Section 4

Assessment and Management of Key Environmental Issues

PREAMBLE

The assessment and management of the key environmental issues identified in Section 3 commences with an outline of background information relevant to a number of the subsequent issues. The issues are then generally addressed in the order of priority established in Section 3.3.2.

For each key environmental issue, the existing features are described and the constraint(s) the existing features would have on the design and operation of the project are identified. The mitigation measures and operational procedures required to manage each issue are then outlined together with the predicted changes to that component of the environment on and/or surrounding the Project Site. Residual impacts are then assessed against statutory criteria or goals or relevant guidelines and/or policies. Where appropriate, a program of monitoring and documentation is proposed to demonstrate the predictions presented in this document are being achieved and compliance criteria or goals satisfied.

The text for the bulk of this section is drawn from studies undertaken by a range of specialist consultants commissioned by the Proponent. Wherever possible, the study results have been summarised focussing only upon the key points. Readers should refer to the relevant part in the Specialist Consultant Studies Compendium in the event further detail is required.

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4.1 BACKGROUND INFORMATION

4.1.1 Introduction

The various assessments of potential environmental impacts throughout this section are reliant upon a range of background information which is common to many of the key environmental issues assessed. The following subsection provides a summary of relevant background information relating to topography, meteorology, land ownership, land uses and surrounding residences.

4.1.2 Topography

4.1.2.1 Regional Topography

The topography of the North Coast Region is characterised by a typical sequence from a coastal sand barrier and riverine floodplains through to low foothills and ranges to the steep slopes and gorges along the escarpment of the Great Dividing Range with elevations ranging from sea level up to 1500m AHD.

4.1.2.2 Local and Project Site Topography

The Project Site is located on a broad flat alluvial floodplain situated on the southern bank of the Tweed River approximately 10km south of the river mouth. The Project Site itself is essentially a flat floodplain with elevations ranging from approximately 0.8m AHD to 1.2m AHD (see **Figure 4.1**). To the south, the Project Site abuts the Cudgen Plateau with elevations rising steeply to approximately 38m AHD. To the east of the Project Site, the land is low lying whilst land to the north and west is slightly more elevated.

4.1.3 Meteorology

4.1.3.1 Rainfall

The Bureau of Meteorology maintains a number of rainfall recording stations in the north coast regions with the closest site with being the Coolangatta Airport (Station 040717) approximately 10km to the north of the Project Site. As can be seen in **Table 4.1**, the average annual rainfall is 1 510mm with the wettest month being April receiving on average 225mm and the driest month being September receiving on average 36mm.

4.1.3.2 Temperature

Average daily maximum and minimum temperatures recorded at Coolangatta are presented in **Table 4.1**. The Coolangatta area has a sub-tropical climate characterised by high temperatures in summer and mild temperatures in winter. Mean daily temperatures range from 10.3^{o}C (minimum) to 20.9^{o}C (maximum) in winter, and from 19.7^{o}C (minimum) to 28.0^{o}C (maximum) in summer. February is the warmest month and July the coldest month.

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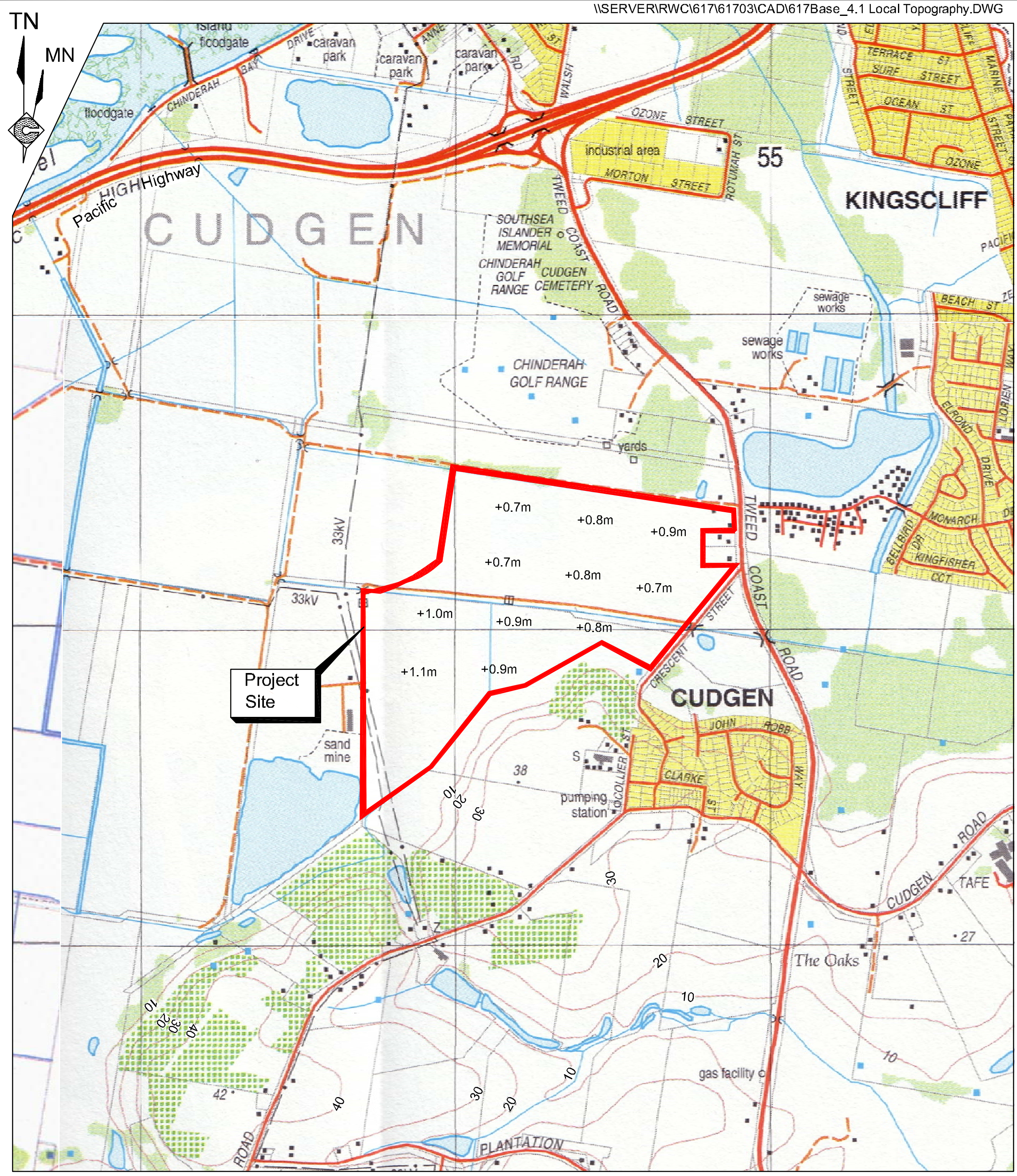

REFERENCE
Project Site Boundary
+0.7m Spot Height (m AHD)

SCALE 1:20 000
200 0 200 400 600 800 1000 m

Source: Tweed Heads & Cudgen 1:25 000 Topographic Maps (2000)

Figure 4.1
LOCAL TOPOGRAPHY

Table 4.1
Monthly Meteorological Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
TEMPERATURE (^oC) Coolangatta Airport – 12 years of records													
Mean Maximum	27.9	28	27.1	25.1	23	20.9	20.3	20.9	23	23.9	25.3	26.8	
Mean Minimum	20.9	20.9	19.9	17	14.5	11.5	10.3	10.8	13.5	16.1	18.1	19.7	
Lowest	13.8	15.0	13.3	7.3	1.2	1.5	0.8	3.6	6.0	8.5	9.9	12.9	
Highest	34.9	40.0	33.4	30.3	28.8	27.5	26.1	28.3	32.7	33.5	37.9	38.0	
RAINFALL (mm) Coolangatta Airport – 10 years of records													
Mean	131	137	219	225	170	111	88	49	36	86	119	140	1510
Mean Rain Days	13.9	16.1	18.7	17	17.2	12.8	9.8	8.4	7.4	10.9	13.6	13.1	158.9
Highest	370	429	521	645	381	308	202	186	153	207	208	312	
Lowest	32	19.4	65.2	29.4	13.4	13.4	23.8	0.2	0.2	28.6	40.4	51	
EVAPORATION (mm) Alstonville Tropical Fruit Research Station - 29 years of records													
Mean Monthly Pan Evaporation	179.8	141.25	133.3	105.0	83.7	75.0	83.7	108.5	138.0	158.1	165.0	189.1	1560
WIND SPEED (km/hr) Coolangatta Airport – 9 years of records													
Mean 9:00am	18.7	18	18.1	16.3	15.8	14.1	14.4	16.3	18.2	18.6	19.4	19.3	
Mean 3:00pm	23.4	22.1	22.2	19.9	18.5	17.2	18.7	20.5	22.2	22.3	22.6	22.8	
Maximum Wind Gust Recorded	72.4	53.6	76	51.8	64.8	83.2	55.4	57.2	55.4	83.2	59.4	68.4	
RELATIVE HUMIDITY (%) Coolangatta Airport – 8 years of records													
Mean 9:00am	71	73	73	72	73	73	67	65	65	68	70	70	
Mean 3:00pm	69	71	69	66	66	62	57	59	64	69	70	70	
Source: Bureau of Meteorology													

4.1.3.3 Evaporation

The closest station measuring pan evaporation is at Alstonville Tropical Fruit Research Station (Station 058131) 62km south-southwest of the Project Site. **Table 4.1** presents the average monthly evaporation data showing the highest evaporation in January and lowest evaporation in June. The annual average evaporation recorded between 1963 and 2004 was 1 560mm, a level comparable to average annual rainfall recorded at Coolangatta Airport. It is noted from **Table 4.1** that evaporation exceeds rainfall during the months of March to July. For the remaining months, rainfall exceeds evaporation.

4.1.3.4 Wind

Figure 4.2 displays both the average annual and seasonal wind roses recorded for Coolangatta.

The prevailing wind directions are from the following directions.

Spring	Summer	Autumn	Winter
North and South	North, South and Southeast	South and Southwest	South and Southwest

The closest residences to the Project Site are generally located to the northeast, east and southeast.

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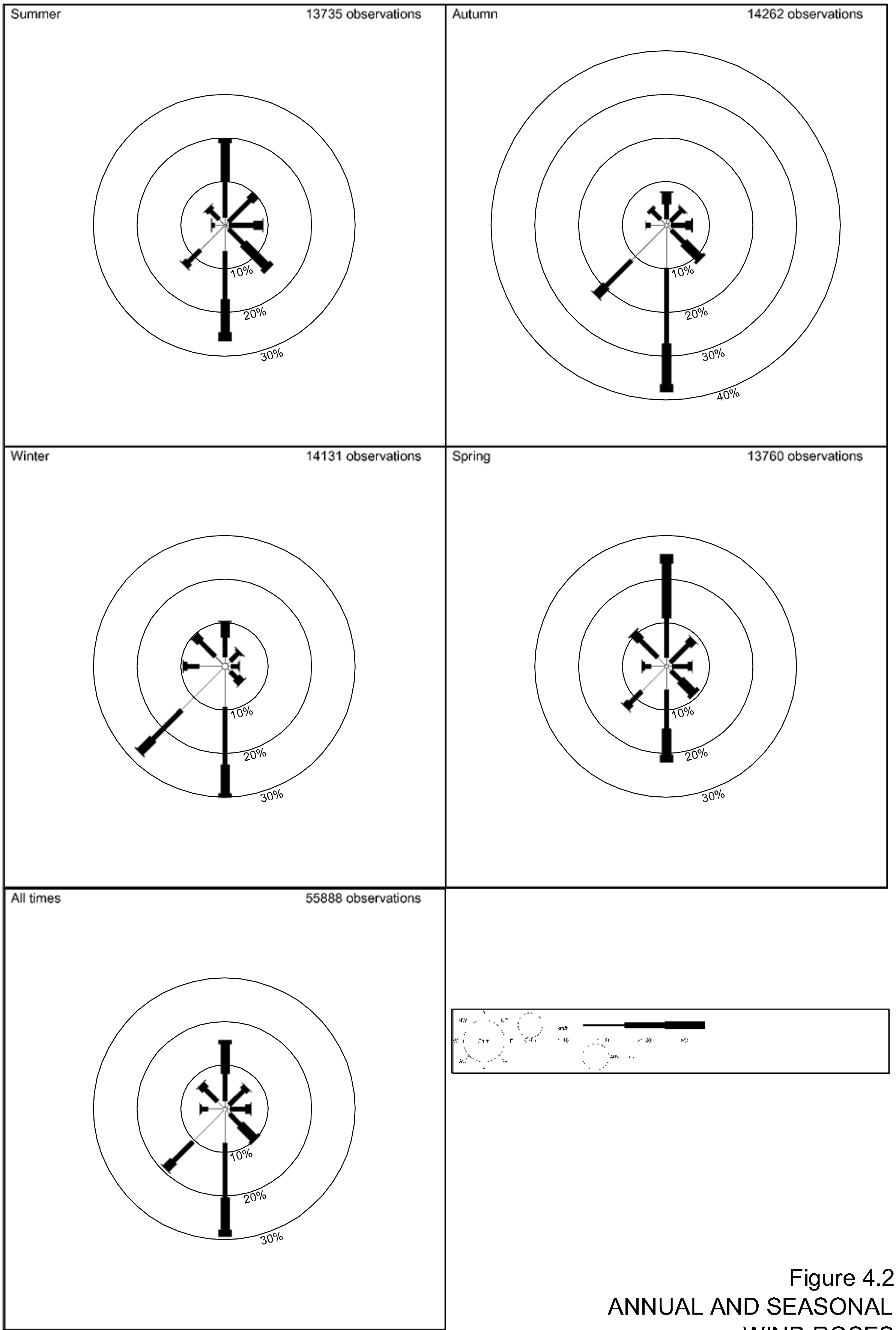

Source: Bureau Of Meteorology (3 August 2007)

Figure 4.2
ANNUAL AND SEASONAL
WIND ROSES

4.1.4 Surrounding Land Ownership, Land Uses and Residences

4.1.4.1 Surrounding Land Ownership

Figure 4.3 presents the ownership of land within approximately 1km of the boundary of the Project Site. This information has been sourced from the Land Ownership Register maintained by the Department of Lands.

4.1.4.2 Land Uses

As discussed in Section 1.4.2, the Project Site has historically been used as a wet grazing block. A number of agricultural developments including a tropical grass and legume seed nursery (operating between 1964 and 1971) and cane farm (operating 1973 to 1984) were also undertaken on the Project Site. However, due to the soil and drainage problems, the Project Site has only been used for cattle grazing since this time.

Currently, the Project Site is used for cattle grazing. The initial dredge pond associated with an approved sand extraction operation (see Section 1.4.4) has also been established in the southwestern part of the Project Site.

The bulk of the landholdings surrounding the Project Site comprise residential house blocks to larger rural landholdings. Surrounding land uses range from residential, agricultural, recreational and extractive industry. A brief overview of the surrounding land uses is provided below.

North — Marginal grazing land is located to the north of the Project Site together with the Chinderah Golf Range and a small number of residential properties fronting onto Tweed Coast Road. The existing Kingscliff Waste Water Treatment Plant is located to the northeast. The Pacific Highway and Tweed River are also located approximately 1km to the north of the Project Site.

East — The Project Site is bounded to the east by Crescent Street and Tweed Coast Road. There are a number of residential areas to the east and southeast including the Noble Lakeside Park Estate containing approximately 400 residents and the residential areas of west Kingscliff. However, large areas of land remain undeveloped, some of which are currently being grazed. The Proponent owns a substantial area of land east of the Project Site, much of which is zoned for development.

South — The Cudgen Plateau is located immediately south of the Project Site and is primarily used for agricultural purposes including cropping and orchards. The Cudgen residential area is located to the southeast incorporating Cudgen Public School directly west of the residential area.

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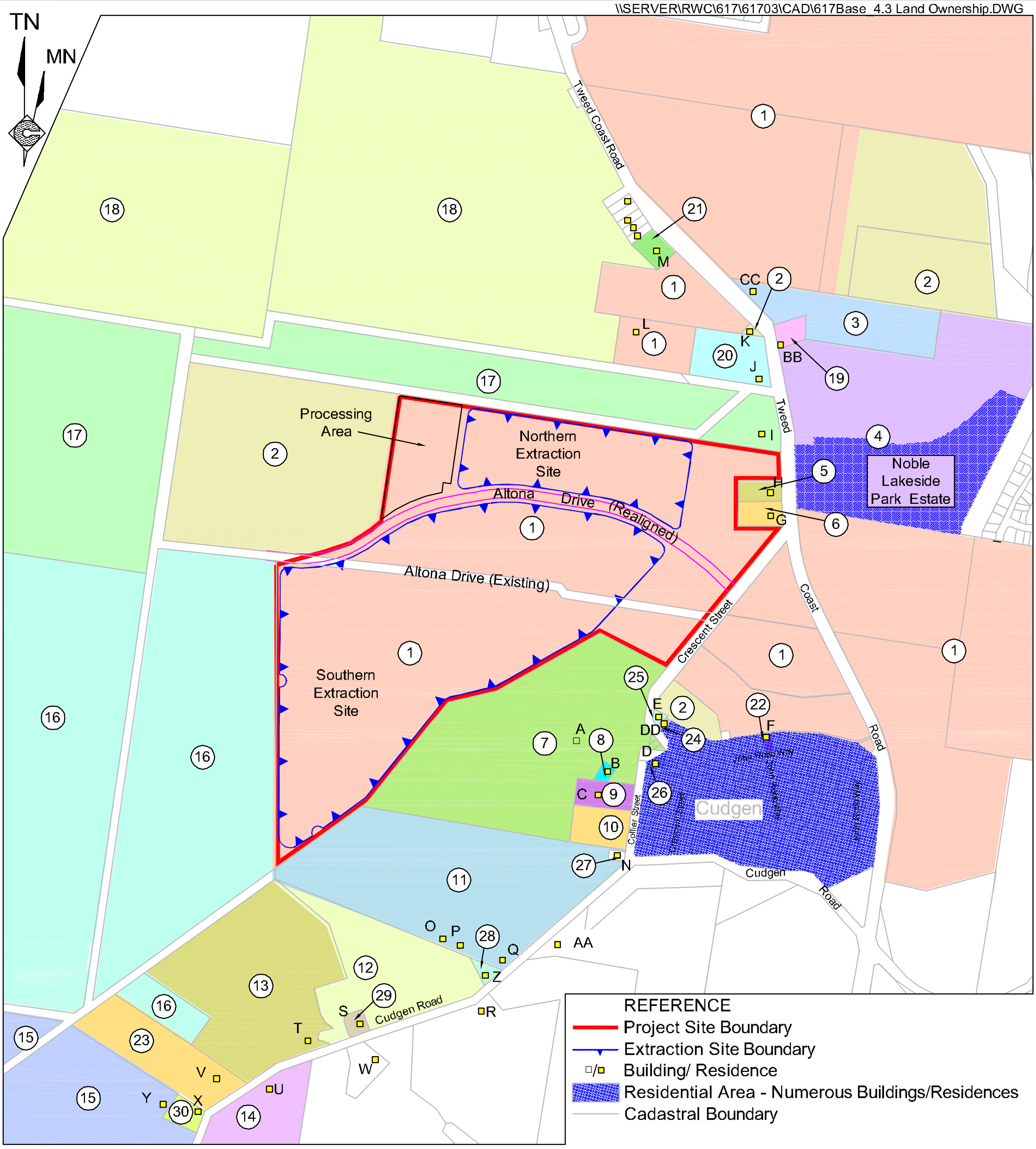


REFERENCE
- Project Site Boundary
- Extraction Site Boundary
- Building/ Residence
- Residential Area - Numerous Buildings/Residences
- Cadastral Boundary

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

* Cudgen Public School
\# Chinderah Golf Club

SCALE 1:15 000

250 0 250 500 750 m

Land Ownership Source: Dept. of Lands (2005)

Figure 4.3
SURROUNDING LAND OWNERSHIP AND RESIDENCES

West An existing sand extraction operation, Hanson Tweed Sand (formerly Tweed Turf and Sand) adjoins the Project Site to the west (see Section 1.4.5.1 for further detail). The sand extraction operation has recently been approved to operate for a further 30 years (until 2036) at an extraction rate of 150 000m^3 per year. Tweed Shire Council is constructing the new Kingscliff WWTP immediately west of the proposed processing area (see Section 1.4.5.2 for further detail).

An aquaculture development has been approved approximately 0.75km to the west of the Project Site but construction had not yet commenced at the time this document was written (see Section 1.4.5.3 for further detail). The Pacific Highway and Tweed River are located over 1km to the west (see Section 1.4.5.3 for further detail).

4.1.4.3 Surrounding Residences

Figure 4.3 also presents the locations of the residences on the surrounding properties generally within 1km of the boundary of the Project Site. It is noted that the Noble Lakeside Park Estate also has in the order of 280 residences. **Table 4.2** lists approximate distances from representative residences surrounding the Project Site to the closest and most distant point of sand removal and the closest part of the processing area.

Table 4.2
Proximity of Representative Residences to Project Site Activities

Page 1 of 2

Residence / Building	Approximate Distance (m) to Project Site Activities		
	Closest Point of Sand Removal (Northern Extraction Site)	Closest Point of Sand Removal (Southern Extraction Site)	Closest Point of Processing Area
A	535m	190m	645m
B	580m	290m	745m
C@	640m	325m	780m
D	540m	330m	790m
E	430m	240m	415m
F	515m	455m	930m
G	195m	250m	740m
H	185m	270m	735m
I	155m	335m	695m
J	210m	435m	690m
K	285m	520m	685m
L	225m	425m	435m
M	420m	620m	475m
N	765m	475m	930m
O	1040m	370m	985m
P	1055m	400m	1005m
Q	1090m	485m	1060m
R	1210m	550m	1165m
S	1265m	430m	1175m
T	1325m	445m	1225m
@ Cudgen Public School			

Table 4.2 (Cont'd)
Proximity of Representative Residences to Project Site Activities

Page 2 of 2

Residence / Building	Approximate Distance (m) to Project Site Activities		
	Closest Point of Sand Removal (Northern Extraction Site)	Closest Point of Sand Removal (Southern Extraction Site)	Closest Point of Processing Area
U	1460m	555m	1350m
V	1480m	555m	1360m
W	1405m	520m	1260m
X	1565m	640m	1445m
Y	1585m	655m	1455m
Z	1125m	490m	1085m
AA	1000m	550m	1065m
BB	300m	530m	750m
CC	370m	605m	725m
Noble Lakeside Park Estate*	240m	325m	810m

* Closest residence within the estate

4.2 WATER RESOURCES

4.2.1 Introduction

Water resources within and surrounding the Project Site comprise both surface water and groundwater. Given the strong inter-relationship between the two, and a number of common management issues, this section describes the occurrences and use of surface water and groundwater together with the existing flooding and drainage environment. This section also presents the proposed mitigation measures and management procedures that would be adopted throughout the life of the Project to protect and/or manage the surface water and groundwater resources on and beyond the Project Site and the potential impacts from flooding.

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential water resource-related impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Groundwater Pollution by leaking/spilt hydrocarbons (low to high risk).
- Drawdown of groundwater levels resulting in:
  - reduction of bore yields (high risk); and
  - acidification of PASS (high risk).
- Impacts on Groundwater Dependent Ecosystems (high risk).
- Increased flood levels and land inundation (high risk).
- Erosion within the Project Site (moderate risk).
- Erosion external to the Project Site (low to moderate risk).
- Discharge of sediment-laden or turbid water from the Project site (moderate risk).

The residual impacts of the Project upon the water resources and the flooding regime within and beyond the Project Site are described with the assumption that all proposed mitigation measures are adopted. This subsection concludes with the monitoring proposed to record the extent (or absence) of impacts the Project would have on the water resources within and surrounding the Project Site.

The information presented in this section is drawn from two reports prepared by specialist consultants commissioned by the Proponent, namely Australasian Groundwater and Environmental Consultants (Groundwater) and Stephen N Webb & Associates Pty Ltd (Flooding and Drainage). These reports are respectively referred to as AGE (2008) and Webb (2008) incorporated as Parts 1 and 2 in the *Specialist Consultant Studies Compendium* for the Project.

4.2.2 Existing Drainage and Flooding Regimes

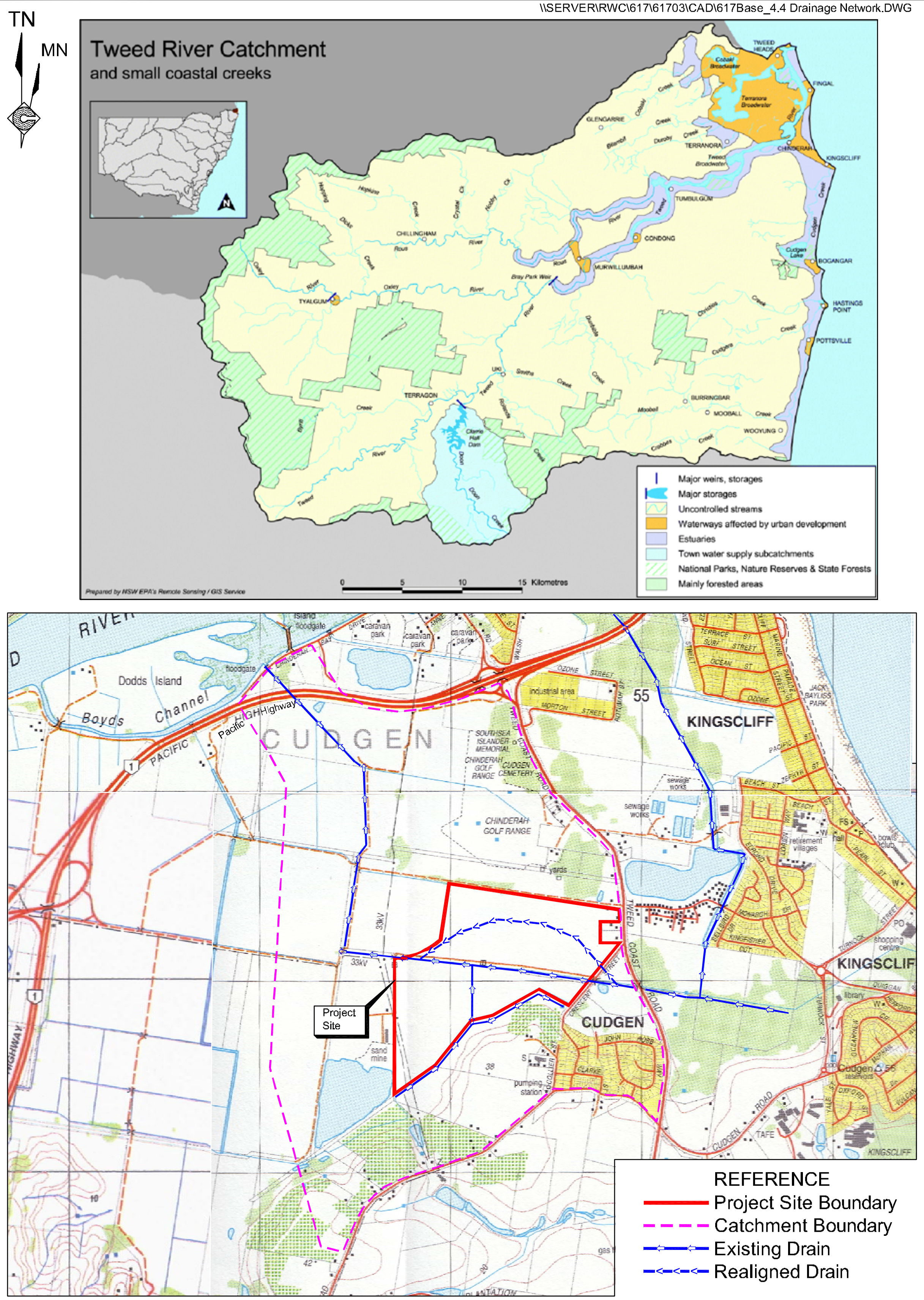
4.2.2.1 Regional Drainage

The Project Site is located within the lower reaches of the Tweed River floodplain. The headwaters of the Tweed River begin near Kunghur, approximately 50km southwest of Chinderah and generally flow in a northeasterly direction. Numerous rivers, creeks and tributaries feed into the Tweed River including the Oxley River approximately 5km southwest of Murwillumbah and the Rouse River west of Tumbulgum. The mouth of the Tweed River is located immediately east of Tweed Heads discharging into the Pacific Ocean. The tidal influence of the Pacific Ocean extends just upstream of Murwillumbah (WBM, 2005).

4.2.2.2 Local Drainage Network and Flooding Regime

Figure 4.4 displays the catchment boundary and local drainage network of the Kingscliff-Chinderah-Cudgen Floodplain. The boundaries of the local catchment are defined by Tweed Coast Road to the east, Cudgen Road to the south, the Pacific Highway to the north and the mid-point between two parallel drains to the west. The topography of the floodplain is very flat, generally ranging from 0.8m AHD to 2.0m AHD.

The floodplain is criss-crossed by a network of interconnecting agricultural drains and flood gates which convey water from the floodplain to the Tweed River. The main drain through the catchment ("the western drain") is shown in blue on **Figure 4.4** and flows westwards from Tweed Coast Road parallel to Altona Drive before turning northwards adjacent to the existing Hanson Tweed Sand Quarry terminating at the Tweed River. Water discharges to the Tweed River through culverts under the Pacific Highway and Chinderah Bay Drive, adjacent to the river, with flood gates on the river side of the culverts under Chinderah Bay Drive. Other minor drains run east-west and north-south across the floodplain and generally discharge into the western drain. The floodplain is subject to inundation from both the local catchment floods as well as Tweed River overbank floods.



SCALE 1:30 000

500 0 500 1000 1500 m

Source: Tweed Heads & Cudgen 1:25 000 Topographic Maps (2000)

Figure 4.4
DRAINAGE NETWORK

Local Catchment Floods

Local catchment floods are generated from heavy rainfall over the floodplain and surface runoff flowing from Cudgen Plateau onto the floodplain. An example of this type of flood occurred in late June 2005 when in excess of 600mm of rain fell across a localised area in northern NSW and southern Queensland. Initially flood waters pond on the floodplain until the level of Tweed River reduces and flood waters drain away through the drainage network into the river, generally within one or two days.

Based on previous modelling and measured events, a local catchment flood with a 1 in 100 year average recurrence interval (ARI) results in flood levels across the floodplain in the order of 1.2m AHD to 1.3m AHD. A flood of this magnitude would result in water depths of 0.3m to 0.5m across the Project Site.

Tweed River Overbank Floods

Tweed River overbank floods occur when the Tweed River overtops its natural levee banks. The natural levee banks and the Pacific Highway provide a barrier to floods up to somewhat in excess of 1 in 20 year period ARI in the Tweed River. During an overbank flood, flood levels on the Project Site would generally be greater than 1m in depth and in the order of 2.5m during a 100 year ARI flood event. As for a local catchment flood, the flood waters would pond across the floodplain and drain to the Tweed River through the drainage network over a number of days.

4.2.2.3 Project Site Drainage and Flooding Regime

The Project Site lies near the southern boundary of the Kingscliff-Chinderah-Cudgen floodplain adjacent the northern boundary of the Cudgen Plateau. The Project Site is traversed by the western drain which is aligned parallel to and south of Altona Drive (existing). The Project Site is also drained by two drains which are aligned east-west adjacent to the southern and northern boundaries of the Project Site and a minor north-south drain located within Lot 2 DP 216705 (see **Figure 4.4**). The topography of the extraction sites and processing area is flat with elevations ranging from 0.8m AHD to 1.0m AHD.

The Project Site is influenced by both local catchment floods and Tweed River overbank floods. During a flood, the velocity of floodwaters traversing the Project Site is very low and generally in the order of 0.1m/s.

4.2.3 Surface Water Occurrences and Uses

A number of significant water bodies exist within the Tweed River Catchment including the Cobaki, Tweed and Terranora Broadwaters south and west of Tweed Heads, Cudgen Lake southeast of Cudgen and Clarrie Hall Dam southeast of Terragon (see **Figure 4.4**).

Within the local area, major surface water occurrences within the Tweed River floodplain include the dredge pond created by the Hanson Tweed Sand Quarry (currently approximately 18ha and approved to expand to 50ha) and Noble Lake, an artificial lake (area = 9.2ha) created during the construction of the Noble Lakeside Park development. A number of private dams are also located on surrounding properties which are generally used for irrigation purposed. A number of these dams are classified as 'window lakes' into the underlying groundwater aquifer (see Section 4.2.4.2).

Other than the initial 0.5ha dredge pond created under Development Consent DA 96/518 and the roadside drain discussed in Section 4.2.2.3, there are no significant or permanent surface water sources within the Project Site.

4.2.4 Groundwater Occurrences and Uses

4.2.4.1 Introduction

The groundwater resources within the local area are located within two aquifers, namely the Quaternary sands beneath the Tweed River floodplain and the Tertiary basalts of the Cudgen Plateau. The basement unit is the Neranleigh-Fernvale Group which outcrops to the north of the Tweed River and to the southwest of the Project Site. The following subsections provide a summary of the extent, aquifer properties, water quality, water flow and usage for each aquifer.

4.2.4.2 Quaternary Sand Aquifer

The Quaternary sand aquifer extends from the base of the Cudgen Plateau at the southern boundary of the Project Site and extends north to the Tweed River. The sands within the aquifer are fine to medium grained quartzose sand and extend to an average depth of approximately 20m beneath the Project Site. The sand is underlain with low permeability marine clays which are in turn underlain by residual clay of the basement rocks (ie. the Neranleigh-Fernvale beds).

No in situ permeability testing has been undertaken on site, however the hydraulic conductivity of the Quaternary sands is likely to range between 5m/day to 15m/day. Collection of water samples from monitoring bores within the aquifer indicate that "groundwater purging had virtually no effect on groundwater levels with recovery to within 20mm or better of pre-purge levels occurring almost immediately" (Coffey Geosciences, 1999).

Recharge to the Quaternary sands occurs by direct rainfall infiltration through the sandy soils and by inflow from the Tertiary basalt aquifer that forms the Cudgen Plateau. Rainfall recharge to the sand aquifer is expected to be relatively high at 20% to 35% of the annual rainfall.

Groundwater levels indicate a very slight gradient to the north of the Project Site of between 1 in 10 000 to 1 in 20 000. It is also likely that there are slight depressions of the water table adjacent to the drains that surround or traverse the Project Site, however, the monitoring network is not sufficient to detect this. No tidal fluctuation is evident in monitoring data

collected at the Project Site. Groundwater monitoring within the Project Site indicates that the water table beneath the Project Site has a fluctuation range from 0.75m AHD to -0.75m AHD, with a seasonal fluctuation of about $\pm$0.5m and an average level of about 0.25m AHD.

Discharge from the sand aquifer occurs through 'windows' in the aquifer created by existing and past sand pits, ornamental lakes and open drains, by discharge to the Tweed River and by evapotranspiration where there is a shallow water table and dense vegetation cover. There are also approximately 30 registered bores and five unregistered spears recorded within the aquifer within a 4km radius of the Project Site (see **Figure 4.5** and **Table 4.3**).

Water from these bores is used for a range of purposes including monitoring, domestic, stock and irrigation. Water bores installed in the Quaternary sand aquifer appear to have relatively low yields, typically less than 1L/s. These low yields are likely due to the bores being relatively shallow, installed at depths of less than 6m, and therefore not tapping the full thickness of the aquifer. The depth of most of the bores in the area has probably been restricted to the upper section of the sand aquifer due to the presence of saline groundwater at depth and due to the fact that 1L/s is sufficient for irrigation of gardens.

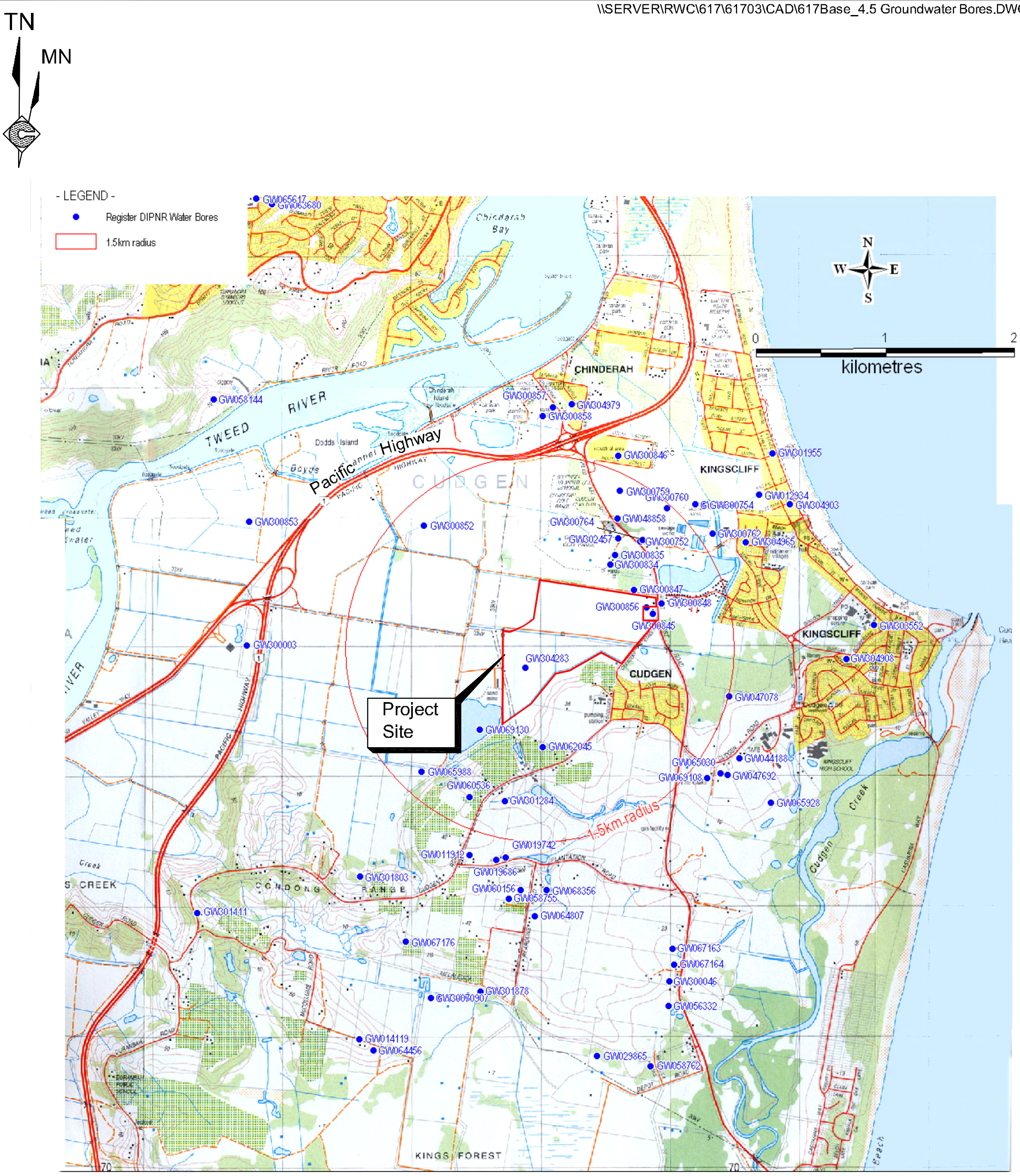
Groundwater quality within and surrounding the Project Site is generally good. Previous monitoring suggests that groundwater is fresh to a depth of approximately 15m and becomes saline towards the base of the aquifer at about 20m depth. Groundwater also becomes more saline to the north, towards the Tweed River. Section 4.2.5 provides further detail of groundwater quality in the immediate vicinity of the Project Site.

4.2.4.3 Tertiary Basalt Aquifer

The extent of the Tertiary basalt aquifer is defined by the Cudgen Plateau which covers an area of approximately 8.4km^2. The aquifer encompasses two surface water catchments with the catchment divide corresponding approximately to Cudgen Road, which generally traverses across to top of Cudgen Plateau. North of Cudgen Road, surface flows are to the north towards the Tweed River, and to the south of Cudgen Road, surface flows are to the east to Cudgen Creek. The groundwater divide and groundwater levels generally form a subdued reflection of the topography.

Available data from bore logs on the DWE database indicate that most bores drilled in the aquifer intersected basalt inter-bedded with layers of clay with the thickness of the basalt being highly variable and dependent on the ground elevation and depth of the underlying Neranleigh-Fernvale beds. Of the two bores present to the north of Cudgen Road, that is, north of the groundwater divide beneath Cudgen Plateau, the closest bore to the Project Site is located approximately 300m to its south (GW62045 – see **Figure 4.5**). During the drilling of this bore, weathered basalt was intersected to a depth of 18m, followed by 3m of grey clay, which was inturn underlain by black, water-bearing basalt from 21m to 54m (-24m AHD based on an assumed elevation of the bore of 30m AHD from the topographic map).

\\SERVER\RWC\617\61703\CAD\617Base_4.5 Groundwater Bores.DWG



REFERENCE

Project Site Boundary

Registered Groundwater Bore

SCALE 1:50 000

0.5 0 0.5 1.0 1.5 2.0 2.5 km

Source: AGE (2008) - Figure 5

Figure 4.5
GROUNDWATER BORES
SURROUNDING THE PROJECT SITE

Table 4.3
Existing Bores within 4.0km of the Project Site Boundary @

Bore Number	Date	Lot and DP	Land Owner	Purposes	Construct. Method	Final Depth (m)	SWL (mbns)	Salinity (mg/L)	Yield (L/s)
GW047078	1978	L2 DP568845	N/A	Domestic Irrigation Stock	Excavation	2.5	-	-	-
GW062045	-	L1 DP547984	-	Irrigation	Rotary	54	-	-	-
GW069130	1991	L2 DP777905	Hanson	Sand & Gravel Irrigation	Excavation	0	-	-	-
GW300003	1993	L1 DP 780237	Christiansen	Farming Irrigation	Rotary	122	17.1	-	0.63
GW300752	1995	L32 DP847319	Tweed Council	Monitoring Bore	RC	2	1.4	300	0.1
GW300753	1995	L32 DP847319	Tweed Council	Monitoring Bore	Open Hole	2	1.5	370	0.1
GW300754	1995	L32 DP847319	Tweed Council	Monitoring Bore	Open Hole - Water	6	1.5	280	0.1
GW300756	1995	L32 DP847319	Tweed Council	Monitoring Bore	Rotary	2	1.5	-	0.1
GW300759	1995	L32 DP847319	Tweed Council	Monitoring Bore	RC	6	1.5	-	0.1
GW300760	1995	L32 DP847319	Tweed Council	Monitoring Bore	RC	2.5	2.5	-	
GW300762	1995	L32 DP847319	Tweed Council	Monitoring Bore	RC	2	1.4	180	0.1
GW300764	1995	L32 DP847319	Tweed Council	Monitoring Bore	(Unknown)	6	1.4	108	0.1
GW300834	1980	C DP33290	Rudman	Domestic Stock	-	6	-	-	0.57
GW300835	1980	L1 DP781709	Rudman	Domestic Stock	-	6	-	-	0.57
GW300845	1968	L1 DP105009	Hermann	Domestic	-	-	-	-	-
GW300846	1979	L7 DP249122	Harrison	Domestic	-	6	-	-	-
GW300847	-	L33 DP755701	Cooper	Domestic	-	-	-	-	-
GW300848	1962	L1 DP348858	Mye	Domestic	-	-	-	-	-
GW300852	1996	L57 DP755701	Brinsmead	Stock	Hand Dug	6	1	-	1
GW300853	1990	L3 DP755701	Brinsmead	Domestic Stock	-	6	1.5	-	1
GW300856	-	L1 DP611021	Martins	Domestic	-	-	-	-	-
GW300857	-	L109 DP755701	Mackay	Domestic	-	-	-	-	-
GW300858		L109 DP755701	Mackay	Domestic	-	-	-	-	-
GW302457	1996	L1 DP771798	Brinsmead	Domestic	Hand Dug	6	2	-	2
GW304283	2003	L2 DP216705	Kareena Dev	Industrial - Sand & Gravel	-	-	-	-	-
GW304965	2004	L93 DP867769	Varela	Domestic	Hollow Flight Auger	6	3.5	200	0.5
GW304979	2004	L13 DP246190	Wilson	Domestic	Hollow Flight Auger	6	2	200	0.5
GW305057	2005	L9 DP830659	Action Sands Pty Ltd	Industrial – Sand & Gravel	-	-	-	-	-
GW305128	2000	L2 DP777905	Hanson	Monitoring Bore	-	12	-	-	-
GW305151	2004	L2 DP611021	Tweed Council	Monitoring Bore	Rotary	6	0.9	-	-
Phillips 1	2005	L1 DP227034	Phillips	Domestic	-	5.5	~1-1.5	-	0.8
Phillips 2	2001	L1 DP227034	Phillips	Monitoring	-	5.1	1.08	-	-
Rudman	1958	L1 DP397479	Rudmann	Domestic	-	4.1	-	-	-
Julius East	-	L1 DP598073	R. Julius	Irrigation	-	-	-	-	-
Julius West	-	L1 DP598073	R. Julius	Irrigation	-	-	-	-	-

Notes: - mbns = metres below natural surface @ Data drawn from DWE Database NA = Not Available
RC = Reverse circulation SWL = Standing Water Level

No information on the hydraulic conductivity of the Tertiary basalt is available, however, experience in other areas suggests that the hydraulic conductivity is highly variable and depends on whether the basalt is massive, fractured or vesicular. Recharge to the Tertiary basalt aquifer occurs by direct infiltration through the permeable krasnozem soils which cover the plateau.

