

# ENVIRONMENTAL IMPACT STATEMENT

Nautilus Minerals Niugini Limited

## Solwara 1 Project

### Executive Summary

September 2008

CR 7008\_9\_v4



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# EXECUTIVE SUMMARY

## 1. Introduction

### 1.1 Solwara 1 Project Proponent

Nautilus Minerals Niugini Limited (Nautilus) is advancing a proposal to develop the Solwara 1 Project ('the Project'). The development involves the recovery of high-grade polymetallic Seafloor Massive Sulphide (SMS) deposits that are located at approximately 1,600 m water depth on the floor of the Bismarck Sea, New Ireland Province, Papua New Guinea (PNG), about 50 km north of Rabaul (Figure ES01).

The development of the Project is being designed through Nautilus, a wholly owned subsidiary of Nautilus Minerals Inc., which is a publicly listed company on the Toronto Stock Exchange and the London (AIM) Stock Exchange.

Among Nautilus' cornerstone shareholders are three of the world's largest resource companies, namely Anglo American (5.7%), Teck Cominco (7.2%), and Epion Holdings (22.4%).

Within PNG, Nautilus holds exploration licences in the Bismarck and Solomon seas, including 51 granted exploration licences covering 107,917 km<sup>2</sup> and 37 exploration licence applications covering 88,906 km<sup>2</sup>. Outside PNG, Nautilus holds granted prospecting licences in Tonga and the Solomon Islands and has applications pending in Fiji and New Zealand.

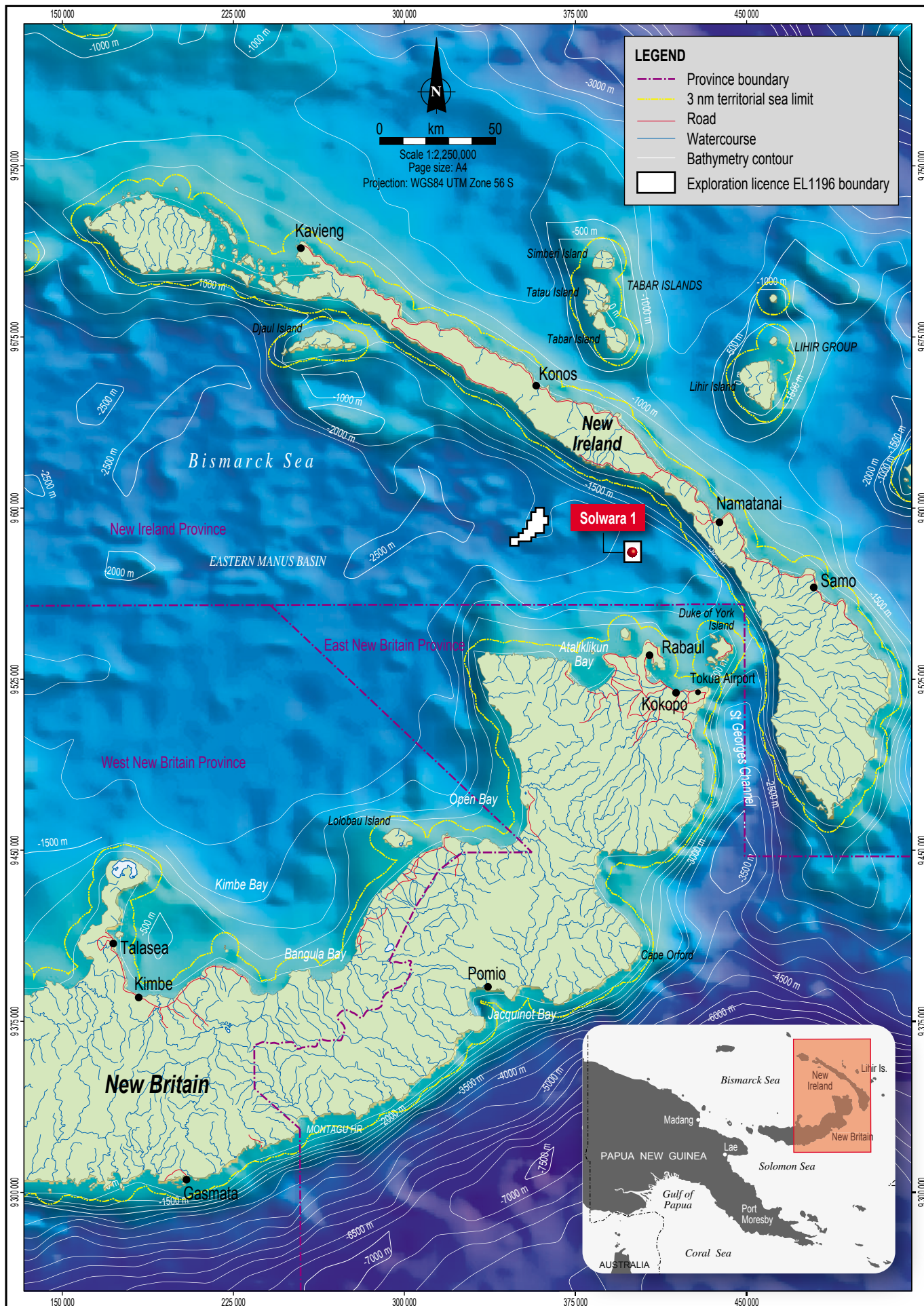
While the exploration licences typically cover large areas of ocean floor, the actual footprint or area disturbed by the SMS mining proposed at Solwara 1 and covered in this Environmental Impact Statement (EIS) is extremely small, comprising in total only 0.112 km<sup>2</sup>.

### 1.2 Objectives and Concepts of the Development

Focusing on the recovery of copper and gold, the proposed development will mine SMS deposits from the seafloor at Solwara 1 using methods that are socially acceptable, environmentally responsible, technologically achievable and economically viable. The Project will implement the PNG resource development policy in a manner consistent with current legislation and national goals.

Seafloor mining presents a potential new source of income and growth for PNG from a resource that has yet to be utilised. The Project will bring benefits in the form of royalties and improvements in the nation's balance of trade. While employment and business opportunities are not as high for Phase 1 as with other mines, potential will be generated for new industrial development that will have positive social and economic effects within PNG. It should be noted that these benefits could be maintained, not just for the nominal Project life, but for many years to come, as this new industry of seafloor mining unfolds.

Mining of the seafloor opens new concepts in technology and environmental management. The location of mineralised ores on (or immediately below) the seafloor avoids the need for pre-stripping or land clearance activities and the associated handling of large volumes of overburden that are normally involved in land-based mining. The technologies proposed for the recovery of ore and its transfer to the surface support vessel are proven in other offshore oil and gas, telecommunication and dredging industries and, upon completion, all seafloor and surface mining infrastructure can simply be relocated to other areas.



Impacts and discharges from seafloor mining will all occur on the deep seafloor without exposing coastal coral reefs or fisheries to any contaminants. Nautilus has completed extensive scientific research of the area that has shown the dynamic nature of the seafloor at Solwara 1. The geothermal energy responsible for forming the SMS deposits cannot be extinguished by mining.

Observations of venting and new chimney lattice structures starting to reform in matters of hours after disturbance, and subsequent colonisation by animals, present significant opportunities for both natural and enhanced recovery of mined areas. Being the proponent of the first seafloor mining of its kind, Nautilus has, with the assistance of the scientists involved, committed to a number of conservative mitigation measures aimed to ensure the protection of biodiversity and to demonstrate the ecological sustainability of the operation.

### 1.3 Project Overview

The SMS deposits at Solwara 1 are associated with high grade polymetallic sulphide systems and are considered modern-day analogues of terrestrial Volcanogenic Massive Sulphide (VMS) deposits, which are a major source of the world's copper, zinc, gold and silver. In particular, the Project aims to mine high-grade copper and gold deposits. The Project comprises two phases and it is proposed to develop Phase 1 in advance of Phase 2. The two Project phases can be summarised as follows:

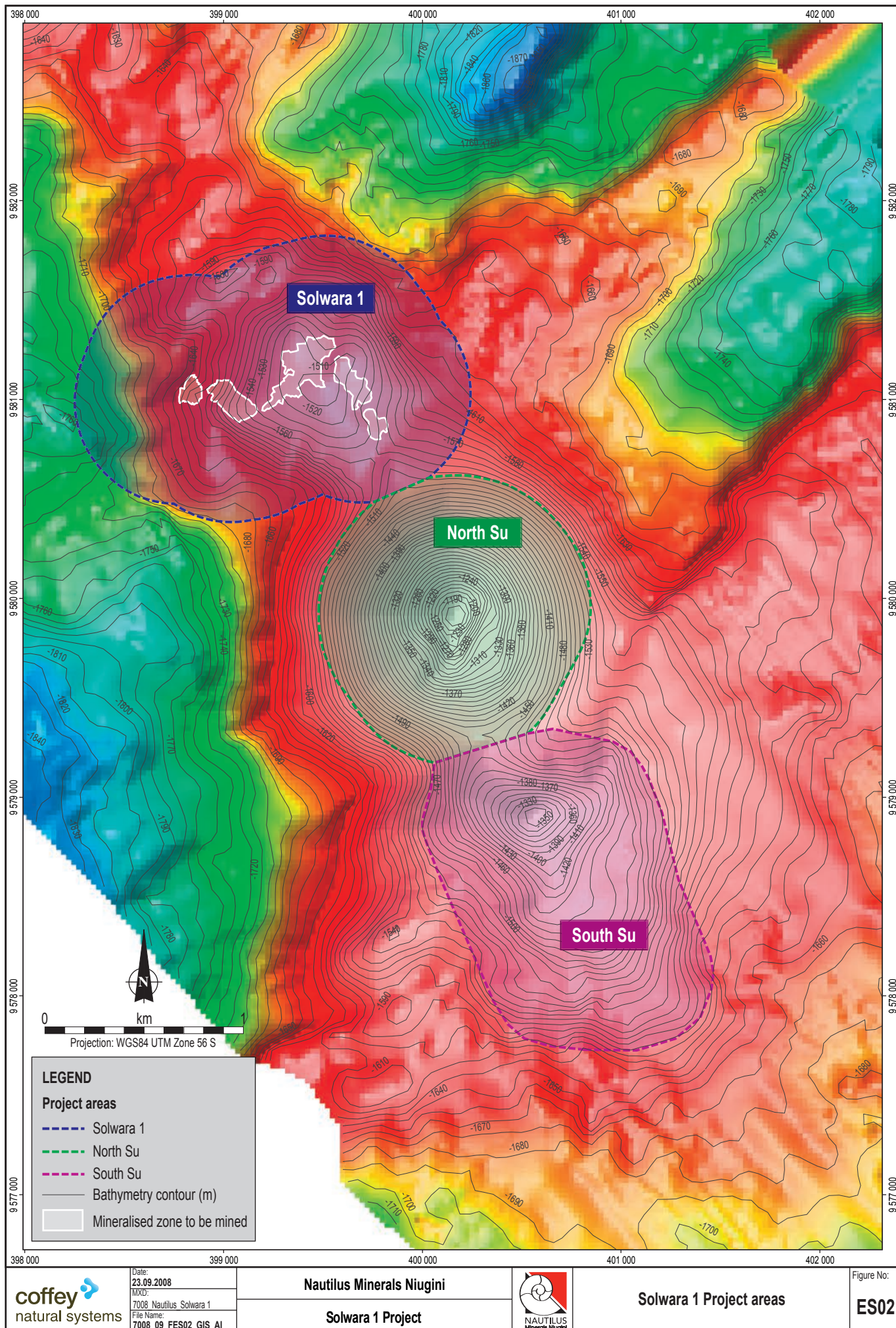
- **Phase 1.** The first phase (which at this stage has a nominal mine life of 30 months) involves mining and whole-of-ore export of copper- and gold-rich SMS ore deposits from the ocean floor using a Seafloor Mining Tool (SMT) deployed from a Mining Support Vessel (MSV). Ore mined by the SMT is pumped to the MSV via a riser and lift system (RALS). At the surface, the ore will be dewatered and barged to a temporary holding facility in the Port of Rabaul and then shipped overseas to a processing facility and smelter.
- **Phase 2.** The second phase involves treating the recovered materials locally in PNG and a feasibility study will commence when Phase 1 has demonstrated the extraction and recovery process and the Project has successfully achieved commercial production. The dewatered ore mined from the seafloor will be barged to a concentrator (the preferred location within PNG is yet to be finalised) for processing and the concentrate then shipped to an overseas smelter.

Phase 1 and Phase 2 of the Project will be addressed in separate EISs to allow for flexibility in Project schedules. This EIS addresses Phase 1 only.

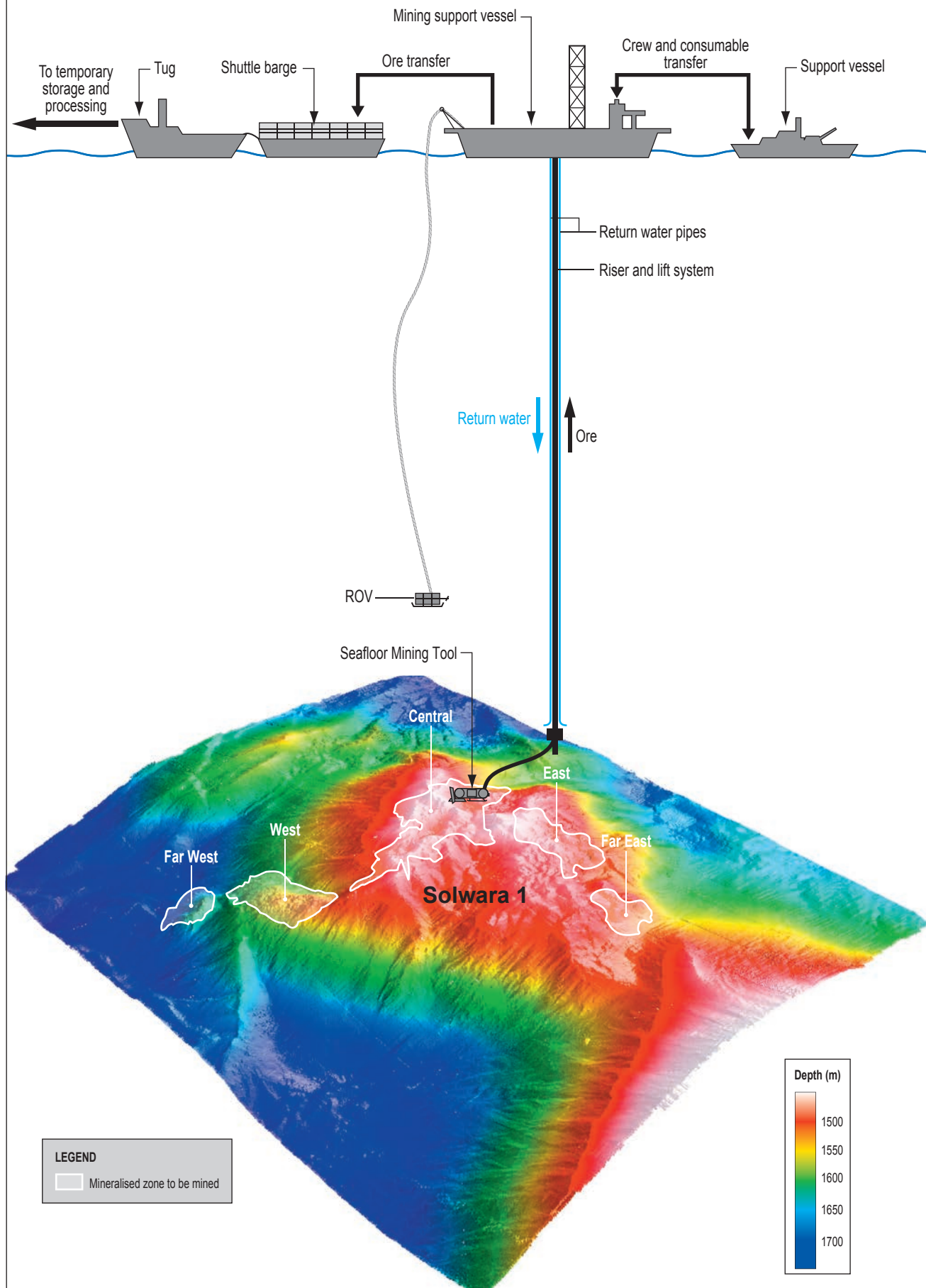
The Solwara 1 target area is located on the northwestern flank of the North Su actively erupting subsea volcano. South Su, which is not currently planned to be mined, is a potential reference site with active chimneys that lies about 2 km distant on the opposite southeastern flank of North Su (Figure ES02).

