Air Quality

13

Chapter 13 - Table of Contents

VERSION CONTROL: 28/06/2017

List of Figures

List of Tables

13 Air Quality

13.1 Introduction

This section of the EIS provides an assessment of the air quality impacts associated with the construction and operation of the Great Barrier Reef Resort. The key potential air quality impacts associated with the proposed development include particulate emissions during construction, odour emissions from waste storage and sewage treatment, and combustion emissions from diesel power generation. The sensitive receptors considered in the assessment include the residential receptors associated with the proposed resorts, sensitive ecological environments and the marine environment. Predictions of pollutant concentrations were completed using the computational model CALPUFF for the sources associated with the operation of the redevelopment; whereas, Ausplume was utilised for assessing dust emissions from construction. These predictions were compared to the adopted air quality criteria from the *Environmental Protection (Air) Policy 2008* (EPP).

Further supporting information including information on model calibration is included in the technical assessment presented in **Appendix K - Air Quality**.

Addendum: *This EIS was initially prepared assuming that the safe harbour was to be part of the Lindeman Great Barrier Reef Resort Project. With the commencement of the Great Barrier Reef Marine Park Authority's (GBRMPA) Dredging Coral Reef Habitat Policy (2016), further impacts on Great Barrier Reef coral reef habitats from yet more bleaching, and the recent impacts from Tropical Cyclone Debbie, the proponent no longer seeks assessment and approval to construct a safe harbour at Lindeman Island. Instead the proponent seeks assessment and approval for upgrades to the existing jetty and additional moorings in sheltered locations around the island to enable the resort's marine craft to obtain safe shelter under a range of wind and wave conditions. Accordingly, remaining references to, and images of, a safe harbour on various figures and maps in the EIS are no longer current.*

13.2 Statutory Framework

13.2.1 Environmental Protection Act 1994

The Environmental Protection Act (EP Act) provides the legislative framework by which Queensland's environment is protected while allowing for development that improves the total quality of life, both now and in the future. Specifically, the EP Act seeks to maintain a range of environmental values including:

(a) *a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or*

(b) *another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.*

For the purposes of the environmental impact statement, reference is made to the environmental values provided in the *Environmental Protection (Air) Policy 2008* (EPP Air) established under the EP Act. The following sections provide an overview of the environmental values identified in this policy along with the objectives established achieve their protection.

13.2.2 Environmental Protection (Air) Policy 2008

The EPP (Air) provides air quality objectives for a range of compounds with the potential to impact on the health and well-being and aesthetics of the environment. Specifically, the objectives are intended to enhance or protect the following environmental values:

(a) *the qualities of the air environment that are conducive to human health and wellbeing; and*

(b) *the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and*

(c) *the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and*

(d) *the qualities of the air environment that are conducive to protecting agricultural use of the environment.*

Table 13-1 presents a summary of the air quality objectives applicable to assessment of potential impacts associated with the Lindeman Island redevelopment.

Table 13-1. EPP(Air) Air Quality Goals.

Indicator	Environmental value	Air quality objectives µg/m3	Period
Carbon monoxide (CO)	Health and wellbeing	11,000	8 hours
Nitrogen dioxide (NO2)	Health and wellbeing	250	1 hour
		62	1 year
	Health and biodiversity of ecosystems	33	1 year
PM2.5	Health and wellbeing	25	24 hours
		8	1 year
PM10	Health and wellbeing	0	24 hours
Total suspended particulates (TSP)	Health and wellbeing	90	1 year

The construction phase of the redevelopment has a potential to impact on the surrounding sensitive ecological areas (including the Great Barrier Reef Marine Park) through deposition of dust generated by construction activities. It is noted that no specific air quality goals that have been established for dust deposition in Australia and the evidence regarding the impact and mechanisms for impact on marine reef environments remains an area of significant research and debate. For sensitive flora in the area there is, internationally, a range of research which has considered the potential impacts associated with dust emissions on the productive and economic capacity of various plant species and agricultural uses. Many researchers (Harmens et al. 2005; Naidoo and Chirkoot, 2004; Hirano, Kiyota, and Aiga, 1995; Ricks and Williams, 1974 cited in Grobler and Liebenberg-Enslin (2011:98), McCrea 1986 and Naidoo and Chirkoot (2004)) have reported a range of potential impacts on plants and crops as a result of dust. Impacts reported typically relate to dust deposition onto the leaves of the plants which in turn has the potential to impact on:

- Plant photosynthesis, transpiration and respiration;
- Incidence of plant pests and disease;
- Reduced light intensity on fruit; and
- Flower pollination.

Other research into potential impacts of dust loading on plant production has considered situations that would be considered extreme cases by Australian standards. For example, research considering the potential impacts of stone crushing on *Shorea robusta* and *madjuca indica* foliage considered impacts on plants at suspended particulate concentrations well in excess of 500 µg/m3 near to a quarry site and 137 – 183 µg/m^3 at the control (background) site. These concentrations (including the background site) are considered significantly higher than those typically encountered in the Australian environment. Given this, where compliance with Australian air quality objectives is achieved, the impact on vegetation on the island is expected to be negligible. Given this, the assessment of potential impacts associated with dust deposition of both sensitive human and ecological receptors has adopted the guideline value (see **Table 13-2**) applied by Department of Environment and Heritage Protection (EHP) in licensing a range of environmentally relevant activities (Department of Environment and Heritage Protection 2014).

Table 13-2. Deposited Dust Nuisance Objective.

