- There is no change in water levels at the downstream limit of Sg Pulai close to Tg Bin as a result of the construction of the reclamation for both normal and extreme river flow events.
- There is no significant change to the tidal prism in Sg Pulai as a result of the construction of the reclamation.

Based on this it is concluded that there is no impact on the hydrology of Sg Pulai as a result of the Project.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **No Change**.

Criteria	Score	Description
Importance	2	Important to areas immediately outside the local condition
Magnitude	0	No Change
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-Cumulative
Environmental Score	0	
Description	**N**	**No Change**

6.5.3.2 Streams Discharging on the eastern shoreline of Tg. Piai

The impact on water levels at two locations within the channel between the reclamation and the eastern shoreline of Tg. Piai has been modelled (refer to Section 6.2.4). This has shown that there is no significant change in high water levels in this area during periods with extreme river flows from the five streams that discharge in this area as a result of the reclamation works.

Based on this it is concluded that the construction of the Project will not impact flow or flood levels in the five streams that discharge into the channel between the reclamation and the eastern shoreline of Tg. Piai.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **No Change**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	0	No Change
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-Cumulative
Environmental Score	0	

Criteria	Score	Description
Description	**N**	**No Change**

6.5.3.3 Mitigation Measures

No additional mitigation measures specific to hydrology are proposed, although the mitigation measures described in Section 6.2.4.2 are also relevant.

6.5.3.4 Residual Impacts

No residual impacts.

6.6 Air Quality

6.6.1 Evaluation Framework

Project related impacts to air quality have been assessed in terms of their compliance with emission limits that govern atmospheric emissions releases (i.e. concentration of the pollutant at the discharge source) and air quality standards. Analysis of emission limit compliance entailed a comparison of whether the emitted concentrations of the inventoried list of atmospheric emissions were lower than established emission limits.

Compliance with short-term air quality standards involved applying emission inventories (i.e. associated with conservative construction and operational scenarios) with the US EPA dispersion model Industrial Source Complex Short Term Model Version 3 (ISCST3). The Gaussian plume model is widely used to compute short-term pollution concentration and/or deposition values on specified locations, i.e. receptors from multiple sources. It combines source data, meteorological information, terrain, and dispersion coefficients to predict ground level concentrations of air pollutants.

Annual average Volatile Organic Compounds (VOCs) concentrations were also modelled. This allowed for an assessment of compliance with EU standards for atmospheric benzene and potential odour impacts.

This evaluation framework is discussed further in the sub-sections below.

6.6.1.1 Ambient Air Quality Guidelines

Ambient air quality guidelines have been developed by the Department of Environment (DOE), Malaysia in 1988 and will be applied for this assessment. The recommended ambient air quality standards are presented in Table 6.16.

Table 6.16 Malaysia: Ambient air quality guidelines

Pollutant	Averaging Time	Malaysia Guidelines	
		ppm	µg/m^3 / (mg/m^3)
Total Suspended Particulate (TSP)	24 Hours 12 Months		260 90
Particulate Matter (PM_{10})	24 Hours 12 Months		150 50

Pollutant	Averaging Time	Malaysia Guidelines	
		ppm	µg/m³ / (mg/m³)
Sulphur Dioxide (SO_2)	1 Hour 24 Hours	0.13 0.04	350 105
Nitrogen Dioxide (NO_2)	1 Hour 24 Hours	0.17 0.04	320
Carbon Monoxide	1 Hour 8 Hours	30.0 9.0	(35) (10)

6.6.1.2 Environmental Quality (Clean Air) Regulations 2014

During the operational phase, the stack emission concentrations shall comply with the new Environmental Quality (Clean Air) Regulations 2014 which states the limit as 50 mg/m^3 for Total Suspended Particulate (TSP) for combustion boiler of less than 10MW.

6.6.1.3 American Conference of Governmental Industrial Hygienists (ACGIH)

ACGIH is a scientific association that publishes guidelines known as Threshold Limit Values (TLVs) for use by industrial hygienists in making decisions regarding safe levels of exposure to various chemical and physical agents found in the workplace /5/. The TLV to be referred for this assessment is shown in Table 6.17.

Table 6.17 ACGIH Threshold Limit Value

Pollutant	Type	Threshold Limit Value (TLV)
Volatile Organic Compounds (VOC) Time weighted average for 8 hour a day or 40-hours a week exposure	Clean Products	200 mg/m^3 (jet fuel)
	Dirty Products	100 mg/m^3 (fuel oil)

6.6.1.4 Methodology / Assumptions

Construction Stage

During the construction stage, the impact evaluation focuses on emissions from the operation of machinery and dust. Sources considered include:

- Operation of Machinery and Power Generation - Heavy machinery such as dredgers, pilling rigs, excavators, concrete mixers, etc. used during construction phase generates various pollutants to the air caused by the combustion of various fuels such as diesel (i.e. the main fuel). The pollutants of concerned are NOx, SOx and PM_{10}.
- Suspended Dust - Heavy construction activities during reclamation and facilities construction are known to generate substantial amounts of dust. Dust particles or particulate matter can negatively affect local air quality and human health.

Operations Stage

The air quality analysis of the Project considered all relevant emission sources when establishing air quality modelling parameters. An inventory of these emissions is outlined the following sub-sections.

Integrated Petroleum Hub
The proposed project requires steam boilers to generate heat for heating of petroleum products. Gaseous emissions will be released via stacks and the pollutants emitted from these combustion activities are typically including particulate matters (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO). CO will only be released during incomplete combustion and the amount of release is expected to be negligible. Regular maintenance of the boilers should be sufficient to address this issue and hence, CO is not further assessed in this study.

Mercury is normally present in crude oil (dirty product). Its level in crude oil can be widely variable according to reservoirs and geographical areas. Typically, it traces below 20 parts per billion (ppb) in most of the crude oil sources. Mercury poses more severe issue for oil refineries as the refining process tends to release the mercury component via air emission, wastewater or waste-solids. Unlike refining process, direct release of mercury is not known to be credible for storage and transfer operations. Therefore, parameter of mercury is not considered in the modelling.

Apart from the boiler stacks, petroleum product storage tank will emit organic vapours or known as Volatile Organic Compounds (VOC) via its venting system. Locations of the boiler stacks and storage tanks are shown in Section 3.6.3.4. Table 6.18 shows the details of the identified point sources.

Table 6.18 Details of points source emissions

Pollution Source	**Point Source Description**	**Released Pollutants**
Stack release gaseous emissions due to combustion activities from 8MW steam boilers powered by diesel.	• Stack height – 28.0 m • Stack diameter – 0.9 m • Exit velocity – 9 m/s • Exit temperature – 250°C	PM, SO_2, NO_2
Organic vapours released via vent of storage tanks	Internal floating roof tanks for clean products – gasoline, jet fuel, kerosene. Internal floating roof tanks for dirty products – crude oil, fuel oil, and diesel.	VOC

Vessel Transport
Fugitive gas emissions of organic vapour could be expected from terminal facilities in particularly during product transfer. However the emitted amount of VOCs from these sources is expected to be low and insignificant. With proper transfer procedures and safeguard measures to avoid excessive leakage, it is unlikely to cause any adverse impact due to the fugitive emitted VOC and are not considered further.

Land-Based Traffic
For the purpose of this EIA it is assumed that land-based traffic or truck loading activities would be limited and as most transport activities are marine-based. Given this, emissions from land-based traffic are expected to be negligible or low and are not further evaluated.

6.6.2 Sensitive Receptors and Baseline Air Quality Features

Baseline information essential for assessing project related air quality impacts includes existing air quality and the sensitive receptors that can most be affected by air quality impacts. A brief description of these features is provided.

Figure 6.69 shows the map of sensitive receptors location in the vicinity of project area. These include residential, school and recreational area. The aforementioned “public health” receptors points are also used for evaluating the impact on ecological areas.

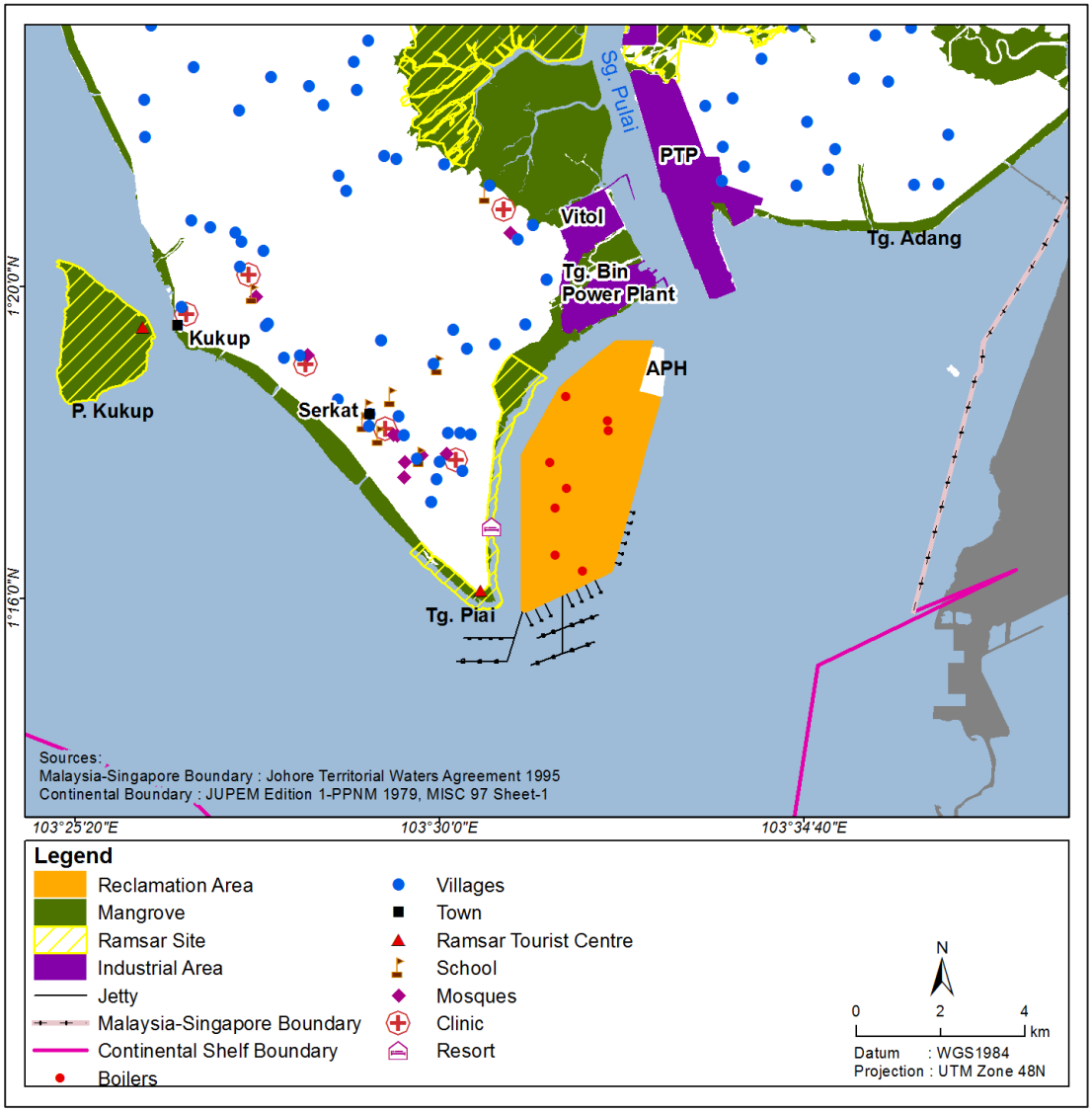

Figure 6.69 Local receptors identified around the proposed project.

Ambient air quality at these sensitive features is generally good with pollutants within the recommended limits. Volatile Organic Compound (VOC), Mercury and Carbon Monoxide are below detectable limits.

6.6.3 Construction

6.6.3.1 Potential Impact

Construction phase activities generate atmospheric emissions from the operation of machinery and equipment, as well as from earth works.

Baseline analysis showed that pollutants of concern, mainly NO_2, SO_2 and PM_{10}, are well below the recommended guideline. It is noted that the spread of airborne dusts and emissions to the nearby sensitive receptors due to construction activities are very much dependent on the wind direction, topography, vegetation or other characteristics of the

project site. For example, the proposed location has quite flat topography, so theoretically dust impacts can spread to further inland if not controlled. However, with proper implementation of mitigation measures, the dust impact to the nearby receptors can be minimised.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	-1	Negative Change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-Cumulative
Environmental Score	-6	
Description	**-A**	**Slight negative impact**

6.6.3.2 Mitigation Measures

General good practice measures that could be applied during construction phase to reduce the air quality impact include:

- Establish hoarding along the site boundary to minimise the spread of flying dust to the surroundings.
- All loaded vehicles going to and leaving the construction site should be adequately covered to prevent spillage of materials from the vehicle during transport.
- All vehicles' wheels should be cleaned prior to exiting the site and entering the main road to minimise dust generated during vehicle's movements.
- Trucks used in construction site should comply with requirements for exhaust emissions. It is also a good practice to switch off all engines, equipment and machinery when not in use to reduce emission and wastage.
- Regular water spraying of access roads and internal roads within the project site particularly during dry and windy weather conditions.
- Regular maintenance of vehicles and machinery to reduce their emissions of smoke and soot into the atmosphere.
- Open burning of cleared vegetation or construction debris is strictly prohibited.
- Speed limits shall be imposed on all vehicles entering and leaving the Project Site to prevent dust turbulence.
- Exposed areas should be vegetated as soon as possible.

6.6.3.3 Residual Impacts

No change to impact significance.

6.6.4 Operational Phase Impacts

6.6.4.1 Estimated Emission Concentrations

The stack emission concentrations on Total Suspended Particulate (TSP) was compared with the new Environmental Quality (Clean Air) Regulations 2014. Based on the emission rates of 0.10 g/s, stack diameter and exit velocity, emission concentrations of the pollutants was estimated to be 17.5 mg/m^3 which is below compliance limit of 50 mg/m^3 for combustion boiler of less than 10MW.

6.6.4.2 Air Quality Modelling Results

Two parameters of air pollutant concentrations are often used, namely Incremental Ground Level Concentrations (GLC) and Cumulative GLC. Incremental GLC refers to additional concentrations of pollutant at ground level due to the proposed project while cumulative GLC refers to ambient concentrations at ground level in considering the incremental GLC and the background / baseline level. The modelling results as in maximum incremental Ground Level Concentrations (GLC) due to the stack emissions are summarised in Table 6.19.

Table 6.19 Predicted maximum incremental Ground Level Concentrations (GLC)

Pollutant	Averaging Time	Maximum Incremental GLC µg/m^3 / (mg/m^3)	Recommended Guideline Limit µg/m^3 / (mg/m^3)
TSP	24 Hours	0.8	260
	12 Months	0.2	90
PM_{10}	24 Hours	0.5	150
	12 Months	0.1	50
NO_2	1 Hour	47.7	320
	24 Hours	7.9	
SO_2	1 Hour	33.8	350
	24 Hours	5.6	105
VOC	8 hours	(0.26)	(100)

As shown in Table 6.19, the maximum incremental GLC of all pollutants are low and below their respective recommended limits. The predicted value is based on worst case scenario, where the relevant sources are operating simultaneously. The actual concentrations are expected to be lower during the operations.

To obtain cumulative GLC, the baseline results for TSP and PM_{10} collected for 24 hours averaging time is considered similar to 1 year averaging time. Meanwhile, the baseline results for SO_2 and NO_2 collected for 24 hours averaging time is considered similar to 1 hour averaging time. The results indicate that the levels of TSP, PM_{10}, NO_2 and SO_2 were up to 68.6 µg/m^3, 35 µg/m^3, 7.3 µg/m^3 and 10.5 µg/m^3 respectively. In addition to these background levels, the cumulative GLC are below the stipulated guideline limit and are not expected to pose any significant impacts to the atmospheric environment. Similarly, low GLC of VOC is not significant in this case. The highest GLC of VOC is predicted at 260 µg/m3, which is much lower than the reference limit of 100,000 µg/m^3. At the sensitive

receptors, lower GLC result is obtained as shown in Table 6.20. The respective air pollutant contours are given in Figure 6.70 to Figure 6.77.

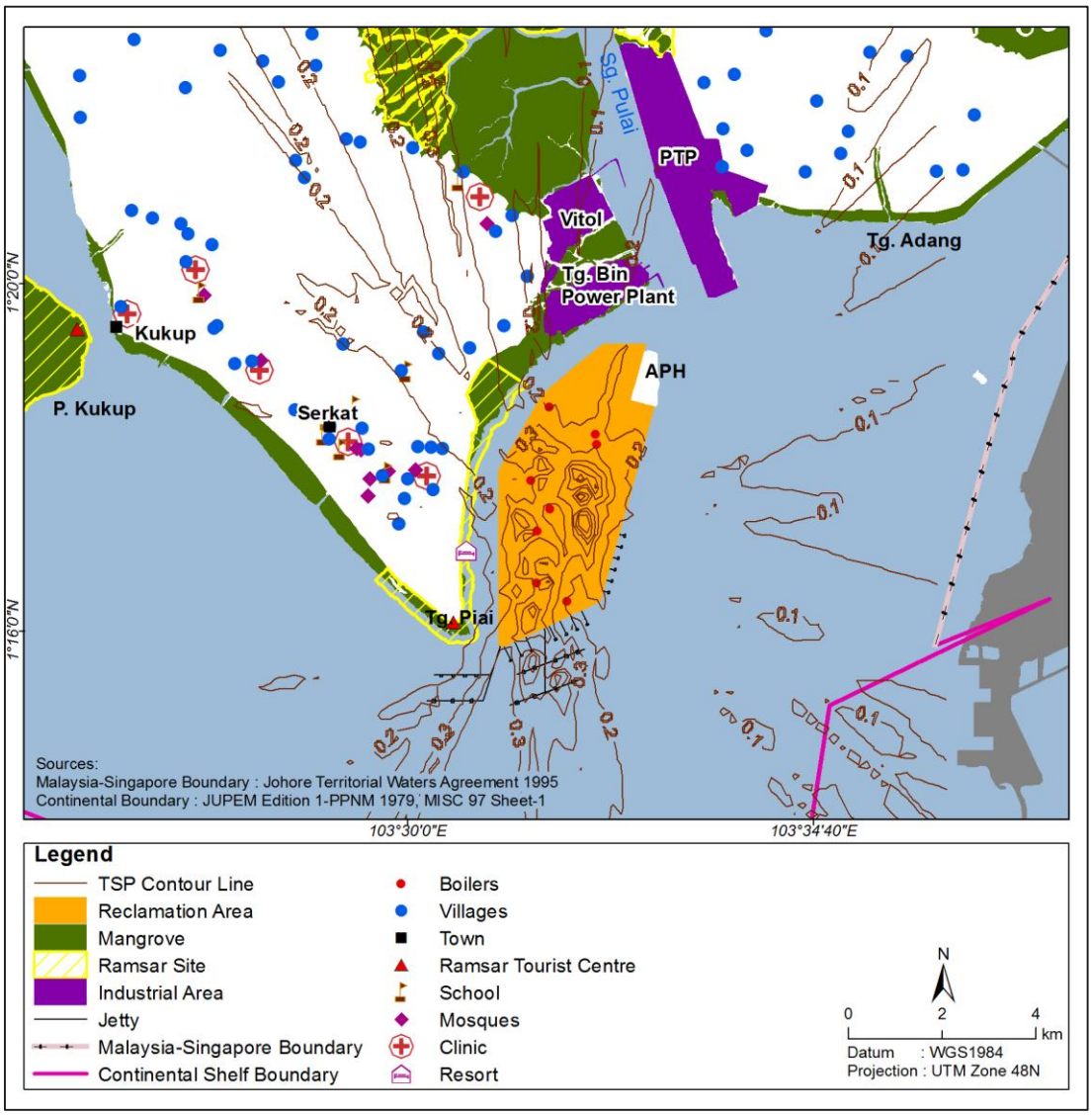

Figure 6.70 Predicted GLC of TSP Contours (0.1 µg/m^3 interval) for 1-yr averaging time during operation phase

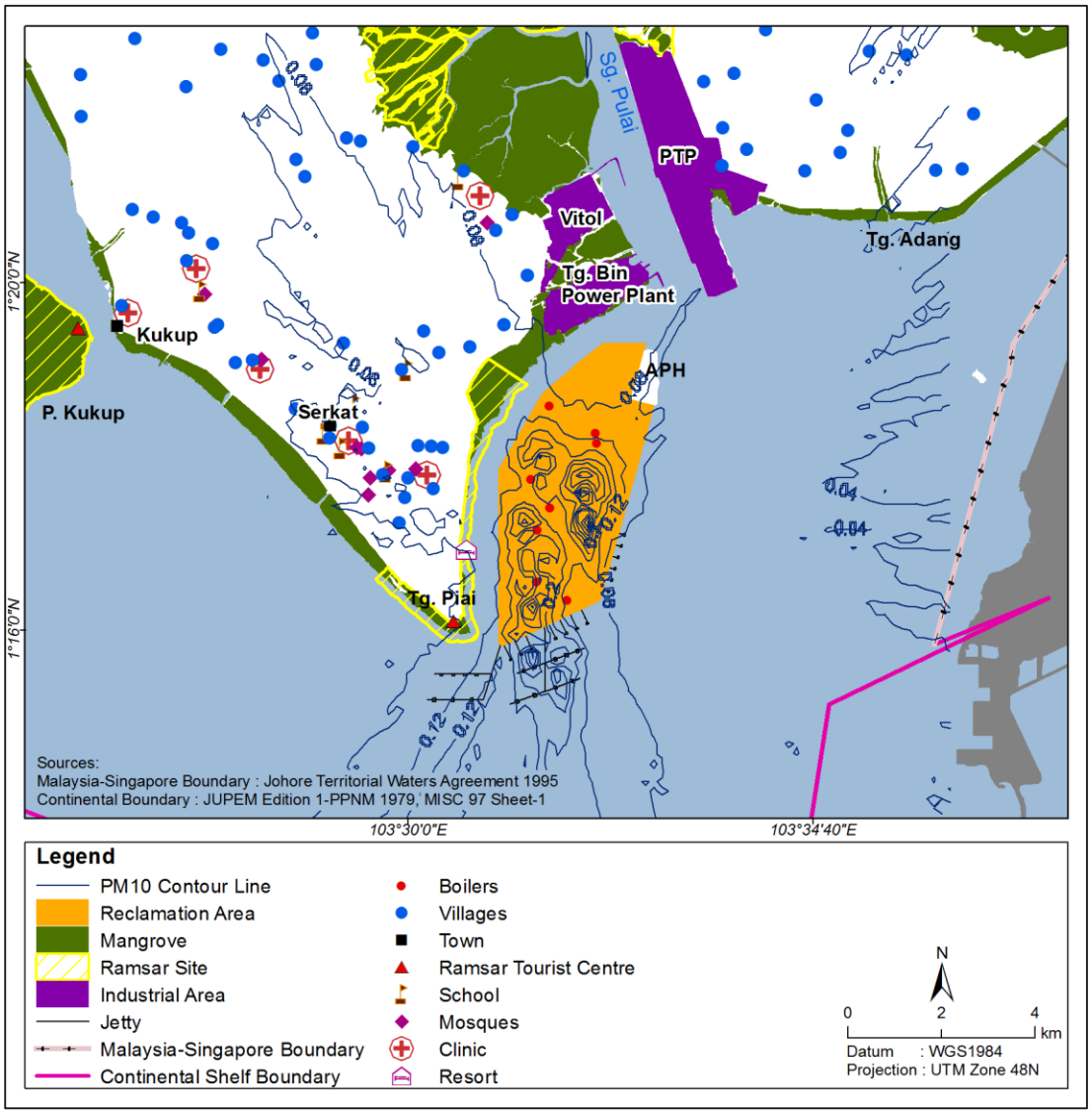

Figure 6.71 Predicted GLC of PM_{10} contours (0.04 µg/m^3 interval) for 24-hr averaging time during operation phase

