Marine Reclamation Works on the West Coast of Sabah

Terms of Reference for

Environmental Monitoring and Management Programme for the Construction of

“[Insert project name]”

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PREFACE

The present Terms of Reference (TOR) provides a generic description of the scope of work required by the Sabah State Government for developers to fulfil the requirements for Environmental Monitoring and Management in connection with marine reclamation works.

1. INTRODUCTION

It is a strong concern of the authorities of Sabah that the development of any marine reclamation project is undertaken with the aim of minimising the negative impact of the development on the physical-chemical and biological-ecological environment.

Realising this need, the Ministry of Culture, Environment and Tourism, Sabah (MCET) together with the Department of Irrigation and Drainage (DID) and the Town and Regional Planning Department, Sabah (TRPD) have established a Shoreline Management Plan (SMP), which delineates areas suitable for land reclamation along the West Coast of Sabah from Pulau Mukan in the north to Menggalung River in the south. These present Terms of Reference (TOR) are developed by the Sabah State Government as a guide to developers in order to ensure a standard of Environmental Monitoring and Management in compliance with Federal requirements for approval of marine reclamation projects.

The comprehensive Shoreline Management Plan for reclamation projects on the West Coast of Sabah has been accomplished for the Ministry of Culture, Environment and Tourism, Sabah by a team comprising Danish Hydraulic Institute, VKI, PEM Consults and Hasløv & Kjærsgaard supported by Universiti Malaysia Sabah, Sustainable Environmental Management Consultants and Sepakat Setia Perunding Sdn. Bhd. Results from this study will be available for the detailed planning of the Environmental Monitoring and Management Programme of "[Insert project name]". The consultant chosen to undertake the Environmental Monitoring and Management Programme of the "[Insert project name]" (hereinafter called the Consultant) is expected to ensure that his work is performed taking full advantage of the findings of the SMP in terms of baseline data, model set-up and calibration. These data and reports are available from MCET.

The present TOR documents the requirements for an Environmental Monitoring and Management Programme (EMP) for marine reclamation works in the sensitive environments off the West Coast of Sabah. Supporting TOR for Detailed Environmental Impact Assessment is also available from MCET.

2. OVERALL MONITORING AND MANAGEMENT STRATEGY

The overall strategy for the Environmental Monitoring and Management Programme shall be applied in connection with the reclamation works for "[Insert project name]" is to be based upon the principle of feedback monitoring.

Applying the principles of feedback monitoring implies that the monitoring forms an integral part of the construction process as described below:

i) Environmental Baseline

Feedback variables are identified, instrumented and monitored for a statistically significant period prior to construction.

ii) Elaboration of work plans

The Contractor elaborates a work plan specifying the distribution of the work in time and space and the procedure for a single construction phase (typically 3 months)

iii) Assessment of work plans

The effect of performing the work plan on the environment is assessed through forecast modelling

iv) Revision of work plans

If the forecasted impact resulting from implementation of the work plan leads to unacceptable effects, e.g. violation of environmental criteria, the work plan is revised and reassessed.

v) *Construction phase*

Construction commences

vi) *Control monitoring*

Monitoring of daily control variables, in accordance with the description in section 3.3 is performed. If daily control limits are violated, mitigation actions take place in accordance with predetermined plans. If no violation of limits occur, work and daily monitoring continue.

vii) ***Habitat monitoring***

Monitoring of biological habitat feedback variables in accordance with the description in section 3.4 is performed to an appropriate time schedule for the anticipated response rates.

viii) ***Evaluation of construction phase***

On the basis of the results of the biological monitoring of feedback variables and the utilization of hindcast impact modelling of the realized construction process, the temporal and spatial impacts of the construction phase are assessed. If feedback limits or environmental criteria are violated, mitigation actions take place in accordance with predetermined plans or through additional forecast modelling scenarios investigating different mitigation measures. On the basis of the realized impacts, environmental criteria and control criteria for the next construction phase are updated.

ix) ***Next Construction Phase***

The construction and monitoring process returns to task 2 and the process is repeated until construction is complete.

x) ***Completion of construction***

An environmental audit is produced at the end of the construction period as formal documentation of the impacts realised during the construction phase, based upon the result of the control, habitat and support monitoring together with the results of the hindcast modelling of impacts.