Indicator	Environmental Value	Air quality objectives µg/m^3	Period
Deposited Dust a)	Nuisance	120 mg/m2/day	24 Hours
a) Daily nuisance goal typically adopted by the Department of Environment and Heritage Protection			

13.2.3 Odour Impact Assessment from Developments Guideline

To assess the potential for air quality impacts on nearby sensitive receptors, reference has been made to the Odour Impact Assessment from Developments Guidelines (Department of Environment and Heritage Protection 2013). The guideline document specifies the following criteria:

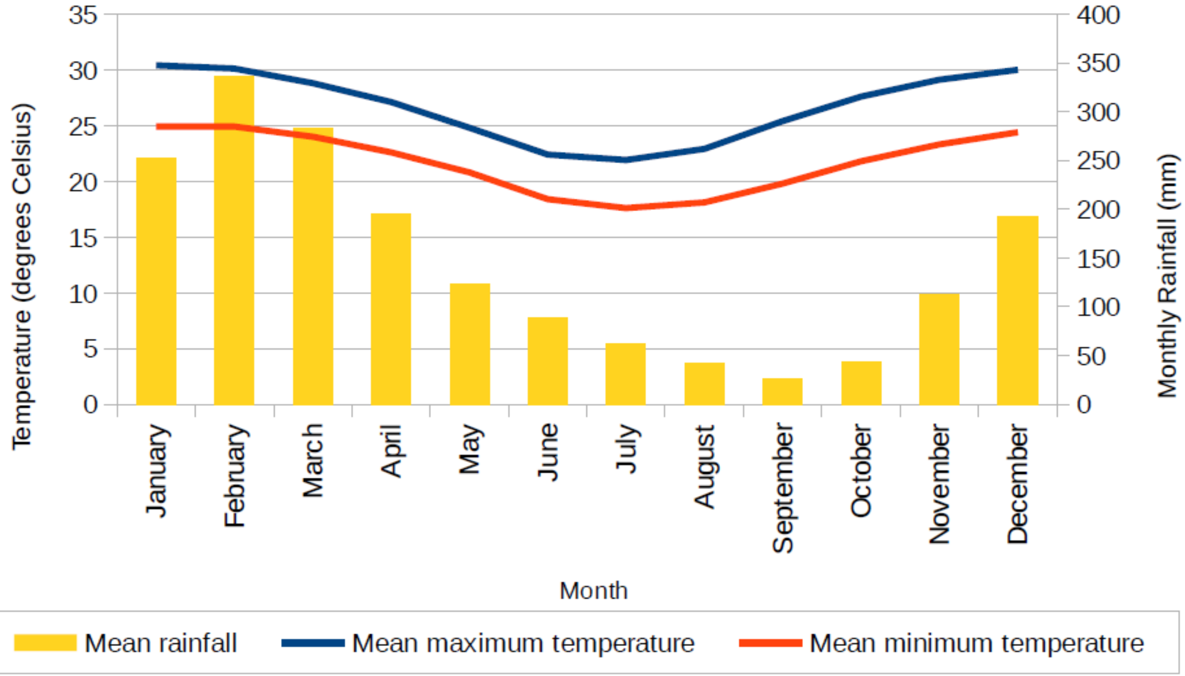
- 0.5 odour units, 1-hour average, 99.5th percentile for tall stacks; and
- 2.5 odour units, 1-hour average, 99.5th percentile for ground-level sources and down-washed plumes from short stacks.

The identified sources of odour emissions at the proposed redevelopment include sewage treatment and refuse storage. Review of the proposed site plans indicate emissions from both of these sources are likely to be emitted at a height of 1.5 m above ground level. As such it is appropriate to adopt the 2.5 odour units (1-hour average, 99.5th percentile) criteria for short stacks for this assessment.

13.3 Existing Environment

Lindeman Island enjoys a tropical climate. The nearest meteorological monitoring station in the area is located on Hamilton Island approximately 15 km to the north of Lindeman Island. Review of long term statistical monitoring data for the Hamilton Island monitoring station indicates maximum daytime temperatures in the region are typically 29-30 degrees during the summer months and 21- 25 degrees during the winter months. A large proportion of rainfall occurs in the months from December through to March with the driest months being August through to October. **Figure 13-1** below presents long term temperature and rainfall data for the Hamilton Island monitoring station which is expected to be representative of conditions at the site.

Figure 13-1. Typical rainfall and temperature patterns for Hamilton Island (average over all years from 1985 to 2002).



Lindeman Island is located in the trade wind belt for most of the year resulting in south to south-east winds. During the warmer months afternoon north-east sea breezes are common. Fresh south-easterlies can blow along the coast for lengthy periods during summer and autumn.

Figure 13-2 presents 9 am and 3 pm windroses for the Hamilton Island monitoring station. For all periods the occurrence of calms in the area is low with less than 1 % calms recorded in any season of available monitoring data.

Figure 13-2. 9 am and 3 pm windroses for Hamilton Island monitoring station (Source: Bureau of Meteorology).

9am Windrose:

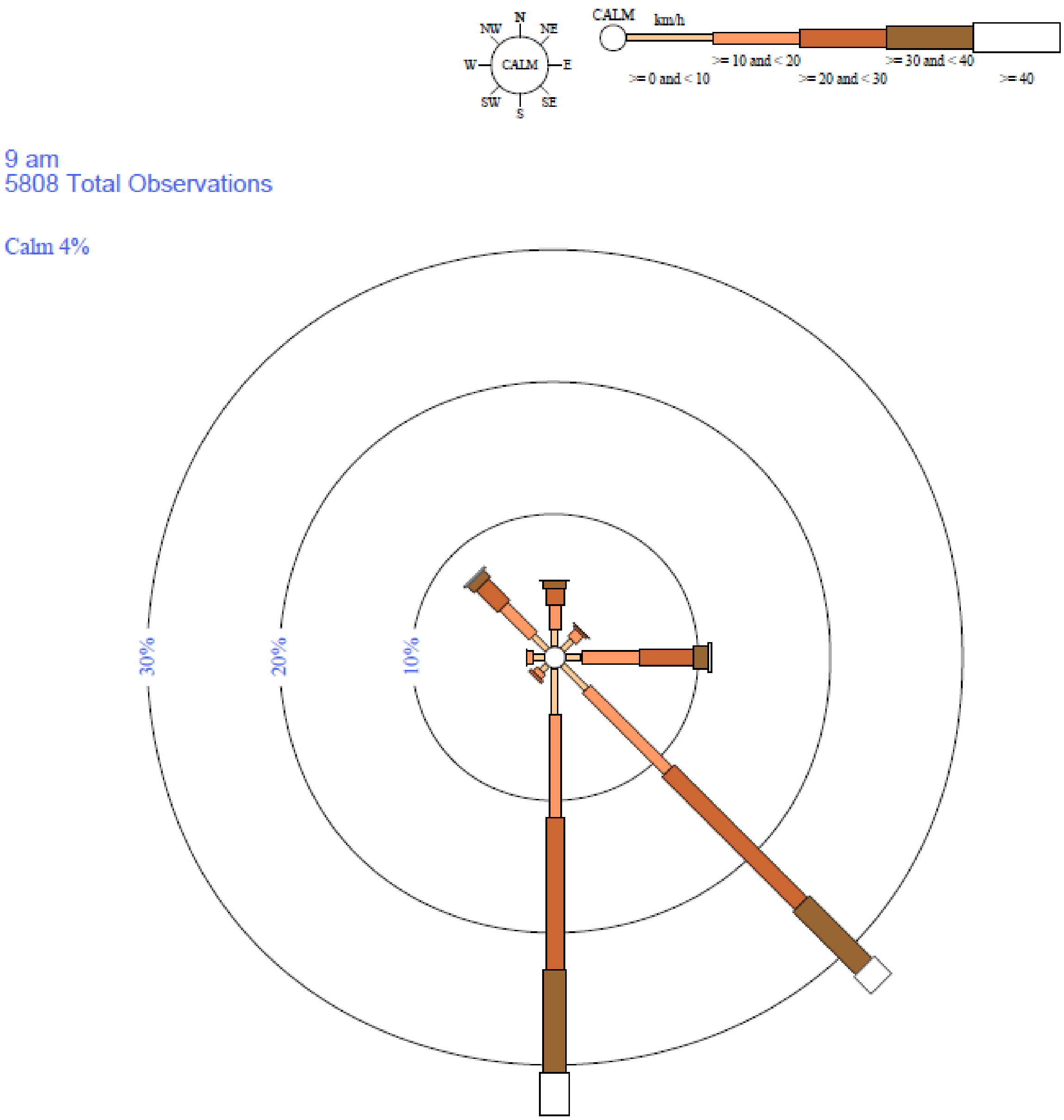
Rose of Wind direction versus Wind speed in km/h (30 Aug 1985 to 15 Mar 2002)

Custom times selected, refer to attached note for details

HAMILTON ISLAND

Site No: 033255 • Opened Aug 1985 • Still Open • Latitude: -20.3528° • Longitude: 148.9511° • Elevation 22.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.

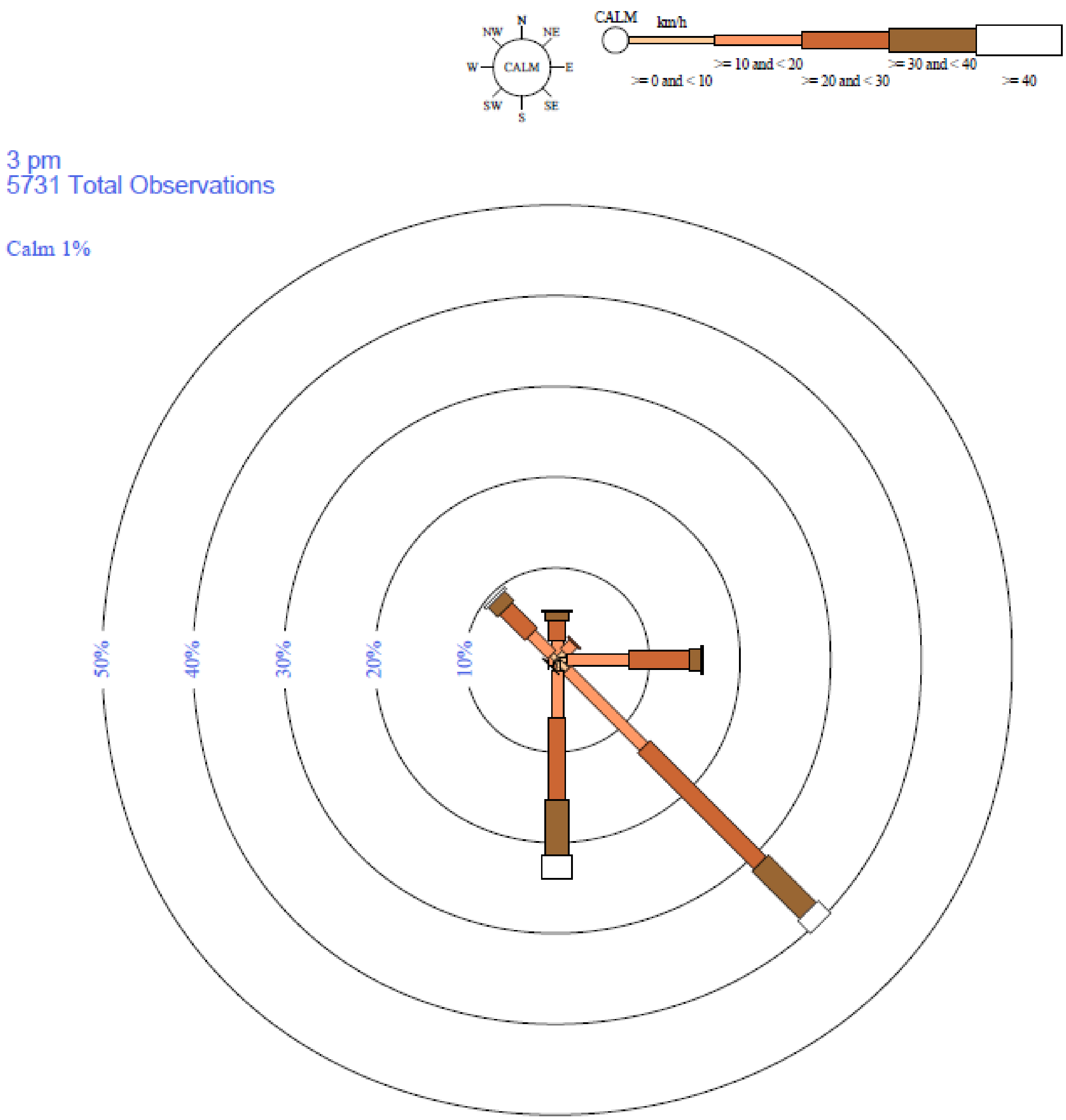


3pm Windrose:

Rose of Wind direction versus Wind speed in km/h (30 Aug 1985 to 15 Mar 2002)
Custom times selected, refer to attached note for details

HAMILTON ISLAND
Site No: 033255 • Opened Aug 1985 • Still Open • Latitude: -20.3528° • Longitude: 148.9511° • Elevation 22.m

An asterisk (*) indicates that calm is less than 0.5%.
Other important info about this analysis is available in the accompanying notes.



