Gales-Kingscliff Pty Ltd

ABN: 75 093 540 080

Cudgen Lakes Sand Extraction Project

Air Quality Assessment

Prepared by

Simmonds and Bristow Pty Ltd

April 2008

Specialist Consultant Studies Compendium

Part 9

Gales-Kingscliff Pty Ltd

ABN: 75 093 540 080

Cudgen Lakes Sand Extraction Project

Air Quality Assessment

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EXECUTIVE SUMMARY

Introduction

This report provides a description of the proposed Cudgen Lakes Sand Extraction Project near Kingscliff in the Tweed River Valley of northern New South Wales. It evaluates site specific and cumulative air quality impacts from potential air emissions during progressive stages of site development and sand extraction and processing. It further recommends environmental safeguards and mitigation measures designed to maintain air quality within NSW Department of Environment and Conservation (DECC) air quality goals for dusts.

The Project Site covers an area of 67ha which includes an extraction area north of Altona Drive (9ha), an extraction area south of Altona Drive (37ha) and a processing area north of Altona Drive (3.7ha). The sand extraction operation would occur within part of the Project Site to supply fill sand to a number of nominated fill sites (via two pipeline corridors) and produce a range of sand products for sale to the local construction industry. The Project would also be appropriately licensed to accept virgin excavated natural material (VENM), which would either be used in production of saleable sand products or placed within the extraction ponds. The Project would involve the removal of approximately 5 000 000m^3 of sand over a period of 15 to 20 years in a series of 11 stages.

The operation has been designed to optimise the recovery of sand while addressing and managing the environmental constraints within and surrounding the Project Site. As the Project proceeds, finalised sections of the extraction ponds would be progressively rehabilitated in order to form a recreational lake, surrounding parklands and land suitable for sporting facilities.

Sand would be extracted from the northern extraction site (excavation) over a period of 2 to 3 years for use in production of construction materials. Following completion of the northern extraction site, sand from the southern extraction site, south of Altona Drive (dredging operation), would be used to supply sand to the processing area. It is possible that dredging south of Altona Drive would occur concurrently to supply the Proponent's fill sand requirements.

Local air quality

Local air quality in the Cudgen area is influenced by sub-tropical climatic conditions in the Tweed River Valley. High average rainfall, mainly in summer, and changes in summer and winter wind directions are key factors affecting air quality.

Emission sources of particulates appear to be mainly from diffuse sources such as road transport (motor vehicles) and intensive agriculture (sugar cane). Current (and future) sand extraction (Hanson Tweed Sand) adjacent to the Project Site is also a potential source of localised dusts.

The Condong Sugar Mill is the only significant source of particulates, gases and volatile organics reported within the Tweed River Valley. Motor vehicle emissions would be limited in local dispersion to areas near major roadways.

There is no ambient air quality monitoring reported for the Tweed River Valley airshed by the State or Local Government. Variations in dusts can be expected during cane production and harvesting, other agricultural activities, changes in summer and winter conditions, rainfall and short-term events such as bushfires and strong wind gusts.

Approach to assessment

The primary sources of off-site air emissions from the Project would be dusts or particulates. Vehicle or dredge emissions would be relatively insignificant and practically confined to site and access road corridors. Therefore, air quality assessment for the Project focussed on potential dust emissions during different phases or stages of sand extraction activities and included cumulative air quality impacts on the local airshed.

The approach to this assessment was to use air dispersion modelling (Ausplume V6.0) to predict ground level concentrations of particulates during various phases and activities. Ausplume calculates the pollutant concentration surrounding a source using information on the pollutant emission rate, characteristics of the emission source, local topography, local meteorology and background concentrations of the pollutant. Modelling was carried out in accordance with DECC (2005). *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW.*

Emission sources

A dust emissions inventory has been developed to cover selected model scenarios for the sand extraction and processing activities. This includes adoption of control measures such as road watering and proposed vegetation barriers.

The sand extraction process involves stripping of topsoil, excavation of the upper loamy sand and extraction (dredging or excavation) of the fine-grained sand resource. The processing phase comprises activities such as loading and unloading of materials, stockpiling of materials, screening, blending and transport of materials and products (both on-site and off-site). This analysis addresses the operational aspects of the Project only. Dust emissions from the site decommissioning and final landform stage have not been included as they are expected to be the same as or less than the existing site.

It is proposed to complete extraction in the northern extraction site (i.e. north of Altona Drive) over a period of 2 to 3 years. The sand resource (5m depth) would be recovered by excavation. Due to the high watertable and hence, wet condition of the sand, this approach would not generate significantly greater dust emissions than dredging using a 300mm cutter dredge, which is the proposed technique for recovering sand in the southern extraction site (i.e. south of Altona Drive) over a 15 to 20 year period. Sand recovered during extraction by dredging, and subsequent conveying, washing and stockpiling are wet or moist and sand processing emissions would be negligible.

The cumulative scenarios simulate dust emissions from both the Cudgen Lakes Sand Extraction Project and the Hanson Tweed Sand extraction operation. The dust generating activities at Hanson Tweed Sand are understood to include stockpiling, loading and unloading and the movement of haul trucks on the access road.

Background concentrations

The selection of ambient or background concentrations of dusts for modelling purposes was constrained by the absence of DECC monitoring data for this local airshed and region and only indicative local measurements of TSP and PM_{10}. The approach therefore was to assume conservative background concentrations based on monitoring carried out in Helensvale (Gold Coast Qld) because the NSW Air Monitoring Plan (for the NEPM for ambient air quality) considers the Tweed Heads area to be contiguous with the Gold Coast. The background total deposited dust rate was derived from monitoring carried out at nearby residences from August 2005 to September 2007.

The assumed background concentrations are:

- PM_{10} maximum 24 hour average of 31µg/m^3;
- PM_{10} annual average of 17µg/m^3;
- TSP annual average of 34µg/m^3 (assumes PM_{10} fraction comprises 50% of TSP); and
- total deposited dust rate of 1.5 g/m^2/month.

Meteorological datafile

The meteorological datafile was prepared by pDs Consultancy from Bureau of Meteorology data for the year 2001, which was determined to be a representative year. The nearest meteorological weather station at a similar elevation is located at Coolangatta Airport. This weather station is approximately 10.3km north and 4.6km east of the Project Site. The use of this data is consistent with DECC (2005), which states that site-representative data should preferably be collected at a meteorological monitoring station.

Site control measures

The design of the proposed sand extraction operation includes dust control measures that have been included in the air dispersion modelling. In the northern extraction site, it is proposed to use road watering to reduce dust emissions from vehicle movements on the site. This control measure is expected to reduce dust emissions from this source by 50%.

Road watering would also be carried out in the southern extraction site and has been assumed as standard practice for Hanson Tweed Sand. The processing area has been designed to minimise off site emissions by the construction of a 3m to 4m high continuous bund and vegetation screen. The use of a vegetation screen is expected to reduce dust emissions from the processing area by 30%. Processing controls would include the use of misting sprays, selected covering of conveyors and operation of the screening and blending plant at an average rate of 100 tonnes per hour.

Analysis results

The air quality modelling of both Project and cumulative scenarios predicted peak ground level concentrations of TSP, PM_{10} and deposited dusts at sensitive receptors (e.g. residences and school) located near to the Project activities.

Results of modelling for site establishment indicated small increases in predicted TSP, maximum concentrations of PM_{10}, annual PM_{10} and deposited dusts with total levels remaining well below air quality goals at all receptor locations. Modelling of excavation and processing scenarios in the northern extraction site and extraction activities within the southern extraction site predicted increases in maximum concentrations of PM_{10} at most receptors though levels remained below the air quality goal of 50µg/m^3. The highest predicted PM_{10} value (24hr average) was 47.0µg/m^3 at the Chinderah Golf Range during modelling of combined activities at both Stages 4 and N1. Predicted TSP, annual PM_{10} and deposited dust impacts were also below air quality goals.

Modelling of sand extraction (dredging) and processing scenarios for the southern extraction site, following completion of the northern extraction site, also predicted increases in PM_{10} concentrations at a number of locations surrounding the Project Site. The highest predicted PM_{10} value (24hr average) was 47.1µg/m^3 at the Chinderah Golf Range during modelled activities at Stage 7 of the southern extraction site, ie. below the air quality goal of 50µg/m^3.

TSP, annual PM_{10} and deposited dust levels were well below air quality goals at all locations during each stage of the southern extraction site.

Two cumulative scenarios were also modelled which included approved sand extraction operations at the Hanson Tweed Sand Quarry. Modelling predicted increases in maximum PM_{10} levels at several receptor locations during combined activities within the northern and southern extraction sites and the Hanson Tweed Sand Quarry. The highest predicted PM_{10} value (24hr average) was 50.0μg/m^3 at the Chinderah Golf Range during both scenarios which is equal to the air quality goal. Cumulative TSP, annual PM_{10} and deposited dusts were predicted to be below air quality goals at all locations.

Overall, modelling showed that the significant source contributions to 24 hour PM_{10} concentrations were dusts generated by the screening and blending plant, vehicle movements and clearing of topsoil (primarily in the northern extraction site). Based on administrative controls (e.g. regulating processing rates for screening and blending) and source controls (e.g. maintenance of moisture content), the predicted ground level 24 hour PM_{10} concentrations at the surrounding receptors would comply with the accepted air quality criteria.

It is important to note that predicted air quality impacts are considered to be conservative due to modelling methodologies and assumptions adopted. Emissions from screening and blending, for example, assumes a constant daily processing rate, whereas in practice the plant is unlikely to operate on each operational day. Nonetheless, the assessment supports the need for environmental safeguards and mitigation measures, in conjunction with the air quality monitoring program recommended by this assessment, to control fine dust emissions and demonstrate compliance with air quality goals.

1 INTRODUCTION

Envirotest, now Simmonds and Bristow, has been commissioned by R.W. Corkery & Co. to conduct an air quality assessment for the Cudgen Lakes Sand Extraction Project (the "Project") on behalf of Gales-Kingscliff Pty Ltd (the "Proponent").

The air quality assessment forms part of the Environmental Assessment (EA) for the Cudgen Lakes Sand Extraction Project at Cudgen near Kingscliff in the Tweed Local Government Area (LGA), northern NSW.

The environmental requirements raised by the Director-General of the NSW Department of Planning and the environmental issues raised by various government agencies require that the EA must assess the potential impacts of the Project on air quality and describe what measures would be implemented to avoid, minimise, mitigate, offset, manage and/or monitor these impacts. **Appendix 3** of this report lists each of the EA requirements relevant to air quality and provides reference to the sections of this report where each requirement is addressed.

2 SCOPE OF AIR QUALITY ASSESSMENT

The scope of work covered in the air quality assessment of the Project is summarised below.

1. Literature review of available air quality-related studies.
2. Investigation and assessment of existing air quality at the Project Site and nearby receptors.
3. Assessment of the potential impact of the Project on local air quality using seven operational scenarios for air modelling purposes.
4. Assessment of the potential cumulative impact of surrounding land uses on air quality.
5. Design of operational safeguards or mitigation measures.
6. Preparation of an air quality assessment report incorporating methodology used, modelling data, results of above assessments, and safeguards for the Project.

The scope takes into account the Director-General's Requirements for the Project which relate to air quality.

3 DESCRIPTION OF PROJECT

3.1 Project Site

The Project Site covers an area of 67ha which includes:

- a 9ha extraction site north of Altona Drive ('northern extraction site');
- a 37ha extraction site south of Altona Drive ('southern extraction site'); and
- a processing area north of Altona Drive covering an area of 3.7ha.

Figure 1 shows the location of the Project Site and Study Area while **Figure 2** shows the layout of the Project Site.

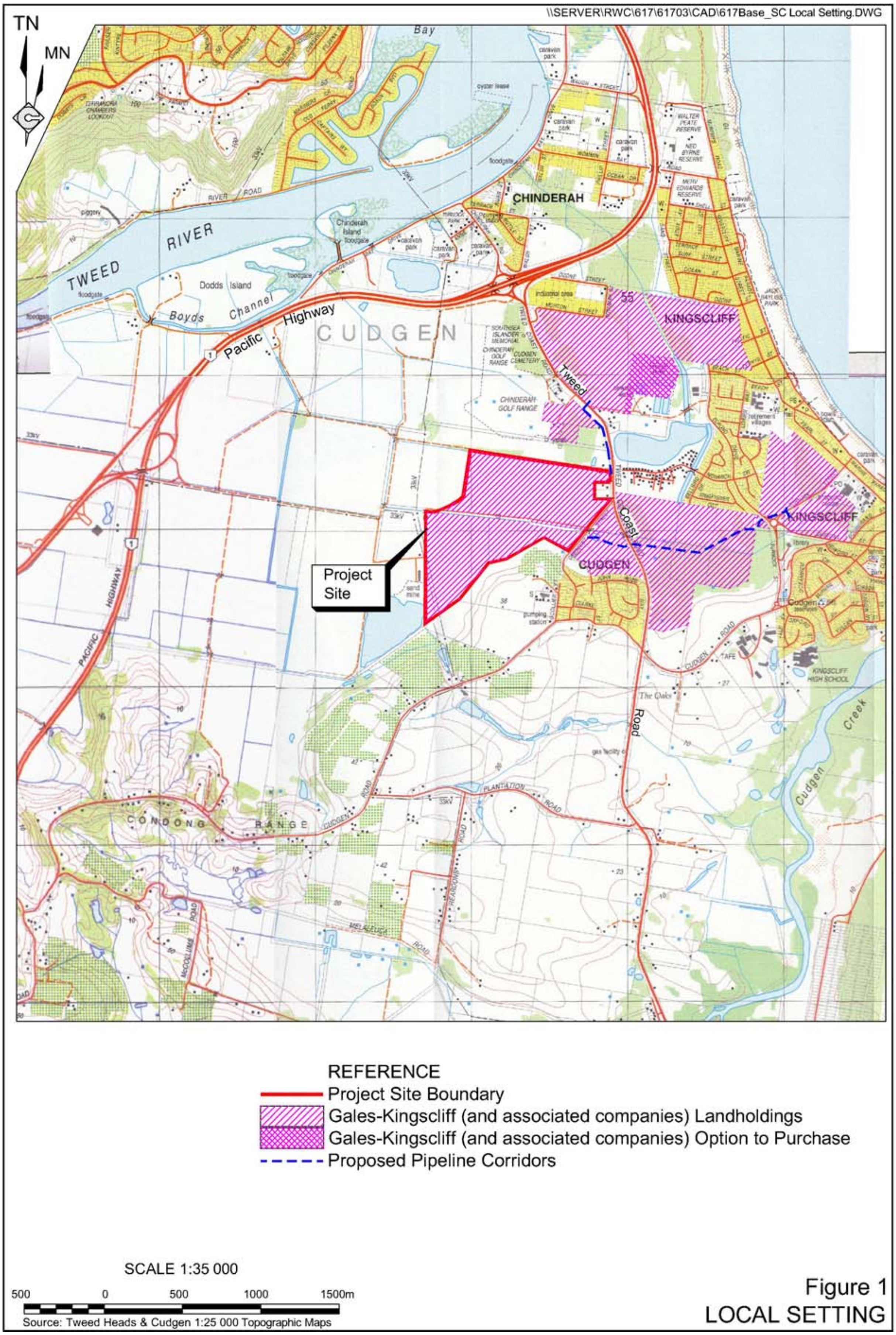


Figure 1
LOCAL SETTING

Note: A colour version of this figure is available on the Project CD.

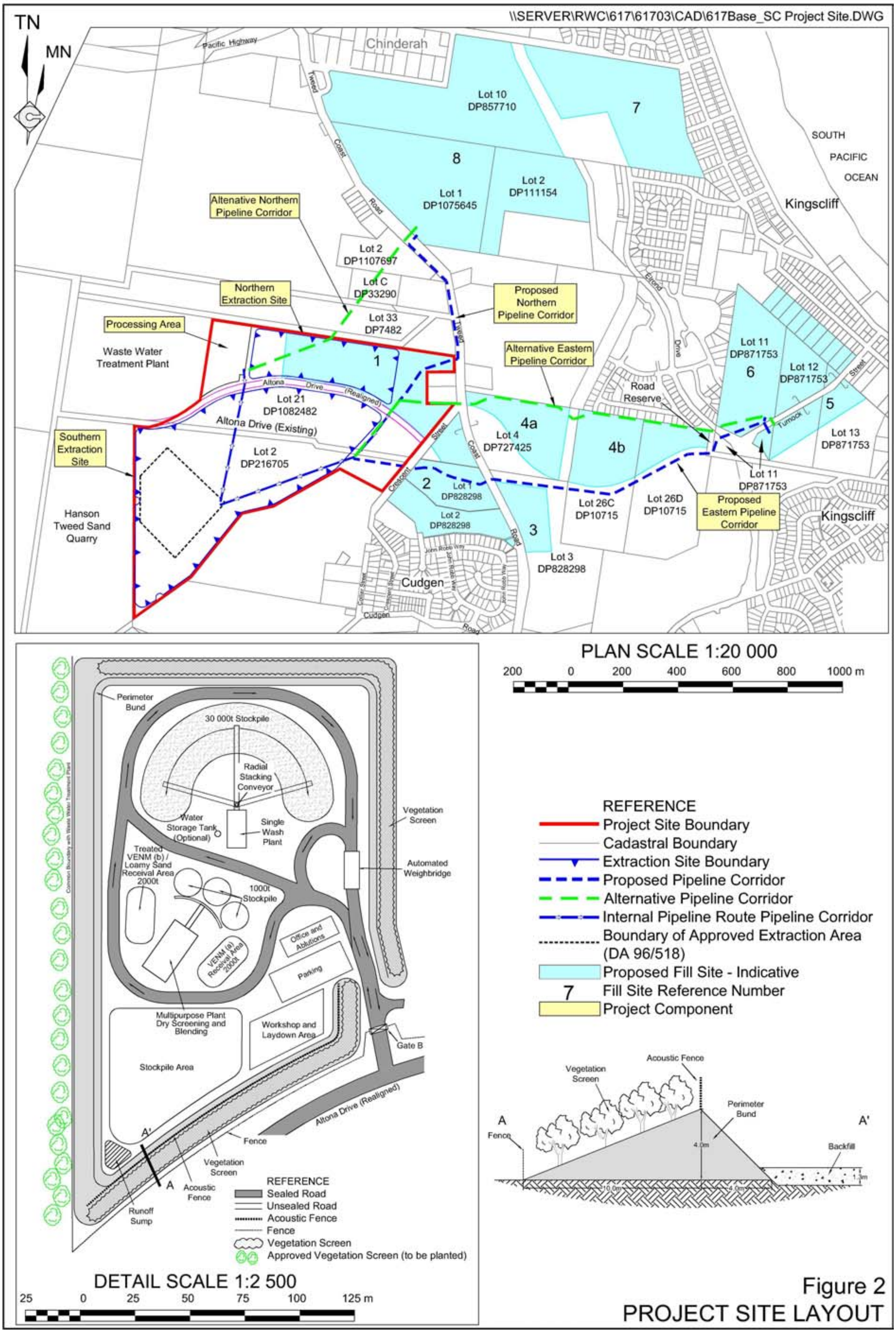


Figure 2
PROJECT SITE LAYOUT

Note: A colour version of this figure is available on the Project CD.

Two pipeline corridors are also proposed extending north and east from the southern extraction site (see **Figure 2**). These are referred to as the "northern pipeline corridor" (0.8km in length) and the "eastern pipeline corridor" (1.5km in length). The proposed northern pipeline corridor would be located in the road reserve on the western side of Tweed Coast Road. The proposed eastern pipeline corridor would be located within the road reserve for a proposed subdivision road east of Tweed Coast Road within land owned by the Proponent. It is acknowledged that the proposed road east of Tweed Coast Road has not yet been approved. Therefore, an alternative eastern pipeline corridor (see **Figure 2**) has been proposed in the event that the proposed road is not approved within a suitable timeframe. An alternative northern pipeline has also been proposed in the event that suitable agreements are reached with an adjoining landholder.

The extraction sites and processing area are located within Lot 21 DP 1082482 and Lot 2 DP 216705 together with the existing road reserve for Altona Drive. The proposed northern pipeline corridor commences adjacent to the northeastern boundary of Lot 21 DP 1082482, is aligned for a distance of approximately 450m adjacent to the western side of Tweed Coast Road and then crosses Tweed Coast Road ending on the boundary of Lot 1 DP 1075645. The proposed eastern pipeline corridor commences adjacent to the eastern boundary of Lot 21 DP 1082482, crosses Tweed Coast Road and traverses Lots 1 and 3 DP 828298, Lot 26C and 26D DP 10715, Lot 11 DP 871753 and the road reserve situated between Lot 26D DP 10715 and Lot 11 DP 871753 before crossing Elrond Drive and Turnock Street.

The Project Site and Pipeline corridors are located within the County of Rous and the Tweed Local Government Area.

3.2 Site Activities

The Proponent proposes to develop and operate a sand extraction operation to supply fill sand to a number of nominated fill sites via two pipeline corridors and to produce a range of sand products for sale to the local construction industry. The Project would also be appropriately licensed to accept virgin excavated natural material (VENM) which would be used in the production of saleable sand products, used to backfill the northern extraction pond or interned at or near the base of the southern extraction pond. The Project would involve the removal of approximately 5 000 000m^3 of sand over a period of 15 to 20 years.

The operation has been designed to optimise the recovery of sand whilst at the same time addressing and managing the environmental constraints within and surrounding the Project Site. As the Project proceeds, the northern extraction pond would be progressively backfilled to ultimately form sporting fields and recreational facilities and finalised sections of the southern extraction pond would be progressively rehabilitated in order to form a recreational lake and surrounding parklands.

Construction and site establishment would occur over an approximately 3 month period in which three site entrances and internal roads would be constructed together with the processing plants, offices, workshop and perimeter bunding. The dredge, pipelines to the processing area, pumps and other equipment would also be installed during the construction period. Construction activities would occur between 7:00am and 6:00pm Monday to Friday and 7:00am to 1:00pm Saturday.

The extraction sequence would involve: stripping of topsoil; formation of bunds; and extraction of the sand resource (loamy sand and fine grained sand). Extraction of all material within the northern extraction site would be undertaken over a single stage incorporating four substages progressing east to west to a depth of up to 5m using excavator and trucks. Sand would be extracted from the northern extraction site over a period of 2 to 3 years and supply sand to the processing area for the production of construction materials.

Within the southern extraction site extraction would occur over 10 stages, generally progressing west to east. Extraction would occur to the depth of the resource, typically 20m below current ground level with the upper loamy sand material extracted using an excavator and the remaining fine grained sand material extracted using a cutter-suction dredge.

The upper loamy sand material would be treated using alkaline amendments, such as agricultural lime, prior to being transferred to the processing area for production of various construction materials, such as mortar sand. The fine grained sand material would either be trucked or pumped to the processing area and washed to remove oversize and undersize materials, producing construction grade sand, or be pumped to a nominated fill site (southern extraction site only) for use as fill material. All fines separated during processing or returned from the fill sites would be returned towards the base of either the northern or southern extraction pond.

All soil removal and excavation of sand (ie. mechanical removal) would occur between 7:00am and 6:00pm Monday to Friday and 7:00am to 1:00pm Saturday. Dredging and pumping of sand to the processing area, and processing activities, would occur between 6:30am and 10:00pm Monday to Friday and 7:00am to 4:00pm Saturday whilst dredging of sand for pumping to fill sites would occur between 6:30am and 6:30pm Monday to Friday and 7:00am to 1:00pm Saturday.

Sand to be used as a filling material to raise the level of various parcels of land in the Kingscliff, Chinderah and Cudgen areas would be pumped hydraulically to the fill sites from the southern extraction site as a sand / water slurry. Water draining from the sand at the fill sites would be pumped back to the southern extraction pond. The Proponent intends to use up to two enclosed staging pumps beyond the dredge to convey the sand to the fill sites, one located within the Project Site and one within each pipeline corridor. Pumping would only occur along one corridor at a time. Up to 450 000m^3 of sand could be pumped annually to the fill sites.

Based on maximum annual sales of 300 000tpa (200 000m^3) average truck loads of 20t and transportation 5.5 days per week, 50 weeks per year the average number of product truck movements on any weekday or Saturday would be approximately 100 and 60 respectively (50 and 30 loads). As sales would vary from day to day, the 85th percentile number of product truck movements on the local roads on a busy weekday or Saturday would be 130 and 80 respectively (65 and 40 loads). It is noted that, in reality most products would be despatched using truck and dog trailer rigs with capacities of 30t to 33t. Therefore the use of 20t truck capacities is considered conservative. Based on the importation and receipt of up to 45 000tpa (30 000m^3) of VENM, it is estimated that the incoming VENM would generate approximately 24 truck movements (12 loads) per week. The 85th percentile volume has been estimated at 32 truck movements (16 loads) per day.

In total, it is assumed, once the Project is fully operational, the despatch of products and importation of VENM would generate up to 124 truck movements (62 loads) per day on an average day. All product distribution and VENM receipt would occur between 7:00am to 6:00pm Monday to Friday and 7:00am to 1:00pm Saturday.

Both non acid generating VENM - VENM(a) and acid producing VENM – VENM(b) would be received at the Project Site via road trucks, appropriate details recorded and the material classification verified. VENM(a) would either: be processed to produce saleable products or used to backfill the northern extraction pond or finalised edges of the southern extraction pond. VENM(b) which is suitable for processing would be placed adjacent to the southern extraction pond for treatment, as for the loamy sand material, prior to processing. VENM(b) not suitable for processing would be either used to backfill the northern extraction pond or interned at or near the base of finalised sections of the southern extraction pond.

All VENM delivered to the Project Site and processed materials despatched from the processing area would be transported via Altona Drive, Crescent Street and Tweed Coast Road. Access to the Project Site would be provided via three entrances off Altona Drive, one to the processing area and northern extraction site and two to the southern extraction site.

The Proponent would adopt a progressive approach to site landscaping and rehabilitation to ensure that, wherever possible, disturbed areas are either temporarily or permanently stabilised to limit erosion and adverse visual impacts. An important component of the rehabilitation of the Project Site would be the progressive backfilling of selected finalised sections of the shore of the southern extraction pond and introduction of native vegetation to create wetland areas and parklands. The construction of recreational facilities such as walking and equestrian / cycling tracks would occur following completion of sand extraction activities. The final lake would have a depth of up to 20m and cover an area of approximately 37ha.

3.3 Surrounding Land Uses

The Project Site is located in the Kingscliff, Chinderah, Cudgen area and is surrounded by a mix of urban development, infrastructure (e.g. road networks and sewage), sports, recreation and educational facilities, sand extraction activities, agricultural cropping and grazing lands.

An existing extractive industry trading as Hanson Tweed Sand Quarry (formerly Tweed Turf and Sand) is located to the west of the Project Site. A range of agricultural activities (e.g. horticulture and grazing) is also located around the boundaries of the Project Site to the south and north.

The nearest urban development is the residential area of Cudgen located to the southeast on the Cudgen Plateau partly overlooking the Project Site. Two residential properties are located near the eastern boundary of the Project Site adjacent Tweed Coast Road with sub-division development on the other side of this road, further to the east. The southern boundary of the Chinderah Golf course operates approximately 150m to the north of the Project Site.

Further developments of interest to the Project include:

- a wastewater treatment plant (WWTP) adjacent the northwestern boundary of the Project Site which is currently undergoing construction; and
- a recently approved expansion (to the area of extraction and Project life) of the Hanson Tweed Sand extraction operation on the western boundary of the Project Site.

The construction of the WWTP would be undertaken in two stages based on estimated population growth. Stage 1 construction is to be completed by late 2007 and is to serve 25 000 equivalent persons. The WWTP will be further augmented (Stage 2) by 2015 to serve 50 000 equivalent persons (GHD, 2002).

The approved expansion of the Hanson Tweed Sand operation involves an area of 77.22ha, approximately 800m west of the Cudgen residential area, within Lot 22 DP10824351, Lot 23 DP1077509 and Lot 494 DP720450 Crescent Street, Cudgen (Jim Glazebrook and Associates Pty Ltd, 2005). Future expansion phases (3 to 4) cover an area of about 53.2ha (68% of the site) with phase 4 located to the west of the existing operations.

