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Report

Preliminary Economic Assessment of the Solwara Project, Bismarck Sea, PNG

Nautilus Minerals Niugini Ltd

Technical Report compiled under NI 43-101

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There are no Mineral Reserve estimates for Solwara 1 and the potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study. The terms “mineralised material” and "material" are used in this report to denote mineralised material above a cut-off grade on which the proposed mining, processing and product shipping activities are designed to operate. It does not imply that Mineral Reserves have been estimated at the date of this report.

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List of Acronyms and Terms

acQuire – a Geoscientific Information Management System

ALS – ALS Group, an analytical data service and metallurgy service provider for the mining industry

API - American Petroleum Institute

APASA – Asia Pacific Applied Science Associates, a science and technology company

AQIS – Australian quarantine inspection service

AUV – Autonomous Underwater Vehicle

BSL – Below Sea Level

BSSIPIC – Bismarck Solomon Seas Indigenous Peoples Council

BTS – Brazilian indirect tensile strength

CEPA – Conservation and Environmental Protection Agency

CHIRP – Sonar used to image shallow subsurface structure beneath the seafloor

CIQ – Exit-Entry Inspection and Quarantine Bureau of the PRC

Coffey – Coffey Natural Systems Pty Ltd, a consultancy firm

CRM – Certified reference material

CSIRO – Commonwealth Scientific and Industrial Research Organisation

CuEq – Copper equivalent

DEC – PNG Department of Environment and Conservation

DPS – Dynamic positioning system

DRA - DRA Pacific Pty Ltd

DRS - Drillers Record Sheet

DSMC – Deep-Sea Mining Campaign

DTM – Digital Terrain Model

EIR – Environmental Inception Report

EIS – Environmental Impact Statement

EL - Exploration Licence

ELA – Exploration Licence Application

EM – Electromagnetic

EMP – Environmental Management Plan

EP – Environmental Permit

EPCM – Engineering, procurement, and construction management

ESIA – Environmental and Social Impact Assessment

FF – Fracture frequency

FOS – Factor of Safety

GAAP – Generally accepted accounting principles

GE – General Electric

Golder Associates – Golder Associates Pty Ltd, an earth science, engineering and environmental consulting company

GSI – Geological Strength Index

HARD – Half absolute relative difference

HRD – Half relative difference

Hmax – Maximum Wave Height

Hs/Hsig – Significant wave height

Hz – Hertz, cycles per second

ICP-AES – Inductively Coupled Plasma Atomic Emission Spectrophotometry

ICP-MS - Inductively Coupled Plasma Mass Spectrometry

ICP-OES - Inductively Coupled Plasma Optical Emission Spectrometry

IDW – Inverse Distance Weighting

IFC – International Finance Corporation

IMDG - International Maritime Dangerous Goods

IMSBC – International Maritime Solid Bulk Cargoes

LBMA – London Bullion Market

LCT – Locked cycle flotation test

LDL – Lower Detection Level

LME – London Metals Exchange

LPF – Low Pass Filter

LS – Lithified Sediments

MAC – Marine Assets Corporation

MARPOL - International Convention for the Prevention of Pollution from Ships

MBES – Multi Beam Echo Sounder

mc – Moisture content

The Mining JV – An unincorporated joint venture between Nautilus and the government of PNG formed for exploiting Solwara 1

ML – Mining Lease

MLA – Mining Lease Application

MODA - McArthur Ore Deposit Assessments Pty Ltd

MRA - Mineral Resources Authority of Papua New Guinea

MSE – Mean Specific Energy

MSL – Mean Sea Level

MV – Marine Vessel

NATA – National Association of Testing Authorities, Australia

NGO – Non-governmental organisation

NI – National instrument

NITON – A field portable X-ray fluorescence analyser marketed by Thermo Fisher Scientific Inc.

NSR – Net Smelter Return

NUSD – Secondary reference material produced by Nautilus from drill core collected at Solwara 1

OFEM – Ocean Floor Electromagnetic

OFG – Ocean Floor Geophysics

OK – Ordinary Block Kriging

PACMANUS – Papua Niugini-Australia-Canada-Manus

PCD – Polycrystalline Diamond

PEA - Preliminary Economic Assessment

PLCM - Portable linear cutting machine test

PNG – Independent State of Papua New Guinea

PRC – The People's Republic of China

PSM – Pells Sullivan Meynink, a geotechnical consultancy firm

PSS – Perry Slingsby Systems, provider of remote intervention technologies and equipment systems

QAQC – Quality Assurance Quality Control

RC – Refining chage

REM – REM Offshore, Norwegian supply shipping company

ROV – Remote Operated Vehicle

RPS – RPS Group Plc. Includes the subsidiary company RPS Metocean

RQD – Rock quality designation

RV – Research Vessel

SEDAR – The System for Electronic Document Analysis and Retrieval, a filing system used by the Canadian Securities Administrators

SGS - Société Générale de Surveillance, inspection, testing, certification & verification services

SLCM - Small-scale linear cutting machine test

SMD - Soil Machine Dynamics Ltd

SMS - Seafloor Massive Sulfide

SP – Self Potential

SQL – Structured query language

SRK – SRK Consulting, mining consultants

SRM – Secondary Reference Material

SWIR – Short Wave Infrared

TC – Treatment Charge

The Project – Nautilus's Solwara 1 project

The Property – Nautilus's entire tenement holding in the Bismarck Sea

TML – Transportable Moisture Limit

TNT – TNT, Express transportation distribution

Tp – The wave period, at the peak spectral energy (in seconds). This is an indication of the wave period of those waves that are producing the most energy in a wave record.

TSM – TS Marine, specialist marine and subsea operations services provider

TSS – Total suspended sediment

Tz – Average period (average period of waves observed, weighted by wave energy)

Ug – Mean Gust Speed over a second period

U1 – Mean Wind Speed over a 1-minute period

U10 – Mean Wind Speed over a 10-minute period

U60 – Mean Wind Speed over a 60-minute period

UCS – Uniaxial compressive strength

USACE – U.S. Army Corps of Engineers

USBL – Ultra Short Baseline (method of underwater acoustic positioning)

UTEC – Offshore survey services supplier

V-5 – Steady current at 5 m below mean sea level

V-325 – Steady current at 325 m below mean sea level

V-610 – Steady current at 610 m below mean sea level

VHMS – Volcanic Hosted Massive Sulfide

XRF – X-ray Fluorescence

Ag – Silver

Al - Aluminium

Au – Gold

As – Arsenic

Ba – Barium

Be – Beryllium

Bi – Bismuth

Ca – Calcium

Cd – Cadmium

Co – Cobalt

Cr – Chromium

Cu – Copper

Fe – Iron

Hg – Mercury

K – Potassium

Li – Lithium

Mg – Magnesium

Mn – Manganese

Mo – Molybdenum

Na – Sodium

Ni – Nickel

P – Phosphorus

Pb – Lead

S – Sulfur

Sb – Antimony

Se – Selenium

Si – Silicon

Sr – Strontium

Te – Tellurium

Ti – Titanium

V – Vanadium

W – Tungsten

Zn – Zinc

N – North
E – East
S – South
W – West
NNE – North North East
NE – North East
ENE – East North East
ESE – East South East
SE – South East
SSE – South South East
SSW – South South West
SW – South West
WSW – West South West
WNW – West North West
NW – North West
NNW – North North West

° – degree
% – percentage
% volume/volume – a percentage calculated by reference to volumes
°C – degrees centigrade
$ – US dollar
$/g – US dollars per gram
µm – micrometre
bcm – bank cubic metre
cm – centimetre
cP – centipoise (the unit for viscosity)
d/a – days per annum
dB – decibel
dmt – dry metric tonne
h/d – hours per day
hr – hour
Hz – Herz
g/t – grams per tonne
k_h – Seismic coefficient values
kg – kilogram
kL/day – thousand litres per day
km^2 – square kilometre
koz – thousand ounces
kPa – kilopascal
kt – kilotonne
kW – kilowatt

kWh/t – kilowatt hours per tonne

m – metre

mbsl – metres below sea level

m/min – metres per minute

m/h – metres per hour

m/hr – metres per hour

m/s – metres per second

m^2 – square metre

m^3 – cubic metre

m^3/hr – cubic metres per hour

m^3/h – cubic metres per hour

MJ/bcm – megajoules per bank cubic metre

MJ/m^3 – megajoules per cubic metre

mg/L – milligrams per litre

min/cycle – minutes per cycle

Mtpa – million tonnes per annum

MPa – megapascal

mm – millimetre

ppm – parts per million

s – second

t/d – tonnes per day

t/h – tonnes per hour

t/m^3 – tonnes per cubic metre

wmt – wet metric tonne

1 Summary

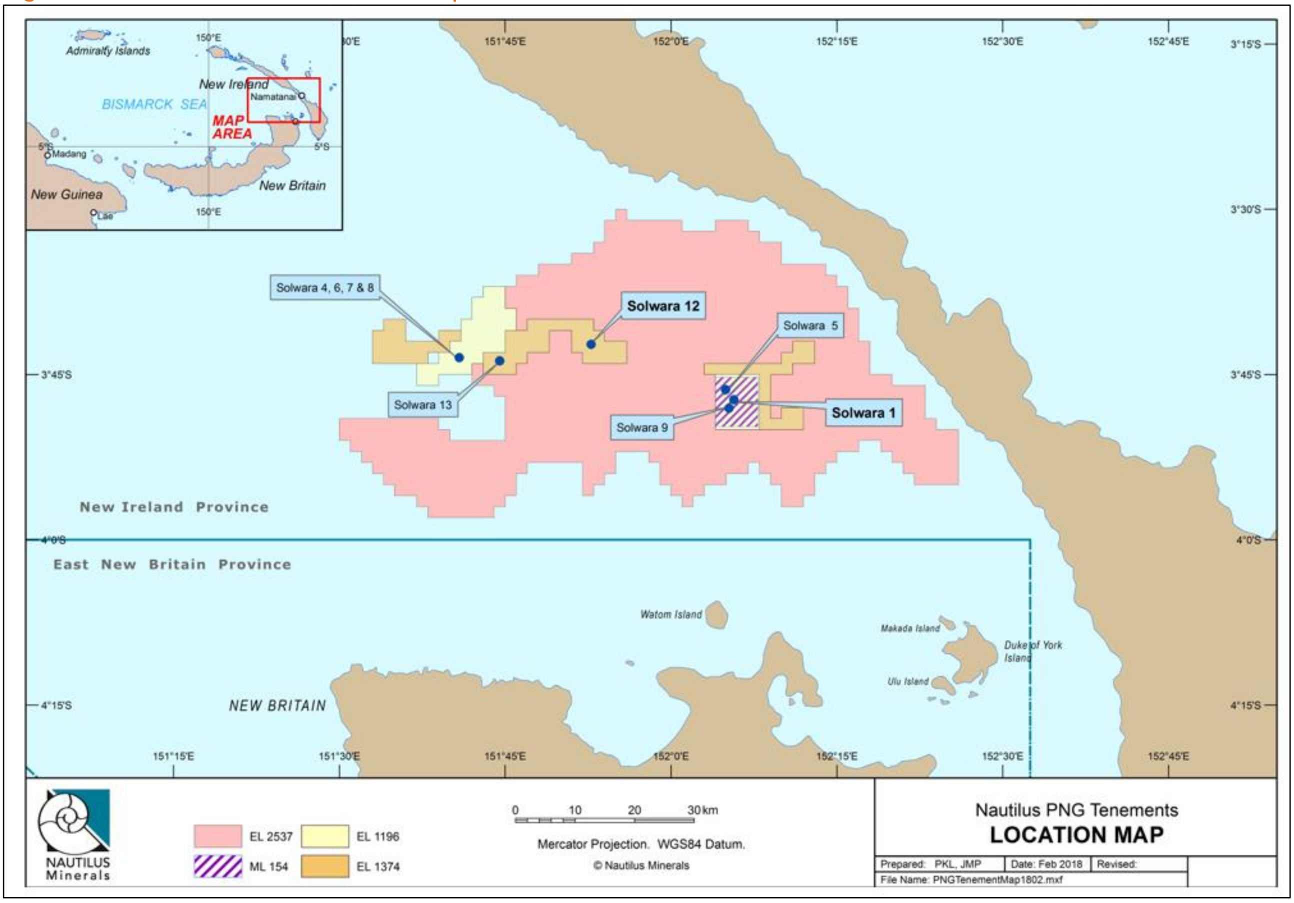
Nautilus Minerals Niugini Ltd (Nautilus) engaged AMC Consultants Pty Ltd (AMC) to undertake a Preliminary Economic Assessment (PEA) for the Solwara 1 project (the Project) and compile a Technical Report compliant with Canadian National Instrument (NI) 43-101.

The Solwara 1 project is a deep-sea mining project where construction of a commercial-scale mining operation to extract deep-sea metallic mineral resources is well advanced. Production has not yet occurred.

There are no Mineral Reserve estimates for Solwara 1 and the potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study. The terms "mineralised material" and "material" are used in this report to denote mineralised material above a cut-off grade on which the proposed mining, processing and product shipping activities are designed to operate. It does not imply that Mineral Reserves have been estimated at the date of this report.

The Solwara 1 Seafloor Massive Sulfide (SMS) deposit is located in the Bismarck Sea at latitude 3.789° S and longitude 152.094° E, approximately 50 km north of Rabaul (Figure 1.1). It lies within the territorial waters of the Independent State of Papua New Guinea (PNG). The deposit contains significant resources of massive base metal sulfides, gold and silver. The metals of primary economic interest are copper and gold.

Figure 1.1 Solwara 1 location map



Nautilus holds title over the Solwara 1 deposit through Mining Lease (ML) 154, which was granted in January 2011. Exploration Licence (EL) 1196 has been held since 1997.

A PEA is a conceptual study of the potential viability of mineral resources. This PEA indicates that the Solwara 1 project is potentially economically viable, however, due to the preliminary nature of some aspects of project planning, and the untested nature of the specific mining production systems at a commercial scale, economic viability has not yet been demonstrated.

AMC understands that Nautilus intends to use this technical report to inform the market of its updated estimates of production rate and mine life for Solwara 1 and disclose, for the first time, estimates of operating costs and potential cash flow. AMC understands that Nautilus intends to use this public disclosure to raise capital and advance the Project.

1.1 Geology and Mineral Resources

The Solwara 1 deposit is a stratabound SMS located on the flank and crest of a sub-sea volcanic mound that extends approximately 150-200 m above the surrounding seafloor. The average depth of the deposit is about 1,550 m below sea leval (BSL). The slopes of the mound are relatively steep and interrogation of a coarse digital terrain model (DTM) indicates slopes are generally in the range of 15° to 30° but can be locally steeper. There are some flatter areas near the crests of the ridges where much of the deposit is located.

The sub-surface geological sequence at Solwara 1, from the top down, may be summarized as:

Unconsolidated sedimentary rocks (lithology code SS). These typically comprise of dark grey clays and silts ranging in thickness from 0 to 5.62 m, with an average of about 1.94 m in the core holes. Due to the softness and low cohesiveness of this material, drilling recovery is commonly low in this domain.

Consolidated sedimentary rocks (lithology code SC). These typically comprise a layer of pale to dark grey, lithified volcanic sandstone varying from 0 – 4 m thick and averaging 1.54 m thick.

Mineralised and sulfate altered sedimentary rock (lithology code PT). A distinctive layer of pale to dark grey, fine to medium grained consolidated volcaniclastic sands with an average thickness of 1.1 m but locally can be up to 6 m thick. The sediments are interpreted to have been flooded by hydrothermal fluids that have precipitated a cement of opaline silica, sulfide and sulfate minerals.

Sulfide-dominant rocks (lithology code RI) and conduit facies (lithology code CF). This is the main mineralisation horizon and it varies in thickness from 0 – 29 m in the holes drilled to date. It consists mainly of pyrite and chalcopyrite, with variable amounts of anhydrite and barite.

Clay and sulfate-dominant rocks (lithology code RC and RA). The footwall to the mineralisation commonly consists of altered volcanic rocks in which most of the primary minerals and textures have been altered to clays, anhydrite, barite and disseminated sulfide. These rocks are commonly weak and core recovery is commonly low in this domain.

Local variations occur in this sequence. In addition, areas of relatively fresh lava rock overlie small areas of the mineralised domains.

Sulfide-rich chimneys are generally 2–10 m in height, but have been recorded up to 15 m high, and occur on the surface of the deposit. Most chimneys occur in several discrete chimney 'fields' separated by unconsolidated sediments (and locally by volcanic flows). Scattered chimneys occur between the main fields.

There is localised hydrothermal activity at Solwara 1. The location of venting chimneys has been identified from video footage and this venting has been shown to be episodic.

The Solwara 12 prospect is located in Mining Lease Application (MLA) 512, 25 km NW of Solwara 1 and was discovered by Nautilus during the Fugro Solstice Target Generation and Target Testing program in 2009. In addition to the size of the mapped chimney field, a remote operated vehicle (ROV) based geophysical survey indicated both an electromagnetic and a self-potential anomaly within this area. High base and precious metal grades were returned from assayed chimney samples.

The Solwara project has been explored by ROV dive videos, bathymetric surveys, geophysical techniques, surface sampling and by core drilling. To establish the extent and nature of deeper mineralisation at Solwara 1, Nautilus completed four drilling programs between 2006 and 2011.

In 2006, diamond core holes were drilled from the DP Hunter vessel from the surface at 35 locations. Core recovery was generally poor. Although the samples were generally not of sufficient quality for resource estimation, the drillholes demonstrated the presence of widespread massive sulfide mineralisation. In addition to the core drilling data, chimney samples were collected from the seafloor. These demonstrated high-grade copper, gold, zinc and silver mineralisation. Downhole geophysics conducted at the time confirmed that the copper-rich mineralisation is very conductive and could be expected to respond well to electromagnetic methods (EM).

In 2007 Nautilus conducted a six-month field campaign over Solwara 1 during which further chimney sampling and a comprehensive diamond drilling program was completed. Two ROV operated drill systems were deployed, which significantly improved drill core recovery and efficiency. The ROV drills utilised a conventional drilling system and reached depths up to 18 m below the seafloor. At completion of the drilling campaign, 111 holes for a total drilling length of 1,084 m were completed, from which 1,432 samples were sent for assay (including quality control samples). A total of 362 geotechnical tests and over 680 density measurements on drill core samples, and 86 density measurement on chimney samples were conducted on the ship. A further 90 geotechnical tests were also conducted within onshore laboratories. This data was supplemented by a high resolution 20 cm × 20 cm bathymetric survey, and the world's first underwater mineral delineation EM campaign. Detailed environmental monitoring and sampling was also carried out to provide input into environmental assessment studies, and the companies Environmental Impact Statement (EIS) to support the mining lease application.

The core recovery in the massive sulfide domain was much improved and the drilling results clearly demonstrated the continuity of sulfide mineralisation across the Solwara 1 deposit. In addition, over 80 chimney samples were collected. An extensive geotechnical testing program on drill core and chimney samples provided confidence on average density and geotechnical parameters of the mineralisation at Solwara 1. Independent audit of the logging confirmed the widespread occurrence of significant chalcopyrite mineralisation in the chimneys and drill core, broadly consistent with the copper geochemical analyses.

During the 2007 campaign, Nautilus successfully trialled and then deployed an ocean floor electromagnetic (OFEM) system over Solwara 1. The system measures electromagnetic fields associated with induced subsurface electrical currents. It was designed and built for delineating areas of near-surface copper-rich massive sulfides on the seafloor. The survey delineated a conductivity anomaly that correlates extremely well with the drillhole data and was used to aid the interpretation of the geology.

The exploration work in 2006 and 2007 enabled a 3-D geological model of the Solwara 1 deposit to be constructed. Geological modelling was carried in two stages: (1) sectional interpretation followed by wireframing to form triangulated surfaces of the sub-chimney lithology; and (2) a floating circle approach to model the base of chimneys.

To resolve differences between the drillhole collars and the final bathymetric surface, the drillholes were registered to the bathymetric surface prior to sectional interpretation.

Block grade estimation employed unfolding techniques and hard boundaries between stratigraphic domains. Due to the amount of core loss and the irregular sampling intervals compositing was not undertaken. However, to account for the variable sample lengths, samples were length-weighted during block grade estimation. Drillhole data used for resource estimation was capped at variable Cu, Au, Ag and Zn grades appropriate for the stratigraphic domain. Downhole and omni-planar correlograms were used to determine three-dimensional continuity of mineralisation. Cu, Au, Ag and Zn grades for 10 x 10 x 0.5m blocks were estimated by ordinary block kriging (OK).

Validation of the resource block model included: (1) on-screen visual comparisons with the drillhole data; (2) statistical checks between declustered data and OK estimates; and (3) an alternative inverse distance weighting estimate. No obvious errors or inconsistencies were observed. Vertical discontinuities that were observed were related to the interpreted stratigraphic contacts that were used as hard boundaries during block grade estimation.

The modelling work resulted in a maiden resource estimate for Solwara 1 of over 2 million tonnes at a 4% Cu cut-off grade (Lipton, 2008).

In 2008, a scout drilling campaign was carried out at the Solwara 1, 4, 5, 6, 7, 8 and 10 prospects, completing an additional 31 diamond holes for a total advance of 176 m. During this campaign, Nautilus also discovered buried mineralisation at the Solwara 1 North Zone while drill testing ocean floor EM anomalies proximal to the Solwara 1 outcrop. The limited number of drillholes at Solwara 1 was not sufficient to materially alter the mineral resource estimate.

The 2010/11 drilling program, conducted from the MV REM Etive, primarily focused on deeper drilling because many of the 2007 and 2008 drillholes at Solwara 1 had ended in high-grade mineralisation. Other improvements included a larger diameter drill core to improve sample size; a wire-line drill string to drill deeper holes more efficiently; an improved casing capability to enable deeper holes; and an improved landing system to handle the rugged terrain better.

Throughout each of the cruises, Nautilus executed well-planned and thorough documented procedures for gathering data and handling samples. These included comprehensive quality assurance/quality control (QAQC) procedures. The Qualified Person for the Mineral Resource statement is satisfied that the sampling, QAQC, sample preparation and assaying work was satisfactory for Mineral Resource estimation.

The 2010/11 drilling program increased geological knowledge of Solwara 1 and demonstrated continuity of high-grade mineralisation in the Solwara 1 North Zone and at Solwara 12. The additional core data obtained for Solwara 1 enabled the resource model to be updated and a maiden resource estimate for Solwara 12 to be made. Both models were built using essentially the same methods as used for the maiden resource model for Solwara 1.

The mineralisation classified as Indicated Mineral Resource was tested by drillholes spaced from less than 10 m to a maximum of approximately 50 m. Within the Indicated Mineral Resource, most of the blocks were estimated in the first estimation pass and the core recovery in the intercepts used to estimate the blocks was generally greater than 70%. In the area classified as Inferred Mineral Resource, the drillhole spacing ranges up to 200 m, but is generally less than 100 m, and the core recovery was more variable. Chimney material, where estimated, has been classified as Inferred Resource. The main criteria for this lower classification is that chimney sampling was limited to pieces of chimney that could be broken off from the mounds and that the internal grades have not been suitably tested. The Mineral Resource estimates are summarized in Table 1.1 and Table 1.2.

Table 1.1 Mineral Resource estimate for Solwara 1 and 1 North at 2.6% Cu equivalent cut off

	Class	Domain	Tonnes (kt)	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
1	Indicated	Sulfide dominant	1030	7.2	5.0	23	0.4
	Inferred	Chimney	80	11.0	17.0	170	6.0
		Consolidated Sediment	27	4.1	4.5	49	1.4
		Sulfide dominant	1330	8.1	5.8	25	0.6
		Inferred Total	**1440**	**8.2**	**6.4**	**34**	**0.9**
1 North	Inferred	Consolidated Sediment	14	2.8	9.1	81	3.4
		Sulfide dominant	65	7.8	7.5	49	1.3
		Upper footwall	21	2.8	1.1	5	0.2
		Inferred Total	**100**	**6.0**	**6.3**	**43**	**1.3**
Total	**Indicated**	**-**	**1030**	**7.2**	**5.0**	**23**	**0.4**
	Inferred	**-**	**1540**	**8.1**	**6.4**	**34**	**0.9**

Note: rounding may result in errors in reproducing the totals from the individual components shown in this table.
Solwara 1 and 1 North estimated using ordinary kriging
The effective date of the Mineral Resource is 1 January 2018.
Cu Equivalent CuEq = 0.915*Cu + 0.254*Au + 0.00598*Ag

Table 1.2 Mineral Resource estimate for Solwara 12 at 2.6% Cu equivalent cut off

Class	Domain	Tonnes (kt)	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
Inferred	Sediment	46	2.9	2.0	35	2.2
	Sulfide dominant	185	8.4	4.0	61	4.0
	Upper footwall	0.7	3.7	0.7	13	0.3
	Inferred Total	230	7.3	3.6	56	3.6

Note: rounding may result in errors in reproducing the totals from the individual components shown in this table. Solwara 12 estimated using ordinary kriging.
The effective date of the Mineral Resource is 1 January 2018
Cu Equivalent CuEq = 0.915*Cu + 0.254*Au + 0.00598*Ag

AMC considers that the following risks and opportunities may materially influence the resource estimate:

- Several drillholes at Solwara 1 ended in massive sulfide material. In such instances, and where no adjacent drillhole information was available from which the true thickness could be reasonably interpreted, the base of the drillhole was interpreted to be the base of the massive sulfides. The massive sulfide resource is therefore open at depth in some areas.
- Drillhole intercepts in the unconsolidated sediment at Solwara 1 suggested that this domain contains some material above cut-off grade. Whilst this may be likely in the form of chimney rubble or interstitial sulfide precipitation, this material has been excluded from the resource estimate for Solwara 1.
- Few drillholes were located on the exposed chimney mounds due to difficulty in landing on these structures. Consequently, the block grade estimates for interpreted massive sulfide material below these mounds is based on holes drilled adjacent to these mounds. It is possible that the massive sulfide material beneath the chimney mounds may have a different mineralogical composition being closer to the interpreted mineralising fluid source.
- Core loss in the massive sulfide domain could result in estimation bias if the core loss was preferentially related to low or high-grade material. Close-spaced (<5 m) drilling for metallurgical and geotechnical samples suggests that the probability of such preferential core loss is low.
- Significant lateral extrapolation of massive sulfide mineralisation to the boundaries of the EM anomaly was supported by all holes drilled in 2007. However, drilling in 2010/11 of the EM anomaly in part of the eastern zone failed to intersect significant thickness of sulfide mineralisation. A proportion of the Inferred Resource relies on the EM anomaly in areas that have not been tested by drilling. Furthermore, it is not possible to determine the thickness of the conductor sulfide material from the EM data, thus, the interpreted thickness of massive sulfide in areas distant to drilling is of low confidence.
- The higher-grade chimney mounds have only essentially been surface sampled by breaking off protruding chimney pieces. The interpreted depth of the chimney mounds is based on an automated algorithm that produces a truncated bathymetry that is considered geologically reasonable. However, until these mounds are tested by drilling their grade, density and depth should be considered of low confidence. If the chimney mound/massive sulfide interface is not correctly positioned then the risk to the contained metal is considered to be low to moderate as the higher grade/lower density chimney material would most likely be substituted by lower grade/higher density massive sulfide material.

The work to date at Solwara 1 and Solwara 12 has demonstrated the presence of massive sulfide mineralisation and has been sufficient to define Indicated and Inferred Resources. There remains potential for the discovery of additional resources in feeder zones extending down the main hydrothermal pathways or in buried (stacked) lenses.

1.2 Mineral processing and metallurgical testing

The Solwara 1 SMS deposit shows very similar mineralogical features to terrestrial volcanic hosted massive sulphide deposits (VHMS). The approach to minerals processing design for the Project has been to confirm that industry-standard practice for the treatment of VHMS deposits is applicable to Solwara 1 and will give an acceptable economic outcome. Despite the young age of the deposit, its location on the sea floor simplifies some aspects of its processing. For example, there is no oxidised zone or supergene zone of mineralisation to potentially cause mineral separation problems when treated by flotation.

There have been five phases of metallurgical test work on the Solwara 1 Project:

1. 1998 “skirmish” testing of five chimney specimens from various Solwara deposits.
2. 2005 “skirmish” testing of a single composite sample of chimney specimens from the Solwara 1 deposit.
3. 2007-2010 testing of Nautilus drill core from 24 drillholes in the Solwara 1 deposit supported by mineragraphy on 16 drillholes and quantitative mineralogy on material from 17 drillholes. After initial “sighter” tests at ALS AMMTEC in Perth, Australia, detailed flowsheet development was done at ALS Metallurgy in Burnie, Tasmania, Australia.
4. 2011-2012 detailed testing of Solwara 1 deposit material aimed at flowsheet optimisation, examining options to increase gold recovery, variability testing, and determination of materials handling characteristics.
5. 2012-2014 testing of aliquots of Solwara 1 samples by several potential offtakers in the People’s Republic of China (PRC).

Early testwork by Rio Tinto (1998) and Placer Dome (2005) indicated that the metallurgical characteristics of the concentrate produced from the seafloor sulfide material were similar to those from terrestrial mining operations.

A mineralogical-based approach was the driver for the metallurgical test work by Nautilus, emphasizing characterisation of the material given the difficulty and expense of obtaining samples. The materials examined and tested from Solwara 1 by Nautilus are:

- Mineragraphy – on 21 core samples from 16 drillholes.
- Quantitative mineralogy – on 10 samples composited from 24 different drillholes and 28 chimney samples.
- Metallurgical test work – on the same 10 samples as for quantitative mineralogy above.
- Variability samples for quantitative mineralogy on 21 samples from 17 drillholes and nine chimney grab samples.

The results of the mineralogical and metallurgical test work can be summarised as follows:

- Copper is present almost exclusively as chalcopyrite.
- Chalcopyrite liberation is significant at a sizing of 80% -40 µm with the test flowsheet using a primary grind of 80% -55 µm with regrinding of rougher concentrate to 80% -25 µm.
- Treatment by conventional grinding and flotation processing produced copper concentrates grading 25% to 30% Cu; copper recovery in bench scale laboratory open circuit tests has been 85% - 90%.
- Laboratory locked cycle flotation testing on a blend of likely feed produced a 25% Cu copper concentrate at 92% copper recovery; these results require the standard 2% absolute discount applied in the industry when predicting the metallurgical performance of an operating mineral processing plant.
- Arsenic is the only significant deleterious element in the massive sulphide with the main carrier being arsenopyrite with some contribution from tennantite, and possibly orpiment, however, arsenic levels in concentrates from samples tested were below penalty levels and current Peoples Republic of China (PRC) import limits (0.5% As).
- Gold is refractory, being mostly associated with pyrite.
- Gold recovery to a 25% Cu copper concentrate is approximately 25%. This would increase to approximately 42 - 45% by making a lower grade concentrate at 20% Cu, which contained more auriferous pyrite.
- Around 65 - 70% of the gold content can be recovered into a pyrite concentrate from the copper flotation section tailing when making a 25% Cu copper concentrate. This pyrite concentrate would assay about 7 - 9 g/t Au and approximately 45% sulfur.
- At least 80 - 90% of the gold reporting to the auriferous pyrite concentrate can be extracted by the conventional technologies of roasting / cyanidation or pressure oxidation / cyanidation. This would give a total gold recovery to copper concentrate + bullion of 75 to 90%.
- Melnikovite or ‘primitive pyrite’, which accounts for around 15% of the pyrite, has a gold content of approximately 44 g/t Au compared with crystalline euhedral pyrite at approximately 4 g/t Au i.e. an order of magnitude higher.

- The samples tested have a Bond Ball Mill Work Index values in the range of 10-12 kWh/t, indicating a low to medium resistance to comminution.

The results presented above have not been optimised, but the following important points should be noted:

- Quantitative mineralogical data is an excellent predictor of sulfide flotation performance.
- Copper flotation results are consistent across all samples tested and for four laboratories (two in Australia and two in the PRC).
- Flotation work has included both batch and locked cycle tests.
- Dilution with low-grade materials or country rock should not affect copper metallurgical performance.
- Copper concentrates are clean and should not present any problems for treatment by custom copper smelters.
- Gold recovery can be significantly increased by reducing the target copper concentrate grade from 25% Cu to 20% Cu.
- Production of an auriferous pyrite concentrate will be necessary to get gold recovery to copper concentrate and doré bullion to 75–90%.
- Exposure of the materials tested to ambient conditions for up to eight weeks has not caused any major deterioration in metallurgical performance.
- The only attempt at making a zinc concentrate gave an encouraging result, with a product high in precious metals that might be upgraded by the established technique of reverse flotation.
- Metallurgical types in the deposit can be resolved into two main classes and several subsets.
- While there has been a significant sampling program undertaken by Nautilus, there remain parts of the deposit at depth that have had little metallurgical sampling and testing. Nonetheless, the core logging to date did not identify any minerals or textures that would be expected to negatively affect recoveries.

The uniformity of the mineralisation types recognised, the excellent correlation between mineralogy and metallurgical response, and the shallowness of the drillholes into Solwara 1 (less than 20 m), give very high confidence in the prediction of metallurgical performance for the mineral resource.

1.3 Mining methods

There are no Mineral Reserve estimates for Solwara 1 and the potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study. The terms “mineralised material” or "material" are used in this report to denote mineralised material above a cut-off grade on which the proposed mining, processing and product shipping activities are designed to operate. It does not imply that Mineral Reserves have been estimated at the date of this report.

The target Mineral Resources at Solwara 1 are located on the seafloor, approximately 1,550 m below sea level, and are covered with a thin layer of unconsolidated sediment.

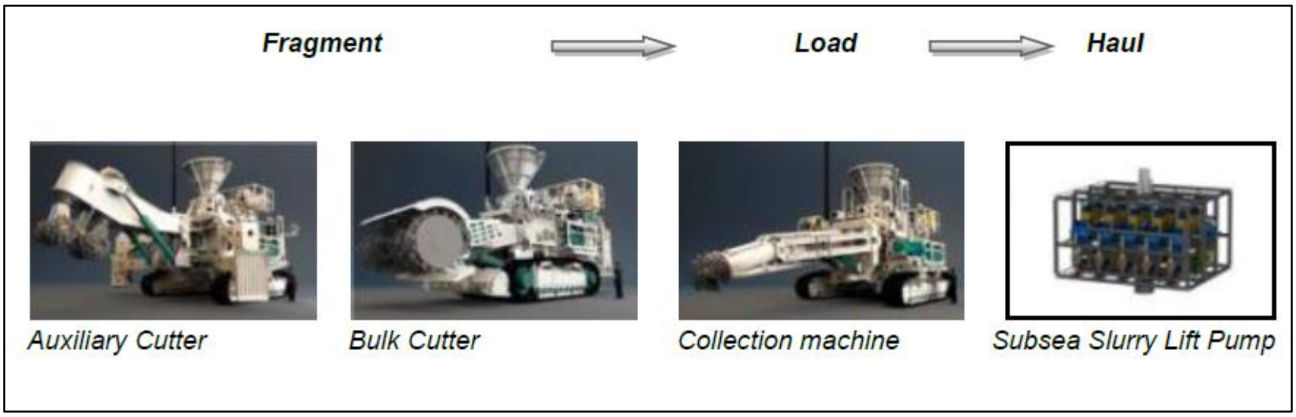
The conceptual mine plan contemplates the extraction of Indicated and Inferred Mineral Resources containing copper and gold at copper grades significantly higher than most terrestrial mines.

The depth and the relative competence of the massive sulphide means the deposit is not amenable to extraction by dredge technology. A mining method suited to the deposit style and location has been identified. Sediment removal, mechanical rock cutting, and transfer of fragmented cuttings to a vessel on the ocean surface by pump and riser is the chosen mining method.

Mining equipment has been designed, constructed, and tested. The mining equipment is mobile and is expected to be reusable at future deep-sea mining projects.

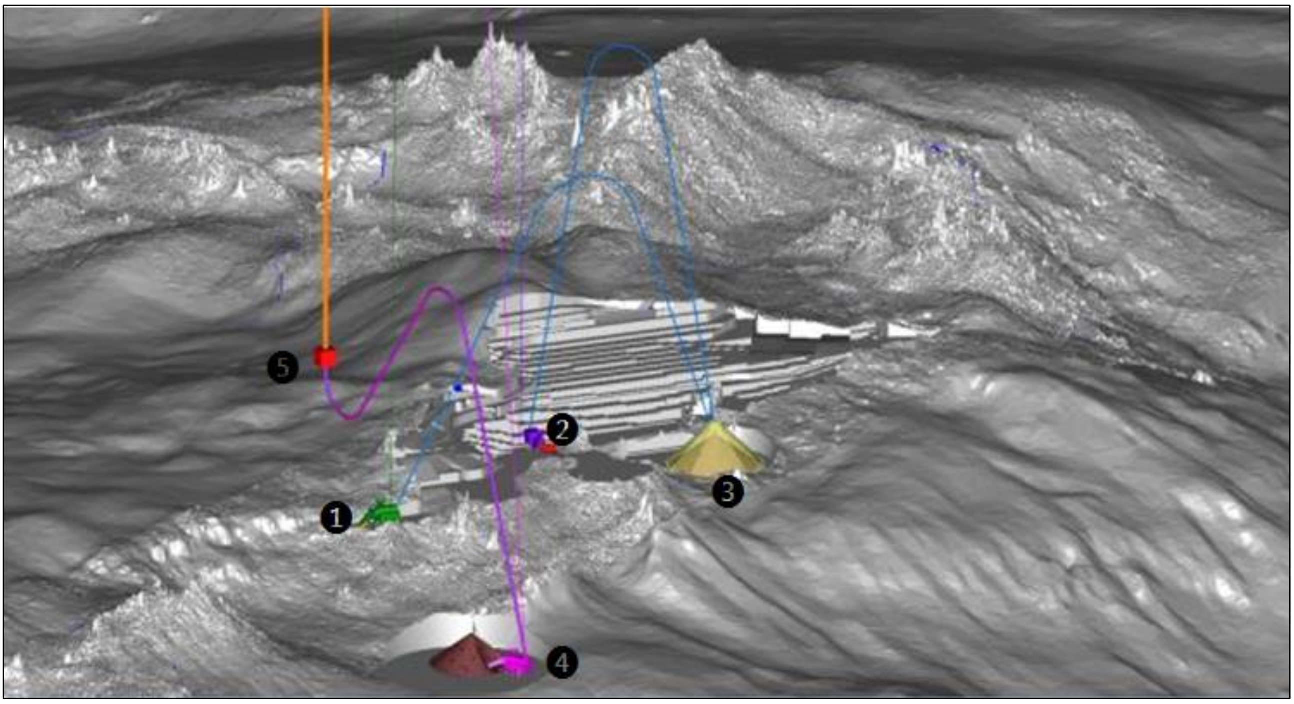
The three main mining tasks (sediment removal, rock cutting, and transfer of fragmented cuttings to surface) are performed by three seafloor production tools and a positive displacement pump, which are the four machines listed below and shown in Figure 1.2, and known collectively as the seafloor production equipment.

Figure 1.2 The seafloor production equipment



The seafloor production equipment will be remotely controlled by operators located on board a surface vessel stationed over the deposit. The proposed seafloor operation is illustrated in Figure 1.3.

Figure 1.3 Proposed seafloor mining operations for the Solwara Project



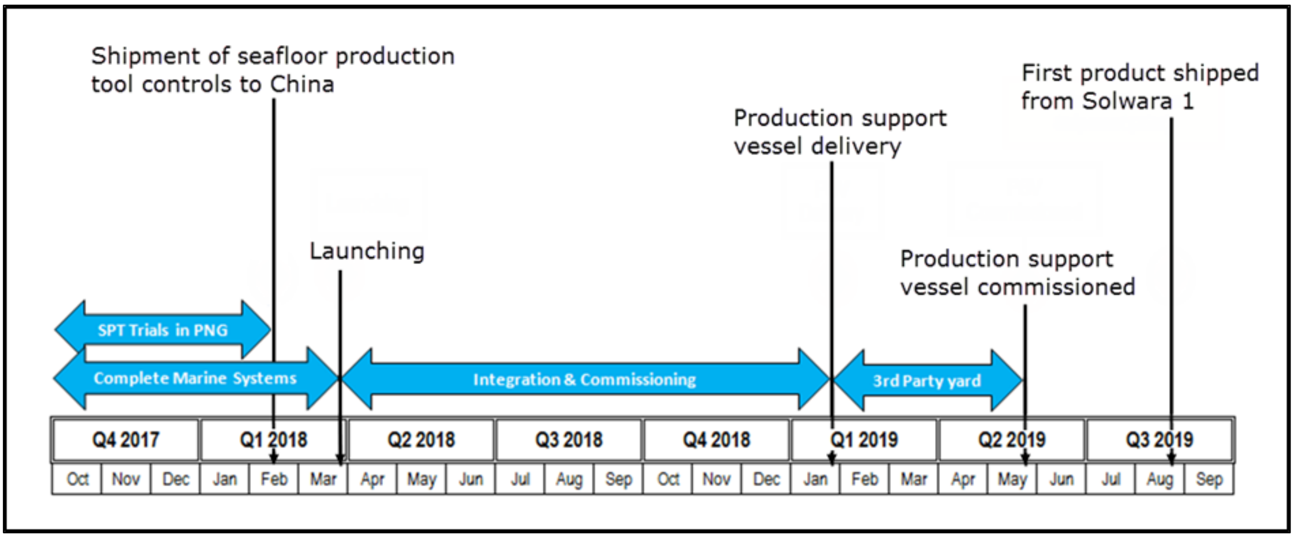
1. Auxiliary cutter – developing new area for production.
2. Bulk cutter – production cutting.
3. Stockpile – receiving fragmented rock from the auxiliary cutter and bulk cutter simultaneously.
4. Collection machine – collection from stockpile and delivering to subsea slurry lift pump.
5. Subsea slurry lift pump – receives mineralised slurry from collection machine. Boosts pressure and flow to hoist rock to production support vessel.

The mobile seafloor production tools have undergone submerged trials in a flooded pit near Port Moresby. The seafloor production tools components have functioned in submerged conditions as designed. The subsea slurry lift pump has been manufactured and factory acceptance testing is complete. Submerged trails of the pump have not yet occurred.

1.4 Recovery methods

A production support vessel is currently being constructed in the PRC. The launch of the vessel is scheduled for late in Q1 2018 (Figure 1.4). Integration of the vessel's systems will then continue after launch. Commissioning and sea trials are scheduled for completion in Q2 2019. The design of the production support vessel (Figure 1.5) is novel, and is a hybrid of a mobile offshore drilling unit, a cargo ship, and various special purpose ships. Nautilus has contracted to charter, but not own, the production support vessel.

Figure 1.4 Project construction and commissioning schedule



The production support vessel will serve several functions. It will generate power, house the mining crew, provide a platform for the launch, recovery and servicing of the seafloor production tools, and provide a place for dewatering and temporary storage of mineralised material before shipment to offtakers for further processing, smelting and precious metals recovery.

Figure 1.5 Design of the production support vessel

Broken mineralised material will be pumped to surface via the riser and lifting system directly to a dewatering plant, which is located on the production support vessel. The dewatering plant is the only mineral processing function that will occur at Solwara 1 prior to mineralised material storage, transfer and shipment. It is important to note from an environmental management perspective that no surfactants, filter aids or other processing chemicals will be used in the operation of the dewatering plant.

The proposed dewatering plant has a similar function to a coal washing plant, which is separation into the various size fractions and dewatering each fraction with suitably designed equipment. The dewatering plant will be used to reduce the water content of the mineralised material to below the transportable moisture limit (TML) prior to shipping (approximately 10% moisture). The technology is well proven and accepted worldwide.

The dewatered mineralised material will be stored on the production support vessel until loaded directly onto Handymax-sized vessels that will come alongside the production support vessel. The product will be shipped directly to the PRC for further processing. Other than dewatering, no minerals processing activities will occur at sea. No minerals will be stockpiled on land in PNG, and the mineralised material will be exported directly from the Solwara 1 site, which shall be declared a sufferance port under PNG customs legislation. Customs officials shall be transported to the production support vessel to witness sampling of all shipments and complete the required export documentation.

Nautilus has an agreement to sell the mineralised material to the Tongling Nonferrous Metals Group Co. Ltd. (Tongling). Tongling will treat the mineralised material in a custom-built concentrator adjacent to the Tongling Smelter, Anhui Province, PRC. The obligation for Tongling to build this concentrator is part of the Ore Sales and Processing Agreement between Nautilus and Tongling. The concentrator shall produce both copper and pyrite concentrates as well as a small quantity of tailings.

Copper concentrate will be treated through the recently commissioned Tongling double flash smelter, while the pyrite concentrate will be treated in Tongling's existing acid plant and precious metals recovery circuits. The flotation tailings will be sold as feed material to cement works operating near-by.

1.5 Environmental studies, permitting, community or social impact

Nautilus has carried out a series of environmental studies designed and conducted by various consultants, research organisations and universities during the assessment phase, prior to submission of its EIS to the PNG Government in late 2008. These studies were conducted to:

- Define the existing environment.
- Estimate the potential impacts.
- Inform potential impact mitigation strategies.

The studies included observation, sampling, and modelling focusing not only on the biological communities of both active and inactive hydrothermal vents, but also on the background marine environment, including physical, chemical and distal biological areas.

Nautilus has submitted an Environmental Inception Report (EIR) (Enesar, 2007) and an EIS (Coffey, 2008) for the Solwara 1 Project. Following public hearings in November 2008 and an independent review by third-party specialist consultants (Cardno Acil, Australia), the EIS was approved 'in principle' by the PNG Environment Minister on 31 August 2009.

After the EIS, further investigations to gain a better understanding of the environment at Solwara 1 and surrounds have been carried out as part of environmental campaigns undertaken from 2008 to 2015.

The seafloor environment at Solwara 1 is an active deposition site with its sulfide-rich chimneys venting hydrothermal fluids and other rock debris into the lower water column layer, resulting in high sedimentation rates in the surrounding area. Studies show that sedimentation rates at Solwara 1 are on average 50 times higher than the open ocean where hydrothermal vents and volcanic activity do not occur (ERIAS Group, 2017).

The main impacts of the Solwara 1 Project are expected to occur at, or just above, the seafloor and include material and habitat/animal removal, plumes from cutting and stockpiling, noise, vibration and light.

It is envisaged that under normal operating conditions, there will be negligible impacts to the marine life in the mid-water column. Impacts are likely to be restricted to those resulting from the presence of the riser and lifting system, and the occasional transit of seafloor production tools, and remote operated vehicles during ascents and descents. Nautilus has developed methods to minimise sediment/suspended particulate matter entrainment from the seafloor during ascents of the seafloor production tools and remote operated vehicles, and these have been incorporated into the environmental management plans.

The potential impacts to surface pelagic animals will be restricted to the presence of the surface vessels and their normal operations. Potential impacts include lighting, underwater noise, routine discharges (in compliance with relevant maritime acts and regulations) and emissions to air. These impacts are expected to be similar to shipping generally and exploration surveys already completed by Nautilus.

Deep-sea sedimentation rates will be affected by the mining operations causing a net increase where sedimentation rates are already naturally high. Suspended sediment modelling was carried out (Coffey, 2008, and Asia Pacific Applied Science Associates (APASA), 2016) to quantify the sediment load on the seafloor resulting from full surface sediment removal during pre-strip and subsequent mining operations. Modelling indicated that at the completion of mining at Solwara 1, sediment will be distributed over a 4.47 km^2 area that encompasses the mining footprint. The estimated depth of this material ranges from the background level of 5.8 mm to 500 mm nearer the discharge points of unconsolidated sediments during pre-strip. Coarse material is expected to settle rapidly while lighter materials will travel further from disposal points. The lightest fragments are expected to form a plume near the seafloor, however all the sediment is expected to settle within the boundaries of the ML with the furthest point of influence no further than 1.4 km from the mining area. Figure 1.6 shows the maximum extent of deposition and sediment concentrations resulting from mining activity with respect to the ML boundaries.

Figure 1.6 Modelled maximum extent of sediment deposition at Solwara 1

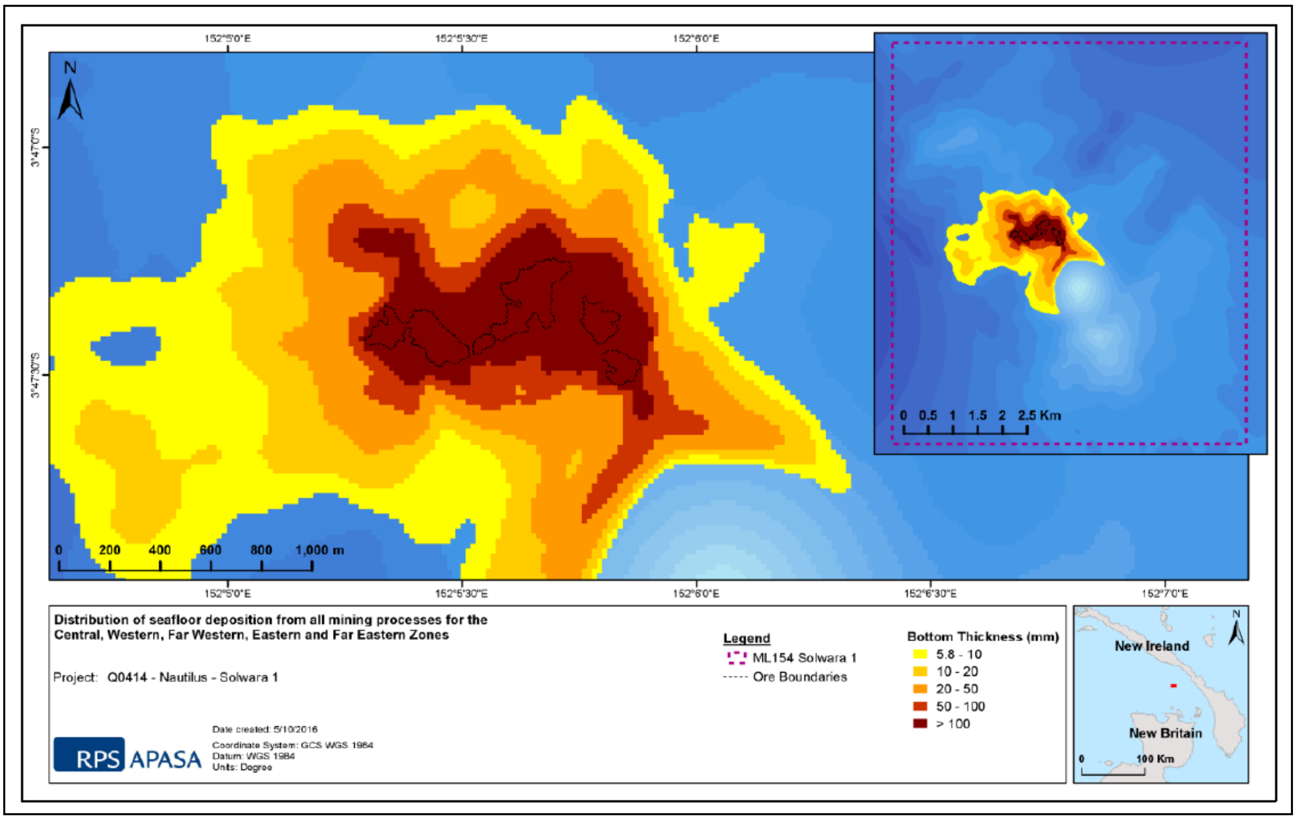


Figure 1.6 is based on APASA modelling for operation of Solwara 1 over a 27-month period, for 300 days per year at a production rate of 5,900 t/day. This is equivalent to total production of approximately 4 Mt, which is 35% more than the entire indicated and inferred resource at Solwara 1. The modelling has been based on extremely conservative input parameters. The modelling technique used by APASA was jointly developed by the U.S. Army Corps of Engineers (USACE), Engineering Research and Development Center, and APASA. Proof of performance for the model has been documented in a series of USACE dredging operations and environmental research program technical notes and published in peer-reviewed literature. Furthermore, the model has been applied to, and validated by APASA, against observations of sedimentation and suspended sediments at multiple locations in Australia.

The seafloor production tools are designed to minimise the loss of mineralised material to the environment, with overall recovery expected to be approximately 95% (Coffey, 2008). Localised, partial burial of immobile fauna, is expected, however, fauna may, to a degree, be pre-adapted to high rates of sedimentation given the nearby presence of active volcanoes and their associated eruptive sediment plumes.

The return water from the dewatering plant will discharge material smaller than 8 µm at a height of between 40 m to 180 m above the sea floor. The results of modelling indicated that total suspended solids (TSS) concentrations from this return flow were minimal. While the initial concentration of the slurry discharging from the return flow pipe is in the order of 4,000 mg/L, the width of the two return pipe plumes is only 0.2 m. Such a plume undergoes rapid dilution during its jet phase and the subsequent concentrations in the far-field are low, only exceeding the minimum threshold of 10 mg/L up to a distance of less than 100 m from the discharge point. These sediments will settle over a wide area but maximum depositional thickness will not exceed 1.0 mm. Thus, rates of settling are less than the existing deep-sea sediments rates measured at Solwara 1.

Geochemical changes in the mineralised material that could potentially result in increased leaching of soluble metals are not expected during the mining and dewatering process, as these materials will not remain at their original temperature and oxygen fugacity. Nautilus has undertaken reactivity tests and modelling that indicate target water quality standards (ANZECC/ARMCANZ 2000) to 95% protection levels, will be met, due to dilution, within 85 m from the discharge point.

Modelling reported in the EIS predicts that return water sediments will not rise above 1,400 m in the water column and, consequently, will not affect pelagic tuna, tuna fisheries or near-shore coral reefs, including traditional fisheries.

In 2016 Nautilus commissioned an underwater noise and vibration impact assessment that assessed potential impacts on marine fauna (including whales, turtles, marine reptiles, fish and macroinvertebrates) and marine resource use. The study determined that noise impacts to marine fauna will be negligible and require animals to be within 10 m of noise sources for impacts to occur.

Air emissions will consist of combustion emissions from the production support vessel’s dynamic positioning system (DPS) thrusters, vessel power supply and the mining, transfer and processing power supply. It is expected that there will be limited dust emissions from processing or transport activities due to the moisture content of the processed mineralised material. Emissions to air from this Project should not have a direct impact on marine life.

With the approval of the EIS, the PNG Government signalled that it was comfortable with the effectiveness (i.e. decision, process, and content) of Nautilus’s socio-economic and community engagement program for Solwara 1.

Nautilus has changed the Project description since the approval of the EIS to include:

- The use of a single production support vessel as opposed to three separate ones.
- Stockpiling of mineralised material on the seafloor.
- The use of offshore trans-shipment (in place of product storage at the Port of Rabaul).

These changes have been the subject of a Variation of the ML and an amendment of the Environmental Permit (EP), and are captured and addressed in the current Environmental Management Plan (EMP) and will not require revision of the EIS.

Nautilus undertook extensive studies over 2015 and 2016 (listed in Item 20.1.2) in support of the EMP which was completed and submitted to the Conservation and Environment Protection Authority (CEPA) in 2017. During preparation of the EMP a number workshops were held with relevant PNG government entities to obtain input to the EMPs.

As the major components of the proposed mining and trans-shipment activities are located offshore, many of the socioeconomic and sociocultural issues normally associated with terrestrial mining projects are likely to be absent from Solwara 1. The Project will not cause the displacement of people from their land or alter existing land use practices. However, based on other larger projects in PNG, local impacts could potentially arise in the following areas:

- Employment created during the operational phase of the Project.
- Business opportunities generated by the supply of goods and services.
- Subsidiary employment and business opportunities arising from expenditure of incomes earned from Project employees.

- The distribution of beneficial streams (i.e. taxes and royalties).

External financing provides a very large proportion of financial resources available for the support and facilitation of the Government's development program.

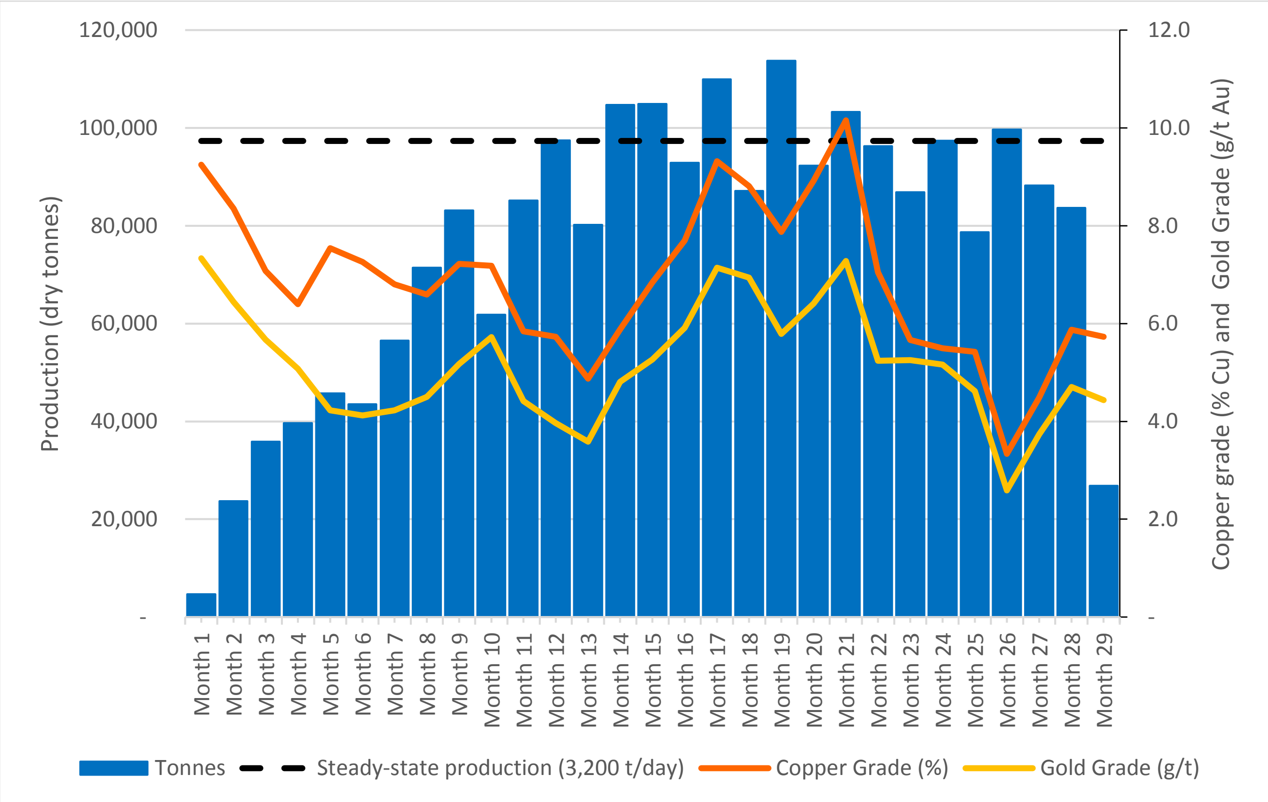
The Project will provide revenue to the PNG Government through royalties and taxes and establishing a Community Development Fund that will support existing provincial development projects in New Ireland and the island provinces.

While there has been some negative sentiment towards the Project, Nautilus has endeavoured to engage with the relevant parties to address their concerns, including commissioning and publishing independent reports on environmental and social benchmarking and environmental and social standards compliance of the Project (Earth Economics). As part of its ongoing risk assessment for the Project, Nautilus is actively monitoring community sentiment and implementing a strategic plan for corporate social responsibility in consultation with state, provincial and local level governments.

1.6 Conceptual production schedule

The conceptual production schedule, inclusive of dilution and mining losses, for Solwara 1 is shown in Figure 1.7. A 15-month linear productivity ramp-up has been allowed. The maximum production rate is constrained by the pumping capability of the collection machine.

Figure 1.7 Solwara 1 conceptual production schedule



Extraction of 0.9 Mt of Indicated Mineral Resource grading 6.4% Cu,4.6 g/t Au, and 1.3 Mt of Inferred Resource grading 7.0% Cu, 5.5 g/t Au (undiluted), has been scheduled. A peak production rate of approximately 3,200 t per day is planned. Solwara 1 is scheduled to be in production for a period of 29 months. The conceptual plan contemplates recovery of approximately 130 kt of copper and 180 koz of gold from Solwara 1.

The production schedule is not a Mineral Reserve estimate. It is based in part on Inferred Mineral Resources, which are too speculative geologically to be used in a definitive economic analysis.

The main risks to the mining plan include:

- There is no redundancy in the mining fleet. All the seafloor production equipment is required to function as planned for the duration of the Project. Loss or catastrophic failure of any seafloor production tool will materially affect Nautilus's ability to execute the production plan.
- The estimate of production rate ramp-up is based on engineering judgement and analysis by analogy with terrestrial mining projects. Deep-sea mining has not yet been attempted and there are no very close analogues to the proposed mining project. The actual production ramp-up might be slower and longer than expected, resulting in higher operating costs. Conversely, the ramp-up might be significantly better than has been allowed for in the schedule, and actual project duration might be less, resulting in significant reduction to the average production cost.
- Most of the target Mineral Resource is in the Inferred category, meaning (by definition) that the density of data is insufficient to demonstrate geological continuity and grade continuity. The actual deposit characteristics could vary from the prevailing geological interpretations.
- The production plan requires that the seafloor production equipment be operated and dynamically positioned within certain tolerances. The survey equipment and systems for Solwara 1 have not yet been finalised. Existing technology that is routinely used in the subsea oil and gas industries might be adopted at Solwara 1. However, there are many practical issues to resolve and it is conceivable that maintaining constant accurate position control will not always be possible, and the production rate, and rates of mineralised material loss and dilution might vary from the plan.
- An important step in addressing some of the risks outlined above, are submerged trials of the seafloor production tools and subsea slurry lift pump to be undertaken prior to production. The seafloor production tool trials were completed in PNG late in 2017 and early in 2018, and the subsea slurry lift pump submerged trials are planned for the second and third quarters of 2018. Preliminary analysis of the results of the seafloor production tool trials indicates that the tools can perform to design specifications. The machine components all functioned as designed in submerged conditions although there are several design modifications being considered to improve operations.

1.7 Capital cost

The total capital cost (capex) estimate for Nautilus's deep-sea mining system, which will first be deployed at Solwara 1, is US$530 million.

Of the total capex, 59% (US$315 million) has been committed in existing contracts, and 54% (US$287 million) has already been incurred. The estimate of capital, yet to be committed, that is required to complete the Project is US$215 million. Of this amount, the largest cost item (US$60 million) is for integration of the production support vessel systems. Completion and testing of the seafloor production tools, the riser and lift system, the dewatering plant, the purchase of spare parts, "first fill" consumeables, and the mobilisation of all equipment and personnel to site are also significant outstanding capital cost items within this budget estimate.

1.8 Operating cost

The average cost of production is expected to be approximately of US$274 per tonne of mineralised material over the life of the Project. The production cost estimate is based on vessel charter contracts, crewing services contracts, the Ore Sales and Processing Agreement, and estimates of consumables consumption.

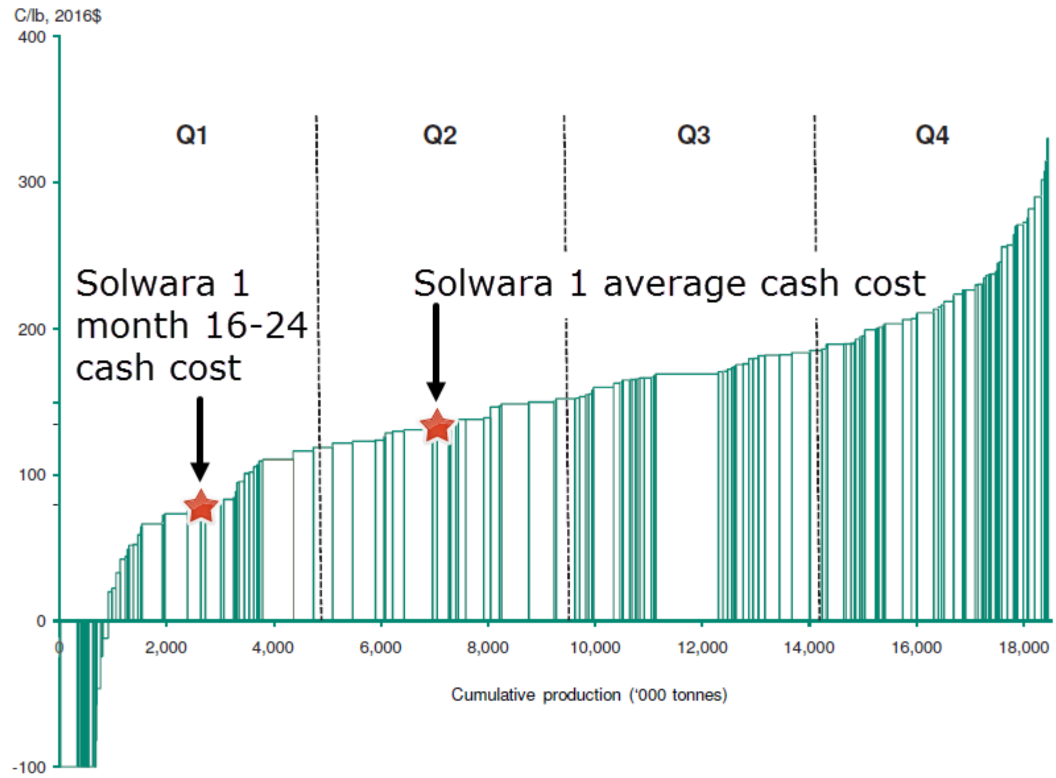
The operating cost is made up of both fixed (time-based) and variable (tonnage-based) components, and is therefore sensitive to project duration, and production ramp up rates. The average split of fixed and variable costs is 52%:48%. A variation of three months in project duration is expected to change the average operating cost by approximately US$15 per tonne. The high proportion of fixed costs means the Project is highly leveraged to metal grade, metal prices, and production rate.

AMC has estimated a C1 cash cost for Solwara 1 of US$1.36 per pound of payable copper, net of gold credits, over the life of the Project. This estimate includes the 15-month production ramp-up period when cash costs are negatively impacted by lower copper and gold production. During the period when the production rate is stable at around 3,200 tpd in months 16 to 24, the C1 cash cost is expected to be US$0.80 per pound. This is indicative of cash costs that might be achievable for subsequent deep-sea mining projects that have metal grades similar to Solwara 1. This is because the experience gained at Solwara 1 could reasonably be expected to reduce the ramp-up period for these subsequent projects to less than 15 months.

C1 cash cost per pound is a financial performance measure based on cost of sales and includes treatment and refinement charges and by-product credits, but excludes the impact of depreciation and royalties. C1 does not have any standardized meaning under Generally Accepted Accounting Principles (GAAP) or International Financial Reporting Standards, and may not be comparable to similar measures of performance presented by other companies.

The C1 cash cost of US$1.36 per pound of payable copper, net of gold credits, compares favourably to the cash costs of terrestrial mining operations (Figure 1.8). Such cash costs would place the Solwara 1 project in the second quartile of global copper mining operations with respect to copper industry cash costs.

Figure 1.8 Copper cost curve, adapted from Wood Mackenzie 2016



Source: Wood Mackenzie (Q3'16 Cost Service), 2016 Oyu Tolgoi Technical Report and Turquoise Hill Resources.
Normal C1 cost + sustaining capex, range capped at -100/lb & 400/lb for base, highly probable and probable mines only.

1.9 Preliminary Economic Assessment

In January 2018, AMC conducted preliminary economic modeling of the Solwara 1 Project using the available study reports, information about the production systems under construction, and on-going mine planning work by Nautilus. The modeling indicates a positive economic outcome for the Solwara 1 project as presented in this PEA.

AMC's economic modelling indicates that copper contributes 80% of the Project value, gold 19%, and silver 1%. The copper price used in the modeling is based on the results of a price forecast provided to Nautilus by specialist consultants, CRU International Limited. A copper price of US$7,319 per tonne of copper, and a gold price of US$1,200 per ounce of gold were used in the analysis.

The Qualified Person considers the metal prices are reasonable for the purpose of preparing this PEA. The spot metal prices on the effective date (1 January 2018) were US$7,250 per tonne, US$1,304 per ounce, and US$17.01 per ounce for copper, gold and silver respectively. The metal prices used in the preliminary economic modeling are not materially different to the spot prices on the effective date.

The metal payability factors used are as agreed in the Ore Sales and Processing Agreement between Nautilus and the off-taker, Tongling Nonferrous Metals Group Co., Ltd. The economic modeling was undertaken on a post-tax basis. No inflation was assumed because the Project life is short.

Undiscounted post-tax cash flow (for all cash flows after 1 January 2018) of US$179 million is expected. An internal rate of return of 28% has been modelled. Discounted cash flow analysis, discounting at 15% per annum, indicates a project net present value of US$56 million.

Royalty, Community Development Fund payments, corporate tax and adjustments for tax relief have been estimated. The financial modelling indicates that the Solwara 1 project will contribute over US$100 million in taxes and royalties, payable to the government of PNG.

The Qualified Persons caution that this PEA is preliminary in nature, that it includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the results presented in this PEA will be realized. A prefeasibility study has not been undertaken. Mineral resources are not mineral reserves and do not have demonstrated economic viability.

The sensitivity of project economics to metal price was tested by using copper and gold prices based on forward pricing curves. A copper price of US$7,981 per tonne, and a gold price of US$1,391 per ounce, which are the averages indicated by forward price curves for the duration of the Solwara 1 project, were used as inputs to the economic model. These prices are approximately 10% higher than the inputs used in the central case. Price decrease by the same factor were also modelled. The post-tax results of the modelling are shown in Table 1.3. The sensitivity analysis indicates the Project is highly leveraged to changes in metal price.

Table 1.3 Economic sensitivity analysis

	-10% to copper and gold price	Central case (US$7,319/t Cu)	Forward price curves
Net undiscounted cash flow (US$ million)	94	179	268
Net present value discounted at 15% (US$ million)	0	56	115
Internal rate of return	15%	28%	40%

2 Introduction

2.1 Terms of reference

Nautilus engaged AMC Consultants to compile a PEA for the Solwara 1 project and Technical Report compliant with Canadian National Instrument (NI) 43-101.

Nautilus has completed a significant amount of investigation for the Project over the last 10 years, using a skilled in-house team and well-qualified consultants. The work has been meticulously documented. The AMC team has critically reviewed the relevant work and compiled this NI 43-101 technical report. This is the first PEA for the Project. All the Qualified Persons are independent of Nautilus.

2.2 Purpose of the Technical Report

This report is intended to be used by Nautilus subject to the terms and conditions of its contract with AMC. This contract permits Nautilus to file this report as a Technical Report with Canadian Securities Regulatory Authorities pursuant to NI 43-101, Standards of Disclosure for Mineral Projects and thereby make it publicly available.

AMC understands that Nautilus intends to use this technical report to inform the market on its updated estimates of production rate and mine life for Solwara 1, and disclosure for the first time estimates of operating costs and expected cash flow.

AMC understands that Nautilus intends to use this public disclosure to raise capital and advance the Project.

2.3 Sources of information and data

This Technical Report is based on information supplied to AMC by Nautilus, including:

- NI 43-101 Technical Report of Mineral Resource estimate for Solwara Project
- Solwara 1 Development Programme
- Mine design and production scheduling 2014
- Revised Production Ramp-up
- 6-9-15-24 month Ramp Up - Factored Schedule_v9.xls
- Master Ore Sales and Processing Agreement - Tongling (Executed)_ENGLISH
- Failure mode, effects and criticality analysis (FMECA) records for seafloor production toolss
- Nautilus Minerals DWP FMECA Report Rev 0
- Various confidential contractual documents, and associated invoice records, related to the procurement of the PSV
- Forward metal pricing curves from Jefferies Investment Banking
- Ore Sales Agreement with Tongling Nonferrous Metals Group Co., Ltd.
- 2016 Nautilus Financial model 2016105 V0.5- no atrisk
- Solwara 1 Project – Basis of 10 year Financial Model (2016)
- Capex Re-start 2017 Version 3
- NAT005_Solwara_1_Offshore Production System Definition and Cost Study_Rev_2_21June2010
- Presentation on 3D seismic survey at Solwara 1, June 2013, by Nautilus Minerals
- Physical Oceanography. Solwara 1 Project. ERIAS Group. October 2017.
- Post-2007 Water and Sediment Quality. Solwara 1 Project. ERIAS Group. September 2017.
- Biology. Solwara 1 Project. ERIAS Group. October 2017.

Item 27 lists additional background documents that are referenced by the higher-level reports.

2.4 Field involvement

Ian Lipton, currently a full-time employee of AMC Consultants, was from 2002 – 2014 a full-time employee of Golder Associates Pty Ltd. He visited the REM Etive which was stationed above Solwara 1 from 25 to 26 November 2010 at the completionof 38 drillholes at Solwara 1.

The purpose of the site visits was to review the geological procedures associated with the resource definition drilling program and to confirm that these procedures and their execution were suitable for mineral resource estimation. During the course of the visit Mr Lipton held discussions with a variety of staff from Nautilus and Société Générale de Surveillance (SGS), operators of the on-board sample preparation facility.

The implementation of the written field procedures was reviewed during retrieval and processing of the core from hole SD-S12-006.

The drill cores from 23 holes from Solwara 1 (SD165, SD166, SD167, SD 168, SD169, SD173, SD174, SD175, SD176, SD177, SD178, SD179, SD180, SD181, SD182, SD183, SD186, SD193, SD194, SD196, SD197, SD198 and SD201) were examined.

The drill parameter plots from 27 holes from Solwara 1 (SD171, SD176, SD177, SD178, SD179, SD180, SD181, SD182, SD183, SD184, SD185, SD186, SD187, SD188, SD189, SD190, SD192, SD193, SD194, SD195, SD196, SD197, SD198, SD199, SD200, SD201, and SD202) were examined.

2.5 Personnel

AMC assembled a well-qualified team for this assignment. The Items that each of the team members were responsible for are summarized in Table 2.1.

Table 2.1 List of Qualified Persons responsible for each Item

Qualified Person	Company	Responsible for the following report items:
Ian Lipton	AMC Consultants Pty Ltd	Items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 20, 23, 24, 25, 26, 27
Ed Gleeson	AMC Consultants Pty Ltd	Item 14.1,15, 16, 17, 18, 21, 22
Peter Munro	Mineralis Consultants Pty Ltd	Item 13, 17 (dewatering, etc), 19

In addition, each of the team members contributed to Items 21, 22, 25, 26, 27, as required.

3 Reliance on Other Experts

The property description as presented in Item 4 was researched and reported by Simon Beams. Mr Beams is a Principal Geologist with Terra Search Pty Ltd and has over 30 years of managing exploration and mining tenements across several jurisdictions in Australia and five years experience working in PNG, in close liaison with the MRA and Department of Mining.

The project infrastructure as presented in Items 18, 21, 22, 25 and 26 was written by Peter Keane. Mr Keane is a mechanical engineer with 28 years manufacturing and mining industry experience, including asset management, operations and business performance within heavy engineering, manufacturing, mining and oil and gas sectors.

The environmental and social aspects of the project presented in Items 1, 5, 20, 25 and 26 of this report were written by Michael Wright. Mr Wright is a Principal with ERIAS Group Pty Ltd, an environmental and social impact assessment, planning and regulatory approvals consultancy specialising in the permitting of development projects. Mr Wright has 22 years mining industry experience, including leading environmental investigations for 5 seafloor mining projects.

The Qualified Persons have relied upon the work of Messrs Keane, Wright and Beams in these Items.

4 Property Description and Location

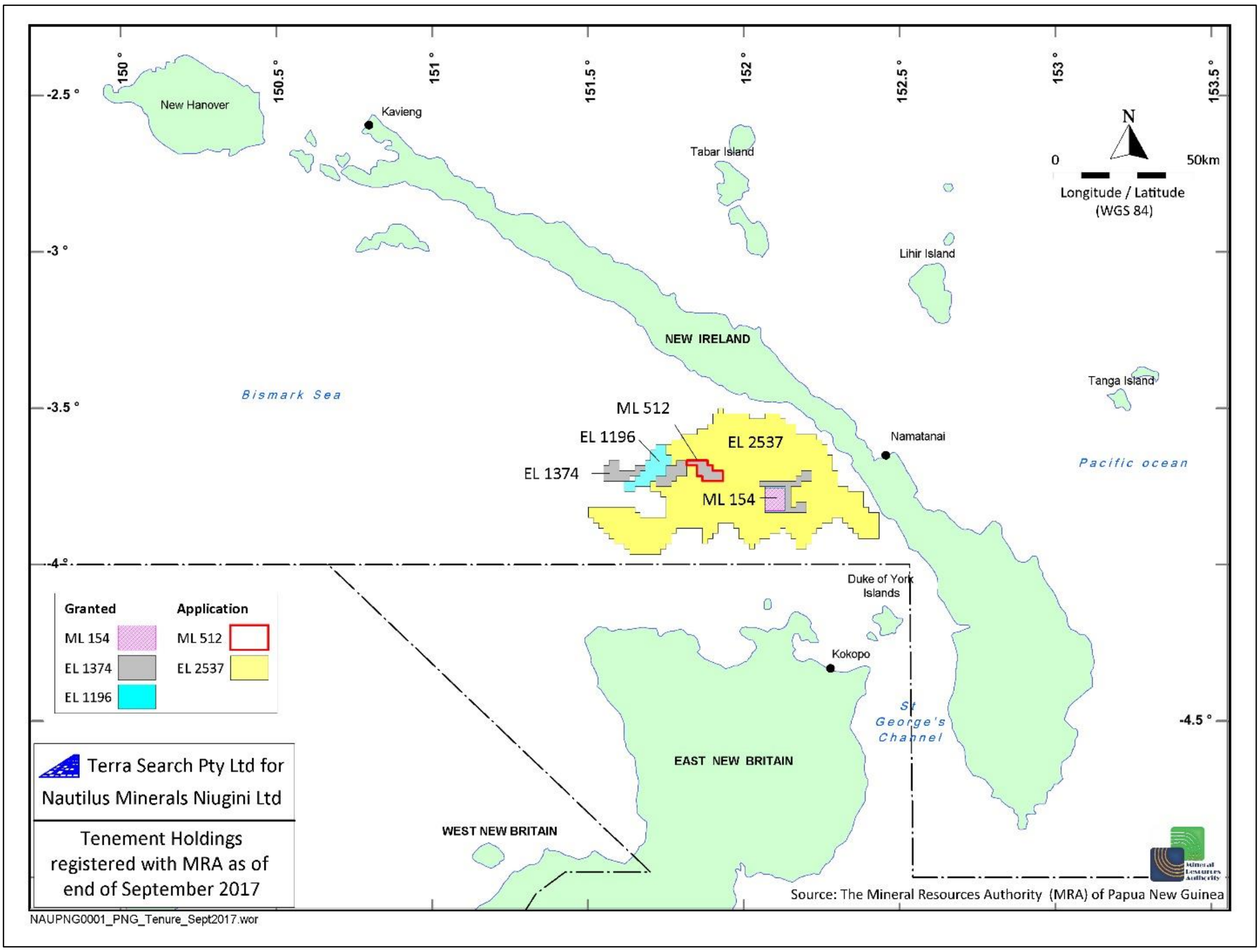
In accordance with "the Property" definition from NI 43-101, this report includes the entire Nautilus tenement holding in the Bismarck Sea as "the Property."[1]

The Nautilus Property consists of four granted ELs, as well as one granted ML and one other ML application (Table 4.1 and Table 4.2). All tenements are located within the Bismarck Sea west of New Ireland Province, PNG (Figure 4.1).

Nautilus Minerals Inc. is exploring for polymetallic (Cu-Zn-Au-Ag) Seafloor Massive Sulfides (SMS) bodies.[2] Nautilus Minerals Niugini Limited is a wholly owned subsidiary of Nautilus Minerals Inc. established 9 October 1995 under the law of PNG.[3]

As at 17 November 2017 ELs comprise a total area of 879 sub-blocks, or approximately 2,997 km^2. MLs under application and granted cover a total area of 113.68 m^2.[4]

Figure 4.1 Location plan showing Nautilus's Bismarck Sea Property



[1] AMC Consultants (2017). Nautilus Solwara 1 PEA, Nautilus Minerals Niugini Ltd. p.29.
[2] Nautilus Minerals Niugini Ltd (2016). EL 1196 Annual and Renewal Report. p.1.
[3] Nautilus Minerals Inc. (2017). Annual information form for the fiscal year ended December 31, 2016. p.12.
[4] PNG Mining Cadastre Portal (portal.mra.gov.pg), 17/11/2017

Table 4.1 Nautilus's Bismarck Sea granted tenements

EL/ ML	Name	Status	Area km^2	Grant Date	Expiry Date
ML 154	Solwara 1	Granted (2)	59.11	13/01/2011	12/01/2031
EL 1196	Solwara 1 & 4	Renewal pending-registration complete (1)	125.07	28/11/1997	27/11/2017
EL 1374	Eastern Manus Basin Extended	Granted (1)	255.75	10/09/2004	9/09/2018
EL 2537	SuSu	Granted (3)	2557.50	18/01/2018	18/01/2020

Table 4.2 Nautilus's Bismarck Sea tenement applications

EL/ ML	Name	Status	Area km^2	Application lodged
MLA 512	Solwara 12	Application-hearing complete (1)	54.57	16/02/2016

(1) Nautilus Minerals Niugini Limited (100%)

(2) Nautilus Minerals Niugini Limited (85%); Eda Kopa (Solwara) Limited (15%)

(3) Nautilus Minerals Niugini 3 Limited (100%)

4.1 Tenement details

Exploration and mining activities, including seafloor exploration and mining within PNG territorial waters are principally regulated by the *Papua New Guinea Mining Act 1992 ('Mining Act')*. The act is administered in the main by the Mineral Resources Authority (MRA).

MLs and ELs are granted in conjunction with an EP as per the *Mining Act 1992* and the *Environmental Act 2000*. The environmental permit process addresses both environmental and social considerations.[5]

Tenements are subject to additional legislation including, but not limited to the *Mining (Safety) Act 1977*; the *Water Resources Act 1982*; and the *Mining (Royalties) Act 1992*.

4.2 Exploration licences

The area unit for ELs is measured in sub-blocks of approximately 3.41 km^2 to a maximum area of 750 sub-blocks. 25 sub-blocks constitute one block, the boundaries of which are derived by graticular sections of Greenwich meridians of five minutes, or multiples of five minutes longitude; and five minutes, or multiples of five minutes latitude.[6]

ELs are granted over an initial period of two years with provision for further renewal of no more than two years each renewal term. A statutory 50% relinquishment of the total area is required at each renewal unless approved otherwise. ELs of 30 sub-blocks or less are not required to relinquish further area. Licence holders may apply to the MRA to waive or reduce the statutory relinquishment requirements for ELs consisting of between 30 and 75 sub-blocks.

Those granted ELs must submit annual and bi-annual summary reports. Further, the holder company is required to catalogue and preserve all core and drill test samples taken during the course of exploration.[7]

Annual rent is paid based on the area unit. The annual rent rate at September 2017 is PGK470.00 per sub-block.

[5] Approvals and regulation in Papua New Guinea | AusIMM Bulletin (https://www.ausimmbulletin.com/feature/approvals-and-regulation-in-papua-new-guinea)

[6] Golder Associates Pty Ltd (2012). Mineral Resource Estimate; Solwara Project, Bismarck Sea, PNG. Technical Report compiled under NI 43-101, p.16.

[7] Golder, 2012, p.15

Under the *Mining Act 1992*, ELs entitle the holder company exclusive rights to undertake exploration activities including the extraction, removal and disposal of such materials as are permitted in the approved work program issued for each licence. For ELs located offshore in PNG territorial waters, this includes materials from the mean low water spring level to such depth as is required for the extraction of these materials.[8] The holder of an existing EL may receive priority for the approval of ML over the same area.

4.3 EL status

EL 1196, Solwara 1 & 4

EL 1196 consists of two non-contiguous areas. The easternmost area is overlain by ML 154, Solwara 1 (Figure 4.2). The EL was originally granted across 750 sub-blocks and has been reduced through successive relinquishments to the current area of 36.67 sub-blocks or 125.07 km^2. Nautilus successfully applied to waive further relinquishment from EL 1196 in 2009. As at 24 October 2017, the Mineral Resources Authority of PNG (MRA) confirmed that the EL is in compliance with grant conditions.[9] On 8 November 2017, the company sought to refresh the relinquishment waiver for this EL pursuant to s.22(3) of the *Mining Act 1992*.[10]

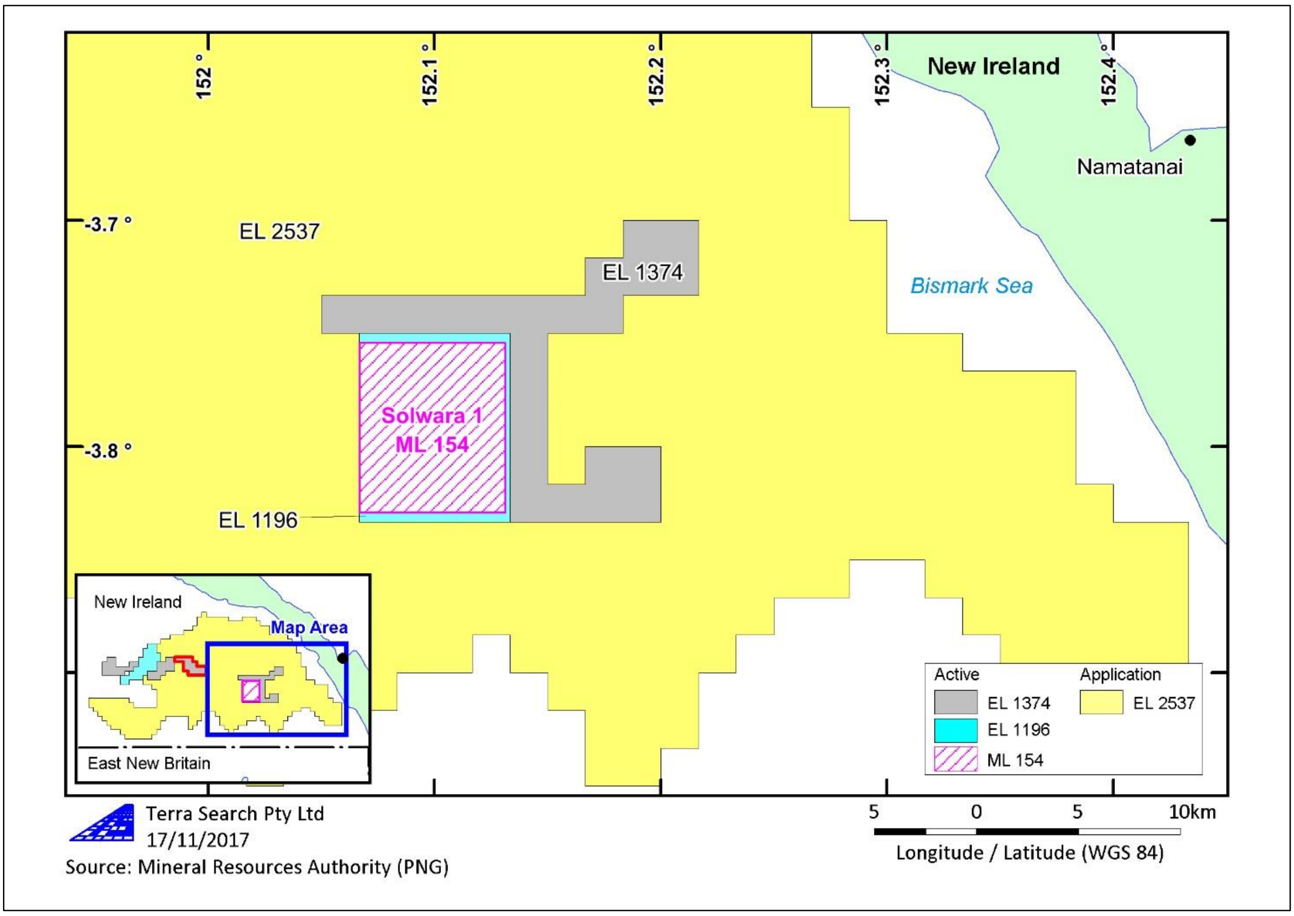
EL 1196 has been renewed every two years from grant and was scheduled to expire on 27 November 2017. An application for extension of term was submitted 9 November 2017.[11] The application reported the balance of expenditure had been exceeded for the previous term from 28 November 2015 to 27 May 2017 (Table 4.3). The MRA responded to this application seeking clarification on several points for which Nautilus provided information on 16 January 2018. The MRA was still to provide the date for a Warden's Hearing on this renewal application at the time of completing this report.

Table 4.3 Balance of expenditure summary, current term to 27 November 2017[11]

Period	Expenditure	Commitment
28 November 2015 – 27 November 2016	PGK429,017.00	PGK108,000
28 November 2016 – 27 May 2017	PGK682,004.23	PGK174,000
Total	**PGK1,111,021.23**	**PGK282,000**

[8] Golder, 2012. P.15
[9] Compliance Status Report – EL 1196, Mineral Resources Authority 24/10/2017
[10] Nautilus Minerals internal, letter to the Director, Mineral Resources Authority, 8/11/2017
[11] Nautilus Minerals, submission to Mining Advisory Board, receipted 9/11/2017

Figure 4.2 Location map of Solwara 1 (ML 154) in EL 1196



EL 1374, Eastern Manus Basin Extended

EL 1374 consists of three non-contiguous areas, part of the centremost area of which is overlain by MLA 512, Solwara 12 (Figure 4.3). The EL was granted over 696 sub-blocks and successive relinquishments have reduced the total area to 75 sub-blocks or approximately 256 km^2. In 2016, Nautilus applied to vary further relinquishment requirements for EL 1374.[12] As of November 2017, MRA has not confirmed the status of this application.

As at 24 October 2017 the MRA confirmed that the EL is compliance with grant conditions.[13] The minimum annual expenditure commitment for EL 1374 is PGK150,000. The reported annual expenditure for the 12 months ending 9 September 2017 was PGK886,570.16.[14]

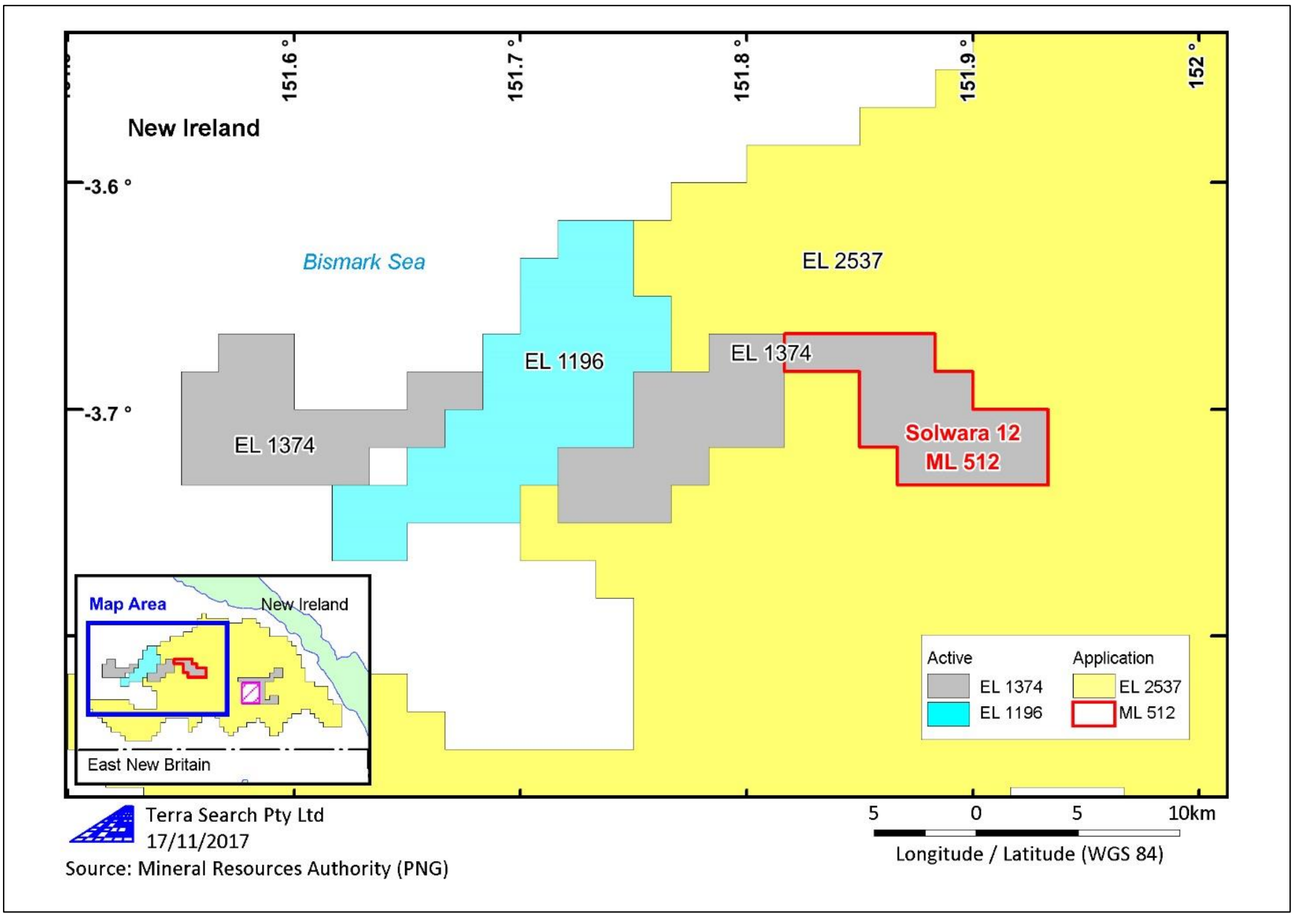
EL 1374 is scheduled to expire on 9 September 2018. Application to renew the EL for a further term must be submitted within 90 days of the expiry date in accordance with the *PNG Mining Act 1992*.

[12] Nautilus Minerals Niugini Ltd (2016). EL 1374 Annual and Renewal Report. p.4

[13] Compliance Status Report – EL 1374, Mineral Resources Authority 24/10/2017

[14] Nautilus internal spreadsheet, supplied by Adam Wright, VP – PNG operations, 16/10/2017

Figure 4.3 Location map of Solwara 12 (ML 512) in EL 1374



EL 2537, SuSu

EL 2537 was applied for on 2 June 2017 over a total area of 750 sub-blocks or 2,558 km^2. The EL rings the majority of granted exploration interests held by Nautilus in the Bismarck Sea (Figure 4.1). The application assessment has been completed and Nautilus have nominated a minimum first annual expenditure commitment of PGK300,000.[14]

Assessment of the EL application has been completed[15] and, on 18 January 2018, MRA confirmed that the EL had been granted for an intial period of two years.

4.4 Mining Leases

MLs must be marked out at each corner of the lease area using a coloured post established at least 1.2 m above the surface.[16] However the MRA appreciates that placing physical markers on the deep seabed serves no purpose, and has indicated that paper-staking by providing coordinates of each corner of a mining lease on the deep seabed electronically, is sufficient to satisfy survey requirements under the *Mining Act 1992*. MLs are granted for an initial term of no more than 20 years with provision for further renewal subject to recommendation from the MRA and the final consent of the Minister for Mining. Renewal periods must not exceed 10 years on every given renewal subject to the approval of the Minister.

[15] PNG Mining Cadastre Portal (portal.mra.gov.pg), 17/11/2017
[16] Golder, 2012, p.16

4.5 ML status

ML 154, Solwara 1

ML 154 was granted on 13 January 2011 for an initial term of 20 years to expire 12 January 2031. The Lease area is 59.11 km^2 and covers most of the eastern area of EL 1196 (Figure 4.2). The Lease is held by Nautilus Minerals Niugini Limited (85%) and Eda Kopa (Solwara) Limited (15%).

The ML is granted with an associated environmental permit under the Environmental Act 2000. The environmental permit for ML 154 was approved on 29 December 2009 incorporating a Mining Feasibility Plan and proposal for development.[17] Application to vary the approved proposal for development was lodged on 24 November 2017 after company meetings with MRA representatives. The application to vary condition 8 of ML 154 was subsequently approved by the Mining Minister on 18 January 2018 such that the mine must now be commissioned by 1 October 2019.[18]

ML 512, Solwara 12 (application)

ML application number 512 was applied for on 16 February 2016 of an area of 54.57 km^2. The ML covers part of centremost section of EL 1374 in the Bismarck Sea (Figure 4.3).

ML application number 512 has passed the Warden’s hearing phase of the application process.[19] As of November 2017, MRA had not confirmed the status of the application.

4.6 Environmental liabilities

An amount of PGK6,000 per licence is to be held in the form of a security deposit to cover such environmental liabilities as may be incurred during exploration activities.[20]

An amount of PGK48,000 per lease is to be held in the form of a security deposit to cover such environmental liabilities as may be incurred during the life of the Lease.[22]

Prior to commencing either onshore construction activities or seafloor mining operations, an ML and an EP must be granted in accordance with the Mining Act 1992 and the Environment Act 2000, respectively. The environmental permit process addresses both environmental and social considerations and requires the submission of a Mining Feasibility Plan. The EP for Solwara 1 was approved on 29 December 2009.[22]

[17] Golder, 2012, p.16
[18] Nautilus Minerals internal, letter to the Honorable Johnson Tuke, Minister for Mining, 24 November 2017
[19] PNG Mining Cadastre Portal (portal.mra.gov.pg), 17/11/2017
[20] Golder, 2012, p.16

4.7 Royalties and other payments

The holder of an ML is entitled to all resources lawfully extracted from the lease. Under the Mining (Royalties) Act 1992 the Independent State of Papua New Guinea is entitled to 2% of the net smelter return on extracted mineral product and a further 0.25% levy is paid to the Mineral Resources Authority.[21]

The Independent State of Papua New Guinea has the right to acquire up to 30% equitable interest in each project. In 2014, the Independent State of Papua New Guinea entered into an equity agreement for ML 154 entitling the State to a 15% equity stake administered through Eda Kopa Solwara Limited as a joint venture partner. In December 2015 the State Nominee, the Company's joint venture partner in the Solwara 1 Project, elected not to exercise its option to extend its' interest to the full 30% stake.

This interest applies only to the Solwara 1 project and does not affect the State's right to exercise equitable interest options in other projects.

4.8 Obligations

Nautilus is obliged to comply with all regulations associated with PNG exploration licences and mining leases.[22]

[21] M.A- Deputy Manager – Technical Assessment - Mineral Resources Authority
[22] Golder, 2012, p.19

5 Accessibility, Climate, Local Resources, Infrastructure and Physiography

In 2008 Nautilus commissioned an independent report by Met Ocean Engineers Pty Ltd to establish the design criteria for the Solwara 1 project in the Bismarck Sea (RPS Metocean, 2008). The outcomes of this study are summarised below.

5.1 Accessibility and infrastructure

Solwara 1 is located 50 km north of Rabaul in East New Britain. Rabaul is located on the NE coast of the island of New Britain and is the main port of East New Britain Province. The population of Rabaul town is 4,785 (2011 census). It is served by a small airport with a sealed strip, located at Kokopo (population 31,965) serviced by daily jet aircraft flights to Port Moresby. Rabaul has a natural harbour capable of docking large vessels, and a local network of roads, most of which are sealed.

The Solwara project will be serviced from a supply base set up at the port of Kimbe, the capital of the province of West New Britain. Kimbe's port facilities are the third largest in PNG. A supply vessel and up to two tugs will be operating out of the supply base to both service the production support vessel and support the safe positioning, loading and unloading activities of the Handysize vessels which will transport concentrate to the customer.

Crew transport between the production support vessel and the airport of Kokopo will be via helicopter. This will ensure the timely transfer of crew to the airport, and limit the need for additional crew to manage the production support vessel operations during transfer.

5.2 Environment and climate

The climate of the Bismarck Sea and surrounds is tropical, with high temperatures and high rainfall throughout the year. The location of Solwara 1 is approximately 4° S of the equator in a sheltered sea (except to the W where the fetch can be > 1,000 km) well outside of the tropical cyclone belt.

There are two distinct monsoonal regimes, the NW Monsoon, which persists typically from about November to April (summer) and the SE Monsoon (Trade Winds), which persists typically from about May to October (winter). The months of April and October are transition months, when winds of either Monsoon (NW or SE) may persist.

5.2.1 Air temperature and rainfall

The climate at Solwara 1, based on data collected from East New Britain and central New Ireland, is described as Lowland Humid (McAlpine et al., 1983), a category which includes regions with elevations between 0 and 500 m and annual rainfall between 2,000 and 3,500 mm. Relative humidity is high throughout the year and shows little seasonal variation, with an annual average of about 80 to 85%.

Temperatures in the area vary little with the monthly average ranging between 27 °C and 30 °C throughout the year. The highest rainfall occurs in January during the NW monsoon season (the wet season). In Rabaul the average monthly rainfall in January is 352 mm (McAlpine et al., 1975). The lowest rainfall is recorded in September during the SE monsoon season (the dry season), during which time the average monthly rainfall for Rabaul is 86 mm.

5.2.2 Wind

The wind conditions at Solwara 1 are generally benign, with occasional strong to gale force winds. Strong to gale force winds from the W – NW in the summer NW Monsoon and from SE – S in the winter SE Monsoon. Higher maximum winds occur during the summer NW Monsoon, while higher mean winds will occur during the winter SE Monsoon.

Mean wind speeds (10 minute means) are typically lightest in and around the transition months (April to May and October to December) between the two Monsoons, with mean speeds ranging from only about 4.7 to 5.6 m/s. Mean wind speeds are typically strongest during the winter SE Monsoon months of July and August with 10 minute mean speeds ranging from about 6.8 to 7.4 m/s. Maximum wind speeds are typically strongest during the summer NW Monsoon months of March and April with 10 minute mean speeds ranging from about 18.2 to 20.3 m/s.

Reports of gale force winds (> 17.5 m/s or 34 knots) over the Bismarck Sea area are rare (< 1% chance of occurrence). Most gales are due to very localised conditions, such as convective squalls or a big surge in the NW Monsoon due to a distant tropical cyclone. The strongest monsoon (non-convective) winds range from about 16.0 to 20.3 m/s and can come from the W – WNW during the summer months of March and April or from the SE –S during the winter months of August and September. The strongest convective or squall type winds (e.g., during thunderstorms) occasionally reach speeds of 20 – 30 m/s and are possible during almost any month of the year.

5.2.3 Waves

The Solwara 1 location is well protected (with significantly limited fetches) to the arrival of significant sea-states from the N through E and SSW directions. Fetches at Solwara 1 are only significant (i.e. 700-1,000 km) to the WSW to WNW. As a result, the total waves at Solwara 1 are mostly locally generated wind waves (seas with Tp <7 sec) roughly following the directions of the NW and SE Monsoons (i.e. from the W in summer and from the SE – SSE in winter), with only fairly minor contributions of swell waves (with Tp >7 sec and up to 19.5 sec) approaching Solwara 1 from the W (with larger amplitudes) and from the SSE (with very small amplitudes) generated in distant regions of the southern and northern Pacific Ocean.

At Solwara 1, the strongest winds (>14.5 m/s) are from the W – WNW during the NW Monsoon months of February to April and are from the ESE – SSE during the SE Monsoon months of June to September. However, the largest waves (>3 m) affecting the Solwara 1 location are only from the W – WNW directions (where sufficient fetch exists) during the summer NW Monsoon months of December to April. During the SE Monsoon months of June to September, the largest waves are typically only just greater than 2 m (due to limited fetch) and are from the SE – SSE directions.

A summary of annual wave exceedance data against significant sea-state is presented in Table 5.1.

Table 5.1 Solwara 1 sea state exceedance summary (RPS Metocean, 2008)

Significant Wave Height - H_{sig} (m)	% Exceedance
0.0	100.0%
0.5	58.1%
1.0	19.2%
1.5	7.2%
2.0	3.2%
2.5	1.3%
3.0	0.6%
3.5	0.4%
4.0	0.2%

5.2.4 Tides

Solwara 1 experiences a maximum spring tide range of only around 0.8 m. The tides of the area are predominantly diurnal (occasionally mixed), with typically one high and one low each day. Mean Sea Level (MSL) is approximately only 0.7 m above Lowest Astronomical Tide and approximately 0.5 m below Highest Astronomical Tide. The tidal levels at Solwara 1 and the Port of Rabaul are presented in Table 5.2 and Table 5.3.

Table 5.2 Solwara 1 tidal data (RPS Metocean, 2008)

Location	Position relative to datum (+/-m)
Highest Astronomical Tide	+1.2
MSL	+0.5
Lowest Astronomical Tide	+0.00

Table 5.3 Port of Rabaul tidal data (RPS Metocean, 2008)

Location	Position relative to datum (+/-m)
Highest Astronomical Tide	+1.18
MSL	+0.52
Chart Datum	**0.00**
Lowest Astronomical Tide	-0.01

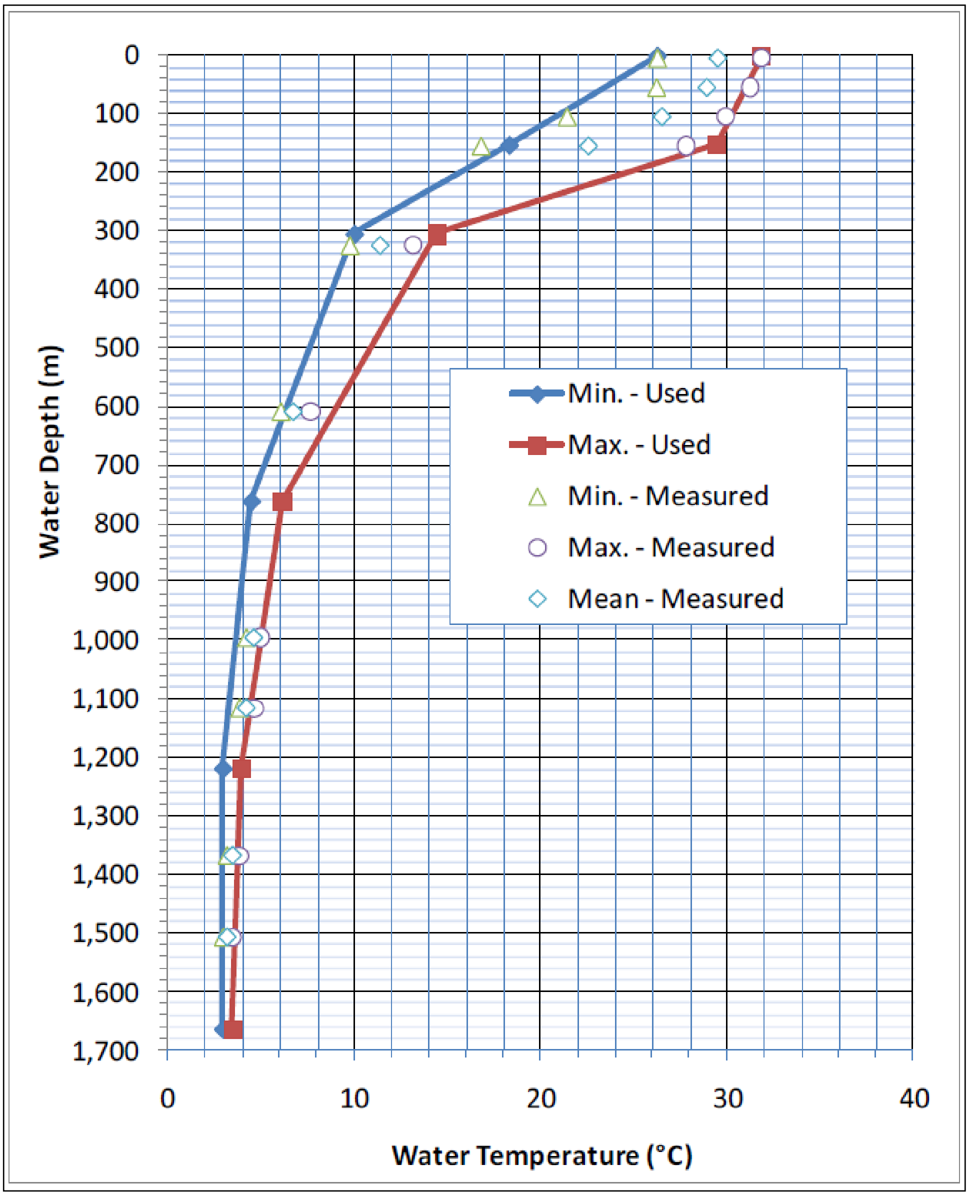
5.2.5 Currents

The ambient total steady currents (combined tide, wind-driven and regional drift components) at Solwara 1 for the upper 150 m of the water column (i.e. the mixed layer) are mostly dominated by the reversing monsoonal drift and wind-driven currents which are more easterly flowing in summer and more westerly flowing in winter. The combined effect of the mostly diurnal tides (i.e. alternating flow towards the W-WSW and E-ENE) and still present drift currents (i.e. tending to be more westerly oriented) will dominate the water column from about 200 mbsl to about 1,300 mbsl. The lower 200 m of the water column (down to 1,500 mbsl) are more strongly tidally dominated with alternating flow towards the W-WSW and E-ENE.

