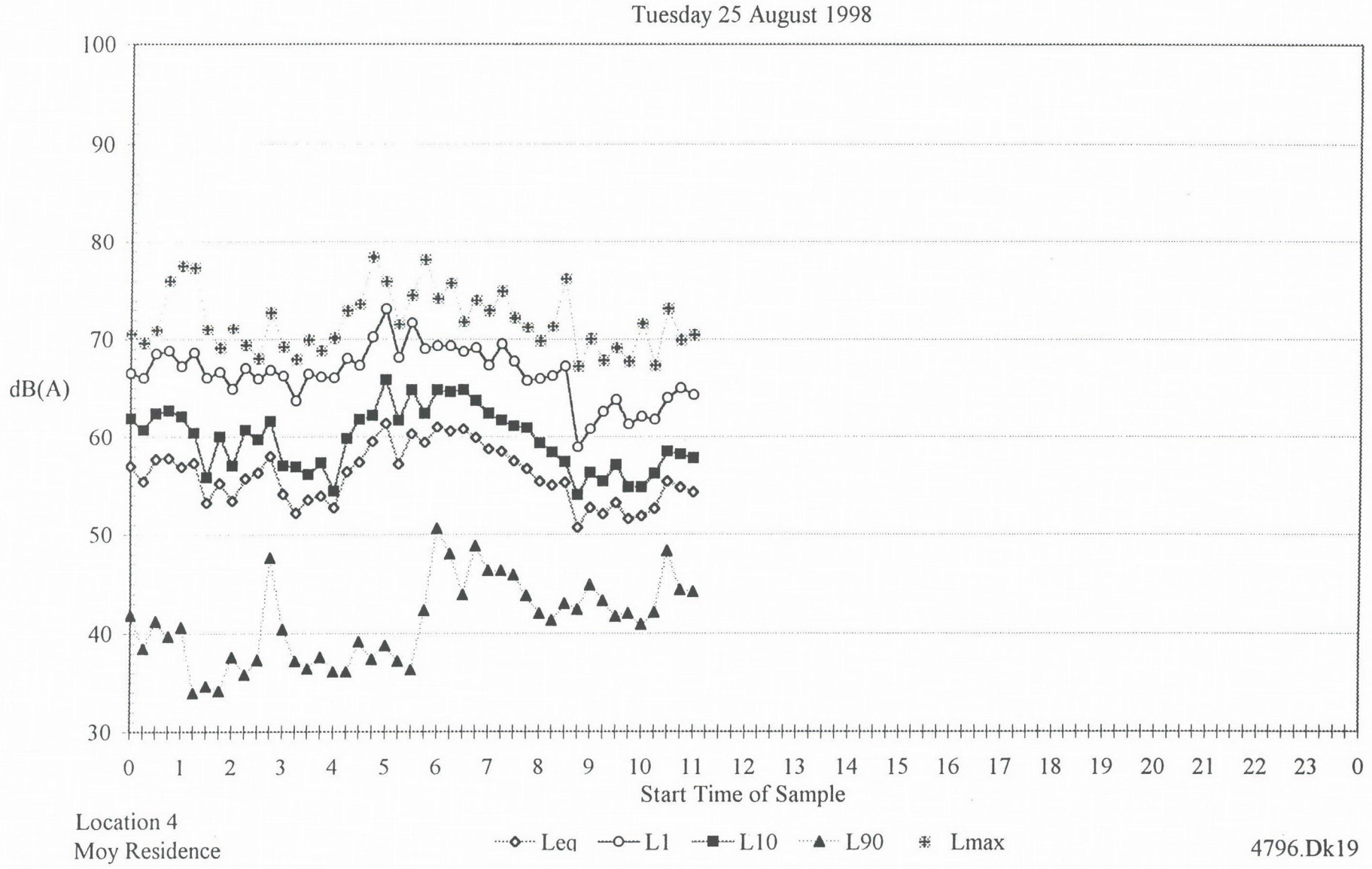

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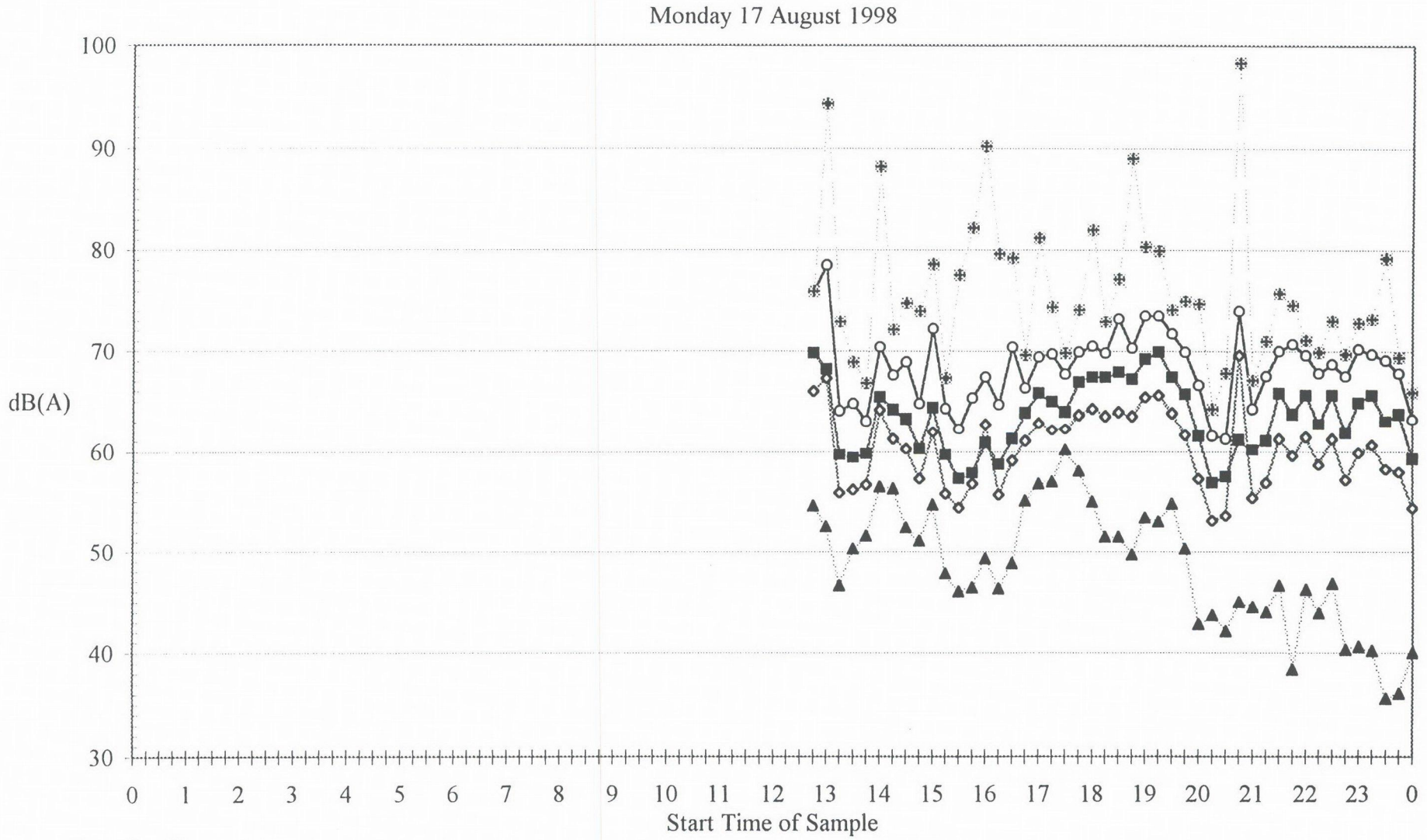

Location 5
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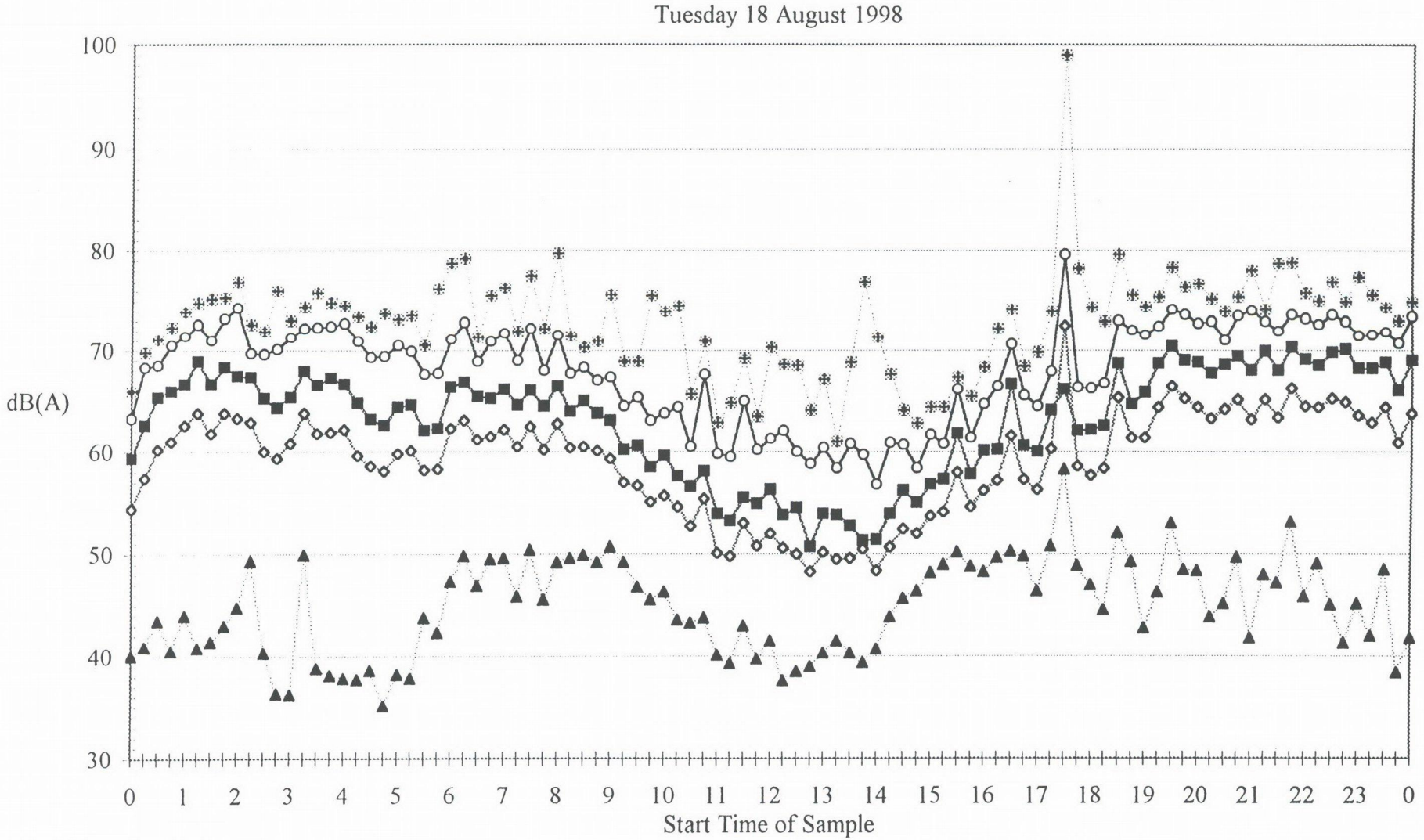

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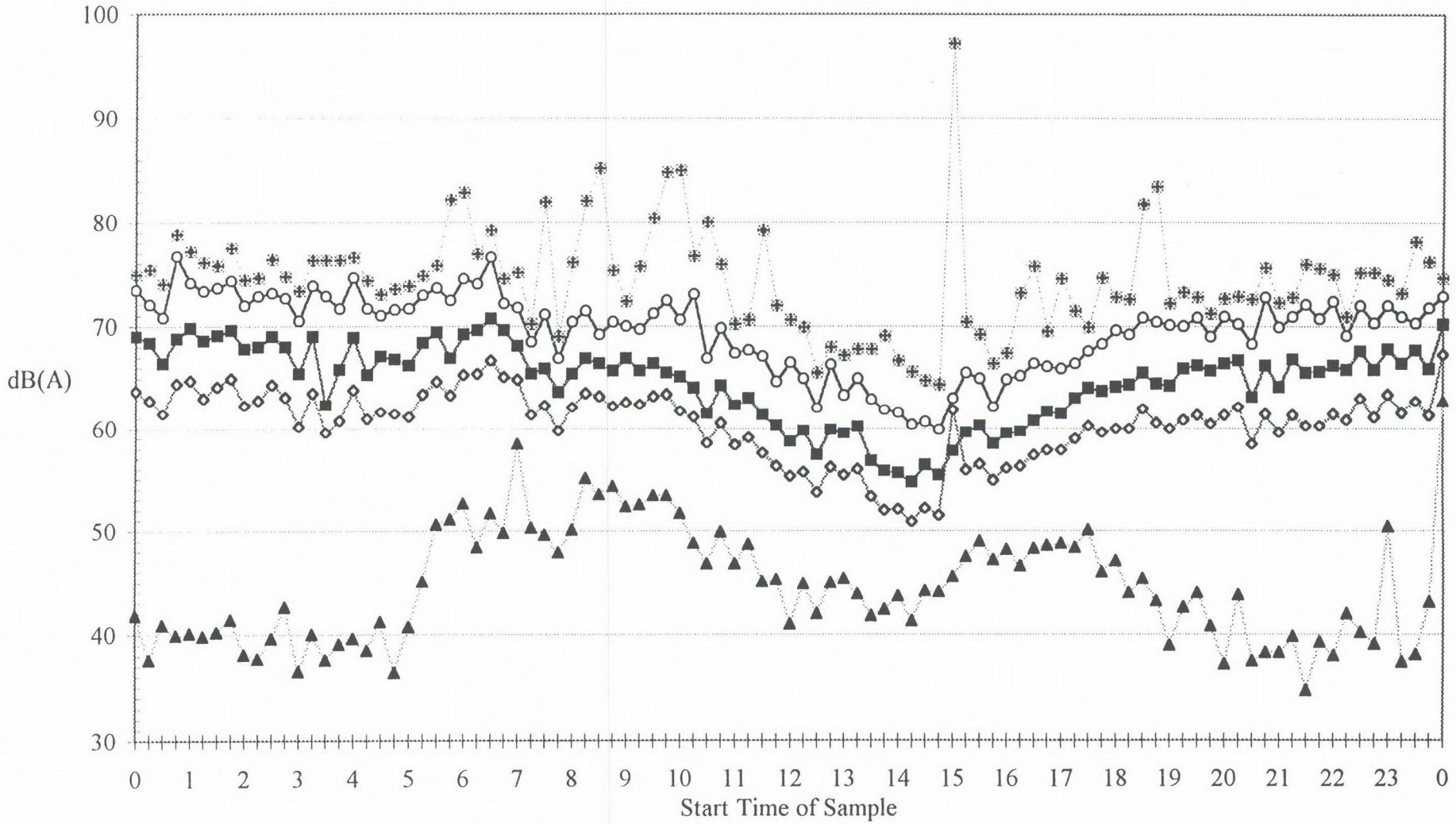

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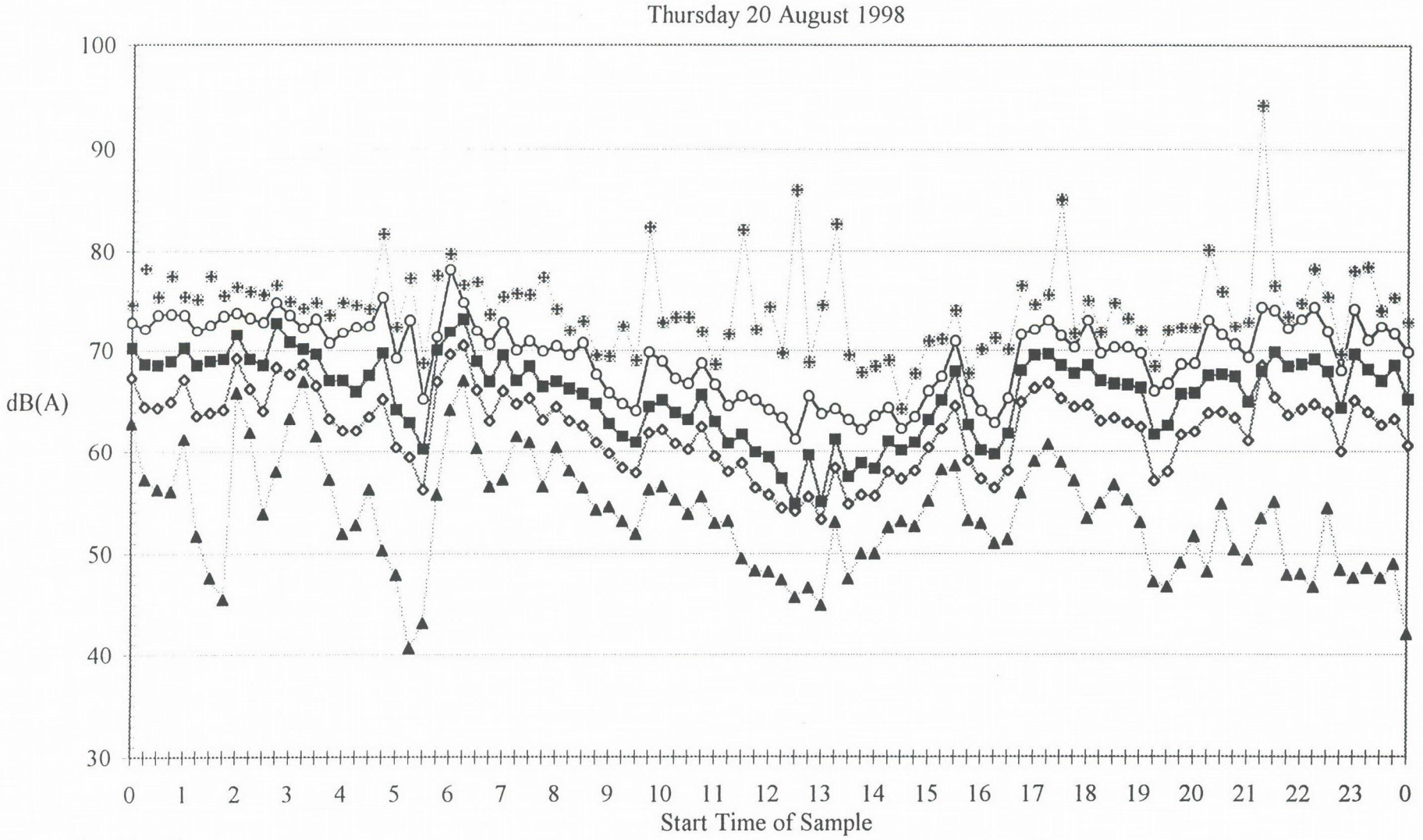

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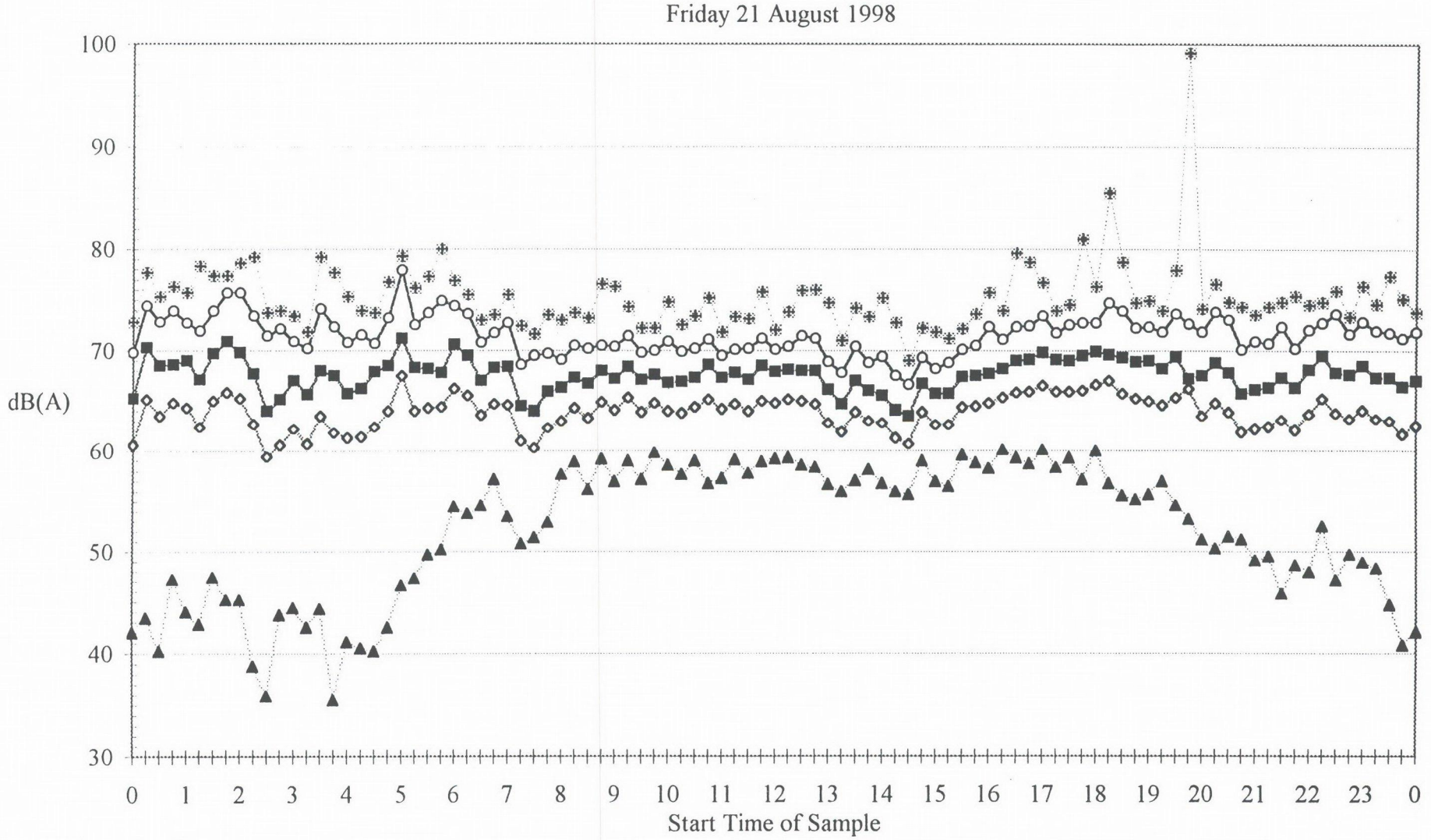

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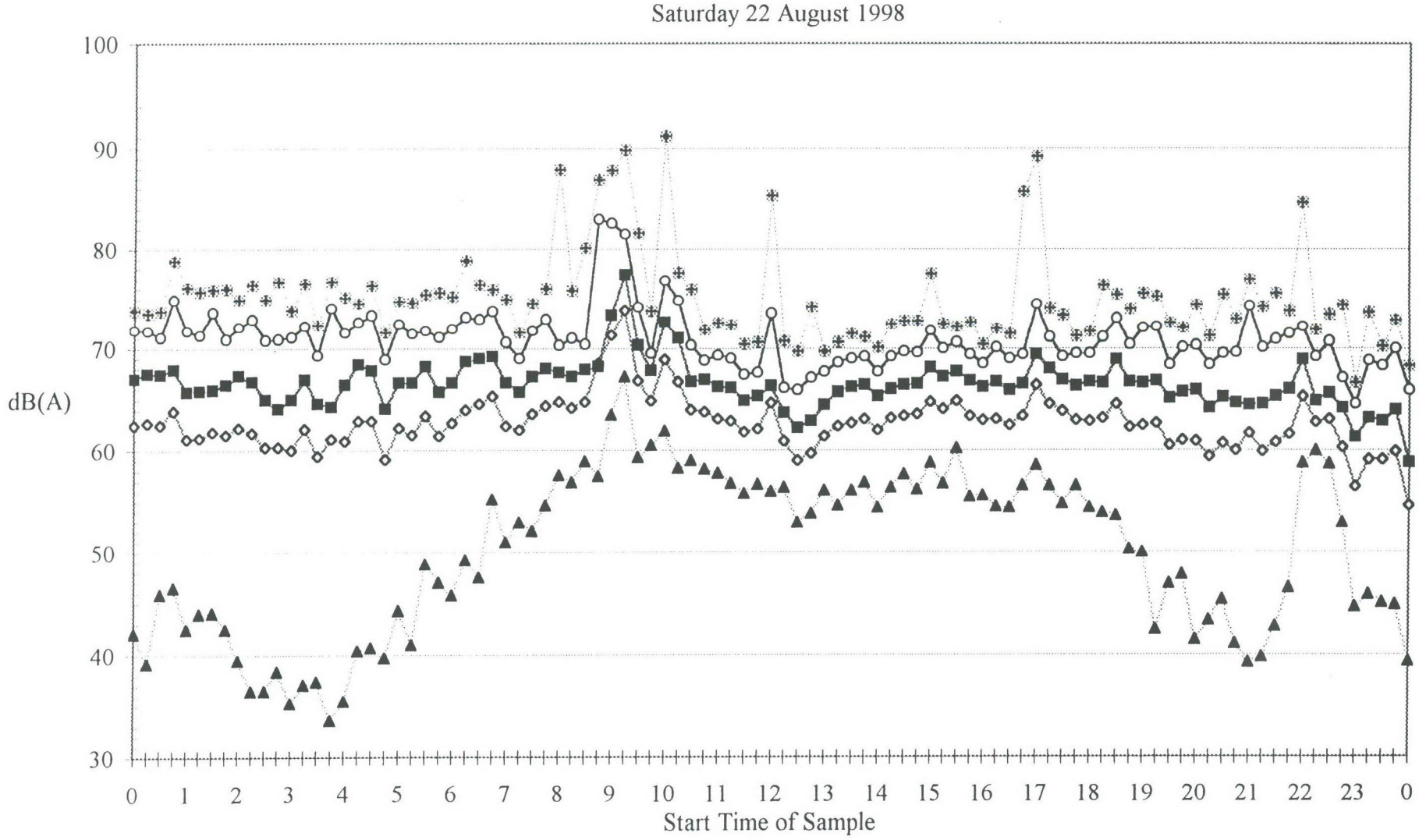

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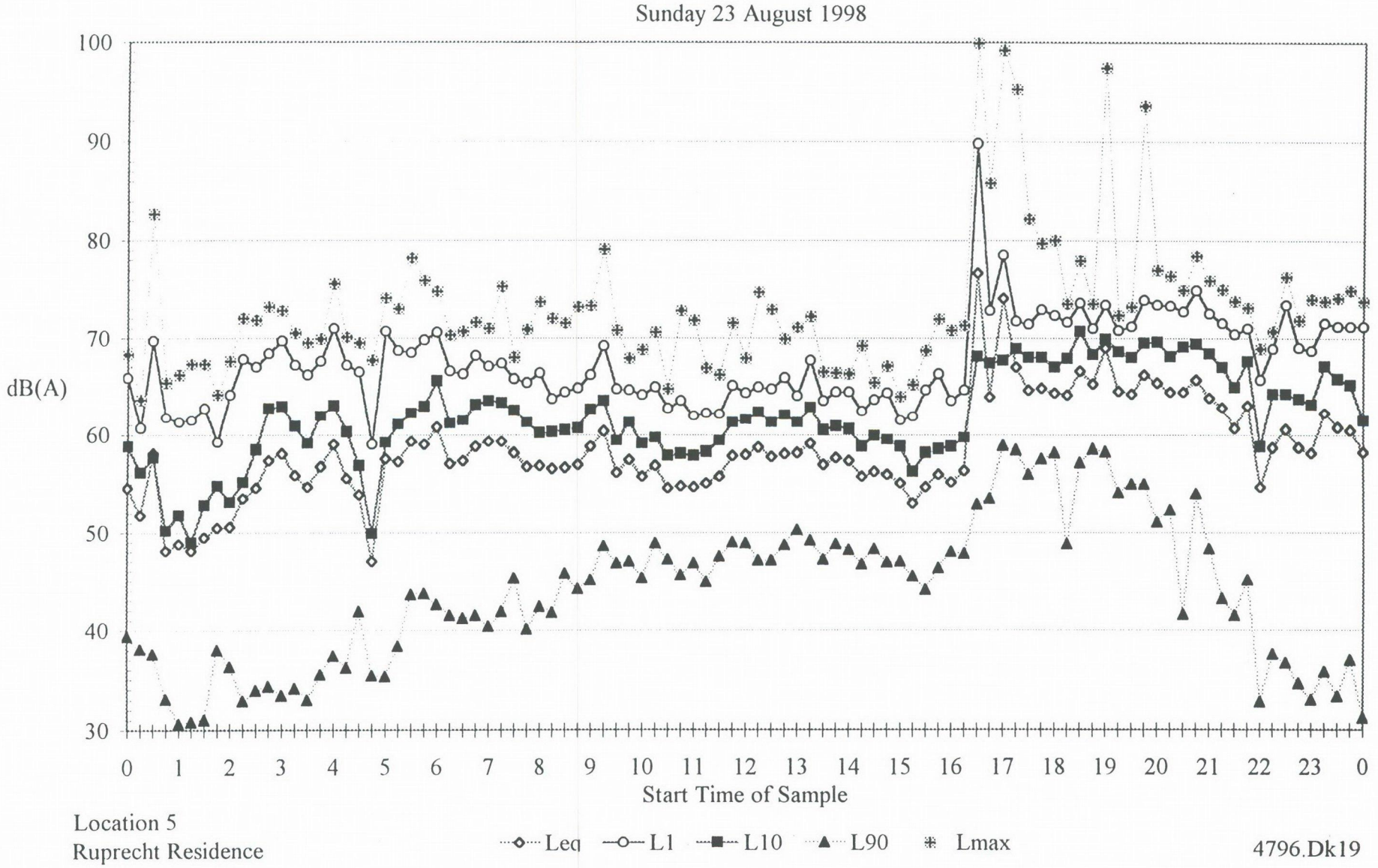

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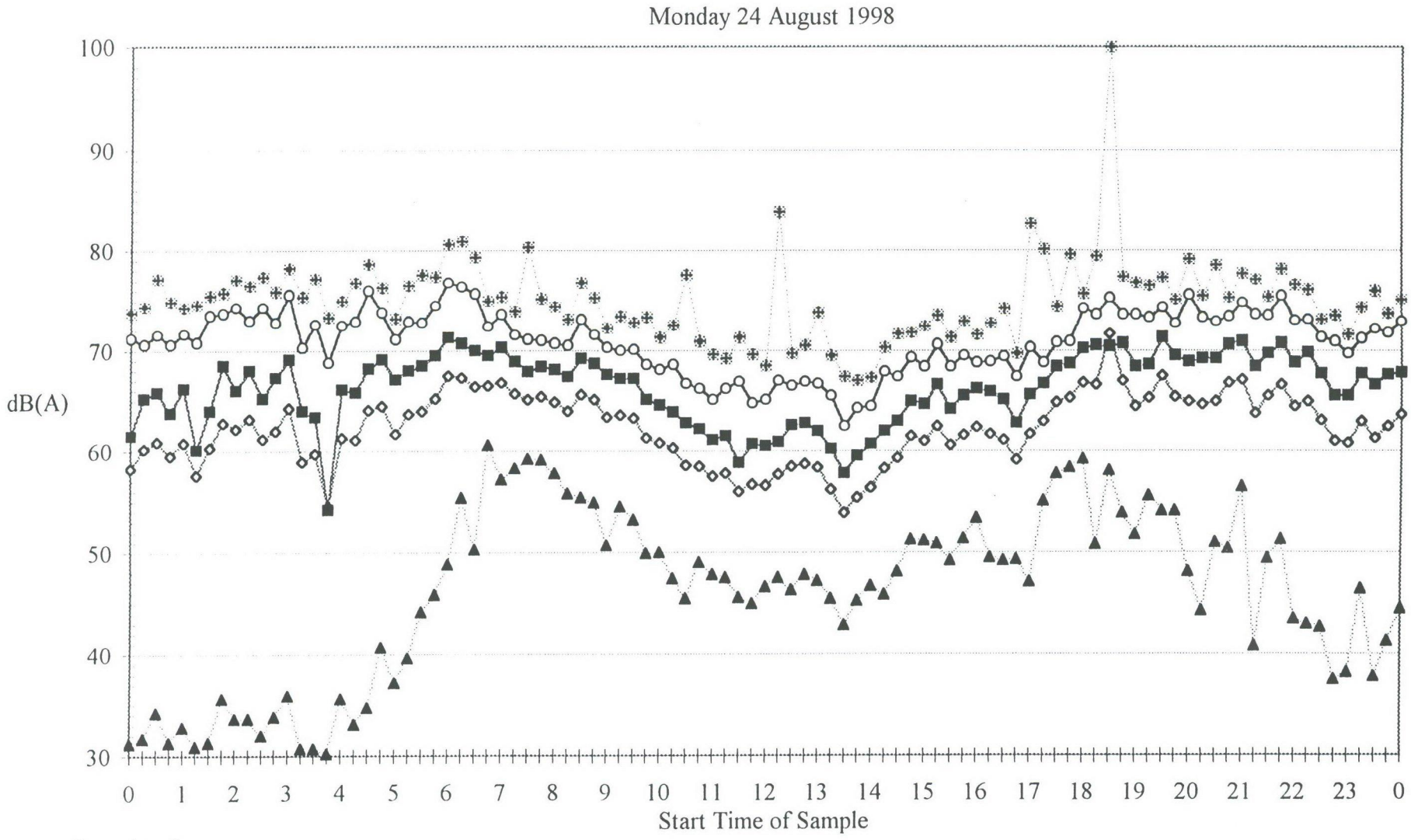

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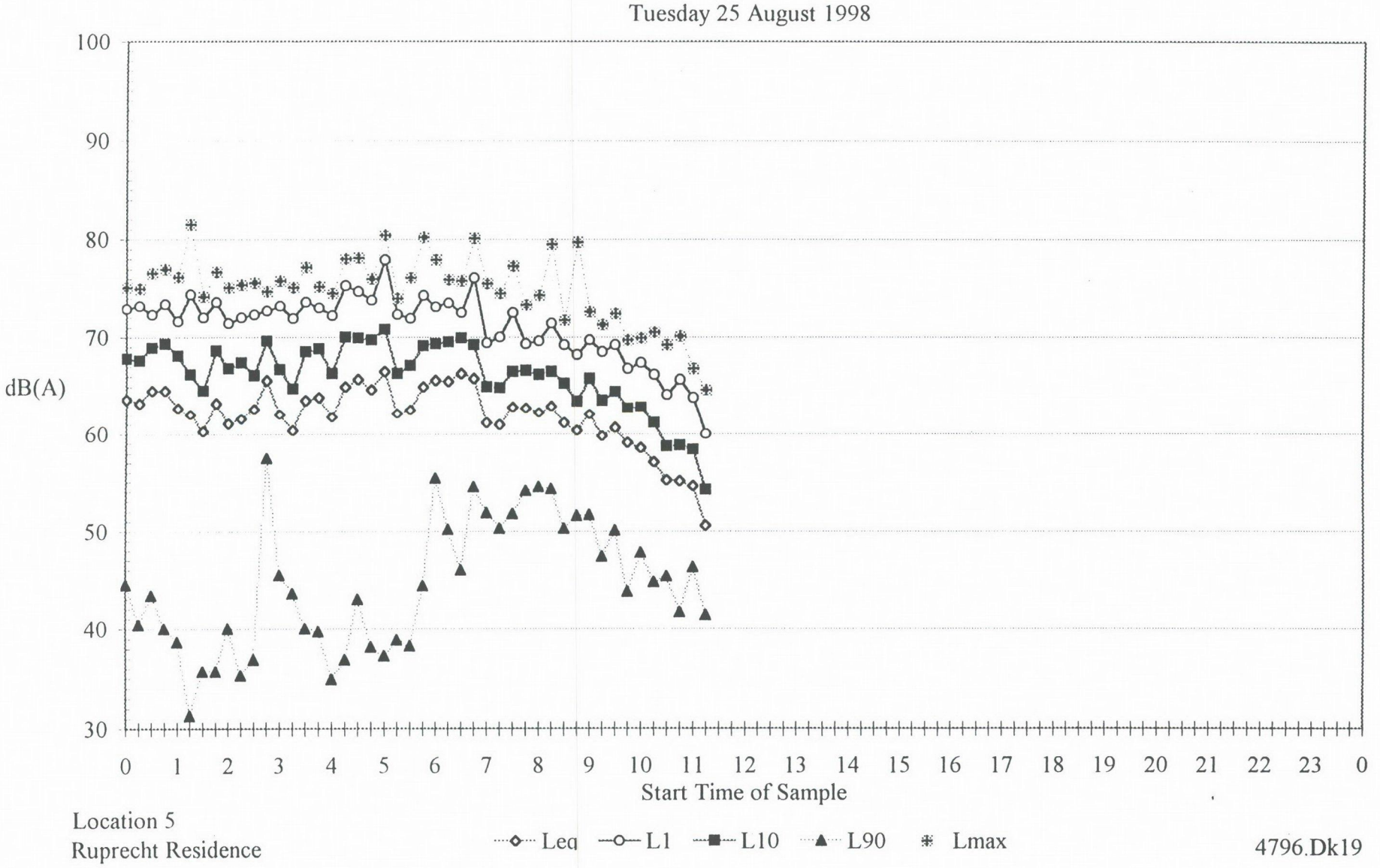

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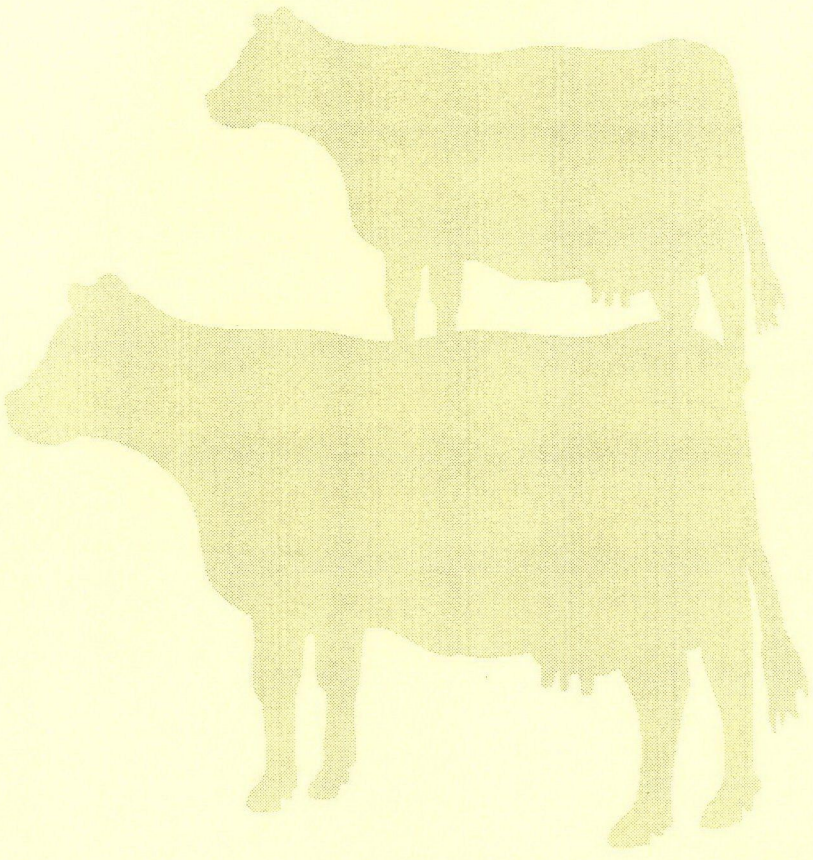

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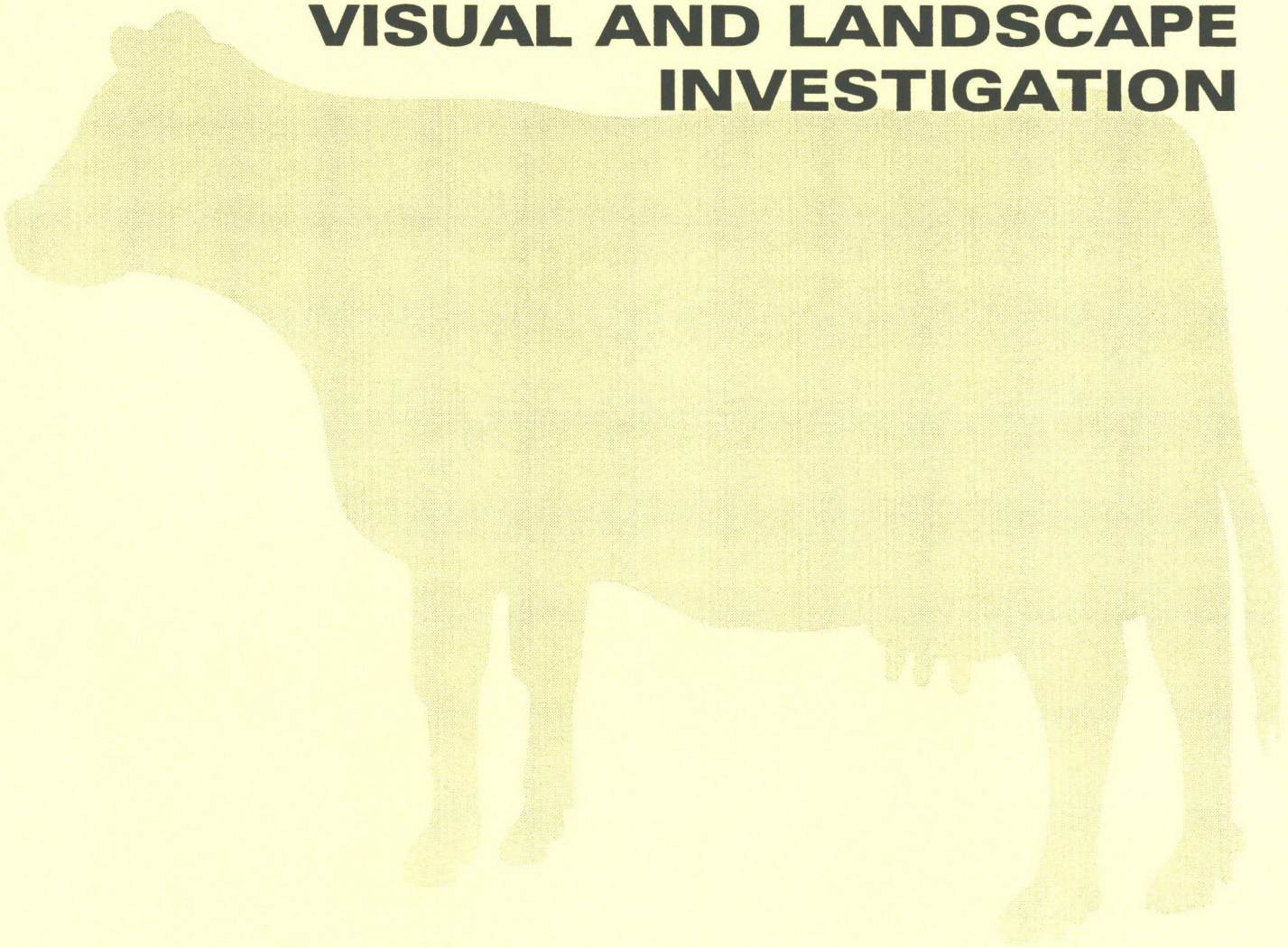

Roads and Traffic Authority of NSW

Pacific Highway Upgrade - Taree to Coopernook
Review of Environmental Factors

LANDSCAPE & VISUAL ASSESSMENT

FINAL REPORT
October 1998

Prepared by

Tract Consultants Landscape Architects
Level 1 186 Blues Point Road McMahons Point

Roads and Traffic Authority of NSW

Pacific Highway Upgrade - Taree to Coopernook
Review of Environmental Factors

LANDSCAPE & VISUAL ASSESSMENT

FINAL REPORT
October 1998

Document Number	**298030 R01**

Revision Status

Number	Date	Description	Prepared	Approved	Pages revised
00	7-9-98	Draft Issue	ME / MG		
01	23-9-98	Revised Draft	MG		All
02	21-10-98	Final	MG	GR	18,21,22,23,26,27

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1.0 INTRODUCTION

1.1 Background

This landscape and visual assessment contributes to the Review of Environmental Factors being prepared by Connell Wagner Pty. Ltd. on behalf of the Roads & Traffic Authority of NSW for the upgrade of The Pacific Highway north of the Taree bypass between the northern tie-in of the Taree bypass to the southern tie-in of the Coopernook bypass (refer Figures 1 & 2).

The majority of the road proposal is located on Jones Island. The proposal is essentially for the construction of a separated dual carriageway with two travel lanes in each direction in place of the existing two lane carriageway. The new alignment, for the most part, follows the existing highway alignment with some straightening near Blacks Lane and Ghinni Ghinni Creek associated with the new bridge crossing.

Jones Island forms part of the Manning River delta and is bordered by Ghinni Ghinni Creek to the west, the Manning River to the south and east and Lansdowne River defines the northern edge. The island's topography is basically flat due to its location on the flood plain of the Manning River. The Coopernook and Lansdowne State Forests some 4-10km to the north, and the Kiwarrak State Forest some 10km to the south provide distant and wooded backdrops to views over the Manning River valley.

Figure 2 illustrates the Study Area.

1.2 Study Objective

The key objectives of this study are:

- To assess the visual impact of the proposed road in terms of people who view the road from outside its easement and the road users who view the surrounding landscape from the road.
- To assess the impact of the proposed road on the existing landscape.
- Provide recommendations for landscape treatment for ameliorating the roads impacts on both the landscape and visual environment.
- Provide a landscape concept for the design of the road corridor including placement of fencing, extent and type of revegetation and any other matters required to ameliorate the impacts of the roadway.

In assessing the roads impact the following base information has been used.

- CMA topographic maps at 1:25,000 for:
  Coopernook
  Cundletown and
  Taree
- Aerial photographs of the site
- Proposed road design drawings

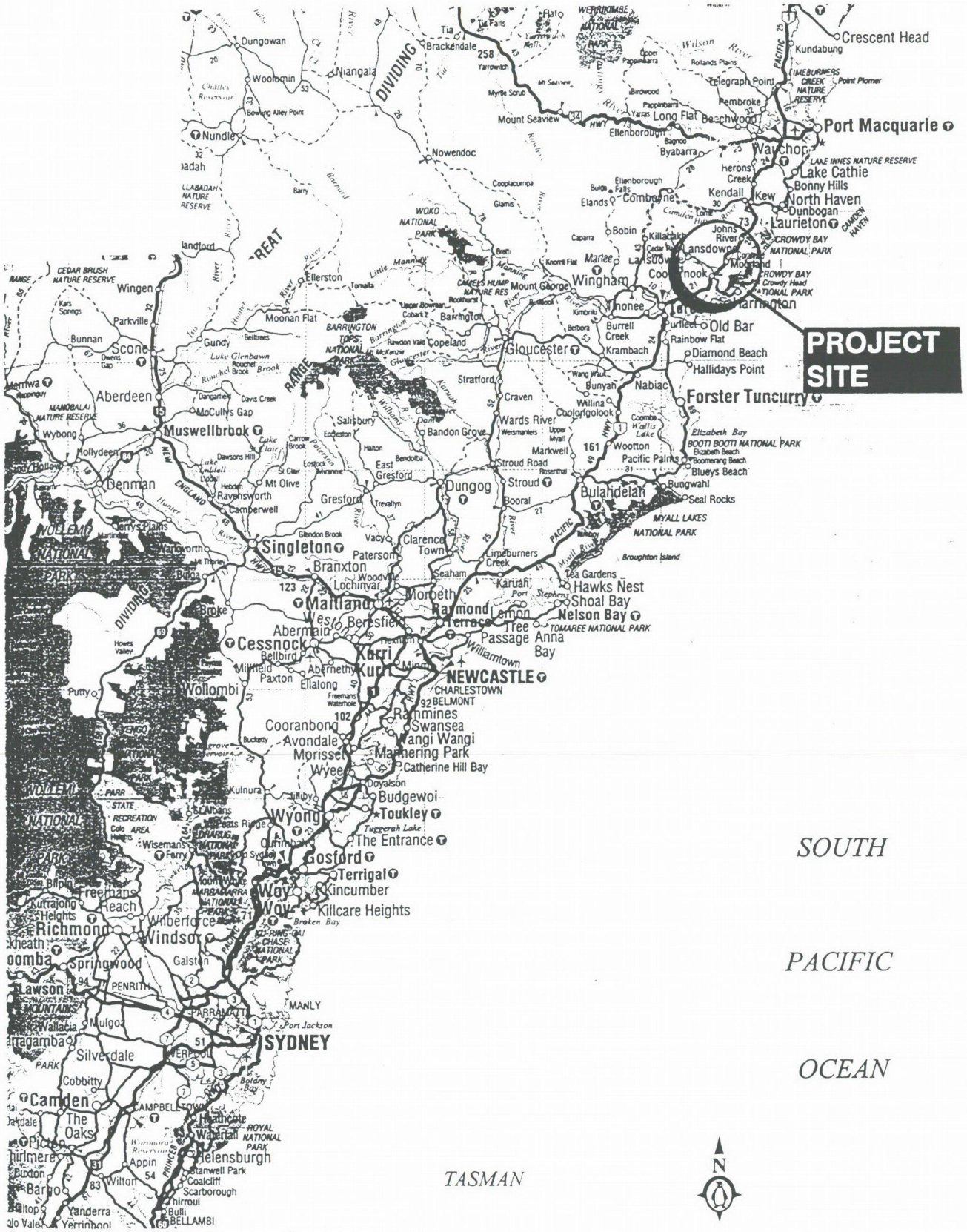


FIGURE 1 **Location Map**

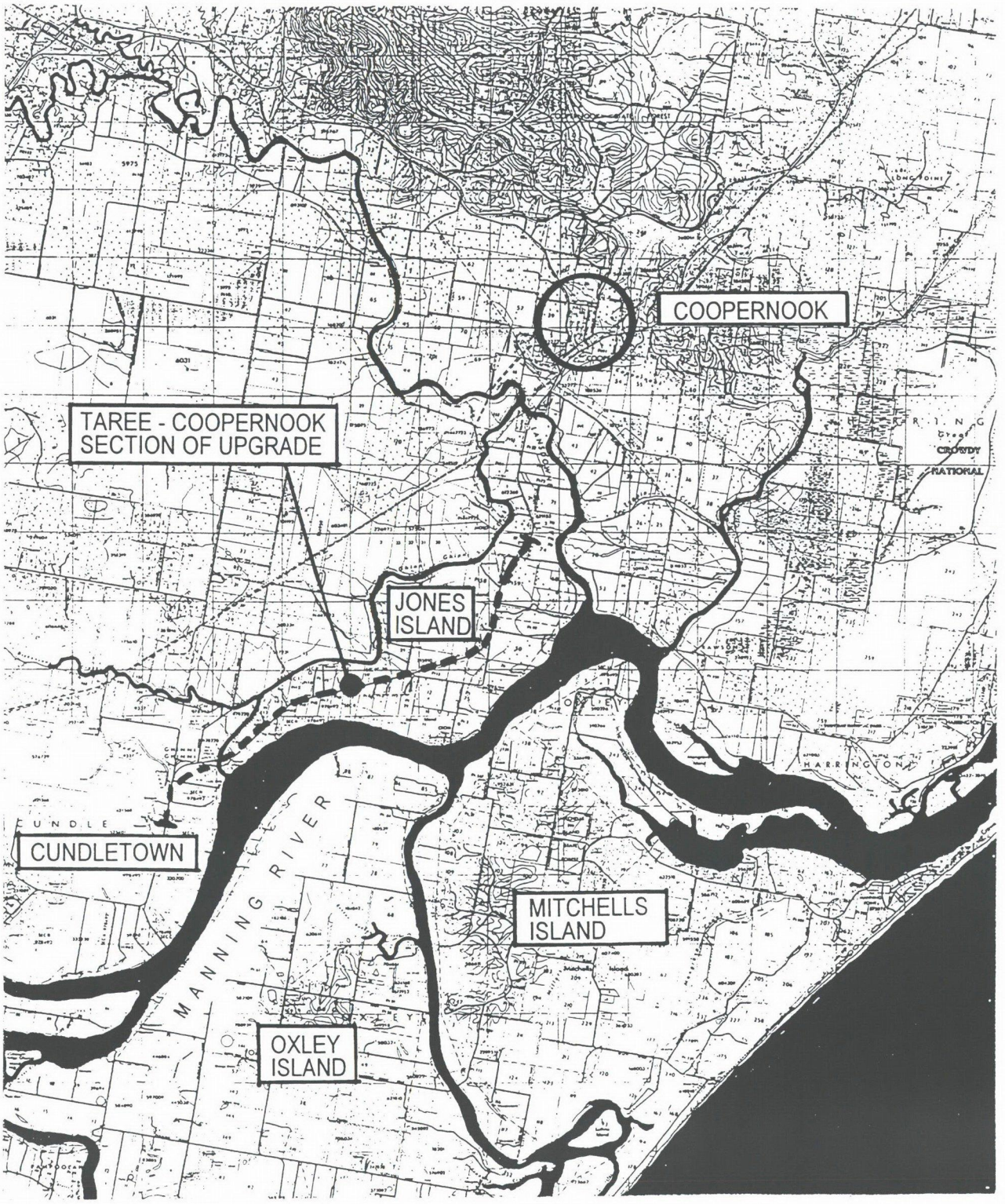


FIGURE 2 **Study Area**

2.0 METHODOLOGY

2.1 General

The assessment methodology adopted for this study is described below.

i). Description of Existing Landscape & Visual Quality

- The existing landscape of the site and its environs are described in terms of its topography, vegetation and land use patterns.
- The level of visual sensitivity and sensitivity to change within the study area is then assessed. Landscape and visual sensitivity relates to the ability of a landscape or site to absorb change. The degree of sensitivity is a measure of how any change will impact on existing landscape and visual quality. A low level of sensitivity indicates that change could be readily absorbed whereas a high level indicates that change would result in substantial alteration to existing conditions.

ii). Analysis of Potential Impacts

- Landscape and visual impacts are described separately. Landscape impacts are those that change the general fabric and pattern of the existing landscape and its component parts, such as landform modification, vegetation removal and modification of existing drainage patterns all of which combine to give a 'place' or 'area' its particular landscape quality. Visual impacts relate solely to alterations to views and/or viewing opportunities from or to the site of the works.
- From the available information the likely magnitude of the potential impacts is estimated.
- The significance of the various impacts is assessed.

iii). Determination of Appropriate Mitigation Measures

- Strategies and techniques for reducing the potential landscape and visual impacts are determined.