The general arrangement of offshore Project activities is shown in Figure ES03. The mineral resource at Solwara 1 is comprised of sulphide-rich chimney fields sitting over several massive sulphide bodies. The deposit sits proud of the surrounding seafloor with a thin drape of non-mineralised, unconsolidated sediment covering the deposit in some places, i.e., there is no significant overlying layer of non-mineralised overburden. Therefore, after removal of the unconsolidated sediment, the deposit will be mined in a method similar to offshore dredging of hard rock or terrestrial open-pit mining.







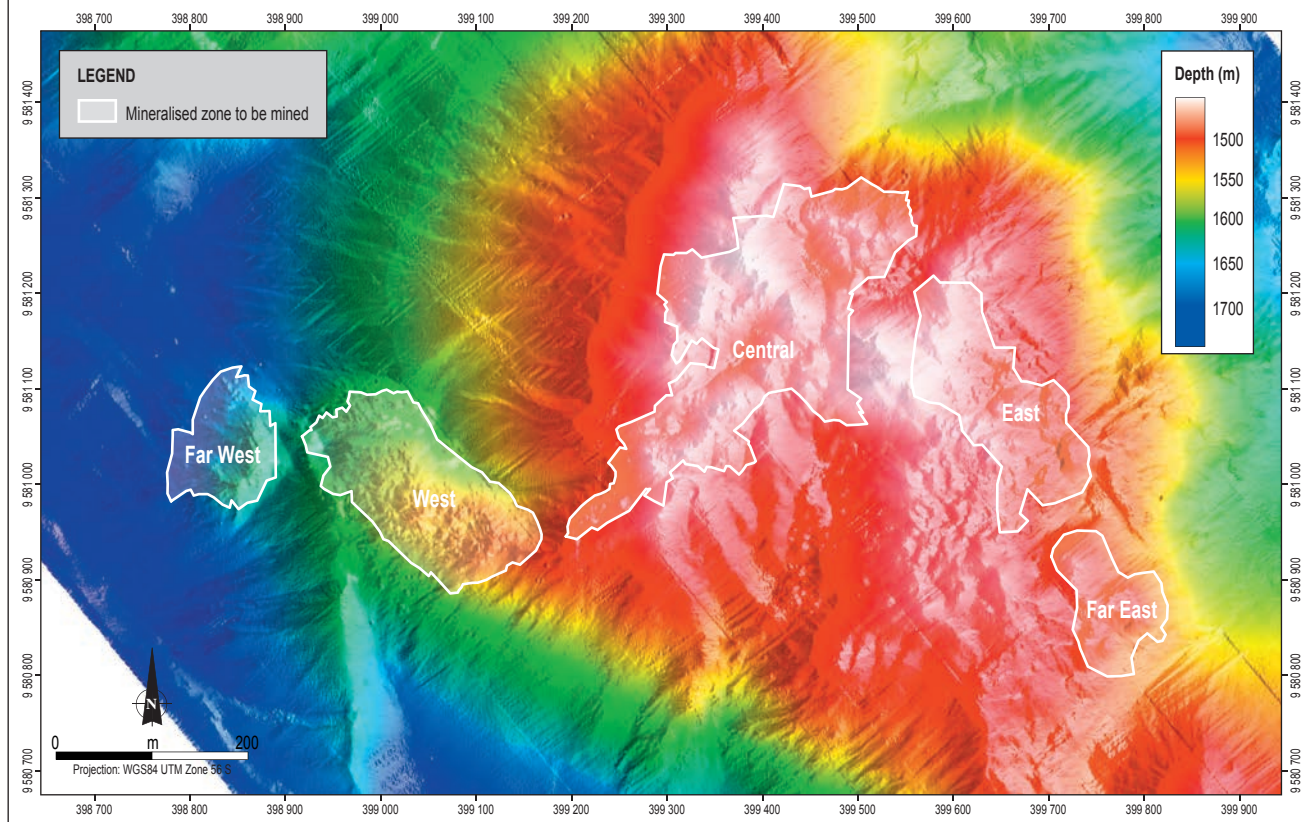


The main components of the development are:

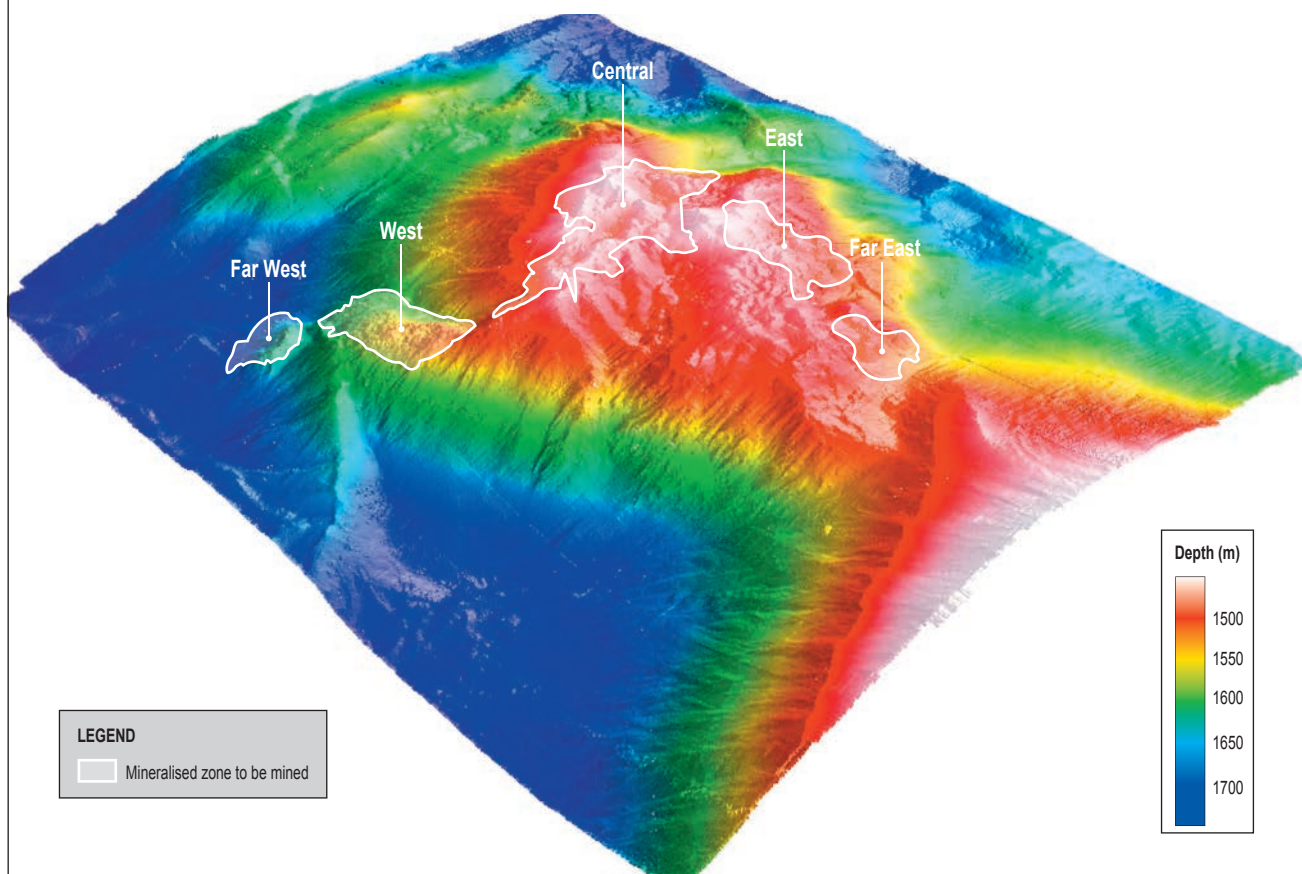
- **Mine Area** (Figure ES04). Mineral resource investigations have identified five main zones of mineralisation at Solwara 1. Prior to mining, approximately 130,000 t of non-mineralised unconsolidated surface sediment will be removed. Competent waste material (i.e., waste rock) will be minimised and approximately 115,000 t is expected to be moved to the same area as the unconsolidated sediment.
- **Seafloor Mining Tool (SMT)** (Figure ES05). Two SMTs will be constructed, each weighing approximately 250 t in air and 190 t in water. The machine will measure 8 m tall, 17 m long (with the boom extended) and 13 m wide. The tool is capable of working in depths up to 2,500 m and can operate in water temperatures ranging from 0°C to 35°C. At any time only one will operate; the other will either be on standby or undergoing maintenance on the MSV. The SMT will 'move' along the seafloor and extract ore from the specific target areas with a cutting head and associated suction mouth. The ore will be disaggregated to the size required for transfer to surface. The SMT will be remotely controlled from the surface and aided in its precision mining activities by two remotely operated vehicles (ROVs).
- **Riser and Lift System (RALS)** (Figure ES06). Mined ore will be pumped to the surface via a riser pipe attached to the SMT. One pump attached to the bottom of the RALS will pump both water and ore to the surface as a slurry. The pump will be hydraulically powered by return water from the surface. A flexible riser transfer pipe (RTP) connects the SMT to the base of the RALS.
- **Mining Support Vessel (MSV)** (Figure ES07). A dynamically positioned, 153-m-long MSV will be used as the base for the associated surface mining activities. A control room on the MSV will remotely control the SMT and ROV operations and the MSV will include all facilities for dewatering the ore prior to its transfer to shuttle barges for transport to temporary storage at the Port of Rabaul. Water separated during dewatering will be pumped back to the seafloor and used to drive the RALS pump. The main discharge to the environment is from the dewatering, where the extracted water, with some retained fine (<8 µm) suspended solids, is pumped down two return pipes and discharged at depths of approximately 25 to 50 m above the seafloor, whence it originated.
- **Remotely Operated Vehicles (ROVs)**. Two work-class ROVs will be used to assist in all aspects of mining operations on the seafloor at Solwara 1, including the removal of non-mineralised unconsolidated sediments. Additionally, the ROVs will be used to undertake environmental monitoring and management activities.
- **Shuttle Barges**. Shuttle barges, either self-propelled or towed by tugs, will be used to transfer dewatered ore from the MSV to the Port of Rabaul.
- **Support Vessel**. Consumables such as fuel, lubricants, spare parts, food and water will be regularly transported to the SMT by shuttle barges or an ancillary support vessel. Crew transfers will also occur at regular intervals using the same method.

The onshore facilities (Figure ES08) will be located at the Port of Rabaul (within Simpson Harbour), which is an established international port with existing facilities and port operations. It does not require significant modification prior to use as a storage location. Apart from dedicated

## Plan view of proposed mining area at Solwara 1

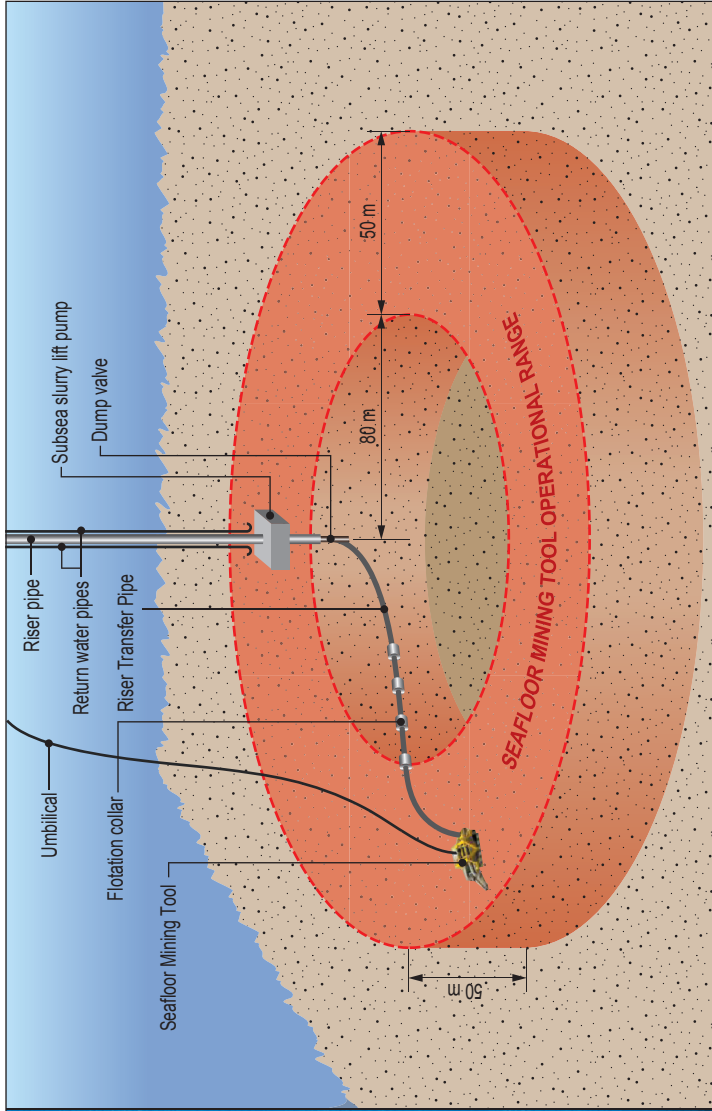
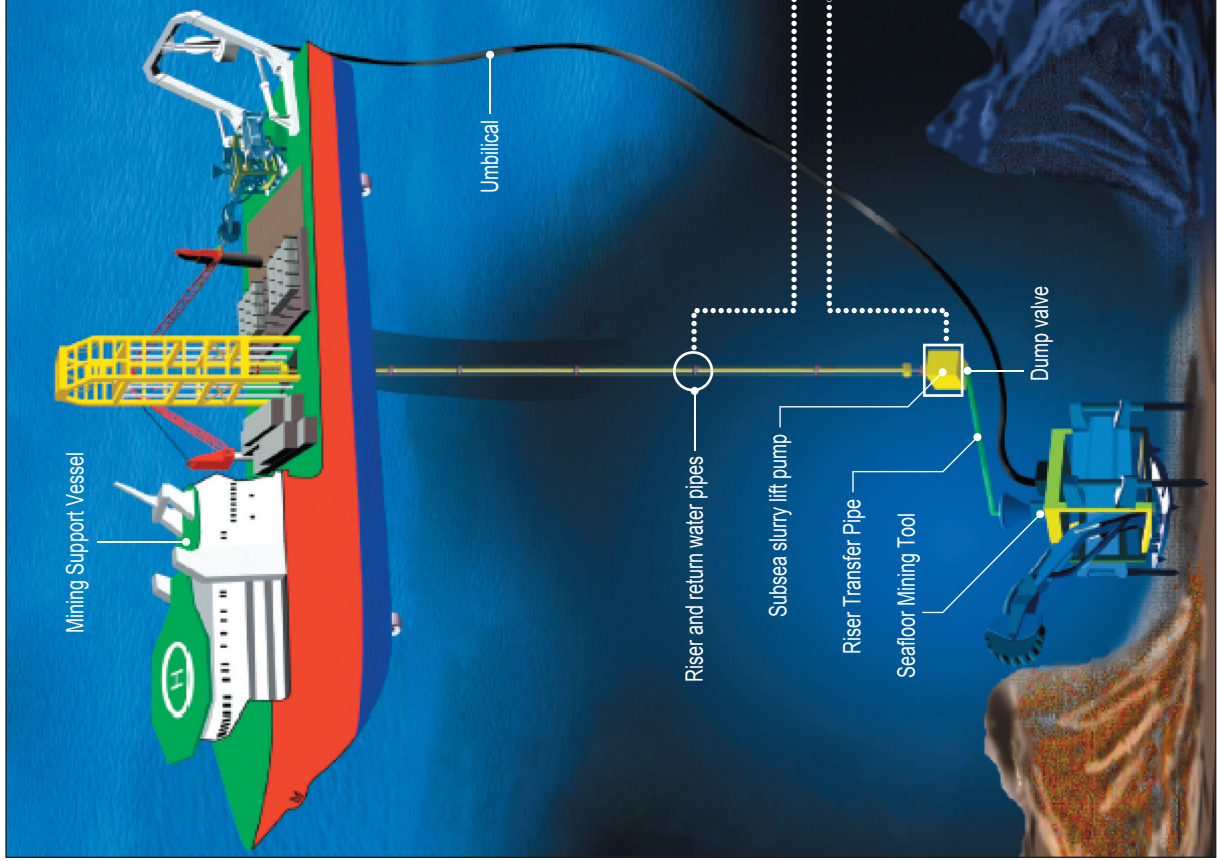


