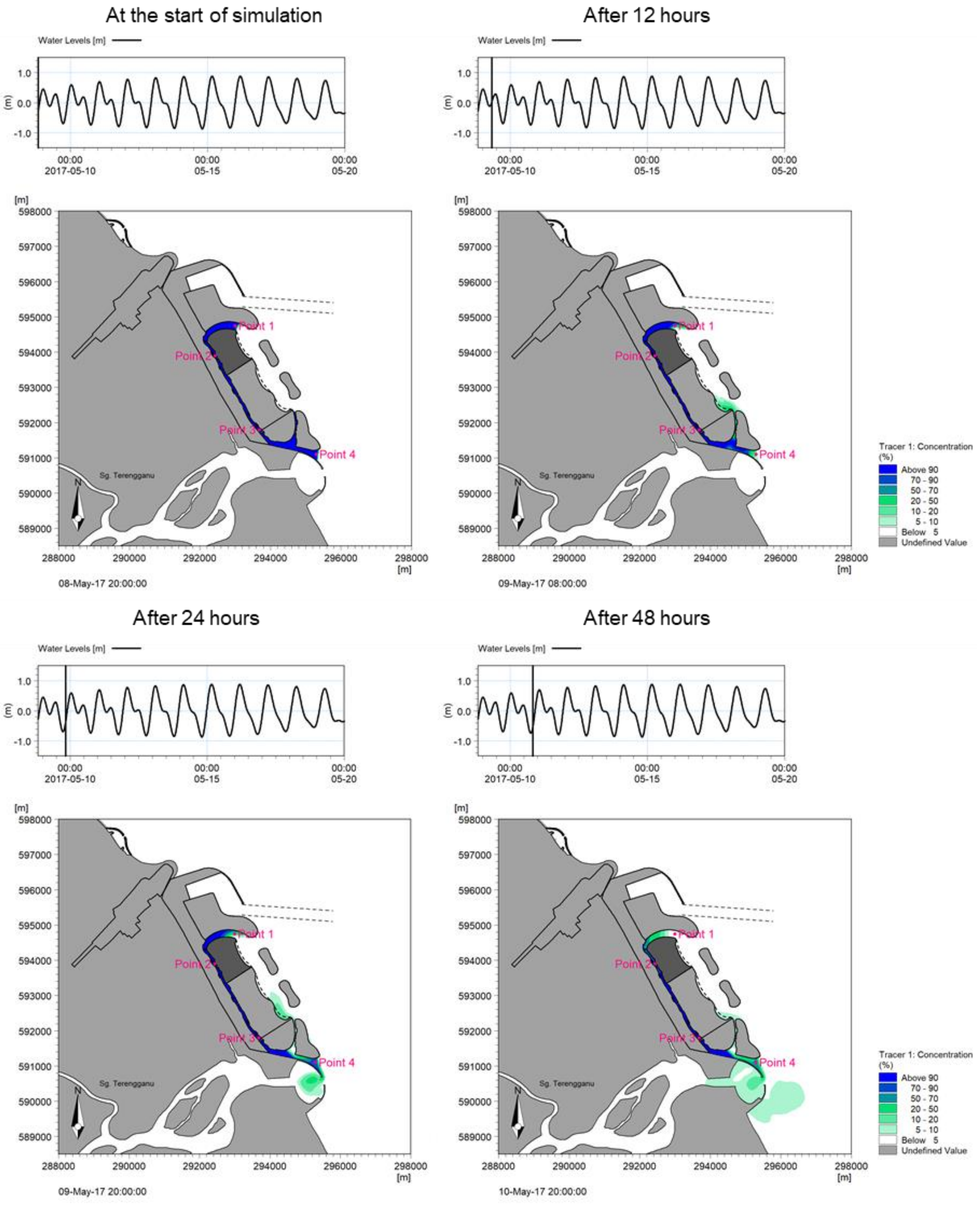

Figure 7.8 Concentration of conservative tracer in the inner channel at the start of simulation, after 12 hours, 24 hours and 48 hours for Tracer 1.

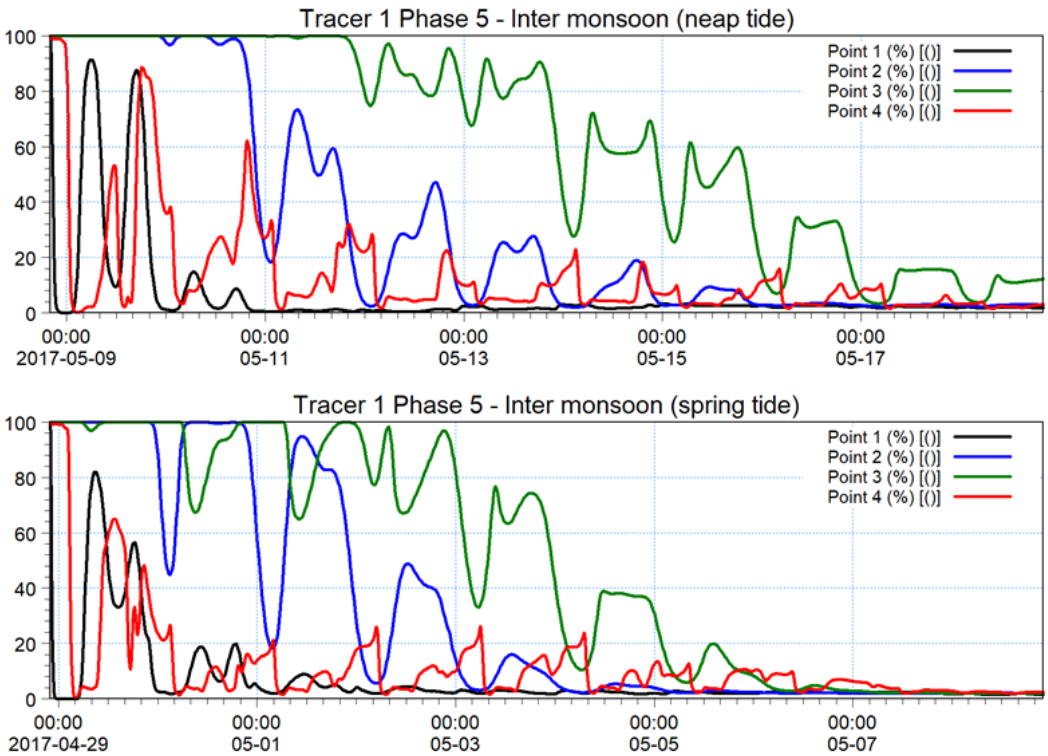

Figure 7.9 Concentration time series of Tracer 1, released during neap (top) and spring tide (bottom) at four locations within the inner channel as shown in Figure 7.8.

Table 7.15 T_{50} at four locations within the inner channel (refer to Figure 7.8).

Tracer 1	Point 1	Point 2	Point 3	Point 4
T_{50} during neap tide	23 hours	3 days	7 days	2 days 1 hours
T_{50} during spring tide	21 hours	3 days	5 days 2 hours	18 hours

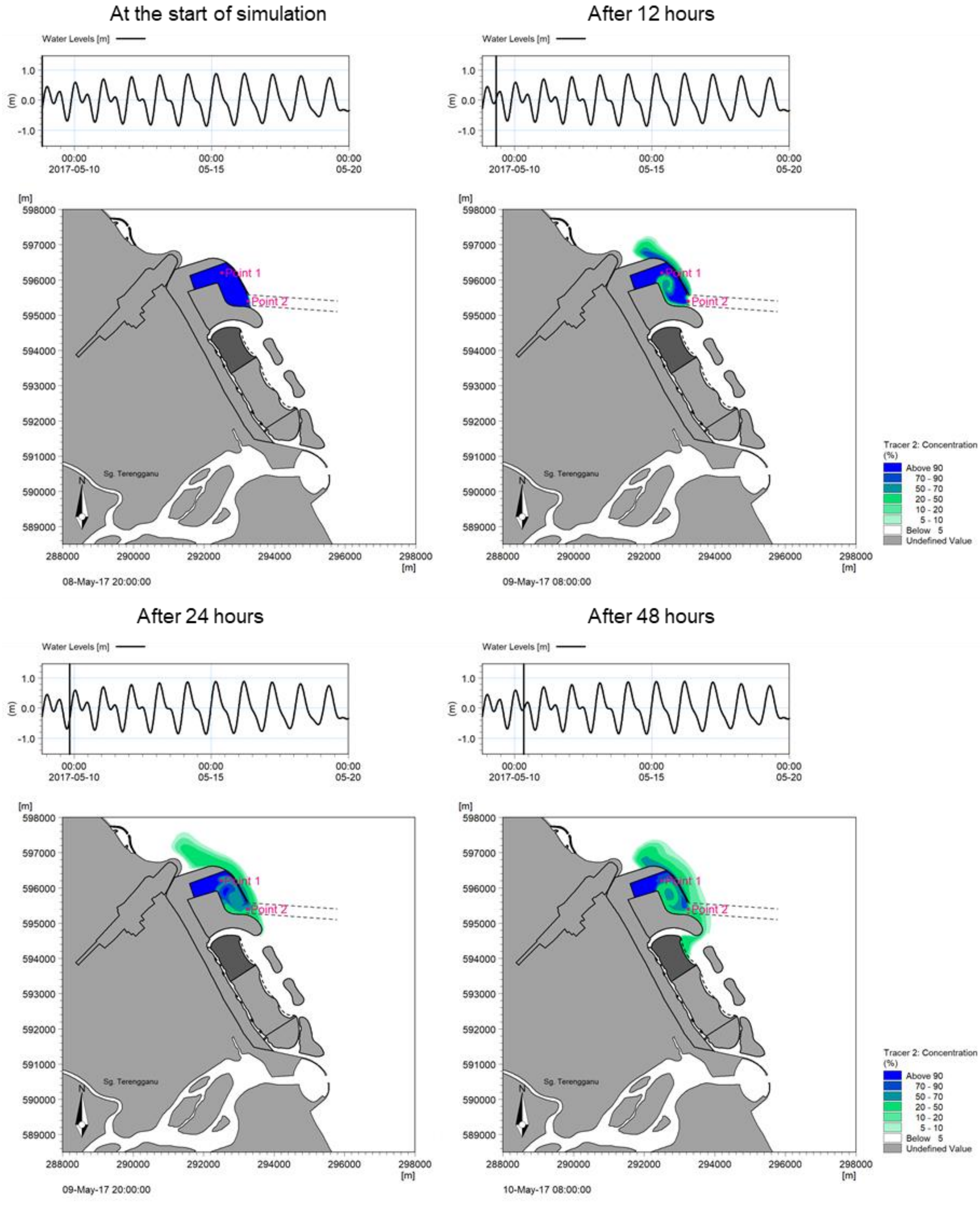

Figure 7.10 Concentration of conservative tracer in the basin at the start of simulation, after 12 hours, 24 hours and 48 hours for Tracer 2.

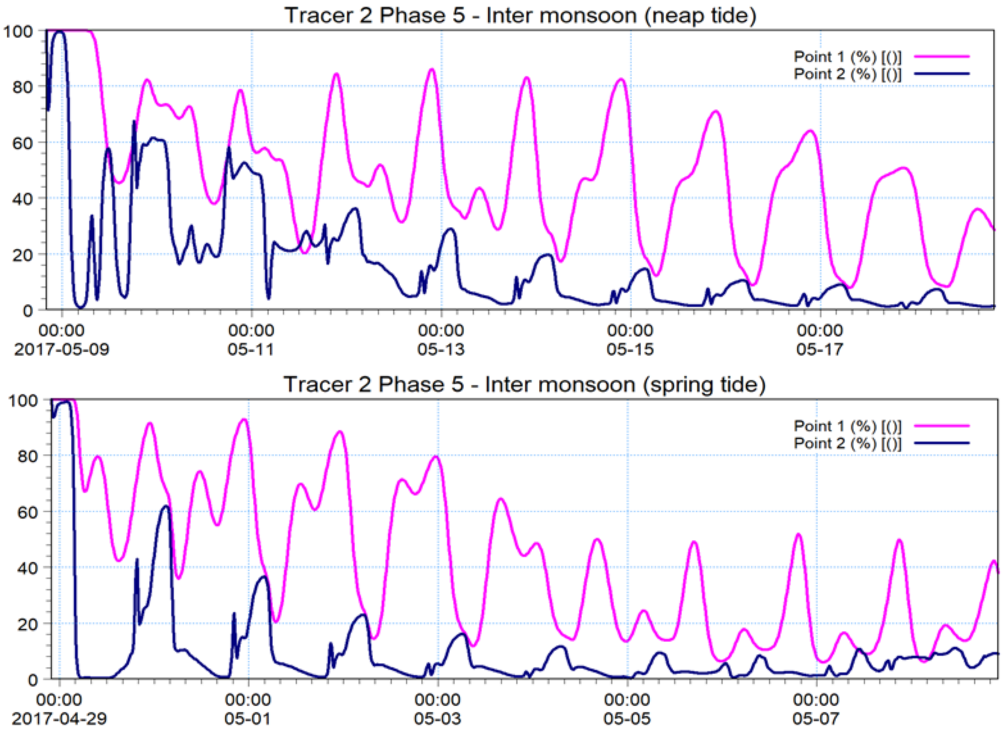

Figure 7.11 Concentration time series of Tracer 2, released during neap (top) and spring tide (bottom) at two different locations within the basin as shown in Figure 7.10.

Table 7.16 T_{50} at two different locations within the basin (Tracer 2), refer to Figure 7.10.

Tracer 2	Point 1	Point 2
T_{50} during neap tide	9 days 2 hours	2 days 3 hours
T_{50} during spring tide	7 days 21 hours	1 days 6 hours

Impact Evaluation

Based on the RIAM, the impact is a **minor negative** impact as the effects are mostly localised within the Project area. In terms of mitigation, it will be important that pollutant discharges into the channel and basin are avoided during the operations stage of the mixed development; however, this can only be addressed in the subsequent detailed planning and impact assessment(s) for the topside developments.

Criteria	Score	Rationale
Importance	1	Confined to area within the Project area and 1 km from the Project area.
Magnitude	-2	Poor flushing in the inner channel and inner basin however with little existing pollution in the nearshore waters and no anticipated discharges into the waterways, water quality deterioration is likely to be minor to moderate.
Permanence	3	Permanent as the changes on flushing capacity is induced by presence of reclaimed land.