Available water level data from selected bores on the DWE database indicate water levels between approximately 2m AHD and 26m AHD (based on assumed elevations from the topographic map). The available data indicates that the water levels in the Tertiary basalt are generally significantly above those in the Quaternary sand aquifer, indicating a flow gradient towards the floodplain though the available water level information is insufficient to define groundwater flow directions. A conceptual representation of groundwater flow in the Quaternary sand and Tertiary basalt is shown in **Figure 4.6**.

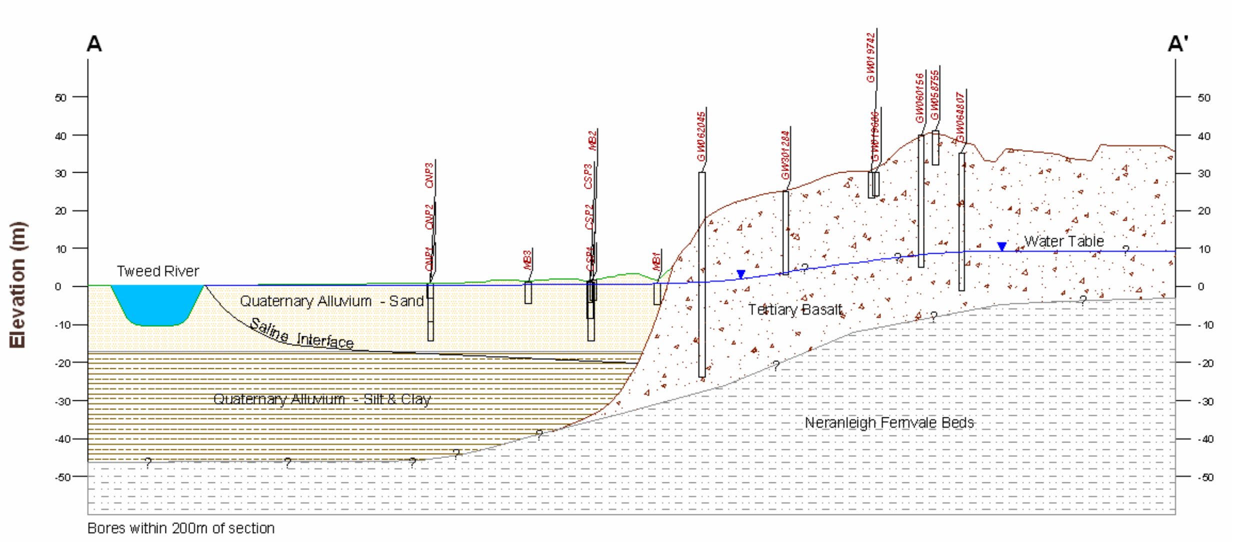


Figure 4.6
Conceptual Groundwater Flow Model

Discharge from the Tertiary basalt occurs to the surrounding Quaternary sands. Some discharge from the Tertiary basalt aquifer also occurs through extraction from bores. There are 25 registered bores located in the basalt aquifer within a 4km radius of the Project Site (see **Figure 4.5**). Seventeen bores have no information on yields, however available records show that yields from the bores in the Tertiary basalt are low to moderate and vary between <1L/s to about 5.5L/s.

4.2.5 Water Quality

Surface and groundwater quality within the Quaternary sand aquifer are intrinsically linked. In most cases surrounding surface water sources are 'window lakes' into the Quaternary sand aquifer. Hence, the water quality of surrounding surface water bodies generally reflects the water quality measured within the upper groundwater.

As discussed in Section 4.2.4.2, groundwater within and surrounding the Project Site is generally fresh to a depth of approximately 15m and becomes saline towards the base of the aquifer and towards the Tweed River. Based on monitoring undertaken between 1991 and 1992 Woodward-Clyde (1996) concluded that "*Groundwater quality ranges from fresh near Cudgen Ridge to weakly saline in bores …… approximately 1km northwest of Cudgen Ridge…The data suggests that a wedge of fresh water thins northwards from the presumed recharge area of Cudgen Ridge…..the groundwater quality is largely controlled by the degree of mixing between fresh waters from (Cudgen Ridge) and deep, saline waters originally derived from estuarine and marine infiltration*". Baseline monitoring undertaken for the Project confirms this conclusion.

No information is available on the water quality in the Tertiary basalt, however, in areas of high rainfall, basalt aquifers typically contain good quality water. Also groundwater from the basalt is used for irrigation of crops and for domestic purposes, suggesting it is of high quality.

Monitoring of surface water quality within the surrounding drainage network indicates that the water quality in the drains is variable with some tidal influence noted, especially during dry conditions, when electrical conductivity (EC) levels of 32 100µS/cm have been recorded within the western drain to the northwest of the southern extraction site. Samples collected from the drain along the southern boundary of the Project Site have generally been fresh (EC<510µS/cm) although brackish to saline conditions have also been recorded (EC 2300 & 19510 µS/cm) during low flow conditions. Measurements within bores located adjacent to drains also indicate that the groundwater next to the drains can become slightly brackish as a result of the tidal influence within the drains during dry periods. Recorded pH levels have generally been near neutral (ie. pH 7.0).

Table 4.4 presents a summary of monitoring results for monitoring bores located within and surrounding the Project Site. All data within **Table 4.4** is compared to ANZECC 2000 guideline trigger values for aquatic ecosystems for estuaries in southeast Australia. The data indicates that the groundwater, both shallow and deep, is generally more acidic than the trigger value.

A range of groundwater samples were also collected by HMC Environmental Consulting during a bore census undertaken for the Project and submitted to Tweed Laboratory Centre for analysis. Of interest are the relatively high concentrations of iron in bores to the northeast of the Project Site that reported increased iron concentrations during the construction of Noble Lake.

The concentrations of iron reported in registered bores GW300834, 300845, 300856 and the unregistered bore on the Phillips and Rudman properties were relatively high being between 8.4mg/L and 17mg/L. In comparison iron concentrations in samples collected from the Julius and Kettle properties that adjoin the Project Site to the south reported concentrations of iron typically less than 1mg/L.

The source of the high iron concentrations in selected bores to the northwest is uncertain but the presence of iron together with dissolved aluminium in these water samples suggests some interaction with acid sulfate soils. The concentrations of iron make the water unsuitable for drinking and problematic for irrigation.

Table 4.4
Summary of Baseline Groundwater Quality Data

Location	Bore	Screens (mbns)	pH	EC (µS/cm)	Ca	Mg	Na	K	SO_4	Fe	Al	Mn	Cl	HCO_3
ANZECC Guideline Trigger Values			7.0-8.5	-	-	-	-	-	-	ID	ID	1.2	-	-
South of Altona Drive (Realigned) Lot 2 DP216705	**MB1**	2.6-5.6	6.54-7.32	872-1866	137-193	23-36	23-61	5-6	179-528	0.01-26	0.01-0.1	0.22-0.34	35-154	142-283
	MB2	2.3-5.3	4.62-7.72	115-2394	0.4-1.7	0.33-2.5	12-19	8-17	11-27	2.26-17	0.42-12	0.01-0.05	10-40	6-146
	MB3	2.8-5.8	6.56-7.46	874-3140	14.9-219	33-60	19-43	6-10	175-259	0.24-3.35	0.01-0.11	0.14-0.29	35-53	165-311
	MB10	19.0-21.0	7.09-8.75	29400-43800	205-233	1070-1150	7330-7440	290-290	1740-2490	0.81-1.90	0.09-0.34	0.14	3500-12828	72-302
	MB4	2.6-5.6	6.38-7.37	1056-6930	83-163	38-82	186-449	11-21	46-117	2.52-9.44	0.01-0.34	0.15-0.33	290-650	193-351
	MB5	2.7-5.7	5.77-7.8	171-4850	82-153	36-78	155-285	11-40	185-291	0.06-6.43	0.01-0.09	0.16-0.34	217-328	190-315
	MB6	NR	7.62-7.89	4310-6800	89-121	87-126	879-1080	34-52	234-657	0.65-2.67	0.12-0.23	0.15-0.31	1700-4062	177-199
	MB6A	NR	7.47-8.03	4040	39-63	23-43	369-508	10-18	175-178	0.49-2.74	0.09-3.91	0.04-0.11	625-941	180-187
	MB7	NR	7.61-7.80	15060-15800	-	-	-	-	-	-	-	-	-	-
	MB8	NR	6.40	21070	-	-	-	-	-	-	-	-	-	-
	MB8A	NR	7.27-7.66	5500	52-87	51-87	523-832	23-34	257-340	3.34-6.59	1.2-2.7	0.06-0.08	810-1227	202-223
	MB9	NR	7.51	5820	-	-	-	-	-	-	-	-	-	-
	CSP3	3.4-5.4	6.5-7.8	300-901	50-157	5-17	9-22	5-28	7.44	3-15	0.04-0.26	0.21-0.43	8-67	161-201
	CSP2	7.6-9.6	6.8-7.9	350-757	61-251	4-427	12-2570	1-234	7.7-764	3-17	0.05-0.2	0.52-0.64	13-70	190-250
	CSP1	13.2-15.2	6.9-8.0	320-1179	67-321	6-36	12-105	1-312	32-329	0.9-3	0.06-0.51	0.24-0.61	13-70	190-250
North of Altona Drive (Realigned) Lot 20 & 21 DP 1082482	**CNP3**	2.0-4.0	6.2-7.3	897-1500	75-123	18-108	58-769	5-5	5.2-313	8-17	0.1-0.48	0.16-0.33	105-1230	202-214
	CNP2	8.0-10.0	6.3-7.5	10200-16700	134-251	316-601	2320-3410	9-51	537-888	3-25	0.07-0.6	0.24-0.52	4200-5850	353-415
	CNP1	13.0-15.0	6.6-7.6	12500-22300	188-344	427-1060	3110-4380	12-85	1050-1560	3-25	0.15-0.8	0.18-0.39	5100-7500	563-670
	MB11	2.5-3.5	6.81-7.54	1492-1625	211-289	65-72	127-220	11.19	456-484	3.57-11	0.64-3.13	0.20-0.33	300-311	23-302
	MB12	6.7-9.7	6.84-7.46	1587-1619	322-433	54-59	43-66	12-13	528-706	1.61-2.98	0.12-0.74	0.28-0.35	87-147	24-223
	MB13	17.6-20.6	6.36-7.18	32200-36800	559-1170	1050-2040	6870-6940	215-217	2260-4000	1.8-19	0.17-0.75	0.81-0.83	247-15198	33-304

Notes:
i) mbns = metres below natural surface
ii) ID = insufficient data to derive reliable trigger value
iii) ANZECC guidelines are trigger values for aquatic ecosystems for estuaries in south-east Australia
iv) NR – not recorded

Source: AGE (2008) – Table 5

4.2.6 Mitigation Measures and Management Procedures

4.2.6.1 Flooding and Drainage

The mitigation measures and management procedures to be adopted with respect to flooding and drainage would include the following.

- Construction and maintenance of shallow spillways within the bunds surrounding the extraction ponds. The spillways would be located at the eastern and western extent of the bunding adjacent the deepest part of the extraction pond. The top of the bund would be at 1.8m AHD and the spillways at 1.3m AHD, approximately 1.0m and 0.5m above the natural ground surface respectively. The spillways would act to equalise floodwaters outside the extraction ponds and inside the ponds allowing the bund to overtop in a safe manner, reducing scour and erosion.
- Removal of sections of the bunding once floodwaters have receded to allow floodwaters trapped behind the bunds to drain freely to the western drain.
- Filling of the processing area approximately 0.75m to 1.0m above the natural ground surface (1.55m AHD to 1.8m AHD). This would prevent inundation of the processing area during local catchment floods.
- Prior to a forecast Tweed River overbank flood, the entrance to the processing area would be blocked with sand relocated from on-site stockpiles to reduce the level of inundation within the processing area.
- Maintenance of drainage paths, outside of the bunded and filled areas, to the western drain parallel and south of Altona Drive. This would allow floodwaters to drain freely once the Tweed River drops and the drainage network regains function.
- Preparation of a flood evacuation plan prior to commencement of operations. The plan would relate primarily to a Tweed River overbank flood and would ensure that personnel respond appropriately to a warning of an imminent overbank flood. Due to the extensive warning times (6 to 12 hours) for an overbank flood, vulnerable equipment and machinery could be moved / removed and personnel safely evacuated.

The realignment of the western drain adjacent to and south of Altona Drive as part of the approved realignment of Altona Drive would also provide a more efficient drain and allow faster drainage of floodwaters towards the Tweed River.

4.2.6.2 Surface and Groundwater

The most critical management control relating to groundwater would involve monitoring of a range of groundwater parameters to ensure the predictions discussed in Section 4.2.7.2 are being achieved. Details of the proposed groundwater monitoring program are presented in Section 4.2.10.2. Mitigation measures which relate to impacts from the exposure of potential acid sulfate soils and associated impacts on water quality would be implemented as described in Section 4.3.5.

In order to reduce potential impacts on groundwater levels, the maximum extraction rate within the southern extraction pond has been limited to 450 000m^3 per year for the first two years of operations or until a sufficient size extraction pond is created to allow extraction at a rate of 650 000m^3 per year. Furthermore, during the first year of operations, extraction within the southern extraction pond would commence at an equivalent rate of 100 000m^3/ year and progressively ramp up in increments of an equivalent rate of 100 000m^{3}per year throughout the year. During this ramp up period (and throughout the life of the operation), the level of extraction would be adjusted to ensure that groundwater drawdown levels remain within the limits predicted.

It should be noted that the current approval (DA 96/518) requires that the extraction of 400 000m^3 in 26 weeks. This is an equivalent rate of 800 000m^3 per year which is much greater than that currently proposed.

In addition to the above management measures, appropriate hydrocarbon handling and storage procedures would be implemented to reduce the potential for contamination of surface water or groundwater. In particular, the following measures would be implemented.

- All hydrocarbons would be securely stored within the designated storage areas.
- All storage tanks and areas would be either self bunded or bunded with impermeable surfaces and capacity to contain 110% of the largest storage tank capacity.
- All water from the workshop would be directed to an oil-water separator. (Rob – wash down bay?).

In cases where the quality or availability of surface water or groundwater on a surrounding landholding has been adversely affected as a result of the Project, the most effective mitigation measure would be to reach an agreement to either replace any reductions in available groundwater supplies through re-establishment of water yields, such as extending the depth of the bore (if appropriate), or provide an alternative source of water, such from the extraction ponds or from groundwater sources elsewhere on the Proponent's land. Where appropriate, some other form of agreement with the owners of affected properties would be reached. Further details of the Proponent's approach to negotiated agreements are provided in Section 4.2.9.2.

4.2.7 Outcomes from Groundwater Modelling

4.2.7.1 Introduction

The initial design for the proposed sand extraction operation involved all sand extraction being undertaken south of Altona Drive (realigned) – the southern extraction site. However, as a result of imposed development consent conditions on the realignment of Altona Drive, the southern extraction site was reduced in size and a northern extraction site north of Altona Drive (realigned) introduced.

The proposal to extract sand from north of Altona Drive (realigned) was made subsequent to the completion of numerical modelling for the southern extraction site. Therefore, considering the comparatively small scale of the northern extraction site and the planned use of only mechanical extraction methods, it was deemed appropriate that the potential impact on groundwater levels from the introduction of the northern extraction site be assessed using analytical methods, and no additional numerical modelling was considered necessary.

The following subsections outline the results of the predictive modelling undertaken for the northern and southern extraction sites and their cumulative effect upon each other.

4.2.7.2 Numerical Modelling (Southern Extraction Site)

Model Development

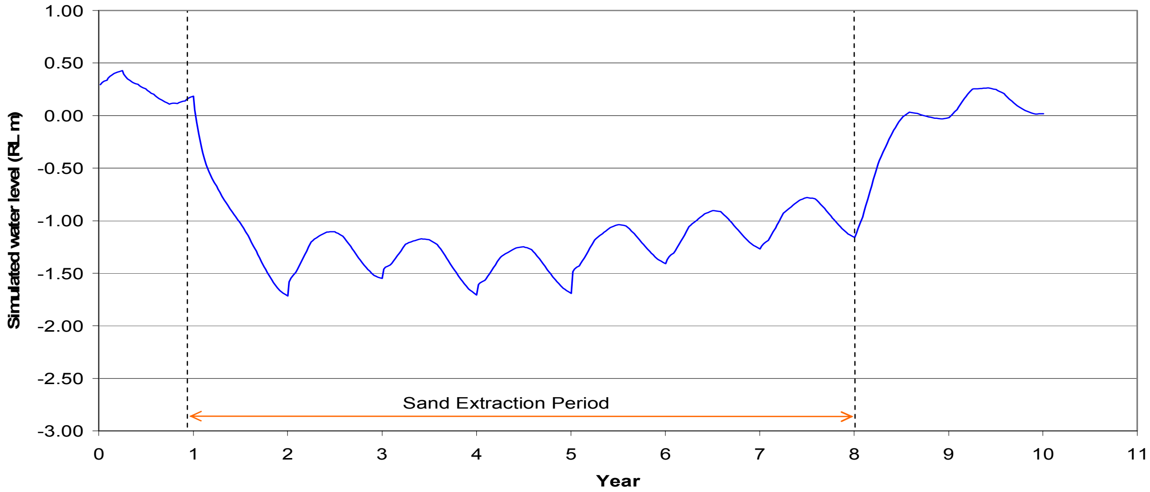
The numerical model for assessment of the Project was developed using the MODFLOW code, a modular, three-dimensional, finite difference groundwater flow model developed by the United States Geological Survey. The MODFLOW numerical code is currently the most widely used code for groundwater flow modelling and is presently considered as industry standard. The model was created with the use of the PMWIN v7.0.31 interface. PMWIN is a pre- and post-processing interface which allows the graphical input of data and output of results.

A single layer model was used to simulate the Quaternary alluvium and the Tertiary basalt aquifers. The base of the model was set at -19m AHD and was based on a review of boreholes drilled within and around the model domain. The area simulated encompassed the Cudgen alluvial plain and the Cudgen Plateau with the Tweed River providing the northern and western boundary, the Pacific Ocean the eastern boundary and the southern boundary was set at the southern boundary of the Cudgen Plateau. Surrounding water bodies, drainage systems and existing groundwater extraction was also taken into account during the development of the model.

The maximum annual extraction rate (ie. 450 000m^3 for first 2 years and 650 000m^3 for subsequent years) was used within the model to represent the worst case scenario. Details of the model and its calibration and validation are presented in AGE (2008 - Part 1 of the *Specialist Consultant Studies Compendium*).

Model Results

The simulated water level of the southern extraction pond is shown in **Figure 4.7**. The water level within the southern extraction pond would fall to about -1.5m AHD during the early stages of the Project and would gradually recover as the Project progresses and as the size of the southern extraction pond increases. It is noted that the groundwater level fluctuations depicted in **Figure 4.7** reflect the natural variations attributable to the wet summer and dry winter seasons. At the cessation of sand extraction, the water level in the final lake would recover rapidly and within a 1 year period return to background levels.



(Source: AGE 2008 – Figure 20)

Figure 4.7
SIMULATED SOUTHERN EXTRACTION POND/LAKE WATER LEVEL

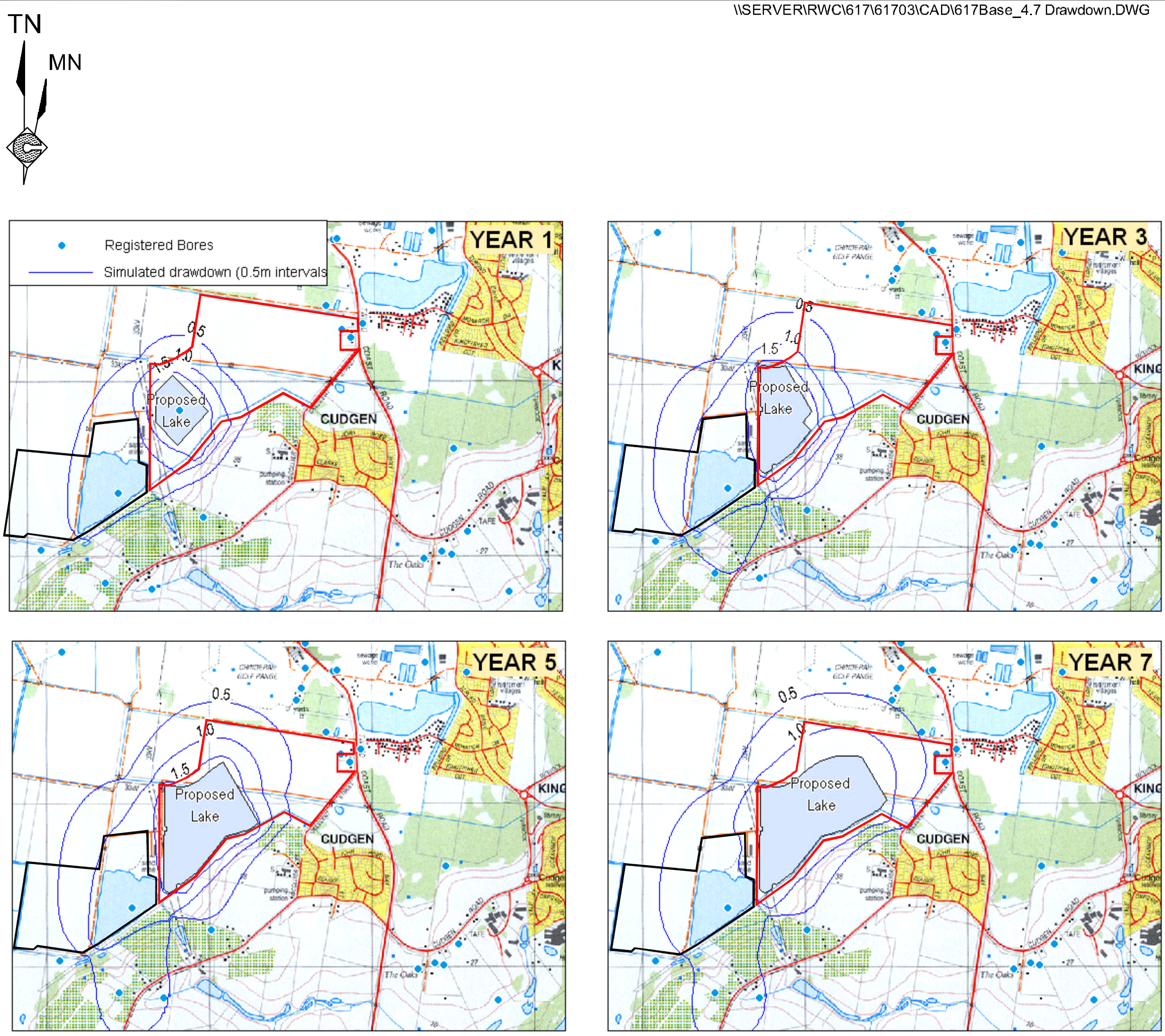
The drawdown external to the southern extraction pond at Years 1, 3, 5 and 7 is presented in **Figure 4.8**. The limit of drawdown is presented as 0.5m which is the typical annual fluctuation observed in groundwater levels in the alluvium. As within the southern extraction pond, water levels external to the Project Site would recover to pre-extraction levels within 12 months of the cessation of extraction. As can be seen from **Figure 4.8**, drawdown in groundwater levels is greatest during the early years of extraction and gradually decreases due to the increasing input from rainfall as the extraction pond expands. The model predicts that drawdown extends to a maximum distance of about 500m to the north in the alluvial floodplain. At Year 7, a drawdown of between 0.5m and 1.0m extends about 500m to the south in the Cudgen Plateau.

Figure 4.9 shows the simulated water level at the two closest registered groundwater bores and two simulated groundwater bores both with and without the proposed sand extraction operations.

It is important to note that it is highly unlikely that an annual extraction rate of 650 000m^3 per year would be achieved each year. In the likely event that actual sand extraction rates are lower than the maximum rate used in the model and extraction is undertaken over a longer period, the level and extent of drawdown is expected to be less than that predicted. Therefore **the results of the modelling are considered to be a worst case scenario**.

The closest groundwater bores to the Project Site are the unregistered spears located on the R. Julius property adjacent to the southern boundary of the Project Site. The spears are used for topping up dams which are used to irrigate agricultural crops on the Cudgen Plateau. As the spears are not registered, the construction details are not known, however, the effect of the sand extraction operations was simulated in the model as simulation bores SIM 4 and SIM5. In the early stages of sand extraction, drawdown in the area of the westernmost spear (SIM 5) is predicted to be between 0.75m and 1.75m below the water level that would naturally occur without the proposed sand extraction. At the eastern spear (SIM 4), the drawdown is predicted to be between 0.5m and 1.0m below the naturally occurring water level.

\\SERVER\RWC\617\61703\CAD\617Base_4.7 Drawdown.DWG



REFERENCE
Project Site Boundary
Approved Extraction Limit - Hanson Tweed Sand Quarry
1.5 Simulated Drawdown (0.5m Interval)

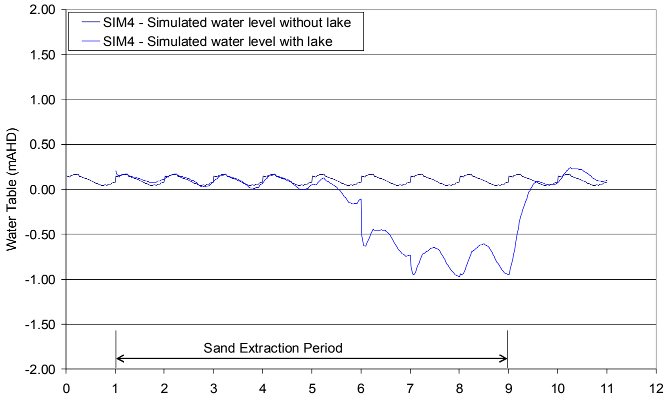
SCALE 1:40 000

0.5 0 0.5 1.0 1.5 2.0 km

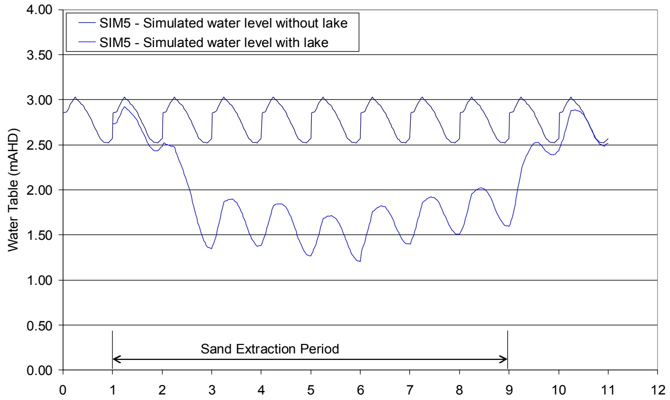
Source: AGE (2008) - Figure 21

Figure 4.8
SIMULATED WATER TABLE DRAWDOWN

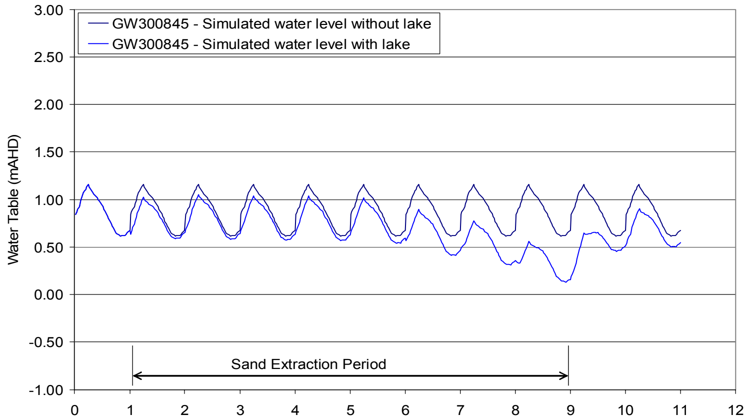
\\SERVER\RWC\617\61703\CAD\617Base_4.9 Drawdown.DWG



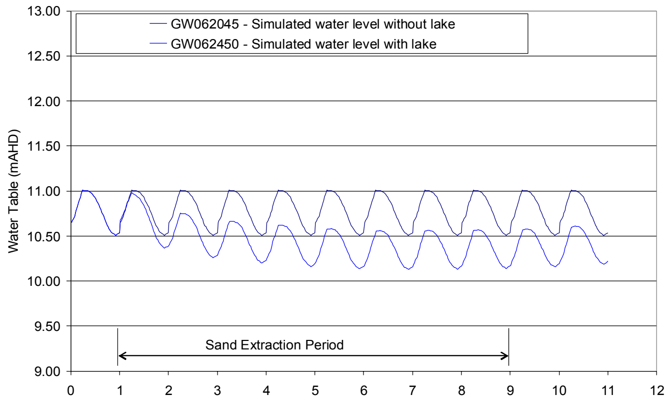
Simulated Water Levels SIM4



Simulated Water Levels SIM5



Simulated Water Levels GW300845



Simulated Water Levels GW062045

Figure 4.9
SIMULATED WATER TABLE DRAWDOWN (HYDROGRAPHS)

Source: AGE (2008) - Figures 22, 23, 24 & 25

A colour version of this figure is available on the project CD

The dams located adjacent to the R. Julius spears are effectively small window lakes each with an approximate base level of -1.7m AHD. The modelling did not indicate dewatering below this level.

The closest registered bores in the Quaternary sand aquifer are located approximately 500m to the northeast of the southern extraction site. The maximum predicted drawdown at the closest bore GW300845 is less than 0.5m and occurs in the latter stages of extraction. Bore GW300845 is screened between to 3.2m and 4.2m below ground level (approximately -1.7m AHD to -2.7m AHD). Predictive modelling indicates that the groundwater level at this bore would be lowered to about 0.2m AHD in the latter stages of sand extraction leaving a total of about 2.9m of water within in the bore when not in use.

The closest registered bore on the Cudgen Plateau is bore GW062045, located approximately 550m to the south of the southern extraction site. Bore GW062045 is screened between 6.5m and 17m below ground level. The maximum predicted drawdown at GW062045 is approximately 0.5m which is less than the natural groundwater table fluctuation range.

4.2.7.3 Analytical Modelling (Northern Extraction Site)

Model Development

In order to assess the potential groundwater impacts of sand extraction operations within the northern extraction site, analytical equations were used based on the previously developed conceptual model (see **Figure 4.6**).

Extraction within the northern extraction site was assumed to occur at an annual rate of 200 000m^3 for the first two years of the operation. This rate would be the maximum rate and realistically is unlikely to be achieved during the first two year of operation. Hence, results from the modelling are conservative. It was also assumed that the extraction pond would be progressively backfilled with VENM starting at the end of the first year.

Full details of the analytical model and equations used are presented in AGE (2008 - Part 1 of the *Specialist Consultant Studies Compendium*).

Model Results

Based on the analytical groundwater modelling, it is concluded that:

- the 0.1m drawdown contour associated with sand extraction from the proposed northern extraction site would occur at a radius of approximately 60m from the excavation;
- the total radius of influence of the northern extraction site would be approximately 100m, that is groundwater levels would not be affected at all at greater than 100m from the extraction site; and
- subsequent to completion of sand extraction in the northern extraction site at the end of Year 2, there would be minimal net loss or gain of water to the remaining extraction pond and the water level would reflect natural groundwater levels.

4.2.7.4 Cumulative Results

The cumulative impact on groundwater levels from the northern and southern extraction sites during Years 1 and 2 must be assessed to obtain a total potential impact. As can be seen from **Figure 4.8**, in Year 1, the 0.5m drawdown contour from the southern extraction site only extends marginally into the northern extraction site and there would be no overlap with the 0.1m drawdown associated with the northern extraction site.

At Year 3 the 0.5m drawdown from the southern extraction site would extend into the northern extraction site, but by this time sand extraction would be completed within the northern extraction site and the extraction pond would be progressively backfilled. At Year 2, there would be minimal net loss or gain of water from/to the northern extraction site and therefore the water level in the northern extraction pond should return to the natural water table level.

The data indicates that there would not be a cumulative impact on groundwater levels as a result of hydraulic extraction (ie. dredging) in the southern extraction site and mechanical extraction (ie. excavator) in the northern extraction site during years 1 and 2.

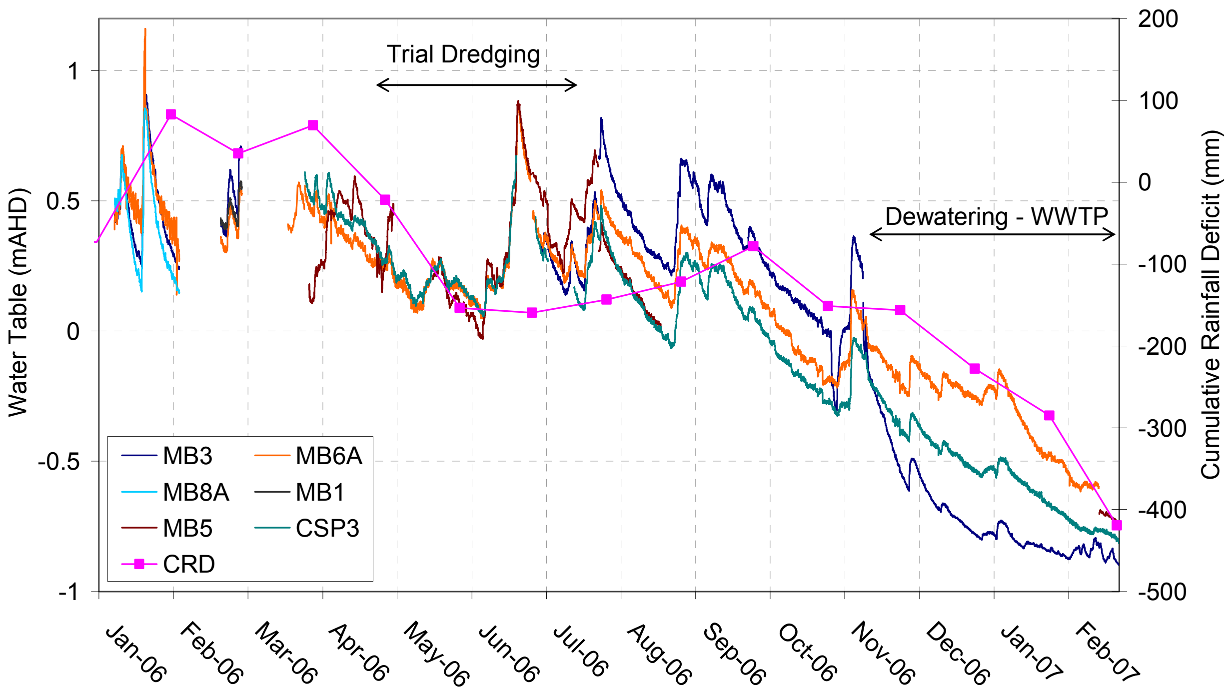
4.2.7.5 Post Modelling Monitoring and Review of Model Assumptions

In January 2006, electronic water level loggers were installed in several monitoring bores within the Project Site to gather transient data for the numerical modelling. The groundwater modelling component of the Project was completed in March 2006, however, the loggers were retained in the bores at the site to gather further data. As the modelling identified the potential for lowering of groundwater levels on the adjacent R. Julius property, electronic monitoring of water levels and extraction rates from two dams (window lakes) on this property was also implemented with the agreement of the landowner.

Groundwater levels recorded by the electronic loggers installed in selected bores within the Project Site between January 2006 and February 2007 are presented in **Figure 4.10**.

Review of the rainfall record indicates that above average rainfall was received in January 2006, however, since then rainfall has been below average in 9 out of 14 months. Throughout the monitoring period, total rainfall was 345mm below the average for the Murwillumbah Station.

The hydrographs presented in **Figure 4.10** indicate that groundwater levels have generally fallen about 1.5m over the monitoring period because discharge (including natural discharge to drains and evapotranspiration) and extraction from the aquifer has exceeded rainfall recharge. A summary of the extractions from the aquifer are discussed as follows and provided in full in AGEC (2008).



Source: AGE (2008) Figure 34

Figure 4.10
MONITORING BORE HYDROGRAPHS

Trial Dredging

Preparatory works involving a small-scale dredging operation was undertaken between 19 April 2006 and 12 July 2006 to establish the initial dredge pond for the approved extraction of 400 000m^3 of sand under Development Consent DA 96/518. Operational dredging has not yet commenced, however, these preparatory works have been used as a "trial dredging operation" to gather feasibility data that would assist to validate the assessment of the Project. The dredge was operated Monday to Friday between 7am and 4pm with a total of about 22,000m^3 of sand extracted. The tailwater was returned directly to the dredge pond. The extraction rate adopted during the trial dredging was equivalent to an annual sand extraction rate of about 104,000m^3 per year.

During the early stages of trial dredging, the closest monitoring bore, MB5, showed a slight drawdown of about 0.05m to 0.1m during the day with water levels recovering when the dredge was not operating overnight. None of the other monitoring bores responded significantly to the operation of the dredge. Overall, the hydrographs show a general decline in groundwater levels from the commencement of the trial dredging on 19 April to 11 June 2006. However, the rate of decline in monitoring bores in close proximity to the dredging (MB5, CSP3) was similar to that observed in more distant monitoring bores (MB6A) suggesting that the general decline in water levels was due to the below average rainfall recorded over the period and was not significantly impacted by the trial dredging.

As the trial dredging was undertaken at an equivalent rate of about 104,000m^3 per year, a rate similar to that which would initially occur during the ramp up period and about one-quarter of the proposed extraction rate, the monitoring results record drawdown levels commensurate with the reduced rate of extraction and are supportive of the assumptions used in the modelling.

Dewatering During the Waste Water Treatment Plant Construction

Dewatering associated with construction of the Tweed Shire Council Waste Water Treatment Plant (WWTP) located to the northwest of the Project Site commenced in mid Nov 2006. It is understood that spear points were installed at a depth of about 12m for dewatering with groundwater discharged to the surrounding agricultural drains. The spear points were pumped at a rate of about 25L/s up to mid January 2007 when the rate was reduced to 20L/s until the end of February 2007. The pumping rate was further reduced from February 2007 to about 7L/s and continued until May 2007. The dewatering period is shown in **Figure 4.10**.

The hydrographs show again a general decline in groundwater levels in all monitoring bores from June 2006, however, the closest monitoring bore to the WWTP construction site, MB3, shows a more rapid decline in groundwater levels at the commencement of dewatering in November 2006. As the dewatering rates declined, the rate of decline observed in groundwater levels in MB3 also reduced (refer **Figure 4.10**). In February 2007 the groundwater levels in MB3 were similar to those in monitoring bores on the Project Site indicating that the reduced extraction rates were not resulting in any significant drawdown beyond the WWTP site.

During the initial years of sand extraction the groundwater removal rate on from the southern extraction pond is estimated to be between 20L/s and 30L/s. Groundwater extraction occurred at a similar rate (25L/s) during dewatering associated with the new WWTP site with a relatively limited impact on regional groundwater levels in the sand aquifer. Although the dewatering on the WWTP site was for a relatively limited period, the observations provide a level of confidence in the outputs of the numerical modelling that predicted a relatively limited cone of depression from the proposed sand extraction at similar groundwater extraction rates.

Dam Extraction Rates

Electronic water level loggers were installed in each of the dams within the R. Julius property, referred to as Dam East and Dam West. In addition, flow meters were installed on the pumps that extract water from these dams for irrigation of crops on the Cudgen Plateau.

The volume of water extracted since installation of the monitoring equipment in December 2006 is summarised in **Table 4.5**.

Table 4.5
Adjacent Dam Extraction Volumes

Month	Dam West		Dam East	
	m^3	ML	m^3	ML
Dec-06 (21 days)	1467	1.5	1048	1.0
Jan-07 (31 days)	4346	4.3	639	0.6
Feb-07 (28 days)	3412	3.4	79	0.1
Mar-07 (9 days)	683	0.7	533	0.5
TOTALS	**9908**	**9.9**	**2299**	**2.3**
Equivalent continuous extraction rate (L/s)	1.4		0.3	

Approximately 9.9ML of water was extracted from the Dam West and 2.3ML from Dam East throughout the summer season. This equates to an equivalent continuous extraction rate of 1.4L/s and 0.3L/s for the western and eastern dams respectively. Of interest is that this measured rate is similar to the extraction rate of 1.3L/s assumed for each of the spears on the site in numerical modelling prior to availability of the monitoring data.

4.2.8 Assessment of Residual Impacts

4.2.8.1 Flooding and Drainage

Local Catchment Floods

The residual impacts from a local catchment flood upon the Project would be minimal. During a 100 year ARI local catchment flood, the site access road, Altona Drive, would still be trafficable, although the road may be overtopped by 10cm of water prior to its realignment. Additionally, the processing area would remain dry and normal local drainage provisions would mean that the balance of the Project Site would drain freely once the rain stopped and the Tweed River levels dropped. Based upon the provision of suitable flow paths, the planned development and final land use following Project completion would also be compatible with local catchment flooding conditions.

The residual impacts from the Project on the local catchment flooding regime would also be minimal. Only small parts of the floodplain would be excluded from the flood storage area, however, because of the relatively small size of the floods there would be minimal impacts. Furthermore, the realigned drain, parallel to and south of Altona Drive, would be more efficient and allow faster drainage of floodwaters than the present drain.

In summary, the Project would be minimally impacted by local catchment floods and would have minimal impacts on such floods and hence negligible or no increase in adverse flooding impacts on surrounding properties and land users.

Tweed River Overbank Floods

The residual impacts from a Tweed River overbank flood upon the Project would be disruptive to operations but would pose minimal risk to personnel. Due to the long warning times prior to an overbank flood, damage to the physical facilities and the safety risk to personnel would be minimised by the proposed mitigation measures. The Project Site could not be accessed via Altona Drive during a 1 in 100 year ARI, however, the maintenance of unobstructed drainage paths to the western drain would minimise down time once floodwaters have receded to the Tweed River.

The residual impacts from the Project on the overbank flooding regime would again be minimal. Due to the height of overbank floods, the entire Project Site would be covered by floodwaters. The reduction in flood storage capacity from the use of fill to raise the height of the processing area and for the perimeter bunds around the extraction area would be more than compensated for by the excavation and removal of material above the water table within the

southern extraction pond. The available volume of flood storage would further increase as the pond was enlarged, with a net increase in flood storage capacity over time. As flow velocities are small, the minor effects of obstructions such as the bunds around the extraction ponds and the processing area would have minimal effect as floodwaters pass over and around them.

In summary, the Project would be minimally impacted by Tweed River overbank floods other than a short period of down time and would result in negligible or no increase in adverse flooding impacts on surrounding properties and land users.

Fill Sites

An assessment of the nominated fill sites has also been undertaken by Webb (2008). The experience of the June 2005 flood and recent modelling using the data from this flood has demonstrated that local catchment flooding after filling of the nominated sites would not have adverse impacts on adjoining properties. Furthermore, the planned developments would be free from the impacts of such floods.

For Tweed River floods, ensuring that there are adequate drainage flow paths for floodwaters to safely enter the area on the rising stage of the flood, and safely leave the area as the flood levels drop back within the banks of the Tweed River, would ensure negligible impacts on the new development areas and existing development.

The filling design would be finalised in accordance with results of the various flood studies allowing for adequate drainage and minimisation of flow path obstruction and fill volumes required. The final filling design and flood assessment of the design would be completed prior to seeking approval to fill the nominated sites.