4 ASSESSMENT OF EXISTING AIR QUALITY

4.1 Approach

The air quality assessment involves several phases which are outlined below.

- Review, investigation and assessment of existing air quality at the Project Site and proposed fill sites.
- Review of available air quality data relevant to the Tweed River Valley airshed, local emission sources and likely air quality ranges.
- Identification of existing and potential air pollutants (e.g. particulates).
- Limited field monitoring for airborne particulates, i.e. PM_{10}, total suspended particulates (24hr) and insoluble dust deposition to indicate background ranges from existing activities in the local airshed.
- Assessment of existing emission sources, available air quality data and potential project-related and cumulative impacts.
- Design of operational safeguards and mitigation measures.

4.2 Local Airshed

The local airshed is defined by the Tweed River Valley (the "Valley") which is described as a large eroded caldera formed over the past 20 million years from the Mt Warning shield volcano (World Heritage Information Network, 2005). The Valley floor is bounded by the McPherson Range to the north, the dominant magma plug of Mt Warning and the Tweed Range to the west, the Nightcap Range to the south and the coastal foothills and alluvial plains that meet with the Pacific Ocean to the east.

The well drained and rich post glacial deposits of alluvia on the caldera floor have favoured the development of intensive sugar cane on the lower river flood plains, cattle and dairy farming mainly in the upper valleys and foothills and also horticulture. Horticulture has developed in the red Krasnozem soils present on coastal hills around Cudgen. There is sand extraction in the lower Tweed River, flood plain and coastal deposits of sedimentary sands. The extraction of beach mineral deposits has also historically occurred along the coastal foredunes at Kingscliff.

Human settlement has concentrated mainly along the Tweed River at Tweed Heads, Murwillumbah, Condong, Chinderah and Tumbulgum. Coastal urban development has focussed at Tweed Heads, Kingscliff and Cudgen. Small rural villages such as Stokers Siding and Uki have established in the Upper Valley. Within the local area, tourism and urban development have expanded at Kingscliff with urban sub-division extending to West Kingscliff and into the rural areas of Cudgen.

Major infrastructure impacts in the Valley are primarily related to the Pacific Highway upgrade and diversion of the highway west of the Project Site and also the upgrade of Tweed Valley Way through Murwillumbah. Within the Study Area, other major roads include Tweed Coast Road and Cudgen Road. The existing Kingscliff waste water treatment plant is located approximately 0.6km to the northeast of the Project Site but is currently being relocated adjacent to the northwest boundary of the Project Site. Secondary industrial activity in the Valley is relatively minor with the only significant point source emission being from the sugar mill at Condong.

Large areas of the Valley floor and coastal plain have been cleared for intensive agriculture, mainly sugar cane. However, remnant vegetation includes coastal dune vegetation, coastal wetlands and eucalypt forests, while the entire basin of the Valley and mountainous regions are bounded by four world heritage listed national parks.

The topography and intensity of activities in the Valley are key factors influencing the existing air quality in the local airshed of the proposed development along with climatic factors such as drainage flows of air. Such factors are discussed below.

4.3 Climate

The Valley's climate is sub-tropical with an average rainfall of 1510 to 1740 mm/year. It experiences warm to hot wet summers and dry, mild to cold winters. Strong coastal breezes dominate during summer between Tweed Heads and Kingscliff. Southerly winds are common in the mornings with a shift to northerly and southeasterly in the afternoons.

Winter conditions tend to be dominated by surface winds flowing down the inland slopes and river valley towards Tweed Heads-Kingscliff. Southerly and southwesterly winds are prevalent in the mornings shifting to southerly winds in the afternoons.

Offshore breezes are considered refreshing during summer. Winter and autumn winds, however, occur from the south and southwest and are more likely to transport airborne dusts or particulates from the valley floor towards Cudgen and West Kingscliff. Rainfall data for Tweed Heads and Coolangatta are given in **Table 1**.

Table 1
Climate Data – Coolangatta and Tweed Heads

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Coolangatta													
Mean daily max	27.9	28.0	27.1	25.1	23.0	20.9	20.3	20.9	23.0	23.9	25.3	26.8	24.4
Mean daily min	20.9	20.9	19.9	17.0	14.5	11.5	10.3	10.8	13.5	16.1	18.1	19.7	16.1
Mean Rainfall	130.5	136.6	219.0	224.5	170.3	110.8	88.2	49.4	35.9	85.9	119.2	139.7	1509.9
Median Rainfall	88.6	124.0	158.8	117.6	141.2	71.2	53.6	45.6	18.1	68.5	118.2	132.6	1317.0
Mean Rain Days	13.9	16.1	18.7	17.0	17.2	12.8	9.8	8.4	7.4	10.9	13.6	13.1	158.9
Source: Bureau of Meteorology 2006 (1982-2004)													
Tweed Heads													
Mean daily max	28.1	28.1	27.6	25.9	23.4	21.1	20.5	21.1	22.7	23.8	25.7	27.5	24.63
Mean daily min	21.8	21.7	20.7	18.5	15.5	12.6	11.6	12.1	14.5	16.6	18.8	20.8	17.1
Mean Rainfall	194	266	262	159	147	127	87	68	55	116	117	142	1740
Median Rainfall	158	196	240	138	131	73	57	59	46	91	86	111	1386
Mean Rain Days	12	13	14	11	10	8	7	6	6	9	9	10	115
Source: Tweed Shire Council, 2006													

4.4 Air Emissions

4.4.1 Types of Air Pollutants

Existing and potential air pollutants of interest in the local airshed can be broadly classified as the following.

- Particulates or dusts (total suspended particulates (TSP)) and fine particulates (PM_{10}, $PM_{2.5}$).
- Gases (carbon monoxide, nitrogen oxides and sulphur dioxide).
- Halides (hydrogen chloride, hydrogen fluoride and chlorine).

- Volatile organic compounds (VOCs) (petroleum hydrocarbons, aldehydes, benzene and toluene).
- Metals (lead, zinc and cadmium).
- Odorous compounds (e.g. hydrogen sulphide, ammonia and various volatile organics).
- Pesticides (e.g. insecticides, fungicides and herbicides).

However, the major air pollutant from the Project would be particulates, which may be generated by land clearing, earthworks, sand handling and haul trucks and are discussed in the following sections. Haul trucks would also contribute to combustion gas emissions (e.g. nitrogen oxides) in the region and there would be minor diesel emissions from the dredge. There would be no halide, VOC, metal, odorous compounds or pesticides emissions generated by the Project.

Particulates or dusts are particles that are suspended in the air (total suspended particulates). The period that particulate matter remains suspended depends on the range of particle sizes. Larger particles (greater than 50µm) remain in the air for a short time and settle near the source (dust deposition). Smaller particles (less than 10µm, known as PM_{10}) can remain in the air for several days and be spread by winds over wide areas or long distances from the original source. Fine particles (0.1-2.5µm) may remain in the atmosphere indefinitely (Qld EPA, 2006). Suspended particulates are generally removed from the atmosphere by rain and when they come into contact with surfaces.

Combustion processes such as motor vehicles emit most of the particulate emissions in urban areas. Other noticeable sources of particulate emissions include domestic solid fuel heaters and woodstoves.

High levels of particulate matter may contribute to increased rates of respiratory illnesses and symptoms. Studies indicate that adverse effects are dependent on a number of factors including:

- particle size (i.e. whether particles can penetrate lower airways);
- the intensity of the exposure;
- the chemical nature of the particles and their interaction with human tissue;
- the presence or absence of pre-existing conditions (especially diseases of the respiratory tract); and
- meteorological factors such as winds, humidity, temperature inversions, rain or thunderstorms.

Respirable particles (those with diameter less than 10µm) are understood to pose the greatest risk to human health (Qld EPA, 2006). There have been extensive studies into the health effects of different levels of particulate pollution but no studies have yet determined a threshold value for long-term or short-term exposure below which no adverse health effects are observed.

Of the total PM_{10} fraction those particles with aerodynamic diameters below 2.5µm, or $PM_{2.5}$, are now considered to be the major contributor to human health effects, as these particles can penetrate and block the very small passages of the lungs. The National Environment Protection Measure (NEPM) for ambient air quality has been varied to include an advisory $PM_{2.5}$ standard of 25µg/m^3 for 1 day and 8µg/m^3 for 1 year (NEPC, 2003).

Silica is the main component of the sand to be extracted. Fine grained silica dust (<10μm) (capable of contributing to health issues) is usually generated when materials with a high silicon content are milled, crushed or processed in a way that generates fine particulates which in turn becomes an occupational health and safety issue. There would be no milling or crushing operations proposed in this Project. Hence, this issue is not addressed in this report.

4.4.2 Sources of Emissions

1. Point Sources

There are insignificant point sources of emissions in the local airshed at West Kingscliff and Cudgen. Further west at Condong, the sugar mill (and proposed cogeneration plant) is a visible source of smoke particulates during the cane crushing season (between June and December). The proposed cogeneration plant would result in the generation of emissions continuously throughout the year, however, the proposal includes a scrubber system to substantially remove particulates and gaseous emissions.

2. Area or Diffuse Sources

The area sources of significant air emissions in the airshed can be divided into the following.

Biogenic

Sugar cane burning prior to harvest is a major seasonal source of particulate deposition and fine particulates (smoke). Less than 2% of growers in NSW were reported to be harvesting cane green (NSW DECC (EPA), 1997), but the future trend in the valley is towards green harvesting which will practically eliminate this form of background particulate pollution in this airshed.

Bushfires and forestry burning are also infrequent regional airshed sources of smoke particulates. The impact on air quality will largely depend on meteorological conditions at the time of burning. Hazard reduction burning is a practice carried out in National Parks and water supply catchments (NSW DECC (EPA), 1997).

Traffic Emissions

Significant traffic emissions (particulates, carbon monoxide, nitrogen oxides and VOCs) will occur along the Pacific Highway and to a lesser degree along the Tweed Coast Road and Cudgen Road. Exposures to traffic emissions are practically limited to 20m or less from the roadside, especially in the case of flowing traffic. Dispersed and persistent emissions such as fine particulates and lead, however, contribute to the "background" contaminants in the airshed.

Existing Sand Extraction Operation

Hanson Tweed Sand Quarry (formerly Tweed Turf and Sand) operates a sand extraction operation on land off Crescent Street, Cudgen, which is located immediately adjacent to the western perimeter of the Project Site. It is a potential source of particulate emissions. The existing land use on the site includes its Phase 1 and 2 sand extraction areas, a tea tree plantation (50ha) and tea tree distillery/manufacturing plant (NSW Department of Planning, 2006).

The primary air pollutants from the operation would include airborne particulates with minor diesel exhausts from mobile plant and dredges.

Development consent to extend the existing sand quarry into Phases 3 and 4 was received in July 2006. Phase 3 involves additional sand extraction from the existing Phase 1 pond to a depth of approximately 20m and Phase 4 involves expansion of the extraction area to the west of Phases 1 and 3.

Existing Waste Water Treatment Plant (WWTP) – Kingscliff, Tweed Coast Road

Secondary waste water treatment plants are potential sources of odours and gaseous emissions (e.g. hydrogen sulphide). The new WWTP is currently being constructed to the northwest of the Project Site and will replace the existing plant.

Agriculture

Exposed soils and farm activities such as ploughing are significant sources of windborne dusts that will influence air quality within the local airshed. The large areas of intensive sugar cane in the local airshed are potential sources of seasonal dusts and local deposition depending upon climatic conditions.

Pesticide spraying can also cause infrequent local impacts depending upon factors such as method of application, droplet sizes, active ingredients, toxicity, odours and environmental conditions. Local horticulture, sugar cane farming and roadside vegetation control are potential sources that can affect the existing airshed near residential areas.

Construction Works

Construction activities due to urban expansion and road building are other diffuse sources of dust emissions to the airshed. Critical factors include soil silt content, moisture, wind speed, the exposed area, stockpiles, mechanical disturbance and control measures.

4.5 Existing Air Quality

4.5.1 NPI Reported Emissions

The National Pollutant Inventory provides additional detail on air emissions to the Tweed Shire. The top sources of emissions are indicated in **Table 2**. The primary sources are transport-related emissions, the sugar mill, hydrocarbons and solvent emissions.

Table 2
NPI Emissions Data for Tweed Shire Airshed

Source	%
Aeroplanes	18.5
Motor vehicles	15.0
Other food manufacturing (Condong Sugar Mill)	14.8
Architectural surface coatings	12.8
Domestic/commercial solvent aerosols	11.9
All others	26.9
Source: NPI Database (2006)	

Emissions of interest from the main point source, i.e. the Condong Sugar Mill, are given in **Table 3**. These are ranked by the NPI as low. In May 2005, a new Project known as the ‘Cogeneration Project’ commenced at the Condong Sugar Mill (Tweed Shire SoE, 2005). This Project involves installing a state-of-the-art boiler and 30 Mega Watt (MW) steam generator, which is expected to improve air emissions quality. The Project also involves processing green cane, which will reduce cane burning in the Shire.

Table 3
Condong Sugar Mill Emissions to Air of Major Substances (2004 to 2005)

Substance	kg/year
Carbon monoxide	380000
Ethanol	4800
Oxides of nitrogen	210000
Particulate matter (10μm)	710
Total volatile organic compounds	4800
Sulphur dioxide	57000
Source: NPI Database (2006)	

4.5.2 NSW DECC (EPA) Monitoring

The NSW Air Monitoring Plan for the NEPM for ambient air quality identifies three types of regions based on population data and concentration within a region. A region for the purposes of performance monitoring is a geographical area where the air quality for a pollutant is determined either entirely or in large part by the influence of a common collection of anthropogenic emission sources.

For the Tweed Heads area, which is considered by the plan to be contiguous with the Gold Coast, it is proposed that it falls into a Type 3 region (i.e. a region with a population in excess of 25 000 but with no significant point or area based emissions), so that ancillary data can be used to infer that direct monitoring is not required and it is not proposed to conduct monitoring here (NSW DECC (EPA)).

The Plan considers that the region is not densely populated and has no major industrial, domestic or commercial sources. Even so, it is part of a continuous airshed with the Gold Coast which will be monitored as part of the Queensland monitoring plan and the data will be used to infer concentrations in the sub-region of the Tweed Heads for review of classification (NSW DECC (EPA), 2002).

As indicated above, ambient air quality in the Tweed River Valley airshed has not been monitored historically.

4.5.3 Other Ambient Air Quality Data

1. Tweed Shire Council

No air quality monitoring is reported in State of the Environment Reports.

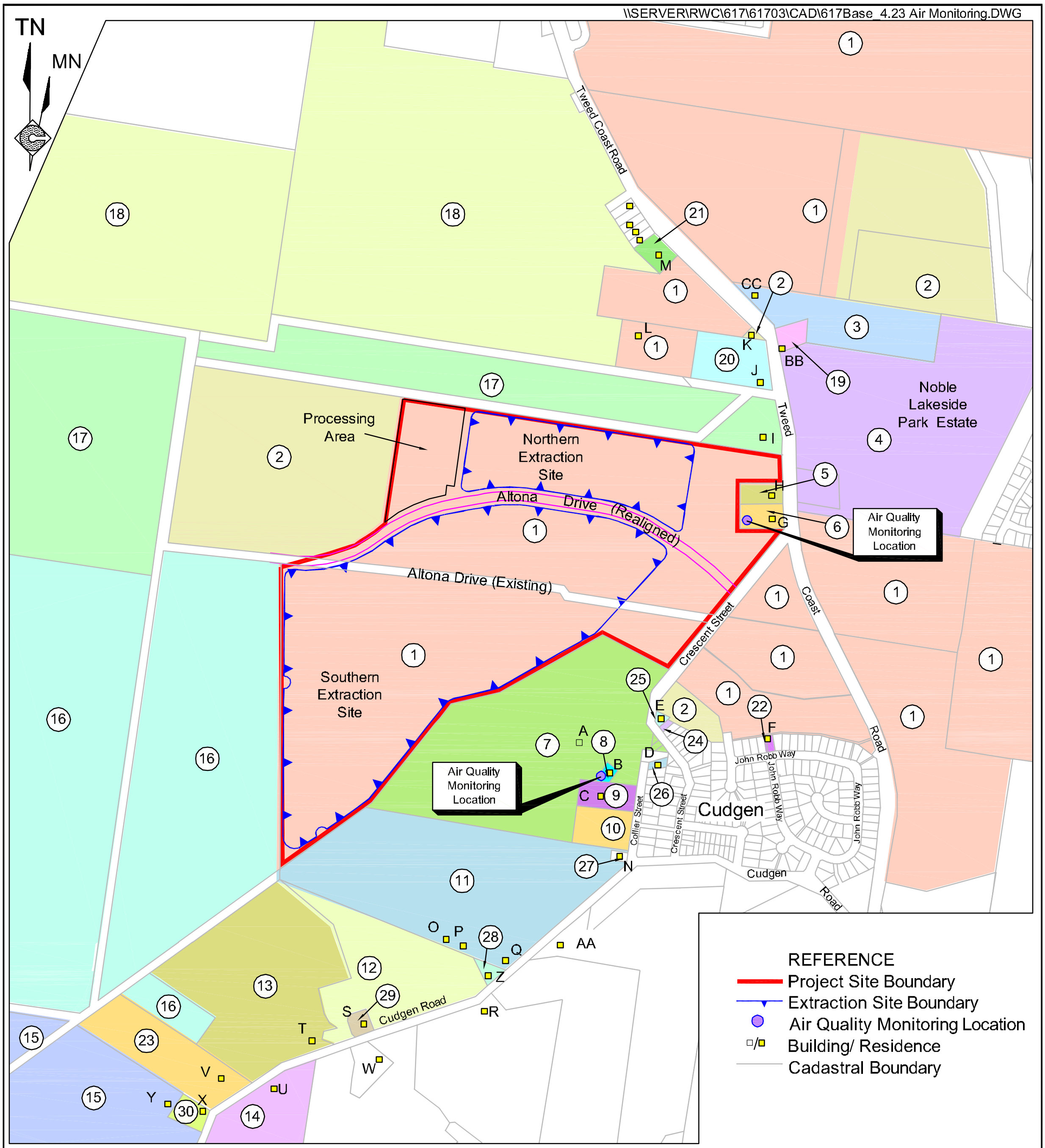
2. Industrial Sources – Hanson Tweed Sand Quarry

The EIS prepared for the proposed expansion of the existing sand extraction operation (Jim Glazebrook and Associates Pty Ltd, 2005) does not include any site specific ambient monitoring data for this operation or the local airshed.

4.5.4 Project Site Surrounds

As part of this assessment undertaken for RWC on behalf of the Proponent, Simmonds and Bristow has conducted indicative "background" monitoring of ambient levels of suspended particulates, insoluble dust fallout and indications of PM_{10} at two monitoring locations around the Project Site, namely:

- Receptor B (R and B Julius, farm residence on Cudgen Plateau, adjacent Cudgen Public School) (**Figure 3)**; and
- Receptor G (L and P Hermann, private residence on the corner of Crescent Street and Tweed Coast Road).



Reference	Owner
1	Gales Holdings / Projects Pty Ltd
2	Tweed Shire Council
3	P. Phillips
4	Baglon Pty Ltd
5	K. Martin
6	L. & P. Hermann
7	R. Julius
8	R. & B. Julius
9	NSW Dept. of Education
10	Tweed Shire Council
11	C. Pritchard & W. Julius
12	H. & R. Taylor
13	S. Thomson
14	S. & G. Melville
15	I. Kettle & M. Stephens
16	P Guinane Pty Ltd
17	C. Cooper
18	J. Brinsmead
19	B. Rudman
20	M. & J. O'keeffe
21	J. Brinsmead
22	T. & L. Rascionato
23	S. Elworthy
24	S. & A. Lawton
25	V. Long
26	D. & J. Clark
27	R. & C. Prichard
28	P. & H. Hardy
29	Country Energy
30	D. Green

SCALE 1:15 000

250 0 250 500 750 m

Land Ownership Source: Dept. of Lands (2005)

Figure 3
MONITORING LOCATIONS

Note: A colour version of this figure is available on the Project CD

The dust gauge at Receptor G was located in the southwestern corner of the backyard. The dust gauge at Receptor B was located approximately 100m north of the property boundary with Cudgen Public School and adjacent an unsealed access road and active agricultural fields.

Monitoring for total suspended particulates (TSP) was carried out using a calibrated Microvol ambient air sampler. The 24 hour dust results for Receptor G ranged from <20µg/m^3 to 93µg/m^3 with an estimated mean of ≤22µg/m^3 (9 to 16 September 2005). At Receptor B, the range was from <20µg/m^3 to 46µg/m^3 (9 to 12 September 2005) with an estimated mean of ≤22µg/m^3.

Estimated means at both sites were equal which indicates consistent prevailing climatic conditions at both sites. Receptor B is elevated and potentially influenced by farm activities, while Receptor G is adjacent to Tweed Coast Road. September winds measured at Coolangatta Airport (BOM Station No. 040717) are variable from the north to southwesterlies at night and until early morning switching to the north and southeasterly during the day.

Ambient PM_{10} dust readings using a TSI Dust Trak monitor measured at Receptor G averaged 5µg/m^3 (1µg/m^3 to 11µg/m^3) on 9 September 2005. Further PM_{10} readings on 8 October 2005 (afternoon) averaged 64µg/m^3, adjacent to Crescent Street near Cudgen Plateau. Strong wind gusts (NE/E) and hot conditions (35°C) prevailed. In the Condong Mill area, the average PM_{10} was 62µg/m^3 on the same day. Visibility throughout the Valley was substantially reduced and Mt Warning was completely obscured by haze. Winter readings of PM_{10} (short term) by Envirotest around Cudgen in August 2000, in the absence of sand extraction activities, have indicated low average values of <10µg/m^3.

Deposited dust monitoring results are shown in **Table 4**. The average result from both sites over all monitoring events is 1.5 g/m^2/month. The rate of dust deposition at Receptor B varied from 2.0g/m^2/month during the first 12 month period and 1.4g/m^2/month during the second 12 month period. At Receptor G, average deposited dust levels were 0.6g/m^2/month during the first 12 months and 1.8g/m^2/month during the second period of 12 months. The higher results at Receptor B during the first 12 months were likely to be influenced by farm activities at this location. The reason(s) for the consistent increase in deposited dust at Receptor G since October 2006 has not yet been established.

Table 4
Insoluble dust fallout, Cudgen (September 2005 to September 2007)

Sampling Period	Insoluble dust fallout (g/m^2/month)		Sampling Period	Insoluble dust fallout (g/m^2/month)	
	Receptor B	Receptor G		Receptor B	Receptor G
09/09/05 – 08/10/05	1.9	0.8	26/09/06 – 26/10/06	1.7	1.7
08/10/05 – 10/11/05	2.5	0.4	26/10/06 – 26/11/06	1.4	2.4
10/11/05 – 10/12/05	1.9`	0.8	26/11/06 – 26/12/06	2.5	1.4
10/12/05 – 13/01/06	1.2	0.7	26/12/06 – 31/01/07	1.4	2.2
13/01/06 – 16/02/06	-*	0.8	31/01/07 – 26/02/07	2.0	0.6
16/02/06 – 19/03/06	1.9	0.8	26/02/07 – 26/03/07	1.6	3.2
25/03/06 – 26/04/06	4.3	0.5	26/03/07 – 26/04/07	1.4	2.6
26/04/06 – 26/05/06	1.3	0.5	26/04/07 – 26/05/07	1.1	1.2
26/05/06 – 26/6/06	1.2	0.4	26/05/07 – 26/06/07	1.0	1.9
26/06/06 – 26/07/06	1.4	0.6	26/06/07 – 26/07/07	0.4	1.1
26/07/06 – 26/08/06	1.4	0.5	26/07/07 – 26/08/07	0.5	1.7
26/08/06 – 26/09/06	3.3	18.6#	26/08/07 – 26/09/07	2.3	1.6
Average	2.0	0.6	Average	1.4	1.8

*Sample container was removed
#Sample contaminated by solids from bird droppings (not included within average)

4.6 Conclusions

Existing air quality in the Cudgen area is influenced by sub-tropical climatic conditions in the Tweed River Valley. High average rainfall, mainly in summer and changes in summer and winter wind directions are key factors.

Emission sources of particulates appear to be mainly from diffuse sources such as road transport (motor vehicles) and intensive agriculture (sugar cane). Current (and future) sand extraction, adjacent to the Project Site, is a potential source of localised dusts.

The Condong Sugar Mill is the only significant point source of particulates, gases and volatile organics reported within the Tweed River Valley. Motor vehicle emissions are considered to be significant also but limited in local dispersion to near roadways. There is no ambient air quality monitoring reported for the Tweed River Valley airshed by the State or Local Government.

Indicative monitoring of "background" levels of particulates (TSP, PM_{10} and insoluble dust fallout) for the purposes of this study suggests that average dust levels are relatively low and below ambient air quality goals and guidelines used by the NSW DECC (EPA) (see Section 5). Variations in dusts can be expected due to factors such as cane production and harvesting, other agricultural activities, changes in summer and winter conditions, rainfall and short-term events such as bushfires and strong wind gusts.

Gaseous and volatile organic emissions in the vicinity of the proposed sand extraction operation (and pumping corridors) are likely to be related to existing motor vehicle traffic and confined to within road corridors and existing urban areas. The ambient air contaminants of particular interest, however, are airborne particulates.

5 AIR QUALITY GOALS

The DECC has developed a set of air quality goals for particulates in air and dust deposition under the 2001 Action for Air initiative in New South Wales. These air quality goals are summarised in **Table 5**.

Table 5
NSW DECC Air Quality Goals for Particulates and Dust Deposition

Air Quality Indicator	Averaging Period	Maximum Increase	Maximum Level
Deposited dust or dust fallout	Annual	2g/m²/month	4g/m²/month
TSP	Annual	-	90µg/m³
PM_{10}	24 hour	-	50µg/m³
	Annual	-	30µg/m³
Source: NSW DECC (EPA) (2004)			

The criteria for deposited dust allows for a maximum increase of $2g/m^2$ month from the existing dust deposition levels (background) and a maximum total dust deposition level of $4g/m^2$/month at surrounding non Project-related residences/receptors.

The limits for dust deposition are based on levels at which dust becomes or is perceived as a nuisance to the extent that it is considered unacceptable.

The air quality goals also include the National Health and Medical Research Council (NHMRC) goal for total suspended solids of $90µg/m^3$ (annual average). It is recommended as a maximum limit for urban environments. This goal has limited usefulness, however, in evaluating potential health impacts.

Fine particulate matter with particle size of less than 10µm (diameter), known as PM_{10}, can penetrate into the lungs and cause increased rates of respiratory illness and symptoms, decreased lung function and excess mortality from lung and heart disease. The NSW DECC have adopted the National Environmental Protection Measure (NEPM) for PM_{10} of 50µg/m^3 (24 hour averaging period) and an annual average goal of 30µg/m^3.

6 ASSESSMENT OF POTENTIAL AIR QUALITY IMPACTS

6.1 Objectives and Scope

The objective of this section is to evaluate potential impacts of the Project on local air quality at Cudgen. The scope of this assessment refers to the proposed site establishment and construction, sand extraction, processing, landscaping and rehabilitation phases of the Project. The approach is outlined below.

- Determination of Study Area and receptor sites.
- Preparation and evaluation of a meteorological dataset (hourly) (TAPM) to meet NSW DECC (EPA) criteria for air dispersion modelling.
- Description of Project scenarios for air modelling purposes.
- Estimation of emissions of air pollutants (dusts) for each scenario.
- Air dispersion modelling using Ausplume V6.0 to predict ground level concentrations (PM_{10} and dust deposition).
- Presentation of modelling data outputs including ground level concentration contours for the cumulative scenario.
- Assessment of air quality impacts at receptor sites under different scenarios, namely:
  - environmental nuisance;
  - environmental health risks; and
  - environmental risks (e.g. horticulture).
- Comparisons with NSW DECC (EPA) and other relevant air quality goals, standards and guidelines.

6.2 Air Quality Assessment Scenarios

6.2.1 Project Components

The Project has been described in detail in Section 3.0 and this information forms the basis of the air quality assessment. The fundamental components of the Project that have the potential to release air emissions into the local airshed, to different degrees include the following.