2.2 Site Investigations

This involved the investigation of the study area and its environs by day to record the existing conditions by way of photographic record with supplementary annotations. Prior to site investigations a review of topographical features was made from available topographic maps and likely vantage points from which the proposed road could be viewed were identified.

An inspection of the proposed road alignment was undertaken by traversing the study area on existing tracks and roads, by vehicle and on foot. Surrounding areas were investigated to establish the location from which the proposed road may be visible.

3.0 EXISTING ENVIRONMENT

3.1 Landform

As part of the Manning River floodplain, the study area is essentially flat with minimal differences in elevation.

The floodplain is made up of a series of islands and plains. The islands include Jones Island (which comprises the bulk of the study area), Mitchell's Island, Mamboo Island and Oxley Island. These plains and islands have been extensively cleared for agricultural production because of their rich alluvial soils.

The essentially flat nature of the existing landform is a key factor in relation to the visibility of the proposed road development.

3.2 Landuse

Initial agricultural developments began to develop in the valley during the 1830-40's and were predominantly focused towards maize production. During this period Jones Island had no land links to the adjoining areas and was reliant on water transport. Eventually a bridge was built providing access which eventually lead to the bridge that exists today as part of the Pacific Highway. In the 1890's there was a shift to dairy farming which continues today as the dominant industry. As such the landuse has led to a landscape that has been substantially cleared with scattered remnant trees. This is made up of a series of small/medium sized rural land holdings each, typically, with a residence on it and two small hamlets, Croki and Ghinni Ghinni.

3.3 Vegetation

As a consequence of this agricultural heritage, pasture grasses form the dominant vegetative cover. Remnant vegetation continues to grow in isolated pockets throughout the valley and on the islands and consists of a range of species including those of the littoral rainforest and swamplands of the valley.

Fig trees form key landscape features on Jones Island as they remain as scattered trees providing stock shelter within pastures. A number of fig trees also occur adjacent to the road.

Swampland species include Melaleuca quinquenervia, Melaleuca stypheloides, Casuarina glauca and a number of wetland species including Eleocharis spp. and Juncus spp. These stands remain along watercourses and depressions.

The river edges of the Manning and Lansdowne Rivers, and Ghinni Ghinni Creek are stabilised by mangroves. These form strong, bold outlines in the landscape and provide distinctive landform definition.

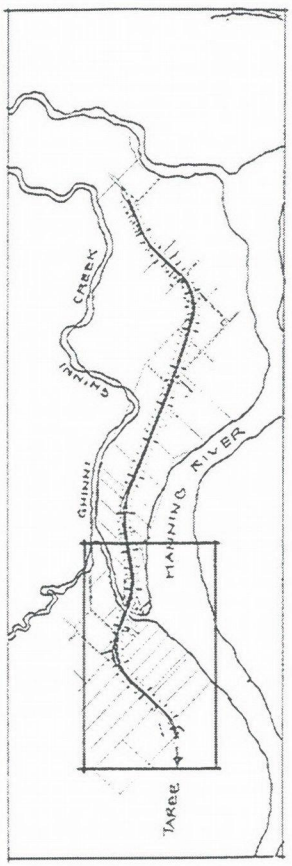
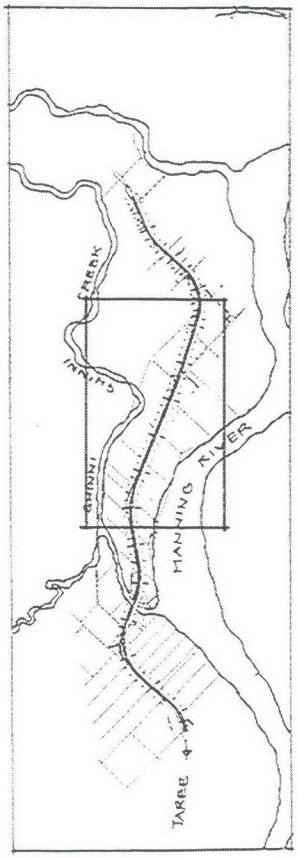
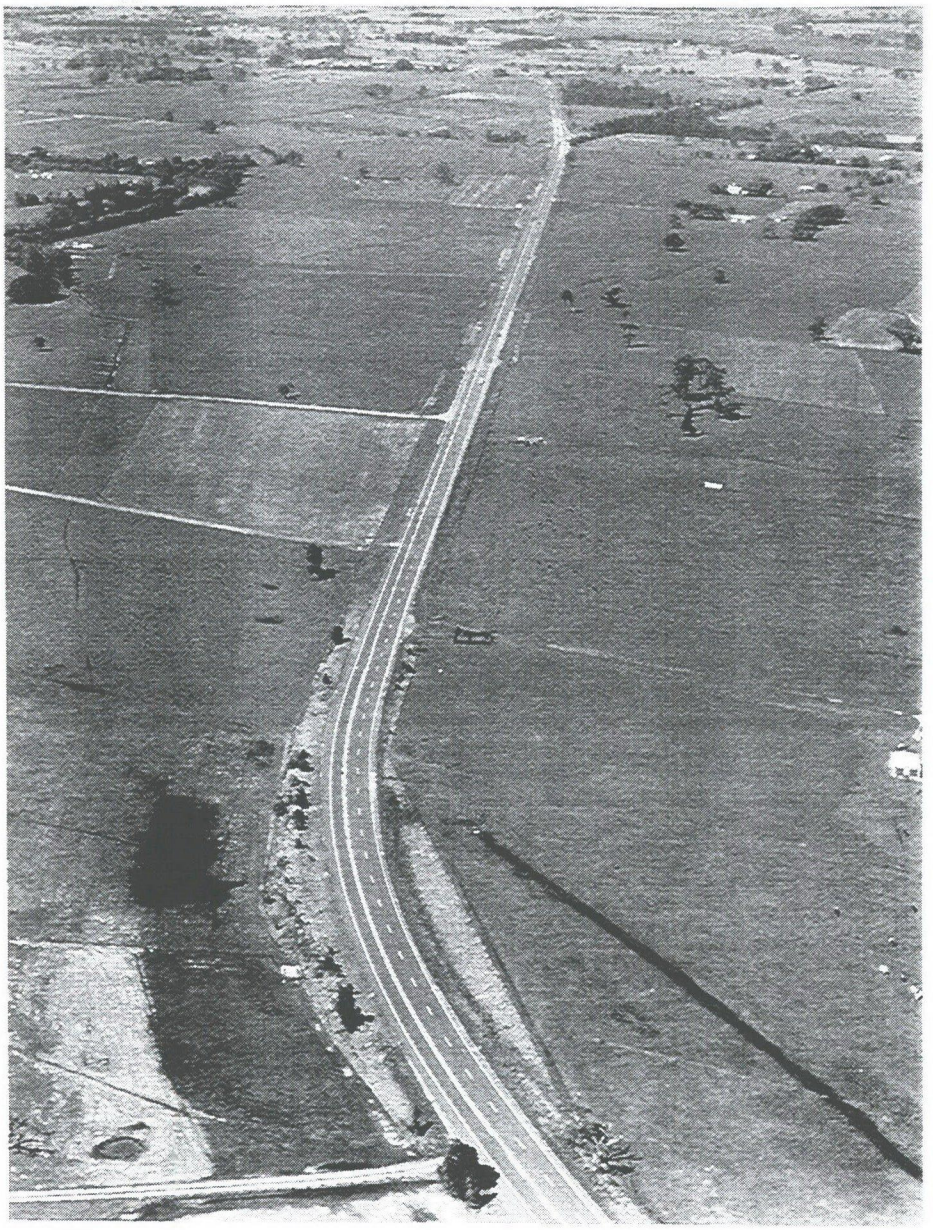






FIGURE 3 **Existing Landscape - Southern Section**





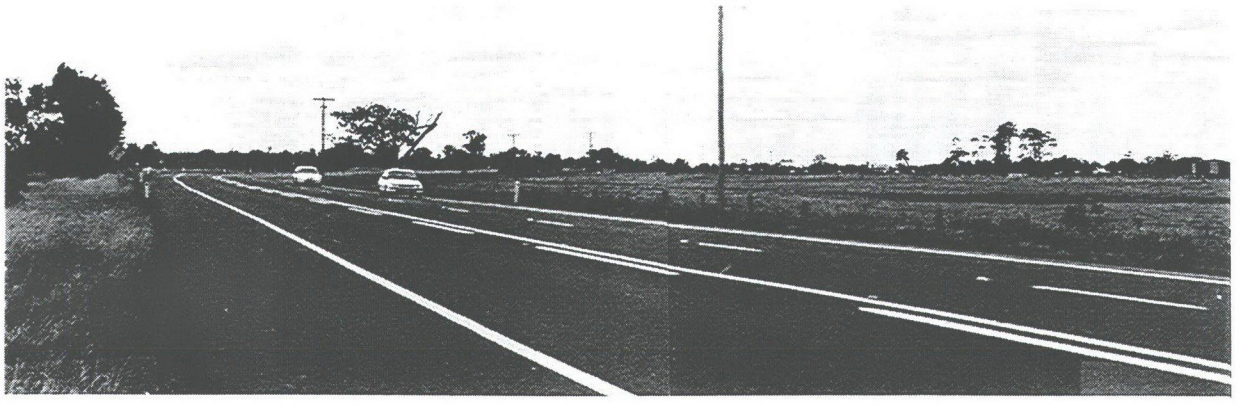
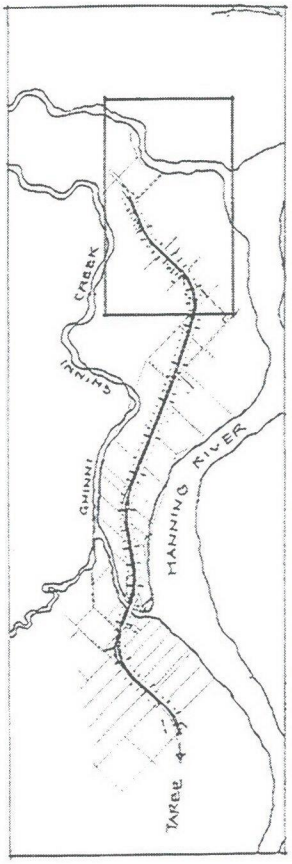


FIGURE 4 **Existing Landscape - Central Section**



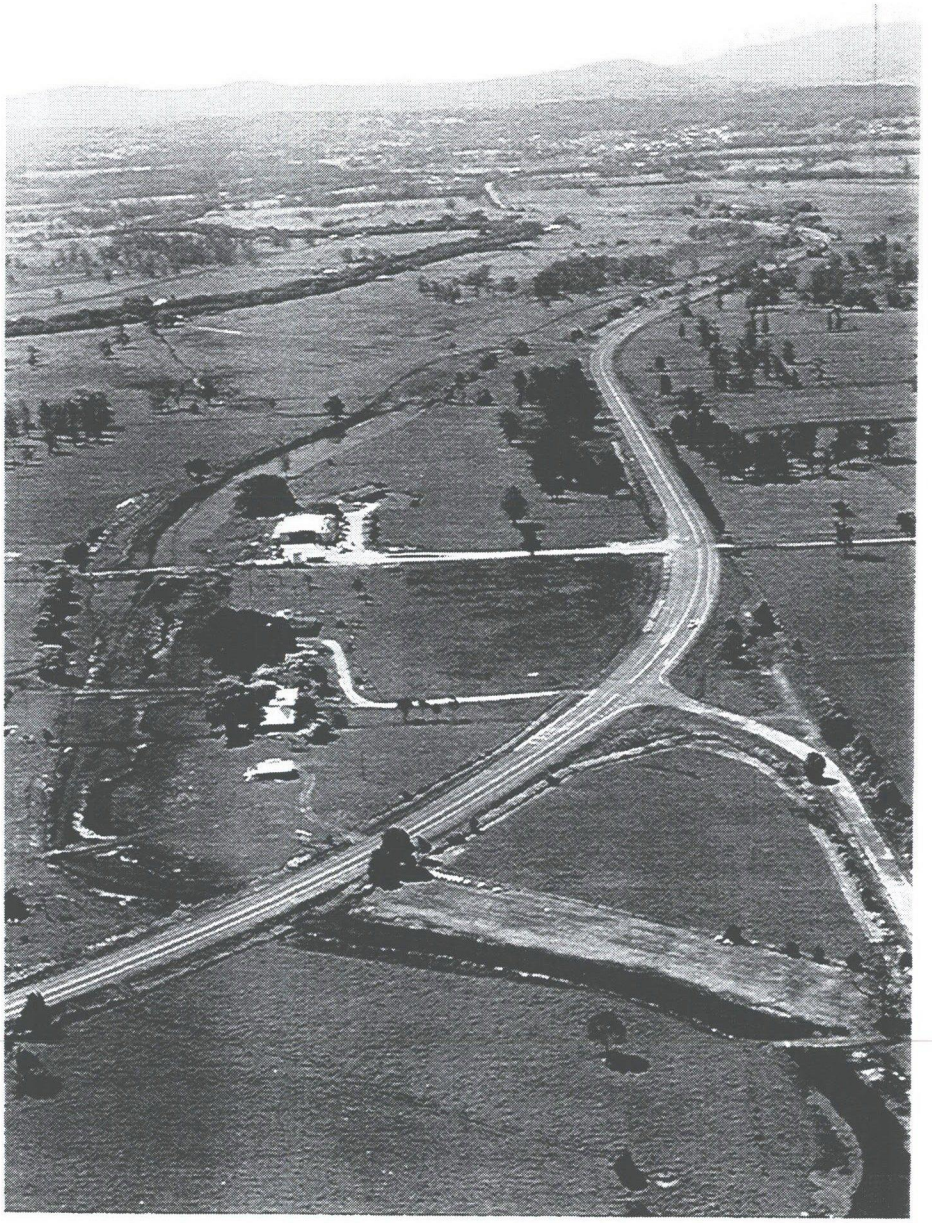




FIGURE 5 **Existing Landscape - Northern Section**

4.0 ANALYSIS

4.1 Site Visibility

A number of possible vantage points exist beyond and within the proposed road easement. These were investigated to establish the likely extent of impact of the proposed road. These areas include the adjoining farm holdings, on which the various dwellings typically face the existing highway, views from Oxley & Mitchell Island's, and views from the northern side of Lansdowne River on Mamboo Island.

A review of topographical features revealed the closest high point to be on Mitchell's Island, a distance of 2-3km to the east of the proposed road. This area has an elevation of 20-30m. Much of this elevated zone forms part of the Mitchell's Island State Forest with views being limited to the edge of the forest. From this point the existing highway is not visible, however, vehicles using the highway are but they are only just discernible. (Refer figure 7)

The proposed road construction will have no impact on views from these elevated areas.

From the riverside dwellings along the edge of Oxley Island opposite Jones Island, vehicles using the existing highway are visible through breaks in the riverside mangrove edge, however the highway itself is not visible due to the low viewing angle ie, the position of the viewer is at a similar elevation to that of the highway. For the most part however, the mangrove margins along the river prevent views of the highway corridor.

Views from the road corridor within Jones Island have a catchment that generally extends only to the edges of the island. The almost continuous edge of mangroves around the island, combined with the flat terrain effectively prevent views beyond the mangroves, with the exception of distant panoramic views of the main range to the west and views of the elevated portions of Oxley and Mitchell Islands. These elements create a backdrop to the floodplain, together creating a generally pleasing and interesting visual environment.

As the proposed road follows the existing highway alignment, views from and to the proposed road will be virtually the same as those that exist for the existing highway. There are various landscape elements along the length of the road that determine the interest of the view. Essentially the journey is one through green pastures with isolated scattered trees, predominantly Fig trees or casuarinas, with a number of farm houses and out buildings. The relationship of the road to the adjoining landscape is generally level with minimal difference in elevation. Typically the road sits approximately 1.5metres above existing ground levels with the exception of the proposed bridge crossing at Ghinni Ghinni creek and at selected locations where the road rises gradually over cattle underpasses to enable sufficient clearance.

From the bridge over Ghinni Ghinni Creek, more expansive views of the Manning River and the surrounding islands will be possible.

Typically on Jones Island viewing distance is generally no greater than 1km although views to the adjoining mountains some 10km away helps to create interest. The most enclosed view catchment occurs at the southern end of the island where viewing distance is limited to 200 metres from the road.

In terms of views of the road from the adjoining farms, for the most part the road will not be visible only the vehicles travelling on it will be. The reason being that the viewing angles from the adjoining lands are so flat. (Refer figure 8)

Views from the northern side of Lansdowne Creek on Mamboo Island are limited in much the same way as those from Oxley & Mitchell Island's, with mangroves and scattered tree cover restricting views into the site.

4.2 Existing Landscape

As previously described, the existing landscape of the proposed road corridor and it's environs is flat with small depressions forming the main alterations in topography. The dominant elements of the landscape are essentially:-

- broad, flat pastures and grazing cattle, farm dwellings and outbuildings
- large fig trees
- scattered remnants and regrowth of Casuarina and Eucalyptus trees
- small marsh and bog areas
- avenue plantings of poplars and camphor laurels at Ghinni Ghinni
- the school and dwellings at Ghinni Ghinni

4.3 Landscape And Visual Sensitivity

The existing landscape of the study area is completely modified from it's original state being the result of extensive clearing for agriculture with only small patches of remnant vegetation. As a result it is not particularly sensitive to change in landscape or visual terms.

In visual terms the new road would be easily absorbed. For the most part the road would not be visible for those looking onto it from adjoining properties, as the viewing angles are too flat.

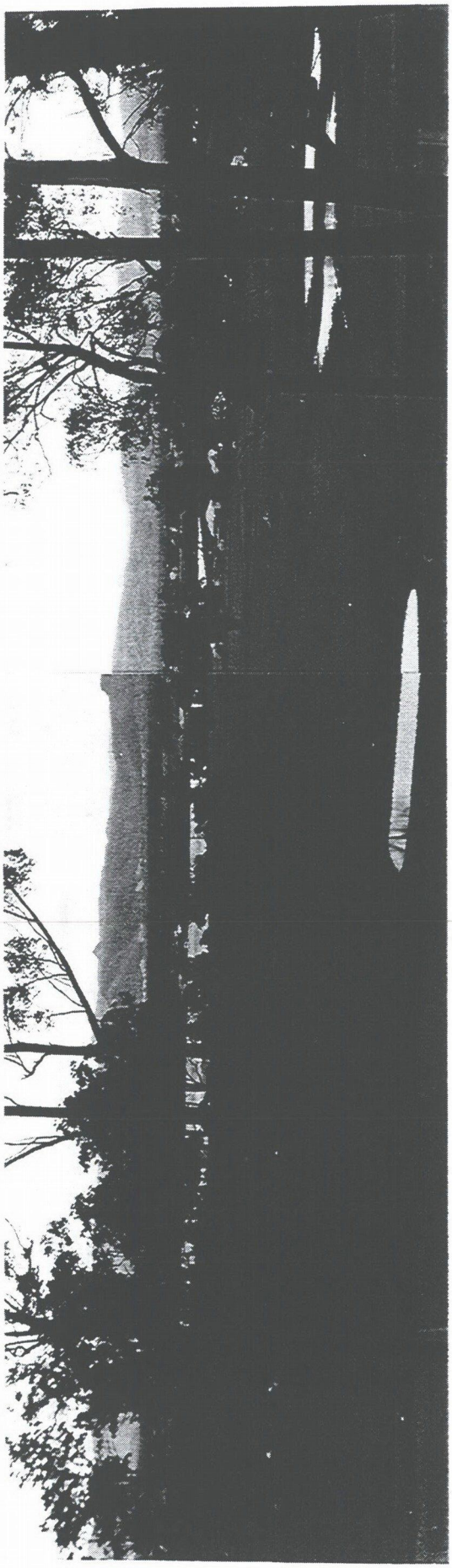
In landscape terms the proposed road would require the removal of pasture land and the vegetation alongside the existing highway. The only significant elements of vegetation that occur alongside the existing highway are four fig trees at the northern end of the road opposite the existing roadside rest area, (Refer figure 9) and the mangrove margin along Ghinni Ghinni creek at the proposed bridge crossing.



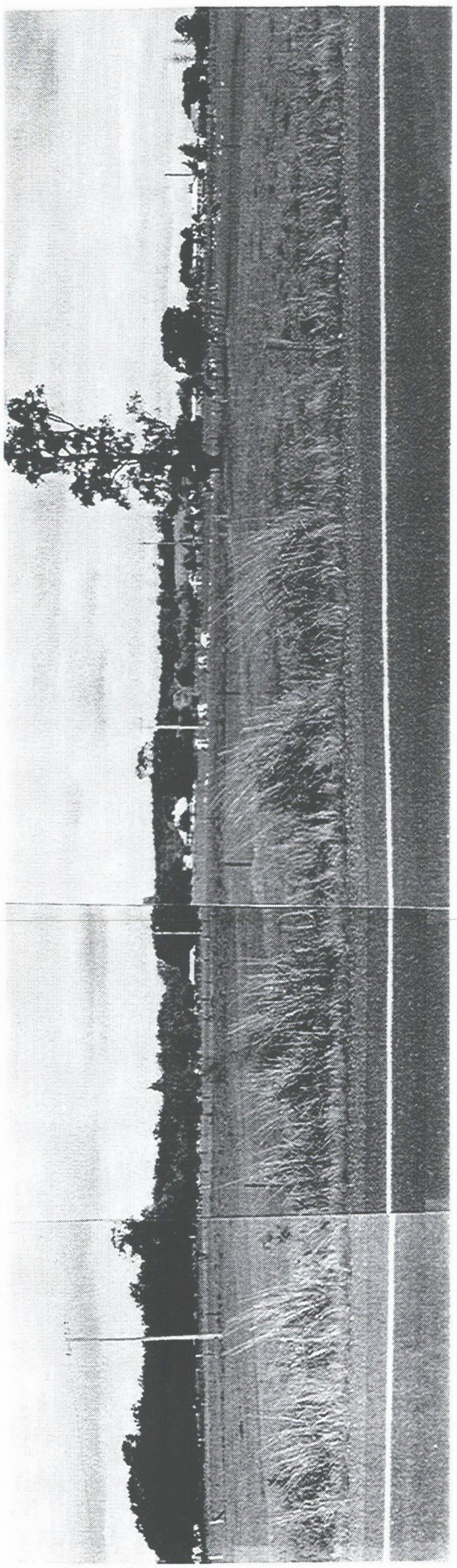
KEY

1. Extended views across floodplain to mangroves and woodlands approximately 2km away
2. Elevated views over floodplain and Manning River from bridge over Ghinni Ghinni Creek
3. Views from road corridor generally restricted by mangrove margins to Manning River & Ghinni Ghinni Creek. Viewing distances to edges range from 200m to 1200m. Where mangrove margin on Jones Island side are non-existent, views extend over Manning River to the margins of Oxley & Mitchell Islands
4. Forested crests and cleared slopes of elevated lands visible above mangrove margins.
5. Mangrove margins to Manning River & adjoining creeks form distinctive edges and landform outlines
6. Riverside properties on Oxley, Mitchell & Mamboo Island approximately 1 km from road reserve. Occasionally visible from road reserve.
7. Distant panoramic views of main range to west.

FIGURE 6 **Site Visibility**

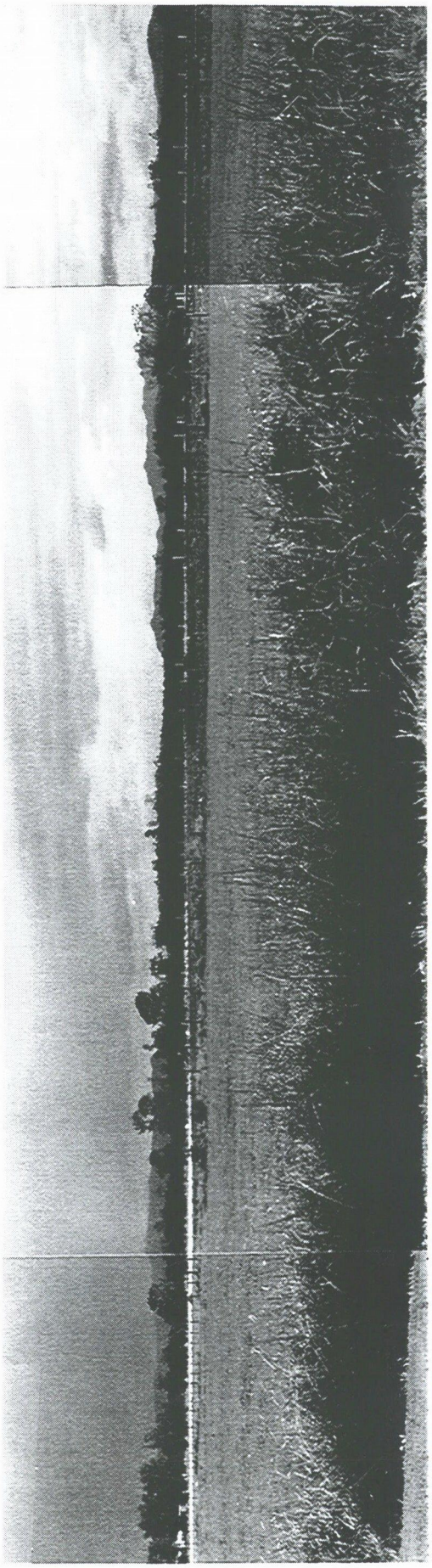


View from elevated slopes of Mitchells Island to Jones Island, highway not visible.

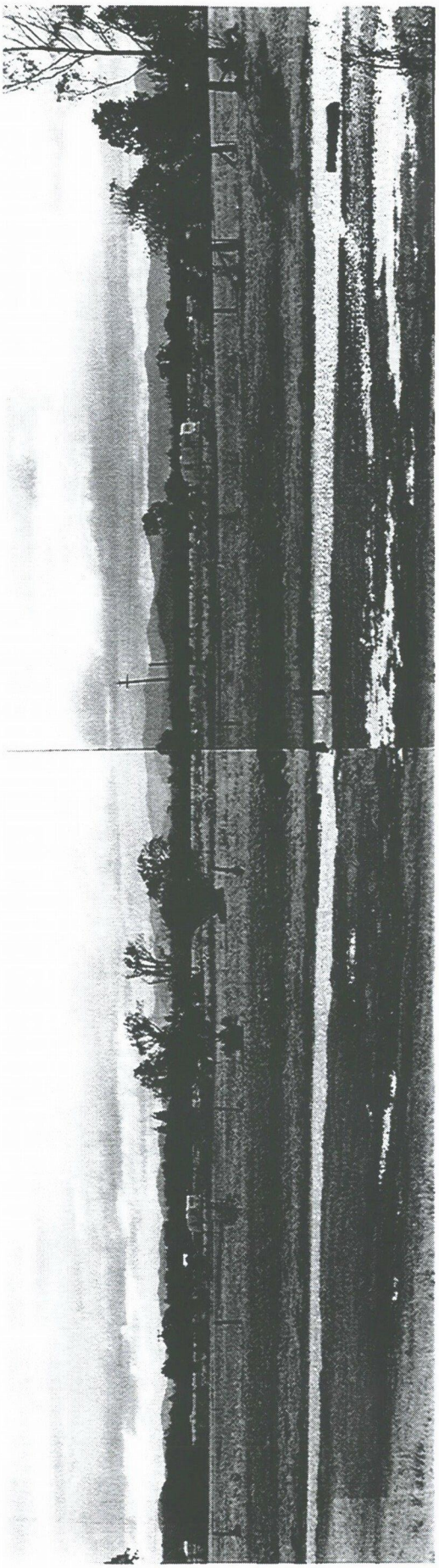


View towards Croki from highway - Mitchells & Oxley Island in background.

FIGURE 7 **Existing Site Views**



View of existing Taree bypass under construction from adjoining lands - visual impact minimal



Typical view of existing highway from adjoining lands
Note: road surface/formation not visible only vehicles using road are visible

FIGURE 8 **Existing Site Views**

5.0 IMPACTS

5.1 Landscape Impacts

Landscape impacts are those that change the general fabric and pattern of the landscape. This involves both the removal of vegetation and alteration and/or loss of landforms.

5.1.1 Landform

The proposal involves the formation of a slightly elevated road formation for its entire length, typically 1.5 metres above existing ground levels, with the exception of the Ghinni Ghinni creek crossing and also selected locations where it gently rises over proposed cattle underpasses.

The road corridor is approximately 50-60m in width which is slightly double what would be considered to be the present corridor. As a result of this width increase a small proportion of the existing agricultural lands will be lost. It is proposed to minimise the amount of lost grazing land by locating paddock fence lines as close as possible to the proposed carriageways subject to safety and maintenance considerations.

Loss of landscape features is limited due to the flat and featureless nature of the topography. Ghinni Ghinni Creek is the main creek line to be crossed and will be bridged requiring alterations to topography similar to those of the existing bridge crossing.

5.1.2 Vegetation

Vegetation losses will be minimal due to the cleared nature of the site. However there are six fig trees within the proposed road easement. There are two isolated trees at chainages (approx. only) 13 500 and 14 250 that are of poor form and condition, consequently their removal will not be of significance. However, at the northern end of the corridor there is a significant group of four fig trees occurring between chainage 17 670 and chainage 17 900 each of these trees is shown in Figure 9.

At the time of the site inspection it was felt that two of the figs, one at chainage 17 700 and the other at chainage 17 900 appeared to be of good form and in general good health, the remaining two appeared to be of somewhat poorer condition and form. The two better trees are certainly worth preserving, this would involve transplanting them to new locations within the road reserve roughly in the vicinity of their existing locations. It is recommended that a more detailed horticultural assessment of the four figs be undertaken to provide a more accurate assessment of their condition, structure and their ability to withstand the transplanting process. It may be that all four should be transplanted.

Also, at the northern end of the site, near Drury stock feeds, an existing cluster of Casuarina glauca immediately adjacent to the existing highway will also be lost, however they are of no particular significance and are easily replaced. Generally, the vegetation through which the road passes is of limited significance and can be easily replicated.

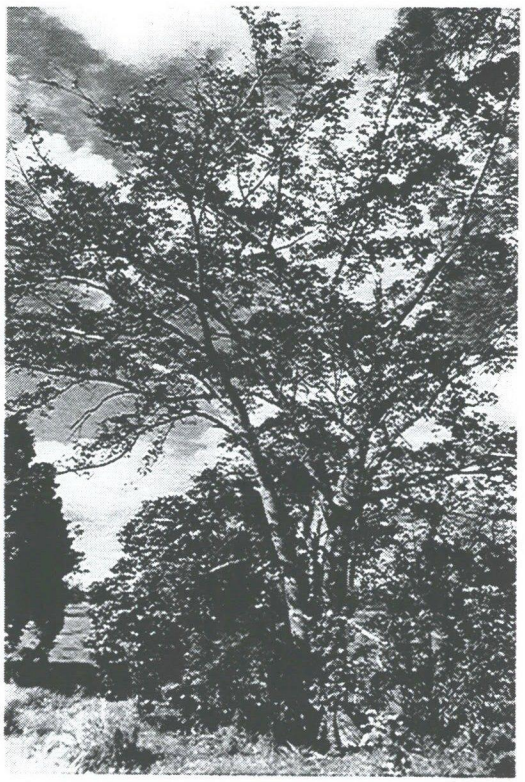
5.2 Visual Impacts

Given that the proposed highway alignment essentially follows the existing highway alignment and will be finished at a similar elevation the likely visual impacts will be much as they are now for the existing highway. Figure 8 illustrates the relationship of the existing highway to its immediate environs. For the most part the road itself is not visible, only the traffic using the road is. Figure 8 also shows a section of the existing Taree bypass under construction, this particular section is representative of how the new highway will appear as it traverses Jones Island. Essentially the visual impact of the road formation alone will be minimal and when considered in light of the proposed landscape treatment

there will be an overall positive impact in both landscape and visual terms for users of the road and for those viewing the road from the adjoining lands.

The dwellings on the adjoining farm lands are generally setback from the road a minimum of 100m and maximum of 1km. The view of the road from these dwellings is typically as illustrated by the photographs in Figure 8. The only anticipated difference in this view will occur where the road gently rises over the two proposed cattle underpasses between chainages 14 100 & 14 200 and chainages 16 300 & 16 400. These changes in the road elevation are very gradual and are not expected to have any more visual impact than the rest of the road. The landscape recommendations described in Section 6 makes provision for tree planting at both locations as indicated in landscape treatment types 2, & 4 in Figures 16 & 18.

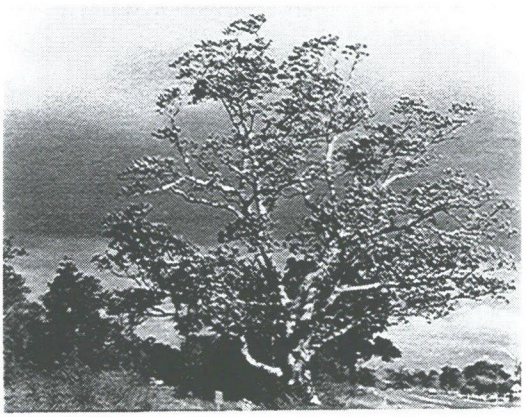
In terms of road users, the present road is defined by the fencelines of adjoining properties and the view catchment of the island. The new road is unlikely to change this relationship although may use planting to improve the interest of the road side and to better define views.



Location - Ch. 17 670



Location - Ch. 17 700



Location - Ch. 17 800



Location - Ch 17 900

FIGURE 9 **Existing Fig Trees at Northern End**

6.0 LANDSCAPE RECOMMENDATIONS

6.1 General

Mitigation of the road impacts involves a number of issues:

- design of road profiles and batters to better suit the landscape of the area;
- minimisation of impacts on existing remnant vegetation;
- appropriate landscape design to take advantage of the visual assets of the site and to better serve the adjoining properties; and
- minimisation of land take.

6.2 Landscape Character

The assessment of landscape impacts revealed that few landscape features will be impacted by this proposal. The most significant being the loss of land area.

A number of the adjoining property owners have raised the issue of the extent of the proposed road easement. These include the following:-

-Lot PT7 DP9337, Lot 8 DP9337
-Lot 1 DP998328, Lot 77 DP754409, Lot 2 DP534778
-Lot 1 DP741558, Lot 15 DP71868, Lot PT 6 DP978492, Lot PT 5 DP978492

Their concern relates to the maintenance of the road verge and loss of pasture lands. In order to minimise land take and improve maintenance of the road verges the possibility of locating pasture fencelines over part of the road verge should be considered. Such a proposal helps blend the road within the rural landscape. Presently the relationship between edge of road and fenceline is approximately 5-7m apart with the road verge comprised of escaped pasture grasses. The new easement trebles this zone. The landscape design of this zone needs to consider both the ongoing maintenance needs plus the legalities of providing lease provisions within the road easement.

The other issues relating to landscape mitigation deal with loss of trees and/or the need to provide some form of screening between the road and adjoining houses.

As discussed in a previous section, six fig trees fall within the road corridor, the group of four at the northern end of the corridor between chainages 17 600 & 17 900 are significant in terms of their contribution to the landscape character of the roadside environment, two of this group appear to be of good form and general good health, with the other two being of somewhat poorer condition. It is proposed that at least the better two of this group be transplanted to new locations in the road reserve, with the possibility of the remaining two also being transplanted, subject to a detailed horticultural assessment. New plantings of fig trees are also proposed at selected locations to further enhance the roadside environment.

The installation of Casuarina glauca screen planting and scattered Eucalypt plantings at selected locations are also proposed to further enhance the existing landscape character of the roadside environment by both defining views and mitigating the visual impact on adjoining properties. A number of properties have requested that tree planting being undertaken in the road reservation along their property boundaries. The design of the road verges should address both the screening requirements of the roads immediate neighbours plus provide visual interest for the road user.

6.3 Landscape Concept

The landscape concept has been developed following a complete review of impacts and possible mitigation measures.

Essentially the landscape approach to the new road development is to maintain and enhance the existing rural landscape character. This is achieved by maintaining as much pastureland as possible by way of locating the pasture fencelines as close to the road as possible, introducing more scattered tree plantings of Eucalypt and Fig trees and introducing screen planting of Casuarina glauca at selected locations. There are essentially four landscape treatment types involved. These have been determined by their location in relation to adjoining properties, the need for complete or partial screening and adjoining vegetation patterns.

6.4 Landscape Treatment Types

- TYPE 1 - Grassland (no tree or shrub plantings).

This involves the location of fencelines as close to the proposed carriageway as appropriate in relation to safety and maintenance considerations. The benefits of such a proposal is the reduction in maintenance requirements, minimising loss of pastoral lands and retention of views across the island.

- TYPE 2 - Grassland with scattered plantings of Eucalyptus tereticornis (Forest Red Gum).

This involves the location of fencelines as close to the proposed carriageway as appropriate in relation to safety and maintenance considerations. The benefits of such a proposal are as for Type 1. Scattered Eucalypts break up the view and provide shade within the paddocks. Tree planting is setback 9.0 metres from the adjoining travel lanes in accordance with RTA safety requirements in relation to clear zones adjacent to the road.

- TYPE 3 - Grassland with group plantings of Ficus superba and/or Ficus macrophylla.

This involves the location of fencelines as close to the proposed carriageway as appropriate in relation to safety and maintenance considerations. The benefits of such a proposal are as for Types 1 & 2. The use of figs strengthens the existing clumps of remnant fig trees which are scattered throughout the island and enhances this characteristic element of the existing landscape environment. Tree planting is setback 9.0 metres from the adjoining travel lanes in accordance with RTA safety requirements in relation to clear zones adjacent to the road.

- TYPE 4 - Casuarina grove planting.

This planting uses the proposed road corridor in full. Casuarina glauca is planted in grove formation at approximately 1 metre spacings in mulched planting zones. This type of planting provides a dense screen which delineates the road corridor and screens houses from the passing traffic, it is also representative of the nature of the vegetation which would have once been abundant. In grove formations, Casuarina glauca is considered to be frangible and therefore suitable for use adjacent to the road without the use of safety barriers. The planting areas would be setback approximately 6.0m from the edge of the road pavement.

6.5 Plant Species

Recommended plant species for these works are as follows:

Landscape Treatment - Type1 - Grassland

Selected native grass species only, no tree and shrub planting included.
Typical species :-

- Themeda australis
- Imperata cylindrica

Landscape Treatment - Type 2 - Scattered Eucalyptus Plantings in Grassland

- Eucalyptus tereticornis (Forest Red Gum)
- Selected native grass species as for Type 1

Landscape Treatment - Type 3 - Group Plantings of Figs in Grassland

- Ficus superba
- Ficus macrophylla (Moreton Bay Fig)
- Selected native grass species as for Type 1

Landscape Treatment - Type 4 - Casuarina Grove Plantings with Grassland margins

- Casuarina glauca (She-oak)
- Selected native grass species as for Type 1

Additional Species for Water Quality Control Ponds

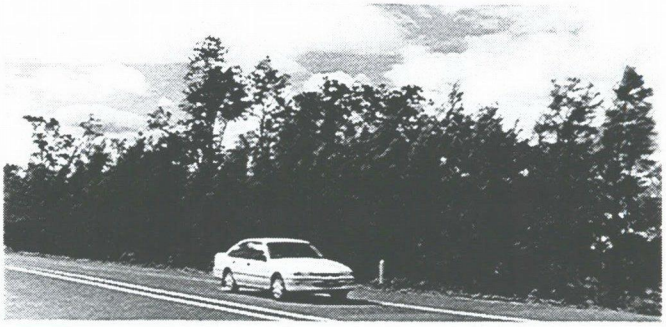
- Eleocharis sphacelata
- Eleocharis equisetina
- Juncus usitatus
- Gahnia spp.



Hamlet of Ghinni Ghinni - note avenue of poplars



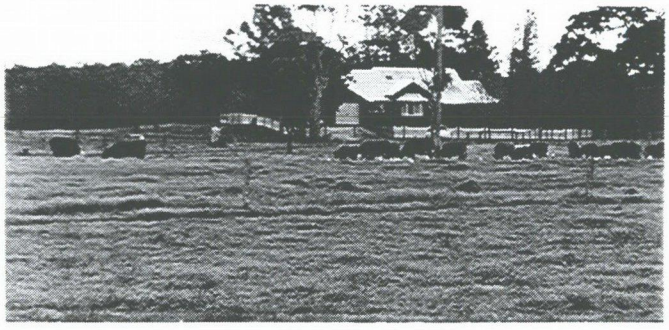
Existing fig tree in farm paddock



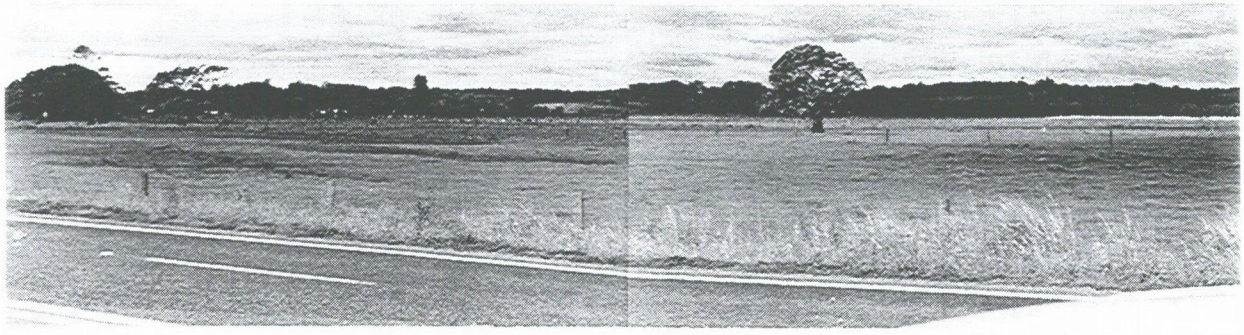
Existing roadside grove plantings of Casuarina Glauca opposite Drury Stock feeds



Existing red farm shed - former Croki Post Office near Ghinni Ghinni Creek crossing



Typical farm setting on Jones island



Open pasture lands with scattered fig trees

FIGURE 10 **Typical Elements of The Existing Landscape**

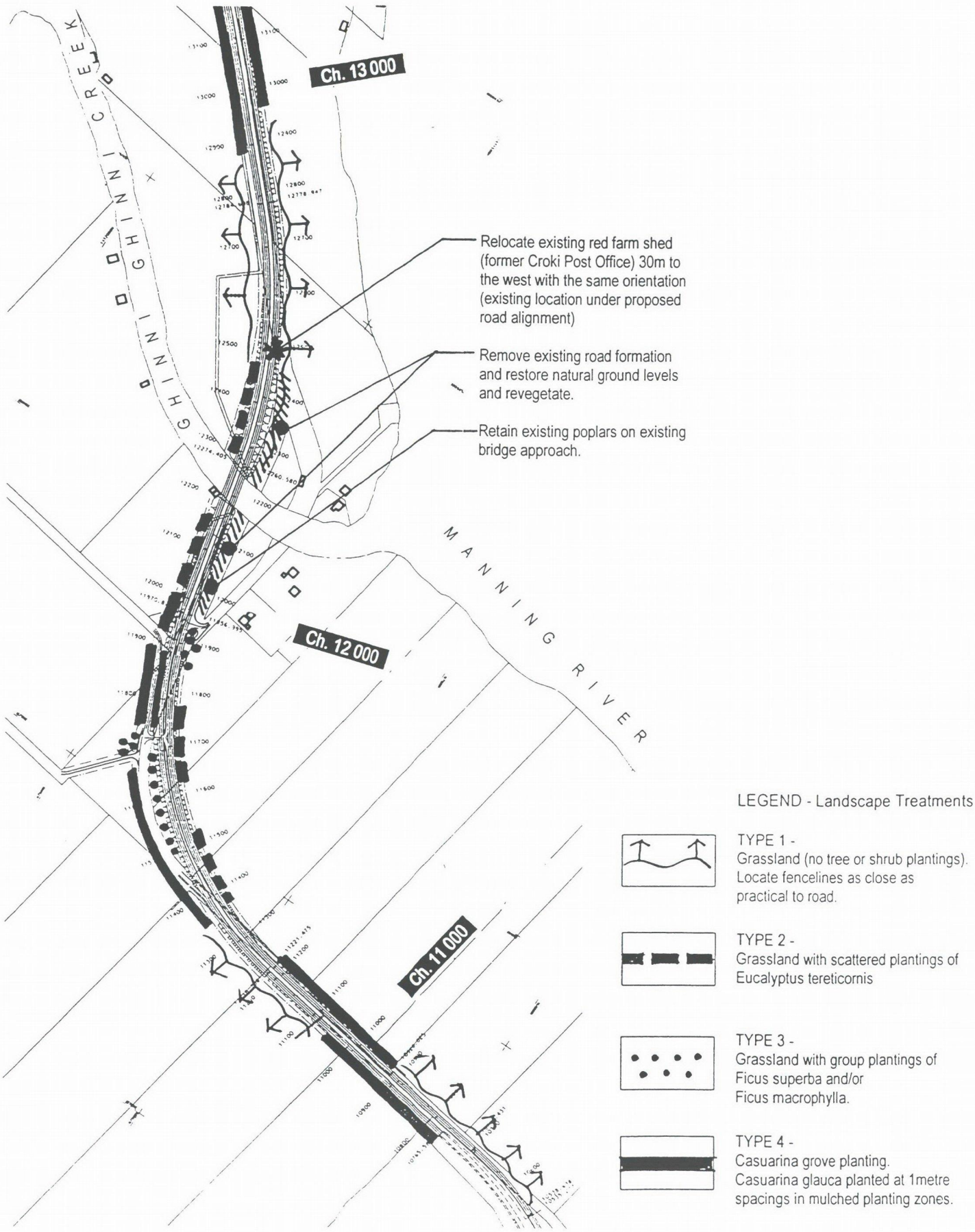


FIGURE 11 **Landscape Concept** (Sheet 1 of 3) **Ch - 10 700** (Taree By-pass 'Tie-In') - **Ch.- 13 000**

