APPENDIX 3 – GEOPHYSICS
3.2 Geophysical Habitat Mapping

Prepared for:
Namibian Marine Phosphate (Pty) Ltd.

Prepared by:
Jeremy Midgley

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Mr Jeremy Midgley Pr.Sci.Nat
J. Midgley & Associates
PO Box 110
Constantia 7806
South Africa
Email: mwjmidg@mweb.co.za

Report Preparation and Approval

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1 August 2014	Draft 1	J. Midgley	B. Ludick
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Email: info@namphos.com
127 Theo-Ben Gurirab Street
Walvis Bay
Namibia

SUMMARY

The interpreted geophysical data reveals a flat, smooth seafloor with a homogeneous surficial sediment cover across the entire survey block, with no protruding obstacles (natural or artificial).

The sediment surficial sediment of the deposit consists of a mixture of silty sand particles, typically with dense shell. This has been confirmed from grab and core samples collected from in and around the target dredge site SP-1.

The geophysical information was collected using integrated multi beam echo sounder and side-scan sonar equipment.

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1 SURVEY AREA

A geophysical survey trial, to map the seafloor surficial sediments in support of habitat distribution, was undertaken over a period of 5 days during September 2013 from the MV *DP Star* with Side-scan-Sonar (SSS) and multibeam echo sounder (MBES) equipment. The purpose was to characterise the seafloor of the target dredge area SP-1 and also to test the effectiveness of the different geophysical technics for optimisation of equipment to assess seafloor conditions for the planned dredging operations.

A block of 4 x 5 km², covering the first 10 years of dredging inside SP-1, was selected as the survey location. A series of parallel NS-lines were run with side-scan sonar and/or multibeam echo sounder equipment although full coverage with both were not achieved due to adverse weather conditions (Figure 1a & 1b).