## 3-dimensional image of proposed mining area at Solwara 1, looking north

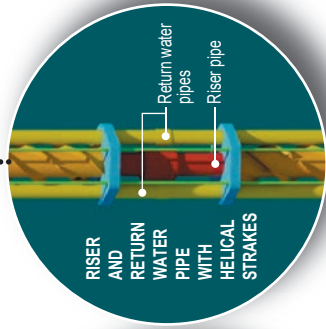
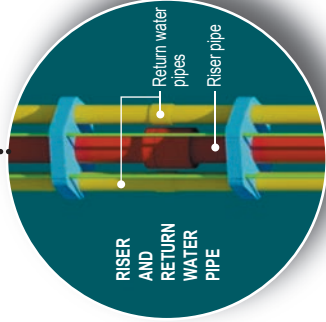
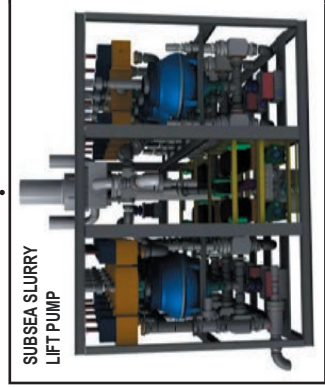








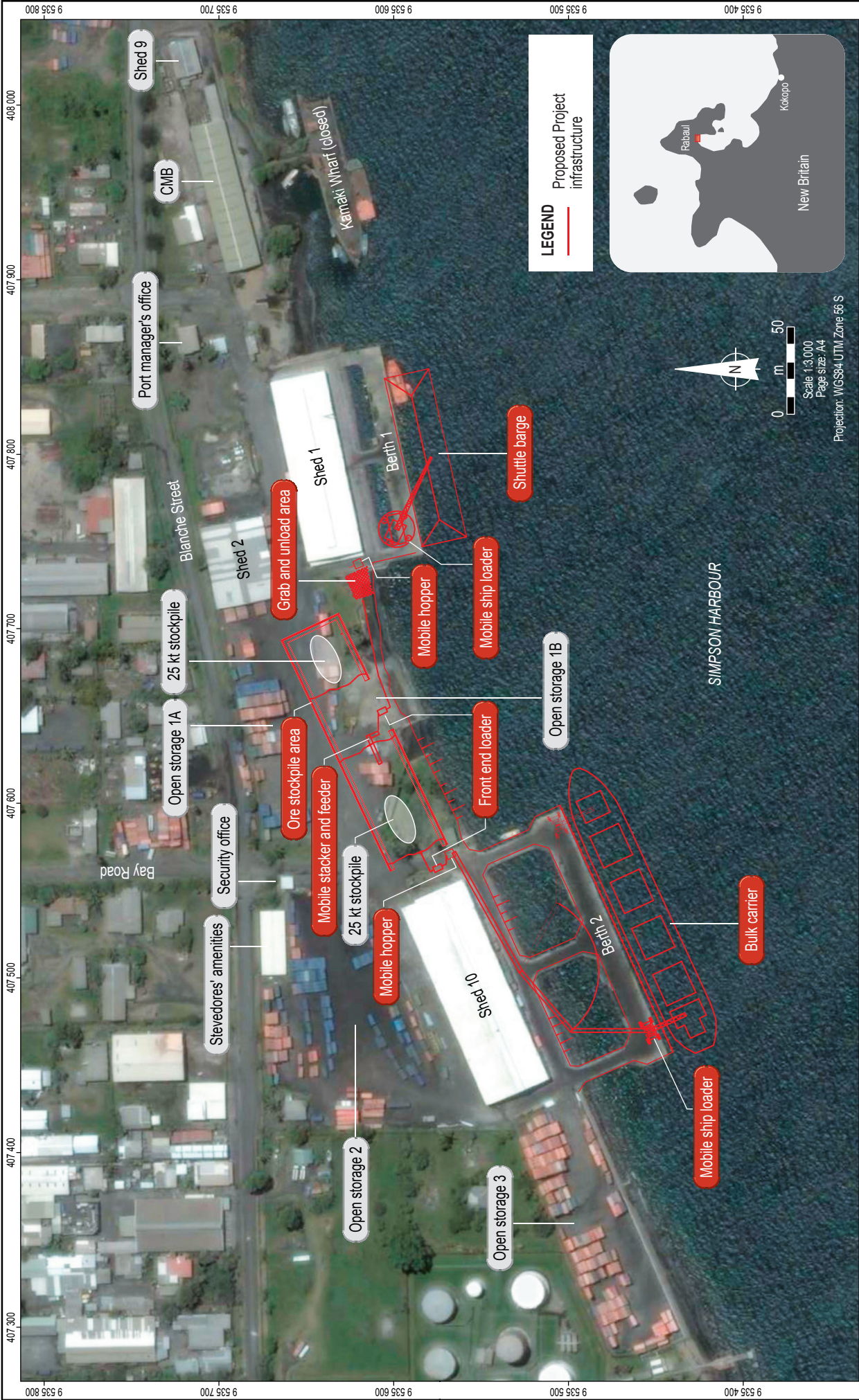
Not to scale











Source: Imagery from Google Earth. Note: Proposed Project infrastructure is schematic.				Date: 22.09.2008 WGS84: Nautilus_Solwara1 Fig Name: 7008_03_FES08 GIS AI		Nautilus Minerals Niugini Solwara 1 Project				Port of Rabaul proposed Project infrastructure		Figure No: ES08
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conveyor and ship-loading facilities, the operation can be conducted within the existing infrastructure and current operations of the port. Simpson Harbour is well protected and provides safe sea conditions year round and, being only 50 km from Solwara 1, allows for minimal shipping distance. The port is located on alienated land and therefore does not require the use of customary land, as may be necessary elsewhere.

The main components of the Phase 1 onshore and offshore operations are:

- Extraction of ore.
- Lifting and dewatering of ore.
- Loading of ore onto barges and transport to the Port of Rabaul.
- Transfer of ore from the shuttle barges to the stockpile area using a conveyor and front end loaders.
- Temporary stockpiling of ore in a new, covered storage facility until enough material has accumulated for transfer to bulk carriers for shipping to an overseas processing facility.
- Ship loading by a dedicated ship loader to transfer ore from temporary storage to bulk carriers.

#### **1.4 Technical Viability of the Project**

The Project is the first proposed commercial development of SMS deposits anywhere in the world. Much of the remote subsea technology required is available or adaptable from that commonly used in offshore oil and gas, telecommunication and dredging industries. Technologies commonly used by these industries, such as ROVs, subsea trenching vehicles, riser components, pumping systems and control and power umbilical cables, are expected to be directly transferable to the Project. Nautilus has developed partnerships and alliances with key offshore equipment and service providers, which have conducted engineering test trials and assisted in the development of suitable seafloor mining equipment.

The viability of the Project is underpinned by the high grades of Solwara 1. Indicated resources are 870,000 t of 6.8% copper and 4.8 g/t gold. Inferred resources are 1,300,000 t of 7.5% copper and 7.2 g/t gold.

#### **1.5 Project History and Characteristics**

After initial discovery in 1995, exploration at Solwara 1 occurred in late 2005 and early 2006, when Placer Dome Oceania Limited, at that stage part of a joint venture with Nautilus, led a bulk sampling and drilling campaign. During this campaign, simultaneous biological and physical environmental characterisations of Solwara 1 commenced.

In mid 2006, Nautilus took over all exploration rights from Placer Dome Oceania Limited and undertook further exploration and scientific work. A scientific cruise with Woods Hole Oceanographic Institute in August 2006, and a six-month exploration and environmental investigation campaign in 2007 allowed further geological characterisation of the mineral resource and EIS studies to take place. Results from these geological investigations have confirmed the presence of copper and gold in grades high enough to allow commercial development. Nautilus has committed to developing the Project and engineering design has proceeded in parallel with this EIS.

Mineralisation is hosted by chimneys and, due to the process in which the deposit has formed, occurs at the surface of the deposit, which means that there are only very small volumes of hard-rock overburden (approximately 115,000 t). Parts of the deposit are covered by non-mineralised, unconsolidated sediment, which will be moved prior to mining, but volumes are again small (approximately 130,000 t).

To date, drilling has occurred to a maximum depth of 20 m, but to what depth the mineralised zone extends below the seafloor is unclear. Of the core holes drilled during exploration, 44% of them have terminated within the ore body. Additionally, mineralisation may occur laterally outside the identified zones of mineralisation. Therefore, potential exists for the mineral resource to be greater than that presently indicated, and may result in an extended mine life beyond the nominal 30 months.

If mineralisation continues outside of the mineralised zones or deeper than currently modelled, mining will likely continue until mineralisation ceases or it becomes either financially, technically or environmentally unfeasible to continue.

There are no constructional stages of land clearance, pre-stripping or construction of haul roads. The only offshore surface mining facilities are the single MSV and the attendant ore transport barges and tugs (nominally seven trips per week).

In comparison with terrestrial mines in PNG, the area to be mined at Solwara 1 is small (only 0.112 km<sup>2</sup> of seafloor, see Figure ES04), and there is virtually no overburden (unconsolidated sediment and competent waste material) requiring ongoing management (Table ES01).

**Table ES01 Comparison of the Solwara 1 Project with other PNG mines at time of EIS approval**

Mine	Ore at Time of Project Approval (Mt/a)	Overburden (Mt/a)	Ore and Overburden (Mt/a)	Status	Type
Ok Tedi	15.2	23.7	38.9	Operations	Open cut
Hidden Valley	2.1	27.7	29.8	Constructing	Open cut
Lihir	7.2	20.6	27.8	Operations	Open cut
Porgera	17.0	2.7	19.7	Operations	Underground and open cut
Misima	5.1	6.3	11.4	Closed	Open cut
Ramu	4.6	1.1	5.7	Constructing	Open cut
Solwara 1	1.2	0.12	1.32	Seeking approval	Seafloor open cut
Kainantu	1.17	0.07	1.24	Operations	Underground
Simberi	1.1	0.0	1.1	Constructing	Open cut
Tolukuma	0.2	0.81	1.01	Operations	Underground
Wau CIP	0.4	0.39	0.79	Closed	Open cut

## 1.6 Investment, Revenues, Employment and Project Life

In February 2007, Nautilus completed a listing on the London (AIM) Stock Exchange and raised US\$100 million in a brokered institutional equity placement and also raised US\$75 million in a brokered private placement on the Toronto Stock Exchange.

Mining (first ore) is scheduled to commence in Q4 2010 and the estimated total direct benefits to PNG is projected to be US\$142 million over the nominal Project life. Construction will mostly be undertaken in international build yards but Phase 1 operations will require a workforce of approximately 130, the majority being PNG citizens (increasing over the life of mine) and wages paid to those citizens over the life of the Project is estimated at US\$6 million. It is anticipated that both the net cash flow to landowners and employment opportunities will substantially increase under Phase 2.

## **1.7 Mining Agreement**

The *Mining Act 1992* is presently the principal policy and regulatory document governing the mining industry in PNG. *The Mining Act 1992* vests ownership of all minerals in or below the surface of land with the national government, and governs the exploration, development, processing and transport of minerals.

## **1.8 Environmental Impact Statement**

The Project is a Level 3 activity under the *Environment Act 2000* (Sub-Category 17), which requires that an EIS be submitted to the Department of Environment and Conservation (DEC). Nautilus has prepared this EIS in accordance with the *Environment Act 2000* (Section 53). The EIS seeks from the PNG Government approval to construct and commission Phase 1 of the Project and acceptance of the residual impacts described and commitment to the mitigation measures outlined by Nautilus. Operations will commence and continue under relevant licences, permits and approvals.

## **1.9 EIS Setting**

There are a number of aspects that set this Project apart from all other mining projects, not just those in PNG.

Firstly, it is extremely small scale; there is no need for site preparation or construction of complex facilities, no machinery for moving and storing overburden and no direct landowner issues. Its environmental footprint is mainly that of a single MSV (with attendant support vessels) and precision mining machinery operating on a seafloor target area of just 0.112 km<sup>2</sup>.

Secondly, it represents the first proposed commercial exploitation of SMS deposits. The likelihood that such areas would one day be exploited has been envisaged since their discovery during the 1970s, with hydrothermal vent scientists and other interested stakeholders universally calling for a precautionary approach to any mining.

