CHAPTER 7

EVALUATION OF IMPACTS

7.1 Identification And Prediction Assessment

The Proposed Project involves development on rehabilitation and land reclamation works Jelutong, Daerah Timur Laut, Pulau Pinang to cater for a block of mixed coastal development.

A. Physicochemical Environment

(i) Lithosphere

The Proposed Project site covering an area of 160 acres comprising of the Jelutong Landfill site and a new landmass has generally flat terrains of RL+4.35 m to RL+37 m above mean sea level for the landfill site. The landfill site is to be rehabilitated and dump materials removed from the site and suitable material that can be used will be used for the reclamation site and top up with fill material to final platform level of +5.75 m NGVD (National Geodatic Vertical Datum).

With the development of the Proposed Project, which will see the project site turning into a mixed development area comprising of residential and commercial land use, houses and business opportunities will be provided for the local population as well as external to Penang. Thus, aspects that have to be considered include changes in land form and potential land contamination due to the changes in land use.

(ii) Atmosphere

In terms of air quality the project site and its surrounding area has a relatively good ambiance with air quality below the ambient air quality guidelines for PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO and O_3. Noise levels measured at the project site for daytime levels are within the guidelines for urban residential use however the nighttime noise levels are found to be within the guidelines for urban residential use.

Presently the existing landfill landmass is vegetated scattered with shrubs and undergrowth and all biomass have to be managed and removed from the site. The ESCP will be put in place followed by rehabilittion and reclamation works and earthworks will proceed once approval is obtained for the individual land parcels for the Proposed Project. Prior to temporary drains, sedimentation ponds, silt traps, washing bays and site offices will be constructed at site to cater for the construction parcels and plots.

Once the earthwork is completed this will be followed by the construction of new buildings, structures and infrastructure planned for the Proposed Project. Thus aspects to be considered that may cause impacts to the atmosphere include air quality.

Fugitive emission is anticipated due to turbulance winds or the exposed areas which may result in the degradation of the ambient air quality during rehabilitation work, reclamation work, earthwork and building work.

(iii) Hydrosphere

The reclamation works may affect water quality. The topside development once implemented will generate surface runoffs and stormwaters which will have to be managed in a sound manner so as not to cause localized floodings and soil wash out resulting in erosion. The external drains surrounding the project site are already in place. All stormwater discharges and runoffs from the Proposed Project site will enter the proposed man made drainage system planned for the Proposed Project which enters into the sea. Domestic sewage from the worker camps for the individual land parcel will be collected and treated in septic tanks approved by SPAN during the construction stage while during occupancy, sewage however will be channeled to the regional sewage treatment plant already operational in the area (IWK Asset No. PEG 227) operated and managed by IWK. The marine during the field sampling is at the coastal area is excellent at the time of sampling.

Thus aspects to be considered that may result in impacts to the hydrosphere that has to be considered include changes in hydrology and water quality.

B. Biological Environment

As outlined in **Chapter 6**, mangrove are not evident along the coastline where the area will be reclaimed. On the existing landfill only shrubs and undergrowth can be found. Nonetheless measures are to be in place to ensure the issues are addressed.

C. Human Environment

The construction stage will generate job opportunities for both skilled and unskilled workers. Other service industries supporting the construction industry will also be given business opportunities. Thus, the construction industry will temporary occupy the site of the Proposed Project.

Noise and safety issues due to the construction activities at site during foundation, excavation and trenching works and others are aspects that have to be managed in order to ensure the health and safety of the workers at site and surrounding population are not affected during the construction stage.

Once the Proposed Project is fully completed, the demographic profile of the area will change resulting in additional population of approximately 91,714 PE in the mixed developed area. With the increase in population, domestic wastes and sewage will be generated and traffic will be generated/produced in the new developed area.

Thus impacts to the human and social environment that has to be looked into include health and safety issues, noise and socio economy.

D. Impact Assessment Criteria

This chapter therefore identifies and appraises the salient environmental issues brought upon by the implementation of the Proposed Project and the impacts generated by the Proposed Project throughout the implementation stage of the Proposed Project.

The discussion focuses on the key activities and issues likely to create impacts to the various environmental resource and components in the surrounding area for each stage of project development.

The assessment approach is undertaken by addressing environmental issues in its three stages of project implementation that will be undertaken for the development i.e. the pre-construction, construction and operation stage and by assessing the impacts on the physiochemical biological component as described earlier in **Chapter 6** of the report. For this purpose to ease the assessment conducted for the Proposed Project a summary of the impact assessment in tabulated form is provided in this chapter which outlines all activities to be conducted in implementing the Proposed Project at various stages of development.

Basic environmental resource factors for each environmental component are identified on the horizontal axis of the table some of which are described in **Chapter 6** of this report. The project activities for each stage of development, covering the pre-construction, construction and operation stage identified in **Chapter 5** of the report are presented on the vertical axis of the table.

The potential impacts of the project activities on each of the environmental resource factor in each environmental component is rated according to a scale based on professional judgment, guidelines and quantitative assessments made.

Symbols are used for the impact assessment table with this rating; I if the impacts is insignificant and exclude from the matrix, e if the environmental impacts that is potentially significant but on a temporary basis and will assume equilibrium after certain period of time, E if the environmental impacts that is potentially significant but about which there is insufficient data to make a reliable prediction and close monitoring and control is recommended, P if the impact is potentially significant adverse environmental impact for which a design solution has been identified, R if the impact is residual and significant adverse environmental impact and S if the impact is a significant environmental enhancement. This rating scale appears in the boxes provided under each environmental component assessed. Based on individual assessment of the resource factor, which is grouped under the column of environmental component, the degree of significance is assessed and the appropriate ratings are then placed in each of the cell in the table as shown in **Table 7.1**.

After evaluating the significance of the impact, mitigation measures are then recommended and outlined in **Chapter 8** of this report. Residual impacts if any, with the mitigation measures in place are also identified in **Chapter 7.**

At the end of the impact assessment, a matrix table is provided to highlight the issues of concern for each implementation stage according to environmental component.

Prior to the impact assessment, the entire project activities at each stage of project development are briefly discussed as guidance in the assessment process. This is then followed with detailed assessments.

7.2 Details Of Impact Assessment

A. Pre Construction Stage

As outlined, the activities during the pre construction stage are mainly related to surveys and site investigations which are normally conducted in small scale and localized. These activities therefore does not cause any significant impacts. The studies conducted are used to plan and design the Proposed Project. Nonetheless measures are to be in place to ensure that the studies are conducted in a competent and professional manner.

Table 7.1
Summary Of Impact Assessment

Key:	
I	Insignificant and excluded from Matrix
e	Environmental impact that is potentially but on a temporary basis and will assume equilibrium after certain period of time
E	Environmental impact that is potentially significant but about which there is insutificient data to make a reliable prediction. Close monitoring and control is recommended
P	Potentially significant adverse environmental impact for which a design solution has been identified
R	Residual and significant adverse environmental impact
S	Significant environmental anhancement
	Identification of Activites

				PROJECT ACTIVITIES													
				PRE-CONSTRUCTION			CONSTRUCTION						OPERATION AND MAINTENANCE				
				SURVEY	INVESTIGATION	LAND ACQUISITION	ACCESS ROAD	SITE CLEARING	EARTHWORKS	BUILDING CONSTRUCTION	UTILITIES	ABANDOMENT	OCCUPATION	WASTE DISPOSAL	TRAFFIC	MAINTENANCE	ABANDONMENT
ENVIRONMENTAL COMPONENTS	PHYSICOCHEMICAL	LAND	Landforms	I	I	I	I	P	P	P	P	P	I	I	P	I	I
			Soil Profile	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Soil Composition	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Slope Stability	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Subsidence and Compaction	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Seismicity	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Flood Plains/Swamps	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Land Use	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Engineering and Mineral Resources	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Buffer Zones	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		SURFACE WATER	Shore Line	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Bottom Interface	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Flow Variation	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Water Quality	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Drainage Pattern	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Water Balance	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Flooding	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Existing Use	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		GROUND WATER	Water Table	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Flow Regime	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Water Quality	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Recharge	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Aquifer Characteristics	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Existing Use	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		ATMOSPHERE	Air Quality	I	I	I	P	P	P	P	P	P	I	I	I	I	I
			Air Flow	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Climatic Changes	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Visibility	I	I	I	I	I	I	I	I	I	I	I	I	I	I

Table 7.1 (Continue)

Key:	
I	Insignificant and excluded from Matrix
e	Environmental impact that is potentially but on a temporary basis and will assume equilibrium after certain period of time
E	Environmental impact that is potentially significant but about which there is insutificient data to make a reliable prediction. Close monitoring and control is recommended
P	Potentially significant adverse environmental impact for which a design solution has been identified
R	Residual and significant adverse environmental impact
S	Significant environmental anhancement
	Identification of Activites

				PROJECT ACTIVITIES													
				PRE-CONSTRUCTION			CONSTRUCTION						OPERATION AND MAINTENANCE				
				SURVEY	INVESTIGATION	LAND ACQUISITION	ACCESS ROAD	SITE CLEARING	EARTHWORKS	BUILDING CONSTRUCTION	UTILITIES	ABANDOMENT	OCCUPATION	WASTE DISPOSAL	TRAFFIC	MAINTENANCE	ABANDONMENT
ENVIRONMENTAL COMPONENTS		NOISE	Intensity	I	I	I	I	P	P	P	P	I	I	I	P	I	I
			Duration	I	I	I	I	P	P	P	P	I	I	I	P	I	I
			Frequency	I	I	I	P	P	P	P	P	I	I	I	P	I	I
	BIOLOGICAL	SPECIES AND POPULATIONS	Terrestrial Vegetation	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Terrestrial Wildlife	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Other Terrestrial Fauna	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Aquatic/Marine Flora	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Fish	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Other Aquatic/Marine Fauna	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		HABITATS AND COMMUNITIES	Terrestrial Habitats	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Terrestrial Communities	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Aquatic Habitats	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Aquatic Communities	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Estuarine Habitats	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Estuarine Communities	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Marine Habitats	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Marine Communities	I	I	I	I	I	I	I	I	I	I	I	I	I	I
	HUMAN	HEALTH AN D SAFET Y	Physical Safety	I	I	I	P	P	P	P	P	P	I	P	P	I	I
			Psychological Well-Being	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Parasitic Disease	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Communicable Disease	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Physiological Disease	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		SOCIAL A ND ECON OMIC	Employment	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Housing	I	I	I	I	I	I	I	I	I	S	I	I	I	P
			Education	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Utilities	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Amenities	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Property & Settlement	I	I	I	I	I	I	I	I	I	I	I	I	I	I
		AESTHETIC AND CULTURAL	Landforms	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Biota	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Wilderness	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Water Quality	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Atmospheric Quality	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Climate	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Tranquility	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Sense of Community	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Community Structure	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Man-Made Objects	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Historic Places or Structure	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Religious Places or Structure	I	I	I	I	I	I	I	I	I	I	I	I	I	I
			Landscape	I	I	I	I	I	I	I	I	I	I	I	I	I	I

Source : Environmental Impact Assessment Guidelines in Malaysia

B. Construction Stage

Construction stage will only commence when all related approvals have been obtained and involves activities such as rehabilitation of the Jelutong Landfill and reclamation of new land, construction on both rehabilitation and reclamation land involves earthworks, construction of buildings and infrastructure including building finishing and landscaping. The discussion in this section is provided in two parts namely impacts during the rehabilitation works and impacts due to the reclamation activities on the new land mass.

(i) Rehabilitation Works On Existing Landfill

According to the report entitled "Jelutong Dump Site, Penang – Preliminary Investigation & Conceptual Closure Options Appraisal" prepared for PDC (Penang Development Corporation) by M.E.I. Consultants Sdn. Bhd. and CH2M HILL Malaysia Sdn. Bhd., records indicate that the solid waste disposal commenced at Jelutong Landfill as early as the late 1990s as part of the redevelopment of adjoining land and the construction of the Tun Dr Lim Chong Eu Expressway in 2001. The predominant waste stream is understood to have been residential collection wastes comprising putrescible, biodegradable materials (referred to herein as MSW) such as food, packaging, paper, timber, and plastics in the earlier years.

A majority of the wastes after 2002 comprised of construction, demolition and soils excavated as part of the ongoing development works on Penang Island. Green wastes collected from parkland areas were also disposed at the Jelutong Landfill.

Formal records of individual waste streams are not available prior to 2005. However, it is considered that a greater proportion of the waste input would be comprised of MSW derived from residential dwellings.

From 2005, following the diversion of residential (household) waste streams away from the Jelutong Landfill, disposal of wastes is largely estimated to be from construction, demolition and soil materials derived from foundation construction works on the Island (e.g., piling). Green (park) type wastes are still being accepted at Jelutong Landfill, but is likely to represent a low percentage by tonne of the current total waste input to the site.

Based on a topographic survey of the landfill carried out in August 2021, the estimated volume of the dump site materials is 11,329,285 m^3 and the waste height has reached some 37 m above MSL (Mean Sea Level).

The current lateral extent of the Jelutong Landfill is already at its capacity for the waste disposal operations to expand southwards, northwards or eastwards. Expansion of the waste disposal operations is blocked by two stormwater/treatment plant drains located immediately north and south of the landfill.

However, it is understood that wastes are still being dumped at Jelutong Landfill annually by increasing the waste height. This is significant in terms of maintaining stable side slopes now that the waste height is up to 37 m above MSL.

The following provides the potential impacts of disturbing the Jelutong Landfill as the material will be excavated out, temporary stockpile at site and suitable material will be recyled for reuse whilst unusable material will be stockpiled and dispose for sale to vendors or at MBSP disposal site in Pulau Burung.

(a) Gaseous Emissions At Landfill site

According to the US Department of Health the gases produced in landfills, ammonia, sulfides, methane and carbon dioxide are of most carbon. Ammonia and hydrogen sulfide are responsible for most of the odors at landfills. Methane is flammable and concentrations have sometimes exceeded levels indoors. Methane and carbon dioxide can also collect in nearby buildings and displace oxygen.

According to the baseline data outlind in **Chapter 6.5**, ammonia, sulfides, carbon dioxide and methane are detected at the landfill site. Of concern is the concentration of the methane gas ranging from 11,200-310,000 mg/m^3. This shows that there is still activities below the ground level of Jelutong Landfill.

Generally methane and carbon dioxide make up 90 to 98% of the landfill gas while the remaining 2 to 10% includes nitrogen, oxygen, ammonia, sulfides hydrogen and various other gases. Landfill gases are produced when bacteria breakdown organic waste. The amount of these gases depicts on the type of waste present in the landfill, age of the landfill, oxygen content, the amount of moisture and temperature. For example gas production will increase if the temperature or moisture content increases. Though production of these gases generally reaches a peak in 5 to 7 years, a landfill can continue to produce gases for more than 50 years.

Odors in landfill gas are caused primarily by hydrogen sulfide and ammonia, which are produced during breakdown of waste material. For example if construction and demolition debris contain large quantities of wallboard (also called drywell or gypsum board) large amounts of hydrogen sulfide can be formed. Hydrogen sulfide has the foul smell of rotten eggs, while ammonia has a strong pungent odor. Humans can detect hydrogen sulfide and ammonia odors at very low levels in air, generally below levels that would cause health effects.

Short term exposures (typically up to about 2 weeks) to elevated levels of ammonia and hydrogen sulfide in air can cause coughing, irritation of the eyes, nose and throat, headache, nausea and breathing difficulties. These effects usually go away once the exposure is stopped.

Studies by the Department of Health, USA have been conducted in communities near landfills and waste lagoons to evaluate health effects associated with exposure to landfill gases. These studies lasted for several months and reported health complaints which coincided with periods of elevated levels of hydrogen sulfide and landfill odors.

The reported health complaints included eye, throat and lung irritation, nausea, headache, nasal blockage, sleeping difficulties, weight lost, chest pain and aggravated asthma. Although other chemicals may have been present in the air, many of these effects are consistent with exposure to hydrogen sulfide.

Methane is a component of natural gas of O_2 in a sealed room and is usually harmless but it can cause asphyxiation by reducing the percentage. According to https://www.ncbi.nlm.nih.gov›pmcmethane is highly flammable and can form explosive mixtures with air if it concentrates in an enclosed space with poor ventilation. The range of air concentrations at which methane levels are considered to be air explosion hazard is 5 to 15% of the total air volume. Landfill gas explosions are not common occurences.

Methane and carbon dioxide are colorless, odorless, gases that can displace oxygen in enclosed spaces. Health effects associated with both methane and carbon dioxide result from the lack of oxygen rather than direct exposure to these gases. Health effects caused by a reduced oxygen level include a faster heartbeat and having to take deeper breaths, nausea, vomiting, headache, mood changes and vision problems and in lower dosage similar to the effects felt after vigorous exercise. A freshly reduced oxygen level (that is when the oxygen level is well below its usual level of 21% of the total air volume) can cause reduced coordination, fartigue, nausea, vomiting and unconsciousness. These effects have rarely been reported from landfills.

Due to the presence of methane at the existing landfill, safety is an important aspect while conducting the rehabilitation works at the existing landfill.

Methane is lighter than air, having a specific gravity of 0.554. It is only slightly soluble in water. It burns readily in air, forming carbon dioxide and water vapor. As it is easily ignited, any sparks or ignition will cause flaring or fires at site. High levels of methane can reduce the amount of oxygen breathered from the air.

Besides impacts due to health and safety, methane is also the primary contributor to the formation of ground level ozone, a hazardous air pollutant and greenhouse gas and thus contibutes to climate change as it is able to trap heat in the atmosphere. Although methane's lifespan in the atmosphere is relatively short compared to those other greenhouse gases, it is more efficient at trapping heat than other gases. Also as the rehabilitated land will be used in future for the top side developmental projects, the presence of methane gas in the rehabilitated site is of concern.

Thus, measures are to be in place to ensure the safety and workers health are protected while doing the rehabilitation works at site.

Landfill Gas Emissions Model (LandGEM)

With the proposed mixed development at the TPSJ (Tapak Pelupusan Sisa-Pepejal Jelutong) site which is closed in year 2002, there are currently an estimated waste volume of 11,329,285 cubic metre (m^3) or 13,595,142 tons at the site assuming 1 m^3 of municipal solid waste (MSW) = 1.2 tons. With rehabilitation of the site, an expected 6,225,282 m^3 (7,470,338 tons) of usable recycle material from an estimated volume of 11,329,285 m^3 will be removed leaving behind a remaining volume of 5,104,003 m^3 or 6,124,803 tons of solid waste at the development site.

With this current 13,595,142 tons and post rehabilitation 6,124,803 tons of solid waste at the site, landfill gas is released from the site. CH_4 (Methane) and CO_2 (Carbon Dioxide) are the primary constituents of emitted landfill gas. These gases are produced by microorganisms within the waste under anaerobic conditions. H_2S (Hydrogen Sulphide) which has a strong stench and non-methane organic compounds (NMOC) are produced in very small quantities and NH_3 (Ammonia), benzene and toluene which are organic compounds that may also be released in trace amounts. Toxic gases are not expected to be released as this is a non-hazardous waste dumpsite.

Assessment of air pollutants released consist of two parts, the first part uses the United States Environmental Protection Agency (USEPA) Landfill Gas Emissions Model (LandGEM) Version 3.03 released in 2020 (USEPA, 2020) to estimate the amount of landfill gases (methane and others) emitted currently based on the current amount of solid waste present at the site (7,470,338 tons) and launching of the mixed development based on the amount of solid waste present post rehabilitation (6,124,803 tons). The second part uses AERMOD to predict the ambient air concentrations of gaseous pollutants released by the remaining waste at the site during the operation phase of the mixed development project.

During the operation phase of the project, although CO_2 is emitted by remaining waste, it was not assessed because the background concentration of it is already high at 377 ppm(v) (WMO, 2006) which is equal to 678.6 mg/Nm^3 and those produced by the site will not change this level much and will not have any impact on the surrounding environment.

In this environmental impact study, to estimate the amount of landfill gas emitted by the remaining solid waste at the mixed development site, the

USEPA Landfill Gas Emissions Model (LandGEM) Version 3.03 released in 2020 was used.

The USEPA LandGEM Model provides an automated estimation tool for quantifying air emissions from non hazardous MSW (Municipal Solid Waste) landfills. The model was developed by the United States Environment Protection Agency's Control Technology Center. This model can be used to estimate emission rates for methane, carbon dioxide, non-methane organic compounds, and individual toxic air pollutants from landfills. In the United States, the model can also be used by landfill owners and operators to determine if a landfill is subject to the control requirements of the federal NSPS (New Source Performance Standard) for new MSW landfills (USEPA, 1991a) or the emission guidelines for existing MSW landfills (USEPA, 1991b).

The model is based on a first order decay equation. The model can be run using site-specific data for the parameters needed to estimate emissions or, if no site-specific data are available, using default values. There are two sets of default values. One set is based on the requirements of the NSPS and emission guidelines. This set of default values produces conservative emission estimates and can be used to determine whether the landfill is subject to the control requirements of the NSPS and emission guidelines. The other set of default values is based on emission factors in the U.S.EPA's (Environmental Protection Agency's) compilation of emission factors, AP-42. This set of default values produces more representative emission values and can be used to produce typical emission estimates in the absence of site-specific test data.

LandGEM is regarded as a screening and prediction tool. Often it is not until a gas extraction system is placed in a landfill that the quantity of landfill gas produced can be accurately determined. Landfill gas production test data may be needed to determine the quantity of gas emitted from a particular landfill.

The United States CAA (Clean Air Act) default values in the model provide emission estimates that would reflect the expected maximum emissions and generally would be used only for determining the applicability of the regulations to a landfill. To estimate actual emissions in the absence of site-specific data, a second set of default values (the AP-42 defaults) is provided in the model. The AP-42 default values in the model are based on emission factors from the U.S. Environmental Protection Agency's compilation of emission factors, AP-42 (EPA, 1995). The AP-42 default values provide emission estimates that should reflect typical landfill emissions and are the values suggested for use in developing estimates for state inventories and suitable for use in estimating ambient concentrations.

This computer model uses a first-order decomposition rate equation and estimates annual emissions over any time period specified by the user. Total landfill gas emissions are estimated by estimating methane generation and doubling it (the landfill gas is assumed to be half methane and half carbon dioxide). Methane generation is estimated using two parameters: Lo, the potential methane generation capacity of the refuge, and k, the methane generation rate constant, which accounts for how quickly the methane generation rate decreases once it reaches its peak rate. The methane generation rate is assumed to be at its peak upon closure of the landfill or final placement of waste at the site. The model allows the user to enter Lo and k values derived using site-specific test data collected at the landfill (site-specific data may be collected using the test methods specified in the NSPS and emission guidelines for MSW landfills), or to use the CAA or AP-42 default values.

The model estimates emission rates for CH_4 (Methane), CO_2 (Carbon Dioxide), NMOC (Non-Methane Organic Compounds), and a list of toxic air pollutants expected to be emitted from landfills based on test data from the U.S. EPA's compilation of air pollutant emission factors, AP-42 (USEPA, 1995).

The LandGEM Model estimates the emissions resulting from the biodegradation of refuse in landfills. The anaerobic decomposition of refuse in solid waste landfills causes emissions of landfill gas. As landfill gas passes through the refuse, it sweeps NMOC and toxic air pollutants if any present in the refuse to the surface. The composition of MSW landfill emissions is estimated by the model to be about 50 percent CH_4 (Methane) and 50 percent CO_2 (Carbon Dioxide), with additional, relatively low concentrations of NMOC and if any toxic air pollutants. This was assumed in this modeling as it represents the worst case scenario.

Landfill gas was assumed to be half CH_4 and half CO_2. The model assumes that CO_2 emissions are the same as methane emissions and landfill gas emissions are twice the methane emissions. The generation of methane from a landfill is a function of two values: k, the methane generation rate constant and Lo, the methane generation potential.

The methane generation rate constant, k, determines the rate of generation of methane for each sub-mass of refuse in the landfill. The higher the value of k, the faster the methane generation rate increases and then decays over time. The value of k is a function of the following factors: (i) refuse moisture content, (ii) availability of the nutrients for methanogens, (iii) pH, and (iv) temperature. The k values obtained from the data collected for the NSPS and emission guidelines range from 0.003 to 0.21 (EPA, 1991b).

These values are obtained from theoretical models using field test data and from actual field test measurements. If no user-specified k value is entered into the Landfill Air Emission Estimation Model, default values are used for k.

Two default k values are used by the program: 0.05 litre/yr for the CAA default option and 0.04 litre/yr for the AP-42 default option.

The value for the potential methane generation capacity of refuse (Lo) depends only on the type of refuse present in the landfill. The higher the cellulose content of the refuse, the higher the value of Lo. The values of theoretical and obtainable Lo range from 220 to 9540 ft^3 (6.2 to 270 m^3) CH_4/Mg refuse (EPA, 1991a). If no user-specified Lo value is entered into LandGEM, default values are used for Lo. The default values of Lo used in the model are 6000 ft^3 (170 m^3) CH_4/Mg of refuse for the CAA default option and 4411 ft^3 (124.9 m^3) CH_4/Mg of refuse for the AP-42 default option. The method for deriving these values is outlined in a memorandum in Public Docket A-88-09 (Pelt, 1993).

Landfill gas contains low concentrations of other and toxic air pollutants, from the leaching and decomposition of waste. In this site at Jelutong, as there are no hazardous waste disposed at the site, toxic gas emissions are expected to be non-existent or negligible.

H_2S was considered and assessed in the study as there may be sulphur compounds in the solid waste and this will produce H_2S, a reduced compound of sulphur. In addition, although in trace amounts, the quantity of benzene and toluene released was computed and discussed.

The NMOC (Non Methane Organic Compounds) concentration in the landfill gas is a function of the types of refuse in the dumpsite and the extent of the reactions that produce various compounds from the anaerobic decomposition of refuse. To determine NMOC concentrations, NMOC data were collected from emission test reports from industry and state and local regulatory agencies (Pelt, 1993). The NMOC concentrations from 23 landfills ranged from 240 to 14,300 ppm(v). Three suggested default NMOC concentrations are used in the model: one for the CAA default option and two for the AP42 default option, one for co-disposal and one for no co-disposal. If the system is using CAA defaults, the default NMOC concentrations as hexane is 4000 ppmv; if the system is using AP-42 defaults, the default NMOC concentration as hexane for co-disposal is 2420 ppmv, and for no co-disposal is 595 ppm(v). Because the NMOC concentration in landfill gas varies from landfill to landfill, collection of site-specific data will provide the most accurate estimates.

Air emissions from landfills and dumpsites come from landfill gas, generated by the decomposition of refuse in the landfill and dumpsite. Landfill gas is assumed by this model to be roughly half methane and half carbon dioxide, with additional, relatively low concentrations of other air pollutants. The following information was used to estimate emissions from the remaining waste at the project site:-

- Current amount of solid waste at project site : 13,595,142 tons;
- Amount of solid waste after rehabilitation : 6,124,803 tons;
- Methane generation rate (k): 0.04 l/yr (default A.P. 42 value);
- Potential methane generation capacity (Lo): 124.9 m^3 CH_4/ton (A.P.- 42 default)
- Concentration of non-methane organic compounds (NMOC) found in the landfill gas: 595 ppm(v) as hexane (default value);
- The concentrations of toxic air pollutants found in the landfill gas: 0 no co-disposal option; and
- Disposal site type: Non hazardous municipal solid waste.

Two landfill gas emission scenarios using the LandGEM Model were assessed, i). landfill gas emission at current solid waste amount of 13,595,142 tons – before rehabilitation and ii) landfill gas emissions after rehabilitation of dumpsite with solid waste amount of 6,124,803 tons. **Table 7.2** below shows the annual amount of CH_4, NMOC, H_2S, NH_3, benzene and toluene released into the atmosphere from the amount of solid waste at the project site before and after the dumpsite is rehabilitated based on default scenario of the USEPA A.P. 42 default values for these two scenarios mentioned. The released amount was computed based on the assumption that the landfill gases are not treated and the decomposition is anaerobic to reflect the worst case scenario.

Table 7.2
Peak Annual Amount And Emission Rate

Gas	Before Rehabilitation (13,595,142 tons Solid Waste)		After Rehabilitation (6,124,803 tons Solid Waste)	
	Annual (tons)	Emission Rate (g/s)	Annual (tons)	Emission Rate (g/s)
CH_4	25,090.0	795.5	9,731.0	308.6
NMOC	1,079.0	34.2	418.2	13.26
H_2S	3.83	0.121	1.489	0.047
NH_3	0.0	0.0	0.0	0.0
Benzene	0.464	0.0147	0.180	0.0057
Toluene	11.24	0.365	4.359	0.139

The emission rate of these gases are used as inputs in the dispersion modelling and according to the LandGEM Model, there are no NH_3 emissions.

The air quality analyses of the potential impact of gaseous emissions from the closed dumpsite were conducted in accordance with USEPA Guideline on Air Quality Models (GAQM; as incorporated in Appendix W of 40 CFR Part 51).

The guideline recommends a three phase approach which are as follows:-

Phase 1 — Apply a simple screening procedure to determine if either (1) the source clearly poses no air quality problem or (2) the potential for an air quality problem exists.

Phase 2	If the simplified screening results indicate a potential threat to air quality, further analysis is warranted, and the detailed screening (basic modelling) procedures should be applied.
Phase 3	If the detailed screening results or other factors indicate a problem, then a more refined analysis is necessary.

As this assessment involves multiple sources, refined analysis was conducted. It should be noted that the USEPA promulgated a revision to the GAQM on November 9, 2005 and the revised version of GAQM adopts AERMOD as the preferred dispersion model.

Dispersion modelling was conducted with the latest USEPA's AERMOD model (Version 22112, released in June 2022) and one year of meteorological data generated by the Mesoscale Meteorological Model (MM5). This one-year data set was processed with AERMET, the meteorological processor for AERMOD, in accordance with guidance provided by USEPA in the recently revised AERMOD Implementation Guide (AIG; USEPA, March 19, 2009).

Air pollutant parameters modelled as presented in this report are for CH_4 (Methane), NMOC (Non-Methane Organic Compounds), H_2S (Hydrogen Sulphide), benzene and toluene. The predicted concentrations of these pollutants were compared with the most restrictive of the air quality standards of the AAAQG (Arizona Ambient Air Quality Guidelines) as these pollutants are not listed in the current MAAQS (Malaysian Ambient Air Quality Standards).

AERMOD is a refined dispersion model for simple and complex terrain for receptors within 50 km of a modelled source. AERMOD is a steady-state plume model. In the SBL (Stable Boundary Layer), it assumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the CBL (Convective Boundary Layer), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian pdf (probability density function). Additionally, in the CBL, AERMOD treats "plume lofting," whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates into the elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate. For sources in both the CBL and the SBL, AERMOD treats the enhancement of lateral dispersion resulting from plume meander. AERMOD incorporates current concepts about flow and dispersion in complex terrain. Where appropriate the plume is modelled as either impacting and/or following the terrain, thus AERMOD removes the need for defining complex terrain regimes. All terrain is handled in a consistent and continuous manner while considering the dividing streamline concept in stably stratified conditions.

One of the major improvements that AERMOD brings to applied dispersion modelling is its ability to characterize the PBL (Planetary Boundary Layer) through both surface and mixed layer scaling. AERMOD constructs vertical profiles of required meteorological variables based on measurements and extrapolations of those measurements using similarity (scaling) relationships. Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using all available meteorological observations. AERMOD is designed to run with a minimum of observed meteorological parameters. As a replacement for the ISC3 (Industrial Source Complex Version 3) model, AERMOD can operate using data of a type that is readily available from most NWS (National Weather Service) stations. AERMOD requires only a single surface measurement of wind speed measured at between 10 and 100 meters, wind direction and ambient temperature. Like the ISC3 model, AERMOD also needs observed cloud cover. However, if cloud cover is not available two vertical measurements of temperature, typically at 2 and 10 meters and a measurement of solar radiation can be substituted. A full morning upper air sounding is required in order to calculate the convective mixing height throughout the day. Surface characteristics (surface roughness, Bowen ratio, and albedo) are also needed in order to construct similarity profiles of the relevant PBL parameters.

Unlike existing regulatory models, AERMOD accounts for the vertical in homogeneity of the PBL in its dispersion calculations. This is accomplished by "averaging" the parameters of the actual PBL into "effective" parameters of an equivalent homogeneous PBL.

Inputs for AERMOD include emission rates of gaseous pollutants released from the closed dumpsite and other source information such as the length and width of the dumpsite, the release height of the gaseous pollutants, the types of sources and coordinates of the sources with respect to the receptor grid.

Sources of landfill gases emitted were treated as point sources as these gases are vented from a network of tubes that are planted into the ground. The release height of the pollutants from the tubes is 2.0 metre and the UTM (Universal Transverse Mercator) coordinates of the source network is X: 646750 and Y : 596250.

In order to simulate the impact of emissions from ground and elevated sources, receptors must be chosen and ground level ambient concentrations determined for each of the receptor locations.

In this particular case study, a 6 X 6 km cartesian grid (3 km radius) with 100 metres spacing was used for the impact modelling. The grid was centred at the centre of the project site; that is, the origin of the grid system is at the centre of the project with UTM coordinates X : 646750 and Y : 596250.

Being located in well developed area, there are nearby sensitive receptors in the receptor grid and the selected sensitive receptors are i) Mutiara Idaman 1 and ii) Summer Place. These two receptors are also baseline air quality monitoring site AQ1 and AQ3 respectively. In addition to these sensitive receptors, a discrete receptors which is the project boundary baseline monitoring point AQ2 at the closed dumpsite is selected. The sensitive and discrete receptors with its coordinates in UTM units are shown in **Table 7.3** below. Impacts from emission sources were predicted at these receptors listed.

Table 7.3
Sensitive And Discrete Receptors

Sensitive/discrete Receptor	UTM	
	X-coordinate (m)	Y-coordinate (m)
Mutiara Idaman 1, AQ1	646164.09	596082.23
Project site, AQ2	647025.70	596496.89
Summer Place, AQ 3	647600.16	597028.88

Accurate air quality modelling is highly dependant on the quality of the meteorological and emission data used. Consequently, the best available and most representative data was used to allow for minimal margin for error in the modelling.

One year of meteorological data generated by the MM5 (Mesoscale Meteorological Model) for the project site was used in the modelling.

The latest version of the AERMET meteorological pre-processor (Version 22112) was used to process the data required for AERMOD. Boundary layer parameters used by AERMOD, which are required as input to the AERMET processor, include albedo, Bowen ratio, and surface roughness. These parameters were determined by examining a 3 km radius area surrounding the project site in accordance with current USEPA guidance. Based on the land use classification, site-specific values of surface roughness, albedo, and Bowen ratio was obtained from the AERMET user's guide (USEPA 1998) for appropriate sectors around the site.

The upper air data generated by the MM5 Model was processed to assign 00 GMT (Greenwich Mean Time) to a time near local sunrise that is needed by the meteorological pre-processor, AERMET.

The application of the model requires characterization of the local (within 3km) dispersion environment as either urban or rural, based on a USEPA-recommended procedure that characterizes an area by prevalent land use. This land use approach classifies an area according to 12 land use types. In this scheme, areas of industrial, commercial, and compact residential land use are designated urban. According to USEPA modelling guidelines, if more than 50 percent of an area within a 3 km radius of the proposed facility is classified as rural, then rural dispersion coefficients are to be used in the dispersion modelling analysis. Conversely, if more than 50% of the area is urban, urban dispersion coefficients are used.

For this analysis, visual inspection of aerial photography shows that the 3 km area surrounding the proposed development project is developed. Thus the urban option was selected for the modelling.

Local topography plays an important role in the selection of the appropriate dispersion model. Available dispersion models were formerly divided into two general categories: those applicable to terrain that is below stack top (simple terrain) and those applicable where the terrain is above stack top (complex terrain). However, AERMOD, which has been extensively evaluated on many terrain types, removes this distinction and allows a seamless treatment of project impacts on terrain both above and below stack top elevation.

As the project site is located at the coast which is flat, the effect of terrain on dispersion was not accounted for in this assessment.

The types of output available with the model are:-

- Summaries of high values (highest, second highest, etc.) by receptor for each averaging period and source group combination;
- Summaries of overall maximum values for each averaging period and source group combination; and
- Tables of concurrent values summarized by receptor for each averaging period and source group combination for each day of data processed.

In this assessment, the maximum incremental concentration for the period was computed. This means that for the 24-hour average concentration, the maximum 24-hour average concentration is the highest computed 24-hour average concentration over the entire meteorological data period.

In the case of the long-term average or the seasonal average concentration, the computed average concentration is the average of all the hourly concentration over the entire meteorological data period.

The output parameters generated are as follow:-

- CH_4 (Methane)
  - Annual average concentration.
- NMOC (Non Methane Organic Compound), H_2S (Hydrogen Sulphide), NH_3 (Ammonia), benzene and toluene
  - Maximum 1-hour and 24-hour average concentration.

This was to determine compliance with the AAAQG (Arizona Ambient Air Quality Guidelines) for these gases as there no guideline limits in the 2020 MAAQS (Malaysian Ambient Air Quality Standards) for these gases.

As discussed earlier, landfill gases such as methane and to a lesser extent NMOC and trace amounts of H_2S, benzene and toluene are emitted by the closed dumpsite and released into the atmosphere if the landfill gas is not treated. The amount emitted varies over time. In this assessment study, landfill gas emission is based on the amount of solid waste at the dumpsite before and after rehabilitation of the dumpsite and the age of the dumpsite. The emission rates of these landfill gases are relisted below in **Table 7.4.**

Table 7.4
Emission Rates

Gas	Before Rehabilitation (13,595,142 tons Solid Waste)		After Rehabilitation (6,124,803 tons Solid Waste)	
	Annual (tons)	Emission Rate (g/s)	Annual (tons)	Emission Rate (g/s)
CH_4	25,090.0	795.5	9,731.0	308.6
NMOC	1,079.0	34.2	418.2	13.26
H_2S	3.83	0.121	1.489	0.047
Benzene	0.464	0.0147	0.180	0.0057
Toluene	11.24	0.365	4.359	0.139

As mentioned, CH_4 (Methane), NMOC (Non-Methane Organic Compounds), H_2S (Hydrogen Sulphide), benzene and toluene are assessed in this modelling assessment. It should be noted that CH_4, NMOC, H_2S, benzene and toluene are released only when landfill gas from the closed dumpsite is vented without any treatment which is the case for this proposed mixed development project.

i. Methane

A significant amount of CH_4 is emitted by the closed dumpsite and the emission rate varies with the age of the dumpsite.

Based on the amount of waste at the site before rehabilitation (Scenario 1), the predicted annual average CH_4 concentration in ambient air is between 0.3 mg/m^3 at the edge of the receptor grid 3 km away in the west direction and 10 mg/m^3 at the project boundary. The predicted annual average CH_4 incremental concentration contours are plotted and shown in **Figure 7.1.**

After rehabilitation of the site (Scenario 2), predicted annual average CH_4 concentrations as shown in **Figure 7.2** are between 0.1 mg/m^3 and 5.0 mg/m^3 at the project site boundary.

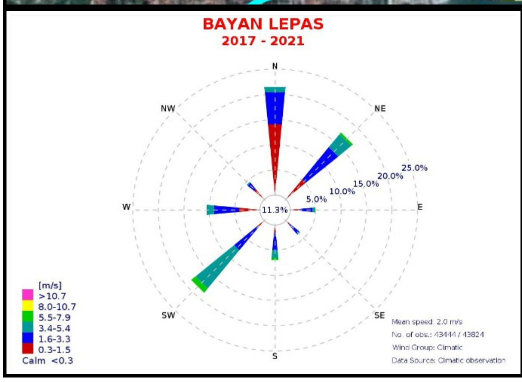


Figure 7.1 Annual Average Methane Incremental Concentration (mg/m³)
Scenario 1: Before Rehabilitation

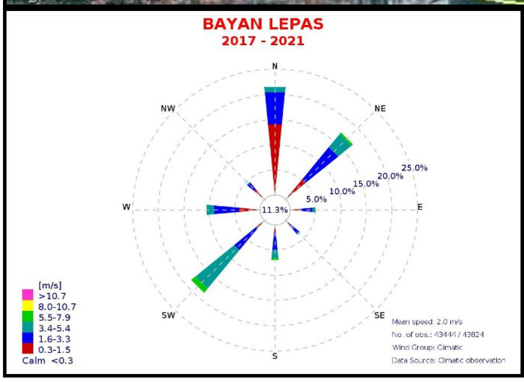


Figure 7.2 Annual Average Methane Incremental Concentration (mg/m^3) Scenario 2: After Rehabilitation

Currently, there are no ambient air quality guideline for CH_4. Methane is a greenhouse gas and except for its explosive nature, CH_4 is a relatively non-reactive gas. It is the least reactive hydrocarbon (Butler, 1979). As regards its impact on health, there are no threshold limits. Methane under the American Conference of Governmental Industrial Hygienists (ACGIH, 1996) classification is a simple asphyxiant. A simple asphyxiant is a gas when present in high concentrations, act primarily as simple asphyxiant without significant physiological effects. A TLV (Threshold Limit Value) is not recommended because the limiting factor is the available oxygen in air.

Annual average CH_4 concentrations in mg/m^3 at the sensitive and discrete receptors before and after rehabilitation are tabulated in **Table 7.5** below.

Table 7.5
Predicted CH_4 Concentration

Receptor	Existing Baseline	Annual Average Incremental Concentration (mg/m^3)	
		Before Rehabilitation	After Rehabilitation
Mutiara Idaman 1, AQ1		6.58	2.57
Project site, AQ2		3.37	1.30
Summer Place, AQ 3		0.82	0.31

ii. Non Methane Organic Compounds

NMOC (Non-Methane Organic Compounds) are emitted by this dumpsite of this capacity in moderate quantities, nevertheless, its concentration in ambient air was modelled as well. **Figure 7.3 and Figure 7.4** show the maximum 1-hour and 24-hour average NMOC incremental concentration respectively when emission from the closed dumpsite before its rehabilitation. At this stage, the maximum 1-hour average NMOC concentration in ambient air is found to be between 2 mg/m^3 at the western edge of the receptor grid and 20 mg/m^3 at the project boundary. For the 24-hour average, as shown in **Figure 7.4,** it is between 0.2 mg/m^3 and 4.0 mg/m^3 at the boundary.

After rehabilitation, with less waste remaining at the dumpsite, predicted maximum 1-hour and 24-hour average NMOC incremental concentrations as shown in **Figure 7.5 and Figure 7.6** respectively are lower. Concentrations are between 0.1 mg/m^3 and 8.0 mg/m^3 for the 1-hour average and between 0.1 mg/m^3 and 2.0 mg/m^3 for the 24-hour average.

Maximum 1-hour and 24-hour average non-methane organic compound incremental concentrations in mg/m^3 at the sensitive and discrete receptors before and after rehabilitation are tabulated in **Table 7.6** below.

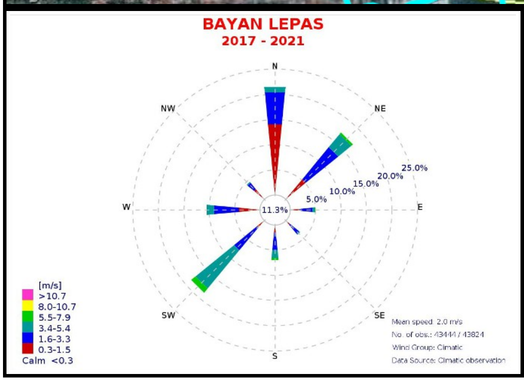


Figure 7.3 Maximum 1-Hour Average NMOC Incremental Concentration (mg/m³)
Scenario 1: Before Rehabilitation

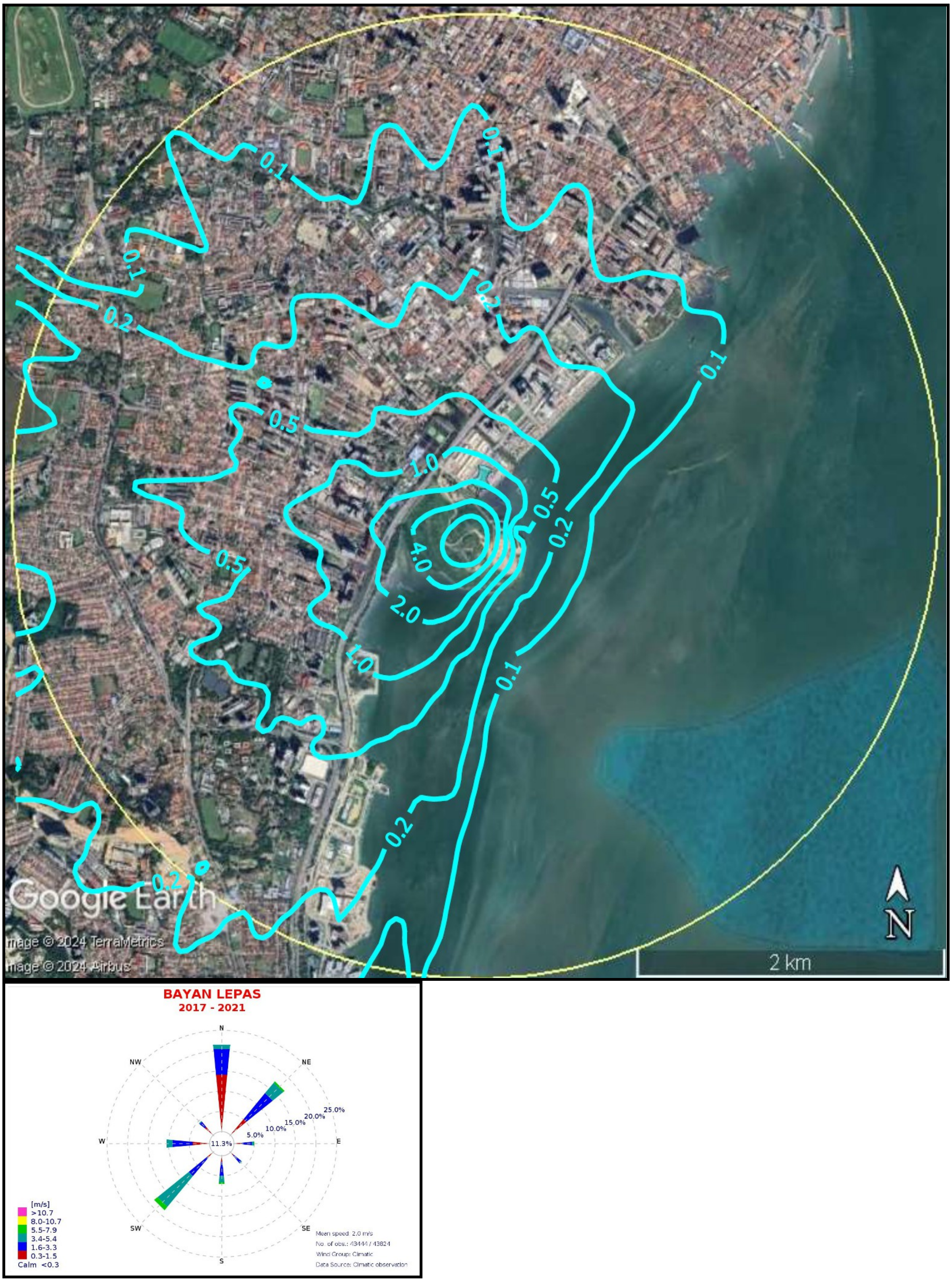


Figure 7.4 Maximum 24-Hour Average NMOC Incremental Concentration (mg/m³) scenario 1: Befoe Rehabilitation

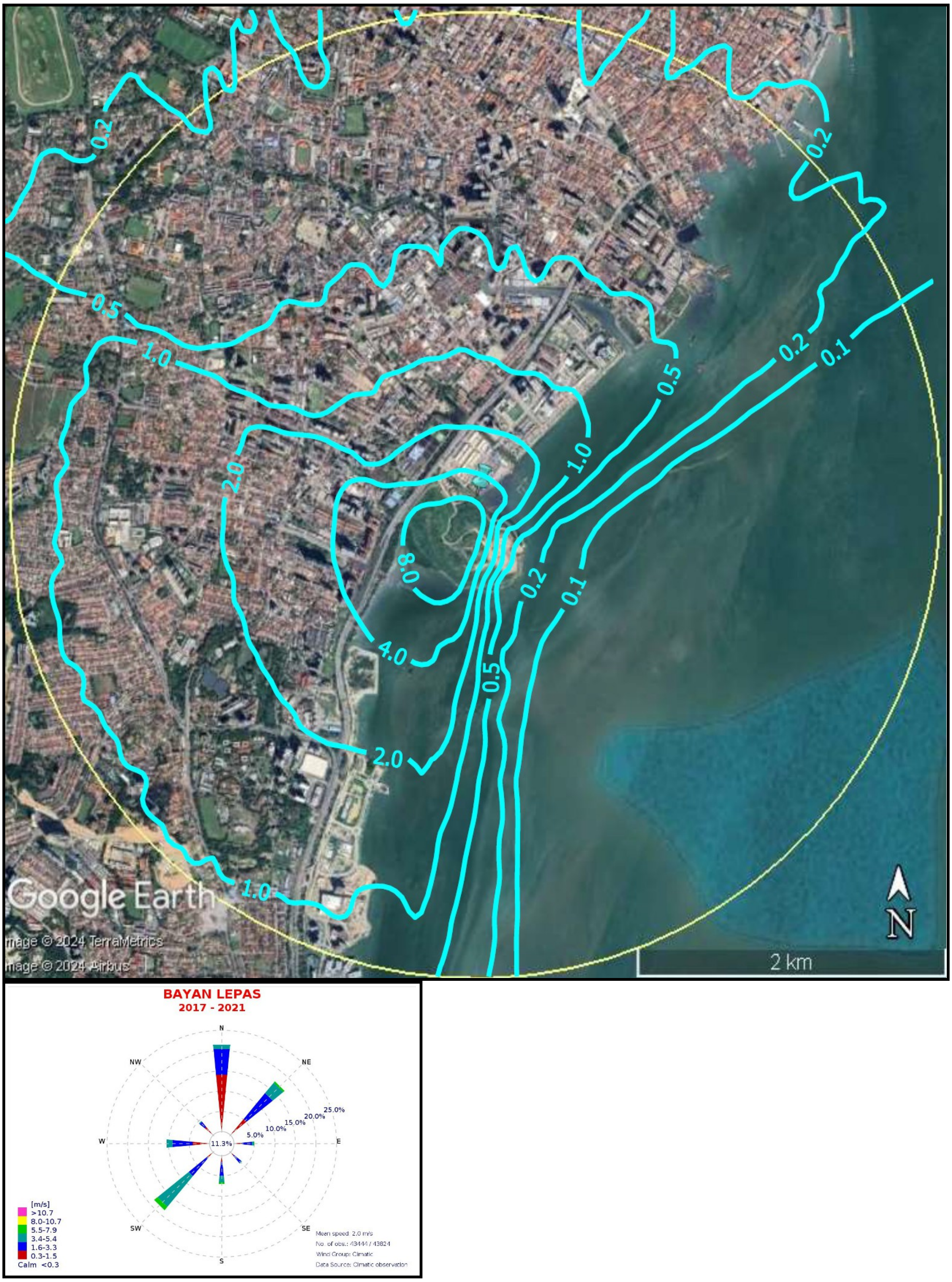


Figure 7.5 Maximum 1-Hour Average NMOC Incremental Concentration (mg/m^3)
Scenario 2: After Rehabilitation

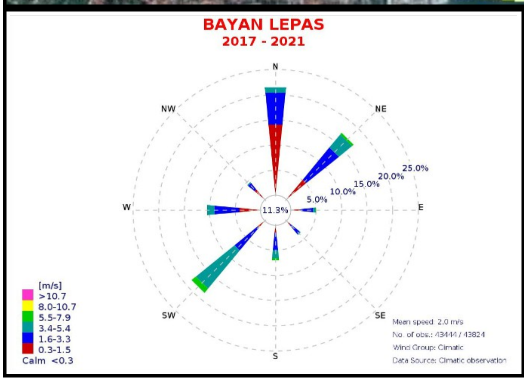


Figure 7.6 Maximum 24-Hour Average NMOC Incremental Concentration (mg/m^3) Scenario 2: After Rehabilitation

Table 7.6
Predicted NMOC Concentration

Receptor	Existing Baseline Conc.	Before Rehabilitation		After Rehabilitation	
		1-hr Average	24-hr Average	1-hr Average	24-hr Average
Mutiara Idaman 1, AQ1	-	15.64	3.63	6.24	1.44
Project site, AQ2	-	6.05	0.74	2.47	0.29
Summer Place, AQ 3	-	2.09	0.21	0.86	0.09

iii. Hydrogen Sulphide

The amount of H_2S (Hydrogen Sulphide) emitted from a dumpsite or landfill of this capacity is very small and its concentration in ambient air was modelled and assessed. As there are no guideline limits in the MAAQS, the AAAQG (Arizona Ambient Air Quality Guideline) limit of 180 μg/m^3 and 110 μg/m^3 for the maximum 1-hour and 24-hour average concentration respectively was used as the basis of assessment.

Predicted maximum 1-hour and 24-hour average H_2S concentrations for the case before rehabilitation are within these AAAQG limits mentioned above. The results of the modelling are plotted and shown in **Figure 7.7 and Figure 7.8** for the 1-hour and 24-hour average incremental concentration respectively.

In the case with H_2S emission from this dumpsite after rehabilitation, predicted maximum 1-hour and 24-hour average H_2S concentrations for this case as shown in **Figure 7.9 and Figure 7.10** respectively, are lower and well within the AAAQG limits.

Table 7.7 provides the maximum 1-hour and 24-hour H_2S concentrations (μg/m^3) at the sensitive and discrete receptors before and after rehabilitation with the AAAQG limits for H_2S for comparison.

Table 7.7
Predicted Hydrogen Sulphide Concentration

Receptor	Existing Baseline Conc.	Before Rehabilitation		After Rehabilitation	
		1-hr Average	24-hr Average	1-hr Average	24-hr Average
Mutiara Idaman 1, AQ1		35.3	12.8	22.1	5.1
Project site, AQ2		21.4	2.6	8.8	1.0
Summer Place, AQ 3		7.4	0.8	3.1	0.3
AAAQG for H2S				180	110

AAAQG: Arizona Ambient Air Quality Guidelines

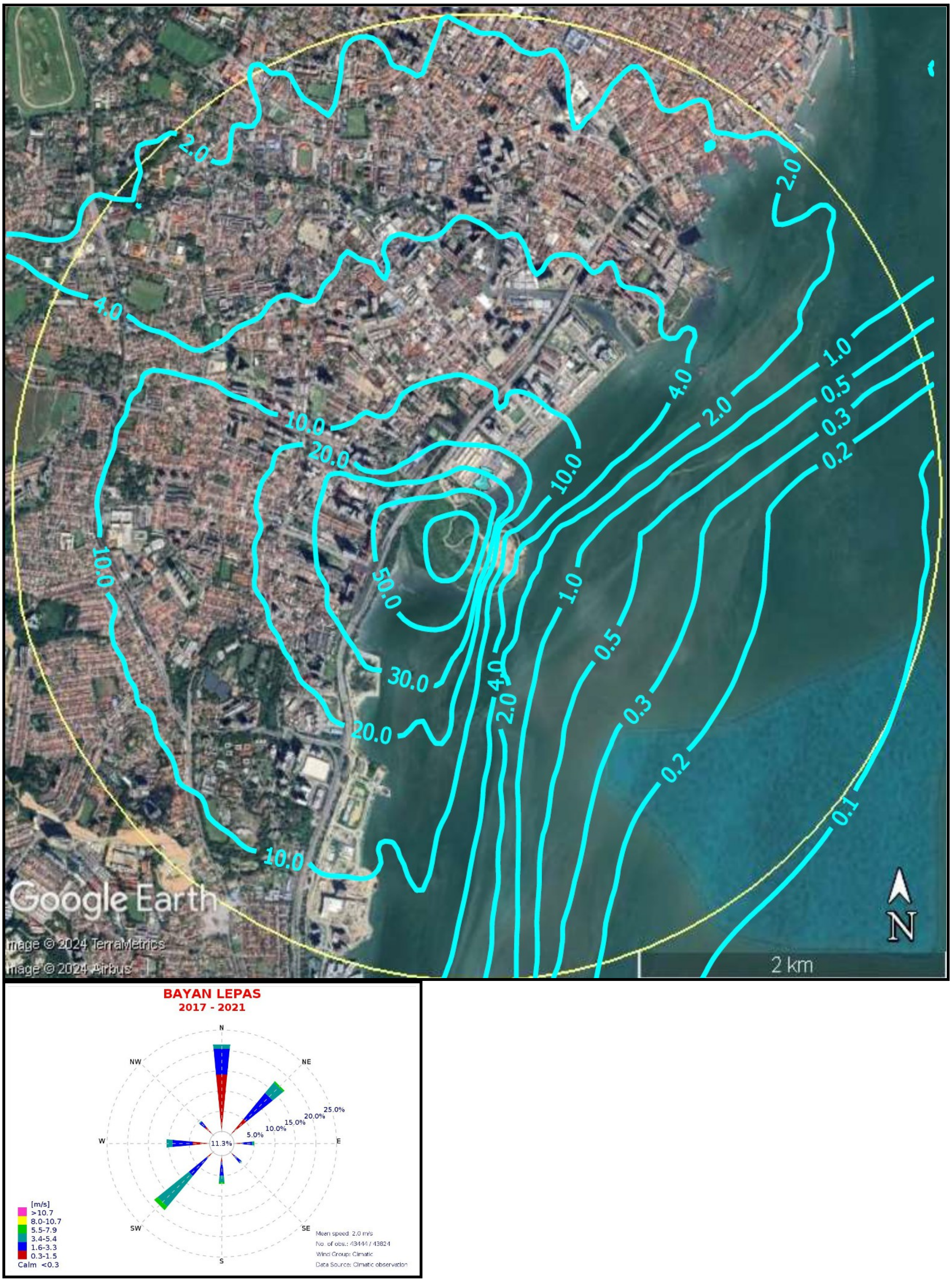


Figure 7.7 Maximum 1-Hour Average H_2S Incremental Concentration (µg/m^3) Scenario 1: Before Rehabilitation

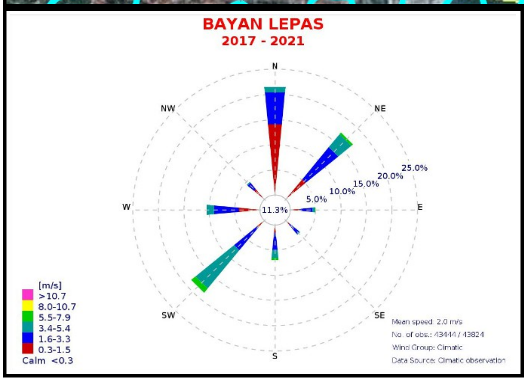


Figure 7.8 Maximum 24-Hour Average H_2S Incremental Concentration ($\mu g/m^3$) Scenario 1: Before Rehabilitation

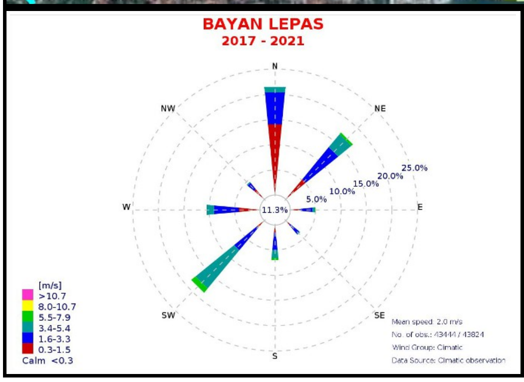


Figure 7.9 Maximum 1-Hour Average H_2S Incremental Concentration (µg/m^3) Scenario 2: After Rehabilitation

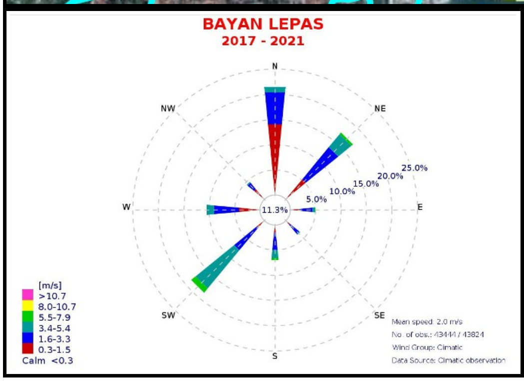


Figure 7.10 Maximum 24-Hour Average H_2S Incremental Concentration (μg/m^3) Scenario 2: After Rehabilitation

iv. Benzene

Benzene is released in trace amounts in landfills as well as dumpsites. Modelling of benzene released from this closed dumpsite based on the amount of waste before rehabilitation showed that the maximum 1-hour and 24-hour average incremental concentrations are between 0.1 μg/m^3 and 8.0 μg/m^3 for the 1-hour average and between 0.1 μg/m^3 and 1.0 μg/m^3 for the 24-hour average. These predicted concentrations are below the AAAQG limits of 170 μg/m^3 and 44 μg/m^3. Contours of the predicted maximum 1-hour and 24-hour average benzene incremental concentration are plotted and shown in **Figure 7.11 and Figure 7.12** respectively.

After rehabilitation, benzene emissions are lower and predicted maximum 1-hour and 24-hour average incremental concentrations as shown in **Figure 7.13 and Figure 7.14** respectively are between 0.1 μg/m^3 and 4.0 μg/m^3 for the 1-hour average and below 1.0 μg/m^3 for the 24-hour average. These concentrations are well below the AAAQG limits of 170 μg/m^3 and 44 μg/m^3.

Table 7.8 below are the maximum 24-hour benzene concentrations (μg/m^3) at the sensitive and discrete receptors before and after rehabilitation with the AAAQG limits for benzene for comparison.

Table 7.8
Predicted Benzene Concentration

Receptor	Existing Baseline Conc.	Before Rehabilitation		After Rehabilitation	
		1-hr Average	24-hr Average	1-hr Average	24-hr Average
Mutiara Idaman 1, AQ1		6.7	.1.6	2.7	0.6
Project site, AQ2		2.6	0.3	1.1	0.1
Summer Place, AQ 3		0.9	0.1	0.4	<0.1
AAAQG for benzene				170	44

AAAQG: Arizona Ambient Air Quality Guidelines

v. Toluene

Just as in the case of H_2S and benzene, toluene is emitted in small amounts by landfills and dumpsites. Before rehabilitation, predicted incremental concentrations in ambient air are shown in **Figure 7.15 and Figure 7.16** for the maximum 1-hour and 24-hour average respectively. With this case, predicted ambient air concentrations of toluene although higher compared to H_2S and benzene are between 20 μg/m^3 at the western edge of the receptor grid and 200 μg/m^3 at the project boundary for the 1-hour average and between 2 μg/m^3 and 40 μg/m^3 for the 24-hour average. These concentrations are well below the AAAQG limits of 4,400 and 3,000 μg/m^3 for the maximum 1-hour and 24-hour average respectively.

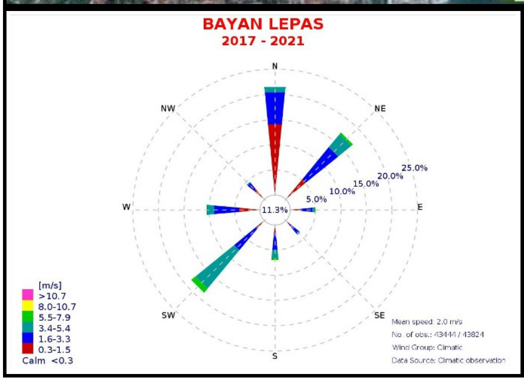


Figure 7.11 Maximum 1-Hour Average Benzene Incremental Concentration (µg/m³) Scenario 1: Before Rehabilitation

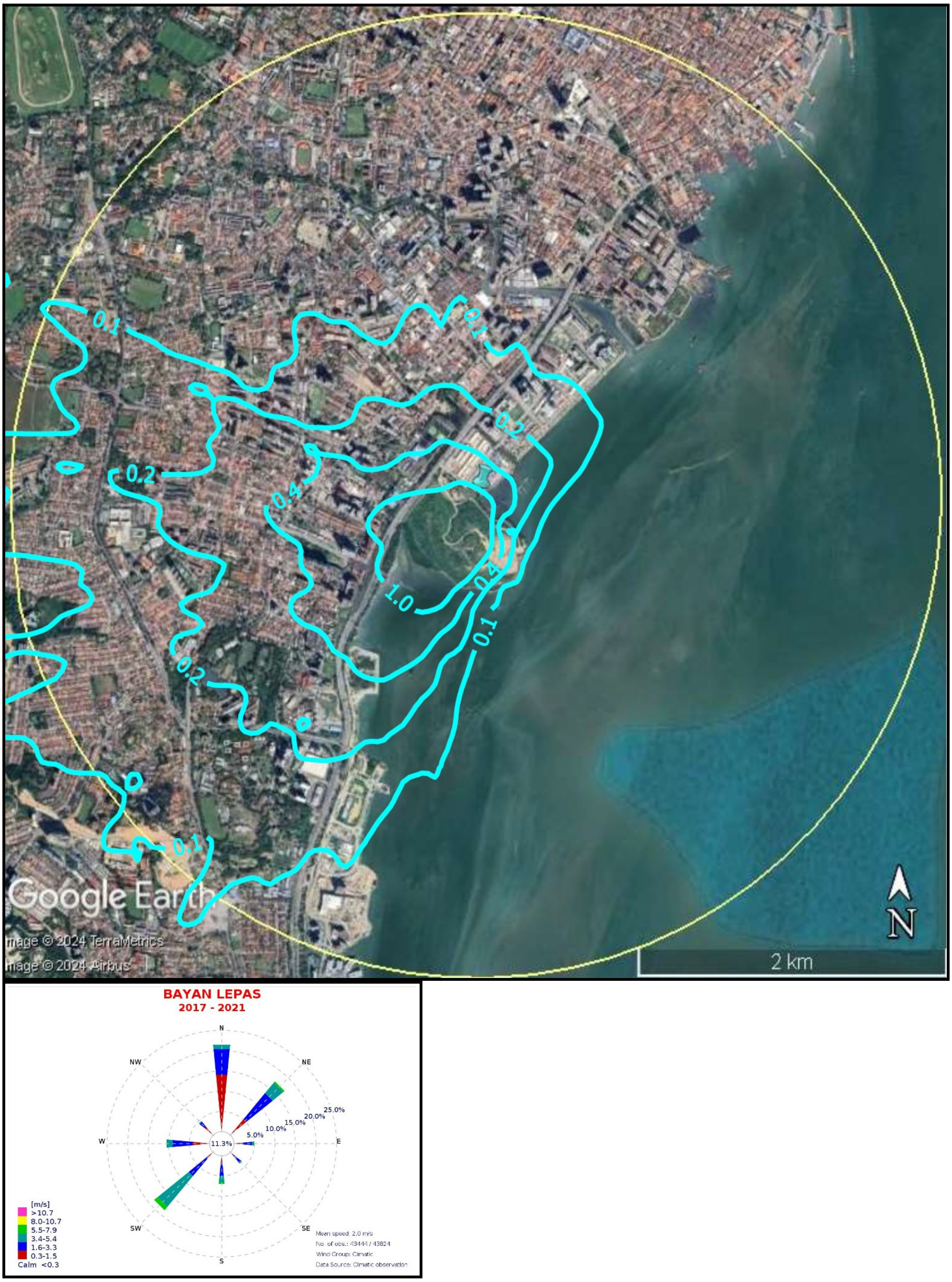


Figure 7.12 Maximum 24-Hour Average Benzene Incremental Concentration (μg/m³) Scenario 2: Before Rehabilitation

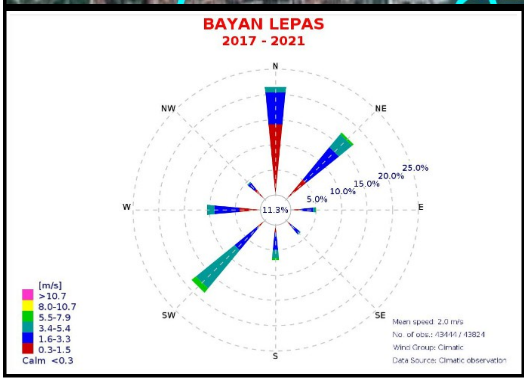


Figure 7.13 Maximum 1-Hour Average Benzene Incremental Concentration (µg/m³) Scenario 2: After Rehabilitation

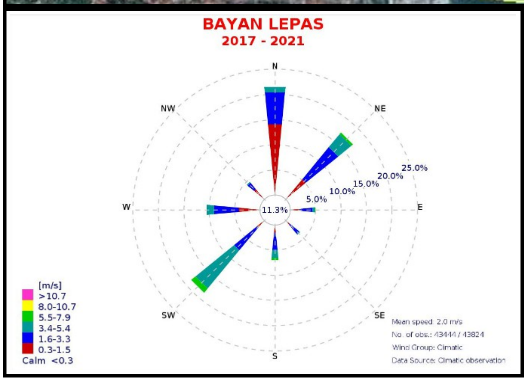


Figure 7.14 Maximum 24-Hour Average Benzene Incremental Concentration (µg/m^3) Scenario 2: After Rehabilitation

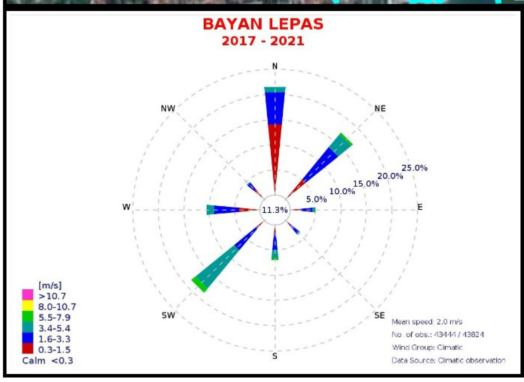


Figure 7.15 Maximum 1-Hour Average Toluene Incremental Concentration (µg/m³) Scenario 1: Before Rehabilitation

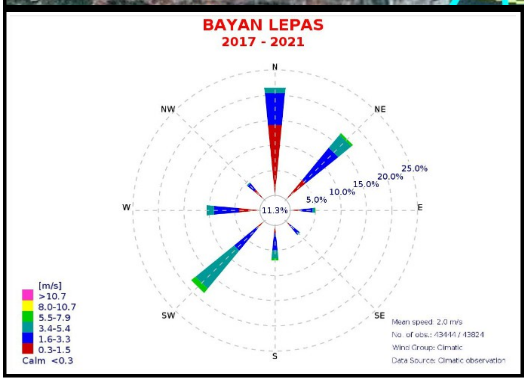


Figure 7.16 Maximum 24-Hour Average Toluene Incremental Concentration (µg/m^3) Scenario 1: Before Rehabilitation

After rehabilitation, predicted maximum 1-hour and 24-hour average toluene incremental concentrations as shown in **Figure 7.17 and Figure 7.18** respectively are lower and also well below the AAAQG limits of 4,400 μg/m^3 and 3,000 μg/m^3.

Table 7.9 below are the maximum 1-hour and 24-hour average toluene concentrations (μg/m^3) at the sensitive and discrete receptors before and after rehabilitation with the AAAQG limits for toluene for comparison.

Table 7.9
Predicted Toluene Concentration

Receptor	Existing Baseline Conc.	Before Rehabilitation		After Rehabilitation	
		1-hr Average	24-hr Average	1-hr Average	24-hr Average
Mutiara Idaman 1, AQ1		162.8	37.8	65.0	15.1
Project site, AQ2		62.9	7.7	25.7	3.0
Summer Place, AQ 3		21.7	2.2	9.0	0.9
AAAQG for toluene				4,400	3,000

AAAQG: Arizona Ambient Air Quality Guidelines

vi. Conclusions

For landfill gases, currently, there are no ambient air guidelines for methane and non-methane organic compounds. These gases are not expected to have any significant impacts.

However, hydrogen sulphide, and toluene which are release in small amounts and benzene in trace amounts was assessed against the Arizona Ambient Air Quality Guidelines limits and found to be below their respective guideline limits.

(b) Groundwater Contamination At Landfill Site

According to the USEPA (United States Environmental Protection Agency), leachate is formed when rainwater filters through wastes placed in a landfill. When this liquid comes in contact with buried wastes, it leaches or draws out chemicals or constituents from those waste.

In order to gauge the impacts of the groundwater discharge from the Jelutong Landfill site, groundwater modeling for existing condition before rehabilitation work and post rehabilitation work was conducted to assess the impacts to the marine waters as discussed below.

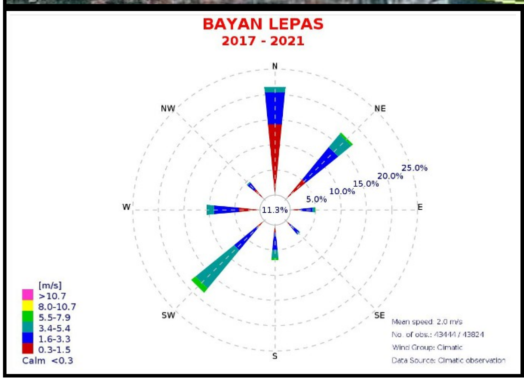


Figure 7.17 Maximum 1-Hour Average Toluene Incremental Concentration (µg/m^3) Scenario 2: After Rehabilitation

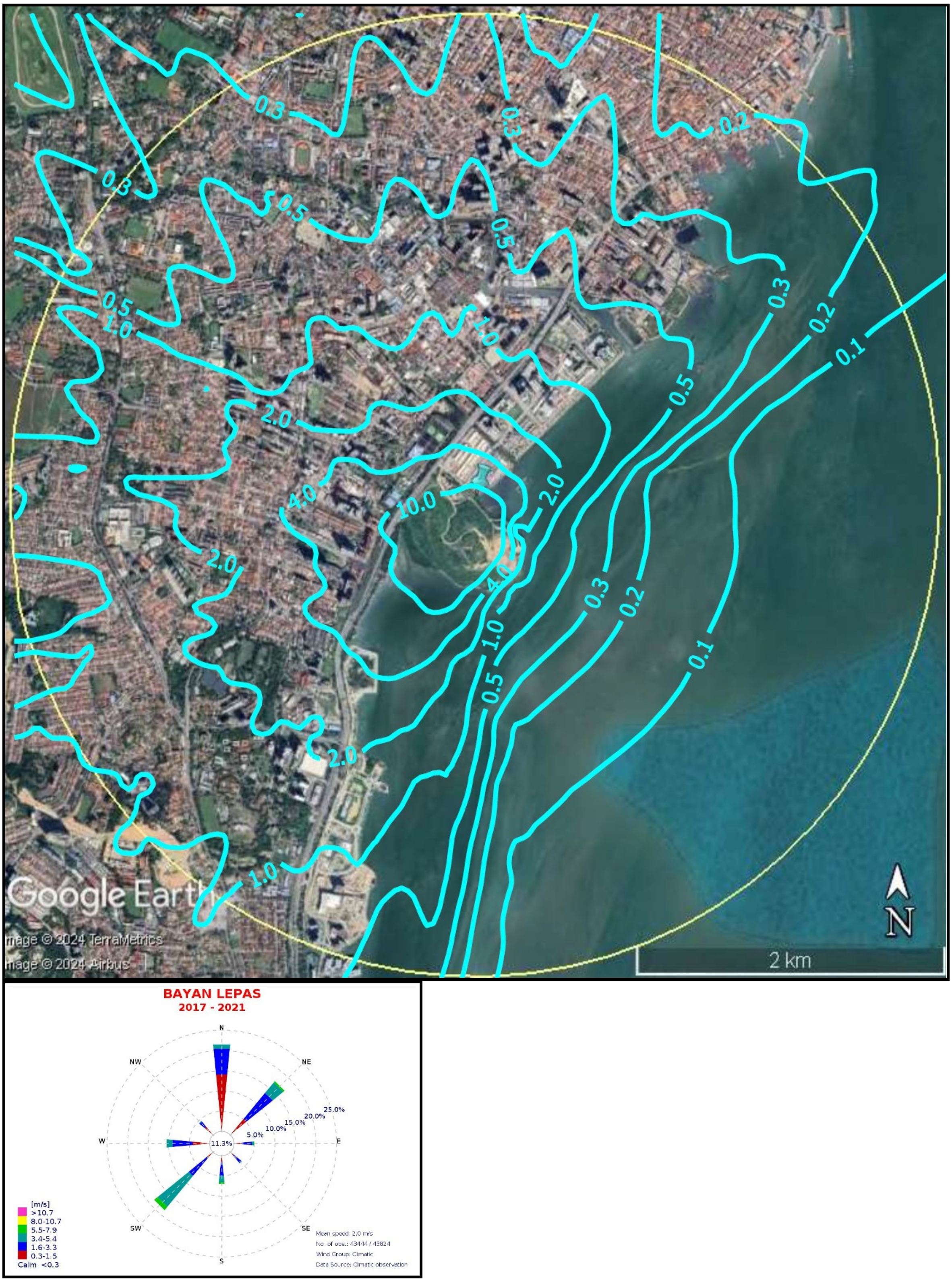


Figure 7.18 Maximum 24-Hour Average Toluene Incremental Concentration (µg/m^3) Scenario 2: After Rehabilitation

Groundwater Quality Modeling

The development of groundwater model includes major assumptions, the model grid and layering, the boundary conditions used in the flow model, and the aquifer properties assigned to the model grid. The complex hydrogeological conditions that control the movement of groundwater in the subsurface are never fully known, therefore some assumptions and simplifications must be made in the development of groundwater model. The following simplifying assumptions were made in the design of the dumpsite groundwater flow model:-

- The groundwater flow system at the project site receives recharge by infiltration of precipitation in the undeveloped open areas;
- No flow boundaries between the project site and inland areas;
- The layer of dumping material has a uniform lithological property; and
- Constant-head boundaries at the sea.

i. Model Domain

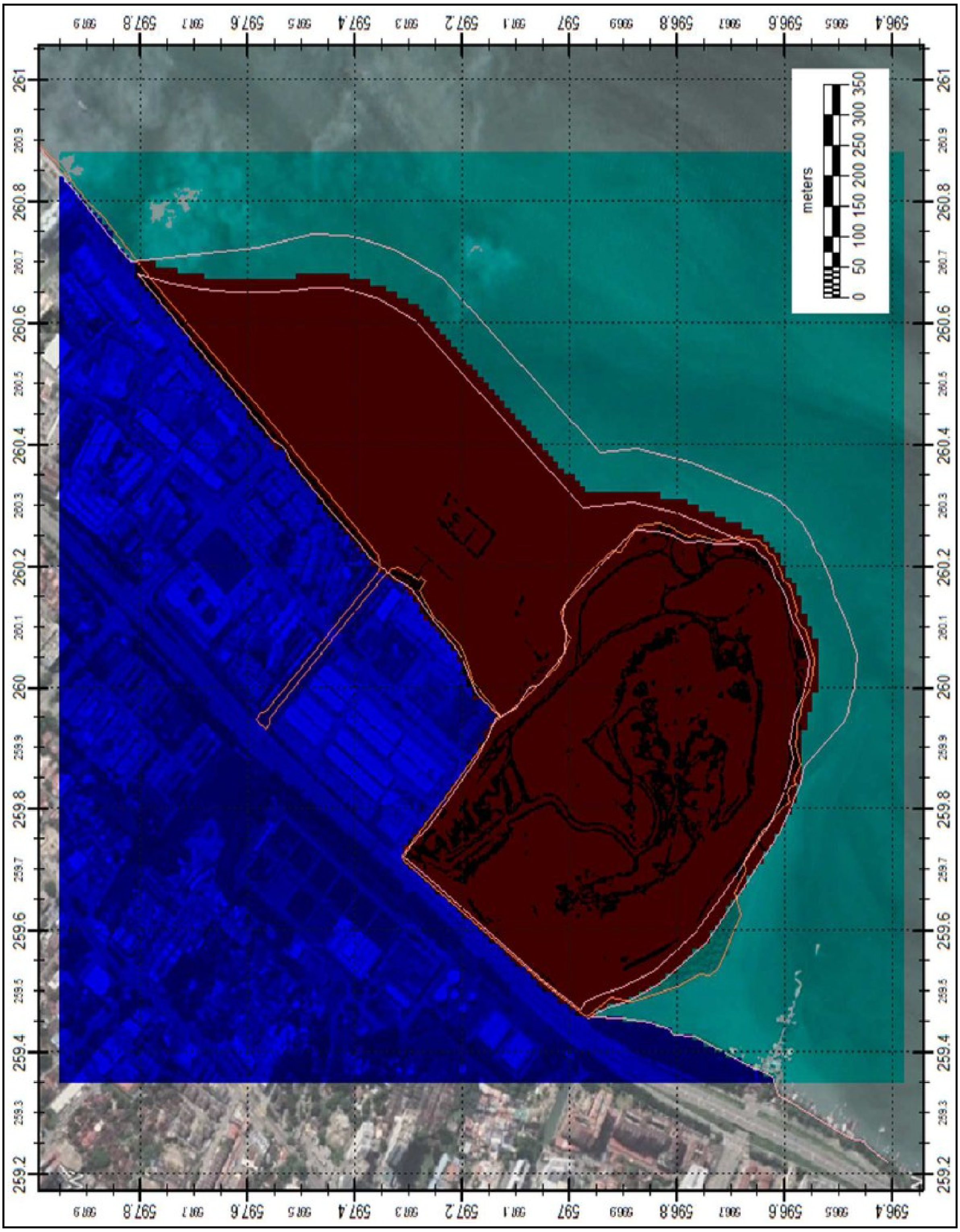
In order to adequately model the groundwater flow and contaminant flux through the project site, the domain of the model was expanded to include landfill, reclamation area and the adjacent sea area as shown in **Figure 7.19.**

ii. Model Grid

A groundwater flow model for the domain was built using iMOD. The model was divided into 153 rows and 157 columns with the size of each cell being 10 × 10 m. The model includes three layers to represent the hydrogeological conditions and data on the porous aquifers at the study site.

iii. Flow Boundary Conditions

For the lateral boundary conditions, the Dirichlet boundary condition and the Neumann boundary condition exist in the model. The sea boundary is the Dirichlet boundary condition because there is a connection between the groundwater and the sea. The groundwater flow and variations in the aquifer occur over much longer timeframes than that of tides. Due to the slower response of groundwater flow compared to tidal changes, the assumption of a constant hydraulic head (mean sea level) along the shoreline can simplify modelling without significantly impacting accuracy, especially when the study is focusing on long-term groundwater impacts. In the interface of project site and inland the boundary is assumed as a no flow boundary. For the vertical boundary conditions, the top boundary was defined for net recharge flux. The bottom boundary condition at the base of the deep aquifer was treated as no flow boundaries.



Not To Scale

Figure 7.19 Groundwater Model Domain Including The Landfill And Reclamation Area

iv. Recharge

Precipitation and withdrawal are the main recharge and discharge for groundwater, respectively. There is no existing withdrawal or plan after the reclamation work in the project site. The net recharge for groundwater is rainfall less surface runoff, direct evaporation and evapotranspiration. Estimating all these parameters can be challenging without adequate data. In natural groundcover conditions, it's common to assume that approximately 25% of rainfall infiltrates into the aquifer. With a mean annual rainfall of 2350 mm/yr, this assumption yields a mean recharge rate of 1.61 mm/day for the project site. This recharge rate remains applicable after the rehabilitation reclamation works, before further development.

v. Model Input Parameters

The formation and distribution of groundwater is controlled by the formation lithology, the geologic structure and the geomorphologic shape. The field geological observations show that the porous aquifer at the dumpsite consists of backfill, dumping materials and marine clay. The bottom layer consists of marine clay, characterized by very low permeability (k). A typical low value of 0.01 m/day is set for this layer. The hydraulic permeabilities for the dumping material layer and backfill layer were determined through calibration with the measured groundwater head. The inner and centre regions of the dumpsite is high (37 m) and densely packed, and the permeability is about 0.05 m/day. For outer region the dumpsite is much lower (about 4 m) and less packed, the permeability is higher and 1 m/day. The permeability for the backfill is 0.45 m/day. With the calibrated permeability, the simulated groundwater head agrees well with the measured head, as shown in **Table 7.10**.

Table 7.10
Comparison Between Measured And Simulated Groundwater Levels

Location	BH2	BH5	BH8	BH6
Measured Level (mMSL)	28.40	18.78	5.55	1.59
Simulated Level (mMSL)	28.33	18.37	5.73	2.01

For the post condition, the landfill is excavated to the level of 3.35 m, which is close to the level of the existing outer region. Therefore, the permeability for the remaining dumping layer is assumed to be 1 m/day, consistent with that of the existing outer region. The assumed permeabilities for the sand fill and surcharge layers in the reclamation area are assumed to be 1 m/day which is similar to the minimum permeability for sand refills required in geotechnical design (10^{-3} cm/sec, 0.86 m/day).

vi. Contaminant Concentration

The existing contaminant concentration in the dumpsite groundwater is determined based on the field measurement. After the rehabilitation work, the upper layers of dumping material will be removed to the level of +4 m. It is assumed that the contaminant concentration is linearly proportional to the volume of dumping material. The estimated contaminant concentration percentage for the post condition is presented in **Table 7.11.**

Table 7.11
Estimation Of Contaminant Concentration Percentage

	Dumping Material Levels	Dumping Material Volume	Concentration Percentage
Existing	37m ~ 10.7m	11,329,285	100%
Post-Condition	3.35m ~ 10.7m	5,103,457	45%

vii. Model Calibration

It is important to decide if the groundwater model settings is reasonable in the calibration process. The measured groundwater level at the boreholes BH2, BH5, BH6 and BH8 were used as calibration targets. Trial and error was used to calibrate the model. The hydraulic permeability were adjusted to minimize the variance of the differences of the groundwater levels. The measured and simulated groundwater levels at the monitoring boreholes are shown in earlier **Table 7.10**. It can be seen that the two levels agree well.

viii. Groundwater Flow

Mean groundwater flow fields were simulated using the steady state model. **Figure 7.20** displays the simulated groundwater levels, while **Figure 7.21** illustrates the corresponding flow directions at the existing landfill. The groundwater level appears higher in the inner region where the ground elevation is greater, gradually decreasing towards the boundaries adjacent to the sea. The groundwater flow directions generally align perpendicular to the contour lines of the groundwater levels, dispersing to the sea along the landfill shorelines. The average groundwater discharge rate into the sea along the landfill shoreline is in the order of 0.35 m^3/day/m. This agrees with the groundwater budget as shown in **Table 7.12.**

Table 7.12
Groundwater Budget

	Project Area (m^2)	Mean Recharge (mm/day)	Mean Recharge Volume (m^3/day)	Shoreline Length (m)	Discharge Rate into the Sea (m^3/day/m)
Existing	364217 (90 Acres)	1.61	586	1680	0.35
Post-Condition	647498 (160 Acres)	1.61	1042	2280	0.46

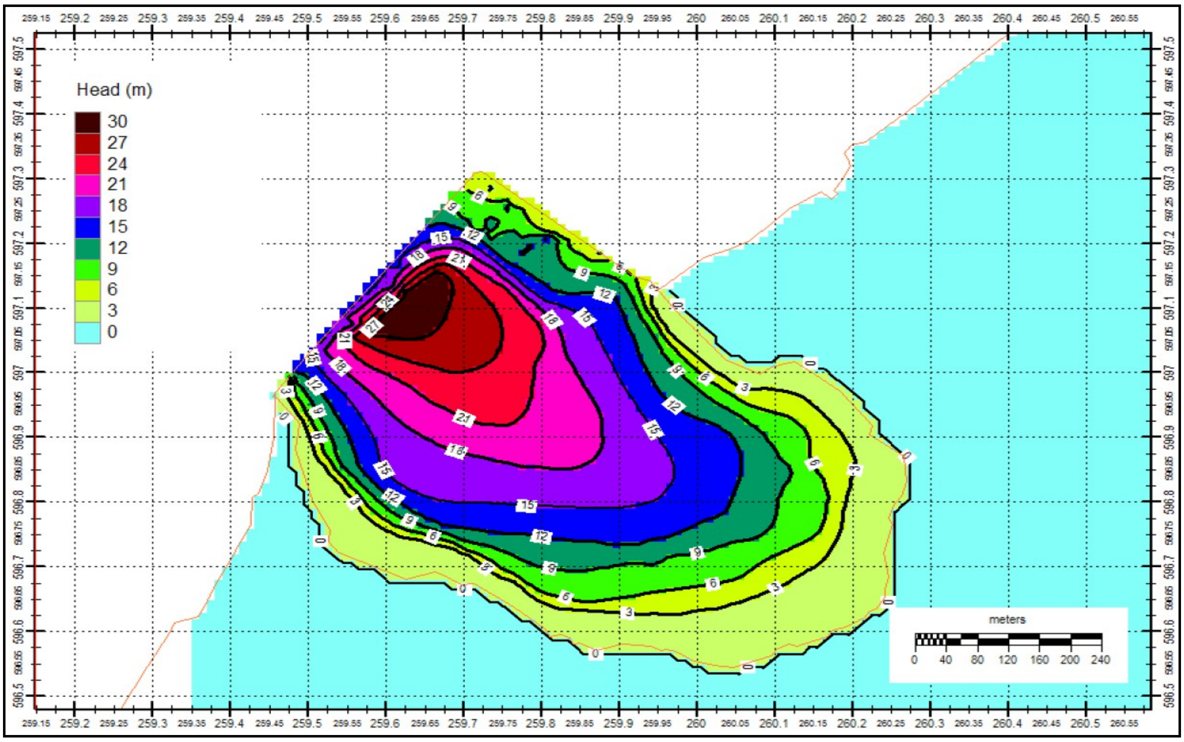


Figure 7.20 Simulated Groundwater Level Distribution At The Existing Landfill

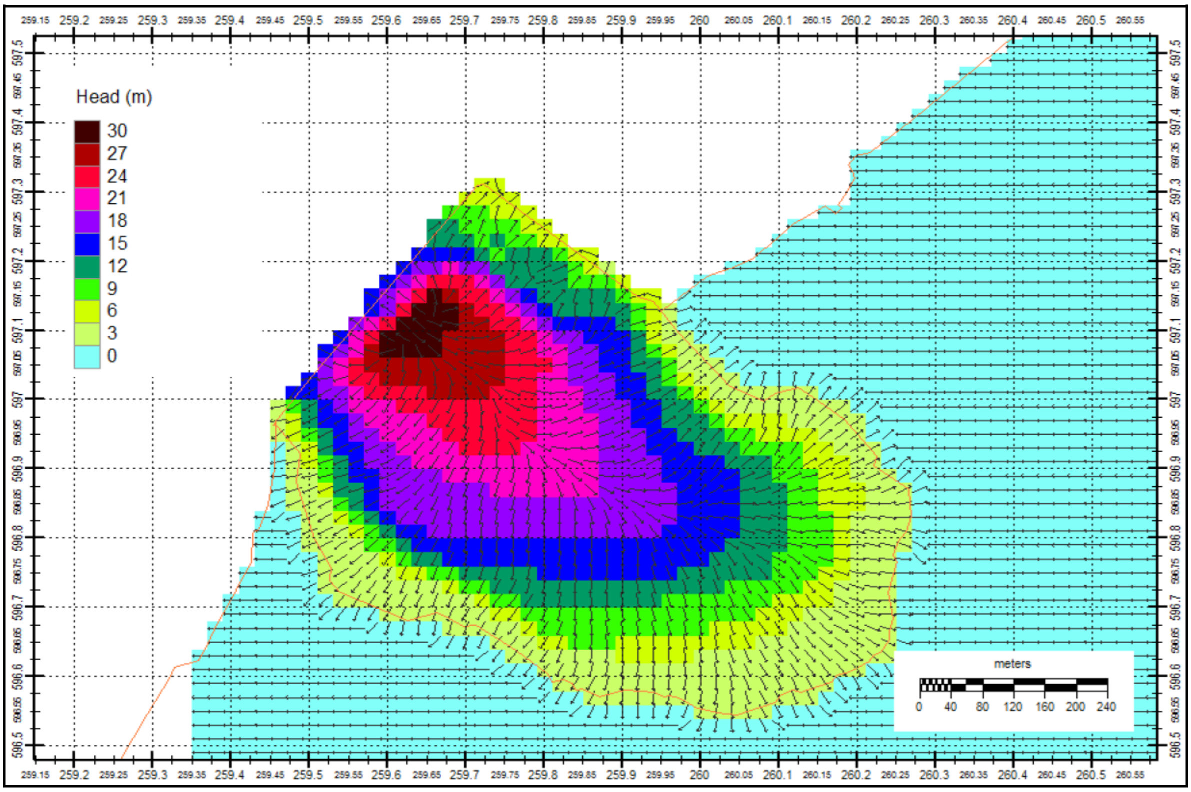


Figure 7.21 Simulated Groundwater Flow Direction At The Existing Landfill

The groundwater level distribution and flow directions after rehabilitation and reclamation works are illustrated in **Figure 7.22 and Figure 7.23**, respectively. At the boundary between the two areas, the groundwater appears to flow from the landfill area towards the reclamation area. Groundwater level contour lines are extended in both regions. The groundwater generally flows perpendicular to the groundwater level contour lines, ultimately discharging into the sea along the new shorelines. The average groundwater discharge rate into the sea along the new shoreline is in the order of 0.46 m^3/day/m.

ix. Groundwater Water Quality

The transport of the concerned contaminants with the flow are simulated based on the groundwater flow model. **Figure 7.24 to Figure 7.39** illustrate the mean concentration distribution of sixteen (16) contaminants in the project site under the existing and after reclamation conditions. Contaminants are dispersed into the sea with the groundwater flow discharge along the shorelines. As there is no significant cross flows, the dispersion of contaminant to the reclamation area is not observed.

The contaminant concentration is estimated to be 45% after the rehabilitation work based on the assumption that is proportional to the remaining dumping material volume. This reduction in the contaminant concentration corresponds to decreasing in the discharge rate of contaminants into the sea, indicating a positive impact on the contamination to the seawater.

The contaminant concentration is estimated to be 45% after the rehabilitation work based on the assumption that is proportional to the remaining dumping material volume.

This reduction in the contaminant concentration corresponds to decreasing in the discharge rate of contaminants into the sea, indicating a positive impact on the contamination to the seawater.

Given the low groundwater flow rate and moderate contamination levels, the concentrations are expected to rapidly dilute in the vicinity of the site upon discharge into the sea, meeting the marine water quality standards.

The detailed transport and dispersion patterns for various contaminants will be modelled using a coastal hydraulic model.

