

CHAPTER 3:

PROJECT DESCRIPTION

FINAL REPORT



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CHAPTER 3. THE SANDPIPER PROJECT

3.1 INTRODUCTION

The information in this chapter focuses exclusively on the marine component of the project relating to the operations to be undertaken in marine mining licence ML170 located some 120km to the southwest of Walvis Bay. This chapter is based on information provided by the project proponent (Namibian Marine Phosphate Pty Ltd) (NMP) and its appointed specialist consultants/contractors.

The project proponent (NMP) is a Namibian registered joint venture company comprising of a Namibian women’s empowerment group Tungeni Investments cc (15%) as well as the Namibian subsidiaries of two Australian Listed Stock Exchange companies, Minemakers Limited (42.5%)¹, and UCL Resources Limited² (42.5%).

Phosphates in the marine environment were first discovered and regionally mapped on the Namibian shelf in the late 1960s and 1970’s, with subsequent exploratory work undertaken by the South African mining company Gencor Ltd and others in the 1990s and 2000’s. The phosphate deposit off Walvis Bay was termed “Sandpiper Deposit ” by Gencor, and that name has been retained. Phosphate deposits (of various type and grade) are known to be widely distributed on the Namibian continental shelf. In the 1990s the Sandpiper deposit was considered as sub economic based on current prices for rock phosphate concentrate (1991: US\$ 42.50 tonne). From 2007 the value of phosphate rock concentrate (32 % P₂O₅) increased rapidly from US\$ 80.00 per tonne, peaking at US\$ 430.00 per tonne in August – September 2008 resulting in a re-rating of the economic viability of phosphate projects worldwide. The current market price is significantly lower than the 2008 peak price placed currently at around US\$ 192.50³ (February 2012), which still leaves several projects, including the Sandpiper project at economically viable levels.

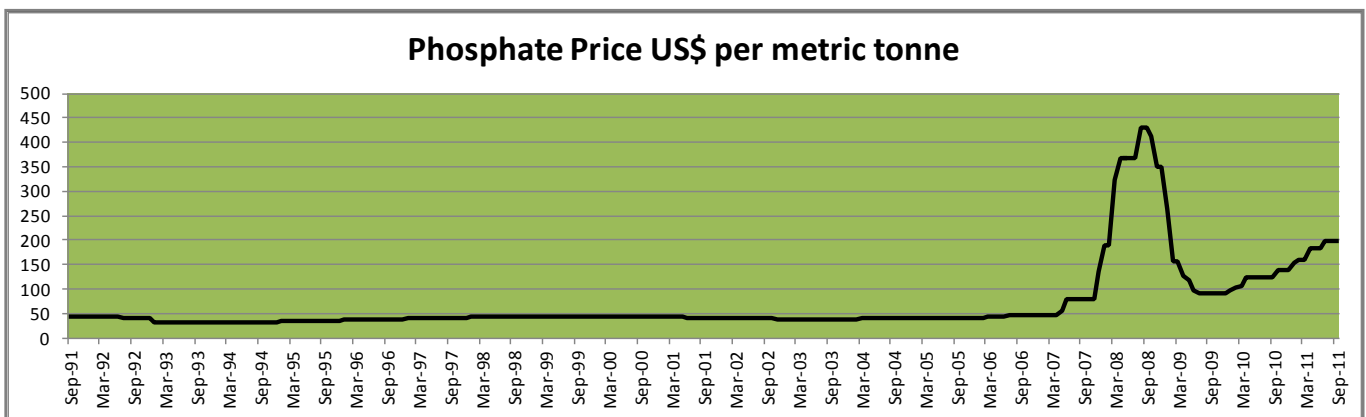


Figure 3.1⁴: Twenty-year phosphate price.

¹ MAK.AX

² UCL.AX

³ Commodity prices - World Bank data – www.indexmundi.com/commodities

⁴ Commodity prices - World Bank data – www.indexmundi.com/commodities.

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Phosphorus (P) is an essential nutrient of all plants and animals. There is an ever-increasing demand for phosphate of good quality, which the Sandpiper deposit provides, as a component of fertilizer in the agricultural industry (for farming and as an ingredient of animal feeds) as well as in the food industry as a food additive. As the traditional world phosphate reserves decline, the impacts to society are potentially immense. This directly relates to declining farm output (produce decline). This in turn has generated higher food prices and contributes significantly to food insecurity and associated escalating socio-economic challenges. Riots related to prices and lack of availability of food occurred across the world in 2008 and 2009 and still continue to flare up today. Some countries (particularly China and Saudi Arabia) are currently ensuring their own food resources by securing large tracts of arable land in foreign countries, notably Africa (Zambia, Angola, Mozambique, and Tanzania).

Through the proposed development of the Sandpiper Phosphate Project by NMP, Namibia has the opportunity to participate in the global phosphate industry thereby positively contributing to the global phosphate resource and in this way contributing to securing farming output as well as to world food security. Food, food production, food security and nutrients (in particular phosphate) are extremely important in the global economy and the stability of food based economic strategies. Namibia has the opportunity to become a global influence and in this regard, as well as becoming a significant role player in the stability of society's sustained social and economic well-being.

While global reserves of phosphate appear to be large, they are finite and will be subjected to upward price pressure as world demand for food rises, population increases (9 billion in 2050), available arable land decreases and the quality of the mineable reserves declines. Morocco, China, South Africa and the USA hold 83% of the world's easily exploitable phosphate and contribute two thirds of the annual production. At current rates of extraction, known USA reserves are projected to last 40 years. Globally 90 years' (15,000 million metric tons) worth of phosphorus remains. Namibia, with NMP's recently established current resources of 1,832 Mt (at 15 % P₂O₅), now ranks as the seventh largest in terms of global resources⁵. The demand for phosphate is very likely to grow based on population growth with associated increased living standards⁶.

NMP is in the process of conducting a Definitive Feasibility Study (DFS) on the Sandpiper Phosphate Project. The base case (as determined from earlier investigations) for this DFS study are:

- An economic life of mine of 20 years;
- Recovery of 5.5 million tonnes of marine sediment annually;
- Export of 3.0 million tonnes of rock phosphate (concentrate) annually ;

Provisional investigations by NMP through appointed environmental consultants and specialists has determined that the recovery (dredging) and terrestrial processing/beneficiation (washing and separation) of the phosphate, with appropriate mitigation and responsible management practices in place, will not have a significant detrimental impact on the environment at each of the affected locations. However, this remains to be confirmed through this formal EIA-EMPR process.

⁵ 1,832 million tons (at 15% P₂O₅) [comprising: Measured 4.09 Mt at 20.5 % P₂O₅; Indicated 220,35 Mt at 20.13 % P₂O₅ and Inferred 1,607.8 Mt at 18.9 % P₂O₅]

⁶ Data source, United States Geological Survey.

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As stated, the separate primary activities of the project will be dealt with under two parallel EIA processes that will, when combined, evaluate the entire project:

- Marine activities – includes all activities undertaken in the ML170 area (located 60km offshore and some 120 km SW of Walvis Bay) per the conditions issued by the Ministry of Mines and Energy, and incorporating phosphate sediment recovery (dredging) and transport to the coast off Walvis Bay; and
- Terrestrial activities – includes the treatment/beneficiation of the material recovered and incorporating, slurry transfer pipeline to pump the material onshore from the dredger, a buffer pond to receive and screen material, the processing of the phosphate slurry to produce the export product ‘rock phosphate’ and the associated infrastructural requirements⁷.

These two EIA processes have been registered with the Ministry of Environment and Tourism in accordance with the Environmental Management Act (Act 7 of 2007)⁸.

3.2 OBJECTIVES OF THE PROJECT

The primary objective is to develop a world class phosphate project in Namibia and to supply phosphate (‘rock phosphate’) to Namibia, regionally in Africa and also to world phosphate markets at competitive prices, to undertake this development in a responsible manner, with due and proper consideration to corporate, social, economic, and environmental matters.

In addition to the primary objective there are several key project objectives, which are of significant importance to ensure the appropriate development of the project from conceptualization through design to development and including ongoing project management, these are:

- Taking a key role in establishing Namibia as a leader in the provision of rock phosphate to regional and world markets⁹;
- Creation of sustained direct (employee) and indirect (subcontractor) employment;
- Identifying, evaluating and responsibly mitigating/managing matters of environmental concern;
- Providing open pathways for the presenting and resolution of possible conflicts of interest that may occur;
- Cooperating and developing synergistic projects with local communities and stakeholders;
- Contributing to securing agricultural productivity and food production in Namibia, the surrounding regions in Africa as well as other parts of the world;

⁷ Rock phosphate is an industry term. The term is applied to this project; however, the product recovered is a fine black sand in the case of the Namibian marine phosphate product.

⁸ Appendix 2b.

⁹ Based on the 1,832 million tons (at 15% P₂O₅) [comprising: Measured 4,09 Mt at 20.5 % P₂O₅; Indicated 220,35 Mt at 20.13 % P₂O₅ and Inferred 1,607.8 Mt at 18.9 % P₂O₅] confirmed by NMP, Namibia has the seventh largest phosphates reserves in the world. (United States Geological Survey)

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- Establishing the framework for taking the project to higher levels of in-country beneficiation by becoming a fully vertically integrated fertilizer manufacturer;
- Contribution to regional and national growth of the GDP through employment, royalties and tax revenues, and
- Providing a return on investment to shareholders.

The medium to long-term objectives of the project would be subject to separate feasibility and environmental studies to address advanced beneficiation and chemical processing of the recovered rock phosphate to produce a range of fertiliser products including:

- Partially Acidulated Phosphate Rock
- Single Super Phosphate,
- Phosphoric acid.
- Fertiliser products

3.3 PROJECT CONCEPTUALISATION

The development of the project has two primary drivers:

- Commodity price and demand; and
- Current dredging and phosphate beneficiation technology developments.

Detailed project conceptualization is based on the following:

- That marine rock phosphate is potentially suitable for direct application to the soil;
- That marine rock phosphate is potentially suitable for downstream production of phosphoric acid and fertilizer products
- The commodity price of phosphate (currently is US\$ 192.50 per tonne (February 2012) is predicted to remain in a steady price range over the next 10 years, possibly to increase in the medium term as supply is outstripped by demand;
- Global terrestrial traditional rock phosphate reserves are diminishing in quality and grade throughout the world¹⁰;
- Demand for good quality phosphate fertilizer is expanding due to the increasing food needs of the growing world population (estimated 7 billion people in November 2011¹¹ and projected to 9 billion by 2050) and more recently, by the demand for biofuels as renewable alternatives to fossil fuels;
- Currently there is no artificial substitute for phosphate as a critical component in agricultural fertiliser and feed;
- The increase of agricultural production has to be achieved mainly on the existing agricultural land as most of the arable land is already used. Only in South America and Sub-Saharan Africa can further land be made arable by clearing;
- Morocco, with the largest reserves in the world (26 billion tonnes), is also the largest annual producer. China, which holds the second largest world reserves (14.1 billion

¹⁰ J. von Horn and C Sartorius: Impact of supply and demand on the price development of phosphate (fertilizer) - 2009: Fraunhofer Institute Systems an innovation Research, Breslauder Str. 48, 76139 Karlsruhe, Germany

¹¹ National Geographic Magazine – September 2011.

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tonnes), applies a 150 % premium on exported phosphate. It has been reported but not verified that the country has stopped exporting phosphate and is retaining its production for in-country use, and

- Development of this project will place Namibia in a significant position in the global rock phosphate industry with regard to both quantity of phosphate resource as well as annual production.

The key operational aspects for the marine component of the project comprise:

- Recovery of Phosphate sediment from water depths of up to 275 m;
- An annual recovery volume of 5.5 million tonnes of phosphate rich sea bed material to a thickness of 3 m (potentially up to 6 m), extracted from an area of up to 3 km²;
- Transporting the recovered sediments by vessel and transferring (by pumping) the material to shore;
- Conducting the marine operation in a safe and responsible manner with respect to the conditions at sea, other marine users and also applying environmental management practices as described in the environmental management plan¹²;

The key operational aspects of the terrestrial component of the project involves¹³:

- A temporary sinker line pipeline for the transfer of the slurry from the vessel to the shore;
- Receiving the slurry in a coastal buffer pond;
- Screening the slurry at the coastal buffer pond pre-processing site;
- Pumping the phosphate enriched slurry via a pipeline to the processing plant;
- Beneficiating (separating (screening and gravity), washing and drying) the incoming material at a processing plant;
- Managing final products, which includes transporting phosphate to an enclosed stockpile, and the tailings material to final disposal site, and
- Transfer of saleable products to the Port of Walvis Bay or point of sale.

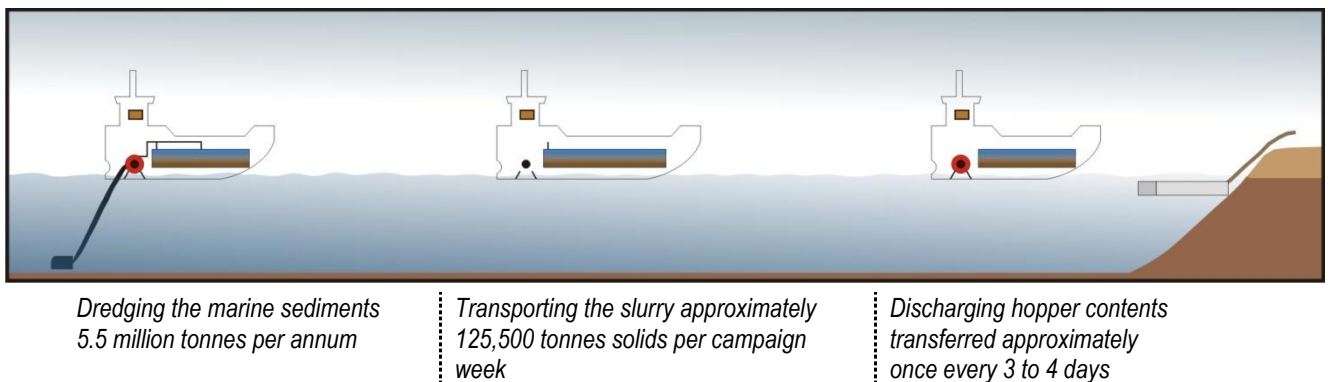


Figure 3.2: The dredging cycle (schematic).