5.2.6 Water temperature

Seawater temperatures for Solwara 1 location are warm throughout the year, with mean monthly sea surface temperatures only ranging from a maximum of 30.1 °C (in November) to a minimum of 28.9 °C (in August). Throughout the year, mean near-seabed water temperatures remain virtually constant at approximately 3 °C. Figure 5.1 presents seawater temperature profile through the water column.

Figure 5.1 Solwara 1 water column water temperatures (RPS Metocean, 2008).



5.2.7 Cyclones

Due to its proximity to the equator and the considerable protection of the surrounding islands, tropical cyclones (tropical storms or depressions) historically have not occurred within the Bismarck Sea. However, within the months of November to June, distant tropical cyclones do occasionally occur in the Solomon Sea, Coral Sea and SW Pacific Ocean to the SSE of the Bismarck Sea. These distant storms can still act to enhance the normal monsoon winds over the Bismarck Sea. For example, tropical cyclone Justin (920 km at its closest point of approach) which occurred in March 1997 in the Coral Sea, strongly enhanced the NW monsoon over the Bismarck Sea. This resulted in the largest modelled winds (U10 = 20.25 m/s) and waves (Hs = 5.53 m) at Solwara 1 location in this metocean study.

Within a 1,000 km-radius of Solwara 1, historically only 36 tropical cyclones occurred during the months of November to May (predominantly summer) and only one storm passed within 400 km over the approximately 42-year period (1961 – 2002). April is the most active month for cyclone activity and most storms are of Category 3 strength and less.

5.2.8 Solwara 1 extreme design conditions

Design criteria results at Solwara 1 for year return periods of 1, 2, 5, 10, 25, 50 and 100 years are summarised in Table 5.4.

Table 5.4 Solwara 1 Summary of extreme metocean data (RPS Metocean, 2008).

Annual non-cyclonic conditions			**Return period (years)**						
			1	**2**	**5**	**10**	**25**	**50**	**100**
Winds									
3 sec. Gust speed	Ug	(m/s)	18.5	20.1	22.0	23.4	25.1	26.3	27.5
1 min. mean speed	U1	(m/s)	16.4	17.8	19.5	20.7	22.2	23.4	24.4
10 min. mean speed	U10	(m/s)	14.8	16.1	17.6	18.7	20.1	21.1	22.0
60 min. mean speed	U60	(m/s)	13.6	14.7	16.1	17.1	18.4	19.3	20.2
Total waves									
Significant wave height	Hs	(m)	3.08	3.50	4.02	4.40	4.89	5.25	5.61
Spectral peak wave period	Tp	(s)	8.90	9.25	8.95	9.37	9.84	10.2	10.5
Average zero-crossing period	Tz	(s)	5.83	6.17	6.57	6.84	7.18	7.41	7.63
Maximum single wave height	H_{max}	(m)	5.73	6.50	7.48	8.19	9.10	9.77	10.4
Total steady currents (combined tidal, oceanic drift & storm)									
-5m MSL Current	V-5	(m/s)	0.82	0.90	1.00	1.06	1.15	1.20	1.25
-325m MSL Current	V-325	(m/s)	0.36	0.38	0.40	0.42	0.44	0.46	0.47
-610m MSL Current	V-610	(m/s)	0.31	0.33	0.34	0.35	0.36	0.38	0.39
-1005m MSL Current	V-1005	(m/s)	0.38	0.42	0.46	0.49	0.54	0.56	0.60
-1355m MSL Current	V-1355	(m/s)	0.22	0.23	0.24	0.25	0.26	0.27	0.29
-1495m MSL Current	V-1495	(m/s)	0.26	0.27	0.28	0.29	0.32	0.33	0.34

Notes:
1. Table presents summary only and is for reference purposes only. Full data is available upon request.
2. Current data includes predicted and measured results at differing depths, detailed explanation available upon request.

5.3 Physiography

5.3.1 Solwara 1 (ML 154)

ML154, in which Solwara 1 is located, covers an area of moderately deep ocean, up to 2,000 m deep, within which there are several seafloor mounds rising to 700 m above the surrounding seafloor. Two of the mounds (North Su and South Su) are volcanic centres that are active, as indicated by thermal plumes and fresh volcanic rocks. The Solwara 1 deposit occurs on a small ridge on the flank of North Su. The surface expression of the deposit is characterised by the presence of sulfide-rich chimneys which can reach up to 15 m in height. Some of these chimneys are still active and venting hydrothermal fluids, but most of the chimney fields are inactive. A veneer of unconsolidated sediments, rarely exceeding 2 m thick, has been deposited over parts of the Solwara 1 deposit that do not contain outcropping chimneys.

5.3.2 Solwara 12 (MLA 512)

EL 1374 covers three areas of moderately deep ocean, with the three areas being broadly classified as Marmin Knolls; Pual Ridge, Desmos Caldera and Umbo Seamounts; and Bugave Ridge and Kaia Natai seamount. Solwara 12 lies outside the southwestern rim of Desmos Caldera, on a local bathymetric high between Desmos Caldera and Umbo Seamounts. The surrounding seafloor in this area lies at approximately 2150 m below sea level, while Desmos is a 2 km wide caldera, with rims rising to approximately 300 m above the surrounding seafloor. Umbo consists of a pair of seamounts with associated ridges, rising close to 500 m above the seafloor. Solwara 12 occurs in a localised low on an E-W trending ridge. The surface expression of the deposit is characterised by the presence of sulfide-rich ‘chimneys’ which can reach up to 10m in height. These chimneys are inactive. A veneer of up to several metres of unconsolidated sediments has been deposited over parts of the Solwara 12 deposit that do not contain outcropping chimneys.

6 History

6.1 Exploration and discovery

The first discovery of submarine hydrothermal sulfides and black smokers in PNG was at what was to become the Solwara 2 deposit, when in 1985 the US research vessel RV Moana Wave photographed seafloor sulfides there. Since then, occurrences of submarine sulfides in the Bismarck Sea, where some of Nautilus's PNG tenements are located, have been studied by research groups from many countries, including France, Germany, Canada, USA, Japan, Korea, UK and Australia.

Research cruises have supplied detailed bathymetry of the Solwara 1, 2, 3 and 4 locations, and these locations have also been observed by manned submersible dives and numerous deep-tow video traverses. Dredging traverses were extensively employed during the various "PACMANUS" and "Binatang" research cruises, and it is estimated that, since 1991, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) has acquired several tonnes of sulfide samples from the Solwara 1 and Solwara 4 hydrothermal fields. Basic descriptions of dredge contents are recorded in the various cruise reports, which were compiled on board, prior to chemical analyses. Submersible and deep-tow video observations supplemented by the dredge reports have enabled researchers to compile and publish basic geological reconnaissance reports and maps of several of the hydrothermal fields.

The hydrothermal field at Solwara 1 was first discovered by the CSIRO during the 1996 PACMANUS III cruise on the RV Franklin in the far eastern sector of the Eastern Manus Basin. The detection of an intense particulate plume during the PACMANUS II cruise in 1993 led the researchers to the NNW-trending volcanic edifice that hosts Solwara 1. The volcanic ridge is approximately 5 km long and is mainly basalt, with two major andesite-dacite domes (North Su and South Su). Solwara 1 is to the NNW of North Su, and lies at the intersection with a NE-trending extensional rift structure (Bugave Ridge). The Solwara 1 mineralisation is outcropping for a strike length of approximately 1.4 km and located at a water depth of 1,500–1,650 m below sea level (BSL).

In 2000, as part of the Ocean Drilling Program (Leg 193), a series of partially cored holes were drilled at three of the active Solwara 4 fields to investigate geological and geophysical conditions to depths of 370 m below the seafloor, providing detailed logs, core photographs and descriptive data (ODP 193, 2000).

During the German/UK Research Cruise "Condrill" (SO166) in late 2002, an initial phase of drilling to 5 m depth into the surface of the Solwara 4 hydrothermal fields was conducted using the drilling services of the British Geological Survey. Of the ten holes drilled, three recovered massive chalcopyrite mineralisation, and six recovered sphalerite-rich chimney materials (Petersen *et al.*, 2003).

Exploration in 1990 in the eastern and central Manus back-arc basin using a deep-towed bottom survey platform on the Hakuho Maru (Cruise KH90-3 Leg2) discovered hydrothermal vents at Desmos Caldera (Sakai, 1991). The survey platform equipped with a video-CTD (conductivity, temperature, depth probe) package detected water-temperature anomalies, vent-associated fauna, and bacterial mats. Hydrothermal activity was discovered on a small terrace on the NW inner wall of the Desmos Caldera.

The research cruises in and around Nautilus's Bismarck Sea tenements are summarised in Table 6.1.

Table 6.1 Summary of selected research cruises in and around Nautilus's Bismarck Sea tenements

Research Cruises	Ship/Cruise	Dates	Area
CSIRO-led Cruises			
PACMANUS/PACLARK V	RV Franklin: FR08/91	Sep-Oct 1991	Eastern Bismarck Sea
PACMANUS II	RV Franklin: FR05/93	June 1993	Eastern Bismarck Sea
PACMANUS III	RV Franklin: FR10/96	Nov-Dec 1996	Eastern Bismarck Sea
PACMANUS IV	RV Franklin: FR09/97	Oct-Nov 1997	Eastern Bismarck Sea
BINATANG	RV Franklin: FR03/00	Apr -May 2000	Eastern Bismarck Sea
ODP Leg 193	JOIDES Resolution	Nov 2000 – Jan 2001	Eastern Bismarck Sea
BISMARCK-SOLAVENTS 2002	RV Franklin: FR02/2002	March 2002	Western Bismarck Sea
Southern Bismarck Arc	RV Southern Surveyor	Jul-Aug 2007	West & south Bismarck Sea
Cruises with CSIRO participation			
Edison '94	*RV Sonne*: SO 94	Mar-Apr 1994	Lihir-Feni Chain and Eastern Manus Basin
ManusFlux	*Yokosuka*/Shinkai 6500: Y95-07	Oct-Nov 1995	Eastern Bismarck Sea (Solwara 4)
BioAccess 98	*Natsushima*/Shinkai 2000: NT98-13	Oct-Dec 1998	Eastern Bismarck Sea (Solwara 4)
KODOS '99	*RV Onnuri*	May 1999	Eastern Bismarck Sea
Dae Yang 2002 Leg 1	*RV Onnuri*	Aug-Sep 2002	Lihir Island and Eastern/Western Bismarck Sea
Other cruises			
Moana Wave (USA)	*RV Moana Wave*: MW8517-18	1985-86	Bismarck Sea, Woodlark Sea and Islands
OLGA I (German)	*RV Sonne*: SO 63	Jul-Sep 1989	Eastern Bismarck Sea
OLGA II (German)	*RV Sonne*: SO 68	Apr-Jun 1990	Eastern Bismarck Sea
21st Cruise	*RV Akademik Mstislav Keldysh*: Leg 3	May-Jun 1990	Eastern Bismarck Sea
Aquarius	*Hakuho-Maru*: KH90-33 Leg 2	Nov-Dec 1990	Eastern Bismarck Sea
MMAJ for SOPAC	*RV Hakurei-Maru* No 2	Aug-Oct 1992	Central Bismarck Sea
BioAccess 96	*Natsushima*/Shinkai 2000: NT96-14/15	Oct-Dec 1996	Eastern Bismarck Sea (Solwara 4)
Manaute	*RV L'Atalante*/Nautile	Mar-Apr 2000	Central and Eastern Bismarck Sea
Condrill	*RV Sonne*: SO 166	Sep-Oct 2002	Solwara 4 and Conical Seamount
Bismarck Sea Survey 2005	*RV Onnuri*	Sep-Oct 2005	Central Bismarck Sea
Woods Hole Oceanographic Institute	*RV Melville*	Jul – Aug 2006	Manus Basin
Jamstec	*Yokosuka*/Shinkai 6500	Sep 2006	Manus Basin

6.2 Previous resource estimates

This is the second NI 43-101 Mineral Resource estimate for the Solwara 1 deposit. The maiden Solwara 1 Mineral Resource estimate was prepared by Golder Associates in 2007-2008 (Lipton, 2008).

This was superseded by a mineral resource estimate for Solwara 1 and 12 prepared by Golder Associates in 2011 (Lipton, 2011). The 2011 estimate remains current and details of it are presented in this Technical Report.

6.3 Historical production

No mineral production has occurred in the Project area.

7 Geological Setting and Mineralisation

7.1 Regional geology

The Manus Basin, located in the Bismarck Sea is an active arc/back-arc basin bounded to the south by the active subduction zone of the New Britain Trench and to the north by the inactive subduction zone of the Manus Trench, formed at the convergence zone between the Australian Plate to the south and the Pacific Plate to the north. So far, Nautilus has identified 17 separate SMS prospects in the Manus Basin and two barite-rich systems (Solwara 17 and Solwara 19) (Figure 7.1).

The Basin's major structures include the rapidly opening (approximately 10 cm/year) Manus Spreading Centre, which hosts the Solwara 2, 3, 10, 14, 15 and 16 prospects; the Willaumez Spreading Centre, which hosts the Solwara 11, 17 and 18 prospects and the rift zone of the Eastern Manus Basin bounded by two major W to NW left lateral transform faults (the Djaul and Weitin Faults – Figure 7.1). The East Manus Basin hosts the Solwara 1, 4, 5, 7, 8, 9, 12 and 13 prospects (Figure 7.2). Associated volcanism is of basaltic to dacitic composition.

Nautilus does not currently hold tenure over Solwara 2, 3, 10, 11, 14, 15, 16, 17, 18, or 19.

The East Manus basin formed over the last million years, with rotation of the South Bismarck microplate (including the New Britain Block) southward. Oblique convergence at the plate's NE margin (between New Britain and New Ireland) has led to repeated docking and rifting. The East Manus basin thus formed from extensional and left lateral tectonics behind eastern New Britain. Accommodation zones between variable areas of extension have focused recent volcanic and associated hydrothermal activity.

A series of prominent submarine volcanic edifices have formed along some of these accommodation zones on the seafloor of the East Manus Basin, extending in an en echelon configuration across the trend of the rift basin (Binns and Scott, 1993). These edifices are the sites of active hydrothermal venting and associated deposition of SMS deposits.

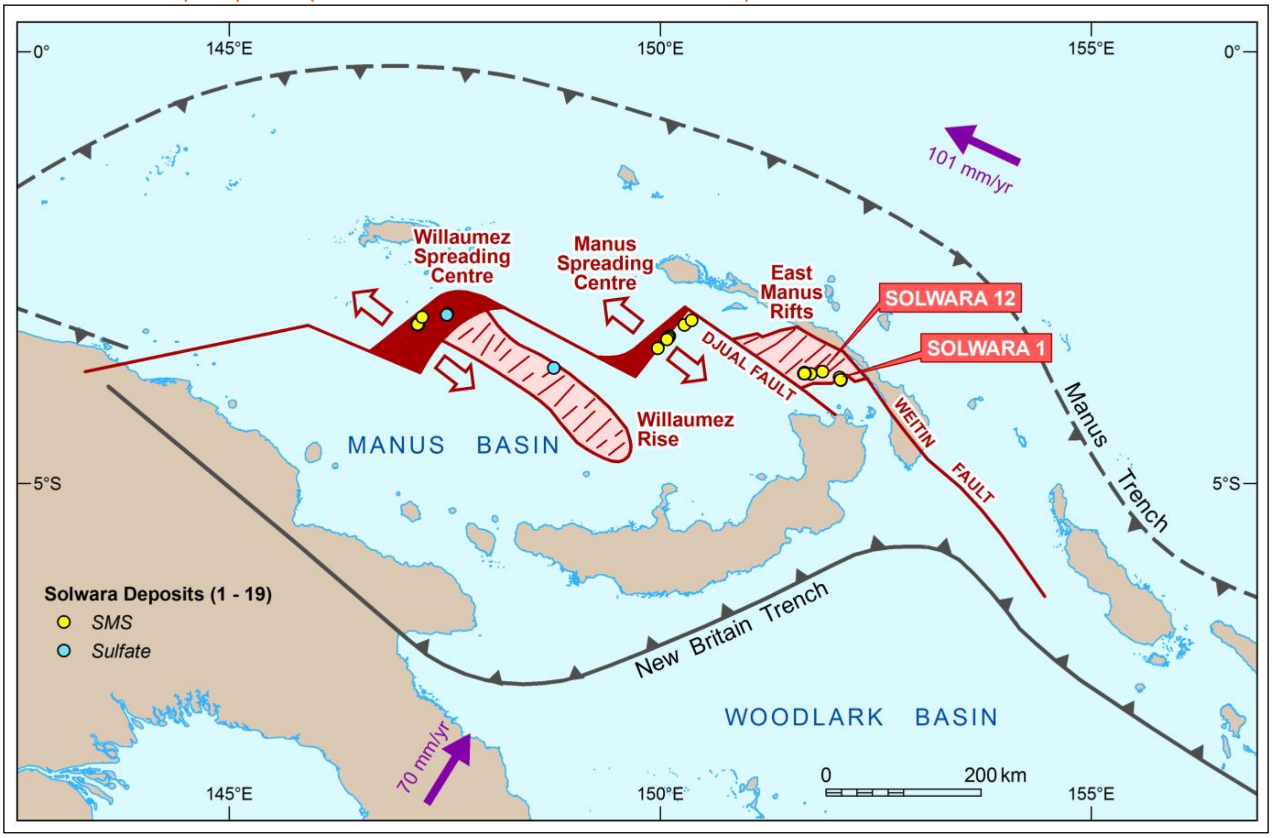
7.2 Local geology

The Solwara 1 deposit is located on the crest and slopes of the Suzette volcanic edifice at an average depth of 1,520 mbsl. Suzette is the northernmost edifice of the Su Su knolls, which also includes North Su and South Su, at 1,150 and 1,320 mbsl respectively (Yeats et al., 2014).

Su Su knolls are part of a NNW trending volcanic ridge that is about 7 km long and comprises basalt to dacite lavas and breccias (Yeats et al., 2014). At Suzette, hydrothermal mineralisation is found along the top and flanks of the ridge including chimneys and clay-altered volcanics. Coherent volcanic facies including pillow lavas, sheet and block-jointed lavas are exposed. Volcaniclastic facies include breccias, talus and fine grained volcanic sediments. The Solwara 5, Solwara 9 and South Su prospects are also located on this ridge.

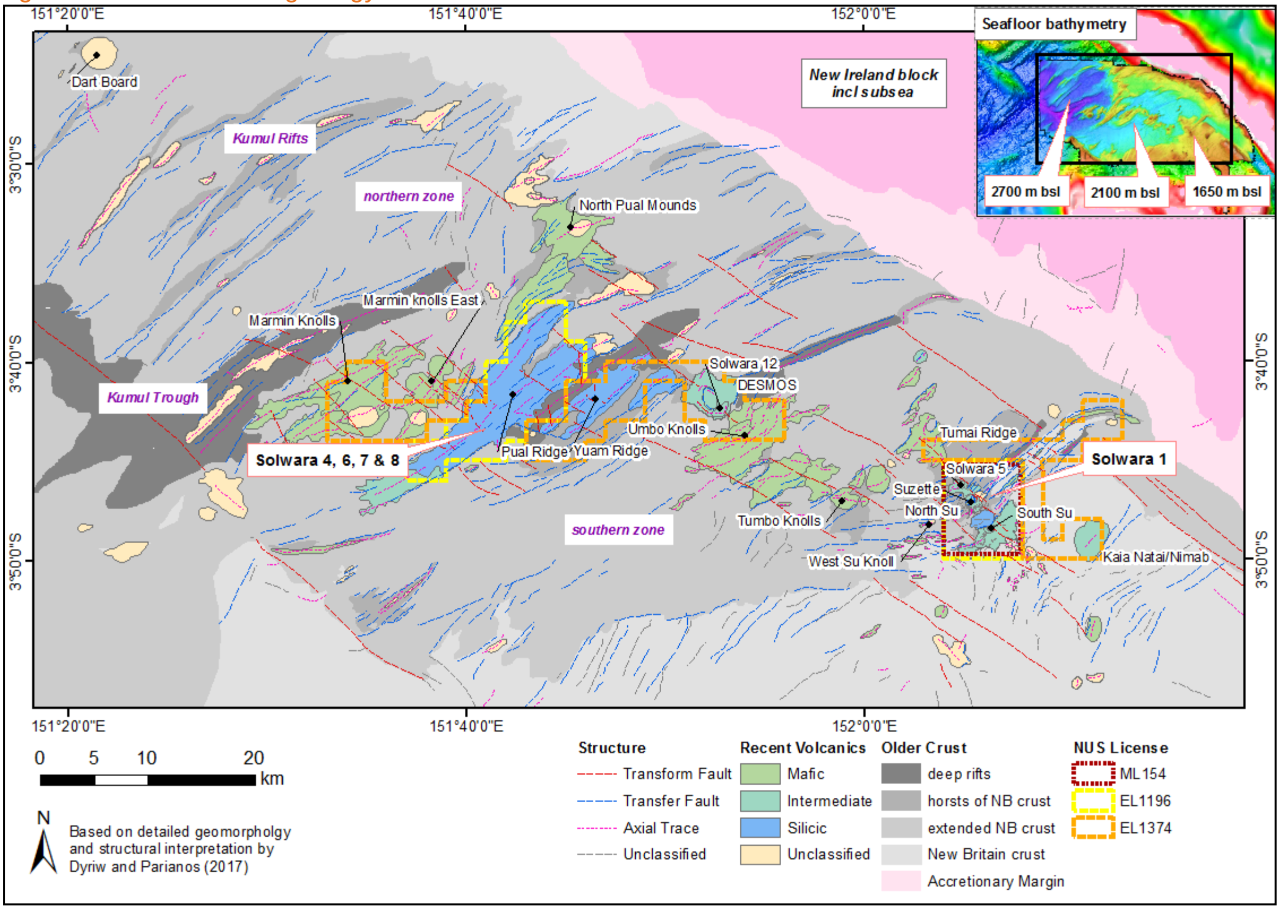
Solwara 12 is located on the SE edge of the Desmos Caldera on a distinctive knoll at around 1,850 mbsl to 1,900 mbsl. The mapped chimney field is around 200 m across and includes clusters of old, inactive chimneys with sediment cover in-between. The Solwara 12 outcropping chimneys are large (up to 10 m high).

Figure 7.1 Summary map of the geological features in eastern PNG and location of Solwara deposits and prospects (Modified from Scott and Binns, 1995).



Notes: Yellow dots: SMS prospects. Blue dots: sulphate prospects

Figure 7.2 Seabed geology of the Eastern Manus Basin



Solwara 1 is a tabular flat-lying deposit of massive sulfide-dominant mineralisation lying on the Suzette volcanic edifice (Figure 7.3). Suzette rises 150 to 200 m above the surrounding seafloor. The edifice locally has steep flanks of up to 30 degrees; but the top comprises a flatter undulating terrain with volcanic rocks, hydrothermal chimneys, and minor sediment cover.

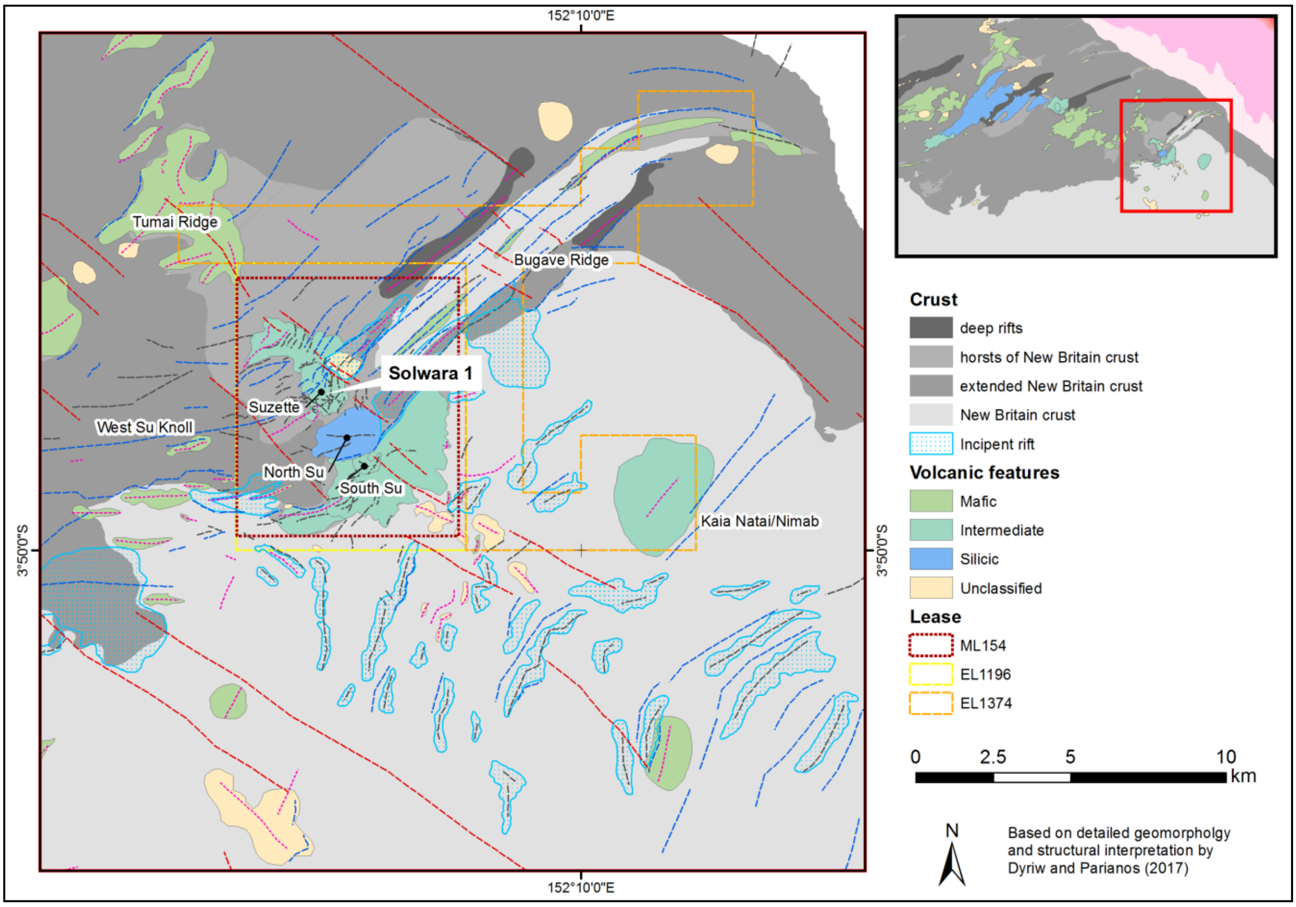
Exposed and drilled volcanic rocks comprise lavas (block jointed and pillows) and breccia (block lava to volcanic talus). Compositions are dominated by tholeiitic to calc-alkaline basaltic andesite to dacite. Some volcanics occur as thin volcanic flows that cap part of the main sulfide-dominant mineralisation within the eastern and northern zones of the deposit.

The main area of the Solwara 1 deposit contains numerous hydrothermal vents or chimneys. Nautilus has sampled many of the chimneys across the deposit and they are composed dominantly of chalcopyrite and pyrite, with minor amounts of sphalerite, and sulfates (barite and anhydrite). Chimney heights generally range from 2 to 10 m and have been observed up to 15 m in height. Where chimney development is strongest the chimneys coalesce into distinct mounds or occur in linear zones that are interpreted to be related to underlying structural features.

Drilling has found massive sulphides below the chimneys, and hydrothermal clay altered volcanics grading to fresh volcanics below the massive sulphides.

Unconsolidated sediments (clay to sand-size particles) are found extensively on top of volcanic and mineralised units. These sediments are from nearby hydrothermal and volcanic venting as well as lesser pelagic input.

Figure 7.3 Geological interpretation of Solwara 1 sub-region



7.3 Solwara 1 logging schema

The sub-surface geological sequence at Solwara 1 has been investigated by shallow diamond drilling to a maximum depth of 51.62 m. Unconsolidated sediments (lithology code SS) cover much of the seafloor, and typically comprise dark grey clays and silts averaging 1.94 m in thickness. Drilled thickness ranges from 0 to 5.62 m, with a maximum intersection in SD071. Recovery is generally low due to the softness and low cohesiveness of this material.

The unconsolidated sedimentary rocks are generally underlain by consolidated sediments (lithology code SC), which are typically cemented with opaline silica. Biogenic features such as worm burrows are preserved. Drilled thickness ranges from 0 to 4.0 m, with an average depth of 1.54 m.

Three domains in the mineralisation system (excluding the surface chimneys) have been defined beneath the consolidated sediments:

- **Mineralised and sulfate altered sedimentary rock (lithology code PT):** a distinctive layer of pale to dark grey, fine to medium grained consolidated volcaniclastic sands has an average thickness of 1.1 m but locally can be up to 6 m thick. The maximum drilled depth of this material is 13.57 m (SD181). The sediments are interpreted to have been flooded by hydrothermal fluids that have precipitated a cement of opaline silica, sulfide and sulfate minerals. Rare fragments of sulfide-rich chimneys are entrained within this domain. Locally this unit is well mineralised containing significant chalcopyrite and sphalerite as both clasts and pervasive replacement.
- **Sulfide dominant rock (lithology code RI) and conduit facies (lithology code CF):** this is the main mineralised domain, varying in thickness from 0 to 29.0 m. The domain consists dominantly of pyrite and chalcopyrite with anhydrite or barite gangue. Chalcopyrite is commonly more abundant closer to the surface where it is observed around open channel ways or conduits. It has a similar appearance to the internal texture seen in surface chimney samples. In most drillholes chalcopyrite content tends to diminish with depth and is replaced by pyrite. Anhydrite and barite occur in variable amounts throughout the sulfides as veins and breccia matrix, particularly towards the base of the domain.
- **Clay and sulfate dominant rocks (lithology codes RC and RA):** the footwall to the sulfide-dominant rock is comprised of clay and sulfate dominant rocks (with lesser sulfide) interpreted to represent texturally destructive alteration. The protolithology is interpreted to have been a volcanic or volcano-sedimentary rock from rare primary textures, geochemical studies and lateral and vertical gradation between altered and less altered rocks. Sulfides (pyrite and lesser chalcopyrite) and sulfates (anhydrite and barite) occur as fine grained disseminated replacement or as veins that cross cut the clay dominant rocks. Sulfates can also be present as breccia infill and veins. Clay analysis by short wave infrared (SWIR) studies of the altered footwall indicate zonation of alteration minerals. Smectites and opal are dominant on the periphery of the system and micas (muscovite/paragonite/illite) form the dominant alteration minerals in the centre of the system. Rare pyrophyllite and kandite/dickite have been identified in some drillholes. In most cases drilling has not been deep enough to fully constrain the vertical extent and character of the altered footwall rocks. Interpretation of the drill core indicates mineralisation extends into deeper feeder zones under chimney areas or within localised breccia zones. These deeper zones can contain significant copper and gold mineralisation with low levels of zinc. It is likely that these zones are narrower than the footprint of the deposit.

Massive, fresh or weakly altered volcanics occur laterally and in some locations above the sulfide and sulfate mineralised domains.

The Solwara 1 deposit is comprised of several zones (Figure 7.4) which are interpreted to comprise a single mineralised system based on their stratigraphic continuity. Geologically the central, western and eastern zones show strong similarities. The northern zone (Solwara 1 North), located 300 m north of the main mineralisation at Solwara 1 is located on the ridge flank 150 m below the main mineralised ridge. The zone is characterised by a low mound with clusters of inactive chimneys within a steep sloping valley. The surrounding area is covered by sediment.

Solwara 1 North was first drilled in 2008 with five scout holes to a maximum depth of 10.8 m. Subsequent drilling in 2010/11 extended the maximum depth to around 28 m, with an average depth of 14.7 m in 12 holes. Soft sediment cover extends down to 1.3 m and overlies a thin zone of mineralisation characterised by sphalerite, galena and gold associated with anhydrite and barite. This unit generally caps the main sulfide-dominant mineralisation at Solwara 1 North which extends down to 15.89 m and is characterised by massive chalcopyrite and pyrite with lesser sphalerite and galena. A second deeper zone of mineralisation was intersected 17-20 m below the seafloor. The two mineralised zones are separated by a sequence of volcanic rocks with alteration of varying intensity. A short wave infra red (SWIR) study indicates the footwall volcanics contain illite and gypsum which are interpreted as alteration minerals formed at moderate to high temperature. Smectite occurs in the volcanic rocks in the periphery and is interpreted to be alteration formed from low temperature near neutral pH fluids.

Figure 7.4 Map of Solwara 1 showing outline of mineralised areas. Cross section A-A' shown in Figure 7.5.

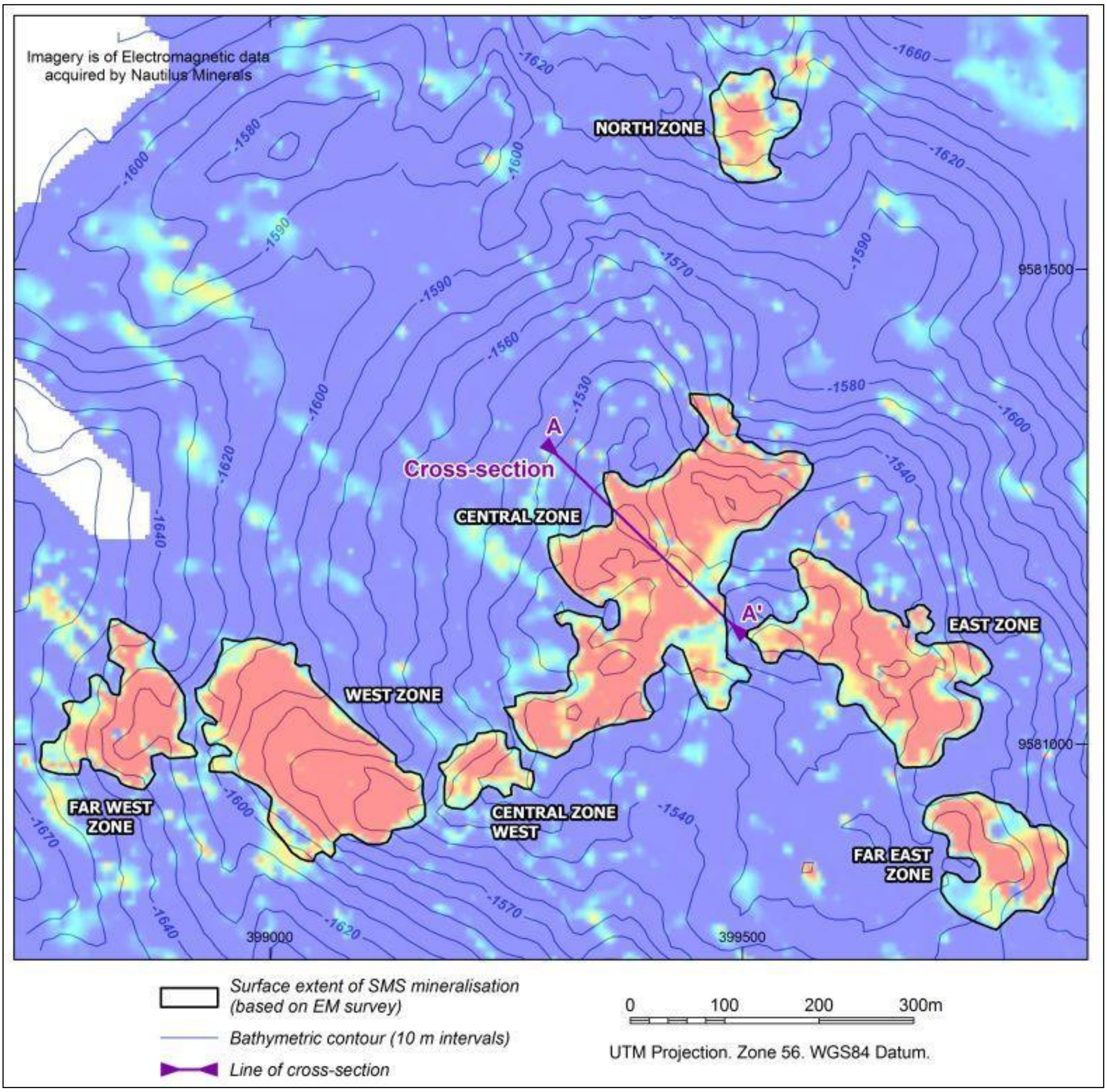
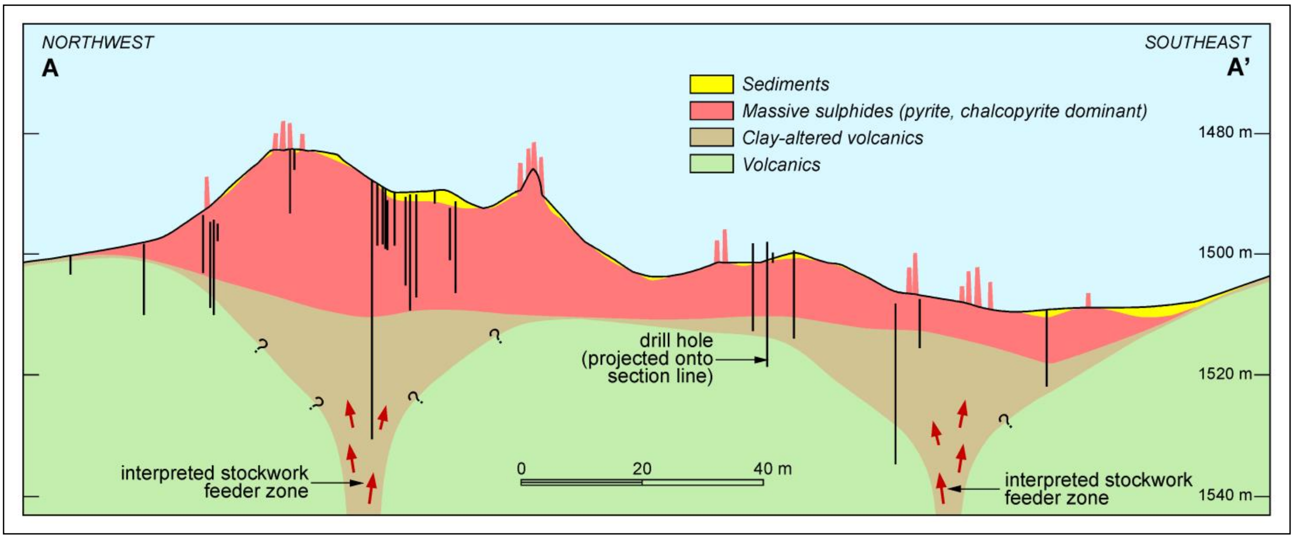


Figure 7.5 Solwara 1 schematic geological cross section A-A' looking NE. Location of cross section shown in 7.4.



7.4 Solwara 12 Geology (MLA 512)

The Solwara 12 deposit was discovered in 2009 by Nautilus during the Fugro Solstice Target Generation and Target Testing program while conducting grid-based ROV traverse mapping of Desmos Caldera. Detailed mapping identified an area of inactive sulfide chimneys approximately 180 m by 170 m which includes a central cluster of Cu-rich chimneys surrounded by Zn-rich chimneys. Chimneys are up to 15 m high and several metres across at the base. There is extensive sediment cover in the area.

Drilling during 2010/11 averaged 12 m depth with six holes drilled to depths greater than 15 m (Figure 7.6, Figure 7.7 and Figure 7.8). Unconsolidated sediments intersected in drill holes average 2 m in thickness but extend up to 8 m in places. Intersections of fine grade sulfide mineralisation occur within cohesive mud as subhorizontal bands with grades of up to 6% Cu and 0.2% Pb (SD_S12_026).

A domain of Zn-rich sulfide mineralisation dominated by sphalerite and chalcopyrite, with lesser galena, barite and pyrite, occurs below the unconsolidated sediment and extends to a maximum depth of 10.3 m. Elevated Au and Ag values up to 18.5 g/t and 234 g/t are also present. This domain overlies the main sulfide-dominant mineralisation domain. The sulfide-dominant domain contains pyrite and chalcopyrite with lesser sphalerite and galena and has an average depth of 6 m and maximum depth of 17 m. Strongly altered (clay, sulfide and sulfate) footwall volcanic rocks occur directly below the sulfide-dominant domain. Several of the deeper holes intersected disseminated pyrite and chalcopyrite mineralisation below the main sulfide-dominant domain between 15 – 25 m from surface within clay-altered volcanics. Further drilling is required to fully establish the extent of this mineralisation.

A SWIR mineral analysis study of the altered minerals in the footwall indicates a zonation of alteration minerals, with smectite and Fe-carbonates identified around the periphery of the system and a dominant mineral assemblage within the centre and western part of the system of illite and gypsum. Pyrophyllite and kandites were not identified from samples collected at Solwara 12.

Figure 7.6 Location of Solwara 12 drillholes and bathymetry. Location of cross section AA' and BB' in Figure 7.7 and Figure 7.8.

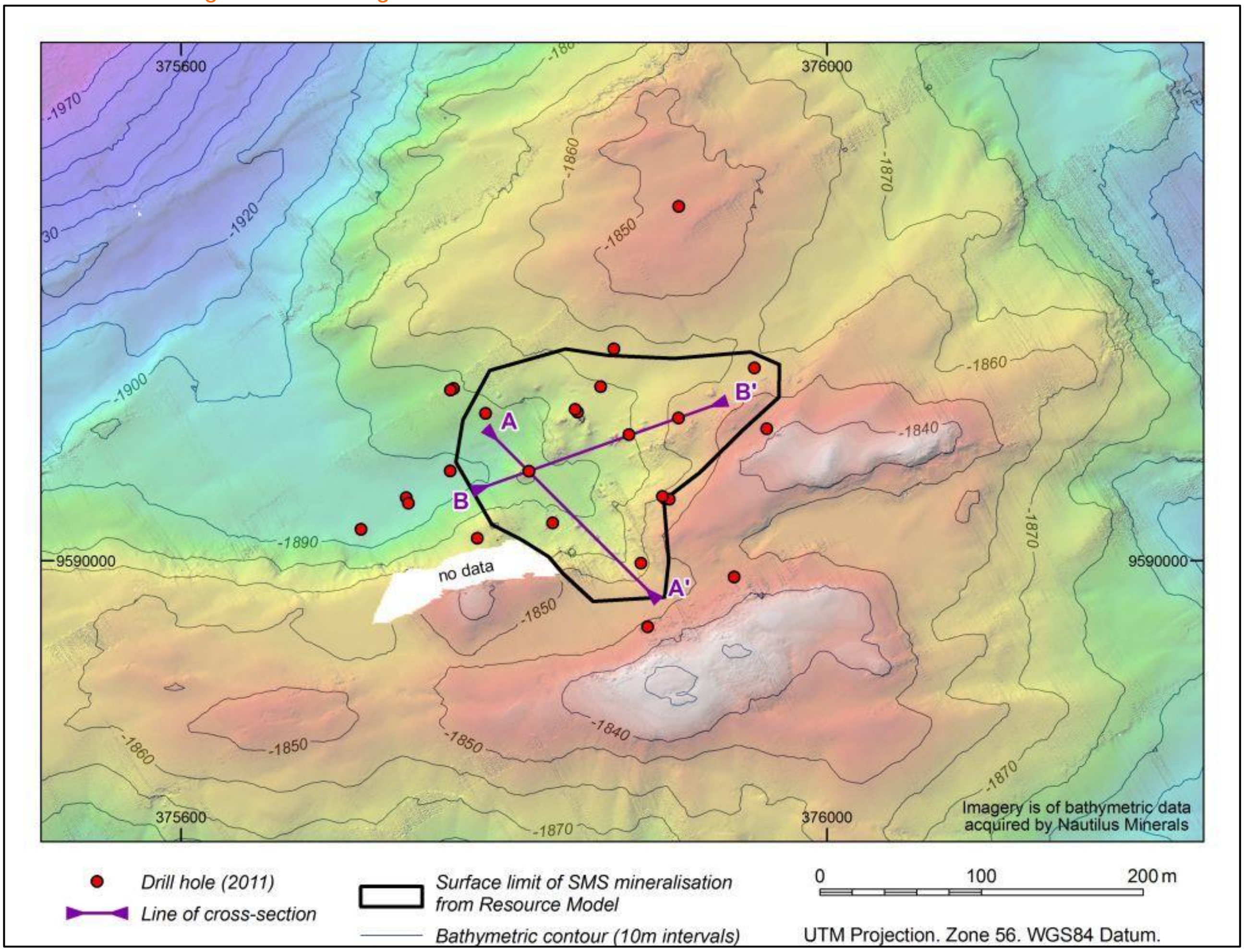


Figure 7.7 Solwara 12 cross section AA' looking NE. Location of cross section shown in Figure 7.6. Approximate seafloor chimney locations from seafloor mapping results.

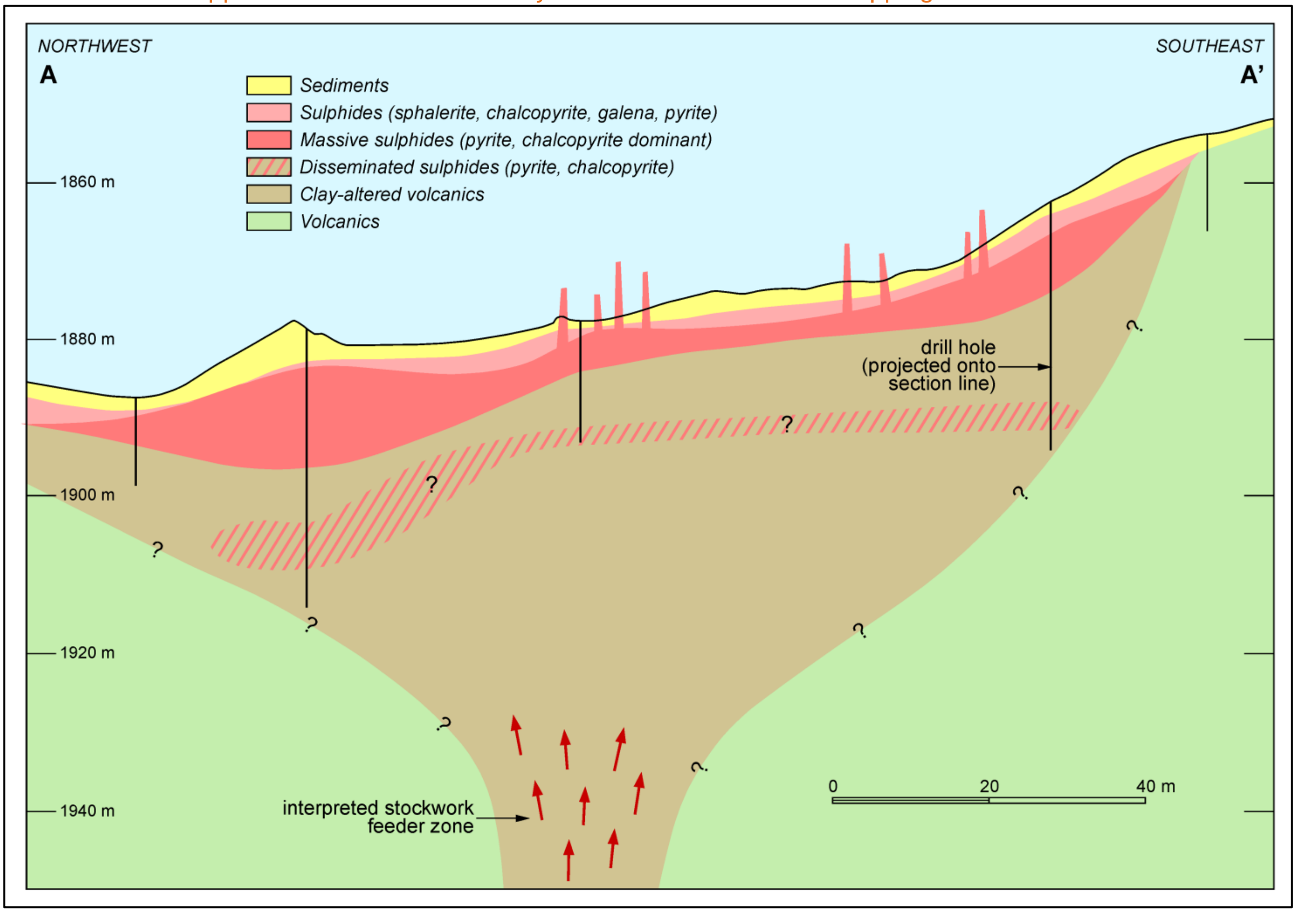
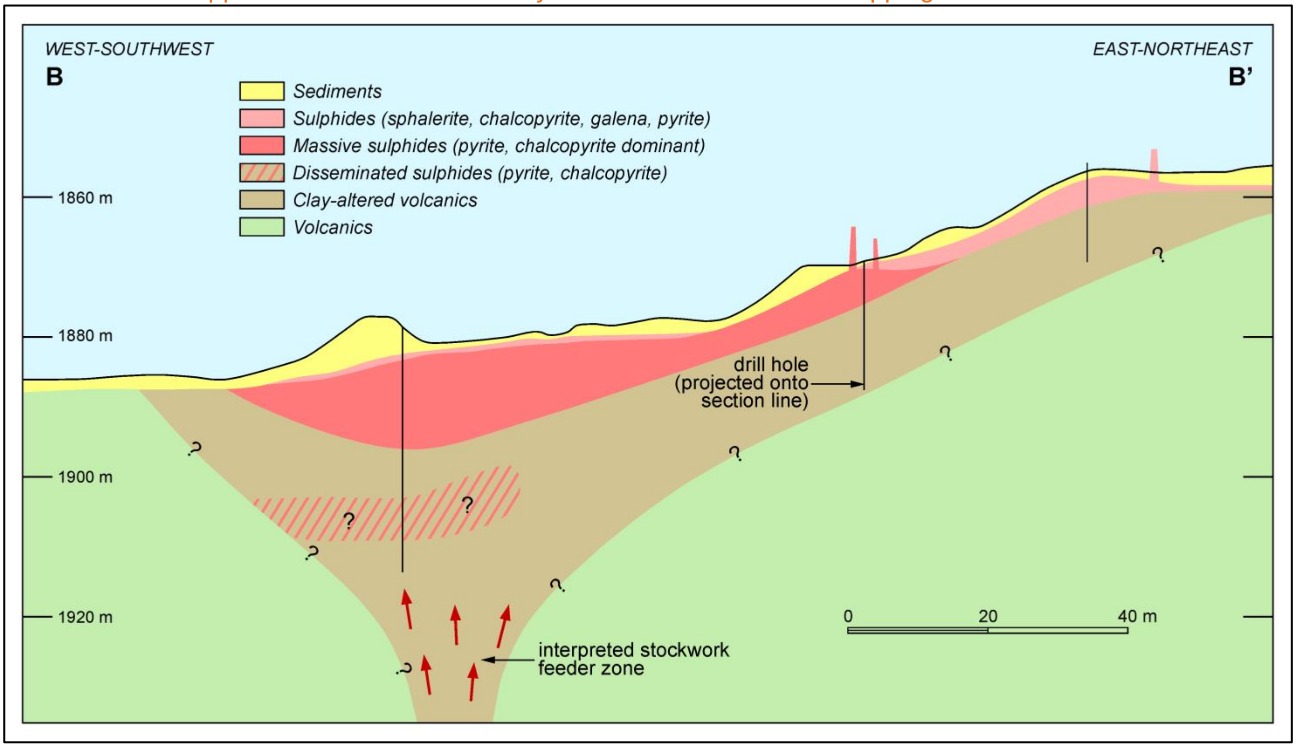


Figure 7.8 Solwara 12 cross section B-B' looking NW. Location of cross section shown in Figure 7.6. Approximate seafloor chimney locations from seafloor mapping results.



7.5 Other Bismarck Sea prospects

In addition to Solwara 1 and Solwara 12, Nautilus's Bismarck Sea Property contains another eight separate SMS prospects. The location and geological setting for each prospect is summarised Table 7.1.

Table 7.1 Summary of location and geological setting of Nautilus's Bismarck Sea prospects

Solwara Prospect	Prospect type	Water depth (mbsl)	Distance (km) and bearing from Rabaul		Nautilus Licence	Geological Setting	Brief Description
4	SMS	1654-1800	77	NW	EL1196	On the Pual Ridge	Six SMS chimney occurrences (4a, b, c, d, e, f) of varying size. Extensively sampled by research drilling and dredging.
5	SMS	1635-1680	48	NNW	EL1196	Northwest of North Su	SMS chimney area is approximately 250 m by 170 m with significant sediment cover. Surrounded by outcrops of felsic to intermediate-mafic volcanic rocks.
6	SMS	1730-1775	75	NW	EL1196	On the Pual Ridge	SMS chimney area is approximately 50 m by 50 m with individual chimneys up to several metres in height. Sediment cover is present.
7	SMS	1755-1815	77	NW	EL1196	On the Pual Ridge	SMS chimney area is approximately 200 m by 20 to 25 m wide. Solwara 7 extension is a 10x10m area of chimneys 220m NW along strike from Solwara 7.
8	SMS	1654-1800	76	NW	EL1196	On the Pual Ridge	SMS chimney area immediately adjacent to Solwara 4e and 4c; possibly part of the Solwara 4 hydrothermal system.
9	SMS	1680	44	NNW	EL1196	On the SW flank of North Su Caldera.	Comprises two SMS chimney areas (9a and 9b) approximately 220m and 180m long respectively with a width averaging 40m.
12	SMS	1850	65	NW	MLA512	On the SE rim of the Desmos Caldera	Inactive SMS chimney area is approximately 180m by 170m comprising chimneys up to 10m high
13	SMS	2000	70	NW	EL1374	Southwest end of the Yuam Ridge	SMS chimney area is approximately 200m by 150m, comprising chimneys up to 20m high.

Adapted from Jankowski, 2007

8 Deposit Types

SMS deposits are considered to be modern analogues of ancient terrestrial Volcanic Hosted Massive Sulfide (VHMS) deposits. VHMS deposits form a major part of the world's reserves of copper, lead and zinc, as well as being producers of gold and silver. Over 800 terrestrial VHMS deposits have been identified around the world and are well studied (Large et al. 2005).

8.1 VHMS deposits

VHMS deposits are commonly found in clusters consisting of dozens of individual deposits around 1 to 10 Mt in size within a larger mining district. They are hosted in volcanic or volcano-sedimentary successions and were originally deposited under water. Large (1992) summarized the features common to VHMS deposits, as follows:

- They are the same age as the host succession.
- The host rocks vary from volcanic to volcaniclastic or sedimentary facies and range in composition from basalt through andesite and dacite to rhyolite.
- Most deposits are hosted in thin volcaniclastic units (less than 100 m thick) between major volcanic formations.
- The economic parts of the deposits typically comprise >80% sulfide minerals by volume, principally pyrite, sphalerite, chalcopyrite and galena.
- Massive sulfide lenses are commonly aligned parallel to volcanic strata.
- Stringer (or stockwork) sulfide zones commonly underlie the massive sulfides and may contain economic copper grades.
- Metal contents and metal ratios vary considerably. Deposits may be copper-rich, Au-rich, copper-Zn rich or polymetallic (Cu-Zn-Pb-Ag-Au) types.
- Ore metals within sulfide deposits are typically vertically zoned, from copper at the stratigraphic base to zinc, lead, silver, gold and barium towards the top. However, there are many exceptions to this zonation pattern.

The widely accepted genetic model for the formation of a VHMS deposit is based on the formation of deep-seated hydrothermal convection cells focussed around active submarine spreading ridges. Circulating seawater undergoes heating at depth and consequently leaches metals from the deep volcanic stratigraphy through which it passes. The circulating fluid may also mix with and entrain magmatic fluids sourced from crystallizing sub-volcanic intrusions. Finally, the hot, metal-laden reduced hydrothermal fluid is expelled onto or immediately below the seafloor surface where it cools via mixing with oxidized seawater and precipitates sulfides, sulfates and Fe-oxide minerals. Long lived precipitation eventually builds up a mound of metal-rich sulfide on or immediately beneath the seafloor.

Within a mining camp VHMS deposits tend to be spatially clustered with multiple deposits commonly forming at a single stratigraphic level. Deposits are localised at the prospect scale by the distribution of synvolcanic extension faults. These extension faults are active during the formation of the deposits and create the permeability required to allow transport of the upward-migrating metal-laden fluids to reach either the seafloor or the immediate sub-seafloor porous environments.

8.2 SMS deposits

SMS deposits are formed on the seafloor near plate margins in either:

- Divergent plate margins such as mid-ocean ridge spreading centres or spreading back arc basins
- Convergent plate margins such as island arcs or continental margins; or
- Intra-plate oceanic islands

SMS deposits are formed in geological settings where extensional fault systems facilitate the deep circulation of sea water in convection cells, formed by heat flow from submarine volcanic activity. Active sulfide deposition on the ocean floor (Figure 8.1) is confined to sites where hot (>200 °C) rising hydrothermal vent fluids (± magmatic volatiles and metals) mix with cool (2 °C) ambient ocean water. Through the accumulated precipitation of the sulfides at the vent site, chimney-like structures form. These chimneys consist of anhydrite and polymetallic sulfides. The combined processes of: 1) episodic flux of the hydrothermal vent fluid; 2) seafloor oxidation; and 3) seismic events contribute to the collapse of the old chimney structures and the initiation of new chimney structures. This cyclical process results in the formation of a sulfide mound on the seafloor. As the size of the mound increases, through prolonged hydrothermal activity, the permeability of the upper part of the mound decreases to a point where precipitation, replacement and remobilisation of sulfides can occur inside and beneath the mound Figure 8.2).

The obvious similarities (tectonic setting, mineralogy, metal zonation and alteration zonation) between SMS deposits and VHMS deposits have led the research community to conclude the systems are analogous.

Figure 8.1 Schematic model for development of SMS deposits in a mid-ocean ridge spreading centre setting (Humphris and McCollom, 1998).

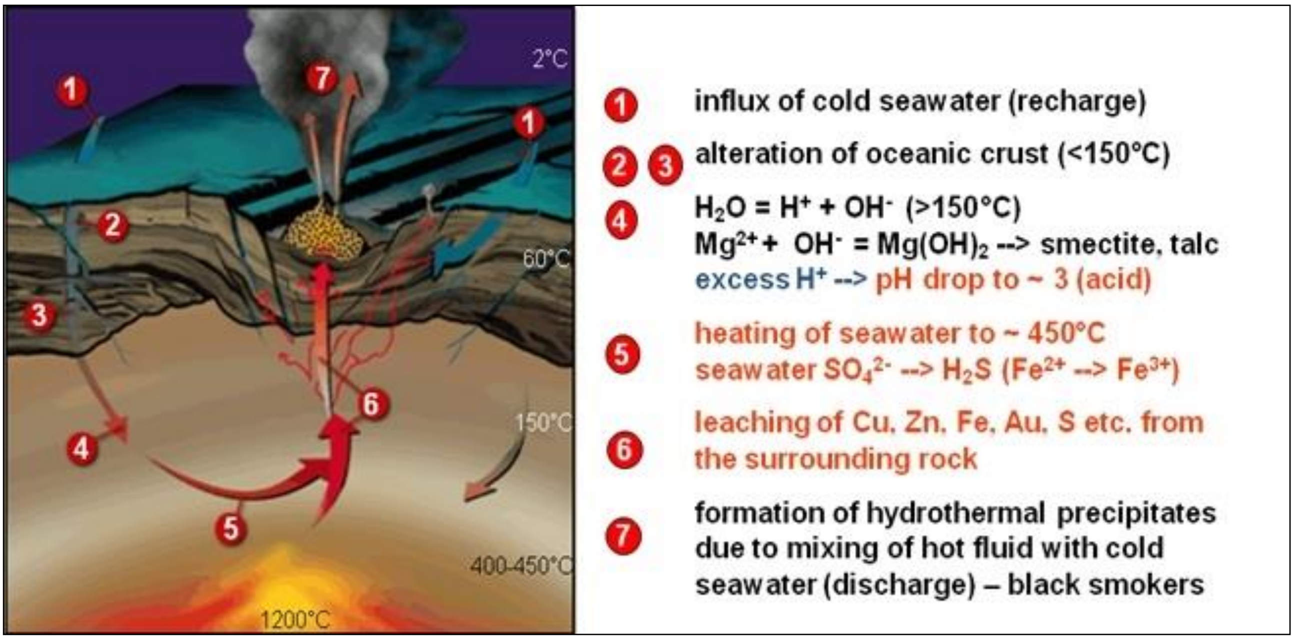
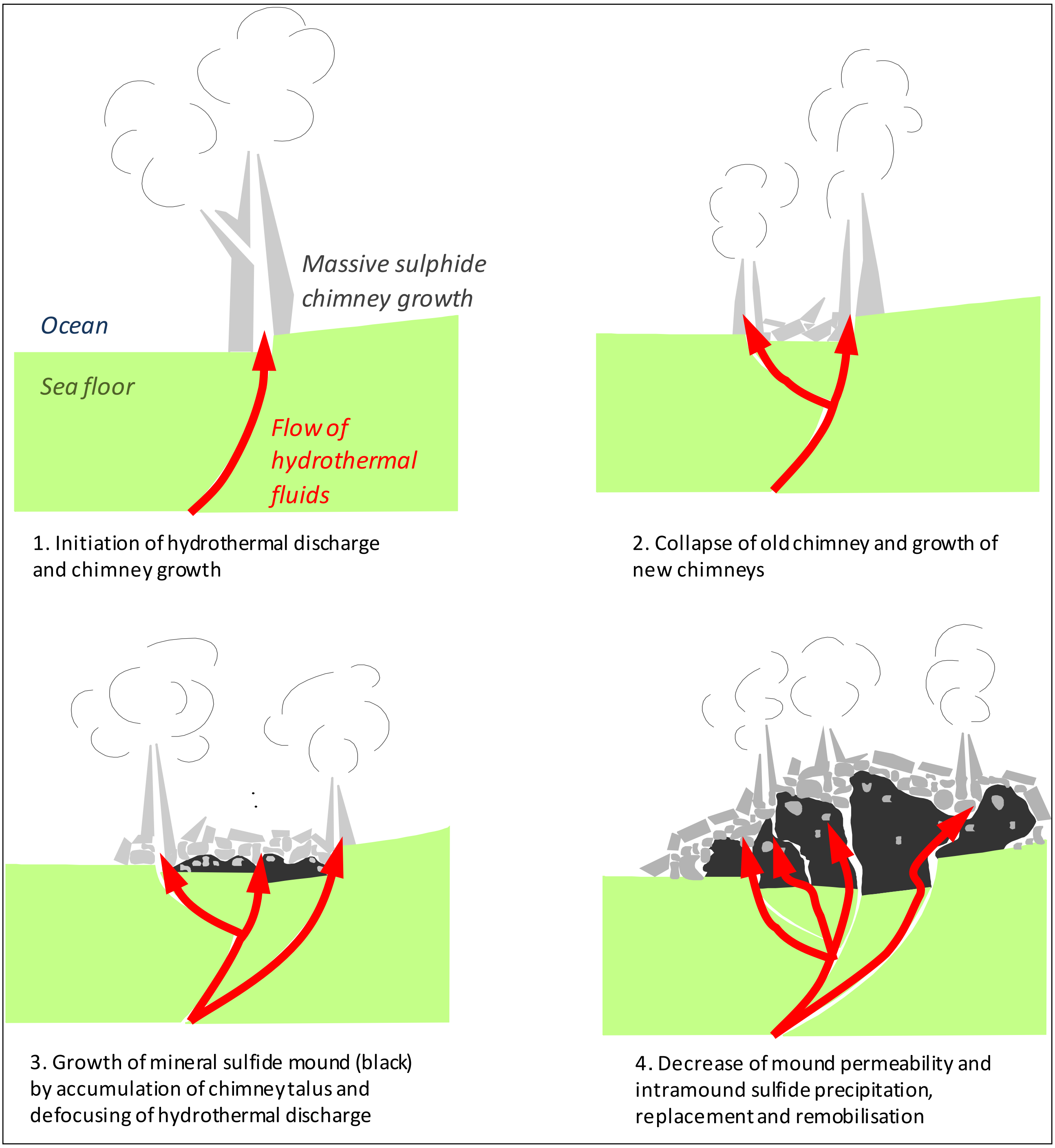


Figure 8.2 Schematic diagram showing hypothesis for the development of SMS mounds on the seafloor (modified from Jankowski, 2011).



9 Exploration

9.1 Seafloor mapping

The seafloor in the Solwara project areas has been mapped by ROV video dives, bathymetric surveys, and geophysical techniques including OFEM, self potential (SP), and compressed high-intensity radar pulse (CHIRP) sub-bottom profiler.

9.1.1 Seafloor mapping techniques and procedure

Seafloor geological mapping is completed with the ROV in low-fly mode, with the aim to map out areas of mineralisation. Traverses of the seabed are completed with the ROV in visual contact with the seafloor, generally at an altitude of 1-5 m. Live video feed from two forward looking cameras, a forward-looking sonar, and other geophysical sensors are monitored by geologists to aid in event logging. Visibility is generally good and sufficient to easily identify hydrothermal chimneys and outcrop of volcanic rocks. The location of the ROVs is continuously recorded through an on-board ultra-short baseline (USBL) acoustic beacon location system referenced to the global positioning system aboard the vessels. All geological, biological and geophysical sensor observations made in the water column, and on the seafloor, are captured using the NautiCal Event Logging system developed by Nautilus and displayed in real-time in ArcGIS via a live open database connectivity link to the Structured Query Language (SQL) database onboard the vessel.

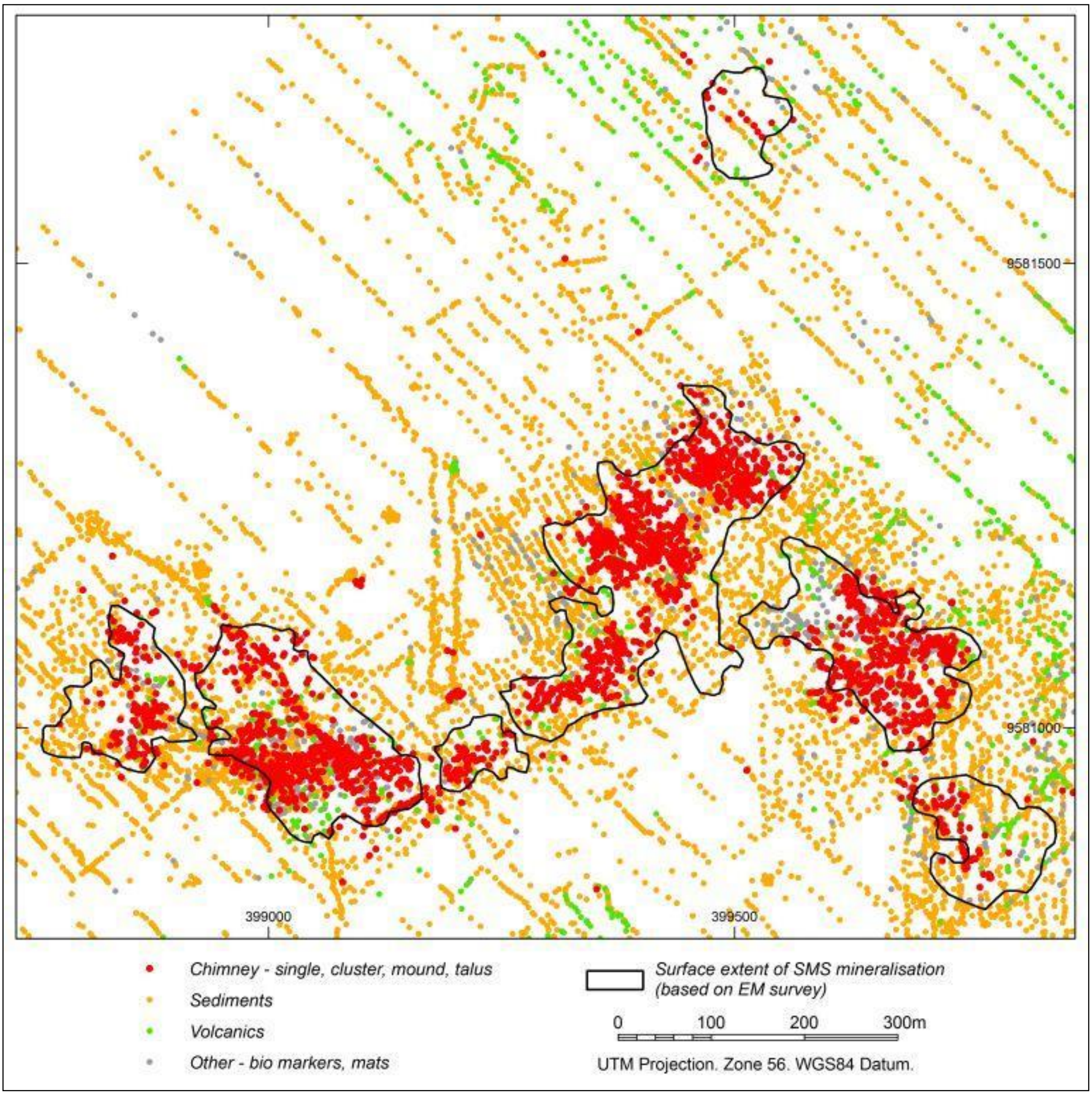
9.1.2 Solwara 1 seafloor mapping results

The seafloor at Solwara 1 was extensively mapped in 2006, 2007, 2008 and 2009 by video camera fly-over using ROVs. Refer to Table 9.1 and Figure 9.1 for the summary and location of activities completed. The surface extent of SMS based on EM survey includes an area of dominantly volcanic observations in the video logging in the south of the West Zone, in the East Zone and the North Zone. This is likely a result of conflict between the surficial nature of the video logging and the EM, which has a penetration of up to 6 m. These parts of the deposit are likely covered with thin volcanic flows, which are not of sufficient thickness to block the EM response of the underlying sulfides.

Table 9.1 Summary of seafloor mapping and sampling activities at Solwara 1.

Year	Vessel	Chimney Samples	Volcanic Samples	Sediment Scoops	Sediment push cores	Event Logs
2006	DP Hunter	41	–	–	–	2,589
2007	MV Wave Mercury	96	4	12	–	8,327
2008	MV NorSky	9	–	–	–	9,678
2009	MV Fugro Solstice	10	1	–	–	3,712
2010/11	REM Etive	–	–	–	102	–
Total		**156**	**5**	**12**	**102**	**24,306**

Figure 9.1 Location of Solwara 1 event logging by ROV.



9.1.3 Solwara 12 seafloor mapping results

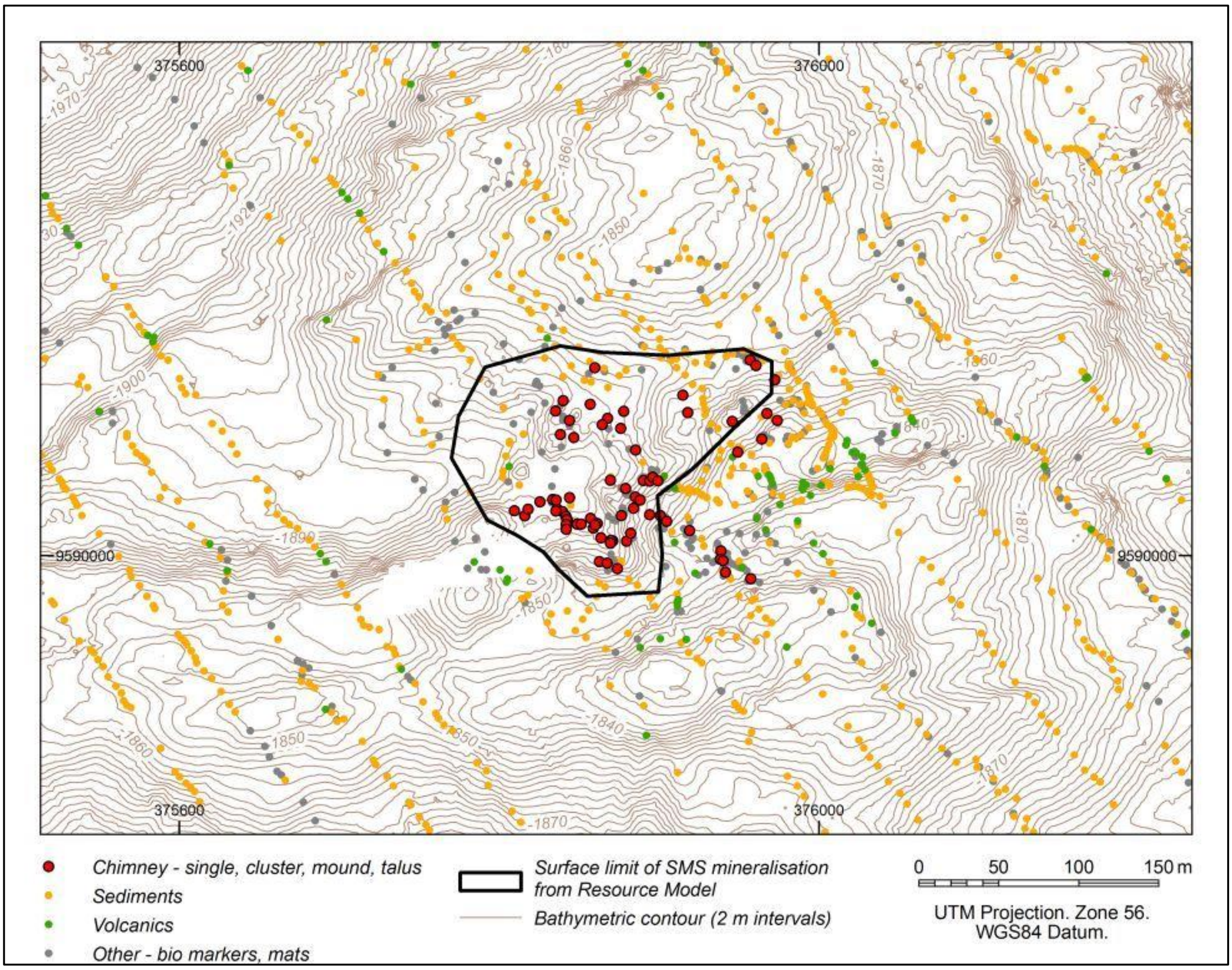
The seafloor at Solwara 12 was extensively mapped in 2009 by video camera fly-over using ROVs. Refer to Table 9.2 and Figure 9.2 for the summary and location of activities completed.

The seafloor mapping identified clusters of inactive grey coloured chimneys in an area generally covered by sediment. The chimneys are up to 15 m high and are several metres in diameter at the base. There was no sign of any active venting and chimneys are slightly rounded suggesting it is an old SMS field.

Table 9.2 Summary of seafloor mapping and sampling activities at Solwara 12.

Solwara 12						
Year	**Vessel**	**Chimney Samples**	**Volcanic Samples**	**Sediment Scoops**	**Sediment push cores**	**Event Logs**
2009	MV Fugro Solstice	10	2	3	4	1,019
2010/11	REM Etive				47	
Total		**10**	**2**	**3**	**51**	**1,019**

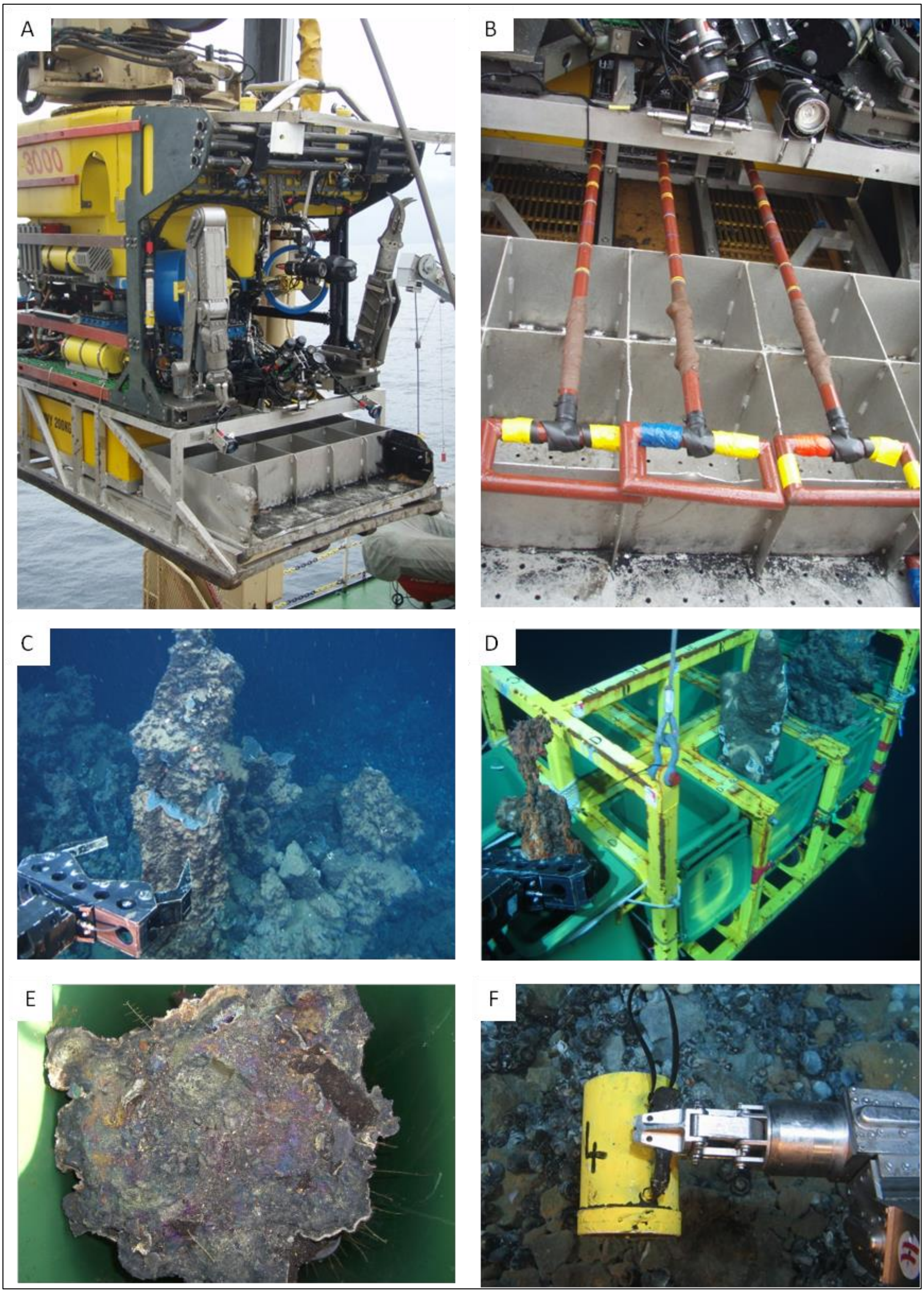
Figure 9.2 Location of Solwara 12 event logging by ROV



9.2 Seafloor sampling

Seafloor sampling programs entailed physical sampling of seafloor sediment, rock and sulfide chimneys using ROVs and samplers lowered on cables (Figure 9.3). Seafloor sampling was carried out at and around Solwara 1 in 2006, 2007, 2008, 2009, 2010/11, and 2016/17. Dredge sampling was carried out at Solwara 1 prior to 2006 but the location of the samples is not well defined. Seafloor sampling was carried out at Solwara 12 in 2009 and 2010/11.

Figure 9.3 Photographs of sampling equipment



A) ROV and Geobox; B) Sediment push corers attached to Geobox (FS09); C) ROV chimney sampling using manipulator arm; D) Sample being placed into chimney basket; E) View of chimney inside wheelie bin of chimney basket; F) Sediment scoop sampling using ROV manipulator arm.

9.2.1 Seafloor grab sampling

Sampling programmes conducted by Nautilus are designed to collect representative samples from chimneys, sulfide mounds, sediments and volcanic outcrop. Volcanic rock samples are collected to help understand the geological setting and aid in the interpretation of geophysical signatures.

Sample locations are chosen by the geologist supervising the ROV dive. Sample numbers are assigned at the time of sampling from a pre-numbered sample ticket. Sample numbers and descriptions are entered using NautiCal software when sampling has taken place. During sample processing, details are loaded directly into the Nautilus's acQuire database.

The samples are taken using the hydraulic-operated arms on the ROV. The arms can pick up and manipulate loose objects, or grasping and breaking of parts of standing chimneys. The samples are placed in the GeoBox or chimney basket.

Softer samples of altered and poorly consolidated material are collected using scoops. Custom made plastic cylinders with a handle and spring-loaded lid are used to collect enough material for analysis. The scoops are sometimes used during ROV mapping in areas where the manipulator arms are unable to grab a sample.

During initial target evaluation, the chimney sampling programs aim to collect around 6 to 12 chimneys at each major sulfide field and 2 to 10 volcanic samples. Where no sulfide material is discovered, 1 to 2 volcanic samples are collected to help characterise the geology over the target area. Sampling density was increased at Solwara 1 with additional chimney samples taken systematically across the deposit.

Sample handling during ROV operations include the following:

- GeoBox – a compartment box secured under the ROV and moved forward during sampling to expose the compartments. The box is retracted during transit to protect the samples. Each compartment, measuring 25 × 25 × 30 cm deep, has a unique identification number. The compartments are designed to hold small samples (up to 15 kg) of volcanic rock, sedimentary rock, talus or small chimneys. If space permits, scoops can be stored in the individual compartments.
- Chimney basket (wheelie bins) – used to collect large chimney samples up to 100 kg comprises 10 large wheelie bins, each with a unique alpha-numeric code, clearly visible during sampling operations. The basket is lowered on a separate wire and can be brought to the surface independent of the ROV, unloaded and replaced with an empty set of bins and redeployed.
- Scoops – for collecting sediment, loose rocks, talus, weathered and altered volcanic. Scoops are attached to the ROV via a pole or placed in vacant compartments in the GeoBox. Each sample scoop is made from metal tube approximately 20 cm in diameter and 30 cm long. One end is capped while the other end is spring loaded open. After each sample is collected the end cap is released to close the scoop, securing the sample. Each scoop is marked with a unique identification number.
- Sediment push cores – during the Fugro Solstice 2009 program, sediment push corers were attached to the ROV GeoBox and retrieved when required. The used sediment push corers were then stored on the front of the GeoBox in a horizontal position. The 2010/11 sediment push core collection utilised the ROV tether management system fitted with holsters. Each ROV dive was deployed with two sediment push corers and deployed at designated sites. Upon completion, the sediment push corers were returned to the holsters on the tether management system.

9.2.2 Sediment push cores, box cores, and kasten cores

9.2.2.1 ROV sediment push cores

Sediment push cores were trialled during the 2009 Fugro Solstice cruise to test sediments overlying Solwara 12. The method entailed pushing a steel tube vertically into the sediment using the ROV. During any one ROV dive four sediment push corers, each with a unique colour banding identification where deployed. The depth of penetration was measured by observing 10 cm intervals marked on each sediment push corer. Each sediment push core was extracted into individual core trays using a push rod. The samples were lithologically logged, analysed using a hand-held x-ray fluorescence (XRF) analyser and sampled for laboratory analysis. The remaining half core was sealed and archived.

During the REM Etive drilling campaign in 2010/11, an extensive sediment push core program was conducted on Solwara 1 during drilling activities. Samples were collected using an undisturbed wet sampler with the sample retained in a soft clear plastic liner. The sampler is made from stainless steel tube with a threaded removable nose piece containing a plastic retaining valve with an internal diameter of 34 mm. Two sample tube lengths were used, either 100 cm or 150 cm. Each handle of the sampler was given a unique identification number and recorded during the sampling process.

Sediment push core sampling was deployed on the ROV and flown to the sampling site when required. The ROV used vertical thrusters to push the sampler into the sediment. The depth of penetration was recorded for 25%, 50% and 100% thrust by observing 10 cm intervals marked on each sediment push core. Details of each sample were recorded on the Sediment Sampling Form and transmitted to Nautilus. Samples were generally taken immediately prior to the ROV planning a return to surface to minimise sample loss.

A second, larger diameter sediment push core system was developed during the program. The push core was modified from a Shelby tube soil sampler with a nominal 70 mm diameter lined with a soft clear plastic liner. The same technique applied to the undisturbed wet sampler was used for the Shelby tube.

Each sediment push core sample was processed onboard, including recovery measurement, basic lithology description and photographed. The ends of the sample tubes were sealed and then transferred to the refrigerated core storage container.

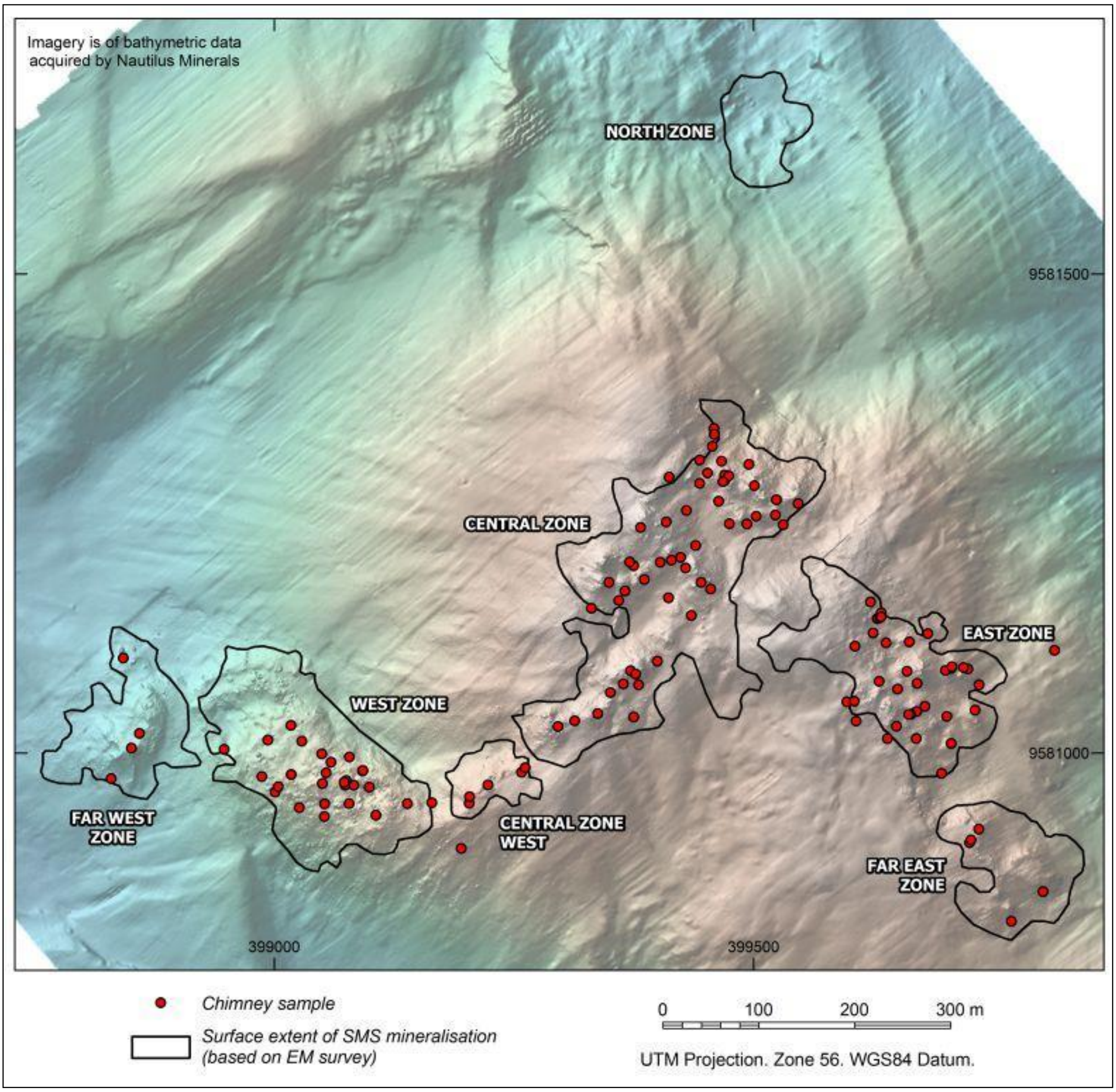
9.2.3 Solwara 1 seafloor sampling results

Due to the variable size of the chimneys and the impracticality of sampling very large chimneys it was not possible to sample chimneys on a regular grid. Only thin chimneys and chimneys on the edges of chimney mounds could be sampled. The formation of the chimneys is interpreted to be a dynamic process that evolves over time with variations in the temperature and chemistry of the hydrothermal fluids and the permeability of the chimneys. It is therefore uncertain how representative the chimney samples are of the mineralisation within the thickest parts of the chimney mounds.

The 2007 sampling program was designed to augment the 2006 sampling program covering the main chimney fields. Successful results from the 2007 drilling campaign, and later drilling, have largely superseded surface sampling. As a result, sampling in 2008 was exclusively for environmental purposes. Seafloor samples collected in 2009 were not submitted for geochemical analysis. Figure 9.3 shows the location of 133 seafloor samples which were used for resource estimation at Solwara 1.

At Solwara 1, sediment push cores were taken along the CHIRP survey lines and near the 2010/11 drillhole locations.

Figure 9.4 Location of Solwara 1 chimney samples used in resource estimation.



9.2.4 Solwara 12 seafloor sampling results

A total of 10 chimney samples were collected from Solwara 12 in 2009 across the mapped chimney field (Table 9.3 and Figure 9.5). The analyses returned very high Zn-Cu-Au-Ag-Pb assays. Three of the samples in the center of the chimney field were high in copper (up to 32.4%) and contain abundant chalcopyrite-bornite mineralisation. Zinc-rich chimneys (up to 52.0%) surround the cpper-rich chimneys, and are comprised mainly of sphalerite mineralisation. Some of the zinc-rich chimneys are also rich in lead (up to 12.7%). Both the copper and zinc-rich chimneys are highly anomalous in silver (up to 682 g/t) and gold (up to 39.7 g/t).

Two volcanic samples and three sediment scoops were also collected from Solwara 12 (Figure 9.5).

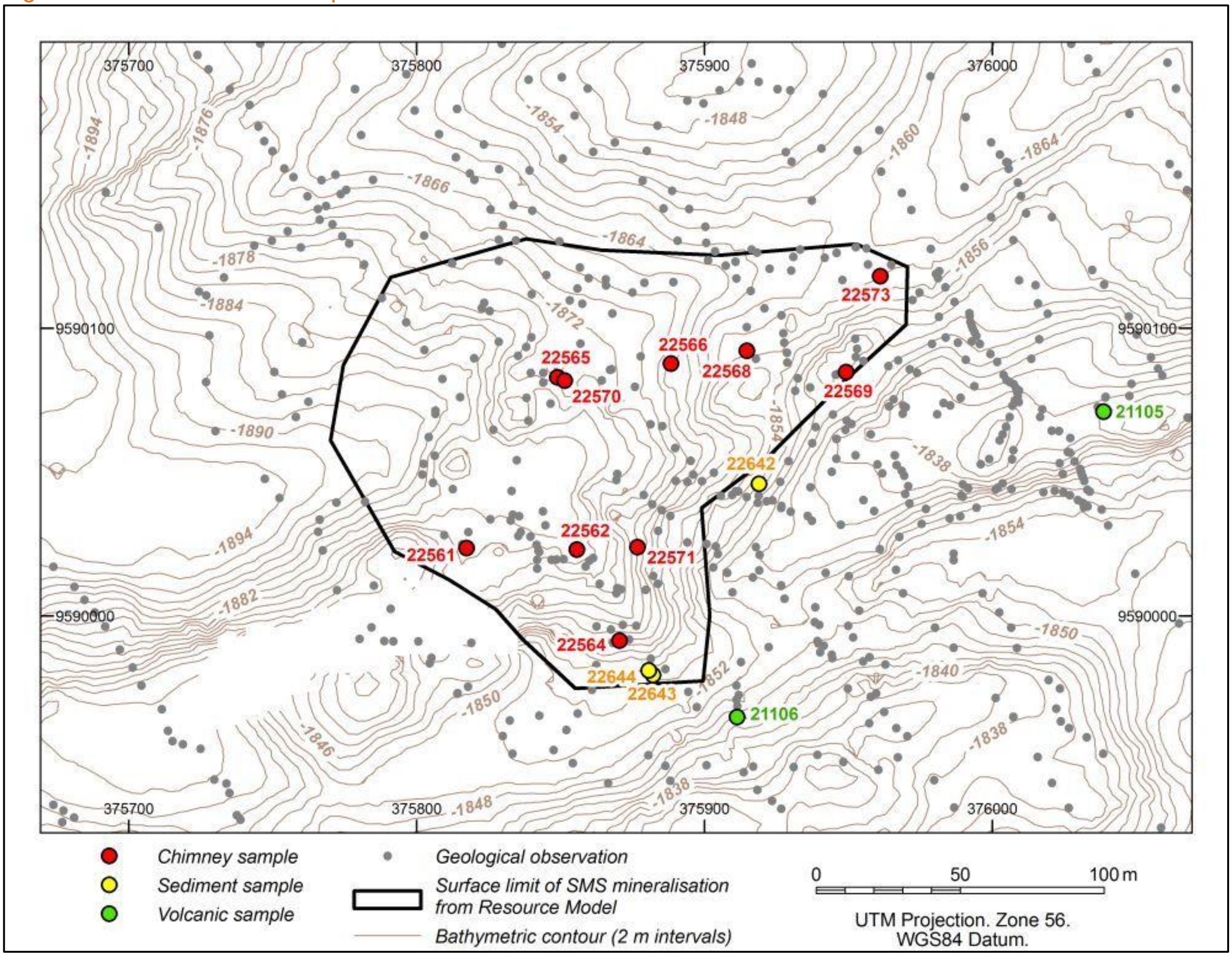
During 2009 and 2010/11 sediment push cores were collected at Solwara 12 (Table 9.2). Depth penetrations of 70-80 cm were achieved. All samples showed some degree of compression after extraction from the corer. The maximum recovery was 50 cm. The sediment push core samples are dominated by clay-rich sediments with variable internal layering and lamination. Several coarser grained silt-sandy horizons less than 5 millimetres thick are dominated by shards of volcanic glass. Minor fragments of pumice, generally pale in colour, were also observed. Assay results show highly anomalous base and precious metals from the sediment overlying Solwara 12. Values up to 2.3 g/t Au, 4.3 g/t Ag, 0.9% Cu, 0.67% Zn and 0.14% Pb were returned from sediments within the mapped chimney area, which is significantly higher than typical background sediments. The metal values significantly decrease outwards from the Solwara 12 system, but still include some layers that are well above normal background levels in Ag, Cu, Pb and Zn.

Table 9.3 Solwara 12 seafloor chimney sample results

Solwara12		Final assay result[1,3]								
Sample No	Weight (g)	Cu %	Zn %	Pb %	Au g/t	Ag g/t	Easting[2]	Northing[2]	Depth[2]	Lithology
22561	4700	0.006	52.0	3.15	<0.01	451	375817	9590023	-1876	Massive Sulfide
22562	4900	0.101	22.9	2.29	0.63	538	375856	9590023	-1866	Massive Sulfide
22564	5500	0.044	20.9	0.89	0.01	186	375870	9589991	-1910	Massive Sulfide
22565	3900	21.8	3.42	0.095	16.2	313	375849	9590083	-1922	Massive Sulfide
22566	5200	0.530	30.2	2.52	12.1	453	375888	9590088	-1907	Massive Sulfide
22568	5500	0.512	36.1	2.43	39.7	458	375915	9590092	-1899	Massive Sulfide
22569	3700	0.257	17.4	10.4	24.8	682	375949	9590085	-1887	Massive Sulfide
22570	7300	13.4	14.5	0.222	3.70	271	375852	9590082	-1923	Massive Sulfide
22571	4500	32.4	9.90	0.73	5.65	292	375877	9590024	-1901	Massive Sulfide
22573	5200	0.932	18.9	12.7	34.2	601	375961	9590118	-1905	Massive Sulfide
Minimum		0.006	3.42	0.095	0.00	186				
Maximum		32.4	52.0	12.7	39.7	682				
Average		7.00	22.6	3.54	13.7	425				

1. Results received from ALS Laboratory
2. Coordinates projected as UTM zone 56 south using a WGS 1984 datum
3. <0.01 = below detection limit

Figure 9.5 Seafloor sample locations at Solwara 12



9.2.5 Geophysical techniques and procedures

Nautilus employed several geophysical techniques to explore for SMS. The geophysical programs over Solwara 1 and Solwara 12 are summarised in Table 9.4 and Table 9.5. Several of the programs were used primarily to facilitate early stage exploration and are only mentioned briefly here.

The principal geophysical data that contribute to the geological understanding and the resource models include:

- ROV mounted multibeam echo sounder (MBES) to define a high-resolution bathymetry.
- OFEM used to delineate areas of conductive material such as subcrop of chalcopyrite.
- CHIRP sub-bottom profiler to estimate the typical thickness of the thin sediment drape covering parts of Solwara 1.

Table 9.4 Summary of geophysical surveys carried out at Solwara 1

Year	Vessel	Geophysical Method	Equipment	Survey Extent (within ML154) #	Survey Location	Line Spacing
2005	MV Genesis	Sidescan sonar (deep tow)	AMS60	56.8 sq km	Susu	1100m
		Magnetics (deep tow)	C-BASS	97.5 linear km	Susu	–
		Resistivity & SP (deep tow)	C-BASS	11.0 linear km	Susu	–
		Gravity	C-BASS	47 stations	Susu	–
2006	DP Hunter	Multibeam bathymetry (ROV)	Reson 8101	2.7 sq km	Solwara 1	50m
		Sidescan Sonar (ROV)	Reson 8101	46.7 linear km	Solwara 1	50m
2006	RV Melville*	Multibeam bathymetry (Vessel)	Seabeam	60 sq km	Manus Basin	–
		Multibeam bathymetry autonomous underwater vehicle (AUV)	Simrad 2000	1.13 sq km	Solwara 1	50m
		Multibeam Bathymetry (AUV)	Simrad 2000	3.82 sq km	Susu Knolls	50m
		Magnetics (AUV)	Develco Fluxgate Magnetometer	38.8 linear km	Solwara 1	50m
		Magnetics (AUV)	Develco Fluxgate Magnetometer	74.5 linear km	Susu Knolls	50m
2007	MV Aquila	Sidescan Sonar (Deep Tow)	AMS60	22.9 sq km	East Manus	900m
		Multibeam Bathymetry (Vessel)	Reson 8160	24.1 sq km	East Manus	900m
		Magnetics (Deep Tow)	Seaspy Magnetometer	21.9 linear km	East Manus	900m
2007	MV Wave Mercury	Multibeam Bathymetry (ROV)	Imagenex 837A Delta-T	0.32 sq km	Solwara 1	25m
		Electromagnetics (ROV)	OFEM Mk 1	37.7 linear km	Solwara 1	50m / 25m
		Electromagnetics (ROV)	OFEM Mk 1	18.6 linear km	Solwara 5	50m
		CHIRP	Edgetech Chirp SBP	12.5 linear km	Solwara 1	50m
		CHIRP	Edgetech Chirp SBP	18.6 linear km	Solwara 5	50m
2008	MV Sepura**	Multibeam Bathymetry (Vessel)	Reson 8160	54.0 sq km	Susu	1000m
2008	MV NorSky	Electromagnetics & Self Potential (ROV)	OFEM Mk 2	155 linear km	Solwara 1, 5, 9	200/50m
2009	MV Fugro Solstice	Multibeam Bathymetry (Vessel)	Reson 8160	40 sq km	Manus Basin	–
		Multibeam Bathymetry (ROV)	Imagenex 837A Delta-T	0.17 sq km	Solwara 5	40m
		Electromagnetics & Self Potential (ROV)	OFEM Mk 3	61.6 linear km	Solwara 1 & 5	100m / 50m / 25m
		Magnetics (ROV)	OFG Magnetometer	76.7 linear km	Solwara 1 & 5	100m / 50m
		Sidescan Sonar (ROV)	Edgetech 2200	34.0 linear km	Solwara 1 & 5	100m / 50m
2012	SV Duke	Multibeam Bathymetry (Vessel)	EM 302 (30 kHz)	59.11 sq km	Su Su	single
		Seismic	Bolt guns (4x180cuin, 4 x 220 cuin) sercel solid UHR3.125 grp streamers	6.5 sq km	Solwara 1	12.5m
2016/17	MV Miss Rankin	Self Potential and Magnetics (Deep Tow)	Mano Mk1 SP system w/ APS 534D fluxgate	121.4 linear km	Su Su	500m

*Collaborative cruise between Woods Hole Oceanographic Institute and Nautilus.
**Cruise operated by Teck Cominco under a partnership agreement.
Survey extents tabulated are for the parts of the surveys that fall within ML154, some surveys extend beyond the ML154

Table 9.5 Summary of geophysical surveys carried out at Solwara 12.

Solwara 12						
Year	**Vessel**	**Geophysical Method**	**Equipment**	**Survey Extent (Entire Survey)**	**Survey Location**	**Line Spacing**
2007	MV Aquila	Sidescan Sonar (Deep Tow)	AMS60	915.6 sq km	East Manus	900m
		Multibeam Bathymetry (Vessel)	Reson 8160	1007.3 sq km	East Manus	900m
		Magnetics (Deep Tow)	Seaspy Magnetometer	877.4 line km	East Manus	900m
2009	MV Fugro Solstice	Multibeam Bathymetry (Vessel)	Reson 8160		Manus Basin	
		Multibeam Bathymetry (ROV)	Reson 7125	4.0 sq km	Solwara 12	100m
		Electromagnetics & Self Potential (ROV)	OFEM Mk 3	57.6 line km	Solwara 12 & Desmos Caldera	300m / 50m
		Magnetics (ROV)	OFG Magnetometer	167.1 line km	Solwara 12 & Desmos Caldera	300m / 100m / 50m
		Sidescan Sonar (ROV)	Edgetech 2200	167.1 line km	Solwara 12 & Desmos Caldera	300m / 100m / 50m

9.2.5.1 Multibeam echo sounder

Multibeam echo sounder (MBES) is a technique whereby the seafloor is imaged with a broad acoustic pulse to map the bathymetry of the seafloor (subsea equivalent of topography) by measuring the difference in travel time of the echo between the sensor and the seafloor. Multiple beams are produced perpendicular to the track of the survey line to produce a swathe of data. The seabed is traversed in such a manner as to provide overlap of data swaths between adjacent survey lines to provide complete coverage of the seafloor. This produces a detailed digital terrain map, showing the depth with respect to sea level (or Z datum) of the seafloor across the survey area.

At Solwara 1, an Imagenex Delta T MBES system was used on a ROV to produce a high resolution bathymetric model at 20 cm lateral resolution. At Solwara 12, a Reson 7125 system was used on a ROV to produce a bathymetric model at 40 cm lateral resolution. At these resolutions, it is possible to map individual SMS chimneys on the seafloor.

9.2.5.2 Ocean floor electromagnetic system

Ocean floor electromagnetic system (OFEM) was designed and built for the purpose of delineating areas of conductive material such as near-surface massive sulfides on the seafloor. OFEM is a novel system built by Ocean Floor Geophysics (OFG) with support from Nautilus and Teck Cominco Limited. It is a controlled source method that measures electromagnetic fields associated with induced subsurface electrical currents. The system is currently under a patent application that precludes complete disclosure of its design and operational specifications.

The Solwara 1 mineralisation, which typically contains high concentrations of conductive chalcopyrite, responds particularly well to the OFEM instrument. Chalcopyrite is the only mineral occurring at Solwara 1 with conductivity significantly higher than that of seawater.

The OFEM data has been used, together with observed sulfide outcrop and drilling results, to delineate the seafloor extent of Solwara 1 chalcopyrite mineralisation.

The key limitations of the OFEM instrument are that it:

- Maps the extent of surface mineralisation only (to approximately 3 – 6 m below seafloor);
- Reveals very little, if anything of the mineralisation thickness; and
- Does not respond to high-grade Zn and precious metal mineralisation (making it less useful for seafloor delineation in Zn-rich deposits). Sphalerite, which is the major Zn hosting mineral, has a similar conductivity to seawater, sediment, and heavily altered volcanic and thus does not respond in a distinctive fashion to the OFEM instrument.

9.2.5.3 CHIRP sub-bottom profile sonar

Compressed high-intensity radar pulse (CHIRP) sub-bottom profiler is a single-beam sonar source used for imaging unconsolidated thin sediment cover. The acoustic pulse penetrates the seafloor sediments and echoes are produced for the top of sediment at seafloor, and the contact between the base of sediment and underlying bedrock. An Edgetech CHIRP sub-bottom profiler system was used on an ROV to survey Solwara 1 at a vertical resolution of approximately 10 cm along 50 m line spacing. The data was processed and the top and base of sediment cover were digitized to produce 2D cross sections showing the distribution and variation in thickness of the sediment drape.

The relatively wide line spacing of 50 m over terrain which is characterised by a rugged bathymetric profile means that the data cannot be confidently interpolated and gridded between lines to produce an accurate base of sediment surface or sediment thickness map. However, the CHIRP data appears to confirm that sediment cover is generally thin or absent.

9.2.5.4 Self-potential

SP measures the difference in redox potentials caused by fluid flow from venting high temperature hydrothermal fluids. In addition, it also measures difference in redox potentials between metalliferous ore bodies and the host rock. The technique is therefore used to detect active hydrothermal venting and detect inactive SMS systems where they are exposed to seafloor and undergoing oxidation (corrosion).

SP data is typically acquired during:

- OFEM ROV surveys using the measured Direct Current component of the recorded signal
- Towed regional surveys using a stand-alone instrument.

9.2.5.5 Side scan sonar

Side scan sonar is a technique whereby the seafloor is imaged with a broad acoustic pulse with a low grazing angle to map the variability in the strength of acoustic echoes from which seafloor features, bottom type (soft sediment versus hard outcropping bedrock) and roughness can be inferred. Because of the low grazing angle of the incident beam, acoustic shadows are produced from features such as chimneys. During the 2009 *Fugro Solstice* campaign, an Edgetech 2200 120/410 kHz sidescan sonar system was mounted on the ROV. The primary use of this equipment was to extend the real-time field of view of the ROV out to include 40-80 m on either side, and gave the ability to identify chimney features. This data was also recorded and provides an additional useful indicator of chimney locations and small scale structural faulting.

9.2.5.6 Magnetometer

Magnetometers, measuring the Total Magnetic Intensity, have been added as ancillary instruments to various ROV, autonomous underwater vehicle (AUV), and deep tow surveys. There are no magnetic minerals within the Solwara 1 or Solwara 12 mineralised systems. As a result, the magnetic method is limited to:

- Mapping late (unaltered) volcanic flows that may cover mineralisation (e.g. over the North Zone of Solwara 1).
- Mapping magnetic domains that represent different host rock volcanic intrusions.
- Identifying larger scale alteration systems (destruction of magnetite in the host rock).
- Mapping and understanding regional faults.

9.2.5.7 Seismic

In early 2012, Nautilus retained Gardline Singapore to collect seismic data in the East Manus Basin. Detailed 3D data was collected by the R/V Duke over Solwara 1.

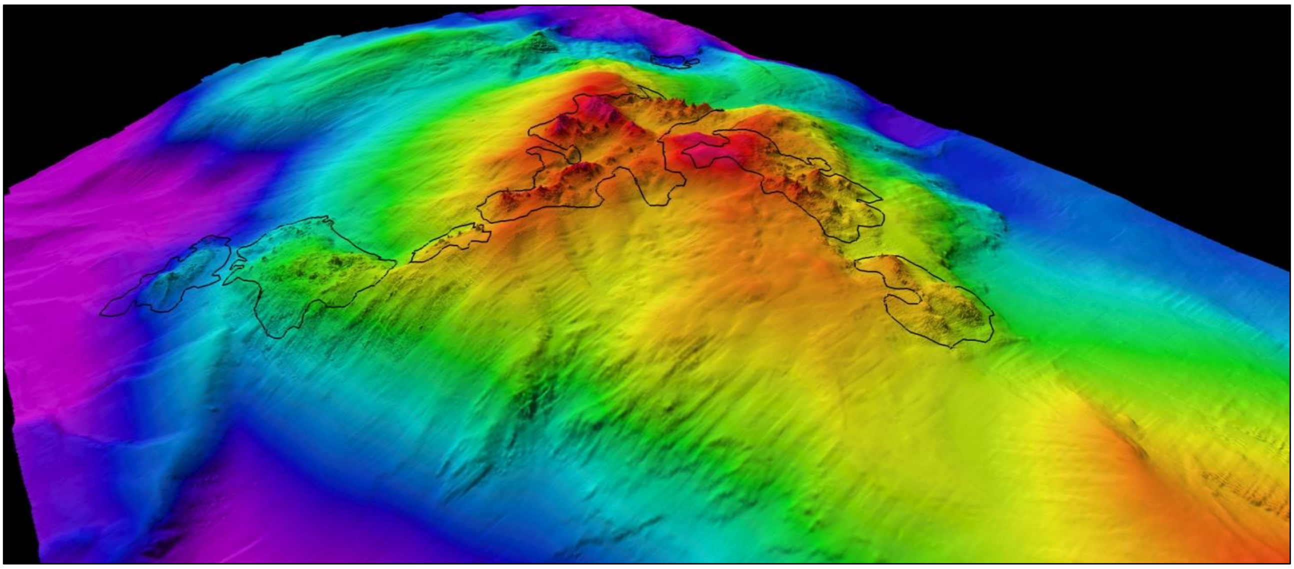
9.2.6 Geophysical results

9.2.6.1 Multibeam

The MBES bathymetry resolution is sufficient to map out individual chimneys. Figure 9.6 shows a 3D perspective view of the Solwara 1 bathymetry data. The data at Solwara 1 is a compilation of a 1 m lateral resolution dataset over the whole area (collected in 2006 from a Reson 8101 ROV mounted multibeam system deployed from the DP Hunter), and a more detailed 20 cm lateral resolution dataset collected at a lower survey height from an Imagenex Delta T multibeam mounted on an ROV in 2007 and deployed from the Wave Mercury. Figure 9.7 shows a 3D perspective view of the high-resolution bathymetry collected at Solwara 12 in 2009.