- Site establishment and construction.
- Sand extraction involving removal of loamy sand and dredging of underlying sand to depths of up to 20m (southern extraction site) and excavation to depths of 5m (northern extraction site).
- Processing and blending operations to produce sand products and the recycling of suitable VENM.

- Treatment of VENM received and backfilling operations.
- Transportation of materials on and off site.
- Site landscaping and rehabilitation.
- Site decommissioning and creation of final landform.

6.2.2 Project Phases and Activities used for Assessment of Air Quality

The development of air quality scenarios for modelling and assessment purposes considered the phases and timetable aspects of the Project (establishment and construction, combined operational phases and rehabilitation) to derive a set of risk scenarios for potential dust emissions. The scenarios are intended to be representative of activities, progressive and conservative in the sense that "worst case" conditions are to be evaluated by modelling.

The approach is intended to assist in the design of effective safeguards and mitigation measures for potential dust control. The scenarios adopted for the air quality assessment are described below.

Site Establishment and Construction Activities

<u>Soil Removal</u>

Site establishment would involve the progressive removal of the upper 0.3m of "topsoil" from the area of extraction required for the first 6 to 12 months of operation within the southern extraction site. Stage 1 of sand extraction would involve a 7ha area with stripped "topsoil" used to construct bunding surrounding the perimeter of the stripped area. Similarly, within the northern extraction site, stripped topsoil would be used to construct bunding surrounding the extraction area. Up to 2ha would initially be stripped within the northern extraction site.

Filling

The processing area would be filled with sand extracted from the initial western excavation pond in the northern extraction site. Approximately 36 000m^3 of sand would be required to raise the processing area by approximately 1.0m and construct the perimeter bund. The extraction of sand to raise the height of the processing area would involve the excavation and spreading of sand across the processing area using dozers.

Construction Activities

Construction activities would include:

- the entrances to the extraction sites and processing area;
- internal access roads within the extraction sites and processing area;
- planting of a vegetative screen surrounding the processing area and along the eastern boundaries of the extraction sites and along part of Altona Drive;
- construction of the processing facilities and processing plants; and
- laying of pipelines within the designated pipeline corridors.

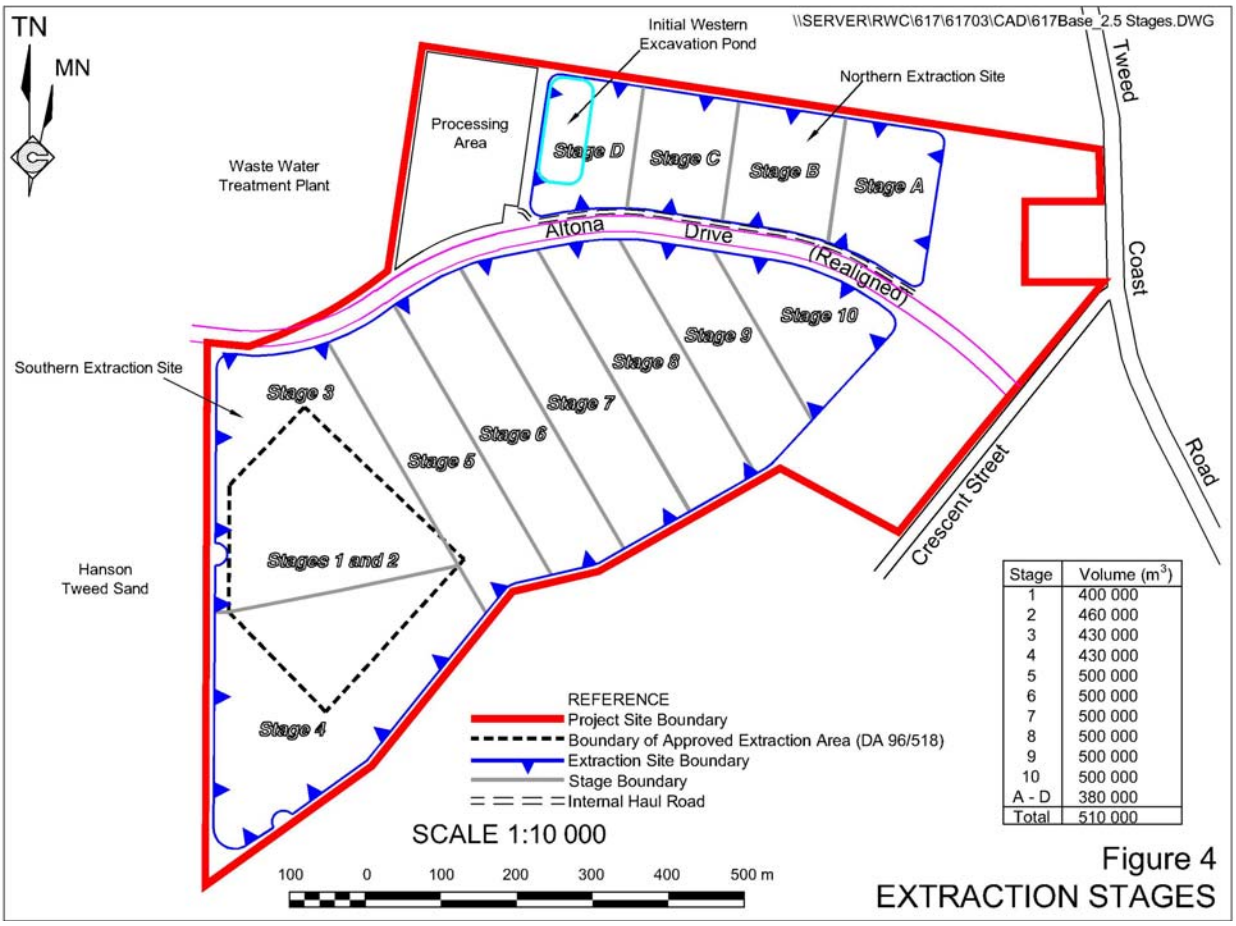
During site establishment and construction activities, potential fugitive dust emissions may occur during “topsoil” removal and spreading / shaping by dozers. Other fugitive dusts can originate from wind action upon exposed sub-surface areas (loamy sands) and minor stockpiles. Any low moisture or dried soils would also be a potential source of fugitive dusts depending on factors such as silt, organic matter and moisture content and winds. Construction and use of unsealed internal access roads can also be a significant source of local dust generation along with disturbance of open areas such as the processing area. It is considered that the installation of the pipelines would result in minimal dust generation.

Overall, the initial activities have the potential to generate variable fugitive dusts from exposed and disturbed surface areas containing “topsoil”, loamy sands and sand fill.

Sand Extraction and Processing Operations

Sand Extraction

Extraction would commence in the northern extraction site within Stage N1 (**Figure 4**) progressing from east to west. The upper loamy sand and underlying fine sand resource would be extracted using an excavator and trucks. Extraction would occur in a single stage with four substages. Sand would be extracted over 2 to 3 years at a rate of up to 200 000m^3 and would be used for the production of construction materials. Following completion of the northern extraction site, sand from south of Altona Drive would be used to supply sand to the processing area for production of construction materials. It is intended that dredging south of Altona Drive would occur concurrently to supply the Proponent’s fill sand requirements.



Stage	Volume (m^3)
1	400 000
2	460 000
3	430 000
4	430 000
5	500 000
6	500 000
7	500 000
8	500 000
9	500 000
10	500 000
A - D	380 000
Total	510 000

Figure 4
EXTRACTION STAGES

Note: A colour version of this figure is available on the Project CD.

Sand extraction within the southern extraction site would occur over 10 progressive stages over a period of approximately 15 to 20 years. The extraction activities within the southern extraction site would cover three (3) steps, namely:

- stripping of "topsoil" to an approximate depth of 0.3m and bunding up to 1m within that stage to provide for 6 to 12 months of extraction area and a suitable stockpiling area for loamy sand and VENM(b);
- removal of the upper 0.5 to 1.0m of loamy sand using a 30t excavator and/or swamp dozer; and
- extraction of the underlying fine sand using a 300mm cutter suction dredge.

Extraction within the southern extraction site would generally progress from near the western boundary of the Project Site in an easterly direction towards Tweed Coast Road and Crescent Street, as shown in **Figure 4.** The maximum combined annual rate of extraction throughout the life of the Project would not exceed 650 000m^3.

Processing and Blending

The processing area would cover an area of approximately 3.7ha and be surrounded by a 3m to 4m high continuous perimeter bund and vegetation screen. The processing activities with potential to generate dust emissions include the following.

- A 30 000t capacity stockpile area for the washed sand (max. height of 8m to 10m) fed by a central radial stack from the wash plant.
- Multipurpose plant for dry screening and blending (daily average of 100 tonnes per hour (tph)) to produce construction materials or products.
- Separate 1000 tonnes stockpiles of individual products fed by a swing conveyor from the multipurpose plant.
- VENM(a) receival area (2000t).
- Treated VENM(b) and loamy sand receival area (2000t).
- Internal access roads.

It is noted that the potential screening and blending rates may range from 50tph to 200tph depending on the type of product being produced, however, the daily average processing rate would not exceed 100tph. It is also noted that the continual operation of the multipurpose plant at the average processing rate would result in the production of more than the maximum proposed annual sales of 300 000tpa. Therefore, the use of an average processing rate of 100tph for the multipurpose plant is a conservative assumption as it is unlikely this plant would operate on each operational day.

The washing of dredged sand within the wash plant is unlikely to contribute to dust emissions as all fines from the washing process would be returned towards the base of the extraction ponds. The indicative layout for the processing area is shown in **Figure 2.**

VENM Receival Treatment and Backfilling

VENM(a) material not used in production of saleable products would be deposited along the edges of the finalised sections of the southern extraction pond or used to backfill the northern extraction pond. Between about 9m^3 and 15m^3 of VENM(a) would be required to fill each lateral metre of the southern extraction pond shoreline.

VENM(b) delivered to the site and loamy sand extracted on site would be stockpiled within a suitable area near the active part of the southern extraction pond. The stockpiled materials would be treated with an alkaline amendment (e.g. lime) over a period of 2 or 3 months prior to use in the production of mortar sand and other construction products.

There is some potential for local dust emissions during stockpiling of loamy sand and VENM and also load out of VENM materials. A swamp dozer and/or 30t excavator would be used for loamy sand movement and backfilling of available VENM(a). Backfilling along the shoreline is expected to be conducted under moist to wet conditions with low to negligible dust generation potential from deposited materials.

Transportation

Truck transportation of loamy sand, sand products from the processing area and receipt and handling of VENM have the potential to generate local dusts along unsealed access roads in the processing area and extraction site.

As discussed in Section 3.2, at maximum production, it has been conservatively estimated that the average number of product trucks movements on any weekday would be approximately 100. It is also estimated that the receipt of VENM would result in an additional 24 truck movements.

Other Project related traffic would include staff and site servicing movements and truck movements related to the campaign removal of loamy sand. In total, it is estimate that, on average, 204 vehicle movements (light and heavy vehicles) would occur to and from and within the Project Site on weekdays.

Landscaping and Rehabilitation

Landscaping and rehabilitation procedures would commence during the site establishment and construction phase (e.g. stabilisation and planting of bunding) and would continue to occur progressively to stabilise all disturbed areas to limit erosion and dust lift off.

Operational areas would be stabilised either through placement of chipped vegetation/mulched shrubs or vegetated with a pasture seed mix.

Combined Activities of Operational Phase

Point source and fugitive dust emissions for all dust generating activities are to be evaluated in the operational scenario. This includes sand extraction, processing and blending, truck movements, loading and product despatch from the processing area.

Site Decommissioning and Final Landform

At the end of the Project, buildings and structures would be removed and internal roads rehabilitated except for those required for future land uses.

The final lake within the southern extraction site would cover about 37ha and include a number of shallow wetland areas along the shoreline.

Fugitive dust emissions during this final phase prior to proposed long-term land uses (e.g. sporting and recreation facilities) would be controlled by the progressive landscaping and rehabilitation measures implemented throughout the operational phase. Hence, disturbed and exposed soil areas would be minimised as potential sources of dust lift off.

6.3 Air Quality Modelling

6.3.1 Introduction

The approach to this assessment was to use air dispersion modelling (Ausplume V6.0) to predict ground level concentrations of particulates during various Project phases and activities. Ausplume calculates the pollutant concentration surrounding a source using information on the pollutant emission rate, characteristics of the emission source, local topography, local meteorology and background concentrations of the pollutant. Modelling was carried out in accordance with NSW DECC (2005) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW.* The full emissions inventory is shown in **Appendix 1**.

Ausplume V6.0 (or later versions) is the approved dispersion model for use in most simple near-field applications in NSW, where coastal effects and complex terrain are of no concern. This model was appropriate because the sensitive receptors are located in close proximity to the source (e.g. 500m to 1km) and the dust sources are located approximately 2km from the shoreline. There are sensitive receptors located on the Cudgen Plateau (~40m high) approximately 200m south of the boundary but the remainder of the terrain within the modelling domain is flat. Terrain effects are not computed for area sources in Ausplume, or other more advanced dispersion models such as Calpuff or TAPM, however, terrain effects are computed for volume sources.

6.3.2 Particulate Sources

The sand extraction process involves stripping of topsoil, excavation of the upper loamy sand and extraction (dredging or excavation) of the fine-grained sand resource. The processing phase comprises activities such as loading and unloading of materials, stockpiling of materials, screening, blending and transport of materials and products (both on-site and off-site). This analysis addresses the operational aspects of the Project only. Dust emissions from the site decommissioning and final landform stage have not been included as they are expected to be the same as or less than the existing site.

It is proposed to complete extraction in the northern extraction site (i.e. north of Altona Drive) over a period of 2 to 3 years. The sand resource would be extracted to a depth of approximately 5m using an excavator. This approach would generate marginally greater dust emissions than dredging as the bulk of the sand would be saturated given it would be removed from below the water table. The fine sand within the southern extraction site would be extracted using a 300mm cutter dredge and would occur over a 15 to 20 year period. Sand recovered during extraction by dredging, and subsequent conveying, washing and stockpiling would be wet or moist and hence sand processing emissions would be negligible.

The cumulative scenarios simulate dust emissions from both the Cudgen Lakes Sand Extraction Project and the Hanson Tweed Sand Quarry operation. The dust generating activities at Hanson Tweed Sand Quarry are understood to include stockpiling, loading and unloading and the movement of haul trucks on the access road.

Hanson Tweed Sand holds an approval for extension of the existing sand extraction operation into Phases 3 and 4. Phase 3 involves additional sand extraction from the existing Phase 1 pond. Dust emissions from this phase of the activity are not expected to be greater than those currently generated by the quarry. Phase 4 involves expansion of the extraction area to the west of Phase 1 and 3. It is noted that there would be some additional dust emissions during clearing of the new extraction area, however, all other activities and hence dust emissions are expected to remain the same.

Dust emissions from excavation and loading are described as fugitive dusts, that is, emissions are transient depending on the activity and meteorological conditions, and therefore are modelled as volume or area sources. Dust emissions from cleared areas could also be described as diffuse, which means spread over a large area. For comparison, stack emissions are usually controlled and continuous throughout the hours of operation.

6.3.3 Model Scenarios

The particulate emission rates from seven scenarios are described in the following sections. The seven scenarios are summarised in **Table 6** and listed below.

Scenario 1. Site establishment.

Scenario 2. Extraction (excavator) north of Altona Drive (Stage N1), extraction (dredge) south of Altona Drive (Stage 4) and processing.

Scenario 3. Cumulative scenario – Stage N1, Stage 4 and Hanson Tweed Sand Quarry (Phase 2).

Scenario 4. Extraction (dredge) south of Altona Drive (Stage 4) and processing.

Scenario 5. Extraction (dredge) south of Altona Drive (Stage 7) and processing.

Scenario 6. Extraction (dredge) south of Altona Drive (Stage 10) and processing.

Scenario 7. Cumulative scenario – Stage 7 and Hanson Tweed Sand (Phase 4)

Scenarios 1, 2, 4, 5 and 6 address different stages of the Cudgen Lakes Sand Extraction Project. Scenarios 3 and 7 consider the cumulative impacts of the Cudgen Lakes Sand Extraction Project and the Hanson Tweed Sand operation, both existing activities (Phase 2) and future activities (Phase 4).

Dusts due to activities at the new Kingscliff Waste Water Treatment Plant (currently under construction to the northwest/west of the site) are expected to be insignificant at the time of the above scenarios.

6.3.4 Dust Emission Rates

The dust emission rates are summarised in **Table 7**. Dust emission factors were taken from:

1. USEPA: *AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary and Area Sources*, and
2. Environment Australia: *National Pollutant Inventory Emission Estimation Technique Manuals*.

Most of the factors reported by the National Pollutant Inventory were derived from the USEPA AP 42 Factors. The analysis covers both TSP and PM_{10}. The derivation of emission rates from these factors is described in the emissions inventory in **Appendix 1**.

Table 6
Dust Emission Scenarios and Activities

Activity	Scenario 1	Scenario 2		Scenario 3			Scenario 4	Scenario 5	Scenario 6	Scenario 7	
	Site establishment	Extraction Stage N1, extraction Stage 4 & processing		Cumulative Stage N1, Stage 4 & Hanson Tweed Sand (Phase 2)			Extraction south (Stage 4) & processing	Extraction south (Stage 7) & processing	Extraction south (Stage 10) & processing	Cumulative Stage 7 & Hanson Tweed Sand (Phase 4)	
		Stage N1	Stage 4	Stage N1	Stage 4	Hanson Tweed Sand				Stage 7	Hanson Tweed Sand
Clearing											
Topsoil removal (scraper)	✓	✓	✓	✓	✓	-	✓	✓	✓	✓	✓
Wind erosion cleared areas	✓	-	-		-	-	-	-	-	-	-
Extraction											
Removal of loamy sand	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-
Sand excavation (excavator)	-	✓	-	✓	-	-	-	-	-	-	-
Loading sand (excavator)	-	✓	-	✓	-	-	-	-	-	-	-
Wheel generated	-	✓	✓	✓	✓	-	✓	✓	✓	✓	-
Stockpile erosion VENM$_{(b)}$	-	-	✓	-	✓	-	✓	✓	✓	✓	-
Processing											
Wind erosion of stockpiles	-	✓		✓		✓	✓	✓	✓	✓	✓
Load/unloading sand	-	✓		✓		✓	✓	✓	✓	✓	✓
Load/unloading blended products	-	✓		✓		-	✓	✓	✓	✓	-
Load/unloading VENM stockpiles	-	✓		✓		-	✓	✓	✓	✓	-
Screening and blending	-	✓		✓		-	✓	✓	✓	✓	-
Wheel generated	-	✓		✓		✓	✓	✓	✓	✓	✓

Table 7
Dust Emission Rates

Source	Units	Uncontrolled emission rate		Controlled emission rate	
		TSP	PM_{10}	TSP	PM_{10}
Site establishment					
Scraper removing topsoil	g/s	0.14	0.07	na	na
Wind erosion	g/s	0.00001	0.000006	na	na
Extraction (northern area)					
Scraper removing topsoil	g/s	0.07	0.04	na	na
Removal of loamy sand	g/s	0.02	0.01	na	na
Wet excavation	g/s	0.02	0.01	0.01	0.005
Load to truck	g/s	0.76	0.33	0.38	0.17
Wheel generated dust	g/s	2.9 (total)	0.8 (total)	1.5 (total)	0.4 (total)
Extraction (southern area)					
Scraper – Stages 4, 7 & 10	g/s	0.07	0.04	na	na
Removal of loamy sand	g/s	0.02	0.01	na	na
Wheel generated dust	g/s	2.9 (total)	0.7 (total)	1.5 (total)	0.4 (total)
Stockpile erosion (VENM(b))	$g/s/m^2$	0.00002	0.00001	na	na
Processing					
Wheel generated dust	g/s	7.5 (total)	1.8 (total)	2.6 (total)	0.6 (total)
Stockpile erosion (washed sand)	$g/s/m^2$	0.0000002	0.0000001	0.00000014	0.00000007
Load out washed sand	g/s	0.53	0.23	0.37	0.16
Loading stockpile (VENM(a))	g/s	0.004	0.002	0.0028	0.0014
Loading stockpile (VENM (b))	g/s	0.03	0.01	0.02	0.007
Unloading stockpile (VENM(a))	g/s	0.03	0.01	0.02	0.007
Unloading stockpile (VENM(b))	g/s	0.24	0.11	0.17	0.08
Screening and blending	g/s	2.3 (100 tph)	1.7 (100 tph)	1.6 (100 tph)	1.2 (100 tph)
Stockpile erosion –blended materials (3 stockpiles)	$g/s/m^2$	0.00001	0.000006	0.000007	0.000004
Load out blended materials (3 stockpiles)	g/s	0.19 (total)	0.08 (total)	0.13 (total)	0.06 (total)
Hanson Tweed Sand (Phase 2)					
Wheel generated dust	g/s	9.8 (total)	2.4 (total)	4.9 (total)	1.2 (total)
Loading stockpiles	g/s	0.08	0.03	na	na
Stockpile erosion (washed sand)	$g/s/m^2$	0.0000002 $g/s/m^2$	0.0000001	na	na
Load out sand products	g/s	0.6	0.3	na	na
Hanson Tweed Sand (Phase 4)					
Scraper removing topsoil	g/s	0.07	0.04	na	na
Removal of loamy sand	g/s	0.03	0.01	na	na
Wheel generated dust	g/s	9.8 (total)	2.4 (total)	4.9 (total)	1.2 (total)
Loading stockpiles	g/s	0.08	0.03	na	na
Stockpile erosion (washed sand)	$g/s/m^2$	0.0000002 $g/s/m^2$	0.0000001	na	na
Load out sand products	g/s	0.6	0.3	na	na

Note; the shaded cells indicate the emission rates used in the air dispersion model

Conservative assumptions were used in the air dispersion model to determine worst-case concentrations. These assumptions included the number of truck trips per day, the average weight of trucks, the processing rate of the screening and blending plant and the moisture content of the sand resource in the northern extraction site. It is acknowledged that, in reality, fewer truck movements would occur than assumed and that due to the saturation of the fine grained sand, moisture levels would be higher than those used within the model.

As previously noted in Section 6.2.2, the assumption of a daily average processing rate of 100tph has been assumed for the screening and blending plant. However, it is unlikely that the screening and processing plant would operate at this level on each operational day as this would result in the production of more than the maximum annual sales of 300 000tpa (which includes both washed and screened/blended products). Therefore, average daily screening and blending rates would generally be below 100tph and hence resultant emissions would be less than those used within the air dispersion model.

The dust emission rates include control measures where indicated in **Table 7**. The proposed control measures include:

- road watering at 2.0 L/m^2 per application, 6 applications per day;
- the construction of a 3m bund and vegetation barrier around the entire processing area;
- a vegetation barrier on the eastern boundaries of the extraction sites and along part of Altona Drive (realigned).

Estimated control factors for dust emissions have been reported by Environment Australia (2001). These factors have been used in this report for vehicle dusts (50%) and wind erosion (30% for wind breaks).

For modelling purposes, the operating hours of the site activities have been assumed to be 7am to 6pm. Wind erosion of stockpiles, however, would occur 24 hours per day. The activities at Hanson Tweed Sand are carried out from 7am to 5pm.

6.3.5 Receptors

The receptor grid was designed to capture the peak concentrations of emissions from the activity. It covers an area that extends 500m from the Project Site boundary on all sides. The model domain in total is 2.4km x 2.0km (25 x 21 receptors at 100m intervals). Trial model runs showed that dust concentrations were highest close to the source.

The following discrete receptors were also included in the model and are shown in **Figure 5**.

- Receptor A: residence, south, on hillside (Monitoring Receptor B).
- Receptor C: school, south, on hilltop.
- Receptor M1: model location representing worst-case concentration for receptors near southwest corner.
- Receptor M2: model location representing worst-case concentration for receptors near southern boundary of Hanson Tweed Sand.

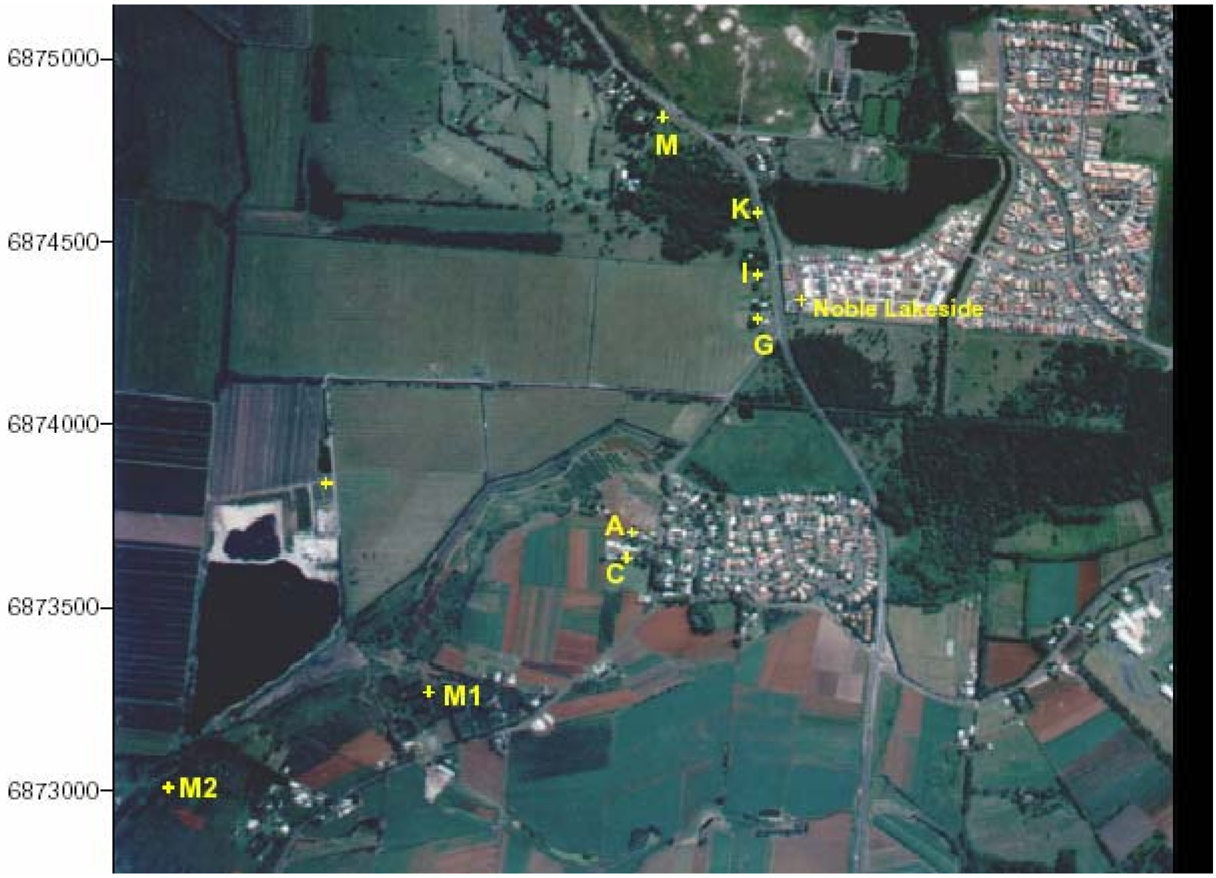


Figure 5
Receptor Locations Included in Air Dispersion Model

- Receptor M: Chinderah Golf Range, north, building.
- Receptor K: residence, north.
- Receptor I: residence, north, close to northern boundary.
- Noble Lakeside Park Estate: residences, east side of Tweed Coast Road.
- Receptor G: residence, eastern boundary of northern extraction site (Monitoring Receptor G).

6.3.6 Background Concentrations

The cumulative impacts have been assessed by modelling the particulate emissions from the adjacent sand extraction activity (Hanson Tweed Sand Quarry). There are no other extractive industries in the vicinity or other industrial sources of dust emissions (with the exception of seasonal sugar cane burning) and the NSW DECC does not monitor ambient air quality in this region.