¹² The final requirements of environmental management plan will be confirmed in the Environmental Contract with the Ministry of Environment and Tourism and responsible line ministries.

¹³ Full detail of the terrestrial component of this project will be provided in a separate EIA report.

3.4 PROJECT ALTERNATIVES

In common with the exploitation of all mineral deposits there is no alternative to the proposed project. The proposed project has been evaluated as a viable operation in respect of all corporate responsibilities, liabilities and requirements. However, a wide range of alternatives has been considered in respect of evaluating recovery, storage, transportation systems and discharge of the phosphate-rich marine sands¹⁴. These alternatives have been assessed primarily in respect of technical matters related to sediment recovery. However, corporate liabilities and responsibilities, within which environmental concerns are evaluated, have been appropriately considered.

On a global scale, the number of successful, currently operating dredging recovery systems that can operate under these conditions are limited. Six dredging/recovery system alternates have been evaluated for this project, (Figure 3.3), these included:

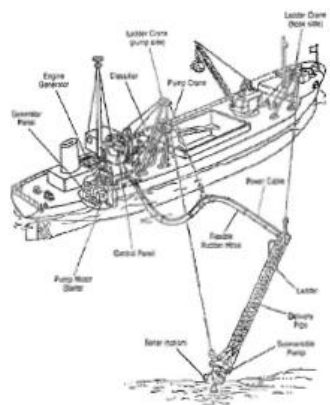
- Wireline Dredge Pipe;
- Large diameter drill;
- Mechanical grab;
- Fall pipe and Remotely Operated Vehicle (ROV),
- Flexible hose and ROV; and
- Training Suction Hopper Dredge (TSHD)

Each of these operational recovery systems was evaluated against the following assessment criteria:

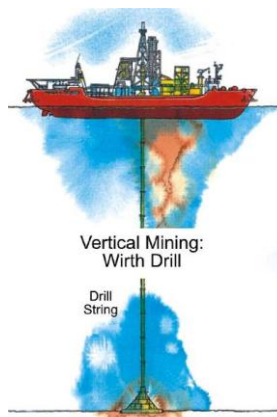
- Vessel availability;
- System availability;
- Production capacity;
- Market flexibility;
- Material transport;
- Operation complexity;
- Capital cost;
- Operator skill level;
- System maturity, and
- Recovery accuracy.

¹⁴ These systems were evaluated by IHC Marine and Minerals Projects; PO Box 53156 Kenilworth Cape Town 7745

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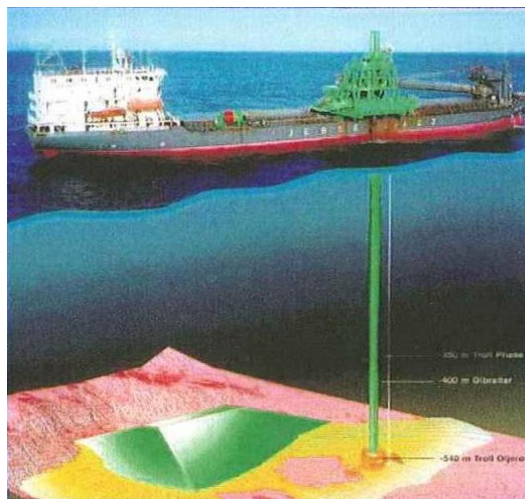
Wire Line Sand Dredge



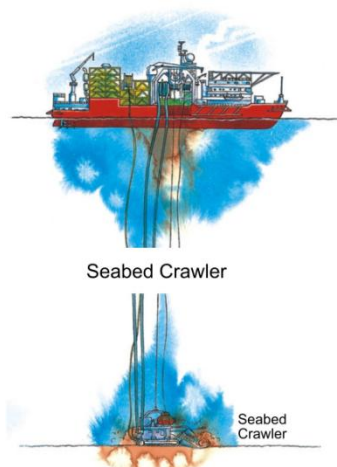
Wirth Drill



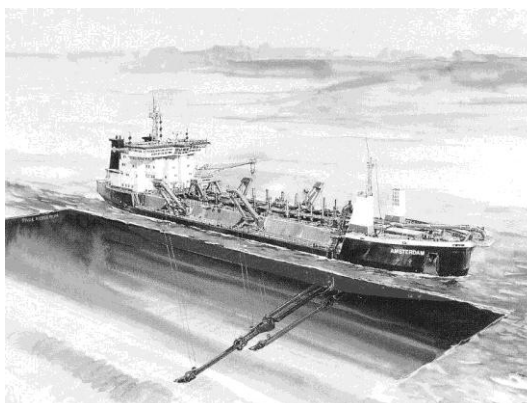
Mechanical Grab



Fall Pipe & ROV



Crawler ROV



Trailing Suction Hopper Dredge

Figure 3.3: Alternative marine sediment recovery systems.

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The appointed experts established that the TSHD is the preferred recovery option. The TSHD allows for both recovery and transportation of the marine sediments in the same vessel.

The principal reasons for the TSHD being the preferred option include:

- A large hopper (space where the slurry is stored onboard) provides for economy of scale;
- TSHD technology is proven and is supported by well known established environmental protocols;
- Processing at sea and transfer of slurry to barges for transfer to shore is eliminated, which minimizes the safety risks inherently associated with transfers at sea;
- The vessel when not dredging has a relatively fast sailing speed, this shortens the 'dredge – sail – discharge' turn around time (the dredge cycle), and
- The vessel has its own power source (ship's power and pumping capacity) for discharging the slurry via pipeline to the buffer pond on shore.

3.5 LOCATION OF THE PROJECT

The Sandpiper marine phosphate project is located on the Namibian continental shelf approximately 120 km south southwest (SSW) of Walvis Bay. The eastern boundary of the Mining Licence Area is approximately 40-60 km off the coast (directly west of Conception Bay). The water depths in the licence area range from 180 to 300 m, (Figure 3.4). The Mining Licence Area is 25.2 km wide (greatest width) and 115 km long (longest length).

NMP has verified to internationally approved standards the existence of a potential world-class phosphate deposit of 1,832 Mt (at 15 % P₂O₅) in the Mining Licence Area¹⁵. The Mining Licence Area covers 2233 km².

The phosphate enriched sediments and defined mineral resources are located throughout the entire Mining Licence Area. Within the ML three initial target-mining areas have been selected. These areas are referred to as; Sandpiper-1 (SP-1), Sandpiper-2 (SP-2) and Sandpiper-3 (SP-3), (Figure 3.5, Figure 3.6, Figure 3.7, Figure 3.8).

¹⁵ 1,832 million tons (at 15 % P₂O₅) [comprising: Measured 4,09 Mt, Indicated 220,35 Mt at 20.13 % P₂O₅ and Inferred 1,607.8 Mt at 18.9 % P₂O₅]

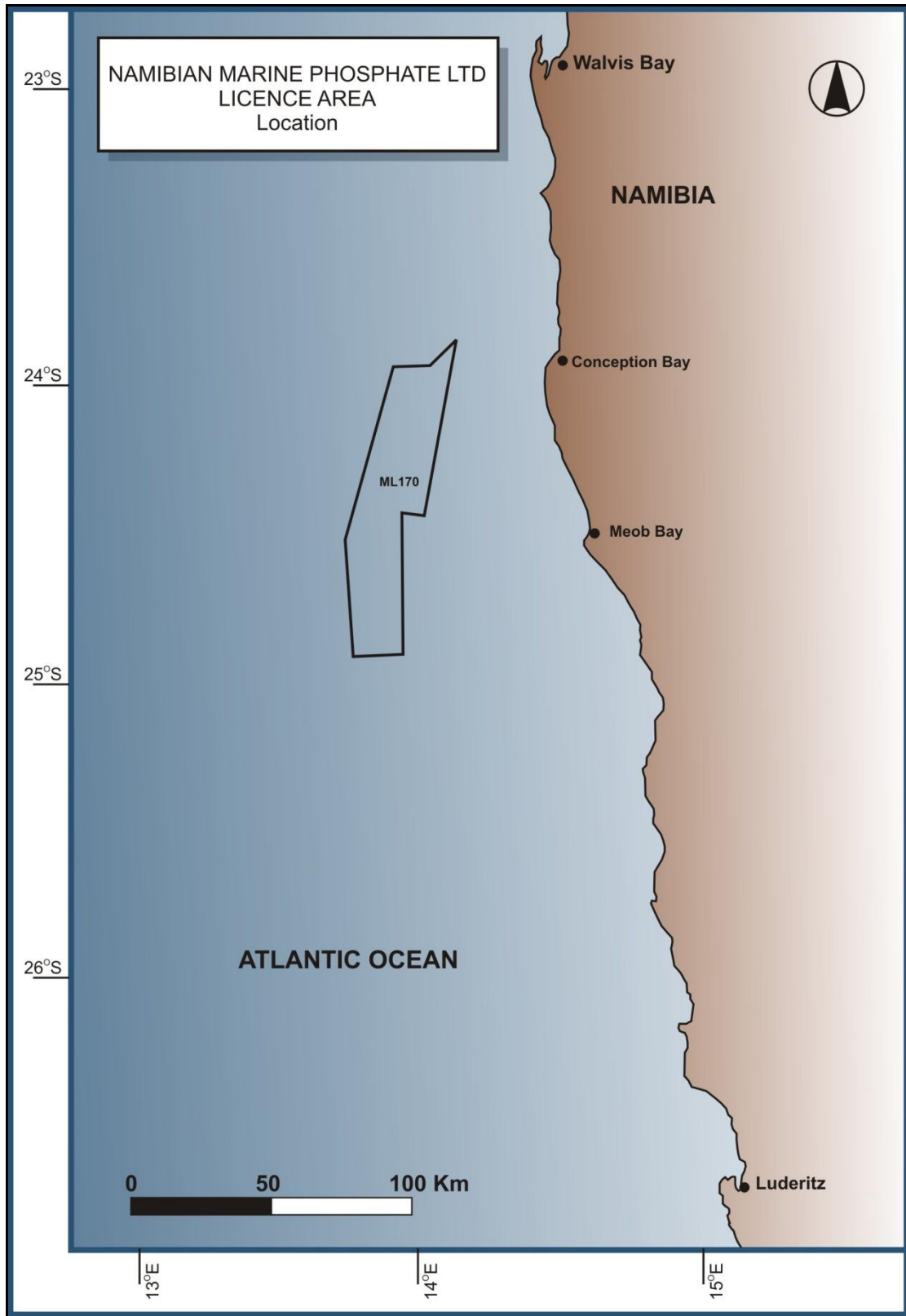


Figure 3.4: General Location of the project of Mining Licence 170.

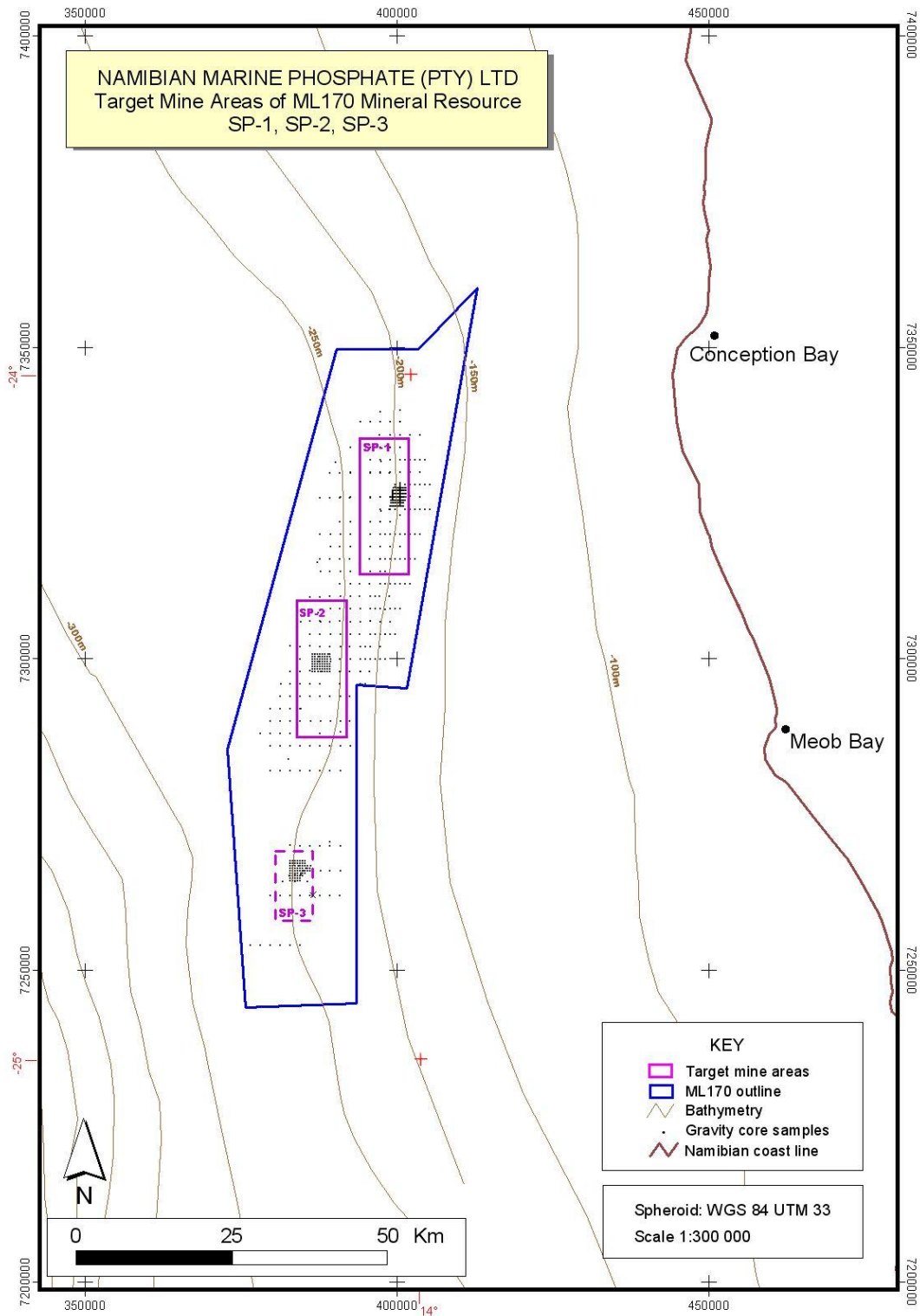


Figure 3.5: General distribution of the initial target recovery areas of the Sandpiper project within the Mining Licence Area.