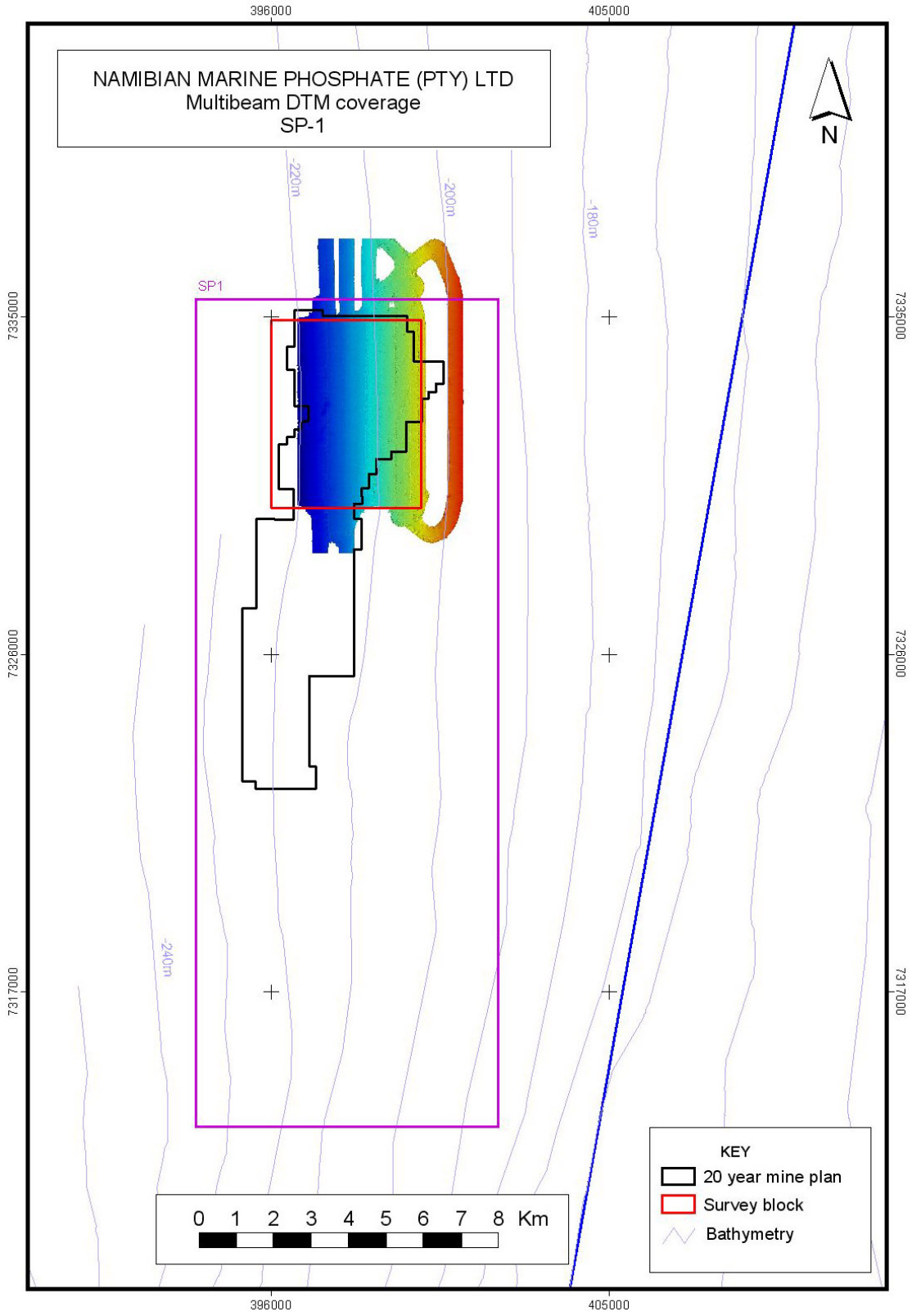

Figure 1a. Multibeam echo sounder and side-scan sonar coverage within SP-1

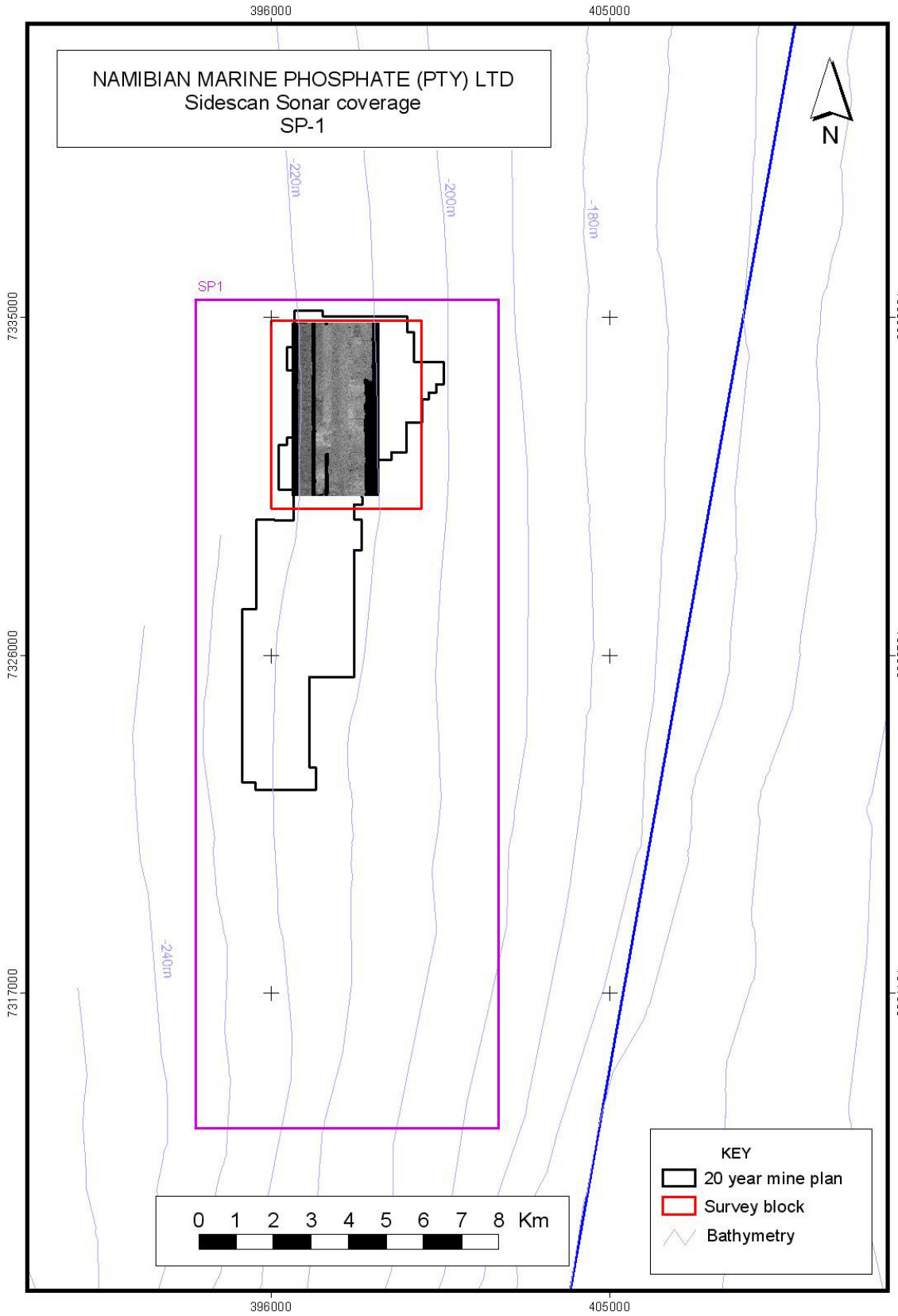

Figure 1b: Side-scan sonar coverage within SP-1

2 SURVEY EQUIPMENT AND DATA CAPTURING

The equipment selected for the geophysical survey consisted of the following:

2.1 MULTI BEAM ECHO SOUNDER (MBES)

- Kongsberg EM170, hull mounted on the MV *DP Star*, connected to MRU (type Seatex MRU5) and DGPS (type C-Nav3050)

2.2 SIDE-SCAN SONAR

- Dual simultaneous (Edgetech 2000-DSS) with combined SSS-SBP fish towed from winch and A-frame combination

Jan De Nul (an international dredging company) operated the SSS configuration and managed the data capture, with support from a marine surveyor, a marine geologist and a marine geophysicist. The MBES was operated by marine hydrographers from NUTAM (PYT) Ltd (a marine mining and exploration company).

3 DATA PROCESSING

Marine Data Consultants (MDC) (Appendix 3.1) was commissioned by Namibian Marine Phospahte (NMP) (PTY) Ltd to post-process the Kongsberg EM710 Multi Beam Echo Sounder (MBES) Bathymetry EM710 Snippets and the EdgeTech side-scan sonar data. Data supplied to MDC were original raw Kongsberg (*.all) files and raw *.xtf EdgeTech files.