4.2.8.2 Groundwater

Numerical and analytical modelling has shown that the impact of sand extraction on the groundwater table is dependent on the rate at which sand is extracted and on the size of the extraction ponds. Under maximum extraction rates, maximum drawdown would be about 1.5m in the southern extraction pond for the first 2 years of operations reducing to 1.0m after Year 5. As previously discussed, the rates modelled represent a ‘worst case’ scenario.

In reality, the average extraction rate would be lower than those modelled, particularly during the initial year of operations whilst extraction rates ‘ramp up’ to maximum levels. Furthermore, Development Consent DA 96/518, which requires the removal of 400 000m^3 of sand within 6 months, would be surrendered following the issue of project approval. Hence, the level and extent of groundwater drawdown associated with the southern extraction site is expected to be less than that predicted and the likely drawdowns associated with the current approved operation would not occur.

The radius of influence or the “cone of depression” created in the surrounding water table, as indicated by the 0.5m drawdown contour generally remains within the Project Site, with the exception of a 1.0m to 1.5m drawdown in the area adjacent the southern boundary at the toe of

the Cudgen Plateau, as shown on **Figure 4.8**. Drawdown also occurs to the west of the Project Site, however, this is partially related to extraction from the adjacent Hanson Tweed Sand Quarry operation which currently extracts sand at a rate of up to 150 000m^3 per year.

Analytical modelling indicates that extraction within the northern extraction site would not influence water levels within the southern extraction pond with approximately 0.1m of drawdown extending within a 60m radius from the northern extraction site during extraction. These predicted drawdown levels have the potential to affect:

- acid sulfate soils and sediments;
- groundwater quality;
- other groundwater users; and
- groundwater dependent ecosystems.

Acid Sulfate Soils and Sediments

Based on conclusions of HMC (2008 – Part 3 of the *Specialist Consultant Studies Compendium*), no acid sulfate soil and sediment impacts would be expected where groundwater drawdown remains within the range of previously observed groundwater fluctuations. Therefore the maximum simulated drawdown that can occur whilst remaining within this range is 1.0m. However, as discussed by HMC (2008), a precise elevation at which groundwater drawdown would result in the generation of acid cannot be defined. In fact, HMC (2008) recorded PASS above observed groundwater fluctuations and that monitoring of groundwater quality indicated that no adverse effects have occurred as a result of this exposure. It is considered likely then that exposure of PASS below the observed groundwater fluctuations would similarly not result in adverse impacts on groundwater quality (HMC, 2008).

Regardless, in the event that acid is generated as a result of groundwater drawdown, the southern extraction pond would always be a sink to groundwater flow during extraction operations. Therefore any acidic groundwater would discharge into the southern extraction pond rather than discharging off site or to the drainage network. Due to the buffering capacity within the sand and sediments below 6.0m in depth (-5.0m AHD), any acidic groundwater entering the southern extraction pond is likely to be effectively neutralised (HMC, 2008).

Monitoring of the water quality within the extraction ponds would be undertaken (see Section 4.2.10) and, if required, hydrated lime or similar alkaline amendments would be applied to treat any excessive acidity. Further details of the residual impacts resulting from potential exposure of acid sulfate soils and sediments are outlined in Section 4.3.6.1.

Impact on Groundwater Quality

Based on monitoring undertaken at the adjoining Hanson Tweed Sand Quarry, it can be concluded that the electrical conductivity (EC) of the southern extraction pond water would be similar, that is, an EC of around 2500μS/cm. However, as previously discussed, there would be a lowering of the water table which would potentially expose PASS material, and may lead to the generation of acidic water. It is expected that the buffering capacity of the sand and sediments below -5.0m AHD would be sufficient to maintain the extraction pond water at a neutral pH.

However, an Acid Sulfate Soils and Sediments Management Plan would be developed and measures implemented to ensure that any acidity is managed to prevent environmental harm.

It is also assessed that water quality at surrounding bores would not be significantly affected as a result of the Project.

Impact on Other Groundwater Users

There is potential during the initial years of sand extraction for the landowners on the northern slopes of the Cudgen Plateau, particularly at the base of the Plateau, to be adversely impacted. As discussed, groundwater levels are predicted to be lowered by between 1.0m and 1.5m in this area which could result in lower yields from bores or spears, and dams excavated below the water table level may go dry in an extended drought.

An agreement has been reached with the most potentially affected landowner (R. Julius) to monitor water levels within the dams on the property that would potentially be affected and water usage rates. Monitoring commenced in December 2006. In the event that groundwater supplies are adversely affected as result of the proposed operation, an agreement would be reached for compensation or the provision of an alternative water supply (see Section 4.2.9.2).

It is noted that the adjoining Hanson Tweed Sand Quarry would also experience groundwater drawdown levels greater than currently experienced under the quarry's existing operations. The effect of the Project on the Hanson Tweed Sand Quarry would be greatest during the initial years of development with drawdown levels of between approximately 1.0m and 1.5m, within the easternmost part and between 0.5m to 1.0m over the remainder of the Hanson Tweed Quarry site.

It is important to note that a proportion of the drawdown would be as a result of operation of the Hanson Tweed Sand Quarry itself. The hydrological assessment undertaken by Gilbert and Sutherland (2005) for the extension to the quarry incorrectly assumed that the groundwater drawdown would not occur as precipitation exceeds rainfall within the Tweed area. However, the water required to replace the volume of sand extracted was not accounted for. The groundwater model prepared for the Project by AGE (2008) includes a water balance for the Hanson Tweed Sand Quarry which allows for the extraction of 150 000m^3 per year.

It is accepted that the bulk of the predicted drawdown during the early years of operation would be as a result of the Project, however, the contribution of the Project during the later years of the Project life would be greatly reduced. It also reiterated that modelling has predicted the worst case scenario and that it is unlikely that the predicted magnitude of drawdown would eventuate. Continued monitoring, particularly within bore MB2, would be undertaken and regular discussions held with site management at the Hanson Tweed Sand Quarry to ensure that drawdown related to the Project is not significantly affecting the operation.

Groundwater Dependent Ecosystems

It is considered unlikely that groundwater dependent ecosystems would be adversely impacted for the following reasons.

1. The shallow water table of the floodplain has previously been lowered by the extensive drainage network.
2. The area has been used for agricultural pursuits for a long period of time, leaving the Project Site, and much of the surrounding areas devoid of woody vegetation.
3. Any drawdown outside of the Project Site which would influence potential groundwater dependent ecosystems would be within natural levels of groundwater fluctuation.

4.2.9 Undertakings to Surrounding Land Owners

4.2.9.1 Flooding and Drainage

Results of the flooding and drainage predictions by Webb (2008) indicate no impact would occur as a result of the Project. As such, there will be no need for any negotiated agreements with surrounding landowners.

4.2.9.2 Surface Water and Groundwater

In light of predicted drawdown on surrounding bores and dams, the Proponent would continue to consult with each of the potentially affected landowners and undertake monitoring to determine the impact, if any, on groundwater levels and yields attributable to the Project.

In addition to the monitoring outlined in Section 4.2.10, an agreement would be sought with the relevant landowners for the monitoring of water levels within the closest potentially affected groundwater bores. In particular, agreements would be sought for monitoring of registered groundwater bores GW062045, GW300845, GW300847 and GW300856. Monitoring would be initially undertaken on a monthly basis with the frequency regularly reviewed and adjusted as appropriate throughout the Project life. Continued monitoring of the unregistered spear pumps within the R. Julius property would also be undertaken.

In the event that water quality or quantity on a surrounding landholding has been adversely affected as a result of the Project, the Proponent would offer to negotiate an agreement for:

- deepening of the existing bore or installation a replacement bore; or
- paying a cash compensation equal to the assessed cost of deepening the bore; or
- provision of an alternative water supply, such as from the extraction ponds or groundwater bore registered to the Proponent; or
- provision of an appropriately sized rainwater storage tank to enhance property water storage.

Copies of negotiated agreements would be separately provided to the Department of Planning and Department of Water and Energy for their records.

4.2.10 Monitoring and Documentation

4.2.10.1 Flooding and Drainage

No monitoring is considered necessary for flooding. Warning of Tweed River overbank floods are issued by Bureau of Meteorology to the public and to the State Emergency Service who in turn provide direct warnings to the public in the potentially affected area through the media, phone calls and door knocking. The Proponent would contact the State Emergency Service prior to the commencement of extraction to ensure that notification would be given to relevant site personnel in the event of a Tweed River overbank flood.

4.2.10.2 Surface and Groundwater

As discussed in Section 4.2.6.2, an important component of the ongoing management of the groundwater resources would be the monitoring of both groundwater levels and water quality. The monitoring program would involve the continued monitoring of the existing monitoring bore network within and surrounding the Project Site. During the first year of operations, monthly monitoring would be undertaken, reducing to quarterly monitoring following the first year. A summary of the frequency and parameters to be monitored is as follows.

- Monthly monitoring for pH, EC, temperature, REDOX potential and groundwater level (m AHD) in the groundwater network and the two dams located on the R. Julius property would be undertaken during the first year of operations and subject to review, monitoring would be extended to quarterly monitoring.
- Groundwater level monitoring (m AHD) within the northern and southern ponds and the two Julius dams would be undertaken concurrently with the monthly / quarterly groundwater monitoring program. Extraction from the Julius dams (as indicated by flow meter readings) would also be recorded on a monthly basis.
- Quarterly monitoring for pH, EC, temperature, REDOX potential, groundwater level (m AHD), dissolved oxygen, calcium, magnesium, sodium, potassium, bicarbonate, sulfate, chloride, filterable iron, aluminium and arsenic would be undertaken by a suitably qualified or trained person at the approved monitoring locations. Analyses would be undertaken at a NATA accredited laboratory.
- Quarterly groundwater monitoring in accordance with the above schedule would continue following the cessation of extraction and placement of VENM. This would continue for 12 months with a reduction to annual monitoring if compliance with background water quality objectives can be demonstrated. Annual monitoring would cease after five years if no variation in water quality (due to previous site activities) can be demonstrated.

Monitoring results would be reviewed quarterly by a suitably qualified or trained person as part of the auditing process for the site during the first year to ensure the data being collected is meaningful to the ongoing monitoring of potential impacts of the Project. Following the first year, monitoring results would be reviewed on a six monthly basis.

Should the following be detected, a more detailed sampling and analysis program would be undertaken to identify the source of the drawdown or contamination.

- Deterioration in groundwater quality outside of the effects of drought or flood due to on-site activities.
- Significant variations in groundwater level outside drought or flood conditions due to on-site activities.
- Formation of a cone of depression or a groundwater mound that extends beyond the site boundary.

A summary of the monthly/quarterly data relevant to each bore would be provided to the respective landowners and a yearly summary of all monitoring results would be compiled and forwarded to DWE as part of the annual return for the site.

The Proponent intends to coordinate all monitoring activities with those already underway by Hanson Construction Materials and Australian Bay Lobster to ensure meaningful analyses can be obtained from all monitoring on the floodplain.

4.3 ACID SULFATE SOILS AND SEDIMENTS, SOIL CONTAMINATION AND AGRICULTURAL SUITABILITY

4.3.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential impacts relating to acid sulfate soils and sediments, soil contamination and agricultural suitability requiring assessment and their **unmitigated** risk rating are as follows.

- Soil stripping and extraction leading to exposure of potential acid sulfate soils and sediments (low to high risk).
- Temporary or permanent loss of agricultural land (high risk).
- Transfer of contaminated material (low to moderate risk).

The following subsections provide a summary of the assessment of acid sulfate soils and sediments (ASS), potential soil contamination and agricultural suitability of the Project Site has been prepared by HMC Environmental Consulting Pty Ltd (HMC, 2008). A full copy of HMC (2008) is presented as Part 3 in Volume 1 of the *Specialist Consultant Studies Compendium* and draws upon a review of previous studies on and surrounding the Project Site, published soil maps, aerial photo interpretation, field assessment and sampling, and laboratory analyses of sampled soils and sediments, and interviews with surrounding landholders and residents.

4.3.2 Soils and Sediments

4.3.2.1 Regional Setting

The Project Site lies within a "Tweed landscape variant" (twb) soil landscape on the "Murwillumbah – Tweed Heads" 1: 100 000 scale Soil Landscape map sheet area (Morand, 1996). This landscape is described as consisting of deep Quaternary alluvium and estuarine sediments of the lower Tweed Catchment, local relief >1m and elevation between 1m and 3m, up to 50cm of black, strongly structured clay overlying >200cm of grey sand. The soils are considered acidic, however, acid sulfate potential is not listed as a limitation.

The Project Site also lies within the Cudgen 1:25 000 Acid Sulfate Soil Planning Map (DLWC 1997). The Project Site is located within a Class 3 area which may be affected by acid sulfate soils. The corresponding 1:25 000 Acid Sulfate Soil Risk Map for Cudgen (DLWC 1997) indicates that there is a high probability of ASS being encountered at depths of 1m to 3m within an aeolion sand plain with an elevation of 2m to 4m AHD. It is noted that the bulk of the Project Site lies at or below 2m AHD.

4.3.2.2 Project Site Soils and Sediments

The soil landscape sequence described regionally is not generally consistent with the sequence observed beneath the Project Site. The soil profile appears to reflect a Kingscliff Soil Landscape with dark loamy sand topsoil with the underlying grey sand recorded as extending to a maximum depth of 21m. It is noted that the Kingscliff Soil Landscape which is mapped immediately east of the Project Site is characterised by very strong acidity, low Cation Exchange Capacity, very low nutrient status, low water storage capacity and localised acid sulfate potential.

A number of previous acid sulfate soil studies have been undertaken within and surrounding the Project Site which have been supplemented by further investigations by HMC (2008) undertaken since May 2005 on behalf of the Proponent. These investigations have identified that the soils and sediments within the Project Site consist of black silty sand topsoil ranging from approximately 0.2m to 0.5m overlying a medium to fine grained grey sand interbedded with shelly and humic material to a depth of approximately 20m. **Table 4.6** provides a summary of the various investigations undertaken, including the depth of sampling, number of samples and results of ASS testing.

The survey conducted by HMC (2008) consisted of eight boreholes (BH 1 to BH 8) across the southern extraction site to a maximum depth of 20m and a further two boreholes (BH 9 and BH 10) within the northern extraction site (see **Figure 4.11**). Samples were collected at a range of intervals ranging from 0.5m to 3.0m throughout the soil and sediment profile and subject to a range of analyses.

Table 4.6
Summary of ASS Investigations

Site	Investigator	No. of Boreholes	Depth (m)	ASS Testing					
				Y	N	No. of Samples		Max	Max
						pH_F/pH_{FOX}	$S_{CR}/_{POS}$/TAA	$\%S_{CR}/_{POS}$	TAA
Project Site	Coffey & Partners (1985)	6	11.0-26.0		✓				
	AGC Woodward Clyde (1992)	13 3 pits 3	1.30 4.0 4.0-23.5	✓ ✓ ✓		40 33 	 3	 0.05	
	Coffey & Partners (1999)	6	5.3-5.8		✓				
	Gilbert & Sutherland (2003)	2	1.8	✓			12	0.39	35
	HMC Environmental (2008)[#]	**10**	**9.5-20**	✓		**148**	**79**	**0.41**	**12**
New Waste Water Treatment Plant	AGC Woodward Clyde (1992)	2 1 pit 3	1.30 4.0 4-23.5	✓ ✓ ✓		7 8 	 3	 0.04	
	GHD (2004)	9 6	14.95 – 40.45 5-6	 ✓ ✓		108	15	0.40	2
	Coffey & Partners (2004)	30	4-6.5	✓		21	21	0.36	12
Tweed Turf and Sand (formerly Hanson Tweed Sand)	Gilbert & Sutherland (2000)	14	6	✓		172	69	0.22	
	Gilbert & Sutherland (2004)	11	16	✓		353	54	0.58	12
Bay Lobster Aquaculture Project	Douglas Partners (2004)	10	4	✓		80	10	0.25	30

Source: HMC (2008) – Table 1 [#] see **Table 4.7**

A total of 148 samples were subjected to preliminary screening including measurement of field pH (pH_F), peroxide oxidised field pH (pH_{FOX}) and reactions with hydrogen peroxide (H_2O_2) and hydrochloric acid (HCl). Of these samples, 79 were subject to further analysis for chromium reducible sulfur (S_{CR}) or peroxide oxidation combined acidity and sulfate (POCAS) tests. **Table 4.7** provides a summary of the results from analyses undertaken by HMC (2008). It is noteworthy that all samples relate to discrete intervals in the column of sand, however, in reality the method of extraction will result in the mixing of the sand across considerable depths. Hence, any abnormally high or low results for a discrete interval are unlikely to be repeated in a mixed sample.

The results of analysis of samples collected during the investigations undertaken by HMC (2008) (see **Table 4.7**) indicate that the oxidisable sulfur exceeded the action criteria (S_{CR} 0.03%) at varying depths with the average recorded S_{CR} level for each borehole varying from 0.11% to 0.20%. The maximum oxidisable sulfur level in the sand/silty sand was 0.58% (BH1 at 2.5m depth). The residual clay below the sand/silty sand recorded the highest oxidisable sulfur level from the investigations (S_{CR} 1.07%).

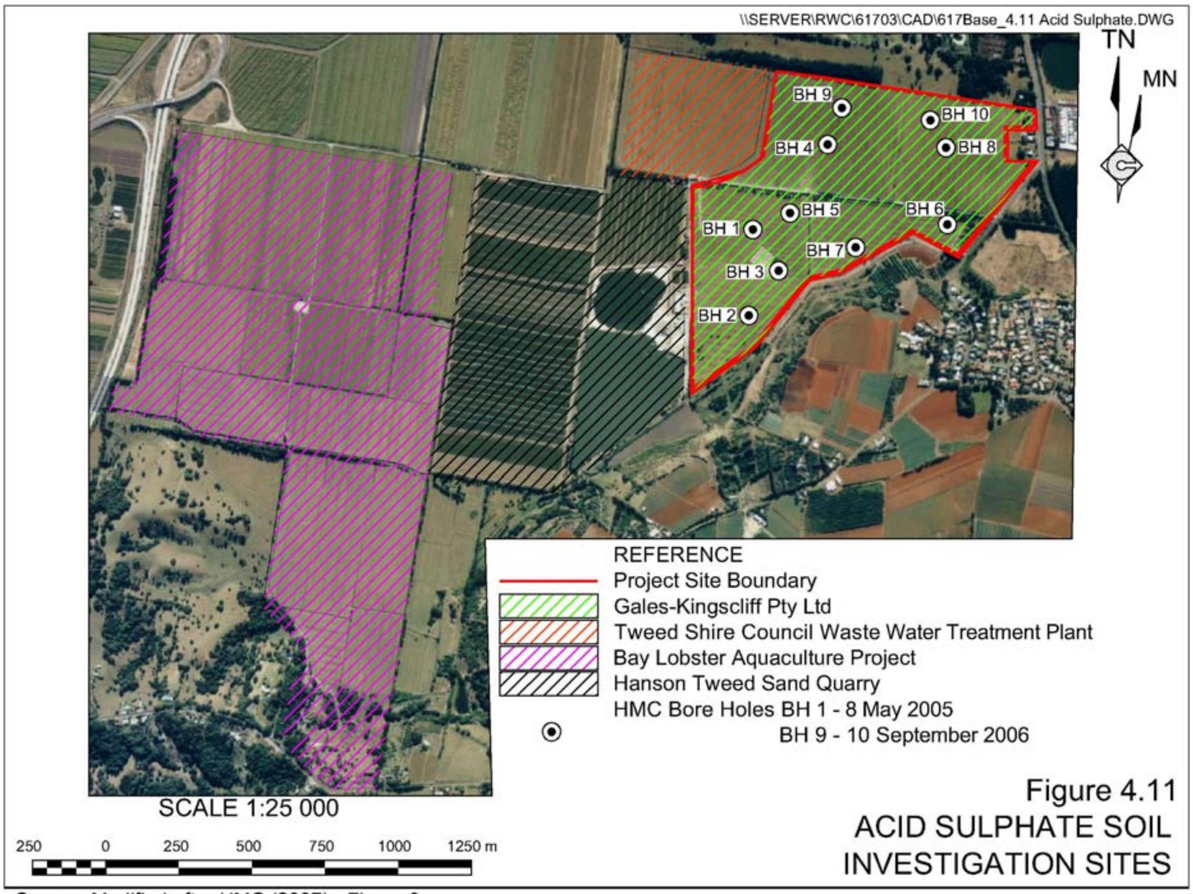


Figure 4.11
ACID SULPHATE SOIL INVESTIGATION SITES

Source: Modified after HMC (2007) - Figure 8

Table 4.7
Summary of Soil Analysis Results – HMC (2008)

Bore Hole Number	Test					
	pH_F	pH_{FOX}	Reaction to HCl	Chromium Reducible Sulfur %S	Total Actual Acidity mol H^+/Tonne	Acid Neutralising Capacity mol H^+/Tonne (%S)
BH1	4.6 – 9.2	2.2 – 7.2	Nil – strong	0.00 – 0.58	0.0 – 7.0	0 – 263 (0.42)
BH2	5.2 – 9.1	2.0 – 6.9	Nil – moderate	0.00 – 0.33	0.0 – 9.0	0 – 376 (0.60)
BH3	5.7 – 9.0	2.0 – 7.0	Nil – strong	0.00 – 0.26	0.0 – 4.0	0 – 195 (0.31)
BH4	5.2 – 9.3	2.1 – 7.2	Nil – strong	0.05 – 1.07	0.0 – 0.0	116 (0.19) – 1449 (2.32)
BH5	5.2 – 8.5	2.1 – 6.1	Nil – slight	0.00 – 0.28	0.0 – 0.0	0 – 129 (0.20)
BH6	5.8 – 8.9	2.1 – 6.8	Nil – moderate	0.00 – 0.41	0.0 – 3.0	0 -125 (0.20)
BH7	4.4 – 9.0	2.1 – 7.1	Nil – slight	0.01 – 0.12	0.0 – 0.0	0 – 101 (0.16)
BH8	5.2 – 8.3	2.2 – 6.5	Nil – slight	0.00 – 0.25	0.0 – 0.0	7 – 177 (0.28)
BH9	4.5 – 8.7	2.0 –6.7	Slight – strong	0.03 – 0.15	0.0 – 12.0	0 – 40 (0.06)
BH10	4.5 – 9.1	2.3 –6.1	Slight – strong	0.04 – 0.17	0.0 – 10.0	0 – 148 (0.24)
Action Criteria	**≤4.0**	**≤3.0 & min 1 unit < pH_F**	**Strong (indicative of shell etc)**	**0.03 (sandy sediments)**	**18 mol H+/Tonne (sandy sediments)**	**-**

Source: HMC (2008) – Modified from Tables 10 to 12

However, generally, with few exceptions, the buffering capacity in the sand/silty sand below 6m depth exceeds the acid generating potential with evidence of shell and reaction to HCl confirming this observation. A moderate to strong reaction to HCl was noted in all the soil

samples collected from below 8m depth in BH1 to BH4. A strong reaction was also recorded in samples collected at or below 5.0m in BH9 and BH10. Borehole BH8 recorded only a slight reaction to HCl with the buffering capacity thought to be related to the saline groundwater at depth in this part of the Project Site.

The acid neutralising capacity within the residual clay sample also greatly exceeds the acid generating potential, however, the residual clays would not be extracted as part of the Project.

These results indicate that potential acid sulfate soil and sediments (PASS) are present in all boreholes in the upper soil and sediment profile (<6m depth). However, there is very little existing acidity in the soil and sediments with total actual acidity levels in all samples below the action criteria (18mol H+/tonne). Of considerable note was the observation that some PASS lie above the fluctuating water table. However, their presence above the water table is not reflected in the nearby water quality which invariably has a slightly alkaline to neutral pH.

In order to assist in confirming the presence of pyrite and any minerals which might be contributing to the observed acid neutralising capacity of the soil, several soil samples (BH1 at 2.5m, BH1 at 10m, BH2 at 3.0m, BH3 at 5.0m) were forwarded to the Environmental Analysis Laboratory at Southern Cross University and subjected to analysis via a scanning electron microscope.

Pyrite framboids were noted in the samples from 3.0m, 5.0m, and 10.0m depth. No framboids were noted in the sample from 2.5m depth. These results support the laboratory analysis undertaken on these samples which recorded elevated levels of oxidisable sulfur in the samples from 3.0m, 5.0m and 10.0m depth. Very low levels of oxidisable sulfur (0.01%) were measured in the sample from 2.5m depth. The soil sample from 10.0m depth which had the extremely high acid neutralising capacity showed evidence of crystalline calcium minerals which supports the evidence of buffering capacity measured within these sediments.

The results from the various soil investigations (see **Table 4.6**) both within the Project Site and from surrounding areas of the Tweed River floodplain are very consistent with each other and the findings of HMC (2008) indicating that the soil strata is generally homogenous.

In addition to the soil investigations, monitoring of surface and groundwater also indicates that there is an extra source of sulphate from previous sulphide oxidation, however, average pH levels are close to neutral (ie. not acidic).

4.3.3 Potential Contaminated Soil

4.3.3.1 Introduction

An assessment of the potential for soil contamination and the risk associated with the Project has been undertaken in accordance with the publication *Managing Land Contamination Planning Guidelines SEPP 55 – Remediation of Land*. Tweed Shire Council's DCP 16 also requires that, where land is identified as being contaminated, it must be demonstrated that it is suitable for development pursuant to SEPP 55.

Table 1 of the guidelines lists agriculture as an activity potentially causing contamination. Therefore, considering the agricultural history of the Project Site, an investigation was undertaken to assess the potential for existing site contamination. The investigation included the following elements.

- Compilation of a detailed site history including review of available mapping and aerial photography.
- A walk-over field inspection.
- Identification of contaminants of potential concern.
- Soil survey including soil sampling and laboratory analysis for contaminants of concern.

The following subsections summarise the outcomes of these investigations.

4.3.3.2 Site History

An examination of historic parish maps dating back to 1913 and topographic maps to 1947 confirm that the land has consistently been used for agricultural purposes. The early parish maps show the land as swamp while the 1947 topographic map indicates some drainage, presumably to improve the grazing potential of the land. It is understood that the land within the Project Site was previously used as a wet grazing block until 1964 when the land was purchased and partially drained and developed as a tropical grass and legume seed nursery and farm by Anderson Seed Ltd and Terranora Pastures Pty Ltd. However, due to a high water table and water logging, great difficulty was experienced in growing and harvesting legume and grass seeds. Subsequently Anderson Seed Pty Ltd went into liquidation and the property was apparently purchased by Altona Pastoral Co. Pty Ltd on 13 December 1971 and developed as a sugar cane property during a period of rapid expansion of the sugar cane industry from 1973.

By 1984, the sugar cane enterprise was determined to be non-viable due to history of production costs exceeding income. Due to the soil and drainage problems associated with the land, apart from occasional grazing of cattle during dry periods, the land has not been used for agricultural activities since around this time. It therefore appears sugar cane cultivation occurred on the site for a period of between 10 and 15 years.

4.3.3.3 Soil Survey and Investigations

A review of the soil contamination assessment within the EIS for the Hanson Tweed Sand Quarry operation was undertaken. The assessment utilised a detailed site history to establish the potential for soil contamination. It is noted that no soil sampling and analysis for residual chemicals was undertaken. It was concluded by Gilbert & Sutherland (2005) that "*the preliminary site history investigation did not identify any previous land use activities at the site and surrounds that may have potentially resulted in contamination. The current and previous use of agrichemicals appears to be extremely limited*".

During previous work undertaken by HMC (2008) within long-term cane farming areas no residual chemical levels have been recorded above accepted health investigation levels. It is noted that the duration for which the Project Site was under cane farming is less then these similar investigations and therefore the risk of soil contamination is reduced.

In order to help confirm the contaminant status of the Project Site, a soil survey including sampling and laboratory analysis was undertaken in March 2006. A systematic sampling pattern was implemented and no potential "hotspots" were identified.

Six locations were established south of the existing Altona Drive alignment and three locations north of the alignment. A 20m x 20m grid was measured around each sampling location and samples collected at the corners of each grid giving a total of 36 samples. Soil samples were collected from a depth of 0 to 150mm. The samples within each grid were used to form a single composite sample for each location.

The samples were forwarded to a Nata-accredited laboratory for compositing and analysis for lead, arsenic, mercury, organochlorine pesticides and organophosphorus pesticides. The results are summarised in **Table 4.8** and confirm that all the identified contaminants of concern are below recognised guidelines for residential or commercial/industrial land uses (see Schedule 7(b) of the National Environment Protection Council – *National Environment Protection (Assessment of Site Contamination) Measure 1999*, Table 11-A (NEPC,1999)).

Table 4.8
Soil Analysis Summary

Analyte	Range mg/kg	Health investigation Level mg/kg (Residential, NEPC 1999) [1]
Organo-chlorine	<1.0	2.5 (Aldrin + dieldrin)
Organo-phosphorus	<0.5	(2)
Lead	<2 – 3	75
Arsenic	<1 – 1	25
Mercury	0.07 – 0.17	10 (organic), 15 (inorganic)

[1] Adjusted to allow for 4 composite samples [2] No guidelines value
Source: HMC (2008) – Table 22

No organochlorine or organophosphorus residuals were detected in any composite sample. The maximum adjusted lead and arsenic concentrations were approximately 4% of the investigation threshold for sensitive residential use. The maximum adjusted mercury level was approximately 3.5% of the investigation threshold for sensitive residential land use.

4.3.3.4 Potential Exposure to Contaminants of Concern

As the land has been previously used for sugar cane cultivation, several residual agrichemicals were identified by HMC (2008) as being the primary contaminants of concern. These included various organochlorine and organophosphorus pesticides, arsenic, lead and mercury which have been recorded constituents of agrichemicals used within cane growing operations.

Using the risk-based approach the potential exposure of any person associated with the proposed development to contaminants of concern is extremely low, given the results of the soil survey and that the occupation of the site is limited to staff operating equipment which is either on water (dredge) or enclosed (loader, fuel tanker, water truck and tippers). Only the dredge operator and the loader driver are continuously on site and then only during working hours.

4.3.4 Agricultural Suitability

As discussed in Section 1.4.2, the Project Site has a history of failed agricultural enterprises. An agricultural report for the Project Site has previously been prepared by Crofts (1986) which includes a review of the previous agricultural activities and a full set of soil analysis. The report concluded that:

- the paddocks are highly variable in their mineral availability resulting in difficulty in correcting mineral deficiencies;
- low to medium nitrate and potassium levels and cation exchange capacity indicate that large quantities of nitrogen and potassium fertilisers would need to be frequently applied to optimise cane yields; and
- high levels of iron and exchangeable aluminium indicating high levels of phosphatic fertilisers would also need to be applied.

It was concluded that because of the soil and drainage problems, the Project Site would unlikely become a viable cane farm unless cane prices soar and would appear to be more suited for other purposes.

The Project Site has also been assessed to determine an appropriate agricultural suitability class in accordance with the DPI "Rural Land Evaluation Manual" system. The system allocates land an agricultural land class of between 1 and 12 according to their productivity for a wide range of agricultural activities and aims to determine the potential for crop growth within certain limits. The Project Site is located within a Class 4 area which is defined as "Land suitable for grazing but not cultivation. Native or improved pastures established with minimum tillage".

The Project Site is also located within an area mapped as Regionally Significant Farmland as defined by the Northern Rivers Farmland Protection Project. The Northern Rivers Farmland Protection Project seeks to establish a system which protects a broad range of lands to cater for a range of agricultural industries that may be important currently or in the future.

4.3.5 Operational Safeguards and Management Controls

4.3.5.1 Introduction

A site specific Acid Sulfate Soil and Sediment Management Plan (ASSMP) would be compiled for the Project in accordance with relevant legislation and in consultation with government agencies, in particular DWE and DECC. The management plan would cover two main aspects, namely the management of acid generation during extraction operations and the management of potentially acid generating VENM(b).

A summary of the management safeguards, monitoring and corrective actions that would be included within the management plan are provided as follows together with a short summary of soil erosion and sediment control measures. No specific operational safeguards or management controls relating to existing soil contamination or agricultural suitability have been deemed necessary.

4.3.5.2 Management of Acid Generation During Extraction Operations

It would be the Proponent's objective to:

- place all pyritic fines within the extraction ponds in a manner which ensures adopted surface and groundwater quality criteria are met;
- treat stripped topsoil/loam at determined rates prior to use in earth bunds or rehabilitation; and
- treat and validate washed sand where required.

The objectives would be achieved using the following measures during stripping of topsoil.

- Collection and analysis of soil samples at a rate of four per hectare prior to the removal of topsoil/loam.
- Incorporation of alkaline amendment into the soil at the calculated rate (based on the results of sampling) prior to stripping or following placement on treatment pads.
- Completion of validation soil sampling of treated material at a rate 1 sample per 1 000m^3 prior to final placement.

The objectives would be achieved using the following measures during sand extraction and processing.

- Bunding of extraction and processing areas to control drainage.
- Ensuring that all surface water from the extraction and processing areas drain or is pumped into the extraction ponds.
- Processing of extracted material via a hydrocyclone (such as would be used within the wash plant) or similar to hydraulically separate the fines (potentially containing pyrite) from the sand resource.
- Treatment of all material not processed using a hydrocyclone or similar with alkaline amendments.
- Pumping of return water (from both the wash plant and fill sites) in a manner which ensures fines / silts remain in suspension and do not settle in the return pipelines.

- Returning all separated fines to the extraction ponds for final placement with the return outlet located at a minimum 1m below the water surface within the southern extraction pond.
- Settlement of silts/fines a minimum depth (typically 2m) below the surface of the southern or northern extraction ponds.
- No extraction of residual clay material from the base of the sand resource.

It is noted that the action of the dredge within the southern extraction pond would result in the mixing of the PASS within the upper profile with the deeper materials which have excess buffering capacities.

Validation testing of extracted sand and stripped topsoil/loam, would be also be undertaken as described in **Table 4.9**. The required number of samples would be collected and tested in accordance with the NSW ASS Manual (ASSMAC, 1998) and amended laboratory methods.

Table 4.9
Acid Sulfate Soil and Sediment Testing

Site	Period	Frequency	Tests	Action criteria
Extracted sand (following hydraulic separation at fill sites) and washed sand products	Initial 2 weeks following commissioning of sand extraction operation	1 sample/day	S_{CR}/TAA	>0.03%/18 mol H^+/t
	Ongoing	1 sample/week	S_{CR}/TAA	>0.03%/18 mol H^+/t
Stripped topsoil/loamy sand / unwashed sand	During stripping operations	4 samples/ha	S_{CR}/TAA	>0.03%/18 mol H^+/t
	Post treatment validation	1 sample/1000m^3	S_{CR}/TAA	>0.03%/18 mol H^+/t
Source: HMC (2008) – Table 17.				

In the event that validation or monitoring criteria are exceeded, the following corrective actions would be implemented.

- For stripped topsoil or hydraulically separated sands, the acid neutralising capacity of the material would be tested. If the measured acid neutralising capacity is insufficient to neutralise the existing and potential acidity, alkaline amendments would be incorporated at the appropriate rate.
- For stockpiled loamy sand and unprocessed sand, the total actual acidity would be tested and, alkaline amendments would be incorporated into the material at the appropriate rate.
- Following treatment of loamy sand and unprocessed sand, validation testing would be undertaken and additional alkaline amendments applied as required. This process would be repeated until compliance with action criteria is met.

Records of monitoring would be kept on site together with the application rates of the alkaline amendment used as neutralising agents. These records would be made available to statutory authorities upon request.

The effectiveness of the operational safeguards and monitoring would also be audited internally on a quarterly basis with environmental audits of extraction and processing operations conducted by an external environmental consultant and site management on an annual basis. Where appropriate, sampling and / or testing procedures would be modified in light of external environmental audits.

4.3.5.3 Management of Imported Acid Generating VENM(b)

It is intended that the Project would provide a regional facility to treat, use or store VENM(b) in accordance with relevant environmental guidelines. Therefore, it would be the Proponent's objective that:

- imported VENM(b) is properly managed, including treatment and validation as required, to permit production of material suitable for construction uses or placement either at or near the base of the southern extraction pond or below the water table within the northern extraction pond;
- any acidic runoff is treated with alkaline amendments to meet adopted water quality targets; and
- a verification process is in place and implemented to provide protection from the receipt of unsuitable material.

These objectives would be achieved using the following operational safeguards and management measures for imported VENM(b).

- Assessment of the imported material by a suitably qualified or trained person in accordance with the ASSMAC guidelines and classification as VENM(b) prior to acceptance at the Project Site.
- Provision of documentation for each truck load of VENM(b) received at the Project Site that demonstrates that the excavation of VENM(b) and its transport and handling was conducted in accordance with the NSW ASS Manual to prevent the generation of acid.
- Placement of VENM(b), received at the premises which is intended to be:
  i. dredged or interned at or near the base of the southern extraction pond; or
  ii. placed within the northern extraction area at a depth of at least 2m below the water surface or <1.0m AHD;

  both within 24 hours of the time of its excavation at the originating site.
- Testing of the pH of the VENM(b) immediately prior to under-water disposal / backfilling to ensure the pH is not less than 5.5.
- Testing of the pH of the water into which the VENM(b) is placed to ensure it is not less than 6.5 at any time.
- Termination of VENM(b) receipt at the premises, if the pH of the water falls below 6.5, until approval to continue is received in writing from the DECC(EPA).

As discussed within Section 2.6.2, the Proponent would also follow a VENM verification procedure designed to ensure that the only waste received at the premises is VENM. An outline of procedures that would be adopted is provided in full in HMC (2008). Any material identified not to be VENM would not be accepted at the site.

Monitoring as outlined in **Table 4.10** would be undertaken in relation to VENM(b) receipt and processing / internment. The locations and frequency of testing would be regularly reviewed to ensure meaningful monitoring data being assembled.

Table 4.10
VENM(b) Testing and Related Monitoring

Monitoring Site	Period	Frequency	Tests	Action criteria
VENM	Ongoing	1 sample/day from each load immediately prior to placement	pH(1)	<5.5
Extraction Pond Water	During placement of VENM(b)	1 sample/day	pH	<6.5
	Minimum six months after final placement	1 sample/week	pH	<6.5
Groundwater Up & Down Gradient	During placement and minimum 1 year after final placement	Monthly	pH, elevation (mAHD)	<6.5 (2) Minimum 0.5m above top of untreated VENM(b) in northern extraction site

Source: HMC (2008) – Table 18
(1) In accordance with NSW Acid Sulfate Soil Manual (Method 21A and/or Method 21Af) or other approved method.
(2) This criteria may be varied, subject to approval from statutory bodies, to more closely reflect baseline conditions.

The following corrective actions would be undertaken in the event that monitoring criteria are exceeded or incorrect handling or receipt practices are identified.

- Any VENM(b) which has dried out, undergone any oxidation of sulfidic minerals or which has a pH of less than 5.5 would be sampled at the maximum rate of 1 sample/1 000m^3 and tested for S_{CR} and total actual acidity. If any records indicate S_{CR} >0.03% or total actual acidity > 18mol H+/t, the material would be treated with the calculated amount of alkaline amendment. Prior to final placement or further processing, verification testing at the rate of 1 sample/1 000m^3 to confirm S_{CR} <0.03% and total actual acidity <18mol H+/t would be undertaken.
- As soon as possible after becoming aware that any waste/material accepted at the premises is not VENM, the Proponent would:
  - (a) notify the DECC (EPA) in writing;
  - (b) remove the material/waste from the premises and dispose of it at a facility licensed to take such waste; and

(c) implement a procedure to audit all further incoming loads from that waste origin site prior to accepting any further waste, until such time as the results of such audits demonstrate that the waste origin site's screening and assessment procedures have been corrected to prevent further miss-classification of waste.

- Re-testing of materials in the designated treatment pads using S_{CR} + total actual acidity with additional alkaline amendment applied as necessary.
- If the extraction ponds water quality fails accepted background levels, hydrated lime would be introduced at the appropriate rate. Care would be taken to ensure target pH level is not "overshot" leading to severely alkaline conditions (pH>9.0).

The Proponent would submit to the DECC(EPA) an annual return (in accordance with the issued Environment Protection Licence) which would outline the results of all required monitoring. The Proponent would also retain certain documentation for each truck load of VENM(b) received at the site which indicates:

(a) the details of the originating site (name, address, owner & developer, contact details);

(b) the details of the transportee (name, address, contact details, vehicle registration);

(c) date and time of the extraction of the VENM(b);

(d) pH of the VENM(b) at the time of its extraction, and at the time immediately prior to its placement underwater; and

(e) the name of the person (certified practicing soil scientist) who assessed the material and classified it as VENM(b).

During the initial stages of the operation, a monthly internal environmental audit of VENM(b) receipt and treatment would be undertaken to ensure appropriate treatment is being conducted and records are up to date. Additionally, verification of neutralising agent application volumes and verification results would be sought prior to burial of VENM(b).

4.3.5.4 Monitoring

In the event that acid is generated by either the soils or sulfidic sediments on site or the imported VENM(b), its presence would be identified in either the groundwater or surface water. Consequently, a comprehensive groundwater and surface water monitoring program would be undertaken to establish the impacts (or lack of impacts) that site activities are having on water quality.

Groundwater

Groundwater monitoring as described within Section 4.2.10.2 would be undertaken. In addition to this monitoring, a height gauge would be installed within the Southern Extraction Pond so that water levels can be monitored daily relative to m AHD. Regular inspections of the site, the types, locations and effectiveness of control actions in place would also be undertaken. Complaints of poor water quality in neighbouring dams/bores would also be investigated.

In the event that groundwater quality or levels are identified outside specified criteria or where detrimental effects to groundwater quality are likely to occur, the following corrective actions would be implemented.

- Treatment of oxidising PASS as required and monitoring of runoff.
- Isolation of acid sulfate soil and sediments exposed due to lowering of groundwater table from stormwater and off site drainage.
- Reduction of extraction rate in event that off site groundwater drawdown exceeds predicted levels and are identified to be causing environmental impacts

Surface Water

Surface water quality would be monitored as described in **Table 4.11**.

Table 4.11
Surface Water Quality Monitoring

<table>
<tr><th>Site</th><th>Period</th><th>Frequency*</th><th>Tests*</th><th>Action criteria</th></tr>
<tr><td rowspan="3">Extraction Ponds (0.5m depth)</td><td>Initial 2 weeks following sand extraction operation commencement</td><td>Daily</td><td>pH, EC, dissolved oxygen, redox and water level (m AHD)</td><td>pH <5.0
water quality trend outside adopted background levels</td></tr>
<tr><td rowspan="3">Ongoing during operation</td><td>Weekly</td><td>pH, EC, dissolved oxygen, redox and water level (m AHD)</td><td>pH <5.0
water quality trend outside adopted background levels</td></tr>
<tr><td>Monthly</td><td>Above + calcium, magnesium, sodium, potassium, sulfate, chloride, bicarbonate, filterable iron, aluminium, arsenic, and water level (m AHD)</td><td>pH <5.0
water quality trend outside adopted background levels</td></tr>
<tr><td>Extraction Ponds (1.0m depth intervals to base of excavation)</td><td>Quarterly</td><td>pH, EC, dissolved oxygen, redox</td><td>pH <5.0
water quality trend outside adopted background levels</td></tr>
<tr><td>Southern Extraction Pond (0.5m depth)</td><td>Post Operation</td><td>Quarterly</td><td>Above + calcium, magnesium, sodium, potassium, sulfate, chloride, bicarbonate, filterable iron, aluminium, arsenic, and water level (m AHD)</td><td>pH <5.0
water quality trend outside adopted background levels</td></tr>
<tr><td>Drains (SW5, SW6, MB1A, MB3A, MB5A)</td><td>Ongoing during operation</td><td>Monthly</td><td>pH, EC, dissolved oxygen, redox</td><td>pH <5.0
water quality trend outside adopted background levels</td></tr>
<tr><td colspan="3">Source: HMC (2008) – Table 20</td><td colspan="2">* To be reviewed annually</td></tr>
</table>

If a significant deterioration in extraction pond water quality occurs, VENM placement would be temporarily ceased until the source is identified and appropriate ameliorative measures implemented.

4.3.5.5 Erosion and Sediment Control

Due to the flat and low-lying nature of the Project Site and non dispersive sandy soil, erosion and sedimentation is not considered a high risk. The primary risks involve areas of concentrated water flow during flooding events or through wind and wave action upon the edges of the dredge pond / final lake.