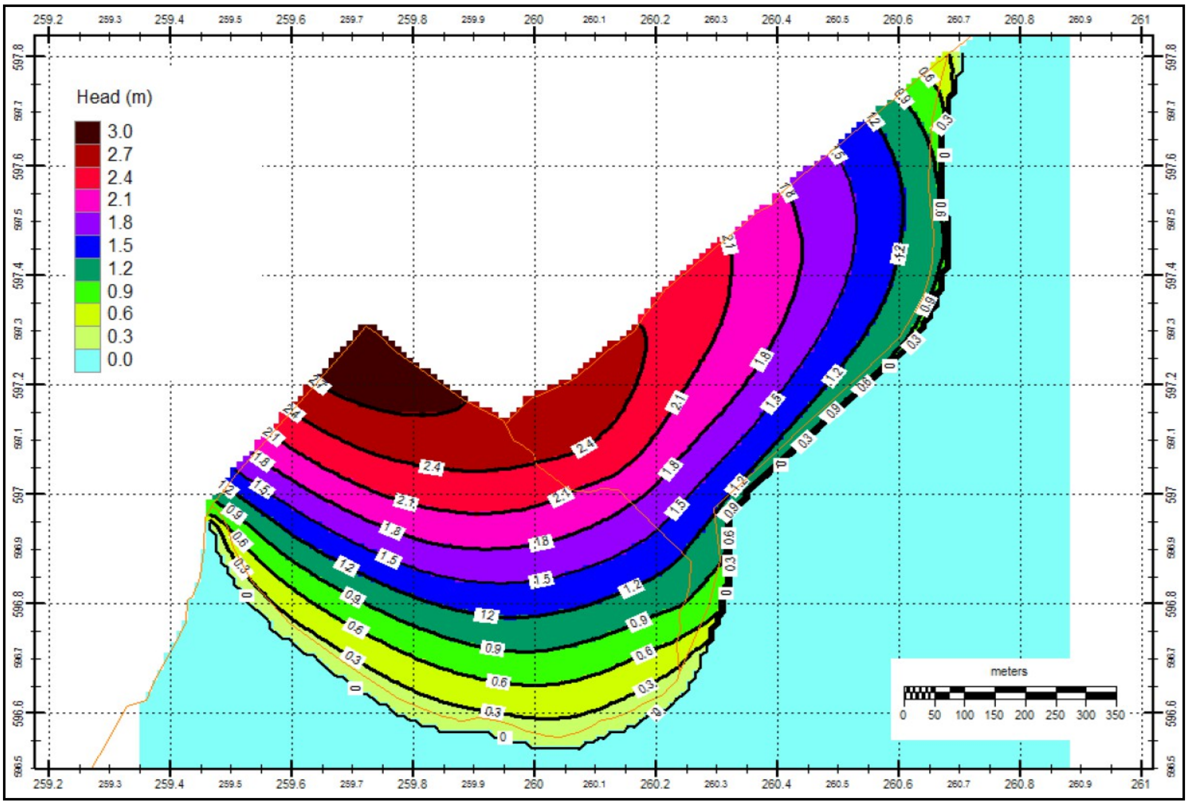


Figure 7.22 Simulated Groundwater Level Distribution After Rehabilitation And Reclamation

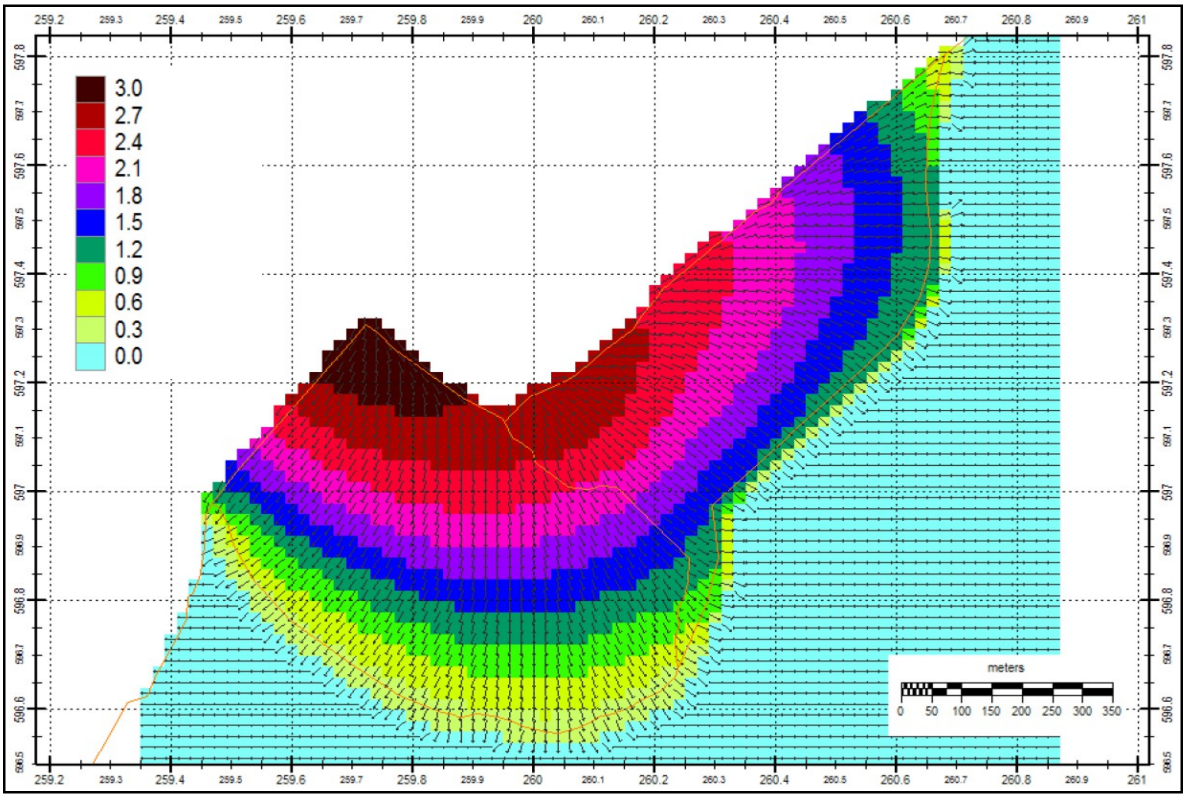


Figure 7.23 Simulated Groundwater Flow Direction After Rehabilitation And Reclamation

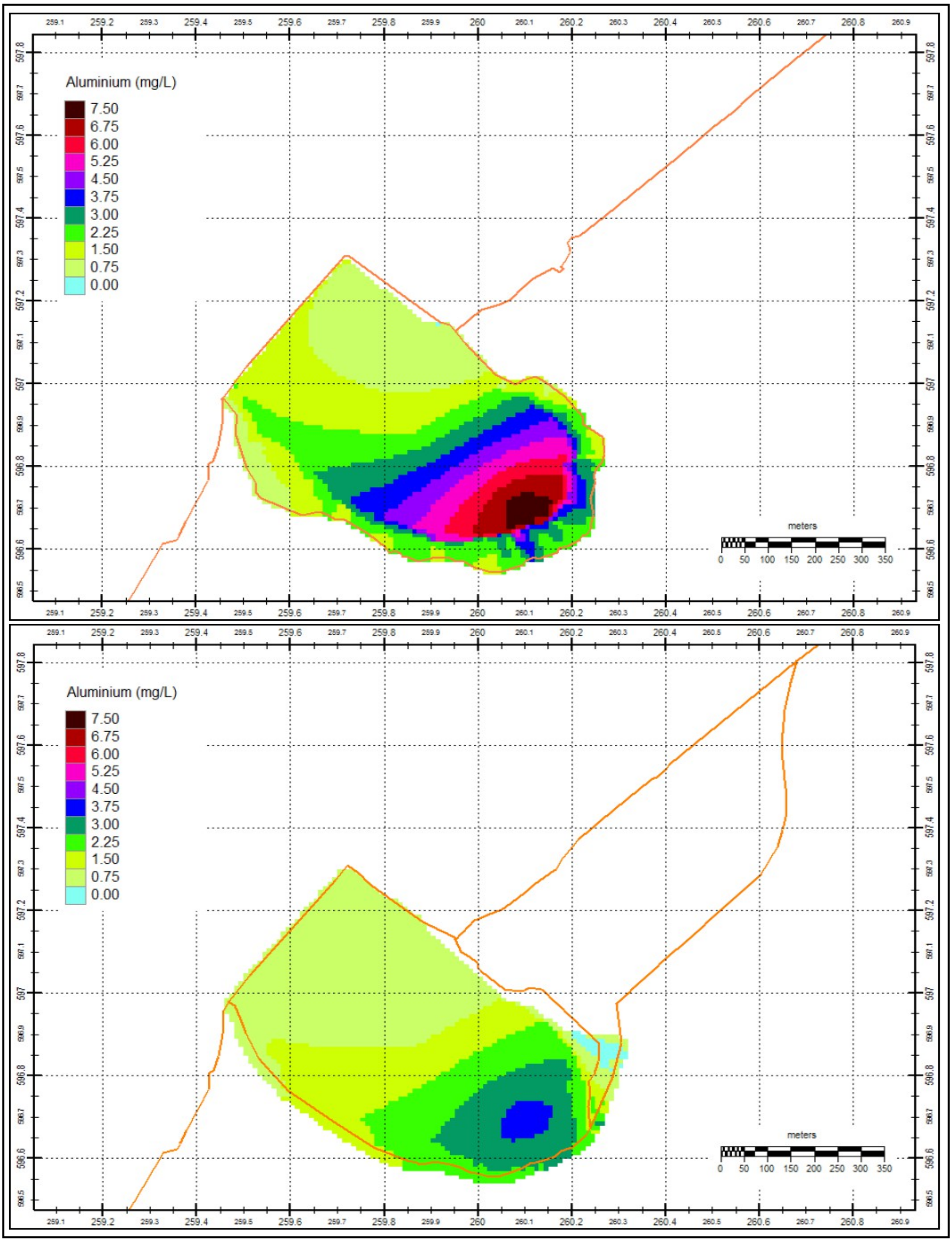


Figure 7.24 Mean concentration distribution of Aluminium in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

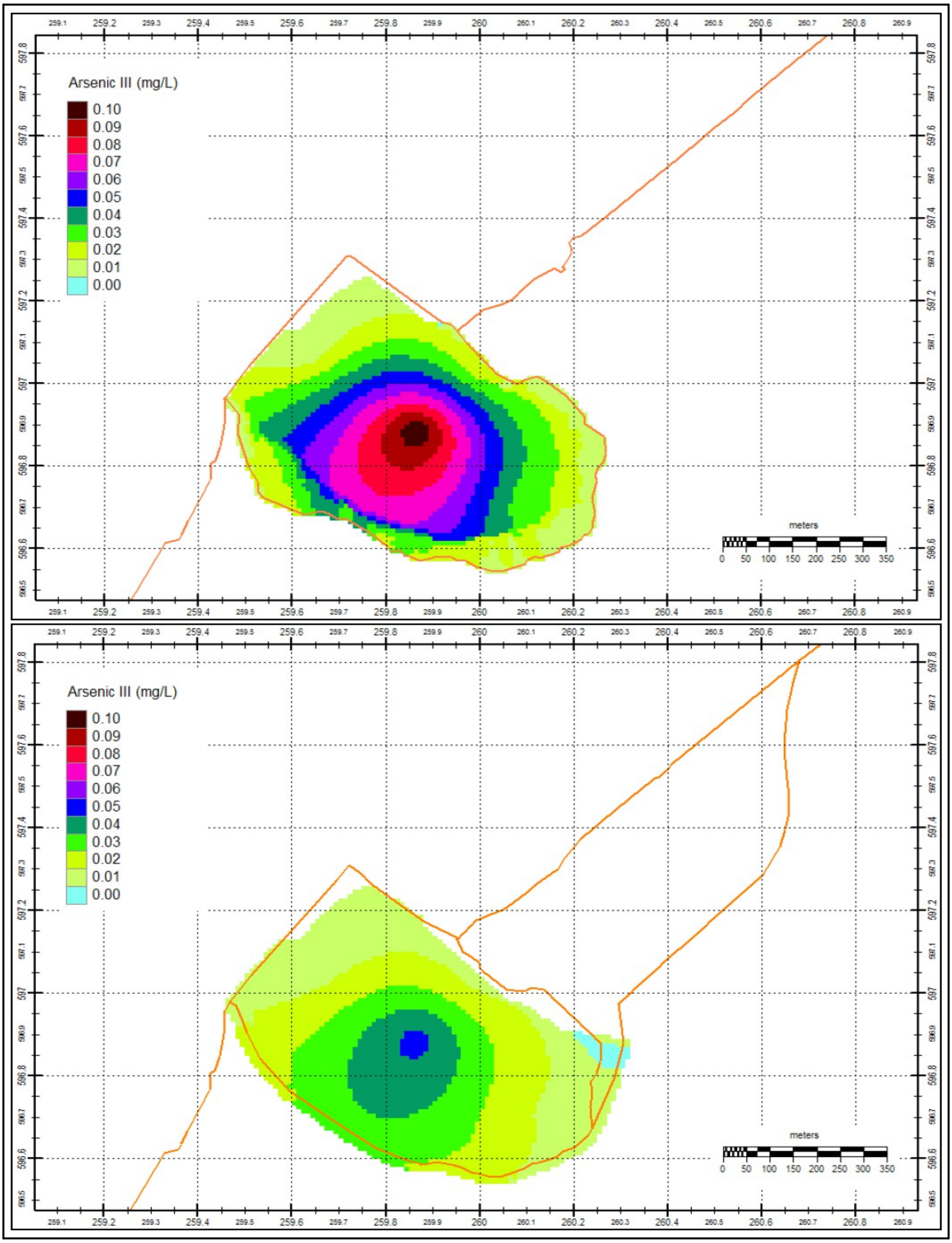


Figure 7.25 Mean concentration distribution of Arsenic (III) in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

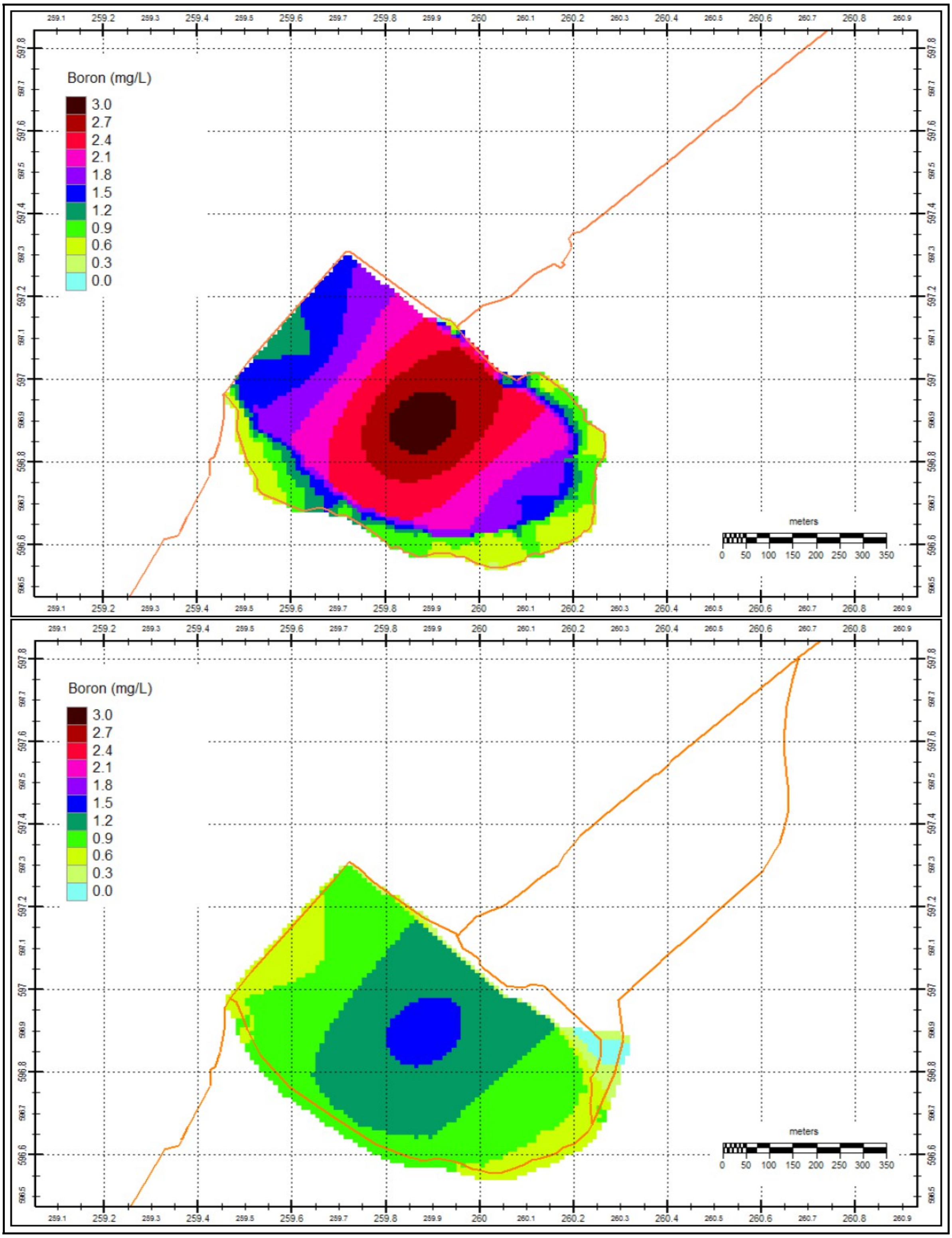


Figure 7.26 Mean concentration distribution of Boron in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

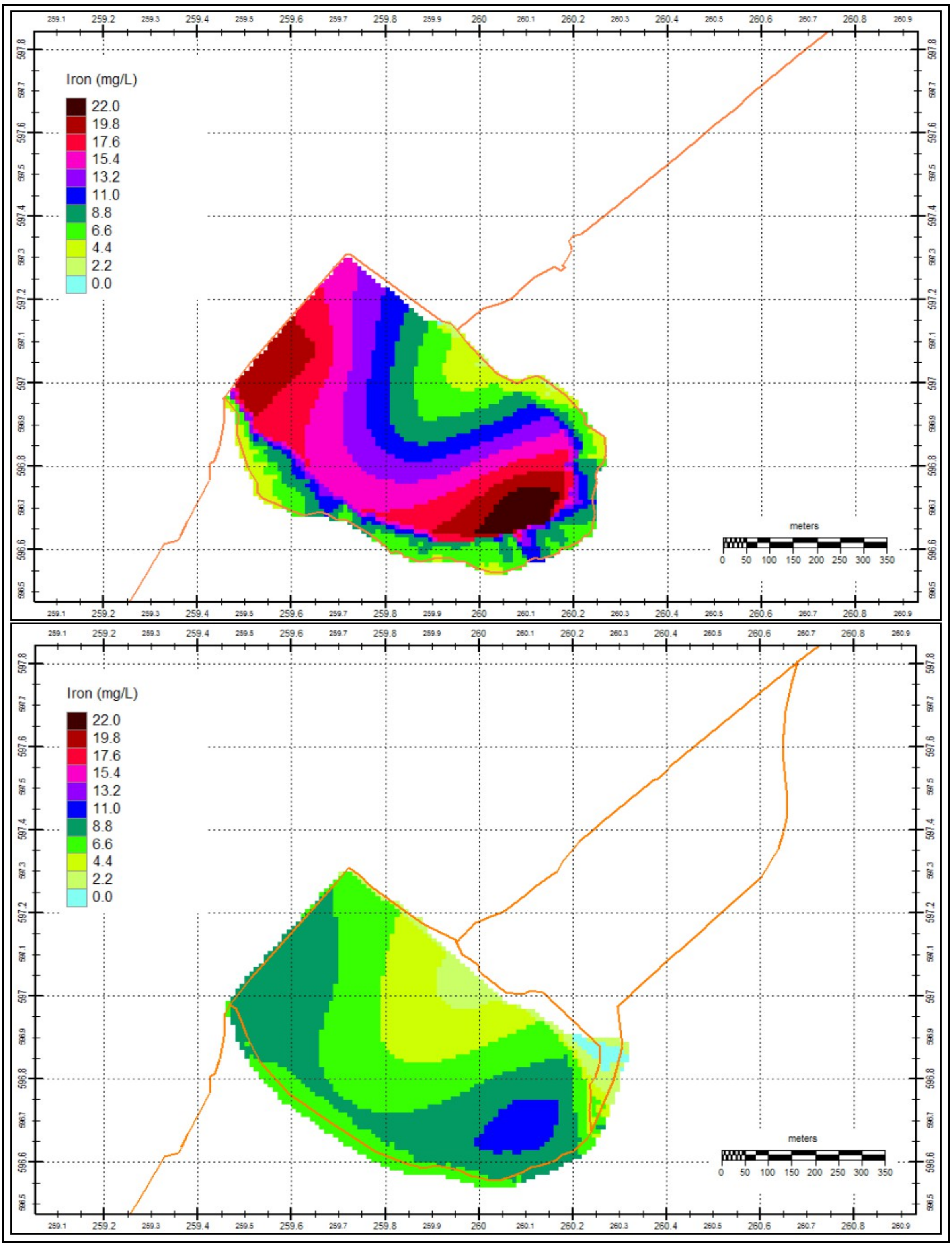


Figure 7.27 Mean concentration distribution of Iron in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

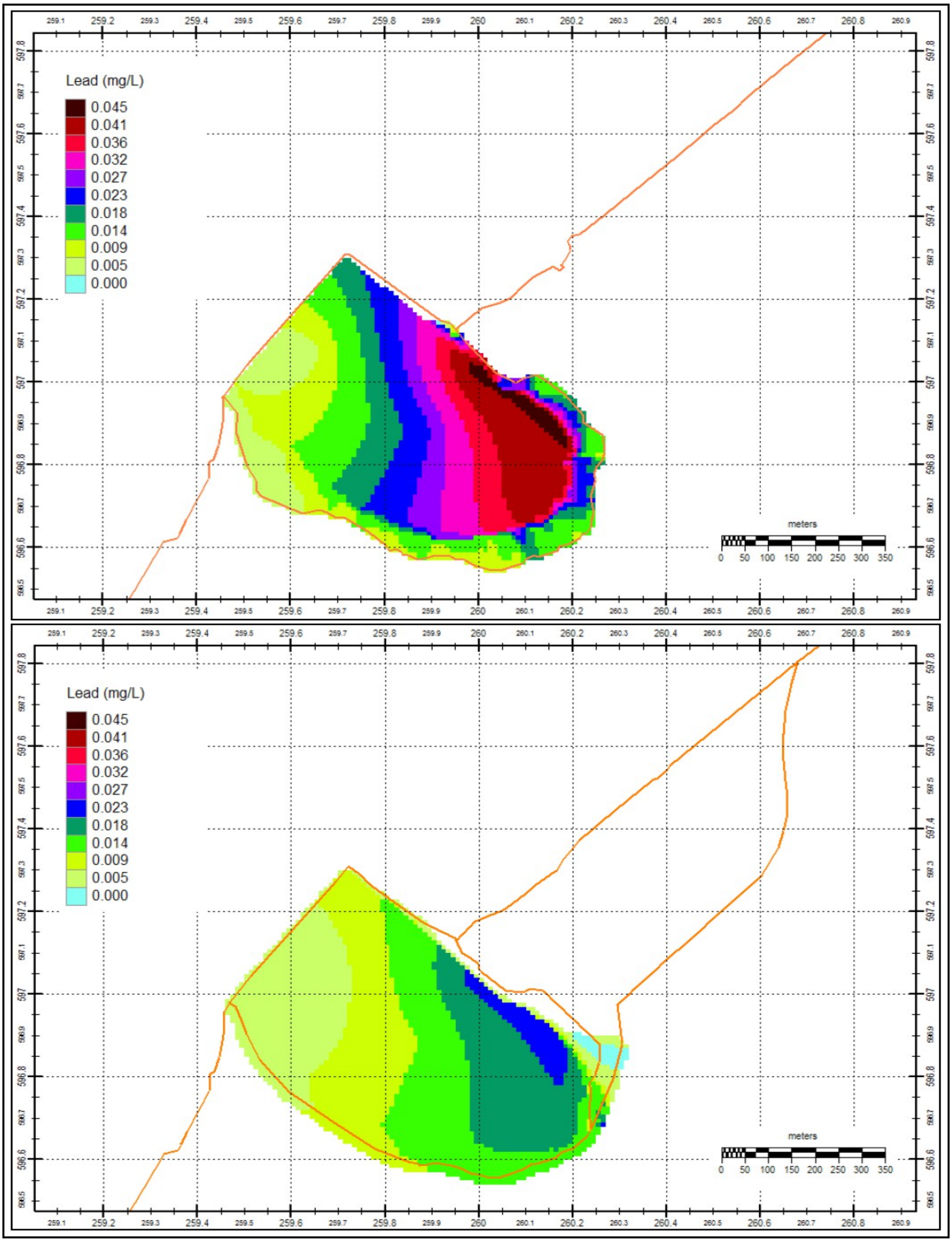


Figure 7.28 Mean concentration distribution of Lead in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

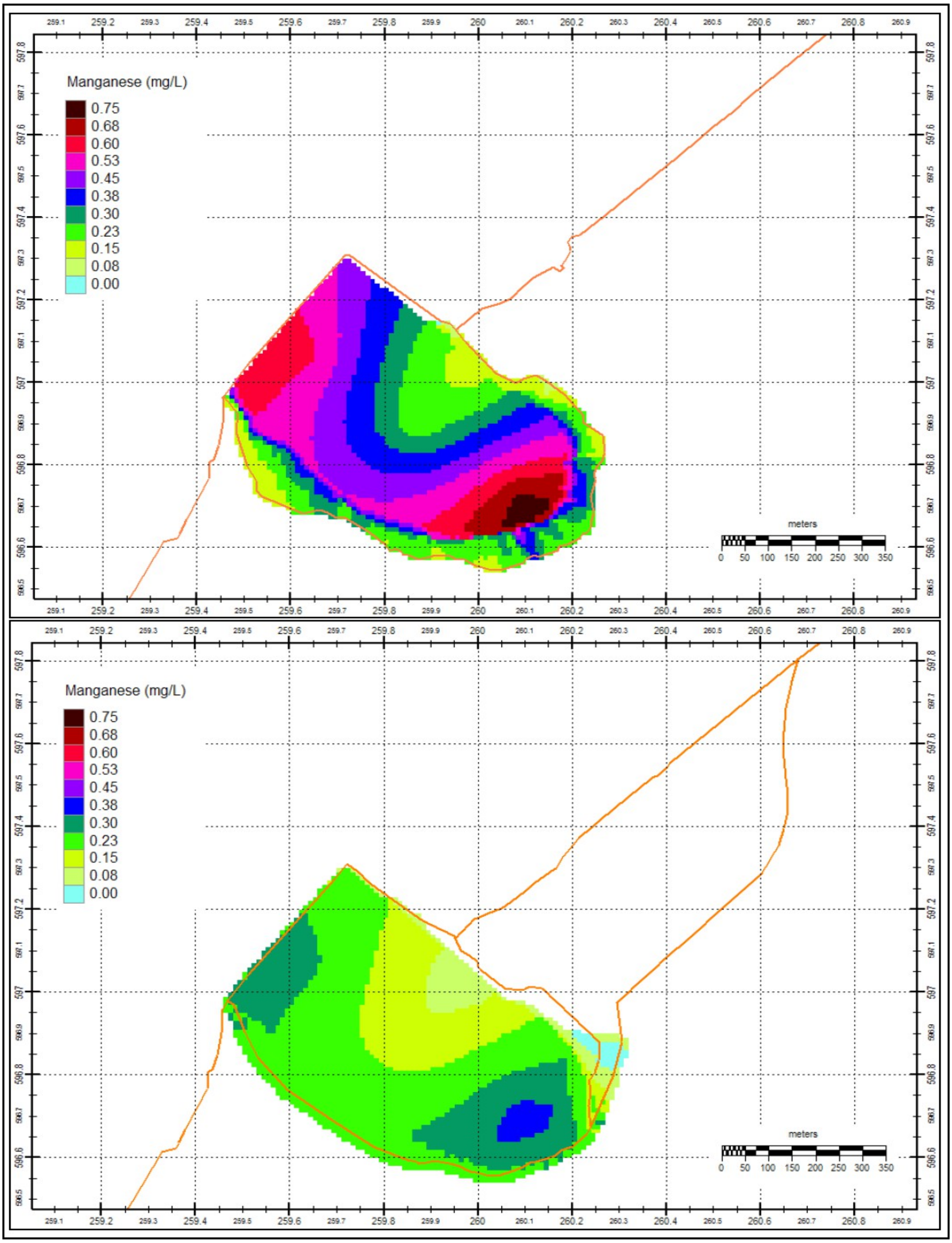


Figure 7.29 Mean concentration distribution of Manganese in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

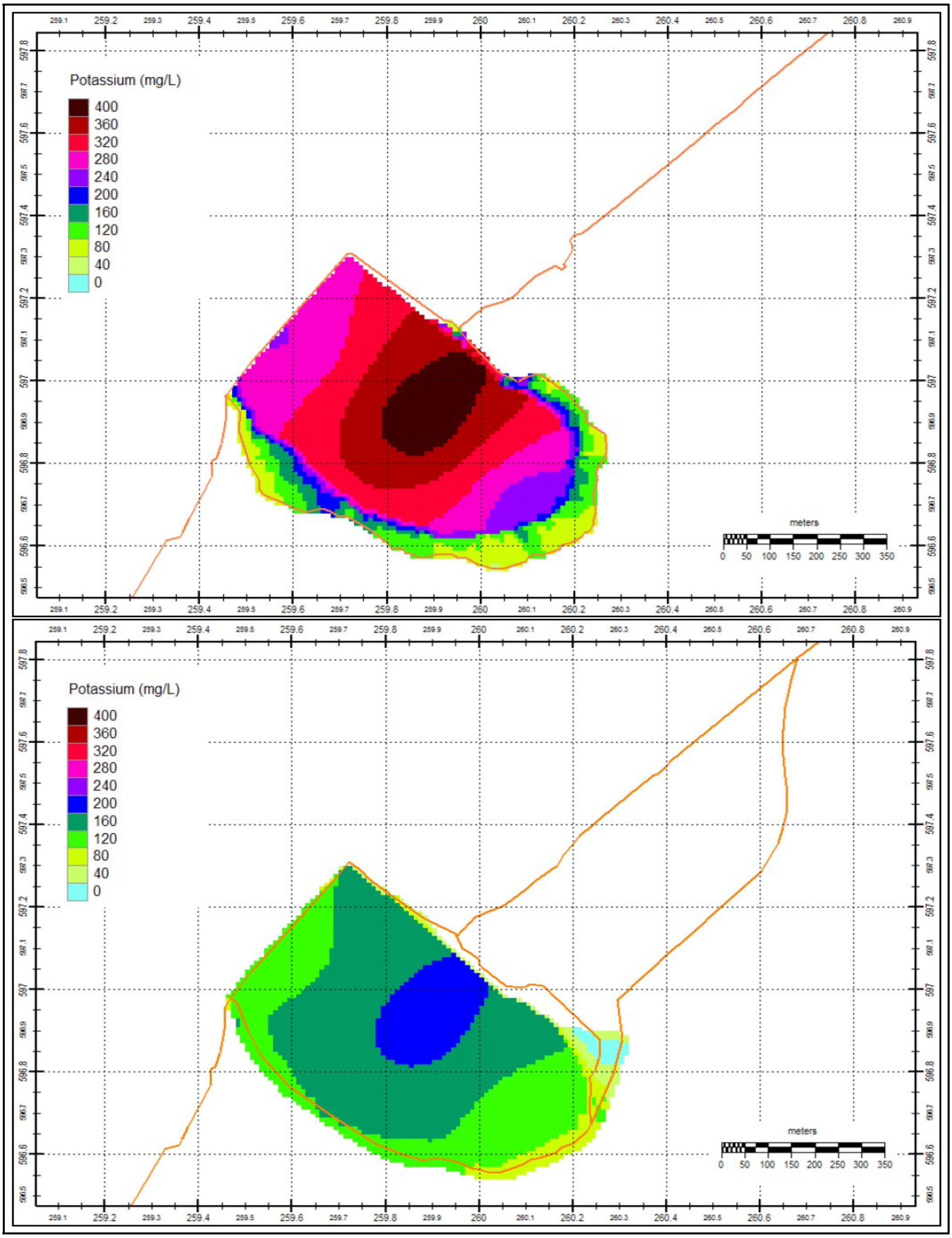


Figure 7.30 Mean concentration distribution of Potassium in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

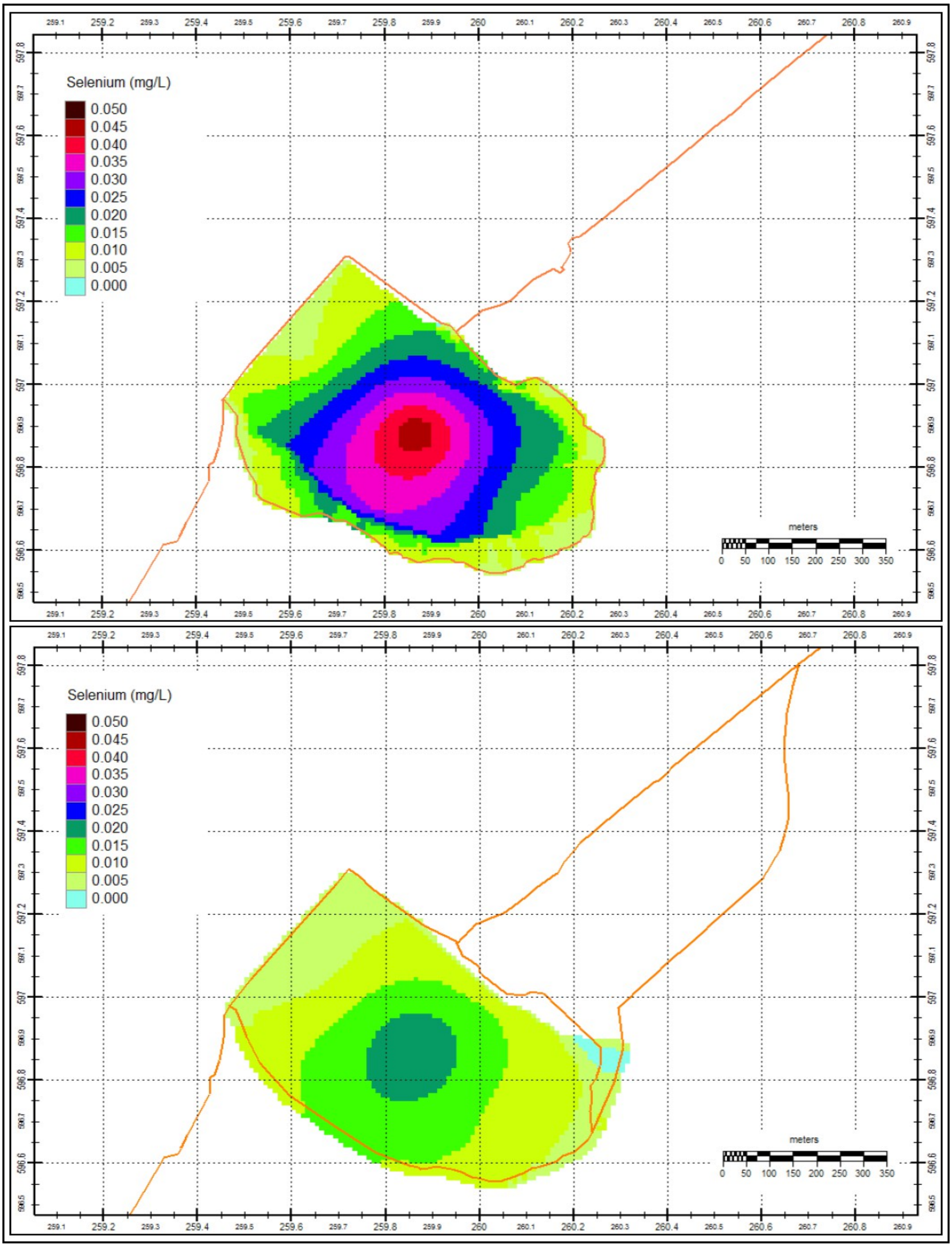


Figure 7.31 Mean concentration distribution of Selenium in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

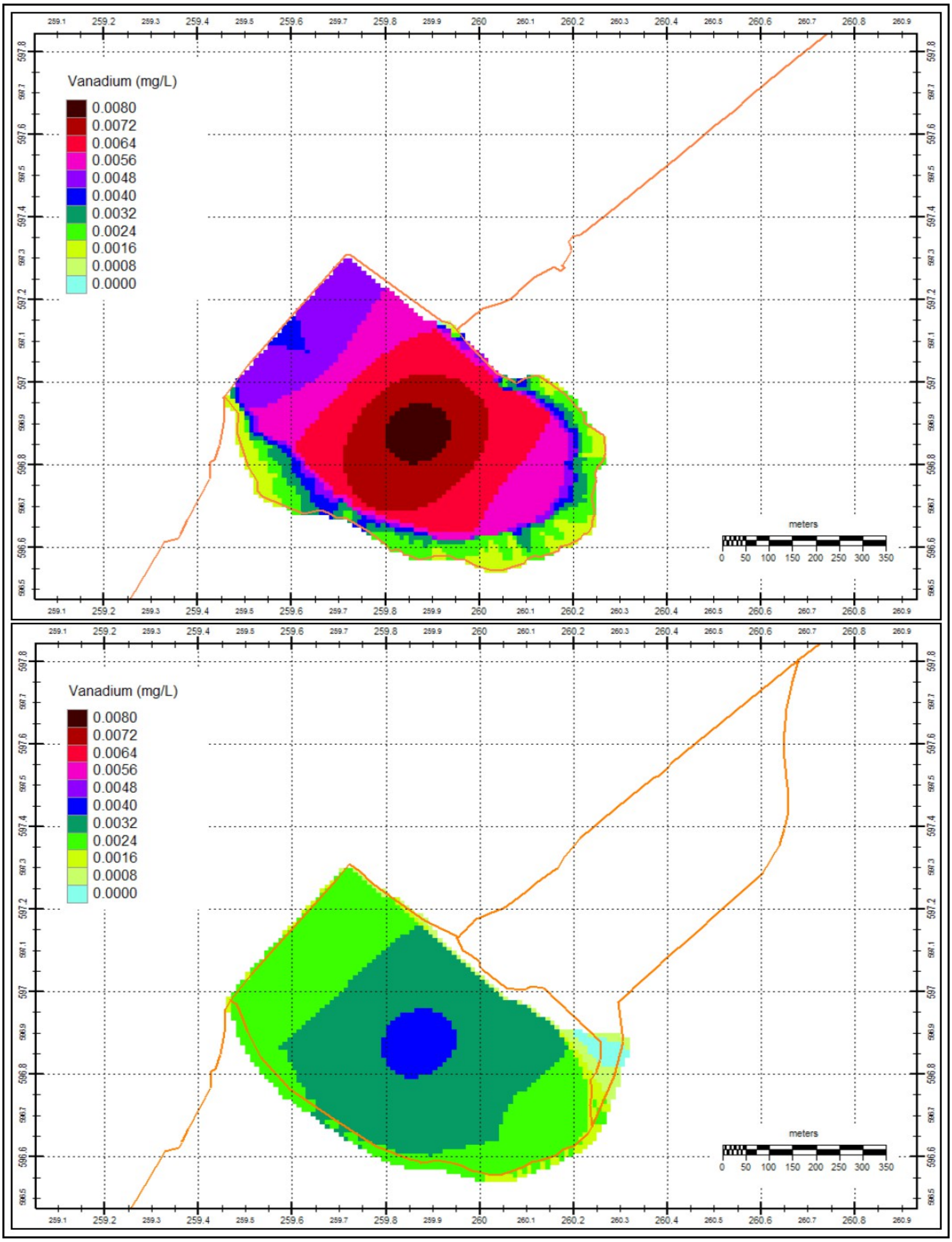


Figure 7.32 Mean concentration distribution of Vanadium in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

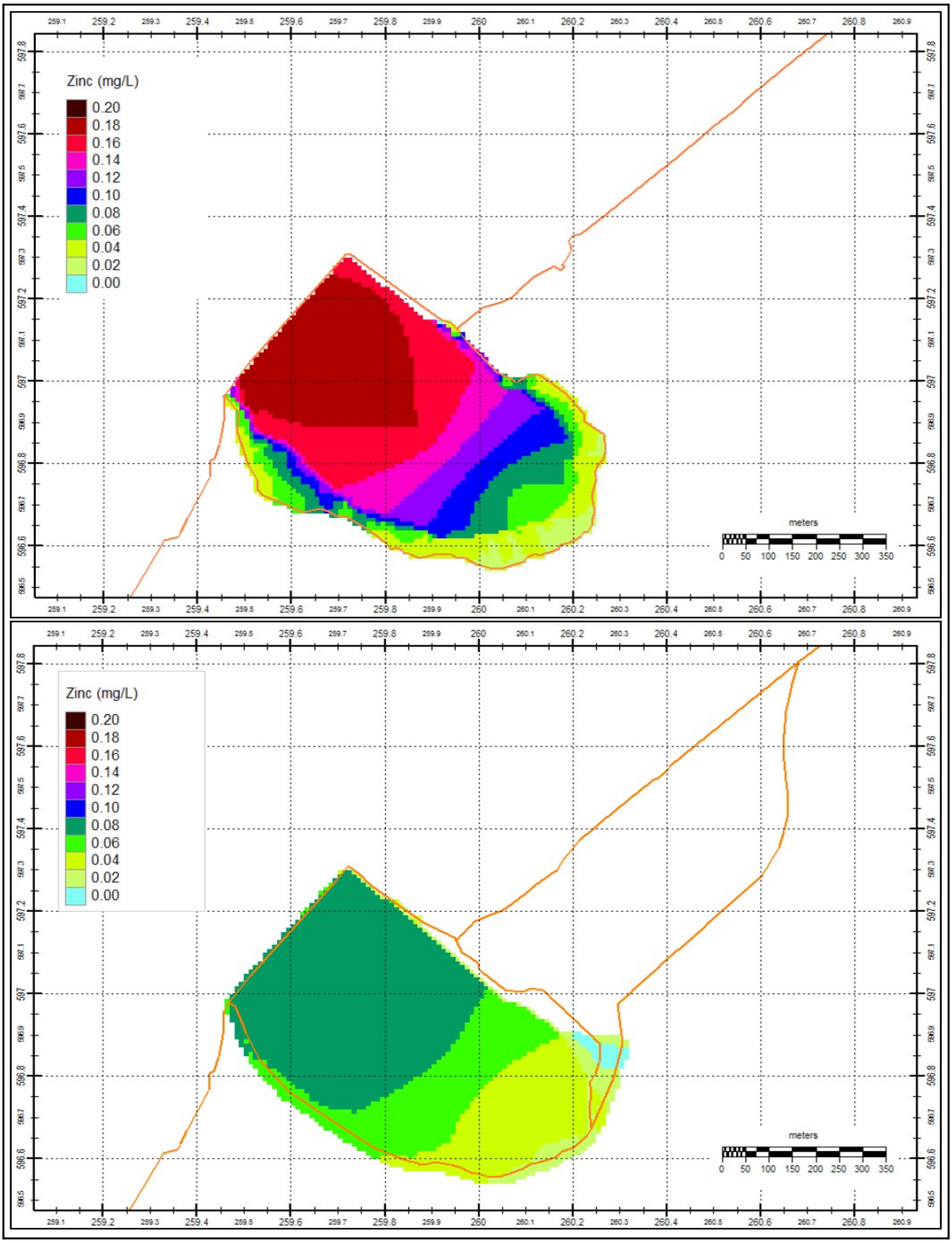
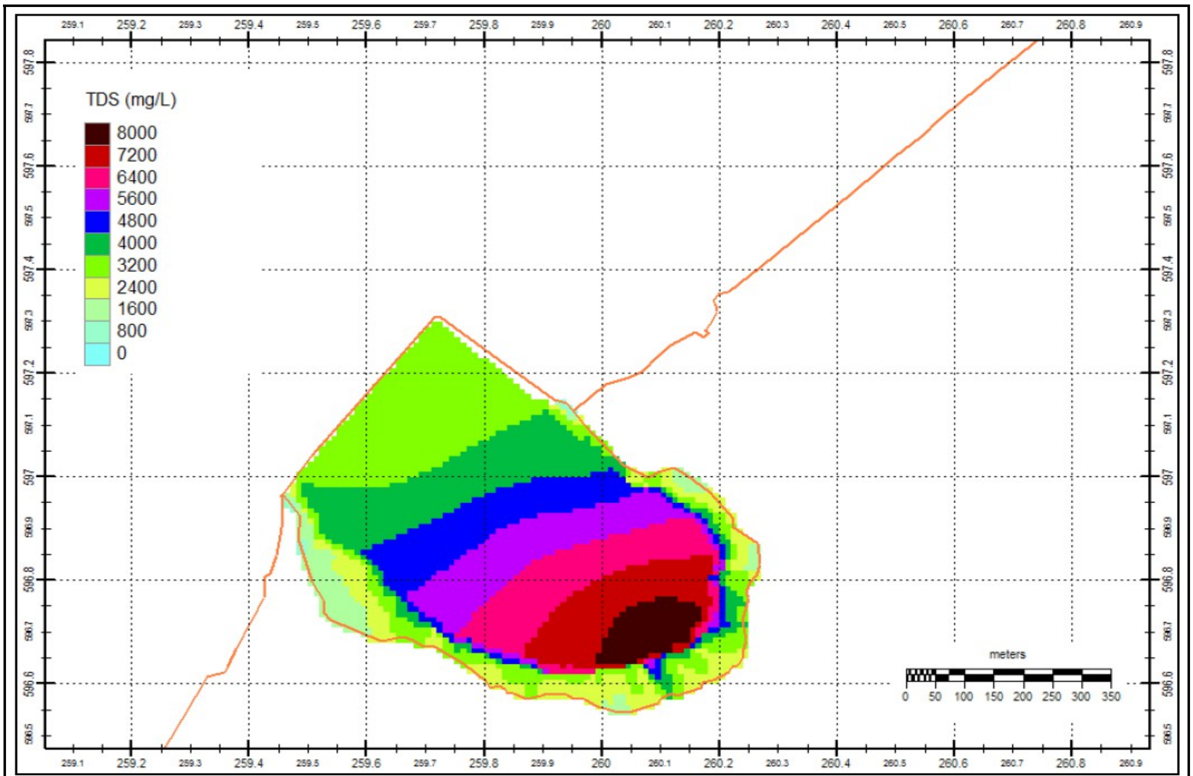


Figure 7.33 Mean concentration distribution of Zinc in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition



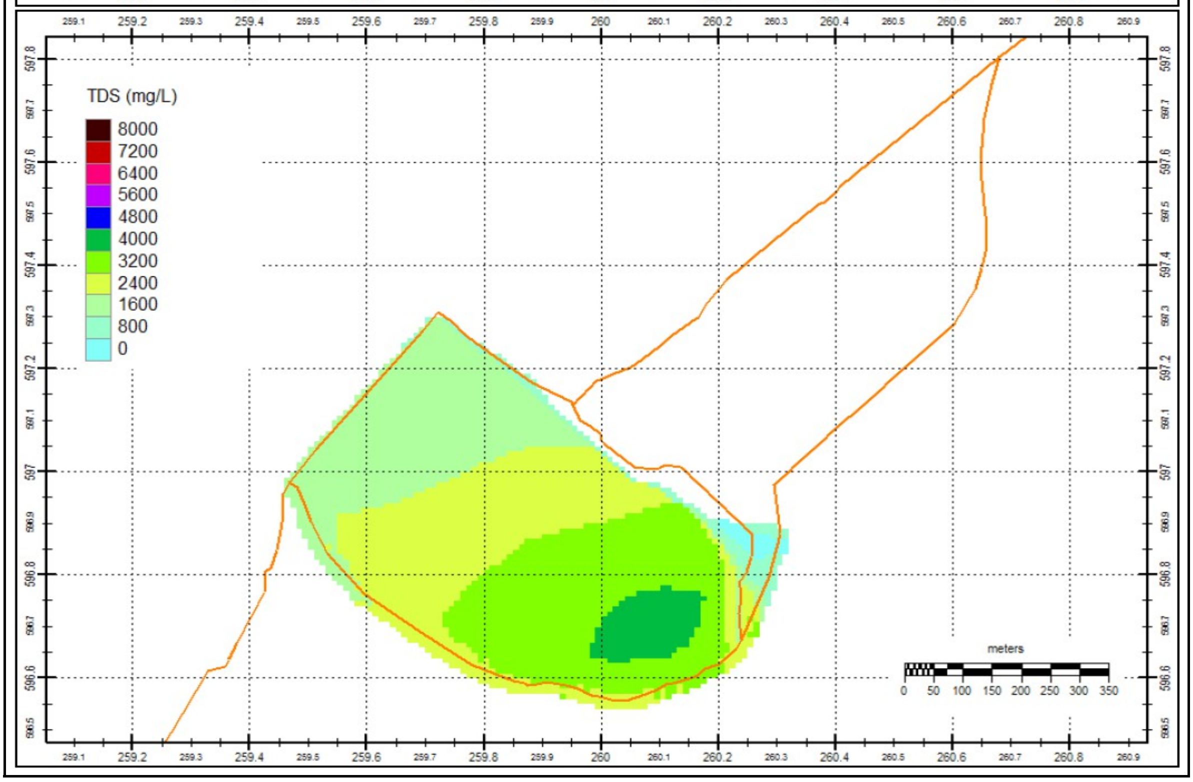


Figure 7.34 Mean concentration distribution of Total Dissolved Solids (TDS) in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

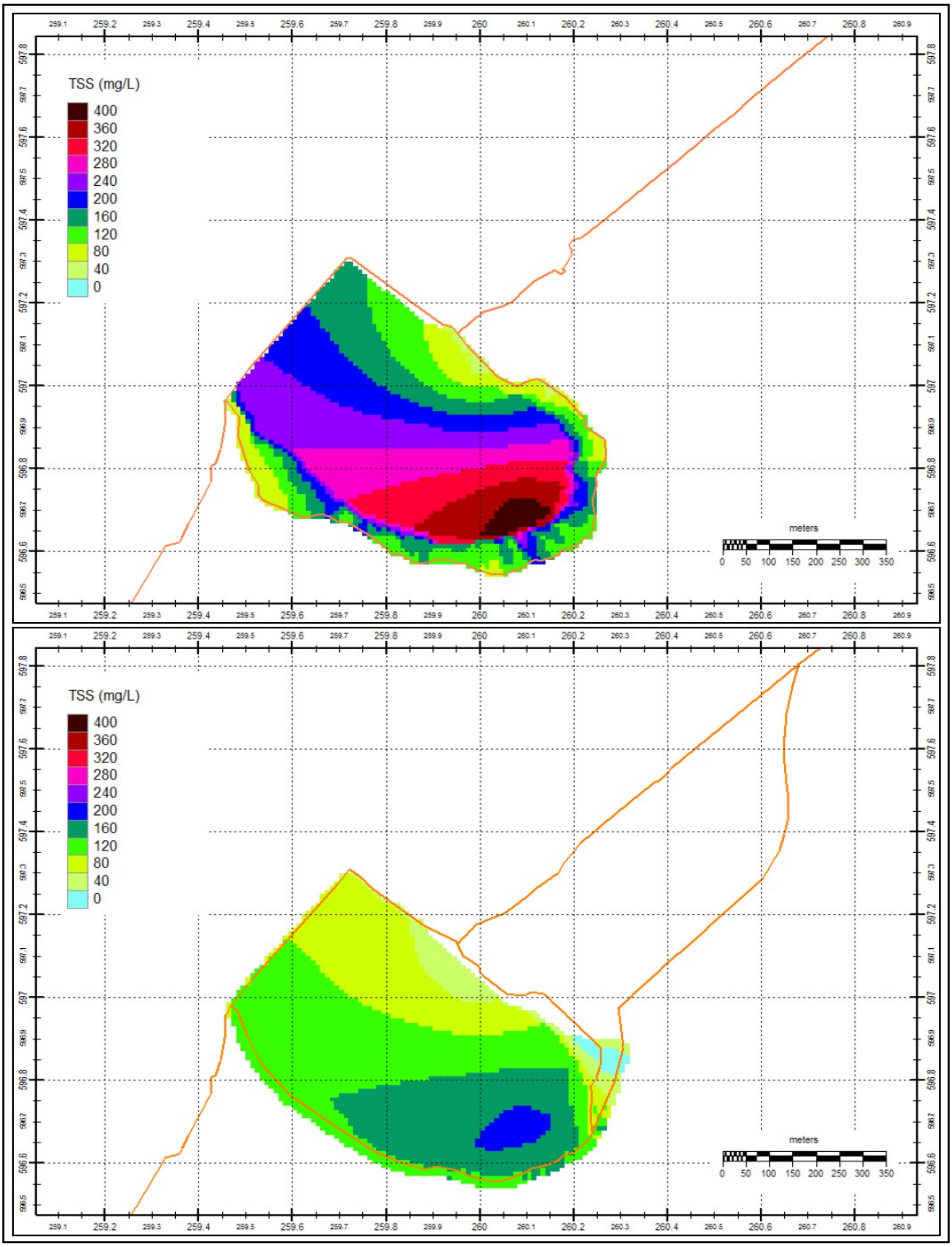


Figure 7.35 Mean concentration distribution of Total Suspended Solids (TSS) in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

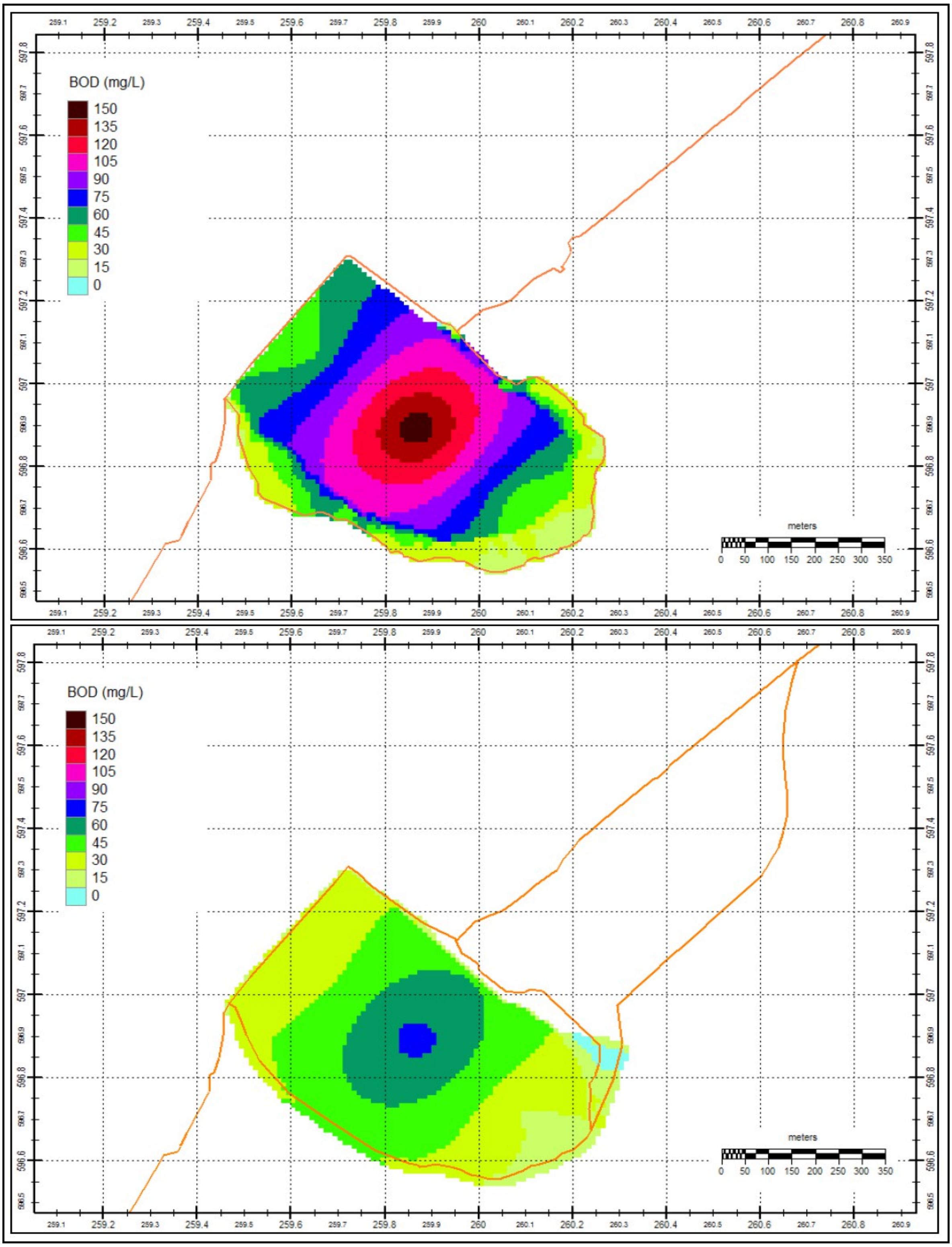


Figure 7.36 Mean concentration distribution of Biochemical Oxygen Demand (BOD) in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

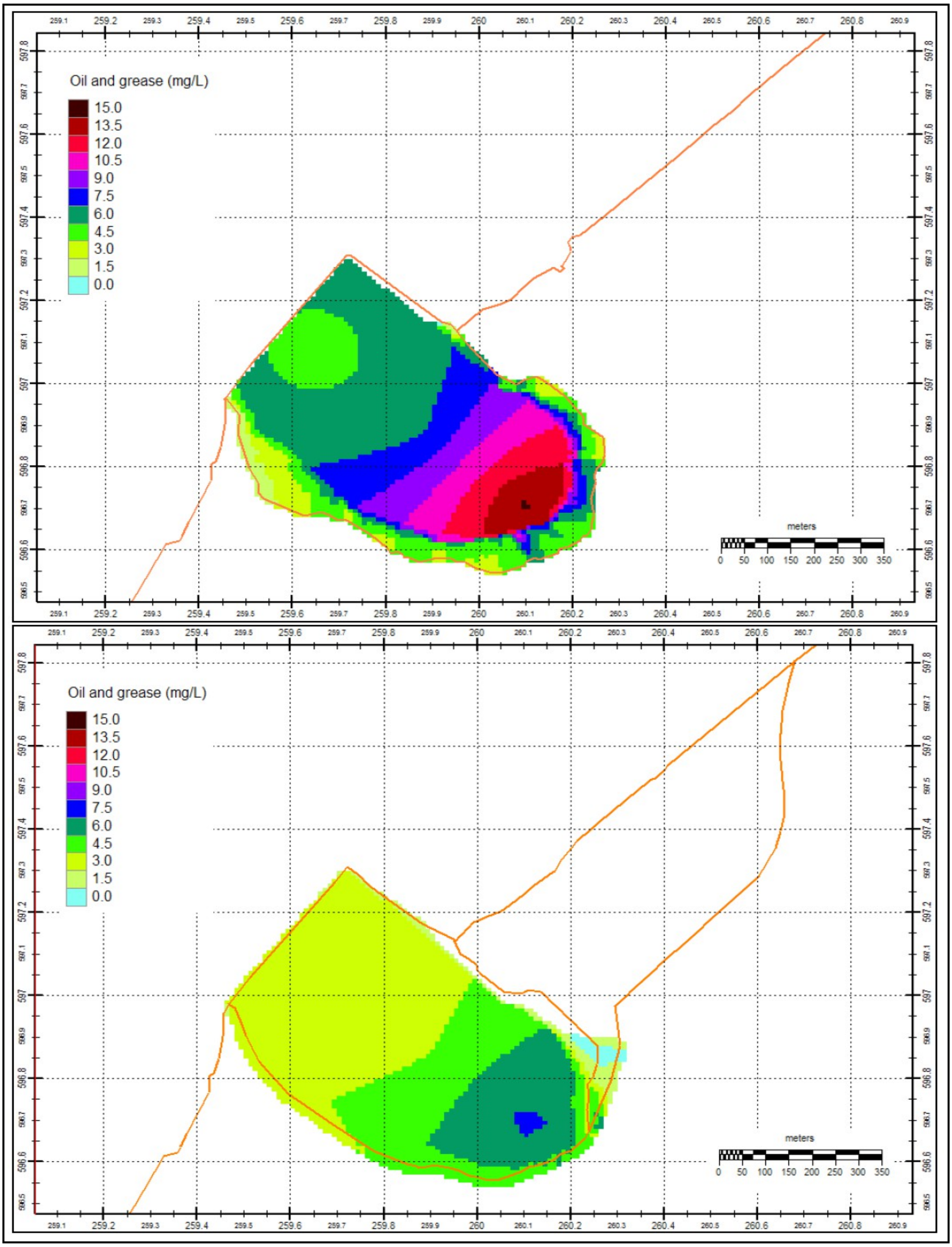


Figure 7.37 Mean concentration distribution of Oil and Grease in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

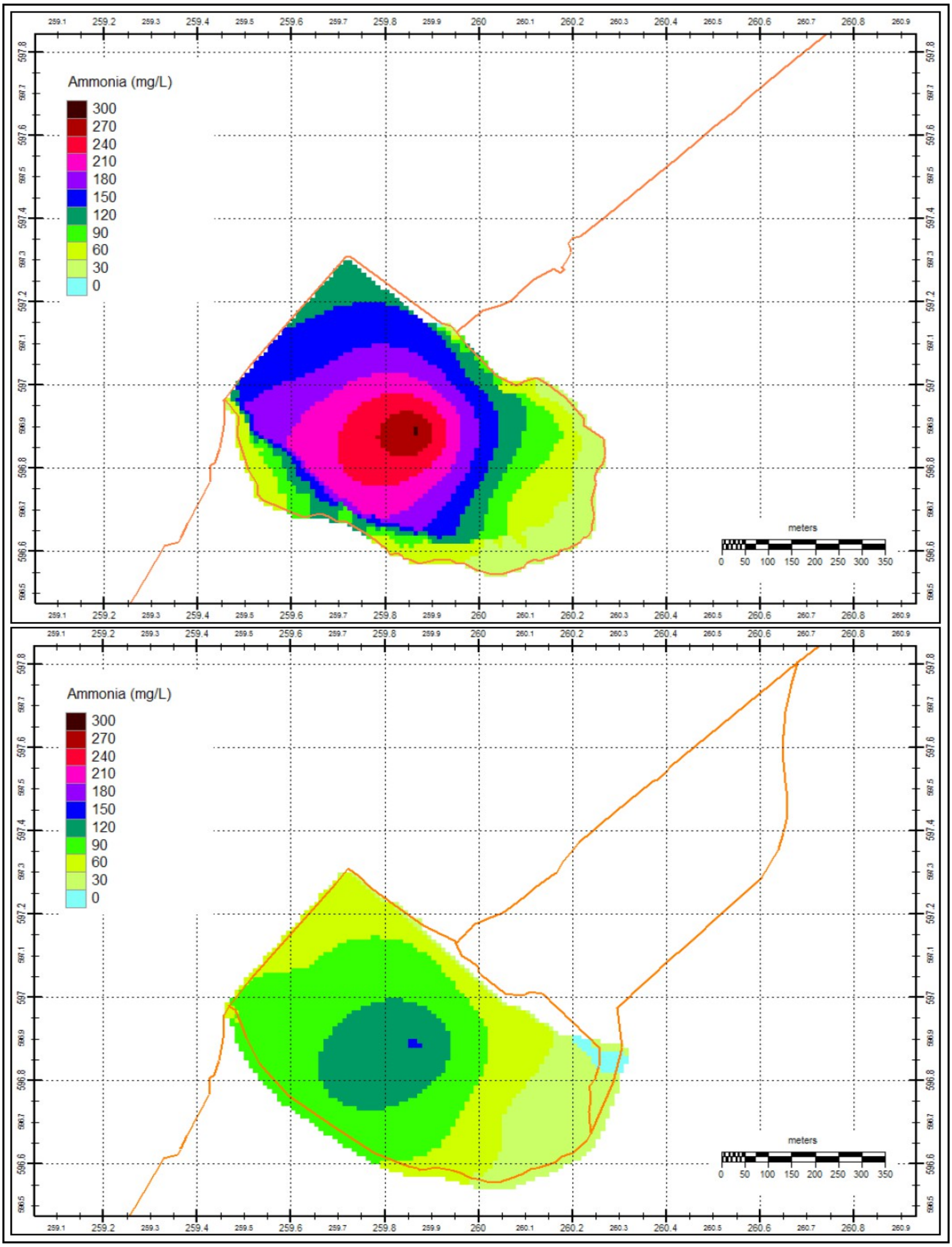


Figure 7.38 Mean concentration distribution of Ammonia in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

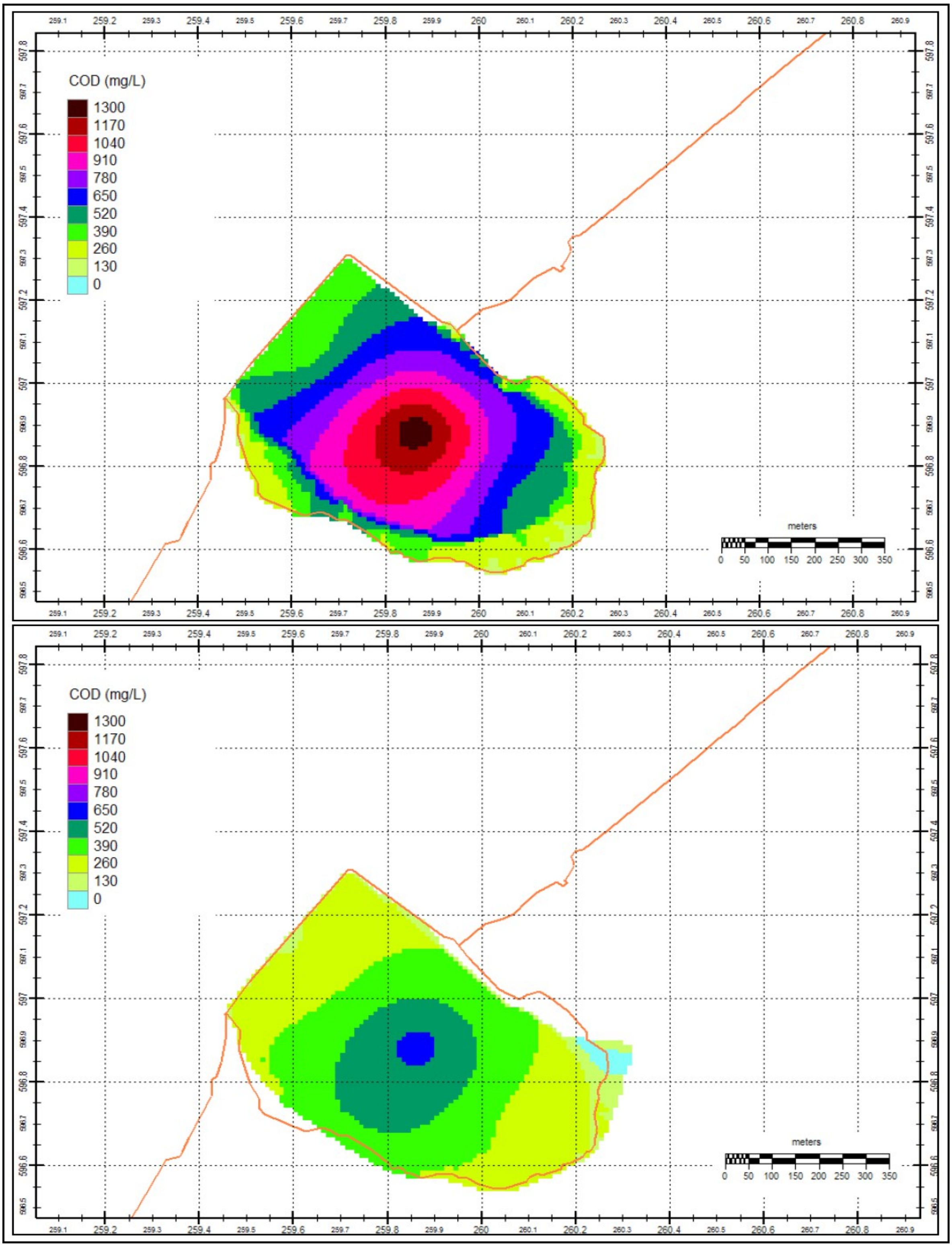


Figure 7.39 Mean concentration distribution of Chemical Oxygen Demand (COD) in the groundwater, upper panel for the existing condition and lower panel for the post reclamation condition

x. Summary

The groundwater level appears higher in the inner region where the ground elevation is greater, gradually decreasing towards the boundaries adjacent to the sea.

The groundwater flow directions generally align perpendicular to the contour lines of the groundwater levels, dispersing to the sea along the dumpsite shorelines.

The average groundwater discharge rate into the sea along the dumpsite shoreline is in the order of 0.35 m^3/day/m.

After rehabilitation and reclamation works, there is no significant cross-flow between the dumpsite and reclamation area. The groundwater generally flows perpendicular to the groundwater level contour lines, ultimately discharging into the sea along the new shorelines.

The average groundwater discharge rate into the sea along the new shoreline is in the order of 0.46 m^3/day/m.

About 55% of the dumping material will be removed in term of volume. It is assumed that the contaminant concentration is proportional to the remaining volume. Consequently, the contaminant concentration is estimated to be 45% after the rehabilitation work.

This reduction in the contaminant concentration corresponds to decreasing in the discharge rate of contaminants into the sea, indicating a positive impact on the contamination to the seawater.

Contaminants are dispersed into the sea with the groundwater flow discharge along the shorelines. Given the low groundwater flow rate and moderate contamination levels, the concentrations are expected to rapidly dilute in the vicinity of the site upon discharge into the sea, meeting the marine water quality standards.

Marine Water Quality Modeling

The development of marine water quality model takes the hydrological analysis and output of groundwater modelling results as the discharge and concentration input into the marine water. This chapter will touch on the derivation of inputs and the resulting output of the marine water quality modelling.

The focus of this study consideration is within the rehabilitation area of Jelutong site. With an area of 0.41 km^2, the rehabilitation site was demarcated into seven (7) catchment areas based on the topographical terrain as shown in **Figure 7.40.** The size of each catchment is tabulated in **Table 7.13.** Hydrological analysis was carried out to derive the design flow discharges along the boundary of the rehabilitation site for both existing condition and proposed condition (after levelling of rehabilitation site to the Final Ground Level).

Table 7.13
Catchment Area For Demarcated Jelutong Site

Catchment Number	Catchment Area (km^2)
1	0.07
2	0.08
3	0.03
4	0.07
5	0.07
6	0.05
7	0.04
Total	0.41

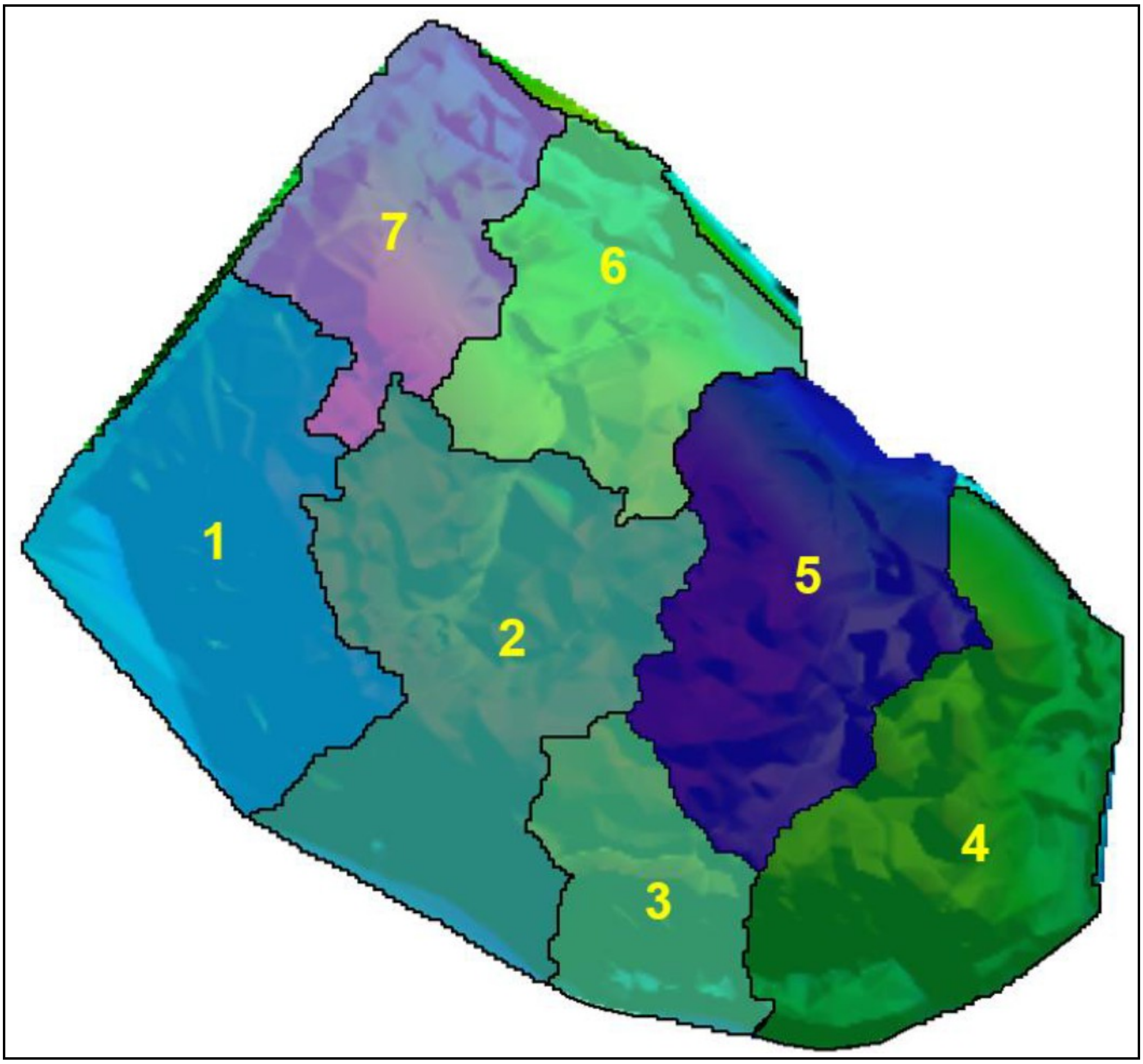
Source: Groundwater And Marine Water Quality Modeling Report, April 2024

The design flow for baseline and proposed conditions are tabulated in **Table 7.14**. Based on the analysis, the most extreme conditions are highlighted in yellow column, with the 0.5-hour rainfall duration being the highest discharge for Baseline Condition and 1-hour for the Proposed Condition. The flow under proposed condition is lower due to milder slope proposed for the future levels. The respective discharge flow and duration were used in the modelling based on these values, in addition to the concentration values based on the results of groundwater quality modelling.

Table 7.14
Discharge Flow For Each Studied Rainfall Duration

Rainfall Duration / Catchment	Baseline Condition						Proposed Condition					
	0.25-hr	0.5-hr	1-hr	3-hr	6-hr	12-hr	0.25-hr	0.5-hr	1-hr	3-hr	6-hr	12-hr
1	0.7	0.9	0.8	0.5	0.3	0.2	0.1	0.2	0.4	0.3	0.2	0.2
2	0.6	0.9	0.9	0.5	0.3	0.2	0.1	0.3	0.4	0.4	0.2	0.2
3	0.3	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
4	0.8	0.9	0.8	0.5	0.3	0.2	0.1	0.3	0.4	0.3	0.2	0.2
5	0.8	0.9	0.8	0.5	0.3	0.2	0.1	0.3	0.4	0.3	0.2	0.2
6	0.6	0.7	0.6	0.4	0.2	0.2	0.1	0.2	0.3	0.2	0.1	0.1
7	0.4	0.5	0.5	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.1	0.1

Source: Groundwater And Marine Water Quality Modeling Report, April 2024



Source: Groundwater And Marine Water Quality Modeling Report, April 2024

Figure 7.40 Sub-Catchment For Jelutong Rehabilitation Site

The Marine Water Quality Modelling focuses on the dispersion of sixteen (16) parameters listed in **Table 7.15** from the rehabilitation site into the marine water. It shall be noted that the concentration of the discharged flow were based on the results of the groundwater quality modelling. **Figure 7.41 to Figure 7.72** presents the mean and maximum dispersion for each parameter for both Existing Condition and After Reclamation Condition.

Table 7.15
List Of Modelled Parameters

No	Parameters	No	Parameters
1	Aluminium	9	Vanadium
2	Arsenic (III)	10	Zinc
3	Boron	11	Total Dissolved Solids (TDS)
4	Iron	12	Total Suspended Solids (TSS)
5	Lead	13	BOD
6	Manganese	14	Oil and grease
7	Potassium	15	Ammonia
8	Selenium	16	COD

In general, the mean dispersion is non-existent, with the values of each modelled parameter being far below the acceptance limit of each respective class. This is likely due to the low concentration dispersed from the Jelutong site in addition to the high current flow which quickly dilutes the discharge within the water column. Observation over the maximum dispersion shows that the discharges are more concentrated to the southwest of the Jelutong site which corresponds to the higher concentration discharge from the groundwater modelling, in addition to the shallow waters. It shall be noted however that the maximum dispersion is based on the worst-case scenario, where the peak of the runoff hydrograph coincides with the Spring Ebb tide, when the water is at the lowest tide level. Despite that, the maximum extent of significant dispersion within 200 m radius.

Similarly, the northern area of Baseline Condition scenario also experiences higher concentration within the water column due to the nature of shallow seabed. However, the concentration and dispersion has been significantly reduced after the rehabilitation work has been completed. The eastern side of the rehabilitation site has higher current flow in a deep channel which quickly dilutes and disperses the discharged parameters within the water to an insignificant value. The dispersion of each parameter discharged are considered to be localized and will be dispersed quickly with the current.

Table 7.16 to Table 7.19 shows the observed values for each parameter at the identified ESR area around the Study Area for Baseline Condition. Meanwhile, **Table 7.20 to Table 7.23** shows the parameter values around the Study Area after the reclamation work has been completed and the Jelutong site has been rehabilitated.

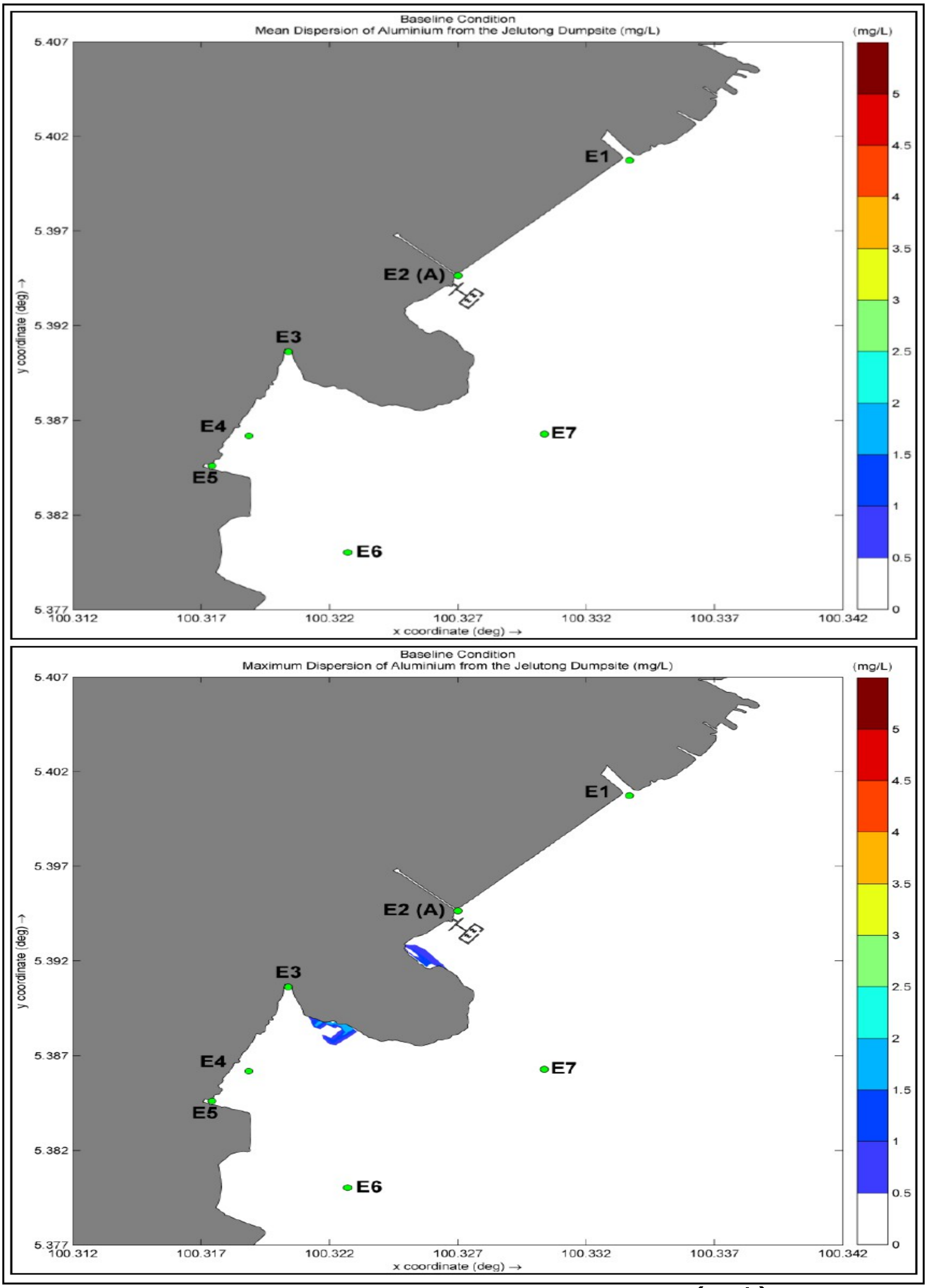


Figure 7.41 Mean and maximum dispersion for Aluminium (mg/L) for Baseline Condition

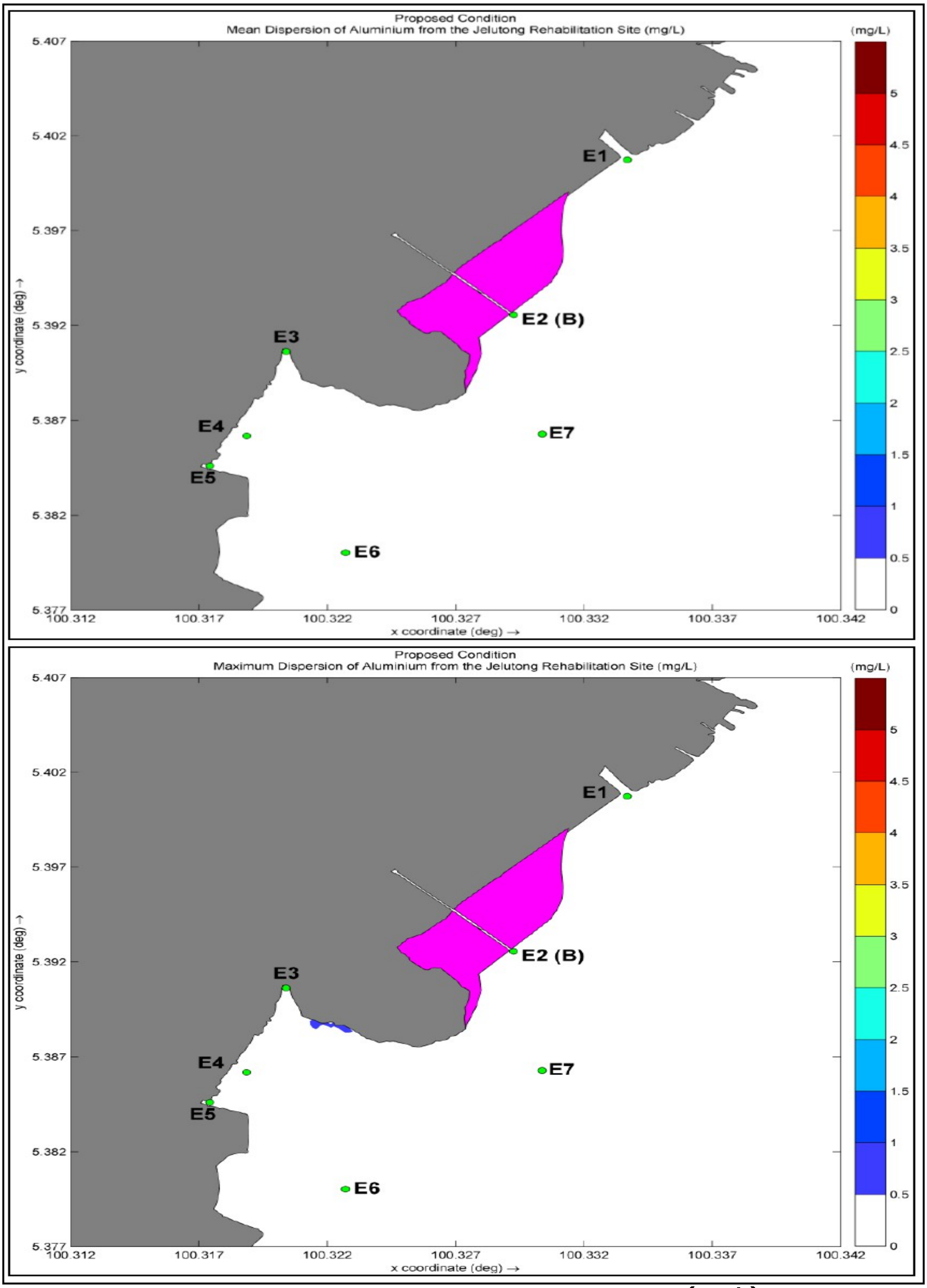


Figure 7.42 Mean and maximum dispersion for Aluminium (mg/L) for Proposed Condition

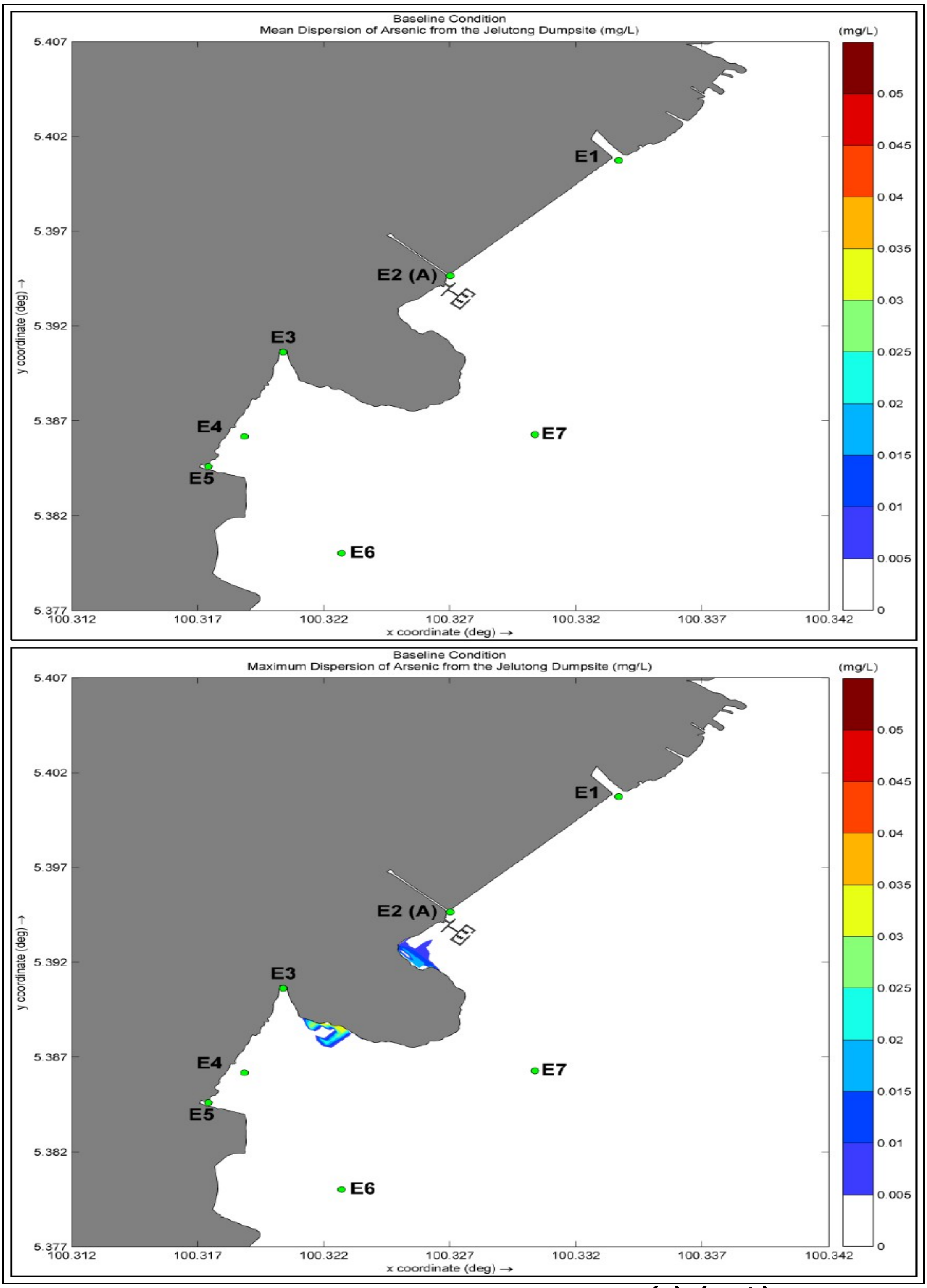


Figure 7.43 Mean and maximum dispersion for Arsenic (III) (mg/L) for Baseline Condition

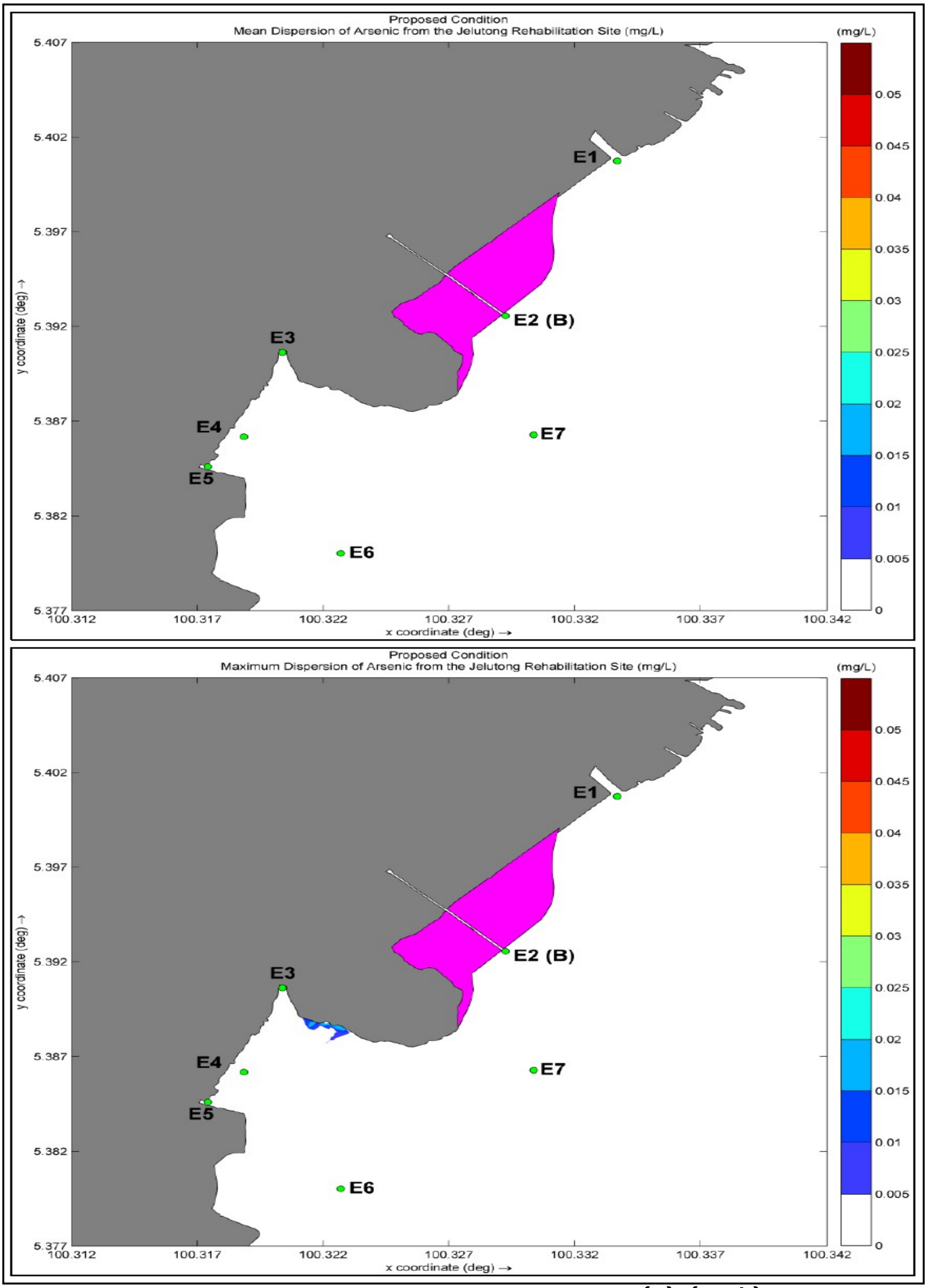


Figure 7.44 Mean and maximum dispersion for Arsenic (III) (mg/L) for Proposed Condition