3.1 GEODETIC PARAMETERS USED

Kongsberg *.all files and EdgeTech Discover *.xtf files are by definition, Geographic. All data were imported in Fledermaus DMagic (V7.4.0d) and re-projected with the following Geodetic Setup Parameters:

Horizontal Grid Coordinates: WGS 84, UTM Zone 33S
Vertical Datum: Mean Sea Level (MSL)

3.2 EM710 BATHY PROCESSING PROCEDURE

1) SANHO 10 min predicted tides were applied (co-tidal solution using linear interpolation from Lüderitz and Walvis Bay tide stations. All soundings reduced to mean sea level (MSL).
2) A 1 m Combined Uncertainty and Bathymetry Estimator (CUBE) surface was built in DMagic to IHO Order-1 (S44).
3) Blatant “fliers” (noise) were flagged as deleted in Fledermaus 3D Editor and the 1m CUBE updated.
4) An automated filter was applied 1 m above and below the CUBE surface and all soundings outside 1 m from the CUBE surface were flagged and rejected.

5) The final 1 m CUBE surface was checked for sounding density and standard deviation, with subsequent exported to ASCII (E,N,Z) for DTM creation and contouring.
6) The ASCII (E,N,Z) file was imported into QINSy (V8.10) Sounding Grid Utility for contouring (DXF) and Geotiff/KML Raster file creation.

3.3 EM710 SNIPPETS (PSEUDO BACKSCATTER) MOSAIC PROCESSING PROCEDURE

1) The *.all files were imported into Fledermaus Geocoder Toolkit (FMGT) and re-projected to WGS84, UTM33S.
2) Processing Sonar Defaults were applied for Simrad EM710 MBES model 710.
3) The cleaned (processed) EM710 bathymetry data were loaded into FMGT, mosaic resolution set to 50 cm, and mosaicked to 50 cm pixel resolution using the DTM bathy data for range and angle corrections (no flat-bottom assumption).
4) Final geotiff mosaics (*.tiff) were exported from FMGT at 50 cm pixel resolution using Grey scale and Copper colour palates.
5) An automated surficial seabed classification Angle versus Range Analysis (ARA) was performed on the dataset, revealing “Medium Muddy Sand” throughout the mosaicked survey area with no noticeable variation in the surficial sediment type.

3.4 EDGETECH 4200 SIDE-SCAN SONAR (SSS) MOSAIC PROCESSING PROCEDURE

1) The *.XTF files were imported into Fledermaus Geocoder Toolkit (FMGT) and re-projected to WGS84, UTM33S.
2) Processing Sonar Defaults were applied for Edgetech 4200.
3) The cleaned (processed) EM710 bathymetry data were loaded into FMGT, mosaic resolution set to 30 cm, and mosaicked to 30 cm pixel resolution using the DTM bathy data for range and angle corrections (no flat-bottom assumption).
4) Final geotiff mosaics (*.tiff) were exported from FMGT at 30 cm pixel resolution using Grey scale and Copper colour palates.
5) An automated surficial seabed classification Angle versus Range Analysis (ARA) was performed on the dataset, revealing “Medium Sand” throughout the mosaicked survey area with no noticeable variation in the surficial sediment type (consistent with the ARA results for the EM710 Snippets data over the same survey site).

4 RESULTS

4.1 MULTI BEAM ECHO SOUNDER (MBES) BATHYMETRY

A 5 m x 5 m bathy digital terrain model (DTM) grid was produced from the processed bathymetry and colour-shaded by water depth (Figure 2).

The clipped MBES DTM image shows an overall flat seafloor with depths ranging between -204 to -220 m. The 1 m isobaths contoured from the data, to a vertical resolution of 20 cm, strikes north-south with an eastward dip of around 0.3 degrees.

A single, shallow depression in the sediment, noticed in the DTM, is less than 1 m deep and seems to be an exception to the rule. No positive relief features in the form of reef outcrops or shipwrecks of any kind is present in the data.

Weather conditions were less than desirable during the survey, with the pitch and roll of the vessel causing some artefacts as can be seen (spikes) in the data. Nevertheless, the data overall confirmed the expected flatness of the seafloor.