As discussed in Section 4.2.6.1, spillways would be constructed within the bunds surrounding the extraction ponds, acting to equalise floodwaters and allowing the bunds to overlap safely, reducing scour and erosion. Where required additional scour protection would be provided at these points such as through jute mesh and rock armouring. Disturbance would also be limited to areas required for the next 6 to 12 months of operation and areas no longer required rehabilitated. Hence the areas subject to erosion would be minimised.

As discussed in Sections 2.6.4 and 2.14.3.2, selected finalised areas of the dredge pond shoreline would be backfilled and rehabilitated to wetlands. Where additional erosion control measures are required beyond the use of vegetation and other 'soft' control measures, 'hard' control measures, such as rock armouring would be implemented.

4.3.6 Assessment of Residual Impacts

4.3.6.1 Soils and Sediments

The analyses of representative soil and sediment samples across the Project Site reveal that low levels of oxidisable sulfur are present in the sand and sediments throughout the depth of the sand resource. Below a depth of approximately 6m, there appears to be adequate buffering capacity to neutralise any acid generation associated with the potential oxidation of the sulfidic sediments.

Considering the long-term successful operation of the adjoining Hanson Tweed Sand Quarry and the successful creation of the initial dredge pond on the Project Site for the approved sand extraction (see Section 1.4.4), with the adoption of the proposed management strategies, the Project would be able to be managed to ensure any impacts remain within acceptable limits.

The Project would also be appropriately managed in relation to acceptance and treatment of VENM. Regular monitoring of soil, surface water and groundwater would provide an accurate assessment of the adequacy of practices implemented as part of the operation or the need to adjust practices.

4.3.6.2 Potential Contaminated Soil

The preliminary site contamination investigation, including soil sampling program, did not record any potential soil contamination across the Project Site. No contamination "hotspots" have been identified. Therefore, it has been assessed that there is a very low level of risk that the Project Site is contaminated with remnants of chemicals from former sugar cane cultivation or other agricultural practices.

The Project Site can reasonably be considered, for the purpose of the proposed development, to be uncontaminated. It is considered that there is little environmental or health hazard associated with the proposed use of the Project Site for sand extraction.

4.3.6.3 Agricultural Suitability

As discussed in Section 4.3.4, the Northern Rivers Farmland Protection Project seeks to protect important farmland from urban and rural residential development pressures, thereby keeping farming options open for the future. The objectives of the Northern Rivers Farmland Protection include:

- making provision for the co-management of important agricultural land including farming, conservation and extractive industry; and
- recognising extractive industry as a legitimate rural use which has a priority over non-rural use.

Therefore the Cudgen Lakes Sand Extraction Project is not considered an urban use and would not undermine the integrity of a Regionally Significant Farmland area as rural industry is recommended as being allowed in farmland protection areas, without restriction. However, HMC (2008) has assessed the Project against the more stringent industrial use criteria and established that the Project would:

- not undermine the integrity of Regionally Significant Farmland;
- not compromise local or regional agriculture through alienating agricultural infrastructure, transport routes or decreasing 'critical mass' for agricultural industry;
- not compromise the agricultural use of nearby regionally important land;
- not be located in an area where there was an identified risk of land use conflict near an existing agricultural enterprise;
- not involve filling part of a floodplain unless consistent with a floodplain management plan prepared in accordance with the Floodplain Management Manual; and
- not be able to be undertaken in a commercially viable manner, as proposed, on other land within the area.

Based on previous assessments of the agricultural viability of Project Site, it assessed that the Project Site is not suitable for intensive agriculture and is subject to a number of constraints including waterlogging and poor, uneven fertility. Therefore, the Project would not affect the viability of cane production/processing or other intensive agriculture within the Tweed area.

Additionally, the elevated horticultural/small cropping land to the south of the Project Site has been farmed successfully for a number of years coexisting with the ongoing Hanson Tweed Sand Quarry operation to the west of the Project Site. As the proposed sand extraction would

implement management strategies to ensure that existing groundwater and dam water quality and quantity on surrounding landholdings are not significantly affected (see Section 4.2), it is considered that the Project would not significantly impact upon surrounding agricultural land uses.

4.4 FLORA

4.4.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential ecological (terrestrial and aquatic) impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Disturbance leading to local extinction(s) (Extreme Risk).
- Disturbance leading to local population reduction (High Risk).
- Disturbance to Threatened flora / fauna and endangered communities (High Risk).
- Disturbance to native vegetation / habitat within nominated areas (High Risk).
- Reduction in regional biodiversity (High Risk).
- Disturbance to native vegetation / habitat outside nominated areas (Moderate Risk).
- Reduction in local biodiversity (Moderate Risk).

The following subsections describe the existing vegetation communities and flora species within and surrounding the Project Site and pipeline corridors and their conservation significance. The potential impacts that the Project would have on these vegetation communities and Threatened flora species are described together with the design and operational safeguards and management procedures to be employed.

The information presented in this section is drawn from the flora assessment undertaken by Idyll Spaces (Idyll, 2008) whose full report is included in the *Specialist Consultant Studies Compendium* (Volume 1, Part 4). This subsection presents a summary of the contents of the flora assessment report. It is noted that for the purposes of the flora assessment, Idyll Spaces considered a Study Area incorporating both the Project Site and adjoining land to the north and east of the Project Site (see **Figure 4.12**).

4.4.2 Study Methodology

4.4.2.1 Background Research

The desktop component of the flora assessment involved review of previous flora assessments undertaken within and surrounding the Study Area and a web-based search of the documented records held on the DECC, Atlas of NSW Wildlife Database and Environment Australia Protected Matter Search Tool. Records of Threatened or Endangered flora species, populations

or communities known to occur within 10km of the Study Area were obtained from the Tweed Heads and Murwillumbah 1:100 000 map sheets and records for the Murwillumbah (Qld – Southeast Hills and Ranges) subregion. The Study Area refers to the Project Site and land parcels crossed by the proposed and alternative pipeline corridor (see **Figure 4.12**).

Current schedules of the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the existence of any relevant Threatened species recovery or threat abatement plans, and preliminary determinations, were also reviewed online.

4.4.2.2 Field Survey

A field survey of Lot 21 DP 1082482, the proposed northern pipeline corridor and the alternative eastern pipeline corridor was undertaken over 8 hours on 9 and 10 May 2005. A survey of Lot 2 DP 216705 was also undertaken over two hours on 14 November 2003, and survey of land east of Tweed Coast Road was undertaken between 29 July and 2 August 2003.

A total of twenty-one $400m^2$ rectangular survey plots located within the Study Area were used to collect structural and full floristic data. Plot selection utilised systematic sampling stratified according by vegetation community, as other biophysical attributes of the Study Area were apparently uniform. Plots were selected to sample all native vegetation communities, replicated according to area and the widest geographic spread of exotic communities. Final placement of the survey plots in the field was according to a 25m GPS grid.

Random meander searches targeting plant species of conservation significance were undertaken travelling between plots, along drains, and along the pipeline corridor routes.

4.4.3 Existing Flora Species and Vegetation Communities

Ten vegetation communities were identified within Study Area (see **Figure 4.12**). A brief description of each community is provided as follows.

Community 1: Casuarina glauca Woodland

This relict community occurs as a narrow strip on wet soils on the banks and in shallower waters of the major drain currently running east-west parallel with Altona Drive and as several small patches in roadside table drains in the northern pipeline corridor.

The community consists of sparse small stands of trees, or isolated trees, to 12m tall and 30cm diameter, with a sparse to mid-dense ground layer of exotic grasses. Stands of Swamp Oak *Casuarina glauca* are the dominant species, with other tree species limited to occasional Blackwood Wattle *Acacia melanoxylon*. Mile-a-minute *Ipomoea cairica* is the only midstratum species and the native sedge *Schoenoplectus validus* is the dominant ground layer species in flooded drains, and mats of *Bacopa monniera* occur on exposed mud. Higher land is dominated by exotic pasture grasses.

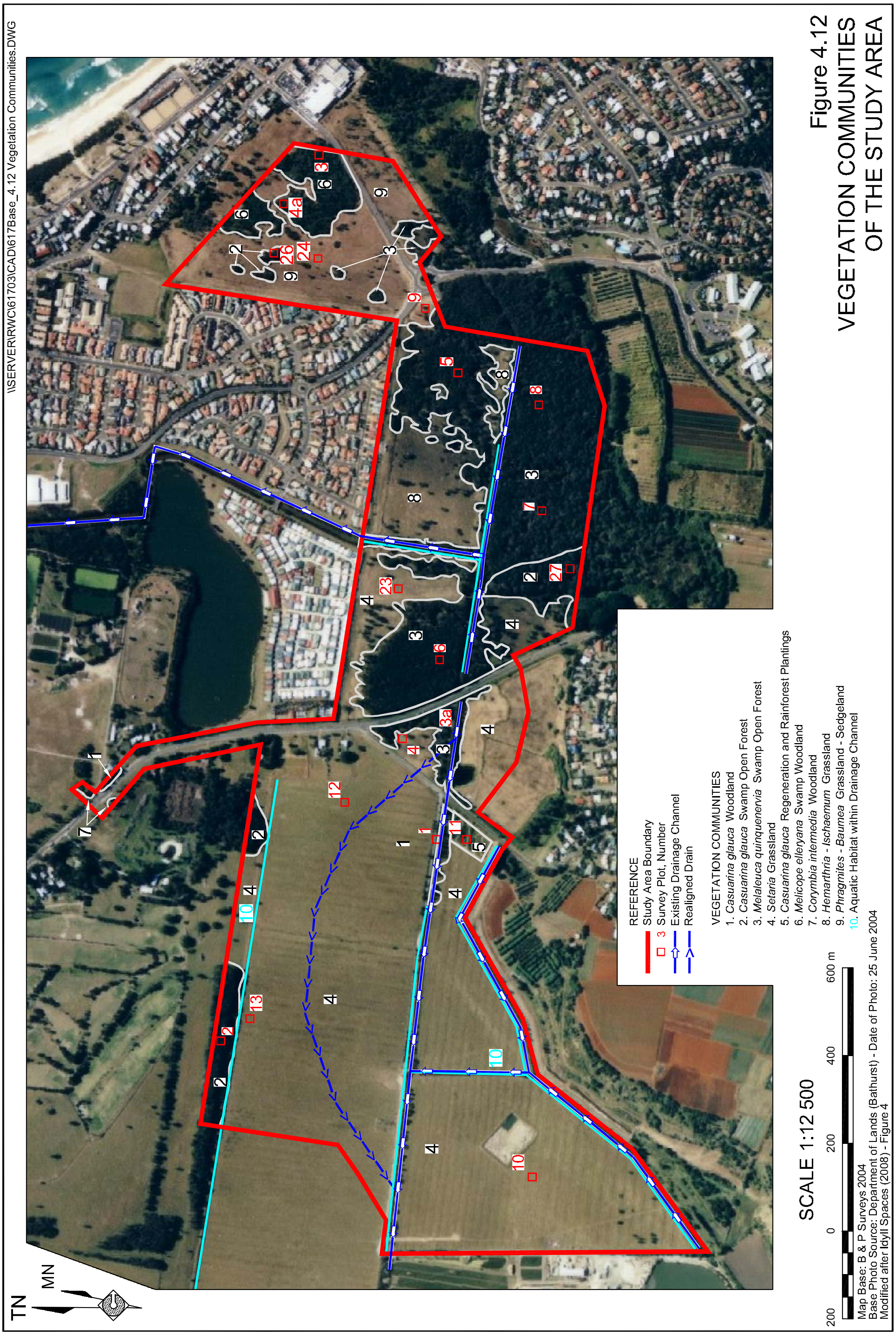


Figure 4.12
VEGETATION COMMUNITIES OF THE STUDY AREA

This community represents a seriously disturbed, isolated and depauperate stand of *Casuarina glauca*. It is categorised as a relict of Forest Ecosystem (FE) 143, a community regarded as Vulnerable in northeastern NSW, and may fall within the broad definition of Swamp Oak floodplain forest, listed as an Endangered Ecological Community (ECC) under the TSC Act (Scientific Committee 17 December 2004).

No Threatened or Endangered species were detected in Community 1 within the Study Area or are considered likely to occur there.

Community 2: Casuarina glauca Swamp Open Forest

This is a groundwater dependent native vegetation community. It occurs as remnants in grazed pasture directly north of the Project Site and consists of a sparse stratum up to 20m tall and 60cm diameter, a upper midstratum to 12m tall, and a sparse lower midstratum approximately 4m tall. The mid-dense ground layer of exotic grasses is around 1m tall.

Swamp Oak *Casuarina glauca* is the dominant species, with Broadleaved Paperbark *Melaleuca quinquenervia* subdominant. Other common tree species include Willow Bottlebrush *Callistemon salignus* and Camphor Laurel *Cinnamomum camphora*. The lower strata include the common rainforest species Sandpaper Fig *Ficus coronata*, Cockspur Thorn *Maclura cochinchinensis* and the weed Lantana *Lantana camara.*

Setaria Grass *Setaria sphacelata* is the dominant ground cover, at least on the edge of the stand.

This community represents disturbed and isolated remnants of a *Casuarina glauca* Swamp Forest, identifiable as Forest Ecosystem (FE) 143, a community regarded as Vulnerable in northeastern NSW, and may constitue Swamp Oak Floodplain Forest, listed as an ECC under the TSC Act (Scientific Committee 17 December 2004).

No Threatened or Endangered species were detected or are considered likely to occur within this community within the Study Area.

Community 3: Melaleuca quinquenervia Swamp Open Forest

This is a groundwater dependent native vegetation community consisting of open stands of trees to around 12m tall over mid-dense grasses and occasional sedges. Paperbark is the dominant tree species, with occasional Swamp Oak. Silkpod Vine is a common woody climber, otherwise a midstratum is absent. Ground layer vegetation is dominated by the exotic grasses, especially Setaria Grass *Setaria sphacelata* and Sourgrass *Paspalum conjugatum*.

This community is classified as FE 112 Paperbark, a Vulnerable Ecosystem. It may also be classified as WTF002a, regarded as adequately conserved in northeastern NSW or Swamp Sclerophyll Forest on Floodplain, listed as an Endangered Ecological Community by the Scientific Committee (17 December 2004).

No Threatened or Endangered species were detected in this community within the Study Area. No ROTAP listed species were detected in this community within the Study Area but *Cordyline congesta* is known to occur in this community elsewhere in the locality.

Community 4: Setaria Grassland

This community occupies most of the Project Site, including the ground layer of forest and woodland communities west of Tweed Coast Road. This community is a dense to mid-dense sod grassland, from less than 10cm tall when recently mowed or heavily grazed, to over 1m tall elsewhere. Although trees were generally absent, Swamp Oak coppice occurred occasionally.

The exotic species Setaria Grass was clearly the dominant species during the survey in May 2005, but was co-dominant with Carpet Grass *Axonopus fissifolius* when surveyed in November 2003. A range of other common exotic grasses were also observed during both surveys.

This community is not a native vegetation community and has no intrinsic conservation status.

Community 5: Casuarina glauca Regeneration and Rainforest tree plantings

This community occurs in a small fenced paddock at the eastern extremity of the Study Area adjoining Crescent Street and consists of a sparse stand of young trees to 6m tall over a dense ground layer to 60cm tall.

In November 1993, the exotic annual *Aster subulatus* and exotic perennial *Cuhea carthagenensis* were the dominant species in this community, but subsequently Swamp Oak coppice present then has grown, together with planted rainforest trees of Blue Fig *Elaeocarpus grandis*, Umbrella Cheese Tree *Glochidion sumatranum* and Macaranga *Macaranga tanarius.*

Other common species include the exotics Setaria Grass and Stinking Pennywort *Hydrocotyle bonariensis*, and the natives *Centella asiatica*, Buttercup *Ranunculus inundatus* and Blue Commelina *Commelina cyanea*.

This community is a relict community with introduced tree species and has no intrinsic conservation status. No Threatened or Endangered species were detected within this community or are considered likely to occur within this community within the Study Area.

Community 6: Melicope elleryana Swamp Woodland

This community occupies waterlogged peaty black soils adjoining the footslopes of the barrier dune west of the main street of Kingscliff and comprises a woodland of scattered regrowth trees to 8m and a sparse midstratum to 3m over a dense ground layer of grasses, sedges and ferns to 1.5m tall.

There is sparse cover of Doughwood *Melicope elleryana*, Umbrella Cheese Tree *Glochidion sumatranum* and Umbrella Tree *Schefflera actinophylla* among numerous dead Blackwood Wattle *Acacia melanoxylon.* The midstratum is dominated by Lantana *Lantana camara* with occasional stands of other weeds. The ground layer vegetation consists of dense cover of Harsh Ground Fern *Hypolepis muelleri* with occasional Sawsedge *Gahnia sp*, Swamp Fern *Blechnum sp*, and Common Reed *Phragmites australis*. In mowed areas Swamp Ricegrass *Leersia hexandra* and introduced *Setaria* sp and Para Grass *Urochloa mutica* are dominant.

This community is not recognised as a Forest Ecosystem or Association, and has no intrinsic conservation status. No Threatened or Endangered species were detected or are considered likely to occur in this community within the Study Area. The ROTAP listed species *Cordyline congesta* is reported from the southeastern corner of this community.

Community 7: Corymbia intermedia Woodland

This community is located within the road reserve of Tweed Coast Road towards the northern end of the proposed northern pipeline corridor and consists of scattered regrowth trees to 10m over a mowed mid-dense grassland.

Tree species include Pink Bloodwood *Corymbia intermedia*, Brush Box, Coast Banksia*,* Swamp Oak and Broadleaved Paperbark. The midstratum flora is absent, and the ground layer consists of mowed exotic grasses and occasional small sedges.

This community is not recognised as a Forest Ecosystem or Association and has no intrinsic conservation status. No Threatened or Endangered species were detected in this community or are considered likely to occur in this community within the Study Area.

Community 8: Hemarthria uncinata-Ischaemum Grassland

This community occurs on loam soils of cleared and mowed areas in the eastern part of the Study Area and consists of a mid-dense to dense grassland approximately 7cm tall, recently mowed, with smaller shade-tolerant herbs below the grasses and occasional stands of sedges in depressions.

The native grasses Matgrass *Hemarthria uncinata* and *Ischaemum australe* are typically codominant, and Carpet Grass *Axonopus fissifolius* is very common. Other common species include the native grass *Paspalidium sp*, the woody-rooted forb *Gonocarpus chinensis*, and herbs such as *Hydrocotyle laxiflora* and *Velliea spathulata*. There are occasional seedlings and coppice of *Melaleuca quinquenervia* and sedges *Baumea spp* in depressions.

This community has no known flora conservation values. It is not a recognisable community in the Tweed Vegetation Management Plan. No Threatened or Endangered species were detected or are considered likely to occur in this community within the Study Area.

Community 9: Phragmites - Baumea Grassland-Sedgeland

This community occurs on inundated peaty mud of cleared and mowed areas within the eastern extent of the Study Area and consists of a sparse mixed grassland and sedgeland, with occasional fern and taller grass up to 60cm tall and isolated young Paperbark Trees.

Baumea rubiginosa is generally common together with the natives, Common Reedgrass *Phragmites australis* and Swamp Ricegrass *Leersia hexandra,* Swamp Fern *Blechnum sp* and the sedge *Schoenus brevifolius*. Introduced grasses such as Sourgrass *Paspalum conjugatum*, Vasey Grass *Paspalum urvillei*, Guinea Grass *Panicum maximum*, Para Grass *Urochloa mutica* and Carpet Grass are common, and locally dominant on disturbed areas such as fill batters.

This community is not a recognisable community in the Tweed Vegetation Management Plan. Although it has elements of the vegetation community Freshwater Wetlands on Coastal Floodplains, listed as an Endangered Ecological Community by the Scientific Committee (17 December 2004), it is considered here as derived from species characteristic of a swamp forest understorey that have been favoured by artificial ponding.

No Threatened or Endangered species were detected or considered likely to occur in this community within the Study Area. It includes one mature specimen of the Swamp Banksia *Banksia robur*, regarded as a significant species in the Tweed Vegetation Management Plan.

Community 10: Drains & Aquatic Vegetation

This community occurs within the drainage network across the Study Area with its structure varying according to water depth, with isolated individual floating aquatics and stands of emergents in deeper water, and mats of low growing species on exposed mud.

In larger drains, the native sedge *Schoenoplectus validus* is the dominant ground layer species in flooded drains, and mats of *Bacopa monniera* occur on exposed mud. There are occasional plants of Water Lily *Nymphaea capensis* in deeper areas of water. In smaller drains, Setaria Grass is the dominant species.

This community is not recognisable as a native vegetation community and has no intrinsic conservation status. No Threatened or Endangered species were detected in this community or are considered likely to occur in this community in the Project Site.

4.4.4 Conservation Significance

4.4.4.1 Vegetation Communities

Two TSC Act listed EECs are assessed as potentially occurring within the Study Area, namely:

- Swamp Oak Floodplain Forest, which may occur within the Study Area as Community 2; and
- Swamp Sclerophyll Forest, which may occur within the Study Area as Community 3.

No Critical Habitat is listed for the Study Area under the TSC Act or the EPBC Act.

4.4.4.2 Threatened Species

No Threatened or Endangered flora species as listed under the TSC Act or the EPBC Act have been detected within the Study Area, despite numerous field surveys. However, three TSC Act listed Threatened flora species have been assessed as potentially occurring in vegetation communities of the Study Area. These species (and their corresponding communities) are:

- *Drynaria rigidula* (Community 2);
- *Geodorum densiflorum* (Community 3); and
- *Oldenlandia galioides* (also known as *Hedyotis galioides)*(Community 3).

No Endangered Populations are listed for the Study Area under the TSC Act or the EPBC Act.

4.4.5 Design and Operational Safeguards

The proposed and alternative pipeline corridors have been located to avoid the need for clearance of native vegetation. Completed works within the Project Site would be progressively rehabilitated to maximise cover of native vegetation and minimise opportunities for erosion and weed invasion.

The following measures recommended by Idyll Spaces (2008) would also be implemented to minimise and mitigate impacts on native vegetation within the Project Site.

- Vegetation to be retained would be clearly defined and marked prior to the commencement of site establishment to ensure that native vegetation clearing is confined only to those areas required for Project operations.
- Noxious weeds would be controlled on the Project Site.
- Rehabilitation and landscaping would utilise local native plant species recommended by Idyll Spaces (2008) that provide forage opportunities for nectarivorous and frugivorous birds and bats (as outlined within Section 2.14).

4.4.6 Assessment of Impacts

4.4.6.1 Threatened Species Conservation Act 1995

Table 4.12 summarises the area of each vegetation community that would be disturbed / cleared as a result of the Project.

Table 4.12
Areas of Vegetation Communities within the Study Area

Community		Approximate area to be cleared/disturbed (ha)	Approximate extent in Study Area (ha)
1	*Casuarina glauca* Woodland	0.5	0.5
2	*Casuarina glauca* Swamp Open Forest (EEC)	0.0	3.9
3	*Melaleuca quinquenervia* Swamp Open Forest (EEC)	0.0	26.7
4	*Setaria sp* Grassland (exotic grassland)	50.0	83.9
5	*Casuarina glauca* and Rainforest tree plantings	0.0	0.6
6	*Melicope elleryana* Swamp Woodland	0.0	3.6
7	*Corymbia intermedia* Open Forest	0.0	0.1
8	*Hemarthria uncinata-Ischaemum australe* Grassland	0.0	7.6
9	*Baumea rubiginosa -Phragmites australis* Mixed Grassland-Sedgeland	0.0	11.8
10	Drains & Aquatic Vegetation	0.1	0.5
	Total	**50.6**	**139.2**
Source: Idyll Spaces (2008) – Table 3			

No direct impacts on Swamp Oak and Swamp Sclerophyll forests within the Study Area, which, for this assessment, were assumed to be the EEC's Swamp Oak Floodplain Forest and Swamp Sclerophyll Forest on Coastal Floodplains, are predicted to occur as they are outside of the clearing / direct disturbance envelope of the Project. The EECs are groundwater dependent ecosystems, however, there is potential for indirect impact arising from the Project due to alteration in groundwater regimes, in particular, lowering of the water table and associated oxidation of potential acid sulfate soils and sediments or intrusion of saline groundwater.

Groundwater studies undertaken by AGE (2008 – see Part 1 of the *Specialist Consultant Studies Compendium*) indicate that groundwater levels under these communities would remain within normal seasonal fluctuations. Additionally, with appropriate management practices, oxidation of acid sulfate soils is not expected to cause any significant alterations to water quality (HMC, 2008 – see Part 3 of the *Specialist Consultant Studies Compendium*). Water quality monitoring undertaken at the operating sand extraction facility of Tweed Turf and Sand (now Hanson Tweed Sand) on the western boundary of the Project Site also indicates that no significant increase in salinity would likely occur. Therefore no indirect impacts are expected.

Potential habitat for the following Threatened species occurs in the Swamp Oak and Swamp Sclerophyll forests of the Study Area.

- *Drynaria rigidula.*
- *Geodorum densiflorum.*
- *Oldenlandia galioides.*

For the reasons outlined above, no direct or indirect impacts on these species are expected.

In accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC 2005) and *Threatened Species Assessment Guidelines* (DECC 2007), a 'seven-part test' under Section 5A of the EP&A Act has also been completed for Threatened species with potential habitat within the Study Area. The test found that the likely impact from the Project would not be significant.

There would be no need for vegetation clearing within either the proposed or alternative northern pipeline corridors. Furthermore, Tweed Coast Road and the proposed road east-west from Tweed Coast Road to Turnock Street would provide the necessary access to the pipelines for servicing. In the event that the alternative pipeline corridors are used, a "service track" approximately 4m wide would run parallel to the pipelines, however, where necessary the service track and/or pipeline orientation would be adjusted to avoid the need to remove trees and shrubs.

4.4.6.2 Environment Protection and Biodiversity Conservation Act 1999

No vegetation communities or flora species detected on the Project Site are listed under the schedules of the EPBC Act and application of the Administrative Guidelines finds that there would no significant impacts on any EPBC Act listed vegetation communities or flora species.

4.4.6.3 EIS Guideline: Extractive Industries - Dredging and Other Extraction in Riparian and Coastal Areas

Areas protected under State Environmental Planning Policy (SEPP) 14 (Coastal Wetlands), SEPP 26 (Littoral Rainforest) or SEPP 44 (Koala habitat) do not occur within the Study Area. Vegetation protected under the *Fisheries Management Act 1994* also does not occur within the Study Area and is unlikely to be impacted by the Project.

Under the register of significant trees, locally significant trees have been identified adjacent to Crescent Street and Cudgen Road, however, they do not occur within the Project Site or Study Area.

The following species protected under Schedule 13 of the *National Parks and Wildlife Act 1974* occur within the Study Area (in Community 3 only).

- Bangalow palm *Archontophoenix cunninghamiana*
- Birds-nest fern *Asplenium australisicum*
- Swamp Banksia *Banksia robur*
- Willow bottlebrush *Callistemon salignus*
- Thickleaved bottlebrush *Callistemon pachyphyllus*

These protected species would not be impacted by the Project.

4.4.7 Conclusion

Swamp Sclerophyll Forest on Coastal Floodplain and Swamp Oak Floodplain Forest, listed as Endangered Ecological Communities under the *TSC Act* were assumed to occur within the Study Area. These communities are also classified as groundwater dependent. It has been assessed that these communities would not be adversely affected by the Project.

No Threatened flora species have been identified by surveys throughout the Study Area. Habitat requirements for the Threatened flora species *Drynaria rigidula, Geodorum densiflorum* and *Oldenlandia galioides*, all listed as Endangered under the *TSC Act* may be met in the Study Area, however, their occurrence is considered unlikely due to habitat modification.

No Endangered Populations or Critical Habitat are listed for the Study Area under the TSC Act or the EPBC Act.

Given the implementation of the proposed mitigation measures, it is expected that the Project would maintain or improve biodiversity outcomes, and in particular, would not reduce the long-term viability of a local population of any species, population or ecological community, accelerate the extinction of any species, population or ecological community or place it at risk of extinction, or adversely affect critical habitat.

4.5 FAUNA

4.5.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential ecological (terrestrial and aquatic) impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Disturbance leading to local extinction(s) (Extreme Risk).
- Disturbance leading to local population reduction (High Risk).
- Disturbance to Threatened flora / fauna and endangered communities (High Risk).
- Disturbance to native vegetation / habitat within nominated areas (High Risk).
- Reduction in regional biodiversity (High Risk).
- Disturbance to native vegetation / habitat outside nominated areas (Moderate Risk).
- Reduction in local biodiversity (Moderate Risk).

The following subsections describe the existing fauna habitats and fauna species within and surrounding the Project Site and pipeline corridors and their conservation significance. The potential impacts that the Project would have on identified fauna species are described together with the design and operational safeguards and management procedures to be employed. The fauna that occurs within the drains and surrounding water bodies is separately addressed in Section 4.6.

The information presented in this section is drawn from the fauna assessment undertaken by Kendall & Kendall Ecological Services Pty Ltd (Kendall, 2008) whose full report is included in the *Specialist Consultant Studies Compendium* (Volume 1, Part 5). This subsection presents a summary of the contents of the fauna assessment report.

4.5.2 Study Methodology

4.5.2.1 Background Research

Records of fauna species known to occur within the locality (area within approximately 10km of the Study Area) were obtained under licence from the NSW DECC wildlife atlas database and records of significant fauna or fauna species habitat potentially occurring within 5km of the Study Area were obtained from the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA). The Study Area collectively refers to the Project Site and proposed pipeline corridors.

Current schedules of the TSC Act and the EPBC Act, the existence of any relevant Threatened species recovery or threat abatement plans, and preliminary determinations, were also reviewed online.

4.5.2.2 Field Surveys

Two field surveys were conducted for the Project. The initial survey concentrated on the Project Site and proposed northern pipeline corridor, the second survey concentrated on the proposed eastern pipeline corridor.

The Project Site and proposed northern pipeline corridor were surveyed between 9 May 2005 and 13 May 2005. Fauna sampling techniques involved the use of:

- 20 tree mounted Elliott traps set over 4 nights;
- 20 hair tubes set over 4 nights;
- 20 ground placed Elliott traps set over 4 nights;
- 6 cage traps set over 4 nights;
- nocturnal call playbacks;
- spotlighting on 4 nights incorporating nocturnal herpetology searches;
- 30 minutes anabat recording for microbats over 2 nights;
- opportunistic identification of birds and bird calls;
- diurnal and nocturnal herpetology searches; and
- searching for sign of significant fauna.

The locations of sampling sites using these techniques are indicated on **Figure 4.13**. Sampling at Sites 1, 2 and 3 involved a number of methodologies including Elliott and cage trapping, hair tubing and herpetology searches. No harp trapping was implemented, as the Project Site does not contain suitable harp trapping sites.

The proposed eastern pipeline corridor was surveyed between 21 November 2006 and 26 November 2006. Fauna sampling techniques involved the use of:

- 30 tree mounted Elliott traps set over 4 nights;
- 75 ground placed Elliott traps set over 4 nights;
- 60 ground and arboreal hair tubes set over 4 nights;
- 6 cage traps set over 4 nights;
- nocturnal call playbacks;
- spotlighting on 4 nights incorporating nocturnal herpetology searches;
- Anabat recording for microbats over 2 nights;
- opportunistic identification of birds and bird calls;
- diurnal and nocturnal herpetology searches; and
- searching for sign of significant fauna.

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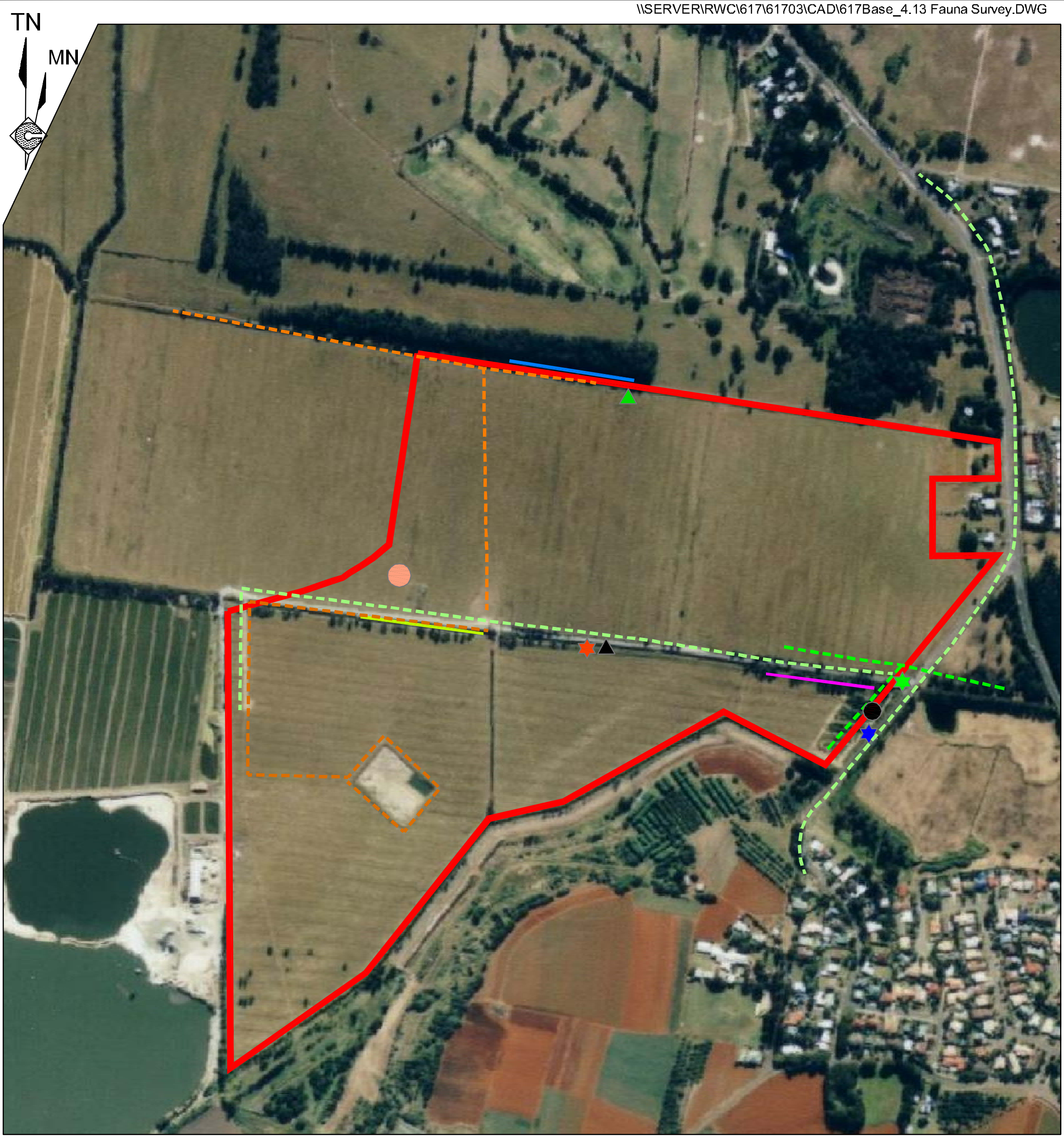

REFERENCE

- Project Site Boundary
- Site 1*
- Site 2*
- Site 3*
- Spotlight 1
- Spotlight 2 and 3
- Spotlight 4
- Spotlight 5
- Anabat 1
- Anabat 2
- Nocturnal Call Playback 1
- Nocturnal Call Playback 2, 3 & 4
- Nocturnal Call Playback 5
- Nocturnal Call Playback 6 & 7
- Herpetology Search of Rubbish Pile

*Includes combination of trapping, hair tubing and herpetology searches

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Base Photo Source: Department of Lands (Bathurst) - Date of Photo: 25 June 2004
Source of survey Locations: Kendall (2008) - Figure 4

Figure 4.13
FAUNA SURVEY - PROJECT SITE AND SURROUNDS

The locations of sampling sites using these techniques are indicated on **Figure 4.14**.

4.5.3 Significant Fauna Species or Populations Records within the Locality

4.5.3.1 Threatened Species Conservation Act 1995

A total of 31 Threatened species are recorded by the DECC wildlife atlas within 5km of the Project Site. Based on habitat requirements, 13 of these species are considered as possible or likely to occur within the Project Site or have been confirmed to be present within the Study Area. **Table 4.13** provides a summary of these species.

Table 4.13
TSC Act Threatened Species Recorded Within Approximately 5km of the Study Area

Page 1 of 2

Scientific Name	Common Name	Legal Status TSC Act 1995	Habitat	Likelihood of occurrence within Study Area	Approx. Distance to closest record (km)	No. of records within 5km
Pandion haliaetus	Osprey	V	Beach, estuaries, rivers and adjoining areas.	Possible	1.0	67
Ixobrychus flavicollis	Black Bittern	V	Dense vegetation fringing and in streams, swamps, tidal creeks and mudflats, particularly amongst swamp she-oaks and mangroves (NPWS 2002).	Possible	5.0	1
Ephippiorhynchus asiaticus	Black-necked Stork	E	Swamps, mangroves, mudflats, dry floodplains, and irrigated land, occasionally in open grassy woodland (NPWS 2002).	Possible	4.1	5
Ptilinopus magnificus	Wompoo Fruit-Dove	V	Recorded mainly from subtropical and dry rainforest (Gilmore and Parnaby 1994), swamp forest (Kendall pers obs) and expected to occur where mesic fruiting plants occur.	Possible	5.6	1
Ptilinopus regina	Rose-crowned Fruit-Dove	V	Subtropical rainforest and dry rainforest and occasionally in other rainforest and moist eucalypt forest and swamp forest they feed on fruit (Gilmore and Parnaby 1994).	Possible	2.0	2
Ninox connivens	Barking Owl	V	Occupies eucalypt woodland, open forest, swamp woodland and timber along watercourses, occasionally roosts in denser habitat but hunts over more open country, nests in tree hollows (NPWS 2002).	Possible	4.3	1
Tyto capensis	Grass Owl	V	Swamps and rank grasslands.	Likely	1.7	3
Pteropus alecto	Black Flying-fox	V	Forms communal camps in coastal subtropical rainforest or swamp forest feed on rainforest fruits, nectar and pollen from flowering eucalypts, paperbarks and banksias. When native foods are scarce, they take fruit from orchards (NPWS 2002).	Confirmed	0.4	32
Pteropus poliocephalus	Grey-headed Flying-fox	V	Roosts in camps in lowland rainforest and swamp forest, forage on fruit, nectar and pollen in rainforests and eucalypt forests (NPWS 2002).	Confirmed	0.4	22
Syconycteris australis	Common Blossom-bat	V	Roost in littoral rainforest and forage in adjacent coastal heath and paperbark swamp (NPWS 2002).	Possible	1.9	2

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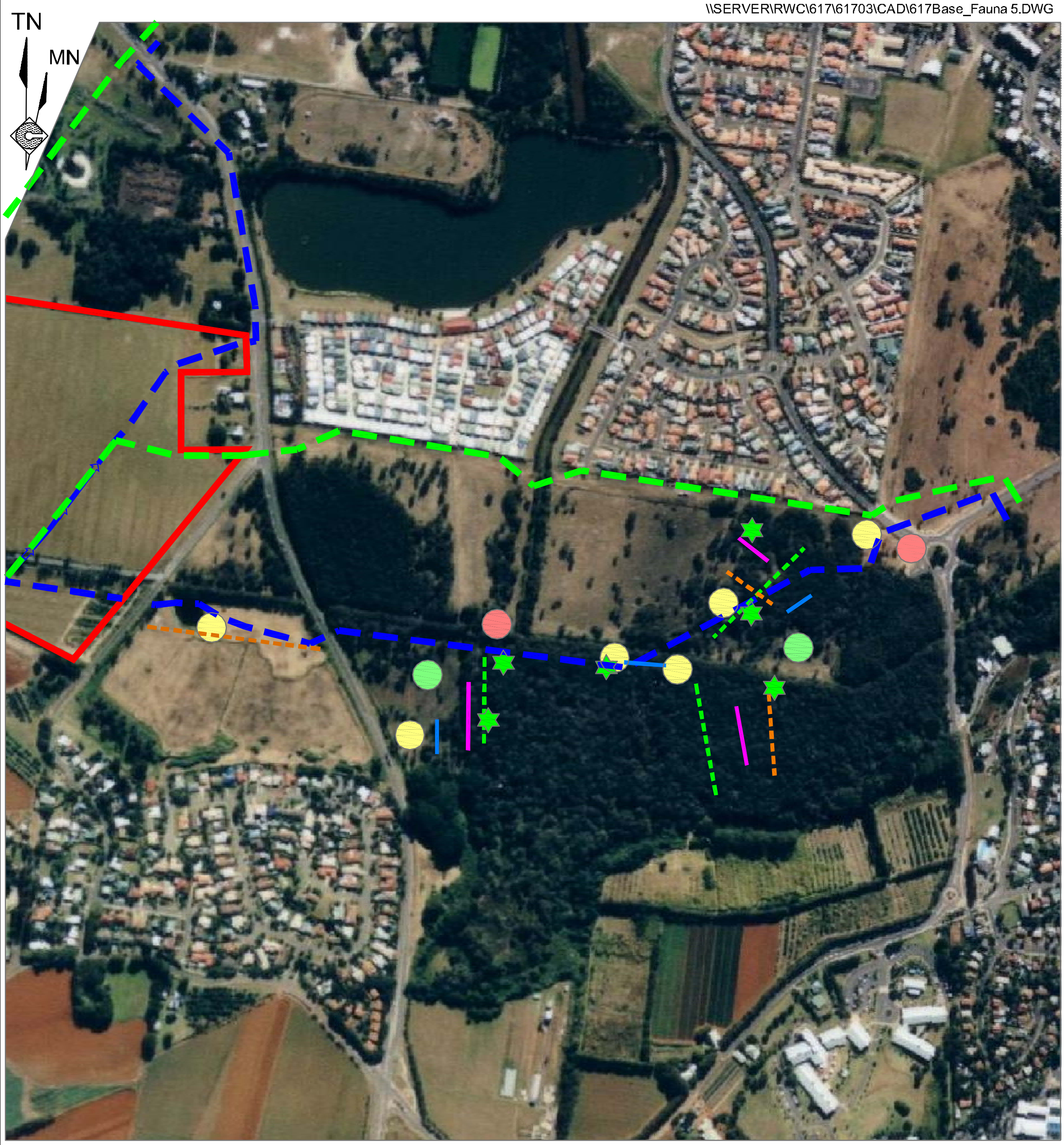


REFERENCE
- Project Site Boundary
- Proposed Pipeline Corridor
- Alternative Pipeline Corridor
- Elliots A Ground
- Elliots B Aboreal
- Elliots B Aboreal Scattered
- Hair Tube
- Pit Fall Trap
- Anabat Recording
- Harp Trap
- Nocturnal Call Playback
- Cage Trap

SCALE 1:10 000

100 0 100 200 300 400 500 m

Base Photo Source: Department of Lands (Bathurst) - Date of Photo: 25 June 2004
Source of survey Locations: Kendall (2008) - Figure 4

Figure 4.14
FAUNA SURVEY - EASTERN PIPELINE CORRIDOR AND SURROUNDS

Table 4.13 (Cont'd)
TSC Act Threatened Species Recorded Within approximately 5km of the Study Area

Page 2 of 2

Scientific Name	Common Name	Legal Status TSC Act 1995	Habitat	Likelihood of occurrence within Study Area	Approx. Distance to closest record (km)	No. of records within 5km
Miniopterus australis	Little Bentwing-bat	V	Moist eucalypt forest, rainforest and dense coastal banksia scrub, roost in caves, tunnels and sometimes tree hollows. (NPWS 2002).	Possible	3.8	1
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	Found in wide variety of forest types where they feed just above canopy, roost and breed in caves (Churchill 2002).	Possible	3.9	4
Nyctophilus bifax	Eastern Long-eared Bat	V	Lowland subtropical rainforest and wet and swamp eucalypt forest, extending into adjacent moist eucalypt forest. Coastal rainforest and patches of coastal scrub are particularly favoured (DECC 2006).	Possible	3.9	2
V = Vulnerable species (TSC Act) E = Endangered species (TSC Act)						
Source: Kendall (2008) – Modified from Table 2						

A further 19 Threatened species are listed in Murwillumbah subregion but not recorded within 10km of the Project Site that are considered as possible or likely to occur within the Project Site.

4.5.3.2 Environment Protection and Biodiversity Conservation Act 1999

Table 4.14 lists EPBC Act significant fauna species recorded by the DEWHA Protected Matters Search Tool as occurring within 5km of the Study Area and which have potentially suitable habitat within the Study Area.

