4 Climate

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QUEENSLAND COKE & ENERGY

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Summary

A sub-tropical humid climate is characteristic of both Fitzroy Shire in which the Project is proposed to be located, and Gladstone, with wet summer periods occurring generally between December and March, and dry winters generally between June and September. The long-term monthly temperature averages range between 27 °C during summer and 16 °C in the winter. Mean annual rainfall for Rockhampton Airport (as an indicator of that in Stanwell) is 805.2 mm. Mean monthly rainfall at Gladstone Radar (as an indicator of that at Fisherman's Landing) is 918.4 mm. Wind around the Stanwell area blows in a dominant east-west direction. Southerly winds, which have the potential to transport emissions from the Coke Plant to closest residential areas of the Stanwell township, occur relatively infrequently (less than 5% of the time).

On average, an impact from a tropical cyclone occurs about once in every four years in the Rockhampton region. On a long-term average, approximately 1.4 cyclones pass within 500 km of Gladstone each year. In the event of a cyclone, the Fisherman's Landing area is likely to be somewhat protected from storm tide due to the position of Curtis and Facing Islands. The risk to inland areas, such as Stanwell, when a cyclone crosses land is usually due to flooding. Preliminary modelling of the risk of flood at the project site suggest that during a 100-year Average Recurrence Interval (ARI) flood and a 50-year ARI flood, Neerkol Creek would reach a respective height of approximately 44.5 m AHD and 43 m AHD adjacent to the project site. A small floodplain located to the west of the project site could be an important storage area in the event of major flooding.

The entire Central Coastal region is declared as suffering a severe drought. To manage the impact of drought, the Project will be designed to ensure sufficient capacity water infrastructure, including for storage, is available to meet the project water supply requirements. Options for water re-use and recycling will also be incorporated into the design of the Project.

The area in the immediate north, west and south of Stanwell is a medium bushfire hazard due the extent of surrounding vegetation and therefore, the Project would be at a greater risk of bushfire than grassfire, particularly from north-westerly, westerly or south-westerly directions. Calliope Shire, where Fisherman's Landing wharf is located, has a high potential grassfire risk. The greater area around Fisherman's Landing is categorised as having a medium bushfire hazard. The proponents will collaborate with SPS and work in conjunction with the SPS fire crew in reducing the fire hazard risk in areas adjacent to the site. The maintenance of fuel reduced zones around the site of a minimum 10 m in width is a key aspect in reducing the impact of bush and grass fires. Such zones also provide access points for fire brigades should a fire occur.

4.1 Atmosphere

4.1.1 Atmospheric Monitoring

Stanwell Power Station (SPS) has conducted extensive monitoring of meteorological and air quality parameters over several years. SPS has been monitoring air quality at a total of seven sites in the Stanwell region since December 1997 until the decommissioning of the last monitoring site in November 2003.

Meteorological monitoring sites at Seierup, Kalapa and Mercy provide a long-term data set, while other meteorological stations operated for shorter time intervals.

Meteorological parameters (wind speed, wind direction and its standard deviation (sigma theta) and vertical wind speed) were measured at six locations. The Seierup site (2.5 km to the south-west of SPS) also measured temperature, net radiation, solar radiation, rain, relative humidity at 10 m height, and horizontal and vertical winds, temperature and relative humidity at 30 m height. This comprehensive data set has been used in characterising the local climate. Some data from this monitoring are summarised below and the relevance of these parameters to the air quality assessment is discussed in Section 7 - Air.

4.1.2 Wind

The wind flows around the Stanwell area are influenced significantly by the terrain to the north-west and south of the project site. The winds are channelled in a dominant east-west direction. The Mercy site shows lighter winds compared to the other monitoring sites, as the location is quite sheltered due to local terrain and vegetation. As such, it is not representative of regional flows. The Kabra site is the furthest east of the monitoring sites and is less affected by the terrain to the north-west. As a consequence, this site has recorded a higher proportion of east/south-easterly winds.

