7. PROPOSAL AREA ENVIRONMENT

7.1 BACKGROUND

The Wagerup alumina refinery has been in operation since 1984 and consequently is contained in a significantly modified environmental setting. The following sections describe the "existing environment" including aspects relating to air quality, noise emissions and water supply.

The refinery and bauxite residue operations are contained within freehold land owned by Alcoa. Land uses on the non-industrial Alcoa owned land and on adjacent properties are primarily agricultural, mainly cattle grazing on dry or irrigated pasture.

7.2 REGIONAL CONTEXT

Wagerup refinery is located on the Pinjarra Plain or more specifically the Ridge Hill Shelf which forms the foothills of the Darling Scarp. This geomorphic unit consists of a series of laterite covered spurs, dissected by numerous small creeks which flow westward. Soils are generally high in iron and aluminium oxides.

The Willowdale mine, which supplies bauxite ore to the refinery, is located on the Darling Plateau in the Jarrah Forest to the east of the Ridge Hill Shelf. The plateau is characterised by an undulating hilly landscape and lateritic uplands with major valleys along the scarp. Mining operations are outside the scope of this ERMP assessment.

The Residue Storage Area is located to the west of the refinery on the alluvial Pinjarra Plain at the foot of the Darling Scarp. The plain is covered with clays and loams in the valley flats and poorly sorted clayey sands and gravels in the piedmont zone (Playford *et al.*, 1976). Drainage lines of various sizes drain across the plain and small seasonal swamps are not uncommon.

7.3 CLIMATE

The Wagerup area is characterised by a Mediterranean climate with mild wet winters and warm dry summers.

A summary of climatic data observed in the year 2004 at the Bancell Road monitoring station, operated by Alcoa and near the Wagerup refinery, is presented in Table 7.

Table 7: Climatic Data for Wagerup Refinery[1]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Daily Max. Temp (°C)	30.2	30.8	27.7	24.2	19.8	18.0	16.2	15.6	18.1	20.1	23.3	28.7	22.7
Mean Daily Min. Temp (°C)	17.0	18.3	15.2	14.7	11.6	11.9	9.2	8.8	9.3	10.9	13.4	15.1	13.2
Mean 9am Rel. Hum. (%)	49	51	48	57	65	72	73	76	61	62	54	44	59
Mean 3pm Rel. Hum. (%)	36	38	34	44	52	67	62	66	55	56	47	37	49
Monthly rainfall (mm)	1.2	1.0	0.4	17.2	111.2	200.5	127.4	175.6	28.0	59.0	43.2	3.0	767.7
Highest recorded daily rainfall (mm)	1.2	0.6	0.2	5.8	43.0	38.2	26.4	35.6	8.1	17.0	10.7	2.0	-
Mean 9am wind speed (m/s)	3.0	2.9	2.8	2.8	3.2	3.1	3.1	2.9	2.7	2.9	3.6	2.3	2.9
Mean 3pm wind speed (m/s)	3.2	3.1	3.5	2.8	3.0	3.2	2.7	3.3	3.0	3.3	3.1	2.7	3.1

Notes 1. Data collected at Bancell Road for the 2004 calendar year

The nearest Bureau of Meteorology monitoring station to Wagerup is located at Wokalup, approximately 22 km south of the refinery. Records have been collected at the Wokalup station since 1951. Averaged data since that time are presented in Table 8.

Table 8: Climatic Data for Wokalup[1]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Mean Daily Max. Temp (°C)	30.9	30.8	28.3	24.3	20.2	17.4	16.7	17.1	18.6	21.0	24.0	27.8	23.0
Mean Daily Min. Temp (°C)	15.6	16.1	14.8	12.7	10.6	9.0	8.0	7.9	8.5	9.5	11.4	13.6	11.4
Mean 9am Rel. Hum. (%)	54	56	59	68	77	81	83	79	75	69	63	56	68
Monthly rainfall (mm)	14.0	16.9	21.8	50.5	137.4	193.7	187.7	135.6	93.2	61.7	36.9	14.4	963.7
Highest recorded daily rainfall (mm)	108.6	90.4	79.2	56.0	60.8	63.5	52.3	66.5	49.8	65.6	44.6	35.8	-
Mean 9am wind speed (m/s)	4.1	4.4	4.2	3.4	2.5	2.5	2.7	2.9	3.2	3.4	3.5	3.6	3.4

Notes 1. Averaged data collected by the BOM at Wokalup station since 1951.

7.3.1 Temperature and Humidity

Wagerup temperatures are characteristic of the South West region, with warm to hot summers and mild winters. The warmest months are January and February, with maximum temperatures in these months exceeding 40 °C and averaging over 30 °C. The coldest months are July and August, when the average maximum temperature is 17 °C. Average minimum temperatures range from 8 °C in August to 16 °C in February (Wokalup data). These temperature ranges are very similar to those recorded in Perth.

Humidity at Wagerup tends to reach a peak in the early mornings and drops during the day, with winters being more humid than summers. These effects are common in the South West region, and monthly averages are similar to those recorded at Perth.

7.3.2 Rainfall and Evaporation

Annual rainfall in the vicinity of the Wagerup refinery averages approximately 950 mm, with approximately 75% falling between May and September. However, although most rainfall occurs in winter, the most intense rainfall events tend to occur in the summer months.

Due to orographic (passage of air of a ridge) effects, rainfall is generally lower on the coastal plain to the west of the Darling Range in comparison to that of the Jarrah forest of the Darling Scarp to the east (Anderson 1984:4). Due to the close proximity of the refinery to the base of the Darling Scarp (within 1 km), rainfall is higher here than for much of the coastal plain.

7.3.3 Winds

Winds at Wagerup have previously been categorised by Sinclair Knight Mertz (in SKM, 2001 & SKM, 2003). The following description is based on those reports.

The winds at Wagerup are controlled by synoptic weather patterns and local features such as the topography and sea and land breezes. In the summer the passage of high pressure systems to the south generates synoptic easterlies over the region, whilst in the winter months the passage of cold fronts and low pressure systems results in more frequent westerly synoptic flows between periods of lighter winds. For the Wagerup refinery, at the base of the Darling escarpment, topographical features are particularly important in modifying these larger scale winds. These topographic features tend to:

- Generate very strong local winds during summer, principally at night and in the early morning, which are known as “gully wind” or “foothill winds;
- Create rotors or wind reversals near the foothills under easterly winds;
- Channel or deflect westerly winds near the base of the escarpment along the escarpment; and
- Create light drainage (katabatic flows) down the escarpment.

7.4 TOPOGRAPHY AND GEOLOGY

The Wagerup refinery is located at the foot of the Darling Scarp where the land gently slopes towards the west. Elevation on the eastern side of the refinery and edge of the Upper Dam is 55 mAHD, which drops approximately 40 m to 45 mAHD on the western side of the refinery. The residue storage area and surface water detention pond are constructed on the Pinjarra Plain at an elevation of approximately 15 mAHD on the western side of the residue area and 20 m to 25 mAHD on the eastern side of the residue area.

The area is dissected by North Yalup Brook and Lower Yalup Brook just north of the refinery and Bancell Brook to the south of the refinery. Overflow from the fresh water catchment dams and ponds on Alcoa's property flows into the Black Tom Brook Diversion Drain which flows along the eastern and southern sides of the residue area and drains into South Sampson Drain (Figure 13).

Geology below the refinery is characterised by the superficial Yoganup Formation (leached or ferruiginised beach sand, conglomerate and dunes) which is approximately 15 m thick and includes a variable thickness (of up to 3 m) of surface fill comprising sandy clay and lateritic gravel overlain by sand placed there during refinery construction (Peck and Thomas, 1997). The composition of the superficial formations below the refinery are highly variable, but can be sandy on the lower part of the Yoganup Formation and sandy clays in the upper part of the formation. The superficial formations are underlain by low permeability silty clays possibly from the Cattamarra Coal Measures (Parsons Brinckerhoff/Nield Consulting, 2004).

Below the residue area, the Guildford formation comprising alluvium (mostly clay and sandy clay), which is variably laterised and podsolised, forms the top 5 m to 15 m of the superficial formations and thins out to the east of the residue area, exposing the Yoganup Formation near the South Western Highway. The Yoganup formation dominates the lower superficial formations below and east of the residue area, but is interspersed by the Ascot limestone formation. The Leederville Formation, comprising sand, siltstone, shale and clay lies below the superficial formations in the vicinity of the refinery operations (Parsons Brinckerhoff/Nield Consulting, 2004).

The soils in the vicinity of the Wagerup refinery are described in Churchward and McArthur (1980) as:

- Guildford Unit: flat plain with medium textured deposits, yellow duplex soils;
- Forrestfield Unit: laterised foothills of the Darling Scarp dominated by gravely and sandy soils; and
- Darling Scarp: very steep slopes with shallow red and yellow earths and rock outcrop.

7.5 SURFACE HYDROLOGY

The Wagerup refinery area is within the lower reaches of the Harvey River catchment, which has an area of 2,055 km^2. Approximately 45% (925 km^2) of the catchment is cleared and 29% (605 km^2) is State Forest (Centre of Excellence in Natural Resource Management (CENRM), 2005). The area is the largest catchment draining into the Peel-Harvey Estuary. The main river system in this catchment is the Harvey River, which lies approximately 4 km to the west of the refinery operations and flows in a north-westerly direction, discharging into the Harvey Estuary.

The natural hydrology of the lower Harvey River catchment was comprised of small rivers and streams draining relatively small catchments from the escarpment onto the coastal plain and to the Harvey River (Figure 13). The majority of the natural drainage lines on the coastal plain have been extensively modified by artificial drainage, irrigation, channelisation and clearing of native vegetation. In the early 1900s the development of irrigation and drainage servicing agricultural activities around the towns of Harvey and Waroona altered the surface hydrology significantly. The Harvey River has been significantly modified for agricultural purposes and is now commonly referred to as the Harvey Main Drain.

The main drainage systems within the Harvey River catchment are:

- Harvey River Main Drain;
- Harvey Diversion Drain, diverting overflow from the Harvey and Wokalup rivers (including Wellesley Creek) to the Indian Ocean at Myalup;
- Weekes, Clarke, Logue, Bancell and Yalup brooks, which discharge into Harvey River Main Drain;
- Samson-Waroona-Drakesbrook drainage system, which includes Black Tom and McKnoe brooks and discharges into the Harvey River Main Drain via both Samson River Main Drain and Drakesbrook Drain;
- Mayfield Drain, which discharges into the Harvey River Main Drain, close to Harvey Delta (CENRM, 2005).

Due to extensive clearing for agriculture on the plain, it is estimated that runoff from the lower Harvey catchment is much greater than under pre-European conditions. Current runoff from the plain is estimated to be about 300% greater (i.e. 141 GL/y) than it was prior to settlement. This is reflected in the total annual flow from the Harvey River into the Harvey estuary increasing by approximately 25 to 50% compared to pre-European flows (Water and Rivers Commission, 1998).

However, climate change has also resulted in reduced rainfall in the region (estimated to be 10% over the last 20 years) which has been shown to reduce streamflow in jarrah forest catchments by between 20% and 40%. Approximately 51% (53 GL) of the total mean annual

streamflow from the upper Harvey River is diverted for irrigation and town water supplies (Water and Rivers Commission, 1996).

The west and south boundaries of the residue area comprise inner and outer dykes, with an intervening drain which collects surface water runoff and leachate from the dykes. This water is pumped back to the leachate collection ponds. Runoff from the refinery area drains into the Storm Surge Pond. A pipeline carries water from the Storm Surge Pond to the cooling pond, or run-off water storage (ROWS) pond located in the residue area. The pipeline to the storage ponds greatly increases the capacity of the system and minimizes the risk of releasing contaminated water to the environment. An overflow pond is designed to accept overflow from the Storm Surge Pond during extreme rainfall events.

The run-off water collection system for the refinery and residue area was designed and operates as a closed system. The refinery is a net user of water, with the major losses from the system associated with evaporation, cooling and moisture retained in the residue.

7.5.1 Surface Water Quality

7.5.1.1 Harvey River Catchment Water Quality

Runoff from the upper catchment areas of the Harvey River Catchment is low in nutrients due to the ancient weathered rock profile of the Darling Range and retention of nutrients by forested areas (Bunn and Davies, 1990). The lower catchment by comparison is largely cleared for agriculture and cultivated, and consequently has a high nutrient status (Rivers and Clarke, 2003).

Runoff from the upper catchment is highly seasonal with very low or no flow between December and April. The construction of dams on the hills catchments and reduced rainfall in the last 20 years has reduced the input of low-nutrient runoff into the Harvey River drainage system, whilst clearing and cultivation on the coastal plain has increased the volume of nutrient-rich runoff into the Harvey system (CENRM, 2005).

Surface water runoff from the upper catchments now only contributes approximately 16% of total flows to the Harvey Estuary compared with 60% prior to European settlement. Therefore the potential for surface water runoff from the upper catchment to dilute or flush nutrient-rich runoff in the lower catchment has been significantly reduced (Black and Rosher, 1980). River flow and total nutrient input to the Peel-Harvey Estuary is strongly seasonal with approximately 85% of nitrogen and phosphorous loadings occurring during winter (CENRM, 2005).

In the past many seasonal and perennial wetlands within the Harvey catchment acted as nutrient sinks. These have been drained, and riparian vegetation which assists nutrient retention, has been cleared for agriculture. Creation of wetlands and re-establishment of

riparian vegetation within the catchment has been identified as a priority by the Department of Environment to assist in the management of nutrient-rich waters.

Assessment of the Harvey Irrigation Area showed that nitrogen in water typically equalled or exceeded the ANZECC Guideline of 0.75 mg/L for total nitrogen in Southwest Australian estuaries, in most samples (Rivers and Clarke, 2003). Drains in the Harvey catchment exhibited similar characteristics but also showed peaks of nitrogen up to 3.0 mg/L.

The estimated historical phosphorus inputs into the Peel-Harvey Estuary are shown in Table 9.

Table 9: Estimated phosphorus inputs into the Peel-Harvey Estuary (after Kinhill, 1988).

Harvey Catchment	**Phosphorus (mg/L)**		**Streamflow (m^3x10^6/a)**		**P Load (t/a)**	
	circa 1930	1977-1986	circa 1930	1977-1986	circa 1930	1977-1986
Hills	0.01	0.01	195	65	2	1
Coastal Plain	0.09	0.46	180	370	16	170
Total	0.10	0.47	375	435	18	171

The increase in nutrient inputs from clearing and agricultural activity is clearly shown and can be compared with the ANZECC Guidelines[1] for total phosphorus in Southwest Australian estuaries of 0.3 mg/L (ANZECC, 1992).

As a result of high nutrient levels in surface water flowing to the Peel-Harvey Estuary, the estuary has suffered massive blue-green algal blooms of *Nodularia spumigena*. The Dawesville Channel, which was constructed and opened in 1995 to allow tidal flushing of the estuary, has reduced the frequency of algal blooms. However, continued urban and rural development within the catchment, including more intensive agricultural practices, continues to threaten the nutrient balance and water quality of the lower Harvey River system.

[1] The ANZECC Guidelines present 'trigger values' which may be used as straight guidelines, or as a starting point to trigger an investigation to develop more appropriate guidelines based on the type of water resource and inherent differences in water quality across regions.

7.5.1.2 Water Quality in Vicinity of Wagerup Refinery

Under its environmental licence (6217/8), Alcoa has implemented a surface water quality monitoring program related to the Wagerup refinery. There are 13 surface water monitoring sites established throughout the surface water systems associated with the refinery operations (Figure 13). Surface water flows and water quality is monitored at these sites on a regular basis. Water quality monitoring includes measurement of pH, electrical conductivity (EC), alkalinity, sodium/chloride ratio and turbidity on a monthly basis and trace elements including aluminium, arsenic, mercury, selenium, vanadium, manganese, molybdenum and uranium are monitored every six months. Surface water monitoring results are collated and reported annually to the DoE.

Surface water monitoring has revealed a high temporal variability of stream-flows and surface water quality in the region, which is primarily linked to agricultural activities. After rainfall events, sharp peaks in flow coincide with sharp dips in salinity due to rainfall dilution, which is a result of clearing for agriculture causing increased surface water runoff (Parsons Brinckerhoff/Nield Consulting, 2004).

Monitoring results from years 2000 to 2003 indicate that the Wagerup refinery operations have not had an impact on surface water quality in the vicinity of the Proposal area (Alcoa, 2003; Alcoa, 2002). Elevated concentrations of sulphate have been found in some agricultural drains in the area. However this appears related to the presence of naturally occurring acid-sulphate soils rather than residue collection (Gerritse and Thomas, 2003).

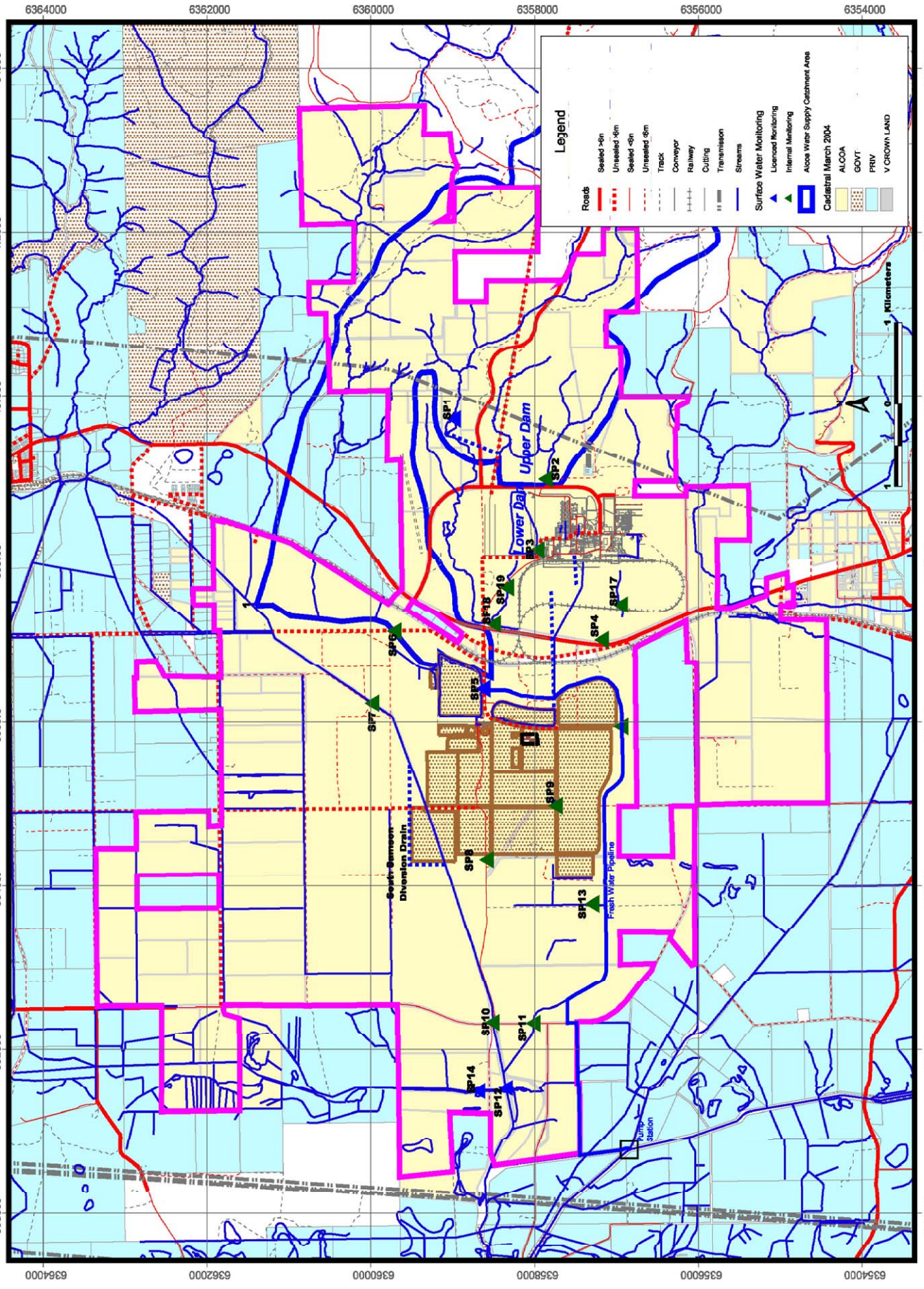

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Figure 13

LOWER HARVEY RIVER CATCHMENT AREA

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The minimal impact refinery operations have had on surface water is shown through comparing the water samples collected for the initial environmental assessment of Wagerup refinery in 1978 and the 2004 surface water samples. Table 10 below contains sample data for Samson Brook (or South Samson drain) and Harvey River Main Drain from the 1978 ERMP and 2004 sampling events (average of the April and October monitoring rounds).

Table 10: Comparison of 1978 water sampling and 2004 monitoring data

Parameter	Samson Brook Drain (1978)	SP12 Average of April and Oct monitoring (2004)	Harvey Main Drain (1978)	SP15 Average of April and Oct monitoring (2004)
EC (us/cm)	225 - 2560	395	500 - 1056	561
Calcium	3.1 – 17.7	5.8	8.7 – 19.2	12.0
Chloride	71 - 310	93	78 - 305	250
Hardness	22 - 198	50	66 - 198	84
Iron	< 0.2 – 1.1	0.24	< 0.2 – 0.8	0.41
M Alkalinity	< 1.0 - 28	22.5	2 - 36	44
Manganese	< 0.5 – 0.12	0.042	<0.5 – 0.11	0.053
pH	6.5 – 8.0	7.0	7.4 – 8.1	7.2
Potassium	1.6 – 4.2	1.9	3.8 – 7.1	5.3
Silica	0.04 – 0.20	5.4	0.04 – 0.15	6.8
Sodium	29 - 121	53.4	53 - 125	68.3
Total P	0.001 – 0.393	0.05	0.003 – 0.110	0.19
Total S	< 1.0 - 36	17.8	17 - 52	24.9
Zinc	< 0.05	0.015	< 0.05 – 0.08	0.013

An additional surface water monitoring site was established in 1999 on the ephemeral stream west of the refinery (Figure 13) where there is evidence of very low level alkaline contamination which has resulted from the former hydrate stockpile. Water quality results from this location were reasonably consistent and showed slightly elevated levels of sodium/chloride ratios and alkalinity. The hydrate stockpile was removed in 2000 and monitoring will continue in order to track the fate of the plume.

Wetlands Protected under the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992

The *Environmental Protection (Swan Coastal Plain Lakes) Policy 1992* (Lakes EPP) was developed to protect the environmental values of lakes on the Swan Coastal Plain. The Lakes EPP prohibits any activities which cause the destruction and degradation of lakes without authorisation from the EPA. The area covered by the Lakes EPP extends approximately from Moore River in the north to Eagle Bay in the south and inland to the escarpment.

The Lakes EPP was reviewed in 1999, following which *Draft Environmental Protection (Swan Coastal Plains Wetlands) Policy 2004* (Draft Wetlands EPP 2004) and *Draft Environmental Protection (Swan Coastal Plains Wetlands) Regulations 2004* (Draft Wetlands Regulations 2004) were released by the EPA for public comment on 19 July 2004 until 15 October 2004.

There are no wetlands listed under the Draft Wetlands EPP 2004 in the immediate vicinity of the Wagerup refinery or residue area. There are three small wetlands near Hamel (approximately 4 km north of the refinery), four small wetlands near Yarloop (approximately 3.5 km south of the refinery) and a wetland known as Exelby wetland on the northern side of Bancell Road (near intersection with Hayes Road) which are listed in the Draft Wetlands EPP 2004. Exelby wetland was traditionally an ephemeral wetland, but has now become a permanent water body with in-flows of excess irrigation waters from the surrounding farmlands. However, it is very unlikely that these wetlands would be affected by existing or proposed changes to the refinery or residue area due to the distance of the operations, and the fact that all potentially contaminated surface water runoff or waste water discharges are contained on site for use by the operations.

The Wagerup refinery was designed as a closed system, maximising the recycling of process and other surface waters collected within the refinery and residue areas. This system protects the natural environment from impact. Other controls in place include; the preparation and implementation of a Hazardous Materials and Spill Management Plan in place which is reviewed and updated annually; and environmental awareness training of staff for spill prevention and spill management.

7.5.2 Surface Water Sources

The upper reaches of South Yalup Brook were dammed in 1978 to supply industrial and domestic water for the Wagerup refinery. Today, Alcoa is licensed under the *Rights in Water and Irrigation Act* (1914), to divert water from the Harvey River Main Drain, Yalup Brook and Black Tom Brook for storage and use by the Wagerup refinery. Diverted water is stored in the existing Upper Yalup Dam, lower Yalup Dam and detention ponds located in the residue area.

The refinery operates as a closed system and all rainfall runoff from the refinery, residue area and process water ponds are transferred to the cooling pond or ROWS pond during winter and then used as make-up water for the refining process during summer. The key water losses from the process include:

- final cooling of process liquor to enable the crystallisation of alumina;
- evaporation of stored fresh water;
- evaporation of process liquor storages and tanks;
- vapour released during the drying and calcination of alumina;
- moisture retained in the residue; and
- water used for dust control within the residue drying areas.

The RDAs also have base drainage systems that collect residue leachate and rainfall infiltration which is then fed into the make-up water system. The Wagerup refinery is almost totally dependent on the above surface water sources to provide the additional process make-up water required annually.

Approval to extract excess winter runoff from the Harvey River Main Drain was granted to Alcoa in 2002 by the Water and Rivers Commission. The installation and commissioning of equipment required to extract winter runoff from the Harvey River Main Drain was completed by October 2003. This surface water source was chosen due to the high volume of water available over the winter period and to support the abstraction of lower quality, winter run-off from the Harvey River Main Drain. The abstraction of lower quality winter run-off was seen to have positive environmental benefits for the lower Harvey River Main Drain and to a lesser extent the Harvey Estuary, through potentially reducing nutrient inputs.

The Harvey River Main Drain allocation replaced the licensed allocation from the Samson Brook South Drain and reduced the allocation from Black Tom Brook. The surface water licence allocations and the volumes abstracted by Alcoa in 2004 are presented in Table 11.

Table 11: Surface Water Licence Allocations and Abstraction Volumes for 2003.

Licence No.	Catchment Location	Expiry	Licensed Abstraction Volume (ML/year)	Volume Abstracted by Alcoa in 2003 (ML/year)
99246	Black Tom Brook	30/06/2007	2,500	1572
97472	Yalup Brook	30/06/2007	1,600	1174
151027	Harvey River Drain	30/06/2007	4,400	1550

Notes:
1. Water can only be abstracted from the Harvey River (Drain) between May and October.

Alcoa is required to divert surface waters in accordance with licence requirements and the agreed operational strategy that is amended from time to time in consultation with the DoE.

Water conservation is a key focus for the Wagerup refinery, especially with increasing concern over the impacts of climate change. Current models for global warming (CSIRO, 1996; 2000) have predicted an increase in summer rainfall and a decrease in winter/spring rainfall, and a potential increase in the duration of drought events. Water conservation initiatives at the refinery in 2004 concentrated on reducing the volume of water used for dust suppression such as:

- Using wood chips sourced from a local Yarloop timber mill and blue metal on some parts of the residue area instead of water;
- Using waste oil for dust suppression on internal residue roads instead of water;
- Residue area bank stabilisation with tar and bitumen; and
- Ripping of residue drying areas during summer to expose wet mud to lower the water usage required for dust suppression of the mud surfaces.

Alcoa continues to improve the efficient use of water where practicable and has a water efficiency plan in place outlining consumption, water auditing and target reductions in water use across the Wagerup operations.

7.6 HYDROGEOLOGY

Shallow groundwater in the area of Alcoa's Wagerup operations flows westward and eventually discharges into the Harvey River Main Drain.

The superficial geological formations in this region are heterogeneous, comprising zones of very permeability clay, sandy clay, laterite and sand (see Section 7.4). A generalised stratigraphic cross section under the residue area and refinery is presented in Figure 14.

Under both the refinery and the residue area, the superficial formations generally can be divided into an upper, low-permeability layer and a lower layer with higher permeability. For simplicity, these layers are referred to as the upper and lower superficial formations.

At the refinery the superficial formations have a thickness of approximately 15 m. In some parts of the refinery, the lower part of the Yoganup Formation contains sandy, permeable materials and the upper part contains sandy clays with lower permeability. However, the composition of the superficial formations under the refinery area is highly variable. The superficial formations are underlain by low-permeability, silty clays.