13.4 Air Quality

The Lindeman Island airshed is relatively undeveloped with only limited development on the surrounding Whitsunday Islands. The largest nearby development is situated on Hamilton Island located approximately 15 km north of the site. At a distance of approximately 20 km from the mainland, the existing air quality experienced on the island is expected to be dominated by low levels of particulate matter (including regional dust emissions from the mainland and sea salt). With the exception of the existing generator currently supplying power to the caretakers on the Lindeman Island, there are no significant emission sources on the Island. For the purposes of the assessment, data from the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) operated Townsville air quality monitoring stations have been utilised in the assessment. Data has been obtained from both the 2014 Queensland Air Monitoring Report (Department of Science, Information Technology, Innovation and the Arts 2015) and monthly air quality bulletins from December 2013 to November 2015 (Queensland. Department of Science et al. 1999). It should be noted, this is expected to represent a significant over-estimate of actual concentrations experienced on the island given the increased industrial activity typical in Townsville and the increased influence of regional dust loads from mainland Australia when compared with that of Lindeman Island. **Table 13-3** presents the estimated baseline particulate concentrations.

Table 13-3. Estimated Baseline Particulate Concentrations.

Pollutant	Averaging Period	Ambient Pollutant Concentration µg/m3	Monitoring Station
PM_{10}	24 Hour - 75_{th} Percentile	17.4	Townsville (Pimlico)
TSP	Annual Average	29.4	Townsville (Coast Guard)

13.5 Resort Operation Potential Impacts

13.5.1 Waste Handling Facility

The management of waste at Lindeman Island is expected to incorporate a range of both on-site and of-site treatment and disposal activities. Putrescible waste is proposed to be collected daily from the villas, hotels and other facilities and transferred to a purpose built storage facility located within the services area of the resort. Transfer of the stored waste is expected to occur at least weekly with waste loaded into an enclosed truck and shipped to the mainland for ultimate disposal at a designated landfill. Potential odour emissions originating from the storage of solid waste has been identified as having a potential to impact on the amenity of the proposed redevelopment.

13.5.2 Sewage Treatment Facility

The existing secondary wastewater treatment plant which operated under Environmental Authority (EPPR00854613) is currently decommissioned and will be demolished (refer to **Chapter 24 – Infrastructure**). A new tertiary wastewater treatment plant will be constructed for treatment of wastewaters generated within the development and is to operate under a new Environmental Authority. The *Environmental Protection Act 1994* provides for the granting of environmental authorities for wastewater treatment activities referred to as Environmentally Relevant Activity ERA 63. The *Environmental Protection Regulation 2008* includes the requirements for protection of receiving environments for activities relating to wastewater treatment works.

The *Model Operating Conditions for ERA 63 – Wastewater Treatment* published by DEHP in 2014 provides a framework of conditions to apply for applications for wastewater treatment works within Queensland.

The wastewater treatment plant at the Lindeman Island Resort will require a new approval for operation as described by Schedule 2, Part 13, 63 Wastewater Treatment of the *Environmental Protection Regulation* 2008 with a threshold of 100 -1,500 EP. The primary sources of odour expected as a result of the upgraded STP include the inlet works and sludge press and collection facilities. These have a potential to impact on the amenity of the proposed resort.

13.5.3 Power Generation

Power requirements for the redeveloped resort are expected to be met through on-site generation. The ultimate capacity required, and therefore the option chosen is expected to be impacted by a range of factors including the design of the built form and the opportunities for incorporation of a range of energy minimisation features. It is expected that the development will incorporate a range of state-of-the-art Environmentally Sustainable Design (ESD) features such as:

- Building design to maximise natural flow ventilation and reduce the need for air conditioning;
- Building design to maximise natural light and reduce power requirements;
- Low energy usage appliances installed in all buildings;
- Transportation around the island to be predominantly by foot, bicycle or electric carts;
- Motion sensors to be installed in buildings to reduce energy use wastage; and
- State-of-the-art energy metering to monitor and manage energy usage and efficiency.

The current proposal for power generation will include approximately 35-44% solar PV technology/battery storage with the balance from diesel generation. Initially, it is expected that power generation would be served by diesel generation alone (due to the reduced loads) with increases in loads over time serviced by solar PV technologies. The on-site generation of power using diesel generators provides a potential source of impact on air quality at the resort resulting from emissions of carbon monoxide (CO), nitrogen dioxide (NO2) and particulates.

13.6 Resort Construction Potential Impacts

Given the size and magnitude of the Lindeman Island redevelopment, the required construction work is expected to be undertaken in stages commencing in mid 2018 and being completed mid 2021. At this stage it is envisaged that the staging of the development would see all areas with the exception of the Villas constructed concurrently. That is, there is likely to be construction works being undertaken across both five star resorts and the six star resort at the same time. It is noted however that optimisation of these activities is likely to result in different activities being undertaken in different zones of the development. In addition to the construction crews, it is proposed that the construction operations would include operation of an on-site concrete batching plant (to supply concrete to construction of pre-cast elements and other activities as required) and a hard rock quarry (at the former quarry site) to supply gravel to the construction works and concrete batching plant as required. Dust emissions from the concrete batching plant, land clearing, demolition and construction have a potential to impact on both the construction camp, the nearby sensitive ecological areas and the marine environment. **Table 13-4** below presents a summary of the expected construction staging along with anticipated sources of emissions to air for each of these stages.

Table 13-4. Summary of Construction Staging.