3. ENVIRONMENTAL MONITORING PROGRAMME

3.1 Objectives

The main objective of the Environmental Monitoring Programme for the "[Insert project name]" is to monitor the project impacts on the biological, physical and social environment, from which reliable management input can be given through the use of predictive modelling tools where relevant to limit the negative impact of the construction works upon the environment. In addition, the Environmental Monitoring Programme shall document the realized impacts upon the environment through specific measurements.

3.2 Monitoring Programme

The environmental monitoring program consists of three distinct components

Control monitoring: This is used to ensure the day-to-day compliance with environmental quality objectives and tolerance limits

Habitat monitoring: Biological monitoring of important marine habitats, so-called feedback variables are utilised to:

- Document the realised impact upon the habitats
- Provide specific evidence of impacts with respect to dose response, with the dose being established from the results of the control monitoring and spill hindcast modelling.

Support monitoring: This is used to ensure adequate documentation of the net effects of the construction work on the environment as a whole. Generally support monitoring concentrates upon indicators with a long time scale response.

3.3 Control monitoring

3.3.1 Variable Requirements

The monitoring variables for the daily control of the construction operation should ideally comply with the following demands:

Representative: The choice of variables must reflect the potential impacts such that immediate response to violation of control limits is meaningful in terms of environmental protection.

Criterion related: Prior to initiation of the environmental monitoring it shall be possible to establish provisional limits or thresholds for the control variables that shall not be violated during the construction works.

Operational: Monitoring of control variables must be possible at low cost with a high degree of reliability from direct reading instrumentation.

3.3.2 Choice of Variables

The choice of control variables is straightforward and is not particularly site-dependent for the West Coast of Sabah.

Suspended Sediments

The concentrations of suspended sediments originating from the borrow dredging works, transportation barges and the reclamation itself must be carefully monitored to ensure day-to-day compliance with environmental quality objectives. The following stations should be utilised.

- Dredging plant: 100m down drift and 400m down drift.
- Reclamation: Outlet from overflow.
- A minimum of 10 stations placed at critical sites in the potential impact areas predicted by the Detailed Environmental Impact Assessment for the marine dredging and reclamation works, with 2 control stations outside the potential impact area.

Measurement of turbidity are to be taken 1m below the surface and mid depth at each site using a high quality turbidity meter calibrated against laboratory measurements of suspended solids recovered from the control stations corresponding with the turbidity measurements. Re-calibration of the meter must be performed at least once per month against laboratory analysis of suspended sediments. Secchi depth should be recorded in conjunction with the turbidity measurements.

Noise

Noise measurements shall be performed if any town, village or settlement is situated inside an area where the noise level predicted by the Detailed Environmental Impact Assessment is anticipated to exceed 55 dBA. One monitoring station shall be established in each settlement. A minimum of one monitoring station is required irrespective of the coastal population.

Dust

Dust measurements shall be performed if any town, village or settlement is situated inside an area where the airborne particulate matter level predicted by the Detailed Environmental Impact Assessment is anticipated to exceed an API equivalent of 50. One monitoring station shall be established in each settlement. A minimum of one monitoring station is required irrespective of the coastal population.

3.3.3 Monitoring Frequency

Control monitoring shall be performed on a daily basis as per the following schedule:

Suspended Sediments: Twice per day, once at peak north going and once at peak south going current. Measurements should be initiated a minimum of 1 month prior to the start of the construction works to establish variability in the background turbidity levels.

Noise: Noise shall be recorded continuously and measurement shall be initiated a minimum of 3 days prior to the start of the construction works.

Dust: Dust measurements shall be performed once per day and shall be initiated a minimum of 1 week prior to the start of the construction works.

3.4 Biological Monitoring of Marine Habitats

3.4.1 Variable requirements

The monitoring variables for the biological monitoring programme ideally comply with the following demands:

Representative: It is not possible to monitor all aspects of a certain ecosystem. Some ecosystem variable or some species – key species – are selected for monitoring. It is essential that the chosen ecosystem variable or key species for the monitoring

- are representative for the populations that live in the ecosystem, and
- The level of the ecosystem variable or the condition of the chosen species reflects the general condition of the populations.