Criteria	Score	Rationale
Reversibility	3	Irreversible as the reclaimed land is in place.
Cumulative	2	Non-cumulative
Environmental Score	-16	
Description	-B	Minor negative impact

7.2.2 Coastal Morphology

The behaviour of coastal environments is largely governed by the dynamics between tides, waves, winds and the geological and morphological characteristics of the coastal interfaces. The implication is that Project development (reclamation and dredging works) may alter the existing hydrodynamic regimes in the area that define the coastal and marine characteristics of the Project area, including sediment transport and morphology. The likelihood of hydrodynamic changes has been assessed using numerical modelling techniques, which include numerical modelling of water levels, currents, waves, cohesive and non-cohesive sediment transport, and littoral drift modelling. The hydraulic modelling study was carried out in accordance with the Department of Irrigation and Drainage (DID) guidelines and the hydraulic report was submitted to DID in June 2019 /81/.

7.2.2.1 Evaluation Framework

Construction Phase

During construction, the assessment evaluates the short-term sedimentation impacts arising from the siltation of sediment plumes generated by reclamation and dredging works. The suspended sediment plumes excursion has been predicted through numerical modelling of the dredging and reclamation activities as outlined in Section 5 Project Description.

The Mud Transport (MT) module of the MIKE 21 FM describes erosion, transport and deposition of mud or sand/mud mixtures induced by the dredging and reclamation works. The MT module operates interactively with the hydrodynamic model and was used to assess the extent (importance), concentrations of suspended sediment levels and subsequent settling and deposition of these suspended sediments including also resuspension. Details of the modelling assumptions and scenarios have been described in Section 7.2.1.1. In order to capture the spring-neap tidal cycles and seasonal variations, simulations are carried out over 28-day period during the Northeast, Southwest, and inter-monsoons for existing and each Project phase conditions. The results are scaled to give annual change in sedimentation rate by combining three months for Northeast monsoon, three months for Southwest monsoon, and four months for inter-monsoon.

Post-construction Phase

The morphological conditions in the study area are largely dominated by waves propagating from the South China Sea that tend to break in the shallow nearshore areas and induce wave-driven currents and littoral transport. In order to simulate the complex sediment transport pattern induced by the waves and the potential impacts of the proposed development, 2D coupled models (wave, wave driven current, and wave driven littoral transport) have been applied for the existing condition and with the Project in place.

The 2D model is a computationally demanding process to investigate long-term processes, therefore, the simulations were carried out for representative wave conditions as presented in Table 7.17. These conditions were derived from statistical analysis of computed littoral transport during a period of 10 years. The model applied for these calculations is the LITDRIFT module of the LITPACK system that allows to derive the frequency of occurrence of sediment transport conditions in relation to wave height, wave direction and the littoral transport rates.

Littoral transport varies non-linearly with wave height, period and direction and it is linearly proportional to the frequency of occurrence of the wave conditions. The conditions that represent the medium to long term littoral transport usually do not correspond to the largest waves, as they occur for short periods of time, but to conditions that are not extreme but occur frequently.

Table 7.17 Defined offshore wave conditions applied into ST model.

Case	Wave condition	Wave Height (m)	Wave Period (s)	Wave direction (°N)	Water Level (m MSL)	% occurrence / Hours per year
1- NE monsoon	South-going	1.6	8	55	0	0.9 / 79
2- NE monsoon	North-going	1.6	8	75	0	0.04 / 3.5
3- SW monsoon	North-going	1.2	5	95	0	0.06 / 5.3

Sensitive Receptors

Sensitive receptors have been identified as Pantai Batu Buruk immediately south of the KT breakwater, and the shoreline fronting UMT, north of the area where a coastal protection scheme has been implemented by JPS, and presently is defined as a critical area in the National Coastal Erosion Study (2015).

7.2.2.2 Construction Phase

Sedimentation

Predicted impacts on morphology during construction are related to deposition of fines that have been released from the dredging and reclamation activity in the seabed. Re-suspended sediment from the construction works will tend to be suspended in the water column and settle down in areas of lower current speed. The predicted annual siltation rates for the different project phases are shown in Figure 7.12 and Figure

7.13. The results show the phases with the greatest impact extent are Phase 1 c and Phase 2, where dredging and reclamation are occurring concurrently. Nevertheless, the predicted sedimentation over one year outside the immediate project area is between 2 cm to 20 cm (0.02 to 0.2 m) during Phase 1 c, and mostly below 5 cm for Phase 2.

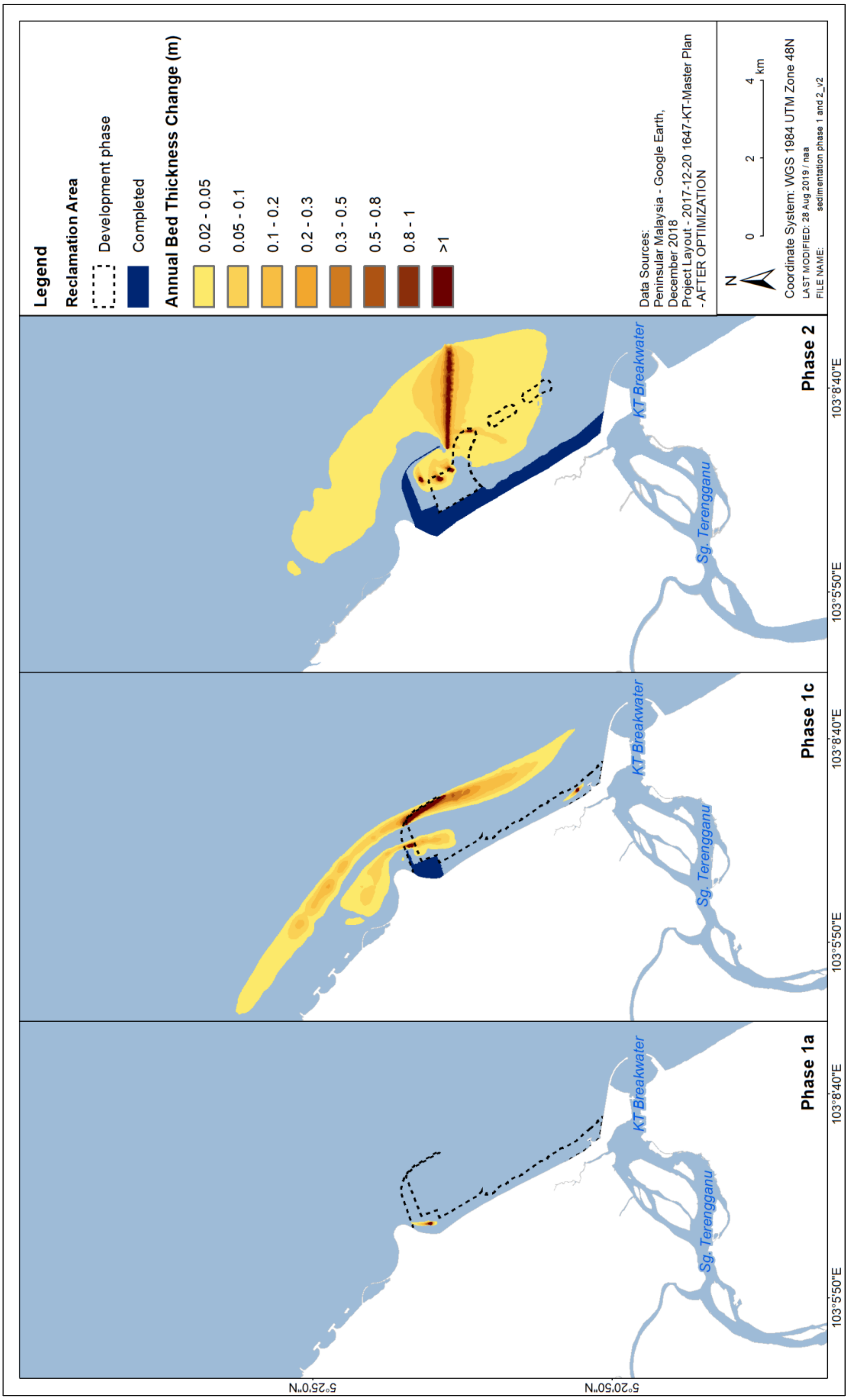

Figure 7.12 Predicted annual bed thickness due to siltation of fines generated during construction phases 1a, 1c and 2.

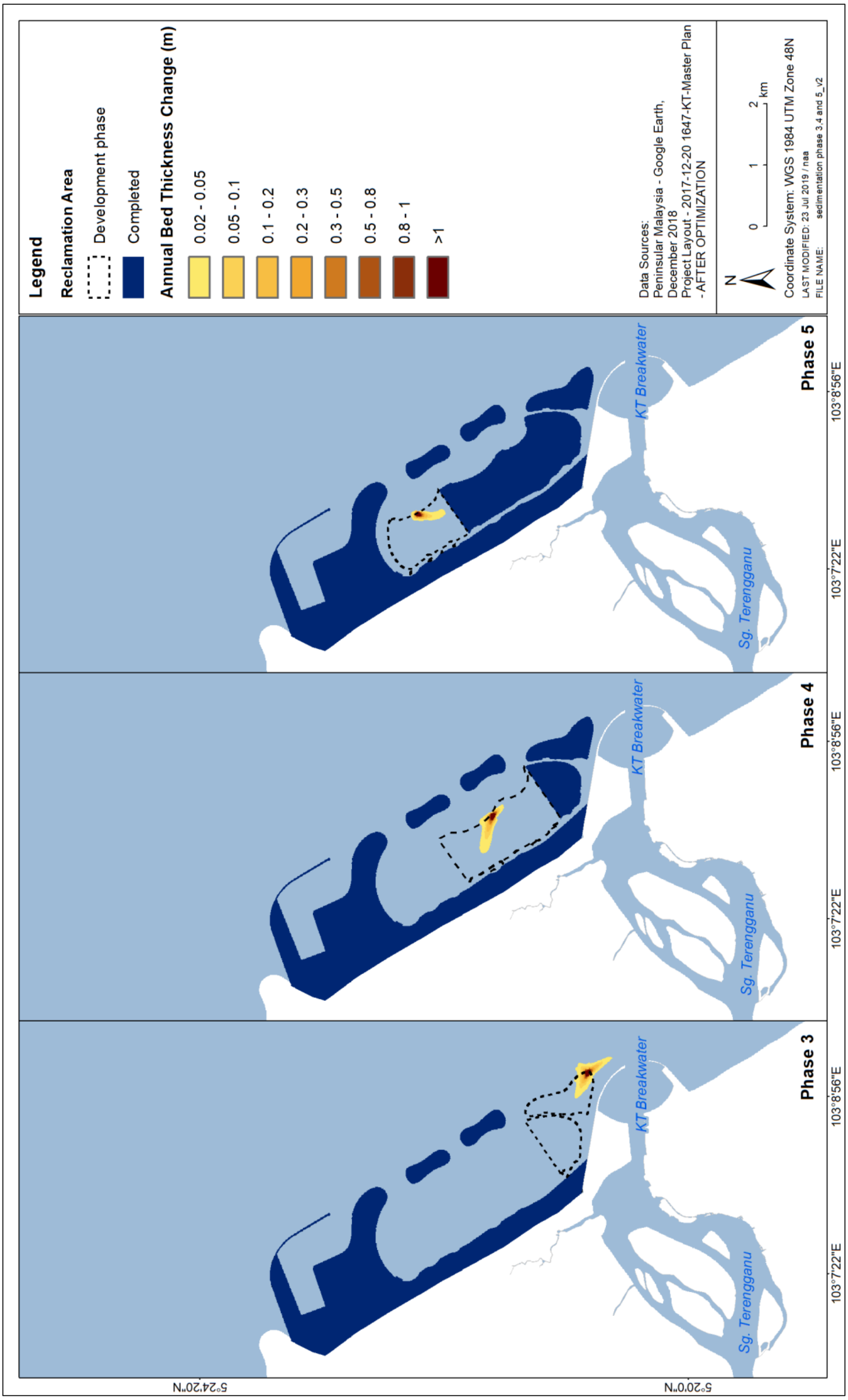

Figure 7.13 Predicted annual bed thickness due to siltation of fines generated during construction of phases 3, 4 and 5.

Impact Evaluation

Based on the RIAM matrix, the impact is considered to be **minor negative** impact.

Criteria	Score	Rationale
Importance	3	The predicted annual sedimentation outside the Project area ranges between 2 cm to 20 cm, covering an area of just over 5 km from the Project site (at 2-5 cm).
Magnitude	-1	Predicted changes outside the Project footprint are primarily between 5-10 cm over the year, mostly contributed by the dredging activity.
Permanence	2	Temporary
Reversibility	2	The impact is reversible upon cessation of dredging and reclamation
Cumulative	2	Non-cumulative
Environmental Score	-18	
Description	-B	Minor negative impact

7.2.2.3 Post-construction Phase

Coastal Morphology

The study area is located in a coastal stretch that is separated from the beaches north and south of it by two large marine structures, the Sultan Mahmud Airport runway extension to the north and the Kuala Terengganu breakwater to the south. Both structures extend approximately 800m from the existing shoreline into deep waters and they limit the amount of sediments that can be transported around it. Therefore the Project coastline can be considered as an independent cell where sediment transport occurs only within it; as such, developments within this cell will not influence adjacent areas.

Nevertheless, due to the large footprint of the Project, an evaluation of changes in wave conditions, littoral currents and sediment transport has been carried out for different climatic conditions with and without the Project in place. It is noted that sediment transport is a highly non-linear process whereby small variations in the simulated calculations can lead to unrealistic results. Thus, to provide an accurate description of the changes, the focus has been on variations of the overall sediment transport pattern and evaluation of differences in the wave conditions and wave-driven-littoral currents.

Results of the simulations are presented in Figure 7.14 to Figure 7.16 or the evaluated wave condition case 1 as discussed in Section 7.2.2.1. The figures show the predicted wave field on top, the predicted currents in the middle and below the sediment transport; and from left to right existing conditions, post-construction and the differences between the two. The key findings are summarised below:

- **Waves:** The predictions show that wave changes are mainly localised within the coastal cell and no changes are observed in nearby areas. Most predicted changes are along the dredged channel, this tends to produce a re-direction of the incoming wave energy but still localised in the development

- **Currents:** Similar to the wave conditions the changes in current speed are mainly localized within the coastal cell. Some differences are observed along the Sultan Mahmud runway extension and south of Tok Jembal, mainly offshore. To the south of the Kuala Terengganu breakwater no changes are predicted.

- **Sediment transport**: The results show that the predicted sediment transport patterns are very similar north and south of the study area. Changes are observed localised within the coastal cell. As previously presented, the large coastal structures - the Sultan Mahmud runway extension and the Kuala Terengganu breakwaters, limit the movement of sediments in and out the cell and the model show that the Sunrise City development does not modify this mechanism. To further quantify this process the littoral transport associated with each of these conditions is presented in Table 7.18 that present the calculated sediment transport (m^3/hour) at the Sultan Mahmud and Kuala Terengganu areas.