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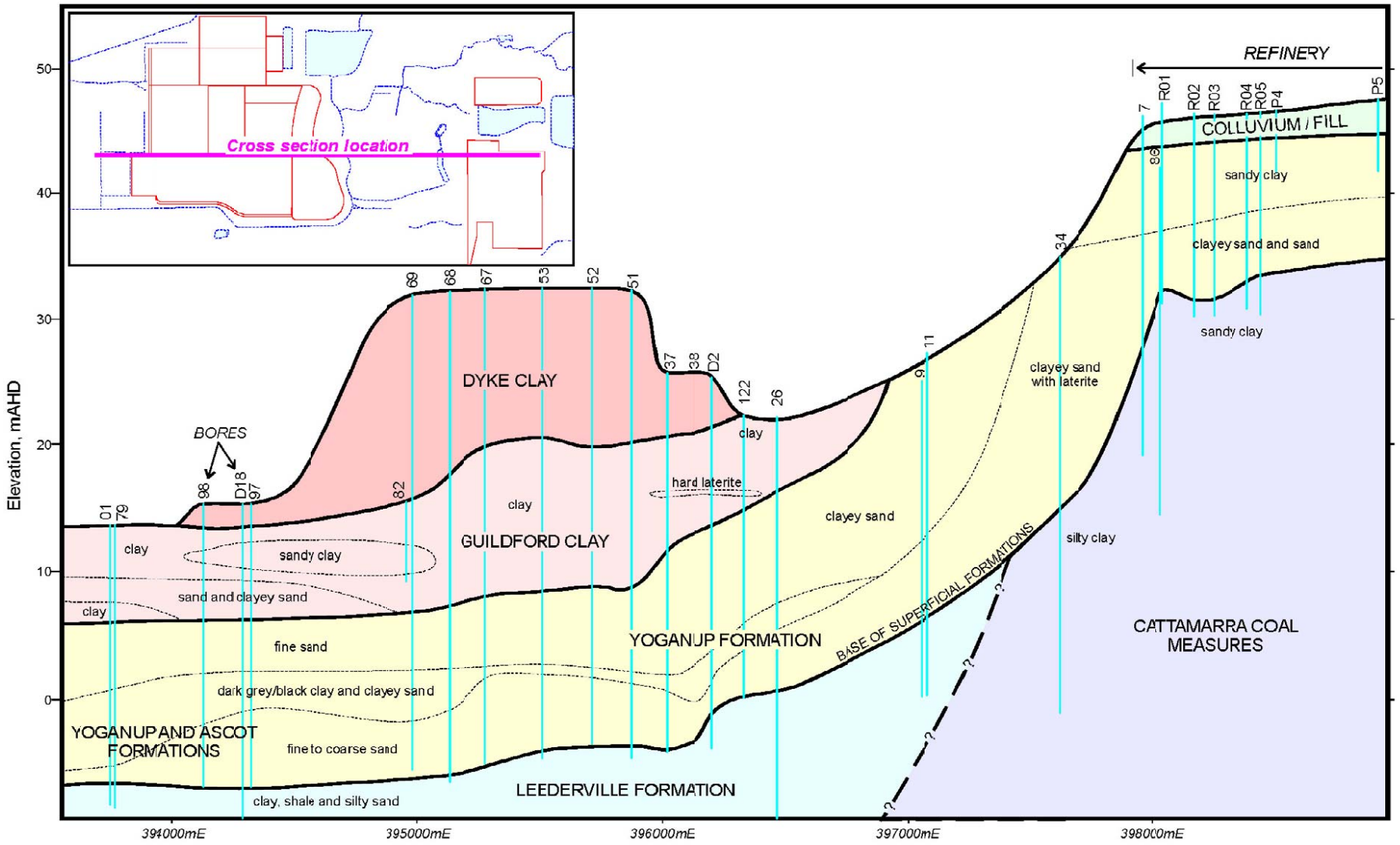
STRATIGRAPHIC CROSS SECTION BELOW THE RESIDUE AREAS AND REFINERY



SOURCE: Parsons Brinckerhoff/Nield Consulting, April 2004.

Figure 14

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Below the residue area, the low permeability clays and sandy clays of the Guildford Formation generally restrict vertical groundwater movement in the superficial aquifer. This is underlain by sands and clayey sands of the Yoganup and Ascot Formations. These sandy formations intercept and together form a regionally continuous aquifer, which is the main conduit for horizontal groundwater movement in the superficial formations. This aquifer is confined by the less permeable, overlying clayey materials of the Guildford Formation.

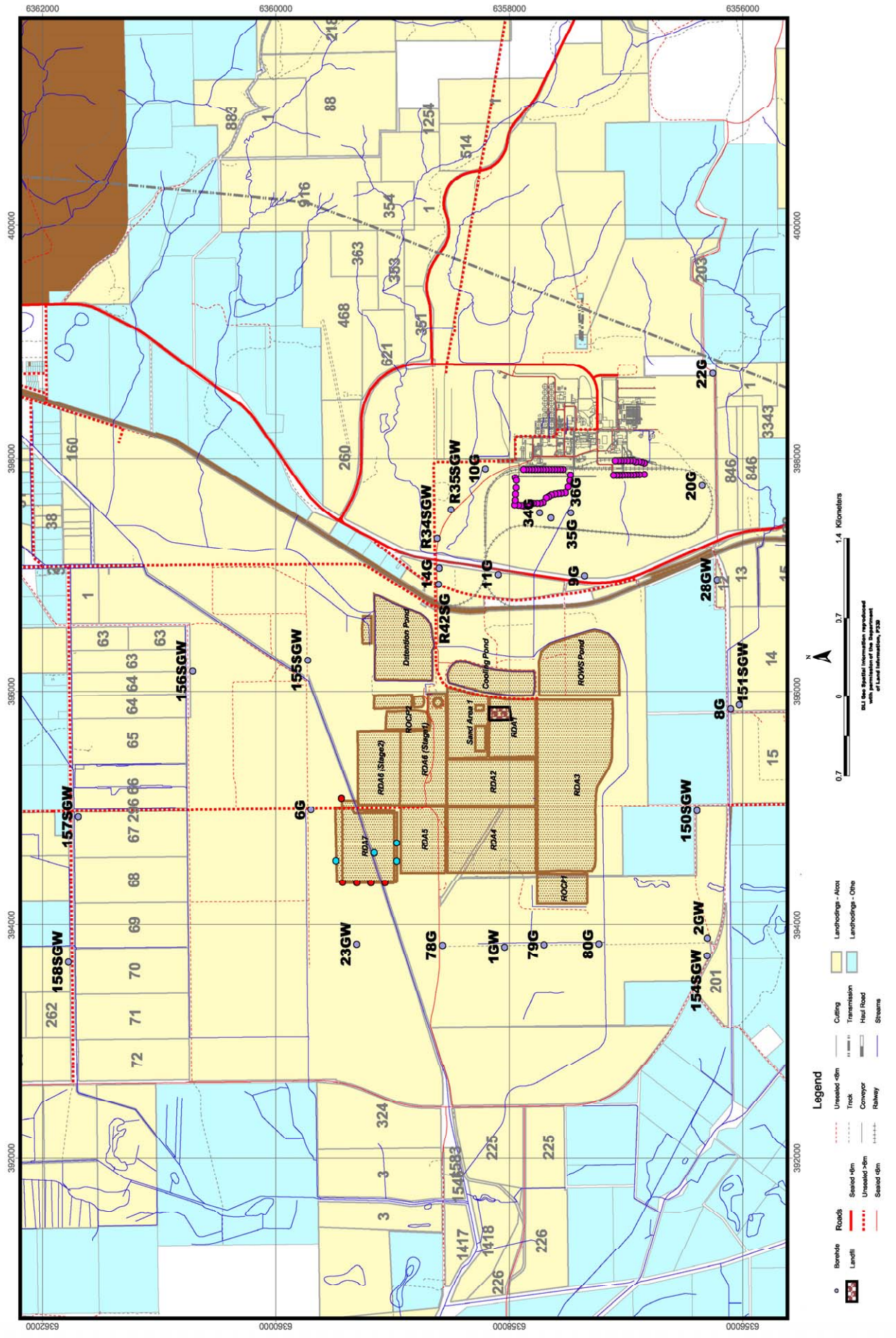
The contact between the Leederville and Yoganup Formations is generally identifiable due to a layer of carbonaceous or greenish-grey silty clay and shale. This layer restricts the vertical movement of groundwater between the superficial formations and the underlying Leederville Formation.

7.6.1 Groundwater Quality

A comprehensive groundwater monitoring program exists across the Wagerup operations which incorporate approximately 420 groundwater monitor bores. Groundwater quality monitoring is conducted as part of ongoing groundwater quality investigations and is also required by the DoE at several locations across the operations. Most bores are sampled twice yearly around April and November. Parameters monitored include pH, EC, alkalinity, sodium/chloride ratio, standing water level and uranium, in accordance with DoE Licence 6217/8.

Alcoa installed a set of regional groundwater monitor bores into the superficial and underlying formations around the refinery in 2001 (Figure 15). Results from these bores are being used to provide further information on regional groundwater flow, groundwater quality and general hydrogeology of the area (Alcoa, 2003). Monitoring results are reported to the DoE on an annual basis.

Groundwater quality investigations have identified groundwater contamination in certain locations beneath the refinery and the residue area. These investigations are contained in the Wagerup refinery Water Resource Management Plan and areas where most work has been undertaken are outlined below. Additional information is available in the Wagerup Annual Environmental Report, 2004.



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GROUNDWATER MONITORING LOCATIONS IN VICINITY OF REFINERY

Figure 15

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7.6.1.1 Refinery Groundwater Quality

Monitor bores installed near refinery process buildings into the superficial formations have shown some low level contamination. Plumes of contaminated groundwater extend westwards beyond several process buildings and facilities notably in the area of the:

- northern refinery (Buildings 26, 25A, 30, 30A);
- southern refinery (Buildings 45, 45E);
- caustic unloading facility; and
- hydrate stockpile (now removed).

The highest contamination levels in the lower superficial formations in this zone are evident near the centre of a cluster of bores referred to as R17Y, R21Y and R46G west of Building 45 (Figure 16). Increasing alkalinity at down-gradient bores in 2002 and 2003 is consistent with the passage of a mobile plume with relatively low-level contamination past this point. This plume extends beyond the refinery footprint into adjacent land but has not impacted on surface water or environmentally sensitive areas.

In 2001 and 2002 the source of contamination near Building 45 was identified. A network of temporary monitoring bores were installed west of the northern refinery buildings and the caustic unloading facility in late 2003 to determine the extent of alkaline plumes from these areas. Alcoa review of groundwater data from these monitoring sites has been undertaken and further monitoring and investigations are recommended.

The former hydrate stockpile located in the south-west corner of the refinery was identified as a source of groundwater contamination and was removed in 2000. A series of temporary monitor bores were installed to the west of the hydrate stockpiles to determine the extent of contamination from this area. Since the stockpile removal, groundwater quality in the close vicinity has generally improved, although additional monitoring and investigations are recommended to better define the movement and spatial extent of the plume (Peck and Thomas, 2005). Additional monitoring should be continued to ensure the movement and spatial extent of the plume is well understood.

7.6.1.2 Residue Area Groundwater Quality

Some localised Low level groundwater contamination has occurred beneath the older residue area as a result of seepage from these facilities. Design and construction of the RDAs has improved significantly over time (with a clay seal, geomembrane and underdrain system) however the clay seal of the older RDAs are not 100% impermeable and some seepage may occur over time.

Elevated alkalinity and pH occur naturally in the Leederville Formation and in the superficial formations, due to the natural of weathering reactions of aquifer materials. In the lower superficial formations, a westerly trend of increasing alkalinity and pH is evident from the bores monitored. This trend may be enhanced by up-flow of groundwater from the Leederville Formation and by natural weathering reactions of aquifer materials in the superficial formations rather than due to alkaline contamination from the Wagerup operations. The trend of westerly increasing alkalinity is also evident in bores to the north and south of the residue area. It is very unlikely that these bores have been affected by residue leachate, due to the westerly groundwater flow.

However, below the residue area this natural trend appears to have been enhanced by seepage of residue leachate, particularly below the older residue drying areas (RDAs 1 to 4) (Gerritse and Thomas 2001, Nield Consultants and Parsons Brinkerhoff/Nield Consulting, 2004). The higher levels of contamination beneath RDAs 1 and 2 are in part due to the construction method of the monitor bores installed on the internal dykes, and operational practices. Monitoring bores on these dykes will be decommissioned in accordance with residue planning and groundwater remediation undertaken, if required.

High salinity in shallow groundwater in the vicinity of the residue area is thought to have been present prior to construction of the RDAs, due to extensive clearing for agriculture (intensive irrigation activities) and subsequent rising of the water table and evaporation. These high salinities would buffer the effects of minor leachate seepage on pH, alkalinity and sodium/chloride ratios in the groundwater. However, minor seepage of leachate is implicated by elevated alkalinities in bores around the residue area.

Elevated sodium/chloride ratios occur in numerous shallow bores near the eastern margin of the residue area. However, other chemical parameters indicate either low or negligible levels of contamination. At other bores, the presence of slight contamination may have had a relatively large effect on sodium/chloride ratios, due to the relatively low salinity of the natural water along the eastern margin of the residue area. Near-background water quality is evident in the more transmissive, lower superficial formations in this area (Gerritse and Thomas, 2001; Parsons Brinkerhoff/Nield Consulting, 2004).

Run-off Containment Pond 1 (ROCP1)

RCOP1 was commissioned in early 1992 to receive runoff water from residue deposited in RDA3 (refer to Figure 16). In 1997 it was discovered that an excessive pressure differential between the pond water and the underlying groundwater had caused heaving and rupture of the clay basement seal. This allowed pond water to move into groundwater. Elevated alkalinity (amount of carbonate, bicarbonate and hydroxide present in terms of calcium carbonate) has been observed downstream of ROCP1 in groundwater monitoring results. Low-level alkaline contamination has been recorded in the superficial aquifer beneath the pond and has moved at least 80 m in the near surface aquifer west of the pond. During part of

each year a small volume of this contaminated groundwater discharges into shallow drains located 10 m to 20 m west of the pond. Sampling of the farm drains immediately west of ROCP1 and RDA4 and has shown elevated uranium levels (but below guideline values for irrigation and stock water use). Surface water monitoring down gradient of these locations does not show any elevated levels of uranium. Uranite, a natural mineral present in the aquifer is the source of the uranium that has been mobilised by the elevated levels of alkalinity, which are influenced by residue leachate contamination.

Current management includes reduction of seepage from ROCP1 through groundwater abstraction to equalise pressure on the clay seal, and reduced by maintaining low pond levels and reducing leachate inflow into ROCP1. Investigations during 2003 indicated that very low or non-existent contamination from residue sources is present in ground and surface water down-gradient of ROCP1.

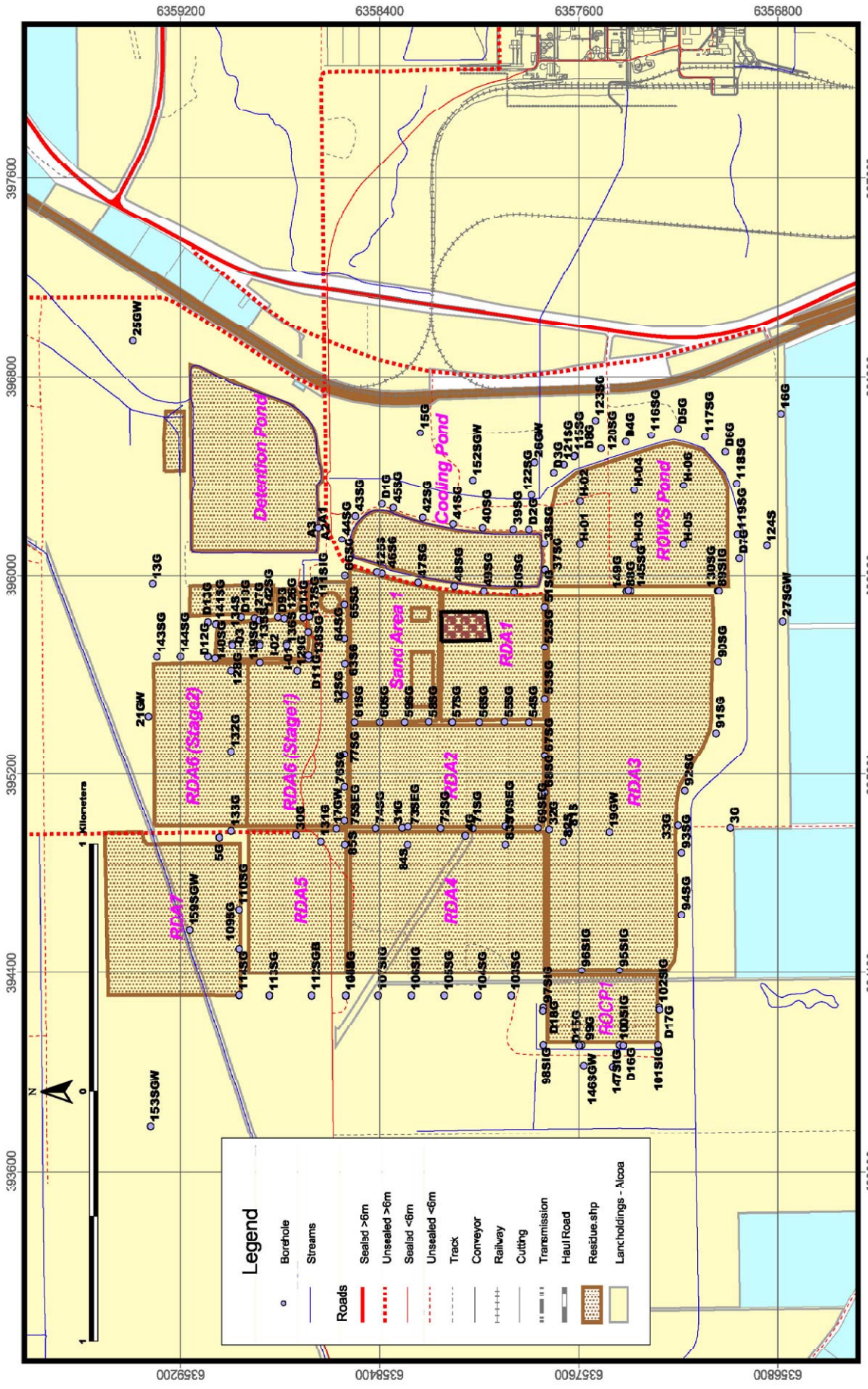
Western Dyke of Run-off Water Storage Pond (ROWS).

Groundwater contamination in one of the bores located on the western dyke of the ROWS pond (Figure 16) was first observed in 1999. Further studies indicated that this bore may be acting as a vertical conduit, allowing contamination to move from the residue area into the lower superficial formations. As a result, the bore was sealed and groundwater quality monitoring results have since indicated significantly lower levels of alkaline contamination.

7.6.2 Groundwater Sources

The region along the Darling Range has complex deep hydrogeology due to faulting. At Pinjarra, Alcoa established a major groundwater supply from the Cattamarra Formation at a depth of around 100 m to 200 m. Alcoa undertook a preliminary investigation of groundwater potential in 1979/80 to see if a similar formation occurred at Wagerup. The investigation included the drilling of two exploratory wells to depths of 300 m to 400 m, which encountered low permeability strata and brackish groundwater. It was therefore concluded that a suitable groundwater resource was not likely to exist in the area (Layton Groundwater Consultants, 1980).

Alcoa currently holds a groundwater extraction licence for up to 550 MLpa to allow the operation of depressurising bores around the residue area. Abstraction is carried out under Groundwater Well Licence 102669, issued by the Water and Rivers Commission on 28 May 2001. The use of these bores is minimised in line with their depressurising role and in recent times approximately 250 MLpa has been abstracted and used as part of the refinery process water.



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GROUNDWATER MONITORING LOCATIONS IN VICINITY OF RDA

Figure 16

ENVIRON

Drawn: KP Date: 04/05

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7.7 FLORA AND VEGETATION

The Wagerup refinery and surrounding Alcoa farmlands is located on the eastern edge of the Swan Coastal Plain within the Pinjarra Plain System and on the Darling Scarp. The area lies on the edge of the Drummond and Dale Botanical Sub-districts within the Darling Botanical District of the Southwest Botanical Province (Beard 1979, 1980, 1981 and 1990). The Pinjarra Plain contains favourable soils for agriculture and extensive clearing following European settlement left very little of the original vegetation.

Prior to extensive clearing, the vegetation in well drained areas consisted of Marri (*Corymbia calophylla*) woodland with some Wandoo (*Eucalyptus. wandoo*) and Jarrah (*E. marginata*) in the higher areas. In lower lying areas subject to flooding, the vegetation would have consisted of *Melaleuca rhaphiophylla* low woodland or forest and thickets of *Melaleuca preissiana* or sedgelands (Beard, 1981).

Heddle *et al.* (1980) and Mattiske and Havel (1998) describe three vegetation complexes within vicinity of the Wagerup refinery:

- Guildford Complex: Dominated by a mixture of an Open Forest, in sections a Tall Open Forest of *Corymbia calophylla* (Marri) – *Eucalyptus wandoo* (Wandoo) – *Eucalyptus marginata* subsp. *marginata* (Jarrah) and Woodland of *Eucalyptus wandoo* (Wandoo).
- Forrestfield Complex: Dominated by an Open Forest of *Corymbia calophylla* (Marri) – *Eucalyptus wandoo* (Wandoo) – *Eucalyptus marginata* subsp. *marginata* (Jarrah) on the heavier gravely soils and of *Eucalyptus marginata* subsp. *marginata* (Jarrah) – *Corymbia calophylla* (Marri) – *Allocasuarina fraseriana* (Sheoak) on sandier soils.
- Darling Scarp Complex: Mosaic of Open Forest of *Eucalyptus marginata* subsp. *marginata* (Jarrah) – *Corymbia calophylla* (Marri), with some admixtures with *Eucalyptus laeliae* in the north, with some *Eucalyptus marginata* subsp. *elegantella* (Jarrah) and *Corymbia haematoxylon* in the south on deeper soils adjacent to outcrops. Woodland of *Eucalyptus wandoo* (Wandoo), low woodland of *Allocasuarina huegeliana* (Rock Sheoak) on shallow soils over granite outcrops, closed heath of Myrtaceae – Proteaceae species and the lithic complex on or near granite outcrops in all climate zones.

The Wagerup operations are in the majority surrounded by paddocks, used mainly for grazing of livestock. Near the residue area the paddocks have generally been levelled to allow even water flow and are irrigated by an extensive system of drains. Vegetation in this area consists of pasture grasses and a mixture of *Eucalyptus* spp. trees and shrubs. Some stands of native vegetation in good condition are located near the refinery but the majority of the trees located near the residue area have been planted as wind breaks and generally occur along fence lines and roads.

The Alcoa farmlands at Wagerup cover an area of approximately 6,000 ha. Of this approximately 65% is on clay flats and 35% on elevated terrain of the Darling Scarp. Mattiske Consulting was commissioned by Alcoa to undertake a flora and vegetation survey of selected remnant bushland areas on the Alcoa Farmlands adjacent to the Wagerup refinery.

Ten vegetation communities were defined and mapped for the remnant vegetation areas on the Alcoa farmlands, and compared with previous descriptions of vegetation in the area. Overall condition of the vegetation surveyed was very good with the exception of one site which had heavy weed infestation (Mattiske, 2003). Three vegetation communities are considered to be significant in a regional context (Figure 17). These are:

- M2(d): This vegetation community is equivalent to Community 3a defined by Gibson *et al.,* (1994) characterised by *Corymbia calophylla* (marri) – *Kingia australis* woodlands on heavy soil. This vegetation community occurs in a very small pocket southwest of the Wagerup refinery and at the time of the survey was very degraded with only a few native plants remaining. This community is listed as a Critically Endangered Threatened Ecological Community (TEC) at the State level, and Endangered under the *Environmental Protection Biodiversity Conservation Act* (EPBC Act) 1999.

- M3: This vegetation community is equivalent to Community 3b defined by Gibson *et al.,* (1994) as *Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils. This community occurs in several small slightly degraded pockets adjacent to community B1. This community is listed as a Vulnerable TEC at the State level

- B1: This vegetation community has a mixture of *Banksia attenuata*, *Eucalyptus marginata* subsp. *marginata* and *Xylomelum occidentale* and is considered by Mattiske (2003) as equivalent to Community 20b described by Gibson *et al*., (1994). This community is listed as an Endangered TEC at the State level.

LEGEND

B1 - Woodland of *Banksia attenuata Eucalyptus marginata* subsp. *marginata* with occasiona *Xylomelum occidentale* over mixed uncerstorey on sandy soils (equivalen to the state listed TEC "20b' as defined by Gibson *et al*. 1994 and English and Blyth 1997).

E1 (d) - Woodland of *Eucalyptus rudis Corymbia calophylla* with occasional *Melaleuca rhaphiophylla* over *Taxandria linearifolia* on loamy soils in ocalized drainage lines.

M1 (d) - Disturbed Open Woodland of *Corymbia calophylla* over the occasional shrub and largely pasture species or loamy-sandy soils.

M2 (d) - Woodland of *Coiymbia calophylla* over the occasiona *Kingia australis*, shrub species and a range of pasture species understorey on loamy-sandy soils (equivalent to a distuibed varian of the critcally endangered state listed TEC "3a" as defined by Gibson *et al*. 1994 and English and Blyth 199* and the nationally listed endangered TEC EPBC Act 1999).

M3 - Woodland o' *Corymbia calophylla Eucalyptus marginata* subsp. *marginata* over mixed shrub species on loamy-sandy soils (equivalent to the vulnerable state listed TEC "3b" as defined by Gibson *et al* 1994 and English and Blyth 1997).

R1 - Open Woodland *Corymbia calophylla - Eucalyptus marginata* subsp. *marginata* over shrub species reflecting shallow gravelly soils over granite such as *Grevillea bipinnatifida* (equivalent to Havel 1975a and 1975b - "R" site-vegetation type).

S1 - Open Forest of *Corymbia calophylla - Eucalyptus marginata* subsp. *marginata* with occasional *Banksia grandis* over mixed understorey on gravelly soils (equivalent tc Havel 1975a anc 1975b - "S' site-vegetation type).

S1 (d) - Disturbed Open Woodland of *Corymbia calophylla - Eucalyptus marginata* subsp. *marginata* with occasional *Banksia grandis* over mixed understorey on gravelly soils (equivalent a disturbed version of the "S" site-vegetation type as defined by Havel 1975a and 1975b).

T1 - Open Forest of *Corymbia calophylla - Eucalyptus marginata* subsp. *marginata* with occasional *Eucalyptus patens* over mixed understorey on loamy-gravel soils (equivalent to Havel 1975a and 1975b - "T" site-vegetation type).

W1 - Open woodland of *Eucalyptus wandoo Eucalyptus marginata* subsp. *marginata* over mixed understorey on clay-loams.

CL - Cleared Land

NOTES:

Horizontal Datum AMG84 (Zone 50)
Vertical Datum: AHD

This map is to be read in conjunction with Mattiske Consulting Pty Ltd Report numbered ALC0303/034/03

0 250 500 750m
Scale

SOURCE: Mattiske Consulting Pty Ltd, Dwg No. j714veg.dgn.

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VEGETATION COMMUNITIES WITHIN VICINITY OF THE WAGERUP REFINERY

Figure 17

ENVIRON

Drawn: KP Date: 04-05

Three other vegetation communities described by Mattiske (2003) were considered to be locally significant:

- R1: This community is a relatively undisturbed Open Woodland of *Eucalyptus marginata* subsp. *marginata* and *Corymbia calophylla* (Jarrah – Marri) over heath species such as *Grevillea bipinnatifida* and *Allocasuarina* species (with some *Banksia grandis* and the occasional *Eucalyptus patens*) on mid and upper slopes of the Darling Scarp. It is considered equivalent to Community R as defined by Havel (1975a and 1975b).

- S1: This is an Open Forest of *Corymbia calophylla – Eucalyptus marginata* subsp. *marginata* on mid and upper slopes of the Darling Scarp. This community is considered equivalent to Community S described by Havel (1975a and 1975b).

- T1: This is a relatively undisturbed Open Forest of *Eucalyptus marginata* subsp. *marginata* - *Corymbia calophylla* (with some *Banskia grandis* and the occasional *Eucalyptus patens*) on mid and upper slopes of the Darling Scarp. Understorey species include *Pteridium esculentum* and *Clematis pubescens*. This community is considered equivalent to Community T defined by Havel (1975a and 1975b).

All three of these communities are present on the Darling Scarp to the east of the refinery.

The remnant bushland areas contained on the Alcoa farmlands are managed in a manner to protect, restore and enhance these areas. This is achieved through planting of native species, fencing of bushland areas, removal of exotic species and working with the local landcare group, Peel Harvey Catchment Council, Harvey River restoration trust, Harvey Water and educational centres.

A total of 58 plant families, 170 genera and 324 plant taxa have been recorded Alcoa farmlands including 34 introduced species. The dominant families are Proteaceae, Myrtaceae, Papilionaceae and Mimosaceae (Mattiske, 2003).

Approved development of the residue area within the 30-year footprint identified in the 2001 LTRMS will occur on Alcoa farmlands, consisting of cleared paddocks with some isolated trees. Therefore the impact on vegetation will be minimal. Any further expansion outside of this existing 30 year footprint and the potential for impact on flora and vegetation will be managed through the Residue Planning Liaison Group (RPLG) and be subject to the requirements of the Minister for Environment (see Section 4.3).

7.7.1 Flora of Conservation Significance

The following three rare species, declared under the *Wildlife Conservation Act* (1950), have previously been located, or potentially could occur, in the Wagerup area:

- *Caladenia huegelii*: A rare orchid recorded on the ridge hill shelf communities by Fermco (1982);
- *Diuris purdiei*: A rare orchid that has been recorded in wetlands between Perth to Waroona, although it is rarely seen because it rapidly establishes after intense fires and then declines;
- *Synaphea stenoloba*: Previously recorded near the Pinjarra refinery and more recently near the old Wagerup townsite. This species may potentially occur in the remnant vegetation areas near Wagerup refinery.

The two orchid species are also listed under the EPBC Act 1999 as 'Endangered' (i.e., taxa which is not critically endangered and is facing a very high risk of extinction in the wild in the immediate or near future).

Based on current information, no Priority species were recorded in the Wagerup refinery area (Mattiske, 2003).

As the residue area will be expanded over the next 30 years in an area predominantly cleared for agriculture, the risk of impact on these species from existing and proposed developments at Wagerup is considered low.

7.8 FAUNA

The endemic fauna of the Swan Coastal Plain have not been well researched as a result of urban and agricultural development in this area occurring prior to extensive scientific fauna surveys being conducted (Anderson, 1984). In 1978, the Western Australian Museum conducted the most detailed fauna survey of the region which included the refinery area. Approximately 33 mammal species were listed including:

- grey kangaroo (*Macropus fuliginosus*);
- wallaby species (*M. irma, M. eugenii* and *Setonix brachyurus*);
- rat kangaroo (*Bettongia pencillatta*);
- possums species (*Trichosaurus vulpecula* and *Pseudocheirus peregrinus*),
- burrowing mammals (eg. *Macrotis lagotis* and *Bettongia lesueur*);
- dingo (*Canis familiaris*); and
- various small mammals including rats, mice and bats.