Sensitive: The variables that are chosen for the monitoring purpose – being growth rate, survival, abundance etc. – shall be highly sensitive to the foreseen impacts by the activity that are being monitored.

Predictable: The variables that shall be used for feedback monitoring shall be predictable in relation to the most important impact types. In other words it shall be possible to establish some kind of “dose-response” relationship between impact and

effect so that a model can be established, which can be used to forecast the effects of a given dose on the habitat.

Criterion related: Prior to the initiation of the Environmental Monitoring it shall be possible to establish a limit or threshold for the variable that shall not be violated during the construction work, or if violated shall be reason for mitigating actions.

Fast responding: It shall be possible to see a response in the chosen variables within a short period of time so that unforeseen or otherwise unwanted effects can be mitigated while construction work is still in progress. Therefore, the results of the monitoring shall be available in days-weeks as a maximum after completion of a given the monitoring phase.

Operational: The chosen variables shall give results at a reasonable level of statistical significance with use of sensible resources.

3.4.2 Choice of variables

The Biological Monitoring Programme of the project shall contain but need not be limited to the following feedback monitoring items within the geographical area that may possibly be affected by the reclamation works (as established by the Detailed Environmental Impact Assessment) and at the sites where raw materials are exploited, e.g. borrow areas. It shall also include stations in areas that are outside the area of impact, and selected in such a way that they can act as a non-effect reference.

In the event that the Consultant chooses to exclude or replace a specific item from his tender, written justification for such exclusion must be provided in the tender submission.

Depending upon the location of the reclamation and borrow site, three habitats shall be monitored:

Coral reefs:

Key variables:

a) Area coverage of different growth forms of hard corals
b) Frequency of bleached hard corals
c) Growth rates of local and transplanted hard coral colonies
d) Recruitment of reef organisms on settling plates

Key species:

Suggestion: *Acropora sp.*

Monitoring stations:

At least five transects in potential impact areas and one reference transect outside the impact area shall be monitored.

Monitoring methods:

The following monitoring methods are suggested:

- Area coverage and frequency of bleached hard corals, using fixed quadrants at selected sites and using photography and image analysis;
- Growth rates, using coral species with a reasonable growth rate and staining with Alizarin for determination of growth;
- Colonisation studies, using settling plates

Four positions along the transects shall be marked as sub-sites. At each sub-site a stainless steel or PVC frame of 1 x 1 metre shall be placed on both sides of the transect line, giving a total of 8 m^2. The coverage of hard and soft corals (in % of area), the coverage of live and dead corals and the extent of bleaching and coverage with epizootic algae shall be estimated. All 8 m^2 shall be photographed for documentation and, when visibility permits, photo analyses.

At each fixed station, areas with a high occurrence of *Acropora* sp. shall be selected. Here four coral ”branches” with 3-5 ”sub-branches” shall be incubated for 24 hours for staining with the dye Alizarin Red. At each of the following monitoring campaigns, the stained branches shall be broken off to measure growth in length, allowing a general estimate of the growth conditions for *Acropora* sp.

At stations without a natural occurrence of this species, 5-10 colonies from one or two other sites shall be stained and transplanted on metal rods at each monitoring sites to minimise the biological variance.

At one or more sub-sites at each station, a fired-clay-roofing tile shall be placed on the sea floor and fixed to a coral block. This shall be replaced by a fresh tile during each campaign, with the original tile being brought back to the on-site laboratory to evaluate the colonisation of juvenile corals on the tile by number and species.

Seagrass beds:

Key variables:

a) Biomass of leaves and rhizomes
b) Height and density of shoots
c) Growth rate of leaves and turnover of shoots

Key species:

Suggestion: *Thalassia sp.*

Monitoring stations:

At least five stations in potentially impacted areas and one-reference stations outside the impact area shall be monitored if the distribution of seagrass beds in the impact area so warrants.