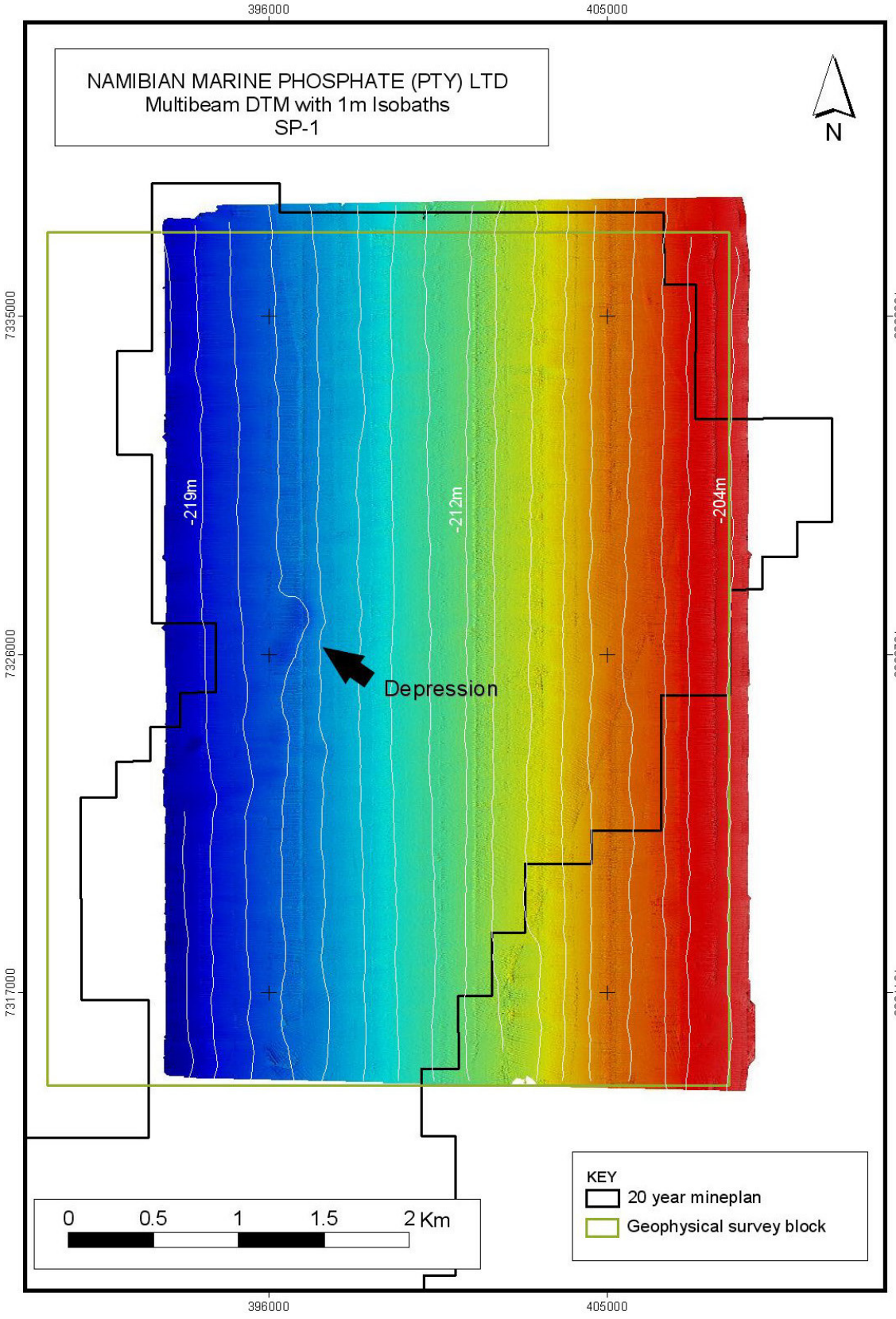

Figure 2: MBES bathymetry data

4.2 PSEUDO BACKSCATTER MOSAIC

The backscatter image (Figure 3) with a 50 cm pixel resolution produced from the MBES data shows a featureless, homogeneous surficial seafloor, indicated as a medium muddy sand surface by applying the automated surficial seabed classification Angle versus Range Analysis (ARA).

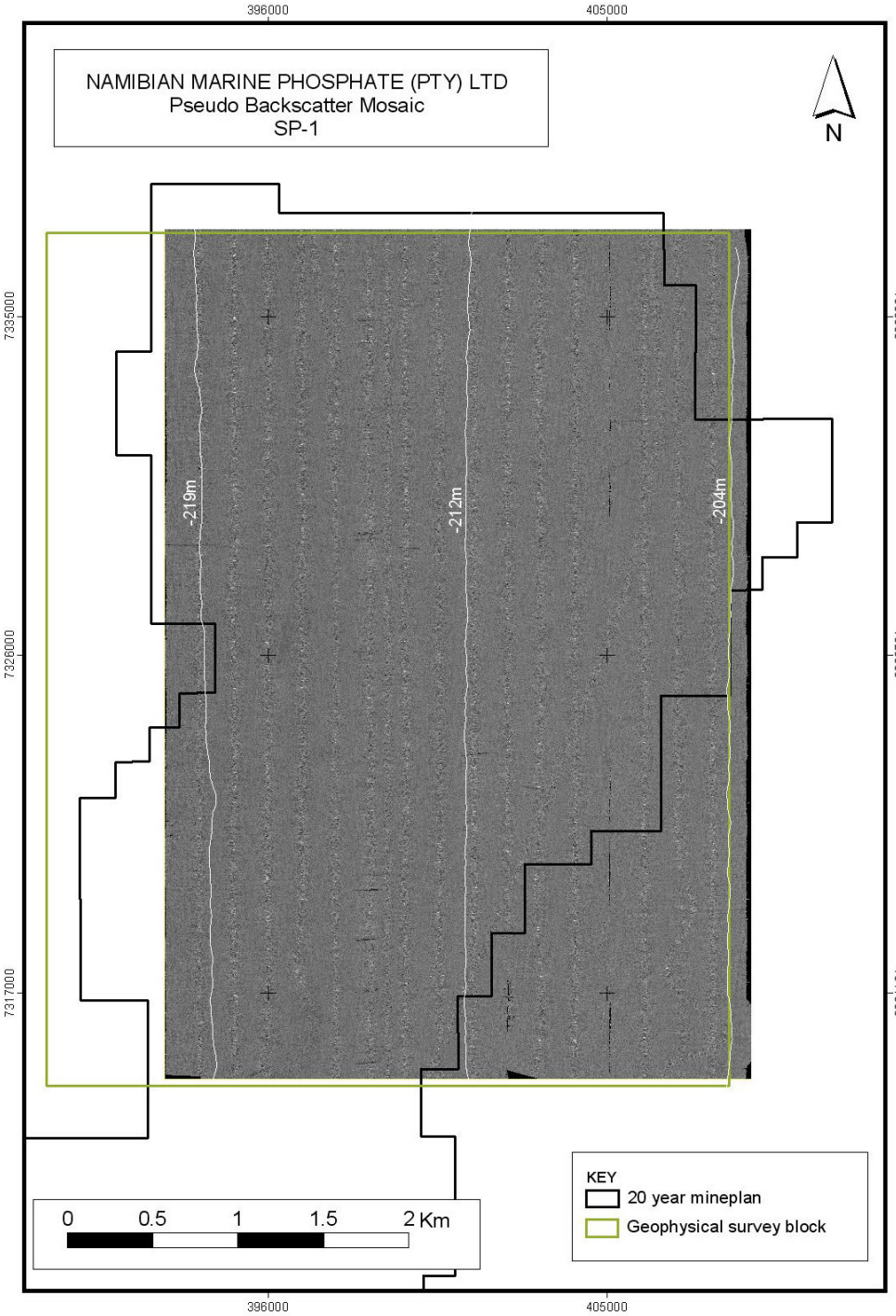

Figure 3: Pseudo Backscatter image

4.3 SIDE-SCAN SONAR (SSS) IMAGE

The side-scan sonar image (Figure 4) also confirms a smooth seafloor with an absence of any features or variance. The ARA result indicates a medium sand surface for all of the mosaic, which is consistent with the backscatter result.