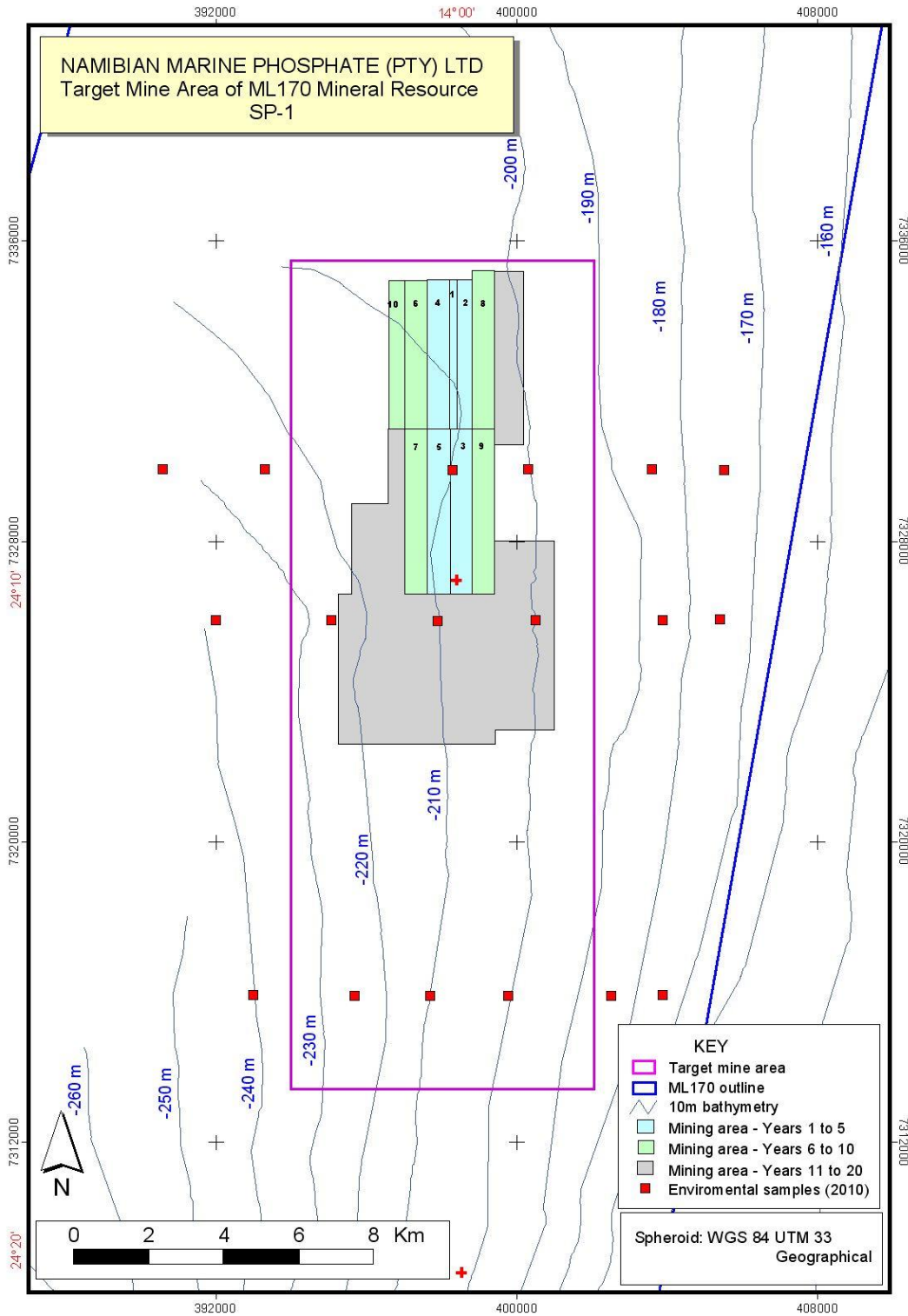


Figure 3.6: The Sandpiper-1 initial target recovery area of the mineral resource. Showing a possible 20 year mineable area

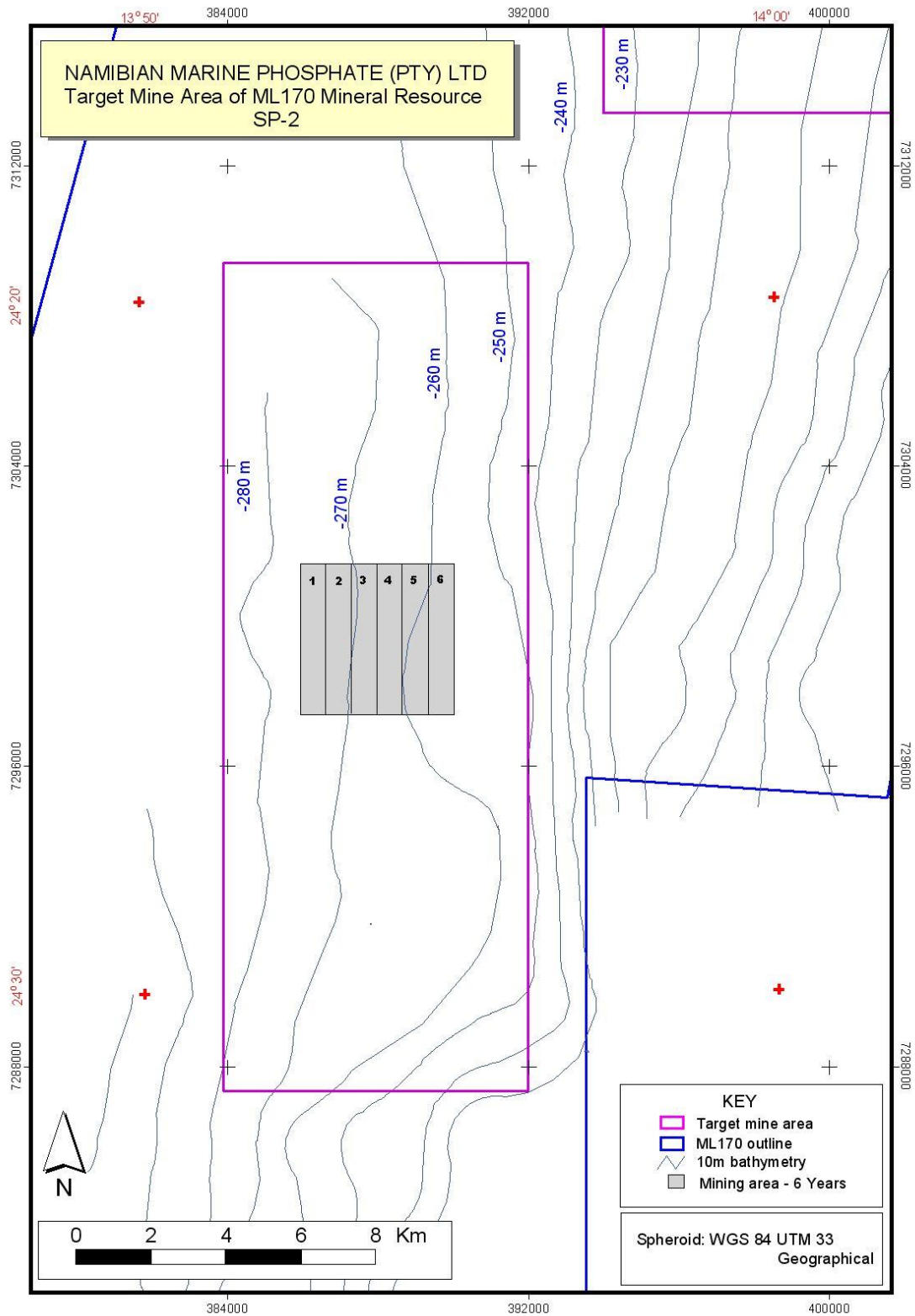


Figure 3.7 The Sandpiper-2 target recovery area of the mineral resource. Showing a possible 6 year mineable area

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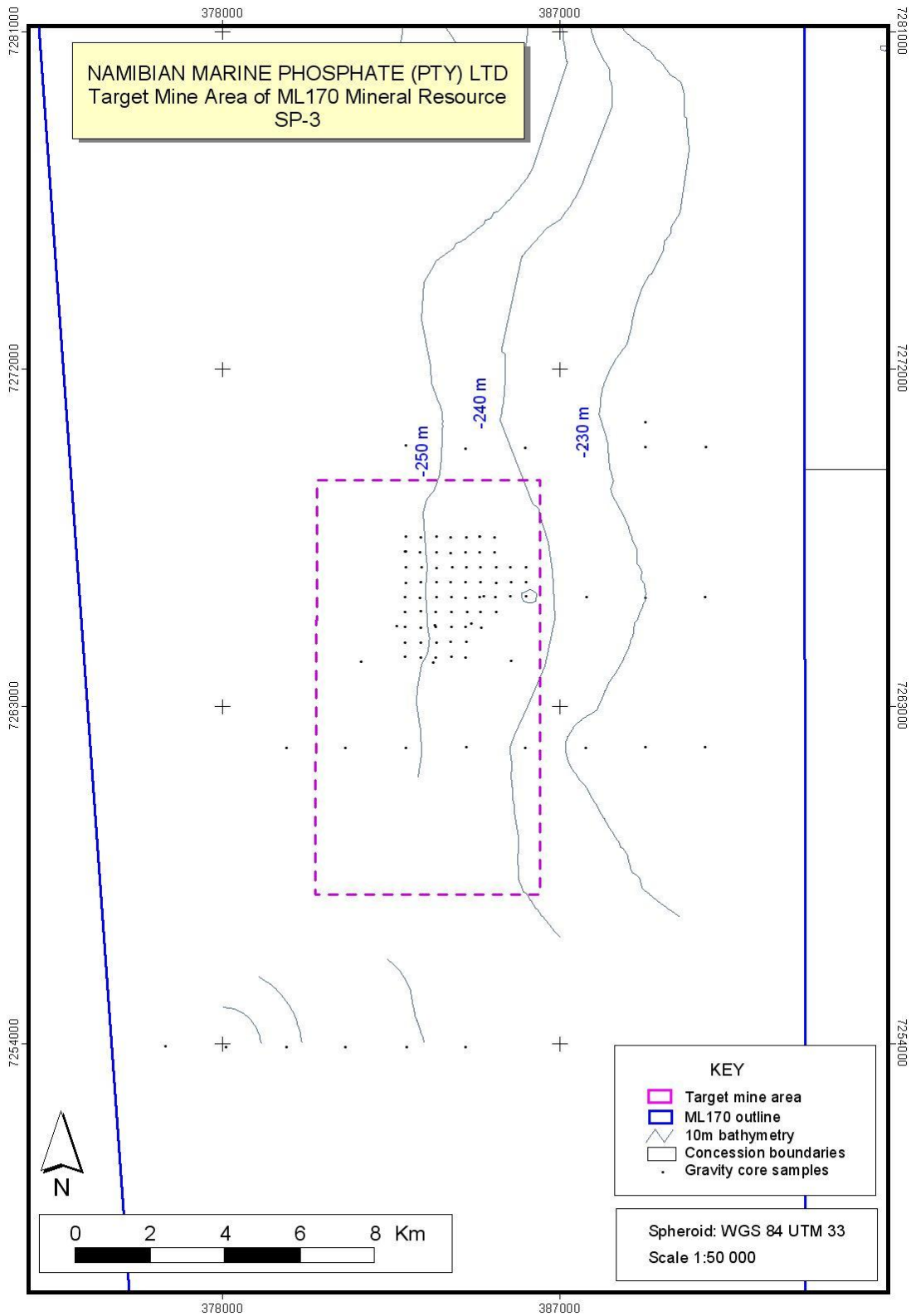


Figure 3.8: The Sandpiper-3 target recovery area of the mineral resource.

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Details of the three target recovery areas of the Sandpiper deposit are presented in Table 3.1, from within which up to 3km² will be mined annually, (60 km² for the life of the mine).