Table 4.14
EPBC Act Significant Species considered as possible to occur on the Study Area

Page 1 of 2

Common Name	Scientific name	EPBC Act Status	Possibility of Occurrence
Swift Parrot	Lathamus discolour	Endangered	Unlikely
Black-throated Finch (southern)	*Poephila cincta cincta*	Endangered	Unlikely
Australian Painted Snipe	*Rostratula australis*	Vulnerable	Unlikely
Regent Honeyeater	*Xanthomyza phrygia*	Endangered & Migratory	Unlikely
Large-eared Pied Bat, Large Pied Bat	*Chalinolobus dwyeri*	Vulnerable	Unlikely
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population)	*Dasyurus maculatus maculatus (SE mainland population)*	Endangered	Unlikely
Long-nosed Potoroo (SE mainland)	*Potorous tridactylus tridactylus*	Vulnerable	Unlikely
Grey-headed Flying-fox	*Pteropus poliocephalus*	Vulnerable	Confirmed
Mitchell's Rainforest Snail	*Thersites mitchellae*	Critically Endangered	Unlikely

Table 4.14 (Cont'd)
EPBC Act Significant Species considered as possible to occur on the Study Area

Page 2 of 2

Common Name	**Scientific name**	**EPBC Act Status**	**Possibility of Occurrence**
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Migratory	Possible
White-throated Needletail	*Hirundapus caudacutus*	Migratory	Likely
Rainbow Bee-eater	*Merops ornatus*	Migratory	Confirmed
Black-faced Monarch	*Monarcha melanopsis*	Migratory	Possible
Spectacled Monarch	*Monarcha trivirgatus*	Migratory	Possible
Satin Flycatcher	*Myiagra cyanoleuca*	Migratory	Possible
Rufous Fantail	*Rhipidura rufifrons*	Migratory	Possible
Latham's Snipe, Japanese Snipe	*Gallinago hardwickii*	Migratory	Possible
Painted Snipe	*Rostratula benghalensis s. lat.*	Migratory	Unlikely
Source: Kendall (2008) – Table 4			

It is noted that the DEWHA Protected Matters Search Tool does not include all species covered by the provisions of the EPBC Act including: international migratory birds listed under the Japan-Australia Migratory Bird Agreement (JAMBA); China-Australia Migratory Bird Agreement (CAMBA); and Convention on the Conservation of Migratory Species of Wild Animals - (Bonn Convention) for which Australia is a range state.

The DEWHA website provides a list of bird species covered by the above agreements.

4.5.4 Fauna Habitats and Wildlife Corridors

A search of the CANRI website indicates that the majority of the Study Area does not occur on any regional or subregional wildlife corridor identified in the NSW NPWS key habitats and corridor study. However, the proposed and alternative eastern pipeline corridors pass across the Cudgen-Wommin Lake regional corridor and the proposed eastern pipeline also passes through an area of key habitat (see **Figure 4.15**).

The Cudgen-Wommin Lake regional corridor links Wommin Lake and Cudgen Creek.

Kendall (2008) adopts the vegetation community descriptions provided in Idyll Spaces (2008). Kendall (2008) also concludes that the Study Area does not contain important habitat attributes such as hollow-bearing trees or any other important sheltering resource that may be used by hollow-dependent Threatened species that may occur in the locality. Furthermore, no caves, rock crevices or rocky area habitats were noted to occur throughout the Study Area.

Some rainforest plants were noted during the survey whose fruit may provide a foraging resource for some Threatened species including the Grey-headed and Black Flying-foxes and the Yellow-eyed Cuckoo-shrike. Banksia and Broad-leaved Paperbark that occur in some vegetation communities may also provide a suitable foraging resource for the Common Blossom Bat and Grey-headed Flying-fox.

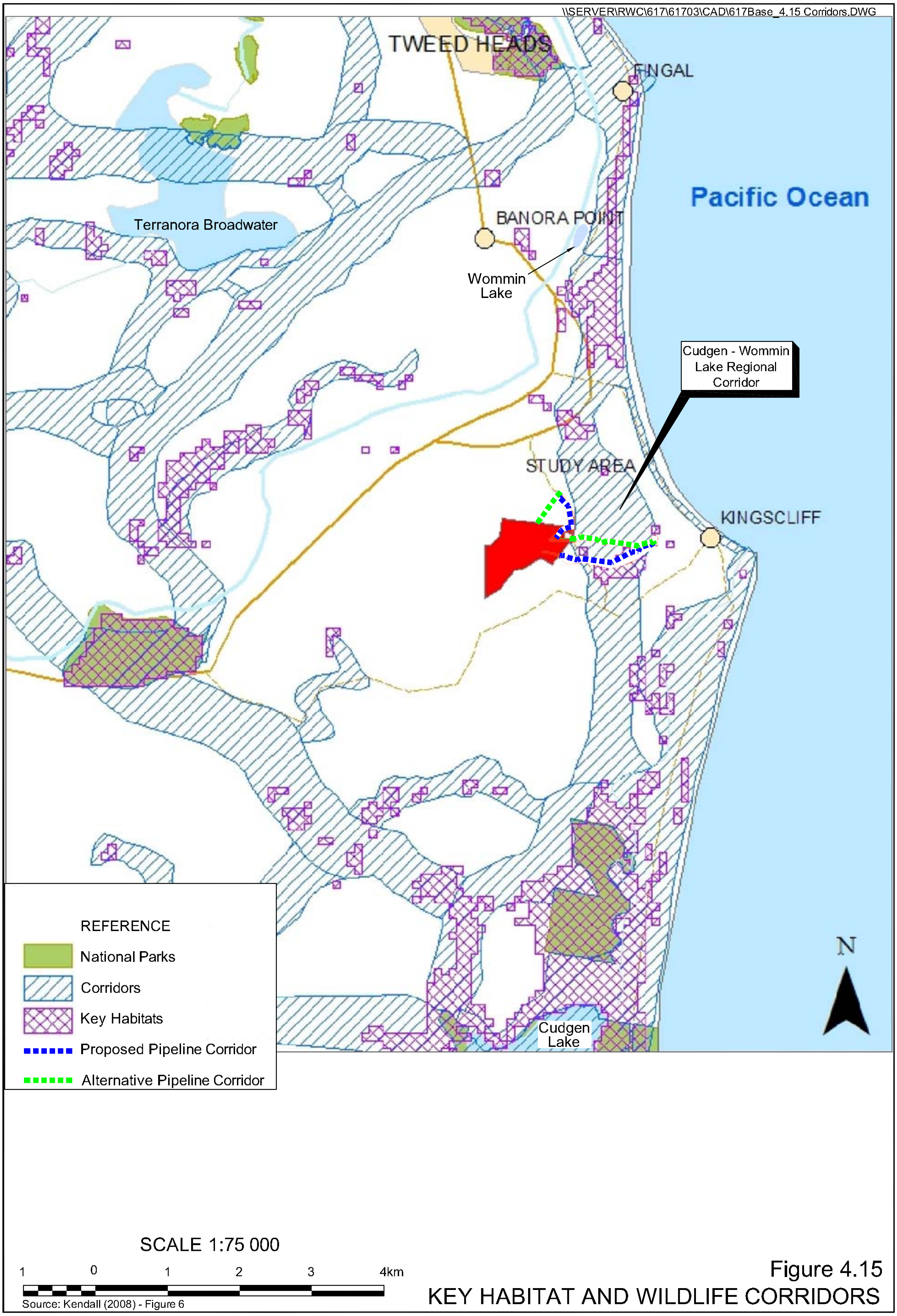


Figure 4.15
KEY HABITAT AND WILDLIFE CORRIDORS

The Study Area does not contain browse tree species important for Koalas, however, a limited amount of a browse tree species for the Glossy Black Cockatoo occurs within the proposed northern pipeline corridor.

Kendall (2008) also notes that the two farm dams located within the property adjoining Project Site owned by R. Julius do not support wetland flora species or fringing vegetation and that the system of linear drains only covers a small area and their coverage is sparse. Further consideration of aquatic ecology habitats is provided by the aquatic ecology assessment completed by TEL (2008 – see Part 6 of the *Specialist Consultant Studies Compendium)*.

4.5.5 Fauna Species

4.5.5.1 Project Site and Proposed Northern Pipeline Corridor

Recorded fauna species within the Project Site and proposed northern pipeline corridor included:

- 75 bird species;
- 14 mammal species of which one was a probable recording of a microbat species;
- three reptile species;
- seven amphibian species; and
- one introduced fish species.

Threatened species listed on Schedule 2 of the TSC Act recorded during the field survey included the:

- Grey-headed Flying-fox (*Pteropus poliocephalus*);
- Black Flying-fox *Pteropus* (*alecto*); and
- Yellow-bellied Sheath-tail Bat (*Saccolaimus flaviventris*).

All of these species were recorded flying over the Study Area. The recording of the Yellow-bellied Sheath-tail Bat was attained soon after sunset by Anabat analysis of recorded microbat calls. It is assumed that the animal may have been roosting in tree hollows observed to the north of the Study Area in senescent Red Gums.

The Grey-headed Flying-fox is also listed as vulnerable under the provisions of the EPBC Act. A total of 16 species listed under the migratory provisions of the EPBC Act were recorded on the Project Site and proposed northern pipeline corridor (see **Table 4.15**).

Table 4.15
EPBC Act Migratory Bird Species Recorded Within the Study Area during the Field Survey

Family Name	**Scientific Name**	**Common Name**
Anatidae	*Anas gracilis*	Grey Teal
Anatidae	*Anas superciliosa*	Pacific Black Duck
Anatidae	*Chenonetta jubata*	Australian Wood Duck
Anatidae	*Dendrocygna arcuata*	Wandering Whistling-Duck
Anatidae	*Dendrocygna eytoni*	Plumed Whistling-Duck
Ardeidae	*Ardea alba*	Great Egret
Ardeidae	*Ardea ibis*	Cattle Egret
Accipitridae	*Accipiter fasciatus*	Brown Goshawk
Accipitridae	*Haliastur indus*	Brahminy Kite
Accipitridae	*Haliastur sphenurus*	Whistling Kite
Scolopacidae	*Gallinago hardwickii*	Latham's Snipe
Scolopacidae	*Tringa stagnatilis*	Marsh Sandpiper
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt
Charadriidae	*Vanellus miles*	Masked Lapwing
Meropidae	*Merops ornatus*	Rainbow Bee-eater
Campephagidae	*Coracina tenuirostris*	Cicadabird
Sylviidae	*Acrocephalus stentoreus*	Clamorous Reed-Warbler
Sylviidae	*Cisticola exilis*	Golden-headed Cisticola
Sylviidae	*Megalurus timoriensis*	Tawny Grassbird
Source: Kendall (2008) – Table 5		

A number of introduced vertebrate species were also recorded during the field survey including the:

- House Mouse (*Mus musculus*);
- Cane Toad (*Bufo marinus*);
- Fox (*Vulpes vulpes*);
- Mosquitoe Fish (*Gambusia holbrooki*);
- Brown Hare (*Lepus capensis*); and
- Common Myna (*Acridotheres tristis*).

4.5.5.2 Proposed Eastern Pipeline Corridor

In total, 102 vertebrate species (including two probable identifications of microbat species by Anabat Call analysis) were recorded within the area around the proposed eastern pipeline corridor with additional unidentified microbats recorded during spotlighting and an unidentified skink which was also observed.

Threatened species listed on Schedule 2 of the TSC Act recorded during this field survey include the:

- Wallum Froglet *(Crinia tinnula);*
- Little Bent-wing Bat *(Miniopterus australis);*
- Eastern Freetail Bat (Probable) *(Mormopterus norfolkensis);*
- Large-footed Myotis *(Myotis adversus); and*
- Grey-headed Flying-fox *(Pteropus poliocephalus).*

The Grey-headed Flying-fox is also listed as vulnerable under the provisions of the EPBC Act. There were 12 species listed under the migratory provisions of the EPBC Act recorded within the proposed eastern pipeline corridor (see **Table 4.15**).

Introduced vertebrate species recorded during the field survey in addition to those identified within the Project Site include Cattle (*Bos taurus*) and the Black Rat (*Rattus rattus*).

4.5.6 Operational Safeguards

In addition to the safeguards recommended by Idyll Spaces (2008), it is proposed that, in the unlikely event that a small number of trees are required to be removed for the laying of the pipelines, replacement plantings of the same tree species would be undertaken within the same area. In particular, within the northern pipeline corridor, *Banksia integrifolia*, a nectar-producing plant utilised by such species as the Common Blossom Bat, and *Allocasuarina littoralis*, a specific food tree species of the Glossy Black Cockatoo, would be avoided wherever possible.

No additional safeguards within the Project Site are considered necessary to protect the fauna that currently occurs or is likely to occur within the Project Site.

4.5.7 Assessment of Impacts

4.5.7.1 Threatened Species Conservation Act 1995

Local Impacts

Considering the disturbed nature of the Project Site and proposed northern pipeline corridor and minor area of native habitat that would be disturbed by the Project, the Project would have little impact on fauna that occur in the locality of the Study Area. As shown in **Table 4.12** only 0.6ha of native vegetation would be disturbed/cleared as a result of the Project. The remainder of the area to be disturbed within the Project Site comprises the non-native Setaria grassland. Furthermore, as the pipelines within the proposed northern and eastern pipeline corridors would be laid beside existing or approved roads, no clearing of vegetation would be undertaken for the purposes of the pipeline corridors.

In the event that the alternative northern or eastern pipeline corridors are required to be used, the pipelines would be laid on the ground surface across existing cleared areas and would avoid any existing trees.

As the Project would involve retention of open space areas and establishment of wetland flora species adjoining the finalised lake, many of the fauna species that currently use the Study Area would continue to use the Study Area following completion of operations.

It is therefore assessed that the Project would have minimal negative impact upon the fauna within the locality and may result in positive effects through the creation of important wetland habitat areas.

Regional Impacts

The NSW government conducted a Comprehensive Resource Assessment (CRA) that identified priority fauna species for northeastern NSW. These include Threatened species listed under the TSC Act whose distribution covers northeastern NSW and other identified priority species for northeastern NSW.

The following northeastern NSW priority species have been recorded within 5km of the Study Area on the DECC wildlife atlas.

- Wallum Froglet (*Crinia tinnula*).
- Black Bittern (*Ixobrychus flavicollis*).
- Black-necked Stork (*Ephippiorhynchus asiaticus*).
- Osprey (*Pandion haliaetus*).
- Glossy Black-Cockatoo (*Calyptorhynchus lathami*).
- Common Planigale (*Planigale maculata*).
- Koala (*Phascolarctos cinereus*).
- Black Flying-fox (*Pteropus alecto*).
- Grey-headed Flying-fox (*Pteropus poliocephalus*).
- Common Blossom-bat (*Syconycteris australis*).
- Little Bentwing-bat (*Miniopterus australis*).
- Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*).

All of these species are listed on the TSC schedules.

It has been assessed that the Project would not significantly impact on regional fauna habitat values due to the lack of important habitat attributes within the Project Site and pipeline corridors for the above listed species and the fact that no vegetation would be removed along the proposed eastern or northern pipeline corridors.

In accordance with the *Draft Guidelines for Threatened Species Assessment* (DEC 2005) and *Threatened Species Assessment Guidelines* (DEC 2005b), a 'seven-part test' under Section 5A of the EP&A Act has also been completed for Threatened species confirmed as occurring within the Study Area, or considered as likely or possible to occur within the Study Area. The test found that the likely impact from the Project would not be significant on the relevant species. Details of the seven-part test are presented in full in Kendall (2008).

4.5.7.2 Environmental Protection and Biodiversity Conservation Act 1999

There has been no recovery plan prepared for the Grey-headed Flying-fox, an EPBC Act vulnerable species, recorded flying over the Study Area. Of the species considered as likely to occur within the Study Area, recovery plans have been prepared for the Swift Parrot and Regent Honeyeater. It is considered that the Project is not inconsistent with the actions described in the plans as the Study Area does not contain favoured habitat for either species as described in their respective recovery plans.

Application of the Administrative Guidelines finds that there would no significant impacts on any EPBC Act listed fauna species or terrestrial migratory species considered to potentially have suitable habitat within the Project Site.

4.5.7.3 State Environmental Planning Policy 44 Koala Assessment

Schedule 1 of SEPP 44 contains a list of local government areas to which the SEPP 44 applies. Tweed LGA is included in the schedule. Schedule 2 of SEPP 44 contains a list of tree species that are favoured feed tree species of Koalas in NSW.

Potential Koala habitat is defined in the SEPP as areas of vegetation where the trees of the types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component. No Schedule 2 tree species occur within the Study Area, therefore, the Study Area is not potential Koala habitat as defined in the SEPP and hence the SEPP is not applicable.

4.5.7.4 NPWS Key Habitats and Corridors

As discussed in Section 4.5.4, the Project Site is located to the west of the Cudgen – Wommin regional wildlife corridor and does not contain any identified key habitat. However, the proposed and alternative eastern pipeline corridors traverse the Cudgen – Wommin regional corridor and the proposed eastern pipeline corridor passes through an area of identified key habitat.

As the laying or placement of the pipelines would not require the clearing of any vegetation and would not restrict the passage of fauna species, it is considered that there would be no significant impacts upon the regional corridor or key habitat.

4.5.8 Conclusion

It is considered that past land uses have severely modified the fauna habitat within the Study Area to the extent that the Study Area has little native fauna habitat value. Nevertheless, impact assessments using the Section 5A assessment of the EP&A Act ie. a "seven part test" has been prepared for TSC Act Threatened species likely to occur on or in the vicinity of the Study Area. These assessments indicate that the Project will not have a significant impact on these species provided that the recommended ameliorative measures are implemented.

An assessment using the "Environmental Guidelines" under the EPBC Act has also been prepared for migratory and Threatened species recorded on or in the vicinity of the Study Area, or considered likely to occur on or near the Study Area. It is concluded that the Project would not cause a significant impact on these species and hence the referral of the Project to the Commonwealth Environment Minister is not considered necessary.

4.6 AQUATIC ECOLOGY

4.6.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential ecological (terrestrial and aquatic) impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Disturbance to native vegetation / habitat within nominated areas (High Risk).
- Disturbance to native vegetation / habitat outside nominated areas (Moderate Risk).
- Disturbance to Threatened flora / fauna and endangered communities (High Risk).
- Disturbance leading to local population reduction (High Risk).
- Disturbance leading to local extinction(s) (Extreme Risk).
- Reduction in local biodiversity (Moderate Risk).
- Reduction in regional biodiversity (High Risk).

The following subsections describe the existing aquatic habitats within and surrounding the Project Site, the conservation significance of the existing aquatic habitats and the study methodology used. The potential impacts, both positive and negative, that the Project would have on these habitats are described together with the design and operational safeguards and management procedures to be employed.

The information presented in this section is drawn from the aquatic ecology assessment undertaken by The Ecology Lab Pty Ltd (TEL, 2008) whose full report is included in the *Specialist Consultant Studies Compendium* (Volume 1, Part 6). This subsection presents a summary of the contents of the aquatic ecology assessment report.

4.6.2 Study Methodology

Information about aquatic habitats, aquatic fauna species, commercial and recreational fishing, water quality and acid sulfate soils was obtained from available inventories, published studies and specific studies conducted by other specialist consultants for the Project. Reference is made to a fish fauna study conducted by The Ecology Lab for the RTA relating to the Yelgun to Chinderah section of the Pacific Highway upgrade. Aerial photographs and the Tweed and Cudgen 1:25 000 topographic maps were also reviewed to identify aquatic habitats within the Project Site and surrounds. A review of relevant legislation and policies was then undertaken to determine the conservation significance of any habitat likely to occur within or surrounding the Project Site.

4.6.3 Existing Aquatic Habitat

A single shallow drainage channel is aligned east-west through the southern extraction site with other drainage channels running along the southern and northern boundaries of the Project Site. A shallow drain is located between the western drain to the southern drain, however, it is of higher elevation, dry for long periods and hence of little aquatic value. **Figure 4.12** shows the identified drainage channels and surrounding vegetation communities.

The drainage channels are part of a network of straight and narrow drains connected to the Tweed River. Information from Idyll Spaces (2008) indicates that the aquatic vegetation along the western drain is dominated by the native sedge, *Schoenoplectus validus* with mats of *Bacopa monniera* on exposed mud and occasional water lilies, *Nymphaea capensis* in deeper areas of water. The drainage channels do not always contain standing water and the presence of water lilies suggests that there is very little flow and the water levels within the channels are generally shallow, however, it is possible for the channels to hold deeper water following rain periods. There is limited information on the water quality within the channels, though it is understood that the water is generally fresh and not excessively acidic, but may be poor during dry periods and become slightly brackish as a result of tidal influence.

The drainage channels are classed as Class 3 waterways ie. named or unnamed waterways with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (eg. fish and yabbies) with semi-permanent pools forming within the waterway after a rain event.

Species of freshwater fish that are likely to be found within the east-west drainage channel are listed in **Table 4.16**. There is also potential for some estuarine fish and prawns (particularly juveniles) to migrate up the drains from the Tweed River during a flood event or when floodgates are opened. Estuarine species previously identified within sections of the Tweed River where the drainage channels connect to are also included in **Table 4.16**.

No coastal lakes or wetlands are located within the Project Site or its immediate surrounds.

Table 4.16
Fish and Invertebrates known to occur in Freshwater Tributaries of the Tweed River and in the Estuarine Section of the lower Tweed River near the extraction site

Family	Species	Common Name	BIONET Search	Sampled by The Ecology Lab (2004)	Sampled by The Ecology Lab (1990)
Freshwater					
Eleotridae	*Hypseleotris compressa*	Empire gudgeon	x	x	
	Hypseleotris galii	Firetailed gudgeon	x	x	
	Gobiomorphus australis	Striped gudgeon	x	x	
	Butis butis	Flathead gudgeon	x		
	Gobiomorphus coxii	Cox's gudgeon	x		
	Hypseleotris klunzingeri	Western carp gudgeon	x		
	Philypnodon grandiceps	Big-headed gudgeon	x		
Poeciliidae	*Gambusia holbrooki*	Mosquitofish	x	x	
Ambassidae	*Ambassis jacksoniensis*		x		
	Ambassis marianus	Silver perchlet	x		
Retropinnidae	*Retropinna semoni*	Australian smelt	x		
Mugilidae	*Trachystoma petardi*	Fresh water mullet	x		
Pseudomugilidae	*Pseudomugil signifer*	Southern blue-eye	x		
Melanotaeniidae	*Melanotaenia duboulayi*	Duboulay's rainbowfish	x		
	Melanotaenia fluviatilis	Crimson-spotted rainbowfish	x		
	Rhadinocentrus ornatus	Soft-spined rainbowfish	x		
Freshwater					
Plotosidae	*Tansanus tandanus*	Freshwater catfish	x		
Perichthyidae	*Macquaria novemaculeata*	Australian bass	x		
Estuarine					
Clupeidae	*Harrengula abbreviata*	Southern herring			x
	Hyperlophus vittatus	Sandy Sprat			x
Engraulidae	*Engraulis australis*	Australian anchovy			x
Hemiramphidae	*Arrhamphus sclerolepis*	Snubnosed garfish			x
Scorpaenidae	*Centropogon australis*	Fortescue			x
Platycephalidae	*Platycephalus fuscus*	Dusky flathead			x
Ambassidae	*Priopidichthys marianus*	Ramsay's perchlet			x
	Vellambassis jacksoniensis	Port Jackson perchlet			x
Teraponidae	*Pelates quadrilineatus*	Trumpeter			x
Sillaginidae	*Sillago ciliata*	Sand whiting			x
Pomatomidae	*Pomatomus saltator*	Tailor			x
Gerridae	*Gerres ovatus*	Silver biddy			x
Sparidae	*Acanthropagrus australis*	Yellowfin bream			x
	Rhabdosargus sarba	Tarwhine			x
Monodactylidae	*Monodactylus argenteus*	Silver batfish			x
Scorpipidae	*Microcanthus strigatus*	Stripey			x

Table 4.16 (Cont'd)
Fish and Invertebrates known to occur in Freshwater Tributaries of the Tweed River and in the Estuarine Section of the lower Tweed River near the extraction site

Page 2 of 2

Family	Species	Common Name	BIONET Search	Sampled by The Ecology Lab (2004)	Sampled by The Ecology Lab (1990)
Estuarine (Cont'd)					
Mugilidae	*Liza argentea*	Flat-tail mullet			x
	Mugil cephalus	Sea mullet			x
	Myxus elongatus	Sand mullet			x
Sphyraenidae	*Sphyraena* sp.				x
Blenniidae	*Petroscirtes lupus*	Brown sabertooth blenny			x
Gobiidae	*Arenigobius bifrenatus*	Bridled goby			x
	Arenigobius frenatus				x
	Bathygobius kreffti	Kreft's goby			x
	Callogobius dpressus				x
	Favonigobius exquisitus	Exquisite goby			x
	Parkraemaria cf. ornata				x
	Pseudogobius olorum	Swan River goby			x
	Redigobius macrostoma	Large-mouth goby			x
Eleotridae	*Philypnodon grandiceps*	Flathead gudgeon			x
	Philypnodon sp.				x
Monocanthidae	*Meuschenia trachylepis*	Yellowfinned leatherjacket			x
Bothidae	*Pseudorhombus* sp.				x
Soleidae	*Achlyopa nigra*	Black sole			x
	Aseraggodes macleayanus	Macleay's sole			x
Tetradontidae	Unidentified species	Toad fish			x
Source: TEL (2008) – Table 1					

4.6.4 Conservation Significance

Assessment of the aquatic habitat together with desktop searches of Threatened species databases indicate that there are no Threatened species, population or ecological communities or areas of conservation significance that are likely to be affected by the Project.

The only potential for Threatened species to be affected by the Project would be in the event that acid sulfate soils, sediments or VENM(b) are not managed correctly and acidic water enters the drainage channels and subsequently enters the Tweed River.

4.6.5 Design and Operational Safeguards

As part of the realignment of the western drainage channel (approved as part of the realignment of Altona Drive), care would be taken to:

- maintain the original connection to other upstream and downstream drainage channels;

- avoid stranding native fish and, where possible, relocate them to similar habitat; and
- where permanent crossing are to be constructed (eg. access road crossings), they allow fish free passage through the channel.

Throughout the operations, fringing wetlands would be created along finalised sections of the dredge pond (see Sections 2.6.4 and 2.14.3.2). These wetlands would not only provide valuable aquatic habitat but would also act to reduce nutrient loads entering the dredge pond and final lake and metabolise nutrients within the water. Once the southern extraction pond has reached a suitable size, consideration would also be given to the introduction of appropriate fish species that would graze upon any algae and hence assist in controlling blooms. DPI (Fisheries) would be consulted prior to the release of any fish into the southern extraction pond.

Additionally, a Blue-Green Algae Management Plan would be developed which would include a monitoring program. Water monitoring would include measurements of:

- temperature;
- dissolved oxygen;
- concentrations of blue-green algae;
- colour; and
- nutrients (nitrogen and phosphorous).

As algal blooms can develop rapidly, frequent and regular monitoring (i.e. weekly) would be undertaken during summer and monthly monitoring during winter. Samples and readings would be obtained from the upper 0.5m of the water at least at four locations around the periphery of the dredge pond and two in the centre.

Water quality within the extraction ponds, any drainage from the extraction sites and groundwater would also be monitored to ensure excessive acidity does not occur. Care would also be taken to adequately handle and treat potential acid sulfate soils. Management of acid sulfate soils / sediments and VENM(b) is outlined within Sections 2.6, 2.7.2 and 4.3.5.

4.6.6 Assessment of Impacts

It is assessed that the main component of the Project of direct relevance to aquatic ecology would be the creation of a 37ha artificial lake (the completed southern extraction pond). The artificial lake has the potential to have positive impacts through the creation of a lake with attributes similar to other freshwater lakes on coastal floodplains. These habitats are recognised as endangered ecological communities under the TSC Act.

The water quality within the lake and depth stratification would be similar to the profile for groundwater with the surface waters being fresh and the deeper waters (>15m deep) brackish. The horizontal flow of groundwater from the Cudgen Plateau may also dilute the surface layers reducing nutrient accumulation. However, some stratification of the water would be expected due to the temperature differences between the surface water and deeper water, particularly during summer. This, combined with potential nutrient rich runoff water from surrounding land creates the possibility of blue-green algal blooms.

The establishment of wetlands and a Blue-Green Algae Management Plan, including a monitoring program, as discussed in Section 4.6.5 would reduce the potential for algal blooms to occur and allow the early detection of conditions which could result in the formation of an algal bloom. In the event that blue-green algae levels exceed acceptable criteria, measures to reduce the risk of human exposure would be implemented. As there would be no surface water discharge from the extraction ponds, except in the event of a flood, there would be limited risk to humans or wildlife external to the Project Site.

Although approved under development consent, DA 05/1450, the realignment of the western drainage channel would be undertaken in accordance with the design and operational safeguards described in Section 4.6.5 and in consultation with local DPI (Fisheries) and DECC officers. Considering the relatively low habitat value of the existing east-west drain and the proposed operational and design measures, it is expected that no significant impacts to aquatic ecology would occur. Furthermore, the crossing of the drainage channels by pipelines carrying fill sand would unlikely have any impact upon aquatic ecology.

Should adequate management of acid sulfate soils and sediments be undertaken during the operation there is also limited potential for damage to aquatic ecology from contaminated surface drainage or groundwater.

4.6.7 Conclusions

Based on the proposed operational and design measures it is concluded that the Project would:

- have no significant impact on existing aquatic habitat or Threatened species or population; and
- result in the creation of a coastal freshwater lake providing additional habitat that would potentially be recognised as an endangered ecological community.

4.7 TRANSPORTATION

4.7.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential traffic and transport impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Increased traffic congestion (Medium Risk).
- Road pavement deterioration (High Risk).
- Elevated risk of accidents/incidents on local roads (Medium to High Risk).

The following subsection draws upon the traffic and transport assessment completed by Veitch Lister Consulting Pty Ltd (VLC, 2007) and includes information on:

- the context of the existing road network, including existing road classifications, traffic levels and safety considerations (Section 4.7.2);
- the Project-related roadworks and proposed traffic types and levels (Sections 4.7.3.5 and 4.7.4);
- the proposed management of traffic and operational safeguards (Section 4.7.5); and
- an assessment of the potential impacts of the Project and Project-related roadworks on the local and regional road network and road users (Section 4.7.6).

VLC (2007) is presented in full as Part 7 in Volume 2 of the *Specialist Consultant Studies Compendium*.

4.7.2 The Existing Environment

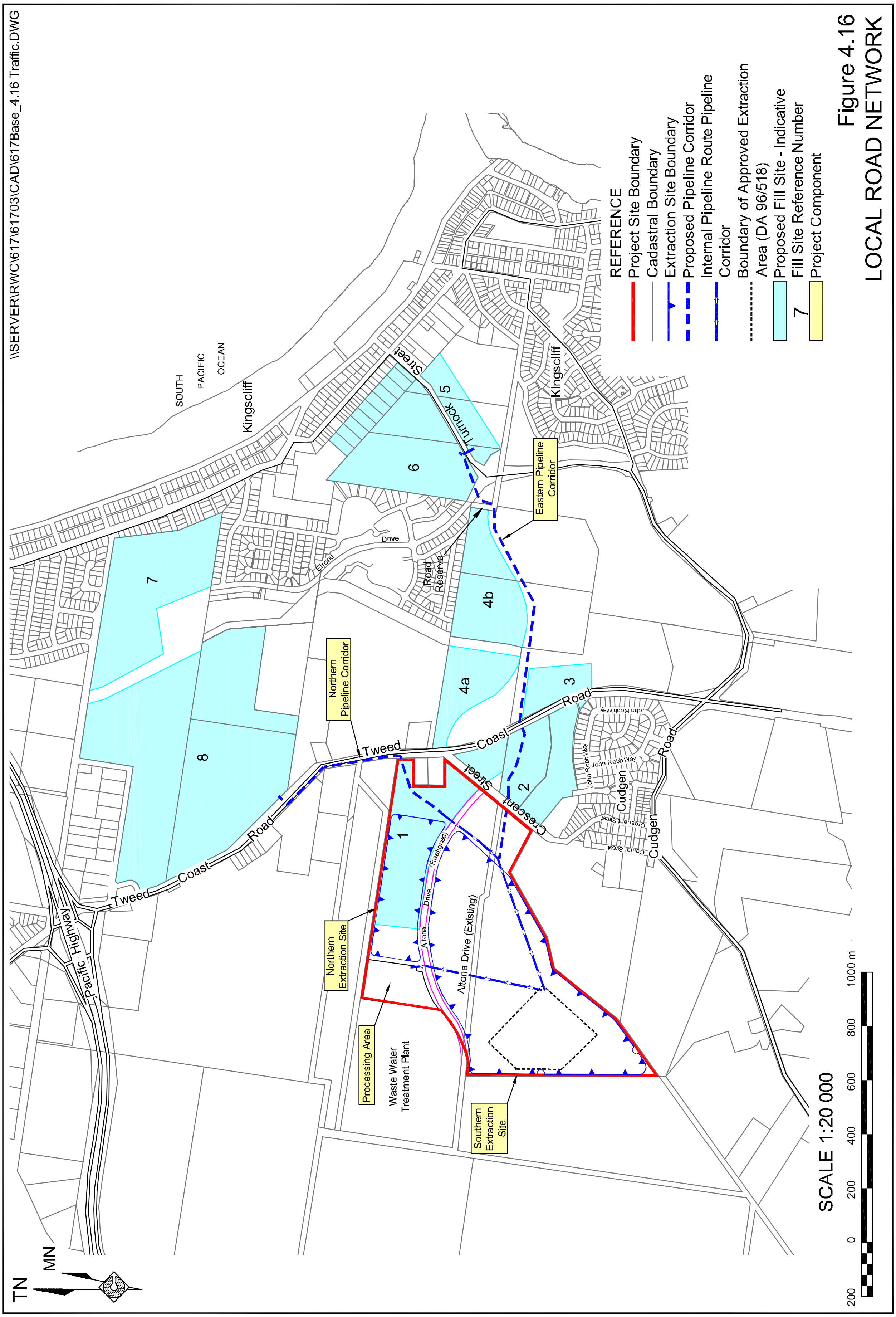
4.7.2.1 Existing Road Network

The Project Site straddles the existing alignment of Altona Drive approximately 1.5km south of the Tweed Coast Road - Pacific Highway interchange. **Figure 4.16** displays the relationship between the Pacific Highway, Tweed Coast Road, Cudgen Road, Crescent Street, Altona Drive and the remaining local roads around the Project Site.

The Pacific Highway is a State highway (SH10) which provides regional links between Byron Bay, the Gold Coast and Coolangatta airport. The Pacific Highway also provides local links between Murwillumbah, the Tweed Coast and the urban north. In the vicinity of the Project Site, the Pacific Highway is a high speed, divided, two-lane, two-way highway under the management of the RTA.

Tweed Coast Road (MR 450) and Cudgen Road are undivided, two-lane, two-way sub-arterial roads under the control of Tweed Shire Council. Tweed Coast Road links the coastal villages and connects them to the Pacific Highway at Chinderah to the north of the Project Site and Wooyung to the south of the Project Site whilst Cudgen Road provides east-west connectivity between the coast and Murwillumbah. Cudgen Road intersects with Tweed Coast Road directly to the southeast of Cudgen Heights Estate.

Crescent Street and Altona Drive are local roads both controlled by Tweed Shire Council. Crescent Street is a 6m wide (approximately) two-lane, two-way sealed road exiting west off Tweed Coast Road and providing access to Cudgen residential area before joining with Cudgen Road. The southern section of Crescent Street has a 10t vehicle limit. Altona Drive exits west from Crescent Street and currently has a 7m to 8m wide sealed width for the eastern 15m reducing to a 4m to 6m sealed width for the balance of the road to the new Kingscliff WWTP. Altona Drive provides access to the existing Hanson Tweed Sand Quarry, the new Kingscliff WWTP and the Australian Bay Lobster Farm. As discussed in Section 1.4.5.4, development consent has been granted for the realignment and upgrade of Altona Drive.


\\SERVER\RWC\617\61703\CAD\617Base_4.16 Traffic.DWG
SOUTH PACIFIC OCEAN
Kingscliff
Kingscliff
Cudgen
Tweed Coast Road
Pacific Highway
Turnock Street
Crescent Street
Cudgen Road
Altona Drive (Existing)
Altona Drive (Realigned)
Elrond Drive
Road Reserve
John Robb Way
Collier Street
Northern Pipeline Corridor
Eastern Pipeline Corridor
Northern Extraction Site
Southern Extraction Site
Processing Area
Waste Water Treatment Plant
1
2
3
4a
4b
5
6
7
8
REFERENCE
Project Site Boundary
Cadastral Boundary
Extraction Site Boundary
Proposed Pipeline Corridor
Internal Pipeline Route Pipeline Corridor
Boundary of Approved Extraction Area (DA 96/518)
Proposed Fill Site - Indicative
Fill Site Reference Number
Project Component
Figure 4.16
LOCAL ROAD NETWORK
SCALE 1:20 000
200 0 200 400 600 800 1000 m
TN
MN

4.7.2.2 Traffic Levels and Conditions

Numerous traffic counts have been undertaken on roads in the vicinity of the Project Site, however, most of these are outdated. A more complete and recent estimate of daily traffic volumes has been sourced from a traffic model of the Tweed LGA road network developed by VLC in 2004. **Figure 4.17** shows estimated daily traffic volumes for major roads in the area, as of 2001, whilst **Table 4.17** compares the daily capacity and estimated daily traffic volumes for selected local roads as of 2007. **Table 4.17** indicates that most of the key roads within the local area are currently operating well within their daily capacities.

Table 4.17
Performance of Surrounding Road Links in 2007

Road / Location#	Lanes	Daily Capacity	Est. 2007 Volume	V/C*
Pacific Highway:				
At Tweed River	6	120 000	42 000	0.35
North of Chinderah	6	120 000	32 000	0.27
South of Chinderah	4	70 000	25 000	0.36
South of Tweed Valley Way	4	70 000	17 500	0.25
Tweed Coast Road:				
North of Cudgen Road	2	15,000	12 000	0.80
South of Cudgen Road	2	15,000	9 000	0.60
Cudgen Road:				
East of Tweed Coast Road	2	12,000	7 000	0.58
West of Tweed Coast Road	2	10,000	1 750	0.18
Crescent Street	2	3,000	500	0.17

*V/C = volume to capacity ratio #see **Figure 4.18**

Source: VLC (2007) – Table 3.1

A number of key intersections surrounding the Project Site through which most of the traffic generated by the Project would travel were examined by VLC during February 2006. At each key intersection, turning movement counts were conducted as follows.

- PM counts from 3:00pm to 5:00pm (Thursday, 9 February 2006).
- AM counts from 7:30am to 9:30am (Friday, 10 February 2006).

The peak 1-hour turning movement demands at four selected intersections are displayed in **Figure 4.18** whilst **Table 4.18** shows indicators of the performance of each intersection.

Table 4.18 indicates that three out of the four intersections are operating well within their operating capacities each with low degrees of saturation and excellent levels of service[1], generally ranging between A and C during peak times. The intersection of Tweed Coast Road and Cudgen Road, however, operates at a higher degree of saturation and a lower level of service.

[1] Level of Service is a qualitative measure describing operational conditions within a traffic stream and takes into account service measures such as speed and travel time, freedom to manoeuvre, traffic interruptions, safety, comfort and convenience. There are six levels of service, designated A (best – free flow) to F (worst – breakdown in flow) (Austroads, 1988).

\\SERVER\RWC\617\61703\CAD\617Base_4.17 Traffic Vol.DWG

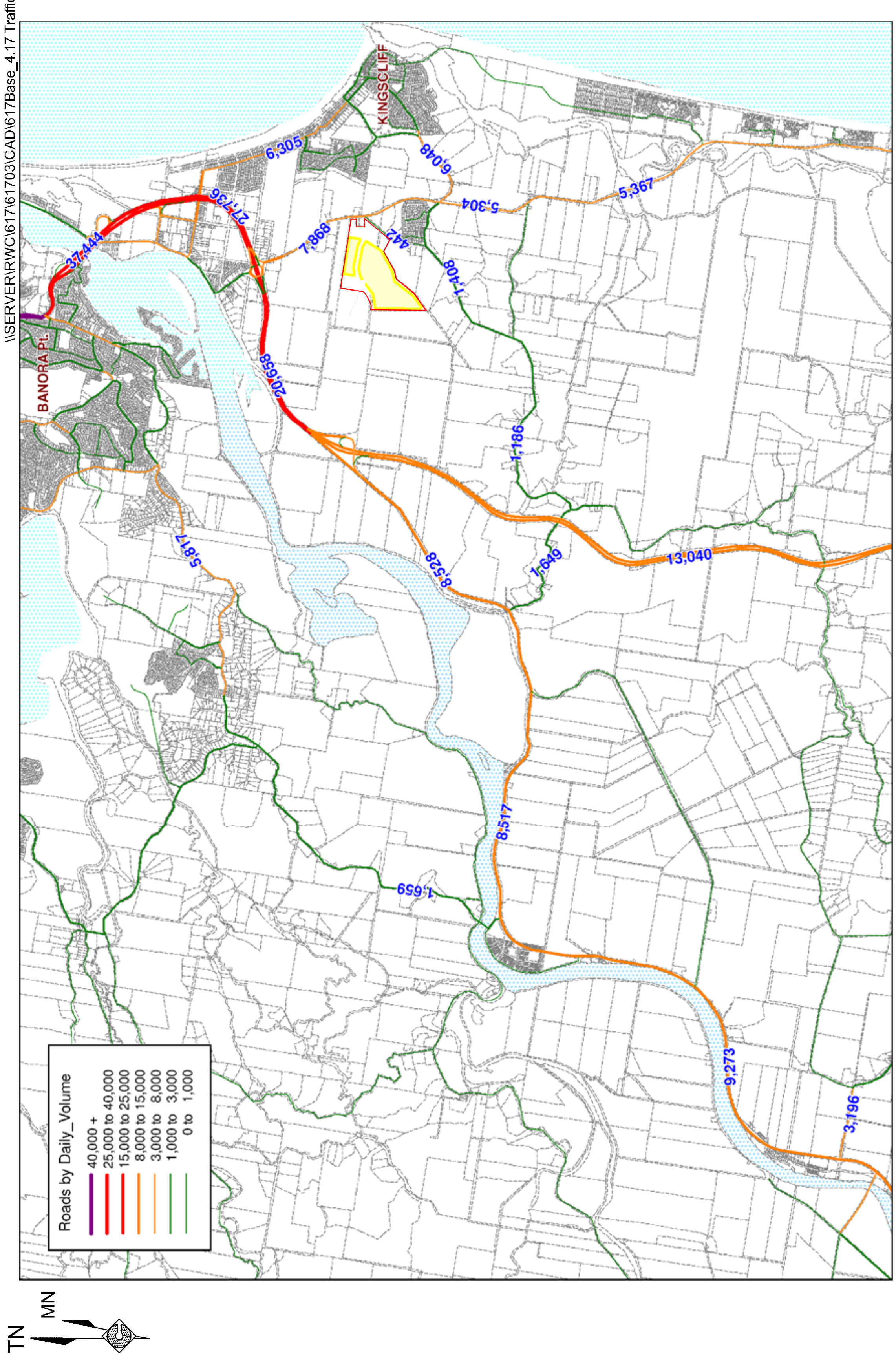
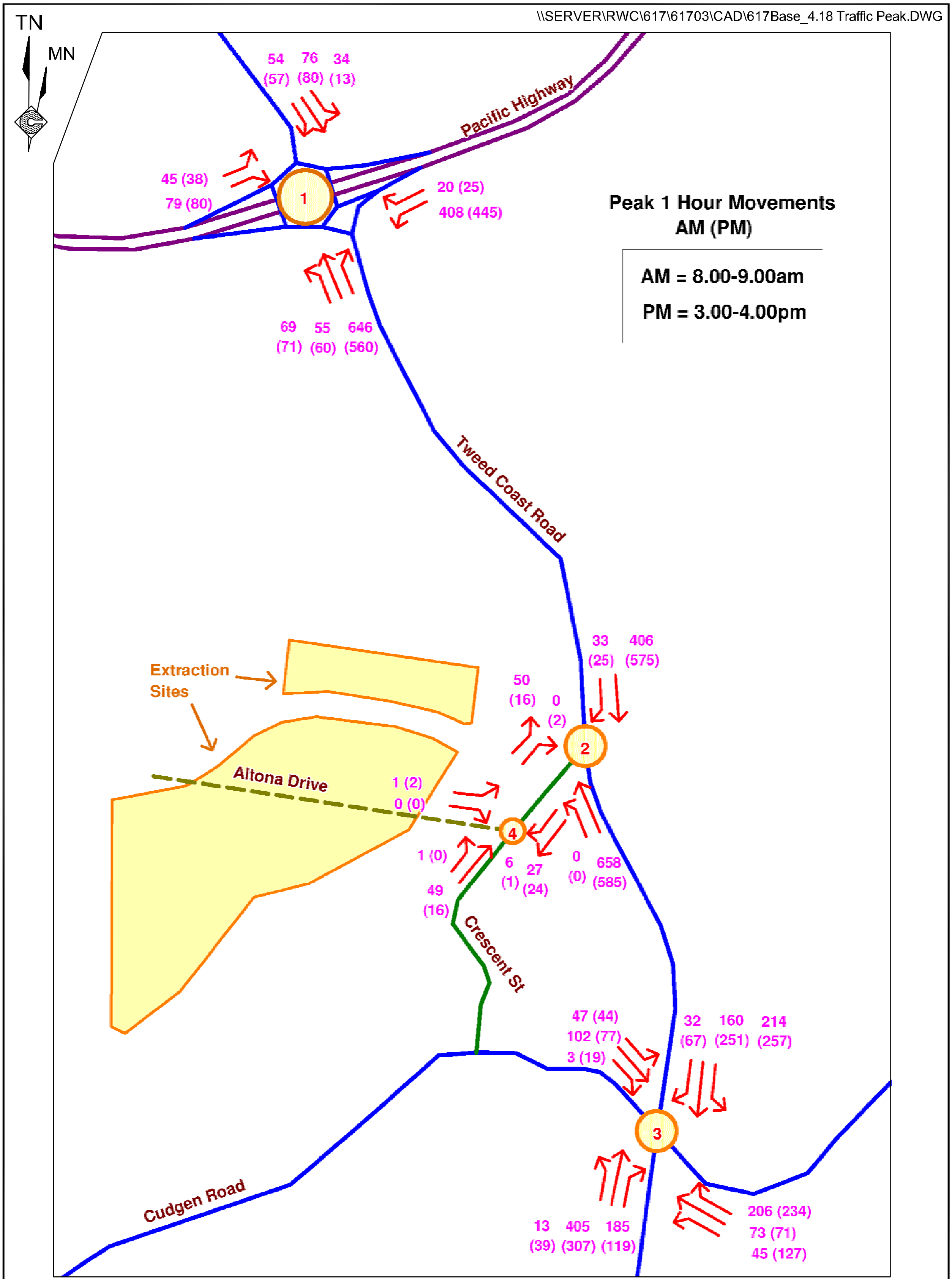


Figure 4.17
FORECAST 2001 DAILY TRAFFIC VOLUMES

Source: Modified after VLC (2007) - Figure 3.2



Source: VLC (2007) - Figure 3.3

Figure 4.18
INTERSECTION PEAK HOUR TURNING MOVEMENTS (February 2006)

Table 4.18
Performance of Existing Intersections (in 2006)

Intersection	Type	Degree of Saturation		Level of Service(1)	
		AM	PM	AM	PM
1. Pacific Highway / Tweed Coast Rd	R'bout	0.39	0.33	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.37	0.34	A / D	A / C
3. Tweed Coast Rd / Cudgen Rd	Signals(2)	0.73	0.82	C / D	C / D
	Signals(3)	0.66	0.59	C / D	C / D
4. Crescent St / Altona Dr.	Priority	0.03	0.02	A / B	A / B

Notes :
1. Intersection Overall / Worst Major Movement.
2. With pedestrian crossing critical, at optimum cycle time = 80 secs.
3. With pedestrian crossing ignored, at optimum cycle time = 60 secs.