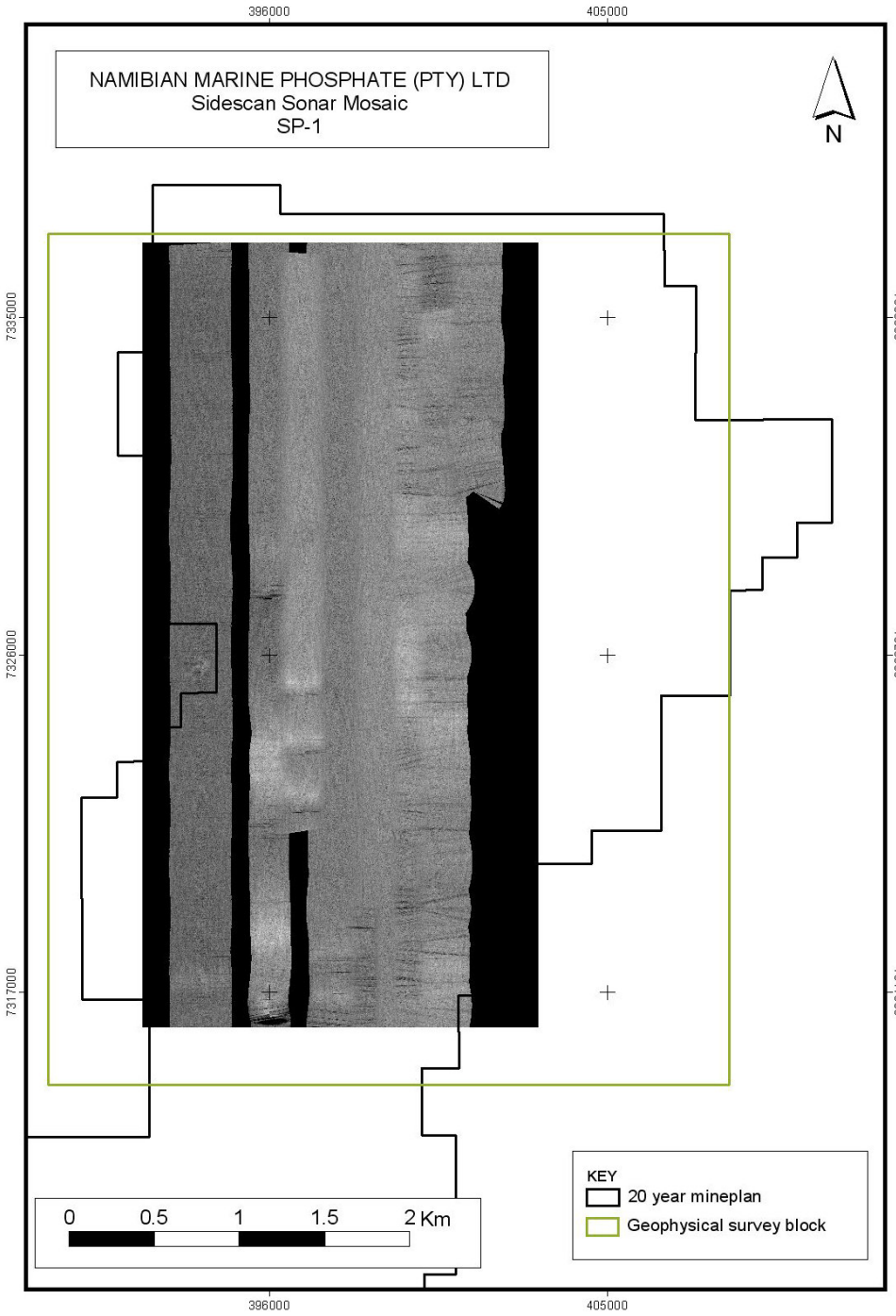

Figure 4: Side-scan Sonar Mosaic

For the NMP 2013 and 2014 Verification Survey, the information collected from in around the SP-1 target dredge site for the verification survey is extensive, from these surveys and data analysis the habitat has been assessed. The data coverage of the SP-1 target dredge site (Figure 5) consists of:

- A 90 day long instrument deployment, measuring: turbidity, current velocity, oxygen, conductivity, temperature and salinity
- 26 surficial sediment grab sites, from which, sediment characteristics were determined, macro and meio fauna samples were subsampled and analysed
- Collection of sediments for macrofauna impact sites referencing, and collection of 2 sets of reference sites (4 north and 4 south of the target dredge site). These sites together constitute the benthic macrofauna monitoring suite of samples
- Five samples sites, with CTD measurements and water samples recovered from depths of: 10 m, 20 m, 100 m, and ~ 200 m
- 25 cores of 90 mm were collected, each core of maximum length up to 3.0 m, these were subsequently analysed for sediment characterisation
- 10 surficial sample samples for the determination of bacterial content
- 24 monk demersal trawls (12 night and 12 day) of ~ 0.5 nm (30 minute trawl duration) over 8 days, with corresponding CTD deployments, full fisheries analysis of the catch, analysis of epifauna assemblage, and mammal and bird observations
- Geophysical survey, using, side-scan sonar, and multibeam equipment, with a total of 235 km line coverage.