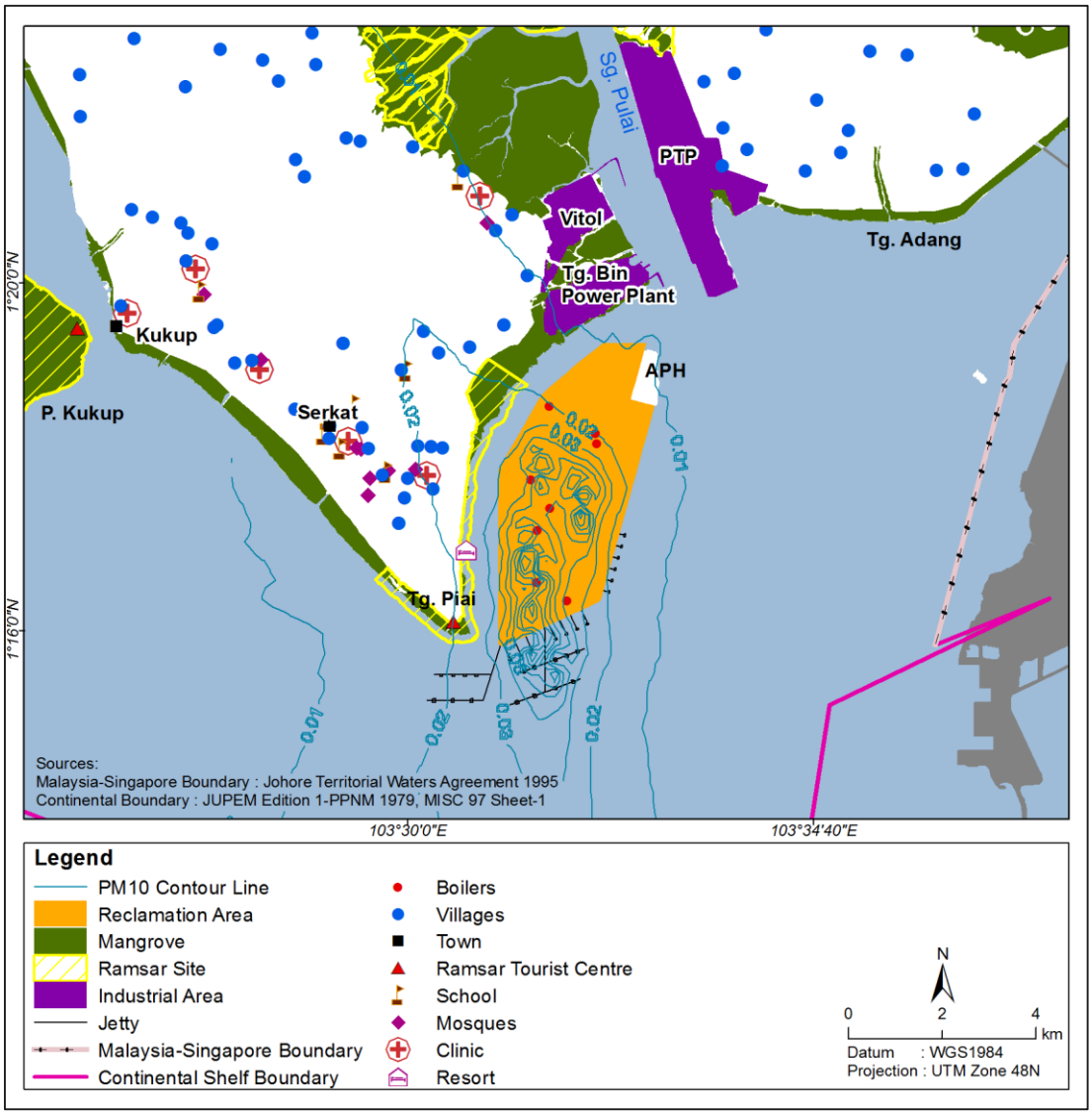

Figure 6.72 Predicted GLC of PM_{10} contours (0.01 µg/m^3 interval) for 1-yr averaging time during operation phase

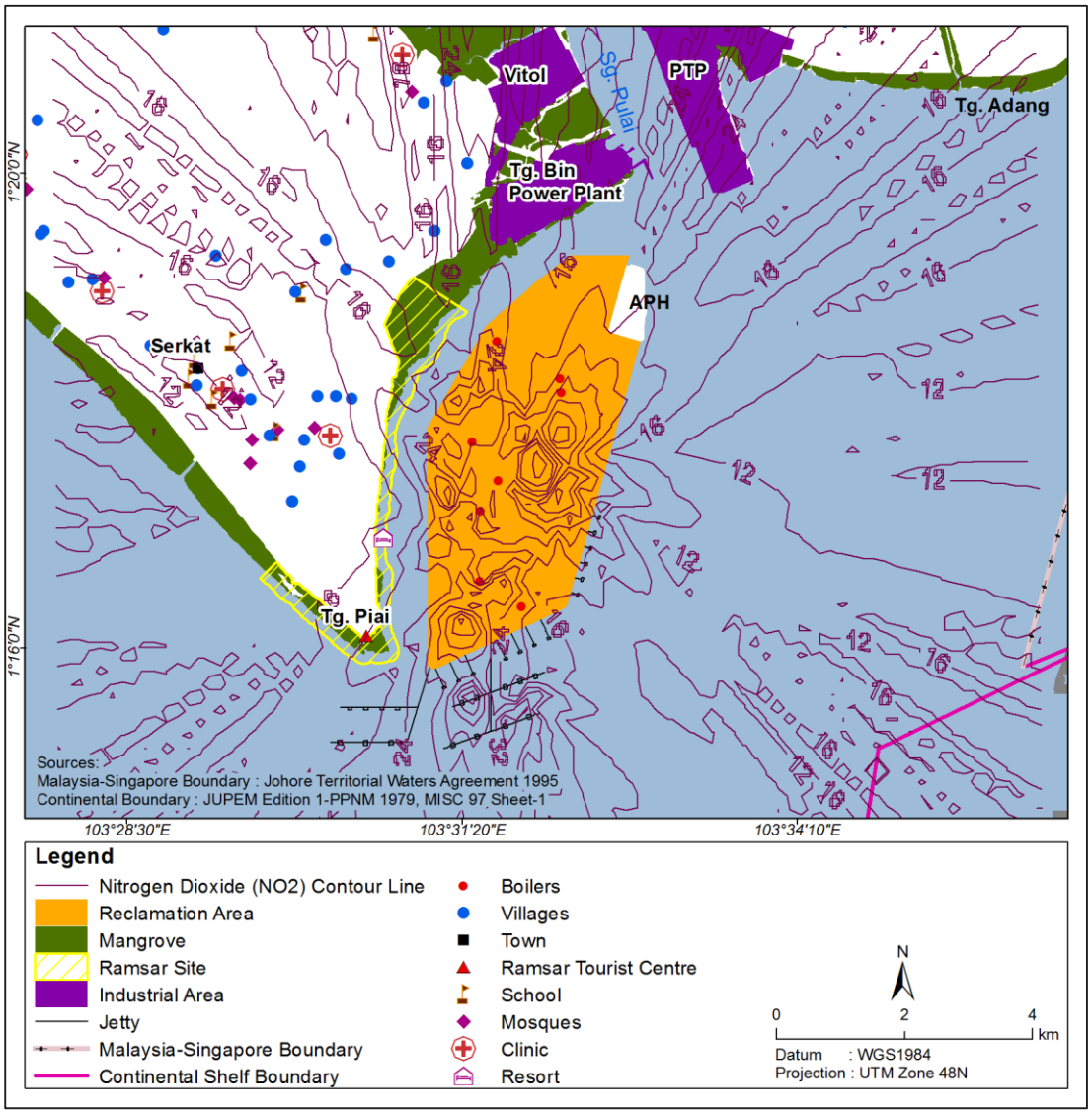

Figure 6.73 Predicted GLC of NO_2 contours (4.0 µg/m^3 interval) for 1-hr averaging time during operation phase

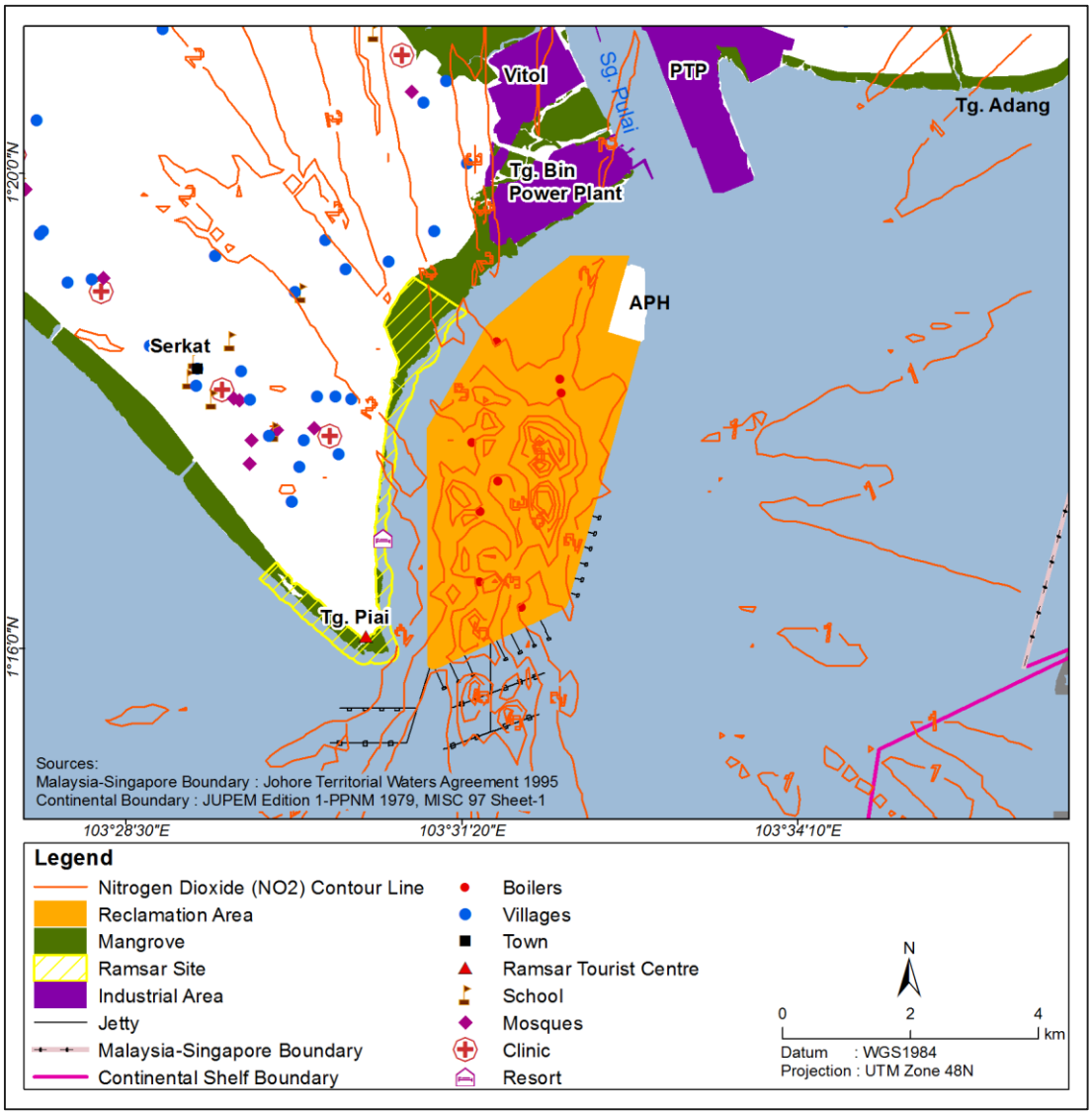

Figure 6.74 Predicted GLC of NO_2 contours (1.0 µg/m^3 interval) for 24-hr averaging time during operational phase

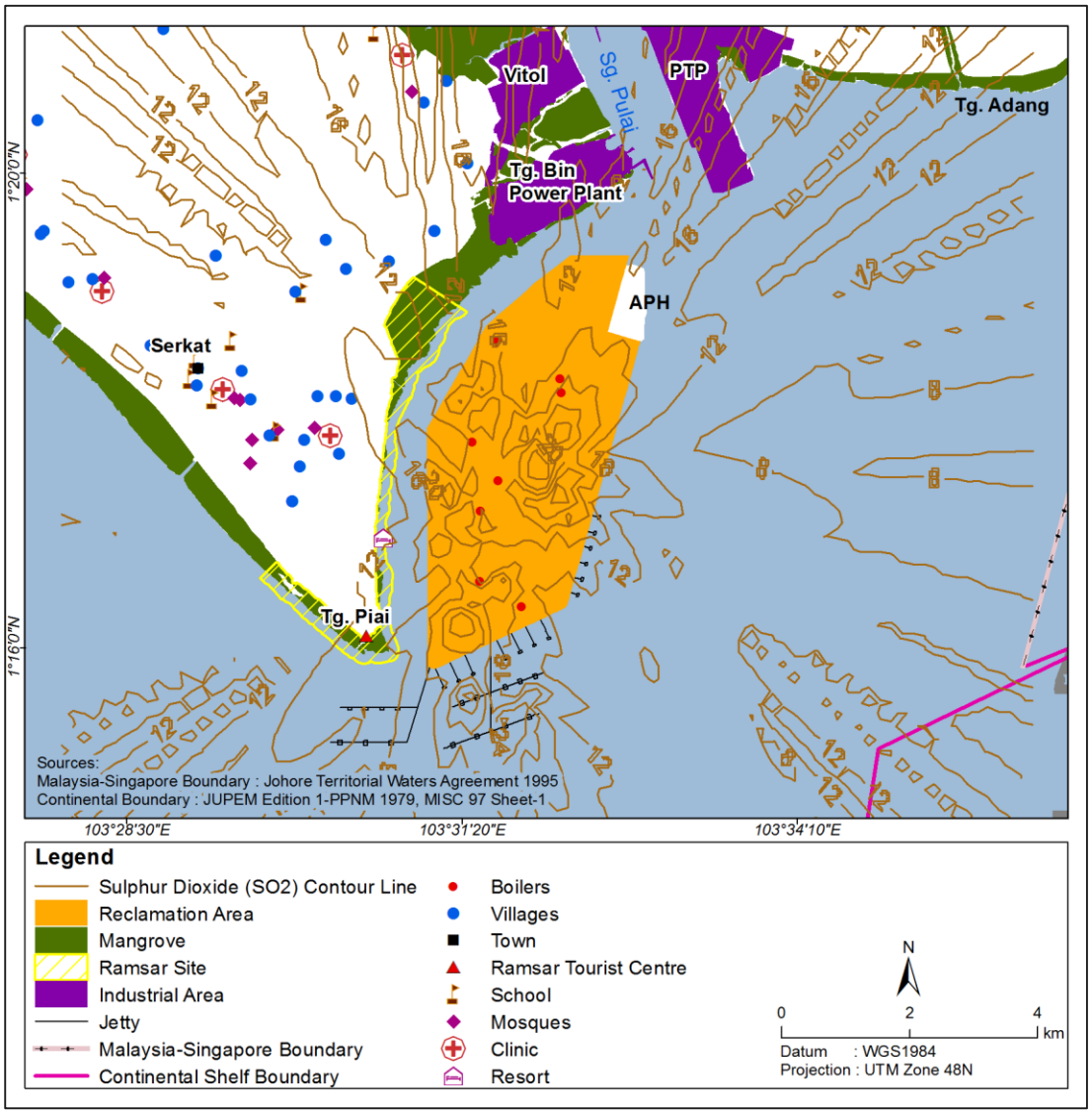

Figure 6.75 Predicted GLC of SO_2 contours (4.0 µg/m^3 interval) for 1-hr averaging time during operational phase

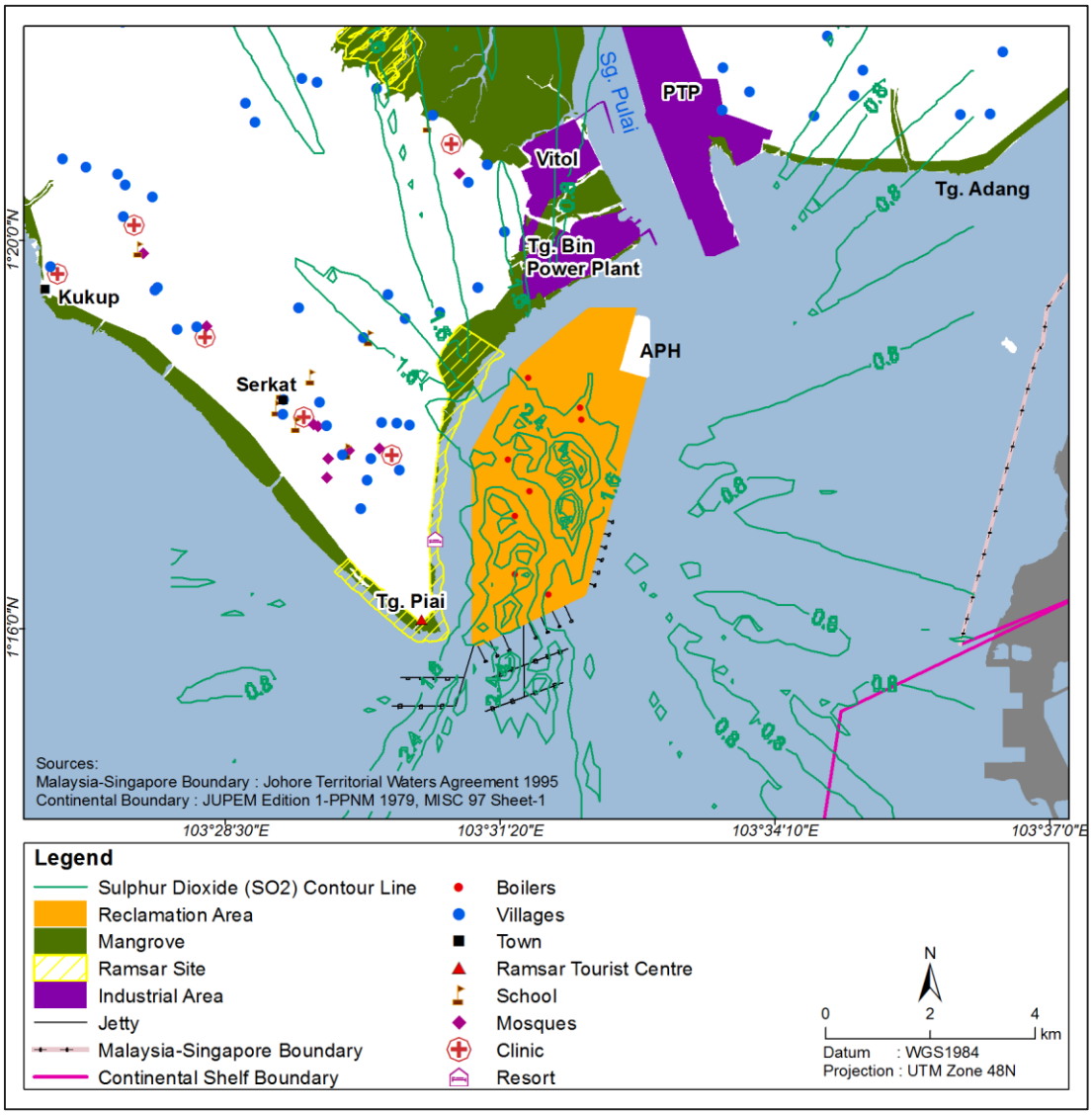

Figure 6.76 Predicted GLC of SO_2 contours (0.8 µg/m^3 interval) for 24-hr averaging time during operational phase