The winds recorded at 30 m at Seierup (Figure 4.1) show a dominance of north-easterly winds with higher wind speeds than at the 10 m level, as expected. During the daytime the wind speed is almost three times stronger at 30 m than at the 10 m level. During the night time, the average wind speed at 30 m is generally double that at 10 m. The diurnal variations of wind speeds indicate that the winds are strongest at about 5 pm (due to the presence of the late sea breeze) and lightest in the early morning. The morning air drainage flows are generally from the south-west and north-east, with a high tendency of calm winds during the period from midnight to 6 am. Southerly winds, which have the potential to transport emissions from the proposed Coke Plant to closest residential areas of the Stanwell Township, occur relatively infrequently (less than 5% of the time).

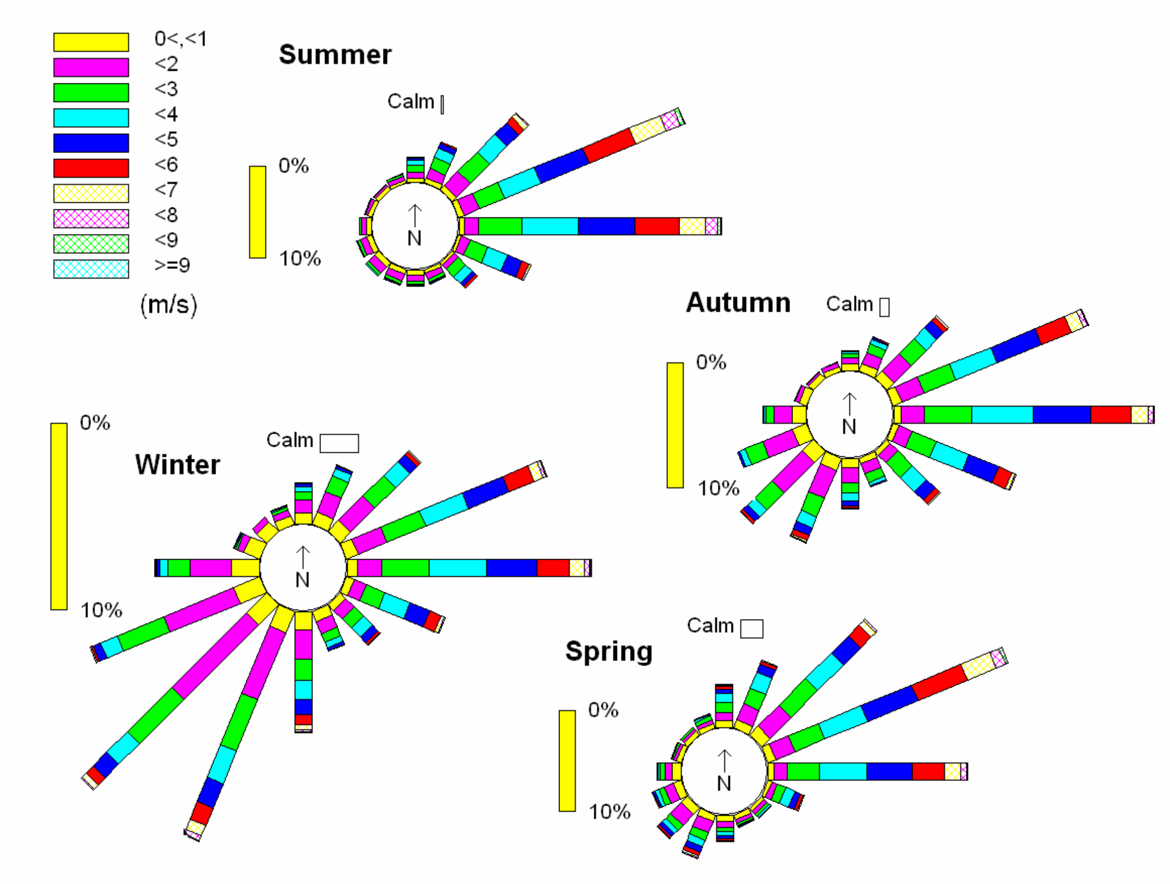
4.1.3 Temperature

Long-term temperature measurements were recorded at Seierups at 1.2 m and at 30 m for the period from December 1997 to November 2003. The monthly averages range between 27°C during summer and 16°C in the winter. A maximum temperature of 43.7 °C was recorded on the 25 December 2001 at 3:40 pm and a minimum of –0.8 °C on 19 August 1999 at 7 am.