The need to understand the biology and potential impacts of mining on the hydrothermal vent communities and the surrounding seafloor, where knowledge of the dynamics of recruitment, growth, diversity and geographic interrelationships is still under development, is one of the key environmental issues for this Project.

Nautilus has recognised the extent of the necessary studies, the need to engage international scientific expertise in hydrothermal vent systems and deep sea fauna to design and conduct the studies, and the need to provide the oceanographic and seafloor sampling facilities to bring this about. The remoteness, technical difficulty and high expense required to improve the knowledge and address the precautionary approach demanded in the detailed study of deep sea hydrothermal vent environments would at first seem insurmountable. There are a number of key factors that clearly demonstrate otherwise for this Project.



First, the geothermal energy source that underpins the vent ecosystem will not be extinguished by mining, and chimney structures will reform around vents once mining ceases in each particular area. This has been observed and demonstrated during Nautilus' environmental assessment campaigns. The essential conditions for faunal succession from microbial organisms to more complex macrobenthic communities will therefore reform relatively rapidly. While the time for recovery to existing conditions may be some years, strategies to enhance this process are also proposed in this EIS.

Second, and unique to this type of development, is the fact that the facilities needed for the environmental research are provided by the same oceanographic vessel and ROV seafloor sampling equipment as needed for mineral exploration of the seafloor. Once the vessel and ROV facilities are mobilised for exploration, Nautilus has ensured that time has been dedicated to the necessary environmental studies. In some of the areas of study, the collaborating scientists (i.e., their institutes) have contributed time and resources to extend the studies to more general scientific research and the scientists involved in these studies are free to publish findings in the scientific literature. Consequently, Solwara 1 and South Su are now the most intensively studied hydrothermal areas in the region.

In particular, sampling by ROV enables visual and manipulative precision in sampling (e.g., of sediments and animals) that is impossible by remote grab sampling from the surface. Nautilus engineers, in turn, have found ways to accommodate certain manipulative mitigation strategies (proposed by the scientists) into the mine plan, which now places this Project in quite a different light in its ability to overcome the initial – and widely held – concerns of risks to biodiversity from seafloor mining.

In comparison with a typical EIS for a land-based project, the offshore location of the Project has necessarily shifted the primary consultative focus from landowner issues - as there are no direct impacts - to the international scientific input described above. Nevertheless, consultations with governments, regional communities in East New Britain and New Ireland Provinces, and offshore resource users have been followed throughout to ensure awareness of the fundamentals of the Project, particularly those that differentiate it from other projects, and to provide the forum for raising and receiving responses to concerns and developing strategies to minimise any impacts.

## **2. Project Development Timetable**

Based on the current resource estimates, the Project has a mine life of approximately 30 months, extracting ore at a maximum rate of 5,900 t/d; however, this could extend to five years if additional mineralisation at Solwara 1 is discovered.

The Port of Rabaul facilities will be commissioned by Q2 2010, mining equipment by Q3 2010 and first ore in Q4 2010.

## **3. Project Setting**

### **3.1 Offshore**

The offshore Project area includes the SMS mounds of Solwara 1 and South Su, respectively located about 1 km to the northwest and southeast of the centrally located active submarine volcano known as North Su (see Figure ES02). The mineralised ore body of Solwara 1 forms a mound approximately 2 km in diameter that sits about 200 m above the adjacent seafloor.

The main characteristics of the area, and the reason for the presence of the mineralised resource, are defined to a great extent by the regional tectonics, seismicity and volcanism. PNG straddles several major tectonic plate boundaries and the complex movement of these plates has resulted in significant faulting and seismic activity, creating the potential for both shallow- and large-magnitude earthquakes and volcanic eruptions, both on land and in the sea.

The hydrothermal fields were initially discovered by oceanographic transmissometry profiles that detected naturally occurring plumes in the water column at depths between 1,090 and 1,460 m across what were believed, from their bathymetry, to be active volcanoes. The source of these naturally occurring plumes, and the unconsolidated sediments that lie in places within and around Solwara 1, is most likely to be eruptions from North Su with lesser contributions from South Su and Solwara 1. Nearby active land-based volcanoes may also contribute to the sediment composition by fallout of ash.

Mineral resource investigations have identified five main zones of mineralisation (see Figure ES04), that will form the basis of mining activities and which include the majority of the active mineralised chimneys. At Solwara 1, it is estimated that there are 40,000 chimneys over 0.25 m high. Between the chimneys, the seafloor consists of exposed hard sulphide deposits (target ore) interspersed with thin veneers of unconsolidated sedimentary deposits, although accumulating in some areas to depths of up to 6 m.

### **3.2 Offshore Environmental Studies**

Leading research bodies and universities from around the world carried out specific studies. While the major foci of the studies were the biological communities and potential endemism of the hydrothermal vent species at Solwara 1 and South Su, the environmental studies have included the following physical, chemical and biological baseline studies of the offshore environment:

- Macrofauna of hard seafloor areas (College of William and Mary, Duke University).
- Macrofauna and meiofauna of sediments (Scripps Institution of Oceanography).
- Abyssal meiofauna (Dr John Moverley and Coffey Natural Systems).
- Sediment geology (University of Toronto).
- Sediment geochemistry – elutriate and toxicity testing (CSIRO and Charles Darwin University).
- Biomass, biodiversity and bioaccumulation (Hydrobiology).
- Water quality (CSIRO and Coffey Natural Systems).
- Natural hazards (Rabaul Volcano Observatory).
- Oceanography (Coffey Natural Systems).
- Underwater acoustic modelling (Curtin University of Technology).
- Discharged water and sediment dispersion modelling (Asia-Pacific Applied Science Associates).

### **3.3 Main Baseline Findings**

Studies to characterise the seafloor environmental communities focused heavily on the actively venting environments but a substantial effort was also directed at sampling all seafloor habitats potentially affected by the Project. This sampling was undertaken quantitatively, with parallel replicate samples and equivalent numbers at active and inactive, hard and soft seafloor areas of Solwara 1 and South Su, to enable statistical analysis.

One of the first significant observations made during the 2006, 2007 and 2008 environmental research surveys was of the variability in venting activity at Solwara 1, with an apparent switching on and off of vents. Some areas that were strongly venting one year were weakly venting or not



venting they were re-surveyed in subsequent years. Conversely, in later surveys, venting was observed in some areas where it had not previously been observed. The comparisons of activity in 2006, 2007 and 2008 are shown in Figure ES09.

Piles of dead snails (Plates ES01 and ES02) were also observed at several of the areas where venting had ceased, suggesting that these areas could no longer support these vent-dependent species (Figure ES10). Furthermore, resumed venting was observed after disturbance during exploration, with chimney lattice starting to reform (Plate ES03) in a matter of days. These observations are of major significance because they indicate a hydrothermally dynamic system with natural variation in the active and inactive areas, where (at least in these areas) conditions are not conducive to establishment of long-term, stable, vent-dependent communities.

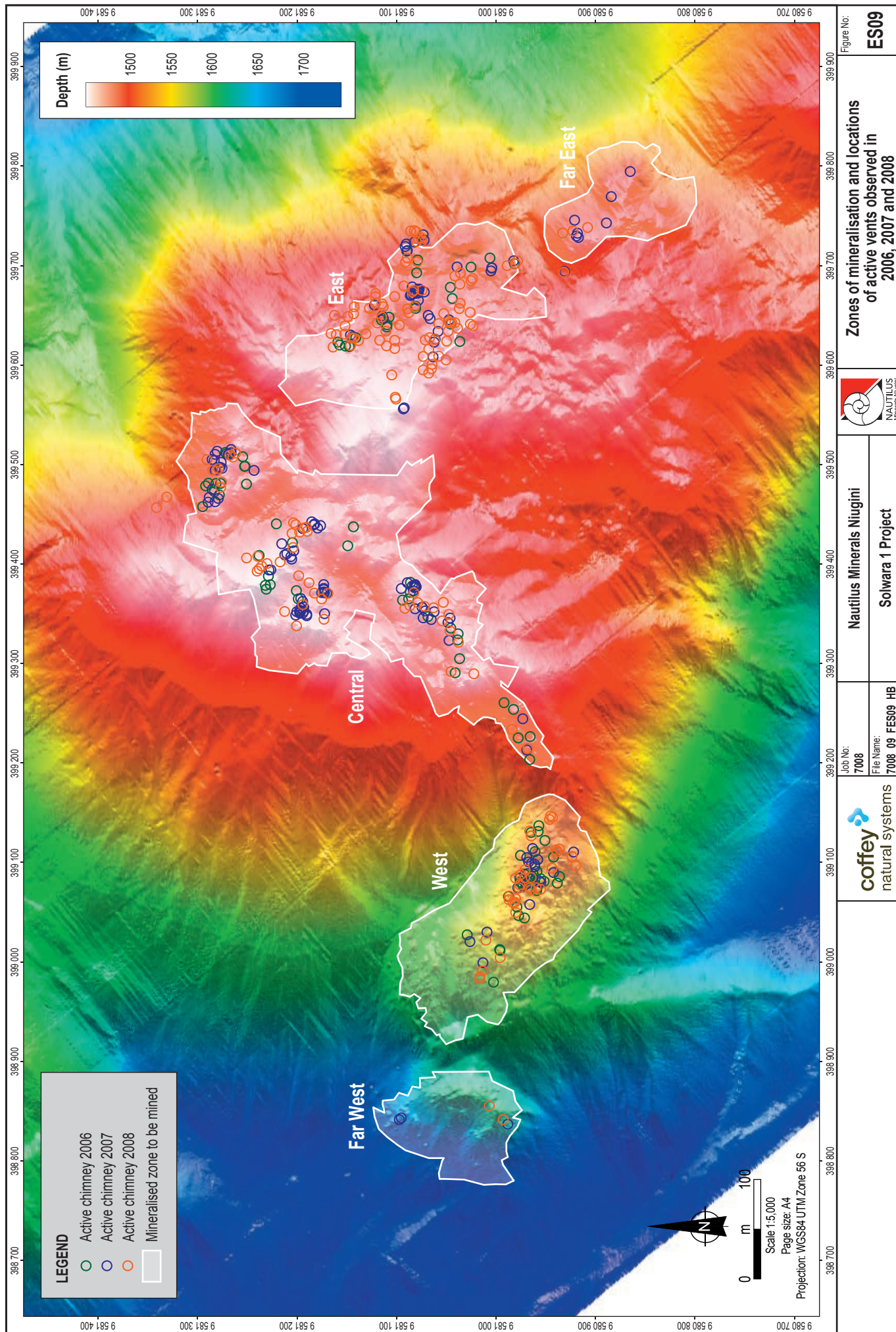
### Seafloor Communities

The active mineralised chimney habitats are colonised by faunal communities that are dependent on chemoautotrophic (e.g. sulphur-oxidising) micro-organisms for energy rather than energy from the sun. Species such as tube worms, bivalves and gastropods (and their associated fauna) cannot exist away from hydrothermal vents and in this EIS, are termed vent-dependent species.

At Solwara 1 and South Su, the active venting sites are characterised by a number of biomass-dominant species such as *Alviniconcha* sp (a species of gastropod snail), *Ifremaria nautiliei* (also a gastropod snail), *Eochionelasmus* sp (a barnacle) and, at South Su only, the mussel *Bathymodiolus manusensis*. These animals occurred in defined zones around vents and numerous other species (crabs, shrimps limpets, etc.,) were living in association with the dominant groups (Plate ES04). Species of vestimentiferan worms, characteristic of vents in other parts of the world, were not observed at Solwara 1 and only two species were observed at South Su. In general, there were few significant differences between communities at Solwara 1 and South Su.

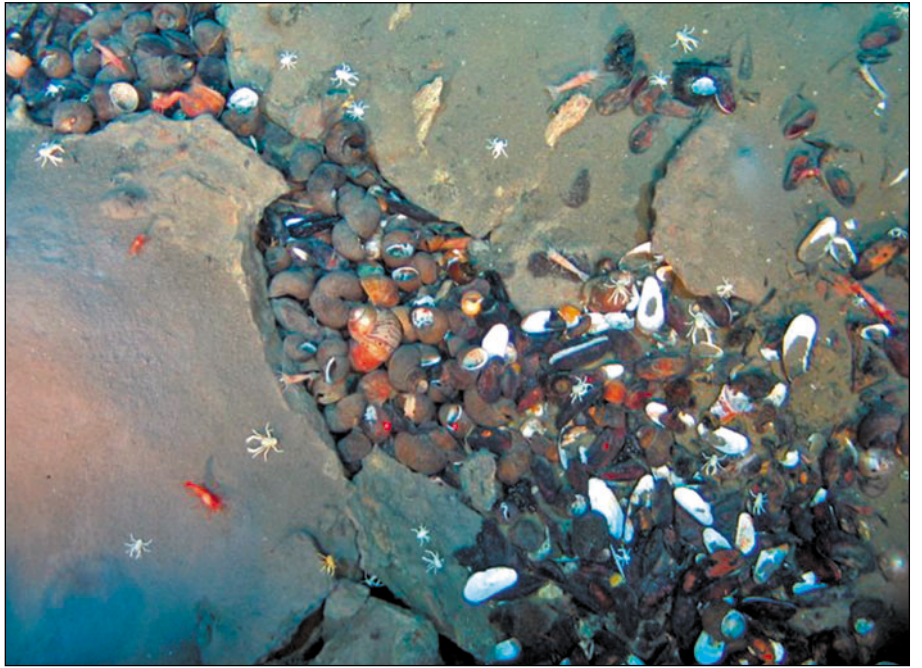
Considerable effort was expended in sampling both hard and soft sediments in the inactive areas. Hard areas of seafloor were colonised mainly by stands of bamboo corals (*Keratoisis* sp), which is typically found on deep seamounts. The soft sediments at Solwara 1 and South Su appeared heterogenous in terms of different surface features of colour, undulations and the presence or absence of faecal pellets. In these sediments, the numbers of macrofauna (animals in the sediment generally larger than 1 mm) and meiofauna (microscopic animals in the sediments) were very low compared with values given in the scientific literature from equivalent areas, possibly reflecting dynamic processes such as intermittent deposition of volcanic sediments, as numbers of meiofauna were higher at sites more remote from Solwara 1.

Genetic characterisation of macrofauna collected from active hydrothermal vents at Solwara 1 and South Su and matching with other available data showed that some biomass dominant species (*Ifremaria nautiliei*, *Munidopsis lauensis*) have ranges that extend across all regional back arc basins, while other species (*Alviniconcha* sp 1 and 2, *Arcovestia ivanovi*) inhabit some basins but not all, and some species (*Bathymodiolus manusensis*) are so far only observed in the Manus Basin. More baseline studies are underway to determine the genetic associations between species at Solwara 1, South Su and other areas.