In addition to the mammals, a total of 223 bird species (including numerous water fowl), 70 species of amphibians and reptiles and 13 species of freshwater fish were recorded has having once occurred on the coastal plain (Anderson, 1984).

7.8.1 Fauna Recorded in the Proposal Area

A number of fauna surveys have been conducted at the Wagerup refinery with the latest being undertaken by Environmental Management and Research Consultants in 2002. The fauna survey was undertaken on the farmlands in the vicinity of the Wagerup refinery (refer to Figure 3).

The survey recorded 14 mammal species, including Grey Kangaroos, Bandicoots, Possums and Wallabies. The Brush-tailed Phascogale, Southern Brown Bandicoot, Brushtail Possums and Yellow-footed Antechinus (Mardos) were all trapped in the remnant jarrah woodland just west of the refinery. Seven introduced mammal species were recorded during the 2002 survey, including fox's, cats, rabbits, rats and mice. Of these, the fox is considered the species of most concern, due to its prevalence throughout the area and predatory nature.

Eighty-six bird species were recorded during the 2002 survey, including the following species, Crebe, Commorant, Heron, Ibis, Duck, Kite, Hawk, Eagle, Cockatoo, Cuckoo, Parrot, Wren, Magpie and Honeyeater.

Eleven reptile species were sighted or trapped in the 2002 survey, with a further eight species reported by Alcoa staff, making a total of 19 recorded species. Eight or possibly 10 frog species were recorded during the survey. Species recorded included Gecko, Lizards, Skinks, Goanna, Tortoises, Snakes and Frogs.

7.8.2 Threatened Fauna

Only one officially gazetted rare species was recorded. Baudin's Cockatoo (formerly named the White-tailed Black Cockatoo) is listed as Vulnerable under the Commonwealth EPBC Act 1999 and 'Rare, or likely to become extinct' under the WA *Wildlife Conservation Act* 1950. This species was recorded in two sites, one at the base of the Darling Escarpment on Yalup Brook. The site is mostly cleared with some remnant trees and tall shrubs along the brook. The second site is further downstream and is mainly cleared with some remnant vegetation along the brook (EMRC, 2002). The expansion of the Wagerup refinery occurs within the refinery's existing footprint and will not impact on the sites where the Baudin's Cockatoo was recorded or other areas of remnant vegetation.

There were no other fauna species recorded at Wagerup in 2002 officially listed as either rare or specially protected under the WA *Wildlife Conservation Act* 1950, or in any category under the Commonwealth EPBC Act 1999 (EMRC, 2002).

7.9 EXISTING AIR QUALITY

7.9.1 Background

Wagerup has an extensive ambient air monitoring programme in place. This programme has been evolving over several years, in response to concerns and requirements of the community and the environmental regulator. A key role of the ambient monitoring programme is to address the requirements of the environmental licence, which specifies ambient targets and limits for key parameters. In addition Alcoa has undertaken a range of voluntary and joint ambient monitoring projects with DoE, the Chemistry Centre of WA (CCWA), CSIRO and the community. The following sections provide a brief summary of the existing ambient air quality in the vicinity of the Wagerup Refinery with a focus on volatile organic compounds (VOC), odour and dust. More detailed information is available in the Air Quality Summary Report (AQSM) in Appendix G.

Figure 18 shows the base map upon which all modelling results (contours) are overlaid. The following information is shown on the base map:

- Residence locations – shown by white numbers;
- Nearby townsites – Yarloop, Hamel and Waroona;
- Refinery and residue area;
- Area A boundary – shown by dotted white line

Figure 18: Base map outlining the key features for modelling studies

7.9.2 Volatile Organic Compounds

A study was undertaken in 2004 to provide detailed information on the ambient air quality in the region surrounding the Wagerup alumina refinery, including the townships of Waroona and Yarloop and the associated rural environment.

274 volatile chemical compounds were analysed for. Of these, 35 compounds were identified at quantifiable levels, and a further 31 were indicated in some samples but at levels too low to quantify. The compound types identified were: aldehyde and ketones (29 different compounds), aromatics (9), alkanes & cycloalkanes (14), alcohols, phenols & cresols (8), heterocycles (2), organohalides & halides (3) and others (1)

The overall air quality was found to be typical of rural environments in both the nature and the levels of chemical compounds detected, except for acetaldehyde which was elevated. All of the compounds detected were at levels well below applicable environmental and health standards (Van Emden and Power, 2005).

The main chemical compounds detected are all known to be present in refinery emissions. The levels found in the ambient environment are generally many times greater than the predicted refinery influence for each compound based on dispersion modelling of refinery and RDA emissions. Additionally, the chemical compounds detected and their levels in the atmosphere showed little spatial variation and for the most part appeared to be randomly distributed, limiting the ability to attribute specific sources (Van Emden and Power, 2005).

Elevated levels of both carbonyls and VOCs were found at the Waroona and Yarloop township sites, consistent with the effects of human activities associated with the use of fossil fuels. Sampling sites closest to the refinery generally showed lower concentrations of the compounds measured, although indications of higher than average levels of carbonyls were detected at the Boundary Rd and to a lesser extent the Hoffman Rd sites.

The Wagerup Ambient Air Quality Monitoring Programme (Van Emden and Power, 2005) outlines the contribution of refinery emissions to the most prevalent VOC's detected at Boundary Road. All compounds shown in the Table 12 were detected at concentrations typical of rural environments and well below levels of concern. These same compounds are present in refinery emissions, and the ground level concentrations (GLC's) for the compounds have been calculated by Commonwealth Scientific and Industrial Research Organisation (CSIRO) using the The Air Pollution Model (TAPM). It is therefore possible to estimate the approximate contribution of the refinery emissions to the ambient environment for each compound (Van Emden and Power, 2005).

It can be seen (refer to table 12) that the refineries contribution is small in comparison to the background concentrations from other sources, which are likely to be a combination of natural and anthropogenic sources (Van Emden and Power, 2005).

Table 12: Existing Refinery Contribution to Ambient VOC Concentrations at Boundary Rd

	Measured Ambient Levels (over a 6 week monitoring period)		**Refinery Contribution**
	Average [1]	Max Detected	Peak 24hr 95%*
	ug/m3	ug/m3	ug/m3
Formaldehyde	3.3 [2]	6.8	0.06
Acetaldehyde	2.6 [2]	11.4	0.15
Acetone	1.3 [2]	5.4	0.65
Propanal	0.31 [2]	1.0	
Hexanal	0.2 [2]	0.5	
MEK	0.16 [2]	0.6	0.07
Benzaldehyde	0.14 [2]	0.6	
Benzene	non detect	non detect	0.02
Toluene	non detect	non detect	0.05
Acrolein	-**	0.25	

*Peak 24-hour 95th percentile values

**Insufficient data to calculate averages

1 – 6 week means of all samples at the Boundary Rd site.

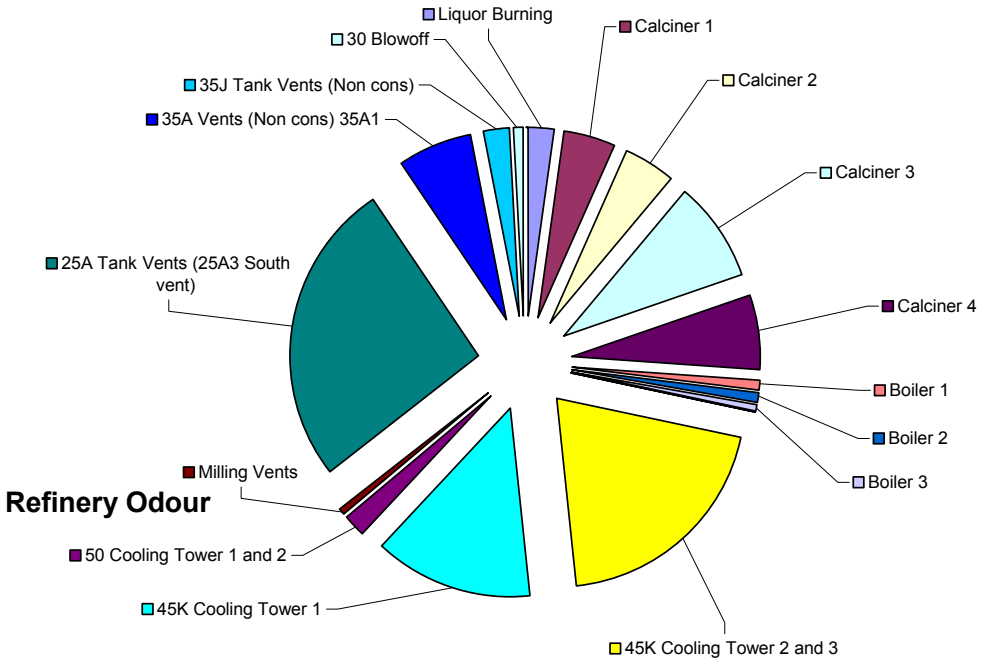
2 - taken as 8 hour sample from 7am to 3pm, 3 days per week

This outcome is consistent with a conclusion that the levels of chemicals in the ambient atmosphere surrounding Wagerup Refinery are dominated by human and natural processes (fires, vehicles, urban activity) other than the refinery operation.

7.9.3 Odour Emissions

The major sources of odour at Wagerup Refinery currently are the calcination stacks, 25A slurry vents, and the precipitation building (45) cooling towers. Liquor burning, digestion (30) and evaporation buildings have been significant sources in the past, but with emission reductions performed over 2000 – 2002 have now been almost eliminated, or reduced to very minor contributors. Less prominent though still significant sources of odour are the green liquor tank (35A) vents and causticisation building (35J) vents. A pie chart showing the breakup of odour contributions for the above sources is given in Figure 19 below:

Figure 19: Wagerup Refinery Odour Source Contributions



The RDA and diffuse area sources including the drying areas, cooling pond, Superthickener, and Lower Dam are additional sources of odour that vary with temperature, time of day, season and wind speed. These sources are discussed fully and presented in the report entitled 'Air Dispersion Modelling of Fugitive Emissions', Wagerup Refinery (Air Assessments, 2005).

There are many potential sources of background odour in the surrounding environment including: -

- rural and agricultural odours related to farming and livestock operations;
- odours related to combustion emissions from vehicle traffic, wood burning heaters, bushfires and prescribed burns;
- natural odours related to biogenic (living trees and plants) emissions from forests and bushland;
- odours related to breakdown and rotting of vegetation in the natural and agricultural environments;
- odours emanating from solid waste storage and disposal activities – both domestic and commercial/industrial;
- odours related to fuel storage and distribution activities; and

- other odours related to human activity such as cigarette smoking, cooking and heating, and recreational activities such as trail bikes, off-road vehicles, power boating and the like.

While background odours would generally be clearly distinguishable from odour of refinery origin when at levels where odour recognition is possible, this will not be the case at odour threshold levels.[2] This means that for odours barely above their detection threshold, the character and origin of the odour can be quite difficult to positively identify. At these sorts of levels there is likely to be some confusion as to the true source of odours, making positive identification of the odour source difficult. Thus an odour needs to be clearly recognisable before its source can be confirmed with any confidence.

The modelled odour levels for the current Wagerup refinery operations (includes RDAs) are shown in Figure 20 and 21. The odour levels have been predicted through dispersion modelling using TAPM for the refinery sources and Calpuff for the RDA and diffuse area sources. Odour emission rates used in the modelling were based upon measured odour emission rates and a odour/VOC regression relationship developed by Alcoa using all available refinery odour and VOC emissions data. The development of the relationship and its statistical properties is described fully in the Air Quality Summary document in Appendix G.

It should be noted, that in a comparison of model performance against measured odour concentrations reported by Sinclair Knight Mertz (2002) found TAPM may over-predict ground level concentrations from low height refinery emission sources, which are important contributors to the modelled ground level concentrations of odour. This could mean the predicted odour contours in Figures 20 and 21 may be higher than what would actually occur for the existing refinery. Discussions on predicted odour concentrations for the Proposal and emission controls works is detailed in section 8.3.8.

[2] By definition the odour detection threshold is the point at which an odour is only just detectable (able to be sensed by 50% of the population, meaning that 50% are not able to sense it).

Figure 20: Average (99.5th percentile) 3-minute odour concentrations for the existing refinery. Contours in odour units/m^3

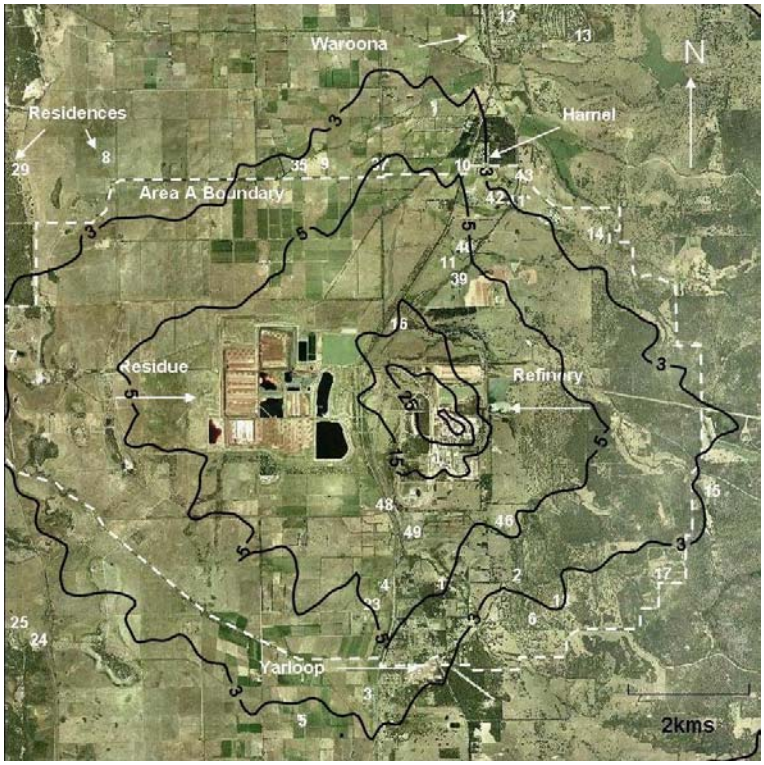


Figure 21: Peak (99.9th percentile) 3-minute odour concentrations for the existing refinery. Contours in odour units/m^3.

Two previous field odour surveys have been carried out in the Wagerup region by Environmental Alliances (Sinclair Knight Merz, 2002; Environmental Alliances, 2003). These surveys attempted to capture information from actual refinery plumes as a function of distance from the refinery. The work was therefore carried out in the winter months under morning conditions when the meteorology was considered conducive to the grounding of the refinery plume. The technique was successful in capturing odour events and tracking the intensity of plumes as at various distances from the refinery. The collected data was used to ground truth predicted odour levels in the vicinity of the refinery from dispersion modelling.

The odour levels predicted and presented in Figures 20 and 21 vary from the previous modelled odour contours predicted by SKM in 2002. The reasons for these differences are outlined following.

1. Odour emission rates used in the 2004/5 dispersion modelling were based on the development of an odour/VOC regression relationship. This is described more fully in an Alcoa report by (Peterson, 2004 – refer Appendix G). The use of a regression relationship improves the statistical validity of odour emission rates derived from VOC emission rates for the following reasons: -

    - Uncertainty for individual and collective odour concentration measurements is higher than that for individual and total VOC and carbonyl species measurements. This is because the accuracy and precision of chemical species measurement is greater than that for dynamic olfactometry;
    - A greater number of VOC and carbonyl monitoring runs performed compared to odour monitoring, especially since late 2002 onwards. This increases the statistical significance and reduces the uncertainty of VOC and carbonyl monitoring results;
    - By extension (through the regression relationship) use of a greater number of VOC monitoring results improves certainty and statistical significance of estimated odour emission rates.
    - Use of a regression relationship also enables prediction of odour concentrations for future emissions knowing what actions and reductions will be achieved in VOC emission rates.

2. For a number of sources the odour emission rates used in modelling the expanded refinery are significantly changed to those previously published and used in past odour modelling. These changes are both positive (reductions) and negative (increases). The overall effect of the changes is an increase in the total refinery odour emission rate estimated for the base case of April 2003 – March 2004.

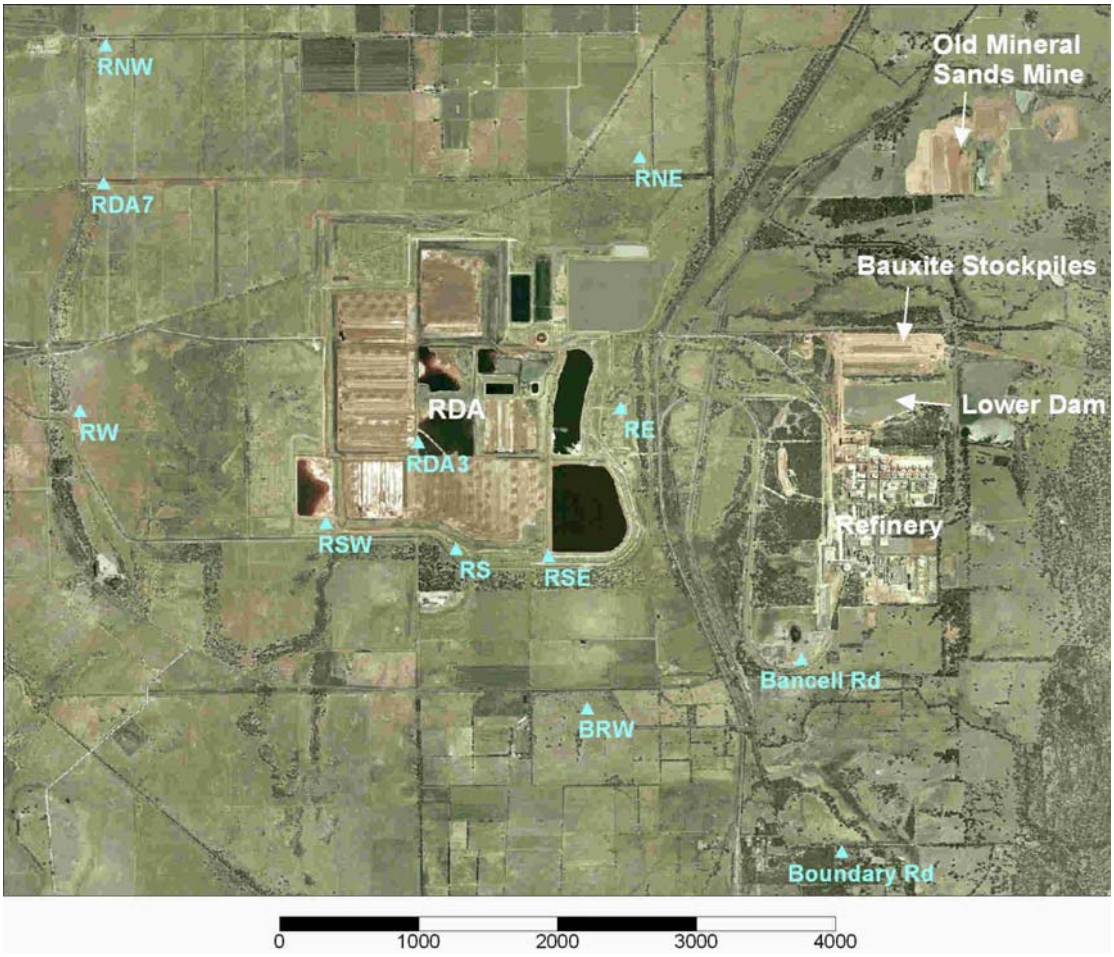
Key sources within the refinery had differing odour emission rates compared to what was modelled in 2001. The most notable differences are related to the following sources, 25A slurry tank vents, the 35A and 35J tank vents, the calciners (2 and 3) and the cooling towers.

Detailed information on the odour modelling is provided in Air Quality Summary Report in Appendix G

7.9.4 Ambient Particulate Emissions

Alcoa has a network of dust monitors (TSP and PM10) located around the Wagerup refinery operations, the locations are shown on Figure 22. The locations have been chosen to provide information on dust levels for all the main wind directions, and the sites are in conformance with AS 2922-1987. Results of the monitoring are given in the Annual and Triennial Environmental Reviews, submitted by Alcoa to the DoE.

Figure 22: Wagerup Refinery Dust Monitoring sites (aerial photo 2003)



A summary of background particulate concentrations represented as Total Suspended Particulates (TSP) and PM_{10} (particulate matter less than 10µm) is provided in Table 13. The data indicate that background TSP levels at Wagerup are low, below the Kwinana EPP standard and limit. For PM_{10} there was 1 day just above the NEPM standard in the 12 month period, but this is well below the goal of no more than 5 exceedances per year. As a comparison to the Wagerup PM_{10} concentrations, the PM_{10} concentrations from the Bluewaters site (5 km NE of Collie) are also presented from SKM (2005a). This shows similar, though slightly higher concentrations than at Wagerup (Air Assessments, 2005).

Table 13: Wagerup Background Particulate Concentrations

Statistic	Wagerup Background TSP	Wagerup Background PM_{10}	Collie (Bluewaters) PM_{10}
Years	4 years (2000/2001 - 2003/2004)	1 year (2004)	3 years (2001-2003)
Maximum	59 - 86 (64)	50.6	73
# of Exceedances of NEPM standard	NA	1	0.66 (ave for 3 years)
90th Percentile	23-31 (26.5)	21.8	23.6
70th Percentile	16-19 (17.8)	15.4	16.0
Average	13.8 - 17.4 (15.3)	12.1	14.1

Notes:

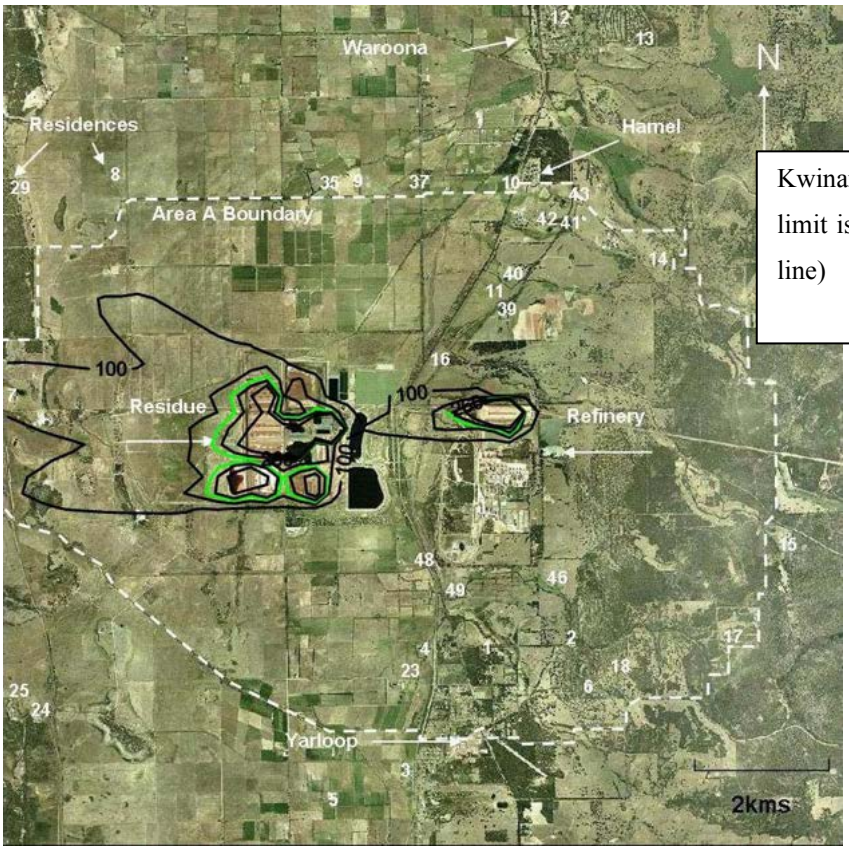
1) Wagerup Background TSP are given for the range of concentrations for the 4 years and for the average of the 4 years (in brackets). Collie (Bluewaters) maximum is the maximum of the 3 years, whilst other statistics are the averages of the three years.

The main source of fugitive particulate emissions from the refinery operations are from uncontrolled sources such as dust from residue drying areas, dust from the material handling operations such as stacking and reclaiming at the bauxite stockpiles and wind generated dust from the stockpiles.

Ambient particulate levels are also influenced by external factors such as the mineral sands mine to the north of the refinery (previously "mothballed" now operational – refer Figure 22), farming operations that dependent on the time of year can be a significant source of dust, and particulates from burning off and wildfires.

Modelled particulate emissions (TSP and PM_{10}) for the current Wagerup refinery operations are shown in Figure 23 and 24. The particulate emissions have been predicted through dispersion modelling using TAPM for the refinery sources and Calpuff for the RDA and diffuse area sources. The RDA and diffuse area sources are the greatest contributors to the Wagerup refinery operations particulate emissions.

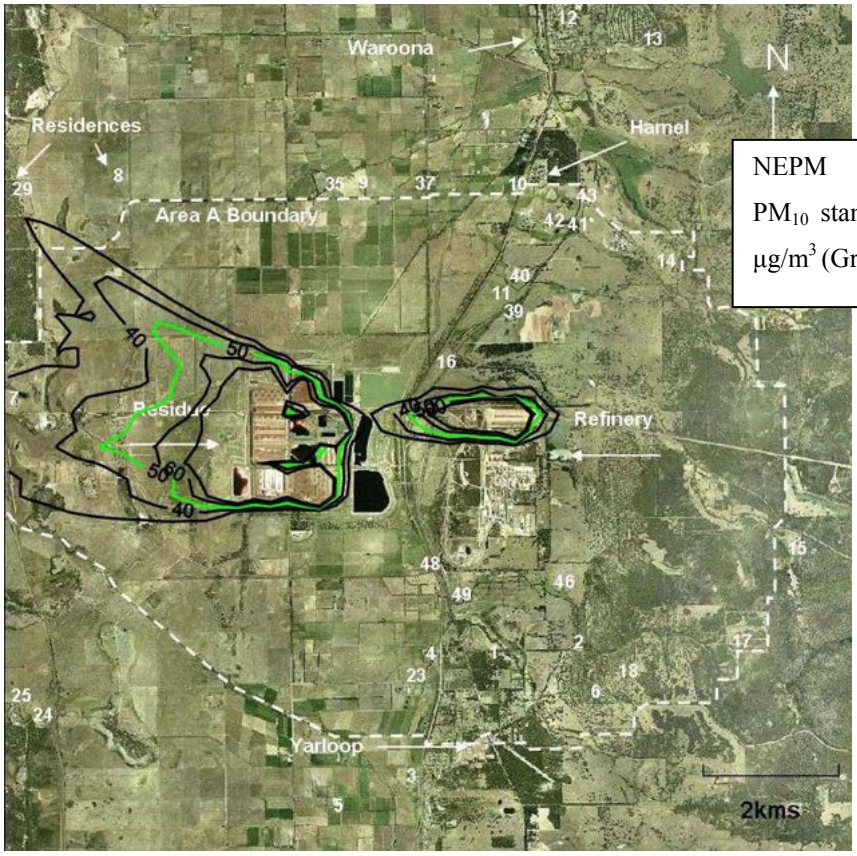
Figure 23: Maximum 24-hour average dust (TSP) concentration for existing Wagerup Refinery Operations. Contours in µg/m^3



Kwinana EPP Area B limit is 260µg/m^3 (Green line)

As can be seen from Figure 23 the refinery contribution to the TSP levels is small and at all receptors well within the 260 µg/m^3 limit identified in the Wagerup Refinery licence and based on the Kwinana EPP

Figure 24: Peak (99.5th percentile) 24-hour average dust (PM10) concentrations for existing Wagerup Refinery Operations. Contours in µg/m^3



As can be seen from Figure 24 the refinery contribution to PM_{10} levels is well within the 50 µg/m^3 standard identified in the NEPM at all receptors

Detailed information on ambient and modelled dust emissions is provided in Air Quality Summary Report in Appendix G

7.9.5 Bunbury Port Emissions

Alcoa's Bunbury Shipping Terminal is located in the Inner Harbour complex as part of the Bunbury Port Authority facilities. Alcoa's port operations receive, store and transfer alumina to, and caustic from, ships for the Pinjarra and Wagerup refineries, along with handling alumina for the Worsley Alumina Refinery. Caustic soda solution is imported and transported to the refineries by rail from Alcoa's caustic storage facilities at Bunbury Port.

Alcoa has an *Ambient Air Monitoring Strategy* (Document No. 59498) that forms the basis of air quality monitoring programmes at each of its facilities within Western Australia. The strategy is risk based and designed to provide information for location environmental professionals to make the most appropriate decisions regarding air quality. The strategy is a

general approach, and specific procedures for dust monitoring and measures to reduce dust at the Bunbury Port are also used.

Dust monitoring at the Bunbury Port consists of a series of strategically placed High Volume Air Sampling (HVAS) units monitoring total suspended particulate (TSP) dust levels and one HVAS unit monitoring dust levels of particulates less than 10 μm (PM_{10}). Data are primarily used for dust control performance monitoring. One TEOM is placed at various sites within the location when high resolution data is required. Monitoring procedures for the HVAS are designed to comply with AS/NZS 3580.9.3:2003: *Methods for sampling and analysis of ambient air - Determination of suspended particulate matter - Total suspended particulate matter (TSP) - High volume sampler gravimetric method* and AS/NZS 3580.9.6:2003: - *Determination of suspended particulate matter - PM_{10} high volume sampler with size-selective inlet - Gravimetric method*.