Table 3.1: Parameters describing three target recovery areas of the Sandpiper deposit.

Detail	Sandpiper-1	Sandpiper-2	Sandpiper-3
Boundary coordinates (Lat - Long) of the target mining areas	A: 24° 05' 24.500" S 13° 57' 25.716" E	A: 24° 19' 27.201" S 13° 51' 24.056" E	A: 24° 41' 19.540" S 13° 49' 07.630" E
	B: 24° 05' 26.359" S 14° 02' 09.025" E	B: 24° 19' 29.265" S 13° 56' 07.875" E	B: 24° 41' 21.178" S 13° 52' 41.105" E
	C: 24° 17' 21.597" S 14° 02' 03.644" E	C: 24° 31' 24.458" S 13° 56' 01.869" E	C: 24° 47' 18.753" S 13° 52' 37.895" E
	D: 24° 17' 19.720" S 13° 57' 19.895" E	D: 24° 31' 22.375" S 13° 51' 17.605" E	D: 24° 47' 17.108" S 13° 49' 04.251" E
Approx width - km	8	8	6
Approx length - km	22	22	11
Area (km²)	176	176	66
Thickness Avg - m	1.69	1.70	1.30
Thickness Max - m¹⁶	2.5	2.25	1.85
Thickness Min (m)	0.50	0.50	0.60
Area mineable - km²	160	162	54
Avg area mined/pa - km²	2.44	2.42	3.17
Water depth range - m	190 - 235	245 - 285	235 - 270
Deposit > 3 m¹⁷	Non	Non	Non
Life of deposit - yrs	51	79	20

3.5.1 Adjacent Licence holders

The location and extent of Mining Licence 170 in relation to neighbouring concessions is shown (Figure 3.9) and listed (Table 3.2).

¹⁶ Not all cores terminated on footwall, these figures may change with further exploration.

¹⁷ Depths in excess of 3 m are to be further evaluated with vibracoring sampling equipment.

Table 3.2: Companies holding lease areas adjacent to ML 170.

Company	Area	Licence Type
Samicor	EPL 2027 G	Industrial Minerals and Precious stones
Samicor	EPL 2027 H	Industrial Minerals and Precious stones
Samicor	EPL 2027 I	Industrial Minerals and Precious stones
Guinas Angonam Mining	EPL 2501	Industrial Minerals and Precious stones
Samicor	EPL 3291	Industrial Minerals and Precious stones
Magundje Minerals	EPL 3736	Industrial Minerals and Precious stones
LL Namibian Phosphate	EPL 3946	Industrial Minerals
Namibian Marine Phosphate	EPL 4009	Industrial Minerals
Pelagian Progress	EPL 4068	Industrial Minerals
Duiker Investments	EPL 4260	Precious metals & semi-precious stones

3.6 MINERAL LICENCES

The licence history of the Mining Licence Area is as follows:

EPL 3323 was originally granted to Bonaparte Diamond Mines Namibia (Pty) Ltd in 2005 and was transferred to Bonaparte Tungeni Joint Venture Exploration (Pty) Ltd. on the 7th September 2006, which was subsequently re-named Minemakers Tungeni Joint Venture Exploration (Pty) Ltd. EPL3323 was transferred to Namibian Marine Phosphate (Pty) Ltd. on the 4th October 2010 after signing of the shareholders agreement in June 2010.

EPL 3414 was granted to Sea Phosphates Namibia (Pty) Ltd. on the 25th April 2006 before being transferred to Namibian Marine Phosphate (Pty) Ltd. on the 4th October 2010.

EPL 3415 was granted to Sea Phosphates Namibia (Pty) Ltd. on the 25th April 2006 before being transferred to Namibian Marine Phosphate (Pty) Ltd. on the 4th October 2010.

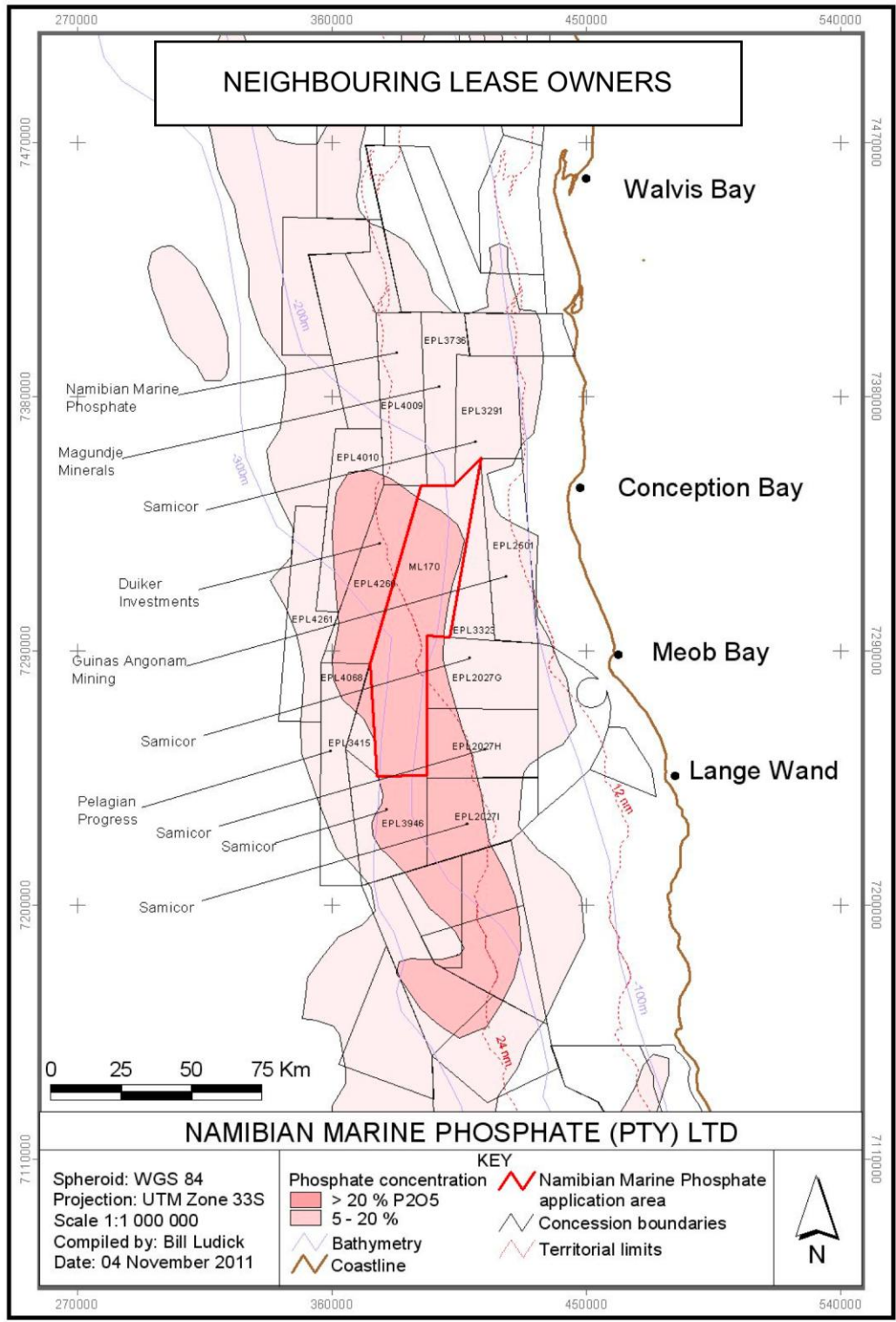


Figure 3.9: Neighbouring concession holders.

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NMP has been granted a Mining Licence (ML 170)¹⁸ for Industrial Minerals by the Ministry of Mines and Energy, the licence is issued for 20 years, for the period 13th July 2011 to 12th July 2031. The area incorporates the whole of EPL 3414 and parts of EPLs 3415 and 3323.

The coordinates (Table 3.3) describing the location of Licence Area (refer to Figure 3.5) are:

Table 3.3: Coordinates of Mining Licence 170.

	Lat	Long
A	-23° 57' 48"	14° 03' 05"
B	-23° 52' 31"	14° 08' 39"
C	-24° 27' 15"	14° 01' 43"
D	-24° 27' 01"	13° 57' 00"
E	-24° 32' 25"	13° 56' 58"
F	-24° 54' 15"	13° 56' 47"
G	-24° 54' 10"	13° 46' 12"
H	-24° 32' 19"	13° 44' 48"
I	-23° 57' 46"	13° 55' 53"

The issued mining licence requires that¹⁹:

- The holder shall observe any requirements, limitations or prohibitions on the operation as may be in the interest of environmental protection imposed by the Minister;
- An Environmental Impact Assessment must be prepared and provided to MET for approval, and
- The holder of the mining licence shall enter into an Environmental Contract with MET.

In addition to the Mining Licence Area (ML 170) of 2233 km² the Company also holds six Exploration Prospecting Licences (EPLs) (Table 3.4) over 4810 km² with identified phosphate mineralization (Figure 3.10). Exploration activities are current and ongoing within these EPLs, as is the case in the Mining Licence Area where resource development continues.

¹⁸ Appendix 2b: Copy of the mining licence.

¹⁹ From the Notice to Grant the Mining licence. (Titled "Notice to applicant of preparedness to grant application for a mining licence No 170 – 08 July 2011")

Table 3.4: Exploration Prospecting Licences held by NMP.

EPL	Area (km ²)	EPL	Area (km ²)
3323	560	3415	250
4009	1000	4010	1000
4021	1000	4059	1000

3.7 CHARACTERISTICS OF THE DEPOSIT

These phosphate deposits are characterized by their spatial continuity (especially in a SSW - NNE direction) and general uniformity in grade. The variations in thickness are generally the product of thicker accumulation of sediment in very shallow palaeo-topographic depressions in the underlying clay surface, which is locally burrowed, with these burrows being filled with phosphate rich sediment. The phosphate is thought to be the product of syngenic chemical precipitation and early diagenetic concretionary growth within the unconsolidated sediment. With the various changes in sea level since the Miocene the original deposits have been winnowed (removal of fines) and redistributed.

3.7.1 Stratigraphy

The stratigraphy throughout the project area has been ascertained from gravity cores (with a restricted maximum penetration potential of up to ~ 3 m) and older (Gencor) vibrocores (with a penetration of up to 6 m). The phosphatic horizon, which overlies a grey-green footwall clay of Miocene age, is subdivided into two distinct layers; an upper (layer 1) 0.1 to 1.0 m thick Miocene shelly phosphorite demonstrating a downward fining sequence and a lower (layer 2) 0.05 to > 2.0 m Miocene thick clayey phosphorite. Alternating phosphate and clay layers below layer 2 are known from the Gencor cores. The extent and significance of these deeper deposits is the intended subject of further exploration.

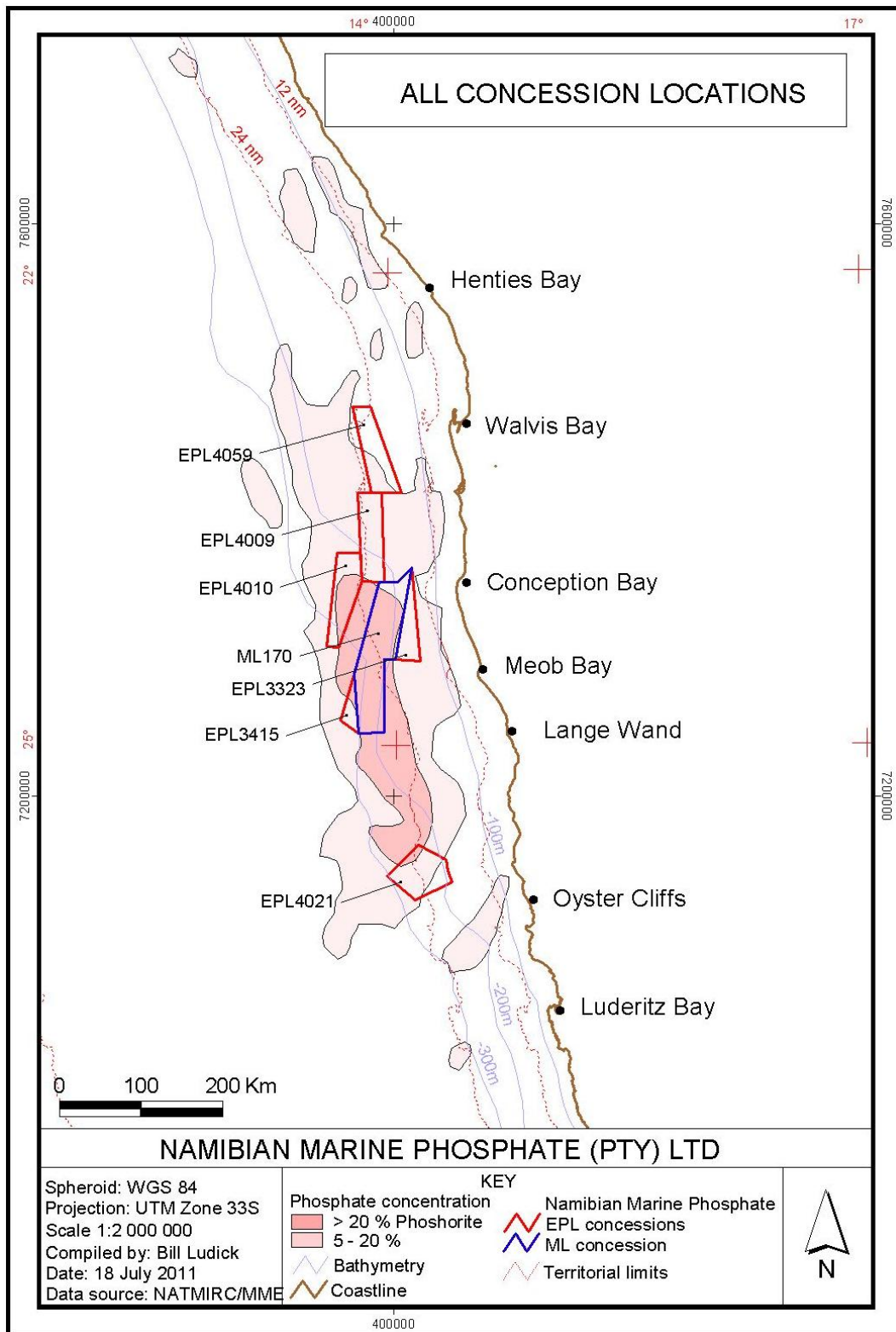


Figure 3.10: Mining and exploration licence areas held by NMP.