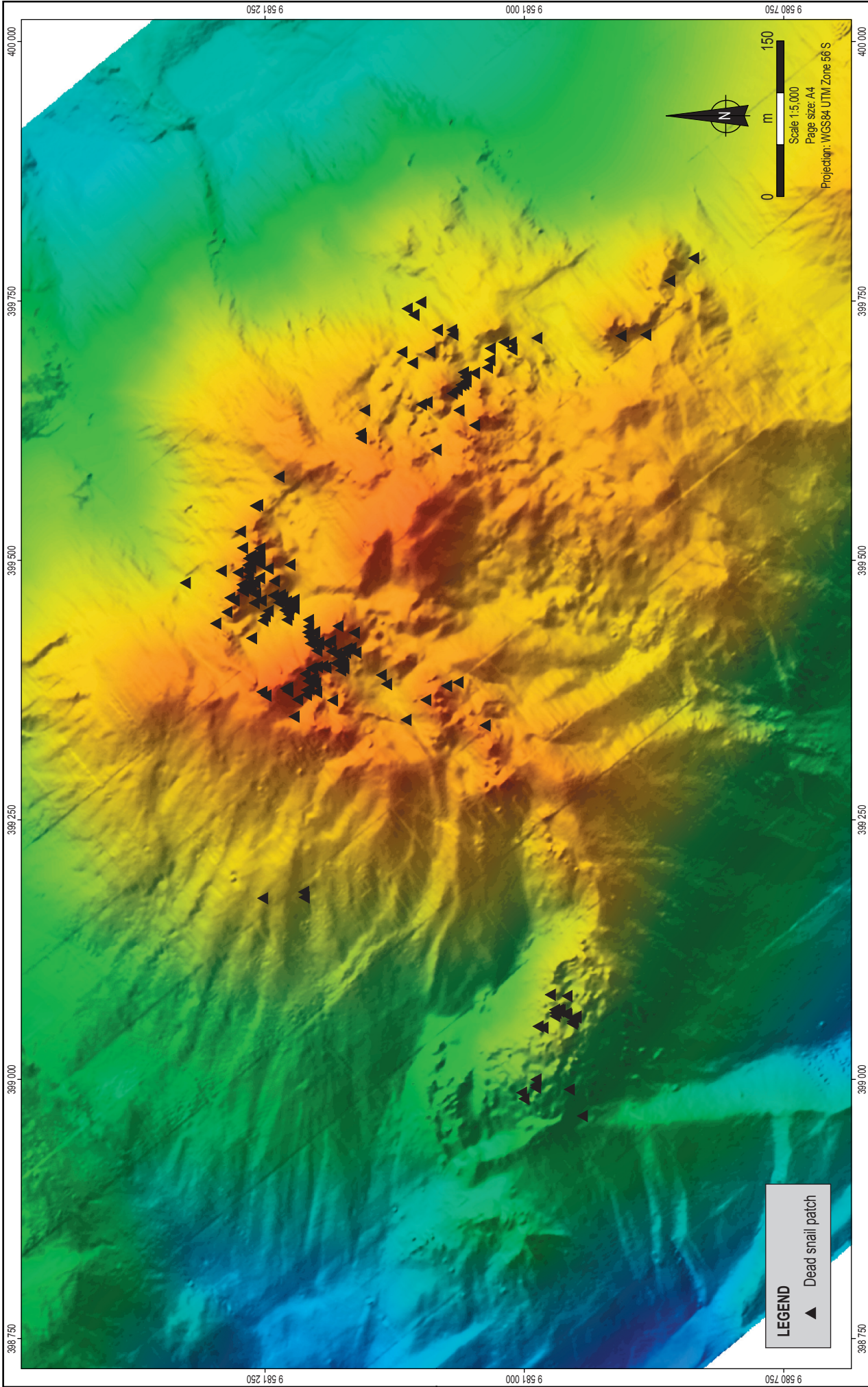
**Plate ES01**  
Dead snails




**Plate ES02**  
Dead snails

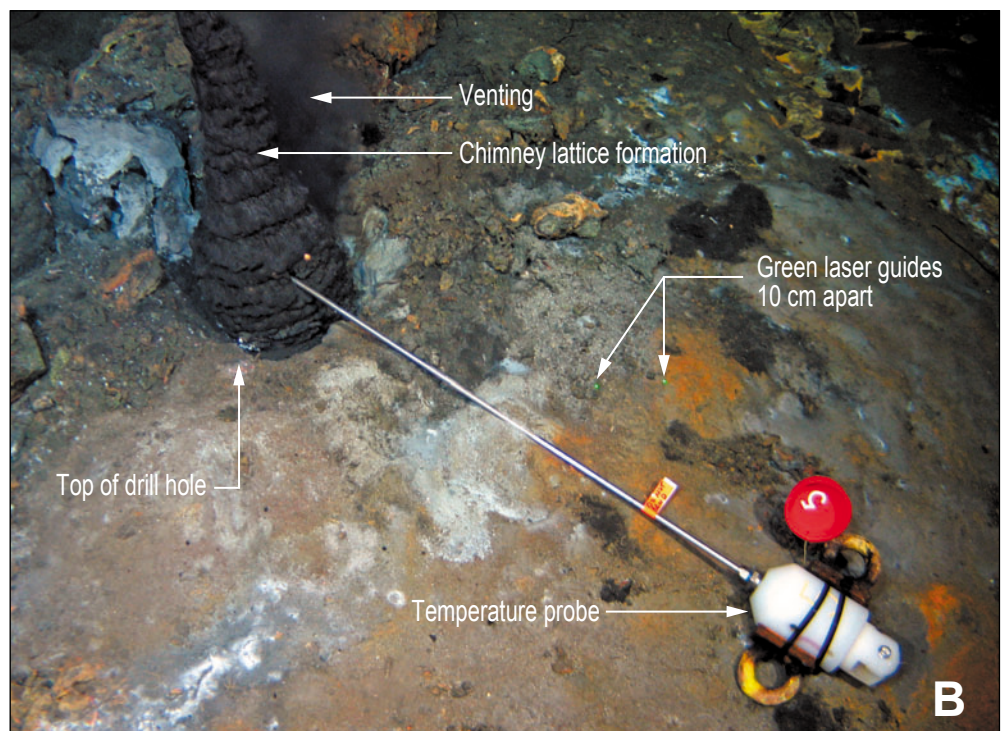
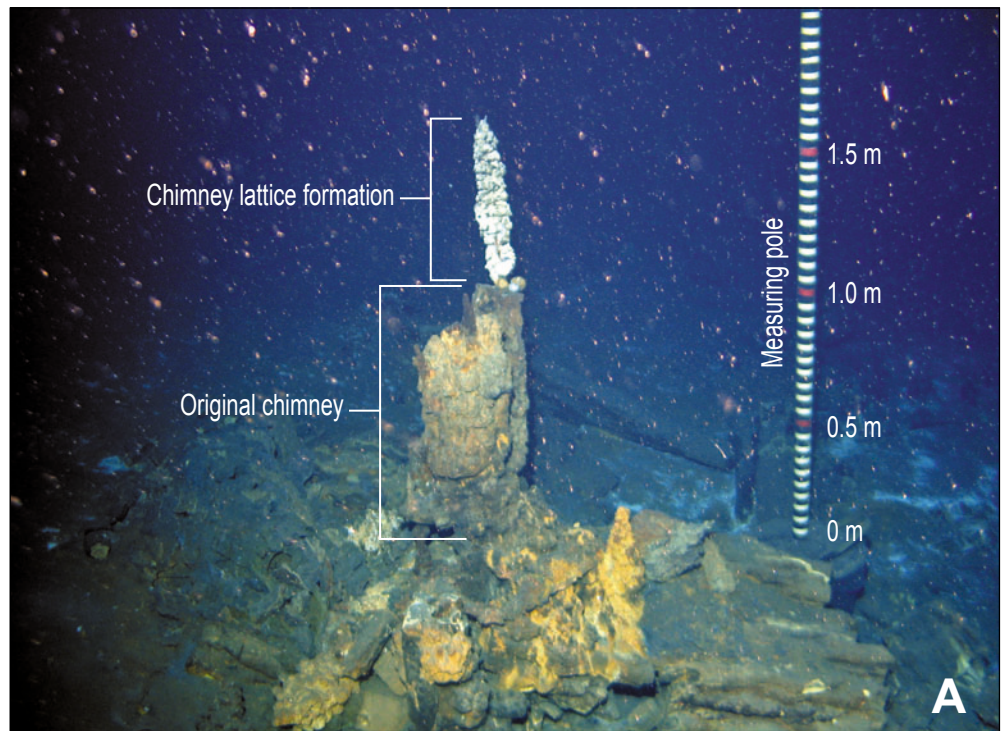






	<b>Date:</b> 22.09.2008			<b>Solwara 1 dead snail patches</b>	<b>Figure No:</b> <b>ES10</b>
	<b>WOC:</b> 7008 Nautilus Solwara 1				
<b>File Name:</b> 7008_03_FES10_GIS_AI		<b>Nautilus Minerals Niugini</b>			
		<b>Solwara 1 Project</b>			

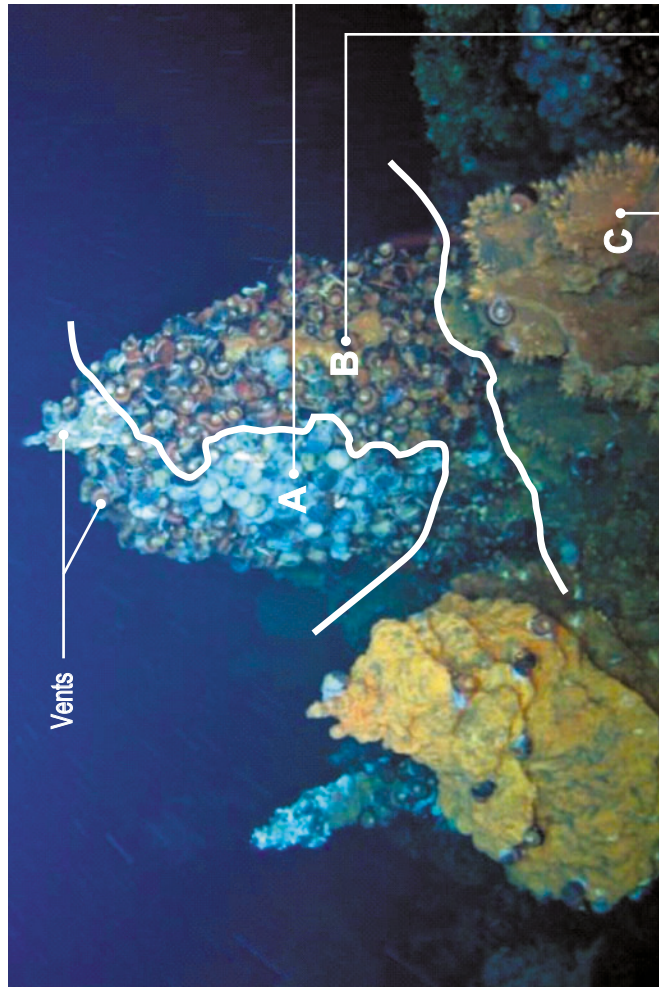




**Plate ES03** Formation of chimney lattice in Solwara 1 West Zone:

- A.** Formation of 58 cm of new chimney lattice over 12 months following the removal of the top part of an existing chimney.
- B.** Formation of 60 cm of new chimney lattice over two days from the top of a drill hole.





**Plate ES04** Active (venting) sites at both Solwara 1 and South Su were dominated by three habitat zones defined by their biomass-dominant species:

Habitat A closest to the vent: *Alviniconcha* sp. (Hairy Snails), Habitat B middle zone: *Ifrimeria nautilei* (Black Snails) and Habitat C outer zone: *Eochionelasmus ohtai* (Barnacles).



## **Coastal, Shallow- and Mid-water Environments**

Within PNG, the local coastal people have expressed most concern for the quality of the marine environments and the protection of the reefs and fisheries upon which they depend, as well as on the well-being of the larger animals that are present such as whales, sharks and turtles. The maintenance of health of the marine environment is not a matter for negotiation and the Project must demonstrate that shallow water animals are not exposed to the mineralised materials of the seafloor to which they have not adapted, so that there is no risk to daily subsistence and traditional local activities, such as shark calling.

A review of the types of animals occurring or likely to occur in the shallow waters and throughout the water column was completed to assess impacts from potential exposure to any Project-related discharges, particularly from the dewatering process. In the offshore oceanic environment, surface schooling pelagic fish species such as tuna frequent the area, along with the occasional passage of large marine animals such as whales, dolphins and turtles.

The surface and mid-water levels are also known to be habitats for various species of plankton, small shrimps, fish and squid, many of which make migrations through the water column between day and night time and form the basis of the food chain. Species of tuna and squid were observed during ROV dives indicating depths (to hundreds of metres) to which some surface species (e.g., yellowfin tuna) can go in search of prey.

However, it is proposed to discharge the water from dewatering (and some entrained sediment) close to its point of origin at depths between 25 to 50 m from the seafloor, and not at shallow or mid-water depths. This decision was made primarily for pumping efficiency, but effectively avoids any exposure or impacts on surface ecosystems. Modelling has shown that plumes from this return seawater will not rise above 1,300 m in the water column. The processes of mining and dewatering will therefore not affect the pelagic tunas, tuna fisheries or nearshore coral reefs including traditional reef fishing activities such as shark calling.

Potential impacts to surface pelagic animals are therefore only from the presence of the surface vessels and their normal operations, including lighting, underwater noise and routine discharges (in compliance with MARPOL). To that extent, impacts are similar to shipping generally and to the exploration surveys already completed.

Noise from ship thrusters will be audible underwater for several hundreds of kilometres, as is the case from most large ships and other man-made and natural sources, but levels are not high enough to cause physiological harm. Some behavioural avoidance and attraction (by some proportion of whales) is likely to happen within 15 km of the vessel but, once established, familiarisation with this new 'landmark' is likely to occur. The annual humpback whale migrations have continued off the east and west coasts of Australia notwithstanding the extensive shipping and oil and gas activities.

The MSV is virtually stationary, and the barges move at slow enough speeds to minimise risks of collisions with whales, turtles and other large marine animals. Published literature on turtle migratory pathways does not indicate major routes between New Ireland and New Britain and, although it is expected that most species may do so, the operations present no threat or obstacle to normal migration that would be materially different from normal shipping and commercial fishing activities.

Seabirds will likely alight on the vessel superstructure, and deck lights needed for safety reasons during night work will attract fish but, being so far offshore, are unlikely to cause disorientation to laying or hatching turtles.

To a very great extent, the exploration activities that have occurred over the past few years from vessels such as the *DP Hunter* (December 2005 to February 2006), *Wave Mercury* (March 2007 to October 2007) and the *NorSky* (June 2008 to September 2008) represent similar aspects and magnitudes of vessel presence, lighting, underwater sound and discharge of treated and macerated food waste and sewage as expected for the MSV.

The *Wave Mercury* has similar dimensions and power as the MSV; hence, the impacts of the activities of the MSV during operations have been experienced already over protracted periods, albeit without the SMT or the ore barging operations. The reported success of the West Coast, Central New Ireland shark calling festival at Kontu Village (approximately 80 km from Solwara 1) from 30 July to 1 August 2008 coincided with active survey by the *NorSky* vessel in the area, suggesting neither the surface vessel's activities nor its underwater noise spectrum negatively affected the reef sharks or shark calling.

### **Water and Sediment Quality**

Water quality was mostly typical of open ocean water, with most trace metals below detection limits, except in some samples taken close to chimneys where ambient concentrations of total metals (i.e., copper, lead and zinc) were higher than ANZECC/ARMCANZ (2000) guidelines for 95% protection.