Table 7.18 Predicted changes in littoral transport capacity (m^3/hour) for pre- and post-development conditions. Negative values indicate southward transport while positive values indicate northward transport.

Case	**Transect 1 (at UMT coastline protection structure)**		**Transect 2 (Sultan Mahmud Airport runway extension)**		**Transect 3 (KT breakwater)**		**Transect 4 (coastline further south of KT breakwater)**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	1,100	1,100	60	20	-200	-200	-700	-700
2	2,000	2,000	800	700	300	200	1100	1100
3	400	400	300	100	200	200	400	400

Based on the present analysis it can be concluded that:

- The Project is located in a coastal cell that is presently an isolated sediment transport area separated from nearby beaches by the large coastal by the Sultan Mahmud airport runway extension and the Kuala Terengganu breakwaters and sediment transport is confined within this area with minimum exchange with nearby areas;

- Predicted sediment transport changes are confined to within the Project area, with no significant changes to the sediment transport processes north of the Sultan Mahmud Airport runway extension or south of the Terengganu breakwaters;

- The existing sediment movement around Sultan Mahmud Airport Runway Extension and KT breakwater is minor and the reclamation does not result in any significant changes to this process;

- The two sensitive receptors at Pantai Batu Buruk immediately south of the KT breakwater, and the shoreline fronting UMT, north of the area where a coastal protection scheme has been implemented by JPS, which is presently defined as a critical area in the National Coastal Erosion Study (2015) /18/, are not expected to suffer any significant impacts due to these works.

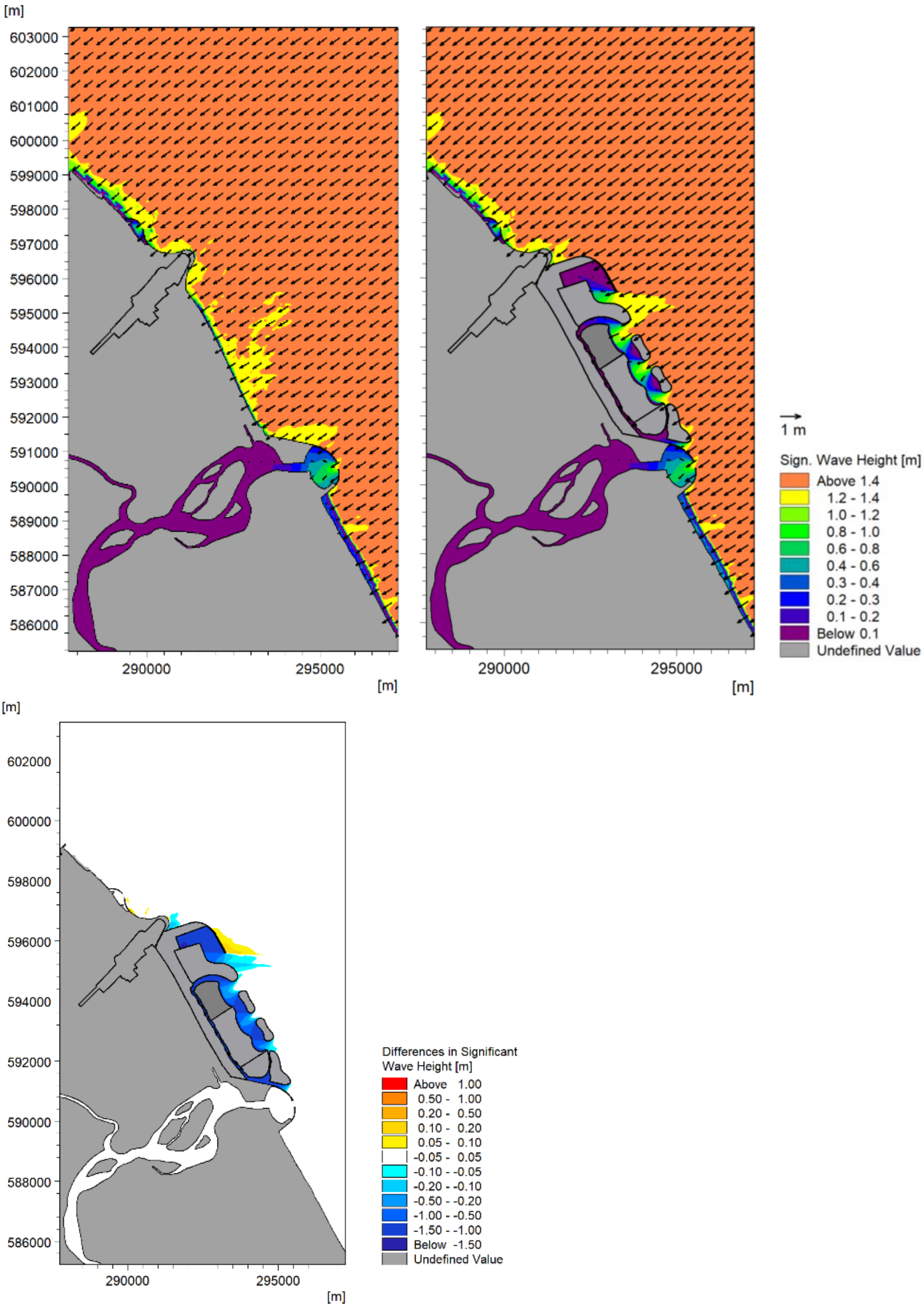

Figure 7.14 Predicted wave heights (top left – existing conditions; top right – with Project) and changes (bottom) during mean sea level condition. Case 1: NE monsoon (wave height of 1.6 m, coming from 55ºN).

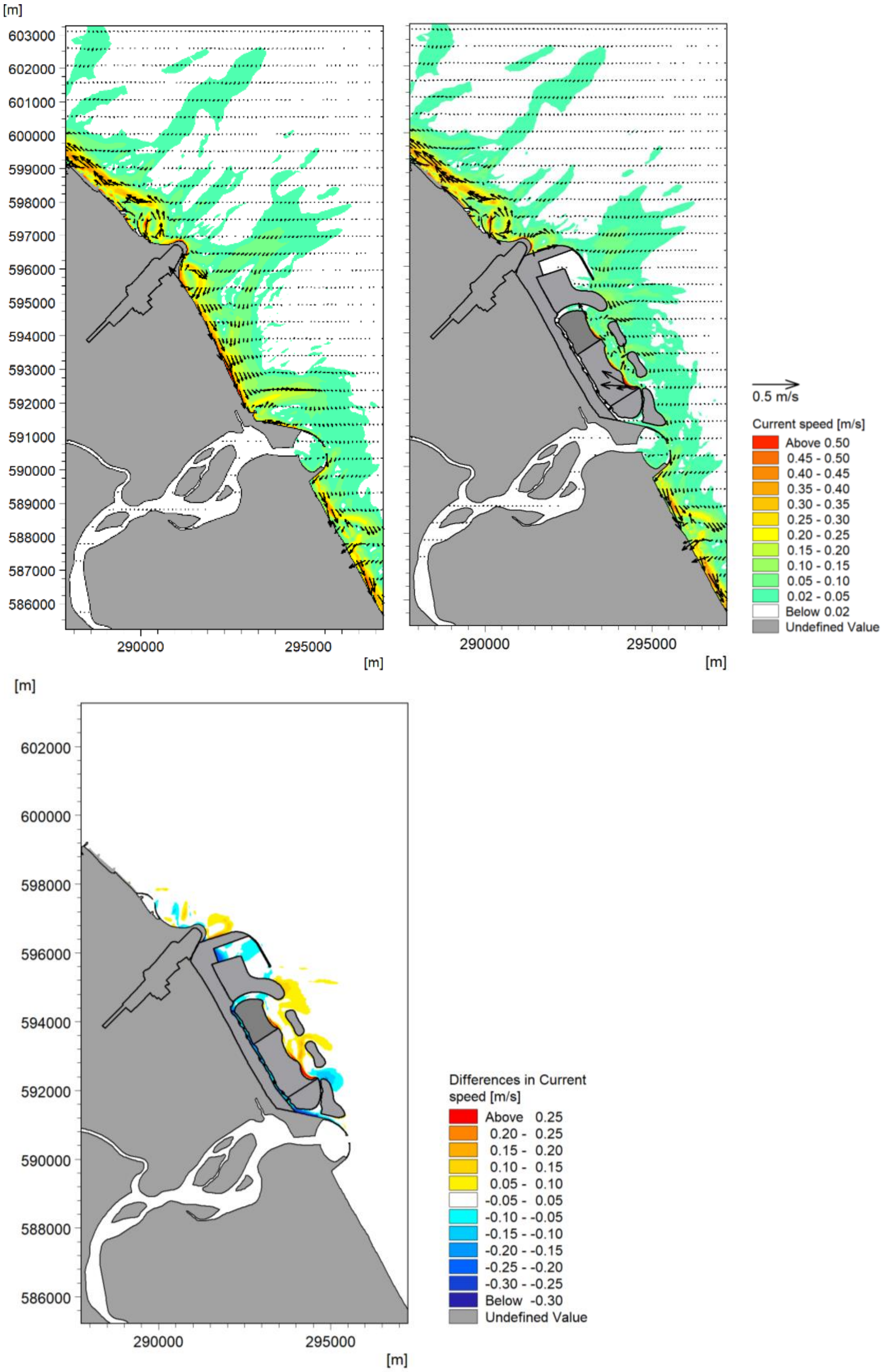

Figure 7.15 Predicted wave-driven-currents (top left – existing conditions; top right – with Project) and changes (bottom) during mean sea level condition. Case 1: NE monsoon (wave height of 1.6m, coming from 55ºN).

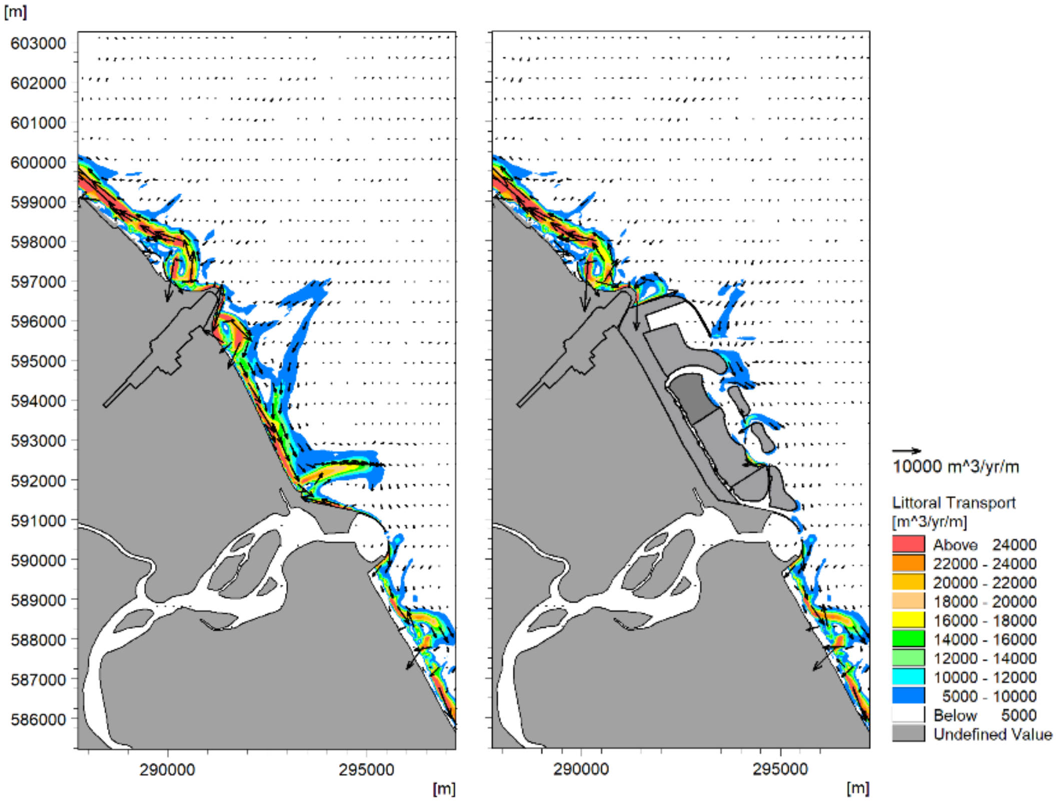

Figure 7.16 Predicted littoral transport patterns during mean sea level condition. Left – existing conditions; right – with Project. Case 1: NE monsoon (wave height of 1.6m, coming from 55ºN).

Impact Evaluation

Based on the impact matrix, the impact is **slight negative**, no mitigation required. Monitoring will however be carried out to detect unanticipated impacts.

Criteria	Score	Rationale
Importance	1	Confined to area within the Project area
Magnitude	-1	Minor changes in sediment transport are not predicted to affect the coastline.
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulative	1	Non-cumulative
Environmental Score	-7	
Description	-A	Slight negative impact

7.2.3 Hydrology and Drainage

7.2.3.1 Evaluation Framework

The key potential impact on the hydrology in the area would be if the Project affects flow from Sg. Terengganu and the airport drainage outlet in the northern part of the Project area under peak flow conditions, as this could potentially lead to increased flooding. There are no drainage outlets elsewhere along the Project area, as hinterland drainage is channelled through three soakaway pits.

As discussed in Section 6.2.3, localised flooding has been reported by villagers along Pantai Teluk Ketapang; this is most likely due to localised drainage issues and for higher rainfall events, overflow from Sg. Terengganu and its tributaries, in particular, the small unnamed tributary running parallel to the shoreline approximately 200 meters m inland from the shoreline.

Construction impacts are those related to localised sedimentation and blockage of the drain outlet along the Project shoreline, whereas **post-construction** stage impacts are related to Project footprint post-construction. During the post-construction stage, the potential impact of the Project footprint to increase flooding risk due to changes in flow around Sg. Terengganu river mouth has been assessed based on modelling of water levels in the river mouth, whereby an increase in water levels around the river mouth indicates an increase in flood risk. The evaluation criteria is therefore that there should be no significant increase in water levels in Sg. Terengganu as a result of the reclamation footprint.

The modelling of water levels was carried out using MIKE 21 FM HD for a combined/dynamic flow between river discharge and tidal variations (spring tide). The hydraulic modelling was carried out in accordance with the Department of Irrigation and Drainage (DID) guidelines and the hydraulic report was submitted to DID in June 2019 /81/.

A maximum discharge rate of 1,906 m^3/s was used, being the maximum discharge recorded from DID gauging data in Sg. Terengganu at Kg. Tanggol over 40 years (year 1960 – 2000) /83/. To capture all stages of a spring tide, this maximum discharge rate was taken to be constant in the model throughout a 2+3-day simulation period.