In addition to externally imposed particulate emission standards, Alcoa uses internal standards to measure the performance of control practices on dust levels. The internal standards relating to dust control at the Bunbury Shipping Terminal are 260 ug/m^3. The monitoring locations are provided in Table 14 following:

Table 14: Bunbury Shipping Terminal Monitoring Locations

Monitoring Site Name	Monitoring Site Code	Monitoring Type	Monitoring Site Status	Parameter Measured	Data Type
A1 Conveyor	CA001	HVAS	Active	TSP	24 hours average
	CA002	HVAS	Active	PM_{10}	24 hours average
Worsley	WA001	HVAS	Active	TSP	24 hours average
Hot Water Port	HW001	HVAS	Active	TSP	24 hours average
Port Authority	PA001	HVAS	Active	TSP	24 hours average
NE boundary	BU001	TEOM	Active	PM_{10}	Continuous

The main potential sources of dust at Alcoa's port operations are ship loading activities, conveyor operations and filling of the alumina bins.

Air quality monitoring data indicates 156 results above the 260 ug/m^3 internal standard in 2003, and 95 in 2004. However, due to the close proximity of other dust sources to Alcoa's Port operations it is difficult to know how many of these results were actually caused by Alcoa's operations. During 2004 a significant capital project was completed to upgrade Alcoa's shiploader (installing a Cascade Cleveland Chute) resulting in significantly reduced dust emissions during ship loading. Another significant project is currently underway to reduce dust from the conveyor galleries, mainly for occupational hygiene reasons, but this will also provide environmental benefits.

7.10 COMMUNITY HEALTH

7.10.1 Summary of Health Surveys and Research

University of Western Australia Health Survey, 2001

In August 1999, the Survey Research Centre (SRC) undertook a survey of residents near Wagerup refinery at the request of the Environmental Health Service of the Department of Health of Western Australia (Mercer, 2001). The purpose of the survey was to investigate claims of health effects experienced by residents of the Yarloop area living in close proximity to the Wagerup refinery.

Fifteen families who had made themselves known to the Wagerup Community Health Awareness Group were selected for the study. The families chose to report on 31 out of 44 people, as the 31 were considered by the families to be affected. Fourteen of the 15 residences were located in a small area in the northern corner of Yarloop.

Results of the survey included the following points:

- 23 out of 31 people (74%) said their symptoms started between 1995 and the survey;
- 21 out of 31 people (68%) noticed the symptoms in a particular season, with winter being the most common (61%), followed by autumn (35%);
- 22 out of 31 people (71%) noticed the symptoms under specific conditions in which the winds were from the north or north-east and there was cloud cover or humid/damp atmosphere;
- 10 out of 31 people (32%) reported some symptoms experienced elsewhere, most locations being in Yarloop or near the refinery and the residue area. One person reported experiencing the symptoms in any situation in which there is exposure to pollution or chemicals including cleaning products and synthetic materials;
- 13 out of 31 people (42%) reported experiencing a symptom without an odour being present;
- 18 out of 31 people (58%) reported experiencing a symptom and an odour at the same time. The odours were described as “wet cement”, “caustic smell”, “like Kwinana refinery”;
- 14 out of 31 people (45%) experienced an odour with no symptoms. The odour was described as “caustic”, “sulphur like”, “like lime”; and
- 18 out of 31 people (58%) had sought medical attention related to their symptoms.

Symptoms were categorised by type and frequency.

- 18 out of 31 people (58%) reported 4 or less symptom types;
- 27 out of 31 people (87%) reported at least 1 mucous membrane symptom (eyes, nose, mouth, throat, lower respiratory tract);
- 22 out of 31 people (71%) reported at least 2 mucous membrane symptoms; and

- Approximately 50% reported at least 3 mucous membrane symptoms.

Reports were sought from doctors treating 18 of the 31 people. Eleven reports were returned on 4 people:

- For one person "the doctors considered that the conditions experienced by the subject were not relevant to chemical exposure."
- For one person "although extensive tests were performed no specific diagnosis was proposed."
- For one person "allergic and vasomotor rhinitis were diagnosed."
- For one person "some allergies had been identified and chronic eczema diagnosed." Allergic rhinitis had also been diagnosed.

The conclusions of the study included: "Only two of these subjects appear to have symptoms consistent with existing descriptions of MCS (multiple chemical sensitivity)" and … "It is reasonable to conclude that there is a commonality between the symptoms experienced by the respondents to the questionnaire. It seems that a mucous membrane irritant is present in the atmosphere and is affecting the group of people who live on the northern border of Yarloop. This irritation occurs under certain climatic conditions and is often accompanied by an odour." (Mercer, 2001).

The Medical Practitioner's Forum

The Government of Western Australia established a Medical Practitioners' Forum (MPF) to investigate concerns that emissions from the Wagerup refinery were impacting on community health. The MPF was headed by Professor D'Arcy Holman, Head of the School of Population Health at the University of Western Australia. The MPF included eminent health professionals and representatives from relevant government agencies. The Forum was convened on 19 September 2001 in Perth and 23 October 2001 in Mandurah. Having reviewed the available data and consulted with the medical fraternity and local community the MPF made a series of recommendations to government. Alcoa undertook several measures in response to the recommendations.

1. *Further research into identifying causality is unlikely to be rewarding and hence should not be a major priority. However an open dialogue should be maintained on this issue and it is recommended that a workshop on Multiple Chemical Sensitivity be convened by the Department of Health.*

In February 2002, Professor Mark Cullen visited Western Australia. Professor Cullen is an international expert on multiple chemical sensitivity (MCS). He is Professor of Medicine and Public Health at Yale University and is also Chief Medical Adviser to Alcoa. Professor Cullen discussed the issue of MCS with the Minister for the Environment, health professionals, the MPF, members of the community and government officials.

Professor Cullen provided a report on his investigations into the Wagerup refinery issue and Alcoa has followed his recommendations. This report is described in further detail later in this section.

2. There needs to be improved focus on the clinical management of these affected people. There needs to be a focus on getting affected people out of the exposure situation.

In relation to employees, Alcoa developed appropriate rehabilitation measures which involved alternative duties with minimal exposure to emissions. With regard to community members, the Department of Health operated a community health clinic at Yarloop during the period November 2002 to October 2003. The Community Health Nurse's report is described elsewhere in this document.

3. The Forum supported exposure reduction via a planned buffer zone.

Alcoa had developed a land management strategy with the aim to:

- Give people choice about whether they continue to live where they do;
- Protect property values; and
- Invest in the future of Yarloop and Hamel.

4. The Forum supported exposure reduction via reduction of emissions.

Since 1998, Alcoa has invested over $40 million on emission reduction projects at the Wagerup refinery. These environmental projects included:

- Installation of a Catalytic Thermal Oxidiser and high efficiency scrubber on the liquor burning plant, reducing VOC and odour emissions by over 90%.
- Significant overall reductions in refinery odour emissions, verified by a government-appointed independent auditor in May 2003 and a CSIRO review in May 2004.
- Development of new technology to capture gases from the digestion system.
- Construction of a multi-flue calciner stack to increase dilution and reduce emission ground-level concentrations.
- Installation of low nitrogen oxide burners to reduce power station emissions.
- A significant reduction in refinery noise at the refinery boundary (5 decibels)

Comprehensive ambient air quality data has been collected and analysed. All of the data demonstrates compliance with relevant standards and guidelines such as the National Environmental Protection Measures (NEPM).

5. There be an ongoing commitment to surveillance and monitoring and review process involving this Medical Forum.

The MPF met five times, with the last meeting on 4 June 2003. The various actions and improvements outlined above were considered and discussed.

6. That further opportunities be explored that will reduce exposure at the individual worker level.

The extensive emission control measures described above clearly reduced exposures both within the refinery and in the surrounding area

7. That a delegation of this group, headed by the Chair (Prof. Holman), meet with the community and workers as well as briefing the Ministers for the Environment, Health and Minerals and Petroleum Resources.

A delegation from the MPF, headed by Professor Holman, met with the Minister for the Environment and the Minister for Health. A Ministerial Council comprising these Ministers and the Ministers for State Development and Consumer and Employment Protection reviewed the Forum's recommendations.

The MPF also undertook consultation with government agencies and the local community. A public information evening was arranged by the Department of Health (DOH) to present and discuss the findings of the MPF with the local community and workers of the refinery. A delegation from the MPF and the DOH also met with representatives from the Waroona Shire and local Members of Parliament to discuss the recommendations of the MPF.

Professor Holman, along with a delegation of medical practitioners and officers from the DOH, presented the recommendations of the MPF at the public meeting.

Professor Cullen's Report

In February 2002, Professor Mark Cullen visited Western Australia. Professor Cullen is an international expert on multiple chemical sensitivity (MCS). He is Professor of Medicine and Public Health at Yale University and is also Chief Medical Officer to Alcoa.

Professor Cullen discussed the Wagerup refinery issue and MCS with:

- Wagerup employees who believed their health was affected
- Members of the community
- The Medical Practitioner's Forum, chaired by Professor D'Arcy Holman
- Dr Moira Somers, who had diagnosed MCS among some Wagerup employees
- Other concerned medical practitioners
- The State Minister for the Environment
- State Health and Environment Authorities
- Union representatives
- Alcoa's senior management team

Professor Cullen provided a report on his investigations into the Wagerup refinery issue, in which he stated:

"It became clear early in my discussions that addressing the social dimension of the physical manifestations of Wagerup health issues was at least as important as (entirely necessary) medical and engineering solutions. The company has by no means ignored the social dimension but appears to have placed greater emphasis on the latter."

He made several specific recommendations:

- With respect to the Workplace

"The aggressive program for rehabilitation of previously affected workers needs to go forward with all deliberate speed."

"Achievement of best results requires open and active cooperation with treating physicians chosen by affected individuals and their representatives."

"As noted previously, acknowledgment by the company of its responsibility for the best outcome, as well as expression of regret for perceived delays and diversions which may have occurred, is essential."

"All health problems and complaints, notwithstanding, it is crucial that Alcoa effectively communicate to its workforce that the Wagerup Refinery is, and has always been, a very well run facility with levels of injury and complaints due to chemicals used in the refining process at, or exceeding, the high standards set by Alcoa for its refineries worldwide. Furthermore, although the liquor burning facility created previously unrecognised odours and irritation because of the unique nature of the bauxite mined in the region, careful assessment of the many dozens of organic chemicals involved in liquor burning emissions, as well as extensive sampling throughout the plant of the levels of these emissions, shows that under no circumstance would these be expected to cause long term harm, such as cancer or injury to major organs, despite the odour and irritation problems which have occurred. Such reassurance, as validated to the extent necessary by the Holman group, is essential for successful abatement of the current situation."

- With respect to the Community

"As expeditiously as humanly possible, the company must complete all emissions abatement measures currently planned. Moreover, at the completion of these measures, a full

environmental assessment must be undertaken to document that the predictions of the models for substantial reduction in all emission levels are substantiated in fact. Furthermore, complete sharing of this data with the Holman group, and timely provision of additional data as requested by members of that group, is also essential to assure independent confirmation of the success of the abatement. Should measured levels, or the Holman group itself, or members of any governmental agency suggest the need to institute additional abatement strategies, consideration of these and the optimal technical means for achieving them must be given the highest priority by professional staff and engineers of the company."

"The additional plan already introduced for land management must be fine-tuned to achieve not only its originally stated goals, but also the perception of fairness and equity for the affected parties. Additional efforts that the company can undertake to support further the infrastructure of the community, such as its education or health resources, would be beneficial."

"As with the rehabilitation of affected workers, full acknowledgment of Alcoa's role and responsibility for effective abatement is essential. As long as it is perceived by any in the community that Alcoa has shirked that responsibility or shunted responsibility to other parties, such as governmental agencies, successful resolution will be negatively impacted."

"As with successful rehabilitation of workers, it is essential that all members of the community, whether affected or not, be reassured that none of the emissions from the plant poses significant long-term health risks. This is based, in my opinion, on knowledge of the toxicology of all chemicals involved which have been carefully speciated, but also knowledge of the doses of these chemicals which fall far below those with toxic effects other than odour and irritation. As with the work force, the role of the Holman group in independently confirming this information is essential to assure the highest level of trust."

"Although it would appear to many involved that the conduct of a health survey by members of the Holman group would increase our overall knowledge of the situation and lead to a better understanding of what aspect of the emissions may have contributed to various symptoms, my considered recommendation is that at the present time such a study not be undertaken. The basis for this is my belief that conditions are adverse for the conduct of a valid study, given the high level of distrust and acrimony. However, if it is the conclusion of appropriate experts on the Holman group that a health study be considered, I would be

personally prepared to participate collegially in such considerations and, if appropriate, its design and conduct to assure the best possible study, with full company cooperation."

Following Professor Cullen's visit, Alcoa improved the rehabilitation of employees with a diagnosis of MCS. Rehabilitation was undertaken in close consultation with employees and their rehabilitation provider, and employees' medical practitioners were included as much as possible. Alcoa made every effort to assist employees in rehabilitation and retraining, or to accommodate individuals in the workplace.

Wayne Osborn, Managing Director of Alcoa World Alumina – Australia stated "The company acknowledges that, while it has implemented a vigorous technical program to reduce odour and emissions from the Wagerup refinery, it has been too slow in moving towards resolution of the concerns of affected Wagerup employees and surrounding community, and regrets the impact this may have had on individuals."

Comprehensive emission controls were completed and thorough ambient air quality monitoring and computer modelling has been undertaken. The details of these programs are listed elsewhere in this document. Wagerup is now the world benchmark for alumina refineries in terms of emission control.

The land management program has been refined and community consultation has been greatly enhanced.

With regard to plant safety and the risk of serious illness Professor Cullen stated:

"It is my opinion, based on the known effects of plant emissions and existing data and patterns of existing data, that the threat of serious illness from the refinery is negligible. If I held any other view I would recommend the immediate closure of the facility – in line with Alcoa values."

"There has been no long term health risk to the vast majority of Wagerup employees and, when plant emissions have been reduced as per plan, the incidence of short term irritation and other chemical sensitivities should also be negligible."

Community Health Nurse Report, 2002 to 2003

The Department of Health operated a community health clinic at Yarloop during the period November 2002 to October 2003 in response to a recommendation from the Medical Practitioners Forum. The Community Health Nurse's report presents descriptive data recorded during this period (Cook, 2003).

Observations from the report included the following:

- During the 12 month period a total of 70 individuals presented to the clinic;
- Over 50 of the 70 people reported dry itchy eyes and fatigue;
- Over 40 people reported sleep disturbances, weeping eyes, headache, worry, sneezing, coughing and sinusitis;
- Over 30 people reported loss of motivation, feeling moody, a dry itchy sore throat, a dry or metallic taste in their mouth, emotional lability, rhinitis, breathing difficulties, night sweats or feeling hot, memory loss at times, dizziness and muscle cramps or spasms;
- 20 people reported 46 symptoms;
- The month of May saw the highest number of complaints regarding health effects with 24 complaints logged by 12 individuals;
- During the months of June and July there were a total of 20 health complaints by 9 and 8 individuals respectively;
- Some individuals were able to clearly state the time of detecting odour preceding their symptoms, others did not notice an odour prior to feeling unwell;
- When there were a number of people gathered, some detected the odour whilst others did not;
- Similarly some reported the immediate onset of symptoms, others reported symptoms were experienced many hours following detection of odour.

The symptoms recorded in this study are generally "non-specific" and occur commonly in any community. The report did not indicate a cause for the symptoms or relate the symptoms to refinery emissions, however it does provide useful information on the nature of symptoms reported in the area during the time of the study.

Healthwise, 2004

In June 2004 the second report of the Healthwise cancer incidence and mortality study was released (Healthwise, 2004). Healthwise is a long-term study designed to assess whether there is any relationship between health outcomes and working at Alcoa in Australia. It is undertaken by researchers from Monash University and the University of Western Australia. The cancer incidence and mortality study includes current and former employees who started work for Alcoa in Australia at any time from 1983.

The 2004 analysis was an update using the latest available data from the cancer and death registers up to the end of 2002. The study now includes more than 11,000 past and present employees throughout Australia. The second report found:

- a lower overall risk of death in Alcoa employees compared with the general population;
- mortality rates for all four major categories of death (circulatory disease, respiratory disease, cancer and injury/trauma) were lower amongst Alcoa employees than in the general population;

- the total incidence of cancer in past and present Alcoa employees was lower than the general population.

The research demonstrated that on the whole, Alcoa employees live longer and are healthier than the general population, but the study also raised a number of findings that are being investigated further.

The cancer incidence rates for melanoma continued to be higher in Alcoa's Western Australian operations than the general population. This is most likely due to UV exposure from the sun and more work is required to understand where and when this exposure has occurred – either in childhood, outdoor leisure activity or outdoor work. The research shows that the increase in melanoma incidence is similar across production, maintenance and office workers which would suggest it is not work related.

Medical literature suggests that occupational exposure to UV may not increase the risk of melanoma and it may well be that the increased number of cases is due to a greater awareness of skin cancer and that employees are seeing their doctors more regularly to screen for melanoma.

The cancer incidence rate for thyroid/endocrine glands in office workers in Western Australia was also higher than the general population. This finding was unexpected and this will be monitored in future searches.

While this ongoing study has continued to find in Alcoa's Western Australian operations the mortality rates and incidence of pleural cancer (mesothelioma) were higher than the general population, these cases were matched with the WA Mesothelioma Registry (WAMR) where an independent expert panel found the exposure to asbestos which causes mesothelioma, did not occur at Alcoa, except for one case which may be related to exposure at the Kwinana refinery power station (Healthwise, 2004).

The next steps in this study are to examine those cancers found to occur in excess in the current findings and in particular to investigate duration of employment, workplace exposures and the role of smoking data for participants with a smoking history. A third round of death and cancer national registry matching will take place in 3 to 5 years time when further data are available.

Department of Health - Study of Cancer Incidence and Mortality by Statistical Local Area, 2004

In 2004 the Department of Health published a report on cancer incidence and mortality in each statistical local area (SLA) of Western Australia (Threlfall *et al.*, 2004).

The report covered the period 1998 to 2002. The following quotes from the report indicate that cancer incidence and mortality rates in Waroona Shire and Harvey Shire are no greater than for Western Australia as a whole.

Waroona Shire

"Cancer incidence: Cancer incidence rates for males and females, for individual cancers and all cancers combined, were not significantly different from the all-W.A. rates."

"Cancer mortality: There was a lower mortality rate for lung cancer in males than expected (Standardised Rate Ratio 0.21, 95% confidence interval 0.00-0.77). All other cancer mortality rates for males and females, for individual cancers and all cancers combined, were not significantly different from the all-W.A. rates."

Harvey Shire - Part B

"Cancer incidence: Cancer incidence rates for males and females, for individual cancers and all cancers combined, were not significantly different from the all-W.A. rates."

"Cancer mortality: There was a significantly lower lung cancer mortality rate in females than expected (SRR 0.23, 95% cancer incidence 0.00-0.85). Otherwise cancer mortality rates for males and females, for individual cancers and all cancers combined, were not significantly different from the all-W.A. rates."

7.11 COMMUNITY COMPLAINTS

7.11.1 Community Complaint Analysis

Alcoa maintains a 24 hour, 7-day per week complaint response service linked to a free 1800 number for refinery neighbours which was introduced in 2004. The response process in place at the Wagerup refinery provides for:

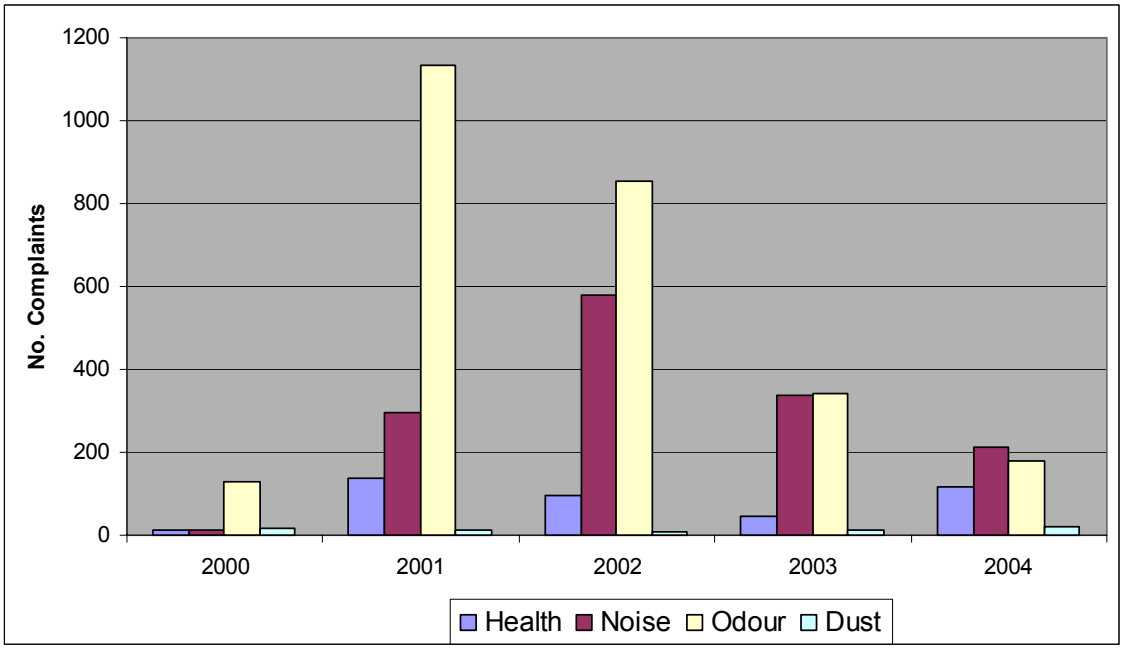
- Immediate complaint response including the offer for Alcoa staff to attend the complainant's residence and record relevant information including, nature of complaint, symptoms and environmental observations;

- Immediate consideration of potential causes including weather conditions and plant operating conditions; and
- The collection of refinery operating data, which enables subsequent assessment if relationships exist between refinery operating conditions and characteristics of the complaint database.

The complaint data base records complaints lodged from 1990 to the current day and includes complaints lodged directly with Alcoa and those lodged through the community-based Wagerup Community Health Awareness Group (WCHAG).

Figure 25 shows that the number of environment-related (odour, noise, health and dust) complaints have declined steadily since their peak in 2001. This is particularly evident with odour and noise complaints. Substantially fewer health complaints have been recorded in each year from 2001 to 2003, however, there has been an increase in health complaints from 2003 to 2004. Dust complaints remain very low in comparison to other categories.

Figure 25: Environment-related complaints by category for the period 2000 to 2004

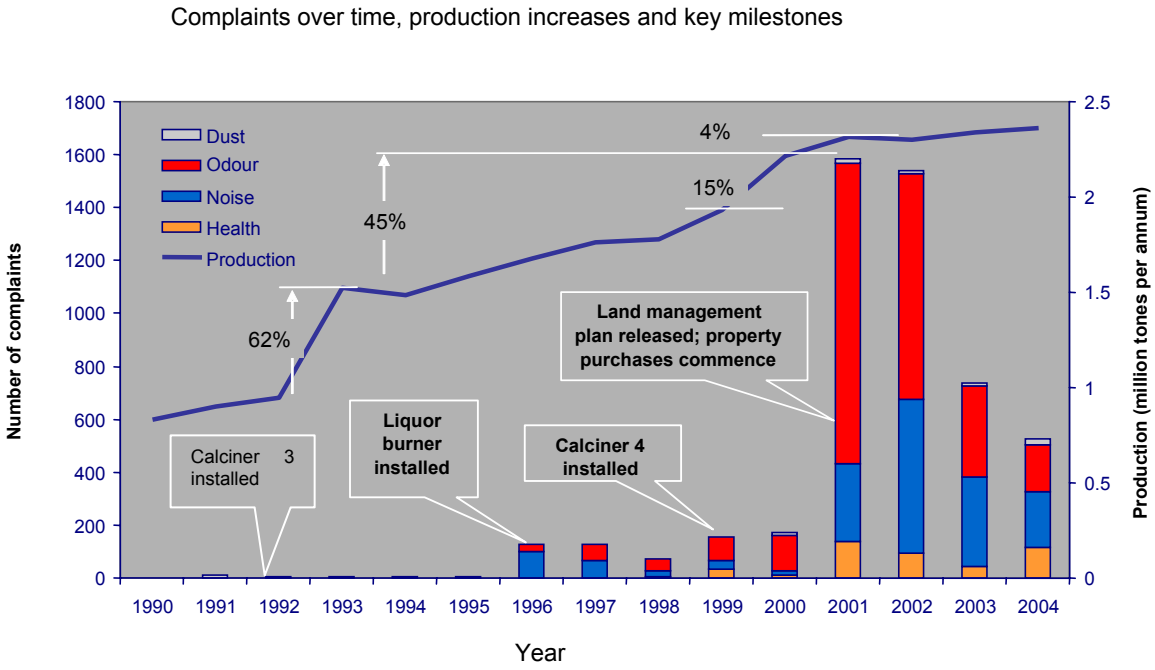


Many factors may influence environment-related complaints and a comparison of complaint numbers over a longer period (1990 – 2004) offers various observations regarding factors that may influence complaints.

Figure 26 shows the number of environmental complaints lodged between 1990 and December 2004 together with annual refinery alumina production and major changes to refinery equipment. Key characteristics of the figure include:

- Complaints increased noticeably during 1996 (from 7 to 127) when the refinery's liquor burner was commissioned. The majority of these complaints related to noise, with a smaller amount related to odour. A similar number of complaints were lodged during 1997, however, noise complaints decreased and odour complaints rose. This is consistent with community and employee feedback that malodorous emissions became a significant issue when the liquor burner was operated during 1996 and 1997;
- Liquor burner emissions were then reduced during 1998 with the installation of emission control equipment (a catalytic thermal oxidiser). This coincided with a reduction in complaints during 1998 (71);
- Complaints rose again during 1999 (157 complaints) and 2000 (173 complaints) which coincided with the installation and commissioning of an additional calciner (1999) and cooling tower (2000);
- There was a very large increase in complaints during 2001, rising from a total of 173 in 2000 to over 1,500 in 2001. This rise did not coincide with a significant increase in production or other changes in refinery operation. Alcoa believes the most notable change that occurred during 2001 was the commencement of discussions between Alcoa and community members regarding nearby property purchases;
- Odour and health complaints declined from 2001 to 2002, however the total number of complaints increased due to a significant increase in the number of noise complaints, rising from 315 to 1104. Alcoa is not aware of any changes to refinery equipment or operating practices resulting in increased noise emissions from 2001 to 2002. However, this period corresponds to Alcoa's community consultation over the use of noise emission contours as the basis for defining the extent of the Area A property purchase offer. Alcoa also submitted an application for a variation to the Environmental Protection (Noise) Regulations during this period; and
- The total number of complaints decreased significantly during 2003 and again in 2004. During this period Alcoa continued to implement various emission control works (following the works implemented during 2000 and 2001) and purchased a number of properties in the area surrounding the refinery, many of these property purchases were for residences from which complaints had originated.

Figure 26: Annual complaints, refinery alumina production and major influencing factors for the period 1990 to 2004



7.11.2 The Nature of Health Complaints to Alcoa

Wagerup refinery's complaints database indicated that 74 people made 376 health complaints to Alcoa over the period 01 January 2000 to 20 September 2004. A description of complaints numbers over time and the number of households lodging complaints is described in Section 7.11.2 while a brief summary of health complaint characteristics is given below.

- the number of complaints made per complainant ranged from 1 to 46.
- 55 of 74 complainants (74%) complained of symptoms of the upper respiratory tract (nose, sinuses, mouth, throat);
- 32 of 74 complainants (43%) complained of symptoms of the eyes;
- 25 of 74 complainants (34%) complained of symptoms of the lower respiratory tract (mostly coughing); and
- 41 of 74 complainants (55%) complained of symptoms affecting other parts of the body. These included headache, nausea, vomiting, skin problems, poor sleep, musculoskeletal pain, abdominal pain, lethargy,

The most common symptoms are consistent with irritation of the upper respiratory tract. However these relatively non-specific symptoms are commonly reported in many communities and may relate to a variety of personal, environmental or lifestyle factors. The

proposed health survey (intended to be conducted prior to commissioning of the Proposal, if approved) would be able to determine whether the occurrence of these common and non-specific symptoms is different to other communities, and if so what factors are associated with their occurrence.

At various times a concern has been raised that an increase in complaints or community impacts has corresponded with significant production increases at the Wagerup refinery. Figure 26 shows that the most significant increase in complaints, in 2001, corresponded with only a 4% increase in production, whereas previous production increases of 62% in 1993 and 15% in 2000 did not correspond with significant increases in complaints. Over recent years, the belief that complaints or community impacts are linked with production levels has been partly reinforced by the maintenance of a production limit in the refinery environmental licence. Figure 27 and 28 shows a comparison between alumina production and complaints at the monthly and daily scales respectively.