Monitoring methods:

At each station the degree of vegetation coverage within a radius of approximately 20 metres shall be visually described. Six iron frames sized 0.25 x 0.25 metres shall be placed in areas with the highest density of seagrass. Within each framed area, all seagrass biomass above and beneath the sediment shall be harvested and processed in the following manner:

- The number of shoots per 0.025 m^2 shall be calculated.
- Mean length of shoots shall be calculated based on measurements of 15 shoots chosen at random from each sample.
- All material above and below the bed shall be carefully cleaned of sediment and transported in refrigerated plastic bags to the laboratory for the determination of wet and dry weight. The above-bed and below-bed material shall be processed separately.
- At each site the growth rate of leaves shall be measured by marking young leaves on 10 to 15 shoots with plastic clips and measuring changes in leaf length over 4 to 8 days.

Mangroves:

Key variables:

a) Height and density of pneumatophores
b) Growth and survival rates of seedlings
c) Sediment level

Key species:

Suggestion: *Sonneratia* sp. (pneumatophores) and
Rhizophora sp. (seedlings)

Monitoring stations:

At least five stations in potentially impacted areas and one-reference stations outside the impact area shall be monitored if the distribution of coastal mangroves in the impact area so warrants.

Monitoring methods:

For the mangroves, the monitored variables shall be:

- Sediment level (support variable)
- Number and height above the sediment of pneumatophores
- Total number, as well as growth and survival of seedlings

The relative level of sediment shall be measured using a meter stick driven deep into the ground at each site.

Six samples of 1 x 1-metre frames shall be randomly distributed around at the station. Within each sample the number of pneumatophores shall be counted. The average height of the pneumatophores shall be estimated by measuring the height of 20 to 30 pneumatophores per m^2.

The growth and survival of the seedlings shall be documented by marking all seedlings (maximum 15) per station. The state of the sampling stations shall be documented photographically.

3.4.3 Monitoring frequency

The feedback monitoring of marine habitats should not be more frequent than possible to identify changes in the habitat components between two monitoring rounds, whilst being sufficiently frequent to allow for mitigating actions while construction work is still in progress. For the West Coast of Sabah it is anticipated that bi-monthly sampling of the feedback variables will be sufficient provided that analysis is accomplished and results are available within 3 weeks after sampling. A minimum of one monitoring campaign must be completed prior to the start of construction.

3.4.4 Positioning

Positioning of underwater transects should be such as to allow exact repeat sampling. Start and end points of transects should be marked with a visible reference that is difficult for local fishermen, etc. to remove. The start and end points shall be referenced to accuracy appropriate for the local underwater visibility, using a differential GPS or time average GPS location. For shore-based stations, visible references coupled with hand held GPS locations are sufficient to allow exact locations to be identified and revisited.

3.5 Support Monitoring

The Environmental Monitoring Programme of the project shall contain but need not be limited to the following support variables within the geographical area that may possibly be affected by the reclamation and at the sites where raw materials are exploited, e.g. borrow areas. It shall include stations in areas that are outside the study area (impact area) of the project, and selected in such a way that they can act as a non-effect reference.

In the event that the Consultant chooses to exclude a specific item from their tender, written justification for such exclusion must be provided in the tender submission.

3.5.1 Physical-chemical conditions

Hydraulic circulation

For reclamation sites in the vicinity of critical cross sections, for example the Gaya Straits, there is a requirement to document the impact of the construction works on the natural through flow. It is the state government's wish that through flow is maintained at existing or improved levels to ensure good flushing along the foreshore. The consultant will be required to quantify through flux using Acoustic Doppler profiling equipment prior to, during and after construction.

Coastal morphology

For reclamation sites in the vicinity of high quality beaches or moderate quality open littoral beaches there is a requirement to document the impact of the construction works on the shoreline and beach levels.

Suspended solid measurements should be taken from a minimum of 3 offshore stations and from all significant discharge channels in the study area. One sample per day for a period of 15 – 30 days (coincident with the offshore current measurements) is required. The samples for the suspended solid measurements should be taken at the same time as the water flux in the channels is recorded.

Analysis of the suspended solid samples should include suspended solid content (mg/l) by microprobe filter technique (all samples), suspended solid grading or fall velocity by hydrometer or oven tube technique (2 samples per drainage channel).