The impacts on water levels upstream of Sg Terengganu, and thus the potential for flooding impacts, can be assessed by considering the changes induced by the reclamation to the water levels, compared to existing conditions (i.e. without reclamation).

7.2.3.2 Construction Phase

Airport Drainage Outlet Blockage

During the construction phase there is a potential for short term blockage of the airport drainage outlet within the Project area, due to the reclamation works, and runoff and sedimentation from the dredging and reclamation works (Figure 6.21). This however is readily addressed through appropriate site management measures and construction of adequate temporary drainage during construction.

Figure 7.17 Location of affected airport discharge outlet in the Project area.

The flows from Sg. Terengganu will not be impacted by the construction works as shown in Section 7.2.2.2.

Impact Evaluation

Based on the RIAM analysis, the impact is categorised as **minor negative** impact, mitigation required.

Criteria	Score	Description
Importance	2	Potentially affecting airport runway
Magnitude	-1	Negative change
Permanence	2	Temporary

Criteria	Score	Description
Reversibility	2	Reversible
Cumulative	2	Non-Cumulative
Environmental Score	-12	
Description	-B	Minor negative impact

7.2.3.3 Post-construction Phase

Airport Drainage Outlet Blockage

The reclamation will be constructed in front of the southern airport drainage outlet. Discharge from this outlet will therefore need to be incorporated into the drainage system of the proposed Sunrise City development. There are no other drains discharging along the Project area. Therefore, no impact to any drain is expected from the development of this Project.

Impact Evaluation

Based on the impact matrix, the impact is **slight negative** impact, mitigation required.

Criteria	Score	Rationale
Importance	1	Confined to area within the Project footprint
Magnitude	-1	Potential restriction in flow if airport discharges not adequately accommodated in the development plan.
Permanence	3	Permanent
Reversibility	3	Irreversible as the reclaimed land is in place.
Cumulative	2	Non-cumulative
Environmental Score	-8	
Description	-A	Slight negative impact

Flooding Risk

The predicted maximum water levels of Sg. Terengganu for the existing conditions and with the Project and the difference between the two are shown in Figure 7.18. This shows that no changes in maximum water levels are predicted in Sg Terengganu. Therefore, the Project will not impose any changes to flooding risk along Sg Terengganu.

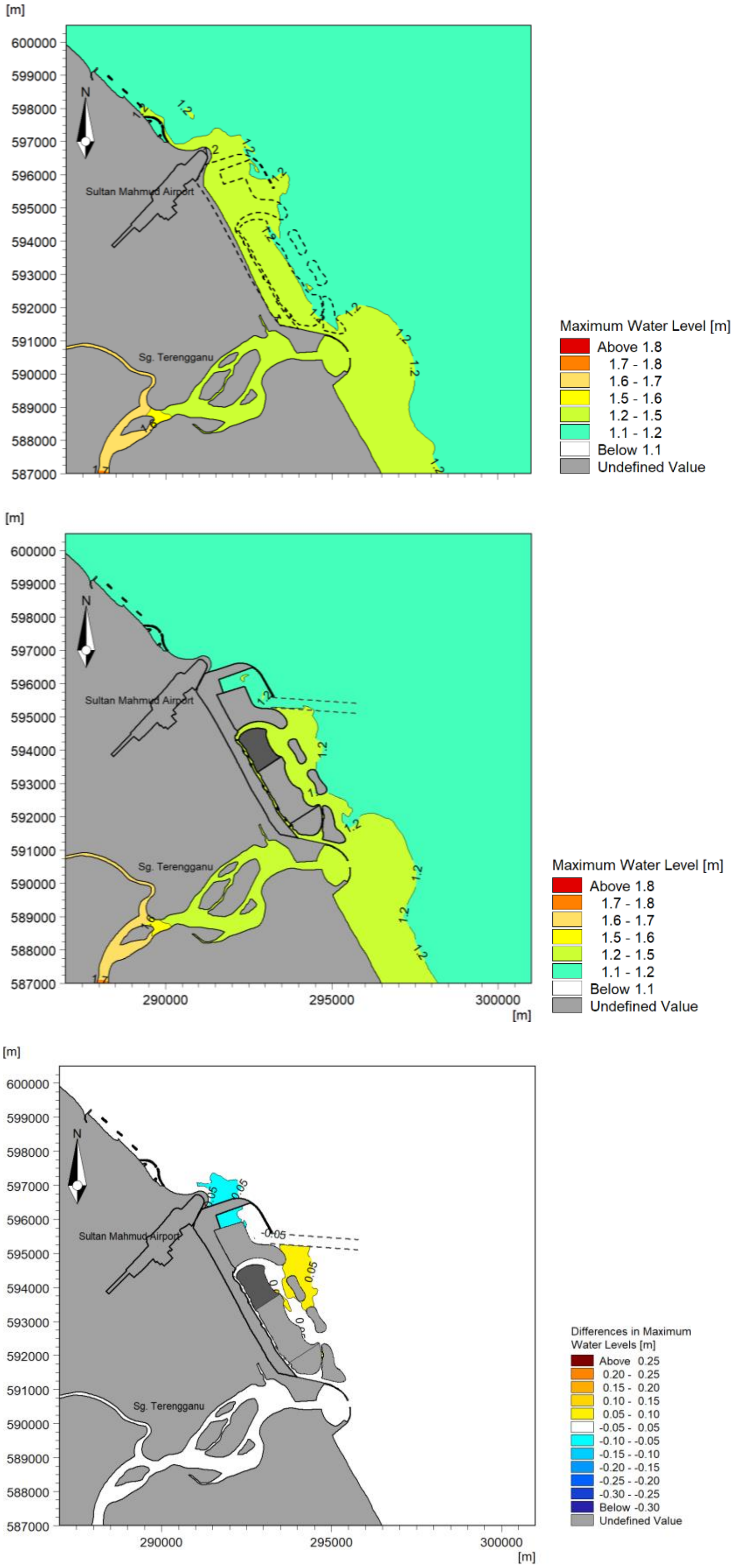

Figure 7.18 Predicted maximum water levels for existing (top), with Project (middle) and difference (bottom).

Impact Evaluation

Based on the impact matrix, there is **no change** to flooding risk in Sg. Terengganu.

Criteria	Score	Rationale
Importance	1	Confined to area within the Project footprint
Magnitude	0	No changes in maximum water levels for existing condition and operation stage.
Permanence	3	Permanent
Reversibility	1	No change
Cumulative	1	Non-cumulative
Environmental Score	0	
Description	N	No change

7.2.4 Air Quality

Impacts during reclamation and dredging stage are expected to be limited to dust dispersion and emissions from vehicles and machinery. The air quality impact from construction of buildings and the topside operations will be assessed in separate EIAs, hence this assessment focuses solely on the construction stage, namely dredging and reclamation works.

7.2.4.1 Evaluation Framework

There are 13 settlements (kampungs, residential areas and army camp) within 1 km of the Project. As expected in a residential and coastal environment, baseline surveys showed that the ambient air quality is good, with concentrations of PM_{10} and $PM_{2.5}$ well below the recommended guideline and CO, SOx and NOx concentrations below the laboratory detection limit.

Project-related impacts to air quality have been assessed in terms of compliance with air quality standards. Analysis of air quality compliance entailed a comparison of whether the activities involved at each phase will affect the established baseline ambient air quality concentrations with the standard limits.

Compliance with short-term air quality standards involved applying emission inventories (i.e. associated with conservative construction and operational scenarios) with the New Malaysia Ambient Air Quality Standard. Only particulate matter (PM_{10} and $PM_{2.5}$) parameters are assessed as these are the main pollutants anticipated from the Project activities. As previously noted, impacts from operational activities associated with the topside development will be addressed in separate EIA(s).

The New Malaysia Ambient Air Quality Standard have been developed by the Department of Environment (DOE), Malaysia and the guidelines for interim target 2 for 2018 are applied for this assessment (Table 7.19).

Table 7.19 The New Malaysia Ambient Air Quality Standard.

Pollutant	Averaging Time	Guideline
		μg/m³
Particulate Matter (PM_{10})	1 year 24 Hours	45 120
Particulate Matter ($PM_{2.5}$)	1 year 24 Hours	25 50

The evaluation framework with respect to the assessment of *Magnitude* is shown below.

Score	Definition	Evaluation Framework
1	Negative change to status quo	Air quality, primarily dust, expected to be localised with occasional exceedances of the New Malaysia Ambient Air Quality Standard at sensitive receptors.
2	Significant negative dis-benefit or change	Air quality, primarily dust, expected to exceed the New Malaysia Ambient Air Quality Standard at sensitive receptors for short-to medium durations.
3	Major dis-benefit or change	Air quality, primarily dust, expected to exceed the New Malaysia Ambient Air Quality Standard at sensitive receptors for prolonged periods.

7.2.4.2 Construction Phase

Airborne Dust

Dust particles or particulate matter can negatively affect local air quality and human health. During construction, heavy construction activities such as reclamation, earthworks and building construction are known to create airborne dust nuisance. As the sand filling works will be conducted using hydraulic fill (sand-water slurry) with a low percentage of fine sediments, impact from dust is expected to be low and limited to dry and windy conditions.

In addition, heavy machinery such as dredgers, excavators, etc. used during the reclamation and dredging phase generate various air pollutants from the combustion of fuels such as diesel (i.e. the main fuel). However, given the numbers and types of machinery, these emission sources are low compared to the dispersion capacity of the airshed in this coastal location.

The spread of airborne dust and emissions to the nearby sensitive receptors due to construction activities is very much dependent on the wind direction, vegetation or other characteristics around the Project area.

The seasonal wind roses derived from measurements near Project area show that wind direction during Southwest and inter-monsoon are predominantly from the south direction heading seaward (Figure 7.19). During Northeast monsoon, the wind is predominantly from north eastern direction.

Therefore, the impact of dust blown from the site to the residential areas is only expected at relatively short period (only during one season throughout the year). There will still be risk of dust blown from north eastern part of the Project particularly during NE monsoon where sensitive receptors (residential area) is located. Lower risk is expected at these sensitive areas during SW and inter-monsoon as wind from the south prevails.

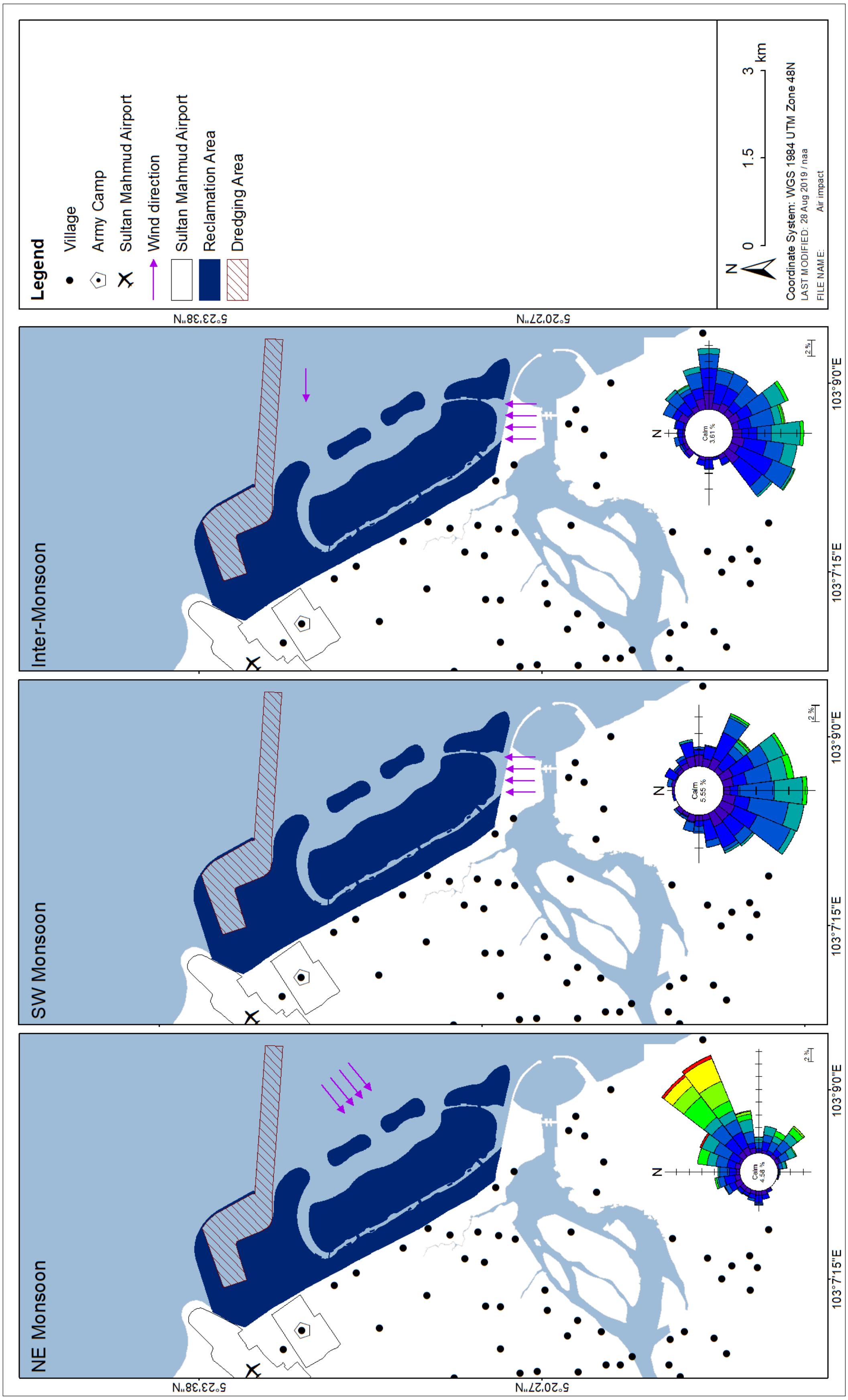

Figure 7.19 Predominant wind direction during NE monsoon, SW monsoon and inter-monsoon (wind rose shown at bottom right).

Impact Evaluation

The increases in air pollution (dust and exhaust emissions) during construction are low in magnitude, temporary and reversible. Based on the RIAM matrix, the impact is categorised as **minor negative**. Despite this, there are mitigation measures that would further minimise the impacts (see Section 8.2.4 below).

Criteria	Score	Rationale
Importance	2	Confined to area within 5 km radius of Project Area
Magnitude	-1	The wind direction is predominantly from south during Southwest and inter-monsoon. There are still risk of dust blown from Project area to sensitive receptors during Northeast monsoon. It is noted that these impacts can be readily mitigated through the implementation of BMPs
Permanence	2	Temporary during construction and limited to hot and dry periods coinciding with high winds
Reversibility	2	Reversible
Cumulative	2	Non-cumulative
Environmental Score	-12	
Description	-B	Minor negative impact

7.2.4.3 Post-construction Phase

Not applicable.