Toxicity tests of elutriate water prepared to represent conditions in water and sediments discharged after dewatering were undertaken to determine potential effects if these were to be discharged in shallow or mid-water depths. While these showed some toxicity to surface test organisms (and at surface temperatures), the findings are not relevant given that the return water will be discharged close to the seafloor, where fluids discharged from vents are naturally elevated in metals and the resident animals are tolerant of these highly mineralised areas.

### **Oceanography**

The Bismarck Sea predominantly experiences diurnal tides (one high and one low per day) with a maximum tidal range in the order of 1 m. The surface mixed layer<sup>1</sup> at Solwara 1 varies in depth from the surface to 185 m below the surface, while the euphotic zone<sup>2</sup> ranges from 33 to 80 m water depth.

Full water column current monitoring has been completed over 12 months using moored Acoustic Doppler Current Profiler (ADCP) instruments. On average, current velocities at Solwara 1 range between 10 and 20 cm/s, with the greatest current speed exceeding 50 cm/s in the upper water column (from the surface to around 250 m water depth) at various times throughout the year. The upper 400 m of the water column has a constant northwest net flow.

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<sup>1</sup> The surface mixed layer is the upper layer of the ocean that is kept well mixed by the turbulent action of wind and waves, and tends to be composed of water of similar temperature, salinity and density.

<sup>2</sup> The euphotic zone is the upper part of the ocean that is exposed to sufficient sunlight for photosynthesis to occur. It extends from the surface downwards to a depth where light intensity falls to 1% of that at the surface.

The mid-water column (from 400 to 800 m) is characterised by current velocities of 10 to 20 cm/s moving in a southeasterly direction during the northwest monsoon season. During the southeast monsoon season, currents in the mid-water column are predominantly west-northwest at similar speeds.

Compared to current in the water column, currents immediately above the seafloor at Solwara 1 are relatively weak. The median current velocity recorded at this depth is 6 cm/s and the maximum speed is 35 cm/s; however, only 5% of the current speeds exceeded 15 cm/s. Progressive vector plot results from 12 months of continuous monitoring show that over a period of weeks the net horizontal water direction immediately above Solwara 1 is from the southeast to the northwest.

As shorter time scales (days) currents immediately above Solwara 1 are influenced by the tidal cycle and oscillate along an axis aligned northeast to southwest.

### **3.4 Onshore Facilities**

The Port of Rabaul on the north coast of New Britain will be used to stockpile ore until enough has accumulated for transfer to bulk carriers for shipping to an overseas processing facility (see Section 1). Rabaul is situated in a large volcanic caldera, which is open to the sea (Blanche Bay) on the eastern side. The naturally sheltered Simpson Harbour is situated in the northern extent of the caldera with several extinct, dormant and active volcanic vents are scattered along the northern and eastern rim of the caldera. Rabaul township and the Port of Rabaul are located on a narrow, coastal fringe inside the caldera at the northern edge of Simpson Harbour. Today, the town of Rabaul is slowly rebuilding after the 1994 volcanic eruptions of Vulcan and Tavurvur. The Port of Rabaul continues to act as the main port in the region for incoming and outgoing cargo. Kokopo, located approximately 20 km southeast of Rabaul remains the administrative and provincial centre.

The Port of Rabaul is the fourth largest port in PNG and has an average goods throughput of approximately 300,000 t/a. The layout of Port of Rabaul is shown in Figure ES08. It is approximately 4.5 ha in size. Of the two main berths, Berth 2 is the largest and most frequently used. The smaller Berth 1 is used as a back-up facility.

Port of Rabaul is part of PNG Ports Corporation Limited (PPCL). PPCL operates 17 commercial ports in PNG and is responsible for the regulatory control of declared ports, the movement of shipping in such ports and the provision and maintenance of navigation aids, mooring, wharves, and other facilities used in connection with such ports.

East New Britain Port Services is the sole licensed stevedore for Port of Rabaul. Currently, the port is operating without any environmental management systems or procedures. An environmental management plan for port operations will be prepared by Nautilus and will specify relevant environmental procedures and controls for emissions and wastes to which all Project contractors must adhere.

### **3.5 Environmental and Cultural Setting**

The Port of Rabaul is a developed industrial facility and it is likely that any culturally significant materials will have been removed. During World War II, Rabaul served as the main Japanese naval base in the South Pacific. As a result, Simpson Harbour has a multitude of ships and aircraft wrecks, which are now popular diving sites for local tour operators.

There is a high diversity of marine species in and around Simpson Harbour, typical of nearshore reef areas. Before the 1994 volcanic eruptions, coral reefs flourished with live coral cover typically around 50%. Following the eruptions, the fringing reefs within the harbour were buried by ash and mudflows but by 1996 corals had extensively recolonised hard surfaces.

There is very little information available on the air quality of Rabaul. However, monthly reports from the Rabaul Volcano Observatory indicate that Tavurvur emits almost continuous ash and vapour plumes that are a source of ash and SO<sub>2</sub> in the atmosphere. Hydrogen-sulphide (H<sub>2</sub>S) odour is also regularly detected in Rabaul.

## **4. Issues, Mitigation and Residual Impacts**

### **4.1 Offshore Issues**

Impacts on the seafloor and its biological communities will arise from a number of sources, as represented in Figure ES11. The SMT will directly remove seafloor substrate, including active and inactive areas, causing loss of habitat and associated animals. Ultimately, it is expected that the majority of the target areas indicated in Figure ES04 will be mined, subject to mitigation measures proposed to protect biodiversity (see below).

Disturbance to the seafloor and sedimentation will result from mining and from the removal and relocation of the surface layers of unconsolidated sediment (and some competent waste material) to the outer margins of Solwara 1 (Figure ES12). Water containing elevated concentrations of metals and some retained sediments from the dewatering of ore will be discharged 25 to 50 m above the seafloor.

Once dewatered, barges will transfer ore to the Port of Rabaul, where it will be unloaded for temporary storage prior to export.

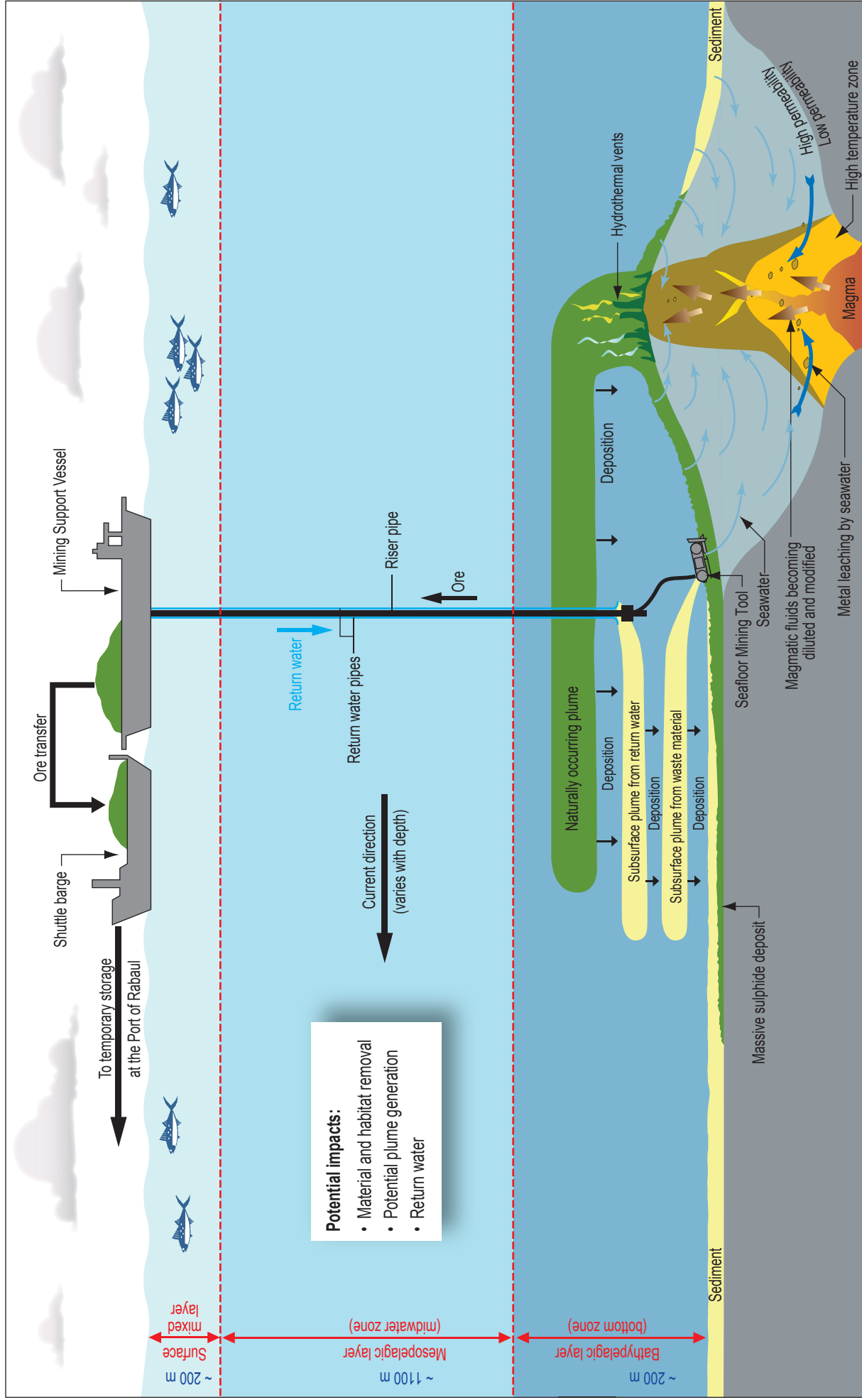
The most significant source of underwater noise is predicted to be from cavitation noise produced by the thrusters on the MSV, although this will not be substantially different from the underwater noise from the vessels involved in exploration and research. If unplanned events were to occur, additional issues could arise from loss of material from abnormal conditions, ranging from minor leaks of hydraulic fluids, pump and rise pipeline failures, spillage of ore during transfer, to ship collisions (unlikely).

### **4.2 Mitigation – Natural**

There are many mitigation approaches open to Nautilus, including design of the mine plan based around enhancing natural aspects of the prevailing environment and minimising impacts. Mining cannot remove or exhaust the natural venting energy source at Solwara 1, which will continue until the underlying geothermal energy source naturally dissipates. The active venting field will remain, chimney structures will reform and the underlying hydrothermal energy basis will still exist for the potential re-establishment of vent-dependent and associated communities.

The time sequence for the recovery of fauna is not known precisely but it is expected, from observations during research surveys, that within a few years, the major faunal elements will have re-established. It is also evident that animals living in such a highly mineralised area are tolerant to the naturally elevated levels of metals in ambient water and sediments compared with those from mid water or shallower and less naturally contaminated environments.





Note: Diagram not to scale

**coffey**  
natural systems

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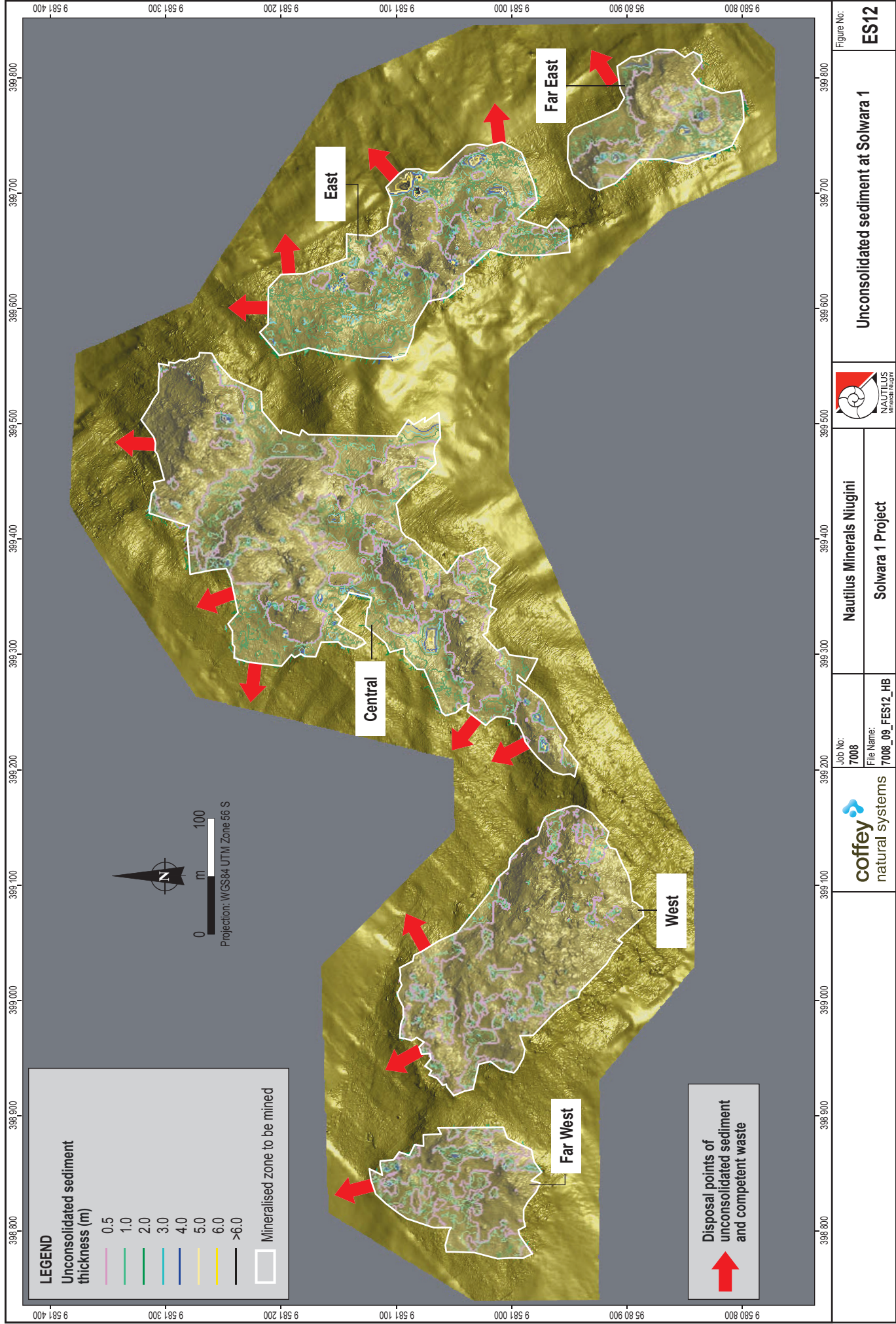
Solwara 1 Project



Sources of potential impact from  
offshore mining operations

Figure No:

**ES11**



Disturbance of the seafloor and the return of water and some entrained sediment to its area of origin is unlikely to affect the resident benthic animals as it might do to the shallow water test organisms. Even so, the assessment of potential impacts from water and sediments (e.g., from dewatering) are based on calculations of dilution factors to meet ANZECC/ARMCANZ (2000) water quality guidelines for dissolved metals.