Temperature Inversions

Air pollution in an area can be intensified by a weather phenomenon known as a "temperature inversion". Temperature inversions occur when temperature increases with increasing height and the colder air at ground level is trapped below warmer air. Low-level inversions often occur with fogs which also trap any pollutants contained in the cold air, resulting in smog in city areas. Usually the air closest to the ground is warmer, becoming cooler with increased distance from the surface of the ground.

Figure 4.1 Seasonal wind roses for Stanwell (Seierups 30 m winds 1997 - 2003)



However, if cold air enters from outside an area, it may flow along the surface of the ground, below the warmer air. If the difference in the density and temperature of the two air parcels is sufficient they will form two distinct layers, with the cold air forming the lower layer and the warmer air becoming the upper layer. A strong inversion forms at night at the surface due to cooling of the ground through loss of heat by radiation. This nocturnal or surface inversion is best developed on clear calm nights.

The temperature inversion occurs when the colder air is not able to penetrate the warmer air. If the cooler air layer contains air emissions and fine particles (eg. dust), these are also trapped within the temperature inversion until the layers begin to mix and the material can be dispersed. Cold air flows and calm conditions that are usually associated with temperature inversions occur most commonly on winter nights. As the day progresses and the air temperatures increase, the temperature inversion usually begins to dissipate (Environmental Protection Agency, 2003).

Under stable atmospheric conditions (most of the evening and night time) a buoyant plume or tall stack plume will reach an elevation that is above the mixing height (height at which the warmer air mixes with the cooler air). The plume will remain above the mixing height because of its relative temperature and the warmth of the surrounding air. It is therefore unlikely to give rise to any ground-level pollution impacts except when the plume strikes elevated terrain. During winter, temperature inversions in the Stanwell area typically occur from 3 pm to 9 am with a mean strength of 4 °C and maximum strength of over 11

°C. The strength and duration of inversions decrease in the warmer months with typical inversions of 1-2 °C occurring between 5 pm and 7 am during summer with a maximum strength of 5 °C.

4.1.4 Radiation

Solar radiation is a measure of the amount of direct radiation from the sun and is therefore set to zero at night time. The main features that influence the solar radiation measured at a site are the time of day, the distance from the equator, the time of year and amount of cloud cover in the sky. Net radiation is the difference between the amount of incoming solar radiation and the amount of radiation going out due to reflection from clouds and radiation from the earth. Net radiation is one of the variables used to calculate atmospheric stability. At the project site, the peak radiation levels were generally recorded at 11 am to 12 pm. The proportion of net radiation to solar radiation at this peak time was 0.6. During summer, sunrise is typically between 5-6 am and sunset between 6-7 pm. During winter, sunrise is between 6-7 am and sunset is between 5-6 pm.

4.2 Rainfall, Evaporation and Humidity

A sub-tropical humid climate is characteristic of both Fitzroy Shire and Gladstone, with wet summer periods generally between December and March, and dry winters generally between June and September.

4.2.1 Rockhampton Data

Rainfall, evaporation and humidity data (1939 – 2004) for the project site were obtained from the Bureau of Meteorology (BOM) for the meteorological station at Rockhampton Airport (Station Number 039083), located approximately 30 km north-east of Stanwell. Monthly and annual averages are presented in Table 4.1 and summarised below.

The mean annual 9 am and 3 pm relative humidity at Rockhampton Airport is 69% and 47% respectively. February experiences the highest relative 9 am humidity (73%). October/November experiences the lowest 9 am relative humidity (62%) and August/September has the lowest 3 pm relative humidity (40%).