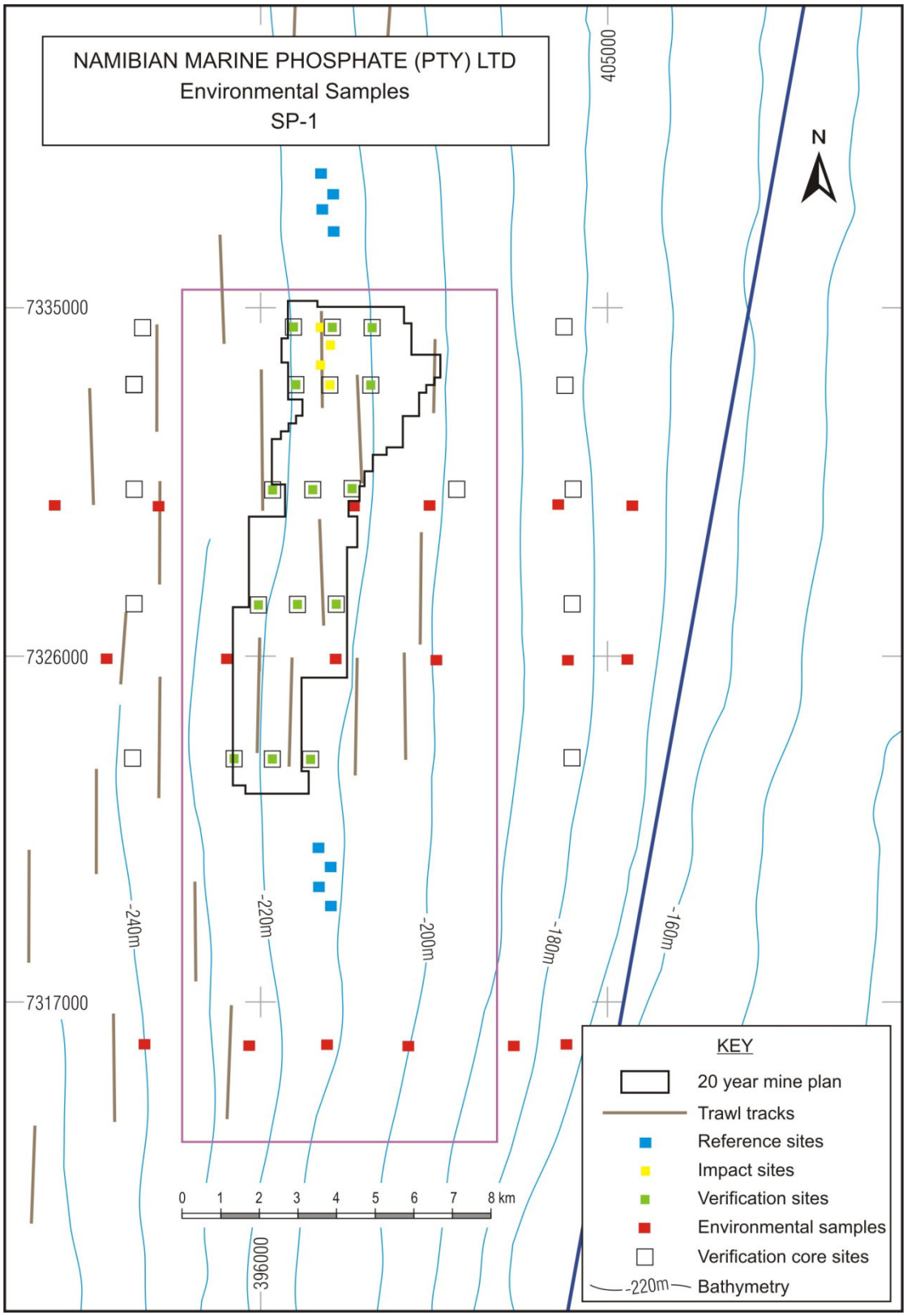

Figure 5: Consolidated sampling locations, SP-1: NMP verification survey

5 MACROFAUNA AND MEIOFAUNA

5.1 MACROFAUNA AND SURFACE SEDIMENT CHARACTERISATION

Sediment characteristics are discussed in detail in Section C, Chapter 2.1, here only a short description is provided. Surficial sediments in SP-1 can generally be classed as silty sand with an average median (D_{50}) sediment particle size of 114.39 µm and low porosity implying a firmly packed sediment with low pore water volumes. Surficial sediment layers frequently included dense shell layers, which were denser on the eastern boundary of the survey area than further to the west. With the exception of one site (SP1VS18), the measured particle size distributions were relatively similar at all the sites being dominated by medium and fine sand with a steady decline towards the smaller grain size (Figure 6). The combined fractions of <63 micron, *i.e.* the mud fraction, yielded around 30% while clay generally contributed <2%. In contrast to all other sites, SP1VS18 was highly dominated by very coarse sand (>70%).