Phosphorite Horizon:

Layer 1: An upper 0.1 to 1.0 m thick shelly phosphorite identified as Miocene in age and demonstrating a downward fining sequence. This consists of a coarse broken shell bed that contains delicate off-white to brown bivalves and occasional *Turritella* shells supported in a very dark brown (blackish) matrix of phosphorite pellets (fine sand sized particles) and dark green organic mud. Shell fragments become smaller and the phosphorite pellet component and clay increase with depth until the horizon becomes mostly a fine phosphorite sand with a small clay content. This horizon passes gradationally into layer 2.

Layer 2: A lower 0.05 to > 2.0 m thick clayey phosphorite identified as Miocene in age. This consists of a very dark brown (blackish), soft, sticky, clayey, fine phosphorite sand, which usually becomes more clayey with depth (there are exceptions where the clay content can decrease with depth). The phosphorite content is usually highest in this part of the sequence although in some areas clay predominates. Commonly brown porous bone fragments (often vertebrae) appear towards, or at the, base of the horizon.

Clay Horizon (footwall)

The phosphorite horizon has a sharp bioturbated contact with an underlying Miocene marine footwall clay which gravity coring has penetrated to a maximum of 2m. This contact represents a sedimentary hiatus. This zone is a pale grey to dark olive green-grey, firm, sticky clay with coarse burrows in the top 15 cm filled with sediment from the layer above.

Typical sedimentary sequence of the deposit is shown (Figure 3.11 and Figure 3.12), with core 1877 showing both layers 1 and 2 of the deposit and core 1939, showing only Layer 1.

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NAMIBIAN MARINE PHOSPHATE (PTY) LTD	
Registration No. 2009/0916	
SEABED CORE LOG	
EPI: 3414	SAMPLE NO: 1877
PROJECT: PHOSPHATE	DATE: 19 th MARCH 2011
EASTING: 390893	SAMPLE TYPE: GRAVITY CORE
NORTHING: 7307891	WATER DEPTH: 253
LATITUDE: 24° 20.301' S	CORE LENGTH: 2.76
LONGITUDE: 13° 55.470' E	CORE DIAMETER: 3"
GEO SIGNATURE: <i>TWK 12</i>	PENETRATION: 2.76
Depth (m)	Description
0.0 to 0.35m	- Downward fining sequence Coarse to fine shell, delicate off-white to brown bivalve fragments, supported in a dark brown matrix of phosphite pellets (fine sand sized particles) and dark green organic mud.
0.5	
0.35 to 1.00m	- Very dark brown (brownish black), shell fragments become smaller. Phosphite pellets and clay increase with depth as shell component declines.
1.0	
1.00m	- Brief gradational contact
	Very dark brownish black clay with fine phosphite sand, soft, loamy, clay increases with depth, becoming clayey.
1.5	
2.0	
2.5	
2.70m	- Brief gradational contact
	Light grey clay, firm, sticky.
3.0	End 2.76 m



Core log No. 1877	0 to 0.65 m	0.45 to 1.14 m
-------------------	-------------	----------------



0.97 to 1.62 m	1.41 to 2.05 m	1.89 to 2.56 m	2.10 to 2.76 m
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Figure 3.11: Sediment core log (1877) & photograph: Collected from the north-eastern area of Sandpiper-2.

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The photograph and core log (sample 1877) collected from 235 m water depth (directly west of Sandpiper-1), shows layer-1, which is a shell rich phosphate rich mud 0.35 m thick, with approximately 60 % phosphate, 20 % shell and 20 % mud. Layer-1 continues to 1.0 m, it shows decreasing abundance of shell fragments with depth. Layer-2, is typically 80 % phosphate and 20 % mud (shell is absent in this layer throughout the deposit) is well represented in this core, (1.0 to 2.70 m). Layer-2 of the deposit sits on a footwall of bioturbated clay. These burrows are typically filled with phosphate rich mud.

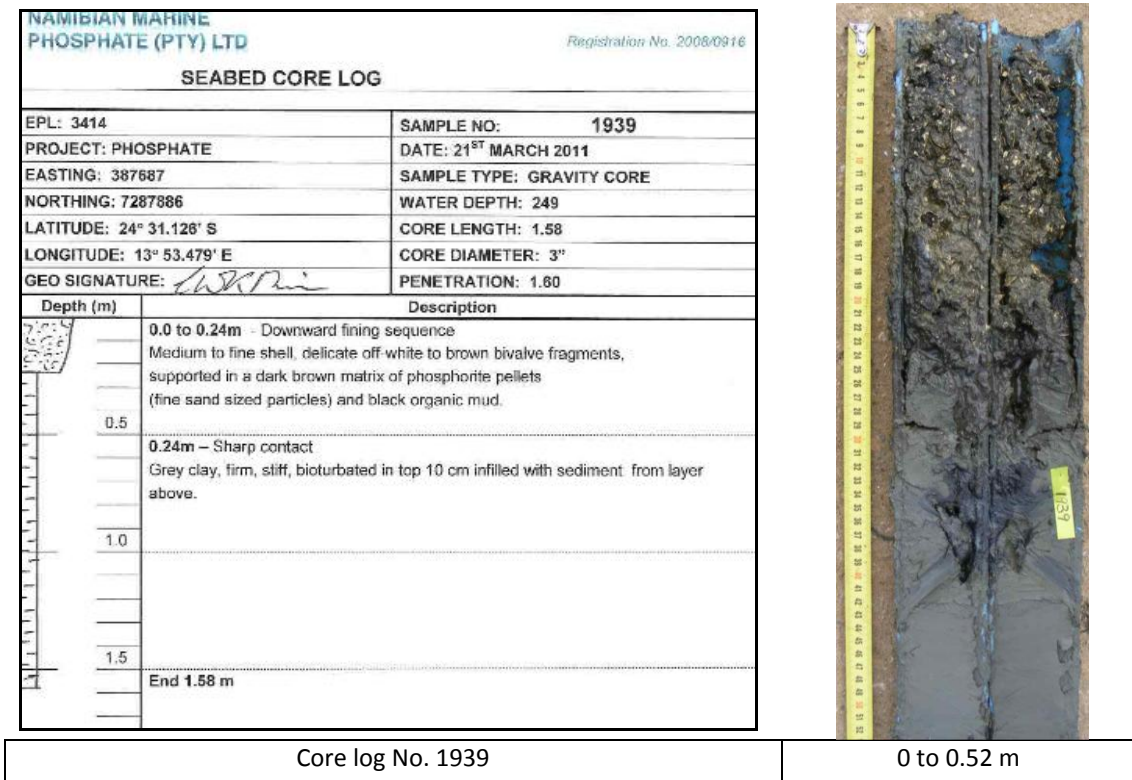


Figure 3.12: Sediment core log (1939) & photograph: Collected from the southern area of Sandpiper-2.

The photograph and core log (sample 1939) collected from 249 m water depth, (directly west of Sandpiper-1), shows layer-1, which is a shell rich phosphate rich mud 0.24 m thick, with approximately 60 % phosphate, 20 % shell and 20 % mud. The upper layer (layer-1 of the deposit) sits on a footwall of bioturbated clay. The phosphate rich, layer-2 is not present at this location.

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3.7.2 Nature of the Phosphate Material

The phosphatic material within the sediment predominantly comprises unconsolidated fine sand sized phosphorite ooliths and pellets, falling in the 100 to 500 micron grain size range (mostly 150 to 250 microns). These pellets are formed of concentric phosphate layers and predominantly comprise calcium carbonate and phosphate (P_2O_5). They can also contain quartz grains, ilmenite and sulphides.

The phosphorite pellets form a matrix with organic rich mud and supports a downward fining and declining bed of coarse to fine shell fragments (bivalves and foraminifera) in the winnowed upper part of the deposit. The lower part of the deposit is shell free and clay rich in the matrix.

Grades for individual samples rarely exceed 23% P_2O_5 and the majority lie between 17 and 21% P_2O_5 . Average layer grades are typically 19 - 20% P_2O_5 for the lower layer (2) and 18 -19% for the upper layer (1).

3.7.3 Mineralogy and Geochemistry²⁰

The mineralogy of the phosphate material has been studied using both X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) techniques (Figure 3.13 and Figure 3.14) and can be summarized for layers 1 and 2 below and is based on identifying the peaks of each mineral in the scan. Each peak on the XRD scan is labelled with a letter signifying the mineral it represents. Each mineral has multiple peaks and some overlap in which case the peak is attributed to two minerals.

The minerals are Francolite (F), Calcite (C), Aragonite (A), Quartz (Q), Mica (M) and Kaolinite (K). Francolite is also referred to as carbonate fluorapatite and is an apatite containing carbonate and fluoride. Mica refers to all 10\AA (Angstrom) minerals and includes illite and muscovite. The relative intensity of the peaks is used to estimate the relative abundance of the minerals present in each sample, but refer to comments below on quantifying the amount of each mineral present.

²⁰ The comparative mineralogy of phosphatic sediments from three resources area in EPLs 3323, 3414 and 3415. Associate Professor John Compton, University of Cape Town 2010.

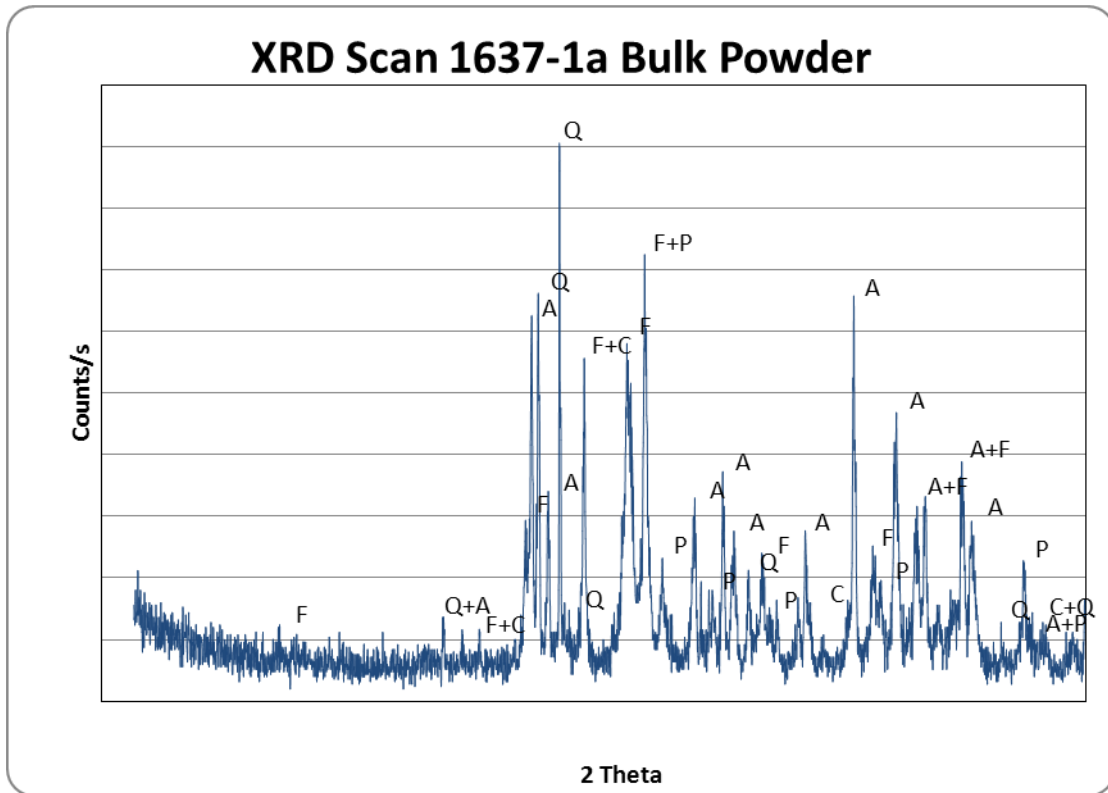


Figure 3.13: XRD scan of layer 1 bulk powder sample.