Mean monthly rainfall is greatest in February (140.5 mm) which also has the greatest mean number of rain days (12.2). The lowest mean monthly rainfall and lowest number of rain days occurred in September (23 mm and 4.1 respectively). The mean annual rainfall for this area is 805.2 mm and annual mean number of rain days is 88.3. The month with the highest recorded rainfall is January (660.2 mm) and the lowest recorded rainfall of 0 mm has occurred in April, June to September and November. December has recorded the highest daily rainfall at 271.5 mm. Rainfall averages suggest a distinct wet and dry season, with the wet season generally from December to March and the dry season from June to September.

Mean daily evaporation is greatest in December (7.6 mm) and the lowest evaporation levels usually occur in June/July (3.6 mm). The annual mean daily evaporation is 5.7 mm.

4.2.2 Gladstone Data

A rainfall, evaporation and humidity dataset (1957 – 2004) for the Fisherman’s Landing area (Gladstone Radar - Station Number 039041) was obtained from the BOM and is presented in Table 4.2.

The mean annual 9 am and 3 pm relative humidity at Gladstone Radar is 68% and 60% respectively. The highest relative humidity at 9 am and 3 pm is experienced in the month of February (72% and 64% respectively). January also shares the highest 3 pm relative humidity. September/October experiences the lowest 9 am relative humidity (63%) and July has the lowest 3 pm relative humidity (53%).

Mean monthly rainfall is greatest in January (154.5 mm) which also has the greatest mean number of rain days (12.8). The lowest mean monthly rainfall and number of rain days occurred in September (24.4 mm and 4.2 respectively). The mean annual rainfall for this area is 918.4 mm and annual mean number of rain days is 97.5. The month with the highest recorded rainfall is February (709.8 mm) and the lowest recorded rainfall of 0 mm has occurred in June, July and September. February has recorded the highest daily rainfall at 229.4 mm.

Mean daily evaporation is greatest in January (6.4 mm) and the lowest evaporation levels usually occur in June (3 mm). The annual mean daily evaporation is 4.8 mm.

4.3 Climate Extremes

Extreme climate events (cyclones, floods, bushfires and drought) that may affect the project site and Fisherman’s Landing wharf are discussed below. The impact of these events and potential mitigation measures are discussed in Section 15 – Health and Safety, as is a hazard analysis of earthquake risk.

4.3.1 Cyclones

Tropical cyclones threaten the Rockhampton and Gladstone areas mostly in January, February and March, although some cyclones have occurred in April. There is a strong year-to-year variation in the number of tropical cyclones in the region, with nearly twice as many impacts occurring during La Niña conditions than during El Niño.

Tropical cyclones are accompanied by destructive winds and very heavy rain which often produces disastrous flooding overland after the cyclone crosses the coast (landfall). Over the ocean, the intense wind fields generate very large waves and strong ocean currents, which can result in coastal inundation at landfall (Callaghan, 2003).

Since 1863, 37 tropical cyclones are known to have caused an impact in the Rockhampton area between St. Lawrence and Gladstone. The monthly distribution of these 37 events is shown in Table 4.3.

Table 4.1 Rainfall Evaporation and Humidity Statistics for Rockhampton Airport

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Number of years	Percentage complete (%)
Mean 9 am relative humidity (%)	70	73	72	71	72	72	72	69	65	62	62	66	69	64.8	100
Mean 3 pm relative humidity (%)	53	57	54	50	48	45	43	40	40	43	46	49	47	64.8	100
Mean monthly rainfall (mm)	130.8	140.5	98.6	45.3	48.8	36.2	30.1	28.5	23	50.4	69.9	103.2	805.2	65.3	100
Median (5th decile) monthly rainfall (mm)	87.2	97.6	64.6	32.3	31.9	22.8	14.4	18.4	11.2	44.8	63.6	80.6	755.2	64	
Mean no. of rain days	11.1	12.2	10	6.6	6.2	4.7	5.2	4.2	4.1	6.6	7.8	9.6	88.3	65.2	100
Highest monthly rainfall (mm)	660.2	453.1	447.4	198.6	303.8	186.4	184	228.4	107.3	152.4	285.6	533.4		65.3	100
Lowest monthly rainfall (mm)	1.6	2.8	2.3	0	0.3	0	0	0	0	0.4	0	3.6		65.3	100
Highest recorded daily rainfall (mm)	219	183.1	172.2	59.4	108.2	74.6	58.6	77.6	55.4	69.6	111.4	271.5	271.5	65.2	100
Mean daily evaporation (mm)	7.2	6.5	6.2	5.3	4.1	3.6	3.6	4.4	5.8	6.8	7.5	7.6	5.7	52.8	100