The existing air quality in the region has been discussed in Section 4 and highlights the absence of information on particulate concentrations in the local area. The NSW DECC (2005) modelling guidelines acknowledge that the availability of ambient air monitoring data collected from a proposed site is extremely rare and the accepted approach is to use data from a monitoring site located as close as possible to the proposed location and where the sources of air pollution resemble the existing sources at the proposed site. However, in this case there are no NSW DECC air monitoring stations located near the proposed development site.

The NSW Air Monitoring Plan for the NEPM for ambient air quality states that the region is not densely populated and has no major industrial, domestic and commercial sources (NSW EPA 2002). The plan also considers the Tweed Heads area to be contiguous with the Gold Coast and recommends using data from the Queensland monitoring plan to infer concentrations in this subregion.

The Gold Coast City Council *Our Living City Report 2004-05* reports that air quality on the Gold Coast is believed to be of a high standard because it does not have major industrial sources or high volumes of traffic to generate significant local air pollution problems. However, air quality on the Gold Coast was only monitored at Helensvale and Beenleigh throughout the period from 1998 to 2002.

Particulate matter was monitored at Helensvale and the average maximum 24 hour PM_{10} concentration from 1998 to 2002 was 31µg/m^3 (Qld EPA 1998, 1999, 2000, 2001, 2002) whilst annual average PM_{10} was 17µg/m^3.

As discussed in Section 4.5.4, Simmonds and Bristow has conducted dust monitoring of total suspended particulates, PM_{10} and insoluble dust fallout at two locations near the Project Site, namely:

- Receptor G (L and P Hermann, private residence); and
- Receptor B (R and B Julius, farm residence on Cudgen Plateau near Cudgen Public School).

TSP concentrations (24 hour) at Receptor G ranged from <20µg/m^3 to 93µg/m^3 with an estimated mean of ≤22µg/m^3 (9 to 16 September 2005). At Receptor B, concentrations ranged from <20µg/m^3 to 46µg/m^3 with an estimated mean of ≤22µg/m^3. Short-term PM_{10} measurements taken on the 9 September 2005, ranged from 1µg/m^3 to 11µg/m^3 at Receptor G (mean = 5µg/m^3).

The particulate monitoring results undertaken for the Project were consistent with the historical maximum 24 hour concentrations recorded at Helensvale, assuming TSP comprises 50% PM_{10}. For example, the maximum 24 hour average TSP concentration measured at Receptor G over a 6-day period was 93µg/m^3 with an estimated PM_{10} fraction of 47µg/m^3. The maximum 24 hour average TSP measured at Receptor B was 46µg/m^3 with an estimated PM_{10} fraction of 23µg/m^3.

Dust deposition results are shown in **Table 8**. The average result from both sites over all monitoring events is 1.5g/m^2/month.

The approach used in this report was to assume conservative background concentrations for modelling purposes, which in this case are based on monitoring carried out in Helensvale (on the Gold Coast) between 1998 and 2002. The background concentration for dust deposition was assumed to be the average of monitoring results collected to date.

The adopted background concentrations are:

- PM_{10} maximum 24 hour average of 31µg/m^3,
- PM_{10} annual average of 17µg/m^3,
- TSP annual average of 34µg/m^3 (assumes PM_{10} fraction comprises 50% of TSP), and
- Total deposited dust rate of 1.5 g/m^2/month.

Table 8
IOA Between Model Year and Long-Term Averages

Statistic	Long-term average data	2000	2001	2002	2003	2004
		Index of agreement (IOA) with long-term average data				
Mean monthly air temperature (°C)	1983-2005	0.990	0.988	0.984	0.988	0.979
Mean monthly wind speed at 9am (km/hr)	1991-2005	0.817	0.912	0.810	0.830	0.815
Mean monthly wind speed at 3pm (km/hr)	1991-2005	0.756	0.931	0.840	0.850	0.842
Average IOA		**0.855**	**0.944**	**0.878**	**0.889**	**0.879**

It is important to note that the maximum 24hr average for PM_{10} of 31µg/m^3 has been assumed to occur every day where, in reality, the median 24hr average for PM_{10} levels would be well below the maximum. The average median 24 hour concentration at Helenvale from 1998 to 2002 was 15µg/m^3.

6.3.7 Building Wake Effects

Building downwash effects are not computed for area or volume sources in Ausplume, Calpuff or TAPM.

6.3.8 Terrain Effects

Elevation data was included in the model. While terrain effects are not computed for area sources, they are computed for volume sources. Terrain effects are not computed for dust deposition.

Terrain data was taken from the Cudgen Topographic and Orthophoto Map (9641-3N). Most of the terrain within the model domain is flat and was assumed to have an elevation of 5m (10m contour map). Cudgen Plateau, located to the south of the Project Site, rises to an elevation of 38m and further to the southwest, at the boundary of the model domain, with an elevation of 42m.

6.3.9 Meteorological Data

The meteorological datafile was prepared by pDs Consultancy from Bureau of Meteorology data for the year 2001. The nearest meteorological weather station, at a similar elevation (i.e. near the coast), is located at Coolangatta Airport. This weather station is ~10.3km north and 4.6km east of the Project Site. This use of this data is consistent with DECC (2005), which states that the site-representative data should be preferably collected at a meteorological monitoring station.

The year 2001 was selected because it showed a strong Index of Agreement (IOA) with long-term average data in terms of air temperature and wind speed. Data from 2000 to 2004 were compared with the long-term average data from 1983/1991-2005. All years showed good agreement but 2001 showed the highest IOA (see **Table 8**).

A detailed description of the meteorological datafile is provided in **Appendix 2**. The datafile has 95% coverage and autumn, winter, spring and summer are well represented. The annual wind rose shows a predominance of southerly (28%) and southwesterly (22%) flows. Wind speeds were mainly between 2m/s and 6m/s and the percentage of light winds (<0.7m/s) was 1%.

The seasonal wind roses indicated that there are:

- southerly (21%) and northerly (21%) winds in summer;
- southerly (38%) and southwesterly (24%) winds in autumn;
- southerly (32%) and southwesterly (29%) winds in winter; and
- northerly (20%), southerly (19%) and southwesterly (17%) winds in spring.

Temperature, wind speed and mixing height statistics for each stability class are described in **Appendix 2**. The average wind speed for all hours was 4.3 m/s. Lower wind speeds occur during very unstable (Stability Class A) and very stable conditions (Stability Class F). While the occurrence of very unstable conditions was low (<1%), the occurrence of stable and very stable conditions (Classes E and F) was relatively high (16% respectively). These conditions are generally associated with clear skies and night time and early morning periods. Dispersion of fugitive dusts from exposed materials would be lowest during these periods.

6.4 Model Results

The model results from the activities of the Cudgen Lakes Sand Extraction Project (Scenarios 1, 2, 4, 5 and 6) are discussed in the following sections. The model results from Scenarios 3 and 7 are discussed in Section 7 in the assessment of cumulative impacts.

6.4.1 Scenario 1: Site Establishment

This scenario describes the predicted ground level concentrations of TSP, PM_{10} and deposited dust from bulldozing and wind erosion during stripping of topsoil and loamy sand removal during site establishment (predominantly occurring at the western end of the Project Site. The incremental impact of annual TSP (**Table 9**) from removal of topsoil by scraping is conservative because this activity would only be carried out about 5 times per year, for 5 to 6 days each time. The model, however, assumes constant emissions throughout the year (i.e. topsoil removal every day of the year). The incremental impact of PM_{10} represents the highest dust concentration that may occur during the 30 days per year of topsoil stripping and loamy sand removal (**Table 10**).

The total deposited dust concentrations (**Table 11**) are also conservative because the model does not account for elevated receptors. Also, the deposited dust levels have been assessed on a daily basis to account for the level of activity described above.

Table 9
Predicted TSP Impacts (Site Establishment) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, annual average		
A - Residence south on hillside	34	1.1	35.1
C - School south on hilltop	34	1.0	35
M1 - Receptor southwestern corner hillside	34	1.3	35.3
M2 - Receptor southern boundary Hanson Tweed Sand	34	0.3	34.3
M - Chinderah golf range building	34	2.3	36.3
K - Residence north	34	1.7	35.7
I - Residence north close to site boundary	34	1.5	35.5
Noble Park Estate - Residence east side of Tweed Coast Road	34	1.1	35.1
G – Residence eastern boundary of northern extraction site	34	1.3	35.3
Air quality goal - ***TSP (annual)***	**-**	**-**	**90**

Table 10
Predicted PM_{10} Impacts (Site Establishment) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, 24 hr average		
A - Residence south on hillside	31	11	42
C - School south on hilltop	31	14	45
M1 - Receptor southwestern corner hillside	31	11	42
M2 - Receptor southern boundary Hanson Tweed Sand	31	5.7	36.7
M - Chinderah golf range building	31	6.6	37.6
K - Residence north	31	9.2	40.2
I - Residence north close to site boundary	31	5.6	36.6
Noble Park Estate - Residence east side of Tweed Coast Road	31	7.2	38.2
G - Residence eastern boundary of northern extraction site	31	8.5	39.5
Air quality goal - ***PM_{10} (24 hr)***	-	-	**50**
	µg/m³, annual average		
A - Residence south on hillside	17	0.6	17.6
C - School south on hilltop	17	0.6	17.6
M1 - Receptor southwestern corner hillside	17	0.8	17.8
M2 - Receptor southern boundary Hanson Tweed Sand	17	0.2	17.2
M - Chinderah golf range building	17	1.4	18.4
K - Residence north	17	1.0	18.0
I - Residence north close to site boundary	17	0.9	17.9
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.6	17.6
G - Residence eastern boundary of northern extraction site	17	0.8	17.8
Air quality goal - *PM_{10} (annual)*			**30**

Table 11
Predicted Deposited Dust Impacts (Site Establishment) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	g/m²/month[1]		
A - Residence south on hillside	1.5	0.2	1.7
C - School south on hilltop	1.5	0.2	1.7
M1 - Receptor southwestern corner hillside	1.5	0.4	1.9
M2 - Receptor southern boundary Hanson Tweed Sand	1.5	0.1	1.6
M - Chinderah golf range building	1.5	0.2	1.7
K - Residence north	1.5	0.2	1.7
I - Residence north close to site boundary	1.5	0.1	1.6
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.1	1.6
G - Residence eastern boundary of northern extraction site	1.5	0.1	1.6
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	-
Maximum total deposited dust level	-		**4.0**

[1] Annual average

No exceedances of air quality goals are predicted to occur during site establishment activities.

6.4.2 Scenario 2: Extraction Stage N1, Stage 4 and Processing

Sand from Stage N1 would be extracted using excavation techniques. The sources of dust emissions therefore include removal of topsoil (scraper), removal of surface loamy sand, excavation, loading saturated excavated sand to trucks for transport to the processing area, and truck movements (wheel generated dust).

Dust sources from the Stage 4 extraction include soil stripping, removal of loamy sand, wheel generated dust, and stockpile erosion (VENM(b)) from the extraction area.

Dust sources from the processing area include wheel generated dust, stockpile erosion, product load-out emissions, loading/unloading stockpile emissions, and screening and blending emissions.

Results of the predicted TSP, PM_{10} and deposited dust levels are shown in **Tables 12**, **13** and **14**.

Table 12
Predicted TSP Impacts (Stages N1 & 4) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	μg/m³, annual average		
A- Residence south on hillside	34	3.4	37.4
C - School south on hilltop	34	2.7	36.7
M1 - Receptor southwestern corner hillside	34	3.2	37.2
M2 - Receptor southern boundary Hanson Tweed Sand	34	1.1	35.1
M - Chinderah golf range building	34	4.1	38.1
K - Residence north	34	2.8	36.8
I - Residence north close to site boundary	34	2.8	36.8
Noble Park Estate - Residence east side of Tweed Coast Road	34	1.8	35.8
G - Residence eastern boundary of northern extraction site	34	2.7	36.7
Air quality goal - ***TSP (annual)***	**-**	**-**	**90**

Table 13
Predicted PM_{10} Impacts (Stages N1 & 4) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	μg/m³, 24 hr average		
A - Residence south on hillside	31	8.6	39.6
C - School south on hilltop	31	7.0	38.0
M1 - Receptor southwestern corner hillside	31	6.7	37.7
M2 - Receptor southern boundary Hanson Tweed Sand	31	5.5	36.5
M - Chinderah golf range building	31	16	47
K - Residence north	31	10	41
I - Residence north close to site boundary	31	12	43
Noble Park Estate - Residence east side of Tweed Coast Road	31	10	41
G - Residence eastern boundary of northern extraction site	31	15	46
Air quality goal - ***PM_{10} (24 hr)***	-	-	**50**
	μg/m³, annual average		
A - Residence south on hillside	17	1.2	18.2
C - School south on hilltop	17	0.9	17.9
M1 - Receptor southwestern corner hillside	17	1.2	18.2
M2 - Receptor southern boundary Hanson Tweed Sand	17	0.4	17.4
M - Chinderah golf range building	17	1.5	18.5
K - Residence north	17	1.0	18.0
I - Residence north close to site boundary	17	1.0	18.0
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.7	17.7
G - Residence eastern boundary of northern extraction site	17	1.0	18.0
Air quality goal - *PM_{10} (annual)*	-	-	**30**

Table 14
Predicted Deposited Dust Impacts (Stages N1 & 4) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	g/m²/month[1]		
A - Residence south on hillside	1.5	1.3	2.8
C - School south on hilltop	1.5	1.1	2.6
M1 - Receptor southwestern corner hillside	1.5	1.5	3.0
M2 - Receptor southern boundary Hanson Tweed Sand	1.5	0.4	1.9
M - Chinderah golf range building	1.5	1.2	2.7
K - Residence north	1.5	0.6	2.1
I - Residence north close to site boundary	1.5	0.6	2.1
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.4	1.9
G - Residence eastern boundary of northern extraction site	1.5	0.6	2.1
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	-
Maximum total deposited dust level	-		**4.0**
[1] Annual average			

No exceedances of air quality goals are predicted to occur during Scenario 2. The concentration contours for 24hr PM_{10} are shown in **Figure 6**.

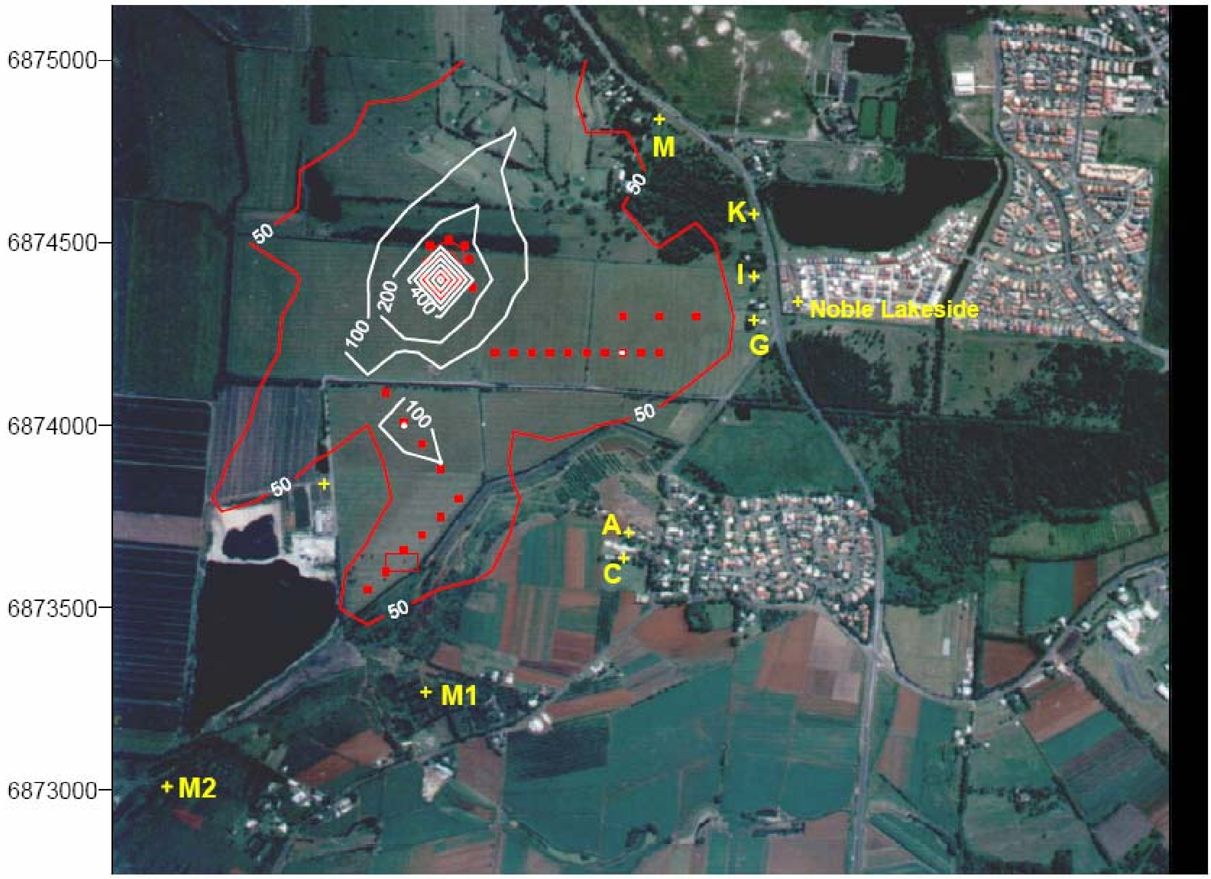


Figure 6
Scenario 2 - PM_{10} (μg/m³) 24hr average

1.1.3 Scenario 4: Extraction Stage 4 and Processing

This model scenario includes:

- soil stripping, removal of loamy sand, wheel generated dust, and stockpile erosion (VENM(b)) from the southern extraction site; and
- wheel generated dust, stockpile erosion, product load-out emissions, loading/unloading stockpile emissions, and screening and blending emissions from the processing area.

Results of the predicted TSP, PM_{10} and deposited dust levels are shown in **Tables 15**, **16** and **17.**

Table 15
Predicted TSP Impacts (Stage 4) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$\mu g/m^3$, annual average		
A - Residence south on hillside	34	2.0	36
C - School south on hilltop	34	1.6	35.6
M1 - Receptor southwestern corner hillside	34	2.8	36.8
M2 - Receptor southern boundary Hanson Tweed Sand	34	0.9	34.9
M - Chinderah golf range building	34	2.2	36.2
K - Residence north	34	1.3	35.3
I - Residence north close to site boundary	34	1.2	35.2
Noble Park Estate - Residence east side of Tweed Coast Road	34	0.9	34.9
G - Residence eastern boundary of northern extraction site	34	1.2	35.2
Air quality goal - *TSP (annual)*	**-**	**-**	**90**

Table 16
Predicted PM_{10} Impacts (Stage 4) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$\mu g/m^3$, 24 hr average		
A - Residence south on hillside	31	7.4	38.4
C - School south on hilltop	31	6.2	37.2
M1 – Receptor southwestern corner hillside	31	6.4	37.4
M2 – Receptor southern boundary Hanson Tweed Sand	31	3.8	34.8
M - Chinderah golf range building	31	16	47
K - Residence north	31	9.6	40.6
I - Residence north close to site boundary	31	7.5	38.5
Noble Park Estate - Residence east side of Tweed Coast Road	31	5.5	36.5
G – Residence eastern boundary of northern extraction site	31	9.7	40.7
Air quality goal - *PM_{10} (24 hr)*	**-**	**-**	**50**

Table 16 (Cont'd)
Predicted PM_{10} Impacts (Stage 4) at Off Site Sensitive Receptors

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Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, annual average		
A - Residence south on hillside	17	0.7	17.7
C - School south on hilltop	17	0.6	17.6
M1 – Receptor southwestern corner hillside	17	1.0	18.0
M2 – Receptor southern boundary Hanson Tweed Sand	17	0.3	17.3
M - Chinderah golf range building	17	0.9	17.9
K - Residence north	17	0.5	17.5
I - Residence north close to site boundary	17	0.5	17.5
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.4	17.4
G – Residence eastern boundary of northern extraction site	17	0.5	17.5
Air quality goal - *PM_{10} (annual)*	-	-	**30**

Table 17
Predicted Deposited Dust Impacts (Stage 4) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	g/m²/month[1]		
A - Residence south on hillside	1.5	0.6	2.1
C - School south on hilltop	1.5	0.6	2.1
M1 – Receptor southwestern corner hillside	1.5	1.3	2.8
M2 – Receptor southern boundary Hanson Tweed Sand	1.5	0.4	1.9
M - Chinderah golf range building	1.5	0.5	2.0
K - Residence north	1.5	0.2	1.7
I - Residence north close to site boundary	1.5	0.3	1.8
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.2	1.7
G – Residence eastern boundary of northern extraction site	1.5	0.3	0.8
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	**-**
Maximum total deposited dust level	-	-	**4.0**
[1] Annual average			

No exceedances of air quality goals are predicted to occur during Scenario 4. The predicted concentration contours for 24hr PM_{10} are shown in **Figure 7.**

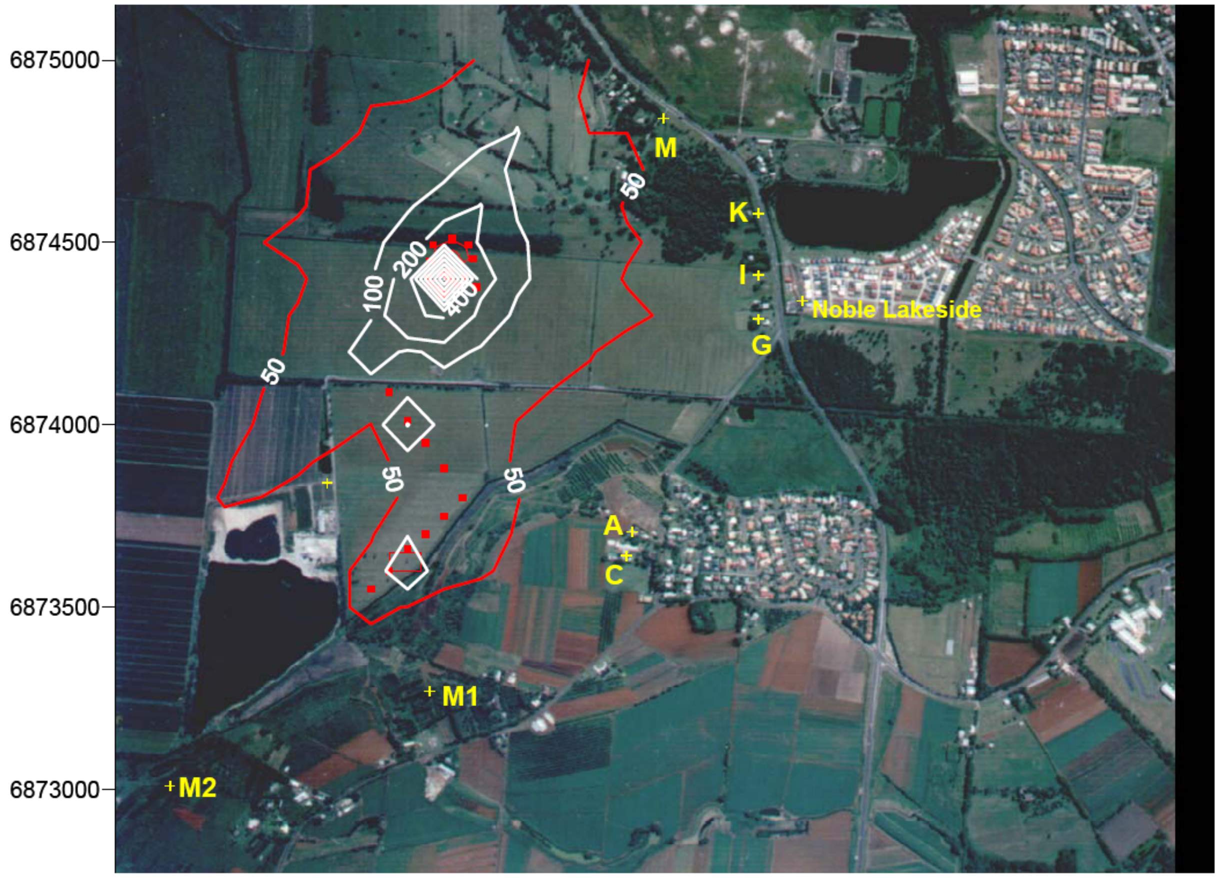

Figure 7
Scenario 4 - PM_{10} ($\mu g/m^3$), 24hr Average

6.4.2 Scenario 5: Extraction Stage 7 and Processing

This model scenario includes:

- soil stripping, removal of loamy sand, wheel generated dust, wind erosion and stockpile erosion (VENM(b)) from the southern extraction site; and
- wheel generated dust, stockpile erosion, product load-out emissions, loading/unloading stockpile emissions, wind erosion and screening and blending emissions from the processing area.

Results of the predicted TSP, PM_{10} and deposited dust levels are shown in **Table 18**, **19** and **20**.

Table 18
Predicted TSP Impacts (Stage 7) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$\mu g/m^3$, annual average		
A - Residence south on hillside	34	3.2	37.2
C - School south on hilltop	34	2.3	36.3
M1 - Receptor southwestern corner hillside	34	1.9	35.9
M2 - Receptor southern boundary Hanson Tweed Sand	34	0.8	34.8
M - Chinderah golf range building	34	2.8	36.8
K - Residence north	34	1.6	35.6
I - Residence north close to site boundary	34	1.5	35.5
Noble Park Estate - Residence east side of Tweed Coast Road	34	1.1	35.1
G - Residence eastern boundary of northern extraction site	34	1.3	35.3
Air quality goal - *TSP (annual)*	**-**	**-**	**90.0**

Table 19
Predicted PM_{10} Impacts (Stage 7) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$\mu g/m^3$, 24 hr average		
A - Residence south on hillside	31	16	47
C - School south on hilltop	31	9.6	40.6
M1 – Receptor southwestern corner hillside	31	4.7	35.7
M2 – Receptor southern boundary Hanson Tweed Sand	31	2.6	33.6
M Chinderah golf range building	31	16	47.1
K- Residence north	31	9.9	40.9
I- Residence north close to site boundary	31	7.9	38.9
Noble Park Estate - Residence east side of Tweed Coast Road	31	8.0	39.0
G – Residence eastern boundary of northern extraction site	31	13	44
Air quality goal - *PM_{10} (24 hr)*	-	-	**50.0**
	$\mu g/m^3$, annual average		
A - Residence south on hillside	17	1.2	18.2
C - School south on hilltop	17	0.8	17.8
M1 - Receptor southwestern corner hillside	17	0.7	17.7
M2 - Receptor southern boundary Hanson Tweed Sand	17	0.3	17.3
M - Chinderah golf range building	17	1.1	18.1
K - Residence north	17	0.6	17.6
I - Residence north close to site boundary	17	0.6	17.6
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.4	17.4
G - Residence eastern boundary of northern extraction site	17	0.5	17.5
Air quality goal - *PM_{10} (annual)*	-	-	**30**

Table 20
Predicted Deposited Dust Impacts (Stage 7) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Total
	g/m²/month[1]		
A - Residence south on hillside	1.5	1.3	2.8
C - School south on hilltop	1.5	0.9	2.4
M1 - Receptor southwestern corner hillside	1.5	0.9	2.4
M2 - Receptor southern boundary Hanson Tweed Sand	1.5	0.3	1.8
M - Chinderah golf range building	1.5	0.6	2.1
K - Residence north	1.5	0.3	1.8
I - Residence north close to site boundary	1.5	0.3	1.8
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.2	1.7
G - Residence eastern boundary of northern extraction site	1.5	0.3	1.8
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	**-**
Maximum total deposited dust level	-	-	**4.0**
[1] Annual average			

No exceedances of air quality goals are predicted to occur during Scenario 5. The predicted concentration contours. The concentration contours for 24hr PM_{10} are shown in **Figure 8**.