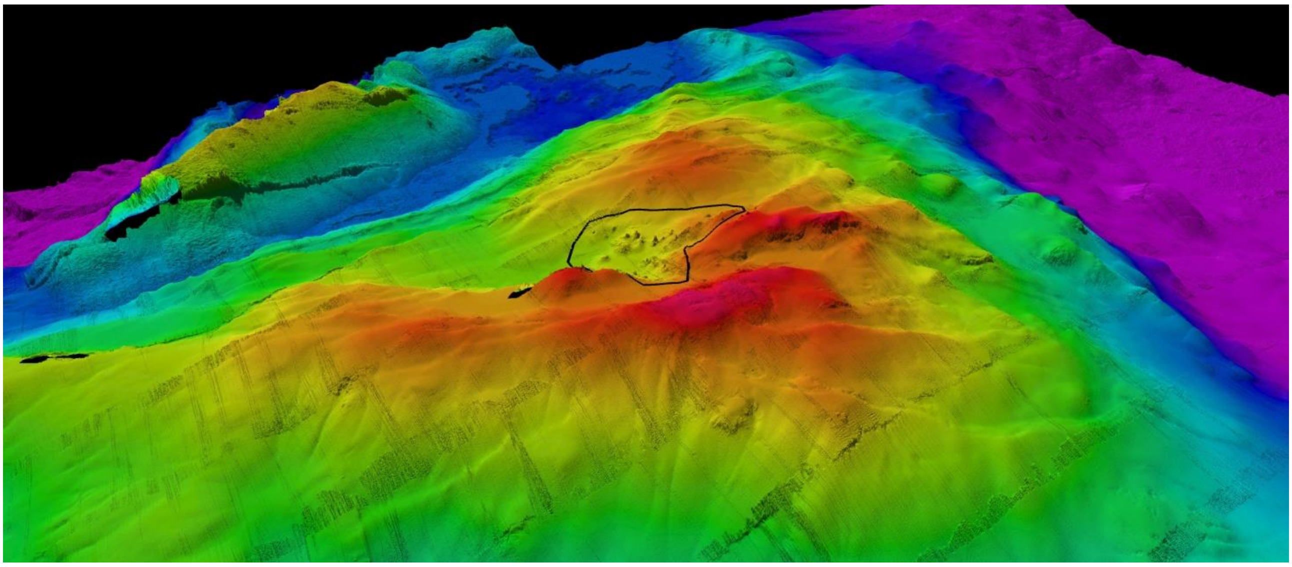
All deep subsea MBES systems used at Solwara 1 have vertical resolutions better than 2 cm, with the major limiting factor to accuracy being the ROV navigation. The depth sensors on the ROVs were all Paroscientific Digiquartz® pressure/depth gauges, with vertical resolutions in these water depths of better than 15cm. Navigation for the high resolution 20 cm Solwara 1 and 40cm Solwara 12 datasets was calculated by merging of the ROV USBL (acoustic) navigation, with INS (inertial navigation system) data to provide accurate high frequency orientation and navigation components, which are overlain over the more accurate but less sensitive USBL navigation data. The Solwara 12 survey was also carried out with a Doppler Velocity Logger, which tracks the relative velocity of the seafloor to the ROV, providing another dataset for the navigation of the ROV, which was included in the filtering to produce the final navigation solution. As yet, there is no detailed tidal information available in this part of the Bismarck Sea, and thus there is some long period variation in the vertical datum that this data was acquired with. This has been partially corrected in processing, however, the overall digital terrain model has been warped by the lack of reference to a fixed vertical datum.

Figure 9.6 3D perspective view of the Solwara 1 high resolution bathymetry (20 cm lateral resolution) looking North



NB: Outline of surface extent of SMS mineralisation (based on EM survey) shown for reference

Figure 9.7 3D perspective view of the Solwara 12 high resolution bathymetry (40cm lateral resolution) looking North



NB: Outline of surface limit of SMS mineralisation from Resource Model shown for reference

9.2.6.2 OFEM

Nautilus successfully trialled and deployed OFG's OFEM system over Solwara 1 in 2007, 2008 and 2009, and at Solwara 12 in 2009.

Combination of the 2007 Solwara 1 results with the 2008 and 2009 results produced the compilation dataset shown in Figure 9.8. The 2008 resource estimate incorporated the 2007 OFEM data only. Additional OFEM data collected during 2008 and 2009 has improved the confidence and quality of the interpreted boundary of chalcopyrite mineralisation.

In 2009, the Fugro Solstice conducted an EM survey at Solwara 12, identifying a conductive sulfide anomaly on two adjacent lines through the centre of the deposit (Figure 9.9). The penetration of the OFEM system is less than 3 m, so in areas of thicker surficial sediment, or low copper grades at surface the OFEM system may not record a conductive response.

Figure 9.8 Solwara 1 OFEM (from compilation of EM datasets from 2007, 2008 and 2009) results with updated EM outline and survey lines.

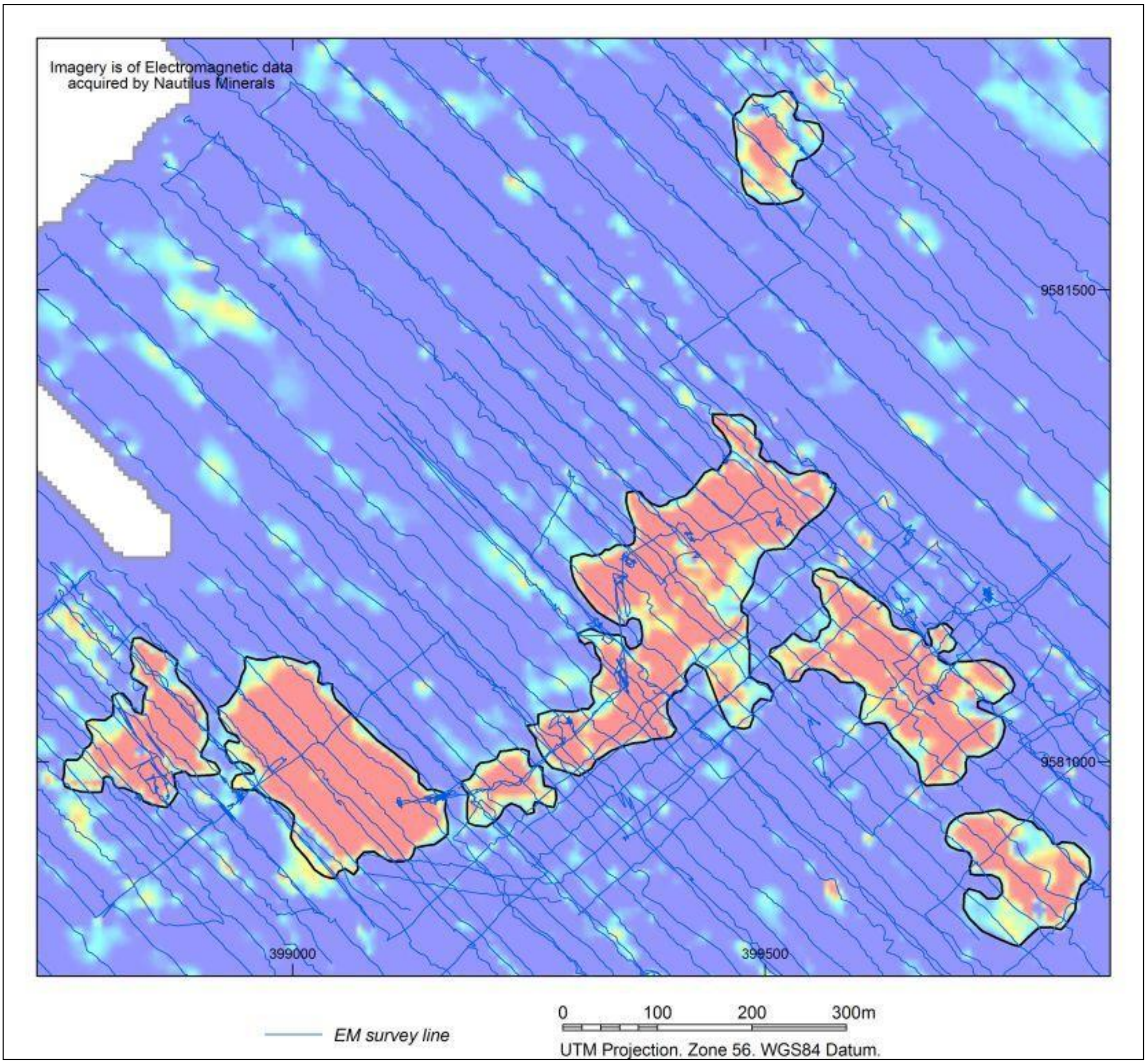
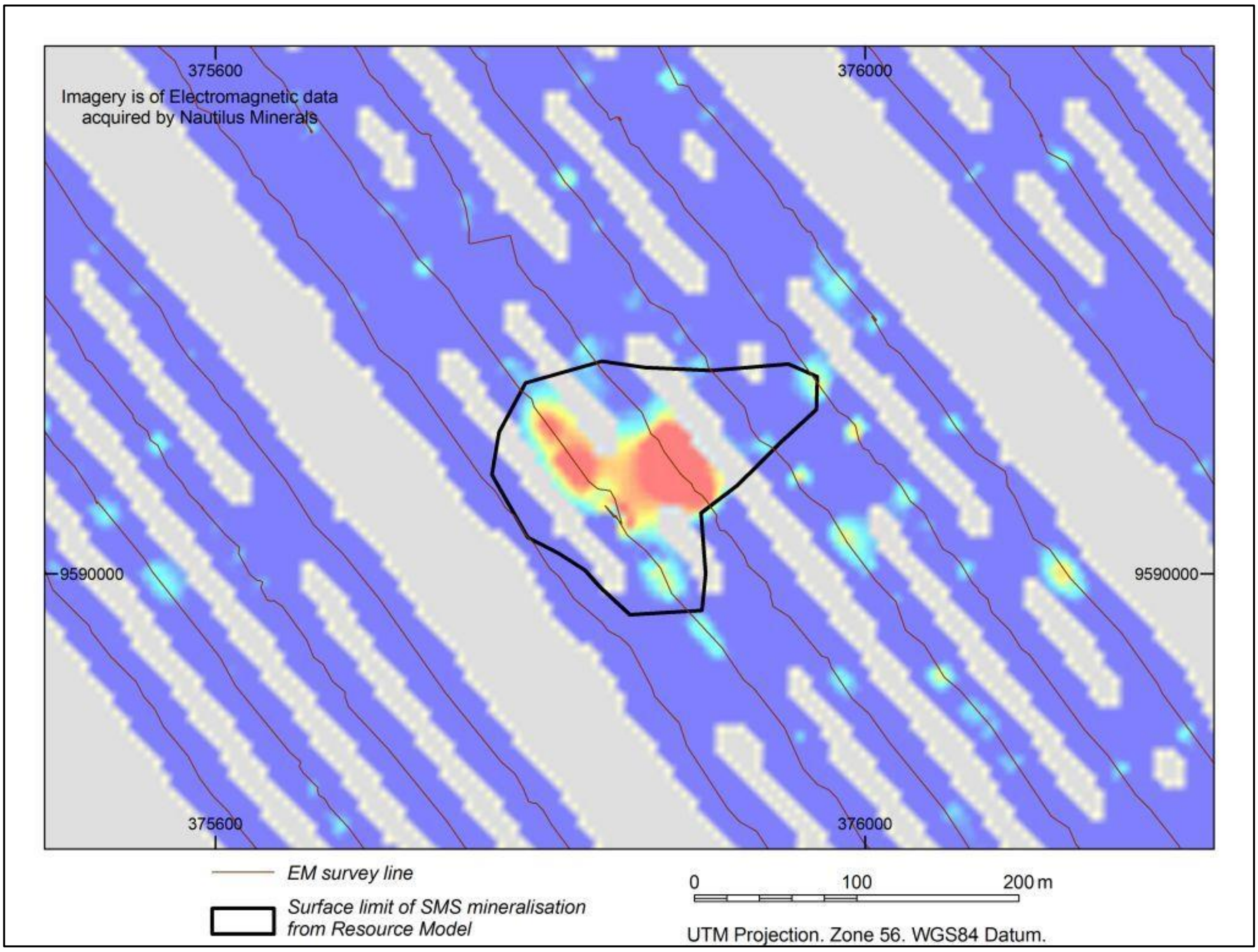


Figure 9.9 Solwara 12 OFEM results with resource model boundary and survey lines.

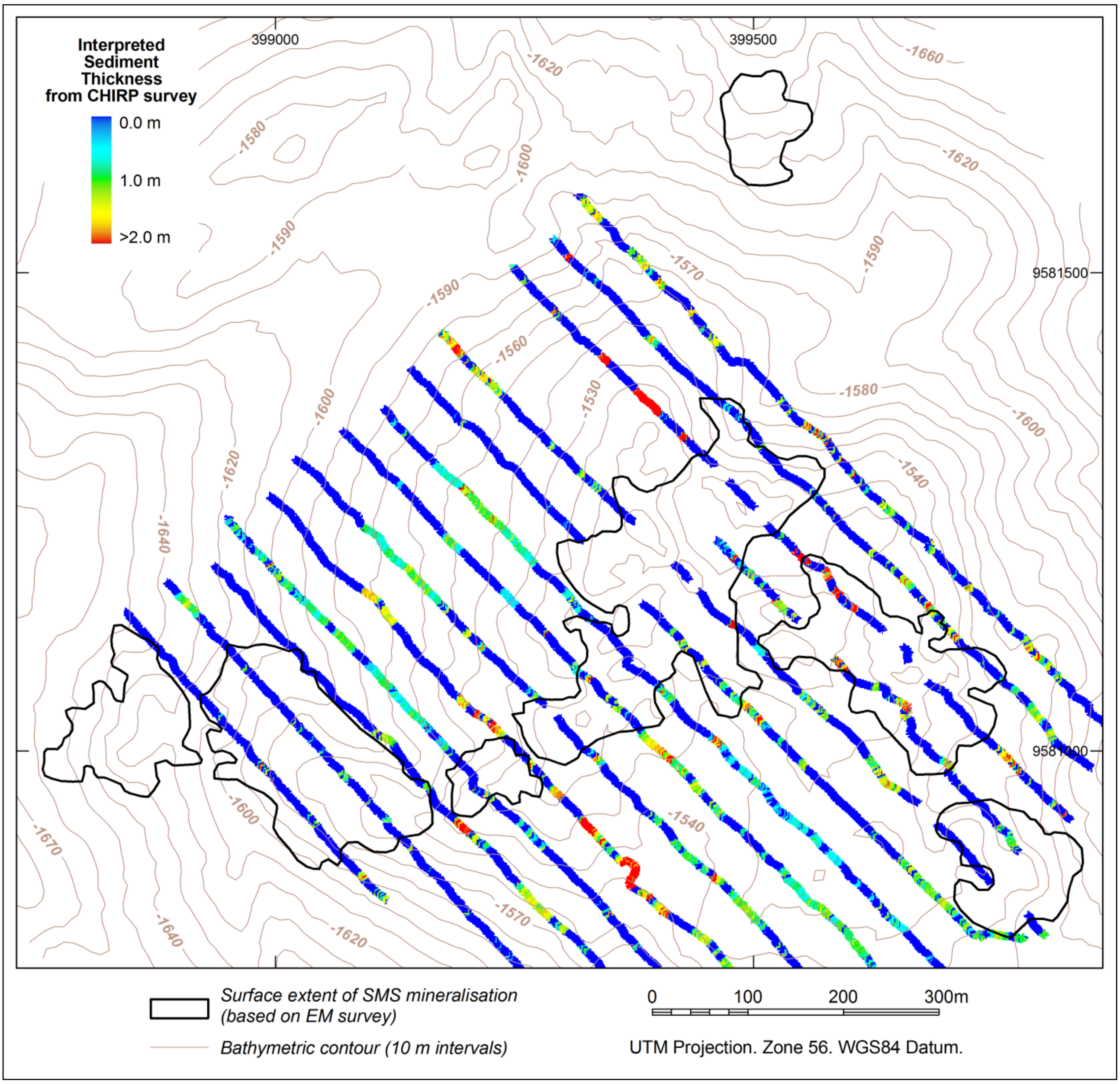


9.2.6.3 CHIRP

The CHIRP data was used to provide confidence on the thickness of sediment cover at Solwara 1. The difference in acoustic travel time between the top and base of the sediment was converted to sediment thickness assuming a velocity of 1700 m/s. Figure 9.10 presents the interpreted sediment thickness imaged along lines.

The CHIRP data provides sediment thickness estimates along the cross sections (+-0.5 m) and gives confidence that the sediment drape ranges from zero thickness in outcropping areas to generally less than 2 m thick over most of the Solwara 1 deposit.

Figure 9.10 Solwara 1 CHIRP interpreted sediment thickness.



9.2.6.4 Self Potential

Self potential surveys are used by Nautilus in early stage exploration. The data is semiquantitative in nature and is not used to estimate the mineral resource at Solwara 1 and Solwara 12.

9.2.6.5 Side scan sonar

Side scan sonar was used by Nautilus in early stage exploration. The data was not used to estimate the mineral resource at Solwara 1 and Solwara 12.

9.2.6.6 Magnetometer

Magnetometer surveys are used by Nautilus in early stage exploration. The data was not used to facilitate the resource estimate for Solwara 1 and Solwara 12.

9.2.6.7 Seismic

The seismic data collected in early 2012 was processed later that year and the 3D data over Solwara 1 was integrated with the drilling, electromagnetic, and bathymetric data for that deposit.

Although the interpreted data is complex, good correlation was found between drillhole lithologies and discrete seismic horizons. Some refinement of the base of sulphide resource model horizon may be possible but more detailed QA/QC (test drilling) is required before the interpretation can be included in any updated Mineral Resource.

9.3 Survey and positioning

Survey control for operations during the 2007 to 2011 drilling and seafloor sampling programs was provided by UTEC Survey Ltd (UTEC) of Singapore. Geodetic parameters for Solwara 1 surveys are shown in Table 9.6. The survey method, validation and supporting documentation summarised below is described fully in UTEC reports (UTEC 2007, 2008, and 2011).

Table 9.6 Geodetic parameters for Solwara 1 and Solwara 12 drillhole and sampling survey positions

Geodetic parameters	Value
Ellipsoid	WGS 84
Geodetic Datum	WGS 84
Semi-Major axis	6378137.0m
Inverse flattening	1/298.257223563
Projection	UTM South
UTM Zone	56
Central Meridian	153° East
False Northing	0m
False Easting	500000.0m
Grid Units	Metres

9.3.1 Survey method

The survey method and calibration is described fully in UTEC reports (UTEC 2007, 2008, and 2011). An example of a typical calibration is described below (UTEC, 2011):

On the 5 December 2010, a USBL calibration was performed on the installed HiPAP 500 system on the REM Etive in 550 m of water. On completion of the calibration UTEC conducted another calibration in the EIVA Navipac survey system to determine any errors in the survey system, the method is detailed below. The calibration was performed as follows:

- Sound velocity profile was taken at the calibration site.
- In conjunction with the sound velocity profile a transponder was deployed to the seabed.
- The sound velocity profile data was then entered into the HiPAP APOS system.
- The prevalent weather conditions were assessed and a vessel heading of 025° was chosen to minimize vessel movement and noise during calibration.
- The vessel's HiPAP pole was set directly above the transponder and the vessel was rotated through 360°. 843 data points were logged in total for the purposes of the vessel spin.
- The positions of 4 cardinal points were calculated such the transponder was directly aft, abeam and ahead of the vessel at a horizontal distance of 350 m from the transponder.
- The vessel's HiPAP was set directly over each cardinal point with the heading maintained at 025°. A series of 100 data points were logged at each cardinal point thus 400 points were logged for the box-in.
- The data was then processed to remove erroneous points using the Navipac USBL calibration software.
- The offsets inside the Navipac USBL calibration software were fixed as zero and both datasets were manually processed independently.
- The scale factor and pitch, roll, and heading corrections for the HiPAP 500 head were then solved for and entered into the Navipac navigation software.

- The vessel was then positioned at a horizontal distance of approximately 100 m away from transponder and a 360° spin was carried out.
- The transponder position was logged for the duration of the spin and it was seen that the scatter plots described was not within normal operating parameters of the HiPAP 500 system in this depth of water.
- To minimise noise and try to obtain the best data possible the distance of the beacon was reduced to 1 x water depth (350 m).
- The final spin test was conducted.
- A position check was then performed on a drill rod in 1,500 m water depth.

9.3.2 Survey validation

To confirm consistency of survey measurements with prior surveys, validation and verification was routinely carried out on different features throughout the survey program. Features used for validation included drillholes and seafloor monuments (large concrete blocks with a pillar placed by Nautilus on the seabed). An example of typical position verification was performed as follows on drillhole SD177 (UTEC, 2011):

- Vessel was located to position the crane offset over the drill site.
- HiPAP settings were checked to confirm that they were set as for the calibration correction obtained from the last Kongsberg calibration.
- ROV went off deck and positioned as close as possible to the drill rod or feature.
- With the vessel on a heading of 075°, 100 positions fixes were taken on Q5 5 function offset.
- The vessel heading was changed 25° clockwise to a heading of 100°.
- Another 100 position fixes were taken on Q5 5 function offset.
- The vessel heading was changed 20° counter clockwise to a heading of 120°.
- Another 100 position fixes were taken on Q5 5 function offset.
- After outlying positions were deleted the average position was entered into an excel spread sheet and compared to the co-ordinates supplied by Nautilus.

The average co-ordinate was 5.01 m @ 117.33° (Grid) from the Nautilus supplied co-ordinate.

A second verification was taken on Monument 5 (UTEC, 2011). The Crane at 90° offset was positioned over Monument 5 and 100 fixes were taken with the REM Etive on an easterly heading. The REM Etive was then positioned on a southerly heading and another 100 fixes were taken. This was repeated on a westerly and northerly heading. Each of the 100 fixes were checked for gross errors then averaged. The average of the four positions was checked against the position of Monument 5. The difference in easting was -0.28 m and the northing difference was 0.51 m.

9.3.3 Survey results

In 2007 the ROV drill location was determined using a series of accumulative acoustic fixes using a Ranger Widebeam USBL system with data processed by the UTEC Navipac Navigation software (UTEC, 2007). During the drilling operations, accumulative acoustic fixes were taken every three hours. ROV locations on the seafloor were determined to be generally accurate to approximately ±1-3 m which is satisfactory for estimation of the mineral resource.

In 2008, UTEC provided a drillhole position report post recovery from each site (UTEC, 2008). The drillhole position report supplied coordinate difference from average, vector distance from average, circular error probability, accuracy to 2 sigmas, and distance to 2 root mean square. The 2 sigma positional accuracies had a radial error of 0 m - 3.65 m with an average error of 1.31 m for 18 drillholes.

In 2010/11 UTEC was subcontracted to provide survey services onboard the REM Etive, including subsea positioning for ROV and ROV Drill, and to provide documentation of survey operating procedures, field reports and final operations reports (UTEC, 2011). Calibration of the survey equipment was conducted in Singapore prior to mobilisation, with USBL calibration being conducted in PNG on 10 November 2010. Calibration of the TSS Meridian Gyrocompasses, Veripos Differential Global Positioning System, and the dimensional control survey for most of the vessel offset positions were conducted by Atlas Consulting Surveyors using traditional land survey techniques. UTEC provided a drillhole position report post recovery from each site (UTEC, 2011).

EIVA Navipac software was utilised to take 500 fix sample set at deployment and prior to recovery for a total of 100 samples. Twenty-five percent of each sample set were removed through furthest outlier rejection during statistical filtering. The drillhole position report supplied coordinate difference from average, vector distance from average, circular error probability accuracy to 2 sigmas, and distance to 2 root mean square as well as a scatter plot of each sample set. Post landing survey accuracies were within ±2 m which is satisfactory for estimation of the mineral resource.

9.4 Exploration results from the property

In addition to Solwara 1 and Solwara 12, Nautilus carried out exploration throughout its Bismarck Sea Property on the other 16 identified prospects. The exploration activities on the respective prospects are reported in a Technical Report pursuant to NI 43-101 (Jankowski, 2011); this report is available on the SEDAR website. Average grab sample compositions from Jankowski (2011) for the prospects are shown in Table 9.7. Note that some of these grades are from unverified third-party scientific reports and may be based on samples that were specifically selected for detailed analysis and scientific research. Therefore, the grades stated only reflect the grades of the samples selected and may not reflect the average grade of underlying mineralisation.

Table 9.7 Average compositions of grab subsamples from the Solwara Prospects (from Jankowski, 2011)

Prospect	Cu%	Zn%	Au g/t	Ag g/t	Samples	Exploration Stage
Solwara 4+8	11.1	23.0	14.9	259	54 chimney samples	Prospect delineation
Solwara 5	6.0	8.3	14.6	282	12 chimney samples	Prospect delineation
Solwara 6	11.7	18.4	16.1	203	7 chimney samples	Target testing
Solwara 7	5.1	21.5	15.0	359	8 chimney samples	Target testing
Solwara 9	6.3	10.6	19.9	296	17 chimney samples	Target testing
Solwara 12	7.0	22.6	13.7	425	10 chimney samples	Prospect delineation
Solwara 13	9.1	30.7	4.7	546	7 chimney samples	Target testing

Note: Cut-off grade based on mineralised samples where Au > 0.97 g/t or Ag > 29 g/t or Cu > 1.87% or Zn >2.21%

10 Drilling

To establish the extent and nature of mineralisation at Solwara Project, Nautilus completed four drilling programs between 2006 and 2011 (Table 10.1).

In 2006 Nautilus performed scout drilling at Solwara 1 with a conventional offshore surface driven derrick drill rig. This drilling technique was successful in returning thick intersections of high-grade sulfides below the exposed chimney mineralisation. However, it returned low core recovery, particularly in the high-grade top sections of the SMS deposits.

Nautilus subsequently deployed the world's first ROV operated seafloor drill system in 2007. It significantly improved drill core recovery and productivity which enabled Nautilus to publish an independent, Canadian NI 43-101 compliant, resource estimate in early 2008. During a small 2008 drilling program, Nautilus discovered buried mineralisation at Solwara 1 North Zone while drill testing OFEM anomalies.

Building on drilling experience gained in previous campaigns, in mid-November 2010 Nautilus commenced a drilling program utilising the new ROV Drill 3 system owned by Seafloor Geoservices. The program focussed primarily on drilling deeper at Solwara 1 because many of the 2007 drillholes had ended in high-grade mineralisation. Improvements of the ROV Drill 3 system included a larger diameter drill core to improve sample size; a wire-line drill string to drill deeper holes more efficiently, casing ability and an improved landing system to handle the rugged terrain better.

The 2010/11 drilling program increased the available geological knowledge at Solwara 1 and Solwara 12, and demonstrated continuity of high-grade mineralisation in the Solwara 1 North Zone.

Table 10.1 Summary of Nautilus drilling programs at the Solwara Project

Ship	Year	Drilling type	Location	Number of holes	Total length drilled (m)
MV DP Hunter	2006	Seacore R100 Marine Drill (Surface derrick, wire-line diamond core drilling)	Solwara 1	42	380.9
MV Wave Mercury	2007	Perry Slingsby Systems (PSS) ROV Drill 1 - seafloor conventional rod diamond core drilling	Solwara 1	110	1067.9
MV NorSky	2008	Perry Slingsby Systems (PSS) ROV Drill 2 - seafloor conventional rod diamond core drilling	Solwara 1 Solwara 4 Solwara 5 Solwara 8 Solwara 10	31	176.4
MV REM Etive	2010/11	Seafloor Geo Services (Seafloor) M80 ROV Drill 3 Seafloor wire-line diamond core drilling	Solwara 1	66	1065.7
			Solwara 5	5	90.2
			Solwara 12	28	328.5
		Polycrystalline diamond open hole	Solwara 1	11	143.9
			Total Solwara 1	247	2,779.2
			Total Solwara 12	28	328.5

NB: Nautilus does not currently hold tenure over Solwara 10.

10.1 Drilling techniques and procedures

10.1.1 Seacore R100 marine drill

The Seacore R100 marine drill mounted on the MV DP Hunter was designed for deeper exploratory holes on the scale of hundreds of metres into the seabed rather than the relatively short (approximately 20 m) drillholes required for exploration of SMS deposits. Several holes were drilled vertically into each hydrothermal mound in Solwara 1 as a scout exploration program.

Several different bit and core catcher assemblies were used, depending on the material being drilled. A hydraulic piston corer was used for soft sediments, an extended nose assembly for hard and soft rock units, and an alien coring assembly for hard rock. The core barrel had a diameter of 61 mm; housed within an outer reamer-type drill bit more than 200 mm in diameter. The core recoveries were low and the survey accuracy was poor and therefore the results were not used for resource calculations.

10.1.2 PSS ROV Drill subsea drill

The Perry Slingsby Systems (PSS) ROV Drill 1 and ROV Drill 2 is a subsea drilling system designed to take geological core samples (nominal 52 mm diameter) to depths between 12-18 m, using conventional diamond drilling techniques in water depths to 3,000 m. The ROV Drill is designed for use in conjunction with a heavy-duty work class ROV as a bolt on package.

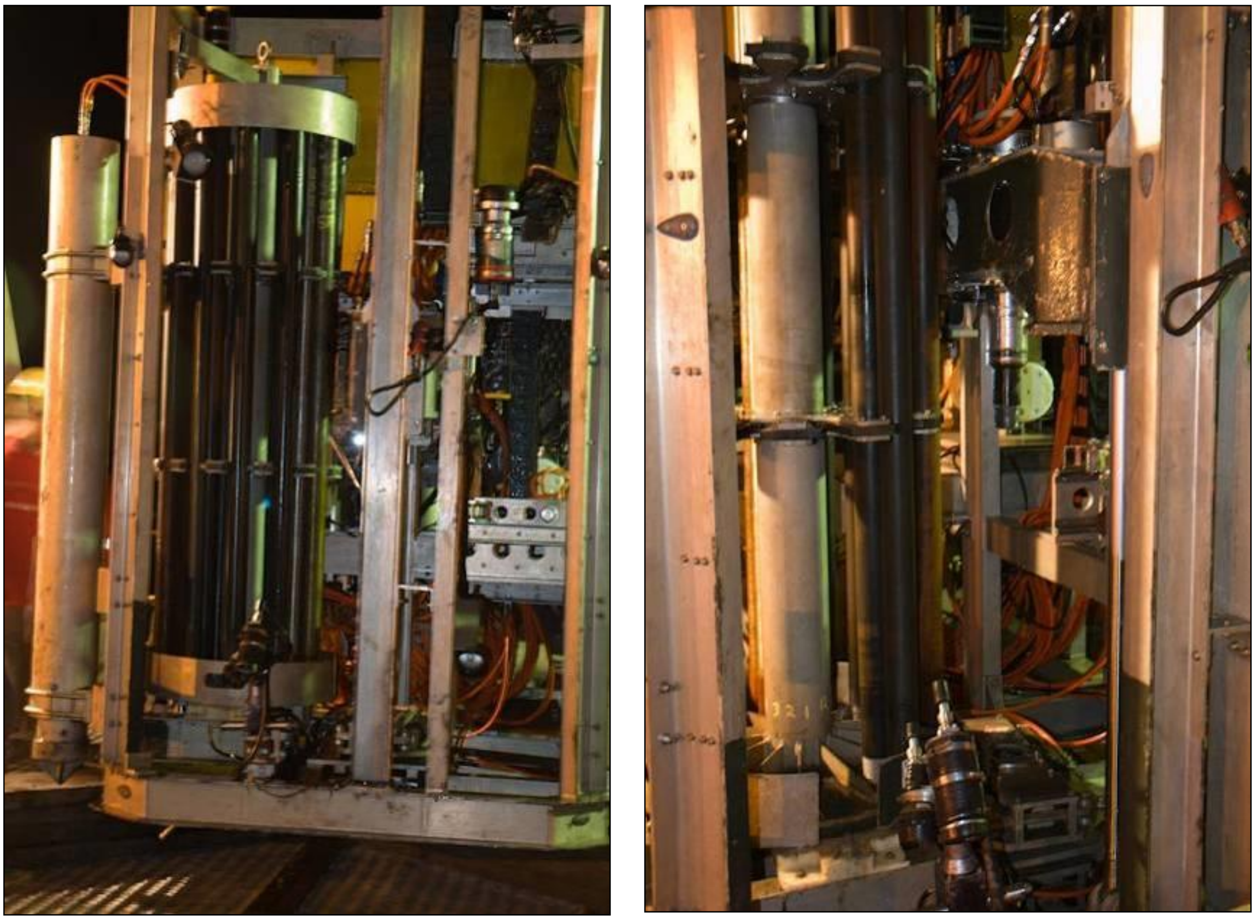
The core barrels and drill rods were stored on board each drill rig in a carousel. Each rod was 1.5 m in length and the configuration of carousel and rods allowed a maximum drilling depth of about 18 m. The drilling operations were managed and remotely controlled by the contractor onboard the Wave Mercury via an umbilical cable. Video cameras mounted on the ROV Drill and ROVs provided visual control of the program to the drilling crews and Nautilus operations room. At the end of each hole, the ROV Drill was returned to the deck, the core barrels were unloaded and the rig was serviced.

On retrieval of the ROV Drill from the seafloor, the core barrels were unloaded from the carousel (Figure 10.1). Each barrel and position on the carousel was individually numbered and the numbers checked during unloading to ensure that the barrels were opened in the correct down-hole sequence.

Nautilus geologists received the core from the barrels opened by the Canyon Offshore Ltd drillers. When the split inner tube was opened the condition of the core and any natural breaks were noted. Any contaminating material (for example, mud containing gastropods) that may have fallen into the hole during the rod change was then removed. The length of the recovered interval was measured and recorded in a field notebook and on the Canyon Offshore Ltd drill report. The core was photographed in the drill split before being carefully transferred to the core trays. The core pieces were immediately reassembled in their in situ configuration. Intervals of core loss were replaced with cylinders of polystyrene foam cut to the length of the lost core. The position of core loss was based on visual core inspection and discussion with the driller.

All holes were drilled vertically.

Figure 10.1 ROV Drill1 on deck showing core barrels held in the carousel.



10.1.3 ROV Drill 3

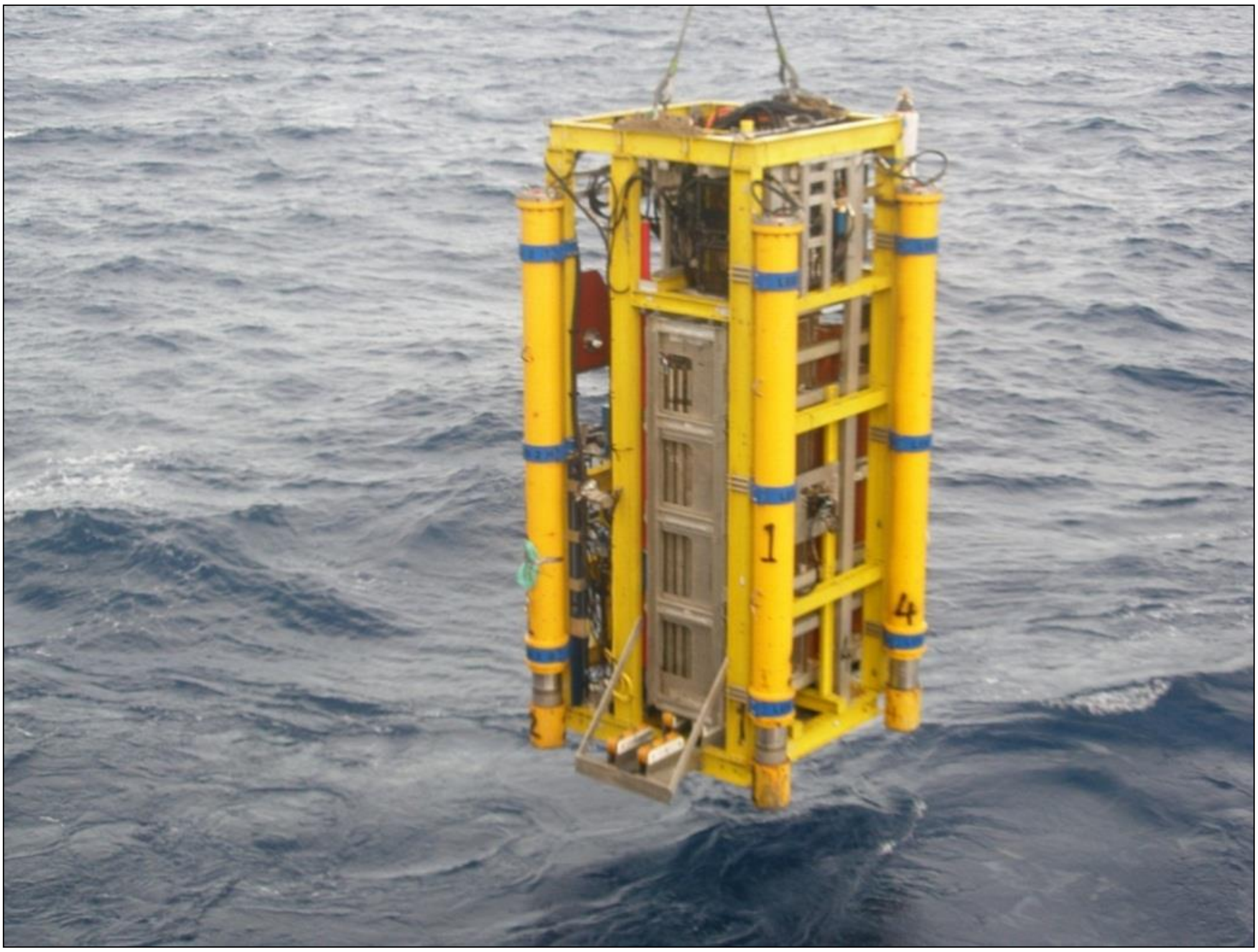
The improved ROV Drill 3 system (Figure 10.2) was designed using experience gained from previous Nautilus drilling programs, and has several significant technological improvements. Amongst these is a new style wire line 400F coring system unique to seafloor drilling. These improvements were intended to provide better core recovery, more representative samples and more efficient drilling operations.

Key technical features include:

- Wire line rotary, push sampling and cone penetration tests.
- Coring depth rating up to 80 m.
- Inner tube capacity of 40 tubes, each 2.38 m long.
- Larger diameter (70 mm) core.
- Rods 100 mm outside diameter by 3 m long.
- Casing 125 mm outside diameter by 3 m long.
- Drill casing system to 40 m depth.
- Ability to drill multiple holes on a single dive.
- Landing - Four leg jack up that has >30° slope landing capability.
- Soft sediment landing options.
- Real time drill parameter data feedback.
- A “look-up camera” that allows geologists to view drill core on the rig within the inner-tubes.
- Mud injection system.
- Removable tool tray for quicker on deck turnaround.

The crane wire length on the ship enabled operations down to 1900 mbsl at Solwara 1. A 1000 m pennant wire was used to extend the depth of operations at Solwara 12. The work instructions for the 2010/11 REM Etive drilling campaign were based on the 2008 procedures. Once the drill rig was recovered to the deck of the REM Etive at the end of each deployment, core was extracted from the inner-tube splits under the direct observation of Nautilus's staff before a formal hand-over of the drill core to Nautilus.

Figure 10.2 ROV Drill 3 drilling rig being launched from the REM Etive.



10.1.3.1 Observed drill set up and core handling

Due to the criticality of the retrieved core sample handling and chain of custody and in the interests of optimizing productivity and safety, some significant provisions for deck handling and processing of the drilling rig and core sample handling processes and equipment were developed. The process flow from deployment and retrieval of the drill module through to removal, processing and hand-over of the core samples was carefully planned (Figure 10.3). This included risk assessments and human intervention scenarios and as a result a suite of custom designed handling systems were manufactured and mobilized on the back deck of the vessel as an essential component of the offshore operating spread. A comprehensive and detailed set of procedures were also developed to supplement and optimize the handling spread.

Figure 10.3 Deck processing facilities

(A) Sub- tray being removed from ROV Drill
(B) Sub-tray containing inner tubes
(C) Core sorting table and core extraction table
(D) Core sorting table

A dive plan, outlining the site locations, landing window and any other drilling related information, was provided to the contractor 24hrs prior to the commencement of the dive. The dive plan outlined the sequence of holes to be drilled, alternative landing sites if priority sites were unable to be landed out successfully and any holes of opportunity.

During ROV Drill land-out, as-found surveys were conducted in the specified landing window for each site. Footage gathered provided an accurate gauge of the surrounding topography, allowing a suitable landing site to be chosen. A marker was placed on a suitable land out site and a set of 20 fixes were taken with the ROV hovering above the marker. If the position was outside the landing window or the 30° slope landing capability of the rig, the marker would be moved and the process repeated until a final approval given on the position of the marker. The ROV Drill was then lowered to the seabed and landed as close to the marker as possible.

All holes were drilled from a vertical position (as measured by the pitch and roll of the drill rig) with no downhole orientation surveys taken.

During drilling operations, drill parameters were transmitted at 10 Hz live to ROV Drill Control for recording and displayed graphically in real time. The data was also streamed to Survey and Nautilus Operations. Eight video cameras with lighting all simultaneously transmitted to the surface and recorded using VisualSoft.

Drillers recorded the drilling information on a Drillers Record Sheet (DRS) as follows:

- Run number.
- Inner tube identification number.
- Start depth/time and end depth/time for each run.
- Run length.
- Head position (start/end).
- Rods in hole.
- Driller's comments, including bit weight, rotation, penetration and mud flow rate.

The DRS is provided at the end of each dive and prior to the core extraction process. The DRS is checked and any discrepancies are raised with the drillers and corrected. The DRS is entered into acQuire using the Drillers Run data object.

As each inner tube is extracted from the drill string via the wireline, the bottom of the inner tube is observed via a camera positioned close to the foot clamps, allowing the geologist to view the material in the core catcher assembly in real time. The video is recorded and delivered to Nautilus after the completion of the dive. The inner tube is then racked into the next available vacant position in the sub-tray and the drilling sequence resumed.

Most holes were cased to a minimum of two lengths (each length of casing was 2.54 m) to preserve surface integrity of the collar. Holes were cased further as required to prevent collapse, return loss and any other down-hole problems that might cause the hole to be abandoned.

Varying ground conditions required different parameters of rotation, water flow, bit weight and torque. These are controlled by the driller and monitored by Nautilus during the drilling. Four main types of lithology were identified that required a specific drilling strategy to be applied whilst drilling:

- Unconsolidated sediment near the top of the drillholes.
- Competent massive sulfide-dominant rock.
- Clay rich rocks, usually beneath sulfide-dominant rock.
- Fresh to altered volcanic rocks.

During ROV Drill recovery, as-left surveys were conducted for each site. Footage gathered provided an accurate gauge of the impact of drilling at each site. On completion, the marker was retrieved and returned to the ROV tether management system.

The ROV Drill is brought onboard using the vessel crane and lowered into a bunded landing frame. The ROV Drill is then connected to deck communications and power. The tool tray is transferred to the upending frame and the sub-tray containing the inner tubes with core is laid on the deck next to the gantry structure.

10.1.3.2 PCD open hole

A series of open hole Polycrystalline Diamond (PCD) test drillholes (from ROV Drill 3) were also completed as part of the mine engineering scope of work. Eleven PCD open holes for 143.9 m were drilled in the 2010/11 program. They were not used for resource estimation.

10.1.4 "Hobbit" scout rig

To improve exploration cost-efficiency, Nautilus has developed its own drilling rig designed to meet scout (exploration) drilling requirements. A shallow water seafloor geotechnical rig was upgraded for deep water work and equipped with the drilling mast and drill string/tooling from a terrestrial drill rig (Figure 10.4). The rig's features include:

- A simple and robust system.
- The ability to easily land and effectively recover samples from SMS systems.
- The ability to be deployed from relatively small vessels.
- A standard work class ROV handling system.
- Suited for deployment using a standard Work Class ROV and launch and recovery system umbilical.

- Conventional drill tooling.
- Proven mineral industry mast, head and foot clamp arrangement.
- Three leg (tripod) design, low centre of gravity and no levelling of the rig required.
- Hydraulic damping / soft landing solution, no need for elaborate / expensive heave compensated winch.
- Mast dump function to deploy deck slip / centraliser onto the seafloor.
- Fast swappable carousel for quick deck turn around.
- Standard American Petroleum Institute (API) threads on tooling for remote make / break.
- Capable of deploying a Nautilus Minerals developed Down Hole Tool and stand-alone data logger.
- Magnetic susceptibility.
- Conductivity.
- Natural gamma.

The rig is designed for an optimum sub-seafloor sampling depth of 6 m and a maximum depth of 18 m. The current design allows for geotechnical applications as well as options for reverse circulation.

The rig was built in 2017 but has not yet been used at sea. So far, it has successfully met design targets in a series of land-based trials. This rig could potentially be used to complete resource conversion and exploration work recommended by the author in Item 26 of this report.

Figure 10.4 Hobbit class seafloor scout rig

10.2 Core handling and logging procedure

Core handling and logging followed a set of detailed procedures designed by Nautilus and Golder Associates in 2007 and updated into formal work instructions for the REM Etive drilling campaign and reviewed by Golder Associates in 2010.

The following summarises these procedures:

- Each core barrel is removed from the ROV carousel and placed into the barrel racks.
- Core barrels are opened in the sequence drilled, as documented on the Geologist Log Sheet. Both the driller and geologist confirm the correct core barrel is being opened.
- The barrel is disassembled by driller and the core extracted.
- The recovered core is measured and the recovery recorded on the DRS.
- The drill core is photographed whilst still in the split.
- The drill core is transferred to pre-labelled trays by the geologist. The core loss intervals are represented by foam insets or wooden blocks. The core loss is allocated to the top of the first run and any subsequent core loss allocated to the bottom of the run. This results in a systematic layout of the core for geotechnical purposes. Core block markers are placed in the tray(s) to represent the run number and the depth to the end of each run.
- Core barrels and equipment are cleaned by the drillers.
- Core trays are transferred to the logging area for logging.
- Geological and material type intervals are marked on the drill core by the geologist, representing the sample boundaries. Geological intervals greater than 1.30 m are split into multiple samples for the same lithological interval.
- Sample numbers and sampling intervals are clearly marked on the drill core by the geologist.
- Each sample interval is analysed using a handheld portable XRF analyser. Each sample interval is analysed at least 10 times along the drill core and forward averaging applied to generate an average grade.
- All logging is entered into acQuire. The database provides data entry validation, including lithology codes, sample numbers and overlapping intervals.
- Core trays are photographed prior to sampling.
- Drill logs are reviewed and approved by a Senior Geologist.

All documents relating to each drillhole are filed on the cruise file server under a well-structured directory for easy retrieval. Any data transmittals between Nautilus and the contractor are filed together then copied to the relevant drillhole folder.

Results from hand held XRF analyses were not used in the resource calculation and are not discussed further.

10.3 Geological logging procedure

The geological logging system was designed to capture descriptive information in a consistent coded format such as rock type, physical characteristics, rock texture, mineralisation type including texture, grainsize and volume percentage. Geologists identify each unique geological interval within the core and enter the descriptive codes into acQuire via a data entry screen. The system allows for validation of logging intervals and codes at the time of logging to ensure consistency between geologists. The comments field was utilised to capture geological detail that could not be coded.

The geological and geotechnical logging and definition of geochemical samples are carried out on a lithological basis. All boundaries were defined by from and to depths. The intervals may include part of a single drillers run or cover several drillers runs. Lithological continuity was based on the interval having similar rock type and mineralisation and core character (i.e. competent core, rubble). A new lithological zone was defined when there was a significant change in these parameters, however the logging intervals were generally no smaller than 50 cm. Within lithological zones, geochemical sample boundaries were marked down hole from the first boundary with a target length of 1 m. Intervals greater than 1.3 m were split into two equal sample lengths.

10.3.1 Lithology classification

A set of lithological types was identified from drilling at Solwara 1 in 2006 and utilized in 2007 and 2008 drill programs. Re-interpretation of the available drill core during late 2009 suggested that a simplified classification system may more accurately represent the different material types than the previous lithology and material type subdivision. Material types were defined to represent geological processes that could be identified by distinct features of the drill core observable at hand specimen scale and a new lithological classification was devised in 2010 (Table 10.2). All previous drill core was re-logged into the 2010 lithology classification.

Hydrothermal material was logged as PT, CF, RI, RA or RC depending on texture, chemistry, and whether sulfide, sulfate or clay was dominant.

Table 10.2 Lithology classification system

<table>
<tr><td rowspan="2">Sediment units</td><td>Mud-silt-sand-gravel</td><td>SS</td><td colspan="2">Unconsolidated to weakly consolidated sediments. Grain-size, 'cohesive muds' and sulfide clasts to be noted during detailed logging.</td></tr>
<tr><td>Cemented sediment</td><td>SC</td><td colspan="2">Any sedimentary material that has been cemented by fine-grained/cryptocrystalline sulfide or sulfate minerals and/or amorphous opaline silica. May contain filled or open worm burrows and gastropod shell-fragments replaced by sulfides.</td></tr>
<tr><td rowspan="5">Hydrothermal units</td><td>Sparry precipitate</td><td>PT</td><td colspan="2">Precipitate of sulfate crystals, often with bladed barite, found within or at the base of the sediment units. Crystal size is generally larger than within the cemented sediments with bladed barite visible to the naked-eye and fractured surfaces on the rock having a "sparry" appearance. Does not contain any sedimentary features or relict clasts.</td></tr>
<tr><td>Conduit-bearing Facies</td><td>CF</td><td colspan="2">Similar appearance to the internal texture seen in surface chimney samples. Zoning of sulfides around open conduits is a key diagnostic feature. Any other indication of open channel-ways (including open vugs with visible coatings of euhedral sulfides) also suggests chimney building processes at work. Chimney structures can be identified from the detailed bathymetry, and drillholes proximal to these are likely to intersect Conduit-bearing facies under any cover sediments. Conduit-bearing facies are usually found at the top of sulfide dominated mineralisation but their root-zone of feeder channel-ways may extend to depth in drill core.</td></tr>
<tr><td>Sulfide dominant rock</td><td>RI</td><td rowspan="3">Material that has no relict texture indicating a sediment or volcanic parent. No obvious open, or previously open, channel-ways showing zoned mineral-precipitation (as seen in the Conduit-bearing facies), but may contain sealed veins (commonly of anhydrite). Formed from replacement and vein infill of an unknown precursor lithology.</td><td>Sulfide dominated. Total sulfide percent is generally greater than the sum of anhydrite+clay. Sulfides are dominated by pyrite; sulfates are dominated by anhydrite but may include barite. Analogous to Massive Sulfide in VHMS deposits.</td></tr>
<tr><td>Sulfate dominant rock</td><td>RA</td><td>Sulfate dominated. Sulfates are dominated by anhydrite but may include barite.; sulfides are dominated by pyrite but may include chalcopyrite. Generally, found in a ‘footwall’ position below the main mineralised zone but may also occur lateral to the root-zone of chimneys.</td></tr>
<tr><td>Clay dominant rock</td><td>RC</td><td>Clay dominated. Sulfates are dominated by anhydrite but may include barite; sulfides are dominated by pyrite but may include chalcopyrite. Generally, found in a ‘footwall’ position below the main mineralised zone but may also occur lateral to the root-zone of chimneys.</td></tr>
<tr><td rowspan="2">Volcanic units</td><td>Volcaniclastic breccia</td><td>VB</td><td colspan="2">Matrix-poor volcaniclastic breccia with close-packed clasts of the massive volcanic material. May be strongly altered but retains textural evidence of a volcanic precursor lithology.</td></tr>
<tr><td>Massive volcanic</td><td>VC</td><td colspan="2">Dark, glassy or cryptocrystalline, often feldspar phyric and vesicular. May be strongly altered but retains textural evidence of a volcanic precursor lithology.</td></tr>
<tr><td></td><td>Core loss</td><td>xL</td><td colspan="2"></td></tr>
<tr><td></td><td>Void</td><td>xV</td><td colspan="2">Natural void interpreted from drillers data/comments and supported by evidence in core.</td></tr>
</table>

10.3.2 Validation of lithological classifications

Validation of the logged lithology was carried out using normative mineralogy calculations and geochemical discriminant analysis. The mineralogy of Solwara 1 drill core is well understood from previous geology and metallurgical studies and consequently the expected mineralogy can be calculated with reasonable confidence. The mineral assemblage in each sample was estimated using normative mineralogy calculations from drillhole assays, using simplified assumptions about the occurrence of Cu, Zn, Pb, As, Fe, Al, Ca, and Ba (Table 10.3).

The calculations apply best to sulfide bearing lithologies including Conduit-bearing Facies (CF) and Sulfide Dominant Rock (RI) and are approximate for the Sulfate Dominant Rock (RA) and Clay Dominant Rock (RC) lithologies. The normative mineral calculations are not suitable for fresh volcanic rocks (VC, VB), sediments (SM, SS, SC) or Sparry Precipitate (PT) as these lithologies are likely to contain more complex mineral assemblages. The sulfide mineral calculations for these lithologies can still be regarded as semi-quantitative.

Drill core samples with >50% predicted total sulfides were reviewed. The normative mineral estimates were used to highlight sample intervals with predicted mineral assemblages that did not match the logged lithologies by plotting the results on ternary diagrams. Figure 10.5 and Figure 10.6 show the final sample classifications after correction of logging errors. The logged lithology of these samples was reviewed using core photographs and, where required, the drill core itself was reviewed. There remain instances where the logged lithology does not correspond to the predicted mineralogy however these can be explained geologically (as summarised in Table 10.4).

Table 10.3 Normative mineral calculations

Minerals calculated	Algorithm applied to drillhole assay to estimate mineral abundance
Chalcopyrite	2.888 x Cu%
Sphalerite	1.490 x Zn%
Arsenopyrite	0.000217 x As (ppm)
Galena	1.155 x Pb%
Pyrite	2.112 x (Fe% - 0.879 x Cu% - 0.000075 x As (ppm) -0.778 x Al%)
Anhydrite	3.40 x Ca%
Barite	1.70 x Ba%
Clay	7.51 x Al% (approximate - based on average altered volcanic). Deficit remaining from normative calculation assigned to this group

Table 10.4 Normative mineral calculations – explanation of anomalies

Lithology with unexpected normative mineral composition	Geological explanation
SC/SS/SM with >50% sulfide	Sediment contains entrained clasts of sulfide rock. Usually overlies sulfide dominant CF unit.
RC with >50% sulfide	Clay-bearing rock with very fine-grained sulfide interpreted to represent replacement of a fine-grained volcanic precursor. Interpreted geologically as footwall. Usually occurs directly beneath RI, the massive sulfide-dominant rock.
RC with >50% sulfate	Veins of sulfate within geologically recognised clay dominant zone. Typically, in the footwall to the sulfide-dominant domain
RC/RA with >50% sulfide	Stringers or veins of sulfide developed in clay or sulfate dominant rock. Occurs in the footwall.
RA with >50% sulfide	Sulfate-bearing with very fine-grained sulfide interpreted to represent replacement of a fine-grained volcanic precursor. Interpreted geologically as footwall as it usually occurs beneath RI, the massive sulfide-dominant rock.
RA with >50% clay+deficit	Clay dominant sample within zone that is mainly sulfate dominated.
RI with <50% sulfide and >50% sulfate	Veins of sulfate within the main massive sulfide-dominant domain.
RI with <50% sulfide and >50% clay	Sample containing altered rock within the main massive sulfide-dominant domain.

Figure 10.5 Ternary classification diagrams of Solwara 1 hydrothermal lithological units.

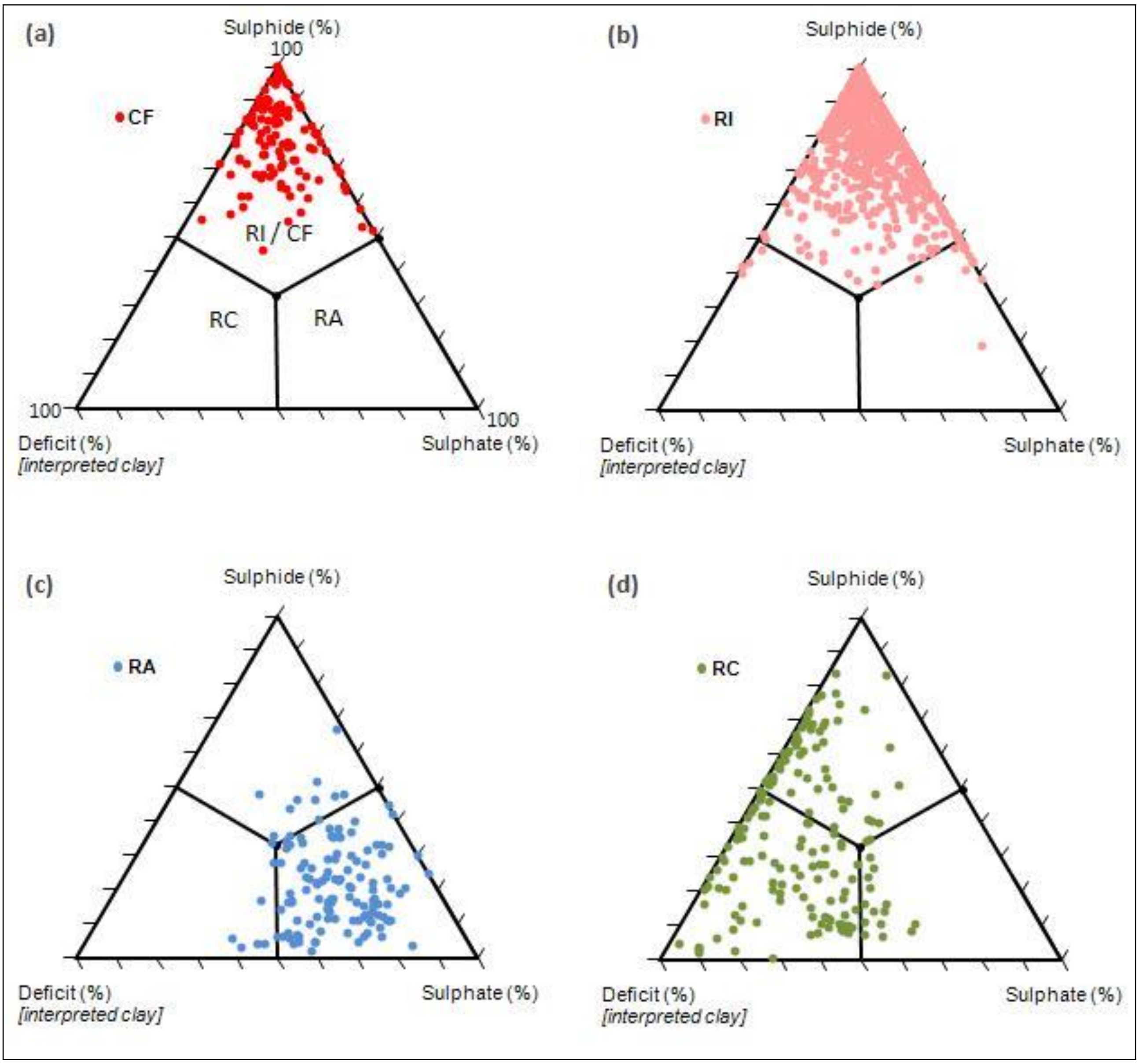
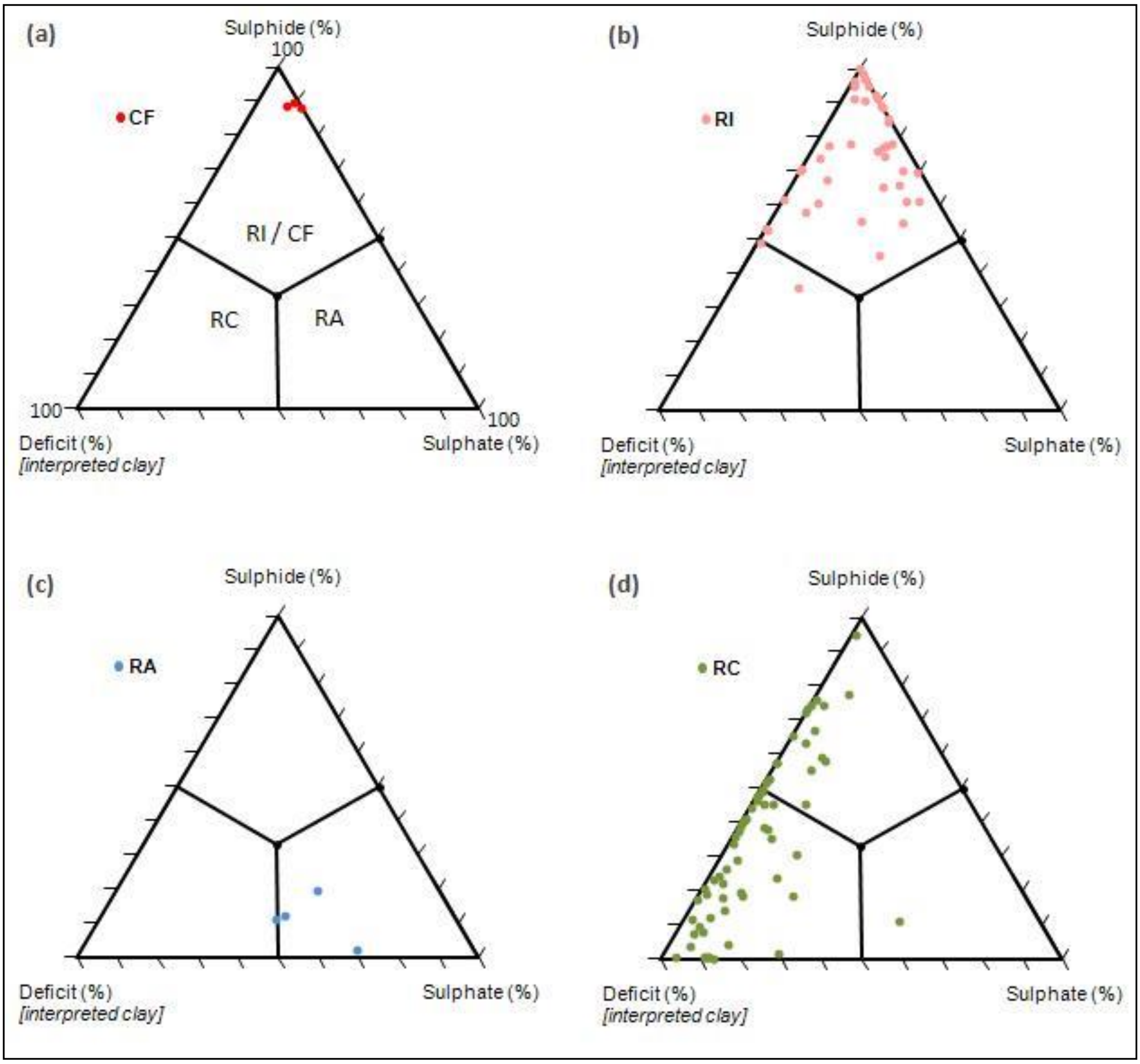


Figure 10.6 Ternary classification diagrams of Solwara 12 hydrothermal lithological units.



10.4 Core loss results

Core recovery varies significantly between lithological units and drilling programs. In general, the unconsolidated sediments on the seafloor are difficult to recover during coring. It was assumed that core loss in the first core barrel could all be attributed to the loss of unconsolidated sediments at the top of the drillhole. From the perspective of mineral resource estimation this is a conservative assumption.

Core recovery in the consolidated sediments and altered sedimentary rocks was also highly variable and consequently the mineral resource within this zone was classified as Inferred Resource.

10.4.1 Seacore R100 Marine drill (2006)

With the vessel mounted drilling platform, coring started at the seafloor surface. Recovery was generally very poor, only averaging 41% over the entire project. Better core recovery was achieved in consolidated massive sulfide-dominant rock than in unconsolidated sediments. Much of the recovered material was in a disaggregated state (broken pieces, loose sands and sludge). The recovery was somewhat better towards the end of the program as the operators became more experienced in drilling the substrate. Eight holes had to be abandoned after the first few metres because of in-fill and collapse. Significant amounts of core were retrieved from 34 of the drillholes.

The core was geologically logged and sampled. The geochemical sampling demonstrated that significant copper, Au and Ag mineralisation, with minor Zn, was present within the Solwara 1 deposit, however due to the poor recovery the geochemical analyses are not suitable for resource estimation. Nonetheless, the geological logs provide corroboration for the current interpretation of the geology of the Solwara 1 deposit.

10.4.2 PSS ROV Drill subsea drill (2007 and 2008)

Drilling with the PSS ROV subsea drill significantly improved the core recovery, particularly as the drill operators gained experience with the drilling equipment and substrate. In the massive sulfide-dominant domain the core recovered in the 2007 drilling program was commonly of excellent quality, forming long continuous sticks of core in the core barrel. The core was easily broken during manual handling, and in some drillholes there was evidence that some core had fallen back into the hole and been redrilled, resulting in some core loss. The core recovery in the massive sulfide-dominant domain, which forms the Indicated Resources and the majority of the Inferred Resources, averaged 74%. The core adjacent to the intervals of core loss was examined in each drillhole. There was no textural evidence (such as mineralogical banding, oxidation of sulfides or crystals formed in open spaces) that might indicate that the drill had passed through a large natural cavity in the rock. In a few cases, there was clay adjacent to the core loss interval but in general there was no evidence to suggest that the lost material was any different to the core either side. It was inferred that the core loss was due to the inherent weakness of the rock, which is a function of the high porosity of this zone.

In the 2008 program, the recovery at Solwara 1 was lower, at 37% overall (of 120.8 m drilled) but 64% in the sulfide dominant domain. The 2008 program was executed by a new team of drill operators. Their inexperience and the short nature of the program is believed to have contributed to the poor core recovery.

10.4.3 ROV Drill 3 (2010/11)

The overall core recovery during the 2010/11 drilling program was 47%, significantly lower than was expected given the advancement of ROV Drill 3. At Solwara 1, the core recoveries in the sulfide dominant domain, upper footwall domain and lower footwall domain were 59%, 52% and 64% respectively. The amount of core loss may be attributed to several factors, including ground conditions, operator inexperience, or early abandonment of the hole. In the West Zone of Solwara 1 where 16 holes were drilled an overall recovery of only 27% was achieved, significantly lower than any other zones drilled at Solwara 1. Excellent recovery (91%) was achieved in SD183 drilled to a depth of 35.85 m, in the Central Zone. Only 7 holes achieved greater than 75% recovery.

At Solwara 12, the overall core recovery was approximately 51% (160.5m recovered from 328.6 m drilled from 28 holes). The core recoveries in the sulfide dominant domain, upper footwall domain and lower footwall domain were 51%, 53% and 74% respectively. The highest recovery (89%) was achieved in SD_S12_025 drilled to a depth of 7.46 m. Only 3 of the 28 holes drilled at Solwara 12 achieved greater than 75% recovery.

10.5 Solwara 1 drilling results

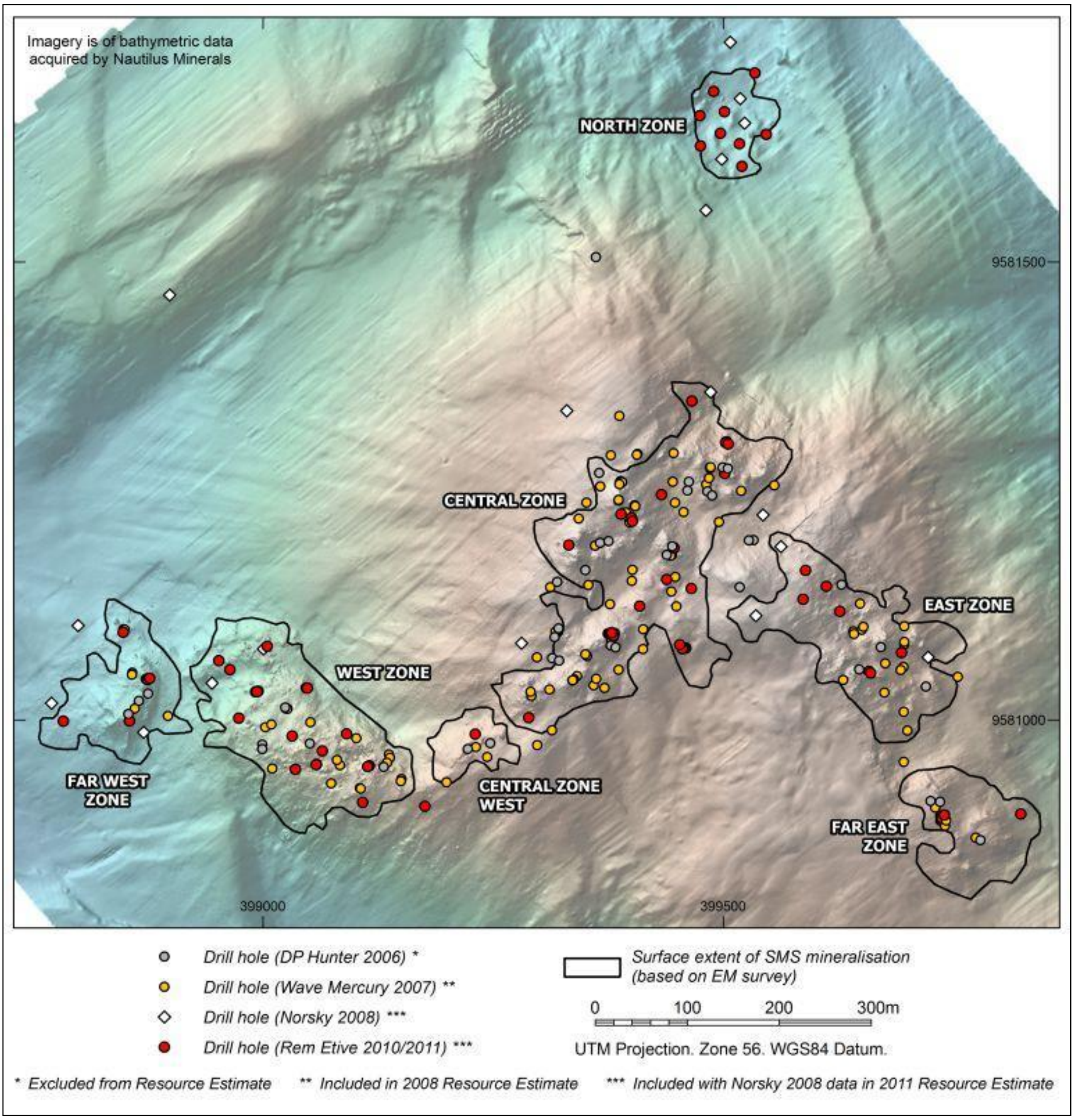
Drilling has been carried out at Solwara 1 in four separate drill programs (Table 10.1,Figure 10.7).

The extent of the Solwara 1 deposit was initially delineated from the mapping of chimney fields, bathymetric survey and the 2006 core drilling results. The 2007 drilling program was designed to test the deposit on a regular grid pattern but the rugged terrain, particularly near the chimney mounds limited the ROV Drill from drilling on a regular grid pattern. Over much of the deposit a final drillhole spacing of approximately 35 m was achieved. At the end of the drilling program a strike length of approximately 1400 m had been drilled to depths of up to 19 m. The 2007 drilling program successfully tested part of the Solwara 1 deposit and demonstrated that the system remained open at depth in some areas and along strike to the west. The drillholes confirmed a widespread sub-horizontal body of sulfide-dominant mineralisation beneath the chimney fields and extending beyond the main chimney mounds. The massive sulfide-dominant mineralisation consisted dominantly of chalcopyrite and pyrite. Significant Au and Ag mineralisation was also identified within the sulfide-dominant domain.

The drilling at Solwara 1 in 2008 and 2010/11 filled in some of the gaps in the coverage by the earlier programs and confirmed extensions of the mineralisation at depth and laterally.

All holes were drilled vertically. As the massive sulfide and altered sediment are essentially flat-lying the reported intersections can be considered true thicknesses of the SMS mineralisation encountered. The drillholes have also demonstrated that thicker than average accumulations of mineralisation are present in some locations. These are interpreted to represent the upper part of feeder zones that have channeled hydrothermal fluids into the main chimney zones and into the seafloor substrate. These zones are interpreted to extend down into the volcanic footwall. There is therefore potential to discover steeply dipping zones of stringer and disseminated mineralisation within the footwall, however, this has been limited to date by the vertical orientation of the drillholes and the lack of sufficient deep holes. The possible location of these footwall zones may be inferred from the structural trend of the main SMS mineralised zones.

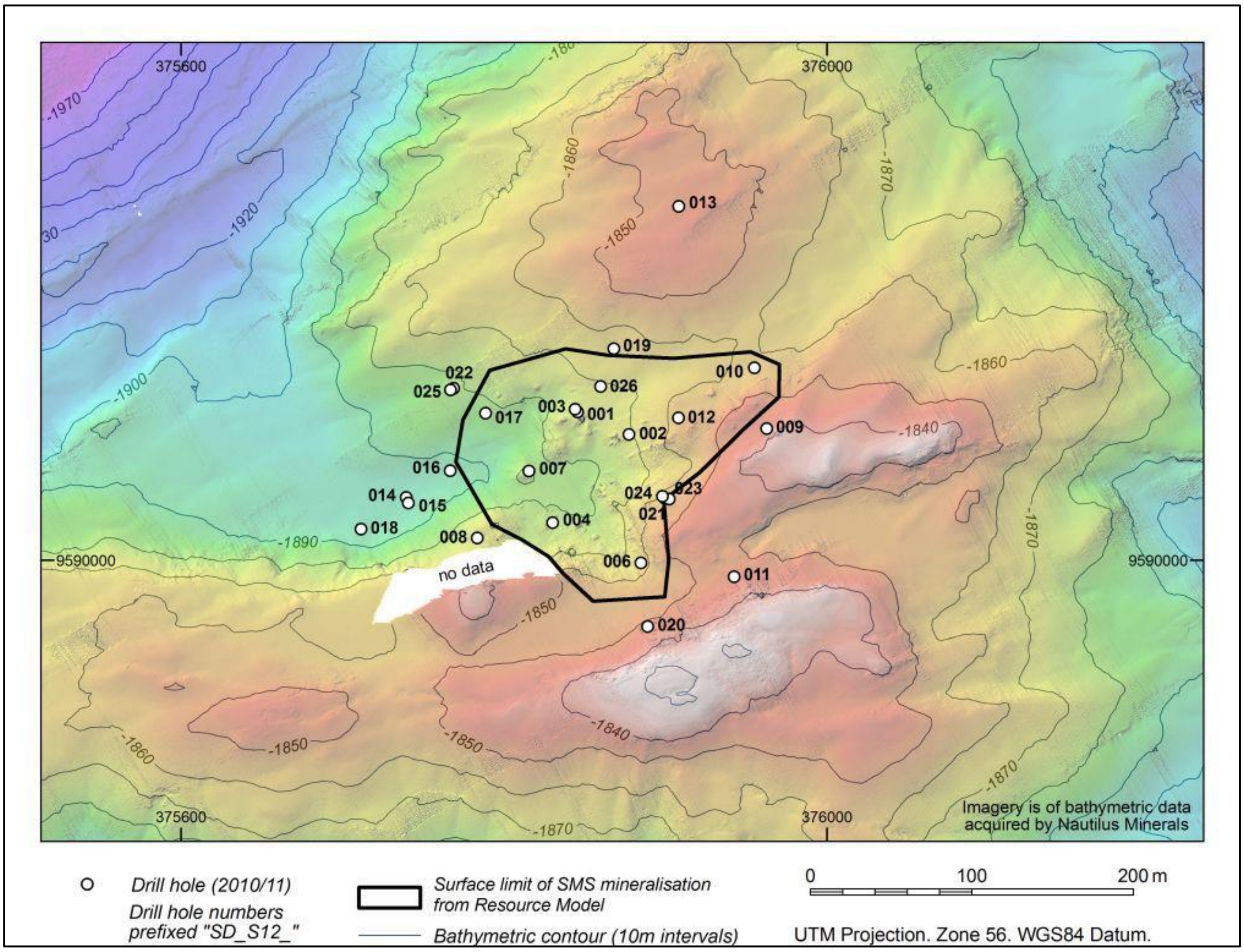
Figure 10.7 Location of drillholes at Solwara 1.



10.6 Solwara 12 drilling results

Solwara 12 was drilled for the first time during the 2010/11 REM Etive drilling program. Scout drilling discovered significant intersections of Cu, Zn, Au and Ag mineralisation. As a result, the drilling program was extended to 25 holes (Figure 10.8). Mineralisation is identified to extend to a maximum depth of 35 m below the seafloor. Interpretation of the drill hole data suggests a main massive sulfide-dominant domain and indications of a second lower disseminated sulfide lens.

Figure 10.8 Location of drill holes at Solwara 12



10.7 Other drilling results

In addition to Solwara 1 and Solwara 12, Nautilus has carried out drilling on four other prospects in its Bismarck Sea Property. The drilling activities on the respective prospects are reported in a Technical Report pursuant to NI 43-101 (Jankowski, 2011); this report is available on the SEDAR website. Drilling statistics for the prospects are shown in Table 10.5 and the results are described in Jankowski (2011).

Table 10.5 Drilling carried out by Nautilus on other prospects in the Bismarck Sea property

Ship	Year	Drilling type	Location	Number of holes	Total length drilled (m)
MV NorSky	2008	Perry Slingsby Systems (PSS) ROV Drill 2 - seafloor conventional rod diamond core drilling	Solwara 4 and 8	4	18.43
			Solwara 5	4	17.77
			Solwara 10*	5	19.26

*Nautilus no longer holds tenure over Solwara 10.

11 Sampling Preparation, Analyses and Security

Samples used for mineral resource estimation were collected during the Wave Mercury, NorSky and Rem Etive cruises utilising the sampling procedures described in this Item. Independent verification was conducted by qualified persons from Golder Associates, who authored the 2012 NI 43-101 report and Mineral Resource estimates for Solwara 1 (restated in this report).

Procedures pertaining to sampling and analysis of drill samples collected during the 2006 MV DP Hunter drilling program are not described as the results were not used to estimate resources.

11.1 Sample preparation and shipping procedures

11.1.1 Seafloor and chimney samples

Samples were collected by Nautilus staff following sample retrieval and sample preparation procedures. Each retrieved chimney sample was photographed with a photocard, detailing the sample number, ROV Dive Number, date collected, target/deposit name and scale bar (Figure 11.1).

In 2006 and 2007 each chimney was sliced radially with a power saw to obtain a sample approximately 3cm thick through the full width of the chimney. During the 2009 program, the chimney samples were cut using a pneumatic chisel/jackhammer. Sub-samples weighing 3-6 kg were taken for assay. The sub-samples were placed in labelled sample bags and weighed. All samples were logged and described in detail using the custom data entry form in acQuire. All remaining material was placed in labelled sample bags and returned to the sample refrigerated container for storage.

Samples of volcanic rock and sediments collected from the seabed were not submitted for assay at the time of collection. However, samples were photographed and weighed prior to being logged and described in detail, using the custom data entry form in acQuire. Samples were placed into labelled sample bags and stored in the sample refrigerated container. At the end of each program the samples were transported to Brisbane for archiving and subsequent sampling.

Figure 11.1 Example of chimney collected during 2007 Wave Mercury sampling program

11.1.2 Core samples

After geological logging, the drill core was sampled for geochemical assay. The sampling method has been modified over the various programs because of different core diameters and the amount of material available for assay.

11.1.2.1 2007 Wave Mercury program and 2008 NorSky program

Samples were collected by the same method for both the 2007 Wave Mercury program and 2008 NorSky program.

Geochemical sampling was carried out by Nautilus personnel after the on-board geotechnical test work had been completed and the geotechnical test residues returned to the core trays. The drill core was cut longitudinally in half with a diamond saw unless the core was very soft in which case a chisel or knife was used.

Each sample was placed in a labelled plastic sample bag and a sample ticket was stapled to the bag for reference. For odd numbered holes, the right-hand half of the core (looking up the core tray) was sampled, for even numbered holes the left-hand half of the core was sampled.

Duplicate core samples were collected at a rate of 1 for every 10 regular samples, taking the remaining half core. The duplicate sample interval was replaced in the core tray with a cylinder of polystyrene foam cut to the length of the duplicate sample and marked with the word “Duplicate” and the duplicate sample number. Each of the sample bags was placed in a labelled vacuum sealer bag and heat sealed using a vacuum sealing machine.

At the end of the drillhole the following quality control samples were inserted into the batch:

- One certified reference material (CRM) sample for every 10 regular samples.
- One secondary reference material (SRM) sample for every 10 regular samples.
- One blank sample for every 10 regular samples.

All samples were weighed and records were updated in acQuire as part of the sample dispatch procedure.

11.1.2.2 2010/11 REM Etive program

Geochemical sampling was carried out by Nautilus personnel after the geotechnical test work had been completed and the material returned to the core trays. Sample intervals were defined on lithological boundaries and/or maximum sample lengths. For quality control purposes, six CRMs and one field duplicate were inserted into every sequence of 14 primary samples. All sample intervals were entered into acQuire. Sample tickets were prepared based on the intervals generated in acQuire and sample bags prepared. Unlabelled CRM samples were inserted into the sample bags.

Each sample interval was marked on the core tray and the sample number marked on the tray. Duplicate sample numbers were also marked on the tray.

The solid drill core was reassembled and marked with a centreline to ensure that orientation relative to each piece of core was maintained during cutting. The drill core was cut longitudinally in half with a diamond saw, with the down-hole direction towards the blade. The right-hand half of the core was returned to the tray in the correct down-hole orientation with the cut surface facing up. The remaining half core was cut longitudinally in half. The two quarters were placed back in the tray in the correct down-hole orientation. The core cutting continued until the entire hole was completed.

The core from the REM Etive program was 70 mm in diameter, compared to the 52-mm core collected from the 2007 and 2008 programs. To maintain relatively consistent statistical support, quarter core (rather than half core) was sampled in the REM Etive program, the left-hand quarter in the down-hole direction was sampled and placed in the individually numbered sample bags. After each interval was sampled, the sample bag was sealed and placed into a sample storage box.

Where the core state was rubble and could not be reassembled, a quarter of the material along the length of the interval was taken directly from the tray and placed into the sample bag. In some cases, the material was cut with a clean knife or trowel.

Once all the primary samples had been taken the duplicate sample was taken from the second quarter, as per the sample list.

All the samples were weighed, including the CRMs and field duplicates and recorded on the sample ticket. The weights were entered into acQuire.

After the sampling was completed, the entire drillhole was rephotographed and transferred to the refrigerated core storage container. Procedures were put in place to restrict the access to the refrigerated core storage container to authorised personnel.

11.1.3 Sample shipping

All samples (drill core, chimney and sediment push cores) followed the same sample dispatch work instructions, allowing for a standard, auditable procedure.

A sample dispatch was created in acQuire by entering the details of the sample selection, such as project name, hole ID(s) and selected sample(s). The dispatch details were entered, including the unique sample submission form identification number, laboratory and Customer Profile Template. A sample submission form was completed for each dispatch including client information, sample information, sample identification and assay requirements.

Each dispatch included the following paperwork:

- Sample Shipping Form / Inspection Sheet.
- Laboratory Sample Submission Form.
- Sample Dispatch Register (acQuire).
- Nautilus Letter of Importation.
- Customs Declaration Form.
- Nautilus PNG Export Permit.
- Australian Quarantine Inspection Service (AQIS) Permit to Import Quarantine Material.

Tamper-proof security tags were applied to all sample dispatches, by attaching the tags to the plastic container or polyweave bag. The tags were positioned such that if the container or polyweave sack were tampered with the seal would break. Each plastic tub was individually numbered, samples packed, security sealed, weighed and photographed.

The Sample Shipping Form or Inspection Sheet was used to track samples dispatched to the analytical laboratory. The form recorded the security identification tags used for each dispatch. During each stage of the dispatch the Custodian and Receiver signed the form indicating acceptance of the samples and that the security tags and packages were intact and that no evidence of tampering observed.

Upon receipt at the laboratory, the dispatch was checked for evidence of tampering and that the original security tags were in place. The security tags were removed, samples inspected and prepared for quarantine heat treatment. Following quarantine, samples were processed under standard laboratory security procedures.

During site visits in 2007, a Golder representative observed the packing of samples for shipment to the analytical laboratory. Also, some consignments were inspected and opened at ALS Laboratory Group in Townsville in the presence of Golder staff. The samples were examined for any evidence of contamination of the sample bags or tampering; none was observed.

During a site visit in 2011, a Golder representative observed the packing of samples for shipment to the analytical laboratory.

11.2 Analytical procedures and analysis

Analytical procedures and techniques pertaining to samples used for resource estimation are summarised in Table 11.1. Two laboratories were used over the course of the programs: ALS Laboratory Group and SGS Australia Pty Ltd.

Table 11.1 Summary of analytical techniques used by Nautilus

Ship	Year	Location	Sample Type	Analytical Laboratory	Summary of Analytical Techniques
MV Wave Mercury	2007	Solwara 1	Drill core	ALS Laboratory Group (Brisbane and Townsville, Australia)	Cu, Ag, Pb and Zn by Material Grade analysis [ME-OG46]
					Au by fire assay [AA25]
		Solwara 1	Chimney		Multi element by after a four-acid digest [ME-ICP61]
					Ba Pressed Powder XRF [ME-XRF07]
MV NorSky	2008	Solwara 1 Solwara 4 Solwara 5 Solwara 8 Solwara 10	Drill core	Same as 2007	Same as 2007
MV REM Etive	2010/11	Solwara 1 Solwara 5 Solwara 12	Drill core	SGS Australia Pty Ltd	Ag, Cu, Pb, Zn by ICP-OES (over-grade by AAS) [ICP15Q]
					Au by fire assay/AAS [AAS15Q]
					Multielement by ICP-OES [ICP40Q]
					Hg, Se and Te by ICP-MS [IMS12S]
					SiO_2 by Sodium peroxide fusion is ICP-AES finish. [ICP90Q]
					Ba Pressed Powder XRF [XRF75V]
					AS and S over-range by ICP-OES [ICP43B]

NB: Nautilus does not currently hold tenure over Solwara 10.

11.2.1 ALS Laboratory Group (2007 and 2008)

Core and chimney samples from the 2007 program were analysed by ALS Laboratory Group in laboratories in Brisbane and Townsville. The laboratories are NATA (National Association of Testing Authorities, Australia) certified.

The samples were dried and crushed to 70% passing 2 mm in a jaw crusher. A rotary splitter was used to split 1 kg which was then pulverised in a ring mill to better than 85% passing 75 µm.

Cu, Ag, Pb and Zn were measured by what is known by laboratories as “ore-grade analysis” using ICP-AES following an aqua regia digest. Several stabilising compounds are used in the digestion to keep Cu, Zn, Pb and Ag in solution at high concentrations.

Au was analysed by fire assay using a 30g charge and an atomic absorption spectrophotometry finish. Due to the high sulfide content, the fire assay charges were reduced for many samples.

Al, As, Be, Bi, Ca, Cd, Co, Cr, Fe, K, Mg, Mn, Mo, Na, Ni, P, S, Sb, Sr, Ti, V, W, Hg, Se, Te and Li were analysed by ICP-AES after a four-acid digest and Ba was analysed by XRF.

ALS uses an extensive set of quality control procedures, including the use of blanks, duplicates and CRMs to monitor the quality of the sample preparation and analyses, and protocols for reanalysis of batches if results are unsatisfactory.

Nautilus carried out its own quality control procedures, including the insertion of duplicates, blanks, CRM and matrix-matched SRM. The results of these procedures are presented in Item 12.

In the author's opinion the sampling, sample preparation, security and analytical procedures were satisfactory for mineral resource estimation.

11.2.2 SGS Australia Pty Ltd (2010/11)

SGS Australia Pty Ltd managed and ran an independent onboard sample preparation facility for the REM Etive drilling project. No aspect of sample preparation was conducted by an employee, officer, director or associate of Nautilus. All core samples underwent the same sample preparation process as follows:

- Samples were received from Nautilus in calico bags with a sample submission sheet.
- Samples were sorted, registered into the lab management system and assigned a job number.
- Samples were dried at 105 °C in the original calico bag.
- Samples were crushed to 70% passing 6.3 mm using a Boyd crusher (dry screening of every 20th sample tested and recorded as a check).
- Nominal 1 kg split was taken from crushed material using a riffle splitter and then pulverised to 90% passing 75 µm in a Labtech LM-2 pulveriser using chrome-steel bowls and pucks (wet screening of every 20th sample tested and recorded as a check).
- Nominal 150 g of the pulverised sample was placed in a wire-tied paper pulp envelope.
- Pulp envelopes were placed into a plastic bag which was nitrogen purged and then heat sealed. The plastic bag was then placed in cardboard box and sealed with packing tape. Details of lab job were marked onto the outside of the cardboard box.

Under a documented chain of custody, sealed boxes of pulps were transferred to shore in Kokopo, PNG, and were then sent via TNT Air Cargo to SGS's analysis facility in Garbutt (Townsville), Australia.

A nominal 30 g of pulp was provided to Nautilus in a small plastic envelope separately to the remainder of the coarse and pulp reject material which was returned in nitrogen purged, heat-sealed bags.

Sample assaying was completed by laboratories of SGS Australia Pty Ltd. SGS operates quality systems based on international standards ISO/IEC17025:1999 "General requirements for competence of calibration and testing laboratories", and ISO9001:2008 "Quality Management Systems -- Requirements". SGS's Australian Mineral Services are also accredited by NATA.

Elements were reported by the following methods:

- Au: fire assay using a Pb collection technique on a 30g sample charge (method FAA303).
- Ag, Cu, Pb, Zn: Digestion in hot Aqua Regia followed by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) determination (method DIG15Q/ICP15Q). Digests reporting over-grade from this method were re-determined by AAS (method AAS15Q).
- Al, As, Be, Bi, Ca, Cd, Co, Cr, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, S, Sb, Sr, Ti, V, W: Four-acid digest (nitric, hydrochloric, hydrofluoric and perchloric) followed by ICP-OES determination (method DIG40Q/ICP40Q). Digests reporting over-grade As were diluted and re-determined by ICP-OES (method DIG43B/ICP43B). Samples reporting over-grade S were vaporised in a LECO/ Eltra furnace before determination in an infra-red cell (method CSD06V).
- Hg, Se, Te: Digestion in Aqua Regia at low temperature followed by ICP-MS determination (method DIG12S/IMS12S).
- Si: Sample was fused with sodium peroxide before being leached with hydrochloric acid followed by determination by ICP-OES (method DIG90Q/ICP90Q).

Nautilus carried out its own quality control procedures, including the insertion of duplicates, blanks and CRMs. Within a sequence of 14 primary samples, CRM samples were inserted giving a nominal ratio of six CRM samples to 14 primary samples. Additionally, one core duplicate was submitted from within every nominal 14 primary samples by submitting a second sample of quarter-core. The results of these procedures are presented in Item 12.

11.3 Bulk density

Bulk density measurements are required for estimation of the tonnage of the mineral resource and for evaluation of geotechnical parameters. Three methods have been used to measure bulk density; an Archimedean method, the caliper method and a water displacement (overflow) method. Generally, both the Archimedean and caliper methods were used on core samples selected for geotechnical testing. The Archimedean and overflow methods were used on the chimney samples prior to dispatching them for geochemical analysis. This approach resulted in a substantial database of duplicate bulk density measurements on both core and chimney samples.

The moisture content measurements on Wave Mercury and REM Etive campaigns were carried out on board as soon as practically possible after the core was available, typically within 12 hrs. The geotechnical test work for the NorSky campaign was not conducted on the vessel but in a Rabaul laboratory after the drilling campaign.

Over the past three drilling campaigns, approximately 1,800 dry bulk density measurements have been carried out on core samples. After the QAQC process a total of 1417 density tests were found to be valid (Table 11.2) for Solwara 1 and 138 for Solwara 12.

Table 11.2 Valid bulk dry density and moisture content tests for Solwara 1

Valid Tests	**Solwara 1**			**Solwara 12**		
Test/Method	**Wave Mercury**	**NorSky**	**REM Etive**	**Wave Mercury**	**NorSky**	**REM Etive**
	2007	**2008**	**2010**	**2007**	**2008**	**2010**
Moisture Content	360	76	448	-	-	152
Total	882			152		
Archimedes	325	75	173	-	-	59
Caliper	357	76	325	-	-	79
Displacement	86	-	-	-	-	-
Sub total	768	151	498	-	-	138
Total	**1,417**			**138**		

The wet and dry masses of all samples were determined using a small electronic balance equipped with a 'live animal' function designed to compensate for small movements of the balance. It was anticipated that this would reduce errors that might arise because of the movement of the ship. Calipers were used to measure the core samples dimension prior to geotechnical testing. These weights and measures allowed the bulk density to be determined by two independent techniques, namely the Archimedean and caliper methods.

The bulk density of chimney samples was measured using two methods: firstly, by collecting the overflow when the sample was lowered into a full bucket of water; and secondly, by a water displacement method based on Archimedes Principal. Unlike the small electronic scales for core samples, the electronic scales used to weigh the chimney samples in air did not have a 'live animal' function and consequently the measurements fluctuated due to the gentle pitching of the ship. Several readings were recorded and averaged to reduce this error.

11.3.1 Dry bulk density measurement Method A: Archimedean

Archimedean water displacement methods for measuring bulk density works on the principal that a solid submerged in a fluid will experience an upward force (buoyancy) equal to the volume of fluid that the solid displaces. The upward force is measured as an apparent reduction in the mass of the sample when weighed in fluid. Sea water was used as the buoyancy medium during the Wave Mercury cruise, while the NorSky and REM Etive used fresh water. This test method was used on both core and chimney samples.

The procedure was as follows:

- Saturate the sample by immersion in fresh water.
- Agitate to remove trapped air.
- Remove the sample from the water; wipe any excess water off the surface quickly with a damp cloth. Weigh the sample in air (Mwet).
- Transfer the sample to the basket in the bucket of fresh water. Determine the saturated submerged mass of the basket plus sample (Mss).
- Determine the moisture content (mc) of the half sample (post geotechnical testing) by drying overnight (or longer if necessary) in an oven.

The bulk wet density was calculated by the following equation:

Equation 1 - Wet Bulk Density - Archimedean

$$\rho_{wet} = \frac{M_{wet}}{(M_{wet} - M_{ss})/\rho_{fluid}}$$

Where

ρ_{wet}	*= wet bulk density*
M_{wet}	*=Mass of saturated sample in air*
M_{ss}	*= Mass of saturated sample in water*
ρ_{fluid}	*= fluid density (fresh water 1.0 g/cc, sea water 1.025g/cc)*

The moisture content was calculated by the following equation after weight adjustment for tray weights:

Equation 2 - Moisture Content

$$mc = \frac{M_{wet} - M_{dry}}{M_{dry}}$$

Where

mc	*= moisture content (%)*
M_{wet}	*=Mass of saturated sample in air*
M_{dry}	*= Mass of sample dry*

The bulk dry density was calculated by the following equation:

Equation 3 - Dry Bulk Density

$$\rho_{dry} = \rho_{wet}\frac{100}{100 + mc}$$

Where

ρ_{wet}	*= dry bulk density*
ρ_{wet}	*= wet bulk density*
mc	*=moisture content*

11.3.2 Dry bulk density measurement Method B: caliper method

If the core is highly porous or vuggy, water displacement methods may underestimate the bulk volume of the rock due the decrease in volume measured related to exposed vugs. In this case, if the core is in competent sticks and the diameter of the core is relatively uniform, the caliper method was preferred.

The procedure was as follows:

- Cut the ends of the core interval perpendicular to the long axis of the core using end grinder.
- Measure the maximum diameter of the core with a pair of calipers to the nearest 0.1 mm. Do not put the points of the caliper jaws inside a cavity. The core diameter should be measured at six points and averaged.
- Measure the length of the core (L) with a pair of calipers to the nearest 0.1 mm.
- Measure the mass of the sample in air (Mwet).

The wet bulk density (ρ_w) was calculated by the following equation:

Equation 4 - Wet Bulk Density - Caliper

$$\rho_{wet} = \frac{M_{wet}}{\pi \times r^2 \times L}$$

Where

ρ_{wet} = wet bulk density
M_{wet} =Mass of saturated sample in air
r = core radius
L = core axial length

The procedure for determining moisture content was the same as that in Method A and was calculated as per Equation 2. The Dry Bulk Density (ρ_d) for the caliper method was calculated as per Equation 3.

11.3.3 Dry bulk density measurement Method C: overflow method

The overflow method was used only for large irregular shaped slices of chimney material. The samples consisted of slices cut perpendicular to the chimney axis with a saw. Samples were generally in the range of 1.5 to 4.5 kg. The procedure was as follows:

The following equipment is required:

- Electronic scales balance to weigh samples of up to 10 kg. The limit of the balance should not exceed ±0.1% of the sample mass.
- For the overflow method: a perforated basket or wire sling that can be suspended in the bucket of water. Fill the bucket until it overflows through the pipe. Immerse the basket in the bucket of water. Collect the overflow water in a large measuring cylinder and measure the volume (Vbasket).
- For the displacement method: perforated basket that can be suspended in the bucket of water from beneath the electronic balance. The basket is suspended in water and the reading on the balance is set to zero.
- A metal tray in which the sample may be placed in an oven for drying. Weigh the empty metal tray (Mtray).

The procedure is as follows:

- Fill a large bucket of water with an overflow pipe until it overflows through the pipe.
- Saturate the sample by immersion in seawater. Agitate to remove trapped air.
- Transfer the saturated sample to the basket and lower the basket into the bucket of water. Collect the overflow water in a large measuring cylinder or bucket and measure the volume (Vsample+basket).
- Remove the sample from the water place it immediately in the metal tray, before pore water has a chance to drain, and weigh on the electronic balance. Record the wet weight (Mwet sample + tray).
- Determine the moisture content (mc) of the half sample by drying overnight (or longer if necessary) in an oven.

The Wet Bulk Density (ρ_{wet})is calculated by:

Equation 5 - Wet Bulk Density – Over Flow

$$\rho_{wet} = \frac{M_{\text{wet sample+tray}} - M_{tray}}{V_{\text{sample+basket}} - V_{basket}}$$

The Moisture content (*mc)* was calculated by:

Equation 6 - Moisture content – Over Flow

$$mc = 100 \times \frac{M_{\text{wet sample+tray}} - M_{dry\ sample+tray}}{M_{\text{dry sample+tray}} - M_{tray}}$$

The Dry Bulk Density (ρ_{dry}) was calculated by:

Equation 7 - Dry Bulk Density (ρ_{dry}) – Over Flow

$$\rho_{dry} = \frac{M_{\text{dry sample+tray}} - M_{tray}}{V_{\text{sample+basket}} - V_{basket}}$$

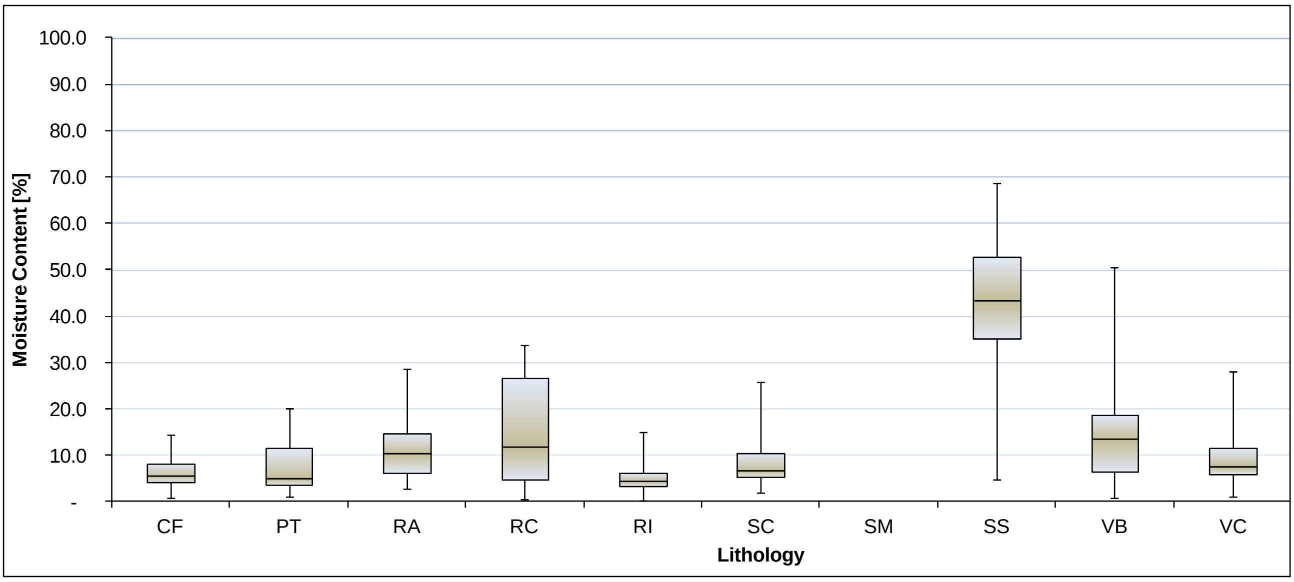
Unlike the small electronic scales used for core samples, the electronic scales used to weigh the chimney samples in air did not have a 'live animal' function and consequently the measurements fluctuated due to the gentle pitching of the ship. The read-out on the scales was observed for several seconds to estimate the average or mid-point reading.

11.3.4 Moisture content

Moisture content testing has been conducted on core samples from the Wave Mercury, NorSky and REM Etive exploration campaigns. It should be noted that the NorSky tests were carried out after the drilling campaign was completed so the samples were re-saturated with sea water for 12 hrs in the laboratory prior to testing. QA-QC was conducted on the moisture content data. Sixteen (16) of the 900 moisture content measurements were found to be invalid and discarded.

Solwara 1 moisture content results were categorised by lithology and are represented in Box & Whisker plots in Figure 11.2.

Figure 11.2 Solwara 1 moisture content per lithology excluding outliers



Due to the high variability of moisture content, an outlier was defined as greater than 3 times the range between the 25% quartile and 75% quartile, above the 75% quartile, or less than 3 times this range below the 25% quartile. Moisture content outliers were removed from sample set as they were deemed to be unrepresentative of the lithological unit. A total of 24 moisture content results were removed in this way for the Solwara 1 resource.

The overall moisture content for each lithology unit for the Solwara 1 resource, after validation and outlier removal, is listed in Table 11.3.

Table 11.3 Solwara 1 – moisture content per lithology unit excluding outliers

Lithology	Number	Moisture Content [%]			
		Mean	Standard Deviation	Max	Min
Conduit bearing facies [CF]	99	6.3	2.8	14.4	0.9
Sparry precipitates [PT]	34	7.1	4.9	20.1	1.1
Sulfate dominant rock [RA]	49	11.0	6.2	28.7	2.7
Clay dominant material [RC]	21	15.1	12.0	35.7	0.6
Sulfide dominant rock [RI]	424	5.1	2.7	15.1	0.3
Cemented sediments [SC]	59	8.5	5.0	26.0	2.1
Sediment Mud [SM]	-	-	-	-	-
Mud-silt-sand-gravel [SS]	16	42.2	18.7	68.7	4.9
Volcaniclastic breccia [VB]	73	14.7	10.5	50.6	0.9
Massive volcanics [VC]	83	10.2	6.8	31.5	1.1
All	858	8.1	8.0	68.7	0.3

11.3.4.1 Solwara 12

The Solwara 12 moisture content results were categorised by lithology and are represented in Box & Whisker plots in Figure 11.3.

Moisture content outliers were removed from sample set as they were deemed to be unrepresentative of the lithological unit. A total of 4 moisture content results were removed in this way from the Solwara 12 data set.

The overall moisture content for each lithology unit for the Solwara 12, after validation and outlier removal, is listed in Table 11.4.

The moisture contents are notably higher than recorded at Solwara 1, which could be a function of higher porosity or less drying between core retrieval and moisture content measurement.

Figure 11.3 Solwara 12 moisture content per lithology excluding outliers

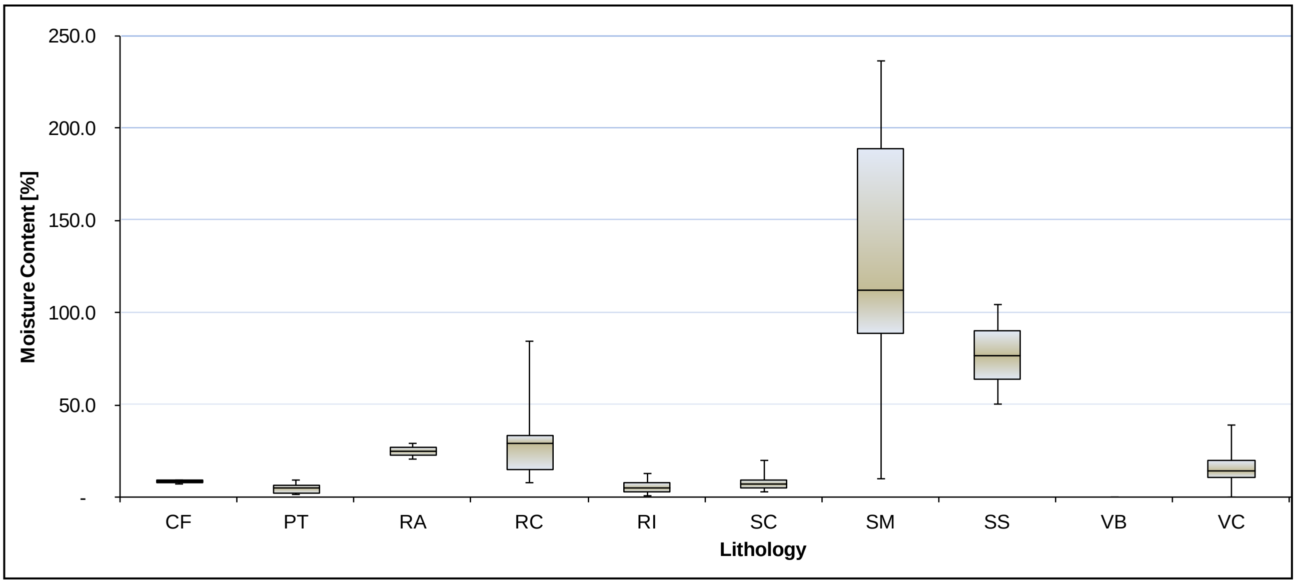


Table 11.4 Solwara 12 moisture content per lithology unit excluding outliers

Lithology	Number	Moisture Content [%]			
		Mean	Standard Deviation	Max	Min
Conduit bearing facies [CF]	3	8.8	1.0	9.7	7.7
Sparry precipitates [PT]	9	4.9	2.8	9.4	1.5
Sulfate dominant rock [RA]	2	25.1	6.2	29.5	20.8
Clay dominant material [RC]	12	33.2	23.8	84.8	8.2
Sulfide dominant rock [RI]	26	6.1	3.3	13.0	0.9
Cemented sediments [SC]	18	8.7	5.0	20.3	2.8
Sediment Mud [SM]	17	131.4	67.0	236.4	10.5
Mud-silt-sand-gravel [SS]	3	77.5	26.8	104.3	50.8
Volcaniclastic breccia [VB]	-	-	-	-	-
Massive volcanics [VC]	58	16.8	8.8	39.2	0.5
All	148	28.9	45.6	236.4	0.5

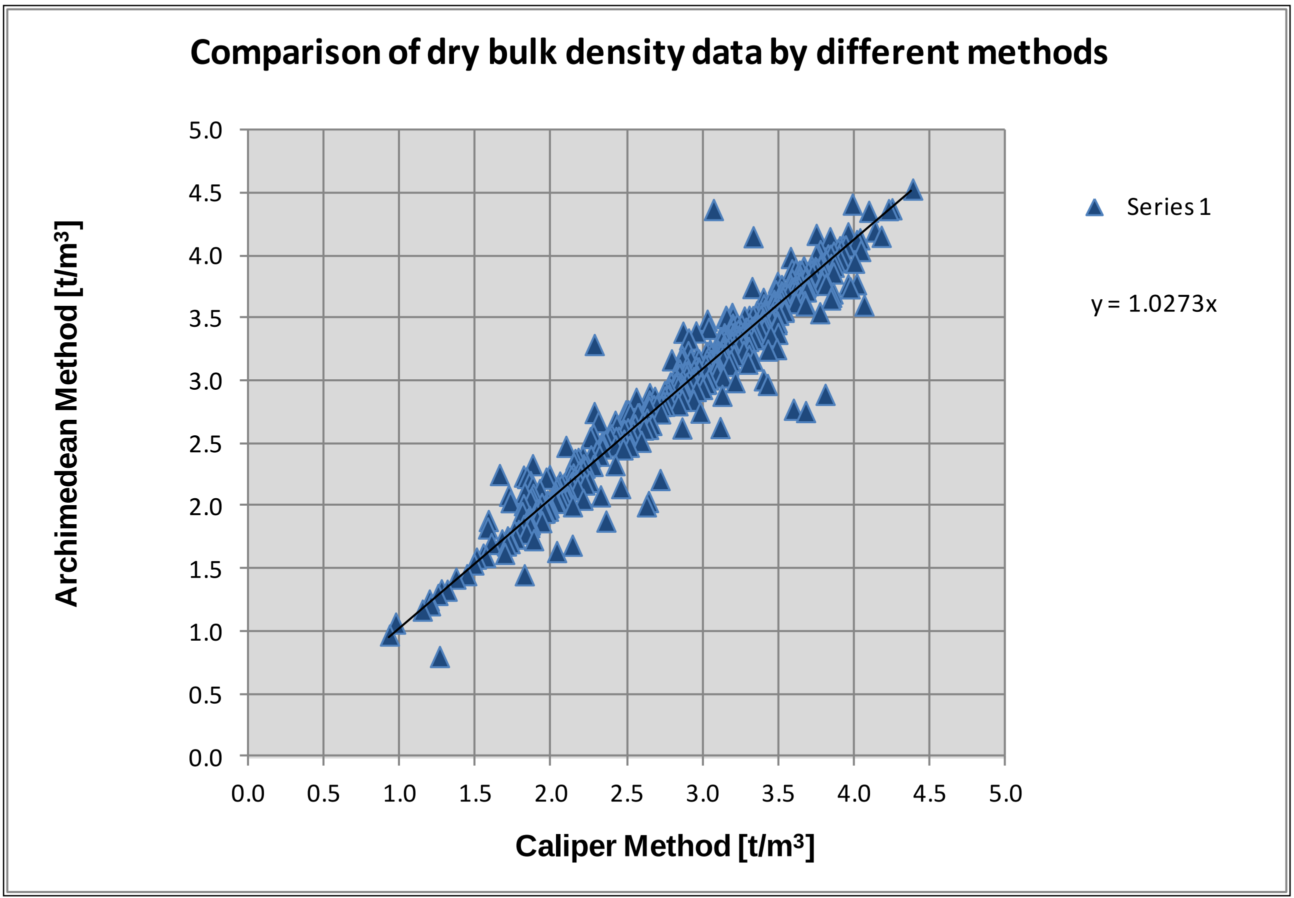
11.3.5 Dry bulk density results

The bulk dry density of the core samples was measured by the either the Archimedean and Caliper method or by both. A total of 559 samples (Solwara 1 and Solwara 12 combined) were measured by both methods (Figure 11.4).