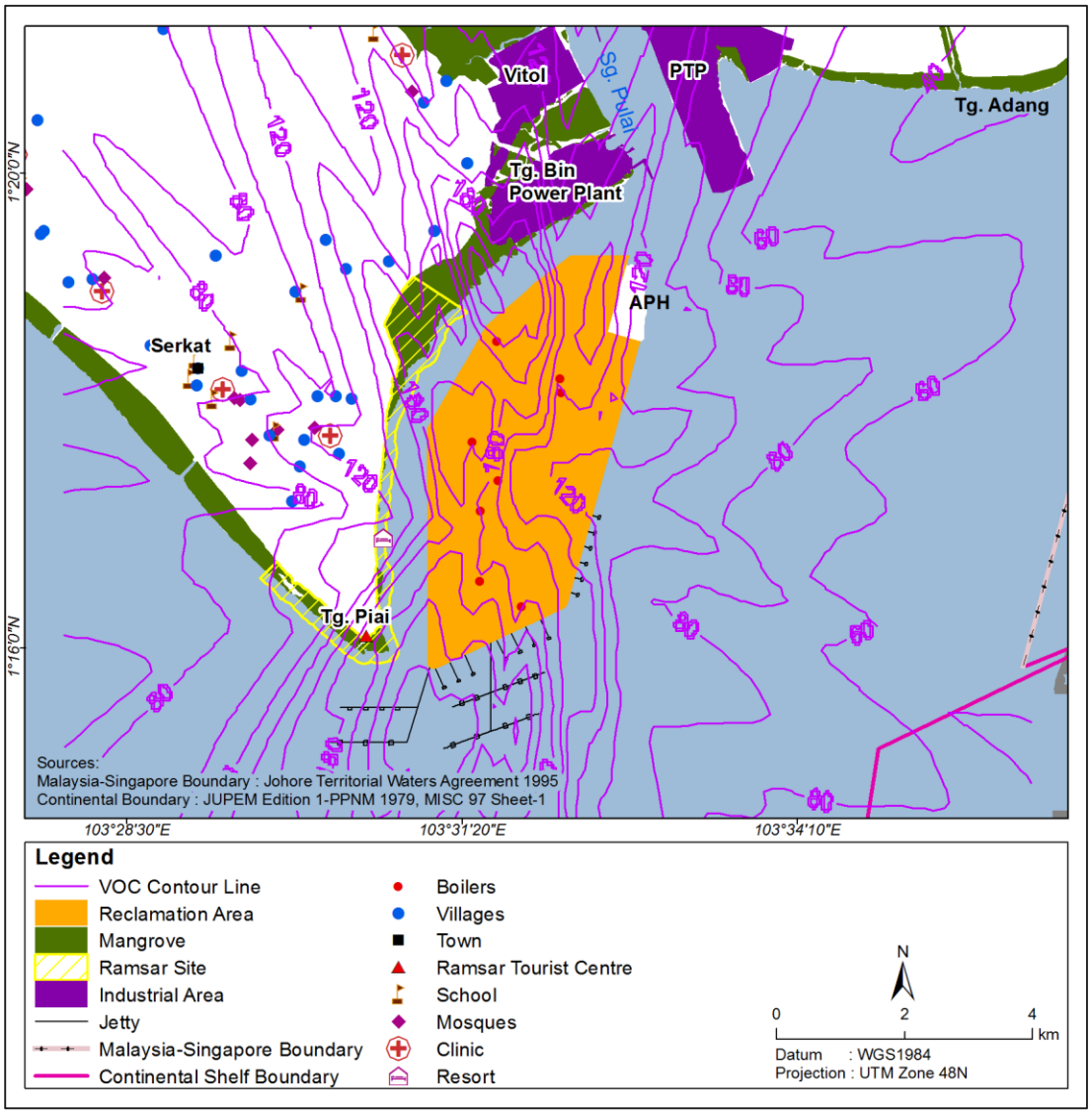

Figure 6.77 Predicted GLC of VOC contours (20.0 µg/m^3 interval) for 8-hr averaging time during operational phase

Table 6.20 Predicted cumulative Ground Level Concentrations (GLC) at receptors

Station	Parameter	Averaging Time	Baseline µg/m^3 / (mg/m^3)	Incremental GLC µg/m^3 / (mg/m^3)	Cumulative GLC µg/m^3 / (mg/m^3)
AN1	TSP	24 Hours	63.8	0.16	63.96
		12 Months		0.03	63.83
	PM_{10}	24 Hours	31	0.08	31.08
		12 Months		0.02	31.02
	NO_2	1 Hour	2.298	19.4	21.698
		24 Hours		1.6	3.898
	SO_2	1 Hour	4.378	13.8	18.178

Station	Parameter	Averaging Time	Baseline µg/m³ / (mg/m³)	Incremental GLC µg/m³ / (mg/m³)	Cumulative GLC µg/m³ / (mg/m³)
		24 Hours		1.1	5.478
	VOC	8 hours	(57.12)	(184.8)	(241.92)
AN2	TSP	24 Hours	60.8	0.18	60.98
		12 Months		0.04	60.84
	PM_{10}	24 Hours	32	0.09	32.09
		12 Months		0.02	32.02
	NO_2	1 Hour	5.788	15.4	21.188
		24 Hours		1.8	7.588
	SO_2	1 Hour	1.242	11.0	12.242
		24 Hours		1.3	2.542
	VOC	8 hours	(57.88)	(125.9)	(183.78)
AN3	TSP	24 Hours	66.4	0.20	66.6
		12 Months		0.03	66.43
	PM_{10}	24 Hours	34	0.11	34.11
		12 Months		0.02	34.02
	NO_2	1 Hour	4.838	16.0	20.838
		24 Hours		2.0	6.838
	SO_2	1 Hour	1.10	11.3	12.4
		24 Hours		1.5	2.6
	VOC	8 hours	(57.387)	(142.2)	(199.587)
AN4	TSP	24 Hours	68.6	0.12	68.72
		12 Months		0.02	68.62
	PM_{10}	24 Hours	35	0.06	35.06
		12 Months		0.01	35.01
	NO_2	1 Hour	7.268	17.1	24.368
		24 Hours		1.2	8.468
	SO_2	1 Hour	10.491	12.2	22.691
		24 Hours		0.8	11.291

Station	Parameter	Averaging Time	Baseline µg/m^3 / (mg/m^3)	Incremental GLC µg/m^3 / (mg/m^3)	Cumulative GLC µg/m^3 / (mg/m^3)
	VOC	8 hours	(59.638)	(117.9)	(177.538)

Referring to the air dispersion pattern, GLC of all parameters is expected to be similar or lower at Malaysia-Singapore border. As the incremental concentrations at receptors in Johor are fairly acceptable during normal and abnormal operations, significant impact on the Singaporean atmospheric environment is not expected.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	-1	Negative Change
Permanence	3	Permanent
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-8	
Description	**-A**	**Slight negative impact**

6.6.4.3 Mitigation Measures

It is recommended to maintain the boilers to avoid any abnormal emissions as well as conduct periodic stack monitoring at the stack outlets. In addition, periodic stack emissions and ambient air monitoring are recommended throughout the terminal operations.

6.6.4.4 Residual Impacts

No change to impact evaluation.

6.7 Noise

6.7.1 Evaluation Framework

This assessment refers to the following legislation and guidelines:

- The Planning Guidelines for Environmental Noise Limits and Control, Department of Environment (DOE) 2007, with reference made to Schedule 1 and Schedule 3.
- The Planning Guidelines for Vibration Limits and Control in the Environment, Department Of Environment (DOE) 2007, with reference made to Schedule 5

6.7.1.1 Standards and Tolerance Limits

The DOE Planning Guidelines for Environmental Noise Limits and Control Schedule 1 provides maximum permissible sound level (L_{Aeq}) based on the type of land use and time of the day as indicated in Table 6.21. As described in Section 5, the sensitive receptors fall under suburban residential, public spaces and recreational areas with a limit of 55/ 45 dB(A) for day/ night-time.

However, the Guidelines also provide for another set of limits in the event of existing high noise climate when the noise limits in Table 6.21 are lower than the existing noise climate (L_{Aeq}), as is the case in many of the stations (see Section 5.1.11). In this case an acceptance criteria based on maintaining a noise level similar to the existing noise climate shall be referred (Table 6.22).

In summary, in the case of low existing noise climate, permissible noise levels are 55 dBA (daytime) and 45 dBA (night time) for suburban residential areas or 50 dBA (daytime) and 40 dBA (night time) for noise sensitive areas such as schools.

Table 6.21 Schedule 1: Maximum permissible sound level (L_{Aeq}) by receiving land use for planning and new development.

Receiving Land Use Category	**Day Time (7 am – 10 pm)**	**Night Time (10 pm – 7 am)**
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas	50 dBA	40 dBA
Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas	55 dBA	45 dBA
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential-Commercial)	60 dBA	50 dBA
Commercial Business Zones	65 dBA	55 dBA
Designated Industrial Zones	70 dBA	60 dBA

Table 6.22 Maximum permissible sound level (LAeq) to be maintained at the existing noise climate.

Existing Levels	**New Desirable Levels**	**Maximum Permissible Levels**
L_{Aeq}	L_{Aeq}	L_{Aeq} + 3 dBA

Source: Schedule 3 of The Planning Guidelines for Environmental Noise Limits and Control, DOE 2007 (2nd Edition).

The baseline monitoring revealed that most sites have high ambient noise relative to the Schedule 1 limits (Table 6.21) and hence the relevant maximum permissible levels outlined in Table 6.22 are applicable. The relevant baseline noise results at sensitive receptors are tabulated in Table 6.23, together with the respective permissible levels.

Table 6.23 Ambient noise level monitoring results and permissible levels, based on a combination of Schedule 1 and Schedule 3 limits.

Stn	**Receptor**	**Land Use Category**	**Daytime**		**Night Time**	
			Baseline - L_{eq}	**Permissible Level**	**Baseline - L_{eq}**	**Permissible Level**
N1	Ramsar Site (Residential)	Park	70	73	66	69

Stn	Receptor	Land Use Category	Daytime		Night Time	
			Baseline - L_{eq}	Permissible Level	Baseline - L_{eq}	Permissible Level
N2	Jalan Perpat Timbul (Residential)	Suburban	51	55	55	58
N3	SK Seri Sinaran Chokoh (Noise Sensitive)	School	54	57	53	56
N4	Kg Sg Chengkeh (Residential)	Suburban	59	62	61	64

The facility will operate on a 24-hour basis, thus the recommended night-time noise levels and permissible level will therefore be the governing criterion.

The facility will also need to consider the occupational noise exposure of its workers. This assessment, however, is not part of the environmental assessment and would normally be undertaken during the detailed design phase of the works.

6.7.2 Sensitive Receptors

Noise sensitive receptors are the villages near the shoreline, the Tg. Piai Resort and the Ramsar Tourist Centre as shown in Figure 6.69. Baseline ambient noise measurements reveal a relatively high ambient noise environment as outlined above, with the predominant contributor of noise being traffic.

6.7.3 Construction

6.7.3.1 Potential Impacts

Noise Sources

Construction Package
Key activities anticipated to be carried out during the construction phase together with the equipment list for each stage of the development are tabulated in Table 6.24.

Table 6.24 Construction scenarios and list of assumed equipment for each scenarios

Scenario	Equipment	Typical Sound Level /6, 7/
Reclamation	Trailer Suction Hopper Dredger (TSHD)	106
	Tug Boat	81
	Work Boat	81
	Heavy duty electric generator	85
	High solids pump	85

Scenario	Equipment	Typical Sound Level /6, 7/
	Bull dozer	96
	Water and dump truck	89
	Front end loader	88
	Barge	88
	Excavator	87
	Grader	85
Dredging	Cutter Suction Dredger	106
	Tug Boat	81
	Work Boat	81
	Heavy duty electric generator	85
	High solids pump	85
Construction of Marine and Onshore Facilities (including earthworks activities)	Piling rigs	98
	Floating crane	100
	Bull dozer	96
	Excavator	87
	Crane	100
	Lorries / Transport trucks	96
	Welding and fabrication equipment	102

Predicted Noise at Receptors

Of these activities the two with the most potential to cause the higher impacts are the reclamation activities and construction of marine and onshore facilities in relations to the proximity of the noise sensitive receivers. These activities are described in Table 6.25 together with the predicted noise level at the noise receiver locations.

Table 6.25 Construction scenarios and the predicted noise level at the noise receivers.

Scenario	Description	Noise Levels of Receiver Locations		
		Noise sensitive	Residential (Average)	Industrial Receptor
Criterion Schedule 1 / Schedule 3	Daytime Night-time	57 56	63 64	70 60
Reclamation Activities	Reclamation activities throughout the three phases.	**77**	**64**	**73**

Scenario	Description	Noise Levels of Receiver Locations		
		Noise sensitive	Residential (Average)	Industrial Receptor
Dredging	Capital dredging only during phase 2.	37	21	21
Construction of marine and onshore facilities including earthworks	Civil and structural construction of marine and onshore facilities.	**86**	**66**	69

Noise prediction has been based on simple noise attenuation calculations based on typical reclamation, dredging and construction equipment as well as assumed number of machinery mobilised for each project component /8, 9/.

To assess the noise levels generated during construction works, the project has been divided into three (3) major construction components: reclamation; dredging; and construction of marine and onshore facilities. The dredging works will be carried out offshore at a distance of 2.6 km from the nearest sensitive receptor and hence no impacts to the sensitive receptors along the shoreline are predicted; this construction component is not considered further here. The noise levels for reclamation and construction works on the reclaimed land are assessed separately as the number and type of equipment utilised may differ between the components and the sequence of construction will not be carried out simultaneously.

The expected maximum noise levels at the sensitive areas are as shown in Figure 6.78 to Figure 6.79. It is noted that these predictions are conservative, worst-case scenarios assuming that all the given equipment are operating at the boundary of the project site at the same time (including percussive noise from piling) and does not take account of noise attenuating or dampening from topography, vegetation or other characteristics of the project site.

Figure 6.78 shows the predicted noise contours from reclamation activities. The predicted noise level at the noise sensitive receptor, Tg. Piai Ramsar Site at a distance of 400 m is 77 dB(A); see also Table 6.25. Residential located approximately 1.5 km inland are predicted to be exposed to maximum sound levels of 64 dB(A).

Noise impact from construction of marine and onshore facilities affects a wider area due to the proximity of the project boundary to the coastline. The nearest sensitive receptor is Tg. Piai Ramsar Site, located approximately 100 m from the boundary of the proposed bridge and 200m from the boundary of the project area. The predicted maximum sound level at the Site is range from 80 – 86 dB(A). Meanwhile, the noise predictions at residential area located approximately 700 m from the project boundary is potentially exposed to sound levels of 66 dB(A). Factory area located at the east of the Tg. Bin coastline is predicted to experience noise exposure of 69 dB(A).

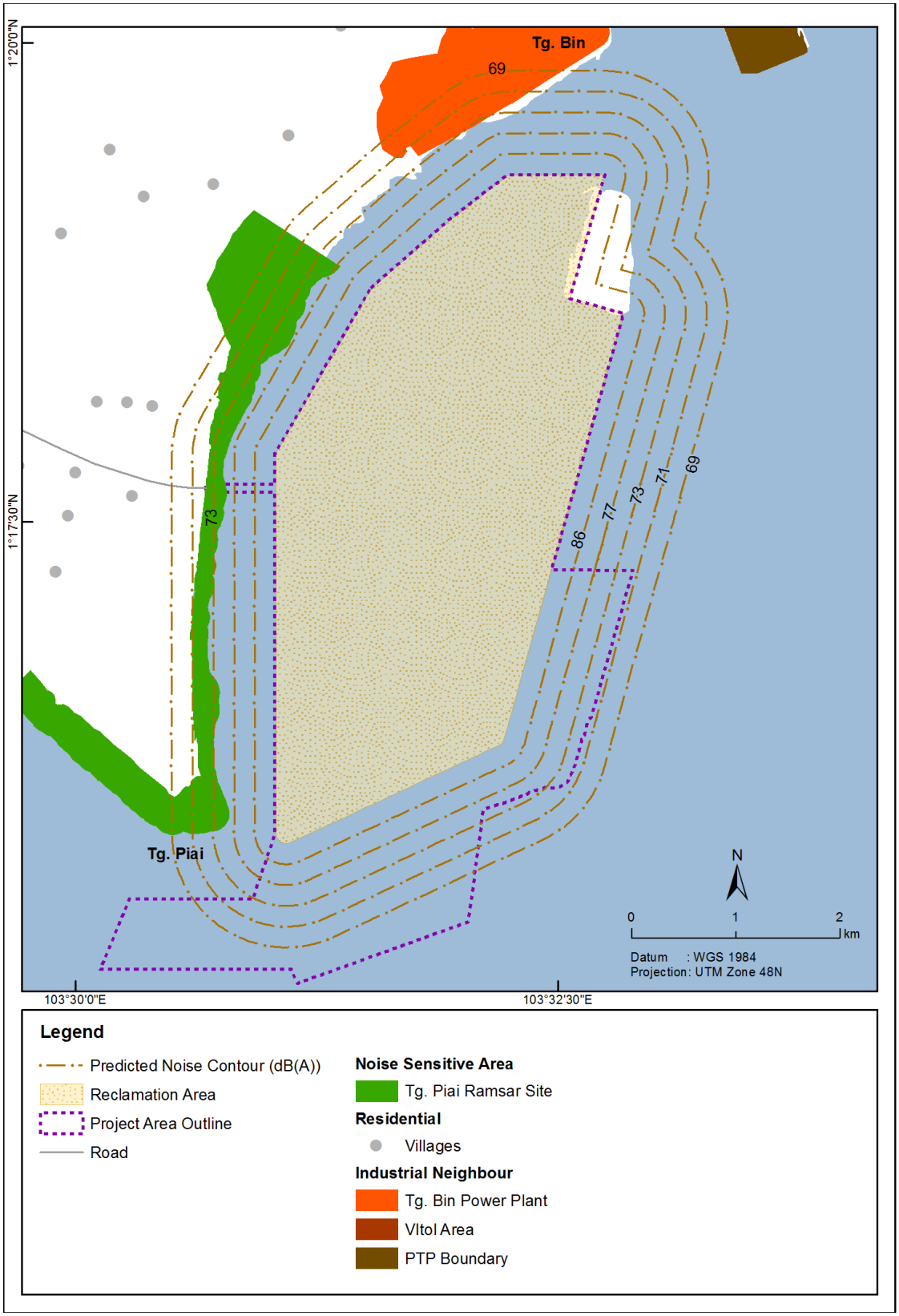

Figure 6.78 Predicted noise contours from reclamation activities

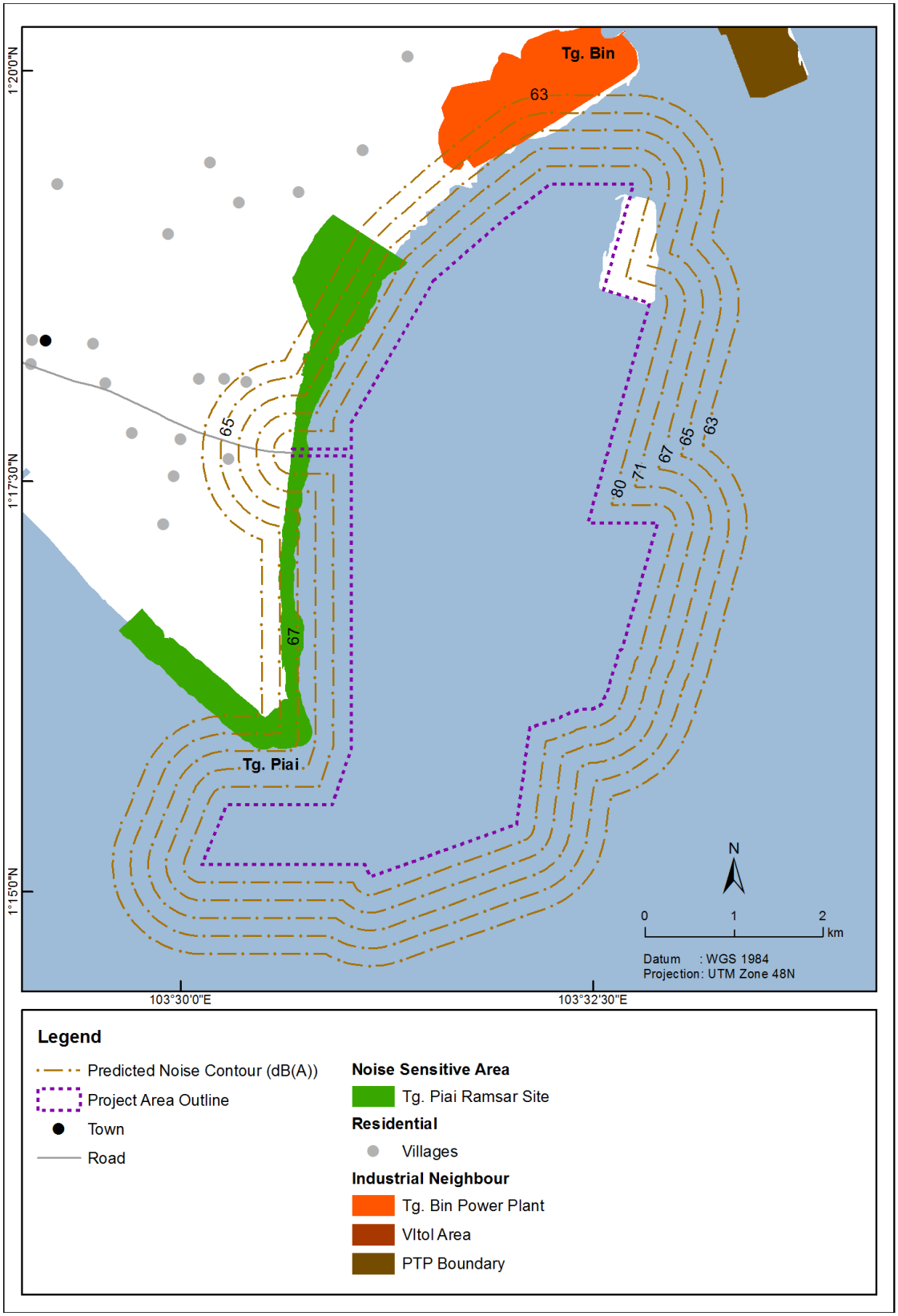

Figure 6.79 Predicted noise contours from construction of marine and onshore facilities

Land-Based Transport
Although the majority of the construction materials have been proposed to be delivered by sea (i.e. prefabricated units, construction materials), there will be noise impacts associated with construction related traffic on the mainland which will be required to deliver some materials through the nearby jetty to the Project site. The types of vehicles used are assumed to include dump trucks and freight trucks. The noise levels associated with these vehicles has been presented in Table 6.26.

Table 6.26 Construction vehicle noise propagation levels in dBA

Vehicle	Example	Noise Levels at Receptor Distances (dBA)		
		10 m	20 m	30 m
Dump Truck	A dump truck delivering construction supplies	79	73	69
Lorry	A lorry delivering raw materials	74	68	64

These noise levels are likely to result in some impacts to the residents and commercial properties situated near the main access roads on the mainland. However, approximately 80% of the materials are likely be delivered to the project site via sea, therefore minimizing the number of vehicles using the mainland routes. Also, it is assumed that these deliveries will occur during the day, when the guideline noise levels are least conservative.

In summary, during the general construction activities negligible to low impact to the surrounding communities during the day or night-time periods is predicted. Minor noise impacts due to land-based traffic delivering construction materials are expected along key road arteries in the area because the majority of the construction materials are expected to be transported to via sea.