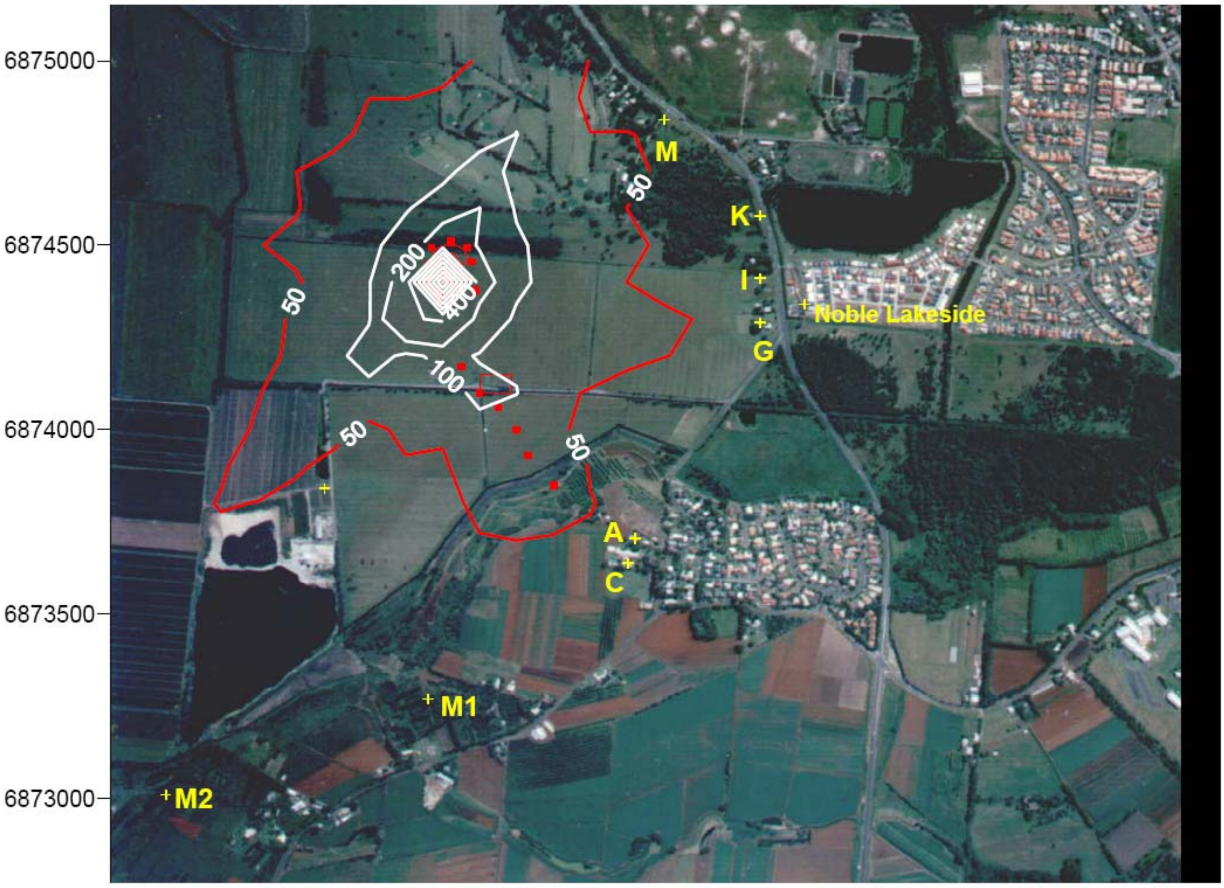

Figure 8
Scenario 5 - PM_{10} (µg/m³), 24hr average

6.4.3 Scenario 6: Extraction Stage 10 and Processing

This model scenario includes:

- soil stripping, removal of loamy sand, wheel generated dust, wind erosion and stockpile erosion (VENM(b)) from the southern extraction site; and
- wheel generated dust, stockpile erosion, product load-out emissions, loading/unloading stockpile emissions, wind erosion and screening and blending emissions from the processing area.

Results of predicted TSP, PM_{10} and deposited dust levels are shown in **Tables 21**, **22** and **23**.

Table 21
Predicted TSP Impacts (Stage 10) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³ annual average	µg/m³, annual average	µg/m³, annual average
A - Residence south on hillside	34	3.3	37.3
C - School south on hilltop	34	2.5	36.5
M1 – Receptor southwestern corner hillside	34	1.6	35.6
M2 – Receptor southern boundary Hanson Tweed Sand	34	0.7	34.7
M - Chinderah golf range building	34	3.4	37.4
K - Residence north	34	2.9	36.9
I - Residence north close to site boundary	34	3.1	37.1
Noble Park Estate - Residence east side of Tweed Coast Road	34	1.8	35.8
G – Residence eastern boundary of northern extraction site	34	2.8	36.8
Air quality goal - *TSP (annual)*	-	-	**90.0**

Table 22
Predicted PM_{10} Impacts (Stage 10) at Off Site Sensitive Receptors

Page 1 of 2

Receptor	Predicted Background Concentration	Maximum Concentration	Background + Increase
	µg/m³, 24 hr average		
A- Residence south on hillside	31	7.6	38.6
C- School south on hilltop	31	5.7	36.7
M1 - Receptor southwestern corner hillside	31	3.8	34.8
M2 - Receptor southern boundary Hanson Tweed Sand	31	2.4	33.4
M - Chinderah golf range building	31	15	46
K - Residence north	31	10	41
I - Residence north close to site boundary	31	9.3	40.3
Noble Park Estate - Residence east side of Tweed Coast Road	31	9.7	40.7
G - Residence eastern boundary of northern extraction site	31	16	47
Air quality goal - *PM_{10} (24 hr)*	-	-	**50**

Table 22 (Cont'd)
Predicted PM_{10} Impacts (Stage 10) at Off Site Sensitive Receptors

Page 2 of 2

Receptor	Predicted Background Concentration	Maximum Concentration	Background + Increase
	$\mu g/m^3$, annual average		
A - Residence south on hillside	17	1.1	18.1
C - School south on hilltop	17	0.9	17.9
M1 – Receptor southwestern corner hillside	17	0.6	17.6
M2 – Receptor southern boundary Hanson Tweed Sand	17	0.3	17.3
M - Chinderah golf range building	17	1.3	18.3
K - Residence north	17	1.2	18.2
I - Residence north close to site boundary	17	1.2	18.2
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.7	17.7
G – Residence eastern boundary of northern extraction site	17	1.1	18.1
Air quality goal - ***PM_{10} (annual)***	-	-	**30**

Table 23
Predicted Deposited Dust Impacts (Stage 10) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increment
	g/m^2/month[1]		
A - Residence south on hillside	1.5	1.0	2.5
C - School south on hilltop	1.5	1.1	2.6
M1 – Receptor southwestern corner hillside	1.5	0.7	2.2
M2 – Receptor southern boundary Hanson Tweed Sand	1.5	0.3	1.8
M- Chinderah golf range building	1.5	0.9	2.4
K - Residence north	1.5	0.6	2.1
I - Residence north close to site boundary	1.5	0.5	2.0
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.3	1.8
G – Residence eastern boundary of northern extraction site	1.5	0.5	2.0
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	**-**
Maximum total deposited dust level	-	-	**4.0**

1 Annual average

No exceedances of air quality goals are predicted to occur during Scenario 6. The predicted concentration contours for 24hr PM_{10} are shown in **Figure 9.**

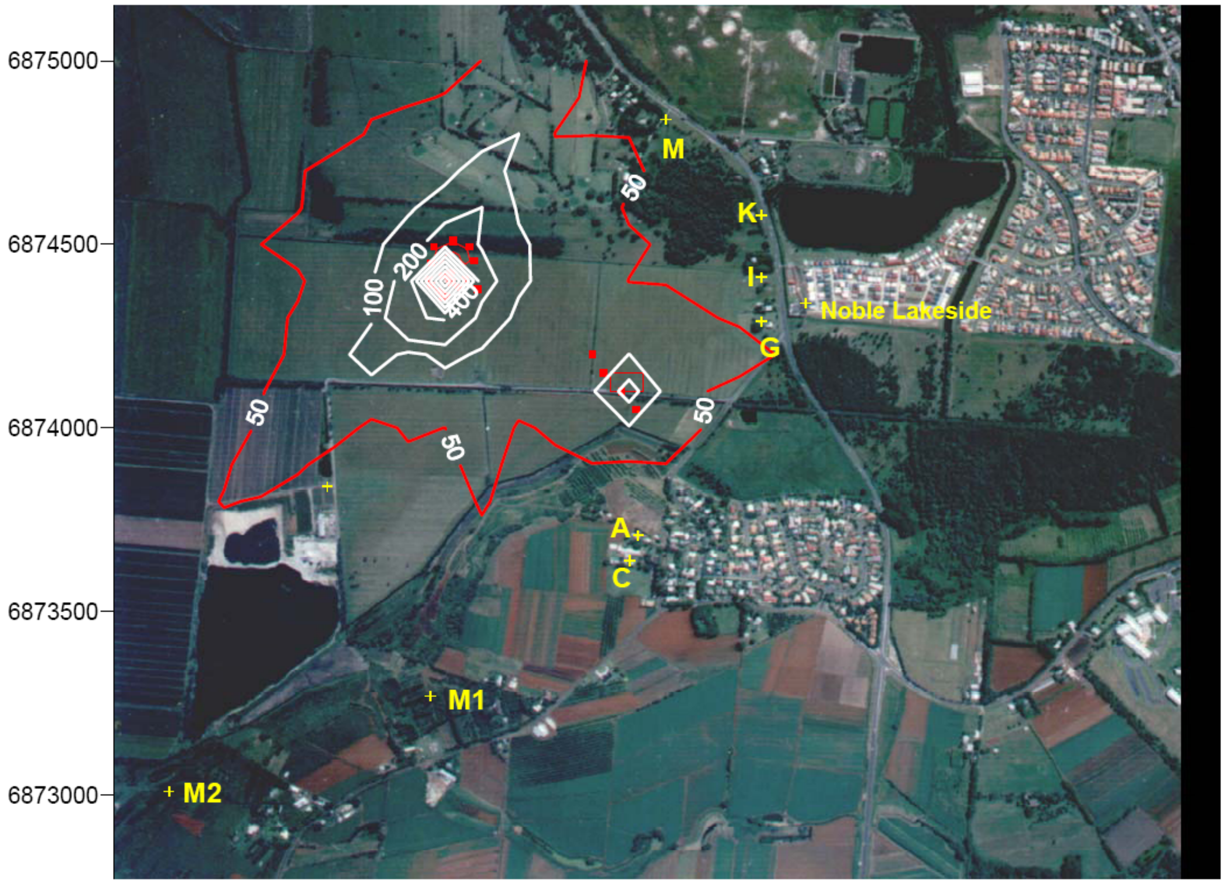

Figure 9
Scenario 6 - PM_{10} ($\mu g/m^3$), 24hr Average

6.5 Assessment of Results

6.5.1 Site Establishment

The main sources of dust emissions during site establishment operations are removal of topsoil by scraping and wind erosion of cleared areas. Air dispersion modelling predicted small increases in maximum concentrations of TSP, PM_{10} and deposited dust at the existing off site specified receptors. The total particulate concentrations were predicted to be below air quality goals at all locations.

6.5.2 Sand Extraction and Processing Stage N1 and Stage 4

Sand excavation within the northern area (Stage N1) and dredging within Stage 4 of the southern area concurrently, together with processing are predicted to generate increases in the maximum concentrations of PM_{10} (24 hour average) for most receptors, particularly Receptor M to Receptor G. There were no predicted exceedances of the air quality goal ($50\mu g/m^3$) assuming a background concentration of $31\mu g/m^3$ (24 hour average).

Annual average increases of PM_{10} are predicted to be minor to insignificant with all receptors well below the air quality goal for PM_{10} (annual average) (**Table 13**). Predicted TSP and deposited dust impacts are also below respective air quality goals.

6.5.3 Sand Extraction and Processing Stages 4, 7, 10

There are two major sources of dust emissions once production fully commences. These sources are the active extraction stages (10 stages in total) and the processing area. Within the active extraction stage, dust may be generated by topsoil removal, removal of loamy sand (overlying the sand resource), wheel generated dust and VENM(b) / loamy sand stockpile erosion. In the processing area, dust may be generated by wheel generated dust, stockpile erosion, loading/unloading activities (materials and final products) and screening and blending (this activity was identified as a major source contribution).

The total TSP impact was well below the air quality goal (90µg/m^3 annual average) during all modelled stages of the development (Stages 4, 7 and 10). The highest predicted TSP was 37.4µg/m^3 recorded at Receptor M during Stage 10. The PM_{10} impacts were also below the air quality goals for both the 24 hour and annual average.

Deposited dust impacts were predicted to be well below air quality goals at all locations during each stage.

7 ASSESSMENT OF CUMULATIVE IMPACTS ON AIR QUALITY

7.1 Objectives and Scope

The objective of this section is to evaluate potential impacts of the Project on local air quality at Cudgen including consideration of the proposed expansion of sand extraction activities at Hanson Tweed Sand Quarry. The same approach has been used as described in Section 6.0 but additional dust sources from this operation have been included.

7.2 Cumulative Dust Emissions Scenarios

Two cumulative scenarios have been evaluated in this report. Scenario 3 considers the near future dust emissions from the Cudgen Lakes Sand Extraction Project (Stages N1 and 4) and existing emissions from Hanson Tweed Sand (Phase 2). Scenario 6 considers cumulative emissions from a later stage of the Cudgen Lakes Sand Extraction Project (Stage 7) and the future activities of Hanson Tweed Sand (Phase 4).

7.2.1 Potential Sources and Emissions

Potential sources of air quality impacts on the local airshed during the operational lifetime of the Project include the following.

- Site development and construction of the Project.
- Combined operational stages of the Project (i.e. sand extraction, processing, blending, backfilling and rehabilitation).
- Future sand extraction activities at Hanson Tweed Sand (Phases 3 and 4) west of the Project Site.

- Traffic emissions from Tweed Coast Road and Crescent Street.
- Agricultural cropping activities and fallow soils.
- Urban activities – Kingscliff.

Of these activities, dust emissions from future sand extraction and processing activities are expected to be the air pollutants of concern because of the scale of operations and potential dust generating activities. Agricultural dust sources are unlikely to increase in intensity and future dusts generated are expected to be equivalent to existing background levels.

Airshed smoke (PM_{10} and $PM_{2.5}$) and ash deposition from sugar burning are also expected to decrease and be phased out as "green harvesting" becomes fully implemented in the lower Tweed River Valley.

Local traffic emissions of fine particulates, combustion gases and hydrocarbons would gradually increase in the airshed during the Project lifetime, but these emissions should be readily dispersed within or close to traffic corridors and not result in significant cumulative impacts on local dust levels at nearby residences or other sensitive receptors.

7.2.2 Cumulative Dust Emissions Scenario

The proposed scenario for evaluation of the Project dust emissions and cumulative dusts from other sources during the Project lifetime consists of a combination of "worst case" scenarios during the Project operational stages and future sand extraction at Hanson Tweed Sand Quarry (Phase 4).

A description of the cumulative dust scenario, including assumptions, is summarised below for air dispersion modelling purposes.

Cudgen Lakes Sand Extraction Project Operation

Sand extraction, processing and blending, VENM treatment and handling, backfilling into pond, landscaping and rehabilitation activities (these activities would be relatively close to the expansion of Hanson Tweed Sand).

Hanson Tweed Sand Operation

Current extraction (Phase 2) commenced in 2001. Phase 3 extraction of additional sand includes deepening the existing pond to up to 20m and removing approximately 812 590m^3 of sand. Phase 4 involves expansion to the west of the Phase 1 to 3 extraction ponds and removal of approximately 3 640 760m^3 of sand. The maximum extraction rate of sand would be 150 000m^3 per annum, which is equivalent to a Project life of about 30 years. At this rate of extraction, Phase 3 would take about 5.5 years.

Phase 3 is expected to be similar to the existing operation (Phase 2) which contributed to the measured "background" dusts.

For modelling purposes, a scenario involving Phase 4 was adopted with an extraction rate of 150 000m^3 per annum and an average daily traffic volume of 80 trucks per day (40 loads). Peak production is estimated at 200 trucks/day (100 loads).

Dust emissions are assumed to be due to excavation, stockpiling and load out of drier loamy sands. These emissions should be similar to those at the Project Site in the later stages (after 5 to 6 years). Progressive site rehabilitation and watering of internal access roads (2.5 litres of water/m²/hour) would be expected (see Jim Glazebrook and Associates, 2005).

7.3 Air Quality Modelling

7.3.1 Air Quality Model

The computer model used in this report was the Gaussian plume model Ausplume V6.0 which is an approved model for near field application in NSW. Modelling was carried out in accordance with NSW DECC (2005) *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* and the model configuration described in Section 6.3.

7.3.2 Model Results – Cumulative Scenario 3: Stage N1, Stage 4 and Hanson Tweed Sand (Phase 2)

The predicted TSP and PM_{10} concentrations are shown in **Table 24** and **Table 25**. The predicted deposited dust rates are shown in **Table 26**. Total impacts (i.e. background concentration plus predicted increase) above the air quality goal have been highlighted.

Table 24
Predicted TSP Impacts (Cumulative Scenario 3) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, annual average		
A - Residence south on hillside	34	4.3	38.3
C - School south on hilltop	34	3.6	37.6
M1 – Receptor southwestern corner hillside	34	5.0	39.0
M2 – Receptor southern boundary Hanson Tweed Sand	34	2.4	36.4
M - Chinderah golf range building	34	4.9	38.9
K - Residence north	34	3.2	37.2
I - Residence north close to site boundary	34	3.2	37.2
Noble Park Estate - Residence east side of Tweed Coast Road	34	2.2	36.2
G – Residence eastern boundary of northern extraction site	34	3.1	37.1
Air quality goal - *TSP (annual)*	-	-	**90.0**

Table 25
Predicted PM_{10} Impacts (Cumulative Scenario 3) at Off Site Sensitive Receptors

Receptor	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, 24 hr average		
A - Residence south on hillside	31	13	44
C- School south on hilltop	31	9.4	40.4
M1 - Receptor southwestern corner hillside	31	9.3	40.3
M2 - Receptor southern boundary Hanson Tweed Sand	31	7.3	38.3
M - Chinderah golf range building	31	19	50
K - Residence north	31	14	45
I - Residence north close to site boundary	31	15	46
Noble Park Estate - Residence east side of Tweed Coast Road	31	12	43
G - Residence eastern boundary of northern extraction site	31	17	48
Air quality goal - *PM_{10} (24 hr)*	-	-	**50.0**
	µg/m³, annual average		
A - Residence south on hillside	17	1.4	18.4
C- School south on hilltop	17	1.2	18.2
M1 - Receptor southwestern corner hillside	17	1.6	18.6
M2 - Receptor southern boundary Hanson Tweed Sand	17	0.8	17.8
M- Chinderah golf range building	17	1.7	18.7
K - Residence north	17	1.2	18.2
I - Residence north close to site boundary	17	1.2	18.2
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.8	17.8
G - Residence eastern boundary of northern extraction site	17	1.1	18.1
Air quality goal - *PM_{10} (annual)*	-	-	**30**

Table 26
Predicted Deposited Dust Impacts (Cumulative Scenario 3) at Off Site Sensitive Receptors

Location	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	g/m²/month¹		
A - Residence south on hillside	1.5	1.6	3.1
C - School south on hilltop	1.5	1.4	2.9
M1 – Receptor southwestern corner hillside	1.5	2.3	3.8
M2 – Receptor southern boundary Hanson Tweed Sand	1.5	1.0	2.5
M - Chinderah golf range building	1.5	1.3	2.8
K - Residence north	1.5	0.7	2.2
I - Residence north close to site boundary	1.5	0.6	2.1
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.4	2.9
G – Residence eastern boundary of northern extraction site	1.5	0.7	2.2
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	**-**
Maximum total deposited dust level	-	-	**4.0**
[1] Annual average			

The predicted maximum 24 hour average PM_{10} concentration at Receptor M is equal to the air quality goal (50µg/m^3). The concentration contours for 24hr PM_{10} are shown in **Figure 10**. The predicted increase in deposited dust at Receptor M1 has been predicted to exceed the air quality goal for increase in deposited dust levels (2.0g/m^2/month), however, the total annual average monthly deposited dust levels at all locations remain below the air quality goal (4.0g/m^2/month)

7.3.2 Model Results – Cumulative Scenario 7 – Stage 7 and Hanson Tweed Sand (Phase 4)

The total emissions from the cumulative scenario consist of the Stage 7 scenario for the Cudgen Lakes Sand Extraction Project (assumed to be a worst case scenario for nearby receptors) and the following activities at Hanson Tweed Sand Quarry during the Phase 4 expansion.

- Wheel generated dust.
- Wind erosion of stockpiles.
- Loading and unloading of stockpiles.

Table 27 to **Table 29** display the results for this cumulative scenario.

Table 27
Predicted TSP Impacts (Cumulative Scenario 7) at Off Site Sensitive Receptors

Location	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m^3, annual average		
A - Residence south on hillside	34	4.1	38.1
C - School south on hilltop	34	3.2	37.2
M1 - Receptor southwestern corner hillside	34	3.6	37.6
M2 - Receptor southern boundary Hanson Tweed Sand	34	2.1	36.1
M - Chinderah golf range building	34	3.6	37.6
K - Residence north	34	2.1	36.1
I - Residence north close to site boundary	34	1.9	35.9
Noble Park Estate - Residence east side of Tweed Coast Road	34	1.4	35.4
G - Residence eastern boundary of northern extraction site	34	1.8	35.8
Air quality goal - *TSP (annual)*	-	-	**90.0**

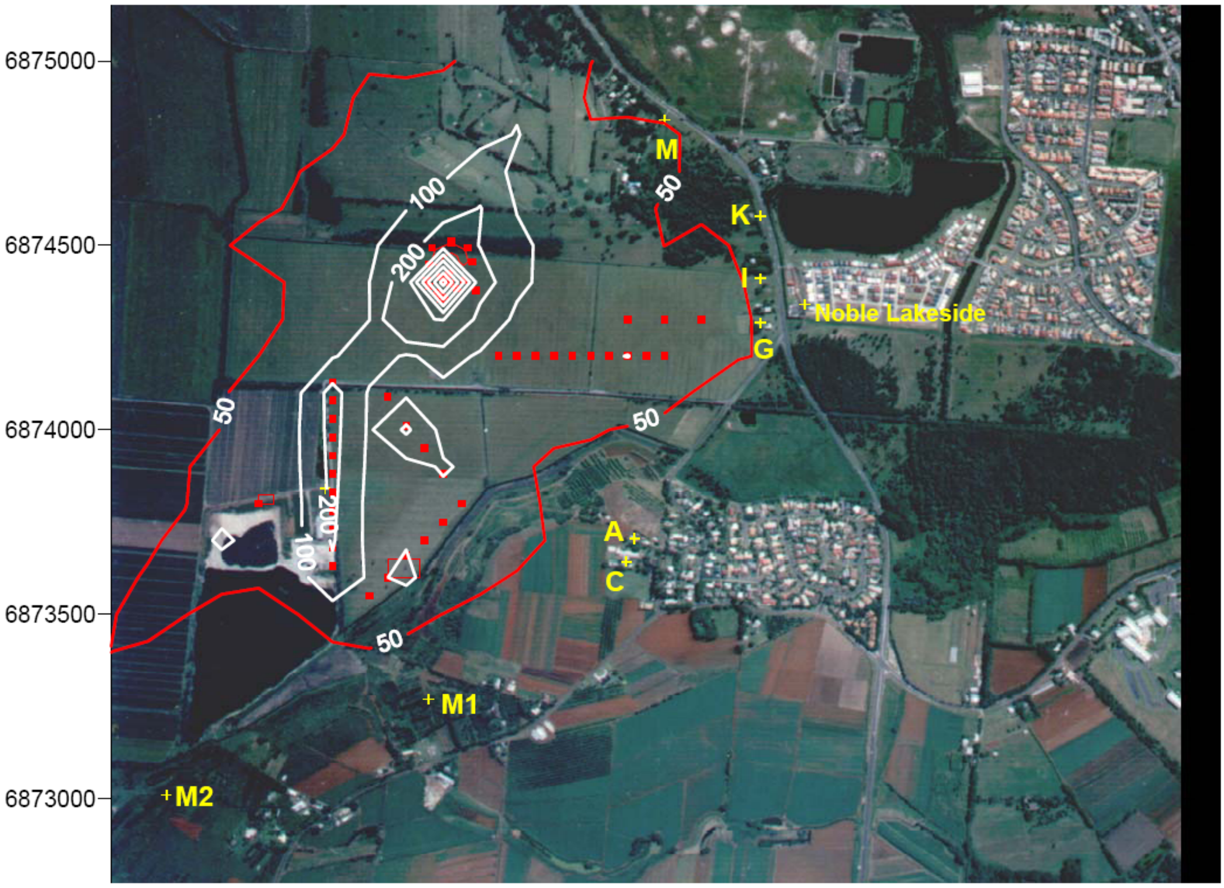

Figure 10
Cumulative Scenario 3 - PM_{10} ($\mu g/m^3$), 24hr average

Table 28
Predicted PM_{10} Impacts (Cumulative Scenario 7) at Off Site Sensitive Receptors

Page 1 of 2

Location	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$\mu g/m^3$, 24 hr average		
A - Residence south on hillside	31	17	48
C- School south on hilltop	31	11	42
M1 – Receptor southwestern corner hillside	31	6.8	37.8
M2 – Receptor southern boundary Hanson Tweed Sand	31	4.8	35.8
M - Chinderah golf range building	31	19	50
K - Residence north	31	10	41
I - Residence north close to site boundary	31	8.9	39.9
Noble Park Estate - Residence east side of Tweed Coast Road	31	9.1	40.1
G - Residence eastern boundary of northern extraction site	31	14	45
Air quality goal - *PM_{10} (24 hr)*	-	-	**50.0**

Table 28 (Cont'd)
Predicted PM_{10} Impacts (Cumulative Scenario 7) at Off Site Sensitive Receptors

Page 2 of 2

Location	Predicted Background Concentration	Maximum concentration (100.00%)	Background + Increase
	$\mu g/m^3$, annual average		
A - Residence south on hillside	17	1.4	18.4
C- School south on hilltop	17	1.1	18.1
M1 - Receptor southwestern corner hillside	17	1.2	18.2
M2 - Receptor southern boundary Hanson Tweed Sand	17	0.7	17.7
M- Chinderah golf range building	17	1.3	18.3
K - Residence north	17	0.8	17.8
I - Residence north close to site boundary	17	0.7	17.7
Noble Park Estate - Residence east side of Tweed Coast Road	17	0.5	17.5
G - Residence eastern boundary of northern extraction site	17	0.6	17.6
Air quality goal - *PM_{10} (annual)*	-	-	**30**

Table 29
Predicted Deposited Dust Impacts (Cumulative Scenario 7) at Off Site Sensitive Receptors

Location	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$g/m^2/month^1$		
A - Residence south on hillside	1.5	1.5	3.0
C - School south on hilltop	1.5	1.2	2.7
M1 - Receptor southwestern corner hillside	1.5	1.7	3.2
M2 - Receptor southern boundary Hanson Tweed Sand	1.5	0.9	2.4
M - Chinderah golf range building	1.5	0.8	2.3
K - Residence north	1.5	0.4	1.9
I - Residence north close to site boundary	1.5	0.4	1.9
Noble Park Estate - Residence east side of Tweed Coast Road	1.5	0.3	1.8
G - Residence eastern boundary of northern extraction site	1.5	0.4	1.9
Air quality goal			
Maximum increase in deposited dust level	-	**2.0**	**-**
Maximum total deposited dust level	-	-	**4.0**
1 Annual average			

The predicted maximum 24 hour average PM_{10} concentrations concentration at Receptor M is equal to the air quality goal ($50\mu g/m^3$). The concentration contours for 24hr PM_{10} are shown in **Figure 11**. No exceedances of TSP, PM_{10} or deposited dust are predicted to occur during Scenario 7.