Figure 27: Comparison of monthly production and odour complaints for the period January 2001 to March 2003

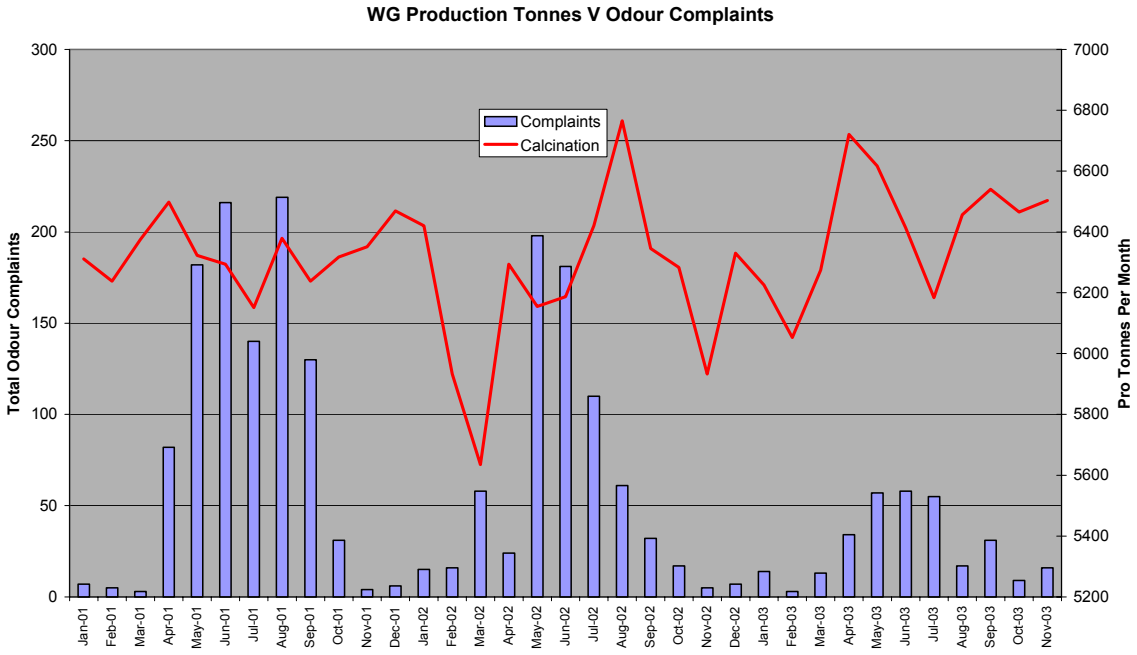
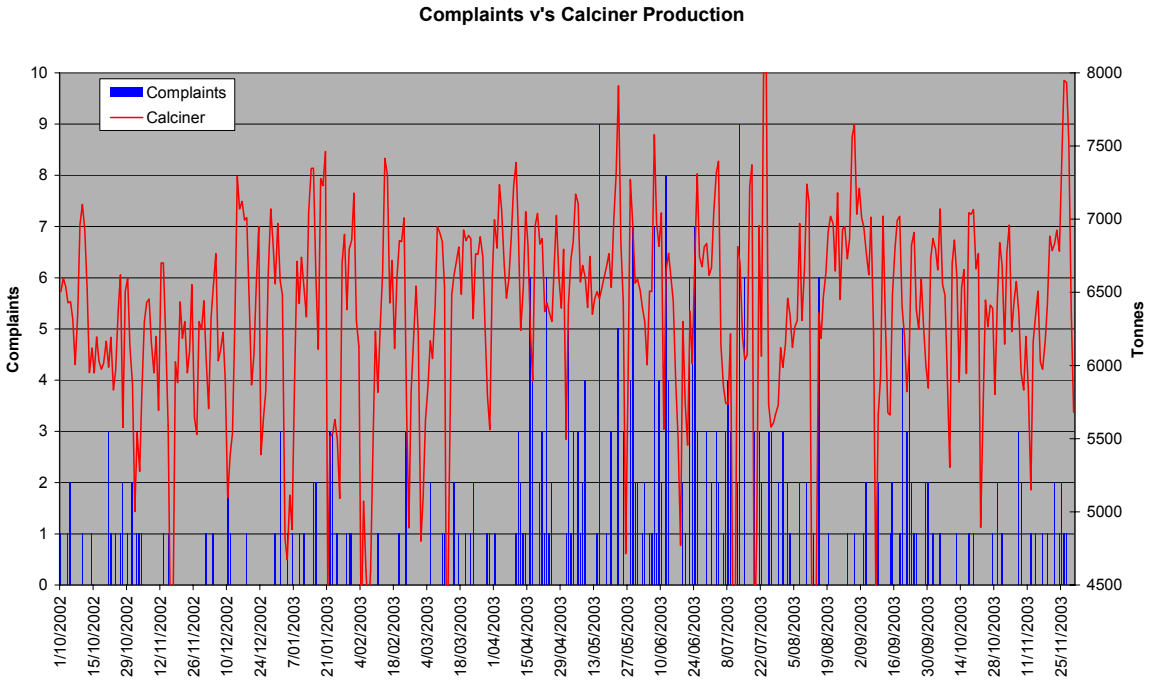


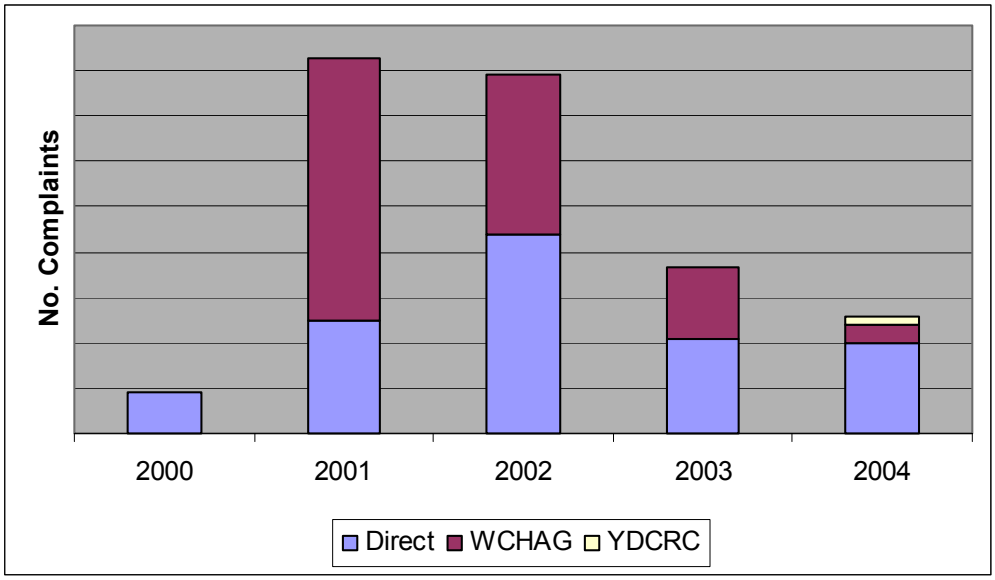
Figure 28: Comparison of daily production and total complaints for the period October 2002 to November 2003



Neither figure indicates a correlation between alumina production and community complaints. Statistical analysis of the complaint and production data sets confirms this observation. The only factors that show a correlation with complaints are aspects of meteorological conditions (e.g. wind direction and wind speed).

Figure 29 shows the total number of environment-related complaints by the method of lodgement during the 2000 to 2004 period. Three sources are identified: "direct" where the complaint is lodged directly with Alcoa; WCHAG, where the complaint is reported to Alcoa through the Wagerup Community Health Awareness Group process; and "YDCRC", where the complaint has been forwarded by a member of the Yarloop and District Concerned Residents Committee.

Figure 29: Number of complaints lodged via different reporting mechanisms



Figures 30, 31 and 32 show the distribution of complaints throughout the calendar year for the 2000 to 2004 period for each of odour, noise and health complaints respectively.

Figure 30 shows that there has been a significant decline in odour complaints from 2001 to 2004 and that the majority of odour complaints arise in the period March/April through until September. This "odour season" corresponds to the autumn and winter periods when meteorological conditions are believed to be most conducive to odours being noticed in the neighbouring residential areas. This is consistent with air dispersion modelling undertaken for this proposal (Section 7.9 and 8.3) which identifies cold still mornings and air inversions as the conditions most likely to carry noticeable odours from the refinery operations to neighbouring residences.

Figure 30: Monthly odour complaints 2000 – 2004

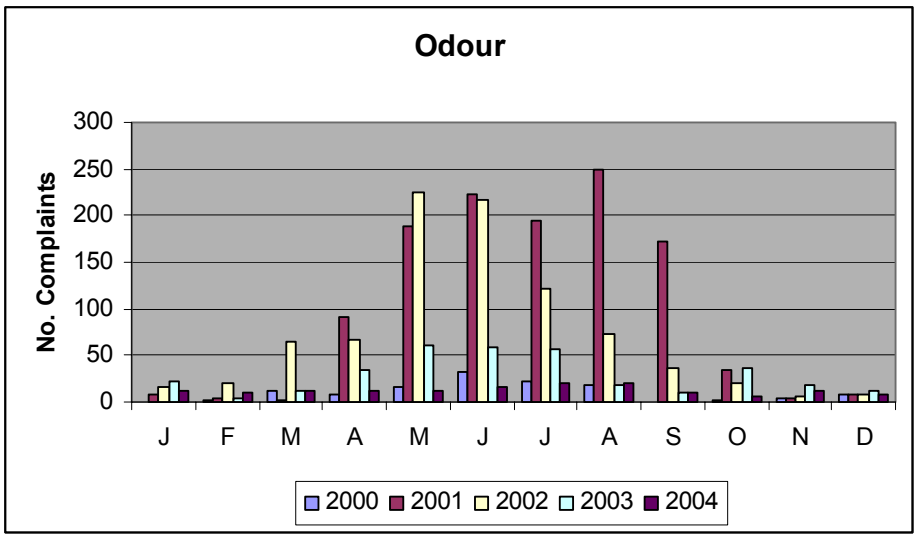


Figure 31 shows a similar pattern with health complaints declining from 2001 to 2003 and the majority of complaints occurring during the autumn – winter period. There is an increase in health complaints from 2003 to 2004.

Figure 31: Monthly health complaints 2000-2004

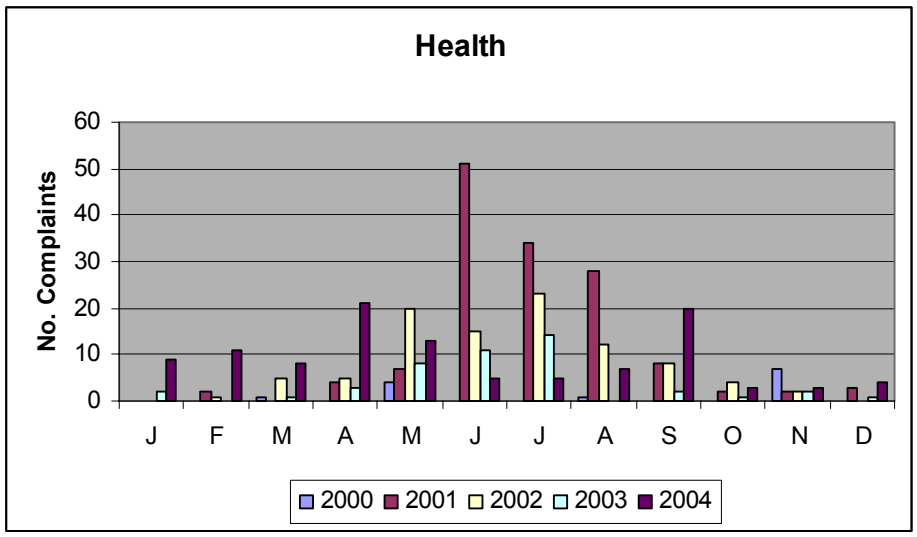


Figure 32 shows the increase in noise complaints during 2002 and the subsequent decline in noise complaints during 2003 and 2004. With the exception of the early months in 2002 the monthly pattern of noise complaints is similar to odour with the majority of complaints being received during the autumn – winter period. Meteorological conditions during this period may increase the likelihood of noise propagation to surrounding residences, particularly cold still nights and temperature inversions.

Figure 32: Monthly noise complaints 2000 – 2004

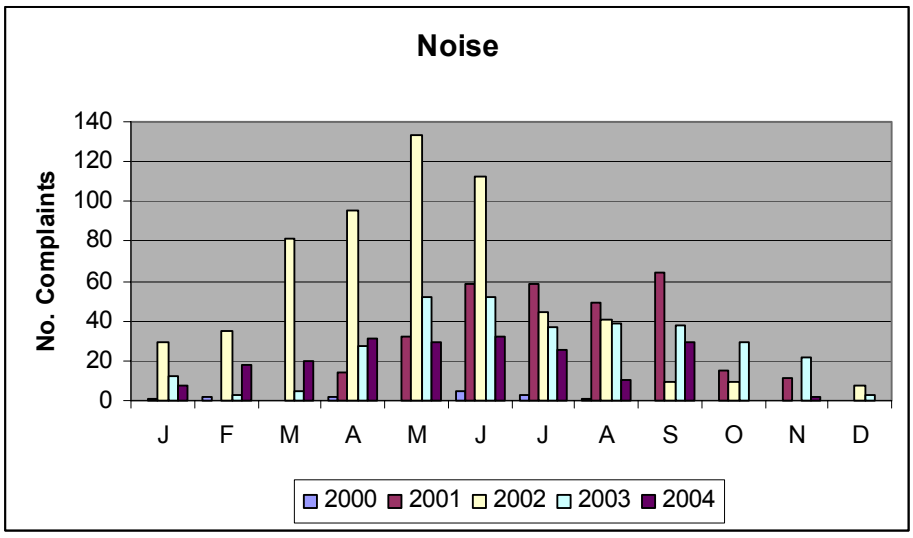


Figure 33 shows the percentage distribution of complainants against total complaints for the 2004 period, with figures 34, 35 and 36 (on the following pages) providing a corresponding description for each of odour, noise and health complaints respectively. Each figure shows the contribution of households most frequently lodging complaints (e.g. household A, household B etc) to the complaint total and the total of all other households lodging complaints (shown as "other").

In 2004 a total of 59 households made a total of 518 complaints with 71% of complaints coming from nine households. The distribution of complainants (people lodging complaints) in each of the main environment related complaint categories can be summarised as follows:

- During the same period 46 households lodged 178 odour complaints, with 49% coming from five households;
- During 2004, 19 households registered 205 noise complaints, with 87% of the complaints coming from five households; and
- A total of 109 health complaints were lodged from 19 households during 2004, again with a high dependency on point of origin with 64% of health complaints coming from two households.

Alcoa recognises that the sources of complaints is not uniformly distributed and that some individuals lodge complaints far more frequently than others, consistent with the varying levels of concern that may be felt in any given community. As a result Alcoa maintains efforts to deal broadly with the possible causes of complaints.

Figure 33: Percentage distribution of total complaints received during 2004

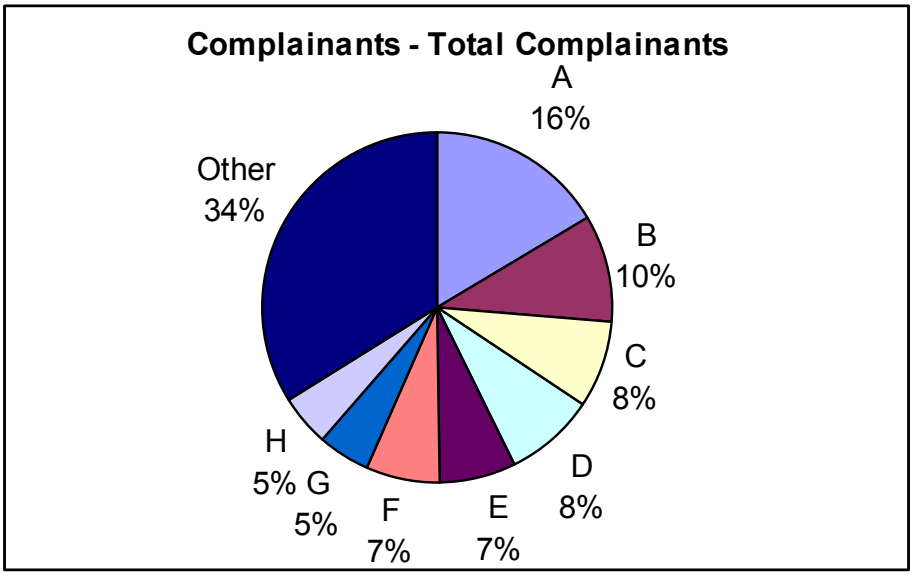


Figure 34: Percentage distribution of odour complaints received during 2004

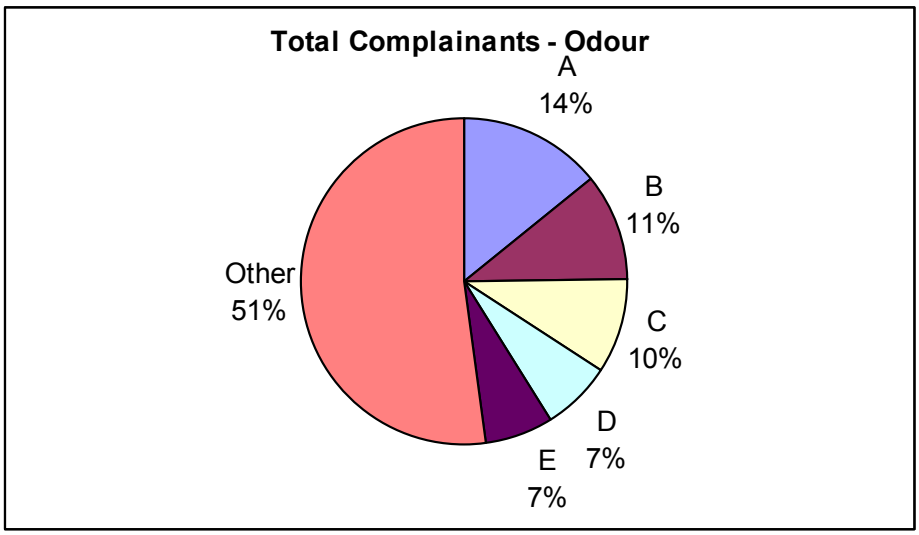


Figure 35: Percentage distribution of noise complaints received during 2004

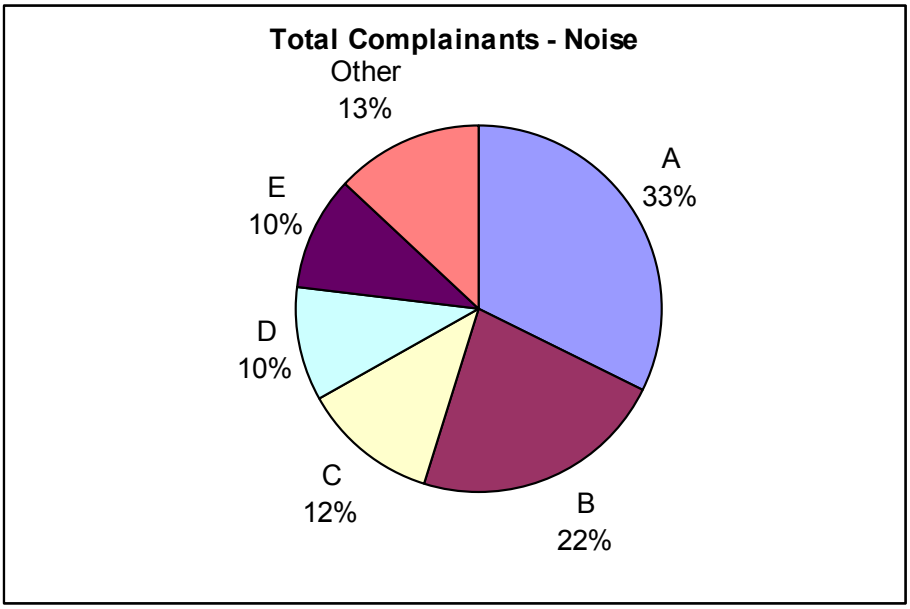
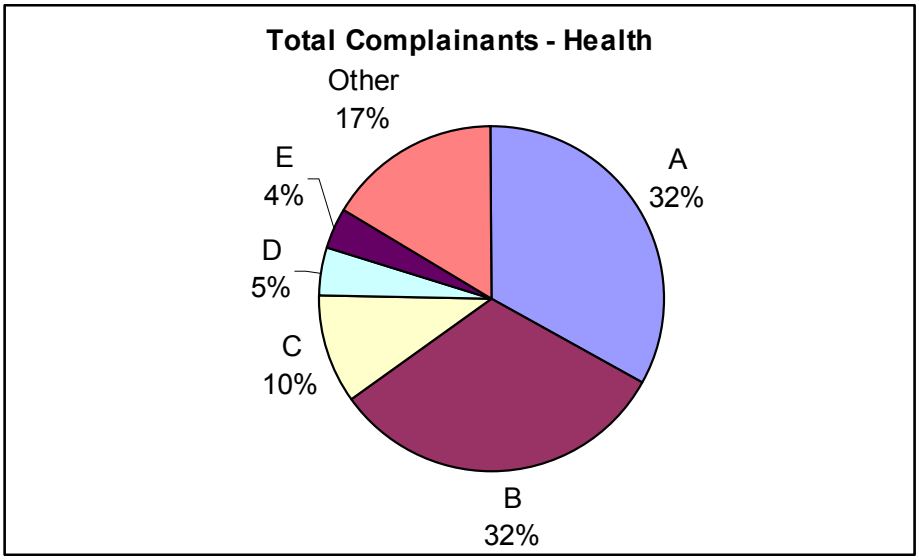


Figure 36: Percentage distribution of health complaints received during 2004



It is clear that complaints have declined significantly since the high levels recorded during 2001 and 2002. This reduction in complaints may be due to several factors, however it is likely that both emission reduction works and Alcoa's purchase of properties in the vicinity of the refinery have played a significant role in the decline in complaints during recent years.

7.11.3 Refinery Operations and Health Complaints

Specialist consultants, Emphron Pty Ltd, were commissioned to undertake statistical analysis of the complaints data base, meteorological conditions and the ambient measurements of oxides of nitrogen and particulates. The report prepared by Emphron is provided in Appendix N which describes the methodology, the study results and conclusions drawn from the analyses. The following represents a summary of the results and conclusions reached in this study.

This study examined whether ambient NOx and particulate concentrations were likely to be of refinery origin by evaluating data from the Boundary Road (Yarloop) monitoring station in conjunction with meteorological data. This study also examined whether there was any relationship between wind direction, particulate concentration, oxides of nitrogen concentration and the incidence of complaints. The report also considers whether the concentrations and alkalinity of particulates measured at Boundary Road are at levels considered likely to cause irritant respiratory impacts in the surrounding community.

7.11.4 NOx and particulate concentrations

Initial analysis of monthly ambient concentrations of nitrogen oxides (NO, NO_2, NOx) and particulates (PM_{10}, $PM_{2.5}$) against wind direction showed that the concentrations of these substances appear to be lower when wind direction is from the refinery. However, wind transport is a complex process influenced by several factors including temperature, humidity, wind speed and wind direction. To allow for this multi-factor consideration, the consultants refined the analysis to investigate the simultaneous effects of several meteorological variables. This analysis also concentrated on determining whether "peak values" were related to wind direction. A peak value is defined as being in the top 5% of all the 6-minute averaged values and allows analysis of possible short-term peak exposures.

This analysis found that for both NO_2 and NOx there is a clearly defined "wind direction effect" whereby both parameters show a correlation with wind direction from the refinery plant, the residue drying area and the township of Yarloop. The work drew the following conclusion in relation to this issue. "The highest probability of a peak concentration of oxides of nitrogen is found when the wind is blowing from the direction of the refinery stacks" and "at each [ambient monitoring] site there also seems to be some elevation in nitrogen oxide concentrations associated with winds from the residential properties at Yarloop". In this regard peaks in ambient NOx concentrations, under defined meteorological conditions provide an indicator of the presence of refinery emissions. A similar effect, of roughly the same magnitude, is produced by winds from the residential area of Yarloop.

A similar analysis was undertaken for particulate concentrations (PM_{10} and $PM_{2.5}$). The study found that peak values of both particulate parameters are associated with winds in the direction 275^o to 360^o, which includes winds coming from the refinery processing area and

the residue area. For $PM_{2.5}$ a similar effect, of roughly the same magnitude, is produced by winds from the residential area of Yarloop.

7.11.5 Meteorological conditions, air quality and complaints

The Emphron study also investigated whether or not the relationships described above have a statistical correlation to complaints. "In particular the study seeks to establish whether or not there is any relationship between wind direction, particle concentration, Oxides of Nitrogen and incidence of complaints. Such a relationship would provide objective evidence of a link between refinery outputs and community complaints. The nature of the relationship might also suggest mitigation strategies" (Emphron 2005).

Complaints records (from the Alcoa complaints data base) were analysed for the period April 2000 to September 2004 with two categories of air quality complaint considered to be available in sufficient quantity for separate analysis: odour and health complaints. For the period 24 April 2000 to 18 September 2004 a total of 3,124 verified complaints, lodged by 250 complainants were available for analysis.

The study found increases in total complaints and odour complaints during the winter months, with a possible increase in health complaints during winter. This led to the study finding "there is a fairly close agreement between the monthly incidence of complaints, and the monthly proportion of each day with a northerly wind" (Emphron 2005).

Further analysis of the data supported this finding providing "some evidence that the incidence of complaints is related to wind direction, NOx and particulate concentrations", however, "it is not possible to rule out complaints being affected by other variables". There is also evidence that complaints are increased when much of the day shows elevated NOx and $PM_{2.5}$ (NOx and $PM_{2.5}$ are unlikely to be the cause of complaints but may act as "markers" for the presence of refinery or township emissions, depending on wind direction).

During the April 2000 to September 2004 period more than 50% of the recorded complaints were lodged by 16 individuals who registered complaints on 50 or more occasions. To facilitate analysis of this unusual distribution the consultants categorised the data into two categories, "high frequency complainants", lodging 50 complaints or more and "low frequency complainants" lodging less than 50 complaints. Analyses were repeated on these categories separately. The results of this analysis are shown in Appendix N.

Table 15: Results of Complainant Distribution Analysis

Complainant Type	Environmental Variable	Confidence Interval by Issue Type: Total			Odour			Health		
		Low	Est	High	Low	Est	High	Low	Est	High
high	Temp	−0.10	−0.04	0.01	−0.09	−0.04	0.02	−0.23	−0.08	0.05
	Wind.N	1.74	3.00	3.94	1.51	2.74	3.73	2.94	5.02	6.91
	Wind.NW	0.37	1.65	3.05	0.57	1.77	2.97	−4.66	0.86	3.90
	PM10	−5.65	−1.27	1.65	−4.83	−1.03	1.71	−23.18	−4.70	6.51
	PM25	−0.31	1.58	5.73	−0.21	1.43	5.61	−6.56	3.60	14.49
	NOx	−1.13	0.50	2.56	−1.11	0.55	2.33	−5.79	−0.02	3.79
low	Temp	−0.11	−0.06	−0.01	−0.12	−0.06	0.00	−0.13	−0.06	−0.01
	Wind.N	1.66	2.51	3.36	1.50	2.51	3.48	0.90	2.56	3.70
	Wind.NW	−1.17	0.22	1.55	−1.07	0.48	1.95	−3.30	−0.48	1.79
	PM10	−2.53	−0.02	2.45	−4.31	−0.88	2.32	−2.17	1.06	4.26
	PM25	0.43	1.97	3.49	−0.53	1.73	4.01	−0.57	2.40	4.36
	NOx	0.71	1.82	3.73	0.01	1.49	3.46	0.51	2.42	5.27

Table 15 indicates the relative importance of each environmental variable in contributing to the relationship with complaints. Results are given for each complaint type (Total, Odour and Health) and for each group of complainants (High Frequency and Low Frequency Complainants). The results are given as best estimates (Est) bounded by lower and upper confidence intervals (Low and High). Only the results which have an upper and lower confidence interval of the same sign (positive or negative) are statistically significant. For those results that are statistically significant, the magnitude of the best estimate value can be used to assess how important that variable is in comparison to others.

If the best estimate of a statistically significant result is positive, complaints increase when that environmental variable increases. If the best estimate of a statistically significant result is negative, complaints decrease when that environmental variable increases. Results which have one positive confidence interval and one negative confidence interval are not statistically significant and can be interpreted as having no importance in the relationship with complaints.

When considering total complaints; low frequency complainants showed a statistically significant relationship with $PM_{2.5}$, NOx and wind direction. High frequency complainants however, have a statistically significant relationship only for wind direction. For odour complaints, low frequency complainants are statistically significantly related to wind direction and NOx, but high frequency complainants show a statistically significant relationship only to wind direction. For health related complaints, low frequency complainants are statistically significantly related to wind direction and NOx, but high frequency complainants show a statistically significant relationship only to wind direction.

In other words, when examining total complaints, both the low frequency and high frequency complaints tend to coincide with times when the wind is coming from the direction of the refinery. Low frequency complaints also tend to coincide with higher ground level concentrations of NOx and $PM_{2.5}$, which may indicate the presence of refinery emissions reaching ground level. When examining odour and health complaints as separate categories,

both types of complaint tend to be associated with wind direction, while only lower frequency complaints also tend to be associated with the presence of NOx at ground level.

The statistical analyses concluded that NOx and particulate concentrations at the Boundary Road monitoring location are strongly influenced by wind direction and that wind direction from the refinery increases the concentration of both parameters at Boundary Road, although these increases are "not markedly greater" than those associated with wind directions from the Yarloop residential area.

7.11.6 Alkalinity of airborne particles

The Emphron study also considered whether or not the alkalinity of refinery particulate emissions might cause irritation of respiratory passages, and therefore be a cause of health complaints. Using an estimate of the sodium-hydroxide (NaOH) equivalent concentration of particles measured at Boundary Road, the authors estimated a peak NaOH concentration that could be expected in particulate emissions reaching the Yarloop township. This investigation reached the following conclusion. "On the basis of conservative estimates of peak alkalinity (i.e., estimates which are likely to over estimate alkalinity), there is no evidence of particles with alkalinity sufficient to cause an irritant response. It is considered unlikely that complaints are generated by an irritant response to airborne alkaline particles" (Emphron 2005).

The alkalinity analysis in the Emphron report utilised data from a study undertaken by the Queensland University of Technology in 2002. Air quality was monitored in the QUT study over a two-week period between 18 August and 2 September 2002 at Boundary Rd, with the objective of investigating possible links between airborne particulate emissions from the refinery and air quality complaints (Morawska *et al.*, 2002).

The Proposal examined the concentrations in terms of number, mass and alkalinity of airborne particulate matter at Boundary Road.

Monitoring included real-time measurements of suspended particulate matter size distributions in the size ranges 0.015-0.723 μm and 0.5-20 μm using, respectively, a Scanning Mobility Particle Sizer (SMPS) and an Aerodynamic Particle Sizer (APS).

Particulate matter of diameter less than 10 μm, accumulated over one week, was collected using high volume samplers. One sampler was located in the Harvey townsite to provide background measurements. Two samplers were located at the Yarloop site, and were programmed to activate alternately depending on whether the wind was from within a 90° wide sector centred on the plant (referred to as the "plant quadrant" in the report) or from some other direction (referred to as the "non-plant quadrants" in the report). These samples were then analysed for average mass concentrations and alkalinity.

