NMP HYDRODYNAMIC MODELLING:
TURBIDITY THRESHOLDS JUSTIFICATION

Specialist Report

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PREPARED FOR:

Namibian Marine Phosphate (Pty) Ltd

PREPARED BY:

Dr. Robin Carter

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Background

The NMP EIA and EIA verification study and environmental risk assessments used the Probyn (2000)[1] suspended sediment concentration (SSC) thresholds as refined in EMBECON (2004)[2]. These were designed for southern African (Namibia and South Africa) marine diamond mining and dredging applications and specified SSC water quality guideline thresholds of:

<20 mg/L – low risk, the monthly average target

20-80 mg/L – medium risk, acceptable over the short-term i.e. 2-3 days

>80 mg/L – high risk, unacceptable over the short or long term, mitigation required.

[1] Probyn TA 2000. Dredging-related resuspension of sediments: guidelines for the Coega harbour. Prepared for ENTECH Consultants (Pty) Ltd by Embecom. 34pp.

[2] EMBECON 2004. Dredging-related re-suspension of sediments: impacts and guidelines for the marine dredging project. Specialist Study #3. Prepared for Pisces Environmental Services (Pty) Ltd. 72 pp.

For monitoring, the levels are to apply beyond 500 m of the source, e.g. dredger, and the median of field-measured test data are to be compared against the thresholds. Where background levels are higher than the 20 or 80 mg/L limits the 80th percentile of the field measured data would be the applicable guideline value.

For the hydrodynamic modelling study, the hazardous SSC for effects on 5% of the test organisms (HC_5) at the effect concentration causing 50% mortality in the tested populations (EC_{50}), as derived from species sensitivity distributions (SSD) for bentonite clays by Smit et al (2008)[3], was substituted for the Probyn derived thresholds. The defined threshold concentration is 7.6 mg/L. Concentrations below this are considered as low risk.

The reasons for this are summarised below.

Justification

The justification for the change is based on the source data employed for the respective thresholds and the utility of the approaches used.

EIA/Verification Study Thresholds

The main purpose of these SSC thresholds was to ensure that effects on biota in the receiving environment were unlikely and that there was clear monitoring guidance for the mining operations. The thresholds were derived from reviews of studies on the effects of suspended sediments on phytoplankton, stages in fish lifecycles, bivalve molluscs, gastropod molluscs and crustacea. Typically, 96-hour exposure EC_{50} (mortality) values were used with a bias to lower concentrations when ranges of EC_{50} values for a group were available. The determined threshold values were then compared against the international best practice and refined to conservative levels.

The low-risk SSC of 20 mg/L is within accepted thresholds for fish (<25 mg/L) and similar thresholds for all marine taxa as practiced in Indonesia, USA and Europe. It does exceed the US EPA protection SSC concentration of 15 mg/L for high protection levels but only marginally so. The medium-risk SSC threshold range is moderated by duration as it is largely based on 96-hour toxicity test exposures. This is valid but brings some complexity in monitoring as it requires semi-continuous sampling within a spatially and temporally variable turbidity plume as it advects away from its point of discharge.

Hydrodynamic Modelling Threshold

The SSD derived threshold was based on toxicity responses in experimental settings to suspended bentonite clays (2.5-4.0 µm diameter) across 12 species extracted from European and USA databases. The species

[3] Smit GD et al 2008. Species sensitivity distributions for suspended clays, sediment burial, and grain size change in the marine environment. Environmental Toxicology and Chemistry, 27(4), 1006-1012.

+27 (0)21 705 0819 +27 (0)21 705 6652 info@lwandle.co.za
www.lwandle.co.za

included phytoplankton, zooplankton, crustaceans (excluding zooplankton) molluscs and fish, all major components of the plankton and micronekton communities inhabiting the water column. The data used were sufficient to enable estimates of medians and confidence intervals (5%-95%) around these allowing more rigorous estimates of effect levels than that applied in the estimates employed in the EIA/Verification studies. Further, bentonite clays comprise very small particles (above) with low settling velocities. It is this size of particle that is most likely to be remaining in the water column at distance from dredger operations and thus affect organisms in the far-field. Smit et al (2008) present an SSD for barite which is coarser than bentonite (6-75 µm vs 2.5-4.0 µm diameter) which has a lower toxicity effect than that estimated for bentonite (HC_5 barite = 17.9 mg/L vs 7.6 mg/L for bentonite. Employing thresholds based on bentonite is thus conservative in terms of anticipated effects.

SSC Threshold Comparisons

The EMBECON (2004) low-risk SSC threshold is less conservative in terms of predicted effects on water column biota than the Smit et al (2008) bentonite clay HC_5 concentration. However, the magnitude of this is low as the mean EC_{50} for phytoplankton extracted from the Smit et al (2008) data range from 10 mg/L for bentonite to 900 mg/L for barite, that for zooplankton from 40 mg/L to 60 mg/L and are >10 000 mg/l for fish. Note that the EMBECON threshold closely matches the HC_5 estimate for barite. In terms of dredging plume particle size distributions, this would be the more applicable scenario for the proposed dredging operations as sediment texture of the target ore body is silty sand in the surficial layers and ranges between silt and silty sand in subsurface sediments[4]. In both cases, mud, equivalent to the bentonite size range, is absent from sediments sampled in the target dredging area. Accordingly, the EMBECON derived threshold would be sufficiently conservative.

The Smit et al (2008) derived bentonite threshold can be considered to be overly conservative in terms of the sediment properties of the target dredging area. However, its adoption and application would be protective should mud/clay lenses be encountered in the dredging process and these finer particle size sediments contribute an appreciable proportion of suspended sediments in turbidity plumes.

It is this aspect that justifies the application of the bentonite HC_5 concentration as the threshold to be applied in the hydrodynamic modelling study.

[4] Lwandle 2014. Nambian Marine Phosphates: Verification Study. Document number LT 149. 78pp.

+27 (0)21 705 0819 +27 (0)21 705 6652 info@lwandle.co.za
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