The presence of natural plumes over the Project area and periodic volcanic deposition originating from North Su (approximately 1 km southeast of Solwara 1), and other sources indicates the dynamic natural processes at play. Within this setting, localised sediment disturbance and dewatering discharges are expected to be minor.

There are also physical limitations to the areas in which the SMT can operate, for example, there are limitations to the hydraulic systems at water temperatures above 35°C. Temperature sensors on the SMT will detect ambient temperatures so that it can withdraw from the area in the event of detection of excess temperature. The extent of the area unable to be mined for reasons of temperature is not fully known but it is expected that the SMT would be able to operate up to 1 m from any hot vent.

### **4.3 Mitigation – Seafloor Biodiversity Protection**

The operational mitigation strategies described below are aimed to reduce the impacts to the seafloor environment to levels as low as can be achieved. These have been developed in consultation with the research scientists who conducted the research and impact assessment work.

The main objectives are the protection of biodiversity and maintenance of nearby communities of animals to enhance the rate of recovery post-mining. The three ways proposed to maximise recovery success are the protection (from current mining) of a nearby reference area at South Su, the retention of temporary unmined refuge areas within Solwara 1, and the enhancement of recolonisation by translocation of animal communities from areas about to be mined to areas where mining is complete.

While it may be difficult to determine which of these methods is most effective, demonstration of recovery and ecological sustainability is the immediate priority of the Project.

#### **Unmined Control Area at South Su**

South Su is proposed to remain as an unmined control area about 2 km up current from Solwara 1 until the completion of mining and confirmation that the rehabilitation techniques are effective at Solwara 1. It is expected to provide a source of recruitment to mined areas and provides a control location to set up transects to monitor natural variations in vent activity and communities over time. Biological comparisons of the two areas have shown that the active sites at both Solwara 1 and South Su share the same biomass-dominant species and generally similar indices of diversity and community structures. Where there are significant differences, South Su generally has higher abundances of secondary species and higher dominance of some groups. Some recruitment may also come from North Su, where mining is not currently planned. However, because of the continuous active conditions and sediment-occluded visibility at North Su at the times of surveys, it has not been possible to characterise its vent communities to the same extent as at Solwara 1 and South Su.

#### **Temporary Refuge Areas within Solwara 1**

Not all of the resource can be mined simultaneously. Mining will be sequenced according to the mine plan that currently proposes that mining of the mineralised East and Far East Zones will be

the last in the development of the Solwara 1. Therefore, these areas will function as undisturbed sources of parent fauna and supply of larvae within Solwara 1 (Figure ES04) for the greatest amount of time. However, it is difficult to prescribe which areas will be the last to be mined, or the size of any areas potentially set aside as refuge areas, while allowing for flexibility in the mine plan during the progress of mining.

This is referred to as a 'temporary refuge area', and it is based on the expectation that recovery will be sufficiently well-progressed to meet specified criteria that monitoring can demonstrate that the major community elements (i.e., the three biomass-dominant species) have re-established at active chimneys in the earliest mined-out area, to enable the refuge areas to be mined. However, mining at the refuge areas will not commence until these recovery criteria have been met.

### **Transplant of Animals**

The loss of animals in the path of the SMT is partially avoidable and it is proposed that the ROV remove large clumps of rock substrate with its biology intact and relocate them initially to unmined areas for preservation and ultimately to venting areas where mining is complete. These clumps will be targeted to maximise the biomass-dominant species and any other associated attached or sessile fauna. Monitoring will be undertaken to confirm the success of this strategy. The extent to which this will be done is a matter of practicality and will be undertaken opportunistically and during routine monitoring.

### **Artificial Substrate**

Colonies of bamboo coral (*Keratoisis* sp.) are characteristic of hard substrates in mainly inactive areas away from the vent ecosystems and it is expected that recovery of these, and their associated fauna after disturbance, will be slower (compared with animals of active areas). In order to enhance this process, hard settlement surfaces (e.g., concrete plates) will be located in appropriate areas. Using the ROV, representative stands of *Keratoisis* will also be removed from the path of mining (where multiple stands are within easy access of the ROV), and repositioned in structures such as crates, where they might reform attached colonies. The survival and growth of such transplants will be monitored, with continued relocation if successful.

### **Disposal of Unconsolidated Sediment and Competent Waste Material**

The Solwara 1 deposit is variably covered by an unconsolidated sediment layer composed of fine silt and clay as well as containing some competent waste material within the designed mine area that is below the mine cut-off grade. It is proposed to remove the unconsolidated sediment (approximately 130,000 t) before mining commences in each area by side casting to the outer areas of Solwara 1 mound as outlined in Figure ES12. The competent waste material (approximately 115,000 t) will also be relocated to the same area. Side casting has less impact on this material than transporting the material to the surface and returning it to the seafloor, as there will be no temperature or oxygenation changes.

## **4.4 Mitigation – Protection of Coral Reefs and Fisheries**

### **Dewatering Plume**

The avoidance of impacts on coral reefs, fish and large marine animals such as whales, dolphins and turtles from discharge of water and entrained sediments from the dewatering process on the MSV will be achieved by:

- Discharging at depths between 25 to 50 m above the seafloor to confine all impacts to the bottom zones from where the water/sediment originated. Benthic animals are most adapted to this material while surface and mid-water species will not be exposed.



- Retaining all particles above (nominally) 8 µm in size, which is expected to significantly reduce the quantities of sediment lost in the dewater discharge. The proportion of particles below this size is estimated to be less than 5% of the total suspended solids.
- Limiting the exposure time to surface temperatures and oxygenation to 12 minutes, thereby reducing potential for geochemical changes. Temperatures are not expected to exceed 13.5°C (note that it is expected to take some start-up time and initial trials to achieve these equilibrium conditions of handling time and discharge temperatures). Additionally, the pipes used to transport the return water to the seafloor will allow for cooling of the return waters.

### **Surface Activities: MSV and Ore Transfer**

An exclusion zone of 500 m will apply around the MSV at all times to avoid risks of collisions. This is a minor area of fishing exclusion for mainly commercial tuna fishing, but the Project area is not one from which catch return statistics indicate there would be any significant impact. Normal maritime navigational and communications procedures will apply for all shipping in the area to maintain safe distances. Being so far offshore, the recorded frequency of inshore vessels such as canoes and small vessels occurring at Solwara 1 is low.

The main source of underwater noise from the Project is the operation of the thrusters on the MSV. Modelling suggests these levels attenuate rapidly within the first 2 km and could only be sufficient to cause whales to deviate in direction if they approach within 1 to 2 km of the source, although some attraction or avoidance behaviour may occur beyond this distance until animals become accustomed to the operations. Sounds are insufficient to cause physiological harm and as a stationary source, risks of collisions or sudden exposure to loud sounds are low. Tug and barge movements will also be very slow (6 to 8 knots) and easily avoidable by large marine animals and other vessels.

### **Hazard Management**

The risks of major losses of equipment or spills of ore or fuel oils (during operational and abnormal conditions) will be extremely low with the implementation of best practise vessel and equipment maintenance procedures, navigational procedures, safety plans, environmental management plans, and emergency response plans.

## **4.5 Residual Impacts**

The residual impacts that are predicted after the implementation of the aforementioned mitigation measures are described as follows.

### **Venting**

In areas where the SMT has completed mining, venting of fluids will continue at new or pre-existing locations. New chimney structures will start to reform within hours to days (depending on temperature and chemistry of venting fluids), as the vent fluids mix with the seawater causing metal sulphides to precipitate. Diffuse venting may also continue in any mined areas where soft sediments settle, although in the directly mined areas, the majority of the existing soft sediments will have been mined or removed.

### **Biodiversity and Endemism**

After an area is mined, recolonisation around actively venting areas is expected to follow a succession that is initiated by the rapid (days to weeks) formation of microbial mats on the newly exposed surfaces, followed by the establishment of the characteristic vent-dependent, zone-forming snail and barnacle species and their associated fauna respectively, as described at other

ocean vent systems. The rate of recovery will depend on the relative success of the following main mitigation measures:

- Active relocation of clumps of biomass-dominant animals to suitable unmined or mined-out areas.
- Migration of adults or settlement of larvae produced by those adults from the unmined areas or temporary refuge areas within Solwara 1.
- Settlement of larvae produced from the unaffected communities of the South Su control area.

With these measures, it is expected that, after a transition period of a few years post mining, populations characteristic of active sulphide mounds will return and reorganise to a condition (biomass and diversity) that resembles the pre-mining state, with overall effects being reversible and moderate.

In the inactive hard (sulphidic) surfaces and sediments, it may take more years to return to pre-mining conditions, due to presumed slower growth rates. Actions to enhance recolonisation of *Keratoisis* and its associated secondary species will be monitored to determine recovery rates.

The efforts of Nautilus to set aside refuge areas and to salvage and relocate animals are expected to lower substantially the risks of loss of biodiversity and endemism. At the inactive sedimentary areas, natural recolonisation is expected to occur but will be slow, with no practical means of enhancement by relocation of benthic fauna.

### **Disposal of Unconsolidated Sediment and Competent Waste Material**

The coarser fraction of disposed material will rapidly settle immediately downslope of the disposal point and form mounds slightly over 500 mm deep. Lighter materials will travel further from the disposal points, and the lightest components of the disposed materials will form plumes near the seafloor.

Plumes will rapidly settle on the seafloor no further than 1 km from the point of discharge around Solwara 1. The resultant footprint depth will be between 0.18 and 500 mm and cover an area just over 2.3 km<sup>2</sup>. Some deposition will occur further afield, but at a thickness less than natural sedimentation rates.

The material being entrained is not expected to undergo significant geochemical change through reaction with seawater under the conditions that exist within the environment downstream of Solwara 1. Fauna in areas of settlement of SMT-induced sedimentation and unconsolidated sediment may be smothered; however, there is very low biomass in the areas that are being considered for sediment placement. Interstitial microbial animals are likely to survive the processes of relocation and resuspension/settlement of sediments by the SMT in newly settled area. Expected impacts are therefore mainly to filter feeding organisms outside the area of mining.

### **Suction and Loss of Organisms at the SMT**

The water pumped from the SMT to the vessel will potentially contain some entrained organisms such as planktonic larvae or small fish that would not be able to survive the rise to surface. The net movement of water over Solwara 1 (to a height of 20 m above the seafloor) measured over 12 months is in the order of 8,800 ML/day. The volume of water sucked in by the SMT during mining is estimated at 24 ML/day, which represents less than 0.3% of the potential larval entrained water around the mound.

## Plumes from Dewatering Discharge

Results of elutriate tests indicate that, at the point of discharge, concentrations of some metals contained in water released to the environment will be above ANZECC/ARMCANZ (2000) guidelines for 95% protection. A 600-fold dilution will be required before guidelines for metals are met. Hydrodynamic modelling indicates that the required number of dilutions will be achieved 85 m from the point of discharge.

Plumes of suspended sediment formed from material entrained in the return water discharge will require a 5,000-fold discharge to meet ANZECC/ARMCANZ (2000) guidelines for 95% protection levels for total suspended solids. On average (i.e., for 183 days per year), plumes will not extend more than 900 m beyond the point of discharge (and cover an area of 0.81 km<sup>2</sup>) before meeting the target TSS concentration protection levels.

Additionally, plumes will not rise above 1,300 m water depth and will not affect North Su or South Su, instead they will generally occur above Solwara 1 and to the northwest. Suspended sediment will flocculate and settle on the seafloor approximately 5 to 10 km to the west and northwest of Solwara 1. Maximum depositional thicknesses will not exceed 0.1 mm and rates of settling are less than existing deep-sea sedimentation rates as measured at Solwara 1 and South Su.

Within the context of the ambient seafloor geology and the fallout from the particulate plumes originating from North Su, and to a lesser extent South Su and Solwara 1, the animals are likely to be adapted to naturally elevated metal concentrations and sedimentation.

## Surface Activities

The application of an exclusion zone and normal maritime navigation and communication procedures will limit the impact of the operations to the area of the site.

Characteristics of the MSV's thrusters have been used to model noise attenuation, which is rapid for the first 2 km, then slower beyond that distance in deep water (with an assumed reflective basaltic seafloor).

Levels are insufficient to cause any physiological harm. As with all vessels in open oceanic water, noise will be audible for considerable distances but all received levels are expected to be below 140 dB re 1 µPa within about 1,100 m from source. The MSV will be stationary, thereby reducing any significant risks of collisions or interference with whales. While some avoidance or attraction may occur, even as far as 15 km from the vessel, habituation is likely. Experience from analogous situations, wherein whale migrations off the east and west coasts of Australia and west coast of USA continue past offshore oil and gas infrastructures, suggests that any risks from the operation are considered to be very low.

## 4.6 Onshore Issues

Onshore issues are those that potentially occur in or in the vicinity of the Port of Rabaul. Pollution of the marine environment can arise from spills of ore, hydrocarbons or chemicals or from inappropriate disposal of waste. The risk of pollution and product spillage is likely to be greater around areas such as refuelling stations and loading/unloading areas.

The highly sulphidic nature of the ore may give rise to the potential for acid generation once exposed to air during the dewatering process, transport and while temporarily stored in stockpiles. Acid rock drainage (ARD) increases the ability for heavy metals to leach from the ore into the surrounding environment, resulting in contamination and potential toxicity to aquatic organisms and groundwater.

During port operations, activities associated with the Project could add to the overall affect on the amenity of surroundings in the form of noise and particulate matter emissions. The closest noise sensitive receptor to the port has been identified as a house approximately 60 m away.

### **Mitigation**

Best management practices will be applied to prevent spills or discharges of ore, hydrocarbons or contaminated water to the land or marine environment. A designated refuelling area, and spill response procedures will be established. Waste from ships will be managed in accordance with the MARPOL 73/78 Convention and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* which states that no disposal of food wastes or untreated sanitary wastes shall take place within 12 nautical miles of land. The MSV is more than 12 nautical miles from land and food scraps and sewage will be macerated and treated to MARPOL standards.

To prevent ARD, the stockpiles will be covered to reduce infiltration of rain and low pH runoff. The ore will be dewatered to 8% moisture content offshore prior to transport onshore. Stockpiles will be bunded and covered to limit exposure to wind and water. Clean water runoff will be diverted away from the stockpiles and drainage from the stockpiles will be directed into sedimentation ponds to enable monitoring and treatment, if necessary. Any contaminated runoff will be neutralised and solids returned to stockpiles and water treated to ANZECC/ARMCANZ (2000) standards and either discharged to Simpson Harbour or returned to the MSV for discharge at depth with return water.

The equipment associated with the most dominant noise sources at the port will be carefully designed to reduce operational noise and any adverse levels to sensitive receivers outside the port facility.

Procedures for managing dust will be included in the operation's Environment Management Plan and will include covered stockpiles, dust suppression, enclosed conveyors and suspension of ore handling in adverse wind conditions.

### **Residual Impacts**

The Project does not involve bulk handling or storage of waste materials onshore i.e., all of the materials transported or stored in bulk are either the product (ore) or fuels and provisions, for which measures will be in place to prevent loss. Implementation of the proposed management measures will reduce the risks of spilling ore, fuels or chemicals to levels as low as practicable. The consequences of any small spills will be minor.