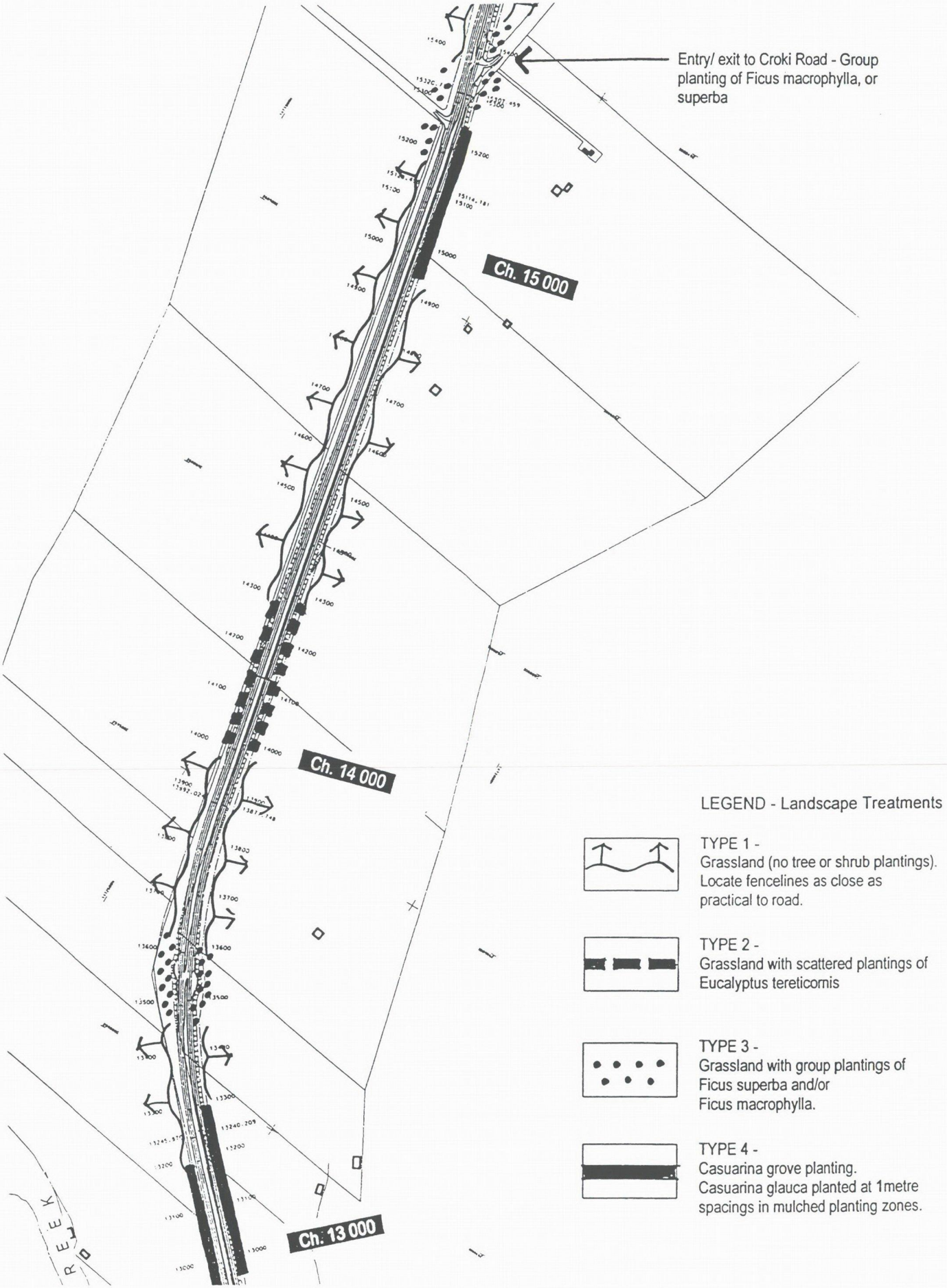


FIGURE 12 **Landscape Concept** (Sheet 2 of 3) **Ch - 13 000 - Ch.- 15 400**

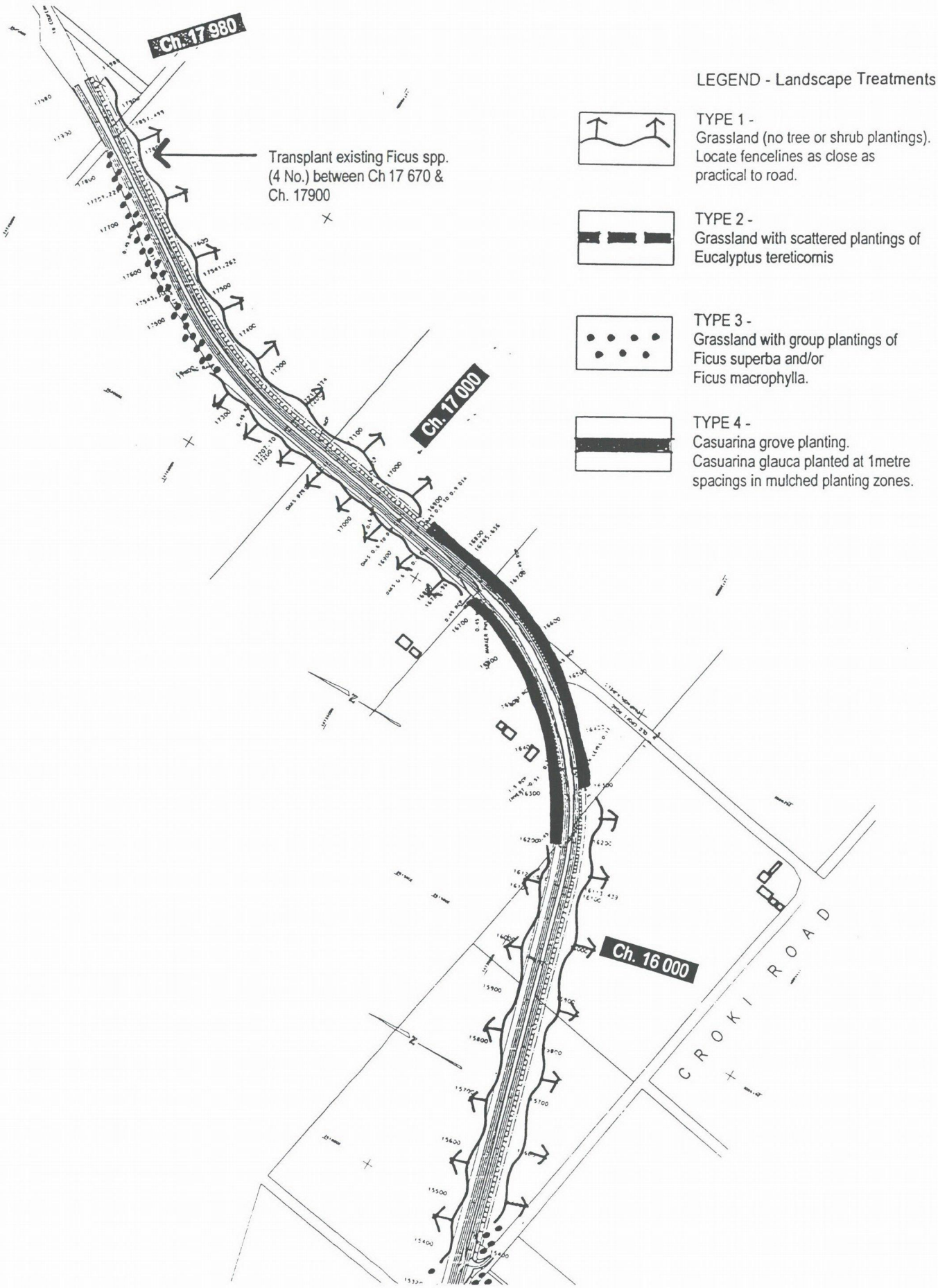
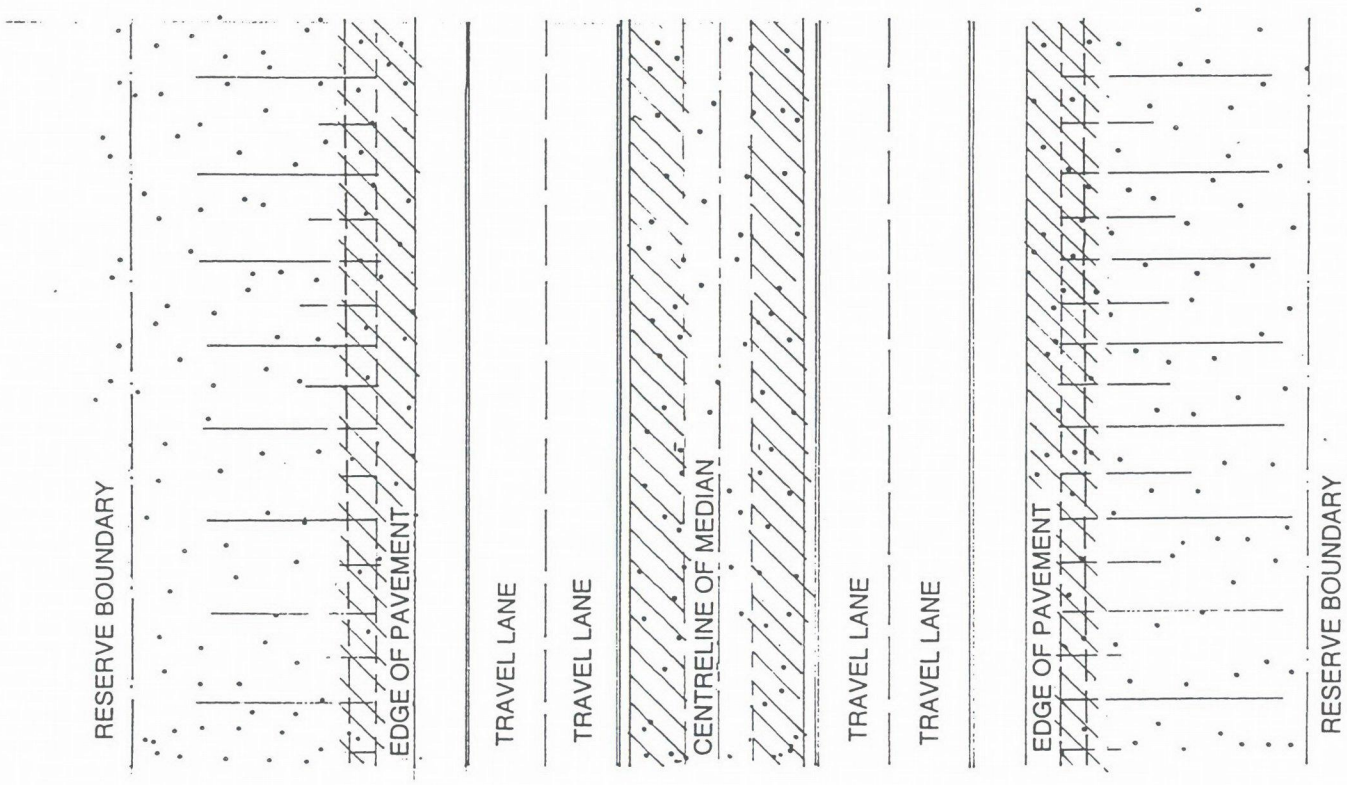
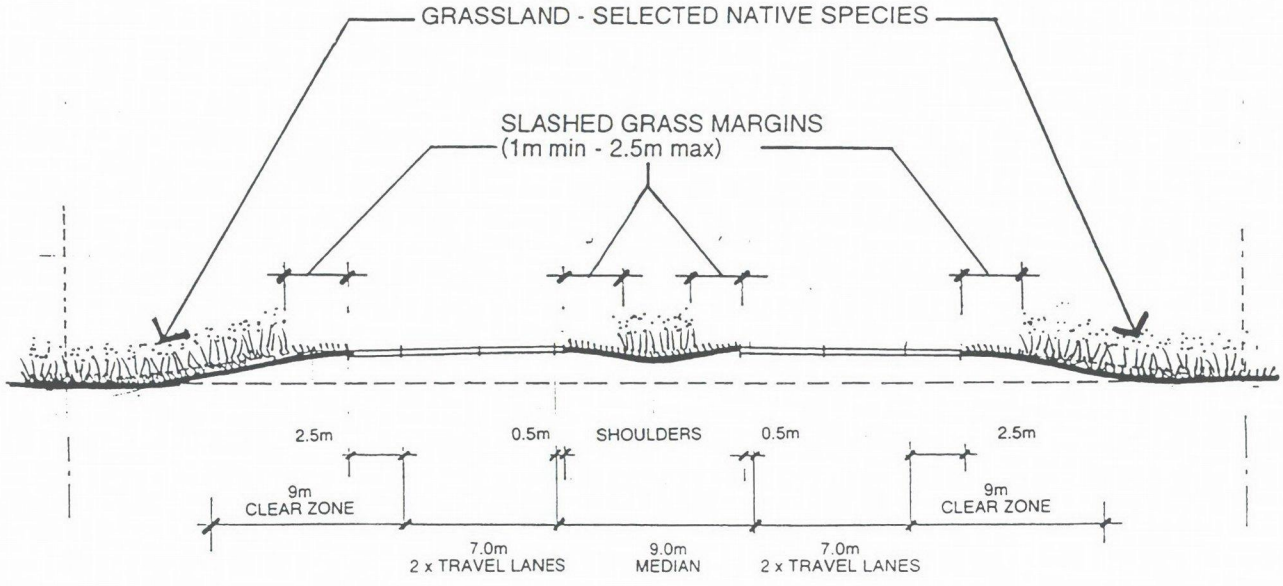


FIGURE 13 **Landscape Concept** (Sheet 3 of 3) **Ch - 15 400 - Ch.- 17 980**

SLASHED GRASS MARGINS

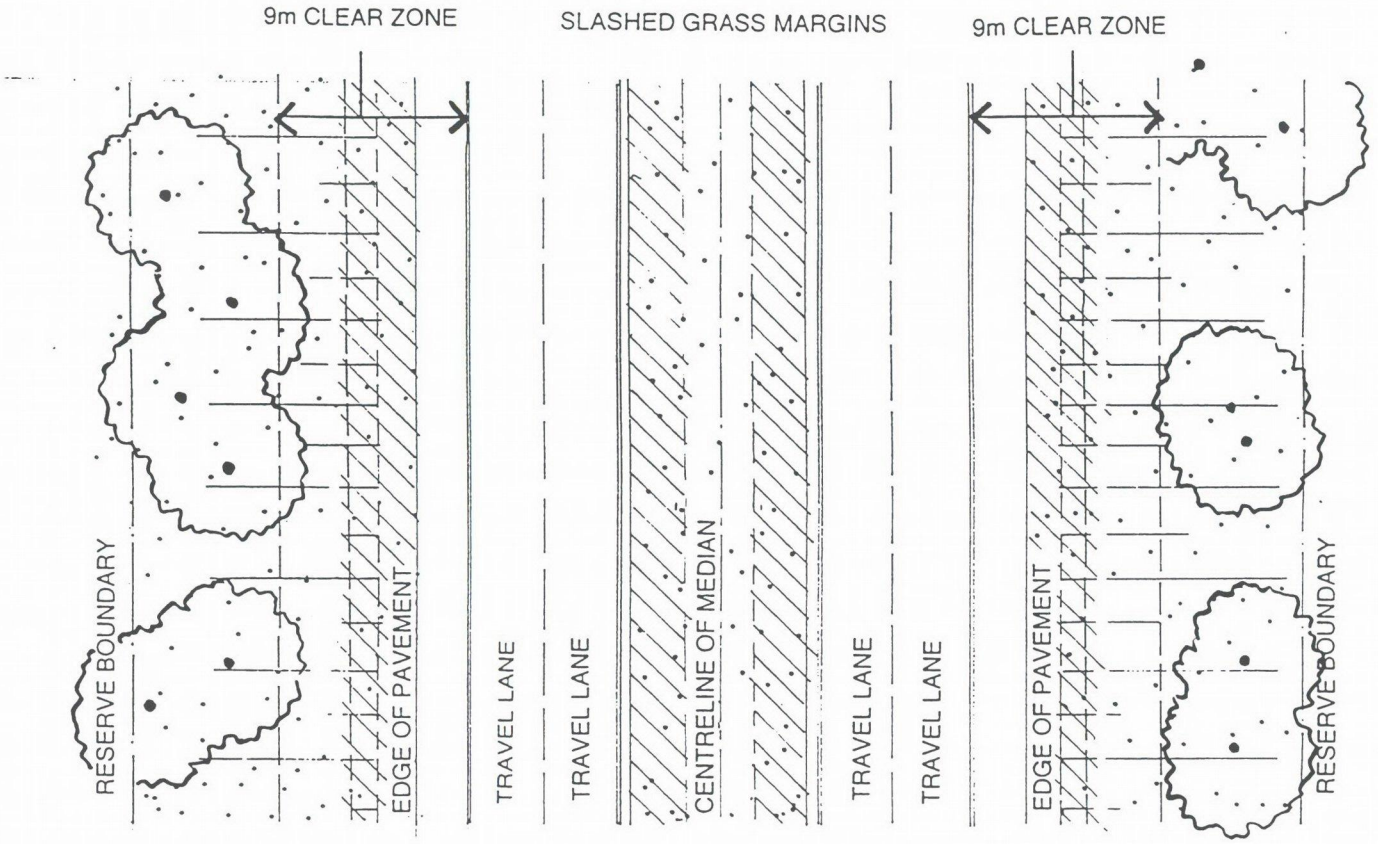


PLAN nts



TYPICAL SECTION nts

FIGURE 14 **Typical Landscape Treatment - Type 1**



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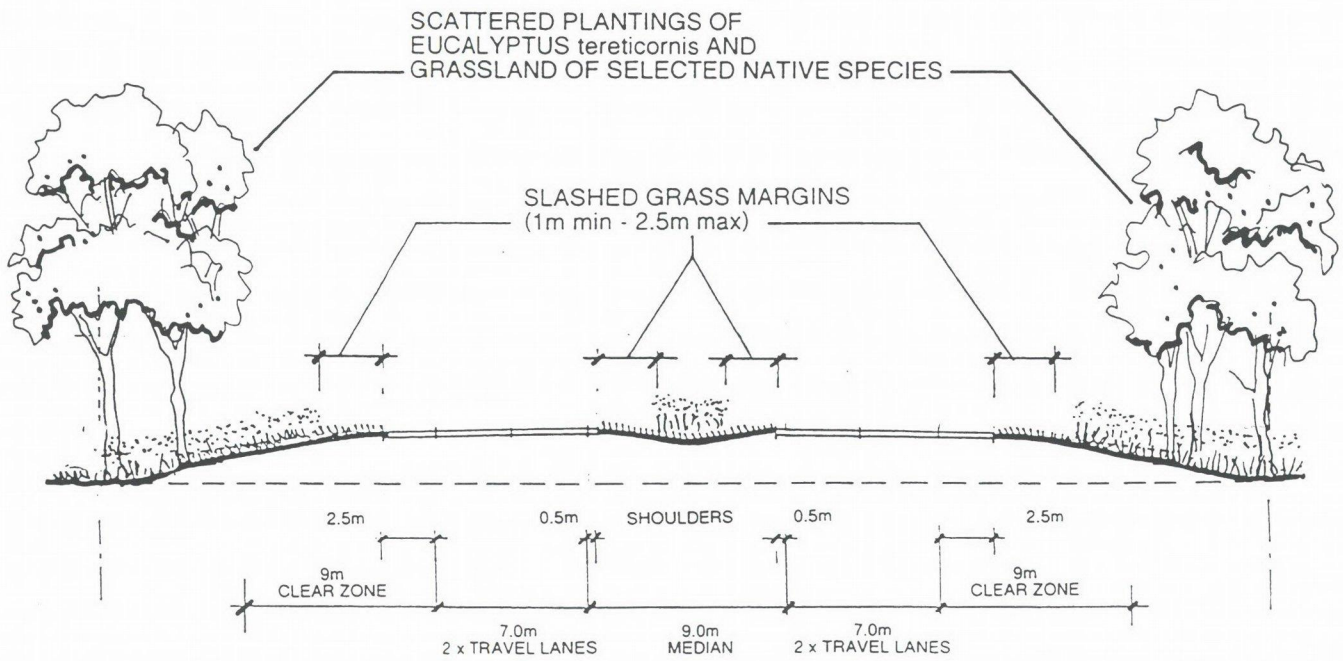
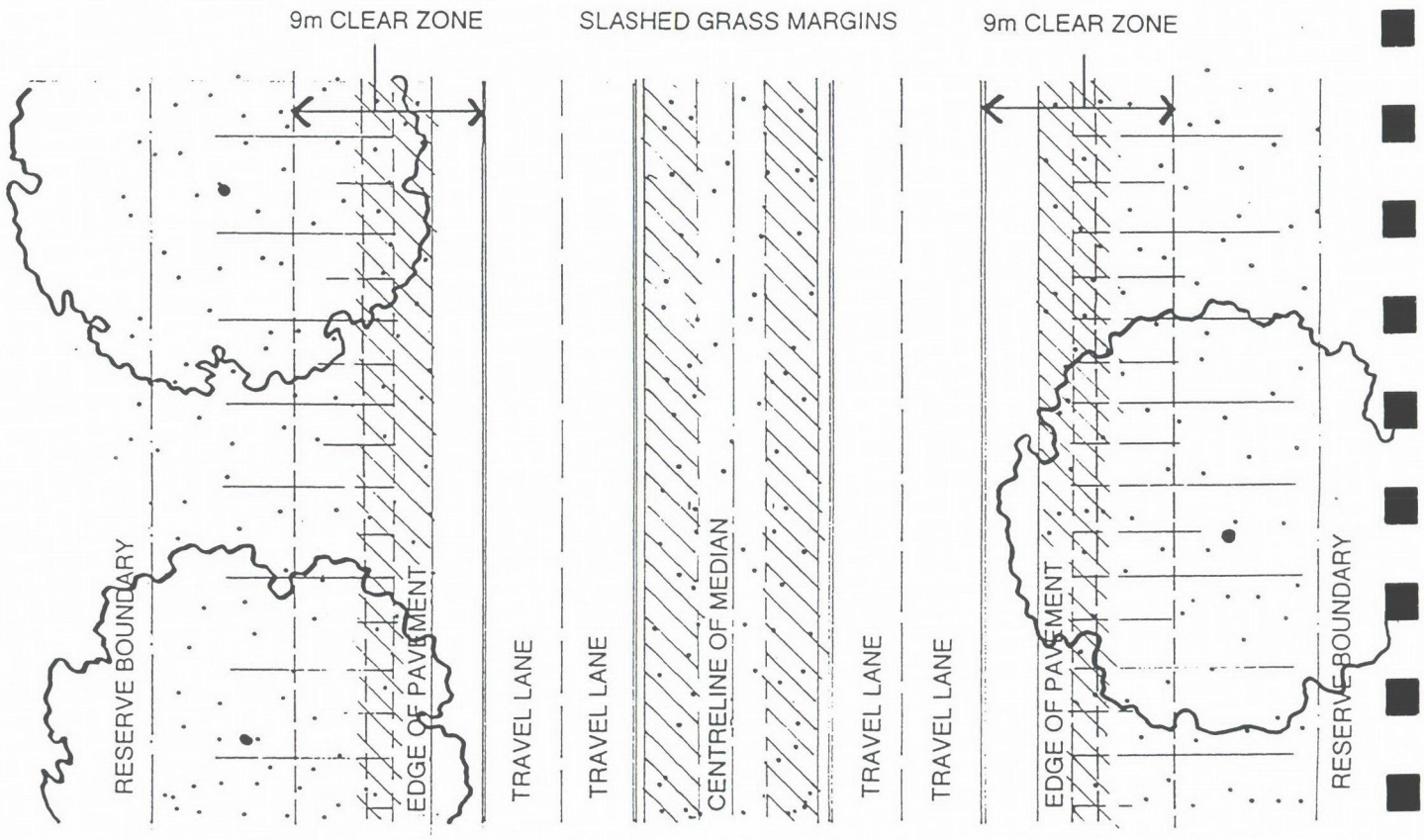
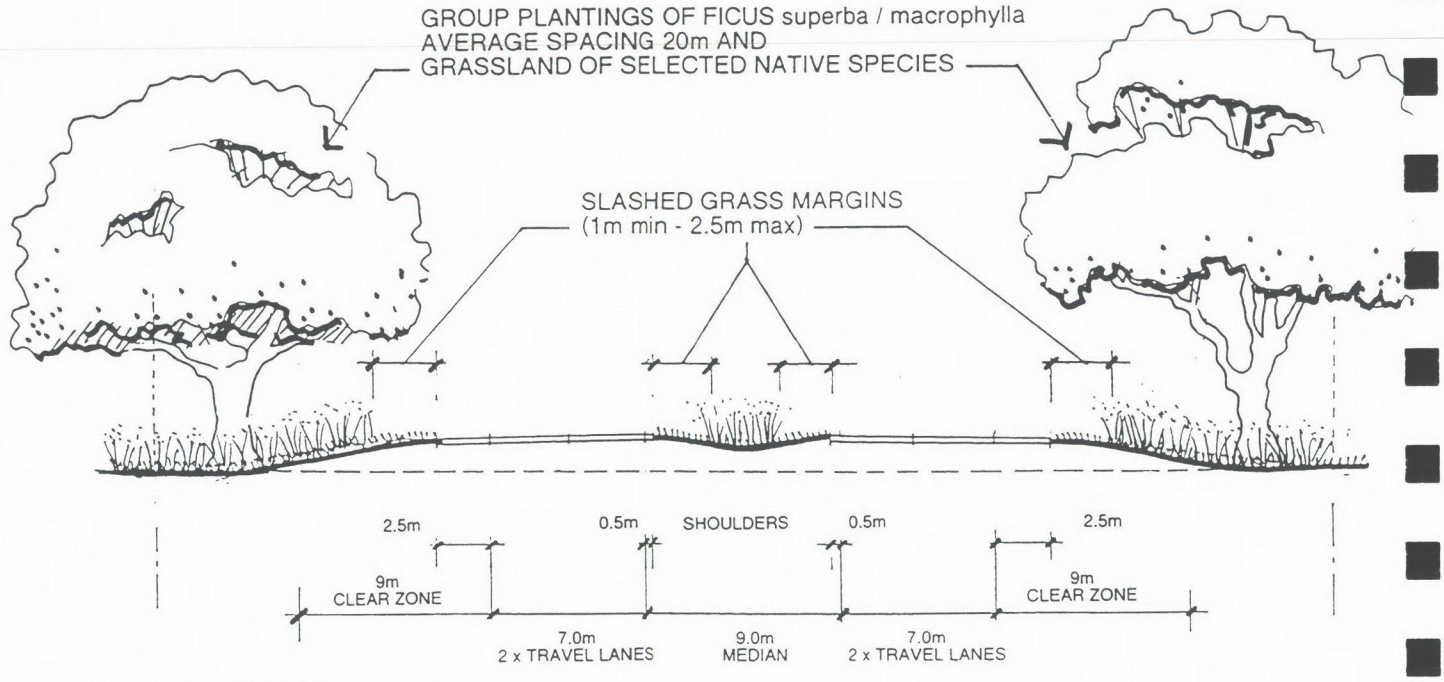


TYPICAL SECTION nts

FIGURE 15 **Typical Landscape Treatment - Type 2**



PLAN nts



TYPICAL SECTION nts

FIGURE 16 **Typical Landscape Treatment - Type 3**

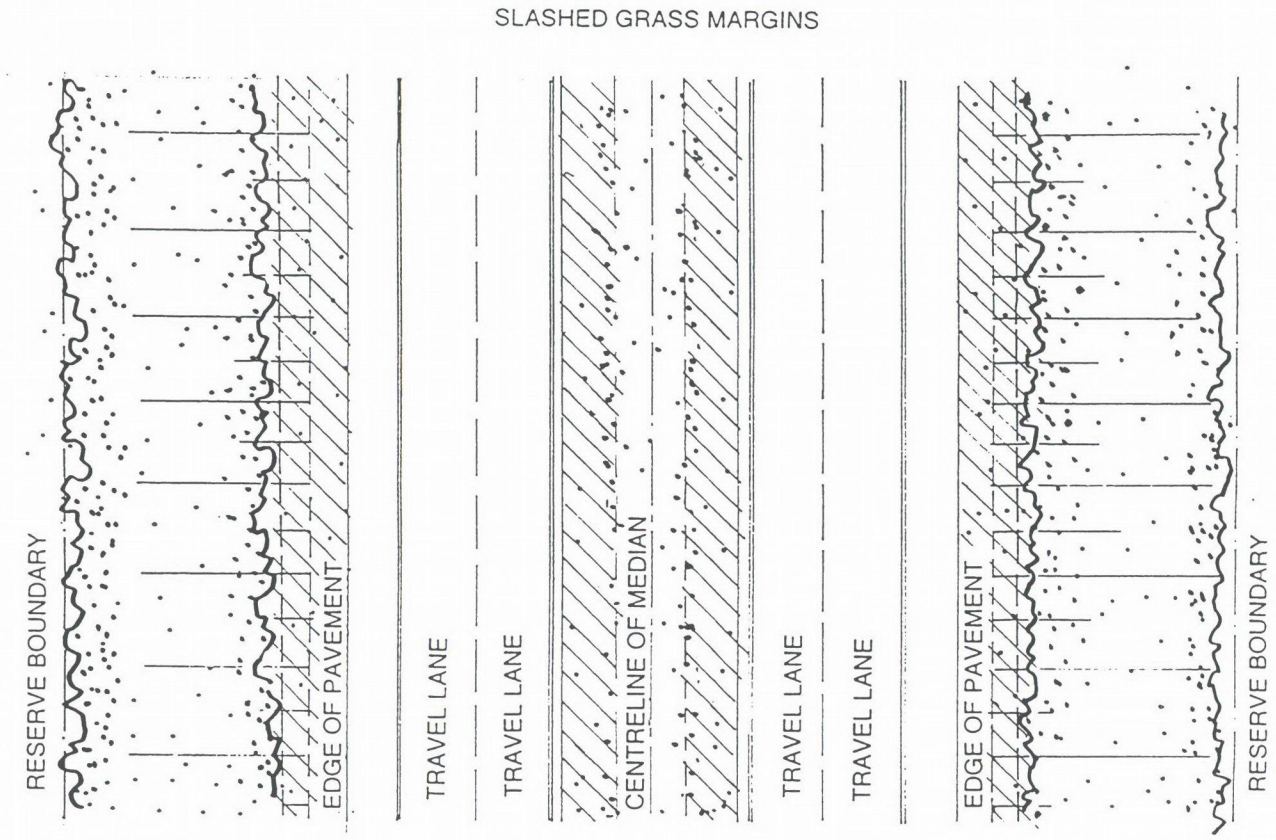
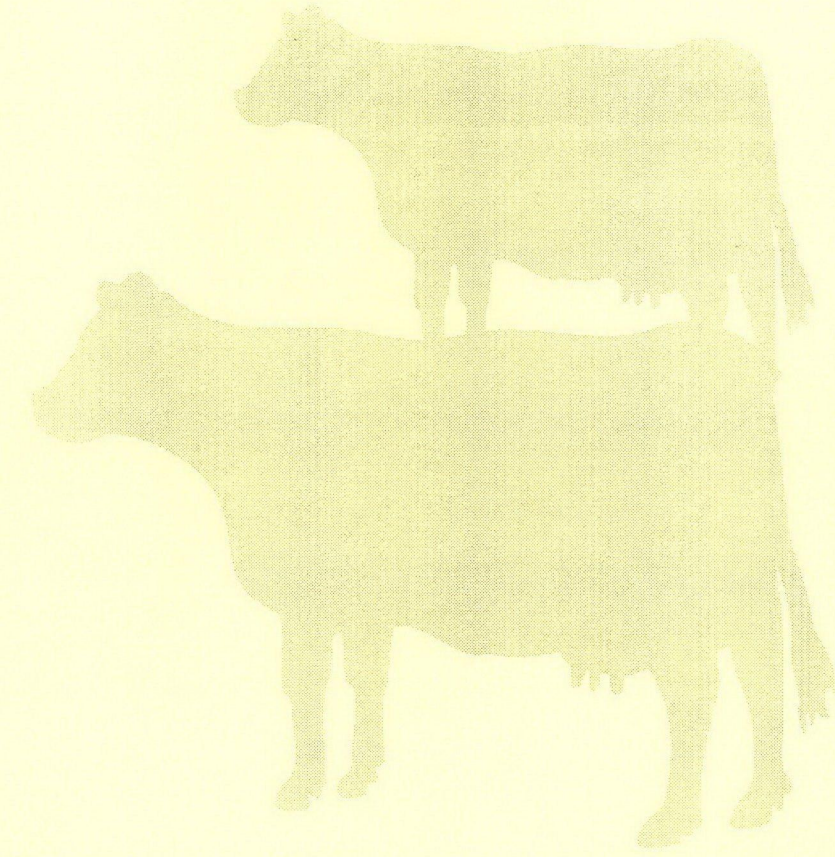
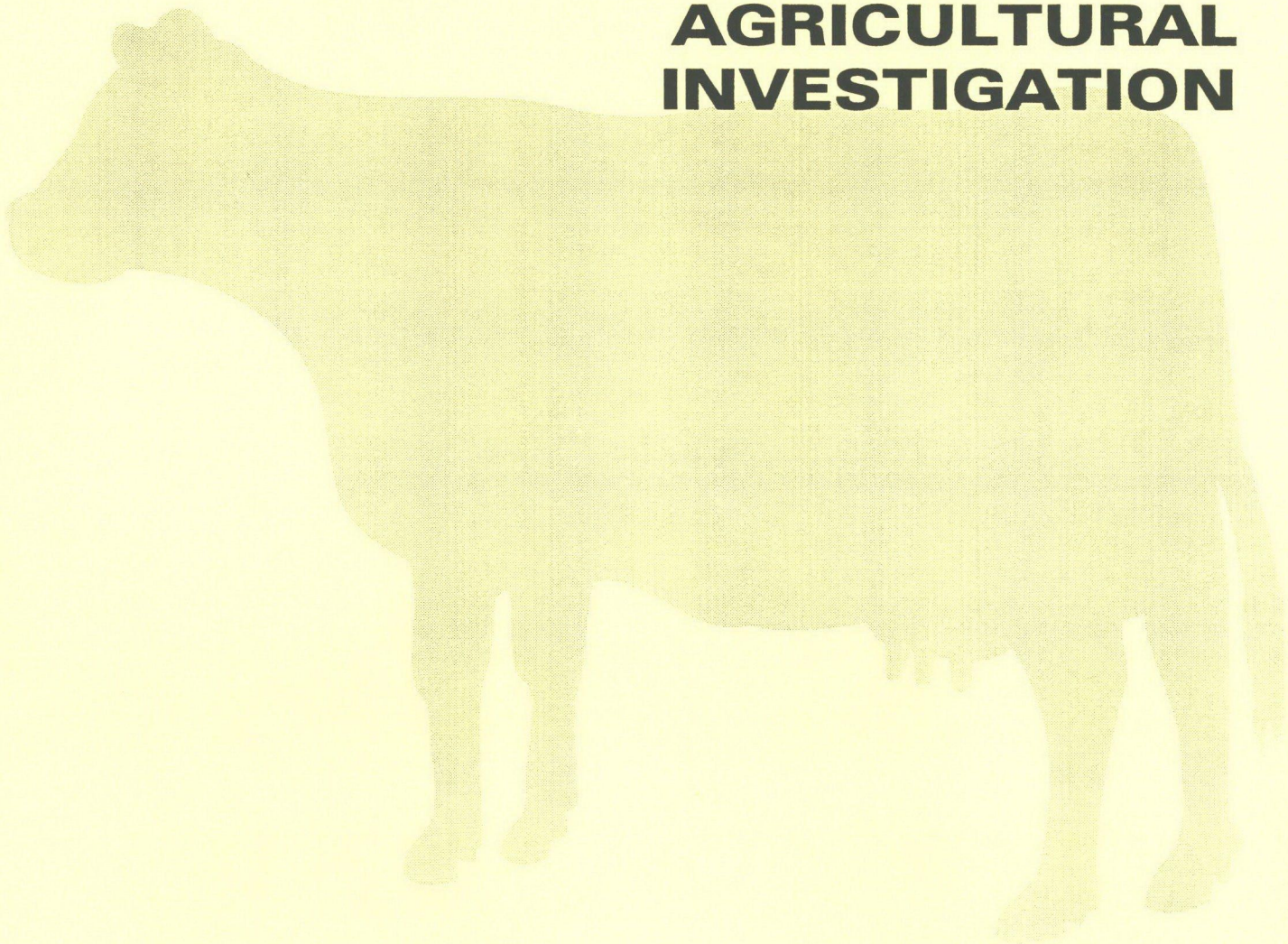


FIGURE 17 **Typical Landscape Treatment - Type 4**



P

AGRICULTURAL INVESTIGATION



AGRICULTURAL ASSESSMENT:

TAREE TO COOPERNOOK

PACIFIC HIGHWAY UPGRADE

Prepared for

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OCTOBER 1998

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Executive Summary

Hassall & Associates has assessed the likely agricultural impacts of the proposed Pacific Highway Upgrade, between Taree and Coopernook. The assessment covers the impacts on both the agricultural resources and the agribusiness and property management effects on properties in the study area.

The highway upgrade proposal links the Taree and Coopernook bypasses, and upgrades the existing road to dual carriageway. The proposal for most of the study area, follows the existing highway and duplicates it. This results in a wider road corridor, with land loss of up to 30 metres. The proposal straightens four corners in the study area, resulting in more significant losses of land at these locations. Although direct land loss is the most visible impact of the proposal, landholders are also impacted by losses in production, infrastructure, drainage, access, changes to management (planning), noise and other impacts.

Most of the land within the study area is Land Capability Class IV and Agricultural Suitability Class 3, which indicates the prime use should be extensive grazing. The higher ground is Land Capability Class III (Agricultural Suitability 2), which indicates limited cultivation is possible. Some of the ground is permanent wetland or drainage areas, and hence can only at best be occasionally grazed. The main industries in the study area are dairy (52% of properties surveyed) and beef (35%), and are therefore the most affected by the proposed road.

The impact of the proposal is significant on individual properties, particularly on beef operations as a proportion of production, but quite minor on the regional resources. The total value of lost production due to land loss represents approximately 2% of the value of study area production and less than 0.4% of regional production.

Most landholder surveyed anticipated compensation negotiations and reasonable outcomes. The most commonly mentioned amelioration measures included:

- Replacement of lost infrastructure;
- For landholders to be kept informed of plans and time lines;
- Minimising extra travel time by having turning bays as close as possible to each landholders access;
- Maintaining existing drains and assure drainage;
- Flood proof mounds to be established to replace lost high ground;
- Access tunnel to be provided for cattle access;
- Plant trees to minimise noise and dust disturbance;
- Providing turning, all weather and access to highway for trucks; and
- Maintain access and services during construction.

The amelioration measures supported for each individual landholder are detailed in a supplementary report and not in this report due to confidentiality issues. However, our experience indicates that reasonable mitigation measures would be adequate to minimise or negate the impact on agriculture of the proposed highway upgrade.

1. Introduction

Hassall & Associates was commissioned by Connell Wagner to undertake an agricultural assessment to determine the likely impacts of the Pacific Highway upgrade proposal between Taree and Coopernook. The agricultural assessment determined the effect of the highway upgrade proposal both on the agricultural resources of the study area and the agribusiness and property management effects of the proposal on the study area properties.

The scope of the study was to:

- Discuss the value of the agricultural resources of the study area in their local and regional context.
- Assess the impact of the proposal on the agricultural resources of the study area.
- Determine and map the agricultural suitability and land capability classifications of the study area.
- Determine the scientific/agribusiness/property management impacts relevant to each potentially affected property in terms of effect on:
  - the property management system
  - loss of land
  - loss of income
  - other impacts of the proposal
- Report on any consultation with property owners with respect to perceived agribusiness effects and potential amelioration measures.

The results of consultations with property owners, including information on current land use, agricultural enterprises and individual landholder concerns regarding the highway upgrade proposal were collected and non confidential information is presented in this report.

Land Capability and Agricultural Suitability Maps for the study area accompany this report (Appendix 1).

Standard multipliers used in the report are detailed in Appendix 2.

2. Methodology

Our methodology followed five steps, namely: assessment preparation, land capability mapping, field visits for landholder interviews, analysis of responses and assessments and documentation.

Assessment preparation included liaising with Connell Wagner to confirm all relevant regional information, and preparing for field visits. The preparation of Land Capability, Agricultural Suitability and Land Use maps of the study area were completed to a 1:25,000 scale.

Field visits were conducted over three days in August, utilising three team members. In consultation with Connell Wagner, there were 30 landholders identified as potentially affected by the proposal.

Telephone contact was made with each landholder prior to field visits in order to make appointments and clarify ownership, leasing and sharefarming arrangements. This process resulted in 24 surveys being undertaken, where 6 identified properties were either owned or being leased by a landholder already being surveyed. Two landholders were surveyed via the telephone due to their unavailability during the time our team was visiting the study area.

One of the surveyed landholders had been included as part of the assessment process for the Taree Bypass, and this proposal did not further impact on the property. Hence this survey was omitted from our analysis. Our report therefore presents the results of 23 surveys.

3. Land Capability

The rural land capability of the study area is predominantly Class IV, suitable for extensive grazing, with some of the high ground Class III, suitable for limited cultivation. There are significant areas of Class VII land, permanent wetlands/drainage.

The agricultural suitability matches the land capability and is predominantly Class 3, suitable for grazing, with some Class 2, limited cropping and Class 5, limited agricultural use.

It should be noted that:

- The Jones Island area has a high presence of high risk acid sulfate alluvial soils with limited agricultural suitability. These soils require high management inputs to utilise the high rainfall potential. The area is fringed by a limited area of levee soils that have already been recognised as domestic and intensive "hobby" agricultural development zones. These would not interfere with the Pacific Highway deviation proposals.

- Jones Island has shallow water tables with high risk acid sulfate soils which are a separate consideration for engineering and construction. The rural land capability and agricultural suitability investigations carried out were limited to landscape physiography, the topsoil and immediate subsoil in terms of drainage and water logging.

- Some small scalded areas were noted on the floodplain area, but it was not possible to delineate them as groundwater or tidally induced. The mapping scale was intensified for these environmentally significant sites, where appropriate, and identifiable.

The methodology and maps are presented in Appendix 1.

4. Value of Agricultural Resources

Local and Regional Agricultural Resources

Locally the study area is part of the Greater Taree City Council, which covers Taree and the Manning Valley. Its main centres are Taree, Wingham, Old Bar, Harrington and Hallidays Point. The local government area has a resident population of 45,000 and an annual average growth rate of 2.1%. The main industries are manufacturing, value-added agriculture, retailing, timber and forestry (Mid North Coast Regional Development Board – MNCRDB 1998). The dairy industry dominates agriculture in the local Taree area. National Dairies, one of the State's leading dairy food processors, produces $36 million worth of value added products annually from its Taree factory, which creates 300 full-time equivalent jobs and operates seven days a week (MNCRDB). The New South Wales Dairy Corporation recognises the significance of the area, basing its northern region office in Taree. North coast milk production reached 364 million litres in 1996/97 (NSWDC 1998).

Regionally the study area is part of the Mid North Coast, its major centres being Taree, Port Macquarie, Kempsey, Nambucca and Coffs Harbour. It has a population of 221,000, which represents 3.7 % of the NSW population, and is projected to grow strongly to 333,000 by 2021, a 55 % increase (MNCRDB).

Agriculture plays a major role in the Mid North Coast's economy. The region has an annual gross output of well over $150 million, seven major rural cooperatives, many hundreds of productive farms and rural services industries. The dairy, timber, beef cattle and fishing industry dominate, featuring value-added and export oriented production. Newer alternative crops such as hydroponics, tea-tree oil production and cut flower growing, are gaining greater acceptance, capturing viable niche markets.

Dairy - The region's dairy herd represents 17% of the state milking cows in an area of just 6% of the state's agricultural land. The region supports processing facilities in Taree. The NSW Dairy Corporation indicates that production from the Mid North Coast, which is supplied to factories at Taree, Comboyne, Wauchope and Gloucester, supported 25% of the States dairy farms in 1997/98. Production data includes trends in production since 1992/93 is included in the table below.

Table 1 Regional Dairy Production Statistics – Taree and the Mid North Coast

1997/98	No. of farms	% change since 1992/93	Milk (litres)	% change since 1992/93	% of NSW production
Taree	232	13%	103,931,733	66	8
Mid North Coast	459	5%	203,033,453	42	16
NSW	1817	-7%	1,236,025,009	25	100

Source: NSW Dairy Corporation

Despite a fall in the number of farms State wide, both the Mid North Coast and Taree have experienced an increase in farm numbers.

Timber - The hard wood timber industry is one of the most important in Australia, it is involved in value-adding processes such as solar powered kiln drying, furniture making, high quality finishing timbers and hardwood timber plantations.

Beef and pork – There are several abattoirs in the region, including the large Mitsubishi-owned Midco Meat Company, at Macksville, with over 400 staff and the Japanese owned Wingham Export Abattoir.

Fish, seafood and aquaculture - The fishing industry has major ports at Coffs Harbour and Crowdy Head, near Taree. Oyster production and processing local product for domestic and export markets also support the industry. There is also an emerging aquaculture industry targeting lucrative export markets.

Bananas, avocados, blueberries and nut crops - Bananas are a well-established crop with at least $50 million produced annually. Growing industries also include blueberries ($7 million annually), avocados ($3 million), stone fruit ($3 million), pawpaws, limes, citrus and passionfruit. Nut crops in the region have production approaching $1 million. (MNCRDB)

Study Area Agricultural Resources

Agricultural enterprises currently being operated by the surveyed landholders include dairy production and the grazing of cattle, sheep and horses. The rural land capability and agricultural suitability assessment of the study area indicates the area is suitable for extensive grazing, with limited cultivation/cropping. There are also significant areas of permanent wetlands/drainage which have limited agricultural use.

12 of the 23 landholders surveyed operated dairy enterprises, eight had beef enterprises and one operated a sheep grazing enterprise. Two landholders had total areas of less than 1 ha and nominated no agricultural enterprises. Dairy production is the predominant land use in the study area, reflecting the local and regional trend. The remaining enterprises are dominated by beef production.

Dairy operations are predominantly family farms and sharefarming is common. Landholders surveyed included third, fourth and fifth generation dairy farmers. The study area, particularly on Jones Island is prone to flooding and landholders accept this as part of there operations routine. The area has acid sulfate alluvial soils which require a high level of management expertise. Typical of small holdings and family operations, landholders in the study area had pride in the quality of their stock and production and were proud of their heritage in the area.

Value of Agricultural Resources

The value of agricultural resources in the study area was estimated as the net present value of agricultural production from all landholders surveyed. Based on information gathered on property size, current enterprises undertaken and local gross margin results for agricultural enterprises, the study area has a net present value of agricultural production of $19 million. The net present value is based on a 15 year period at a 5% interest rate. Dairy production is the predominant land use in the study area and accounted for $18.24 million of the total net present value.

The value of agricultural resources in the local area and region was assessed based on the Greater Taree statistical local area, in the Mid North Coast Statistical Division, as used by the Australian Bureau of Statistics (ABS). ABS regional statistics for 1996/97, indicate a gross value of agricultural commodities produced in the Greater Taree area of $49 million.

For relevance to the study area and due to their predominance in the region, only dairy and beef cattle production was assessed to determine the value of agricultural resources of the region. Milk production and cattle/calves slaughtered data was obtained for 1996/97 from ABS and for comparison with study area data was analysed to produce net present value figures for the region.

The gross value of milk production, $32 million, results in a annual gross margin figure of $17.5 million (Dairy Farmers 1998). The net present value of dairy production in the Greater Taree area is assessed to be $181 million. The gross value of cattle/calves slaughtered, $8 million, was analysed assuming a weaner production system, resulting in an annual total gross margin of $4.3 million (NSW Agriculture 1997). This gives a net present value of beef production in the Greater Taree area of $45 million. The total value of production of dairy and beef enterprises in the Greater Taree region is $226 million.

Future Value of Agricultural Resources

A significant pressure on the dairy industry of the Taree area, results from the deregulation of milk pricing and distribution (beyond the farm gate) in NSW and Queensland. As a result of the deregulation, the NSW Dairy Corporation recently dropped its producer price for fresh milk by 3 cents/litre or 6%, the first decline in more than a decade. The drop was in anticipation of pressure on retail and processor margins and to 'narrow' the gap between Victorian and NSW milk prices.

A review into farm gate pricing will report in November 1998, which may impact further on producers. Removal of farm gate pricing would expose producers to greater volatility and put pressure on the least efficient and smallest third of the industry. However current indications are that farm gate pricing is likely to be maintained in NSW for at least a few years.

Internationally, our dairy industry relies on the SE Asian market for exports where 60% of exported milk powder and butter go to ASEAN countries. Dairy companies in Australia are feeling some pressure on volumes and prices of exported products (Westpac 1998).

The June quarter commodities outlook reported that strengthening international demand for dairy products and the stabilisation of manufacturing milk prices in Australia, were the key influences on the industry. Expansion in Australian milk production is expected in 1988-89 to continue at 3% based on average seasonal conditions. This growth is based on continued improvement in milk yields and to a lesser extent an increase in cow numbers (ABARE 1998).

The outlook for the beef and veal industries is that demand in Pacific Rim beef markets is expected to remain subdued in 1998-99, particularly in the Asian markets. Beef prices are expected to rise, due to herd rebuilding, however volume of exports is expected to decline with value remaining static. Exports are likely to be diverted away from the SE Asian market towards the US and North Asia (ABARE 1998).

The highway upgrade proposal will have a negligible impact on the regions dairy and beef production. These industries faces far greater challenges from within industry issues such as the removal of farm gate pricing and trends in national and international dairy product markets and the impact of the Asian economic crisis on Australian beef exports.

5. Impact on the Agricultural Resources in the Study Area

The highway upgrade proposal links the Taree and Coopernook bypasses, and upgrades the existing road to dual carriageway. The proposal follows the existing highway, through most of the study area, resulting in a widening of the existing road area, with a land loss of up to 30 metres. The proposal straightens four corners in the study area, resulting in more significant losses of land at these locations. Five parcels of land impacted by the proposal are currently owned by the RTA. Three of these are currently leased to local landholders and utilised for agricultural production.

Although direct land loss is the most visible impact of the proposal, landholders are also impacted by the following items.

Loss of production on the remaining landholding: In addition to the direct loss of land, there are losses in the production from the changed holding. The amount and location of land severed will determine the lost production potential on the remaining holding.

Loss of infrastructure: The infrastructure affected included stockyards, gravel roads and laneways, sheds, cattle grids, gateways, turning bays, troughs, a dam, piping across drains, fences, shade trees and other trees. It was assumed that replacement of directly affected infrastructure/improvements will proceed according to RTA acquisition policy.

Changes to access: Only agricultural access was considered, such as impacts on moving stock and machinery, although a number of landholders commented that they would have extra traveling time and inconvenience to go to town (Taree). The following assumptions have been made with respect to access:

- All landholders will have continuous access to and from their properties during construction of the highway;
- All access to properties from the highway is semi trailer and milk tanker friendly; and
- In the case of three landholders who have landholdings on both sides of the highway, an access tunnel for stock, will be available.

Changes to management: These impacts are outlined in the Section 6.

Changes to drainage: A number of landholders were concerned that the road would act as a wall and cause drainage problems. It was assumed that there would be negligible impacts on existing drainage due to the construction of the proposed changes due to amelioration (Connell Wagner 1998).

Noise and other impacts: Noise and dust impacts from construction were mentioned by a few landholders. Noise during operation was also recorded. One landholder mentioned an aesthetic loss from the raised road.

The total impact of the proposal is significant on individual properties but quite minor on the regional resources. The total value of lost production due to land loss represents approximately 2% of the value of study area production and less than 0.4% of regional production.

6. Property Management Impacts

Survey Responses

Property management impacts could result from any of the impacts under the headings of direct loss of land, loss of infrastructure/improvements, drainage, access to local and farm roads and to and across highway, noise, dust and others.

Only 10 landholders indicated that they believed the proposal would result in a change in property management for them. Costs for property planning are included for each of these ten landholders in Table 1. The remaining landholders indicated they would not have to change their operation, or that the changes were low costs and easily achievable.

Of the landholders affected, three face the prospect of significantly altered day to day management due to the utilisation of a proposed access tunnel for stock to travel from one side of the highway to the other. Should access not be provided and land or some other form of mitigation not be available, then a loss of production is expected.

The utilisation of stock access tunnels, and in one case the shared utilisation of a tunnel, raised an issue of disease control between different dairy herds. Based on discussions with landholders and our experience, dairy herds in the area already share laneways and the need to share an access tunnel would pose no greater disease threat than already exists.

Property management impacts may include loss of stock numbers and redesign of property utilisation, redesign and refencing of paddocks, agisting out heifers, maintaining separate sets of machinery on either side of highway, establishing relationships with small area contractors, rescheduling tanker pick up and milking times.

They may also include negotiation time with sharefarmers, negotiating terms of lease, sourcing and provision of additional feed, looking at alternative enterprises, planning as part of other properties and not having a property available for the purchase purpose.

The provision of the upgraded highway will also provide some property management benefits to local and regional landholders, including improved safety. Should the proposal not proceed it could be anticipated that existing levels of traffic would increase making some current management practices, including stock crossing the highway, more hazardous or impossible.

Past and future enterprises

The majority of landholders indicated that there had been no change in their major enterprise in recent years and that their future goals were to increase productivity and profitability. There was a balance between those who had left the dairy industry more than 10 years ago and those who were recent entrants to the industry.

Most of the current dairy farmers indicated a desire to stay in the industry as long as it remained viable, although most expressed concerns about the recent deregulation. Eight landholders indicated they had been dairy farmers for at least 20 years, with two citing 30 years and one citing 40 years. There were several fourth and fifth generation family operations present.

7. Perceived Agribusiness effects and potential amelioration measures

Most landholders surveyed anticipated compensation negotiations and reasonable outcomes. Discussions with landholders are proceeding on the precise extent of land acquisition and property adjustment coinciding with the preparation of the final proposal design. A round of meetings have been conducted with landholders since the surveys for this report were completed.