It should also be noted that the predicted noise levels are based on the worst case scenario without any control measures and assuming all the equipment as listed in Table 6.25 will be operating at the boundary of the Project area at the same time. In practice, this will not be the case and lower noise levels can also be expected when mitigating measures are in place. Furthermore, the topography, landscape, seascapes and vegetation surrounding the project site will also act as a natural barrier to attenuate noise.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	-1	Negative Change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-Cumulative
Environmental Score	-6	
Description	**-A**	**Slight negative impact**

6.7.3.2 Mitigation Measures

In order to minimise the noise impact generated during construction phase, it is recommend that:

- Working hours for onshore works limited to daytime;
- Road transport of equipment and materials is limited to daytime;
- All vehicles and machinery will be properly serviced and maintained to ensure good working condition, thereby reducing the possible noise emission;
- Establish hoarding and a vegetation belt along the western terminal boundary.
- Suitable noise absorbent materials should be installed on machinery that produces high noise levels. Machinery emitting high noise shall be sited within an enclosure to reduce the noise impact;
- Residents are notified prior to the commencement of piling works and informed of their expected duration.
- On-going noise monitoring during construction at sensitive receivers during critical periods (i.e. times when noise emissions are expected to be at their highest) will assist in identifying and controlling high risk noise events
- Active community consultation and the maintenance of positive relations with local residents and will assist in alleviating concerns and thereby minimising complaints
- A telephone number be made freely available so that complaints can be registered, logged and actioned (to the extent deemed necessary)

6.7.3.3 Residual Impacts

No change to impact significance.

6.7.4 Operation

6.7.4.1 Predicted Impacts

Noise Sources

Plant Operation

During the operation phase, noise pollution sources have been identified to be generated primarily from the plant operation and vehicular movement. The principal noise emissions from the plant operation is listed in Table 6.27 and shown in Figure 6.80.

Table 6.27 Principal noise sources of the plant operation

Noise Source	Location	Estimated Sound Power Level (SPL) from Source (dBA)
Loading Pump Station (LPS) consists of 5 pumps with 3,000m^3/hr pumping rate each	16 LPS at tank farm	105 dBA from each pump
Air compressor	6 units at tank farm	85 dBA from each air compressor

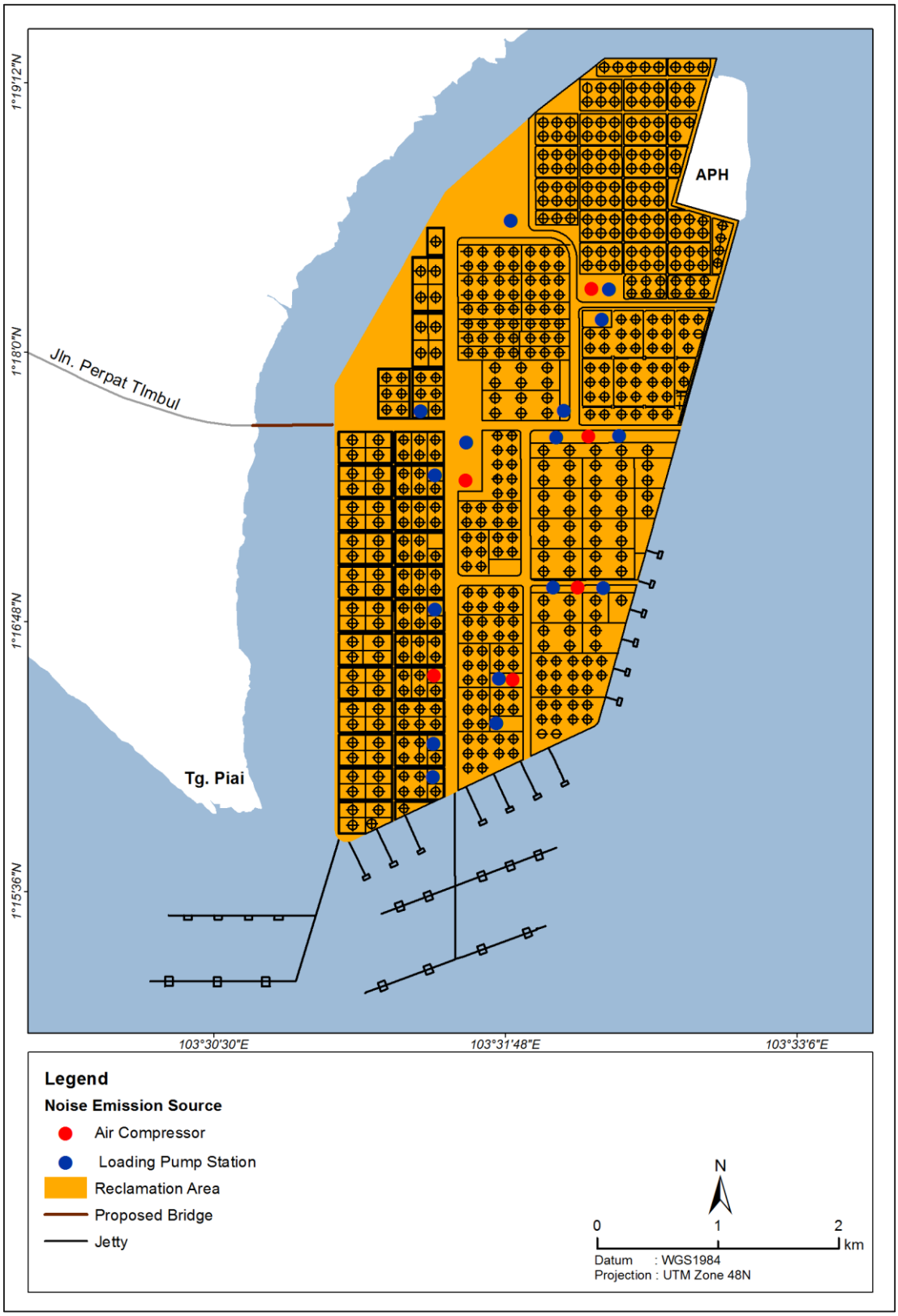

Figure 6.80 Location of noise sources in the plant.

Traffic and Transportation

Besides plant operation, significant noise increment is also expected from the increased traffic movement due to the development. A traffic forecast during the peak hour is estimated and is summarized in Table 6.28. From the forecasted results, there will be

maximum 2,814 pcu during peak hour plying on Jalan Serkat (J111) in year 2030. This figure has been included as part of the noise modelling.

Table 6.28 Traffic forecast due to the project development

AM Peak 2030 (passenger car unit - pcu)		PM Peak 2030 (passenger car unit - pcu)	
Tg. Piai – Kukup	**Kukup – Tg. Piai**	**Tg. Piai – Kukup**	**Kukup – Tg. Piai**
1127	1687	1586	1079

Noise level Modelling Results

Modelling of the noise level showed that exposure of 30 dB(A) or more is wholly confined within the project site. Along the coast line, receptor may expose to about 25 dB(A) in particular the north-western coastline of the project site. Similar to receptor along Jalan Serkat, exposure of about 25 dBA is expected within 100 m from Jalan Serkat.

Predicted incremental noise level at the receiving noise sensitive receptors due to the operational of the proposed development is shown in Table 6.29 and the noise contours is shown in Figure 6.81.

Table 6.29 Predicted incremental noise level at the noise sensitive receptors

Receptor	Noise Sensitive	Residential	Factory
Predicted Incremental Noise Level (approximate dB(A))	10	20	Not affected

Table 6.30 Predicted cumulative noise level at noise sensitive receptors during operational phase

Station	Period	Baseline (L_{Aeq})	Incremental	Cumulative	Permissible Level (dBA)
AN1 – Within Tg. Piai Ramsar Site (Noise sensitive areas – recreational)	Day	69.7	10	69.7	72.7
	Night	66	10	66	69
AN2 – At Jalan Perpat Timbul (near the proposed bridge) (suburban residential – medium density)	Day	51.3	20	51.3	55
	Night	55	20	55	58
AN3 – Sekolah Seri Sinaran Chokoh (noise sensitive areas – school)	Day	54.1	10	54.1	57.1
	Night	53	10	53	56
AN4 – Kg. Sungai Chengkeh (suburban residential – medium density)	Day	59.1	20	59.1	62.1
	Night	62	20	62	65

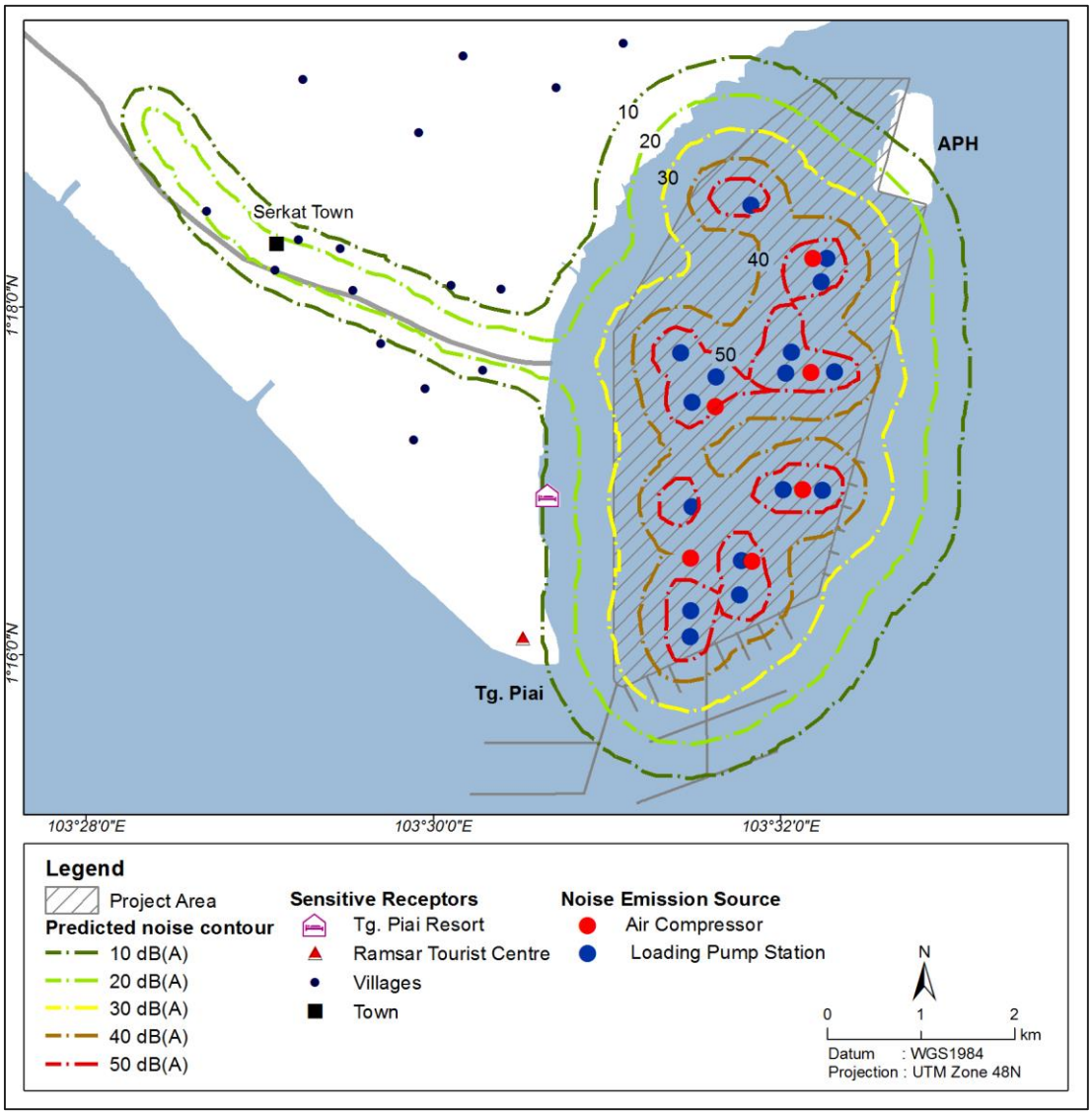

Figure 6.81 Predicted noise contours due to project development

When the plant is fully operational, the resulting noise levels from the activities on the park are well within the permissible level at the noise sensitive, residential, factory areas on the coastline from Tg. Piai to Tg. Bin. At the noise sensitive area of Tg. Piai Ramsar Site, the increase in noise impact predicted to be 10 dB(A) and it remains within the permissible level of ambient noise level.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	-1	Negative Change
Permanence	3	Permanent
Reversibility	2	Reversible
Cumulativity	2	Non-Cumulative

Criteria	Score	Description
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

6.7.4.2 Mitigation Measures

During the plant operation, the noise impact to the surrounding area may be mitigated with the following good practice management including:

- Regular maintenance of heavy vehicles and machinery. A maintenance programme / schedule should be established to inspect and maintain the vehicles and machinery periodically in particular the principle noise sources i.e. pumps and air compressors.
- Silencer to be fitted to noisy equipment, when necessary.
- Substitution of diesel motor to electric motor, where applicable.
- Enclosure of noisy equipment, when necessary.
- Wall fencing and vegetation strip along the western boundary to act as noise attenuation.

6.7.4.3 Residual Impacts

No change in impacts.

6.8 Terrestrial Ecology

6.8.1 Evaluation Framework

Impacts are assessed based on the project activities during construction and operation that would generate disturbance to the health of the terrestrial vegetation and habitat. Sensitive habitats were reviewed including mammals that are categorised as totally protected, protected and not protected according Wildlife Act 2010.

Air Quality Thresholds

The WHO guideline and EU Ambient Air Quality and Cleaner Air for Europe (CAFE) Directive for the exposure of vegetation to NOx is 30 µg/m^3 and SO_2 range from 10 to 20 µg/m^3, with sensitivity depending on vegetation type. The limit of 10 µg/m^3 is related to the protection of species of lichen (which are highly sensitive to pollution), and 20 µg/m^3 is related to the protection of woodland and forest /10/.

In the present case, with the primarily agricultural vegetation found around the project site, the higher limit of 20 µg/m^3 is considered appropriate.

6.8.2 Sensitive Receptors

Terrestrial flora found along the coastline towards Tanjung Piai are predominantly mangroves and mixed vegetation while further inland are dominated by plantations such as coconut, palm oil and rubber, of which the key sensitive wildlife habitat is the mangrove fringe. Impacts on mangrove vegetation are discussed separately in Section 6.9.

Mammals recorded in within the study areas (Kukup, Tg. Piai to Tg. Bin and Sg. Pulai includes carnivores (civet and otter), chiropterans (bats), primates (monkeys), rodentia (rats), ungulate (pig), pholidota (pangolin).

Out of 29 species of mammals documented (in all locations), one species was listed as totally protected (Slow loris *Nycticebus coucang*) which was only recorded in Kukup and twelve species were listed as protected (for example Leopard cat *Prionailurus bengalensis* and Dusky leaf monkey *Trahypithecus obscurus*).

Protected species found between Tg. Piai to Tg. Bin are Common palm civet, Oriental small-clawed otter, Smooth Otter, Malayan Flying Fox, Long-tailed macaque, Dusky leaf monkey and Wild Pig.

The most prevalent large mammal in the survey areas is the wild boar (Sus scrofa). This species is well-known to occupy all types of habitats including mangroves, scrubs, forest fringes, and plantation areas. The wild boar, pangolin, and primates are all protected under the Wildlife Protection Act 2010.

The impacts of the project on avifauna are assessed separately in Section 6.10.

6.8.3 Construction

6.8.3.1 Predicted Impacts

As the project will be constructed on a reclaimed land, site clearing activities is envisaged to be limited to areas along the access road to the site. The following impacts will be assessed within this section:

- Disturbance to terrestrial flora and fauna as a result of noise, visual disturbance, physical disturbance, and human presence
- Changes to terrestrial environmental quality as a result of air quality, marine water quality, or other sources (e.g. soil and groundwater contamination)

Noise

Noise emissions from construction activities such as use of equipment and heavy plant on site, generators, pumps, hand held tools, etc. are likely to lead to startle responses and/or avoidance behaviours in some species of mammal, reptile and birds. Species of vegetation are not considered within this sub-section as they are not deemed sensitive to noise disturbance.

Noise disturbance to wildlife is normally expressed through notable changes to behaviour to either individuals or populations. These changes can include avoidance responses such as altered range or distributions, feeding activities, breeding behaviours, grooming/preening, and rearing of young. Changes in behaviours can also include more subtle startle reactions such as head raising, increased alertness, and/or flight from the noise source.

Damage can also be caused to a species where negative effects are incurred for the overall health of a species. In terms of noise, this can include influences on reproduction success, predator avoidance, habitat use, or even individual injury or mortality in particularly sensitive species under certain circumstances.

Different species have different sensitivities to noise. This is related to a number of factors including, for example, the physiology of the ear and the range of hearing, the natural state of the animal (i.e. predator, prey, pack/herd/flock/lone individual, transient, nocturnal, etc.), and the natural environment (i.e. exposed, enclosed, underground, under water, etc.). As such, some species will be more sensitive than others to changes in noise levels.

The reaction of a species to noise disturbance can also be related to the levels of noise disturbance usually encountered in some cases. Considering that the terrestrial vegetation within the study area is mainly agriculture, the fauna in this area is likely to be accustomed to anthropogenic noise.

Noise generated during the construction phase has been modelled within Section 6.7.3 above. The terrestrial vegetation along the coastline are predicted to experience levels of noise from 63 to 126 L_{eq} dB(A).

Mammals are also relatively noise sensitive. Previous studies of terrestrial mammals have shown that noise levels of 120 dB(A) can damage mammals' ears, while levels at 95 dB(A) can cause temporary loss of hearing sensitivity /11/.

In all likelihood the wildlife present in the mangrove fringe immediately adjacent to the project site will be disturbed by the noise generated during the construction activities without the implementation of suitable management and mitigation measures. It is unlikely that wildlife on the mainland beyond the mangrove fringe will be affected by noise generated by the project construction. The predicted noise disturbance will be temporary and reversible during the course of the construction phase. Overall, the impact associated with noise disturbance is considered a minor to moderate negative impact, with implications to conservation efforts for a number of protected species.

Visual Disturbance/Human Presence

As with noise, a number of species of reptiles and mammals are sensitive to visual stimuli and exhibit startle responses and/or avoidance behaviours due to presence of humans or anthropogenic activities. Visual disturbance is likely to occur within the immediate surroundings of the access road and along the seaward front of the mangrove fringe and it is likely that the disturbance-sensitive species will avoid these areas and move up toward the more pristine mangroves towards Tg. Bin.

It should also be noted that a number of opportunistic species were recorded during the baseline surveys, including rodents. As such, there is a risk that the presence of construction facilities or temporary site facility will provide new feeding opportunities for these species, affecting a change in their diet from natural sources, turning them into 'pests'.

Overall, it is considered that wildlife present within the study area will be visually disturbed by human presence without the implementation of suitable management and mitigation measures. The predicted visual disturbance will be temporary and reversible during the course of the construction phase. Overall, the impact associated with visual disturbance is considered a minor negative impact, with minimal implications to conservation efforts for protected species.

Air

Air quality impacts have been discussed in Section 6.6. However, results are also considered here in terms of their impacts to terrestrial ecology during the construction phase.

It is well known that certain air quality parameters can have deleterious effects on vegetation if present in high enough quantities. These parameters include nitrogen oxides (NO and NO_2, collectively known as NO_x) and sulphur dioxide (SO_2). Heavy machinery such as dredgers, pilling rigs, excavators, concrete mixers, etc. used during construction phase generates various pollutants to the air caused by the combustion of various fuels such as diesel (i.e. the main fuel). The pollutants of concerned are NOx, SOx and PM10.

The WHO and EU guideline for the exposure of vegetation to NO_x is 30 µg/m^3.while the limit for SO_2 ranges from 20 to 30 µg/m^3. The expected NOx and SOx impacts from the construction activities are however low, as the sources are in an open, offshore location. Hence it is considered that there is likely to be a minor negative impact on vegetation, and potentially on wildlife, as a result of air quality emissions during the construction phase.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	-1	Negative Change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative
Environmental Score	-6	
Description	**-A**	**Slight negative impact**

6.8.3.2 Proposed Mitigation Measures

The following mitigation measures as presented in Table 6.31 are recommended for this project.

Table 6.31 Mitigation measures to minimise impact to terrestrial ecology during construction

Aspect	Mitigation Measure
Direct impact from project	To promote natural relocation of mobile species (i.e. where species leave the Project areas naturally to avoid disturbance and direct impact) as far as is possible. No fencing to be erected on site during initial phase. If fencing is required, then it is to be kept minimal with a design that permits passage for affected animals Management strategies implemented to protect remaining native vegetation communities by controlling the occurrence and spread of weeds and minimising the impact of soil erosion/sedimentation
Noise disturbance	Mitigation as described in Section 6.7.3.2 (noise) to be implemented
Visual/human presence	Appropriate waste management to be implemented to prevent the opportunistic feeding of 'pest' species Works to be confined to that necessary for the establishment of the facility Workers to be educated and trained with regard to the protected and threatened species, and the best ecological practices on site
Air Quality	Mitigation as described in Section 6.6.3.2

6.8.3.3 Residual Impacts

The construction phase is temporary and short-term, and as such a number of the ecological impacts expressed during this phase can also be considered temporary and short-term. Impacts can be minimised with correct application of suitable mitigation measures as discussed above.

However, slight residual impacts will remain, and no change to the impact evaluation of **Slight Negative** has been made.

6.8.4 Operation

Operational activities planned for the project present the possibility of noise disturbance, and visual disturbance/human presence to the flora and fauna of the Tg. Piai coastal vegetation. These aspects are discussed and assessed in the sub-sections below.

6.8.4.1 Predicted Impacts

Noise

Species sensitive to noise disturbance have been previously discussed in the previous section. As during the construction phase, there are predicted to also be noise emissions from operational activities such as use of equipment such as generators, pumps, turbines, pipelines etc. which may adversely affect some species of mammal, reptile and bird.

As shown in Section 6.7, the coastline from Tg.Piai to Tg.Bin will experience noise exposure of 20 to 30 dB(A) during the operational phase, which is lower than during the construction stage.

When considering the impact of the operational noise on the terrestrial ecology, it is important to acknowledge that impacts during the planned construction phase, including noise and visual disturbance, may have habituated the wildlife present in the area to a certain degree of noise disturbance.

Noise disturbance can be considered permanent over the operational life of the project. In all likelihood the remaining wildlife present is likely to be disturbed to some degree by the noise generated as a result of operational activities. However, the source will be continuous and so some acclimatisation can be expected. Overall, the impact associated with noise disturbance is considered a 'Minor' negative impact.

Visual Disturbance/Human Presence

As discussed within the construction phase impact assessment, a number of species are sensitive to visual stimuli and exhibit startle responses and/or avoidance behaviours due to presence of humans or anthropogenic activities. Visual disturbance is likely to occur within the project's immediate surroundings and will include lighting during the nightime.

Overall, it is considered that the wildlife will be visually disturbed by operational activities to some degree. It is also likely that some acclimatisation to the visual presence of the facility can be expected. Overall, the impact associated with visual disturbance is considered a minor negative change.