Noise from construction at the port is expected to be moderate and within the background noise levels of existing activities within the port. When operating, equipment may be heard by nearby residents; however, as there are already industrial noise sources in the area, the level of disruption to local residents is not anticipated to be high.

Due to the high background particulate matter associated with the nearby volcanic activity, any increased dust associated with the port operations is expected to have a negligible impact on nearby receptors.

## **5. Social Setting and Impacts**

### **5.1 Social Setting**

As this is an offshore mining project and the small onshore component will utilise an existing commercial facility, the social impact assessment has been based on areas where:

- Local employees will be recruited.
- Contractors and suppliers are located.
- Benefit streams will be distributed, e.g., royalties and taxes.
- Onshore activities will take place, e.g., ore rehandling/blending pads.
- Offshore activities will take place, e.g., fishing and marine traffic.

This primarily relates to the local areas of Rabaul and Kavieng. The broader areas include other parts of PNG; hence, a description of the social setting for both follows.

## **Papua New Guinea In Brief**

### ***Population, Communities and Land Ownership***

While the overall population density in the country is low, there are pockets of high-population density. The spectrum of PNG society ranges from traditional village-based life dependent on subsistence production (sago cultivation, fishing, hunting and gathering and agriculture) and small-scale cash cropping to modern urban life in the main population centres of Port Moresby, Lae, Madang, Wewak, Goroka, Mt Hagen and Rabaul/Kokopo.

Social organisation is mainly based on patrilineal descent, which determines all of the important relationships of people to people, people to land, and people to their spiritual beliefs. PNG has several thousand separate communities, most with only a few hundred people. Divided by language, customs, and tradition, some of these communities have engaged in low-scale tribal conflict with their neighbours for millennia.

The most important feature of PNG society is the primacy of small clan groups and their customary ownership and control of land.

### ***Economics***

Papua New Guinea has a dual economy, comprising a formal, corporate-based economy and a large informal subsistence-based economy. The formal sector provides a rather narrow employment base, consisting of workers engaged in exploitation of PNG's vast natural resources, i.e., mineral and oil or gas production. The bulk of the population is engaged in the informal sector, which provides a subsistence livelihood for 85% of the population.

### **Rabaul**

Rabaul is a township in East New Britain Province that was formally the province capital until it was destroyed by ash from a volcanic eruption in 1994. The capital was moved to Kokopo and consequently the population of Rabaul has declined significantly. The port town remains a tourist destination popular for diving and snorkelling but is no longer the premier commercial and travel destination that it was prior to the 1994 volcanic eruption.

The PNG Millennium Development Goals rank province performance for population, health, and education against the Papua New Guinea average and show that, in general, East New Britain Province performs well above the national average.

### **Kavieng**

Kavieng, the capital of the New Ireland Province, is the largest town on the island of the same name, with a population that is at least three times that of Rabaul.

Kavieng is both a trading and tourist destination serviced by the main port for New Ireland and the Kavieng airport.



The PNG Millennium Development Goals rank show that in general, as for the other provinces in the islands region, New Ireland Province performs well above the national average.

## **Fisheries and Marine Transport**

### ***Commercial Fisheries***

The primary commercial fisheries in PNG target tuna and prawn. The tuna fishery operates within the Bismarck Sea, Coral Sea and Pacific Ocean. In 2005, a total of 284,204 t of tuna were caught within the PNG Exclusive Economic Zone (EEZ). There are no prawn fisheries in the Project area.

The domestic and locally based tuna fishery has a fleet of boats within PNG's EEZ. The annual catch has exceeded 100,000 t since 2003; 112,602 t was recorded in 2005. The licensed international tuna fishery fleet within the PNG EEZ exceeded 155 vessels in 2006 and recorded a total catch of 168,028 t in 2005.

The distribution of fishing effort in the PNG EEZ varies. The domestic and locally based fleets are concentrated in the Bismarck Sea and along the northwest coast of PNG. International fleets are concentrated further offshore.

### ***Subsistence Fisheries***

There are no subsistence fisheries at Solwara 1 and very little subsistence fishing occurs in Simpson Harbour; however, a number of fishing charters operate in and around the harbour. Generally, subsistence fishing occurs around nearshore and coral reef areas and is highly important to local people, as expressed during consultation.

### ***Marine Traffic***

Marine traffic in the Bismarck Sea includes national and local cargo and passenger traffic moving between the main PNG ports. Generally, routes are poorly defined. Smaller local transportation boats (mostly motorised dinghies and banana boats) also move between New Ireland and East New Britain.

## **5.2 Issues**

Many socio-economic and socio-cultural issues that are normally associated with terrestrial mining projects are absent from the Solwara 1 Project as the majority of Project activities will occur at sea and not be located on occupied land. Additionally, land-based Project activities in Rabaul will be limited to the confines of the Port of Rabaul, which is an existing development located on alienated land. Therefore, the Project will not cause the displacement of people from their land or alter existing land use practices.

The positive socio-economic aspects of the Solwara 1 Project relate to the income, services and personal opportunities that development brings. On the negative side are the effects that these changes can bring to social organisation, in terms of conflicts over the distribution of benefits or between immigrants and people adjacent to the Project. Sea-based activities may also disrupt fishing activities and other vessels operating in the vicinity of the Project area.

## **5.3 Mitigation and Residual Impacts**

### **Mitigation**

#### ***Economics***

Nautilus will aim to optimise the socio-economic benefits resulting from the Project by:

- Establishing a cultural awareness program for employees that will include a formal community awareness program induction on arrival at the workplace and distribution of a community awareness booklet that emphasises the rules for employees and contractors.
- Minimising the potential for interaction between outsider employees and the local communities by arranging direct transfer of fly in/fly out employees from airports to the crew boat or vessel.
- Increasing employment opportunities for local labour by implementing a Training Associated Plan that provides general principles for employment and training.

### **Fisheries and Marine Transport**

Measures to manage possible interactions between fishing and other vessels operating near the Project area will include:

- Establishment of a 500-m-radius exclusion zone around the MSV<sup>3</sup>.
- Installation of appropriate devices on the MSV to allow monitoring of and communication with approaching vessels.
- Regular communication with PNG's National Maritime Safety Authority and National Fisheries Authority to advise on Project activities and planned vessel movements.
- Revision of nautical charts (in consultation with PNG's National Maritime Safety Authority) to include the location of the MSV, exclusion zone and routine shipping routes to be used by the Project.

### **Residual Impacts**

#### ***Economic***

Economic benefit streams generated by the Project have the potential to enhance the quality of life of the general populace of PNG, particularly in New Ireland and East New Britain. The state will capture a share of profit and labour income via royalties and taxes. The major government benefit streams are:

- Royalties.
- Taxes.
- Production levy.
- Value added tax.
- Fuel excise tax.
- Community Development Fund.
- Import duties.

#### ***Community Development Fund***

Nautilus will manage a Community Development Fund that will receive two Kina per tonne of ore mined. Nautilus will work with the provincial governments of New Ireland and other island provinces to identify community priorities, and to create opportunities for improved quality of life

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<sup>3</sup> Various acts (e.g., the *Australian Offshore Petroleum Act 2006* and *United Kingdom Petroleum Act 1987*) suggest a minimum 500-m exclusion zone around permanent offshore oil and gas facilities to avoid ship collision.

through the provision of health and education services. It is anticipated that a total of US\$2.21 million (PGK \$5.8 million) will be paid into the fund over the life of the Project.

### ***Industry Diversity and Skills Development***

An active training program will provide training for the people of PNG. This program will be focused on enhancing the employment benefits for PNG and will provide skills development for local people.

### ***In-migration and Community Conflicts***

In-migration to Kavieng and Rabaul has the potential to create added pressures on social and economic infrastructure and to cause disruptive social tensions. Nautilus' recruitment policy will assist in deterring non-local people moving to Rabaul and Kavieng with the expectation of employment with the Project. Therefore, it is not expected that migrants will reduce the opportunity for local people to gain employment. Nautilus will work with local and district authorities to monitor in-migration and, if required, seek ways of improving its management.

### ***Fisheries and Marine Traffic***

Due to the comparatively small size of the exclusion zone that will be established around the MSV at Solwara 1, it is anticipated that any inconvenience experienced by the commercial fleets operating in the Bismarck Sea relating to restriction of movement and fishing areas will be negligible.

Subsistence and small-scale coastal fishing activities are restricted to waters close to shore and no fishing is expected to occur at Solwara 1. Therefore, no adverse effects due to interference with fishing vessels are anticipated.

Overall impact on marine traffic from the Project is anticipated to be low.

## **6. Greenhouse Gas and Climate Change**

Greenhouse gas (GHG) emissions from the Phase 1 Project consist almost entirely of fuel combustion CO<sub>2</sub> emissions, the majority arising from the MSV. As there is no ore processing within PNG in Phase 1, total GHG emissions are relatively low compared to other PNG mining projects and therefore the contribution to PNG GHG (CO<sub>2</sub>-equivalent) emissions in the context of potential climate change impacts is minor.

Phase 1 GHG emissions from fuel combustion for Solwara 1 are 0.062 Mt CO<sub>2</sub>-equivalent/a. This compares to PNG GHG emissions for 2005 (latest available data) of 4.35 Mt CO<sub>2</sub> equivalent/a from the same source. Therefore, the Project is expected to increase annual GHG emissions from fuel combustion in PNG by 1.43%.

## **7. Public Consultation**

Public consultation is a requirement of the state's environmental impact assessment process under the *Environment Act 2000*.

The Project's consultation and disclosure program has involved extensive interactions with stakeholder groups using multiple approaches designed to suit each group and has garnered a large amount of interest. Information about the Project has been presented on a number of occasions to communities in New Ireland Province, East New Britain Province and provinces further afield. There has been ongoing regular consultation with PNG government departments.

Consultation with NGOs and the international scientific community has included formal meetings, presentations and workshops. A comprehensive list of stakeholders has been developed and grouped into broad categories reflecting differing interests in relation to the Project. The categories are shown below:

- PNG national government.
- PNG provincial governments.
- Landowners outside but near Solwara 1.
- NGOs.
- Industry groups.
- Academic and research organisations.

The main goals of the Project's public consultation and disclosure program are to:

- Build an understanding among stakeholders to provide a structure for stakeholder input in the environmental impact assessment process.
- Ensure that relevant government departments and communities adjacent to Solwara 1 are properly informed about the Project.
- Ensure consideration is given to the valid concerns and interests of stakeholders.
- Incorporate concerns into mitigation plans as practicable.
- Provide the groundwork for final presentation of the EIS and ongoing consultation throughout the life of the Project, i.e., construction, operations and decommissioning phases.

The Project's public consultation and disclosure program uses both formal (e.g., presentations, meetings, surveys and workshops) and informal (e.g., visits to villages in New Ireland and East New Britain provinces leaflet and brochure distribution, face-to-face and telephone conversations, emails or facsimiles) methods to disseminate information to, and to solicit comments from, and to address the concerns of stakeholders regarding the Project. The main concerns expressed and means to address these are described in Section 3 above.

In March 2007, a workshop was held in Port Moresby, primarily to solicit the views of international scientific experts on the ecology of sulphide chimneys, was also attended by local and international NGOs, environmentalists, anthropologists, consultants, and representatives from the PNG Department of Mining and Department of Environment and Conservation. The purpose was to allow for early identification of issues, input into EIS study design in the initial phases of the Project, and to provide transparency of proponent purpose.

A follow-up workshop was held in San Diego, USA on 17 and 18 April 2008, principally with the international research scientists. Its purpose was to discuss the findings of the research studies that were completed for the environmental impact assessment and in the light of these, to recommend mitigation measures (principally for the protection of biodiversity of the area and facilitation of recolonisation of mined areas), and further baseline and monitoring studies as appropriate.

These measures have been accepted by Nautilus and also developed with the scientists, and are reflected in the mitigation plans (where they relate to seafloor ecology) and form the basis of the environmental management and monitoring programs.

The information obtained from all forms of public consultation is documented in meeting notes, consultation logs and as part of various EIS studies. These records are maintained by the Project.



Consultation with stakeholders will continue during the remainder of the environmental impact assessment and approvals process associated with the Project and will include:

- An EIS information briefing roadshow by Project representatives with assistance from DEC officers, soon after the submission of the Draft EIS.
- A program for consultation and disclosure prior and during operations to be included in the Environmental Management Plan.

## **8. Cumulative and Associated Impacts**

Being the first to mine SMS deposits implies a likelihood for subsequent seafloor prospect developments and issues of future cumulative effects. This places the onus on Nautilus to manage its impacts and rehabilitation of mined areas without simply relying on the existence elsewhere of similar habitats and fauna to represent those potentially lost at Solwara 1, particularly if these areas themselves become subject to future mining proposals.

Nautilus has proposed mitigation strategies to leave temporary refuge areas within the mineralised area of Solwara 1 and to salvage and relocate animals to mined areas as practicable, thus managing its mining and rehabilitation program without reliance on compensatory 'sterilisation' of other seafloor areas from mining.

In addition, the unmined area at nearby South Su contains very similar biological communities and will also provide source of recruitment to Solwara 1, which is about 2 km down current. The effectiveness of the methods proposed to protect biodiversity and enhance recovery at Solwara 1 will be monitored throughout and beyond the life of the Project, and will provide valuable scientific information to assess the potential for any cumulative effects of future seafloor mining prospects.

## **9. Management and Monitoring**

### **9.1 Management**

The preparation of environmental management plans (EMPs) is expected to be a condition of approval of the EIS. The EMPs will demonstrate how Nautilus' environment policy will be implemented and will expand on the information presented in this EIS.

The EMPs will have specific objectives to document Nautilus' approach to environmental management (such as the environmental management system, schedules, organisational structures and responsibilities), describe how the Project's environmental issues will be addressed, and detail the program that will monitor and report on the Project's effects and its compliance with regulatory permits and licences. The latter includes validation of predicted impacts and identification of unforeseen effects and needs for additional management measures.

The Project will be managed under the governance of an environmental management system that will be developed in accordance with the international EMS standard, ISO 14001:2004, adapted for use in Australia and New Zealand as AS/NZS ISO 14001:2004. These standards provide Nautilus with the elements of an effective environmental management system (EMS), that is, a procedure for implementing, achieving, reviewing and maintaining the company's environment policy, and also incorporate good industry environmental management practice, which forms the basis of a project-specific EMS.

The EMPs for the Solwara 1 Project will be prepared and implemented within the EMS framework and will address the management, monitoring and reporting requirements for the various phases

of the Project, e.g., baseline, operations and decommissioning, taking into account the commitments made in this EIS and the conditions of approval stipulated by the state.

## **9.2 Monitoring**

The validity of the predicted effects of the Project is dependent upon the Project being constructed and operated in the manner described in the EIS. The main components of the monitoring program described in the EIS will reflect reasoned prediction and testable propositions that have been developed in consultation with international scientists and leading environmental practitioners. Further details of Nautilus' proposed monitoring program, including descriptions of the methods, locations and frequency of monitoring, will be included in the detailed EMPs to be submitted to the government after approval of the EIS.

Environmental Impact Statement  
Solwara 1 Project







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