All amelioration measures mentioned by landholders were documented. The most commonly mentioned measures included:

- Replacement of lost infrastructure;
- for landholders to be kept informed of plans and time lines;
- to minimise extra travel time by having turning bays as close as possible to each landholders access;
- Maintaining existing drains and assure drainage (see assumptions in Section 5);
- There is potential to improve existing drainage;
- Flood proof mounds to be established to replace lost high ground;
- Access tunnel to be provided for cattle access;
- Plant trees to minimise noise and dust disturbance;
- Providing turning and access to highway for trucks;
- All weather access to highway; and
- Maintain access and services during construction.

8. Conclusion

The study area is a significant area for agricultural production with the Taree region. Most of the land is suitable for extensive grazing and limited cultivation, with some having limited productive capability as permanent wetland The main industries in the study area are dairy and beef and are therefore the most affected by the proposed road.

The impact of the proposal is significant on individual properties but quite minor on the regional resources. The total value of lost production due to land loss represents approximately 2% of the value of study area production and less than 0.4% of regional production.

There will be some significant impacts on individual properties which will require individual consultation and negotiation discussions, however, the small total amount of land lost due to the proposed highway upgrade, will result in a minimal impact on the study area and region that can be mitigated with reasonable measures..

References

Information and data was sourced through personal communication with:

- Andrew Harding – NSW Dairy Corporation, Sydney (NSWDC 1998);
- Graeme Hollis – Dairy Farmers, Taree (Dairy Farmers 1998); and
- John Brockhoff and Kym Buckley– Connell Wagner (Connell Wagner 1998).

Information was sourced from the website of the Mid North Coast Regional Development Board (MNCRDB 1998).

Australian Bureau of Statistics (ABS) – 1996-97 Agricultural Census Data.

Australian Bureau of Agricultural and Resource Economics (ABARE) – Australian Commodities Forecasts and Issues, June Quarter 1998.

NSW Agriculture – Beef Enterprise Budgets 1997.

Dr. Peter Mears – Draft Agricultural Assessment of Proposed Re-Construction of Pacific Highway, Ulmarra. February 1998.

Sanders & Associates Pty Ltd – Report for Pacific Highway of Coopernook. September 1997.

Westpac – Rural Outlook July 1998.

APPENDICES

Appendix 1 - Land capability and suitability

Methodology

- Rural land capability classification was to the standard current method used by the NSW Department of Land and Water Conservation (DLWC), based on the Soil Conservation Service (SCS) of NSW (Cunningham et al, date unknown), which recognises four broad use categories, and are further subdivided into eight classes.
- Agricultural land classification was from the Department of Planning Rural Land Evaluation Manual (1981), and was based on the rural land capability mapping exercise, discussions with the NSW Agriculture District Agronomist – Taree, and various available maps and reports (qv).
- Field mapping of the area was from existing roads and access tracks (railway and forestry). Mapping was directly onto 1:25,000 topographic maps. Cross references were made to existing 1:100,000 rural land capability maps, regional geological, physiography and soil maps (Taree District Manual – SCS of NSW), and the Sate of Environment Report – Greater Taree City Council. Final maps of the study area were prepared on A3 bases from the topographic maps for subsequent digitisation onto a GIS.
- Floodplains in the study area contain extensive areas of Holocene acid sulfate soils found to varying depths. These areas have recently been mapped by DLWC and presented in acid sulfate risk maps. Acid sulfate issues were not included in the past rural land capability assessment classes. It was decoded these potential risk areas did not justify mapping as Class VIII. These soil landscapes could be adequately described within the existing rural land classes.
- As the environmental risk is occasioned by disturbance (eg. removal, drainage, etc.), the sites have particular engineering problems for roadworks which were addressed by White and Melville (1993) to the Roads & Traffic Authority's (RTA) requirements, in an acid sulfate environment.
- The wetlands associated with stream deposition in the Manning River, Ghinni Ghinni and Dickenson's Creeks (the Jones Island area) were all on private lands, and not subject to SEPP 14 conditions. These areas were considerably modified by grazing and drainage activities, some high levels of grazing productivity were evident, based on subjective biomass levels, and grazing intensities, rather than a rigorous economic appraisal.

Mapping units, rural land capability

The following units were used for the final two Rural Land Capability maps produced for the study area:

- **Class II** – land capability, suitable for sustainable crop cultivation, but requiring simple soil conservation management practices such as contour banks, crop rotation and cover crops. Soil profiles were variable in the depth of the sub-soil (often greater than 2 metres), limited areas of shallow rock were noted (ie. Class VI if a mapping area) and at times associated with areas of Class III cultivated land adjoining SF areas.

- **Class III** – land capability, suitable for cultivation, but requiring more intensive conservation measures. Sometimes associated with Class II elevated lands, but indicating shallower red and lateritised podsolic profiles, and limited cultivation in the study area. On floodplain lands, Class III lands were associated with limiting levee formations in the Jones Island area. These levee formations were selected for house/building and urban development (eg. Croki and Ghinni Ghinni) sites with better surface drainage properties, better accessibility and lower flood liability.
- **Class IV** – land capability, suitable for extensive grazing, prone to waterlogging, requiring simple conservation management, principally by the maintenance of ground cover, stock control, suppression of rabbits, fire management and pasture improvement were practical. Soils are minimal podsolic on floodplain country variable timber or opportunistic re-growth.
- **Class VI** – land capability, suitable for grazing, but requiring strict conservation management for protective ground cover maintenance. Soil depth variable to nil, erosion risk from any clearing or stress from heavy grazing.
- **Class VIII** – "other land" capability which is confined in the study area to significant permanent wetlands and natural drainage lineaments in predominantly shallow, high risk acid sulfate alluvial lands. These lands are a valuable grazing resource in extreme dry conditions, and have a high biomass production which can be altered by grazing pressure to favour the more unpalatable species. The soils are usually peaty loams and grey podsols with characteristic moderate to dense wetland plant growth of *Juncus usitatus* and Cyperaceae species.

The scale of mapping on the 1:25,000 topographic maps was a minimum unit of approximately 25 hectares for regular shaped items, but less for lineaments and prominent features.

Mapping units, agricultural suitability

The rationale of this mapping is not compatible with the rural land capability mapping. Based on the value for agricultural productivity, identification and protection of the best agricultural land, and directing land use not compatible with agriculture to areas with the lowest quality lands.

The same rationale applies as for rural land capability classification in that small areas of high quality, being downgraded to be compatible with the dominant mapped unit. The following units were mapped and some details appended for the study area. A minimum of 25 hectares could again be applied for the scale and level of mapping (for an idealised multi-faceted reconnaissance survey):

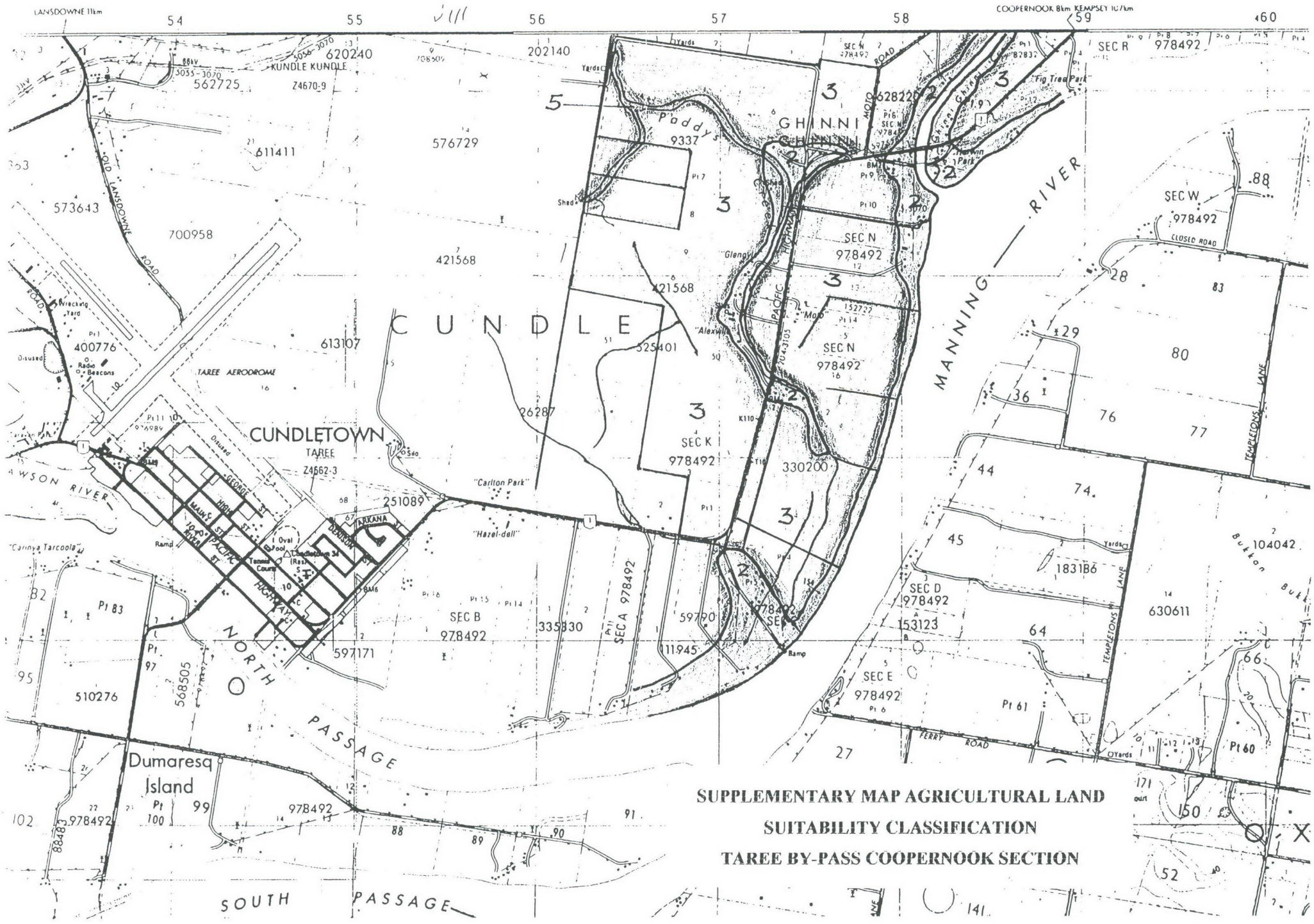
- **Agricultural suitability Class 2** – land suitable for cultivation and cropping, but not suited for continuous cropping or horticulture.

- **Agricultural suitability Class 3** – land suitable for grazing, especially pasture improvement, but constrained by poor profile drainage, periodic water logging necessitating shallow spoon drains. Variable productivity that will require specialised establishment management practices to capitalise on the high rainfall conditions. Soils are usually of low relief and respond poorly to irrigation in urban or closer settlement land use (Croki). Soils are peaty clay loams and grey podsolic, and vary considerably in the Jones Island area.

- **Agricultural suitability Class 4** – land suitable for grazing as native pastures, but not cultivation, productivity is limited and minimum tillage techniques used, localised water logging, land is drainable by shallow surface techniques, problems with some saline scalds, limited grazing potential, poor pasture response, weedy semi-aquatic species invasion (*Rumex crispus*) – minor areas affected, some at the limit of field map definition. Elevated lands normally with limited soil cover, moderate erosion risks without good management.

- **Agricultural suitability Class 5** – extensive wetland areas that are either considered uneconomic to drain, including SEPP 14 wetlands, lineaments that conduct storm and floodwater, limited agricultural value, but could provide valuable biomass for low level grazing at critical times as well as having high environmental vale that meet or encompass the State Wetland policy objectives.

The study area rural land capability and agricultural suitability maps follow.



SUPPLEMENTARY MAP AGRICULTURAL LAND

SUITABILITY CLASSIFICATION

TAREE BY-PASS COOPERNOOK SECTION

Appendix 2 - Standard multipliers used

A. Infrastructure Costs

Infrastructure	Standard multipliers
Shade trees	$ 500
Gravel road	$10,000
Piping	$2,000
Gateway	$ 500
Trough	$ 300
Fence	$ 500
Ramp	$5,000
Shed	$2,000
Stockyards	$20,000
Turning bay	$15,000
Drain	$500
Dam	$2,000
Additional land	at gross margin
Water meters	not quantified

Source: Hassall & Associates

B. Access Costs

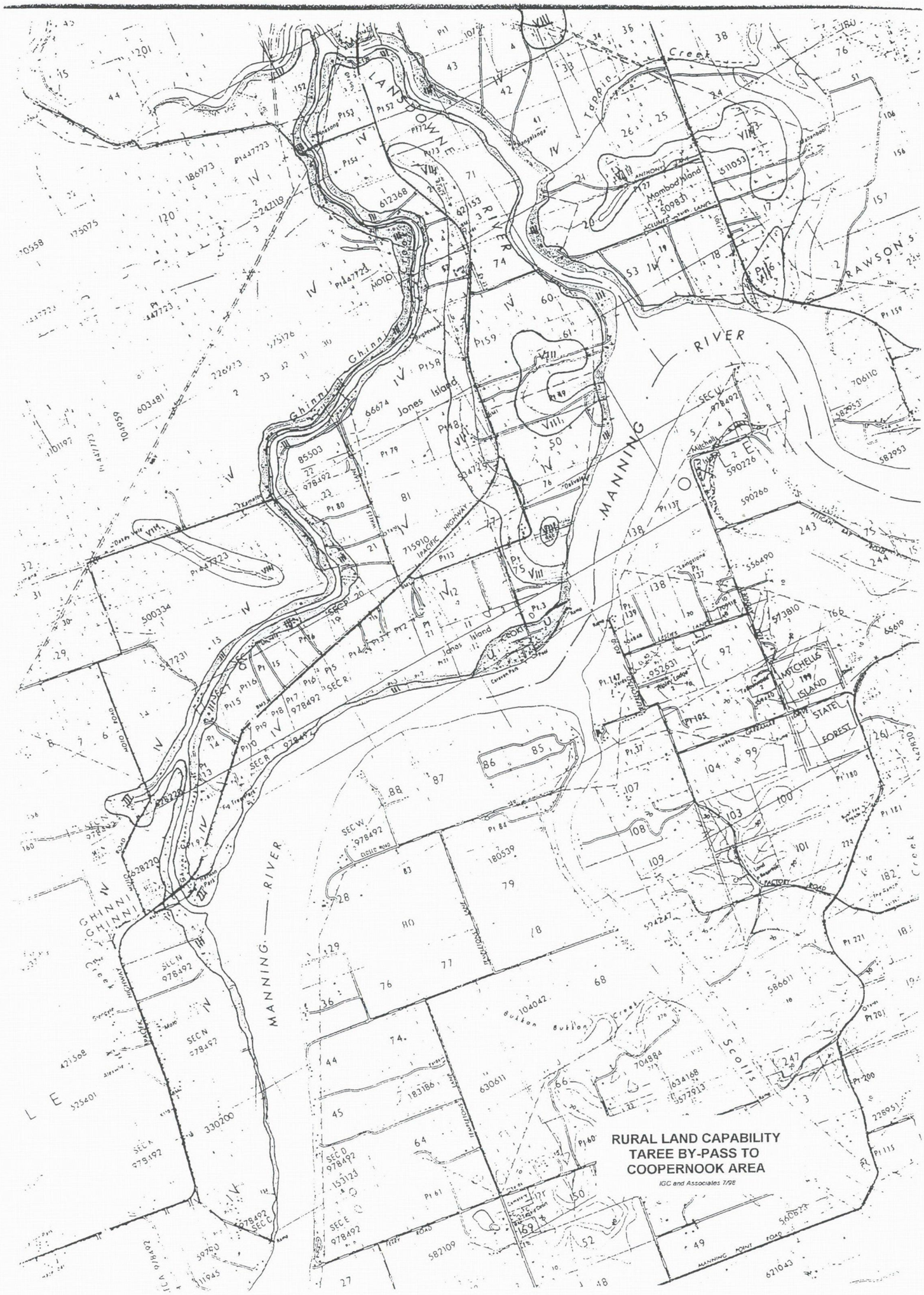
The cost of access issues was based on increased travel time associated with agricultural enterprises due to turning bays replacing direct two way access to the highway for all landholders. The cost to landholders of the increased travelling time was based on the following assumptions, that on average, affected landholders would need to travel an extra 5 kilometres per week, at a total cost (including fuel, depreciation, maintenance etc.) of 50 cents per kilometre. This results in a yearly cost of $130. The net present value of this cost over 15 years at a 5% discount rate is $1,349 per affected landholder.

Source: Hassall & Associates

C. Planning/Other Costs

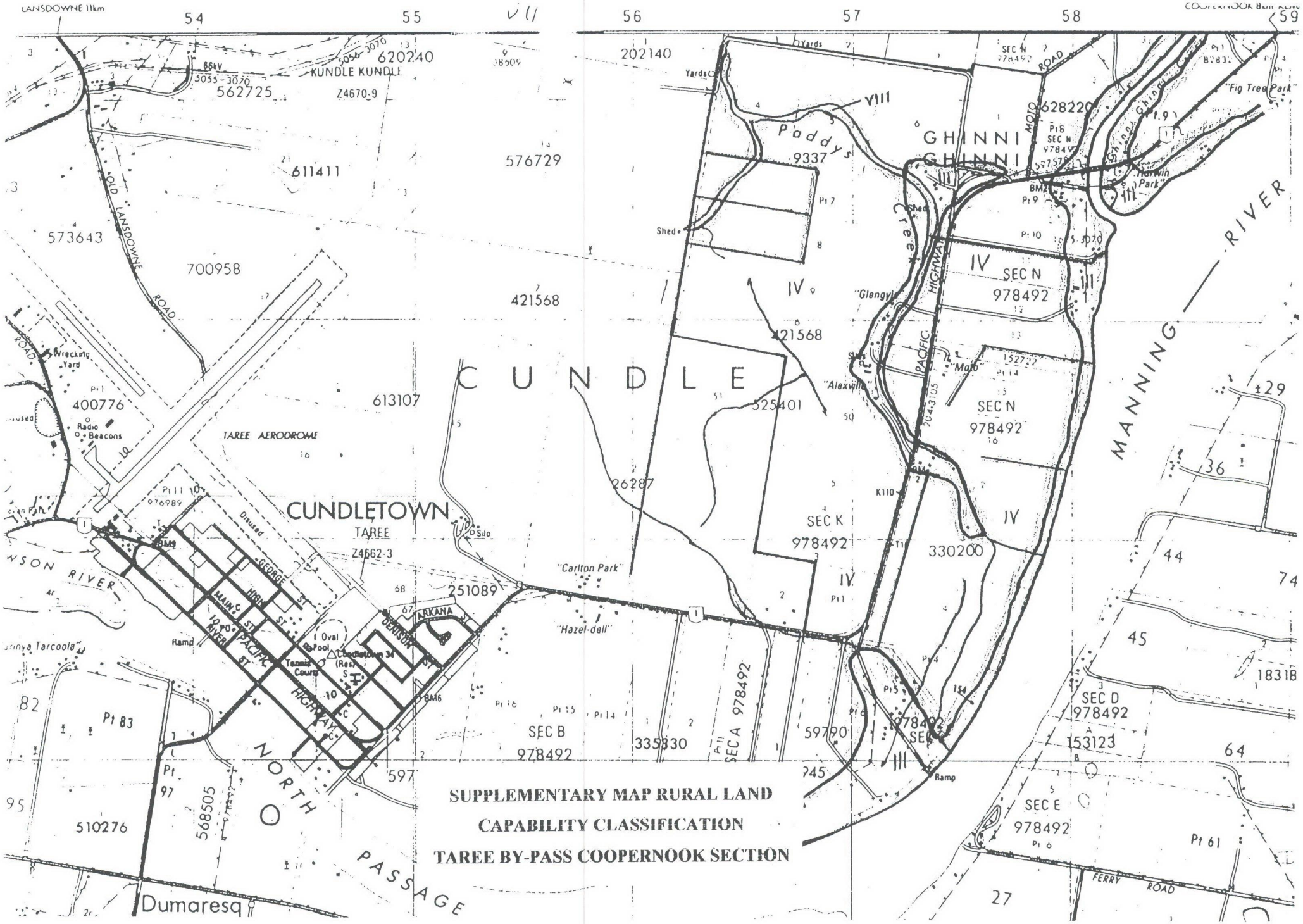
The costs associated with tree planting and the replanning of paddocks were assumed to be $500 and $1,000 respectively. The costs of supplementing lost pasture with hard feed for a dairy herd was calculated based on the percentage increase in hard feed required. The cost per head of that increase was subsequently multiplied by the number of head affected to estimate a total cost figure. This figure was then calculated as a net present value figure over fifteen years with a 5% discount rate.

Source: Hassall & Associates



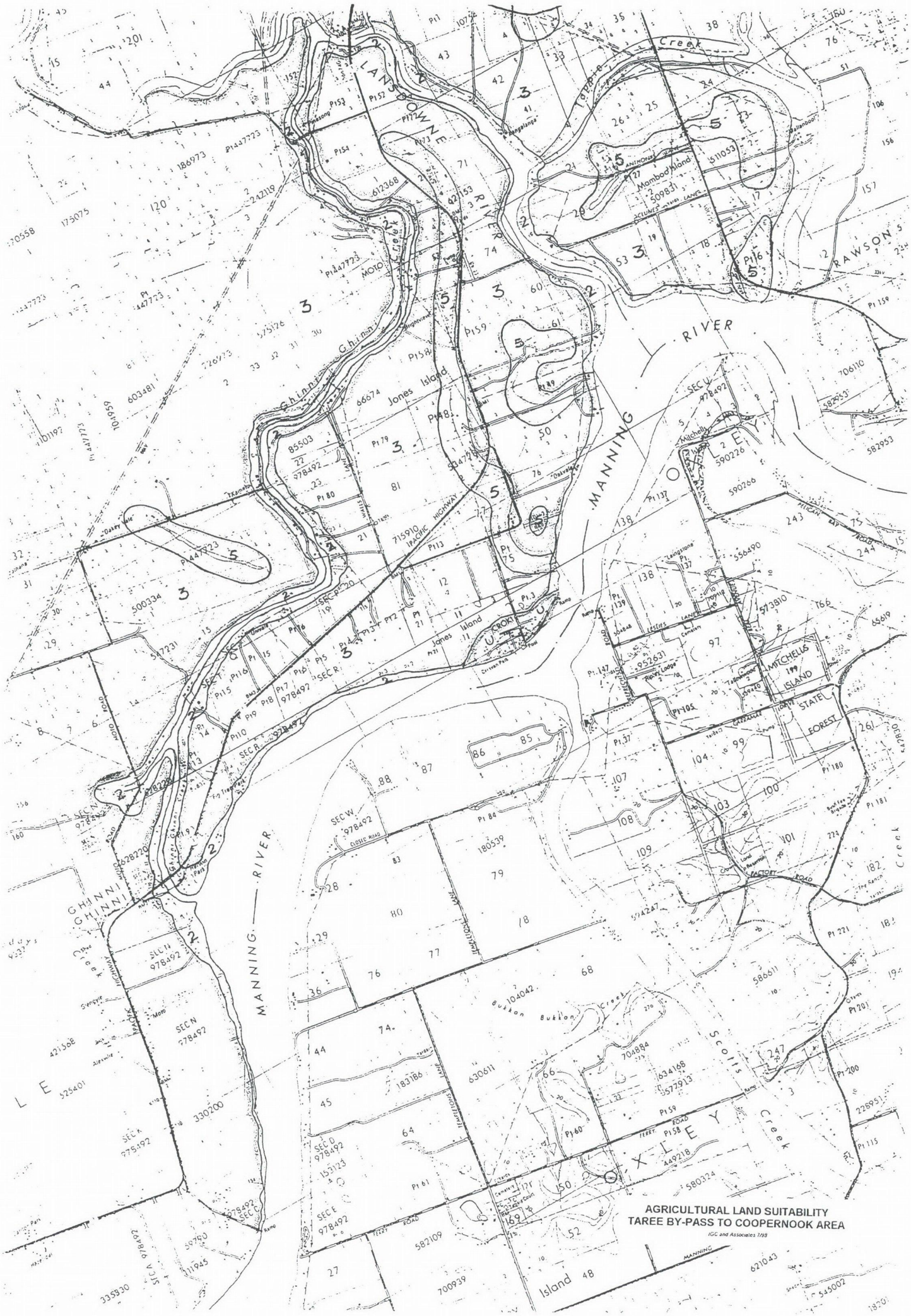
RURAL LAND CAPABILITY
TAREE BY-PASS TO
COOPERNOOK AREA

IGC and Associates 7/98



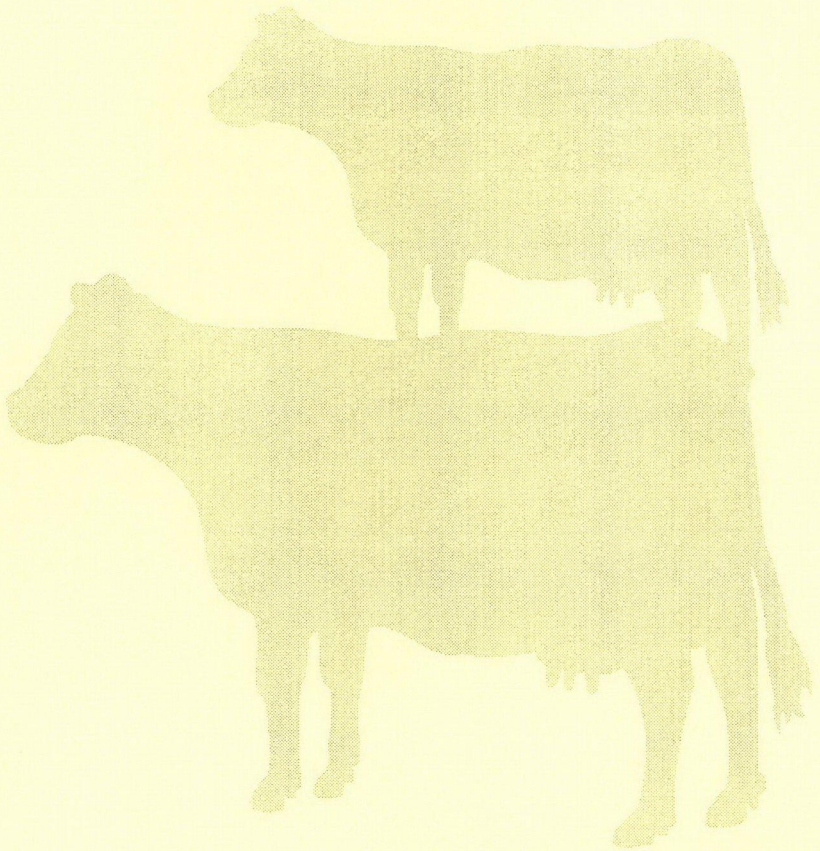
SUPPLEMENTARY MAP RURAL LAND CAPABILITY CLASSIFICATION

TAREE BY-PASS COOPERNOOK SECTION



AGRICULTURAL LAND SUITABILITY
TAREE BY-PASS TO COOPERNOOK AREA

IGC and Associates 7/98



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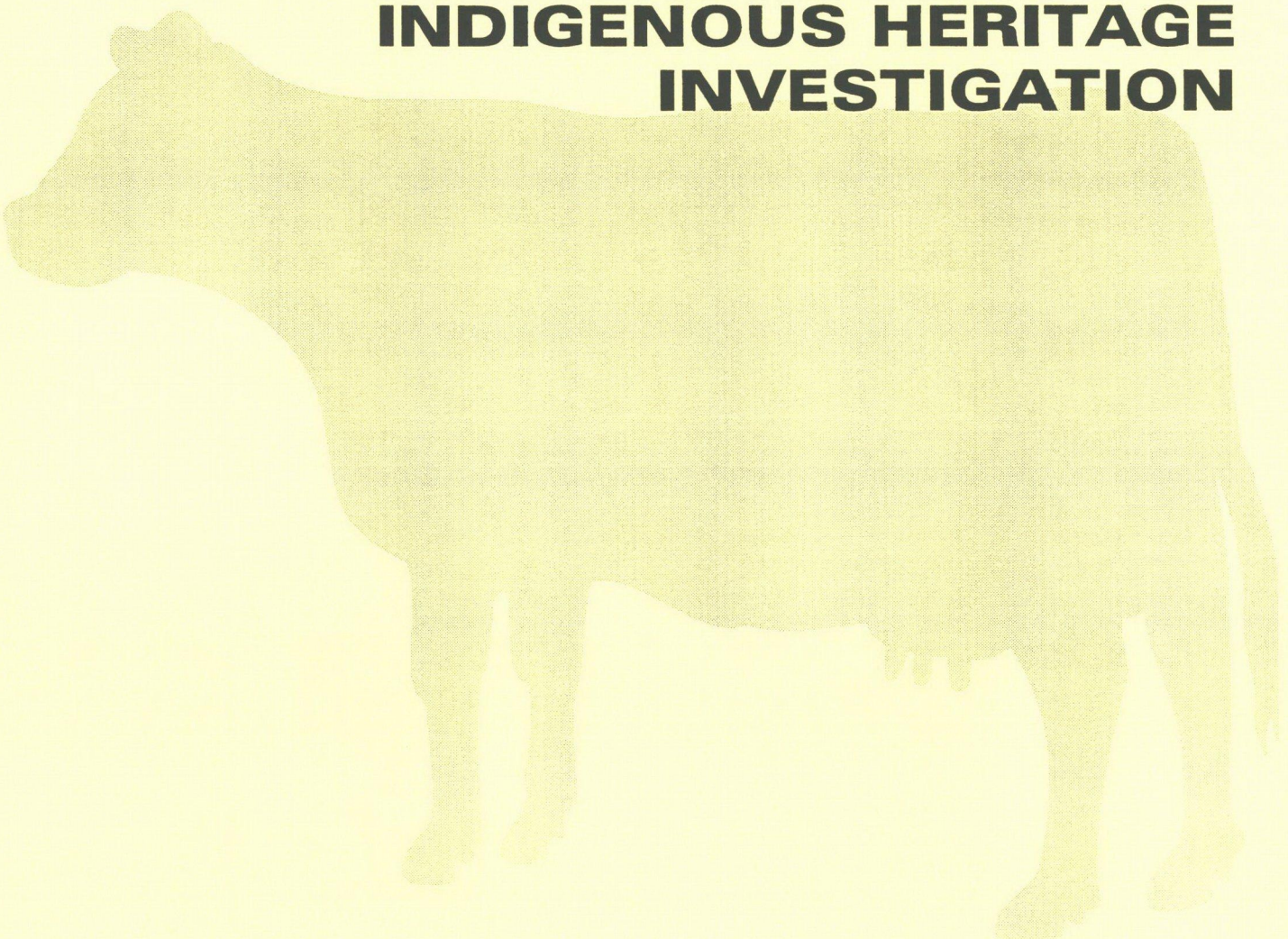
INDIGENOUS HERITAGE INVESTIGATION



- SH10 PACIFIC HIGHWAY -

PROPOSED UPGRADE
TAREE BYPASS TO COOPERNOOK BYPASS:
ABORIGINAL HERITAGE ASSESSMENT

Prepared for the RTA on behalf of-

Connell Wagner Pty Ltd
PO Box 538
Neutral Bay NSW 2089

By -

Jacqueline Collins
Consultant Archaeologist
9 Unique Close,
Dunbogan NSW 2443

October 1998

LOCATIONAL DETAILS OF THE PROPOSED UPGRADING CORRIDOR

Local Government area:	City of Greater Taree	
County:	Macquarie	
Parish:	Cundle	
1:25,000 topographic maps:	Coopernook	9434-3-N
	Cundletown	9434-3-S
Local Aboriginal Land Council:	Purfleet-Taree	

ABSTRACT

The Roads & Traffic Authority (RTA) proposes to upgrade the 7.2km. long section of Pacific Highway between the northern end of the Taree Bypass and the southern end of the proposed Coopernook Bypass on the NSW mid-north coast. This report was prepared on behalf of Connell Wagner and forms the Aboriginal heritage component of a Review of Environmental Factors (REF) for the preferred upgrading corridor. The report is designed to comply with the provisions of both the National Parks & Wildlife Act (1974) and the Environmental Planning & Assessment Act (1979).

The upgrading proposal would directly affect approximately 24ha. of land and involves construction of a 5.4km. single carriageway duplication and a 1.8km. section of dual carriageway highway which would traverse the Manning River floodplain and bridge Ghinni Ghinni Creek. For most of its length the corridor roughly bisects Jones Island mid-way between the Manning River and Ghinni Ghinni Creek some 7-8km. inland of the coastline. Cleared of its natural swamp and gallery rainforest communities, virtually all of the corridor has been ploughed at some stage in the past and currently supports pasture grasses and fodder crops.

Initially, all available ethnohistorical and archaeological literature relevant to the Jones Island area was reviewed, and local Aboriginal knowledge holders consulted, in order to generate a predictive model of site types and their likely distribution along the study corridor. Although 76.6% of the corridor was inspected in the field, surface vegetation severely constrained visibility and exposures adequate for artefact detection accounted for as little as 3.6% of the surveyed sample, and 2.7% of the entire study corridor. The probability of discovering artefacts was further reduced by the presence of alluvial sediments, restricting potential finds to those which had been brought to the surface through ploughing or other disturbance activities.

While no archaeological material or other evidence of Aboriginal use was discovered in the field, one landowner whose property is traversed by the corridor reported unearthing pebble axes during the course of ploughing, suggesting a low-density background distribution of such artefacts on the Manning floodplain. As a result of the impediments to the field survey imposed by surface vegetation and depositional processes, it has been necessary to rely upon the available environmental, ethnohistorical and archaeological evidence in an effort to determine the potential sensitivity of various sections of the corridor, and to develop management recommendations which will minimise the impact that the upgrading proposal may have upon the undiscovered archaeological resource.

Although the distribution and extent of known sites suggests more intensive and sustained prehistoric use of the coastline and areas closer to the mouth of the Manning River, past research has indicated a preference for occupation of locally-elevated rises along the banks of the estuarine system and in the Jones Island locality small resource-specific and single use campsites are expected to occur along both the river and Ghinni Ghinni Creek. Given the study corridor's topographic character and original vegetational regime, a natural levee flanking the southern bank of Ghinni Ghinni Creek has been identified as having a medium level of potential to contain subsurface evidence of Aboriginal occupation (Potential Archaeological Deposit 1 [PAD 1]). In order to avoid any inadvertent destruction of archaeological sites it is recommended that a controlled subsurface investigation be conducted on this levee to establish its cultural status prior to the commencement of any bridge construction work.

During the course of the study it was revealed that a fig tree standing beside the existing Highway on the northern end of the proposed upgrading corridor is believed to have been the focus for the itinerant camping activities of late 19th century Aboriginal transit groups (PAD 2). Although the apparent immaturity of this tree makes it more likely that the campsite was associated with a nearby but now-removed older specimen, it is recommended that removal of the fig and initial disturbance works in its vicinity be monitored by a sites officer from the Purfleet-Taree LALC. It is further recommended that all RTA project management staff, and all contractors and their employees engaged for the upgrading work be advised of their legal requirements with regard to Aboriginal sites. Should any materials thought likely to be of Aboriginal origin be exposed or unearthed at any stage, all activities must immediately cease in the subject locality pending management advice from the National Parks & Wildlife Service and the Purfleet-Taree LALC.

Following participation in the field survey by the sites officer from the Purfleet-Taree LALC a draft copy of this report was supplied to the Land Council. The results and recommendations were subsequently tabled, discussed and endorsed at a full Land Council meeting. While the Land Council has advised that it has no in principle objection to the proposal providing the recommendations made in Section 11 are implemented, it is desirable that the RTA continue to liaise closely with the Land Council, and that it be kept informed of the timetable for all works associated with the planning and construction of the Taree Bypass to Coopernook Bypass upgrading.

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1. INTRODUCTION

1.1. Study background

The Roads and Traffic Authority (RTA) proposes to upgrade the 7.2km. long section of Pacific Highway between the northern end of the Taree Bypass (currently under construction) and the southern end of the proposed Coopernook Bypass on the NSW mid-north coast (Figure 1). Having assessed the suitability of a number of options, a preferred corridor has been selected which utilises as much of the existing road reserve as possible to minimise land take. Where geometry allows, one carriageway has been kept on the current alignment and duplicated to either the east or west, depending on the situation and constraints (Connell Wagner 1998:4)(Figure 2). This report was prepared for the RTA on behalf of Connell Wagner and forms the Aboriginal heritage component of a Review of Environmental Factors (REF) for the preferred upgrading option.

In order to comply with the provisions of the National Parks and Wildlife Act (1974) and the Environmental Planning and Assessment Act (1979), and in line with RTA requirements and the study proposal submitted to Connell Wagner, this component includes:

- A review of National Parks and Wildlife Service (NPWS) sites records and relevant publications/unpublished literature to gain an insight to past Aboriginal landuse patterns and the intensity of prehistoric settlement in the wider study area;
- Liaison with the Purfleet-Taree Local Aboriginal Land Council (LALC) and any individuals known to the Land Council who may have knowledge of the study locality to determine whether the upgrading proposal would affect any culturally-significant sites/places;
- A review of environmental factors which may constrain both the detectability and preservation of Aboriginal sites within the study corridor;
- Development of a predictive model of site type and location for the study corridor;
- Field survey of all potentially sensitive segments of the study corridor;
- An assessment of the significance of any sites recorded during the field survey;
- An assessment of likely locations and condition of any undetected sites which may occur within the study corridor;
- Provision of management recommendations appropriate to the corridor's Aboriginal cultural resource, and advice on any further archaeological investigation which may be warranted prior to the initiation of the proposed upgrading work.



FIGURE 1: General study location on the NSW mid-north coast

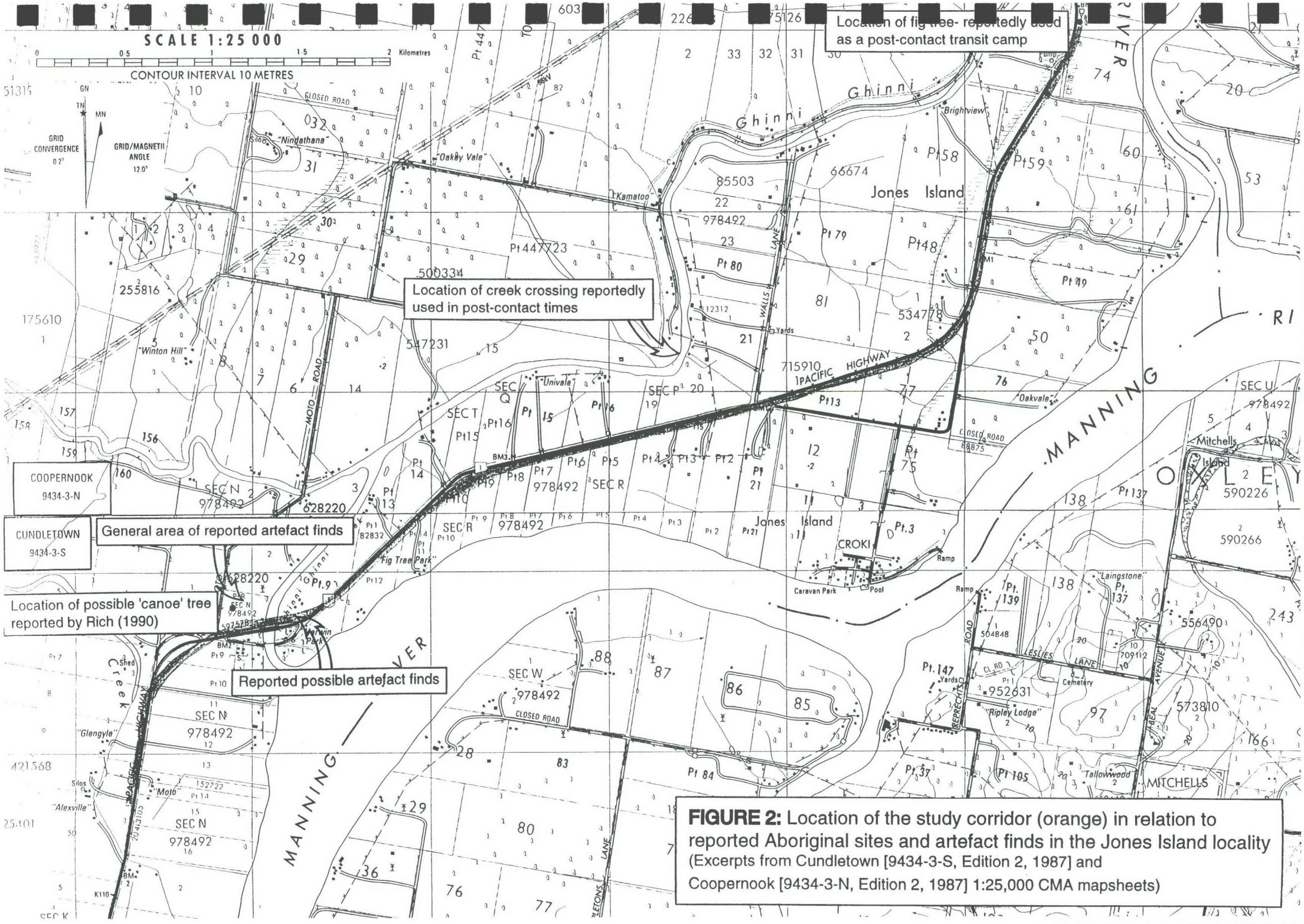

FIGURE 2: Location of the study corridor (orange) in relation to reported Aboriginal sites and artefact finds in the Jones Island locality
(Excerpts from Cundletown [9434-3-S, Edition 2, 1987] and Coopernook [9434-3-N, Edition 2, 1987] 1:25,000 CMA mapsheets)

Given that the RTA's Professional Services Brief requested that any specific requirements for the archaeological assessment be sought from the NSW National Parks and Wildlife Service (NPWS), the consultant's study proposal was forwarded to the Northern Zone office for comment. NPWS commended the proposed methodology, and outlined a number of basic issues which it considers necessary to address in all archaeological assessment reports (see NPWS correspondence, Appendix 1).

1.2. Location of the proposed upgrading corridor

The 7.2km. long proposed upgrading corridor ('the study corridor') occupies a 30m. to 70m. wide easement which generally follows the existing Pacific Highway alignment between the northern end of the Taree Bypass and the southern end of the proposed Coopernook Bypass. Traversing pastoral land north from the Taree Bypass, the corridor allows for a 500m. duplication of the existing Highway to the west. It then crosses to the eastern side of the existing alignment to improve the curve at the Blacks Lane intersection (dual carriageway) before re-crossing the Highway and straightening up for a proposed dual carriageway bridge over Ghinni Ghinni Creek 20m. west of the existing bridge. On Jones Island approximately 525m. north of Ghinni Ghinni Creek, the proposed northbound carriageway joins the current alignment, and with the exception of a short dual carriageway improvement to a curve 450m. further north, the remaining c.5km. allows for a single carriageway duplication along the eastern margin of the existing Highway (Figures 3a & 3b).

Some 7-8km. inland of the coastline, the study corridor lies between 150m. (immediately north of Ghinni Ghinni Creek) and 1.1km. from the western bank of the Manning River, and for the greater part of its length roughly bisects Jones Island mid-way between the river and Ghinni Ghinni Creek.

1.3. The construction proposal and potential impact on sites

The proposal would directly affect approximately 24ha. of land and involves construction of a 5.4km. single carriageway duplication, and a 1.8km. section of dual carriageway highway, all of which would be on fill embankments. The basic configuration would be dual carriageways comprising 2 x 3.5m. lanes, with a 0.5m. shoulder adjacent to the median and a 2.5m. shoulder adjacent to the nearside carriageway. The median would have a depressed centre and a width of 9m. between travel lanes (Connell Wagner 1998:4). Due to the lack of any major topographical variations, the width of the actual impact corridor will be relatively narrow, ranging from 20m. for the duplication route to a maximum of 60m. immediately north of Ghinni Ghinni Creek. Local service roads would be constructed at Blacks Lane (125m. long), Moto Road (110m. long)

and Croki Road (South)(25m. long). The proposed Ghinni Ghinni Creek bridge is the only major structure necessary along the route, though further detailed investigation is required to determine its likely span and design. Other minor structures would include three drainage culverts and two cattle underpasses.

The proposed Pacific Highway upgrading will require the demolition of existing sections of road pavement, bulk earthworks, the provision of drainage, bridge, culvert and underpass construction, and limited vegetation clearing. All of these tasks will involve some disturbance or removal of the natural ground surface and have the potential to destroy archaeological sites. Although topsoil would remain in place along the vast majority of the route where construction is to proceed on fill successively laid over geofabric matting, some sections are likely to require the installation of a grid of wick drains beneath to accelerate consolidation of the embankments. Where this is necessary, some subsurface sediments will be disturbed, along with any artefacts they may contain. Nevertheless, the extent of the impact that the proposed upgrading will ultimately have on the archaeological record will vary according to the types of sites which are present, and to the degree of disturbance that the corridor has already experienced.

Clearly, vulnerable above-ground sites like scarred and carved trees, Bora/ceremonial grounds and stone arrangements will be destroyed if their location coincides with the route. In contrast, stone artefacts are comparatively durable and may survive excavation works undamaged. However, the spatial structure of stone artefact sites is lost when their soil matrix is disturbed, and any artefacts which occur within the depth range of construction-related earthworks will be displaced during the course of construction. In most instances, sites which have lost their spatial integrity are of considerably less scientific value than *in situ* sites. While it is therefore apparent that the upgrading proposal will have the potential to directly destroy and/or adversely affect the scientific value of sites, there is little doubt that this potential has been substantially reduced as a result of the corridor's landuse history. The entire corridor has been cleared of its natural vegetation and subject to disturbance stemming from either the construction of the existing Pacific Highway, or long-term agricultural and/or pastoral activities, with virtually all having been ploughed to some degree in the past. As such, there is a very low probability of the proposed upgrading work disturbing/destroying *in situ* surface sites. On the other hand, it can be anticipated that any *in situ* site which may currently survive below the plough zone will be disturbed/destroyed if the proposed upgrading project proceeds.

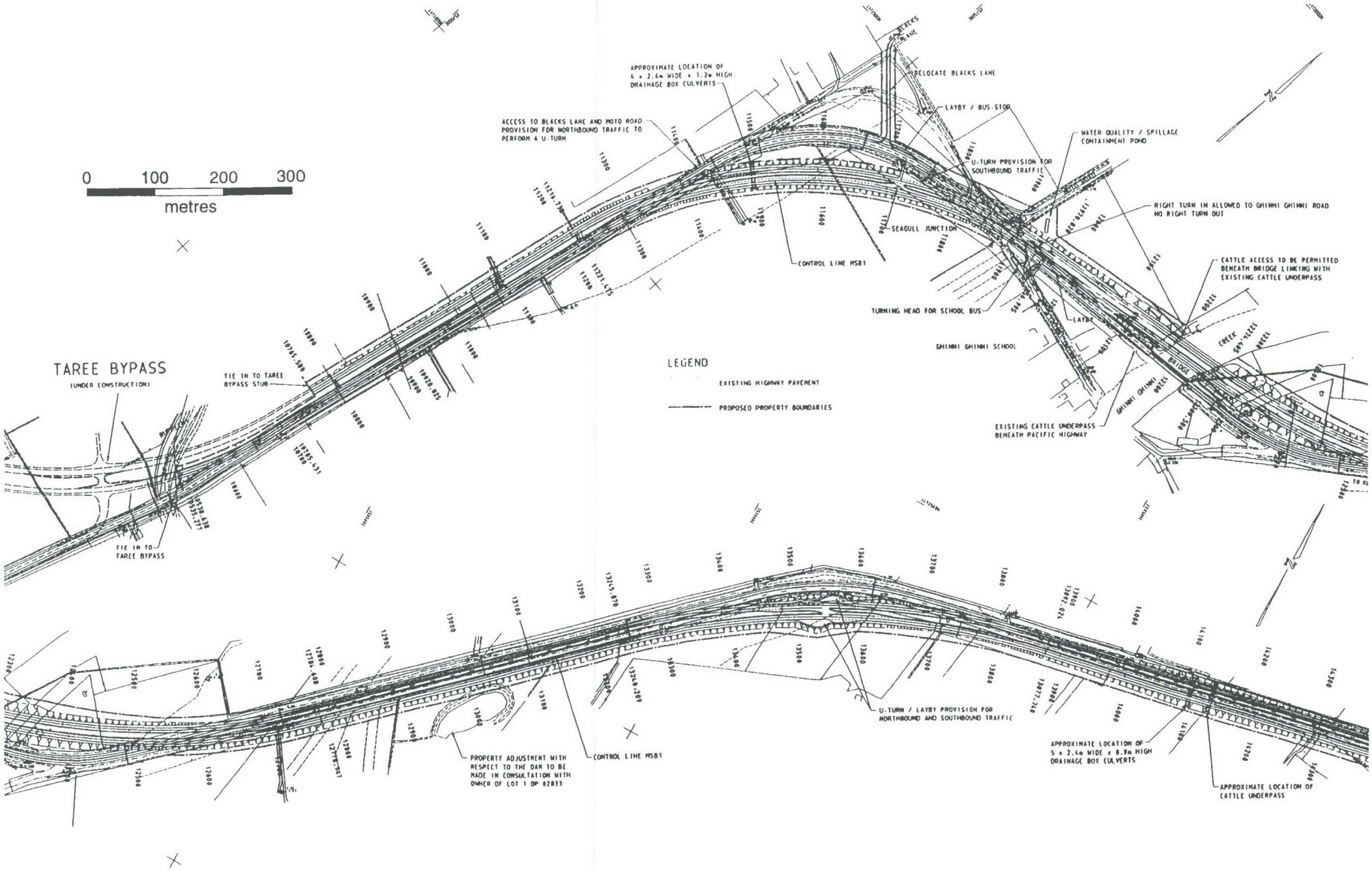

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FIGURE 3a: Proposed concept design (southern section)

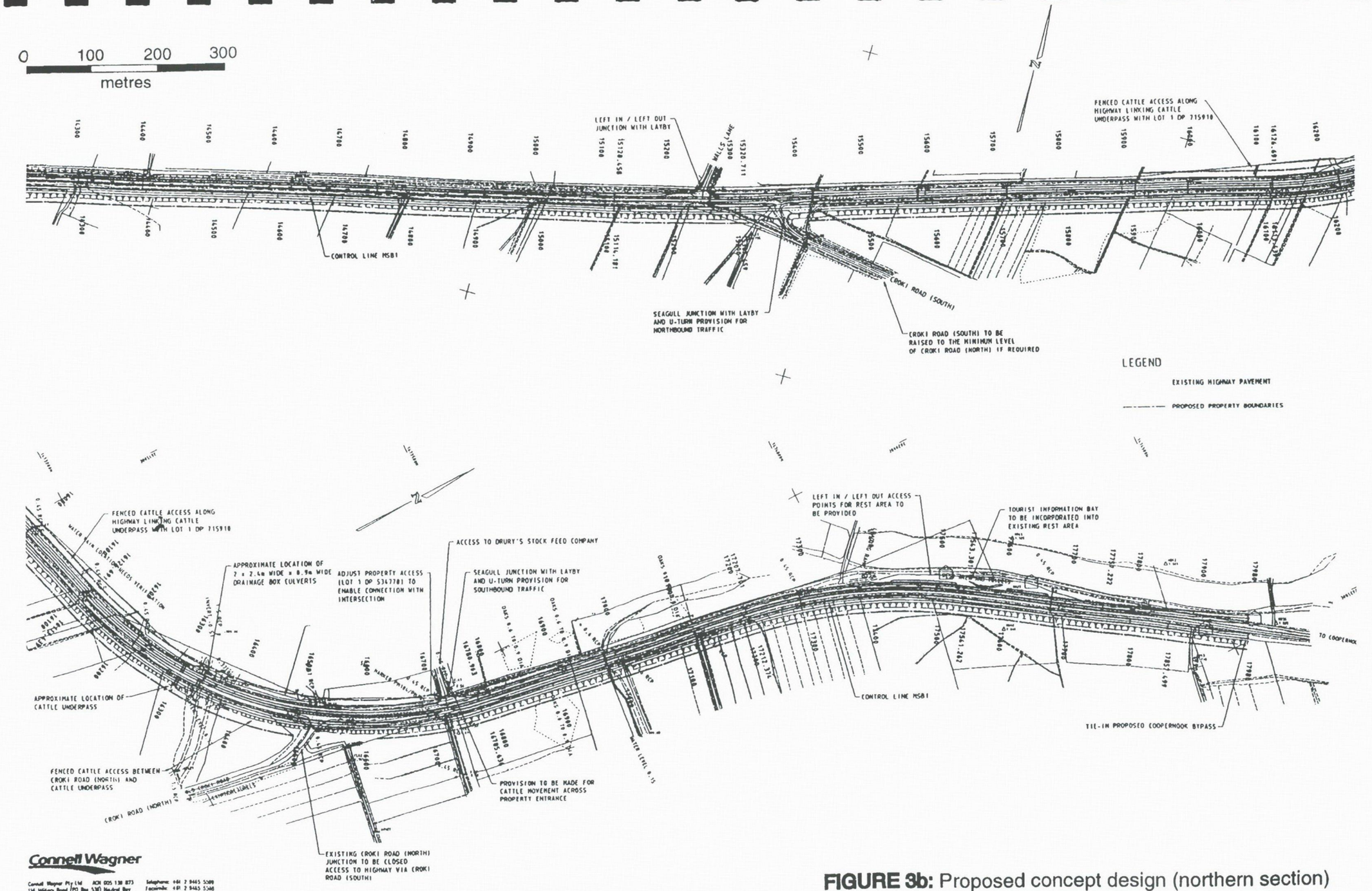


FIGURE 3b: Proposed concept design (northern section)

2. ABORIGINAL INVOLVEMENT

The study corridor falls within the territory administered by the Purfleet-Taree Local Aboriginal Land Council (LALC). This Land Council was contacted at commencement of the study and it was arranged that sites officer Vienna Maslin would provide field assistance (see Land Council field report, Appendix 2). On completion of the survey, the results were discussed with Vienna Maslin and provisional management recommendations were developed through this discussion.