Air

As discussed in the previous section, nitrogen oxides (NO and NO_2, collectively known as NO_x) and sulphur dioxide (SO_2) can have deleterious effects on vegetation if present in high enough quantities.

According to the dispersion results for NO_x during the operational phase as shown in Section 6.6.4, predicted GLC of NO_2 concentrations for 1-hr averaging time are expected to have a maximum concentration of 24 µg/m^3. As such, the majority of the mainland area will be in compliance with the recommended EU and WHO limit of 30 µg/m^3 for protection of vegetation. It is therefore likely that the mainland vegetation will experience no negative impacts from NO_x.

Dispersion patterns as shown in Section 6.6.4 indicated that the predicted GLC of SO_2 concentrations for 1-hr averaging time during the operational phase are projected to have a maximum concentration of 20 µg/m^3, which is just within the WHO limits for the protection of woodland and forest. As such, SO_2 levels during the operation phase are expected to have a negligible effect to the vegetation on the mainland.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important only to local conditions
Magnitude	-1	Negative Change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

6.8.4.2 Proposed Mitigation Measures

The following mitigation measures as presented in Table 6.32 are recommended for the operational phase of this project.

Table 6.32 Mitigation measures to minimise impact to terrestrial ecology during operations

Aspect	Mitigation Measure
Noise disturbance	Mitigation as described within Section 6.7.4.2 (noise) to be implemented
Visual/human presence	Appropriate waste management to be implemented to prevent the opportunistic feeding of 'pest' species
Environmental Quality	Mitigation as described within Section 6.6.4.3 (air quality) to be implemented.

6.8.4.3 Residual Impacts

No change to the impact evaluation.

6.9 Mangrove

6.9.1 Evaluation Framework

The evaluation of impacts to the mangrove was carried out using the results of the suspended sediment plume, the sedimentation and oil spill. Suspended sediment plume impacts occur during reclamation and dredging (i.e. construction) whereas morphological impacts are also expected during operation, once the reclamation footprint is materialised. Impacts of oil spill to the mangrove are assessed based on the scenario detailed in Section 6.4.4.1 (Oil Spill).

All these impacts to the mangrove were carried out based on the available literature on the tolerance level of the mangrove towards these pressures.

6.9.1.1 Scope

The assessment of impacts to the mangrove covers more than 10 km radius from the project area. This area includes the mangroves of:

- Sg. Pulai;
- along the eastern shoreline between Tg. Bin and Tg. Piai;
- along the western shoreline between Tg. Piai and Kukup Town; and
- Pulau Kukup.

6.9.2 Sensitive Receptors

The mangrove condition within the anticipated zone of impacts is summarised in Table 6.33.

Table 6.33 Mangrove condition

Mangrove Area	Condition
Sg. Pulai	Good condition with average density of 1,215 trees/ ha; some clearing observed.
Tg. Piai	Good condition with average density of 4,013 trees/ ha; some erosion observed. Tg. Piai is a Ramsar site.
Along the eastern shoreline between Tg. Bin and Tg. Piai	Good condition with average density of 1,498 trees/ ha. This area is part of a Ramsar site.
Along the western shoreline between Tg. Piai and Kukup Town	Good condition with average density of 808 trees/ ha.
Pulau Kukup	Good condition. The whole island is a Ramsar site.

6.9.3 Construction

6.9.3.1 Predicted Impacts

Increased Suspended Sediment and Sedimentation

During the dredging and reclamation phases, sedimentation from the release of suspended sediments may lead to burial of the mangrove aerial roots, which inhibit the root aeration and thus lead to mortality /12, 13, 14/. However, mangroves are also very tolerant towards the range of suspended sediment loads that may be generated from dredging and reclamation activities /15/. According to Thampanya *et al*. (2002), the mangroves that are sensitive towards sedimentation are those with pneumatophore root systems (e.g. *Avicennia* sp.), though they are highly unlikely to be stressed, except when the sedimentation reaches levels from 10 cm up to 30 cm for a prolonged period of time /16/. The seedlings, on the other hand, are susceptible to sedimentation as the lenticels, which carried out the gas exchange may be blocked by sediment.

The predicted sedimentation rates as outlined in Section 6.3.3 do not affect the Tg. Piai mangrove fringe expect for during phase 2 dredging and reclamation, where the predicted maximum sedimentation rates are 3.5 mm over 28 days. Hence no impacts on the mangrove due to sedimentation arising from the dredging and reclamation activities are predicted.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **No Change**.

Criteria	Score	Description
Importance	1	Important to Tg. Piai
Magnitude	0	No Change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	0	
Description	**N**	**No change**

6.9.3.2 Proposed Mitigation Measures

No mitigation measures specific to mangroves are required; the siltation of sediments released during dredging and reclamation is mitigated by controlling the release and dispersion of the sediments suspended in the water column and are described in Section 6.4.3.2.

6.9.3.3 Residual Impacts

No change to impact significance.

6.9.4 Operation

6.9.4.1 Potential Impacts

Mangrove Conversion

The access bridge from the reclaimed area to the mainland is estimated to be 550 m in length and with an approximate width of 80 m, which includes the construction right of way. It is calculated that approximately 0.8 acres of mangrove will be lost due to the bridge footprint. Based on the estimated mangrove density of approximately 1,500 trees/ ha in the area from Tg. Piai to Tg. Bin, this would result in the loss of approximately 490 individual mangrove trees.

Ecologically, the loss of 0.8 acres (~ 450 trees) is considered to be a negative impact (Magnitude -1) as it will only affect approximately 0.04% of the existing mangrove area along the coastline in the region (mangroves from Kukup to Tg. Adang including Sg. Pulai river mouth) and only 0.1% of the Tg. Piai Ramsar area. It is expected that the ecosystem function of the mangrove area will not be affected although minor changes in abundance may be expected.

In terms of the status of the affected area as a Ramsar Site and a National Park, Malaysia's obligations towards the Ramsar Convention on Wetlands is to ensure that the 'ecological character' of the entire Ramsar Site is maintained. According to the Convention, ecological character is defined as 'the combination of the ecosystem components, processes and benefits/service that characterise the wetland at a given point in time.' As described in the paragraph above, removal of 0.04% of the mangrove area is expected not to affect the

ecosystem function of the entire Ramsar Site. Nevertheless, compensatory measures are proposed as described in Section 6.9.4.2 below.

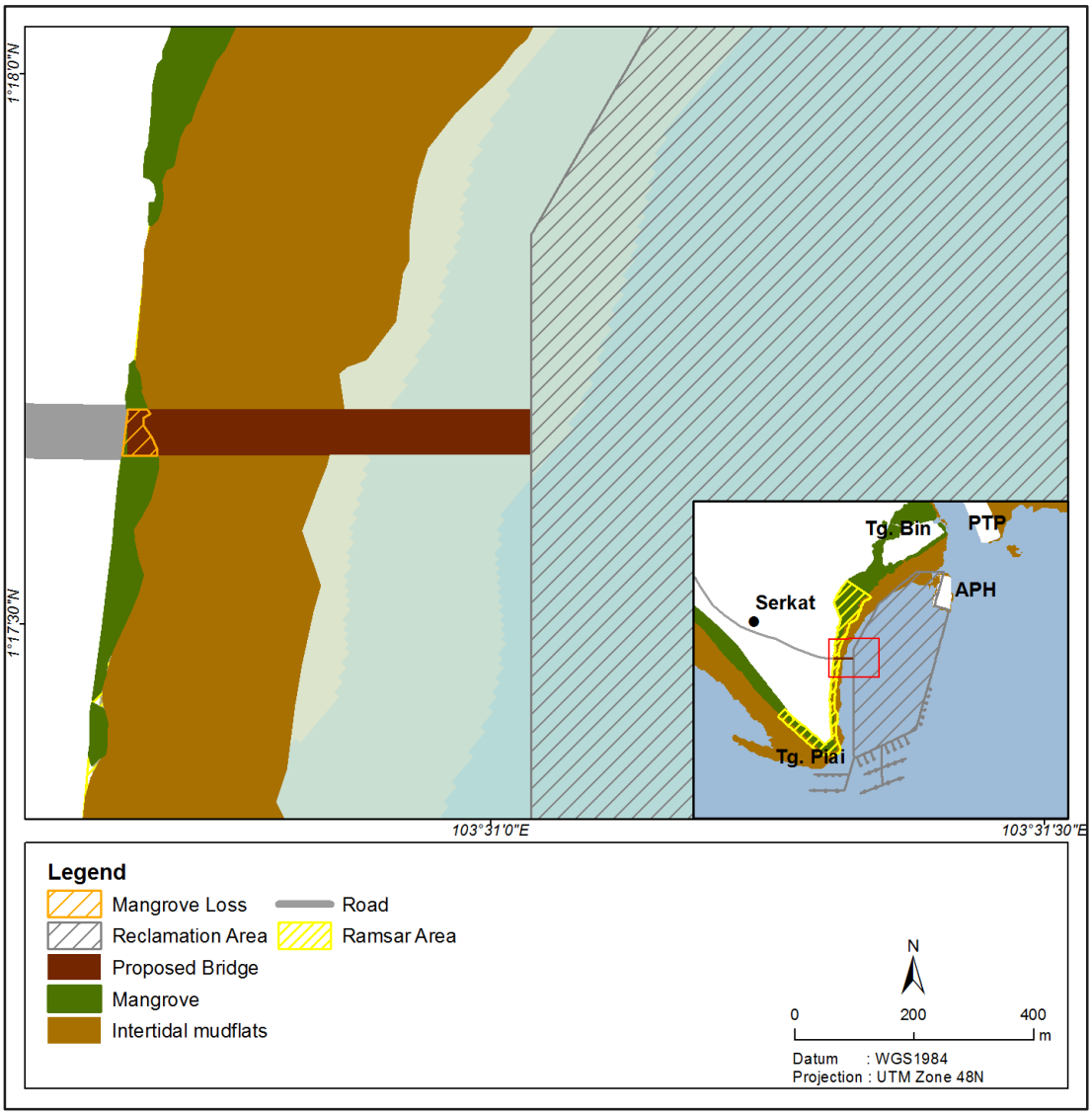

Figure 6.82 Mangrove area loss within bridge footprint

Impact Evaluation

Based on the RIAM analysis, the impact is categorised as a **Moderate Negative**.

Criteria	Score	Description
Importance	4	Important to State/ National interests, given the Ramsar and National Park status.
Magnitude	-1	Negative Change; only
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-cumulative / single.

Criteria	Score	Description
Environmental Score	-32	
Description	**-C**	**Moderate negative impact**

Morphological Impacts

Morphological impacts (erosion and sedimentation) are considered here for the fringing mangroves on the eastern coastline of Tg. Piai only, as no impacts have been predicted to areas beyond this (see Sections 6.2 and 6.3).

As discussed in Section 6.3.4.1 above, the project footprint (reclamation) will provide protection from incoming waves presently contributing to erosion along the eastern coastline of Tg. Piai. It is expected that the coastline will stabilise and a small seaward migration of mangrove fringe will take place after the reclamation is in place.

Conversely, some increases in current flow however are expected along the intertidal area fronting the mangrove. This may potentially affect the mangrove by inducing some erosion on the mudflat.

Overall a conservative valuation would be of a net neutral impact, in the absence of mitigation measures.

Impact Evaluation

Based on the RIAM analysis, the impact is categorised as **No change**.

Criteria	Score	Description
Importance	1	Affects mangrove along east coast Tg. Piai.
Magnitude	0	Net neutral effect
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-cumulative
Environmental Score	0	
Description	**N**	**No change**

Oil Spill

Based on the hydraulic study, accidental oil spills are expected to reach the sensitive habitats which includes the mangroves between Tg. Piai to Tg. Bin, Sg. Pulai estuary, Tg. Piai to Pulau Kukup and Pulau Kukup.

Under the worst case scenario (Scenario D), the most affected area will be the mangroves adjacent to the project between Tg. Piai to Tg. Bin with the time to arrival within 4 hours after the spill event, with oil slick thickness at around 0.1 to 0.5 mm. The oil spill is predicted to reach Sg. Pulai rivermouth within around 2.5 hour, while the time to the mangrove area at Pulau Kukup (Ramsar) is predicted to be around 9 hours, with slicks of up to 1 mm thickness in some areas.

The effect of oil spills in mangroves varies according to the oil composition, relative amounts of oil and dispersants and developmental stage of mangroves. Oil will affect the mangroves through the disruption of gas exchange when aerial roots are coated with oil and can no longer supply oxygen to underground roots in hypoxic soils. Under these circumstances a die off of the mangroves can be expected. Hydrocarbons also can enter mangroves through the root system and be translocated to and accumulate in the leaves. The oil spills also may decrease the survival of mangrove propagules and saplings /17/. These will degrade the distribution of the mangroves at the study area. Recovery of mangroves affected by major oil spills can take many years between 50 to 80 years.

Impact Evaluation
Based on the RIAM analysis, the impact is categorised as **Significant Negative**.

Criteria	Score	Description
Importance	2	Affects mangrove in south western Johor.
Magnitude	-3	Major adverse impact
Permanence	2	Temporary
Reversibility	3	Irreversible
Cumulativity	2	Non-cumulative
Environmental Score	-42	
Description	**-D**	**Significant negative impact**

6.9.4.2 Proposed Mitigation Measures

Mangrove Conversion

The loss of mangrove within the access bridge is a permanent, residual impact. Compensatory mitigation measures are therefore proposed to replace the area of mangrove lost within the Piai Ramsar site itself. The project, through the shelter it affords the Piai coastline, presents a good opportunity for rehabilitation of the mangrove areas that have been lost to erosion over the past several years. The areas currently affected by erosion are shown in Figure 6.83 below. With the protective function of the reclamation, replanting efforts in these areas are likely to be successful. Replanting of mangroves in this sort of situation is a well-established technique and can use naturally occurring mangrove seedlings.

As also shown in Figure 6.83, there are significant areas that have been protected by revetments or seawalls along the shoreline. These structures are not conducive to the establishment of mangroves, and these areas may need rehabilitation to restore the hydrodynamic conditions before mangrove replanting can occur. This would need to be done in consultation with the Department of Irrigation and Drainage.

It is therefore proposed that the Proponent undertake this rehabilitation and replanting works with the target to achieve at least 2.4 acres of healthy mangrove replanted within the Ramsar site. This is based on a rule of thumb of three times the area lost; i.e. 0.8 acres *3 = 2.4 acres.

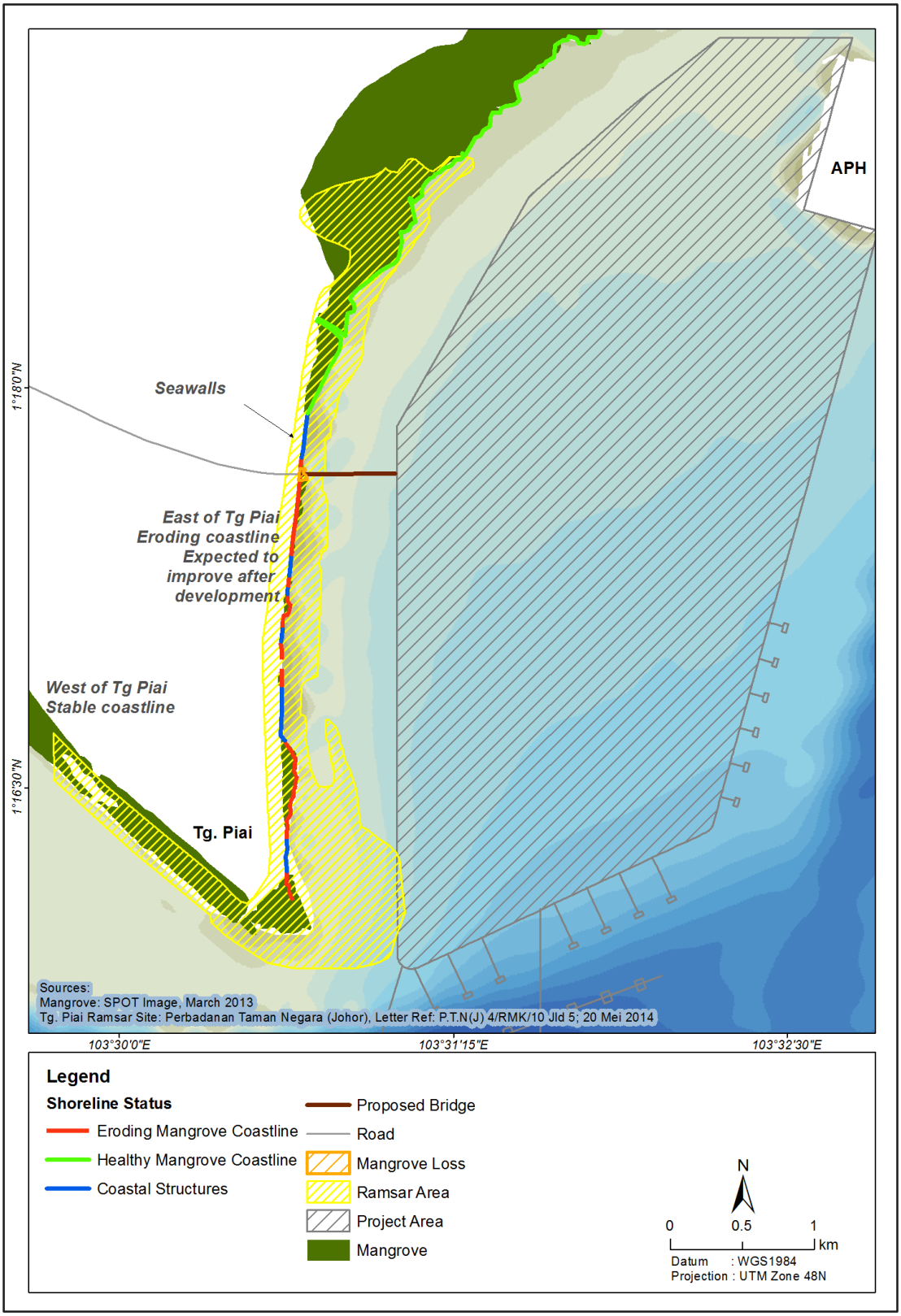

Figure 6.83 Areas to be rehabilitated and replanted – eroding mangroves and seawall areas.

Photo 6.1 Existing coastal protection along the Piai Ramsar site – erosion of mangroves fronting the revetment are evident. Rehabilitation of these areas to restore the original hydrodynamic regime is recommended.

Morphological Impacts

As discussed above, the predicted increase in current speeds along the mangrove frontage may potentially increase scour and cause erosion. Three (3) proposed coastal structures are proposed to mitigate this as presented in Section 6.2.4.2 and this is further expected to mitigate the mangrove erosion problem currently facing the Tg. Piai Ramsar site. These structures are expected to reduce the currents on the inner areas of the mudflats to values similar to or lower than the speeds in the existing condition and therefore no erosion will occur in these areas.

Oil Spill

No mitigation measures specific to the protection of the mangrove are available apart from the measures described in Section 6.4.4.2 above. The recommended response time as stated in this section is less than 60 minutes for oil spill during a tanker collision and less than 30 minutes for a loading arm failure in particular to avoid oil contamination of the mangroves along Tg. Piai and in Sg. Pulai.

6.9.4.3 Residual Impacts

Mangrove Conversion

Assuming that mangrove replanting is successfully carried out at the affected areas, the residual impact is positive as areas currently without mangrove will be replanted.

Impact Evaluation

Based on the RIAM analysis, the impact is categorised as **Moderate Positive**.

Criteria	Score	Description
Importance	4	Important to Malaysia as a whole and cross-border effects to Singapore
Magnitude	1	Improvement in status quo
Permanence	3	Permanent
Reversibility	2	Reversible
Cumulativity	3	Non-cumulative
Environmental Score	32	
Description	**+C**	**Moderate positive impact**

Morphological Impacts

With the reclamation and the coast protection structures recommended, the project will prevent further erosion along the Piai Ramsar site the net residual impact will be positive.

Impact Evaluation

Based on the RIAM analysis, the impact is categorised as **Significant Positive**.

Criteria	Score	Description
Importance	4	Important to Malaysia as a whole and cross-border effects to Singapore (due to Ramsar status)
Magnitude	2	Significant Positive Change
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-cumulative
Environmental Score	+64	

Criteria	Score	Description
Description	**D**	**Significant positive impact**

Oil Spill

With oil spill response equipment in place on site, such that a < 30 minute response time can be achieved to contain the spill before it reaches the Piai Ramsar mangroves, the residual impact is a **Moderate negative** impact. Although no significant oil slick is assumed to reach the mangroves, increased water pollution and minor oil contamination may still be expected.

Impact Evaluation

Based on the RIAM analysis, the impact is categorised as **Moderate Negative**.

Criteria	Score	Description
Importance	4	Important to Malaysia as a whole and cross-border effects to Singapore (due to Ramsar status)
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative/ single
Environmental Score	-24	
Description	**-C**	**Moderate negative impact**

6.10 Avifauna

6.10.1 Evaluation Framework

The impacts to avifauna were assessed based on the disturbance occurred due to the project activities. These activities include the followings:

- Construction
- Reclamation
- Dredging at Phase 2
- Construction of onshore and marine facilities
- Operation
- Daily operations of the terminal

For this purpose, the noise contour modelling is used to assess the impacts to the avifauna during construction and operation. The assessment is then carried out based on existing literature on the subject-matter. Apart from that, the loss of habitat (i.e. mudflat) due to the reclamation footprint is quantified by the findings of the habitat modelling.

6.10.1.1 Avifauna Responses to Construction Disturbance

The impacts of construction disturbance to avifauna were carried out using the scale described by the Institute of Estuarine and Coastal Studies as summarised in Table 6.34.

Table 6.34 Waterbird response to construction disturbance (Source: Institute of Estuarine and Coastal Studies, 2009)

Items	Effect Level			
	1	2	3	4 & 5
Noise level (dBA)	0 – 50	50 – 70	70 – 85	>85
Responses (feeding and foraging)	No effect	Head turning, scanning behaviour, reduced feeding, movement to other areas close by		Maximum response, preparing to fly away and flying away, may leave area altogether
Impact level	Low	• Moderate	Moderate to High	High

6.10.1.2 Scope

As described in Chapter 5, the avifauna was recorded at five (5) areas, namely Kukup-Tg. Piai, Tg. Piai-Tg. Bin, Pulau Kukup, Sg. Pulai and Pulau Merambong. The impact assessment is focused on the avifauna found at these areas. It is beyond the scope of the assessment to assess the impacts of individual avifauna species, but assesses the general possible impacts of the avifauna as a whole based on the scale described in Table 6.34 above. The approach taken in the assessment of impacts to avifauna is precautionary in nature.