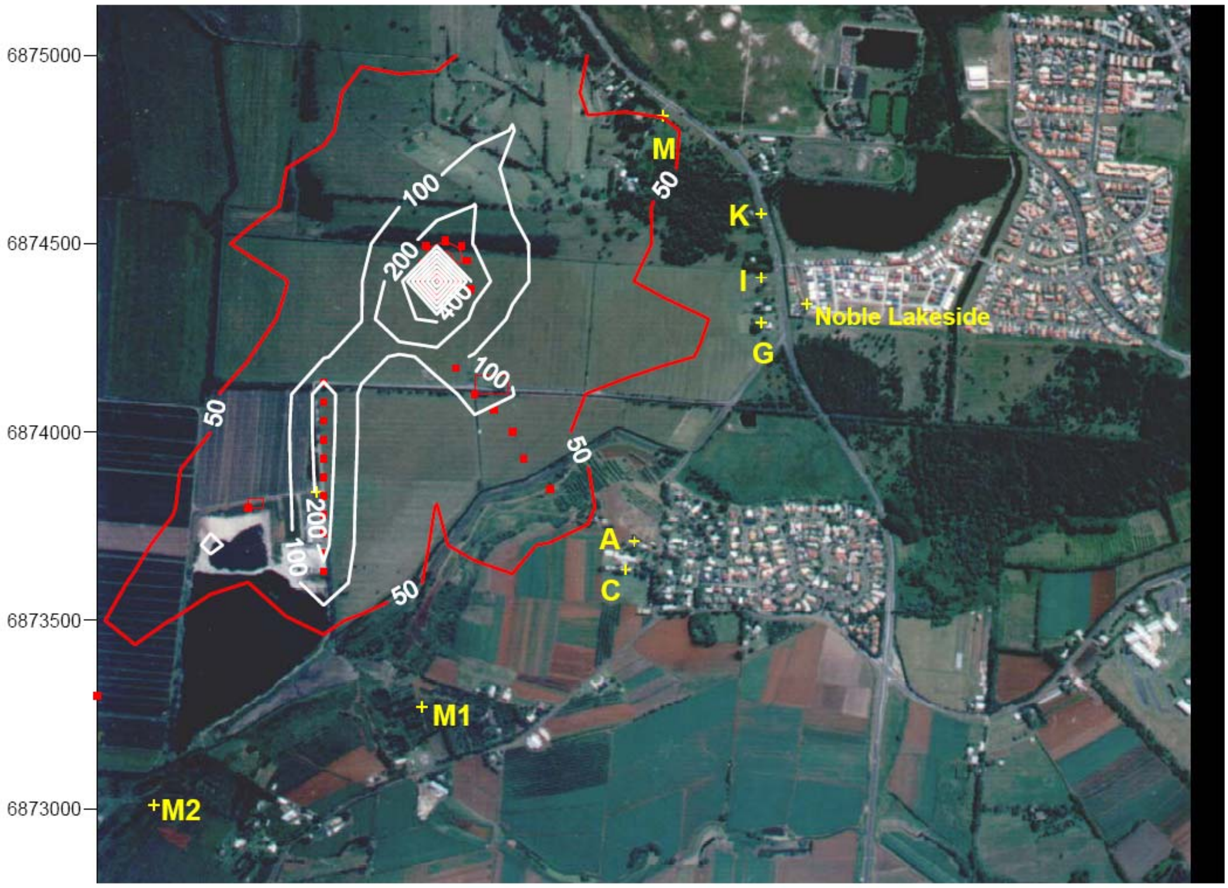

Figure 11
Cumulative Scenario 7 - PM_{10} (µg/m^3), 24hr average

7.4 Assessment of Results

The predicted total impact of the cumulative scenarios is conservative because the existing background concentrations would include the current activities at the Hanson Tweed Sand Quarry operation. The model in this case was configured to simulate proposed expansion of this activity (Phase 2 and Phase 4).

The highest annual TSP predicted was 39.5µg/m^3 at Receptor A (Cumulative Scenario 3), which is less than half of the DECC air quality goal (90µg/m^3 annual average).

Predicted PM_{10} impacts for both cumulative scenarios show maximum PM_{10} concentrations (24hr average) equal to the air quality goal (50µg/m^3) at one receptor site in both scenarios. This site was Receptor M (Chinderah Golf Range Building).

After the completion of the northern extraction site (Scenario 7), maximum PM_{10} concentrations (24hr average) at Receptors K to G were predicted to decrease but were predicted to increase at Receptor A (residence south on hillside) as extraction within the southern extraction site progressed into the later stages.

The highest maximum increase in dust deposition rates was predicted to be 2.3g/m^2/month at model receptor location M1 with a total dust deposition level of 3.8g/m^2/month.

Results for the cumulative scenarios indicated that 24hr PM_{10} levels are a potential issue at Receptor M (**Table 30**) because the total concentrations were predicted to be equal to the air quality goal. However, the predicted 24hr levels are considered conservative and are based on an adopted background concentration of 31µg/m^3. Nonetheless, relative increases in predicted PM_{10} levels emphasise the need for rigorous operational safeguards and mitigation measures and monitoring. These are discussed further in Section 8.

Table 30
Predicted PM_{10} concentrations and locations equal to the air quality goal for cumulative scenarios

Cumulative scenario	Receptor Location	Predicted total concentration (µg/m^3)
Scenario 3 – Stage N1, Stage 4 and Hanson Tweed Sand (Phase 2)	M – Chinderah Golf Range building	50
Scenario 7 – Stage 7 and Hanson Tweed Sand (Phase 4)	M – Chinderah Golf Range building	50

8 RECOMMENDED OPERATIONAL SAFEGUARDS AND MITIGATION MEASURES

8.1 Site Establishment

It is recommended that the following dust controls be employed during site establishment and construction.

- Ensure a higher soil moisture content in disturbed soils which have elevated silt/sediment content (i.e. topsoils). In the event the natural soil moisture is insufficient to avoid generation of excessive airborne dust, water should be applied using the on-site water cart prior to stripping.
- Minimise the area of stripping within the extraction site to provide an area large enough to supply only 6 to 12 months of sand resource.
- Seed fast growing grass species or add mulch cover to all bunds and stockpiled topsoils.
- Minimise the number of internal access roads created and internal access roads no longer required would be cross ripped, topsoiled and seeded.
- Restrict vehicle speeds on unsealed internal access roads to 30km/hr.
- Water internal access roads at a rate of 2L/m² per application using the water cart during high vehicle activity and dry conditions.
- Adopt shut-down procedures in the event of high winds.

Other measures planned for visual or noise amenity purposes would also help to reduce air emissions. These measures include:

- construction of perimeter bunding (approximately 3m high) and acoustic fencing around the processing area; and
- planting of a vegetative screen around the processing area and the northern and eastern boundary of the extraction site (the vegetative screen would be at least 3m or more high, with a porosity density of at least 50%).

Any planting of vegetation on the western and southern boundaries of the extraction site would also provide additional screening of dust emissions.

8.2 Sand Extraction Processing and Blending Operations

It is recommended that the following dust control measures should be employed during extraction, processing and blending.

- Water active unsealed access roads, staging and hardstand areas at 2L/m² per application for six (6) periods per operational day during low soil moisture conditions.
- Water stockpiled materials as necessary, particularly those containing materials with elevated silt content (e.g. stockpiled VENM(b), loamy sand and associated products);
- Use shelters, enclosures or physical barriers for the screening and conveying of loamy sands and VENM materials.
- Partial enclosure of selected conveyors.
- Use water sprays to control dry screening dusts.
- Progressively rehabilitate / stabilise available areas of disturbance (eg. finalised sections or backfilled areas of the extraction ponds).
- Seed fast growing grass species on bunding created as the extraction stages progress.

It is estimated that approximately 30ML to 35ML of water per year would be required for dust suppression. It is recognised that the inherent moisture content of the loamy sand and VENM(b) materials would result in the need for the addition of very little water, if any, during dry screening.

8.3 Transportation

Accumulated tracked road mud, dry dusts, sand or spillages on Altona Drive should be cleaned up as required by using a street sweeper. Product trucks should have covered loads to prevent wind-borne losses and spillages.

8.4 Site Decommissioning and Final Landform

If required, unsealed areas should be watered as required until stabilised with mulch cover, vegetated or sealed for future development. All internal roads not required for future land use should be cross ripped, topsoiled and seeded.

It is expected that dust emissions following site decommissioning would be controlled by the stabilised and vegetated areas and that dust emissions from the site would be the same as "background" levels.

9 MONITORING

It is recommended that an Air Monitoring Program be prepared to ensure DECC air quality goals for dusts (PM_{10} and deposited dust) are met. This program needs to be specifically designed but should include the current deposited dust monitoring sites and consider PM_{10} (24 hour average) monitoring in the vicinity of the model receptor locations Receptor A (for southern extraction scenarios) and Receptor M and Receptor G for northern extraction scenarios. PM_{10} monitoring should be undertaken for a period of 1 year, upon which the results should be reviewed to confirm the need for ongoing PM_{10} monitoring.

Monitoring should be undertaken according to the DECC document "*Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*" (DECC, 2005), and more specifically, in accordance with the following Australian Standards.

- AS 2922-1987 *"Ambient Air – Guide for the Siting of Sampling Units"* (NSW DECC Method AM-1).
- AS 3580.9.6-2003 *"Particulate Matter – PM_{10} – high volume sampler with size-selective inlet".*

Additionally, dust deposition monitoring should be conducted in accordance with AS 2922-1987 and the following Australian Standard:

- AS 3580.10.1-2003 *"Methods for Sampling and Analysis of Ambient Air – Determination of Particulates – Deposited Matter – Gravimetric Method"* (NSW DECC Method AM-19).

An on-site meteorological station should also be established to record wind speed and direction to assist with interpretation of dust monitoring data.

Throughout the operational life of the Project, the dust monitoring program should be reviewed annually to ensure that the data being collected is meaningful.

10 CONCLUSIONS

Off-site dust emissions from the proposed Cudgen Lakes Sand Extraction Project have been predicted by air dispersion modelling (Ausplume V6.0 and local meteorological dataset) to be below DECC Air Quality Goals for TSP and total dust deposition. This assessment includes cumulative dust impacts from the Project and surrounding land uses (i.e. Hanson Tweed Sand Quarry).

In the case of maximum PM_{10} concentrations (24 hour average), levels at Receptor M were predicted to increase during the cumulative scenarios to be equal to the DECC air quality goal (50µg/m^3) based on the maximum 24 hour average background concentration of PM_{10} and conservative assumptions adopted by this assessment. Incremental deposited dust at Receptor M1 was predicted to exceed the incremental deposited dust goal of 2g/m^2/month during the cumulative scenario incorporating activities within the northern and southern extraction sites and Hanson Tweed Sand Quarry. The predicted total deposited dust levels, however, remain within the air quality goal.

Potential sources of dust emissions at different stages of the development of the Project have been identified as stripping of topsoil and loamy sand, wind erosion of cleared areas, wheel generated dusts, unloading and loading of materials, stockpile erosion and screening and blending. Proposed control measures include road watering and the construction of a 3m bund and vegetation barrier around the entire processing area. Additionally, the emissions from the screening and blending plant would be controlled by maintaining an average daily processing rate of 100 tonnes per hour.

Improved environmental safeguards and mitigation measures have been recommended to control the generation of fine dusts during Project related activities and the presence of groundwater on the site would support the intensive use of watering methods during low soil moisture periods.

The assumptions adopted for modelling in this report are conservative and intended to predict worst case conditions. Therefore a monitoring program should be used to demonstrate the effectiveness of control measures and provide site-specific data for comparison with air quality goals and demonstration of compliance. Data should be collected during a 12 month period before being reviewed to determine whether ongoing monitoring is necessary. To assist in interpretation of monitoring results, an automated meteorological station should be installed on site to monitor local conditions.

11 REFERENCES

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APPENDICES

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Appendix 1

Emissions Inventory

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A Emissions inventory

A.1 Dust emission scenarios

The particulate emission rates from seven operating scenarios of the Cudgen Lakes Sand Extraction Proposal are described in the following sections. Two scenarios address the cumulative effects of emissions from Hanson Tweed Sand. The seven scenarios, summarised in **Table A.1**, are:

1. Scenario 1: site establishment (Stages 1 and 2);
2. Scenario 2: extraction (excavator) north of Altona Drive (Stage N1), extraction (dredge) south of Altona Drive (Stage 4) and processing;
3. Scenario 3: cumulative scenario – Stage N1, Stage 4 and current Hanson Tweed Sand;
4. Scenario 4: extraction (dredge) south of Altona Drive (Stage 4) and processing;
5. Scenario 5: extraction (dredge) south of Altona Drive (Stage 7) and processing;
6. Scenario 6: extraction (dredge) south of Altona Drive (Stage 10) and processing; and
7. Scenario 7: cumulative scenario – Stage 7 and future Hanson Tweed Sand.

Table A.1
Dust emission scenarios and activities

Activity	**Scenario 1**	**Scenario 2**		**Scenario 3**			**Scenario 4**	**Scenario 5**	**Scenario 6**	**Scenario 7**	
	Site establishment (Stages 1 & 2)	Extraction Stage N1, extraction Stage 4 & processing		Cumulative Stage N1, Stage 4 & Hanson Tweed Sand (Phase 2)			Extraction south (Stage 4) & processing	Extraction south (Stage 7) & processing	Extraction south (Stage 10) & processing	Cumulative Stage 7 & Hanson Tweed Sand (Phase 4)	
		Stage N1	Stage 4	Stage N1	Stage 4	Hanson Tweed Sand				Stage 7	Hanson Tweed Sand
Clearing											
Topsoil removal (scraper)	✓	✓	✓	✓		-	✓	✓	✓	✓	✓
Wind erosion cleared areas	✓	-	-			-	-	-	-	-	-
Extraction											
Removal of loamy sand	-	✓	✓	✓		-	✓	✓	✓	✓	-
Sand excavation (excavator)	-					-	-	-	-	-	-
Loading sand (excavator)	-					-	-	-	-	-	-
Wheel generated	-	✓	✓	✓		-	✓	✓	✓	✓	-
Stockpile erosion VENM(b)	-		✓	-		-	✓	✓	✓	✓	-
Processing											
Wind erosion of stockpiles	-	✓		✓		✓	✓	✓	✓	✓	✓
Load/unloading sand	-	✓		✓		✓	✓	✓	✓	✓	✓
Load/unloading blended products	-	✓		✓		-	✓	✓	✓	✓	-
Load/unloading VENM stockpiles	-	✓		✓		-	✓	✓	✓	✓	-
Screening and blending	-	✓		✓		-	✓	✓	✓	✓	-
Wheel generated	-	✓		✓		✓	✓	✓	✓	✓	✓

A.2 Dust emission factors

The emission factors were taken from:

1. USEPA: *AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary and Area Sources*, and
2. Environment Australia: *National Pollutant Inventory Emission Estimation Technique Manuals*.

Most of the factors reported by the National Pollutant Inventory were derived from the USEPA AP 42 Factors. The analysis covers both total suspended particulates (TSP) and fine particulates <10µm (PM_{10}). A summary of the emission factors used to derive the emission rates from site establishment is shown in **Table A.2** and from extraction and processing is shown in **Table A.3**. The factors used to derive emission rates for activities carried out by Hanson Tweed Sand are shown in **Table A.4**.

Table A.2
Site establishment emission factors

Source	Dust type	Emission factor equation	Assumptions	Emission factor
Scraper removing topsoil	TSP	Default factor	na	5.7 kg TSP/VKT[1]
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	EF = 2.9 kg/VKT
Wind erosion	TSP	Default factor	na	EF = 0.4 kg/ha/hr[3]
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	EF = 0.2 kg/ha/hr

1 Default factor recommended by Environment Australia (1999).
2 Assumption recommended by Environment Australia (2001).
3 Default factor recommended by Environment Australia (2001) – to be used unless site-specific data is available.

Table A.3
Extraction and processing emission factors

Page 1 of 3

Source	Dust type	Emission factor equation	Assumptions	Emission factor
Extraction area				
Scraper removing topsoil	TSP	Default factor	na	5.7 kg/VKT[1]
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	2.9 kg/VKT
Removal of loamy sand	TSP	$EF = k*0.0016*(U/2.2)^{1.3}*(M/2)^{-1.4}$, k = 0.74	Mean wind speed (U) = 4.3 m/s[3] Moisture content (M) = 6%	0.0006 kg/t
	PM_{10}	$EF = k*0.0016*(U/2.2)^{1.3}*(M/2)^{-1.4}$, k = 0.35	Moisture content (M) = 6% Mean wind speed (U) = 4.3 m/s[3]	0.0003 kg/t

Table A.3 (Cont'd)
Extraction and processing emission factors

Source	Dust type	Emission factor equation	Assumptions	Emission factor
Extraction area				
Wheel generated dust	TSP	EF = $ki*(s/12)^A*(W/3)^B/(M/0.2)^C$ ki = 2.82 A = 0.8 B = 0.5 C = 0.4	Silt content (s) = 10%[4] Vehicle gross mass (t) = 48[4] Moisture content (M) = 2%[4]	3.88 kg/VKT
	PM_{10}	EF = $ki*(s/12)^A*(W/3)^B/(M/0.2)^C$ ki = 0.733 A = 0.8 B = 0.4 C = 0.3	Silt content (s) = 10%[4] Vehicle gross mass (t) = 48[4] Moisture content (M) = 2%[4]	0.96 kg/VKT
Dry excavation (Stage N1)	TSP	EF = $k*0.0016*(U/2.2)^{1.3}*(M/2)^{-1.4}$, k = 0.74	Mean wind speed (U) = 4.3 m/s[3] Moisture content (M) = 6%	0.0006 kg/t
	PM_{10}	EF = $k*0.0016*(U/2.2)^{1.3}*(M/2)^{-1.4}$, k = 0.35	Moisture content (M) = 6% Mean wind speed (U) = 4.3 m/s[3]	0.0003 kg/t
Load to truck (Stage N1)	TSP	Default factor	na	0.03 kg/t[5]
	PM_{10}	Default factor	na	0.013 kg/t[5]
Stockpile erosion ($VENM_{(b)}$)	TSP	EF = $1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right)$	Silt content (s) = 10%[4] Number of days rainfall > 0.25 mm (p) = 158[6] Percent time that wind speed >5.4 m/s = 27%[3]	0.84 kg/ha/hr
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	0.42 kg/ha/hr
Processing area				
Wheel generated dust	TSP	As per extraction area above	As per extraction area above	3.88 kg/VKT
	PM_{10}	As per extraction area above	As per extraction area above	0.96 kg/VKT
Stockpile (washed sand) erosion	TSP	EF = $1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right)$	Silt content (s) = 1% Number of days rainfall > 0.25 mm (p) = 158[6] Percent time that wind speed >5.4 m/s = 27%[3]	0.08 kg/ha/hr
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	0.04 kg/ha/hr
Load out washed sand[6]	TSP	Default factor	na	0.03 kg/t[5]
	PM_{10}	Default factor	na	0.013 kg/t[5]

Table A.3 (Cont'd)
Extraction and processing emission factors

Source	Dust type	Emission factor equation	Assumptions	Emission factor
Processing area				
Loading stockpile (VENM$_{(a)}$)	TSP	Default factor	na	0.004 kg/t[5]
	PM_{10}	Default factor	na	0.0017 kg/t[5]
Loading stockpile (VENM$_{(b)}$)	TSP	Default factor	na	0.004 kg/t[5]
	PM_{10}	Default factor	na	0.0017 kg/t[5]
Unloading stockpile (VENM$_{(a)}$)	TSP	Default factor	na	0.03 kg/t[5]
	PM_{10}	Default factor	na	0.013 kg/t[5]
Unloading stockpile (VENM$_{(b)}$)	TSP	Default factor	na	0.03 kg/t[5]
	PM_{10}	Default factor	na	0.013 kg/t[5]
Screening and blending	TSP	Default factor	na	0.08 kg/t[7]
	PM_{10}	Default factor	na	0.06 kg/t[7]
Stockpile erosion – screened and blended materials	TSP	EF = $1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right)$	Silt content (s) = 5%[8] Number of days rainfall > 0.25 mm (p) = 158[6] Percent time that wind speed >5.4 m/s = 27%[3]	0.42 kg/ha/hr
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	0.21 kg/ha/hr
Load out – screened and blended materials	TSP	Default factor	na	0.03 kg/t[5]
	PM_{10}	Default factor	na	0.013 kg/t7[5]

1 Default factor recommended by Environment Australia (1999)
2 Assumption recommended by Environment Australia (2001)
3 Derived from meteorological datafile prepared for air dispersion modelling at Cudgen
4 Assumptions described in Environment Australia (2001), silt content assumed to be the same as surface soil
5 Default factors recommended by Environment Australia (2001) for loading and unloading e.g. stockpiles
6 Annual raindays at Coolangatta Airport (1982 – 2004)
7 Default factor recommended by Environment Australia (2001) for screening
8 Silt content assumed to be greater than sand (1%) but less than surface soil (10%)

Table A.4
Hanson Tweed Sand emission factors

Source	Dust type	Emission factor equation	Assumptions	Emission factor
Scraper removing topsoil	TSP	Default factor	na	5.7 kg/VKT[1]
	PM_{10}	Default factor	PM_{10} = 50% of TSP[2]	2.9 kg/VKT
Removal of loamy sand	TSP	$EF = k*0.0016*(U/2.2)^{1.3}*(M/2)^{-1.4}$, k = 0.74	Mean wind speed (U) = 4.3 m/s[3] Moisture content (M) = 6%	0.0006 kg/t
	PM_{10}	$EF = k*0.0016*(U/2.2)^{1.3}*(M/2)^{-1.4}$, k = 0.35	Moisture content (M) = 6% Mean wind speed (U) = 4.3 m/s[3]	0.0003 kg/t
Wheel generated dust	TSP	$EF = ki*(s/12)^{A}*(W/3)^{B}/(M/0.2)^{C}$ ki = 2.82 A = 0.8 B = 0.5 C = 0.4	Silt content (s) = 10%[4] Vehicle gross mass (t) = 48[4] Moisture content (M) = 2%[4]	3.88 kg/VKT
	PM_{10}	$EF = ki*(s/12)^{A}*(W/3)^{B}/(M/0.2)^{C}$ ki = 0.733 A = 0.8 B = 0.4 C = 0.3	Silt content (s) = 10%[4] Vehicle gross mass (t) = 48[4] Moisture content (M) = 2%[4]	0.96 kg/VKT
Loading stockpiles	TSP	Default factor	na	0.004 kg/t[2]
	PM_{10}	Default factor	na	0.0017 kg/t[2]
Stockpile (washed sand) erosion	TSP	EF = $1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right)$	Silt content (s) = 1% Number of days rainfall > 0.25 mm (p) = 158[5] Percent time that wind speed >5.4 m/s = 27%[3]	0.08 kg/ha/hr
	PM_{10}	na	PM_{10} = 50% of TSP[1]	0.04 kg/ha/hr
Load out washed sand	TSP	Default factor	na	0.03 kg/t[6]
	PM_{10}	Default factor	na	0.013 kg/t[6]

1 Default factor recommended by Environment Australia (1999)
2 Assumption recommended by Environment Australia (2001)
3 Derived from meteorological datafile prepared for air dispersion modelling at Cudgen
4 Default factor recommended by Environment Australia (2001)
5 Annual raindays at Coolangatta Airport (1982 – 2004)
6 Default factor recommended by Environment Australia (2001) for unloading from stockpiles

A.3 Dust emission rates

A.3.1 Site Establishment Cudgen Lakes Sand Extraction Project

Table A.5
Dust emission rates – site establishment

Source	**Type**	**Unit quantity**	**Hours of release**	**Emission factor**		**Uncontrolled emission rate**	
Stages 1 & 2							
				TSP	PM_{10}	TSP	PM_{10}
Scraper removing topsoil	Volume	0.23 ha/day 1 VKT/day	12.5 hrs per day (6.30am – 7pm)	5.7 kg/VKT	2.9 kg/VKT	0.14 g/s	0.07 g/s
Wind erosion	Area	0.7 ha	24 hrs per day	0.4 kg/ha/hr	0.2 kg/ha/hr	0.00001 g/s/m^2	0.000006 g/s/m^2

Table A.6
Controlled dust emission rates

Source	**Type**	**Uncontrolled emission rate**		**Control method**	**Control efficiency**	**Controlled emission rate**	
Stages 1 & 2							
		TSP	PM_{10}			TSP	PM_{10}
Scraper removing topsoil	Volume	0.14 g/s	0.07 g/s	na	na	na	na
Wind erosion	Area	0.00001 g/s/m^2	0.000006 g/s/m^2	na	na	na	na

A.3.2 Extraction and Processing Cudgen Lakes Sand Extraction Project

Table A.7
Dust emission rates – extraction and processing

Page 1 of 3

Source	Type	Unit quantity	Hours of release	Emission factor		Uncontrolled emission rate (g/s)[1]	
				TSP	PM_{10}	TSP	PM_{10}
Extraction (excavator) north of Altona Drive							
Scraper removing topsoil	Volume	0.5 VKT/day	11 hrs per day (7am – 6pm)	5.7 kg/VKT	2.9 kg/VKT	0.07	0.04
Removal of loamy sand	Volume	1625 t/day 30 days/yr	11 hrs per day (7am – 6pm)	0.0006 kg/t	0.0003 kg/t	0.02	0.01
Wet excavation	Volume	1000 t/day	11 hrs per day (7am – 6pm)	0.0008 kg/t	0.0004 kg/t	0.02	0.01
Load to truck	Volume	1000 t/day	11 hrs per day (7am – 6pm)	0.03 kg/t	0.013 kg/t	0.76	0.33
Wheel generated dust	Volume	40 VKT/day	11 hrs per day (7am – 6pm)	3.54 kg/VKT (loaded) 2.80 kg/VKT (unloaded)	0.89 kg/VKT (loaded) 0.74 kg/VKT (unloaded)	2.9 (total)	0.8 (total)
Extraction (dredge) south of Altona Drive							
Scraper removing topsoil	Volume	0.13 ha/day 0.5 VKT/day	11 hrs per day (7am – 6pm)	5.7 kg/VKT	2.9 kg/VKT	0.07	0.04
Removal of loamy sand	Volume	1625 t/day 30 days/yr	11 hrs per day (7am – 6pm)	0.0006 kg/t	0.0003 kg/t	0.02	0.01

[1] Unless otherwise indicated

Table A.7 (Cont'd)
Dust emission rates – extraction and processing

Page 2 of 3

Source	Type	Unit quantity	Hours of release	Emission factor		Uncontrolled emission rate (g/s)[2]	
				TSP	PM_{10}	TSP	PM_{10}
Extraction (dredge) south of Altona Drive							
Wheel generated dust	Line (volume)	30 VKT/day	11 hrs per day (7am – 6pm)	3.88 kg/VKT	0.96 kg/VKT	2.9 (total)	0.7 (total)
Stockpile erosion (VENM(b))	Area	0.44 ha 100 000 t/yr	24 hrs	0.84 kg/ha/hr	0.42 kg/ha/hr	0.00002 g/s/m^2	0.00001 g/s/m^2
Processing							
Wheel generated dust	Line (volume)	76 VKT/day	11 hrs per day (7am – 6pm)	3.88 kg/VKT	0.96 kg/VKT	7.5 (total)	1.8 (total)
Stockpile erosion (washed sand)	Area	0.4 ha	24 hrs	0.08 kg/ha/hr	0.04 kg/ha/hr	0.000002 g/s/m^2	0.000001 g/s/m^2
Load out washed sand	Volume	705 tpd 220 000 tpa	11 hrs per day (7am – 6pm)	0.03 kg/t	0.013 kg/t	0.53	0.23
Loading stockpile (VENM(a))	Volume	VENM (a) 2000 t = 38 t/day (312 workdays)	11 hrs per day (7am – 6pm)	0.004 kg/t	0.0017 kg/t	0.004	0.002
Loading stockpile (VENM(b))	Volume	VENM (b) 2000 t 100 000 t/y = 320 t/day	11 hrs per day (7am – 6pm)	0.004 kg/t	0.0017 kg/t	0.03	0.01