The results led to the following conclusions:

"The correlation analysis did not support the hypothesis that during periods when the wind direction is from the plant sector, the concentrations of fine and ultra-fine particles (or a size fraction within their respective size distributions) were significantly correlated with records in the complaints register for the Yarloop area.

Correlation between particle size and air quality complaints data was significant for particles smaller than 0.022 μm when all wind directions were considered, however these particles did not arrive at the Yarloop site from the direction of the plant quadrant, which suggests a source other than the refinery. Examination of the much longer term PM_{10} and $PM_{2.5}$ TEOM data for correlation with complaint data is strongly recommended.

The alkalinity of one-week cumulative fine particulate matter samples was higher when the wind direction was from the plant sector than for samples taken from other wind directions".

The average level of alkalinity detected when the wind blew from the direction of the refinery was 0.255 ± 0.007 μgm^{-3} (equivalent of NaOH). By way of comparison, the occupational exposure standard is 2000 μgm^{-3} (Morawska *et al.*, 2002).

The Emphron (2005) study concluded that: "in summary, it is possible that complaints are increased by airborne material from the refinery. The source within the refinery cannot be localised. There is no evidence that complaints are due to an irritant response to alkaline particles" (Emphron 2005).

7.12 ALCOA INFORMAL LAND MANAGEMENT

In October 2001, residents in Yarloop and Hamel received a "Wagerup Land Management Draft Proposal" from Alcoa for community comment. The stated aims of the proposal were to:

- Give people choice about whether they continue to live where they do;
- Protect property values; and
- Invest in the future of Yarloop and Hamel.

The Draft Proposal identified an area around the Wagerup refinery – Area A – where Alcoa proposed to establish a Special Control Area to restrict further residential development. It also identified an Area B where, in order to protect property values, Alcoa would, for 12 months, buy properties if residents wished to sell (refer to Figure 38 in section 7.14 for Area A and B). In light of community feedback, the proposal was revised and adopted in January 2002. The policy was strengthened again in November 2004.

Revised Proposal – January 2002

The Wagerup Land Management Revised Proposal, dated January 2002, contained the following key changes:

1. Identification of only a single area – Area A – where Alcoa would seek changes to the local Town Planning Scheme to ensure land use is compatible with refinery operations;
2. In the townships of Yarloop and Hamel, a commitment to purchase any property at unaffected value for the next five (5) years (assuming no unforeseen events, unrelated to Alcoa, that may lower property values);
3. A commitment to talk to people who live outside the townships of Yarloop and Hamel on a case-by-case basis; and
4. A commitment to liaise directly with business owners who may wish to sell, and to support a process for developing strategies to enhance business opportunities in the local community.

The revised proposal provided that Alcoa would purchase properties in Area A for the operating life of the Wagerup refinery. This Area A included some 118 properties in northern Yarloop.

The commitment to purchase properties in the townships of Yarloop and Hamel (Area B) was extended for a period of five years (i.e. until December 2006) with a five year extension if a study of valuations found house prices had fallen in the town due to Alcoa or publicity about Alcoa.

The boundary of 'Area A' was chosen for three reasons:

- People in this area may experience noise levels above the night time limit allowed under noise regulations (based on the modelled 35dbA noise contour plots surrounding the refinery);
- It corresponds with areas where people may be most annoyed by refinery emissions (at the time this was also the area where over 95 % of community odour complaints were being reported); and
- It allows for future expansion of Alcoa's bauxite residue area to the west of its current site and was chosen to fit the life of the refinery.

The Revised Proposal highlighted Alcoa's commitments to the following:

- Reducing odour and other emissions;
- Reducing noise;
- Investigating health concerns;
- Protecting property values;

- Supporting the integral nature and quality of the community and encouraging people to stay in the area; and
- Making it easy for those who wish to leave to sell their properties.

Alcoa proposed to those living in Area A the following:

- Offer to buy their home at the unaffected market value;
- Plus 35% to cover replacement costs; and
- Plus $7,000.00 to cover relocation costs.

The policy allows individual properties to be purchased only once (i.e. from original residents at the time of the policy announcement). The policy set out three methods of valuation and a valuation management process. It required that two valuations be prepared at Alcoa's expense; one by the owner's valuer and one by a licensed valuer chosen by Alcoa.

November 2004

In November 2004, Alcoa wrote to residents of Area B. The letter addressed recommendations of a community group (Land Management Working Group) that were drafted following an open forum in Waroona in September 2004. With the objective of providing security for those homeowners, the community group recommendations were adopted as:

For people who were, and remain, property owners in Yarloop and Hamel (Area B) on or before 1 January 2002:

1. Alcoa will extend its offer to purchase the property (at any time) from 31st December 2006 to 31st December 2011 (in accordance with the Wagerup Land Management Revised Proposal, January 2002); and
2. Alcoa will offer to purchase a property after 2011, if the owner has first marketed the property for six (6) months but has been unable to find a buyer at fair market value.

In accordance with the group's proposal, this undertaking applies for the life of the property owner or the life of the Wagerup refinery, whichever comes first. In the case of a deceased estate, the same option is available to the executor of that estate or to the person or person(s) to which land title is transferred in accordance with a Last Will and Testament, for a period of up to twelve (12) months after the property owner's death.

The Land Management Working Group continues to examine issues associated with Alcoa's land purchase policy, including valuation methods used to determine market value.

7.13 BASELINE RADIATION LEVELS

The bauxite ore from the Darling Range naturally contains low levels of radioactive elements and these radionuclides pass through the refinery process to the residue area. A baseline radiological assessment at Wagerup was undertaken by Radiation Wise and the report is presented in full in Appendix O. Since the current Wagerup refinery and residue area have been operational for more than 20 years, this study represents the assessment of the current (Year 2004) radiological levels for the Wagerup refinery and residue area.

Over the last 12 months thorium levels and uranium levels in the bauxite feed stock have been measured as 0.8 Bq g-1 and 0.1 Bq g-1 respectively. In the bauxite residue, thorium levels have been measured as 0.8 Bq g-1 in the sand fraction and 1.8 Bq g-1 in the mud fraction. Uranium levels in the residue have been recorded as <0.1 Bq g-1 in the coarse fraction and 0.2 Bq g-1 in the fine fraction (Radiation Wise, 2005).

Based on these measured levels of radioactivity, none of these materials is classified as 'radioactive' under the current Western Australian Radiation Safety (General) Regulations 1983.

It is not possible to establish a true baseline of gamma radiation at the Wagerup site due to its use for mineral processing over the last 20 years. However, the mean value of 0.16 μGy h-1 which was measured at the site boundary is considered the 'baseline' value that should be used for future rehabilitation of the site (Radiation Wise, 2005).

The gross alpha activity concentrations of dust in the vicinity of the refinery operations was determined through the analysis of dust samples collected through routine daily sampling. Five 24-hour samples from the months of January, April, July and October 2004 were selected and dust concentrations varied relative to the seasons. The potential mean annual internal radiation dose to a member of the public from inhaling dust would be a total of 0.02mSv. This is one fiftieth of the public limit of 1mSv and is considered conservative as an occupational rather than a passive breathing rate was assumed and no background subtracted (Radiation Wise, 2005).

Limited radon concentrations in air data are available for the Wagerup area. A measured mean value of 18 Bq m-3 is higher than the mean value of 16 Bq m-3 reported for Western Australian homes and the world-wide mean value of 10 Bq m-3, which is as a result of higher levels of uranium and thorium naturally occurring in the local soils (Radiation Wise, 2005).

Samples of groundwater from a number of bores at the Wagerup refinery were analysed for radium 226 and radium 228. Based on the analysis results a mean activity concentration of 65 mBq L-1 and 280 mBq L-1 for 226Ra and 228Ra, respectively, should be regarded as the 'baseline' value for the refinery (Radiation Wise, 2005).

7.14 NOISE

7.14.1 Refinery Noise Emissions

The refinery contribution to noise levels in its vicinity is caused by the combined emissions of numerous pieces of equipment across the refinery. Equipment that significantly contributes to noise emissions includes:

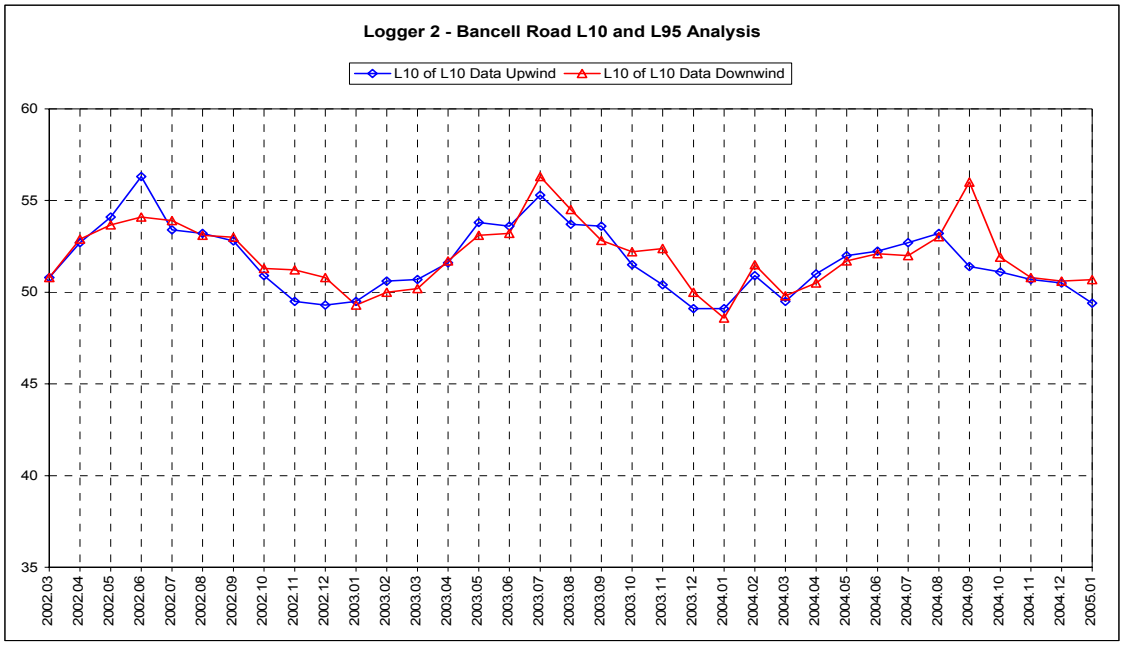
- ore and alumina conveyors;
- ore stacking and reclaiming machines;
- semi-autogenous grinding (SAG) mills;
- pumps, fans and blowers involved in liquid, steam, air and solids movement;
- liquid steam and air flow control valves and associated equipment;
- calcining kilns;
- steam generation and electric power generation plant;
- fans and pumps associated with pollution control equipment; and
- pipework used for liquid, slurry and steam movement around the refinery.

The refinery's overall contribution to noise levels in its vicinity, are well understood, having been characterised through numerous sound level monitoring campaigns. Monitoring data has been collected by acoustic consultants and from a network of fixed sound level monitoring stations. Three fixed sound level monitoring stations are located to the North and South of the refinery and have been in place since 2000. Monitoring of weather conditions at a meteorological station located to the south of Wagerup refinery is also performed, since meteorology is the major influence on the propagation of noise in any given direction.

Analysis of the monitoring data from the fixed monitoring stations and data collected by acoustic consultants, suggests that there has been no increase in the refinery contribution to ambient noise levels over the past three years. The data indicate that the actual refinery sound power level (noise emission) is relatively constant. Despite this, the recorded sound level at any measurement location varies from time to time. This variation is primarily caused by meteorological conditions. In particular, wind direction, wind speed and the presence or absence of temperature inversions play a significant role in causing this variation. It has been shown that refinery noise propagation towards the Yarloop townsite is favoured in the autumn and winter months due to the prevailing meteorological conditions.

Sound level data measured to the south of the refinery at the Bancell Rd fixed monitoring station from March 2002 to December 2004 is presented in Figure 37 as an example of the typical measured sound levels in the vicinity of the refinery.

Figure 37: Noise Levels Measured at the Bancell Rd Fixed Monitoring Station



NOTES

1. The fixed noise monitoring stations incorporate a precision sound level meter that records overall A weighted sound pressure levels to a data logger including the Regulatory requirements of L_{A0}, L_{A1} and L_{A10}. Sound levels measured at the fixed monitoring stations provide information on ambient noise levels including contributions from the refinery, traffic, wildlife, livestock etc.
2. Each data point in this chart represents the upper 10th percentile value of all 6-minute data points recorded each month at the Bancell Rd monitoring station under specific wind speed conditions (light winds, 0.5 to 3m/sec, since background noise is lowest at these speeds).
3. The upwind and downwind categories in this chart distinguish the location of the monitor relative to the refinery eg. down wind represents winds blowing from the refinery to the monitoring station.
4. Monitoring data collected prior to 2002 is provided in HSA report 9578-4-00029-4.2 (HSA, 2002a).

Figure 37 shows that there is little difference in the up-wind and down wind L_{A10} values measured at the Bancell Rd fixed monitoring station. This indicates that background noise is a significant influence on the L_{A10} values recorded at the monitoring location and that the refinery is not a significant contributor to the measured L_{A10} levels. Noise measurements recorded at this station vary seasonally, with higher levels recorded in the autumn and winter months (April to August) when the prevailing winds are often of higher average velocity. Another significant factor is the dominance of frog call noise during the winter period.

Since the sound level measurements conducted in the vicinity of the refinery are heavily influenced by other ambient noise sources, it is difficult to quantify the actual refinery contribution at any measurement location. For this reason, computer modelling has been used to estimate the refinery noise contribution at premises surrounding the refinery. A noise model has been developed for Wagerup refinery using the SoundPlan noise modelling software (version 6.2) and the associated CONCAWE algorithms (SVT, 2005a and HSA, 2002b).

The current model has been progressively developed by Herring Storer Acoustics (HSA) over a number of years. The model has been calibrated using comprehensive sound power measurements involving 193 survey points located near to the main refinery noise sources. The model predictions have been verified on many occasions under a range of meteorological conditions by field surveys conducted by qualified noise technicians (hand-held meter readings and observations) and by the fixed monitoring station data (SVT, 2005a). It is believed that the model predicts the refinery's noise contribution at noise sensitive premises to within +/- 3 dB(A) which is considered to reflect noise modelling capability (SVT, 2005a and Burgess, 2005b).

The noise model has been used to predict refinery noise contribution under maximum (worst case) sound propagation conditions, i.e., 3m/sec wind blowing from the source to the receiver combined with thermal inversion. In reality worst case propagation conditions occur very infrequently. The predicted noise levels are for the refinery only and will be less than the overall measured level at any location due to the significant influence of background noise.

The current refinery maximum noise levels predicted by noise modelling for the worst case weather conditions are shown in Figure 38. The contours shown in Figure 38 are considered "worst case" because the maximum noise levels will only occur occasionally (when meteorological conditions are suitable for maximum propagation). The figure also shows maximum refinery noise propagation in all directions simultaneously. In reality this situation can't exist as downwind conditions can only occur in one direction at any one time.

The possible variation in refinery noise contribution at receptors caused by meteorological conditions is shown in Figures 39 and 40. Figure 39 shows the predicted noise levels when the wind is blowing from the north whilst Figure 40 shows the predicted noise levels when the wind is blowing from the south. These two meteorological scenarios cause significant variations in noise levels at receptor locations even though the refinery noise output has remained constant. For example, at Boundary Rd to the south of the refinery, the two meteorological scenarios shown in Figures 39 and 40 cause a noise level variation of greater than 5 dB(A).

Figure 38: Existing Refinery Worst Case Modelled Noise Predictions in all Directions

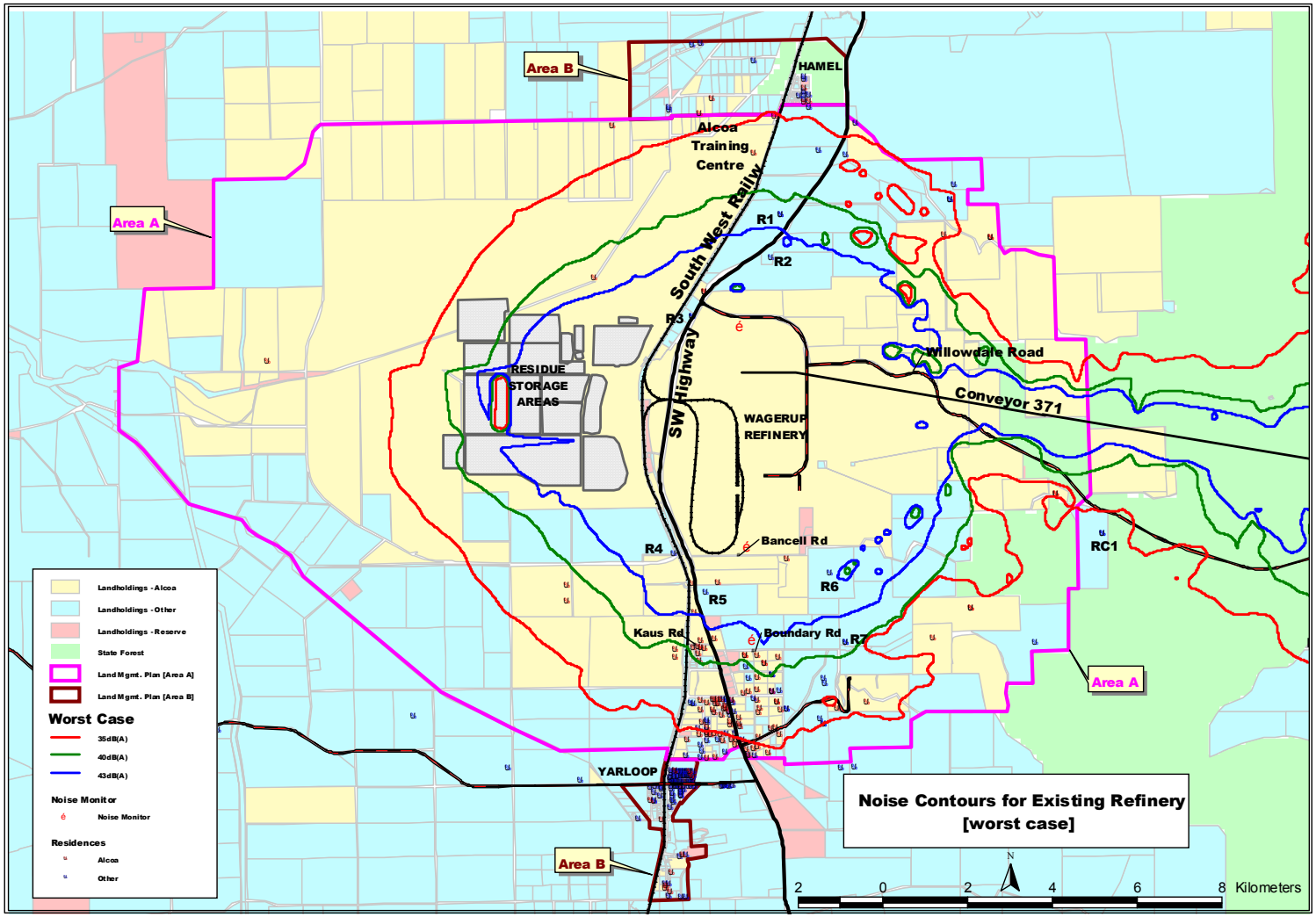


Figure 39: Existing Refinery Worst Case Modelled Noise Predictions with Northerly Winds

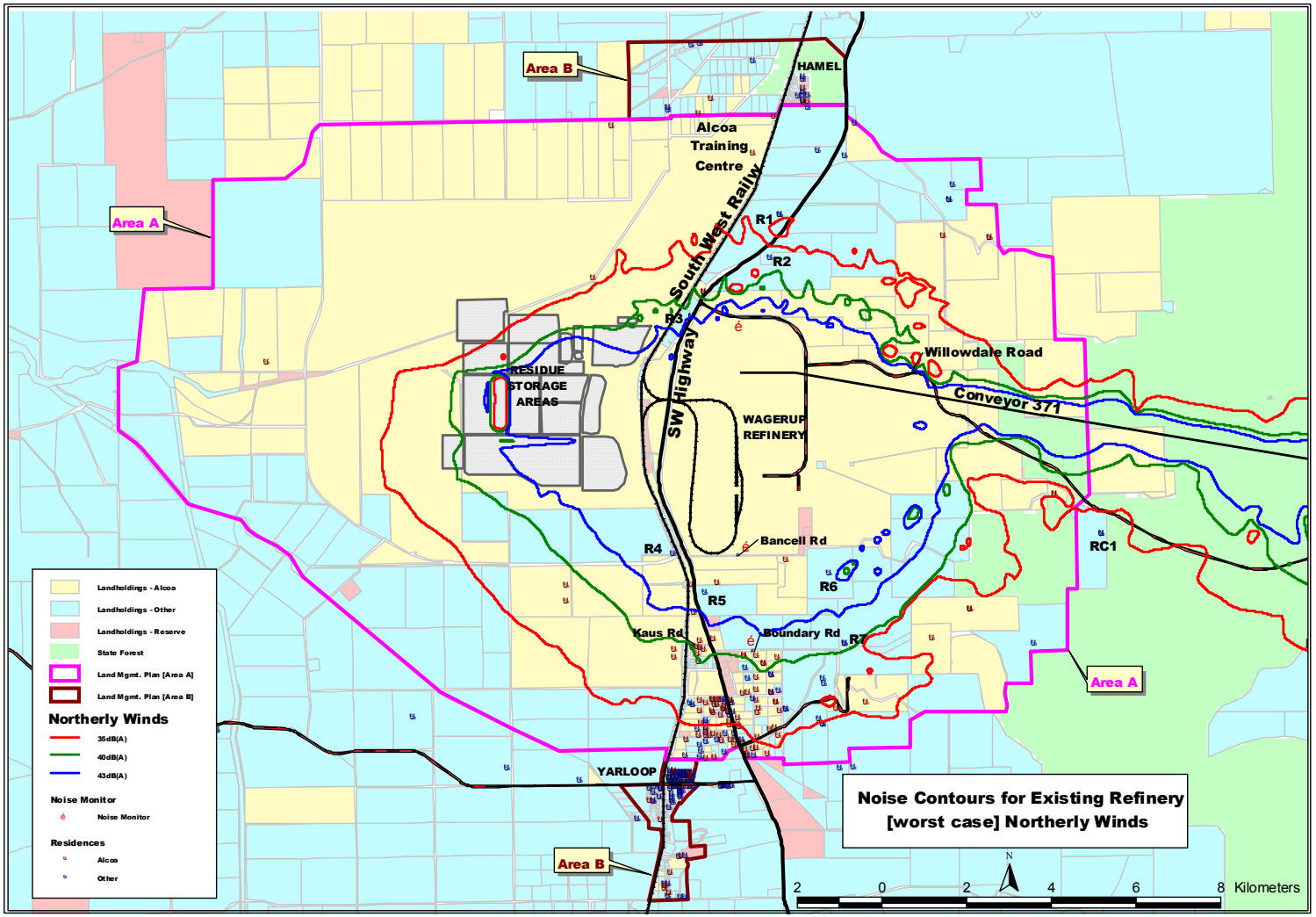
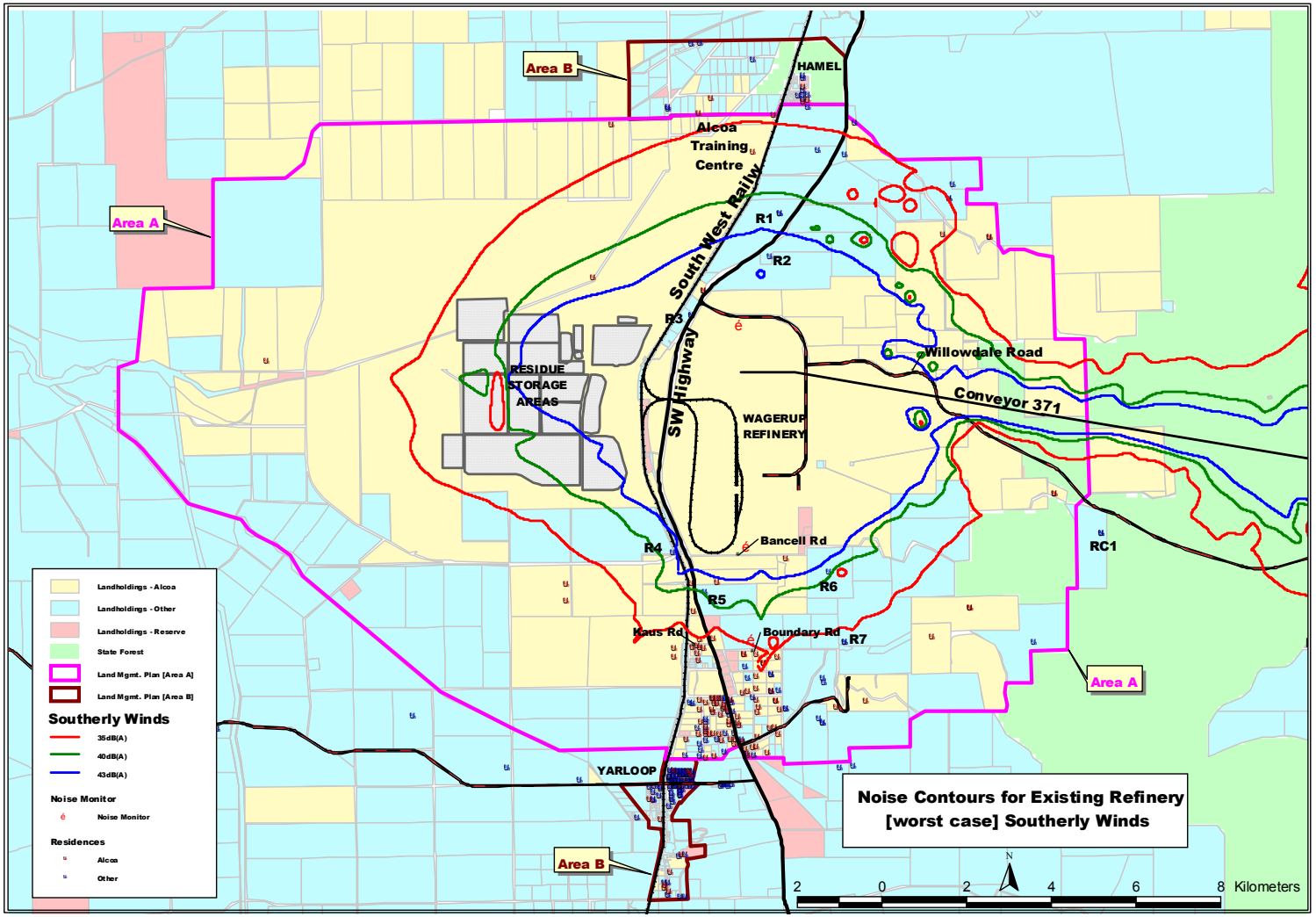


Figure 40: Existing Refinery Worst Case Modelled Noise Predictions with Southerly Winds



7.14.2 Compliance with Noise Regulations

The Environmental Protection (Noise) Regulations (The Regulations) were promulgated in 1997 and came into effect in 1999. Thus, neither Unit 1 nor Unit 2 of the Wagerup refinery (completed in 1984 and 1992 respectively) were designed or constructed to comply with the more stringent requirements of the *Environmental Protection (Noise) Regulations* 1997 which now apply (Table 16).

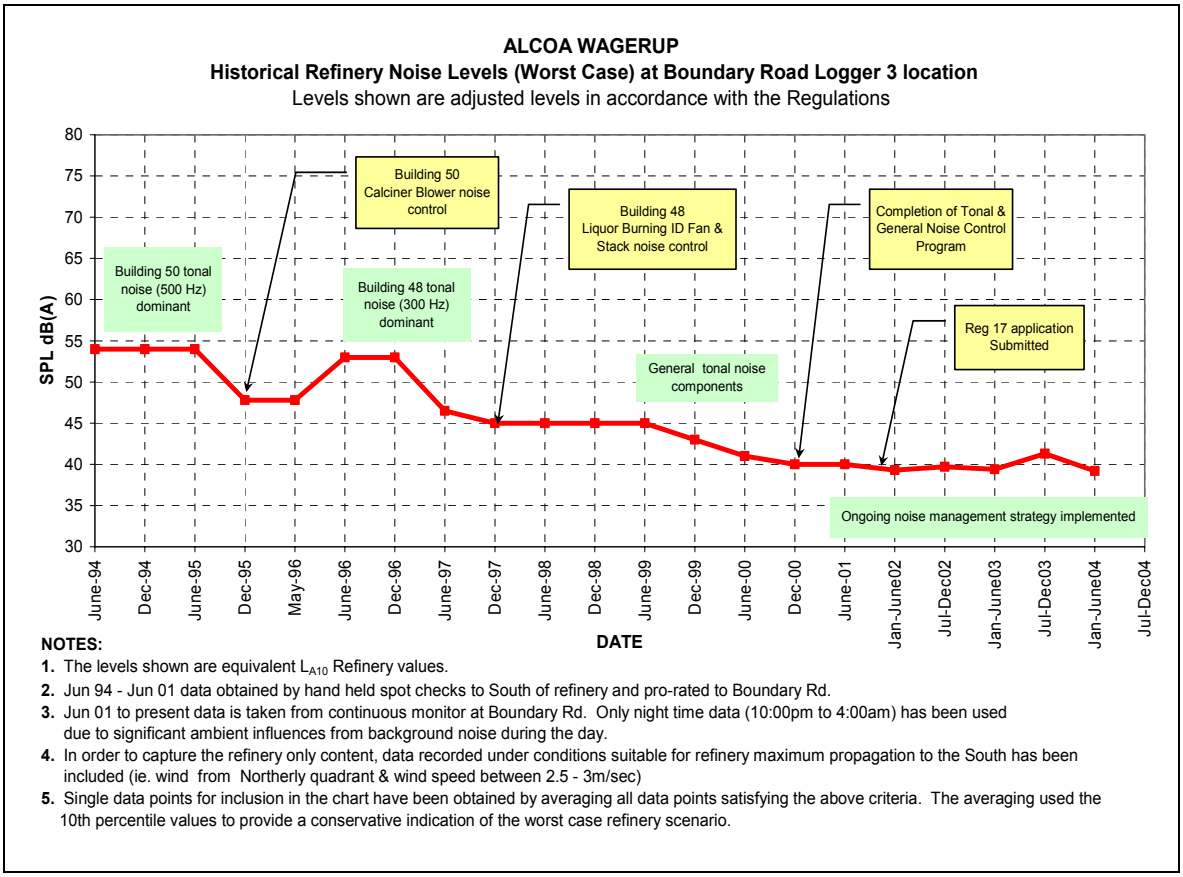
Table 16: Assigned Noise Levels for Sensitive Premises under the *Environmental Protection (Noise) Regulations 1997*

	Assigned Noise Level dB(A)		
Time of Day	**L_{A10}**	**L_{A1}**	**L_{AMax}**
0700 – 1900 (Mon to Sat)	45	55	65
0900 – 1900 (Sun & Public Hols)	40	50	65
1900 – 2200 (All days)	40	50	55
2200 – 0700 (Mon – Sat)	35	45	55
2200 – 0900 (Sun & Public Hols)	35	45	55

Prior to the introduction of the Noise Regulations Alcoa initiated a noise monitoring program and implemented a noise control program in consultation with the DoE. Several refinery noise sources were acoustically treated in the mid 1990's, including the calciner blower system and the liquor burner stack. Although some refinery noise sources had been acoustically treated, monitoring conducted in 1999 indicated that refinery noise levels exceeded the new night-time regulatory limits and that tonal characteristics were present.