The strong correlation between the two data sets and small amount of scatter between individual pairs of values indicates that use of the small electronic balance, using the live animal function, effectively accounted for movement of the ship. It was therefore inferred that the caliper method could be assumed to be reliable for bulk dry density measurement. Where a sample has both an Archimedean and Caliper bulk dry density measurement, the Caliper method was the preferred as the Archimedes test was commonly carried out on a portion of the sample (post destructive geotechnical testing fragments of original sample where used for Archimedes method).

It should be noted that 187 Solwara 1 and 61 Solwara 12 Archimedean bulk dry density measurements collected during the 2010/11 program were excluded from the data set due to the test procedure not being carried out correctly in the latter part of the REM Etive campaign, thus rendering those tests invalid.

Figure 11.4 Comparison of dry bulk density data from drill core



11.3.5.1 Solwara 1 drilling

The corresponding dry bulk densities of 24 moisture content outliers from Solwara 1 were excluded from the dry bulk density sample set.

Solwara 1 dry bulk density results were categorised by lithology and are represented by Box & Whisker plots in Figure 11.5, outliers for each lithology have been removed. An outlier is a dry bulk density value that is 1.5 times the interquartile range above the 75% quartile or below the 25% quartile.

A total of 17 dry bulk density measurements (10 low and 7 high) were considered to be outliers of dubious quality and were removed. There are 829 valid dry bulk density samples, of which 764 are based on the caliper method and 65 on the Archimedean method. The dry bulk density results for the core samples are summarized in Table 11.5.

Figure 11.5 Solwara 1 Dry Bulk Density per lithology excluding outliers

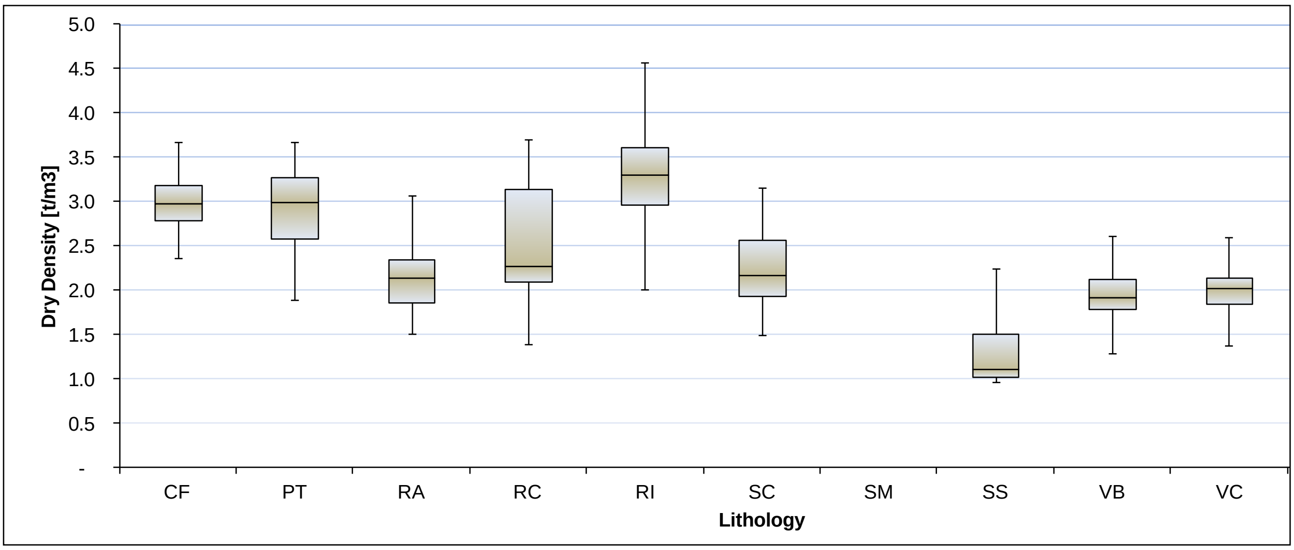
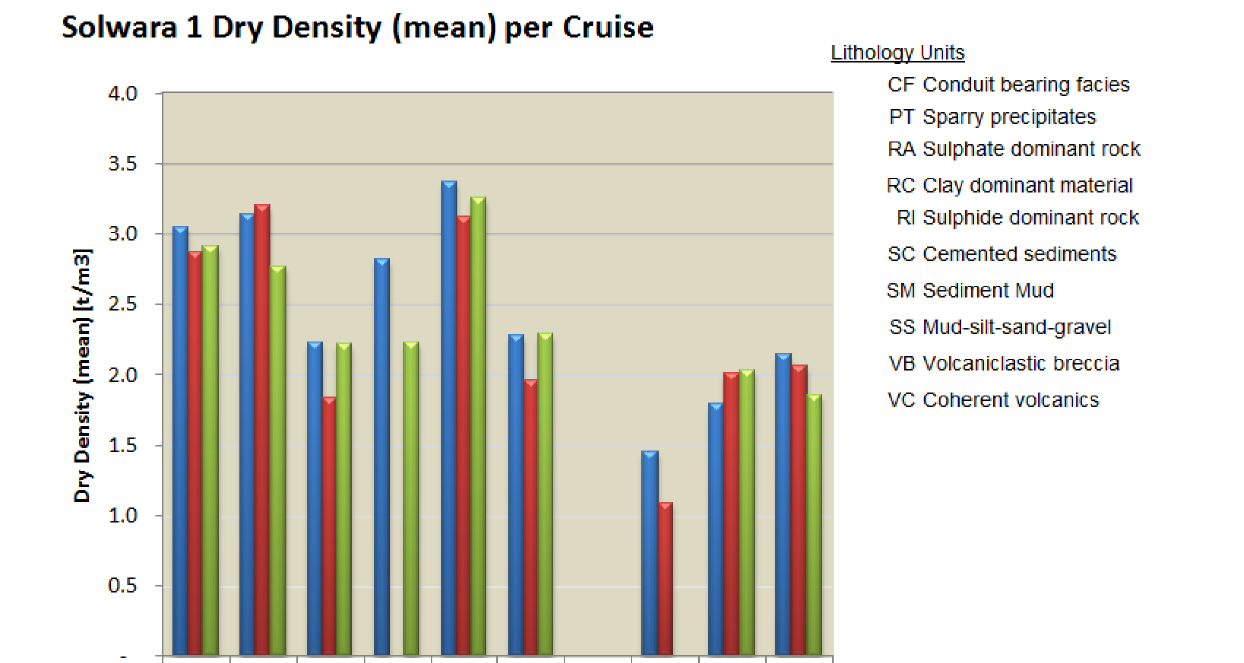


Table 11.5 Solwara 1 Dry bulk density per lithology unit excluding outliers

Lithology	Number	Dry Density [t/m^3]			
		Mean	Standard Deviation	Max	Min
Conduit bearing facies [CF]	99	2.98	0.30	3.68	2.36
Sparry precipitates [PT]	32	2.95	0.42	3.67	1.89
Sulfate dominant rock [RA]	45	2.15	0.34	2.96	1.51
Clay dominant material [RC]	13	2.54	0.73	3.70	1.40
Sulfide dominant rock [RI]	415	3.30	0.41	4.39	2.19
Cemented sediments [SC]	58	2.27	0.43	3.16	1.49
Sediment mud [SM]	-	-	-	-	-
Mud-silt-sand-gravel [SS]	10	1.22	0.30	1.85	0.97
Volcaniclastic breccia [VB]	58	1.95	0.24	2.52	1.36
Massive volcanics [VC]	73	2.01	0.26	2.59	1.41
All	803	2.85	0.68	4.39	0.97

The valid dry bulk density tests are displayed graphically per campaign per lithology in Figure 11.6. The Wave Mercury campaign returned slightly higher density measurements for some lithology units in comparison to the latter campaigns. The variation may be due to the natural variability of the rock mass or precision of the test methods.

Figure 11.6 Comparison of dry bulk density per lithology per drilling campaign



	CF	PT	RA	RC	RI	SC	SM	SS	VB	VC
WaveMerc07	3.0	3.1	2.2	2.8	3.4	2.3	-	1.4	1.8	2.1
Norsky08	2.9	3.2	1.8	-	3.1	2.0	-	1.1	2.0	2.1
Drilling10	2.9	2.8	2.2	2.2	3.3	2.3	-	-	2.0	1.9

11.3.5.2 Solwara 1 chimneys

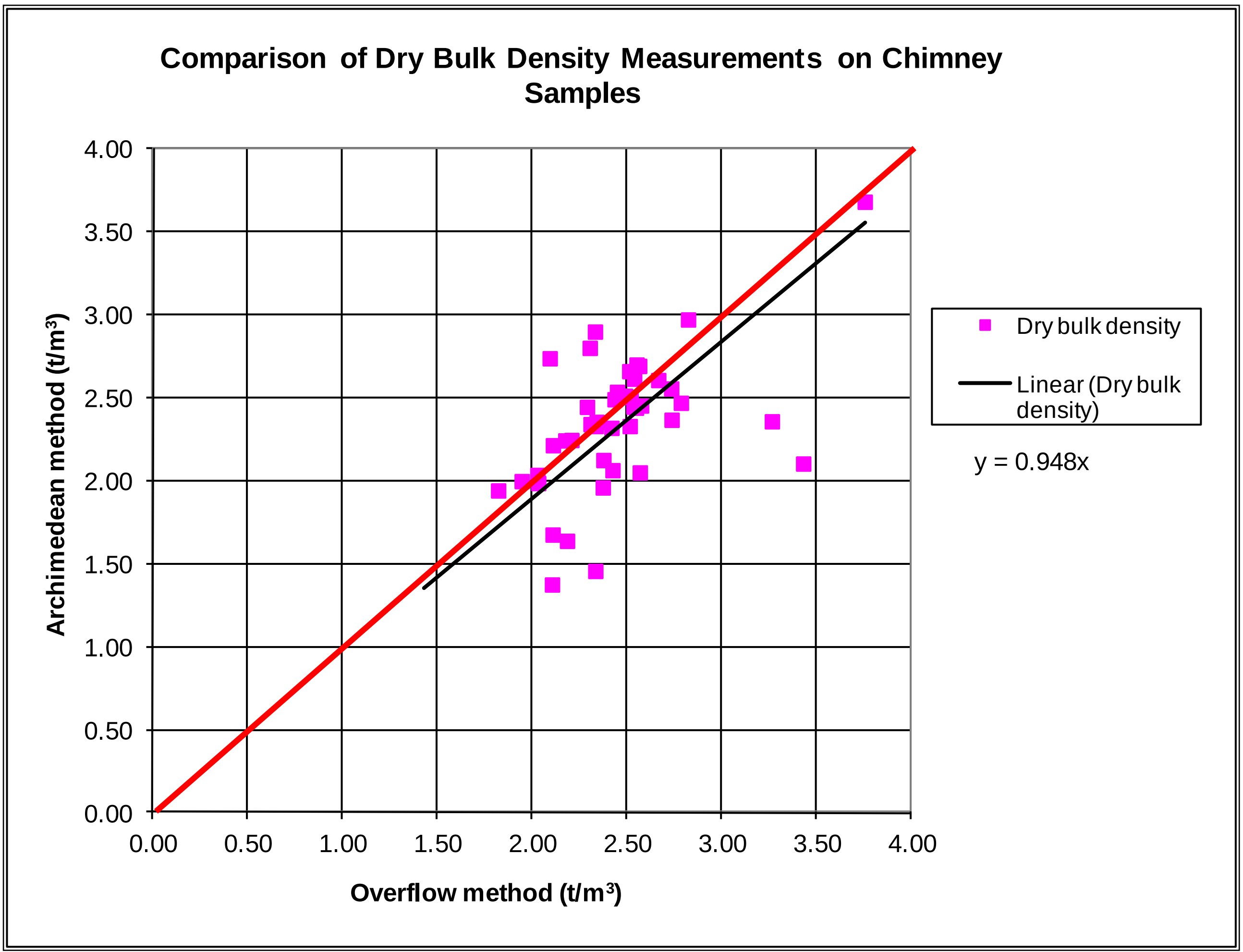
A similar validation exercise was completed for the bulk density data for the chimney samples. Nautilus measured the dry bulk density of 78 samples (and 8 duplicates) from 49 individual chimneys using a simple water displacement method during the Wave Mercury campaign. The samples consisted of slices cut perpendicular to the chimney axis with a saw. Samples were generally in the range of 1.5 to 4.5 kg.

Bulk density measurements on 43 of these samples were also carried out using a water displacement method based on Archimedes Principle. The paired results from the two methods were compared in a scatter plot (Figure 11.7). The scatter plot shows that there was a small bias between the results produced by the two methods. This was confirmed by calculation of the mean values (2.45 t/m^3 and 2.35 t/m^3). The average of the overflow method results was about 5% higher than the results from the Archimedean method. It was therefore decided that the results of the overflow method, which was less well-controlled than the Archimedean method, should be reduced by a factor of 5%. The standard deviations (0.37 and 0.41) of the chimney sample measurements are lower than for the core sample measurements, which is to be expected since the sample size is significantly larger.

The chimney samples contain some cavities greater than 5 mm in diameter which penetrate the sample and will not be correctly measured by water displacement methods. For each sample, a visual estimate of the proportion of such penetrative voids was made by the geologists. After correcting for the bias in the overflow data a further correction of -2.4% was made to the average bulk density estimate of the chimney samples to account for the average proportion of penetrative voids in these samples. This led to a final estimate of dry bulk density of the chimneys of 2.24 t/m^3.

The strong correlation between the measurements using two different methods provides additional confidence in the dry bulk density data. In the author’s opinion, the dry bulk density data is satisfactory for mineral resource estimation.

Figure 11.7 Comparison of dry bulk density data from chimney samples



11.3.5.3 Solwara 12

The corresponding dry bulk densities of 4 moisture content outliers from Solwara 12 have been excluded from the dry bulk density sample set.

Solwara 12 bulk dry density results were categorised by lithology and are represented box & whisker plots in Figure 11.8, excluding outliers. An outlier is a dry bulk density value that is 1.5 times the interquartile range above the 75% quartile or below the 25% quartile.

A total of 2 dry bulk density measurements were considered to be outliers; 1 low and 1 high outlier. In general, the values are slightly lower than those at Solwara 1. The dry bulk density results for the core samples from Solwara 12 are summarized in Table 11.6.

Figure 11.8 Solwara 12 Bulk Dry Density per lithology excluding outliers

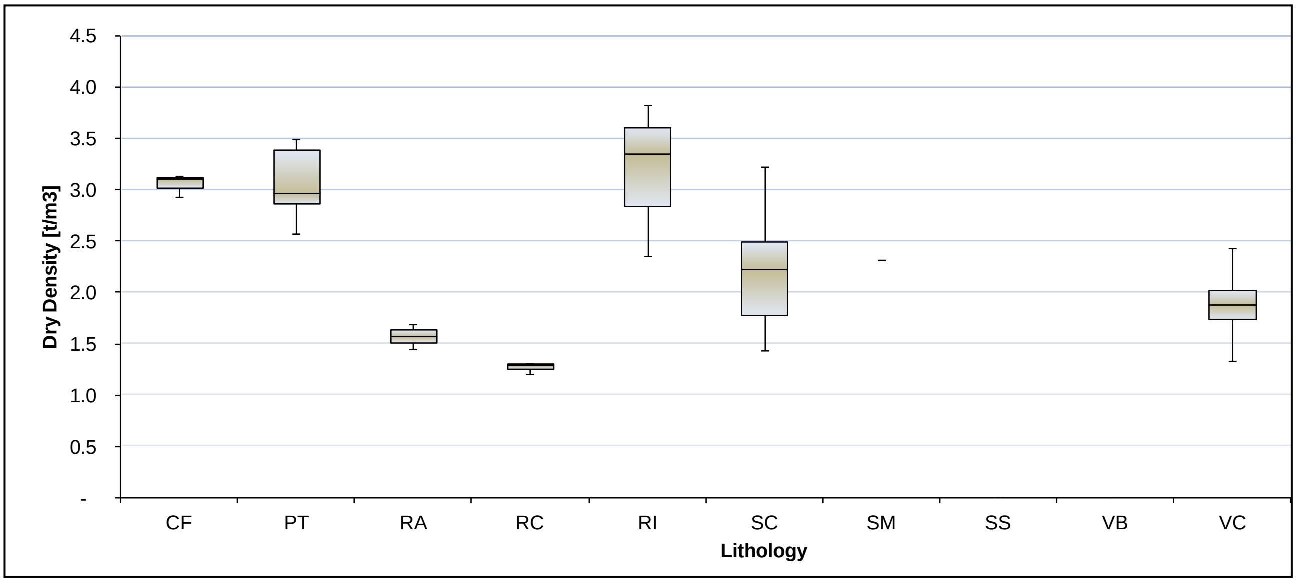


Table 11.6 Solwara 12 Dry bulk density per lithology unit excluding outliers

Lithology	Number	Dry Density [t/m3]			
		Mean	Standard Deviation	Max	Min
Conduit bearing facies [CF]	3	3.08	0.11	3.15	2.96
Sparry precipitates [PT]	9	3.08	0.35	3.50	2.57
Sulfate dominant rock [RA]	2	1.68	0.13	1.77	1.59
Clay dominant material [RC]	3	1.44	0.04	1.47	1.40
Sulfide dominant rock [RI]	25	3.24	0.44	3.85	2.40
Cemented sediments [SC]	15	2.21	0.54	3.23	1.50
Sediment Mud [SM]	1	2.34	-	2.34	2.34
Mud-silt-sand-gravel [SS]	-	-	-	-	-
Volcaniclastic breccia [VB]	-	-	-	-	-
Massive volcanics [VC]	33	1.91	0.23	2.44	1.54
All	91	2.46	0.72	3.85	1.40

11.3.6 Core loss bulk dry density estimation

A considerable portion of the deposit has not been sampled due to low core recovery. The nature of the core loss must be inferred from the adjacent recovered core and any other lines of evidence. During the REM Etive campaign, the torque, weight on bit, rotation speed and rate of penetration along the length of the hole were continuously recorded during drilling of each hole. This data was used to calculate the Mean Specific Energy (MSE) used to cut the core. Drilling MSE is defined as the amount of energy required to cut, fragment or crush the rock. It is typically expressed as energy per unit mass or volume, and it is described by Teale's Equation:

Equation 8 – Teale's Equation for Drilling Specific Energy (SE_{Drill})

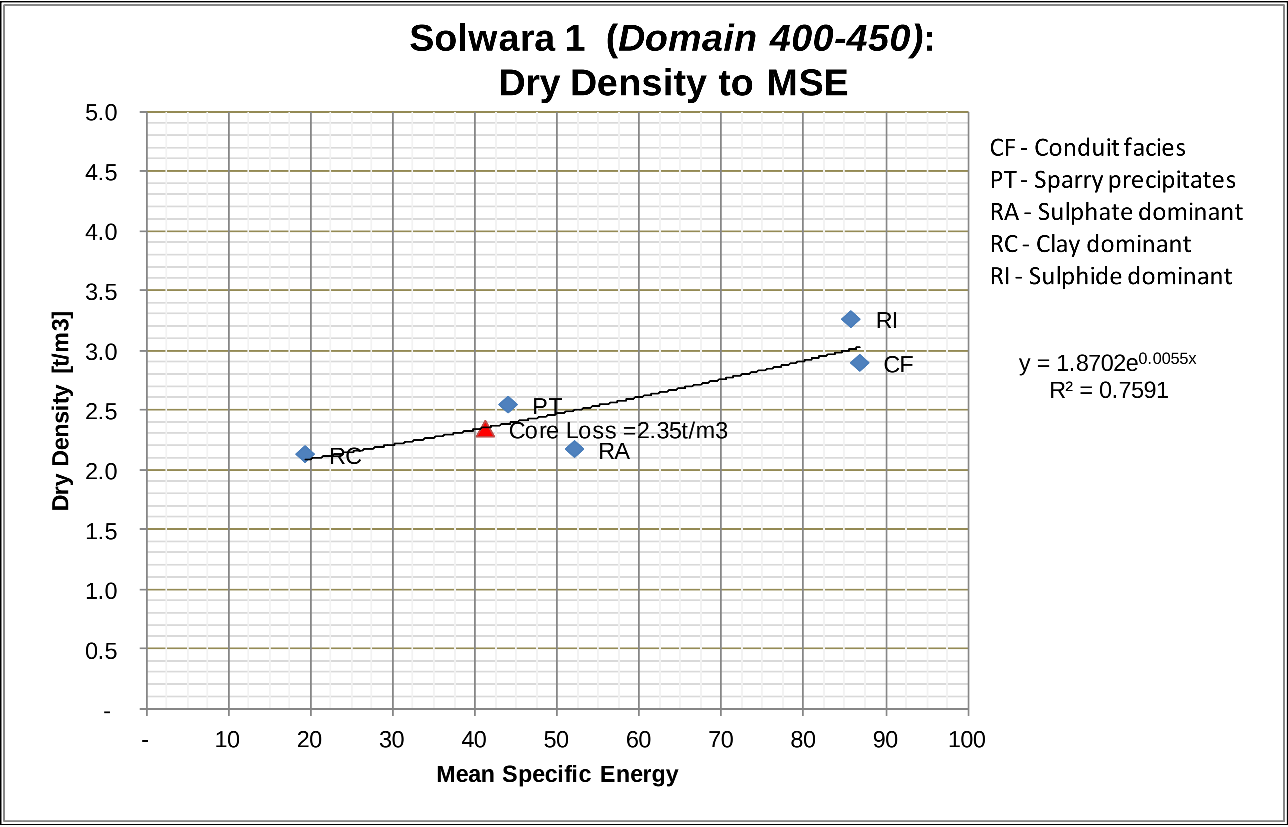
$$SE_{Drill} = \frac{WOB}{A_b} + \frac{120 \times \pi \times \tau}{A_b \times ROP}$$

Where

WOB = Weight on Bit
A_b = Borehole Area
ROP = Rate of penetration
τ = Torque

The domains of principal interest were 400, the sulfide dominant domain, and 450, the upper footwall. The average MSE was estimated for each logged lithology unit within these domains at Solwara 1. Note that there is some error in the correlation of MSE and lithology because the location of the core loss intervals within the drillholes was not precisely known and was, as a matter of consistent procedure, considered to be at the bottom of the drill runs. The lithology MSE values were graphed against their respective average dry bulk densities, as per Figure 11.9.

Figure 11.9 Empirical relationship between dry bulk density and Drilling MSE



A positive correlation was observed between dry bulk density and MSE. An exponential curve was fitted to this data. The average MSE recorded in intervals of core loss within Domain 400 & 450, was 41 MJ/m^3. Based on the fitted curve, the dry bulk density of the core loss material is estimated to be 2.35 t/m^3. This figure is consistent with sulfide dominant rocks containing of the order of 40% voids. It is likely that such high porosity would lead to disaggregation of the core during drilling and high core loss.

Equation 9 Core Loss estimation - Domain 400 & 450

$$Dry\ Bulk\ Density = 1.87e^{0.0055\,(MSE)}$$

In the author's opinion, the allocation of a dry bulk density estimates of 2.35 t/m^3 to core loss material is a reasonable approach for mineral resource estimation.

12 Data Verification

The Solwara 1 drillhole and chimney data and Solwara 12 drill hole data were verified by several means.

Independent audit of the Solwara 1 logging in 2007, 2010 and 2011 confirmed the widespread occurrence of significant chalcopyrite mineralisation in the chimneys and drill core, broadly consistent with the copper geochemical analyses.

The location of the drillholes containing massive sulfide-dominant mineralisation correlate closely with the results of the EM survey. The EM survey therefore, provides a degree of confidence in the interpretation of the lateral extent of the massive sulfide-dominant mineralisation but not its depth continuity.

Sample preparation and geochemical analyses were verified using quality control samples including CRMs, SRM, blank samples and duplicate samples. These materials were submitted without marks which would identify their origin to the laboratory staff. They therefore provide quality control independent of the laboratory.

In view of the observations of copper mineralisation in the core, the correlation between the hand-held XRF results and the laboratory geochemical analyses, the observed chain of custody of the samples from the ship to the independent laboratory, and the quality control samples, independent corroborative sampling was judged to be unnecessary.

12.1 Certified reference material samples

12.1.1 Solwara 1 – 2007 Wave Mercury program

Nine unique CRMs, sourced from Geostats Pty Ltd, Fremantle Australia (samples with GBM prefix) and ORE Pty Ltd, Melbourne Australia (samples with OREAS prefix) were selected for use as quality control samples in the 2007 program of drill geochemical analysis (Table 12.1).

Table 12.1 List of CRMs and certified values used in drill sampling programs at Solwara 1.

CRM	Drill Program	Cu%	Au ppm	Ag ppm	Zn%	Pb%
GBM304-11	2007, 2008	10.4011	–	–	0.0109	–
GBM304-16	2007	2.2721	–	–	0.0718	–
GBM305-15	2007, 2008	26.2422	*52.3	*51.1	0.1367	–
GBM906-13	2007, 2008	2.1862	*0.263	3.74	0.3036	–
GBM906-16	2007, 2008, 2010/11	10.6807	*1.06	19.71	0.4783	–
GBMS304-2	2007, 2008, 2010/11	1.4325	6.04	5.1	0.0057	–
GBMS304-4	2007, 2008	0.9698	5.67	3.4	0.0149	–
OREAS-10Pb	2007, 2008	–	7.15	–	–	–
OREAS-62Pb	2007, 2008	–	11.33	–	–	–
OREAS-24P	2008	0.00582	0.0002	–	–	–
GBM309-14	2010/11	2.8433	–	156	23.0789	1.5231
GBM904-1	2010/11	0.013	–	0.6	0.0917	0.0056
G909-3	2010/11	–	13.16	–	–	–
GLG907-1	2010/11	–	0.00387	–	–	–

* Indicative value from single neutron activation analysis

The mineralised CRMs consisted of sulfide-bearing rock. They were primarily chosen to cover a range of Cu and Au grades because these were expected to be the most valuable elements within the Solwara 1 deposit. The CRM also provided certified values for Ag and Zn. A total of 84 CRM samples were submitted within the batches of regular drill core samples.

The relative variations of each of the CRM results from the certified values were plotted in sample number sequence. Performance was measured against 5% and 10% relative variation from the certified values. The CRM results for Cu (Figure 12.1) were satisfactory with all except five results within ±5% of the certified values. The remaining five were within ±10% of the certified values.

CRM results for Ag (Figure 12.1) were of relatively low precision due to proximity to the limit of detection (1ppm). The CRM with the highest Ag grades (GBM906-16 with a certified value of 19.17 g/t and GBM305-15 with an uncertified single result of 51.1ppm) performed the best but still showed poor precision and a possible high bias of about 5%.

CRM results for Au (Figure 12.2) were not as good as for Cu but were satisfactory. Results for OREAS10Pb, OREAS62Pb and GBMS304-4 were generally with ±5% and all within ±10%, except for sample 61898 which has Au and Ag values consistent with mislabelling of OREAS62Pb as OREAS10Pb. Two results for GBMS304-2 were very poor (both from batch TV07084347). Several samples from this batch were reanalysed but the re-assays only differed from the original assays by an average of 2%. It was therefore concluded that no systematic error was present in the batch. These are the only (four) standards with certified values.

CRM results for Zn were variable (Figure 12.2). Results for four of the CRM were within ±10% of the certified value. A fifth, GBM906-16 returned results about 10% higher on average than the certified value. The results from two very low Zn grade CRM showed very poor precision because they were close to the detection limit (0.01% Zn). Since Zn is of no economic interest in the Solwara 1 deposit the CRM results were deemed to be adequate for resource estimation.

The CRM results show that the analytical data from the 2007 Wave Mercury program is adequate for estimation of Inferred and Indicated Resources of Cu, Au, Ag and Zn but that greater accuracy and precision may be required to define Measured Resources of Ag and Zn. This may entail further analysis of sample pulps by alternative methods.

Figure 12.1 Solwara 1 CRM results from 2007 drilling program (Wave Mercury 2007) for Cu and Ag.

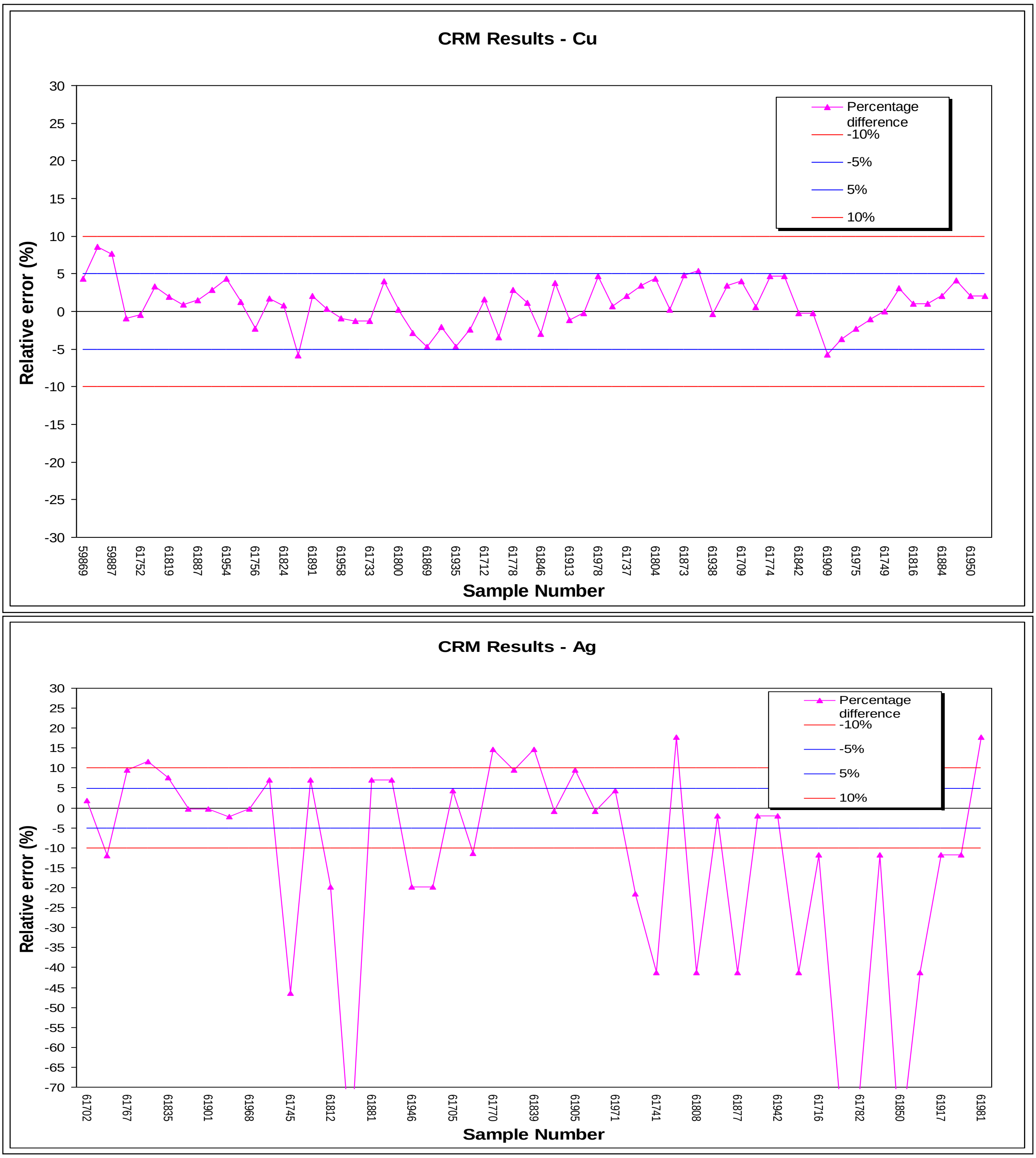
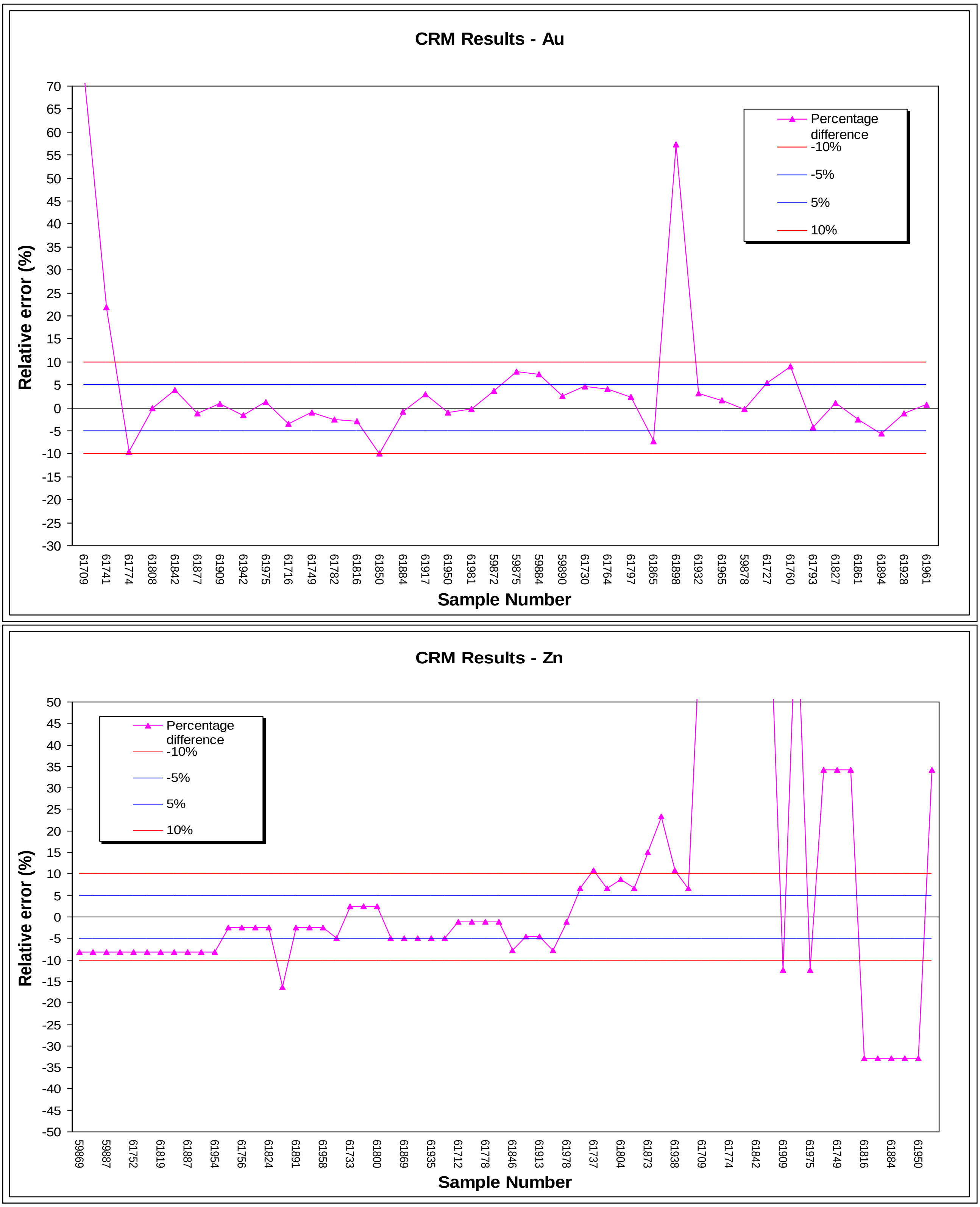


Figure 12.2 Solwara 1 CRM results from 2007 drilling program (Wave Mercury 2007) for Zn and Au.



12.1.2 Solwara 1 – 2008 NorSky program

Eight of the nine CRMs used in the 2007 program and one additional CRM were selected for use as quality control samples in the 2008 Norsky program of drill geochemical analysis (Table 12.1), with the exception of GBM304-16, which was not used. A total of 31 CRM samples were submitted within the batches of regular drill core samples.

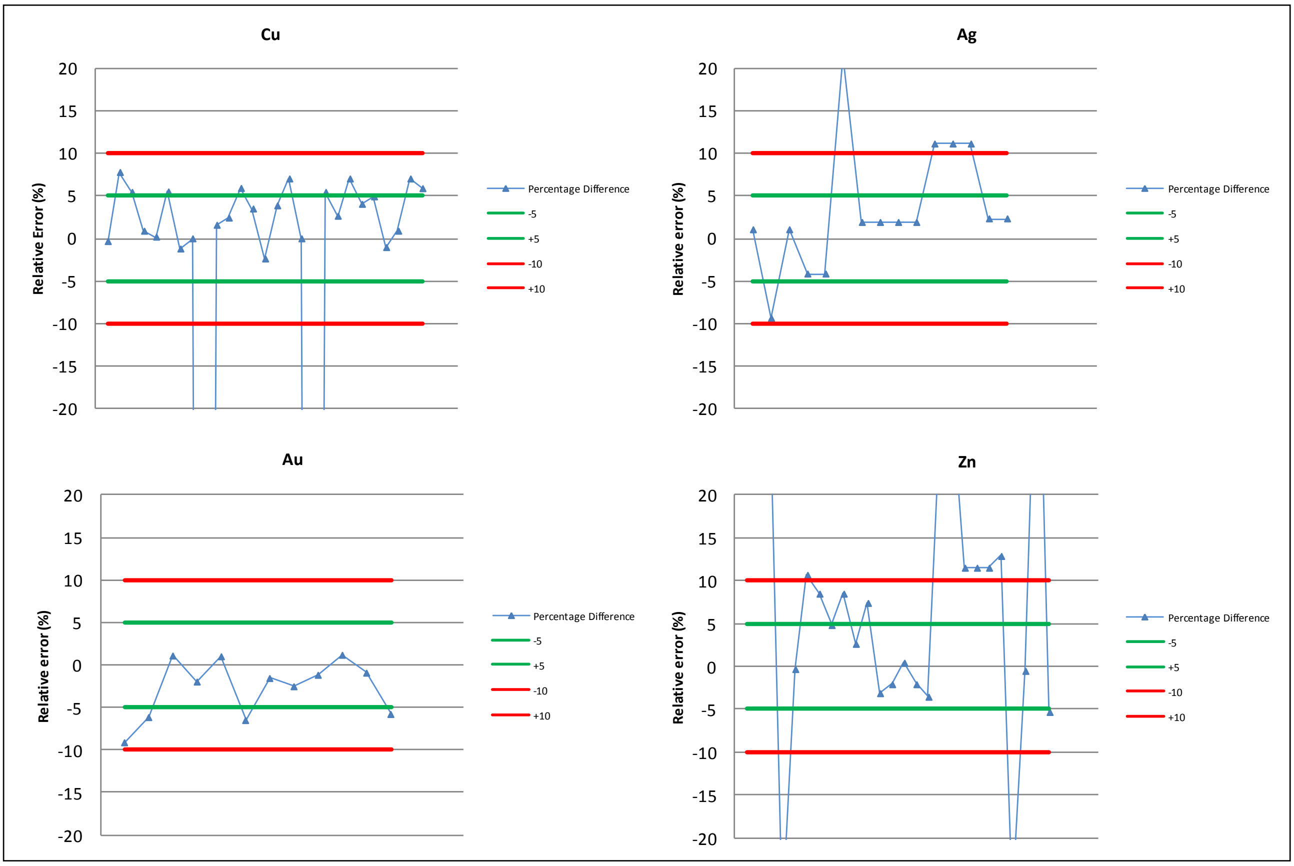
The relative variations of each of the CRM results from the certified values were plotted in sample number sequence. Performance was measured against 5% and 10% relative variation from the certified values (Figure 12.3). The CRM results for Cu were satisfactory with only two CRM results falling outside of the ±10% acceptance level. Both were CRM OREAS-24P which had an expected value of 0.01% Cu and reported 0.02% Cu and a standard deviation of 0.007. As these values are very close to the lower detection limit the deviations from the certified values were not considered to be significant.

The CRM results for Au were satisfactory with all except four results within ±5% of the certified values. The remaining five were within ±10% of the certified values.

CRM results for Zn were variable. Results for four of the CRMs were within ±10% of the certified value. The four other low-grade Zn CRMs, GBM304-11, GBM305-15, GBMS304-2 and GBMS304-4 returned results about 10% higher on average than the certified value. The results from two very low Zn grade CRMs showed very poor precision because they were close to the detection limit (0.01% Zn). Since Zn is of no economic interest in the Solwara 1 deposit the CRM results were deemed to be adequate for resource estimation.

CRM results for Ag were of relatively low precision due to proximity to the limit of detection (1 ppm). The CRMs with the highest Ag grades (GBM906-16 with a certified value of 19.17g/t and OREAS-62Pb with an uncertified single result of 21.5 g/t) performed the best but still showed poor precision and a possible high bias of about 5%.

Figure 12.3 Solwara 1 CRM results from 2008 drilling program (NorSky 2008) for Cu, Au, Zn and Ag



12.1.3 Solwara 1 and Solwara 12 – 2010/11 REM Etive program

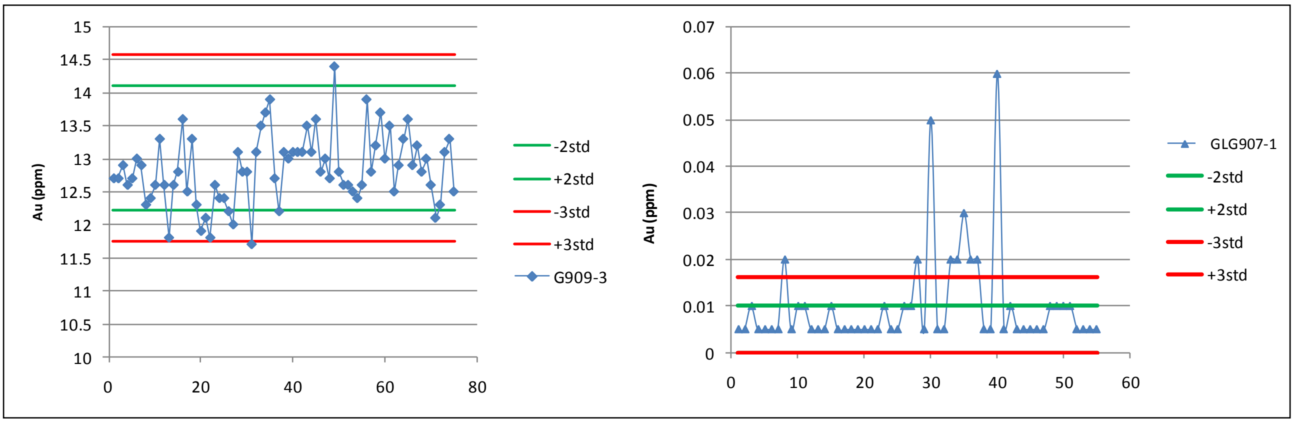
Six unique CRMs (Table 12.1), sourced from Geostats Pty Ltd, Fremantle Australia, were selected for use as quality control samples in the program of geochemical analysis of drillhole samples. They all consisted of sulfide-bearing rock. They were primarily chosen to cover a range of Cu and Au grades because these were expected to be the most valuable elements within the Solwara 1 and 12 deposits. The CRMs also provided certified values for Ag and Zn. A total of 533 CRM samples were submitted within the batches of regular drill core samples.

Different limits of acceptability were applied to the CRM results in 2010-2011 compared to 2007-2008. In 2010/11, reference material analytical results received by Nautilus were checked before data was accepted into Nautilus's acQuire™ database. If the reference material results were outside three standard deviations, or repeatedly outside two standard deviations of the certified values, the laboratory was requested investigate the source of the error and repeat the analyses.

12.1.3.1 G909-3

G909-3 served as a high gold CRM (Figure 12.4). One sample (23692) was more than 3 standard deviations from the certified value, however there was insufficient material to re-assay that particular CRM. All the surrounding samples were re-assayed and found to have a high level of repeatability. The SGS internal QAQC showed no contamination across samples. Consequently, this result was not regarded as significant. Generally, the results were within acceptable limits.

Figure 12.4 Solwara 1 and Solwara 12 CRM G909-3 (left) and GLG907-1(right) results for Au from the REM Etive 2010/11 drilling program



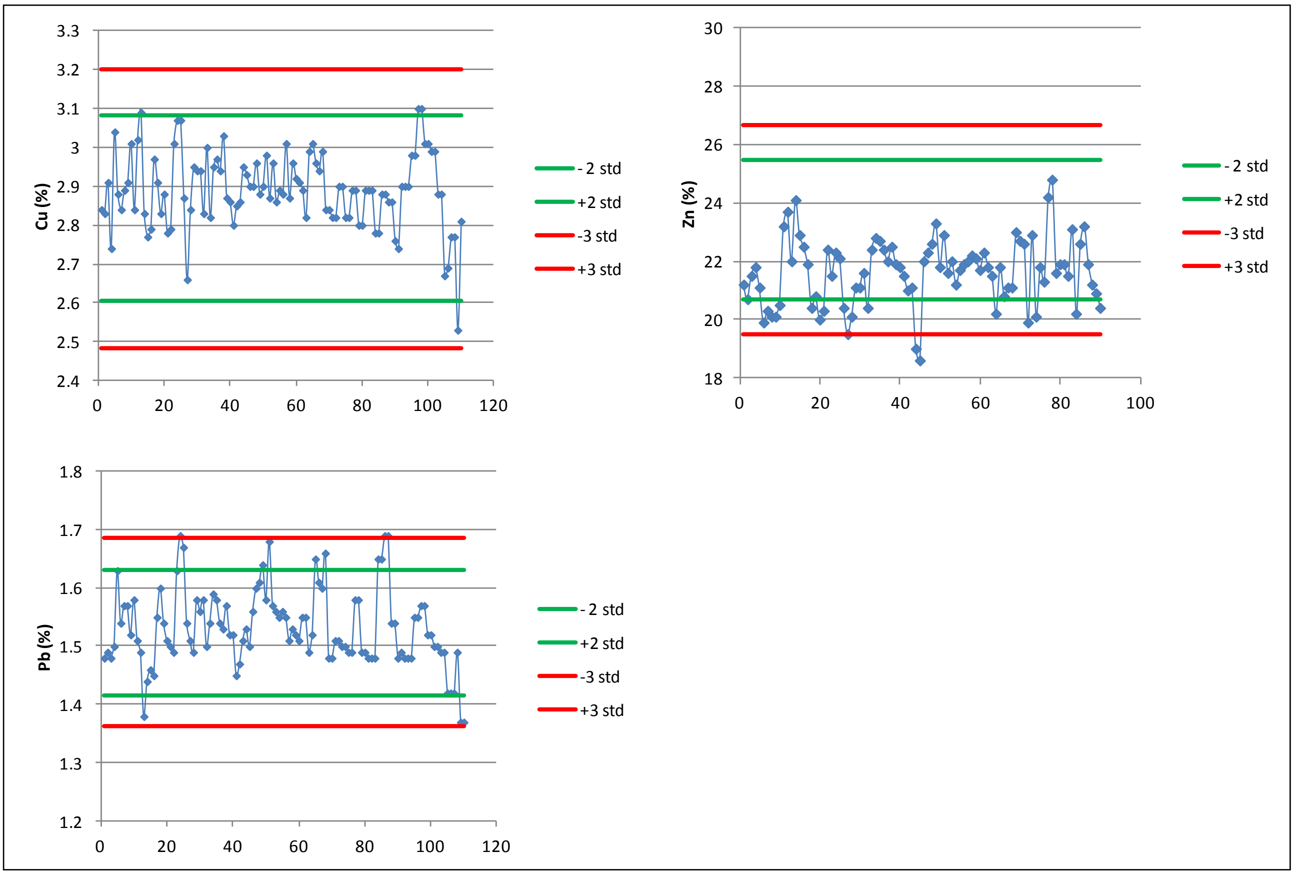
12.1.3.2 GLG907-1

G907-1 served as a low gold CRM (Figure 12.4). Most of the CRM results reported at or below the lower detection limit (LDL) of 0.01 ppm and the remaining results were too close to the LDL to be regarded as statistically significant deviations. The SGS internal QAQC showed no contamination across samples. The variation in Au grades is not significant relative to the detection limit or the resource estimate.

12.1.3.3 GBM309-14

All standards returned values for Cu and Pb within three standard deviations (Figure 12.5). Two standards (23806 and 23785) from the same hole failed the QAQC (below three standard deviations) for Zn. There was insufficient material to re-assay these CRM however the batch of samples passed the internal QAQC at the laboratory. Samples either side of the CRM were re-assayed and found to have a high degree of repeatability. The SGS internal QAQC showed no contamination across samples. The Zn results were generally lower than the certified value by about 5% and may therefore be slightly conservative.

Figure 12.5 Solwara 1 and Solwara 12 CRM (GBM309-14) results from 2010/11 drilling program (REM Etive 2010/11) for Cu, Pb and Zn



12.1.3.4 GBM906-16

All samples returned Cu values within three standard deviations and the majority of CRM samples returned Ag values within three standard deviations (Figure 12.6). The Pb results were too close to the LDL to be regarded as statistically significant deviations from the LDL.

As in 2007, the results for Zn in GBM906-16 were biased slightly high. This is the opposite of the bias in GBM309-14. Analysis of performance of GBM906-16 and GBM309-14 (Figure 12.7) over the same time period, sorted by sample return date, shows that the biases in the two sets of results are not correlated. This suggests that the bias may be specific to the particular material in GBM906-16 rather than the Zn analyses in general. Since Zn is of no economic interest in the Solwara 1 deposit the results for Zn were deemed to be adequate for resource estimation.

Figure 12.6 Solwara 1 and Solwara 12 CRM (GBM906-16) results from 2010/11 drilling program (REM Etive 2010/11) for Ag, Cu, Pb and Zn

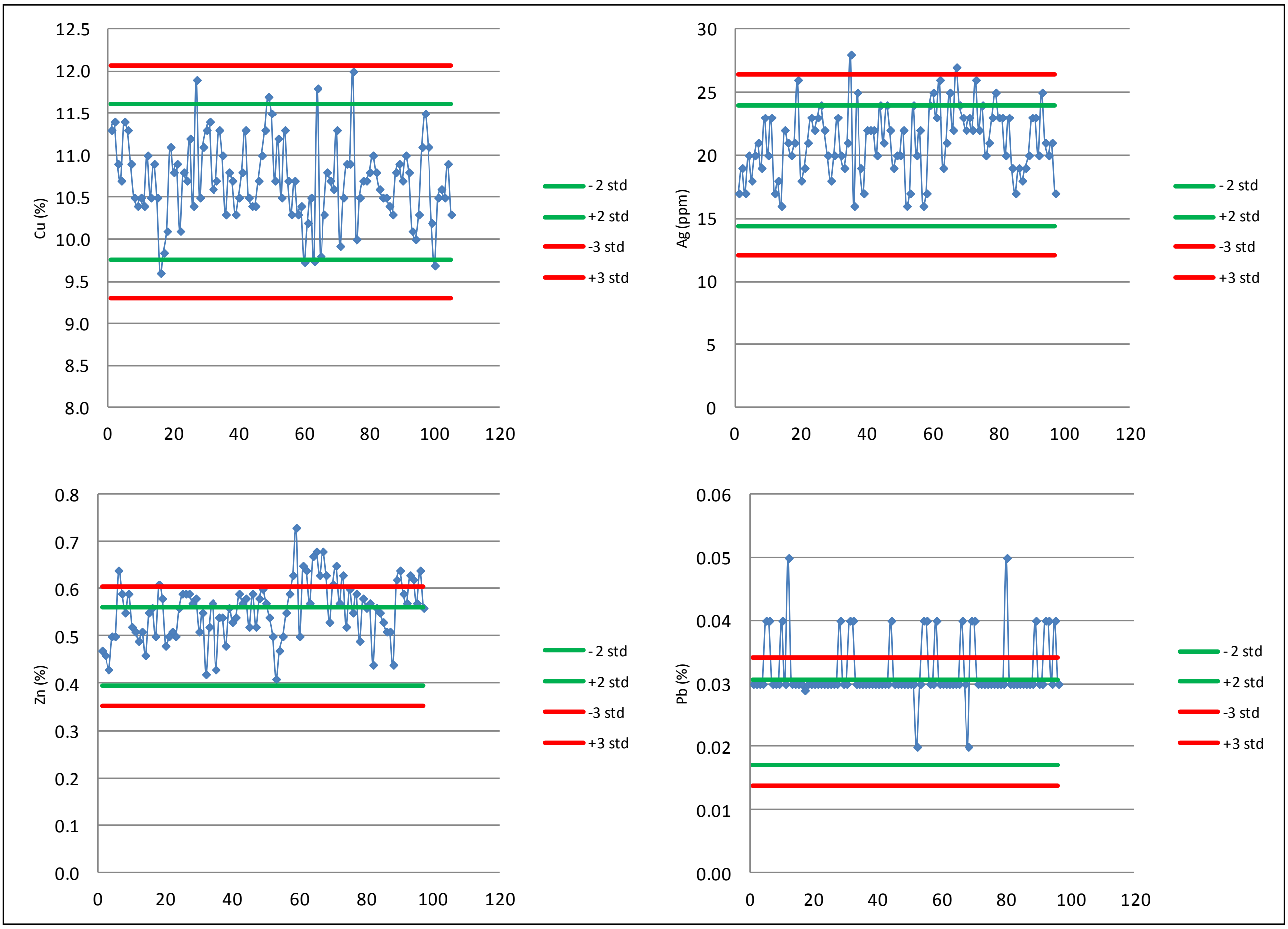
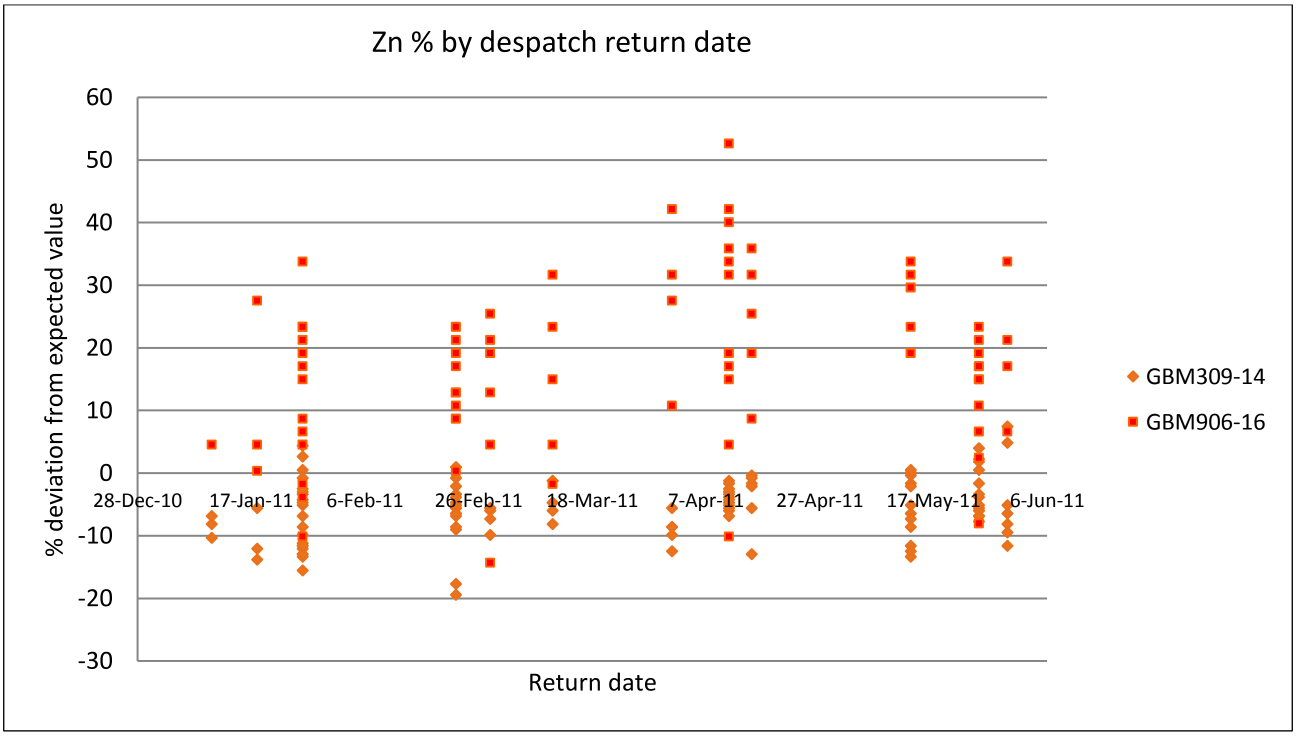


Figure 12.7 Solwara 1 and Solwara 12 CRM (GBM906-16) showing Zn value percentage deviation from expected value for final accepted assays (REM Etive 2010/11)



12.1.3.5 GBM904-1

This CRM has very low certified values for Cu, Zn, Pb and Ag and was used in place of a blank (barren sample) (Figure 12.8).

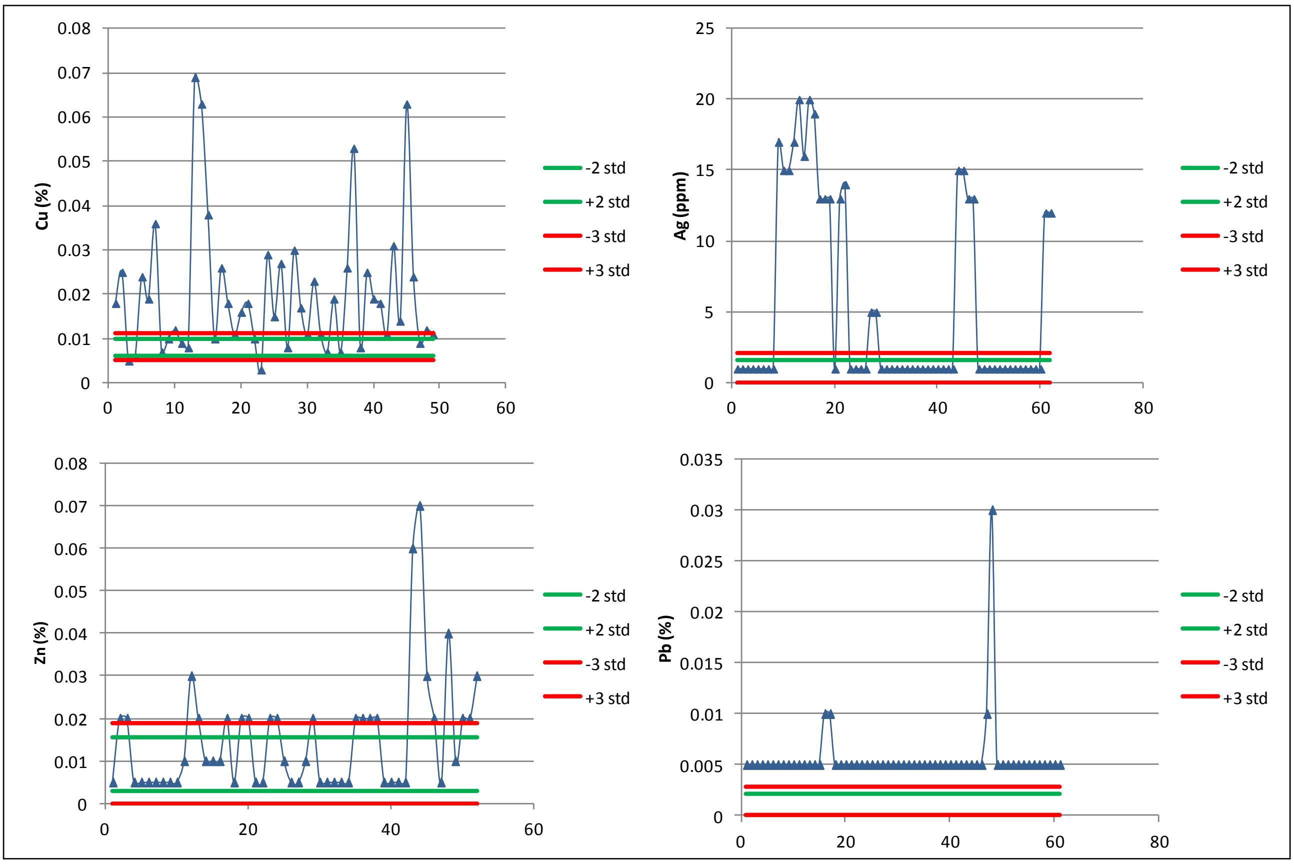
Four CRMs reported Cu above the recommended lower limit of confidence of 0.05%. While the material is assaying slightly high for Cu, the levels are not significantly relevant to the grades in the mineral resource. These dispatches were re-assayed and the same values were returned. The dispatches passed the laboratory internal QAQC checks and the surrounding samples had a high degree of repeatability.

All CRMs reported Ag within ten times the LDL. All CRMs reported Pb within ten times the LDL.

Two CRMs reported Zn above the recommended lower limit of confidence of 0.05% for Zn. While the material returned slightly high Zn values, the levels are not significantly relevant to the grades in the mineral resource. These dispatches were re-assayed and the same values were returned. These dispatches were re-assayed and the same values were returned. The dispatches passed the laboratory internal QAQC checks and the surrounding samples had a high degree of repeatability.

The poor performance of these samples is due to proximity to the LDL and is not of concern.

Figure 12.8 Solwara 1 and Solwara 12 CRM (GBM904-1) results from 2010/11 drilling program (REM Etive 2010/11) for Ag, Cu, Pb and Zn



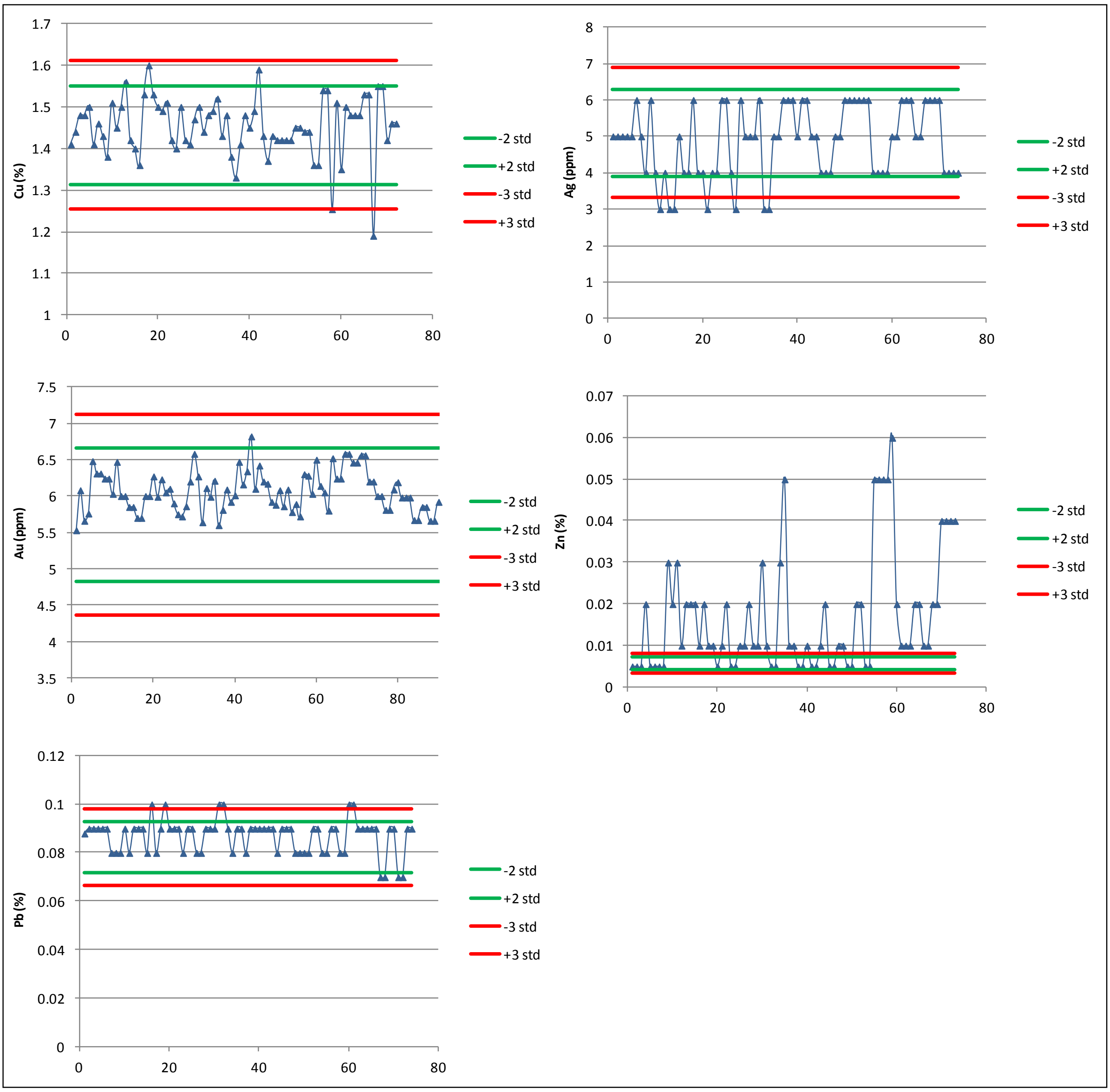
12.1.3.6 GBMS304-2

This CRM has very moderate certified values for Cu and Au and low certified values for Ag, Pb and Zn.

One sample (24914) exceeded three standard deviations for Cu (Figure 12.9). There was insufficient material to re-assay the CRM but all the surrounding samples were re-assayed and found to have a high level of repeatability. The SGS internal QAQC showed no contamination across samples.

All CRMs reported Au within three standard deviations. All CRMs reported Ag within ten times LDL. All CRMs reported Pb within ten times LDL. Six CRMs returned values slightly high for Pb, although the levels are not significant with respect to the mineral resource.

Figure 12.9 Solwara 1 and Solwara 12 CRM (GBMS304-2) results from 2010/11 drilling program (REM Etive 2010/11) for Ag, Cu, Pb and Zn



All CRMs reported Zn below the recommended lower limit of confidence of 0.05%, except for sample number 23350 which reported at 0.06% Zn. While the material is returning a value slightly high for Zn, the value is not significant with respect to the mineral resource.

12.2 Secondary reference material samples

12.2.1 2007 Wave Mercury program

Nautilus commissioned the production of a pulverized homogenised composite of sulfide material from Solwara 1 as a secondary reference material. The composite, known as NUSD, was made from approximately 100 kg of coarse and pulp rejects from drill core from the massive sulfide-dominant domain intersected in the 2006 drilling program. The preparation was conducted at HRL Testing in Albion, Queensland. The samples were stage crushed then pulverized to 90% passing at 75 µm. The samples were then blended and split into 60 g aliquots using a scoop.

Aliquots were submitted by Nautilus to five Australian laboratories to determine the average grades of the material. The laboratories were ALS Laboratories, Brisbane, Amdel Laboratories of Thebarton, UltraTrace Laboratories of Canning Vale, Becquerel Laboratories of Malaga and Standard and Reference Laboratories, also of Malaga. The first four laboratories analysed five samples. Standard and Reference Laboratories analysed a single sample.

Standard and Reference Laboratories was chosen as an umpire laboratory in this program. The results are considered to be the most analytically reliable due to the use of classical chemistry. Cu was determined by short iodide; gold by fire assay with corrections for slag, crucible and cupel losses; Ag by fire assay with corrections for cupel losses and referenced to pure proofs; Zn by multiple teams with separation from multiple analytical element groups and Pb by hydrobromic/bromine digest with sulfate separation.

ALS, Amdel and Ultratrace all used similar methods for analysis. Gold was assayed using a 20-30 g fire assay (lower charge weights were sometimes used to ensure proper dissolution of the gold in the high S matrix) and finished with ICP-OES in aqua regia digest. Base metals and Ag were assayed using ICP-OES following a four-acid digest with stabilizing compounds to combat precipitation.

Becquerel Laboratories used neutron activation analysis for Au, Ag and Zn. Cu and Pb were determined by ICP-OES with a four-acid digest.

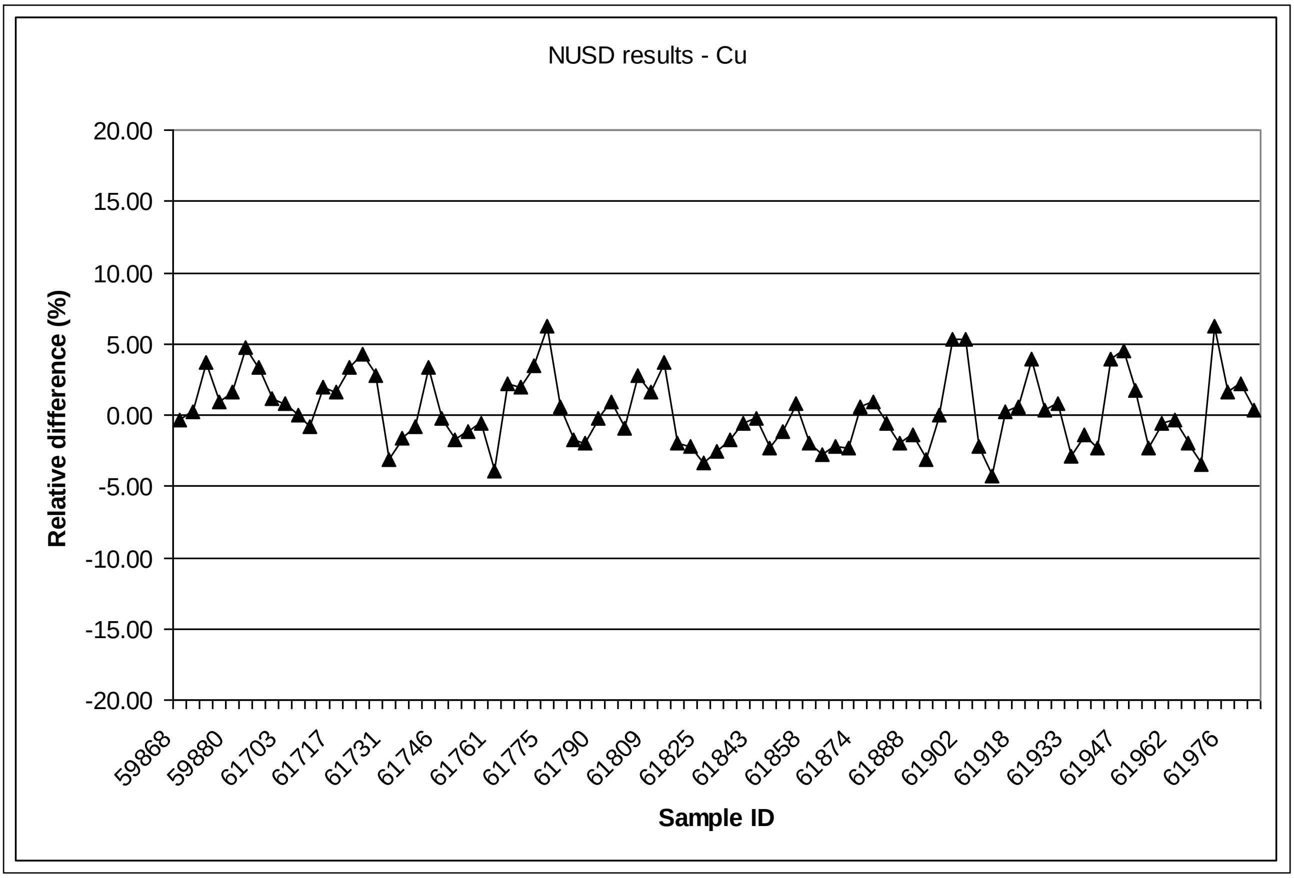
Nautilus compiled the results of the analyses. Results that were clearly biased, or of unacceptably high variability were discarded. The averages of the remaining results were taken as the reference value. These were 5.11% Cu, 5.91g/t Au, 44ppm Ag and 1.71% Zn.

A total of 83 samples of NUSD were submitted within the batches of regular drill core samples.

The Cu results for NUSD (Figure 12.10) were satisfactory with all results within ±6% of the reference value and no bias. The Au results for NUSD (Figure 12.11) had lower precision than the Cu but were generally within ±10% of the reference value and showed a bias of less than 1%. They were deemed satisfactory for resource estimation.

The Ag results for NUSD (Figure 12.10) had lower precision than the Cu but were generally within +5% and -10% of the reference value. A low bias of 2.7% was evident. The results were deemed satisfactory for resource estimation. The Zn results for NUSD (Figure 12.11) had similar precision to the Cu and were generally within ±5% of the reference value. A low bias of 2.7% was evident. The results were deemed satisfactory for resource estimation.

Figure 12.10 Cu and Ag results for NUSD SRM submitted with drill core samples during the 2007 Wave Mercury program



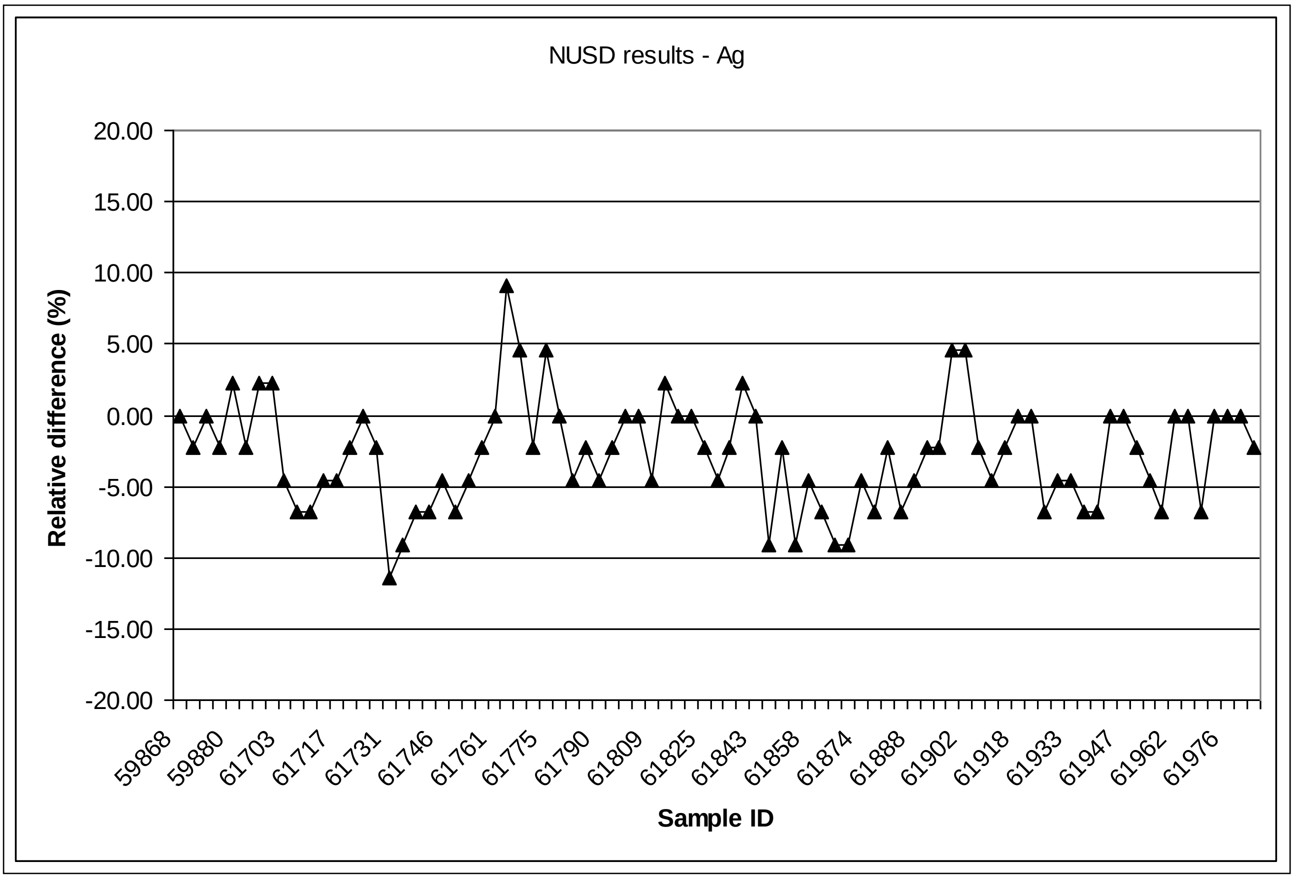
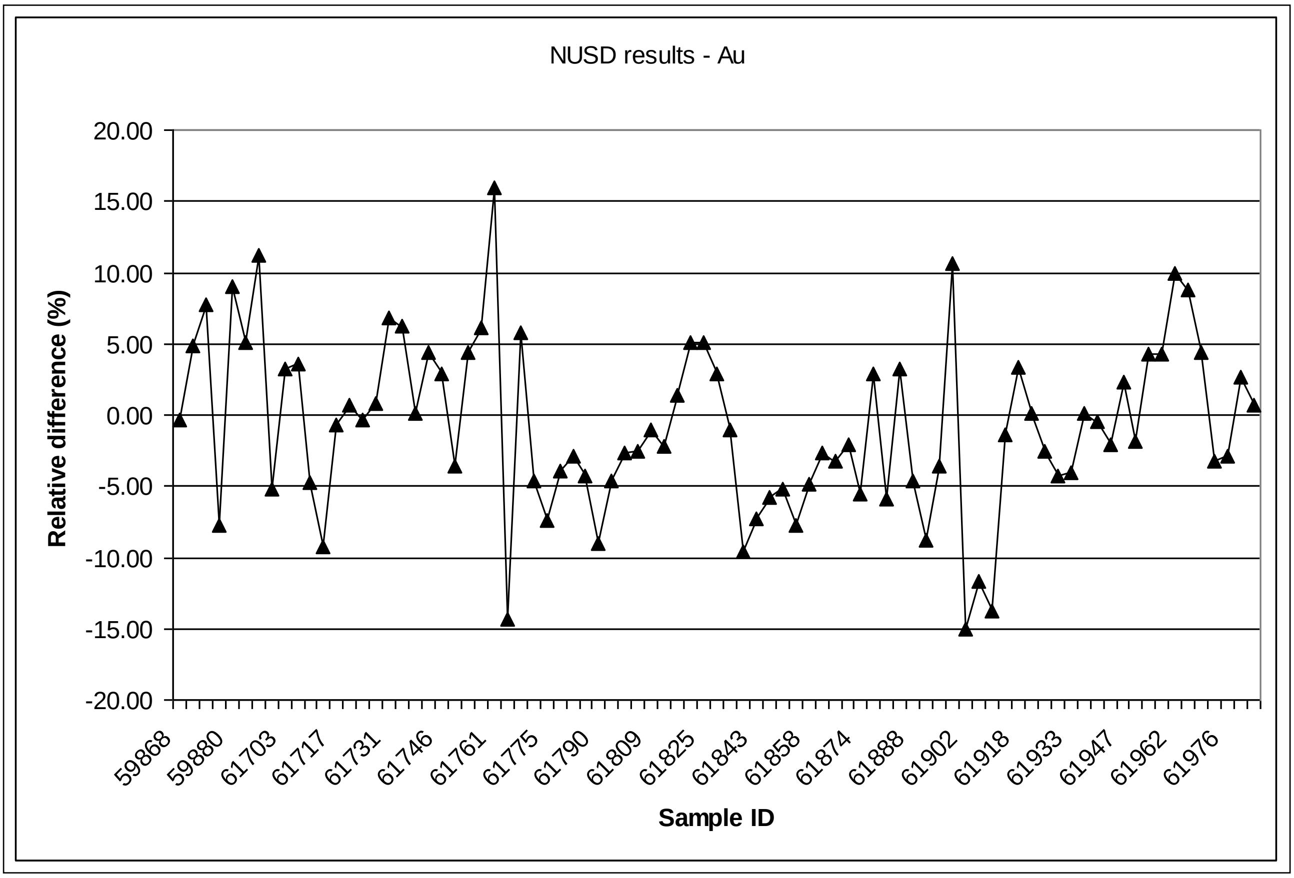
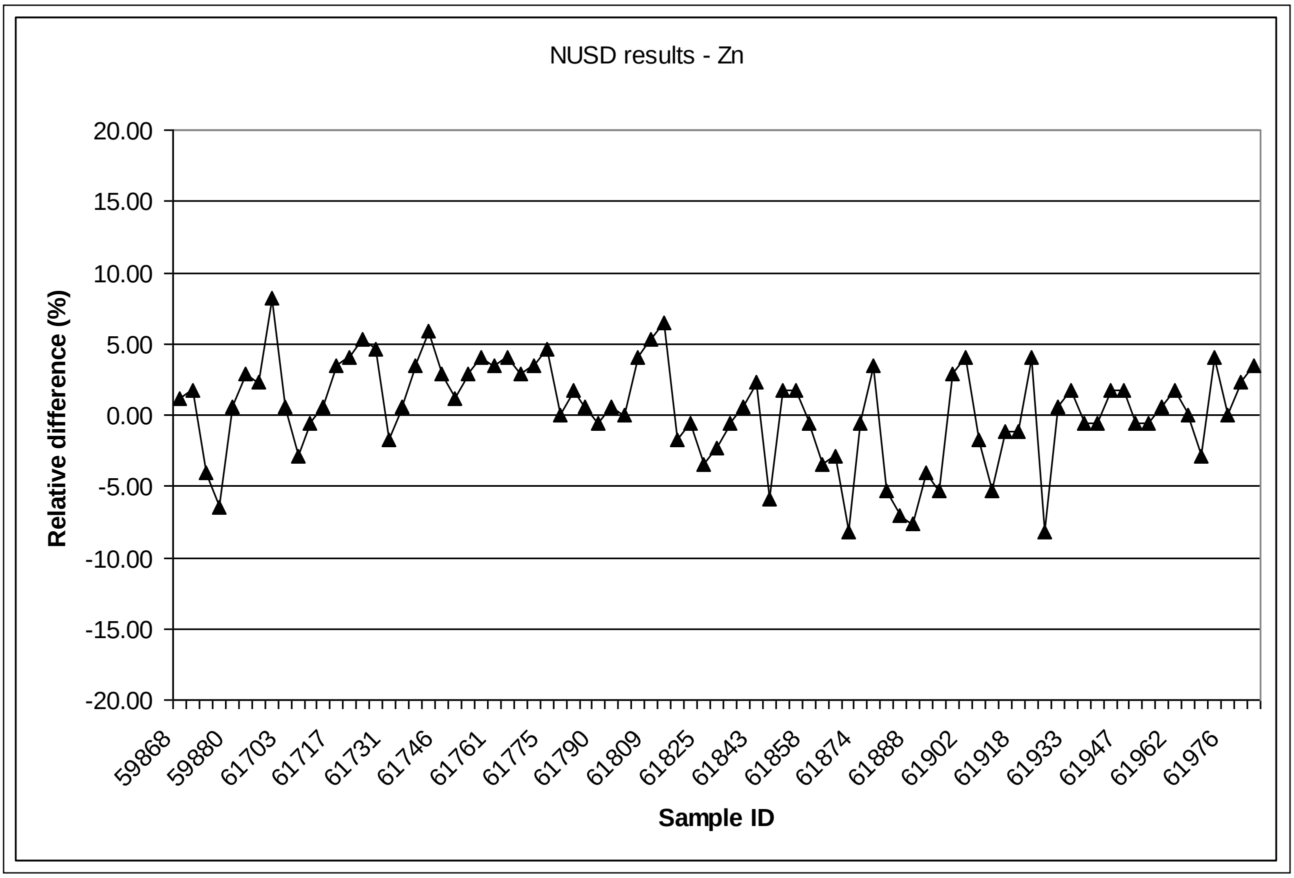


Figure 12.11 Au and Zn results for NUSD SRM submitted with drill core samples during the 2007 Wave Mercury program





12.2.2 2008 NorSky program

The NUSD SRM from the 2007 program was also used in the 2008 NorSky program. Large low biases were observed for all elements. Nautilus personnel, Brett Wallbank (ALS Laboratory Manager in Townsville) and Shaun Kenny (ALS Laboratory Manager in Brisbane) reached a consensus that significant oxidation of the samples and moisture absorption during storage had altered the composition of the samples and biased the elemental analyses. Consequently, it was decided that the use of the NUSD SRM would be discontinued.

12.2.3 2010/11 REM Etive program

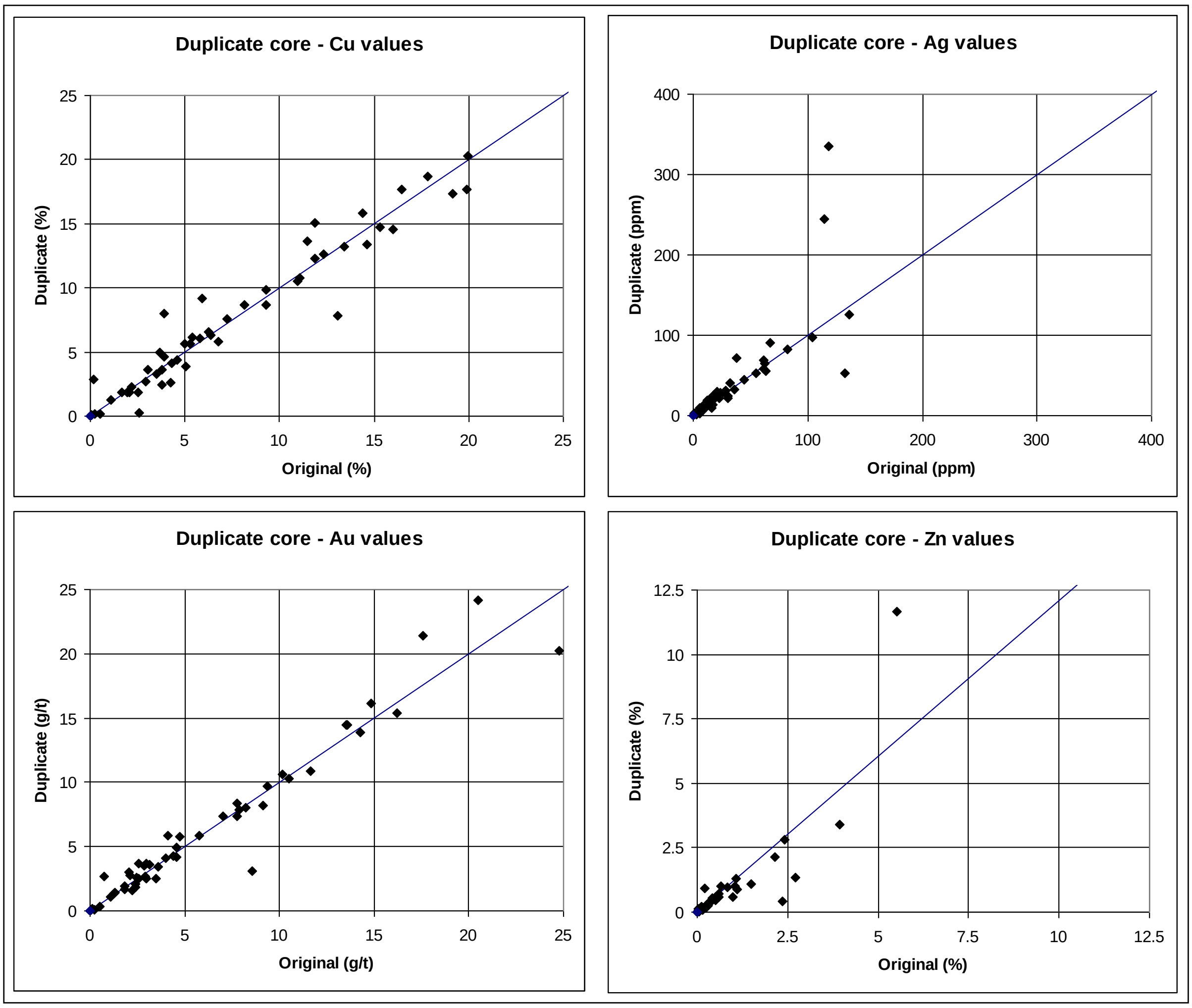
No SRMs were tested during this campaign.

12.3 Duplicate samples

12.3.1 Solwara 1 – 2007 Wave Mercury program (drill samples)

A total of 53 duplicate samples were obtained by collecting the second half of the core from the core trays. Each duplicate sample was submitted in the same batch as the original sample. The analytical results for the original and duplicate samples were compared using various scatter plots (Figure 12.12), half relative difference (HRD), and half absolute relative difference (HARD) plots. The HRD results show that there was no significant bias between the original and duplicate samples. The HARD values provide a measure of the precision or repeatability of the sampling. Ideally, in a relatively homogeneous type of deposit, Golder recommends a target of 90% of sample pairs having a HARD less than 10%. In the case of the Solwara 1 core sample duplicates, only about 73% of the Cu results and 69% of the Au results met this target. Only 50% of the HARD values for Ag and Zn met the ideal 10% target, partly due to the number of values close to the detection limit.

Figure 12.12 Scatter plots of Cu, Ag, Au and Zn from duplicate core samples from the 2007 Wave Mercury drill program

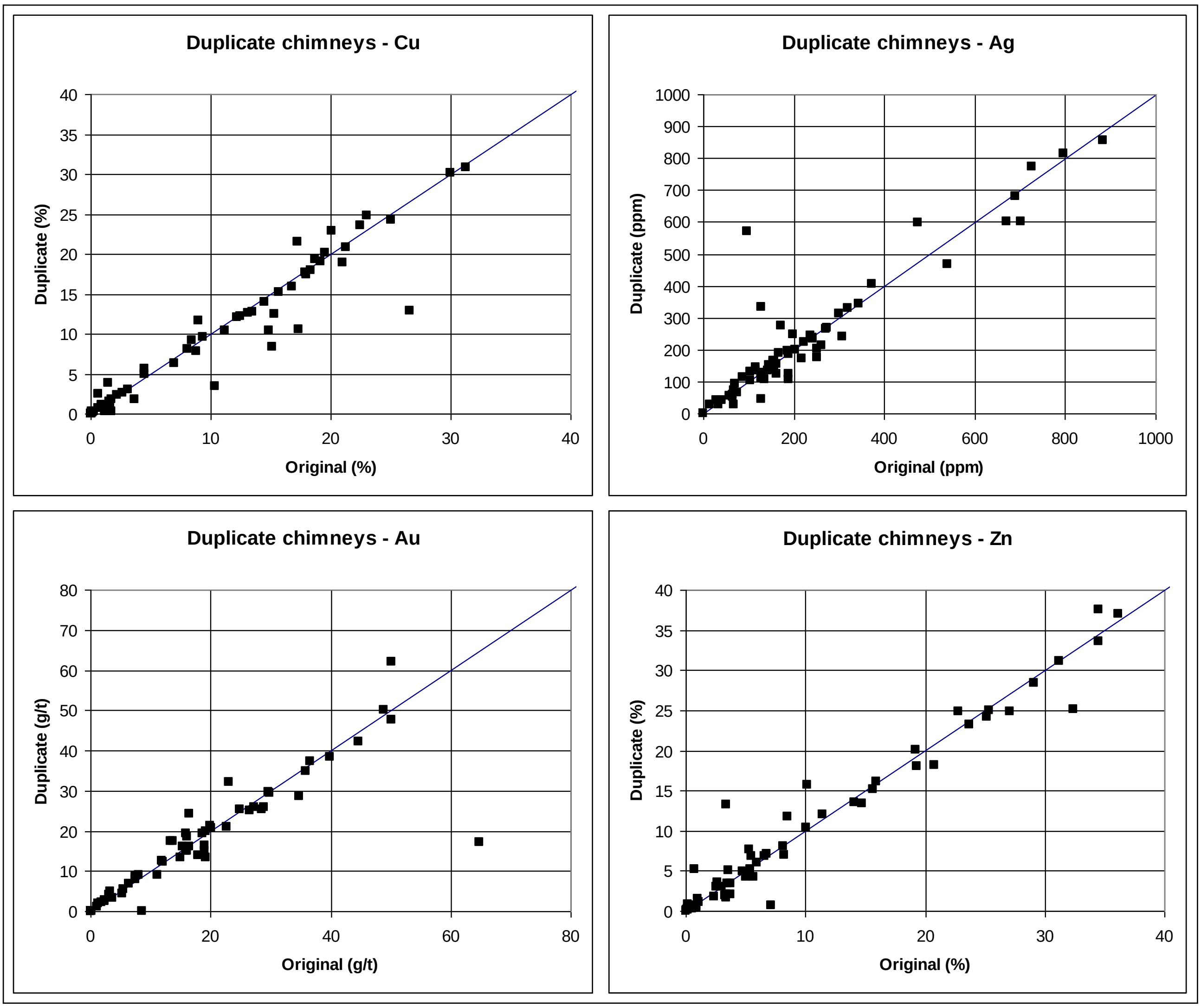


Since most of the Cu and Au grades are well above the limit of detection it is inferred that the low precision of the duplicates is due to the inhomogeneity of the mineralisation. This is consistent with the coarse grain size of the sulfide mineralisation and the irregular nature of anhydrite distribution interstitial to the sulfide grains and in veins.

12.3.2 Solwara 1 – 2007 Wave Mercury program (chimney samples)

A total of 66 duplicate samples of chimneys were obtained by collecting a second slice of chimney from adjacent to the original slice. Each duplicate sample was submitted in the same batch as the original sample. The analytical results for the original and duplicate samples were compared using various scatter plots (Figure 12.13), HRD, and HARD plots. There was no significant bias between the original and duplicate samples. Only about 68% of the Cu results and 67% of the Au results from the chimney sample duplicates had a HARD less than 10%. The precision of the Cu and Au analyses is like that of the core samples. For Ag and Zn, 65% and 62% of the pairs met the ideal 10% target; this is better than the results for the core samples at least partly because there were fewer values close to the detection limit. Consistent with the core samples, it is inferred that the low precision of the duplicates is due to the inhomogeneity of the mineralisation.

Figure 12.13 Scatter plots of Cu, Ag, Au and Zn from duplicate seafloor chimney samples collected during the 2007 Wave Mercury program

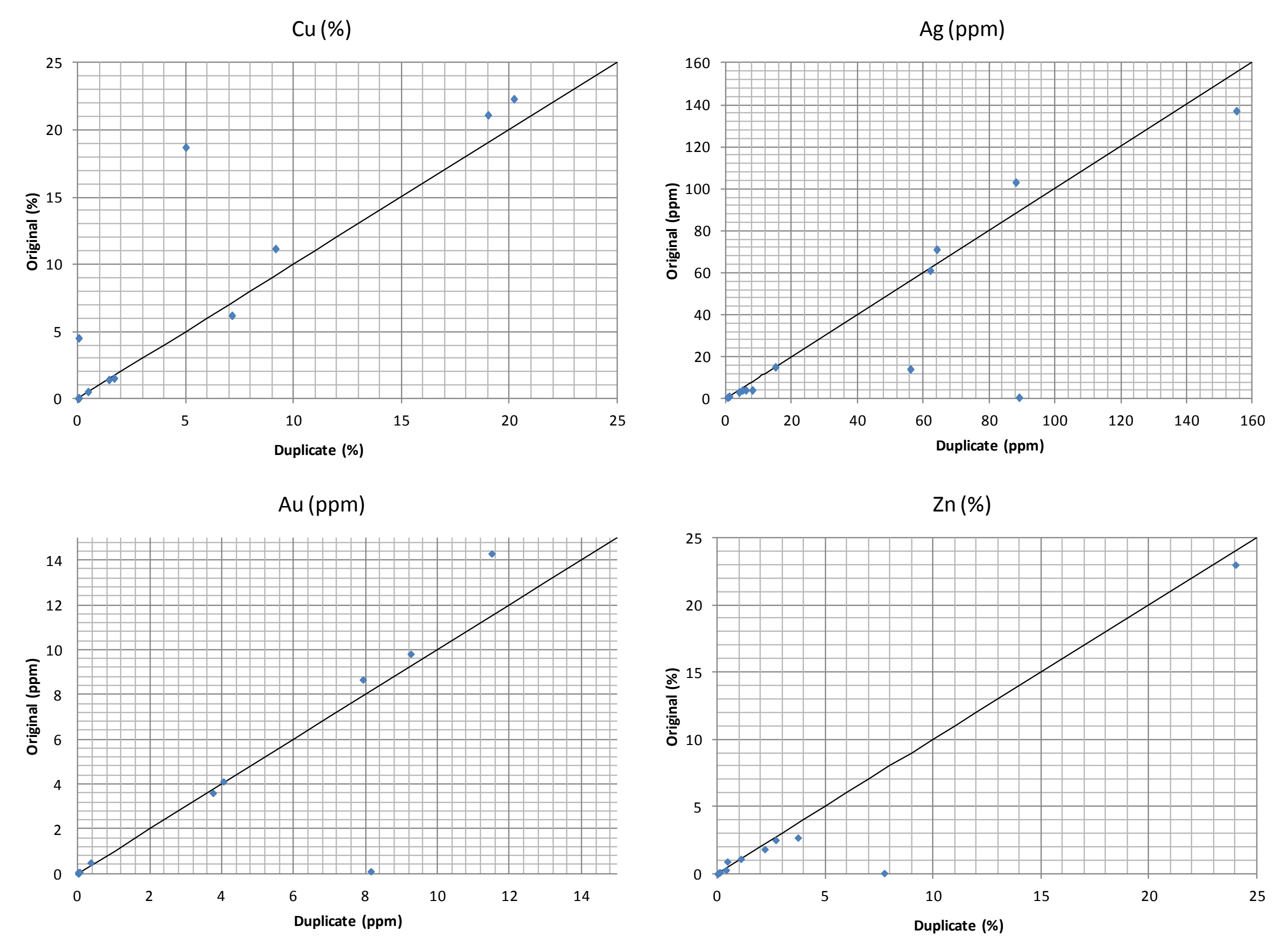


12.3.3 Solwara 1 – 2008 NorSky program (drill samples)

A total of 13 duplicate samples were obtained by collecting the second half of the core from the core trays. Each duplicate sample was submitted in the same batch as the original sample. The analytical results for the original and duplicate samples were compared using various scatter plots (Figure 12.14), HRD, and HARD plots. The HRD results show that there was no significant bias between the original and duplicate samples. About 85% of the Cu results and 62% of the Au results met a HARD target of less than 10%. Only 54% of the HARD values for Ag and Zn met the 10% target, partly due to the number of values close to the detection limit. Since most of the Cu and Au grades are well above the limit of detection it is inferred that the low precision of the duplicates is due to the inhomogeneity of the mineralisation. This is consistent with the coarse grain size of the sulfide mineralisation and the irregular nature of anhydrite distribution interstitial to the sulfide grains and in veins.

The repeatability of the analyses is quite poor but generally consistent with the 2007 program. One pair of samples appear to have been incorrectly identified (i.e., the original and duplicate are not a pair).

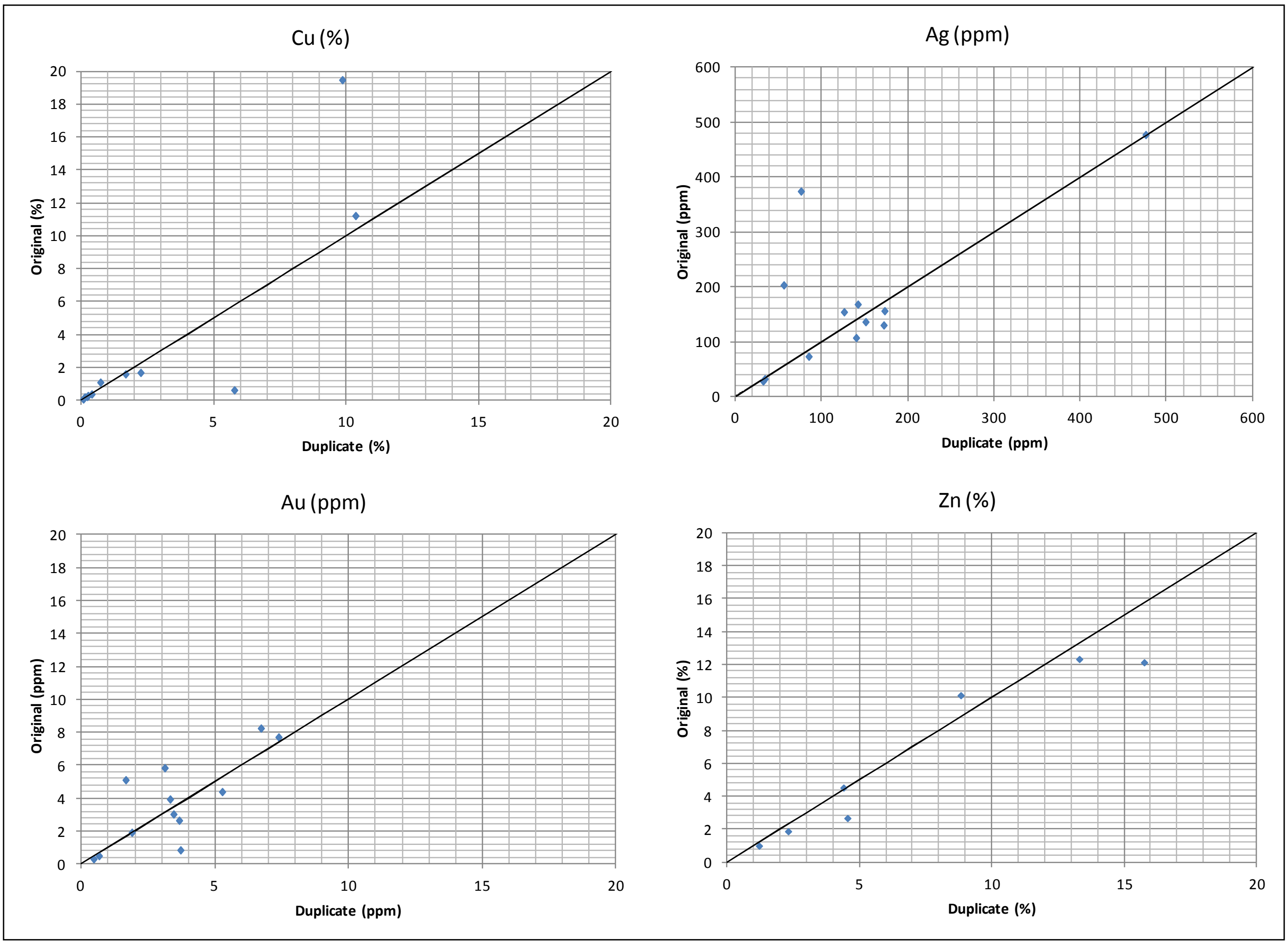
Figure 12.14 Scatter plots of Cu, Ag, Au, Zn from duplicate drill core samples collected during the 2008 NorSky drill program



12.3.4 Solwara 1 – 2008 NorSky program (chimney samples)

A total of 12 duplicate samples of chimneys were obtained by collecting a second slice of chimney from adjacent to the original slice. Each duplicate sample was submitted in the same batch as the original sample. The analytical results for the original and duplicate samples were compared using various scatter plots (Figure 12.15), HRD, and HARD plots. There was no significant bias between the original and duplicate samples. Only about 55% of the Ag results and 64% of the Au results from the chimney sample duplicates had a HARD less than 10%. The precision of the Cu and Au analyses is like that of the core samples. For Cu and Zn, 48% and 36% of the pairs met the ideal 10% target. Consistent with the core samples, it is inferred that the low precision of the duplicates is due to the inhomogeneity of the mineralisation.

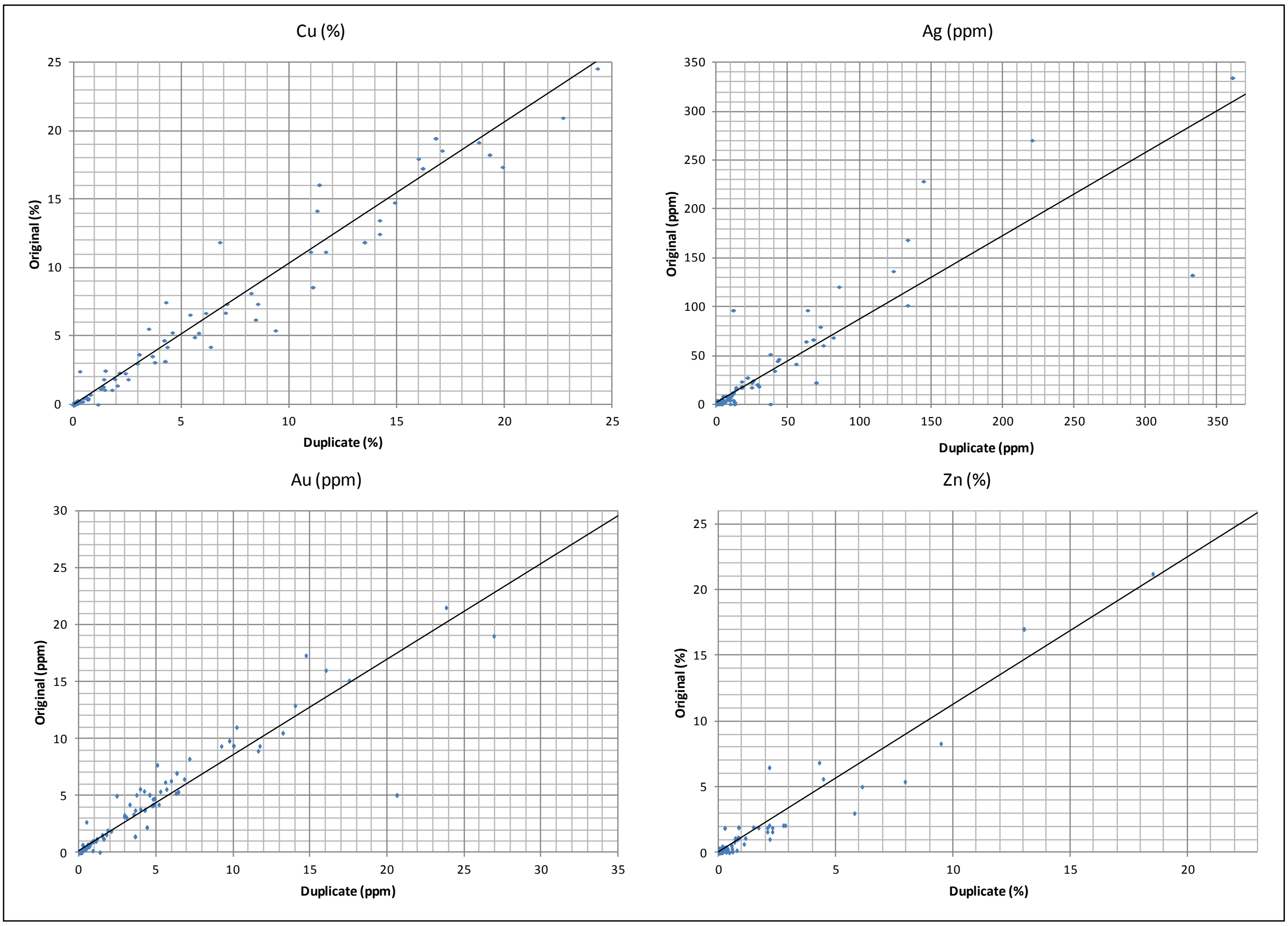
Figure 12.15 Scatter plots of Cu, Ag, Au and Zn from duplicate seafloor chimney samples collected during the 2008 Norsky program



12.3.5 Solwara 1 and Solwara 12 – 2010/11 REM Etive program (drill samples)

A total of 122 duplicate samples were obtained by collecting the second quarter of the core from the core trays. Each duplicate sample was submitted in the same batch as the original sample. The analytical results for the original and duplicate samples were compared using various scatter plots (Figure 12.16), HRD and HARD plots. There was no significant bias between the original and duplicate samples. Only 48% of the HARD values for Cu and 64% of the Au results met a HARD target of less than 10%. Only 36% of the HARD values for Zn and about 55% of the Ag results met the ideal 10% target. It is inferred that the low precision of the duplicates is due to the inhomogeneity of the mineralisation but the cause of the lower precision of the Cu duplicates compared to the 2007 Wave Mercury program is unclear.