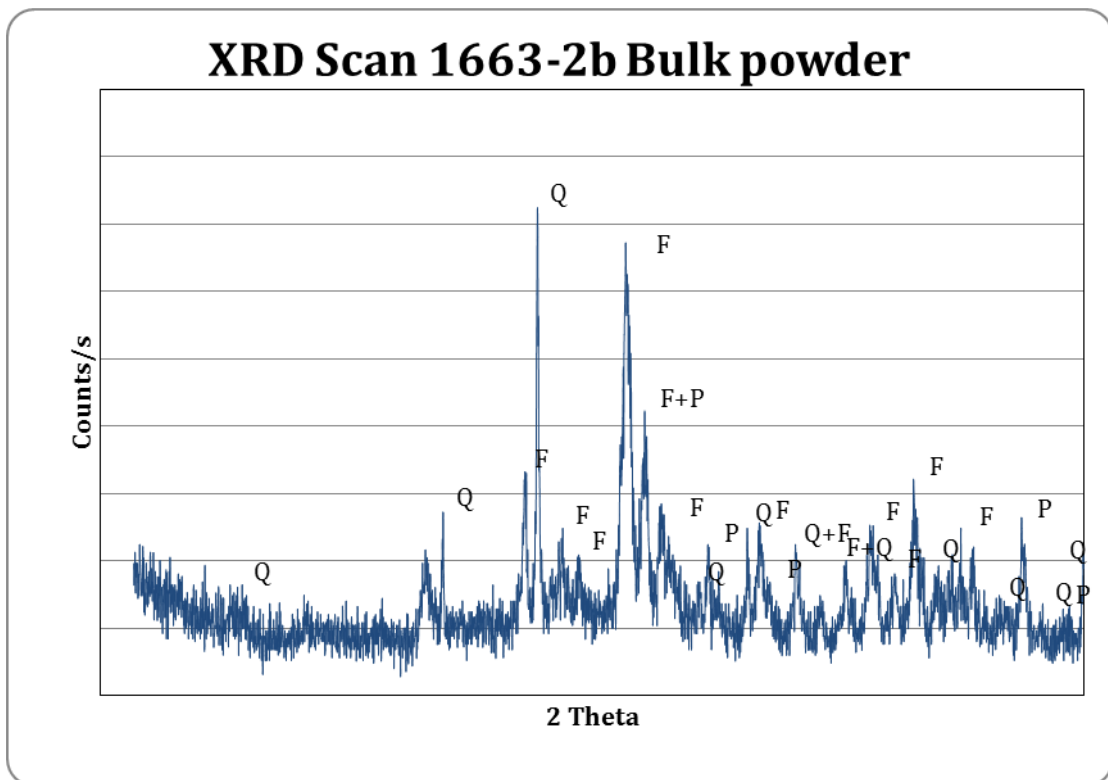


Figure 3.14: XRD scan of layer 2 bulk powder sample.

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The eight samples can be subdivided into two groups based on their mineralogy:

Group 1 consists of samples 1385-7, 1552-2b, 1640-2b, 1663-2b (Layer 2 samples) which all contain the minerals francolite (carbonate fluorapatite) (abundant), quartz (minor) and mica (very minor).

The relative abundance of these minerals is similar for all three of these samples.

A1	Sample 1385-7:	Francolite > Quartz > Mica
A2	Sample 1552-2b:	Francolite > Quartz > Mica
A3	Sample 1640-2b:	Francolite > Quartz > Mica > Kaolinite
A3	Sample 1663-2b ²¹ :	Francolite >> Quartz = Pyrite = Mica (Illite) = Kaolinite
A3	Sample 1663-2b ²² :	Mica (Illite) > Kaolinite > Quartz = Pyrite

Group 2 consists of samples 1376-4, 1553-1b, 1650-1a, 1637-1a (Layer 1 samples) which all contain the minerals francolite (abundant), calcite (abundant), aragonite (abundant), quartz (minor) and mica (very minor). Aragonite and calcite are most abundant (relative to carbonate fluorapatite) in sample 1650-1a and least abundant in sample 1553-1b. Otherwise, all three samples have a similar mineralogy.

A1	Sample 1376-4:	Francolite > Aragonite = Calcite >> Quartz > Mica
A2	Sample 1553-1b:	Francolite > Calcite > Quartz > Aragonite > Mica
A3	Sample 1650-1a:	Calcite > Francolite = Aragonite > Quartz > Mica
A3	Sample 1637-1a ²³ :	Francolite = Aragonite > Calcite > Quartz = Pyrite > Mica (Illite)
A3	Sample 1637-1a ²⁴ :	Mica (Illite) > Kaolinite > Quartz = Pyrite

The Group 1 samples are non-carbonate and tend to have more terrigenous minerals such as quartz and mica in comparison to the carbonate rich samples of Group 2. The XRD scans support the presence of clay minerals with a 10 Å mica or illite peak in most samples and a possible 7 Å kaolinite peak in sample 1640-2b.

Francolite (carbonate fluorapatite) is the principal mineral present and the amount can be estimated by combining the XRD profiles with any available elemental (XRF) data. The ideal formula for francolite is $Ca_5(PO_4, CO_3)_3(OH,F)$ with the amount of carbonate (CO_3) substitution for phosphate (PO_4) generally between 3-6 Mol% and the amount of fluoride (F) generally greater than 1wt%. The corresponding approximate element composition for 100% francolite would then be 55% CaO, 40% P_2O_5 and 5 % volatiles (LOI or lost on ignition and including OH, F and CO_2). Calcite and aragonite are polymorphs of calcium carbonate ($CaCO_3$) and they can be quantified from the CaO remaining after the amount of CaO has been attributed to the amount of P_2O_5 in the sample. Clay mineral abundance could be estimated from the aluminium oxide content (Al_2O_3). Table 3.5 provides detail of the XRF geochemistry.

²¹ Bulk black powder

²² Clay size fraction

²³ Bulk black powder

²⁴ Clay size fraction

Table 3.5: XRF Geochemistry of the samples.

Resource Area	Sample #	% Fe ₂ O ₃	% MnO	% Cr ₂ O ₃	% TiO ₂	% CaO	% K ₂ O	% P ₂ O ₅	% SiO ₂	% Al ₂ O ₃	% MgO	% Na ₂ O	% LOI	Total
A1 Layer 1	1376-4	3.16	0.02	0.36	0.11	42.75	0.16	19.52	7.24	2.56	0.65	2.54	15.38	94.45
A1 Layer 1	1650 1A	2.30	<0.02	0.10	0.08	43.76	<0.02	18.00	6.89	2.19	1.80	2.77	19.05	96.88
A2 Layer 1	1553 1B	4.16	0.02	0.34	0.15	41.11	0.46	23.77	10.13	2.14	2.07	2.90	6.98	94.22
A3 Layer 1	1637 1A	3.82	0.02	0.34	0.14	39.96	0.15	17.72	11.68	2.19	1.15	<0.02	12.31	89.49
A1 Layer 2	1385-7	4.20	0.01	0.16	0.27	33.59	1.43	20.54	14.37	5.87	2.04	2.76	9.76	94.99
A1 Layer 2	1640 2B	3.73	<0.02	<0.02	0.30	31.73	0.98	20.26	14.85	4.85	1.64	3.62	12.11	94.08
A2 Layer 2	1552 2B	4.17	0.03	0.40	0.27	35.51	1.07	23.15	15.73	5.26	2.28	2.01	5.88	95.76
A3 Layer 2	1663 2B	4.86	0.03	0.39	0.32	31.34	1.48	20.24	19.37	6.73	3.13	2.93	5.70	96.52

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The modal mineralogy of these bulk powders obtained by integrating the XRD mineralogy with the XRF elemental analyses indicates that they consist of between 51 to 70 wt% francolite (17.7 - 23.8 wt % P₂O₅), 3.8 - 8.6 wt % quartz, 1 - 24 wt % calcite, 0 - 16.5 wt % aragonite, 0.3 - 19 wt % illite (mica), 0 - 6 wt % chlorite/smectite, 0 - 5 wt % kaolinite, 0 - 4.5 wt % halite, 1.5 - 5.8 wt % pyrite, 0.2 - 0.74 wt % Cr-Mn-Ti oxides, and 0 - 6.3 wt % organic matter. The clay size fraction XRD analysis of preferred orientated slides helps to resolve the clay mineralogy but the profiles are not well defined.

Phosphate rock (PR) contains various metals and radionuclides as minor constituents in the ore. Among these elements are various metals which are more commonly referred to as "heavy metals," which include: Cadmium, Arsenic, Lead, Mercury, Chromium, Vanadium, Selenium and two radioactive elements Uranium and Thorium.

Table 3.6 indicates typical heavy metal and radionuclides values for average shale, sedimentary phosphates and compares these with those of the Sandpiper deposit. Sandpiper values of As, Cd and U are within the normal range of other sedimentary phosphate deposits.

Table 3.6: Metal and radionuclide trace element abundances in sedimentary phosphate rock, and average shales. (Kauwengberg 2009)

Element	Average Shale	Sedimentary Average Phosphate Rock	Range	Sandpiper Range	Sandpiper Average ²⁵
As	6.6	13.2	3 – 79	54 - 96	70.8
Cd	0.3	20.6	1 – 150	12 - 29	20.4
U	3.7	120	10 - 390	107	107

The heavy metals and radionuclides found in the marine phosphate are in an insoluble none available form due to among other things the "common ion/ ionic concentration / inherent low solubility equilibriums " effects²⁶.

The presence of these elements in the NMP materials after millions of years under water is a major proof of their lack of solubility and therefore access into biological or aqueous systems.

²⁵ Bateman Advanced Technologies Ltd

²⁶ John Sinden. Consultoria e Assessoria. Rua Ministro Xavier de Toledo, 143 - Campo Grande – Santos / SP - CEP 11070-300

3.8 ONGOING RESOURCE DEVELOPMENT AND ENVIRONMENTAL SAMPLING

Within the Mining Licence Area ML170, there is the need to continue with resource development and characterisation, this primarily relates to the:

- Thickness determination of layers 1 and 2;
- Identification of phosphate layers beyond 3 m;
- Determination of phosphate grade;
- Ground characteristics, relating to sediment cohesiveness, and
- The collection of environmental samples.

These development samples will be collected from relatively small vessels, ranging from converted fishing vessels (20 m length) to dedicated supply / service vessels of 50 m or more in length. The particular vessel used will depend on the type and duration of sampling to be conducted. The suite of sampling options includes, but is not necessarily limited to:

- Van veen grab of 0.2 m² for the collection of benthic fauna and sediment characterization;
- Gravity cores – recovering between 0.5 and 3.5 m core samples (65 cm diameter);
- Vibro cores – recovering up to 6 m core samples (~ 65 cm diameter), and
- Clamshell grab - capable of taking a 2.5 tonne sediment bite.

In each case, dependent on the particular objectives of the sampling programme, a number of samples will be collected. The largest by volume would be samples collected by the clamshell grab, where up to 300 tonnes may be collected from a 'bulk sample' campaign. Typically these samples are collected for supply to test process plants where a particular market needs to evaluate specifically the characteristics of the phosphate behaviour in downstream beneficiation processes. It is envisaged that bulk sampling would be undertaken infrequently.

The type and volume of samples collected from within the Mine Licence Area which was formerly all of EPL 3414 and portions of EPLs 3415 and 3323 are presented in Table 3.7.

Table 3.7: Summary of samples recovered.

Licence	Grab Samples	Core samples	Bulk Samples	Vibro cores	Enviro samples
EPL 3323	239 x 5kg	-	-	-	-
ML 170	1 x 400kg 1 x 100kg 1 x 700kg	343 x 6kg, 489 x 12kg	2 x 1 Tonne	13 x 32kg	95 x 4kg
EPL 3415	1 x 100kg	116 x 6kg	-	18 x 32kg	5 x 4kg

3.9 THE DREDGING SYSTEM

TSHD technology is currently determined as the optimal method by which the deposit can be developed (Figure 3.15).

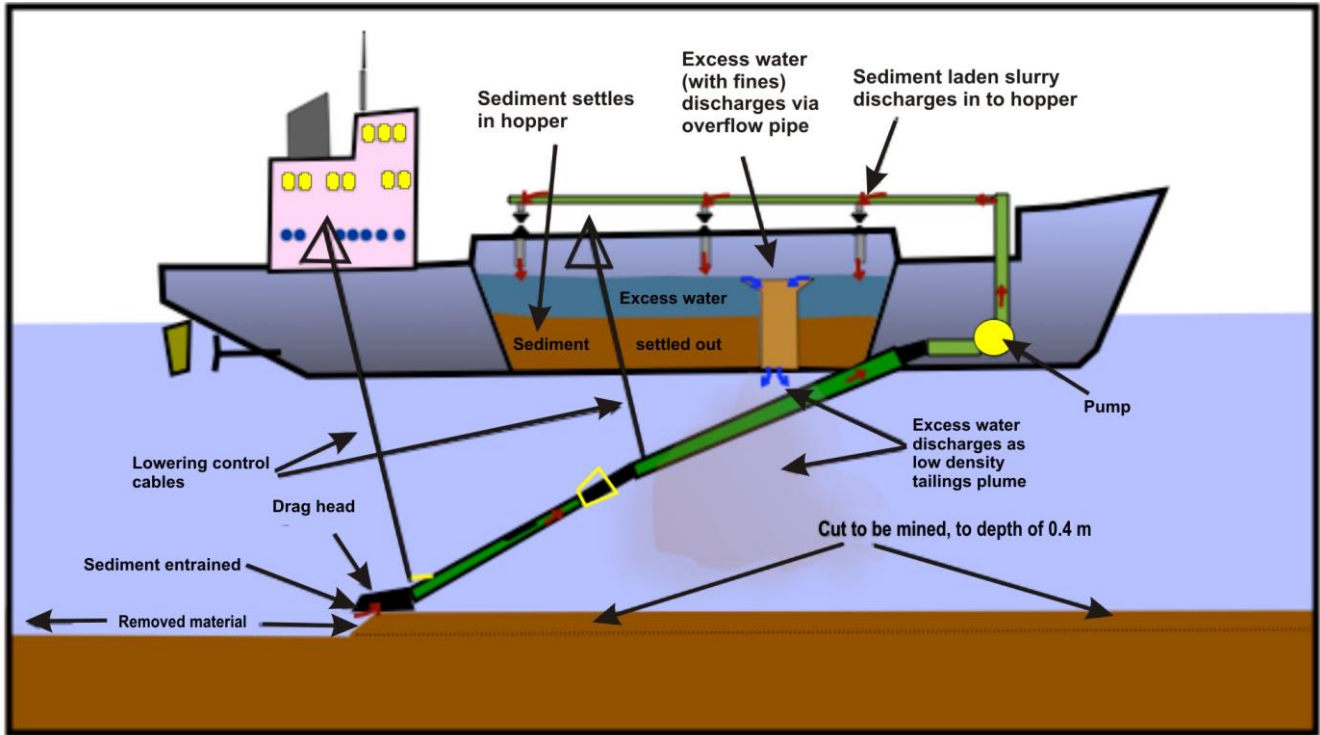


Figure 3.15: A schematic of a TSHD.