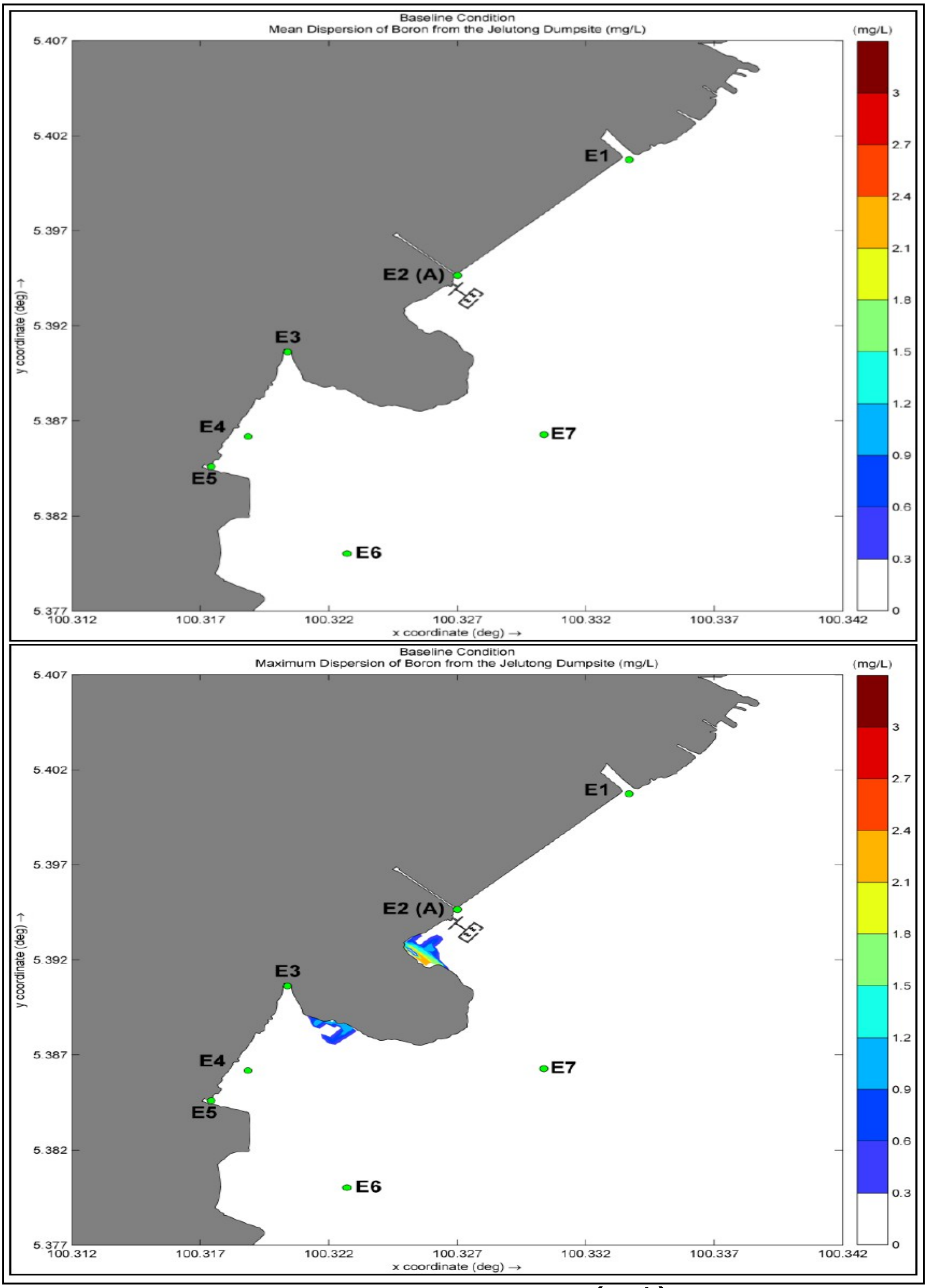


Figure 7.45 Mean and maximum dispersion for Boron (mg/L) for Baseline Condition

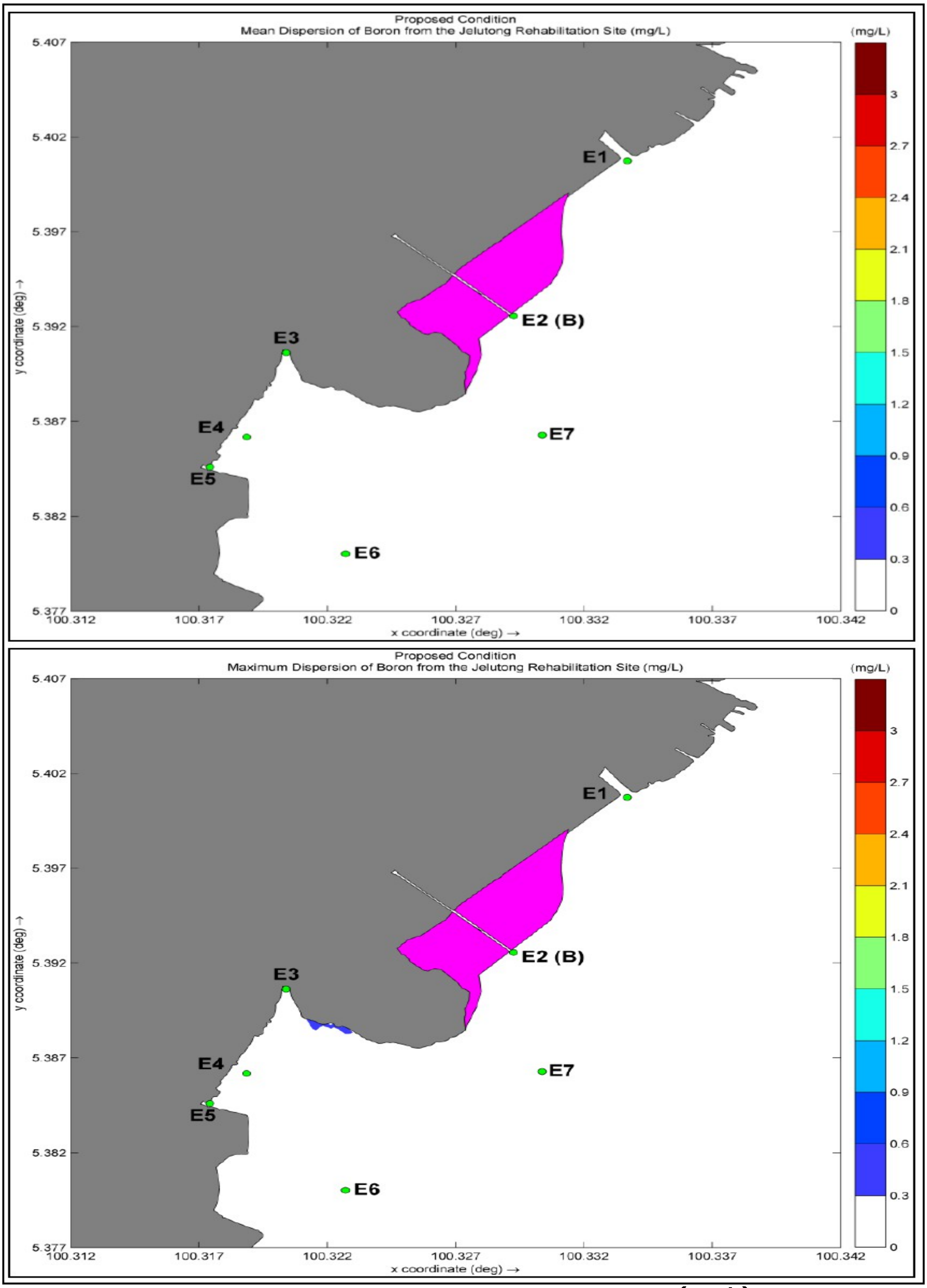


Figure 7.46 Mean and maximum dispersion for Boron (mg/L) for Proposed Condition

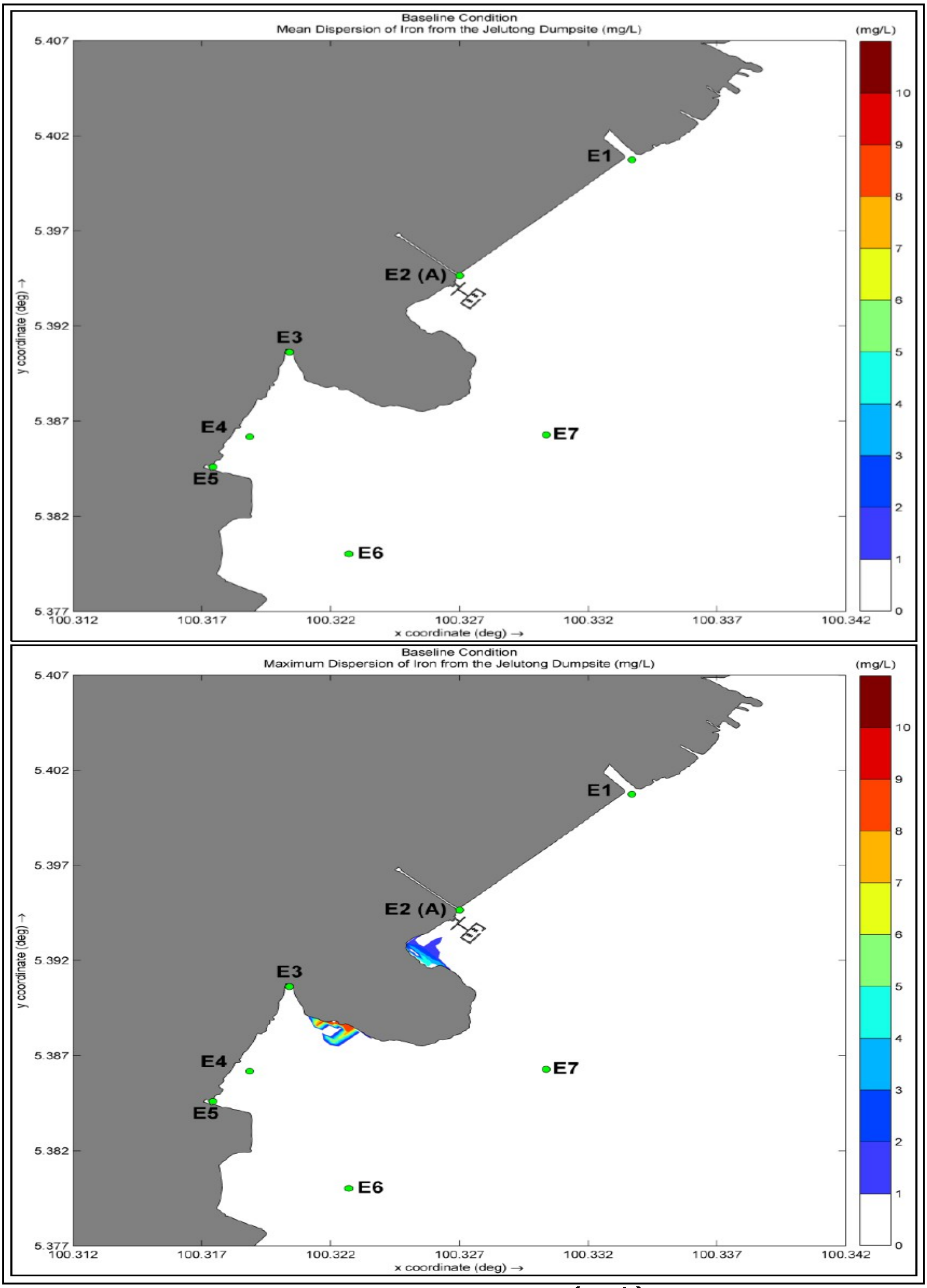


Figure 7.47 Mean and maximum dispersion for Iron (mg/L) for Baseline Condition

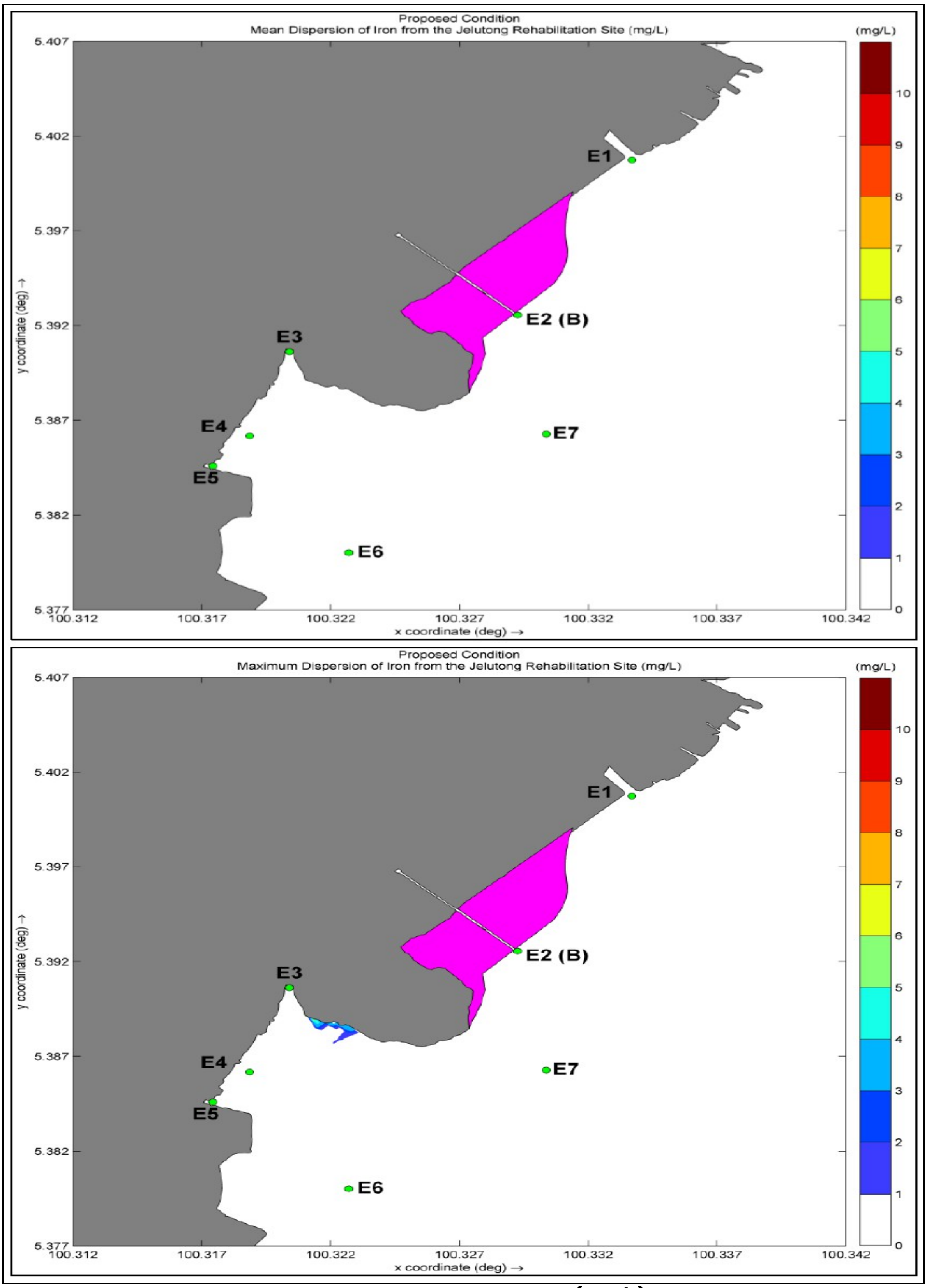


Figure 7.48 Mean and maximum dispersion for Iron (mg/L) for Proposed Condition

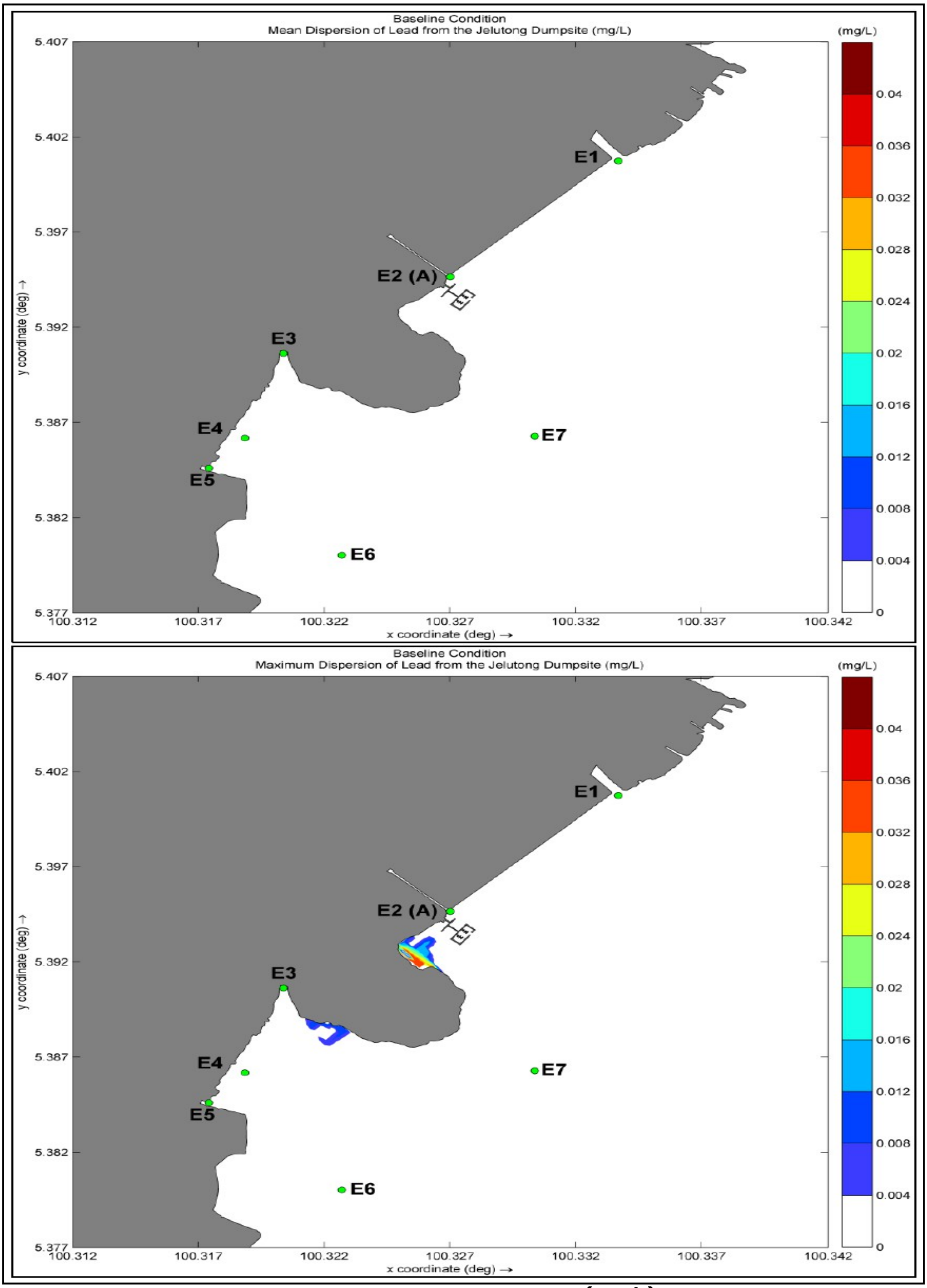


Figure 7.49 Mean and maximum dispersion for Lead (mg/L) for Baseline Condition

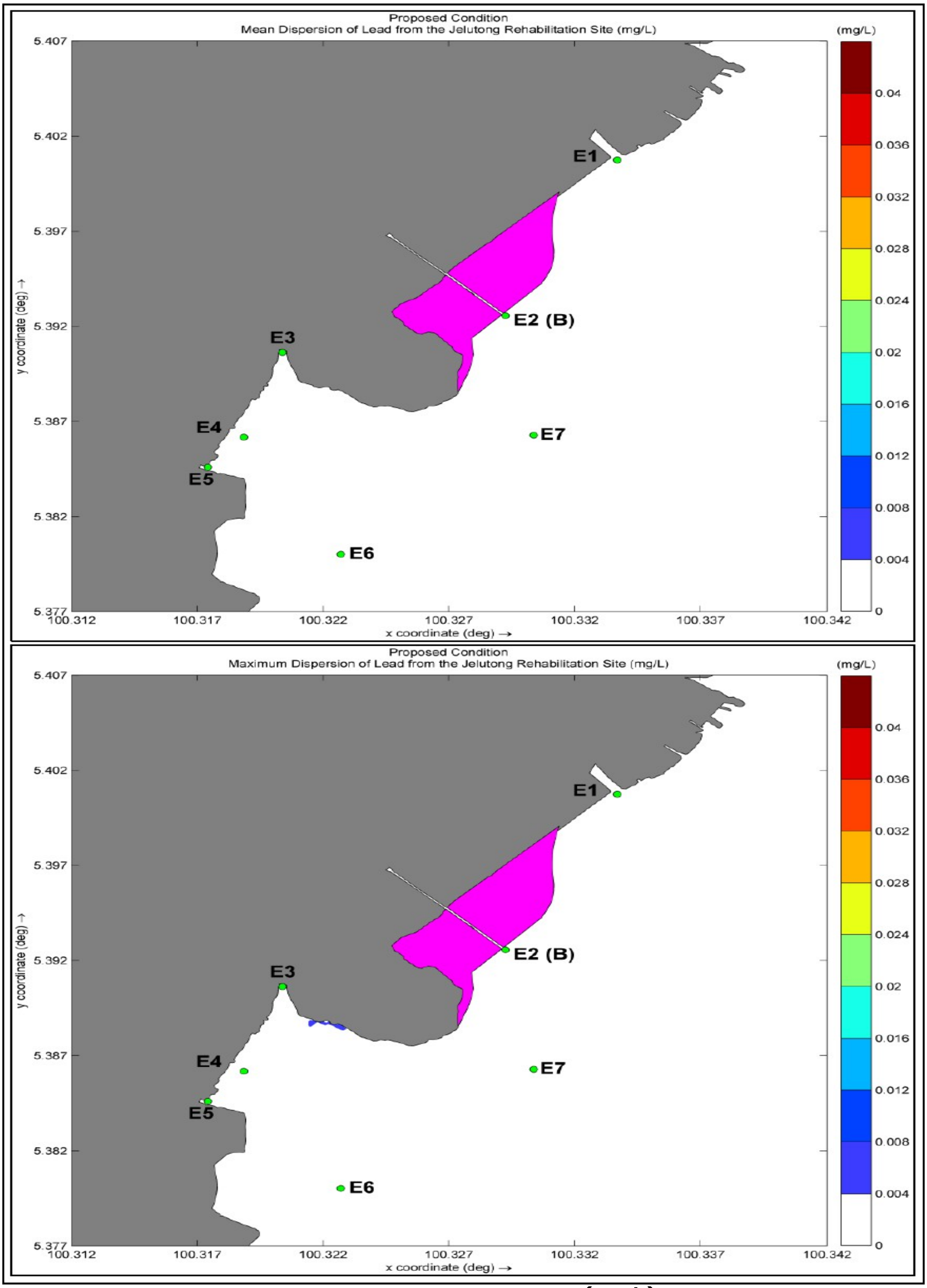


Figure 7.50 Mean and maximum dispersion for Lead (mg/L) for Proposed Condition

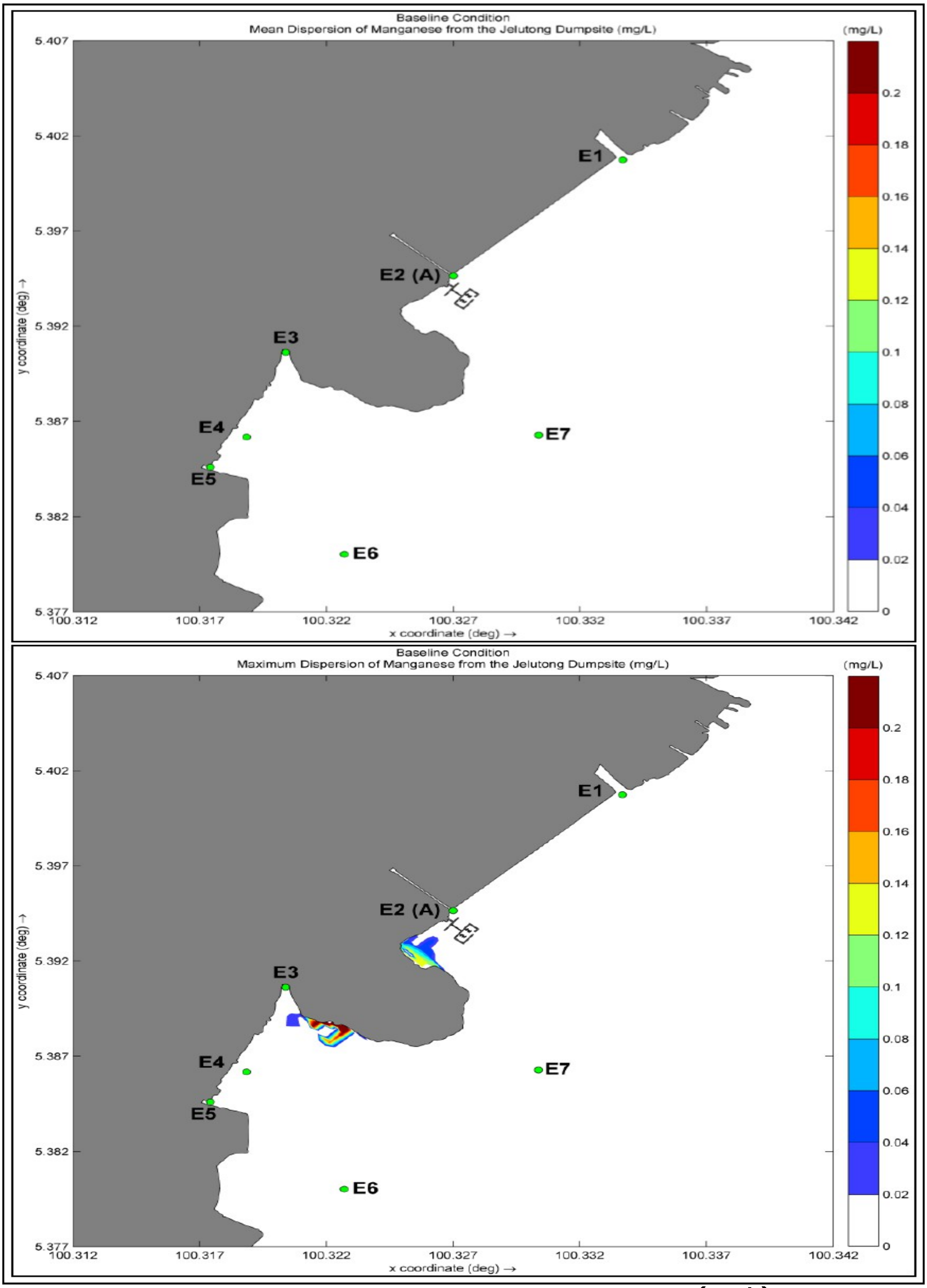
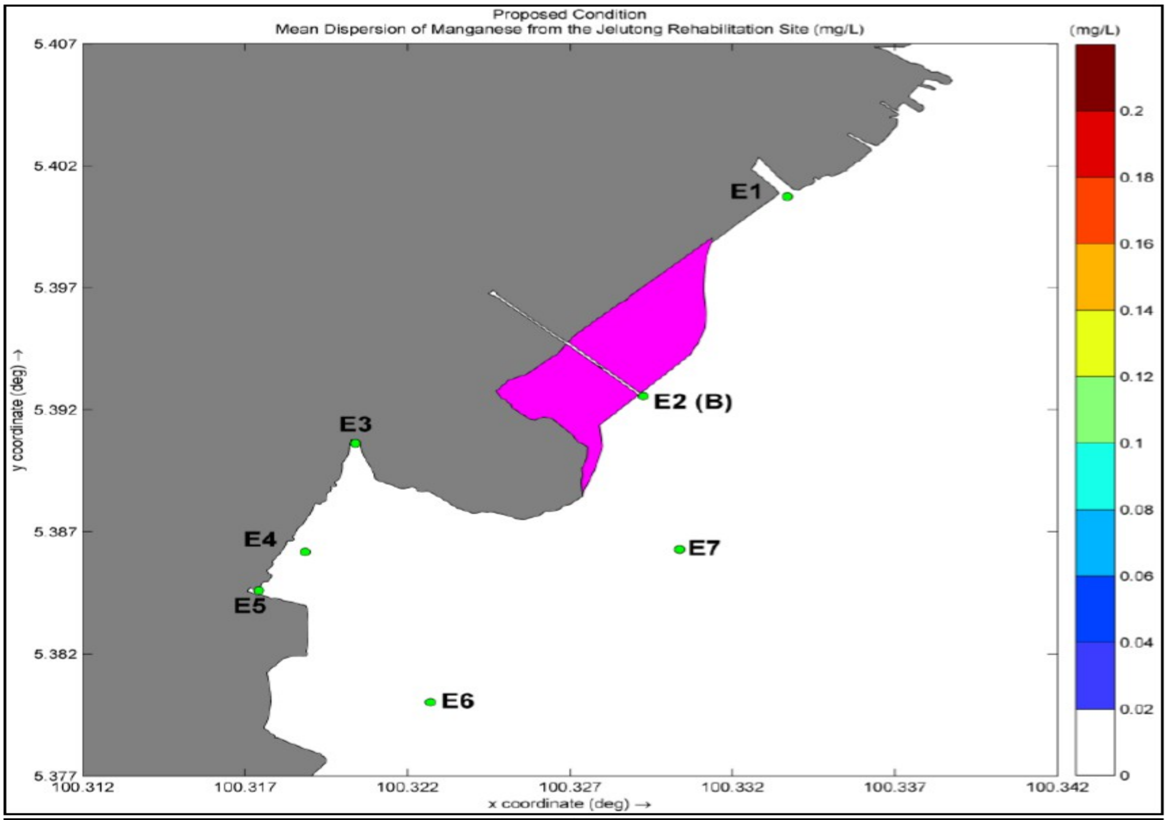


Figure 7.51 Mean and maximum dispersion for Manganese (mg/L) for Baseline Condition



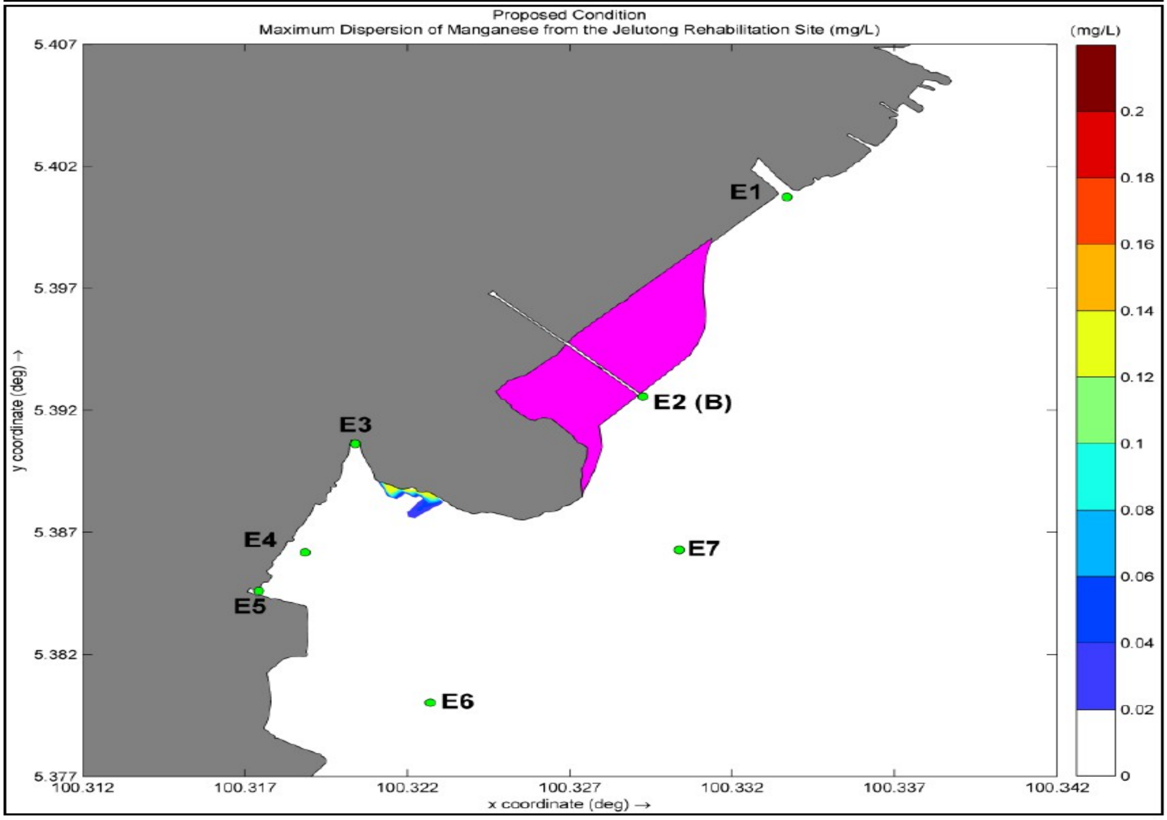
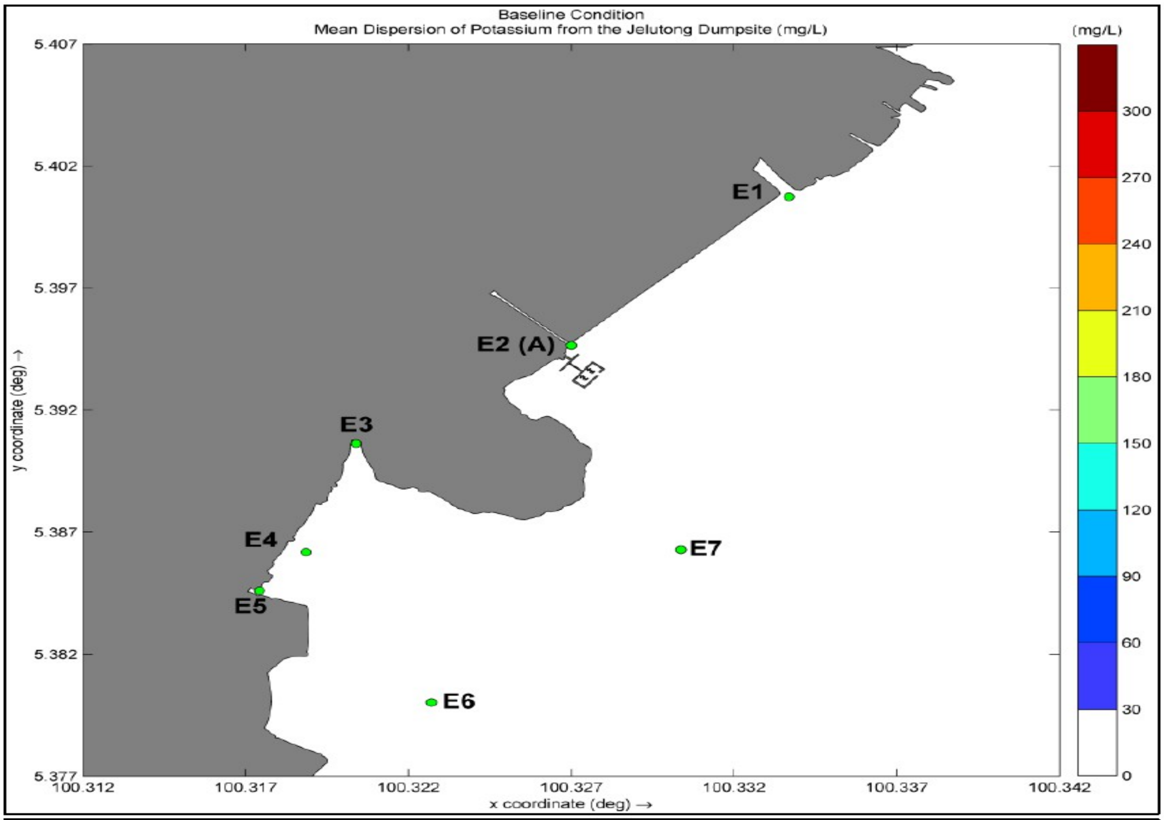


Figure 7.52 Mean and maximum dispersion for Manganese (mg/L) for Proposed Condition



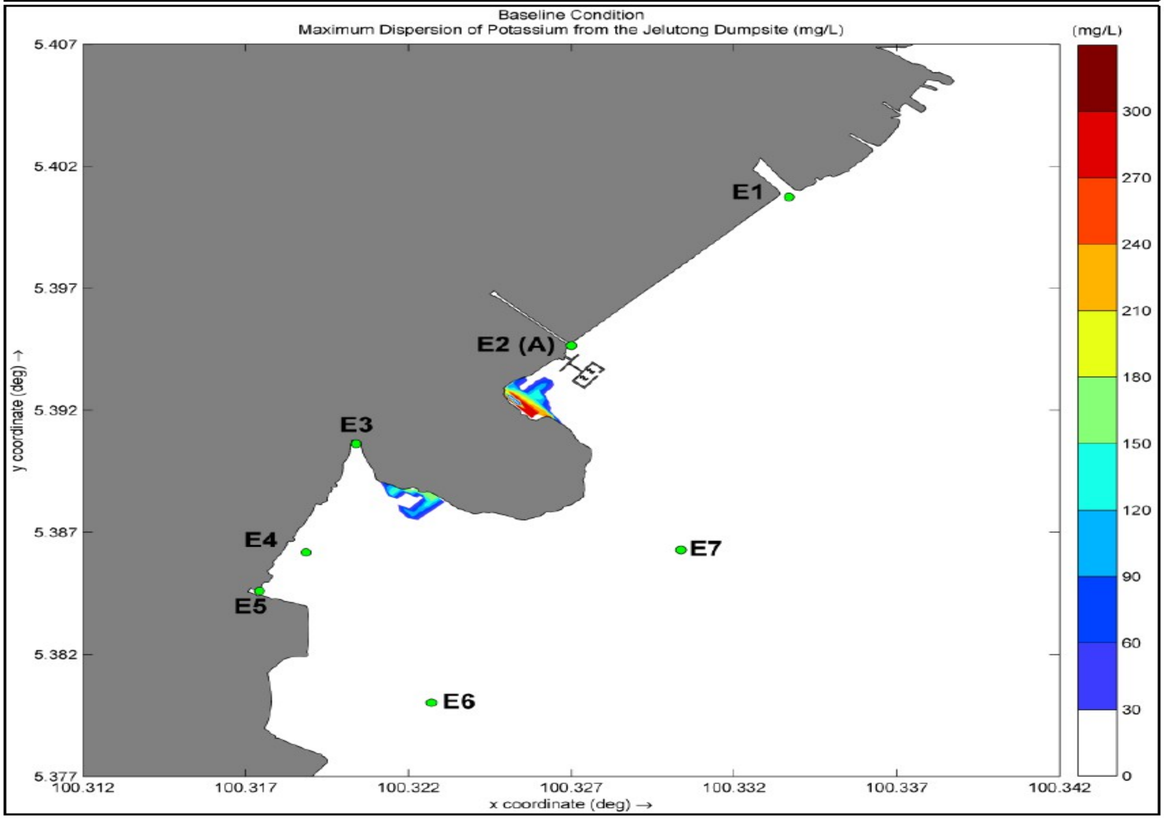


Figure 7.53 Mean and maximum dispersion for Potassium (mg/L) for Baseline Condition

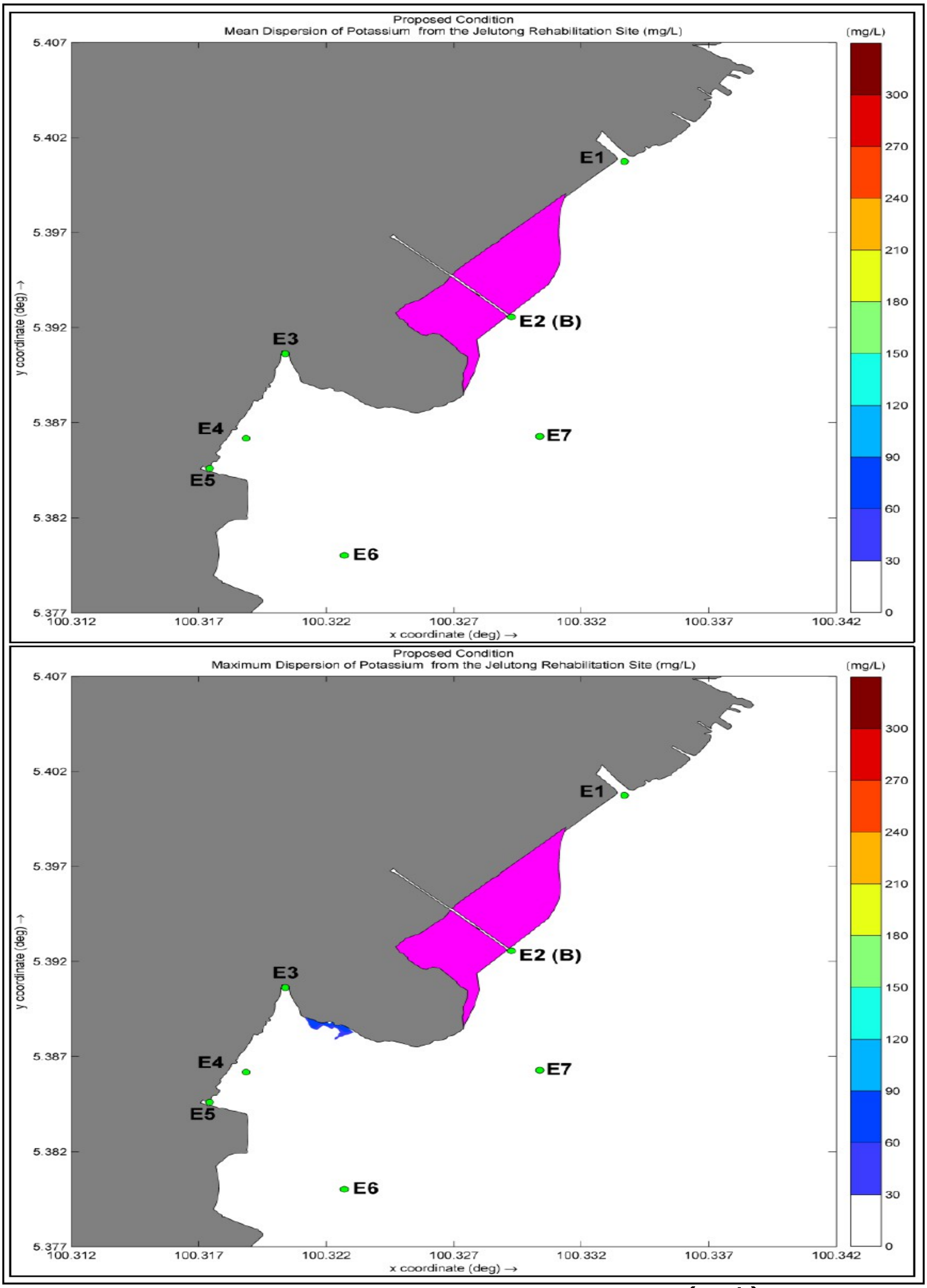


Figure 7.54 Mean and maximum dispersion for Potassium (mg/L) for Proposed Condition

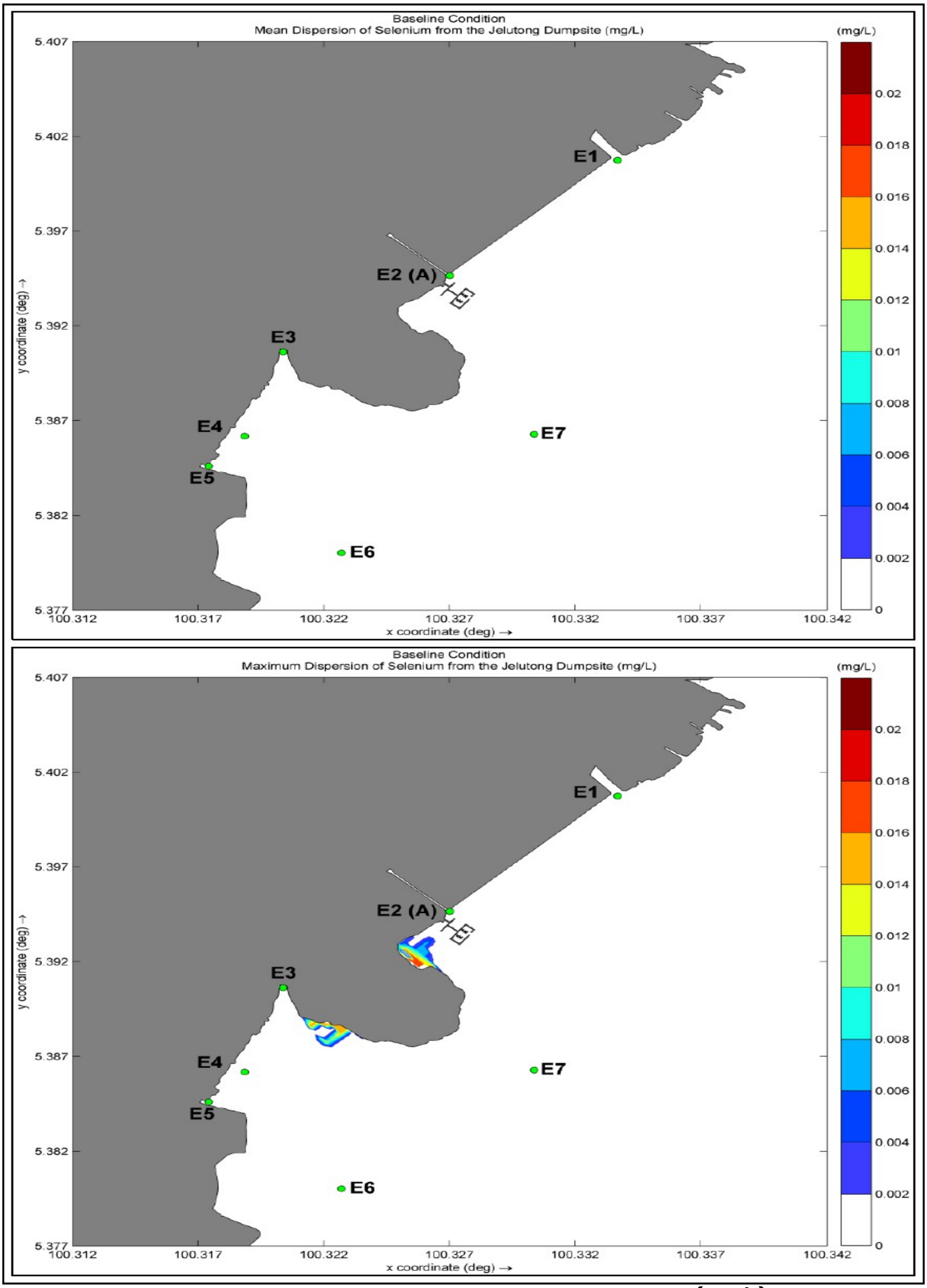


Figure 7.55 Mean and maximum dispersion for Selenium (mg/L) for Baseline Condition

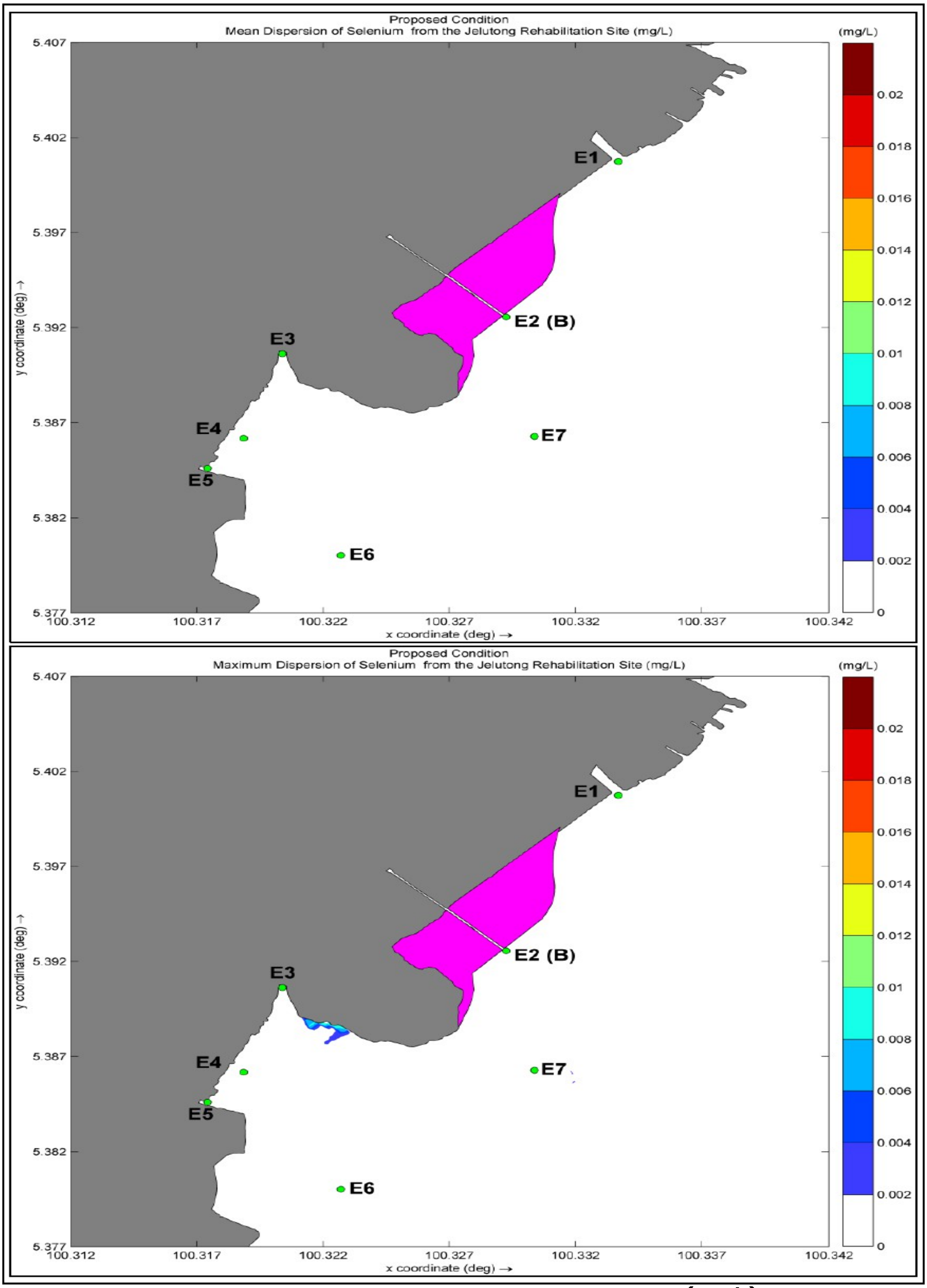


Figure 7.56 Mean and maximum dispersion for Selenium (mg/L) for Proposed Condition

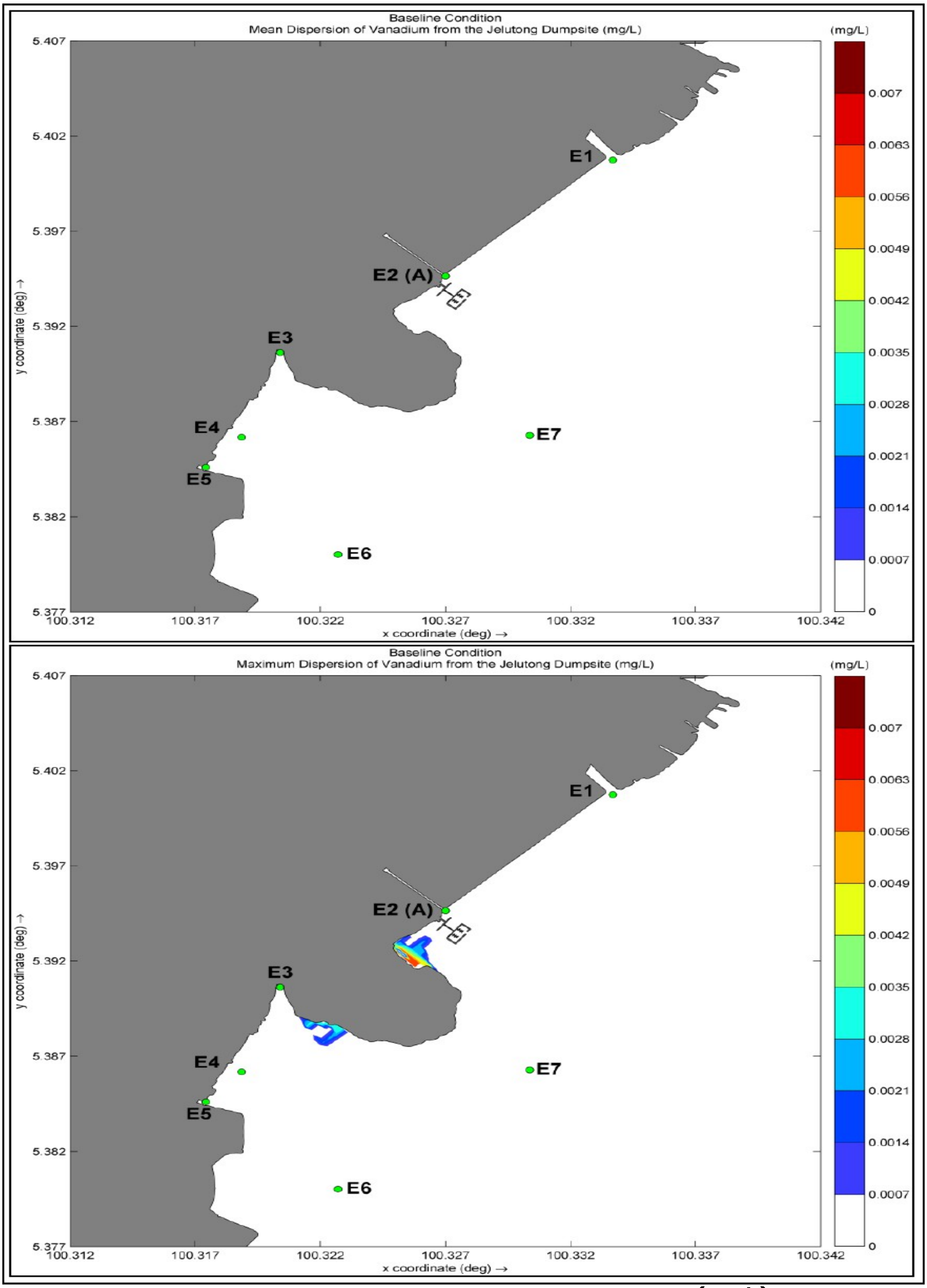


Figure 7.57 Mean and maximum dispersion for Vanadium (mg/L) for Baseline Condition

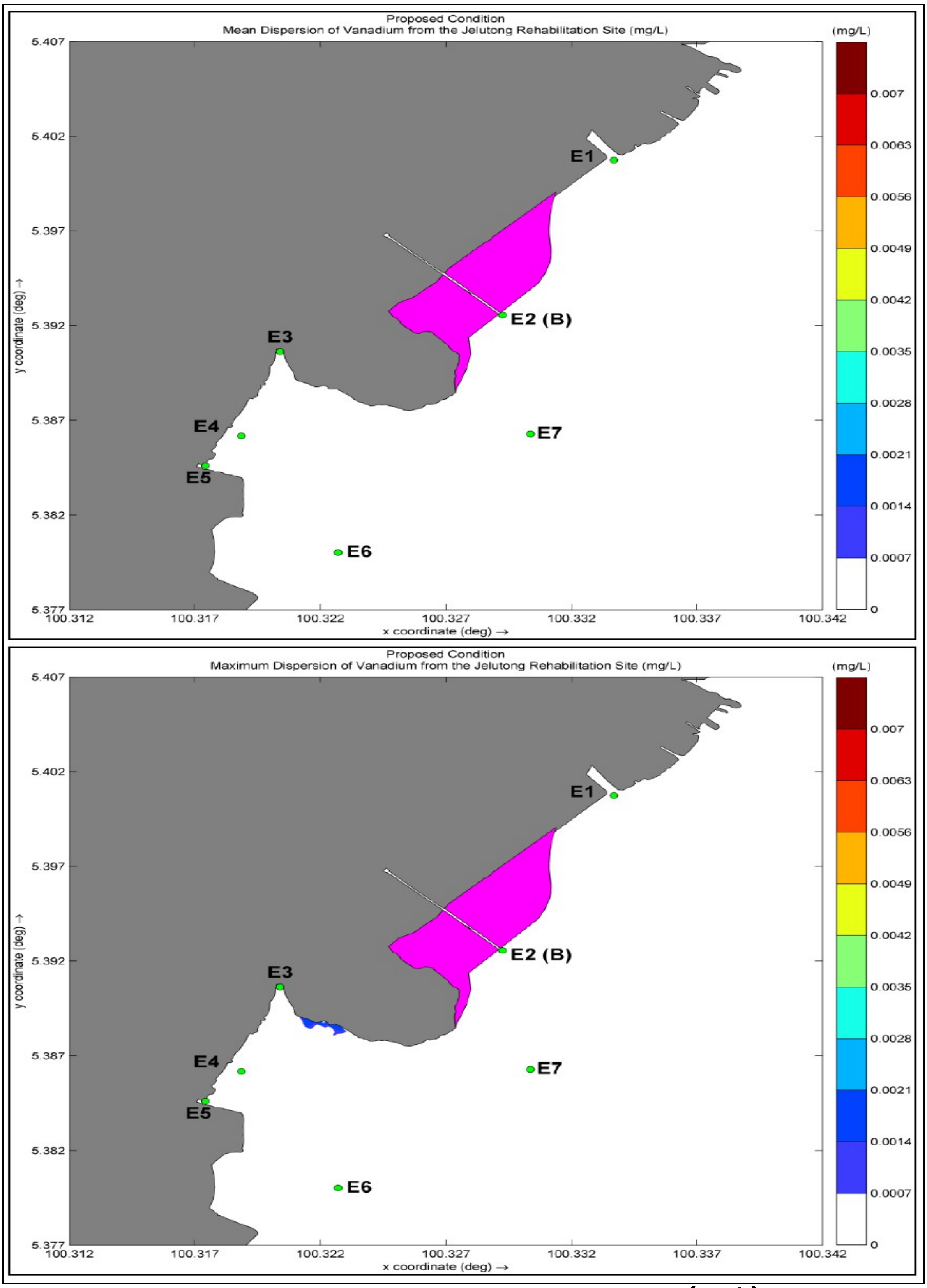


Figure 7.58 Mean and maximum dispersion for Vanadium (mg/L) for Proposed Condition

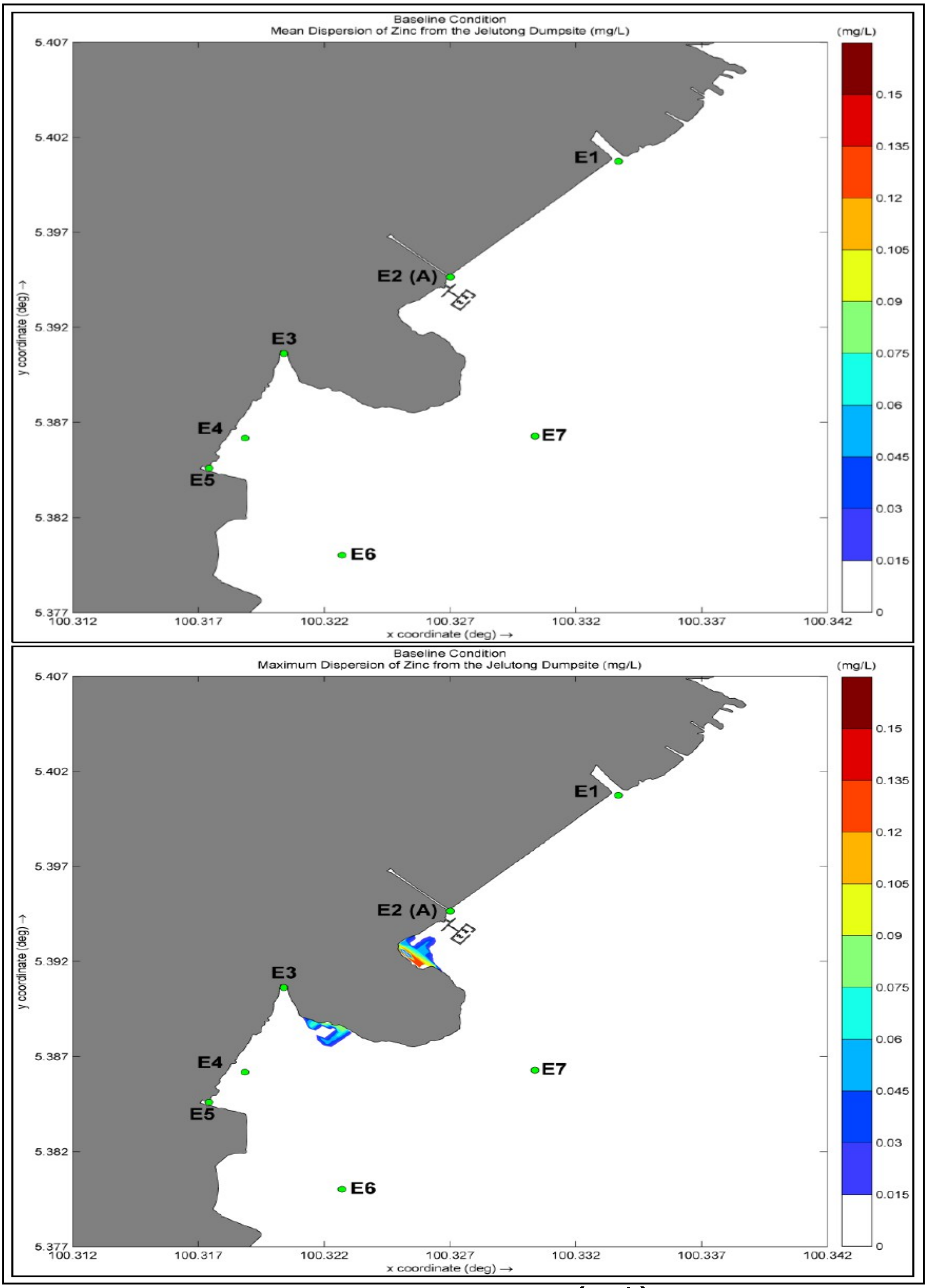


Figure 7.59 Mean and maximum dispersion for Zinc (mg/L) for Baseline Condition

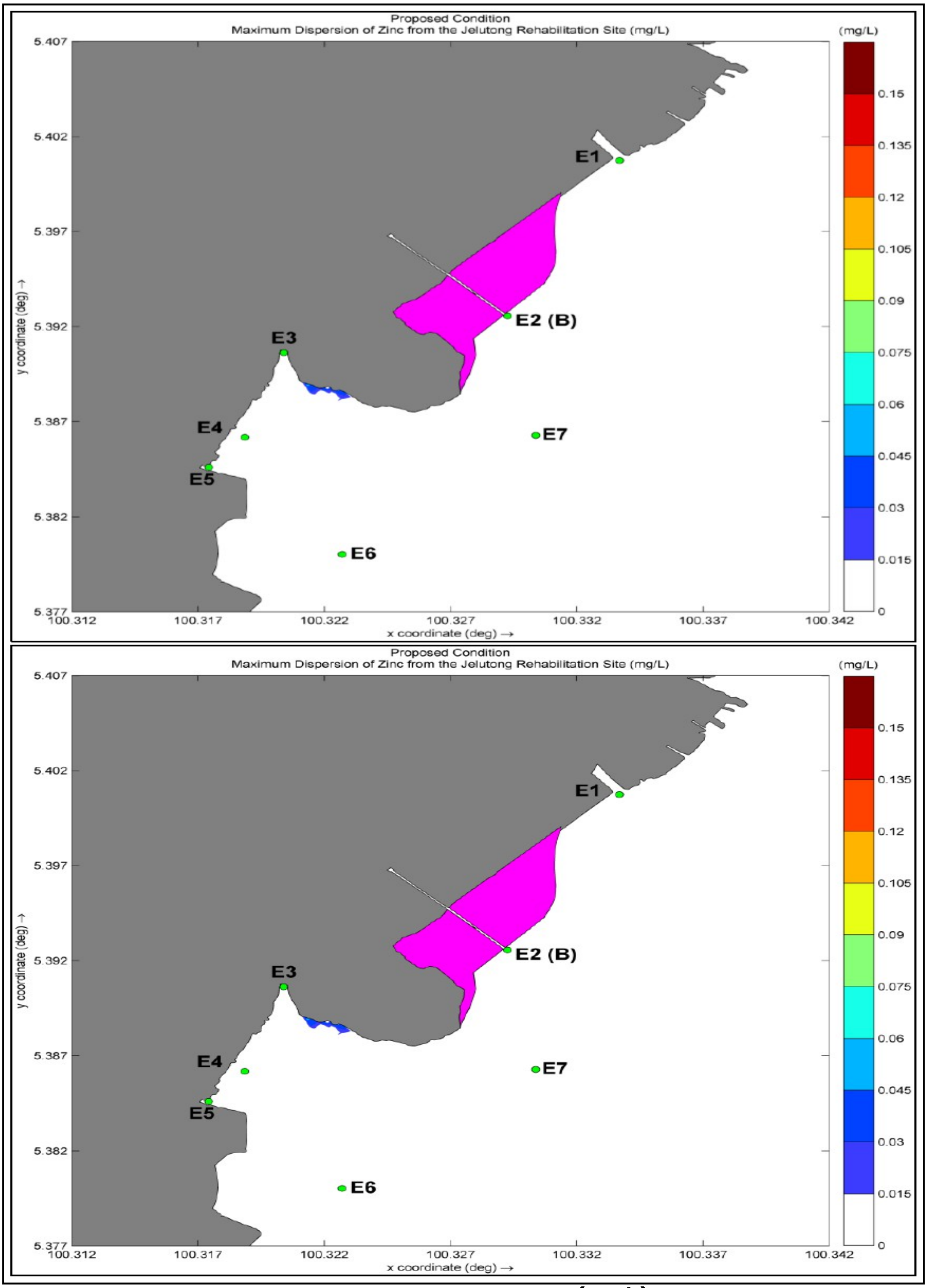


Figure 7.60 Mean and maximum dispersion for Zinc (mg/L) for Proposed Condition

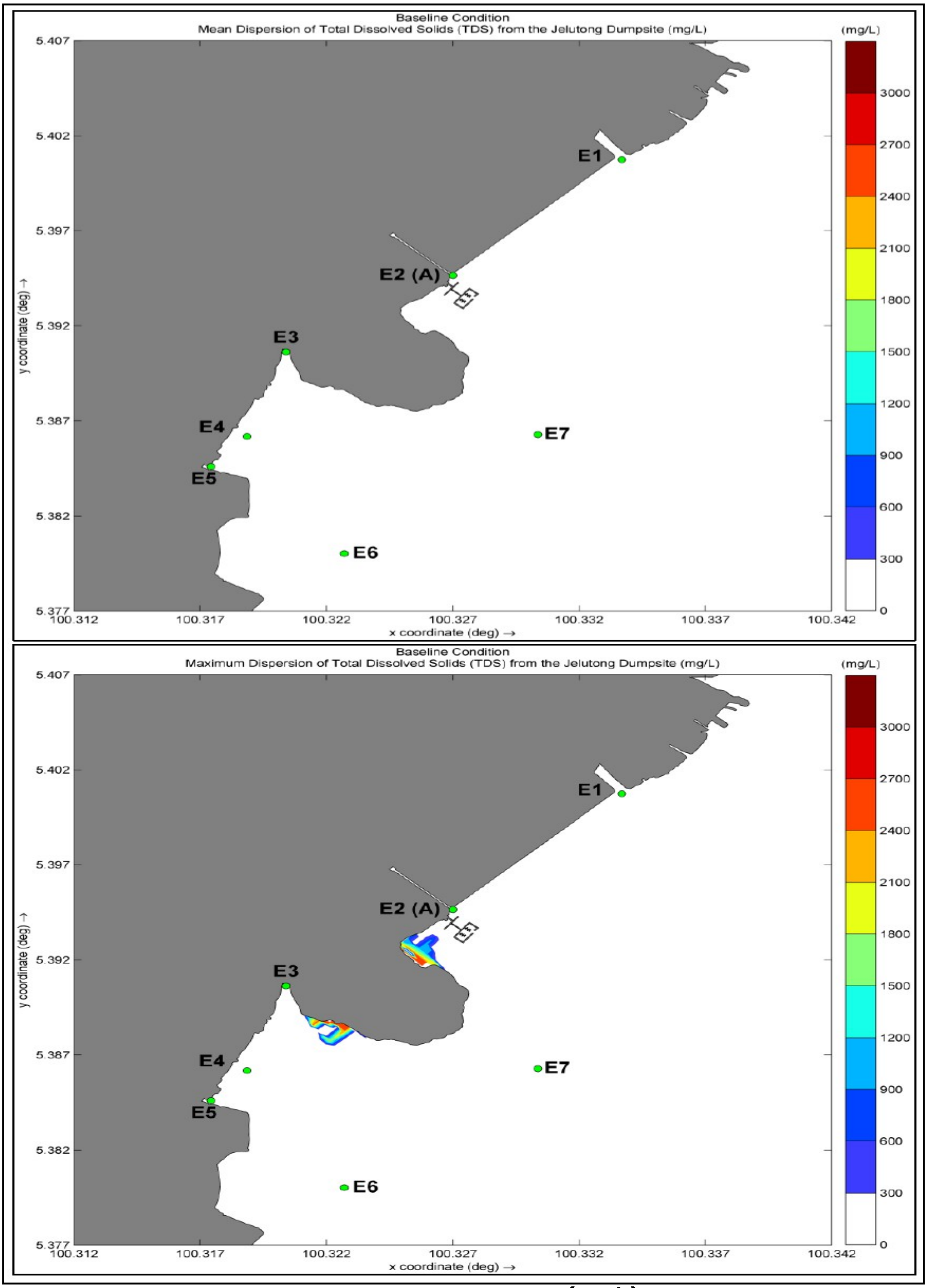
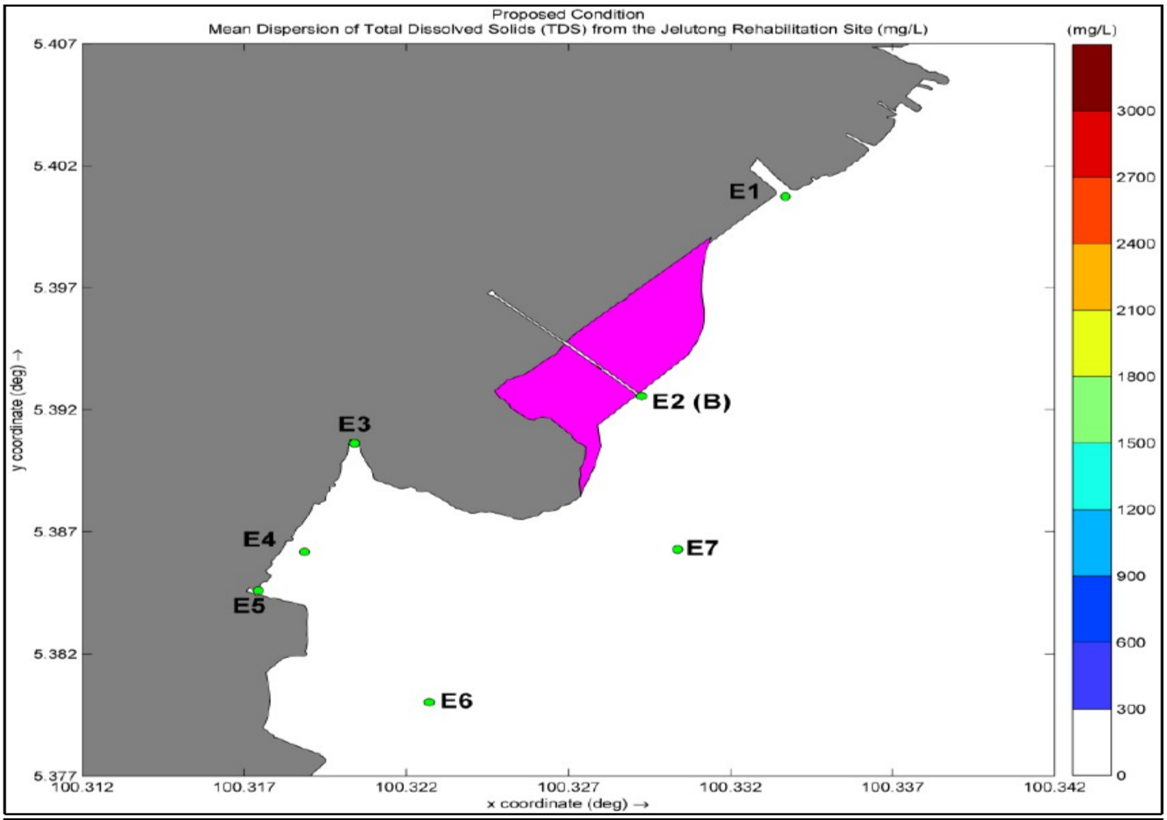


Figure 7.61 Mean and maximum dispersion for TDS (mg/L) for Baseline Condition



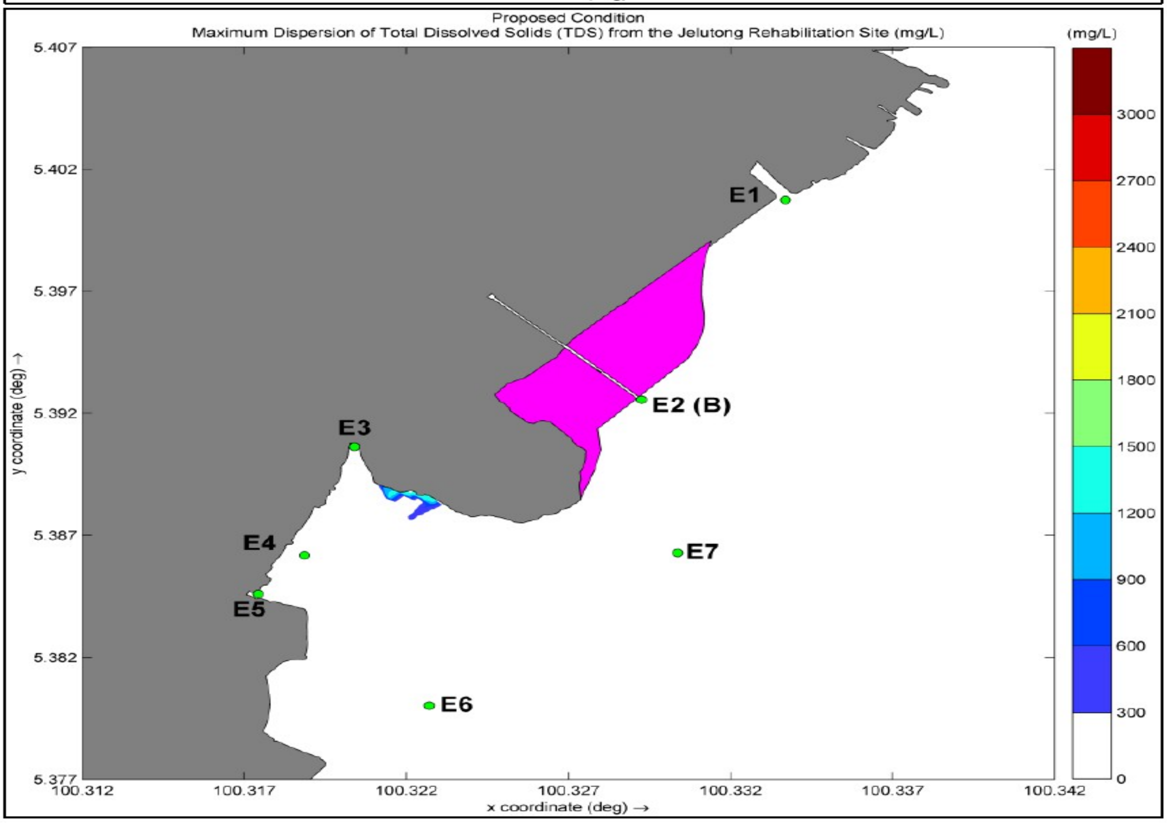


Figure 7.62 Mean and maximum dispersion for TDS (mg/L) for Proposed Condition

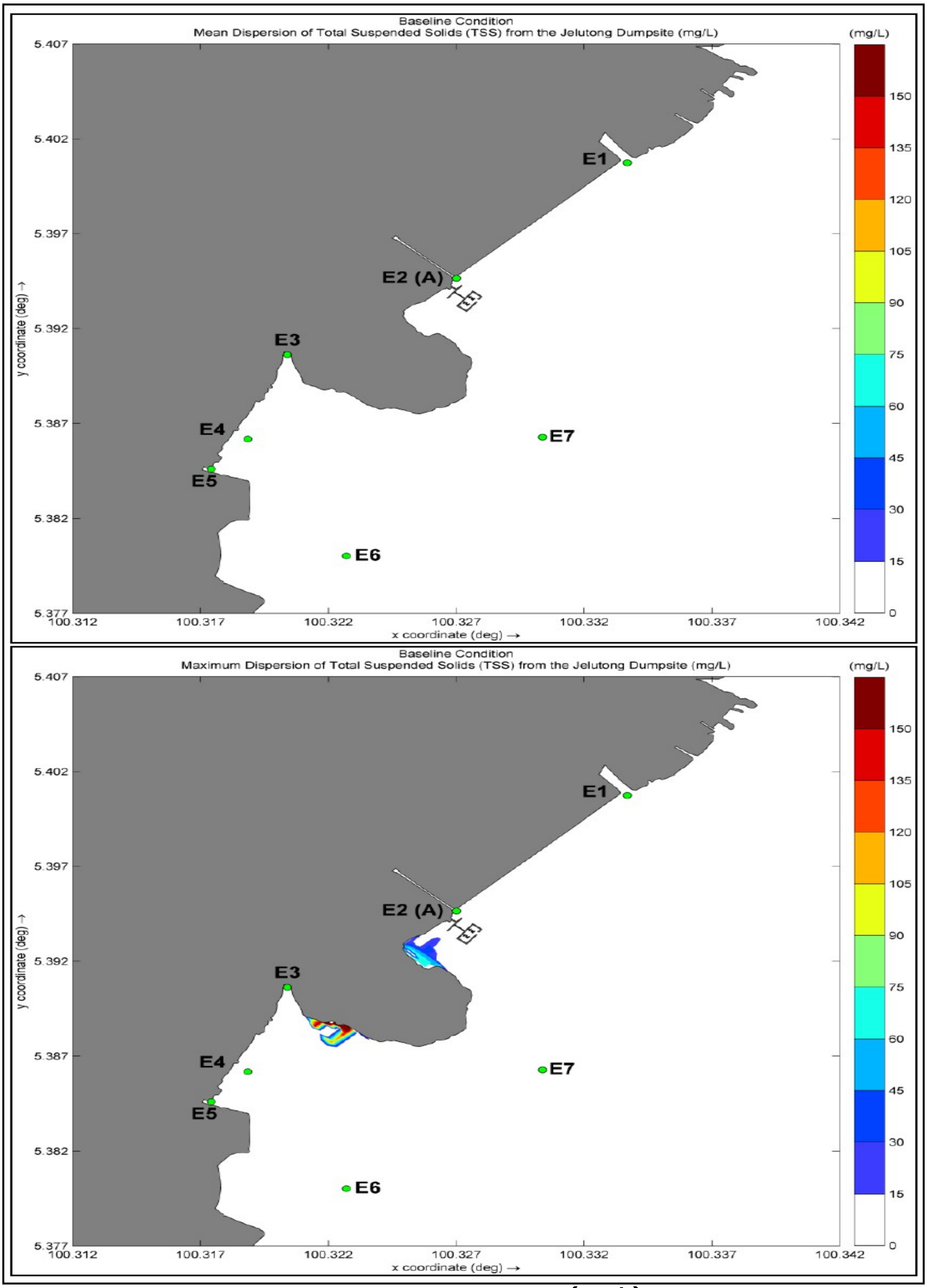


Figure 7.63 Mean and maximum dispersion for TSS (mg/L) for Baseline Condition

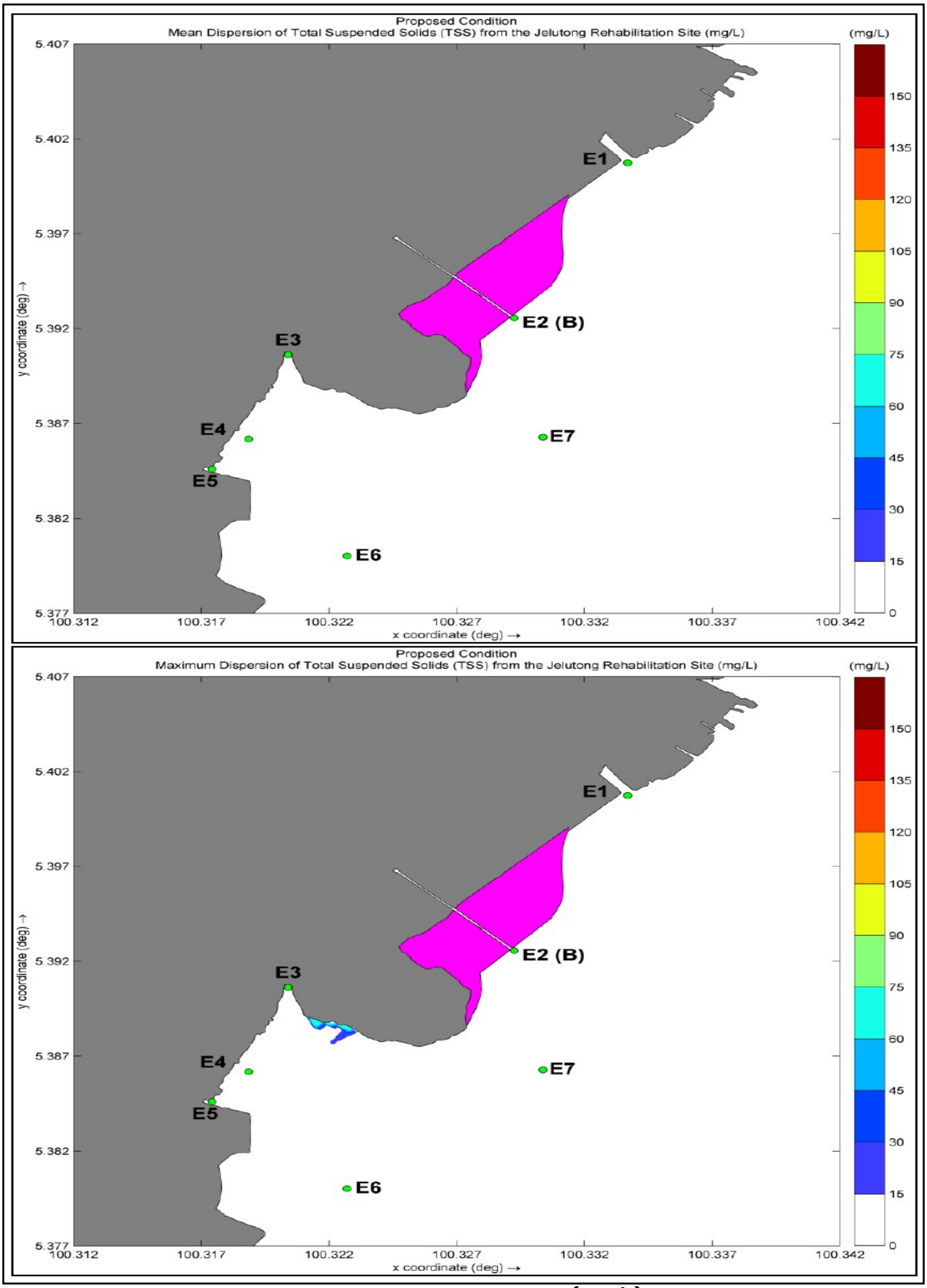


Figure 7.64 Mean and maximum dispersion for TSS (mg/L) for Proposed Condition

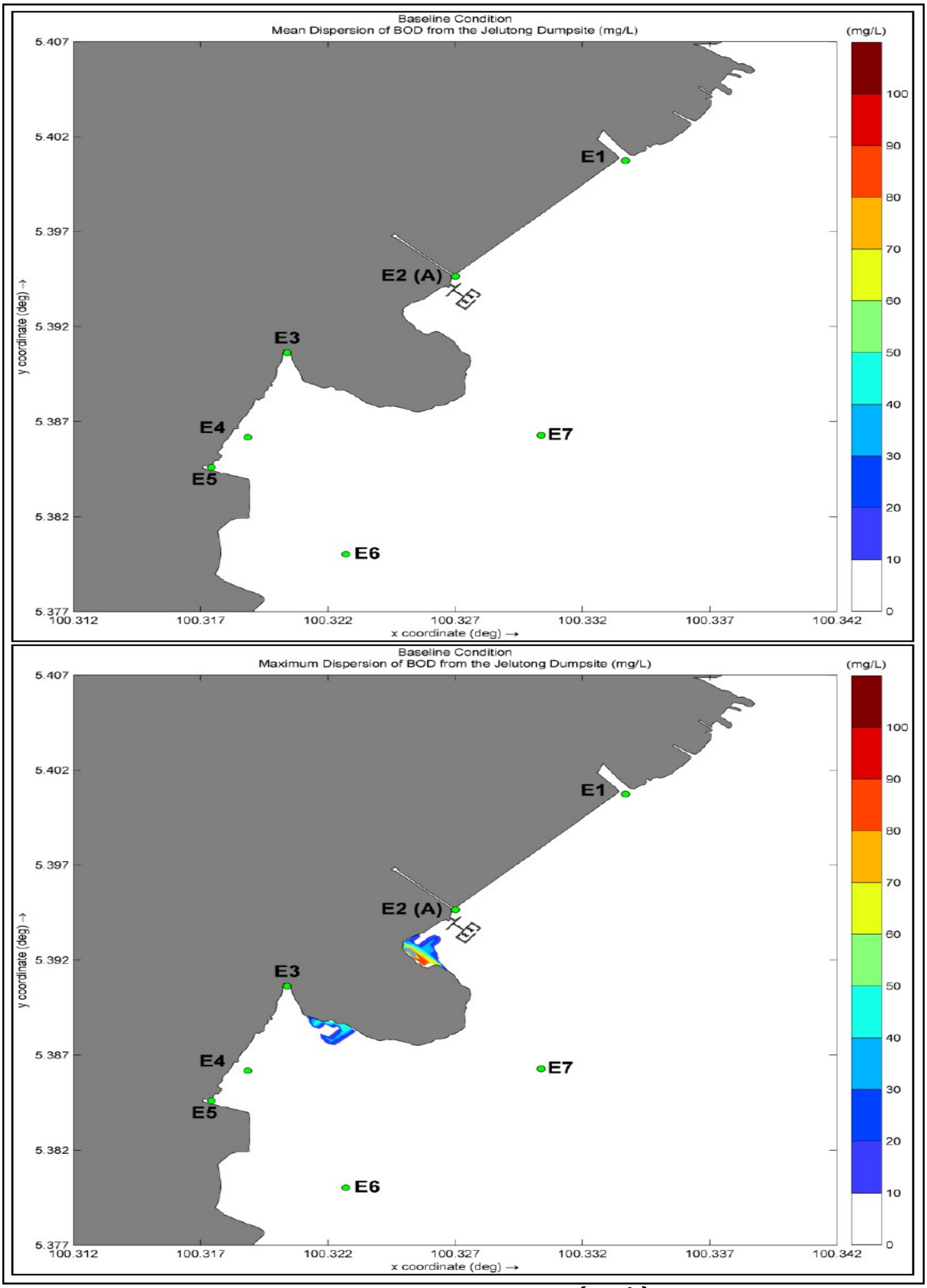


Figure 7.65 Mean and maximum dispersion for BOD (mg/L) for Baseline Condition

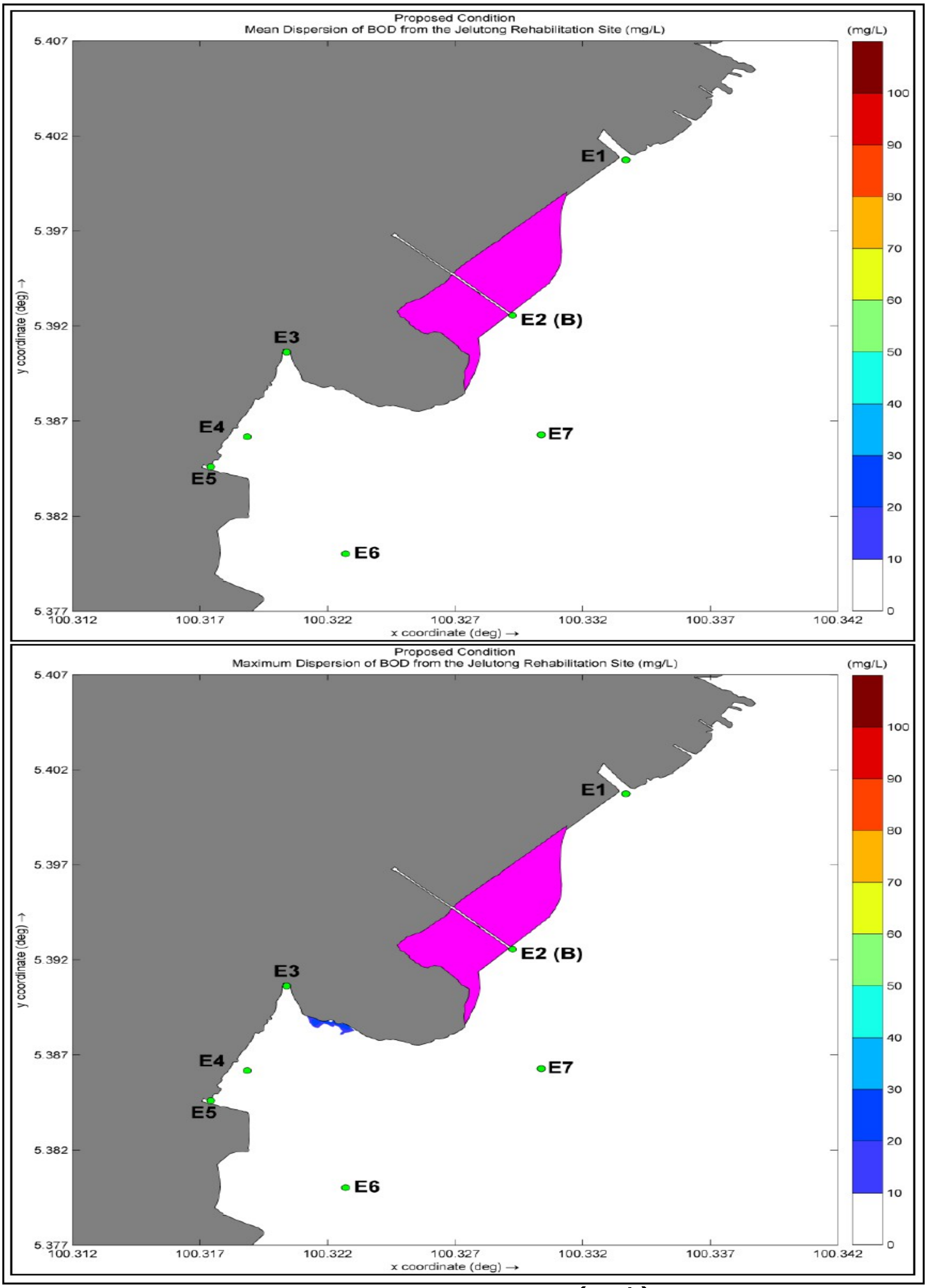


Figure 7.66 Mean and maximum dispersion for BOD (mg/L) for Proposed Condition

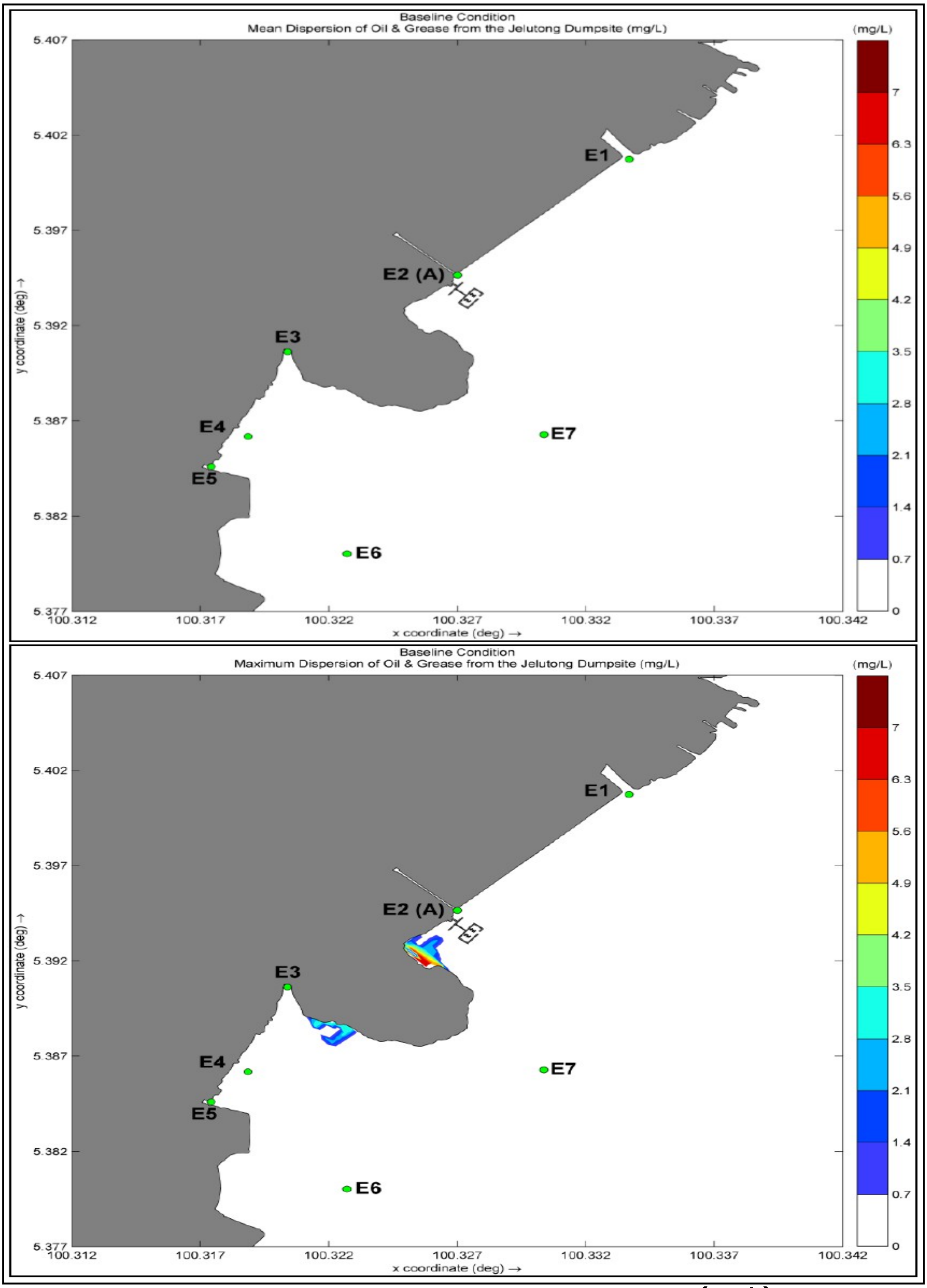


Figure 7.67 Mean and maximum dispersion for Oil & Grease (mg/L) for Baseline Condition

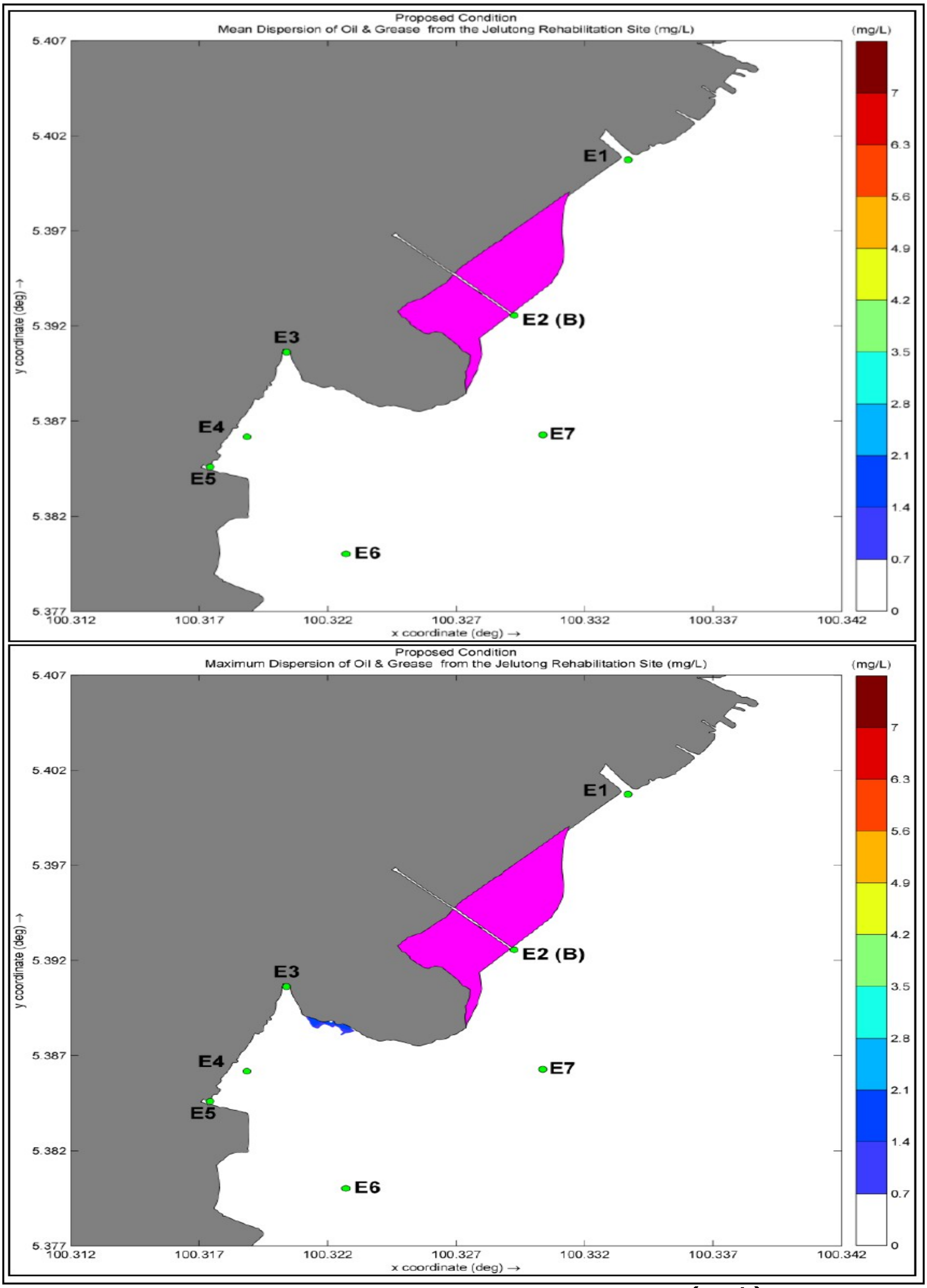


Figure 7.68 Mean and maximum dispersion for Oil & Grease (mg/L) for Proposed Condition

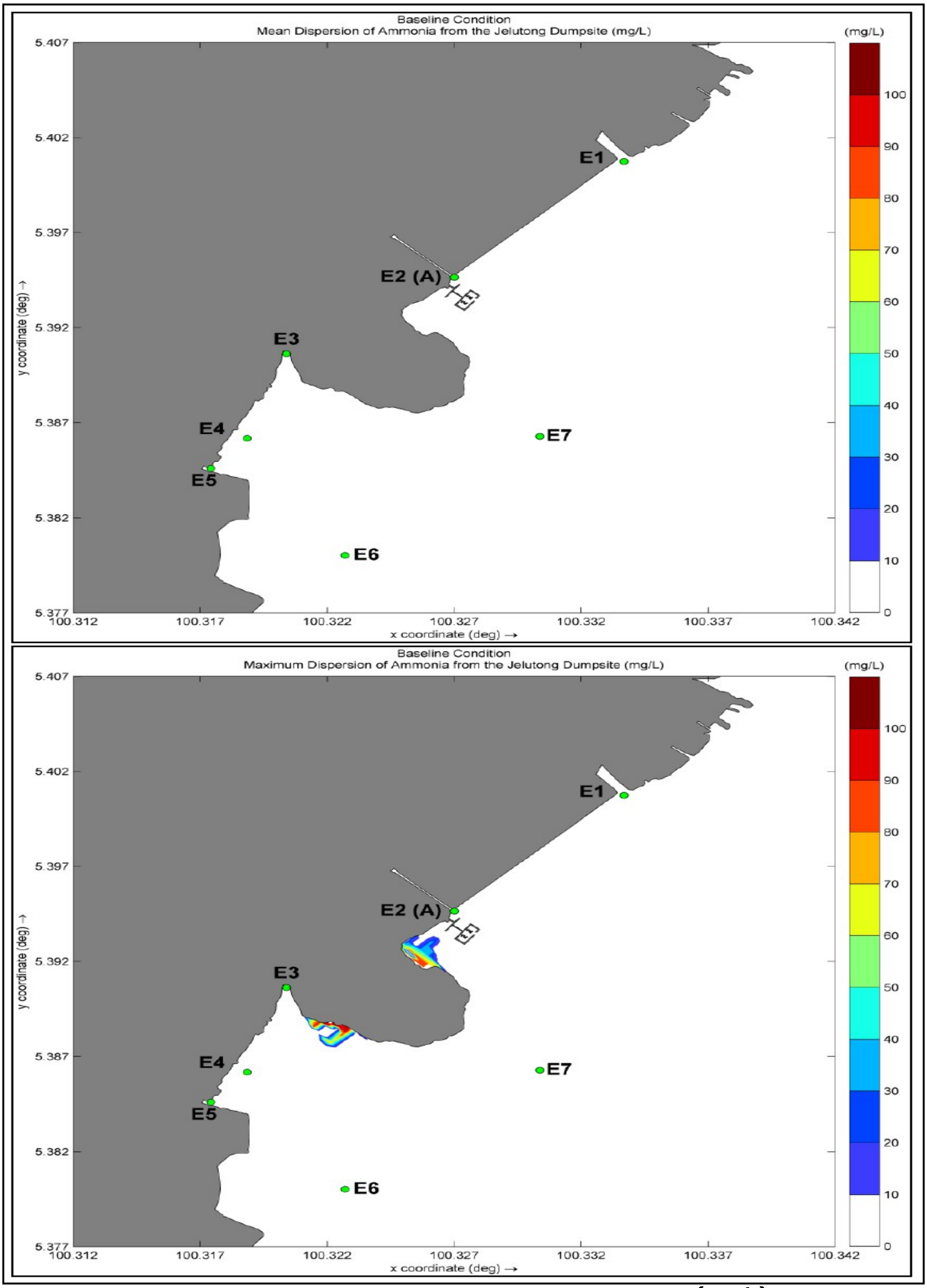


Figure 7.69 Mean and maximum dispersion for Ammonia (mg/L) for Baseline Condition

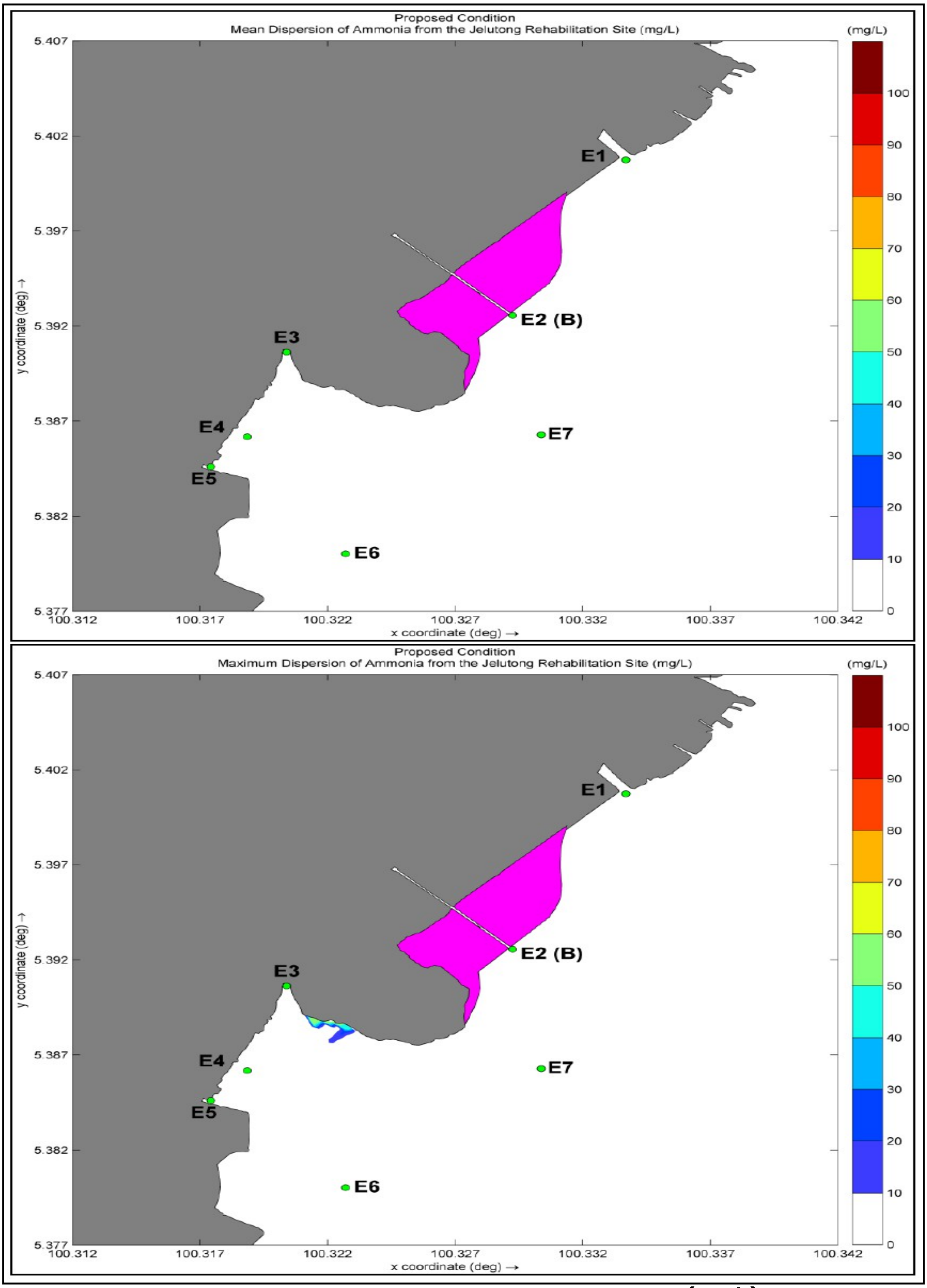


Figure 7.70 Mean and maximum dispersion for Ammonia (mg/L) for Proposed Condition