Source: VLC (2007) – Table 3.2

The layout and signal phasing of the intersection of Tweed Coast Road and Cudgen Road provides for a pedestrian crossing movement which influences the overall cycle time. Taking into account clearance time for pedestrians, the degree of saturation during peak times is relatively high with an adequate level of service ranging from 'C' to 'D'. It was noted during the survey, however, that pedestrian demand was relatively low. Ignoring the pedestrian clearance time, the degree of saturation improves allowing the intersection to operate more efficiently.

For each intersection survey, a breakdown of traffic types is either not available or questionable. However, based on observation of VLC (2007) the proportions of heavy vehicles are estimated to be between 7% to 9% for Tweed Coast Road and 15% to 18% for Crescent Street. The relatively high proportion of heavy vehicles on Crescent Street is attributed to a lower base traffic volume, bus movements and truck movements from the existing Hanson Tweed Sand Quarry.

It is noted that, despite its adequate performance, the Tweed Coast Road and Crescent Street intersection does not fully comply with Austroads' standards. The primary aspect of the intersection which requires modification is the right turn off Tweed Coast Road for which a channelised right turn lane is justified. The required modification appears achievable through the use of signs and line markings (VLC, 2007) and should be considered by Tweed Shire Council regardless of whether or not the Cudgen Lakes Sand Extraction Project proceeds.

Other than the pedestrian crossing at the intersection of Tweed Coast Road and Cudgen Road, there are no other pedestrian or cyclist facilities (ie. footpaths, cycling lanes, pedestrian crossings etc). Some occasional pedestrian traffic has been observed, however, by R.W. Corkery & Co. Pty Limited within the road reserve for Crescent Street.

4.7.2.3 Road Safety Conditions

Accidents rates are a measure of road safety used to assess the safety of the local road network. Accident records for the local road network were obtained from the RTA for a 5 year period between October 2001 and September 2006. **Table 4.19** presents a summary of all recorded intersection and mid block accidents in this time period.

Table 4.19
Summary of Accidents Surrounding the Project Site (October 2001 to September 2006)

Location	Accident Severity			Heavy Vehicle Accident	Light Vehicle Accident*	Total Vehicle Accidents
	Killed	Injury	Non injury			
INTERSECTION						
Tweed Coast Road with						
• Pacific Highway	0	4	8	1	11	12
• Crescent Street	0	0	0	0	0	0
• Cudgen Road	0	7	8	0	15	15
Crescent Street with Altona Drive	0	0	0	0	0	0
Intersection Total	**0**	**11**	**16**	**1**	**26**	**27**
MIDBLOCK						
Tweed Coast Road (Cudgen Road to Pacific Highway)	0	6	13	2	17	19
Crescent Street	0	1	0	0	1	1
Cudgen Road (Pacific Highway to Tweed Coast Road)	0	8	10	2	16	18
Altona Drive	0	0	0	0	0	0
Midblock Total	**0**	**15**	**23**	**4**	**34**	**38**
Total	**0**	**26**	**39**	**5**	**60**	**65**
Source: NSW RTA (2007)	*Includes motorcycles					

No fatal accidents were recorded within this time period and accidents resulting in no injury accounted for 60% of all recorded accidents (39 of 65). Mid block accidents accounted for 60% of all accidents (38 of 65) with the remaining 40% of accidents (27 of 65) occurring at intersections. Notably, only a small proportion (8%), of total accidents involved heavy vehicles and no accidents have occurred at the intersection of Tweed Coast Road and Crescent Street.

Also of note, only once accident, occurring on Cudgen Road, involved pedestrians.

4.7.3 Future Road Network and Traffic Levels

Expected changes to the surrounding road network over the life of the Project include the duplication of Tweed Coast Road from the Pacific Highway to Casuarina between approximately 2011 and 2016 with the northern section (between Crescent Street and the Pacific Highway) expected to be upgraded first. A range of other road improvements and additional road linkages are also likely to occur as part of the Proponent's Structure Plan, however, these improvements will be subject to separate approval.

As seen in **Table 4.17**, existing traffic levels are well below the existing capacity of the daily capacity of selected roads. **Table 4.20** presents the peak morning and afternoon peak traffic volumes on Tweed Coast Road under ambient conditions (without the Project) during 2008, 2011 and 2023. It is noted that the traffic estimates for the year 2023 actually account for the expected ultimate development of the area.

Table 4.20
Predicted Future Ambient Traffic Levels

Road / Location#	Direction	Predicted Ambient Volume 2008		Predicted Ambient Volume 2011		Predicted Ambient Volume 2023	
Tweed Coast Road		AM	PM	AM	PM	AM	PM
South of Pacific Highway	North Bound	828	738	914	810	1517	1574
	South Bound	612	659	688	742	1295	1234
North of Cudgen Road	North Bound	716	618	803	670	-	-
	South Bound	438	625	484	701	-	-
South of Cudgen Road	North Bound	662	510	752	581	-	-
	South Bound	238	451	284	532	-	-

Source: Modified after VLC (2007) – Tables 6.2, 6.5 and 6.9. # See **Figure 4.18**

4.7.4 Project-related Roadworks and Traffic

4.7.4.1 Project-related Roadworks

As discussed in Section 2.9.2, Altona Drive is to be realigned in accordance with DA 05/1450 prior to sand extraction within the southern extraction site reaching the existing alignment of Altona Drive. However, prior to despatch of construction sand products from the processing area or the receipt of VENM (ie. prior to the generation of any significant operational heavy vehicle movements attributable to the Project), the upgraded intersection of Altona Drive and Crescent Street (see detail of **Figure 4.19**) would be constructed together with a short section of road to link with the existing Altona Drive. An additional two passing bays along the existing alignment of Altona Drive would also be constructed.

The new intersection would include the relocation of the existing intersection approximately 50m to the north and would include a right turn lane from Crescent Street to Altona Drive with appropriate markings and traffic islands on both Altona Drive and Crescent Street for safe pedestrian crossing. The realigned Altona Drive would be upgraded to a two-lane, 7m wide carriageway with 1m unsealed shoulders on both sides.

Four entrances to the Project Site would also be constructed from Altona Drive which would involve the sealed carriageway of Altona Drive being flared out to 9m wide for approximately 15m in advance of each access (from the right hand turn perspective) using a 25m transitional length. Each Project Site access road would be 10m wide at its intersection with Altona Drive providing a 15m inside radius for the left hand turn out.

4.7.4.2 Project-related Traffic

Section 2.9.5 presented the estimated traffic types and volumes to be generated by the Project during both the site establishment and construction phase and during normal operations. During site establishment and construction, it is estimated that maximum daily traffic movements would be approximately 66 movements (33 return trips) of which about 8 movements (4 return trips) would be by heavy vehicles. Morning and afternoon peak traffic levels during site establishment would be approximately 18 in bound movements and 18 outbound movements respectively. Site establishment and construction would occur over a period of approximately 3 months.

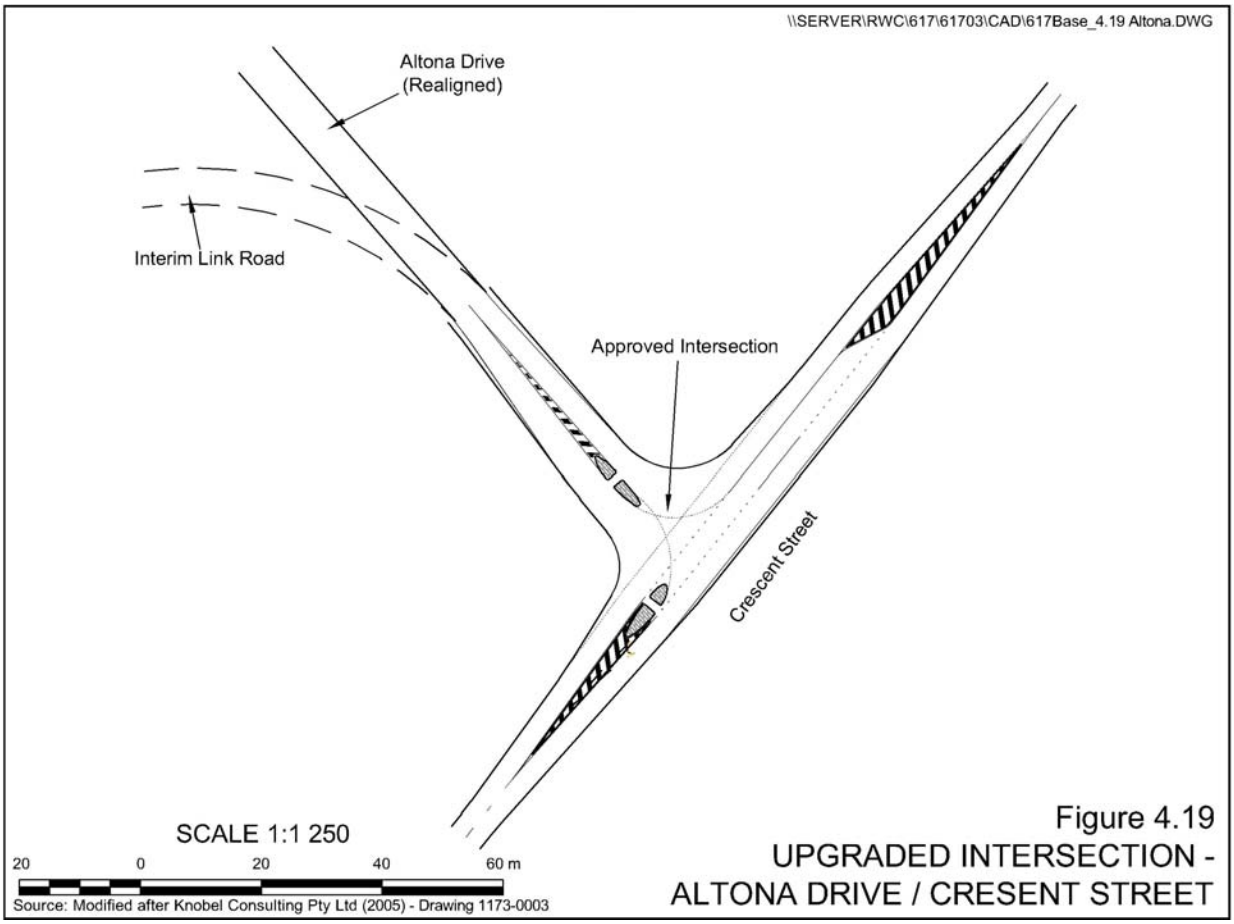


Figure 4.19
UPGRADED INTERSECTION -
ALTONA DRIVE / CRESENT STREET

Table 4.21 provides a summary of vehicle movements for the various activities that would occur during normal operations.

Table 4.21
Summary of Operational Vehicle Movements

Activity	**Maximum External Traffic Movements**		
	Week Days	**AM Peak Hr.**	**PM Peak Hr.**
1. Staff	16	5 inbound	5 outbound
2. Site Servicing	16	1 in / 1 out	1 in / 1 out
3. Pipeline Inspection / Operation	4	1 in / 1 out	1 in / 1 out
4. Product Distribution	130*	7 in / 6 out	6 in / 7 out
5. VENM Importation	40*	2 in / 2 out	2 in / 2 out
6. Excavation (Intermittent)	10	3 inbound	3 outbound
Total	216	19 in / 10 out	10 in / 19 out
Source: Modified after VLC (2007) – Table 5.3			* 85th Percentile

A number of 'internal' truck movements related to carriage of VENM and loamy sand between the southern extraction site and the processing area / northern extraction site would also occur and would necessitate the crossing of Altona Drive. As the access gates would be located opposite each other, travel between the processing area / northern extraction site and southern extraction site would simply involve the crossing of Altona Drive without the need to travel along Altona Drive.

It is important to note that the total maximum traffic levels in **Table 4.21** are highly unlikely to occur as it is assumed that all activities occur simultaneously and that the maximum traffic levels associated with these activities all occur on the same day. Furthermore, the traffic levels associated with product distribution and VENM receipt do not allow for any back loading of materials, which is more economical and operationally practical and hence would be undertaken, whenever possible.

It is also noted that, as most operational activities commence prior to the observed morning peak hour (8:00am to 9:00am) and cease after the afternoon peak hour (3:00pm to 4:00pm), most onsite employee related trips to and from the Project Site would not occur during the observed peak hour traffic times.

However, for assessment purposes, the impact assessment has been based upon the worst case scenario, ie. the total combined maximum traffic movements of all activities occurring simultaneously and peak traffic movements occurring during observed peak hour traffic times.

4.7.5 Operational Safeguards and Management Measures

As discussed in Section 4.7.4.1, a range of design measures would be implemented including the construction of the upgraded intersection of Altona Drive and Crescent Street, appropriately designed Project Site access intersections and the eventual realignment and upgrade of Altona Drive.

In addition to these design measures, a range of safeguards and management measures would also be implemented.

During site establishment, few traffic management controls would be required other than the use of warning signs and limited manual traffic control such as temporary speed limits. These controls would primarily be required during the laying of pipelines adjacent to Tweed Coast Road and during the underboring of the road crossings. The majority of work would be undertaken well clear of the carriage way. The location of services would be confirmed prior to any digging or underboring operations.

During normal operations, following the implementation of the various design features described in Section 4.7.4.1, the level of impact associated with the proposed transportation of construction sand products and importation of VENM would ultimately depend on the management of heavy vehicles entering and exiting the Project Site. The following management procedures and operational safeguards are proposed and would be implemented.

- Product despatch and VENM receipt would only be undertaken within the proposed (and subsequent approved) hours of operation (see **Table 2.3**), that is, no vehicles would enter or leave the Project Site outside the designated hours.
- All speed limits would be strictly adhered to.

- No vehicles would be permitted to turn right from Crescent Street to Tweed Coast Road (unless appropriate upgrades of the intersection are undertaken during the duplication of Tweed Coast Road). All south-bound vehicles would need to make an appropriate turn at the Pacific Highway – Tweed Coast Road interchange.
- No heavy vehicles would be permitted to turn right from Altona Drive to Crescent Street (due to the 10t limit).
- Hinged or unhinged truck turning signs would be erected as appropriate at suitable locations on Altona Drive, Crescent Street and Chinderah Road and be displayed during operational hours. Should hinged signs be utilised, discussions would be held with the management at Hanson Tweed Sand Quarry to ensure appropriate display of the signage during operations at both quarries.
- The Proponent would establish a telephone complaints line, advertised in the local telephone directory, to enable any traffic-related incidents, unsafe operation or general concern to be reported. The Proponent would investigate all complaints and act decisively on substantiated incidents.
- All exiting trucks would use an on-site weighbridge to ensure all RTA weight restrictions are adhered to.
- Mechanical road sweeping on Altona Drive and the Project Site entrances would be undertaken, when required, to reduce the potential for dust lift-off.
- The Proponent would ensure all product loads are covered to minimise dust, particulate matter and debris emissions.

Additionally, a truck drivers code of conduct would be implemented and be required to be signed by all Company employed or contracted truck drivers. The code would outline the truck drivers responsibility and the process undertaken in the event of a complaint.

4.7.6 Assessment of Impacts

4.7.6.1 Introduction

Traffic would be generated by the Project at various stages and through various activities. The critical stages of the Project relating to traffic generation which have been assessed are the site establishment and construction and operational phases. In undertaking the impact assessment, consideration has been given to the changes in the surrounding road network and ambient traffic levels throughout the Project life (see Section 4.7.3).

The site establishment scenario has been undertaken based upon works being completed during 2008 when the surrounding road network would be unchanged from that which currently exists. However, the assessment of the operational phase has considered two scenarios accounting for expected changes to the surrounding road network and changes to the ambient traffic levels.

These scenarios are as follows.

- In 2011, with the surrounding road network as it currently exists, except with the new intersection of Altona Drive and Crescent Street.
- In 2023, with Tweed Coast Road duplicated and the realignment of Altona Drive completed.

4.7.6.2 Site Establishment - 2008

2008 Ambient Traffic Conditions

Pending project approval, site establishment is expected to occur during 2008. It is noted that the first stage of the Kingscliff WWTP construction will have been completed and therefore this construction-related traffic has not been further considered. The performance of surrounding key intersections under the predicted ambient traffic during 2008 is shown in **Table 4.22**.

Table 4.22
Performance of 'Existing' Intersections in 2008 Ambient Scenario

Intersection	Type	Degree of Saturation		Level of Service(1)	
		AM	PM	AM	PM
1. Pacific Hwy / Tweed Coast Rd	R'bout	0.42	0.36	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.41	0.36	A / D	A / C
3. Tweed Coast Rd / Cudgen Rd	Signals(2) Signals(3)	0.80 0.68	0.89 0.63	C / D C / D	C / E C / D
4. Crescent St / Altona Dr (realigned)	Priority	0.03	0.02	A / C	A / B

Notes :
1. Intersection overall / worst major movement.
2. With pedestrian crossing critical, at optimum cycle time = 80 secs.
3. With pedestrian crossing ignored, at optimum cycle time = 60 secs.

Source: VLC (2007) – Table 6.1

Traffic Conditions During Site Establishment

It is estimated that the maximum traffic likely to be generated by the Project throughout site establishment activities would include 18 inbound vehicles during the morning peak hour and 18 outbound vehicles during the afternoon peak hour. It is likely that the majority of these movements would occur to and from the north, however, two worst case scenarios have been used to assess the potential impacts of the Project, namely:

- Scenario A – all traffic to/from the north; and
- Scenario B – all traffic to/from the south.

Table 4.23 provides a summary of the performance of the four key intersections under Scenarios A and B.

Table 4.23
Performance of 'Existing' Intersections in the 2008 Site Establishment Scenarios

Intersection	**Type**	**Degree of Saturation**		**Level of Service**(1)	
		AM	**PM**	**AM**	**PM**
Scenario A:					
1. Pacific Hwy / Tweed Coast Rd	R'bout	0.42	**0.38**	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.41	0.36	A / D	A / D
4. Crescent St / Altona Dr.	Priority	**0.04**	**0.03**	A / C	A / B
Scenario B:					
3. Tweed Coast Rd / Cudgen Rd	Signals(2) Signals(3)	0.80 0.68	0.89 0.63	C / D C / D	C / E C / D
4. Crescent St / Altona Dr.	Priority	**0.04**	**0.03**	A / C	A / B

Notes : 1. Intersection overall / worst major movement.
2. With pedestrian crossing critical, at optimum cycle time = 80 secs.
3. With pedestrian crossing ignored, at optimum cycle time = 60 secs.

Source: VLC (2007) – Table 6.3

Performance measures in bold indicate those which have changed as a result of the Project. As can be seen in **Table 4.22** and **4.23,** there would be very little change to the performance of the surrounding key intersections as a result of the Project with all intersections continuing to operate satisfactorily.

Based upon the predicted 2008 ambient traffic levels presented within **Table 4.20** the percentage increase in traffic levels on Tweed Coast road would range from 2.4% south of the Pacific Highway during the afternoon peak hour to 4.0% south of Cudgen Road during the afternoon peak hour.

4.7.6.3 Normal Operations - 2011

2011 Ambient Traffic Conditions

The performance of surrounding key intersections under the predicted ambient traffic during 2011 is shown in **Table 4.24**.

Table 4.24
Performance of 'Existing' Intersections in 2011 Ambient Scenario

Intersection	**Type**	**Degree of Saturation**		**Level of Service**(1)	
		AM	**PM**	**AM**	**PM**
1. Pacific Hwy / Tweed Coast Rd	R'bout	0.48	0.40	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.50	0.40	A / E	A / D
3. Tweed Coast Rd / Cudgen Rd	Signals(2) Signals(3)	0.86 0.76	0.88 0.75	C / E C / D	C / E C / D
4. Crescent St / Altona Dr.	Priority	0.03	0.02	A / B	A / B

Notes : 1. Intersection overall / worst major movement.
2. With pedestrian crossing critical, at optimum cycle time = 80 secs.
3. With pedestrian crossing ignored, at optimum cycle time = 60 secs.

Source: VLC (2007) – Table 6.4

It is noted that the results of the 2011 ambient traffic scenario indicate that the intersection performances of the three intersections along Tweed Coast Road will have experienced moderate decreases in performance compared to the 2008 ambient scenario (see **Table 4.22**). In particular, the Tweed Coast Road and Crescent Street intersection would provide a poor level of service (E) for traffic turning out of Crescent Street.

VLC (2007) considers that the expected delays to turn left from Crescent Street are not excessive, however, they would be in the "grey zone". The expected delays to turn right from Crescent Street, however, would be excessive and would encourage drivers to take excessive risk. Hence, the requirement for all south-bound truck drivers to turn left and travel to the Chinderah Roundabout to then travel southwards.

It is important to note that these conditions have been predicted in the absence of Project-related traffic and hence, regardless of whether or not the Project proceeds, improvement of this intersection should be considered by at least early 2011 for the ongoing use of the intersection by existing users, including the Hanson Tweed Sand Quarry and traffic travelling to and from the Waste Water Treatment Plant.

Traffic Conditions During Operations

As for the site establishment scenario, for the operational scenarios it is difficult to predict which direction Project-related traffic would travel to and from the Project Site as the product destination and VENM sources may vary from day to day. Therefore three scenarios have been used to assess worst case scenarios, namely:

- Scenario A – all traffic to/from the north;
- Scenario B – all traffic to/from the south; and
- Scenario C – all traffic to/from the west.

Table 4.25 provides a summary of the performance of the four key intersections under Scenarios A, B and C.

Performance measures in bold indicate those which have changed as a result of the Project. As can be seen in **Table 4.24** and **4.25,** the additional traffic related to the Project would have very little impact on the peak hour performance of these key intersections. Of particular note is that the potential increase in the average delays for turning northwards out of Crescent Street onto Tweed Coast Road, as a result of the Project, would be minimal and as such would not increase the degree of saturation or level of service (see **Table 4.25**) .

Based upon the predicted 2011 ambient traffic levels presented within **Table 4.20** the percentage increase in traffic levels on Tweed Coast road would range from 1.0% south of the Pacific Highway during the morning peak hour to 3.6% south of Cudgen Road during the afternoon peak hour.

Table 4.25
Performance of 'Existing' Intersections in the 2011 Operational Scenarios

Intersection	Type	Degree of Saturation		Level of Service[1]	
		AM	PM	AM	PM
Scenario A (north):					
1. Pacific Hwy / Tweed Coast Rd	R'bout	**0.49**	**0.42**	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.50	0.40	A / E	A / D
4. Crescent St / Altona Dr.	Priority	**0.04**	**0.03**	A / B	A / B
Scenario B (south):					
1. Pacific Hwy / Tweed Coast Rd	R'bout	**0.49**	**0.42**	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.47	0.39	A / E	A / D
3. Tweed Coast Rd / Cudgen Rd	Signals[2]	0.86	**0.91**	C / E	C / E
	Signals[3]	**0.77**	0.75	C / D	C / D
4. Crescent St / Altona Dr.	Priority	**0.04**	**0.04**	A / B	A / **C**
Scenario C (west):					
1. Pacific Hwy / Tweed Coast Rd	R'bout	0.48	**0.41**	B / B	B / B
2. Tweed Coast Rd / Crescent St	Priority	0.50	0.40	A / E	A / D
4. Crescent St / Altona Dr.	Priority	**0.04**	**0.04**	A / B	A / **C**

Notes : 1. Intersection overall / worst major movement.
2. With pedestrian crossing critical, at optimum cycle time = 80 secs.
3. With pedestrian crossing ignored, at optimum cycle time = 60 secs.

Source: VLC (2007) – Table 6.6

In view of the delays for turning out of Crescent Street, under both ambient conditions and with the operation of the Project, the following works will be required.

- Left turn – installation of an acceleration lane along Tweed Coast Road. It is noted that the planned duplication of Tweed Coast Road will occur near 2011.
- Right turn – banning the right turn, particularly for heavy vehicles, requiring heavy vehicles that are travelling south to turn left and travel north to the roundabout at the Pacific Highway before turning southward.

These improvements will be required regardless of whether or not the Project proceeds and will be important for the existing industry and development currently utilising this intersection including the Hanson Tweed Sand Quarry and new Kingscliff WWTP. in order to ensure equity during the upgrade of this intersection, the Proponent would be willing to contribute towards the upgrade in proportion to contributions provided by Hanson (ie. proportional to the traffic generation contributed by each operation). Discussions between Tweed Shire Council and relevant stakeholders, including the Proponent and Hanson, will be required prior to the upgrade works to ensure that the upgraded intersection design and capacity safely meets the current and future needs for all users of the intersection.

It is noted that this would also provide an economic opportunity to undertake any minor works to the northern section of Crescent Street during the upgrade of this intersection which would contribute to the effective long-term use of this intersection.

4.7.6.4 Normal Operations - 2023

2023 Ambient Traffic Conditions

Due to significant levels of development expected in the Kingscliff and Tweed Coast area by 2023, traffic volumes, particularly along Tweed Coast Road are expected to also increase significantly. The upgrade of Tweed Coast Road (from the Pacific Highway to Casuarina) is planned to accommodate not only the predicted 2023 traffic demands, but also the longer-term traffic volumes expected from the ultimate development of the coastal area.

Following these upgrades, it is expected that all but one of the key intersections will have a reasonable degree of spare capacity and will be able to easily accommodate the small additional traffic associated with the Project. The exception is the intersection of Tweed Coast Road and Pacific Highway (Chinderah Roundabout), which is not anticipated to be upgraded to accommodate the ultimate traffic volumes.

As it is difficult to predict what proportion of the ‘ultimate growth’ in local traffic that would occur by 2023, for assessment purposes, it has been assumed that ‘ultimate growth’ is reached by 2023. The performance of the existing Chinderah roundabout (2006 arrangement), operating under these ultimate traffic volumes would have inadequate capacity, with degrees of saturation of 1.21 and 0.92 in the morning and afternoon peak hours respectively and levels of service ranging from C to F.

Using the SIDRA traffic model, VLC (2007) assessed that the heavy right-turn movement (from Tweed Coast Road to the eastbound on-ramp) would limit the capacity of the two critical movements. The reasons for this include the restriction of the right turn movement (by lane markings) to only the right hand lane and the fact that there is only a single circulatory lane on the north side of the Chinderah roundabout.

Regardless of whether the Project proceeds, it will be necessary for an improvement to be implemented to ensure adequate functioning of the roundabout.

Traffic Conditions During Operations

Considering the need for these improvements to the Chinderah Roundabout under ambient traffic conditions, it is considered appropriate that the potential impact of the Project-related traffic be assessed for the improved roundabout. Under the same operational scenarios as for 2011, following improvement of the roundabout, Scenario A and B would have negligible impact on the peak hour performance of the roundabout. Scenario C would result in a more noticeable impact on the morning peak hour though the improved roundabout would still operate satisfactorily and retain the same level of service.

Based upon the predicted 2023 ambient traffic levels presented within **Table 4.20** the percentage increase in traffic levels on Tweed Coast south of the Pacific Highway during the morning peak hour would range from 0.7% northbound and 1.5% southbound and during the afternoon peak hour from 0.8% southbound and 1.2% northbound.

4.7.6.5 Conclusion

Based on the proposed Project-related road works and safeguards and mitigation measures, it is considered that the Project would have minimal impact upon the function of the surrounding road network and users, both private and commercial. Furthermore, considering the relatively small contribution of the Project to overall traffic levels, both heavy and light vehicles, together with the implementation of appropriate management measures, such as a truck driver's code of conduct, it is considered that the Project would not significantly impact upon public transport infrastructure or services (eg. bus services).

It is recognised, however, that appropriate discussions and planning will be required between Tweed Shire Council and existing commercial/industrial stakeholders utilising the local road network to avoid redundant works and ensure that any upgrade works undertaken meet both current and future requirements. This will particularly relate to the duplication of Tweed Coast Road and the various improvements and road linkages likely to occur as part of the Proponent's Structure Plan (subject to approval).

4.8 NOISE

4.8.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential noise impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Increased noise levels associated with Project Site activities causing annoyance, distractions, ie. amenity impacts (Moderate Risk).
- Increased noise levels associated with Project-related road traffic activities causing annoyance, distractions, ie. amenity impacts. (Moderate Risk).

The following subsections describe the existing noise environment surrounding the Project Site, environmental noise criteria, proposed operational safeguards and mitigation measures and an assessment of the residual impacts following the implementation of these safeguards and mitigation measures.

The information presented in this section is drawn from the noise assessment undertaken by Ron Rumble Pty Ltd (Rumble, 2008) whose full report is included in the *Specialist Consultant Studies Compendium* (Volume 2, Part 8). This subsection presents a summary of the contents of the noise assessment report.

4.8.2 Existing Noise Climate

Ambient noise levels were measured using a combination of unattended noise logging and attended noise measurements to identify existing noise sources and noise levels around the Project Site.

Unattended noise logging was carried out at four receptor locations (see **Figure 4.20**) surrounding the Project Site from 16 to 23 August 2005. These locations were selected to represent the nearest and most potentially affected non-Project-related residences and to characterise the varying noise environments around the extraction sites. The Rating Background Levels (RBL) derived from the measured ambient noise levels at each of the four receptors are summarised in **Table 4.26**.

Table 4.26
Rating Background Levels

Receptor*	Rating Background Level L_{A90} (dB(A))			Equivalent L_{Aeq} (dB(A))#		
	Day 7am – 6pm	**Evening** 6pm – 10pm	**Night** 10pm – 7am	**Day** 7am – 6pm	**Evening** 6pm – 10pm	**Night** 10pm – 7am
Receptor G	51	42	38	62	59	56
Receptor DD	42	41	35	55	49	45
Receptor F	42	40	35	58	58	47
Receptor B	41	39	37	55	47	48

Source: Modified from Rumble (2008) – Tables 4 to 11. * See **Figure 4.20**
Logarithmic Average of all measurement data

It is noted that the background noise level at the Cudgen Public School would be comparable to Receptor B.

Existing L_{Aeq} noise levels at Receptors G, DD and F were almost entirely dominated by traffic noise from Tweed Coast Road. No noise from industry was audible or measurable at these locations other than the movement of trucks on Crescent Street and Altona Drive from the existing Hanson Tweed Sand extraction operation which were audible at Receptor DD. Noise from the Hanson Tweed Sand extraction operation was not audible at the closest assessment location, Receptor B, or measurable during site visits.

A series of attended ambient noise level measurements were also carried out during the day on 23 August 2005 to establish noise sources at each noise logging location. Results of the attended measurements are provided in Table 12 of Rumble (2008). It is noted that the L_{A90} and $L_{Aeq\ (15\ minute)}$ levels recorded during the attended measurements were generally within 1dB(A) to 2dB(A) of the unattended levels.

The noise environment at an additional location (Receptor O) south of the existing Hanson Tweed Sand extraction operations (see **Figure 4.20**) was also assessed. Though the ambient noise levels were not directly measured, the existing noise climate was assessed to be similar to that experienced at Receptor B.

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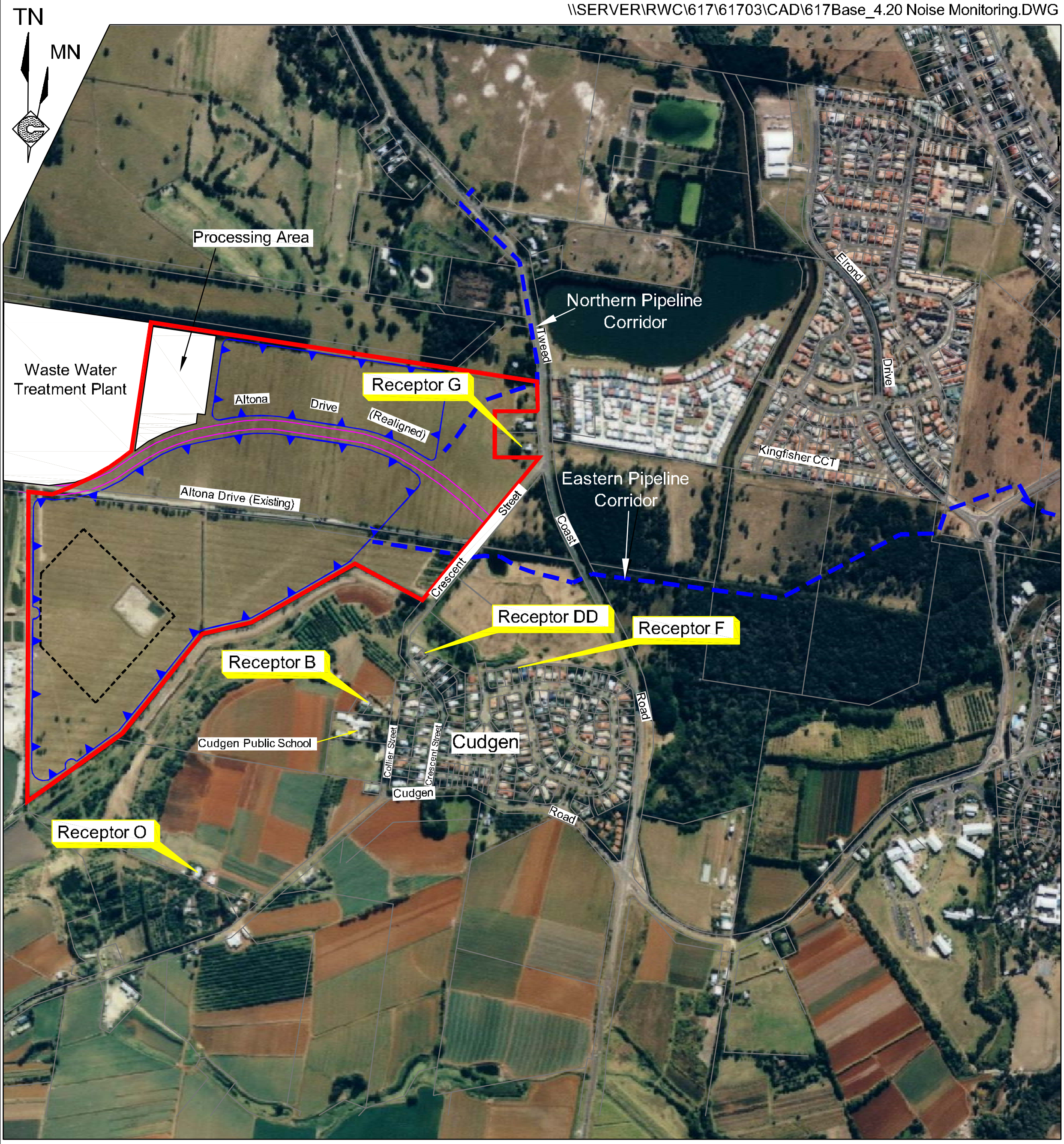


REFERENCE
Project Site Boundary
Proposed Pipeline Corridor
Extraction Site Boundary

SCALE 1:15 000

250 0 250 500 750 m

Source: Ron Rumble (2008) - Figure 3

Figure 4.20
NOISE ASSESSMENT LOCATIONS

4.8.3 Environmental Noise Criteria

4.8.3.1 Introduction

The assessment of impacts of the Project upon the local noise climate has been undertaken by calculating likely noise levels under a range of site establishment and operational scenarios, the proposed road traffic environment and comparing those noise levels against the noise criteria established through reference to:

- the Industrial Noise Policy (INP) – for site operational noise;
- relevant sections of the Environmental Noise Control Manual (ENCM) – for site construction activities;
- relevant sections of the Environmental Criteria for Road Traffic Noise (ECRTN); and
- the existing noise climate established at five assessment locations, namely the potentially most affected residences.

4.8.3.2 Construction Noise Criteria

The Project would require site establishment and construction works including boundary definition and fencing, earthworks for the processing area, construction of the processing plant and related infrastructure, and tree screen planting. It is anticipated that these activities would occur within approximately the initial 3 months of the Project and as such the following criteria, as outlined in the ENCM, apply.

- $L_{A10\ (15\ minute)}$ restricted to RBL + 10dB(A) during daytime period only.

Table 4.27 presents the construction noise criteria at the five representative locations surrounding the Project Site.

Table 4.27
Construction Noise Criteria

Receptor*	Period	Rating Background Noise Level, (L_{A90} dB(A))	Construction Noise Limits
Receptor G	Day	51	61dB(A) $L_{Aeq, 15\ min}$
Receptor DD		42	52dB(A) $L_{Aeq, 15\ min}$
Receptor F		42	52dB(A) $L_{Aeq, 15\ min}$
Receptor B		41	51dB(A) $L_{Aeq, 15\ min}$
Receptor O		41	51dB(A) $L_{Aeq, 15\ min}$

Source: Rumble (2008) – Table 17. * see **Figure 4.19**

4.8.3.3 Operational Noise Design Criteria

The environmental noise criteria for the Project needs to consider both the "intrusiveness" criterion which limits $L_{Aeq(15minute)}$ noise levels from industrial sources to RBL + 5dB(A), and the "amenity" criterion which considers cumulative noise impacts in areas with competing industrial noise sources. Based on the distance of the nearest source of industrial noise, namely the existing Hanson Tweed Sand extraction operation, to Receptors G, BB, F and B and the results of the attended measurements, the contribution of industrial noise is considered negligible. At Receptor O, the amenity noise limits have been calculated assuming the noise levels predicted within the assessment undertaken for James Heddle Acoustical consultants (2005) for the Hanson Tweed Sand extraction operation.

The INP-based noise intrusive and amenity assessment criteria the nearest potentially affected residences are presented in **Table 4.28**. At each location, the most stringent limits have been identified and set as the Project specific noise limit.

Table 4.28
Project Specific Noise Criteria

Period	Receptor	Intrusive Noise Limit, $L_{Aeq, 15 min}$ dB(A)	Amenity Limit $L_{Aeq, period}$ dB(A)	Project Specific Limits
Day	G	56	55	55dB(A) $L_{Aeq, period}$
	DD	47	55	47dB(A) $L_{Aeq, 15 min}$
	F	47	55	47dB(A) $L_{Aeq, 15 min}$
	B	46	55	46dB(A) $L_{Aeq, 15 min}$
	O	46	55	46dB(A) $L_{Aeq, 15 min}$
Evening	G	47	49	47dB(A) $L_{Aeq, 15 min}$
	DD	46	45	45dB(A) $L_{Aeq, period}$
	F	45	48	45dB(A) $L_{Aeq, 15 min}$
	B	44	45	44dB(A) $L_{Aeq, 15 min}$
	O	44	45	44dB(A) $L_{Aeq, 15 min}$
Night	G	43	46	43dB(A) $L_{Aeq, 15 min}$
	DD	40	40	40dB(A) $L_{Aeq, 15 min}$
	F	40	40	40dB(A) $L_{Aeq, 15 min}$
	B	42	40	42dB(A) $L_{Aeq, period}$
	O	42	40	40dB(A) $L_{Aeq, period}$
Shoulder Period (6:00am-7:00am)	G	49	50	49dB(A) $L_{Aeq, 15 min}$
	DD	43	48	43dB(A) $L_{Aeq, 15 min}$
	F	43	48	43dB(A) $L_{Aeq, 15 min}$
	B	44	48	44dB(A) $L_{Aeq, 15 min}$
	O	44	48	44dB(A) $L_{Aeq, 15 min}$
Source: Ron Rumble (2008) – Table 16				

4.8.3.4 Sleep Disturbance Design Criteria

Assessment of sleep interference by intermittent noise is required under the INP between the hours of 10:00pm to 7:00am. For the Project, the activities occurring during this period (between 6:30am and 7:00am) would be dredging and processing. Neither of these activities generate intermittent noise, only continuous noise which has been assessed using the amenity and intrusive noise criteria. Sleep disturbance has therefore not been further assessed.

4.8.3.5 Traffic Noise Design Criteria

Noise emissions from the realigned Altona Drive and Crescent Street have been assessed against the NSW EPA Environmental *Noise Management: Environmental Criteria for Road Traffic Noise* (ECRTN). The noise criteria for a *New Collector Road corridor* presented in Table 1 of the ECRTN have been applied to traffic on Altona Drive and Crescent Street. In accordance with these criteria, the following limits should desirably be met at any residence affected by all traffic travelling along these roads.

- Day (7am-10pm) $L_{Aeq(1hr)}$ 60dB(A)
- Night (10pm-7am) $L_{Aeq(1hr)}$ 55dB(A)

Tweed Coast Road is also classified as a collector road, however, assessment has been made against Criterion 8 of the ECRTN: *Land use developments with potential to create additional traffic on Collector Road*. For additional traffic arising from a development, Criterion 8 requires that noise emissions from a particular road must not increase by more than 2dB(A).

4.8.4 Project Noise Controls

Following initial noise modelling, it was identified that in order to comply with the project-specific noise criteria a number of noise attenuation measures would need to be adopted, predominantly to reduce noise emissions from the dredge and equipment within the processing area.

Specific design and attenuation measures would include the following.