Stage	Items	Anticipated Sources of Emissions
1	Construction Camp Civil Works Infrastructure	Land clearing and demolition.
2	Jetty Upgrade Airport Upgrade Village Sports Centre and Facilities Staff Accommodation Golf Course Five Star Resort	Earthworks and demolition.
3	Eco Resort	Earthworks and demolition.
4	Spa Resort	Earthworks and demolition
5	Villa and Glamping Facilities Construction	Earthworks and demolition
All Stages	Concrete Batching Plant Quarry operation	Concrete batching plant Excavation, crushing, screening and transportation of hard rock and gravel.

While there are periods of overlap between the various stages of construction, it is proposed that activities will be streamlined such that the structure crew would commence on Stage 1. Once nearing completion, the structure crew would commence on Stage 2 while the finishes crew worked on Stage 1. As such it is expected that emissions associated with bulk earth works, land clearing and demolition would be confined to one stage at a time. The exception to this is the upgrading of the airport and existing jetty which are both expected to utilise work crews separate to the hotel and resort precincts.

13.7 Assessment of Potential Impacts

Atmospheric dispersion modelling involves the mathematical simulation of the dispersion of air contaminants in the environment. The modelling utilises a range of information to estimate the dispersion of pollutants released from a source including:

- Meteorological data including surface and upper air wind, temperature and pressure profiles, as well as humidity, rainfall, cloud cover and ceiling height information;
- Emissions parameters including source location and height, source dimensions and physical parameters (e.g. exit velocity and temperature) along with pollutant mass emission rates;
- Terrain elevations and land use both at the source and throughout the surrounding region; and
- The location, height and width of any obstructions (such as buildings or other structures) that could significantly impact on the dispersion of the plume.

Dispersion modelling provides a means for both the regulators and the proponents of a project to assess the potential implications of the proposed development on air quality.

Appendix K - Air Quality details the modelling input parameters, calibration and the basis for their derivation.

13.7.1 Air Dispersion Modelling

13.7.1.1 Calpuff

For the purposes of the assessment, the CALPUFF dispersion model has been utilised to assess the potential impacts of emissions from the operation of the facility. CALPUFF is a non-steady state Lagrangian Gaussian puff model able to incorporate effects dispersion effects associated with complex terrain, overwater transport, coastal interaction effects and building downwash. The CALPUFF modelling system treats emissions as a series of puffs. These puffs are then dispersed throughout the modelling area and allowed to grow and bend with spatial variations in meteorology. In doing so, the model is able to retain a memory of the plume's movement throughout a single hour and from one hour to the next while continuing to better approximate the effects of the complex air flows noted in the project area.

CALPUFF utilises the meteorological processing and prediction model CALMET to provide three dimensional wind field predictions for the area of interest. The final wind field developed by the model (for consideration by CALPUFF) includes an approximation of the effects of local topography, the effects of varying surface temperatures (as is observed in land and sea bodies) and surface roughness (resulting from varied land uses and vegetation cover in an area). The CALPUFF model is able to resolve complex terrain influences on local wind fields including consideration of katabatic flows and terrain blocking along with sea breeze recirculation effects associated with the region. In particular the model is able to address the following issues considered to be relevant to the assessment:

- Incorporation of the three-dimensional wind field data generated by CALMET to allow the consideration of complex terrain effects associated with the elevated terrain features on Lindeman Island and the surrounding islands;
- Consider the influence of sea-breezes on dispersion of emissions during both the construction and operational phases of the project; and
- Incorporation of building downwash effects associated with building structures via the use of the PRIME building downwash algorithm.

Post processing of modelled emissions is undertaken using the CALPOST package. This allows the rigorous analysis of pollutant predictions generated by the CALPUFF system. In particular CALPOST is able to provide an analysis of predicted pollutant concentrations for a range of averaging periods from 1 hour to 1 year. The CALPUFF modelling domain incorporated the portion of the domain utilised by CALMET surrounding the site. Gridded receptor positions were included with a scaling factor of 2 providing a gridded receptor point every 50 m both latitudinally and longitudinally. Predicted contaminant concentrations for each of these receptor grid locations are considered in the air quality assessment.

13.7.1.2 Ausplume

The Ausplume model (version 6.0) has been used in this assessment to predict dust emissions from the construction phase of the redevelopment. Ausplume is an approved Gaussian plume dispersion model for regulatory assessment in Queensland. The model accounts for meteorological data, building wake effects and terrain effects in the prediction of ground level concentrations of pollutants from stack, area or volume sources. Ausplume assumes steady state meteorology for the field of influence of the source being considered. Steady state meteorology assumes that for any given time period of model calculation (usually 1 hour), the wind and other meteorological conditions are uniform over the entire area being modelled, and that a plume is assumed to travel instantaneously to the edge of the modelled area in a straight line. A number of additional parameters are considered in the modelling. Each of these parameters is considered in the following sections. The site specific meteorological predictions generated using TAPM (Version 4.04) was utilised in the model.

13.7.2 Sensitive Receptors

The nearest sensitive receptors include residential receptors, ecologically sensitive environments and the marine environment. The following section outlines the receptors considered in the assessment.

13.7.2.1 Resort Accommodation and Staff Accommodation Receptors

Given the proposed construction staging, it is considered unlikely that accommodation (apart from construction workers) would occur prior to completion of the construction works. The exception to this is construction of the Villa precinct which is expected to occur over time subject to sales during operation of the balance of the resort. As such, these construction activities are likely to be similar in scale to a residential dwelling construction and therefore are not expected to be significant in terms of their potential for adverse impacts. Therefore, for the construction phase, the sensitive receptors (or “residential receptors”) considered in the assessment include all staff accommodation areas which are expected to be utilised throughout the construction works. For the operational phase, sensitive receptors considered included all resort areas and worker accommodation zones. **Figure 13-3** presents the sensitive receptor locations. Predicted concentrations of odour from the STP and solid waste storage as well as combustion emissions from the diesel generator at these locations have been considered in the assessment.

Figure 13-3. Sensitive Receptors.