6.10.2 Sensitive Receptors

The avifauna found within the area can be categorised based on (a) the habitat it was found as shown in Figure 6.84 and (b) its status. These habitats can be categorised as follows:

- Coastal vegetation (i.e. Pulau Merambong);
- Mangrove forest (i.e. Kukup to Tg. Piai, Tg. Piai to Tg. Bin, Pulau Kukup and Sg. Pulai); and
- Intertidal mudflat (i.e. Kukup to Tg. Piai and Tg. Piai to Tg. Bin).

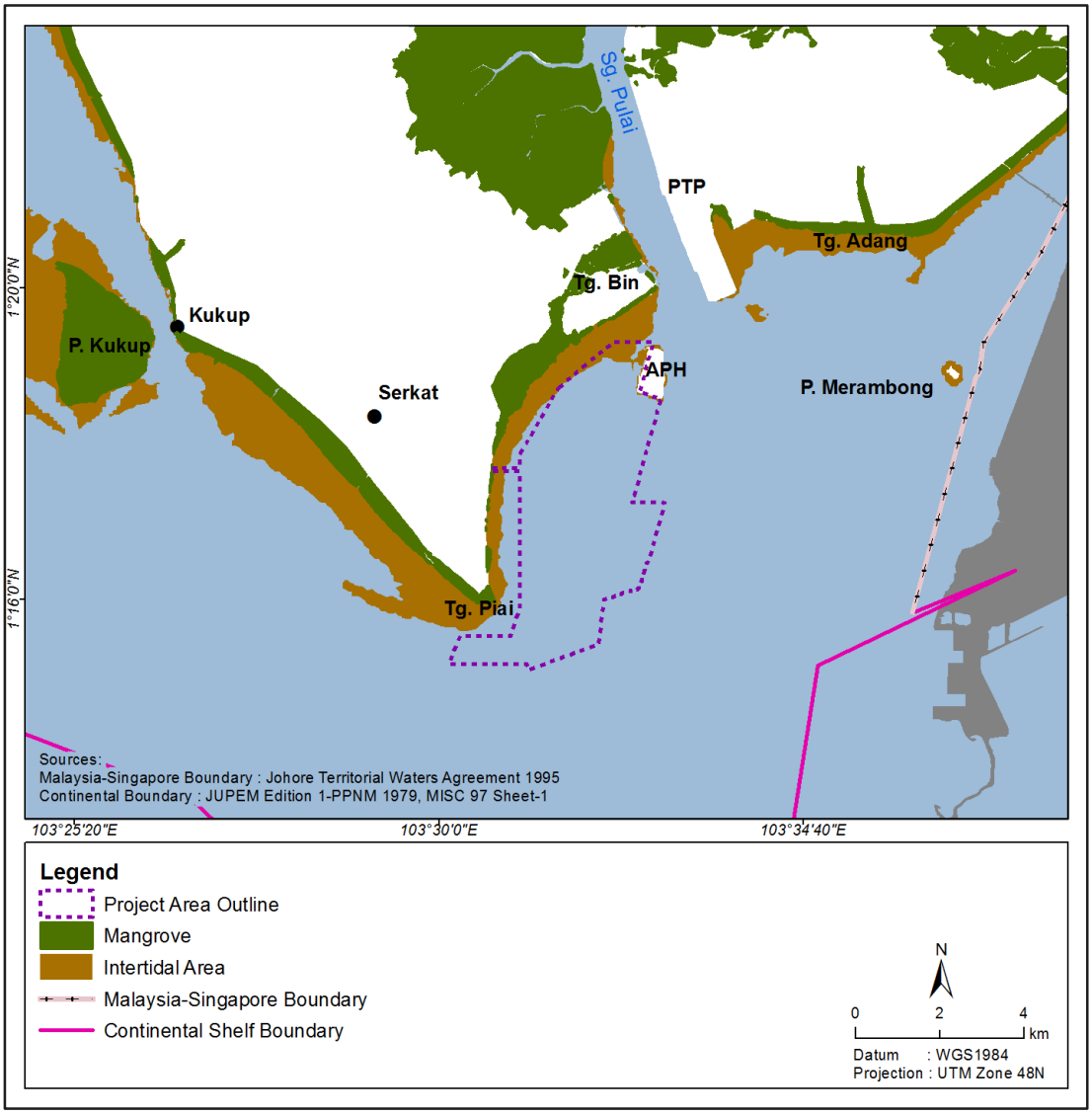

Figure 6.84 Habitats for avifauna found within the project area

As for the status of the bird species, they can be categorised as resident, migrant visitor and introduced found within the habitats as mentioned above.

6.10.3 Construction

6.10.3.1 Potential Impacts

Disturbance in the form of increase noise has been shown to have detrimental effects to the behaviour of the avifaunal community. A study by Francis *et al.* (2009) has found that noise negatively influences bird populations and communities, especially the communities' breeding trend in which some avian communities avoid breeding within noisy habitats /18/.

As mentioned in Section 6.7.3, the increase of noise is predicted to be confined only within the mangrove area along the shoreline between Tg. Piai and Tg. Bin. This increase is expected to be as follows:

- During reclamation: Increase of between 69 and 76 dB(A)
- During dredging at Phase 2: No impact
- During construction of onshore and marine facilities: Between 63 and 125 dB(A)

Using the above prediction, the impacts of the construction activities have been determined based on the impact scale in Table 6.34, as follows:

- During reclamation:
  - Only birds found within the mangrove between Tg. Piai and Tg. Bin (including Tg. Piai Ramsar Site) and the mudflat may become impacted.
  - Moderate impact (Level 2) is predicted.
  - Birds are expected to respond as follows: head turning, scanning behaviour, reduced feeding, movement to other areas close by.

- During dredging at Phase 2:
  - No impact to the avifauna as increase disturbance is expected to be confined within the marine area, where birds are rarely found.
  - During construction of onshore and marine facilitates:
  - Birds found within the mangrove between Tg. Piai and Tg. Bin (including Tg. Piai Ramsar Site) and the mudflat may become impacted.
  - Moderate to High (Level 2 to Level 5).
  - There is possibility that birds will fly away and leave the area completely.

In summary, the avifaunal community within the project area (especially the mangrove fronting the project area) may become disturbed by the project activities, which may then cause them to fly away to other areas completely. On the other hand, as presented in Section 5, both the western coastline of Tg. Piai and the riverine mangroves of Tg. Pulai with their healthy and larger tracts of mangrove, would offer a suitable and nearby alternative habitat.

Impact Evaluation
Based on the RIAM, the impact is considered to be **Moderate Negative**.

Criteria	Score	Description
Importance	2	Important to south western Johor
Magnitude	-2	Significant change (moderate to high impact levels)
Permanence	2	Temporary; higher impact levels are limited to Phase 2 dredging
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative
Environmental Score	-24	
Description	**-C**	**Moderate negative impact**

6.10.3.2 Proposed Mitigation Measures

The following mitigation measures are proposed:

- Construction noise levels should be restricted to below 70 dBA along the shoreline as the avifaunal community may be able to endure regular noise below this level. Where possible, sudden irregular noise above 50 dBA should be avoided as this may cause disturbance to the birds community
- Construction activities (i.e. construction of onshore and marine facilities) should only be allowed during the day. This is to ensure that resident bird species are not disturbed all the time.

- Whenever possible, noise emission activities during the construction of the onshore facilities (e.g. piling) should be carried out during the non-migratory season to ensure that migratory birds (that forage on the mudflat) are less disturbed.
- The mangrove between Tg. Piai and Tg. Bin beyond the project footprint must not be disturbed or removed during the construction stage.
- Avifauna monitoring is proposed to be carried out on a quarterly basis throughout the construction phase. The frequency is increased to monthly during the migratory seasons.

6.10.3.3 Residual Impacts

Although all the mitigation measures are implemented, some residual impacts may still persist. The resident birds inhabiting within the mangrove between Tg. Piai and Tg. Bin will be the key receptors especially during the construction of onshore and marine facilities.

Impact Evaluation
Based on the RIAM, the impact is considered to be **Minor Negative**.

Criteria	Score	Description
Importance	2	Important to south-western Johor
Magnitude	-1	Negative change (stress/ behavioural change)
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative
Environmental Score	-12	
Description	**-B**	**Minor negative impact**

6.10.4 Operation

6.10.4.1 Potential Impacts

Increased Disturbance

With the project adjacent to the mangrove and associated mudflats, disturbance to the birds utilising these habitats may occur in the form of noise and lighting emanating from the terminal.

Lighting associated with the project has the potential to affect some seabirds, whereby behavioural responses to light can alter foraging and breeding activity. It is likely that the impact will be behavioural in terms of foraging and competitive success. This is likely to result in slight impacts as this is limited to nightime.

During operations, noise from the daily operations (assuming it will be in operation 24 hours a day) of the project may disturb the resident bird species along the Tg. Piai to Tg. Bin area. During migratory season, migratory bird species may also be affected. From the noise modelling results (Section 6.7), it was found that along the shoreline, receptors may be exposed to approximately 25 dBA of noise during operations. Based on the scale in Table 6.34, this exposure is considered to be Effect Level 1, meaning that:

- There will be no effect on the feeding and foraging responses of these birds; and

- The impact level is low.

The disturbance from the project operational activities may result in birds changing their preferences for foraging sites to the adjacent unaffected habitats such as the mudflat and mangrove of Pulau Kukup, between Kukup and Tg. Piai, Sg. Pulai and Pulau Merambong since these areas will not be affected by the project. These areas may provide permanent shelters and feeding ground for the displaced birds since the distance to these areas is within the flight distance for most bird species.

Impact Evaluation
According the RIAM, the impact is considered to be **Minor Negative**.

Criteria	Score	Description
Importance	2	Important to southwestern Johor
Magnitude	-1	Negative impact
Permanence	3	Permanent
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative
Environmental Score	-14	
Description	**-B**	**Minor negative impact**

Loss to Habitat

The area that will mostly be impacted is the area from Tg. Piai to Tg. Bin. Within this area, bird species and their distribution may become affected once the reclamation is completed. It is however noted that the area of intertidal mudflat that is utilised by waders lost to the reclamation is limited to an area of 72.61 ha in the northern part of the site and in most cases the reclamation boundary is a minimum of 500 m from the mangrove fringe. This constitutes 2% loss from the total intertidal mudflat.

Changes to the dynamics of the mangrove areas can affect mangrove-dependent bird species. There is an unavoidable loss of a small portion of mangrove associated with the access bridge. However, the project is also expected to positively affect the mangrove fringe in this area due to the protection the reclamation footprint offers from ship wake and other wave patterns which have contributed to the erosion currently seen at the site.

In addition, the number of species recorded within the Tg. Piai to Tg. Bin area is relatively low compared to other areas in the vicinity in particular the west coast of Piai and Sg. Pulai, and all species were also found in other areas studied. This indicates that the other areas (i.e. Pulau Kukup, Kukup to Tg. Piai, Sg. Pulai and Pulau Merambong) can provide adequate resources for the survival of bird such as nesting areas, shelter and food.

It is also noted that the predicted impacts to overall benthic biomass (food source for many of the birds) remains neutral (i.e. no change) following the reclamation (see Section 6.11).

The avifauna species of high concern is the Lesser Adjutant. It was once found throughout the west coast mangrove areas of Peninsular Malaysia but, due to habitat loss and alteration and human disturbances, this species is now mainly restricted to some isolated areas of Peninsular Malaysia. According to the previous reports, Lesser Adjutant is mostly recorded in mangrove areas of Pulau Kukup, Kukup to Tg. Piai, Tg. Piai to Tg. Bin, and Sg. Pulai. However, the present avifauna surveys found that this species was recorded in small

numbers in the Tg. Piai to Tg. Bin mudflats and mangroves whereas and high numbers were recorded from Pulau Kukup and Pulau Kukup to Tg. Piai areas. The Lesser Adjutant is a species with the ability to fly within a range of 100 km to forage. The Lesser Adjutant has been previously observed to travel from the mangrove areas of Kuala Gula, Perak to coastal areas of Penang to forage. It is predicted that the Lesser Adjutant found at the Pulau Kukup Ramsar site is also able to travel within 100 km to the other mangrove areas to forage.

Impact Evaluation
According the RIAM, the impact is considered to be **Moderate Negative**.

Criteria	Score	Description
Importance	4	Important to Malaysia as a whole and cross-border effects to Singapore
Magnitude	-1	Negative change
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-cumulative/ single
Environmental Score	-32	
Description	**-C**	**Moderate negative impact**

6.10.4.2 Proposed Mitigation Measures

Disturbance
To minimise general disturbance, lighting and noise impacts:

- A belt of vegetation will be planted along the western boundary of the reclamation site to screen noise and lighting.
- Use lighting equipment that minimises the upward spread of light near to and above the horizontal, in particular along the western perimeter of the project site.
- Lighting along the perimeter of the project should be directed toward the project and away from the shoreline.

Loss of Habitat
The impacts to avifauna are related to the project footprint itself, and mitigation measures such as an adequate buffer zone to avoid impacts to the intertidal mudflats have already been taken into account in the project design. Hence additional mitigation measures are limited and include:

- Rehabilitation of mangrove areas as described in Section 6.9 (Mangrove).
- Birds found within the project area are not to be disturbed especially during migratory seasons

6.10.4.3 Residual Impacts

Disturbance
No change in impact significance

Loss of Habitat
No change in impacts significance.

6.11 Macrobenthos

6.11.1 Evaluation Framework

Sediment communities have been found to play a critical role in the food chain for the marine organism /19/. Benthic macrofauna are also one of the most important food sources for marine demersal fish /20, 21/. Thus, the loss of macrobenthic fauna at and adjacent to the site would clearly impact on fish fauna currently found there. Sediment communities relate closely with primary and secondary productivity along the entire coastline. Therefore, directs effects of constructions works on these organisms and disturbance to the seabed communities can also deleteriously affect organisms on higher trophic levels in adjacent area by depriving them of food.

The following thresholds have been used:

- TSS (primarily affecting filter feeders) – 25 mg/l
- Sedimentation - The sensitivity of benthic invertebrates to burial from siltation is species specific. Mobile species of polychaetes, bivalves, gastropods and crustaceans were able to migrate between 2 – 26 cm during eight days after an acute burial by 32 cm of sand /22/. Mortality of most species was low in sand and high in silt.
- Temperature – Malaysian Marine Water Quality Standard of < 2° change from ambient

6.11.1.1 Scope

The following impacts have been addressed for macrobenthic impacts:

- Sedimentation during dredging and reclamation (Construction)
- Permanent loss of benthic habitat due to project footprint (Operations)
- Impacts due to long term changes in hydrodynamics (Operations)
- Impacts due to change in Tg. Bin Power station thermal plume patterns (Operations)
- Impacts due to changes in flushing and salinity (Operations)

6.11.2 Sensitive Receptors

The soft bottom benthic community is distributed throughout the study area; intertidal and shallow subtidal zones are directly impacted by the project footprint. Eight (8) major macrobenthos phyla were recorded at the study area i.e. Annelida, Arthropoda (Crustacea), Mollusca, Echinodermata, Chordata, Sipunculida, Cnidaria and Platyhelminthes. The dominant phylum was Annelida. Species diversity was high at most of the sampling stations.

Benthic biomass showed a positive correlation with sand content, and the inverse for current speeds. The project area is one of moderate zoobenthic biomass. The area with the highest biomass was to the north east of the Project site off PTP/ Tg. Adang.

6.11.3 Construction

6.11.3.1 Potential Impacts

Suspended Sediment

Crustaceans such as shrimps and molluscs (gastropod and bivalves), which have limited mobility and are largely dependent upon food and shelter on the foreshore area can be seriously affected due to reclamation, dredging and pilling activities. This in turn, would reduce the abundance of these organisms. A study by Ingle (1952) /23/ reported that high levels of suspended sediments have been shown to kill bivalves. Other impacts arise from the disturbance of seabed are destruction of spawning areas and smothering or suffocation of sessile organisms in the area /24/.

The predicted sediment plume excursion has been presented in Section 6.4.3 above. Concentrations above 25 mg/l for more than 5 % of the time is expected to be confined to within the working area for Phases 1 and 3. During Phase 2 which involves both dredging and reclamation, the zone of impact extends beyond the project boundaries to a very limited extent.

Impact Evaluation
The impact is **Slight Negative** as it is localised, temporary and reversible.

Criteria	Score	Description
Importance	1	Important to Tg. Piai
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

Sedimentation

The macrobenthic fauna can be affected by the siltation of the suspended sediments generated during the dredging and reclamation works. The sensitivity of benthic invertebrates to burial from siltation is species specific. Mobile species such as polychaetes, bivalves, gastropods and crustaceans have been shown to migrate between 2 cm (20 mm) and 26 cm (260 mm) during 8 days after burial by 32 cm (320 mm) of sand /25/.

As discussed in Section 6.3.3.1 above, the predicted net sedimentation rates over 28 days for numerical modelling was well below recorded tolerance limits for most macro invertebrates, with the maximum net sedimentation of more than 1.75 cm (17.5 mm) occurring over 28 days. This sedimentation rate is only confined within the reclamation areas. Depending on phase and monsoonal season, the sedimentation rate at the intertidal mudflat area fronting the project area is between 1 mm (0.1 cm) and 7 mm (0.7 cm).

It has been shown that the macrobenthic communities can survive a burial of 32 cm (320 mm) of sand; thus no potential mortality band is predicted within the intertidal mudflat fronting the project area.

Impact Evaluation
Based on the RIAM, the impact is considered to be **No Change**.

Criteria	Score	Description
Importance	1	Important to Tg. Piai
Magnitude	0	No change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative/ single
Environmental Score	0	
Description	**N**	**No change**

Temporary Habitat Loss

Approximately 143 ha of subtidal benthic habitat will be affected by the capital dredging along the berths on the eastern side of the project. The macrobenthic fauna can be affected by the dredging operations through direct removal of the habitat and associated benthos, as well as potential changes in the bottom conditions after the cessation of dredging. However, in general, effects of the dredging are not expected to be permanent as benthic communities will be able to recolonise the area once the dredging is complete /22/. The site is presently dominated by polychaetes, which are opportunistic species that have been found to account for a large part of the increase in macrobenthic abundance following dredging.

Impact Evaluation
The loss of macrobenthic organisms due to dredging is considered a **Minor Negative** impact.

Criteria	Score	Description
Importance	1	Important to Tg. Piai
Magnitude	-2	Significant impact (removal of benthic organisms)
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative/ single
Environmental Score	-12	
Description	**-B**	**Minor negative impact**

6.11.3.2 Proposed Mitigation Measures

No mitigation measures specific to macrobenthos habitats are available, however measures to control suspended sediments as outlined in Section 6.4 (water quality) will also serve to reduce impacts to the macrobenthos from sedimentation during construction.

6.11.3.3 Residual Impacts

Suspended Sediments
No change in impact significance.

Sedimentation
No change in impact significance.

Temporary Habitat Loss
No change in impact significance.

6.11.4 Operation

6.11.4.1 Potential Impacts

Habitat Loss and Modification
The nature of reclamation is such that it will lead to an irreversible change in the area to be developed. The original physical, biological resources and productivity within the project footprint will be lost permanently. In addition, the reclamation footprint may also induce changes in current speeds, sedimentation etc. that may further impact the benthic habitats.

The total loss of intertidal benthic habitat to the reclamation footprint (reclaimed area layout + 50 m buffer) is 73 ha. This represents approximately only 2% of the intertidal areas (from shoreline to 0 m CD) determined within the study area which includes the mudflats around Pulau Kukup, Pulau Merambong, mudflats along the shoreline from Kukup to Tg. Bin, mudflats within Sg. Pulai and at Tg. Adang (Figure 6.85). In addition, 1,343 ha of subtidal mudflat area will also be lost permanently to the reclamation footprint, which represents approximately 13% of the subtidal area within the study area.

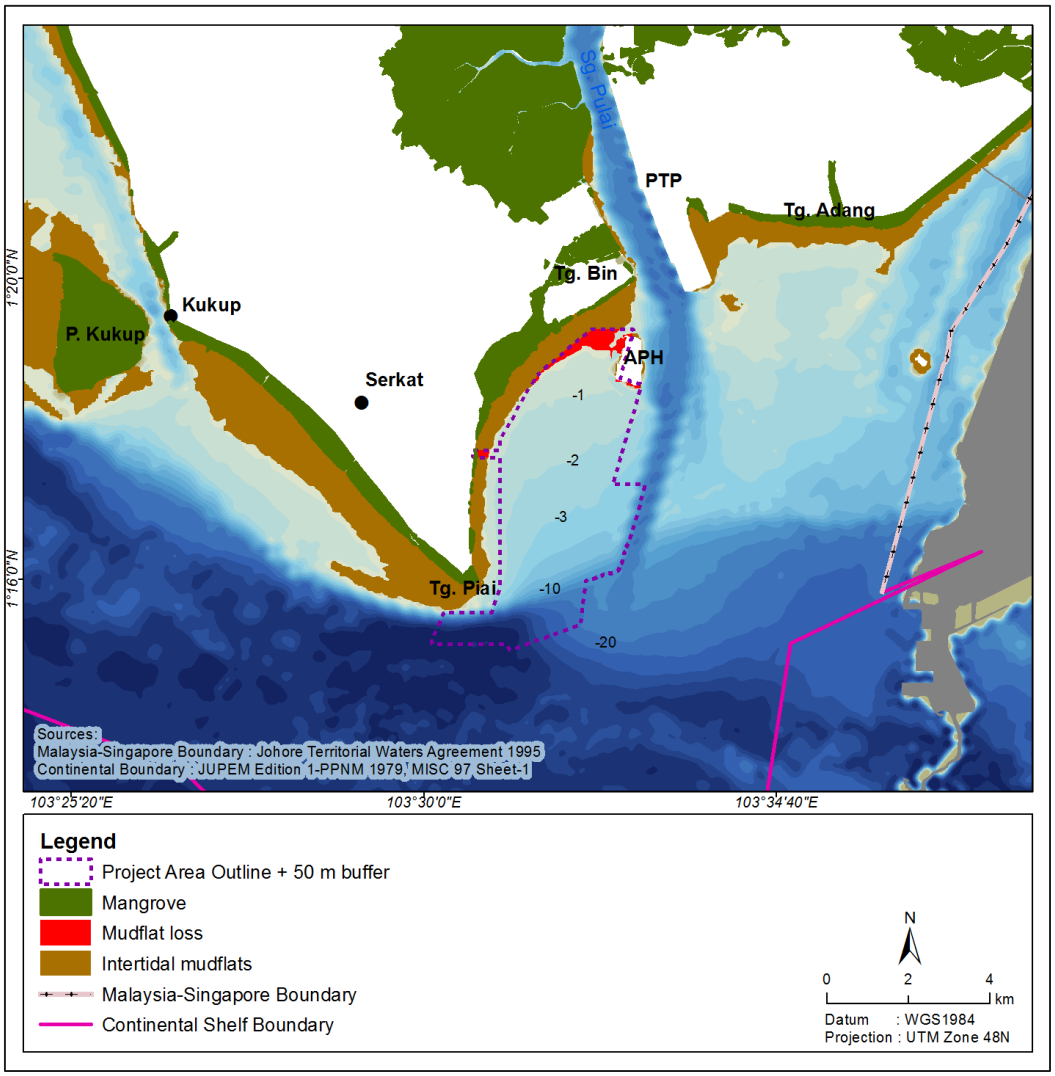

Figure 6.85 Location of intertidal mudflat loss.