7.2.5 Ambient Noise

As stated in Section 1.2, the Project comprises three main activities, namely reclamation, capital dredging, and construction of breakwater, bridges, roads and islands on piles. These main activities are unlikely to cause significant noise impacts.

Noise during operations is not considered as topside development activities are not covered in this EIA. The key potential impact is hence expected to occur during the construction phase.

7.2.5.1 Evaluation Framework

The assessment of noise impacts on the human environment from dredging, reclamation and construction activities is based on:

- Baseline noise levels in the immediate vicinity of the Project area;
- Existing landuse and sensitive receptors in the Project area surroundings;
- Existing data on dredging and construction equipment sound emissions;
- Noise prediction based on noise modelling using noise modelling software (CadnaA); and

- The Planning Guidelines for Environmental Noise Limits and Control, Department of Environment (DOE) 2007, referred to hereafter as the DOE Noise Guidelines /84/, in particular Schedule 6 and Schedule 3 (see following subsection).

The criteria for evaluating the magnitude of noise impact is shown in Table 7.20.

Table 7.20 Noise magnitude scoring criteria.

Impact / Magnitude scoring	**Criteria**
Major Adverse (-3)	Reclamation and construction noise levels are predicted to regularly exceed DOE noise criteria by more than 10 dB(A). Mitigation measures may ameliorate some of the impacts on receivers, however mitigation of any form is unlikely to remove all adverse effects
Moderate Adverse (-2)	Reclamation and construction noise levels are predicted to exceed DOE noise criteria by between 5 to 10 dB(A) or occasionally by more than 10 dB(A). Mitigation measures such as physical noise barriers may ameliorate some of the impacts on receivers.
Minor Adverse (-1)	Reclamation and construction noise levels are predicted to exceed established noise criteria by up to 5 dB(A). Exceedances of this magnitude may be manageable by implementation of mitigation measures.

Guideline Noise Limits

The noise impact assessment refers to Schedule 6 of the DOE Noise Guidelines 2007 /84/. Schedule 6 provides the maximum permissible sound level (Percentile, L_N and L_{max}) of Construction, Maintenance and Demolition Work by receiving land use as detailed in Table 7.21. The predicted cumulative noise is compared against the L_{max} limit, as the modelling results represent the maximum sound levels from construction activities if all equipment operate at the same time.

As noted in the table (Note 1), the night time limit for residential areas refers to Schedule 1 which provides permissible sound level (L_{Aeq}). However, as L_{Aeq} baseline is higher the limit of 45 dB(A) stipulated in Schedule 1, the Schedule 3 limit is adopted as outlined in Table 7.22.

Table 7.21 DOE guideline Schedule 6: Maximum Permissible Sound Level (L_N and L_{max}) of Construction, Maintenance and Demolition Work by Receiving Land Use.

Receiving Land Use Category	**Noise Parameter**	**Day Time (dB(A))**	**Evening (dB(A))**	**Night Time (dB(A))**
		7.00 am – 7.00 pm	**7.00 pm – 10.00 pm**	**10.00 pm – 7.00 am**
Residential (Note 2**)	L_{90}	60	55	*(Note 1)
	L_{10}	75	70	*
	L_{max}	90	85	*

Receiving Land Use Category	Noise Parameter	Day Time (dB(A))	Evening (dB(A))	Night Time (dB(A))
		7.00 am – 7.00 pm	**7.00 pm – 10.00 pm**	**10.00 pm – 7.00 am**
Commercial (Note 2**)	L_{90}	65	60	NA
	L_{10}	75	70	NA
Industrial	L_{90}	70	NA	NA
	L_{10}	80	NA	NA

Source: The Planning Guidelines for Environmental Noise Limits and Control, 2007.

Notes:

*1 At these times the maximum permissible levels are stipulated in the Schedule 1 for the respective residential density type shall apply. This may mean that no noisy construction work can take place during these hours.

**2 A reduction of these levels in the vicinity of certain institutions such as schools, hospitals, mosque and noise sensitive premises (apartments, residential dwellings, hotel) may be exercised by the local authority or Department of Environment. Where the affected premises are noise sensitive, the limits of the schedule 1 shall apply.

3. In the event that the existing sound level (L_{90}) without construction, maintenance and demolition works is higher than the L_{90} limit of the above schedule, the higher measured ambient L_{90} sound level shall prevail. In this case, the maximum permissible L_{10} sound level shall not exceed the Ambient L_{90} level + 10 dBA, or the above Schedule L_{10} whichever is the higher.

4. NA = Not Applicable

Table 7.22 Maximum permissible sound level (L_{Aeq}) to be maintained at the existing noise climate (Schedule 3 of Noise Guideline 2007) adopted for night time limit.

Existing Levels	New Desirable Levels	Maximum Permissible Levels
L_{Aeq}	L_{Aeq}	L_{Aeq} + 3 dB(A)

Sensitive Receptors

Noise sensitive receptors identified through landuse mapping are the residential dwellings immediately adjacent to Project area (Kg. Teluk Ketapang, Kg. Telaga Daing, Kg. Baharu Seberang Takir, Kg. Hulu Takir and Tmn. Permint Perdana), prayer houses and Pantai Teluk Ketapang (Figure 7.20). The nearest houses are located between 30 to 40 m from the Project boundary. It is noted that the ambient noise levels during night-time are well above the standard of 45 dB(A) for residential areas under Schedule 1.

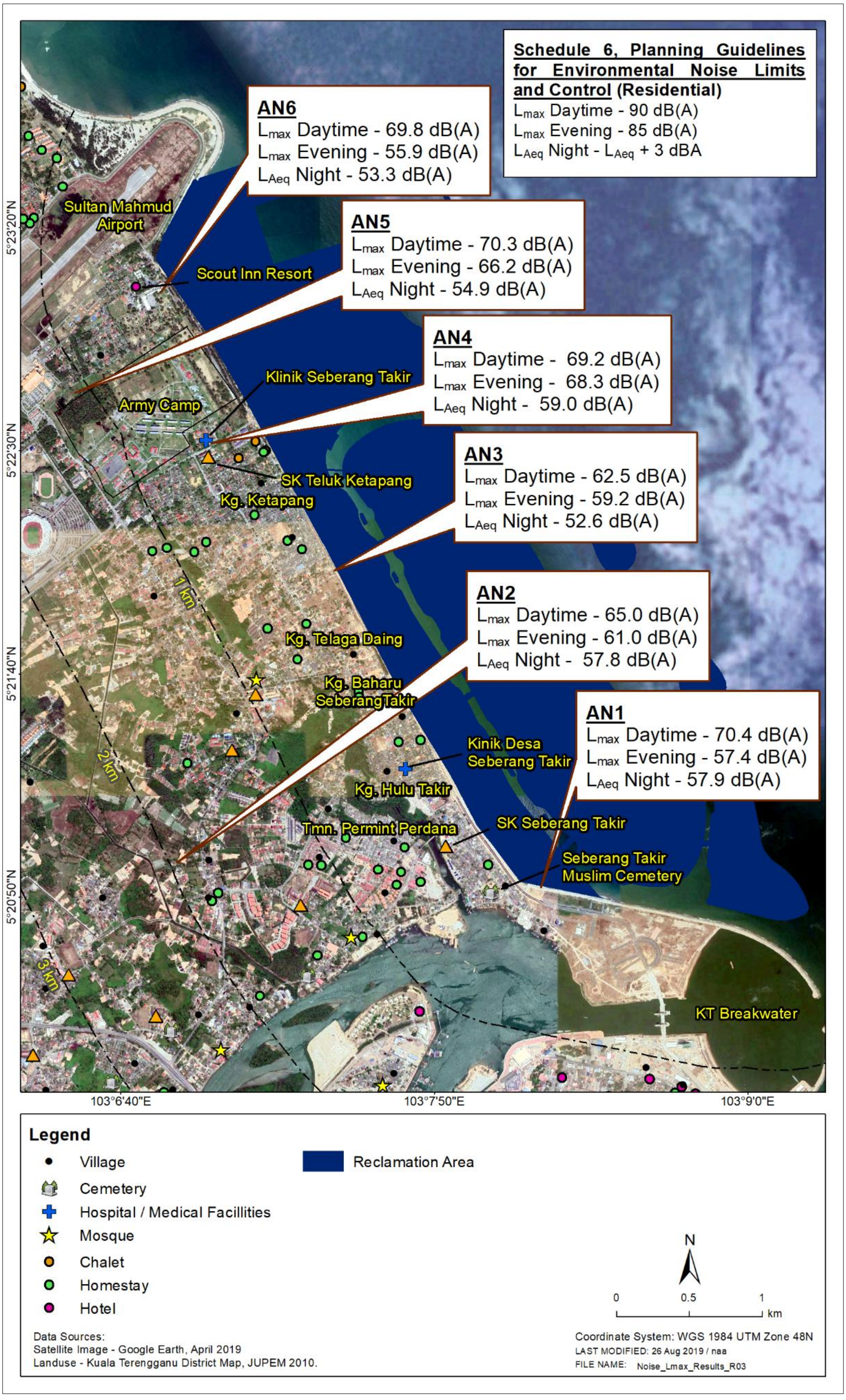

Figure 7.20 Sensitive receptors and baseline ambient noise.

Noise Sources

In the assessment of noise, a common statistical descriptor is L_{Aeq}. L_{Aeq} is the constant, average noise level, which over a period of time, contains the same amount of energy as the varying levels of the background or traffic noise. The total equivalent sound level for a typical workday during a particular construction activity can be computed as follows:

$$LAeq = 10 \times log\,10 \sum_{i=1}^{K} 10^{\frac{LAeq\,i}{10}}$$

Where,

L_{Aeq}, total = the total equivalent noise level for a typical workday during a given period;

k = the number of different types of equipment; and

L_{Aeq}, i = the equivalent noise level for equipment type, i.

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 7.23. With the above equation, the total equivalent noise level for each activity is computed assuming one unit for each equipment.

Table 7.23 Typical noise level from construction equipment /85/.

Activities	**Equipment**	**Typical Sound Level (dBA) at 30 m from Source**
Reclamation / Dredging with marine vessels	Trailing Hopper Suction Dredger (THSD)	84
	Cutter Suction Dredger	84
	Tug Boat	81
	Total Noise Emission Level	87.98
Land Grading Works	Work Boat	81
	Generator	75
	Bulldozer	79
	Truck	78
	Loader	76
	Excavator	79
	Grader	77
	Total Noise Emission Level	86.72

Noise Modelling

The prediction of noise level with construction activities was carried out using CadnaA software. The basis of the model is the linear sound propagation equation, which is used to model simple point source emissions from vehicles or industries.

Calculation of noise propagation is based on ISO 9613-2 for point source or linear source. The A-weighted sound pressure level at a receiver point LAT (equivalent continuous sound pressure level) according to ISO 9613-2 is calculated by:

$$L_{AT} = L_W + D_I + D_\Omega - A_{div} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

Where: L_W = sound power level in dB, relative to the reference sound power of 1 pW sound pressure level at 1m is assumed as sound power level.

D_I = directivity index

D_Ω = correction for solid angle

A_{div} = attenuation due to geometrical divergence

A_{atm} = atmospheric absorption

A_{gr} = attenuation due to ground effect

A_{bar} = attenuation due to screening (berms, barriers, buildings, topography)

A_{misc} = attenuation due to miscellaneous effects (foliage, industrial sites, housing)

The following assumptions are made for modelling input of noise sources:

- The modelling adopts the reclamation activities as a single point source with total equivalent noise level of 88.0 dB(A) at 30m and 86.7 dB(A) at 30m for Machinery A (dredging and reclamation machinery) and Machinery B (land grading works machinery) respectively.
- During daytime, one source for dredging and reclamation machinery and three sources for land grading works machinery are identified.
- During night time, only one noise source (dredging and reclamation machinery) will be used as dredging and reclamation works will be conducted for 24 hours. The source has been placed around 800 m from the shoreline as the area closer to the shoreline is too shallow for the dredgers.
- 88.0 dB(A) at 30 m and 86.7 at 30 m is further propagated to 1 m in distance from source, equals to 117.52 dB(A) at 1 m and 116.26 dB(A) at 1 m respectively. This value is considered as sound power level of the noise sources and is used as model input.
- The ground is considered completely flat and the entire Project area is sitting on a similar elevation.
- No obstacles between noise sources and receivers to demonstrate the worst-case scenario.
- Meteorological parameters of 30ºC temperature and 80% relative humidity was used.

It should be noted that the predicted noise level is solely from the construction activities. With the baseline noise monitoring results as background noise, the maximum cumulative ambient noise level due to the construction noise as well as the background noise is computed by the equation as follows:

$$L_{Aeq\ total} = 10\ \times Log\ 10 \sum 10^{\frac{LAeq\ i}{10}}$$

Where:

LAeq, total = the total equivalent noise level (dB) for a typical workday during a given period; and

LAeq, i = the equivalent noise level for equipment type, i.

7.2.5.2 Construction Phase

Increased Noise Exposure

Based on the results for the modelled scenarios as shown in Figure 7.21, the predicted zones of impacts during daytime can be estimated as approximately:

- Exposure to up to 55 dBA just over 1 km from the Project area, potentially affecting up to nine villages;
- Exposure to up to 60 dB(A) around 500 m from the Project area, affecting two villages;
- Exposure of up to 65 dB(A) approximately 200 m from the Project area, potentially affecting five villages.