Sediment Levels

Sediment levels in coastal mangroves are critical to the survival of the ecosystem. In particular, erosion resulting from modified wave action is the most likely source of potential damage from reclamation activities, unless the outfall from the reclamation area is situated close to the coastal mangrove fringe, in which case high sedimentation rates are the critical factor. The monitoring of sediment levels in the mangrove fringe should follow the requirements and the schedule of biological monitoring discussed in section 3.4.2.

Monitoring of sedimentation in other marine habitats is difficult and should only be embarked upon if the Detailed Environmental Impact Assessment identifies a specific habitat area particularly at threat from sedimentation, for example a sheltered coral reef within a few hundred metres of dredging activities. The monitoring of sediment levels in critical areas will be rate dependent.

Water quality

The following minimum variables shall be analysed in the samples from minimum 3 representative stations inside the impact area and for 1 reference station. If the impact area embraces beaches that are used for bathing and swimming, one additional water quality station shall be placed at the coast in that area.

- Ammonium Nitrogen (NH_4^+-N)
- Oxidised Nitrogen (NO_2-N and NO_3-N)
- Total Nitrogen
- Phosphate Phosphorus(PO_4---)
- Total Phosphorus
- Coliform Bacteria
- Chlorophyll-a concentration
- Oxygen concentration
- Oxygen saturation
- Secchi depth
- Temperature
- Salinity

Two samples per month are required as minimum. The samples shall be analysed at a laboratory that can demonstrate its ability to analyse for the variables. The analytical methods to be used shall be described and the Consultant shall demonstrate the laboratory capability in the proposal.

3.5.2 Biological Conditions

Fish Stocks

Although extremely difficult to monitor it is essential that an indication of the impact of the construction works upon fish stocks, including diversity, is attained. The monitoring shall consist of an underwater survey of 3 representative sites within the impact area and one control site outside the predicted impact area, covering a period of 6 days (2 days per site separated by 2 days) every 6 months during the construction period.

Ornithology

Although extremely difficult to monitor, it is essential that an indication of the impact of the construction works upon the ornithological population, including impacts on diversity, is attained for any important wading or breeding areas identified by the Detailed Environmental Impact Assessment as likely to be impacted by the construction works. The monitoring shall consist of visual survey of representative sites within the impact area and one control site outside the predicted impact area covering a period of 6 days (2 days per site separated by 2 days) every 6 months during the construction period.

Turtles

In the event that the Detailed Environmental Impact Assessment reveals the presence of turtle landings with 2km of the reclamation area, it will be the responsibility of the Consultant to perform regular beach surveys to establish the number of landings and to liase with the relevant authorities for the protection of nesting sites.

Terrestrial Habitats

Marine reclamation works should in general not effect terrestrial habitats and monitoring of terrestrial flora and fauna is not anticipated as a general requirement for the Environmental Monitoring and Management program. In the event that the Detailed Environmental Impact Assessment reveals any particularly important terrestrial habitats within 1km of the reclamation boundary then specific monitoring may be required on a case by case basis.

3.5.3 Socio-economic conditions

Traffic

Periodic monitoring of any public road fronting on the access to the reclamation site is required to ensure that damage to the road does not endanger motorists safety or hinder the flow of traffic. In the event that damage arises the results of the monitoring will be used to attribute the proportion of repair charges to be attributed to the Contractor. The monitoring shall constitute a photographic survey of all roads within 1km of the entrance to the project site traversed by the Contractor's construction plant.

Fishing

Prior to construction the number of fishing boats regularly utilising the area within 1km of the borrow site and reclamation area should be established. Ten control boats should be identified and their catches recorded in their normal fishing grounds for a period of 7 days prior to construction. Every 6 months during construction the catches of the 10 control boats shall be monitored for a period of 7 days to establish the approximate impact upon fish catches as a result of disruption caused by the reclamation activity.

Public health and safety

The monitoring of public health and safety issues, in particular squatter development, should follow existing state and federal guidelines for construction works.

4. ENVIRONMENTAL MANAGEMENT PROGRAMME

In the present context, environmental management refers to the control of the construction activities through optimisation of work schedules and practices for achieving environmental quality objectives and the initiation of mitigation measures in the event that tolerance limits are exceeded, whilst minimising disruption to construction activities.