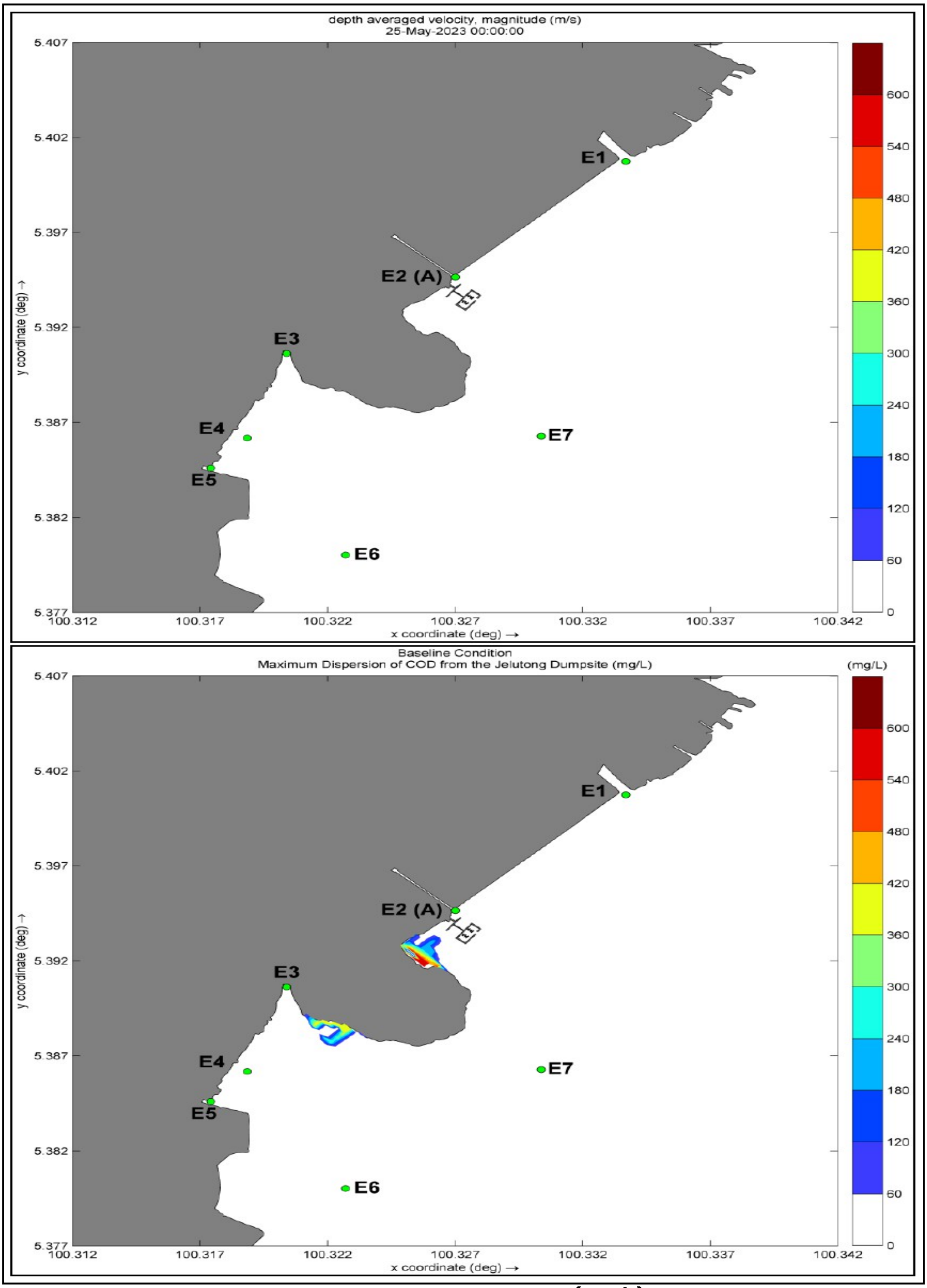


Figure 7.71 Mean and maximum dispersion for COD (mg/L) for Baseline Condition

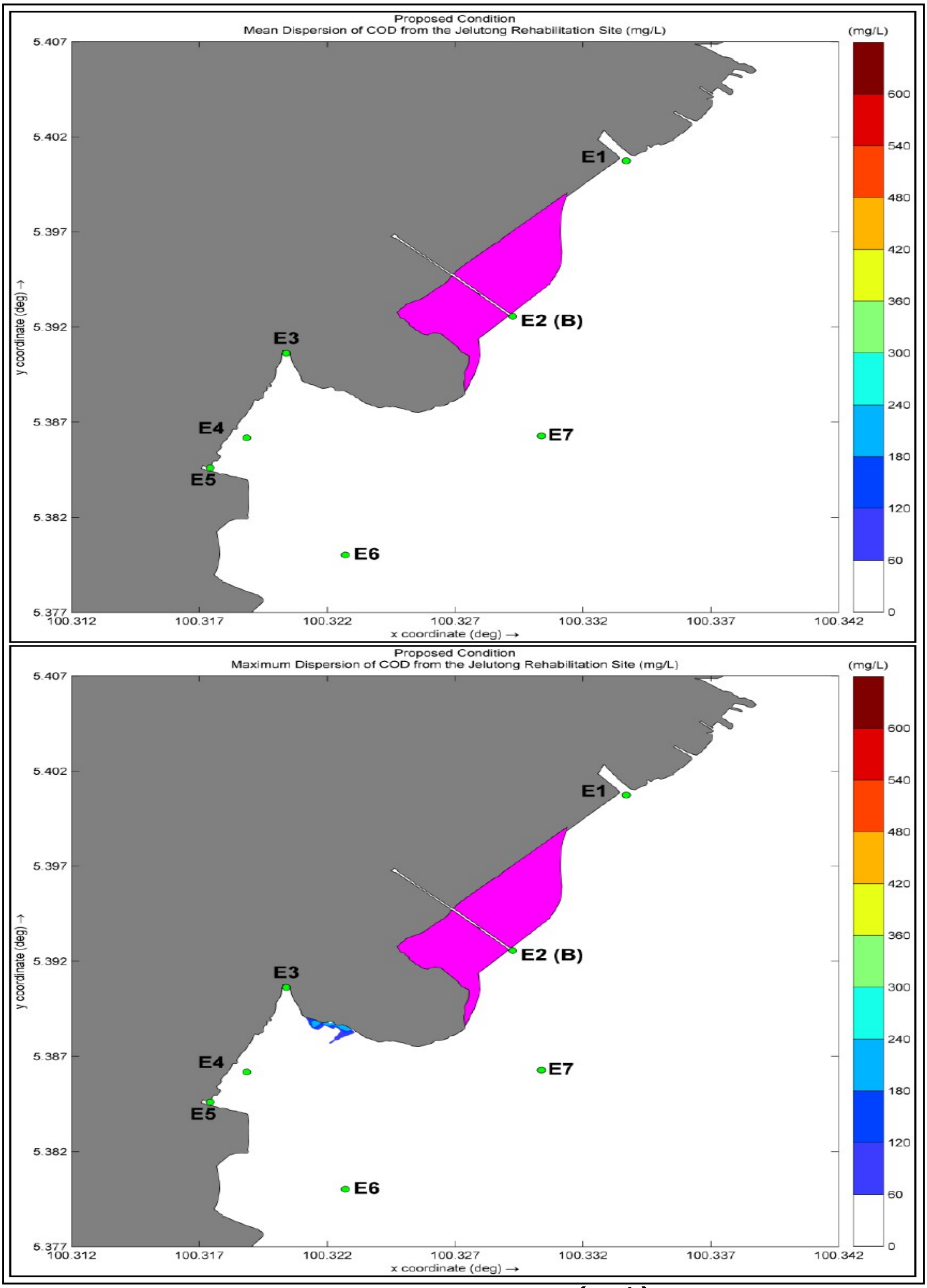


Figure 7.72 Mean and maximum dispersion for COD (mg/L) for Proposed Condition

Table 7.16
Dispersed Values from Existing Jelutong Dumpsite for Aluminium, Arsenic (III), Boron and Iron at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	Aluminium (mg/L)				Arsenic (III) (mg/L)				Boron (mg/L)				Iron (mg/L)			
			MMWQS* Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	27	0.0000	0.0007	✓	3	0.0000	0.0000	✓	0.8	0.0000	0.0003	✓	1	0.0000	0.0020	✓
E2 (A)	Jelutong Outlet (Before Reclamation)	Interim Class E1* / Class IV**	27	0.0000	0.0007	✓	3	0.0000	0.0000	✓	0.8	0.0000	0.0005	✓	1	0.0000	0.0022	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	27	0.0004	0.0532	✓	3	0.0000	0.0013	✓	0.8	0.0003	0.0405	✓	1	0.0022	0.2960	✓
E4	Boat Landing Area	Class 2* / Class III**	27	0.0000	0.0017	✓	3	0.0000	0.0000	✓	3.4	0.0000	0.0012	✓	1	0.0001	0.0084	✓
E5	South Outlet	Interim Class E1* / Class IV**	27	0.0000	0.0008	✓	3	0.0000	0.0000	✓	0.8	0.0000	0.0006	✓	1	0.0001	0.0040	✓
E6	Southern Side	Class 2* / Class III**	27	0.0000	0.0002	✓	3	0.0000	0.0000	✓	3.4	0.0000	0.0001	✓	1	0.0000	0.0007	✓
E7	Middle Bank	Class 1* / Class I**	27	0.0000	0.0004	✓	1	0.0000	0.0000	✓	-	0.0000	0.0003	-	1	0.0000	0.0011	✓

Table 7.17
Dispersed Values from Existing Jelutong Dumpsite for Lead, Manganese, Potassium and Selenium at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	Lead (mg/L)				Manganese (mg/L)				Potassium (mg/L)				Selenium (mg/L)			
			MMWQS* Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	1.3	0.0000	0.0000	✓	0.2	0.0000	0.0001	✓	-	0.0005	0.0419	-	0.02	0.0000	0.0000	✓
E2 (A)	Jelutong Outlet (Before Reclamation)	Interim Class E1* / Class IV**	1.3	0.0000	0.0000	✓	0.2	0.0000	0.0001	✓	-	0.0009	0.0643	-	0.02	0.0000	0.0000	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	1.3	0.0000	0.0003	✓	0.2	0.0001	0.0096	✓	-	0.0406	5.3723	-	0.02	0.0000	0.0006	✓
E4	Boat Landing Area	Class 2* / Class III**	8.5	0.0000	0.0000	✓	0.1	0.0000	0.0002	✓	-	0.0020	0.1548	-	0.25	0.0000	0.0000	✓
E5	South Outlet	Interim Class E1* / Class IV**	1.3	0.0000	0.0000	✓	0.2	0.0000	0.0001	✓	-	0.0014	0.0802	-	0.02	0.0000	0.0000	✓
E6	Southern Side	Class 2* / Class III**	8.5	0.0000	0.0000	✓	0.1	0.0000	0.0000	✓	-	0.0006	0.0175	-	0.25	0.0000	0.0000	✓
E7	Middle Bank	Class 1* / Class I**	2.2	0.0000	0.0000	✓	0.1	0.0000	0.0000	✓	-	0.0005	0.0413	-	-	0.0000	0.0000	-

Table 7.18
Dispersed Values from Existing Jelutong Dumpsite for Vanadium, Zinc, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	Vanadium (mg/L)				Zinc (mg/L)				Total Dissolved Solids (TDS) (mg/L)				Total Suspended Solids (TSS) (mg/L)			
			NWQS** Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	MMWQS * Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	-	0.0000	0.0000	-	16	0.0000	0.0000	✓	1000	0.0093	0.8004	✓	30	0.0004	0.0368	✓
E2 (A)	Jelutong Outlet (Before Reclamation)	Interim Class E1* / Class IV**	-	0.0000	0.0000	-	16	0.0000	0.0000	✓	1000	0.0130	0.8719	✓	30	0.0006	0.0394	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	-	0.0000	0.0001	-	16	0.0000	0.0027	✓	1000	0.7482	101.7849	✓	30	0.0404	5.3724	✓
E4	Boat Landing Area	Class 2* / Class III**	-	0.0000	0.0000	-	50	0.0000	0.0001	✓	1000	0.0300	2.5640	✓	50	0.0016	0.1534	✓
E5	South Outlet	Interim Class E1* / Class IV**	-	0.0000	0.0000	-	16	0.0000	0.0000	✓	1000	0.0215	1.2199	✓	30	0.0011	0.0724	✓
E6	Southern Side	Class 2* / Class III**	-	0.0000	0.0000	-	50	0.0000	0.0000	✓	1000	0.0089	0.2561	✓	50	0.0004	0.0116	✓
E7	Middle Bank	Class 1* / Class I**	-	0.0000	0.0000	-	7	0.0000	0.0000	✓	1000	0.0072	0.5414	✓	25	0.0003	0.0218	✓

Table 7.19
Dispersed Values from Existing Jelutong Dumpsite for BOD, Oil & Grease, Ammonia and COD at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	BOD (mg/L)				Oil & Grease (mg/L)				Ammonia (mg/L)				COD (mg/L)			
			NWQS** Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	MMWQS * Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	12	0.0001	0.0112	✓	1	0.0000	0.0015	✓	5	0.0002	0.0165	✓	100	0.0011	0.0936	✓
E2 (A)	Jelutong Outlet (Before Reclamation)	Interim Class E1* / Class IV**	12	0.0002	0.0178	✓	1	0.0000	0.0018	✓	5	0.0003	0.0212	✓	100	0.0019	0.1289	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	12	0.0141	1.9084	✓	1	0.0013	0.1807	✓	5	0.0280	3.8170	✓	100	0.1216	16.5399	✓
E4	Boat Landing Area	Class 2* / Class III**	6	0.0006	0.0482	✓	0.14	0.0001	0.0038	✓	50	0.0010	0.0958	✓	50	0.0048	0.4173	✓
E5	South Outlet	Interim Class E1* / Class IV**	12	0.0004	0.0233	✓	1	0.0000	0.0021	✓	5	0.0007	0.0456	✓	100	0.0034	0.1984	✓
E6	Southern Side	Class 2* / Class III**	6	0.0002	0.0051	✓	0.14	0.0000	0.0005	✓	50	0.0003	0.0070	✓	50	0.0014	0.0371	✓
E7	Middle Bank	Class 1* / Class I**	1	0.0001	0.0114	✓	0.01	0.0000	0.0011	✓	35	0.0002	0.0139	✓	10	0.0011	0.0847	✓

Table 7.20
Dispersed Values from Jelutong Rehabilitated Site for Aluminium, Arsenic (III), Boron and Iron at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	Aluminium (mg/L)				Arsenic (III) (mg/L)				Boron (mg/L)				Iron (mg/L)			
			MMWQS* Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	27	0.0000	0.0004	✓	3	0.0000	0.0000	✓	0.8	0.0000	0.0001	✓	1	0.0000	0.0014	✓
E2 (B)	Jelutong Outlet (After Reclamation)	Interim Class E1* / Class IV**	27	0.0000	0.0002	✓	3	0.0000	0.0001	✓	0.8	0.0000	0.0001	✓	1	0.0000	0.0008	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	27	0.0002	0.0205	✓	3	0.0000	0.0005	✓	0.8	0.0002	0.0246	✓	1	0.0017	0.2400	✓
E4	Boat Landing Area	Class 2* / Class III**	27	0.0000	0.0006	✓	3	0.0000	0.0000	✓	3.4	0.0000	0.0004	✓	1	0.0000	0.0036	✓
E5	South Outlet	Interim Class E1* / Class IV**	27	0.0000	0.0003	✓	3	0.0000	0.0000	✓	0.8	0.0000	0.0002	✓	1	0.0000	0.0014	✓
E6	Southern Side	Class 2* / Class III**	27	0.0000	0.0001	✓	3	0.0000	0.0000	✓	3.4	0.0000	0.0000	✓	1	0.0000	0.0003	✓
E7	Middle Bank	Class 1* / Class I**	27	0.0000	0.0001	✓	1	0.0000	0.0000	✓	-	0.0000	0.0000	-	1	0.0000	0.0003	✓

Table 7.21
Dispersed Values from Jelutong Rehabilitated Site for Lead, Manganese, Potassium and Selenium at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	Lead (mg/L)				Manganese (mg/L)				Potassium (mg/L)				Selenium (mg/L)			
			MMWQS* Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	1.3	0.0000	0.0000	✓	0.2	0.0000	0.0000	✓	-	0.0002	0.0176	-	0.02	0.0000	0.0000	✓
E2 (B)	Jelutong Outlet (After Reclamation)	Interim Class E1* / Class IV**	1.3	0.0000	0.0001	✓	0.2	0.0000	0.0001	✓	-	0.0001	0.0089	-	0.02	0.0000	0.0001	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	1.3	0.0000	0.0001	✓	0.2	0.0000	0.0063	✓	-	0.0249	3.2425	-	0.02	0.0000	0.0003	✓
E4	Boat Landing Area	Class 2* / Class III**	8.5	0.0000	0.0000	✓	0.1	0.0000	0.0001	✓	-	0.0008	0.0718	-	0.25	0.0000	0.0000	✓
E5	South Outlet	Interim Class E1* / Class IV**	1.3	0.0000	0.0000	✓	0.2	0.0000	0.0000	✓	-	0.0005	0.0278	-	0.02	0.0000	0.0000	✓
E6	Southern Side	Class 2* / Class III**	8.5	0.0000	0.0000	✓	0.1	0.0000	0.0000	✓	-	0.0002	0.0048	-	0.25	0.0000	0.0000	✓
E7	Middle Bank	Class 1* / Class I**	2.2	0.0000	0.0000	✓	0.1	0.0000	0.0000	✓	-	0.0001	0.0033	-	-	0.0000	0.0000	-

Table 7.22
Dispersed Values from Jelutong Rehabilitated Site for Vanadium, Zinc, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	Vanadium (mg/L)				Zinc (mg/L)				Total Dissolved Solids (TDS) (mg/L)				Total Suspended Solids (TSS) (mg/L)			
			NWQS** Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	-	0.0000	0.0000	-	16	0.0000	0.0000	✓	1000	0.0057	0.4946	✓	30	0.0003	0.0248	✓
E2 (B)	Jelutong Outlet (After Reclamation)	Interim Class E1* / Class IV**	-	0.0000	0.0001	-	16	0.0000	0.0001	✓	1000	0.0033	0.2561	✓	30	0.0002	0.0123	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	-	0.0000	0.0001	-	16	0.0000	0.0022	✓	1000	0.3380	43.1921	✓	30	0.0240	3.2401	✓
E4	Boat Landing Area	Class 2* / Class III**	-	0.0000	0.0000	-	50	0.0000	0.0000	✓	1000	0.0122	1.0430	✓	50	0.0007	0.0591	✓
E5	South Outlet	Interim Class E1* / Class IV**	-	0.0000	0.0000	-	16	0.0000	0.0000	✓	1000	0.0077	0.4718	✓	30	0.0004	0.0245	✓
E6	Southern Side	Class 2* / Class III**	-	0.0000	0.0000	-	50	0.0000	0.0000	✓	1000	0.0030	0.0967	✓	50	0.0002	0.0053	✓
E7	Middle Bank	Class 1* / Class I**	-	0.0000	0.0000	-	7	0.0000	0.0000	✓	1000	0.0024	0.0898	✓	25	0.0001	0.0042	✓

Table 7.23
Dispersed Values from Jelutong Rehabilitated Site for BOD, Oil & Grease, Ammonia and COD at nearby identified ESRs

ESR	Description	MMWQS* / NWQS** Class	BOD (mg/L)				Oil & Grease (mg/L)				Ammonia (mg/L)				COD (mg/L)			
			NWQS** Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	MMWQS* Limit	Mean	Max	Com-pliance	NWQS** Limit	Mean	Max	Com-pliance
E1	Sungai Pinang Rivermouth	Interim Class E1* / Class IV**	12	0.0001	0.0061	✓	1	0.0000	0.0010	✓	5	0.0001	0.0072	✓	100	0.0006	0.0478	✓
E2 (B)	Jelutong Outlet (After Reclamation)	Interim Class E1* / Class IV**	12	0.0000	0.0031	✓	1	0.0000	0.0005	✓	5	0.0001	0.0039	✓	100	0.0004	0.0250	✓
E3	Sg Jelutong Rivermouth	Interim Class E1* / Class IV**	12	0.0064	0.8157	✓	1	0.0006	0.0818	✓	5	0.0181	2.4441	✓	100	0.0548	7.0188	✓
E4	Boat Landing Area	Class 2* / Class III**	6	0.0002	0.0196	✓	0.14	0.0000	0.0015	✓	50	0.0004	0.0443	✓	50	0.0018	0.1695	✓
E5	South Outlet	Interim Class E1* / Class IV**	12	0.0001	0.0081	✓	1	0.0000	0.0007	✓	5	0.0003	0.0156	✓	100	0.0011	0.0682	✓
E6	Southern Side	Class 2* / Class III**	6	0.0000	0.0016	✓	0.14	0.0000	0.0002	✓	50	0.0001	0.0023	✓	50	0.0004	0.0110	✓
E7	Middle Bank	Class 1* / Class I**	1	0.0000	0.0012	✓	0.01	0.0000	0.0002	✓	35	0.0001	0.0014	✓	10	0.0003	0.0089	✓

The extracted mean and maximum concentration for all parameters at each of the identified ESRs are well below the allowable limit for Baseline and Post-Reclamation condition.

Contaminants are dispersed into the sea with the groundwater flow discharge along the shorelines. Given the low groundwater flow rate and moderate contamination levels, the concentrations are expected to rapidly dilute in the vicinity of the site upon discharge into the sea, meeting the marine water quality standards.

For marine water quality, mean dispersion is generally non-existent, with the values of each modelled parameter being far below the acceptance limit of each respective class. This is due to quickly dilutes the discharge within the water column.

Observation over the maximum dispersion shows that the discharges are more concentrated to the southwest of the Jelutong site which corresponds to the higher concentration discharge from the groundwater modelling, in addition to the shallow waters. Modelled dispersion is based on the worst case scenario, where the peak of the runoff hydrograph coincides with the Spring Ebb tide, when the water is at the lowest tide level. The concentration and dispersion has been significantly reduced after the rehabilitation work has been completed.

The dispersion of each parameter discharged are considered to be localized and will be dispersed quickly with the current.

The extracted mean and maximum concentration for all parameters at each of the identified ESRs are well below the allowable limit for Baseline and Post-Project condition.

(c) Waste Handling At Waste Recycling Site

The rehabilitation works for the Proposed Project involves the excavation and transportation of the excavation wastes for temporary storage and sorting and there on conducting the various recycling process. Dust will be generated from the crushing process which will be removed in the dust collector. The residual wastes or unsuitable material from the recycling process are to be collected, kept in temporary storage and disposed accordingly.

The workers employed at the Proposed Project will be trained on various matters including wastes management, safety and environmental management.

Finally all equipment used in the recycling operations will have to be maintained on a routine basis to ensure continuous performance. Environmental monitoring is also required in compliance to the relevant conditions of approvals for operating the Proposed Project.

The significant impacts derived from the impact assessment conducted for the waste recycling are in relation to the following aspects:-

- Impacts on air quality due to the generation of fugitive emissions from the recycling processes;
- Impact on the generation of unsuitable wastes; and
- Impacts of human health and safety due to operational hazards from the recycling process.

The following provides a discussion of the impacts of the various activities during the recycling operations.

(i) Air Pollution

As discussed in **Chapter 5**, the recycling process will generate fugitive air emissions from the temporary stockpile area and the crushing and separation process where a dust collector is recommended to be installed. If the dusts are not collected, long term impacts on air quality and subsequently can be a nuisance and can effect the health of the community staying in the surrounding area.

(ii) Water Pollution

The recycling process will not generate industrial effluent thus impact due to water pollution is not anticipated during the recycling process.

(iii) Residual Wastes Or Unsuitable Material

Residual wastes or unsuitable material will be generated from the recycling operations which are outlined in **Chapter 5** of the EIA report. These wastes are shown in **Table 7.24.**

Table 7.24
Unsuitable Material Generated From Recycling Process

Type Of Waste	Estimated Quantity	Disposal Method
Metal	132,480 tons	Landfill Site/Sales
Wood	99,360 tons	Landfill Site/Sales
Plastics	99,360 tons	Landfill Site/Sales
Residue (By Product)	2,318,400 tons	Landfill Site/Sales

Spills or leakages from the storage can contaminate land and if the wastes enters the drainage system may pollute the waterway rendering the waterway unfit for its beneficial use. Thus measures are to be in place to address the issue.

During the operations of the Jelutong Landfill, regulated wastes or industrial waste were not accepted for dumping at the site. However, construction and demolition wastes accepted at the Jelutong Landfill may contain empty paint cans which were used at construction sites. Thus measures are to be in place if such wastes are detected at site.

(iv) Hazards

The rehabilitation works related to the Proposed Project may pose a hazard to the workers and the surrounding population. To assess the hazards of operating the recycling plant, a risk assessment is conducted for the Proposed Project.

A risk assessment is conducted to identify the potential risk associated with the Proposed Project and to evaluate the safety measures for minimizing the potential risks of the Proposed Project. The risk assessment also involves evaluating possible safety measures and safety management systems to be adopted so as not to create any hazards to the neighboring environment. For this purpose the risk assessment is initiated with a QRA (Qualitative Risk Assessment) and if further quantitative assessment is required, a Quantitative Risk Assessment follows as outlined in the Environmental Impact Assessment Guidelines for Risk Assessment published by the Department of Environment.

The overall methodology used in the risk assessment is outlined in **Figure 7.73.**

The assessment is initiated with a qualitative analysis which involves the following steps:-

- Identify the hazards of operating the Proposed Project;
- Estimate the likelihood of the hazard for the worse credible scenario;
- Estimate the consequence and severity of the hazard for the worse credible scenario; and
- Estimate the risk ranking for the hazard.

At this stage if the risk ranking indicates a level above the threshold level of 8 as outlined in the EIA Guidelines for Risk Assessment than further analysis involving the Quantitative Analysis is carried out. However, no further assessment is required if the Qualitative Risk Analysis is below 8.

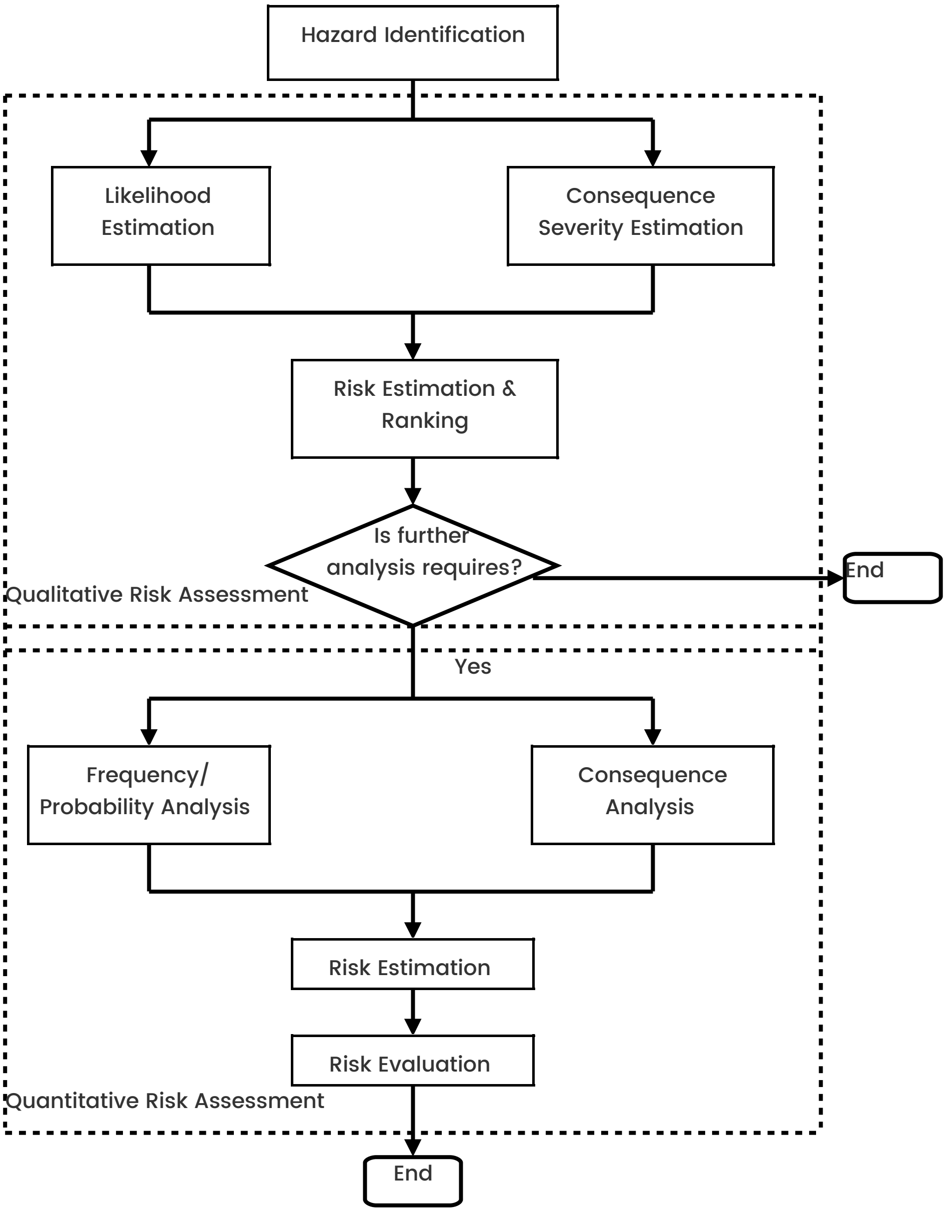


Figure 7.73
Methodology Used For Estimating Risks

If the qualitative assessment shows a threshold level of 8 and above a quantitative assessment is than conducted. The quantitative assessment involves the following steps:-

- Quantifying the consequence of the hazard;
- Quantifying the frequency, probability of the hazard; and
- Conduct the risk estimation and risk evaluation.

The assessment was initiated with a qualitative analysis which involves the hazard identification. hazard identification is a systematic approach to identify, detect and analyze the potential hazards from the Proposed Project.

The procedure involves a critical examination of all situations in which potential hazards may exist, followed by a disciplined analysis of the combination or sequences of events that could transform the potential hazards into an accident. In identifying the major hazards from the operations of the Proposed Project the following aspects were considered:-

- Determining whether a given operation or unit process or activity for the Proposed Project has the potential to cause major hazards followed by an assessment of how it can happen. This involves identifying the routes by which each of these major hazard events could occur;
- Determining the consequences of such major hazard to the process; and
- Proposing the preventive measures to minimize the hazard.

The following information was used in the hazard identification exercise:-

- Information on the properties of the waste and gases released so that their nature and harmful potential is fully understood;
- Knowledge of the Proposed Project and the processes under study;
- Operational experience of processes to be adopted for the Proposed Project under study;
- General knowledge of the Proposed Project e.g. transport route, safety, utilities, fire protection and fire fighting equipment, emergency procedures and others;
- Detailed professional knowledge on various engineering fields, e.g. instrumentation and control, mechanical engineering, chemical engineering, chemistry, etc;
- Production management aspects; e.g. production throughput, manning, shutdowns, maintenance, modification, etc;
- Knowledge of plant incidents causing major hazards; both for the Proposed Project and on similar plant/process; and
- Risk analysis experience on hazard identified.

The potential hazards associated with the Proposed Project are functions of the materials being handled, transferring systems, procedures used for operating and maintaining the Proposed Project, and hazard detection and mitigation systems provided.

The danger or risk to the environment and the community at large from the recycling operations is no greater than that associated with any other industrial processes.

Toxic releases therefore is considered as one of the process control irregular not the uncontrollable hazard as safety measures will be integrated in the process design so as not to cause any impact. In addition, mitigation measures will be implemented to reduce the frequency of the hazard. Fires can also occur at the Proposed Project due to faulty wiring.

Table 7.25 provides a summary of the hazards identified for the Proposed Project based on unit process.

Table 7.25
Summary Of Hazards Identified For Each Unit Process

Unit Process	Substances/Material	Hazard Scenario	Consequence
1. Excavation & Transport of Excavated Wastes	• Excavated Wastes	• Spillage within vehicle	• Potential wastes uncontained within vehicle.
		• Transport vehicle catches fire.	• Transfer of wastes from vehicle to storage area.
		• Accident spillage due to traffic accidents • Accidental release of methane gas	• Spillage of excavated wastes uncontained on roadway. • High methane concentration will be nuisence to the local community and potential fire hazard if there is an ignition source
2. Excavated Waste Storage	• Excavated Wastes	• Spillage while unloading of wastes	• Potential wastes uncontained in plant.
3. Recycling Process	• Excavated Wastes	• Spillage of wastes during material handling	• Spillage unlikely as the excavated wastes from waste storage will be handled manually
4. Residue (By Product) Handling and Storage	• Residue • Wood • Metal • Plastic	• Accidental human exposure to residues	• No direct human contact with residues as residues are kept in residual storage area.

The potential release that may result from the various failures and operation errors that may result from the Proposed Project as shown in earlier **Table 7.25** are discussed further as follows:-

(i) Collection And Transport Of Excavated Wastes

Spillage of excavated wastes is a consequence of failures such as traffic accidents or operator error. Spillage during traffic accidents will result in the excavated wastes to be uncontained within the site.

Spillage in the transport vehicle will result in excavated wastes to be contained within the vehicles. Owing to the fact that the excavated wastes can be re-handled and re-collected for proper handling the risk involved in handling the hazard will only involve risks to workers health.

Improper controls during waste excavation may result in accidental release of methane gas if uncontrolled may result in high concentration of methane at TPSJ. Methane is highly flammable and in the present of an ignition source will lead to fires. Health effect associated with methane is from the lack of oxygen rather than direct exposure to methane. Thus safety is an important aspect during the rehabilitation activities.

Thus workers have to be in proper attire to handle the excavated wastes and medical checks are to be conducted immediately after cleaning up the excavated wastes spilled during collection and transport.

(ii) Excavated Waste Storage

Improper handling of the excavated wastes during storage may result in spillage. Containment is to be provided to avoid potential of the wastes entering any drainage system.

(iii) Recycling Process

The recycling process generates fugitive emissions whereby a dust collector will be provided to release the emissions. The worse credible scenario is release from the dust collector to the environment.

(iv) Residue Handling And Storage

Table 7.26 provides an inventory of all the unsuitable material to be handled and stored on site.

Table 7.26
Inventory Of Unsuitable Material Stored On Site

Type Of Waste	Estimated Quantity	Disposal Method
Metal	49,806 tons	Sales
Wood	186,774 tons	Sales
Plastics	93,387 tons	Sales
Residue (By Product)	1,380,059 tons	Sales

Besides these unsuitable material, some scheduled wastes if found at site will be temporary stored prior disposal. As these wastes are solids, they are easily handled with the use of proper PPE.

Amongst the hazard incidents, it can be said judging from the hazard incidents, fires and fugitive emissions are the worse potential hazard scenario for the Proposed Project.

For purpose of depicting the worse credible scenario a fault tree analysis was conducted to provide potential releases for the hazards identified as shown in **Figure 7.74.**

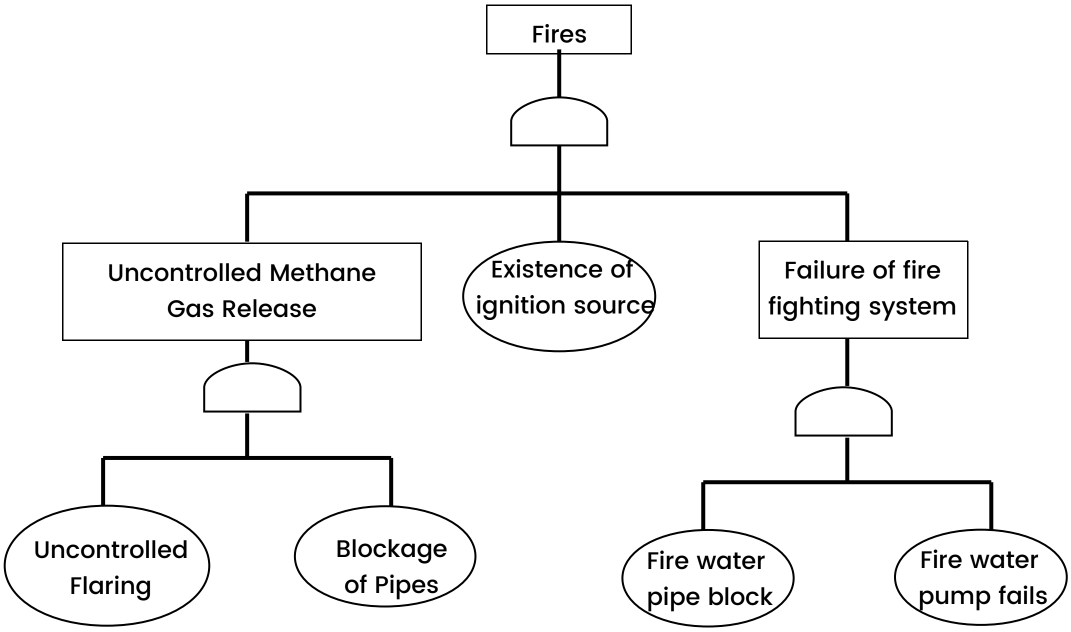


Figure 7.74 Fault Tree Analysis For General Fires

To rank the risks of the Proposed Project a risk matrix is used which uses a combination of the levels of consequence as shown in **Table 7.27** and levels of likelihood as shown in **Table 7.28.** The risk ranking for the various processes **Table 7.29 to Table 7.30** provides the risk matrix for the worse credible scenario which is for fires and toxic releases.

Table 7.27
Levels Of Consequence

Description	Level	Definition of Description
Catastrophic	5	Major off site toxic release with detrimental effects to environment, death, huge financial loss
Major	4	Major off site toxic release without detrimental effects to the environment, major injuries (permanent disablement or / and genetic defects), major financial loss
Moderate	3	On – site released contained with outside assistance, requires hospitalization, large financial loss
Minor	2	On – site released contained without outside assistance major injuries, some financial loss
Insignificant	1	First aid cases, low financial loss

Table 7.28
Levels Of Likelihood

Description	Level	Definition of Description
Very likely	4	Is expected to occur in most circumstances (> 10^{-5} per year)
Likely	3	Will probably occur in most circumstances (10^{-6} – 10^{-5} per year)
Unlikely	2	Might occur at some time (10^{-8} – 10^{-6} per year)
Highly unlikely	1	May occur in exceptional circumstances (<10^{-8} per year)

Table 7.29
Summary Of Risk Ranking For Individual Process

Process		Worse Credible Scenario	Level of Likelihood	Level of Consequence	Risk Ranking
1.	Collection/Transport	Fire	Unlikely (2)	Minor (2)	4
2.	Excavated waste Storage	Fire	Unlikely (2)	Moderate (2)	4
3.	Recycling Process	Fire	Unlikely (2)	Moderate (2)	4
4.	Residue Handling	Fire	Unlikely (2)	Moderate (2)	4

Table 7.30
Summary Of Risk For Worse Case Scenario

		Consequence				
		Catastrophic (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Likelihood	V. Likely (4)	E. High (20)	E. High (16)	E. High (12)	High (8)	Medium (4)
	Likely (3)	E. High (15)	E. High (12)	High (9)	Medium (6)	Medium (3)
	Unlikely (2)	High (10)	High (8)	Medium (6) (Fires/Fugitive Emissions)	Medium (4)	Low (2)
	Highly Unlikely (1)	Medium (5)	Medium (4)	Low (3)	Low (2)	Low (1)

The risk for general fires and fugitive releases from the Proposed Project is within the medium risk (level 4). As the threshold level for quantitative risk assessment is set at 8, further assessment is not required. As the risk is of medium level (6) and below the threshold value of 8, quantitative risk assessment is not required.

A separate methodology using the Risk Reference Table is used as an alternative methodology and second tool of evaluation to assess the risks of operating the Proposed Project.

The risk reference table uses the following parameters:-

- Frequency of Exposure of work done;
- Likelihood of an incidence; and
- Consequences of incidence which can be further divided into intensity and extensivity.

The level of risks is given as an index as a result of multiplying the scores for each of the parameters mentioned above.

Tables 7.31, Table 7.32, Table 7.33, Table 7.34 and Table 7.35 shows the scores for the descriptors for frequency (F), Likelihood (L), Consequence Intensivity

(I), Consequence Extensivity (Persons) (EP) and Consequence Extensivity (Area).

Table 7.31
Frequency (F)

Description	Score
Infrequently	1
Annually	2
Monthly	4
Weekly	8
Daily	16
Continuously	32

Table 7.32
Likelihood (L)

Description	Score
Practically impossible	1
Unlikely but conceivable	2
Remotely Possible	4
Unusual but possible	8
Quite possible	16
Expected Sometimes	32
Certain, no doubt	64

Table 7.33
Consequence Intensivity (I)

Description	Score
No injury	1
First Aid cases without medical leave	2
Injury or health effect requiring less than 4 days medical leave	4
Non major injury or health effects, but require 4 days medical leave	8
Major injury or health effect, but requires 4 days medical leave	16
Major injury or health effect but not permanent disablement	32
Fatality	64

Table 7.34
Consequence Extensivity (Persons)(EP)

Description	Score
1-4 persons	1
5-9 persons	2
10-14 persons	4
15-20 persons	8
> 20 persons	16

Table 7.35
Consequence Extensivity (Area)(EA)

Description	Score
On Site	1
Off Site but within district control	2
Outside District control but within state boundary	4
Within National boundary but outside state boundary	8
Beyond national boundary	16

Risk score is calculated by multiplying all the parameters considered. That is:

Risk Score = F x L x I x EP x EA

The threshold value for this assessment before quantitative risk assessment is required is 4096 (i.e. F = 8, L= 32, I = 16, EP = 1 and EA =2). **Table 7.36** provides the Risk Reference Table conducted for the Proposed Project. As the risk score is less than the threshold value of 4096 as stipulated in the EIA Guidelines for Risk Assessment, a quantitative risk assessment is not required for the Proposed Project.

Table 7.36
Risk Reference Table For Proposed Project

Process	Material	TE	ETE	F	L	Consequence			Risk Score
						I	EP	EA	
Storage and Recycling Process	•C&D waste •Unsuitable material	Spills	Fugitive release	32	16	1	1	2	1,024
		Fire	Firing	32	2	16	1	2	2,048
								Total	**3,072 <4096**

Table 7.37 provides the measures to be in place to minimize risks for the Proposed Project.

Table 7.37
Mitigation Measures To Manage Risks Due To Transportation, Storage And Handling Of Excavated Wastes

No.	Risk	Mitigation Measure
1.	Accidental spillage of excavated wastes upon loading.	Will be managed by the on site personnel whereby excavated wastes will be collected and contained.
2.	Accidental spillage of excavated waste on the way to temporary storage	Transporter will immediately cardon off the area of spillage. Spill control technique such as on site detention will be carried out by transporter in assistance with the mobile team. Driver will be trained in safe handling of the excavated waste. The truck will carry dry type fire extinguisher (s).
3.	Handling of excavated waste	Proper PPEs will be used to eliminate chances of occupational exposure to contaminated excavated wastes.
4.	Safe storage of the wastes	Material with fuel characteristic shall be handled with care. Excavated waste shall be unloaded carefully to prevent any spillage. Sufficient circulation area around the working area will be maintained to operate and also to serve as fire break distances. Storage areas for scheduled wastes if found at site are to be provided with secondary containment.

Figure 7.75 provides the emergency response to control fires.

Flow Chart	Action
Witness of Fire	Shout 'Api / Api'. Inform surrounding personnel
↓	
Acknowledgment and Announcement of Fire	Incident Commander (IC) Safety Officer (SO)
↓	
Formation of ERT	First Responder and ERT • Respective members of ERT • Use CO_2 if fire is near storage of oils • Use water from fire hydrant is fire is at factory building
↓	
Try to isolate fire from spreading	
↓	
Remove casualty (if any)	
↓	
Inform POLICE, BOMBA and Hospital	SO
↓	
Accompany ambulance to pick up casualty	SO
↓	
To decide to evacuate	Incident Commander (IC)
↓	
Preparation of emergency log and liase with POLICE, BOMBA, Hospital and Medic	IC and SO

Figure 7.75
Emergency Response To Control Fires

(ii) Reclamation Works At Coastal Area

Proposed Project also involve reclamation of a new land mass to be implemented in tandem. Generally, the impacts associated with the reclamation stage can be summarized as follows:-

- Impact due to coastal processes and changes in shoreline;
- Impacts on marine water quality due to sediment transport;
- Impacts due to increase in sea traffic; and
- Impacts on shoreline.

The above impacts are discussed below:-

(a) Impact on Coastal Processes from Reclamation Activity

The reclamation works involves transporting the fill material to be filled at the reclamation site whereby barge and trailing suction dredger will be used to transport the fill material. Generally, the turbidity in the water column during the reclamation activities differs in intensity on the filling action.

The potential environmental impacts of reclamation activities are showed in **Table 7.38**.

Table 7.38
Potential Environmental Impacts Of Reclamation Activities

Issue	Impact	Concern
Short Term		
Removal of benthos and bottom living species	Loss	Fishing, marine habitat
Deposition	Loss	Wildlife, coastal access
Suspended solids settlement	Deposition	Navigation, fishing, marine habitat
Turbidity	Reduced light	Fishing, marine habitat
Suspended solids	Discolouration	Tourism, recreation
Release of contaminants	Pollution	Marine life, fishing, recreation
Direct interference	Obstruction	Navigation
Operation	Pollution	Noise, dust, oil spill
Longer Term		
Altered bathymetry	Currents Waves Salinity	Navigation Safety. erosion, coast protection Marine habitat, irrigation
Altered coastal form	Currents Waves Coastal Processes	Navigation Safety, erosion Erosion and deposition
Recovery	Recolonisation	Marine habitat

Generally water quality at the reclamation site during the filling activity would deteriorate with higher turbidity, resuspension of contaminated materials into the water colum, dissolved oxygen depretion, release of nutrients and other contaminated materials from the sediments and the creation of scum.

The degree of impacts on water quality are influenced by many factors including the sand types, quantity of material handled and the equipment selected for transportation and placement of fill material currents.

Both fill sourcing and placement of fill material generate sediment in suspension, which may be dispersed by currents. The degree of these impacts as mentioned are much more significant if the mitigation measures are not in place. The generation and dispersion of the sediment plume has implications to water quality and impacts to fish and other aquatic life.

To gauge the impacts of the reclamation activity a hydraulic model is conducted by the appointed hydraulic engineer. The following provides, the findings of the coastal hydraulic study which has obtained approval from JPS via letter reference (6) dlm.PPS14/7/P50 dated 9th December 2022 as shown in **Appendix A-001**:-

Hydraulic Impact Assessment On Temporary Drainage

i) Water Level Impacts

The maximum water level profiles comparing between the existing and during construction scenarios for all the 100-year ARI storm durations (i.e., 15-minutes, 30-minutes, 1-hour, 3-hour and 6-hour) are shown in **Figure 7.76**. The statistics of maximum water level difference are summarized in **Table 7.39**. Based on the modelled results, the following observations are inferred:-

Table 7.39
Statistics Of Maximum Water Level Comparing Between The Existing And During Construction Scenarios For Various 100-year ARI Storm Durations

ARI	Storm Duration	Max Water Level (m)		
		Existing	During Construction	Difference
100-year	15-min	1.39	1.40	0.01
	30-min	1.39	1.41	0.02
	1-hr	1.39	1.41	0.02
	3-hr	1.39	1.39	0.00
	6-hr	1.38	1.39	0.01

- In general, the maximum water level within the drain generally increases less than 0.03 m above the HAT level (i.e., 1.38 mMSL);

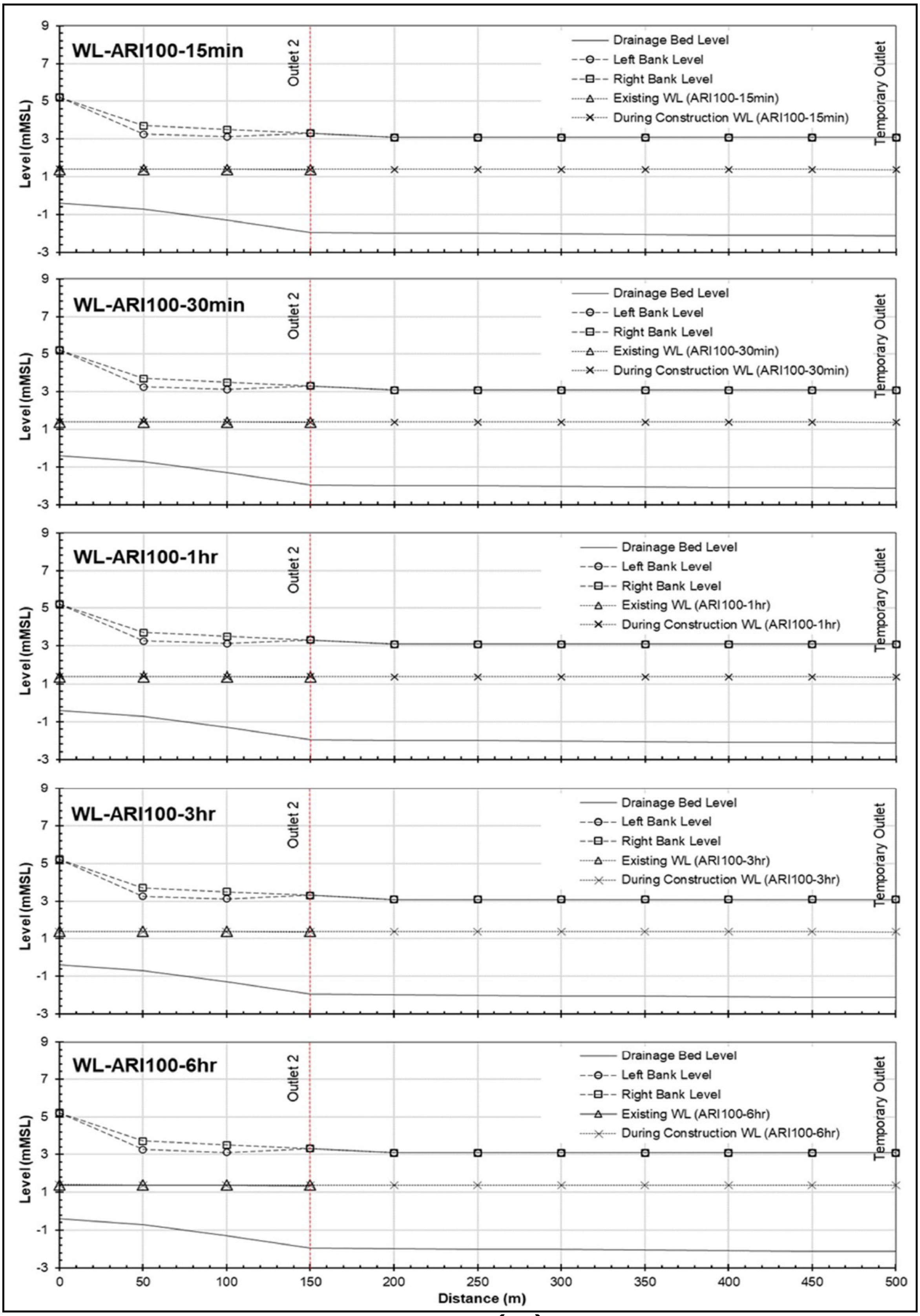


Figure 7.76 Modeled Maximum Water Level (WL) Profile Comparing Between The Existing And During Construction Scenarios For Various 100-year ARI Storm Durations

- Under Existing condition, the maximum water level generally increase to about 1.39 mMSL for the storm duration of 15-minutes to 3-hour. For storm durations above 3-hour, the existing maximum water level was generally at HAT level;
- Under the During Construction scenario (i.e., with the temporary drain), the maximum water level was generally about 1.40 to 1.41 mMSL for the storm durations of 15-minutes to 1-hour. Above the 1-hour storm duration, the maximum water level was predicted at about 1.39 mMSL;
- Comparing between the Existing and During Construction scenarios, the difference in the modelled maximum water level within the drain was observed to be negligible with maximum changes generally about 0.02 m associated to the 30-minutes and 1-hour storm events; and
- For all the modelled 100-year ARI storm duration, no overflow above the existing drainage bank level (i.e., CH0 to CH150) and the reclamation platform level (i.e., CH150 to CH500) was observed.

ii) Flow Discharge Impacts

The maximum flow discharge profiles comparing between the existing and during construction scenarios for all the 100-year ARI storm durations (i.e., 15-minutes, 30-minutes, 1-hour, 3-hour and 6-hour) are shown in **Figure 7.77**. The statistics of maximum flow discharge difference are summarized in **Table 7.40**. Based on the modelled results, the following observations are inferred:-

Table 7.40
Statistics Of Maximum Water Level Comparing Between The Existing And During Construction Scenarios For Various 100-year ARI Storm Durations

ARI	Storm Duration	Max Discharge (m^3/s)		
		Existing	During Construction	Difference
100-year	15-min	10.40	10.50	0.10
	30-min	14.40	14.44	0.04
	1-hr	15.92	16.00	0.08
	3-hr	10.41	10.46	0.05
	6-hr	8.20	8.22	0.02

- In general, the flow discharge within the drain increases with increasing inflow magnitude with peak flow observed for the 1-hour storm duration;
- Under the Existing condition, the discharge generally increases from 10.40 m^3/s to 15.92 m^3/s for storm duration of 15-minutes to 1-hour. Above the 1-hour storm, the discharge gradually decreases from 10.41 m^3/s to 8.20 m^3/s as the critical storm duration increases from 3-hour to 6 hour;

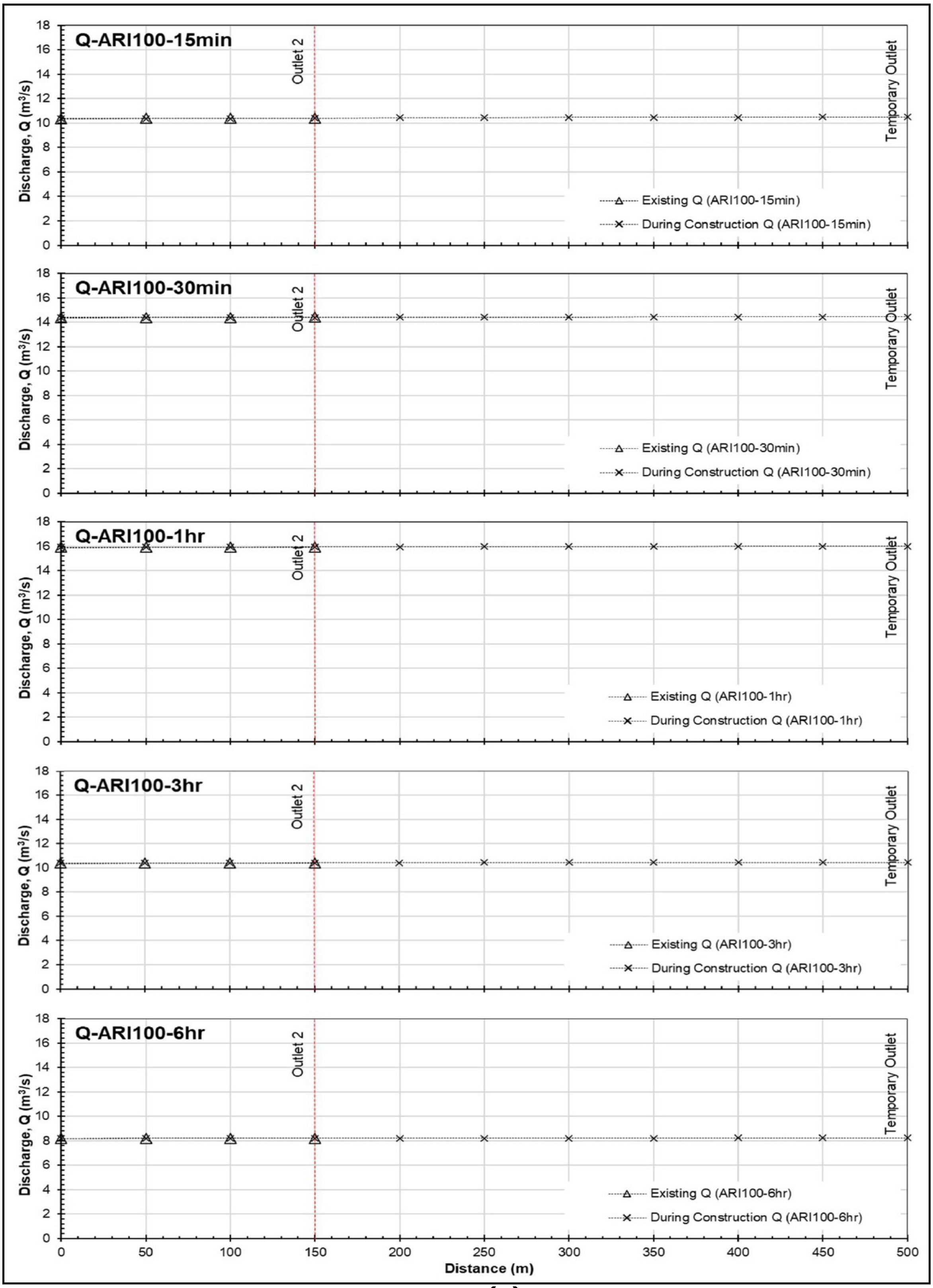


Figure 7.77 Modeled Maximum Discharge (Q) Profile Comparing Between The Existing And During Construction Scenarios For Various 100-year ARI Storm Durations

- Under the During Construction condition (i.e., with the temporary drain), the discharge generally increases from 10.50 m^3/s to 16.00 m^3/s for storm duration of 15-minutes to 1-hour. Above the 1-hour storm, the discharge gradually decreases from 10.46 m^3/s to 8.22 m^3/s as the critical storm duration increases from 3-hour to 6 hour;
- Comparing between the Existing and During Construction conditions (i.e., with and without the temporary drain), changes in the flow discharge was observed to be negligible with difference observed about 0.10 m^3/s and below; and
- The assessment shows that the presence of the temporary drain would have negligible impacts to the conveyance capacity of the existing Outlet 2 drainage system and as such, no mitigation measures are required.

Hydrodynamic Impact Assessment

This section will further explore and elaborate the finding of the long-term impacts to the existing environment on two parameters:-

- Water Level; and
- Current Speed.

It is worth mentioning that the Project site is sheltered within the Penang Strait and the monsoon seasons (e.g., NE (Northeast) and SW (Southwest) monsoon) have minimal impacts on the hydrodynamic aspect due to limited fetch length. As such, the analyses were only carried out for Pure Tide condition (e.g., no monsoon wind driving the current).

i) Impacts On Water Level

The following observations were made based on the analysed modelling results and MSL (Mean Water Level) with description shown in **Table 7.41** for the ESR points and reults as shown in **Figure 7.78 to Figure 7.83.**

- Based on **Figure 7.78**, the mean water level has little variation with reference to the MSL. The water level variations observed within the Study Area ranges from 0 m MSL to 0.04 m MSL;
- There are patches of areas observed having the mean water level of 0.02 m MSL, specifically at the middle bank area (M31) near the Proposed Project as well as around jetties and terminals on the western coast of Penang mainland (M5 to M10) and and Penang Island (M34 to M47);
- This condition is observed to be largely similar for all modelling scenarios without significant changes;

Table 7.41
List Of ESR Points

ID	Description
M1	Jetty Bagan Ajam
M2	Pantai Bersih
M3	North Butterworth Container Terminal (NBCT)
M4	Butterworth Floating Mosque
M5	Jetty A
M6	Terminal Pengangkutan Sementara
M7	Shell Bagan Luar Terminal
M8	Fisherman Landing
M9	Pangkalan Sultan Abdul Halim Ferry Terminal
M10	South Butterworth Container Terminal (SBCT)
M11	River mouth Sg. Prai
M12	Shell and Esso Storage
M13	Prai Power Plant
M14	Pengkalan Cargo PPSB
M15	Mangroves Seberang Prai
M16	Mangroves at 1st Penang Bridge
M17	River mouth Sg. Juru
M18	Cockle Farm
M19	Pulau Jerejak Aquaculture Farm (South)
M20	River mouth Sg. Nibong Kecil
M21	Pulau Jerejak Aquaculture Farm (North)
M22	Rivermouth Sg. Besar
M23	Jetty B
M24	Jetty C
M25	Rivermouth Sg. Gelugor 2
M26	Seagrass
M27	Pulau Ros
M28	Pulau Gazumbo
M29	Rivermouth Sg. Gelugor 1
M30	Aquaculture Jelutong 1
M31	Middle Bank
M32	Aquaculture Jelutong 2
M33	Rivermouth Sg. Pinang
M34	Chew Jetty
M35	Pengkalan Raja Tun Uda Ferry Terminal
M36	Tanjung City Marina
M37	Swettenham Pier
M38	Eastern and Oriental Seaside
M39	Gurney Beach
M40	Tanjung Tokong Development
M41	Straits Quay Marina

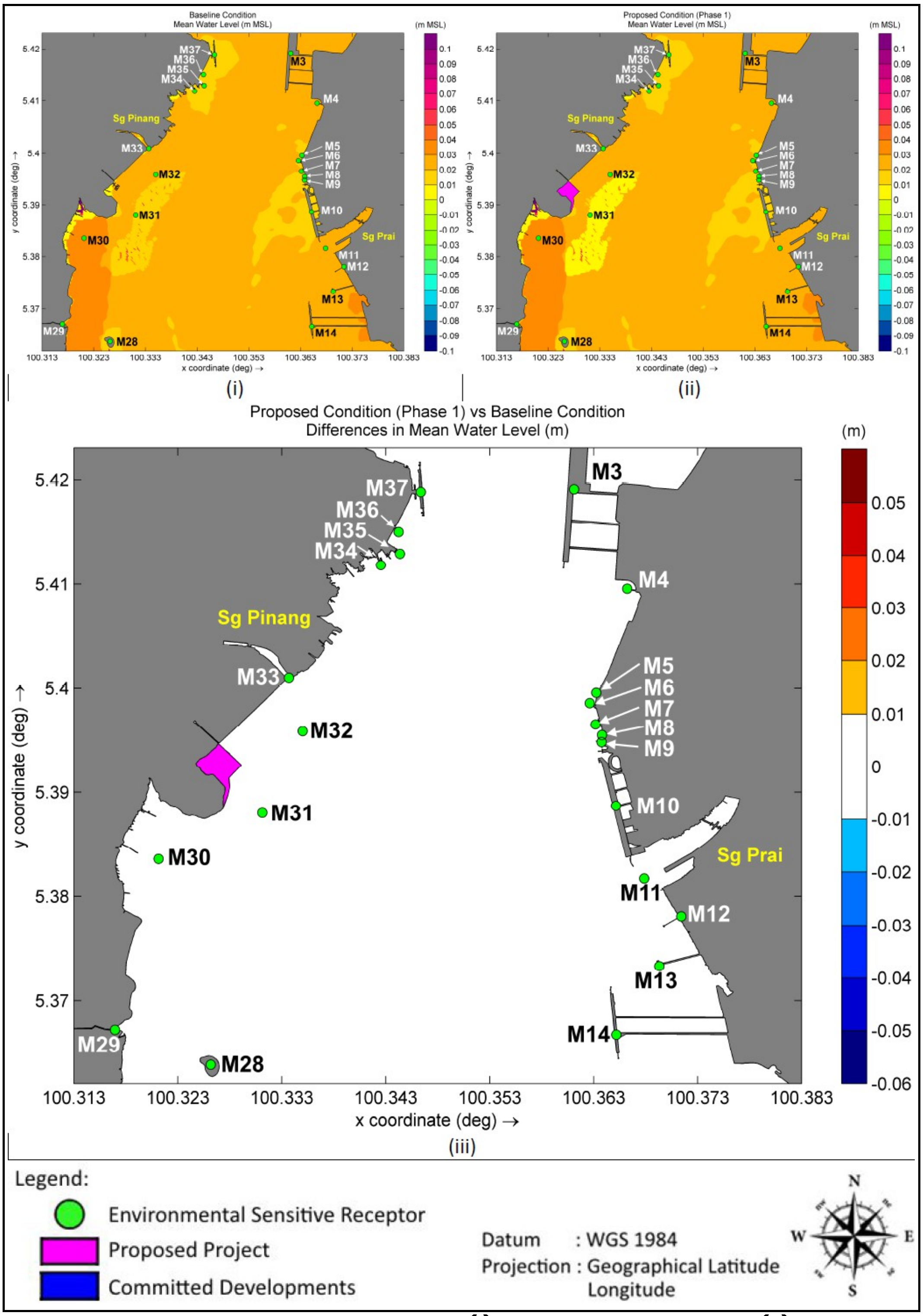


Figure 7.78: Mean Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Mean Water Level Between (i) And (ii).

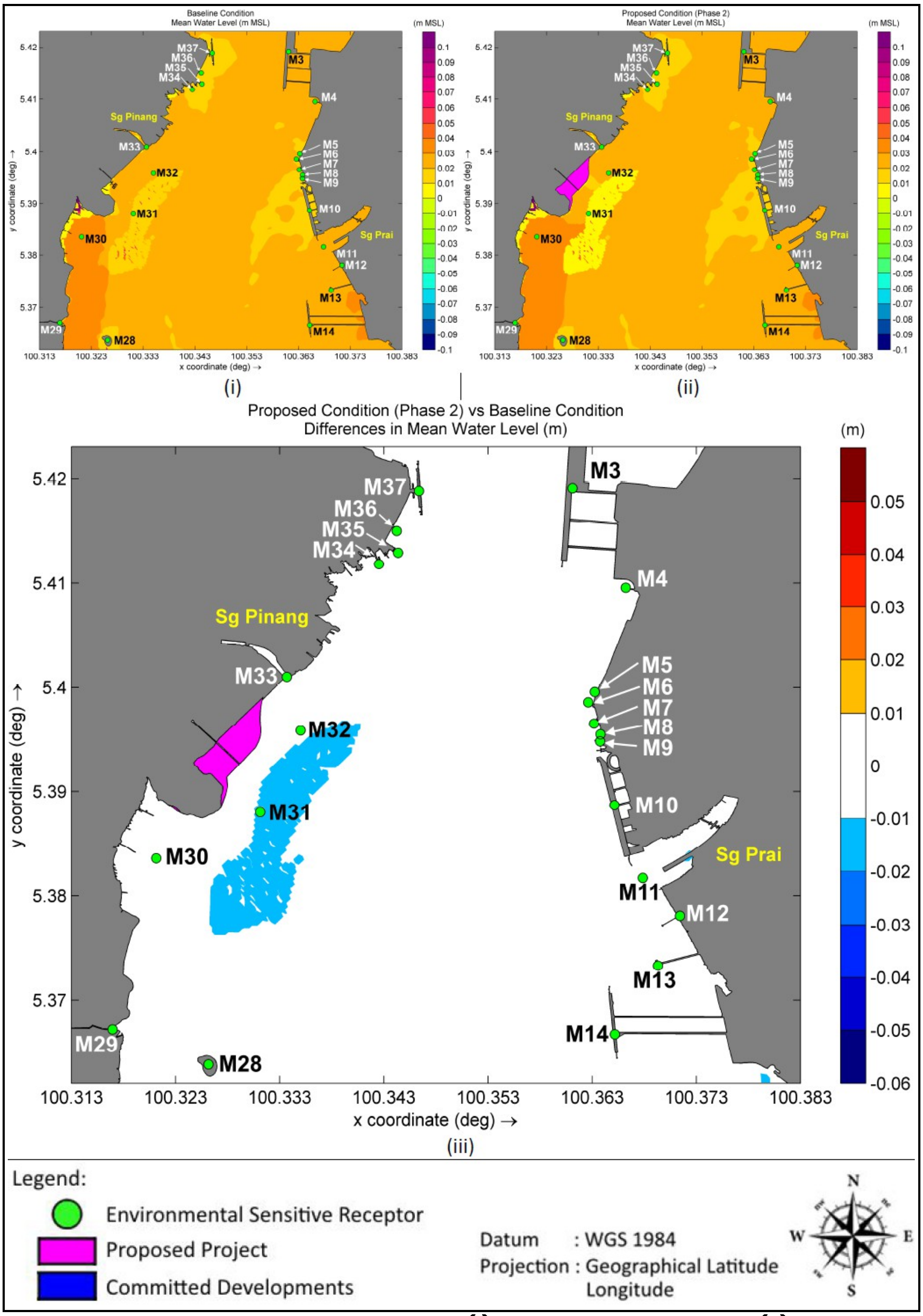


Figure 7.79: Mean Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Mean Water Level Between (i) And (ii).

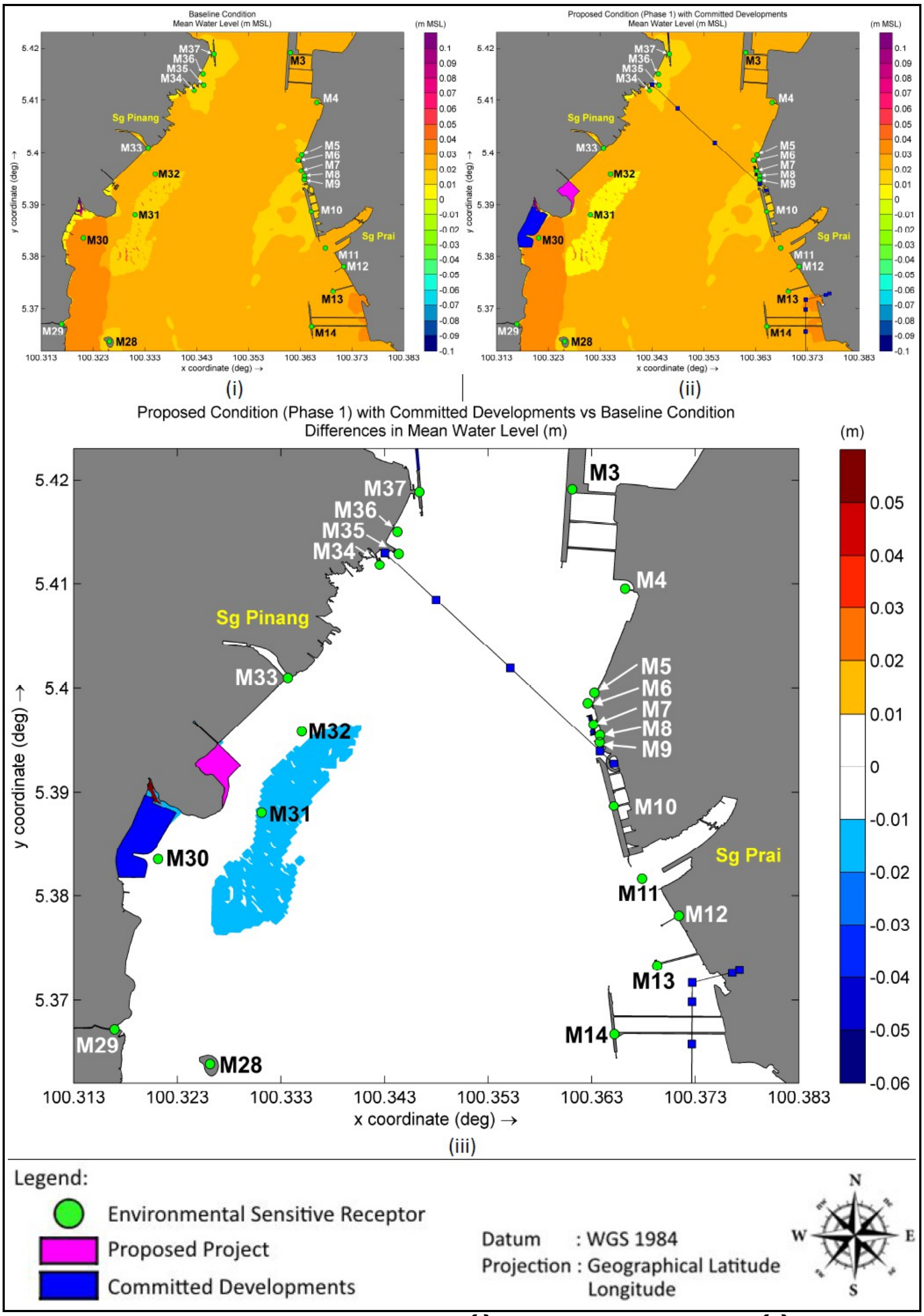


Figure 7.80: Mean Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Mean Water Level Between (i) And (ii).

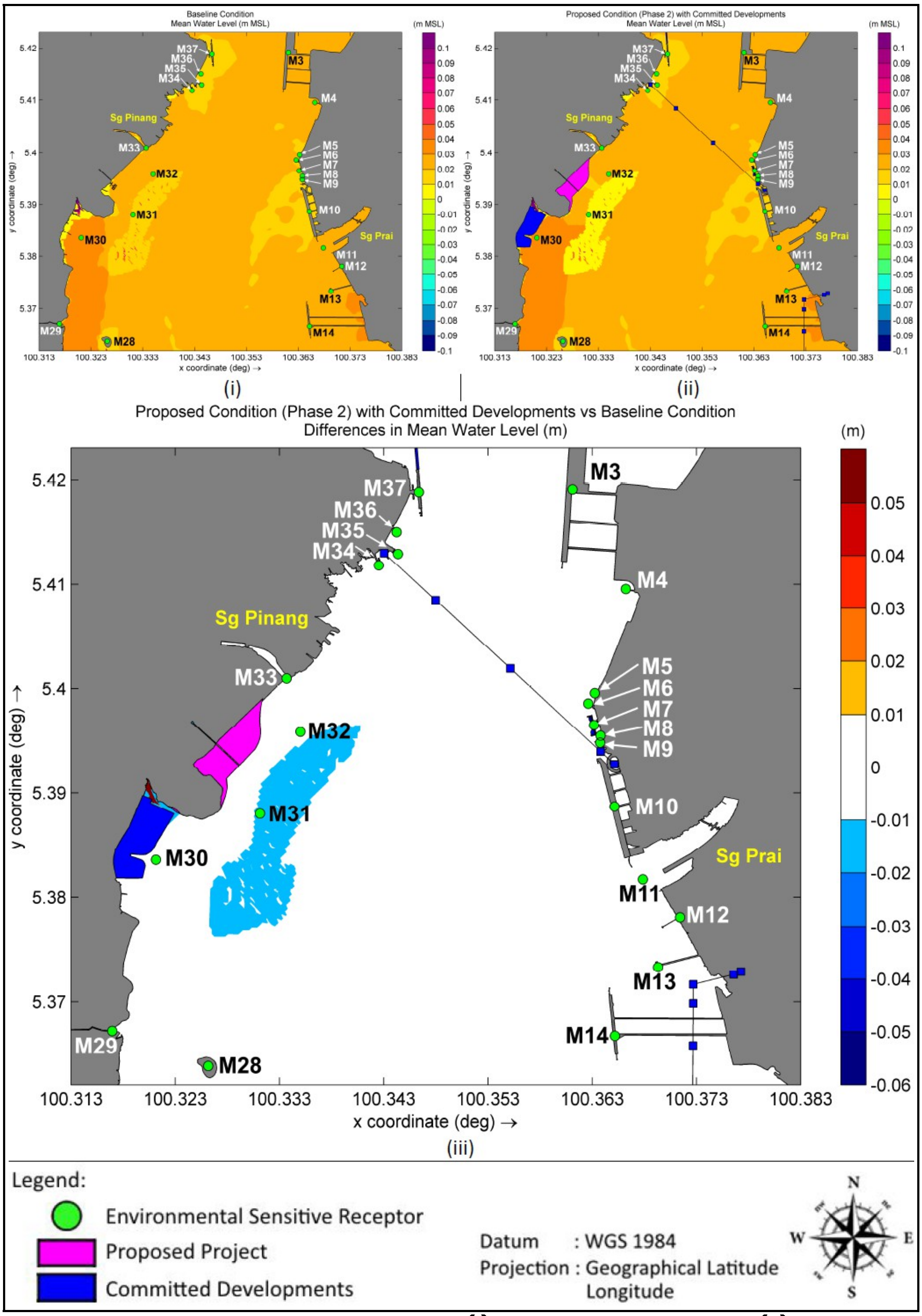


Figure 7.81: Mean Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Mean Water Level Between (i) And (ii).

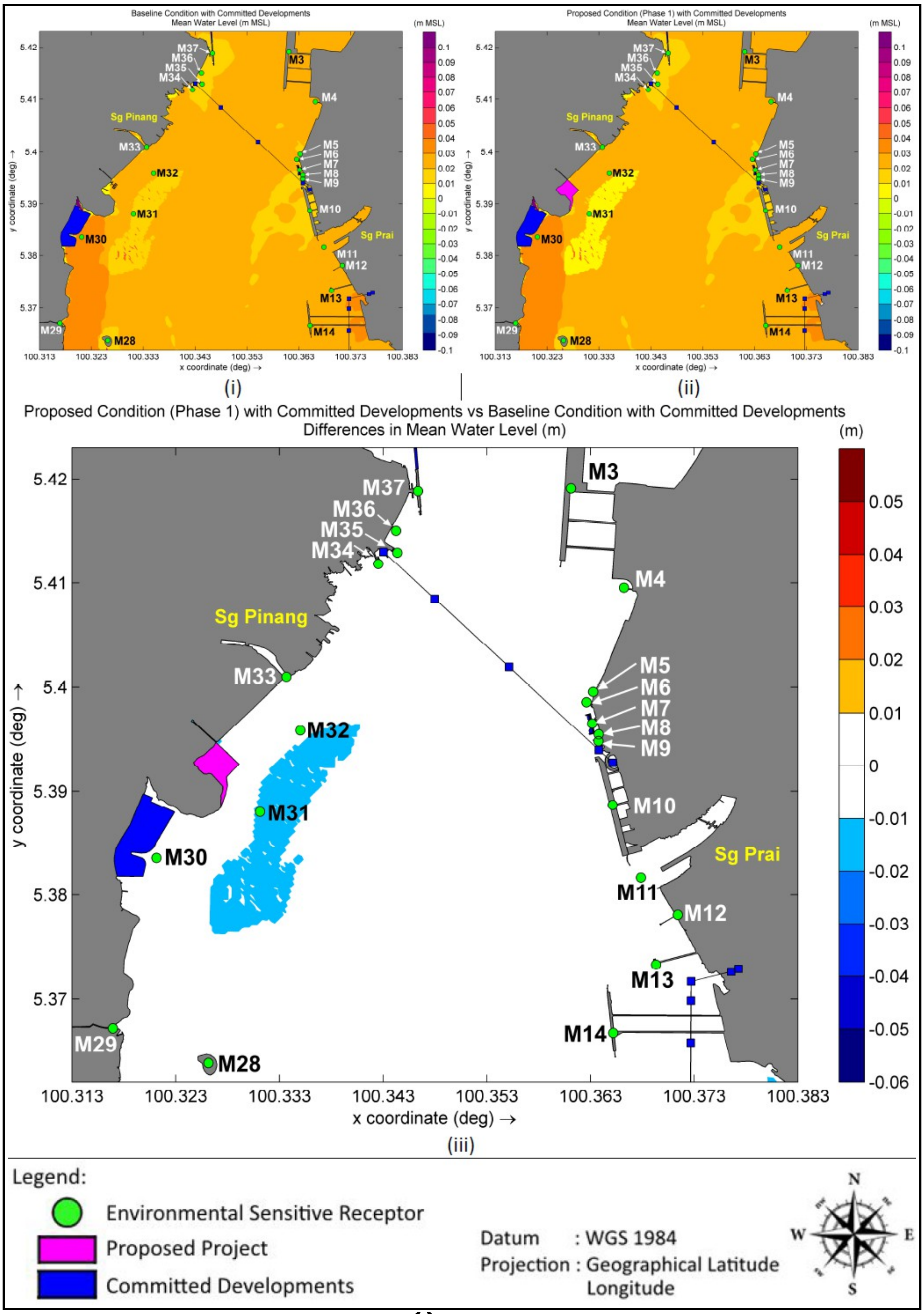


Figure 7.82: Mean Water Level For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Mean Water Level Between (i) And (ii).

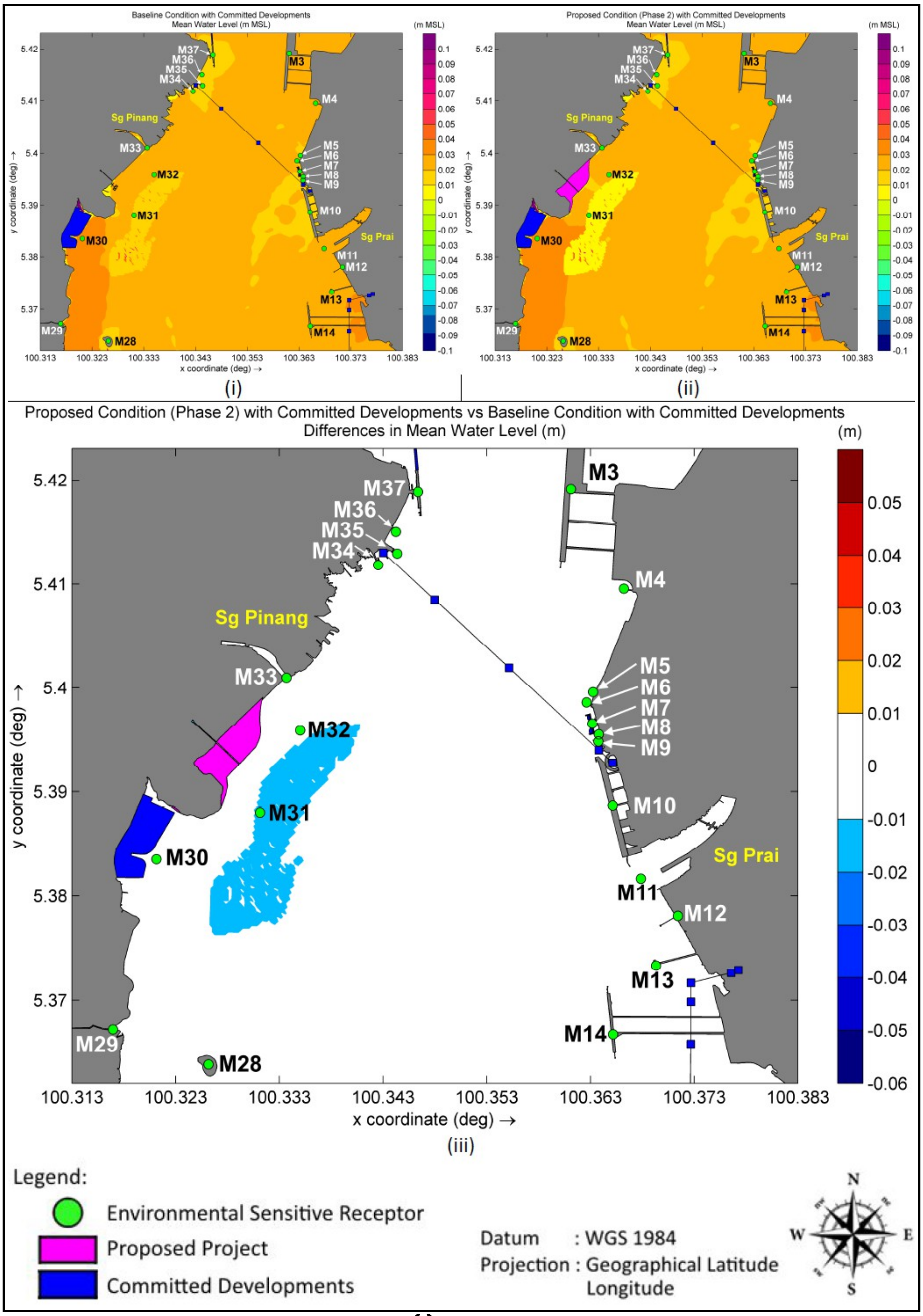


Figure 7.83: Mean Water Level For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Mean Water Level Between (i) And (ii).

- The comparison differences on mean water level shows minimal impacts on mean water level within immediate vicinity of the proposed project area due to the proposed reclamation work for both phases. Changes in the mean water level, if any, is expected to be less than 0.02 m (< 2 cm);
- There are no other visible impacts on the mean water level besides the middle bank area (M31). Any development in the Penang Strait (Proposed Project or Committed Developments) would cause a reduction of of 0.02 m (2 cm) in the mean water level of the middle bank area. This is mainly due to the shallow depth level of the middle bank which affects the mean water level variation due to the exposure of this area during low tide;
- According to **Table 7.42**, changes observed at the identified ESR shows that the changes are minimal, less than 0.01 m (1 cm) at all ESR points; and
- The results indicate that changes in mean water level due to Proposed Project are considered negligible for both reclamation phases.

The following observations were made based on the analysed modelling results and the Maximum Water Level is shown in **Figure 7.84 to Figure 7.89**:-

- Based on **Figure 7.84**, the maximum water level has a variation ranging from 1.29 m MSL to 1.34 m MSL within the Study area;
- The middle of the Strait has higher maximum water level compared to the shoreline along Penang island and Penang mainland;
- This condition is observed to be largely similar for all modelling scenario;
- Based on **Figure 7.84**, differences comparison on maximum water level shows that is a reduction of water level around the boundary of the Proposed Project. The reduced water level due to Proposed Project is observed to be less than 0.02 m (< 2 cm);
- **Figure 7.85** shows that the cumulative impacts include localized changes in maximum water level at the middle of the Strait by the pylons supporting the Penang Skycab cable car. The order of magnitude for both increased and reduced water level is less than 0.02 m (2 cm);
- According to **Table 7.42,** changes observed at the identified ESR point M31 due to Proposed Project are less than 0.01 m (< 1 cm); and
- The results indicate that changes in maximum water level due to Proposed Project are considered negligible.

ESR Points	Description	Water Level (m MSL)												Differences in Water Level (m)											
		Baseline Condition (A)		Proposed Condition (Phase 1) (B)		Proposed Condition (Phase 2) (C)		Baseline Condition & Committed Developments (D)		Proposed Condition (Phase 1) & Committed Developments (E)		Proposed Condition (Phase 2) & Committed Developments (F)		Scenario (B) – (A)		Scenario (C) – (A)		Scenario (E) – (A)		Scenario (F) – (A)		Scenario (E) – (D)		Scenario (F) – (D)	
		Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff
M1	Jetty Bagan Ajam	0.03	1.35	0.03	1.35	0.03	1.35							0.00	0.00	0.00	0.00								
M2	Pantai Bersih	0.03	1.35	0.03	1.35	0.03	1.35							0.00	0.00	0.00	0.00								
M3	North Butterworth Container Terminal (NBCT)	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M4	Butterworth Floating Mosque	0.02	1.32	0.02	1.32	0.02	1.32	0.02	1.32	0.02	1.32	0.02	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M5	Jetty A	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M6	Terminal Pengangkutan Sementara	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M7	Shell Bagan Luar Terminal	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M8	Fisherman Landing	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.32	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01
M9	Pangkalan Sultan Abdul Halim Ferry Terminal	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M10	South Butterworth Container Terminal (SBCT)	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M11	River mouth Sg. Prai	0.03	1.31	0.02	1.31	0.02	1.31	0.03	1.31	0.03	1.31	0.03	1.31	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M12	Shell and Esso Storage	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.31	0.03	1.31	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01
M13	Prai Power Plant	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M14	Pengkalan Cargo PPSB	0.03	1.32	0.03	1.32	0.03	1.32	0.03	1.32	0.03	1.32	0.03	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M15	Mangroves Seberang Prai	0.29	1.31	0.29	1.31	0.29	1.31	0.29	1.31	0.29	1.31	0.29	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M16	Mangroves at 1st Penang Bridge	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M17	River mouth Sg. Juru	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M18	Cockle Farm	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M19	Pulau Jerejak Aquaculture Farm (South)	0.03	1.25	0.03	1.25	0.03	1.25	0.03	1.25	0.03	1.25	0.03	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M20	River mouth Sg. Nibong Kecil	0.03	1.26	0.03	1.26	0.03	1.26	0.03	1.26	0.03	1.26	0.03	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M21	Pulau Jerejak Aquaculture Farm (North)	0.03	1.29	0.03	1.29	0.03	1.29	0.03	1.29	0.03	1.29	0.03	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M22	Rivermouth Sg. Besar	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M23	Jetty B	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M24	Jetty C	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M25	Rivermouth Sg. Gelugor 2	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M26	Seagrass	0.03	1.31	0.03	1.30	0.03	1.30	0.03	1.31	0.03	1.31	0.03	1.31	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M27	Pulau Ros	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M28	Pulau Gazumbo	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M29	Rivermouth Sg. Gelugor 1	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.32	0.03	1.32	0.03	1.31	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01
M30	Aquaculture Jelutong 1	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.32	0.03	1.32	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01
M31	Middle Bank	0.03	1.32	0.03	1.32	0.03	1.31	0.03	1.32	0.03	1.32	0.03	1.32	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M32	Aquaculture Jelutong 2	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M33	Rivermouth Sg. Pinang	0.02	1.33	0.02	1.33	0.03	1.33	0.02	1.33	0.02	1.33	0.03	1.33	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
M34	Chew Jetty	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M35	Pengkalan Raja Tun Uda Ferry Terminal	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M36	Tanjung City Marina	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M37	Swettenham Pier	0.01	1.29	0.01	1.29	0.01	1.29	0.01	1.29	0.01	1.29	0.01	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M38	Eastern and Oriental Seaside	0.03	1.34	0.03	1.34	0.03	1.34	0.03	1.35	0.03	1.35	0.03	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
M39	Gurney Beach	0.03	1.34	0.03	1.34	0.03	1.34	0.03	1.35	0.03	1.35	0.03	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
M40	Tanjung Tokong Development	0.03	1.33	0.03	1.33	0.03	1.33	0.03	1.35	0.03	1.35	0.03	1.35	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00
M41	Straits Quay Marina	0.03	1.35	0.03	1.35	0.03	1.35							0.00	0.00	0.00	0.00								

Table 7.42 Mean And Maximum Water Level (m) At Identified ESRs For Each Scenario And Their Differences

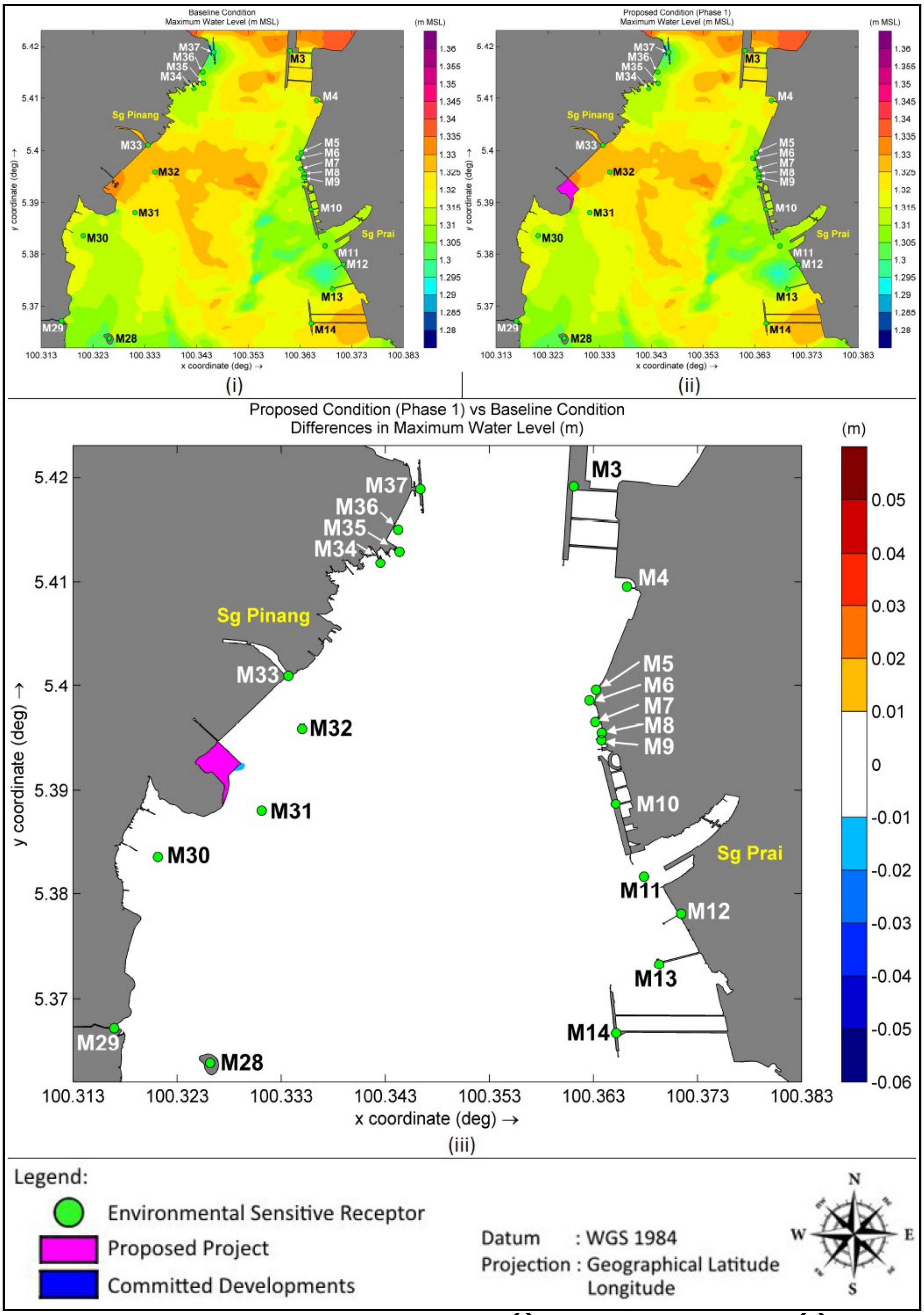


Figure 7.84: Maximum Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Maximum Water Level Between (i) And (ii).

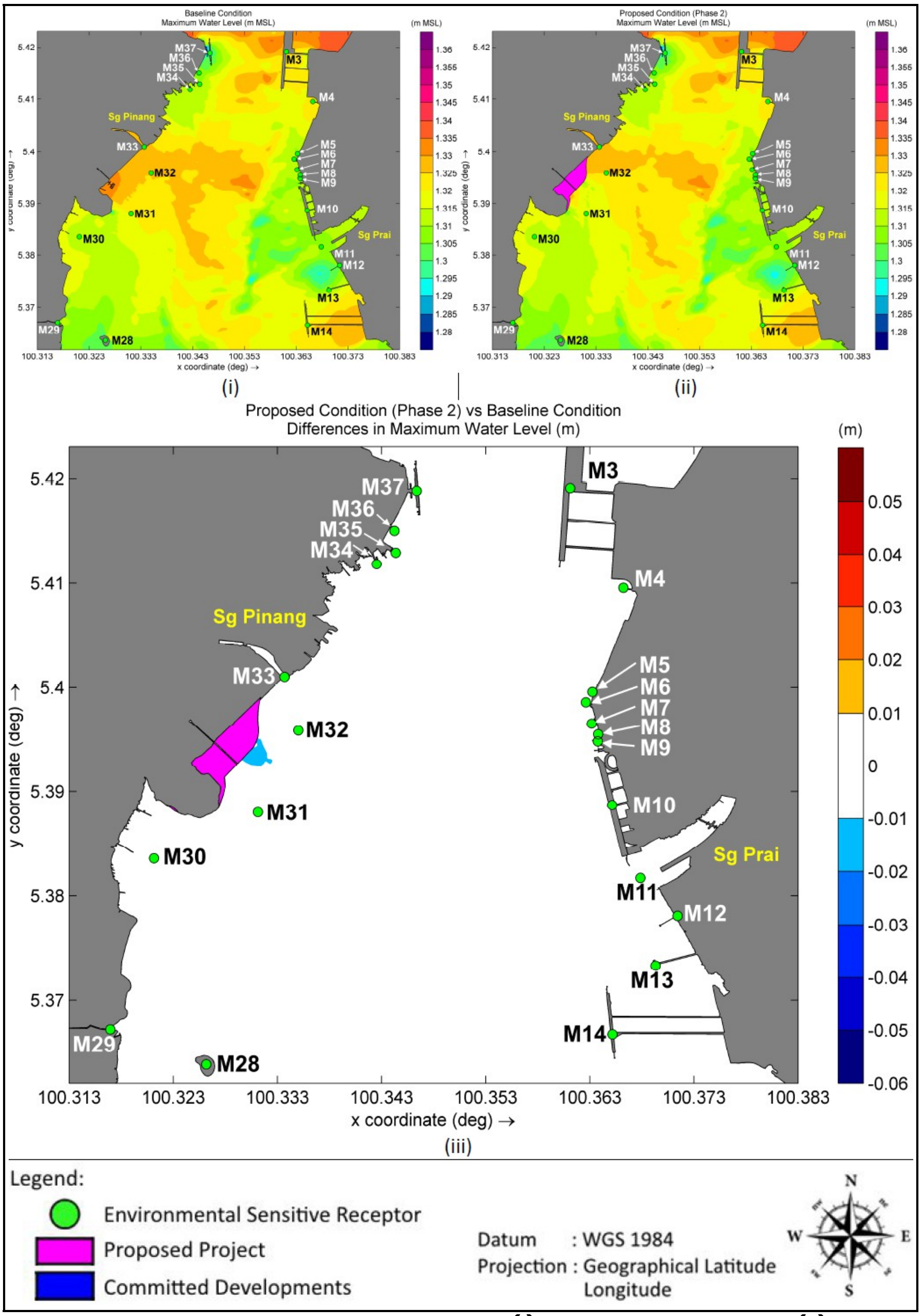


Figure 7.85: Maximum Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And(iii) Differences In Maximum Water Level Between (i) And (ii).

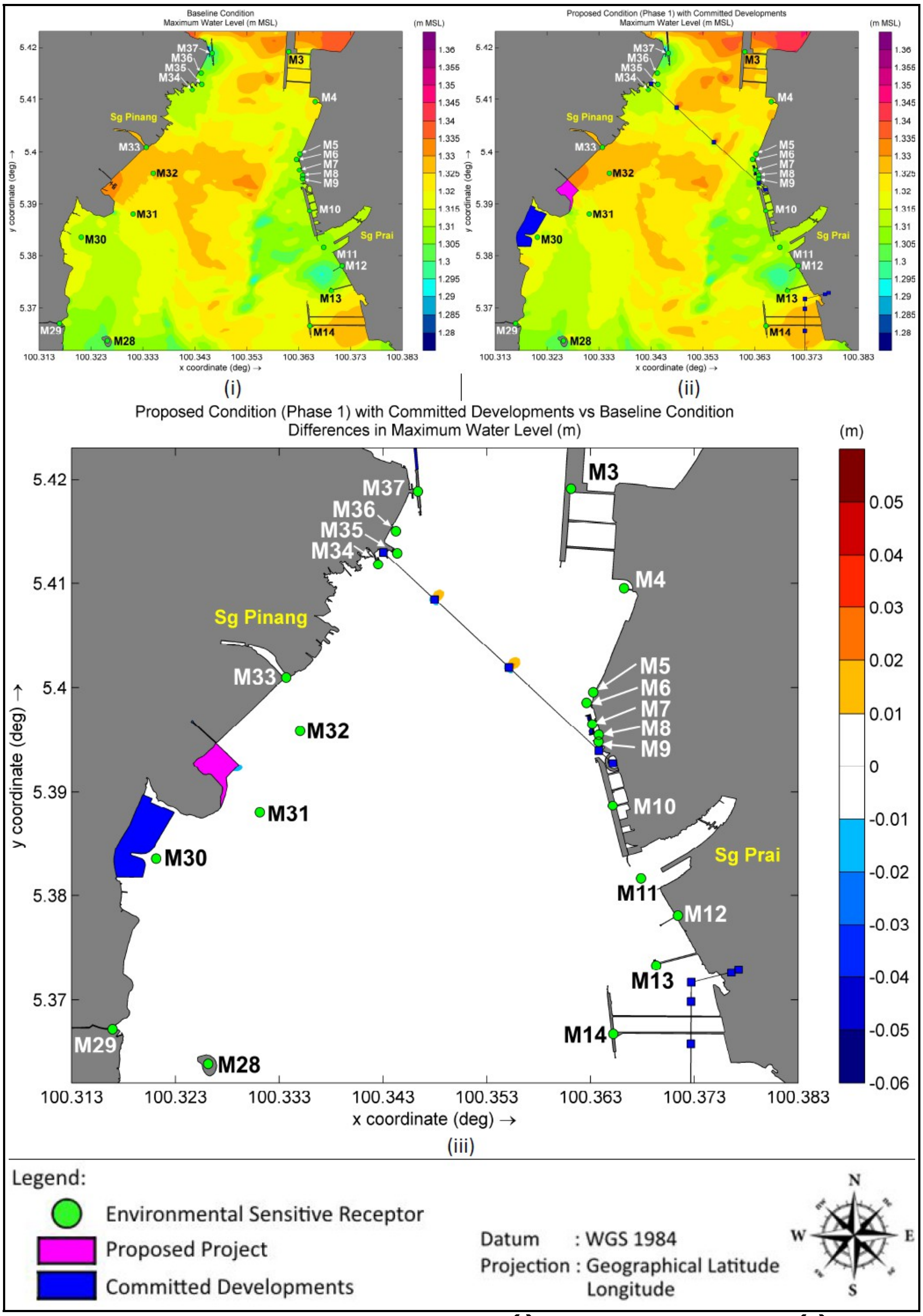


Figure 7.86: Maximum Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; and (iii) Differences In Maximum Water Level Between (i) And (ii).