Figure 12.16 Scatter plots of Ag, Cu, Au, Zn from duplicate drill core samples collected during the 2010/11 REM Etive drill program



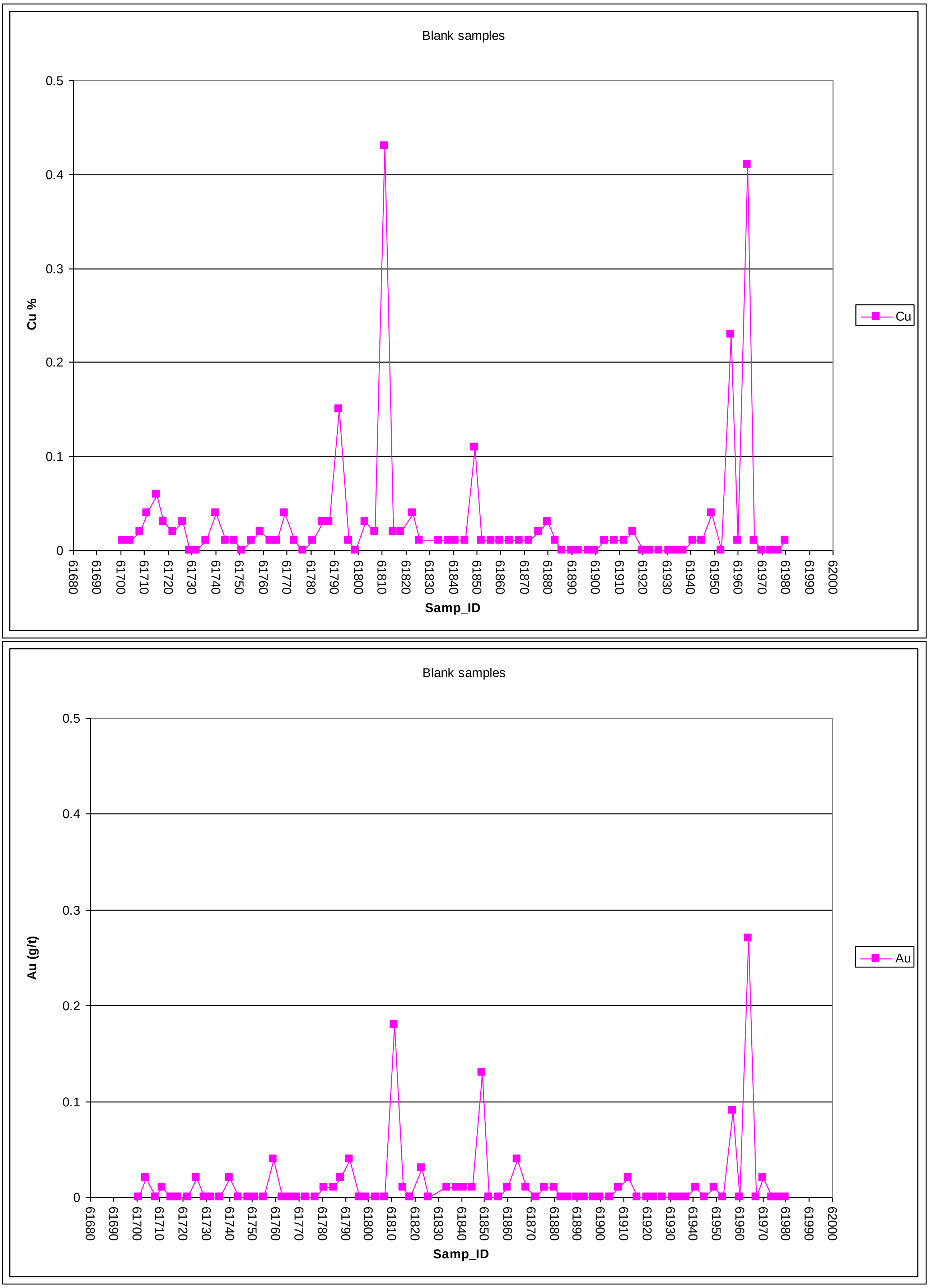
12.4 Blank samples

12.4.1 Solwara 1 – 2007 Wave Mercury program (drill samples)

Grey volcanic sand in 1 kg bags was used as blank (i.e., unmineralised) samples. A total of 76 blank samples inserted in the batches of regular drill samples were analysed.

Five blanks were recognizably contaminated with Cu-Au bearing sulfides; as indicated by elevated levels of Cu, As, Co, Mo, S and Au. Zinc, Ag and Pb were close to the detection limit. Other elements in these samples were consistent with the typical chemistry of the blank material (Figure 12.17). The blank samples show that there were some sporadic instances of minor contamination of samples during sample preparation but there is no evidence of systematic problems. The contamination levels and frequency pose only a minor risk to the resource estimate.

Figure 12.17 Cu and Au results for blank samples inserted during the 2007 Wave Mercury program

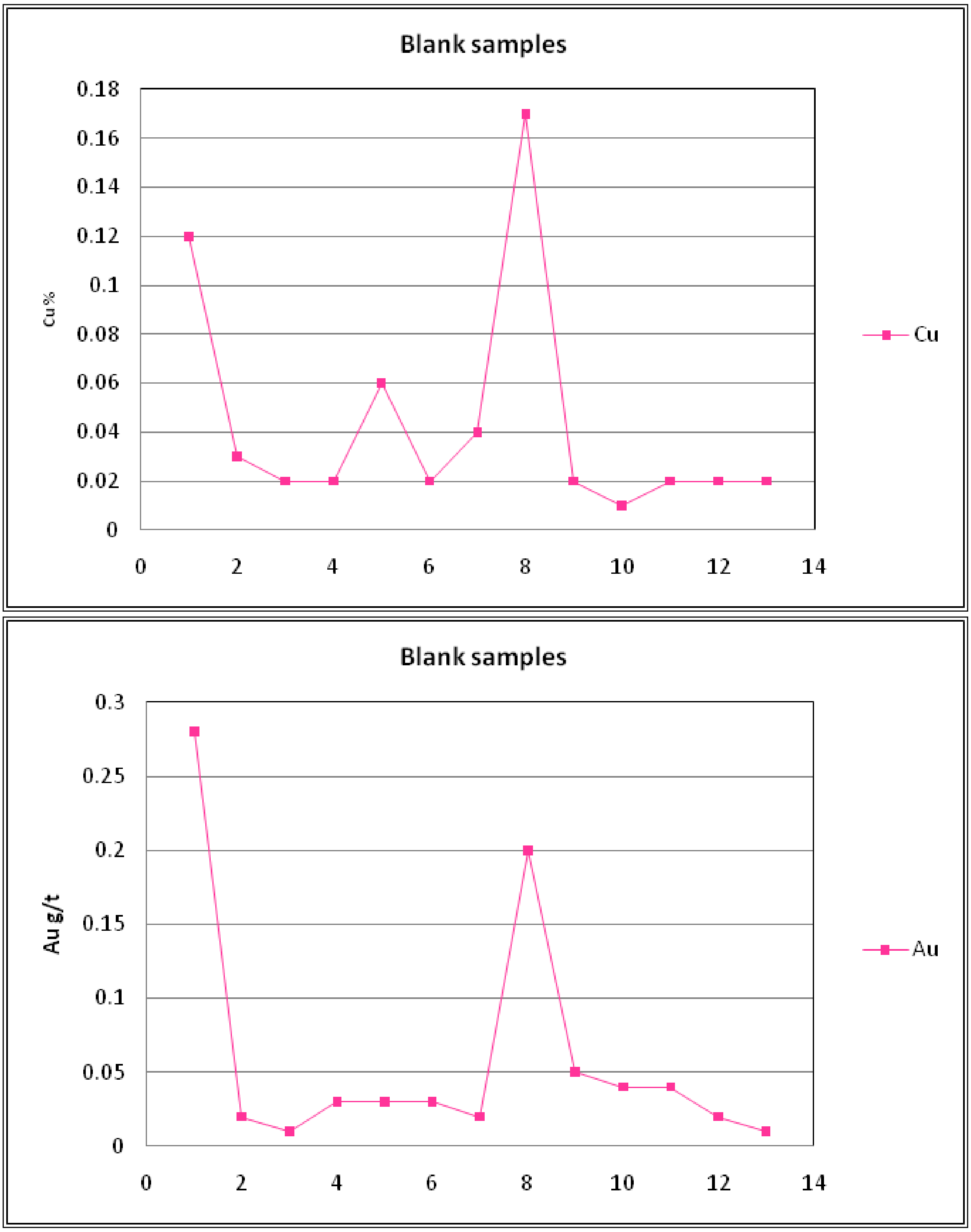


12.4.2 Solwara 1 – 2007 Wave Mercury program (chimney samples)

Grey volcanic sand in 1 kg bags was used as blank (i.e., unmineralised) samples. A total of 13 blank samples were inserted in the batches of regular chimney samples.

Two blanks were recognizably contaminated with Cu-Au bearing sulfides, as indicated by elevated levels of Cu, As, Co, Mo, S and Au. Zinc, Ag and Pb were close to the detection limit. Other elements in these samples were consistent with the typical chemistry of the blank material (Figure 12.18). The blank samples show that there were some sporadic instances of minor contamination of samples during sample preparation but there is no evidence of systematic problems. The contamination levels and frequency pose only a minor risk to the resource estimate.

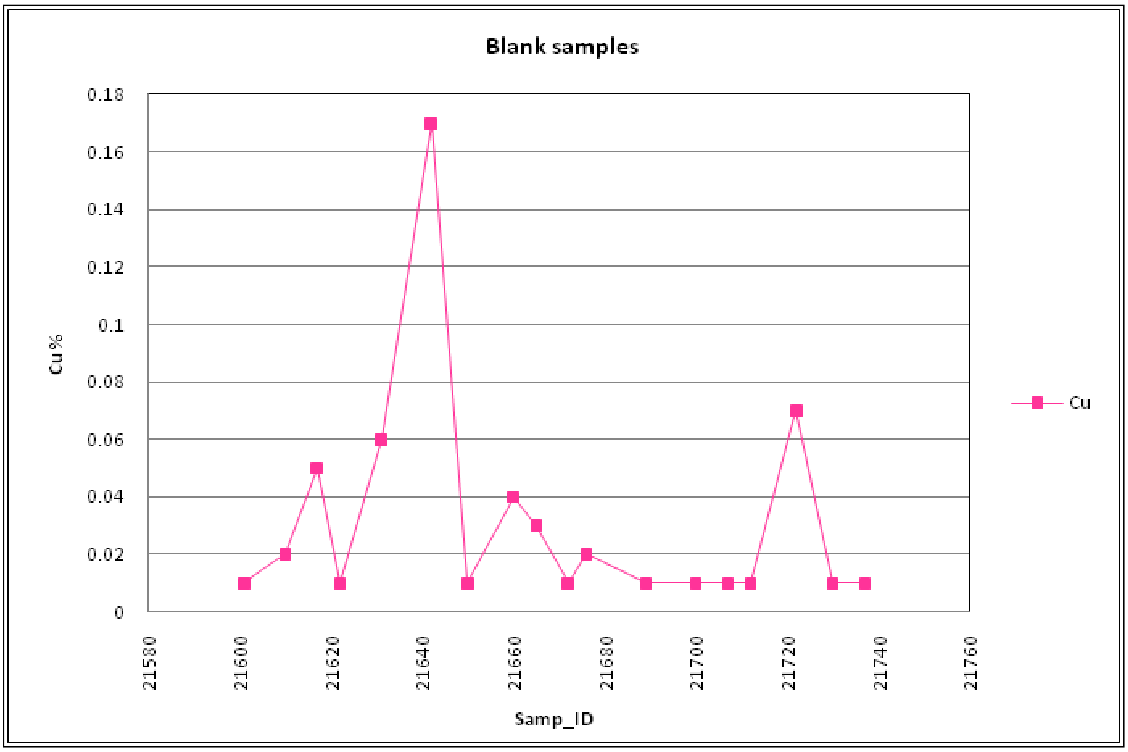
Figure 12.18 Cu and Au results for blank samples inserted during the 2007 Wave Mercury program.

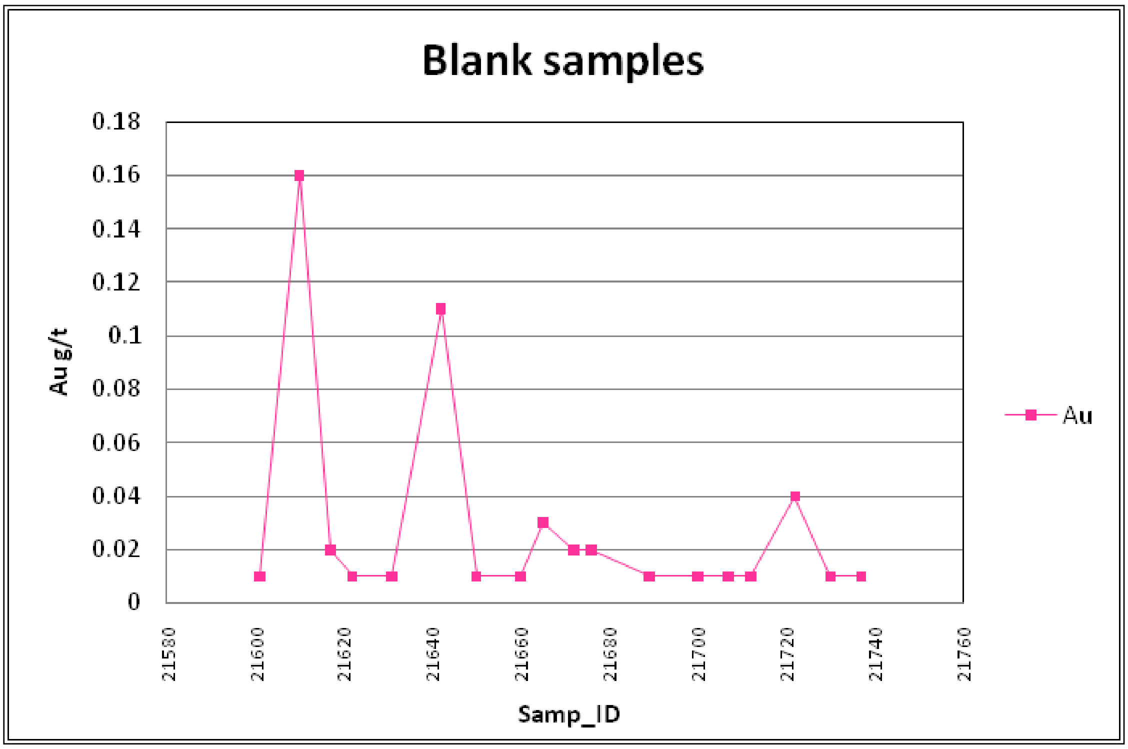


12.4.3 Solwara 1 – 2008 NorSky program (drill samples)

Grey volcanic sand in 1 kg bags was used as blank (i.e., unmineralised) samples. A total of 18 blank samples were inserted in the batches of regular drill samples. Blanks returned acceptably low results, generally less than 10 times the detection limits, for all economic elements (Figure 12.19). Three samples returned higher results than were expected. These samples were re-assayed and the high values were repeated. This suggests that the anomalously high value was created in the preparation phase and not in the analytical phase.

Figure 12.19 Cu and Au results for blank samples inserted during the 2008 NorSky program.





12.4.4 Solwara 1 and Solwara 12 2010/11 REM Etive program (drill samples)

Low-grade CRMs were used during this drill campaign instead of blank samples.

13 Mineral Processing and Metallurgical Testing

Solwara 1 is a SMS deposit with very similar mineralogical features to terrestrial VHMS deposits. The approach to minerals processing design for the Project has been to confirm that industry-standard practice for the treatment of VHMS deposits is applicable to Solwara 1 and will give an acceptable economic outcome. Despite the young age of the deposit, its location on the sea floor simplifies some aspects of its processing. For example, there is no oxidised zone or supergene zone of mineralisation to potentially cause mineral separation problems when treated by flotation.

There have been five phases of metallurgical test work on the Solwara 1 Project:

1. 1998 “skirmish” testing of five samples (chimney specimens) from different areas of various Solwara deposits.
2. 2005 “skirmish” testing of a single composite sample of chimney specimens from the Solwara 1 deposit.
3. 2007-2010 testing of Nautilus drill core from 24 drillholes in the Solwara 1 deposit supported by mineragraphy on 16 drillholes and quantitative mineralogy on material from 17 drillholes. After initial “sighter” tests at ALS AMMTEC in Perth, Australia, detailed flowsheet development was done at ALS Metallurgy in Burnie, Tasmania, Australia.
4. 2011-2012 detailed testing of Solwara 1 deposit material aimed at flowsheet optimisation, examining options to increase gold recovery, variability testing, determining materials handling characteristics.
5. 2012-2014 testing of aliquots of Solwara 1 samples by several potential offtake customers in the People’s Republic of China (PRC).

Items 3 and 4 above have been under the control and direction of Nautilus. Service providers for this work have been:

- Mineragraphy – McArthur Ore Deposit Assessments Pty Ltd (MODA) in Burnie, Tasmania, Australia.
- Quantitative mineralogy – G&T Metallurgical Service Ltd in Kamloops, British Columbia, Canada.
- Mineral processing e.g., comminution, flotation, solid-liquid separation etc. – mostly at ALS Metallurgy Burnie, Tasmania, Australia.

A mineralogical-based approach was the driver for the metallurgical test work emphasizing characterisation of the material given the difficulty and expense of obtaining samples.

No metallurgical test work programs have been carried out at Solwara 12. All results reported below are from Solwara 1.

13.1 Chimney sample test work

13.1.1 1998 test work

In 1998, five Manus Basin seafloor chimney specimens supplied by CSIRO (Rio Tinto, 1998) underwent preliminary bench scale tests by Rio Tinto Exploration’s Research and Technology Development section. One of the samples was from the Solwara 1 deposit.

Assay results for two of the Solwara 1 composite samples were:

BB4 0.45% Cu, 41.4% Zn, 2.29% Fe, 16.6% Ba, 25.8% S.

BB8 8.02% Cu, 23.6% Zn, 11.9% Fe, 17.3% Ba, 28.3% S.

Flotation tests focussed on maximising the recovery of Cu and Zn to their respective rougher concentrates.

Greater than 90% recovery of Cu and Zn to sulfide concentrates was achieved by rougher flotation. Given the recovery from the rougher sample, no cleaner flotation tests to achieve maximum concentrate grade were performed.

The test work on these SMS composites showed their flotation characteristics to be similar to terrestrial VHMS mineralisation.

13.1.2 2005 test work

In 2005, a composite sample of chimney mineralisation from the Solwara 1 deposit was tested by Placer Dome Inc. The sample consisted largely of chalcopyrite, pyrite, and barite. Bulk flotation recovered 97% of the Cu, 75% of the Au, 93% of the silver, 90% of the lead and 96% of the Zn. This bulk-sulfide concentrate assayed 15.51 g/t Au, 440 g/t Ag, 26.64% Cu, 3.38% Pb and 4.92% Zn. The sample was compared to other massive sulfide concentrates (such as from the Duck Pond Mine, Canada; and Brunswick, Canada). The metallurgical characteristics of the concentrate produced from the seafloor sulfide material were similar to those from these terrestrial mining operations.

13.2 Nautilus test work

The materials examined and tested from Solwara 1 by Nautilus are:

- Mineragraphy – on 21 core samples from 16 drillholes.
- Quantitative mineralogy – on 10 samples composited from 24 different drillholes and 28 chimney samples.
  - Sample 1 – 22 drillholes
  - Sample 2 – 21 drillholes
  - Sample 3 – 10 drillholes
  - Sample 4 – 9 drillholes
  - Sample 5 – 7 drillholes
  - Sample 6 – 2 drillholes
  - Sample 7 – 4 drillholes
  - Sample 8 – 5 drillholes
  - Sample 9 – 17 chimney grab samples
  - Sample 10 – 11 chimney grab samples
- Metallurgical test work – on same 10 samples as for quantitative mineralogy above.
- Variability samples for quantitative mineralogy on 21 samples from 17 drillholes and nine chimney grab samples.

To date, mineralogical examination and metallurgical test work have been carried out on material from 61 drillholes and 37 chimney grab samples. The uniformity of the mineralisation types, the excellent correlation between mineralogy and metallurgical response and the shallowness of the drillholes into Solwara 1 (less than 20 m) give very high confidence in the prediction of metallurgical performance for the mineral resource.

In 2010, an improved Solwara 1 geological model incorporating revised lithology units in addition to test work and detailed mineralogy programs (carried out by Nautilus between 2007-2010) resulted in a classification of the mineralisation into two main Metallurgical Types with several subsets (Table 13.1).

Table 13.1 Description of Nautilus metallurgical types

Metallurgical Type (2011)	Description	Mineralisation Types (2007)
Met Type 1	Iron sulfide-chalcopyrite mineralisation with low sphalerite content and pyrite as the dominant gangue mineral; this comprises the majority of the contained metal values.	1, 2, 3, 4, 5, 6, 7, 8
Met Type 2	Iron sulfide-chalcopyrite mineralisation with elevated sphalerite content (and associated galena). In Solwara 1 this is associated with chimney-type material which is currently thought to be a very minor portion of the deposit. In processing by flotation, the sphalerite will either have to be depressed if present in “nuisance” amounts, or recovered into a Zn concentrate.	9, 10

13.2.1 Sample collection

A program to drill and obtain representative samples for metallurgical assessment was carried out in 2007. In all, 24 holes were drilled to provide material for systematic metallurgical assessment (Figure 13.1). The metallurgical drillholes were logged for lithology and material type. In addition, 28 chimney samples spread across the deposit, totalling 100 kg, were collected (Figure 13.2). These were zinc-bearing sample sites selected to provide a representative geographic spread across the deposit and to provide zinc-rich and copper-rich material.

The drill core and chimney samples were washed in fresh water, dried, vacuum sealed, placed in a nitrogen purged container, and shipped to ALS Ammtec Laboratories (Ammtec) in Perth, Australia. Drill samples were dispatched as whole core. The samples were processed by Ammtec. The drill samples were first crushed and screened and a 100g sample obtained for geochemical analysis. The remaining sample was then tested as part of a “sighter” program to determine their metallurgical performance. Chimney samples were not sub-sampled but went straight to metallurgical testing.

Figure 13.1 Location of the metallurgical test samples from drillholes

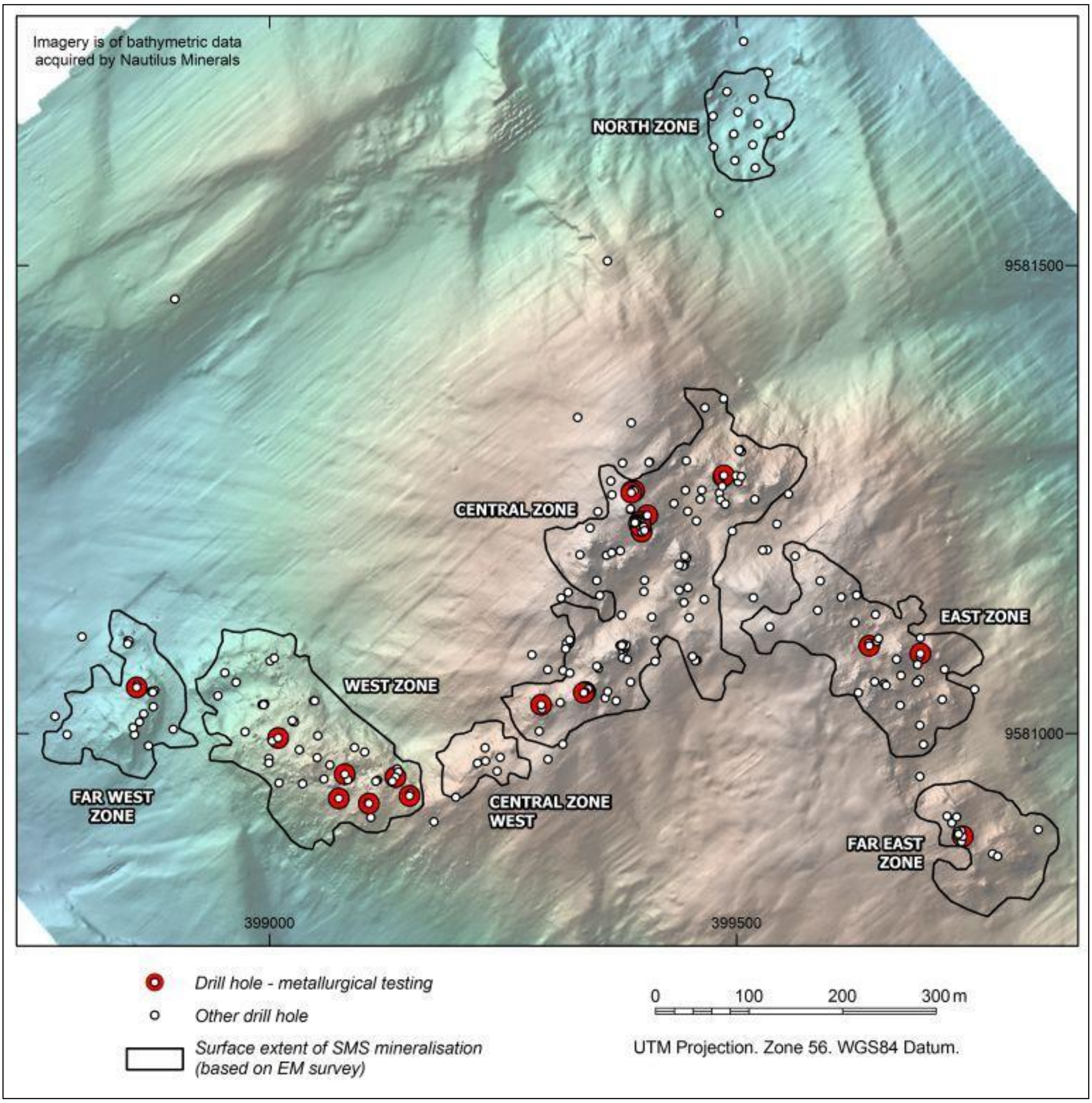
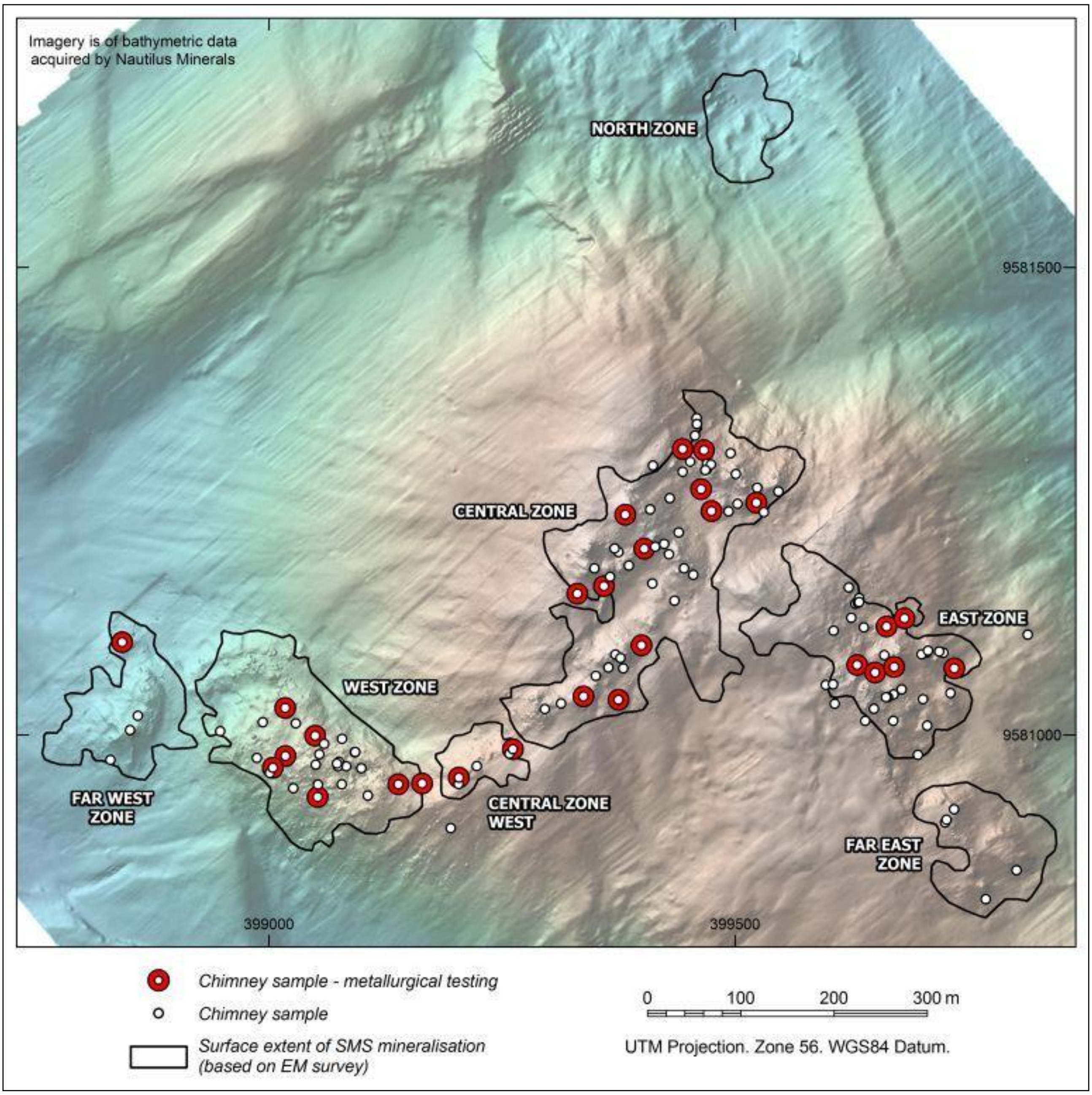


Figure 13.2 Location of the metallurgical test samples from chimneys.



13.2.2 2007 test work

Nautilus initially defined eight main Mineralisation Types, based on logging of a selection of 29 out of the total of 111 resource drillholes drilled in 2007 (Table 13.2). Metallurgical samples of each of these Mineralisation Types were then composited from 24 new core holes drilled specifically for metallurgical test work. These holes were located as close as possible to previous resource drillholes and designed to produce proportions of each Mineralisation Type representative of its abundance in the deposit. Two composite chimney metallurgical samples were also collected, one zinc-rich and one zinc-poor. This brought the number of Mineralisation Types examined up to 10. Sample locations of the drillhole and chimney metallurgical samples are shown in Figure 13.1 and Figure 13.2 respectively.

The metallurgical samples were cleaned in fresh water, dried, vacuum sealed, placed in a nitrogen purged container and shipped to the AMMTEC Limited laboratory in Perth, Australia. The samples were dispatched as whole core.

Table 13.2 Description of Mineralisation Types sampled for metallurgical test work in 2007.

Mineralisation Type Sample	Material Type Description	Estimated percentage of Solwara 1 2008 Inferred and Indicated Resource	Sample Mass (kg)
1	Chalcopyrite-pyrite -sphalerite mineralisation as veins, blebs, clasts, breccias and disseminations within sedimentary units above the massive sulfide-dominant domain	14	132
2	Vuggy and porous chalcopyrite-pyrite mineralisation within the massive sulfide-dominant domain	53	325
3	Dense massive sulfides (chalcopyrite-pyrite), rare vugs; can be banded. Main part of massive sulfide-dominant domain	22	137
4	Brecciated massive to semi-massive sulfide, chalcopyrite-pyrite	7	313
5	Dominant anhydrite/barite overprint, veins within altered footwall volcanics pyrite-chalcopyrite Transition zone between massive sulfide-dominant domain and footwall.	n/a	74
6	Chalcopyrite-pyrite mineralisation with anhydrite overprint and veins within altered footwall volcanic rocks. Transition zone between massive sulfide-dominant domain and footwall.	n/a	24
7	Altered brecciated footwall volcanics with disseminated and vein pyrite-chalcopyrite	n/a	85
8	Altered basaltic volcanics brecciated with blebs and disseminated pyrite-chalcopyrite	n/a	23
9	Zn-poor chimney sample	3	44
10	Zn-rich chimney sample		56

13.2.3 2008 test work

Further metallurgical test work was performed on the 10 samples under the direction of Mineralurgy Pty Ltd in 2008. This work was mostly done at ALS Metallurgy Burnie. The emphasis was on producing a saleable copper concentrate with payable precious metals. It excluded making a zinc concentrate, as zinc rich material is a relatively minor proportion of the Solwara 1 resource.

Mineralogical studies showed that the dominant copper-bearing mineral is chalcopyrite, with much lesser amounts of bornite, chalcocite and covellite. A very low proportion of the copper content is in the arsenic-bearing copper sulfide minerals tennantite and enargite, so that a high copper recovery should not result in a copper concentrate containing unacceptably high arsenic. Arsenopyrite occurs in up to 1% of the mineralisation and may report to the concentrate unless depressed with pyrite.

Pyrite is the dominant gangue mineral with the low pyrite: chalcopyrite mass ratio of around 2:1 being favourable for flotation separation.

The Bond Ball Mill Work Index ranged from 10 to 12 kWh/t, which is a low to moderate value for mineral processing. Processing Solwara 1 material will be a separation-dominated operation rather than a throughput-dominated one as would be the case for a low-grade porphyry copper deposit.

Flotation characterisation tests did not show any significant issues affecting copper mineral flotation performance. Accordingly, copper concentrates were produced by conventional laboratory batch flotation technique. Copper concentrate grades were all above 25% Cu, with the main diluent being pyrite. Taking a target concentrate grade of 28% Cu gave an expected copper recovery of 85 to 90%. All copper concentrates produced had payable gold contents but a recovery of only ~25%. The copper flotation performances on each sample were achieved with essentially the same conditions. No locked cycle flotation tests were done, nor was any pilot scale work undertaken.

Testing of diluents (e.g. transition, footwall) showed that these will not deleteriously affect the flotation performance.

Production of a pyrite concentrate from the copper flotation tailings reduced gold lost into the final discard flotation tailings to less than 10%. Diagnostic experiments showed that gold remaining after production of a copper concentrate is 'refractory' because of its intimate association with pyrite. Preliminary tests showed that a bulk pyrite concentrate would contain 4 to 15 g/t Au, with pressure oxidation and subsequent cyanidation giving 95-99% gold extraction after 98-99% sulfur oxidation.

Saleability of the auriferous pyrite concentrate was not determined.

The resource contains a minor amount of zinc-rich mineralisation. A single sighter test resulted in 71% Zn recovery to concentrate grading 43% Zn. It is expected that this result could be improved upon but any zinc concentrate is expected to be lead-rich and contain high amounts of gold and silver. Such a product is more suited for treatment in an Imperial Smelting Furnace smelter rather than in a more conventional roast-leach-electrowinning plant.

13.2.4 2010 test work

In 2010, additional metallurgical tests were carried out at ALS Metallurgy Burnie using similar sample materials to that for AMMTEC. These tests were to generate design data for a concentrator. Thus, they followed the flowsheet and reagent regime from the 2008 AMMTEC grinding and flotation work with the addition of locked cycle testing plus solid-liquid separation including thickening and filtration. The latter primarily was aimed at giving input to the design of the dewatering section for processing the mined material on the production support vessel.

Laboratory batch flotation tests completely replicated the results of the 2008 AMMTEC work. Examination of 2008 test data suggested that gold recovery to the copper concentrate could be increased to approximately 40-45% by targeting a lower grade concentrate of 20% Cu. This was partially confirmed by interpolation of individual test results from ALS Metallurgy Burnie's work and subsequently by locked cycle flotation tests in 2011.

Laboratory locked cycle flotation testing on a blend of likely feed produced a 25% copper concentrate at 92% recovery; the higher copper recovery at lower concentrate grade compared with the 2008 work being the expected result when going from an open circuit batch test to a locked cycle one. These results require the standard discount of up to 2% recovery applied in the industry when predicting the metallurgical performance of a production plant treating Solwara 1 material.

Quantitative mineralogy showed that the copper concentrate approached industrial quality at just under 80% (weight/weight) copper sulfides while pyrite concentrates from single stage rougher flotation was surprisingly good at well over 80% (weight/weight) iron sulfides.

Aliquots of samples collected for metallurgical test work were sent to a potential customer in the PRC. The potential customer carried out tests focussing on extractive metallurgical processes to maximise recovery of copper and gold. These showed that a conventional flowsheet of roasting the pyrite concentrate followed by cyanidation of the calcine could extract 80-85% of the gold in an auriferous pyrite concentrate produced after making a copper concentrate.

13.2.5 2011-2012 test work

This test work program expanded on the 2010 test work aimed at flowsheet optimisation and examined options to increase gold recovery, particularly by determining the grade-recovery relationship for copper and its effect on gold recovery to the copper concentrate. Lowering the target copper concentrate grade to 20% Cu did not significantly increase the copper recovery because of the relatively high mineral liberation of chalcopyrite under the test conditions. However, it did raise the gold recovery to 42-45% because more auriferous pyrite was recovered into the copper concentrate.

Investigation of the effects of aging on mineralised material demonstrated that these could be countered by conventional flotation operating practices such as increasing pH and/or addition of sodium sulfide/hydrosulfide. Variability testing included more mineragraphy. The mineralogical work showed that these samples had identical characteristics to those previously examined. This confirmed the results of the previous work that Solwara 1 mineralised material shows predictable behaviour with respect to its processing. Tests to determine materials handling characteristics were also conducted.

13.2.6 2012-2014 test work

Aliquots of samples collected for metallurgical test work were sent to two potential customers in the PRC which were assessing the flotation characteristics. The work of these laboratories confirmed the metallurgical outcomes of Nautilus's tests.

13.2.6.1 2015-2016 test work

Refinements of mineralised material classification test work for the determination of the International Maritime Dangerous Goods (IMDG) code classification were completed by Davoren Environmental in March 2016. This work concluded that the Solwara 1 material analysed was classified as Non-Dangerous Goods under the Australian Dangerous Goods and the IMDG Codes. Furthermore, the mineralised material was found not to be classified as Material Hazardous only in Bulk under the International Maritime Solid Bulk Cargoes (IMSBC) Code. Finally, the mineralised material was also demonstrated to be Not Harmful to the Marine Environment under the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V.

13.3 Mineral processing design basis

The objective of the metallurgical test programs completed to date has been to put the processing of Solwara 1 material in the context of the characteristics of other VHMS deposits, i.e. to show that its submarine occurrence does not directly impact on processing.

Variability of 30 samples was also examined mineralogically to determine whether each sample had clear similarities in its properties to those of the composite example of that metallurgical type (as used for metallurgical design). The examination concluded the composites were suitable for flow sheet development.

The results of the mineralogical and metallurgical test work can be summarised as follows:

- Copper is present almost exclusively as chalcopyrite.
- Chalcopyrite liberation is significant at a sizing of 80% -40 µm with the test flowsheet using a primary grind of 80% -55 µm with regrinding of rougher concentrate to 80% -25 µm.
- Treatment by conventional grinding and flotation processing produced copper concentrates grading 25% to 30% Cu; copper recovery in bench scale laboratory open circuit tests has been 85% - 90%.
- Laboratory locked cycle flotation testing on a blend of likely feed produced a 25% Cu copper concentrate at 92% copper recovery; these results require the standard 2% absolute discount applied in the industry when predicting the metallurgical performance of a production plant treating Solwara 1 material.
- Arsenic is the only significant deleterious element in the massive sulphide, with the main carrier being arsenopyrite with some contribution from tennantite, and possibly orpiment. However, arsenic levels in concentrates from samples tested were below penalty levels and also below the limits prescribed by Exit-Entry Inspection and Quarantine Bureau of the PRC (CIQ) regulations.
- Gold is refractory, being mostly associated with pyrite.
- Gold recovery to a 25% Cu copper concentrate is approximately 25%. This would increase to approximately 42 - 45% by making a lower grade concentrate at 20% Cu which contained more auriferous pyrite.
- Around 65 - 70% of the gold content can be recovered into a pyrite concentrate from the copper flotation section tailing when making a 25% Cu copper concentrate. This pyrite concentrate would assay about 7 - 9 g/t Au and approximately 45% sulfur.
- At least 80 - 90% of the gold reporting to the auriferous pyrite concentrate can be extracted by the conventional technologies of roasting / cyanidation or pressure oxidation / cyanidation. This would give a total 'gold recovery' to copper concentrate + bullion of 75 to 90%.
- The samples tested have a Bond Ball Mill Work Index values in the range of 10-12 kWh/t indicating a low to medium resistance to comminution.

These results have not been optimised but the following important points should be noted:

- Quantitative mineralogical data is an excellent predictor of sulfide flotation performance.

- Copper flotation results are consistent across all samples tested and for four laboratories (two in Australia and two in the PRC).
- Flotation work has included both batch and locked cycle tests.
- Dilution with low-grade materials or country rock should not affect copper metallurgical performance.
- Copper concentrates are clean and should not present any problems for treatment by custom copper smelters.
- Gold recovery can be significantly increased by reducing the target copper concentrate grade from 25% Cu to 20% Cu.
- Production of an auriferous pyrite concentrate will be necessary to get a gold recovery to copper concentrate and doré bullion of 75 - 90%.
- Exposure of the materials tested to ambient conditions for up to 8 weeks has not caused any major deterioration in metallurgical performance.
- The only attempt at making a zinc concentrate gave an encouraging result, with a product high in precious metals that might be upgraded by the established technique of reverse flotation.
- Metallurgical types in the deposit can be resolved into two main classes and several subsets (Table 13.1).
- While there has been a significant sampling program undertaken by Nautilus, there remain parts of the deposit at depth that have had little metallurgical sampling and testing. Nonetheless, the core logging to date did not identify any minerals or textures that would be expected to negatively affect recoveries.

14 Mineral Resource Estimates

The Mineral Resource estimates for Solwara 1 and Solwara 12 are discussed in this report.

14.1 Cut-off grade and copper equivalency

The two common methods of differentiating between ore and waste, in polymetallic ore-bodies, are the Net Smelter Return (NSR) and the metal equivalent cut-off grade methods. Both methods take into consideration mill recoveries for each rock type, transport costs, processing costs, treatment and refining charges, smelter charges and marketing. The preliminary economic assessment presented elsewhere in this report supports the process described herein used to evaluate an appropriate cut-off grade.

NSR calculates the revenues expected from the mill feed for each metal mined. NSR factors for each metal are used to calculate the value of each block from which an inventory of positive blocks within a boundary defines the resource. The assessment of processing, smelting and refining options at the time the Mineral Resource Estimate was prepared, was not sufficiently advanced to support an NSR calculation.

Metal equivalent grades were calculated as the revenue generated by all the metals within a unit of mineralised material expressed as the equivalent of a single recoverable metal. The recoverable Cu equivalent grade (CuEq) is used to differentiate between mineralised material and waste for the Solwara resource statement. The CuEq was calculated as:

$$CuEq = Cu * CuRec_n + [(Au * AuRec_n * AuPrice)/CuPrice] + [(Ag * AuRec_n * AgPrice)/CuPrice]$$

Where

Cu = % Cu

CuPrice = Cu price ($/t)

$CuRec_n$ = Recovery of Cu (after adjusting for metallurgical, transport and royalty losses)

Au = Au (g/t)

$AuRec_n$ = Recovery of Au (after adjusting for metallurgical, transport and royalty losses)

AuPrice = Au price ($/g)

Ag = Ag (g/t)

$AgRec_n$ = Recovery of Ag (after adjusting for metallurgical, transport and royalty losses)

AgPrice = Ag price ($/g)

Preliminary cost modelling and analysis was completed using data compiled in April 2011, using customary ranges of certainty for determining an appropriate cut-off grade.

Losses during processing and transport were estimated by Nautilus at 3%. PNG royalties are 2.25% of metal produced. Metallurgical recoveries were estimated based on test work from 2008 to 2010 as 91.5% for Cu, 45% for Au and 50% for Ag.

The total cost cut-off grade for determining the resource limits is defined as:

$$CuEq_{cut\text{-}off} = (TC + MC) / CuPrice$$

Where

TC = Treatment Cost ($/t)

MC = Mining Cost ($/t)

The resulting Mineral Resource cut-off grade was calculated as 2.6% CuEq.

In calculating copper equivalency, the pricing assumptions for Cu, Au and Ag involved utilising published London Metal Exchange forward curve prices to Q4 2015 and then using analysts' consensus pricing compiled by TD Securities for 2011 and beyond.

The World Bank "Pink-Data" monthly averages were used for historical commodity price data.

Price projections were based on the assumption that Solwara 1 mining would commence in middle of 2013 and be completed by end of 2015. The average forward curve prices between July 2013 and December 2015 used in the cut-off grade calculation were \$3.90/lb Cu, \$1,510/oz Au, and \$32/oz Ag. Although these are somewhat higher than spot prices in January 2018, the average grade of the Mineral Resource, expressed in copper equivalent terms, is not materially changed and is much higher than the marginal cut-off grade.

14.2 Solwara 1 and 1 North

14.2.1 Geological modelling

Geological modelling of the Solwara 1 SMS deposits comprised of sectional interpretation of the stratigraphy and mineralisation and a floating circle approach using detailed bathymetry to define the base of chimneys. The strings produced during sectional interpretation of the stratigraphy were used to build three-dimensional wireframe surfaces of the stratigraphic contacts, which were then used to build a block model for grade estimation.

14.2.1.1 Solwara 1 sectional interpretation

The Solwara 1 deposit was divided for resource estimation purposes into stratigraphic domains, as follows:

- Domain 600. Chimneys, comprised of massive sulfides.
- Domain 200. Unconsolidated sediments (lithology code SS).
- Domain 300. Consolidated sediments (lithology code SC) and mineralised and sulfate altered sedimentary rock (lithology code PT). Where consolidated sediments or sparry precipitate were not present in a drillhole the domain was pinched out around the drillhole by modelling the lower surface of the domain to be coincident with base of the unconsolidated sediments.
- Domain 400. Sulfide dominant rock (generally lithology code RI with minor RA or RC) and conduit facies (lithology code CF). This is the main mineralised domain. The EM conductor anomaly was interpreted to define the outer limits of the massive sulfide deposit. It correlates very well with observed massive sulfide drillhole intersections. The EM anomaly is not a guide to the base metal grades of the massive sulfides.
- Domain 450. Upper footwall beneath the sulfide dominant zone. Clay and sulfate dominant rocks (lithology codes RC and RA) with disseminated or stringer mineralisation.
- Domain 500. Lower footwall. Dominantly volcanic (lithology code VC or VB) but may include clay and sulfate dominant rocks (lithology codes RC and RA).

The 2006 drillholes were used to supplement the geological interpretation. The logs from 2006 were treated with caution, especially in drillholes where the core recovery was low.

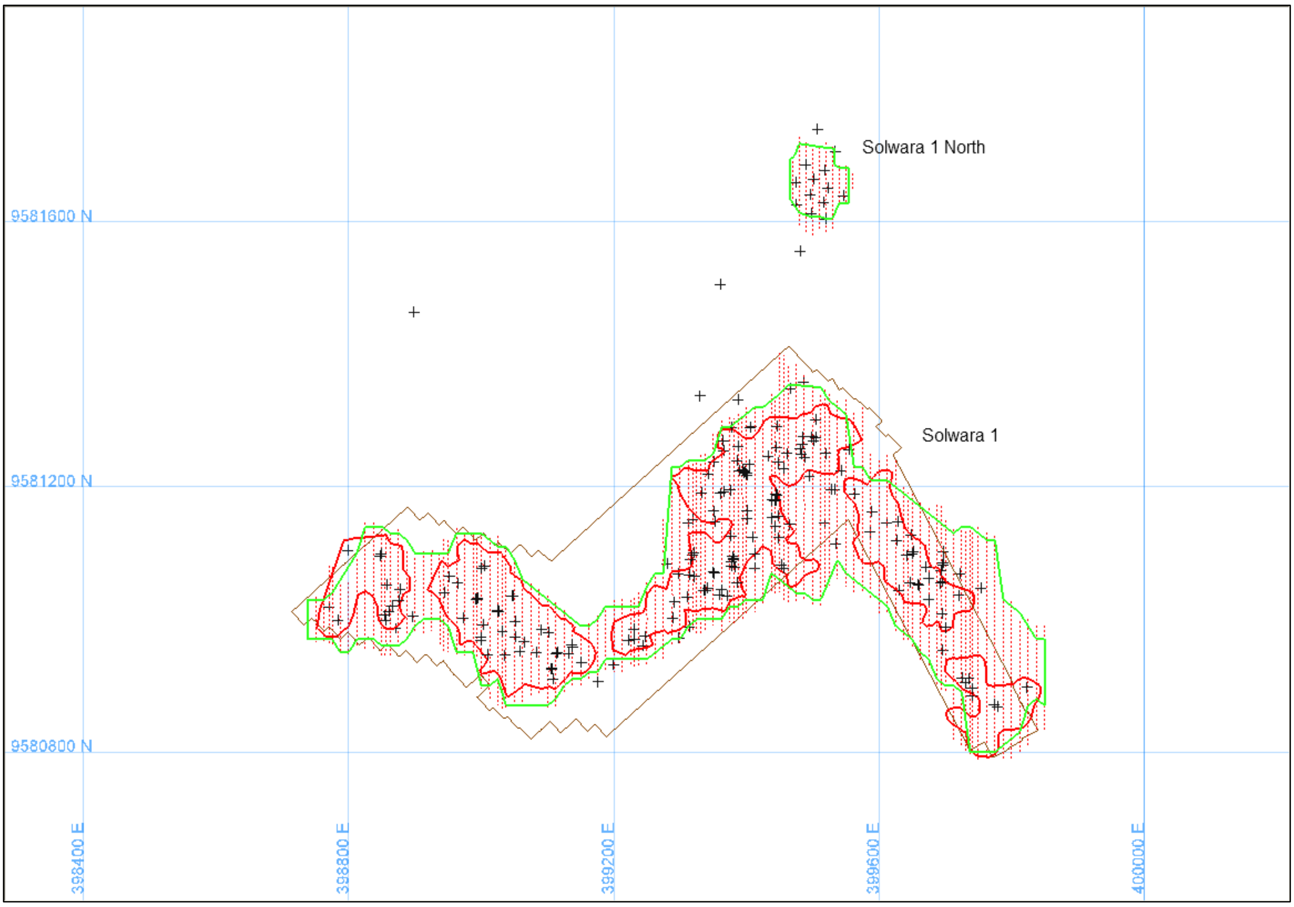
Whilst there is strong evidence that faults provide the focus for the transport of hydrothermal fluids up through the volcanic rocks, the overall form of the massive sulfide domain and sediments is of a layer parallel to the seafloor. This may be due to the lateral migration of hydrothermal fluids and precipitation of sulfide mineralisation as the rising fluids approach the seafloor interface. At Solwara 1 this layer is divided laterally into six discrete areas separated by poorly mineralised volcanic rocks.

Manual interpretation of the boundaries between stratigraphic horizons was conducted on N-S sections at 12.5 m intervals from 398,750E to 399,850E (Figure 14.1). At drillhole locations, the individual strings were “snapped” to the drillhole sample end-points unless the confidence in the drillhole was considered to be low (i.e., the 2006 drillholes). In sections with limited drilling, the interpretation of the stratigraphic contacts from adjacent sections was used to constrain the interpretation.

Sparse drilling beneath the sulfide dominant domain (Domain 400) indicates widespread alteration and disseminated and stringer mineralisation. This material (Domain 450) was modelled by copying the base of Domain 400 downwards by 2.5 m and combining this surface with a surface representing the interpreted extent of altered and mineralised material around deeper drillholes.

Stratigraphic assignment of core loss intervals was based on the core above and below the core loss interval. A generally conservative approach to modelling Domain 400 was adopted; core loss above the first down-hole intersection of sulfide dominant rock was assumed to be either SS or SC, core loss below the deepest intersection of sulfide dominant rock was assumed to be altered volcanic rocks of the footwall. This avoided the risk of over-estimating the thickness of Domain 400 in the drillholes.

Figure 14.1 Data limits and section lines for Solwara 1 and Solwara 1 North



Brown line = bathymetry limits; red line = EM anomaly; green line = limit of resource model; broken red lines = section lines; black crosses = drillhole locations.

14.2.1.2 Solwara 1 North sectional interpretation

At Solwara 1 North soft sediment cover extends down to 1.3 m and overlies a thin domain of mineralisation characterised by sphalerite, galena and gold associated with anhydrite and barite. This unit generally caps the main mineralisation at Solwara 1 North which extends down to 15.89 m and is characterised by massive chalcopyrite and pyrite with lesser sphalerite and galena.

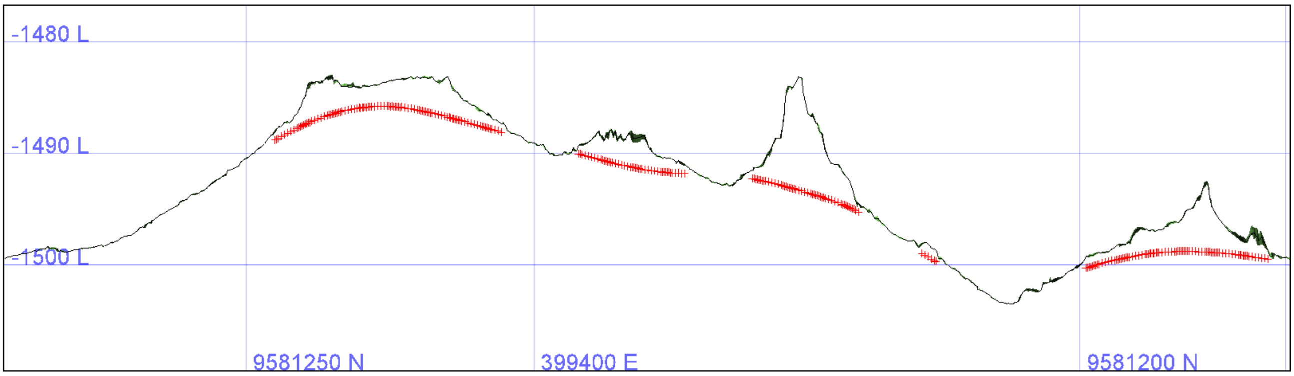
Manual interpretation of the boundaries between stratigraphic horizons at Solwara 1 North was carried out using the same methods as were used for Solwara 1. Surface wireframes were constructed for the contacts between the unconsolidated sediment, consolidated and mineralised sediment, sulfide dominant rocks and altered footwall domains.

14.2.1.3 Chimney interpretation

There were no new chimney samples collected in 2010/11 and the detailed bathymetry has not been updated since late 2007. Geological interpretation of the Solwara 1 chimney domain was therefore not updated. The detailed bathymetry (20 cm by 20 cm resolution) and the chimney assay data that was used in estimating the Mineral Resource for Solwara 1 in late 2007 was used for this estimate.

In 2007 the geological interpretation of the chimney domain was performed using an automated floating circle algorithm that identified either local chimney peaks or sulfide mounds and created a surface beneath the base of the chimney mounds (Figure 14.2). This surface is referred to in this report as the truncated bathymetry, with the chimney domain representing the area between the original and truncated bathymetry. The chimney domain contained 36,500 m^3 of material.

Figure 14.2 Section looking NE, showing original (solid line) and truncated (crosses) bathymetry



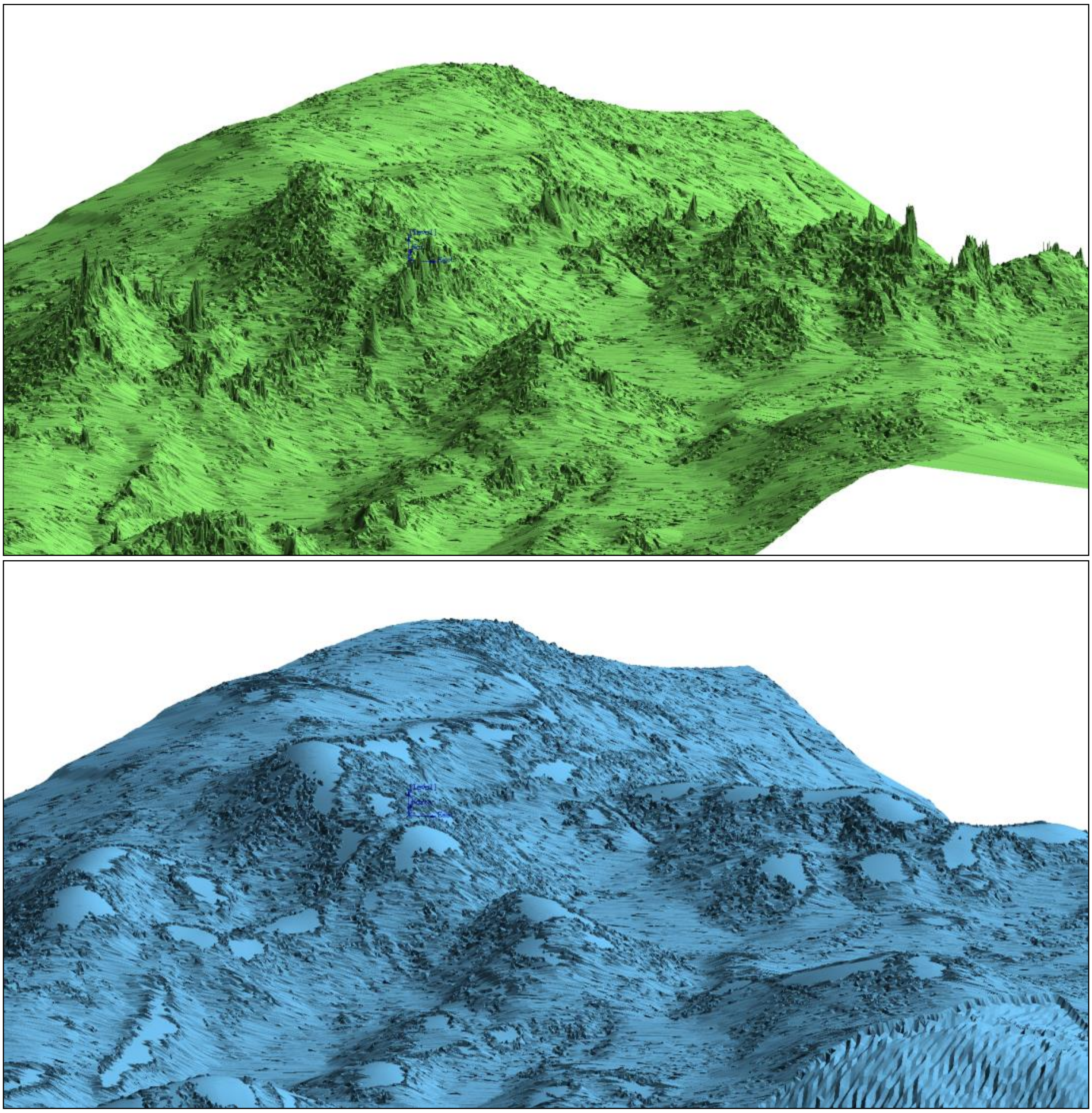
The truncated bathymetry was estimated solely from the 20 cm by 20 cm bathymetric data. Due to the limited extent of this high-resolution data it is possible that the chimney volume material is conservatively estimated. In particular, there appears to be two small sulfide mounds that straddle the high and low-resolution bathymetry in the SE corner of the deposit that may not be fully accounted for by the approach used.

Figure 14.3 shows screen captures of the original (top) and truncated (bottom) bathymetry. In the bottom, right-hand corner of the truncated bathymetry are linear artefacts that are due to the contact between the high resolution (20 cm by 20 cm) and lower resolution (1 m by 1 m) bathymetry.

Alternate chimney domain volumes were estimated independently by Nautilus in 2007 using two additional methods:

- A grid-based method in which a Low-Pass Filter (LPF) was applied to the gridded result using a fast fourier-transform. The implementation of the LPF produced a new grid that contained only long-wavelength features (i.e., the chimneys were removed, subject to the “strength” of the filter), which was then subtracted from the original bathymetric grid to produce a grid solely of the chimneys. In those areas where the LPF is above the true bathymetric level, the difference is reset to 0. The results of six LPFs with cut-off wavelengths varying from 5 m through to 30 m in 5 m increments were examined and are shown in (Table 14.1).
- A line-based method in which artificial lines separated by 20 cm were extracted from the grid into a database. These pseudo-lines were then filtered using a Non-Linear Filter designed to remove short-wavelength features such as chimneys. Although the process is automatic, each line required careful quality control resulting in the process being very time consuming. However, the process indicated that the 20-m wavelength in the grid-based method produce the most reasonable result.

Figure 14.3 Perspective view of original (top) and truncated (bottom) bathymetry for Solwara 1 and Solwara 1 North



The alternate chimney volume of 38,000 m^3 derived by Nautilus supports the 36,500 m^3 derived by Golder, which was used for resource estimation. The variability of chimney volume results in Table 14.1 is mostly related to the definition of the base of the chimney mound and not to the identification of individual chimneys.

Table 14.1 Low pass filter chimney volumes for various wavelength

LPF wavelength (m)	Chimney volume (m^3)
5	9,300
10	17,000
15	26,800
20	38,000
25	49,100
30	60,500

The chimney domain at Solwara 1 North is insignificant and has no material impact on the resource estimate and was therefore not modelled separately.

14.2.2 Block modelling

Computer block models with block dimensions of 10 m by 10 m by 0.5 m blocks were constructed by filling between the wireframe surfaces of the stratigraphic contacts to the base of the chimneys. The block model definitions are presented in Table 14.2. Sub-blocking was not used but entire blocks were assigned to geological domains on a maximum proportion basis. The proportion of the block below the base of the chimneys (truncated bathymetry) was retained for resource volume and tonnage calculations.

The horizontal block dimensions represent approximately 1/3rd of the average drillhole spacing within the Indicated Resource area. In areas where the drillhole spacing is wider the block size could result in over-smoothing of the block grade estimates. The vertical block dimension of 0.5 m is considered suitable when compared to the average sample length and enables all mining extraction scenarios to be investigated. Overall, the block size is appropriate for approximating the volume of the stratigraphic domains and block grade estimates.

Table 14.2 Block model dimensions for Solwara 1 and Solwara 1 North

Area	Dimension	Minimum	Maximum	Size (m)	Number
1	X	398,700mE	399,850mE	10	115
	Y	9,580,750mN	9,581,450mN	10	70
	Z	-1,750mRL	-1,470mRL	0.5	560
1 North	X	398,360mE	399,680mE	10	32
	Y	9,581,500mN	9,581,800mN	10	30
	Z	-1,750mRL	-1,470mRL	0.5	560

For the Solwara 1 model, complete blocks containing grade estimates of the local chimney volume (proportion) were superimposed on top of the sub-chimney model. In other words, the block model was designed to represent accurately the lithological unit volumes rather than appear aesthetically pleasing. The block model was extended to 50 m below the bathymetric surface. No discrepancies between the stratigraphic surfaces and block model domain codes were observed.

14.2.3 Resource estimation database

Block grade estimation was undertaken in the sub-chimney domains using only information from the 2007, 2008 and 2010/11 drilling programs. The drillhole database that was used for grade estimation included 187 diamond core drillholes with the “SD” prefix (Table 14.3 and Table 14.4). Only surface chimney samples were used for block grade estimation in the chimney domain (Table 14.5).

Table 14.3 Solwara 1 drillhole collar coordinates

HOLEID	PROJECT	EAST	NORTH	RL	HOLEID	PROJECT	EAST	NORTH	RL
SD036	WaveMerc07	398848.8	9581099	-1630.28	SD124	WaveMerc07	399338	9581044	-1503.46
SD037	WaveMerc07	398849.6	9581099	-1630.07	SD125	WaveMerc07	399395.8	9581225	-1490.02
SD038	WaveMerc07	398858.2	9581051	-1615.65	SD126	WaveMerc07	399398.3	9581215	-1492.67
SD039	WaveMerc07	398860.9	9581012	-1609.01	SD127	WaveMerc07	399642.1	9581094	-1519.15
SD040	WaveMerc07	398896.9	9581004	-1614.07	SD128	WaveMerc07	399696.9	9581085	-1520.49
SD041	WaveMerc07	399002.8	9580992	-1572.05	SD129	WaveMerc07	399742.1	9580890	-1520.68
SD042	WaveMerc07	399051.6	9580997	-1563.23	SD130	WaveMerc07	398857.9	9581049	-1614.78
SD043	WaveMerc07	399083.9	9580950	-1557.21	SD131	WaveMerc07	399009.4	9580995	-1571.62
SD044	WaveMerc07	399243.7	9580960	-1521.75	SD132	WaveMerc07	399336.3	9581043	-1504.14
SD045	WaveMerc07	399199.6	9580932	-1529.81	SD133	WaveMerc07	399486.4	9581276	-1508.02
SD046	WaveMerc07	399150.6	9580935	-1543.5	SD134	WaveMerc07	399390.4	9581259	-1495.38
SD047	WaveMerc07	399105.5	9580926	-1551.58	SD135	WaveMerc07	399387.2	9581257	-1493.85
SD048	WaveMerc07	399101.7	9580980	-1555.4	SD136	WaveMerc07	399397.1	9581226	-1489.84
SD049	WaveMerc07	399137	9580962	-1552.77	SD137	WaveMerc07	399395.9	9581223	-1490.92
SD050	WaveMerc07	399231.4	9580970	-1524.47	SD138	WaveMerc07	399397.1	9581221	-1490.98
SD051	WaveMerc07	399137.8	9580959	-1551.77	SD139	WaveMerc07	399519.5	9581250	-1510.81
SD052	WaveMerc07	399291.8	9581026	-1504.7	SD140	WaveMerc07	399360.8	9581190	-1505.37
SD053	WaveMerc07	399352	9581070	-1504.98	SD141	WaveMerc07	399010.3	9580947	-1574.95
SD054	WaveMerc07	399341.4	9581048	-1502.83	SD142	WaveMerc07	399445.2	9581260	-1519.51
SD055	WaveMerc07	399400.8	9581152	-1517.06	SD143	WaveMerc07	399394.5	9581226	-1489.45
SD056	WaveMerc07	399397.3	9581223	-1490.2	SD144	WaveMerc07	399376.9	9581126	-1519.52
SD057	WaveMerc07	399386.3	9581239	-1483.06	SD145	WaveMerc07	399648.6	9581127	-1521.1
SD059	WaveMerc07	399403.9	9581234	-1490.62	SD146	WaveMerc07	399676	9581062	-1520.62
SD060	WaveMerc07	399343.2	9581219	-1502.14	SD151	Norsky08	399562.8	9581189	-1511.97
SD061	WaveMerc07	399444.3	9581180	-1499.66	SD152	Norsky08	399722.6	9581068	-1533.11
SD062	WaveMerc07	399442.9	9581179	-1499.68	SD153	Norsky08	399280.8	9581084	-1516.26
SD063	WaveMerc07	399446.2	9581291	-1517.03	SD154	Norsky08	398944.5	9581040	-1605.99
SD064	WaveMerc07	399485.6	9581276	-1508.37	SD155	Norsky08	398770.3	9581018	-1646.95
SD065	WaveMerc07	399388.6	9581261	-1492.91	SD156	Norsky08	398870.4	9580986	-1619.09
SD066	WaveMerc07	399387.4	9581332	-1503.2	SD157	Norsky08	398799.3	9581103	-1643.22
SD067	WaveMerc07	399650.6	9581098	-1519.76	SD158	Norsky08	399543.3	9581224	-1518.13
SD068	WaveMerc07	399652.1	9581101	-1520.12	SD159	Norsky08	399486.2	9581358	-1546.31
SD069	WaveMerc07	399641.6	9581096	-1518.24	SD161	Norsky08	399000.6	9581077	-1587.37
SD070	WaveMerc07	399695.9	9581057	-1527.11	SD164	Norsky08	399535.4	9581114	-1489.94
SD071	WaveMerc07	399692.7	9581054	-1526.9	SD165	Drilling10	399176	9580906	-1544.9
SD072	WaveMerc07	399696	9581009	-1529.19	SD166	Drilling10	399047.2	9581035	-1575.3
SD073	WaveMerc07	399696	9580954	-1536.03	SD167	Drilling10	399031.8	9580982	-1562.5
SD074	WaveMerc07	399700	9580988	-1531.79	SD168	Drilling10	399400.5	9581221	-1490
SD075	WaveMerc07	399730.4	9580904	-1515.6	SD169	Drilling10	399401.3	9581217	-1491.5
SD076	WaveMerc07	399740.8	9580884	-1522.32	SD171	Drilling10	399455.9	9581078	-1513.4
SD077	WaveMerc07	399774.1	9580871	-1526.86	SD172	Drilling10	399465.5	9581143	-1509.4
SD078	WaveMerc07	399630.4	9581043	-1508.72	SD173	Drilling10	399466	9581348	-1534.6
SD079	WaveMerc07	399370.9	9581035	-1512.1	SD174	Drilling10	399288.6	9581002	-1514
SD080	WaveMerc07	399378.5	9581087	-1495.5	SD175	Drilling10	399452.6	9581082	-1511.1
SD081	WaveMerc07	399314	9580988	-1509.65	SD176	Drilling10	399452.7	9581082	-1511.1
SD082	WaveMerc07	399298	9580972	-1509.52	SD177	Drilling10	399389.2	9581225	-1488.4
SD083	WaveMerc07	399311.2	9581033	-1504.72	SD178	Drilling10	399064.5	9580966	-1557.6
SD084	WaveMerc07	399297.6	9581068	-1514.8	SD179	Drilling10	398964.1	9581055	-1597.1
SD085	WaveMerc07	399318	9581096	-1508.07	SD180	Drilling10	399501.7	9581269	-1506.4
SD086	WaveMerc07	399312.2	9581145	-1503.73	SD181	Drilling10	399589.5	9581163	-1499.17
SD087	WaveMerc07	399449	9581124	-1508.04	SD182	Drilling10	399230.7	9580984	-1531.3
SD088	WaveMerc07	399448	9581156	-1507.63	SD183	Drilling10	399505.2	9581301	-1525
SD089	WaveMerc07	399443.8	9581140	-1511.61	SD184	Drilling10	399380.7	9581091	-1495.8
SD090	WaveMerc07	399386.3	9581055	-1512.38	SD185	Drilling10	399380.6	9581092	-1496.7
SD091	WaveMerc07	399413.1	9581099	-1511.26	SD186	Drilling10	399378.8	9581095	-1498.3
SD092	WaveMerc07	399412.7	9581077	-1510.83	SD187	Drilling10	399115.7	9580950	-1549.8
SD093	WaveMerc07	399350.2	9581072	-1505.34	SD188	Drilling10	399113.8	9580949	-1550.3
SD094	WaveMerc07	399401.2	9581164	-1515.84	SD189	Drilling10	399108.5	9580910	-1556.6
SD095	WaveMerc07	399378	9581289	-1500.27	SD190	Drilling10	398992.2	9581031	-1580.47
SD096	WaveMerc07	399366.5	9581255	-1498.37	SD191	Drilling10	399058.3	9580951	-1562.09
SD097	WaveMerc07	399456.9	9581227	-1520.29	SD192	Drilling10	399058.1	9580951	-1561.9
SD098	WaveMerc07	399481.5	9581257	-1512.02	SD193	Drilling10	398973.9	9581002	-1582.53
SD099	WaveMerc07	399447.6	9581237	-1520.13	SD194	Drilling10	398855.3	9580999	-1608.47
SD100	WaveMerc07	399397.8	9581222	-1490.3	SD195	Drilling10	398877.1	9581045	-1607.3
SD101	WaveMerc07	399484.6	9581264	-1512.86	SD196	Drilling10	399438.7	9581153	-1508.3

HOLEID	PROJECT	EAST	NORTH	RL	HOLEID	PROJECT	EAST	NORTH	RL
SD102	WaveMerc07	399406.7	9581290	-1500.87	SD197	Drilling10	399693.7	9581073	-1522.5
SD103	WaveMerc07	399406.2	9581289	-1500.96	SD198	Drilling10	399740.3	9580896	-1520.74
SD104	WaveMerc07	399359.4	9581037	-1510.51	SD199	Drilling10	399823.1	9580897	-1553.3
SD105	WaveMerc07	399336.1	9581043	-1503.76	SD203	Drilling10	399091	9580985	-1558.97
SD106	WaveMerc07	399362.1	9581045	-1509.02	SD204	Drilling10	398994.8	9581031	-1580.12
SD107	WaveMerc07	399555.5	9581256	-1514.81	SD205	Drilling10	398993.7	9581031	-1580
SD108	WaveMerc07	399495.5	9581216	-1516.97	SD206	Drilling10	399004.9	9581080	-1587.6
SD109	WaveMerc07	399696.6	9581082	-1520.35	SD207	Drilling10	399035.4	9580946	-1567.1
SD110	WaveMerc07	399696.7	9581102	-1525.28	SD208	Drilling10	398952.1	9581065	-1598.7
SD111	WaveMerc07	399754.7	9581047	-1545.82	SD209	Drilling10	398783.4	9580999	-1642.5
SD112	WaveMerc07	399485.9	9581274	-1508.32	SD210	Drilling10	398848.1	9581096	-1628.66
SD113	WaveMerc07	399353.6	9581147	-1509.89	SD211	Drilling10	399048.3	9581035	-1575.43
SD114	WaveMerc07	399675.1	9581030	-1519.22	SD212	Drilling10	399586.7	9581132	-1500.38
SD115	WaveMerc07	399351.5	9581237	-1502.54	SD213	Drilling10	399658.2	9581053	-1512.9
SD116	WaveMerc07	399388	9581259	-1494.87	SD214	Drilling10	399660	9581051	-1512
SD117	WaveMerc07	399404.4	9581233	-1491.31	SD215	Drilling10	399611.9	9581146	-1504.3
SD118	WaveMerc07	399150	9580933	-1543.78	SD216	Drilling10	399626.8	9581118	-1512.5
SD119	WaveMerc07	399106.3	9580925	-1551.25	SD217	Drilling10	399409.3	9581124	-1507.2
SD120	WaveMerc07	399134.9	9580953	-1550.06	SD218	Drilling10	399332.2	9581191	-1499
SD121	WaveMerc07	399080.4	9580956	-1557.68	SD219	Drilling10	399446.4	9581188	-1498.3
SD122	WaveMerc07	399074	9580930	-1562.72	SD220	Drilling10	399433	9581246	-1515.25
SD123	WaveMerc07	399290.8	9581030	-1505.69					

Table 14.4 Solwara 1 North drillhole collar coordinates

HOLEID	PROJECT	EAST	NORTH	RL	HOLEID	PROJECT	EAST	NORTH	RL
SD148	Norsky08	399523.1	9581651	-1624.47	SD202	Drilling10	399534.3	9581706	-1634.2
SD149	Norsky08	399498.1	9581612	-1610.43	SD221	Drilling10	399501.4	9581664	-1628.6
SD160	Norsky08	399481.1	9581556	-1589.44	SD222	Drilling10	399517.5	9581629	-1616.98
SD162	Norsky08	399518.3	9581678	-1633.85	SD223	Drilling10	399475.3	9581626	-1614.38
SD163	Norsky08	399507.6	9581740	-1644.12	SD224	Drilling10	399520.2	9581604	-1607.92
SD200	Drilling10	399496.8	9581640	-1619.6	SD225	Drilling10	399474.7	9581660	-1625.54
SD201	Drilling10	399489.8	9581686	-1633	SD241	Drilling10	399546.7	9581639	-1619.1

Table 14.5 Chimney sample coordinates

SAMPLEID	SiteNo	UTM_56S_ DGPS_X	UTM_56S_ DGPS_Y	Z	SAMPLEID	SiteNo	UTM_56S_ DGPS_X	UTM_56S_ DGPS_Y	Z
58505	SSU_07_CH_006	399059.0	9580990.0	-1567.0	59744	SOL1_07_CH_069	399049.5	9580999.0	-1582.0
58506	SOL1_07_CH_001	399607.0	9581033.0	-1503.0	59746	SOL1_07_CH_070a	399052.2	9580933.3	-1588.2
58508	SSU_07_CH_008	399083.0	9580966.0	-1548.0	59748	SOL1_07_CH_070b	399052.6	9580946.7	-1586.9
58542	SOL1_07_CH_002	399706.0	9581088.0	-1500.0	59750	SOL1_07_CH_071	399026.0	9580942.7	-1595.5
58543	SOL1_07_CH_003	399470.0	9581284.0	-1500.0	59752	SOL1_07_CH_072	399017.7	9580977.2	-1597.5
58544	SOL1_07_CH_004	399700.5	9581086.0	-1500.0	59754	SOL1_07_CH_073	399004.2	9580964.6	-1596.7
58545	SOL1_07_CH_005	399470.0	9581290.0	-1500.0	59756	SOL1_07_CH_074	399028.8	9581012.2	-1577.0
58546	SOL1_07_CH_006	399474.0	9581289.0	-1500.0	59758	SOL1_07_CH_075	398993.4	9581013.4	-1600.0
58547	SOL1_07_CH_007	399468.0	9581283.0	-1500.0	59760	SOL1_07_CH_076a	399017.5	9581028.7	-1603.2
58548	SOL1_07_CH_008	399412.0	9581288.0	-1500.0	59762	SOL1_07_CH_076b	399017.5	9581028.7	-1603.2
58549	SOL1_07_CH_009	399700.0	9581086.0	-1500.0	59764	SOL1_07_CH_077	398842.5	9581099.0	-1657.9
58550	SOL1_07_CH_010	399092.0	9580981.0	-1500.0	59766	SOL1_07_CH_078	399624.7	9581125.0	-1533.7
58551	SOL1_07_CH_011	399092.0	9580981.5	-1500.0	59768	SOL1_07_CH_079	399605.8	9581111.1	-1529.5
58553	SOL1_07_CH_013	399092.5	9580981.0	-1500.0	59770	SOL1_07_CH_080a	399662.6	9581115.9	-1540.7
58554	SOL1_07_CH_014	399092.5	9580981.5	-1500.0	59772	SOL1_07_CH_080b	399681.8	9581124.5	-1547.4
58556	SOL1_07_CH_017	399696.0	9580978.4	-1533.3	59774	SOL1_07_CH_081	399630.9	9581074.5	-1532.7
58557	SOL1_07_CH_018	399706.0	9581009.7	-1529.9	59776	SOL1_07_CH_082a	399650.1	9581066.4	-1533.7
58558	SOL1_07_CH_019	399678.6	9581048.5	-1519.4	59778	SOL1_07_CH_082b	399670.7	9581072.4	-1538.3
58559	SOL1_07_CH_020	399638.2	9581114.9	-1517.4	59780	SOL1_07_CH_083	399723.5	9581087.4	-1544.4
58560	SOL1_07_CH_021	399622.0	9581157.7	-1510.8	59782	SOL1_07_CH_084	399735.3	9581070.9	-1550.1
58561	SOL1_07_CH_022	399546.6	9581260.4	-1512.1	59784	SOL1_07_CH_085	399730.9	9581044.5	-1544.7
58562	SOL1_07_CH_025	399374.9	9581195.4	-1503.9	59786	SOL1_07_CH_086	399701.6	9581037.8	-1547.2
58563	SOL1_07_CH_027	399435.0	9581143.4	-1509.7	59788	SOL1_07_CH_087	399649.1	9581027.8	-1535.0
58564	SOL1_07_CH_028	399371.8	9581085.6	-1499.6	59790	SOL1_07_CH_088	399669.8	9581014.8	-1545.9
58565	SOL1_07_CH_029	399350.7	9581062.9	-1506.3	59792	SOL1_07_CH_089	399639.6	9581014.9	-1527.2
58566	SOL1_07_CH_030	399295.8	9581027.5	-1509.1	59794	SOL1_07_CH_090	399597.3	9581053.3	-1530.9
58567	SOL1_07_CH_031	399258.0	9580979.5	-1515.1	PNGSW2001	SUZ_Surf_002	399725.4	9580906.0	-1522.8
58568	SOL1_07_CH_032	399203.2	9580947.2	-1533.5	PNGSW2002	SUZ_Surf_003	399726.8	9580909.0	-1519.7
58569	SOL1_07_CH_033	399106.1	9580935.0	-1553.1	PNGSW2003	SUZ_Surf_005	399386.0	9581181.0	-1511.0
58570	SOL1_07_CH_034	399000.9	9580959.0	-1577.4	PNGSW2004	SUZ_Surf_007	399366.0	9581169.0	-1512.5
58571	SOL1_07_CH_035	398859.3	9581020.3	-1610.6	PNGSW2005	SUZ_Surf_009	399377.0	9581082.0	-1503.0
58572	SOL1_07_CH_036	398947.7	9581003.6	-1593.4	PNGSW2006	SUZ_Surf_010	399054.0	9580979.0	-1500.0
58573	SOL1_07_CH_023	399439.4	9581216.5	-1512.5	PNGSW2007	SUZ_Surf_011	399078.0	9580947.0	-1500.0
59674	SOL1_07_CH_037	399443.8	9581305.5	-1593.5	PNGSW2008	SUZ_Surf_012	399099.0	9580964.0	-1562.0
59676	SOL1_07_CH_038	399466.6	9581304.4	-1548.2	PNGSW2009	SUZ_Surf_013	398987.0	9580975.0	-1581.0
59678	SOL1_07_CH_039a	399459.0	9581332.4	-1549.4	PNGSW2011	SUZ_Surf_014	398830.0	9580973.0	-1623.0
59680	SOL1_07_CH_039b	399459.0	9581332.4	-1549.4	PNGSW2014	SUZ_Surf_019	399349.0	9581178.0	-1504.0
59682	SOL1_07_CH_039c	399458.9	9581338.6	-1553.3	PNGSW2016	SUZ_Surf_018	399605.0	9581054.0	-1500.0
59684	SOL1_07_CH_040	399456.9	9581319.9	-1550.5	PNGSW2017	SUZ_Surf_021	399769.0	9580824.0	-1535.0
59686	SOL1_07_CH_041	399495.1	9581301.3	-1544.2	PNGSW2018	SUZ_Surf_026	399735.0	9580920.0	-1516.0
59688	SOL1_07_CH_042	399500.8	9581278.8	-1519.0	PNGSW2019	SUZ_Surf_025	399633.0	9581142.0	-1521.0
59690	SOL1_07_CH_043	399523.6	9581264.1	-1526.8	PNGSW2021	SUZ_Surf_028	399660.0	9581085.0	-1520.0
59692	SOL1_07_CH_044a	399493.0	9581239.1	-1535.9	PNGSW2022	SUZ_Surf_027	399629.0	9581140.0	-1516.0
59694	SOL1_07_CH_044b	399502.6	9581247.0	-1529.3	PNGSW2023	SUZ_Surf_022	399802.0	9580855.0	-1550.0
59696	SOL1_07_CH_045	399522.7	9581248.2	-1528.0	PNGSW2025	SUZ_Surf_020	399707.0	9581090.0	-1526.0
59698	SOL1_07_CH_046	399463.5	9581262.6	-1542.3	PNGSW2027	SUZ_Surf_030	399632.0	9581141.0	-1521.0
59700	SOL1_07_CH_047	399474.8	9581239.2	-1542.9	PNGSW2028	SUZ_Surf_031	399662.0	9581040.0	-1501.0
59702	SOL1_07_CH_048	399443.9	9581281.2	-1539.0	PNGSW2029	SUZ_Surf_032	399664.0	9581040.0	-1505.0
59704	SOL1_07_CH_049	399408.8	9581240.9	-1514.3	PNGSW2031	SUZ_Surf_033	399670.0	9581043.0	-1508.0
59706	SOL1_07_CH_050	399382.3	9581235.5	-1510.6	PNGSW2051	SUZ_Surf_006	399414.2	9581201.0	-1505.7
59708	SOL1_07_CH_051	399402.6	9581199.1	-1519.0	PNGSW2052	SUZ_Surf_015	399452.0	9581292.0	-1523.0
59710	SOL1_07_CH_052	399370.9	9581199.2	-1523.6	PNGSW2053	SUZ_Surf_017	399719.0	9581089.0	-1533.0
59712	SOL1_07_CH_053	399455.1	9581171.1	-1527.6	PNGSW2054	SUZ_Surf_020	399707.0	9581090.0	-1526.0
59714	SOL1_07_CH_054	399445.3	9581177.9	-1520.1	PNGSW2056	SUZ_Surf_023	398851.0	9581005.0	-1613.0
59716	SOL1_07_CH_055	399411.3	9581161.8	-1539.0	PNGSW2057	SUZ_Surf_024	399633.0	9581146.0	-1520.0
59718	SOL1_07_CH_056	399359.4	9581158.9	-1532.8	PNGSW2058	SUZ_Surf_029	399660.0	9581085.0	-1520.0
59720	SOL1_07_CH_057	399330.6	9581150.8	-1528.6	PNGSW2059	SUZ_Surf_034	399429.0	9581193.0	-1502.0
59722	SOL1_07_CH_058	399399.6	9581095.5	-1446.4	PNGSW2061	SUZ_Surf_035	399424.0	9581204.0	-1500.0
59724	SOL1_07_CH_059	399374.9	9581037.3	-1535.2	PNGSW2065	SUZ_Surf_036	399050.0	9580968.0	-1561.0
59726	SOL1_07_CH_060	399337.3	9581040.8	-1506.5	PNGSW2068	SUZ_Surf_037	399073.0	9580969.0	-1558.9
59728	SOL1_07_CH_061	399313.4	9581033.4	-1527.8	PNGSW2069	SUZ_Surf_038	399075.0	9580971.0	-1558.2
59730	SOL1_07_CH_062	399261.7	9580984.4	-1546.3	PNGSW2072	SUZ_Surf_039	399074.0	9580966.0	-1560.1
59732	SOL1_07_CH_063	399222.8	9580966.3	-1550.9	PNGSW2074	SUZ_Surf_040	399430.0	9581253.0	-1522.6
59734	SOL1_07_CH_064	399203.8	9580954.2	-1557.1	PNGSW2077	SUZ_Surf_041	399531.0	9581238.0	-1524.8
59736	SOL1_07_CH_065	399138.6	9580946.9	-1563.5	PNGSW2079	SUZ_Surf_042	399380.0	9581071.0	-1513.0
59738	SOL1_07_CH_066	399164.4	9580947.9	-1578.3	PNGSW2081	SUZ_Surf_043	399364.0	9581072.0	-1511.0
59742	SOL1_07_CH_068	399078.4	9580995.6	-1581.4					

14.2.4 Compositing

Compositing of drillhole samples was not undertaken due to core loss and irregular sampling intervals. To account for the variable sample lengths in block grade estimation length-weighting was used. The minimum and maximum drillhole sample lengths are 0.04 m and 1.85 m respectively, with an average of 0.66 m. Samples from the 2010/11 program were on average slightly shorter, probably due to the lower core recovery compared to 2007. Figure 14.4 shows histograms of the sample lengths.

Figure 14.4 Histogram of sample lengths for Solwara 1 (left) and Solwara 1 North (right)

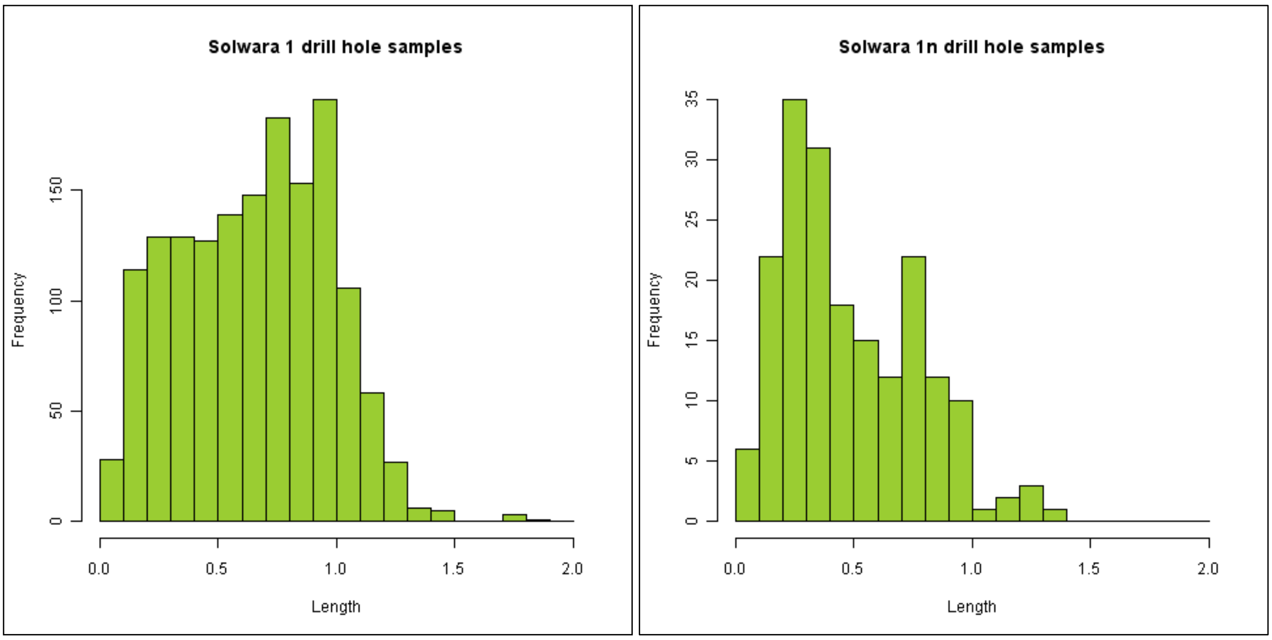
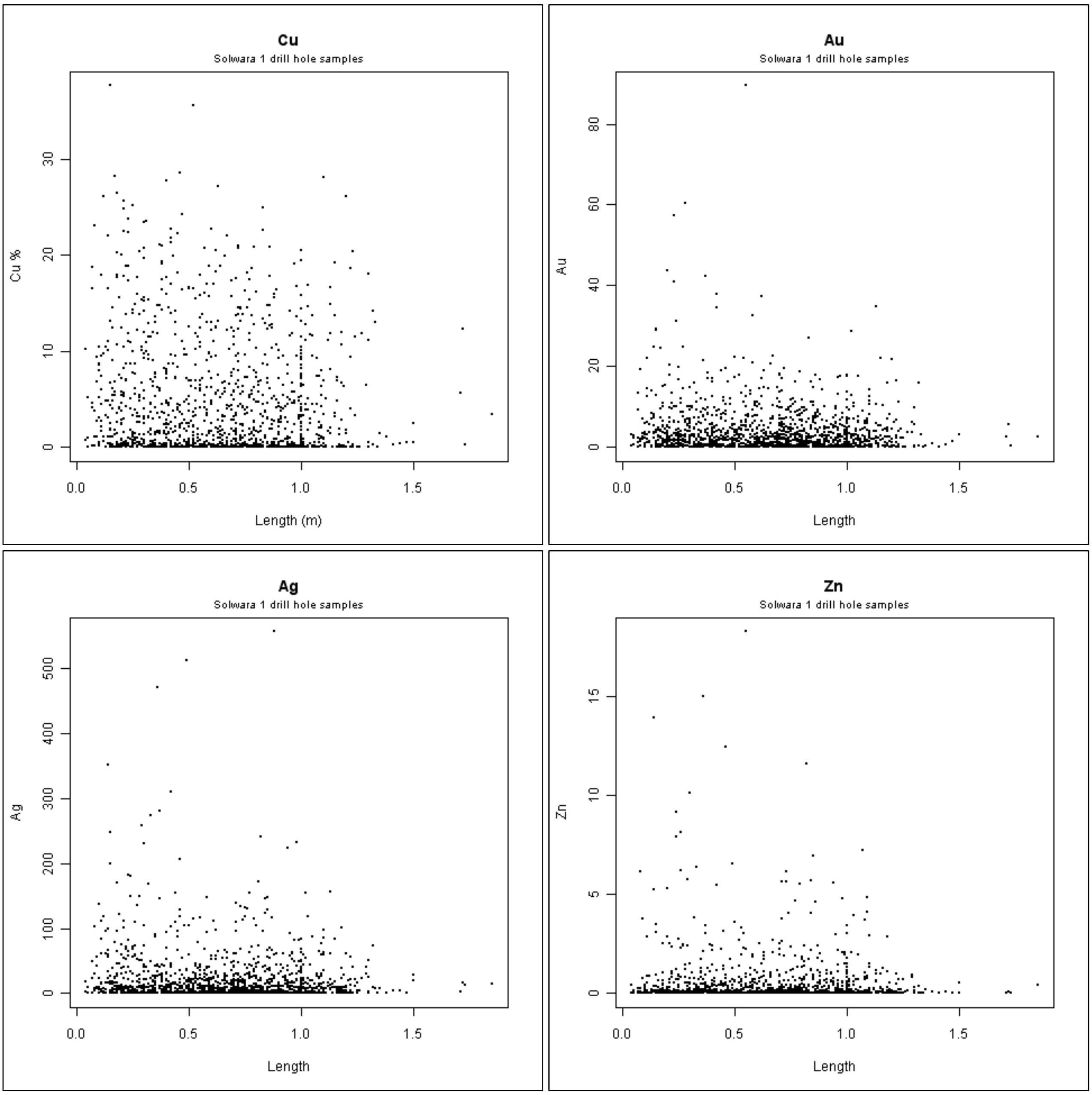


Figure 14.5 shows scatter plots of Cu, Au, Ag and Zn grades versus drillhole sample length. These plots indicate that grades are not correlated with sample length, supporting the decision not to composite the samples but rather to use their lengths for weighting during block grade estimation.

Figure 14.5 Scatter plots of grade versus sample length for Solwara 1



14.2.5 Statistical analysis

Both the diamond drilling and surface chimney sampling were observed to be clustered. To reduce the influence of data clustering in the summary statistics, cell declustering with a 25 m by 25 m horizontal cell dimension was used to calculate individual sample weights. Summary statistics with declustering weights applied are presented in Table 14.6 and Table 14.7. The declustered summary statistics were used to validate the kriged block model. It is important to note that the declustered statistics do not account for extrapolation within or at the margins of the resource area.

Cumulative probability plots for Cu, Au, Ag and Zn by stratigraphic domain are shown in Figure 14.6, Figure 14.7, and Figure 14.8. The cumulative probability plots were used to identify high-grade outliers in the drillhole sample distributions and determine appropriate high grade-cut values (Table 14.8) to reduce the influence of those high-grade outliers in block grade estimation. High grade top-cuts were identified on the cumulative probability plots by observing where the distribution started to break down above the 90th percentile. The coefficient of variation for Cu, Au, Ag and Zn for each stratigraphic domain was used to check the impact of applying the top-cuts.

Table 14.6 Declustered length weighted summary statistics for Solwara 1

Element	Domain name	Domain code	No. Obs.	Min.	Max.	Mean	Variance	Coefficient of Variation
Cu (%)	Unconsolidated	200	60	0.01	25.2	2.26	26.94	2.30
	Consolidated	300	92	0.03	20.8	4.46	17.03	0.93
	Sulfide dominant	400	737	0.001	37.7	7.67	43.97	0.86
	Upper footwall	450	260	0.004	9.7	0.54	0.80	1.65
	Lower footwall	500	203	0.003	4.42	0.24	0.29	2.28
	Chimney	600	137	0.04	25	10.50	64.8	0.77
Au (g/t)	Unconsolidated	200	60	0.005	11.2	1.81	6.79	1.44
	Consolidated	300	92	0.05	37.3	5.49	43.53	1.20
	Sulfide dominant	400	737	0.03	60.3	6.05	38.72	1.03
	Upper footwall	450	260	0.005	9.32	0.63	0.66	1.29
	Lower footwall	500	203	0.005	19.5	0.28	1.81	4.87
	Chimney	600	137	0.01	40	14.91	98.6	0.67
Ag (g/t)	Unconsolidated	200	60	0.5	258	15.70	800	1.80
	Consolidated	300	92	0.5	556	56.98	6245	1.39
	Sulfide dominant	400	737	0.5	470	28.57	1374	1.30
	Upper footwall	450	260	0.5	34	3.75	38.29	1.65
	Lower footwall	500	203	0.5	44	3.56	37.93	1.73
	Chimney	600	137	10	300	151.7	6466	0.53
Zn (%)	Unconsolidated	200	60	0.002	5.74	0.28	0.34	2.11
	Consolidated	300	92	0.005	11.6	1.70	5.21	1.34
	Sulfide dominant	400	737	0.001	15	0.52	1.07	1.99
	Upper footwall	450	260	0.003	1.84	0.11	0.09	2.80
	Lower footwall	500	203	0.001	7.22	0.14	0.40	4.60
	Chimney	600	126	0.05	20	5.85	42.3	1.11

Table 14.7 Declustered length weighted summary statistics for Solwara 1 North

Element	Domain name	Domain code	No. Obs.	Min.	Max.	Mean	Variance	Coefficient of Variation
Cu (%)	Unconsolidated	200	14	0.01	14.9	0.17	2.05	8.41
	Consolidated	300	20	0.09	25.7	3.57	23.28	1.35
	Sulfide dominant	400	43	0.25	30.1	8.12	28.65	0.66
	Upper footwall	450	28	0.02	9.00	2.58	6.27	0.97
	Lower footwall	500	71	0.007	20.4	1.06	10.92	3.12
Au (g/t)	Unconsolidated	200	14	0.005	13.5	0.20	1.71	6.68
	Consolidated	300	20	0.24	20.9	10.67	41.57	0.60
	Sulfide dominant	400	43	0.43	26.2	8.49	65.22	0.95
	Upper footwall	450	28	0.03	7.82	1.50	2.39	1.03
	Lower footwall	500	71	0.01	21.2	0.97	5.21	2.36
Ag (g/t)	Unconsolidated	200	14	0.5	50	6.57	144.3	1.83
	Consolidated	300	20	9	580	182.55	28880	0.93
	Sulfide dominant	400	43	1	333	61.39	4964	1.15
	Upper footwall	450	28	1	20	6.27	27.89	0.84
	Lower footwall	500	71	1	423	13.16	717	2.04
Zn (%)	Unconsolidated	200	14	0.003	4.05	0.39	0.76	2.25
	Consolidated	300	20	0.16	23.2	8.50	64.33	0.95
	Sulfide dominant	400	43	0.02	12.8	1.86	5.93	1.31
	Upper footwall	450	28	0.01	3.95	0.40	0.48	1.75
	Lower footwall	500	71	0.005	22.7	0.70	2.73	2.37

Figure 14.6 Cumulative probability plots for sub-chimney domains for Solwara 1

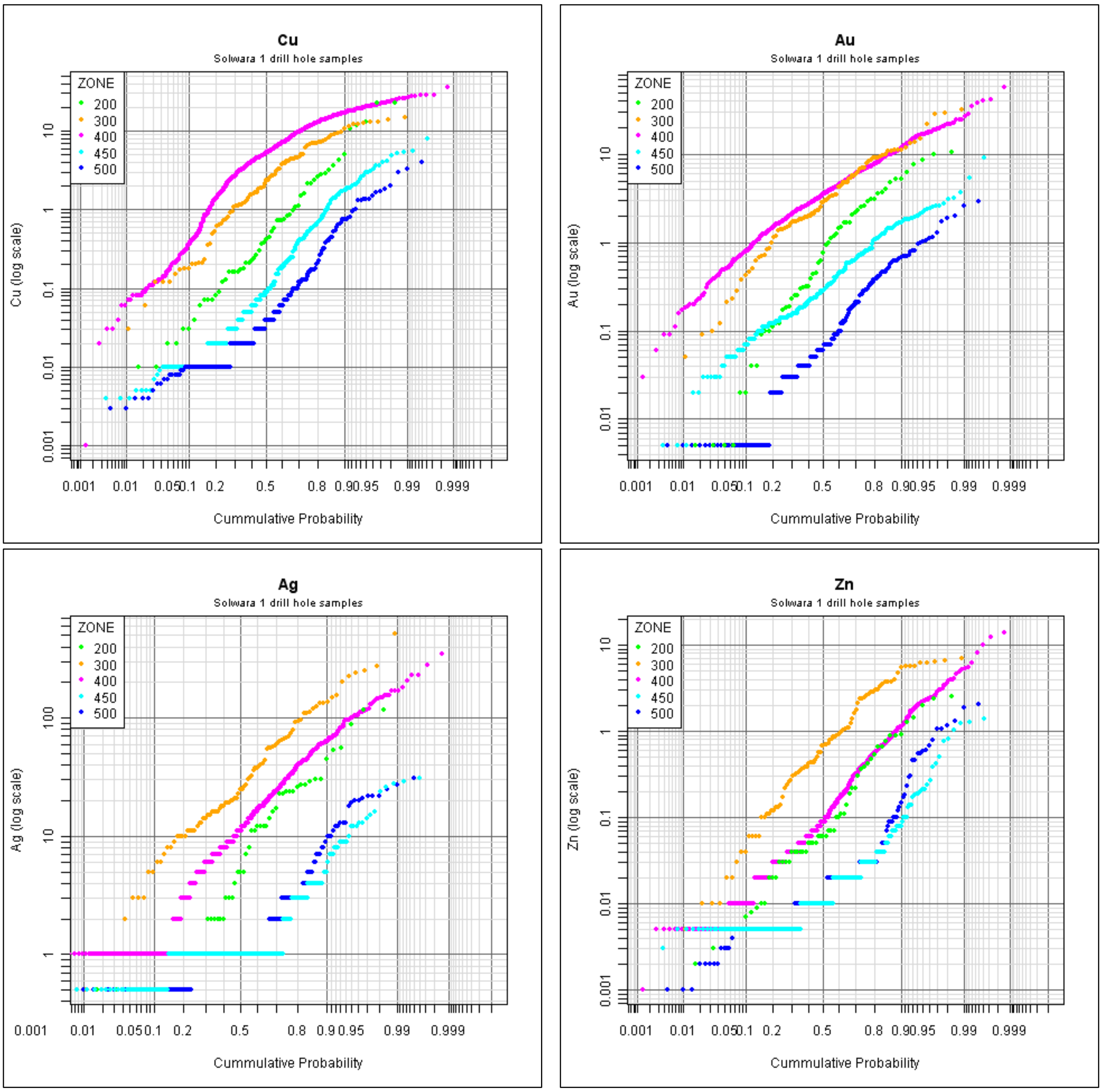


Figure 14.7 Cumulative probability plots for chimney domain for Solwara 1

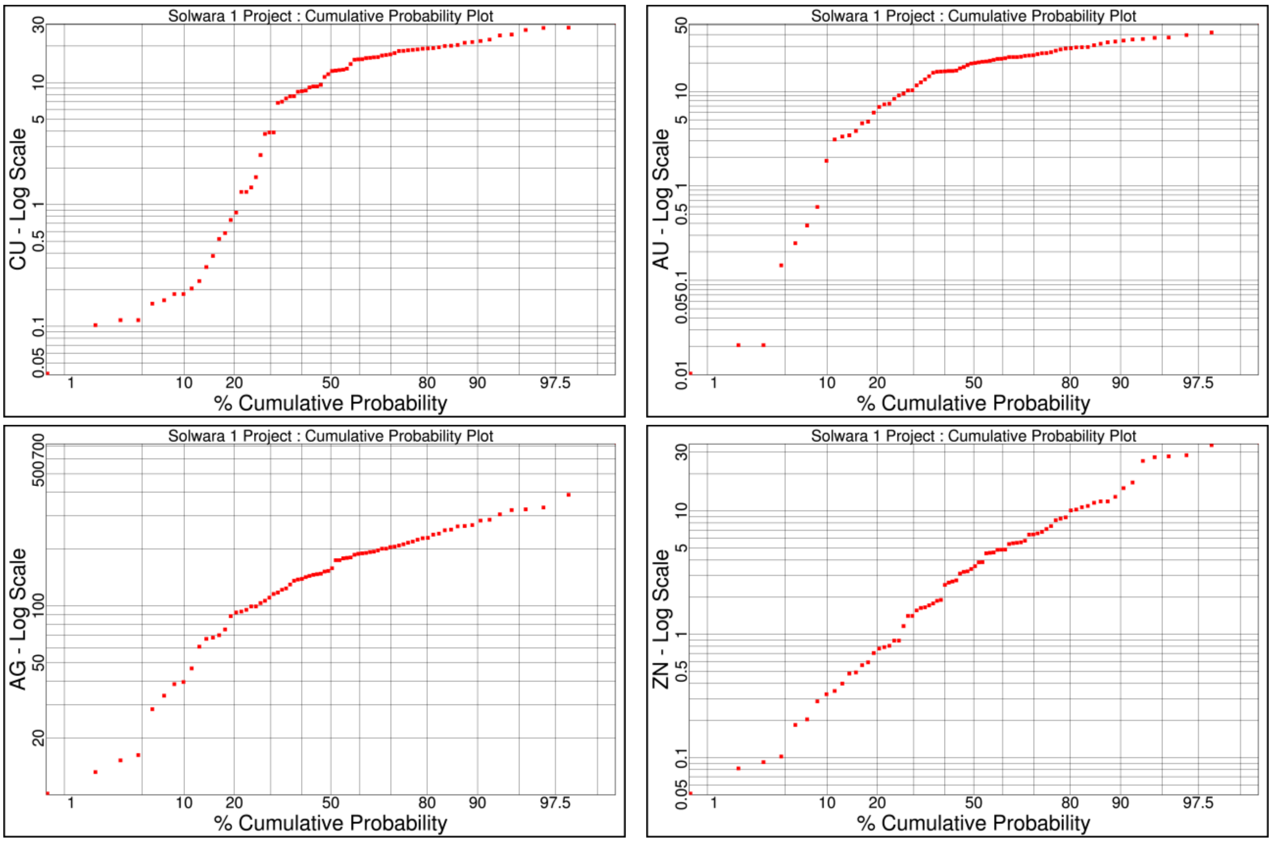


Figure 14.8 Cumulative probability plots for sub-chimney domains for Solwara 1North

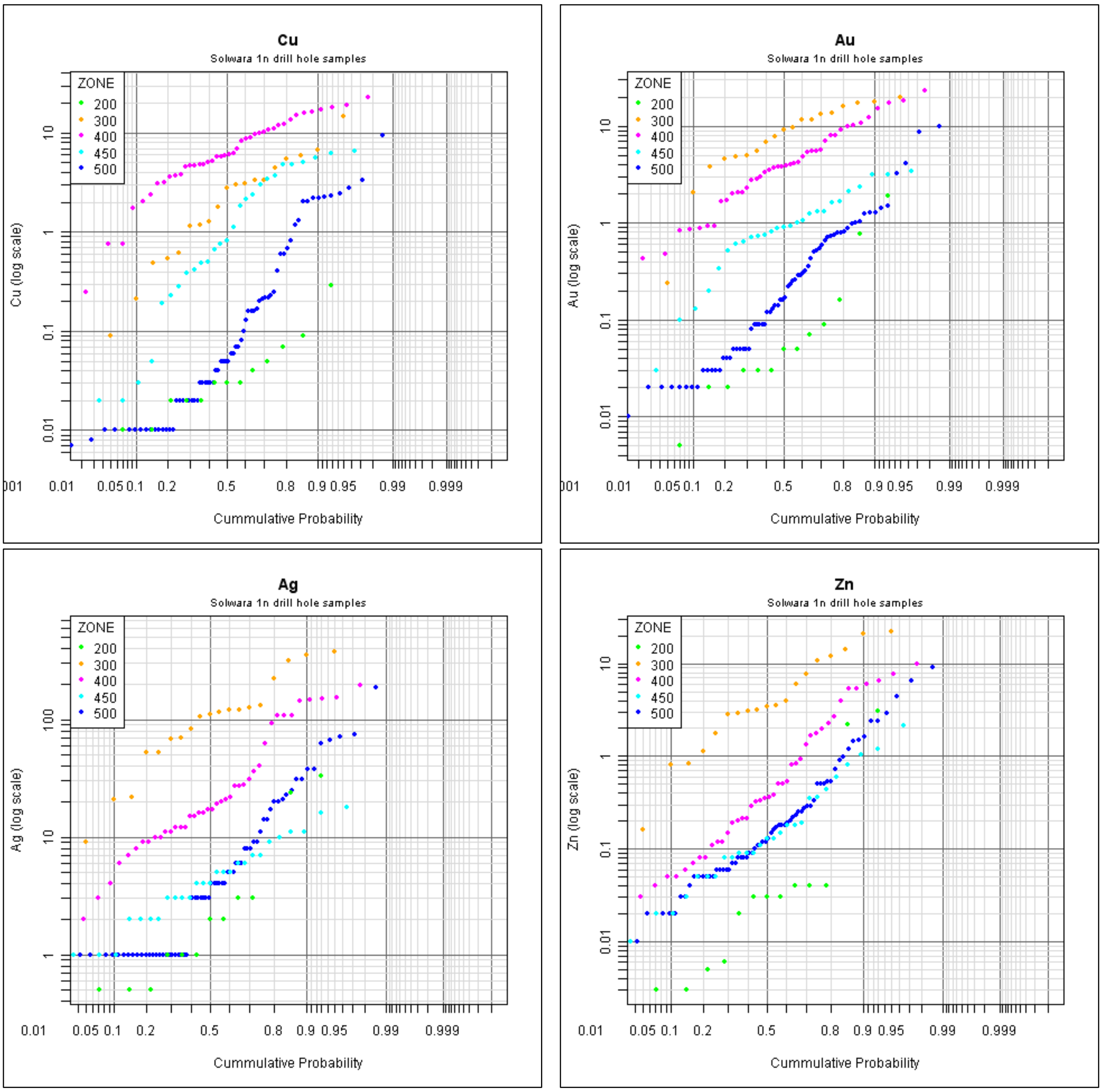


Table 14.8 High grade cuts for Solwara 1 and Solwara 1 North

Area	Domain name	Domain code	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
1	Unconsolidated	200	5	10	30	1.5
	Consolidated	300	12	20	150	5
	Sulfide dominant	400	28	30	200	6
	Upper footwall	450	5	4	30	0.5
	Lower footwall	500	2	2	30	0.3
	Chimney	600	25	40	300	20
1 North	Unconsolidated	200	0.2	0.5	20	0.1
	Consolidated	300	10	15	100	4.0
	Sulfide dominant	400	20	20	100	5.0
	Upper footwall	450	4	2	20	1.0
	Lower footwall	500	2	2	20	1.0

14.2.6 Bulk density

Measurements of dry bulk density were determined on samples of drill core and chimneys, as described in Item 11.3. Table 14.9 lists the weighted average dry bulk density of samples from each stratigraphic domain, the average values of the dominant material types in each domain and the adjusted dry bulk density used in estimating the resource tonnage. For the resource model, a single adjusted dry bulk density value was assigned to each domain.