The environmental management of the construction works consists of three distinct processes:

Assessment of work plans: The forecast of potential impacts is based upon detailed work plans provided by the contractor. Based upon these results and preliminary tolerance limits for the marine habitats in the impact area, work plans are optimised to achieve a construction process which, in principle, adheres to the environmental quality objectives specified for the project.

Environment control: On the basis of the control the Consultant initiates monitoring, immediate response to events exceeding tolerance limits. Such response may be enforced down time, deployment of silt screens, modified production schedules, equipment maintenance etc.

Impact Assessment: For each construction phase the temporal and spatial distribution of impact upon the marine environment is established by combining the results from numerical hindcast modelling of the transport and fate of material released from the dredging and reclamation operations combined with the biological monitoring of feedback habitat variables. The results of the impact assessment are used to establish the environmental quality objectives for the next construction phase (which will effect the requirements for mitigation measures and schedule control for the next phase) and to establish if any remedial direct mitigation is required in the event of a serious breach of quality objectives. Further the results of the impact assessment are used to update the tolerance limits for the control variables as a clearer picture of the dose response tolerance of the marine habitats in the impact area are revealed.

4.1 Assessment of Work Plans (Forecast)

Prior to the initiation of the construction work, the effect of the Contractor's work plans on the environment shall be forecasted through the use of numerical spill modelling (section 5) in order to ensure that the plans do not violate environmental criteria set for the project. The construction work plans may have been sufficiently assessed in the Detailed Environmental Impact Assessment as to allow the exclusion of this task, however, this is unlikely as the construction schedule and procedures are

generally not known until appointment of the contractor. If work plans do not cover the whole construction phase, the remaining constructions work shall be assessed when the work plans are finalised. Typically, the contractor will only know in detail the schedule and procedures 3 months in advance of a given construction phase such that a 3-month repeat forecast should be anticipated.

For forecast purposes, sediment spreading and sedimentation shall be modelled using a numerical model (see section 4). The results of the forecast model shall be compared to known marine habitats and the potential impacts assessed using provisional dose response criterion. If unacceptable limits are predicted, alternative work schedules and procedures are to be investigated until an acceptable impact level is attained. These work plans will then be the work plan executed by the contractor.

4.2 Environmental Control

Based upon the results of the day-to-day control monitoring, mitigation measures shall be initiated in the event that tolerance limits are exceeded for a pre-determined number of repeats.

Mitigation measures that may be initiated through the day-to-day environmental control are:

- Deployment of silt screens
- Enforced down time in the event of unfavourable climatic conditions
- Modifications to production schedules
- Equipment maintenance

In the event that major changes to the work procedures are deemed necessary due to unforeseen circumstances, such as adverse geotechnical conditions at the borrow site, updated forecast modelling may be required to establish the optimum revised work schedule.

4.3 Impact Assessment (Hindcast)

During the execution of the construction works, the Contractor due to either technical reasons or violation of environmental criteria will continuously revise plans.

At the completion of each construction phase, typically every two to three months, the net temporal and spatial distribution of environmental impact shall be assessed through a combination of hindcast modelling of the transport and fate of the material released from the realised construction schedule and processes, combined with the results of the biological monitoring of the feedback variables for the marine habitats.

The temporal and spatial impacts are derived from the maps of light attenuation and sedimentation produced by the hindcast models using the dose responses observed in the biological monitoring.
For example, if biological monitoring indicates a reduction in coral growth rate of X% for a weekly average light attenuation of Y% ambient levels prior to construction, then the hindcast models are used to expand the single point biological monitoring data to cover the entire coral impact area using this biological dose response criterion.

4.4 Updating of Tolerance Limits

Prior to any further work-plan assessment, the biological monitoring data shall be used to improve the “dose-response” model and tolerance limits for the feedback variables and tolerance limits for the control variables. In other words, the site specific experience already achieved is used to improve forecast and control to prevent further costly changes in work schedules after a given construction phase has been initiated and to avoid costly mitigation measures if environmental quality objectives are found to be exceeded at the end of a given construction phase.