A TSHD is a large self-propelled vessel with:

- Retractable dredge arms (usually two, but in this instance only one), which 'trail' on the sea floor behind the vessel;
- Large pumps which generate a suction force, via which the dredge head entrains the sediments with seawater;
- A suction 'dredge' head, designed to extract (typically 'cut and jet') the target sediments;
- An integrated large cargo hold, ("hopper") in to which the dredged sediments are held temporarily, and
- Secondary pumps are used to transfer (pump) the sediment from the vessel to the shore.

The Belgian company, Jan De Nul, has been currently identified as a preferred supplier of services being a major international dredging company with the optimal experience, capacity and resources to recover the marine phosphate-rich sediments.

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Dredging of these marine sediments will be conducted from a large TSDH dredge vessel, such as but not limited to, the MV *Cristobal Colon*²⁷. Such a vessel (in this case the *Cristobal Colon*) has the following characteristics as built:

- Built in 2009;
- Accommodation for 46 persons;
- 223 m length;
- 41 m beam;
- Draught loaded 15.15 m;
- A dredging depth of 155 m;
- Dredge head of 11m width;
- 46,000 m³ hopper capacity;
- A dredging speed of 1 to 2 knots;
- A maximum sailing speed of 18 knots;
- The vessel has total bunker capacity of 6,740 m³;
- Under normal operational conditions the vessel can remain at sea for approximately three weeks without requirement for additional bunkers or victualling.
- Hopper capacity:
 - Effective 37,750 m³ hopper capacity, (equates to 64,175 tonnes of phosphate enriched sediments²⁸). The actual capacity of the hopper is 46,000 m³ but 8,250 m³ of sediments are retained to optimize vessel stability;
- Lean water overboard:
 - Excess water containing fine overflow material is discharged from the hopper between 10 and 15 m below the sea surface, depending on total vessel load. [NOTE: the discharge takes place through the bottom of the ship, i.e. there are no over the side discharges on to the sea surface.
 - Between 10 and 20 % of the dredged fine material (this being a portion of the < 100 micron size fraction) will be discharged with the 'lean water overboard.'

Recovery of marine phosphates from the water depths of the Mining Licence Area, with water depths of greater than 190 m, has required that aspects of the recovery system be modified. These key modifications are, the length of the trailing arm and the size of the dredge head:

- Dredging depth:
 - The dredging depth has been extended to 225 m and a design to enable dredging in 275 m water depth is being developed. These depth extensions (originally 155m) are to allow recovery of sediments of the Sandpiper deposit, i.e. Sandpiper-1 (190 to 235 m) and Sandpiper-2 & 3 (up to 275 m) target mine areas of the mineral resource within the Mining Licence Area;
- Dredge head:

²⁷ At some time in the future economics may well require that an alternate dredging vessel is used.

²⁸ The specific gravity of phosphate enriched marine sediments of this deposit is 1.7.

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- The dredge head will be designed to optimise material recovery and to minimize the total weight of the extension dredge arm (The dredge head is currently configured to a 3 m width); and
- The individual dredge lane depths are in the order of 0.5 m.

The operations of the dredger are supported by a tender vessel, the services of which include:

- Assistance with connection to, and disengagement from the transfer pipeline buoy, and
- Supplies, including equipment, food, materials and personnel.

Dredging control

Dredging control for the vessel is typically maintained by means of the following systems and equipment:

- A positioning system;
- A dredging computer;
- A suction tube position monitoring system (STPM), and
- A dynamic tracking computer.

Positioning system

Dredging control is based upon a vessel positioning system. The Z or vertical co-ordinate of the ship is obtained from swell and tidal data from a prediction model based on historical data. The positioning computer determines the actual ship and draghead position as co-ordinates and presents the results, relative to the area to be dredged, on navigational displays. These position results are derived by calculation from the X, Y, Z inputs from the STPM system as described below and the ship's bearing provided by the gyrocompass. The positioning computer also determines the actual vertical offset of the draghead as compared to the target dredge depth. Information outputs from the computer include:

- Plots of dredged tracks;
- Position of vessel and draghead visualized on screen on a background of bathymetric data, obstacles and buoys, the display is in plan view with a differential colour chart showing the amount still to be dredged, together with a longitudinal and cross profile of the trench marking seabed level and target level, and
- Changes in X and Y co-ordinates as input to the dynamic tracking system.

Dredging control computer

The dredging control computer enables all the dredging processes such as the dredging level of the draghead, pump settings and 'lean water' to be controlled. The interface between the positioning computer and the dredging control computer enables control of the dredging process to pre-defined levels of input to the system from pre-dredge survey information and pipe profile design requirements.

Suction tube position monitoring system (STPM)

The STPM is a system comprising a system of pressure and angle transducers, which allows the determination of the draghead position relative to the ship. This makes relative X, Y and Z co-ordinates of the draghead available to the positioning system and dredging computers.

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Dynamic tracking

This system can automatically control the vessel's track and therefore the draghead's horizontal position by compensating for wind and current effects on the ship. It achieves such control by automatically adjusting rudder direction, propellers and bow thrusters.

Progress monitoring

During the process of line cut dredging, the progress is monitored on board by means of the dredging control systems and the multibeam or survey results. The dredging control system allows for the actual draghead depth and the target depth at the draghead position to be compared online and the difference displayed.

Survey

The survey procedures ensure that the survey methods used comply with the specifications and that surveys are carried out in an accurate and efficient manner. The procedures cover all survey works.

Equipment

The dredger is equipped with a multibeam echo sounder. This allows online surveys without the need of a separate survey vessel within the mining area. Alternatively, should the circumstances make surveying from the dredger less favourable, a separate survey vessel can be mobilized.

3.10 THE DREDGING CYCLE

The dredging cycle is divided into four consecutive activities, these are:

1. *Dredging*: Recovery of the phosphate-rich sediments;
2. *Sailing loaded*: With a fully loaded hopper, sailing to the location of discharge;
3. *Discharging*: Transferring the load to a containment location (buffer pond) ashore, and²⁹
4. *Sailing back empty*: Returning to the Mine Licence Area, to initiate further dredging cycles.

The estimated duration of the various components of the dredge cycle based on current technical assumptions, are presented in Table 3.8.

3.11 RECOVERING PHOSPHATE ENRICHED SEDIMENTS OF THE DEPOSIT

The economic controls of the project require the *in situ* dredging of 5.5 million tonnes of phosphate-enriched sediment. After processing this generates 3.0 million tonnes of export quality rock phosphate annually.

In order to accommodate product supplies to the market place, as well as building a stockpile of exportable rock phosphate, a three-year ramp up of production (Table 3.9), is envisaged. This ramp up may be shortened due to increased demands for the final product by the world market. This will of necessity be supported by revised production campaigns (vessel at sea time) and process plant production rates.

²⁹ Land based environmental implications related to the transfer of sediments to shore are discussed in the Terrestrial EIA-EMPR.

Table 3.8: Duration (estimated) of the dredge cycle.

Activity	Estimated Duration
Lowering: The vessel is on station, and dredge arm is lowered and the dredge head engages the sea floor.	0.25 hrs
Dredging: The dredge head is engaged in the sediments. Through a series of transects in the target mine area dredge head will be engaged with the seabed in order that hopper is filled to capacity, 46,000 m ³ . (Sailing speed of 1 to 2 knots) ³⁰	16.0
Hoisting: The hopper is full, and the dredge arm is returned inboard.	0.25
Sailing: The vessel sails to the point of discharge. This duration will vary depending on sea conditions and, in particular, on the distance to be travelled. Maximum sailing speed is 18 knots.	6.0
Connecting: Connecting to the sinker line buoy, with the assistance of a support vessel.	0.5
Transfer slurry ashore: Pumping the sediment ashore.	6.2
Disconnecting: Disconnection from the sinker line buoy, with the assistance of support vessel.	0.5
Sailing: The vessel sails back to the Mining Licence Area.	6.0
Estimated duration of the average dredge cycle	35.7 hrs

Table 3.9: Envisaged three year production ramp up

Year	Sediment mined (mt) ^{31*}	Sea time (weeks)*
1	1.33	11
2	2.75	22
3	5.5	47
On going	5.5	47

³⁰ Cut depth is variable as relates to, sea surface swell and hydraulic compensation to the drag head, speed of the vessel and the specific characteristics of the sediments dredged.

³¹ These estimates are based on current technical assumptions.

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These sediments will be recovered from either or both of the Sandpiper-1 or Sandpiper-2 deposits (Figure 3.5 to Figure 3.8). Phosphate sediment recovery will initially take place within the Sandpiper-1 deposit. The sediments here are located between 190 and 225 m water depth. Sediment recovery will subsequently take place within the Sandpiper-2 and 3 deposits, within water depths of up to 275 m. The actual timing of this is dependent on the successful design and testing of a deepwater extension dredge arm. Other factors may also influence the decision to recovery phosphate sediments from Sandpiper-2 and 3, these include the phosphate market, grade variability of the phosphate in the sediments (Layer 1 vrs Layer 2), volumes of shell which are associated with Layer 1 and a variety of environmental factors.

The vessel will recover sediments from individual continuous lanes within the target mine area initially from within the Sandpiper-1, subsequently Sandpiper-2 and Sandpiper-3 deposits. The length of each lane (cut) is 4 km. This lane length may vary orientation as determined from geotechnical feedback information obtained during the dredging process and or as established from ongoing resource development exploration. Dredging will predominantly take place in a north – south (or south – north) direction i.e. aligned with the predominant swell and wind direction.

Each particular target mine area has a mine plan, wherein individual blocks are identified to provide a resource for the year of mining. Initially during year 1, the block will be 200 m x 4 km, year 2, 400m x 4 km, and in year 3, which represents full production the active mine block is 600 m x 4 km. In the initial 4km cut, the dredger will steam at 1 knot, which results in the seabed engaged dredge head cutting to a depth of 0.75 m. In order to fill one hopper (vessel) load, 4 parallel adjacent, or near adjacent cuts within the mine area are dredged, the vessel will cover approximately 4 km during this period. Subsequent cuts, within the same lane will be made, so that the full vertical extent of the deposit can be extracted. By varying the speed of the vessel, the depth of cut, can be increased (shallower cut) or decreased (deeper cut, to a maximum of 0.75 m).

The vessel will continue to dredge vertically within the particular lane to a point just above the footwall clays. Depending on the particular location within the deposits, these footwall clays may be located at depths from 1 m to 3 m or more below the original seabed level. The intention is not to cut (dredge) into the footwall clay, but to rather leave a residual thickness of marine sediments over the footwall. This thickness will vary, but is envisaged to be between 10 and 15 % of the original volume of target sediment layer(s). This will remain in situ on completion of recovery. The depth of recovery during dredging will be managed through positional software integrated with the hydraulic winch systems that control the position of the dredge arm and the location drag head. This residual sediment remaining above the footwall clay will be present as an uneven ‘hummocked’ surface.

Recovery of phosphate enriched sediments from depths greater than 275 m is not described in this report but is expected to be an equivalent to the operations as described for the shallower recovery depths.

3.12 EXCLUSION ZONE AROUND THE TARGET DREDGING AREA

In order to ensure the safety of operations, an operational safety exclusion 'no go' zone will be declared over the active target mining area³². In the case of SP-1 and SP-2 this is a 23 x 9 km rectangular area, each totalling 207 km². Note: the target area of SP-1 and SP-2 is a 22 x 8 km block, the safety exclusion zone is larger to accommodate for vessel turning. Only one of the dredge target exclusion areas will be declared at any one time³³. This is a restricted area from which the sediments are recovered³⁴. The restricted area applies only to fishing activities, and not to general vessel traffic. Fish stock assessment and research surveys are not intended to be restricted by the enforcement of this exclusion zone, standard rights of passage under international maritime convention will apply under these conditions³⁵.

These exclusion zones will be established with the authorities and advised to all shipping through notices to mariners.

3.13 THE SCALE OF THE DREDGING AREA

The scale of the dredge area is primarily controlled by the annual export/sales requirement of 3 million tonnes of 'rock phosphate'. In order to generate the required export volume, 5.5 million tonnes of marine sediments needs to be recovered on an annual basis. This is based on the average tonne of marine sediment containing 60% ore grade phosphate.

The actual area that needs to be dredged in a year to meet the export target of 3 million tonnes of rock phosphate depends on the thickness of the deposit³⁶. The thickness of the deposit (Layers 1 and 2 combined) varies from 0.5 m, to 2.25 m. From currently available information the resource average thickness is:

- 1.69 m for the Sandpiper-1 deposit, which at full production results in area of 2.44 km² being dredged annually, and
- 1.7 m for the Sandpiper-2 deposit, which at full production results in area of 2.42 km² being dredged annually.
- The envisaged maximum annual area dredge for the deposit is thus up to 3 km² based on a minimum recovered deposit thickness of one meter.