[2] Unless otherwise indicated

Table A.7 (Cont'd)
Dust emission rates – extraction and processing

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Source	Type	Unit quantity	Hours of release	Emission factor		Uncontrolled emission rate (g/s)[3]	
				TSP	PM_{10}	TSP	PM_{10}
Processing							
Unloading stockpile (VENM(a))	Volume	38 t/day	11 hrs per day (7am – 6pm)	0.03 kg/t	0.013 kg/t	0.03	0.01
Unloading stockpile (VENM(a))	Volume	320 t/day	11 hrs per day (7am – 6pm)	0.03 kg/t	0.013 kg/t	0.24	0.11
Screening and blending	Volume	50 tph – 200 tph	11 hrs per day (7am – 6pm)	0.08 kg/t	0.06 kg/t	2.3 (100tph)	1.7 (100tph)
Stockpile erosion – blended materials	Area	0.02 ha/stockpile (3 x 1000 t)	24 hrs	0.42 kg/ha/hr	0.21 kg/ha/hr	0.00001 $g/s/m^2$	0.000006 $g/s/m^2$
Load out blended materials	Volume	256 t/day 3 stockpiles	11 hrs per day (7am – 6pm)	0.03 kg/t	0.013 kg/t	0.19 (total) 0.06/stockpile	0.08 (total) 0.03/stockpile

[3] Unless otherwise indicated

Table A.8
Controlled dust emission rates – extraction and processing

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Source	Type	Uncontrolled emission rate (g/s)[2]		Control method	Control efficiency	Controlled emission rate (g/s)[4]	
		TSP	PM_{10}			TSP	PM_{10}
Extraction (excavator) north of Altona Drive							
Scraper removing topsoil	Volume	0.07	0.04	No control	na	na	na
Removal of loamy sand	Volume	0.02	0.01	No control	na	na	na
Wet excavation	Volume	0.02	0.01	High moisture content	50%	0.01	0.005
Load to truck	Volume	0.76	0.33	High moisture content	50%	0.38	0.17
Wheel generated dust	Volume	2.9 (total)	0.8 (total)	Road watering @ 2.0 L/m^2 6 applications/day	50%	1.5 (total)	0.4 (total)
	Stage N1 – 10 sources				na	0.15	0.04
Extraction (dredge) south of Altona Drive							
Scraper removing topsoil – Stages 4, 7 & 10	Volume	0.07 g/s	0.04 g/s	No control	na	na	na
Removal of loamy sand	Volume	0.02	0.01	No control	na	na	na
Wheel generated dust	Line (volume)	2.9 (total)	0.7 (total)	Road watering @ 2.0 L/m^2 6 applications/day	50%	1.5 (total)	0.4 (total)
	Stage 4 – 9 sources Stage 7 – 6 sources Stage 10 – 4 sources					0.16 (Stage 4) 0.25 (Stage 7) 0.38 (Stage 10)	0.04 (Stage 4) 0.07 (Stage 7) 0.1 (Stage 10)
Stockpile erosion (VENM(b))	Area	0.00002 g/s/m^2	0.00001 g/s/m^2	No control	na	na	na

[4] Unless otherwise indicated

Table A.8 (Cont'd)
Controlled dust emission rates – extraction and processing

Source	Type	Uncontrolled emission rate (g/s)[2]		Control method	Control efficiency	Controlled emission rate (g/s)[5]	
		TSP	PM_{10}			TSP	PM_{10}
Processing							
Wheel generated dust	Line (volume)	7.5 (total)	1.8 (total)	Road watering @ 2.0 L/m^2 6 applications/day Vegetation screen	50% 30%	2.6 (total)	0.6 (total)
	11 sources	-	-			0.24/source	0.05/source
Stockpile erosion (washed sand)	Area	0.000002 g/s/m^2	0.000001 g/s/m^2	Vegetation screen	30%	0.0000014 g/s/m^2	0.0000007 g/s/m^2
Load out washed sand	Volume	0.53	0.23	Vegetation screen	30%	0.37	0.16
Loading stockpile (VENM(a))	Volume	0.004	0.002	Vegetation screen	30%	0.0028	0.0014
Loading stockpile (VENM (b))	Volume	0.03	0.01	Vegetation screen	30%	0.02	0.007
Unloading stockpile (VENM(a))	Volume	0.03	0.01	Vegetation screen	30%	0.02	0.007
Unloading stockpile (VENM(b))	Volume	0.24	0.11	Vegetation screen	30%	0.17	0.08
Screening and blending	Volume	2.3 (100 tph)	1.7 (100 tph)	Vegetation screen	30%	1.6 (100 tph)	1.2 (100 tph)
Stockpile erosion – blended materials	Area	0.00001 g/s/m^2	0.000006 g/s/m^2	Vegetation screen	30%	0.000007 g/s/m^2	0.000004 g/s/m^2
Load out blended materials – 3 stockpiles	Volume	0.06	0.03	Vegetation screen	30%	0.042	0.021

[5] Unless otherwise indicated

Table A.9
Dust emission rates – cumulative scenarios (Hanson Tweed Sand)

Source	Type	Quantity	Hours of release	Emission factor		Uncontrolled emission rate (g/s)[6]	
				TSP	PM_{10}	TSP	PM_{10}
Current activities (Phase 2)							
Wheel generated dust	Line (volume)	100 VKT/day 200 trucks/day	10 hrs per day (7am – 5pm)	3.88 kg/VKT	0.96 kg/VKT	9.8 (total)	2.4 (total)
Loading stockpiles	Volume	800 tpd average	10 hrs per day (7am – 5pm)	0.004 kg/t	0.0017 kg/t	0.08	0.03
Stockpile erosion (washed sand)	Area	0.1 ha (~10% proposed expansion area)	24 hrs	0.08 kg/ha/hr	0.04 kg/ha/hr	0.000002 g/s/m^2	0.000001 g/s/m^2
Load out sand products	Volume	800 tpd average	10 hrs per day (7am – 5pm)	0.03 kg/t	0.013 kg/t	0.6	0.3
Future activities (Phase 4)							
Scraper removing topsoil	Volume	0.5 VKT/day	10 hrs per day (7am – 5pm)	5.7 kg/VKT	2.9 kg/VKT	0.07	0.04
Removal loamy sand	Volume	1625 t/day 30 days/yr	10 hrs per day (7am – 5pm)	0.0006 kg/t	0.0003 kg/t	0.03	0.01
Wheel generated dust	Line (volume)	100 VKT/day 200 trucks/day	10 hrs per day (7am – 5pm)	3.88 kg/VKT	0.96 kg/VKT	9.8 (total)	2.4 (total)
Loading stockpiles	Volume	800 tpd average	10 hrs per day (7am – 5pm)	0.004 kg/t	0.0017 kg/t	0.08	0.03
Stockpile erosion (washed sand)	Area	0.1 ha	24 hrs	0.08 kg/ha/hr	0.04 kg/ha/hr	0.000002 g/s/m^2	0.000001 g/s/m^2
Load out sand products	Volume	800 tpd average	10 hrs per day (7am – 5pm)	0.03 kg/t	0.013 kg/t	0.6	0.3

[6] Unless otherwise indicated

Table A.10
Controlled dust emission rates – cumulative scenarios (Hanson Tweed Sand)

Source	Type	Uncontrolled emission rate (g/s)[7]		Control method	Control efficiency	Controlled emission rate (g/s)[4]	
						TSP	PM_{10}
Current activities (Phase 2)							
Wheel generated dust	Line (volume)	9.8 (total)	2.4 (total)	Road watering @ 2.0 L/m^2 per application	50%	4.9	1.2
	11 sources					0.45/source	0.11/source
Loading stockpiles	Volume	0.08	0.03	Assumed none	na	na	na
Stockpile erosion (washed sand)	Area	0.000002 g/s/m^2	0.000001 g/s/m^2	Assumed none	na	na	na
Load out sand products	Volume	0.6	0.3	Assumed none	na	na	na
Future activities (Phase 4)							
Scraper removing topsoil	Volume	0.07	0.04	Assumed none	na	na	na
Removal loamy sand	Volume	0.03	0.01	Assumed none	na	na	na
Wheel generated dust	Line (volume)	9.8	2.4	Road watering @ 2.0 L/m^2 per application	50%	4.9	1.2
	11 sources					0.45/source	0.11/source
Loading stockpiles	Volume	0.08	0.03	Assumed none	na	na	na
Stockpile erosion (washed sand)	Area	0.000002 g/s/m^2	0.000001 g/s/m^2	Assumed none	na	na	na
Load out sand products	Volume	0.6	0.3	Assumed none	na	na	na

[7] Unless otherwise indicated

A.4 Dust deposition rates

The dust deposition rate is influenced by the particle size distribution of the total suspended particulates (TSP) fraction. The size range of total suspended particulates is usually 0 to 30µm but may range up to 50µm in windy conditions. The particle size distributions used in these model scenarios were derived from a review carried out by SKM for the National Pollutant Inventory in 2005 (SKM, 2005). These distributions are described in **Table A.11** and show that approximately 60% of TSP generated by fugitive sources is less than 15µm. The remainder of the particle size distribution, above 15µm, was assumed to be 30µm.

Table A.11
Particle-size distributions for dust deposition modelling

Source	**Percentage particle size**			
	2.5µm	10µm	15µm	30µm
Load-in/Load-out	15	32	18	35
Wheel generated Industrial	4.5	25.5	29	41
Wind erosion	20	30	10	40

A.5 Source characteristics

A.5.1 Site establishment south of Altona Drive (Stages 1 and 2)

The total area to be cleared during Stages 1 and 2 is 7 ha. This model scenario considers the dust emissions from topsoil removal from ~0.23 ha per day (4-6 times per year for 5 days per campaign) and wind erosion. The wind erosion component was assumed to cover the total area of 7 ha.

Table A.12
Area source

Source		**Area type**	**Initial vertical spread**	**Vertex coordinates/side length**	
ID	Description			x	y
AREA	Wind erosion	Polygon	0.3m	553900	6873675
				553750	6873800
				553710	6873980
				553850	6874020
				554050	6873820

Table A.13
Volume source

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
	Extraction area						
SCRAPE	Scraping of topsoil	553750	6873800	5	1	2	1

A.5.2 Extraction north of Altona Drive (Stage N1) and south of Altona Drive (Stage 4) and processing

Table A.14
Stage N1 Volume sources

Source		Location			Height (m)	Horizontal spread (m)	Vertical spread (m)
ID	Description	x	y	z			
Extraction area							
SCRAN	Scraping of topsoil	554500	6874300	5	1	2	0.5
ESRN	Removal of loamy sand	554500	6874300	5	1	0.5	0.5
EXCAV1	Dry excavation	554700	6874300	5	2	0.5	0.5
LOAD	Load truck	554600	6874300	6	2	2	0.5

Table A.15
Stage N1 Line sources

Source		Location			Height (m)	Horizontal spread (m)	Vertical spread (m)
ID	Description	x	y	z			
Extraction area							
NEV1	Wheel generated dust	554600	6874200	5	0.5	20	0.25
NEV2		554550	6874200	5	0.5	20	0.25
NEV3		554500	6874200	5	0.5	20	0.25
NEV4		554450	6874200	5	0.5	20	0.25
NEV5		554400	6874200	5	0.5	20	0.25
NEV6		554350	6874200	5	0.5	20	0.25
NEV7		554300	6874200	5	0.5	20	0.25
NEV8		554250	6874200	5	0.5	20	0.25
NEV9		554200	6874200	5	0.5	20	0.25
NEV10		554150	6874200	5	0.5	20	0.25

Table A.16
Stage 4 Area sources

Source		**Area type**	**Initial vertical spread**	**Vertex coordinates/side length**	
ID	Description			x	y
Extraction area					
PILEVB	Stockpile erosion (VENM(b))	Rectangular	0.75m[1]	553850 (SW)	6873600 (SW)
				Side length = 88m	Side length = 50m
Processing area					
PILEWS	Stockpile erosion (washed sand)	Polygon	2.5m[1]	553969	6874455
				553978	6874488
				554022	6874507
				554060	6874488
				554068	6874455
				554055	6874446
				554044	6874455
				554038	6874471
				554022	6874480
				554002	6874471
				553994	6874455
				553983	6874446
S1	Stockpile erosion (stockpile 1)	Circle	0.75m[1]	553994	6874414
S2	Stockpile erosion (stockpile 2)	Circle	0.75m[1]	554008	6874408
S3	Stockpile erosion (stockpile 3)	Circle	0.75m[1]	554018	6874397

[1] one-quarter of stockpile height, assumes wake effects

Table A.17
Stage 4 Volume sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
SCRAPE	Scraping of topsoil	553800	6873550	5	1	2	1
ESR	Removal of loamy sand	553800	6873550	5	1	0.5	0.5
Processing area							
PLVA	Loading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PLVB	Loading stockpiles (VENM(b)	553961	6874389	5	1	0.5	0.5
PULVA	Unloading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PULVB	Unloading stockpiles (VENM(b))	553961	6874389	5	1	0.5	0.5
PLOWS	Load out washed sand	554022	6874507	5	1	0.5	0.5
PSB	Screening and blending	553983	6874373	5	2	1	1
PLOS1	Load out stockpile 1	553994	6874414	5	1	0.5	0.5
PLOS2	Load out stockpile 2	554008	6874407	5	1	0.5	0.5
PLOS3	Load out stockpile 3	554018	6874397	5	1	0.5	0.5

Table A.18
Stage 4 Line sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
EV1	Wheel generated dust	553850	6873600	5	0.5	20	0.25
EV2		553900	6873660	5	0.5	20	0.25
EV3		553950	6873700	5	0.5	20	0.25
EV4		554000	6873750	5	0.5	20	0.25
EV5		554050	6873800	5	0.5	20	0.25
EV6		554000	6873880	5	0.5	20	0.25
EV7		553950	6873950	5	0.5	20	0.25
EV8		553900	6874010	5	0.5	20	0.25
EV9		553850	6874090	5	0.5	20	0.25
Processing area							
PV1	Wheel generated dust	554088	6874378	5	0.5	20	0.25
PV2		554055	6874405	5	0.5	20	0.25
PV3		554016	6874422	5	0.5	20	0.25
PV4		554038	6874383	5	0.5	20	0.25
PV5		553994	6874356	5	0.5	20	0.25
PV6		553955	6874405	5	0.5	20	0.25
PV7		553961	6874449	5	0.5	20	0.25
PV8		553970	6874493	5	0.5	20	0.25
PV9		554022	6874510	5	0.5	20	0.25
PV10		554066	6874493	5	0.5	20	0.25
PV11		554079	6874455	5	0.5	20	0.25

A.5.3 Cumulative scenario – Stage N1, Stage 4 and current Hanson Tweed Sand (Phase 2)

The characteristics of dust sources from extraction north of Altona Drive (Stage N1) and south of Altona Drive (Stage 4) and processing are described in Section A.5.2.

The characteristics of dust sources from the current operations by Hanson Tweed Sand are shown in **Table A.19**, **Table A.20** and **Table A.21**.

Table A.19
Hanson Tweed Sand Area sources

Source		**Initial vertical spread**	**Vertex coordinates**	
ID	Description		x	y
CPWS	Stockpile erosion (washed sand)	1m	553500	6873800
			553540	6873800
			553540	6873825
			553500	6873825

Table A.20
Hanson Tweed Sand Volume sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
CLPILE	Loading stockpiles	553500	6873800	5	2	1	1
CLOUT	Load out of sand products	553500	6873800	5	1	0.5	0.5
CSR	Removal loamy sand	553100	6873300	5	1	0.5	0.5

Table A.21
Hanson Tweed Sand Line sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
CV1	Wheel generated dust	553700	6874130	5	0.5	25	0.25
CV2		553700	6874080	5	0.5	25	0.25
CV3		553700	6874030	5	0.5	25	0.25
CV4		553700	6873980	5	0.5	25	0.25
CV5		553700	6873930	5	0.5	25	0.25
CV6		553700	6873880	5	0.5	25	0.25
CV7		553700	6873830	5	0.5	25	0.25
CV8		553700	6873780	5	0.5	25	0.25
CV9		553700	6873730	5	0.5	25	0.25
CV10		553700	6873680	5	0.5	25	0.25
CV11		553700	6873630	5	0.5	25	0.25

A.5.4 Extraction south of Altona Drive (Stage 4) and processing

Table A.22
Stage 4 Area sources

Source		**Area type**	**Initial vertical spread**	**Vertex coordinates/side length**	
ID	Description			x	y
Extraction area					
PILEVB	Stockpile erosion (VENM(b))	Rectangular	0.75m[1]	553850 (SW)	6873600 (SW)
				Side length = 88m	Side length = 50m
Processing area					
PILEWS	Stockpile erosion (washed sand)	Polygon	2.5m[1]	553969	6874455
				553978	6874488
				554022	6874507
				554060	6874488
				554068	6874455
				554055	6874446
				554044	6874455
				554038	6874471
				554022	6874480
				554002	6874471
				553994	6874455
				553983	6874446
S1	Stockpile erosion (stockpile 1)	Circle	0.75m[1]	553994	6874414
S2	Stockpile erosion (stockpile 2)	Circle	0.75m[1]	554008	6874408
S3	Stockpile erosion (stockpile 3)	Circle	0.75m[1]	554018	6874397

[1] one-quarter of stockpile height, assumes wake effects

Table A.23
Stage 4 Volume sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
SCRAPE	Scraping of topsoil	553800	6873550	5	1	2	1
ESR	Removal of loamy sand	553800	6873550	5	1	0.5	0.5
Processing area							
PLVA	Loading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PLVB	Loading stockpiles (VENM(b)	553961	6874389	5	1	0.5	0.5
PULVA	Unloading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PULVB	Unloading stockpiles (VENM(b))	553961	6874389	5	1	0.5	0.5
PLOWS	Load out washed sand	554022	6874507	5	1	0.5	0.5
PSB	Screening and blending	553983	6874373	5	2	1	1
PLOS1	Load out stockpile 1	553994	6874414	5	1	0.5	0.5
PLOS2	Load out stockpile 2	554008	6874407	5	1	0.5	0.5
PLOS3	Load out stockpile 3	554018	6874397	5	1	0.5	0.5

Table A.24
Stage 4 Line sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
EV1	Wheel generated dust	553850	6873600	5	0.5	20	0.25
EV2		553900	6873660	5	0.5	20	0.25
EV3		553950	6873700	5	0.5	20	0.25
EV4		554000	6873750	5	0.5	20	0.25
EV5		554050	6873800	5	0.5	20	0.25
EV6		554000	6873880	5	0.5	20	0.25
EV7		553950	6873950	5	0.5	20	0.25
EV8		553900	6874010	5	0.5	20	0.25
EV9		553850	6874090	5	0.5	20	0.25
Processing area							
PV1	Wheel generated dust	554088	6874378	5	0.5	20	0.25
PV2		554055	6874405	5	0.5	20	0.25
PV3		554016	6874422	5	0.5	20	0.25
PV4		554038	6874383	5	0.5	20	0.25
PV5		553994	6874356	5	0.5	20	0.25
PV6		553955	6874405	5	0.5	20	0.25
PV7		553961	6874449	5	0.5	20	0.25
PV8		553970	6874493	5	0.5	20	0.25
PV9		554022	6874510	5	0.5	20	0.25
PV10		554066	6874493	5	0.5	20	0.25
PV11		554079	6874455	5	0.5	20	0.25

A.5.5 Extraction south of Altona Drive (Stage 7) and processing

Table A.25
Stage 7 Area sources

Source		Area type	Initial vertical spread	Vertex coordinates/side length	
ID	Description			x	y
Extraction area					
PILEVB	Stockpile erosion (VENM(b))	Rectangular	0.75m[1]	554100	6874100
				Side length = 88m	Side length = 50m
Processing area					
PILEWS	Stockpile erosion (washed sand)	Polygon	2.5m[1]	553969	6874455
				553978	6874488
				554022	6874507
				554060	6874488
				554068	6874455
				554055	6874446
				554044	6874455
				554038	6874471
				554022	6874480
				554002	6874471
				553994	6874455
				553983	6874446
S1	Stockpile erosion (stockpile 1)	Circle	0.75m[1]	553994	6874414
S2	Stockpile erosion (stockpile 2)	Circle	0.75m[1]	554008	6874408
S3	Stockpile erosion (stockpile 3)	Circle	0.75m[1]	554018	6874397

[1] one-quarter of stockpile height, assumes wake effects

Table A.26
Stage 7 Volume sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
SCRAPE	Scraping of topsoil	554300	6873850	5	1	2	1
ESR	Removal of loamy sand	554300	6873850	5	1	0.5	0.5
Processing area							
PLVA	Loading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PLVB	Loading stockpiles (VENM(b)	553961	6874389	5	1	0.5	0.5
PULVA	Unloading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PULVB	Unloading stockpiles (VENM(b))	553961	6874389	5	1	0.5	0.5
PLOWS	Load out washed sand	554022	6874507	5	1	0.5	0.5
PSB	Screening and blending	553983	6874373	5	2	1	1
PLOS1	Load out stockpile 1	553994	6874414	5	1	0.5	0.5
PLOS2	Load out stockpile 2	554008	6874407	5	1	0.5	0.5
PLOS3	Load out stockpile 3	554018	6874397	5	1	0.5	0.5

Table A.27
Stage 7 Line sources

Source		Location			Height (m)	Horizontal spread (m)	Vertical spread (m)
ID	Description	x	y	z			
Extraction area							
EV1	Wheel generated dust	554300	6873850	5	0.5	20	0.25
EV2		554230	6873930	5	0.5	20	0.25
EV3		554200	6874000	5	0.5	20	0.25
EV4		554150	6874060	5	0.5	20	0.25
EV5		554100	6874100	5	0.5	20	0.25
EV6		554050	6874170	5	0.5	20	0.25
Processing area							
PV1	Wheel generated dust	554088	6874378	5	0.5	20	0.25
PV2		554055	6874405	5	0.5	20	0.25
PV3		554016	6874422	5	0.5	20	0.25
PV4		554038	6874383	5	0.5	20	0.25
PV5		553994	6874356	5	0.5	20	0.25
PV6		553955	6874405	5	0.5	20	0.25
PV7		553961	6874449	5	0.5	20	0.25
PV8		553970	6874493	5	0.5	20	0.25
PV9		554022	6874510	5	0.5	20	0.25
PV10		554066	6874493	5	0.5	20	0.25
PV11		554079	6874455	5	0.5	20	0.25

A.5.6 Extraction south of Altona Drive (Stage 10) and processing

Table A.28
Stage 10 Area sources

Source		**Area type**	**Initial vertical spread**	**Vertex coordinates/side length**	
ID	Description			x	y
Extraction area					
PILEVB	Stockpile erosion (VENM(b))	Rectangular	0.75m[1]	554450	6874100
				Side length = 88m	Side length = 50m
Processing area					
PILEWS	Stockpile erosion (washed sand)	Polygon	2.5m[1]	553969	6874455
				553978	6874488
				554022	6874507
				554060	6874488
				554068	6874455
				554055	6874446
				554044	6874455
				554038	6874471
				554022	6874480
				554002	6874471
				553994	6874455
				553983	6874446
S1	Stockpile erosion (stockpile 1)	Circle	0.75m[1]	553994	6874414
S2	Stockpile erosion (stockpile 2)	Circle	0.75m[1]	554008	6874408
S3	Stockpile erosion (stockpile 3)	Circle	0.75m[1]	554018	6874397

[1] one-quarter of stockpile height, assumes wake effects

Table A.29
Stage 10 Volume sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
SCRAPE	Scraping of topsoil	554520	6874050	5	1	2	1
ESR	Removal of loamy sand	554520	6874050	5	1	0.5	0.5
Processing area							
PLVA	Loading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PLVB	Loading stockpiles (VENM(b))	553961	6874389	5	1	0.5	0.5
PULVA	Unloading stockpiles (VENM(a))	554005	6874361	5	1	0.5	0.5
PULVB	Unloading stockpiles (VENM(b))	553961	6874389	5	1	0.5	0.5
PLOWS	Load out washed sand	554022	6874507	5	1	0.5	0.5
PSB	Screening and blending	553983	6874373	5	1	0.5	0.5
PLOS1	Load out stockpile 1	553994	6874414	5	1	0.5	0.5
PLOS2	Load out stockpile 2	554008	6874407	5	1	0.5	0.5
PLOS3	Load out stockpile 3	554018	6874397	5	1	0.5	0.5

Table A.30
Stage 10 Line sources

Source		**Location**			**Height (m)**	**Horizontal spread (m)**	**Vertical spread (m)**
ID	Description	x	y	z			
Extraction area							
EV1	Wheel generated dust	554520	6874050	5	0.5	20	0.25
EV2		554480	6874100	5	0.5	20	0.25
EV3		554430	6874150	5	0.5	20	0.25
EV4		554400	6874200	5	0.5	20	0.25
Processing area							
PV1	Wheel generated dust	554088	6874378	5	0.5	20	0.25
PV2		554055	6874405	5	0.5	20	0.25
PV3		554016	6874422	5	0.5	20	0.25
PV4		554038	6874383	5	0.5	20	0.25
PV5		553994	6874356	5	0.5	20	0.25
PV6		553955	6874405	5	0.5	20	0.25
PV7		553961	6874449	5	0.5	20	0.25
PV8		553970	6874493	5	0.5	20	0.25
PV9		554022	6874510	5	0.5	20	0.25
PV10		554066	6874493	5	0.5	20	0.25
PV11		554079	6874455	5	0.5	20	0.25

A.5.7 Cumulative scenario – Stage 7 and future Hanson Tweed Sand (Phase 4)

The source characteristics of dust emissions from Stage 7 are described in Section A.5.5. The source characteristics of dust emissions from the activities carried out by Tweed Turf and Sand are shown in **Table A.31**, **Table A.32** and **Table A.33**. These characteristics are similar to those described in Section A.5.3 because the process activities and infrastructure will not change. The main difference will be clearing of the Phase 4 extraction area (Phase 3 involves additional sand extraction from the existing Phase 1 pond).

Table A.31
Hanson Tweed Sand Area sources

Source		**Initial vertical spread**	**Vertex coordinates**	
ID	Description		x	y
CPWS	Stockpile erosion (washed sand)	1m	553500	6873800
			553540	6873800
			553540	6873825
			553500	6873825

Table A.32
Hanson Tweed Sand Volume sources

Source		Location			Height (m)	Horizontal spread (m)	Vertical spread (m)
ID	Description	x	y	z			
CSCRAPE	Scraping topsoil	553100	6873300	5	1	2	1
CSR	Removal loamy sand	553100	6873300	5	1	0.5	0.5
CLPILE	Loading stockpiles	553500	6873800	5	2	1	1
CLOUT	Load out of sand products	553500	6873800	5	1	0.5	0.5

Table A.33
Hanson Tweed Sand Line sources

Source		Location			Height (m)	Horizontal spread (m)	Vertical spread (m)
ID	Description	x	y	z			
CV1	Wheel generated dust	553700	6874130	5	0.5	20	0.25
CV2		553700	6874080	5	0.5	20	0.25
CV3		553700	6874030	5	0.5	20	0.25
CV4		553700	6873080	5	0.5	20	0.25
CV5		553700	6873930	5	0.5	20	0.25
CV6		553700	6873880	5	0.5	20	0.25
CV7		553700	6873830	5	0.5	20	0.25
CV8		553700	6873780	5	0.5	20	0.25
CV9		553700	6873730	5	0.5	20	0.25
CV10		553700	6873680	5	0.5	20	0.25
CV11		553700	6873630	5	0.5	20	0.25

6.0 Receptor locations

Table A.34
Receptor locations

Description	Easting	Northing	Elevation (m)
R1: residence, south, on hillside.	554400	6873700	30
R2: school, south, on hilltop.	554400	6873600	35
R3: residence, near southwest boundary corner, hillside.	553960	6873270	25
R4: residence, southern boundary of Hanson Tweed Sand.	553250	6873010	10
R5: building western boundary (adjacent Hanson Tweed Sand).	553680	6873840	5
R6: Chinderah Golf Range, north, building.	554600	6874840	5
R7: residence, north.	554860	6874580	5
R8: residence, north, close to northern boundary.	554860	6874410	5
R9: residences, east side of Tweed Coast Road.	554980	6874340	5
R10: residence, eastern boundary of northern extraction area.	554860	6874290	5

7.0 References

Environment Australia (1999). *National Pollutant Inventory Emission Estimation Technique Manual for Fugitive Emissions.*

Environment Australia (2001). *National Pollutant Inventory Emission Estimation Technique for Mining* (Version 2.3).

SKM (2005). *Improvement of NPI Fugitive Particulate Matter Emission Estimation Techniques.* Sinclair Knight Merz. May 2005.