The adjusted dry bulk density value used for the unconsolidated sediment domain was based on the assumption that the recovered samples of the SS material type were representative of the domain. It is clear from the average of the samples in the domain, that some materials with higher density than the SS material type are incorporated into this domain in the resource model.

Similarly, there are clearly some samples of low density SS within the consolidated sediment domain in the resource model. A value of 2.4 t/m^3 was selected as the adjusted dry bulk density value used for the consolidated sediment domain to better reflect the dominant PT and SC materials in the domain.

For the sulfide dominant domain, the dry bulk density value was adjusted to include an allowance for the likelihood that some of the intervals of core loss may be due to higher than average porosity. In the sulfide dominant domain, the average core recovery was 67% and the dominant material type, RI, has an average dry bulk density of 3.3 t/m^3. The dry bulk density of the core loss material was estimated to be 2.35 t/m^3 (Item 11.3.6). If the recovered core was all RI, the weighted average of core and core loss was estimated to be about 3.0 t/m^3, which was also the value used in the 2008 resource estimate. This compares to the weighted mean dry bulk density of the samples within the domain in the resource model, which was 3.14 t/m^3.

There is currently insufficient data to justify different density estimates for Domains 450 and 500, so an adjusted dry bulk density value of 2.2 t/m^3 was used for estimation of the footwall domains, reflecting the average of all the RA and RC dry bulk density measurements.

Table 14.9 Dry bulk density values assigned to resource domains

Domain name	Domain code	Weighted mean dry bulk density of samples in the domain (t/m^3)	Mean dry bulk density of dominant materials (t/m^3)	Adjusted value for resource estimate (t/m^3)
Unconsolidated	200	1.59	SS =1.22	1.2
Consolidated	300	2.13	PT = 2.95, SC = 2.27	2.4
Sulfide dominant	400	3.14	RI = 3.30, CF = 2.98	3.0
Upper footwall	450	2.28	RC = 2.54, RA = 2.15	2.2
Lower footwall	500	2.02	RC = 2.54, RA = 2.15	2.2
Chimney	600	2.22	2.3	2.2

14.2.7 Unfolding

In instances where stratigraphic units have been subjected to folding, or where the mineralisation continuity does not follow a planar orientation along strike or down dip, standard methods of variography and interpolation using linear vectors in space often do not provide a good representation of continuity. One way to account for this would be to subdivide the deposit into domains of almost constant dip orientation and perform variography for each domain independently. However, this would probably result in very few sample pairs for some domains. An alternative method, which ensures maximum correlation, uses an unfolding plane to relate samples from adjacent drillholes.

Following the definition of three-dimensional surface wireframes representing the geological interpretation, a folded surface can be defined that follows the footwall, hangingwall, or median points of each domain. Alternatively, a separate surface that follows the maximum (or minimum) tenor of mineralisation within a wireframe can be defined. These surfaces may be modelled in three dimensions to create a series of unfolding surfaces about which both the data sets and the block model can be considered to be unfolded for the purpose of variography and grade estimation. The unfolding method enables the spatial relationships between geological samples to be correctly represented. For example, by unfolding using a surface, all the sample points that are equidistant from that surface become related for the purpose of estimating grades into blocks that are also equidistant from that surface.

The unfolding process allows for varying plunge and dip directions, which essentially reduces the variogram search directions to two dimensions removing the vertical search direction. The major and semi-major axes are now defined as the directions of greatest continuity within the plane of unfolding. When the unfolding technique is employed, the plunge and dip orientations are not relevant in the definition of the major directions of continuity.

Due to the variable orientation of the mineralisation at Solwara 1, unfolding was employed for resource modelling in the stratigraphic domains below the chimney domain. The following interpreted surfaces across the deposit were adopted for unfolding:

- Domain 200 was unfolded to the base of Domain 200.
- Domain 300 was unfolded to the top of Domain 400.
- Domain 400 was unfolded to the top of Domain 400.
- Domain 450 was unfolded to the base of Domain 400.
- Domain 500 was unfolded to the base of Domain 450.

14.2.8 Variography

Golder investigated potential spatial anisotropy for the grade variables Cu, Au, Ag, and Zn by calculating experimental semi-variogram models for the sulfide dominant domain (Domain 400). Correlograms were selected for analysis as they are robust in the presence of erratic grades. The correlograms used are inverted (1 – correlogram) to present like variograms with an expected sill value of 1.0.

There was insufficient data to generate correlogram maps to assess directional anisotropy in the unfolded plane. Down-hole and omni-planar experimental correlograms were modelled for Cu, Au, Ag and Zn for the sulfide dominant domain to provide parameters for kriging, and are shown in Figure 14.9 and Figure 14.10. Omni-planar correlograms represent the average correlogram within the unfolded plane.

Figure 14.9 Downhole correlograms for Solwara 1: Domain 400

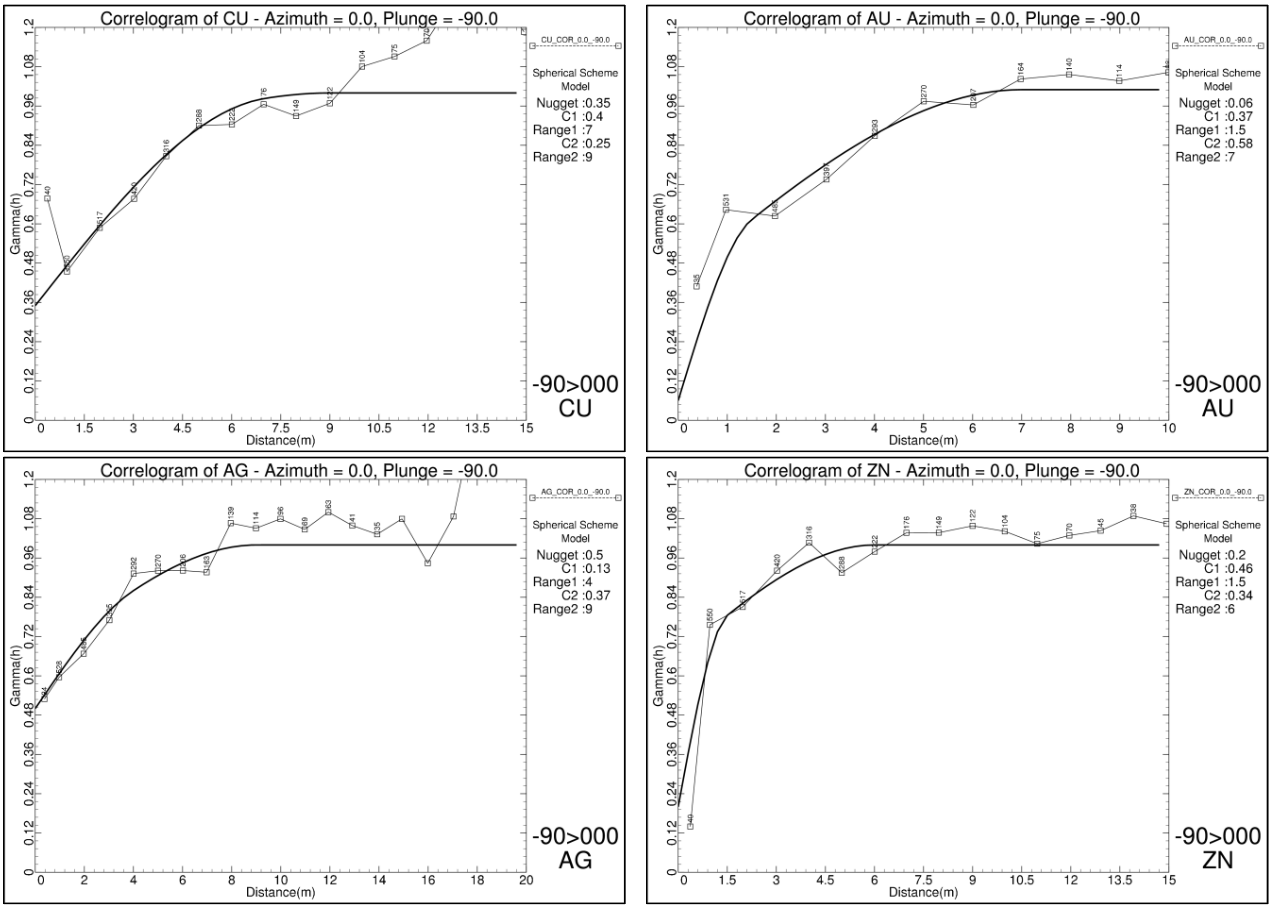
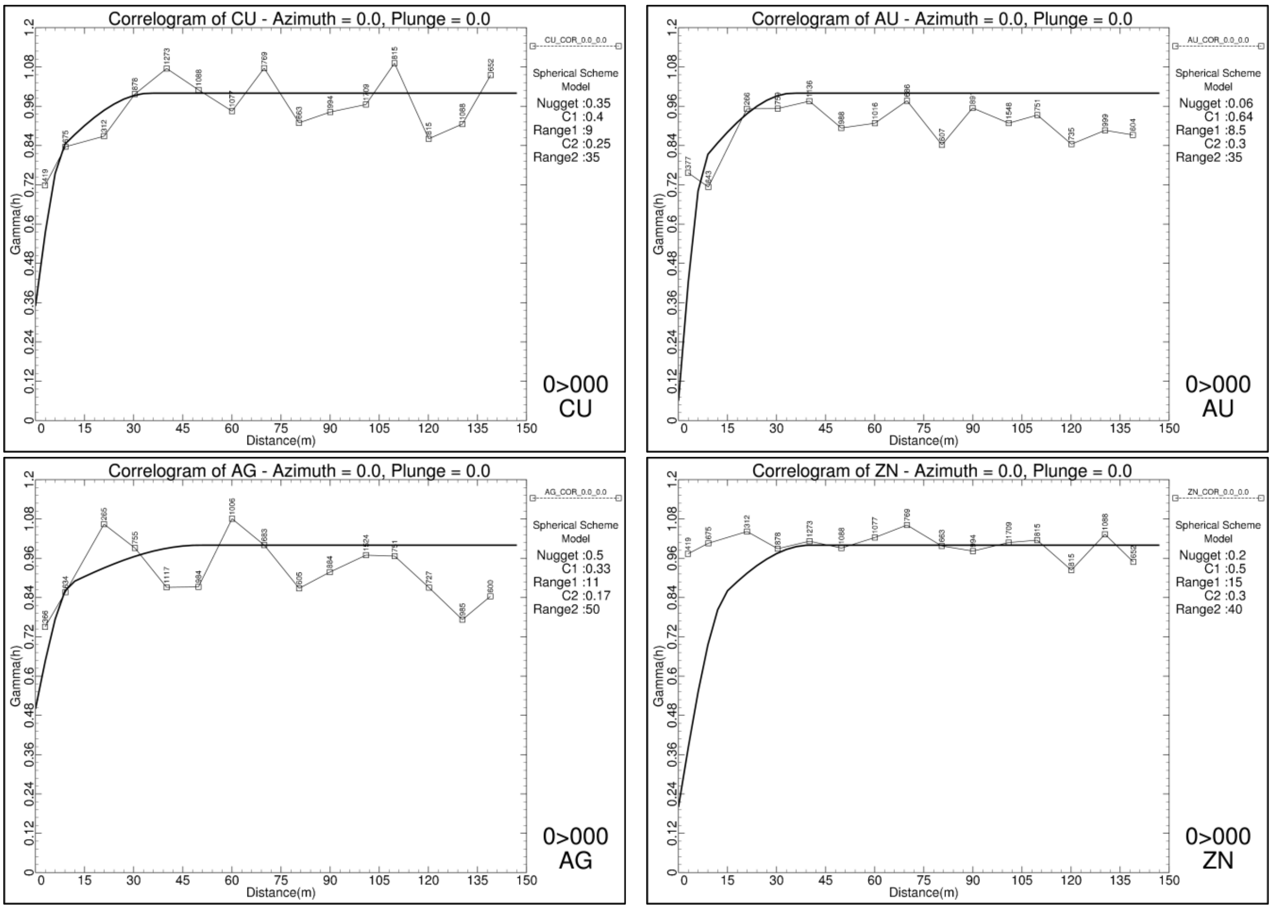


Figure 14.10 Omniplane correlograms for Solwara 1: Domain 400



14.2.9 Grade estimation

Block grade values were estimated by ordinary kriging (OK) and inverse distance weighting (IDW) for Cu, Au, Ag and Zn using unfolding. The estimation parameters included:

- Two pass search strategy with search ranges of 50 m in the unfolded plane and 3 m vertically for the 1st pass, and 500 m and 5 m for the 2nd pass.
- Minimum of 7 and a maximum of 12 samples for the 1st pass, and 1 and 12 for the 2nd pass.
- Maximum of three samples per drillhole.
- Block discretisation of 4 by 4 by 1 (X, Y, Z).
- Only samples from the corresponding stratigraphic domain were selected, i.e. hard boundaries between the stratigraphic domains.
- Sample length weights were applied to the ordinary kriging weights and then re-standardized to one.
- Inverse distance power of 2.

For many blocks, the effective search range was substantially reduced by the constraints on the total number of samples and number per drillhole. A small number of blocks in some domains were not estimated. These non-estimated blocks were sufficiently distant from any drillholes that they are considered unsuitable for classification even as an inferred resource.

14.2.10 Model validation

Golder carried out the following block model validation checks:

- On-screen visual comparisons with the drillhole data.
- Statistical checks between declustered data and ordinary kriging estimates (Table 14.10).
- An alternative inverse distance weighting estimate for comparison purposes.
- Generation of swath plots comparing the block model grades with the drillhole sample grades by section (Figure 14.11).

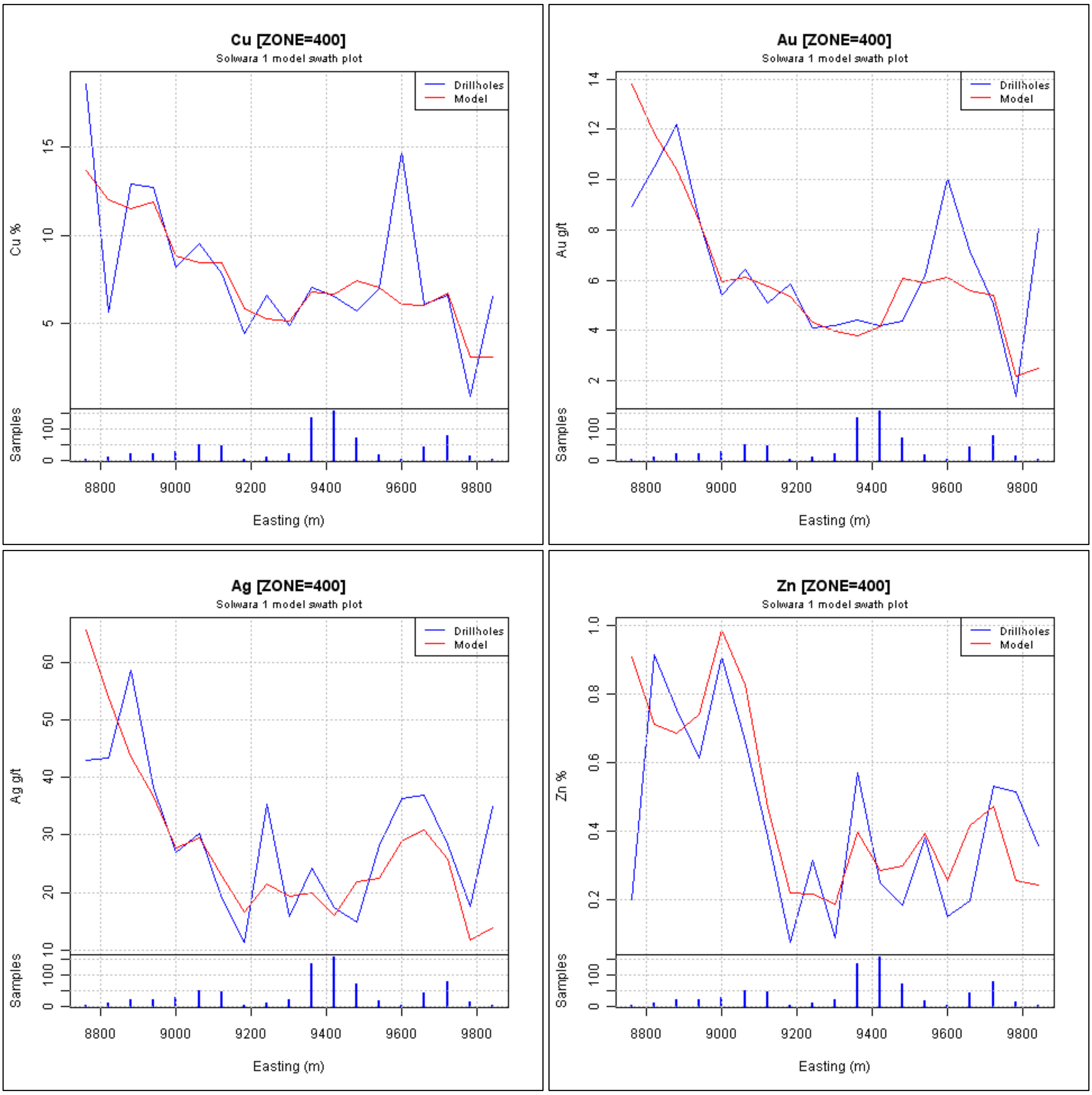
No obvious errors or inconsistencies were observed. Vertical discontinuities that were observed were related to the interpreted stratigraphic contacts that were used as hard boundaries during block grade estimation.

Table 14.10 Block model mean grades for Solwara 1 and 1 North

		Solwara 1			Solwara 1 North		
Element	**Domain code**	**Sample**	**OK**	**IDW**	**Sample**	**OK**	**IDW**
Cu (%)	200	1.18	1.30	1.20	0.03	0.05	0.04
	300	4.30	4.01	4.54	2.93	2.86	2.82
	400	7.66	7.39	7.56	7.84	7.82	7.90
	450	0.53	0.68	0.76	1.98	2.54	2.76
	500	0.22	0.28	0.23	0.49	0.51	0.30
	600	10.5	10.97	10.91	-	-	-
Au (g/t)	200	1.79	2.09	1.81	0.06	0.12	0.09
	300	5.03	4.50	4.53	9.40	9.07	9.77
	400	5.94	5.41	5.53	7.74	7.69	7.91
	450	0.61	0.73	0.76	1.10	1.11	1.11
	500	0.19	0.28	0.22	0.49	0.52	0.36
	600	14.9	16.92	16.86	-	-	-
Ag (g/t)	200	10.06	11.42	10.17	4.43	5.26	4.45
	300	47.8	48.94	46.5	82.19	80.45	79.90
	400	28.18	24.37	24.51	45.01	49.44	49.09
	450	3.71	4.02	3.78	6.27	5.88	5.12
	500	3.51	3.7	4.44	7.06	5.68	7.08
	600	151.7	170.7	170.0	-		-
Zn (%)	200	0.23	0.20	0.22	0.03	0.03	0.03
	300	1.48	1.37	1.17	3.08	3.39	3.18
	400	0.51	0.48	0.46	1.23	1.30	1.28
	450	0.06	0.07	0.07	0.29	0.24	0.24
	500	0.05	0.05	0.06	0.29	0.26	0.29
	600	5.85	5.93	5.92	-	-	-

Table 14.10 shows the declustered sample and block (OK and IDW) mean grade values. The ordinary kriging and inverse distance estimates are similar to the declustered drillhole means. Differences between the mean estimates and the drillhole declustered sample means (length-weighted and with topcuts applied) are considered to be mainly the result of extrapolation into the margins of the deposit, which are not adequately covered by sample declustering.

Figure 14.11 Swath plots comparing estimated block grades with drillhole sample grades for the Domain 400 for Solwara 1



Note that the Easting on the plots in Figure 14.11 has been truncated by subtracting 390000.

The number of drill core samples and the core recovery in the unconsolidated sediment domain are very low. Furthermore, the sample statistics and block estimates for this domain were found to be inconsistent with the grades of unconsolidated sediment samples that were collected by spearing methods for environmental purposes. In view of this, this domain has been excluded from the resource estimate.

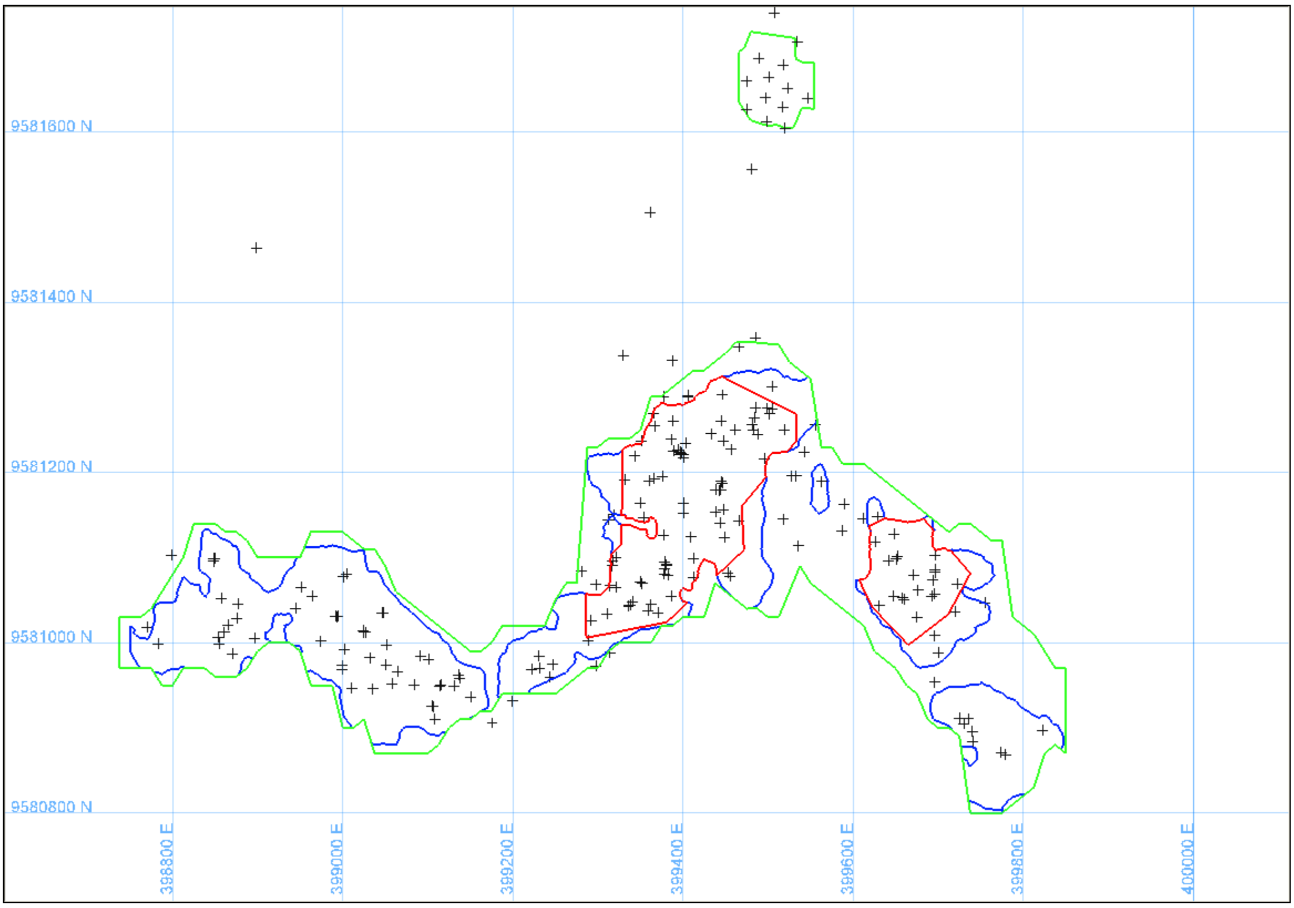
14.2.11 Resource classification

Resource classification considered the following:

- Good geological continuity was observed. The stratigraphic sequence was consistent across the deposit, except for a small area intersected by two adjacent drillholes where a lava flow appears to overly the massive sulfide.
- The mineralisation outcrops over significant areas of the deposit and the presence of chimneys suggests that the lateral extent of massive sulfide development has been appropriately modelled.
- High resolution 20 cm by 20 cm bathymetry covers the majority of the resource area with 1 m by 1 m horizontal resolution in some peripheral parts.
- A strong EM anomaly that is interpreted to indicate the presence of near surface sulfide mineralisation is consistent with all drillhole intersections but is not indicative of the thickness of conductive sulfide mineralisation.
- Core recovery was highly variable and in some drillholes is less than 60%.

The mineralisation classified as Indicated Resource was tested by drillholes spaced from less than 10 m to a maximum of approximately 50 m. Within the Indicated Resource, most of the blocks were estimated in the first estimation pass and the core recovery in the intercepts used to estimate the blocks was generally greater than 70%. In the area classified as Inferred Resource the spacing of effective drillhole intercepts (i.e., intercepts of the full thickness of Domain 400) ranges up to 100 m, but is generally less than 50 m, and the core recovery was more variable. All chimney material has been classified as Inferred. The main criteria for this lower classification are that chimney sampling was limited to pieces of chimney that could be broken off from the mounds and that the grades within the mounds are therefore not estimated with confidence. Figure 14.12 shows a plan view of the Mineral Resource classification.

Figure 14.12 Indicated and Inferred Resource areas for Solwara 1



Red line = Indicated Resource limit; blue line = Inferred Resource boundary, green line = limit of resource model; Black crosses = drillhole collar locations.

14.2.12 Resource estimate

The Mineral Resource estimate for the Solwara 1 and 1 North massive sulfide is shown in Table 14.11. The resource is declared for a 2.6% Cu equivalent cut-off grade. The effective date of the Mineral Resource is 1 January 2018.

Table 14.11 Mineral resource estimate for Solwara 1 and 1 North at 2.6% Cu equivalent cut off

Area	Class	Domain	Tonnes (kt)	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
1	Indicated	Sulfide dominant	1030	7.2	5.0	23	0.4
	Inferred	Chimney	80	11.0	17.0	170	6.0
		Consolidated Sediment	27	4.1	4.5	49	1.4
		Sulfide dominant	1330	8.1	5.8	25	0.6
		Inferred Total	**1440**	**8.2**	**6.4**	**34**	**0.9**
1 North	Inferred	Consolidated Sediment	14	2.8	9.1	81	3.4
		Sulfide dominant	65	7.8	7.5	49	1.3
		Upper footwall	21	2.8	1.1	5	0.2
		Inferred Total	**100**	**6.0**	**6.3**	**43**	**1.3**
Total	**Indicated**	**-**	**1030**	**7.2**	**5.0**	**23**	**0.4**
	Inferred	**-**	**1540**	**8.1**	**6.4**	**34**	**0.9**

Note: rounding may result in errors in reproducing the totals from the individual components shown in this table.
Solwara 1 and 1 North estimated using ordinary kriging. Cu Equivalent CuEq = 0.915*Cu + 0.254*Au + 0.00598*Ag

14.2.13 Comparison with 2008 resource estimate

To assess the change in the resource model as a result of the incorporation of the 2001/11 drillhole data, the 2008 resource model and the current resource model were compared using a 4% Cu cut-off, as was used in 2008. This comparison is provided by Table 14.12 and Table 14.13. The comparison between the current and 2008 Mineral Resource estimates for Solwara 1 at a 4% cut-off grade show a 15% increase in contained Cu, and a 9% increase in contained Zn. The contained Au and Ag are not significantly changed. These changes are attributed to better definition of the interpreted stratigraphic domains and new drillholes that increased the resource in Cu-rich areas and reduced the resource in Cu-poor areas. The resource tonnages in each category increased by 5%.

Table 14.12 2008 Mineral resource estimate for Solwara 1 at 4% Cu cut off

Class	Domain	Tonnes (kt)	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
Indicated	Sulfide dominant	870	6.8	4.8	23	0.4
Inferred	Chimney	80	11	17	170	6
	Consolidated Sediment	2	4.5	5.2	36	0.6
	Sulfide dominant	1,200	7.3	6.5	28	0.4
	Inferred Total	**1,300**	**7.5**	**7.2**	**37**	**0.8**

Note: rounding may result in errors in reproducing the totals from the individual components shown in this table.

Table 14.13 2012 Mineral resource estimate for Solwara 1 and 1 North at 4% Cu cut off

Area	Class	Domain	Tonnes (kt)	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
1	Indicated	Sulfide dominant	910	7.7	5.4	24	0.4
	Inferred	Chimney	80	11	17	170	6
		Consolidated Sediment	12	5.4	5.5	52	1.1
		Sulfide dominant	1,200	8.8	6.2	27	0.6
		Inferred Total	**1,300**	**8.8**	**6.9**	**36**	**0.9**
1 North	Inferred	Consolidated Sediment	–	–	–	–	–
		Sulfide dominant	65	7.8	7.5	49	1.3
		Upper footwall	–	–	–	–	–
		Inferred Total	65	7.8	7.5	49	1.3
Total	**Indicated**	**-**	**910**	**7.6**	**5.4**	**24**	**0.4**
	Inferred	**-**	**1,365**	**8.8**	**6.9**	**36**	**0.9**

Note: rounding may result in errors in reproducing the totals from the individual components shown in this table. Solwara 1 estimated using OK and Solwara 1 North with IDW.

14.2.14 Resource estimate risks

AMC considers that the following risks and uncertainties may materially influence the Solwara 1 resource estimate:

- Several drillholes ended in massive sulfide material. In such instances, and where no adjacent drillhole information was available from which the true thickness could be reasonably interpreted, the base of the drillhole was interpreted to be the base of the massive sulfides. The massive sulfide resource is therefore open at depth in some areas.
- The Inferred Resource in the upper footwall domain is estimated from widely spaced drillhole intercepts, using the reasonable inference that intense alteration and disseminated and stringer mineralisation is continuous beneath the massive sulfide body. Further drilling would be required to confirm continuity in this domain.
- Drillhole intercepts in the unconsolidated sediment domain at Solwara 1 suggested that this domain contains some material above cut-off grade. Whilst this may be likely in the form of chimney rubble or interstitial sulfide precipitation, this material has been excluded from the resource estimate for Solwara 1.
- No drillholes were located on top of the exposed chimney mounds, consequently, the block grade estimates for interpreted massive sulfide material below these mounds is based on holes drilled adjacent to these mounds. It is possible that the massive sulfide material beneath the chimney mounds may have a different mineralogical composition being closer to the interpreted source of the mineralising fluid.
- Core loss could result in estimation bias if the core loss was preferentially related to low or high-grade material. Close-spaced (<5 m) drilling for metallurgical samples and very low correlation of grade with core length suggests that the probability of such preferential core loss and bias is low.
- Significant lateral extrapolation of massive sulfide mineralisation to the boundaries of the EM anomaly was supported by drilling. However, some of the Inferred Resource relies on this EM anomaly in areas that have only been tested by sparse drilling. The EM provides no information on base metal grades. Furthermore, it is not possible to determine the thickness of the conductive sulfide material from the EM data, thus, the interpreted thickness of massive sulfide in areas distant to drilling is of low confidence.
- The higher-grade chimney mounds have essentially only been sampled at the surface, by breaking off protruding chimney pieces. The interpreted depth of the chimney mounds is based on an automated algorithm that produces a truncated bathymetric profile that is considered geologically reasonable. However, until these mounds are tested by drilling, their grade, density and depth should be considered of low confidence. If the chimney mound/massive sulfide interface is not correctly positioned then the risk to the contained metal is considered to be low to moderate as the higher-grade/lower density chimney material would most likely be substituted by lower grade/higher density massive sulfide material.

14.2.15 Conditional simulation

In 2012, Nautilus commissioned Martlet Consultants to conduct a trial conditional simulation study on the Solwara 1 deposit. The study aimed to demonstrate the application of conditional simulation for assessing variability in Mineral Resource estimates and selective mining units.

The exercise was based on Domain 400 of the block model used by Golder for the 2012 Mineral Resource estimate. The model was unfolded and sequential Gaussian simulations were conducted for Cu, Au, As and Hg.

The sequential Gaussian simulations produced results consistent with the Mineral Resource model. As expected, the Mineral Resource model provides a smoother local estimate than the sequential Gaussian simulations.

14.3 Solwara 12

14.3.1 Geological modelling

The Solwara 12 deposit was divided for resource estimation purposes into stratigraphic domains, as follows.

- Domain 600. Chimneys, comprised of massive Zn-rich sulfides.
- Domain 200. Unconsolidated and lithified sediments (lithology code SS and SC).
- Domain 400. Sulfide dominant rock (generally lithology code RI with minor RA or RC) and conduit facies (lithology code CF). This is the main mineralised domain. The EM conductor anomaly is small and does not fully cover the extent of mineralisation defined by drilling and was not used to define the outer limits of the massive sulfide deposit.
- Domain 450. Upper footwall beneath the sulfide dominant zone. Clay and sulfate dominant rocks (lithology codes RC and RA) with disseminated or stringer mineralisation.
- Domain 401. A lens of disseminated Cu-rich sulfide mineralisation occurring within Domain 450.
- Domain 500. Lower footwall. Generally, clay and sulfate dominant rocks (lithology codes RC and RA) but may include altered volcanic (lithology code VC or VB).

The drill hole data for modelling the Solwara 12 deposit was all from the 2010/11 drilling program.

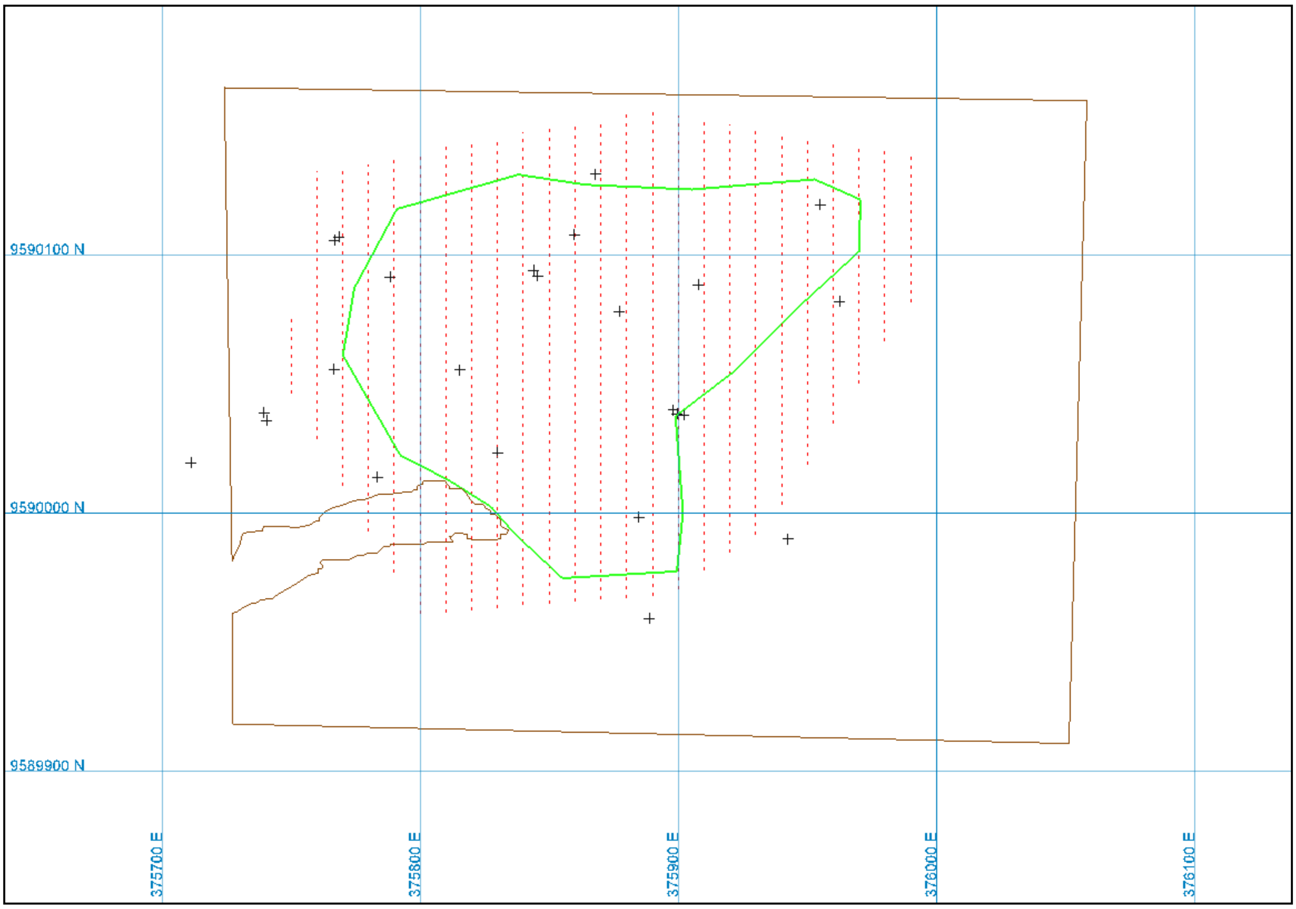
Geological modelling of the Solwara 12 deposit comprised of manual sectional interpretation of the stratigraphy and mineralisation and a floating circle approach using detailed bathymetry to define the base of chimneys. The strings produced during sectional interpretation of the stratigraphy were used to build three-dimensional wireframe surfaces of the stratigraphic contacts, which were then used to build a block model for grade estimation.

14.3.1.1 Sectional interpretation

Manual interpretation of the contacts between stratigraphic horizons was conducted on N-S sections at 10 m intervals from 375,750E to 376,000E (Figure 14.13).

At drillhole locations, the individual strings were “snapped” to the drill hole sample end-points. In areas of limited drilling, the interpretation of the stratigraphic contacts and bathymetry from adjacent sections were used to constrain the interpretation.

Figure 14.13 Data limits, section lines and drill hole locations for Solwara 12



Brown line = bathymetry limits; green line = resource model boundary; broken red lines = section lines.

Stratigraphic assignment of core loss intervals was based on the core above and below the core loss interval. A generally conservative approach to modelling the sulfide dominant domain was adopted; core loss above the first down-hole intersection of sulfide dominant rock was assumed to be unconsolidated sediment, core loss below the deepest intersection of sulfide dominant rocks was assumed to be altered volcanic rocks of the footwall. This avoided the risk of over-estimating the thickness of Domain 400 in the drillholes.

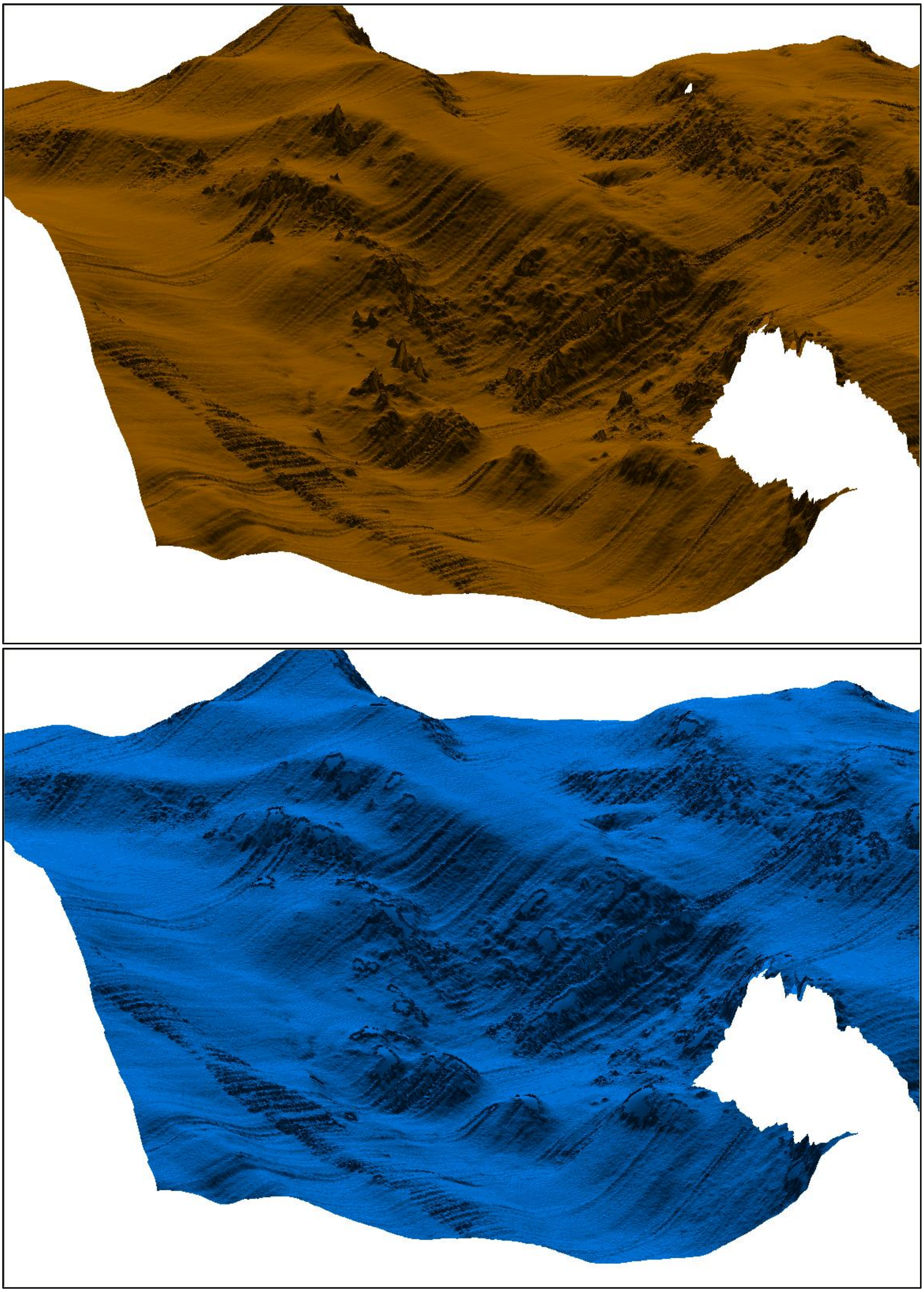
14.3.1.2 Chimney interpretation

The Solwara 12 deposit has been mapped with a bathymetric survey at 40 cm by 40 cm resolution. The volume of the chimney domain was modelled using the same approach was used as for modelling the chimneys at Solwara 1. Modelling of the chimney domain was performed using an automated floating circle algorithm that identified either local chimney peaks or sulfide mounds and created a surface beneath the base of the chimney mounds. This surface is referred to in this report as the truncated bathymetry, with the chimney domain representing the area between the original and truncated bathymetry. The chimney domain contains 5,100 m^3 of material.

Figure 14.14 shows screen captures of the original (top) and truncated (bottom) bathymetry.

The modelling confirmed that the chimney domain at Solwara 12 is very small. Only 10 samples have been collected from the chimneys, with average grades of 7.0% Cu, 17g/t Au, 425g/t Ag and 22.6% Zn (very high Zn and Ag and lower Cu, compared with Solwara 1). For these reasons the data was not considered to be sufficient for resource estimation and was not included in the resource estimate.

Figure 14.14 Perspective view of original (top) and truncated (bottom) bathymetry for Solwara 12



14.3.2 Block modelling

A computer block model with block dimensions of 10 m by 10 m by 0.5 m blocks was constructed by filling between the wireframe surfaces of the stratigraphic contacts to the base of the chimneys. The block model definition is presented in Table 14.14. Sub-blocking was not used but entire blocks were assigned to geological domains on a maximum proportion basis. The proportion of the block below the base of the chimneys (truncated bathymetry) was retained for resource volume and tonnage calculations.

The horizontal block dimensions represent approximately 1/4th of the average drill hole spacing of about 45 m. In areas were the drill hole spacing is wider the block size could result in over-smoothing of the block grade estimates. The vertical block dimension of 0.5 m is considered suitable when compared to the average sample length and enables all mining extraction scenarios to be investigated. Overall, the block size is appropriate for approximating the volume of the stratigraphic domains and block grade estimates.

Table 14.14 Block model dimensions for Solwara 12

Dimension	Minimum	Maximum	Size (m)	Number
X	375,700mE	376,100mE	10	40
Y	9,589,900mN	9,590,200mN	10	30
Z	-2,000mRL	-1,750mRL	0.5	500

14.3.3 Resource estimation database

Block grade estimation was undertaken in the stratigraphic domains using only information from the 2010/11 drilling program. The drillhole database that was used in grade estimation included 28 diamond core drillholes with the “SD_S12” prefix (Table 14.15).

Table 14.15 Solwara 12 drillhole collar coordinates

HOLEID	PROJECT	EAST	NORTH	RL	HOLEID	PROJECT	EAST	NORTH	RL
SD_S12_001	Drilling10	375845.5	9590092	-1870.79	SD_S12_015	Drilling10	375740.7	9590036	-1894.9
SD_S12_002	Drilling10	375877.3	9590078	-1867.75	SD_S12_016	Drilling10	375766.7	9590056	-1891.8
SD_S12_003	Drilling10	375844.1	9590094	-1872.63	SD_S12_017	Drilling10	375788.5	9590091	-1883.24
SD_S12_004	Drilling10	375830.1	9590023	-1878.53	SD_S12_018	Drilling10	375711.4	9590019	-1886
SD_S12_005	Drilling10	373908.5	9592392	-1826.82	SD_S12_019	Drilling10	375868	9590131	-1862.8
SD_S12_006	Drilling10	375884.7	9589998	-1863.6	SD_S12_020	Drilling10	375888.9	9589959	-1849.42
SD_S12_007	Drilling10	375815.4	9590055	-1879.7	SD_S12_021	Drilling10	375899.6	9590038	-1855.94
SD_S12_008	Drilling10	375783.5	9590014	-1871.1	SD_S12_022	Drilling10	375768.7	9590107	-1880.69
SD_S12_009	Drilling10	375962.6	9590082	-1846	SD_S12_023	Drilling10	375902.3	9590038	-1852.9
SD_S12_010	Drilling10	375955	9590119	-1859.2	SD_S12_024	Drilling10	375898	9590040	-1858.8
SD_S12_011	Drilling10	375942.5	9589990	-1847.3	SD_S12_025	Drilling10	375766.9	9590106	-1880.87
SD_S12_012	Drilling10	375908	9590088	-1858.3	SD_S12_026	Drilling10	375859.8	9590108	-1871.6
SD_S12_013	Drilling10	375908.2	9590219	-1847.3	SD_S12_027	Drilling10	374909	9589958	-1951.8
SD_S12_014	Drilling10	375739.4	9590039	-1895.7	SD_S12_028	Drilling10	374890.2	9589942	-1955.3

14.3.4 Compositing

Compositing of drillhole samples was not undertaken due to core loss and irregular sampling intervals. To account for the variable sample lengths in block grade estimation length-weighting was used. The minimum and maximum drill hole sample lengths are 0.03 m and 1.33 m respectively, with an average of 0.45 m. Figure 14.15 shows a histogram of the sample lengths.

Figure 14.15 Histogram of sample lengths for Solwara 12

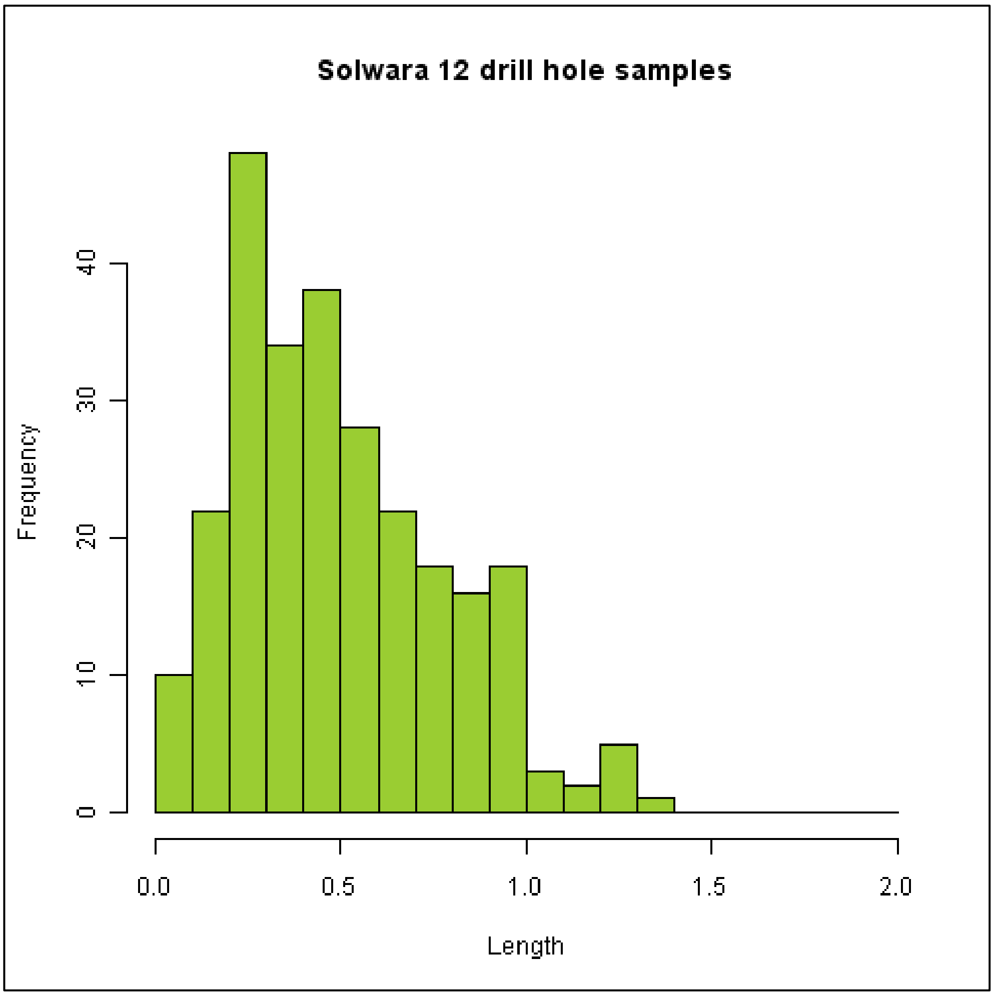
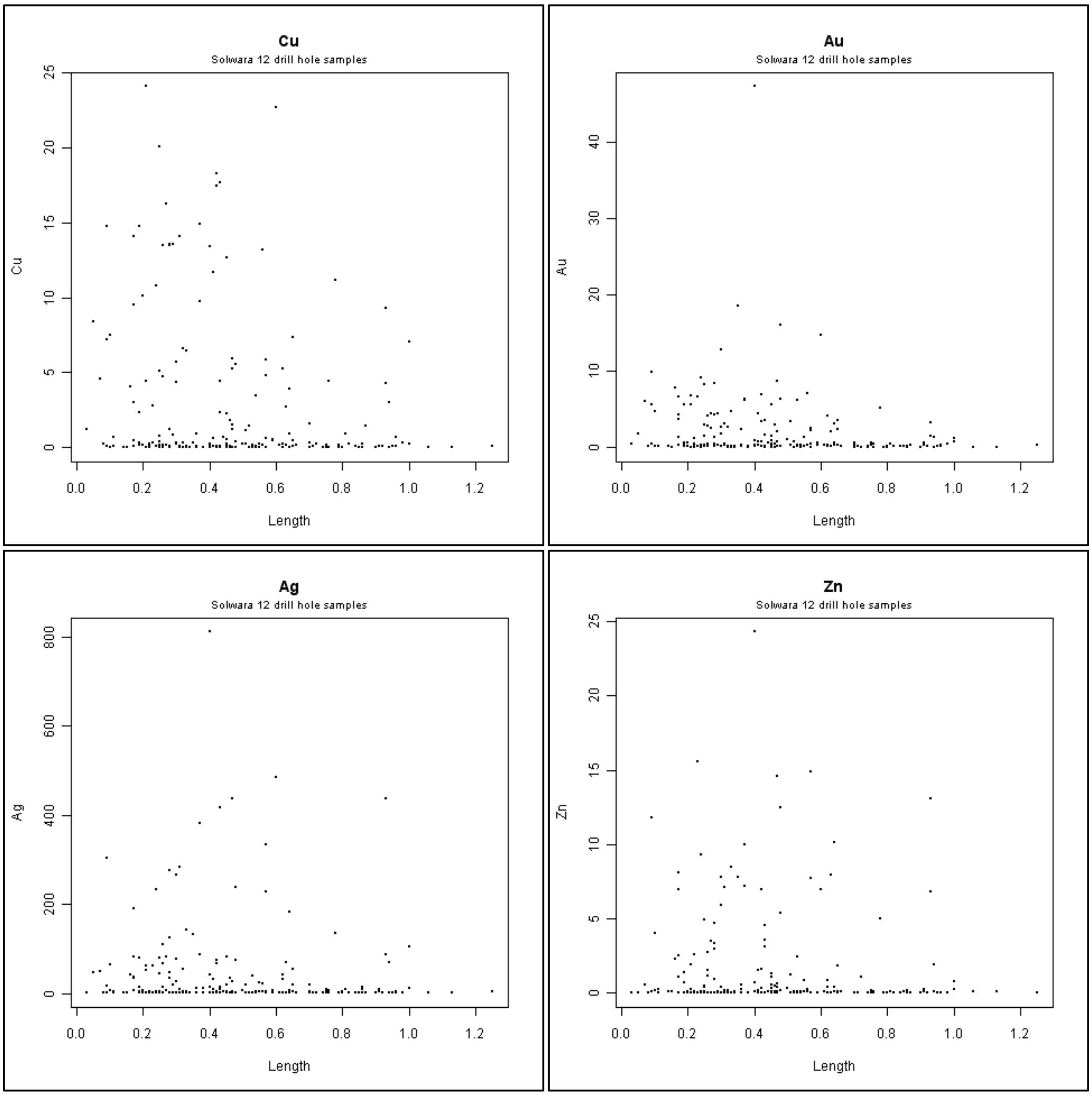


Figure 14.16 shows scatter plots of Cu, Au, Ag and Zn grades versus drill hole sample length. These plots indicate that grades are not correlated with sample length, supporting the decision not to composite the samples but rather to use their lengths for weighting during block grade estimation.

Figure 14.16 Scatter plots of grade versus sample length for Solwara 12



14.3.5 Statistical analysis

The diamond drilling sampling was observed to be clustered. To reduce the influence of data clustering in the summary statistics, cell declustering with a 25 m by 25 m horizontal cell dimension was used to calculate individual sample weights. Summary statistics with declustered weighting applied is presented in Table 14.16.

The declustered summary statistics were used to validate the kriged block model. It is important to note that the declustered statistics do not account for extrapolation within or at the margins of the resource area.

Cumulative probability plots for Cu, Au, Ag and Zn by stratigraphic domain are shown in Figure 14.7. The cumulative probability plots were used to identify high-grade outliers in the drill hole sample distributions and determine appropriate top-cut values (Table 14.17) to reduce the influence of those high-grade outliers in block grade estimation. High grade top-cuts were identified on the cumulative probability plots by observing where the distribution started to break down above the 90th percentile. The coefficient of variation (CV) for Cu, Au, Ag and Zn for each stratigraphic domain was used to check the impact of applying the top-cuts.

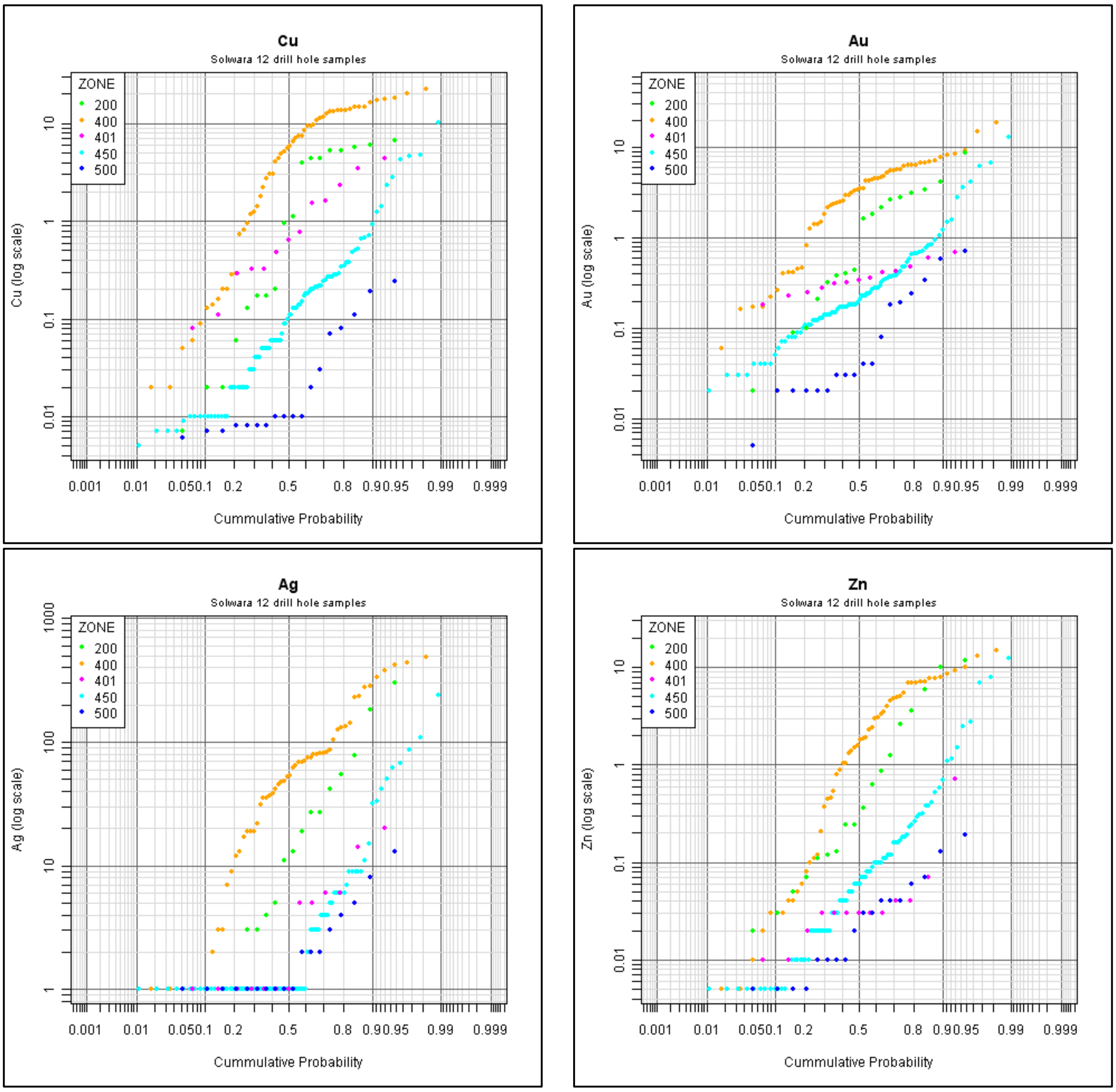
Table 14.16 Declustered summary statistics for Solwara 12

Element	Domain name	Domain code	No. Obs.	Min.	Max.	Mean	Variance	CV
Cu (%)	Unconsolidated sediments	200	18	0.02	7.23	2.62	6.27	0.96
	Sulfide dominant	400	58	0.02	24.10	7.52	41.68	0.86
	Disseminated	401	14	0.08	14.10	2.07	10.01	1.53
	Upper footwall	450	96	0.005	13.50	0.53	1.76	2.51
	Lower footwall	500	16	0.007	0.48	0.05	0.01	1.83
Au (g/t)	Unconsolidated sediments	200	18	0.02	9.86	1.90	4.59	1.13
	Sulfide dominant	400	58	0.06	47.30	4.48	33.10	1.29
	Disseminated	401	14	0.18	1.36	0.44	0.06	0.56
	Upper footwall	450	96	0.02	16.00	0.87	5.05	2.58
	Lower footwall	500	16	0.005	1.40	0.19	0.12	1.90
Ag (g/t)	Unconsolidated sediments	200	18	1	437	48.98	9827	2.02
	Sulfide dominant	400	58	1	811	107.43	19886	1.31
	Disseminated	401	14	1	191	14.63	1737	2.85
	Upper footwall	450	96	1	265	17.67	2276	2.70
	Lower footwall	500	16	1	25	3.44	36.27	1.75
Zn (%)	Unconsolidated sediments	200	18	0.02	14.6	2.18	15.19	1.79
	Sulfide dominant	400	58	0.005	24.3	3.83	19.87	1.17
	Disseminated	401	14	0.01	8.12	0.492	3.21	3.64
	Upper footwall	450	96	0.005	15.6	0.91	6.65	2.85
	Lower footwall	500	16	0.005	0.85	0.10	0.05	2.09

Table 14.17 High grade cuts for Solwara 12

Domain name	Domain code	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
Unconsolidated sediments	200	6	5	100	10
Sulfide dominant	400	16	10	100	10
Disseminated	401	3	1	50	0.3
Upper footwall	450	1	1	30	0.3
Lower footwall	500	0.2	0.5	20	0.3

Figure 14.17 Cumulative probability plots for sub-chimney domains for Solwara 12



14.3.6 Bulk density

Average dry bulk density values were assigned to the block model on a domain basis. The volume of dry bulk density data available for Solwara 12 (91 measurements for all lithology types) is much smaller than for Solwara 1 and the results were not significantly different. Therefore, the average dry bulk density values for Solwara 1 (Table 14.9) were used for Solwara 12.

14.3.7 Unfolding

Due to the undulating nature of the mineralisation at Solwara 12, unfolding was employed for resource modelling in the stratigraphic domains below the chimney domain. The following interpreted surfaces across the deposit were adopted for unfolding:

- Domain 200 was unfolded to the base of Domain 200.
- Domain 400 was unfolded to the top of Domain 400.
- Domain 401 was unfolded to the centre of domain (the solid wireframe).
- Domain 450 was unfolded to the base of Domain 400.
- Domain 500 was unfolded to the base of Domain 450.

14.3.8 Variography

There was insufficient data to perform meaningful spatial analysis. Grade continuity was assumed to be similar to Solwara 1. The Solwara 1 correlograms (Figure 14.9 and Figure 14.10) were used for grade estimation.

14.3.9 Grade estimation

Block grade values were estimated by ordinary kriging and inverse distance for Cu, Au, Ag and Zn using unfolding. The chimney domain was not estimated. The estimation parameters included:

- Two pass search strategy with search ranges of 50 m in the unfolded plane and 3 m vertically for the 1st pass, and 500 m and 5 m for the 2nd pass.
- Minimum of 7 and a maximum of 12 samples for the 1st pass, and 1 and 12 for the 2nd pass.
- Maximum of three samples per drill hole.
- Block discretisation of 4 by 4 by 1 (X, Y, Z).
- Only samples from the corresponding stratigraphic domain were selected, i.e. hard boundaries between the stratigraphic domains.
- Sample length weights were applied to the ordinary kriging weights and then re-standardized to one.
- Inverse distance power of 2.

For a large number of blocks, the effective search range was substantially reduced by the constraints on the total number of samples and number per drill hole. A small number of blocks in some domains were not estimated. These non-estimated blocks were sufficiently distant from any drillholes that they are considered unsuitable for classification even as an inferred resource.

14.3.10 Model validation

Golder carried out the following block model validation checks:

- On-screen visual comparisons with the drill hole data.
- Statistical checks between declustered data and OK estimates (Table 14.18).
- An alternative inverse distance weighting estimate for comparison purposes.
- Swath plots comparing the block model grades with the drill hole sample grades by section were generated but due to the limited number of sections and drillhole samples these plots are not useful.

No obvious errors or inconsistencies were observed. Vertical discontinuities that were observed were related to the interpreted stratigraphic contacts that were used as hard boundaries during block grade estimation.

Table 14.18 shows the declustered sample and block (OK and IDW) mean grade values. The ordinary kriging and inverse distance estimates are similar to the declustered drillhole means. Differences between the mean estimates and the drillhole declustered sample means (length-weighted and with topcuts applied) are considered to be mainly the result of extrapolation into the margins of the deposit, which are not adequately covered by sample declustering.

Table 14.18 Block model mean grades for Solwara 12

Element	Domain Name	Domain Code	Samples	OK	IDW
Cu (%)	Unconsolidated sediments	200	2.59	2.81	2.67
	Sulfide dominant	400	7.15	8.35	8.41
	Disseminated	401	1.29	1.50	1.15
	Upper footwall	450	0.25	0.31	0.29
	Lower footwall	500	0.04	0.04	0.06
Au (g/t)	Unconsolidated sediments	200	1.69	1.88	1.91
	Sulfide dominant	400	3.80	4.00	4.09
	Disseminated	401	0.42	0.41	0.43
	Upper footwall	450	0.37	0.36	0.37
	Lower footwall	500	0.12	0.12	0.14
Ag (g/t)	Unconsolidated sediments	200	26.69	33.41	31.80
	Sulfide dominant	400	57.06	60.75	60.65
	Disseminated	401	7.30	5.72	6.99
	Upper footwall	450	6.66	5.87	6.15
	Lower footwall	500	3.11	1.79	2.37
Zn (%)	Unconsolidated sediments	200	1.95	1.95	2.49
	Sulfide dominant	400	3.43	3.92	3.83
	Disseminated	401	0.06	0.05	0.07
	Upper footwall	450	0.12	0.10	0.11
	Lower footwall	500	0.06	0.04	0.08

14.3.11 Resource classification

Resource classification for Solwara 12 considered a number of issues:

- The average drill hole spacing is about 45 m.
- Geological continuity was observed and the stratigraphic sequence was consistent across the deposit.
- The mineralisation outcrops over the area of the deposit and the presence of chimneys suggests that the lateral extent of massive sulfide development has been appropriately modelled.
- High resolution 40cm by 40cm bathymetry covers the resource.
- A small EM anomaly is present over a portion of the deposit but the mineralisation extends beyond the EM anomaly.
- Core recovery averages 51%.

As a consequence of the low core recovery and the lack of corroboration by the EM of the continuity of the full extent of the subsurface mineralisation, the resource was classified as Inferred Mineral Resource.

14.3.12 Resource estimate

The Mineral Resource estimate for the Solwara 12 massive sulfide is shown in Table 14.19. The resource is declared for a 2.6% Cu equivalent cut-off grade.

Table 14.19 Mineral resource estimate for Solwara 12 at 2.6% Cu Equivalent cut off

Class	Domain	Tonnes (kt)	Cu (%)	Au (g/t)	Ag (g/t)	Zn (%)
Inferred	Sediments	46	2.9	2.0	35	2.2
	Sulfide dominant	185	8.4	4.0	61	4.0
	Upper footwall	0.7	3.7	0.7	13	0.3
	Inferred Total	**230**	**7.3**	**3.6**	**56**	**3.6**

Note: rounding may result in errors in reproducing the totals from the individual components shown in this table. Solwara 12 estimated using OK.
Cu Equivalent CuEq = 0.915*Cu + 0.254*Au + 0.00598*Ag

15 Mineral Reserve Estimates

There are no Mineral Reserve estimates for Solwara 1 or Solwara 12 and the potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study.

Prefeasibility study would require more drilling to convert the Inferred Mineral Resource to Indicated category, and trial mining with an expected order of magnitude cost in excess of US$50 million, and would delay the Project schedule by 6 - 9 months.

16 Mining Methods

16.1 Overview of proposed operations

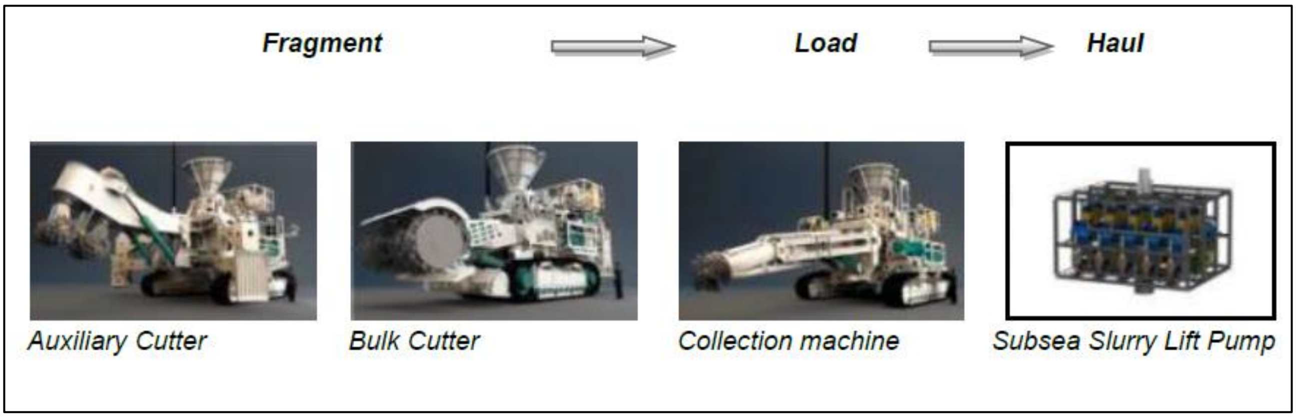
There are six closely-spaced massive sulfide bodies that contribute to the total Solwara 1 Mineral Resource. These are located on the seafloor and are covered with a thin layer of unconsolidated sediment (from zero to 2.7 m thick). The terrain in the Project area includes crests and steep-sided valleys, with localised gradients up to 30°.

The selected mining method is based on a common surface mining method, open pit benching. The process of mining is the same as terrestrial mines: to expose mineralised material, achieve fragmentation, load and haul. Fragmentation at Solwara 1 will be achieved by mechanical cutting rather than drill-and-blast.

The three main mining tasks (sediment removal, rock cutting, and transfer of fragmented cuttings to surface) are performed by three seafloor production tools and a positive displacement pump, which are the four machines listed below and shown in Figure 16.1, and known collectively as the seafloor production equipment.

- Auxiliary cutter
- Bulk cutter
- Collection machine
- Subsea slurry lift pump

Figure 16.1 The seafloor production equipment



The seafloor production equipment will be remotely controlled by operators located on board the production support vessel. The seafloor production equipment will be periodically serviced on the deck of the production support vessel. Power will be supplied to the seafloor production equipment via umbilical power cables that connect the units to the production support vessel.

The production process is broken down into the following tasks:

1. Remove the unconsolidated sediments.
2. Level the chimneys.
3. Establish the site and prepare a bench for bulk cutter operations.
4. Bulk cutter production – mineralised material pumped to stockpile;
    a. ramp-down to the toe of the bench to be cut
    b. cut a bench (bulk cutter production cut), bench may vary from 1 m to 4 m in height.
5. Auxiliary cutter production – mineralised material pumped to stockpile;
    a. cut 4 m benches when auxiliary cutter available (auxiliary cutter production), or in locations where the bulk cutter cannot operate due to terrain constraints.

6. Auxiliary cutter and bulk cutter clean-up – mineralised material pumped to stockpile;
    a. trim the bulk cutter bench with the auxiliary cutter (auxiliary cutter trim cuts)
    b. bulk cutter crushes auxiliary cutter oversize (stockpile bulk cutter clean-up)
    c. bulk cutter mines 4 m bench on auxiliary cutter bench.
7. Collect the auxiliary cutter and bulk cutter mineralised material from stockpile with the collection machine.

16.2 The seafloor production equipment

The seafloor production tools have been manufactured by a UK firm, Soil Machine Dynamics Ltd (SMD), and following factory acceptance testing and a short period of storage, they have undergone submerged trials in a flooded pit near Port Moresby in PNG.

The subsea slurry lift pump was manufactured by GE Hydril. Factory acceptance testing of the subsea slurry lift pump was completed in early 2017 and the pump is in storage in Houston. Submerged trials of the pump are planned to be undertaken in the PRC in the second or third quarters of 2018.

16.2.1 Auxiliary cutter

The auxiliary cutter is a track-mounted primary rock cutting tool. Its primary purpose is pioneering mining operations on the seafloor and preparing suitable platforms for the bulk cutter to operate. The machine is 16.4 m long and 6.9 m wide, and weighs approximately 250 t in air. The machine is fitted with 1,000 mm wide track shoes to allow it to track over soft ground and exert a static bearing pressure of 200 kPa.

The auxiliary cutter is similar in many ways to existing machines used in other industries: a road header, as found in the tunnelling industry and the RT1 subsea pipeline trencher, as found in the petroleum industry.

The auxiliary cutter is designed to have a range of vertical, horizontal and swivel slew movements which allow the cutter to cut platforms in rough terrain. The auxiliary cutter has two counter-rotating cutting heads attached to a 6.4 m sweeping boom. It is designed to cut a face of up to 10 m wide and 4 m high. It will remove fragmented material via an intake system from the face, and pump it to a stockpile up to 180 m from the cutting face via a 16” buoyed hose.

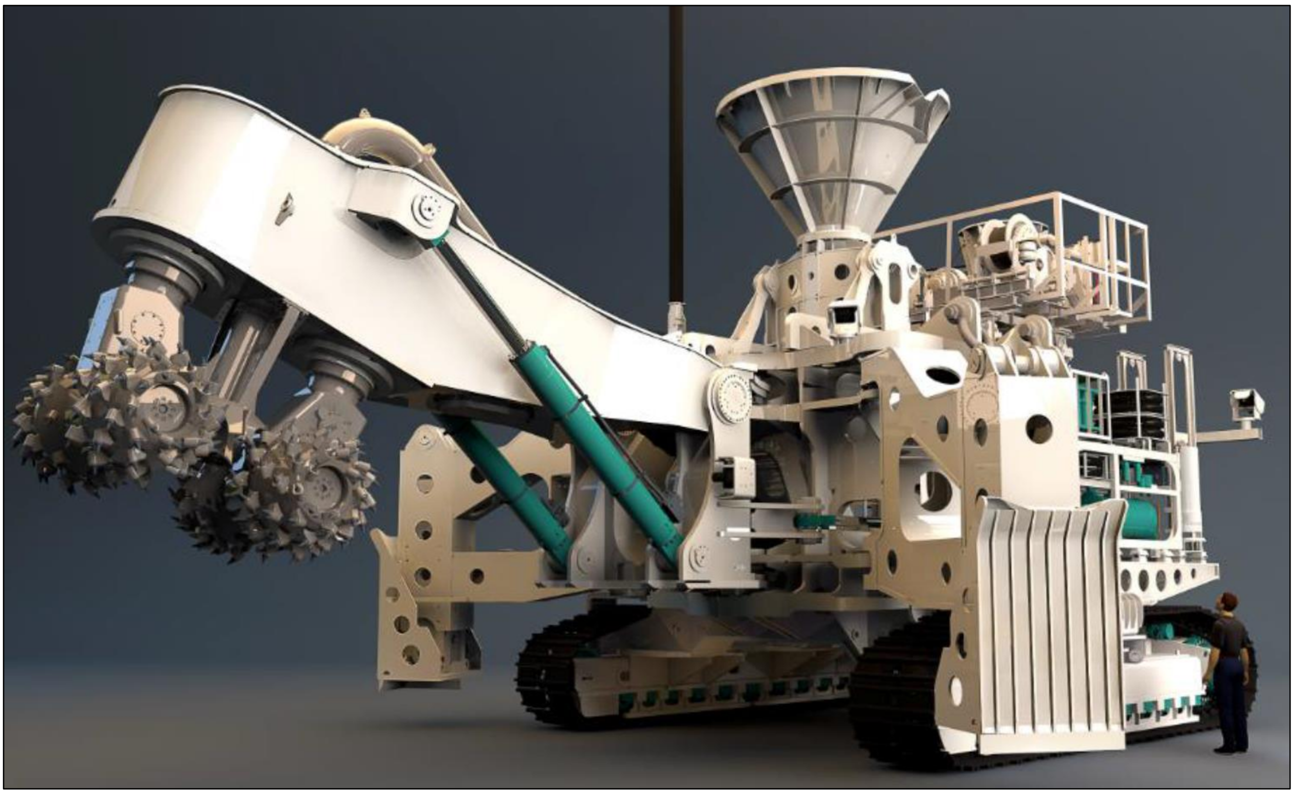
The auxiliary cutter’s pump is powered by a 650-kW electric motor (direct drive) with variable speed drive control. The dredge system is designed to pump a 4.6% slurry with a flow of 3,206 m^3/h, and deliver approximately 472 tonnes per hour.

The auxiliary cutter’s functions are to:

- Remove chimneys.
- Remove sediments overlying the mineralised rock by side casting.
- Cut ramps and stockpile areas.
- Prepare benches that are suitable for the bulk cutter.
- Remove edge sections of benches that cannot be accessed by the bulk cutter.

The design of the machine includes components from several manufacturers. The auxiliary cutter is shown in Figure 16.2.

Figure 16.2 The auxiliary cutter



16.2.2 Bulk cutter

The bulk cutter is a track-mounted primary rock cutting tool. It is the main production unit. The machine is 15.5 m long and 4.2 m wide, and weighs approximately 275 t in air. The machine is fitted with 810 mm wide track shoes to allow it to track over soft ground and exert a static bearing pressure of 300 kPa.

The bulk cutter has a single transversely orientated 4.2 m-wide cylindrical cutting drum. The drum houses 119 helically laced picks on a spacing of 50 mm. The drum is powered by two 600 kW variable speed drive electrical motors. The electrical motors can deliver up to 900 kW of cutting power via two gear boxes housed inside the cutter drum. The drum is designed to cut rock up to 100 MPa in strength. Test work (Table 16.1) indicates that expected hardness of sulphide dominant rocks will be approximately 52 MPa. Other rock types will be weaker.

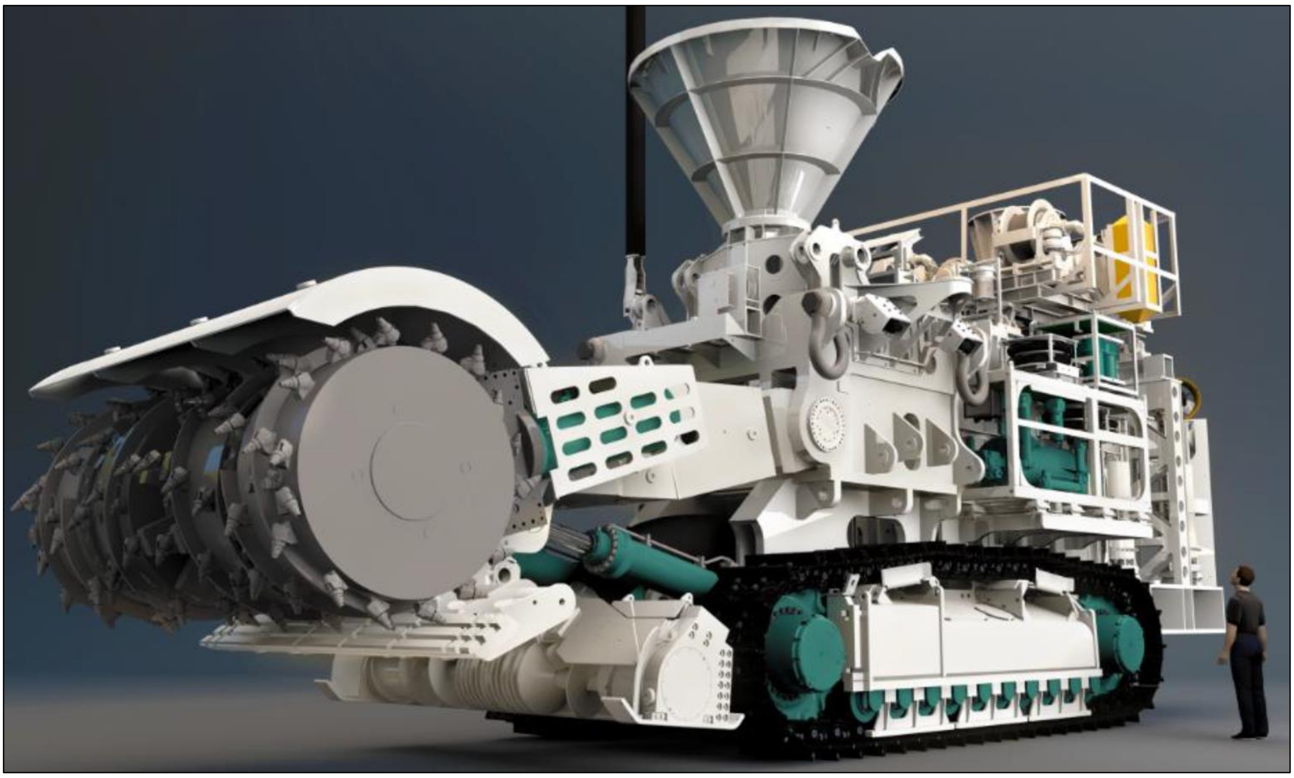
The bulk cutter can operate in a limited range of conditions, including gradient of ±10° or less. The operating plan generally calls for work areas for the bulk cutter to be prepared by the auxiliary cutter.

Excavated material will be collected by the front-mounted rotary collection drum with a grizzly sizing mechanism, and fed to an auger-assisted suction system. The material will be pumped to a stockpile, via a stockpile hose. The bulk cutter's pump is powered by a direct drive 650 kW electric motor with variable speed drive control. The dredge system is designed to pump a 4.6% slurry with a flow of 3,206 m^3/h, and deliver 472 tonnes per hour.

The method of restraining the stockpile hose at its termination point (the stockpile) has not been finalised. Stockpile diffusion hoods, and tripod arrangements are under consideration.

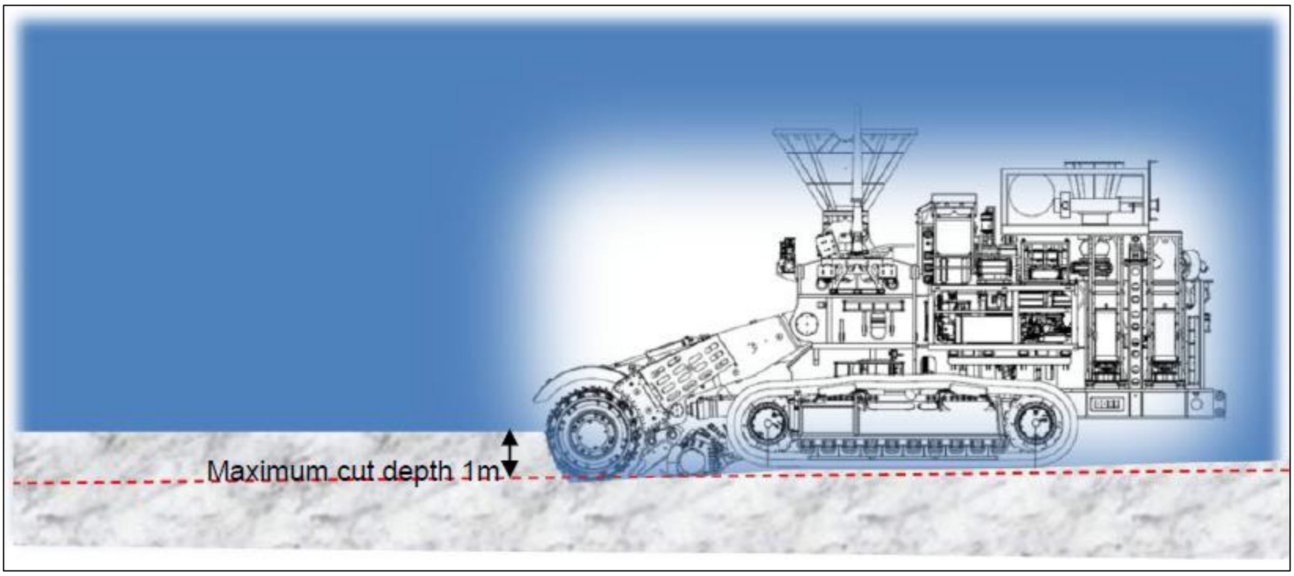
The design of the bulk cutter includes components from several manufacturers. The bulk cutter is shown in Figure 16.3.

Figure 16.3 The bulk cutter



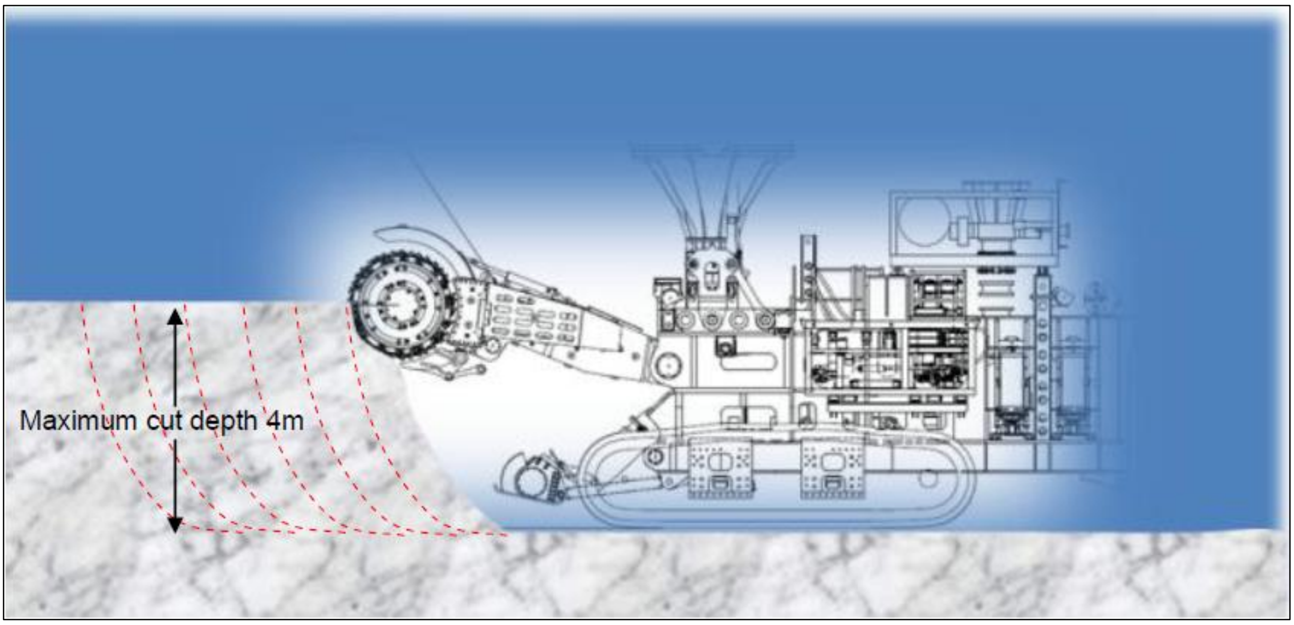
The bulk cutter is designed to operate in either of two cutting modes: continuous cutting, and cyclic cutting. Continuous cutting (Figure 16.4) is the preferred method, and requires the bulk cutter to cut while advancing forward under track power. The maximum face area for such a cut is 4.2 m wide and 1 m high. Typical advance rates for this cutting action are expected to be in the order of 0.5–0.9 m/min.

Figure 16.4 Continuous cutting mode



Cyclic cutting (Figure 16.5) is performed while the machine is stationary and the machine tracks forward only in periods of non-cutting This mode will be adopted when the bulk cutter is required to take cuts that exceed 1.0 m in height to a maximum of 4 m. Cyclic cutting is expected to offer lower productivity than continuous cutting and be prone to generating oversize material.

Figure 16.5 Cyclic cutting mode



16.2.3 Collection machine

The collection machine is a track-mounted machine designed to reclaim fragmented material from seafloor stockpiles and pump it as a slurry to the subsea slurry lift pump. The machine is 17 m long and 6 m wide, and weighs approximately 185 t in air. The machine is fitted with 750 mm wide track shoes to allow it to track over soft ground and exert a static bearing pressure of 200 kPa.

The stockpile dimensions will have a spread dimension of approximately 25 m diameter and a height of 12 m. Gathering of the fragmented rock will always commence at the base of the stockpile. The collection machine will work in a segmental approach around the circumference to avoid hang-ups. Should hang-up occur, the collection machine has a vertical reach capability of approximately 5 m, which should overcome this event.

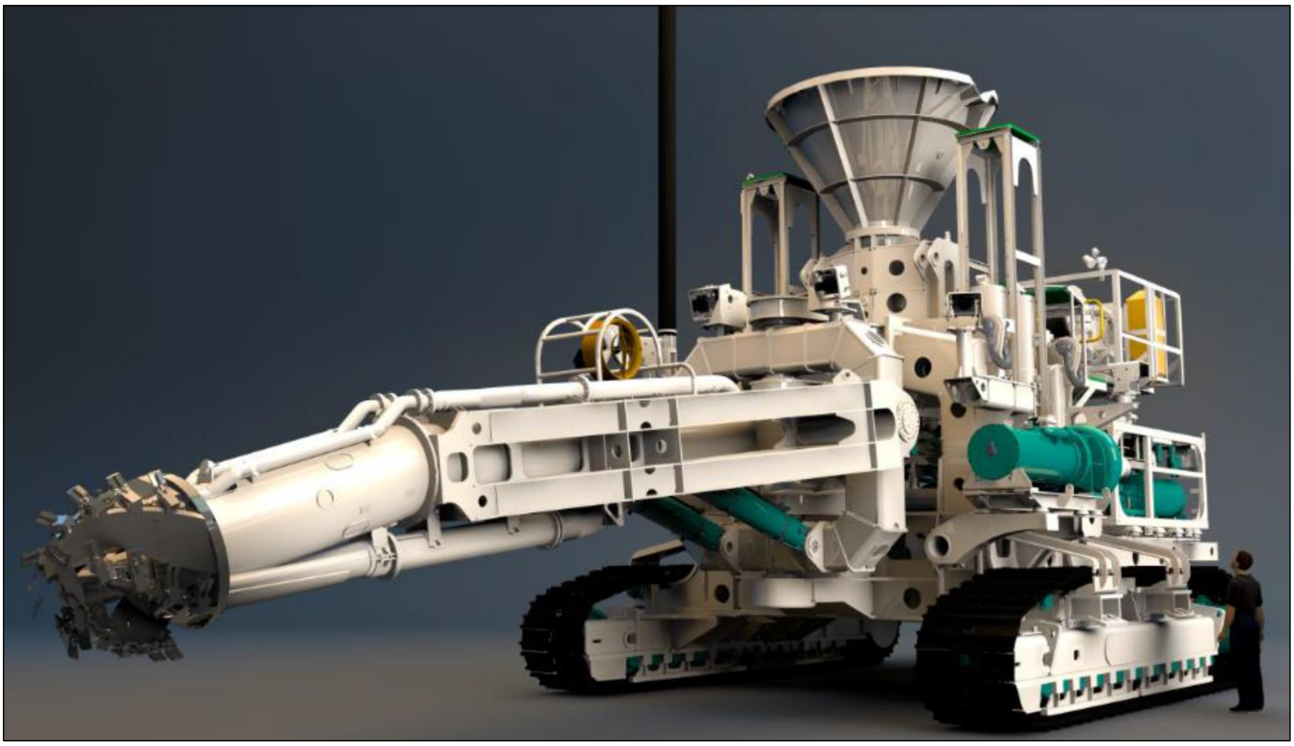
The boom is fitted with a 1.05 m-diameter dredge crown cutter. The crown cutter is directly driven from a 150-kW hydraulic motor, which rotates at maximum of 20 rpm. The crown cutter's primary function is to agitate the stockpile material to improve collection efficiency. In addition, it can impart 120 kW of cutting power to the rock through the 25 chisel picks laced on the cutter. While the collection machine can cut rock, it is not really designed for the purpose as the long boom could be overstressed. The boom slew cylinders will relieve at 118 kN to protect the boom.

The collection machine is equipped with a three-stage slurry pumping system to deliver the slurry to the subsea slurry lift pump at a concentration of 12% at a minimum discharge pressure of 5 bar. Each stage is directly driven by a 330-kW electrical motor. Each motor has variable frequency drive control to adjust the rotation speed and pump flow. The collection machine has a riser transfer pipe connected to it to transport the collected material to the subsea slurry lift pump.

The collection machine has a secondary function of side casting unconsolidated, unmineralised sediments.

The design of the machine includes components from several manufacturers. The collection machine is shown in Figure 16.6.

Figure 16.6 The collection machine



16.2.4 Riser transfer pipe

The riser transfer pipe is a flexible hose that connects the collection machine to the subsea slurry lift pump. It has a nominal 280 mm internal diameter and its approximate length is 150 m to 200 m. The riser transfer pipe will have syntactic buoyancy floats to prevent tangling, and allowing the free-flow of slurry to the subsea slurry lift pump.

Work on the riser transfer pipe was suspended in 2012, and fabrication has not yet restarted

16.2.5 Subsea slurry lift pump

The subsea slurry lift pump is a 10-chamber positive displacement pump. This pump takes a direct slurry feed from the collection machine and boosts the pressure and flow to lift the mineralised slurry in a single stage to the production support vessel. Pumping is via a 10 ¾" (273 mm) diameter riser. The subsea slurry lift pump is driven by high-pressure water, supplied by an electrically powered multi-stage centrifugal pumps located on the production support vessel, and reticulated to the subsea slurry lift pump pumping chambers via two injection lines housed on the riser string.

The subsea slurry lift pump is designed to pump the nominal flow rate of 863 m^3/h of a 12% slurry, (delivering 331 t/hr) and can do so with up to two failed chambers. It can also continue to pump (potentially at a reduced rate) if one additional chamber fails.

Each pump chamber has four primary valves, two on the water side and two on the slurry side of the diaphragm. The values are timed to minimise pulsation on the slurry side.

The subsea slurry lift pump is designed to be maintained four times per year. The maintenance time required for each of these quarterly services is 24 hours. It is anticipated that in a worst-case scenario 20 of the 40 valves may require servicing each maintenance cycle. Each time the subsea slurry lift pump is serviced the riser string is raised up through the moon pool of the production support vessel one section at a time by the derrick. It is estimated that it will take three days to retrieve the subsea slurry lift pump to the deck and another three days to lower after servicing.

The subsea slurry lift pump has completed its factory acceptance testing at the General Electric Oil & Gas (Hydril) testing facilities. During this time, the subsea slurry lift pump completed 450,000 cycle trials with various mineral densities, shapes and sizes, like the fragmentation expected during mining operations at Solwara 1. To date, the tests have been very successful with no significant damage or failure occurring.

16.2.6 Riser and lifting system

The riser and lifting system is the pipe that will transfer mined rock as a slurry from the subsea slurry lift pump (using positive displacement) to the production support vessel, and to return water and fine sediments under pressure back to the seafloor.

The riser and lifting system comprises a three-pipe steel structure, with the largest diameter pipe having an internal diameter of 308 mm. This main pipe is for the transfer of the primary process slurry from the stockpiles via the collection machine and subsea slurry lift pump.

The two smaller pipes return water and sediment back to the seafloor. Each pipe has an internal diameter of 194 mm and is clamped onto the main riser pipe. Each section of pipe is 18.2 m in length. Under normal operational conditions, there will be approximately 85 lengths of the riser and lifting system in operation. The top 500 m of the riser and lifting system will have helical strakes to prevent vortex-induced vibration, which is a common principal used in engineering for long lengths of narrow cylinder-like structures. A third of riser pipe lengths will be buoyed using syntactic foam buoyancy units.

Fabrication and factory acceptance testing of the riser and lifting system is complete and the systems are in storage.

16.3 Submerged trials of seafloor production tools

16.3.1 Objectives

Submerged trials of the seafloor production tools have occurred. The two main objectives of the trials were to ensure the seafloor production tools can operate in a submerged environment, and ensure the seafloor production tools can achieve their functional performance requirements when submerged. Functional performance is measured by trials designed to analyse each machine’s stability, manoeuvrability, collection efficiency, operability, and maintainability. Trials are carried out in phases designed to measure specific performance criteria, with each phase a gate to the next phase. Remedial work is identified and completed prior to progressing to the next phase. Common to each trial are the first four phases:

1. Onshore function tests: Tests of all components to ensure they function correctly. These tests were performed before the machine was deployed in water.
2. Submerged function tests: Function tests performed with the machines deployed in the water to test the machine component functions when submerged, and integrity of the data collection and measurement system.
3. Submerged endurance trials: Endurance trials with the machines deployed in water, to trial longer period simultaneous operation of machine functions and validate the slurry measurement system operation (mass flow measurement).
4. Submerged collection trials: Evaluate the effectiveness of the material handling and dredge system when collecting screened aggregate (mass flow).

The performance of the cutting and dredging system on the auxiliary cutter and bulk cutter was also evaluated with an addition trials phase: cutting and stability trials:

5. The cutting and stability trial: the cutter deployed in water to trial the system and controls available to effectively fragment rock to the required size and collect at the required slurry density (control of mass flow).

Details of the submerged trials are summarised in Table 16.1.

Table 16.1 Submerged trial details

Activity	Collection machine		Auxiliary cutter		Bulk cutter	
Date of test	23 Aug 2017		14 Nov 2017		29th Jan 2018	
	Total Hours	Submerged Hours	Total Hours	Submerged Hours	Total Hours	Submerged Hours
Hydraulic power unit operation	318	178	569	255	222	90
Dredge operation	104	104	237	237	89	89
Cutter operation	66	60	115	87	34	27
Tracks operation	15	10	15	9	20	13

16.3.2 Preliminary results for collection machine submerged trial

The test plan implemented for the collection trial included the development of an 8-metre high conical stockpile of -50 mm selected aggregate with 5% oversize. The collection machine successfully collected 371 t of aggregate from this stockpile, which was pumped to a dredge bag collection system for sampling. Reconciliation of the material collected showed that the mass-flow measurement was accurate, and the collection machine performed satisfactorily with respect to collection efficiency.

16.3.3 Preliminary results for auxiliary cutter submerged trial

The auxiliary cutter submerged trial test plan focused on how effectively the cutting process can be controlled to achieve the target production rate and particle size distribution, and the capability to develop ramp access. Production rate is directly related to the rock mass characteristics such as compressive strength, brittleness ratio and rock quality. The rock excavated from the submerged trial pit was significantly harder and more massive than that expected at Solwara 1.

During the submerged trials the auxiliary cutter collected 138 m^3 (365 t) of aggregate from the remnants of the collection machine stockpile. This material was pumped to a collection impoundment and reconciliation demonstrated that the mass flow measurement was accurate and that the auxiliary cutter performed satisfactorily with respect to collection efficiency.

Cutting performance was measured by the auxiliary cutter developing a ramp transitioning to 20° over 19 m comprising 10 cuts. The planned volume of the cuts was 291 m^3 with an average height of 2.2 m and maximum height of 3.6 m. During the trial the auxiliary cutter excavated 283 m^3 (749 t) of rock from the 10 cuts, achieving the design profile with 3% lost mineralised material. The Solwara 1 mine plan estimates 10% mineralised material loss during excavation. These results indicated that the auxiliary cutter performed satisfactorily with respect to cutting efficiency.

16.3.4 Preliminary results for bulk cutter submerged trial

The bulk cutter submerged trial test plan focused on the effectiveness of gathering material with the auger and pumping it to the collection impoundment, as well as evaluating the different controls available to fragment the rock effectively.

During the submerged trials the bulk cutter collected aggregate from the remnants of the collection machine stockpile. This material was pumped to a collection impoundment and reconciliation demonstrated that the mass flow measurement was accurate. Initial collection efficiency was very low requiring a modification of the opening size on the auger and collection system. Following this modification, the bulk cutter performed satisfactorily with respect to collection efficiency.

During the trial the bulk cutter excavated 47 m^3 (122 t) of rock from the three cuts, achieving the design profile. While the duration of this phase of the trial was limited, the results indicated that the bulk cutter performed satisfactorily with respect to cutting efficiency.

16.4 Survey

The survey equipment and systems for Solwara 1 have not yet been finalised.

Subsea mining at a depth of 1,600 m is a new application of acoustic positioning systems. However, there is a significant amount of practical experience with similar systems in the oil and gas industry where it is not uncommon to install infrastructure and pipelines in deeper water with more demanding accuracy than is required by the Solwara 1 Project. Nevertheless, there are expected to be some issues to resolve in terms of the operating environment and detailed positioning specifications required for Solwara 1.

Accurate positioning of the seafloor production tools, riser transfer pipe, stockpile hose, and associated risers and flexible hoses is required. The items for which precise positioning is required includes:

- The three mobile seafloor production tools must be positioned with an accuracy of ±100 mm. The systems located on the auxiliary cutter and bulk cutter must be able to accurately position the tools in a 40-m deep cut trench at all times.
- The seafloor production tools are disconnected from the lift wires during operation. The position of the lift wire bullets (for reattachment) will need to be known.
- Three seafloor production tools umbilicals connect the Seafloor production tool to the production support vessel. The real-time catenary shape of these umbilicals is required. The umbilical shape will be modelled using a physics simulation and the position verified by a transponder at the mid-point of the umbilical.
- Two flexible stockpile hoses connect the auxiliary cutter and bulk cutter to the stockpile. These stockpile pipes will be buoyant and form an inverted U-shaped catenary in the water column. The midpoint of the catenary will need to be positioned. The pipes will be disconnected from the seafloor production tools during moving operations, and in this case, both the ends of the pipe and clump weights, used to anchor the hose ends, should be monitored. The pipe shape will be modelled using a physics simulation and the position verified by a transponder at the mid-point of the pipe.
- A 160-m riser transfer pipe will join the collection machine to the subsea slurry lift pump. This has an S-shape and at least two points may be used to verify the position generated by the real-time physics simulation. Again, this pipe will be disconnected periodically from the collection machine and both the ends of the pipe and clump weights should be monitored.
- The position of the subsea slurry lift pump, which is attached to the production support vessel by a rigid riser, should also be monitored.
- It is expected that at least two ROVs with tether management systems will be used for seafloor assistance work, and their position should be known.

Recognising the importance of accurate positioning for its seafloor production system, Nautilus appointed RPS Group Plc (RPS) to explore all commercial available undersea positioning systems. RPS invited four companies to participate in their study based on the manufacturer’s ability to work towards a relative positioning accuracy of ±100 mm.

After extensive research, RPS concluded that there are no off-the-shelf systems available that meet all the survey requirements. All four manufacturers acknowledged that some additional development work will be required. One or more of the four survey contractors investigated will be engaged to supply the Project with its survey equipment.

16.5 Mine Planning

The Solwara 1 mine plan considers the following:

- Geological and bathymetric modelling
- Resource estimation.
- Geotechnical modelling.
- Equipment design.
- Environmental requirements.
- Economic evaluation.

16.5.1 Geotechnical analysis

Extensive geotechnical analysis has been undertaken by Nautilus and its consultants. The main and most recent findings are summarised in "PSM Geotechnical Assessment Report" (Pells Sullivan Meynink (PSM), 2012a), and the supporting "Factual Geotechnical Data Report" (PSM, 2012b), and "Assessment of Block Size Distribution Report" (PSM 2012c). The PSM reports review, analyse, and summarise the geotechnical information from the various drilling campaigns, but primarily from the 2010/11 Rem Etive campaign.

16.5.1.1 Geotechnical data and test work

The test work carried out during the Rem Etive program is summarised as follows:

- Pocket penetrometer tests on selected soft footwall samples.
- Uniaxial compressive strength (UCS) measurements, the most common, universally accepted laboratory measure of the strength of intact rock. Elastic (Young's) modulus and Poisson's ratio were determined for each UCS test.
- Brazilian indirect tensile strength (BTS) measurements, a relatively simple test to estimate the tensile strength of rock.
- Point load testing both diametral and axial. From this test, a point load strength index can be obtained.
- Dry bulk density and moisture content.

16.5.1.2 Slope stability analysis

Limit equilibrium analyses were undertaken to assess the possibility of overall slope failure.

Material strengths for the limit equilibrium analyses were based on the average strength values from the rock strength testing, downgraded to rock mass strength using the RocData (or the older discontinued RocLab) software package (RocScience, 2015b). The stronger materials have Hoek-Brown values assigned, while the soft hangingwall and footwall units were modelled as undrained material with Mohr Coulomb shear strength parameters.

The input parameters required to obtain the empirically derived Hoek-Brown constants include: geological strength index (GSI), UCS, and two additional parameters m_i and D.

PSM (2012a) reported GSI for each lithological unit by two methods, namely, from the rock mass rating (RMR) and estimating a value from the GSI nomogram. Engineering judgement was then used to select an appropriate GSI value.

The value for rock mass parameter m_i was obtained from typical values recommended in the literature, while the disturbance factor D was set as zero, which is suitable for open pit walls excavated by mechanical means that are expected to be relatively undisturbed (Hoek et al, 2002).

Factor of safety (FOS) analysis was done using Slide software (RocScience, 2015a). The limit equilibrium analyses were carried out assuming a water depth of 1,700 m to reflect the hyperbaric pressure on the slope being analysed.

The FOS values for slopes constructed in mineralised rock or the underlying volcanic rocks (mostly the sulfate dominant (RA) rocks, sulfide dominant rocks (RI), and the coherent volcanic unit (VC unit), or a combination) are all between 4.4 and 9.4 against circular failure and 4.6 to 9.6 for non-circular failure. For the two cross-sections where the slope is constructed in a mixture of clay dominant rock (RC) and volcanics (VC), the FOS is 4.4 or 7.7 against circular failure and 1.9 or 7.6 for non-circular failure.

Overall slope angles of between 22° and 42° were assessed and slope heights were in the range of 15 m to 30 m. Locally steeper slope sections were measured from the cross-sections and found to range between 31° and 68°.

PSM assessed the possibility of the mineralisation sitting on top of an extensive, thick soft zone by substituting RC for RA, and running circular and non-circular failure analyses for two cross sections. The presence of weaker footwall material (RC) results in a large reduction in the FOS in both cases, from FOS of 4.4 and 5.4, down to 1.8 and 2.0 against circular failure. If the dip of the contact is steeper than that analysed, the FOS may drop into the range where failure is possible. This localised steepening of the footwall contact is more likely to occur on a smaller scale, i.e. bench-scale.

The analysis indicated that if the mine is excavated as planned, slope failure is unlikely under normal conditions. Geotechnical issues would be expected only if clay dominant footwall rocks are both more prevalent than has been modelled and have steeper contact angles than modelled.

16.5.1.3 Preliminary seismic analysis

The seismic analysis work reported in PSM 2012a is titled “preliminary”, and it is clear that additional work is required to better quantify the likelihood and severity of earthquakes at or near the mining area during the relatively short span that operations will be carried out. Seismic coefficient values (k_h) of 0.1, 0.3, and 0.5, representing the ratio of horizontal ground acceleration to gravity, were analysed.

The lowest factor of safety (FOS) for k_h = 0.1 was 1.3 for a weak slope in the RC rock unit. The two slopes modelled with RC in the footwall (to simulate extensive weak footwall conditions) both had FOS <1 for k_h=0.3 and 0.5, the lowest value being 0.6.