The tables below (Tables 3.10 and 3.11) provide further detail on the annual areas to be dredged for various thicknesses of the deposit (yellow – deposit average thickness, blue – deposit maximum thickness). The information is presented for ramp³⁷ up production of year 1 and 2, and also for year 3, which relates to full-scale production.

³² The areas of exclusion will be reviewed with fisheris so as to minimise the the potential loss of access to fishing grounds.

³³ Revisions to these exclusion zones may infrequently need to be made in order to accommodate operational and geotechnical variations. The respective parties will be consulted should this be necessary.

³⁴ The total Mining Licence Area is 2233 km², the area of exclusion of target mining area SP-1 is 207 km², and hence, restricted access covers approximately 9 % of the Mining Licence Area.

³⁵ Notification is required of the intention to conduct such surveys 14 days before the planned survey.

³⁶ Production deposit thicknesses will differ to some degree from that determined from exploration activities.

³⁷ Only presented for Sandpiper-1 target mine area, as this is the location where dredging is expected to start.

Table 3.10: Estimated annual resource extraction area of the Sandpiper-1 deposit³⁸.

Sandpiper-1 deposit

Ramp up year 1

Mt	Density	Million m ³	Thickness m	Area km ²
1.33	1.7	0.8	1.1	0.7
1.33	1.7	0.8	1.85	0.4

Ramp up year 2

Mt	Density	Million m ³	Thickness m	Area km ²
2.5	1.7	1.5	1.1	1.3
2.5	1.7	1.5	1.85	0.8

Full Production

Mt	Density	Million m ³	Thickness m	Area km ²
5.5	1.7	3.2	1.1	2.9
5.5	1.7	3.2	1.85	1.7

Table 3.11: Estimated annual extraction area of the Sandpiper-2 deposit.

Sandpiper-2 deposit

Full Production

Mt	Density	Million m ³	Thickness m	Area km ²
5.5	1.7	3.2	1.7	1.9
5.5	1.7	3.2	2.25	1.4

The thickness indicated is from exploration work conducted in the Mining Licence Area. There will be some variance in final dredged depths related to recovery accuracy and the thickness of the residual layer left draping the footwall.

The footprint of the impact of dredging will be larger than the actual extraction area. The impact footprint relates to the tailings plume (lean water overboard discharge) is evaluated in the specialist reports, which are presented in the appendices. (Appendix 1b)

³⁸ A variation of deposit density would change the final area needed to be dredged in order to recover the 5.5 Mt required annually.

3.14 DISCHARGING THE SLURRY TO SHORE

During slurry discharge operations, the vessel remains well behind the surf zone in water depths of greater than 18 m, this being between 0.6 and 1.2 km offshore. The vessel connects with the flexible end of a pipeline that extends from the shore³⁹.

The discharge pipeline consists of a marine and a land portion. The land portion, is an extension of the marine portion and it terminates in the coastal buffer pond. The marine portion is constructed by welding a series of steel sections, and is approximately 0.6 to 1.2 km long. The end of the steel section is connected to a flexible pipe, of approximately 100 to 200 m in length.⁴⁰ The steel section of the pipeline is at various points anchored to the seabed. When it is not connected to the dredger, the flexible section is either floating (positive buoyancy) or remains on the seabed (negative buoyancy), from where it can be recovered and coupled to the dredgers discharge connection. The discharge line is marked at the surface with one or more illuminated locator buoys.

The coupling and decoupling process:

- The flexible section of the discharge line is either floating or submerged, lying on the seabed.
- The coupling at the end of the flexible section is connected to a hauling wire whose other end is connected to a locator buoy.
- The coupling of the dredger with the riser section of the sinker line pipe is facilitated by a support vessel;
- When the dredger approaches the discharge line, weather conditions may require her to deploy the stern anchor as a safety measure. In normal conditions, the position is held by the propellers, bow and stern thrusters;
- The support vessel assists by handing over a rope connected to the hauling wire and the surface indicator buoy to the dredger;
- The dredger recovers the rope using a winch, followed by the connector chains of the coupling unit;
- The coupling unit is drawn into the connector of the vessel and secured with a hydraulic clamp;
- The support boat may leave for port to perform transfer of personnel or materials to the dredging vessel or remain on standby at site.
- Seawater pumping is initiated to draw the air out of the discharge line, subsequently the slurry is discharged. Discharge takes between 4 and 6 hours;
- On completion of the slurry discharge, seawater is pumped in order to flush any residual phosphate slurry from the pipeline into the buffer pond. The duration and volume depends on the length of the discharge line. This prevents backwash into the sea from the pipeline;

³⁹ The area, location and end point of the pipeline and its route will be surveyed, so as to verify seabed characteristics.

⁴⁰ The construction and deployment detail of the laying of the sinker line is described in the terrestrial component of the project EIA-EMPR.

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- Subsequently the couplings are lowered to the seabed and the marker buoy is released overboard again. The dredger departs from the site, returning to the Mining Licence Area to initiate a further dredge cycle.

Operational Vessel safety considerations during the discharge process are:

- Other marine traffic in the immediate area;
- Visibility reduced by fog or rain;
- The sea state, currents and wind conditions are adverse;
- The support vessel is not available to assist in the recovery of the leader cable of the marker buoy;
- A section of the sinker line system is damaged, and
- The Master of the dredger declares the operation unsafe.

3.14.1 Exclusion Zone

In order to ensure the safety of vessels at sea it is necessary that an exclusion zone of 500 m radius is declared at the location of the locator buoy. This location will be described on navigational charts. This exclusion zone will apply to all vessels and all vessel activity, with exception of the operation to hand.

In addition a navigational hazards warning will be posted via a notice to Mariners advising of the length and location of the pipeline. The pipeline may be a hazard to the fishing industry with their nets becoming attached to the pipeline or the anchors on the seabed.

3.14.2 Pipeline Integrity

The discharge pipeline is constructed from steel pipes. The individual pipes are transported as 12m long sections and bolted or welded together. The flexible hose sections are also 12m long. The pipelines are recovered, inspected and repaired (or replaced) at the end of each dredging campaign. During operations, the wear of the pipeline sections is regularly monitored by ultrasonic measurement or visual inspection. Divers can inspect the marine section of the pipeline and or an autonomous camera deployed inside the pipeline. The wear of the pipe is more pronounced on the bottom, these sections may be rotated in order to increase the lifetime of the pipe.

3.15 SUPPORT VESSEL

The dredging operations require the assistance of a support vessel. The key functions of the support vessel are:

- Assisting with connecting the flexible pipe of the discharge line to the dredger discharge coupling. (The slurry held in the hopper of the dredger is pumped to the shore via this pipeline);
- The transfer of materials, stores and equipment;

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- The transfer of crew (including maintenance and inspection functions), visitors and officials, and
- Emergency assistance as required.

The support vessel will operate out of the Port of Walvis Bay, the vessel will be chartered by the appointed dredging contractor who will verify the full scope of required services. An ideal vessel is a 1000 hp tug, which typically has a minimum manning of two persons, who are supported by a crew of 3 or 4 persons, the actual number of crew is dependent on the particular services provided and the frequency of such. It is intended that the support vessel will be sourced locally if possible.

The vessel will primarily operate within the Harbour limits and up to 15 nm to the south of Walvis Bay between 0.6 and 1.5 km offshore, at the dredger discharge point.

The frequency of this support is expected to be once every 3 to 4 days. The support vessel will be required to sail 15 nm (30 nm round trip) to the south of Walvis Bay to assist with connecting the discharge line to the dredger. Assistance to the connection may be combined with:

- The transfer of crew may occasionally take place at sea, but is envisaged to form part of the regular three weekly port calls of the dredging vessel;
- Transfer of visitors and officials to the dredger will be performed on an “as needed” basis. These persons will access the dredge by gangway or pilot ladder depending on the weather conditions, and
- Transfer of stores and materials on an “as needed” basis, loaded by the dredge’s crane.

3.16 BUNKERING

The receipt of bunkers is a standard marine practice. This can occur, along side in the port, at anchor (within the port limits) or on the open sea. For each of these an operational procedure is adhered to which is in line with MARPOL guidelines, codes and procedures approved by the vessel Flag State, the National authority and Port Control.

Refuelling at sea in Namibian Territorial waters has become a standard practice, mainly in the bunker provision to the marine diamond mining fleet. This has been practised since the mid 1990’s. As far as it is known no spills have been reported from these operations. The supply of bunkers is restricted to a select number of service providers, who have now had significant opportunity to optimise standards and safe exchange operational practices.

Whilst bunkering at sea is a standard practice, it is not totally devoid of risk. It requires the cooperative skills and open communication between the Masters of the supply and receiving vessels. Key areas of potential risks of the operation relate to:

- Vessel approach;
- Sea state, actual and expected;
- The integrity of the pipelines / transfer systems, and

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- During the transfer, the operations and communication procedure is strictly adhered to.

These risks are managed through the respective vessel Masters, who have the final authority over all bunkering exchanges. The operating company of the dredger has extensive experience in receiving bunkers on the high sea.

The following key safety measures are of primary importance:

- The Chief Engineer of each vessel briefs his crew prior to the transfer;
- Establish good communication with supplier;
- Bunker transfer checklists need to be completed, with all items confirmed;
- No smoking allowed in the area, all hot work permits are suspended during the transfer;
- Fire fighting equipment ready;
- Maximum allowable rate and pressure during bunkering is not exceeded;
- Oil absorbent equipment ready on standby, and
- Fail safe valves at each end of the bunker line to be in place and functional (only automatic fuel dispensers are allowed, hoses with open ends are not accepted).

In the event that bunkering at sea is to take place, a request will be made to the MWTC (Department of Maritime Affairs), and the process will be conducted under the requirements as advised by the authority.

3.17 PRE MINING SURVEYS

A geophysical survey of the target mining area is conducted prior to the dredger initiating operations, this is undertaken to identify the regional sediment characteristics, as well as the identification of any hazards that may present risk to the dredging operation (in particular damage the drag head and drag arm). This survey will provide information that can be presented in two and three dimensions. The following are typical attributes that can be determined from these surveys:

- Potential hazards (type and location), including, but not limited to:
 - Hard rock outcrops;
 - Shipwrecks;
 - Pipelines, cables and anchors;
 - Shipping containers, and
 - Fishing trawling gear.
- Geological footwall quality, profile and depth;
- Surface sediment characterisation, and
- Reflective layers, which includes gas pockets.

In addition these surveys provide the opportunity to collect additional baseline environmental information.

The typical equipment that may be deployed during the pre mining surveys are:

Side scan sonar

A high frequency system, with a towed underwater fish ('towfish') which sends out short high frequency, high intensity sound bursts which are beamed from either side of the towfish in a direction perpendicular to the direction of travel. The acoustic beam is narrow in the horizontal plane yet sufficiently broad in the vertical plane to produce echoes from the seabed. These echoes, once detected by the transducers, are sent via the tow cable to the recorder that electronically processes the signals and prints them, line by line, to produce the sonar image.

Swath Bathymetry

A "swath-sounding" multibeam sonar system is one that is used to measure the depth in a line extending outwards from the sonar transducer. The system acquires data in a swath at right angles to the direction of motion of the vessel. As the vessel moves forward, these profiles sweep out a ribbon-shaped surface of depth measurement, known as a swath.

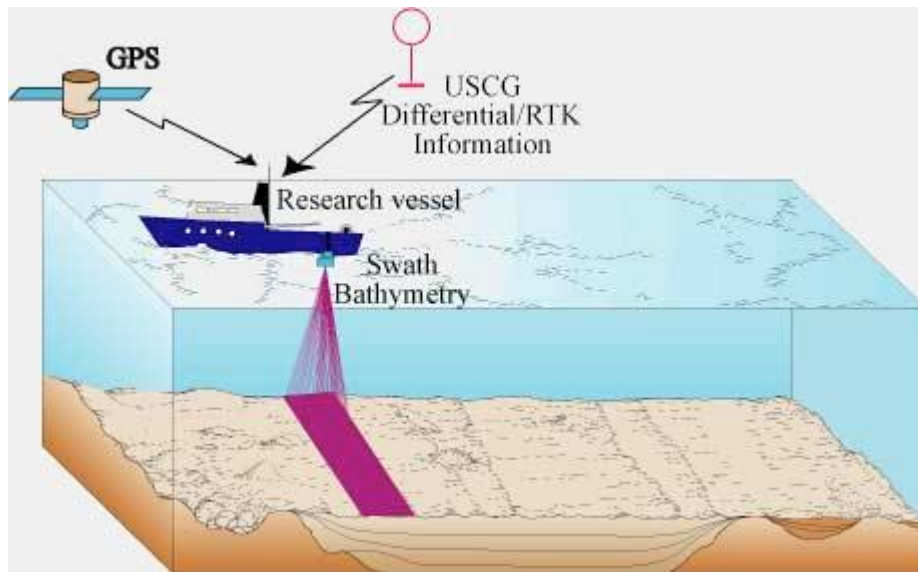


Figure 3.16: Schematic of survey operations.⁴¹

Shallow Reflection Seismic Profiling

This system provides shallow sediment penetration surveys of up to a maximum of 50 m depending on system frequency, configuration and particulars of the target horizon.

⁴¹ Image source: <http://woodshole.er.usgs.gov/operations/sfmapping/swath.htm>