- Acoustical treatment of the dredge including the enclosure of the engine with acoustic louvres and installation of a high performance muffler. It is expected that such treatments would reduce the sound power level by between 5dB(A) and 10dB(A).
- Increasing the height of the noise barrier on the southern side of the processing area. This would be achieved through the installation of an acoustic fence on the perimeter bund (see Figure 2.6). The actual height of the barrier necessary to achieve the reduction would depend on the height and final configuration of the plant.
- Noise reduction of the plant through the enclosure of noisier components of the equipment.

Barrier heights and / or enclosure of plant would need be determined during commissioning of the plant, however, for the purposes of the noise assessment, it has been assumed that the additional height of the noise barrier and / or enclosing parts of the plant would reduce the noise of the sand plant by 5dB(A).

In addition to these specific design measures, the following mitigation measures would also be implemented to reduce potential noise impacts.

- All mobile vehicles on the site would be fitted with broadband type reversing beepers or alternative safety devices such as strobe lights and / or cameras.
- All equipment on site would be regularly serviced to ensure sound power levels of each item remains at or below that nominated for noise modelling purposes.
- The internal road network would be maintained to an acceptable standard to limit body noise from empty trucks.
- All hours of operation presented in Section 2.10.2 would be strictly adhered to.

4.8.5 Assessment of Residual Impacts

4.8.5.1 Introduction

In order to assess the potential impact of noise generated by the Project, five operational scenarios, representing worst-case site establishment / construction and four operational situations were modelled by Rumble (2008). The noise levels that would be received at the nearest potentially affected residences under each scenario were predicted prior to the implementation of specific attenuation measures. Based on the outcomes of this preliminary modelling specific design measures were devised in order to reduce the potential impact at the surrounding assessment locations to within the Project specific noise criteria (see **Table 4.28**). The noise model was then re-run and the results assessed against the Project specific noise assessment criteria.

4.8.5.2 Assessment Methodology

Site Establishment and Operational Noise

Predictions of noise emissions from the Project Site have been predicted using the SoundPlan™ computer program configured to model the noise emissions using the CONCAWE algorithms. Five scenarios were modelled as described in **Table 4.29**.

Scenario 1 was further divided into Scenarios 1A, 1B and 1C to represent a range of locations for various equipment during site establishment. Scenarios 2A to 3B were also subdivided into day and evening periods and early morning shoulder periods. During the evening period and early morning, only the dredge and processing plant would be operating. Further details of the modelling scenarios and equipment locations are provided in Section 8.2 of Rumble (2008).

Table 4.29
Modelling Scenarios

Scenario	Description	Activities
1	Site Establishment	Placement of cutter suction dredge within initial dredge pond, enlargement of the southern extraction pond, stripping of topsoil and formation of bunding, laying of pipelines, formation of processing area base and bunding, formation of access roads, placement of processing equipment and formation of Initial Western Excavation Pond.
2A	Operations Extraction and Processing – Stages 1 to 4 and A to D	Dredging of sand from southern extraction site to processing area, refuelling of dredge, excavation of loamy sand from southern extraction site and sand from northern extraction site, transport of sand from northern extraction site to processing area, processing of sand, loamy sand and VENM, delivery and handling of VENM material, handling and loading of sand products and transport of products via Altona Drive.
2B	Operations Extraction and Processing – Stages 8 to 10	Operations as described for Stage 2A, however, extractive operations within the northern extraction site would have ceased and the northern extraction pond would be progressively backfilled with VENM.
3A	Operations Pumping to Fill Sites and Processing – Stages 1 to 4 and A to D	Processing of sand, loamy sand and VENM, dredging of sand from the southern extraction site to the fill sites utilising onsite booster pump, excavation of sand from the northern extraction site and transport to the processing area, delivery and handling of VENM material, handling and loading of sand products and transport of products via Altona Drive.
3B	Operations Pumping to Fill Sites and Processing – Stages 8 to 10	Operations as described for Stage 3A, however, extractive operations within the northern extraction site would have ceased and the northern extraction pond would be progressively backfilled with VENM.
Source: Rumble (2008) – Section 8.2		

During Scenarios 3A and 3B, extracted material would be pumped to remote fill sites to the north and east of the Project Site. In addition to the booster pumps located within the Project Site (as noted in **Table 4.29**) there would also be, at times, a remote booster pump located part way along the eastern pipeline corridor. The exact location of the remote booster pump would be determined at the commencement of pumping, however, the location on the proposed eastern pipeline corridor would be approximately 240m from the nearest residences in Kingfisher Circuit and approximately 30m south of residences in Kingfisher Circuit on the alternative eastern pipeline corridor. A separate assessment of the booster pump has been provided.

Traffic Noise

As there is no specific model which can calculate the $L_{Aeq(1hr)}$ noise with the low traffic flows anticipated on Altona Drive the SoundPlan computer model prepared for the Project Site was modified to predict the noise emissions from heavy vehicles travelling along the realigned roadway.

For Tweed Coast Road, as the applicable criteria relates to the increase in noise levels the changes to noise emissions attributable to Project-related trucks travelling on Tweed Coast Road were calculated using the TNOISE™ computer program. Full details of the traffic assessment methodology are provided in Section 12.2 of Rumble (2008).

4.8.5.3 Results – Site Establishment

For each of site establishment scenarios, noise emissions from the proposed development are predicted to be well below the construction noise limits at all locations, including under the default downwind condition of 3m/s (see **Table 4.30**).

Table 4.30
Predicted Site Establishment Noise Levels – dB(A)

Receptor	Predicted $L_{Aeq(15min)}$ Emissions (Noise Limit)	
	Under Calm Conditions	Under Downwind Conditions 3m/s
Scenario 1A		
Receptor G	33.8 (61)	40.5 (61)
Receptor DD	31.1 (52)	37.4 (52)
Receptor F	36.0 (52)	41.2 (52)
Receptor B	47.3 (51)	48.1 (51)
Receptor O	35.4 (51)	42.3 (51)
Scenario 1B		
Receptor G	43.8 (61)	47.0 (61)
Receptor DD	41.0 (52)	45.2 (52)
Receptor F	41.5 (52)	44.3 (52)
Receptor B	47.3 (51)	47.8 (51)
Receptor O	32.2 (51)	39.5 (51)
Scenario 1C		
Receptor G	49.0 (61)	50.4 (61)
Receptor DD	38.8 (52)	43.5 (52)
Receptor F	41.6 (52)	44.1 (52)
Receptor B	45.5 (51)	46.3 (51)
Receptor O	31.1 (51)	38.3 (51)
Source: Rumble (2008) Tables 19 to 21		

4.8.5.4 Results – Operational Noise

Following the implementation of the design measures outlined in Section 4.8.4, noise emissions from the proposed development are predicted to comply with the Project specific noise limits at all locations, including under the default downwind condition of 3m/s (see **Table 4.31**). The compliance achieved at Receptor B would also result in compliance at Cudgen Public School.

Table 4.31
Predicted Operational Noise Levels – dB(A)

Receptor	Predicted $L_{Aeq(15min)}$ Emissions (Noise Limit)					
	Under Calm Conditions (dB(A))	Under Downwind Conditions 3m/s	Evening Operations - Calm Conditions	Evening Operations - Downwind Conditions 3m/s	Early Morning Operations - Calm Conditions	Early Morning Operations - Inversion Conditions
Scenario 2A						
Receptor G	36.9 (55)	41.4 (55)	29.4 (47)	35.8 (47)	29.8 (49)	36.2 (49)
Receptor DD	31.4 (47)	37.9 (47)	28.3 (45)	34.9 (45)	28.6 (43)	35.3 (43)
Receptor F	34.1 (47)	39.0 (47)	29.0 (45)	34.4 (45)	29.3 (43)	34.8 (43)
Receptor B	44.6 (46)	45.3 (46)	37.9 (44)	39.4 (44)	37.7 (44)	39.7 (44)
Receptor O	30.5 (46)	37.4 (46)	25.4 (44)	32.6 (44)	25.8 (44)	33.1 (44)
Scenario 2B						
Receptor G	38.0 (55)	42.7 (55)	31.1 (47)	36.8 (47)	31.4 (49)	37.2 (49)
Receptor DD	37.4 (47)	42.4 (47)	31.0 (45)	36.7 (45)	31.2 (43)	37.0 (43)
Receptor F	37.0 (47)	40.8 (47)	30.7 (45)	35.3 (45)	31.0 (43)	35.7 (43)
Receptor B	44.9 (46)	45.3 (46)	38.6 (44)	39.8 (44)	38.9 (44)	40.1 (44)
Receptor O	27.5 (46)	35.1 (46)	23.9 (44)	31.6 (44)	24.5 (44)	32.2 (44)
Scenario 3A						
Receptor G	44.1 (55)	46.4 (55)	29.0 (47)	35.5 (47)	21.3 (49)	35.9 (49)
Receptor DD	35.8 (47)	40.9 (47)	28.6 (45)	35.3 (45)	11.3 (43)	35.7 (43)
Receptor F	36.8 (47)	40.5 (47)	29.1 (45)	34.4 (45)	24.7 (43)	34.9 (43)
Receptor B	43.7 (46)	44.6 (46)	38.0 (44)	39.5 (44)	36.6 (44)	39.9 (44)
Receptor O	30.4 (46)	37.5 (46)	25.8 (44)	33.0 (44)	26.5 (44)	33.6 (44)
Scenario 3B						
Receptor G	36.8 (55)	41.5 (55)	31.0 (47)	36.8 (47)	31.3 (49)	37.1 (49)
Receptor DD	39.0 (47)	44.2 (47)	35.1 (45)	41.1 (45)	35.3 (43)	41.4 (43)
Receptor F	37.5 (47)	41.4 (47)	33.1 (45)	37.9 (45)	33.5 (43)	38.4 (43)
Receptor B	44.7 (46)	45.5 (46)	40.1 (44)	41.6 (44)	40.4 (44)	41.6 (44)
Receptor O	29.9 (46)	37.5 (46)	27.9 (44)	35.4 (44)	28.4 (44)	36.0 (44)
Source: Rumble (2008) – Table 27						

4.8.5.5 Results – Remote Booster Pumps

The potentially affected residences on Kingfisher Circuit are located at a similar distance back from Tweed Coast Road as Receptor F and for the purposes the assessment the Project Specific Noise Criteria for Receptor F have been used. Based on criteria at Receptor F, the lowest noise level that must be met during the proposed hours of operation is 43dB(A) during the early morning shoulder period of 6:00am-7:00am. The noise level from the pump to be installed would be checked prior to installation and the pump positioned in a location that would ensure the 43dB(A) criterion is satisfied at the closest residences in Kingfisher Circuit.

Rumble (2008) provides a sliding scale recording the required separation distance between the residences and the pump based on the sound power level of the pump. The results of calculations are shown in **Table 4.32**.

Table 4.32
Booster Pump Separation Distance to meet Noise Limits

Pump Sound Power L_{WA}	Necessary Separation distance (m)
105dB(A)	500m
100dB(A)	275m
95dB(A)	160m
90dB(A)	90m
81dB(A)	30m
Source: Rumble (2008) – Table 31	

As the booster pump on the proposed eastern pipeline corridor would be located approximately 240m from residences in Kingfisher Circuit the pump would need to have a sound power level of ≤99dB(A) L_{WA} in order to comply with a noise limit of 43dB(A).

It is noted that booster pumps similar to what would be used were recorded to have sound power level of 101dB(A) $L_{WA.}$ Reductions in sound power level for such pumps could be managed through additional acoustic cladding and orientating the pump so as to orientate the quieter end towards residences.

4.8.5.6 Results – Cumulative Noise Impact Assessment

There are two locations which could be considered to be effected by cumulative impacts from the existing Hanson Tweed Sand extraction operation, namely Receptor B and Receptor O. A new waste water treatment plant is also being constructed to the northwest of the Project Site. Waste water treatment plants by their nature do not emit significant levels of noise and no account has therefore been made of its contribution.

Considering the distance of Receptor B from the Hanson Tweed Sand extraction operation, the fact that noise from the Hanson Tweed Sand Quarry was not audible or measurable during the attended site visits and that the occupier of this residence advised Rumble (2008) that noise from the Hanson Tweed Sand extraction operations were not audible at the residence, no further consideration has been given to cumulative operational noise impacts at this location.

At Receptor O, noise impact from the approved Hanson Tweed Sand extraction operations was assessed by James Heddle Acoustical Consultants (2005). Noise emissions at Receptor O as a result of the Hanson Tweed Sand extraction operation were predicted to be 40dB(A) L_{Aeq} during the daytime period under calm conditions and up to 43dB(A) when the Hanson Tweed Sand operates within the southeastern corner of their approved extraction area. Under downwind conditions, noise impact could increase by an additional 2dB(A) to 5dB(A) resulting in noise levels between 42dB(A) and 45dB(A).

As the timing of dredge locations at the Hanson Tweed Sand site in conjunction with this Project Site are unknown, the assessment of the combined effect has been based on a 40dB(A) contribution from the Hanson Tweed Sand Quarry during calm conditions and 42dB(A) contribution during downwind conditions. The combined impact is shown in **Table 4.33**.

Table 4.33
Predicted Combined Noise Level Impact L_{Aeq} dB(A) at Receptor O

Scenario	Condition	Hanson Tweed Sand Contribution	Project Contribution	Total	Project Specific Noise Limit	Compliant
1A	Calm	40	35.5	41.3	56	Yes
	Downwind	42	42.3	45.2	56	Yes
1B	Calm	40	31.5	40.6	56	Yes
	Downwind	42	38.7	43.7	56	Yes
1C	Calm	40	31.2	40.5	56	Yes
	Downwind	42	38.4	43.6	56	Yes
2A	Calm	40	35.0	41.2	46	Yes
	Downwind	42	42.0	45.0	46	Yes
2B	Calm	40	30.7	40.5	46	Yes
	Downwind	42	38.3	43.5	46	Yes
3A	Calm	40	33.4	40.9	46	Yes
	Downwind	42	40.5	44.3	46	Yes
3B	Calm	40	33.7	40.9	46	Yes
	Downwind	42	41.3	44.7	46	Yes
Source: Rumble (2008) – Table 26						

The predicted cumulative noise impacts from both operations would still comply with the project-specific noise limits.

The combined traffic noise impact from both developments has been assessed as part of the traffic noise assessment (see Section 4.8.5.7)

4.8.5.7 Results – Traffic Noise

Noise emissions calculated using the ECRTN for the combined truck traffic on Altona Drive from both the Hanson Tweed Sand extraction operation and the Project would be well within the traffic noise design criteria (see **Table 4.34**).

Table 4.34
Calculated Truck Noise Levels $L_{Aeq(1hr)}$ on Altona Drive

Receptor	Predicted $L_{Aeq(1hr)}$ Noise level due to Altona Drive Traffic
Receptor G	57.6dB(A)
Receptor DD	48.5dB(A)
Receptor F	56.0dB(A)
Receptor B	53.2dB(A)
Criteria	**60.0dB(A)**
Source: Rumble (2008) – Table 29	

The increase in the noise levels due to the additional trucks on Tweed Coast Road have been calculated between 0.3dB(A) and 0.4dB(A). This change in noise levels would be less than the permissible change of 2dB(A) specified by the ECRTN.

4.8.6 Monitoring

A program of noise monitoring would be undertaken to confirm that noise emission levels from the site establishment and construction period are within acceptable limits at the surrounding assessment locations. Prior to completing the commissioning of the sand processing plant, a series of tests would be undertaken to establish the additional height of the noise barrier necessary to ensure compliance with the noise limits at all locations and confirm that the equipment to be used on the Project Site have sound power levels comparable to or less than those used within the noise modelling assessment.

An ongoing monitoring program would also be undertaken to demonstrate that noise emissions from the Project Site are within the Project specific noise limits at the surrounding assessment locations. Monitoring would be undertaken on a quarterly basis during the first year and an annual or biennial basis thereafter.

The extent of noise monitoring would be regularly reviewed throughout the life of the Project to ensure meaningful data is being collected.

4.8.7 Conclusion

With the proposed attenuation measures in place, compliance with both the construction and operational noise limits would be achieved at all surrounding residences during all scenarios including under default downwind and inversion conditions prescribed by the INP.

Furthermore, the cumulative noise impact of the Project with the Hanson Tweed Sand Quarry has been assessed as remaining compliant with the established noise limits.

The noise impact of trucks on the realigned Altona Drive (including the combined effect of trucks from the Hanson Tweed Sand extraction operation) and the effect of increased traffic on Tweed Coast Road has been assessed and shown to comply with the ECRTN.

The monitoring and compliance program proposed would assist in demonstrating that the noise limits are being met and would confirm the modelling results.

4.9 AIR QUALITY

4.9.1 Introduction

Based on the risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential air quality impacts requiring assessment and their **unmitigated** risk rating are as follows.

- Deposited dust levels attributable to the Project occasionally (for one or two months every year) above DECC guideline, affects only adjacent landholders (High Risk).

- Deposited dust levels attributable to the Project regularly (exceedances greater than DECC guideline for >5 months per year) affects landholders some distance from the Project Site (High Risk).
- PM_{10} levels attributable to the Project occasionally (once every 1 to 2 years) above the Project goal, affects only adjacent landholders (Moderate Risk).
- PM_{10} levels attributable to the Project occasionally (>5 times per year) above the Project goal, affects landholders some distance from Project Site (Moderate Risk).
- Greenhouse gas emissions (Moderate risk).

The following subsections describe the existing air quality environment surrounding the Project Site, air quality criteria, proposed operational safeguards and mitigation measures and an assessment of the residual impacts following the implementation of these safeguards and mitigation measures.

The information presented in this section relating to particulate emissions is drawn from the air quality assessment undertaken by Simmonds & Bristow Pty Ltd (S&B, 2008) whose full report is included in the *Specialist Consultant Studies Compendium* (Volume 2, Part 9). This subsection also presents a greenhouse gas emission assessment.

4.9.2 Existing Air Quality

4.9.2.1 Introduction

Air quality standards and goals refer to pollutant levels which include both the operational and existing sources. In order to fully assess impacts against all the relevant air quality standards and goals, it is therefore necessary to have information or estimates on existing dust and particulate matter concentrations and dust deposition levels.

4.9.2.2 Air Pollutants and Emissions

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

- Particulates or dusts (suspended particulates and fine particulates (PM_{10}, $PM_{2.5}$).
- Deposited dust (coarse particulates typically >50µm).
- 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).

The major air pollutant from the Project would be particulates. The Project would also contribute to combustion gas emissions (e.g. nitrogen oxides). There would be no halide, VOC, metal, odorous compounds or pesticides emissions generated by the Project. Therefore, the remainder of this assessment has focused upon particulates and gas emissions.

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 (deposited dust). 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.

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 grained 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.

The primary existing sources of particulate and gaseous emissions within the local airshed may be divided into point sources and diffuse sources.

Point Sources

There are no significant point sources of emissions in the local airshed, however, 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.

Area or Diffuse Sources

The area sources of significant air emissions in the airshed include the following.

- Biogenic

  Sugar cane burning prior to harvest is a major seasonal source of particulate deposition and fine particulates (smoke). Bushfires and forestry burning are also infrequent regional airshed sources of smoke particulates.

- Traffic Emissions

  Significant traffic emissions (particulates, carbon monoxide, nitrogen oxides and VOCs) 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 (formerly Tweed Turf and Sand) operates a sand extraction operation located immediately adjacent to the western perimeter of the Project Site. It is a potential source of particulate emissions.

- Waste Water Treatment Plant (WWTP)

  Secondary waste water treatment plants are potential sources of odours and gaseous emissions (e.g. hydrogen sulphide). The new WWTP to the northwest of the Project Site is expected to be commissioned mid to late 2008 and will replace the existing plant located in Chinderah.

- Agriculture

  Exposed soils and farm activities such as ploughing are significant sources of windborne dusts that influence air quality within the local airshed.

- Construction Works

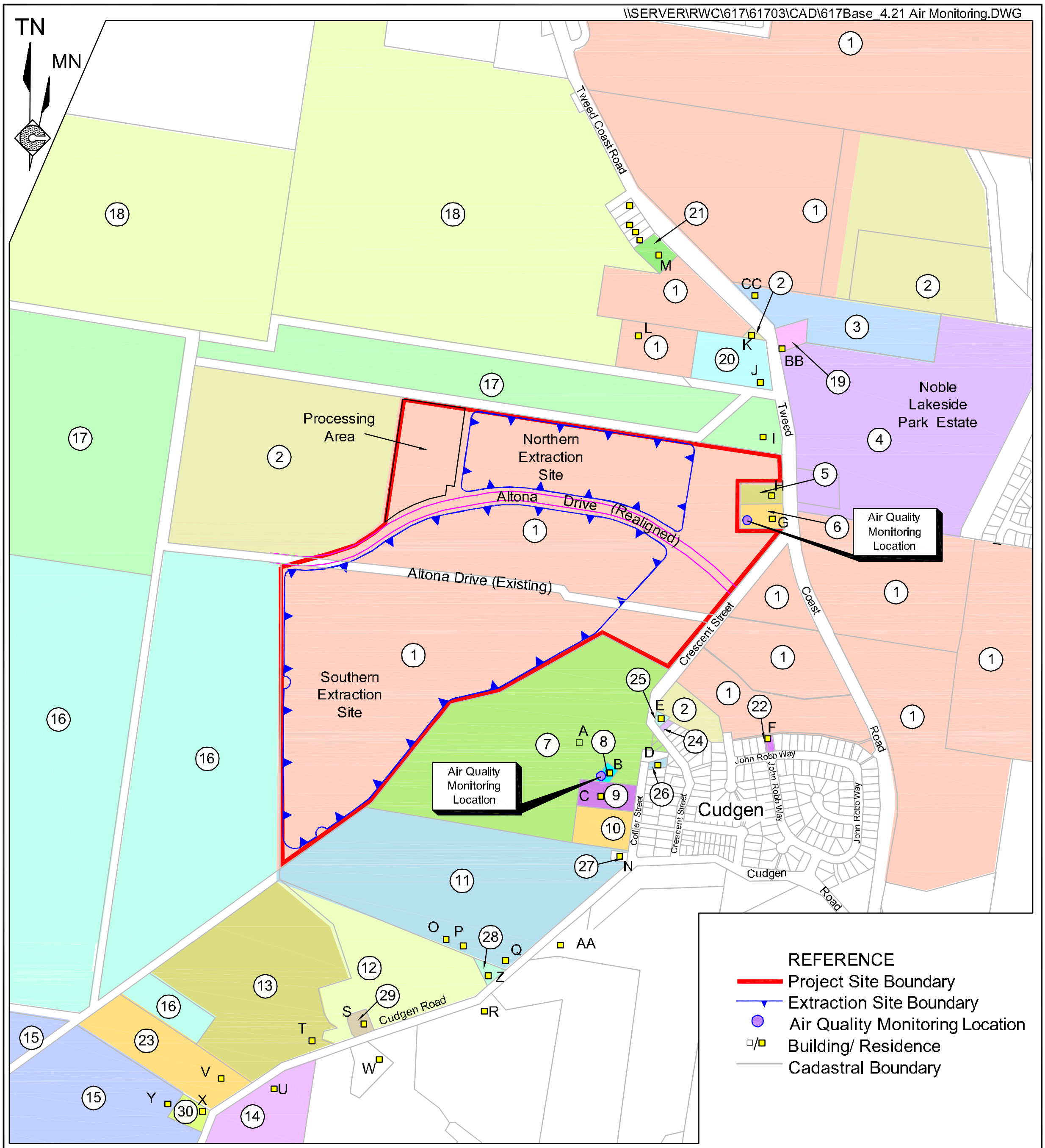
  Construction activities due to urban expansion and road building are other diffuse sources of dust emissions to the airshed.

4.9.2.3 Local Air Quality Monitoring Data

Limited existing air quality data is available for the local air shed including from the adjacent sand extraction operation, Hanson Tweed Sand Quarry, for which no monitoring data is available relating to past or current activities. As part of the assessment undertaken for the Project, Simmonds and Bristow conducted indicative background monitoring of ambient levels of suspended particulates, insoluble dust fallout and indications of PM_{10} at two monitoring locations, namely:

- Receptor G (L and P Hermann, private residence on the corner of Crescent Street and Tweed Coast Road); and
- Receptor B (R and B Julius, farm residence on Cudgen Plateau, adjacent Cudgen Public School) (**Figure 4.21**).

The deposited 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. The deposited dust gauge at Receptor G was located in the southwestern corner of the property.



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

SCALE 1:15 000

250 0 250 500 750 m

Land Ownership Source: Dept. of Lands (2005)

Figure 4.21
AIR QUALITY MONITORING LOCATIONS

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

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 the afternoon of 8 October 2005 averaged 64µg/m^3, adjacent to Crescent Street near Cudgen Plateau. In the Condong Mill area, the average PM_{10} was 62µg/m^3 on the same day.

Deposited dust monitoring results are shown in **Table 4.35**. The average result from both sites over all monitoring events is approximately 1.5g/m^2/month. The rate of dust deposition at Receptor B varied from an average of 2.0g/m^2/month during the first 12 month period to 1.4g/m^2/month during the second period (of 12 months). 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 4.35
Insoluble Dust Fallout, Cudgen

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	0.8
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 – 26/06/06	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)
Source: Simmonds & Bristow (2008) – Table 4

4.9.2.4 Adopted Background Air Quality

Due to the short-term nature of the available monitoring data for suspended particulate concentrations in the local area, in accordance with the NSW DECC (2005) modelling guidelines, monitoring data from the closest comprehensive air quality monitoring station has been used to determine background levels for suspended particulates. The closest suitable monitoring station is located at Helensvale on the Gold Coast.

The NSW *Air Monitoring Plan* for the National Environmental Protection Measure for Ambient Air Quality (NSW EPA 2002) considers the Tweed Heads area to be contiguous with the Gold Coast and the use of data collected through the Queensland monitoring plan to infer concentrations in this subregion is considered appropriate, although it is recognised the Kingscliff area does not have the population / commerce density of either the Gold Coast or Tweed Heads, hence, the use of data from Helensvale is considered conservative.

Particulate matter monitored at Helensvale has an average maximum 24 hour PM_{10} concentration of 31µg/m^3 and an annual average PM_{10} of 17µg/m^3 (Qld EPA 1998, 1999, 2000, 2001, 2002). The particulate monitoring results undertaken for the Project (see Section 4.9.2.3) 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. The range at the two locations therefore was 23µg/m^3 to 47µg/m^3 compared to an adopted background concentration of 31µg/m^3.

Based on the suspended particulate monitoring carried out in Helensvale and the average of the deposited dust monitoring results undertaken for the Project, the assumed background concentrations are as follows.

- 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).
- Deposited dust rate of 1.5g/m^2/month.

It is important to note that the approach used for the air quality assessment has been to assume <u>conservative</u> background concentrations for modelling purposes. In particular, the maximum 24hr average for PM_{10} of 31µg/m^3 has been assumed to occur every day at all locations where, in reality the 24hr average PM_{10} levels would be highly variable. For comparison, the average median PM_{10} concentration at Helensvale was 15µg/m^3.

4.9.3 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 4.36**.

Table 4.36
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	$2g/m^2/month$	$4g/m^2/month$
TSP	Annual	-	$90\mu g/m^3$
PM_{10}	24 hour	-	$50\mu g/m^3$
	Annual	-	$30\mu g/m^3$
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 limit for dust deposition is based on levels at which dust becomes or is perceived as a nuisance to the extent that it is considered unacceptable rather than from health related issues.

The air quality goals also include the National Health and Medical Research Council (NHMRC) goal for TSP of $90\mu g/m^3$ (annual average). It is recommended as a maximum limit for urban environments. However, this goal has limited usefulness, in evaluating potential health impacts.

The primary health concern are particulates less than $10\mu m$ (PM_{10}) which 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 has adopted the National Environmental Protection Measure for PM_{10} of $50\mu g/m^3$ (24hr averaging period) and an annual average goal of $30\mu g/m^3$.

4.9.4 Management of Air Quality

4.9.4.1 Site Establishment

The following dust controls would be employed during site establishment and construction.

- In the event that the natural soil moisture is insufficient to avoid generation of excessive airborne dust, water would be applied using the on-site water cart prior to stripping.
- The area of stripping within the extraction sites would be minimised to provide an area large enough to supply only 6 to 12 months of sand resource.
- Fast growing grass species would be seeded or mulch cover added to all bunds and stockpiled topsoil.

- The number of internal access roads created would be minimised and internal access roads no longer required would be cross ripped, topsoiled and sealed.
- Vehicle speeds on unsealed internal access roads would be restricted to 30km/hr.
- Internal access roads would be watered at a rate of 2L/m² per application using the water cart during high vehicle activity and dry conditions.
- Shut-down procedures would be adopted in the event of high winds.

Other measures planned for visual and noise amenity purposes would also act to reduce air emissions. Such measures include the 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 eastern boundary of the extraction sites.

4.9.4.2 Sand Extraction Processing and Blending Operations

The following dust controls would be employed during extraction, processing and blending.

- Active unsealed access roads, staging and hardstand areas would be watered at 2L/m² per application for six periods per operational day during low soil moisture conditions.
- Stockpiled materials would be watered as necessary, particularly those containing materials with elevated silt content (e.g. stockpiled VENM(b), loamy sand and associated products).
- Shelters, enclosures or physical barriers would be used for the screening and conveying of loamy sands and VENM materials.
- Selected conveyors would be partially enclosed.
- Misting water sprays would be used to control dry screening dusts.
- Progressive rehabilitation / stabilisation of available areas of disturbance (eg. finalised sections or backfilled areas of the extraction ponds) would be undertaken.
- Fast growing grass species would be seeded on bunding created as the extraction stages progress.
- Control of blending and screening operations to achieve a daily average processing rate of 100tph.

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 screening. It is also noted that daily average processing rates would generally be below 100tph as continuous operation at this level would result in the production of far in excess of the proposed sales of 300 000tpa (combined washed and screened/blended products). Therefore, the use of a daily average processing rate within the air quality modelling is considered to be conservative.

4.9.4.3 Transportation

Accumulated tracked road mud, dry dusts, sand or spillages on Altona Drive and on sealed areas within the processing area would be cleaned up, as required, using a street sweeper. Product trucks would have covered loads to prevent wind-borne losses and spillages.

4.9.4.4 Site Decommissioning and Final Landform

If required, unsealed areas would be watered until stabilised with mulch cover, vegetated or sealed for future development. All internal roads not required for future land use would 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.

4.9.5 Assessment Methodology

4.9.5.1 Introduction

Computer predictions of fugitive emissions from the Project Site were undertaken using the Ausplume V6.0 software ("Ausplume"). Ausplume V6.0 (or later versions) is the approved dispersion model for use in most simple near-field applications in NSW. 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.*

4.9.5.2 Modelling Scenarios

The particulate emission rates for seven scenarios were used to predict potential air quality impacts and are described as follows.

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 (existing operations - 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 Quarry (future approved operations - Phase 4).

Scenarios 1, 2, 4, 5 and 6 address different operational stages of the Project whilst Scenarios 3 and 7 consider the cumulative impacts of the Project and the adjoining Hanson Tweed Sand Quarry operation.

4.9.5.3 Particulate Emission Factors

Dust emission factors used within Ausplume 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 within the emissions inventory included as Appendix 1 of S&B (2008).

4.9.5.4 Meteorological Data

The meteorological data file was prepared by pDs Consultancy from Bureau of Meteorology data for the Coolangatta Airport during the year 2001. Coolangatta Airport is the closest meteorological station located approximately 11km north-northeast of the Project Site and at similar elevation. The year 2001 was selected because it showed a strong Index of Agreement with long-term average data. This use of this data is consistent with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* DECC (2005).

4.9.5.5 Terrain Effects

Elevation data was included in the model and was taken from the Cudgen topographic and orthophoto map. Most of the terrain within the model domain is flat except for Cudgen Plateau which rises to the south of the Project Site.

4.9.6 Impact Assessment

4.9.6.1 Site Establishment and Operational Scenarios

Deposited Dust

Table 4.37 presents the assumed background level, the maximum predicted increase and total predicted deposited dust results for the site establishment and operational scenarios. The total deposited dust concentrations are considered conservative because the model does not account for elevated receptors and the deposited dust levels have been assessed on a daily basis to account for the level of activity.

Table 4.37
Predicted Deposited Dust Levels at Off-site Receptors

Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	g/m²/month [1]		
Scenario 1 – Site Establishment			
A	1.5	0.2	1.7
C	1.5	0.2	1.7
M1[2]	1.5	0.4	1.9
M2[2]	1.5	0.1	1.6
M	1.5	0.2	1.7
K	1.5	0.2	1.7
I	1.5	0.1	1.6
Noble Lakeside Park Estate	1.5	0.1	1.6
G	1.5	0.1	1.6
Scenario 2 - Extraction Stage N1, Stage 4 and Processing			
A	1.5	1.3	2.8
C	1.5	1.1	2.6
M1[2]	1.5	1.5	3.0
M2[2]	1.5	0.4	1.9
M	1.5	1.2	2.7
K	1.5	0.6	2.1
I	1.5	0.6	2.1
Noble Lakeside Park Estate	1.5	0.4	1.9
G	1.5	0.6	2.1
Scenario 4 - Extraction Stage 4 and Processing			
A	1.5	0.6	2.1
C	1.5	0.6	2.1
M1[2]	1.5	1.3	2.8
M2[2]	1.5	0.4	1.9
M	1.5	0.5	2.0
K	1.5	0.2	1.7
I	1.5	0.3	1.8
Noble Lakeside Park Estate	1.5	0.2	1.7
G	1.5	0.3	0.8
Scenario 5 - Extraction Stage 7 and Processing			
A	1.5	1.3	2.8
C	1.5	0.9	2.4
M1[2]	1.5	0.9	2.4
M2[2]	1.5	0.3	1.8
M	1.5	0.6	2.1
K	1.5	0.3	1.8
I	1.5	0.3	1.8
Noble Lakeside Park Estate	1.5	0.2	1.7
G	1.5	0.3	1.8
Scenario 6 - Extraction Stage 10 and Processing			
A	1.5	1.0	2.5
C	1.5	1.1	2.6
M1[2]	1.5	0.7	2.2
M2[2]	1.5	0.3	1.8
M	1.5	0.9	2.4
K	1.5	0.6	2.1
I	1.5	0.5	2.0
Noble Lakeside Park Estate	1.5	0.3	1.8
G	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 * See **Figure 4.22**

[2] Model receptor locations representing worst-case concentrations for residences in area

Source: Simmonds & Bristow (2008) – Modified from Tables 11, 14, 17, 20 and 23.

It is predicted that there would be no exceedances of the deposited dust goals for any scenario with total levels ranging from 1.6g/m^2/month to 3.0g/m^2/month but generally remaining well below the deposited dust goal.

TSP

Table 4.38 presents the assumed background level, the maximum predicted increase and total predicted TSP results for the site establishment and operational scenarios. As for deposited dust, it is predicted that there would be no exceedances of the TSP goals for any scenario with total levels ranging from 34.3µg/m^3 to 38.1µg/m^3, which are well below the annual average TSP goal of 90µg/m^3.

PM_{10}

The predicted background, maximum increase and total 24 hour and annual average PM_{10} concentrations are presented in **Tables 4.39** and **4.40** respectively.

No exceedances of the 24 hour or annual average PM_{10} goals are predicted under any scenario with 24 hour PM_{10} ranging from 33.4µg/m^3 to 47.1µg/m^3 and annual average PM_{10} ranging from 17.2µg/m^3 to 18.5µg/m^3.

4.9.6.2 Cumulative Scenarios

Deposited Dust

Table 4.41 presents the assumed background level, the maximum predicted increase and total predicted deposited dust results for the cumulative impact scenarios (Scenarios 3 and 7). It is predicted that there would be no exceedances of the total deposited dust goals for either cumulative scenario with total levels ranging from 2.1g/m^2/month to 3.8g/m^2/month. However, one exceedance (2.3g/m^2/month at receptor location M1) of the maximum increase in deposited dust was predicted during Scenario 3. Model receptor M1 is located closer to the site boundary than surrounding residences in this area and therefore, it is expected that dust deposition levels at residences O and P would be lower. It is noted that the total deposited dust levels remain compliant with deposited dust goals.

TSP

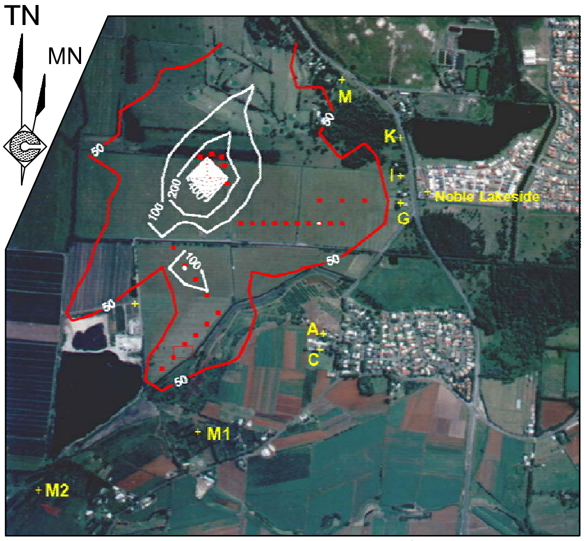
Table 4.42 presents the assumed background level, the maximum predicted increase and total predicted TSP results for each cumulative scenario. It is predicted that there would be no exceedances of the TSP goals for either cumulative scenario with total levels ranging from 35.4µg/m^3 to 39.0µg/m^3 which are well below the annual average TSP goal of 90µg/m^3.

Table 4.38
Predicted TSP Levels at Off-site Receptors

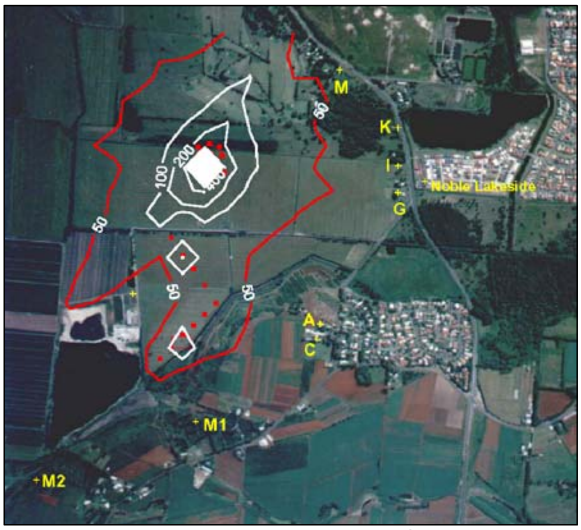
Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, annual average		
Scenario 1 – Site Establishment			
A	34	1.1	35.1
C	34	1.0	35.0
M1[1]	34	1.3	35.3
M2[1]	34	0.3	34.3
M	34	2.3	36.3
K	34	1.7	35.7
I	34	1.5	35.5
Noble Lakeside Park Estate	34	1.1	35.1
G	34	1.3	35.3
Scenario 2 - Extraction Stage N1, Stage 4 and Processing			
A	*34*	3.4	37.4
C	*34*	2.7	36.7
M1[1]	*34*	3.2	37.2
M2[1]	*34*	1.1	35.1
M	34	4.1	38.1
K	34	2.8	36.8
I	34	2.8	36.8
Noble Lakeside Park Estate	34	1.8	35.8
G	34	2.7	36.7
Scenario 4 - Extraction Stage 4 and Processing			
A	*34*	2.0	36
C	*34*	1.6	35.6
M1[1]	*34*	2.8	36.8
M2[1]	*34*	0.9	34.9
M	34	2.2	36.2
K	34	1.3	35.3
I	34	1.2	35.2
Noble Lakeside Park Estate	34	0.9	34.9
G	*34*	1.2	35.2
Scenario 5 - Extraction Stage 7 and Processing			
A	34	3.2	37.2
C	34	2.3	36.3
M1[1]	34	1.9	35.9
M2[1]	34	0.8	34.8
M	34	2.8	36.8
K	34	1.6	35.6
I	34	1.5	35.5
Noble Lakeside Park Estate	34	1.1	35.1
G	34	1.3	35.3
Scenario 6 - Extraction Stage 10 and Processing			
A	34	3.3	37.3
C	34	2.5	36.5
M1[1]	34	1.6	35.6
M2[1]	34	0.7	34.7
M	34	3.4	37.4
K	34	2.9	36.9
I	34	3.1	37.1
Noble Lakeside Park Estate	34	1.8	35.8
G	34	2.8	36.8
Air quality goal - TSP (annual)		-	**90.0**

* See **Figure 4.22**
[1] Model receptor locations representing worst-case concentrations for residences in area
Source: Simmonds & Bristow (2008) – Modified from Tables 9, 12, 15, 18 and 21.

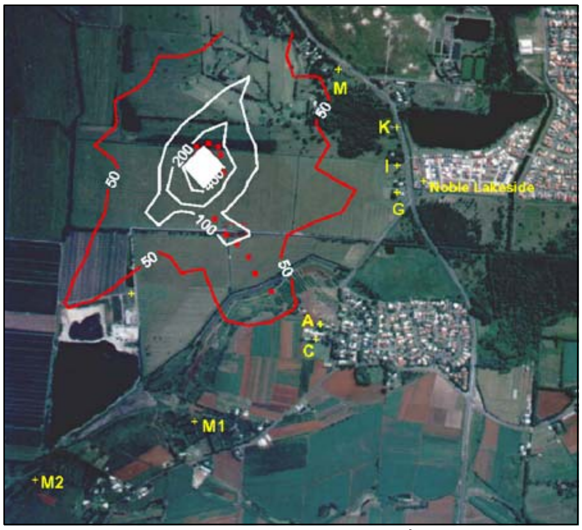
\\SERVER\RWC\617\61703\CAD\617Base_4.22 Dust Contours.DWG



Scenario 2 - PM_{10} ($\mu g/m^3$) 24hr Average

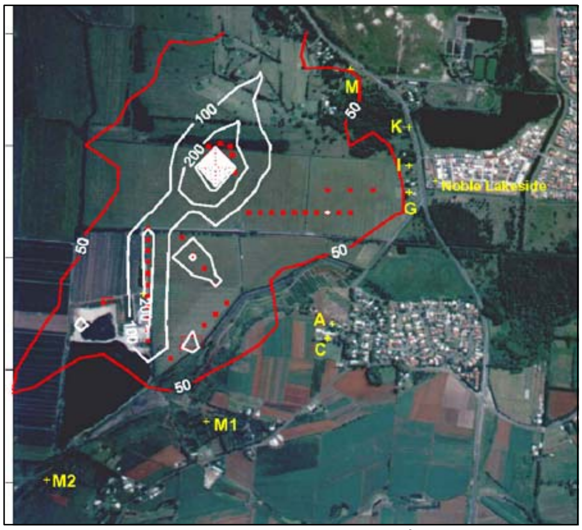


Scenario 4 - PM_{10} ($\mu g/m^3$) 24hr Average

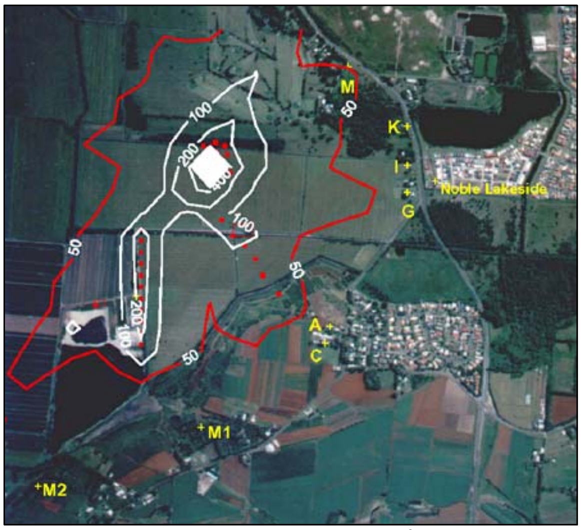


Scenario 5 - PM_{10} ($\mu g/m^3$) 24hr Average

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



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



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

Figure 4.22
24 HOUR PM_{10}
CONCENTRATION CONTOURS

Source: Simmonds and Bristow (2008) - Figures 6 - 11

Table 4.39
Predicted PM_{10} Levels at Off-site Receptors (24hr)

Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	μg/m³, 24 hr average#		
Scenario 1 – Site Establishment			
A	31	11	42
C	31	14	45
M1[1]	31	11	42.
M2[1]	31	5.7	36.7
M	31	6.6	37.6
K	31	9.2	40.2
I	31	5.6	36.6
Noble Lakeside Park Estate	31	7.2	38.2
G	31	8.5	39.5
Scenario 2 - Extraction Stage N1, Stage 4 and Processing			
A	31	8.6	39.6
C	31	7.0	38.0
M1[1]	31	6.7	37.7
M2[1]	31	5.5	36.5
M	31	16	47
K	31	10	41
I	31	12	43
Noble Lakeside Park Estate	31	10	41
G	31	15	46
Scenario 4 - Extraction Stage 4 and Processing			
A	31	7.4	38.4
C	31	6.2	37.2
M1[1]	31	6.4	37.4
M2[1]	31	3.8	34.8
M	31	16	47
K	31	9.6	40.6
I	31	7.5	38.5
Noble Lakeside Park Estate	31	5.5	36.5
G	31	9.7	40.7
Scenario 5 - Extraction Stage 7 and Processing			
A	31	16	47
C	31	9.6	40.6
M1[1]	31	4.7	35.7
M2[1]	31	2.6	33.6
M	31	16	47.1
K	31	9.9	40.9
I	31	7.9	38.9
Noble Lakeside Park Estate	31	8.0	39.0
G	31	13	44
Scenario 6 - Extraction Stage 10 and Processing			
A	31	7.6	38.6
C	31	5.7	36.7
M1[1]	31	3.8	34.8
M2[1]	31	2.4	33.4
M	31	15	46
K	31	10	41
I	31	9.3	40.3
Noble Lakeside Park Estate	31	9.7	40.7
G	31	16	47
Air quality goal – PM_{10} (24 hr)			**50.0**

* See **Figure 4.22** # See **Figure 4.22**
[1] Model receptor locations representing worst-case concentrations for residences in area
Source: Simmonds & Bristow (2008) – Modified from Tables 10, 13, 16, 19 and 22.