In order to assess the impact of the reclamation on the macrobenthos, habitat modelling has been carried out (see Appendix H). The habitat model predictions were used to both map changes in the distribution of benthic biomass and bivalve density for the different project phases and quantify the overall changes in the total biomass and bivalve density for the entire model area, including the project footprint.

Benthic Biomass

As presented in Section 5, the key drivers of benthic biomass were determined to be current speeds and sediment texture, where benthic biomass increased with sand content, but decreased with current speeds. The habitat models have taken into account the predicted changes in the hydraulic variables presented in Section 6.2 (Coastal Hydraulics) to predict the benthic biomass response based on these drivers.

The results for benthic biomass are presented in Figure 6.86 to Figure 6.8 for the Southwest monsoon period. The modelling did not show any significant differences between the seasons, however the results for the Northeast monsoon and Intermonsoon periods can be referred to in Appendix H.

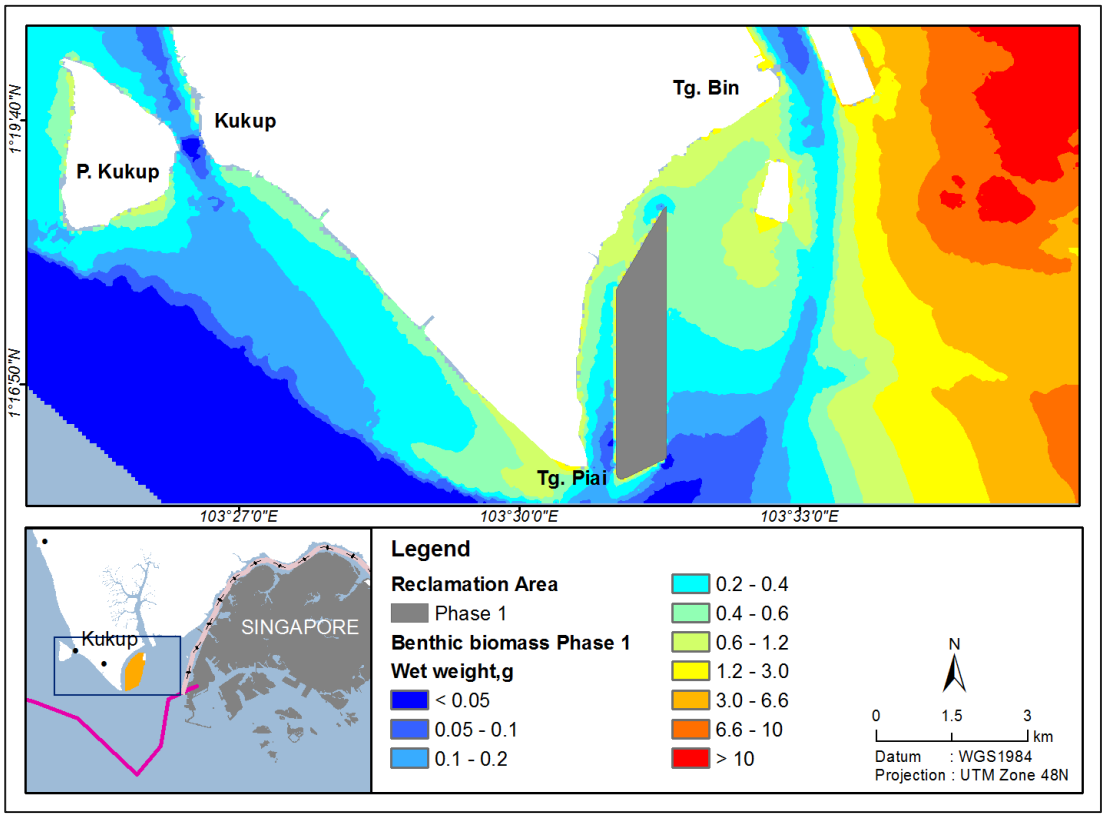

Figure 6.86 Predicted macrobenthos biomass – Phase 1, Southwest Monsoon.

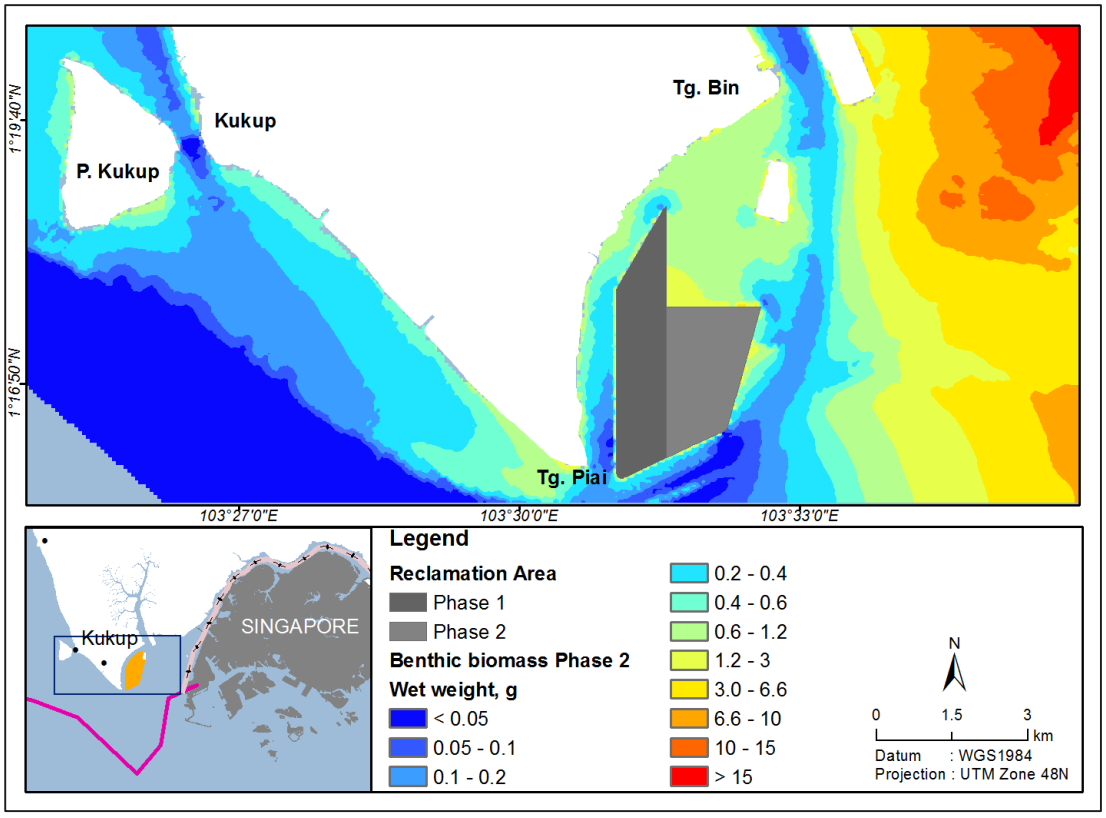

Figure 6.87 Predicted macrobenthos biomass – Phase 2, Southwest Monsoon.

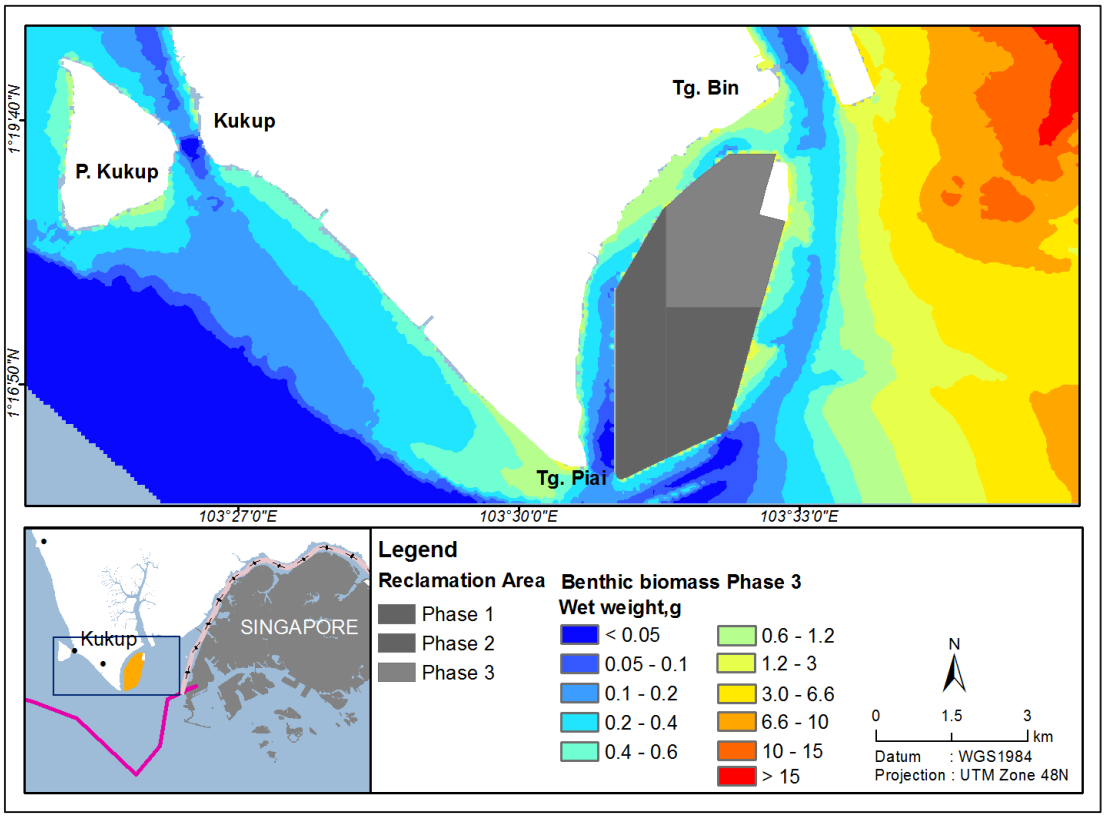

Figure 6.88 Predicted macrobenthos biomass – Phase 3, Southwest Monsoon.

The quantification of the changes in total predicted biomass of zoobenthos showed that in spite of the reduction in habitat area, the total benthic biomass in the area does not reduce as a whole (Table 6.35). The reduction in the area of available benthos habitat amounts to 2.6% during Phase 1, to 5.5% during 5.5% and to 9.8% with the full extent of the project.

Predicted zoobenthos biomass changes amount to a slight reduction (less than 1%) during Phase 1 and Phase 2 (NE monsoon), and following the full extent of the project the total biomass is **slightly increased** (0.56%-0.7%). The interpretation of the almost negligible impact on predicted total zoobenthos biomass is that the biomass is positively correlated to current velocities, and hence the loss the habitat due to footprint of the project may be compensated by the new habitats of lower current velocities created in the proximity to the terminal.

Table 6.35 Changes in predicted total biomass of zoobenthos (wet weight) during the different project phases and monsoon seasons.

Monsoon	Phase	Area of habitat (km^2)	Mean biomass (g) /m^2	Total biomass tons	Change in area of habitat %	Change in biomass %
NE Monsoon	Baseline	144.7	66.7	9660.7		
SW Monsoon	Baseline	144.7	60.4	8736.8		
Inter Monsoon	Baseline	144.7	75.9	10986.5		
NE Monsoon	Phase 1	141.0	68.5	9649.2	-2.6	-0.12
SW Monsoon	Phase 1	141.0	61.9	8723.1	-2.6	-0.16
Inter Monsoon	Phase 1	141.0	77.9	10978.4	-2.6	-0.07

Monsoon	Phase	Area of habitat (km^2)	Mean biomass (g) /m^2	Total biomass tons	Change in area of habitat %	Change in biomass %
NE Monsoon	Phase 2	136.7	70.3	9606.8	-5.5	-0.56
SW Monsoon	Phase 2	136.7	63.5	8675.7	-5.5	+0.16
Inter Monsoon	Phase 2	136.7	79.9	10924.2	-5.5	+0.07
NE Monsoon	Total project	130.6	72.3	9438.3	-9.8	+0.56
SW Monsoon	Total project	130.6	65.2	8514.3	-9.8	+0.70
Inter Monsoon	Total project	130.6	82.2	10740.3	-9.8	+0.57

Bivalve Density

Bivalve density patterns show similar gradients as for total biomass, with the density of bivalves increasing with percentage sand, but decreasing with current speeds.

The predicted change in densities due to the project development are shown for the Southwest monsoon period in Figure 6.89 to Figure 6.91.

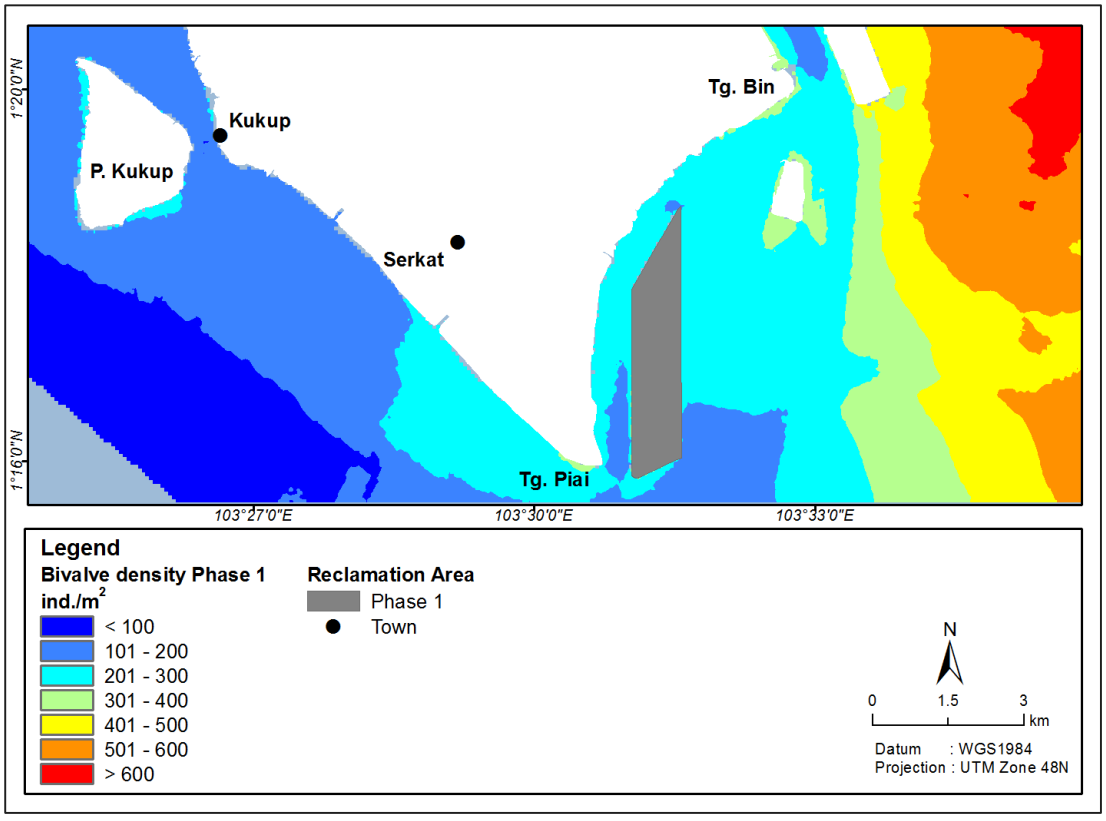

Figure 6.89 Predicted bivalve density – Phase 1, Southwest Monsoon.

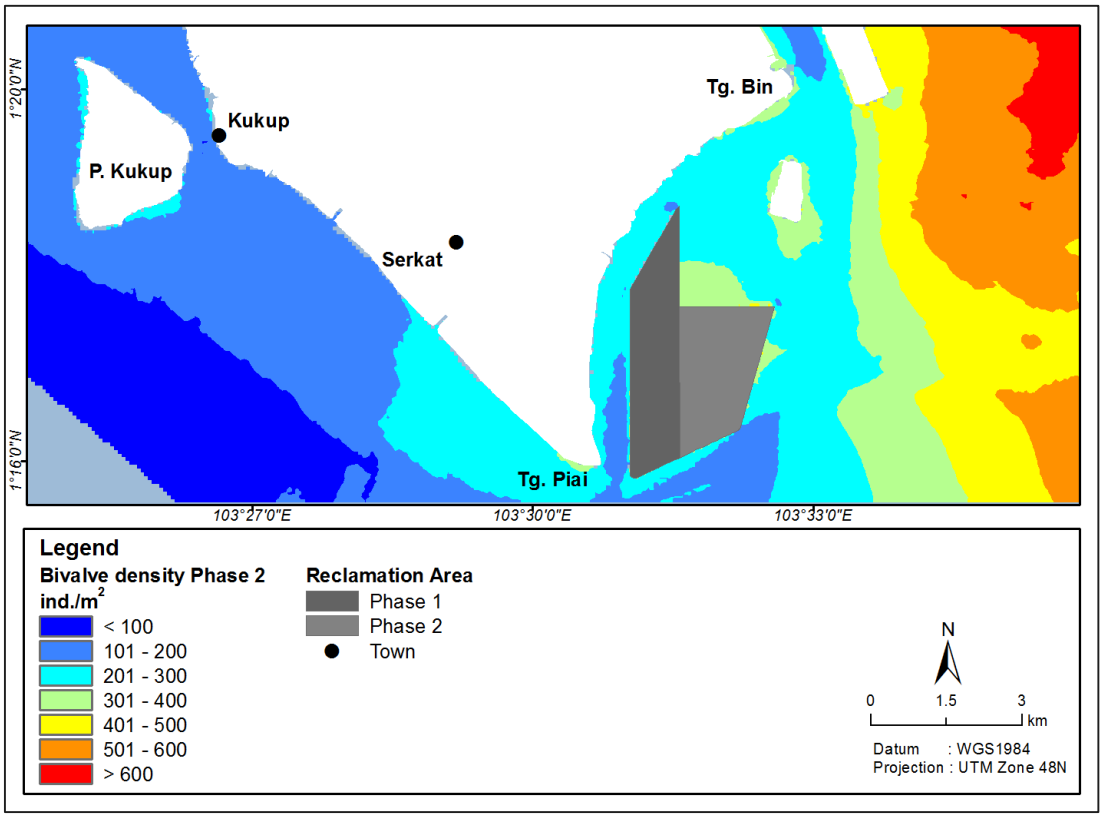

Figure 6.90 Predicted bivalve density – Phase 1, Southwest Monsoon.

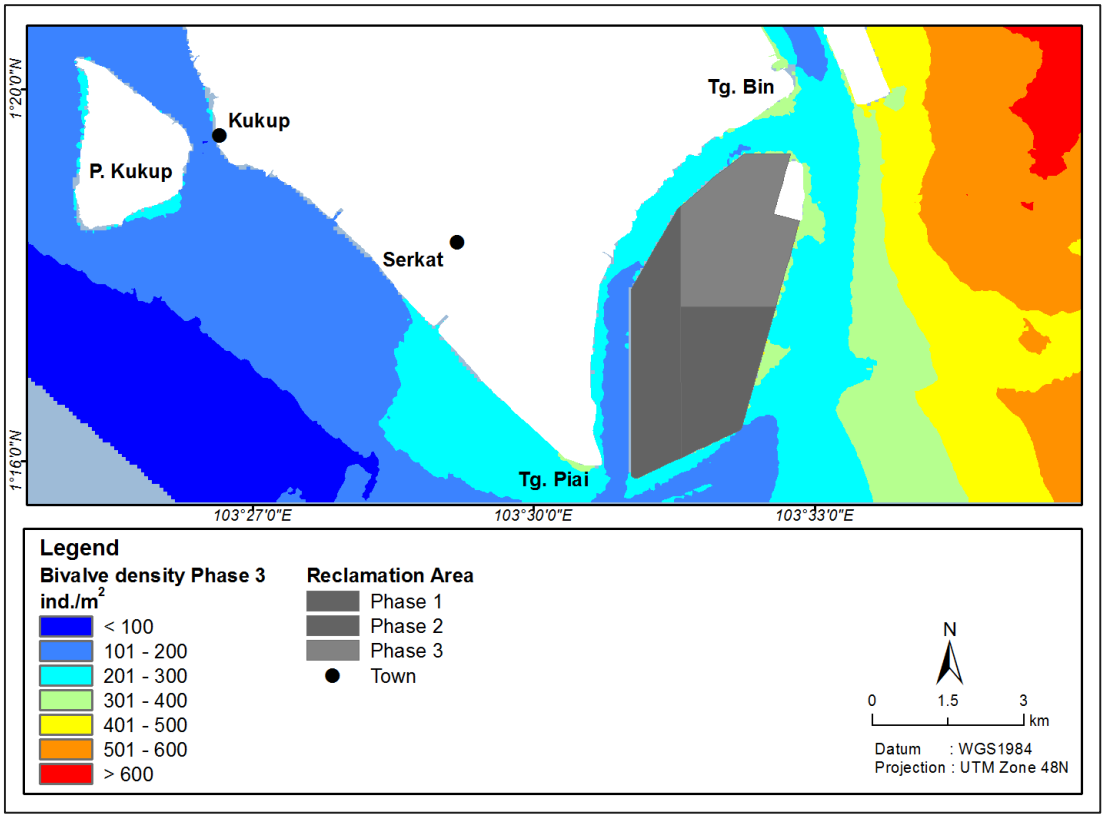

Figure 6.91 Predicted bivalve density – Phase 1, Southwest Monsoon.

The quantification of the changes in predicted abundance of bivalves showed that the impact of the project on bivalve abundance may be larger than on overall benthic biomass. The

reduction of total predicted number of bivalves amounts to just under 2 % during Phase 1, to around 2.5 % during Phase 2 and around 4.5 to 4.6 % with the full extent of the project (Table 6.36).