Table 4.2 Rainfall, Evaporation and Humidity Statistics for Gladstone Radar

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Number of years	Percentage Complete (%)
Mean 9 am relative humidity (%)	70	72	71	69	71	68	67	66	63	63	64	67	68	44.3	98
Mean 3 pm relative humidity (%)	64	64	63	61	60	55	53	54	56	60	62	63	60	44.2	98
Mean monthly rainfall (mm)	154.5	143.2	96.8	51	69.6	34.4	39.8	30.9	24.4	60.3	78.1	135.5	918.4	35.6	100
Median (5th decile) monthly rainfall (mm)	115.2	78.3	53	32.8	41.7	23.9	25.1	23.1	23.2	48.6	62.2	109.7	842.5	44	115.2
Mean no. of rain days	12.8	12.4	11	7.1	7.6	4.6	5	4.8	4.2	7.6	9.3	11.1	97.5	35.6	100
Highest monthly rainfall (mm)	640.1	709.8	311.6	250.4	316.4	220.3	170.2	110.8	83.8	276.8	218.1	508.9		35.6	640.1
Lowest monthly rainfall (mm)	6.2	7.2	12.2	3.8	0.2	0	0	0.4	0	3.1	1.4	2.8		35.6	6.2
Highest recorded daily rainfall (mm)	196.8	229.4	112.3	93.4	178	62.5	92.7	78.2	75	149.4	84.2	196	229.4	35.7	196.8
Mean daily evaporation (mm)	6.4	5.9	5.4	4.5	3.4	3	3.1	3.5	4.3	5.4	6	6.3	4.8	25.7	6.4

Table 4.3 Monthly Distribution of Cyclone Events in the Rockhampton Region

Month	Number
January	9
February	14
March	12
April	2
Total	37

The impacts of these 37 tropical cyclones including the following:

- 23 December 1990 – Tropical cyclone Joy caused exceptional flood rains to fall over the period of 23 December 1990 to 7 January 1991. The damage cost reached $62 million.
- 11 March 1950 – The tropical cyclone recurved over Gladstone and Hervey Bay causing sea water flooding at Hervey Bay and floods in south-east Queensland;
- 26 February 1949 - The tropical cyclone made landfall and passed over Gladstone and Rockhampton. Fifteen towns suffered widespread damage and four people were killed. In Rockhampton 1,000 houses were damaged, 500 were wrecked and two people were killed; and
- 16 February 1863 - The tropical cyclone brought damaging winds and seas to the region between Rockhampton and Hervey Bay. Houses were unroofed in several centres with many trees blown down (Callaghan, 2003).

On average, an impact from a tropical cyclone occurs about once in every four years in the Rockhampton region. On a long-term average, approximately 1.4 cyclones pass within 500 km of Gladstone each year. In the past 91 years of detailed record, the centre of 10 of these cyclones has passed within 100 km of Gladstone.

Large cyclones can cause considerable damage to coastal areas even though the centres of these cyclones are well removed from the region (Callaghan, 2003). The risk to inland areas, such as Stanwell, when a cyclone crosses land is usually due to flooding (Section 4.3.2). In the event of a cyclone, the area at Fisherman's Landing is likely to be somewhat protected from storm tide due to the position of Curtis and Facing Islands. The main area of concern in Gladstone would be the coastal strip where shielding from wind and storm tide would be minimal.

4.3.2 Floods

Due to its immense size and fan-like shape, the Fitzroy River catchment is capable of producing severe flooding following heavy rainfall events (such as those associated with cyclones). Its major tributaries, the Dawson, Mackenzie and Connors Rivers rise in the eastern coastal ranges and in the Great Dividing Range and join together about 100 km west of Rockhampton. Major floods can result from either the

Dawson or the Connors-Mackenzie Rivers. Significant flooding in the Rockhampton area can also occur from heavy rain in the local area below Riverslea. Neerkol Creek at Stanwell also has a history of flooding.