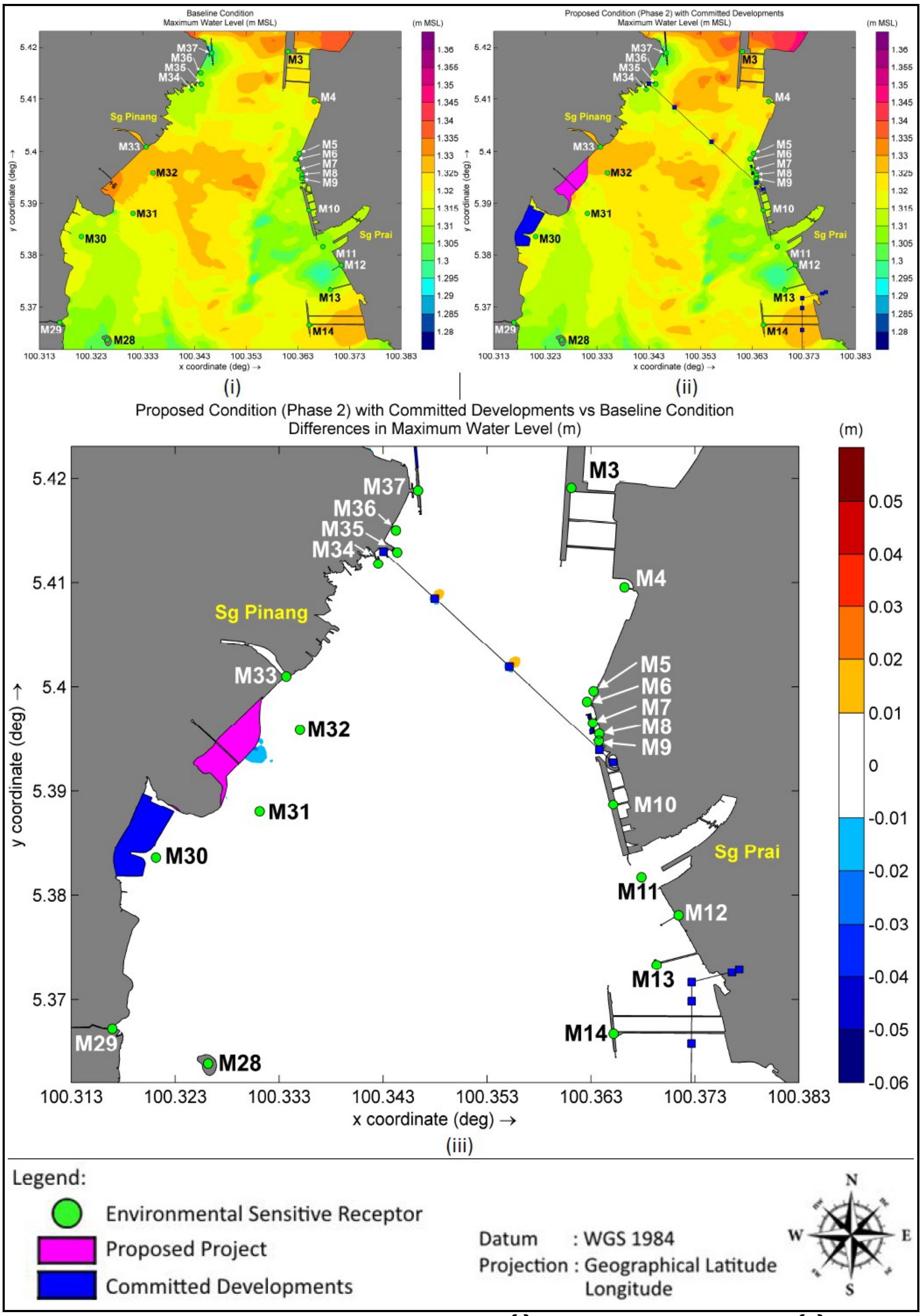


Figure 7.87: Maximum Water Level For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; and (iii) Differences In Maximum Water Level Between (i) And (ii).

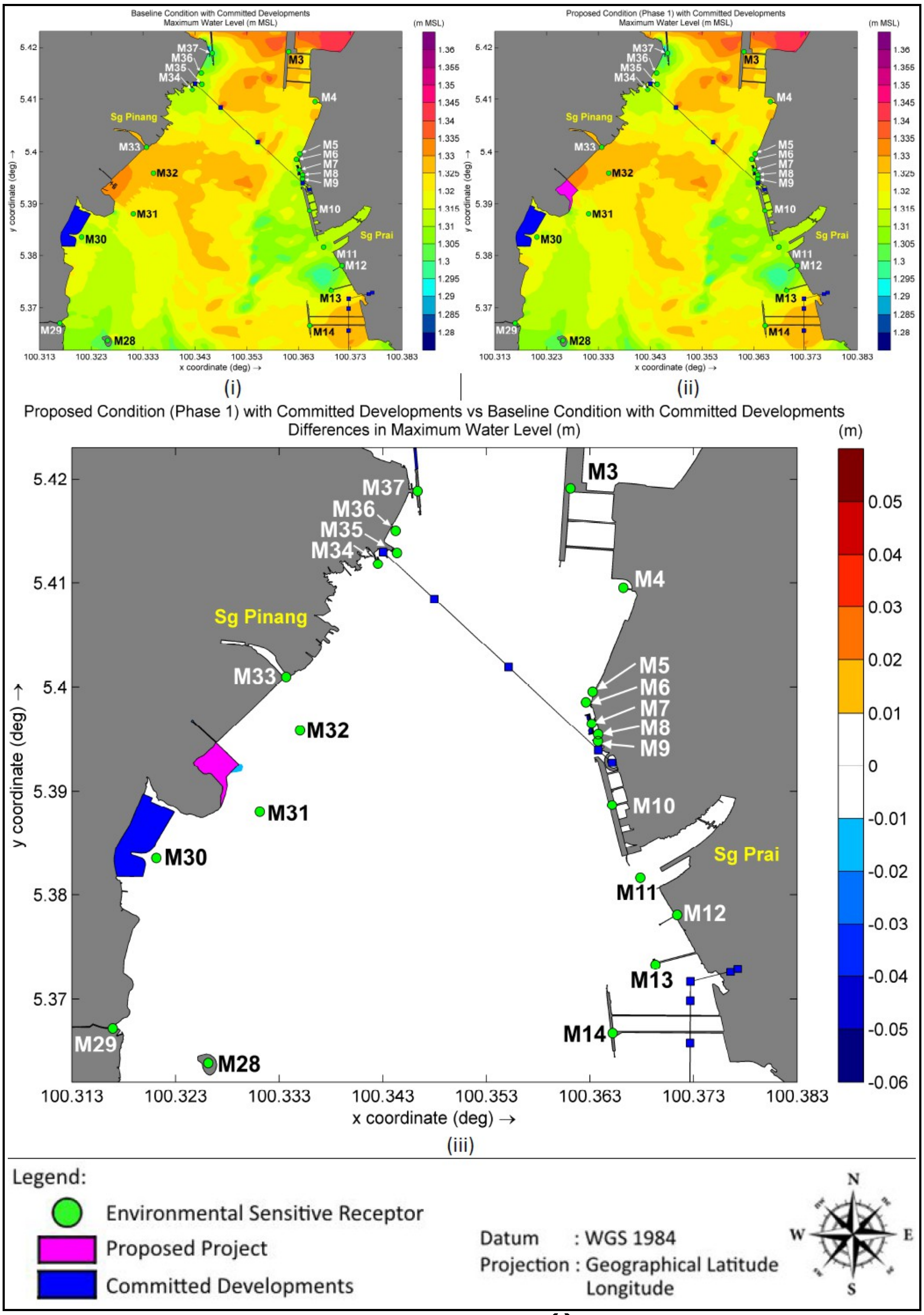


Figure 7.88: Maximum Water Level For (i) Existing With Committed Developments (ii) Proposed Condition (Phase 1) With Committed Developments; and (iii) Differences In Maximum Water Level Between (i) And (ii).

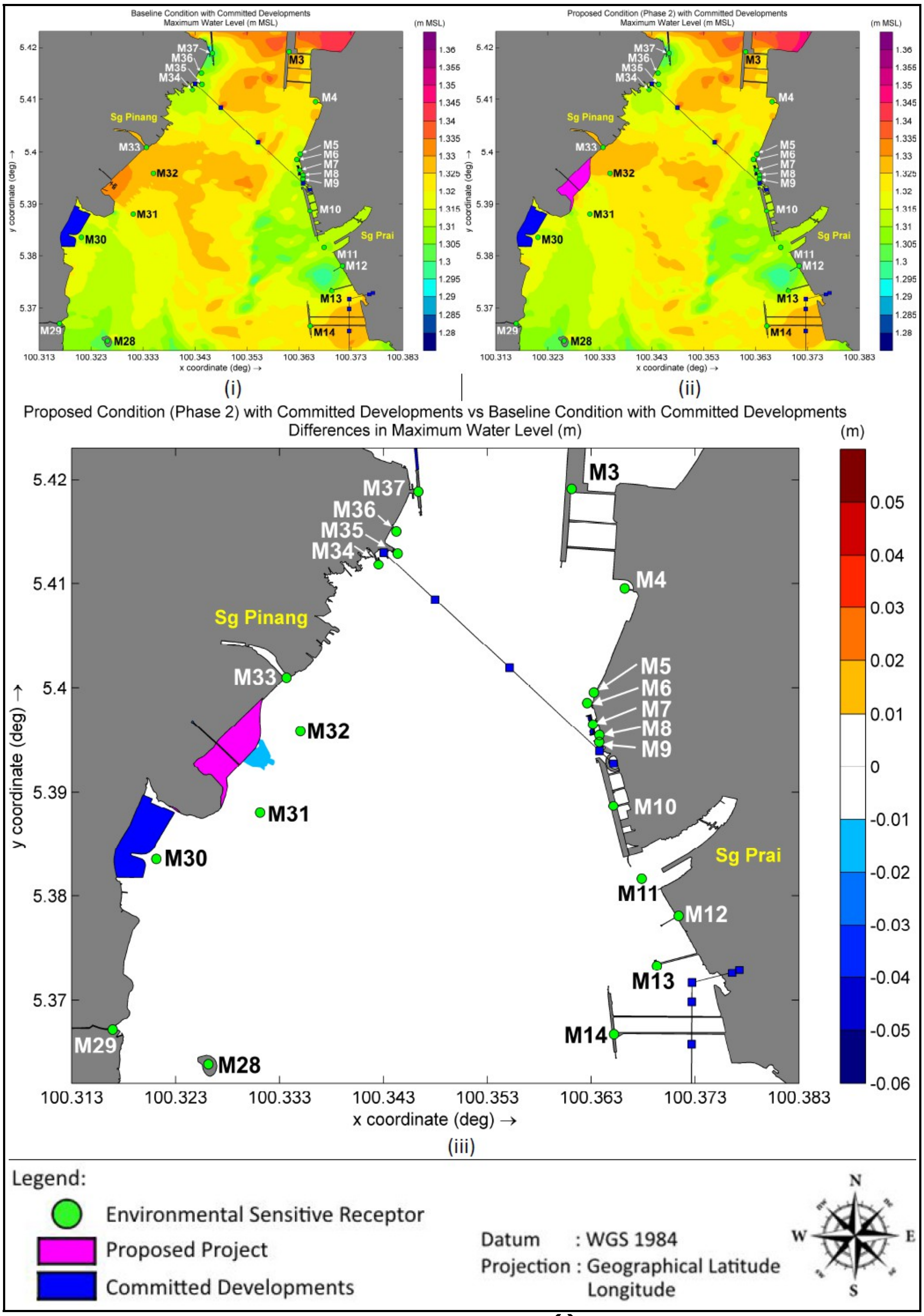


Figure 7.89: Maximum Water Level For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; and (iii) Differences In Maximum Water Level Between (i) And (ii).

ii) Impacts On Current Speed

The following observations were made based on the analysed modelling results and the Mean Current Speed is shown in **Figure 7.90 to Figure 7.95**:-

- The mean current speed is widely varied within the Penang Strait depending on the location as shown in **Figure 7.90**. Along the shoreline, the mean current speed ranges up to 0.3 m/s. In the deeper channel adjacent to Proposed Project area as well as the middle of Penang Strait however, the mean current speed ranges from 0.4 m/s to 0.6 m/s;
- Due to the shallow level of the middle bank area (M31), the current in the area is almost nonexistent;
- The magnitude of current speed is observed to correspond to the water depth and shoreline morphology;
- Differences comparison on mean current speed for Phase 1 reclamation shows minimal reduction of current speed less than 0.2 m/s along the proposed project boundary as shown in **Figure 7.90**;
- Based on **Figure 7.91**, differences comparison on mean current speed shows that there will be a reduction of mean current speed along the shallow nearshore area to the northeast of the Proposed Project, up to Sg Pinang river mouth (M33). The magnitude of mean current speed reduction goes up to 0.3 m/s. However, there is an increase of current flow up to 0.3 m/s in the deep channel adjacent to the Proposed Project. The presence of the newly reclaimed Proposed Project will contribute to higher current speed due to narrowing of the channel;
- From **Figure 7.92**, cumulative impacts due to other approved committed developments show that there are reduction of current speed near the IJM land (near M30) as well as reduced current speed along the pylons for Penang SkyCab in the middle of the Strait. All reductions of mean current speed are less than 0.2 m/s;
- According to **Table 7.43**, changes observed at the identified ESR points due to Proposed Project are minimal, less than 0.01 m/s at most ESR points except for ESR points which are nearer to Proposed Project area (M31 and M32) which experiences reduction of mean current speed up to 0.03 m/s;
- **Table 7.43** also shows that the cumulative changes due to approved committed developments cause higher mean current speed changes at the identified ESRs up to 0.04 m/s for most ESR points, except Jetty C (M34) which experiences changes of 0.12 m/s; and

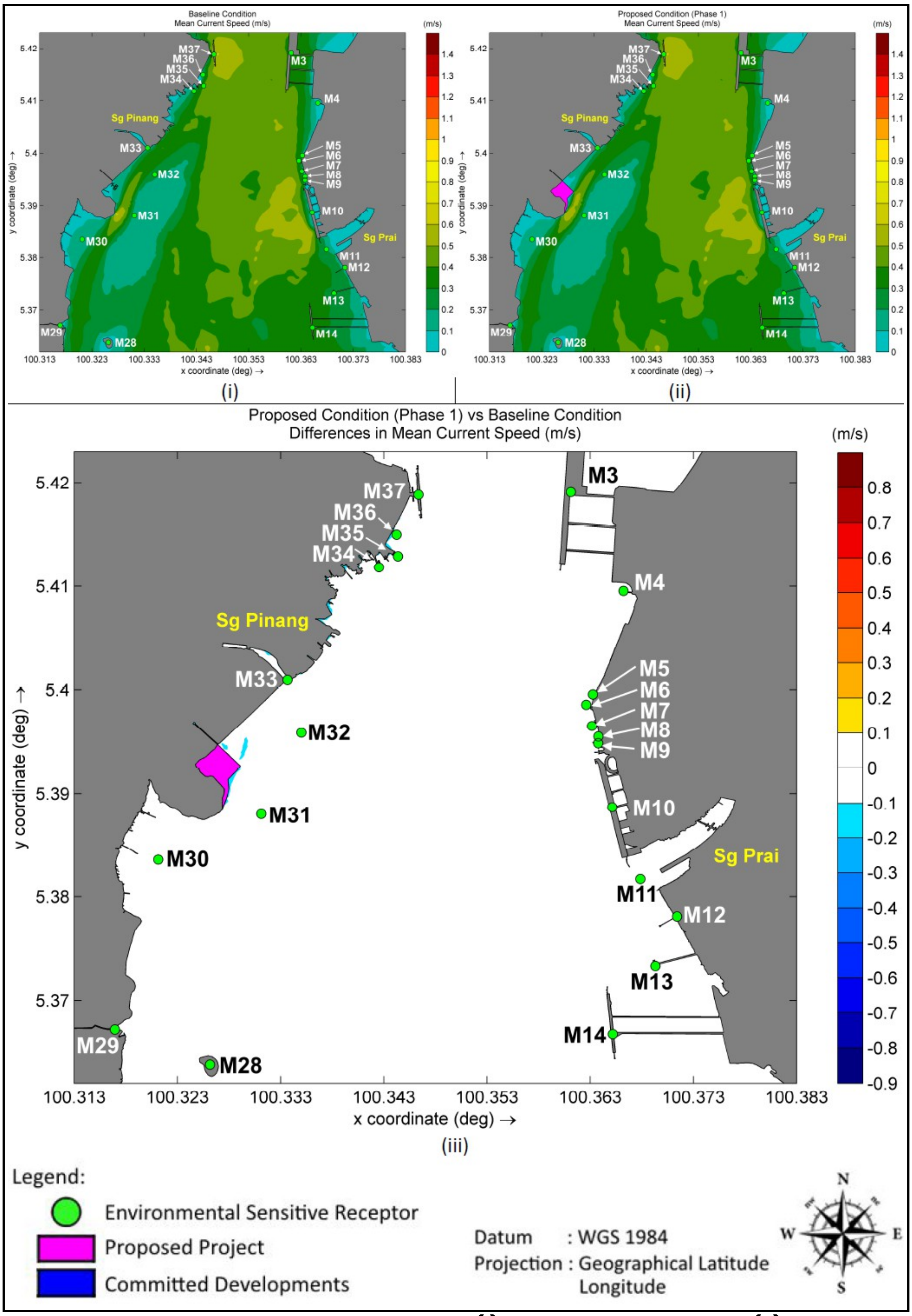


Figure 7.90: Mean Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Mean Current Speed Between (i) And (ii).

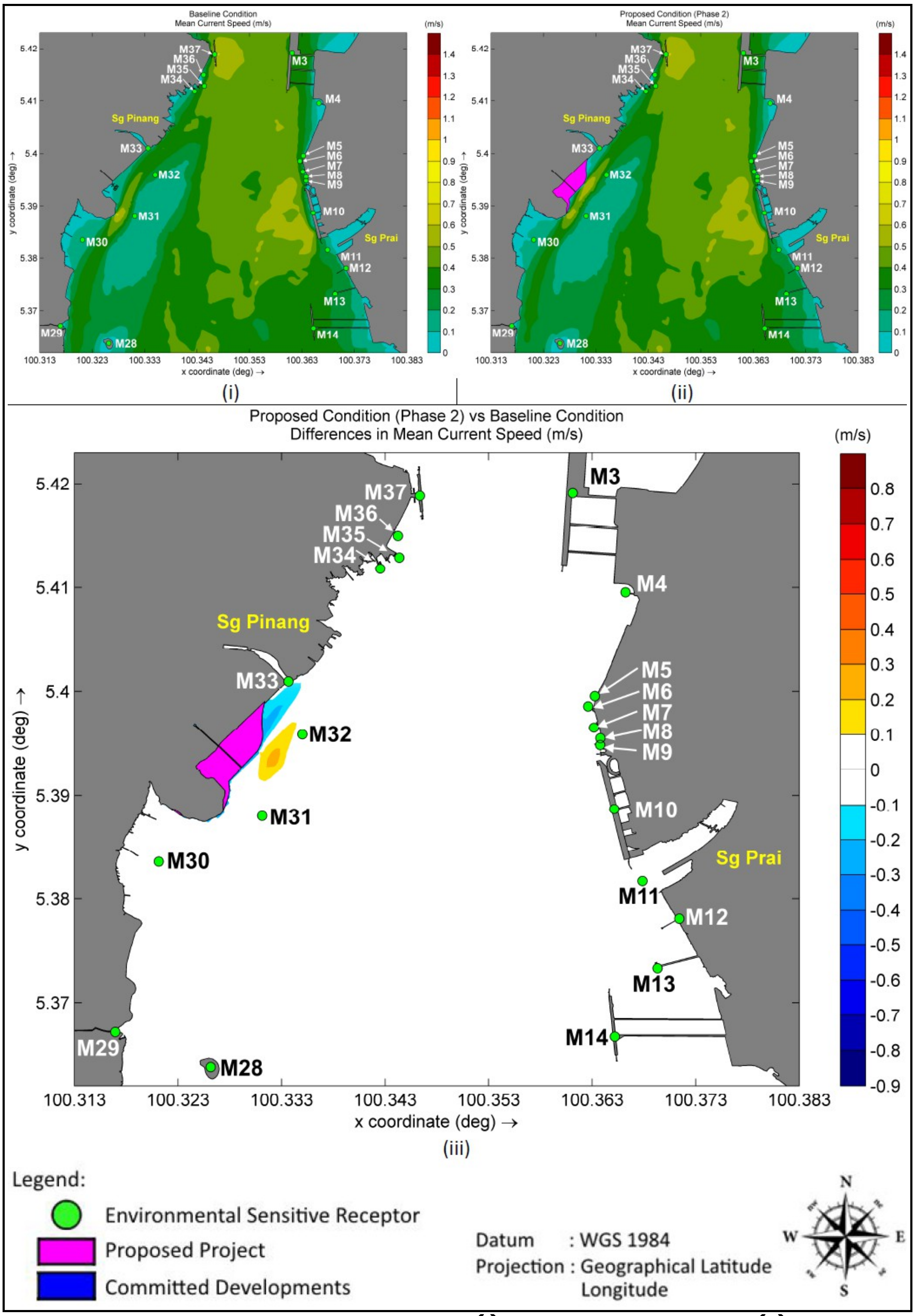


Figure 7.91: Mean Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Mean Current Speed Between (i) And (ii).

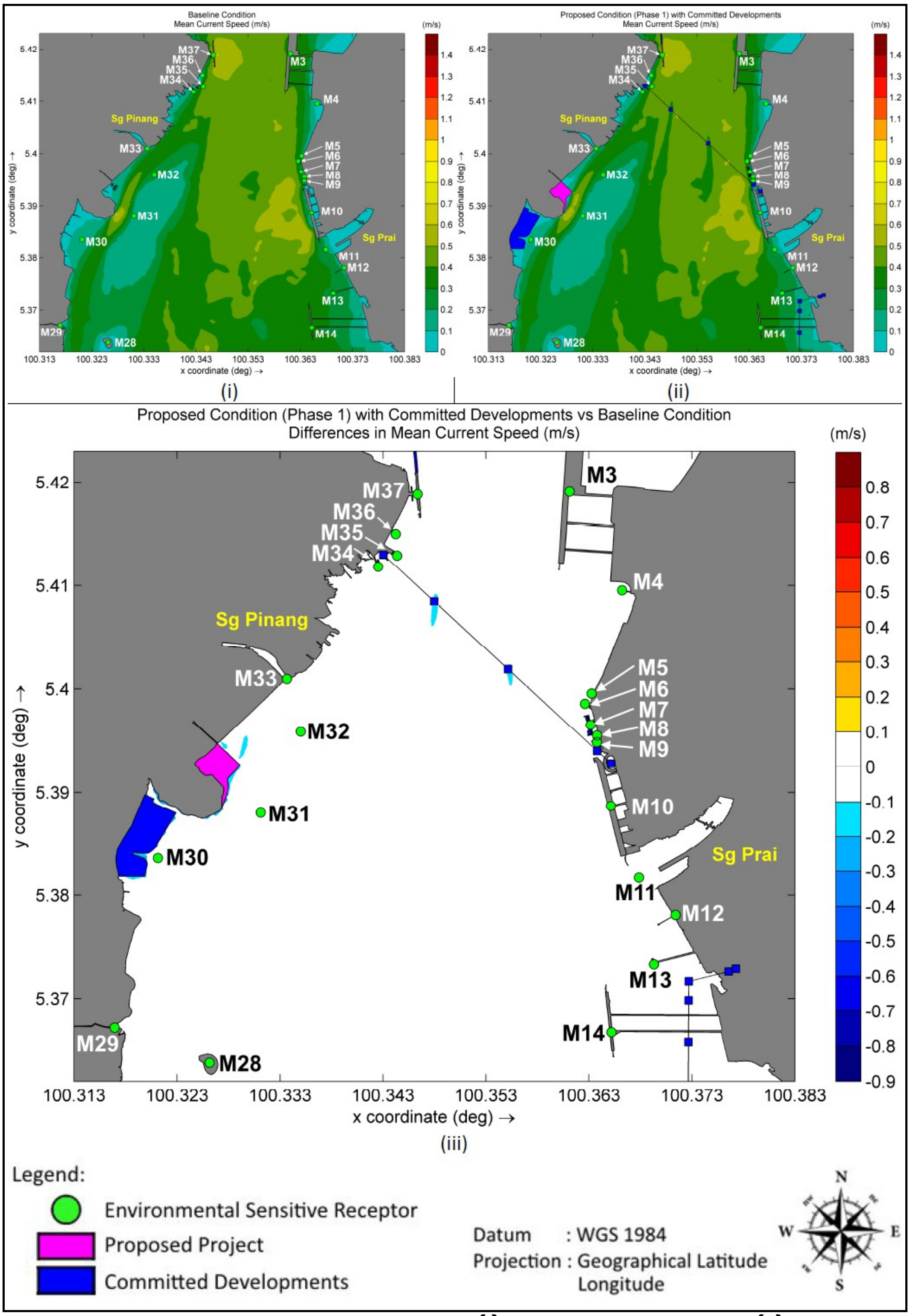


Figure 7.92: Mean Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Mean Current Speed Between (i) And (ii).

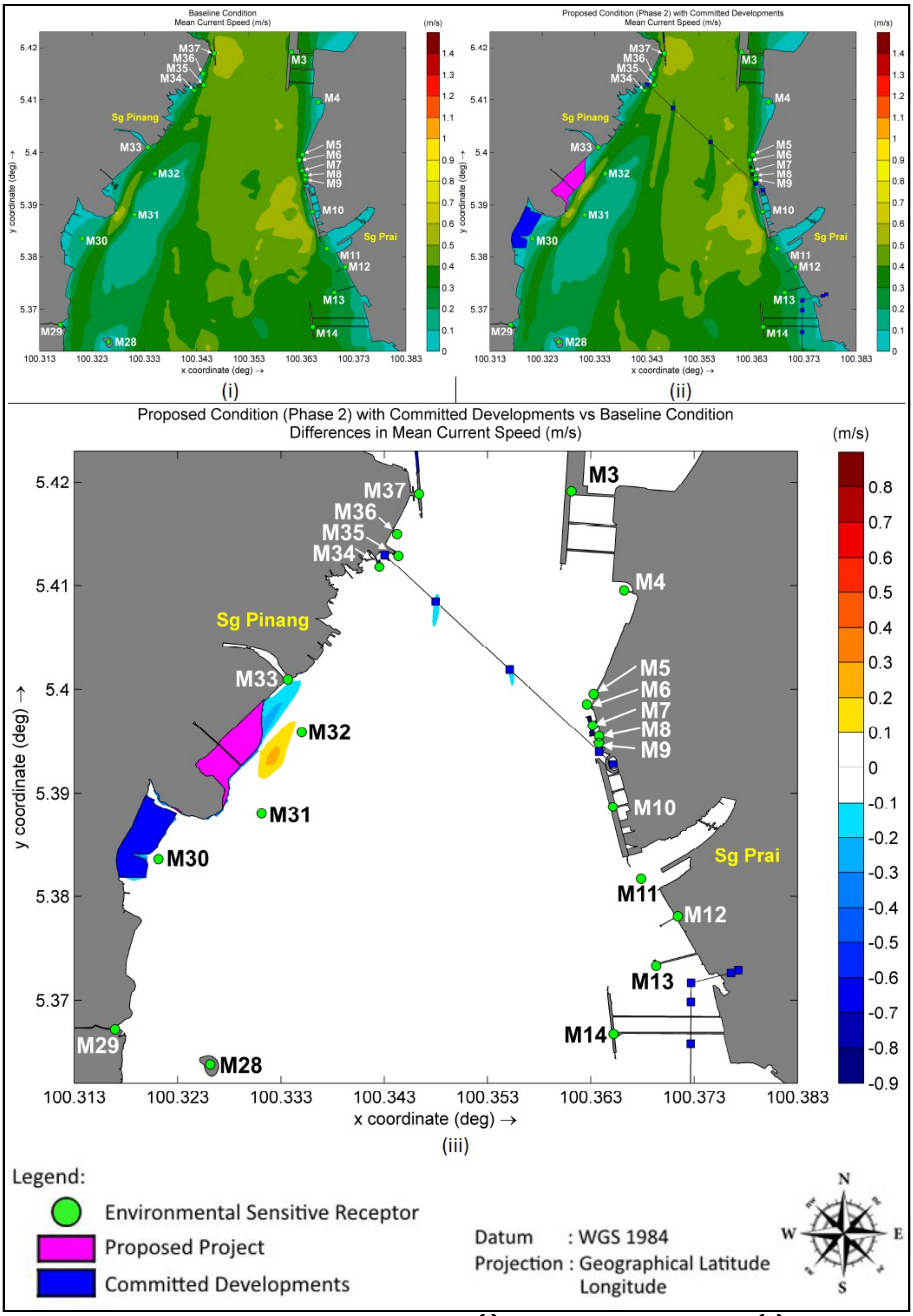


Figure 7.93: Mean Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Mean Current Speed Between (i) And (ii).

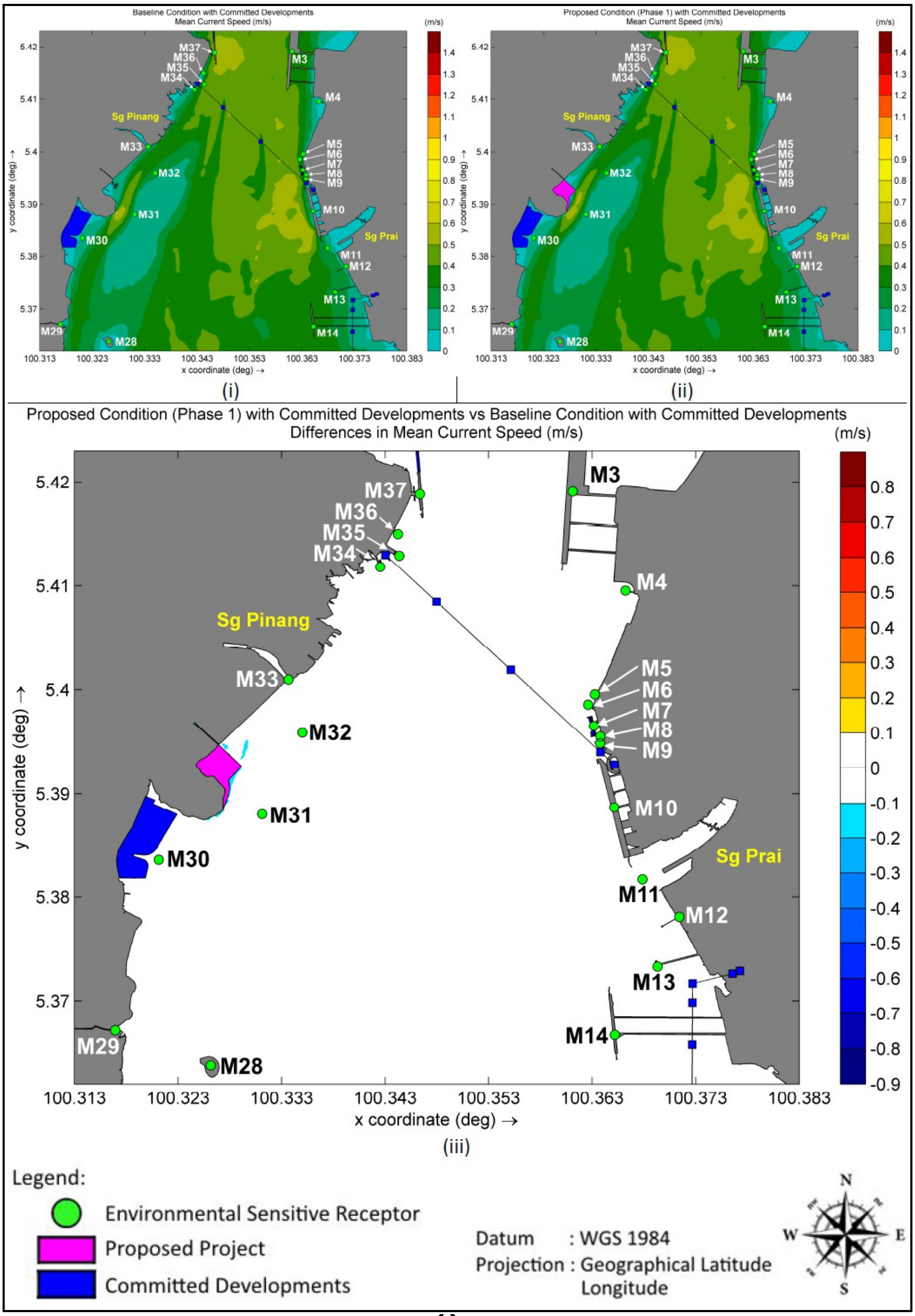


Figure 7.94: Mean Current Speed For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Mean Current Speed Between (i) And (ii).

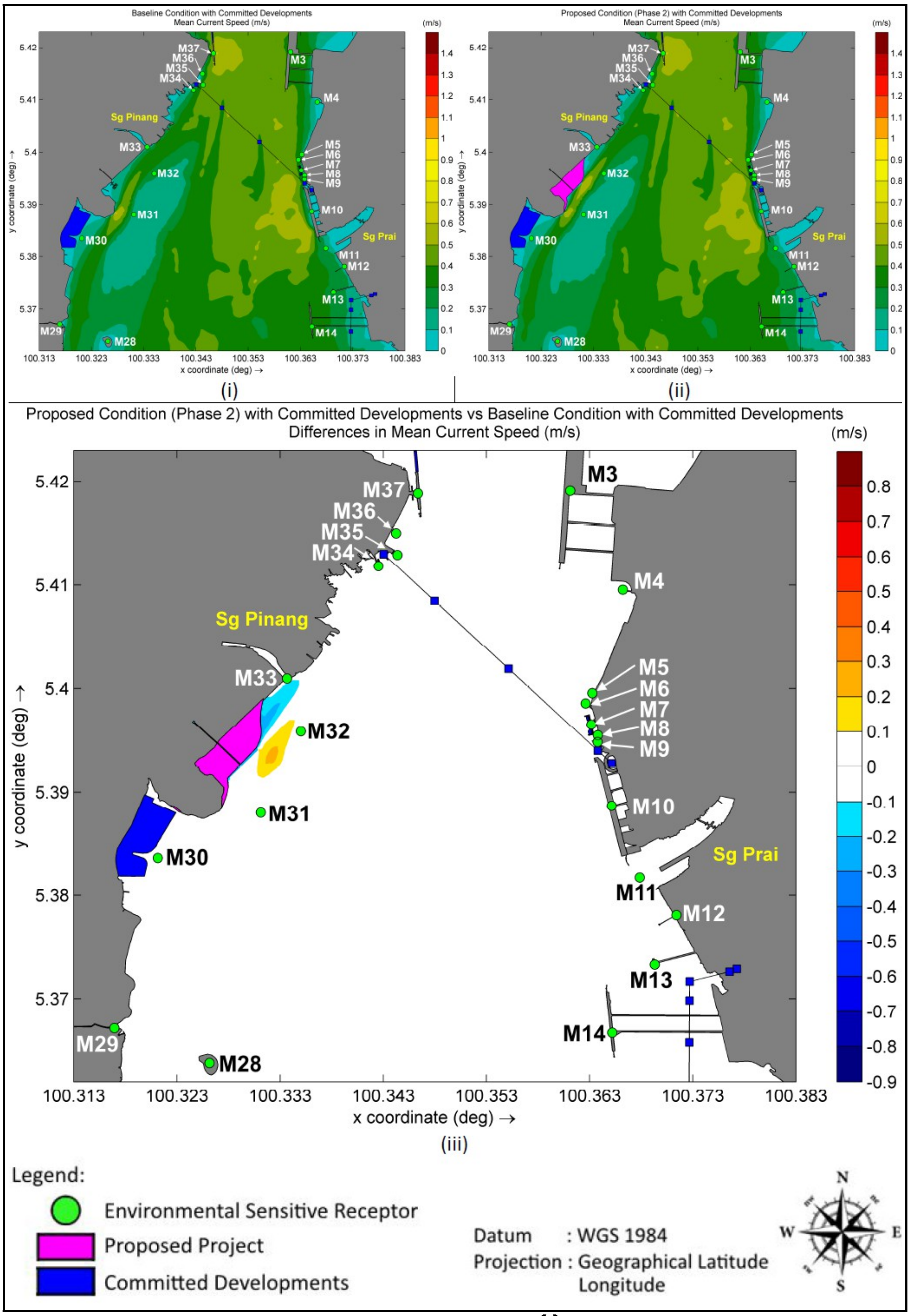


Figure 7.95: Mean Current Speed For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Mean Current Speed Between (i) And (ii).

ESR Points	Description	Water Level (m MSL)												Differences in Water Level (m)											
		Baseline Condition (A)		Proposed Condition (Phase 1) (B)		Proposed Condition (Phase 2) (C)		Baseline Condition & Committed Developments (D)		Proposed Condition (Phase 1) & Committed Developments (E)		Proposed Condition (Phase 2) & Committed Developments (F)		Scenario (B) – (A)		Scenario (C) – (A)		Scenario (E) – (A)		Scenario (F) – (A)		Scenario (E) – (D)		Scenario (F) – (D)	
		Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff
M1	Jetty Bagan Ajam	0.03	1.35	0.03	1.35	0.03	1.35							0.00	0.00	0.00	0.00								
M2	Pantai Bersih	0.03	1.35	0.03	1.35	0.03	1.35							0.00	0.00	0.00	0.00								
M3	North Butterworth Container Terminal (NBCT)	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M4	Butterworth Floating Mosque	0.02	1.32	0.02	1.32	0.02	1.32	0.02	1.32	0.02	1.32	0.02	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M5	Jetty A	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M6	Terminal Pengangkutan Sementara	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M7	Shell Bagan Luar Terminal	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M8	Fisherman Landing	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.32	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01
M9	Pangkalan Sultan Abdul Halim Ferry Terminal	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M10	South Butterworth Container Terminal (SBCT)	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M11	River mouth Sg. Prai	0.03	1.31	0.02	1.31	0.02	1.31	0.03	1.31	0.03	1.31	0.03	1.31	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M12	Shell and Esso Storage	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.31	0.03	1.31	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01
M13	Prai Power Plant	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M14	Pengkalan Cargo PPSB	0.03	1.32	0.03	1.32	0.03	1.32	0.03	1.32	0.03	1.32	0.03	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M15	Mangroves Seberang Prai	0.29	1.31	0.29	1.31	0.29	1.31	0.29	1.31	0.29	1.31	0.29	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M16	Mangroves at 1st Penang Bridge	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M17	River mouth Sg. Juru	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M18	Cockle Farm	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.29	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M19	Pulau Jerejak Aquaculture Farm (South)	0.03	1.25	0.03	1.25	0.03	1.25	0.03	1.25	0.03	1.25	0.03	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M20	River mouth Sg. Nibong Kecil	0.03	1.26	0.03	1.26	0.03	1.26	0.03	1.26	0.03	1.26	0.03	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M21	Pulau Jerejak Aquaculture Farm (North)	0.03	1.29	0.03	1.29	0.03	1.29	0.03	1.29	0.03	1.29	0.03	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M22	Rivermouth Sg. Besar	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M23	Jetty B	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.03	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M24	Jetty C	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M25	Rivermouth Sg. Gelugor 2	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M26	Seagrass	0.03	1.31	0.03	1.30	0.03	1.30	0.03	1.31	0.03	1.31	0.03	1.31	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M27	Pulau Ros	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M28	Pulau Gazumbo	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.03	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M29	Rivermouth Sg. Gelugor 1	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.32	0.03	1.32	0.03	1.31	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.01
M30	Aquaculture Jelutong 1	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.31	0.03	1.32	0.03	1.32	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01
M31	Middle Bank	0.03	1.32	0.03	1.32	0.03	1.31	0.03	1.32	0.03	1.32	0.03	1.32	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M32	Aquaculture Jelutong 2	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.02	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M33	Rivermouth Sg. Pinang	0.02	1.33	0.02	1.33	0.03	1.33	0.02	1.33	0.02	1.33	0.03	1.33	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
M34	Chew Jetty	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M35	Pengkalan Raja Tun Uda Ferry Terminal	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M36	Tanjung City Marina	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.02	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M37	Swettenham Pier	0.01	1.29	0.01	1.29	0.01	1.29	0.01	1.29	0.01	1.29	0.01	1.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M38	Eastern and Oriental Seaside	0.03	1.34	0.03	1.34	0.03	1.34	0.03	1.35	0.03	1.35	0.03	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
M39	Gurney Beach	0.03	1.34	0.03	1.34	0.03	1.34	0.03	1.35	0.03	1.35	0.03	1.35	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
M40	Tanjung Tokong Development	0.03	1.33	0.03	1.33	0.03	1.33	0.03	1.35	0.03	1.35	0.03	1.35	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00
M41	Straits Quay Marina	0.03	1.35	0.03	1.35	0.03	1.35							0.00	0.00	0.00	0.00								

Table 7.43 Mean And Maximum Water Level (m) At Identified ESRs For Each Scenario And Their Differences

- The results indicate that changes in mean current speed due to Proposed Project are considered localized.

The following observations were made based on the analysed modelling results and the Maximum Current Speed is shown in **Figure 7.96 to Figure 7.101**:-

- Based on **Figure 7.96**, the maximum current speed is widely varied within the Penang Strait depending on the location. Along the shoreline, the maximum current speed ranges up to 0.6 m/s. In the deeper channel adjacent to Proposed Project area as well as the middle of Penang Strait however, the maximum current speed ranges from 0.6 m/s to 1.3 m/s;
- Due to the shallow level of the middle bank area (M31), the current in the area is about 0.1 m/s to 0.4 m/s;
- According to **Figure 7.96**, differences comparison on maximum current speed for Phase 1 reclamation shows that there will be a reduction of maximum current speed up to 0.4 m/s magnitude along the shoreline adjacent to the Proposed Project, up to Sg Pinang river mouth (M33). However, there is an increase of current flow about 0.2 m/s in the deep channel adjacent to the Proposed Project. The presence of the newly reclaimed Proposed Project will contribute to higher current speed due to narrower channel. There is also a trail of reduced current speed along the channel of 0.3 m/s to the southern side of the channel;
- A similar pattern is observed for Phase 2 reclamation though at a higher magnitude as shown in **Figure 7.97,** with the current speed along the nearshore area northeast of the Proposed Project site decreasing by 0.6 m/s near the river mouth of Sg Pinang (M33). Similarly, the magnitude of current speed increment in the channel also goes up to 0.6 m/s. There is also a trail of reduced current speed along the channel of 0.3 m/s to the southern side of the channel;
- From **Figure 7.98**, cumulative impacts due to other approved committed developments causes changes in current speed near the IJM land (near M30), increasing and reducing by 0.2 m/s. Both reduction and increased current speed are observed around the pylons for Penang SkyCab in the middle of the Strait and pylons for TNB Overhead Lines near M13 and M14, with reduced maximum current speed up to 0.3 m/s and increased current of 0.2 m/s;
- Changes observed at the identified ESR are listed in earlier **Table 7.43**, which observes that the changes in maximum current speed due to Proposed Project are less than 0.05 m/s at all ESR points;
- Earlier **Table 7.43** also shows that the cumulative changes due to approved committed developments cause higher maximum current speed changes at the identified ESRs up to 0.08 m/s for most ESR points, except Jetty C (M34) which experiences changes of 0.21 m/s;

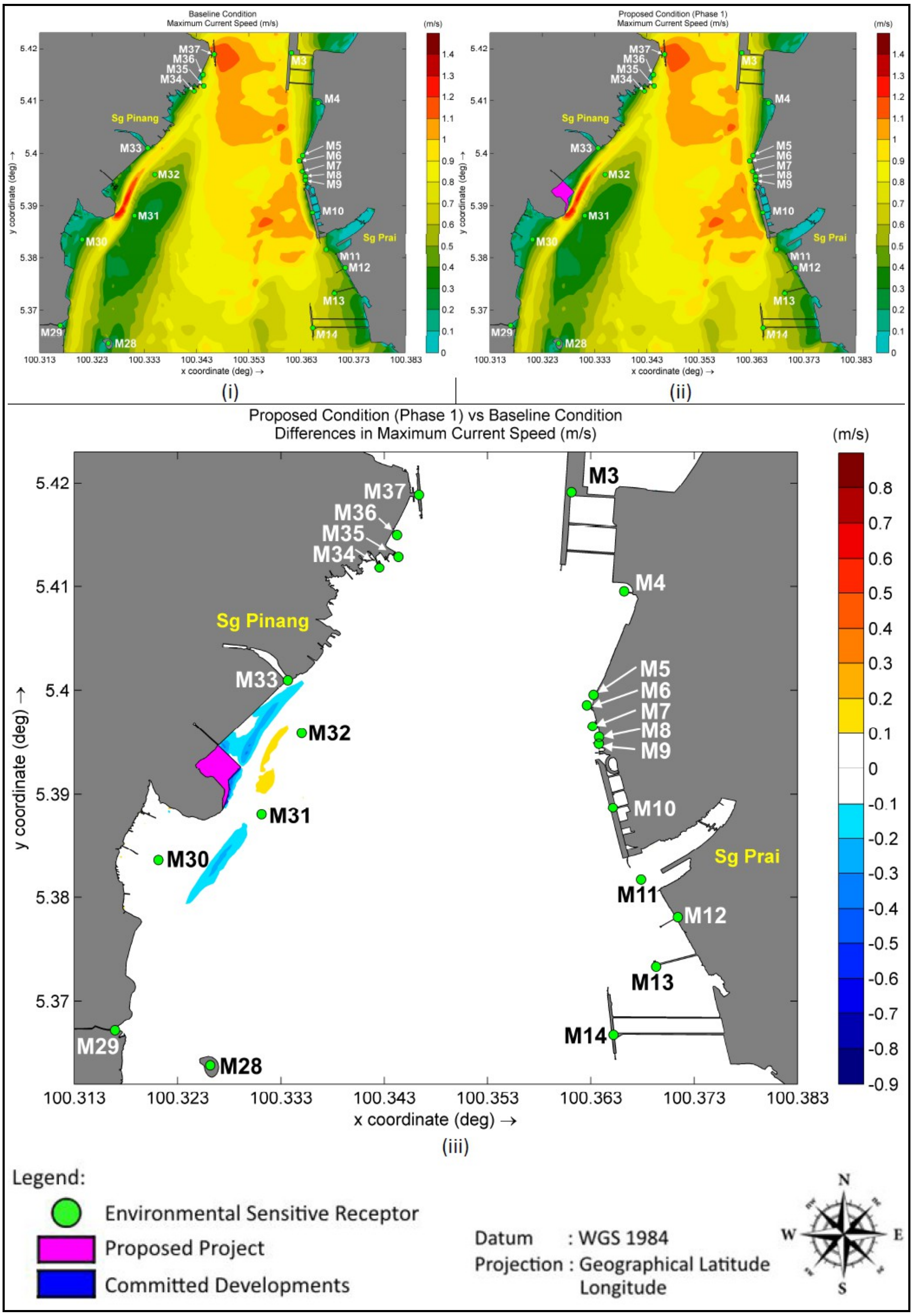


Figure 7.96: Maximum Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Maximum Current Speed Between (i) And (ii).

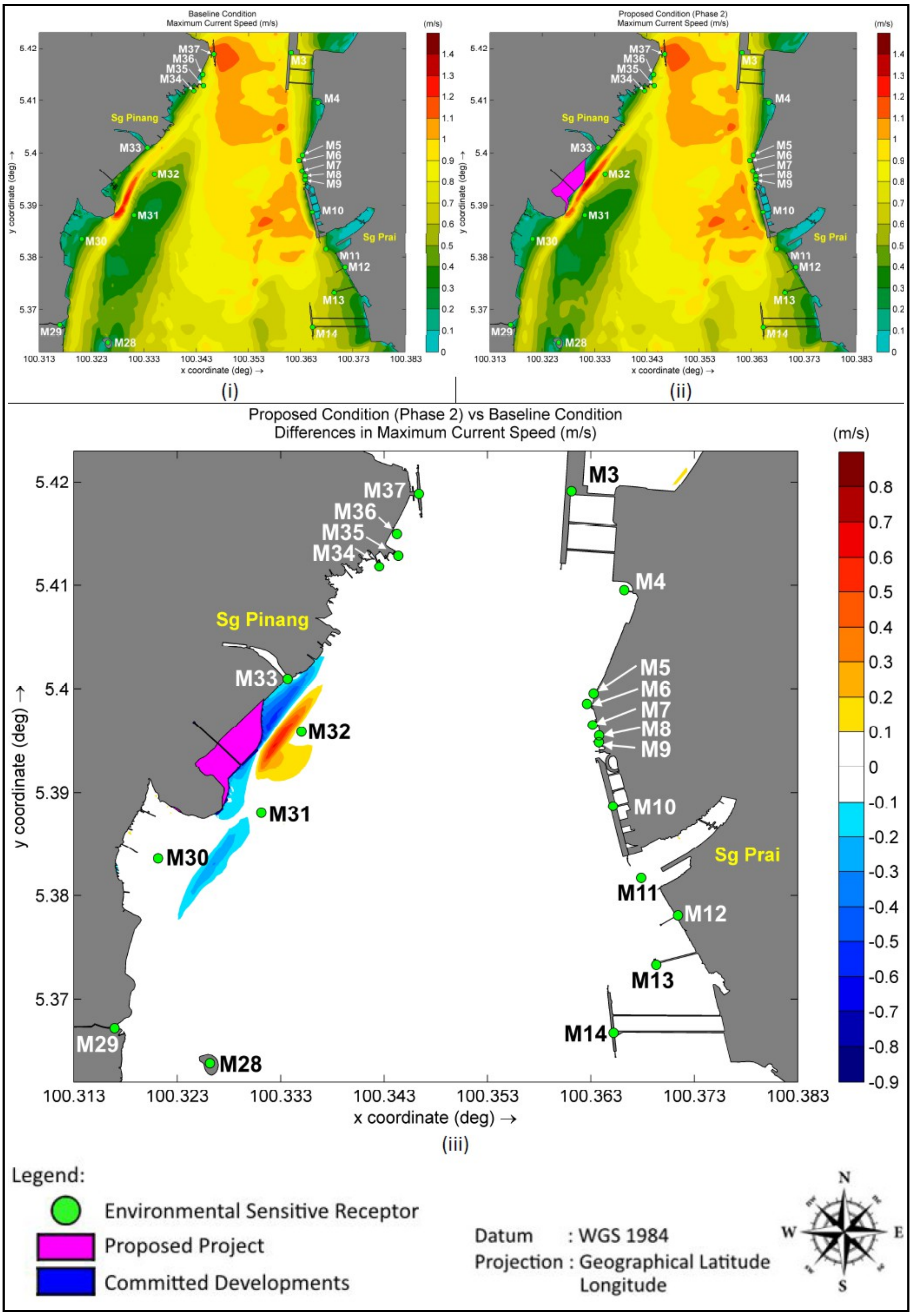


Figure 7.97: Maximum Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Maximum Current Speed Between (i) And (ii).

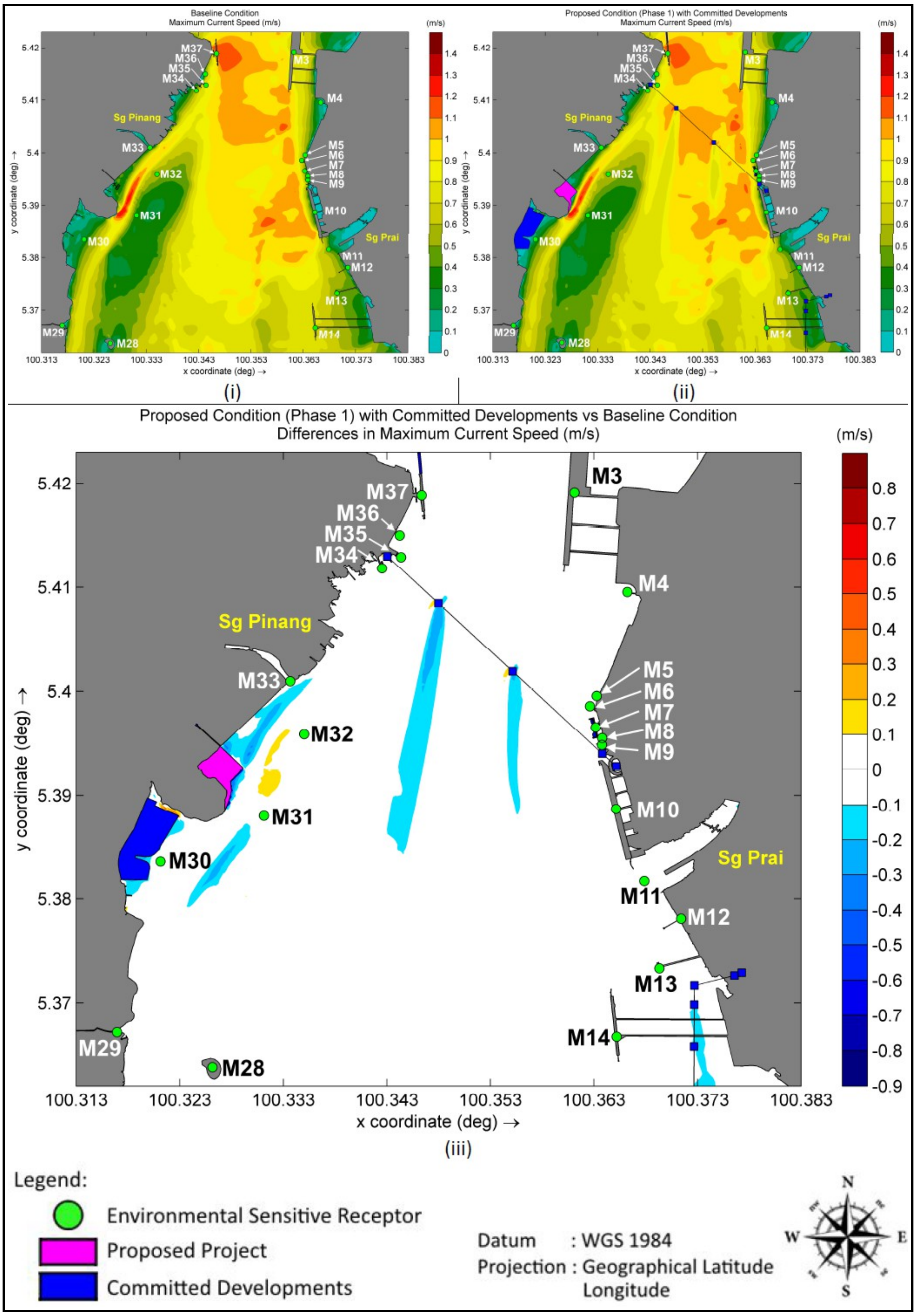


Figure 7.98: Maximum Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Maximum Current Speed Between (i) And (ii).

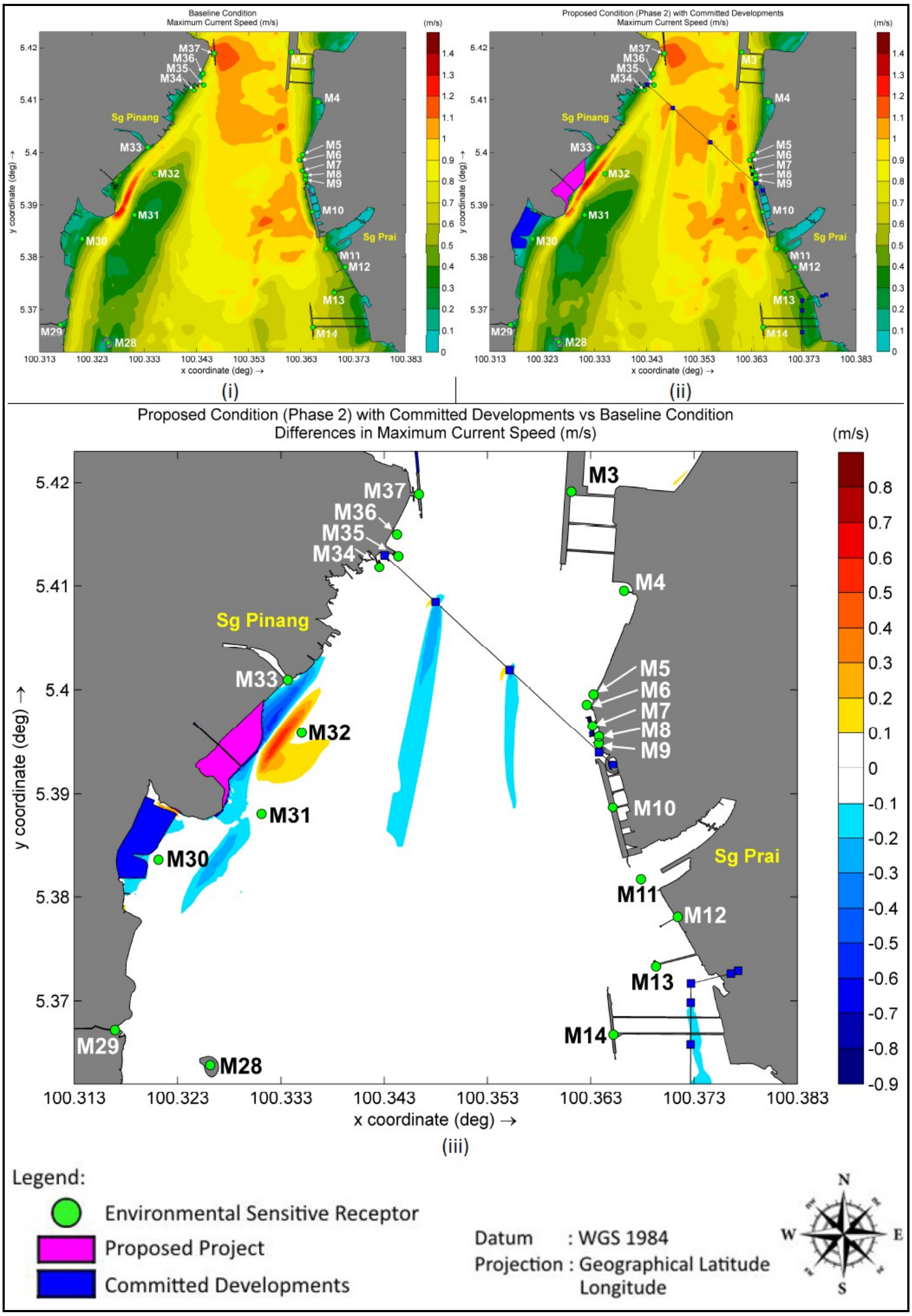


Figure 7.99: Maximum Current Speed For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Maximum Current Speed Between (i) And (ii).

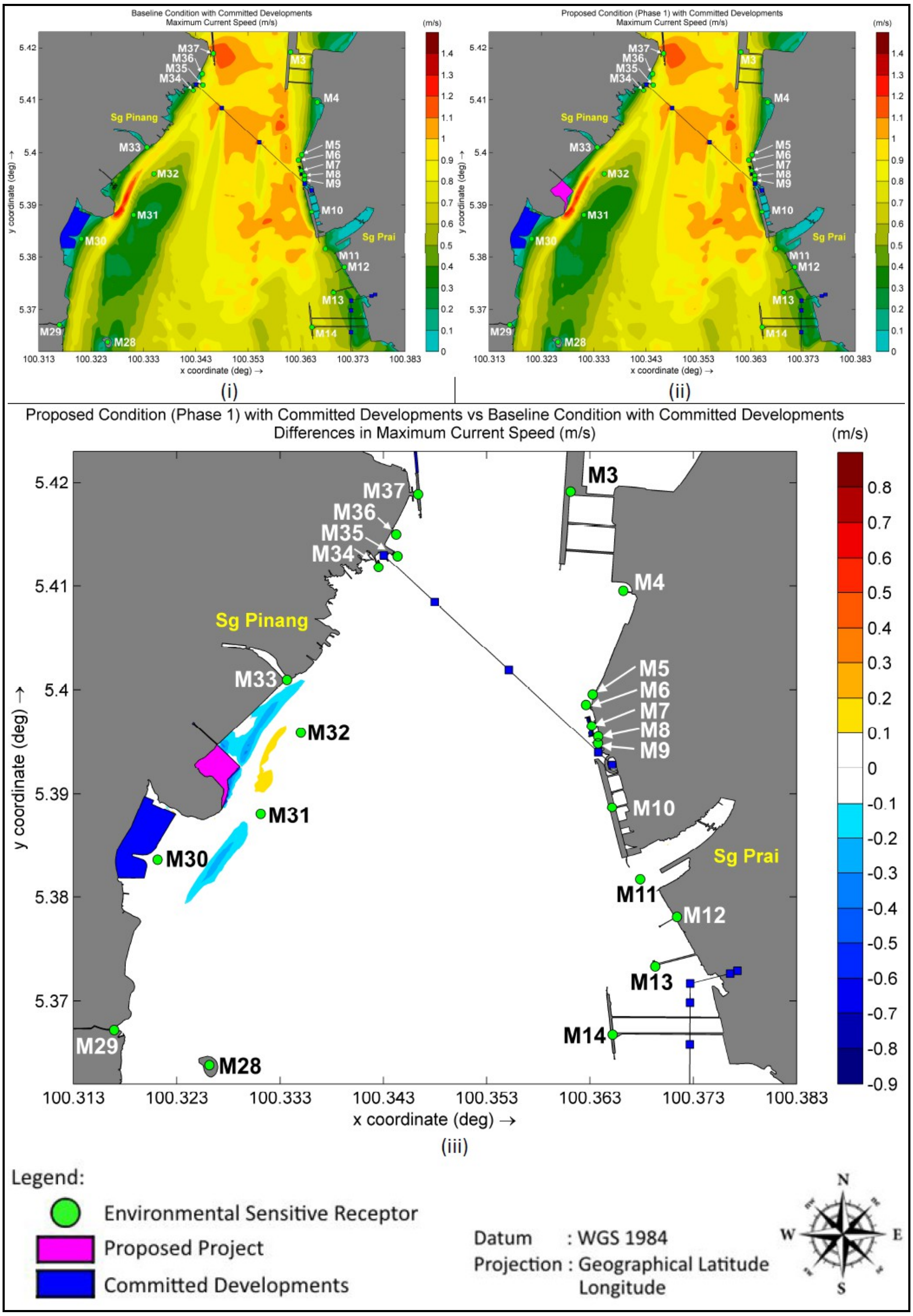


Figure 7.100: Maximum Current Speed For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Maximum Current Speed Between (i) And (ii).

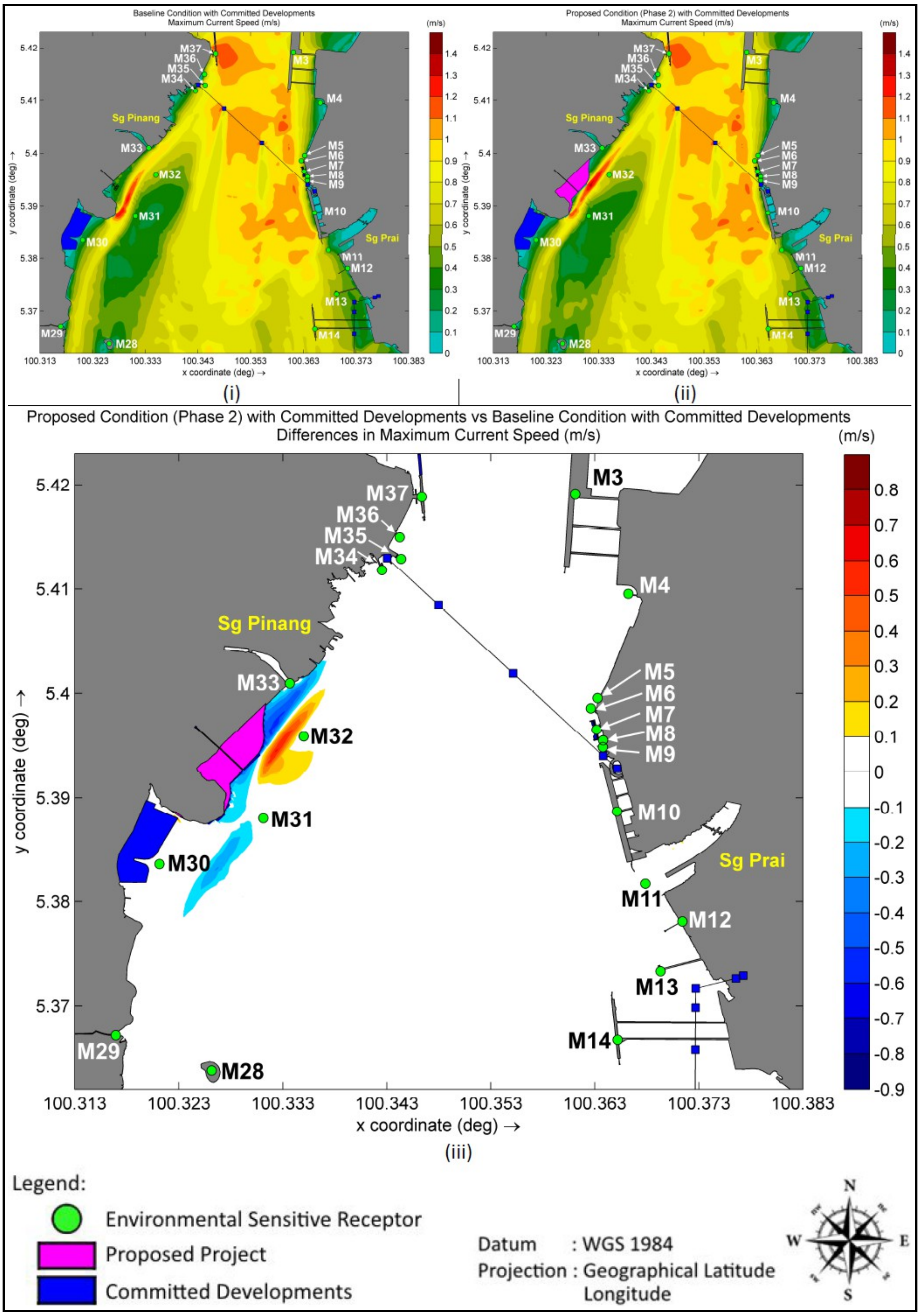


Figure 7.101: Maximum Current Speed For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Maximum Current Speed Between (i) And (ii).

- The results indicate that changes in maximum current speed due to Proposed Project occurs along the deep channel adjacent to Proposed Project area and the nearshore area northeast of the Proposed Project site.

iii) Impacts On Significant Wave Height

The following observations were made based on the analysed modelling results and wind speed 5 m/s from 225° direction as shown in **Figure 7.102** to **Figure 7.107** for Condition 1:-

- Based on **Figure 7.102**, due to the wind coming from 225°, the mean direction for wind-induced wave development within the Penang Strait is towards north to north-easterly direction;
- In the Penang Strait, the significant wave height is higher on the eastern side due to the wind. The magnitude of significant wave height within the Strait is up to 0.3 m;
- On the western side of the Strait, the significant wave height is mostly less than 0.2 m due to the sheltering effect of the Penang Island;
- Due to the shallow bed level of the middle bank area (M31), the significant wave height in the area is lower (< 0.15 m) than the surrounding wave height (around 0.15 m to 0.2 m);
- The significant wave height is observed to be similar for all modelling scenarios without significant changes;
- Based on **Figure 7.102 and Figure 7.103**, the Proposed Project will cause a reduction of significant wave height to the north of the Proposed Project. The magnitude of reduction is less than 0.08 m (< 8 cm). The reduction of wave height occurred due to the presence of Proposed Project which blocks the wave coming from the southern direction;
- The cumulative impacts are shown in **Figure 7.104.** It is observed that there is a slight reduction in significant wave height around the IJM land (near M30), with magnitude of reduction less than 0.06 m (< 6 cm). Other approved committed development however does not cause any significant impacts on the wave heights within the Strait. It is assumed that any potential changes in significant wave height are less than 0.02 m (<2 cm);
- According to **Table 7.44**, changes observed at the identified ESR points due to Proposed Project are minimal, less than 0.01 m (<1 cm) at all ESR points;
- **Table 7.44** also shows that the cumulative changes due to approved committed developments cause similar magnitude of changes less than 0.01 m (<1 cm) at most ESR points, except Jetty C (M24) which experiences reduction of 0.05 m (< 5 cm); and
- The results indicate that changes in significant wave height due to Proposed Project in this wind condition are considered localized.

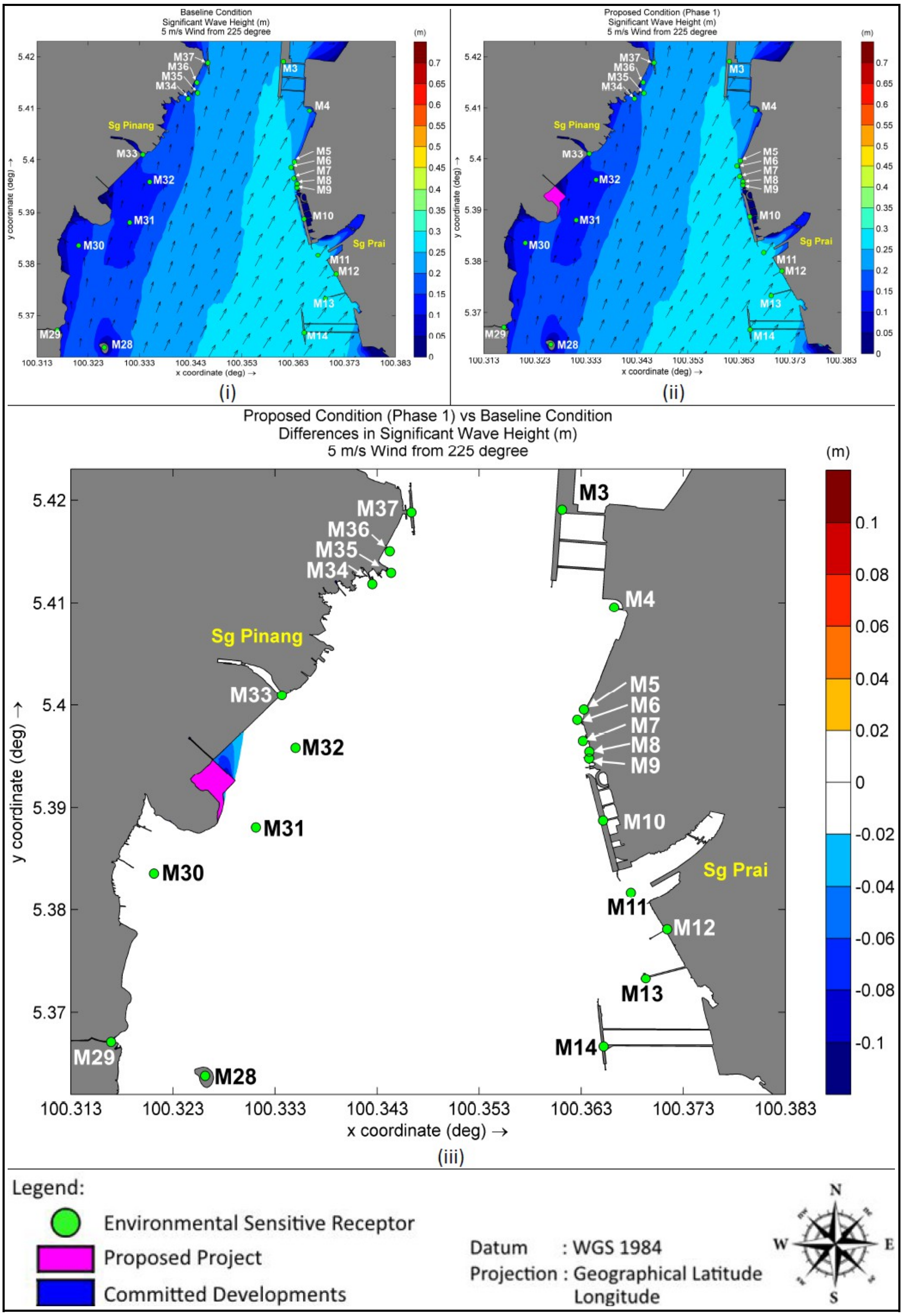


Figure 7.102: Significant Wave Height For Wind Of 5 m/s Speed From 225 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Significant Wave Height Between (i) And (ii).

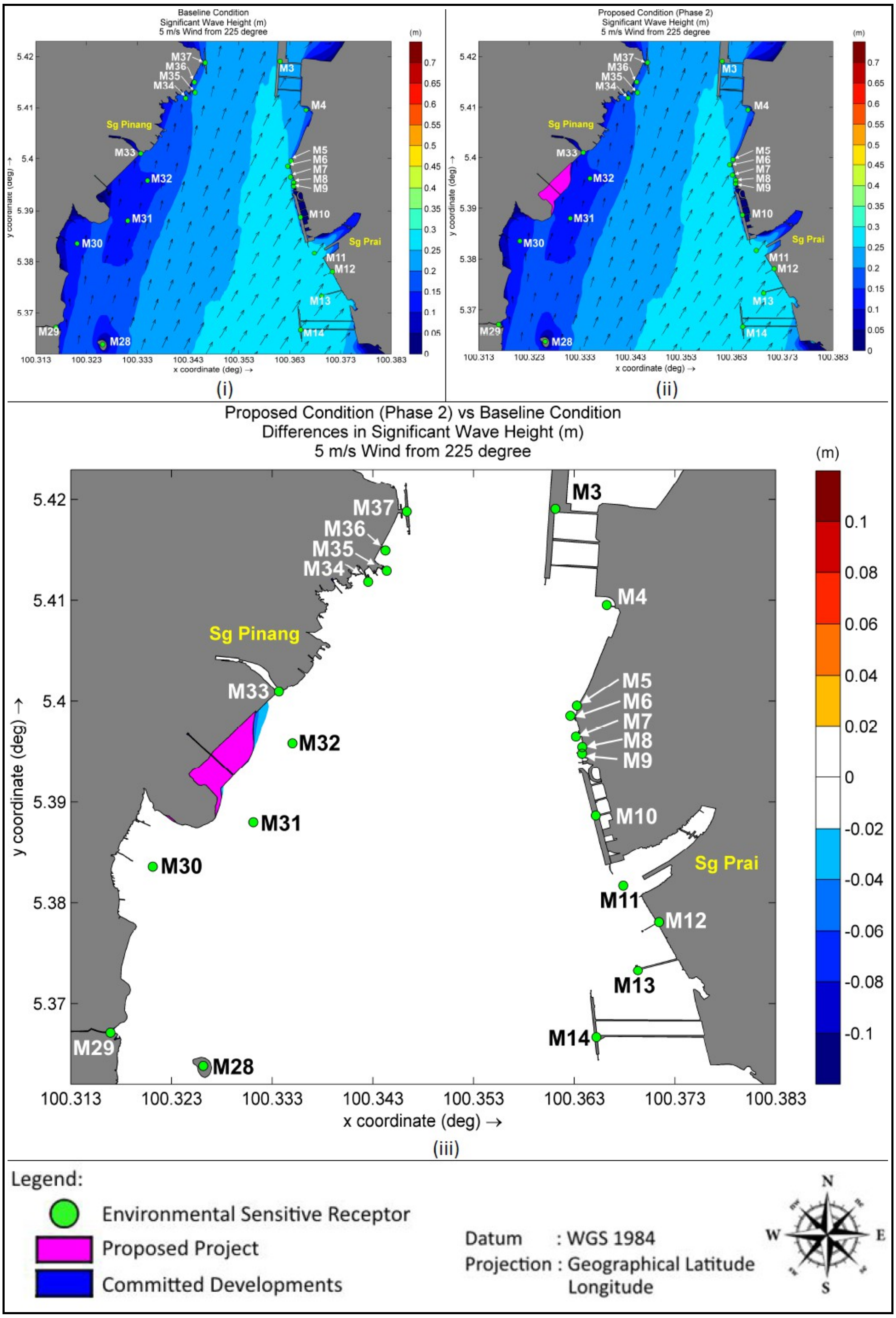


Figure 7.103: Significant Wave Height For Wind Of 5 m/s Speed From 225 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Significant Wave Height Between (i) And (ii).

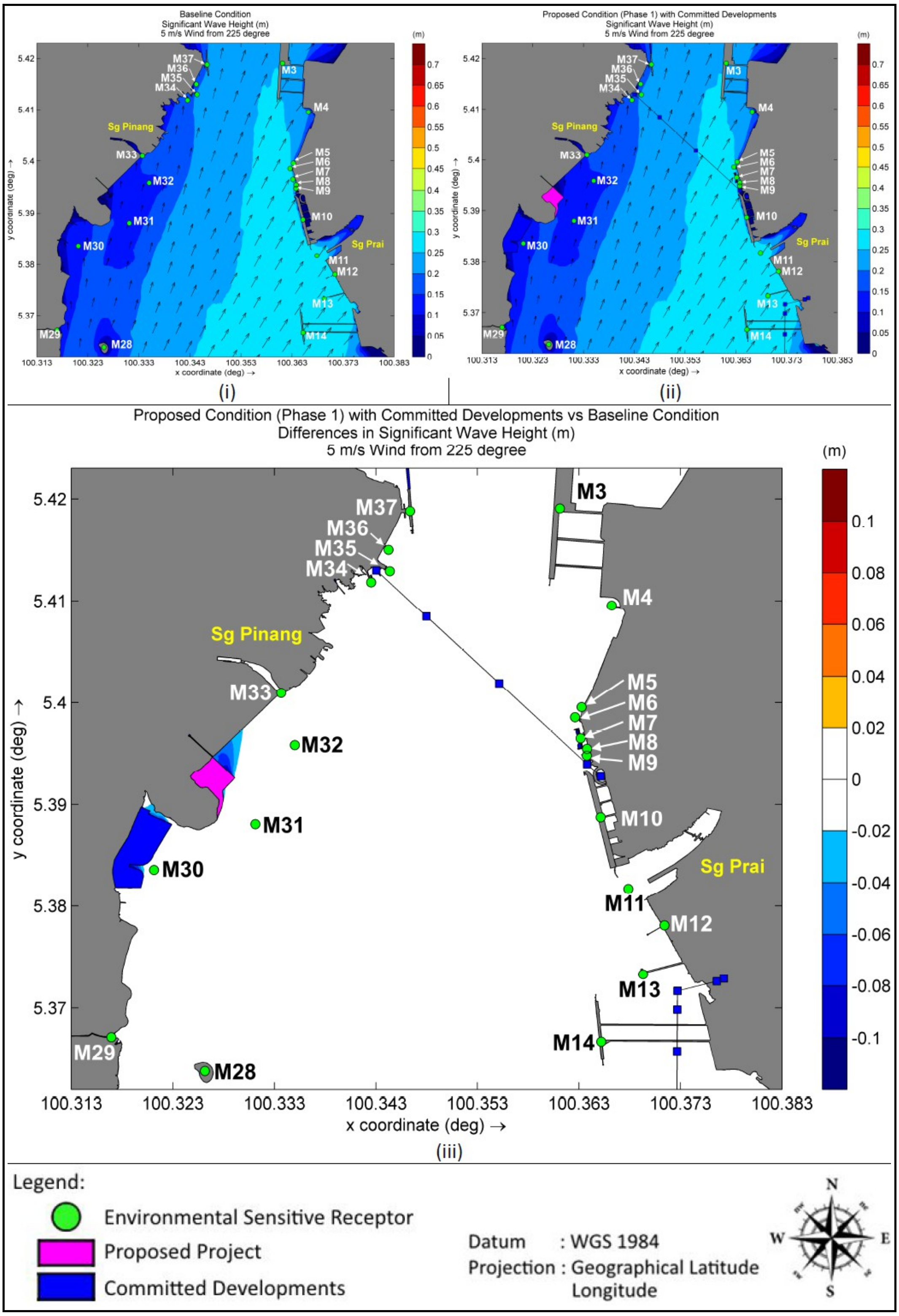


Figure 7.104: Significant Wave Height For Wind Of 5 m/s Speed From 225 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

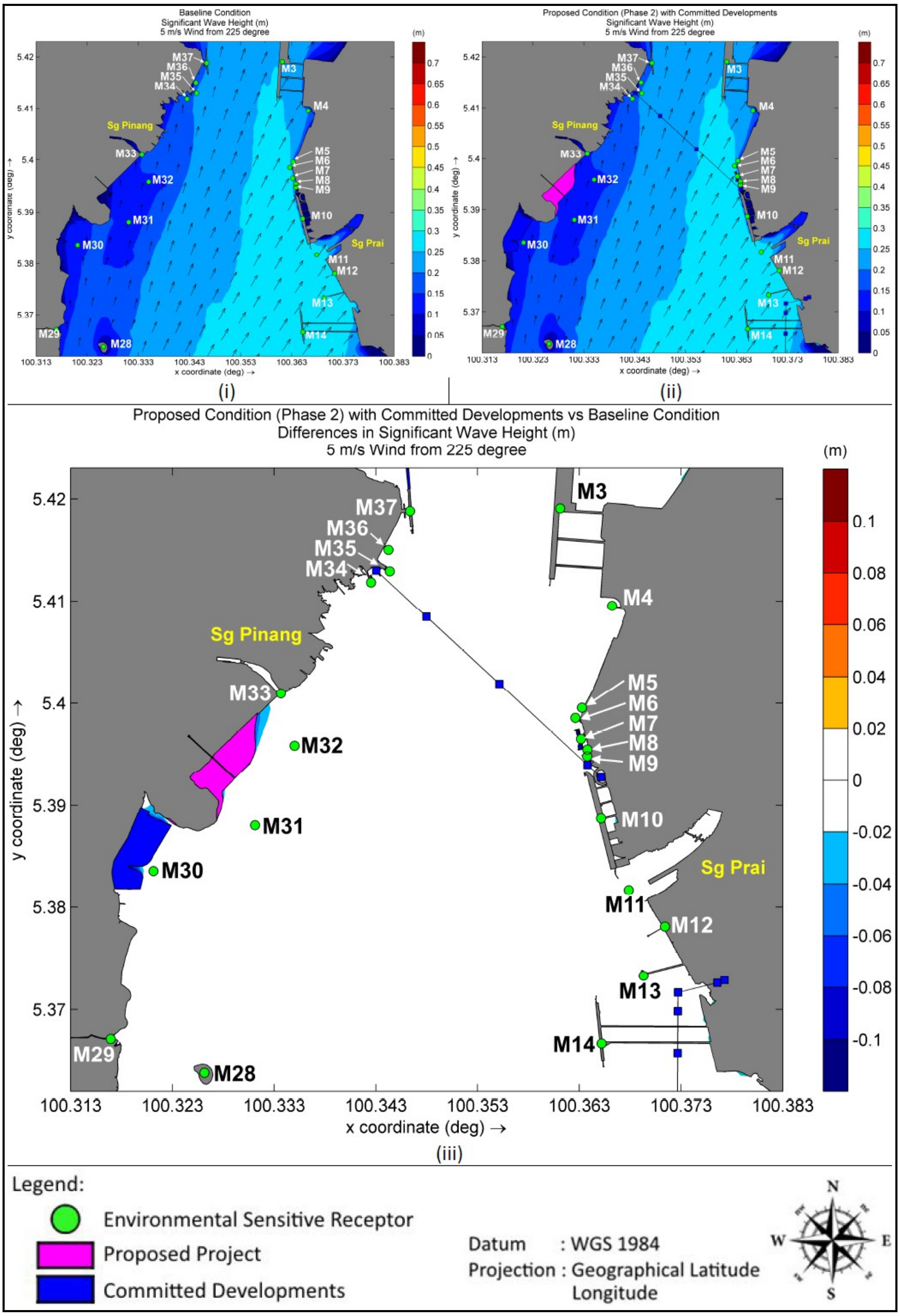


Figure 7.105: Significant Wave Height For Wind Of 5 m/s Speed From 225 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

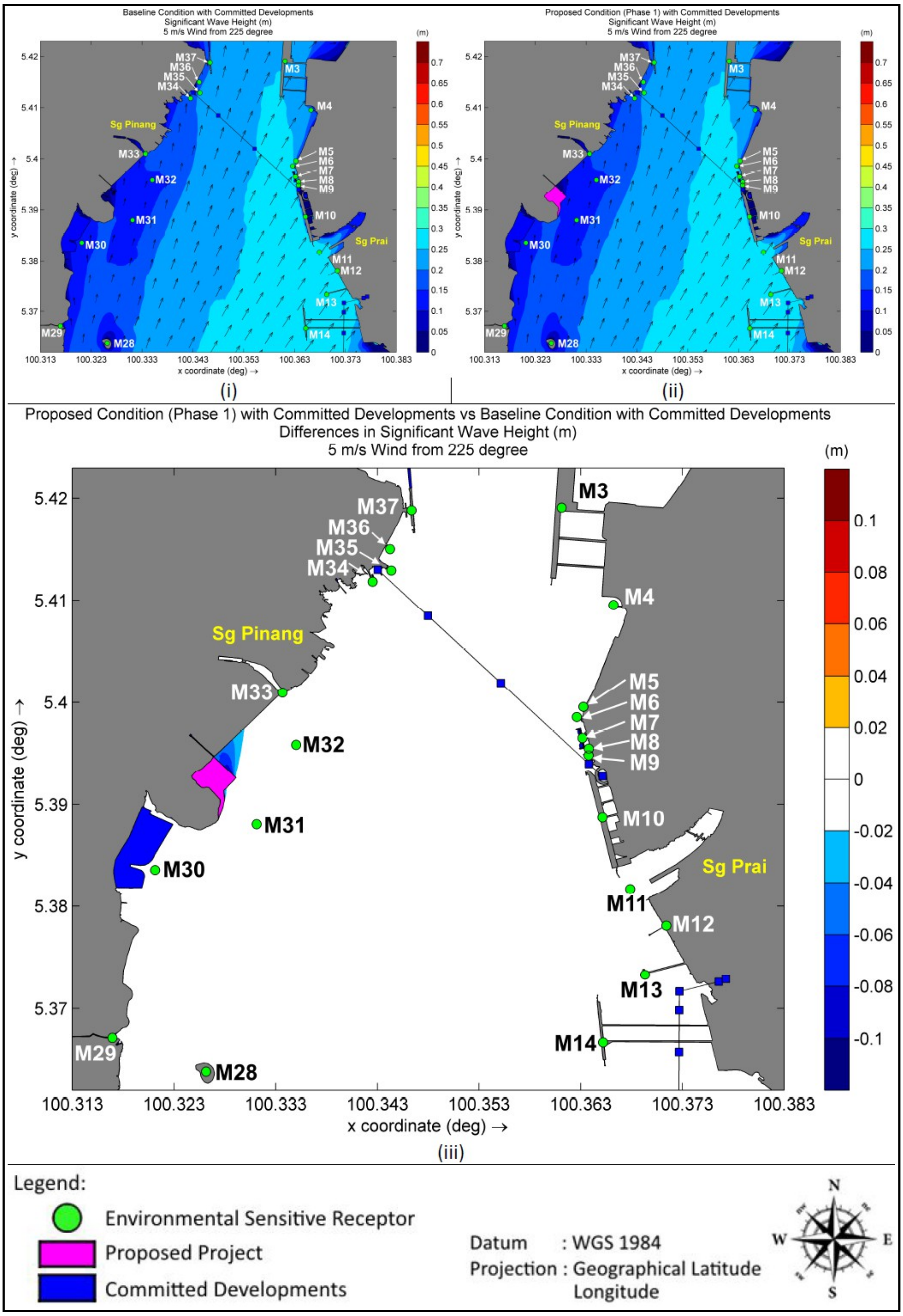


Figure 7.106: Significant Wave Height For Wind Of 5 m/s Speed From 225 Degree Direction For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

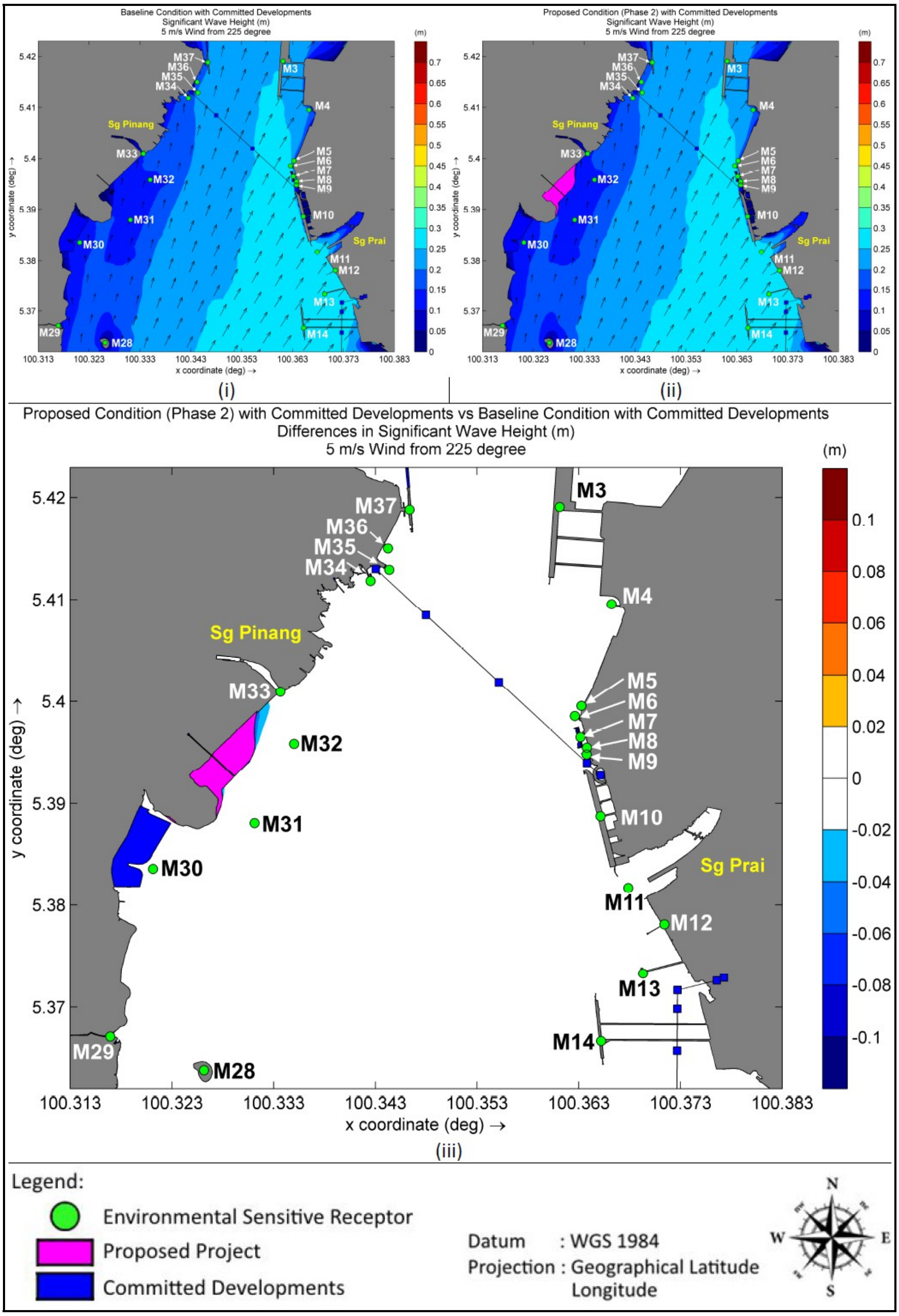


Figure 7.107: Significant Wave Height For Wind Of 5 m/s Speed From 225 Degree Direction For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

ESR Points	Description	Differences in Significant Wave Height (m)																	
		Proposed Condition (Phase 1) vs Baseline Condition			Proposed Condition (Phase 2) vs Baseline Condition			Proposed Condition (Phase 1) with Committed Developments vs Baseline Condition			Proposed Condition (Phase 2) with Committed Developments vs Baseline Condition			Proposed Condition (Phase 1) with Committed Developments vs Baseline Condition with Committed Developments			Proposed Condition (Phase 2) with Committed Developments vs Baseline Condition with Committed Developments		
		5 m/s @ 225 deg	7 m/s @ 315 deg	9 m/s @ 67.5 deg	5 m/s @ 225 deg	7 m/s @ 315 deg	9 m/s @ 67.5 deg	5 m/s @ 225 deg	7 m/s @ 315 deg	9 m/s @ 67.5 deg	5 m/s @ 225 deg	7 m/s @ 315 deg	9 m/s @ 67.5 deg	5 m/s @ 225 deg	7 m/s @ 315 deg	9 m/s @ 67.5 deg	5 m/s @ 225 deg	7 m/s @ 315 deg	9 m/s @ 67.5 deg
M1	Jetty Bagan Ajam	0.00	0.00	0.00	0.00	0.00	0.00												
M2	Pantai Bersih	0.00	0.00	0.00	0.00	0.00	0.00												
M3	North Butterworth Container Terminal (NBCT)	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	-0.01	0.00	0.00
M4	Butterworth Floating Mosque	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M5	Jetty A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M6	Terminal Pengangkutan Sementara	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M7	Shell Bagan Luar Terminal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M8	Fisherman Landing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M9	Pangkalan Sultan Abdul Halim Ferry Terminal (Butterworth)	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M10	South Butterworth Container Terminal (SBCT)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M11	River mouth Sg. Prai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M12	Shell and Esso Storage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M13	Prai Power Plant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M14	Pengkalan Cargo PPSB	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M15	Mangroves Seberang Prai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M16	Mangroves at 1st Penang Bridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M17	River mouth Sg. Juru	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M18	Cockle Farm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M19	Pulau Jerejak Aquaculture Farm (South)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M20	River mouth Sg. Nibong Kecil	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M21	Pulau Jerejak Aquaculture Farm (North)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M22	Rivermouth Sg. Besar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M23	Jetty B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M24	Jetty C	0.00	0.00	0.00	0.00	0.00	0.00	-0.05	0.00	0.00	-0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M25	Rivermouth Sg. Gelugor 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M26	Seagrass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M27	Pulau Ros	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M28	Pulau Gazumbo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M29	Rivermouth Sg. Gelugor 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M30	Aquaculture Jelutong 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
M31	Middle Bank	0.00	-0.01	0.00	0.00	-0.02	0.00	0.00	-0.01	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
M32	Aquaculture Jelutong 2	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
M33	Rivermouth Sg. Pinang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M34	Chew Jetty	0.00	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	0.00
M35	Pengkalan Raja Tun Uda Ferry Terminal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M36	Tanjung City Marina	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M37	Swettenham Pier	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.01	0.00	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M38	Eastern and Oriental Seaside	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.07	-0.01	0.00	-0.07	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M39	Gurney Beach	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.03	-0.01	0.00	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
M40	Tanjung Tokong Development	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.19	-0.08	-0.01	-0.19	-0.08	0.00	0.00	0.00	0.00	0.00	0.00
M41	Straits Quay Marina	0.00	0.00	0.00	0.00	0.00	0.00												

Table 7.44 Differences In Significant Wave Heights Between The Scenarios

The following observations were made based on the analysed modelling results and wind speed 7 m/s from 315° direction as shown in **Figure 7.108** to **Figure 7.113** for Condition 2:-

- Based on **Figure 7.108,** due to the wind coming from 315°, the mean direction for wind-induced wave development within the Penang Strait is towards south to southeasterly direction;
- In the Penang Strait, the significant wave height is higher on the eastern side due to the incoming wind direction. The magnitude of significant wave height within the Strait is up to 0.55 m;
- On the western side of the Strait, the significant wave height is mostly less than 0.2 m due to the sheltering effect of the protuding part Penang Island (near M36);
- Due to the shallow level of the middle bank area (M31), the significant wave height in the area is lower (< 0.15 m) than the surrounding wave height (around 0.15 m to 0.2 m);
- The significant wave height is observed to be largely similar for all modelling scenarios without significant changes;
- Based on **Figure 7.108 and Figure 7.109**, the Proposed Project will cause a reduction of significant wave height to the southeast of Proposed Project, along the adjacent deep channel. The magnitude of reduction is less than 0.06 m (<6 cm);
- The cumulative impacts are shown in **Figure 7.110**. It is observed that the significant wave height will be greatly reduced at the northern part of Penang Strait. Considering the direction of wind, the reduction of wave height is due to the presence of Seri Tanjung Pinang reclamation near the Tanjung Tokong area. The reclaimed area will block the development of wind-induced waves and reduces the significant wave height within the area. The magnitude of reduction is less than 0.06 m (< 6 cm) and extends far, reaching points M13 and M14;
- There will also be reduction of wave height to the east of IJM land (near M30) at the deeper channel area, as shown in **Figure 7.110**. The magnitude of reduction goes up to 0.1 m (10 cm);
- According to earlier **Table 7.44**, changes observed at the identified ESR points due to Proposed Project are minimal, less than 0.02 m (<2 cm) at all ESR points;
- Earlier **Table 7.44** also shows that the cumulative changes due to approved committed developments experience changes less than 0.03 m (< 3 cm) at most ESR points, except points M38 (Eastern and Oriental Seaside) and M40 (Tanjung Tokong Development) with reduction of significant wave heights of 0.07 m (7 cm) and 0.19 m (20 cm) respectively; and
- The results indicate that changes in significant wave height due to Proposed Project in this wind condition are considered localized.

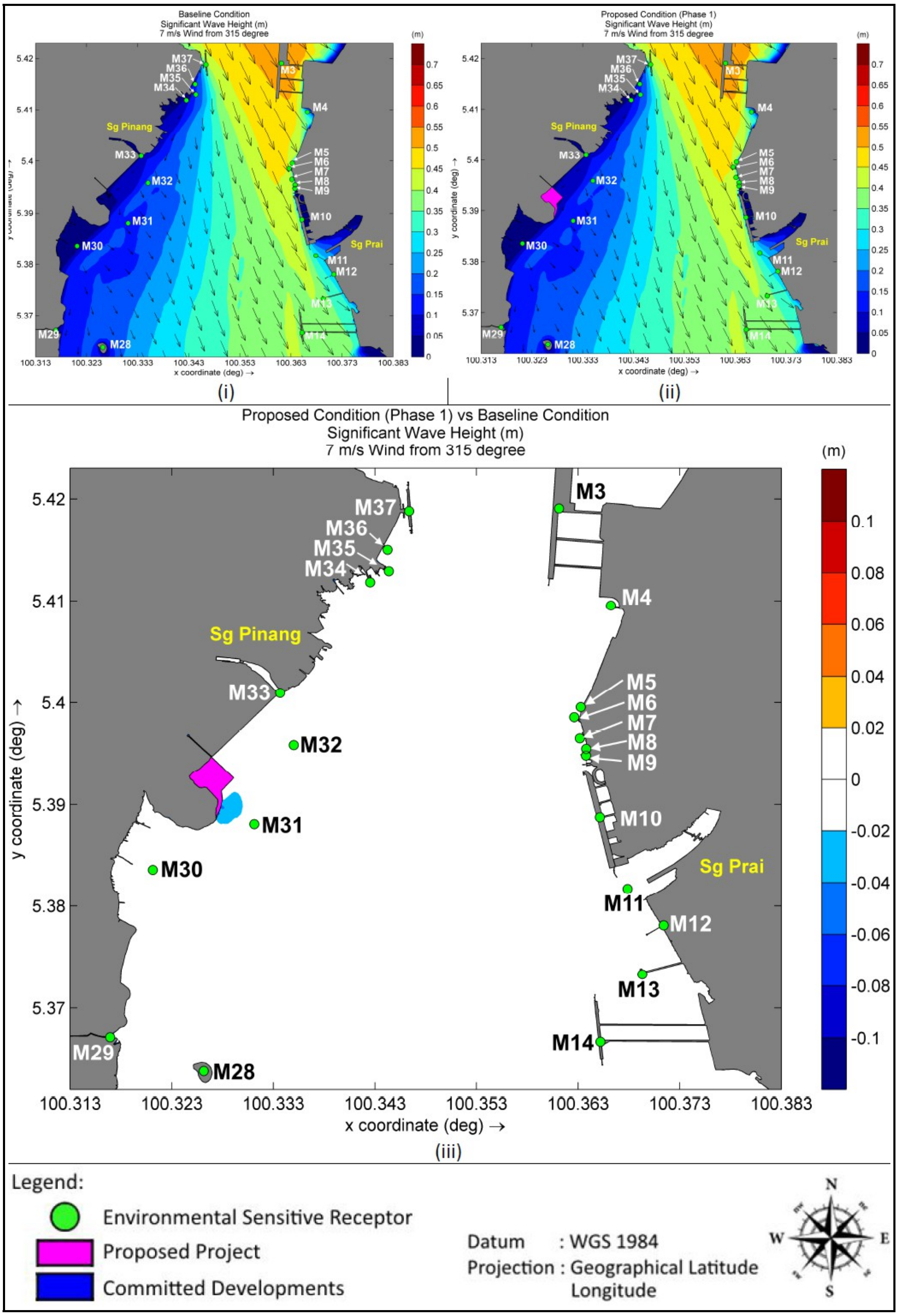


Figure 7.108: Significant Wave Height For Wind Of 7 m/s Speed From 315 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Significant Wave Height Between (i) And (ii).