A draft copy of this report was subsequently supplied to the Purfleet-Taree LALC to enable the survey findings and resulting recommendations to be presented to a wider cross-section of the Aboriginal community, and to determine whether any culturally-significant sites/locations would be affected, either directly or indirectly, by the upgrading proposal. To this end, the draft report was tabled and discussed at a full meeting of the Land Council on 29 September 1998. The survey results were accepted by the meeting and the recommendations presented in Section 11 of this report were fully endorsed (see arising correspondence, Appendix 2).

In an effort to further determine whether the integrity of any culturally-significant sites/locations would be threatened by the proposed upgrading work, Willie Bungie and Horace Saunders, both Elders and holders of traditional knowledge for the lower Manning, were individually consulted during the course of this study. However, neither Elder was aware of any archaeological sites or of any sites of spiritual/ceremonial importance in the wider Jones Island/Ghinni Ghinni Creek locality which would constrain the proposal and had no in principle objection to it proceeding. During the route selection phase, a 'possible canoe tree' (Rich 1990:36) located near Ghinni Ghinni Creek and approximately 100m. north of the current study corridor was inspected by the consultant and Willie Bungie (location plotted, Figure 2). However, the configuration of the scar suggested that it was not of Aboriginal origin and a report prepared by Willie Bungie in relation to the inspection is reproduced, along with other resulting documentation, in Appendix 3.

In the late 1890's at least, Jones Island is known to have been traversed and temporarily occupied by Aboriginal groups in transit between Crowdy Head and areas further inland. According to oral information given to Horace Saunders many years ago by the elderly European residents involved (Mr. & Mrs. Ward), Aboriginal groups crossed a narrow in Ghinni Ghinni Creek (see location, Figure 2) and would often visit the Ward's farmhouse (on the western bank of Jones Island) to exchange ducks and other native foods for salt and tobacco. They would then travel north-east across Jones Island, camping overnight beneath a Moreton Bay fig tree before crossing the Lansdowne River near its confluence with the Manning and proceeding to the coast. Although Horace Saunders believes this fig tree to be that which still stands beside the existing Highway on the northern end of the study corridor (Figure 2), ecological evidence suggests that

the tree is unlikely to be more than 80 years old (J. Brockhoff pers. comm.). It thus seems that the campsite was associated with a nearby but now-removed older tree.

3. ENVIRONMENTAL CONTEXT OF THE STUDY CORRIDOR

Although the nature and distribution of archaeological sites in any landscape will have been ultimately underwritten by cultural choices, it is evident that such choices were often strongly influenced by environmental factors such as climate, topography, bedrock geology and associated soil and vegetational regimes. Because these factors dictate the availability of food, water and other desirable resources, they are expected to have played a key role in determining the location of prehistoric campsites and the pattern and intensity of past Aboriginal use. Erosional and depositional processes are also dictated by environmental variables and these, in tandem with the affects of European landuse, can either expose and in many cases destroy archaeological sites, or bury them, preventing their discovery during surface inspection.

Given these considerations, an understanding of the study environment was a necessary prerequisite to the field survey and is valuable in helping determine those potentially sensitive locations where effective surface inspection was constrained by ground cover or current pastoral practices.

3.1. General setting

With a catchment of almost 10,000km.^{2} the lower course of the Manning River meanders through a broad basin, dividing into a number of distributaries to form an extensive deltaic floodplain downstream of Taree. The river then enters the sea through shallow channels at Harrington and Farquhar Inlets (Birrell 1987:4).

With the exception of small areas of residual soils derived from Carboniferous siltstones on Oxley and Mitchells Islands and a zone of estuarine sand along the coastline of Mitchells Island, the several islands within the floodplain are covered with alluvial soil deposits. Low levees often border the floodplain streams and channels, behind which the land slopes gently away into back swamps and marshes. These poorly drained areas reach their greatest extent in the vicinity of Ghinni Ghinni Creek, and along the lower Lansdowne River immediately north of the study corridor. Numerous old river channels and lagoons mark past drainage patterns across the floodplain (Birrell 1987:8).

Unlike the other islands formed through the divided channels of the Manning River, Jones Island, on the western side of the Manning's north (main) arm and opposite Mitchells Island, is

cut from the mainland by the lower reach of the Lansdowne River tributary in the north, and by Ghinni Ghinni Creek which links the Lansdowne and Manning Rivers along the western and southern margins of the island.

3.2. Climate

The Manning Valley lies near the southern limit of the subtropical zone and the climate remains comparatively mild at all times of year. In the lower valley, mean summer temperatures vary between 28°C and 18°C and cool north-east breezes often temper the effect of midsummer highs. Although several light frosts may be experienced each year, winter temperatures on the riverine lowlands rarely fall below 6°C (Birrell 1987:15).

On the floodplain, annual rainfall averages 1,550mm., though seasonal variability may be extreme. Excessively high summer falls, sometimes greater than 500mm., result from southward extensions of tropical cyclones. Periods of high rainfall also frequently occur during June and July when intense low pressure systems form on the NSW central coast (Birrell 1987:18). On such occasions flood conditions develop along the Manning and its tributaries and the northern end of Jones Island at least may be inundated to a depth of around one metre each three to five years (G. Rogencamp, WBM Oceanics, pers. comm.). A short dry season usually occurs during late winter and early spring, and drought conditions have been recorded at this time, occurring at a rate of around one year in twelve (Birrell 1987:19).

While the cooler winter temperatures, periodic flooding and short dry season may not have unduly inconvenienced the local Aboriginal inhabitants, these factors are likely to have seasonally depleted food and water resources, and if so, they can be expected to have influenced prehistoric settlement and resource exploitation patterns. In present times, for example, the frequency of frosts on the floodplain is sufficient to prevent the successful continuous cultivation of tropical crops, and the seasonal rainfall variability often seriously hindered the establishment of early agricultural settlements (Birrell 1987:16,19).

3.3. Topography

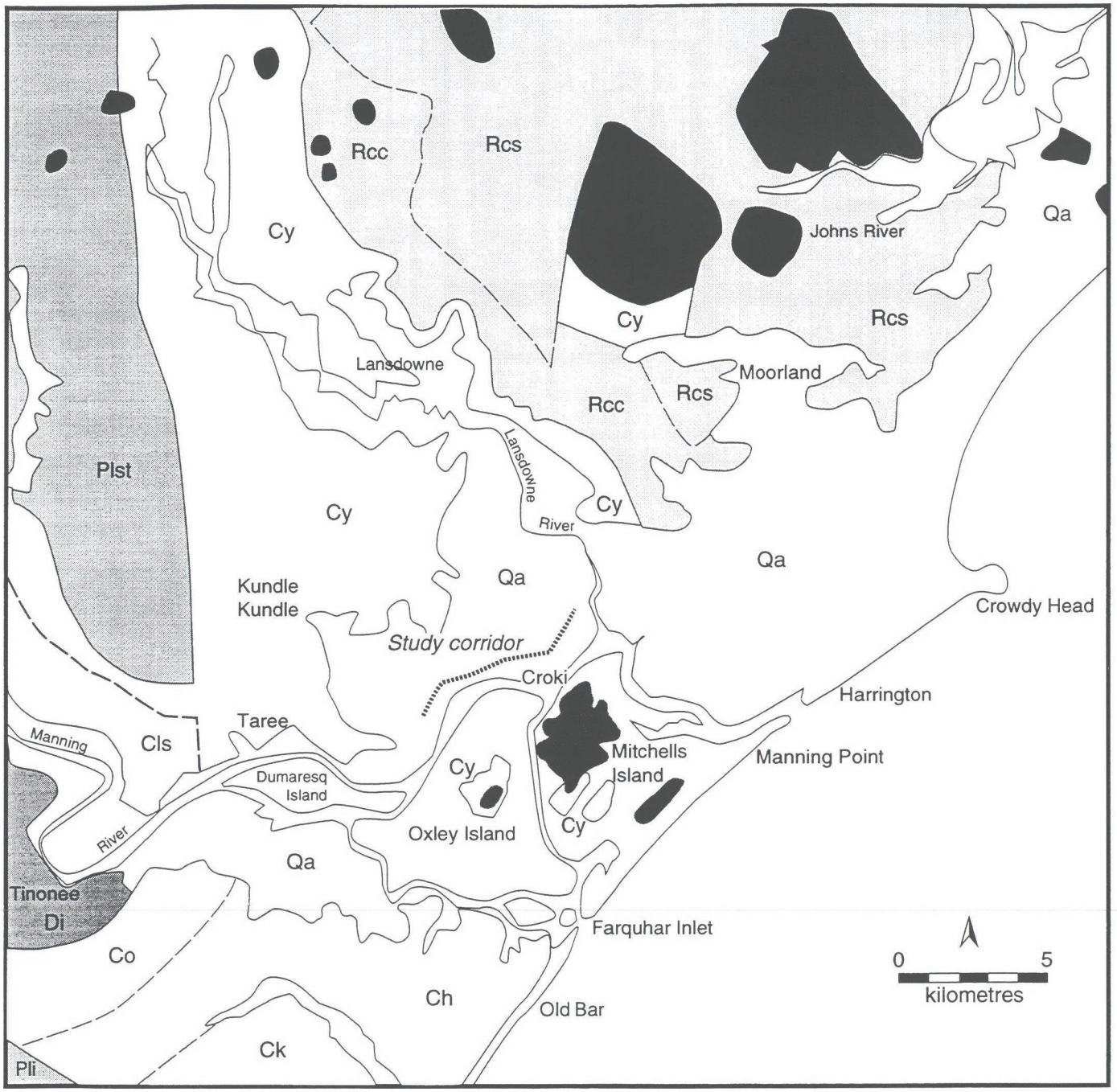
The proposed upgrading corridor traverses the Manning River floodplain, with elevations rarely exceeding 2m. AHD. Although the plain very gently undulates, most is topographically undifferentiated and apart from open water (two stream channels), only five specific landform element types- backplain, scroll, levee, channel bench and swamp (Speight 1990:24-34)- are represented within the study corridor itself. Of these, the backplain element is dominant, comprising around 96% of the corridor.

Topographical variations which may be of relevance to the archaeological survey are restricted to creek margins, particularly those associated with the tidal channel of Ghinni Ghinni Creek. While the entire study corridor is flood-prone, a narrow (c.15m. wide) natural levee extends along the southern side of Ghinni Ghinni Creek, rising to over a metre higher than its backing flooplain before falling c.2m. to creek level in a steep water-cut bank. On its northern side, Ghinni Ghinni Creek is flanked by a poorly-elevated 50m. wide channel bench which gives way to a narrow elongated pocket of swamp. North of the swamp the corridor rises to traverse a low terrace (scroll) before grading to the backplain. In addition to that on the southern side of Ghinni Ghinni Creek, a second low natural levee rises to around 0.6m. above the backplain along the northern bank of a small unnamed creek immediately south of Croki Road (North) on the northern section of the route.

3.4. Geology and soils

The Manning River floodplain is composed of stratified Quaternary alluvial deposits. Geotechnical testing within the study corridor indicates that these deposits typically comprise a 2m. thick surface layer of stiff silty clay overlying a deep (c.26m.) layer of estuarine clay with basal sandy gravels (J. Rubsov, Robert Carr & Associates, pers. comm.). Investigations completed on the northern end of Jones Island and at Coopernook have revealed a relatively uniform distribution of hydrosol (prairie) soils across the floodplain. These strongly acid soils are seasonally or permanently wet, having a saturated profile for prolonged periods in most years (Connell Wagner 1997:6-2; SMEC 1998: 4-3). Although apparently absent from Jones Island, extensive pockets of Quaternary gravels outcrop further east on both Mitchells and Oxley Islands (Figure 4). No natural stone (e.g.rockshelters, gravel beds, surface outcrops) occurs within the study corridor.

Forming the hill and ridge systems edging the lower Manning floodplain are a number of sedimentary rock formations of Devonian to Triassic age (Figure 4). Chief amongst these are the Carboniferous Byabbara (sic.) Beds which stretch to within 2.5km. of Jones Island in the west (Tamworth-Hastings 1:250,000 metallogenic series sheet). Although dominated by siltstones, mudstones and lithic sandstones, scattered chert exposures also occur (Stewart 1953:6-7). 2.5km. north of Jones Island, and arcing north-west parallel with the Lansdowne River, is the southern rim of the Lorne Basin, a small Triassic basin formed on the cratonized New England Fold Belt (Herbert 1974:507). The Camden Haven Group rocks found here consist of clay-shales, coarse sandstones and grits which overlay massive conglomerates. These conglomerates, which include boulders and pebbles of sandstone, mudstone, quartzite, jasper, chert and quartz, outcrop to form a high escarpment on the western rim of the basin north-west of Coopernook (Stewart 1953:9; Voisey 1939:257).



Qa- Quaternary alluvium

Quaternary gravels

Tertiary microgranite & rhyolite or trachyte plug

Triassic
Rcc- Camden Haven Beds [tuff, shale, sandstone]
Rcs- Camden Haven Beds [conglomerate, sandstone, shale]

Permian
Plst- Unnamed beds [mudstone, sandstone, siltstone, conglomerate]
Pli- Giro Beds [mudstone, conglomerate, siltstone, shale, sandstone, limestone]

Carboniferous
Ch- Koorainghat Beds [sandstone, greywacke, laminite, tuff, shale]
Ck- Kiwarrak Beds [laminite, claystone, mudstone, greywacke]
Co- Belbora Beds [tuff, agglomerate, sandstone, laminite]
Cy- Byabbara Beds [sandstone, siltstone, tuff, mudstone, limestone]
Cls- Unnamed beds [mudstone, sandstone, limestone, conglomerate]

Devonian
Di- Tinonee Beds [laminite, tuff, spilite, greywacke, mudstone, shale, sandstone]

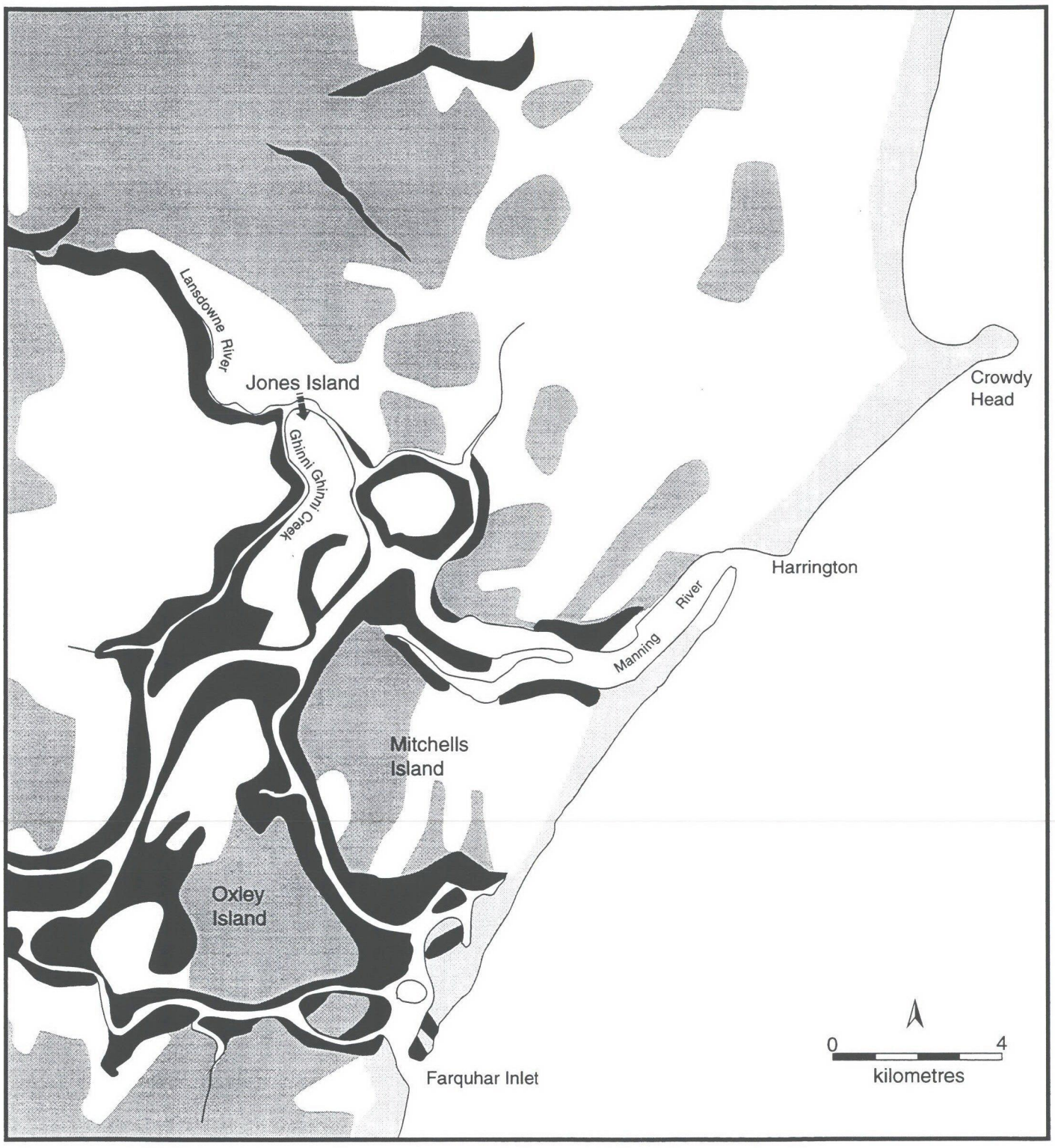
FIGURE 4: Generalised geology of the study locality
(adapted from New England 1:500,000 Geological Series mapsheet)

3.5. Vegetation

As a result of European landuse practices the study corridor has been significantly altered from its natural condition. Virtually all land capable of supporting agriculture has been cleared, and is currently carpeted by grasses and fodder crops. North of Croki Road (South), casuarinas have regenerated in poorly drained areas, particularly along drainage channels and much of the existing Highway Reserve, with some larger regrowth specimens scattered more widely. Pockets of reed swamp and isolated paperbarks occur east of the corridor in this locality. With the exception of the grey mangroves which line Ghinni Ghinni Creek's narrow tidal mudflats, potential remnant vegetation is restricted to two medium-sized Moreton Bay fig trees, and a few mature red gums standing beyond the study boundary south of Ghinni Ghinni Creek.

Prior to clearance, the alluvial soils along the banks of the rivers and creeks supported a dense layered forest community. Called 'brush' by the early colonists, this forest comprised "trees of almost endless variety ... the peculiar appearance [of which] is principally caused by the countless species ..., which interlaced and entwined in inextricable confusion, bind and weave together the trees almost to their summits" (Hodgkinson 1845:3-5). While a dense eucalypt forest formation dominated land away from the water courses, early descriptions suggest that forest cover may have varied considerably with elevation and aspect (Birrell 1987:21-22). At the time of its European discovery, for example, the tract of floodplain stretching from Cundletown to the Lansdowne River immediately west Jones Island supported 'blady grass' and 'fine grass'. "Except for the brush-covered alluvial soil along the levees of the stream [i.e.Ghinni Ghinni Creek], the land was a poorly drained flood plain almost devoid of trees" (Armstrong 1827 *in* Ramsland 1987:14,59).

Based on the initially surveyed portion plans, accounts left by early European observers and his own field inspections, Birrell (1987:22-23) has produced a map plotting the distribution of the Manning Valley's natural vegetation types. Although the identified 'types' are very generalised, Birrell's map shows Jones Island to have been originally covered in swamp with 'brush' (rainforest) largely confined to its margins and southern end (Figure 5). However, during Dangar's 1825 exploratory expedition along the northern side of the Manning, he found it impossible to travel close to the Lansdowne River "because of impenetrable jungle growing for some distance from the river ... From an occasional high ridge it could be seen that the jungle was complete between the two streams" [i.e.the Manning and Lansdowne Rivers](Connors 1985:9). This suggests that the rainforest was more extensive than proposed by Birrell, and that Jones Island was probably once covered by a mosaic of rainforest and swamp communities.



Swamp

Heath and scrub

Dense forest

Brush (rainforest)

FIGURE 5: Natural vegetation of the study locality
(adapted from Birrell 1987:22-23)

Data used by Birrell:
- Portion plans, Department of Lands NSW
- J.H. Maiden Agricultural Gazette NSW Vol.5 1827
- Boat survey of the Manning River by J. Armstrong 1827
- Field survey

4. CULTURAL CONTEXT OF THE STUDY LOCALITY

4.1. Land division

The original inhabitants of the study locality belonged to the Birpai tribe, speaking a closely-related variant of the Kattang language (Holmer 1966). While there is some confusion as to the exact location of boundaries, four surviving 'Birripai' speakers living on the Hastings in 1932 (Enright 1932) reported that this language was spoken north from the Manning River to near the Macleay.

Little archaeological or anthropological work has been completed for the coastal stretch between the Macleay and Hunter River Valleys and as a result the traditional lifestyle of the Birpai people is difficult to reconstruct. However, as with regions to both the north and south, it is likely that the family group formed the basic socio-economic unit, and that several families would co-operate as a highly flexible band. In turn, such bands made up loose clans which regularly exploited a particular range or territory. The size, composition and geographical location of a band within the clan estate varied in response to social and economic demands (Lilley 1984:17; Dawson 1945:25). Groups of clans sharing a common language and/or cultural affiliation then appear to have formed the relatively unstructured larger 'tribal' units.

While the names and geographic limits of the Manning Valley's traditional clan groups remain undocumented, one early settler claimed that at least four separate 'tribes' inhabited the area between the coast and 'No. 1 Station' on the upper river (Fitzpatrick 1914:37). According to Connors (1985:91), the 'Wallaby Clan' occupied the Lansdowne River area and regularly camped on the bedrock hills at Durambah 10km. west of Jones Island and in caves along the western rim of the Lorne Basin near the village of Lansdowne.

Pierce (1971:82-83) used early historical information to estimate prehistoric population numbers for north-eastern NSW. His evidence indicated that the bulk of the Aboriginal population lived on the riverine plains and coastline, and that densities diminished not only with distance inland, but with distance south. On the far-north coast a density of 2-3 persons per km.^{2} was estimated, while a density of only one person per km.^{2} was estimated for Port Stephens. Pierce attributes this discrepancy to the decreasing productivity of aquatic zones with distance south along the coast. Coleman (1978), on the other hand, places the prehistoric population at between one and three persons per km.^{2} for the lower Macleay, suggesting that densities in particularly productive parts of the mid-north coast rivalled those further north.

4.2. Material culture

TABLE 1: Resources used in the manufacture of material items

(Source: Fitzpatrick 1914:29-86 [the reminiscences of Mr. John Allen])

Product	Source	Forest type/environmental context			
		Rainforest	Sclerophyll	Sand plain	Other
Fur belt	possum	X	X		
Rug	possum	X	X		
Tassel	native cat	X	X		
Red raddle [ochre]	Lansdowne or Johns River				X
Tomahawk	steam beds/coastline				X
Fish hook	'ear shell'				X
Canoe	stringybark		X		
	swamp mahogany		X		
	river gum		X		
	vine	X			
Container	eucalypt		X		
Gunyah	stringy bark		X		
	paper bark			X	X
'Coutra' [nulla nulla]	white myrtle			X	
Resin	grass tree			X	
Spear shaft	grass tree			X	
Spear shaft	brown kurrajong		X		
Spear prong	ironbark		X		
Boomerang	white myrtle			X	
Shield	fig tree	X			
'Paddymelon stick'	myrtle			X	
Climbing vine	vine	X			
'Currapah' [clasp]	pademelon bone	X			
		7	10	6	4
Bullroarer	wood		(not specified)		
Pounding stone	various sources		(not specified)		
Net	plant fibre		(not specified)		
Knotted bag	plant fibre		(not specified)		
Tomahawk	water-worn stones		(not specified)		
Spear point	flint and quartz		(not specified)		
Womera	wood		(not specified)		

As is evident in Table 1, a wide variety of the region's material items were made from the wood or bark of various rainforest and sclerophyll forest trees. These include spears, womera, clubs, shields, boomerangs, digging sticks, containers, and fibre nets and bags. Many of these were produced with the aid of stone tools. On the lower Manning, specialised multi-pronged fishing spears were "always pointed with a piece of flint or quartz" (Fitzpatrick 1914:41), and

traditional 'tomahawks' are said to have consisted of unmodified water-worn stones which were discarded once blunt. These were soon replaced with iron axes after contact (Fitzpatrick 1914).

Canoes, fashioned from a single large sheet of stringybark, swamp mahogany, or river gum bark which was cured over an open fire and bound at the ends with vine or rush fibre, were used extensively on the rivers and creeks for both fishing and general travel. A slab of stone or a thick layer of mud was placed in the centre of the canoe to form a hearth so that fish could be cooked and eaten on the spot (cf.Simon 1987:104). Each family had one or two canoes and these were seen in large numbers on the Manning River by early European settlers (Fitzpatrick 1914:35). Shelters "were constructed in a simple manner, by putting up a fork or two, and leaning a sheet or two of stringy bark against them. If stringy bark could not be secured (they) fell back on tea-tree bark. The average black's gunyah was not an uncomfortable concern" (Fitzpatrick 1914:62).

4.3. Settlement pattern

Within the clan estates a seasonal landuse pattern is said to have been followed. In summer, when fish and shellfish were plentiful, residential groups reportedly occupied the lowlands close to the Manning River and its tributaries, or close to the sea. In autumn or early winter these groups migrated to the higher parts of their territory to avail themselves of terrestrial foods (Simon *in* Ramsland 1987:180). According to New (1851), the same camp was rarely occupied for more than a week.

Movement beyond the clan estate was only undertaken by pre-arrangement with adjoining groups for the purposes of meeting specific ceremonial and social obligations (Belshaw 1966; Chevally 1946), apparently utilising defined transit routes which linked both the coastal areas themselves, and the coast with the New England Tableland (cf.Collins & Morwood 1991; Connors 1985). Groups from the Manning Valley are known to have participated in ceremonies as far afield as the Hunter (O'Sullivan White 1850 *in* Belshaw 1966:9) and Hastings Rivers (Fizpatrick 1914:124), and a gathering of 300 Aborigines was observed near the river above Wingham in 1828 (Guilding to Dawson *in* Birrell 1987:31).

While the first European settlers reported a greater density of Aboriginal settlement near the mouth of the Manning than further up-river (Fitzpatrick 1914:37), there is virtually no ethnohistorical information relating to the overall landuse pattern by which to gauge the study corridor's context, frequency, or duration of occupation. However, in post-contact times at least, there was an Aboriginal camp on Jones Island. Given that it was inhabited by 'Jimmy McKay Cookie, King of Croki' (Hannah 1988:22), this camp is likely to have been situated on the bank of the Manning River in the immediate vicinity of the village of Croki one kilometre south-east of

the study corridor's central section. The camp residents, who were casually employed on local farms, rowed boats up Cattai Creek (which enters the Manning 1.25km. east of the Lansdowne River) to find wild bees nests, collecting honey which was then sold.

Former regularly-used camps have been reported at Kundle Kundle 6km. north-west of the study corridor, near Melinga some 4km. north of Kundle Kundle, and at Tinonee on the southern bank of the Manning River upstream of Taree (Connors 1985:40-41,94). The location of these camps, all on low bedrock-soil spurs which interfinger with the alluvial sediments on the edge of the floodplain, suggests the preferential occupation of elevated well-drained ground close to water sources, a pattern which is in accord with the distribution of known archaeological sites on the lower Manning.

4.4. Resource use

With respect to prehistoric economies the scheduling of resource exploitation in both time and place was determined by a complex interaction of factors, which apart from simple availability, included social and cultural practices as well as priority ranking and personal preferences. As Mitchell (1978:140) notes, the desirability of any specific resource is likely to have been tempered by a wide range of considerations- ease of travel, abundance elsewhere, immediate pressing requirements, limits imposed by territorial organisation and social links, and negative factors such as weather, insects etc. For these reasons it is unlikely that all of the resources offered in any one area would have been exploited by Aboriginal groups. Nevertheless, a review of potential resources can assist with the interpretation of archaeological findings and goes some way in determining the capacity for selected areas to have supported prehistoric settlement.

Despite the limitations which are likely to have been imposed by seasonal climatic fluctuations, early reports indicate that the lower Manning floodplain provided a rich resource base for its Aboriginal inhabitants. In addition to those available in the immediate coastal zone, fish were abundant on the estuarine reaches of the Manning and its tributaries, and shellfish and crabs were plentiful in summer. The forests also apparently abounded with animals (Birrell 1987:32; Ramsland 1987:180). Ghinni Ghinni Creek derives its name from the Birpai term for 'many mud crabs' ('Chinny Chinny')(Connors 1985:92,97), suggesting that this creek is likely to have featured prominently in activities centred on the exploitation of estuarine resources.

While it is claimed that "on the salt water [Aboriginal groups] mostly lived by fishing" (Fitzpatrick 1914:37), it is evident that a wide variety of mammals, birds, fish and vegetable foods contributed to the diet and that all of the available habitat types were exploited, including the gallery rainforests. Even though the greatest number of food plants and animals mentioned

in the ethnohistorical sources could have been obtained from the rainforest (Table 2), Byrne (1986:13) believes that it may have been underestimated as a resource zone since much of this vegetation had been cut out before many of the early writers had arrived.

During both prehistoric and early contact times, Aboriginal people controlled the natural fracture properties of fine-grained stones to manufacture a variety of cutting and scraping tools, many of which were used to shape, smooth and maintain wooden weapons and implements. Although basement rocks across the floodplain have been covered by a thick layer of alluvium, gravels suitable for stone tool production outcrop on Mitchells and Oxley Islands east of Jones Island, and high flaking-quality pebbles of mudstone, quartzite, jasper, chert and quartz are readily available from the base of the escarpment at Upper Lansdowne some 8km. north-west of Coopernook. Siltstones, mudstones and scattered chert exposures also occur in places across the bedrock-soil lands which stretch to within 2.5km. west of Jones Island (see Figure 4).

Ochre was used in body painting, decorating wooden weapons, and fibre dyeing (Fitzpatrick 1914:38-42; Cohen 1897:117). Although no local quarry source has yet been recorded, Fitzpatrick states that the Manning Aborigines obtained red 'raddle' from "the Lansdowne or Johns Rivers", providing evidence that this resource was procured in the wider study locality.

TABLE 2: Habitat of reported food resources

(Source: Fitzpatrick 1914:29-86 [the reminiscences of Mr. John Allen])

Brush/rainforest	Sclerophyll forest	Swamp	River	Coast & dunes
Vegetative				
Towruck [yam]	Myall lemon	Bungwall fern [rhizome]		
Maroo [rasberry]	Mo [Burrawang seed]			
Caper fruit	Cundle [fruit]			
Black apple				
Cunjevoi				
Moquat [tuber]				
Tareebit [sandpaper fig]				
Faunal				
Possum	Possum	Kangaroo rat	Perch	Kangaroo rat
Echidna	Echidna	Python	Mullet	Echidna
Flying fox	Wallaby	Eggs	Catfish	Cockle
Kangaroo rat	Kangaroo rat	Tortoise	Tortoise	Oyster
Bandicoot	Bandicoot			Pipi
Python	Python			Lobster
Lizard	Lizard			Eggs
Eggs	Koala			
	Eggs			
Other				
Honey	Honey			
16	13	5	4	7

4.5. The contact period

The intrusion of Europeans into tribal lands was initiated in 1824 when the Australian Agricultural Company began pastoral activities between Port Stephens and the Manning River, and by 1827 the first white settler had arrived on Jones Island (Connors 1985:15). Hostility closely followed the appropriation of the clan estates, resulting in the loss of both Aboriginal and European lives (Blomfield 1981:119-125). In 1838 an Aboriginal family group was reportedly massacred at Kundle Kundle 6km. north-west of the study corridor (Connors 1985:40).

By the early 1850's most of the Manning floodplain had been invaded, and traditional Aboriginal social and landuse systems were severely affected. Deprived of their economic base the Birpai were soon forced to depend on handouts of food and blankets, many becoming fringe-dwellers on the outskirts of pastoral properties and the newly-formed settlements. With the establishment and European occupation of a pastoral holding near the village of Lansdowne 8.5km. north-west of Coopernook, the local 'Wallaby Clan' is said to have made camp on the river bank in its vicinity and remained there (Connors 1985:92).

5. ARCHAEOLOGICAL BACKGROUND

5.1. Registered sites in the study locality

No Aboriginal sites have been recorded either within or in the vicinity of the study corridor, with its closest registered site (#30-6-52 [open campsite]) occurring 2.5km. further south on the western bank of Oxley Island. While 42 shell middens/open campsites have been recorded along the local coastline and close to the mouths of the two main river channels (the Manning River and Manning River South Channel), comparatively few non-coastal sites have been discovered, with only 17 registered within a 10km. radius of Jones Island. Three of these 17 non-coastal sites include two different types occurring at the same location (Table 3). In all, there are nine small open campsites (at least one dating to the post-contact period) situated on the banks of water courses or on the crests and footslopes of bedrock-soil ridges/spurs above creeks and swamps, six scarred trees found in a range of topographic contexts, three shell middens (one in a rockshelter) along the banks of the Manning River South Channel, and a post-contact ceremonial ground and well.

In addition to the registered sites, a possible scarred (canoe) tree was reported on the western side of Ghinni Ghinni Creek 100m. north of the study corridor (Rich 1990:36). Although closer examination revealed that the scar is unlikely to be of Aboriginal origin (Appendix 3), the tree will not be affected by the current upgrading proposal.

TABLE 3: Registered non-coastal sites within 10km. of Jones Island

Site No.	Site type	Environmental context (Location/feature)
30-6-16	Open midden	750m. from south Manning channel (Oxley Island)
30-6-41	Scarred [canoe] tree	Manning floodplain (Oxley Island)
30-6-42	Shelter midden	Bank of south Manning channel (Bohnock)
30-6-43	Open midden	Bank of south Manning channel (Oxley Island)
30-6-52	Open campsite	Near bank of Manning River (Oxley Island)
30-6-53	Open campsite	Near bank of Lansdowne River (Lansdowne)
30-6-54	Open campsite	Slope above 2ndry creek (Lansdowne State Forest)
30-6-69	Scarred tree	Bedrock footslope (Oxley Island)
30-5-16	Scarred tree/well	40m. from creek in paperbark forest (Halls Creek)
30-5-18	Post-contact camp/ceremonial	Spur footslope near 2ndry creek (Halls Creek)
30-5-19	Open campsite/scarred tree	Edge of tidal creek near swamp (Halls Creek)
30-5-20	Scarred tree	Paperbark swamp near tidal creek (Halls Creek)
30-5-21	Open campsite	Low spur near tidal creek & swamp (Halls Creek)
30-5-22	Open campsite	Ridge crest, edge of floodplain/swamp (Halls Creek)
30-5-23	Scarred tree	Ridge crest, wet sclerophyll forest (Halls Creek)
30-5-43	Open campsite	Ridge crest, edge of floodplain/swamp (Halls Creek)
Not yet listed	Open campsite	Low rise near bank of 2ndry creek (Coopernook)

5.2. Previous work in the study locality

In the absence of any academic research, virtually all that is currently known of the Manning region stems from the results of field surveys and site-specific investigations which have been completed for impact assessment ahead of development. Most of these surveys have focussed on the immediate coastal strip (e.g.Brayshaw 1983,1990,1994; Collins 1993; Crew 1989), and are thus not relevant to the present study. However, the results of surveys and investigations which have been conducted in non-coastal floodplain and adjacent areas are pertinent, and these are reviewed in this section to establish the contexts in which local sites occur, and to provide a baseline against which to assess the archaeological potential of the study corridor.

Although most of the hinterland surveys, including those in the general Jones Island locality, have yielded negative results (Brayshaw 1977; Williams 1980; Palmer 1986), Rich (1990) recorded eleven Aboriginal historic and prehistoric sites during survey of the 16km. long and 400m. wide corridor to be potentially affected by construction of the Taree Bypass. The northernmost 1.5km. of this corridor (between the northern end of the Taree Bypass and Ghinni

Ghinni Creek) coincides with the present study corridor. Apart from the 'possible scarred (canoe) tree' near Ghinni Ghinni Creek, no sites were found on the Manning River floodplain, with all eleven of the identified sites occurring on more elevated terrain within 7km. of the corridor's southern end. Several of the sites, including waterholes, scarred trees, a cemetery and a campsite/corroboree ground are associated with post-contact use by the Purfleet Aboriginal community.

Three of the campsites recorded by Rich contained stone artefacts. Of these, one (#30-5-19) covered a 50m.^{2} exposure on the bank of a small tidal creek (Halls Creek), one (#30-5-21) was situated on a low spur above Halls Creek close to backing swamp and was considered likely to cover an area of around 12,000m.^{2}, while the other (#30-5-22) lay on a prominent ridge edging the floodplain and an expanse of swampland and covered an area of some 120,000m.^{2}. Due to its geographical similarity to the Site #30-5-22 ridge, Rich considered that an additional open campsite could occur on an adjoining ridge were access had been denied during her survey. The presence of such a site (#30-5-43, 'TTRR 14') was confirmed during the course of a later archaeological inspection (Collins 1994).

Prior to commencement of construction works on the Taree Bypass, those parts of Sites #30-5-22 ('TTRR 9') and #30-5-43 ('TTRR 14') lying within the impact corridor were salvaged and their stone artefact assemblages analysed (Collins 1994). This analysis suggested contemporaneous use of the two adjacent ridges and although there were demonstrable differences, the assemblages were closely associated both functionally and technologically. The sites represent an occupation based around a ridgeline of naturally outcropping nodules of mudstone, chert, jasper, quartz, quartzite, volcanics and other sedimentary stones. Although specialist strategies aimed at microblade and other flaked tool reduction were identified at Site #30-5-43, it primarily represented a place where stone was procured and tested, and where the early stages of core reduction were performed. In contrast, Site #30-5-22 displayed a far greater emphasis on tool production and use, and it was considered likely that its high-quality stone materials had been selected at, and brought from, the Site #30-5-43 ridge for the more advanced finishing work (Collins 1994:115).

In 1997, Collins surveyed the 4.2km. long and 100m. wide corridor proposed for construction of the Coopernook Bypass. The southern end of this corridor joins the northern end of the current study corridor on Jones Island, stretching north across the floodplain and bridging the Lansdowne River and Coopernook Creek before mounting slopes separating the crests of bedrock hills. One open campsite ('CTRR 1') was recorded during the survey. This site comprises nine stone artefacts which were found on a low rise sandwiched between Coopernook Creek and backing wetland. The site area had been recently ploughed and it was thus likely that

undiscovered subsurface artefacts would be present. Despite the small number of visible artefacts, a range of raw materials (chert, chalcedony, quartz, greywacke and coarse-grained mudstone) was identified. Cores were conspicuously absent, and given the disproportionate number of used 'tools' in the assemblage (two nuclear pebble tools and two flake tools), it was concluded that tool use rather than tool production was a priority. Judging from the number, discrete distribution and character of the artefacts, it was thought that the site most likely reflected a single short-term camping event with on-site activities centred on the preparation of vegetative resources (Collins 1997:31). In addition to Site 'CTRR 1', an elevated natural levee along the northern side of the Lansdowne River was considered to represent a potential occupation area. While grass and sediment cover prevented any effective inspection on this levee, it is to be test excavated in the near future in an effort to determine its cultural context.

A narrow corridor to be affected by the installation of a transmission line between Taree and Port Macquarie was inspected by Brayshaw in 1977. No archaeological sites were discovered along the route which traversed hills and ridges some 8km. west of Jones Island. However, during the course of enquiries with landowners it was revealed that "several stone axes (had been) ploughed up on a farm at Moto some years ago" (Brayshaw 1977:3). Moto lies on the western bank of Ghinni Ghinni Creek opposite Jones Island and directly inland of the study corridor's northern end.

The most areally-extensive survey in the Manning region has been that undertaken by Klaver and Heffernan (1991) during preparation of the Greater Taree Aboriginal heritage study. Klaver and Heffernan divided the Manning basin into four broad terrain units and conducted non-systematically selected sample surveys within each unit. Because Klaver and Heffernan parcel together all land with a slope of <3° in their 'flat terrain' unit, failing to differentiate between the alluvial floodplain, the coastal sand plain, the coastal dune systems and the floors of river and tributary valleys further inland, their findings have little predictive value for the present study. Nevertheless, 45 archaeological sites in all were recorded within the surveyed 18.48ha. (0.018%) 'flat terrain' sample, including 34 shell middens, five open campsites, two scarred trees, two natural mythological sites, a stone arrangement and a Bora/ceremonial ground.

Although Klaver and Heffernan (1991:30) predict that sites will occur on 'flat terrain' at a density of one per 0.41ha., 31 of the sites recorded in this land unit are foredune pipi middens and two are of a non-relic type (natural mythological sites), leaving only 12 archaeological sites to testify to occupation and use of the remainder of the valley. Only one of these sites, a scarred tree (#30-6-69) on the footslopes of a bedrock-soil hill on Oxley Island, actually lay within the estuarine area itself (Klaver & Heffernan 1091:28). Furthermore, because approximately 24% of the surveyed sample covered land on which informants had indicated that they had found sites

(Klaver & Heffernan 1991:20), the resulting site densities will obviously be substantially higher than actually present across the terrain units as a whole, and the perceived site distribution patterns are also likely to have been influenced by the selection methodology. Despite its shortcomings, the Klaver and Heffernan (1991) survey did result in the recording of sites in a range of environmental contexts, including estuary banks and rainforest (Table 4).

TABLE 4: Results reported by Klaver and Heffernan on 'flat terrain' (Source: Klaver & Heffernan 1991:39)

Vegetation/association	Effective survey coverage	No. sites	Mean site area
Rainforest	2,288m.^{2}	3	11.7m.^{2}
Sclerophyll forest	28,250m.^{2}	2	3,050.0m.^{2}
Woodland	288m.^{2}	3	15.7m.^{2}
Heath	144,725m.^{2}	32	21.0m.^{2}
Stream bank, fresh water	3,000m.^{2}	1	200.0m.^{2}
Stream bank, estuary	6,275m.^{2}	4	68.3m.^{2}
	184,826m.^{2}	45	162.8m.^{2}

5.3. Regional issues

It is clear from the review of past archaeological work provided in Section 5.2. that very little is currently known of the Manning Valley's prehistory. The region has been completely neglected by academic researchers, no sites have been dated to determine the chronology of occupation, and subsurface investigations are restricted to those undertaken by Collins (1994) at two open campsites located on low ridges flanking the southern margin of the floodplain on the Taree Bypass.

Although a 3.5km. stretch of discontinuous pipi midden testifies to the exploitation of traditional resources along the Mitchells Island coastline 10.5km. south-east of Jones Island, very few sites have been recorded across the vast tract of floodplain downstream of Taree and the few impact assessment surveys so far completed there have been constrained by grass cover, resulting in low rates of artefact detection. In all, as few as 125 Aboriginal sites are on record for the entire City of Greater Taree local government area (4,030km.^{2}), yielding a density of only one site per 32.3km.^{2}.

Ethnohistorical sources for the Manning Valley fail to supply any detailed accounts of settlement patterns, and the attendant paucity of the known archaeological resource has prevented the development of models explaining the ways in which residential groups articulated with their natural and social environment, allowing a simplistic seasonal landuse model to remain unchallenged for the region. Detailed data on the location and character of sites, and of their

assemblage composition and variability across the full range of terrain units is essential before any reconstruction the Manning Valley's settlement-subsistence system can be validly attempted. This data will permit the development of a regionally-specific site typology, and in turn, the examination of interrelationships between site types, and the interrelationships between site locations and the environment (cf.Plog *et. al.* 1977:111).

Because longer highway corridors tend to cross-cut several dramatically different terrain units their archaeological survey/investigation is capable of elucidating variability in archaeological site types (Goodyear 1977:158). However, while further and more detailed investigation of all terrain types is considered a pressing research requirement in the Manning region, the study corridor itself represents only a narrow transect of a single unit- the alluvial floodplain, and its prehistoric record cannot be expected to offer anything more than a very limited picture of the floodplain component of the settlement-subsistence system. Even so, the corridor does traverse five separate types of landform element (backplain, scroll, levee, channel bench and swamp [Speight 1990:24-34]) and encompasses areas which once supported both swamp and gallery rainforest communities. Thus, depending upon their environmental context, different sections of the corridor are likely to have played different roles in the settlement and exploitation of the floodplain. Within the parameters of the corridor's specific landscape characteristics, this study aims to provide data on the distribution and nature of floodplain sites to supplement any more spatially-extensive investigation which may be conducted in the future.

6. ARCHAEOLOGICAL EXPECTATIONS FOR THE STUDY CORRIDOR

6.1. Potential site types

On the basis of information gained through a review of ethnohistorical sources (Section 4), the distribution of known sites (Section 5.1) and the results of past surveys in the Jones Island locality (Section 5.2), there is some potential for undetected Aboriginal sites to occur within the study corridor. However, in view of its disturbance history, some of the more vulnerable site types recorded in other low-gradient contexts on the Manning (e.g.Bora/ceremonial grounds, stone arrangements, carved trees) could not have survived, and an absence of rock outcrops precludes the existence of occupation shelters, rock art sites, axe grinding grooves and stone quarries. Those types which do have some potential to occur within the study corridor are defined and discussed in this section.

6.1.1. Isolated stone artefacts

These may be located anywhere in the landscape and represent either the remnant of a dispersed open campsite (artefact scatter), or the simple loss or random discard of artefacts. Because Jones Island is known to have been used by Aboriginal groups (Sections 2. & 4.3.), isolated artefacts are likely to be present, though they may be impossible to detect as a result of vegetation cover and alluvial sedimentation.

6.1.2. Open campsites

Open campsites often occur along the banks of rivers, creeks and swamps but may also be found in other open situations. Early illustrations and descriptions show these sites to have consisted of shelters of branches and bark surrounding a central area where cooking and other domestic activities were carried out (Byrne 1989:10). However, as a result of exposure and weathering the actual occupation deposit rarely survives, leaving only stone artefacts and possibly some bone and charcoal at the surface to indicate past Aboriginal activity.

Although the remains of open campsites have the potential to occur within the study corridor, like isolated artefacts, these sites may be impossible to detect due to vegetation cover and alluvial sedimentation.

6.1.3. Shell middens

These sites are generally found near water sources and are essentially the remains of Aboriginal meals of shellfish. Aboriginal middens differ from natural shell beds in that they comprise predominantly mature specimens of edible mollusc species. They may also contain faunal remains, stone artefacts and charcoal and ash from cooking fires. On the mid-north coast Aboriginal burials have also been recorded in direct association with midden deposits.
While middens are the most common type of occupation site in the Manning region, a large number of these have been destroyed by sandmining and natural erosion, and continue to be destroyed ahead of development. As a result, undisturbed examples are now relatively rare.

A number of open estuarine middens have been recorded close to the mouth of the Manning River at Harrington and Manning Point, and near the northern bank of the Manning River South Channel on Oxley Island. Although all of these lie well downstream of Jones Island, Ghinni Ghinni Creek is tidal and it is possible that similar midden sites may survive along its banks.

6.1.4. Contact camps

Unlike prehistoric campsites, the locations of camps occupied after European settlement were not governed by traditional economic concerns, but by the dictates of the white economy (Byrne 1989:22). European land appropriation restricted access to former hunting grounds and

seriously undermined the natural resources traditionally exploited by Aborigines. As a result, new camps had to be directed towards the only alternative food source, and 'fringe camps' were thus established on the outskirts of European settlements and pastoral properties. The Croki camp mentioned by Hannah (1988:22)(Section 4.3.) appears to have been one such 'fringe camp'. Post-contact groups also established camps on the site of the present Taree Showground and on a pastoral property at Lansdowne (Connors 1985:92).

As discussed in Section 2., during the late 1890's Aboriginal groups in transit between Crowdy Head and areas further inland are believed to have itinerantly camped beneath a Moreton Bay fig tree in the immediate vicinity of the study corridor's northern end. While this tree is unlikely to be that which stands within the Pacific Highway Reserve on the northern end of the corridor, the tree surrounds have been extensively disturbed by road construction. Although a number of Aborigines continued to fish along Ghinni Ghinni Creek during the earlier part of the 20th century (c.1915-20) their place of residence remains unknown (K. Black pers. comm.).

6.1.5. Burials

Prehistoric and contact period burials, both as isolated individuals and as groups, are recorded for the mid-north coast. They are usually found as primary interments in soft sediments. While graves were sometimes marked by earth or stone mounds, the majority of known sites have been discovered eroding from middens, dunes or creek banks, or have been unearthed during development activities. Unfortunately, most burials may be detected during survey only if they have been exposed through erosion or if subsurface sediments have been disturbed.

Given that floodplain burials have been unearthed in association with occupational materials near both the Hastings (Collins & Sullivan 1996) and Macleay Rivers (Connah 1975:29), there is some limited potential for such sites to remain along the banks of Ghinni Ghinni Creek. However, unless very recent or directly associated with midden deposits, any burials occurring within the floodplain's acid soils (Section 3.4.) will be either in a very poor state of preservation, or will have disintegrated completely (cf.Dowman 1970).

6.1.6. Scarred trees

These are trees which bear scars caused through the removal of bark or wood for making material items such as canoes, shields and containers, or which have been marked for other reasons (e.g.toe-holds to aid climbing). Because scarred trees are usually associated with domestic activities they may occur anywhere there are suitable tree species, and be found where mature specimens still exist.

Although a few large red gums stand beyond the study boundary, trees with the potential for scarring within the corridor itself are restricted to two Moreton Bay fig trees and a number of grey mangroves which line the banks of Ghinni Ghinni Creek. Both of these latter species supplied the wood preferred in shield manufacture (Fitzpatrick 1914:42; Dick 1915).