Table 6.36 Changes in predicted total density of bivalves during the different project phases and monsoon seasons.

Monsoon	Phase	Area of habitat (km^2)	Mean individuals /m^2	Total individuals	Change in area of habitat %	Change in individuals %
NE Monsoon	Baseline	144.7	285.29	4.13E+10		
SW Monsoon	Baseline	144.7	277.74	4.02E+10		
Inter Monsoon	Baseline	144.7	294.84	4.27E+10		
NE Monsoon	Phase 1	141.0	287.36	4.05E+10	-2.6	-1.89
SW Monsoon	Phase 1	141.0	279.85	3.94E+10	-2.6	-1.86
Inter Monsoon	Phase 1	141.0	297.00	4.19E+10	-2.6	-1.89
NE Monsoon	Phase 2	136.7	289.03	3.95E+10	-5.5	-2.44
SW Monsoon	Phase 2	136.7	281.54	3.85E+10	-5.5	-2.42
Inter Monsoon	Phase 2	136.7	298.68	4.08E+10	-5.5	-2.46
NE Monsoon	Total project	130.6	288.86	3.77E+10	-9.8	-4.54
SW Monsoon	Total project	130.6	281.29	3.67E+10	-9.8	-4.57
Inter Monsoon	Total project	130.6	298.68	3.90E+10	-9.8	-4.48

Impact Evaluation
Based on the RIAM, the impact is categorised as **Minor Negative Impact**.

Criteria	Score	Description
Importance	2	Important to areas immediately outside the local condition due to habitat and food web connectivity
Magnitude	-1	Negative impact; ~ 10 % of habitat removed; changes in biomass / abundance are also < 5 % change.
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-Cumulative
Environmental Score	-16	
Description	**-B**	**Minor Negative Impact**

Thermal Plume Impacts

The reclamation activities are also expected to change the dispersion patterns of the thermal discharges from the Tg. Bin Coal-Fired Power Plant's cooling water outfall, especially during the Phase 3 of the reclamation works. Where benthic fauna are concerned, several studies have indicated that temperature levels 2°C above ambient can cause sub-lethal effects and some mortality to the benthic communities, while 4 to 6°C above ambient cause severe damage or total destruction of natural communities /26, 27, 28/. Odum and Johannes (1975) reported that the upper limits of temperature tolerance for benthic organisms such as barnacles were at 37°C, tree oysters at 36.5°C, sponges at 36°C and tunicates, bryozoans, polychaetes and mangrove oysters at 34.5°C /29/.

Predicted thermal plume impacts on the intertidal areas where these effects would be most likely felt are a maximum increase in mean temperature of 0.5 °C and hence no significant impact to the zoobenthos is predicted.

Impact Evaluation

Based on the RIAM, the impact is considered to be **No Change**.

Criteria	Score	Description
Importance	1	Important to Tg. Piai
Magnitude	0	No change
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	2	Non-cumulative
Environmental Score	0	
Description	**N**	**No change**

Salinity

Where benthos is concerned, most species are adversely affected by salinity fluctuations. Several studies found that the growth and development of the terebelid polychaetes, sipunculids /30/, marine polychaetes (*Arenicola cristata*), gastropods (*Ilyanassa obsolata*) /31/, soft clam (*Mulinia lateralis*), amphipod (*Ampelisca abdita*) /32/, hard clam (*Mercenaria mercenaria*) /33/, grapsid /34/ and xanthid crabs /35/ are impacted by periodic reductions in ambient salinity. According to Zweig *et al*. (1999), the recommended safe limits for marine organisms ranged from 10 to 35 psu /36/.

However, the salinity modelling has not shown any significant difference between the baseline and reclamation (for any phase), with levels ranging from 28 to >30 psu. Overall the simulated changes in the salinity were less than 0.2 psu which are well within natural variability.

Impact Evaluation

The effect of changes is salinity will cause **No Change** to the macrobenthic communities.

Criteria	Score	Description
Importance	2	Important to project area and areas immediately beyond.

Criteria	Score	Description
Magnitude	0	No change
Permanence	0	No change
Reversibility	0	No change
Cumulativity	0	No change
Environmental Score	0	
Description	**N**	**No change**

Oil Spill

There is a potential of oil spills from leaking storage terminal. Oil pollution may also occur through leaks from shore facilities for the supply of fuel and fuel oils to vessels calling at the jetty, bilge water from these vessels, used engine oil dumped overboard and accidental oil and chemical spills. It is known that benthic communities are sensitive to oil spills.

Oil spills potentially affect benthic communities in many ways, for example through modification of habitat characteristics, suffocation and/or poisoning of flora and fauna, and removal of the key habitat forming species that may indirectly affect other components of benthic life /37/.

As discussed in Section 6.4, under the worst case scenario (Scenario D), the most affected area will be the mangroves adjacent to the project between Tg. Piai to Tg. Bin with the time to arrival within 4 hours after the spill event, with oil slick thickness at around 0.1 to 0.5 mm. The oil spill is predicted to reach Sg. Pulai rivermouth within around 2.5 hour, and the mudflats around Tg. Adang in around 14 hours. Towards the west coast of Piai, the time to the mangrove area at Pulau Kukup (Ramsar) is predicted to be around 9 hours, with slicks of up to 1 mm thickness in some areas– see Figure 6.66 and Figure 6.67.

Impact Evaluation

Based on the RIAM, the impact is categorised as **Significant Negative**.

Criteria	Score	Description
Importance	3	Important to Johor and Peninsular Malaysia
Magnitude	-3	Major negative change - widespread mortalities would be expected without control of oil spill
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-63	
Description	**-D**	**Significant negative impact**

6.11.4.2 Proposed Mitigation Measures

Habitat Loss

No mitigation measures specific to macrobenthos are proposed; mitigation measures to preserve the mudflat areas along the shoreline have already been outlined in Section 6.2.4.2 above.

Thermal Plume Impacts

Proposed mitigation measures for thermal plume are to develop Phase 3 of this project only after PTP Phase 3 expansion has been constructed as described in Section 6.4.4.2.

Salinity

No mitigation measures required.

Oil Spill

No mitigation measures specific to macrobenthos are proposed, however adherence to the oil spill emergency response plan should be adhered to minimize its damage on the marine environment as a whole as mentioned in Section 6.4.4.2 (Water Quality Mitigation Measures)

6.11.4.3 Residual Impacts

Habitat Loss

No change in impact significance.

Thermal Plume Impacts

No change in impact significance.

Salinity

No change in impact significance.

Oil Spill

Assuming the mitigation measures proposed are able to prevent the spill from spreading and in particular reaching the intertidal mudflat areas, the residual impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Oil dispersion will be contained within the Project site.
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

6.12 Plankton

6.12.1 Evaluation Framework

Impacts to plankton communities are assessed for both the construction and operations stage. The potential issues addressed in this section include:

- TSS (turbidity) during construction
- Thermal plume impacts (operations)
- Oil spill (operations).

6.12.2 Sensitive Receptors

Three (3) major phyla of phytoplankton were recorded, i.e., Bacillariophyta, Dinoflagellata and Cyanophyta. The most dominant phylum was Bacillariophyta, which constituted more than 98% of the total phytoplankton density. Meanwhile, for zooplankton, eight (8) phyla were recorded, i.e., Arthropoda (Crustacea), Mollusca, Annelida, Chordata, Chaetognatha, Ciliophora, Cnidaria and Echinodermata. The most dominant phylum was Arthropoda, which contributed 95% of the total zooplankton density. Shannon-Weiner diversity index shows that most of the stations were found to be moderately diverse.

6.12.3 Construction

6.12.3.1 Potential Impacts

Sediment Plume

Turbidity is a major factor mediating bacterial and primary productivity in marine waters /38/. The increased load of suspended solids would reduce light penetration and thus reduce the depth of photosynthetic activity by phytoplankton. In addition, high sediment loads can cause water temperatures to increase due to greater heat absorption, in turn, reducing dissolved oxygen concentrations.

Similarly to fish, the turbidity may also reduce the hunting success of zooplankton. On the other hand, the turbidity associated with the reclamation activity may cause temporary increases in the level of organic matter and nutrients available, which may increase productivity outside the plume areas to some extent.

Based on the hydraulic study, the maximum suspended sediment concentrations within the vicinity of the reclamation area are significantly high, in particular during the dredging works (Phase 2),with maximum TSS levels of 75 - >250 mg/L in the vicinity of the Project site whereas the recommended safe limit for aquatic organisms is <80 mg/L /39/.

However, the duration of the spikes in SS concentrations are very short; when considering the time in exceedence of 50 mg/l, the impacts are localised to within the project site only (see Figure 6.46, Figure 6.51 and Figure 6.56 in Section 6.4 (Water quality) above).

Hence the impact to phyto- and zooplankton communities due to the suspended sediment plumes is expected to be low.

Impact Evaluation
According to the RIAM, the impact is categorised as **Minor Negative**.

Criteria	Score	Description
Importance	2	Important to areas immediately outside the local condition
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-14	
Description	**-B**	**Minor negative impact**

6.12.3.2 Proposed Mitigation Measures

There are no mitigation measures recommended specifically with respect to the protection of the planktonic community during the construction stage, however mitigation measures related to the control of suspended sediments as outlined in Section 6.4 (Water quality) will also mitigate impacts to the planktonic communities.

6.12.3.3 Residual Impacts

Assuming the mitigation measures proposed are able to prevent the spill from spreading well beyond the project area, the residual impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Oil dispersion will be contained within the Project site.
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

6.12.4 Operations

6.12.4.1 Potential Impacts

Thermal Plume Impacts

The reclamation also expected to change the patterns of the thermal effluent that is currently discharged from the Tg. Bin Coal-Fired Power Plant, especially during the Phase 3 of the reclamation works. This is due to changes in water flow and wave pattern. During Phase 1 and 2, no significant changes in the plume dispersion were predicted.

High temperature levels from the thermal discharge have a significant impact on the physiological functions of planktonic community that can decrease the density and diversity of the plankton /40/. For example, the temperature levels recorded during the baseline study for the Tg. Bin Coal-Fired Power Plant /41/ were 29.2-30.5 ºC and were found to increase to 29 to up to 35.5 ºC during the monitoring study undertaken in 2013 /42/. A decrease in phytoplankton density was also observed, from 5,266 cells/ml during the baseline study to 7.8 cells/ml during the monitoring in 2013, which may be attributed to the increase in temperatures in the vicinity of the outfall.

The hydraulic and thermal plume modelling for the Tg. Bin Power Plant with the present proposed project has predicted an average increase in temperature of 0.1 to 0.2 °C for the full development (Phase 3), with a maximum increase of up to 0.5 °C in the surface layer.

The highest mean surface temperature predicted for Phase 3 is 33°C which is expected to reach the channel area between the reclamation and mainland. Hohman and Tsuda (1973) found that a rapid decrease in the survival of several species of tropical algae were also found to decline in the range of 30 - 35°C /26/. In this respect, changes in the thermal effluent direction from Tg. Bin Coal-Fired Power Plant during Phase 3 will affect the marine productivity in a limited area at the narrow channel to the northwest of the project site.

Impact Evaluation
Based on the RIAM, the impact is categorised as **Minor Negative**.

Criteria	Score	Description
Importance	2	Important to project site and Sg. Pulai
Magnitude	-1	Negative change
Permanence	3	Permanent
Reversibility	2	Reversible
Cumulativity	2	Non-cumulative
Environmental Score	-14	
Description	**-B**	**Minor negative impact**

Oil Spill

As described in previous sections, under the worst case scenario, an oil spill incident would have far reaching impacts in the marine environment if uncontrolled. The time to exposure to Sg. Pulai for example, is only 2.5 hours after the spill event.

Oil spills can be very harmful to marine organisms and can contaminate plankton, which has been known as the primary producer of the marine food web.

Impact Evaluation
Based on the RIAM, the impact is categorised as **Moderate Negative**.

Criteria	Score	Description
Importance	3	Important to Johor and Peninsular Malaysia
Magnitude	-1	Negative change
Permanence	3	Permanent

Criteria	Score	Description
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-24	
Description	**-C**	**Moderate negative impact**

6.12.4.2 Proposed Mitigation Measures

Thermal Plume Impacts

Proposed mitigation measures for thermal plume are to develop Phase 3 of this project only after PTP Phase 3 expansion has been constructed as described in Section 6.4.4.2.

Oil Spill

Mitigation measures for the management of oil spill are described in Section 6.4.4.2 above.

6.12.4.3 Residual Impacts

Thermal Plume

No significant change in temperatures around the Tg. Bin Power Plant cooling water outfall are predicted to occur with the construction of PTP Phase 3 in place. Accordingly, the residual impact is categorised as **No change**.

Criteria	Score	Description
Importance	2	Important to project site and Sg. Pulai
Magnitude	0	No change
Permanence	0	No change
Reversibility	0	No change
Cumulativity	0	No change
Environmental Score	0	
Description	**N**	**No change**

Oil Spill

Assuming the mitigation measures proposed are able to prevent the spill from spreading beyond the project site, the residual impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Oil dispersion will be contained within the Project site.
Magnitude	-1	Negative change

Criteria	Score	Description
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

6.13 Fish Fauna

6.13.1 Evaluation Framework

This assessment focuses on the following sources of potential impacts:

- Suspended sediment plumes (dredging and reclamation) – threshold of 80 mg/l TSS.
- Disturbance including underwater noise
- Water quality changes (temperature and salinity)

6.13.2 Sensitive Receptors

The mangrove areas around Sg. Pulai, in particular support a rich community of aquatic fauna. The baseline surveys indicated the highest catch around Sg. Pulai and Merambong areas, followed by the nearshore area of Tg. Piai east (i.e. the project area).

A total of 333 individuals of fish, 65 individuals of crustaceans (44 individuals of shrimps, 17 individuals of crabs, 3 individuals of mantis shrimp and single individual of lobster), two (2) individuals of cuttlefish and two (2) individuals of horseshoe crab were caught during three (3) monsoon periods i.e. northeast, southwest and inter monsoon. The fish caught belonged to 24 families and consisted of 52 species, while crustaceans (shrimps, crabs, mantis shrimp and lobster), cuttlefish and horseshoe crab, each belonged to one (1) Family and comprised of seven (7) species.

6.13.3 Construction

6.13.3.1 Potential Impacts

Suspended sediments

The immediate impact on fish fauna would be migration of fish and free-swimming or mobile marine life to safer or less disturbed areas (generally deeper waters) as a natural response to changes in the marine environment /43; 44/ thus avoiding direct deleterious effect. The important source of pollution during the reclamation, dredging and pilling activities would be the discharge of silt as a consequence of disturbance of the seabed. High silt loads are highly deleterious to aquatic environment and has number of effects on fish life.

In addition, high level of suspended sediments leads to light reduction and visual impairment thus fish may have difficulty seeing prey /45/. Furthermore, mating and territorial behaviour patterns which are reported to be highly dependent on visual cues /46/ might be disrupted by turbid water conditions. This could result in a reduced reproductive rate that would eventually

reduce the abundance and diversity of fish. Unfortunately, little is known about the absolute sediment tolerance thresholds of most commercial fish species. For each organism, injury will occur above a different threshold concentration of suspended sediments and also vary among the different life stages (egg, larva, juvenile and adult). The younger stages of the fish would be most vulnerable and sensitive to this effect /47/.

As stated in previous sections, the hydraulic study indicates that sediment plume dispersion within the vicinity of the reclamation area is significantly high, although the duration of exposure to very high concentrations is very low. The recommended safe limit for fisheries is <80 mg/L /39/. Based on the exceedance of 50 mg/l TSS during the reclamation phases (Figure 6.46, Figure 6.51 and Figure 6.56 from Section 6.4.3.1), TSS concentrations of 80 mg/l and above are also expected to be confined to within working area.

Seagrass areas are known nursery areas for juvenile fish. Seagrass beds can be found in the estuary of Sg. Pulai, Merambong Shoals and Tg. Adang Shoals. Around the proposed project site, there will be a decrease in water clarity caused by suspended solids which can affect the ability of fish to see and catch food (see Section 6.4.3.1). However, it could be observed that suspended sediments will only approach the seagrass area during Phase 2 (reclamation and dredging), and at concentrations below the threshold for both fish and seagrass (see Section 6.15 for impact assessment on seagrass).

Suspended sediment can also clog fish gills, reduce growth rates, decrease resistance to disease and prevent egg and larval development. When suspended solids settle to the bottom of a water body, they can smother the eggs of fish. Settling sediments can fill in spaces between rocks which could have been used by aquatic organisms for homes. Damage to the seagrass beds from the reclamation and dredging activities would also have an effect on the nursery areas of fish fry, however, as described further in Section 6.15, no impacts to the seagrass in Sg. Pulai or off PTP and Tg. Adang areas are predicted due to sedimentation.

Impact Evaluation
According to the RIAM, the impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Important to Tg. Piai
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-7	
Description	**-A**	**Slight negative impact**

Underwater Noise Impacts

There is potential for fish fauna to be disturbed by noise and vibration as a result of piling, motors or heavy construction work on site as well as movement of vessels during dredging works. According to McCauley (1994), the response of fish fauna to acoustic emissions can range from no effect to various behavioural changes /48/. However, fish fauna are highly mobile and would generally avoid areas of high sound emissions, when reach levels that may cause pathological effects. The out-migration of fish fauna from the existing fishing grounds adjacent to the project site will affect fish landings as well as fishermen income.

Underwater noise travels further in deeper waters and hence the piling activity for the jetties in particular may cause high percussive sound emissions. It is noted however, that the existing ambient underwater noise in the area is relatively high due to the high amount of shipping traffic in the area.

Impact Evaluation
According to the RIAM, the impact is categorised as **Minor Negative**.

Criteria	Score	Description
Importance	2	Important to South Western Johor (Tanjung Piai, Sungai Pulai) and Johor Straits
Magnitude	-1	Negative change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-14	
Description	**-B**	**Minor negative impact**

6.13.3.2 Proposed Mitigation Measures

Suspended Sediments
No mitigation measures for suspended sediments specific to fish fauna are proposed; however, mitigation measures related to the control of suspended sediments as outlined in Section 6.4 (Water quality) will also mitigate impacts to the fish fauna

Underwater Noise
No specific mitigation measures proposed.

6.13.3.3 Residual Impacts
No change in impact significance.

6.13.4 Operation

Temperature and Salinity
Reynolds and Casterkin (1981) indicated that tropical marine fish species differ greatly in thermoregulatory precision and prefer mean temperatures between 20 - 30°C /36/. High level of temperatures in the water would cause stress, which affects behaviour, feeding, metabolism, growth and immunity to disease /49/. Boyd (1998) reported the recommended temperature levels for aquatic organisms ranged from 28 – 32°C /39/.

Data from the hydraulic study indicates that the thermal plumes from Tg. Bin Coal-Fired Power Plant is expected to reach 33.0°C within the vicinity of the power plant during the northeast and inter monsoon, and towards Sg. Pulai during the southwest monsoon for Phase 1 and Phase 2. During Phase 3, highest mean temperature level of 33°C is expected to reach the channel between the reclamation and mainland and this may affect the distribution and composition of fish fauna at that area.

Several past studies have revealed that salinity affects the physiological processes and morphological developments in marine fish /50; 51/. According to Varsamos et al. (2005), the successful development of fish species in seawater depends on their ability to survive a range of salinity through osmoregulation /50/. Each fish species has a range of salinity in which it can grow or develop optimally and when it is out of this range, other physiological functions need to be expended to provide extra energy for the fish in order to maintain the desired salt concentration. The safe levels for most marine species range from 10 – 35 psu, depending on the stage of their life cycle /49/.

However, data from the hydraulic study indicates that the salinity dispersion model did not show significant difference between the baseline and reclamation, for most seasons for Phase 1, Phase 2 and Phase 3, with levels ranging from 28 - >30 psu. Where salinity is concerned, this shows that there is no significant impact on fish fauna at the study area.

Impact Evaluation
According to the RIAM, the impact is categorised as **Minor Negative**.

Criteria	Score	Description
Importance	2	Important to South Western Johor (Tanjung Piai, Sungai Pulai) and Johor Straits
Magnitude	-1	Negative change
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulativity	3	Cumulative
Environmental Score	-18	
Description	**-B**	**Minor negative impact**

Oil Spill

As described in previous sections, under the worst case scenario, an oil spill incident would have far reaching impacts in the marine environment if uncontrolled.

Oil can be toxic to most shellfish such as lobsters, crabs, clams and oysters, since they normally accumulate high levels of contaminants in their bodies that can be passed on to predators. As for fish, they can be impacted directly through uptake by the gills, ingestion of oil or oiled prey, effects on eggs and larval survival or changes in the ecosystem that support the fish. As a result, fish probably experience reduced growth, enlarged livers, changes in heart and respiration rates, fin erosion and reproductive impairment (Wirwa *et al*., 2010 /52/).

Where aquaculture is concerned, the accidental oil spills could affect the fish cage culture operation at Pulau Kukup. A study by Tahir (1996) /53/ reported that the aquaculture industry in Malaysia was losing an estimated of RM 66.5 million as a consequence of oil spills in Johor. A separate study by Jaswar and Maimun (2013) /54/ reported that Pulau Kukup area has been suffering from oil spills occurring along the Straits of Malacca and Johor Straits. In this respect, any accidental oil spills that occur at the proposed study area may significantly affect the cage culture activity that currently being taken.

Impact Evaluation
According to the RIAM, the impact is categorised as **Moderate Negative**.

Criteria	Score	Description
Importance	2	Important to South Western Johor (Tanjung Piai, Sungai Pulai) and Johor Straits
Magnitude	-2	Significant change
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulativity	3	Cumulative
Environmental Score	-28	
Description	**-C**	**Moderate negative impact**

6.13.4.1 Proposed Mitigation Measures

No mitigation measures specific to fish fauna are proposed.

6.13.4.2 Residual Impacts

Temperature and Salinity

No significant change in temperatures around the Tg. Bin Power Plant cooling water outfall are predicted to occur with the construction of PTP Phase 3 in place. Accordingly, the residual impact is categorised as **No change**.

Criteria	Score	Description
Importance	2	Important to project site and Sg. Pulai
Magnitude	0	No change
Permanence	0	No change
Reversibility	0	No change
Cumulativity	0	No change
Environmental Score	0	
Description	**N**	**No change**

Oil Spill

Assuming the mitigation measures proposed are able to prevent the spill from spreading beyond the project site, the residual impact is categorised as **Slight Negative**.

Criteria	Score	Description
Importance	1	Oil dispersion will be contained within the Project site.
Magnitude	-1	Negative change