The Fitzroy River has flood records dating back to 1859. The highest recorded flood occurred in January 1918 and reached 10.11 m on the Rockhampton gauge. The most recent major flood occurred in January 1991 following the coastal crossing of tropical cyclone Joy near Ayr on 26 December 1990. The flood was the third highest on record and rose to a height of 9.3 m on the Rockhampton gauge (Bureau of Meteorology, 2005a).

The most recent significant flood event in the vicinity of the project site occurred on 6 February 2003 when flash flooding occurred in the Dee River and tributaries and in Neerkol Creek and nearby streams. One person was killed and several houses and public buildings were inundated. Damage to the area was estimated to be over $10 million. The flooding was caused by ex-tropical cyclone Beni. Heavy rainfall fell in the coastal region between Rockhampton and Gladstone and penetrated some 100 to 150 km inland. The highest falls were recorded in the area around Mt Morgan. Neerkol Creek at Stanwell rose over 6.5 m in 3 hours reaching a peak of 9.2 m at 10 am. This was slightly higher than the peak in December 1990/January 1991.

Major flooding requires a large scale rainfall situation over the vast Fitzroy River catchment. Analysis of the weather data at a number of stations following the 2003 flooding indicated that rainfall periods of 3 hour duration (and therefore risk of flooding) would occur once in every 10-20 years on average. Duration of rainfall up to 72 hours would have an average recurrence of once every 20 to 50 years. Rainfall of short duration (2 hours or less) would occur on average less than once every 5 years (Bureau of Meteorology, 2003).

Average catchment rainfalls of in excess of 200 - 300 mm in 48 hours may cause moderate to major flooding and traffic disabilities to develop, particularly in the middle to lower reaches of the Dawson River catchment downstream of Taroom, the Mackenzie River downstream of Tartrus and the Isaac River downstream of Connors Junction, and extending downstream to the Fitzroy River below Riverslea and finally Rockhampton (Bureau of Meteorology, 2005).

Preliminary modelling (Section 5 – Water Resources) suggest that during a 100-year Average Recurrence Interval (ARI) flood, Neerkol Creek would reach a height of approximately 44.5 m AHD adjacent to the Stanwell site. During a 50-year ARI flood, Neerkol Creek would reach a height of approximately 43 m AHD. The model also suggests that a small floodplain, located to the west of the site, could be an important storage area in the event of major flooding. The maximum flow in Neerkol Creek for the February 2003 flood event was approximately 1,625 m^3s^{-1}. Flood frequency analysis suggests this would be between a 10 and 20 year event. Flooding and mitigation measures are discussed in more detail in Section 5 – Water Resources.

4.3.3 Bushfire

A number of factors affect the risk of bushfire including fuel load, type and density, and weather/climatic conditions. In terms of fuel load, the risk of potential grassfire can be measured using a combination of Total Dry Standing Matter (a measure of the amount of dead, standing vegetation in kilograms per hectare (kg/ha)) and Curing Index (indicates the percentage of fuel (grass) that is fully cured/dead).

As at August 2005, the amount of total dry standing matter in Fitzroy Shire approximated 500 kg/ha. Of the grass in the greater Stanwell area 70 to 90% was thought to be dead (i.e. the Curing Index was 70-90%). The remainder of the Shire had a Curing Index ranging between 30 and 70%. The area around Stanwell has a high potential grassfire risk and Fitzroy Shire as a whole has a moderate to high risk. The fire risk during August to October is usually the highest for the year, due to the lack of rain typically experienced over the winter months. The dry conditions results in drier fuel loads.