The stability of low strength sediments outside the pit limits due to earthquake load was not considered in the PSM 2012a report. Such sediments are likely to flow for great distances. The cross-sections indicate that the mining method is more akin to hill top removal. Any sections of the pit beneath large deposits of soft sediment will require this aspect to be further investigated.

The analysis indicated that seismic activity could induce slope failure in areas where the footwall consists of weak, clay-dominant rocks.

16.5.1.4 Structurally controlled failure

PSM considered that the lack of structural data and related structural analyses is a risk to the Project. PSM observed “This aspect remains the biggest single unknown geotechnical factor for Solwara 1 in relation to slope stability”.

PSM assessed the likely block size distribution for the mineralised zone materials at Solwara 1. This assessment was based on rock quality designation (RQD) and fracture frequency (FF) or a variation of FF, depending on the data gathered for the numerous different exploration programs. FF data was given greater weighting than RQD data in the assessment as it was suspected that drilling induced fractures were (incorrectly) included in the RQD calculations.

PSM used four different methods to determine the block volume, namely: the RQD method, the FF method, the FF to RQD correlation method, and the weighted joint density (wJd) method. PSM concluded that the median block size is about 1 m^3 and that 50% of blocks will be between 0.1 m^3 and 3 m^3.

The blocky nature of the rock mass poses some risk to the operation. Large blocks dislodging from bench walls might damage the seafloor production tools, cause blockages, or interfere with accurate machine positioning and cutting. The mine plan correctly maximises the use of the continuous cutting mode for the bulk cutter which should minimise the impact of blocky ground.

16.5.1.5 Rock cuttability test work

Nautilus commissioned rock cuttability test work on drill core obtained from seafloor drilling programs. The first round of testing estimated the production rate for the seafloor production tools in hyperbaric conditions. Five rock types with varying strength parameters (travertine, Kufeki-limestone, limestone, sandstone and beige marble) were used as comparative samples. The following tests were carried out on large blocks of the five rock types:

- Full-scale linear cutting machine test with conical cutter.
- Drilling tests using both polycrystalline diamond compact bits and diamond core bits.
- P and S wave velocities.
- Static and dynamic elastic modulus.
- Dynamic Poisson’s ratio.
- Dry and saturated densities.
- Liquid permeability.
- Apparent porosity.

- UCS and BTS.

A second round of testing included the following:

- Small-scale cutting tests on drill core from the five comparative sample rock types:
  - Small-scale linear cutting machine test (SLCM) with chisel tool.
  - Portable linear cutting machine test (PLCM) with mini disc.
  - The rock parameter tests carried out on the large blocks, plus static Poisson's ratio and point load tests.
  - Cerchar abrasivity index.

Selected mechanical properties and specific energy values of various lithological unit as indicated by the test work are summarised in Table 16.2.

Table 16.2 Selected mechanical properties and specific energy values

Test Type	Parameters (mean)	Volcanoclastic breccia	Conduit-bearing facies	Consolidated sediments	Sulfide dominant rock (1)	Sulfide dominant rock (2)
Rock strength and mechanical properties	UCS (MPa)	2.9	30.1	–	14.9	52.1
	BTS (MPa)	0.07	3.27	–	3.84	4.62
	UCS / BTS ratio	–	9.19	–	3.89	11.28
	Static elastic modulus, E_{sta} (GPa)	–	10.58	–	11.90	12.83
	Dynamic elastic Modulus, E_{dyn} (GPa)	10.83	28.57	–	32.38	50.15
	Apparent porosity, n (%)	40.7	13.2	–	16.1	12.3
	Apparent density (g/cm^3)	1.49	3.04	–	2.82	3.35
	Cerchar abrasivity Index	0.30	1.25	1.15	1.20	3.13
SLCM	SE-SLCM (MJ/m^3)	3.26	13.10	11.58	16.18	21.07
PLCM	SE-PLCM (MJ/m^3)	–	85.19	–	–	96.37

Source: ITU (2011c)

The cuttability analysis was considered in the design and productivity estimates for the seafloor production tools.

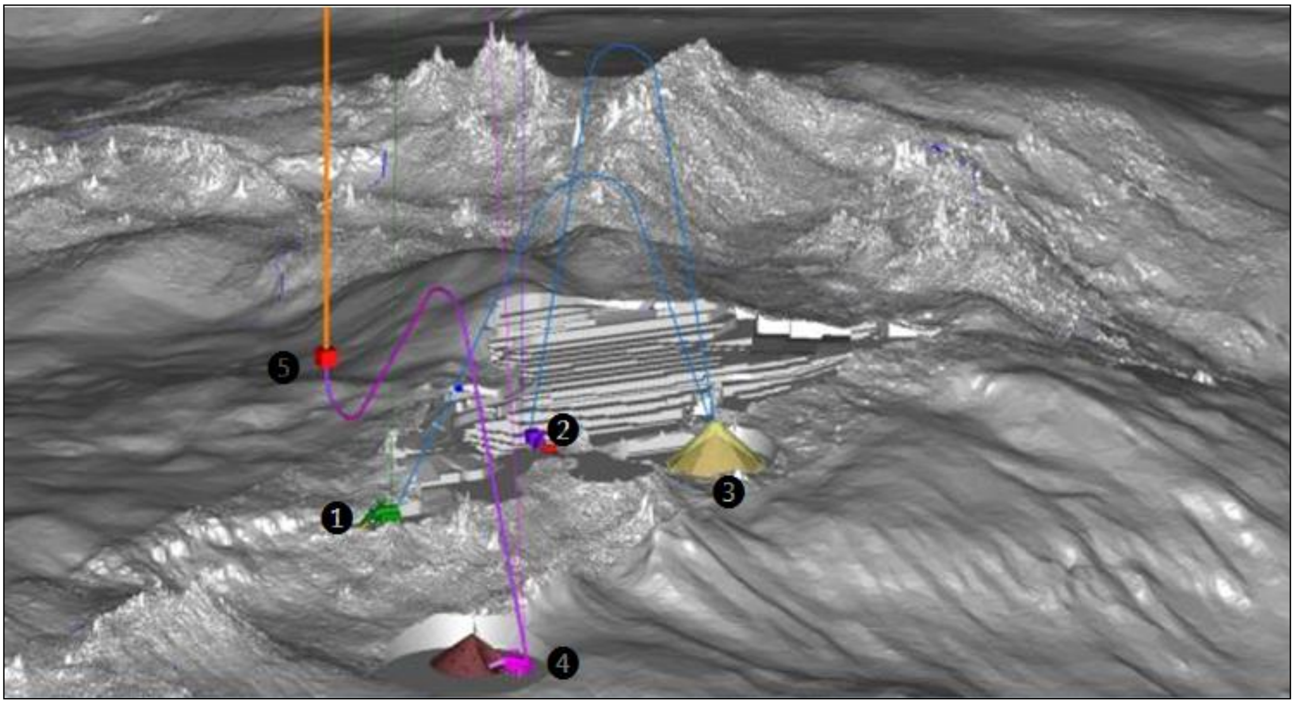
16.5.2 Mine design

The mine design divides the planned mining area into many mining blocks, or panels. The mining sequence is top-down, so all material overlying the mineralisation must be mined first. The blocks were designed to suit the capability of the auxiliary cutter and bulk cutter, and to maximise the use of their most efficient modes of cutting. There are two phases of operation based on the two machines:

- Pioneering mine development including ramp and bench set up completed by the auxiliary cutter.
- Primary production in areas designed to suit the capabilities of the bulk cutter.

The overall seafloor operation is illustrated in Figure 16.7.

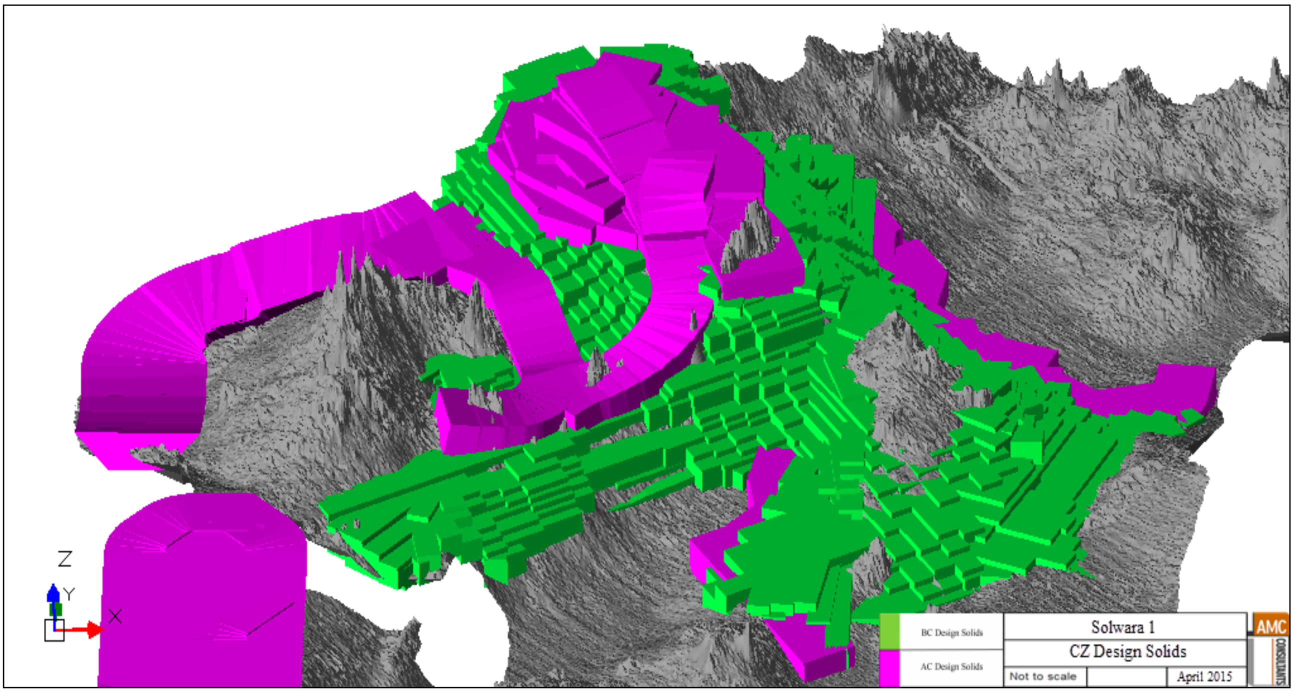
Figure 16.7 Illustration of proposed seafloor mining operations



1. Auxiliary cutter – Developing new area for production;
2. Bulk cutter – Production cutting;
3. Stockpile – receiving fragmented rock from the auxiliary cutter and bulk cutter simultaneously;
4. Collection machine – collection from stockpile and delivering to subsea slurry lift pump; and
5. Subsea slurry lift pump – receives mineralised slurry from collection machine. Boosts pressure and flow to hoist rock to production support vessel.

An example of the mine development is shown in Figure 16.8. The pink blocks represent the pioneering work to be completed by the auxiliary cutter and the green blocks represent the main production blocks to be completed by the bulk cutter. Areas with steep terrain and chimney areas (coloured grey) are excluded from the mine design.

Figure 16.8 Mine design example



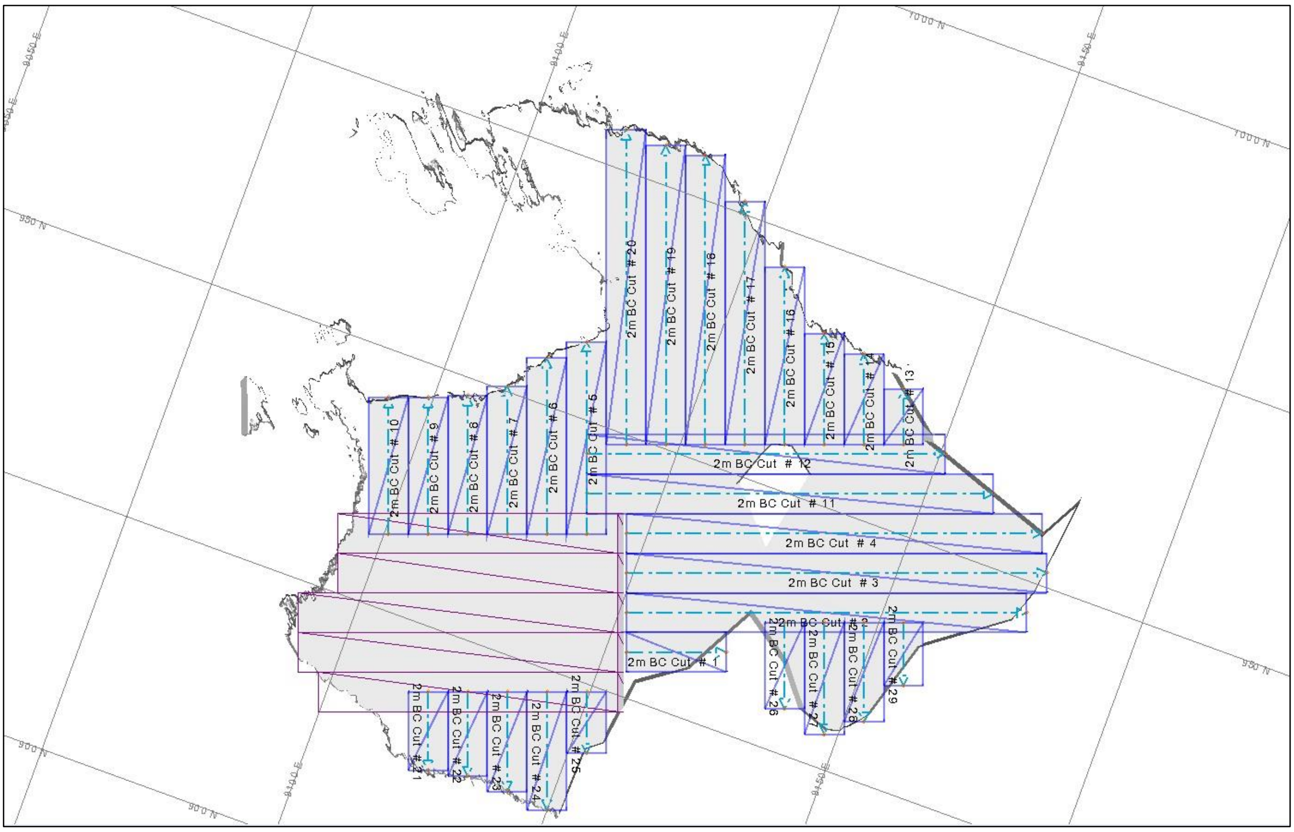
Minimum floor area required for a bulk cutter bench design is 1,500 m^2, which is approximately equal to the minimum ramp area. Continuous cut benches have a maximum height of 1 m while the cut width is limited to 4.0 m, this allows for a 0.1 m overlap to account for minor survey inaccuracies.

The general design philosophy has been to:

- Design from stable ground to less competent ground.
- Maximise cut lengths.
- Limit turning and manoeuvring requirements.
- Maximise resource extraction.
- Limit opportunities for dilution.
- Create designs to maximise auxiliary cutter and bulk cutter independence.

Figure 16.9 shows an example of a single horizon of designed benches (1 m high) that will be excavated by the bulk cutter.

Figure 16.9 Example of bulk cutter bench design



The extent of the mine design matches the extent of the mineralisation within the larger sulfide Mineral Resource, with exclusion of areas where resource width is narrower than the minimum cut width, and where the seafloor terrain is too steep to allow access.

The Mineral Resource cut-off grade of 2.6% CuEq (as calculated in Item 14.1 of this report) was used for mine planning at Solwara 1. A negligible quantity of material below the stated cut-off grade (2.6% Cu) is included in the production schedule.

Some areas of mineralisation were excluded from the mine design on the basis that for these areas:

- The terrain is too steep.
- The ground is too weak (i.e. geotechnically incompetent) to support mining machines.
- Hydrothermal vent activity is expected and there is a likelihood of high water temperatures.
- The deposit is too thin to extract economically.

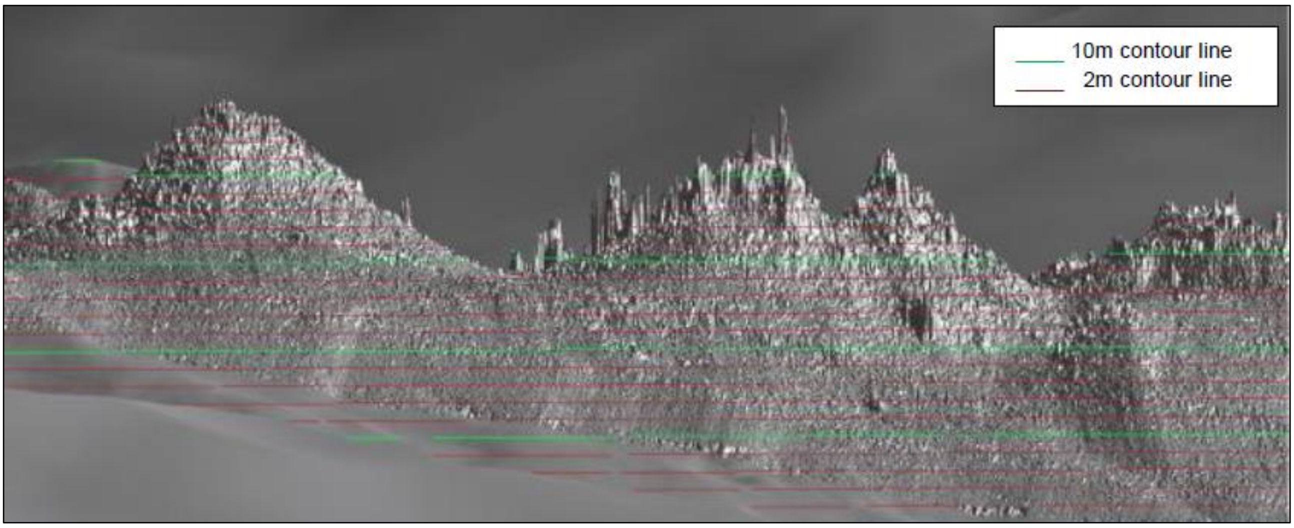
16.5.3 Removal of unconsolidated sediment

Unconsolidated sediment overlays much of the deposit, ranging in thickness typically from zero to 2.7 m, and up to 6 m in localised troughs. With an angle of repose of about 15°, it accumulates in depressions throughout the deposit. The estimated density is 1.2 t/m^3, consisting of silt and sand particles in a seawater matrix. Nautilus proposes to remove the sediment using the auxiliary cutter, with the sediment then being pumped to designated discharge points outside the mineralised zone. It is estimated that there are about 130,000 m^3 of unconsolidated sediment overlying the Solwara 1 deposit. Removal of unconsolidated sediment will be carried out progressively, as required for chimney removal and production activities.

16.5.4 Levelling chimneys

Mineralised chimney mounds in the Project area can be more than 20 m in height, and individual chimneys may be in the order of 15 m in height. There are numerous chimneys that must be levelled prior to the cutting machines entering the area (Figure 16.10). This levelling is required because the chimneys are either too high and out the reach of the cutting machines, or the chimney mounds are too steep for the auxiliary cutter to access.

Figure 16.10 Examples of chimney mounds in the Central Zone of Solwara 1



The method selected for chimney removal is a subsea grab. Nautilus is considering the engagement of Cellular Robotics, Canada to supply the technology required. The method involves the use of the clamshell excavator (an example of an existing clamshell excavator system is shown in Figure 16.11). The excavator would be lowered from the back of a surface vessel. It would be electrically powered and remotely controlled via an umbilical cable.

Figure 16.11 Example of clamshell excavator

The excavated material will be placed immediately adjacent to its excavated location and recovered later by the auxiliary cutter or bulk cutter.

16.5.5 Mining recovery and dilution

Mining recovery losses at the cutting stage, the collection stage, and the dewatering stage have been estimated for the purpose of production scheduling and preliminary economic assessment.

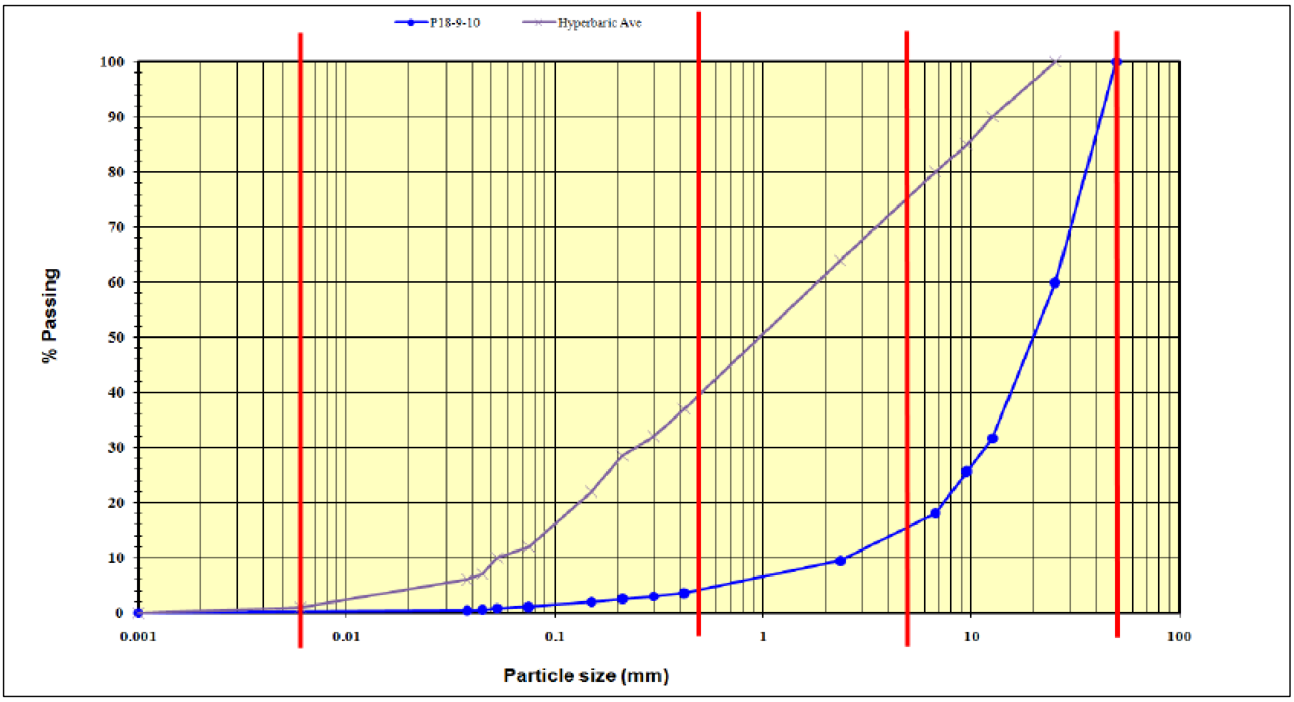
16.5.5.1 Cutting losses

Losses during cutting are expected to include:

- Fines lost during fragmentation. Particles that are less than 130 μm are susceptible to becoming temporarily suspended in the water column and some percentage of particles below this size will be lost.
- Fines lost at the point of discharge onto the stockpile.
- Coarse material which falls outside future mining areas.
- Material left on the bench.

A cutting particle size distribution curve (Figure 16.12) has been estimated based on a linear cutting trial under hyperbaric conditions.

Figure 16.12 Particle size distribution curve



These curves estimate that the amount fines generated (based on the primary fragmentation only) in this range is in the order of 5% to 32% of the material cut.

The total losses associated with cutting have been estimated to be 10%.

16.5.5.2 Collection losses

During stockpile reclamation, the collection machine will agitate the fragmented material on the stockpile with the rotating crown cutter. This is expected to improve the collection efficiency and the production rate. However, in doing so it will disturb the stockpile, which may resuspend fines that may have landed on stockpile. Some of these re-suspended fines are expected to be lost. A thin layer of broken rock may also be left on the stockpile pad on completion.

A mining recovery factor of 98% has been applied to the stockpiled tonnage.

16.5.5.3 Dilution

Planned internal dilution (from within the mining area boundary) and planned external dilution (from outside the mining area boundary has been estimated. The internal dilution results from the expectation that it will not be practical to selectively mine mineralised and non-mineralised rock separately within the mining areas. External dilution is expected because some excavation outside the target areas is required to accommodate the seafloor production tools.

The dilution by mining area within Solwara 1 is summarised in Table 16.3.

Table 16.3 Planned dilution

Zone	Dilution (% tonnage basis)	Relative decrease in grade (%)
Central Zone	16%	10%
Western Zone	6%	5%
Far West Zone	20%	12%
Eastern Zone	20%	13%
Far Eastern Zone	39%	18%
North Zone	34%	16%

Unplanned dilution (for instance, from bench wall failures) is assessed to be an insignificant risk.

16.5.6 Scheduling

A combination of mining industry-standard mine design and scheduling tools have been used to develop a task-based schedule for the Solwara 1 project.

Each designed mining block is ascribed attributes indicated by exploration data, including tonnes, grade, and minimum cutting durations, which reference the mean specific energy of the rock in each cut, and the specified machine capabilities in the selected cutting mode. Ancillary tasks and machine movements are included in the schedule.

16.5.6.1 Production rates

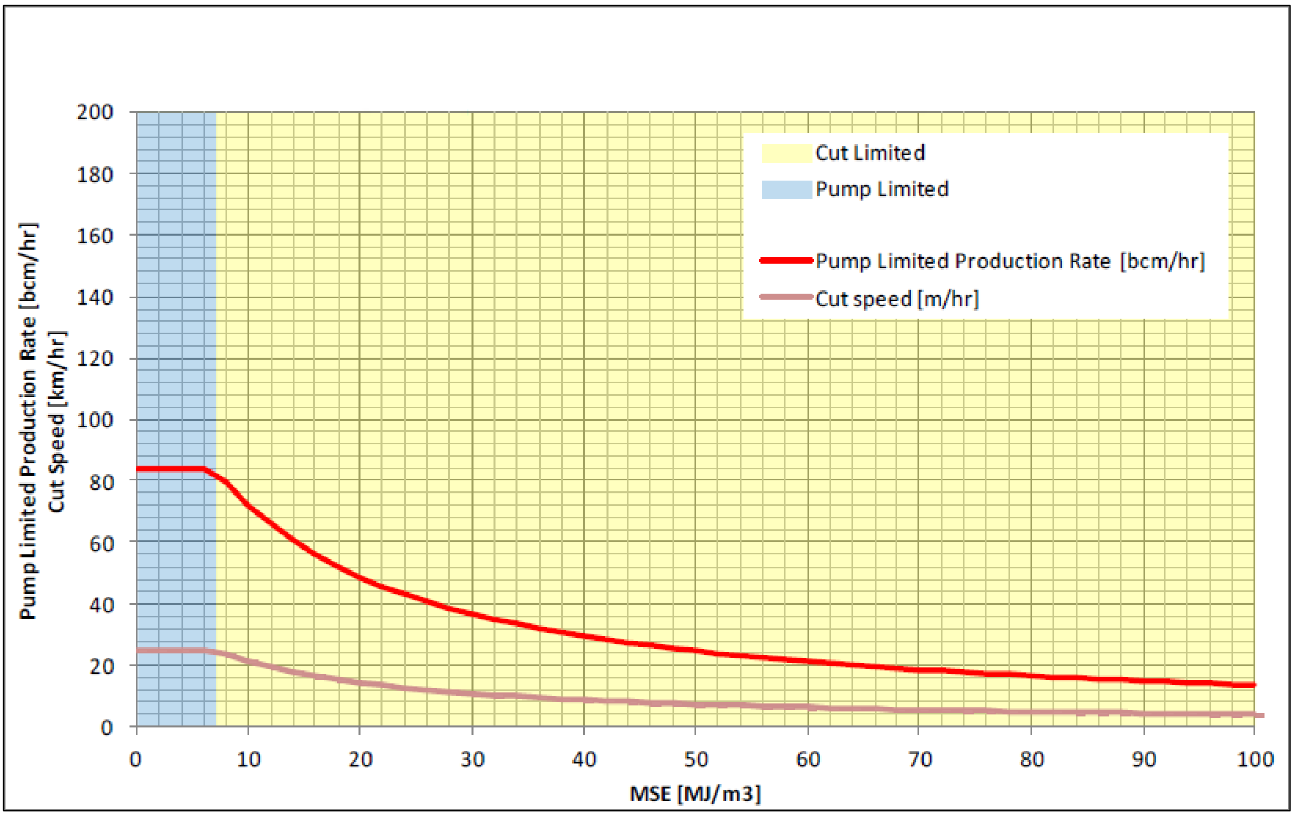
The production schedule is constrained by the operating parameters of the individual seafloor production tools. The production rate for each is not fixed, but depends on the face size it is cutting, and the mean specific energy of the rock mass being cut. The input parameters for estimating the auxiliary cutter production rates are listed in Table 16.4.

Table 16.4 Input parameters for determining the auxiliary cutter cutting rate

Parameter	Value	Unit
Tramming speed	600	m/h
Mean specific energy	17.3	MJ/bcm
Cutting power (into rock)	415.6	kW
Pump rate (nominal)	3206	m^3/h
Slurry concentration (nominal)	4.6	% volume/volume
First pass collection efficiency	70	%
Swell factor	135	%
Face height	4	m
Arc length	11	m
Drum cut depth	0.18	m
Cut sump depth	2.4	m
Number of boom "cut" sweep per face	22.2	cycle
In situ cut volume	106	bcm
Feed rate (boom slew rate)	3.4	m/min
Average cut rate	3.3	m/min
Drum sump in time	0.054	min / cycle
Sweep cutting time	3.337	min / cycle

The production rates of the auxiliary cutter against the mean specific energy (MSE) of the rock is shown in Figure 16.13.

Figure 16.13 Auxiliary cutter production rate as a function of MSE



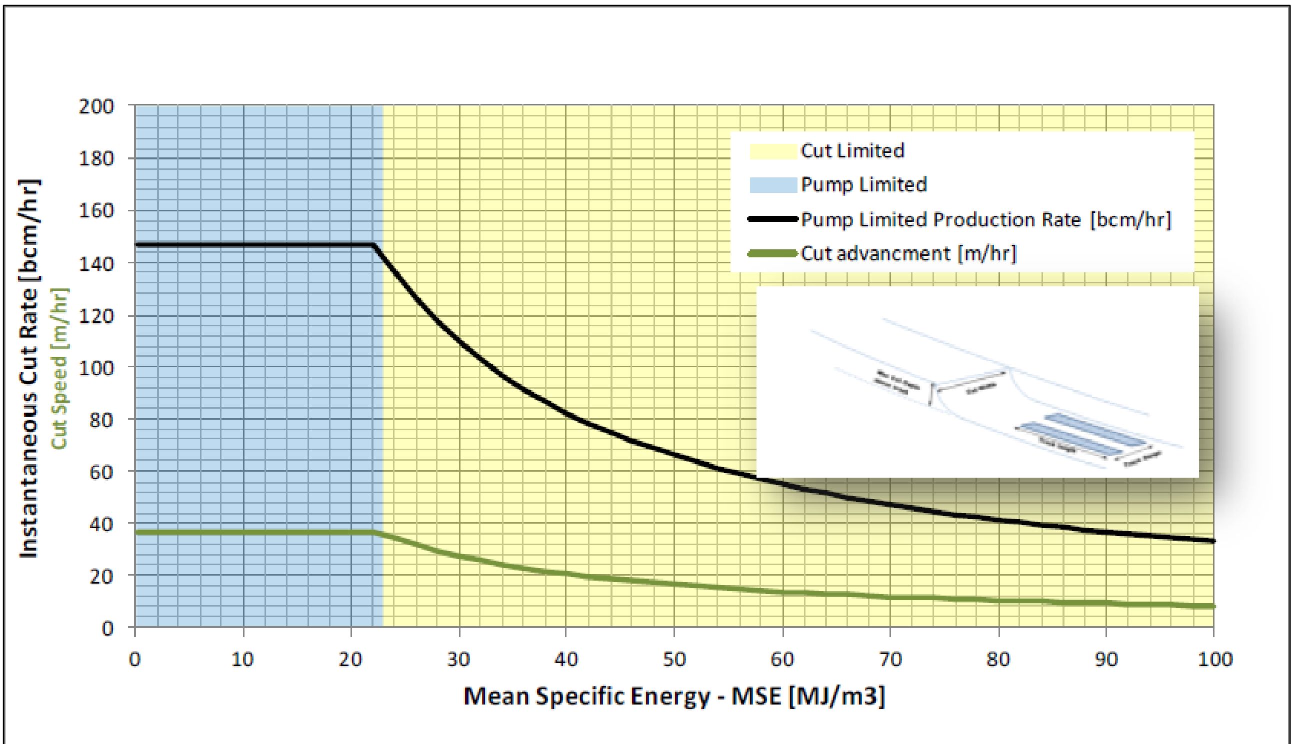
The input parameters for estimating the bulk cutter production rates are listed in Table 16.5.

Table 16.5 Input parameters for determining the bulk cutter cutting rate

Parameter	Value	Unit
Tramming Speed	600	m/h
Average specific energy	17.3	MJ/bcm
Cutting power (into rock)	918	kW
Pump rate (nominal)	3206	m^3/h
Slurry concentration (nominal)	4.6	% volume/volume
Collection efficiency	80	%
Survey accuracy	0.10	m
Cut height	1.00	m
Cut width	4.20	m
Cut depth	1.00	m
Boom hydraulic cylinder speed (raise)	0.032	m/s
Boom hydraulic cylinder speed (lower)	0.048	m/s
Boom hydraulic cylinder stroke length (4 m high cut, boom axis)	1.02	m
Maximum boom height	3.05	m
In situ cut volume	4.00	bcm

The production rates of the bulk cutter against the MSE of the rock are shown in Figure 16.14.

Figure 16.14 Bulk cutter production rate as a function of MSE



The input parameters for estimating the collection machine production rates are listed in Table 16.6.

Table 16.6 Input parameters for determining collection machine production rate

Parameter	Value	Unit
Name plate pump rate	863	m^3/h
Average slurry concentration	12%	% by volume
Maximum slurry concentration	14%	% by volume
Maximum instantaneous slurry (30 sec) concentration	20%	% by volume
Solids pump rate	103.6	bcm/h

Productivity modifying factors were applied during scheduling to model reductions in productivity that are expected in certain circumstances (Table 16.7).

Table 16.7 Productivity factors

Cut Description	Productivity Factor
Pioneering access	60%
Final bench cuts - post bulk cutter mining	30%
Auxiliary cutter production Cutting	75%
Auxiliary cutter ramp Cutting	40%
Auxiliary cutter stockpile cutting	60%
Auxiliary cutter unconsolidated sediment removal	50%
Bulk cutter main production Cutting <1 m cut height	100%
Bulk cutter decline ramp cut	75%
Bulk cutter cyclic cutting >1 m cut height	100%
Collection machine stockpile reclamation	80%

Allowances for delays for planned maintenance and due to bad weather are included in the schedule.

16.5.6.2 Allowance for productivity ramp-up

A 15-month linear productivity ramp-up is allowed in the schedule. In the first month, the time available for productive work is constrained to 20% of the hours in the month. By month 16, the time available for productive work reaches a maximum of 93% of the hours in the month.

Nautilus expects that an extended “learning curve” will be encountered at Solwara 1. Ramp-up, the process where production moves from a low rate and gradually increases to the design production rate as experience is gained, is common to manufacturing processes and mining alike. Achieving best practice for complex, untested systems in a new environment can be expected to take longer than implementation of simple and proven technologies. The production schedule, originally derived from first principles, has been moderated accordingly.

16.6 Production schedule

Total production, based on extraction of 0.9 Mt of Indicated Mineral Resource grading 6.4% Cu,4.6 g/t Au and 1.3 Mt of Inferred Resource grading 7.0% Cu, 5.5 g/t Au, has been scheduled. The production ramp up period is 15 months. A peak production rate of approximately 110 kt per month is planned. Solwara 1 is scheduled to be in production for a period of 29 months.

The production schedule, as delivered to the onboard dewatering plant, inclusive of dilution and mining losses, for Solwara 1 is shown in Figure 16.15 and Table 16.8. The production schedule is not a Mineral Reserve estimate. It is based in part on Inferred Mineral Resources, which are too speculative geologically to be used in a definitive economic analysis.

Figure 16.15 Solwara 1 production schedule by months

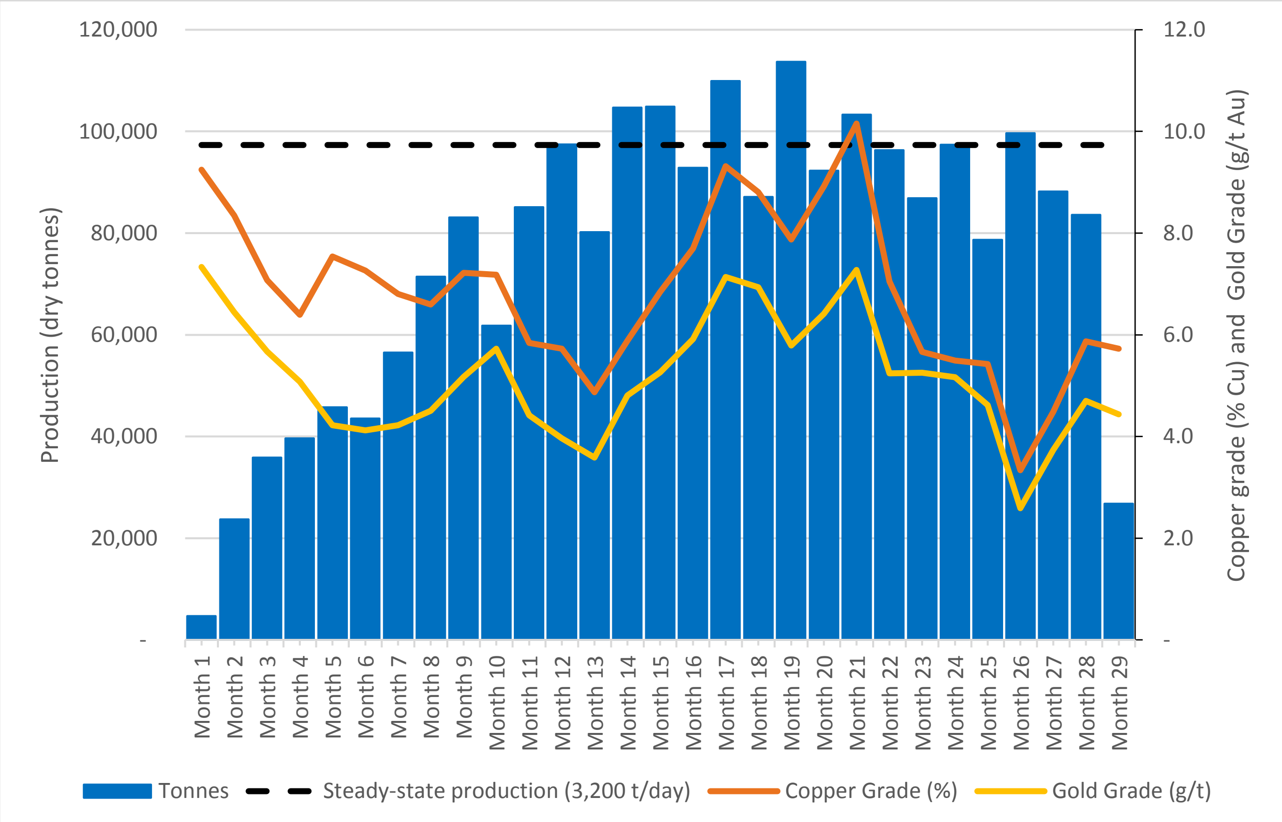


Table 16.8 Solwara 1 production schedule by quarters

	Total	Q4 2018	Q1 2019	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021
Dewatering plant feed (dry kt)	**2,200**	28	120	170	230	280	310	290	290	280	200
Waste moved (kt)	**76**	35	-	2.3	-	13	4.3	4.1	9.2	8.2	-
Cu (%)	**6.8**	8.5	7.0	6.8	6.7	5.5	8.0	8.5	7.7	4.7	5.2
Au (g/t)	**5.1**	6.6	4.9	4.3	5.0	4.2	6.1	6.3	6.0	4.1	4.2
Ag (g/t)	**26**	42	24	21	24	19	32	31	28	24	21
Payable Cu (t)	**130,000**	2,000	6,800	9,900	13,000	13,000	21,000	22,000	19,000	11,000	8,600
Payable Au (oz)	**180,000**	3,000	9,400	12,000	18,000	19,000	30,000	29,000	27,000	18,000	13,000
Payable Ag (oz)	**530,000**	11,000	28,000	33,000	53,000	50,000	93,000	85,000	75,000	62,000	40,000

16.7 Mine planning risks

The main risks to the mining plan include:

- There is no redundancy in the mining fleet. All the seafloor production equipment is required to function as planned for the duration of the Project. Loss or catastrophic failure of any one of the seafloor production tools will materially affect Nautilus's ability to execute the production plan.
- The estimate of production rate ramp-up is based on engineering judgement and analysis by analogy. Deep-sea mining has not yet been attempted and there are no very close analogues to the proposed mining project. The actual production ramp-up might be slower and longer than expected, resulting in higher operating costs. Conversely, the ramp-up might be significantly better than has been allowed for in the schedule, and actual project duration might be less, resulting in significant reduction to the average production cost.
- Most of the target Mineral Resource is in the Inferred category, meaning (by definition) that the density of data is insufficient to demonstrate geological continuity and grade continuity. The actual deposit characteristics could vary from the prevailing geological interpretations.
- The production plan requires that the seafloor production tools be operated and dynamically positioned within certain tolerances. The survey equipment and systems for Solwara 1 have not yet been finalised. There is existing technology, routinely used in the subsea oil and gas industries that might be adopted at Solwara 1. However, there are some practical issues to resolve and it is conceivable that maintaining constant accurate position control will not be achieved, and the production rate, and rates of mineralised material loss and dilution might vary from the plan.

17 Recovery Methods

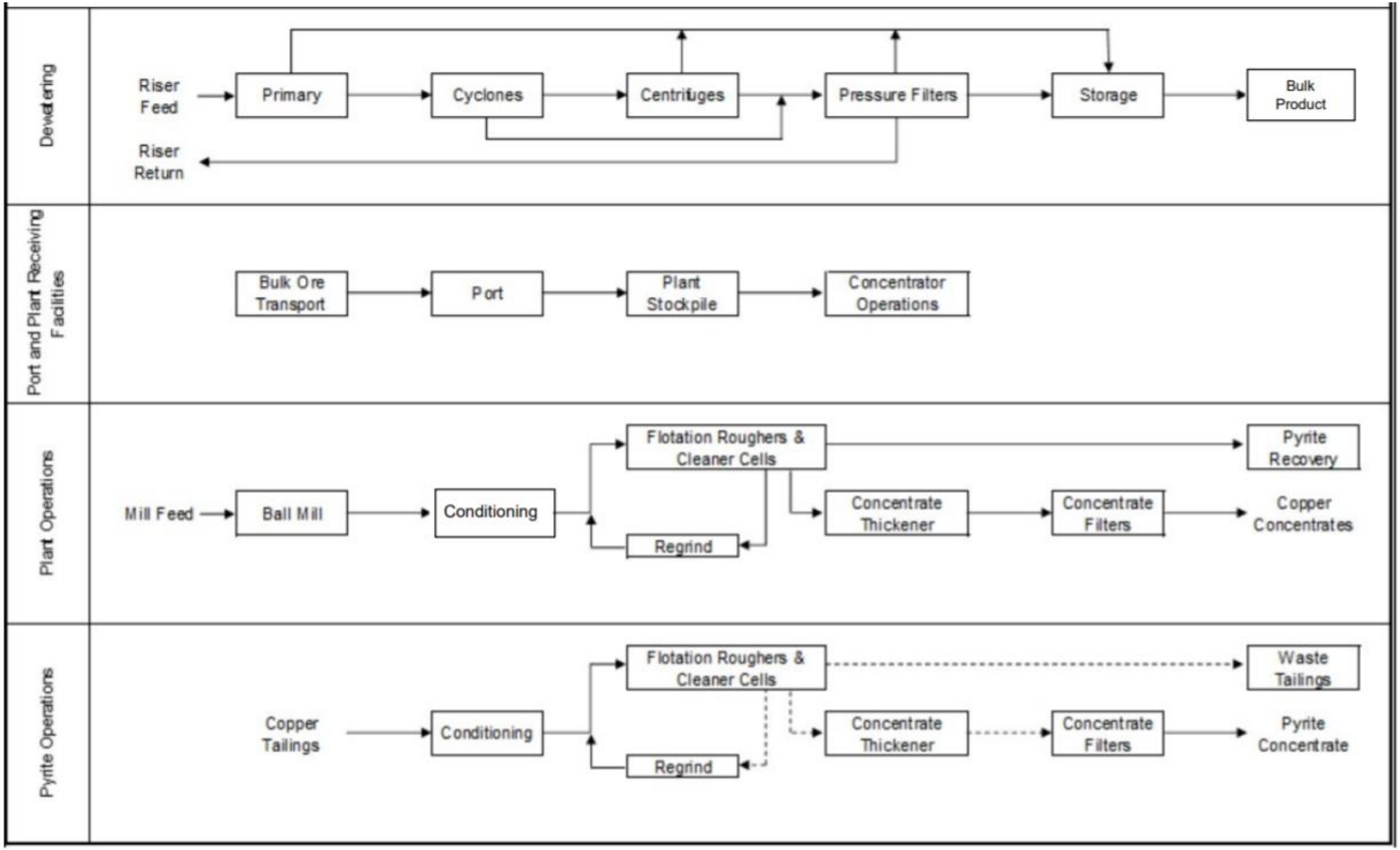
There are no Mineral Reserve estimates for Solwara 1 and the potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study. The terms “mineralised material” and "material" are used in this report to denote mineralised material above an economic cut-off grade on which the proposed mining, processing and product shipping activities are designed to operate. It does not imply that Mineral Reserves have been estimated at the date of this report.

Nautilus’s proposed mineralised material treatment route is summarised in Figure 17.1.

Broken mineralised material will be pumped to surface via the riser and lifting system directly to one of the de-watering plant double-decked screens. The screens are designed to separate the mineralised material into suitable size fractions for dewatering to below 10% moisture. The dewatered mineralised material will be stored on the production support vessel until loaded directly onto bulk carriers for transport to a port for treatment in a copper concentrator.

Nautilus has an agreement to sell the mineralised material to the Tongling Nonferrous Metals Group Co. Ltd. (Tongling). Tongling will treat the mineralised material in a custom-built concentrator adjacent to the Tongling Smelter, Anhui Province, PRC. The obligation for Tongling to build this concentrator is part of the Ore Sales and Processing Agreement between Nautilus and Tongling. The concentrator shall produce both copper and pyrite concentrates as well as a small quantity of tailings, which will be sold as feed material to cement works operating near-by. Copper concentrate will be treated through the recently commissioned Tongling double flash smelter, while the pyrite concentrate will be treated in Tongling’s existing acid plant and precious metals recovery circuits.

Figure 17.1 Proposed Solwara 1 mineralised material treatment route



17.1 Dewatering plant

The dewatering plant, which is located on the production support vessel, is the only mineral processing function that will occur at Solwara 1 prior to material storage, transfer and shipment. It is important to note from an environmental management perspective that no surfactants, filter aids or other processing chemicals will be used in the operation of the dewatering plant.

DRA Pacific Pty Ltd (DRA) was commissioned to design and build the dewatering plant based on earlier concept studies and metallurgical test work. The dewatering plant will be used to reduce the water content of the mineralised material to below the TML prior to shipping.

The dewatering plant typically receives mineralised material containing approximately 12% (volume/volume) solids to produce a product with 10% (weight/weight) moisture. To achieve this, the dewatering plant produces three streams of dewatered solids:

- +10 mm sands as a coarse screen oversize (via vibrating screens).
- -10 mm +150 µm fines (via vibrating screen oversize and primary hydrocyclone underflow which is subsequently dewatered by a centrifuge).
- -105 µm +8 µm filter cake (via primary hydrocyclone overflow and secondary hydrocyclone underflow subsequently dewatered by filters).

The three streams will be combined on a common conveyor and discharged to one of four storage holds of the production support vessel. Prior to discharge, each product will be measured for tonnage and moisture content with samples taken for grade control.

The proposed dewatering plant has a similar function to a coal washing plant, which is separation into the various size fractions and dewatering each fraction with suitably designed equipment. The technology is well proven and accepted worldwide.

The functioning of this plant is critical to production throughput.

17.1.1 Design criteria

Process design is constrained by product specifications, primarily the TML.

The TML is the permitted upper bound moisture content of a bulk solid granular material, defining the highest moisture content for safe marine transport of that material. An assessment of the transport requirements for trans-shipment of Solwara 1 mineralised material concluded that due to the potential variability in TML, testing for TML must be undertaken on the production support vessel. Hence, the design includes continuous monitoring of moisture content with benchmarking to on-site TML testing.

Mineralised material is supplied to the dewatering plant as slurry containing -50 mm particles. TML tests for sands and slimes are well documented and widely used in the industry. However, TML tests for coarse +7 mm size fractions mixed with fines are not clearly defined by the industry. Hence, the current process design incorporates the required moisture of each size fraction to meet a combined TML.

Dewatering plant design assumptions are as follows:

- A surge tank downstream of the dewatering plant screens reduces fluctuations in the plant feed, improving stability of the plant operation, and product quality and consistency.
- Variations in feed rate and material characteristics will be minimised or mitigated without additional equipment.
- Mineralised material will readily dewater on the screens.
- The TML for the -0.5-mm product will be consistent with existing operations shipping similar materials.
- TML for the -50 mm to +0.5 mm product will be similar to that of the -0.5-mm product.

Design criteria for the proposed dewatering plant is summarised in Table 17.1, Table 17.2, and Table 17.3.

Table 17.1 Plant design criteria

	Minimum	Average	Maximum	Units	Source
Annual production	-	-	1.8	Mtpa	Dewatering plant functional spec.
Daily production	0	3,800	9,480	t/d	Dewatering plant functional spec.
Operating days	170	190	210	d/a	Dewatering plant functional spec.
Utilization	60%		70%		
Operating hours	-	12	24*	h/d	Dewatering plant functional spec.
Feed concentration	0	12	14	% volume/volume	Nautilus
Solids feed rate	0	342	400	t/h solids	Nautilus
Specific gravity of mineralised material	3.0	3.3	4.3	t/m³	Nautilus
Slurry feed rate	-	860	1,000	m³/h slurry	Nautilus
Slurry temperature	6		7	°C	Nautilus
Water feed rate	-	757	1,000	m³/h	Nautilus
Residual solid particle size in return water	99% passing 8 µm and 80% passing 6 µm				Nautilus
Dewatered product residual moisture content	<TML (nominally 10%)				Nautilus

Table 17.2 Plant process size distribution envelope

Size fraction (mm)	Finest	Coarsest	Units	Source
50 x 10	14.19	73.37	% of feed	Colorado School of Mines PSD envelope
10 x 1.4 4	30.96	19.61	% of feed	
1.44 x 0.15	32.85	5.08	% of feed	
0.15 x 0.006	21.16	1.9	% of feed	
0.006 x 0	0.84	0.05	% of feed	

Table 17.3 Particle size

Feed	Value	Units	Source
Maximum lump size	Nominally -50	mm	Dewatering plant functional spec

17.1.2 Transportable moisture limits

TML test work was completed on samples of mineralised material fines at -0.5 mm. The TML required for the fine fraction was approximately 10% (weight/weight). Further confirmatory TML test work on a -25 mm sample using the penetration test procedure as detailed in the IMSBC Code supported this number.

17.1.3 Design philosophy

The seawater is expected to enter the riser and lifting system at between 2 °C to 4 °C and is heated to 6 °C to 7 °C on rising through warmer surface waters. On delivery to the surge tank, it is expected to have a viscosity of approximately 1.5 centipoise (cP), whereas at 25 °C it would be 1 cP. This higher viscosity will adversely affect the performance of dewatering plant equipment, in particular, the hydrocyclones and filters. This issue has been taken into account in the design of the dewatering plant.

The functional requirements of the dewatering plant are to:

- Dewater mineralised material to below the TML while optimising mass recovery.
- Measure product mass flow.
- Provide sampling for grade control of seafloor production and downstream process operations.
- Load the mineralised material into the holds of the production support vessel.
- Return excess water and a small volume of entrained solids to the return water disposal system.

The design of the dewatering plant flowsheet allows for some flexibility and adjustment, as an example:

- Standby equipment is provided for each unit operation to maximise plant availability and maintainability and provide additional capacity for variations in material characteristics and flow.
- Coarse screen aperture can be changed to provide bias to either permit more feed (i.e. with a larger screen aperture) to the centrifuge to improve screen capacity or less feed (i.e. with a smaller screen aperture) to reduce centrifuge wear.
- Hydrocyclones can be modified to increase the cut size if either slime losses are lower than filter operating costs, or if filter or hydrocyclone operation is limiting plant throughput.

The design philosophy utilises industry-standard equipment and includes a reasonable throughput design margin. The design margin makes allowance for the anticipated variations in feed characteristics and pumping rate.

17.1.4 Plant description

The proposed dewatering plant flowsheet will:

- Remove the coarse size fractions (-50 mm to +10 mm and -10 mm to +0.5 mm respectively) by screening.
- Remove the bulk of the water and the -0.008 mm slimes from the -0.5-mm undersize using hydrocyclones.
- Dewater the de-slimed fines using pressure filters.

This dewatering process produces three product size fractions: -50 mm to +10 mm, -10 mm to +0.15 mm and -0.15 mm to +0.008 mm that when combined, meet the TML requirements for the transporting the mineralised material to market.

The dewatering plant comprises the following areas:

- Screen feed
- Screens
- Wedge wire basket centrifuge
- Hydrocyclones
- Pressure filters
- Tanks
- Conveyors
- Slurry pumps
- Instrumentation, control and sampling.

17.1.5 Screen feed

The screen feed system design will be based on a steady volumetric flow from the riser and lifting system and the slurry inlet density will be moderated by a hydrocyclone feed/surge tank downstream of the screens. The screen feed system will comprise splitters to distribute the flow to the operating screen. The screen will be selected to remove larger particles, which have a high settling velocity, so only smaller particles need to be kept in suspension in the hydrocyclone feed tank.

Current expectations are that mining operations will result in a relatively constant volumetric slurry flowrate that contains variable solids content (i.e. with large variations in feed solids flow), typically with:

- A normal feed solids flowrate of 342 t/h and a maximum of 398 t/h.
- A maximum instantaneous feed slurry solids content of approximately 20% volume/volume (although this will be modulated via surge tank).
- Feed solids flowrate changes of up to 50 t/h per minute.
- Periods of no solids flow (i.e. the riser and lifting system discharging water only to the dewatering plant).

17.1.6 Screening

Screens have been selected for the initial sizing separation as they are reasonably tolerant to variations in slurry solids content and require only a small footprint. The function of the screens is to separate the feed solids into three size fractions, with most of the water reporting with the finest fraction. The design cut sizes are 10 mm and 0.5 mm. The current design uses one duty double-deck flat screen, with a stand-by screen used during maintenance or for reserve capacity.

17.1.7 Wedge wire basket centrifuge

Centrifuges have been selected to dewater the -10 mm to +0.15 mm size fraction as they are reasonably tolerant to variations in feed rate and require a relatively small footprint. The function of the centrifuge is to dewater the coarse fraction so that, when combined with the top-size sands and fines filter cake, the co-deposited mixture will meet TML requirements.

Wedge wire basket centrifuges are used to dewater coal and salt in the same particle size range as that which will be retained on the dewatering plant's screens' bottom decks. Equipment vendors advise their use for dewatering different mineral types have not been documented. As such, the use of centrifuges entails an identified (but manageable) risk regarding process performance, maintenance and wear life. The proposed design is based on assumed empirical performance estimates and the design and equipment specification should be confirmed on completion of equipment performance and TML test work.

17.1.8 Hydrocyclones

The hydrocyclones reduce the volume of water that reports to the filters with the fines fraction. This equipment provides a flexible and low-cost means of removing a significant portion of the water delivered by the riser and lifting system. However, the water removed contains entrained slimes. These slimes contain metal values and therefore represent a revenue loss.

Using current empirical assumptions, a hydrocyclone cut point of 6 µm to 8 µm has been assessed as the likely operating point that balances cost, operability and metal loss. If there is insufficient value in the fine material above this cut size to cover the costs of its recovery, a higher cut size may be viable. If a higher cut size is viable then fewer, larger hydrocyclones can be used, resulting in lower costs and a reduced propensity for blockage.

17.1.9 Filtration

The filters have been designed to produce a dewatered -0.15-mm fines fraction so that, when combined with the coarse fraction and mid-size sands, the co-deposited mixture will meet TML requirements.

TML test work has been completed on this size fraction with a TML of 10.6% to 11.2% (weight/weight) required. Test work has shown that the TML cannot be achieved without pressure filtration.

The following filter types have been evaluated:

- Vacuum disc filters
- Vertical pressure filter
- Horizontal plate and frame filters.

Pressure filters have been assessed as the most suitable units for the filter duty. Horizontal plate and frame filters, by TH Minerals, have been selected.

17.1.10 Tanks

The circuit contains three slurry tanks. The hydrocyclone feed tank receives the screen underflow and centrifuge centrate. It functions as a pump hopper and supplies four hydrocyclone feed pumps. The tank will be agitated to maintain solids in suspension. During periods of low flow, a facility is provided to recycle cyclone overflow back to the tank. This tank is also sized with sufficient surge capacity to empty the riser and lifting system if required.

The filter feed tank is supplied by the hydrocyclone underflow. Excess slurry supplied to the filters is also returned to the filter feed tank. It functions as a pump hopper and supplies two filter feed pumps. The tank will be agitated to maintain solids in suspension.

The centrate tank receives centrate from the centrifuges for pumping to the hydrocyclone feed tank. It functions as a pump hopper and supplies two centrate transfer pumps. The tank does not require agitation.

17.1.11 Conveyors

All conveyors will be standardised to a 600-mm wide belt and designed to operate at slow speeds (approximately 1 m/s).

Deep troughs will be provided to minimise spillage.

On-stream belt weightometer and moisture meters will be installed for process monitoring and control.

17.1.12 Slurry pumps

Industry standard slurry and water pumps were selected for the required duties. Standby units are provided for all duties and variable speed drives will be employed on the cyclone feed and filter feed pumps.

17.1.13 Instrumentation, control and sampling

The instrument and control system provides the means to sequence plant start-up and shutdown, and to monitor and maintain stable operations. The system monitors and logs the throughput and moisture of the feed as well as the three product size fractions.

Due to limited space, shortness of the conveyors and motion of the production support vessel, the preferred type of belt weightometer is nucleonic. These are contained in a frame that spans the conveyor. On-belt moisture monitors using microwave technology will be housed in similar frames to the weightometers and on-belt elemental analysis (Prompt Gamma Neutron Activation Analysis or similar) may also be installed for feed grade monitoring purposes. The elemental analysis will be fed back to the operators of the seafloor production tools so that digging areas can be adjusted, if necessary. Samples of the product will be collected for TML testing and elemental analysis.

17.1.14 Operating philosophy

Maintenance will be scheduled around periods when the plant is not utilised (i.e. when the collection machine is not operating).

The plant has been designed with some reserve capacity.

The collection machine and the riser and lifting system controls the feed rate to the dewatering plant. Given the use of positive displacement pumps feeding the riser and lifting system, the volumetric feed rate to the dewatering plant is expected to be relatively constant.

The solids content of the feed slurry and its size distribution are expected to vary significantly. The control system will be programmed to manage foreseeable variations during start-up, shutdown, and continuous operation. The control system will provide alarms if the system deviates outside the programmed range.

Key flows, slurry densities, and product moisture will be monitored continuously by instruments. The speed and power draw of pumps will also be instrumented. This data will form the input to the control and monitoring system, which facilitates automated operation of the plant and monitoring of product moisture. Additional on-stream elemental analysis of the run-of-mine material may be employed for grade control.

In addition to the instrumentation, product samples will be taken periodically for laboratory analysis (e.g. size distribution, grade and TML requirements). This independent verification is required for shipping, product purchasing and processing contracts, and to check the calibration of the instrumentation onboard the production support vessel.

17.2 Design report

DRA was commissioned to design and build the dewatering plant based on earlier concept studies and metallurgical test work. This data culminated in a simple, robust design that addresses previous process concerns, maximises mineralised material recovery and fits within the physical footprint and centre of gravity constraints of the vessel. The proposed design addresses the interface with the mining operation and provides flexibility to accept variable feed rates and sizing, as well as limiting interruption to mining and allowing for possible purging of the riser.

Equipment in the dewatering circuit has been selected based on producing the lowest moisture practically achievable by mechanical means. It is estimated that dewatered material moistures of 4.0% to 7.5% (weight/weight) (depending on size distribution) will be achieveable. The proposed concept essentially consists of screening, scroll centrifuges, plate and frame pressure filters, feed surge capacity, dry storage bins and a ship loadout system.

The risk issues addressed during the design phase were:

- Feed size distribution variation: Nautilus provided a size distribution envelope for the basis of the design. At the finest size distribution and maximum dewatering plant feed slurry concentration, a maximum of 16 tph of -8 µm material will be returned to the riser and lifting system. At the constant return flowrate of 1,000 m^3/h, this rate equates to a volumetric concentration of less than the 0.5% volume/volume solids.
- Feed flow rate variation: It is noted that both volumetric and solids flow variation from the riser and lifting system will need to be minimised. The design concept is to operate within a delivery window of 0 m^3/h to 1,000 m^3/h and 0% to 14% volume/volume solids. At zero feed, the dewatering plant will operate via total slurry recirculation. Intermediate volumetric and solids feed rates are catered for via internal recycles and density, pressure, flowrate, and tank level control of classification hydrocyclone circuits. Each screen will have sufficient open area to completely drain 1,000 m^3/h (required when operating at 0% solids).
- Feedback disruption to the mining process on plant shutdown: A surge capacity is included in the DRA design to facilitate purging of the lifting system riser following an unplanned dewatering plant stoppage.

- Feed screen blinding, causing potential water and carry over of fine solids from the 0.5 mm lower deck sizing duty.
- Centrifuge wear from possibly abrasive high sulfide material feed.
- Blockages in desliming hydrocyclones.
- The potential effect of the increase in viscosity due to the low feed temperature.
- The need for standby equipment in the design.
- Continuous monitoring of the moisture content and TML of the dewatered material on the production support vessel.

The design was independently reviewed by a leading multi-national engineering company.

17.3 Shipping

Following dewatering, Nautilus propose to transport the product via Handysize ships (approximately 25,000 t deadweight) for onward transportation to Nantong or Nanjing in accordance with the sales agreement with Tongling Nonferrous Metals Co. Ltd.

Nautilus's trans-shipment concept comprises the following:

- Ship loading from the production support vessel
- Transporting product from the production support vessel to market.

17.3.1 Ship loading

The product will be transferred to export bulk carriers from the production support vessel, which has a nominal 39,000 t storage capacity. The transfer of product to the bulk carriers will occur on an as-required basis.

Peak bulk carrier arrival/departure frequency when steady state production is achieved is expected to be about one per week.

General operational and design criteria include but are not limited to:

- A first-in/first-out policy to be adhered to where possible.
- Loading will continue through rain, consequently all materials handling equipment will have covers.

17.3.2 Moisture limits

Since 1 January 2011, the IMSBC Code is applicable to all ships as a mandatory requirement. Cargoes that may liquify are categorised as Group A. Loading of such cargoes is not allowed when the moisture content exceeds its TML.

Based on the TML requirements, it is essential to obtain an early indication of the TML for the dewatered material and the method of measurement will need to be reviewed as the size range for the seafloor product could be wide-ranging. In addition, each dewatered size fraction is combined onto the main dewatering plant product conveyor as layers on the belt, introducing some heterogeneity that could influence fluidisation characteristics of the material. However, this material then flows through a number of material transfer chutes and a thrower before being deposited in the holds of the production support vessel. This is expected to allow adequate mixing of the size fractions.

It is intended that a laboratory operated on the production support vessel by an independent third party will confirm the TML requirement for representative samples of dewatering plant discharge material over specific periods of time (once or twice per 12-hour shift). This will allow certification of material moisture and TML for receiving ships' captains when the material is later transferred to material carriers for export.

18 Project Infrastructure

Deep-sea mining presents substantial challenges, the most significant being that all operations have to be performed by remotely operated robotic vehicles under very high pressure, which are designed to meet stringent performance and operational function capacities.

The plant and equipment for Nautilus's Solwara 1 project comprises four main categories of equipment being:

- Production support vessel, including the ships systems and supporting production equipment.
- Riser and lift system, including the subsea lift pump.
- Dewatering plant, including the cargo handling system.
- Seafloor production tools.
- Seafloor production tool launch and recovery systems (A-frames and winches).

The seafloor production equipment, including the seafloor production tools, the riser, and subsea slurry lift pump are described in Item 16. The dewatering plant is described in Item 17. The remaining equipment is described in this Item.

18.1 Production support vessel

The production support vessel is being constructed and commissioned at the Fujian Mawei shipyard, in the PRC. The design is a Dynamically Positioned Ship Class 2 vessel, based on industry guidance that forms the basis of safe dynamic positioning operations[23].

The design of the production support vessel is novel. It is a new prototype ship that is a hybrid of a Mobile Offshore Drilling Unit, Cargo Ship and Special Purpose Ship. It is the first in its class and has been patented. Operationally, it will be similar to numerous vessels involved in oil and gas, construction, dredging and transportation industries, where its purpose is to supply a large deck space and a stable platform from which operations are supported.

The vessel's features include automatic and manual positioning, and heading control under specified maximum environmental conditions, during and following any single fault, excluding loss of a compartment, and control is by two independent computer systems.

The operational classification for a Dynamically Positioned Class 2 vessel is described by the International Maritime Organisation as "Operations where loss of position keeping capability may cause personnel injury, pollution, or damage with large economic consequences." The vessel's classification under other organisational guidelines is shown in Table 18.1.

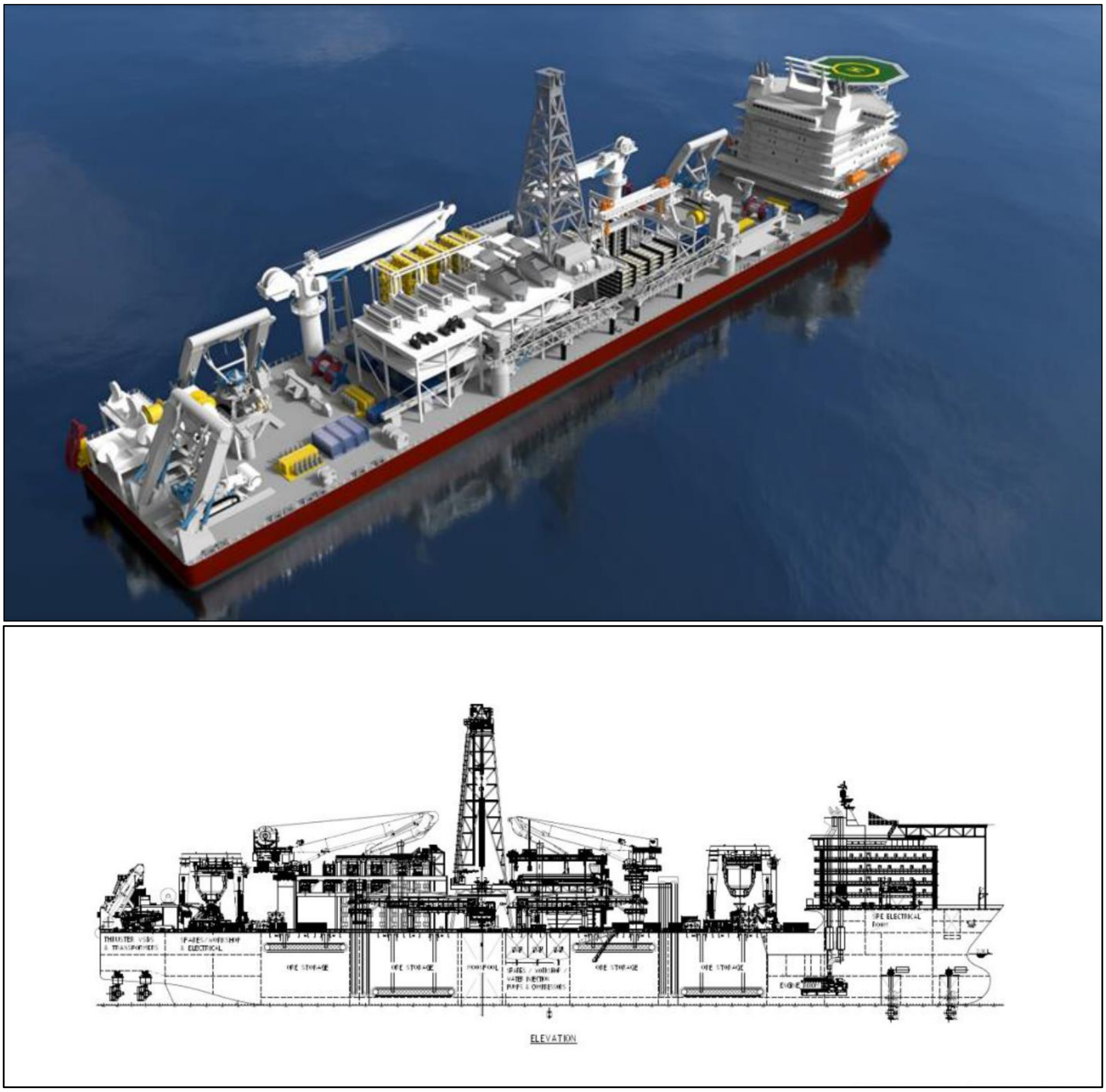
Table 18.1 Classification of the production support vessel

Organisation	Classification
International Maritime Organisation	Class 2
Lloyd's Register	DP (AA)
Det Norske Veritas	DYNPOS- AUTR
Germanischer Lloyd	DP 2
American Bureau of Shipping	DPS-2
Nippon Kaiji Kyokai (NK)	DPS B

The production support vessel is shown in Figure 18.1

[23] International Maritime Organization MSC/Circ.645 – Guidelines for vessels with dynamic positioning systems

Figure 18.1 Production support vessel



Design specifications for the production support vessel are listed in Table 18.2.

Table 18.2 Specifications of the production support vessel

Item	Quantity
Length (overall)	227 m
Length (between perpendiculars)	210 m
Beam	40 m
Depth (moulded)	18.2 m
Draft (design)	13.2 m
Draft (scantling)	13.2 m
Cargo hold	4 × 5,000 m^3
Fresh water	1,500 m^3
Fuel oil	10,000 m^3
Water ballast	38,000 m^3
Installed power	30 MW

18.1.1 Purpose of production support vessel

The main purpose of the production support vessel is to generate power and receive product from the subsea production equipment. To do this, the vessel must maintain its location over the seafloor mine site using dynamic positioning. In addition, the production support vessel must support surface and subsea operations.

The production support vessel will also be required to support the following:

- Bunkering
- Victualling
- Side-by-side mooring
- Product dewatering
- Transfer and storage of consumables
- Waste management/disposal/transfer
- Heating, ventilation, and air conditioning
- Helideck, dispatch and receiving facilities
- Fire detection, protection and suppression
- Life-saving appliances
- Ballast water
- Anti-heel system
- Navigation
- Operation planning
- Voyage data recording
- Lube oil handling
- Lime handling
- Cargo handling, storage and offloading
- Survey system
- Fresh water making
- Crew change out
- Emergency medical transfer capability
- Mooring equipment
- Compressed air systems
- Equipment maintenance
- Grey water systems
- Black water systems
- Overall production control system
- Dynamic positioning
- Subsea equipment launch and recovery systems
- Power and emergency power generation
- Accommodation in a 199 person living quarters
- Subsea, ship-to-ship and deck cranes.

Some of the key top-side production support vessel systems are discussed below

18.1.2 Derrick, draw works, and gantry crane

The purpose of the derrick, draw works and gantry crane is to raise and lower the riser reticulation system, as well as to handle the lengths of riser pipe for storage, maintenance and servicing. The racks will have a holding capacity of approximately 1,700 m of riser, made up of 90 lengths of 18.2 m long pipe. The derrick arrangement, riser handling system and pipe rack unit are shown in Figure 18.2 and Figure 18.3.

Figure 18.2 Derrick side elevation

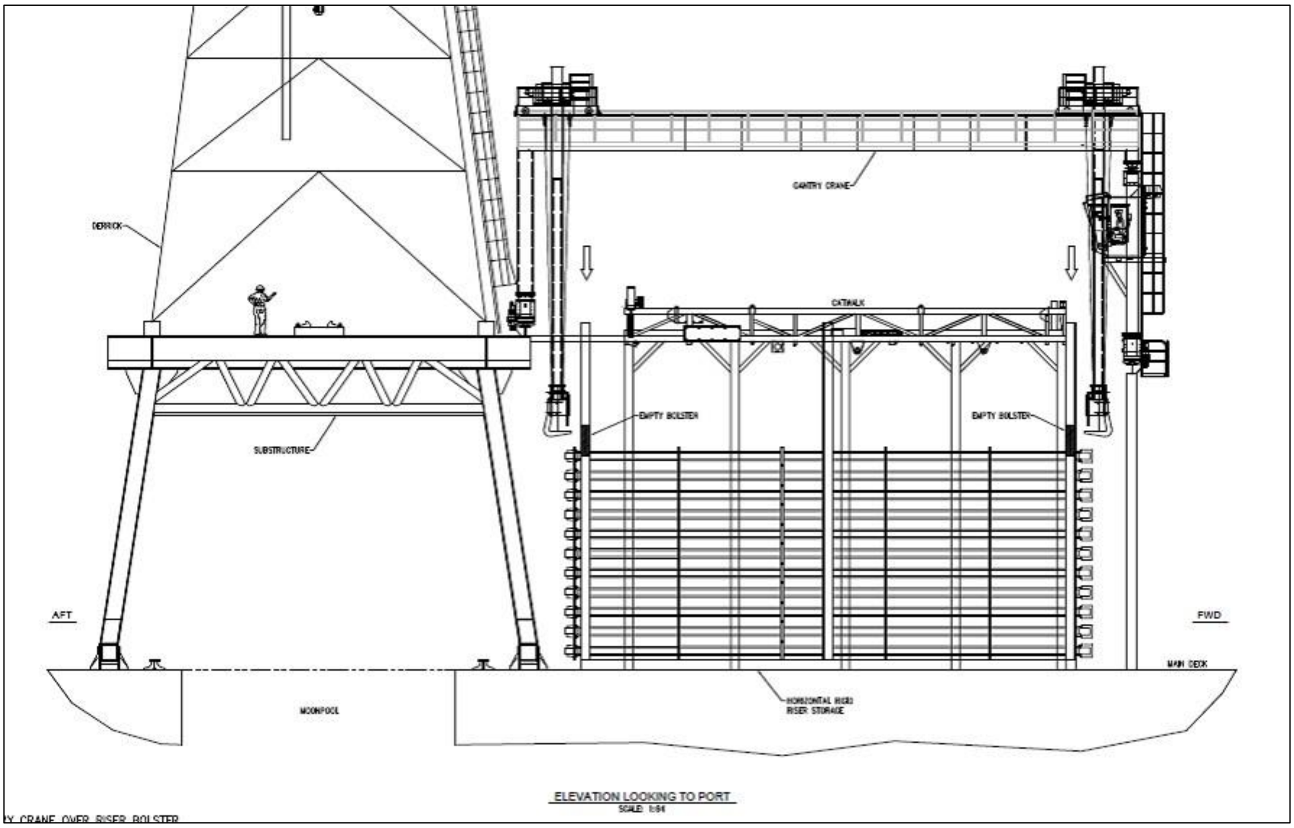
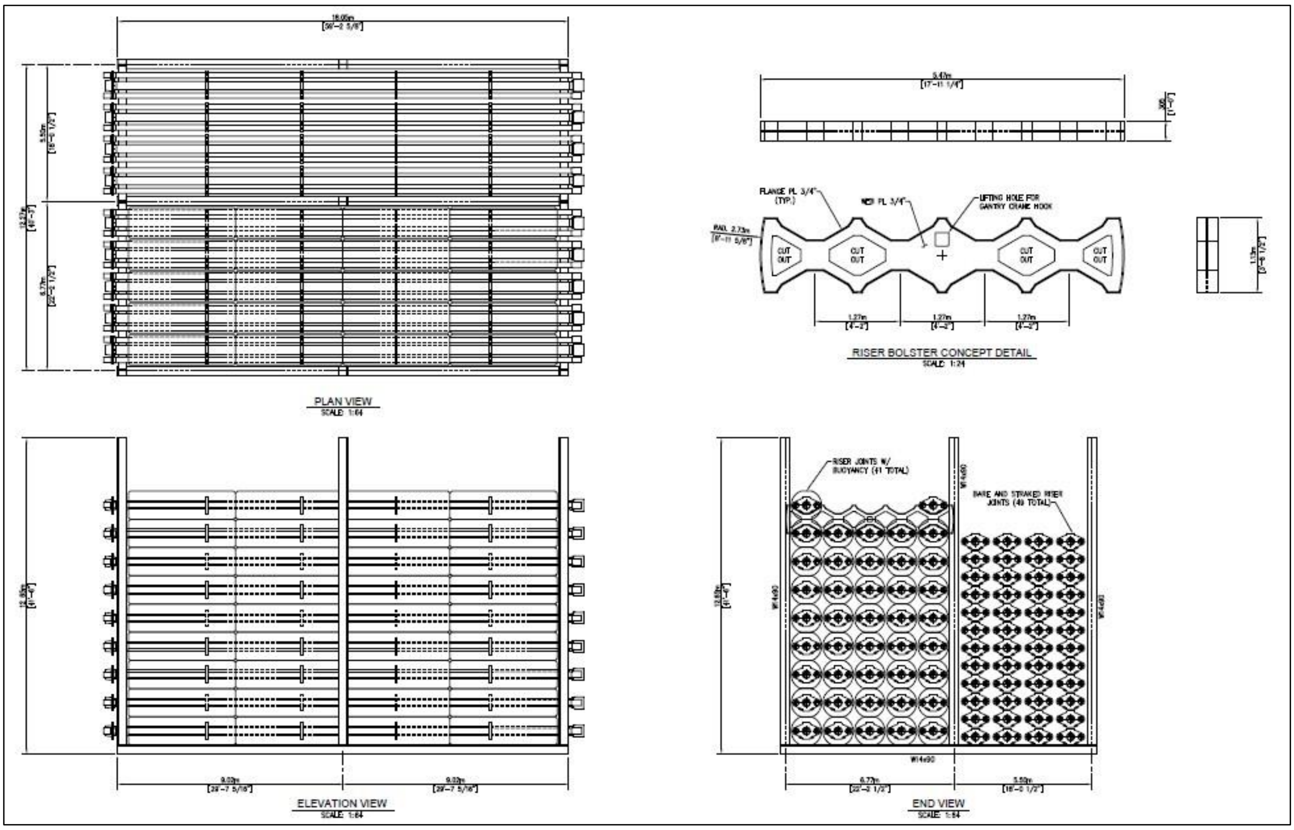


Figure 18.3 Plan and side elevation of storage system



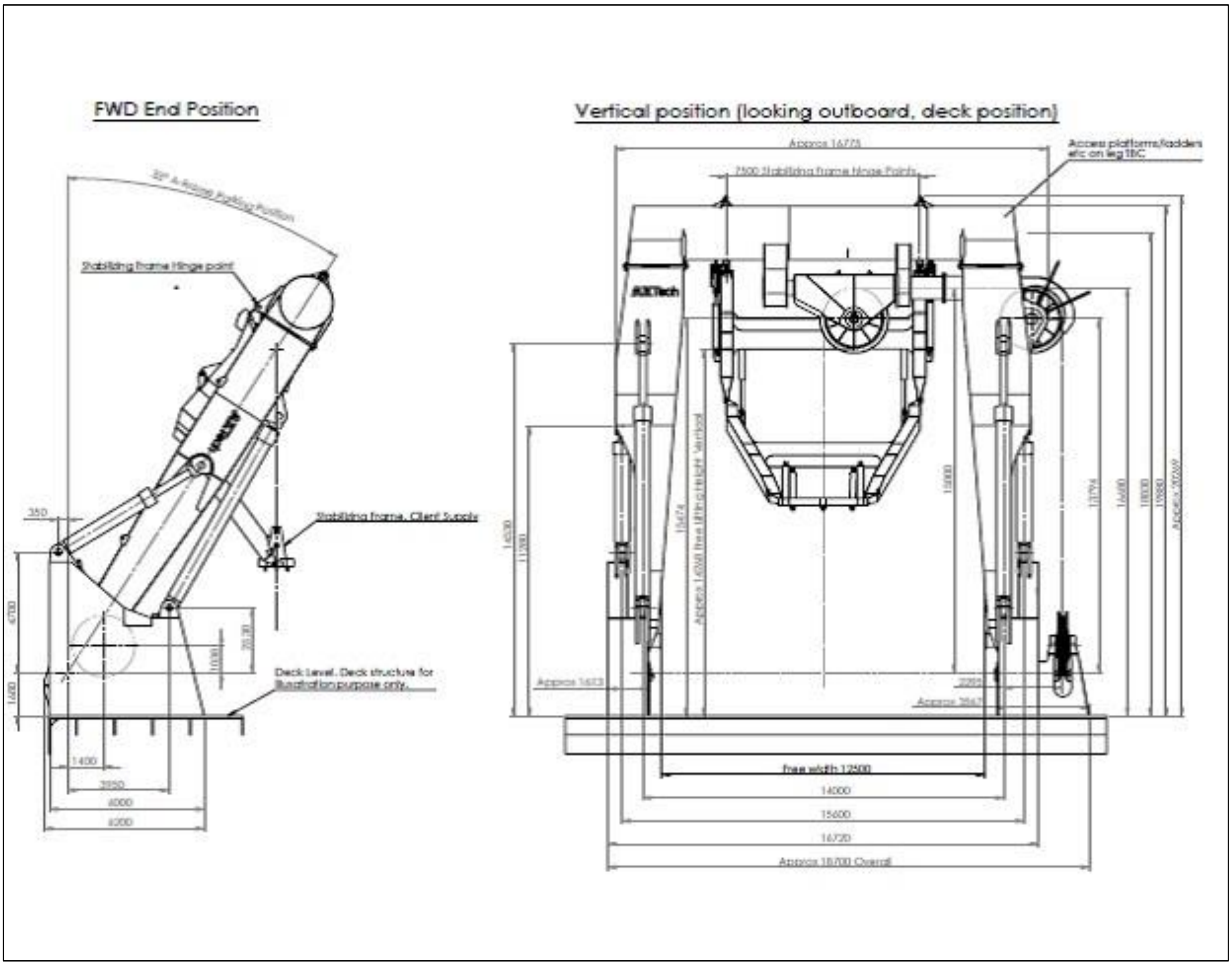
18.1.3 Launch and recovery systems

The purpose of launch and recovery system is to raise and lower the seafloor production tools for seafloor operations, on-deck storage and maintenance, operational movements and recovery in the event of unscheduled breakdown.

The launch and recovery system comprises three A-frames of 210-tonne, 260-tonne, and 310-tonne capacities. These are used for the launch and recovery of the collection machine, auxiliary cutter and bulk cutter respectively.

The launch and recovery systems are currently being assembled and installed on the vessel by Mawei under the supervision of the supplier AXTech. The system is shown in Figure 18.4.

Figure 18.4 Launch and recovery system - side elevation



19 Market Studies and Contracts

19.1 Market studies

Since 2007, Nautilus has developed a targeted marketing approach designed to maximise the value of the Solwara 1 Project and establish long-term strategic relationships. As part of this approach, Nautilus has considered various processing options for Solwara 1, including construction of a concentrator in PNG, direct product sales, and toll treatment to produce:

- Standard-grade (25% to 30% Cu) copper concentrates.
- Low-grade (20% to 25% Cu) copper concentrates with elevated gold recovery.
- Whole-of-mined-material treatment.

Nautilus has carried out trade-off studies, which:

- Reviewed the likely revenue against the estimated capital/operating costs.
- Sought to monetise the gold and silver that does not report to a conventional 25% Cu grade concentrate.

Following this work a sales agreement was negotiated that maximised return on the contained value of the mineralised material without exposing Nautilus to the metallurgical risk of the various processing options. Under this arrangement Nautilus will be paid for a fixed proportion of the recoverable copper in the mineralised material and a fixed proportion of the contained gold. The amount of copper deemed to be recoverable will be determined by locked cycle tests on composite samples performed by an independent laboratory.

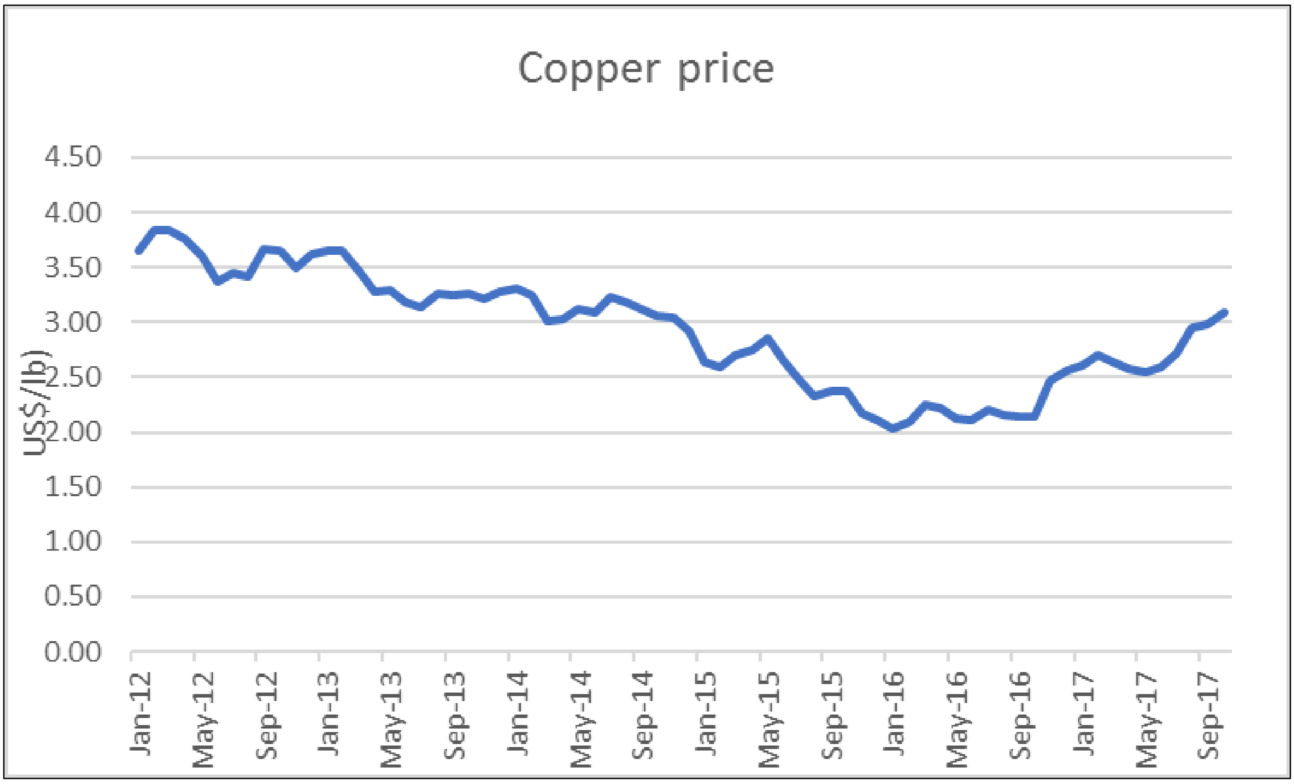
19.2 Pricing

While Solwara 1 contains elevated gold and silver grades, it is predominantly a copper deposit. As a result, the economics of mining the deposit are most sensitive to movements in the copper price.

Copper prices rebounded from a low point of US$1.50/lb in early 2009 to hit a monthly high of US$3.84 in March 2012, then gradually declined to a nadir of US$2.03 in January 2016 (Figure 19.1). Since then, the price has steadily improved, and was above US$3.00/lb at finalisation of this report.

At the time of this Technical Report, the outlook for copper appears robust due to increased demand (driven in part by increasing popularity of electric vehicles), supply disruptions, and limited new orebody discoveries. Many market analysts and mining companies are forecasting a supply deficit in the short to medium term.

Figure 19.1 Copper price (US$/lb) since 2012



Source: World Bank

The terms of the binding Ore Sales and Processing Agreement between Nautilus and Tongling Nonferrous Metals have been used for ongoing economic analysis of the Solwarta 1 Project. For the most part, these terms are fixed with only the treatment charges and refining charges (TC/RCs) subject to annual variation in accordance with standard industry benchmarks. Pricing specified in the Ore Sales and Processing Agreement references London Metals Exchange (LME) and London Bullion Market (LBM) metals prices.

19.3 Sales and processing agreement

Nautilus has entered in an agreement with Tongling Nonferrous Metals Group Co., Ltd. (Tongling) for the sale of mineralised material from Solwara 1.

The basis of this agreement is the definition of the metallurgical performance of the Solwara 1 material when treated in Tongling's concentrator in the PRC. The concept of this notional metallurgical performance follows industry practice used when a seller's material is toll treated at another party's processing facility.

In Nautilus's case, the metallurgical performance for Solwara 1 material treated over a three-month interval at Tongling will be derived by doing locked cycle tests on a composite sample made from up from aliquots taken from the samples used for metal accounting and realization. This composite sample will be sent to ALS Metallurgy Burnie in Australia for bench scale locked cycle flotation testing (LCT) using a treatment protocol agreed by both parties. This establishes a standardized notional metallurgical performance for the quarter eliminating potential variations caused by Tongling's likely short-term need to adjust the target metallurgical performance of its concentrator to optimize the operation of its downstream copper smelter, acid plant and precious metals recovery circuit.

The formula works as follows:

- Gross value of the mineralised material per dry metric tonne (dmt) is calculated by multiplying the grade by prices as determined by the LME and LBM for copper, gold, and silver.
- Metal payable rates are as follows:
  - 95% of the recoverable copper, which is determined by the result of the LCT which produces a target copper concentrate grade of 20% Cu. Based on results of previous metallurgical test work 87.4% is an expected value of payable copper that could be used for evaluation of the Solwara 1 project as a whole.
  - 50% fixed payable for gold. This is a higher payability than the expected gold recovery to the copper concentrate, but reflects the fact that Tongling is expected to recover additional gold from the pyrite concentrate.
  - 30% fixed payable for silver.
  - Gross revenue is obtained by multiplying the individual metal payable rates by assays and metal prices, and summing.
- Deductions – Treatment charges and refining charges:
  - The mass of copper concentrate produced from each tonne of material delivered to Tongling (the “mass pull”) is derived from the head grade, the LCT determined value for recoverable copper and a notional 20% Cu concentrate grade. For a head grade of 7.2% Cu and a recoverable copper result from LCT of 92%, the mass pull would be 33.1%.
  - Asian benchmark treatment charge (TC) for copper concentrate determined annually. Plus, a fixed premium of US$25/dmt of concentrate.
  - Asian benchmark refining charge (RC) for copper content of copper concentrate determined annually. Plus, a fixed premium of US$/0.025/lb of copper.
  - Gold refining charge of US$5/oz fixed.
  - Silver refining charge of US$40/oz fixed.
  - Net smelter revenue is obtained by deducting from the gross revenue the sum of multiplying the mass pull and the TC and RC for contained copper, gold and silver.
- Deductions – Processing and logistics charges:
  - Logistics credit (wet basis) calculated from 78.2 RMB/wmt divided by (1- fixed concentrate moisture content of 10%). This would amount to US$13.58/dmt at exchange rate of US$ 1 = RMB 6.4.
  - Logistics charge (wet basis) calculated from RMB81.30/wmt divided by (1-moisture content of 10%). This would amount to US$12.14/dmt at exchange rate of US$ 1 = RMB 6.4.
  - Concentrator charge of RMB 77.69/dmt. This would amount to US$12.14/dmt at exchange rate of US$ 1 = RMB 6.4.
  - Profit charge of RMB 19.42/dmt. This would amount to US$3.03/dmt at exchange rate of US$ 1 = RMB 6.4.
- Deduction – Provision for other Payments including Port Fees, Sampling Fees, Joint Inspector costs and LCT Test work costs, and any applicable standby or interest charges:
  - US$11/dmt.

19.4 PNG Government investment

The PNG Government holds a 15% interest in the Solwara 1 Project in an unincorporated joint venture with Nautilus (the Mining JV). The Government's share of the joint venture is held by Eda Kopa (Solwara) Limited, a wholly owned subsidiary of Kumul Minerals Holdings Limited (formerly known as Petromin PNG Holdings).

19.5 Key contracts

There are no Mineral Reserve estimates for Solwara 1 and the potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study. Notwithstanding this, Nautilus began procurement and construction of the mining and production equipment for the Solwara 1 Project in January 2010. Many of the key contracts for the Project are completed or significantly advanced.

Nautilus's delivery model is to maintain a small owner's management team centred in Brisbane, Australia, supervising either work packages managed by engineering, procurement and construction management (EPCM) contractors, or equipment purchases provided by vendor design and construct packages. Each significant package is supervised by a dedicated lead engineer or delivery manager within Nautilus who reports to the Chief Operating Officer.

This structure provides the required resource flexibilities and expertise of contracting groups across the range of disciplines required to deliver the Project, while ensuring package interfaces are understood and managed by the Nautilus team. The vessel integration EPCM contractor will have responsibility for managing interfaces involved in transport, preparation and integration of the seafloor mining equipment into the production support vessel.

Nautilus's project team consists of engineering, project controls and procurement and contract specialists, all of whom report to the Chief Operating Officer, who in turn reports to the Chief Executive Officer.

Work under contract has typically been competitively tendered prior to award. Award has generally been on a value for money/best technical risk basis within overall project delivery schedule. Fixed and firm prices were sought where possible with rates based contracting (target price, capped profit and bonus/malus schemes adopted to manage schedule risk). All contracts were based on terms in Nautilus's standard contract documents.

Principal contracts for Nautilus going forward include a strategic partnership, detailed engineering design and construct activities, procurement, trans-shipment and project financing that support the development of the Solwara 1 deposit. In addition, specialist services in the areas of resource development, metallurgical and process engineering support, environmental studies and permitting, community relations and health and safety will also be required on an on-going basis. Contracting activities will continue to be driven by the need to acquire specialists and professional services firms to assist Nautilus with these various activities.

Nautilus has placed commitments with the following companies, as listed in Table 19.1

Table 19.1 Project commitments with various companies

Scope	Consultant/Supplier	Contract type
Vessel build and operation	Marine Assets Corporation, Dubai	Vessel procurement and vessel crewing agreement
Seafloor production tools	Soil Machine Dynamics, Newcastle, UK	Design and Construct
Subsea slurry lift pump	GE Hydril, Houston, USA	Design and Construct
Seafloor production tool, subsea slurry lift pump, and SDH connectors	Logan	Design and Construct
Surface seawater injection pumps	Clyde Union	Design and Construct
Rigid riser system	General Marine Contractor LLC	Design and Construct
Riser and lift running and retrieval system	Sichuan Honghua Petroleum Equipment Co Ltd	Design and Construct
Dewatering plant	Sichuan Honghua Petroleum Equipment Co	Construct

19.5.1 Vessel charter contract

In November 2014 Nautilus entered into agreements with Marine Assets Corporation (MAC) of Dubai for the delivery of a vessel suitable for undertaking the Solwara 1 project. These agreements were as follows:

- MAC and Fujian Mawei Shipbuilding Co Ltd (Fujian Mawei) entered into a ship build contract to deliver a vessel in accordance with Nautilus's requirements.
- MAC and Nautilus Minerals Singapore Pte Ltd entered into a Vessel Procurement Agreement including a Modified Supply Time Charter to provide a vessel in accordance with Nautilus's requirements.
- MAC and Nautilus Minerals Crewing Services (Singapore) Pte Ltd entered into a Crewing Agreement to provide crew and operations/maintenance services for the vessel.
- The Singaporean Nautilus entities then entered into sub-agreements with the Solwara 1 Mining Joint Venture for the charter and crewing of the vessel during the execution of the Solwara 1 project.

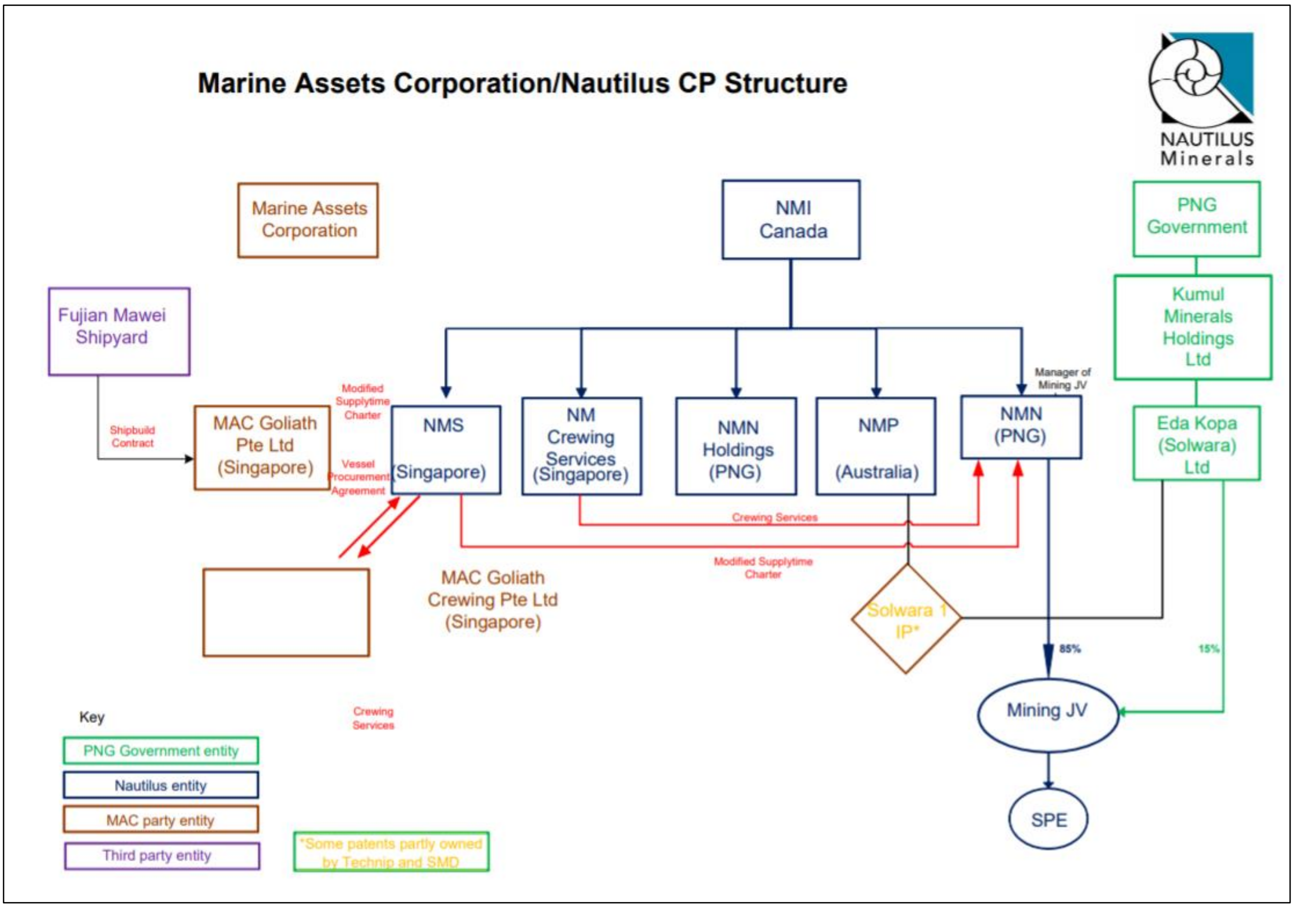
Under the terms of these various agreements MAC shall provide Nautilus with the production support vessel at a daily charter rate of US$199,910 per day, made up of a daily supply time charter payment of US$140,000 and a daily crewing services payment of US$59,910. The charter duration is firm for five years. Nautilus will have five annual options to acquire the vessel on the anniversary date of the charter for the fixed price of US$198 million, less 15% of the supply time charter payments made to that date. Based on this formula, the purchase price of the vessel at the end of the five-year charter would be US$160 million. Nautilus provided a US$10 million guarantee upon the signing of the contract and will provide a further bank guarantee for three months charter payments (US$18 million) upon delivery of the vessel.

The vessel is currently under construction at the Fujian Mawei shipyard in the Fujian Province, in the PRC. The contracted delivery date of the vessel was 35 months from Shipbuilding Contract effectiveness, although this was subsequently modified by mutual agreement of all parties to give a vessel delivery date of mid-December 2018. The seafloor production equipment will be integrated into the vessel at a third-party yard after vessel delivery, although there is potential to undertake some or all of the integration scope at the Fujian Mawei shipyard. The integration work is estimated to take up to three months to complete, and a 50% reduced supply time charter payment would be payable for this post-delivery mobilisation period (capped at 11 weeks) to accommodate integration work.

MAC does not have the in-house capability to provide crewing services. As such a Crewing Services contractor shall be appointed by mutual consent between MAC and Nautilus, well in advance of vessel delivery so that a vessel operating plan can be developed and implemented in accordance with the Crewing Agreement.

A diagram of contract arrangements is provided in Figure 19.2.

Figure 19.2 Contract arrangements



19.5.2 Progress of construction

Fabrication and factory acceptance testing of the following equipment is complete and the systems are either in storage or being installed on the production support vessel as shown:

- Riser system (in storage).
- Subsea slurry lift pump (in storage).
- Pull-in skids system (in storage).
- The riser and lifting system, running and retrieval system (being installed on the production support vessel).
- Surface seawater injection pumps (installed on the production support vessel).

Factory acceptance testing of the subsea slurry lift pump was completed in mid-2017 and the equipment is in storage in Houston. Nautilus is considering options for submerged trials of the pump in the PRC planned for the second or third quarters of 2018.

The work on the stockpile discharge pipes and riser transfer pipe was suspended in 2012. Fabrication has not yet restarted on these subsea hoses, but these items are not on the critical path of the Project schedule.

The work by Honghua on the derrick, which was terminated in 2012, has restarted. The substructure for the derrick and the modules structure for the dewatering plant have also been awarded to Honghua. The derrick and derrick substructure are complete and have been factory acceptance tested and delivered to the Fujian Mawei shipyard ready for installation prior to vessel launch.

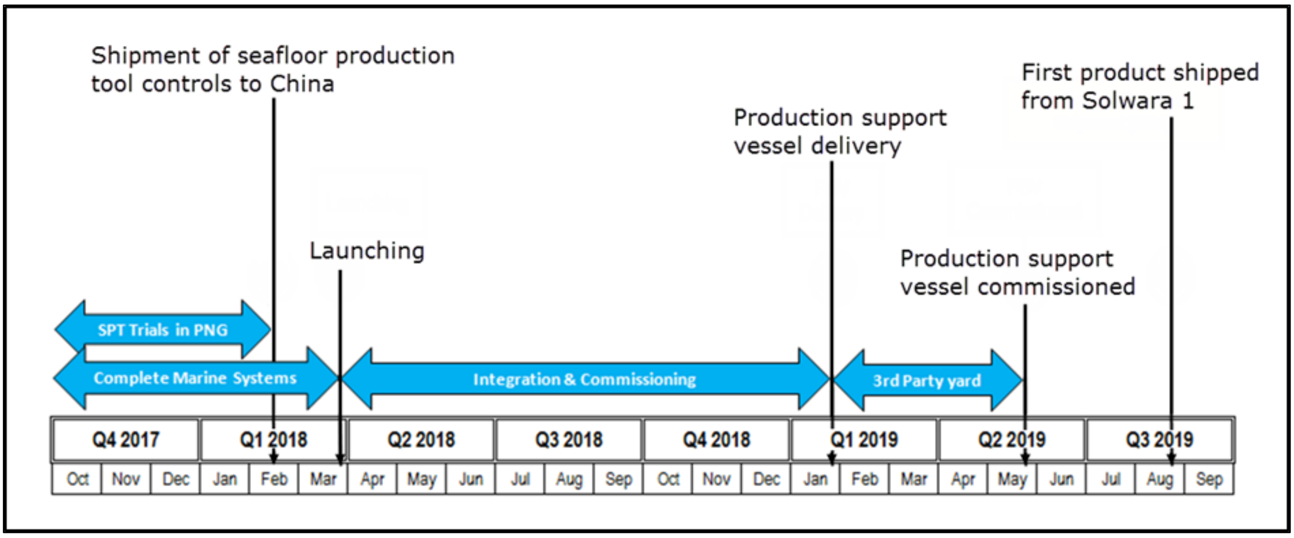
The riser handling tools manufactured by GMC Limited have passed factory acceptance testing and have been delivered to the Fujian Mawei shipyard. The riser, alsio manufactured by GMC Limited is being stored in a secure third-party facility near the port of Houston awaiting shipment to the PRC late in 2018.

The launch and recovery systems for the seafloor production tools including A-Frames, lift winches and spoolers have been delivered to the Fujian Mawei shipyard ready for installation prior to vessel launch.

Construction of the production support vessel (Figure 19.3) is advanced. The launch of the vessel is scheduled for Q1 2018. Integration of the vessel's systems will continue after launch. Commissioning and sea trials are scheduled for completion in early 2019 (Figure 19.4).

Figure 19.3 Construction of the production support vessel as at December 2017

Figure 19.4 Project construction and commissioning schedule



19.6 Insurance

Nautilus has a comprehensive insurance package in place in line with other similar commercial enterprises including, but not limited to equipment and property insurance, professional and public liability, workers compensation, and charterer's liability.

Nautilus manages its insurance risk for the Solwara 1 Project through its contracts by imposing the relevant insurance obligations on those contractors carrying out the services. Nautilus proposes that this regime will apply equally to contractors providing services to the Mining JV in the operational phase.

A contractor is generally required to maintain, during the performance of its obligations, the workers' compensation, public liability as well as motor vehicle, equipment, property and aircraft liability insurance policies on terms, and with reputable insurance companies, approved by Nautilus.

19.7 Product shipment

No contracts are currently in place for Handymax sized vessels to ship product between the production support vessel and the nominated ports of delivery in the Ore Sales Agreement (Nantong or Nanjing, PRC). Up to four vessels will be required at full production rates. Expressions of interest and budgetary pricing have previously been sought and it is estimated that the charter costs for these vessels would be equivalent to approximately US$25 per tonne of product.

20 Environmental Studies, Permitting and Social or Community Impact

20.1 Studies completed for the Environmental Impact Statement

Nautilus has carried out a series of environmental studies designed and conducted by various consultants, research organisations and universities during the assessment phase, prior to submission of its EIS to the PNG Government in late 2008. These studies were conducted to:

- Define the existing environment.
- Estimate the potential impacts.
- Inform potential impact mitigation strategies.

The studies included observation, sampling, and modelling focusing not only on the biological communities of both active and inactive hydrothermal vents, but also on the background marine environment, including physical, chemical and distal biological areas.

Specific studies undertaken for the Solwara 1 Project include:

- Characterisation of the seafloor (benthic habitat).
- Food chain and the potential for contamination (bioaccumulation).
- Lighting and the potential to impact deep-sea fish (bioluminescence).
- Studies of commercial and subsistence fisheries and the potential for interaction.
- Hazard and risk assessment.
- Discharge water quality and depth (hydrodynamic modelling).
- Behaviour and fate of project-derived plumes in the near seafloor environment (hydrodynamic modelling).
- Seafloor macrofauna.
- Infauna (animals that live within the seafloor sediments).
- Meteorology.
- Noise, light and vibration of vessels, and production machinery.
- Seawater column water quality and currents (oceanography).
- Sedimentation/deposition rate determination.
- Sediment geochemistry.
- Visual observation logging to record biological characteristics of the seafloor at Solwara 1.
- Development of a waste minimisation and management plan.
- Water quality to determine baseline water quality at and above Solwara 1.

In addition, Nautilus studied water quality, sedimentation and macro fauna at a nearby SMS occurrence to Solwara 1 known as South Su. South Su provides a control-site thereby allowing Nautilus to understand the natural variability in the Solwara 1 area in the absence of external influence such as mining.

Nautilus's EIS for Solwara 1 was prepared by consultants, Coffey Natural Systems Pty Ltd (Coffey) of Brisbane, Australia, and issued in September 2008. The EIS was subsequently reviewed independently by Cardno Limited.

Relevant information relating to the technical studies carried out by Nautilus and an assessment of the associated impact was included in the Project's EIS.

Numerous studies relating to Solwara 1 have been independently published by the research community as peer reviewed scientific papers.