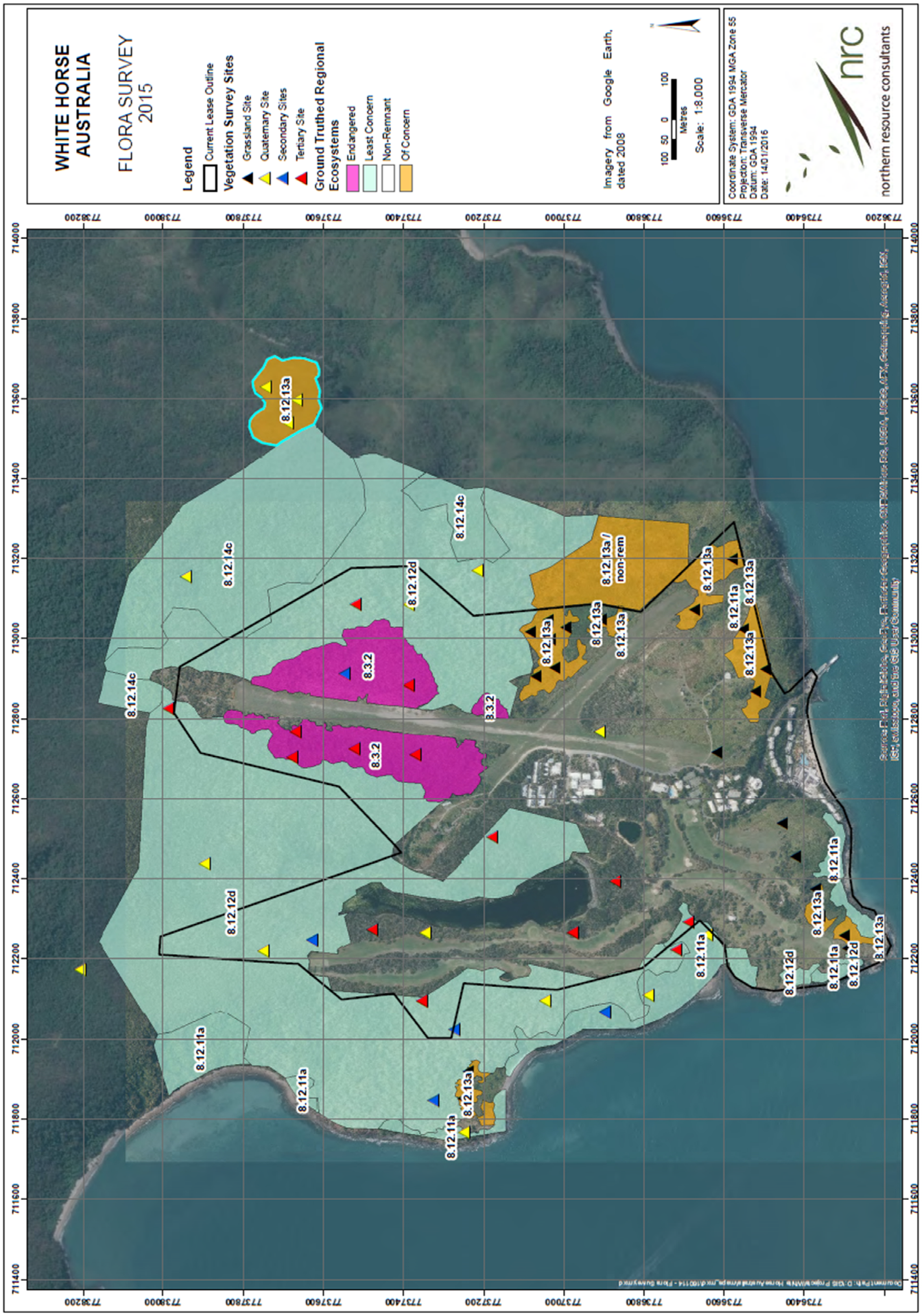
13.7.2.2 Sensitive Flora

A technical flora report from NRC was prepared for the proposed redevelopment. The report found several areas of significance based on field and desktop studies. NRC's findings regarding conserving significant flora ecosystems for the current lease area is presented in **Figure 13-4**. The areas labelled in **Figure 13-4** are described as the following:

- Regional Ecosystem 8.3.2 is endangered under the Queensland *Vegetation Management Act* (VMA) (1999). In order to achieve the necessary safety transitional surfaces for the airstrip some clearing to this community will be required;
- Regional Ecosystem 8.12.13a is a native grassland community occurring in patches primarily on moderate slopes with a southerly aspect. This community has an 'Of Concern' status under the Queensland VMA, but is not a listed community under the EPBC Act. Some of these patches are adjacent to the area proposed to be developed with discrete resort accommodation buildings; and
- Regional ecosystem 8.12.11c is has a 'least concern' status under the Queensland VMA, but is equivalent to the littoral rainforest and coastal vine thickets of eastern Australia TEC listed under the EPBC Act.

A few 'of concern' areas identified as orange in **Figure 13-4** are located within and immediately outside the development area.

Figure 13-4. Sensitive Ecological Receptors (NRC, 2015).



13.7.2.3 Marine Environment

Similar to the sensitive ecological receptors, the most significant impacts on the marine environment are expected to occur during the construction phase of the redevelopment. Dust fall emissions on the surrounding marine environment have been considered in the assessment. Refer to **Chapter 9 – Marine Ecology**.

13.7.3 Air Emissions Data

13.7.3.1 Power Generation

The current proposal for power generation will include approximately 35-44% solar PV technology/battery storage with the balance from diesel generation.. Through information obtained from the proponent, three 880 Kw diesel generators have been considered in the assessment. Technical data has been obtained for likely diesel generators with emissions estimated based on the emission factors provided in the Emissions Estimation Technique Manual for Combustion Engines (National Pollutant Inventory 2008). **Table 13-5** and **Table 13-6** below presents a summary of estimated diesel emissions rates and parameters used in the modelling. Figure 5.8 of **Appendix K - Air Quality** presents the modelled source locations.

Table 13-5. Emissions Estimates – Power Generation (g/s).

CO	NOx	PM2.5	PM10
0.81	1.45	0.1	0.11

Table 13-6. Diesel Generator Emission Parameters.