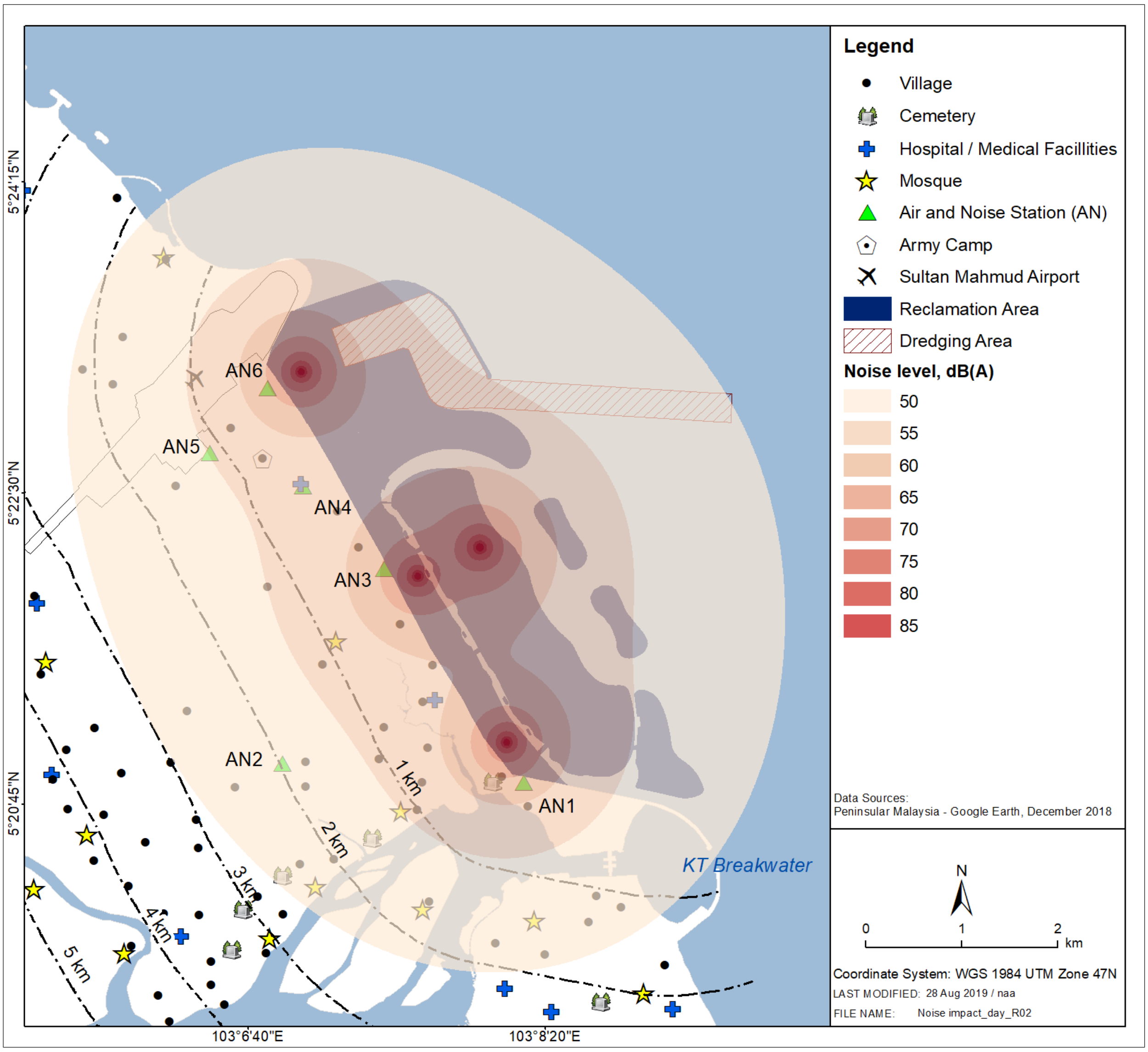

Figure 7.21 Predicted noise source emission contours during dredging, reclamation and earthworks.

Figure 7.22 shows the predicted impact zone for night-time activities. The anticipated zones of impacts are:

- Exposure to up to 50 dBA just over 1 km from the Project area, potentially affecting up to 10 villages;
- Exposure of up to 55 dB(A) approximately 300 m from the Project area, potentially affecting up to six villages.

It should be noted that the estimated values are based on worst case scenario (all machinery operating at the same time and at the Project boundary), without any control measures and does not take account of noise attenuating or dampening from topography, vegetation or other characteristics of the Project area. In practice, lower noise levels would be expected given that the machinery will be moving around within the Project area and not all operating in parallel. Further reductions can be expected with mitigation measures in place.

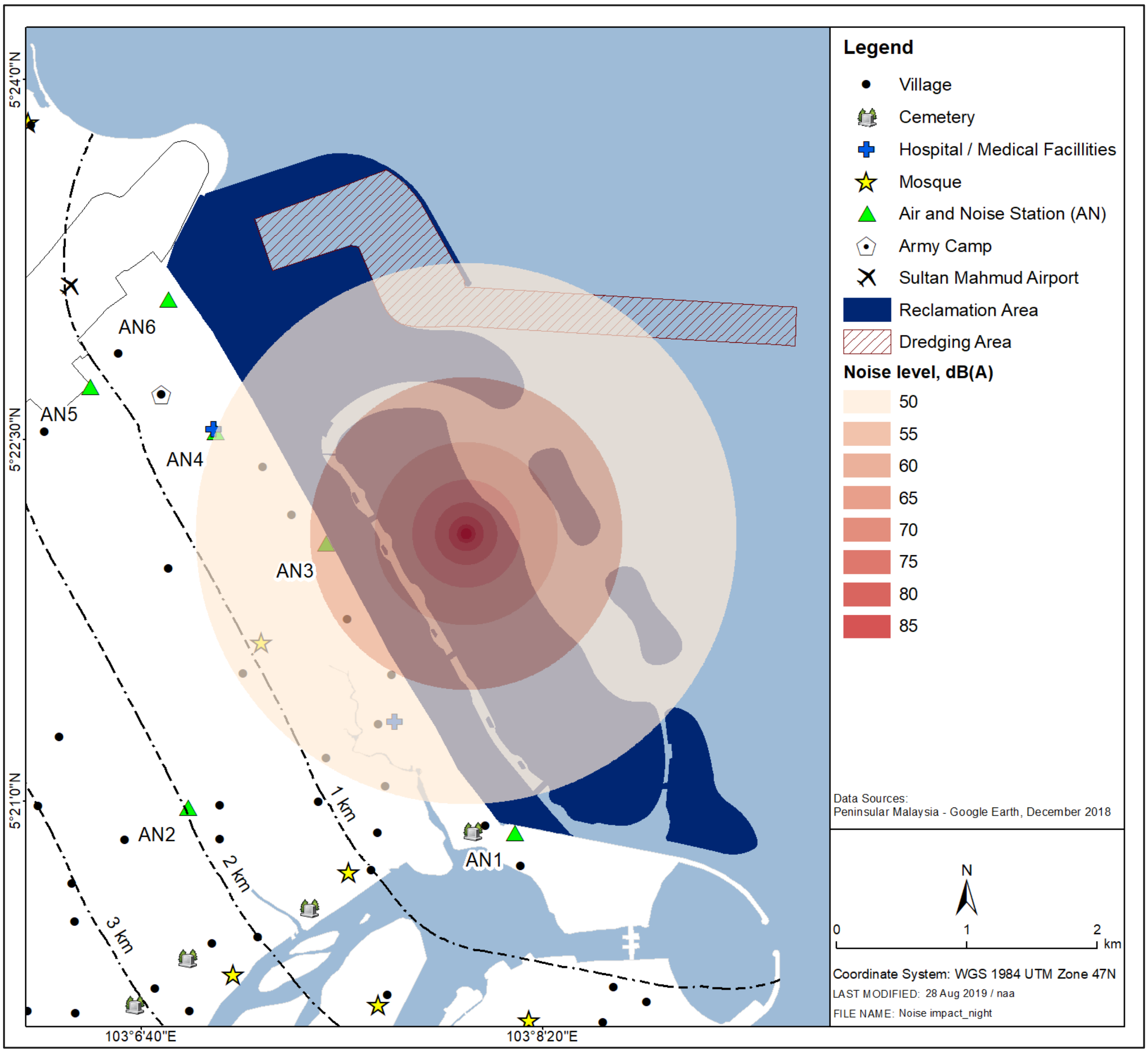

Figure 7.22 Predicted noise source emission contours during night time earthworks.

For a direct comparison to the baseline survey data, the cumulative sound levels at the baseline survey stations (AN1 to AN6), i.e. the predicted total increase in sound level from the construction considering the measured baseline levels, have been calculated as shown in Table 7.24.

Table 7.24 Predicted ambient noise level at the receiving land uses.

Receiving Receptor	Daytime (0700 – 1900), dB(A)			Evening (1900 – 0700), dB(A)			Night time (2200 – 0700), dB(A)		
	Baseline L_{max}	Predicted max. sound level	Cumulative sound level	Baseline L_{max}	Predicted max. sound level	Cumulative sound level	Baseline LAeq	Predicted max. sound level	Cumulative sound level
AN1, Kg. Seberang Takir-within 0.5 km	70.4	62.6	71.1	57.4	48.3	57.9	57.9	48.3	58.4
AN2, near Kg. Banggul Buluh-within 3 km	65.0	52.6	65.2	61.0	46.7	61.2	57.8	46.7	58.1
AN3, near Kg. Ketapang-within 0.5 km	62.5	67.3	68.5	59.2	57.1	61.3	52.6	57.1	58.4
AN4, near Klinik Kesihatan, school and surau-within 0.4 km	69.2	57.4	69.5	68.3	50.9	68.4	59.0	50.9	59.6
AN5, nearby to airport boundary as well as army camp	70.3	55.5	70.4	66.2	46.9	66.3	54.9	46.9	55.5
AN6, Near Scout Inn Resort and boy scout camp-within 3 km	69.8	66.6	71.5	55.9	47.6	56.5	53.3	47.6	54.3

Based on the prediction, the maximum daytime cumulative noise levels at the receptors ranged from 65.2 to 71.5 dB(A) while the maximum evening cumulative noise levels at the receptors ranged from 56.5 to 68.4 dB(A). During the construction phase, noise level guideline limits are referred to Schedule 6 of the Planning Guidelines for Environmental Noise Limits and Control, DOE 2007 as shown in Table 3.4. The estimated noise levels are below the daytime L_{max} – 90 dB(A) and evening L_{max} – 85 dB(A). Compliance to L_{90} and L_{10} during the construction phase could be achieved via mitigating measures and noise control management as highlighted in the following section.

During night time, the maximum night time cumulative noise levels at the receptors ranged from 54.3 to 59.6 dB(A). The noise level guideline limit during night time refers to Schedule 3 of the Planning Guidelines for Environmental Noise Limits and Control, DOE 2007, that is existing L_{Aeq} + 3 dB(A). Based on the night time cumulative results, additional L_{Aeq} is expected up to 1.0 dBA at all receptors except AN3 – Kg Ketapang, which experienced additional 5.8 dB(A). Nevertheless, the estimated values are based on worst case scenario without any control measures. Lower noise level is expected with mitigating measures take place.

The equipment will operate near the Project boundary only during the early stage of development, Phase 1 for nearly 14 months. Dredging activities during Phase 1 is limited to 1.6 months. No significant impact is expected during the following development phases.

Impact Evaluation

Based on the impact matrix, the impact is categorised as **minor negative** impact. Measures to reduce noise impact are required, see Section 8.

Criteria	Score	Rationale
Importance	2	Exposure of 55 dB(A) is limited to 1.5 km radius for daytime and 300 m radius from Project area for night time.
Magnitude	-1	The predicted L_{max} at sensitive receptors are below DOE standard of 90 dB(A) for daytime and 85 dB(A) for evening. Only Station AN3 will exceed the Schedule 3 standard for night time.
Permanence	2	Temporary and non-continuous, for 14 months during Phase 1 only
Reversibility	2	Reversible
Cumulative	2	Non-cumulative
Environmental Score	-12	
Description	-B	Minor negative impact

7.2.5.3 Post-construction Phase

Not applicable.

7.2.6 Primary Producer Benthic Habitats

The following sections detail the discussion on possible impact from Project activities to primary producer habitats, such as coral reefs, seagrass or seaweed bed. Non-primary producers, i.e. macrobenthic communities are discussed separately in Section 7.2.6.

7.2.6.1 Evaluation Framework

The Project area is predominantly sand, with no existing seagrass or coral areas. As such the key sensitive receptors as outlined in Section 6.3.1 are the three concrete FADs within 1 km of the Project area and an estimated 15 FADs within 5 km radius (Figure 7.23). The concrete FADs are generally colonised by soft corals, seaweed and barnacles. These organisms are known to have high tolerance to suspended sediment. No hard corals were observed within the study area; the nearest reported hard coral reefs are located at P. Kapas.

As shown in Figure 7.23, no FADs will be directly affected, i.e. removed, by the Project footprint. They will, however, be exposed to increased turbidity (TSS levels) and siltation during the dredging and reclamation works. Other potential impacts may include damage from anchoring by the working vessels as the nearest FAD is 200 m from the reclamation footprint.

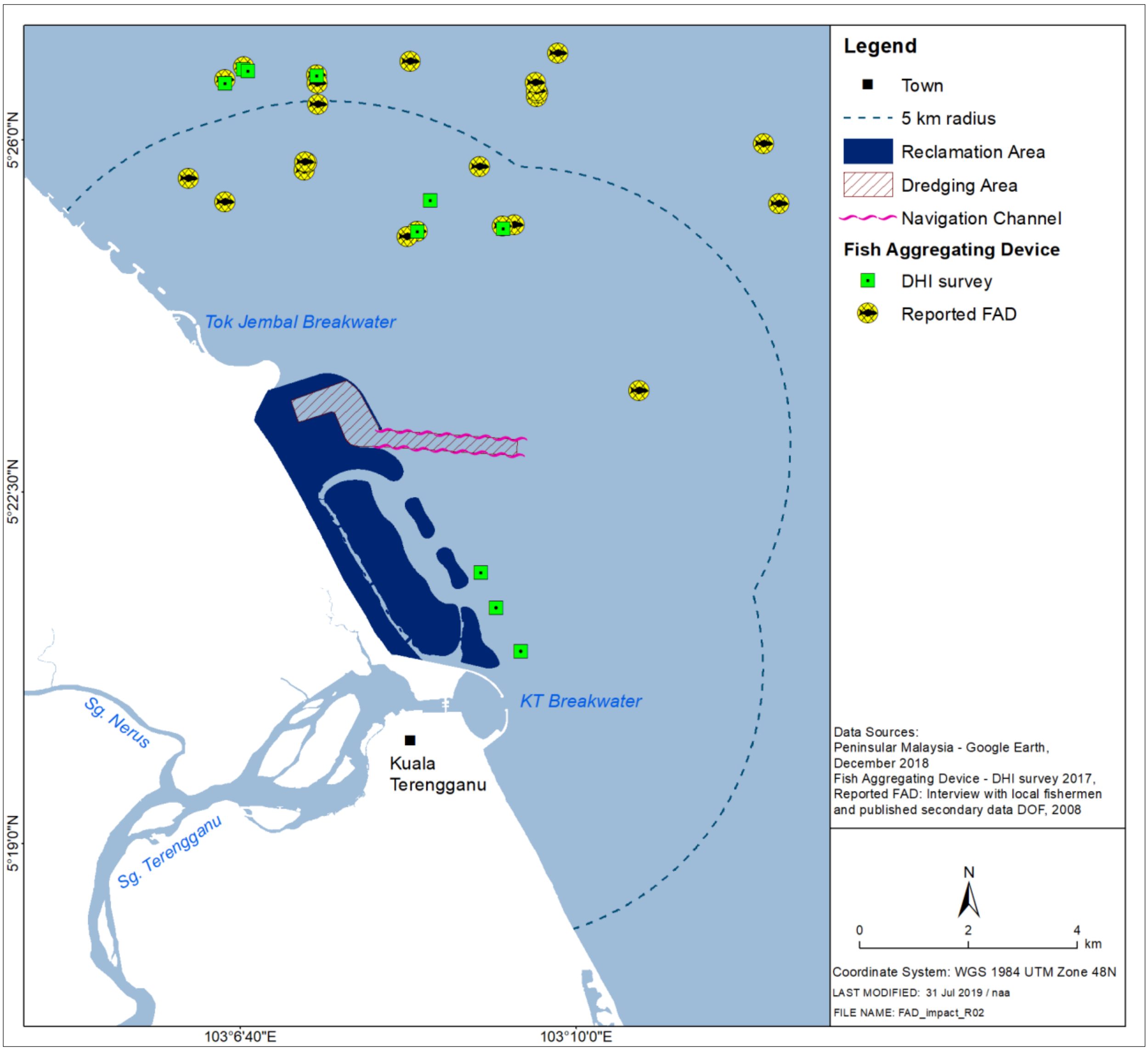

Figure 7.23 FADs within 5 km of the Project.