An upgrade of the Wagerup refinery was completed in 1999 to achieve the current production capacity. This involved the installation of several new pieces of plant and coincided with the commencement of a noise reduction program, which was completed in 2001. This program successfully reduced night-time noise levels at Boundary Road (south of the refinery) by around 5 dB(A) and reduced the tonal components to meet regulatory requirements. Specific details of the noise reduction program are detailed in HSA report 9572-7-00029-4.2 (HSA, 2002c) which has been provided to the DoE previously. Figure 41 shows the effect of the noise reduction program on overall noise levels to the South of the refinery.

Figure 41: Noise Level Reduction Achieved at Boundary Road



NOTES:

1. The levels shown are equivalent L_{A10} Refinery values.
2. Jun 94 - Jun 01 data obtained by hand held spot checks to South of refinery and pro-rated to Boundary Rd.
3. Jun 01 to present data is taken from continuous monitor at Boundary Rd. Only night time data (10:00pm to 4:00am) has been used due to significant ambient influences from background noise during the day.
4. In order to capture the refinery only content, data recorded under conditions suitable for refinery maximum propagation to the South has been included (ie. wind from Northerly quadrant & wind speed between 2.5 - 3m/sec)
5. Single data points for inclusion in the chart have been obtained by averaging all data points satisfying the above criteria. The averaging used the 10th percentile values to provide a conservative indication of the worst case refinery scenario.

Despite this significant noise reduction, under worst-case propagation conditions monitoring and modelling has confirmed that the refinery noise emissions do exceed the night-time assigned levels at some private residences.

Worst case propagation occurs under light (up to 4m/s) down wind conditions or a combination of down wind and temperature inversion conditions (3m/s and 2ºC/100m) (refer Figure 38). Computer modelling and on-site measurement have shown that refinery noise emissions comply with the assigned levels for more than 85% of the time during the night at all residences beyond about 1.7 kilometres south of the refinery (HSA, 2002c). During day time and evening periods, when the assigned levels are higher, compliance with the noise regulations is achieved at all times at all residences located further than 1.7 km from the refinery (HSA, 2002c).

For privately owned residences closer than about 1.7 kilometres from the refinery, compliance will be achieved for lesser periods. For example, at the closest non Alcoa owned residence it is estimated that compliance is never achieved over night, and is not achieved for a considerable proportion of the rest of the time.

Further details of the extent of compliance have been presented in HSA reports 9578-4-00029-4.2 and 9572-7-00029-4.2 (HSA, 2002a and HSA, 2002c) submitted to the DoE in 2002 as part of Alcoa's variation application.

7.14.3 Regulation 17 Application to Vary Assigned Levels

In February 2002 Alcoa submitted an application to the Minister for Environment for a variation to the assigned noise levels, as shown in Table 16 under the provisions of Regulation 17 of the *Environmental Protection (Noise) Regulations 1997*. This provision was included in the Regulations in recognition that some existing facilities might not be able to comply with the newly introduced and more stringent assigned noise levels. Regulation 17 requires noise generators to demonstrate that "all reasonable and practicable" measures have been taken to reduce noise emissions from the facility before a Regulation 17 variation will be approved.

Alcoa's application for a variation to the assigned noise levels for the Wagerup refinery was made after the implementation of a noise reduction program that significantly reduced noise levels measured at Boundary Road to the south of the refinery (refer to section 7.14.1). The application sought to increase the assigned noise levels applicable to the refinery to the levels that had been achieved and monitored as a result of the noise reduction program. The refinery would achieve full compliance with the revised regulations if the Regulation 17 application was accepted.

The Regulation 17 submission proposed an allowable night-time noise level of 47 dB(A) + IF (influencing factor3) at the location of the nearest noise sensitive premises (compared to 35 dB(A) +IF as prescribed by the Regulations). The submission outlined a noise management strategy for ensuring that the noise levels at other potentially noise sensitive premises would not increase and included a commitment that noise emissions from the Wagerup refinery would not increase with any future modification, upgrade or expansion of the facility.

In the application Alcoa committed to:

- ensure ongoing noise emissions were managed by a noise management strategy involving further noise reductions, where reasonable and practicable;
- offer noise attenuation measures for the homes of people who were adversely affected by refinery noise (above the prescribed levels);
- implement a land management strategy (refer section 7.12) to facilitate relocation of adversely affected people;
- implement a complaints management program; and

[3] Refer to *Environmental Protection (Noise) Regulations*, 1997 Schedule 3 for information on how influencing factors for specific noise sensitive premises are determined.

- apply an engineering and procurement policy to adopt a 'lowest practicable' noise emission approach for new or replacement plant and equipment.

The Regulation 17 application has undergone intensive review by the DoE's technical staff since its submission in 2002. The DoE also commissioned an independent third party review by a specialist consultant of the application and the technical data that formed the basis of the application (SVT, 2003). Extensive consultation with community stakeholders and representative groups has been conducted by DoE and Alcoa.

On referral of the proposal to expand the Wagerup refinery, the EPA determined that the Regulation 17 assessment should be incorporated into the EPA's assessment of the proposed expansion of the Wagerup refinery.

7.14.4 Refinery Noise Emission Management

Over the last two years, Alcoa has successfully managed noise impacts related to the Wagerup operations through implementation of the noise management strategy and the land management strategy.

The noise reductions achieved in 2000 and 2001 have been maintained through ongoing programs of monitoring, assessment, maintenance and noise reduction works. This has been demonstrated by monitoring data which shows that noise levels have been sustained at the levels achieved in the 2000 and 2001 reduction program (refer to section 7.14.2).

A key part of Alcoa's noise management strategy was the implementation of the land management strategy. The land management strategy aims to provide community members who experience refinery noise emissions out of compliance with the Regulations, with a choice about remaining within the area.

Noise compliance was a major factor in developing the land management strategy, in that the modelled 35 dB(A) noise contour was adopted to largely define Area A. Area A is the area in which Alcoa has offered to purchase any property at a premium of 35% above market value. As a result of the implementation of the land management strategy a number of properties have been voluntarily sold to Alcoa. This has allowed those people wanting to leave the area to do so, others have remained and some neighbours have opted to stay as tenants after selling their property to Alcoa. Alcoa has also continued to deal directly with relevant residents requesting acoustic control treatment of their residences. The acoustic architect assesses the residence and provides recommendations on treatment that could reduce noise intrusion based on the resident's concerns and noise level measurements taken within the house.

By 2005, Alcoa had organised for its consultants to acoustically assess 10 homes within Area A, at the owner's request. Seven of the owners decided to proceed with the noise treatments following the assessment, which have achieved reductions of between 3 and 5dB(A). Four of

the assessed properties have subsequently been purchased by Alcoa, through the land management strategy.

There are presently 41 privately owned dwellings remaining in Area A (refer to Table 17).

Table 17: Number of Privately Owned Dwellings within Area A

Inside 43 dB(A) predicted contour	Inside 40-43 dB(A) predicted contour	Inside 35-40 dB(A) predicted contour	Area A remainder	Total
8	2	17	14	41

Notes:
1. Data current as at March 2005.
2. Information on private dwelling locations has been obtained from aerial photograph's. Exact numbers may vary slightly.

Alcoa will continue to focus noise control efforts, including the land management strategy, on the premises located within 1.7 kilometres of the refinery as those residents who live beyond 1.7 km are considered to be subject to minimal noise impact from the refinery. Noise emissions from the refinery will continue to be monitored and managed and where reasonable and practical, noise emissions reduced.

7.14.5 Refinery Noise Emission Impact

In early 2004 Alcoa consulted residents of private dwellings located within Area A to help define the most suitable approach for managing noise impacts from the refinery and to remind neighbours of Alcoa's offer to acoustically treat homes.

The results of this consultation suggested that the impact of refinery noise within Area A is limited to a small number of residents. A total of 41 residents were consulted, 34 of whom indicated refinery noise was not an issue as other noise sources were more dominant. Seven residents expressed concern about noise impacts although four of these residents indicated that they only heard refinery noise occasionally.

As a result of the consultation, acoustic treatment was undertaken on two properties and this has successfully managed refinery noise in one instance.

The results of this consultation are supported by the 2004 noise complaint data, where from a total of 209 noise complaints, 76% (159) were received from four residents, located within the 35dB(A) contour (and therefore Area A). These four residents were part of a total of seven that had expressed concern over refinery noise during the consultation conducted by Alcoa in 2004. Additionally, 45 of the 209 complaints were lodged by 11 residents residing outside the 35dB(A) contour, where the refinery noise emissions although occasionally

audible, comply with the noise regulations. The remaining five complaints were lodged by other residents residing inside the 35dB(A) contour.

Based on the 2004 consultation and complaint data it is understood that there are five neighbours within Area A that consider refinery noise emissions to be a continuing concern. Alcoa is undertaking discussions with two of these residents under the land management strategy which may result in these properties being purchased by Alcoa. If purchased, this would leave three residents within the 35dB(A) contour who currently indicate they are impacted by refinery noise emissions.

7.14.6 Costs to meet Noise Regulations

Extensive acoustic reduction work was undertaken at the refinery from 1995 to 2001 to achieve the current refinery noise emission levels. A detailed assessment by acoustic consultants, for the Regulation 17 submission in 2002, indicated that further overall noise reductions could only be achieved at what is believed to be excessive cost and with uncertain results. Nevertheless, in 2004 the cost estimates were reviewed for further 3, 4, 5 and 6 (5.9) dB(A) overall noise reductions for the current refinery scenario (i.e., without the Proposal).

Due to the large number of sources in the refinery that would require noise treatment, the cost was significant, with conservative estimates ranging from $9.8 to $20.7 million dollars. This analysis did not account for indirect costs, such as loss of production and shutdown costs, or include possible compromises with safety and operational controls. The cost estimate was based on achieving a noise reduction to the south of the refinery and would be significantly higher to achieve noise reductions in all directions.

On analysis of the number of residents impacted (refer to section 7.14.5) by refinery noise emissions and the cost of further noise reductions (without certainty of reductions) it was not considered reasonable or practical for further noise reductions to be implemented.

In submitting the Regulation 17 variation application, Alcoa made the commitment that noise impacts from the Wagerup refinery would not increase with any future modification, upgrade or expansion of the facility. This commitment was made because analysis suggested that while it was not reasonable or practicable to achieve further noise reductions, it was considered practicable that the costs of additional noise control works be part of the capital cost of any major expansion works, given the level of investment required for such works. An expansion can only occur through adopting tight noise standards on any new equipment and associated processing facilities. A major expansion also provides the opportunity to optimise the overall facility in ways that reduce noise output to at least offset any contribution from new equipment.

In 2002 it was estimated that the commitment to not increase noise emissions through an expansion would add approximately $14 million to the overall project capital cost. This

estimate was based on an extrapolation of noise control technology that was deployed as part of the noise reduction program conducted in 2000 and 2001. Based on additional work undertaken in 2005, it is evident that the cost of this commitment was significantly underestimated in 2002. Engineering consultants were commissioned in 2005 to re-estimate the costs to maintain the existing noise emissions from the Proposal based on the preliminary design details available at the time of ERMP preparation. The capital expenditure required to maintain the existing refinery noise emissions and still implement the Proposal is estimated to be greater than $50 million.

In addition, between $0.5 to $1 million is spent annually on monitoring and maintaining noise emissions at the current refinery levels. This sum is expected to increase through the expansion of the refinery.

7.14.7 Implications of Further Noise Reductions at the Refinery

In recognition that additional acoustic reduction opportunities may exist as a result of an expansion, the sound power allocation budget (the amount of sound allocated to a particular refinery area as a limit) was reviewed to assess what would be required to achieve a 4 dB(A) reduction in overall noise emissions levels from an expanded refinery. To achieve this overall noise reduction it would be necessary to reduce noise emissions from numerous sources within the refinery. Specialist acoustic consultants concluded that a 4 dB(A) overall reduction in noise levels is not technically feasible (SVT, 2004c).

The consultant identified that at any location there are many noise sources that contribute to the overall noise level. Their analysis indicated that there are so many contributing sources that the highest contribution from any single source is approximately 10 dB(A) below the cumulative noise level from all sources at the refinery (SVT, 2005c). This demonstrates that the noise reduction and management program implemented to date has been rigorous and further reductions will be difficult to obtain. The consultant did not consider that a 4 dB(A) reduction to the south of the refinery was actually possible as in many cases the sound power allocation limits required to achieve a 4 dB(A) reduction may not be technically feasible (SVT, 2005c).

Nevertheless engineering consultants were commissioned to derive preliminary cost estimates of achieving a 4 dB(A) reduction. This costing does not include specific treatments required for the digestion, precipitation or calcination areas as practical acoustic solutions for these areas are unknown. These sources are significant contributors to noise levels received at residences, therefore acoustic treatment will be required in order to achieve an overall noise reduction. It has been estimated that the cost of the reduction would be in excess of $50 million and is in addition to the $50 million (minimum) required to meet the current noise commitment. In addition the cost analysis does not account for indirect costs (i.e. loss of production, shutdown costs, investigation costs) or include possible compromises with safety

and operational controls. A significant amount of engineering followed by noise modelling will be necessary before this cost can be confirmed.

7.14.8 Requirement for Approval of Regulation 17 Application

Given that there are only a small number of residents impacted by refinery noise; the limited time that the refinery is out of compliance with the Regulations at most noise sensitive premises; the technical uncertainty around the ability to actually reduce overall noise levels; and the excessive cost related to further noise reduction Alcoa considers that further noise reduction at the refinery is not reasonable or practicable.

Alcoa has committed to ensure that the environmental noise impacts from the refinery do not increase as a result of the Proposal. This follows on from noise emission reductions achieved by the works programs implemented in 2000 and 2001. These reductions were achieved at a considerable cost and require ongoing expenditure to monitor and maintain. Further off-site noise reduction cannot be achieved at reasonable cost due to the very large number of contributing sources within the refinery, and acoustic consultants are not confident that a measurable reduction in noise levels is technically feasible.

Alcoa remains committed to implementing source reduction opportunities where reasonable and practicable at the refinery. Alcoa believes that continuing negotiations with neighbours within Area A will result in most of those remaining parties aggrieved by noise being satisfied. Alcoa believes that it has demonstrated a realistic degree of flexibility in dealing with the range of difficult issues associated with land acquisition, and continues to explore mutually acceptable ways of achieving adequate separation between the refinery and neighbours.

For its noise management strategy to be effective, Alcoa must ensure it is operating the refinery in full compliance with the *Environmental Protection Act 1986* and its Regulations. At the nearest noise sensitive premises, Alcoa requests that the night time regulatory LA10 criteria be increased from 35 dB(A) + IF to 47 dB(A) + IF, consistent with the predicted contours shown in Figure 38, in accordance with the Regulation 17 application submitted to the Minister for the Environment.

7.14.9 Bunbury Port

The current Alcoa port facility (Bunbury Port) noise emissions are considered to comply with the *Environmental Protection (Noise) Regulations 1997*.

The main existing sources of noise at the Bunbury Port are fans and blowers associated with alumina conveying and dust collection systems. Although the Port complies with the Regulations, noise emissions may be audible at neighbouring residences under certain weather conditions.

Noise emissions from the port are measured periodically to determine compliance with the Regulations. However, the measurement of port noise emissions is complicated due to relatively high ambient noise levels.

The ambient noise environment in the area surrounding the Port facility is very complex. In addition to the Alcoa facility, there is a variety of non-Alcoa owned port facilities that are significant contributors to the noise received at nearby residences. Noise from road, rail and ship traffic is also significant. The major natural ambient noise sources include wind induced tree and vegetation noise and noise from fauna e.g. birds and frogs.

Due to the high level of ambient noise it is difficult to determine the noise contribution of the Alcoa port facilities at a particular location by measurement alone. A noise model has been developed for the Port facility so that its contribution to noise levels at various locations can be calculated in accordance with the Regulations. The noise model has been developed using the SoundPlan 5.0 noise modelling software and the associated CONCAWE algorithms. This model has been developed and refined during ongoing monitoring programs and has been used to predict the Port's noise contribution under maximum (worst case) sound propagation conditions.

The noise model was updated following a noise reduction program conducted in 2000. Worst-case noise levels of 35 dB(A) and 31 dB(A) have been predicted for nearby residences to the south-west and north-east of the Port facilities respectively.

Since this review was undertaken the only change to the equipment operated at the port is an upgrade of the ship loader dust collector fan. Site measurements undertaken recently by SVT show that the new equipment is approximately 3 dB quieter than the old equipment. Based on this information SVT concluded that the current worst-case noise levels will be 32 dB(A) and 31 dB(A) at nearby residences to the south-west and north-east of the port facilities respectively (SVT, 2005b). This confirms compliance of the Alcoa Port facility with the Regulations.

7.15 SOCIAL SETTING

7.15.1 Regional Setting

A detailed review of the social setting within which the Wagerup refinery is located was undertaken by ERM (2005) and is presented in Appendix P.

The Wagerup refinery is located in the Shire of Waroona in the Peel Region near the border with the Shire of Harvey, which is in the South West Region. Peel has the second largest population of all regions in Western Australia (approximately 79,000; 4% of the State's

population) and is experiencing a population growth rate almost double that of the rest of the State, the second highest behind the Perth metropolitan region. Population growth has averaged above 3% per annum since the mid 1990's, with lifestyle and housing options being the main drivers of these inflows. This rapid growth comes with some challenges: for example, public services are often regarded to be lagging behind the growing demand.

Mandurah is the major population and business centre for Peel and is one of the largest urban centres outside the Perth metropolitan area. It is also where most of the infrastructure and services for the region are located. A major asset and driver of the region's growth is the coast and estuary. The main inland centres of Peel are Byford, Pinjarra, Waroona and Boddington. Smaller communities exist at Mundijong, Jarrahdale, Serpentine, North Dandalup and Dwellingup.

The South West region has the largest population of any region outside of Perth with a population of 132,000 (6.9% of Western Australia's population). The average population growth of 2% per annum for the South West is higher than the growth rate for the State (1.4%). The majority of the population lives around the regional centres of Busselton and Bunbury on the coast, and Collie inland. The Shire of Harvey contains 14% of the population in the South West region. The community of Yarloop is located within the South West Region.

The indigenous people in the Peel and upper South West areas tend to be younger than the non-indigenous community. The majority of indigenous people are younger than 25, with nearly half of the indigenous population under 14 years of age, compared with about 23% of the non-indigenous population under 14 years. Approximately 1.4% of the Peel Region and 1.8% of the South West Region identified themselves as Aboriginal in the 2001 Census (ABS, 2001).

The economy of the Peel Region is based predominantly on mining and mineral processing, mainly sourced from Alcoa's Pinjarra and Wagerup alumina refineries, and Huntly and Willowdale bauxite mines, and Worsley bauxite mining operations near Boddington. In 2003 the Peel Region produced $3.1 billion worth of alumina of which $650.7 million worth was produced from bauxite mined in the Shire of Waroona (DoIR, 2004). The 2001 Census reported the major areas of employment for people living in the Shire of Waroona also reflected the minerals processing profile, as follows:

- manufacturing (18%);
- agriculture/forestry/fishing (11%);
- retail trade (11%);
- construction (10%); and
- mining (8%).

Alcoa's refinery operations are included in the manufacturing sector figures, whilst its mining operations are reflected in the mining sector figures.

Although mining and mineral processing is a key industry in the South West, the region has a diverse economy with power generation, agriculture, agricultural processing, viticulture and tourism. Mineral extraction, processing and manufacturing form the most valuable industries in the South West with a total of approximately $2.2 billion in 2001/2002.

The 2001 Census data reported the major areas of employment for people living in the Shire of Harvey were:

- manufacturing (including alumina refining) (20%);
- retail (11%);
- agriculture/forestry/fishing (11%);
- education (8%); and
- construction (7%).

The unemployment rate for the Peel Region as of June 2003 was 8.1%. Whilst this is significantly lower than in 1996/97 when it was 13.5%, this rate is still high compared with regional Western Australia (5.6%) and the State as a whole (5.9%) in June 2003. The latest unemployment estimates available from the ABS at the shire level are 2001 (updated April 2004) and show the Shires of Waroona (5.4%) and Harvey (4.7%) to have relatively low rates of unemployment.

The South West has an unemployment rate of 6% that is similar to that of regional Western Australia and also to that of Western Australia. This is most likely as a result of the diverse economy and the relatively high amount of manufacturing in the region. The importance of manufacturing (including alumina refining) is highlighted in the figures above for the Shire of Harvey.

With the resource sector of the economy currently very strong in Western Australia there a number of proposed large new projects. In the southern part of the State there are at least six proposed large projects in the iron ore, alumina, power and infrastructure industries. Tracking of the skilled labour market by Insite Logistics indicates that there are currently about 13,400 active construction workers in Western Australia (ERM, 2005).

7.15.2 Shire of Waroona

7.15.2.1 Population

The Shire of Waroona has a population of approximately 3,500 people (3,278 people in the 2001 Census), which accounts for under 5% of the population of the Peel Region. Between 1996 and 2016 the population of the Shire is predicted to increase by only 22%. The 2001

Census results showed that between 1996-2001 the number of households in the Shire increased, however the occupancy rate (average number of people inhabiting each household) actually declined by 10%. The decline in occupancy rates is likely to continue at a rate above the State average, but at a slower rate than that observed over 1996-2001, which will result in 'development' rates significantly exceeding rates of population growth.

In the Shire of Waroona, 2.4% of the population identified themselves as of indigenous descent.

The high proportion of people under the age of 14 and in the 25 to 44 age group reflects the employment opportunities and lifestyle in the region for families. The lack of people in the 15 to 24 age group suggests young people tend to move out of the Region to seek employment and further education and training opportunities (ERM, 2005).

7.15.2.2 Industry Profile

Mining and minerals processing is a major economic contributor in the Shire of Waroona although agriculture remains an important industry. Agriculture traditionally focussed around dairy and beef cattle production however, deregulation of the dairy industry and the development of the Waroona Irrigation Scheme have enabled new industries, such as horticulture, citrus and nut orchards to become established.

Mining and minerals processing in the Shire is dominated by Alcoa's bauxite mining operations at Willowdale and alumina processing at Wagerup, although a new mineral sands mine has recently been established in the Shire. The mining industry has resulted in the establishment of several new businesses providing services to mining in the Shire. Tourism and recreation are also important to the Shire with the attraction of the State forests, reserves and dams in the Shire, and the coastal strip (ERM, 2005).

7.15.2.3 Businesses and Services

The majority of businesses in the Shire of Waroona are located in the Waroona townsite. Businesses include:

- several supermarkets;
- food outlets;
- fashion and other retail stores;
- commercial laundry;
- bank;
- agricultural services;
- vehicle and machining services;
- real estate agencies;
- veterinary clinic.

The Shire of Waroona Community Strategic Plan (1999-2004) Status Report (Shire of Waroona, 2004) indicated that there is a lack of low-cost serviced light industrial land in the Peel Region and the Waroona Shire. There is a small industrial area in Waroona which has several larger businesses including machinery hire, steel fabrication, aluminium window and door manufacturing and concrete products manufacture. There is no domestic or commercial gas supply to Waroona, which limits energy options for industry (ERM, 2005).

The Shire of Waroona has two primary schools and one secondary school to year 10 located in Waroona. Students who wish to complete years 11 and 12 must commute to senior high schools located in Pinjarra, Mandurah or Harvey.

There is no public hospital in the Shire of Waroona, with the nearest hospitals located in Yarloop, Harvey and Pinjarra. However a Health and Community Resource Centre has recently been built in Waroona to provide health services, private medical and specialist practitioners and family and youth support services. Waroona also has a dentist and aged care facilities.

The Shire of Waroona has one police station, a district-wide State Emergency Service group and a St John Ambulance located in the town of Waroona. Concern has been expressed by some residents about the ability of currently emergency services to meet demand.

Available recreational facilities include a new recreation and aquatic centre in the town of Waroona which includes a child care facility. Outdoor sports facilities, a golf course and several recreational parks are also located in the town and there is a number of sporting and recreation groups in the Shire. There is a number of attractions in the Shire that cater for outdoor activities such as bushwalking, swimming, water skiing, sailing and fishing including the Darling Range, Waroona Dam, Drakesbrook Weir and the coastal strip (ERM, 2005).

7.15.2.4 Housing

There is a growing demand for new houses in the Shire of Waroona, which is principally driven by development along the coastal strip. The town of Waroona has also experienced steady growth in new housing development, however there is a shortage of serviced residential land in Waroona that could limit future housing and population growth. Demand for housing in Hamel is strong and the quality of existing housing is reasonably good.

Housing developments are located at Preston Beach, Tuart Grove, Armstrong Hills, Harvey River Sanctuary and Drakesbrook Meadows Estate (ERM, 2005).

7.15.2.5 Regional Planning

The Shire of Waroona has undertaken a review of existing planning and has released a discussion paper entitled "Shire of Waroona Local Planning Strategy; Discussion Paper 2", October 2002. The preliminary strategy contains the following objectives:

- consolidation and expansion of the existing Waroona, Hamel, Preston Beach and Lake Clifton settlements;
- support for a coordinated approach to land-use and development around the Wagerup refinery;
- management of land use change in rural areas to achieve positive economic, social and environmental outcomes;
- support for industrial and commercial development;
- provision of residential lifestyle opportunities;
- provision of an integrated approach to land use and infrastructure planning;
- reflection of State and regional planning;
- provision of a land use planning regime responsive to economic and social opportunities;
- protection of environmentally sensitive areas from development; and
- support for the enhancement of the Waroona Town centre.

The Strategy has identified land surrounding the Waroona Town Centre for future/potential expansion of the town centre, however there is not expected to be any need to accommodate expansion of the town centre over the short to medium term. It is anticipated that physical expansion of the town may occur over the medium to long term.

There is currently sufficient zoned land to accommodate a doubling of the Shire population growth rate over the next ten years, with shortfalls not arising for 10 to 15 years. However, there may be a shortage of 'desirable' land in the near future, as some land in Waroona and Preston Beach may be considered somewhat less desirable or development is constrained by significant up-front costs. The Shire of Waroona has recognised that this shortage of 'desirable' land may constrain population growth in the interim and it may be beneficial to identify additional opportunities for residential development and a strategy for protection of these areas from excessive fragmentation and/or incompatible development (Shire of Waroona, 2002).

The Shire has also identified that a number of areas would benefit from more detailed and integrated planning. These areas include: the Hamel Townsite and surrounds (Hamel Eco-Historic Precinct), Preston Beach Townsite and surrounds, Lake Clifton, Wagerup and Waroona Townsite and Centre. For the Wagerup area, more detailed planning would include the identification of a buffer area around the Wagerup refinery (Shire of Waroona, 2002).

Wagerup Refinery

In the Waroona Shire Town Planning Scheme (No. 7) the Wagerup refinery is zoned 'Special Industry Zone' for both the residue area and the refinery itself. This zone enables or permits the operations of the Wagerup refinery and also enables agricultural uses to occur where refinery uses may not be in operation. The refinery and residue area are surrounded by predominantly Rural zones classified as 'General Farming', 'Irrigated Agriculture' and 'Hills Face' (conservation area with large Rural holdings).

The Shire of Waroona Draft Local Planning Strategy reflects the zones in the Town Planning Scheme and reserves the Alcoa Wagerup Refinery as an area for a potential structure plan, for 'Strategic Industry' (areas to accommodate large-scale, capital intensive industries that have the potential to generate significant off-site impacts).

7.15.2.6 Landuse

The Shire of Waroona is an area of approximately 8,355 km2 divided into a number of different land uses. Prior to the commencement of Alcoa's bauxite-alumina operations, agriculture was the main economic activity in the Shire of Waroona. Dairy farming generated most of the revenue but was already in a state of decline as a result of small farm sizes and high land costs contributing to the relocation of a significant number of milk quotas to areas further south. Current landuse is outlined in Table 18:

Table 18: Landuse in the Waroona Shire.