Parameter	Value
Outlet Vent Diameter (m)	0.3
Efflux Velocity (m/s)	20
Temperature (^{o}C)	500
Outlet Vent Height Above Roof (m)	3 m above roof level

13.7.3.2 Odour Emissions

Both the storage of refuse and the proposed sewage treatment plant (STP) have been identified as sources of odour with a potential to impact on the amenity of the proposed redevelopment. In order to predict odour emission rates, odour emission factors for both the STP and refuse storage building have been derived based on available scientific literature and studies, and previous odour sampling data obtained by Air Noise Environment. Both the STP and refuse storage have been modelled as volume sources. **Table 13-7** presents the modelled odour emission rates for each odour source. Figure 5.8 of **Appendix K - Air Quality** presents the modelled source locations.

Table 13-7. Odour Emission Rates.

Source	Estimated Odour Concentration (Ou)	Area (m^2)	Estimated Odour Emission Rate (OUV/s)
STP	13.4	45	422.7
Refuse Storage	9.8	2	275.5

13.7.3.3 Construction Emissions

For the purpose of assessing construction dust impacts, the modelling has considered emissions associated with construction of the 6 Star Resort as representative of the worst-case potential impacts. This development area is the nearest to 'of concern' and endangered flora species (located directly to north of area) and the Great Barrier Reef Marine Park. In order to predict emission rates for the air emission sources associated with the construction activities, a review of available published literature relating to the potential air emission sources has been completed. The following documents have been utilised to estimate emissions:

- *AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.2, Unpaved Roads, November 2006.*
- *AP 42 (5th Edition), Compilation of Air Pollutant Emission Factors, Vol. 1 Stationary Point and Area Sources, Chapter 13.2.4, Aggregate Handling and Storage Piles, November 2006.*
- *National Pollution Inventory, Emission Estimation Technique Manual for Mining, Version 3.1, January 2012.*

The following sections present details on the derivation of emission factors and rates used in the modelling. It should be noted that the derived emission rates assume that all areas of the six star resort subject to construction works would be disturbed at the same time. That is, dust emissions, including wind erosion, land clearing and bulk soil movement sources would occur for all areas of the resort zone concurrently. In reality this is expected to represent a conservative approach with the construction of the zone likely to progress in stages such that smaller areas would be disturbed at any one time.

Derivation of Emission Factors

Table 13-8 presents emission factors derived from the US EPA AP42 and NPI literature. Refer to **Appendix K - Air Quality** for details regarding the calculation of the factors.

Table 13-8. Emission Factors.

No.	Activity/Source	Units	TSP	PM_{10}	$PM_{2.5}$
F1	Material transfer – excavator to truck	kg/t	0.00869	0.00411	0.00062
F2	Crushing	kg/t	0.20000	0.20000	0.00300
F3	Truck Loading	kg/t	0.00869	0.00411	0.00062
F4	Screening	kg/t	0.01250	0.00430	0.00065
F5	Land Clearing/Bulldozing	kg/t	0.00498	0.00373	0.00052
F6	Wind erosion	kg/ha/hr	0.4	0.2	0.1
F7	Haul route – Onsite Haul Truck	g/VKT	6466	1908	191
F8	Haul route – Product Road Truck	g/VKT	4312	1273	127

Derivation of Emission Rates

For the dispersion modelling, area sources have been modelled representing the worst-case construction stage as discussed previously. The estimated quantity of materials for each stage has been obtained from the proponent and used in conjunction with emission factors as presented in **Table 13-8**. In addition to the conservative approach adopted for the emissions estimation, the modelling as also assumed that all sources operate simultaneously 24 hours a day. That is, the modelling assumes that construction is continuous 24 hours per day for the entire year at the worstcase emission level making no allowance for reductions in emissions due to the progress of construction (noting that following completion of bulk earth works emissions would be expected to reduce) (refer to **Table 13-9**). This is expected to further increase the significant level of conservatism inherent in the modelling results. **Figure 13-5** presents the modelled source locations.

Table 13-9. Modelled Construction Stages.

Stage	Quantity of Aggregate (t)	Area (m_2)	TSP (kg/m_2/hour)	PM_{10} (kg/m_2/hour)	$PM_{2.5}$ (kg/m_2/hour)
6 Star Resort	21,343.0	130,610.0	7.20E-05	3.51E-05	1.23E-05

Deposited Dust Modelling

The Ausplume model has been utilised to predict deposited dust levels from the construction activities. Particle size distribution data has been interpolated from the derived TSP, PM10 and PM2.5 emission factors. **Table 13-10** presents the adopted particle size distribution data.

Table 13-10. Adopted Particle Size Distribution Data.

Particle Size (microns)	Mass Fraction
< 2.5	51 %
< 10	32 %
> 10	17 %

Figure 13-5. Modelled Source Locations.

13.7.4 Modelling Results

13.7.4.1 Construction Works

Figures 5.9 to 5.12 of **Appendix K - Air Quality** present the predicted ground level concentrations for deposited dust, TSP, PM10 and PM2.5 respectively. The results of the modelling indicate compliance with the 120 mg/m2/day nuisance criteria at the nearest affected resort receptors, with the exception of a small proportion of the Tourist Villa precinct during construction of the 6 Star Spa Resort area. The results are considered conservative as the modelling assumes worst-case wind directions and the daily dust levels are calculated from a 7-day averaging period (instead of the standard 30 day period). Further, as the Tourist Villa precinct is not expected to be operational prior to completion of the 6 Star Spa Resort, the potential for adverse amenity impacts on these areas is expected to be negligible. Compliance with the TSP, PM10 and PM2.5 criteria is also predicted to be achieved for all areas. Exceedances of the deposited dust nuisance criteria are predicted for the protected vegetation located along the western shoreline and an area extending out 200 m from the shoreline to the south west of the six star resort. It is noted that the nuisance criteria is based on minimising impacts on human populations. There are currently no guidelines or limits in relation to dust impacts on flora or marine park environments. Of the evidence available in the international literature, impacts on sensitive vegetation would not be expected at the levels predicted to occur as a result of the proposed resort development. Further, given the significant conservatism incorporated into the modelling, the risk associated with the proposed resort is considered to be low.