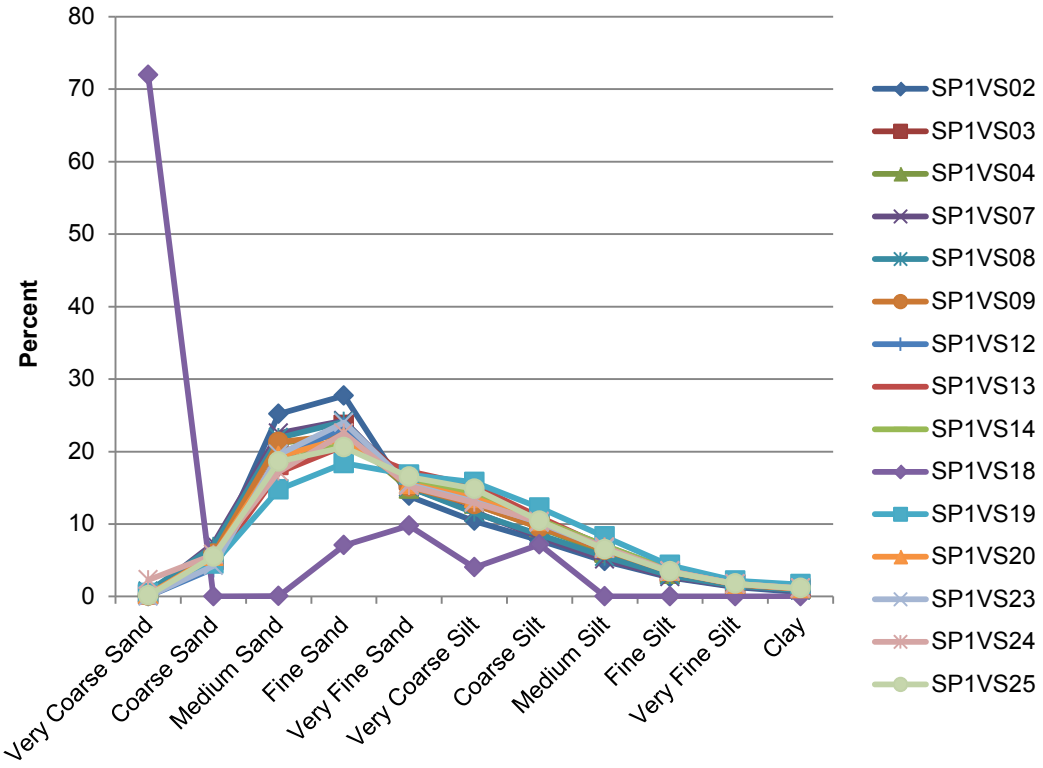

Figure 6: Sediment grain size distribution at the verification survey sites.

Macrofauna characteristics are discussed in detail in Section C, Chapter 2.5, here only a short description is provided. Figure 7 illustrates the sample clusters overlain onto the map of the verification survey sites, showing that Group A contains mostly the slightly shallower sites in the east of the survey grid with the exception of site SP1VS09. Sites SP1VS07 and SP1VS08 also fall into this group. Group B encompasses the western sites and SP1VS09. This information suggests a homogeneous sedimentary environment, with an east – west environmental gradient.