20.2 Studies completed after the EIS

After the EIS, further investigations to gain a better understanding of the environment at Solwara 1 and surrounds have been carried out as part of environmental campaigns undertaken from 2008 to 2017. Studies included:

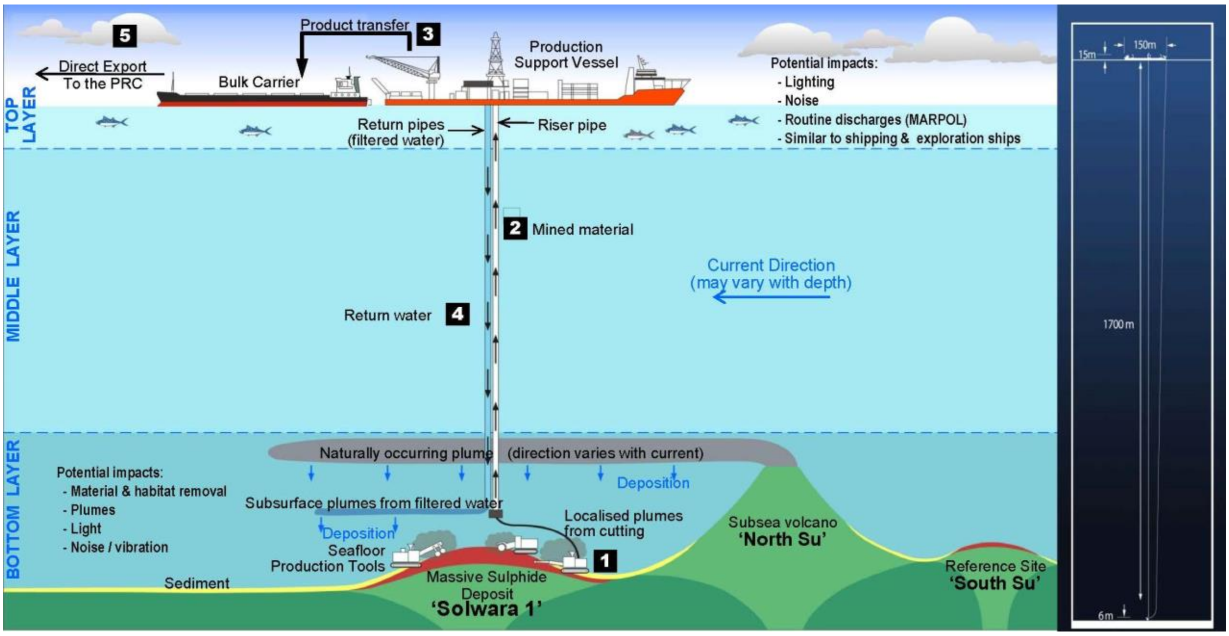
- Measurements of water column structure.
- Characterisation of naturally occurring subsea plumes.
- Seafloor macrofauna.
- Infauna (animals that live within the seafloor sediments).
- Naturally occurring subsea noise.
- Seawater column water quality.
- Sedimentation/deposition rate determination.
- Sediment geochemistry.
- Discharge water quality and depth (hydrodynamic modelling).
- Behaviour and fate of project-derived plumes in the near seafloor environment (hydrodynamic modelling).
- Visual observation logging to record biological and geological characteristics of the seafloor at Solwara 1.
- Pelagic habitat characterisation.
- Zooplankton and icthyoplankton fauna.
- Characterisation of nearshore coral reef ecology along the New Ireland and New Britain coastlines of the Bismarck Sea.
- Development of environmental management plans.

20.3 Potential impacts

Nautilus recognises that any future development at Solwara 1 has the potential to impact various layers within the water column as well as the seafloor. Figure 20.1 shows the water column at Solwara 1 divided into three broad layers and the characteristic types of marine life found in each:

- Top layer: The Surface Mixed Layer ranges between approximately 0 mbsl and 200 mbsl of the water column and contains mostly pelagic fish species including tuna, squid, sharks, and dolphins.
- Middle layer: The Mesopelagic Zone lies between approximately 200 mbsl and 1,000 mbsl of the water column and usually contains squid and occasional short visits by other species such as tuna, which are in search of prey.
- Bottom layer: The Bathypelagic Zone is deeper than approximately 1,000 mbsl where animals typical of active hydrothermal vent sites, such as gastropods, shrimp, crabs and barnacles occur. Away from the hydrothermal vent, amboo coral, stalked barnacles, hydroids and other animals including octopus, swimming sea cucumbers, chimera, deep-sea fish species are rarely observed.

Figure 20.1 Potential marine impacts of the Solwara 1 Project



20.3.1 Seafloor production

The seafloor environment at Solwara 1 is an active deposition site with its sulfide-rich chimneys venting hydrothermal fluids and other rock debris into the lower water column layer, resulting in high sedimentation rates in the surrounding area. Studies show that sedimentation rates at Solwara 1 are on average 50 times higher than the open ocean where hydrothermal vents and volcanic activity do not occur (ERIAS Group, 2017).

The main impacts of the Solwara 1 Project are expected to occur at, or just above, the seafloor and include material and habitat/animal removal, plumes from cutting and stockpiling, noise, vibration and light.

Deep-sea sedimentation rates will be affected (with a net increase) by the mining operations due to:

- Pre-stripping of seafloor unconsolidated sediments and competent waste.
- Mine cutting and stockpiling.
- Discharge of sediments from the return water (although the modelled impact is extremely small).

It is envisaged that under normal operating conditions, there will be negligible impacts to the marine life in the mid-water column. Impacts are likely to be restricted to those resulting from the presence of the riser and lifting system, and the occasional transit of seafloor production tools, and remote operated vehicles during ascents and descents. Nautilus has developed methods to minimise sediment/suspended particulate matter entrainment from the seafloor during ascents of the seafloor production tools and remote operated vehicles, and these have been incorporated into the environmental management plans.

The potential impacts to surface pelagic animals will be restricted to the presence of the surface vessels and their normal operations. Potential impacts include lighting, underwater noise, routine discharges (in compliance with relevant maritime acts and regulations) and emissions to air. These impacts are expected to be similar to shipping generally and exploration surveys already completed by Nautilus.

20.3.2 Hydrodynamic modelling

Asia Pacific Applied Science Associates (APASA) undertook hydrodynamic modelling to predict the behaviour of unconsolidated sediments discharged at the seafloor outside the mining area, (Coffey, 2008). Suspended sediment modelling was carried out to quantify the sediment load on the seafloor resulting from full surface sediment removal during pre-strip and subsequent mining operations. Since

2008 APASA have updated and refined their modelling numerous times to reflect changes and updates in the mine plan and mining methods (e.g., moving from one mining tool to three seafloor production tools).

This hydrodynamic modelling indicated that at the completion of mining at Solwara 1, approximately 951,800 t of sediment will be distributed over a 4.47 km^2 area that encompasses the mining footprint. The estimated depth of this material ranges from 5.8 mm to over 500 mm near the discharge points of unconsolidated sediments during pre-strip. Coarse material is expected to settle rapidly while lighter materials will travel further from disposal points, however all the sediment is expected to settle within the boundaries of the ML with the furthest point of influence no further than 1.4 km from any mining area. Figure 20.2, Figure 20.3 and Figure 20.4 show the maximum extent of deposition and sediment concentrations resulting from mining activity with respect to the ML boundaries and depth in the water column.

Figure 20.2 Modelled maximum extent of sediment deposition at Solwara 1

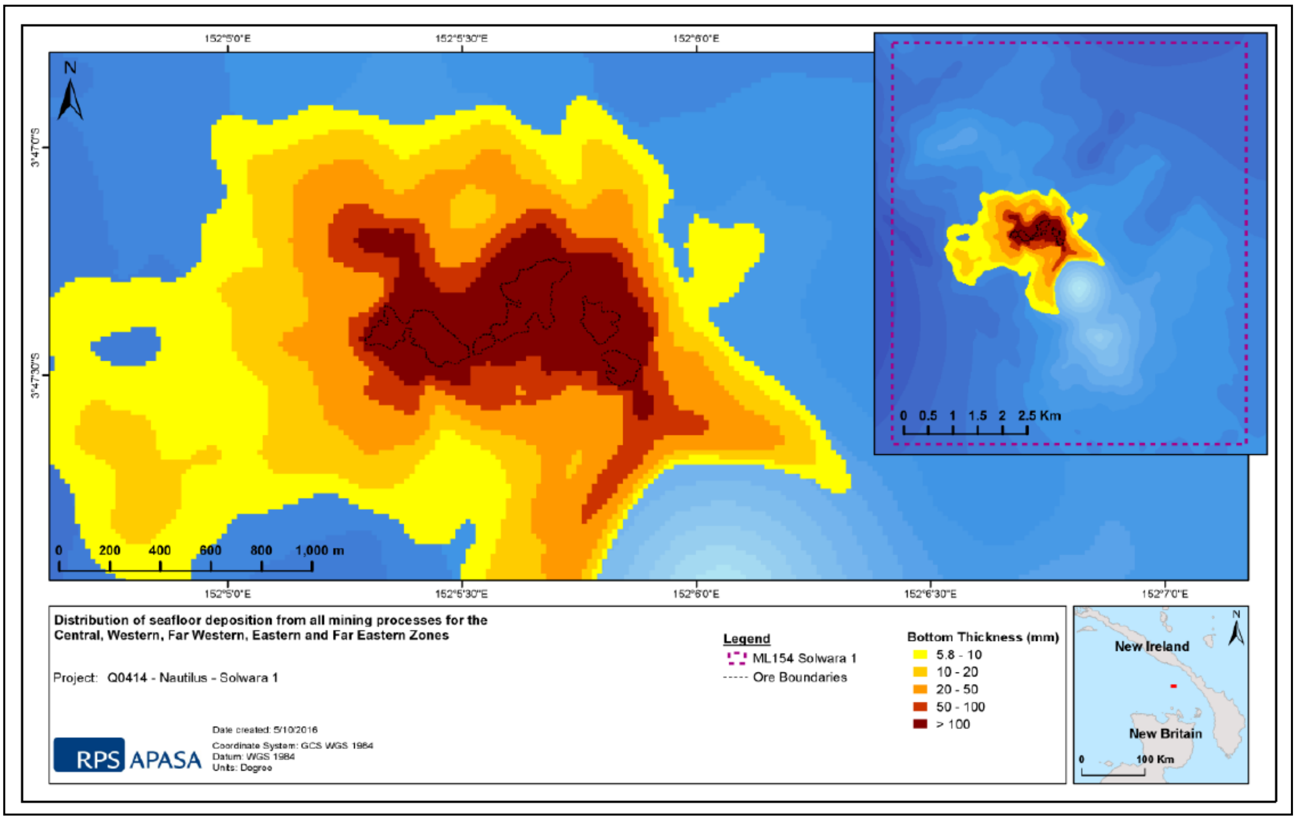


Figure 20.3 Modelled maximum extent of suspended sediment concentrations on the Solwara 1 ML

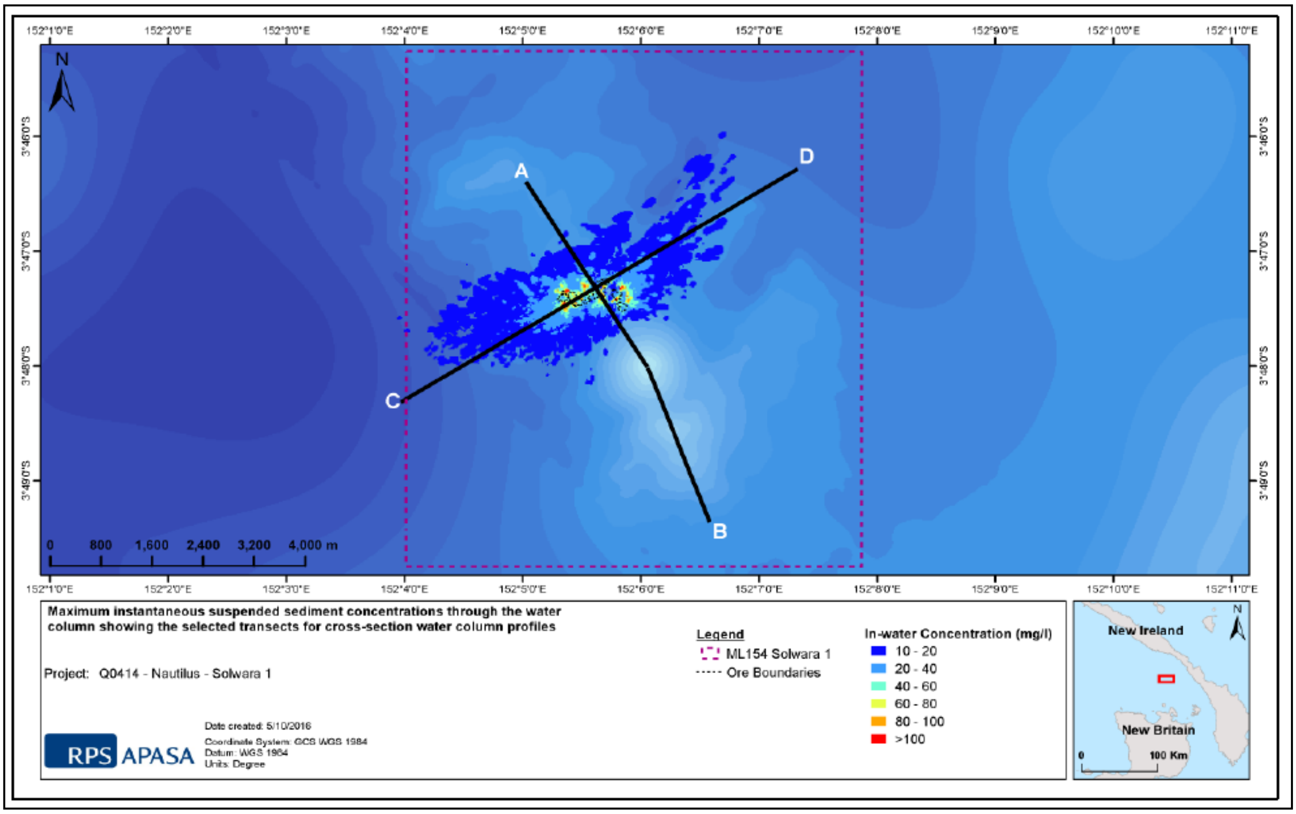


Figure 20.4 Depth of suspended sediment concentrations on the Solwara 1 ML

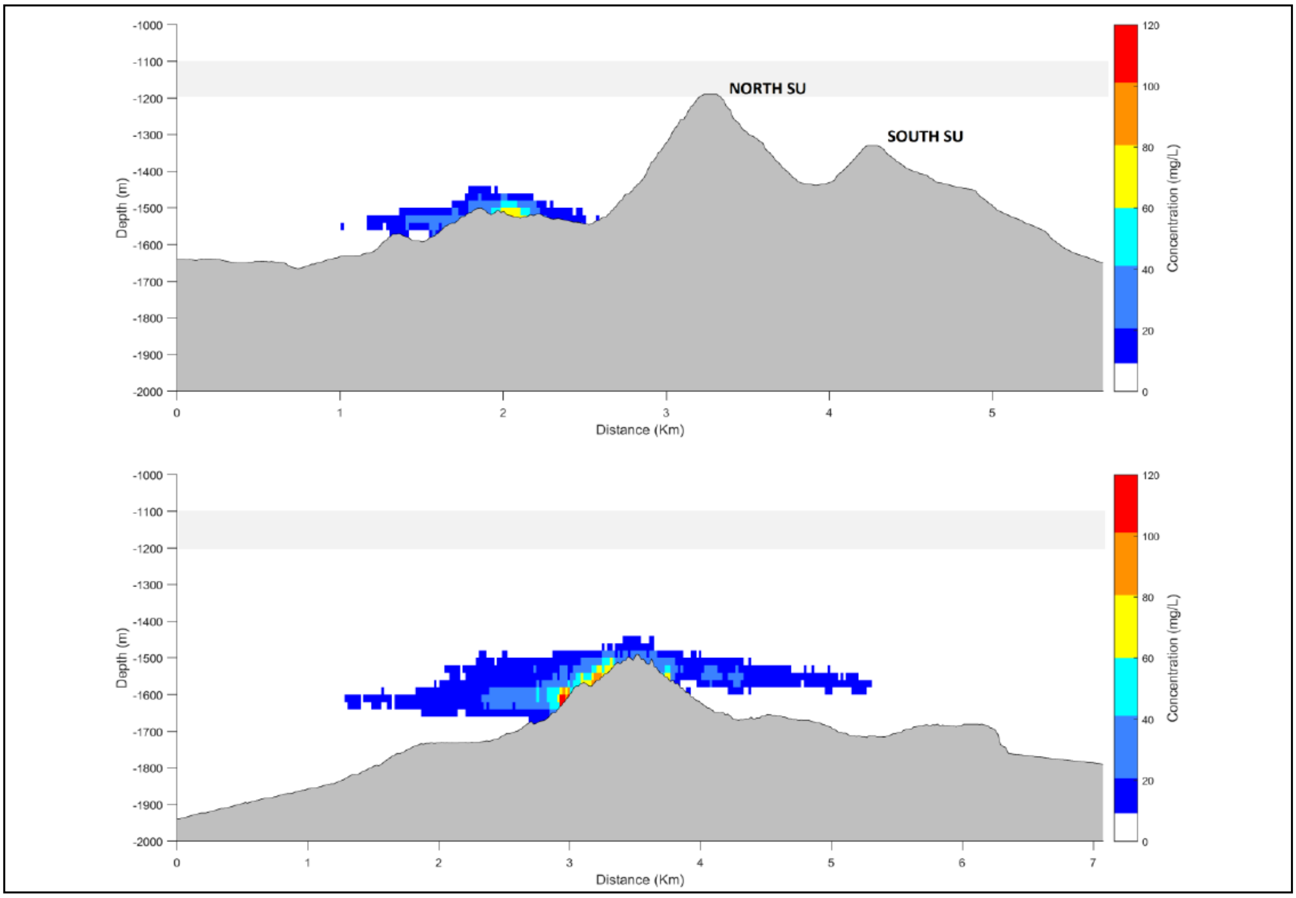


Figure 20.2, Figure 20.3, and Figure 20.4 are based on APASA modelling for operation of Solwara 1 over a 27-month period, for 300 days per year at a production rate of 5,900 t/day. This is equivalent to total production of approximately 4 Mt, which is 35% more than the entire Mineral Resource at Solwara 1. As such the modelling has been based on conservative input parameters. The modelling technique used by APASA was originally jointly developed by the U.S. Army Corps of Engineers (USACE), Engineering Research and Development Center, and APASA. Proof of performance for the model has been documented in a series of USACE dredging operations and environmental research program technical notes and published in peer-reviewed literature. Furthermore, the model has been applied to and validated by APASA against observations of sedimentation and suspended sediments at multiple locations in Australia.

The seafloor production tools are designed to minimise the loss of mineralised material to the environment, with expected overall recovery of approximately 95% (Coffey, 2008). Geochemical changes that could potentially result in an increase in soluble metal discharge are not expected, as these materials will remain at their original temperature and oxygen fugacity. Localised, partial burial of immobile fauna, however, is expected. However, fauna may, to a degree, be pre-adapted to high rates of sedimentation given the nearby presence of active volcanoes and their associated sediment plumes.

The 2016 APASA study also showed that:

- Total suspended sediment (TSS) concentrations greater than 10 mg/L occur up to distance of 3 km in a NE direction from the mineral deposit boundary, and they were contained within the Solwara 1 Mine Lease.
- TSS concentrations greater than 100 mg/L were only observed adjacent to the stockpiling areas up to a distance of 100 m from the mineral deposit boundary.
- Mine-derived plumes do not occur in the water column any shallower than 1,400 mbsl.

20.3.3 Process water discharge

The return water from the dewatering plant will discharge material smaller than 8 µm at a height of between 40 m to 180 m above the sea floor. The results of modelling indicated that TSS concentrations from this return flow, were minimal. While the initial concentration of the slurry discharging from the return flow pipe is in the order of 4,000 mg/L, the width of the two return pie plumes is only 0.2 m. Such a plume undergoes rapid dilution during its jet phase and the subsequent concentrations in the far-field are low, only exceeding the minimum threshold of 10 mg/L up to a distance of less than 100 m from the release point. These sediments will settle over a wide area but maximum depositional thickness will not exceed 1.0 mm. Thus, rates of settling are less than the existing deep-sea sediments rates measured at Solwara 1.

Geochemical changes in the mineralised material that could potentially result in increased leaching of soluble metals could occur during the mining and dewatering process, as these materials will not remain at their original temperature and oxygen fugacity.

Nautilus has undertaken reactivity tests to determine the concentration of potentially toxic metals under dilute, acid-extractable conditions. These tests indicated metal release was high for arsenic, copper, manganese and zinc and relatively low for silver, cadmium and lead. Hydrodynamic modelling of the return water also indicated that for it to meet target water quality standards (ANZECC/ARMCANZ 2000) to 95% protection levels, the metal contained within the return solution required a dilution of 600 times. This dilution occurs within 85 m from the discharge point.

Modelling reported in the EIS predicts that return water sediments will not rise above 1,400 m in the water column and, consequently, will not affect pelagic tuna, tuna fisheries or near-shore coral reefs, including traditional fisheries.

The EIS notes that near some vents, ambient baseline water concentrations of some dissolved metal such as Cu, Pb and Zn, already exceed ANZECC/ARMCANZ 2000 water quality standards (Coffey, 2008). Furthermore, it is important to consider that pre-existing water quality standards may have little relevance to the sensitivity of potentially metal-tolerant, deep-sea fauna to elevated metal concentrations.

20.3.4 Riser system and dewatering plant

Nautilus has carried out hydrodynamic modelling investigating the impact of any unexpected equipment malfunctions resulting in the loss of material in the riser and lifting system. The maximum amount of rock in the riser pipe at any one time is approximately 11 m^3. Failure of the riser and lifting system, while unlikely, would result in dumping this material back onto the seafloor, potentially affecting water quality near the seafloor or in surface waters along with associated smothering of animals on the seafloor.

Using a range of dump scenarios, APASA reported that the furthest extent of impact (>0.05 mm) was between 2.5 km to 2.6 km over the full mine life. The majority of the material will fall within the mine site area and could potentially be re-collected. The riser and lifting system is designed to start/shut down in normal conditions without dumping.

Nautilus has recognised that in rare circumstances, failure may occur in either, the slurry lift pump, surface pump, dewatering screens, or the production support vessel power supply which may result in a dump of material from within the riser. The EIS outlines a specified number of “riser dumps” are to be expected. Riser dumps have been addressed further in the EMP.

The dewatering plant includes a surge bin (3,000- tonne capacity or one full-day’s production) providing contingency for unplanned shutdowns.

20.3.5 Production support vessel

Potential impacts to the top layer of the water column are likely to include lighting, water quality, underwater noise, and routine discharges (in compliance with the relevant maritime permits).

20.3.5.1 Water use and discharge

Potable water on the production support vessel will be obtained using two 35-kL/day reverse osmosis desalination plants resulting in brine production of up to 82 kL/day. This brine will be discharged to the sea. The brine salinity will typically be double the salinity of the sea water, but is not expected to have any material impact. However, pre-treatment requirements for the desalination plants such as chlorination, bromination, dechlorination, coagulation, and filtration may lead to waste streams that may require treatment prior to discharge. A further waste stream associated with desalination through reverse osmosis include filter backwash water with elevated salinity and retained solids.

20.3.5.2 Water quality

Impacts on water quality may occur due to accidental hydraulic fluid leaks, fuel spills during transfers at the site of the production support vessel, spills during transfer to ships and bulk carriers and in extreme cases due to accidental collisions resulting in loss of vessels.

20.3.5.3 Noise

Transmission of noise from operating machinery through the water is an important consideration due to the presence of marine turtles and whales, both of which are protected by international conventions. It was identified that the most likely source of noise that may cause disturbance is from the vessel power generation, DPS, thrusters or seafloor production tools. Modelling indicated that noise levels will drop rapidly within 2 km, and more slowly thereafter. These sounds may be audible (e.g. to whales) at up to 600 km but at long ranges, they will not be greatly above that of background ocean noise depending on sea surface conditions.

The maximum distances for specific received level thresholds being exceeded show that it would not be until an animal approached closer than 1.1 km from the source that the levels would be greater than 140 dB. Harmful effects to whales are unlikely as literature suggests behavioural avoidance at levels generally occurs at levels between 130 dB to 140 dB. Masking of marine animal calls may occur if the mining vessel noise interrupts or prevents the listener from detecting the communicative signal. The operational noise associated with DPS of the mining vessel is continuous over a wide-frequency bandwidth. Animals may suffer signal-masking effects at similar ranges up to approximately 15 km. The noise levels expected at Solwara 1 are in-line with levels emitted by offshore oil and gas operations and intercontinental trenching operations for subsea communication cables.

In 2016 Nautilus commissioned an underwater noise and vibration impact assessment (EnviroGulf Consulting, 2016) that assessed potential impacts on marine fauna (including whales, turtles, marine reptiles, fish and macroinvertebrates) and marine resource use. The study determined that noise impacts to marine fauna will be negligible and estimated that impacts to animals would only occur if they came to within 10 m of noise sources.

20.3.5.4 Emissions to air and lighting

Air emissions will consist of combustion emissions from the production support vessel’s DPS thrusters, vessel power supply and the mining, transfer and processing power supply. Air emissions of most concern are carbon dioxide, carbon monoxide, nitrous oxides and sulphur dioxide. It is expected that there will be limited dust emissions from processing or transport activities due to the moisture content of the product. Emissions to air from this Project should not have a direct impact on marine life.

There is also some potential for modification of marine fauna behaviour (migration or navigation) because of surface lighting on the production support vessel.

20.3.6 Mitigation strategies

Nautilus is committed to minimising the environmental impact of its activities while contributing positively to the sustainable future of the communities in which it works. Nautilus aims to preserve long-term ecosystem health and function in the natural environments affected by its operations.

As noted in the EMP, Nautilus proposes the following management and mitigation measures to minimise adverse environmental and socioeconomic impacts identified:

- The application of sound engineering design, deployment and operational practices for the seafloor production equipment, to minimise disturbance to the seafloor and the suspension of sediments.
- The adoption of a dewatering management strategy that will involve discharge at depths near to where the material originated, thereby avoiding impacts to the water column.
- The retention of an unmined area at South Su and temporary reserve areas in Solwara 1 to aid in the recolonisation of the mined areas and conservation of biodiversity. Relocation of animals to already disturbed areas is to be considered as is placement of artificial substrates to enhance recolonisation.
- The adoption of lighting and noise strategies that will address surface and subsea operational and safety requirements and minimise the potential for the attraction of, and interaction with, marine animals.
- The adoption of a waste management strategy that will address the management of sewage, chemical and hazardous materials to minimise the potential for contamination of the water column.
- Where practicable, the application of policies for the employment and training of the workforce that will maximise benefits to the local communities and minimise adverse social effects.
- The development of emergency response plans to mitigate the effects of natural disasters and unplanned events.

The proposed mitigation strategies for geochemical stability and toxicity of the discharged sediments in the return water include:

- The addition of sea water to aid pumping of discharge wastes and facilitate plume dispersion via initial dilution.
- Discharge at depth.
- A small (24 minute) transit time from seafloor to the production vessel and back to the seafloor (Coffey, 2008). This will limit the opportunity for oxidation of sulfides and the formation of acid (Coffey, 2008).
- Dilution by return seawater and near the discharge point.

Nautilus undertook extensive studies over 2015 and 2016 (listed in Item 20.1.2) in support of the EMP which was completed and submitted to the Conservation and Environment Protection Authority (CEPA) in 2017. During preparation of the EMP a number workshops were held with relevant PNG government entities to obtain input to the EMPs. These entities included CEPA, Mineral Resource Authority, National Fisheries Authority, New Ireland Provincial Government, East New Britain Provincial Government, Petromin and National Marine Safety Authority.

20.4 Current environmental permits and conditions

Nautilus has submitted an Environmental Inception Report (EIR) (Enesar, 2007) and an EIS (Coffey, 2008) for the Solwara 1 Project. Following public hearings in November 2008 and an independent review by third-party specialist consultants (Cardno Acil, Australia), the EIS was approved ‘in principle’ by the PNG Environment Minister on 31 August 2009.

The PNG Department of Environment and Conservation (DEC), now known as the CEPA, subsequently issued the Project’s EP (WD-L3-234) dated 29 December 2009. This permit would expire after two years if works had not been started. In a letter dated 12 December 2011, the PNG Government indicated that Condition 3 (commencement of works) of the EP has been satisfied and the validity of the EP is ongoing.

The EP places 80 conditions on the Project and requires additional actions by Nautilus prior to the commencement of seafloor mining at Solwara 1. Key conditions in the EP include:

- The submission of an EMP, including specified sub-plans for the management of:
  - air quality and dust
  - stockpile and acid-drainage
  - offshore sediment
  - noise and vibration
  - water quality
  - waste
  - lighting
  - marine mammals and turtles
  - introduced marine species
  - benthic ecology
  - emergency response and spill contingency
  - submission of a Mine Closure Plan

The content and timing of the submission of the EMP and Closure Plan for Solwara 1 has been negotiated and agreed with CEPA. The administrative requirement is that the EMP (incorporating a Rehabilitation Plan) is submitted three months prior to commencement of operations.

The EMP has been completed as described above and has been submitted to CEPA for review prior to final approval in advance of project execution.

Given the short mine life of the Solwara 1 Project (approximately 29 months), Nautilus has agreed to lodge a draft Closure Plan one year prior to closure. Due to the unique features of the undersea location, Nautilus proposes to meet the requirement for a Rehabilitation Plan (typically applied in terrestrial environments) by the submission of a Recovery Plan. An updated conceptual closure plan was completed and submitted in 2017 to both CEPA and MRA in accordance with the conditions of the EP and the ML.

20.4.1 Changes to Project definition and consequences for permitting due to trans-shipment

As noted previously, Nautilus has changed the Project description since the approval of the EIS to include:

- The use of a single production support vessel as opposed to three separate ones.
- Stockpiling of mineralised material on the seafloor.
- The use of offshore trans-shipment (in place of product storage at the Port of Rabaul).

These changes have been the subject of a Variation of the ML and an amendment of the EP, and are captured and addressed in the current EMP and will not require revision of the EIS.

20.5 Social and community factors

20.5.1 Status of approvals

The *PNG Environment Act* (s51) requires that the likely social impacts of a proposed activity are set out in the EIS in accordance with the issues identified in the approved EIR. To assist proponents, the DEC provides a guideline (i.e. the Social Impact Assessment guideline) requiring, but not limited to, demographic information, information on existing infrastructure, public health issues, social services availability and the present economic status of the Project area (Coffey, 2008).

Nautilus holds an approved EIS for the Solwara 1 Project. The EIS describes the socio-economic environment of the Project area, workforce requirements and stakeholder consultation, and discusses impacts and proposed mitigation methods.

With the approval of the EIS, the PNG Government has signalled that it is comfortable with the effectiveness (i.e. decision, process, and content) of Nautilus's socio-economic and community engagement program for Solwara 1. Except for Condition 79 in the EP (i.e. "the permit holder must promptly report to the Director any significant health, safety, environment, cultural heritage or community incidents that occur"), there are no conditions addressing social or community aspects.

Nautilus is currently using a strategic plan for Corporate Social Responsibility to guide its ongoing activities with respect to social and community aspects of the Project. This plan outlines programs to be implemented in both the pre-production and production periods of the Project over a five-year planning horizon. The programs span the five areas of stakeholder engagement, infrastructure development, community health, education and business development. The strategic plan targets coastal communities that are geographically closest to the Project site on the west and north coasts of New Ireland and East New Britain Provinces respectively.

20.5.2 Socio-economic environment

Nautilus's 2008 EIS addresses background requirements such as demographics, existing infrastructure, public health, social services availability and present economic status of the Project area.

The proposed mining area at Solwara 1 is located offshore and as such, the Social Impact Assessment was restricted to areas from where unskilled employees are likely to be recruited and to which significant benefit streams (e.g. royalties and tax distribution) are likely to flow. These communities have a high level of interest in the Project as their coastal fisheries are geographically closest to the Project site in the host provionces of New Ireland and East New Britain, PNG.

The PNG Millennium Development Goals rank these two provinces' performance against the PNG average and show that in general, they both perform well above the national average, as shown in Table 20.1 and Table 20.2.

Table 20.1 New Ireland performance against millennium goals

Goal	New Ireland
Average life expectancy (years).	Far above national average
Average percentage for the years 1999 to 2003 for children under age 5 who have attended clinics and weighed less than 80% of that expected for their age.	Above national average
Cohort retention rates (%) at the primary level in 2000.	Above national average
Youth (15 to 24) literacy rates (%) in 2000.	Far above national average
Female labour force participation rates (%) in 2000.	Far below national average
Difference (%) between male and female youth (15 to 24) literacy rates in 2000.	Females performing above national average
Infant mortality rates (per thousand) in 2000.	Below national average
Average percentage for the years 1999 to 2003 of children under age 1 who received their 9 to 11 months dose of measles vaccine.	Above national average
Goal	**New Ireland**
Average percentage for the years 1999 to 2003 of children under age 1 who received three doses of the triple antigen vaccine.	Above national average
Average percentage for the years 1999 to 2003 of pregnant women who had at least one antenatal visit.	Far above national average
Average percentage for the years 1999 to 2003 of births supervised in a health facility or by a trained village birth attendant.	Far above national average

Source: UN, 2004.

Table 20.2 East New Britain performance against millennium goals

Goal	East New Britain
Average life expectancy (years).	Above national average
Average percentage for the years 1999 to 2003 for children under age 5 who have attended clinics and weighed less than 80% of that expected for their age.	About national average
Cohort retention rates (%) at the primary level in 2000.	Far above national average
Youth (15 to 24) literacy rates (%) in 2000.	Far above national average
Female labour force participation rates (%) in 2000.	About national average
Difference (%) between male and female youth (15 to 24) literacy rates in 2000.	Females performing above national average
Infant mortality rates (per thousand) in 2000.	Below national average
Average percentage for the years 1999 to 2003 of children under age 1 who received their 9 to 11 months dose of measles vaccine.	Far above national average
Average percentage for the years 1999 to 2003 of children under age 1 who received three doses of the triple antigen vaccine.	Far above national average
Average percentage for the years 1999 to 2003 of pregnant women who had at least one antenatal visit.	Far above national average
Average percentage for the years 1999 to 2003 of births supervised in a health facility or by a trained village birth attendant.	Far above national average

Source: UN, 2004.

There are no subsistence fisheries at the Solwara 1 site because it is too far from shore in very deep water. However, there may be some interaction between supply vessels and small craft providing transport services between New Ireland and East New Britain. Traditional activities such as shark calling were found to be important locally at several communities to the north of Messi village. The underwater noise and vibration impact assessment (EnviroGulf Consulting, 2016) assessed potential impacts on marine resource use, including fisheries and shark calling (a culturally important traditional activity practised in New Ireland Province). The assessment determined that Project activities will not impact fisheries or shark calling, and the assessment results have been supported by ongoing studies.

20.5.3 Social impacts

As the major components of the proposed mining and trans-shipment activities are located offshore, many of the socioeconomic and sociocultural issues normally associated with terrestrial mining projects are likely to be absent from Solwara 1. The Project will not cause the displacement of people from their land or alter existing land use practices. However, based on other larger projects in PNG, local impacts are expected to arise in the following areas:

- Limited employment created during the operational phase of the Project.
- Non-sustainable business opportunities generated by the supply of goods and services.
- Subsidiary employment and business opportunities arising from expenditure of incomes earned from Project employees.
- The distribution of beneficial streams and related disputes (i.e. taxes and royalties).

External financing provides a very large proportion of financial resources available for the support and facilitation of the Government's development programs in PNG. The Project will provide revenue to the PNG Government through royalties and taxes and establishing a Community Development Fund that will support existing provincial development projects in New Ireland and the island provinces.

Positive socioeconomic aspects of the Solwara 1 Project are likely to include:

- Economic benefits to the national and provincial economies through the payment of royalties and taxes.
- Community development through Nautilus's support of community programs in infrastructure, health, education, and business development sectors.
- Increased industry diversity for PNG and development of specialised knowledge and skills that can be shared with other Pacific Nations where future seafloor mining projects may occur.
- Training associated with employment of PNG nationals on the Project.

Potential negatives identified and relevant throughout the Project include:

- Ineffective or disputed distribution of benefits in the absence of a clearly defined landowner group.
- Migration of people from other parts of New Ireland, East New Britain or other parts of PNG to the west coast of New Ireland. It should be noted however that Solwara 1 will provide limited employment opportunity with only 115 full time positions for PNG citizens. For unskilled labour sourced locally the number of full time positions will be around 30 people. This is an order of magnitude smaller than the corresponding employment opportunities for major terrestrial mines. Nevertheless, if migration did occur, it could reduce opportunities for local people, stress local infrastructure and the provision of Government services and cause social tension.
- Disruption to fishing activities and other vessels operating in the vicinity of Solwara 1 and Project marine transport corridors.
- Danger to local peoples fishing around mining vessels.
- Disruption to local customs (e.g. shark calling).

The EIS and EMP mitigate these risks by:

- The development and implementation of a cultural awareness program for employees out-lining the environmental and social setting of the Project and ensuring all employees understand their responsibilities in this regard.
- Direct transfer of fly-in/fly-out employees to and from the vessel by helicopter to eliminate the need for overnight accommodation in Kokopo. This will minimise the potential for interaction between non-local employees and local communities
- Preparation of a Training and Development Plan that provides general principles for employment and training. The plan maximises employment opportunities for local labour and for other PNG citizens with the required qualifications and experience.

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

- Establishment of a 2.5-km diameter exclusion zone around the production support vessel.
- Installation of appropriate devices on the production support vessel 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 production support vessel and associated exclusion zone.

20.5.4 Stakeholder engagement

Public consultation is a requirement of the PNG Government's environmental impact assessment process under the *Environment Act 2000* and an EIS should provide 'details of the consultation program undertaken by the applicant, including the degree of public interest'.

The EIS describes stakeholder consultation undertaken for Solwara 1, which included national, provincial and local governments, local communities, non-governmental organisations (NGOs) and various other stakeholders, such as the international scientific community.

The EIS documents the various consultation methods, consultation program, record keeping and Project responses to issues and concerns. In the period from August 2007 to June 2008, Nautilus used a variety of engagement methods ranging from formal briefings with the Government and churches to community awareness presentations and workshops. Informal methods included face-to-face meetings and the distribution of brochures and posters. Nautilus maintains consultation logs and a list of those stakeholders who are actively engaged in the consultation process.

The primary concerns raised during the EIS consultation program were:

- Natural disaster.
- Impacts on biological life.
- Impacts on local fishing.
- Unequal distribution of benefits.
- Limited access to jobs.
- PNG Government's limited capacity to regulate mining and limited local involvement.

The Project reportedly has good support in the region. Most community concerns relate to the distribution of benefits and environmental impacts of the Project. Local communities are provided with information addressing these concerns by Nautilus and representatives of government agencies during regular community awareness campaigns mandated by conditions of the ML and a draft Memorandum of Agreement on the Project.

20.5.5 Project support and opposition

Nautilus is aware that there is some negative sentiment regarding the Project and potential environmental impacts. In response, in 2015 Nautilus undertook a toxicological study of nearshore coral reef ecology along the New Ireland and New Britain coastline of the Bismarck Sea to determine the existing state (i.e., baseline) of coral reefs and biota. Nautilus also undertook baseline studies of pelagic habitat at Solwara 1 including zooplankton and ichthyoplankton.

Not all stakeholders are working with Nautilus. In particular, the Bismarck Ramu Group regards the Project negatively. This group has previously pursued a lawsuit against the Ramu Nickel project, which uses deep sea tailings disposal methods. Nautilus has attempted unsuccessfully to engage with this group over a prolonged period of time. Ramu is geographically remote from the Solwara 1 site.

Another potential stakeholder group, the Bismarck Solomon Seas Indigenous Peoples Council (BSSIPC) commissioned a report (Steiner, 2009) to review the EIS. Professor Steiner is cited as a member of the University of Alaska Marine Advisory Program. The report is critical of the "passive consultation" process in the EIS, and among other claims, states that there was "overwhelming" and "strong opposition" expressed to him by local residents following a stakeholder consultation meeting at Bagabag Island in Madang Province, which is further than 500 km from the proposed mining site. Nautilus's attempts to engage with the BSSIPC, other than at an individual member level, met with no response.

The Deep-Sea Mining Campaign (DSMC) is opposed on principle to deep sea mining and the Project and has produced a number of reports attacking Nautilus and the Project, including:

- Out of Our Depth, Mining the Ocean Floor in PNG (DSMC, 2011).
- Physical Oceanographic Assessment of the Nautilus EIS for the Solwara 1 Project (DSMC, 2012).
- Accountability Zero: A Critique of Nautilus Minerals Environmental and Social Benchmarking Analysis of the Solwara 1 project (DSMC, 2015).

These reports include many factual errors, which propagate false, negative and misleading perceptions regarding the Project. Nautilus has attempted to engage with DSMC on several occasions, however the group has to date been unwilling to engage in open and honest dialogue, or address errors identified by Nautilus in DSCM's reports.

In 2015 Nautilus engaged Earth Economics to conduct an independent environmental and social benchmarking analysis (Earth Economics, 2015) of the Project. The primary goal of the analysis was to measure the environmental and social impacts of the Solwara 1 project in comparison with three terrestrial mines. The study concluded the following:

- The project has the potential to significantly reduce the social and environmental impacts of copper mining and may well have far less overall social and environmental impacts than any currently producing copper mine.
- The project is likely to surpass many of the International Finance Corporation (IFC) social and environmental standards for mining practices.
- Nautilus has engaged with the scientific community and promoted study of the seabed with a high level of collaboration and transparency.
- The project has established high standards for social and environmental management of deep sea mining projects.
- Nautilus has engaged effectively with those communities geographically closest to the Project providing benefits through community programs implemented well ahead of production.

While there has been some negative sentiment towards the Project, Nautilus has endeavoured to engage with the relevant parties to address their concerns, including commissioning and publishing the Earth Economics assessment described above. As part of its ongoing risk assessment for the Project, Nautilus is actively monitoring community sentiment and continues to implement the strategic plan for corporate social responsibility in consultation with state, provincial and local level governments.

20.5.6 Customary marine tenure

In a meeting held in Karkum in 2008, the indigenous people of New Ireland, East New Britain and Madang (apparently represented by the BSSIPC and the Madang Indigenous People), declared in a formal statement that:

> "The indigenous people have rights to free prior informed consent over anything potentially impacting on their land and sea resources in the Bismarck Archipelago." (BSSIPC, 2008)

The rights expressed in the formal statement were apparently re-affirmed at a meeting held at Kokopo in 2011 (Tamolita, 2011). Reportedly, the meeting agreed to launch a strong campaign against mining of the ocean seabed within the Bismarck Archipelago. free prior informed consent is based on the concept of customary law as outlined in the United Nations Declaration on Indigenous People.

Such traditional rights only extend to areas of traditional usage, which are not considered relevant or applicable to deep sea areas well beyond traditional reef fisheries.

20.5.7 International Finance Corporation

The IFC's Policy on Social and Environmental Sustainability (IFC, 2006) intends that social and environmental risks are managed in a manner consistent with IFC Performance Standards.

The Performance Standards expect that projects demonstrate effective community engagement with regard to the risks and impacts to the affected communities (IFC, 2006). To achieve this, the IFC requires projects to "engage with affected communities through disclosure of information, consultation, and informed participation, in a manner commensurate with the risk to and impacts on the affected community". The IFC policy commits to the objective of free, prior and informed consultation.

The performance standards of immediate relevance to the Project's social aspects are:

- Performance Standard 1: Social and Environmental Assessment and Management System.
- Performance Standard 2: Labour and Working Conditions.
- Performance Standard 4: Community Health, Safety and Security.
- Performance Standard 7: Indigenous Peoples.
- Performance Standard 8: Cultural Heritage.

Performance Standard 1 establishes the importance of integrated assessment of social and environmental impacts, effective community engagement and management of social and environmental performance throughout the life of a project (IFC 2006b). Risks and impacts are to be analysed in the context of the Project's area of influence (IFC 2006b).

Nautilus's Solwara 1 Project has been independently reviewed against the IFC guidelines, and has been found to meets all applicable IFC performance standards and guidelines, as well as World Bank standards, with a few exceptions. In those areas where Nautilus does not currently meet the standards or guidelines, Nautilus has plans to meet these requirements by the time mining commences.

20.6 Rehabilitation and mine closure

20.6.1 Statutory and administrative requirements

Section 66 of the *Environment Act 2000* provides for the conditioning of rehabilitation requirements following mining activities. Conditions in a project's EP may also refer to specific rehabilitation plans, actions, or requirements.

The typical administrative requirement is that an EMP (incorporating rehabilitation activities) is submitted three months prior to commencement of operations. A Mine Closure Plan is submitted 12 months prior to the cessation of active mining.

Due to the unique features of the undersea mining location, Nautilus proposes to meet the requirement for a Rehabilitation Plan (typically applied in terrestrial environments) through the submission of a Recovery Plan.

A rehabilitation bond is not a statutory requirement under PNG law.

20.6.2 Recovery plan

Nautilus's EIS describes the intended post-mining recovery:

"When the mining operations are complete, the underlying natural hydrothermal energy, which has remained unchanged, will enable venting to continue and associated chimneys to reform at the same or nearby locations to where they previously occurred. As the vents provide the sulphidic trophic basis for the ecological characteristics of the Project area, a succession of vent-dependent communities is expected to re-establish over time. The process of recovery at Solwara 1 will be enhanced by various mitigation strategies, and regular monitoring of recolonization."

The EIS proposes to mitigate the direct impacts of seafloor mining on fauna by incorporation the following:

- Provision of temporary refuge areas.
- Translocation of fauna where viable.
- Placement of artificial substrates.

Natural recolonisation by active adult migration and passive recruitment by mobile larvae is also expected. Recolonisation is expected to occur from communities located in areas unaffected by mining, such as those at the South Su reference site.

One of the key recovery strategies is the commitment by Nautilus to reserve South Su from development in order to;

- Provide a parent stock to help Solwara 1 recover.
- Act as a reference site to study natural environment variability away from the production site.

The time sequence of recovery of fauna is not known but it is expected that within one to three years, the major faunal elements will have re-established (Coffey, 2008).

The EP requires the submission of a Benthic Ecology Management sub-plan as part of the EMP. This document has been prepared and submitted to CEPA in readiness for an independent review of the EMP. This plan provides for recovery of biota in the mined areas.

21 Capital and Operating costs

21.1 Capital expenditure

The total capital cost estimate for Nautilus's deep-sea mining system, which will first be deployed at Solwara 1, is US$530 million.

The planned capital expenditure excludes some costs associated with constructing the production support vessel, and integrating the Nautilus equipment onto the vessel being built for the Marine Asset Corporation by Fujian Mawei, and which the ship builders intend to recoup through the production support vessel charter costs.

The capital cost estimates as at 31 December 2017 are summarised in Table 21.1.

In April 2014, Nautilus and the PNG government agreed to a capital expenditure schedule of US$580 million (including contingency of US$48 million). The agreement included provision for a reconciliation against actual costs on delivery of first product. Nautilus revised the capital expenditure schedule in November 2015 to US$503 million with no contingency. A new line item, 'Adjustment in Scope', (totalling US$29 million), was added to account for the revision. The adjustment in scope was the difference between the control budget that prevailed at the time (US$532 million), and the revised capital estimate (US$503 million) approved by the Nautilus Board in November 2015. These adjustments have now been rolled back into the budget line items.

Of the total capex, 59% (US$315 million) has been committed in existing contracts, and 54% (US$287 million) has already been incurred. The estimate for capital yet to be committed that is required to complete the Project is US$215 million.

There is no contingency built into individual line items in the budget summary.

Table 21.1 Capital costs

Description	Sunk costs (US$m)	Original budget (US$m)	Changes to budget to-date (US$m)	Control budget (US$m)	Committed cost (US$m)	Estimated cost yet to commit to complete (US$m)	Indicated final cost (US$m)
	A	B	C	D = B + C	E	F	G = E + F
Seafloor production tools	21	90	54	144	103	41	144
Riser and lifter system	20	121	34	155	112	43	155
Dewatering plant	–	37	7	44	14	31	44
Mobilisation	–	22	7	29	7	23	29
Production support vessel integration	2	44	30	75	16	59	75
Materials handling	0.04	4	–3	0.2	0.2	–	0.2
Mineralised material processing	0.04	8	10	18	16	1	18
Project services	2	46	13	59	44	14	59
Owner's costs	0.4	9	-2	7	3	4	6
	45	**380**	**150**	**530**	**315**	**215**	**530**
Adjustment in scope	–	–	2	2	–	–	–
Contingency	–	52	–4	48	–	–	–
Total	**45**	**432**	**148**	**580**	**315**	**215**	**530**

A: Expenditure prior to Q1 2011
B: Original budget starting 01 April 2011
C: Identified changes subject to Board approval
E: Value of purchase orders, NMN salaries and expenses
F: value of work yet to be awarded / committed

21.2 Operating costs

The operating costs have been estimated by Nautilus. Key contracts are in place for major cost items, including the Vessel Procurement Agreement that covers the charter costs of the production support vessel; the Crewing Agreement that covers the production support vessel marine crew (55 - 80 positions); and the Master Ore Sales and Processing Agreement that covers processing fees and charges, and specifies the method for determining smelter treatment charges and refining charges.

The operating costs are summarised in Table 21.2.

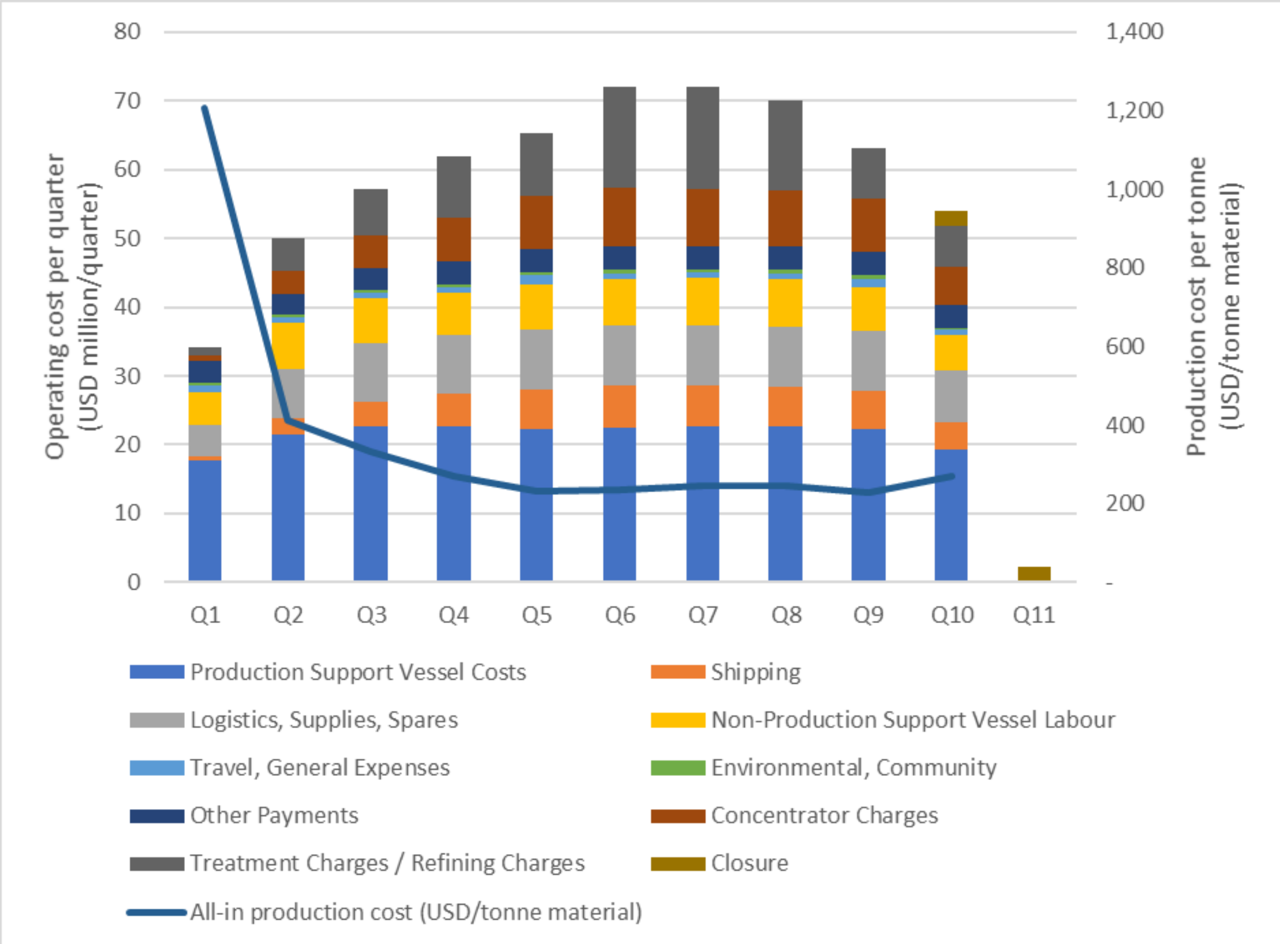
Table 21.2 Operating costs

Cost Item	Value	Units	Life-of-project cost estimate (US$ million)	Sub-totals (US$ million)
Production Support Vessel Costs				
Production support vessel charter	140,000	US$ per day	142.0	
Fuel and lubricants	23,900	US$ per day	24.2	
Production support vessel crew	59,910	US$ per day	30.3	
Accommodation, meals	19,530	US$ per day	19.8	
Sub-total				**216.4**
Product shipping	18.70	US$ per wet tonne	44.2	**44.2**
Logistics, supplies, spares	90,400	US$ per day	80.2	**80.2**
Other labour costs	70,128	US$ per day	62.3	**62.3**
Travel, general expenses	10,700	US$ per day	9.5	**9.5**
Environment, community	4,600	US$ per day	4.1	**4.1**
Other Payments				
Fixed plant capital charge (Tongling)	175	Million RMB per quarter	25.7	
CIQ sampling fee	0.60	RMB per dry tonne product	0.2	
Joint inspector costs	12.00	RMB per dry tonne product	3.9	
Locked-cycle test work	30,000	US$ per quarter	0.3	
Salt removal costs	6.84	RMB per dry tonne product	2.2	
Processing plant standby costs	49,288	RMB per day	0.7	
Sub-total				**33.1**
Concentrator Charges				
Logistics charge	81.30	RMB per wet tonne concentrate	29.4	
Concentrator charge	77.69	RMB per dry tonne product	25.3	
Tongling profit fee	25%	% of the concentrator charge	6.3	
				61.0
Treatment Charges / Refining Charges				
Treatment charge (net of logistic credit of RMB78.21 per wet tonne of concentrate)	61.42	US$ per dry tonne concentrate	41.1	
Copper refining charge	0.075	US$ per lb contained copper	20.9	
Gold refining charge	5.00	US$ per ounce contained gold	0.9	
Silver refining charge	0.40	US$ per ounce contained silver	0.2	
Treatment charge premium	25.00	US$ per dry tonne concentrate	16.6	
Copper refining charge premium	0.025	US$ per lb contained copper	7.0	
Sub-total				**86.6**
Closure			4.4	**4.4**
Total			**601.9**	**601.9**

CIQ means the Exit-Entry Inspection and Quarantine Bureau of the PRC. A foreign exchange rate of 6.40 RMB = 1 US$ was assumed by Nautilus. The Qualified Person considers this assumption is reasonable for the purpose of preliminary economic assessment given the spot exchange rate on the effective date (1 January 2018) was 6.52 RMB = 1 US$, and the three-year trailing average was 6.56 RMB = 1 US$.

A moisture content of 10% was assumed for shipped product. Material loss of 2% at the dewatering stage was assumed. The production costs (by quarter) are shown in Figure 21.1.

Figure 21.1 Forecast quarterly production costs



The average production cost (inclusive of all items listed in Table 21.3) for the life of the Solwara 1 project is US$274 /t mined.

Table 21.3 Summary of costs on “per tonnage mined” basis

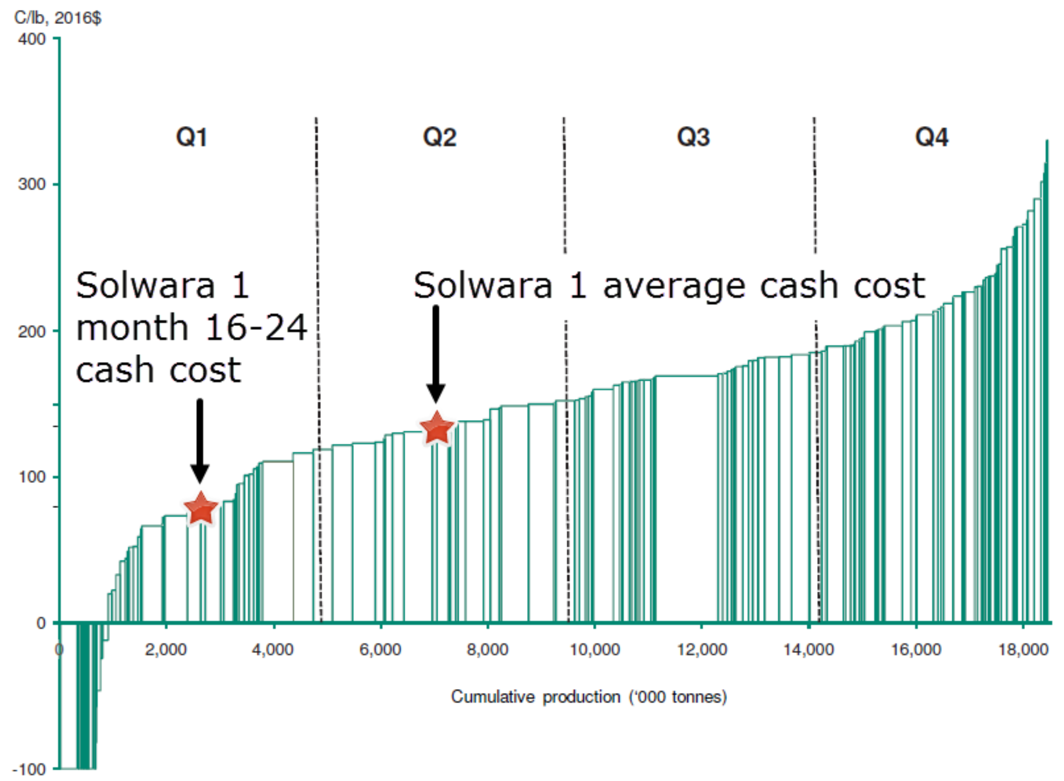
Category	**Cost**	**Unit**
Mining and mine closure	172	US$ per dry tonne mined
Shipping	20	US$ per dry tonne mined
Processing (non-smelter)	43	US$ per dry tonne mined
Processing (smelter TC/RC)	39	US$ per dry tonne mined
Total	274	US$ per dry tonne mined

AMC has estimated a C1 cash cost for Solwara 1 of US$1.36 per payable pound of copper net of gold credits over the life of the Project. This estimate includes the 15-month production ramp-up period when cash costs are negatively impacted by lower copper and gold production. During the period when the production rate is stable at around 3,200 tpd in months 16 to 24, the C1 cash cost is expected to be US$0.80/lb. This is indicative of cash costs that might be achievable for subsequent deep-sea mining projects that have metal grades similar to Solwara 1. This is because the experience gained at Solwara 1 could reasonably be expected to reduce the ramp-up period for these subsequent projects to less than 15 months.

C1 cash cost per pound is a financial performance measure based on cost of sales and includes treatment and refinement charges and by-product credits, but excludes the impact of depreciation and royalties. C1 does not have any standardized meaning under Generally Accepted Accounting Principles (GAAP) or International Financial Reporting Standards, and may not be comparable to similar measures of performance presented by other companies.

The C1 cash cost of US$1.36 per recovered pound of copper net of gold credits compares favourably to the cash costs of terrestrial mining operations (Figure 21.2). Such cash costs would place the Solwara 1 project in the second quartile of global copper mining operations with respect to copper industry cash costs.

Figure 21.2 Copper cost curve, adapted from Wood Mackenzie 2016



Source: Wood Mackenzie (Q3'16 Cost Service), 2016 Oyu Tolgoi Technical Report and Turquoise Hill Resources.
Normal C1 cost + sustaining capex, range capped at -100/lb & 400/lb for base, highly probable and probable mines only.

The operating cost is made up of both fixed (time-based) and variable (tonnage-based) components, and is therefore sensitive to project duration, and sensitive to realisation of expected production ramp up rates. The average split of fixed and variable costs is 52%:48%. A delay of three months is expected to increase the average operating cost by $15 /t. A reduction in project duration by three months is expected to reduce average operating costs by $15 /t.

The major mining-related cost drivers in the financial model and some of the key assumptions are shown in Table 21.4. Shipping and the costs defined in the Ore Sales Agreement are excluded. The high proportion of fixed costs means the Project is highly leveraged to metal grade, metal prices, and production rate. For example, if a steady-state production rate of 4,500 tpd (rather than 3,200 tpd) is eventually achieved, the C1 cash cost for that period would be expected to be $0.63/lb cu (rather than 0.80/lb). Given that the maximum capacity constraint of the mining system is 6,000 tpd, a long-term productivity target of 4,500 tpd is not unreasonable.

Table 21.4 Summary of fixed mining costs

Parameter	Value	Fixed / Variable Assumption
Production support vessel charter rate	US$140,000/day	Fixed
Vessel crew	US$59,900/day	Fixed
Production crew	US$70,125/day	Fixed
Spares and logistics	US$90,400/day	Variable
Fuel (53t marine gasoil/day @ US$449/tonne)	US$23,800/day	66% Fixed (position keeping), 34% variable
Accommodation and Meals (180 persons on board @ US$105/person/day)	US$18,900/day	Fixed
Travel and general costs	US$14,400/day	50% Fixed, 50% variable
Total	US$417,525/day	75% Fixed, 25% variable

22 Economic Analysis

A comprehensive financial model based on estimates of future cash flows for Solwara 1 has been developed in-house by Nautilus. AMC reviewed the logic, input assumptions and integrity of the calculations and forecasts.

The preliminary economic evaluation discussed below is for the Solwara 1 project only, which at a preliminary level of mine planning. AMC notes that there is significant upside potential in the other SMS exploration targets within the extensive subsea tenements that could be investigated once the extraction method is technically and commercially proven.

22.1 Inputs

Real (uninflated) cash flows are discussed in this report, which is reasonable given the short duration of the Solwara 1 project. The preliminary economic assessment assumes the economic parameters listed in Table 22.1.

Table 22.1 Economic inputs

Parameter	Value	Unit
Copper price	7,319	US$/tonne
Gold price	1,200	US$/oz
Silver price	18.00	US$/oz
Copper payability	95%	% of copper recovered in concentrator
Gold payability	50%	% of gold contained in mineralised material
Silver payability	30%	% of silver contained in mineralised material
Foreign exchange rate	6.40	RMB = 1 US$
Royalty	2.25%	% of gross revenue, less smelter TC/RC
Community development fund	0.86	US$/dry tonne mineralised material mined
PNG corporate tax rate	30%	% of taxable income
Tax adjustment for exploration expenditure	25%	% of corporate tax payable to the value of the exploration expenditure
Depreciation	6.25%	% of the value of capital equipment per quarter

The production schedule on which the economic analysis is based is shown, on a quarterly basis, in Table 22.2. The Qualified Person cautions a Prefeasibility study has not been undertaken and that the tonnages and grades shown in the schedule are preliminary in nature and should not be interpreted as a Mineral Reserve. The schedule is based on mineral resources to which dilution and recovery factors have been applied. Approximately 58% of this material is Inferred Resource, which is a low category of geological confidence. Continuity of geology and grade has not been demonstrated for this material.

Table 22.2 Production quantities on which the economic analysis is based

	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Q3 2021	Q4 2021
Dewatering plant feed (dry kt)	28	120	170	230	280	310	290	290	280	200
Concentrator feed shipped (wet kt)	31	130	180	250	300	330	320	310	300	200
Concentrator feed delivered (dry kt)	28	120	170	230	280	300	290	280	270	190
Cu grade mined (%)	8.5	7.0	6.8	6.7	5.5	8.0	8.5	7.7	4.7	5.2
Au grade mined (g/t)	6.6	4.9	4.3	5.0	4.2	6.1	6.3	6.0	4.1	4.2
Ag grade mined (g/t)	42	24	21	24	19	32	31	28	24	21
Cu recovery (%)	95	93	93	93	91	95	95	94	89	90
LCT discount (%)	7.0	7.0	2.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Payable copper (t)	2000	6,800	9,900	13,000	13,000	21,000	22,000	19,000	11,000	8,600
Payable gold (oz)	2,900	9,400	12,000	18,000	19,000	30,000	29,000	27,000	18,000	13,000
Payable silver (oz)	11,000	28,000	33,000	53,000	50,000	93,000	85,000	75,000	62,000	40,000

22.2 Metal prices and payability

AMC's economic modelling indicates that copper contributes 80% of the Project value, gold 19%, and silver 1%. The copper price used in the preliminary economic assessment is US$7,319 per tonne. It is based on the results of a price forecast provided to Nautilus by specialist consultants CRU International Limited. CRU forecast a deficit in copper supply increasing in magnitude over the period 2019-2021, and the forecast copper price increases over that period. AMC has used an average of the forecast copper prices that are contemporary with the planned Solwara production.

The Qualified Person considers the metal prices are reasonable for the purpose of preliminary economic assessment of Solwara 1. The spot metal prices on the effective date (1 January 2018) were US$7,250 per tonne, US$1,304 per ounce, and US$17.01 per ounce for copper, gold and silver respectively. The metal prices used in the preliminary economic assessment are not materially different to the spot prices on the effective date.

The metal payability factors used are as agreed in the Ore Sales and Processing Agreement between Nautilus and the off-taker, Tongling Nonferrous Metals Group Co., Ltd. A payability discount (in the off-taker's favour) called the Locked Cycle Test (LCT) Discount, is applied to the calculation of payable copper. This factor represents lower recoveries during the start-up phase of a concentrator, as well as the industry standard practice of discounting laboratory results to represent the likely performance of a full-scale plant. Whenever the copper head grade is over 3% Cu (which it is scheduled to always be) the discount is 7% during a defined ramp-up period (the first three months or first 175,000 tonnes, whichever is sooner), and 1.5% thereafter.

22.3 Tax

The economic assessment is on a post-tax basis. Royalty, Community Development Fund payments, corporate tax and adjustments for tax relief for off-licence exploration expenditure have been estimated. Taxpayers like Nautilus that have incurred exploration expenditure outside the area of their productive project can elect to add such exploration expenditure to a pool that can be amortised against income. For mining projects, the amount allowable as a deduction from this exploration pool is the lesser of 25% of the un-deducted pool balance, and an amount as reduces the corporate tax payable by 25%.

In undertaking this economic assessment AMC has relied on Nautilus's estimates of tax losses brought forward, the exploration pool losses brought forward, and the cumulative capital investment for calculation of depreciation. AMC has not verified these estimates but notes the tax losses brought forward are consistent with Nautilus's audited financial reports.

The financial modelling indicates that the Solwara 1 project will contribute over US$100 million in taxes and royalties, payable to the government of PNG.

The preliminary economic assessment includes consideration of cash flows for capital-backed bank guarantees that Nautilus is obliged to provide in respect of the minerals processing concentrator and the production support vessel to Tongling and the vessel charterer respectively.

22.4 Results

The undiscounted cashflows from 1 January 2018 until planned closure of Solwara 1 (Q2 2022) are shown in Table 22.3 and Table 22.4. All cash flows are denominated in US dollars. The analysis excludes capital sunk prior to 1 January 2018 (detailed in Item 21), and excludes any residual value of the mining equipment, and excludes the value of the intellectual property that Nautilus will accrue during operation of Solwara 1.

The analysis indicates a positive economic outcome. Undiscounted post-tax cash flow of US$179 million is expected. An internal rate of return of 28% has been modelled. Discounted cash flow analysis, discounting at 15% per annum, indicates a project net present value of US$56 million.

The Qualified Persons caution that this PEA is preliminary in nature, that it includes inferred mineral resources that are considered too speculative geologically to have the economic considerations applied to them that would enable them to be categorized as mineral reserves, and there is no certainty that the results presented in this PEA will be realized. A prefeasibility study has not been undertaken. Mineral resources are not mineral reserves and do not have demonstrated economic viability.

Table 22.3 Summary cashflow from 1 Jan 2018 to closure of Solwara 1

Cash Flow (US$ million)	Total	Q1 2018	Q2 2018	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022
Gross Cu revenue	924.0	–	–	–	–	–	–	14.5	50.1	72.4	96.0	95.4	155.9	158.8	140.4	77.4	63.0	–	–
Gross Au revenue	213.2	–	–	–	–	–	–	3.5	11.3	14.0	21.9	22.3	35.7	35.1	32.4	21.3	15.9	–	–
Gross Ag revenue	9.6	–	–	–	–	–	–	0.2	0.5	0.6	1.0	0.9	1.7	1.5	1.4	1.1	0.7	–	–
Total gross revenue	1,147	–	–	–	–	–	–	18.3	61.9	87.0	118.8	118.5	193.3	195.4	174.2	99.8	79.6	–	–
TC/RC	-87	–	–	–	–	–	–	-1.4	-4.7	-6.8	-9.0	-8.9	-14.6	-14.9	-13.2	-7.3	-5.9	–	–
Net smelter return	1,060.1	–	–	–	–	–	–	16.9	57.2	80.2	109.8	109.6	178.6	180.5	161.0	92.5	73.7	–	–
Shipping	-44.2	–	–	–	–	–	–	-0.6	-2.4	-3.5	-4.6	-5.7	-6.2	-5.9	-5.8	-5.6	-4.0	–	–
Concentrator charges	-61.0	–	–	–	–	–	–	-0.8	-3.3	-4.7	-6.3	-7.8	-8.5	-8.2	-8.0	-7.7	-5.6	–	–
Other payments	-33.1	–	–	–	–	–	–	-3.1	-3.1	-3.2	-3.3	-3.4	-3.5	-3.5	-3.4	-3.4	-3.2	–	–
Net revenue	921.8	–	–	–	–	–	–	12.5	48.3	68.8	95.6	92.7	160.5	162.9	143.7	75.8	60.9	–	–
Net revenue (w/ working capital adjustment)	921.8	–	–	–	–	–	–	10.4	42.0	64.2	90.3	92.3	149.5	160.1	146.7	87.5	65.5	13.3	–
Production support vessel	-216.4	–	–	–	–	–	–	-17.7	-21.5	-22.7	-22.7	-22.2	-22.5	-22.7	-22.7	-22.2	-19.3	–	–
Logistics, supplies, spares	-80.2	–	–	–	–	–	–	-4.6	-7.1	-8.7	-8.7	-8.8	-8.7	-8.7	-8.7	-8.8	-7.4	–	–
Other labour	-62.3	–	–	–	–	–	–	-4.7	-6.6	-6.5	-6.1	-6.5	-6.8	-6.9	-6.9	-6.2	-5.2	–	–
Travel, general expenses	-9.5	–	–	–	–	–	–	-1.1	-0.8	-0.8	-0.8	-1.4	-0.8	-0.8	-0.8	-1.4	-0.7	–	–
Environmental, community	-4.1	–	–	–	–	–	–	-0.4	-0.3	-0.4	-0.4	-0.5	-0.4	-0.4	-0.5	-0.5	-0.3	–	–
Closure	-4.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	-2.2	–	–
Opex (w/ working capital adjustment)	-377.0	–	–	–	–	–	–	-19.1	-30.4	-36.3	-38.1	-39.0	-38.9	-39.3	-39.7	-39.3	-36.2	–	–
EBITDA	544.8	–	–	–	–	–	–	-8.7	11.3	28.1	52.5	53.2	110.4	121.1	107.1	48.0	28.8	-4.8	-2.2

Table 22.4 Summary of capital expenditure, taxation, and net cash flows for Solwara 1

Cash Flow (US$ million)	Total	Q1 2018	Q2 2018	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Q3 2019	Q4 2019	Q1 2020	Q2 2020	Q3 2020	Q4 2020	Q1 2021	Q2 2021	Q3 2021	Q4 2021	Q1 2022	Q2 2022
Seafloor production equipment	-51.7	-8.5	-2.8	-3.2	-10.4	-4.2	-16.1	-5.5	-1.1	–	–	–	–	–	–	–	–	–	–
Riser and lifting system	-55.8	-9.3	-5.1	-8.1	-8.3	-7.1	-9.4	-2.8	-5.6	–	–	–	–	–	–	–	–	–	–
Dewatering plant	-36.1	-2.3	-1.7	-3.9	-15.1	-3.8	-8.5	-0.8	0.0	–	–	–	–	–	–	–	–	–	–
Production support vessel mobilisation	-22.7	-0.3	-0.6	-0.9	-1.2	-1.8	-2.0	-11.8	-4.0	–	–	–	–	–	–	–	–	–	–
Production support vessel integration	-62.5	-1.1	-4.8	-4.0	-2.1	-8.8	-22.8	-36.1	17.2	–	–	–	–	–	–	–	–	–	–
Mineralised material processing	-15.3	-0.1	-0.1	-5.7	-3.0	-2.9	-3.1	-0.5	0.0	–	–	–	–	–	–	–	–	–	–
Project services	-14.7	-0.5	-1.4	-1.7	-2.0	-1.8	-1.5	-1.8	-4.1	–	–	–	–	–	–	–	–	–	–
Owners costs	-3.7	-0.2	-0.1	-0.3	-0.3	-0.1	-0.7	-0.5	-1.4	–	–	–	–	–	–	–	–	–	–
Total capital expenditure	-262.6	-22.3	-16.6	-27.7	-42.3	-30.4	-64.2	-59.8	0.9	–	–	–	–	–	–	–	–	–	–
Cumulative capital investment	–	12.8	35.1	51.8	79.5	121.8	152.2	216.4	259.0	242.0	226.8	212.7	199.4	186.9	175.2	164.3	154.0	144.4	144.4
Additional capital investment	262.6	22.3	16.6	27.7	42.3	30.4	64.2	59.8	-0.9	–	–	–	–	–	–	–	–	–	–
Depreciation	-131.0	–	–	–	–	–	–	-17.3	-16.1	-15.1	-14.2	-13.3	-12.5	-11.7	-11.0	-10.3	-9.6	–	–
Taxable Income	413.9	–	–	–	–	–	–	-25.9	-4.8	13.0	38.3	39.9	97.9	109.4	96.2	37.7	19.2	-4.8	-2.2
Tax Loss brought forward	–	-78.3	-78.3	-78.3	-78.3	-78.3	-78.3	-78.3	-104.2	-109.1	-96.1	-57.8	-17.8	–	–	–	–	–	-4.8
Loss generated	-37.7	–	–	–	–	–	–	-25.9	-4.8	–	–	–	–	–	–	–	–	-4.8	-2.2
Loss utilised	109.1	–	–	–	–	–	–	–	–	13.0	38.3	39.9	17.8	–	–	–	–	–	–
Taxable Income after loss brought forward	342.5	–	–	–	–	–	–	–	–	–	–	–	80.1	109.4	96.2	37.7	19.2	–	–
Income tax payable before adjustment	102.8	–	–	–	–	–	–	–	–	–	–	–	24.0	32.8	28.8	11.3	5.8	–	–
Exploration pool loss brought forward	–	124.5	124.5	124.5	124.5	124.5	124.5	124.5	124.5	124.5	124.5	124.5	124.5	118.5	110.3	103.1	100.3	98.8	98.8
Exploration pool loss utilised	-25.7	–	–	–	–	–	–	–	–	–	–	–	-6.0	-8.2	-7.2	-2.8	-1.4	–	–
Income tax payable after exploration pool	77.1	–	–	–	–	–	–	–	–	–	–	–	18.0	24.6	21.6	8.5	4.3	–	–
Royalty	23.9	–	–	–	–	–	–	0.4	1.3	1.8	2.5	2.5	4.0	4.1	3.6	2.1	1.7	–	–
Community Development Fund payable	1.9	–	–	–	–	–	–	–	0.1	0.1	0.2	0.2	0.3	0.3	0.2	0.2	0.2	–	–
Total taxes and royalties	-102.8	–	–	–	–	–	–	-0.4	-1.4	-2.0	-2.7	-2.7	-22.3	-28.9	-25.5	-10.8	-6.2	–	–
Charterer's bank guarantee	–	–	–	–	–	–	-18.0	–	–	–	–	–	–	–	–	–	–	–	18.0
Tongling bank guarantee	–	–	-5.6	–	-2.8	-2.8	-2.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	–	–	–	–
Net cash flow	179	-22.3	-22.2	-27.7	-45.1	-33.2	-85.0	-67.2	12.5	27.9	51.6	52.3	89.8	93.9	83.4	37.2	22.7	-4.8	15.8

22.5 Sensitivity analysis

The sensitivity of project economics to metal price was tested by using copper and gold prices based on forward pricing curves (sourced from Bloomberg as at 5 January 2018, via Jefferies Investment Banking publication: *Base Metals Landscape, Weekly Industry Update*).

A copper price of US$7,981 per tonne, and a gold price of US$1,391 per ounce, which are the averages indicated by forward price curves for the duration of the Solwara 1 project, were used as inputs to the economic model. These prices are approximately 10% higher than the inputs described in Item 22.2. Price decreases by the same factor were also modelled. The results (post-tax) of the economic sensitivity analysis are shown in Table 22.5.

Table 22.5 Economic sensitivity analysis

	-10% to copper and gold price	Central case (US$7,319 /t Cu)	Forward price curves
Net undiscounted cash flow (US$ million)	94	179	268
Net present value discounted at 15% (US$ million)	0	56	115
Internal rate of return	15%	28%	40%

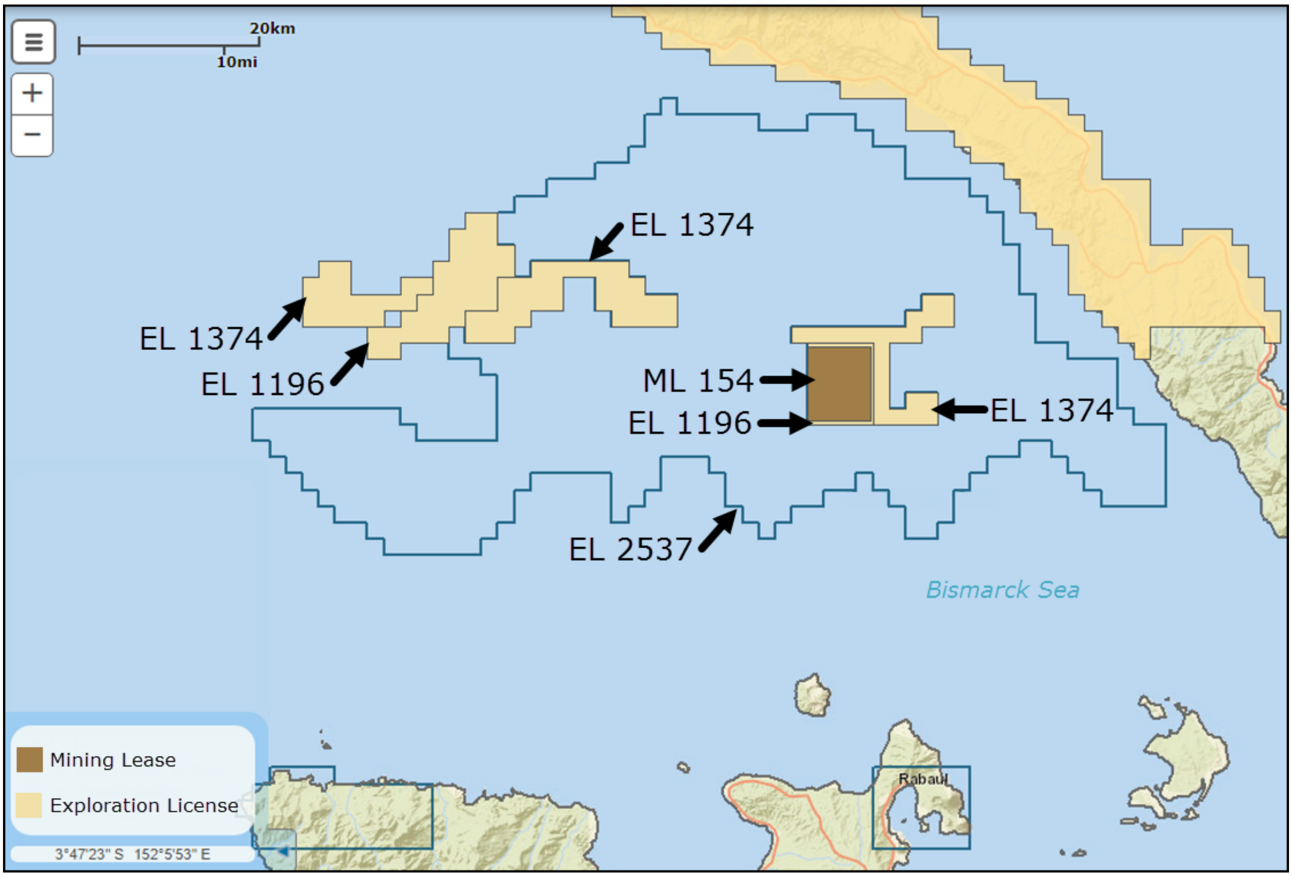
23 Adjacent Properties

There is no additional information in respect of the adjacent properties in the context of Nautilus's Bismarck Sea Property that is material to the information in this Technical Report. The following text clarifies the tenement situation of Solwara 1:

ML 154 is surrounded by EL 1196, EL 1374 and EL 2537, which are held 100% by Nautilus Minerals Niugini Limited or Nautilus Minerals Niugini 3 Limited (Figure 23.1).

EL 1374 consists of three non-contiguous areas, part of the centremost area of which is overlain by MLA 512, which covers the Solwara 12 deposit (Figure 4.3). In 2016, Nautilus applied to vary further relinquishment requirements for EL 1374.[24] As of November 2017, MRA has not confirmed the status of this application.

Figure 23.1 Properties adjacent to EL 1196 and ML 154



[24] Nautilus Minerals Niugini Ltd (2016). EL 1374 Annual and Renewal Report. p.4

24 Other Relevant Data and Information

Mining of seafloor Mineral Resources from ocean depths comparable to Solwara 1 has not yet been demonstrated at commercial scale. However, commercial seafloor mining of diamonds off the coast of Namibia has been carried out in shallower waters since 1961.

Debmarine Namibia Pty Ltd, a 50/50 joint venture between the Namibian government and De Beers Centenary AG, mines diamondiferous gravels at ocean depths up to 150 m using a 280 tonne track-mounted crawler. The crawler has a cutting head with multiple steel picks at the end of a sloughing arm, much like the collection machine constructed for Solwara 1. The crawler is connected to a floating production vessel via an umbilical for power and communications as well as a 165-metre rubber hose, through which 10,000 m^3/hr of gravel and seawater are pumped prior to further mineral processing on the vessel.

Although Solwara 1 is an order of magnitude deeper than the Namibian diamond mining operations, the Debmarine operations are conceptually similar to the proposed Solwara 1 Project and demonstrate that terrestrial technology and methods can be successfully adapted to the marine environment.

25 Interpretation and Conclusions

AMC has conducted a Preliminary Economic Assessment of the Solwara 1 Project using the available study reports, information about the production systems under construction, and on-going mine planning work by Nautilus. The PEA and associated studies indicate that:

- The data acquired during 2006, 2007, 2008, 2010 and 2011 has provided the basis for a reasonable interpretation of the geology of the Solwara 1 deposit from which the continuity of massive sulfide mineralisation can be reasonably assumed or inferred.
- The geology has been modelled and Mineral Resources estimated using appropriate industry practices in accordance with Canadian National Instrument 43-101. The data and methods are adequate to support estimates of 1.0 Mt of Indicated Mineral Resource at 7.2% Cu, 5.0 g/t Au, 23 g/t Ag. And 1.5 Mt of Inferred Mineral Resources at 8.1% Cu, 6.4 g/t Au and 34 g/t Ag.
- Solwara 1 shows very similar mineralogical features to terrestrial volcanic hosted massive sulphide deposits (VHMS). Metallurgical sampling and testwork indicate that industry-standard practice for the treatment of VHMS deposits is likely to be appropriate for Solwara 1.
- A novel method of mining using sea-floor mining tools has been designed. Whilst there are no exactly analogous precedents for mining at Solwara 1, the proposed methods draw from a range of existing technologies and are assembled in a logical manner with reasonable prospects of effective operation.
- A mine plan has been developed using both the Indicated and the Inferred Mineral Resources. Inferred Mineral Resources have a low level of confidence and, therefore, the mine plan is only conceptual and there are no Mineral Reserve estimates.
- Seafloor mining operations will be supported by a single production support vessel which will dewater the product before loading into Handymax-size vessels for transport to customers (smelters)
- The environmental impact of the proposed operation is expected to be small, with no significant impact on the marine environment, coastal communities or traditional fishing activities.
- Costs and revenues have been estimated using reasonable assumptions, supported by contracted expenditure on fabrication of production equipment, and a contracted off-take agreement.
- The project is expected to have a positive economic outcome at the estimated costs and revenues.
- The potential viability of the Mineral Resources has not yet been supported by a pre-feasibility study or a feasibility study. Prefeasibility study would require more drilling to convert the Inferred Mineral Resource to Indicated category, and trial mining with an expected order of magnitude cost in excess of US$50 million, and would delay the Project schedule by 6-9 months.

Nautilus has identified, and the PEA has confirmed, several risks to the successful realisation of the Project and some opportunities. These include:

Resource estimate:

- Several drillholes at Solwara 1 ended in massive sulfide material. In such instances, and where no adjacent drillhole information was available from which the true thickness could be reasonably interpreted, the base of the drillhole was interpreted to be the base of the massive sulfides. The massive sulfide resource is therefore open at depth in some areas and the interpretation is conservative in this regard.
- There remains potential for the discovery of additional resources in feeder zones extending down the main hydrothermal pathways or in buried (stacked) lenses.
- Drillhole intercepts in the unconsolidated sediment at Solwara 1 suggested that this domain contains some material above cut-off grade. Although this is probably in the form of chimney rubble or interstitial sulfide precipitation, this material has been excluded from the resource estimate for Solwara 1 but some might eventually be recoverable.
- Few drillholes were located on the exposed chimney mounds due to difficulty in landing on these structures. Consequently, the block grade estimates for interpreted massive sulfide material below these mounds is based on holes drilled adjacent to these mounds. It is possible that the massive sulfide material beneath the chimney mounds may have a different mineralogical composition being closer to the interpreted mineralising fluid source.
- Core loss in the massive sulfide domain could result in estimation bias if the core loss was preferentially related to low or high-grade material. Close-spaced (<5 m) drilling for metallurgical and geotechnical samples suggests that the probability of such preferential core loss is low.

- A proportion of the Inferred Resource relies on the EM anomaly in areas that have not been tested by drilling. Furthermore, it is not possible to determine the thickness of the conductive sulfide material from the EM data, thus, the interpreted extent and thickness of massive sulfide in areas distant to drilling is of low confidence.
- The higher-grade chimney mounds have only been sampled by breaking off protruding chimney pieces. The interpreted depth of the chimney mounds is based on an automated algorithm that produces a model of the seafloor from which the chimneys have been truncated. This model is considered geologically reasonable but until these mounds are tested by drilling, their grade, density and depth should be considered to be of low confidence. If the chimney mound/massive sulfide interface is not correctly positioned then the risk to the contained metal is considered to be low to moderate as the higher grade/lower density chimney material would most likely be substituted by lower grade/higher density massive sulfide material.

Mining

- There is no redundancy in the mining fleet. All the seafloor production equipment is required to function as planned for the duration of the Project. Loss or catastrophic failure of anyone of the seafloor production tools will materially affect Nautilus's ability to execute the production plan.
- The lack of structural data and related structural analyses means that slope stability is not well-characterised and is a risk to the seafloor mining activities.
- The blocky nature of the rock mass poses some risk to the operation. Large blocks dislodging from bench walls might damage the seafloor production tools, cause blockages, or interfere with accurate machine positioning and cutting. The mine plan correctly maximises the use of the continuous cutting mode for the bulk cutter which should minimise the impact of blocky ground
- The estimate of production rate ramp-up is based on engineering judgement and analysis by analogy. Deep-sea mining has not yet been attempted and there are no very close analogues to the proposed mining project. The actual production ramp-up might be slower and longer than expected, resulting in higher operating costs. Conversely, the ramp-up might be significantly better than has been allowed for in the schedule, and actual project duration might be less, resulting in significant reduction to the average production cost.
- The production plan requires that the seafloor production tools be operated and dynamically positioned within certain tolerances. The survey equipment and systems for Solwara 1 have not yet been finalised. There is existing technology, routinely used in the subsea oil and gas industries that might be adopted at Solwara 1. However, there are some practical issues to resolve and it is conceivable that maintaining constant accurate position control will not be achieved, and the production rate, and rates of mineralised material loss and dilution might vary from the plan.

Mineral processing

- There is some uncertainty regarding the abrasiveness of the Solwara 1 mineralised material. Consequently, there is some risk of abrasion of the proposed centrifuges which may impact maintenance costs due to low wear life.
- While there has been a significant sampling program undertaken by Nautilus, there remain parts of the deposit at depth that have had little metallurgical sampling and testing. However, the core logging to date did not identify any minerals or textures that would be expected to negatively affect recoveries

Environmental and social

- There are some potential near-surface impacts to pelagic animals due to lighting, underwater noise, routine discharges (in compliance with relevant maritime acts and regulations), and emissions to air. These impacts are expected to be similar to shipping generally and exploration surveys already completed by Nautilus.
- Geochemical changes in the mineralised material that could potentially result in increased leaching of soluble metals could occur during the mining and dewatering process, however, the dilution required to meet target water quality standards (ANZECC/ARMCANZ 2000) to 95% protection levels, is expected to occur within 85 m from the deep-sea discharge point.

- In rare circumstances, failure may occur in either the slurry lift pump, surface pump, dewatering screens, or the production support vessel power supply which may result in a dump of mineralised material from within the riser. Riser dumps have been addressed further in the EMP.
- Impacts on water quality may occur due to accidental hydraulic fluid leaks, fuel spills during transfers at the site of the production support vessel, spills during transfer to ships and bulk carriers and in extreme cases due to accidental collisions resulting in loss of vessels. These risks are expected to be similar to the risks of general shipping and exploration surveys already completed by Nautilus. It is noted that all hydraulic fluids used in subsea equipment are biodegradeable.
- The noise levels expected at Solwara 1 are consistent with levels emitted by offshore oil and gas installations and intercontinental trenching operations for subsea communication cables.
- There are potential negative social impacts such as migration of people from other parts of PNG to Rabaul and Kavieng seeking employment, disruption to fishing activities and other vessels operating in the vicinity of Solwara 1 and Project marine transport corridors, however, the EIS and EMP include extensive actions to mitigate these risks.
- There has been some negative sentiment towards the Project and there is a risk of social unrest from sections of civil society. Nautilus is actively monitoring community and NGO sentiment and implementing a strategic plan for corporate social responsibility in consultation with state, provincial and local level governments.

In the opinion of the Qualified Persons, it is reasonable to conclude that the risks associated with the proposed project can either be mitigated by measures proposed by Nautilus or can be addressed by further investigation and study.

This PEA indicates that the Solwara 1 project is potentially economically viable, however, due to the preliminary nature of some aspects of project planning, and the untested nature of the specific mining production systems at a commercial scale, economic viability has not yet been demonstrated.

26 Recommendations

26.1 Exploration and Mineral Resources

The work to date at Solwara 1 has demonstrated the presence of massive sulfide mineralisation and has been sufficient to define Indicated and Inferred Resources. There remains potential for the discovery of additional resources in feeder zones extending down the main hydrothermal pathways or in buried (stacked) lenses. On this basis and subject to further mine planning and economic evaluation, the qualified person is of the opinion that the following work is warranted:

- Infill drilling with the aim of converting Inferred Resources into Indicated Resources. Further work to improve core recovery is required.
- Deeper drilling in the areas in which the mineralisation remains open at depth, with the aim of identifying additional, deeper resources or improving confidence.
- If higher confidence and the definition of Measured Resources are required, further investigation of methods of geochemical analysis and re-assaying of sample pulps may be necessary to improve the accuracy and precision of the Ag and Zn analyses and estimates. However, it should be noted that these elements do not make a material contribution to the Project revenue.
- Regional exploration to identify further SMS targets beyond those already known, using autonomous underwater vehicle technology, ship based multibeam data acquisition, and drilling.
- Continued development of new technology for seafloor drilling and remote sensing to delineate SMS deposits at lower cost.

An appropriate budget for the above exploration programs in the Bismarck sea would be A$15 - A$20 million for the resource work, and up to A$20 million for the regional exploration work. The drill rig described in Item 10.1.4 could be used to undertake this recommended work.

26.2 Mineral processing

- Further metallurgical test work on samples from under-sampled areas at depth in the mineral deposit.
- Identify alternative sales and offtakers to manage the risk that current sales arrangements are for any reason no longer available (Force Majeure etc.)

26.3 Mining

The qualified person recommends that Nautilus continue project development. This entails:

- Completion of fabrication of all incomplete capital items
- Finalisation of the subsea equipment survey positioning methodology
- Finalisation of the pinnacle grabbing technology
- Completion of submerged trials of all seafloor production equipment
- Analysis of submerged trials results and modification of any item that does not perform to specification prior to deployment at sea.
- Should there be any significant delay in the Project schedule that would allow the early deployment of the auxiliary cutter to Solwara 1 for a three-to-six-month period, carry out a trial mining program. This would demonstrate that estimates for productivity, operability and maintainability of the seafloor production tools are correct, and validate certain assumptions with respect to the mineral resource.

The budget for the fabrication of incomplete capital items is approximately US$70 million, while an appropriate budget for the modification of equipment following submerghed trials is around US$5 million. An indicative budget for a 3-6 month trial mining campaign wold be US$30-50 million.

26.4 Environmental

Sufficient information has been collected to predict environmental impacts associated with the Project. The most recent data collected was during 2016, and the Project EMPs have been prepared with input from various PNG government agencies. The qualified person considers that the following work is warranted:

- Work with CEPA to ensure that an independent review is carried out for the EMPs submitted in late 2017. Thereafter make any modifications required to ensure that the EMPs are approved for use by CEPA at least three months prior to operations commencing at Solwara 1.
- Adhere to the monitoring requirements of the EMP to ensure that all commitments of the EMP and conditions of the environment permit are met.

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Appendix A
Mining Lease 154

PAPUA NEW GUINEA
MINERAL RESOURCES AUTHORITY

OFFICE OF THE REGISTRAR OF MINERAL TENEMENTS

NEW GRANT

MINING LEASE 154

HOLDER

MAC NO: 3A/2010

Nautilus Minerals Niugini Limited
P O Box 1161
PORT MORESBY
Papua New Guinea

ITEM NO: 03

INDEPENDENT STATE OF PAPUA NEW GUINEA
Mining Act 1992
Mining Regulation 1992

Act, Sec.38,46
Reg. Sec 3

FORM 4

MINING LEASE

I, **Hon. John Pundari, MP, Minister for Mining** by virtue of the powers conferred by the **Mining Act 1992 (the "Act"),** and all powers me enabling **GRANT** to **Nautilus Minerals Niugini Limited,** a company incorporated in the Independent State of Papua New Guinea **(the "State")** with its registered office at **Level 1 Deloitte Tower, Douglas Street, Port Moresby, Papua New Guinea, Mining Lease No. 154 (the "Lease")** over land situated **within the Bismarck Sea, New Ireland Province** and more particularly described in Schedule 1 attached hereto, as may be varied from time to time, but not including any portion of land comprising an existing tenement, except a mining easement for which the land has not been exercised, for term of **twenty (20) years** from this date and such extensions of the term as may be endorsed hereon for the purpose of mining minerals in accordance with the Act and subject to the following conditions:-

1. That the Lessee shall comply with the provisions of the Mining (Safety) Act.
2. That the Lessee shall comply with the Mining Act 1992.
3. That the Lessee shall comply with the Environment Act 2000 and any specific terms of an environmental permit thereby issued,
4. The Lessee shall provide the Mineral Resources Authority with a Closure Plan and Schedule, at least one year prior to the commencement of commercial operations, notwithstanding parameters that justify premature closure of operations.
5. The Lessee shall submit the mining plan, to the Chief Inspector of Mines, twelve (12) months prior to the commencement of mining operations.
6. The Lessee shall submit to the Chief Inspector of Mines all mine plant plans and details, for the mine construction phase and thereafter.
7. The Lessee shall comply with the **'approved proposal'** described in the Schedule 2 attached hereto, as may be varied from time to time.

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8. The Lessee shall, in good faith, ensure that the seafloor mining equipment, riser and pump, dewatering plant, boat etc. are manufactured, integrated and successfully commissioned on the lease within thirty six (36) months of the date of grant of this lease, and, the 'Director' is thereafter forthwith informed in writing of the date of successful commissioning.

9. The negotiations on the benefit sharing 'Memorandum of Agreement' (MOA) shall progress in good faithful. The Lessee shall pay into trust to the State, any and financial benefits that become due in the interim pending finalization of the said MOA.

10. Within twelve (12) months of informing the 'Director' of successful commissioning as per Condition 8 above, the Lessee shall, in good faith, investigate the viability of constructing and commissioning a processing plant onshore within the State of Papua New Guinea and will advise the 'Director' accordingly.

11. A technical team determined by the Director of the Mining Act shall be established at the time of grant to work in close collaboration and good faith with the Lessee in the design, construction, and commissioning of mining equipment and related mining, processing and monitoring management so as to ensure compliance with the Laws of PNG.

Dated at PORT MORESBY this 13th **day of** January **2011.**

HON. JOHN PUNDARI, MP
Minister for Mining

3

Endorsement for Extensions of Term

Period Extended (years)	**Signature** (Minister for Mining)	**Date**
....	....	....
....	....	....

Accompanying schedules
Schedule 1. Description of boundary

(Registrar's endorsement see Note 1)

Schedule 2. Proposals

To be used for the grant of a Mining Lease under Section 38 of the Act and the extension of term of a Mining Lease under Section 46 of the Act.

NOTE 1: Where land is surrendered under Section 138 of the Act the registrar is required to endorse this document under Section 139 of the Act to the effect that such a relinquishment has taken place and that the original schedule is suspended.

4

SCHEDULE 1

TO ACCOMPANY GRANT DOCUMENT FOR ML 154

The area of land over which the tenement has been applied for is bounded by:

a line starting at	3° 45' 15.618" S	152° 7' 52.296" E
then to	3° 45' 15.282" S	152° 4' 0.966" E
then to	3° 49' 45.042" S	152° 4' 0.648" E
then to	3° 49' 45.156" S	152° 7' 52.188" E
then to	3° 45' 15.618" S	152° 7' 52.296" E

being the point of commencement, comprising an area of 59.115 sq km.

NOTES:

1. Coordinates must be in latitude and longitude and, except for an application for an exploration licence, applicants must state whether description of coordinates is taken from an authorized survey or estimated from a map.

2. If the coordinates have been taken from a survey, the name, number and date of survey or such information as will allow the survey to be correctly identified must be provided.

3. Descriptions other than surveys or amended schedules under Section 97 are to be signed by the applicant. Surveys and amended schedules are to be signed by the registered surveyor and Registrar respectively.

To be used for the describing the boundary of an area of land under Sections 24, 35, 42, 52, 70, 85, 97, 135 and 138 of the Act.

SCHEDULE 2

APPROVAL OF THE PROPOSALS FOR MINING LEASE NO.154

I, **Hon. John Pundari, MP, Minister for Mining** by virtue of the powers vested in me under Section 43 of the Mining Act 1992 and having considered the recommendations of the Mining Advisory Council relating to the application for a Mining Lease (ML) 154 and the accompanying Proposal for Development, hereby approve the proposals on the following terms:

1. That the Lessee, their agents, successors and assigns, including any additional joint ventures shall comply with the Proposals for Development described in the Solwara 1 Feasibility Study Phase 1 dated 18th September 2008 and the Revised Proposal for a three separate mining equipment described in the letter (Re: Solwara 1 Project Description) dated 18th June 2010.

   The Lessee shall also comply with the Conceptual Mine Closure Plan also described in the Solwara 1 Feasibility Study Phase 1;

2. That the Lessee, their agents, successors and assigns including any additional joint ventures shall comply with the terms and conditions of the Mining Lease and such other additional or ancillary tenements in respect of the proposed project;

3. That the Lessee, their agents, successors and assigns including any additional joint ventures shall comply with their obligations under the Memorandum of Agreement to be executed between the State, New Ireland Provincial Government, East New Britain Provincial Government and the relevant Local Level Governments; and

4. That the Lessee, their agents, successors and assigns including any additional joint ventures shall comply with such other approvals including statutory approvals given or to be given by appropriate authorities and form part of the approved proposals for development.

Dated at Port Moresby this 13th **day of** ~~February~~ January **2011.**

Hon. John Pundari, MP
Minister for Mining

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Date

The effective date of this Technical Report is 1 January 2018.

Signature

AMC Consultants Pty Ltd

Ian Lipton
Principal Geologist
ITL

Dated: 27 February 2018

Appendix B

Certificate of Qualified Persons

Ian Lipton
AMC Consultants Pty. Ltd.
179 Turbot Street, Brisbane, Queensland, 4060, Australia
Tel: +61-7-3230-9000
Email: ilipton@amcconsultants.com

CERTIFICATE OF QUALIFIED PERSON

To accompany the report entitled "Preliminary Economic Assessment of the Solwara Project, Bismarck Sea, PNG", dated 27 February 2018.

I, Ian Thomas Lipton, do hereby certify that:

I am a graduate from the University of Birmingham, UK, with a BSc (Hons) Geological Sciences in 1981.

I have continually practiced my profession since my graduation from university in 1981.

I am a Fellow of the Australasian Institute of Mining and Metallurgy and a Fellow of the Australian Institute of Geoscientists.

I have been a Principal Geologist with AMC Consultants Pty Ltd since January 2014. AMC Consultants is a firm of consulting geologists and engineers which has been practicing in this profession since 1980. I hold office at 179 Turbot Street, Brisbane, Queensland, 4060, Australia.

I have 36 years mining industry experience, including mine geology and exploration roles and I have worked as a resource geologist since 1988.

I have read the definition of “qualified person” as set out in National Instrument 43-101 (“NI 43-101”) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a qualified person for the purpose of NI 43-101.

I visited the Solwara 1 property between 10 – 24 June 2007, 22 – 29 July 2007, 5 – 12 September 2007, 25 -26 November 2010 and 1-5 February 2011.

I confirm that, as of the date of this Certificate, to the best of my knowledge, information and belief, this report contains all scientific and technical information that is required to be disclosed to make this report not misleading.

Neither I, nor any affiliated entity of mine is at present, or under an agreement, arrangement or understanding expects to become, an insider, associate, affiliated entity or employee of Nautilus Minerals Inc., and/or any associated or affiliated entities.

Neither I nor any affiliated persons or entity of mine, own, directly or indirectly, nor expect to receive, any interest in the properties or securities of Nautilus Minerals Inc., or any associated or affiliated companies.

I am independent of Nautilus Minerals Inc. in accordance with the application of Definition 1.5 of NI 43-101.

My prior involvement with the subject of this report is limited to the preparation of the 2008 Mineral Resource Estimate Solwara 1 Project Bismarck Sea Papua New Guinea and the 2012 Mineral Resource Estimate, Solwara Project, Bismarck Sea, PNG, commissioned by Nautilus Minerals Inc. and periodic review of the Solwara 1 project in the role of Independent Engineer on behalf of a project financier.

I have read NI 43-101 and Form 43-101F1 and have prepared this report in compliance with that instrument and form.

I am responsible for Items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14 (other than Item 14.1), 20, 23, 24, 25, 26 and 27 of this Technical Report.

I consent to the filing of this report with the relevant securities commission, any stock exchange and other regulatory authorities as may be determined, including general publication in hardcopy and electronic formats in company files or websites to shareholders and to the public.

Dated 27 February 2018

I T Lipton

Ian Thomas Lipton

Edward Gleeson
AMC Consultants Pty. Ltd.
179 Turbot Street, Brisbane, Queensland, 4060, Australia
Tel: +61-7-3230-9000
Email: egleeson@amcconsultants.com

CERTIFICATE OF QUALIFIED PERSON

To accompany the report entitled "Preliminary Economic Assessment of the Solwara Project, Bismarck Sea, PNG", dated 27 February 2018.

I, Edward Vincent Gleeson, do hereby certify that:

I am a graduate from the University of NSW, Australia, with a BEng Mining Engineering in 1996.

I have continually practiced my profession since my graduation from university in 1996.

I am a Member of the Australasian Institute of Mining and Metallurgy and am a Chartered Professional of that body. I am a Registered Professional Engineer of Queensland.

I have been a Principal Mining Engineer with AMC Consultants Pty Ltd since November 2007. AMC Consultants is a firm of consulting geologists and engineers which has been practicing in this profession since 1980. I hold office at Level 17, 30 Raffles Place, Singapore 048622.

I have 21 years mining industry experience, including mine design, cost estimation, and mining project evaluation roles.

I have read the definition of “qualified person” as set out in National Instrument 43-101 (“NI 43-101”) and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a qualified person for the purpose of NI 43-101.

I have not visited the Solwara 1 property.

I confirm that, as of the date of this Certificate, to the best of my knowledge, information and belief, this report contains all scientific and technical information that is required to be disclosed to make this report not misleading.

Neither I, nor any affiliated entity of mine is at present, or under an agreement, arrangement or understanding expects to become, an insider, associate, affiliated entity or employee of Nautilus Minerals Inc., and/or any associated or affiliated entities.

Neither I nor any affiliated persons or entity of mine, own, directly or indirectly, nor expect to receive, any interest in the properties or securities of Nautilus Minerals Inc., or any associated or affiliated companies.

I am independent of Nautilus Minerals Inc. in accordance with the application of Definition 1.5 of NI 43-101.

My prior involvement with the subject of this report is limited to periodic review of the Solwara 1 project in the role of Independent Engineer on behalf of a project financier, and independent third-party review of mine planning of the Solwara 1 project on behalf of the Project owner.

I have read NI 43-101 and Form 43-101F1 and have prepared this report in compliance with that instrument and form.

I am responsible for Items 14.1, 15, 16, 17 (seafloor production systems), 18, 21, and 22 of this Technical Report.

I consent to the filing of this report with the relevant securities commission, any stock exchange and other regulatory authorities as may be determined, including general publication in hardcopy and electronic formats in company files or websites to shareholders and to the public.

Dated 27 February 2018

Edward Vincent Gleeson

Peter Munro
Mineralurgy Pty Ltd
42 Morrow Street, Taringa, Queensland, 4068, Australia
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CERTIFICATE OF QUALIFIED PERSON

To accompany the report entitled "Preliminary Economic Assessment of the Solwara Project, Bismarck Sea, PNG", dated 27 February 2018.

I, Peter Munro, do hereby certify that:

I am a graduate from the University of Adelaide, with a BAppSc in Applied Chemistry in 1970. In addition, I have obtained a BEcon degree in 1975 and a BComm degree in 1979 from the University of Queensland.

I have continually practiced my profession since my graduation from university in 1970.

I am a Fellow of The Australasian Institute of Mining and Metallurgy; Member of The Institution of Engineers, Australia; Member of the Institution of Materials, Minerals and Mining (U.K.); Member of the Society of Mining, Metallurgy and Exploration (USA); Member of the Canadian Institute of Mining, Metallurgy and Petroleum and Member of the Southern African Institute of Mining and Metallurgy.

I am a Senior Principal Consulting Engineer with Mineralurgy Pty Ltd, a firm of consultants to the mining, metallurgical and process industries which has been practicing in this profession since 2000. I hold office at Unit 2, 42 Morrow Street, Taringa, Queensland, 4068, Australia.

I have worked as a metallurgist for a total of 40 years since graduation, predominantly in base metals and gold mineral processing operations, process development and project development.

I have read the definition of "qualified person" as set out in National Instrument 43-101 ("NI 43-101") and certify that by reason of my education, affiliation with a professional association (as defined in NI 43-101) and past relevant work experience, I fulfil the requirements to be a qualified person for the purpose of NI 43-101.

I have not completed a site visit as it was not required given the nature of the site (on the seafloor).

I confirm that, as of the date of this Certificate, to the best of my knowledge, information and belief, this report contains all scientific and technical information that is required to be disclosed to make this report not misleading.

Neither I, nor any affiliated entity of mine is at present, or under an agreement, arrangement or understanding expects to become, an insider, associate, affiliated entity or employee of Nautilus Minerals Inc., and/or any associated or affiliated entities.

Neither I nor any affiliated persons or entity of mine, own, directly or indirectly, nor expect to receive, any interest in the properties or securities of Nautilus Minerals Inc., or any associated or affiliated companies.

I am independent of Nautilus Minerals Inc. in accordance with the application of Definition 1.5 of NI 43-101.

I have been involved in directing metallurgical test work on materials Solwara 1, prior to the commissioning of this report by Nautilus Minerals Inc.

I have read NI 43-101 and Form 43-101F1 and have prepared the part of this report for which I am responsible in compliance with that instrument and form.

I am responsible for Item 13, 17 (dewatering), and 19 of this report.

I consent to the filing of this report with the relevant securities commission, any stock exchange and other regulatory authorities as may be determined, including general publication in hardcopy and electronic formats in company files or websites to shareholders and to the public.

Dated 27 February 2018

Peter Munro

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