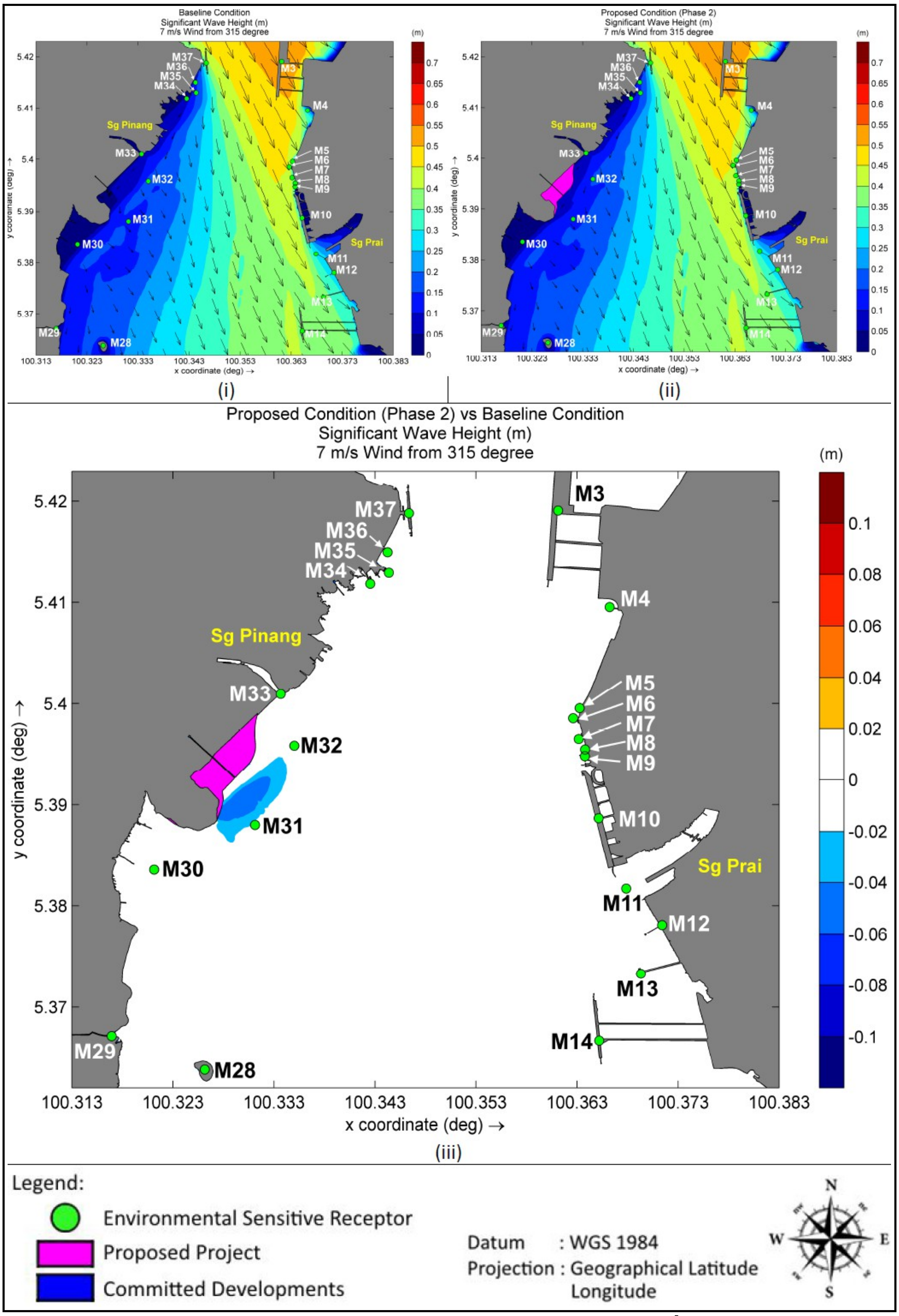


Figure 7.109: Significant Wave Height For Wind Of 7 m/s Speed From 315 Degree Direction for (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Significant Wave Height Between (i) And (ii).

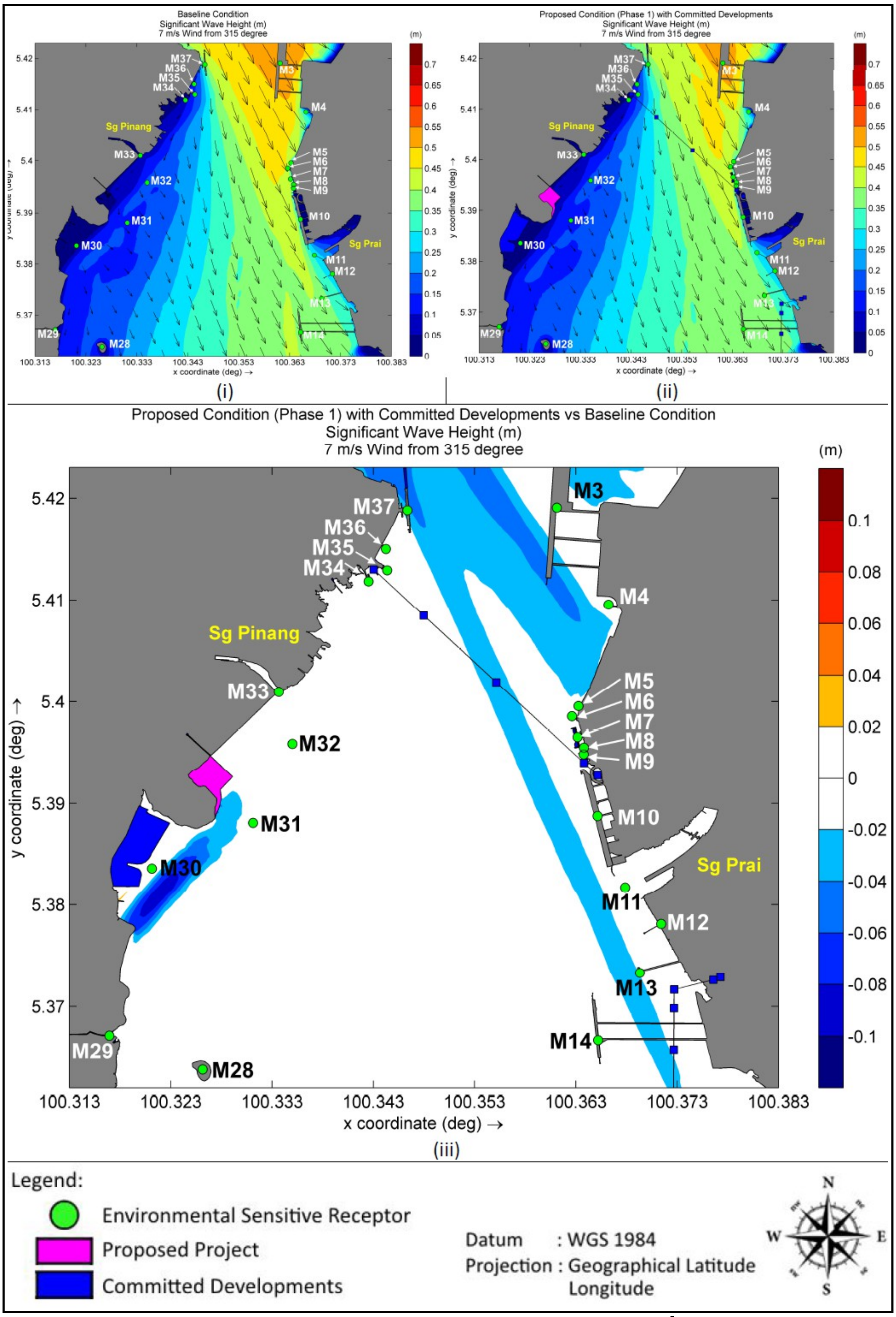


Figure 7.110: Significant Wave Height For Wind Of 7 m/s Speed From 315 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

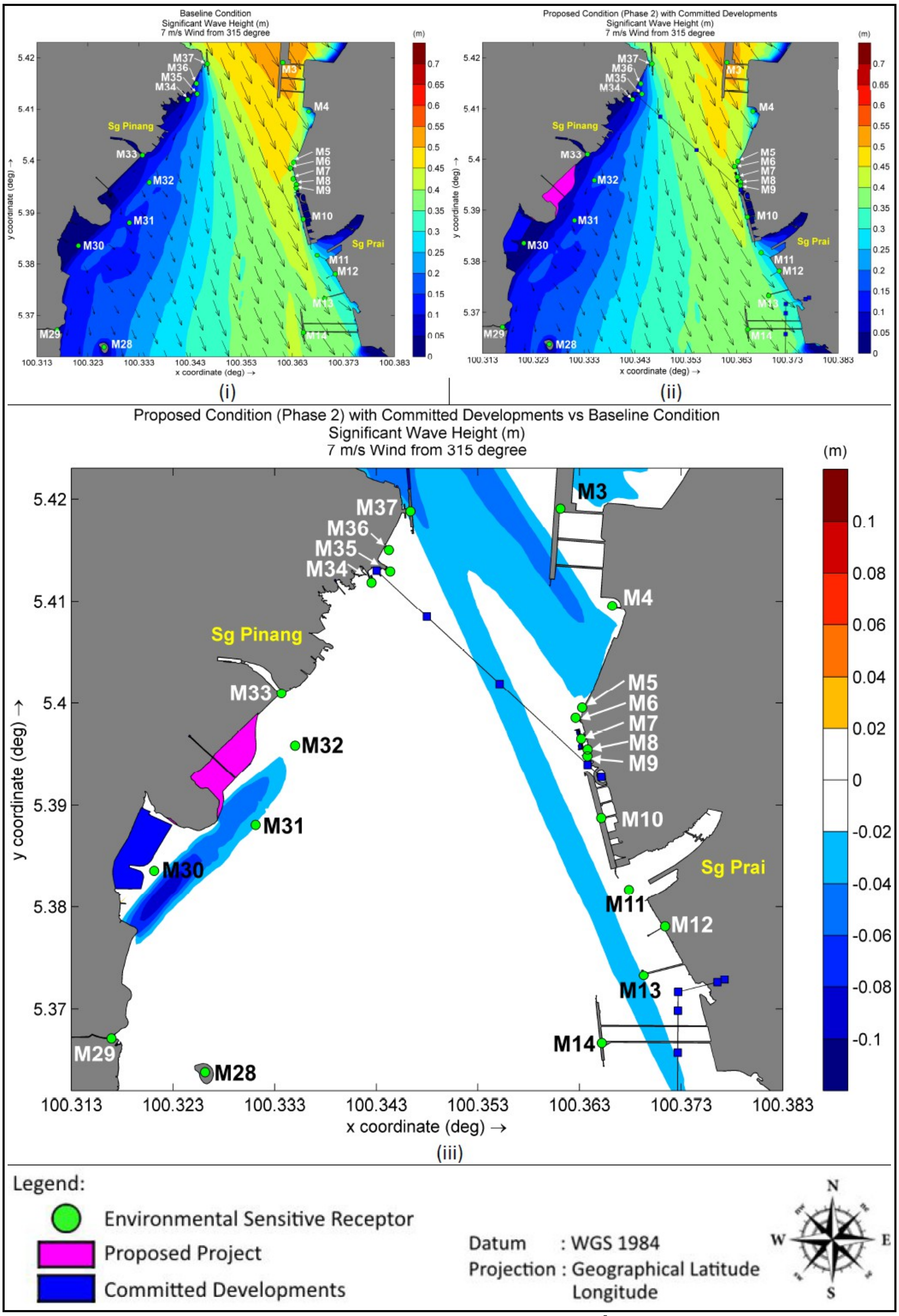


Figure 7.111: Significant Wave Height For Wind Of 7 m/s Speed From 315 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

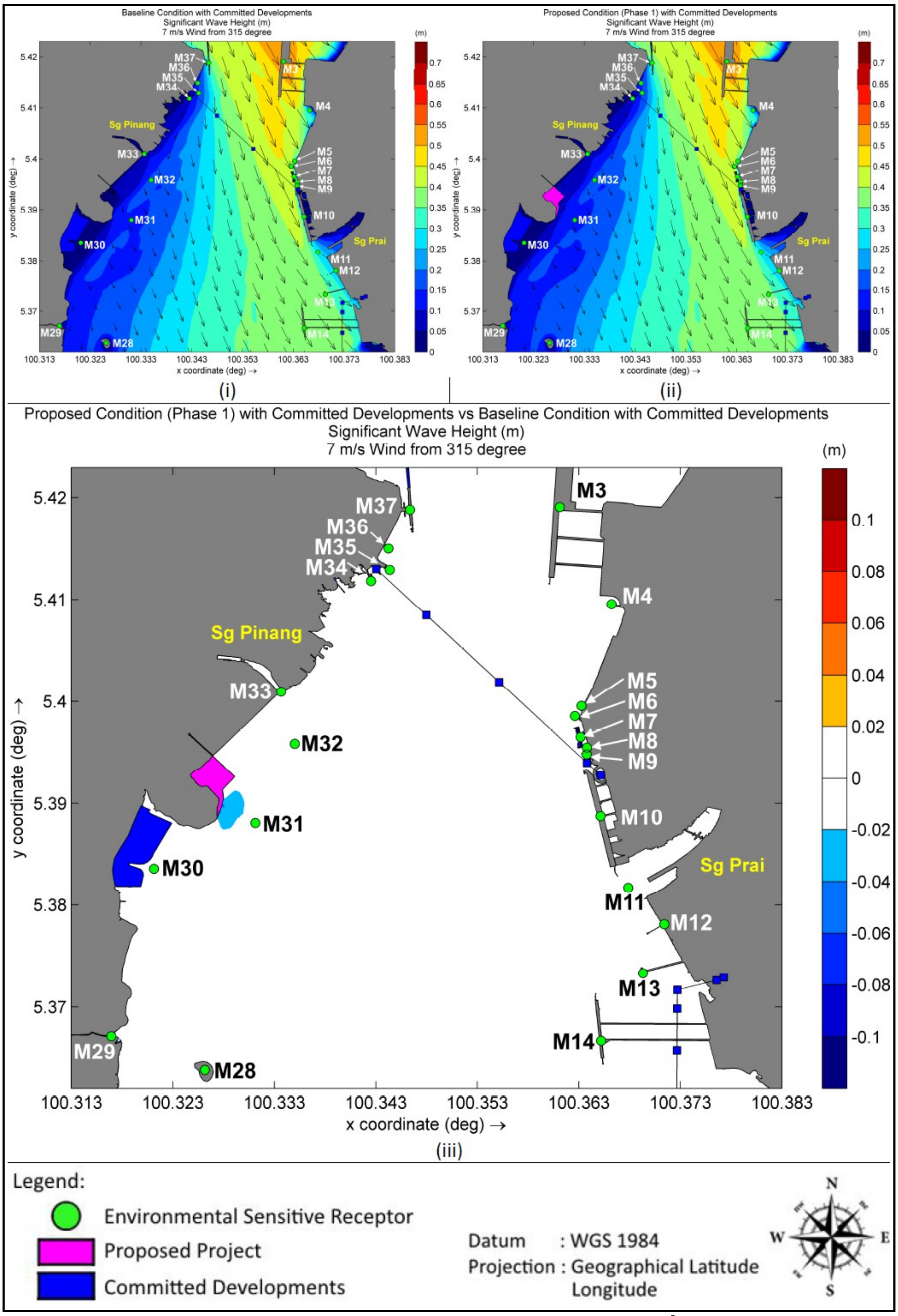


Figure 7.112: Significant Wave Height For Wind Of 7 m/s Speed From 315 Degree Direction For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

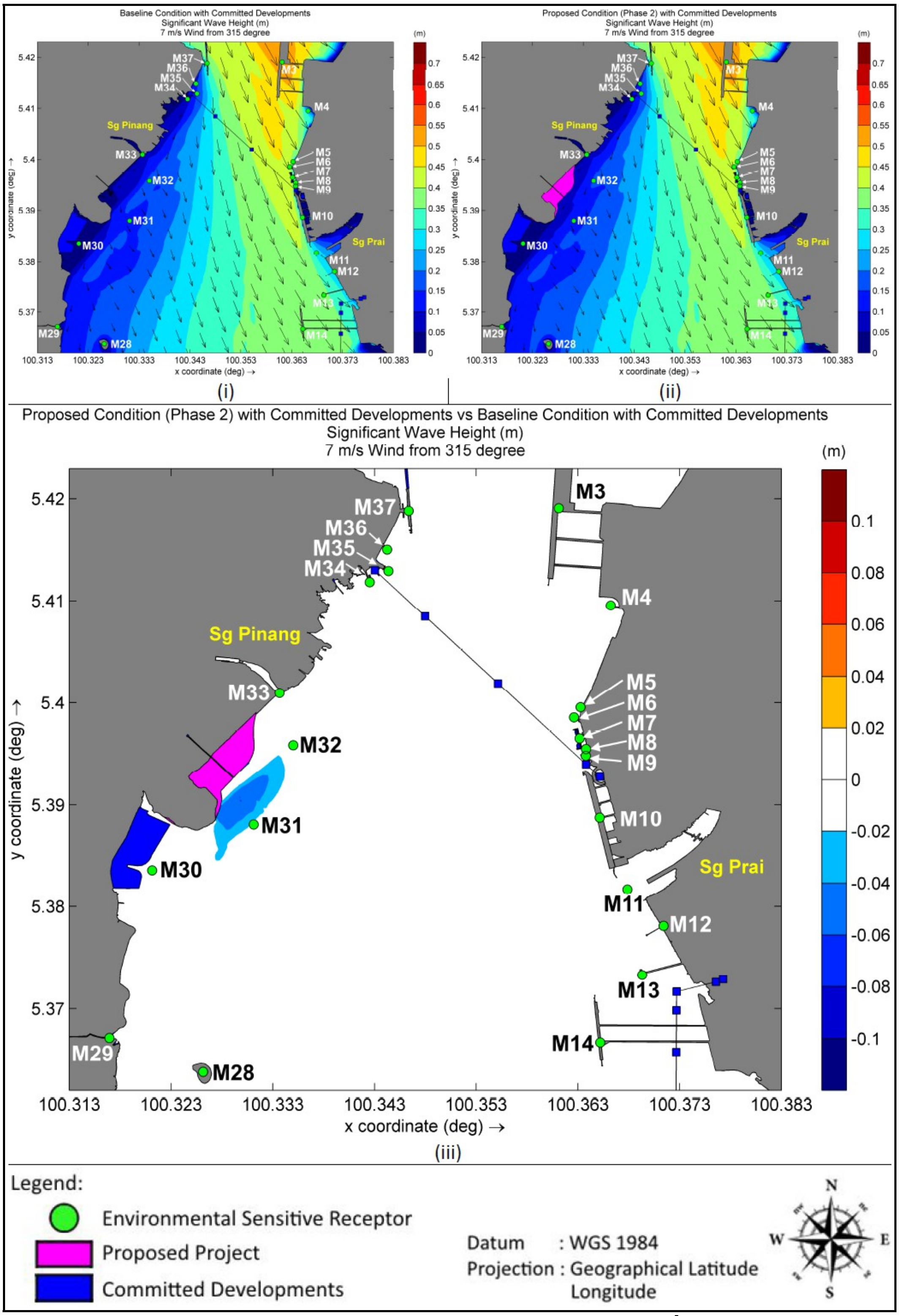


Figure 7.113: Significant Wave Height For Wind Of 7 m/s Speed From 315 Degree Direction For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

The following observations were made based on the analysed modelling results and wind speed 9 m/s from 67.5° direction as shown in **Figure 7.114** to **Figure 7.119** for Condition 3:-

- Based on **Figure 7.114** due to the wind coming from 67.5°, the mean direction for wind-induced wave development within the Penang Strait is towards west to south-westerly direction;
- In the Penang Strait, the significant wave height is higher on the western side due to the wind. The magnitude of significant wave height within the Strait is up to 0.45 m;
- On the eastern side of the Strait, the significant wave height is mostly less than 0.3 m due to the sheltering effect of mainland peninsular Malaysia;
- Due to the shallow level of the middle bank area (M31), the significant wave height in the area is lower (< 0.3 m) than the surrounding wave height (around 0.3 m to 0.35 m);
- The significant wave height is observed to be largely similar for all modelling scenarios without significant changes;
- Based on **Figure 7.114** the Proposed Project will cause minimal reduction of significant wave height along the Proposed Project boundary. The magnitude of reduction is less than 0.04 m (<4 cm);
- The cumulative impacts are shown in **Figure 7.116**. It is observed that there is a slight reduction in significant wave height around and to the south of the IJM land (near M30), with magnitude of reduction less than 0.06 m (<6 cm). Other approved committed development however does not cause any significant impacts on the wave heights within the Strait. It is assumed that any potential changes in significant wave height are less than 0.02 m (<2 cm);
- According to earlier **Table 7.44**, changes observed at the identified ESR points due to Proposed Project are minimal, less than 0.01 m (<1 cm) at all ESR points;
- Earlier **Table 7.44** also shows that the cumulative changes due to approved committed developments experience changes less than 0.01 m (<1 cm) at most ESR points, except point M39 (Tanjung Tokong Development) with reduction of significant wave heights of 0.08 m (8 cm); and
- The results indicate that changes in significant wave height due to Proposed Project in this wind condition are considered localized.

iv) Impacts Due To Sediment Transport

The following observations were made based on the analysed modelling results and Mean Sediment Transport Rate as shown in **Figure 7.120 to Figure 7.126**:-

- Based on **Figure 7.120,** higher mean sediment transport is observable at the deeper channel areas, where the current is proven to be stronger;

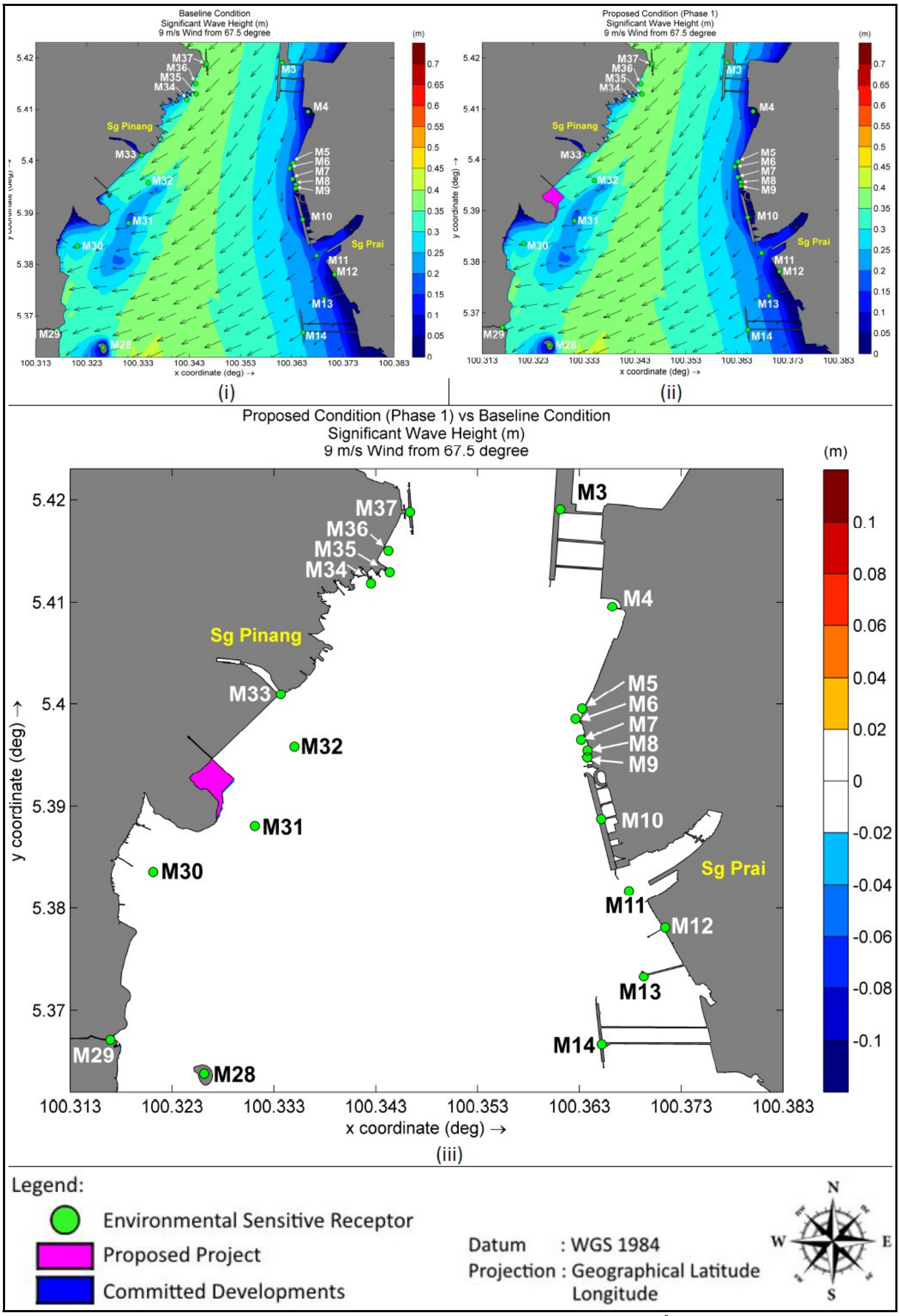


Figure 7.114: Significant Wave Height For Wind Of 9 m/s Speed From 67.5 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Significant Wave Height Between (i) And (ii).

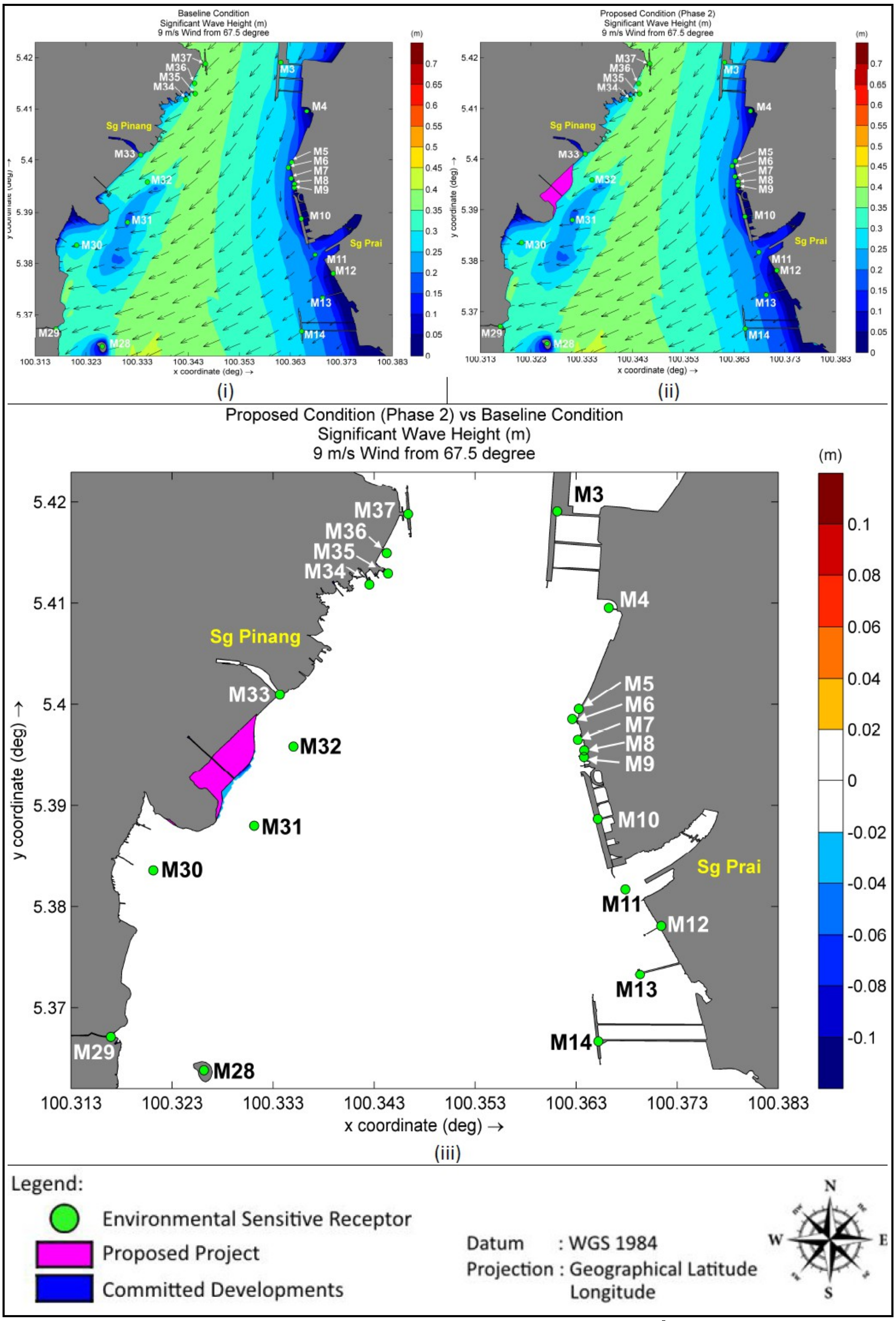


Figure 7.115: Significant Wave Height For Wind Of 9 m/s Speed From 67.5 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Significant Wave Height Between (i) And (ii).

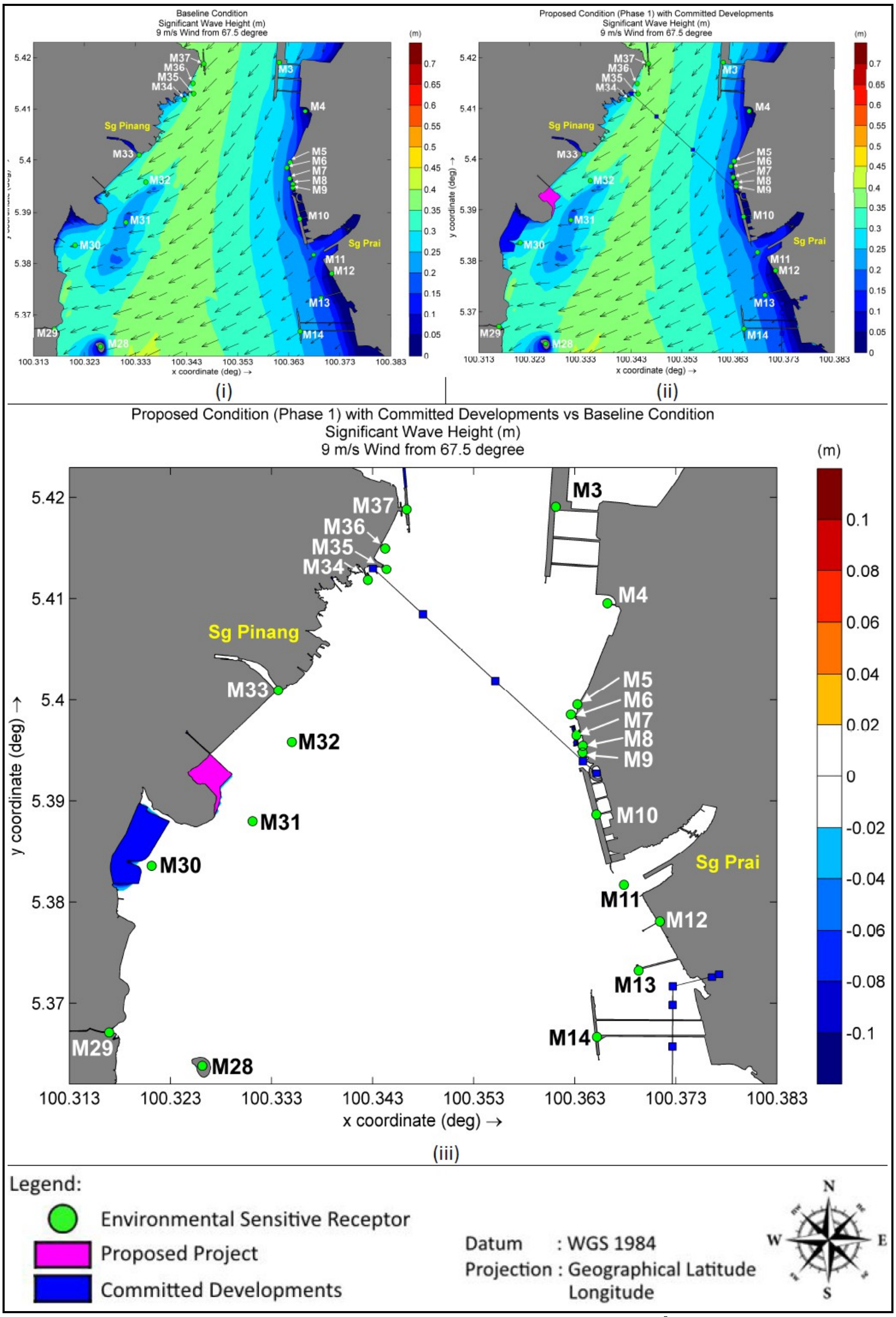


Figure 7.116: Significant Wave Height For Wind Of 9 m/s Speed From 67.5 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

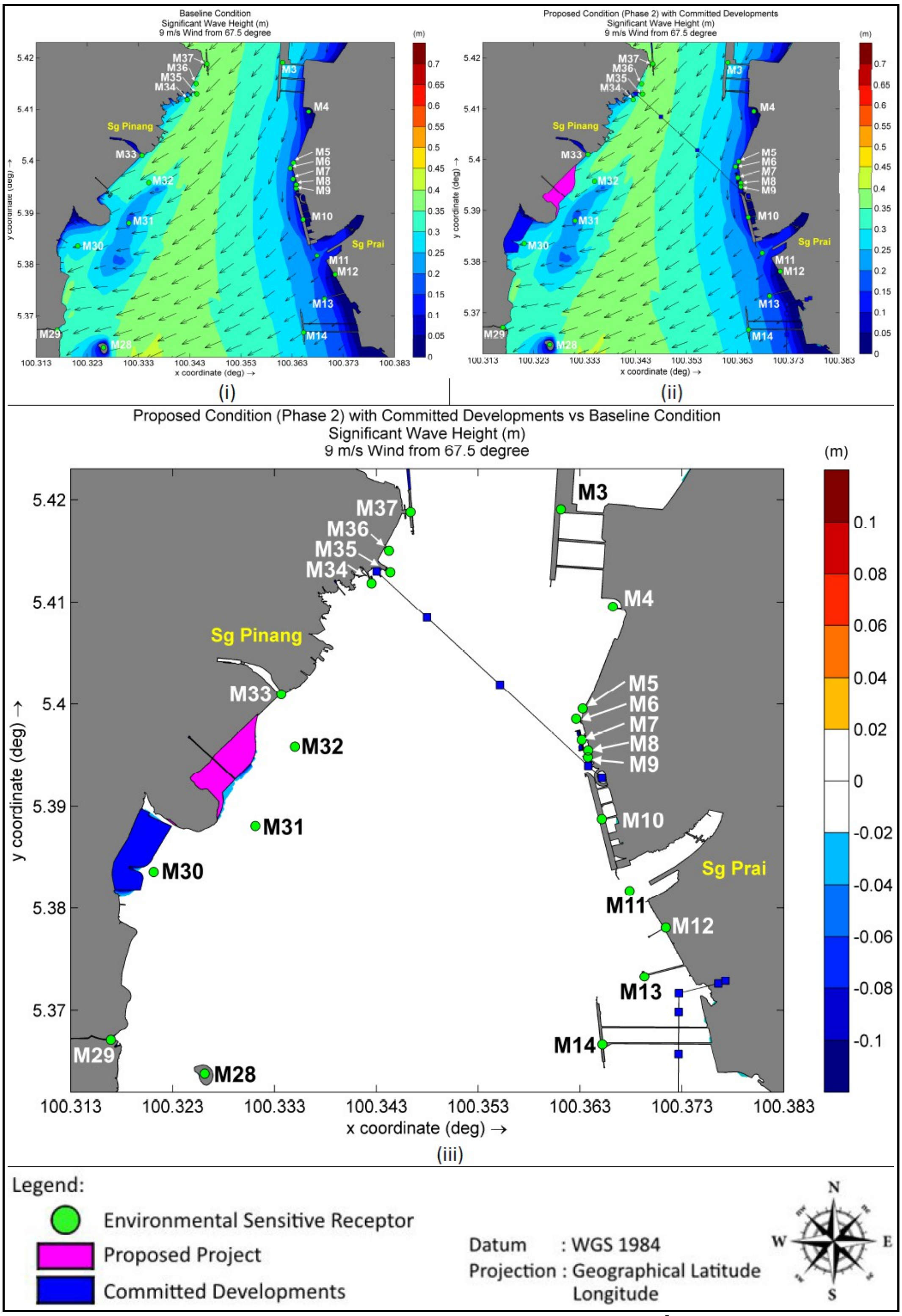


Figure 7.117 Significant Wave Height For Wind Of 9 m/s Speed From 67.5 Degree Direction For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

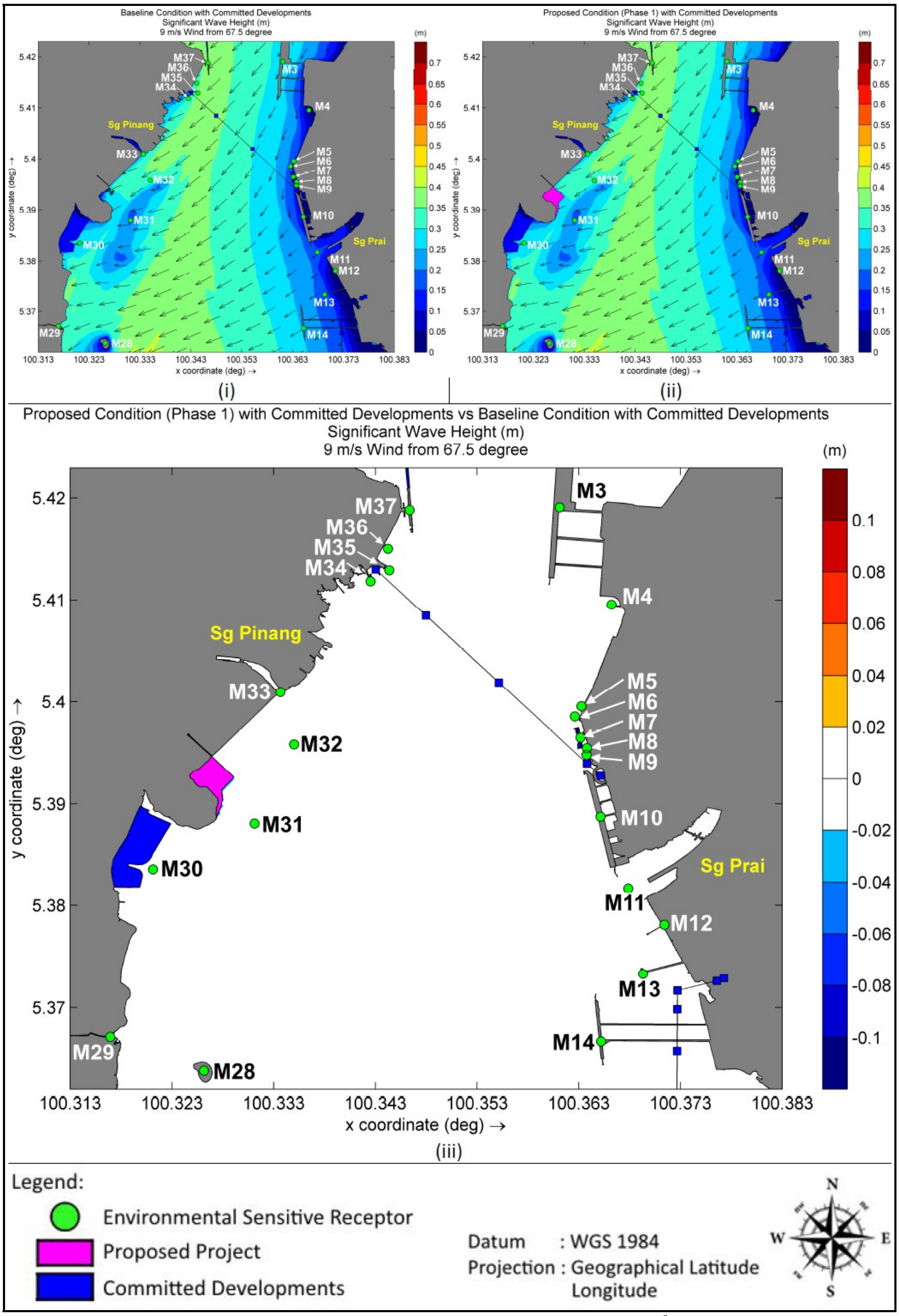


Figure 7.118: Significant Wave Height For Wind Of 9 m/s Speed From 67.5 Degree Direction For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

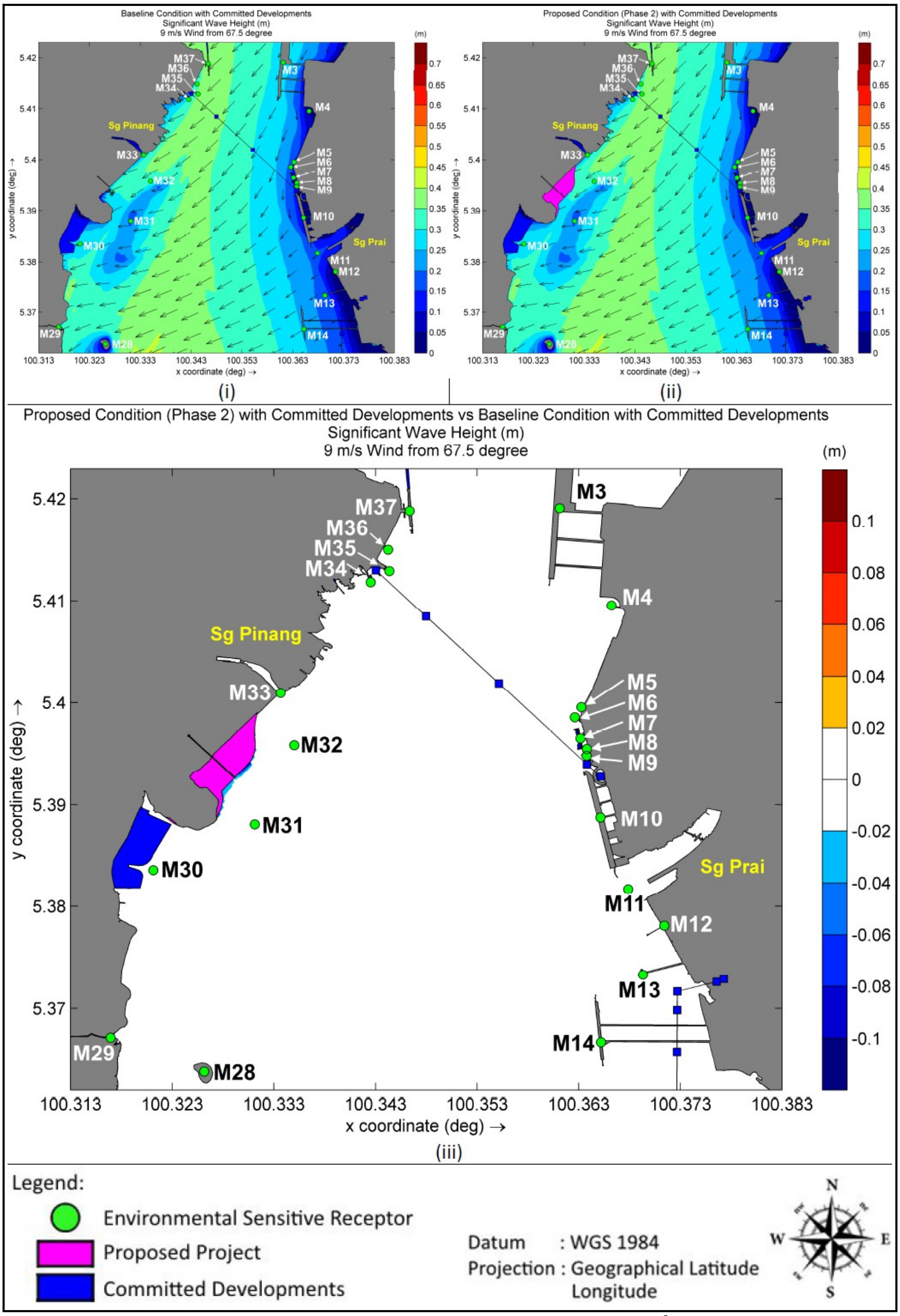


Figure 7.119: Significant Wave Height For Wind Of 9 m/s Speed From 67.5 Degree Direction For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Significant Wave Height Between (i) And (ii).

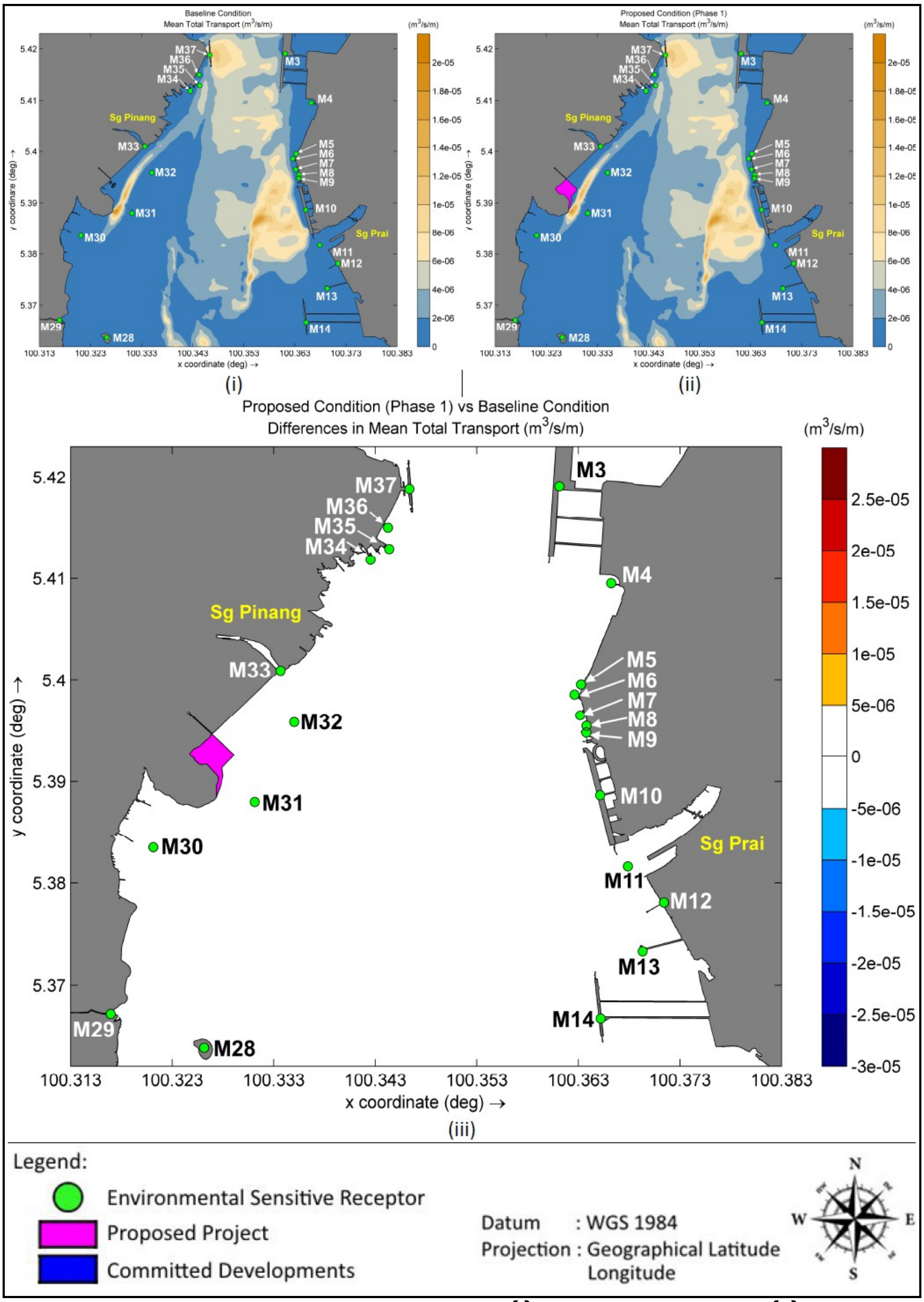


Figure 7.120: Mean Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Mean Sediment Transport Between (i) And (ii).

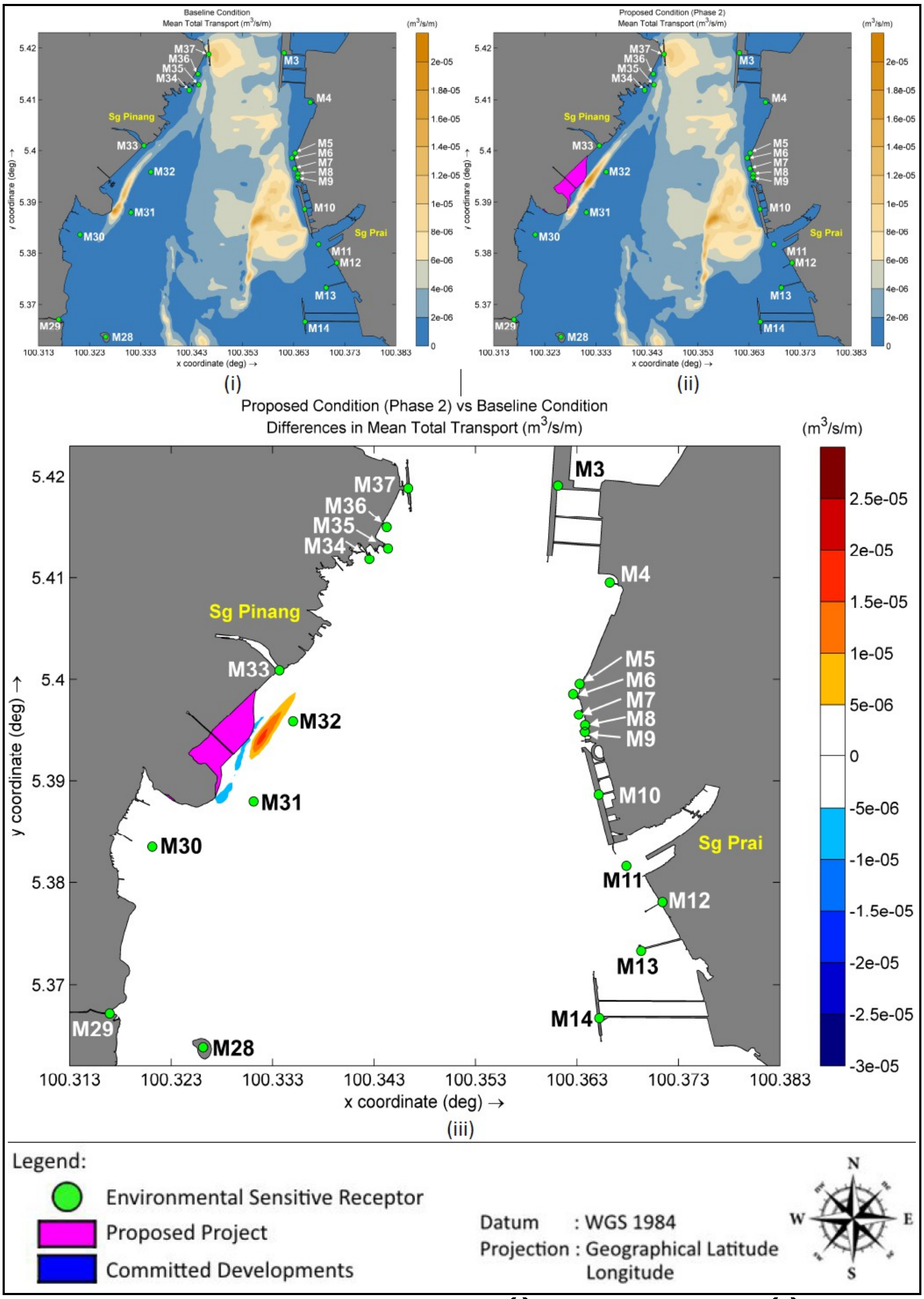


Figure 7.121: Mean Sediment Transport Tor (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Mean Sediment Transport Between (i) And (ii).

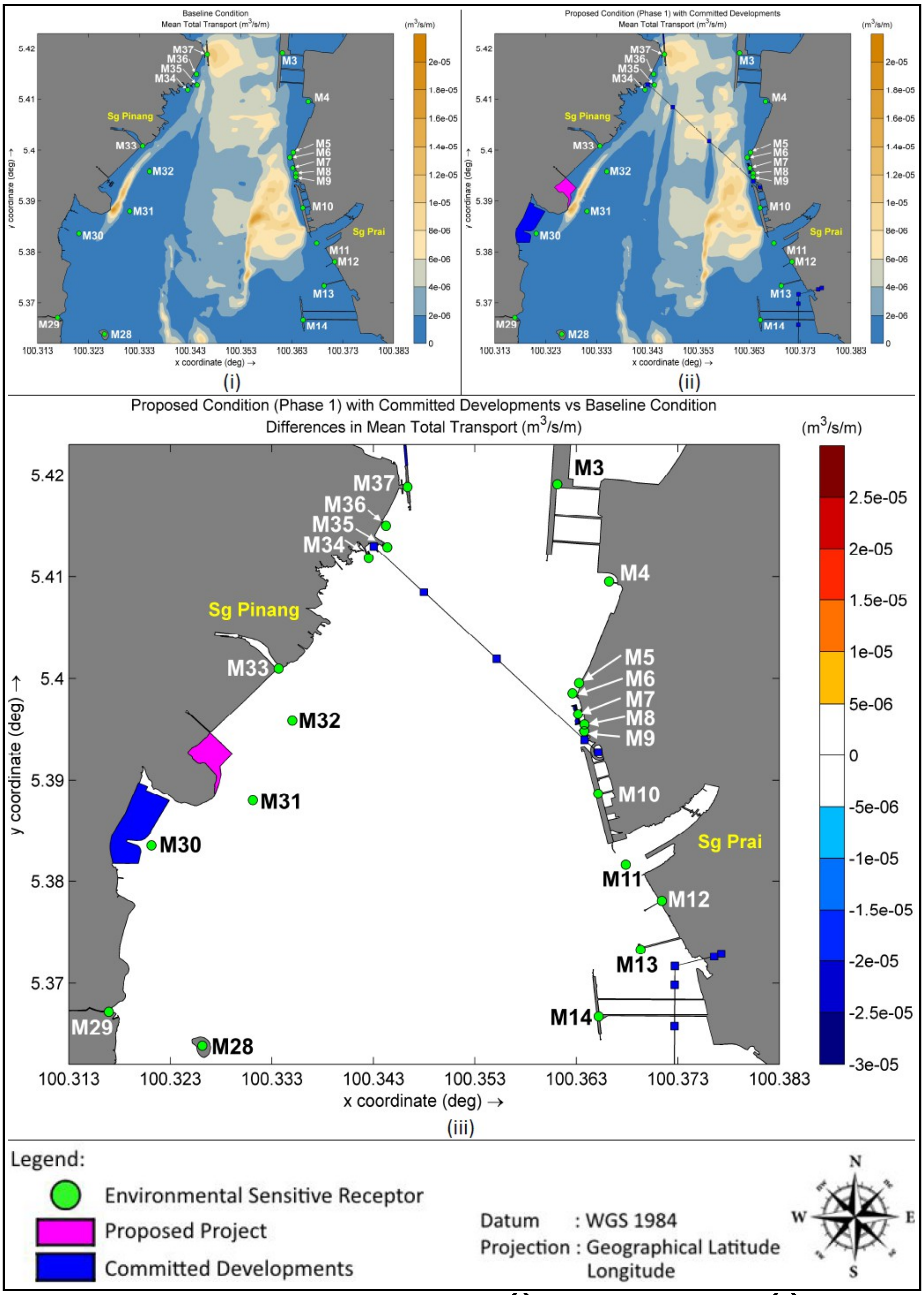


Figure 7.122: Mean Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Mean Sediment Transport Between (i) And (ii).

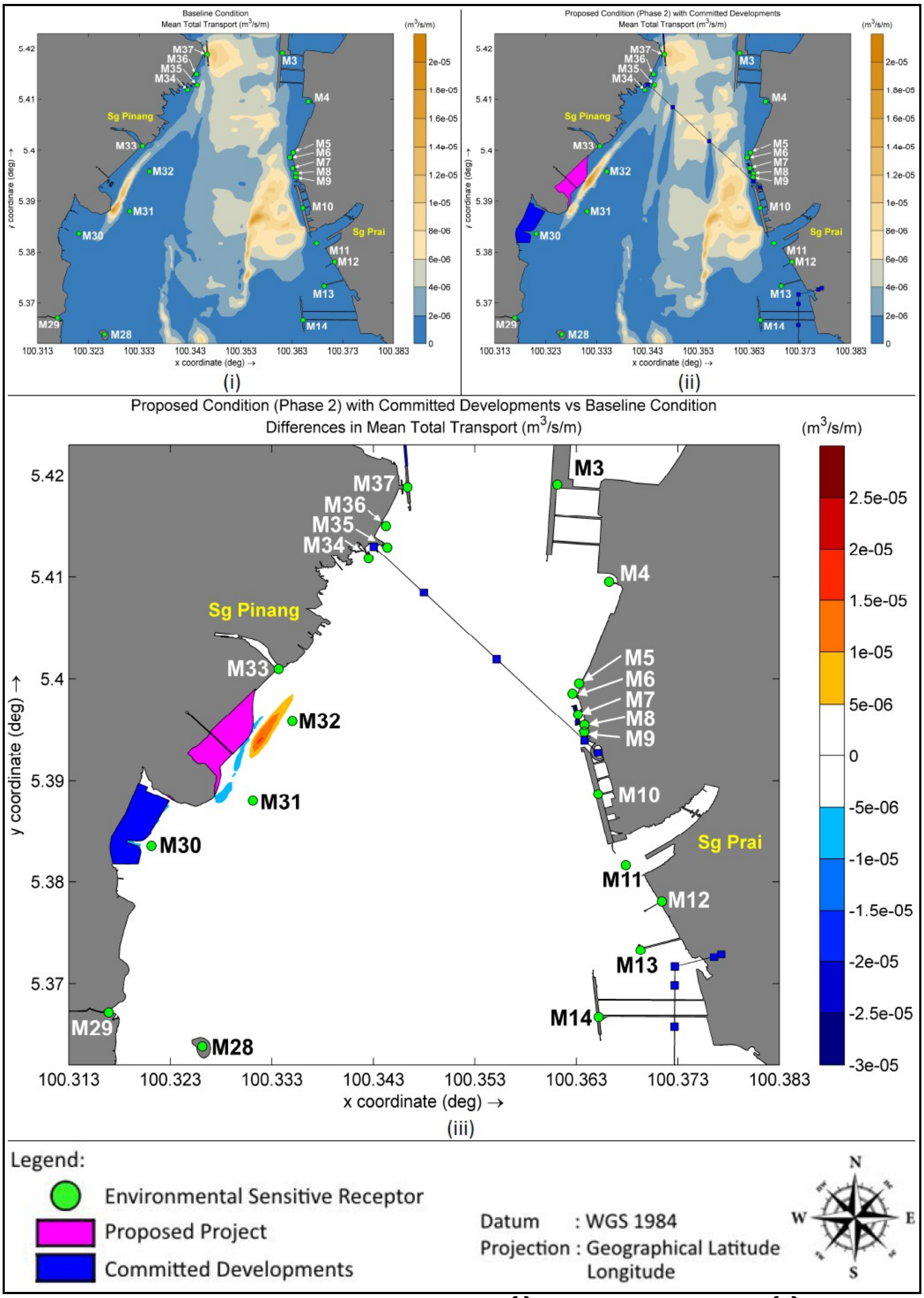


Figure 7.123: Mean Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Mean Sediment Transport Between (i) And (ii).

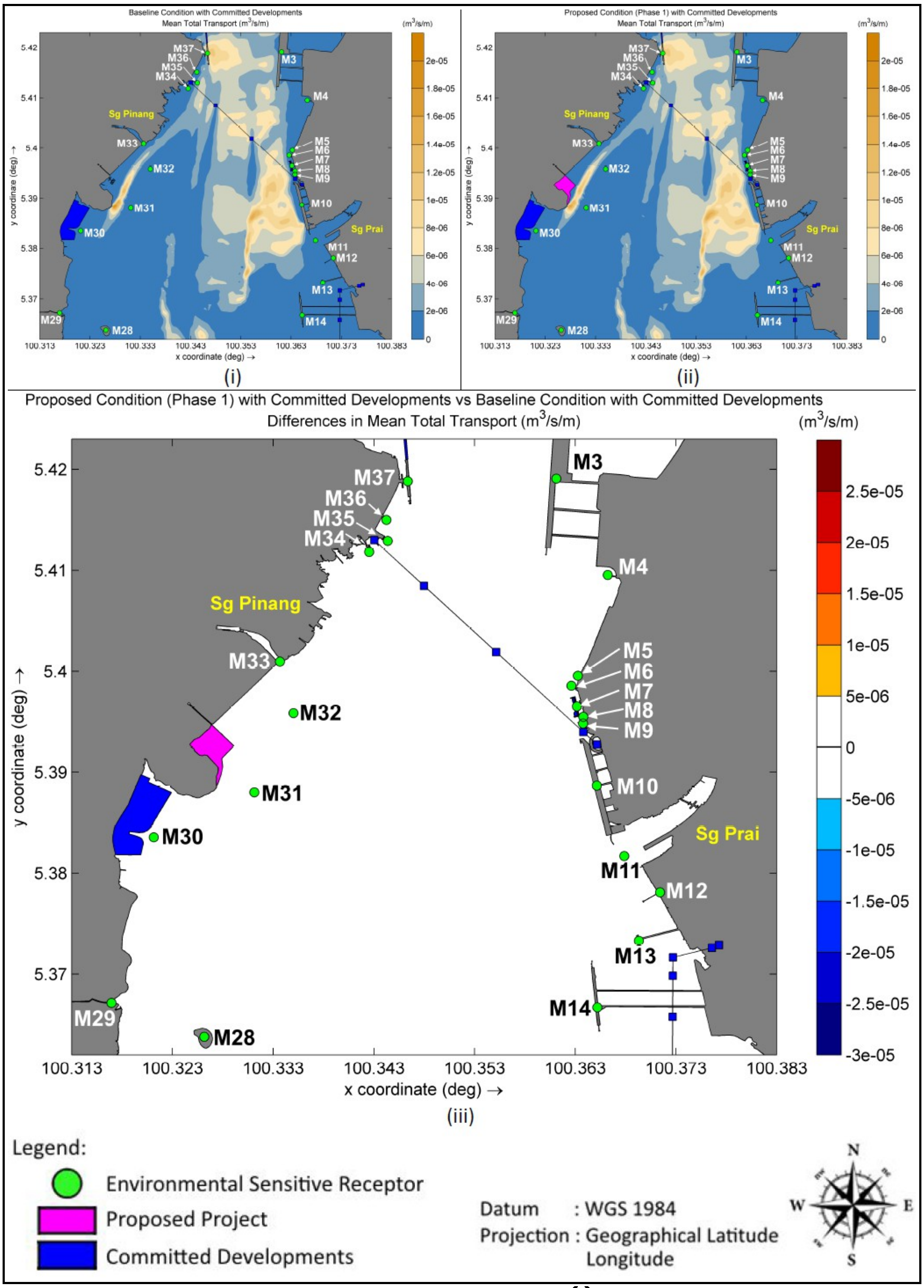


Figure 7.124: Mean Sediment Transport For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Mean Sediment Transport Between (i) And (ii).

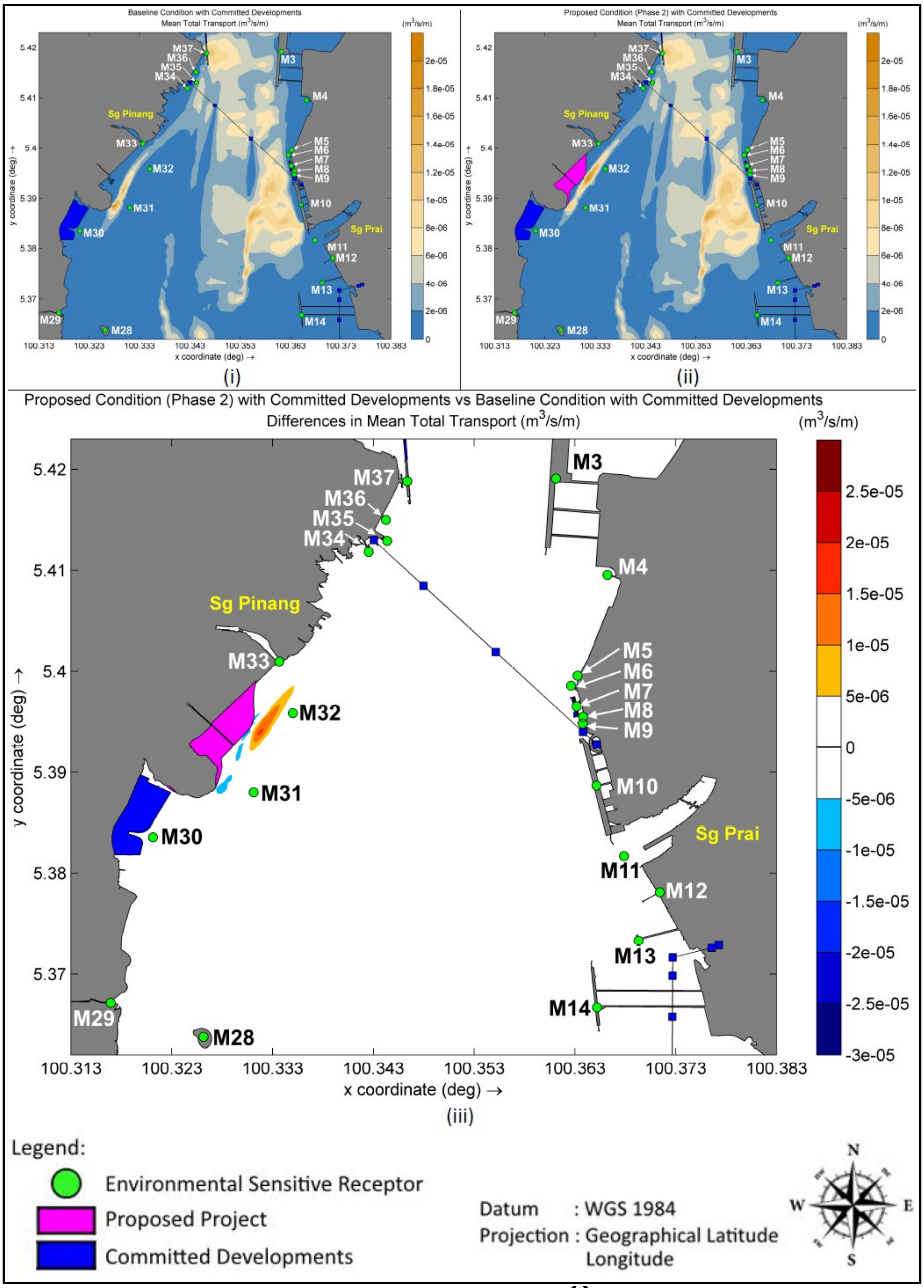


Figure 7.125: Mean Sediment Transport For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Mean Sediment Transport Between (i) And (ii).

- The rate of total sediment transport is proportional to the strength and magnitude of current flow. The mean sediment transport rate at the channel is observed to be up to 2 x 10-5 $m^3/s/m$;
- The mean sediment transport rate is observed to be largely similar for all modelling scenarios without significant changes;
- Based on **Figure 7.120 and Figure 7.121,** it is observed that while Phase 1 reclamation does not cause observable changes on the mean sediment transport rate, the completed Phase 2 reclamation will cause a slight increase in the mean sediment transport rate along the channel adjacent to the Proposed Project. The rate of increase goes up to 2 x 10-5 $m^3/s/m$. There is also slight reduction in magnitude of the mean sediment transport rate, though at a much smaller scale of 1 x 10-5 $m^3/s/m$ along the Proposed Project boundary;
- **Figure 7.122** shows the cumulative impacts due to other approved committed developments on mean sediment transport rate. Although the Proposed with Committed Development scenarios shows a reduction of sediment transport rate around the Pylons of Sky Cab in Figure (ii) of **Figure 7.122,** there is no notable differences in the comparison figure. This indicates that any other changes in mean sediment transport rate due to approved committed developments are less than 5 x 10-6 $m^3/s/m$;
- According to **Table 7.45**, changes in mean sediment transport rate observed at the identified ESR points due to Proposed Project are minimal, less than 1 x 10-7 $m^3/s/m$;
- **Table 7.45** also shows that most ESRs experiences changes less than 2 x 10-7 $m^3/s/m$ except for ESR point M37 (Swettenham Pier) located at the narrowest part of the Penang Strait with changes up to 8 x 10-7 $m^3/s/m$; and
- The results indicate that changes in mean sediment transprot rate due to Proposed Project are considered localized and within near vicinity.

The following observations were made based on the analysed modelling results and Maximum Sediment Transport Rate as shown in **Figure 7.126 to Figure 7.131**:-

- Based on **Figure 7.126** the maximum sediment transport is observable at the deeper channel areas, where the current is proven to be stronger;
- The rate of total sediment transport is proportional to the strength and magnitude of current flow. The maximum sediment transport rate at the channel is observed to be up to 1 x 10-4 $m^3/s/m$;
- The maximum sediment transport rate is observed to be largely similar for all modelling scenarios without significant changes;
- Based on **Figure 7.126 and Figure 7.127**, it is observed that while Phase 1 reclamation does not cause observable changes on the maximum sediment transport rate, the completed Phase 2 reclamation will cause

ESR Points	Description	Sediment Transport Rate $(x10^{-5})$ $(m^3/s/m)$												Differences in Sediment Transport Rate $(m^3/s/m)$											
		Baseline Condition (A)		Proposed Condition (Phase 1) (B)		Proposed Condition (Phase 2) (C)		Baseline Condition & Committed Developments (D)		Proposed Condition (Phase 1) & Committed Developments (E)		Proposed Condition (Phase 2) & Committed Developments (F)		Scenario (B) – (A)		Scenario (C) – (A)		Scenario (E) – (A)		Scenario (F) – (A)		Scenario (E) – (D)		Scenario (F) – (D)	
		Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff	Mean Diff	Max Diff
M1	Jetty Bagan Ajam	0.00	0.00	0.00	0.00	0.00	0.00							0.00	0.00	0.00	0.00								
M2	Pantai Bersih	0.00	0.00	0.00	0.00	0.00	0.00							0.00	0.00	0.00	0.00								
M3	North Butterworth Container Terminal (NBCT)	0.11	1.44	0.11	1.46	0.11	1.44	0.11	1.65	0.11	1.67	0.10	1.65	0.00	0.02	0.00	0.00	0.00	0.23	-0.01	0.21	0.00	0.02	-0.01	0.00
M4	Butterworth Floating Mosque	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M5	Jetty A	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.01
M6	Terminal Pengangkutan Sementara	0.04	0.62	0.04	0.63	0.04	0.64	0.04	0.53	0.04	0.53	0.04	0.54	0.00	0.01	0.00	0.02	0.00	-0.09	0.00	-0.08	0.00	0.00	0.00	0.01
M7	Shell Bagan Luar Terminal	0.01	0.12	0.01	0.12	0.01	0.12	0.01	0.13	0.01	0.13	0.02	0.13	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.00
M8	Fisherman Landing	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M9	Pangkalan Sultan Abdul Halim Ferry Terminal	0.00	0.04	0.00	0.04	0.00	0.04	0.00	0.06	0.00	0.06	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00	0.00
M10	South Butterworth Container Terminal (SBCT)	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M11	River mouth Sg. Prai	0.01	0.12	0.01	0.12	0.01	0.12	0.01	0.11	0.01	0.11	0.01	0.11	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
M12	Shell and Esso Storage	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M13	Prai Power Plant	0.02	0.13	0.02	0.13	0.02	0.14	0.02	0.12	0.02	0.12	0.02	0.13	0.00	0.00	0.00	0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.01
M14	Pengkalan Cargo PPSB	0.11	1.00	0.11	1.00	0.11	1.03	0.11	0.87	0.11	0.88	0.11	0.91	0.00	0.00	0.00	0.03	0.00	-0.12	0.00	-0.09	0.00	0.01	0.00	0.04
M15	Mangroves Seberang Prai	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M16	Mangroves at 1st Penang Bridge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M17	River mouth Sg. Juru	0.00	0.09	0.00	0.09	0.00	0.09	0.00	0.09	0.00	0.10	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00
M18	Cockle Farm	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M19	Pulau Jerejak Aquaculture Farm (South)	0.00	0.05	0.00	0.05	0.00	0.04	0.00	0.04	0.00	0.04	0.00	0.04	0.00	0.00	0.00	-0.01	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
M20	River mouth Sg. Nibong Kecil	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M21	Pulau Jerejak Aquaculture Farm (North)	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M22	Rivermouth Sg. Besar	0.00	0.08	0.00	0.08	0.00	0.08	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-0.07	0.00	-0.07	0.00	0.00	0.00	0.00
M23	Jetty B	0.01	0.15	0.01	0.14	0.01	0.14	0.00	0.07	0.00	0.07	0.00	0.07	0.00	-0.01	0.00	-0.01	-0.01	-0.08	-0.01	-0.08	0.00	0.00	0.00	0.00
M24	Jetty C	0.01	0.16	0.01	0.13	0.01	0.12	0.00	0.05	0.00	0.04	0.00	0.04	0.00	-0.03	0.00	-0.04	-0.01	-0.12	-0.01	-0.12	0.00	-0.01	0.00	-0.01
M25	Rivermouth Sg. Gelugor 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M26	Seagrass	0.05	0.98	0.05	0.74	0.04	0.65	0.05	0.89	0.04	0.68	0.04	0.61	0.00	-0.24	-0.01	-0.33	-0.01	-0.30	-0.01	-0.37	-0.01	-0.21	-0.01	-0.28
M27	Pulau Ros	0.00	0.07	0.00	0.06	0.00	0.06	0.00	0.04	0.00	0.03	0.00	0.04	0.00	-0.01	0.00	-0.01	0.00	-0.04	0.00	-0.03	0.00	-0.01	0.00	0.00
M28	Pulau Gazumbo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M29	Rivermouth Sg. Gelugor 1	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M30	Aquaculture Jelutong 1	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M31	Middle Bank	0.00	0.01	0.00	0.03	0.00	0.01	0.00	0.01	0.00	0.03	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00
M32	Aquaculture Jelutong 2	0.03	0.39	0.02	0.35	0.03	0.39	0.03	0.47	0.03	0.43	0.03	0.47	-0.01	-0.04	0.00	0.00	0.00	0.04	0.00	0.08	0.00	-0.04	0.00	0.00
M33	Rivermouth Sg. Pinang	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M34	Chew Jetty	0.05	0.58	0.04	0.53	0.04	0.52	0.04	0.60	0.04	0.55	0.04	0.47	-0.01	-0.05	-0.01	-0.06	-0.01	-0.03	-0.01	-0.11	0.00	-0.05	0.00	-0.13
M35	Pengkalan Raja Tun Uda Ferry Terminal	0.26	2.33	0.25	2.13	0.26	2.02	0.28	2.68	0.28	2.43	0.28	2.27	-0.01	-0.20	0.00	-0.31	0.02	0.10	0.02	-0.06	0.00	-0.25	0.00	-0.41
M36	Tanjung City Marina	0.00	0.02	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
M37	Swettenham Pier	0.97	10.31	0.96	10.25	0.96	10.14	0.90	9.35	0.89	9.28	0.89	9.19	-0.01	-0.06	-0.01	-0.17	-0.08	-1.03	-0.08	-1.12	-0.01	-0.07	-0.01	-0.16
M38	Eastern and Oriental Seaside	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M39	Gurney Beach	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M40	Tanjung Tokong Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
M41	Straits Quay Marina	0.00	0.00	0.00	0.00	0.00	0.00							0.00	0.00	0.00	0.00								

Table 7.45 Mean And Maximum Sediment Transport Rate $(m^3/s/m)$ At Identified ESRs For Each Scenario And Their Differences.

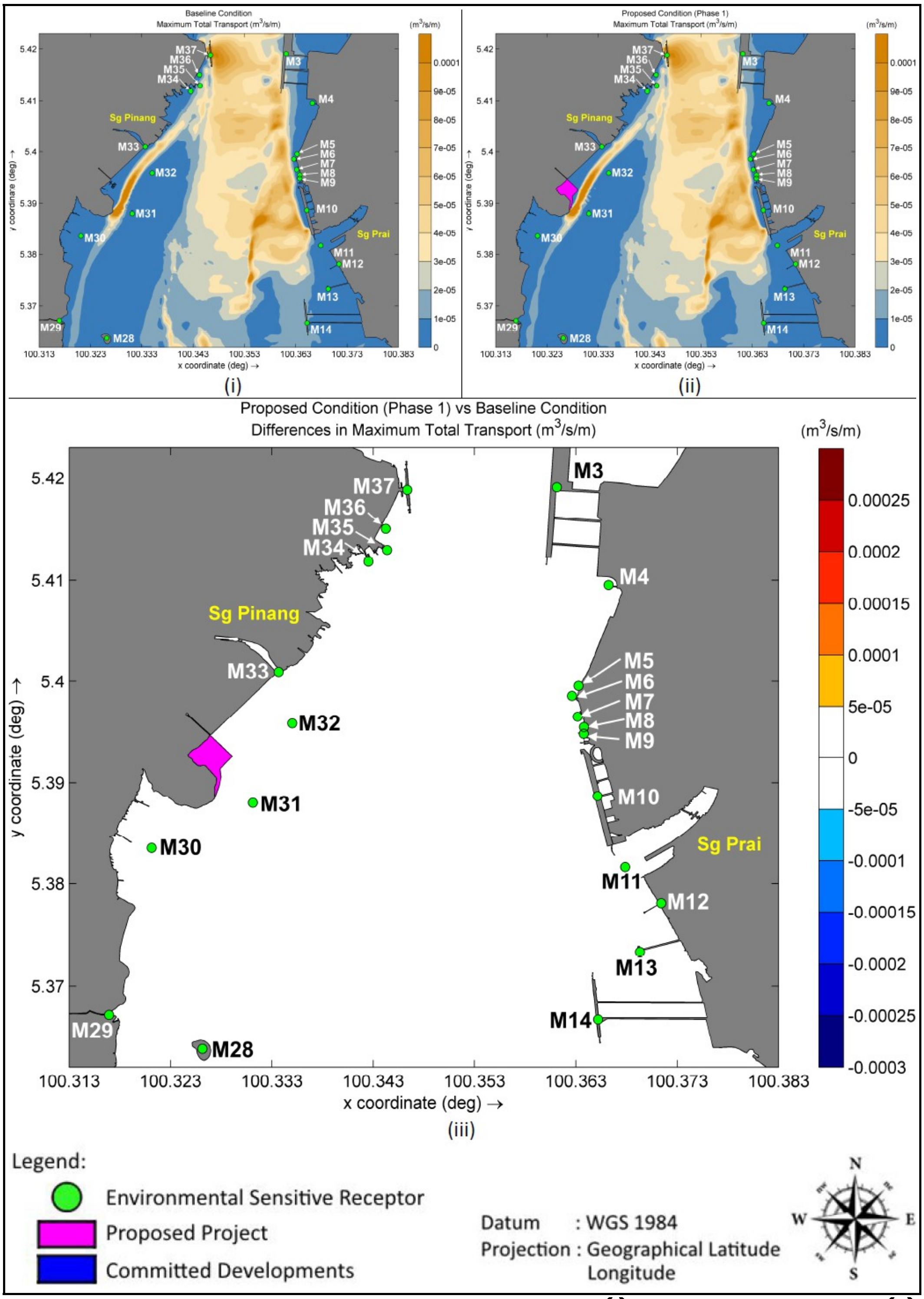


Figure 7.126: Maximum Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 1); And (iii) Differences In Maximum Sediment Transport Between (i) And (ii).

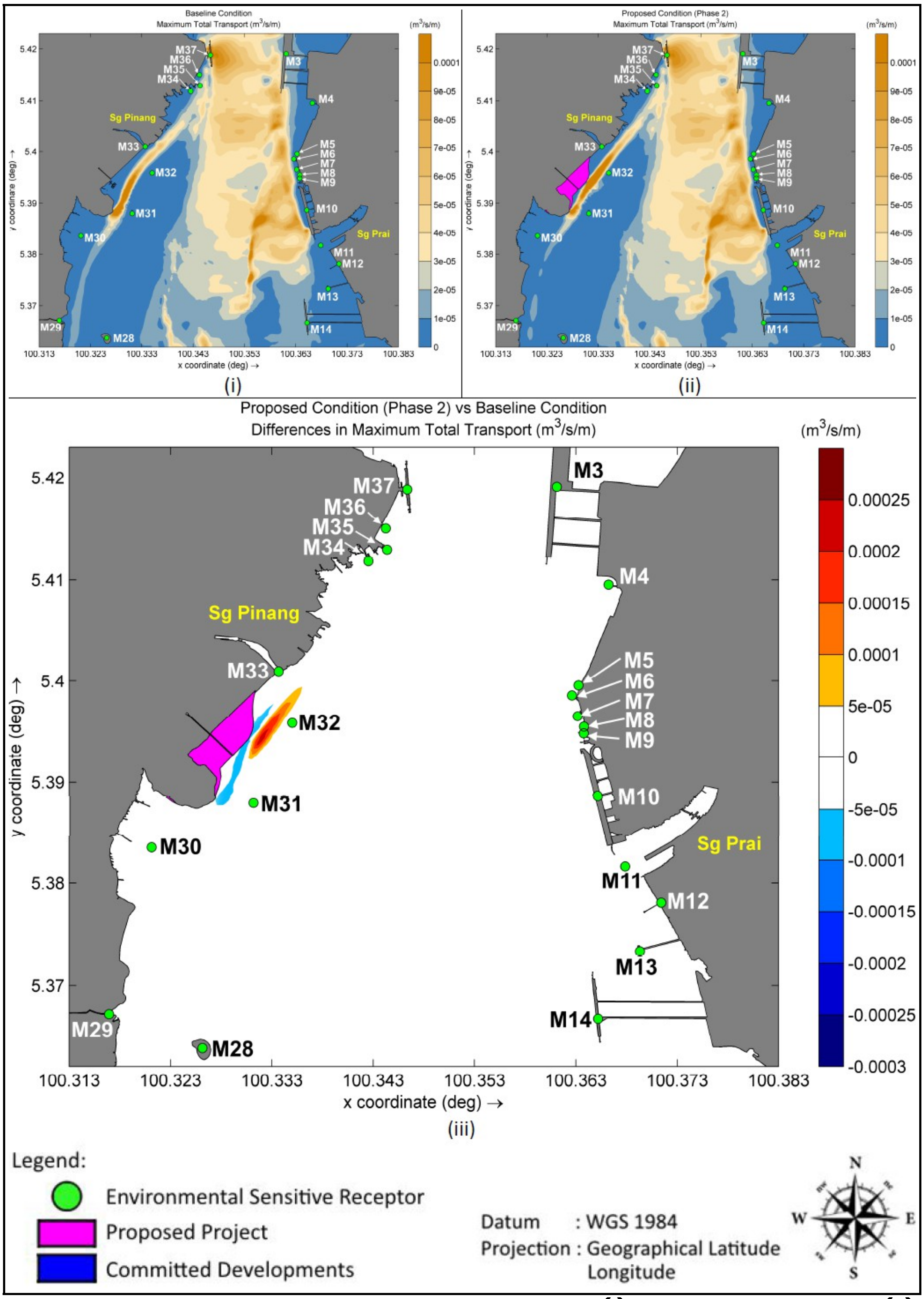


Figure 7.127: Maximum Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 2); And (iii) Differences In Maximum Sediment Transport Between (i) And (ii).

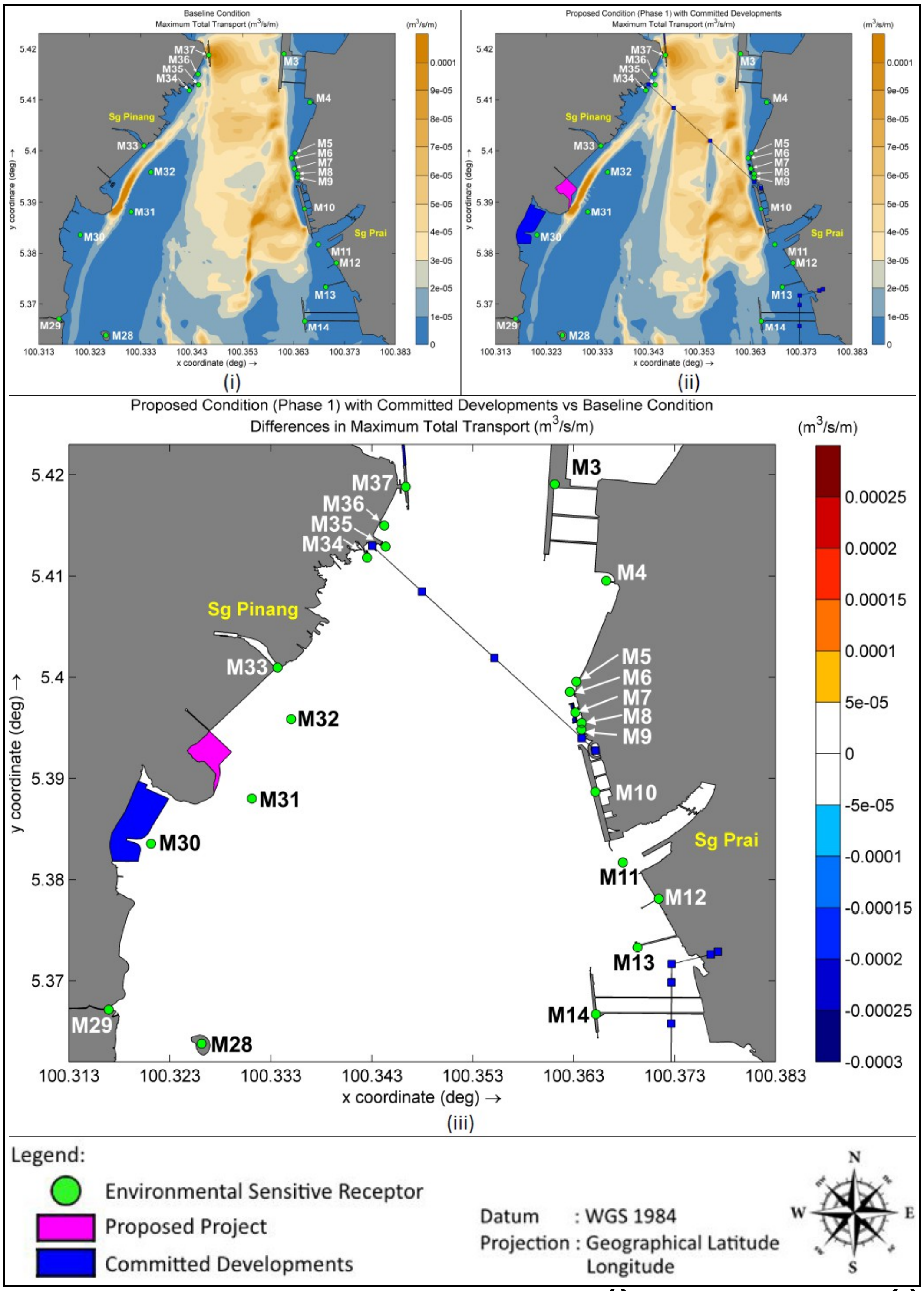


Figure 7.128: Maximum Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Maximum Sediment Transport Between (i) And (ii).

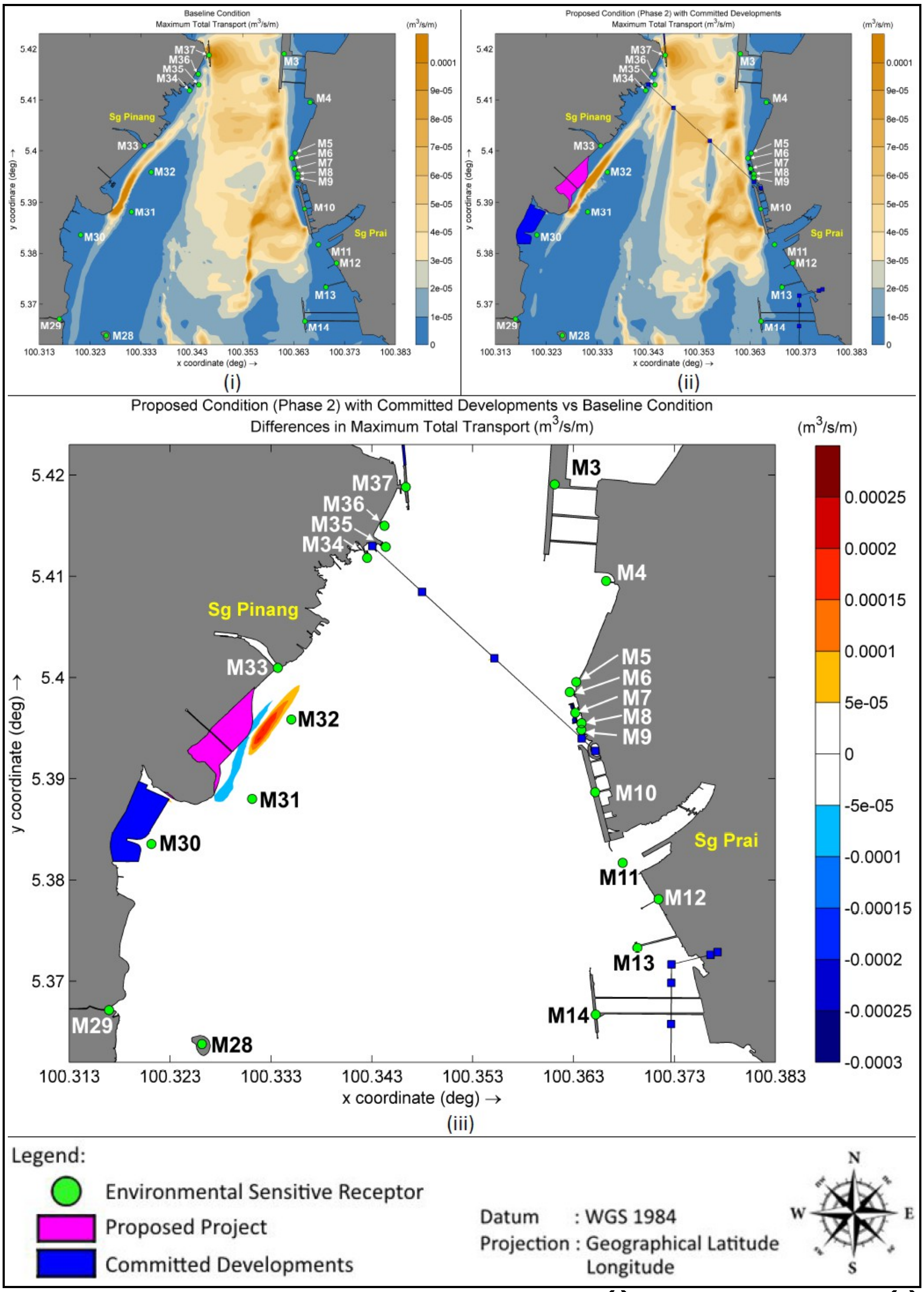


Figure 7.129: Maximum Sediment Transport For (i) Existing Condition; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Maximum Sediment Transport Between (i) And (ii).

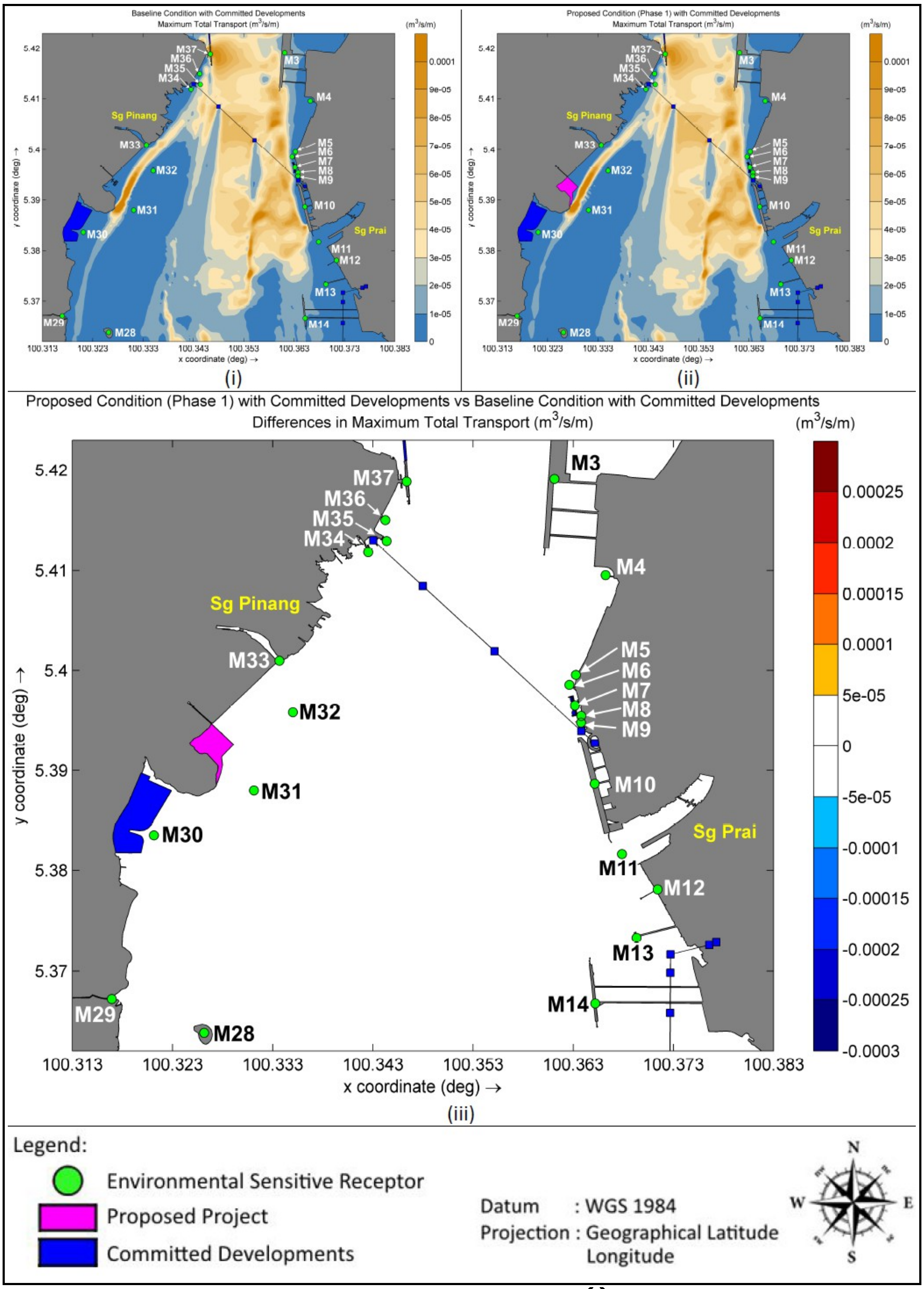


Figure 7.130: Maximum Sediment Transport For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 1) With Committed Developments; And (iii) Differences In Maximum Sediment Transport Between (i) And (ii).