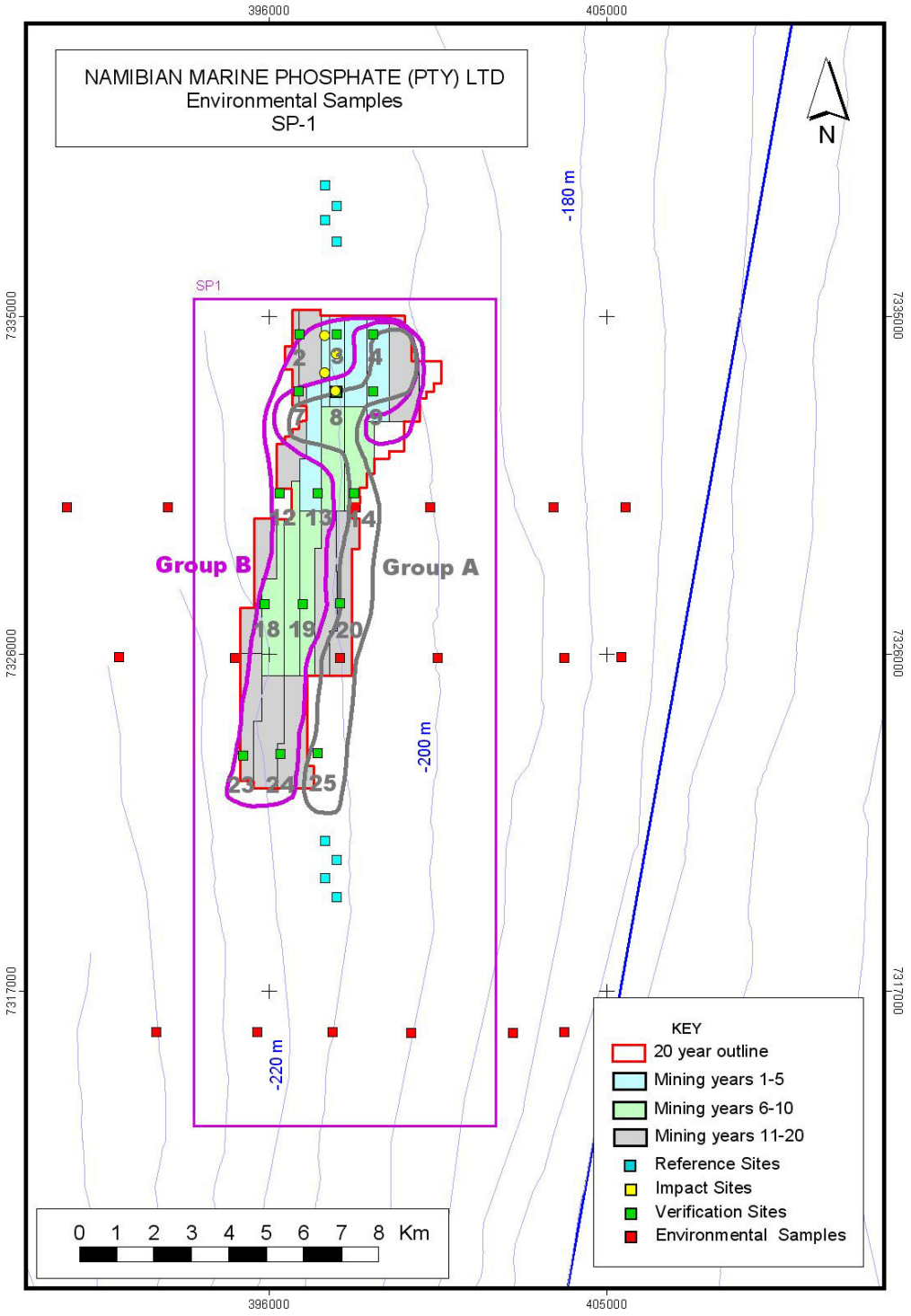

Figure 7: Sample groups as identified by the dendrogram, MDS and PCO plots overlain on the macrofauna survey verification sites

5.2 MULTIVARIATE ANALYSES OF MEIOFAUNAL COMMUNITY DATA

Meiofaunal characteristics are discussed in detail in Section C, Chapter 2.4, here only a short description is provided. The six clusters of structurally-related nematode assemblages identified by the classification analyses and corroborated by the ordination studies have been transposed onto the survey area chart (Figure 8). This reveals a nematode community distribution pattern *that is consistent with the presence of an environmental gradient*. The closely-related Cluster D, E and F meiofaunal assemblages were present at sites located on the eastern side of the verification survey area. Amongst these, the Cluster F communities were confined to the five sampling stations that extended along the eastern side of the grid. The remaining nematode assemblages, i.e. those belonging to Clusters A, B and C, were identified at sites located in the western half of the survey area (Figure 8).

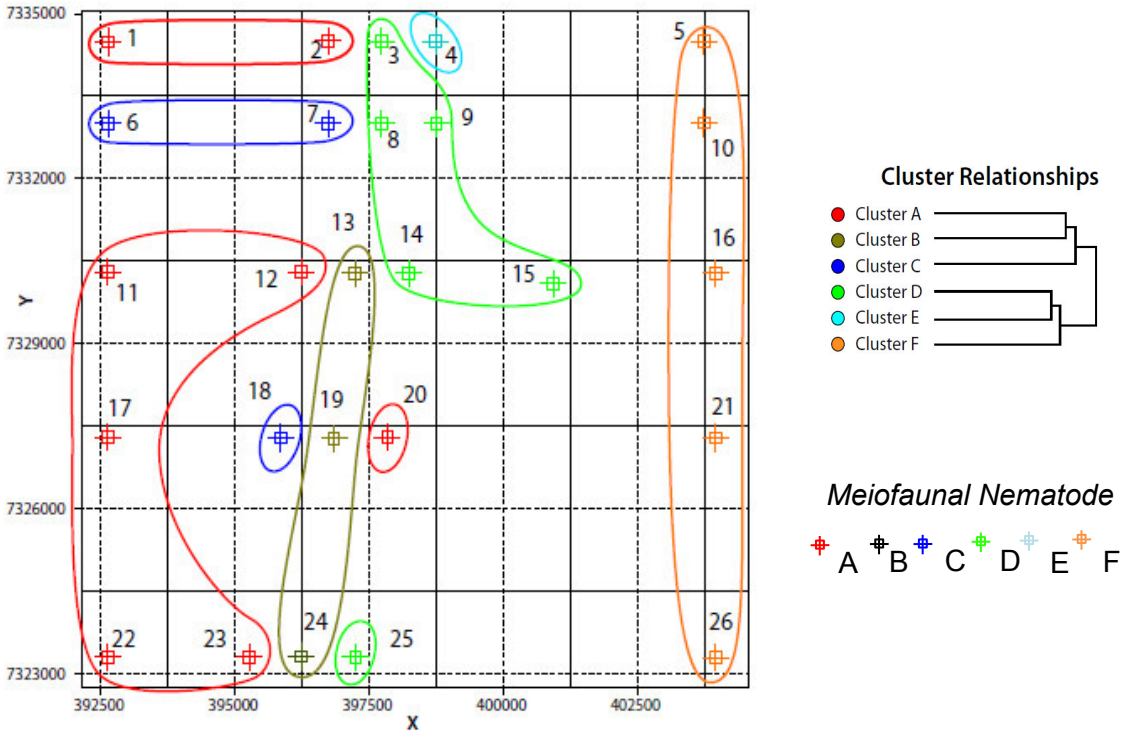

Figure 8: Distributions of structurally – related meiofaunal nematode communities (SP-1, of MLA 170)

6 SUMMARY

The geophysical data conclusively indicates a flat, smooth seafloor with a homogeneous surficial sediment cover across the entire survey block. No protruding obstacles were observed.

The surficial sediment composition of the area is well known from a large number of gravity cores and surficial grab samples that were collected across SP-1 for the purpose of phosphate resource development and environmental characterisation. The top few centimetres of the deposit consists of a mixture of silty sand particles, typically with dense shell. This site-based information confirms the muddy medium sand conclusion reached with the various images produced for, the geophysical survey and is further supported by the multivariate analyses of the macro and meiofaunal communities.

The multibeam echo sounder will be the geophysical tool of choice for dredging extraction control as well as pre - and post - dredging seafloor mapping.