Despite this, it is recommended that best practice dust management measures are adopted during construction of the resort areas on the island including:

- Regular use of water sprays on exposed areas of ground including any internal roadways to ensure soil moisture remains sufficient to suppress visible dust production;
- Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions; and
- Limit vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.

13.7.4.2 Resort Operation

The results of the dispersion modelling for the operation of the redevelopment are presented in **Table 13-11**. A 20% conversion factor has been utilised for the conversion of NOx to NO2. Figures 5.13 to 5.17 of **Appendix K - Air Quality** present the predicted ground level contours. The results of the dispersion modelling indicate the operation of the STP and waste storage area has little potential for impact on the amenity for the surrounding area with results well below the applicable 2.5 odour unit criteria. A maximum predicted concentration of 1.2 odour units is predicted for the staff accommodation followed by concentrations between 0.1 to 0.2 odour units for the remaining resort facilities. Predicted emissions for power generation are shown to comply with the relevant criteria for all modelled pollutants. The highest concentrations are predicted for the staff accommodation areas followed by the tourist Villas. PM10 concentrations are shown to closest to the criteria at 60% (cumulative). Based on the results of the modelling, the potential for adverse health or amenity impacts as a result of the operation of the resort is expected to be negligible. Despite this, it is recommended that all plant and equipment (including power generation and waste handling equipment) are adequately maintained in accordance with environmental best practice.

Table 13-11. Predicted Ground Level Concentrations at the Residential Receptors (ug/m^3).

Resort Facility	CO 8 Hour	NO_2		PM_{10} 24 Hour (Cumulative)	$PM_{2.5}$ 24 Hour	Odour 1 Hour (99.5th Percentile) (Ou)
		1 Hour	Annual			
Staff Accommodation	44.24	86.40	2.98	30.16	12.47	1.22
Tourist Villas	14.97	49.70	0.12	20.14	2.68	0.06
Beach Resort	7.24	17.92	0.20	18.97	1.53	0.07
6 Star Resort	12.21	28.95	0.49	20.26	2.79	0.23
Eco Resort	12.26	29.63	1.40	19.78	2.32	0.13
Criteria	**11,000**	**250**	**62** **33**	**50**	**25**	**2.5**

13.8 Potential Impacts and Mitigation Measures

Based on the results of the predictive modelling, potential impacts have been summarised using a risk assessment matrix. The risk matrix summarises the extent of impacts based on the probability of an event occurring and the likely consequences. **Table 13-12** presents the outcomes of the assessment.

Table 13-12. Risk assessment matrix – air quality.

Potential Impact	Significance of Impact: Unmitigated	Mitigation Measure			Significance of Impact: Mitigated
		Design	Construction	Operation	
Dust impacts associated with construction.	Low (4)	-	• Regular use of water sprays on exposed areas of to suppress visible dust production; • Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions; and • Limiting vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.	• Maintenance of all unsealed pathways and roads to be undertaken on a regular basis	Low (2)
Nuisance odour from waste storage/treatment.	Low (4)	-	• Construction waste is to be collected within appropriate receptacles and removed from the site on a regular basis in accordance with the construction Environmental Management Plan	• Site waste is to be collected and stored within appropriate receptacles • Maintenance of all plant and equipment in accordance with environmental best practice to ensure emissions are minimised as far as practicable.	Low (2)
Diesel generator emissions.	Low (4)	-	-	• Maintenance of all plant and equipment in accordance with environmental best practice to ensure emissions are minimised as far as practicable.	Low (2)

Based on the results of the modelling, the potential for adverse health or amenity impacts as a result of the resort's construction and operation is expected to be negligible, including potential for cumulative impacts. Further, the risk of adverse impacts on the nearby sensitive flora populations and the Great Barrier Marine Park are also expected to be low. It is noted however that these conclusions (which are based on a conservative assessment of potential impacts) assume a range of best practice environmental controls are incorporated into the Environmental Management Plan for construction and operation including:

For the construction phase:

- Regular use of water sprays on exposed areas of ground including any internal roadways to ensure soil moisture remains sufficient to suppress visible dust production;
- Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions; and
- Limiting vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.

For the operational phase:

- Maintenance of all plant and equipment (including power generation and waste handling equipment) in accordance with environmental best practice to ensure emissions are minimised as far as practicable.

13.9 Summary

Predictions of pollutant concentrations were completed using the computational model CALPUFF for the activities associated with the operation of the redevelopment and Ausplume for the construction phase. Predictions were compared against the adopted air quality criteria from the EPP Air and other relevant guidelines. The results of the modelling for the construction phase indicate that the potential for nuisance dust, total suspended particulate, PM10 and PM2.5 impacts on resort areas are minimal provided that appropriate dust management measures are adopted. Exceedances of the deposited dust nuisance criteria are predicted for the protected vegetation located along the western shoreline and an area extending out 200 m from the shoreline to the south west of the six star resort. Given the conservatism incorporated into the modelling and the lack of evidence of adverse impacts on vegetation and marine park environments at these concentrations, the risk associated with the proposed development is considered to be low. Despite this, it is recommended that best practice dust management measures are adopted during construction of the resort areas on the island including:

- Regular use of water sprays on exposed areas of ground including any internal roadways to ensure soil moisture remains sufficient to suppress visible dust production;
- Minimising dust generating activities such as site clearing, levelling and preparation during dry and windy conditions; and
- Limit vehicle speeds on site and/or use of gravel on heavily trafficked haul routes.

Air quality impacts associated with the operation of the redevelopment and potential for cumulative impacts are predicted to be minimal. Predicted emissions for power generation are shown to comply with the relevant criteria for all modelled pollutants. Furthermore, predictions of odour emissions from waste storage and sewage treatment were shown to have minimal impact on the amenity of the proposed sensitive receptors (resort and staff accommodation). Given this, where all plant and equipment (including power generation and waste handling equipment) is adequately maintained in accordance with environmental best practice to ensure emissions are minimised as far as practicable, the potential for both short and long term adverse air quality impacts, is expected to be negligible.