6.1.7. Natural mythological sites/sites of spiritual significance

These sites differ from other site types in that they are usually natural features of the landscape which have not been modified by Aboriginal people. Such sites are not locatable through the usual process of field survey and can only be identified by those individuals who have traditional knowledge of a specific study area. Three natural mythological sites, North Brother (#30-3-23), Middle Brother (#30-6-02) and South Brother (#30-6-01) Mountains (cf.Nayutah & Finlay 1988:71-74), have been registered to the north of Jones Island and serve to illustrate that on the mid-north coast, as in other parts of Australia, culturally-significant sites often correspond with prominent topographic features. Further spiritually-significant places are found on each of the three mountains (Bert Marr pers. comm.).

However, while the study corridor is devoid of any prominent topographic features, this does not preclude it from containing a natural mythological or otherwise spiritually-significant place and this issue was explored during the course of the Aboriginal involvement described in Section 2.

6.2. Likely pattern of prehistoric landuse

Although the distribution of the recorded sites suggests that the sandy coastal strip and the lower estuarine system provided a focus for Aboriginal occupation in the Manning Valley, a number of scarred trees have been identified in a variety of environmental contexts throughout the hinterland, and open campsites have been discovered close to the banks of its creeks and swamps, usually in well-drained elevated locations (Table 3).

Swampy lowlands such as those crossed by most of the proposed upgrading corridor represent an ecological zone wherein a variety of foods and other desirable resources could have been obtained within easy travelling distance of camps situated close to the Manning River and/or Ghinni Ghinni Creek (cf.Lilley 1984; Coleman 1982). Certainly, reports of locals finding axes and other stone artefacts eroding onto the intertidal mudflat along the eastern margin of Jones Island (W. Anderson pers. comm.), and of axes being unearthed at Moto immediately west of the island (Brayshaw 1977), indicate that the estuary banks were well used. While the larger and more frequently occupied campsites are more likely to have been established further downstream on the banks of the Manning, smaller resource-specific and single use campsites

(like that recorded near Coopernook Creek [Collins 1997]) can be expected in the general study locality.

Because the drainage-impeded floodplain soils would have provided few desirable camping locations, any occupational evidence will probably be associated with elevated rises and natural levees bordering the water courses (cf.Byrne 1986). On the basis of such a settlement pattern, the most potentially sensitive parts of the study corridor include the levee on the southern bank of Ghinni Ghinni Creek, the low scroll north of Ghinni Ghinni Creek, and the levee on the northern side of the small unnamed fresh water creek near Croki Road (North).

While the lists of known material culture raw materials and food resources (Tables 1 & 2) attest to Aboriginal exploitation of gallery rainforests along the Manning River and its tributaries, according to exhaustive research undertaken by Byrne (1987), traditional camps appear to have been made near the more productive margins of the rainforest rather than within it. As Byrne (1987:54) notes, the key attribute of gallery rainforest (as opposed to more extensive tracts of rainforest) was its accessibility, and exploitation of its resources, whether systematically or casually, could have been easily scheduled within the mainstream economy of base camps established in neighbouring environments. Obviously, this model hinges on the assumption that neighbouring environments offered suitable well-drained ground. In the current study locality however, the gallery rainforests flanking Ghinni Ghinni Creek, Jones Island and the Lansdowne River are believed to have given way directly to backswamps (Figure 5) without providing any intermediate environmental niche. Thus, any campsites established along the banks of these water courses would, by necessity, have been situated within the rainforest. Given that Birrell's (1987) reconstructed vegetation map is reliable, two open middens (#30-6-40 & 30-6-43) and a rockshelter midden (#30-6-42) along the banks of the Manning River South Channel appear to have been situated within the gallery rainforest, as does an open campsite (#30-6-52) on the western bank of Oxley Island. It would therefore not be inconsistent to expect open campsites and/or middens to occur along the once-rainforested banks of Ghinni Ghinni Creek.

Due to the paucity of recorded floodplain sites data is currently insufficient to allow estimates of site density to be made for the Jones Island area. However, given the narrow transect of land (30-70m.) that the study corridor represents relative to the floodplain landscape unit, any cultural materials which may be present within it are likely to be rare, despite a predicted occurrence of 51 occupation site locations (open campsites, middens and/or isolated finds) based on the density results achieved by Klaver and Heffernan (1991) for 'flat terrain' (2.1 occupation sites/ha.). This is clearly an unrealistic figure which takes no account of substrate type, vegetation or the broader landscape context.

7. FIELD INVESTIGATION

7.1. Potential for site preservation and survey detection

With respect to the archaeological record it is necessary to consider not only those cultural and environmental factors which will have influenced the way in which Aboriginal people used and moved through the landscape, and thus where cultural material may have been originally abandoned, but also factors which will have affected preservation, and hence the location and context of surviving evidence in the modern landscape. Apart from natural attrition, the major determinants of present site location and condition are destructive elements, particularly those stemming from European landuse practices. Additional constraints to the discovery of surface sites are imposed by vegetation cover and by the deposition of alluvial sediments.

For the purposes of this study, the floodplain has been divided into five landform element 'types' - backplain, scroll, levee, channel bench and swamp, which have been delineated on the basis of their topography and morphological characteristics, and which conform with the element definitions given by Speight (1990:24-34). For ease in reporting, the backplain landform element has been sub-divided into five survey sectors (BKP-1, BKP-2 etc.), while the two creek levees are reported separately as Sectors LEV-1 and LEV-2 (see Figures 6a & 6b for the location of survey sectors). Each of the landform element types is considered likely to have been subject to a distinctive pattern of prehistoric landuse, and each imposes its own constraints on the preservation and detection of archaeological sites. These constraints are outlined in this section.

7.1.1. Backplain [96.0% of study corridor]

There is little doubt that modern landuse will have already had a detrimental affect on the spatial integrity of archaeological sites along the full length of the study corridor, particularly those within the plough zone and the existing Highway Reserve (Plate 5). With the exception of the mangrove-fringed banks of Ghinni Ghinni Creek and two potentially remnant Moreton Bay figs, all natural tree cover has been removed and replaced with a patchwork of pasture grasses and fodder crops (Plates 1 & 6). Initial clearing methods included the invasive practice of pulling out large tree roots with a bullock team (Connors 1985:63).

By 1860 all but the northern tip of Jones Island had been appropriated by European settlers for the development of small farms centred on the production of maize crops (Birrell 1987:91; Ramsland 1987:99). Although seeds on the better equipped farms were harrowed in, most early farmers employed basic cultivation methods- a wooden mould-board plough to break the soil, and a hoe to plant (Birrell 1987:120-121). Within forty years dairying had taken over as the main form of income on the lower Manning (Hannah 1988:93-96; Ramsland 1987:105) and the

entire study corridor still supports dairy and beef cattle. While fodder crops across the backplain are now generally surface sown, some landowners reported ploughing to a depth of around 20cm. and at least some localities have been ploughed to a depth of up to 60cm. in the past. During the earlier part of the 20th century, ploughing seems to have been a widespread farming practice on Jones Island (e.g.Hannah 1988:95).

Although mechanical tillage rarely destroys stone artefacts, experimental results have indicated that less than 10% of any plough zone assemblage will be present on the ground surface at any one time, and that the larger artefacts will be over-represented at the surface relative to their overall frequency. Horizontal displacement caused through ploughing is largely related to an artefact's size, land gradient, the type of equipment used, and to the number and direction of equipment passes. Artefacts are scattered along the axis of cultivation, with the larger examples moved further from their origin. The larger artefacts are also moved further outward perpendicular to the axis of cultivation (Boismer 1989:134-141; Lewarch & O'Brien 1981:308). Given that any open campsite occurring within at least 20cm. of the floodplain's surface is likely to have been repeatedly exposed to such processes at some stage, its artefacts will by now be highly dispersed.

In addition to the disturbance cause by ploughing and construction of the existing Highway, narrow transects of the backplain have been impacted by construction of both sealed roads (Blacks Lane, Moto Road, and Croki Roads North and South) and a number of gravelled property access tracks, most of which follow raised causeways edged by table drains.

The entire study corridor is subject to flood inundation and a network of artificial drains indicates that much of the present 'dry' plain was once covered by swamp. Flood-prone surfaces are progressively covered by sediments with each inundation, making it impossible to discover archaeological materials unless they have been brought to the surface through ploughing or other disturbance activities. As a result of the episodic nature of erosion on the upper and middle reaches of the Manning River, sediment transport regimes tend to be extremely variable and unpredictable (Nanson 1986:1474). Thus, while alluvial sediments will have covered prehistoric materials across all landform elements, the depth at which these materials may be encountered cannot be estimated and is likely to vary considerably between localities. While some sites will potentially occur within the plough zone and be detectable at the surface, others may be completely concealed from view.

With the exception of drain cuttings which provided an opportunity to examine subsurface sediments, survey visibility remained extremely low across the backplain, with adequate

exposures largely restricted to tracks and other shallow erosion features caused by vehicles and livestock, and to areas denuded of vegetation around trees.

7.1.2. Scroll [1.5% of study corridor]

As with the remainder of the floodplain, the low terrace-like scroll (Sector SCR) which extends across the study corridor north of Ghinni Ghinni Creek (Plate 4) is flood-prone and has been cleared of its natural vegetation cover. A derelict building (the former Croki Post Office) stands on the scroll crest and is surrounded by exotic trees, offering localised visibility in the order of 60%. The scroll falls toward Ghinni Ghinni Creek in a gentle fully-exposed slope which has been ploughed and cultivated with vegetables. Away from the slope and the immediate Post Office surrounds grass cover is reasonably sparse, yielding a general visibility of 10%.

Like the backplain, the scroll crest is an aggradational feature which is likely to have been ploughed in the past. The discussion in the foregoing section (Section 7.1.1.) with regard to the potential for site survival and detection in the face of these constraints is therefore similarly applicable to this landform element.

7.1.3. Levees [0.6% of study corridor]

The natural levee on the southern side of Ghinni Ghinni Creek (Sector LEV-1)(Plate 2) is subject to inundation during larger-scale flooding of the creek and Manning River, and like the remainder of the study corridor, both the Ghinni Ghinni levee and the second narrow levee edging a fresh water channel further north (Sector LEV-2) represent aggrading landform elements. Any surface artefacts in Sectors LEV-1 and LEV-2 will have been covered by alluvial sediments.

Although both levees are grassed, visibility is reasonably good in Sector LEV-1 (5% general visibility), with shallow full exposures occurring along the length of the creek bank and within yards attached to cow bales on the northern edge of the study corridor. While it is unlikely to have sustained repeated ploughing, Sector LEV-1 has been subject to disturbance stemming from the construction of a cream shed which once stood beside Ghinni Ghinni Creek in the centre of the corridor, and a pig and fowl pen which stretched along the remainder of the bank (K. Black pers. comm.). Although much of the steep cutting which falls from the levee to water level is fully exposed, the landowner indicated that soil and other material had gravitated down the bank over a long period of time and that very little, if any, of its surface is natural (K. Black pers. comm.).

Sector LEV-2 offers low visibility, with exposures restricted to two discontinuous tyre tracks along the levee crest. Apart from tree clearing, disturbance appears minimal.

7.1.4. Channel Bench [1.5% of study corridor]

On Jones Island the study corridor traverses a very poorly elevated channel bench (Sector CBE) which stretches between Ghinni Ghinni Creek and Sector SWP (Plates 3 & 4). While the disturbance context of this element remains unknown, it is unlikely to have been suitable for agriculture and as such may not have been ploughed. It has, however, been cleared of tree cover and now supports grassland offering a general visibility of 5%. With the exception of a geotechnical test pit, full surface exposures are restricted to a tide-affected 5m. wide strip of mangrove forest along the immediate bank of Ghinni Ghinni Creek, and a few narrow cattle tracks further from the creek.

7.1.5. Swamp [0.5% of study corridor]

The narrow elongated pocket of swamp (Sector SWP) which separates Sector CBE from Sector SCR on the southern end of Jones Island (Plate 4) was inundated and thus inaccessible at the time of the field survey. Aside from the presence of reeds, the indistinct swamp boundaries are defined by grading slopes.

As with the remainder of the study corridor, any cultural materials which may occur in or around the swamp will have been covered by alluvial sediments and will only be detectable if they have been brought to the surface during the course of ploughing or other agricultural activities.

7.2. A predictive archaeological model for the study corridor

This model derives from a consideration of the likely pattern of Aboriginal landuse in the Jones Island locality (Section 6.2.), known site distributions (Section 5.1.), the results of past surveys (Section 5.2.), and of what archaeological evidence can be expected to have survived within the study corridor (Section 6.1.).

7.2.1. Backplain

Sectors BKP-1, BKP-2 & BKP-3

- Given that these two sectors encompass largely undifferentiated parts of the floodplain which reportedly once supported gallery rainforest (Figure 5), archaeological evidence is likely to be restricted to a low-density background distribution of isolated stone artefacts discarded or lost during the course of activities associated with rainforest exploitation. Such artefacts are expected to be dominated by locally-available raw materials, particularly siltstone and mudstone. A Moreton Bay fig tree in Sector BKP-2 may display evidence of bark removal.

Because the backplain is heavily grassed and subject to sediment deposition, archaeological evidence may not be detectable at the surface. Any materials within at least 20cm. of the surface will probably have been displaced through ploughing.

Sectors BKP-4 & BKP-5

- Sectors BKP-4 and BKP-5 also traverse undifferentiated parts of the floodplain. However, with the exception of the slightly elevated creek bank on the northern end of BKP-4 and a low rise at northern end of BKP-5, both of these sectors lie below 1m. AHD and would almost certainly have been covered in swamp. While isolated stone artefacts may occur in the higher localities, neither of these sectors are considered to be archaeologically sensitive.

Both Sector BKP-4 and BKP-5 are thickly grassed and subject to sediment deposition. As such, archaeological evidence may not be detectable at the surface. Like Sectors BKP-1, BKP-2 and BKP-3, any materials within at least 20cm. of the surface will probably have been displaced through ploughing.

Sector BKP-5

- During post-contact times, small transit groups are believed to have camped itinerantly beneath a Moreton Bay fig tree somewhere in the immediate vicinity of the northern end of the study corridor. While its apparent age makes this improbable, it has been suggested that the subject tree is that which still stands beside the existing Highway on the northern end of Sector BKP-5 (Section 2.)(Plate 8). Although these camping activities are likely to have resulted in little discard of durable material which could survive in the archaeological record, it is possible that a low-density distribution of occupational materials (stone artefacts, shell, charcoal etc.) may occur in the immediate vicinity of the tree. The fig tree itself may display evidence of bark removal.

Given the disturbance caused through construction of the adjacent Highway and growth of the roots themselves, any materials which do occur in the tree vicinity are extremely unlikely to be *in situ* and will be difficult to detect in the face of vegetation and sediment cover.

7.2.2. Scroll

Sector SCR

- Sector SCR represents an elevated and relatively well-drained landscape element which is thought to have been formerly rainforested and separated from Ghinni Ghinni Creek (70m. away) by a pocket of swamp and a poorly-drained and rainforested channel bench (Figure 5). As a result of its topography the scroll is considered to have a greater level of archaeological potential than the backplain. However, it is unlikely to have been preferred for occupation, particularly when the nearby Ghinni Ghinni Creek levee (Sector LEV-1) is higher, better drained, and lies directly beside the creek channel. While occupation sites are therefore not expected to occur in Sector SCR, it may well contain a higher background density of artefacts relative to the backplain.

Given that the former Croki Post Office has been relocated to the crest, Sector SCR is likely to have been subject to both surface and subsurface disturbance stemming from construction and

other European landuse activities (e.g.vegetable cultivation). As such, any artefacts which are present can be expected to have suffered at least some post-depositional displacement and may not be detectable due to sedimentation and grass cover.

7.2.3. Levees

Sector LEV-1

- Because prehistoric residential groups are most likely to have established camps on locally-elevated landforms along the immediate banks of the estuarine system, the narrow levee bordering the southern bank of Ghinni Ghinni Creek is considered to be archaeologically sensitive and has the potential to contain occupational evidence in the form of small open campsites and/or shell middens. Lying only 250m. upstream of the creek's confluence with the Manning River, easy access to the levee could have been gained by canoe. The larger mangroves fringing the levee bank may display evidence of bark removal.

While some plough-dispersed shell and/or stone artefacts may occur on the surface of Sector LEV-1, as a result of sedimentation, surface inspection alone is unlikely to be adequate for determining the presence or absence of cultural materials.

Sector LEV-2

- Sector LEV-2 is situated on the northern bank of a small fresh water creek (Plate 7) and grades into swamp to the immediate north. The low narrow levee represents an apparently once rainforested landform element (Figure 5), although access by canoe from the Manning River would have required the navigation of over a kilometre of the shallow and reed-infested creek. As a result of its topography Sector LEV-2 is considered to have a greater level of archaeological potential than the backplain. However, given its upstream distance from the river and the fact that the levee widens substantially on the western side of the Pacific Highway, offering higher and better-drained potential camping locations (now covered by houses and farm buildings), it is unlikely that any campsites will lie within the study corridor in Sector LEV-2. Even so, it may contain a higher background density of artefacts relative to the backplain.

Because Sector LEV-2 is grassed and subject to alluvial sedimentation, any artefacts which are present are unlikely to be detectable at the surface.

7.2.4. Channel bench

Sector CBE

- Aboriginal exploitation of tidal mudflats and low-lying areas of gallery rainforest is most likely to have been undertaken from camps established on nearby well-drained levees. While the channel bench may well have been exploited for its resources it is unlikely to have been inhabited in its own right and is considered to have a low level of archaeological

potential. However, the larger mangroves fringing Ghinni Ghinni Creek may display evidence of bark removal.

Although it is possible that Sector CBE will contain a very low-density background distribution of artefacts lost or discarded during the course of activities associated with rainforest exploitation, there is only a minimal probability of detecting this type of evidence given the constraints imposed by grass cover and alluvial sedimentation.

7.2.5. Swamp

Sector SWP

- As with Sector CBE, Aboriginal exploitation of the swamps is most likely to have been undertaken from camps established on nearby well-drained creek levees. While Sector SWP may well have been exploited for its resources, it is unlikely to have been subject to artefact discard and is considered to have a negligible level of archaeological sensitivity.

7.3. Survey strategy

Given the likely pattern of Aboriginal landuse (Section 6.2.), the widespread distribution of former swamps (Figure 5), and the visibility constraints imposed by alluvial sedimentation and grass cover, it was considered both impractical and unnecessary to inspect the entire study corridor. A survey strategy was therefore adopted which aimed to fully inspect all areas with a reasonable level of archaeological potential and to sample areas with low potential. Determination of this potential was based on the predictions made in Section 7.2. 100% of the high potential locations and 75% of the low potential areas were examined, with the latter targeting all land above or approaching 1m. AHD. Particular attention was paid to available surface exposures, including unformed vehicle tracks, tracks and eroded patches created by livestock, and areas denuded of grass cover beneath trees and around cattle yards, as well as mechanically exposed features such as drain cuttings and a ploughed cultivation plot. In grassed areas, surface contours were visually scanned for any localised depressions suggestive of a burial site. Areas below 1m. AHD were examined from the Highway Reserve to assess their available visibility before being rejected from (if no exposures apparent) or included in (exposures apparent) the survey sample.

7.4. Survey method and details

Prior to the fieldwork the relevant landowners were contacted and permission was granted by all for the survey team to enter their land. One of the owners indicated that they had ploughed up artefacts in the vicinity of the study corridor, while another indicated that they had heard of 'Aboriginal items' having once been found within the corridor itself.

Field inspection of the study corridor, totalling 20 person hours, was conducted with the assistance of Purfleet-Taree LALC sites officer Vienna Maslin on 20 and 21 August 1998. The weather was overcast and standing water from recent rains prevented inspection in some localities. The survey was completed across each property in two longitudinal transects with the surveyors walking up to 15m. apart and inspecting all of the available ground surface within their line of sight. Both surveyors inspected drain cuttings and any of the more extensive exposures, as well as the trunks of any reasonably mature trees standing within and immediately beyond the corridor. A concept design plan showing property boundaries, fence lines, buildings and other cadastral details was supplied by Connell Wagner for ease in field orientation, and all pertinent survey information was noted directly onto this plan. Photographs were taken to record the various levels of surface visibility and selected examples have been included in this report to offer the reader a general overview of the survey conditions (see Figures 6a & 6b).

7.5. Survey coverage

Land covered during the survey, representing 76.6% of the study corridor (24ha. excluding open water and existing road pavement), is shaded on Figures 6a and 6b, while Table 6 presents summary details of the context of, and the extent of inspection undertaken within, each of the ten survey sectors.

The concept of coverage analysis has been developed as a means of specifying the proportion of a surveyed sample which permitted the detection of sites. With respect to the more unobtrusive types of sites such as scatters and isolated stone artefacts, site detection can be partially or even completely impaired by vegetation, flood-deposited, slope-washed and wind-blown sediments, modern land modification, gravelly surfaces and/or poor lighting conditions (cf.Witter 1992:85-87). Although 18.03ha. of land was included in the field survey, only a very small proportion of this was actually able to be inspected for surface evidence, the remainder being carpeted by grasses or fodder crops and yielding no visibility at all. Once this impediment is taken into account (by multiplying the area of each survey sector by its mean surface visibility), it is estimated that as little as 3.6% of the surveyed sample and 2.7% (0.64ha.) of the total study corridor was subject to effective survey coverage (Table 7).

Apart from the 195m. of drainage canals which fully exposed transects of the subsurface sediments to a depth of at least 50cm. across the backplain, and the ploughed slope of the scroll north of Ghinni Ghinni Creek, exposures were seldom more that 10cm. deep and obviously lay well within the plough zone.

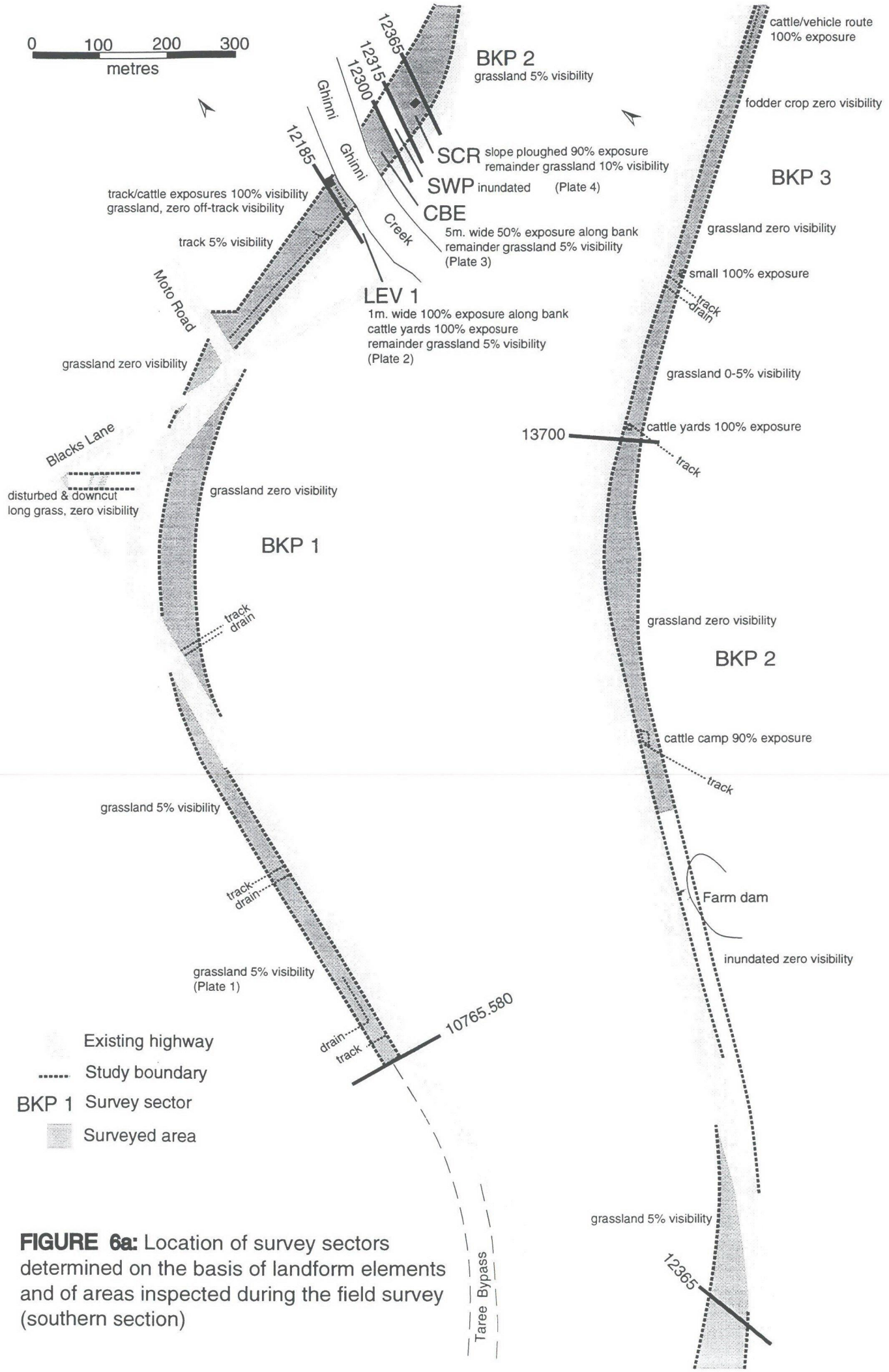


FIGURE 6a: Location of survey sectors determined on the basis of landform elements and of areas inspected during the field survey (southern section)

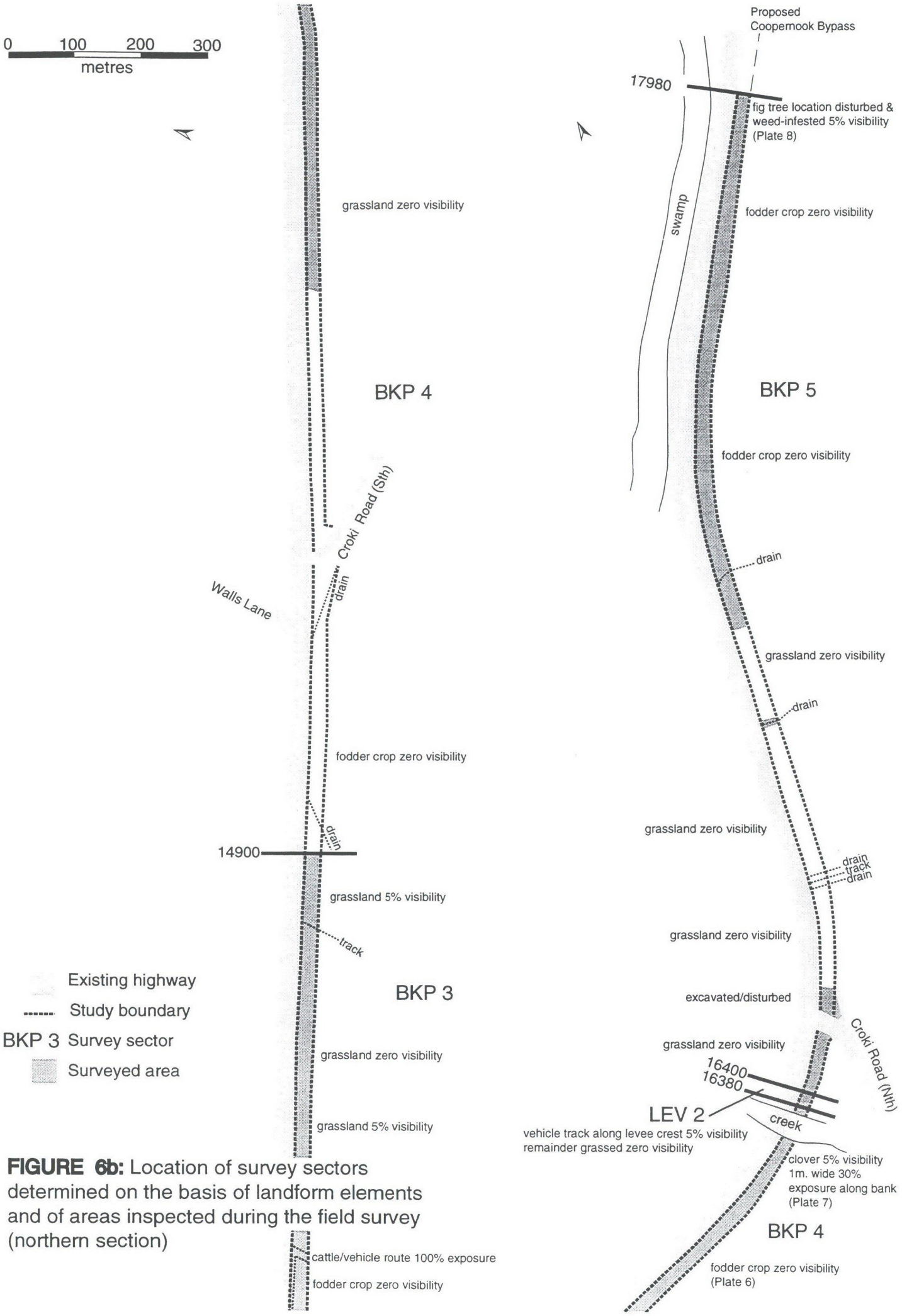


FIGURE 6b: Location of survey sectors determined on the basis of landform elements and of areas inspected during the field survey (northern section)

PLATE 1: View north across grassland west of existing Highway, Sector BKP 1



PLATE 2: South bank of Ghinni Ghinni Creek, view west across Sector LEV 1

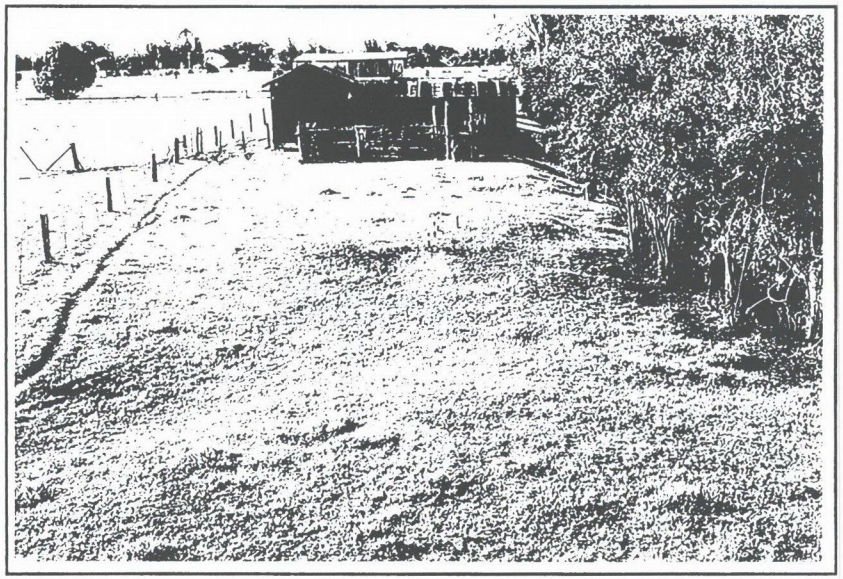


PLATE 3: North bank of Ghinni Ghinni Creek, view west across Sector CBE

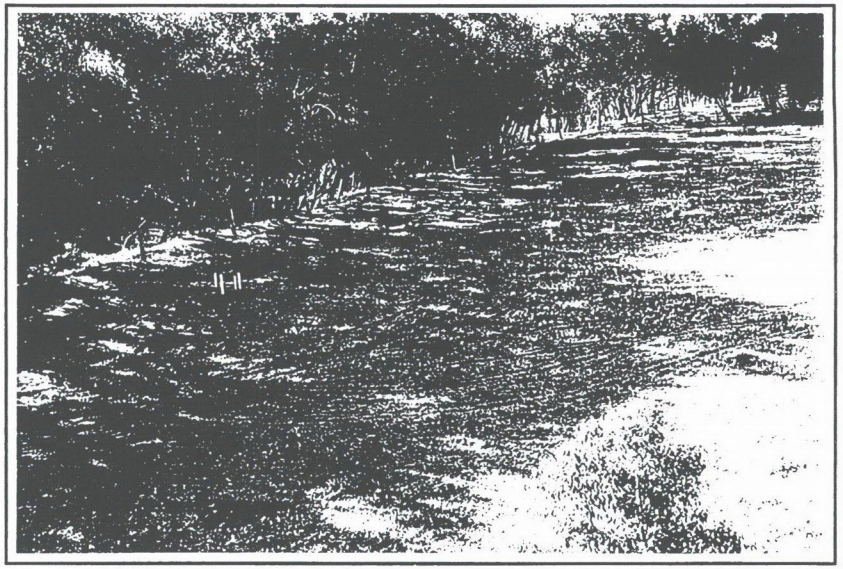


PLATE 4: View north from Sector CBE across Sectors SWP and SCR

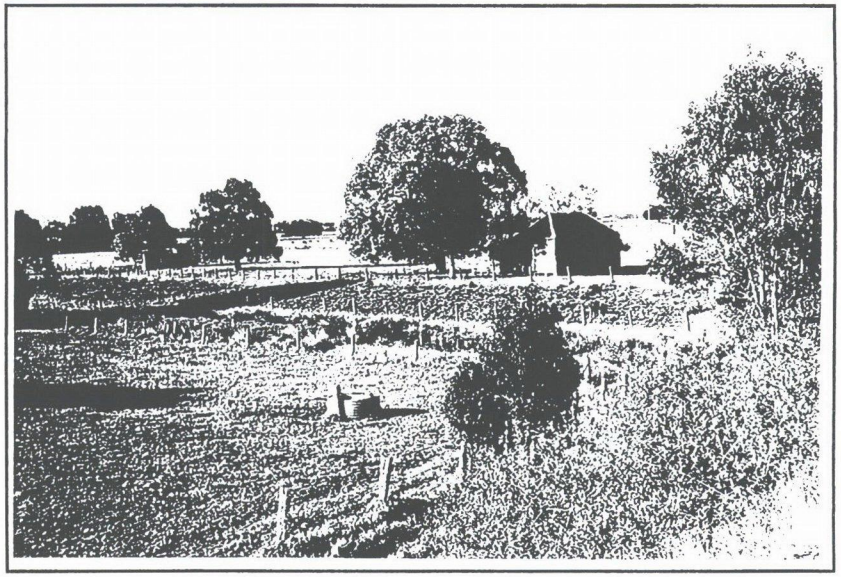


PLATE 5: Typical visibility within the existing Highway Reserve, Sector BKP 3

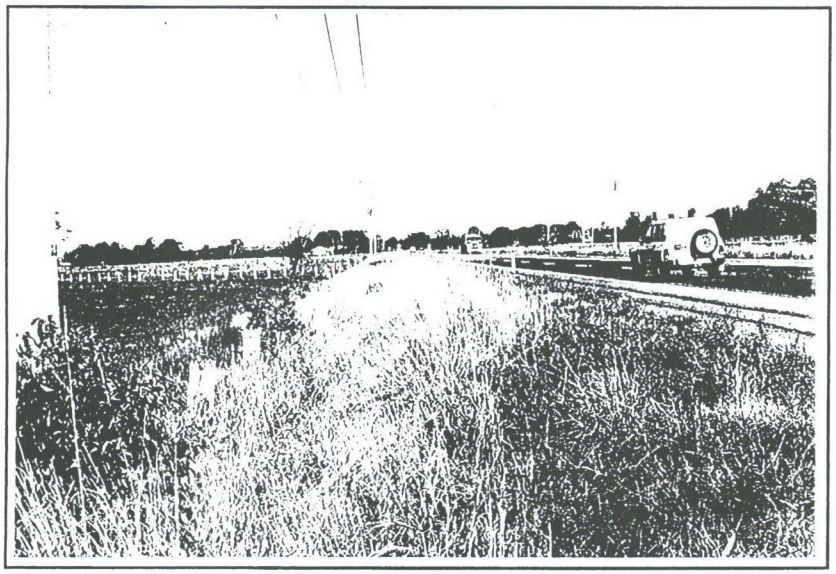


PLATE 6: View south across fodder crop, Sector BKP 4



PLATE 7: View south across creek from Sector LEV 2 to Sector BKP 4



PLATE 8: Fig tree reportedly used as a post-contact campsite, Sector BKP 5



TABLE 6: Summary of areas surveyed on foot

Sector	Mode of geomorph. activity	Geomorph. agent	Disturbance	Total area (ha.)	Survey area (ha.)	% of Sector
Backplain						
BKP-1	A	OV	4-5-8	5.32	5.32	100.0
BKP-2	A	OV	4-5-8	4.65	3.36	72.3
BKP-3	A	OV	4-5-6	3.60	3.60	100.0
BKP-4	A	OV	4-5-6-8	4.31	1.79	41.5
BKP-5	A	OV	4-5-6-8	4.70	3.12	66.1
Scroll						
SCR	A	OV	4-5-6-8	0.35	0.35	100.0
Levees						
LEV-1	A	OV	4-8	0.08	0.08	100.0
LEV-2	A	OV	4	0.06	0.06	100.0
Channel bench						
CBE	A	OV	4	0.35	0.35	100.0
Swamp						
SWP	A	CH-OV	1	0.11	0.00	0.0
TOTAL				23.53	18.03	76.6

Key:

Mode of geomorphological activity (Speight 1990:21)

ER	Eroded
EA	Eroded or aggraded
A	Aggraded
HU	Heaved up or elevated
BU	Built up
EX	Excavated or dug out
SU	Subsided or depressed

Geomorphological agent (Speight 1990:23)

GR	Gravity
S	Solution
SM	Soil moisture changes (creep)
SH	Sheet wash, surface wash
WM	Water-aided mass movements (landslides)
WI	Wind
OV	Overbank stream flow, unchannelled
CH	Channelled stream flow
FR	Frost
HU	Human agents

Site disturbance (McDonald, Isbell & Speight 1990:88)

0	No effective disturbance
1	No effective disturbance other than for hoofed animals
2	Limited clearing
3	Extensive clearing
4	Complete clearing- not cultivated
5	Complete clearing- presently or once cultivated
6	Cultivated- rain fed
7	Cultivated- irrigated past or present
8	Highly disturbed- quarrying, roading, mining, landfill, urban use etc.

TABLE 7: Effective coverage details

Survey Sector	Surveyed area (m^2.)	% of natural surface exposed	% visibility on exposures	Effective coverage ($m.^2$)	No. sites recorded
BKP-1					
Grassland	17,400	5	100	870.0	
Grassland	34,860	0	0	0.0	
Tracks	525	100	100	525.0	
Tracks	150	5	100	7.5	
Drain	105	100	100	105.0	
Other exp.	160	100	100	160.0	
Total	53,200			1,667.5 (3.1%)	0
BKP-2					
Grassland	6,012	5	100	300.6	
Grassland	27,420	0	0	0.0	
Tracks	38	100	100	38.0	
Other exp.	130	90	100	117.0	
Total	33,600			455.6 (1.4%)	0
BKP-3					
Grassland	18,000	5	100	90.0	
Grassland	16,355	0	0	0.0	
Tracks	120	100	100	120.0	
Drain	30	100	100	30.0	
Other exp.	1,495	100	100	1,495.0	
Total	36,000			1,735.0 (4.8%)	0
BKP-4					
Grassland	1,500	5	100	75.0	
Grassland	16,235	0	0	0.0	
Tracks	15	100	100	15.0	
Other exp.	150	100	100	150.0	
Total	17,900			240.0 (1.3%)	0
BKP-5					
Grassland	31,131	0	0	0.0	
Drain	60	100	100	60.0	
Other exp.	9	5	100	0.5	
Total	31,200			60.5 (0.2%)	0
SCR					
Grassland	2,225	10	100	222.5	
Ploughed	1,050	100	100	1,050.0	
Other exp.	225	100	100	225.0	
Total	3,500			1,497.5 (42.8%)	0

LEV-1					
Grassland	640	5	100	32.0	
Other exp.	160	100	100	160.0	
Total	800			192.0 (24.0%)	0
LEV-2					
Grassland	582	0	0	0.0	
Track	18	50	100	9.0	
Total	600			9.0 (1.5%)	0
CBE					
Grassland	3,100	5	100	155.0	
Tracks	40	100	100	40.0	
Other exp.	360	100	100	360.0	
Total	3,500			555.0 (15.9%)	0
TOTAL	180,300[18.03ha.]			6,412.1[0.64ha.](3.6%)	0

While visual scanning of the grassed land surfaces is likely to have been effective for discovering evidence of burial pits should they have survived the surface modification expected after more than a century of agricultural development, the small sample of the study corridor which offered a reasonable level of archaeological visibility is not considered to have been adequate for directly determining the presence or absence of artefacts. However, any survey of the study corridor is clearly limited at the outset by the non-obtrusive nature of those site types which have the potential to survive, and to the sedimentation processes to which it has been subject. Even had extensive surface exposures been present, site detection would necessarily have been restricted to artefacts and/or midden horizons exposed in drain and bank cuttings, and to artefacts and shell dispersed during ploughing and other mechanical activities.

8. SURVEY RESULTS

8.1. Recorded sites

No Aboriginal cultural material or other evidence of Aboriginal activity (e.g.scarred trees) was recorded during the field survey, nor were any depressions considered potentially indicative of a burial pit discovered.

8.2. Reported artefact finds

8.2.1. Sector BKP-1

The owner of land between Moto Road and Ghinni Ghinni Creek (Portion 8, traversed by Sector BKP-1) reported that over a period of many years he has ploughed up several pebble axes in the northern section of the property (see general location, Figure 2). None of these were actually found within the study corridor itself (K. Black pers. comm.). As the artefacts were not collected they were unavailable for recording.

8.2.2. Sector SCR

The former owner of land (now acquired by the RTA) on the southern end of Jones Island bordering Ghinni Ghinni Creek (Portion 9, Sector SCR) reported that at one time 'Aboriginal items' were said to have been found in the immediate vicinity of the old Croki Post Office which has been relocated to the scroll crest (see location, Figure 2). However, the landowner did not see the 'items' and is not aware of their nature or discovery context, or of what became of them (Y. McFarland pers. comm.).

8.3. Potential archaeological deposit (PAD) locations

Although no Aboriginal sites were discovered during the field survey, the constraints imposed by vegetation and alluvial sediment cover were such that the probability of detecting sites was extremely low. As detailed in Section 8.2., however, one local farmer reported unearthing axes during ploughing near Ghinni Ghinni Creek and similar plough finds have been reported at Moto (Brayshaw 1977:3), confirming that artefacts do occur within the floodplain's plough zone. Given the known effects of ploughing on stone assemblages (Section 7.1.1.), there was clearly some potential for artefacts to have been discovered during the survey had their locations coincided with the 6,412m.^{2} of exposures which were effectively inspected. Even though these exposures accounted for only 3.6% of the surveyed sample and as little as 2.7% of the total study corridor, only one of the fifteen landowners contacted prior to the survey indicated that they had discovered artefacts, despite the fact that many had farmed their land for an extended period of time. While it is acknowledged that the smaller and less obvious artefacts may have been overlooked by farmers, the available evidence, including the incidence of pebble axes, is in accord with the predictions made in Section 7.2., suggesting a low-density background distribution of artefacts which have been discarded or lost during the course of activities associated with rainforest exploitation. This being the case the backplain landform element is not considered to have a substantial level of further potential, and with the possible exception of the fig tree location on the northern end of Sector BKP-5 where limited evidence of post-contact use may

occur, there appears to be a low risk of anything other than isolated artefacts being intercepted during the proposed construction work.

However, locally-elevated landform elements, particularly levees along the immediate banks of the estuarine system, have been identified as areas of high potential sensitivity. One such levee is traversed by the study corridor along Ghinni Ghinni Creek, and this levee is considered to have an outstanding level of further potential relative to the remainder of the study corridor. Although no archaeological materials were discovered on the levee despite a reasonable level of visibility, this result does not rule out the possibility that occupational evidence will survive intact below the surface.

In order to accommodate the perceived sensitivity of the two specific areas which are considered to have the highest level of potential to contain undetected subsurface deposits (PAD [Potential Archaeological Deposit] locations), the Ghinni Ghinni Creek levee and the fig tree location are described individually below, and further action in relation to their management is recommended in Section 11 of this report.

8.3.1. PAD 1: Ghinni Ghinni Creek levee (Sector LEV-1)

AMG Reference: 458060.6472730 Cundletown 9434-3-S, Edition 2, 1:25,000

On its southern side, Ghinni Ghinni Creek is flanked by a 15m. wide grassed levee which rises gradually to over a metre higher than its backing floodplain before falling away sharply to the creek. The margin of the levee above the creek bank represents the most elevated point within the study corridor (Figure 7), and would have once offered a level, well-drained potential camping location close to both the estuary and the rainforest/swamp ecotone. While the Ghinni Ghinni Creek/Manning River confluence may well have been selected for occupation in preference to it, PAD 1 is nevertheless considered to have a medium level of potential to contain evidence of prehistoric occupation which may have survived undamaged below the surface. Certainly, the fact that axes have been unearthed across lowland backing the levee (Section 8.2.1.) is indicative of the traditional exploitation of terrestrial resources in the immediate vicinity of PAD 1.

Although more detailed investigation is required to determine the likely span and design of the proposed Ghinni Ghinni Creek bridge, a cattle access is to be permitted along the bank beneath the bridge. As a result, the most elevated and potentially sensitive part of PAD 1 will not be directly affected by the bridge abutment. However, if the upgrading proposal proceeds as planned, the creek bank is likely to sustain at least some subsurface disturbance during bridge construction and will suffer the ongoing adverse effects of its use as a cattle access route.

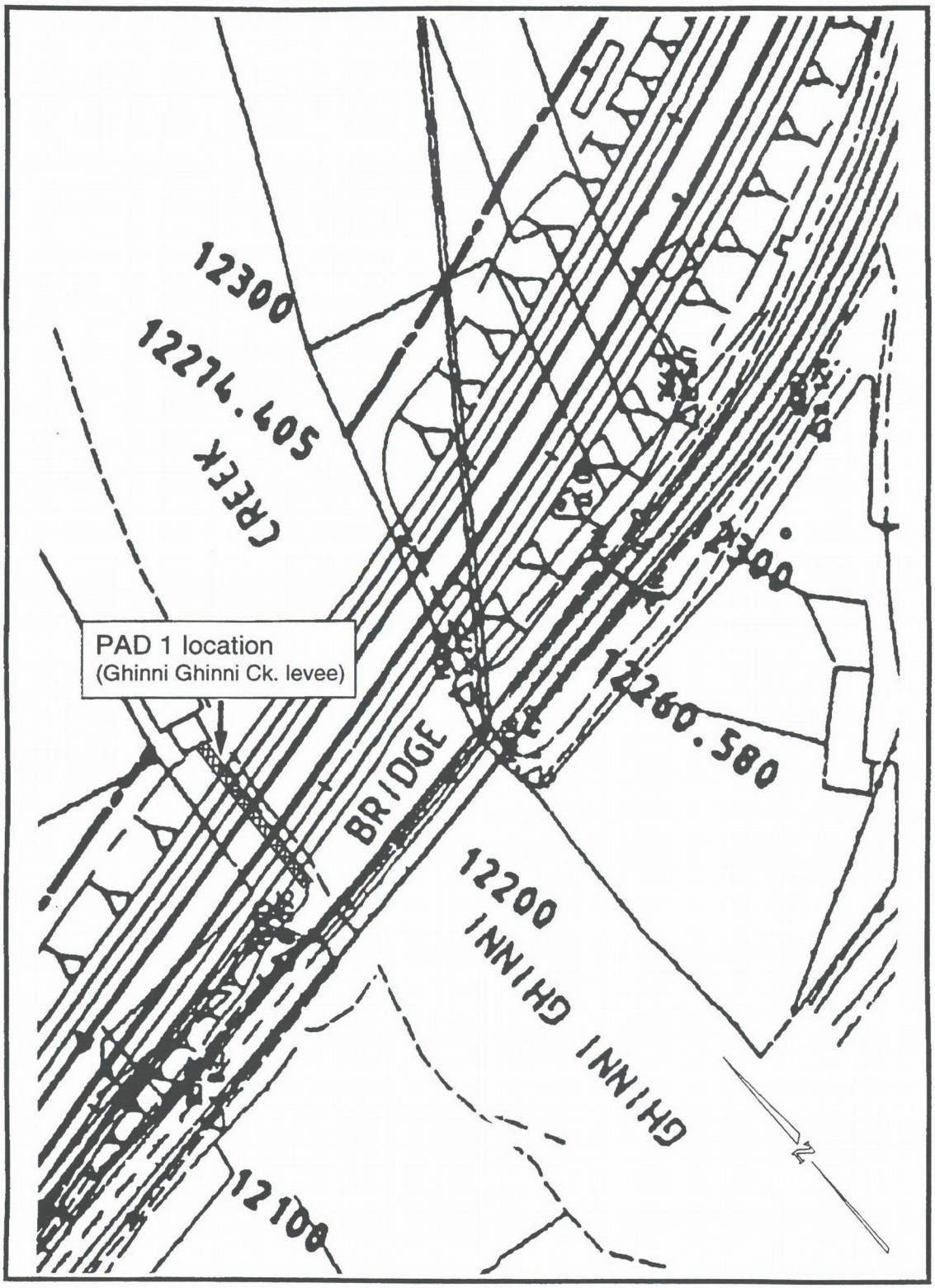


FIGURE 7: Proposed concept design in relation to the PAD 1 location

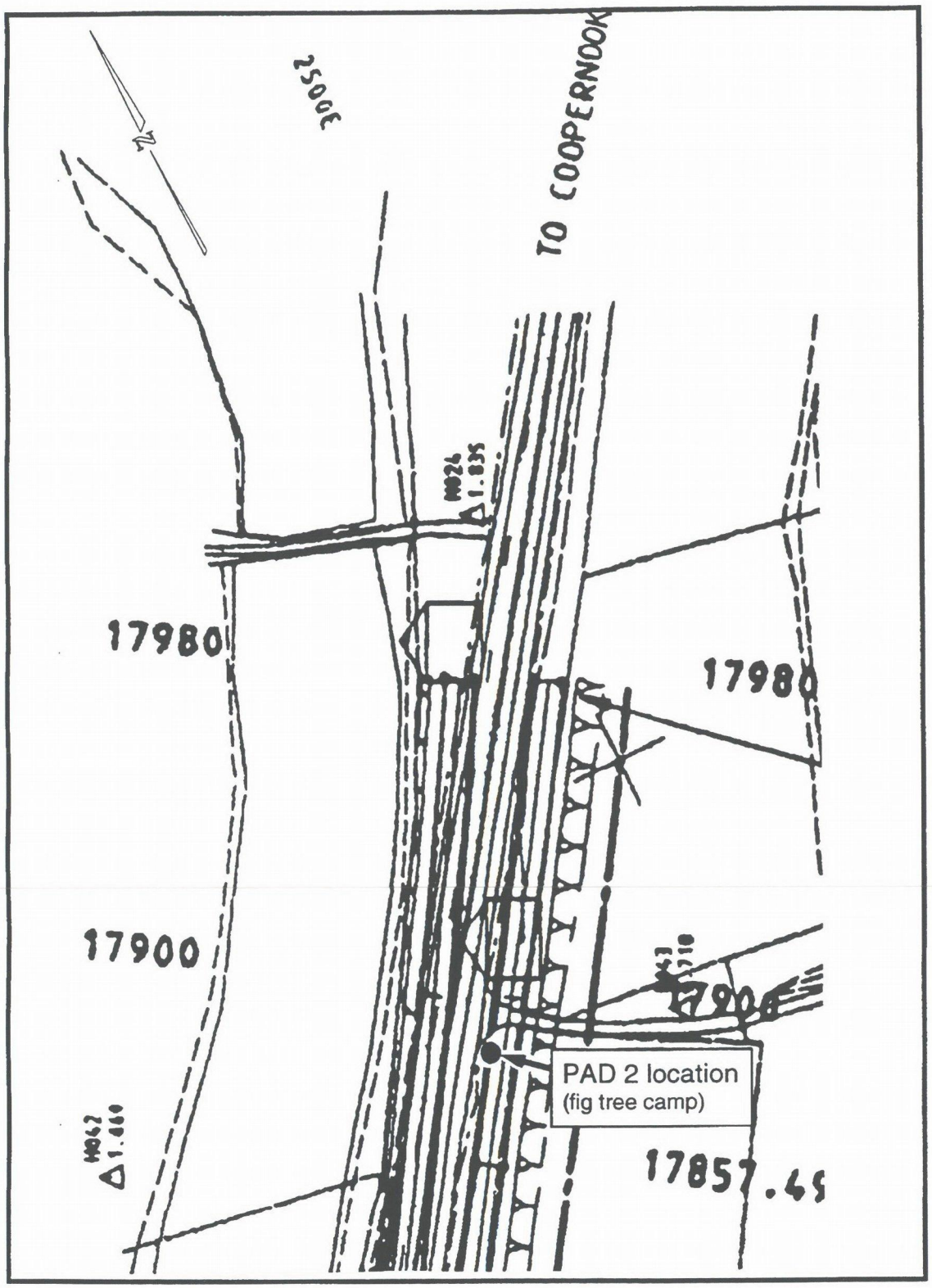


FIGURE 8: Proposed concept design in relation to the PAD 2 location

8.3.2. PAD 2: Reported fig tree camp (Sector BKP-5)
AMG Reference: 462635.6476050 Coopernook 9434-3-N, Edition 2, 1:25,000

Aboriginal transit groups are reported to have itinerantly camped beneath a Moreton Bay fig tree near the northern end of the study corridor and although ecological evidence suggests that this is unlikely, one oral informant believes this tree to be that which remains beside the existing Highway in Sector BKP-5 (cf.Section 2.)(Figure 8). The tree stands on a slightly elevated rise (>1m. AHD) 40m. east of a permanent swamp. It is medium-sized (thought to be no more than 80 years old [J. Brockhoff pers. comm.]) and its trunk has been partially burnt out.