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Appendix 2

Report on Meteorological Datafile for Coolangatta

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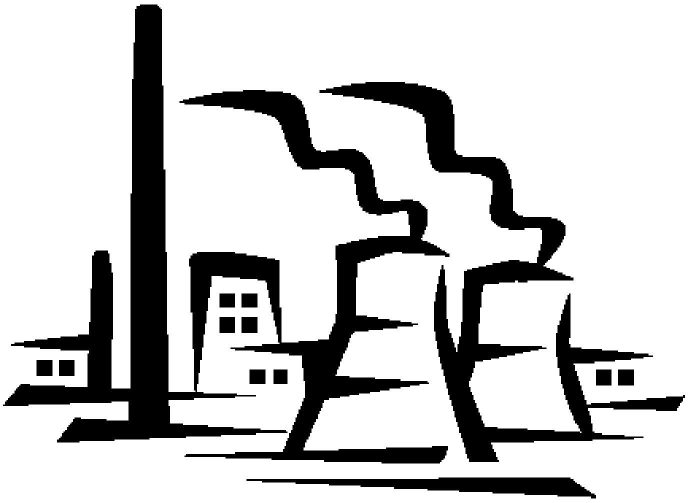
Report on

Coolangatta Input Metrological data file For AUSPLUME

(Victoria, Regulatory Pollution Dispersion Model)



Prepared for

ENVIROTEST Australia Pty Ltd

By

pDs MultiMedia and Consultancy service

MultiMedia & Consultancy pDs Consultancy metfile@tpg.com.au

AUSPLUME input Meteorological Data File for Coolangatta (QLD)

DATA Processing

Mandatory data such as wind direction, speed and ambient temperature were obtained from QLD regional office of the Bureau of Meteorology

QA/QC on Raw data

This data set was treated as follows

- Incomplete days removed
- Suspected wind stalls (both wind direction and speed) carefully examined interpolation done following a very conservative way where necessary.
- Wind Speed converted to m/s from km/h (The speed was recorded for the nearest km/h).
- Wind Direction found to be recorded in 10-degree resolution. The last digit of the wind direction has been randomised to meet air quality standard.
- Temperature and Dewpoint were checked for unusual values
- Pressure and cloud amount were checked for unusual values

Brisbane (BoM) Vertical Temperature Profiles

- Gaps in vertical temperature profiles were filled with previous or following day data for the completeness.

95% data recovered for 2001.

Important Notes:

1. Sensitivity of Anemometers (not known) may not be up to air quality standard.
2. Zero wind speed is allowed, which may not be acceptable to older versions of AUSPLUME.

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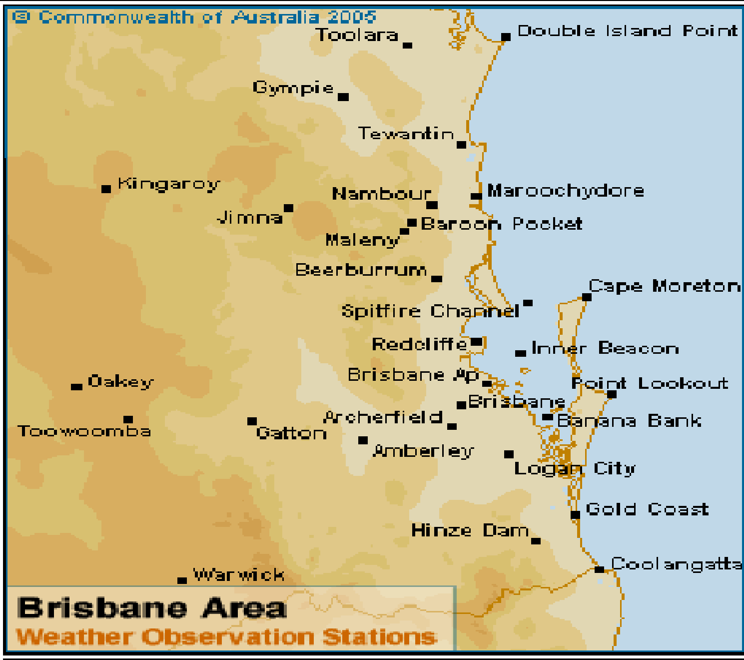
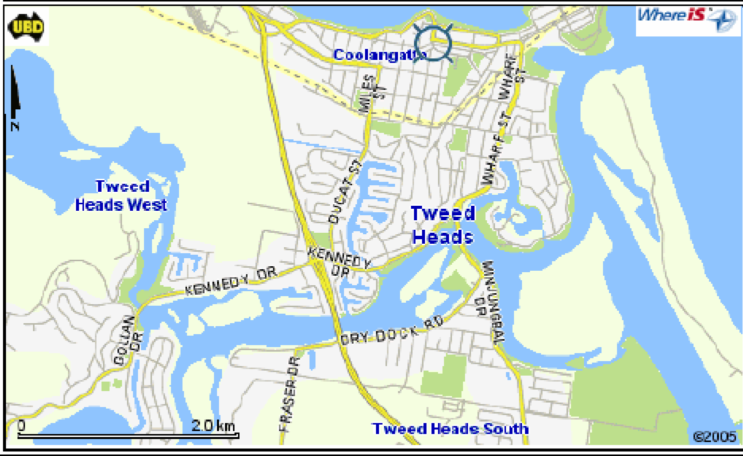
FILE INFORMATION

Coolangatta-QLD

STATE:	QLD
LATITUDE:	-28.17
LONGITUDE:	153.53
EASTING:	552000
NORTHING:	6884000





Data Source

1. **Coolangatta** AWS Data- NSW Regional Office
2. Surface data: Brisbane Clouds
3. Vertical temperature Profiles-**Brisbane** –National Climate Centre- Bureau of Meteorology, Melbourne.

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Input Information

- Onsite (**Coolangatta**) parameters

  a. Wind speed (km/h)
  b. Wind direction
  c. Ambient Temperature (C)
  d. Dew point
  e. Surface Pressure

  Wind was measured at 10m (Anemometer Height), surface roughness assumed to be 0.4m

Offsite

- **Brisbane (QLD)**
  Cloud cover (Total amount)

- **Brisbane (QLD)**
  a. Vertical temperature profiles; Temperature, Dewpoint (2 profiles per day)

Standard Analysis

Data Coverage

Summer	:85	days
Autumn	:92	
Winter	:87	
Spring	:83	
Number of days covered :347	% Coverage :95%	

All 4 seasons are covered and Autumn, Winter, Spring and Summer well represented.

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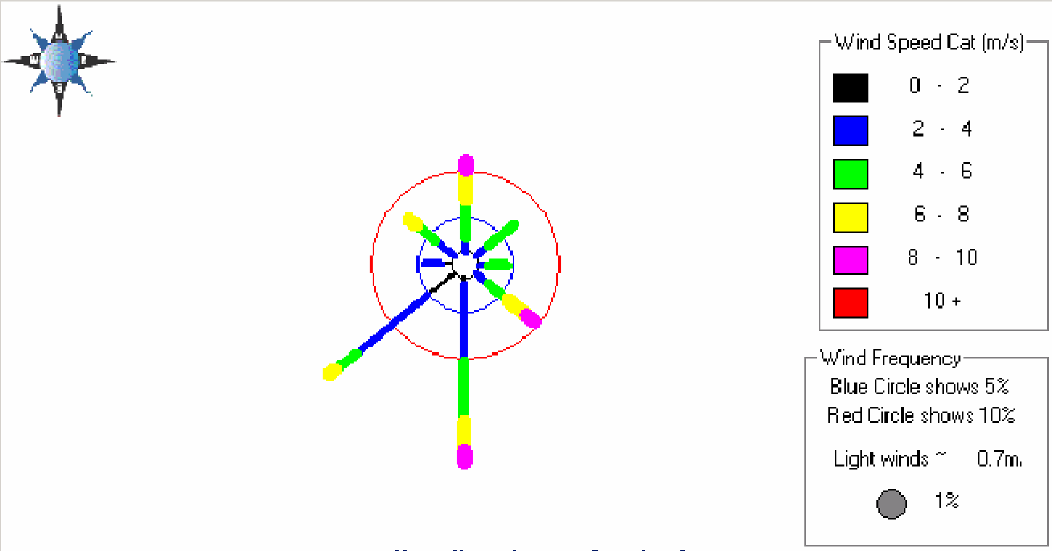
Stability Distribution

Stability Category	% Distribution	Avg Wind Speed	Avg Temperature	Avg Mixing Height
A	%	1.5	22.5	814
B	6 %	3.6	22.7	1144
C	13 %	4.8	22.7	1386
D	49 %	5.4	21.	1443
E	16 %	3.3	18.5	894
F	16 %	1.9	15.6	549

Annual Wind Roses

Annual WindRoses for Coolangatta (QLD):2001



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	0.1	0.1	0.3	1.9	4.7	1.2	0.6	0.3	9%
2 - 4	2.4	1.5	2.4	10.9	12.0	2.6	3.0	2.2	37%
4 - 6	4.3	3.0	3.4	8.8	3.3	0.8	3.2	5.8	32%
6 - 8	0.6	0.7	3.1	4.2	1.4	0.4	1.0	4.3	16%
8 - 10	0.2	0.0	1.2	1.4	0.3	0.1	0.3	1.2	5%
10 +	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.1	1%
Total Dir Freq	8%	5%	11%	28%	22%	5%	8%	14%	

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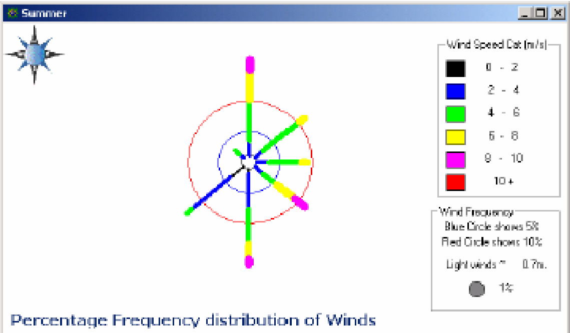
Seasonal Wind Roses

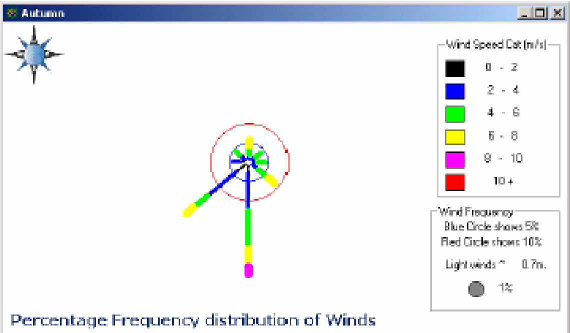
Summer



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	0.2	0.1	0.3	1.4	3.7	0.5	0.3	0.0	7%
2 - 4	3.0	2.5	2.7	7.7	9.8	1.0	1.8	3.1	32%
4 - 6	8.0	5.7	3.3	7.5	1.6	0.0	1.6	8.9	37%
6 - 8	1.1	1.5	4.6	3.3	0.3	0.1	0.5	6.7	18%
8 - 10	0.3	0.1	2.2	1.1	0.0	0.0	0.0	2.2	6%
10 +	0.0	0.2	0.5	0.2	0.0	0.0	0.0	0.3	1%
Total Dir Freq	13%	10%	14%	21%	15%	2%	4%	21%	

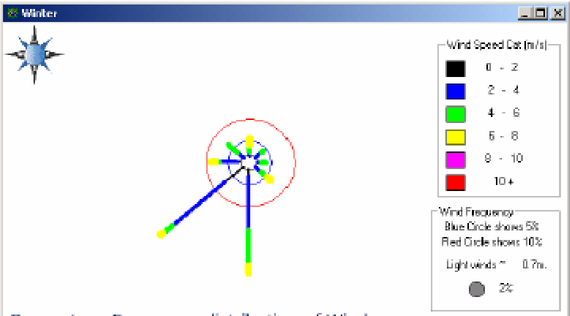
Autumn



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	0.2	0.0	0.7	2.1	3.8	1.2	0.4	0.3	9%
2 - 4	1.8	1.1	2.4	12.8	11.6	2.4	2.5	1.2	36%
4 - 6	2.4	2.1	5.0	12.3	5.1	0.3	2.1	3.7	33%
6 - 8	0.2	0.9	2.9	6.9	3.4	0.1	0.5	2.4	17%
8 - 10	0.0	0.0	0.4	2.6	0.5	0.0	0.3	0.1	4%
10 +	0.0	0.0	0.1	0.9	0.0	0.0	0.1	0.0	1%
Total Dir Freq	5%	4%	12%	38%	24%	4%	6%	8%	

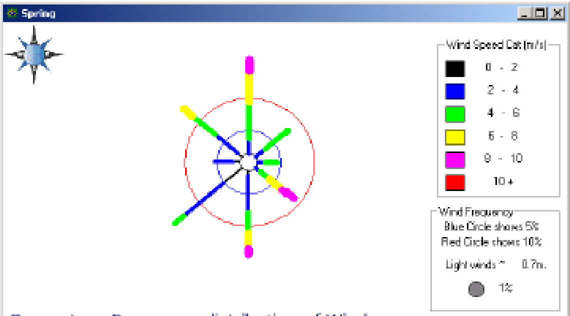
Winter



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	0.0	0.0	0.2	2.7	6.9	1.7	0.6	0.3	13%
2 - 4	2.1	1.0	2.6	15.5	17.0	4.0	2.7	1.4	46%
4 - 6	1.7	1.4	3.0	10.1	3.8	1.7	3.9	2.9	29%
6 - 8	0.5	0.2	1.5	3.0	1.4	1.0	0.9	2.0	10%
8 - 10	0.3	0.0	0.0	0.5	0.3	0.3	0.1	0.3	2%
10 +	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	%
Total Dir Freq	5%	3%	7%	32%	29%	9%	8%	7%	

Spring



Percentage Frequency distribution of Winds

Speed Cat/Dir	NE	E	SE	S	SW	W	NW	N	Total Speed Freq
0 - 2	0.1	0.2	0.1	1.5	4.5	1.5	1.0	0.5	9%
2 - 4	2.6	1.4	2.0	7.3	9.5	3.1	5.1	3.1	34%
4 - 6	5.2	2.8	2.3	4.8	2.5	1.0	5.4	7.8	32%
6 - 8	0.7	0.3	3.4	3.4	0.4	0.6	2.4	6.1	17%
8 - 10	0.0	0.0	2.2	1.4	0.2	0.2	0.9	2.5	7%
10 +	0.0	0.0	0.1	0.2	0.2	0.1	0.1	0.2	1%
Total Dir Freq	9%	5%	10%	19%	17%	6%	15%	20%	

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Secondary parameters

Vertical Stability

Solar Radiation for day time and Modified Pasquill Stability Class outlined in the reference, Davis and Singh, Jl of Hazardous Materials, 11 was used to determine night-time stability class. Solar radiation was theoretically calculated using off site cloud observations.

Table 1 for daytime and part of Table 2 for night-time were used.

Table 1: Stability Classification for Daytime Using Solar Radiation and Wind Speed

	Solar Radiation (W/m^2)			
Wind Speed(m/s)	≥925	≥675	≥175	< 175
< 2	A	A	B	D
< 3	A	B	C	D
< 5	B	B	C	D
< 6	C	C	D	D
≥ 6	C	D	D	D

Table 2: Modified Pasquill stability calsses

Surface Wind Speed m/s at 10m	Daytime incoming solar radiation				Within 1 h before sunset or after sunrise	Night-time cloud amount(Oktas)		
	Strong (>600)	Moderate (300-600)	Slight (<300)	Overcast		0-3	4-7	8
≤ 2	A	A-B	B	C	D	F	F	D
≤ 3	A-B	B	C	C	D	F	E	D
≤ 5	B	B-C	C	C	D	E	D	D
≤ 6	C	C-D	D	D	D	D	D	D
> 6	C	D	D	D	D	D	D	D

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Mixing height

Definition:

The mixing height, the depth of the surface mixed layer is the height of the atmosphere above the ground, which is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable.

The mixing height was determined by using the methodology of Benkley and Schulman (Journal of Applied Meteorology, Volume 18, 1979,pp 772-780). **Brisbane** upper air observation containing temperature and moisture profiles were used to determine daytime mixing height.

Surface wind speeds and roughness are used to calculate the depth of the mechanically forced boundary layer during the night time

$MixH_m$=0.185* Ustar/Cterm

Where Ustar=.35*Usfc/Ln (Ht_{anemo}/Z_0)

Cterm = Coriolis Term =2 Ω Sin(ϕ)

Where Ω is the angular velocity of the earth
ϕ is the latitude

Ht_{anemo}= Anemometer Height, Z_0 is the roughness

Height of the convective boundary layer was determined using daytime temperature sounding (Vertical temperature and dewpoint profiles) in between sunrise and sunset. Evening or nighttime sounding for the same day is used to compensate daytime sounding to calculate convective mixing height at different daylight hours (Temperature difference at 700 hPa layer is used to allow advection). Larger value of the mechanical turbulence or convective turbulence was taken as Mixing height for the daylight hours.

Statistics of Coolangatta (QLD) input Meteorological data file-2001

Stability	Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
A	Max of Temp	26.0	27.0	27.0	24.0	21.0			18.0	21.0	21.0	23.0		27.0
	Min of Temp	25.0	24.0	21.0	21.0	19.0			16.0	21.0	20.0	19.0		16.0
	Average of Temp	25.5	25.4	24.2	22.5	20.0			17.0	21.0	20.8	21.3		22.5
	Max of WS	1.4	2.5	2.5	1.4	1.4			1.4	1.4	2.5	2.5		2.5
	Min of WS	1.4	1.1	0.6	0.6	1.1			0.6	1.4	0.6	0.6		0.6
	Average of WS	1.4	1.9	1.5	1.0	1.3			1.0	1.4	1.4	1.5		1.5
	Max of MixH	746	1455	965	1128	1678			807	1291	909	1471		1678
	Min of MixH	609	430	323	340	567			752	1291	417	397		323
	Average of MixH	678	900	547	734	908			780	1291	731	997		814
B	Max of Temp	31.0	28.0	28.0	26.0	24.0	22.0	20.0	22.0	23.0	28.0	27.0	33.0	33.0
	Min of Temp	22.0	19.0	19.0	16.0	14.0	17.0	15.0	10.0	16.0	18.0	19.0	22.0	10.0
	Average of Temp	26.2	25.5	25.4	23.0	20.5	19.4	18.0	17.8	20.3	22.2	22.7	25.8	22.7
	Max of WS	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	Min of WS	1.1	1.4	2.2	0.6	0.6	1.1	1.1	0.6	1.1	0.6	2.2	0.6	0.6
	Average of WS	4.0	3.7	3.9	3.3	2.8	2.4	3.2	3.4	3.6	4.0	3.8	3.6	3.6
	Max of MixH	1731	1762	1907	2013	1985	1287	1613	2067	2055	2469	1838	1466	2469
	Min of MixH	589	463	538	187	196	356	450	484	390	598	652	329	187
	Average of MixH	1167	1180	1153	1026	912	920	1065	1223	1184	1339	1174	1105	1144
C	Max of Temp	30.0	28.0	31.0	26.0	24.0	24.0	22.0	26.0	23.0	31.0	29.0	35.0	35.0
	Min of Temp	22.0	19.0	20.0	19.0	16.0	14.0	13.0	11.0	14.0	17.0	19.0	19.0	11.0
	Average of Temp	26.4	25.1	25.6	23.2	21.1	20.0	18.8	18.5	20.5	22.5	23.2	25.5	22.7
	Max of WS	11.4	7.8	12.2	6.7	5.8	5.8	5.8	5.8	10.3	9.2	9.7	10.8	12.2
	Min of WS	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	0.6	1.4	0.6	0.6
	Average of WS	5.5	5.0	5.5	4.3	4.1	4.0	3.8	4.4	5.0	5.3	4.9	5.7	4.8
	Max of MixH	3004	1976	3018	2097	1871	1851	2058	2398	2561	2549	2608	2762	3018
	Min of MixH	588	672	675	579	558	518	598	652	598	392	488	161	161
	Average of MixH	1536	1455	1492	1221	1181	1212	1205	1361	1401	1506	1368	1582	1386
D	Max of Temp	29.0	27.0	32.0	26.0	26.0	24.0	24.0	26.0	25.0	32.0	31.0	37.0	37.0
	Min of Temp	18.0	18.0	16.0	11.0	9.0	5.0	4.0	5.0	7.0	12.0	12.0	17.0	4.0
	Average of Temp	24.5	23.1	23.8	21.3	18.2	17.8	17.0	16.6	18.4	20.7	21.6	23.8	21.0
	Max of WS	11.7	11.4	13.3	11.4	10.3	8.6	11.4	9.7	10.3	11.7	13.3	10.3	13.3
	Min of WS	0.6	0.6	1.1	0.6	0.6	0.6	1.1	0.6	0.6	0.6	0.6	0.6	0.6
	Average of WS	5.6	5.5	6.0	5.0	5.2	4.5	5.3	5.3	5.4	5.5	5.4	5.4	5.4
	Max of MixH	2951	2917	3280	2951	2534	2164	2917	2440	2608	3145	2769	2803	3280
	Min of MixH	336	390	376	161	269	296	430	323	215	296	296	282	161
	Average of MixH	1508	1482	1605	1339	1394	1206	1399	1400	1461	1482	1458	1450	1443
E	Max of Temp	27.0	26.0	27.0	25.0	25.0	24.0	22.0	23.0	24.0	26.0	24.0	29.0	29.0
	Min of Temp	19.0	19.0	19.0	13.0	8.0	7.0	5.0	6.0	8.0	13.0	14.0	18.0	5.0
	Average of Temp	23.8	23.2	22.2	20.1	16.8	15.4	14.1	15.3	16.8	19.3	19.7	22.9	18.5
	Max of WS	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7

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	Min of WS	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
	Average of WS	3.6	3.3	3.2	3.1	3.3	3.1	3.2	3.7	3.5	3.6	3.5	3.3	3.3
	Max of MixH	1526	1311	1338	1358	1324	1385	1358	1405	1358	1566	1338	1418	1566
	Min of MixH	518	518	538	430	484	484	464	497	558	430	538	464	430
	Average of MixH	983	901	867	833	852	816	871	961	947	956	926	883	894
F	Max of Temp	25.0	26.0	25.0	24.0	24.0	20.0	19.0	22.0	20.0	24.0	23.0	25.0	26.0
	Min of Temp	18.0	17.0	16.0	12.0	8.0	4.0	5.0	5.0	8.0	12.0	12.0	17.0	4.0
	Average of Temp	20.8	21.0	21.2	18.2	14.9	13.2	12.0	11.2	14.0	17.1	17.8	21.3	15.6
	Max of WS	2.5	2.5	2.5	2.5	2.5	2.5	2.8	2.5	2.5	2.5	2.5	2.5	2.8
	Min of WS	0.6	0.6	1.1	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
	Average of WS	2.0	2.0	1.9	1.9	1.9	1.9	2.0	1.8	2.0	1.9	1.8	1.6	1.9
	Max of MixH	860	820	786	894	914	1243	860	1062	827	1008	880	726	1243
	Min of MixH	161	200	296	161	195	161	161	161	200	200	215	161	161
	Average of MixH	558	555	550	548	576	559	558	517	566	547	540	477	549

Disclaimer

Compilation of input meteorological data file for AUSPLUME was done under the supervision of qualified and experienced meteorologists. Although all due care has been taken, we cannot give any warranty, nor accept any liability (except that required by law) in relation to the information given, its completeness or its applicability to a particular problem. These data and other material are supplied on the condition that you agree to indemnify us and hold us harmless from and against all liability, losses, claims, proceedings, damages, costs and expenses, directly or indirectly relating to, or arising from the use of or reliance on the data and material which we have supplied.

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Appendix 3

Coverage of Environmental Assessment Requirements and Environmental Issues

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Table A3-1
Coverage of Environmental Assessment Requirements and Environmental Issues in the Air Quality Assessment

Page 1 of 3

ENVIRONMENTAL REQUIREMENTS RAISED BY THE DIRECTOR-GENERAL RELATING TO AIR QUALITY (06.01.06)	
	Relevant Section(s)
Key Assessment Requirements, namely:	
• *Air Quality* - Assess the potential impacts of the project (including any potential cumulative impacts that may arise from the combined operation of the project with the existing or approved operations at the Bolster Quarry), and describe what measures would be implemented to avoid, minimise, mitigate, offset, manage and/or monitor these impacts.	S6, 7 & 8
References	
Refer to the:	
• *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (Department of Environment and Conservation).	S7.3.1

ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING TO AIR QUALITY		
Government Agency	**Paraphrased Requirement**	**Relevant Section(s)**
Department of Environment and Conservation (15 October 2004)	Provide maps showing the locality of the proposed development in a regional and local context. Base local context maps on 1:25 000 topographic plans.	Figure 1
	Provide a description of:	
	– the existing environment on the subject and surrounding land;	S4
	– the proposed development and ancillary works; and	S3
	– the manner in which the environment will be modified by the proposal.	S6 and 7
	Clearly identify on an appropriately scaled plan the area subject to development.	Figure 2
	Document surveys and assessments that have been undertaken by suitably qualified persons and provide the qualifications and experience of the person(s) undertaking the work.	S4 and 5
	Describe dates, site locations, design, methodology, analysis techniques, and weather conditions at the time of the assessments and surveys. The limitations of surveys should be identified and the results interpreted accordingly.	S4
	Substantiate conclusions drawn in surveys and assessments with evidence resulting from those surveys and assessments.	S5

Table A3-1 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the Air Quality Assessment

Page 2 of 3

ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING TO AIR QUALITY		
Government Agency	**Paraphrased Requirement**	**Relevant Section(s)**
Department of Environment and Conservation (Cont'd) (15 October 2004)	Identify all sources of air emissions from the development.	S6.2, 6.3 and 7.2
	Provide details of the project that are essential for predicting and assessing air impacts including:	
	– the quantities and physico-chemical parameters of materials to be used, transported, produced or stored;	S6.3 and App 1
	– an outline of procedures for handling, transport, production and storage; and	S6.2.2
	– the management of solid, liquid and gaseous waste streams with potential for significant air impacts.	S6.2.2
	Describe the topography and surrounding land uses. Provide details of the exact locations of dwellings, schools and hospitals. Where appropriate provide a perspective view of the study area such as the terrain file used in dispersion models.	S6.3.8 and Figure 5
	Describe surrounding buildings that may effect plume dispersion.	S6.3.7
	Provide and analyse site representative data on relevant meteorological parameters.	App 2
	Provide a description of existing air quality and meteorology. Include Total Suspended Particulates (TSP), Deposited dust, and particulate matter less than 10 microns (PM_{10}).	S4 and 5
	Identify all pollutants of concern and estimate emissions by quantity, source and discharge point.	S6.2 and 6.3
	Estimate the resulting ground level concentrations of all pollutants. Where necessary use an appropriate dispersion model to estimate ambient pollutant concentrations. Discuss choice of model and parameters with the DEC.	S6.4 and 7.3
	Describe the effects and significance of pollutant concentration on the environment, human health, amenity and regional ambient air quality standards or goals.	S6.5, 7.4 and 10
	Describe the contribution that the development will make to regional and global pollution.	S10
	Provide the emission rates in terms of odour units, use sampling and analysis techniques for individual or complex odours and for point or diffuse sources, as appropriate.	Not Applicable
	Reference to relevant guidelines – *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW (EPA, 2001); Approved Methods for the Sampling and Analysis of Air Pollutants in NSW (EPA, 2001).*	S7.3.1 and 9
	Outline specifications of pollution control equipment and management protocols for both point and fugitive emissions.	S8 and 10

Table A3-1 (Cont'd)
Coverage of Environmental Assessment Requirements and Environmental Issues in the Air Quality Assessment

Page 3 of 3

ENVIRONMENTAL REQUIREMENTS RAISED BY GOVERNMENT AGENCIES RELATING TO AIR QUALITY		
Government Agency	**Paraphrased Requirement**	**Relevant Section(s)**
Roads and Traffic Authority (15 September 2004)	Outline the control of dust from the site and commercial traffic.	S8
Department of Primary Industries (Agriculture) (7 October 2004)	Outline sources of environmental pollution and their management.	S4.4, 6.2.2 and 8

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