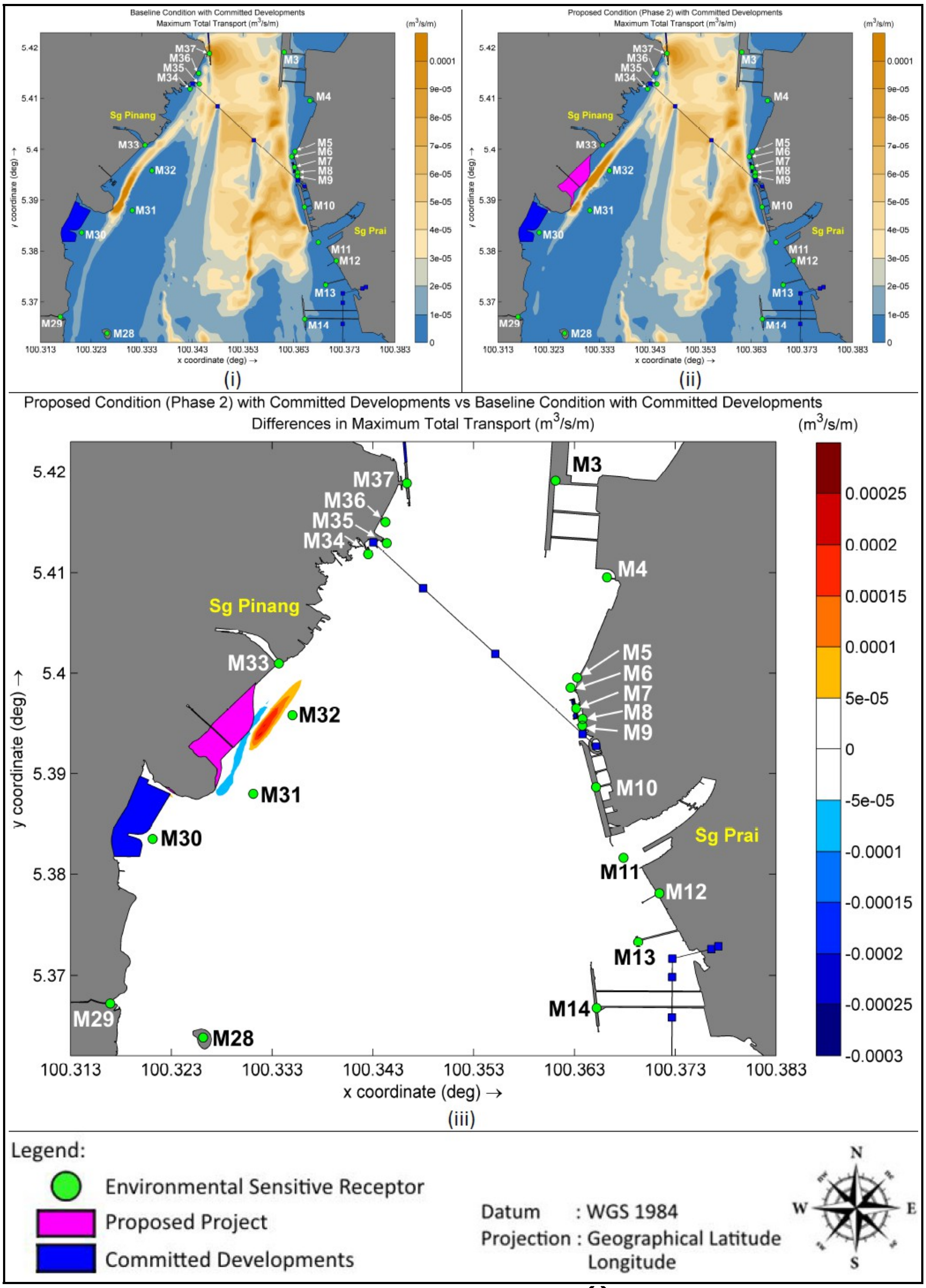


Figure 7.131: Maximum Sediment Transport For (i) Existing With Committed Developments; (ii) Proposed Condition (Phase 2) With Committed Developments; And (iii) Differences In Maximum Sediment Transport Between (i) And (ii).

an increase in the maximum sediment transport rate along the channel adjacent to the Proposed Project. The rate of increase goes up to 2.5 x 10-4 m^3/s/m. There is also slight reduction in magnitude of the maximum sediment transport rate, though at a much smaller scale of 1 x 10-4 m^3/s/m along the Proposed Project boundary;

- **Figure 7.128** shows the cumulative impacts due to other approved committed developments on maximum sediment transport rate. Although the Proposed with Committed Development scenarios shows a reduction of sediment transport rate around the Pylons of Sky Cab in Figure (ii) of **Figure 7.128**, there is no notable differences in the comparison figure. This indicates that any other changes in maximum sediment transport rate due to approved committed developments are less than 5 x 10-5 m^3/s/m;
- According to earlier **Table 7.45**, changes observed on the maximum sediment transport rate at the identified ESR points due to Proposed Project are minimal, less than 6 x 10-7 m^3/s/m at most ESR points except for ESR points M28 (Seagrass), M35 (Pengkalan Raja Tun Uda Ferry Terminal) and M37 (Swettenham Pier) with changes ranging from 1.7 x 10-6 m^3/s/m to 3.3 x 10-6 m^3/s/m;
- Earlier **Table 7.45** also shows higher cumulative changes in maximum sediment transport rate due to approved committed developments at the identified ESR points. Magnitude of differences are less than 1.2 x 10-6 m^3/s/m for most ESR points, except for points M3 (NBCT) and M37 (Swettenham Pier), both of which are notably located in the narrowest part of the Penang Strait as well as ESR point M28 (Seagrass) located along the channel to the south of Proposed Project. These points experiences changes in maximum sediment transport rate from 2.1 x 10-6 m^3/s/m to 1.12 x 10-5 m^3/s/m, with point M37 (Swettenham Pier) experiencing the highest change; and
- The results indicate that changes in maximum sediment transport rate due to Proposed Project are considered localized and minimal.

v) Impacts On Sedimentation/Erosion Rate

Table 7.46 provides the general observations on each modelling scenarios were made based on the results whilst **Table 7.47** provides the summary of impacts from the Proposed Project compared to baseline condition.

Table 7.46
Impact On Sedimentation/Erosion Rate

Sedimentation/ Erosion Rate	Baseline Condition	Proposed Condition	Baseline Condition with Committed Developments	Proposed Condition with Committed Developments
1-Year	• Rate of sedimentation/erosion within deep channel fronting Jelutong site is less than 0.6 m. • Patches of sedimentation and erosion also occurs along the shoreline and deep channels, mostly at a rate less than 0.4 m.		• Sedimentation/erosion condition are similar as Baseline Condition. • Additionally, there will be changes in seabed at the middle of Penang Strait, around the committed developments in similar order less than 0.4 m.	

Table 7.46 (Continue)

Sedimentation/ Erosion Rate	Baseline Condition	Proposed Condition	Baseline Condition with Committed Developments	Proposed Condition with Committed Developments
2-Years	• Predicted erosion within the deep channel fronting Jelutong is observed to occur up to 1.2 m. The sediment is expected to be transported to the side, causing sedimentation along the same channel up to 1.4m. • The middle bank is predicted to experience erosion of 0.4 m. • Patches of both erosion and sedimentation are expected to occur within Penang Strait mostly between 0.4 m to 0.6 m.		• Most of the sedimentation/erosion condition are similar as Baseline Condition. • Obvious differences are noted around the committed developments in the middle of Penang Strait, with both erosion and sedimentation expected to occur up to 0.6 m.	
5-Years	• Generally, the shoreline of Penang Island to the west and Peninsular Malaysia to the east are predicted to observe sedimentation along the coast, with magnitude ranging from 0.4 m to 0.8 m. • Areas that were predicted to have sedimentation and erosion after 1-year and 2-year period will have similar pattern of bed level changes. However, the magnitude of changes are expected to be up to 2.4 m along the deep channel next to Proposed Jelutong site. • Erosion and sedimentation process are expected to occur within the Penang Strait up to 1.4 m. • General observation over the 5 years period show that erosion is the dominant process along the Penang Strait, mostly within 0.6 m. • Sedimentation occurs mainly along shorelines and deep channel, where the eroded sediment are expected to drift and settle along the steep slope within near vicinity.		• Most of the erosion and sedimentation patterns observed in this scenario are similar to the Baseline Condition. • Obvious differences are noted around the committed developments in the middle of Penang Strait, with both erosion and sedimentation expected to occur up to 1.2 m. • The presence of committed developments which include proposed IJM reclamation area will reduce the potential sedimentation along the shoreline to the south of Jelutong site.	
10-Years	• The pattern of sedimentation and erosion areas are similar to the predicted condition for 5 years period. However the magnitude have increased almost twice the magnitude, especially in the deep channel fronting the proposed Jelutong site, observable even during the Baseline Condition. • Heavier sedimentation is expected to occur along the shoreline up to 1.2 m, notably to the south of Project area on the Penang Island side as well as the shoreline near Sg Prai river mouth to the northeast. • For the most part, the Penang Strait is observed to experience widespread erosion ranging from 0.4 m up to 2 m. • It is noted that areas with high sedimentation tend to occur within close vicinity to highly eroded area, which suggested that the movement of sediments are minimal, where the displaced sediments from the erosion process were brought to settle at another area within short distance.		• The erosion and sedimentation patterns observed in this scenario are similar to the Baseline Condition. • The presence of committed developments which include proposed IJM reclamation area will reduce the potential sedimentation along the shoreline to the south of Jelutong site. • Another notable sedimentation area is expected to the northeast of proposed project site near the river mouth of Sg Pinang, with potential sedimentation up to 1.6 m. • It is predicted that the committed developments at the middle part of Penang Strait is expected to cause changes in sedimentation and erosion rate up to about 2 m.	

Table 7.47
Summary Of Impacts From The Proposed Project Compared To Baseline Condition

Year	Description
1-Year	• Changes in bed level condition due to Proposed Project are mostly attributed to erosion within the deep channel with a bit of sedimentation on the slope of the channel. The differences in the predicted seabed changes are less than 0.4 m. • With the presence of proposed reclamation area, the deep channel is expected to have higher erosion and sedimentation in the channel compared to the Baseline Condition.
2-Years	• Changes in bed level condition due to Proposed Project are observed in the deep channel fronting the proposed Jelutong site. The erosion is expected to increase by 1.5 m, whereas sedimentation may occur along the boundary of the proposed reclamation up to the northeast area near the river mouth of Sg Pinang at range less than 0.9 m. • Patches of sedimentation and erosion are expected to occur along the shorelines. The differences due to Proposed Project shows a minimal increase of up to 0.9 m though within small extent.
5-Years	• Changes in bed level condition due to Proposed Project are observed to occur along the deep channel fronting proposed Jelutong site. The magnitude of erosion is expected to increase up to 2.4 m, whereas sedimentation may occur along the boundary of the proposed reclamation up to the northeast area near the river mouth of Sg Pinang at range less than 1.8 m. • Compared to 1-Year and 2-Years extent of seabed changes, the extent is wider in 5-Years where the sedimentation and erosion of bed level is observed further down the south of the channel, though the magnitude are within the range 1.5 m.
10-Years	• The extent of seabed level changes for 10-Years are similar to 5-Years, which are mostly contained within the deep channel alongside Jelutong site. However it is observed that there will be some sedimentation along the middle bank (M31) with increased bed level up to 0.6 m for 10-Years period which was not previously observed in 5-Years period. • The magnitude of differences fronting the proposed project at Jelutong site has noticeable increase with higher values of changes caused by the presence of proposed reclamation.

vi) Impacts On Sediment Budget Analysis

The modelling results demonstrate that the littoral transport rate along the Penang Island coastline where the Proposed Project is located is predominantly moving from Northeast to Southwest direction. The predicted annual gross transport and annual net transport for each transect line is tabulated in **Table 7.48.** It is observed that the sediment budget for each coastal transect lines remain fairly similar and consistent between each transect lines.

Table 7.48
Modeling Scenario

Modeling Scenarios	Annual Gross Transport (m3/year)			Annual Net Transport (m3/year)		
	T1	T2	T3	T1	T2	T3
Baseline Condition	4,600	6,009	6,145	2,836	3,420	3,602
Proposed Condition	3,844 (↓)	5,160 (↓)	5,752 (↓)	2,269 (↓)	3,106 (↓)	3,390 (↓)
Baseline Condition with Committed Developments	4,529 (↓)	5,958 (↓)	6,009 (↓)	2,735 (↓)	3,413 (↓)	3,577 (↓)
Proposed Condition with Committed Developments	3,818 (↓)	5,050 (↓)	5,653 (↓)	2,298 (↓)	3,066 (↓)	3,546 (↓)

From **Table 7.48**, it is observed that, when compared with the baseline condition:-

- Proposed Condition will cause a decrease in the annual transport, ranging between 393 m^3/year to 849 m^3/year for gross transport and between 212 m^3/year to 567 m^3/year for annual net transport along the identified transect lines;
- Baseline condition with Committed Developments will have similar though slightly lower transport values in comparison. The presence of committee developments is expected to lower the overall transport within the identified vicinity at a range less than 100 m^3/year; and
- Proposed Condition with Committed Developments will have similar though slightly lower transport magnitude in comparison to Proposed Condition in general, except slightly higher annual net transport at line T3 at magnitude difference of approximately 150 m^3/year.

vii) Impacts On Shoreline Evolution Analysis

The following observations were made based on the analysed modelling results:-

- Based on **Figure 7.132**, it is observed that the in general overview, any shifts of contours over the ten years period are considered localized, with minor shifts within near vicinity. This general finding is observed for all modelling scenarios; and
- It is observed however, that the presence of proposed reclamation at Jelutong would cause a change in the seabed contour along the deep navigation channel fronting the proposed reclamation area. Based on **Figure 7.132**, the deepest part of the navigation channel is predicted to spread wider in comparison to the baseline condition. However this change is predicted occur from the 5-yr onwards, growing deeper and wider by the tenth year.

viii) Impacts On Flushing Capacity

Referring to United Stated Environmental Protection Agency (EPA, 1985), a complete water exchange in four (4) days is considered "Good", in ten (10) days as "Fair" and "Poor" for longer time is needed. Based on the predicted flushing capacity model, all modelled scenarios therefore had retained "Good" flushing capacity as the pollutant tracer had been fully dispersed and diluted within nine (9) hours.

The presence of the proposed reclamation does not cause any adverse impacts to the flushing capacity of Outlet 2 or any other river and discharge outlets. Therefore, no mitigation measures are required.

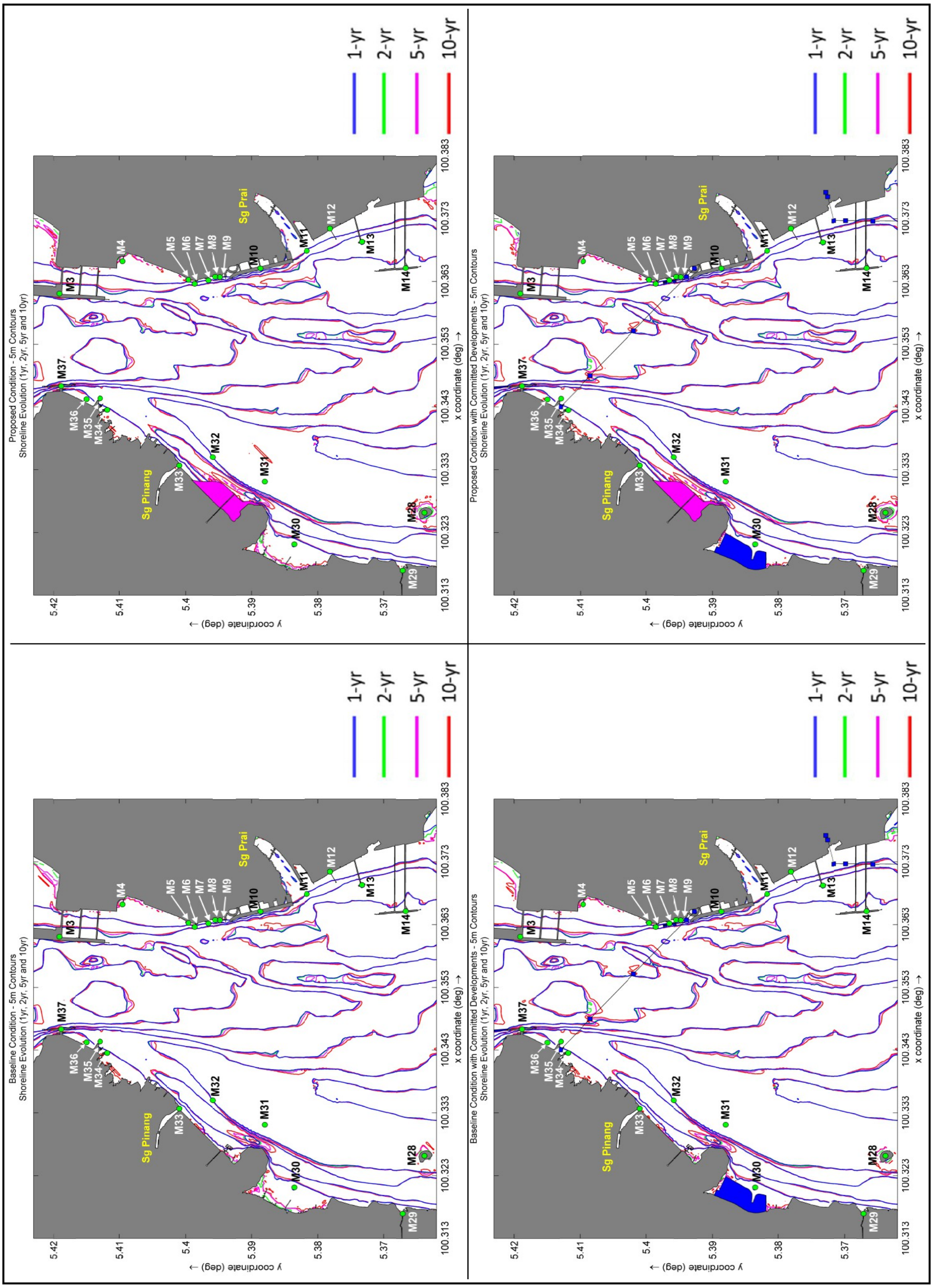


Figure 7.132 Predicted Seabed Elevation Contours For Each Modelled Scenarios For 1-Yr, 2-Yr, 5-Yr And 10-Yr

To be highlighted that the total flushing time condition as per modelled could be achieved provided that the discharge from each respective outlets and river are clean with constant flow as modelled in the Study. Polluted discharge from the rivers will otherwise add to the present pollutants within the waters and increases time needed to achieve complete flushing within the Project Area.

(b) Impact On Marine Water Quality

Sediment Plume Dispersion

This section addresses the sediment plume caused by water discharge during the reclamation works. The sediment plume models have been simulated for a full 16-days period which includes the spring and neap tide. In impact assessment, the simulated sediment concentration is added with the ambient value at the ESA locations and compared with the Marine Water Quality Standard. There are a total of twelve (12) scenarios modelled for the sediment plume assessment.

In order to predict the fill concentration of the sediment spillage discharge from the reclamation work, information of the operation procedure, fill material properties, reclamation phasing and control measures were obtained from the Client.

The following observations were made based on the analysed modelling results:-

General Observation

- It is observed that due to strong current flow in the deep channel adjacent to the Proposed Project, all scenarios largely produce similar pattern of dispersion where the sediment plume is dispersed in an elongated pattern along the current flow path to the north and south of the Project Area;
- Assessments were made to check the dispersion extent and concentration during morning (7am to 7pm) and night (7pm to 7am) times. Although the extent may be reduced slightly during the night, overall observation would suggest that the maximum dispersion extent is maintained regardless of the timing and hours;
- Seagrass area within the Study Area is denoted by the identified ESR M28 (Pulau Gazumbo). It is noted that the existing TSS value for point M28 has readily exceeded the allowable ambient value. However, the increase of sediment in the water column at point M28 during proposed reclamation work are mainly limited within 5 mg/L, as the extent of sediment plume dispersion is mostly contained within the navigation channel and does not easily encroach point M28. On the other hand, the middle bank area at point M32 is located within close

vicinity of the reclamation area, therefore the concentration of plume observed at this point are higher, mostly within the range of 20 mg/L. The impacts of sediment plume dispersion on the seagrass can be considered as minimal outside of the immediate vicinity area. Only the middle bank (M32) is perceived to be most affected seagrass area during proposed reclamation works;

- The sediment spill is observed to disperse in an elongated pattern along the Penang Island shoreline. Adjacent to the project site, the shallow middle bank area (M31) helps to contain the spread within the channel and prevents the sediment spill from spreading towards the middle of the Penang Strait. Consequently, the sediment spill will not reach the peninsular mainland on the eastern side;
- Generally, the extent of mean and maximum sediment dispersion are similar for all reclamation phases irrespective of the wind conditions (ie. Pure Tide condition, Northeast Monsoon, Southwest Monsoon). The wind conditions will not significantly affect the extent of sediment plume dispersion and its concentration;
- Phase 1 and Phase 2 reclamations observed similar dispersion patterns; and
- The silt curtain scenarios with assumed 70% efficiency significantly reduce the extent and magnitude of sediment dispersion.

<u>Without Silt Curtain</u>
Reclamation Phase 1 (**Figure 7.133 to Figure 7.135**).
Reclamation Phase 2 (**Figure 7.136 to Figure 7.138**).

- For mean sediment plume dispersion, the extent of dispersion is limited within the Project Site area. The dispersion is mainly less than 20 mg/L;
- At the discharge point, the concentration of sediment dispersion goes up to 30 mg/L;
- Mean sediment dispersion at the ESR points for both Phase 1 and Phase 2 scenarios are less than 5.1 mg/L;
- For maximum sediment plume dispersion, the extent of dispersion is wider along the Penang island shoreline;
- The dispersion reaches ESR point M37 (Swettenham Pier) to the north and goes beyond M29 (River mouth Sg Gelugor 1) and M28 (Pulau Gazumbo) to the south. The magnitude of sediment concentration that reaches these ESR points are less than 20 mg/L;
- Sediment concentration above 50 mg/L are mostly concentrated within the Project Site and discharge point;
- Three (3) ESR points which exceeded the allowable MMWQS limit due to maximum sediment plume dispersion, which are M25 (River mouth Sg Gelugor 2), M29 (River mouth Sg Gelugor 1) and M32 (Aquaculture Jelutong 2); and

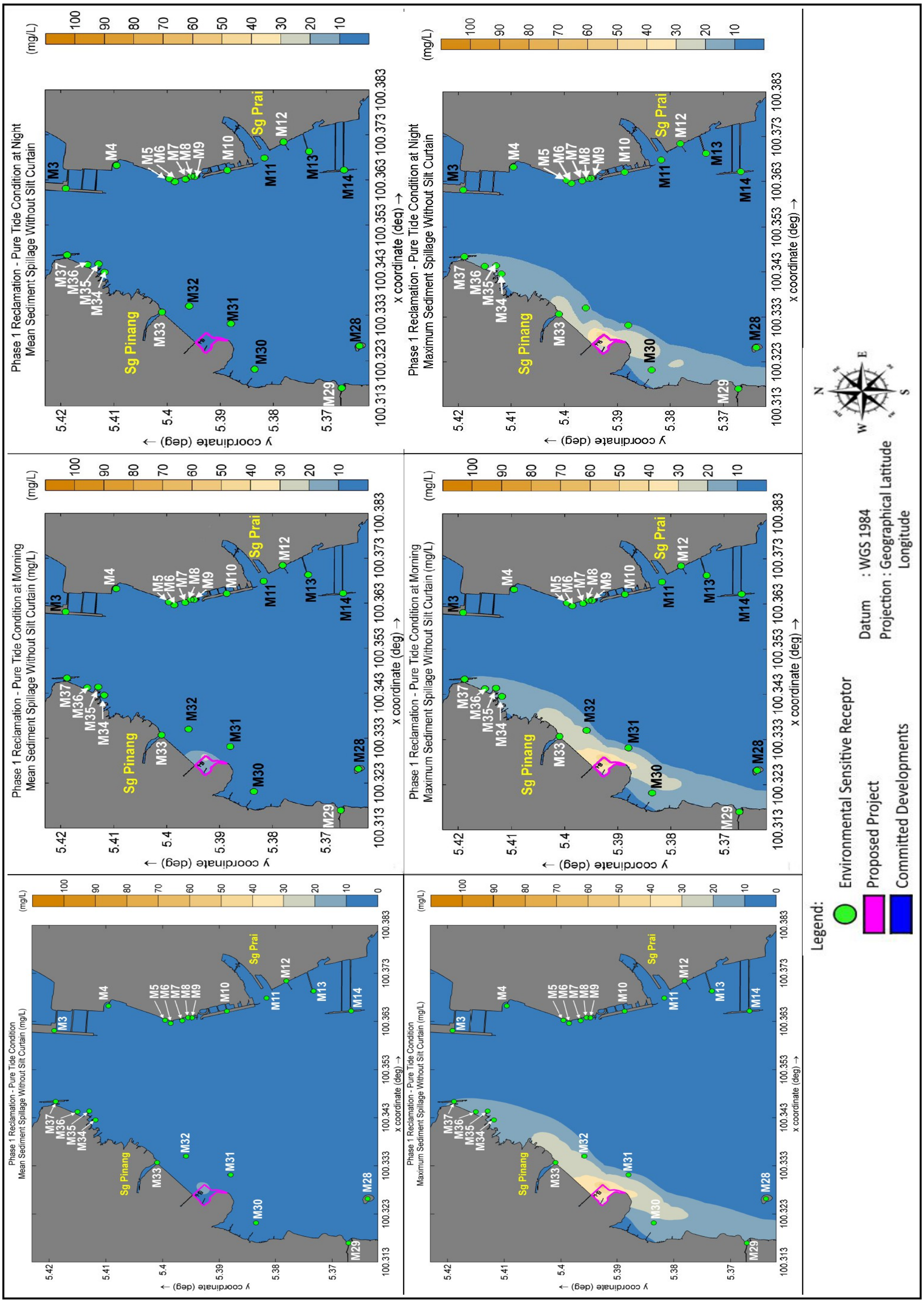


Figure 7.133 Mean And Maximum Sediment Plume Dispersion For Phase 1 Reclamation (Pure Tide Condition) Without Silt Curtain (Overall, Morning & Night Times)

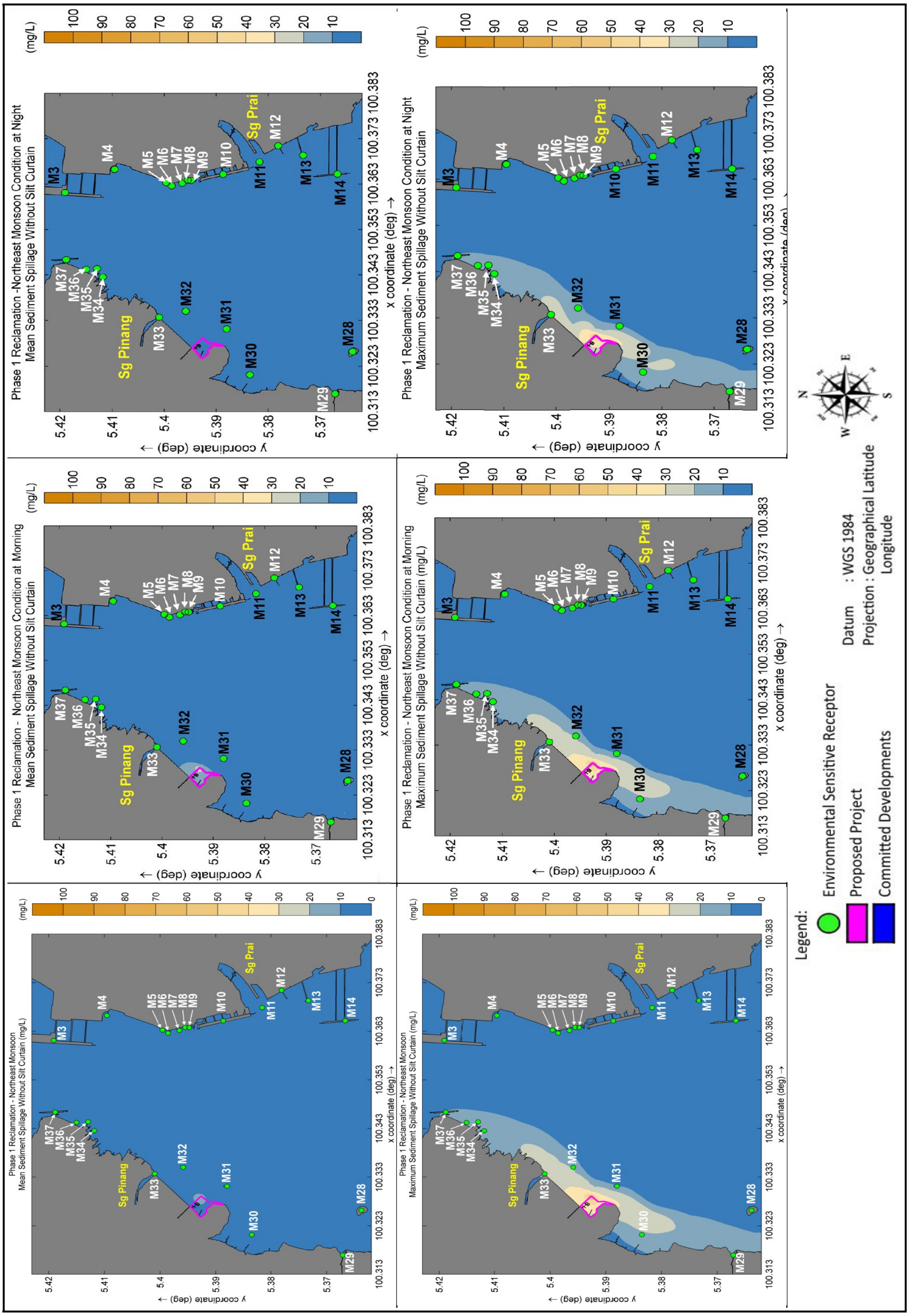


Figure 7.134 Mean And Maximum Sediment Plume Dispersion For Phase 1 Reclamation (Northeast Monsoon) Without Silt Curtain (Overall, Morning & Night Times)

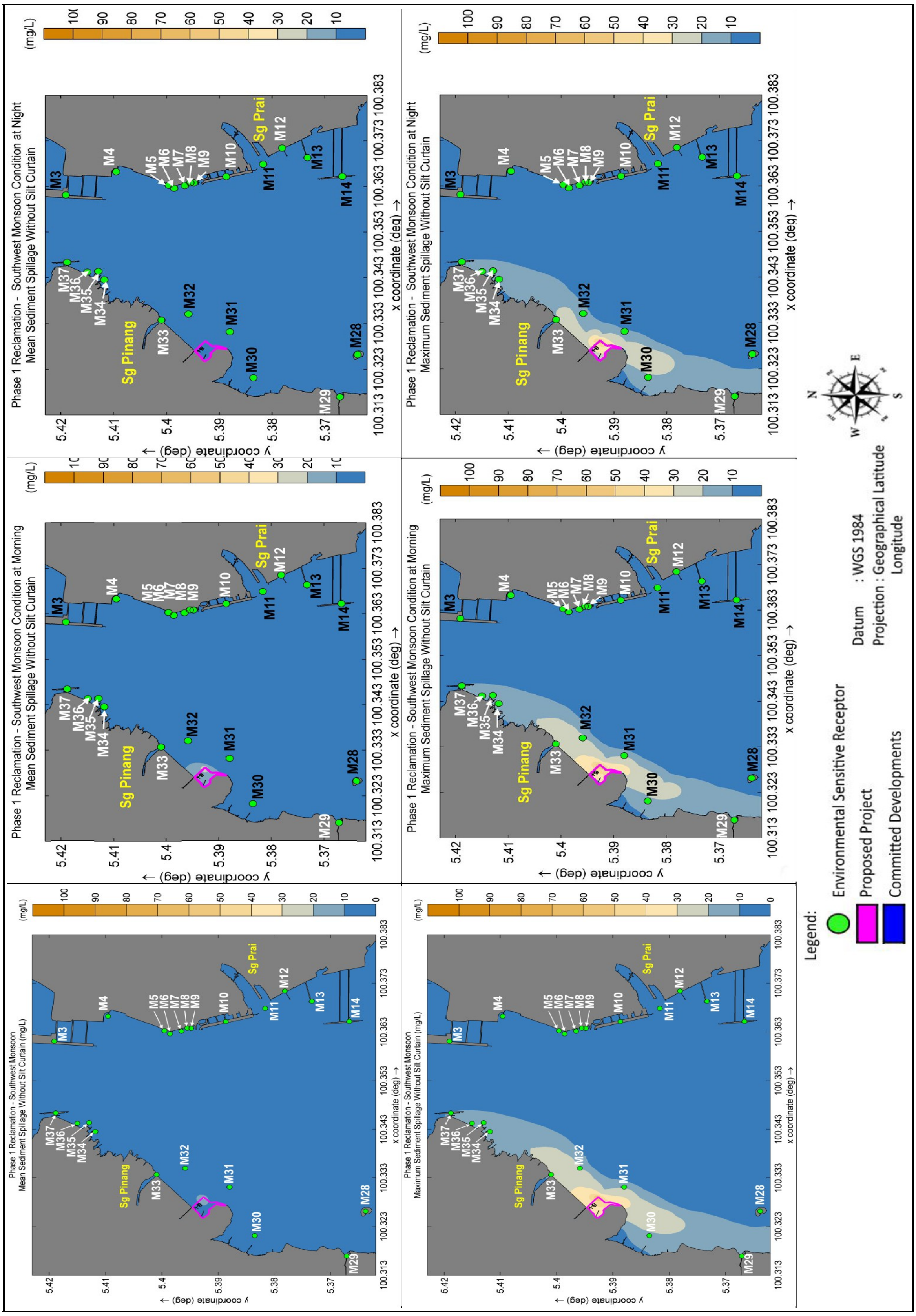


Figure 7.135 Mean And Maximum Sediment Plume Dispersion For Phase 1 Reclamation (Southwest Monsoon) Without Silt Curtain (Overall, Morning & Night Times)

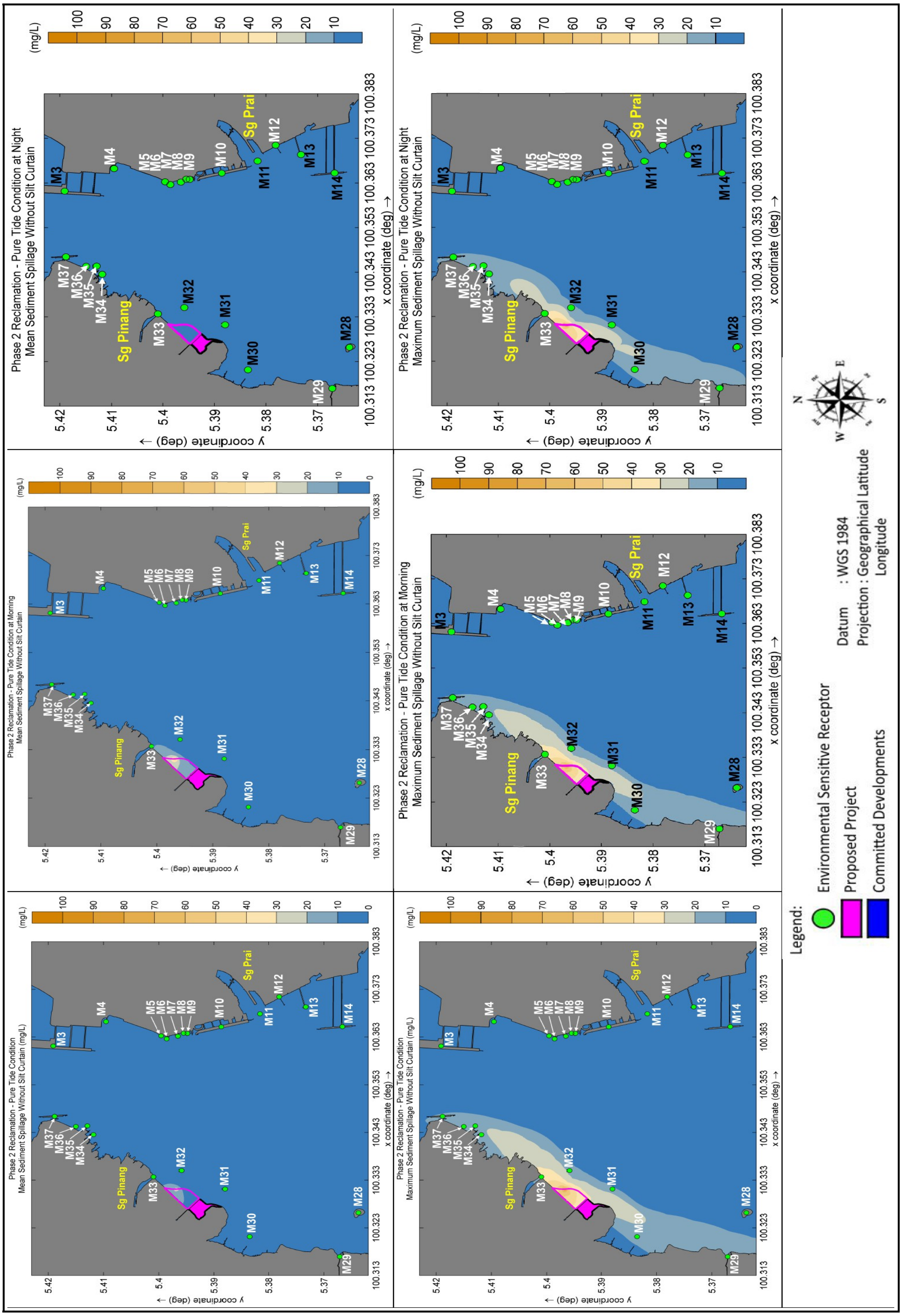


Figure 7.136 Mean And Maximum Sediment Plume Dispersion For Phase 2 Reclamation (Pure Tide condition) Without Silt Curtain (Overall, Morning & Night Times)

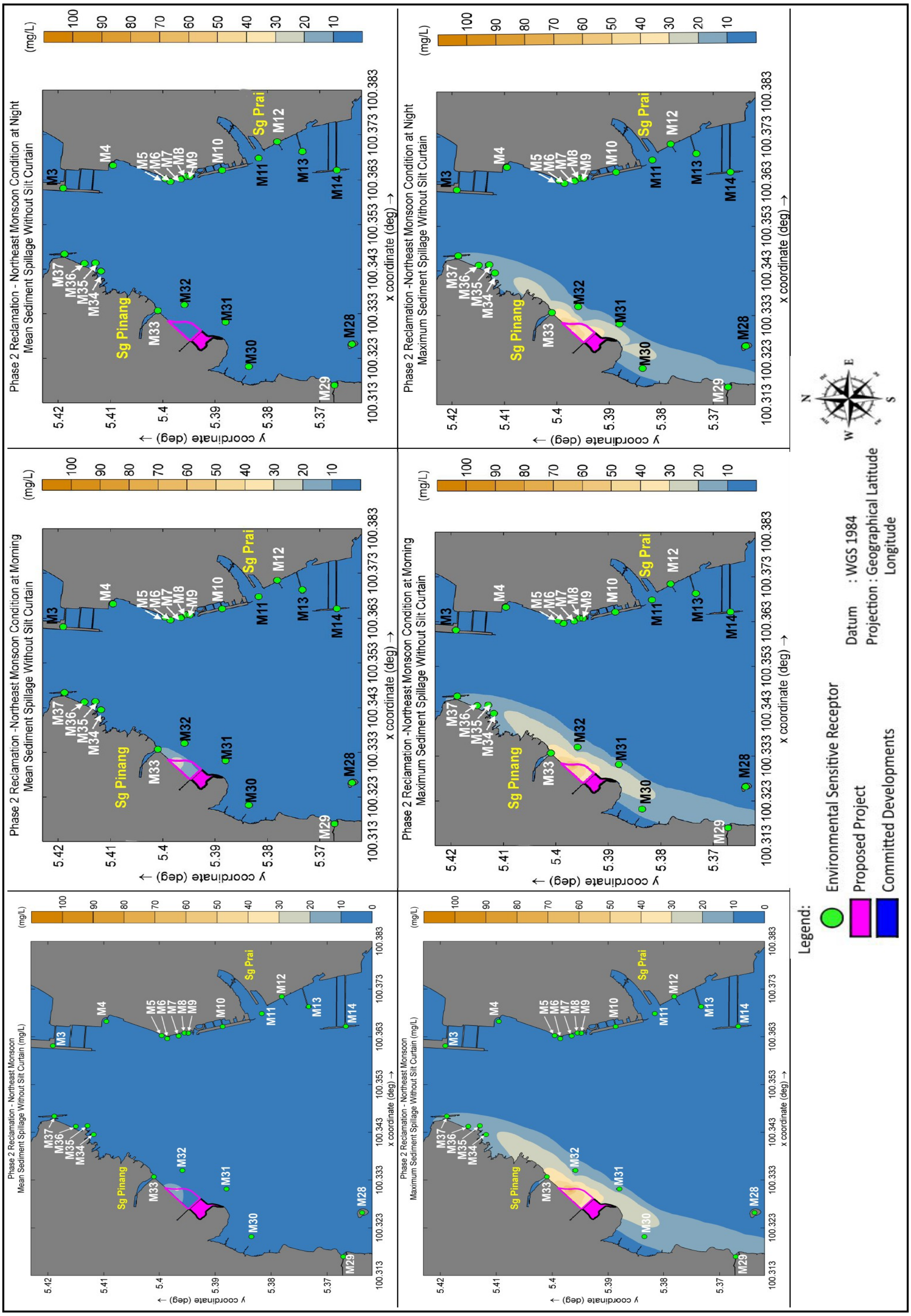


Figure 7.137 Mean And Maximum Sediment Plume Dispersion For Phase 2 Reclamation (Northeast Monsoon) Without Silt Curtain (Overall, Morning & Night Times)

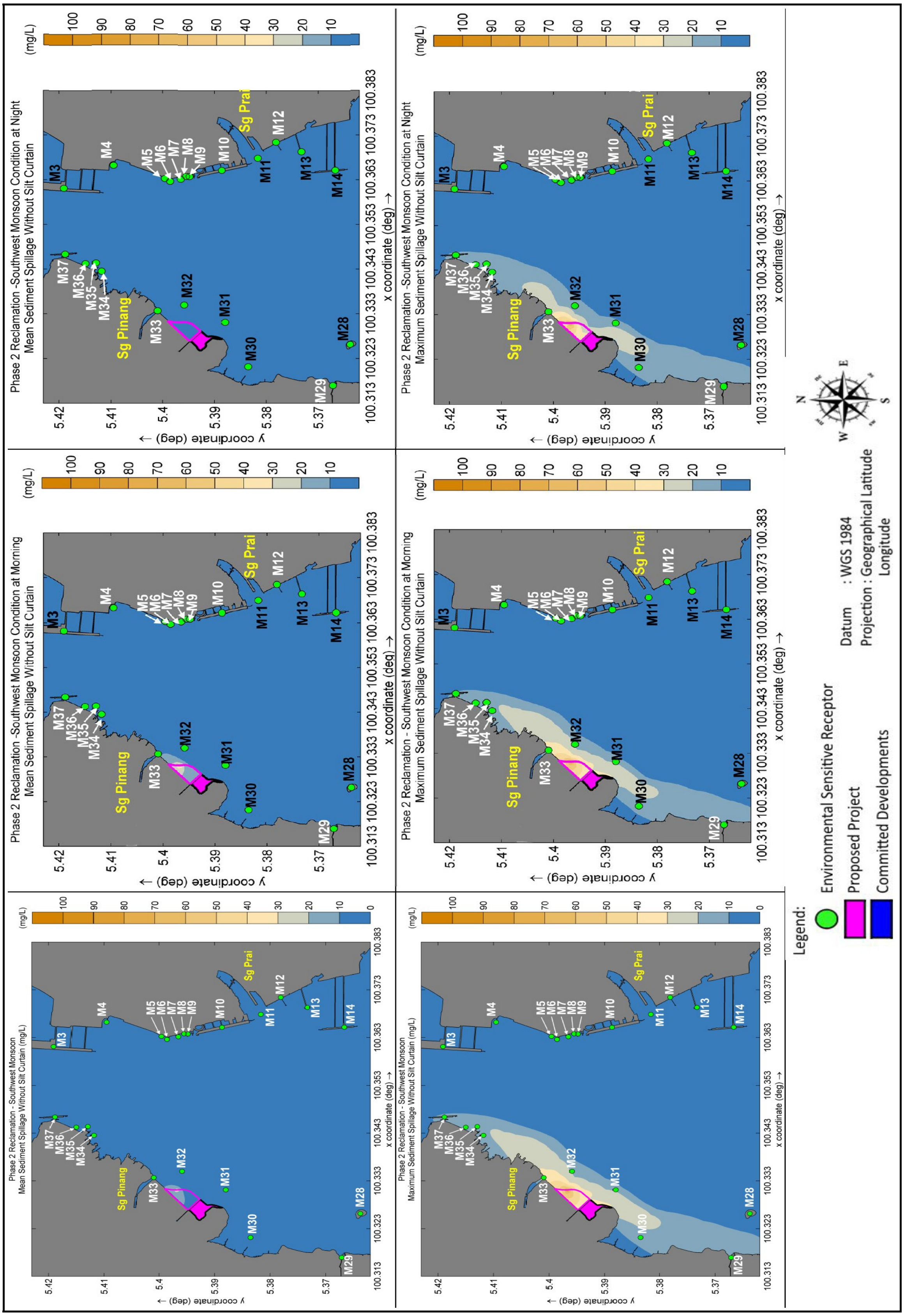


Figure 7.138 Mean And Maximum Sediment Plume Dispersion For Phase 2 Reclamation (Southwest Monsoon) Without Silt Curtain (Overall, Morning & Night Times)

- Maximum sediment dispersion for ESR points on the eastern side of Penang Strait (M1 to M18) are less than 0.4 mg/L, whereas on the western side along the Penang Island shoreline (M19 to M41) the maximum sediment dispersion goes up to 25.3 mg/L, with the highest value observed at ESR point M33 which is the river mouth of Sg Pinang located to the north of Proposed Project.

<u>With Silt Curtain</u>
Reclamation Phase 1 (**Figure 7.139 to Figure 7.141**).
Reclamation Phase 2 (**Figure 7.142 to Figure 7.144**).

- For mean sediment plume dispersion, the extent of dispersion has diminished significantly. The dispersion is localized at the discharge point up to 20 mg/L;
- Mean sediment dispersion at the ESR points are less than 1.5 mg/L;
- Sediment dispersion at the identified ESR points, if any, are less than 10 mg/L;
- For maximum sediment plume dispersion, the extent of dispersion has been reduced. The dispersion of 20 mg/L contour is mainly contained within vicinity of the Proposed Project site;
- For Phase 1 reclamation, the dispersion does not reach ESR points M31, M32 and M33, all of which are located adjacent to the Proposed Project;
- For Phase 2 reclamation, the extent of maximum dispersion for 20 mg/L reaches M33 (River mouth of Sungai Pinang, however it does not reach any other identified ESR points;
- Sediment concentration within the Project Site is mostly less than 20 mg/L, with higher concentration up to 30 mg/L at the discharge point;
- Maximum sediment dispersion for ESR points on the eastern side of Penang Strait (M1 to M18) are less than 0.1 mg/L, whereas on the western side along the Penang Island shoreline (M19 to M41) the maximum sediment dispersion goes up to 7.6 mg/L, with the highest concentration observed at ESR point M33 (River mouth of Sg Pinang) adjacent to the Proposed Project site. All ESR points are within the allowable TSS increase limit.

<u>Sediment Plume - Exceedance Of Sediment Concentration</u>

The probability maps show the percentage of time, during the simulation period, where a certain depth averaged excess SSC (Suspended Sediment Concentration) is exceeded. The selected exceedance thresholds in this assessment are 5 mg/L, 10 mg/L, 25 mg/L and 50 mg/L. The following observations were made based on the analysed modelling results.

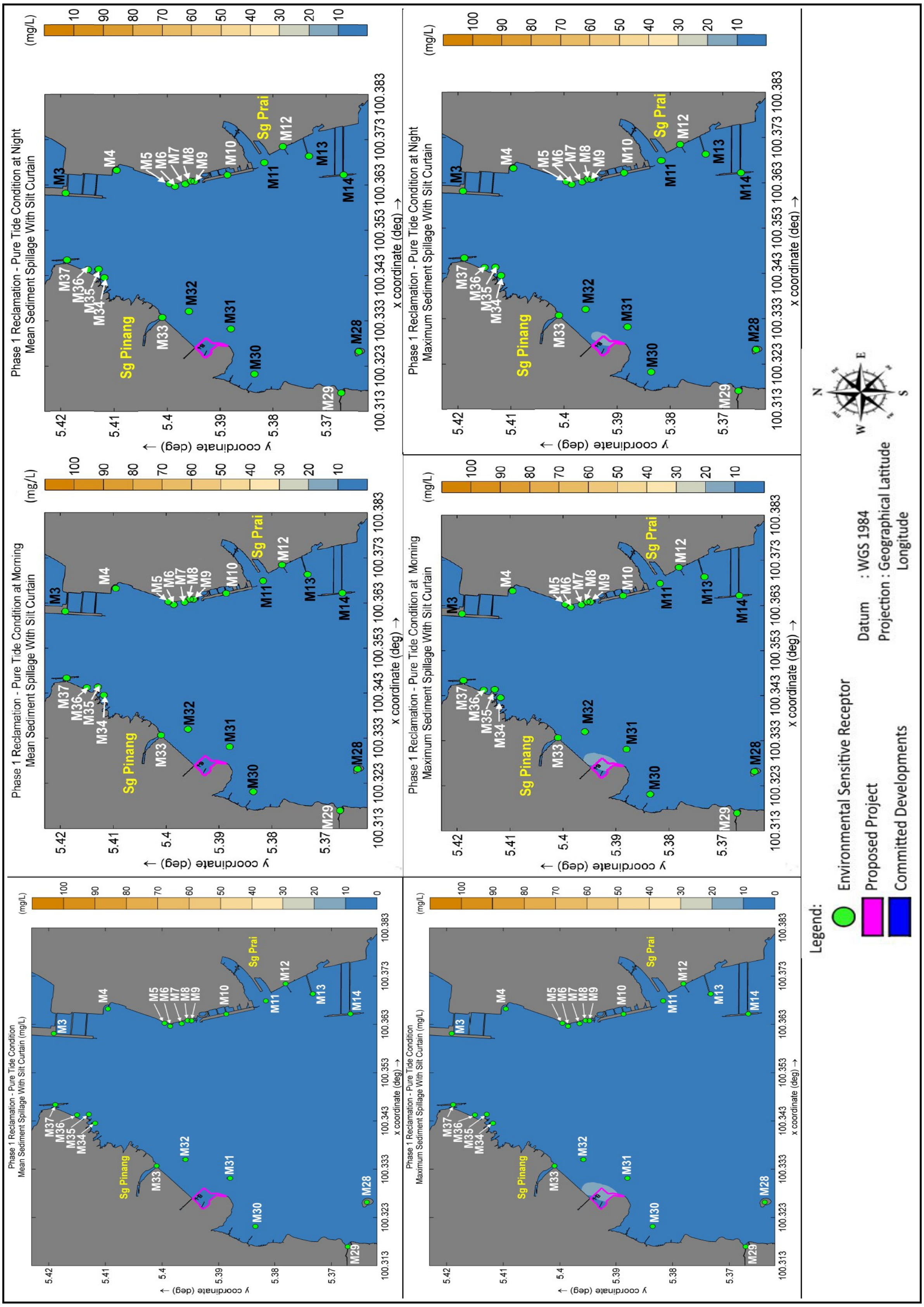


Figure 7.139 Mean And Maximum Sediment Plume Dispersion For Phase 1 Reclamation (Pure Tide Condition) With Silt Curtain Installed (Overall, Morning & Night Times)

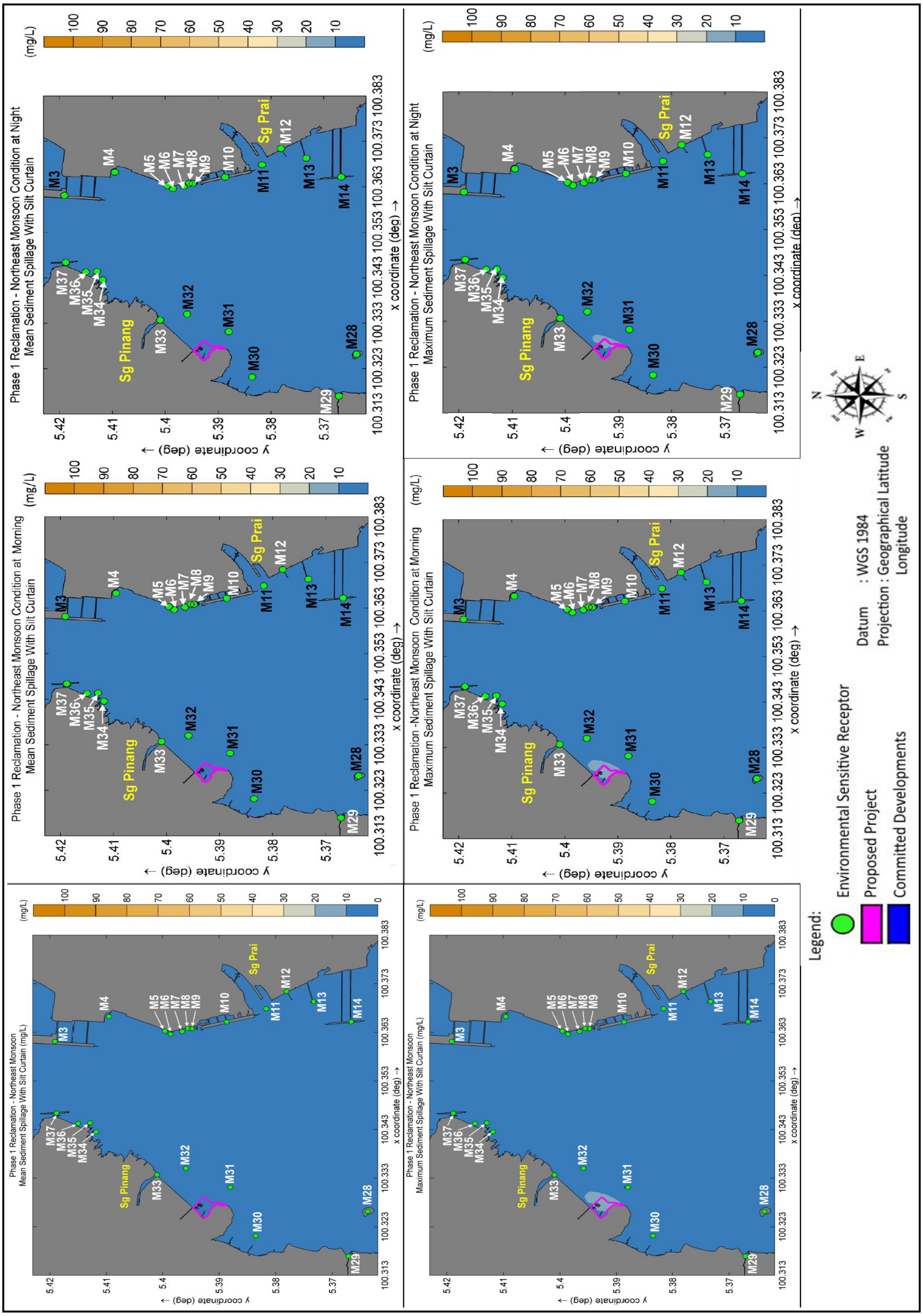


Figure 7.140 Mean And Maximum Sediment Plume Dispersion For Phase 1 Reclamation (Northeast Monsoon) With Silt Curtain Installed (Overall, Morning & Night Times)

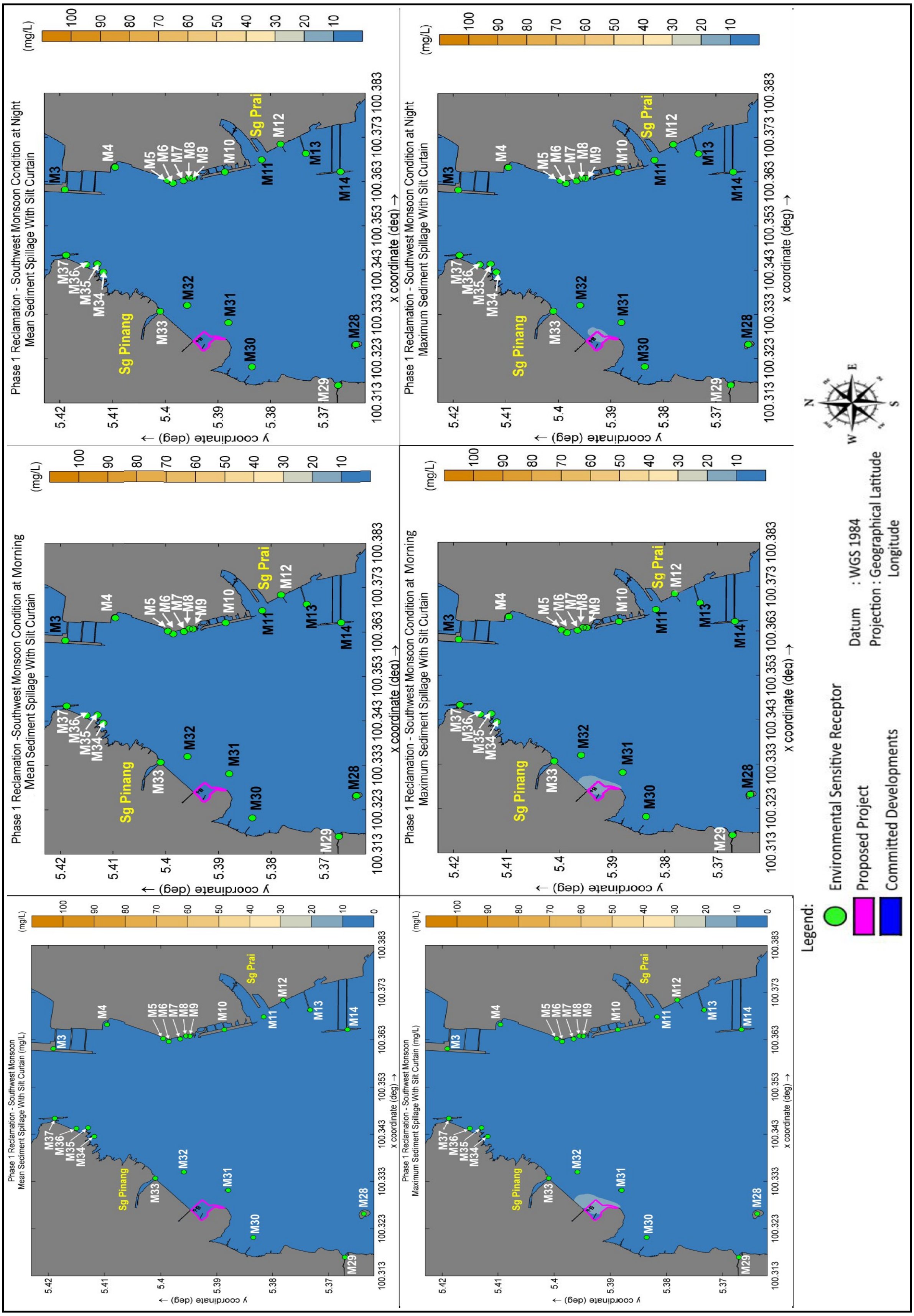


Figure 7.141 Mean And Maximum Sediment Plume Dispersion For Phase 1 Reclamation (Southwest Monsoon) With Silt Curtain Installed (Overall, Morning & Night Times)

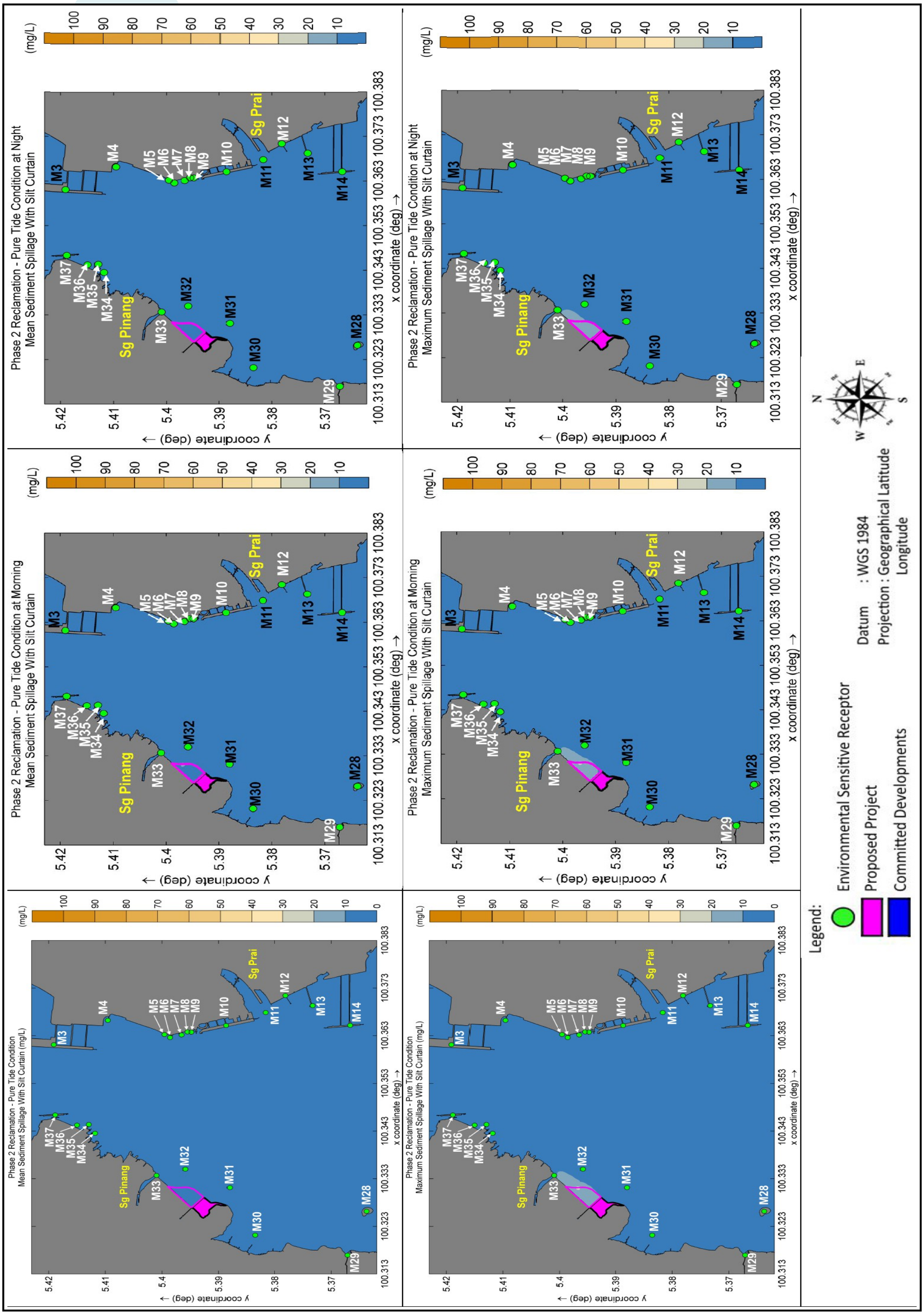


Figure 7.142 Mean And Maximum Sediment Plume Dispersion For Phase 2 Reclamation (Pure Tide condition) With Silt Curtain Installed (Overall, Morning & Night Times)

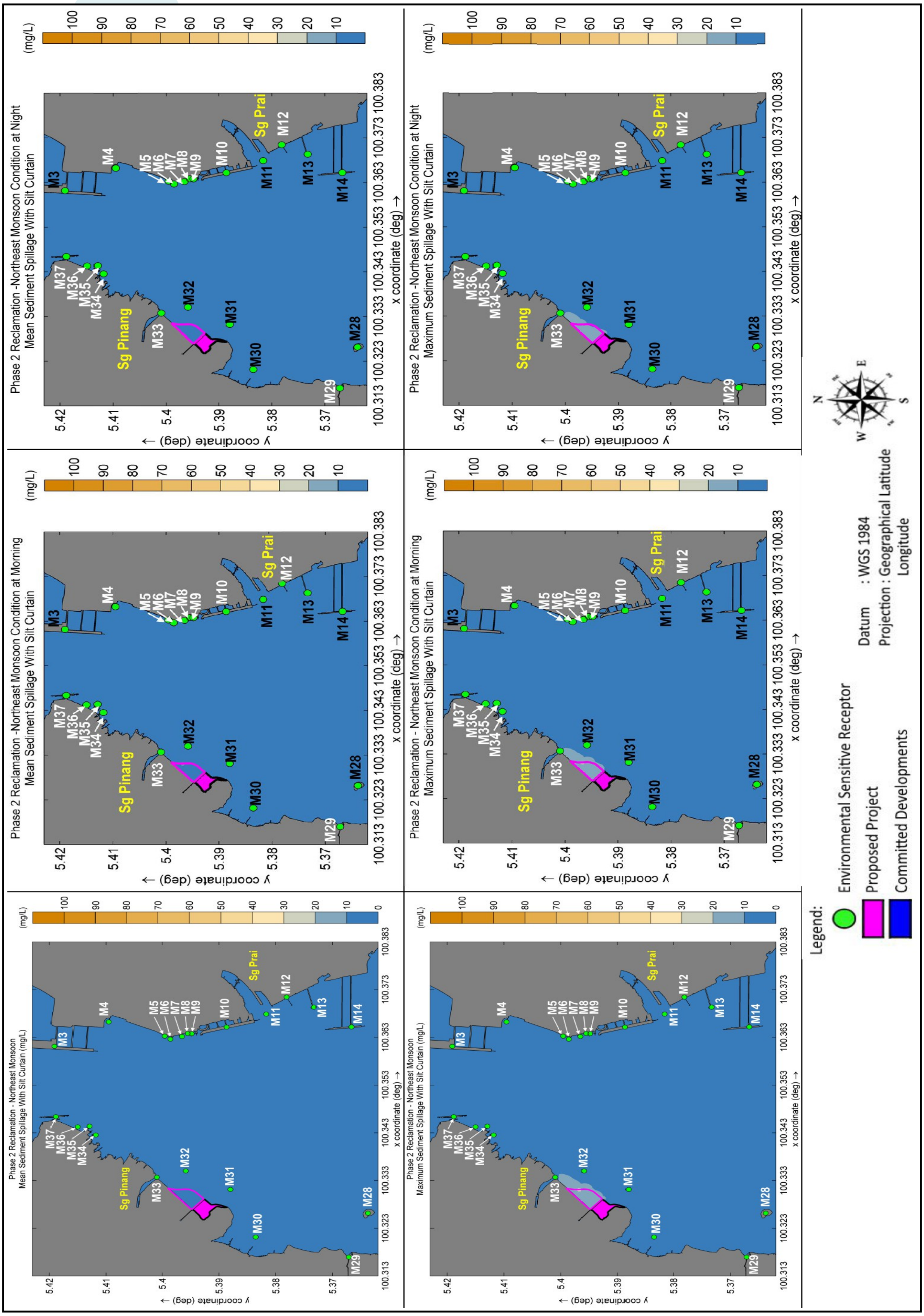


Figure 7.143 Mean And Maximum Sediment Plume Dispersion For Phase 2 Reclamation (Northeast Monsoon) With Silt Curtain Installed (Overall, Morning & Night Times)

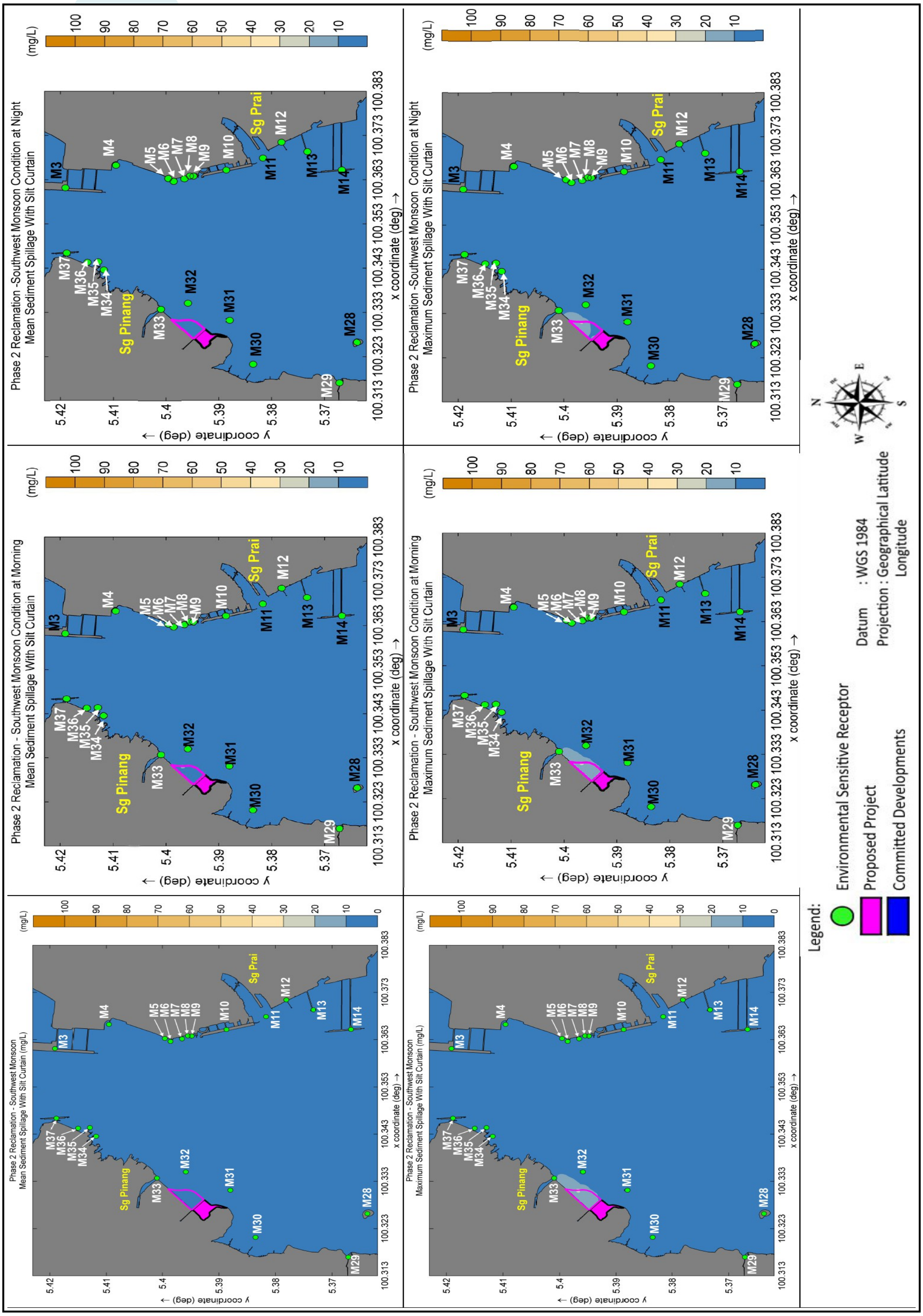


Figure 7.144 Mean And Maximum Sediment Plume Dispersion For Phase 2 Reclamation (Southwest Monsoon) With Silt Curtain Installed (Overall, Morning & Night Times)

General Observations

- All scenarios produce largely similar pattern of dispersion irrespective of the reclamation phases and monsoon wind conditions;
- The sediment spill is observed to disperse along the Penang Island shoreline. Adjacent to the project site, the shallow middle bank area (M31) helps to contain the spread within the channel and prevents the sediment spill from spreading towards the middle of the Penang Strait. Consequently, the sediment spill will not reach the Peninsular mainland on the eastern side; and
- The silt curtain scenarios significantly reduce the extent and magnitude of sediment dispersion.

Without Silt Curtain

Reclamation Phase 1 (**Figure 7.145 to Figure 7.147**).
Reclamation Phase 2 (**Figure 7.148 to Figure 7.150**).

- Probability of exceedance of excess suspended sediment concentration over 5 mg/L.
  - The spread of exceedance reaches ESR point M37 (Swettenham Pier) to the north and goes beyond M29 (River mouth Sg Gelugor 1) and M28 (Pulau Gazumbo) to the south. The percentage of exceedance at these ESR points are up to 15% for M37 and up to 20% for M29.
  - The percentage of exceedance that reaches the cluster of ESR points around Proposed Project site (M30 to M33) goes up to 30% for Phase 1 and up to 35% for Phase 2.
  - Within the Project Site vicinity and discharge point, percentage of exceedance for over 5 mg/L goes up to 50%.
- Probability of exceedance of excess suspended sediment concentration over 10 mg/L.
  - For Phase 1, the spread of exceedance reaches ESR point M34 (Chew Jetty) to the north and around M30 (Aquaculture Jelutong 1) to the south. The percentage of exceedance at these ESR points are up to 10%. For Phase 2, the extent of 10% exceedance goes slightly further to the north, reaching ESR point M36 (Tanjung City Marina).
  - Percentage of exceedance for over 10 mg/L goes up to 20% around ESR point M33 (River mouth of Sg Pinang) for Phase 1 and up to 30% for Phase 2 reclamation.
  - Within the Project Site vicinity and discharge point, percentage of exceedance for over 10 mg/L goes up to 45% and 55% for Phase 1 and Phase 2 respectively.

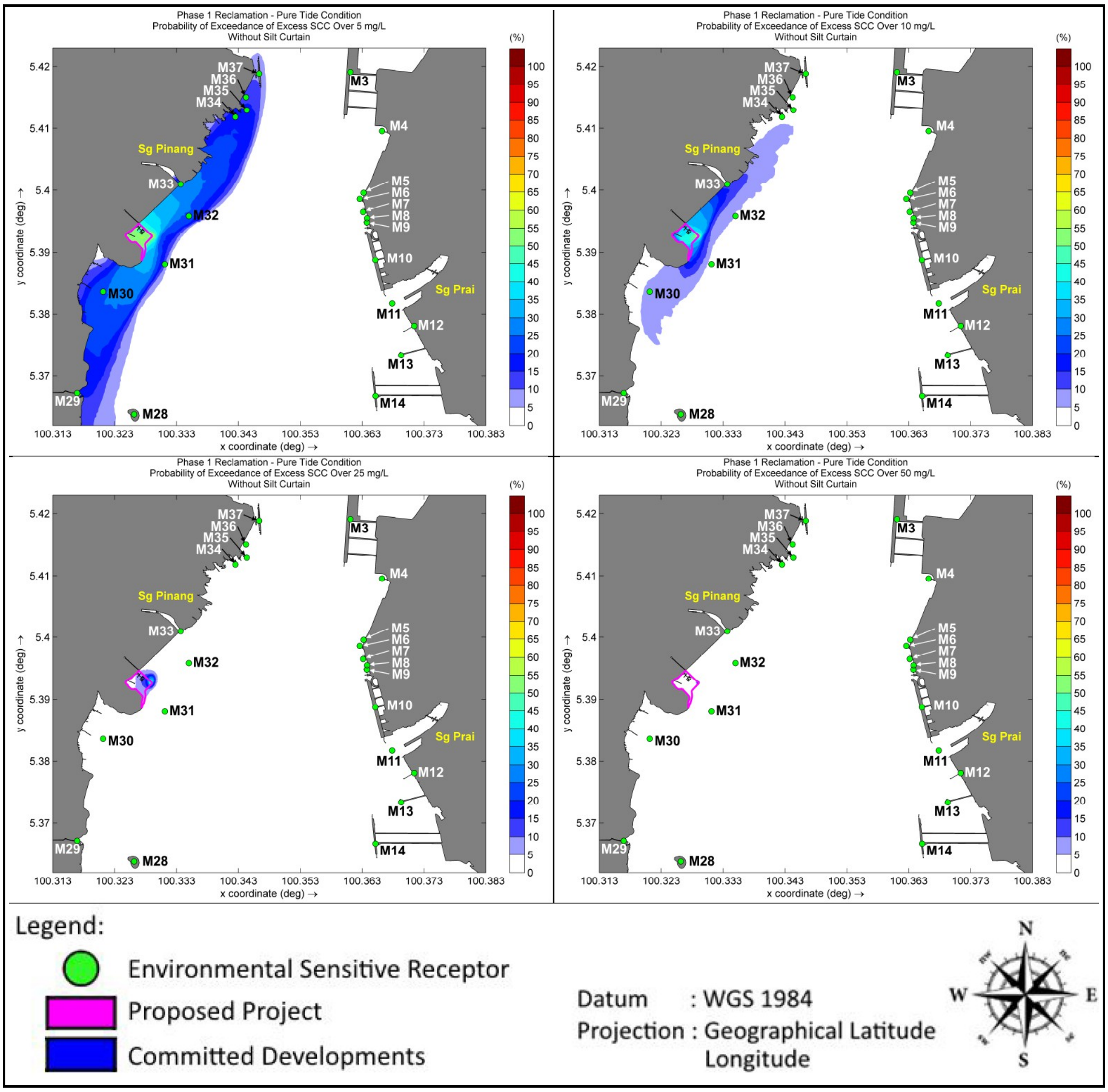


Figure 7.145 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 1 Reclamation Work During Pure Tide Condition Without Silt Curtain.

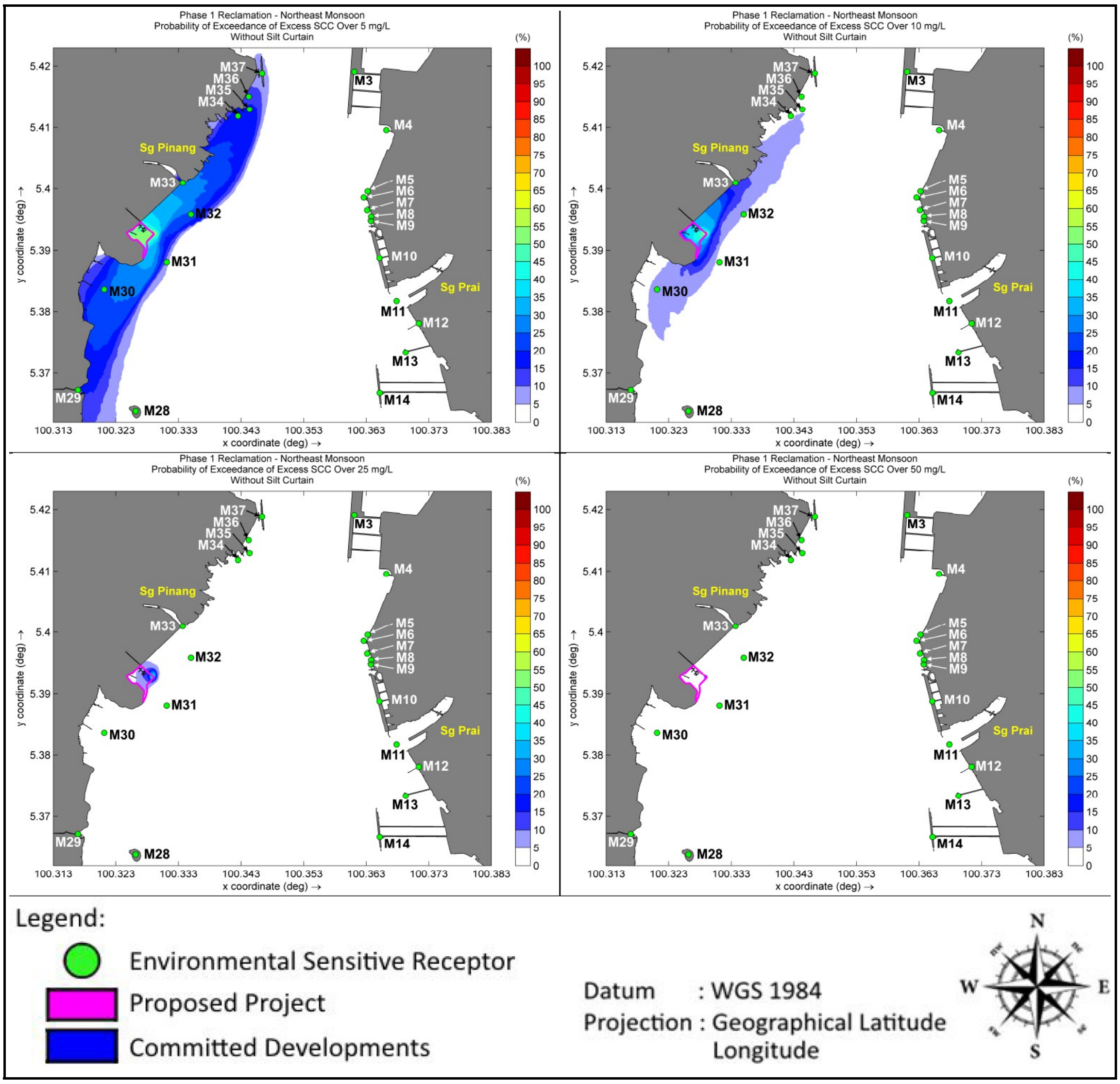


Figure 7.146 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 1 Reclamation Work During Northeast Monsoon Without Silt Curtain.

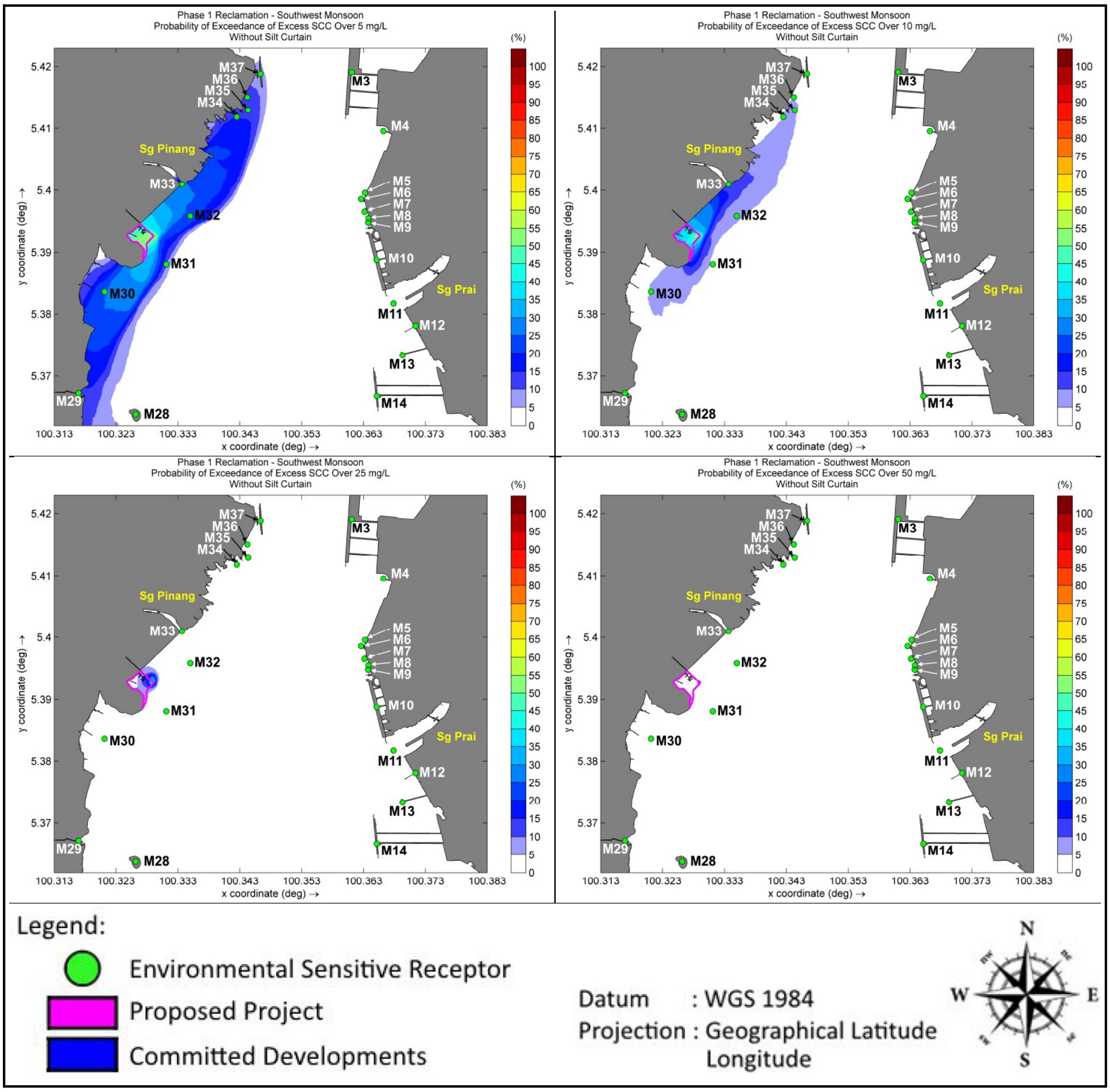


Figure 7.147 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 1 Reclamation Work During Southwest Monsoon Without Silt Curtain.

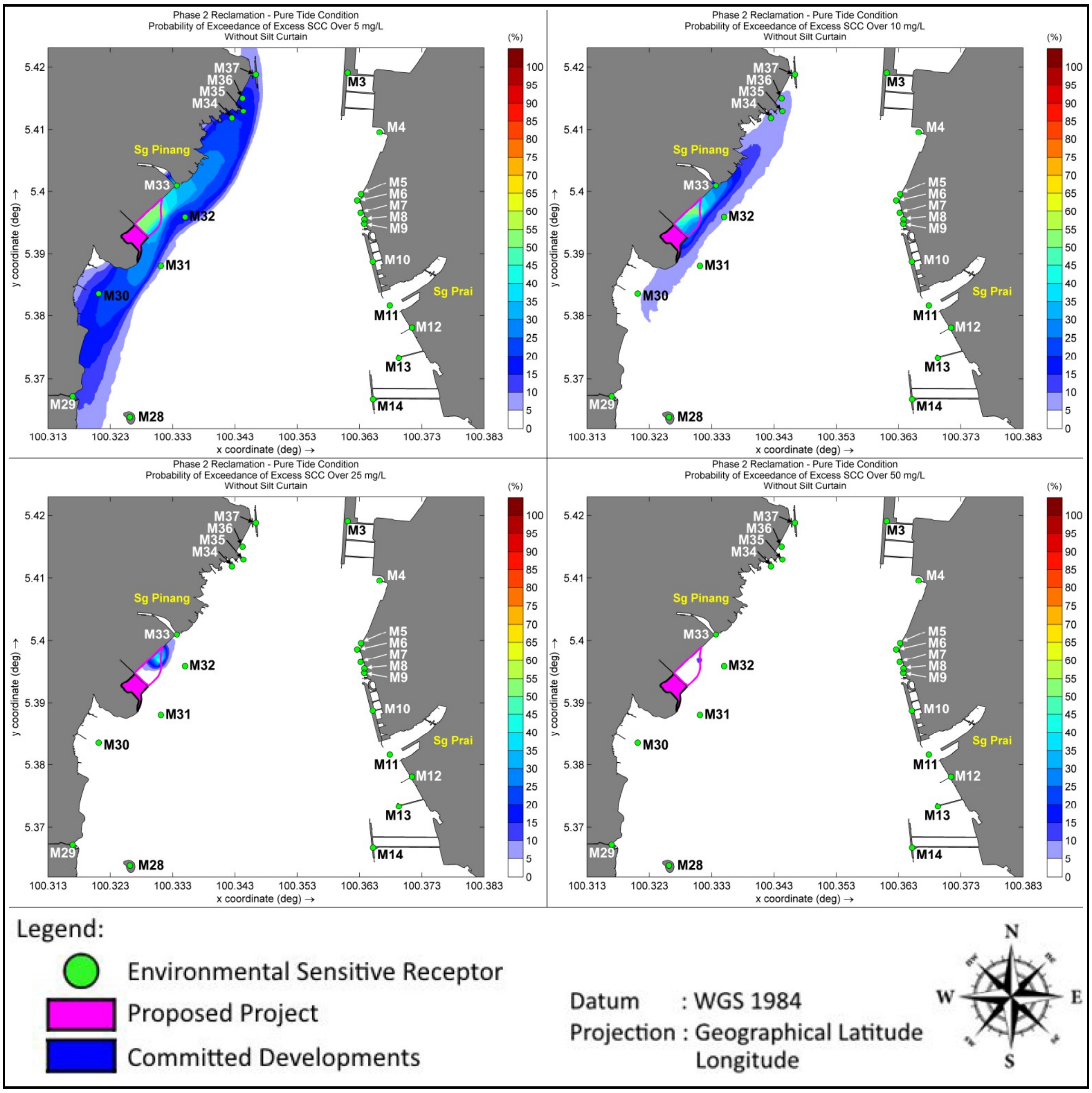


Figure 7.148 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 2 Reclamation Work During Pure Tide Condition Without Silt Curtain.

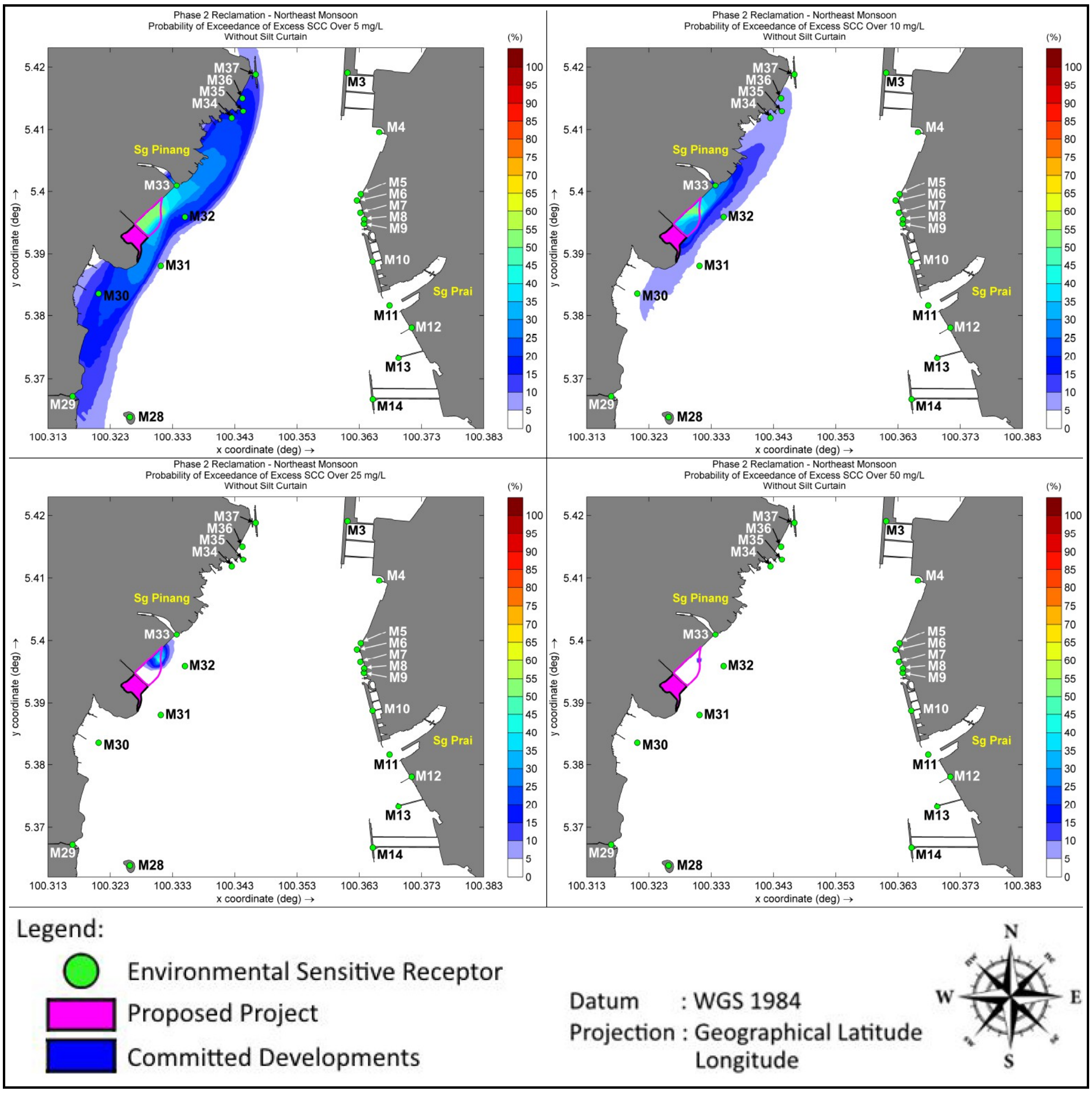


Figure 7.149 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 2 Reclamation Work During Northeast Monsoon Without Silt Curtain.

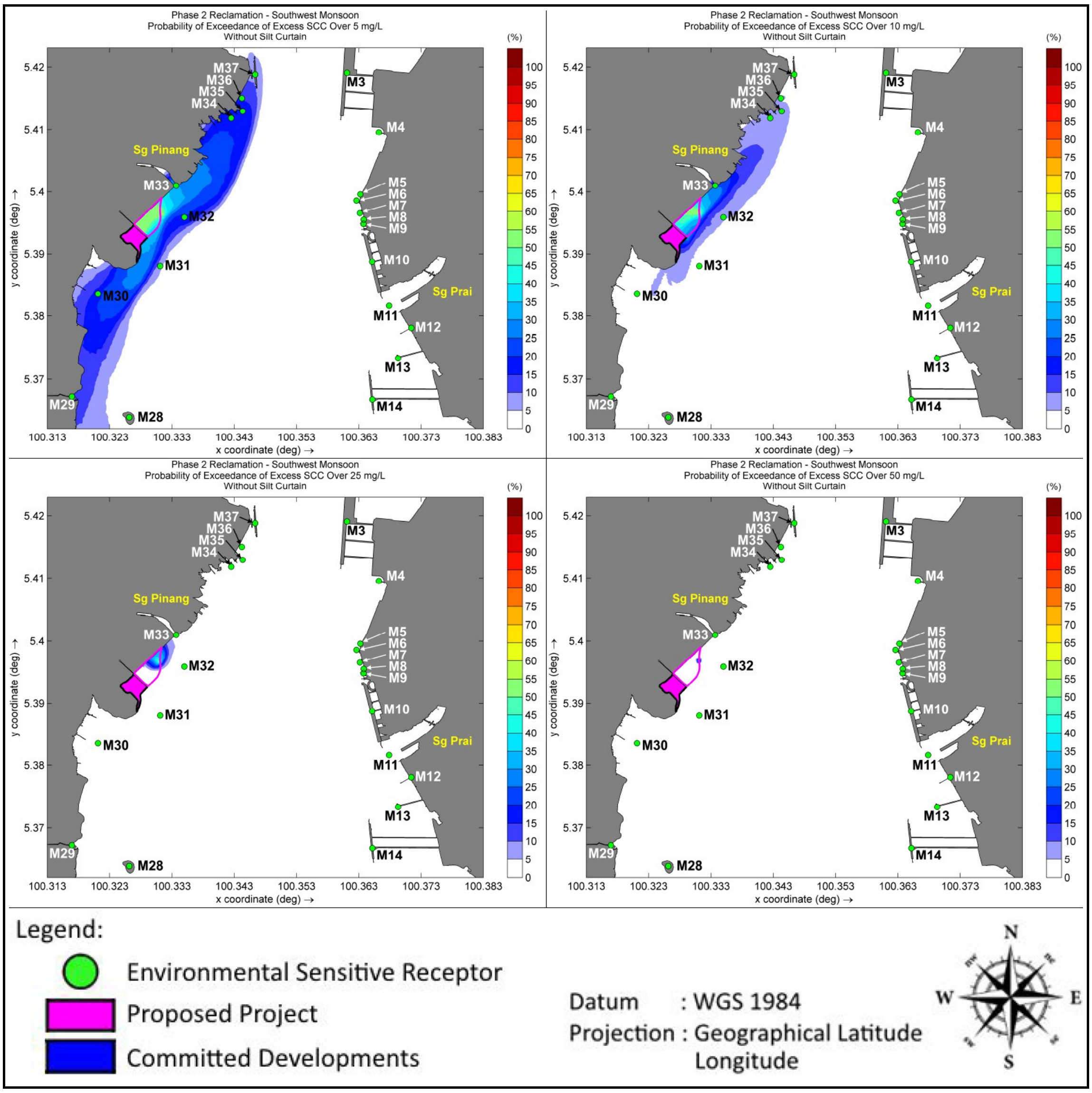


Figure 7.150 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 2 Reclamation Work During Southwest Monsoon Without Silt Curtain.

- Probability of exceedance of excess suspended sediment concentration over 25 mg/L.
  - The spread of exceedance over 25 mg/L is localized within the Proposed Project site and does not reach any of the identified ESR points.
  - Percentage of exceedance for over 25 mg/L goes up to 20% within the vicinity of the Project Site and up to 40% at the discharge point.
- Probability of exceedance of excess suspended sediment concentration over 50 mg/L.
  - The spread of exceedance over 50 mg/L are localized within the discharge point vicinity up to 15% of time.

With Silt Curtain

Reclamation Phase 1 (**Figure 7.151 to Figure 7.153**).

Reclamation Phase 2 (**Figure 7.154 to Figure 7.156**).

- Probability of exceedance of excess suspended sediment concentration over 5 mg/L.
  - For Phase 1 reclamation, the spread of exceedance over 5 mg/L does not reach any of the identified ESR points;
  - For Phase 2 reclamation, the spread of exccedance ove 5 mg/L reaches ESR point M33 (River mouth of Sg Pinang) to the north of Proposed Project up to 15%;
  - Within the Project Site vicinity and discharge point, percentage of exceedance for over 5 mg/L goes up to 45%.
- Probability of exceedance of excess suspended sediment concentration over 10 mg/L.
  - The spread of exceedance over 10 mg/L does not reach any of the identified ESR points and are localized within vicinity of the Proposed Project site and discharge point up 25% of time.
- Probability of exceedance of excess suspended sediment concentration over 25 mg/L.
  - The spread of exceedance over 25 mg/L are localized within the discharge point vicinity up to 10% of time.
- Probability of exceedance of excess suspended sediment concentration over 50 mg/L.
  - The spread of exceedance over 50 mg/L are less than 5% of the time.

Sediment Plume – Overall Siltation Rate

This section analyses the potential siltation rate of fine sediment dispersed during reclamation work. The duration of Phase 1 and Phase 2 reclamation are 190 days and 320 days respectively. The assessment represent the potential siltation rate after the each reclamation phase has been completed based on the estimated duration. The following observations were made based on the analysed modelling results:-

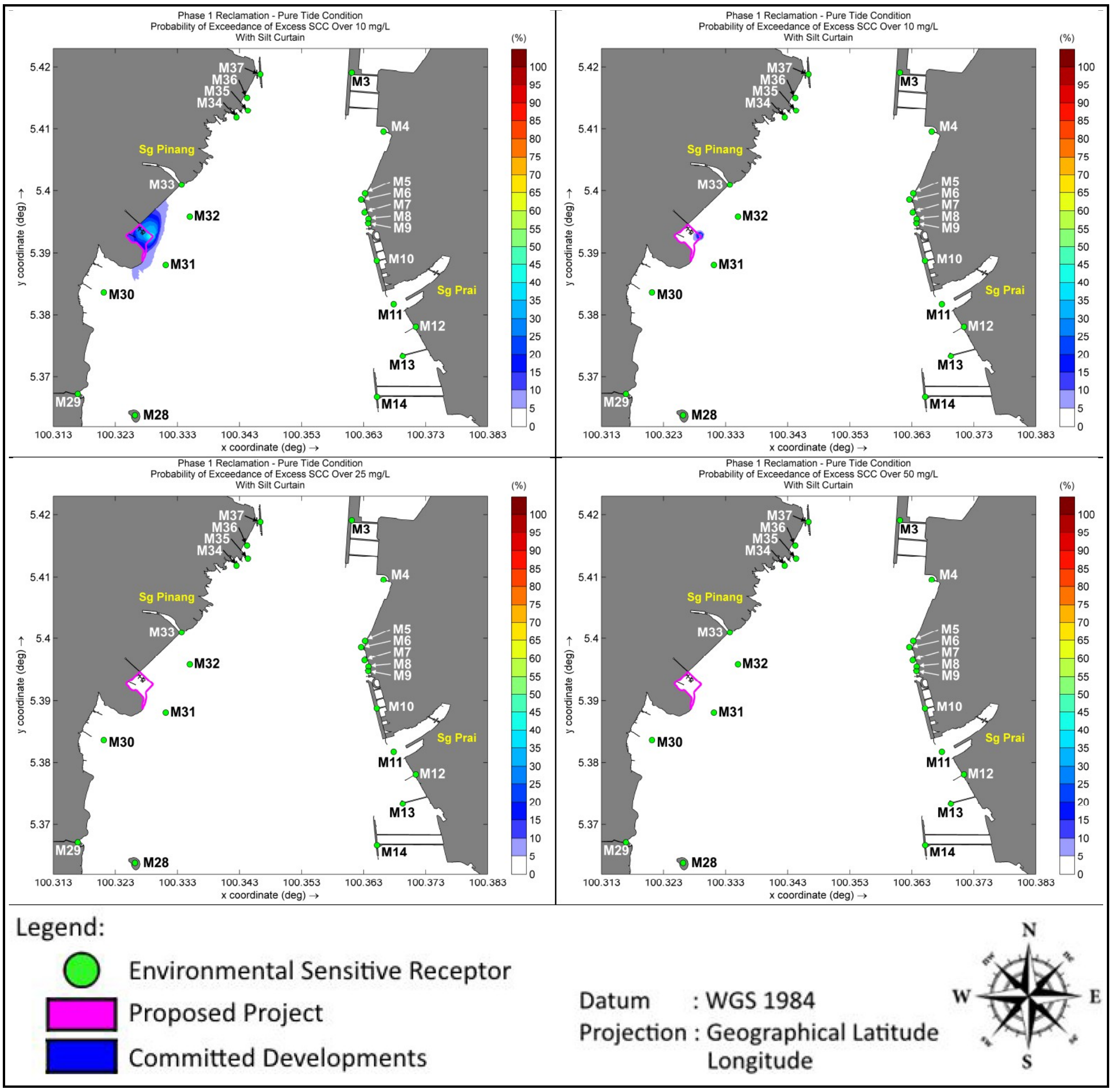


Figure 7.151 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 1 Reclamation Work During Pure Tide Condition With Silt Curtain.