Furthermore, modification of the monitoring sites, both in terms of control and habitat monitoring, may be made based upon the results of the hindcast modelling in order to better reflect the realised and potential impacts of the construction works.

5. MATHEMATICAL MODELLING REQUIREMENTS

The mathematical models that are to be used for the forecast and hindcast modelling in connection with the Environmental Monitoring and Management Programme shall comply with the following basic requirements:

5.1 General Requirements

The flow model shall be at least a fully dynamic 2-dimensional depth integrated model. It must be properly calibrated and validated with field data to accurately simulate the tidal flow and residual flows due to wind and ocean currents. The model must include the effects of flooding and drying and such factors as coriolis bottom friction, etc. The hydraulic flow model must be able to include the effects of wave driven circulations.

The sediment plume model should be able to include the effects of periodic discharge, multiple sediment fractions, concentration-dependent settling sedimentation and re-suspension and moving sources (i.e. trailer dredgers). Further, the model should be able to include the effects of waves upon the settling and re-suspension processes. The plume model should be dynamically coupled to the hydraulic model and be able to be initiated from a hot-start map of suspended sediment concentrations and sedimentation such that the reclamation boundary can be updated in the model to reflect the progress of construction.

5.2 Specific Requirements

5.2.1 Forecast modelling

The time scale of the forecast modelling is typically 3 – 4 months as this is the time horizon generally required for the contractor to know in detail the construction schedule and procedure. The forecast model shall be sufficiently detailed in time and spatial scale so as to resolve the important hydraulic processes. However, compromise will be necessary to ensure acceptable computer requirements in anticipation of the situation where multiple mitigation scenarios will be required.

For the West Coast of Sabah a forecast model grid spacing of 100-150m is appropriate.

Hydraulic conditions should be chosen to be representative of the middle period of the construction phase in terms of the dredging and reclamation process, as well as seasonal ocean currents and waves.

5.2.2 Hindcast modelling

Depending upon the rate of dredging and reclamation, the bathymetry in the model (in terms of the dredging at the borrow site, the construction of bund walls and the progress of reclamation fill) should be updated on a time schedule of 2 to 4 weeks. Spill sources in terms of dredger location, etc. must be updated on a daily basis according to the contractor's records. Production rates from the various plants must be updated on an hourly basis according to the contractor's records.

In order to resolve the details of the dredging and reclamation process, finer grid spacing is required for the hindcast modelling than for the forecast modelling described above. For the West Coast of Sabah a hindcast model grid size of 50 – 75m is appropriate.

Hydraulic conditions should be chosen to be representative of the middle period of the bathymetry update phase in terms of dredging and reclamation process as well as seasonal ocean currents and waves.

Model output shall be in terms of:

- Spatial and temporal distribution of instantaneous suspended sediment concentration
- Spatial and temporal distribution of day time mean suspended sediment concentration
- Spatial and temporal distribution of night time mean suspended sediment concentration
- Spatial and temporal distribution of day time light attenuation at the bed
- Spatial and temporal distribution of weekly average day time light attenuation at the bed
- Spatial and temporal distribution of monthly average day time light attenuation at the bed
- Spatial and temporal distribution of instantaneous sedimentation
- Spatial and temporal distribution of daily average sedimentation
- Spatial and temporal distribution of weekly average sedimentation
- Spatial and temporal distribution of monthly average sedimentation
- Exceedence probability of control limits for suspended sediment concentration, light attenuation and sedimentation
- Time series of light attenuation over all coral and seagrass monitoring stations

6. QUALITY ASSURANCE AND QUALITY CONTROL

Upon tendering, the consultant is required to document in brief the quality assurance and quality control procedures to be adopted. Within 4 weeks of commissioning the consultant is required to produce a full quality control manual for review and acceptance by the client. The following points should be considered essential components of the quality manual:

- Quality control procedures for laboratory analyses
- Quality control procedures for field analyses
- Quality control procedures for capture and analysis of field information
- Quality control procedures for numerical model simulations
- Document control

7. OUTPUT

The deliverables of the Environmental Monitoring and Management Programme for the project shall include:

- A detailed report describing and specifying the Environmental Monitoring and Management Programme. The approach shall be accepted by the client and MCET, DID and DOE, before the commencement of the construction work and the monitoring programme.
- A quality control manual.
- A baseline report documenting the status of the environment in the potential impact area prior to construction.
- An impact forecast report describing the planned construction work schedule and procedures and the forecasted impact upon the marine environment for the upcoming construction phase documenting any requirements for modified construction schedule or procedures necessary to attain satisfactory impact levels. A forecast report is required for each construction phase, typically requiring one for every 3 months of construction.
- Monthly status reports documenting the results and progress of the Control monitoring and environmental control actions.
- Bimonthly status report documenting the results of the biological monitoring
- Six-monthly status report documenting the results of the support monitoring
- Bi- or Tri- monthly hindcast report documenting the net impact upon the marine habitats and other aspects of the marine habitats based upon the realised construction process and the results of the biological monitoring. This report shall document:
  - Temporal and spatial distribution of impacts
  - Requirements for updating control and feedback monitoring limits and/or tolerances for the next construction phase
- Short incident reports at every occasion that the control monitoring results show a violation of the environmental criteria describing the results and the feedback actions taken.
- Annual reports summarising the results of the Environmental Monitoring and Management Programme.
- An environmental audit summarising the results of the Environmental Monitoring and Management Programme after the termination of the construction work.

All reports shall be provided in English with a short executive summary that resumes the problems, methods used, and the basic findings, conclusions and recommendations. The executive summary shall be written in an easily accessible form with parallel copy in Malay.

Draft reports shall be submitted in 5 copies and final reports shall be submitted in 10 copies.

The monitoring results shall be stored in an environmental data management system, such that they can be utilised as a refined basis for monitoring and management of future coastal construction projects in the State of Sabah.

8. TENDER REQUIREMENTS

8.1 Program Description

The consultant shall describe in detail the Environmental Monitoring and Management Programme to be established. The description shall include but need not be limited to the following items:

- A definition of the preliminary environmental criteria (quality objectives, tolerance limits and dose response relationships) to be established for the project. The preliminary criteria may either emerge from legislation and other regulations, be specifically decided by the approving authorities in connection with this specific project, or may be established by the contractor in order to comply with good environmental practice.
- A description of control variables to be monitored.
- A description and evaluation of the choice of key species and variables chosen for the biological monitoring of feedback variables.
- A description of support variables to be monitored.
- A summary of existing information describing the level and variation of the chosen variables prior to the initiation of the construction work.
- A description and specification of the monitoring procedures including number and place of sampling stations, methods of sampling, sampling equipment, number and size of samples, analytical procedures, detection limits, and data treatment.
- A description of the model tools and methods to be used for forecast and hindcast modelling.
- A description of provisional procedures and actions to be taken in case of violation of environmental criteria.
- A description of the management procedures for implementation of recommendations arising from the Environmental Monitoring and Management Programme.
- A description of the system for data management.
- A preliminary quality assurance plan

8.2 Organisation

8.2.1 Consulting Team

The Consultant shall provide details of personnel engaged, equipment, methods, and numerical models to be used to accomplish the Environmental Monitoring and Management Programme.

8.2.2 Work Plan

The Consultant shall provide a detailed work plan for the accomplishment of the Environmental Monitoring and Management Programme. The work plan shall indicate important milestones that enable the client to monitor the progress of the work.

8.2.3 Management

The Consultant shall assign the Consultants' Environmental Manager, who shall be experienced in the execution of Environmental Monitoring and Management Programmes for marine construction works and in the civil engineering aspects of marine reclamation. The environmental manager shall be a full time position on site and be responsible for the initiation of environmental control measures.

A Steering Committee shall be established to steer, manage and co-ordinate the Environmental Monitoring and Management Programme. The client will appoint members of the Steering Committee. As a minimum, the Department of Town and Regional Planning, Drainage and Irrigation Department, and Department of Culture, Environment and Tourism of the state of Sabah will be represented in the Steering Committee. At regular intervals the Steering Committee will meet with the consultants' Project Manager to discuss the progress of the Environmental Monitoring and Management Programme.