The Queensland Rural Fire Service has identified areas in the immediate north, west and south of Stanwell as being a medium bushfire hazard due the extent of surrounding vegetation. The Project would be at a greater risk of bushfire than grassfire due to the surrounding vegetation types and the general intensity of bushfires being greater than those associated with grassfires. The most severe fires (hottest and fastest) come from north-westerly, westerly or south-westerly directions, as the westerly element results in movement of warmer air. The less vegetated areas around Stanwell are of low bushfire hazard. The area immediately around Kabra is a low bushfire hazard as is the broader area around Gracemere (Queensland Rural Fire Service, 2002; G. Seaman, Acting District Inspector Rockhampton, Queensland Fire and Rescue Service, pers. comm., 30.09.05 and 14.10.05).

The fire station at Stanwell has one appliance and on average is called out to bushfires approximately 10 times per year. In the last five years, approximately five bushfires have affected SCL land. The SPS has its own crew that undertakes hazard reduction burning including maintenance of fuel reduced zones (G. Seaman, Acting District Inspector Rockhampton, Queensland Fire and Rescue Service, pers. comm., 30.09.05). The proponents will collaborate with SPS and work in conjunction with the SPS fire crew in reducing the fire hazard risk in areas adjacent to the site. The maintenance of fuel reduced zones around the site of a minimum 10 m in width is a key aspect in reducing the impact of bush and grass fires. Such zones also provide access points for fire brigades should a fire occur.

Calliope Shire, where the Fisherman’s Landing wharf is located, had more Total Dry Standing Matter than Fitzroy Shire, ranging from 1,000 to 2,500 kg/ha and a high potential grassfire risk. Of grass in that Shire, 30 to 70% of it was thought to be dead (Queensland Rural Fire Service, 2005). The greater area around Fisherman’s Landing is categorised as having a medium bushfire hazard (Queensland Rural Fire Service, 2002).

4.3.4 Drought

Drought is a prolonged, abnormally dry period created by the failure of expected rain. The effects of drought impact on agriculture causing reduction or loss of water supplies, crop failures and livestock losses. Drought can also lead to environmental damage through vegetation and wildlife loss, erosion, and toxic algal blooms in depleted dams, rivers and lakes. People may face severe water restrictions and will be affected by rising food prices and reduced supply. Droughts and higher than average temperatures are often linked. Other drought-related hazards include heat waves, dust storms and bushfires.

Serious drought has affected the Fitzroy region in recent years, placing enormous strain on the water supply (Department of Natural Resources and Mines (DNRM), 2004b). Fitzroy Shire and Rockhampton are currently drought declared with the declaration for these areas made on 22 May 2002. The Gladstone area is not drought declared with only 10% or less of properties in the region being individually drought-effected (Department of Natural Resources and Mines, 2005a).

On a national level, the entire Central Coastal region is declared by the Bureau of Rural Science as experiencing Exceptional Circumstance. This means that the current drought is severe (lasting longer than twelve months and is of a scale that affects a significant proportion of farm businesses in a region) and there has been a severe downturn in farm income over a prolonged period (Department of Agriculture, Forestry and Fisheries, 2005).

During extreme drought periods when water supplies are limited, the DNRM would be cautious when issuing water allocations and this may have an impact on the development of the Project. As discussed in Section 5 - Water Resources, of the potential options available for raw water supply, uses that do not increase the overall burden on the Fitzroy Basin would be the most sustainable, reliable and environmentally friendly. The “Fitzroy Basin Resource operations Plan” (ROP) (Department of Natural Resources and Mines, 2004c) seeks to manage water in an integrated and sustainable way to achieve a balance between the needs of current water users, further water-related development in the area and environmental flows needed for aquatic ecosystems. Existing water allocations licensed by DNRM are already part of the ROP and therefore represent relatively secure, sustainable options. The “Fitzroy Basin Water Resource Plan” (FBWRP) (Fitzroy Basin Association, 2004a) indicates that up to 300,000 ML of unallocated mean annual diversion may still be available from the Fitzroy Basin.

The reliability of water supply could be uncertain during drought conditions. However this risk could be managed by developing appropriate infrastructure. The Project will be designed to ensure sufficient capacity water infrastructure, including storage is available to meet the project water supply requirements. Similarly, the Project must also demonstrate that water use will be managed as efficiently as possible to meet the objectives of the FBWRP. Options for water re-use and recycling will be incorporated into the design of the Project, as detailed in Section 5 - Water Resources.