Table 4.40
Predicted PM_{10} Levels at Off-site Receptors (Annual)

Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, annual average		
Scenario 1 – Site Establishment			
A	17	0.6	17.6
C	17	0.6	17.6
M1[1]	17	0.8	17.8
M2[1]	17	0.2	17.2
M	17	1.4	18.4
K	17	1.0	18.0
I	17	0.9	17.9
Noble Lakeside Park Estate	17	0.6	17.6
G	17	0.8	17.8
Scenario 2 - Extraction Stage N1, Stage 4 and Processing			
A	17	1.2	18.2
C	17	0.9	17.9
M1[1]	17	1.2	18.2
M2[1]	17	0.4	17.4
M	17	1.5	18.5
K	17	1.0	18.0
I	17	1.0	18.0
Noble Lakeside Park Estate	17	0.7	17.7
G	17	1.0	18.0
Scenario 4 - Extraction Stage 4 and Processing			
A	17	0.7	17.7
C	17	0.6	17.6
M1[1]	17	1.0	18.0
M2[1]	17	0.3	17.3
M	17	0.9	17.9
K	17	0.5	17.5
I	17	0.5	17.5
Noble Lakeside Park Estate	17	0.4	17.4
G	17	0.5	17.5
Scenario 5 - Extraction Stage 7 and Processing			
A	17	1.2	18.2
C	17	0.8	17.8
M1[1]	17	0.7	17.7
M2[1]	17	0.3	17.3
M	17	1.1	18.1
K	17	0.6	17.6
I	17	0.6	17.6
Noble Lakeside Park Estate	17	0.4	17.4
G	17	0.5	17.5
Scenario 6 - Extraction Stage 10 and Processing			
A	17	1.1	18.1
C	17	0.9	17.9
M1[1]	17	0.6	17.6
M2[1]	17	0.3	17.3
M	17	1.3	18.3
K	17	1.2	18.2
I	17	1.2	18.2
Noble Lakeside Park Estate	17	0.7	17.7
G	17	1.1	18.1
Air quality goal – PM_{10} (annual)			**30.0**

* See **Figure 4.22**

[1] Model receptor locations representing worst-case concentrations for residences in area

Source: Simmonds & Bristow (2008) – Modified from Tables 10, 13, 16, 19 and 22.

Table 4.41
Predicted Deposited Dust Levels at Off-site Receptors

Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	g/m²/month [1]		
Scenario 3 – Stage N1, Stage 4 and Hanson Tweed Sand (Phase 2)			
A	1.5	1.6	3.1
C	1.5	1.4	2.9
M1[2]	1.5	**2.3**	3.8
M2[2]	1.5	1.0	2.5
M	1.5	1.3	2.8
K	1.5	0.7	2.2
I	1.5	0.6	2.1
Noble Lakeside Park Estate	1.5	0.4	2.9
G	1.5	0.7	2.2
Scenario 7 –Stage 7 and Hanson Tweed Sand (Phase 4)			
A	1.5	1.5	3.0
C	1.5	1.2	2.7
M1[2]	1.5	1.7	3.2
M2[2]	1.5	0.9	2.4
M	1.5	0.8	2.3
K	1.5	0.4	1.9
I	1.5	0.4	1.9
Noble Lakeside Park Estate	1.5	0.3	1.8
G	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 * See **Figure 4.22**
[2] Model receptor locations representing worst-case concentrations for residences in area
Source: Simmonds & Bristow (2008) – Modified from Tables 26 and 29.

Table 4.42
Predicted TSP Levels at Off-site Receptors

Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	µg/m³, annual average		
Scenario 3 – Stage N1, Stage 4 and Hanson Tweed Sand (Phase 2)			
A	34	4.3	38.3
C	34	3.6	37.6
M1[1]	34	5.0	39.0
M2[1]	34	2.4	36.4
M	34	4.9	38.9
K	34	3.2	37.2
I	34	3.2	37.2
Noble Lakeside Park Estate	34	2.2	36.2
G	34	3.1	37.1
Scenario 7 –Stage 7 and Hanson Tweed Sand (Phase 4)			
A	34	4.1	38.1
C	34	3.2	37.2
M1[1]	34	3.6	37.6
M2[1]	34	2.1	36.1
M	34	3.6	37.6
K	34	2.1	36.1
I	34	1.9	35.9
Noble Lakeside Park Estate	34	1.4	35.4
G	34	1.8	35.8
Air quality goal – TSP (annual)			**90.0**

* See **Figure 4.22**
[1] Model receptor locations representing worst-case concentrations for residences in area
Source: Simmonds & Bristow (2008) – Modified from Tables 24 and 27.

PM_{10}

Tables 4.43 and **4.44** present the predicted background, maximum increase and total 24 hour and annual average PM_{10} concentrations. No exceedances of the 24 hour or annual average PM_{10} goals are predicted for either cumulative scenario, however, the 24 hour PM_{10} air quality goal of 50µg/m^3 is equalled at Receptor M in both scenarios.

Table 4.43
Predicted PM_{10} Levels at Off-site Receptors (24hr)

Receptor *	**Predicted Background Concentration**	**Maximum Predicted Increase**	**Background + Increase**
	µg/m^3, 24 hr average#		
Scenario 3 – Stage N1, Stage 4 and Hanson Tweed Sand (Phase 2)			
A	31	13	44
C	31	9.4	40.4
M1[1]	31	9.3	40.3
M2[1]	31	7.3	38.3
M	31	19	50
K	31	14	45
I	31	15	46
Noble Lakeside Park Estate	31	12	43
G	31	17	48
Scenario 7 –Stage 7 and Hanson Tweed Sand (Phase 4)			
A	31	17	48
C	31	11	42
M1[1]	31	6.8	37.8
M2[1]	31	4.8	35.8
M	31	19	50
K	31	10	41
I	31	8.9	39.9
Noble Lakeside Park Estate	31	9.1	40.1
G	31	14	45
Air quality goal – PM_{10} (24 hr)		-	**50.0**

* See **Figure 4.22** # See **Figure 4.22**
[1] Model receptor locations representing worst-case concentrations for residences in area
Source: Simmonds & Bristow (2008) – Modified from Tables 25 and 27.

4.9.6.3 Greenhouse Gas Emissions

The primary source of greenhouse gas emissions relating to the Project would be as a result of the combustion of diesel fuel by diesel-powered earthmoving and static equipment and highway trucks. It is estimated that, at full production, approximately 900kL of diesel would be consumed annually to operate all on-site equipment and the pumping stations (booster pumps).

In addition to the on site generation of greenhouse gas emissions, consideration has also been given to emissions generated by product despatch and VENM receipt. **Table 4.45** provides a summary of the estimated diesel consumption resulting form product despatch and VENM receipt.

Therefore, the total annual diesel consumption resulting from the Project would be approximately 1 359kL.

Table 4.44
Predicted PM_{10} Levels at Off-site Receptors (Annual)

Receptor *	Predicted Background Concentration	Maximum Predicted Increase	Background + Increase
	$\mu g/m^3$, annual average		
Scenario 3 – Stage N1, Stage 4 and Hanson Tweed Sand (Phase 2)			
A	17	2.1	19.1
C	17	1.7	18.7
M1[1]	17	2.0	19.0
M2[1]	17	1.0	18.0
M	17	2.6	19.6
K	17	1.8	18.8
I	17	1.8	18.8
Noble Lakeside Park Estate	17	1.2	18.2
G	17	1.7	18.7
Scenario 7 –Stage 7 and Hanson Tweed Sand (Phase 4)			
A	17	1.6	18.6
C	17	1.2	18.2
M1[1]	17	1.4	18.4
M2[1]	17	0.8	17.8
M	17	1.6	18.6
K	17	0.9	17.9
I	17	0.9	17.9
Noble Lakeside Park Estate	17	0.6	17.6
G	17	0.6	17.6
Air quality goal – PM_{10} (annual)		-	**30.0**

* See **Figure 4.22**
[1] Model receptor locations representing worst-case concentrations for residences in area
Source: Simmonds & Bristow (2008) – Modified from Tables 25 and 28.

Table 4.45
Estimated Diesel Consumption – Product Despatch and VENM Receipt

	Truck Loads (per year)	Average Return Trip (km)	Total Kilometres Travelled	Diesel Consumption (kL)[3]
Product Despatch	15 000[1]	40	600 000	327.6
VENM Receipt	3 000[2]	80	240 000	131.0
Total	**18 000**	**-**	**840 000**	**458.6**

Notes: 1. Based on conservative estimate of 20t average truck capacity.
2. Based on conservative estimate of 15t average truck capacity.
3. Sourced from Table 4 of *Australian Greenhouse Office Factors and Methods Workbook* – heavy trucks 0.546L/km

Using Table 3 of the Australian Greenhouse Office document *Australian Greenhouse Office Factors and Methods Workbook*, each 1 000L of diesel consumed results in the emission of 2.7t of CO_2-equivalent. Based on this emission factor, it is estimated that the Project would directly result in the emission of 3 669t of CO_2-equivalent per year.

The Project would also result in indirect greenhouse emissions through the consumption of electricity. Based on the use of 400kW/hrs per year, using Table 5 from Australian Greenhouse Office Factors and Methods Workbook, within NSW, each kW/hr generates 0.863t of CO_2 - equivalent. Therefore, the consumption of electricity would indirectly result in the emission of 357t of CO_2 – equivalent per year.

The total direct and indirect emissions resulting from the Project would therefore be 4 026t of CO_2 – equivalent per year.

Greenhouse gas estimates are assessed relative to 1990 baseline levels for reporting purposes. The *1990 National Greenhouse Gas Inventory* (AGO, 1990) provides estimates of greenhouse emissions in Australia. In 1990, total Australian emissions were estimated to be 392 061kt CO_2-equivalent.

Therefore, the greenhouse gas emissions resulting directly from the Project amount to less than 0.001% of the total baseline year for Australian emissions (1990) annually.

The Project would therefore result in comparatively very small greenhouse emissions and would have negligible impacts.

4.9.7 Monitoring

An air monitoring program would be prepared to ensure that DECC air quality goals for dust (PM_{10} and deposited dust) are met and demonstrate the conservative nature of the predictions. This program would be specifically designed and include the current deposited dust monitoring sites at Receptors B and G and would consider PM_{10} (24 hour average) monitoring in the vicinity of the model receptor locations Receptor A, Receptor M and Receptor G. It is noted that compliance with PM_{10} goals would invariably indicate compliance with TSP goals. Hence, it is not proposed that TSP would be monitored. PM_{10} monitoring would be undertaken for a period of 1 year, upon which the results would be reviewed to confirm the need for ongoing PM_{10} monitoring.

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

Monitoring would 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 would 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).

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

4.9.8 Conclusion

Using the air dispersion model Ausplume V6.0 it was predicted that total deposited dust, TSP and annual PM_{10} levels at surrounding receptors would remain within accepted criteria. Maximum 24 hr PM_{10} concentrations were predicted to equal accepted criteria at Receptor M under the cumulative scenarios incorporating the operations at the Hanson Tweed Sand Quarry.

It is noted that predicted air quality impacts are considered to be conservative due to modelling methodologies and assumptions adopted. However, a monitoring program for deposited dust and 24 hour PM_{10} is proposed to demonstrate compliance with accepted air quality goals and verify the conservative nature of the modelling.

4.10 ABORIGINAL CULTURAL HERITAGE

4.10.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the **unmitigated** risk rating for potential impacts on unidentified sites and/or artefacts of Aboriginal cultural heritage as a result of soil stripping and extraction activities is assessed to be moderate.

The following subsections presents a summary of the Aboriginal heritage assessment conducted for the Cudgen Lakes Sand Extraction Project by Heritage Surveys Archaeological Consultants (Heritage Surveys, 2008) with the assistance of representatives of the Tweed Byron Local Aboriginal Land Council (LALC). Heritage Surveys was commissioned to identify any Aboriginal sites and relics that may be present and make recommendations both to the Tweed Byron LALC and also to the Proponent. The full report of Heritage Surveys (2008) is presented as Part 10 Volume 2 of the *Specialist Consultant Studies Compendium*.

4.10.2 Previous Investigations and Aboriginal Sites Register Search

A review of previous studies and the Aboriginal Heritage Information Management System (AHIMS) register was undertaken prior to field inspections. Numerous studies have been undertaken over parts of the Project Site and nominated fill sites, primarily in response to impact assessments required for development proposals. **Figure 4.23** displays known Aboriginal heritage sites within the area. The closest recorded site (# 4-2-109), an open campsite, is located 175m southwest of the Project Site.

Based on these previous investigations, listings on the Register of National Estate and AHIMS listings, there is potential for Aboriginal heritage sites within the Project Site and pipeline corridors. It was considered that there was a low to moderate potential for the following Aboriginal sites.

Figure 4.23
KNOWN ABORIGINAL HERITAGE SITES

Midden sites - invariably found on elevated ground adjacent to the source of the shellfish. Sources of shellfish include open beaches, rock platforms, tidal mud flats, rocks and mangrove roots.

- Open campsites may be found in almost any elevated position adjacent to wetlands or creeks.
- Quarry sites - potential occur where outcrops of greywacke exist. The only stone within the Study Area occurs on the upper slopes of Lot 3 DP 828298.
- Scarred tree sites - are rare due to the extent of tree felling and natural causes. The only part of the Study Area which contains trees which may be of sufficient age to carry scars of Aboriginal origin is within Lot 3 DP 828298 where mature melaleuca trees exist.
- Burial sites – are unlikely to occur in low lying areas of the floodplain due to the strongly acidic soils, however, a low to moderate potential for burials exists, particularly within sand rises or where associated with shell midden material.

There is also a moderate potential for isolated artefacts to occur within the Study Area. It is considered that there is low to nil potential for Bora / Ceremonial sites to occur within the Study Area.

4.10.3 Survey Results

In August and September 2005, a comprehensive survey was carried out of the entire Project Site and parts of the nominated fill sites by Heritage Surveys with the accompaniment of Mr Cyril Scott representing the Tweed Byron LALC. The site visibility within the Project Site was high (approximately 90%) and within the pipeline corridors low to high (10% to 80%). The survey strategy entailed examining all areas of visible surface exposure in areas of low visibility and use of transects in areas of high visibility.

No Aboriginal sites or relics were found during the survey. Although a number of Aboriginal sites have been found within the local area, the extensive area of surface visibility within the northern and southern extraction sites and processing area was adequate to conclude with a high degree of certainty that Aboriginal heritage sites do not exist in this area. Within the pipeline corridors, there was considered to be a very low potential for Aboriginal sites. The only site considered to have a potential to occur within the eastern corridors were scar trees of which none were found. It is also noted that the road easement for Tweed Coast Road has experienced high levels of mechanical disturbance in the past which could be expected to have had a highly destructive impact upon Aboriginal heritage sites within this area, had they existed.

4.10.4 Mitigation and Management Procedures

Though no Aboriginal sites or relics were found, the Tweed Byron LALC would be invited to observe during the burying of the pipelines within the northern pipeline corridor. In the event that the alternative northern pipeline corridor was required, a field survey by an experienced heritage consultant and the Tweed Byron LALC would be undertaken.

If in the process of site establishment, construction or operational works any Aboriginal sites or relics are found, the following actions would be taken.

- Works at and adjacent to the material would stop.
- The regional archaeologist of the Coffs Harbour DECC and the Tweed Byron LALC would be contacted.
- Works would not proceed in the vicinity of the identified material without authorisation from the DECC and Tweed Byron LALC.

These recommendations have been supported by the Tweed Byron LALC (see Heritage Surveys, 2008).

4.10.5 Assessment of Impacts

Considering that no Aboriginal heritage sites have been identified within the Project Site or pipeline corridors, under the implementation of the mitigation and management procedures described in Section 4.10.4, it is highly unlikely that the Project would result in any impacts to Aboriginal heritage sites.

4.11 SOCIAL AND ECONOMIC ISSUES

4.11.1 Introduction

Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the potential socio-economic impacts requiring assessment and their **unmitigated** risk ratings are as follows.

- Reduced quality of life (actual or perceived) (Medium Risk).
- Reduced property values (Medium to High Risk).
- Improved economic activity and related social impacts (risk not applicable).

The following subsections describe the socio-economic setting and the potential impacts that the Project would have on the socio-economic environment.

The information presented in this section is drawn from the socio-economic assessment undertaken by Darren Gibson Planning (DGP, 2008) whose full report is included in the *Specialist Consultant Studies Compendium* (Volume 2, Part 11).

4.11.2 The Existing Social and Economic Setting

Population and Growth

The Project Site is located within the Tweed Coast, one of the most rapidly growing areas of NSW. Statistics from the Australian Bureau of Statistics (ABS) show that Tweed LGA as a whole has grown from 65 052 persons in the year 1996, to a preliminary estimated figure of 84 325 as at June 2007. This represents an annual average compound rate of increase of 2.39%. In particular, there has been a significant concentration of population growth in the northern and coastal urban sections of the Tweed LGA. In contrast, the average growth rate for the whole of NSW for the 10 years from 1996 to 2006 was just under 1%.

In view of the continuing development of new housing estates to meet demand from incoming residents as well as incrementally increased housing need brought about by gradually declining household sizes, it can be expected that there will be continuing overall growth at or about rates experienced over the last decade (DGP, 2008). Official population projections released by DIPNR (2004), show a forecast growth rate at an average of 2.3% between 2006 and 2011 for the northern and coastal urban areas within Tweed LGA (Part A), gradually declining to about 1.5% in the 2026 to 2031 period. For the southwesterly, rural and village areas throughout the Tweed LGA (Part B), an average annual growth rate of 1.0% between 2006 and 2011 is expected to reduce to 0.8% in the 2026 to 2031 period (see **Table 4.46**).

Table 4.46
Population Forecasts – Tweed LGA – 2006 to 2031

Year (as at June)	Tweed LGA – Part A		Tweed LGA – Part B		Tweed LGA (Total)	Annual Change
	Population	Annual Change	Population	Annual Change		
2006	53 640	-	29 110	-	82 750	-
2011	60 200	2.3%	30 580	1.0%	90 780	1.9%
2016	66 540	2.0%	32 010	0.9%	98 550	1.7%
2021	72 840	1.8%	33 490	0.9%	106 330	1.5%
2026	79 040	1.6%	34 990	0.9%	114 030	1.4%
2031	84 970	1.5%	36 440	0.8%	121 410	1.3%

Source: DGP (2008) – Table 4

The statistical unit considered appropriate for the Project Site's locality and for comparative analysis of demographic and socio-economic characteristics is the postcode area 2487 (incorporating Kingscliff / Chinderah / Cudgen). At the time of the ABS 2001 Census, the area within postcode 2487 contained an estimated resident population of 8 385 persons, which had risen to a preliminary figure of 9 263 by the 2006 Census, representing an annual average growth rate of 2.0%.

4.11.2.1 Age Profile

Table 4.47 outlines the numbers and proportions of persons in 5-year age groupings in postcode 2487 at the time of the recent 2006 Census, compared with proportions contained in Tweed LGA as a whole and in Balance (non-metropolitan) NSW.

Table 4.47
Demographic Profile – Age Groups at 2006 Census

Age Group	Postcode Area 2487 - Number	Postcode 2487 - Percent	Tweed LGA - Percent	Balance NSW - Percent
0-4	470	5.1%	5.3%	6.2%
5-9	549	5.9%	6.2%	6.8%
10-14	601	6.5%	6.9%	7.4%
15-19	573	6.2%	6.4%	6.9%
20-24	411	4.4%	4.3%	5.5%
25-29	354	3.8%	3.9%	4.9%
30-34	468	5.1%	5.1%	5.8%
35-39	571	6.2%	5.9%	6.4%
40-44	655	7.1%	6.8%	7.1%
45-49	682	7.4%	7.5%	7.4%
50-54	661	7.1%	6.8%	6.9%
55-59	602	6.5%	6.7%	6.7%
60-64	592	6.4%	6.0%	5.6%
65-69	519	5.6%	5.6%	4.7%
70-74	513	5.5%	5.5%	4.0%
75+	1,042	11.2%	11.1%	7.8%
Total	**9,263**	**100.0%**	**100.0%**	**100.0%**
Source: DGP (2008) – Table 5				

It can be seen that the age profile within postcode area 2487 was very similar to, but slightly skewed towards an older age distribution than that for the Tweed LGA. Within the Balance of NSW, however, there is a notably younger overall population with higher proportions than in postcode area 2487 in every age grouping up to and including the 35 to 39 year age group.

Conversely, the older age groups were much more strongly represented in postcode area 2487. Nearly 50% of the postcode area 2487 population was aged 45 years and over, compared with about 43% for Balance NSW. Median age for postcode areas 2487 was 44 years and for Balance NSW it was 40 years.

4.11.2.2 Households and Dwellings

Average household size in postcode area 2487 at the 2006 Census was 2.3 persons compared with 2.4 persons for Tweed LGA and 2.5 persons for Balance NSW. These average household sizes can be seen to approximately correspond with average age groupings, with small household sizes being more predominant with higher average age profiles due to greater numbers of single-member and two-member households.

4.11.2.3 Employment

The high proportion of aged residents in Tweed LGA led to the age dependency ratio at the 2006 Census of 68.40 and for the postcode area 2487 a ration of 66.40. The age dependency ratio for NSW as a whole at that time was 50.80 (ie. slightly greater than 50% of the NSW population being of non-working age, compared with nearly 70% of the Tweed LGA population in the non-working age category).

It is noted that, as of the 2001 Census, the unemployment rate was significantly higher in Tweed LGA (12.6%) and postcode area 2487 (13.6%) than for the State as a whole (9.3%), however, by the time of the most recent 2006 Census the rate had reached approximate equilibrium between Tweed Shire and postcode area 2487 and Balance NSW, with comparable unemployment rates for persons of workforce age. Comparative labour force characteristics as at 2006 for postcode area 2487, Tweed LGA and Balance NSW are shown in **Table 4.48**.

Table 4.48
Labour Force Characteristics – 2006 Census

	Postcode 2487		**Tweed LGA**	**Balance NSW**
	Persons	**%**	**%**	**%**
Employed	3,490	93.5	92.9	93.0
Unemployed	241	6.5	7.1	7.0
Total Labour Force	**3,731**			
Source: DGP (2008) – Table 8				

In the postcode area 2487 in 2006, the male unemployment rate (7.0%) exceeded the female unemployment rate (5.9%), however, within the Tweed LGA as a whole, the proportion of male and female unemployed persons in the labour force were approximately equal at 7.0%.

Table 4.49 sets out a summary of numbers and proportions of employed persons by industries in the postcode area 2487 as at the Census in 2006, compared with proportions in the overall Tweed LGA and Balance NSW populations.

The industry employment characteristics of postcode area 2487 are broadly similar to those for Tweed LGA, although there is a higher proportion of the workforce engaged in construction activities than in the Tweed LGA. In postcode area 2487, there is a notably lower share of the employed 2487 postal area population involved in the retail industry, which is the major employment industry not only in Tweed LGA but also the Balance NSW area, as it is intrinsically a labour-intensive activity.

4.11.2.4 Incomes

In 2006, the median weekly household income for the postcode area 2487 was $673, compared with the almost identical figure for Tweed LGA of $683. For the Balance of NSW area as a whole, the median weekly household income was $795.

Table 4.49
Employed Persons by Industries – 2006 Census

Industry*	Postcode Area 2487		Tweed LGA	Balance NSW
	No	**%**	**%**	**%**
Construction	444	13.5	13.0	8.3
Health care & social assistance	428	13.0	13.2	12.2
Retail trade	413	12.6	15.1	13.1
Accommodation & food services	374	11.4	10.8	8.0
Education & training	322	9.8	7.7	8.8
Manufacturing	113	3.4	3.0	3.3
Public administration & safety	96	2.9	3.4	7.4
Professional, scientific & technical services	90	2.7	2.5	1.6
Transport, postal & warehousing	73	2.2	1.8	1.3
Administrative & support services	60	1.8	2.0	2.4
Wholesale trade	41	1.2	1.3	1.3
Agriculture, forestry & fishing	36	1.1	0.9	1.4
Rental, hiring & real estate services	12	0.4	0.3	1.8
Arts & recreation services	218	6.6	7.2	9.9
Financial & insurance services	180	5.5	5.7	7.3
Information media & telecommunications	151	4.6	4.3	4.6
Electricity, gas, water & waste services	119	3.6	4.3	4.6
Mining	117	3.6	3.4	2.7
	3,287	**100.0**	**100.0**	**100.0**

* Excludes "not stated" and "non-classifiable"
Source: DGP (2008) – Table 9

Respective median weekly individual incomes in 2006 were:

- $379 (postcode area 2487);
- $364 (Tweed LGA); and
- $386 (Balance NSW).

Reasons for the differences in average household and individual incomes between Tweed LGA and Balance NSW would principally result from the larger average household sizes in the Balance of NSW, the markedly lower age profile in Balance NSW, with a correspondingly higher workforce participation, as well as the higher proportion of fixed-income aged residents in Tweed LGA.

4.11.3 Social Impact Assessment

The social assessment has focused specifically on the potential impacts requiring assessment as identified by the Tweed DCP 45. While not all are strictly relevant to the Project, all of those matters are addressed as follows.

Community Networks

Tweed DCP 45 indicates that the social impacts in relation to "community networks" need to be considered in the context of whether the Project:

- provides or reduces facilities or opportunities for social interaction;
- improves or reduces community identity and cohesion;
- improves or reduces existing residential amenity;
- creates or removes physical barriers between houses and community facilities;
- impacts or disadvantages social groups; and / or
- consolidates or dislocates existing social or cultural networks.

The potential impacts of the Project (and the cumulative impacts with surrounding land uses) relate principally to the existing residential amenity. All relevant impacts have been assessed throughout Section 4 which were assessed as acceptable or able to be satisfactorily managed (see specifically Section 4.7, 4.8, 4.9 and 4.12).

The Project would also contribute to the transition of the character or identity of the land in the locality (which already features large-scale sand extraction and construction of the new Kingscliff WWTP) from a principally rural or agricultural identity, to one of water-based natural resource utilisation and utility and finally to recreation and sporting

Notwithstanding the above, the principal reason for undertaking the Project is to obtain fill material to enable the Proponent's landholdings to be developed in accordance with a balanced structure plan (see Section 1.4.6). The implementation of the Structure Plan would provide opportunities for social interaction through the provision of civic and community facilities, sporting fields and passive recreation areas and improved transport networks (including pedestrian and cycleways). As previously noted in Section 1.4.6 approval for the filling of nominated sites and their subsequent development in accordance with the Structure Plan will be sought under separate development applications.

The development of the Proponent's landholdings, as envisaged by the Structure Plan, would also provide opportunities for improved access within and between existing residential areas and, in particular, better linkages between existing residential areas and community facilities, recreation areas and commercial services by removing the physical barriers created by the large undeveloped land tracts that currently separate and isolate these areas.

The Project would have no apparent direct impact on disadvantaged groups or social or cultural networks. The Project would not result in the dislocation of any social group.

Public Realm

Tweed DCP 45 indicates that the matters to be considered in relation to the public realm are whether the Project:

- safeguards or threatens heritage sites or buildings, or archaeological sites;

- makes available or enhances, or is detrimental to public places/open space;
- provides or displaces public facilities;
- avoids or exhibits overdevelopment/large scale buildings; and
- has resulted in a significant positive or negative response in submissions and / or meetings.

There are no heritage items or conservation areas on or near the Project Site. Heritage Survey (2008) concludes that the Project would not significantly affect any item or area of cultural heritage significance.

The Project would not result in the displacement or diminution of an existing public place, facilities or open space, however, through the implementation of the Structure Plan, the Project would ultimately facilitate the provision of public sports fields and passive open space areas on the site following the completion of various stages of the sand extraction process. The Structure Plan would also provide for the conservation of large areas of important vegetation and fauna habitat areas.

The scale and character of the Project, including the nature and scale of buildings associated with the sand extraction operation, would be consistent with the scale and character of development in the immediate vicinity of the site (Kingscliff WWTP and the adjoining Hanson Tweed Sand operations). The scale of operations and buildings would be balanced by the large land areas involved. Further detail relating to the visual impact of the Project is provided in Section 4.12.

Consultation has identified a number of issues that, the local community considers, need to be taken into account in the design and management of the Project. Details of public consultation are outlined in Section 3.2.2. All issues raised during consultation have been considered during the design and assessment of the Project throughout the *Environmental Assessment*.

Housing

The Project would directly facilitate the provision of additional residential land for housing in the Kingscliff / Chinderah / Cudgen area through the provision of fill sand allowing residential development in accordance with the proposed Structure Plan. In this respect, there is an opportunity to respond to housing needs within this area, including the following.

- The need to accommodate up to an additional 3 350 people over the next 10 years in the locality.
- The provision of additional well located detached housing to encourage and meet the needs of younger, working families.
- The provision of additional medium density housing forms, such as flats, apartments and townhouses to meet the growing demand for these forms of housing as a result of the ageing population and smaller household sizes.

- The opportunity to provide special needs housing such as seniors living accommodation.
- The opportunity to deliver more affordable housing options in near coastal locations.

The Project would also indirectly contribute to local housing through the supply of construction sand to the construction industry for use in concrete and mortar products.

Access

The Project would have little apparent impact on access issues within the locality. The Project would, however, involve the relocation of the existing alignment of Altona Drive, which would ultimately serve as the main access road to the future sports fields and recreation facilities for the locality.

However, the development of the Proponent's adjacent landholdings as envisaged by the Structure Plan, would significantly improve accessibility within and between areas, particularly through the creation of new road linkages and the implementation of pedestrian pathways and cycleways. These facilities would in turn improve access to existing public transport services. Further, the demand generated by additional population and the provision of specific facilities to encourage public transport use, is likely to lead to an increase in public transport services throughout the locality.

Human Services

The Project would have no apparent effect in relation to the delivery of human services.

Implementation of the development envisaged by the Structure Plan would, however, result in a significant increase in population and a consequent increased demand for community, health and educational services and for retail and recreational facilities. The Structure Plan contemplates the provision of additional human service requirements in the form of additional retail and commercial facilities (including medical facilities), community centre, library and civic centre, private educational institutions and recreation facilities.

4.11.4 Economic Impact Assessment

From an economic impact and land use planning perspective, the principal benefits arising from the Project would be:

- the facilitation of the development of the Proponent's important landholdings at West Kingscliff, Chinderah and Cudgen as a new urban village; and
- the productive utilisation of a regionally significant extractive material resource (FNCRS, 2007) and ancillary development.

The key economic impacts of the Project therefore arise in respect of the following.

- As a result of extracting the sand to provide fill material.
- As a result of providing material for the construction industry.
- As a result of providing a facility to dispose of VENM.
- From the development of the Proponent's adjacent landholdings in accordance with its Structure Plan.
- Comparative economic use of the land and the resource.

Sand Extraction - Filling

Assuming that 2 500 000m^3 would be placed hydraulically over the Proponent's fill sites over a period of approximately 15 years, the net present value of the fill sand compared with importing a similar material from an external supplier is approximately $14.6 million.

The on-site operations would also lead to the creation of five full time equivalent jobs resulting in salaries in the order of $300 000 per year.

Sand Extraction - Construction Industry

Up to 300 000t of sand products would be available for sale to the construction industry per year throughout the life of the project. This sand could be used in concrete manufacture building construction, filling etc. The net present value of external sand sales is also in the order of $14.6 million.

No additional employees to those required for the extraction of fill sand would be required to extract and process the sand to make it available to the construction industry. The extraction of sand for the construction industry would in fact provide a regular employment base for the site. The Project would provide employment for up to 14 truck drivers to transport sand products to external clients and to import VENM material.

It is recognised that the adjoining sand extraction operation operated by Hanson Construction Materials produces some products, principally washed sand, which would be comparable with those produced on the Project Site. However, the Proponent would maximise the production of mortar sand and a variety of other products produced through blending with varying proportions of VENM components that can be recycled on site. As discussed in Section 1.4.7, it is a common feature for individual extractive resources to be extracted by two or more companies supplying their own customers and / or needs.

Furthermore, based on market predictions by Ecoroc between 2005 and 2020, a cumulative collective consumption of 15 million tonnes of fine sand is expected within the Tweed and coastal Northern New South Wales region and Gold Coast City. Within the Tweed to Southeast Queensland area, the total remaining approved and accessible fine sand reserves are estimated to be less than 6 million tonnes, or enough to satisfy market demand for only 6 years.

Plant capacity and development approval restrictions also limit the capacity of approved operations to fully satisfy market demand. New reserves of fine sand are therefore needed to satisfy existing and future market demand, particularly to service the Tweed to Brisbane corridor (Ecoroc, 2007 – Part 12 of the *Specialist Consultants Studies Compendium*).

Processing and Disposal of VENM

The value of the receipt and processing of VENM material is less tangible, given the relative uncertainty as to the demand for this type of facility. Enquiries within the local construction and development industry indicate that up to 30 000m^3 of VENM material could be received per year. Assuming 50% of the material is VENM(a) and 50% VENM(b), annual receipts could be between $675 000 and $1 million, based on disposal costs at similar facilities in other jurisdictions.

It is also expected that approximately 50% of the VENM material could be reprocessed. This would add in the order of $315 000 per year to the value of products sold from the site. The use of VENM in the production of construction materials is recognised, together with recycling of construction materials eg. concrete, as important initiatives that need to be embraced by the extractive industry. For every tonne of VENM used to produce a tonne of construction material, a tonne of natural material would be available for further construction projects. In other words, the life of natural resources are extended which is consistent with recognised sustainability objectives.

Implementation of Structure Plan

The development of the Proponent's landholdings as set out in the Structure Plan (see Section 1.4.6) would make a major contribution to economic development in the local economy through the generation of substantial capital expenditures and the creation of new employment opportunities in the Tweed LGA.

Overall, total estimated development and construction cost is of the order of $723 million (in 2007 dollars), as shown in the summary in **Table 4.50**. This will result in total expenditure in the economy, including output multipliers, of $2 072 million.

Table 4.50
Gales Landholdings – Summary of Projects – Costs, Multipliers and Employment

Project Elements	Construction Cost ($)	Total Output Multipliers ($)	Direct Employment Years (FTE)*	Total Direct & Induced Job Years (FTE)*
Residential Construction	406 620 000	1 165 372 920	2 541	4 829
Non- Residential	208 640 000	597 962 240	1 305	2 479
Civil Construction Works	107 665 000	308 567 890	673	1 279
Totals	**722 925 000**	**2 071 903 050**	**4 519**	**8 587**

Source: DGP (2008) – Table 18 * FTE – Full Time Equivalent

Construction activities are expected to lead to creation of 8 587 direct and directly induced full-time equivalent job years. Facilities to be constructed on the "Employment Lands" within the Proponent's property are predicted to generate direct and directly induced permanent ongoing employment for another 3 390 members of the workforce. A detailed assessment of the economic effects arising from the implementation of the Structure Plan is provided in Section 8.4.4 of DGP (2008).

Overall, it is clear that facilitating development of the Proponent's landholdings, to serve as a key new urban growth area, in accordance with the land's zoning and as anticipated under the Far North Coast Regional Strategy (2007), will act as a significant catalyst to economic activity in the region and a major generator of new employment opportunities.

The economic benefits of alternative development of the District Town Centre site have also been assessed assuming development based on current local statutory planning provisions ie. building works for industrial purposes, bulky goods retailing and associated activities. It has assessed that the alternative development would result in approximately 40% lower expenditure and 40% lower employment generation (DGP, 2008).

The district centre option, in the form of a "town centre", would also allow the opportunity for integration of residential premises of various types within and around the employment lands not otherwise achievable with industrial development. Apart from the urban design and lifestyle benefits of this, it is also notable that it will provide high accessibility for residents in view of the configuration of the major road system.

Alternative Agricultural Land Uses

Given the zoning of the land under the *Tweed Local Environmental Plan 2000* and past land use practices, it is appropriate that the agricultural value of the land be considered.

As discussed within Section 1.4.2, the land within the Project Site has a history of failed agricultural enterprises. An analysis of the agricultural values of the land prepared in respect of the Project indicates that there are physical constraints that prevent the land being used for intensive agricultural purposes (see Section 4.3.6.3 and HMC, 2008).

It is noteworthy that the Department of Primary Industries (Agriculture) land classification maps do not identify the land as comprising prime agricultural crop or pasture land (classes 1, 2 or 3).

It is assessed that the use of the land for sand extraction purposes as proposed, far exceeds its value for agricultural purposes, which is of questionable viability.

4.11.5 Conclusions

The sand extraction Project would result in the productive utilisation of an identified regionally significant sand resource. The net present value of the resource is estimated at approximately $30 million (2007 dollars) with the operation providing total salaries in the order of $300 000

per year. Furthermore the provision of fill sand allowing the implementation of the Structure Plan would result in significant expenditures in the economy and the generation of significant ongoing employment.

The demographic analysis undertaken indicates that significant population growth (and therefore housing demand) is expected over the next 20 years, with growth predicted up until at least 2031. Therefore the trend expected is the continued strong demand for sand based construction materials to meet the needs of the construction industry.

While there is potential for environmental impacts to occur, particularly in relation to local amenity and agricultural land uses, the Project has been designed to specifically respond to issues raised by government agencies and local community members and groups consulted in relation to the Project.

4.12 VISIBILITY

4.12.1 Introduction

As part of the consultation process, one local resident / landowner identified impacts on their visual amenity as an issue of concern. The Director-General's Requirements also identified visual impacts as a key issue for assessment. Based on the environmental risk analysis undertaken for the Project (see Section 3.3 and **Table 3.7**), the **unmitigated** risk rating for potential impacts on visual amenity was considered high for the short to medium term and low for the long term.

This subsection outlines the existing visibility of the Project Site experienced by surrounding residents / landowners, proposed safeguards and mitigation measures and an assessment of the likely impact to the visual amenity.

4.12.2 Existing Visual Amenity

The existing visual character of the Project Site and surrounds is a combination of a rural landscape including grazing and horticultural enterprises, particularly to the south upon the Cudgen Plateau, and industrial developments. Industrial developments include the adjoining Hanson Tweed Sand Quarry and new Kingscliff WWTP on the western boundary of the Project Site and the Australian Bay Lobster Farm which has been approved for construction immediately to the west of the Hanson Tweed Sand Quarry (see **Figure 1.4** and **Plate 1.1**).

The residential areas of Noble Lakeside Park Estate and Cudgen residential area are also located to the east and southeast of the Project Site (see **Figure 4.3**). **Plates 4.1** and **4.2** show the topography and land uses around the Project Site that form the visual character of the Project Site and surrounds.

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Oblique Aerial View to the East over the Kingscliff Waste Water Treatment Plant and the Project Site.
(Ref: E617-C106) Photo Date: 20/04/06

PLATE 4.1

Oblique Aerial View to the west-southwest over Noble Park Lakeside Estate and the Project Site.
(Ref: E617-C094) Photo Date: 20/04/06

PLATE 4.2

For assessment purposes, views of the Project Site may be separated into the following visual catchments.

- Low elevation views from areas surrounding the Project Site (eg. Crescent Street & Tweed Coast Road, Noble Lakeside Park Estate and Chinderah Golf Course) (see **Plate 4.3)**.
- Elevated views from Cudgen Plateau and parts of the Cudgen residential area (see **Plate 4.4** and **Plate 4.5**).
- Distant (approximately 1.5km) elevated views from parts of Kingscliff (see **Plate 4.6**).
- Distant (approximately 3.0km) elevated views from Terranora and Banora Point.

4.12.3 Mitigation Measures and Management Procedures

The following visual controls would be implemented to reduce potential adverse impacts upon visual amenity.

- The processing area would be surrounded by a 3m high bund planted with native shrub species.
- A visual screen would be planted along the eastern extent of the northern and southern extraction sites (see Figure 2.3).
- The Project Site would be progressively rehabilitated so that non-vegetated areas would be minimised.
- The Project Site would be maintained in a clean and tidy condition at all times.
- Air quality controls would be implemented (see Section 4.9.4) to reduce visible dust.
- Floodlights or other required lighting would be positioned and directed so as to minimise light emissions. Where lighting is not required at any given time it would not be used.

As discussed in Section 2.15.3, following the consideration of a number of potential locations, the Proponent has also located the processing area in an area that would result in the least potential visual, noise and air quality impacts.

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Plate 4.3 : View Southwest from Tweed Coast Road to the Project Site
(Ref: E617-E041) Photo Date: 16/05/07

Plate 4.4 : View West from the Project Site to Cudgen Plateau.
(Ref: E617-E013) Photo Date: 16/05/07

Plate 4.5 : View to the north-northwest from Collier Street to the Project Site
(Ref: E617-E048) Photo Date: 16/05/07

Plate 4.6 : View to the northwest from Kingscliff to the Project Site
(Ref: E617-E051) Photo Date: 16/05/07

4.12.4 Residual Impacts

Based upon the available topographic information, observations from surrounding vantage points and the proposed mitigation measures, residual visual impacts have been assessed as follows.

- Low elevation views from areas surrounding the Project Site.

  The existing tree screen on the western side of the Noble Lakeside Park Estate and existing natural vegetation north of the Project Site would result in very limited and obstructed views of on-site activities from within Noble Lakeside Park Estate and the Chinderah Golf Course. Low elevation views of the initial extraction activities would be possible during the early years of site operations from Crescent Street and Tweed Coast Road. These views would diminish as the vegetation screens on the eastern boundaries of the extraction areas achieve heights above 2m to 3m.

- Elevated views from Cudgen Plateau and parts of the Cudgen residential area.

  Partially obstructed views of the processing area would occur from the northern part of the Cudgen residential area and Cudgen Plateau. Within the processing area, the principal components that would be visible would be the washed sand stockpile and the upper sections of the wash plant.

  Relatively unobstructed views of sand extraction activities would also be available from the northern fringe of the Cudgen residential area, particularly of the northern extraction site and the latter stages of the southern extraction area. It is considered, however, that, with the existing truck movements along Altona Drive, existing sand extraction activities associated with the Hanson Tweed Sand Quarry and adjoining Kingscliff WWTP, these activities would not be inconsistent with the existing visual character of the area.

- Distant (approximately 1.5km) elevated views from parts of Kingscliff.

  Considering the distance of the views and the setting against the new Kingscliff WWTP, Hanson Tweed Sand Quarry and Australian Bay Lobster Farm, the residual visual impacts from vantage points in Kingscliff would be limited.

- Distant (approximately 3.0km) elevated views from Terranora and Banora Point.

  Considering the distance of the views and the setting against the new Kingscliff WWTP, Hanson Tweed Sand Quarry and Australian Bay Lobster Farm, the residual visual impacts from vantage points in Terranora and Banora Point would be limited.

Overall, it is assessed that the nature and scale of buildings associated with the sand extraction operation would generally be consistent with the scale and character of development in the immediate vicinity of the site.

As the Project progresses and following completion of rehabilitation activities, it is considered that the visual character of the landscape would in fact improve with the addition the final lake and fringing wetlands and parklands.