The tree surrounds have been impacted by Highway construction and there is little chance that any cultural materials which may be present could have survived intact. Given its disturbance context and the apparent age of the tree, coupled with the fact that any itinerant post-contact camping activities are likely to have produced little in the way of cultural discard, PAD 2 is considered to have a low level of archaeological potential relative to PAD 1.

The fig tree lies within the proposed impact corridor and will be destroyed if the upgrading proceeds as planned.

9. DISCUSSION OF SURVEY RESULTS

Although none were discovered in the field, this study has provided evidence of a low-density distribution of pebble axes on the Manning floodplain which, together with finds of a similar nature at Moto (Brayshaw 1977:3), are probably reflective of subsistence activities centred on the gallery rainforest which once flanked Ghinni Ghinni Creek.

9.1. Backplain

In tandem with the like results of past local work (Rich 1990; Collins 1997), the nil result of the field survey suggests a low overall level of archaeological sensitivity for the backplain landform element. In view of the considerable visibility constraints, however, site detection probabilities remain extremely low across virtually all of the Manning floodplain and this was particularly so in the present case. Of the 22.57ha. of backplain encompassed by the study corridor, surface exposures sufficient for artefact discovery accounted for as little as 0.42ha. (2.4%) of the surveyed sample, and 1.8% of the entire backplain element. The probability of discovering artefacts on these exposures was further reduced by the presence of alluvial sediments, restricting potential finds to those which had been brought to the surface through ploughing or other disturbance activities.

While oral reports testify to the fact that some stone artefacts do occur within the backplain plough zone, such artefacts are likely to constitute a low-density background distribution, the products of random discard or loss during the course of resource exploitation. Even though the field survey cannot claim to have been adequate for directly determining the presence or absence of sites, the undifferentiated topography, low elevation and poor drainage conditions make it unlikely that any specific parts of the backplain would have been preferentially selected for occupation.

The only potential exception to this pattern may occur in the PAD 2 locality (Sector BKP-5) on the northern end of the corridor where disturbed materials associated with the itinerant camping activities of post-contact transit groups may survive. However, for reasons outlined in Sections 2. and 8.3.2., this seems improbable.

9.2. Scroll

As a comparatively well-drained and elevated landform element, the low scroll north of Ghinni Ghinni Creek (Sector SCR) is considered to have a greater level of archaeological potential than the backplain. However, because it is thought to have been rainforested and is separated from Ghinni Ghinni Creek by a pocket of swamp and a 50m. wide poorly-drained and formerly rainforested channel bench, the scroll is unlikely to have been targeted for occupation, particularly when the nearby creek levees offer higher, better drained, opportunities directly beside the creek channel.

Although the scroll was predicted to contain a higher background density of artefacts relative to the backplain (Section 7.2.2.), no archaeological material was discovered despite an effective survey coverage of almost 43% (Table 7) and the full exposure provided by a recently ploughed vegetable plot on its slope above the swamp. While it has been suggested that artefacts were once found on the scroll crest (Section 8.2.2.), nothing is known of their type or discovery context. However, given that pebble axes represent the most readily-recognisable 'Aboriginal items' and that such axes have been found during ploughing in other nearby areas, it is quite likely that the reported artefacts were in fact axes. The incidence of this type of artefact on the scroll is in line with the expected archaeological record of localities which were exploited for their vegetative resources (such as the rainforest) and their presence does not necessarily imply or require that the scroll crest itself was occupied. The fact that more than one 'item' seems to have been discovered is consistent with the prediction that the scroll will contain a higher background density of artefacts than the backplain, although this density will probably still be reasonably low. On the basis of the evidence at hand it is considered unlikely that the proposed upgrading work will affect any undiscovered occupation site in Sector SCR.

9.3. Levees

Of the two creek levees traversed by the proposed upgrading corridor, only that on the southern side of Ghinni Ghinni Creek (Sector LEV-1) is considered to be archaeologically sensitive. The narrow levee flanking a small fresh water creek on Jones Island (Sector LEV-2) widens substantially to the west of the study corridor, offering higher and better drained potential camping locations which are likely to have been selected in preference to that within the corridor itself. Despite a very low level of visibility, and despite the fact that Sector LEV-2 may contain a higher background distribution of isolated artefacts than the swampy backplain, it is concluded that the proposed upgrading work is unlikely to affect any undiscovered occupation site on this levee.

Although no archaeological materials were discovered on the levee bordering the southern bank of Ghinni Ghinni Creek (Sector LEV-1) despite an effective survey coverage of 24% (Table 7), the available evidence indicates a strong preference for the establishment of prehistoric campsites on locally-elevated landforms along the immediate banks of the estuarine system. Given that the Ghinni Ghinni Creek edge of Sector LEV-1 represents the most elevated point within the study corridor and that it would once have offered a well-drained low-gradient potential camping location close to the estuary and the rainforest/swamp ecotone, this particular area (PAD 1) is considered to have a medium level of potential to contain subsurface evidence of occupation.

Unlike occupational materials in eroding landscapes which are usually subject to deflation and mixing, any PAD 1 campsite/midden will have been sealed within, and protected by, sediments deposited during both the span of Aboriginal occupation, and in more recent times. As a result, such a site is more likely to be temporally stratified and to have maintained its spatial integrity than sites found in most other open contexts. Due to its potential level of stratigraphic/spatial integrity, any site which has survived below the surface on PAD 1 can be expected to offer excellent research prospects, even though it is likely to be reflective of resource-specific and probably low-level use.

9.4. Channel bench

Despite alluvial sedimentation and an effective survey coverage of less than 16% (Table 7), the low, poorly-drained and formerly rainforested channel bench on the northern bank of Ghinni Ghinni Creek is very unlikely to have been subject to Aboriginal occupation in its own right. As such, it is not considered to be archaeologically sensitive and there is a low probability of anything other than isolated stone artefacts being affected by the proposed upgrading work across this landform element.

9.5. Swamp

Separating the channel bench and scroll north of Ghinni Ghinni Creek, Sector SWP was inaccessible at the time of survey due to standing water. However, while the swamp may well have been exploited for its resources, it is unlikely to have been subject to artefact discard and there is thus a very low probability of any sites being affected by the proposed upgrading work across this landform element.

10. SIGNIFICANCE ASSESSMENT

10.1. Management principles and the concept of significance

Aboriginal sites and places of significance to Aboriginal people are protected in NSW under the National Parks & Wildlife Act (1974). This legislation is designed to ensure that the archaeological resource is carefully managed, and that unmitigated destruction of cultural material does not occur. The issue for resource managers is to permanently preserve a body of sites which is representative of the resource at the regional level, and this principle has been adopted by the NPWS. A representative sample of sites from a region should include examples of all site types, within the full range of environmental contexts (Clemens 1984). Under such a program, sites which are good representative examples of their type would be conserved, along with unique and rare site types.

The concept of significance has been developed in order to assess sites and to identify those which should be retained as part of a regional sample. These sites may be significant to Aboriginal communities, archaeologists or to the general public, or they may be significant to all or any combination of these groups. Given that the ultimate objective is to preserve a regionally-representative sample, site significance is usually assessed within a regional framework.

10.1.1. Cultural/social significance to Aboriginal people

Archaeological sites, including those which may not have been known to Aboriginal people prior to survey, may take on *general heritage value* by virtue of their ability to demonstrate past occupation of an area, and due to the sense of community which they can provide with previous generations (Bowdler 1983). This is the most common kind of cultural/social significance and the NPWS has respect for such significance when considering applications for consent to investigate, damage or destroy sites. It is NPWS policy to consult with the relevant LALC or Aboriginal community on all aspects of site management, and when consents to salvage/destroy or permits for archaeological excavation are sought, the Director-General seeks and considers the advice of the relevant Aboriginal group/s (NPWS n.d.).

The cultural and social significance of Aboriginal sites and places can only be assessed by the Aboriginal community itself. To enable the Purfleet-Taree LALC to make an informed assessment of the cultural value of the study corridor, a draft copy of this report was provided for discussion at a full Land Council meeting held on 29 September 1998. As a result of its consideration of the draft report the Land Council has advised that it has no objections to the proposed upgrading work proceeding, providing the recommendations made in Section 11 are implemented (see correspondence, Appendix 2).

10.1.2. Scientific/archaeological significance

This type of significance is essentially an assessment of a site's potential to elucidate past behaviour. Such assessment is made not only with regard to currently available knowledge, theories and data retrieval methods, but with consideration of likely future scientific developments. Sites have particular potential, and thus greater archaeological significance, if there are few other sites which can contribute similar types of information, if they are in a good state of preservation, if they can provide a chronology extending back into the past, and if they display a connectedness with other local sites (NPWS 1997:26-28).

Although the research potential of sites is obviously dependent upon the questions being addressed, large and structured concentrations of cultural materials which have retained their stratigraphic and/or horizontal integrity are generally regarded as being archaeologically/ scientifically significant. Because the level to which a site can maintain its spatial integrity declines in proportion to the level of disturbance it has suffered, the most significant sites are usually found in undisturbed environments.

10.2. Significance of the PAD locations

As discussed in Section 8.3., parts of two landform elements which will be impacted by the proposed upgrading work are considered to have a low (PAD 2) to medium (PAD 1) level of potential to contain subsurface evidence of Aboriginal occupation. Obviously, the cultural and scientific significance of any site which does occur on an identified PAD location cannot be assessed until its type, content, extent, and level of spatial and stratigraphic integrity has been established. Due to the aggrading character of the floodplain, however, there is the potential for any occupation site which may occur on PAD 1 to be stratified, well-preserved and thus archaeologically/scientifically significant (cf.Section 9.3.). PAD 2, on the other hand, appears to have been disturbed to such an extent that there is little chance of any *in situ* material surviving, and any site occurring there is unlikely to be archaeologically/ scientifically significant, although it may well be of general heritage value to the Purfleet-Taree LALC.

11. RECOMMENDATIONS

The recommendations presented here were developed in liaison with Purfleet-Taree LALC sites officer Vienna Maslin, and have been endorsed by Aboriginal community members following discussion at a full meeting of the Land Council (Appendix 2).

The following recommendations are based on:

- The provisions of the NSW National Parks & Wildlife Act 1974, which states that it is an offence to knowingly disturb, destroy, deface or damage a 'relic*' or Aboriginal place without the prior written consent of the NPWS Director-General;
- Advice received through the Aboriginal involvement outlined in Section 2;
- The results of the literature review presented in Sections 4. and 5;
- The results of the archaeological survey as detailed in Section 8.

* A 'relic' is defined under the Act (Section 5[1]) as:

> "any deposit, object or material evidence (not being a handicraft made for sale) relating to the indigenous and non-European habitation of the area that comprises NSW, being habitation both prior to and concurrent with the occupation of that area by persons of European extraction"

In order to minimise the impact that the upgrading proposal may have upon the archaeological resource, the recommendations presented in Sections 11.1., 11.2. and 11.3. are made for those locations which have been identified as offering the highest level of potential to contain undetected Aboriginal cultural materials:

11.1. PAD 1: Ghinni Ghinni Creek levee

Recommendation 1

Due to its potential sensitivity, and if feasible in the construction-related context, it is desirable that all bridge construction works be confined to the actual upgrading corridor on the PAD 1 location marked on Figure 7. Clearly, the wider the construction impact zone, the greater the risk of destroying archaeological sites.

Recommendation 2

Once the width of the necessary impact zone for bridge construction has been identified, it is recommended that a controlled archaeological investigation be conducted, within this zone, on the PAD 1 location marked on Figure 7 to establish its cultural status.

This investigation should be conducted by a suitably-qualified archaeologist who would first need to obtain the appropriate NPWS Preliminary Research Permit. A sites officer from the Purfleet-Taree LALC should be engaged to assist with the investigation.

Given that the potential for occupational evidence to occur is not high (the study corridor represents only a narrow transect of the levee landform), the investigation could be effectively undertaken through the excavation of a single line of closely-spaced mechanically excavated (backhoe or auger) test pits along the crest of the levee adjacent to Ghinni Ghinni Creek. Spoil from each pit should be sieved to ensure that cultural materials are detected if they are present. In the event that cultural materials are recovered from a pit, more controlled hand methods would need to be used to excavate an adjoining pit to provide information on the density, stratigraphic context and spatial integrity of the materials.

On completion of the investigation, appropriate management recommendations should be developed for any site which is discovered on the basis of an assessment of its scientific and cultural significance.

In the absence of residential subdivision and other types of largescale developments on the Manning floodplain, there has been little occasion to investigate the cultural context of specific floodplain landform elements. The recommended subsurface testing on PAD 1 would therefore offer a rare and valuable opportunity to investigate the level of use experienced by a (rainforested) levee along one of the major estuarine tributaries of the Manning River. As such, the investigation has the potential not only to elucidate Aboriginal landuse patterns on the floodplain, but to assist with future resource management decisions.

Recommendation 3

If/when construction work proceeds on the Ghinni Ghinni Creek bridge, it is recommended that a sites officer from the Purfleet-Taree LALC be engaged to monitor initial ground disturbance across the PAD 1 location marked on Figure 7. This monitoring is recommended even in the event that no cultural material is detected during the subsurface testing.

Arrangements for the monitoring should be made by either the RTA or the bridge construction contractor in direct liaison with the Purfleet-Taree LALC. The objective of the monitoring is to ensure as far as possible that Aboriginal sites are not inadvertently destroyed during the course of construction work. If any cultural material is detected, the Land Council monitor should inform the supervisor who should immediately cease work in that locality. The NPWS (Port Macquarie District office) should then be contacted and work should not resume in the subject area until clearance has been given by both the NPWS and the Purfleet-Taree LALC.

11.2. PAD 2: Reported fig tree camp

The fig tree which stands beside the existing Highway on the northern end of the study corridor is highly unlikely to be that which served as a focus for itinerant residence by post-contact groups whilst in transit across Jones Island and the probability of artefacts occurring around its base is low. While PAD 2 (Figure 8) is thus not considered to warrant any further archaeological investigation, the following recommendation is made in order to accommodate its perceived cultural sensitivity.

Recommendation 4

> If/when construction work proceeds along the study corridor it is recommended that the RTA engage a sites officer from the Purfleet-Taree LALC to monitor removal of the tree and any initial disturbance works in its immediate vicinity.

Arrangements for this monitoring should be made by either the RTA or the appropriate contractor in direct liaison with the Purfleet-Taree LALC. The objective of the monitoring is to ensure as far as possible that Aboriginal cultural material is not inadvertently destroyed during the course of tree removal/subsequent construction work. In the unlikely event that any material is exposed, the Land Council monitor should inform the supervisor who should immediately cease work. The NPWS (Port Macquarie District office) should then be contacted and work should not resume on PAD 2 until clearance has been given by both the NPWS and the Purfleet-Taree LALC.

11.3. Sector SCR and Sector LEV-2

Although not considered likely to contain occupation sites, the low terrace (scroll) north of Ghinni Ghinni Creek and the narrow levee on the northern side of the small unnamed fresh water creek immediately south of Croki Road (North) do have the potential to contain a higher background density of isolated artefacts (such as pebble axes) than the less well-elevated and comparatively poorly-drained sections of the floodplain. However, the distribution of artefacts across these two elements is unlikely to be sufficient to warrant either subsurface investigation or monitoring work and it may be that very few artefacts, if indeed any, will be intercepted by the upgrading corridor. Nevertheless, at least some allowance must be made for such an eventuality.

Recommendation 5

Prior to the commencement of any construction work along the proposed upgrading corridor it is recommended that the road construction contractor and his/her employees be advised of the potential archaeological sensitivity of both the scroll north of Ghinni Ghinni Creek (Chainage 12315-12365) and the narrow levee north of the creek channel near Croki Road (North)(Chainage 16380-16400). They should also be advised of their legal obligations and of the procedure required should any artefacts be discovered or exposed on these landforms (see Section 11.4.).

11.4. General recommendations

Recommendation 6

Prior to the commencement of any disturbance work along the upgrading corridor, it is recommended that all RTA project management staff, road and bridge construction contractors and their employees, be advised of their legal obligations with regard to Aboriginal cultural materials. This advice should be given in writing, a copy of which should be forwarded to the Coffs Harbour Zone office of the NPWS for their records.

Under the terms of the National Parks & Wildlife Act (1974) it is an offence for any person to knowingly disturb, destroy, deface or damage, or permit the disturbance, destruction, defacement or damage to a 'relic' or Aboriginal place without first obtaining written consent to do so from the NPWS Director-General.

Recommendation 7

Should any materials thought to be of Aboriginal origin be discovered or exposed during any stage of the proposed upgrading, work must immediately cease in that locality. The NPWS (Port Macquarie District office) and the Purfleet-Taree LALC should then be contacted for management advice and clearance given by both of these organisations before work resumes in the subject area.

Recommendation 8

In conclusion, it is recommended that the RTA liaise closely with the Purfleet-Taree LALC in relation to cultural matters, and that the Land Council be kept informed of the timetable for any works associated with the planning and construction of the Taree Bypass to Coopernook Bypass upgrading.

If all of the recommendations made in Sections 11.1., 11.2., 11.3. and 11.4. above are implemented, I consider that the proposed upgrading work should be allowed to proceed along the study corridor without further archaeological or anthropological constraints.

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GLOSSARY

ALLUVIUM
General term for detrital deposits made by rivers or streams (Lapidus 1990:18).

ARCHAEOLOGICAL SITE
A place containing cultural materials of sufficient quality and quantity to allow inferences about human behaviour at that location (Plog *et. al.* 1978:383).

ARTEFACT
Any object having attributes as a consequence of human activity (Dunnell 1971).

ASSEMBLAGE
A set of artefacts found in association with each other and therefore assumed to belong to the one phase or one group of people (Champion 1980:11).

AXE
A hand tool with one end of its head sharpened to a cutting edge (Hanks 1990:49).

AXE GRINDING GROOVE
Groove worn into a (usually sandstone) rock surface as a result of the abrasive action caused through the sharpening/resharpening of a stone axe. Grooves are typically a centimetre or two in depth, a little more in width and 10-30cm. long. They are almost always found in groups or clusters, often close together in rows across the rock surface (NPWS 1988:13).

BACKPLAIN
A large flat resulting from aggradation by overbank stream flow at some distance from the stream channel (Speight 1990:24).

BORA/CEREMONIAL GROUND
While there are a number of different types of Bora ground, most common on the mid-north coast is that composed of one or a pair of raised earth circles ranging in size from two to 40m. in diameter. The Bora ground functioned as a stage for various initiation rites (Byrne 1989:18).

CARBONIFEROUS
The time interval between 360 and 290 million years ago (Lapidus 1987:90).

CARVED TREE
Carved trees carry figures or patterns carved into the bark or wood and are generally found in direct association with either Aboriginal burial or ceremonial grounds. The designs which were carved into the trees were symbolic of totemic groups (Byrne 1989:15).

CHANNEL BENCH
A flat at the margin of a stream channel aggraded and in part eroded by overbank and channelled stream flow (Speight 1990:25).

CHERT
A dense, hard, microcrystalline or cryptocrystalline, siliceous sedimentary rock, consisting mainly of interlocking quartz crystals. It is typically white, black or grey, and has an even to conchoidal fracture (Lapidus 1987:102).

CORE
A piece of stone which has been used as a source for flake production. Cores are thus generally characterised by negative flake scars (Morwood & L'Oste-Brown 1995:162).

CREST
Landform element standing above all or most points in the adjacent terrain. Usually smoothly convex (Speight 1990:13).

DEVONIAN
A time interval of the Palaeozoic Era lasting from 410 to 360 million years ago (Lapidus 1987:158-159).

FLAKE
A piece of stone detached from a larger mass by the application of force and having a feather, hinge or step termination and a bulb of percussion. A platform may be present if the proximal end is unbroken (Crabtree 1972:64).

FLAKE TOOL
A stone implement which has originated as a flake and is not a producer core. Flake tools may be identified as such if carry unequivocal evidence of use-wear and/or if they have been retouched along one or more margins (Witter 1992:35).

FLOODPLAIN
An alluvial plain characterised by frequently active erosion and aggradation by channelled or overbank stream flow (Speight 1990:51).

LANDFORM ELEMENT
A topographic feature of 40m. or more in maximum dimension which forms part of a larger unit, the landform pattern (Speight 1990:9).

LEVEE
A very long, very low, nearly level sinuous ridge immediately adjacent to a stream channel, built up by overbank flow (Speight 1990:31).

MUDSTONE
A commonly-used synonym for Mudrock. A fine-grained sedimentary rock composed chiefly of particles in the silt-clay size range. Mudrock/mudstone is a general term used to distinguish the finer-grained sedimentary rocks from sandstones or limestones (Lapidus 1987:362).

NUCLEAR TOOL
A core which, rather than being used specifically to supply flakes to be used as tools, is the tool itself. Nuclear tools are thus core-like tools which did not originate as flakes (Witter 1992:30).

QUARTZ
Crystalline silica having no cleavage but a conchoidal fracture (Lapidus 1987:429).

QUARTZITE
A metamorphic rock consisting mainly of quartz grains. Formed through the recrystallization of sandstone by thermal or regional metamorphism (Lapidus 1990:430).

QUATERNARY
The most recent period of geological time; a division of Cenozoic (Lapidus 1987:430).

SCROLL
A long, curved very low ridge built up by channelled stream flow and left relict by channel migration (Speight 1990:33).

SILTSTONE
A fine-grained sedimentary rock principally composed of silt-grade material. Intermediate between sandstone and shale, siltstone contains less clay than shale and lacks its fissility and fine laminations (Lapidus 1987:474).

STONE ARRANGEMENT
Aboriginal stone arrangements usually comprise a group of stone heaps or cairns, varying in size up to about half a metre in height and 10m. in diameter. These cairns may be oval, rectangular or square as well as circular. While little is known about the significance of stone arrangements, they are thought to have played a role in higher levels of initiation ceremonies (Byrne 1989:16).

STONE ARTEFACT
Fragment of stone which generally possesses one or more of the following characteristics:
- Positive or negative ring crack
- Distinct positive or negative bulb of force
- Definite eraillure scar in position beneath a platform
- Definite remnants of flake scars (i.e.dorsal scars and ridges)

These traits indicate the application of an external force to a core, and are characteristic of the spalls removed by humans using direct percussion. Stone artefacts which have none of the above may be identified as such if they possess ground facet/s characteristic of human industry (Hiscock 1984:128).

STONE QUARRY/STONE EXTRACTION SITE
The location of a stone source exploited by Aborigines. These sites usually show evidence of procurement and preliminary processing activities and may be found wherever suitable outcrops of siliceous or igneous rocks occur. While quarry sites may be represented by as little as one or two flaked boulders or a single extraction pit, many contain a cluster of quarry pits and/or flaking floors where stones have been trimmed to sizes suitable for transport (NPWS 1988:18).

SWAMP
An almost level, closed, or almost closed depression with a seasonal or permanent water table at or above the surface, commonly aggraded by overbank stream flow (Speight 1990:33).

TRIASSIC
A period of geological time lasting from 250 to about 40 million years ago. The earliest period of the Mesozoic Era (Lapidus 1987:516).

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APPENDIX 1:

Correspondence from the National Parks & Wildlife Service

23 July, 1998

Jacqueline Collins
Consultant Archaeologist
9 Unique Close
DUNBOGAN NSW 2443

Our reference: LD:ld 98/989 File no. 3051-5
Your reference:

ATTENTION: Ms Jacqueline Collins

Dear Jacqueline

Pacific Highway Upgrade, Taree Bypass to Coopernook Bypass

Thank you for your letter of 20 July 1998, which invited the National Parks and Wildlife Service (NPWS) to provide comment on your proposed methodology for the indigenous cultural heritage assessment for the above project. NPWS commends the methodology proposed in your letter. NPWS understands that the assessment will include desktop study, field assessment and report production. NPWS also understands that consultation with the Taree-Purfleet Local Aboriginal Land Council (LALC) will be ongoing throughout the project, and will include the involvement of LALC representatives during the field assessment phase.

The following comments relate to issues you may wish to consider when completing the report for the above project. The comments are based on a consideration of **Part 3** of the *Guidelines for Archaeological Survey Reporting*, which have been produced by NPWS.

Executive Summary

The report should include a summary that briefly describes the study objectives, the impact of the development, the work undertaken, findings and recommendations. Where the study is undertaken to comply with legislative requirements, these should also be stated. NPWS are currently updating their report catalogue; it would be appreciated if the summary could also contain the following details:

- relevant Local Government Area (LGA), County and Parish;
- relevant 1: 25 000 topographic map name(s); and
- relevant Local Aboriginal Land Council area.

NSW NATIONAL PARKS ANI WILDLIFE SERVICE

Northern Zone
GIO House
24 Moonee Street
Coffs Harbour NSW
Australia
PO Box 914
Coffs Harbour 2450
Tel: (02) 6651 5946
Fax: (02) 6651 6187

Head Office
43 Bridge Street
Hurstville NSW
Australia
PO Box 1967
Hurstville 2220
Tel: (02) 9585 644
Fax: (02) 9585 655

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Description of Impact

A full description of the development and its potential impact on the heritage resource is needed. NPWS acknowledges that the nature and extent of the development proposal may change after the archaeological field survey has been undertaken. The possibility of this occurring should be taken into account by the proposed management recommendations.

Landscape Context - Survey Strategy - Survey Coverage Data

The landscape should be considered as the first level for sample stratification when formulating the archaeological survey strategy.

How the survey coverage data for the field survey is presented is largely a matter of personal preference. However, when the report for the above project is reviewed, NPWS will be seeking to determine whether the following key questions have been addressed:

- Do mature trees occur within the proposed development area? Have they been assessed for the presence of Aboriginal scars or carvings?

- Do rock outcrops occur within the proposed development area? If so, have they been adequately assessed for archaeological attributes; for example, grinding grooves, engravings?

- Is the level of ground surface visibility sufficient to enable an assessment of the range of site types that may be present on or below the ground surface? Does ground surface visibility vary between land units, and does this have implications for the conclusions that are drawn? In the event that archaeological material such as stone artefacts is recorded during the field survey, is it possible to confidently establish the likely boundaries and total content of the archaeological site?

Management Recommendations

Due to the constraints imposed by low ground surface visibility, NPWS acknowledges that there is a high likelihood that the field assessment will be unable to provide unequivocal statements on whether archaeological material is present on or beneath the existing ground surface. Under these circumstances it is advisable that the management recommendations be based on a consideration of *all* areas where such material is predicted to occur within the proposed development corridor. The areas can subsequently be differentiated on the basis of whether they constitute disturbed or undisturbed contexts.

The above advice is prompted by the need to address the misconception that the only archaeological materials that require assessment, or warrant consideration, are those that occur in relatively undisturbed contexts. Little consideration has

sometimes been given to the possibility that archaeological material may still be present on landforms that have been heavily impacted by previous landuse activities. Although subsurface investigation is not warranted to verify such issues, archaeological material in these types of contexts is still protected under the *National Parks and Wildlife Act (1974)*, and written permission from the Director of NPWS is required before such material can be disturbed/removed by the proposed development. NPWS considers it the responsibility of the consultant archaeologist to identify to the proponent *all* areas within the proposed development corridor where issues requiring licenses or permits may be of relevance. Given the time required to process such permits, it is strongly recommended that these types of issues be addressed prior to, rather than during, the construction phase.

Concluding Remarks

To reiterate, NPWS expects the report for the above project to adequately demonstrate that the full range of site types have been accounted for in the assessment that was undertaken (eg scarred trees and rock outcrops). With regard to site types that may occur on or beneath the ground surface, NPWS expects that the report will demonstrate that all of the land units that comprise the development corridor have been subjected to a level of assessment that can adequately identify, for each land unit:

- whether archaeological sites are likely to occur;
- if archaeological material is likely to occur, or recorded during field survey, whether it does so in a disturbed or undisturbed context; and
- whether appropriate mitigation strategies have been devised to reflect these concerns

Please do not hesitate to contact Liam Dagg (Archaeologist) on 02 6659 8275 if you require further information, or wish to discuss, any of the above issues.

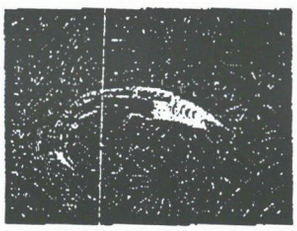
Yours faithfully

for HILTON NADEN
Manager, Northern Cultural Heritage Unit
Aboriginal Heritage Division

for DIRECTOR-GENERAL

APPENDIX 2:

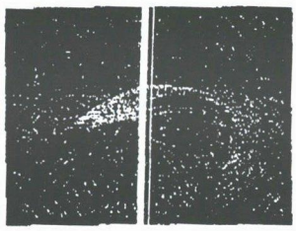
Correspondence from the Purfleet-Taree Local Aboriginal Land Council



PURFLEET-TAREE LOCAL ABORIGINAL LAND COUNCIL

P.O. Box 346, Taree N.S.W. 2430
Phone (065) 52 4106 — Fax (065) 51 0847

(THE SHARK IS THE TRIBAL TOTEM FOR THE BIRIPI PEOPLE)



Jacki Collins
Consultant Archaeologist
9 Unique Close
Dunbogan NSW 2443
12th October 98

Dear Jacki

As per conversation about a week ago your recommendation of your draft repor was passed at the Purfleet/Taree LALC meeting which was held on the 29th September 98.

If you hvae any inquires do not hesitate to give me a call.

Kind Regards
Vienna Maslin
Vienna Maslin
Site Officer

PURFLEET-TAREE LOCAL ABORIGINAL LAND COUNCIL

P.O. Box 346, Taree N.S.W. 2430
Phone (02) 6552 4106 — Fax (02) 6551 0847

(THE SHARK IS THE TRIBAL TOTEM FOR THE BIRIPI PEOPLE)

19th October 98

SURVEY REPORT
GHINNI GHINNI CREEK

Jacki Collins Archaeologist consultant for the RTA,and myself Vienna Maslin site officer for the Purfleet/Taree LALC.Jacki and myself went to inspect the properties along the Pacific Highway were they are constructing the new bypass.

On the 20th & 21st August 1998,Jacki and myself we went to inspect the properties along the right side of the highway and they were all water logged and swampy.

On the southern side of the highway heading towards Taree Jacki and myself surveyed the property on the bank leading to the creek but the areas were mudd and swampy and we could not find any Aboriginal Significance.

If you need any further information do not hesitate to give me a call.

Kind Regards

Vienna Maslin
Site Officer

APPENDIX 3:

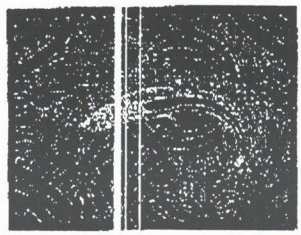
Correspondence regarding the possible scarred tree, Ghinni Ghinni Creek



PURFLEET-TAREE LOCAL ABORIGINAL LAND COUNCIL

P.O. Box 346, Taree N.S.W. 2430
Phone (065) 52 4106 — Fax (065) 51 0847

(THE SHARK IS THE TRIBAL TOTEM FOR THE BIRIPI PEOPLE)



20/01/98

RE: GHINNI GHINNI SITES SURVEY

Travelled north of Taree about 6km to Moto Road along the Pacific Highway to investigate a scarred tree, with Jackie Collins.

The tree is situated about 180m off the highway on the lefthand side of the highway and about 25m off the Moto Road on the righthand side.

On inspection of the tree it was found not to be significant to Aboriginal people and is not considered to be a canoe tree as suspected.

Thank you

Willie Bungie
Sites Officer

JACQUELINE COLLINS - *Consultant Archaeologist*

9 Unique Close Dunbogan NSW 2443 Telephone/Fax (02) 6559 9138

JOHN BROCKHOFF 21.1.98
CONNELL WAGNER
PO BOX 538
NEUTRAL BAY 2089

RE: INSPECTION OF SCARRED EUCALYPT TREE, MOTO ROAD, GHINNI GHINNI CREEK NORTH OF TAREE UNDERTAKEN ON 19.1.98

Dear Mr. Brockhoff,

With the assistance of Willie Bungie, Sites Officer from the Purfleet-Taree Local Aboriginal Land Council, and in the company of the landowners Mr. and Mrs. Ken Black, I inspected a scarred eucalypt (Red Gum ?) tree located in a cleared grazing paddock approximately 180m. north of the Pacific Highway, 25m. east of Moto Road and 225m. west of Ghinni Ghinni Creek (AMG grid reference 45787.647280, Cundletown 1:25,000 CMA map). This tree, noted by Rich (1990:36) to be a 'possible canoe tree', was not inspected during the course of her survey for the Taree Traffic Relief Route due to land access problems. The present inspection was therefore undertaken on behalf of Connell Wagner in response to Rich's (1990:46) recommendation 3.e.

The subject tree is estimated to be at least 30m. in height with a girth of 4.2m. at one metre above ground level and is obviously quite old. The single 3.6m. long scar (from which bark has been removed) evident on its western side has a maximum width of 62cm. and continues down onto the exposed roots, at least to the present ground level. Bark has healed unevenly around the scar, varying from 30cm. thick along the upper and mid section of the southern margin, to 10cm. thick along the northern margin. The top of the scar tapers to a rounded point and the pattern of bark healing immediately above this point is suggestive of limb loss. The remainder of the tree trunk carries numerous small burls and new limbs are currently sprouting from the eastern side opposite the scar, indicating the potential for other lower limbs to have once been present.

Although the scar is elongated and of a size which would be consistent with the removal of bark for use in canoe manufacture, on the basis of our inspection neither Willie Bungie nor I consider it to be attributable to Aboriginal industry. The scar does not exhibit any of the characteristics which would be expected had the bark been deliberately removed. It is not symmetrical, does not terminate above ground level, has uneven regrowth around it margins,

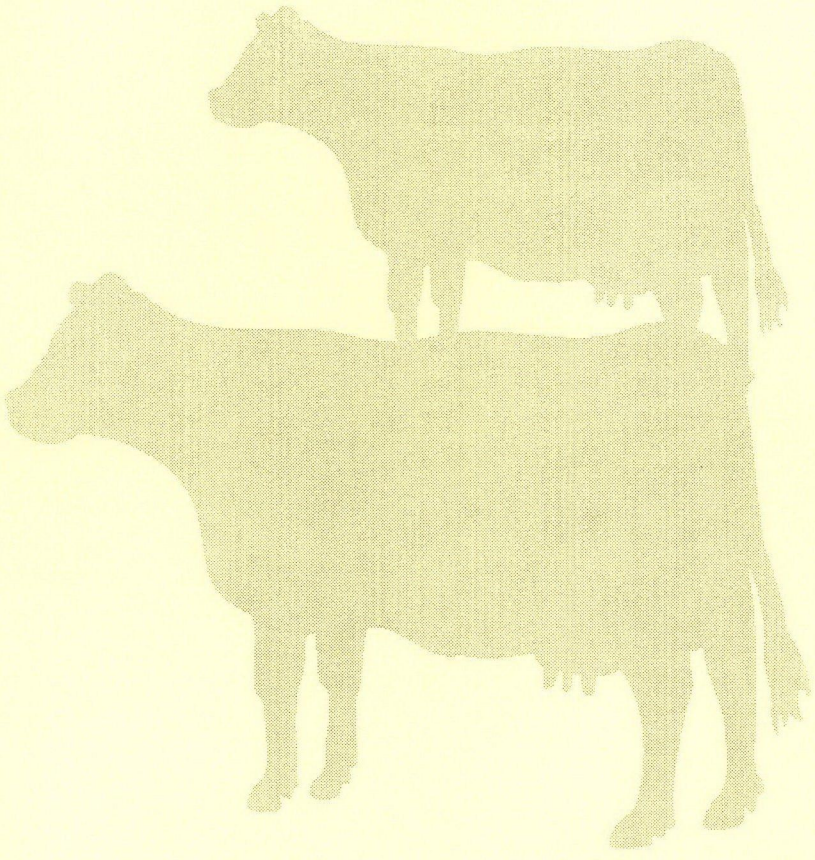
and shows no evidence of axe marking. As a result of our observations it is concluded that the scar is of natural origin and has probably been caused by a limb being torn off, possibly when an adjacent tree has fallen. Furthermore, given the presence of numerous burls on the trunk, the tree is unlikely to have offered bark of a quality suitable for the production of a canoe.

While the tree is not considered to be an Aboriginal site, Ken Black reported that groups of Aborigines continued to fish along Ghinni Ghinni Creek during his uncle's childhood, and that he had once ploughed up an axe near the creek bank. After inspecting the tree, Willie Bungie and I also briefly inspected the western bank of Ghinni Ghinni Creek, including the trunks of its edging Grey Mangroves (known to have been the most favoured species for shield manufacture). However, no evidence of Aboriginal activity/use was apparent.

Please contact me if you have any further queries,

Regards,

Jacqui Collins



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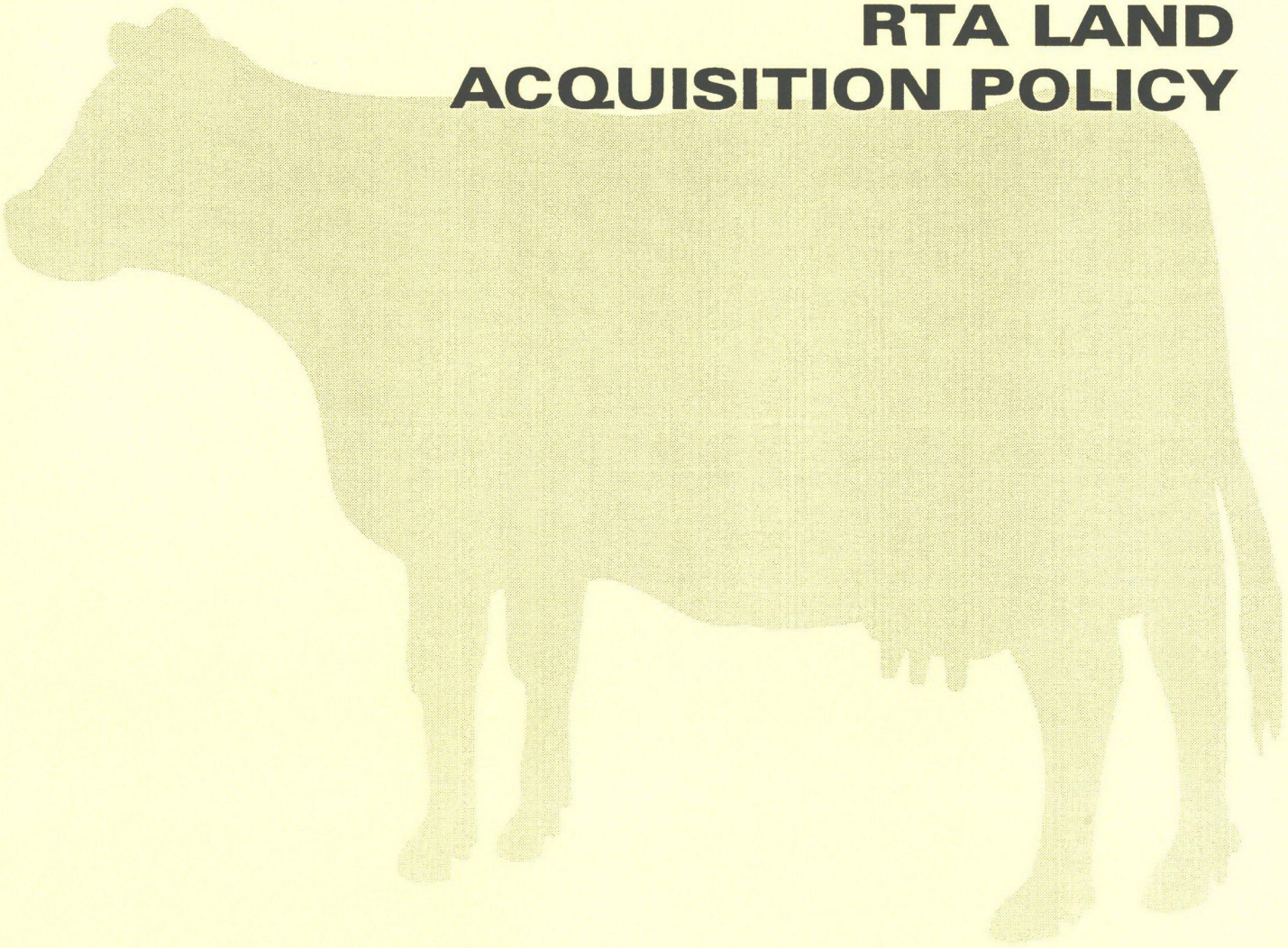
RTA LAND ACQUISITION POLICY



FOI
FREEDOM OF INFORMATION
YOUR RIGHT TO KNOW

RECEIVED - CONNELL WAGNER

10 AUG 1998

PROJECT/FILE No:

DOC No:

Land Acquisitions

RTA

Roads and Traffic Authority
New South Wales

Policy Statement

Land Acquisitions

Owners of property required by the Authority in connection with roadworks are generally aware of the proposals either through enquiries made when purchasing the property or from the proposal being shown on a Local Planning Scheme. New proposals are made public as soon as possible after a final decision has been reached.

A proposal may require public consultation and the preparation of an Environmental Impact Study which enables owners of affected land, to lodge submissions.

Procedures (Authority Initiated Acquisitions)

The Authority endeavours to purchase the land by negotiation in much the same way as a private property transaction. The offer of compensation is assessed in accordance with the Land Acquisition (Just Terms Compensation) Act 1991 hereafter referred to as "The Act". When roadworks are programmed the Authority advises the owner that the land is required and when occupation of the land is required. (Occupation of the land is usually required for adjustment to public utilities prior to actual road construction).

The letter will advise the owner that a Valuer representing the Authority will make arrangements to inspect the property and discuss the acquisition for the purpose of submitting a formal offer for the owner's consideration. The letter will also state that if an owner engages a Registered Valuer and a Solicitor the Authority will reimburse reasonable fees. Valuation fees are reimbursed in accordance with the Authority's schedule included with the letter and Legal fees in accordance with Schedule 1 of the General Order of the Conveyancing Act. Every effort will then be made to negotiate an agreement.

Compensation is to be assessed by having regard to the market value of the property as if it were unaffected by the road proposals. In addition to the market value regard is also taken to special value, severance, disturbance, solatium and any increase or decrease in the value of any other land adjoining or severed by the carrying out of the work. Division 4 of The Act defines the owner's entitlement to compensation.

An advance payment (usually only for the purpose of paying a deposit on a replacement property) will be considered if requested.

If agreement cannot be reached to ensure the Authority's timely entry onto the required land for roadworks the Minister may approve the issue of a written Proposed Acquisition Notice to compulsorily acquire the land. See "Compulsory Acquisition" below.

Partial Acquisition

When only part of a property is required the Authority is responsible for the reconstruction of fencing, driveways and landscaping to a standard similar to that existing and relocation of water and gas meters. Compensation for any improvements lost as a result of the partial acquisition is added to the value of the land taken. A "Before and After" valuation will reflect most compensable items. The Authority will generally make an allowance to an owner who wishes to arrange for his/her own property adjustments.

Where all major improvements are situated outside the road corridor the Authority will generally purchase only the part of the property required for roadworks.

Compulsory Acquisition

Compulsory Acquisition is a statutory process available to the Authority to acquire land. It also provides the means for resolving disputes about the amount of compensation payable.

Compulsory acquisitions are carried out under the provisions of The Act.

The Process

- The Authority seeks the Minister's approval to compulsorily acquire land.

- If the Minister approves, the Authority issues a Proposed Acquisition Notice to each party with a known legal or equitable interest in the land, (eg a registered proprietor, mortgagee, lessee, trustee, occupant, beneficiary of an easement). The Notice advises of the Authority's intention to acquire the land after 90 days. However, a shorter period can be agreed by the owner and Authority, or can be approved by the Minister. A Proposed Acquisition Notice is accompanied by a Compensation Claim Form.

- The issue of a Proposed Acquisition Notice is recorded on the relevant Title registers at the Land Titles Office.

- During the 90 day period after the issue of the Proposed Acquisition Notice, negotiations may continue in an effort to purchase the land.

- If contracts for purchase have not been exchanged within the 90 days the Minister recommends to the Governor that the compulsory acquisition proceed.

- If the Governor approves, an Acquisition Notice is published in the Government Gazette within 120 days of the issue of the Proposed Acquisition Notice unless a longer period is agreed by the owner and the Authority. An extract of the Acquisition Notice is also published in a local newspaper.

- The Authority owns the land from the date of publication of the Acquisition Notice in the Gazette. The legal and equitable interests of each party are converted to an entitlement to compensation.

Advance Payment

Immediately following the publication of the Acquisition Notice the Authority advises affected owners of the acquisition and generally offers to pay 90% of the Authority's purchase offer, in return for vacant possession of the land.

Terms of Continued Occupation

- If possession is not given, the Authority is entitled to charge rent for the land from the date of notification in the Gazette until possession is obtained. The terms of

rental are at the discretion of the Authority. Unpaid rent may be deducted from compensation payable.

Compensation

- Each recipient of a Proposed Acquisition Notice is entitled to lodge a claim for compensation with the Authority. Also, anyone else who considers that they are entitled to compensation but did not receive a Proposed Acquisition Notice may lodge a claim. Claims must be on the prescribed form. Compensation is not paid until a properly completed claim has been lodged. If agreed, compensation may comprise land or works in whole or part settlement of a claim.

- The Valuer General determines the amount of compensation (including legal and valuation costs) to be offered by the Authority in a Compensation Notice.

- A Compensation Notice is issued within 30 days after notification of the compulsory acquisition in the Gazette. This Notice is issued whether or not a claim for compensation has been lodged. However, the Minister may approve delay in the issue of a Compensation Notice by up to an extra 60 days. However in the case of competing claims the Authority does not issue a Compensation Notice until entitlement is resolved.

- If the amount of compensation is accepted, and the necessary settlement papers and claim form are returned to the Authority properly completed, the Authority will pay the compensation within 28 days of receipt of those papers. Interest is paid on the compensation from the date of acquisition to the date of payment.

- If the amount of compensation is not accepted, the claimant may lodge an objection with the Land and Environment Court. The objection should be lodged within 90 days of the Compensation Notice issuing. This ensures that the Court will hear the objection and determine the amount of compensation to be paid. Within 28 days after lodgement of the objection, the Authority will pay the claimant 90% of the compensation offered in the Compensation Notice as an advance on account of compensation if that is acceptable to the claimant. Interest is also paid on the advance. If it is not accepted, the advance and interest will be deposited into a trust account pending the Court decision.

- If, within 90 days of a Compensation Notice issuing, the amount offered in that Notice has not been accepted and an objection has not been lodged with the Land and Environment Court the offer is deemed to have been accepted. The Authority then deposits the amount offered plus interest into the trust account where it is held until it is accepted or until an objection is lodged with the Court. Money earned by the trust account deposit becomes part of the compensation.

- If, the compensation has been in the Trust Account for six years and a claim has not been received, the compensation is paid to the State Treasurer and held in the Treasury until paid to an entitled claimant. Interest is not paid on the compensation for the time that it is held in the Treasury.

Occupation

- People in lawful occupation of land compulsorily acquired and to whom compensation is payable are entitled to remain in occupation as tenants of the Authority until:

  (a) the compensation is paid; or

  (b) an advance payment of not less than 90% of the amount offered in the Compensation Notice is paid; or

  (c) not less than 90% of the amount offered in the Compensation Notice is deposited into the trust account due to a deemed acceptance, Court action, or competing claims;

  whichever occurs first.

- Furthermore, people lawfully occupying their principal place of residence or place of business are entitled to remain in occupation as tenants of the Authority for three months after it is compulsorily acquired, regardless of whether any of the abovementioned payments have been made. However, the Minister may shorten that period.

- Once the Authority is entitled to vacant possession, it may request the Sheriff to deliver possession of the land to the Authority. The Sheriff's costs may be recovered as a debt or deducted from any compensation payable.

Hardship Acquisition

(Owner Initiated Acquisitions)

If a property is affected by a road proposal the Authority will consider acquisition under the "Hardship" provisions of the Act and acquisition clauses in Local Environmental Plans. Hardship has to be demonstrated to the satisfaction of the Authority in accordance with Division 3 of the Act. When hardship has been established to the satisfaction of the Authority the owner may negotiate the acquisition or may require the Authority to compulsorily acquire the land.

An owner who has purchased in knowledge of the Authority's proposal can usually sell on the same basis on which it was purchased and would not normally be able to demonstrate hardship.

The Authority is not obliged to acquire more land than is required for the public purpose.

The valuation will be the market value unaffected by the Authority's proposal. Disturbance items, injurious affection, severance, solatium, and the payment of legal and valuation fees need not (under the provisions of the Act) be taken into account in the assessment of compensation under the Hardship provisions.

Notes

- Solatium means compensation to a person for non-financial disadvantage resulting from the necessity of the person to relocate his or her principal place of residence as a result of the acquisition. The amount of compensation is to be assessed depending on the degree that the person is disadvantaged to a maximum of $15,000 or such increased figure as notified by the Minister in the Gazette.

- The Act does not apply to the acquisition of land by agreement where the land is available for public sale.

ROADS AND TRAFFIC AUTHORITY
PROPERTY ACQUISITION SUMMARY SHEET

In excess of 95% of all properties acquired by the Authority are completed by negotiated agreement. The following steps outline the procedures involved in the purchase of properties by negotiated agreement.

Step One: The Authority writes to the owners to open negotiations to purchase.

Step Two: A Valuer engaged by the Authority will contact the owner with a view to making an appointment to inspect the property.