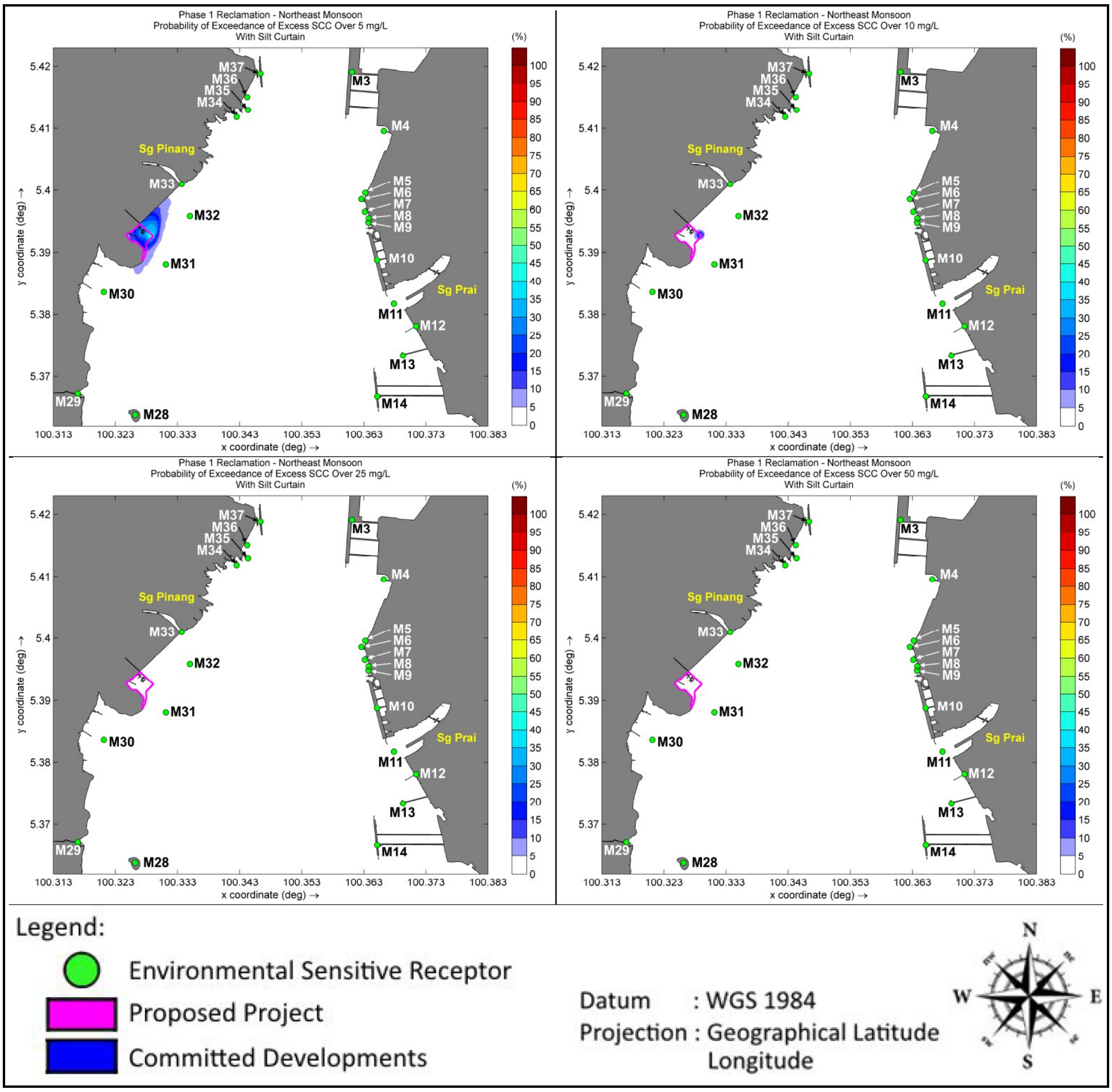


Figure 7.152 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 1 Reclamation Work During Northeast Monsoon With Silt Curtain.

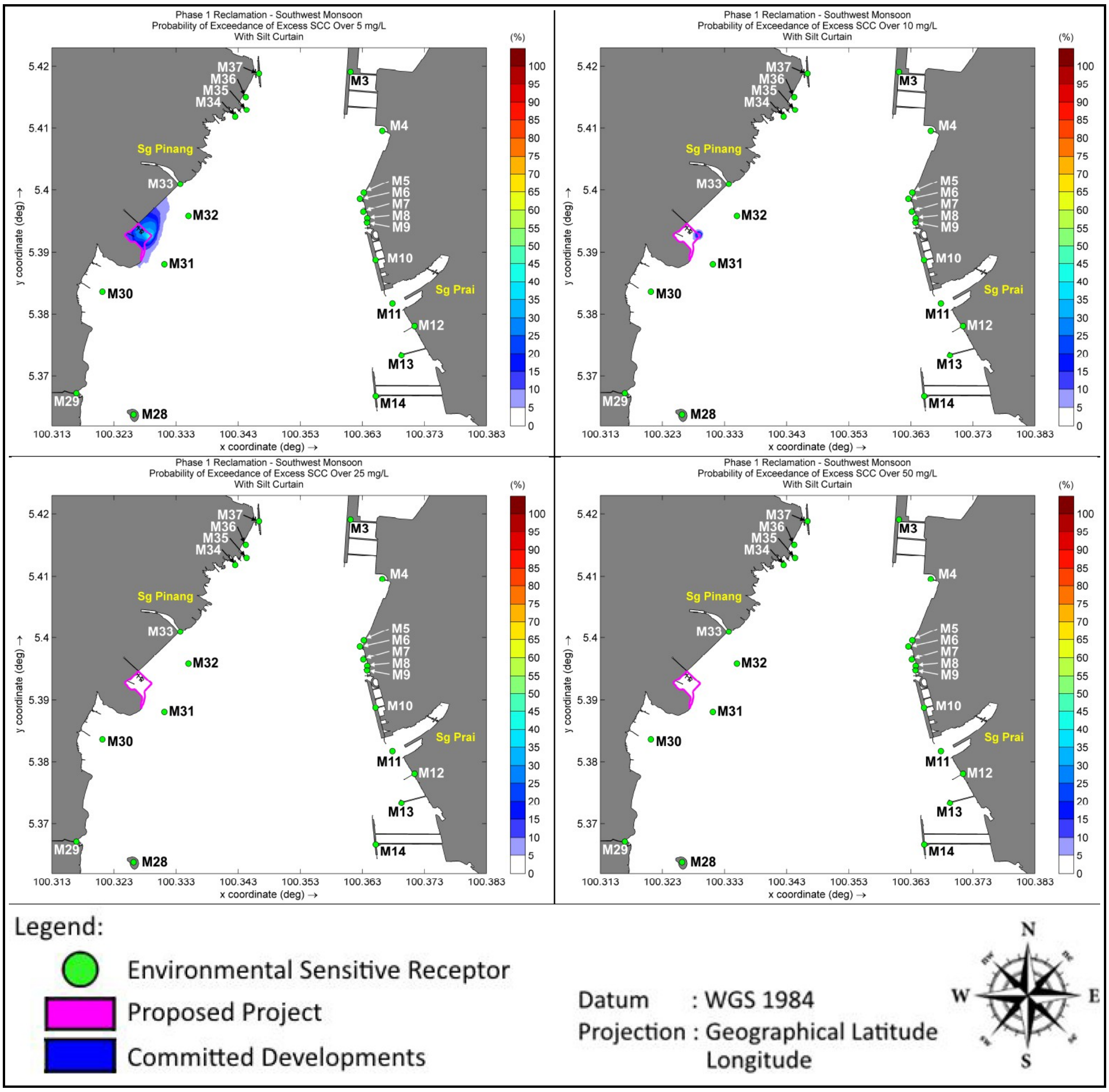


Figure 7.153 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 1 Reclamation Work During Southwest Monsoon With Silt Curtain.

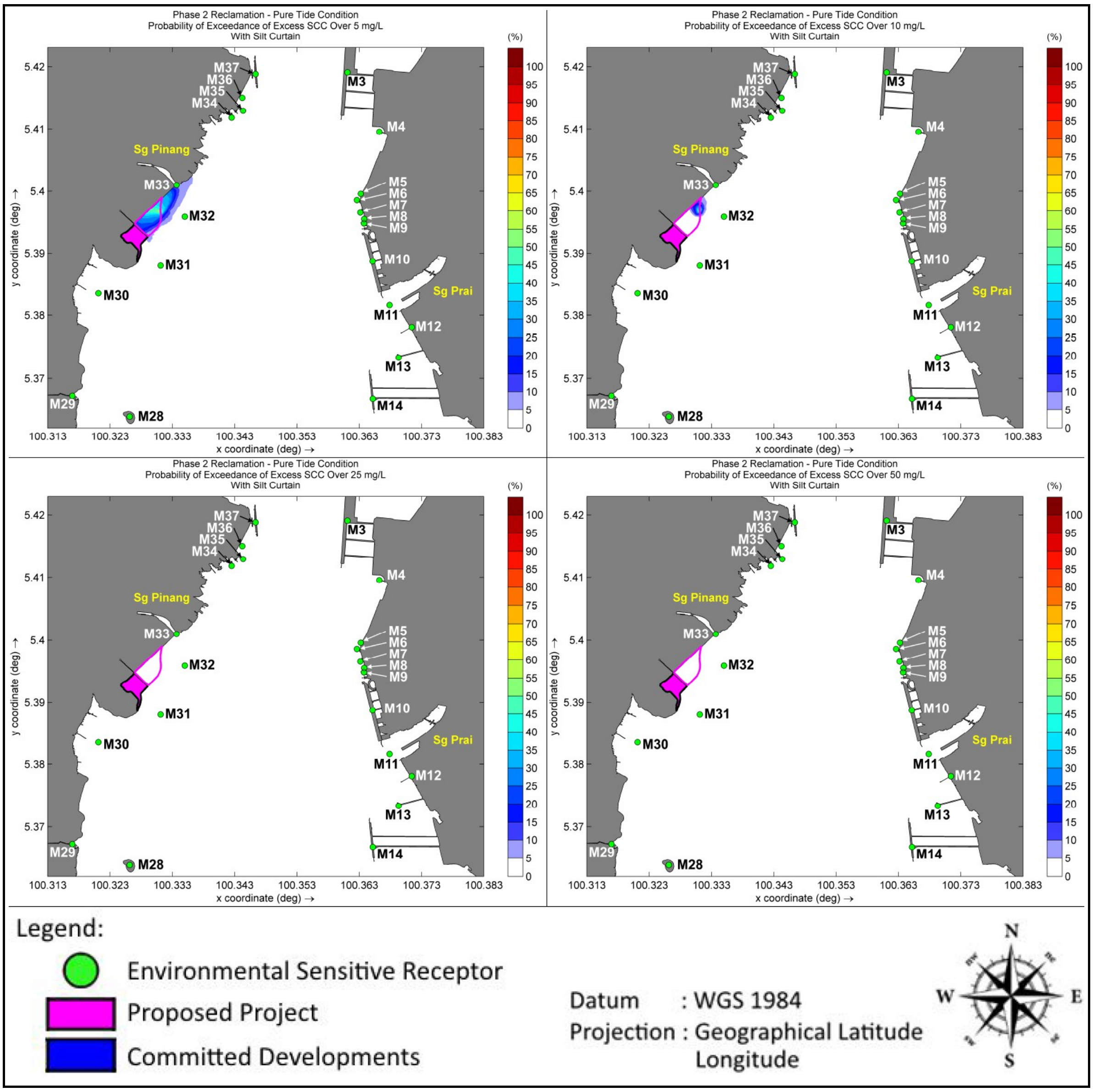


Figure 7.154 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 2 Reclamation Work During Pure Tide Condition With Silt Curtain.

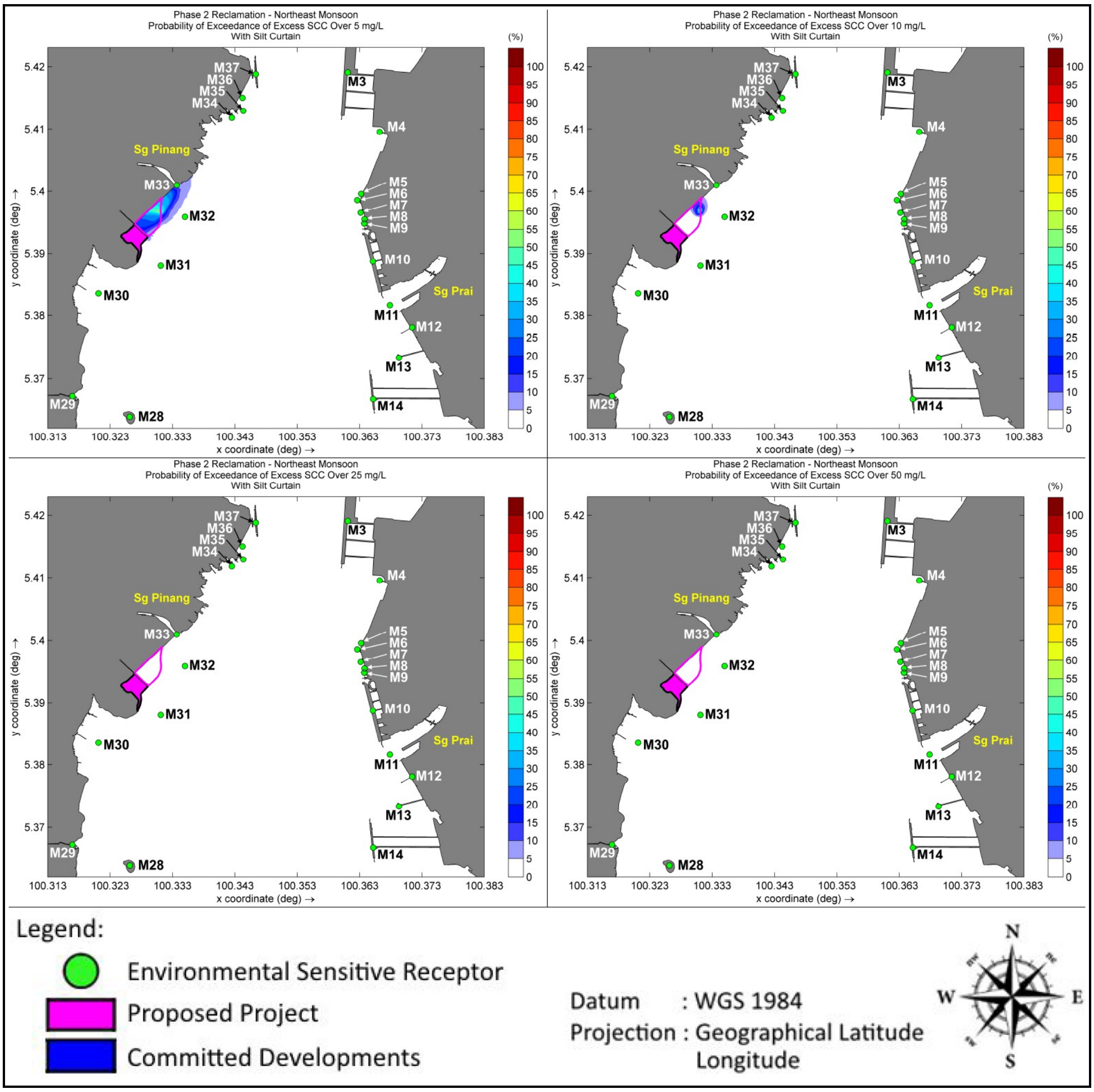


Figure 7.155 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 2 Reclamation Work During Northeast Monsoon With Silt Curtain.

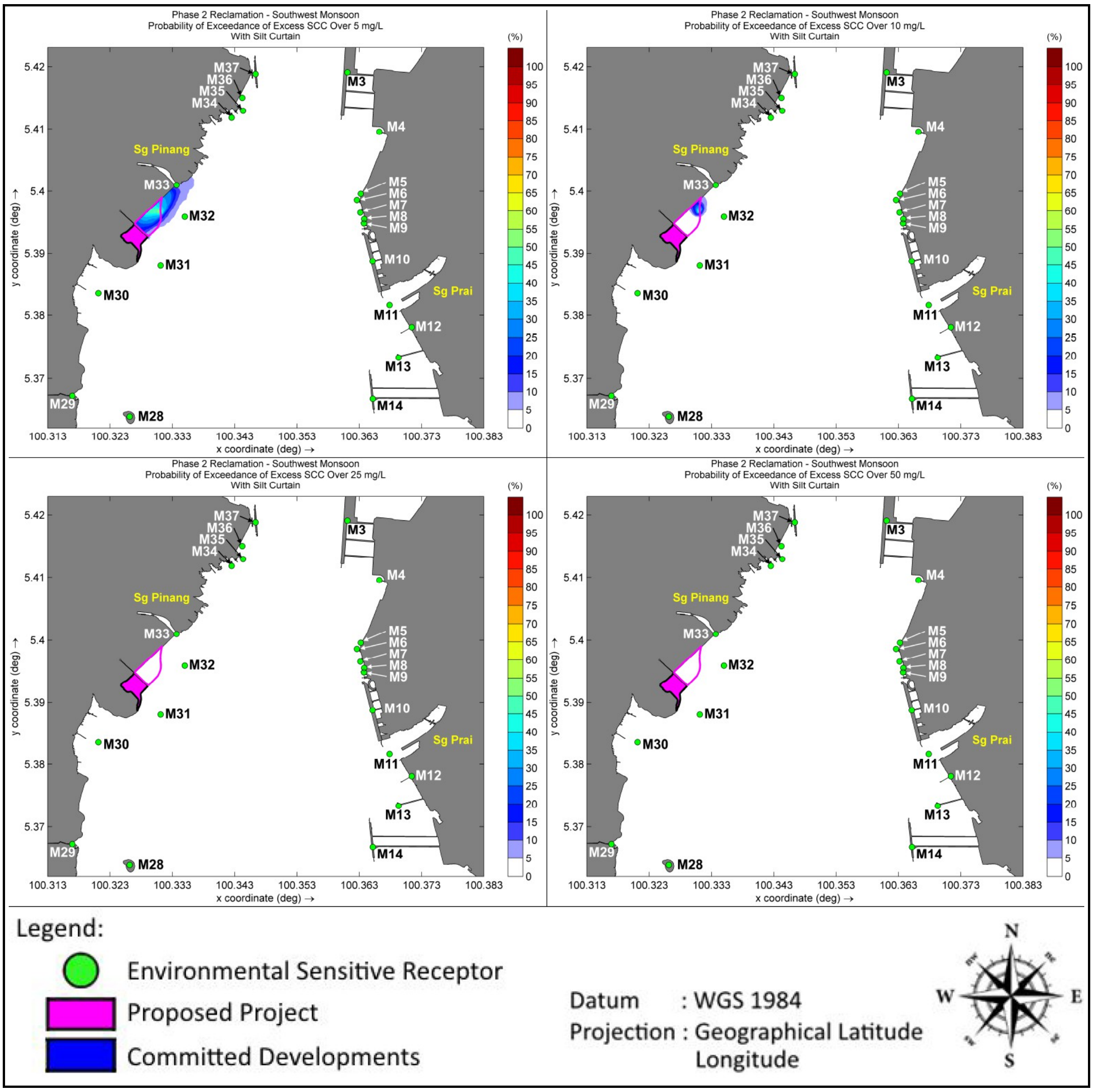


Figure 7.156 Exceedance Probability For Excess Suspended Sediment Concentration (SCC) Of 5mg/L, 10 mg/L, 25 mg/L And 50 mg/L For Phase 2 Reclamation Work During Southwest Monsoon With Silt Curtain.

General Observations

- The general pattern and magnitude of potential siltation rate remained similar between modelled scenarios regardless of the imposed wind condition. The seasonal monsoon winds will not significantly affect the extent and magnitude of siltation;
- The observation are applicable for siltation from both Phase 1 and Phase 2 reclamation; and
- The silt curtain will significantly reduce the potential siltation resulting from sediment plume.

Reclamation Phase 1 (**Figure 7.157**)

- Without silt curtain, the siltation is expected to occur within the Project Site area and close vicinity. The height of resulting siltation is expected to be less than 0.1 m (< 10 cm);
- In comparison, if the sit curtain is implemented, the siltation is expected to be minimal, likely to be much less than 0.05 m (< 5 cm);
- The resulting siltation at identified ESRs without silt curtain implementation is expected to be less than 2 mm for most ESR points, except for selected ESRs (M19 to M36) which are located along Penang shoreline and the deep adjacent channel. These ESR points experienced siltation ranging from 5 mm to 25 mm; and
- With silt curtain implementation scenario, the siltation at identified ESRs are further reduced, where ESR points M22 to M36 experienced siltation up to 7.5 mm.

Reclamation Phase 2 (**Figure 7.158**)

- Without silt curtain, the siltation is expected to spread from the Project Site towards northeast near the river mouth of Sungai Pinang. It is observed that the expected siltation to occur at river mouth of Sungai Pinang ranges up to 0.1 m (< 10 cm), however the siltation and bed changes within Project Site is expected to be up to 0.15 m(< 15 cm);
- In comparison, if the sit curtain is implemented, the siltation is expected to be minimal within near vicinity of the discharge point up to 0.1 m (< 10 cm);
- The resulting siltation at identified ESRs without silt curtain implementation is similar to Phase 1, where most of the points are expected to be less than 2 mm except for selected ESRs (M19 to M36) located along Penang shoreline and the deep adjacent channel. However, the magnitude of siltation at these ESR points are higher than Phase 1, ranging from 5 mm to 40 mm. At ESR point M32 which is the river mouth of Sg Pinang, the value of siltation is expected to be up to 67 mm; and

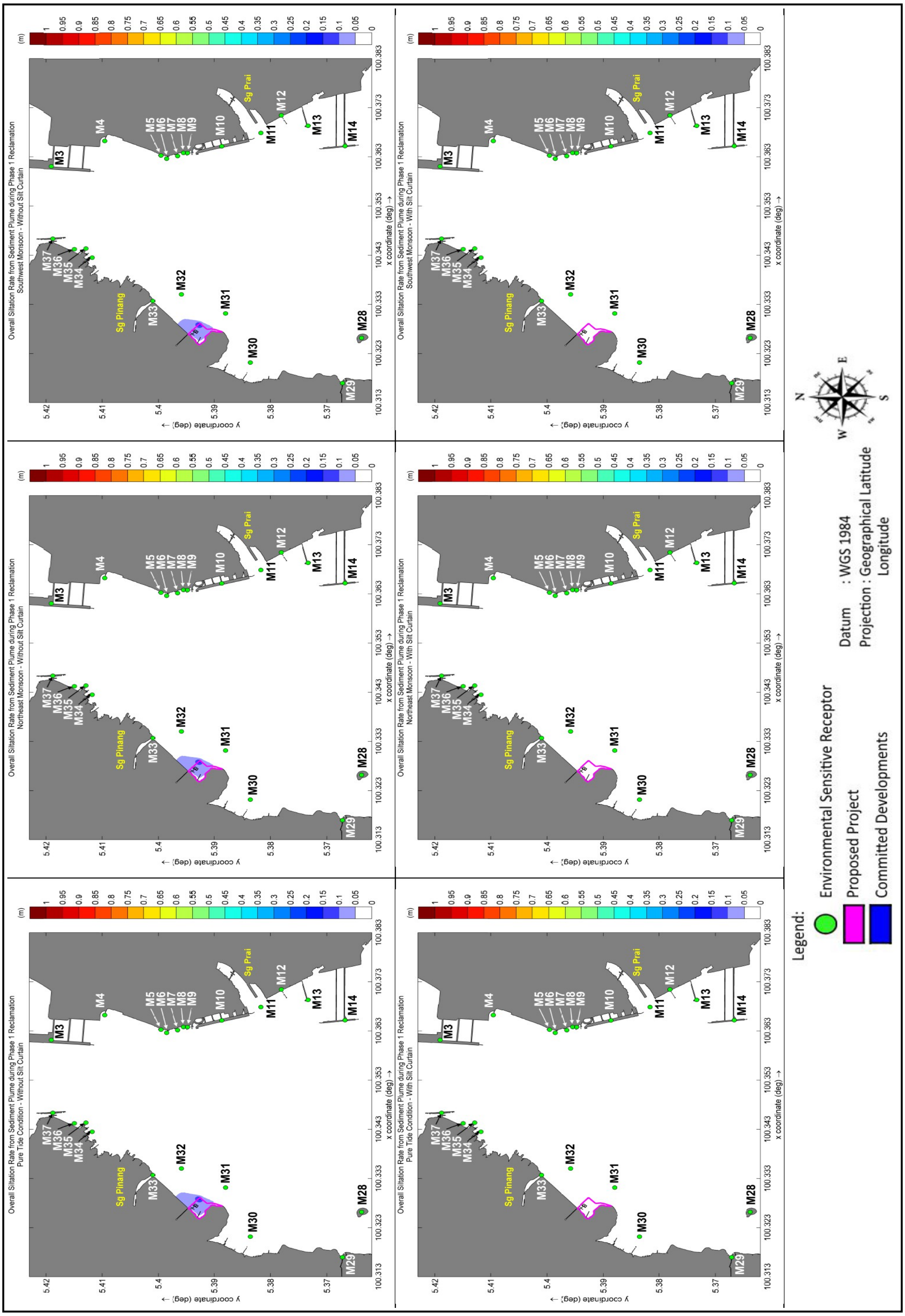


Figure 7.157 Overall Siltation Rate From Sediment Plume Dispersion During Phase 1 Reclamation Work After 190 Days

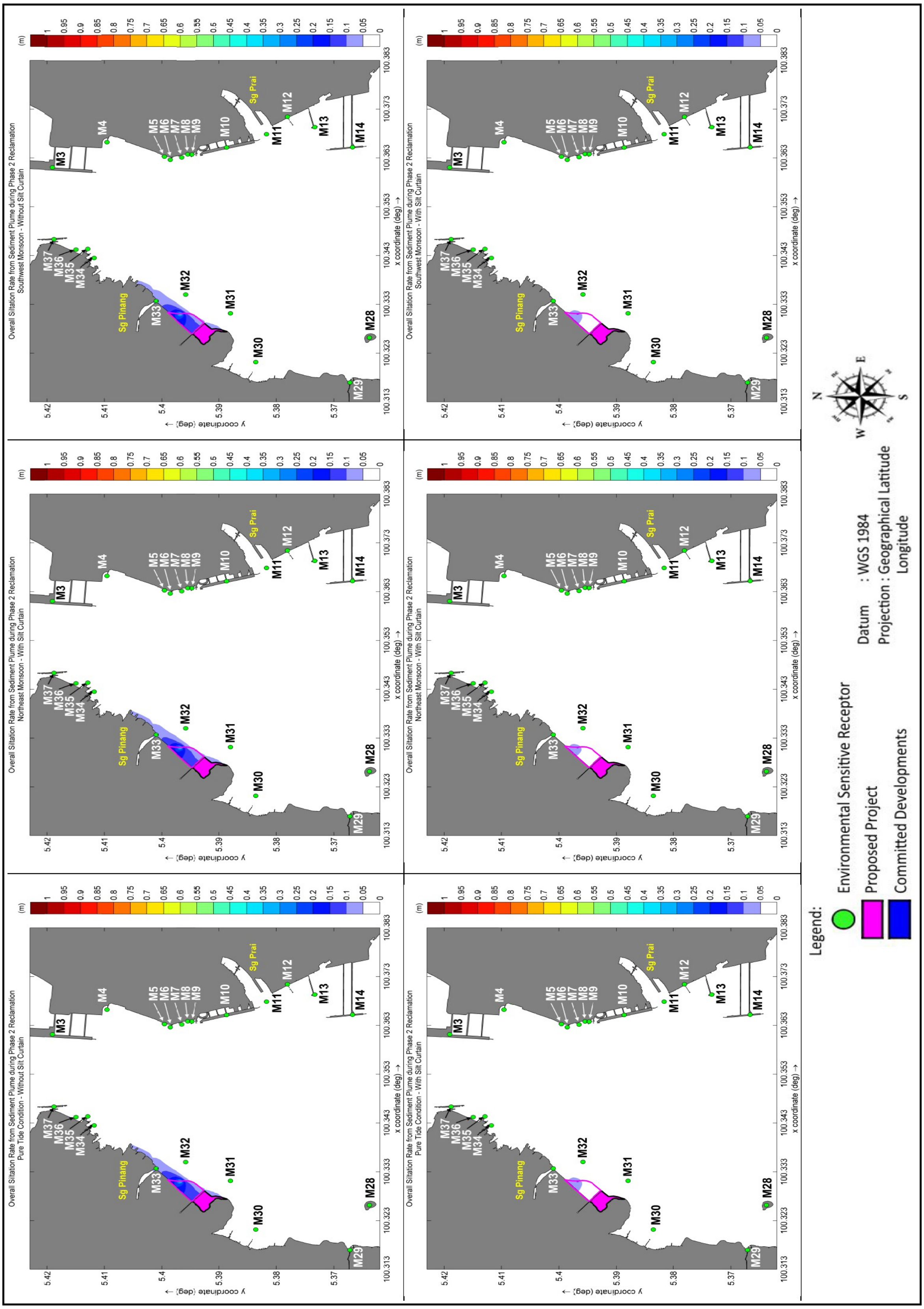


Figure 7.158 Overall Siltation Rate From Sediment Plume Dispersion During Phase 2 Reclamation Work After 320 Days

- With silt curtain implementation scenario, the siltation at identified ESRs are further reduced, where ESR points M22 to M36 experienced siltation up to 12 mm. ESR point M32 is expected to have siltation up to 20 mm instead.

(c) Impact On Seagrass/Marine Sanctuary Area

A marine sanctuary has been proposed in the Middle Bank where seagrass can be found at Pulau Gazumbo. This island was created during the construction of the First Penang Bridge and has the largest seagrass meadow in the Straits of Melaka known as Middle Bank. It consists of a wide variety of marine life ranging from shellfish such as horseshoe crab to marine algae and is also a feeding ground for many marine creatures.

Table 7.49 provides the impact severity matrix for suspended sediment impact on seagrass and **Table 7.50** provides the impact severity matrix for sedimentation impact based on the hydraulic report with silt curtain.

Table 7.49
Impact Severity Matrix For Suspended Sediment Impact On Seagrass

Severity	Definition (Excess concentration)
No Impact	Excess Suspended Sediment Concentration > 5 mg/L for less than 20% of the time
Slight Impact	Excess Suspended Sediment Concentration > 5 mg/L for more than 20% of the time Excess Suspended Sediment Concentration > 10 mg/L for less than 20% of the time
Minor Impact	Excess Suspended Sediment Concentration > 25 mg/L for less than 5% of the time
Moderate Impact	Excess Suspended Sediment Concentration > 25 mg/L for more than 20% of the time Excess Suspended Sediment Concentration > 75 mg/L for less than 1% of the time
Major Impact	Excess Suspended Sediment Concentration > 75mg/L for more than 20% of the time

Source: Doorn-Groen, SM (2007). Environmental Monitoring and Management of Reclamations Works Close to Sensitive Habitats

Table 7.50
Impact Severity Matrix For Sedimentation Impact On Seagrass

Severity	Definition (Excess concentration)
No Impact	Sedimentation < 0.1 kg/m^2/day (<0.25 mm/day)
Slight Impact	Sedimentation < 0.25 kg/m^2/day (<0.63 mm/day)
Minor Impact	Sedimentation < 0.5 kg/m^2/day (<1.25 mm/day)
Moderate Impact	Sedimentation < 1.0 kg/m^2/day (<2.5 mm/day)
Major Impact	Sedimentation > 1.0 kg/m^2/day (>2.5 mm/day)

Source: Doorn-Groen, SM (2007). Environmental Monitoring and Management of Reclamations Works Close to Sensitive Habitats

Based on the above the severity impacts to the seagrass and marine sanctuary in the middle bank can be said to fall under the 'slight impact'.

(d) Impact On Sea Traffic And Risk From Reclamation

i. Hazard Register

There are nine (9) potential hazards identified and described in **Table 7.51.**

Table 7.51
Initial Risk Score For Marine Risk

Hazard Register				Initial Risk		
No	Work/ Activity	Hazard	Possible Accident/ Health and Persons at Risk	Probability	Consequence	Risk
1	Delivery of fill material by 2 in 1 sand carrier or barges	Wreck with charted depth of 4.6m near to Rimau buoy	2 in 1 sand carrier or barge with draft more than 4.6m may run over the wreck causing hull breach and foundering	Rare 2	Major 4	Mod. 8
2	Delivery of fill material by 2 in 1 sand carrier or barges	Shoal with charted depth 4.2m east of Tanjung Teluk Tempoyak	2 in 1 sand carrier or barge with draft more than 4.2m may run aground	Rare 2	Severe 3	Mod. 6
3	Delivery of fill material by 2 in 1 sand carrier or barges	Tidal flat with charted depth 3.6m at Batu Maung	2 in 1 sand carrier or barge with draft more than 3.6m may run aground	Rare 2	Severe 3	Mod. 6
4	Delivery of fill material by 2 in 1 sand carrier or barges	Bridge piers at navigation span of Sultan Abdul Halim Muadzam Shah bridge	2 in 1 sand carrier or barge may collide with the piers	Rare 2	Major 4	Mod. 8
5	Delivery of fill material by 2 in 1 sand carrier or barges	Shoal with charted depth 4.5m south of Jerejak Island	2 in 1 sand carrier or barge with draft more than 4.5m may run aground	Rare 2	Severe 3	Mod. 6
6	Delivery of fill material by 2 in 1 sand carrier or barges	Shoal with charted depth 2.5m south of Jerejak Island	2 in 1 sand carrier or barge with draft more than 2.5m may run aground	Rare 2	Severe 3	Mod. 6
7	Delivery of fill material by 2 in 1 sand carrier or barges	Beacon marking the location of submarine cable near to Sultan Abdul Halim Muadzam Shah bridge	2 in 1 sand carrier or barge may collide with the beacon	Rare 2	Severe 3	Mod. 6
8	Mooring of work vessels at project site	Submarine cables	2 in 1 sand carrier or barge with insecure mooring may drag her anchor and causing damage to the cables	Rare 2	Minor 2	Low 4
9	Movement of other vessels in vicinity of project site	Partly submerged rock bund	Other vessel may run over the rock bund which partly submerged and not visible above thesurface	Rare 2	Major 4	Mod. 8

Source: TOR For Marine Risk Assessment, December 2023.

ii. Risk Control Options

Risks associated with identified hazards can be reduced by adopting RCO (Risk Control Options) as shown in **Table 7.52.**

Table 7.52
Residual Risk Score

No.	Hazard	RCO (Risk Control Option)	Initial Probability	Reduced Probability	Consequence	Initial Risk	Residual Risk
1	Wreck with charted depth of 4.6m near to Rimau buoy	• Sand carriers or barges of more than 600 GT (incl. combined gross tonnage of tug and tow) is subjected to Compulsory Pilotage. • Maximum draft for sand carriers or barges shall be limited to 4m due to 4.5m depth at the entrance via south of Jerejek Island. • Sand carriers or barges shall keep Rimau Fairway buoy on starboard side in order to avoid shallow area with depth less than 5m which lies on east of the fairway. • Rimau buoy shall be kept on starboard side when entering South Channel in order to avoid the wreck. • Isolated danger mark located southwest of Pulau Rimau and Pulau Rimau Lighthouse shall be kept on port side when entering South Channel.	Rare 2	Very Rare 1	Major 4	Moderate 8	Low 4
2	Shoal with charted depth 4.2m east of Tanjung Teluk Tempoyak	• Sand carriers or barges shall not pass between Rimau 1R buoy and isolated danger mark buoy off Teluk Tempoyak. • Isolated danger mark buoy shall be kept on port side in order to avoid the shoal but sand carriers shall stay close to the buoy to avoid grounding at shallow area.	Rare 2	Very Rare 1	Severe 3	Moderate 6	Low 3
3	Tidal flat with charted depth 3.6m at Batu Maung	• Sand carriers or barges shall stay clear from the tidal flat by maintaining Course Over Ground (COG) towards beacon located south of Jerejak Island upon passing the navigation span of Sultan Abdul Halim Muadzam Shah bridge.	Rare 2	Very Rare 1	Severe 3	Moderate 6	Low 3

Table 7.52 (Continue)

No.	Hazard	RCO (Risk Control Option)	Initial Probability	Reduced Probability	Consequence	Initial Risk	Residual Risk
4	Bridge piers at navigation span of Sultan Abdul Halim Muadzam Shah bridge	• Non-propelled barges shall be towed by two (2) tugs when passing under the bridge where one for pulling and the other towing alongside.	Rare 2	Very Rare 1	Major 4	Moderate 8	Low 4
5	Shoal with charted depth 4.5m south of Jerejak Island	• Maximum draft for sand carriers or barges shall be limited to 4m due to 4.5m depth at the entrance via • south of Jerejek Island.	Rare 2	Very Rare 1	Major 4	Moderate 8	Low 4
6	Shoal with charted depth 2.5m south of Jerejak Island	• Sand carriers or barges shall stay at least 1 cable from south of Jerejak Island.	Rare 2	Very Rare 1	Major 4	Moderate 8	Low 4
7	Beacon marking the location of submarine cable near to Sultan Abdul Halim Muadzam Shah bridge	• Sand carriers or barges shall maintain reasonably safe distance from the beacon.	Rare 2	Very Rare 1	Major 4	Moderate 8	Low 4
8	Submarine cables	• Sand carriers or barges shall only anchor at designated anchorage area.	Rare 2	Very Rare 1	Minor 2	Low 4	Low 2
9	Partly submerged rock bund	• Restricted working area shall be established and marked by appropriate buoys.	Rare 2	Very Rare 1	Major 4	Moderate 8	Low 4

Source: TOR For Marine Risk Assessment, December 2023.

(e) Impact On Marine Resources And Productivity

One of the potential water quality impacts arising from reclamation activities of the Proposed Project will be the elevated SS (Suspended Solids) release due to reclamation activities and the release of contaminants and/or impact on dissolved oxygen due to disturbance of sediment. Elevated SS reduces light penetration, reduce the photosynthetic rate of phytoplankton and thus lower the rate of oxygen production in water column. During baseline water quality studied done TSS.

Suspended sediments can elicit a short- and long-term response from aquatic biota depending on the quantity, quality, and duration of suspended sediment exposure (Caux et al., 1997; Newcombe, 2003; Fleming et al., 2005). Effects of suspended sediments on fish depend upon several factors such as fish species, temperature at exposure time (e.g. Servizi & Martens, 1991), type of suspended sediment, (for example particle size (Muck, 2010) and angularity (e.g., Lake & Hinch, 1999)) sediment contaminants (Matta et al., 1999), duration and frequency of exposure, and dose.

Suspended sediment in high concentrations irritates the gills of fish, and clog fish gill structure and eventually can cause fish mortality. Juvenile fish and larval fish (fry) are more susceptible to deleterious impacts from sedimentation through smothering and clogging of their respiratory systems. Adult fish are more likely to move away when they detect certain SS level and therefore, less sensitive to the effects from SS. Increase in SS in water column combining with a number of other physical or biotic factors would reduce dissolved oxygen (DO) in water column. If oxygen levels are depleted to low levels, fishes in early life stages may be unable to tolerate such conditions and suffer hypoxia-induced mortality or stress including reduced feeding and growth rate.

The long-term effects of sediment exposure on aquatic organisms is critical for determining threshold effects and exposure limits to mitigate potential impacts with regard to fish population dynamics. Sediment suspended in the water column can also cause sublethal effects from turbidity and direct physical damage, particularly to fish species (Wilber & Clarke, 2001). Effects of suspended sediments on fish depend upon several factors: species, temperature at exposure time (e.g. Servizi and Martens 1992), type of suspended sediment, [i.e., particle size (Muck 2010) and angularity (e.g., Lake and Hinch 1999)] sediment contaminants (Matta et al. 1999), duration and frequency of exposure, and dose.

In general, fish are more likely to undergo sublethal stress from suspended sediments rather than lethality because of their mobility to move away from danger zone of high sedimentation.

However, excessive amount of sediment might be harmful to fishes such as it can clog fish gills, reducing resistance to disease, lowering growth rates, and affecting fish egg and larvae development. A study review done by EIFAC (1964) deduced the following criteria for the protection of fisheries resources as shown in **Table 7.53.**

Table 7.53
Potential Impact Of Suspended Solids On Fisheries (EIFAC, 1964)

Concentration in mg/L (ppm)	Impact of Suspended Solids
<25	No evidence of harmful effects on fish and fisheries
25 – 80	It should be possible to maintain good to moderate fisheries however, the yield would be somewhat diminished
80 – 400	Unlikely to support good fisheries

The impact of suspended sediment on eggs and larvae of marine organisms has been studies under laboratory conditions (Kiørboe et al., 1981; Morgan et al., 1983; Griffin et al., 2009; Suedel et al., 2012). Auld and Schubel (1978) and Kiørboe et al. (1981) indicated that suspended sediment concentrations have limited effects on egg hatching success, but exposure was not immediate following dispersal. On another studied by Griffin et al. (2009) found that if

Pacific herring (*Clupea pallasii*) eggs were exposed to suspended sediments of 250 and 500 mg/L, within 2 hours of dispersal, sediments adhered to the outside of eggs, which led to increased egg-to-egg attachment, and abnormal larval development. Fine sediment can also exert sub-lethal effects on fish fry including: delaying emergence by trapping fry in interstitial pores (Phillips et al., 1975); and premature hatching of smaller and poorer quality fry, due to exposure to low dissolved oxygen concentrations (Alderdice et al., 1958; Mason, 1969). Researchers have found a relationship between fine sediment (less than 0.850 mm) and fry survival, with decreasing survival of up to 3.4% for each 1% increase in fine sediment (Cederholm et al., 1981).

Generally, reclamation activity in marine ecosystem will increase turbidity. High turbidity which correlated to high TSS will lead fish injury by blocking their respiration organ. Fish normally will avoid the disturbance place by swim away from the pollution source. Suspended sediment size, shape, and exposure duration are likely important risk assessment factors for fishes. Besides that, high suspended solid will have increased water temperature which leads to decreased dissolved oxygen levels. Reclamation activities also produce noise which allow fish to swim to another niche that been less disturbed.

Increased in turbidity can cause changes in feeding behavior of the fish for the simple reason that the prey may be less visible (Ward, 1992). Turbidity, due to the scattering of light, can increase or decrease the contrast between prey and the water column. In the case of some fish larvae, their visual detection of prey increases due to the less inference from light scattering (Utne-Palm 2002). In addition, the protection of larvae from large predators increases from the decreased ability of large visual predators. Thus, in certain cases, turbid environments may offer some benefits for certain species and size groups of fish (planktivores and fish larvae) (Utne-Palm 2002).

A review by Kjelland et al. (2015) have shown limit of tolerance of some fish species on sediment level as shown in **Table 7.54**.

Table 7.54
Effects Of Suspended Sediment Levels By Species

Common Name	Species	Sediment	Concentration	Duration	Mortality (%)	References
Carp	Cyprinus spp.	Montmorillonite clay	175,000 –225,000 ppm (175-225 g/L)	days	100	Wallen, 1951
Fourspine stickleback	Apeltes quadracus	Various sediments	3 – 300 g/L	12–48 h	50	Noggle, 1978
Golden shiner	Notemigonus crysoleucas	Montmorillonite clay	175,000–225,000 ppm (175-225 g/L)	days	100	Wallen, 1951
Mummichog	Fundulus heteroclitus	Various sediments	3 –300 g/L	12–48 h	50	Noggle, 1978

Table 7.54 (Continue)

Common Name	Species	Sediment	Concentration	Duration	Mortality (%)	References
Sheepshead minnow	Cyprinodon variegatus	Various sediments	3 – 300 g/L	12–48 h	50	Noggle, 1978
Shiner perch	Cymatogaster aggregata	Bentonite Clay	0.3 – 0.9 g/L	10 days	10–50	Peddicord et al., 1975; Noggle, 1978
Spot	Leiostomus xanthurus	Estuary sediment/fuller's earth	13 – 111 g/L	24 h	10–90	Noggle, 1978
Striped bass	Morone saxatilis	Bentonite Clay	1 – 5 g/L	10 days	10–50	Peddicord et al., 1975; Noggle, 1978
Striped killifish	Fundulus majalis	Estuary sediment/fuller's earth	1 – 5 g/L	24 h	10–90	Noggle, 1978
White perch	Morone americana	Estuary sediment/fuller's earth	3 – 39 g/L	24 h	10–90	Noggle, 1978
Zebrafish	Danio rerio	Inorganic limestone	4.8 g/L	4 h	100	Reis, 1969

(Source: Kjelland at el., 2015)

During the baseline water quality study on 21st June 2020, (source: Report on Coastal Hydraulic Study, 2022) the analyzed water sample showed a higher TSS concentration at south of rehabilitation area (S1) with an average TSS of 98.7 mg/L. This probably may be due to this sampling location near to aquaculture area. Under this concentration the coastal water will unlikely to support good fisheries. Meanwhile, the rest of the sampling sites were within the range of an average of 25.3 to 58.7 mg/L which probably maintain a good to moderate fisheries however, but the yield might be reduced. Under the MMWQS standard Class 2 relates to both fisheries and mariculture activities with TSS level of 50 mg/L. For ESR (Environmental Sensitive Receptor) area, TSS should maintain at 25 mg/L to be under Class 1.

Based on hydraulic study report (September 2022), sediment transport impact assessment, indicate that changes in mean sediment transport rate due to proposed Project are considered localized and within near vicinity. Sediment plume due to the reclamation works may have negative impacts to the ESRs. Sediment plumes generated from reclamation activities can result in increased turbidity in water and sedimentation. One of ESR i.e. Middle Bank area is located within close vicinity of the reclamation area is preceived to be affected during the proposed reclamation works. However, this impact could be minimized by using silt curtain. The silt curtain scenarios with assumed 70% efficiency significantly reduce the extent and magnitude of sediment dispersion. Another ESR area i.e. Pulau Gazumbo, the impact of sediment plume dispersion can be considered as minimal as it farther away from the proposed Project site.

(f) Impact On Socio Economy

The rehabilitation and land reclamation site is located only short distance within the 0-1 nm from the shoreline whereby in Penang fishery activity is allowed. During the land reclamation activity, the area external to the land reclamation site can still be accessed by the fishermen in the vicinity. A fish landing point located at north of the site where fishermen can still gain access. However, some inconvenience will be felt by the fishing community as a result of the land reclamation activities especially for angles and fishermen with boats not adequate to go further out into the sea. Thus, measures are to be in place to address this issue. **Table 7.55** provides the summary of significance impact during the construction stage.

Table 7.55
Summary Of Significance Impact During Construction Stage

No.	Code	Impact	Significant
1.	KP10	Changes to the natural scenery affecting the recreation area at Persiaran Karpal Singh	Significant (Very High Priority)
2.	KP12	Mining activities will disturb marine life	Significant (Very High Priority)
3.	KP9	The road is broken and dirty	Significant (High Priority)
4.	KP11	Soil erosion will disturb the stability of the slope, damage to nature and the fishing ecosystem	Significant (High Priority)
5.	KP13	The safety of fishermen going in and out of the sea is threatened	Significant (High Priority)
6.	KP14	Seawater pollution (water quality and leachate)	Significant (High Priority)
7.	KP15	Air pollution (dust and dust)	Significant (High Priority)
8.	KP16	The noise disturbs the tranquility of the residents	Significant (High Priority)
9.	KP17	A large influx of foreigners	Significant (High Priority)
10.	KP18	Road congestion and disruption to traffic flow	Significant (High Priority)
11.	KP19	Concerns about delays in completing the project	Significant (High Priority)
12.	KP20	Increased waste and solid waste will drift from the sea to the banks of the construction area	Significant (High Priority)
13.	KP21	Existing drainage is affected	Significant (High Priority)
14.	EK2	Interfering with fishing activities due to the reduction of the catchment area	Significant (High Priority)
15.	EK3	Reducing sea catches, sources of income and increasing the cost of fishing activities	Significant (High Priority)
16.	KK1	Risk of transmission of dengue and infectious diseases	Significant (High Priority)
17.	PG1	Flooding in the upstream area	Significant (High Priority)

C. Construction On Rehabilitated And Reclaimed Land

With the completion of the reclamation works and sufficient setting time given, construction on the reclaimed land will commence for the individual land parcels. It is anticipated that some cutting is required due to basement construction and subsequently filling to the required platform level for the high rise building. The impacts associated with the construction on the reclaimed land as well as the existing land mass can be summarized as follows:-

- Impact due to land disturbance of site clearing activities for the existing landmass;
- Impact to water quality due to soil erosion and sediment and sewage generated from the construction workforce;

- Impact due to fugitive emissions of vehicle movement at the site including pollution from the use of generator sets;
- Impacts from the sources generating noise and vibration from construction activities;
- Impacts to human due to safety health issues;
- Impacts due to the generation of various types of wastes; and
- Impact due to traffic hazards of construction activities.

The above impacts are discussed below and evaluated according to impacts to physiochemical components, component and human component.

(i) Land Disturbance

Each parcel to be developed will result in land disturbance although the issue will not be significant but nonetheless measures have to be in place.

The rehabilitated and reclaimed land is relatively flat with final platform levels of +4.35 m NGVD.

Construction activities have the potential to affect the environment in many ways chief amongst these is potential hazards to workers or to the local residents or the environment surface water quality can be affected during demolition through the generation of fine materials eroded as a result of clearing surface and exposing soils to rainwater and drainage water. This may be deposited in watercources and change the nature of the waterway.

Surface water quality can similarly be affected by such fine material. This will change the quality of the water, especially if the fine material is contaminated as a result of the previous activities on the site.

Construction works also have the potential to affect local air quality. The site clearance activities may generate fugitive emission from lorries moving in and out of the site which may constitute a nuisance for local people. This may become a health hazard if dust is contaminate with toxic chemicals, such as asbestos, local air quality may decline as a result of particulate emissions from vehicle movements on and off site.

Impacts of construction activities on the human environment may take a variety of terms namely health issues and visual impact and nuisance issues. Health impacts are likely to arise when hazardous materials such as asbestos are released into the environment, generally as dust. Nuisance and hazards may be associated from the noise and vibration generated during the construction activities as well as dust from the heavy trucks removing waste off site.

Thus measures are to be in place to address the above issues.

The land disturbing activities mentioned earlier may cause significant impacts to the water quality of the receiving water body if uncontrolled. The EIA study have identified in **Chapter 6.2.3**, the discharges from the site will eventually enter the existing drains already available in the area which discharges into Sungai Siru. Thus during the construction stage, surface runoffs will flow into the drains and ultimately discharge into the sea and thus controls have to be provided as the marine environment will be affected if measures are not in place.

As this planning stae it is not feasible to quantify the earthworks reuired on each parcel of the reclaimed land. However, for the parcels abutting the coastline, further quantification is feasible with the separate EIA studies in place for the various parcels.

Nonetheless, during dry weather and strong wind conditions, any material stockpiled at the construction site can easily be dispersed to other areas while during wet weather, soil can easily be washed out from site and contributed to the stormwater pollutant load. Also, during construction works heavy rainfall will cause on site ponding which will result in a mosquito breeding area if measures are not in place.

The RUSLE (Revised Universal Soil-Loss Equation) can be used to predict the longtime average annual soil loss carried by runoff from specific slopes in specified management conditions. Annual Soil Loss is calculated in terms of A as follows:-

Soil erosion during site preparation involves annual soil loss of 96,261.19 ton/ha/year without any controls as shown in **Table 7.56.**

Table 7.56
RUSLE Annual Soil Loss

Condition	R [MJ.mm/ha/h]	K [tonnes/ha/ [MJ.mm/ha/h]]	Ls	C	P	Annual Soil Loss [tonnes/ha/year]
Pre-Development	17500	0.462	11.901	0.03	0.1	288.78
Construction Without Mitigation	17500	0.462	11.901	1	1	96261.19
Construction With Mitigation	17500	0.462	11.901	0.1	0.06875	661.80
Post Development	17500	0.462	0.121	0.05	0.1	4.89

Soil erosion is anticipated to be relatively significant when compared to the soil loss tolerance rates from the Erosion Risk Map of Malaysia as shown in **Table 7.57** However, with mitigating controls the annual soil loss can be reduce to 661.80 ton/ha/year. With mitigation measures as shown in earlier **Table 7.56** soil loss is to be mitigated by 99% reduction with proposed BMPs as outlined in ESCP.

Table 7.57
Soil Loss Tolerance Rates
from Erosion Risk Map Of Malaysia

Soil Erosion Class	Potential Soil Loss (ton/ha/year)
Very Low	<10
Low	10-50
Moderate High	50-100
High	100-150
Very High	>150

According to the USEPA, Urban Stormwater Guide as shown in **Table 7.58**, the average removal efficiency of suspended solids in retention/sedimentation pond is 70% and a high removal efficiency of 99% can be achieved. Thus, with the mitigation measures in place, it can be inferred that there will be a high removal efficiency for suspended solids so as not to cause significant impacts to the receiving waterway. However if measures are not in place the soil loss and sediment load can effect the land phase of the water cycle involving surface runoff that cause sedimentation to the water body and affect the in stream water quality processes as shown in **Table 7.59** and affect the water cycle as show in **Figure 7.159.**

Table 7.58
Pollutant Removal Efficiency Of Retention Basins

Parameter	Median or Average Removal Efficiency (percent)	Range of Removals (percent)		Number of Observations
		Low	High	
Soluble Phosphorus	34	-12	90	20
Total Phosphorus	46	0	91	44
Ammonia-Nitrogen	23	-107	83	14
Nitrate	23	-85	97	27
Organic Nitrogen	23	2	34	6
Total Nitrogen	30	-12	85	24
Suspended Solids	70	-33	99	43
Bacteria	74	-6	99	10
Organic Carbon	35	-30	90	29
Cadmium	47	-25	54	5
Chromium	49	25	62	5
Copper	55	10	90	18
Lead	67	-97	95	34
Zinc	51	-38	96	32

Source: USEPA Urban Stormwater Guide

Table 7.59
In-Stream Water Quality Processes

Name	Process	Pollutant Affected
Volatilization	Evaporation and aerosol formation	Hydrocarbons, mercury
Sedimentation	Gravity settling of particles and absorbed pollutants	Sediments, hydrocarbons, heavy metals
Pre-Suspension	Re-mobilization of particles by wind or hydraulic turbulence	Sediments, hydrocarbons, heavy metals
Filtration	Mechanical filtration of particles through substrate, aquatic flora or fauna.	Sediments
Absorption	Bonding for ion to sediments or organic matter (generally colloidal)	Hydrocarbons, phosphorus, nitrogen, heavy metals
De-sorption	Release of ions from sediments under adverse conditions (e.g. low pH, anaerobic)	Phosphorus, heavy metals
Oxidation/ reduction (Decomposition)	Oxidation of organic matter by microbial organisms, reduction of metals.	Hydrocarbons, metals, nitrogen, phosphorus
Complexation/ Chelation	Formation of a complex ion by combing a metal ion with an inorganic ion	Metals, phosphorus
Precipitation	Formation or co-precipitation of insoluble compound	Hydrocarbons, metals, phosphorus
Fixation	Fixation of atmospheric nitrogen to ammonia by microbial organisms and chemical fixation	Nitrogen
Nitrification	Microbial conversion of ammonia to nitrate, then to nitrite	Nitrogen
Denitrification	Microbial conversion of nitrate to atmospheric nitrogen	Nitrogen
Biomass update (Assimilation)	Uptake of ions from soil by aquatic plants through root system, limited uptake directly from water uptake by algae	Metal, phosphorus, nitrogen
Aeration	Exchange of oxygen from the atmosphere to the water body	Oxygen demanding substances
Dislocation	Movement of organic matter and algae downstream during high flows	Organic matter, nutrients

Source: Cullen (1986), Harper et al. (1991) and Lawrence et al. (1996)

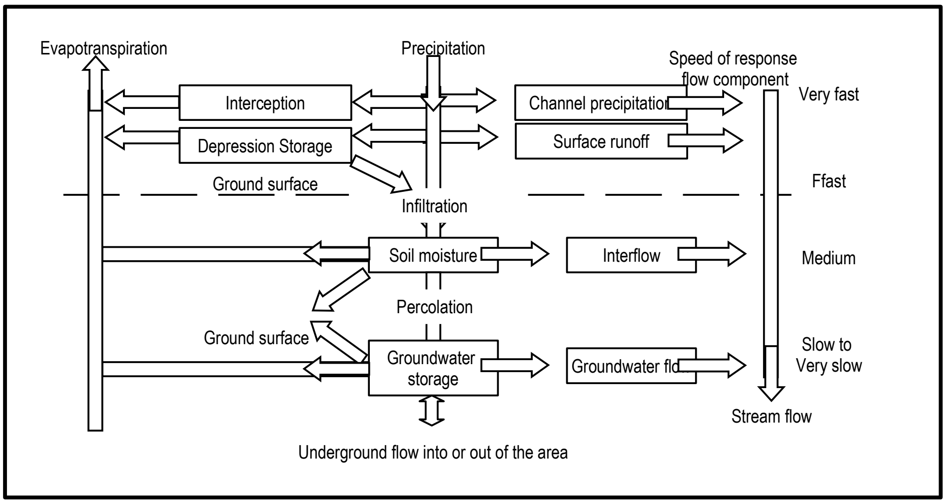


Figure 7.159 Land Phase Of The Water Cycle

The MUSLE (Modified Universal Soil-Loss Equation) can be used to predict the sediment yield in a watershed to a specific location for a specific storm event. This allows designers to accurately determine the sizings of sediment basin based on design storms. Sediment yield per design storm event is calculated in terms of T as:-

The sediment yield per 10 year ARI 20 minutes storm event for the construction site is summarised in **Table 7.60** as follows:-

Table 7.60
MUSLE Sediment Yield per Design Storm Event

Condition	V (m^3)	Qp (m^3/s)	K·Ls·C·P	Y (tonnes)
Pre-development	258	1.03	0.01650	33.72
Construction Without Mitigation	364	0.79	5.50064	11765.53
Construction With Mitigation	364	0.79	0.03782	80.89
Post Development	610	1.19	0.00028	1.00

Sediment yield without mitigation is 11765.53 tons per 10 year ARI 20 minutes storm during construction. However, sediment yield for construction with mitigation (i.e. BMPs practiced on site) was found to be 80.89 tonnes per 10 year ARI 20 minutes storm. In the event of sediment basin effluent not complying with DOE requirements of 50 mg/l, site engineers is required to assess whether the proposed BMPs are installed accordingly as per LDP2M2.

Although there are no flood prone areas in the vicinity due to the hilly terrains, flash floods can occur downstream of the site if measures are not in place. Thus measures outlined in **Chapter 8** shall be in place to address the issue.

(ii) Water Quality

The marine water quality surrounding the reclaimed site can be affected from the following sources:-

(a) Soil Erosion

The land disturbing activities mentioned above may cause significant impacts to the water quality of the receiving water body namely the sea. The EIA study have identified in **Chapter 6** that the discharges from the site will enter the proposed drainage system which flows into the sea. Thus, during the construction activities, surface runoffs if not control will result in deterioration of the water quality in the vicinity.

Earthworks will be conducted according to a staged schedule following the design of the construction at site for each parcel. The earthworks may involve cutting due to basement construction and foundation works.

The earthwork activities will disturb the land and may cause soil loss and increase in sediment loading into the receiving waterways. Thus measures must be in place to address such issues from the development of the individual land parcel.

(b) Impacts To Water Quality

The site will be temporary occupied by construction workers where base camps and site office will be established.

Normally cabins will be mobilized to the site as site offices while temporary structures will be constructed for the workers camps. Utility such as electricity and water will be procured from the existing lines for use at the base camps and site office while septic tanks on mobile toilets will be installed to collect and treat sewage.

Soil erosion and sediment can cause changes to water quality, due to the high concentration of suspended solids discharged from the site if uncontrolled, the water quality of the receiving waterway namely Sungai Ara will be affected. Presently, the water quality of these rivers are slightly polluted. Thus the water quality may deteriorate if measures are not in place.

Besides soil erosion and sediment, untreated sewage discharge from the base camps and site office can also pollute the waterways. Assuming construction workers of 50 people will be employed for each parcels, thus sewage of 2500 gpd will be generated from the site. Generally, the composition of sewage as shown in **Table 7.61** comprise of organic matter, solids (dissolve and suspended), fats and other pollutants. Besides polluting the waterways these pollutants can also create stench and odor and can also cause heath issues attracting flies and other organisms that can feed on biodegradable substances. Thus measures are to be in place to address the issue.

Table 7.61
Influent Values For Sewage

Constituent	Average Concentration (mg/l)
BOD (5-day, 20 Deg. C)	250
COD	500
Suspended Solids	300
Nitrogen, total	50
Ammonia Nitrogen	30
Total Phosphorus	10
Oil & Grease	50

Source: Malaysian Industrial Sewage Guidelines

(iii) Air Pollution

The sources that can contribute to air pollution are from the following:-

- Fugitive emissions from the movement of vehicles to the site and out of the site; and
- Use of fuel burning equipment such as generator sets.

The above sources may reduce air quality and visibility and have adverse effect on health depending on particulate size.

It is estimated that fugitive dust will not be a significant issue as the roads leading to the Proposed Project is paved. However, within the site, issues due to fugitive dusts can be significant during the earthwork activities especially during extreme dry weather as vehicles moving in an out of the site will generate dust plumes as the force of the wheels on the road surface cause pulverization of the surface. Particles are lifted and dropped from the holly wheels on the road surface and exposed to storage currents in turbulent sheor with the surface.

The turbulence wake (behind the vehicles) continues to act on the road surface after the vehicle passed, thereby causing fugitive dusts to be spread in the air. Generator set may also be installed to cater for the power requirements for the site office if procurement from the existing TNB lines is not possible. Diesel is generally used for the generator sets. As a result sulphur oxide and nitrous oxide will be exhausted out from the generator set. However, the generator set is expected to use diesel of small quantity utilizing approximately 10 to 20L of fuel on a daily basis. Due to the small usage of fuel oil emissions in the form of NOx and SOx from the use of generator sets are not anticipated to be significant.

(iv) Noise

Noise levels measured at the sensitive receptors are generally within the DOE's Planning Guidelines for Environmental Noise Limits and Controls for sub-urban residential use for daytime levels except for the nighttime noise levels are found to be higher due to traffic movement.

During the construction stage, noise generating sources are from the following:-

- Noise from vehicle movements;
- Noise from general construction activities.

Exhaust noise from vehicles constitutes the predominant source for normal operation below 55 Km/hr as shown in **Figure 7.160.** Although the noise nuisance is less significant in cars than in trucks, it is the dominant noise source at speeds above 80 Km/hr. Diesel trucks are 8 to 10 dBA noisier than gasoline powered ones. Speed is the dominant noise source from trucks.

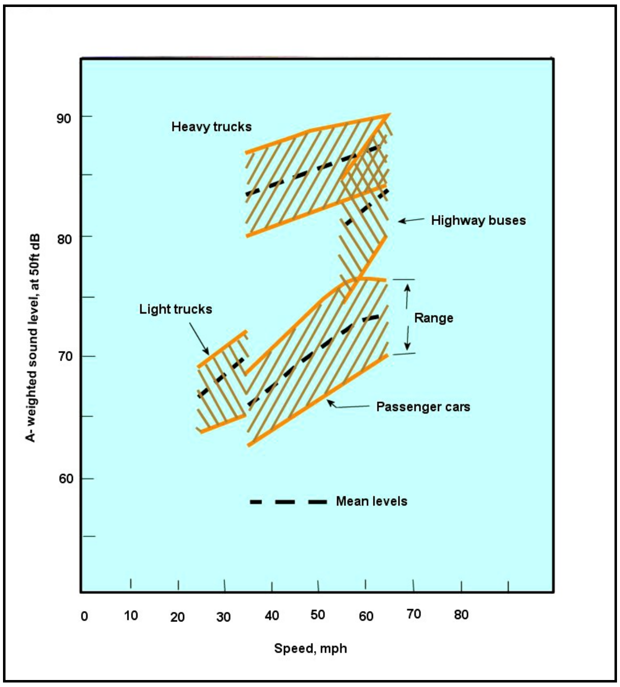


Figure 7.160 Single Vehicle Noise Output As A Function Of Speed

Noise from vehicular movements can cause annoyance to the community staying nearby. According to the USA Environmental Protection Agency, sound pressure level projected from vehicular movements will fall within a range of 65 dB(A) measured 36 m as shown in as shown in **Figure 7.161**.

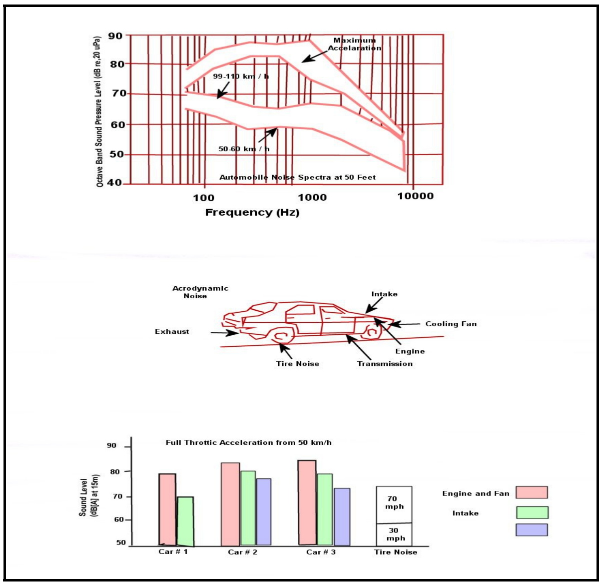


Figure 7.161 Sound Pressure Level

Various plants and equipments to be used during the construction stage will also generate noise during the construction stage. These equipment include trucks, mechanical equipment such as preuratic drills, mixers, weldy mechine and others, diesel generating sets, welding sets, pilers, and others. The range of noise level is expected to be between 63 to 101 dB(A) measured 15 m away as shown in **Table 7.62**.

Table 7.62
Noise Levels From Construction Equipment

Equipment	Noise Level 15 m Away [dB(A)]
Loader (9100-200kW)	83-92
Cranes (Small Mobile)	74-80
Dump Trucks	65-82
Welding Sets (300 A)	69-75
Pile Driver (Air Hammer)	80-101
Chipping Hammer On Steel	63-81
Grinder	63-68
Air Compressor	65-67
Concrete Truck (24T)	69-78
Diesel Generating Sets (250k VA)	74-81
Dowers	85-87
Jackhammer & Rock Drills	82-98
Saws	74-82

Source : Environmental Protection Agency U.S.A

Although a number of construction equipment will be used on the construction site not all equipment operates simultaneously. According to Davis and Cornwell (1981), the following generalizations appear to hold:-

- Single house construction in suburban communities will generate sporadic complaints if the eight hour Leq exceeds 70 dB(A) at the boundary line; and
- Major excavation and construction in a normal suburban community will generate complaints if the eight hour Leq exceeds 85 dB(A) at the boundary line.

8 hour exposure above 90 dB(A) as shown in **Table 7.63** can be detrimental to the residential communities nearby. Noise generated from construction activities is usually perceived by most residents as intrusive in nature due to the situation where the construction noise is a new noise source (disturbance) introduced into an existing community.

Table 7.63
WHO Recommended Noise Exposure Limits

Recommended Noise Exposure Limits dB(A) Leq	Remarks
Less than 75 (8 hr exposure per day)	No identifiable risk of hearing damage, Higher levels at prolonged exposure cause hearing impairment and loss
Less than 45 (background noise)	For good speech intelligibility indoors.
55 or less	Desirable daytime outdoor noise levels which will not likely cause annoyance in community.
45 or less	Desirable nighttime outdoor noise levels
35 or less (bedroom noise limit)	No likelihood of sleep disturbance.

The RCNM (Roadway Construction Noise Model) that is developed based on the US Construction Noise Control Specification 721.560 is used as a computer mathematic model for the prediction of construction noise in this study. It provides a construction noise screening tool to easily predict construction noise levels and to determine compliance with noise limits for a variety of construction noise projects of varying complexity. Its predictions originated from US EPA (Environmental Protection Agency) noise level work and an Empire State Electric Energy Research Corp. Guide which utilizes an "acoustical usage factor" to estimate the fraction of time each piece of construction equipment is operating at full power (i.e. its loudest condition) during a construction operation. The noise level represent the A-weighted maximum sound level (Lmax) measured at a distance of 13.3m (50 ft) from the construction equipment. RCNM allows to (i) easily predict noise emissions from construction equipment and (ii) determine a construction work plans compliance with noise criteria limits.

The RCNM use the primary equation described in us specification 721.560 for the construction noise calculation include:-

Lmax calc= Selected Lmax - 20 log (D/50) - Shielding
where
Selected - Lmax - Spec or Actual Maximum A - weighted Sound Level at 50 ft in dBA
D - Distance between equipment and receptor in ft
shielding - insertion loss of any barriers or mitigation in dBA

Leq = Lmax calc + 10 log (U.F. %/100)
where U.F. % - time averaging equipment usage factor in percent
L 10 = Leq + 3 dBA adjustment factor
Total Leq = 10* log (Σ (individual equipment Leq values))
Total L_{10} = 10* log (Σ (individual equipment Leq values))

Figure 7.162 depicts the location of the receptors in the vicinity of the project site.

3 receptors identified for this modeling:-

- At Mutiara Idaman 1 (116 m);
- At Project Site (36 m); and
- At Summer Place (126 m).

Table 7.64, Table 7.65 and Table 7.66 depicts the noise level predicted at the 3 receptors mentioned earlier.

Receptors	Distance
Mutiara Idaman 1	116 m
Project Site	36 m
Summer Place	126 m

Not To Scale

Figure 7.162 Location Of Nearest Receptors

Table 7.64
Noise Prediction At Mutiara Idaman 1

---- Receptor #1 ----

Description	Land Use	Baselines (dBA) Daytime	Evening	Night
Mutiara Idaman 1	Residential	58.6	58.6	53.3

Description	Impact Device	Usage(%)	Equipment Spec Lmax (dBA)	Actual Lmax (dBA)	Receptor Distance (meters)	Estimated Shielding (dBA)
All Other Equipment > 5 HP	No	50	85		116	3
Backhoe	No	40		77.6	116	3
Bar Bender	No	20	80		116	3
Compactor (ground)	No	20		83.2	116	3
Compressor (air)	No	40		77.7	116	3
Concrete Mixer Truck	No	40		78.8	116	3
Concrete Saw	No	20		89.6	116	3
Crane	No	16		80.6	116	3
Dozer	No	40		81.7	116	3
Dump Truck	No	40		76.5	116	3
Excavator	No	40		80.7	116	3
Flat Bed Truck	No	40		74.3	116	3
Generator	No	50		80.6	116	3
Grader	No	40	85		116	3
Impact Pile Driver	Yes	20		101.3	116	3
Pickup Truck	No	40		75	116	3
Pneumatic Tools	No	50		85.2	116	3
Roller	No	20		80	116	3
Tractor	No	40	84		116	3
Welder / Torch	No	40		74	116	3

Results

	Calculated (dBA)		Noise Limits (dBA)						Noise Limit Exceedance (dBA)					
			Day		Evening		Night		Day		Evening		Night	
Equipment	*Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq
All Other Equipment > 5 HP	64.4	61.4	65	65	65	65	60	60	None	None	None	None	4.4	1.4
Backhoe	56.9	53	65	65	65	65	60	60	None	None	None	None	None	None
Bar Bender	59.4	52.4	65	65	65	65	60	60	None	None	None	None	None	None
Compactor (ground)	62.6	55.6	65	65	65	65	60	60	None	None	None	None	2.6	None
Compressor (air)	57	53.1	65	65	65	65	60	60	None	None	None	None	None	None
Concrete Mixer Truck	58.2	54.2	65	65	65	65	60	60	None	None	None	None	None	None
Concrete Saw	69	62	65	65	65	65	60	60	4	None	4	None	9	2
Crane	59.9	52	65	65	65	65	60	60	None	None	None	None	None	None
Dozer	61	57.1	65	65	65	65	60	60	None	None	None	None	1	None
Dump Truck	55.8	51.8	65	65	65	65	60	60	None	None	None	None	None	None
Excavator	60.1	56.1	65	65	65	65	60	60	None	None	None	None	0.1	None
Flat Bed Truck	53.6	49.6	65	65	65	65	60	60	None	None	None	None	None	None
Generator	60	57	65	65	65	65	60	60	None	None	None	None	0	None
Grader	64.4	60.4	65	65	65	65	60	60	None	None	None	None	4.4	0.4
Impact Pile Driver	80.6	73.7	65	65	65	65	60	60	15.6	8.7	15.6	8.7	20.6	13.7
Pickup Truck	54.4	50.4	65	65	65	65	60	60	None	None	None	None	None	None
Pneumatic Tools	64.6	61.5	65	65	65	65	60	60	None	None	None	None	4.6	1.5
Roller	59.4	52.4	65	65	65	65	60	60	None	None	None	None	None	None
Tractor	63.4	59.4	65	65	65	65	60	60	None	None	None	None	3.4	None
Welder / Torch	53.4	49.4	65	65	65	65	60	60	None	None	None	None	None	None
Total	80.6	75.2	65	65	65	65	60	60	15.6	10.2	15.6	10.2	20.6	15.2

*Calculated Lmax is the Loudest value.

Table 7.65
Noise Prediction At Project Site

---- Receptor #2 ----

Description	Land Use	Baselines (dBA) Daytime	Evening	Night
Persiaran Karpal Singh	Residential	55.8	55.8	53.4

Description	Impact Device	Usage(%)	Equipment Spec Lmax (dBA)	Actual Lmax (dBA)	Receptor Distance (meters)	Estimated Shielding (dBA)
All Other Equipment > 5 HP	No	50	85		36	3
Backhoe	No	40		77.6	36	3
Bar Bender	No	20	80		36	3
Compactor (ground)	No	20		83.2	36	3
Compressor (air)	No	40		77.7	36	3
Concrete Mixer Truck	No	40		78.8	36	3
Concrete Saw	No	20		89.6	36	3
Crane	No	16		80.6	36	3
Dozer	No	40		81.7	36	3
Dump Truck	No	40		76.5	36	3
Excavator	No	40		80.7	36	3
Flat Bed Truck	No	40		74.3	36	3
Generator	No	50		80.6	36	3
Grader	No	40	85		36	3
Impact Pile Driver	Yes	20		101.3	36	3
Pickup Truck	No	40		75	36	3
Pneumatic Tools	No	50		85.2	36	3
Roller	No	20		80	36	3
Tractor	No	40	84		36	3
Welder / Torch	No	40		74	36	3

Results

	Calculated (dBA)		Noise Limits (dBA)						Noise Limit Exceedance (dBA)					
			Day		Evening		Night		Day		Evening		Night	
Equipment	*Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq
All Other Equipment > 5 HP	74.5	71.5	65	65	65	65	60	60	9.5	6.5	9.5	6.5	14.5	11.5
Backhoe	67.1	63.1	65	65	65	65	60	60	2.1	None	2.1	None	7.1	3.1
Bar Bender	69.5	62.5	65	65	65	65	60	60	4.5	None	4.5	None	9.5	2.5
Compactor (ground)	72.8	65.8	65	65	65	65	60	60	7.8	0.8	7.8	0.8	12.8	5.8
Compressor (air)	67.2	63.2	65	65	65	65	60	60	2.2	None	2.2	None	7.2	3.2
Concrete Mixer Truck	68.3	64.4	65	65	65	65	60	60	3.3	None	3.3	None	8.3	4.4
Concrete Saw	79.1	72.1	65	65	65	65	60	60	14.1	7.1	14.1	7.1	19.1	12.1
Crane	70.1	62.1	65	65	65	65	60	60	5.1	None	5.1	None	10.1	2.1
Dozer	71.2	67.2	65	65	65	65	60	60	6.2	2.2	6.2	2.2	11.2	7.2
Dump Truck	66	62	65	65	65	65	60	60	1	None	1	None	6	2
Excavator	70.2	66.3	65	65	65	65	60	60	5.2	1.3	5.2	1.3	10.2	6.3
Flat Bed Truck	63.8	59.8	65	65	65	65	60	60	None	None	None	None	3.8	None
Generator	70.2	67.2	65	65	65	65	60	60	5.2	2.2	5.2	2.2	10.2	7.2
Grader	74.5	70.6	65	65	65	65	60	60	9.5	5.6	9.5	5.6	14.5	10.6
Impact Pile Driver	90.8	83.8	65	65	65	65	60	60	25.8	18.8	25.8	18.8	30.8	23.8
Pickup Truck	64.5	60.6	65	65	65	65	60	60	None	None	None	None	4.5	0.6
Pneumatic Tools	74.7	71.7	65	65	65	65	60	60	9.7	6.7	9.7	6.7	14.7	11.7
Roller	69.5	62.5	65	65	65	65	60	60	4.5	None	4.5	None	9.5	2.5
Tractor	73.5	69.6	65	65	65	65	60	60	8.5	4.6	8.5	4.6	13.5	9.6
Welder / Torch	63.5	59.6	65	65	65	65	60	60	None	None	None	None	3.5	None
Total	90.8	85.3	65	65	65	65	60	60	25.8	20.3	25.8	20.3	30.8	25.3

*Calculated Lmax is the Loudest value.

Table 7.66
Noise Prediction At Summer Place

---- Receptor #3 ----

Description	Land Use	Baselines (dBA) Daytime	Evening	Night
Persiaran Karpal Singh (	Residential	53.5	53.5	45.1

Description	Impact Device	Usage(%)	Equipment Spec Lmax (dBA)	Actual Lmax (dBA)	Receptor Distance (meters)	Estimated Shielding (dBA)
All Other Equipment > 5 HP	No	50	85		126	3
Backhoe	No	40		77.6	126	3
Bar Bender	No	20	80		126	3
Compactor (ground)	No	20		83.2	126	3
Compressor (air)	No	40		77.7	126	3
Concrete Mixer Truck	No	40		78.8	126	3
Concrete Saw	No	20		89.6	126	3
Crane	No	16		80.6	126	3
Dozer	No	40		81.7	126	3
Dump Truck	No	40		76.5	126	3
Excavator	No	40		80.7	126	3
Flat Bed Truck	No	40		74.3	126	3
Generator	No	50		80.6	126	3
Grader	No	40	85		126	3
Impact Pile Driver	Yes	20		101.3	126	3
Pickup Truck	No	40		75	126	3
Pneumatic Tools	No	50		85.2	126	3
Roller	No	20		80	126	3
Tractor	No	40	84		126	3
Welder / Torch	No	40		74	126	3

Results

	Calculated (dBA)		Noise Limits (dBA)						Noise Limit Exceedance (dBA)					
			Day		Evening		Night		Day		Evening		Night	
Equipment	*Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq	Lmax	Leq
All Other Equipment > 5 HP	63.7	60.6	65	65	65	65	60	60	None	None	None	None	3.7	0.6
Backhoe	56.2	52.2	65	65	65	65	60	60	None	None	None	None	None	None
Bar Bender	58.7	51.7	65	65	65	65	60	60	None	None	None	None	None	None
Compactor (ground)	61.9	54.9	65	65	65	65	60	60	None	None	None	None	1.9	None
Compressor (air)	56.3	52.3	65	65	65	65	60	60	None	None	None	None	None	None
Concrete Mixer Truck	57.5	53.5	65	65	65	65	60	60	None	None	None	None	None	None
Concrete Saw	68.2	61.2	65	65	65	65	60	60	3.2	None	3.2	None	8.2	1.2
Crane	59.2	51.2	65	65	65	65	60	60	None	None	None	None	None	None
Dozer	60.3	56.3	65	65	65	65	60	60	None	None	None	None	0.3	None
Dump Truck	55.1	51.1	65	65	65	65	60	60	None	None	None	None	None	None
Excavator	59.4	55.4	65	65	65	65	60	60	None	None	None	None	None	None
Flat Bed Truck	52.9	48.9	65	65	65	65	60	60	None	None	None	None	None	None
Generator	59.3	56.3	65	65	65	65	60	60	None	None	None	None	None	None
Grader	63.7	59.7	65	65	65	65	60	60	None	None	None	None	3.7	None
Impact Pile Driver	79.9	72.9	65	65	65	65	60	60	14.9	7.9	14.9	7.9	19.9	12.9
Pickup Truck	53.7	49.7	65	65	65	65	60	60	None	None	None	None	None	None
Pneumatic Tools	63.8	60.8	65	65	65	65	60	60	None	None	None	None	3.8	0.8
Roller	58.7	51.7	65	65	65	65	60	60	None	None	None	None	None	None
Tractor	62.7	58.7	65	65	65	65	60	60	None	None	None	None	2.7	None
Welder / Torch	52.7	48.7	65	65	65	65	60	60	None	None	None	None	None	None
Total	79.9	74.5	65	65	65	65	60	60	14.9	9.5	14.9	9.5	19.9	14.5

*Calculated Lmax is the Loudest value.

Table 7.67 provides the summary of the noise levels based on the RCNM computer mathematic model. According to the results obtained the noise levels range from 64.6 to 74 dB(A) Leq if control measures are not in place. Thus measures are to be in place to reduce the noise levels to less than 55 dB(A) Leq daytime.

Table 7.67
Summary of Noise Levels Without Control

Location	Without Control (dBA Leq)	Guidelines (dBA Leq)
At Mutiara Idaman 1	75.2	65
At Project Site	85.3	65
At Summer Place	74.5	65

Table 7.68 provide the estimation of noise reduction with noise control measures to be take during construction at site include:-

- Noise reduction at source (5-10 dBA);
- Noise reduction with barrier protection (15-20 dBA); and
- Noise reduction with distance shielding (3 dBA).

Table 7.68
Noise Reduction Estimation

Equipment	Noise Control At Source	Noise Reduction	Barrier Protection	Noise Reduction	Distance Shielding	Noise Reduction
All Other Equipment	Quietest configuration	5-10 dBA	Barrier to be built facing receptor from commercial panels which are lined with sound absorbing material to achieving maximum shielding effect possible with length of the barrier greater than its height	15-20 dBA	Distance to receptors from 6 to 28 m	3 dBA
Backhoe	Retrofitting with mufflers					
Chain Saw	Use saw bladder with built in vibration dampening					
Compactor	Retrofitting with mufflers					
Crane	Retrofitting with mufflers					
Dozer	Quietest configuration with improved exhaust and intake muffling					
Dump Mixer	Quietest configuration with improved exhaust and intake muffling					
Excavator	Retrofitting with mufflers					
Front End Loader	Retrofitting with mufflers					
Grader	Quietest configuration with improved exhaust and intake muffling					
Paver	Retrofitting with mufflers					
Pneumatic Tools	Portable screen					
Tractor	Retrofitting with mufflers					
Welder/Torch	Incorporate some type of return on exhaust line					

It is anticipated noise reduction of 23 – 33 dBA will be achieved with noise control measures in place as shown in **Table 7.69.**

Table 7.69
Summary Of Noise Levels With Control

Location	With Control (dBA Leq)	Guidelines (dBA Leq)
At Mutiara Idaman 1	42.2	65
At Project Site	52.3	65
At Summer Place	41.5	65

* Revert to baseline conditions

(v) Wastes

The site clearing activities may involve the removal of some vegetation at the new landmass comprising undergrowth. If the reclaimed area is left unattanded or idle over time. However, the quantity will be manageable.

The construction stage will also generate domestic wastes from the workers' camp and site office and construction wastes comprising of excess pvc material plastic, wooden formwork, cut material, empty containers and others.

Assuming that each construction worker generate 0.8 kg/day of domestic wastes, 40 kg/day of domestic wastes will be generated at site. It is not possible to estimate the amount of construction waste generated at site as this is dependent on the material being used and construction schedule. Normally the site construction wastes are stockpiled at site prior to disposal off site. Besides the construction wastes, waste regulated under the Environmental Quality (Schedule Wastes) Regulations 2005, may also be generated at site. Normally these wastes may include spent oils (SW 305), spent wastes (SW 417) and contaminated containers (SW 409). Nonetheless measures are to be in place to address the above issue.

(vi) Construction Safety

The construction activities will result in the hiring of skilled and unskilled workers and the establishment of workers'. Normally, foreign workers are employed in the construction industry if local workers cannot be found. Issues relating to the employment of foreign workers are mainly in relation to health and safety as the foreign workers are perceived as a threat to the local community.

During the construction stage also, the daily traffic will also be affected as road diversion will be in place to reroute and divert traffic for the road that will be upgraded adjacent the site whilst the construction activities proceed at site. This may cause stress, longer travel time for the road users besides safety issues.

Safety is another issue related to construction sites which can have adverse repercussions to workers at site. Various factors can cause accidents at construction sites. This includes poor safety provisions, poor supervision of safety requirements, human error. Unsafe working environment may lead to:-

- Accidents, which may result in injuries or even losses; and
- If the accident is a major accident, the construction area will be sealed until the relevant authorities have thoroughly investigated the scene and satisfied that the project proponent, has incorporated additional safety measures and the project will not be completed according to schedule.

Traffic hazard during the construction stage is another issue to be addressed as there will be heavy movement of lorries and transport vehicles moving in and out of the site. The primary road, Jalan Bayan Mutiara provides access to the site.

A number of residential areas and other establishments are already operational along Jalan Bayan Mutiara and the roads linking to Jalan Bayan Mutiara. Thus, as the construction industry will temporary occupy the Proposed Project site it is envisage traffic will be much heavier with the construction industry in place. Thus measures are to be in place to address the issues.

D. Post Construction (Occupation) Stage

Activities in the post construction or occupation stage involve the migration of the new population of occupying the residential and commercial units. As a result, sewage will be generated from the Proposed Project which requires treatment, domestic waste will be generated which requires management and disposal, traffic will also be attracted to the project site as well as generated from the project site.

The occupation stage requires various forms of maintenance. This includes routine maintenance of the drains, detention ponds, roads, slopes, open spaces, public amenities and others that were constructed for the Proposed Project. Thus, the activities that will be assessed include:-

- Occupation of buildings and structures which will result in the generation of stormwaters, domestic wastes, sewage and traffic; and
- Maintenance of various structures and facilities provided at site.

The following provides a brief discussion on the impacts during the occupation stage. During the occupation stage, the impacts to the accrue physicochemical component are as follows:-

(i) Land

The land already developed will occupy the site. The site will also be landscaped and thereby stabilizing the area. The reclamation site will be designed according to the civil and structural requirements to address coastal erosion. Nonetheless measures are to be in place to ensure stability of the landmass.

(ii) Urban Stormwater

Table 7.70 provides the mean EMC (Event Mean Concentration) values for stomrwaters for selected landuse extracted from MSMA.

Table 7.70
Mean EMC Values For Selected Landuses

Pollutants		Landuses			
Parameter	Unit	Residential	Commercial	Industrial	Highway
TSS	mg/l	128.00	122.00	266.00	80.00
Turbidity	NTU	122.00	96.00	147.00	69.00
TDS (Total Dissolve Solids)	mg/l	131.00	43.00	137.00	38.00
pH	-	6.46	6.77	6.66	6.57
BOD (Biochemical Oxygen Demand)	mg/l	17.90	22.90	19.30	14.90
COD (Chemical Oxygen Demand)	mg/l	97.00	134.00	140.00	81.00
AN (Ammonia Nitrogen)	mg/l	0.73	0.85	1.00	0.44
TKN (Total Kjeldahl Nitrogen)	mg/l	2.38	2.53	4.25	1.43
TN (Total Nitrogen)	mg/l	4.21	4.84	5.00	2.25
TP (Total Phosphorous)	mg/l	0.34	0.32	0.49	0.16
O&G (Oil & Grease)	mg/l	2.00	4.00	NA	3.00
Zn (Zinc)	mg/l	0.19	0.34	0.43	0.21
Pb(Lead)	µg/l	6.00	22.00	12.00	20.00
Cu (Copper)	µg/l	28.00	37.00	42.00	28.00
Cr (Chromium)	µg/l	4.00	32.00	31.00	11.00
Ni (Nickel)	µg/l	10.00	17.00	30.00	15.00
Cd (Cadmium)	µg/l	6.00	26.00	5.00	10.00

Source: Local stormwater studies conducted by DID in Malacca, Damansara, Penang and Kajang

Erosion rate prior development on the reclaimed land will revert to stable conditions due to protection offered by pavements and turfing, landscaping and others.

(iii) Sewage

Sewage will be generated from the Proposed Project. Its is estimated that sewage of 4.59 MGD will be generated with the full occupancy of the Proposed Project. Untreated sewage will result in water pollution and will deteorate the water quality of the receiving waterways. Untreated sewage will result in pollution to the waterway besides the odor and health repercussions associated with sewage. Thus measures are to be in place to address the issue.

(iv) Air Pollution From Mobile Sources

Once fully occupied, the only source contributing to air pollution is from the exhaust emissions from mobile sources. Vehicular emissions normally comprise of CO (Carbon Monoxide), SOx (Sulphurious Oxide) and NO_2 (Nitrous Oxide). With the use of unleaded petrol in the country, lead emissions have reduce from mobile sources nonetheless measures have to be in place so as not to cause health issues in the area.

(v) Domestic Wastes

Domestic waste will be generated from the Proposed Project. During full occupancy as much as 71.6 tpd of domestic wastes will be generated which normally compose of putresible wastes, plastic, paper and metals as shown in **Table 7.71**. Thus the domestic waste will have to be managed and disposed off in a proper manner. Currently the nearest domestic waste disposal site is in Pulau Burong in Seberang Perai Selatan which is already facing tremendous pressure.

Table 7.71
Waste Composition According To Category

Category	Percentage (%)				
	Kitchen Waste	Paper	Plastic	Grass & Wood	Metal
High Income	41	14	12	17	4
Middle Income	57	11	13	5	4
Low Income	44	10	16	8	5
Restaurant	57	13	12	5	6
Other Shops	28	26	16	1	5
Institution	21	44	15	2	5
Market	63	15	12	4	1
Street Sweeping	10	9	9	45	1
River	8	1	67	11	1

Source: Waste Amount and Composition Survey, JICA 1997

E. Summary Of Impact Assessment

Table 7.72 provides a summary of the potential impacts from the Proposed Project.

Table 7.72
Summary Of Potential Impacts

Environment Component / Project Activities	Potential Impacts
Surface, River Water Quality And Marine Water Quality	
Rehabilitation Works And Reclamation Works • Rehabilitation activities • Recycling work	• Rehabilitation activities may also cause landfill residual gas and leachate issues. • Reclamation activities may result in sediment transport which will affect the marine water quality in the area. • Reclamation activities may also effect the shoreline.
Construction on Rehabilitated And Reclaimed Lands • Soil erosion & sedimentation • Spillage of hydrocarbon & chemical substances from machinery / equipment • Untreated sewage discharge into water bodies • Disposal or rubbish/construction debris into water bodies	• Increase in turbidity and suspended solids due to earthworks, etc. this will lead to a reduction in light penetration thus affecting aquatic life – due to lower concentration of DO (dissolved oxygen) and increase of BOD (biological oxygen demand); • Gastroenteric micro organism in the sewage discharge can cause outbreaks of water borne diseases i.e. Chlolera, typhoid, etc.; • Contamination of receiving waters due to untreated sewage; and • Increase sediment concentrations in coastal water thus affecting the aquatic life forms and generates noxious odour.
Operational Stage On Reclaimed Land • Operational failure of the sewage treatment plant (STP) • Stormwater runoff	• Water pollution if sewage not treated properly; • Odour would occur if the system is not functioning properly; and • Surface runoff upon completion of the project that contains pollutants i.e. Oil, grease, rubbish, etc. may increase pollutant. • Permanent drains and on site storage shall be provided at site to cater for the increase in stormwater pollution load. Gross pollution trap will be provided at the final discharge manhole to trap all leaves and rubbish from entering the drain; • Engineering details shall be submitted to the JPS for approval; and • Ensure maintenance of drains, oil and silt trap conducted on a routine basis to ensure the continuous performance of these structures and to detect any potential areas of concern. • Generate of urban stormwater is residual
Air Quality	
Rehabilitation and Reclamation Works • Compaction of reclamation area	• Gaseous emission release during excavation work on Jelutong Landfill • Reduce air quality and visibility; and • Increase in sea traffic volume could result in increasing releases of hydrocarbon pollutants.
Construction on Reclaimed Land Fugitive dust dispersion and emission especially during dry weather. • Land disturbance, earthworks and excavation activities • Vehicular and heavy machinery movements • Vehicular emissions from incomplete combustion of vehicles and machinery • Materials handling • Buildings construction (concreting works)	• Reduce air quality and visibility; • Adverse effect on health for certain concentrations and particulates size i.e. Bronchitis, cardiovascular problem, etc; and • Increase in traffic volume could increase the releases of hydrocarbon pollutants and other hazardous compounds.
Operational Stage on Reclaimed Land • Exhaust emissions from vehicles	• Exhaust emissions from vehicles will increase due to increase of number of vehicles.

Table 7.72 (Continue)

Environment Component / Project Activities	Potential Impacts
Noise	
Rehabilitation and Reclamation Works • Transport of fill material using barges	• Noise generation
Construction on Reclaimed Land • Heavy machinery and construction activities • Vehicles movements on site • Piling activities • Buildings construction	• Increase noise levels due to frequent flow of heavy vehicles; • Noise generated by piling and construction machinery/equipment can be harmful to the workers if precautions is not taken; • Noise impact is expected to be insignificant and will only be temporary and confine to the construction period; and • Uncontrolled piling activities will cause vibration levels which may cause structural damages.
Operational Stage on Reclaimed Land • Human activities	• No significant impact is anticipated.
Ecology/Habitats	
Rehabilitation and Reclamation Works • Filling works	• Impacts to Water Quality
Construction on Reclaimed Land • Land clearing activity	• Increase of biomass generation
Operational Stage on Reclaimed Land • Sewage discharge	• Discharge of sewage or any wastes into the water body will affect the water quality hence its life form.
Human Environment	
Rehabilitation And Reclamation Works • Safety and health issues	• Safety issues during rehabilitation works • Generate employment opportunities; • Safety and health of workers on site; • Nuisance and discomfort to surrounding environment due to noise, dust and fumes generation; and • Safety issues due to the movement and presence of barges in the area.
• Socio economy	• Impacts to fishermen due to lose in fishing area
Construction on Reclaimed Land • Safety and health	• Generate employment opportunities; • Safety and health of workers on site; • Social and cultural problems, if foreign workers are employed; • Crime rate may increase; • Spread of communicable and parasitic diseases; • Increased demand on current infrastructures; and • Nuisance and discomfort to surrounding environment due to noise, dust and fumes generation.
Operational Stage on Reclaimed Land • Transient population • Public safety and health	• In-migration of families and transcient population from various background; and • Breeding of disease vectors due to poor maintenance of public utilities and infrastructure system.
Transportation and Sea Traffic	
Rehabilitation and Reclamation Works • Sea going vessels	• Traffic from sand source and reclamation activities.
Construction on Reclaimed Land • Increased in traffic volume • Increase in vehicular emissions	• Increase in traffic volume from construction transporting vehicles; • Increase risk of accidents; • Deterioration of local conditions; and • Traffic congestion and inconvenience to other road users.

Table 7.72 (Continue)

Environment Component / Project Activities	Potential Impacts
Operational Stage on Reclaimed Land • Increased in localized traffic volume • Increased in vehicular emissions	• Increased localized traffic volume due to increase in activities; • Increased risk of accidents to public road user; and • Increased vehicular emissions into the atmosphere.
Waste Management	
Rehabilitation and Reclamation Works • Filling works	• Unsuitable fill material will cause poor filling and contamination.
Construction on Reclaimed Land • Construction wastes • Domestic wastes from workers camps • Generator of scheduled waste	• Potential drainage blockage from the improper disposal of solid wastes. • Improper management of domestic wastes from worker camps could promote disease vector breeding and cause health hazards.
Operation Stage on Reclaimed Land • Domestic wastes	• Increase generation of solid wastes within the region; • Inefficient solid wastes handling can cause odour, visual aesthetic, infestation and human health problems; and • Improper solid waste management could also cause surface water contamination.

7.3 Residual Impacts

Based on the impacts identified the residual impacts of the Proposed Project are as follows:-

- Urban stormwaters generated from the site is residual;
- Sewage generated from the site is also residual;
- Domestic wastes generated from the site is residual; and
- Traffic generation/ attraction and vehicular emissions from the mobile sources will be residual.

7.4 Project Abandonment

It is unconceivable that the Proposed Project will be abandoned after much planning, energy and finance have been invested for the Proposed Project. However, in the rare circumstances that the Proposed Project is abandoned due to external factors or say an economic downturn, the activities involved with project abandonment includes sealing the area, sourcing for other use and dismantling of any structures causing a hazard to the safety of the local population. Thus measures are to be in place to cater for issues relating to abandonment.

7.5 Project Evaluation

The EIA Guidelines for Coastal and Land Reclamation provides a section on cost-benefit analysis which emphasized that the analysis should only refer to the public, as it is the public who will be the final adversaries or beneficiaries of the project outcomes. Since quantitative cost-benefit analysis has been difficult to handle, attempts have been made to provide for a qualitative cost-benefit analysis and it need not be financial alone, but social or ecological as well involving aesthetic and ethical considerations.

For the Proposed Project a qualitatively cost benefit analysis as discussed below has been provided taking into account of the following:-

- The site of the Proposed Project has been gazetted in the RSN Pulau Pinang 2030 as a site to be reclaimed as this will provide additional land to cater for physical expansion of the state to cater for a growing population;
- There are no environmentally sensitive areas in the waters in vicinity of the project site gazetted under the Town & Country Planning Act 1974;
- The fishermen's jetty, a social issue that may result in conflict has been resolved amicably whereby the new fishermen's jetty will be located elsewhere as discussed in **Chapter 5** of this EIA report;
- The Proposed Project also involves rehabilitation of the TPSJ which has raised a lot of concerns to the public in the past due to fires, odour and aesthetics;
- During the reclamation activities, coastal waters from the coastline and areas close to the reclamation site cannot be use. This would result in a reduction in the area for catching fish. However, reduction in fish yield and loses to fisherman cannot be quantified as there are various factors influencing the reduction in fish yield amongst others include water pollution; and
- The coastal hydraulic studies as discussed in earlier section indicated that the extracted mean and maximum concentration of various pollutants discharged in the groundwater modeling at each of the identified ESR's are well below the allowable limit.

Base on the above, **Table 7.73** provides a summary of the development pressures to the coastal environment and their related impact categories in trying to provide the qualitative cost benefit analysis for the Proposed Project.

Table 7.73
Envrionmental Pressures And Impact Categories

Impact Categories	Climate-Related Events And Human Activities		
	Erosion	Siltation	Pollution Water Quality
Tourism	'$'		$
Fishing		'$'	'$', nm
Coastal Residences	'$'	'$'	'$'
Commercial/Buildings etc	'$'	'$'	'$'
Coastal Ecosystems	$, nm		$, nm

Note: nm - non market impacts
$ - market priced major impact
'$' - minor impacts