Suspended Sediment Plume and Sedimentation Impacts

The assessment of impacts to soft coral has been carried out by assessing the severity of the suspended sediment plume and sedimentation due to reclamation and dredging activities. The suspended sediment plumes and sedimentation have been predicted using numerical modelling as described in Sections 7.2.1 (sediment plumes) and 7.2.2 (sedimentation).

Several studies have recorded distribution of octocorals (gorgonians and soft corals) communities in wide range of water turbidity, from clear to turbid /86,87,88/. These studies suggested that zooxanthellate-free taxa of octocoral tend be in abundance at more turbid waters and vice versa. However, there are no sufficient data on octocoral tolerance to suspended sediments/sedimentation available from literature to develop the tolerance thresholds /89/.

Therefore, in the absence of threshold limits for soft coral, impact indicators for hard coral exposure to TSS and sedimentation have been used as outlined in Table 7.25

and Table 7.26 respectively. Given that hard coral is more sensitive to TSS than soft corals, this is a conservative, worst case scenario assessment.

These thresholds are derived from the EIA report for the Wheatstone Project, Australia, where an extensive literature review was carried out to establish coral tolerance thresholds to TSS - Environmental Impact Statement /Environmental Risk Management Plans, Appendix N3, Tolerance Limit Report, undertaken by Chevron Australia /89/.

Table 7.25 Impact severity matrix for suspended sediment on hard corals for near shore waters /89/.

Zone of Impact	Definitions
High Impact Widespread mortality may be expected.	• Excess TSS > 25 mg/L for more than 14% of the time OR • Excess TSS > 10 mg/L for more than 38% of the time OR • Excess TSS > 5 mg/L for more than 63% of the time
Moderate Impact Stress and some (<30%) mortalities can be expected.	• Excess TSS > 25 mg/L for 5-14% of the time OR • Excess TSS > 10 mg/L for 20-38% of the time OR • Excess TSS > 5 mg/L for 50-63% of the time
Minor Impact Corals may experience some stress however 0% mortality expected in this zone.	• Excess TSS > 25 mg/L for 1-5% of the time OR • Excess TSS > 10 mg/L for 1-20% of the time OR • Excess TSS > 5 mg/L for 5-50% of the time
No Impact	• Excess TSS > 25 mg/L for less than 1% of the time OR • Excess TSS > 10 mg/L for less than 1% of the time OR • Excess TSS > 5 mg/L for less than 5% of the time

Table 7.26 Thresholds for sedimentation impact on corals for nearshore waters.

Zone of Impact	Definitions
High Impact	Sedimentation more than 34 mg/cm^2/day (estimated to bed level change of more than 23.8 mm/28 days)
Moderate Impact	Sedimentation 10 - 34 mg/cm^2/day (estimated to bed level change of 7.0-23.8 mm/28 days)
Minor Impact	Sedimentation 2.5 - 10 mg/cm^2/day (estimated to bed level change of 1.8 – 7.0 mm/28 days)
No Impact	Sedimentation less than 2.5 mg/cm^2/day (estimated to bed level change of less than 1.8 mm/28 days)

7.2.6.2 Construction Phase

Suspended Sediment Impacts

The model predicts that the extent of the plume with concentrations above 5 mg/L will affect the FADs at the north of Project area during Phase 1c and at the north and south of Project area during Phase 2 development (Figure 7.24). The 5 mg/L concentrations are however exceeded only between 5 - 20% of the time at the FADs. During Phase 3 development (development closest to the FADs at south), no suspended sediment impacts are anticipated to the FADs. Only Southwest climatic condition modelling result is shown here as no construction activities will be conducted during Northeast monsoon for Phase 1c and 2.

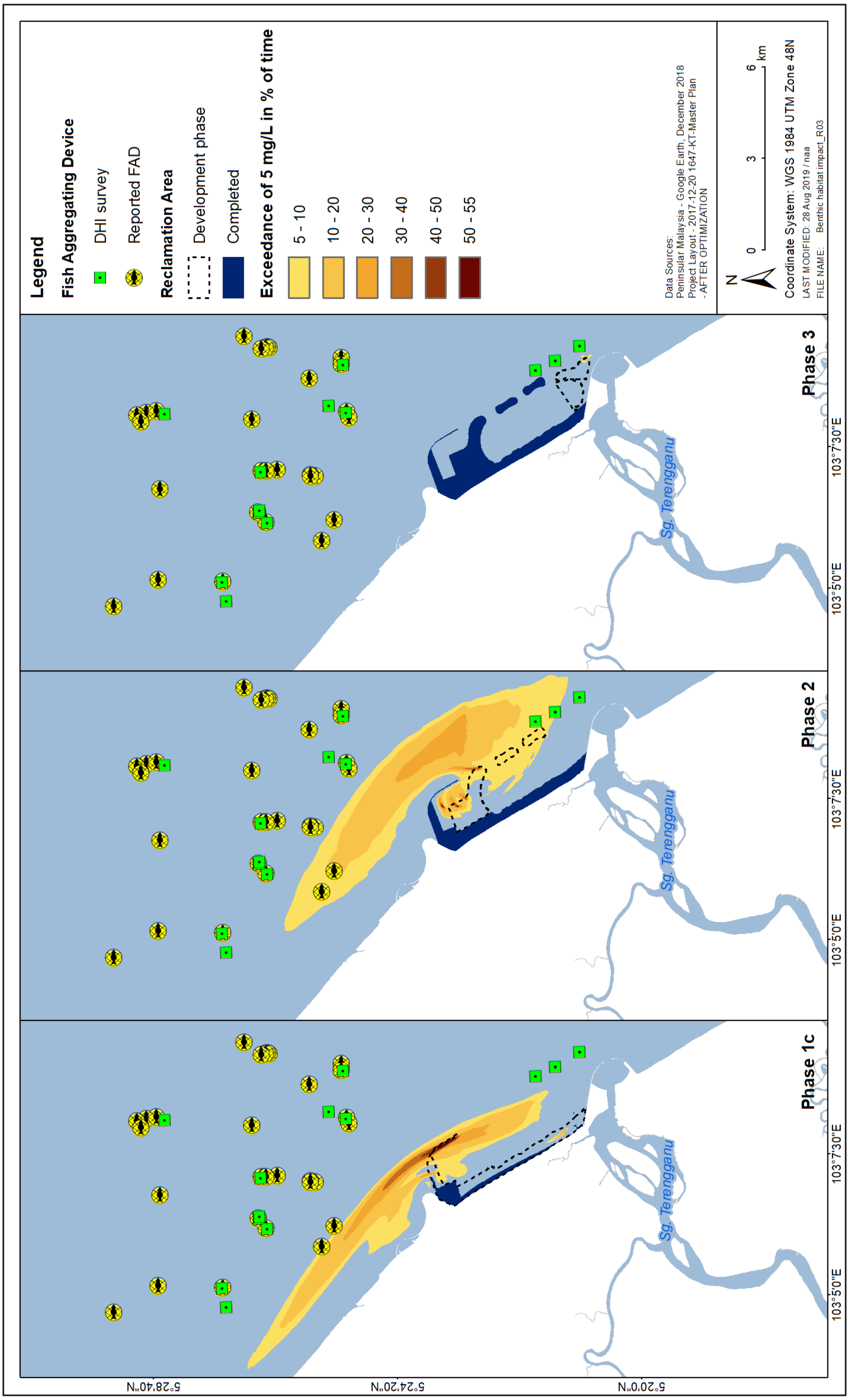

Figure 7.24 Predicted duration in exceedance of 5 mg/L excess TSS concentrations for Southwest monsoon during Phase 1c, 2 and 3 development.

Impact Evaluation

Based on the RIAM matrix, the impact is categorised as **minor negative** impact.

Criteria	Score	Rationale
Importance	2	The potentially affected FADs are three FADs within 300 m of the Project area and two FADs at the north within 5 km of the Project area.
Magnitude	-1	There is a risk of minor impacts on the FADs for Phase 1c and 2 dredging and reclamation works.
Permanence	2	Temporary impact, primarily limited to Phase 1 and 2 SW monsoon.
Reversibility	2	Reversible
Cumulative	2	Non-cumulative
Environmental Score	-12	
Description	-B	Minor negative impact

Sedimentation

As outlined in Section 7.2.2 (Coastal Morphology), sedimentation of fines from reclamation and dredging has been simulated for all development phases and climatic scenarios. Phases 1c and 2, which involve both dredging and reclamation are presented in this section, as well as Phase 3 reclamation works due to its proximity to the sensitive receptors; see Figure 7.25. The results for Southwest climatic condition are presented here as construction activities during the Northeast monsoon will be avoided for the stated development phases.

The model predicts that the impact zone from sedimentation will affect the FADs north of the Project and near the southern part of the Project especially during Phase 2 (Figure 7.25). The impact however, is limited to a minor impact, between 1.8 – 7.0 mm/28 days (as per threshold Table 7.26) with no mortality of corals or seaweed expected.

Impact Evaluation

Based on the RIAM matrix, the impact is categorised as **minor negative** impact.

Criteria	Score	Rationale
Importance	2	Potential impacts of sedimentation are confined to the FADs within 5 km north of the Project.
Magnitude	-1	The change in bed thickness of 1.8 – 7.0 mm/28days falls under minor impact
Permanence	2	Temporary impact until the completion of reclamation and dredging.
Reversibility	2	Reversible

Criteria	Score	Rationale
Cumulative	2	Non-cumulative
Environmental Score	-12	
Description	-B	Minor negative impact

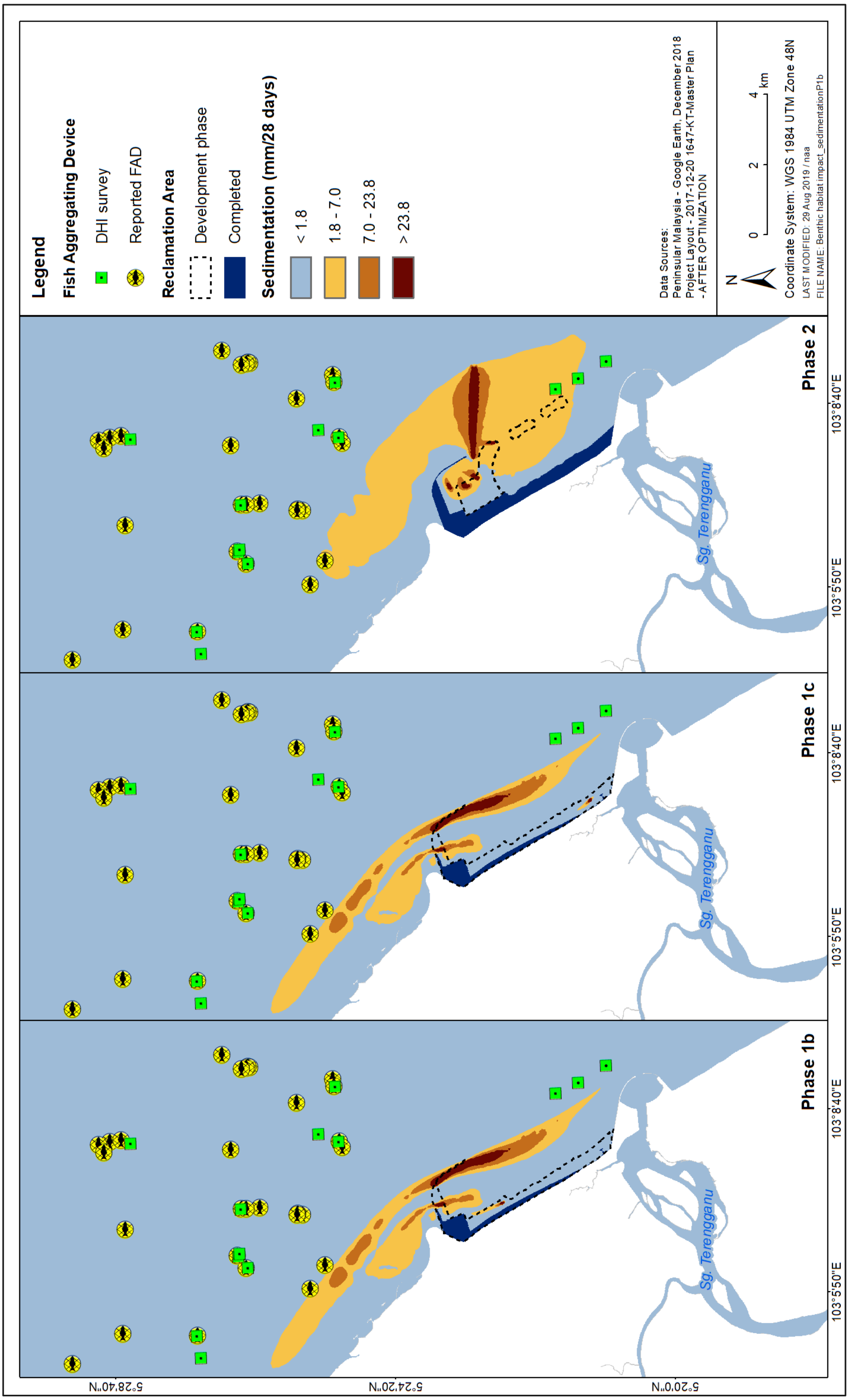

Figure 7.25 Predicted sedimentation rate over 28 days simulation period for Phase 1b, 1c and 2 development during Southwest monsoon.