Step Three: The Valuer will inspect the property and will, within several weeks provide a valuation report to the Authority.

Step Four: The Authority will make a formal offer to owners based on the valuation report. The offer will contain the conditions of purchase including the purchase price. The Purchase Price will contain the relevant heads of compensation which usually include:

	In cases where the Total Property is to be Purchased	**In cases where Part of the Property is to be Purchased**
(a) Real Estate	(the market value of the property)	(market value of land)
(b) Disturbance	(estimated costs that will be incurred in purchasing a replacement property eg; stamp duty, removal allowance, legal fees etc)	(legal and valuation fees)
(c) Solatium	(solatium is payable where the owner's reside in the property and essentially relates to the owner's non financial loss in having to relocate their principal place of residence. The payment can vary from $0-$15,000 depending on the particular circumstances including their length of residence in the property)	
(d) Severance		(loss of value of property due to severance)

Step Five: Upon receipt of the Authority's offer the owner's may either accept that offer by returning a brief letter of acceptance or if they do not agree with the offer they may engage a Registered Valuer to provide them with an independent check valuation. The Authority would be prepared to pay a valuation fee in accordance with the conditions of fee scale that is forwarded with the opening letter. If there is a difference between the Authority's valuation and the owners valuation a meeting can be arranged to discuss the differences. The owners are welcome to attend this meeting if they wish.

Step Six: After the Authority has received a letter of acceptance from the owners, arrangements will be made to have contracts prepared and forwarded to either the owner's or their solicitor.

Step Seven: Contracts are exchanged and settlement will normally take place in approximately 6-8 weeks after exchange. The owners solicitor will generally control the settlement date.

Step Eight: In total property purchases settlement inspection by an Authority's Officer will take place prior to settlement to ensure that the property is vacant and has been left in a clean and tidy condition.

NOTE: In cases of ***Total Property Purchases*** it is strongly recommended that no commitment is made to purchasing a replacement property until contracts are exchanged on the sale to the Authority.



S

EROSION AND SEDIMENT CONTROL PLAN AND WATER QUALITY MANAGEMENT REPORT

CUNDLETOWN TO COOPERNOOK R.E.F.
DRAFT
WATER QUALITY ASSESSMENT, EROSION AND SEDIMENT CONTROL PLAN, AND WATER QUALITY MANAGEMENT REPORT

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Original Date of Issue: 2/10/98

Project Manager: Greg Rogencamp

Library Ref: N0237.R3.0

Title:	Cundletown to Coopernook REF - Water Quality Assessment, Erosion and Sediment Control Plan and Water Quality Management Report
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Client Reference:	Jeff Thompson

Synopsis: This document discusses the water quality impacts associated with the proposed upgrade of the Pacific Highway between the Taree Bypass and the proposed Coopernook Bypass for the REF which is being prepared by Connell Wagner. As well, it presents an Erosion and Sediment Control Plan and Water Quality Management Report for inclusion into a draft EMP.

REVISION/CHECKING HISTORY

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1 INTRODUCTION

The RTA has commissioned Connell Wagner and a team of sub-consultants to prepare an Review of Environmental Factors (REF) for a proposed upgrade of the Pacific Highway between the Taree Bypass near Cundletown and the proposed Coopernook Bypass.

WBM Oceanics Australia was commissioned by Robert Carr and Associates for Connell Wagner on behalf of the RTA to assess the impacts of the proposed road construction on the water quality of the study area. As well, WBM Oceanics Australia were commissioned to prepare an Erosion and Sediment Control Plan and a Water Quality Management Plan for inclusion in an outline EMP.

2 EXISTING GROUND AND SURFACE WATER CHEMISTRY

2.1 Details of Monitoring

Samples of ground and surface water were recovered from ten locations along the proposed alignment and sent to AMDEL Laboratories in Sydney for analysis of general water quality, pH and electrical conductivity.

Ground and surface water samples were collected from the following locations:

- groundwater sample from piezometer P2 installed in bore 5 (deep bore) (BH5)
- groundwater sample from piezometer, P3 installed in bore 5A, (BH5)
- groundwater sample collected from piezometer, P4 installed in bore 7, (BH7)
- groundwater sample collected from piezometer, P6 installed in bore 51, (BH51)
- groundwater sample collected from piezometer, P7 installed in bore 60, (BH60)
- surface water sample from adjacent bore B27, at toe of existing road embankment, (BH27)
- surface water sample from Ghinni Ghinni Creek, upstream of existing bridge, (W1)
- surface water sample from Ghinni Ghinni Creek, downstream of existing bridge, (W2)
- surface water sample from North Croki Floodway, upstream of floodway, (W3)
- surface water sample from North Croki Floodway, downstream of floodway, (W4)

All groundwater samples and the surface water sample collected from adjacent Bore 27 were collected on the 14th September 1998. Refer to Figures 2.1 to 2.5 for bore locations.

2.2 Background Groundwater and Surface Water Quality

Five samples collected from the groundwater piezometers and one sample collected from the toe of an existing culvert adjacent Bore 27 were analysed for general water quality. These laboratory results are presented in Table 2-1 below.

Table 2-1 Groundwater Quality

Analyte	Bore hole Location					
	BH5	**BH5A**	**BH7**	**BH51**	**BH60**	**BH27****
Calcium	54.6	205	17.1	27.3	60.7	77.8
Magnesium	65.3	534	33.7	52	135	69
Sodium	326	3590	48.6	404	981	161
Potassium	16	115	0.9	7.5	41.1	7.9
Aluminium	0.81	<0.25	0.16	0.32	<0.25	ND
Iron	0.57	2.93	1.57	10.52	43.88	4.47
Carbonate	ND	ND	ND	ND	ND	ND
Bicarbonate	13	1367	270	245	239	186
Sulphate	302	205	14	264	631	148
Chloride	558	7397	43	550	1345	397
Nitrate	0.07	ND	ND	ND	0.01	0.03
E.C. (µS/cm)	2540	21200	587	2630	5700	1805
Field pH (pH units)	5.3	6.2	6.9	6.6	5.7	6.5
TDS	1626	13568	376	1683	3648	1155
Cl/SO_4 (ratio by mass)	1.8	36	3.1	2.1	2.1	2.5
Total Petroleum Hydrocarbons						
C6-C36	1.240	11.4	2.43	1.23	1.36	ND
C6-C9	1.235	6.800	2.430	1.225	1.360	ND
C10-C14	ND	0.060	ND	ND	ND	ND
C15-C28	ND	4.600	ND	ND	ND	ND
C29-C36	ND	ND	ND	ND	ND	ND
Heavy Metals						
Arsenic	0.003	<0.035	0.004	0.008	<0.02	0.003
Cadmium	0.0016	0.0001	0.0002	0.0015	0.0013	0.0001
Cobalt	0.059	0.002	0.004	0.011	0.002	0.008
Chromium	0.006	0.044	0.013	0.014	0.016	0.009
Copper	0.006	0.002	0.003	0.007	0.011	0.006
Nickel	0.102	0.018	0.006	0.014	0.018	0.01
Lead	0.305	0.002	0.006	0.032	0.007	ND
Zinc	0.249	0.011	0.032	0.078	0.063	0.012
OC Pesticides	ND	ND	ND	ND	ND	ND
OP Pesticides	ND	ND	ND	ND	ND	ND

All results are expressed in mg/l, unless otherwise stated.

ND – not detected

NA – not applicable as sulphate was below detection limits

*** - BH27 was a surface water sample taken adjacent to the toe of an existing embankment near bore 27.*

The results of the testing indicate that the groundwater has the following characteristics:

- Sodium is the dominant cation in all groundwater bores
- Sulphate is the dominant anion in Bores 5, 51 and 60, chloride is the dominant anion in bore 5A and bicarbonate is the dominant anion in bores 7 and 27.
- Near neutral pH (except for Bore 5 and Bore 60, slightly acidic)
- Salinity varies from fresh (Bore 7) to brackish (Bores 5, 51, and 60) to saline at Bore 5A. The signficantly higher EC value at bore 5A is likely to be a result of the close proximity of the bore to a tidal saltwater creek. The surface water sample, B27 indicates brackish water.
- Nitrate levels were found to be low.

Table 2-2 outlines the criteria established for assessing the presence, or former presence, of acid sulphate soils based on the chloride to sulphate ratio and the pH of the samples. The groundwater samples indicated the presence of pyritic material in most samples with the exception of BH5A. These results are in contradiction to those of the soil samples, which identified insignificant levels of pyritic material. However, it should be noted that the ratio of sulphate to chloride becomes less predictive with low salinity ratios and as such the results of the water analyses are not considered to be as reliable as those of the soil analyses.

Table 2-2 EPA Criteria to Assess the Probable Presence of Pyritic Material

pH	$Cl^-:SO_4^{-2}$ (by mass)	Assessment
6 to 8	approx. 7	No pyritic material present or pyrite has not been oxidised at any time
< 5	approx. 7	No pyritic material present or pyrite has not been oxidised at any time and low pH can be attributed to other causes
6 to 8	< 2, if < 4 do further analysis	Presence of pyritic material plus the presence of a buffering agent
< 5	< 2, if < 4 do further analysis	Presence of pyritic material with little buffering agent

Source: Acid Sulphate Soils Assessment and Management Guidelines

Analyses of Total Petroleum Hydrocarbons (TPH) undertaken on all samples showed the presence of some lighter, C6-C9 fractions in all groundwater samples. Analysis of BH5A also detected the presence of C10-C28 fractions and was found to exceed the criteria of 10mg/l for the C6-C36, (NSW EPA, 19914). The surface water sample, BH 27 did not identify the presence of any TPH fractions.

Analyses of heavy metals indicated that most analytes were low with the following metals found to be above the ANZECC (1992) criteria, for marine waters:

- Copper in BH60 above 0.005mg/l
- Nickel in BH5, BH5A and BH60 above 0.015mg/l
- Lead in BH5, BH7, HB51 and BH60 above 0.005mg/l
- Zinc in BH5, BH51 and BH60 above 0.05mg/l
- Pesticides were not identified in any groundwater samples, or in the BH27 surface water sample.

During the course of the field investigation, field measurements of pH and electrical conductivity were undertaken at 37 surface water locations and at 30 bore groundwater locations. Groundwater encountered in the bores ranged in pH from 6.1 to 7.5 with an electrical conductivity in the range of 175 to 10000µS/cm (ie fresh to brackish / saline). Surface water along roadside drains ranged in pH from 6.1 to 7.4 with an electrical conductivity in the range of 95 to 16000µS/cm (ie fresh to saline). At North Croki Floodway, a low pH reading of 3.1 was encountered which is in contrast to values encountered elsewhere along the route. This appears to be attributable to acid sulphate soil leachate occurring upstream from the road alignment.

2.3 Surface Water Periodic Monitoring

Four surface water samples were collected at Ghinni Ghinni Creek and the North Croki Floodway on two occasions. The first on the 14th August 1998 after a rainfall event of greater than 10mm in the preceding 48 hours. The second on the 26th August 1998 after less than 10mm of rainfall. Laboratory analysis of these samples is presented in Tables 2-3 and 2-4.

Further sampling is currently being undertaken as part of the ongoing monitoring program. These additional results will be reported at a later date.

Samples were collected from Ghinni Ghinni Creek both upstream and downstream of the existing bridge.

The results of the testing indicate that the surface water of the Ghinni Ghinni Creek has the following characteristics:

- Sodium is the dominant cation in both the wet and dry periods
- Chloride is the dominant anion in both the wet and dry periods
- pH was found to be slightly acidic after rainfall and neutral during the drier period.
- Salinity was found to be low after rainfall and was higher during the dry period to slightly brackish
- Nitrate levels were found to be higher during the wet period than the dry period. Nitrate levels were indicative of moderate quality, with the exception of 0.56 mg/l (Sample W2 following rainfall). This high level suggests elevated nitrate levels are present in catchment runoff - this is of potential concern since nitrate is a form of nitrogen which is readily assimilated by algae and plants. Ammonia concentrations were also slightly elevated in the wet period samples.
- Phosphorus was found to vary between the sampling periods, with all values found to be below levels indicative of eutrophic waterways, 0.1mg/l, (ANZECC, 1992)
- Pesticides were not detected in any samples.
- Aluminium was identified at concentrations (up to 2.1mg/l) significantly higher than the desirable guideline concentrations (0.005 or 0.1mg/l, subject to pH) for the protection of aquatic fauna (ANZECC, 1992)

Faecal coliforms were less than livestock or irrigation standards (ANZECC, 1992) with all samples meeting livestock drinking water standard (1000 CFU/ 100 *ml*). The high total coliform downstream of the bridge on 19/8/98 was likely to be associated with an observed localised input of animal waste.

Table 2-3 Surface Water Quality, Ghinni Ghinni Creek

Analyte	Sample Number			
	Upstream of Bridge		Downstream of Bridge	
	W1	W1A	W2	W2A
Date/period	19/8/98 Wet	26/8/98 Dry	19/8/98 Wet	26/8/98 Dry
Calcium	25.9	41.7	25.9	40.4
Magnesium	53.0	92.2	55.8	94.2
Sodium	416	805	386	785
Potassium	17.7	35.0	17.8	34.3
Aluminium	2.1	0.61	1.69	0.59
Lead	ND	ND	ND	ND
Carbonate	ND	ND	ND	ND
Bicarbonate	3	53	7	55
Sulphate	153	212	153	199
Chloride	659	1438	657	1479
Nitrate	0.11	0.09	0.56	0.08
Dissolved phosphorus	ND	0.02	ND	0.02
Total phosphorus	0.06	0.06	0.07	0.04
Ammonia	0.09	0.04	0.08	0.04
E.C. (µS/cm)	2510	5120	2500	5050
pH (pH units)	5.8	7.2	5.9	7.3
TDS	1606	3277	1600	3232
OP Pesticides	ND	ND	ND	ND
OC Pesticides	ND	ND	ND	ND
Total Coliforms, CFU/100ml	210	200	4800	280
Faecal Coliforms, CFU/100ml	3	42	280	30

All results are expressed in mg/l, unless otherwise stated.

ND – not detected

Surface water samples collected from the Croki Floodway were collected from upstream and downstream of the floodway.

Table 2-4 Surface Water Quality, Croki Floodway

Analyte	Sample Number			
•	Upstream of Culvert		Downstream of Culvert	
•	W3	W3A	W4	W4A
Date/period	19/8/98 Wet	26/8/98 Dry	19/8/98 Wet	26/8/98 Dry
Calcium	63.8	59.8	64.9	58.6
Magnesium	148	121	154	122
Sodium	1220	902	1180	861
Potassium	52.5	41	54.7	41.4
Aluminium	1.5	3.18	1.27	2.96
Lead	ND	ND	ND	ND
Carbonate	ND	ND	ND	ND
Bicarbonate	ND	ND	ND	ND
Sulphate	437	514	424	474
Chloride	1938	1588	1982	1545
Nitrate	0.01	ND	0.01	ND
Dissolved phosphorus	ND	ND	ND	ND
Total phosphorus	0.11	ND	0.37	ND
Ammonia	ND	0.03	0.03	ND
E.C. (µS/cm)	6890	6210	6840	5990
pH (pH units)	3.3	3.0	3.4	3.1
TDS	4410	3974	4378	3834
OP Pesticides	ND	ND	ND	ND
OC Pesticides	ND	ND	ND	ND
Total Coliforms, CFU/100ml	<4	<4	<4	<4
Faecal Coliforms, CFU/100ml	0	0	0	0

All results are expressed in mg/l, unless otherwise stated.

ND – not detected

The results of the testing indicate that the surface water of the Croki Floodway has the following characteristics:

- Sodium is the dominant cation in both the wet and dry periods
- Chloride is the dominant anion both the wet and dry periods
- pH was found to be highly acidic and was lower for the dry sampling period. This low pH is likely to be attributable to excavations of acid sulphate soils upstream of the sampling points. Two soil samples (S1 and S2) were collected from stockpiled soil excavated to create a drain further upstream, approximately 400m from the existing highway. POCAS assessment of these samples indicated one sample as an actual and the other as a potential acid sulphate soil. The water from this location had a pH of 2.9.
- Water was brackish and was slightly fresher for the dry sampling period.
- Nitrate levels were found to be low overall, with slightly higher levels observed during the wet period.
- Phosphorus was found to be higher for the wet sampling period and these results were at moderate levels. The total phosphorus concentrations during the wet sampling events exceeded the ANZECC criterion of 0.1 mg/l total phosphorus. Levels above the criterion can be indicative of eutrophic waters.
- Pesticides were not detected in any samples.
- Aluminium was identified at concentrations significantly higher than the ANZECC guideline concentration for aluminium (of 0.005mg/l when the water pH is less than 6.5).
- Low faecal and total coliform concentrations were reported for all samples.

2.4 Groundwater Sources

The Department of Land and Water Conservation has indicated that there are in the order of 20 to 25 registered groundwater sources along the general route of the alignment. Only two of the sources have available data.

Location 33317 near the Ghinni Ghinni Creek bridge and location 33596 south of Wallis Lane comprise shallow bores/ wells up to 3.5m in depth. Groundwater analysis indicates pH of 7.3 and 8 and an electrical conductivity of 860 and 5800µS/cm respectively. Groundwater chemistry indicates that the dominant cation is bicarbonate and sodium with the dominant anion chloride.

It is considered likely that most of the registered locations are shallow bores/ wells into the near surface sandy soils. Considering the clayey and silty nature of the sands and their limited thickness, the yield from shallow bores/ wells is likely to be low.

The occurrence of groundwater extraction bores into the gravel aquifer is unknown at this stage. The gravel aquifer comprises a potential high yield water source. Based on water quality results from bore 5, the groundwater is brackish and slightly acidic. The gravel aquifer may comprise a suitable source of water for construction purposes. The potential impact of groundwater extraction for such purposes would require specific assessment.

3 WATER QUALITY IMPACTS OF PROPOSAL

3.1 General Impact Considerations

Principal water quality considerations relate to possible degradation of water quality in the watercourses of the study area by:

- erosion and transport of extensive amounts of sediment during the construction phase;
- generation of additional pollutants directly attributable to the operation of the proposal;
- potential for spillages during construction and operational phases; and
- disturbance of acid-sulfate soils, with the commensurate potential for the formation of acidic runoff or groundwater.

These potential impacts need to be considered in relation to the existing water quality in the receiving waters and their assimilative capacity.

3.1.1 Construction Impacts

During the construction phase areas will be cleared, leaving soil exposed during the earthworks phase. Erosion from the exposed soil has the largest potential to cause water quality impacts during the construction phase.

Based on WBM Oceanics Australia's monitoring experience, runoff from exposed soil areas (when unmitigated) could easily contain suspended solids concentrations between 500 and 1000mg/L. At this concentration of suspended solids, numerous adverse ecological impacts could occur, including decreasing light penetration (which has implications for photosynthetic and respiration processes), reducing the suitable habitat for some aquatic species which cannot tolerate such turbid conditions and reducing the aesthetic appeal of waterways.

Any sediment washed from exposed areas which enters downstream waterways will also cause siltation in these waterways. Siltation can smother aquatic flora and fauna, particularly submerged macrophytes which stabilise creek banks and benthic fauna.

There is also the potential for accidental spillages of materials associated with road construction (eg. fuel, lubricants etc.) during the construction phase. These materials could cause water quality degradation in downstream waterways if not prevented from entering drains.

3.1.2 Operational Impacts

During the operation phase of the proposal, pollutants may accumulate on the road during dry periods and be washed into downstream waterways during subsequent runoff events. Depending on the pollutants accumulated, water quality degradation and adverse impacts to aquatic flora and fauna may result. Typical pollutants associated with roads include oils and grease, heavy metals and some sediment. Table 3.1 below summarises typical road runoff characteristics from both Australia and Overseas (CSIRO, 1992).

Table 3-1 Road Runoff Characteristics (CSIRO, 1992)

Pollutant	Conc. (ug/L)	ANZECC (ug/L)
Arsenic#	13-94	50
Cadmium	0.2-0.5	0.2-2
Chromium#	7-580	10
Copper	3-14	2-5
Lead	2.2-20	1-5
Nickel	12-70	15-150
Zinc	30-150	5-50

Note # overseas data only

It is likely these metals will be contained both as dissolved and solid forms (particularly attached to sediment). When these metals mix with seawater, colloidal iron oxides will aggregate and precipitate, carrying many of the other metals out of solution also (CSIRO, 1992). It is, therefore, reasonable to assume the fate of these pollutants will be to accumulate in bottom sediments in either the adjacent creeks or downstream waterways. The toxicity of these bottom sediments will depend on their final concentration in the sediment and the organisms in the local aquatic environment.

As roads are impervious, increased volumes of runoff may also result from the proposal. These volumes will represent a negligible proportion of flood runoff during flood events. However, during more frequent rainfall events, these increased runoff volumes will result in an increase in the flow in the drains along the route of the proposal. The impact of this increased frequency of low flows in the drains will be minor.

Detailed discussion on the potential impacts and the assimilative capacities of the individual watercourses are outlined below.

3.2 Ghinni Ghinni Creek

Ghinni Ghinni Creek is a small tidal connective waterway which parallels the Manning River and links the Manning and Lansdowne Rivers. It has a total length of approximately 9 kilometres and drains a predominantly low lying pastoral catchment. The proposal largely follows the existing Pacific Highway alignment throughout the study area. A new bridge crossing of Ghinni Ghinni Creek is required close to its confluence with the Manning River. At the proposed crossing location, the ambient water quality of the creek is strongly influenced by the salinity and other water quality attributes of the Manning River.

Analysis of water samples from Ghinni Ghinni Creek (refer Section 2) collected in August 1998 following generally wet catchment conditions, indicated the following characteristics:

- low salinity (approximately 1.5-3.0g/l - less than one tenth of the salinity of seawater)
- mildly acidic to neutral pH (pH 5.8-7.3)

- slightly elevated nitrogen (ammonia, nitrate) levels which may result in elevated algal growth rates
- low phosphorus concentrations
- elevated aluminium concentrations, which could have undesirable effects upon aquatic fauna
- faecal coliform concentrations which were lower than the appropriate livestock watering criterion, though on occasion bacterial levels were higher than the desirable criterion for recreational (bathing, swimming etc) use of the waterway.

On the basis of the limited water quality data thus far collected, it is evident that the proposal should not seek to result in an increase in the nutrient, aluminium and /or faecal coliform concentrations within the waterway. Excessive increases in sediment should also be avoided, as reduced light penetration and siltation in the waterway can result in significant environmental harm.

Typical road construction and operational impacts seldom result in an increase in the faecal contamination of a receiving waterway, however some increases in the nutrient concentration may be anticipated as a result of exposure of soil (and the nutrients bound to the soil particles) to erosion during construction. Additionally, the aerial exposure of potentially acid sulfate clay soils during construction could result in acidic water leaching aluminium from the clay soils. No information on the assimilative capacity with respect to sediment could be located.

Therefore the capacity of Ghinni Ghinni Creek to assimilate further nutrient (nitrogen) and aluminium appears to be limited and preventative measures will need to be adopted to minimise the potential for their input, principally during construction of the proposal.

Section 4 details recommended mitigation measures to ensure minimal impacts result from the proposal. Specific measures for the treatment and handling of acid sulfate soils are discussed in the Acid Sulfate Soils Management Plan.

3.3 Croki Floodway

Croki Floodway is a small agricultural non-tidal creek/drain which drains the low lying pastoral catchment within Jones Island. The Floodway is isolated from the tidal influence by flap-gated culverts at its confluence with the Manning River. A new culvert crossing of the Croki Floodway is required for the proposal.

Analysis of water samples from the Croki Floodway (refer Section 2) collected in August 1998 following generally wet catchment conditions, indicated the following characteristics:

- low salinity (approximately 4.0-4.5g/l - approximately one eighth the salinity of sea water).
- strongly acidic pH (pH 3.0-3.4) which indicates the water is unsuitable for almost all forms of aquatic fauna within the floodway. The release of waters from the Floodway to the Manning River could potentially impact upon aquatic fauna within adjoining sections of the Manning River.
- low nitrogen (ammonia, nitrate) levels.

- elevated total phosphorus concentrations (up to 0.37 mg/l) which could result in undesirable algal growth.
- high aluminium concentrations (up to 3.2 mg/l), which would have undesirable effects upon aquatic fauna.
- low faecal coliform concentrations.

It is apparent from the acidity and aluminium concentrations that the existing water quality within the Croki Floodway is already seriously degraded by exposure to the runoff from surrounding acid sulfate soils. The Croki Floodway therefore has no capacity to assimilate further runoff from acid sulfate soils.

On the basis of the limited water quality data thus far collected, it is evident that the proposal should not seek to result in an increase in the acidity, nutrient, and /or aluminium concentrations within the waterway.

Section 4 details recommended mitigation measures to minimise the potential environmental impacts resulting from the proposal. Specific measures for the treatment and handling of acid sulfate soils are discussed in the Acid Sulfate Soils Management Plan.

3.4 Groundwater Impacts

There are two major aquifers in the study area. The lower is located in gravel at depths of approximately 25m below ground level. The upper aquifer is located in a layer of silty clayey sands at a depth of 2m to 5m. There are a number of licensed groundwater bores / wells located in the study area which rely upon the upper aquifer. These bores / wells are likely to have a low yield. This upper aquifer is overlaid by a highly impermeable clay layer.

The primary recharge paths for these aquifers is a relatively slow path from the ground level (including surface drains) to the aquifers.

Due to the presence of this overlaying clay layer, the potential for impacts to the groundwater, during both construction and operation, is low. Assuming that the surface water quality of the study area is not significantly altered due to the proposal, the changes to the groundwater quality of the study area attributable to the proposal should be minimal.

4 WATER QUALITY MANAGEMENT REPORT

4.1 Impact Mitigation

The following measures are proposed to mitigate potential impacts from the proposal. The measures have been categorised into pre-construction, during construction and post construction stages.

4.1.1 Pre Construction

Before construction activities begin, the following measures need to be implemented to ensure minimal disturbance and adverse water quality impacts. These measures may be adopted in a staged approach, and may be implemented prior to construction beginning in one section of the proposal. Detailed design of sediment basins will be undertaken in subsequent design phases of the proposal and allowance for the retention of some of these basins for operational phase impact mitigation should be considered. Some sedimentation basins will be temporary to treat runoff during the construction phase only.

- More rigorous baseline water quality monitoring in potentially affected creeks should be undertaken to suitably determine the "pre construction condition" of local waterways for subsequent impact assessment purposes. Section 4.2 details the recommended monitoring program.
- Designating and delineating buffer strips (approximately 20m wide) adjacent to waterways, where possible. These buffer strips will remain vegetated and will filter sediment from construction site runoff. No plant or operations will occur within this buffer zone.
- Sediment fences be constructed on the upstream edges of the designated buffer areas and at the base of fill embankments.
- Designation of areas for plant and construction material storage. These areas should be somewhat removed from waterways and runoff from these areas is directed to a holding pond in case of spillages. As well, runoff from upstream areas should be diverted around these sites.
- Diversion banks be created at the upstream boundary of construction activities to ensure upstream runoff is diverted around any areas to be exposed. Catch drains at the downstream boundary of construction activities should also be created (wherever possible) to ensure any sediment laden runoff is contained and directed toward treatment areas and not permitted to flow onto downstream undisturbed areas. Diversion banks should be constructed approximately along contours to minimise scour along the drains.
- Appropriately designed sediment basins be constructed at downstream ends of catch drains, which convey runoff from exposed areas, to collect excess sediment.
- Hay bales, silt fences and sand bags can be placed along catch drains to slow flow, reduce scour and capture some sediment from runoff.
- Designation and marking of transport routes across undisturbed portions of the site to ensure minimal unnecessary vegetation disturbance.
- Education of site personnel to the sediment and erosion control measures implemented on site.

- Development of a detailed Erosion and Sediment Control Plan as part of the detailed design stage. A concept Erosion and Sediment Control Plan is presented in Figures 4.1 to 4.3. This will form the basis of the detailed plan.
- A soil conservation officer to be employed part-time for the duration of the project.

4.1.2 *During Construction*

Prior to construction, the detailed design phase for the proposal will have been completed. It is recommended that the detailed design encourage diffuse overland flow of road runoff in accordance with the RTA's Draft Water Policy. Road runoff should be directed through grassed buffer strips, grass swales, grassed median strips (where possible) before discharging into waterways, as recommended by the RTA's Draft Water Policy.

Measures to mitigate water quality impacts during construction will include:

- Progressive revegetation of fill batters;
- Construction activities be confined within the necessary construction area(s);
- Mulching and retention of vegetation and topsoil for final site rehabilitation and landscaping works;
- Installation of silt fences downstream of disturbed areas. Silt fences should be located continuously along contours and should treat areas less than 0.6ha per 100m of silt fence. A maximum slope length of 60m will also ensure optimal performance.
- Regular inspection and maintenance of silt fences, sedimentation basins and other erosion control measures. Following rainfall events greater than 20mm inspection of erosion control measures and removal of collected material should be undertaken. Replacement of any damaged equipment should be performed immediately.
- Monitoring of water quality impacts from construction activities. Section 4.2 details monitoring recommendations.

Prior to construction, a detailed acid sulfate soil management plan will need to be prepared. This plan should detail prevention and management techniques to ensure acid sulfate material is not disturbed and acidic runoff is not generated.

4.1.3 *Post Construction*

It is recommended for the fill batters that road runoff flow off the road in a diffuse manner and down the vegetated fill batter. Due to the flat nature of the Manning River floodplain, Flow into sedimentation basins may not be possible and treatment measures such as directing flow from fill batters through grassy swales are more appropriate.

Following the completion of construction works in a section of the proposal, the following activities will be performed:

- Revegetation and landscaping of remaining exposed areas using the topsoil and mulched vegetation retained from initial site clearing. Vegetation should be watered and maintained until vegetation is established.
- Removal of sediment basins not required for the operational phase of the proposal. Detailed sedimentation basin design will be undertaken in subsequent phases of the proposal.

- Maintenance of mitigation measures retained during the operational phases (eg detention basins).
- Water quality monitoring, in accordance with the recommendations in Section 4.2, to monitor any ongoing impacts to water quality from the proposal.

4.2 Monitoring

Pre construction monitoring will allow accurate characterisation of the waterways, as much of the existing data has been collected during dry weather conditions. Monitoring for several months, with several events per month analysed, will allow sufficient data to be collected prior to construction, depending on the season proposed for construction initiation.

Based on the pre-construction data obtained for each waterway monitored, appropriate action values for each major water quality parameter can then be determined. Action values would be specific for each major waterway, and any exceedence above the action value noted during construction would require closer examination to determine the actual cause of the exceedence.

Monitoring sites should be selected both upstream and downstream of proposed construction work, such that the magnitude of any relative impact can be determined.

Monitoring during construction should continue with an event based approach, with similar monitoring frequency to the pre-construction monitoring. Once the construction phase is complete, monitoring for a six to twelve month period on a similar frequency to other monitoring works will ensure any ongoing impacts from the proposal are acceptable.

Should unacceptable impacts from the proposal during the construction or operational phases be revealed through the water quality monitoring exercises, modifications to increase the efficiency of the mitigation measures adopted should be implemented, in consultation with the EPA.

Water quality monitoring parameters should include:

- pH *;
- dissolved oxygen;
- salinity;
- turbidity;
- lead;
- aluminium *;
- chloride *;
- sulfate (SO_4)*;
- suspended solids; and
- total nutrients.

Note * parameters give an indication of acid sulfate status of catchment.



LEGEND

- Deep bore hole (BH1–BH5)
- Shallow bore hole (BH6–BH80)
- Piezocone test location (CP1–CP16)
- Piezometer location (P1–P5)
- Existing Pacific Highway
- Proposed Fills
- Proposed alignment centreline (Northbound and Southbound)

NOTE: Drawing adapted from drawing supplied by Connell Wagner

0 100 200 300
metres

ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:
PACIFIC HIGHWAY UPGRADE
CUNDLETOWN TO COOPERNOOK

CLIENT:	Connell Wagner			PROJECT No:	820
DRAWN BY:	AG	SCALE:	1 : 5000	DRAWING No: 2.1	REV: 0
APPROVED BY:	MGD	DATE:	10/9/98	OFFICE:	NEWCASTLE

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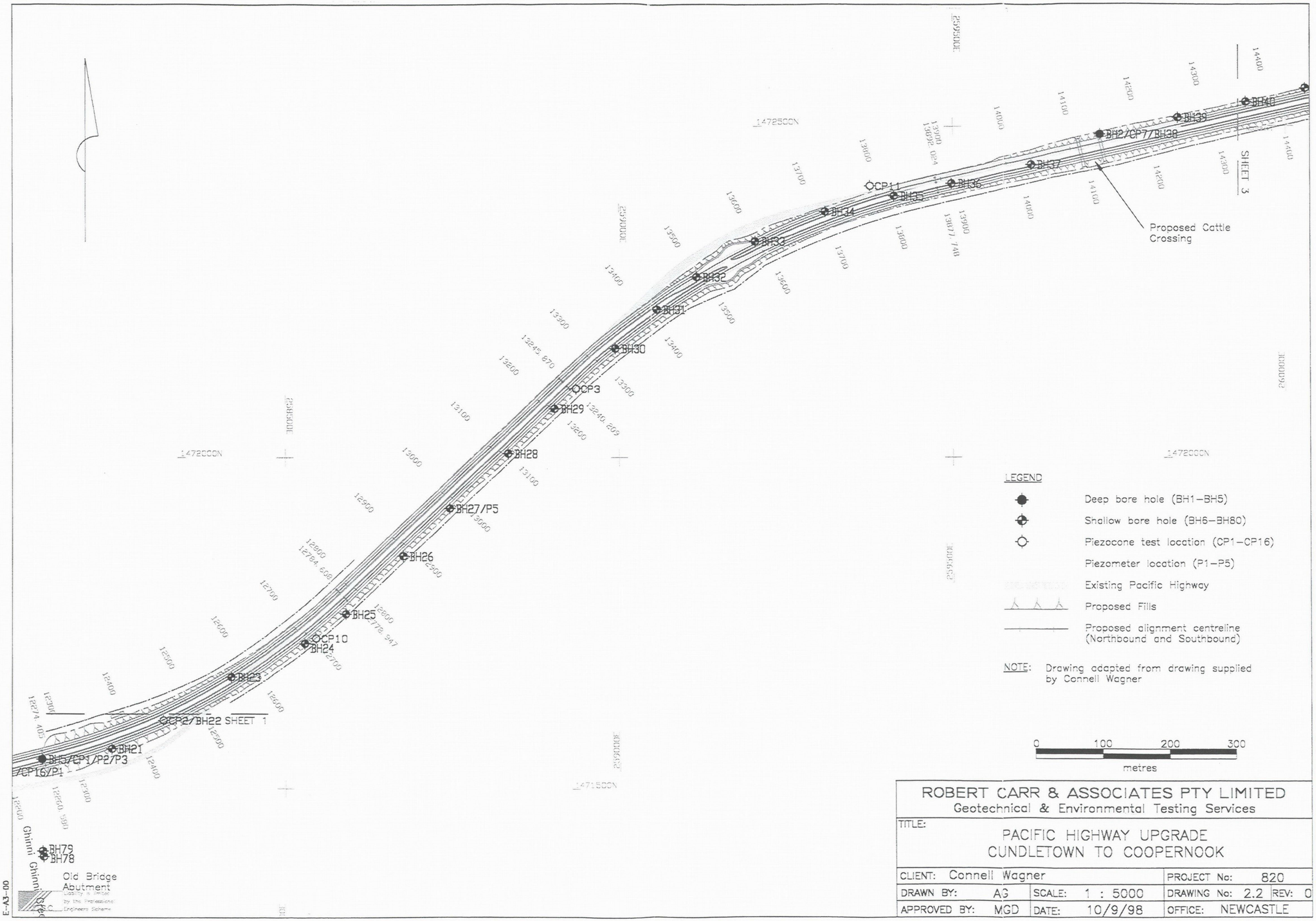

LEGEND

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NOTE: Drawing adapted from drawing supplied by Connell Wagner

0 100 200 300
metres

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TITLE:
PACIFIC HIGHWAY UPGRADE
CUNDLETOWN TO COOPERNOOK

CLIENT: Connell Wagner				PROJECT No: 820	
DRAWN BY: AG	SCALE: 1 : 5000			DRAWING No: 2.2	REV: 0
APPROVED BY: MGD	DATE: 10/9/98			OFFICE: NEWCASTLE	

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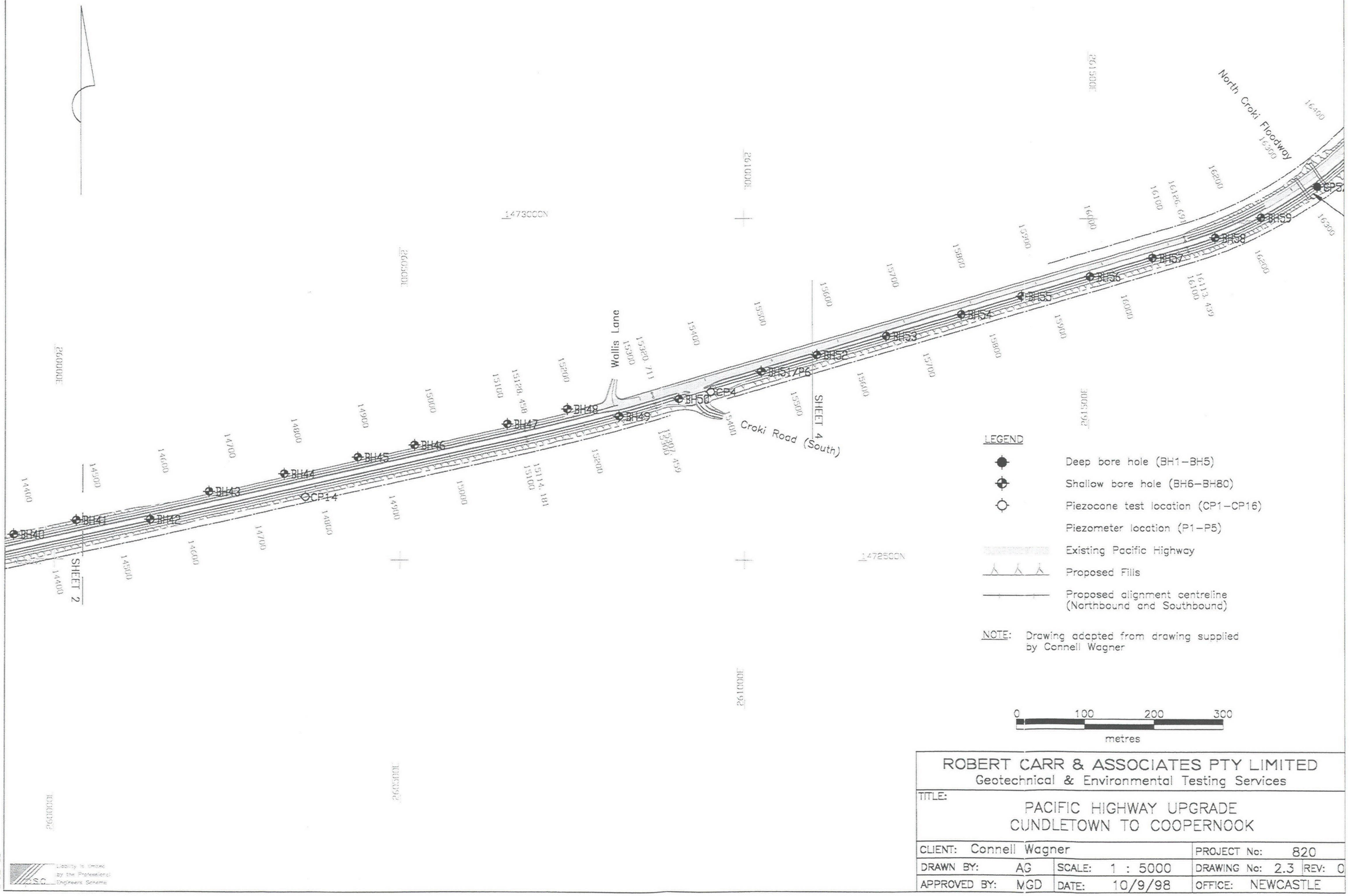

LEGEND

- Deep bore hole (BH1–BH5)
- Shallow bore hole (BH6–BH80)
- Piezocone test location (CP1–CP16)
- Piezometer location (P1–P5)
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- Proposed alignment centreline (Northbound and Southbound)

NOTE: Drawing adapted from drawing supplied by Connell Wagner

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Geotechnical & Environmental Testing Services

TITLE:
PACIFIC HIGHWAY UPGRADE
CUNDLETOWN TO COOPERNOOK

CLIENT: Connell Wagner				PROJECT No: 820	
DRAWN BY: AG	SCALE: 1 : 5000			DRAWING No: 2.3	REV: 0
APPROVED BY: MGD	DATE: 10/9/98			OFFICE: NEWCASTLE	

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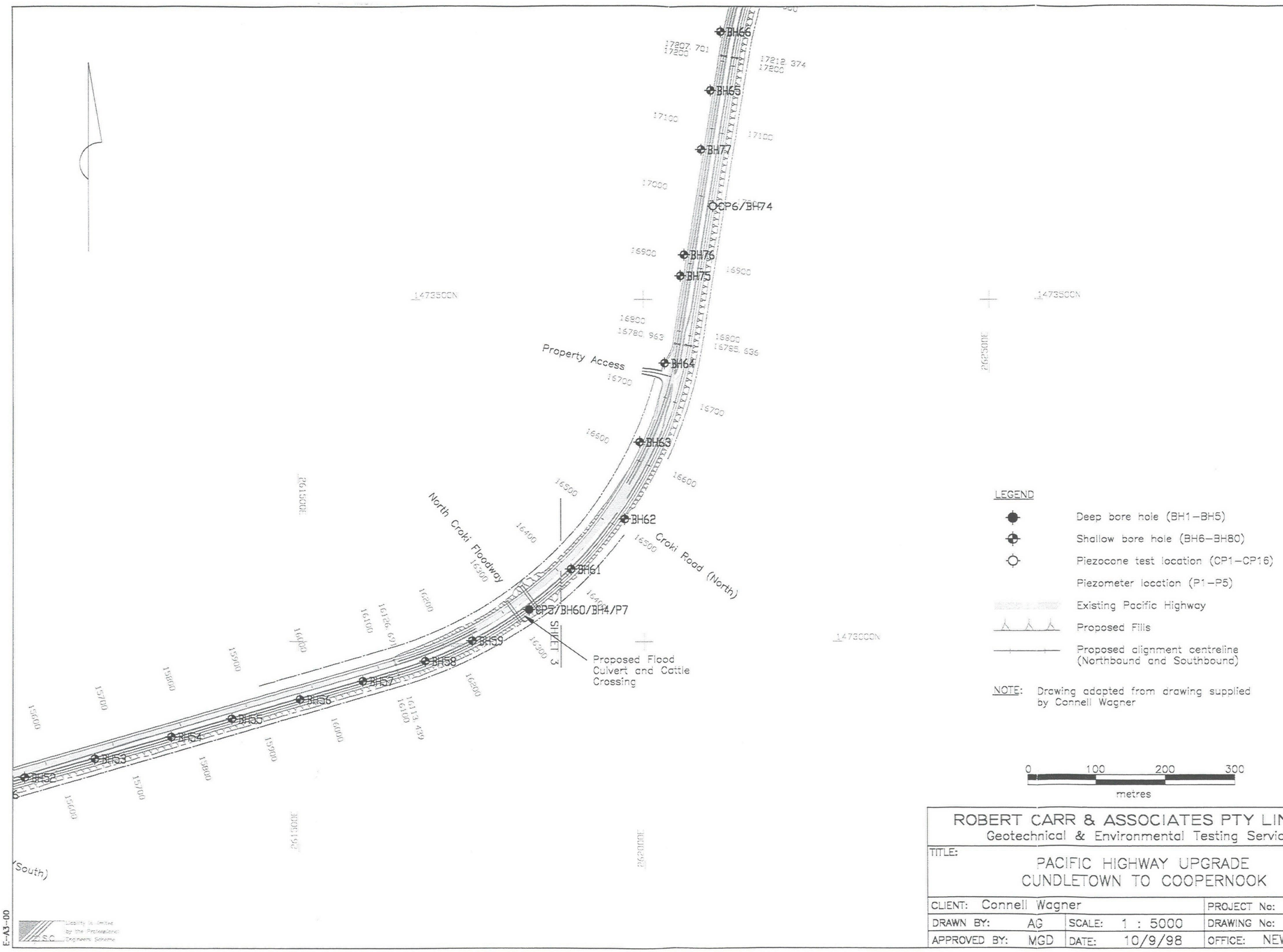
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CP6/BH74
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BH76
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1473500N
16800
16780.963
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16785.636
Property Access
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Croki Road (North)
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LEGEND

- Deep bore hole (BH1–BH5)
- Shallow bore hole (BH6–BH80)
- Piezocone test location (CP1–CP16)
- Piezometer location (P1–P5)
- Existing Pacific Highway
- Proposed Fills
- Proposed alignment centreline (Northbound and Southbound)

NOTE: Drawing adapted from drawing supplied by Connell Wagner

0 100 200 300
metres

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ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:
PACIFIC HIGHWAY UPGRADE
CUNDLETOWN TO COOPERNOOK

CLIENT:	Connell Wagner			PROJECT No:	820
DRAWN BY:	AG	SCALE:	1 : 5000	DRAWING No: 2.5	REV: 0
APPROVED BY:	MGD	DATE:	10/9/98	OFFICE:	NEWCASTLE



LEGEND

- 20kL Sediment/Spill basin (within road reserve)
- Silt fence, construction phase only
- Drain under entire road reserve
- Proposed Fills
- Proposed alignment centreline (Northbound and Southbound)

NOTE: Drawing adapted from supplied by Connell Wagner

0 100 200 300
metres

E-A3-00

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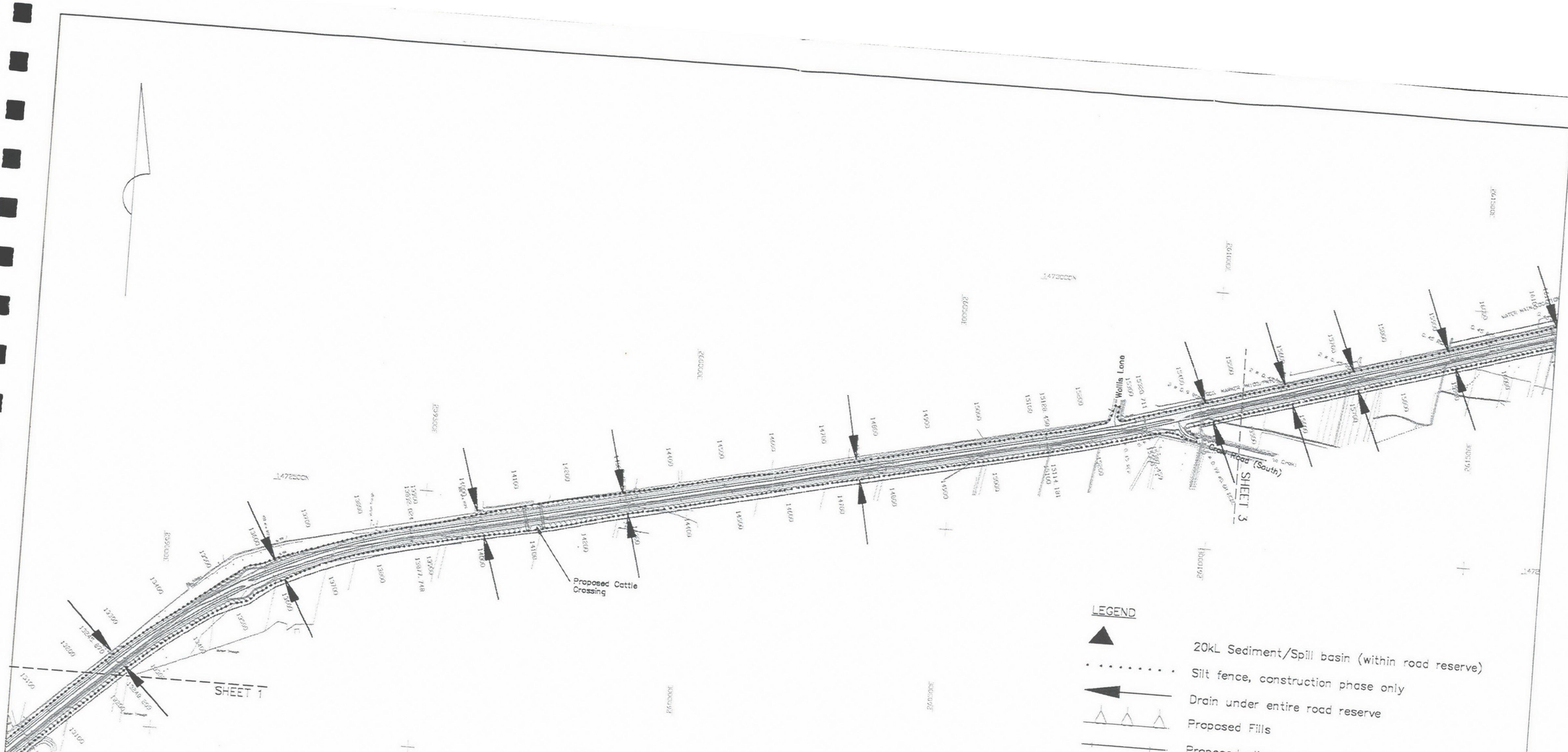
ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:
CONCEPT EROSION SEDIMENT CONTROL PLAN
CUNDLETOWN TO COOPERNOOK PACIFIC HIGHWAY UPGRADE

CLIENT: WBM Oceanics				PROJECT No:	820
DRAWN BY:	AG	SCALE:	1 : 7500	DRAWING No: 4.1	REV: 0
APPROVED BY:	MGD	DATE:	30/9/98	OFFICE:	NEWCASTLE



LEGEND

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- Silt fence, construction phase only
- Drain under entire road reserve
- Proposed Fills
- Proposed alignment centreline (Northbound and Southbound)

NOTE: Drawing adapted from supplied by Connell Wagner

0 100 200 300
metres

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ROBERT CARR & ASSOCIATES PTY LIMITED Geotechnical & Environmental Testing Services	
TITLE: CONCEPT EROSION SEDIMENT CONTROL PLAN CUNDLETOWN TO COOPERNOOK PACIFIC HIGHWAY UPGRADE	
CLIENT: WBM Oceanics	
DRAWN BY: AG	SCALE: 1 : 7500
APPROVED BY: MGD	DATE: 30/9/98
PROJECT No: 820	
DRAWING No: 4.2	REV: 0
OFFICE: NEWCASTLE	



LEGEND

- 20kL Sediment/Spill basin (within road reserve)
- Silt fence, construction phase only
- Drain under entire road reserve
- Proposed Fills
- Proposed alignment centreline (Northbound and Southbound)

NOTE: Drawing adapted from supplied by Connell Wagner

0 100 200 300
metres

ROBERT CARR & ASSOCIATES PTY LIMITED
Geotechnical & Environmental Testing Services

TITLE:
CONCEPT EROSION SEDIMENT CONTROL PLAN
CUNDLETOWN TO COOPERNOOK PACIFIC HIGHWAY UPGRADE

CLIENT:	WBM Oceanics			PROJECT No:	820
DRAWN BY:	AG	SCALE:	1 : 7500	DRAWING No: 4.3	REV: 0
APPROVED BY:	MGD	DATE:	30/9/98	OFFICE:	NEWCASTLE

E-A3-00

5 REFERENCES

ANZECC (1992), Australian Water Quality Guidelines for Fresh and Marine Waters.

CSIRO (1992), Investigation Report CET/LH/IR076 - Road Runoff and its Impact on the Aquatic Environment : A Review.