Land use	Area (ha)
Recreation and/or camping reserve	488.5
Water Reserve	94.5
Townsite Reserve	713.1
Other Reserve	234.4
Public Works Department	435.3
Water Corporation	3.9
State Forest	35,735.2
Timber Reserve – Land Act	13.8
Conservator of Forest Land	195
Vacant Crown Land	640
Private Property	39,100.5
National Park	5414
Flora and/or Fauna Reserve	443.2
Total	**835,512.6**

The Wagerup refinery comprises the majority of industrial activity in the Shire of Waroona, with mineral sands mining also occurring in the Shire along the base of the Darling Scarp. Earthmoving contractors and previously an abattoir have also been major employers in the Shire. Waroona has a light industrial area which accommodates a range of enterprises including panel beating, spray painting, aluminium door and window manufacturing, concrete products manufacturing, toy manufacturing, cabinet making, steel fabrication and machinery hire (Alcoa, 1994).

Land Management Programme

In response to community concerns about the refinery's impacts on residents in close proximity to Wagerup, Alcoa developed a draft 'Wagerup Land Management Draft Proposal' in 2001 which was distributed to the residents of Hamel (Shire of Waroona) and Yarloop (Shire of Harvey) for community comment. Based on community input, the proposal was revised and adopted in 2002 and again revised in 2004.

The aims of the proposal were to:

- Invest in the future of Yarloop and Hamel;
- Protect property values; and
- Give residents a choice about whether they continued to live where they do.

Refer to Section 7.12 for further detail.

7.15.3 Shire of Harvey

7.15.3.1 Population

The Shire of Harvey is located south of the Shire of Waroona and covers an area of 1,766 km2. The town of Yarloop in the Shire of Harvey is located approximately 2.5 km south of the Wagerup refinery. The Shire has a population of 18,397, which is 14% of the population of the South West Region. Approximately 1.7% of the Shire's population are indigenous (ERM, 2005).

7.15.3.2 Industry Profile

The dairy and beef cattle industries continue to be the mainstay of the economy of the Shire of Harvey. However, recent development of the Harvey Irrigation Scheme has enabled more horticulture and viticulture industries to become established. Significant agricultural processing operations in the Shire include the Harvey Fresh milk and juice processing plant, the Peters and Brownes factory at Brunswick Junction, EG Green and Sons abattoir, and winemaking (ACIL Tasman, 2004). In the past the timber industry has also been an important contributor to the Shire, but now employs relatively few people.

There is no current mining activity within the Shire, although the Alcoa and Worsley mining leases extend into the Shire of Harvey. Mineral processing is undertaken at the Kemerton Industrial Park approximately 17 km north east of Bunbury. The industrial park is principally tenanted by Millennium Inorganic Chemicals and Simcoa.

Tourism and recreation is an important contributor to the economy of the Shire of Harvey and mostly centred on the coastal town of Australind. However, there are also facilities that take advantage of the Darling Range (ERM, 2005).

7.15.3.3 Businesses and Services

The Shire of Harvey has a strong commercial sector supported by the populations in the towns of Australind, Brunswick and Harvey. The commercial centre of Harvey itself includes:

- supermarkets and major retail outlets;
- restaurants;
- cafes;
- food services;
- fashion and other general retail;
- banks;
- real estate agencies; and
- small businesses that service the agricultural industry.

The light industrial area on the outskirts of the town of Harvey supports a number of industries including some that service the mining industry. The E.G. Greens abattoir and Harvey Fresh are located close to town.

Yarloop has the Gunns timber mill, drying kilns and veneer plant located in Yarloop, although limited commercial services.

The Kemerton Industrial Estate provides for a number of larger industries including an abattoir, piggery, the Millennium Inorganic Chemicals' titanium dioxide pigment plant and Simcoa's silicon plant.

The Shire of Harvey has 13 pre-primary and primary schools, two secondary schools, the Harvey Agricultural College and two TAFE campuses. The towns of Cookernup and Yarloop provide for primary education only.

There are two public hospitals within the Shire. The hospital at Harvey provides 24 hour accident and emergency service. The Yarloop hospital mainly provides care for the ill elderly, and the town of Harvey also has aged care facilities. The Yarloop hospital will

require temporary closure for proposed upgrades, which has caused some concern about the ability of remaining services to cope with the demand.

There are three police stations, located in Harvey, Yarloop and Australind. Harvey also has a St John Ambulance, State Emergency Services and a local bush fire brigade. Other local bush fire brigades are in Yarloop and Cookernup. However, there is concern about the ability of current emergency services to cope with demand.

The larger towns in the Shire have good built recreational facilities with a number of sporting and recreation groups. The town of Harvey has a swimming pool, outdoor sports facilities, public parks, and a recreation centre. Recreation activities in the Shire are mostly on the coastal strip at Australind and in the Darling Ranges. Nearby attractions include Stirling Dam, Harvey Dam and the Darling Ranges which cater for water skiing, fishing, swimming and bushwalking activities (ERM, 2005).

7.15.3.4 Housing

There is strong demand for housing in the Shire of Harvey, although this is focused on development of the coastal strip near Australind. Harvey Shire has indicated that there is a need for more affordable housing in the Shire, which has been partially met by the Korijekup Heights housing development near Harvey. Demand for housing in Yarloop is relatively low and there are currently no new housing developments proposed for the town.

7.15.3.5 Landuse

Informal Land Management

In October 2001, residents in Yarloop and Hamel received a "Wagerup Land Management Draft Proposal" from Alcoa for community comment. The stated aims of the proposal were to:

1. Give people choice about whether they continue to live where they do;
2. Protect property values; and
3. Invest in the future of Yarloop and Hamel.

The Draft Proposal identified an area around the Wagerup refinery – Area A – where Alcoa proposed to establish a Special Control Area to restrict further residential development. It also identified an Area B where, in order to protect property values, Alcoa would, for 12 months, buy properties if residents wished to sell. In light of community feedback, the proposal was revised and adopted in January 2002. The policy was strengthened again in November 2004.

Revised Proposal – January 2002

The Wagerup Land Management Revised Proposal, dated January 2002, contained the following key changes:

1. Identification of only a single area – Area A – where Alcoa would seek changes to the local Town Planning Scheme to ensure land use is compatible with refinery operations;
2. In the townships of Yarloop and Hamel, a commitment to purchase any property at unaffected value for the next five (5) years (assuming no unforeseen events, unrelated to Alcoa, that may lower property values);
3. A commitment to talk to people who live outside the townships of Yarloop and Hamel on a case-by-case basis; and
4. A commitment to liaise directly with business owners who may wish to sell, and to support a process for developing strategies to enhance business opportunities in the local community.

The revised proposal provided that Alcoa would purchase properties in Area A for the operating life of the Wagerup refinery. This Area A included some 118 properties in northern Yarloop.

The commitment to purchase properties in the townships of Yarloop and Hamel (Area B) was extended for a period of five years (i.e., until December 2006), with a five year extension if a study of valuations found house prices had fallen in the town due to Alcoa or publicity about Alcoa.

The boundary of 'Area A' was chosen for three reasons:

- People in this area may experience noise levels above the night time limit allowed under noise regulations (based on the modeled 35dbA noise contour plots surrounding the refinery);
- It corresponds with areas where people may be most annoyed by refinery emissions (at the time this was also the area where over 95 % of community odour complaints were being reported); and
- It allows for future expansion of Alcoa's bauxite residue area to the west of its current site and was chosen to fit the life of the refinery.

The Revised Proposal highlighted Alcoa's commitments to the following:

- Reducing odour and other emissions;
- Reducing noise;
- Investigating health concerns;
- Protecting property values;

- Supporting the integral nature and quality of the community and encouraging people to stay in the area; and
- Making it easy for those who wish to leave to sell their properties.

Alcoa proposed to those living in Area A the following:

- Offer to buy their home at the unaffected market value;
- Plus 35% to cover replacement costs; and
- Plus $7,000.00 to cover relocation costs.

The policy allows individual properties to be purchased only once (i.e. from original residents at the time of the policy announcement). The policy set out three methods of valuation and a valuation management process. It required that two valuations be prepared at Alcoa's expense; one by the owner's valuer and one by a licensed valuer chosen by Alcoa.

November 2004

In November 2004, Alcoa wrote to residents of Area B. The letter addressed recommendations of a community group (Land Management Working Group) that were drafted following an open forum in Waroona in September 2004. With the objective of providing security for those homeowners, the community group recommendations were adopted as:

For people who were, and remain, property owners in Yarloop and Hamel (Area B) on or before 1 January 2002:

1. Alcoa will extend its offer to purchase the property (at any time) from 31st December 2006 to 31st December 2011 (in accordance with the Wagerup Land Management Revised Proposal, January 2002); and

2. Alcoa will offer to purchase a property after 2011, if the owner has first marketed the property for six (6) months but has been unable to find a buyer at fair market value.

In accordance with the group's proposal, this undertaking applies for the life of the property owner or the life of the Wagerup refinery, whichever comes first. In the case of a deceased estate, the same option is available to the executor of that estate or to the person or person(s) to which land title is transferred in accordance with a Last Will and Testament, for a period of up to twelve (12) months after the property owner's death.

The Land Management Working Group continues to examine issues associated with Alcoa's land purchase policy, including valuation methods used to determine market value.

Further detail of the proposal is available from Alcoa and is summarised in the Socio-economic study by ERM (2005).

7.15.4 Bunbury Port

A major contributor to Alcoa's alumina operations is the Bunbury Port, through which Alcoa imports caustic and exports alumina. Currently, Bunbury Port is the world's largest alumina exporting port with trade through the port valued at more than A$3 billion per annum. Alcoa's alumina is shipped to aluminium smelters throughout the world with the majority destined for China, Canada, Africa, United Arab Emirates and Indonesia. The alumina industry accounts for some 80% of throughput, or more than three ships a week through Bunbury Port. An economic impact study commissioned by the Bunbury Port Authority in 1999/2000 has shown that for each vessel that uses Bunbury Port, two full time equivalent positions are created. Alcoa's Bunbury Port operation's today has 22 Alcoa employees, 21 of whom live in or around Bunbury.

The City of Bunbury has grown and continues to grow around the Port. The city has an estimated resident population of 30,786 with an average annual growth rate of 1.7%. It is estimated that there is a labour force of 16,165 (June 2004) and an unemployment rate of about 7.2%. Most people tend to work in the retail industry, property and business services, construction and health and community services. Approximately 125 people work in manufacturing/mining and 168 in construction (South West Development Commission website www.swdc.wa.gov.au).

Bunbury has a well serviced education sector with several government and private primary and secondary schools, and the campuses of the Edith Cowan University and the South West Regional College of TAFE. The City provides specialist medical services, including major private and public hospitals.

Bunbury has a wide range of businesses and services and acts as a regional centre for commerce, business, entertainment, health, arts and government agencies. The main shopping areas focus around the Shopping Centre in the Central Business District and the Bunbury Forum Shopping Centre in East Bunbury. The City also has extensive heavy and light industry areas including the port area itself.

7.15.5 Alcoa's Community Contribution

Alcoa directly employs nearly 3,800 people in Western Australia and contributes around A$1.1 billion each year to the State's economy. Approximately 900 full time employees work at the Wagerup refinery and Willowdale mine. Of these, 230 people are residents of the Shire of Waroona and over 100 people live in the Shire of Harvey. Total payroll contributions over the past four years averaged approximately $13 million to employees living in the Shire of Waroona and approximately $6 million to employees living in the Shire of Harvey (ERM, 2005).

Alcoa assists local suppliers in the Shire of Waroona and the Shire of Harvey to conduct business with Alcoa and the Wagerup refinery. The company invites local business to bid on locally supplied or manufactured goods or services and gives preference to local businesses. Alcoa works with local business groups to identify and utilise local suppliers and where possible, structures bids to enable local supplier participation (ERM, 2005).

Alcoa has a range of initiatives that support economic, social and environmental development within the local community. Over the 30 years in the region, Alcoa has supported and sponsored an extensive range of community, social and environmental projects including:

- High School scholarships for 'Future Women of Industry';
- around 25 vocational, apprenticeship and other training positions per year;
- funding of TAFE training places in horticulture;
- contract arrangements that include the use of local employees and local suppliers where practicable;
- workshops on the Alcoa procurement process and tendering systems;
- over $1 million for community-based Landcare activities in the Peel-Harvey catchment;
- research into advanced farming and forestry; and
- various partnerships with community programmes and organisations such as the Waroona Community Centre, Family Youth Support Service, and the Yarloop ECU Alcoa Project (YEAP).

The Alcoa Landcare Project was launched in the wheatbelt of Western Australia in 1989. Its aim is to fostering community interest and involvement in landcare, and the project has since become one of Australia's largest and most successful demonstrations of cooperative community action. By the end of Australia's National Decade of Landcare, Alcoa World Alumina Australia had committed over $16 million to community environmental and landcare projects. In 2000, the company contributed a further $1.4 million.

The success of the Alcoa Landcare Project can be attributed to cooperative partnerships that have been developed with farmers, community groups, government agencies, authorities, non-profit organisations and other corporate sponsors.

Alcoa employees also provide a wide array of voluntary effort to the local communities and this is corporately recognised by Alcoa. Three key schemes provide opportunities for Alcoa employees to contribute to the local community:

- PEACH (Personnel Employed by Alcoa Charity Help) is an employee based volunteer charitable trust dedicated to maximising the collection of funds for charity from Alcoa's employees and distributing these funds to a wide range of human care agencies in Western Australia. PEACH donates to a diverse range of organisations from large public hospitals and research institutions, through to small support groups all of which play and important role in the community. Funds have been provided for clinical research; hospital services and medical equipment; health support services and facilities for the sick, the frail and disabled; welfare support services for family and single parent support groups; young people at risk; and safety and emergency services. PEACH has been in operation since 1979 and over 1,400 Alcoa employees have donated in excess of $1.5 million to over 200 community organisations.

- ACTION (Alcoans Coming Together in Our Neighbourhoods) is a company sponsored employee engagement programme, managed by the Alcoa Foundation which is independent of the company. The grants recognise group volunteer initiatives involving at least 10 active full-time employees volunteering for at least 4 hours at qualified non-profit organisations.

- When Alcoa employees volunteer at least 50 hours of community service during a calendar year to a charitable organisation, Alcoa provides financial support to that organisation under the Bravo! programme. Eligible employees may apply through the Alcoa Foundation for one US$250 grant per year for one organisation. Qualifying organisations include non-profit, health, social, welfare, educational, cultural or community organisations.

7.16 CULTURAL HERITAGE

7.16.1 Aboriginal Heritage

There are 27 previously recorded Aboriginal archaeological sites within an 8 km radius of the Wagerup refinery operations (Table 19). Twenty-five of the archaeological sites are artefact scatters and the remaining two are camping grounds. Of the twenty-seven archaeological sites, one site (3232) is located outside the southern edge of the existing residue area. The Proposal will not impact on any known aboriginal archaeological sites.

Table 19: Aboriginal archaeological sites located within an 8 km radius of the Proposal Area

AAD Site ID	AAD Site No.	Name	Type	Size (m²)	No of Artefacts	Reported in
3212	S00332	Lake Preston: Sand Pit S32	Artefact Scatter	NR	8	Novak 1975
3213	S00333	Harvey Estuary 34: Lost	Artefact Scatter	NR	5	Novak 1975
3214	S00334	Harvey Estuary 35: Corner	Artefact Scatter	NR	3	Novak 1975
3215	S00335	Harvey River 36: Bushfire	Artefact Scatter	NR	3	Novak 1975
3216	S00336	Harvey River 37: Harvey BR	Artefact Scatter	NR	46	Novak 1975
3217	S00337	Harvey River 38: Plantation	Artefact Scatter	NR	1	Novak 1975
3218	S00338	Harvey River 39: Blackboy	Artefact Scatter	NR	2	Novak 1975
3219	S00339	Pine Plantation Swamp 40	Artefact Scatter	NR	194	Novak 1975
3220	S00340	Harvey River 41: Drain	Artefact Scatter	NR	9	Novak 1975
3221	S00341	Harvey River Flats 42 A + B	Artefact Scatter	NR	NR	Novak 1975
3222	S00342	Harvey River Flats 43	Artefact Scatter	NR	2	Novak 1975
3223	S00343	Harvey River Flats 44	Artefact Scatter	NR	9	Novak 1975
3232	S00495	Wagerup 1	Artefact Scatter	NR	40	DAS 1977
3233	S00496	Wagerup 2	Artefact Scatter	NR	2	DAS 1977
3234	S00497	Wagerup 3	Artefact Scatter	NR	7	DAS 1977
3234	S00498	Wagerup 4	Artefact Scatter	NR	40	DAS 1977
3236	S00499	Wagerup 5	Artefact Scatter	NR	12	DAS 1977
3259	S00328	Lake Clifton 4: Preston	Artefact Scatter	NR	1	Novak 1975
3260	S00329	Yalgorup Nat. Park 1 30	Artefact Scatter	NR	1	Novak 1975
3309	S00205	Waroona	Artefact Scatter	NR	NR	
3547	S02425	Buller Road Camp	Camping Ground	400	NR	O'Connor 1987
3559	S02442	Johnston Road	Artefact Scatter	100	7	Quartermaine 1987
4144	S01262	NatGas 123	Artefact Scatter	1000	10	Pickering 1982
4282	S00827	Gas Pipeline 94	Artefact Scatter	NR	NR	Pickering 1982
4334	S00825	Gas Pipeline 93	Artefact Scatter	40000	NR	Pickering 1982
5614	S00561	Lake Preston	Artefact Scatter	NR	NR	
15324	S03052	Twin Creeks	Camp and Spiritual Site	NR	NR	Carto-Cult 1997

The majority of the 25 archaeological sites listed in Table 19 were recorded during Aboriginal Heritage Surveys conducted by the Department of Aboriginal Sites (1977), Carto-Cult (1997), Novak (1975), Pickering (1982) and O'Connor (1987) and Quartermaine (1987). The archaeological sites recorded comprise mostly small scatters with numbers of artefacts ranging from 1 artefact to 129 artefacts. Only four sites have had their extent recorded and they range from 100 m² to 40,000 m².

The dominant lithic (stone) raw material, in archaeological sites on the Swan Coastal Plain and the Darling Scarp, is vein quartz (eg. Anderson, 1984; Quartermaine, 1987, 1988; Veitch, Martin & de Gand, 1997). Other lithology components recorded in archaeological sites include dolerite, granite, mylonite, crystal quartz, silcrete, glass, and fossiliferous chert. The Swan Coastal Plain does not possess any sources of natural stone. All of the raw materials, except fossiliferous chert, originate in the Darling Scarp or to the east of the scarp (Anderson, 1984). The sources of fossiliferous chert are postulated as having occurred on the continental shelf, to the west of the current coastline.

The Wagerup operations were surveyed most recently in June 2000 by archaeological consultant, Archae–aus'. This survey was carried out within the refinery boundary, and in the pastoral area surrounding the residue area. During this survey, two archaeological sites and a total of five isolated artefacts were located. All of the archaeological material located in the south-western corner of the Proposal Area appeared to be associated with the low swamp area (Archae-aus, 2000).

The archaeological site comprised a small artefact scatter located in the base of a shallow sandy deflation. The artefacts occurred in the western end of the deflation in an area measuring 5 m (north/south) by 10 m (east/west). The artefact assemblage comprised 12 quartz flakes, flake fragments and pieces of debris. The quartz was fine-grained and crystalline in nature and the quartz artefacts were small, ranging in length from 5 to 20 mm. The nature of the artefact assemblage at this site was consistent with the other sites recorded in the Wagerup area during past surveys (Archae-aus, 2000).

A previously recorded archaeological site 3232 (S00495) was originally recorded as containing a few surface artefacts in a series of closely spaced clusters (Department of Aboriginal Sites 1977; AAD Site File 3232). Subsequent to this site being mined for sand, the artefact assemblage was estimated to be in the order of 10,000 artefacts. In addition, five isolated artefacts were located in the southern part of the Proposal Area, one of which was located amongst sand excavated from a rabbit burrow. Consequently, the pattern of distribution of archaeological material appeared to be spatially associated with a known water source and resource zone. The survey also highlighted that there is considerable potential for sub-surface archaeological material in the southern portion of the survey area (Archae-aus, 2000).

The isolated artefacts were located in two areas; a small sandy rise and a flat sandy paddock with deflation areas located adjacent to a seasonal swamp. Rabbit burrowing activity appeared to have excavated some of the artefacts and indicated that sub-surface artefacts may be present in this area (Archae-aus, 2000).

7.16.2 European Heritage

No place or object within the Proposal area is included on the Register or the Interim List of the Register of the National Estate. There are no known sites or items of non-Aboriginal heritage significance in the Proposal area.

7.17 TRANSPORTATION

7.17.1 General traffic movements

The South Western Highway is the major route for traffic from the Perth metropolitan area to the south-west region including the townsites of Waroona and Yarloop.

A traffic survey was conducted in October 2003, to study traffic movements along the South Western Highway. This study was undertaken by Main Roads on South Western Highway, north of Coolup East Road, and focussed on traffic passing through Waroona and Yarloop.

The survey indicated that there are about 36,000 vehicles per week using the South Western Highway, with an average daily traffic volume during the survey of approximately 5,100 vehicles. Of the 36,000 vehicles, approximately 87% were standard passenger vehicles and cars (light vehicles). Small to medium trucks comprised approximately 6% and the remaining 7% were classed as heavy vehicles.

7.17.2 Existing Wagerup refinery freight movements

Each year there are thousands of freight movements to and from the Wagerup refinery and mining operations by road and rail. These freight movements must comply with strict government regulations which ensure that high safety levels for the public are maintained and that there is minimal inconvenience to the general community.

<u>Rail</u>

The South West Main Line is used by a number of train services each day, including freight trains, passenger trains and those for alumina, coal and caustic.

The rail movements associated with transportation of alumina and caustic on the South West main line is summarised in Table 20 below.

Table 20: Average Train Movements per day

Type	Wagerup Trains	Pinjarra Trains	Total
Alumina	3	4	7
Caustic	1	Same train services Pinjarra	1
Total	**4**	**4**	**8**

Note:

- On occasion there may be four Wagerup and five Pinjarra alumina trains.
- Sometimes two caustic trains are required

Alumina tonnage currently hauled for Alcoa is around 6 Mtpa, from Pinjarra to Kwinana and Bunbury and from Wagerup to Bunbury. Caustic tonnage hauled is approximately 750,000 tpa to Pinjarra and Wagerup.

Road

The refinery has a total of approximately 650 permanent staff, with many working on a shift basis. On average the total number of passenger vehicles per day is approximately 450, representing approximately 9% of all vehicles on South West Highway.

The total vehicle movements associated with deliveries to Wagerup refinery and mining operations is estimated at an average of 334 two-way freight movements per week. This represents approximately 7% of all truck movements on the South West highway.

On a daily basis, Wagerup refinery presently receives approximately seven lime trucks and one general freight semi-trailer. These are classed as heavy vehicles and represent approximately 4% of all heavy vehicles on the South West highway.

The refinery also receives approximately eight general freight vehicles per day, including, five tray-trucks and three 1-tonne courier vehicles. This represents around 5% of all small to medium trucks using the South Western Highway.

The refinery has approximately nine freight movements that occur on a weekly or fortnightly basis. These movements are associated with fuel delivery, laboratory supplies, domestic rubbish collection and recycling.

Vehicle movements for the mining operations are associated with the delivery of fuel and oil, explosives, general goods, logging and mulch contractors. The total average two-way vehicle movements per week associated with the mining operations is approximately 92.

Alcoa has its own transport department and works with relevant State Government agencies, such as the Main Roads Department, to carefully monitor road freight movements and ensure that high safety standards are maintained when transporting freight.

There are strict guidelines relating to the routing of heavy freight vehicles in populated areas and they are designed to reduce the risk of personal injury to members of the public.

The following time restrictions for the delivery of goods to the Wagerup refinery have been implemented:

- Oversize loads are restricted to daylight hours by Main Roads;
- Oversize loads from the Kwinana area are permitted to travel at any time between sunrise to sunset and would likely be in Wagerup at the earliest around 7.30am (in summer months; later in winter);
- Oversize loads from Fremantle, Henderson or Perth areas are only permitted to travel after sunrise but not between 7.30am and 9am or 4.30pm and 6pm on weekdays only. These loads must be off the road at sunset.

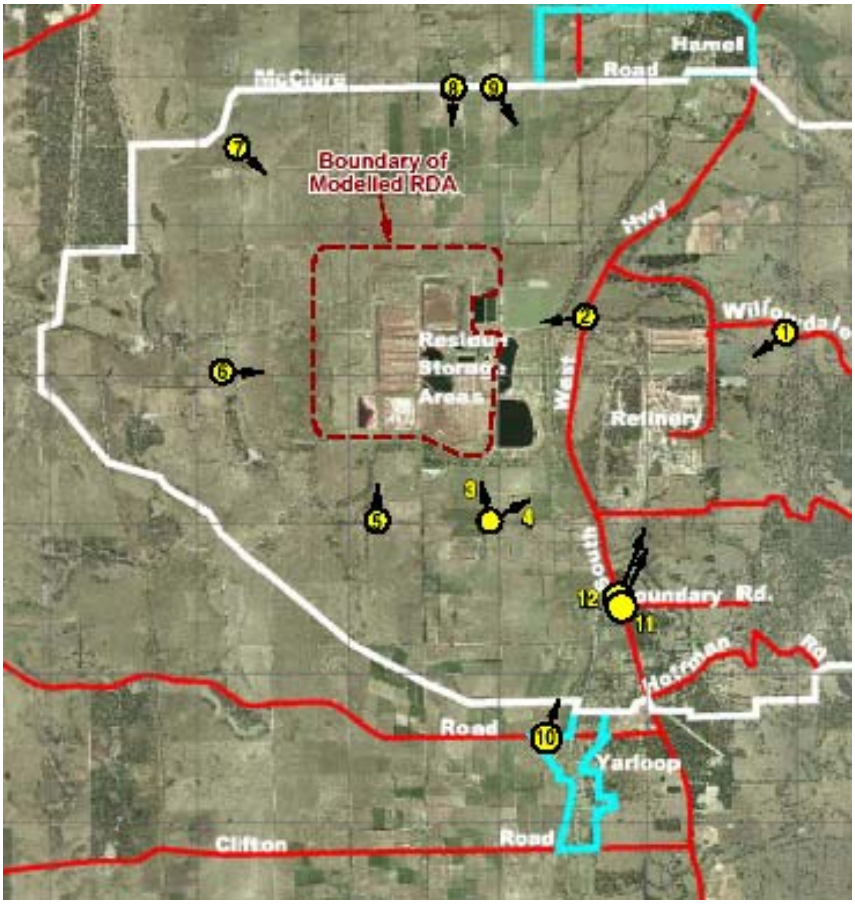
7.18 VISUAL AMENITY

7.18.1 Refinery

A visual impact assessment of the existing refinery and the Proposal was undertaken by Alcoa. Photographs taken of the existing refinery and residue area are shown in Plates 1a to 12 (refer to section 8.15) and proposed visual impact of the Proposal discussed in Section 8.15. Locations of photographic points are shown on Figure 42 on the following page.

The tallest structures on the existing refinery site that are visible from the main public viewing points are the Calciner multiflue (for calciner units 1, 2, and 3) which is 100 m tall, and the Powerhouse multiflue which is 65 m tall. The refinery as a whole is most visible from the Willowdale Mine Access Road, which is a public road, and the stacks are clearly visible from parts of the South West Highway, near Boundary Road. The larger equipment in the refinery, such as the stacks, covered conveyor, alumina storage lime silo and precipitation are visible above the tree line from a number of points surrounding the refinery (refer to Plate 4, 6a, 7a, 9-12).

Figure 42: Visual Amenity Study Photograph Locations



Plumes of steam are visible from various parts of the refinery (e.g. the multiflue) particularly under cool calm conditions, such as just prior to sunrise. Lighting of refinery equipment for safety reasons also makes the facility and its associated light spill visible at night.

7.18.2 Residue Area

The relatively flat landscape surrounding the Wagerup refinery, and the large volume of residue to be stored, means the residue storage area is a prominent feature on the local landscape. The area occupied by residue is visible from viewpoints along the Darling Range and from surrounding farmland. The red colour of the residue contrasts with the surrounding farmland, presenting an obvious change in the landscape. Extensive rehabilitation including mulching and vegetating of existing and new sections of the final external perimeter will reduce intrusive visibility of the residue area.

From the flat plain adjacent to the residue area, the view is dominated by the embankment slopes which are visible from a number of vantage points around the perimeter of Alcoa's property. These are elevated approximately 20 m above the surrounding plain. The existing residue stockpile is visible from Bancell Road (Plate 3a and 5a), South West Highway (Plate

2a) and Somers Roads (Plate 6a and 7a). Residue is barely visible from McClure Road (Plate 8a).

Vegetation planting has been conducted around the residue area over many years with the aim of enhancing visual amenity, providing native vegetation corridors for wildlife and improving species conservation. A Visual Amenity Strategy was prepared as part of planning approval for RDA7 with the aim of:

- enhancing the vegetation screening on Alcoa's property adjacent to the surrounding public roads and neighbouring properties;
- rehabilitate external-facing embankments of the residue area as soon as practicable after construction; and
- blending the residue areas with the surrounding landscape.

Alcoa's current strategy is to blend the residue area into the surrounding landscape by adopting drainage designs that are natural in appearance and creating appropriate contouring and revegetation of the embankments. Significant modification of the views from the Darling Range is not possible. However the proportion of rehabilitated residue area will gradually increase, providing visual improvement of part of the area.

Based on the feedback received via the consultation process for this ERMP, increased emphasis will be placed on vegetation of the embankments to reduce the visible impact of the residue areas from the property boundary.

Closure and Rehabilitation

The rehabilitation of the residue area will be ongoing during the operating life of the refinery. The perimeter embankments will be progressively rehabilitated as the height of the stack rises, and sand capping and revegetation of the surface of the drying beds will occur as each reaches its nominated final elevation. At the time of refinery closure, much of the rehabilitation will be complete with only the minimum drying area remaining to be closed.