Risk of Damage to FADs

The increased number of marine vessels around the Project area could increase the risk of damage to the FADs by the construction vessels colliding, anchoring or dragging the FADs, particularly for FADs at the south of the Project, which are located 200 m from the Project boundary. These FADs are located in water depths of around 8 m MSL.

Impact Evaluation

The potential risk of damage to FADs is a **slight negative** impact based on the RIAM evaluation summarised below.

Criteria	Score	Justification
Importance	1	Impacts likely to be limited to the FADs at the south of the Project
Magnitude	-1	The likelihood of collision is low
Permanence	3	The effect could be permanent, depending on the type of damage to FAD structures
Reversibility	3	Irreversible.
Cumulative	2	Non-cumulative
Environmental Score	-8	
Description	-A	Slight negative impact

7.2.6.3 Post-construction Phase

Eutrophication, Sedimentation and Erosion

The permanent impact of the loss of seabed area of 768 ha due to the Project reclamation footprint affects macrobenthos and with consequent effects on fish fauna, which are assessed in Section 7.2.7 and 7.2.9. Reclamation of a large area of the coast and dredging activities will also change the hydraulics and with potential effects on water quality, sediment erosion and deposition patterns, etc. in the Project area. Based on the assessment of these issues in their respective sections, no impact to the FADs are anticipated. These are briefly summarised as follows:

- Water quality / flushing (Section 7.2.1) – no significant eutrophication is predicted due to changes in flushing in the Project area and hence no impacts to the seaweed and soft corals at the FADs are predicted;
- Sedimentation and erosion (Section 7.2.2.3) – no significant sedimentation or erosion is anticipated within or outside the immediate Project area; no impacts to marine benthic habitats are anticipated.

Impact Evaluation

Based on the RIAM matrix, the impact is categorised as **no change**.

Criteria	Score	Rationale
Importance	1	The changes are confined to the area immediately around the Project
Magnitude	0	No impacts to the FAD area are predicted
Permanence	3	Permanent
Reversibility	3	Irreversible
Cumulative	2	Non-cumulative
Environmental Score	0	
Description	N	No change

7.2.7 Macrobenthos

7.2.7.1 Evaluation Framework

The Project comprises of land reclamation which would directly affect the macrobenthic community through permanent loss of habitat. Sediment communities have been found to play a critical role in the food chain for marine organisms. Therefore, the potential loss of macrobenthic fauna either through reclamation or dredging works would not only negatively impact the fish fauna around the Project area but also other higher trophic levels in the adjacent areas which depends on benthic communities for food.

As described in the earlier chapter, macrobenthos density ranged between 320 to 2,500 individuals/m^2. This density range was similar to the study conducted by Ibrahim *et al.* (2006) at sandy areas at P. Karah, Terengganu, which recorded 700 to 2,000 individuals/m^2. The major taxonomic group present belonged to the phylum Mollusca whereas annelids (dominated by the polychaetes *Ditrupa* sp.) accounted for the highest density. Organisms of this genus are suspension feeders, which means that they may be sensitive to high suspended sediment.

The evaluation of impacts of macrobenthic community was carried out based on the boundary of the reclamation area, as this is the footprint whereby permanent and irreversible loss of the macrobenthic habitat will occur; and the boundary of the dredging area, as well as results of suspended sediment plume modelling and sedimentation to assess construction phase impacts.

The impact of suspended sediment, sedimentation and dredging was assessed based on available literature on the tolerance level of the macrobenthic organisms towards this pressure. The threshold used to assess the impacts due to suspended sediment which primarily affects filter feeders is 10 mg/L as literature has shown that the upper tolerance level for suspended sediment is between 10 and 15 mg/L /92/ whereas for sedimentation, a threshold value of 32 cm deposition was used /90/.

7.2.7.2 Construction Phase

Suspended Sediment

Suspended sediment associated with reclamation and dredging such as the release of sediment during in-filling and resuspension of sediment during settlement due to wave activity will impact the benthic communities by impairing respiration, feeding, and visual foraging due to the increase in turbidity.

The sensitivity of benthic invertebrates to suspended sediment is species specific. The direct physical impacts (gill clog, impairment of respiration and feeding) from suspended sediments can be more vulnerable to suspension feeders such as various polychaete worms and bivalves (e.g. mussels, cockles).

It should be noted that for each organism, effects will occur above a different threshold concentration of suspended sediments and also vary among the different life stages (larva, juvenile and adult) /91/. For example, in Griffiths and Watson (1978), the upper tolerance level for suspended sediment for macroinvertebrates was between 10 and 15 mg/L /92/ whereas in a study by Nicholls *et al.* (2003), the bivalve *Macomona* sp. only showed increased mortality at suspended sediment concentrations of more than 300 mg/L /93/.

Sediment plume excursion for concentrations for in excess of 10 mg/L for more than 5% of the time is expected to extend to a maximum of about 9 km north and 2 km east/southeast from the Project (Figure 7.26). Although this is the case, the impacts to macrobenthos are considered low as the suspended sediment plume is temporary and because the benthic population is capable of recolonization on a time scale of months to a few years post dredging /94/.

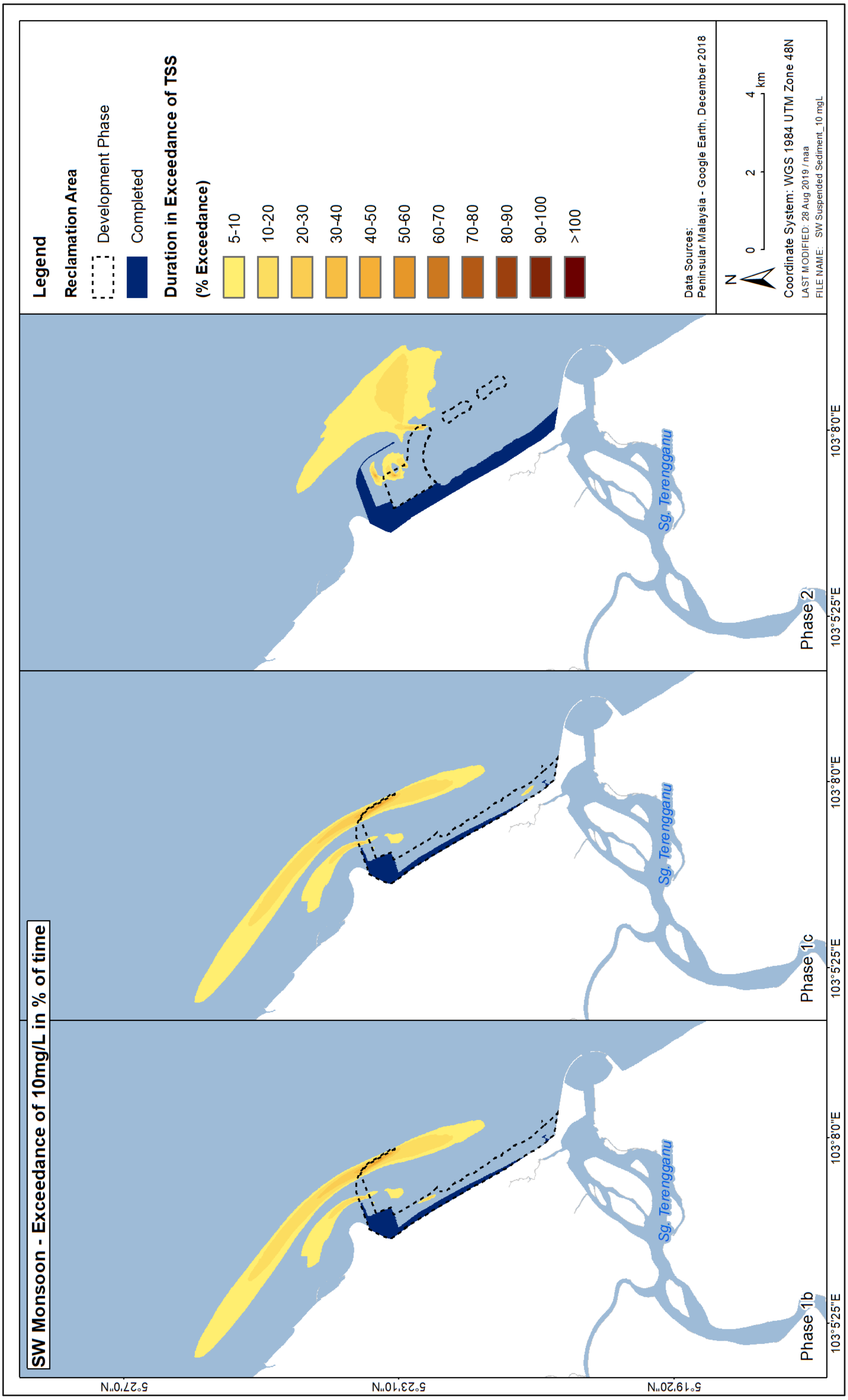

Figure 7.26 Exceedance of 10 mg/L excess TSS in % of time during SW monsoon.

Impact Evaluation

Based on the RIAM, the impact is considered to be **minor negative**.

Criteria	Score	Rationale
Importance	2	The furthest point of 10 mg/L plume excursion is around 5 km from the Project
Magnitude	-1	Excess concentrations above 10 mg/L occur for less than 10% of the time in this zone of impact. Minor change to communities is expected.
Permanence	2	Temporary
Reversibility	2	Reversible
Cumulative	2	Non-cumulative
Environmental Score	-12	
Description	-B	Minor negative impact

Sedimentation

There are several potential direct effects of sedimentation to benthic communities and these include smothering, reduce growth and feeding efficiency of invertebrates. Vulnerable macrobenthos would be the small and recently settled life-stages of many species and so are organisms that mainly dwell on sediment surfaces due to their need to be in contact with the sediment-water interface.

The impact to the benthic communities will largely be dependent on the amount and type of sediment settled including the duration of burial. The sedimentation of fine sediment on sediment surface decreases the substrate particle size distribution, resulting in a change from a heterogenous substrate to a more homogenous substrate. The type benthos present in the area would also determine the scale of impact. Mobile species such as polychaetes, bivalves, gastropods and crustaceans have been shown to migrate between 2 cm and 26 cm during 8 days after burial by 32 cm (320 mm) of sand /90/. In the present EIA, the dominant type found was polychaetes which accounted for 50.5% of the total macrobenthic density.

Figure 7.27 shows the worst-case scenario during SW monsoon (for Phase 1b to Phase 2) and NE monsoon (for Phase 3). Results from the SW monsoon are presented for Phase 1b to Phase 2 as no construction works are anticipated during NE monsoon during these phases (refer to Section 7.2.1 Sediment Plume Modelling). Based on morphological modelling, deposition of fine sediment of above 100 mm/28days is predicted to occur within the Project area during construction works (Figure 7.27). The impact to macrobenthos due to deposition of sediment in this study is predicted to be very low considering the construction works will be temporary and because similar habitats are found nearby the impacted area.

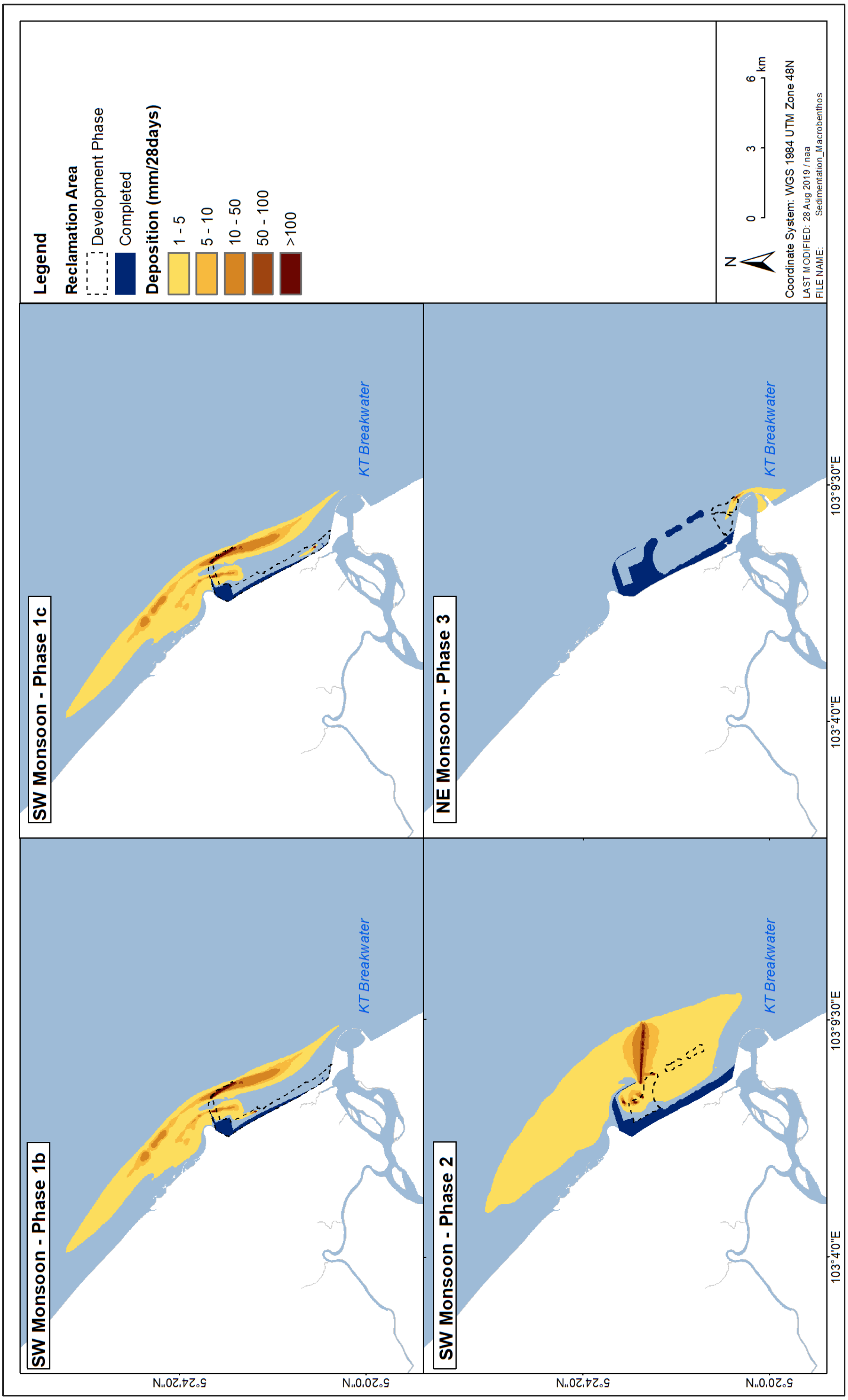

Figure 7.27 Sediment deposition during SW monsoon and NE monsoon.