Attachment 3a: **Siecap Taranaki VTM Project Pre-Feasibility Study Offshore Iron Sands Project 25 March 2025 - Part1**

TARANAKI VTM PROJECT
PRE-FEASIBILITY STUDY
OFFSHORE IRON SANDS PROJECT

Issued: 25 March 2025

Disclaimer

This updated Pre-Feasibility Study (PFS) has been prepared by Siecap NZ in collaboration with Trans-Tasman Resources Ltd and Manuka Resources Ltd to provide the technical and economic feasibility of the Taranaki VTM Offshore Project. The information presented is based on data, assumptions, and methodologies considered reasonable at the time of preparation.

Readers are advised to conduct their own independent assessments and due diligence before making any decisions based on this report. The information contained herein is provided for informational purposes and should not be solely relied upon for investment, financial, or strategic decisions.

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Version Control

25 March 2025	Pre-Feasibility Study	Siecap NZ	TTR	
Date	**Designation**	**Writers**	**Checked By**	**Approved**
Revision		**6**		
Document Number		TTR-01-REP-006		

Table of Contents

List of Figures

List of Tables

Glossary of Terms

AHT	Anchor-Handling Tug
AHV	Anchor Handling Vessel
ASX	Australian Securities Exchange
BFS	Bankable Feasibility Study
BML	Below Mud Line
Capex	Capital Expenditure
CD	Constant Density
CMA	Crown`s Minerals Act 1991
CMS	Cleaner Magnetic Separation
DEME	Dredging, Environmental and Marine Engineering Limited
DTM	Decision to Mine
DTR/DTC	Davis Tube Recovery
DTW	Davis Tube Wash
EEZ Act	Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
EPA	Environmental Protection Agency
EMV	Environmental Monitoring Vessel
FTA Act	Fast Track Approvals Act 2024
FMP	Flow Moisture Point
FOOS	First Ore on Ship
IMV	Integrated Mining Vessel, Processing, Storage and Offloading Vessel
FSO	Floating Storage and Offloading Vessel
GSV	Geological Drill and Survey Vessel
HAZOP	Hazard and Operability Study
IFO	Heavy Fuel Oil
HPF	Hyperbaric Pressure Filter
IMS	Intermediate Magnetic Separation
IMS	Intermediate Magnetic Separators
IMV	Integrated Mining Vessel
IFO	Intermediate Fuel Oil
ITP	Inspection and Test Plan
JORC	Joint Ore Reserves Committee Code 2012
LARS	Launch and Recovery System (for SBC)
LIMS	Low Intensity Magnetic Separator
MIMS	Medium Intensity Magnetic Separator
MCC	Motor Control Centre
Nm	Nautical Mile
NPV	Net Present Value
NZDS	New Zealand Diving and Salvage Limited
OGV	Ocean Going Vessel
Opex	Operating Expenditure
PFD	Process Flow Diagram

PFS	Pre-Feasibility Study
PID	Piping and Instrumentation Diagram
PSD	Particle Size Distribution
QEMSCAN	Quantitative Evaluation of Minerals by Scanning Electron Microscopy
RAS	Replenishment at Sea
RFQ	Request for Quotation
RMA	Resource Management Act 1991
RMS	Rougher Magnetic Separation
RO	Reverse Osmosis
ROM	Run Of Mine
RORO	Roll on Roll Off
SAL	Single Anchor Leg
SBC	Seabed Crawler
SOLAS	Safety of Life at Sea
SONAR	Sound Navigation and Ranging
SOP	Standard Operating Procedures
TSHD	Trailer Suction Hopper Dredge
TTR	Trans-Tasman Resources Limited
VTM	Vanadiferous Titanomagnetite
VTS	Vertical Transport System (ROM Hoses to SMTSBC)
WBS	Work Breakdown Structure
STB	South Taranaki Bight
STS	Slurry Transport System
SSC	Suspended Sand Concentration

1 EXECUTIVE SUMMARY

Trans-Tasman Resources Limited's (TTR) Taranaki VTM Project plans to extract vanadiferous titanomagnetite (VTM) iron sands resource from the seabed off the South Taranaki Bight (STB). The Project will produce iron ore concentrate for export containing critical minerals, vanadium and titanium.

The Taranaki VTM Project has potential to contribute to the New Government's stated aim to double the mining sector's export value to more than $3 billion over the next 10 years to 2035.

The 3.2 billion tonne (Bt) Taranaki VTM iron sands project is located in New Zealand's Exclusive Economic Zone (EEZ), between 22km and 36km off the coast of the STB, in waters ranging between 20 to 50 metres deep, in a region with existing oil and gas infrastructure.

TTR proposes to utilise an integrated mining processing vessel (IMV) and seabed crawler system of proven design to extract approximately 50 million tonnes (Mt) of seabed iron sands a year. The recovered iron sand will be processed by magnetitic separation to produce around 10% (4.9Mt) high grade VTM concentrate for export a year. The residual 45Mt of de-ored iron sand tailings will be continuously returned to the seabed in a controlled manner being redeposited into the area previously mined. The proposed mining method is a low-impact, mechanical, chemical-free process, extracting on average only the top 5 metres of seabed sediment within a tightly controlled 0.3km² dredging zone. The return of iron sand tailings to the seabed creates a minimal sediment plume of 0.5 to 1.5mg/L suspended sediment concentration (SSC) in the ocean and, by comparison, well below safe drinking water limits of 5mg/L SSC.

With regard to environmental safeguards, protection and impact independent experts conclude the TTR's project area in the STB is now regarded as one of the best studied shallow shelf marine environments in Aotearoa New Zealand with a wealth of studies generated by TTR that add to a body of existing scientific knowledge. The information is the best available and mining, subject to the proposed conditions, will avoid material harm, favours caution and environmental protection and the effects of the proposed mining operations and resulting sedimentation (plume) will have no adverse ecological effects on biota in the STB, including on marine mammals.

The mineral recovery process will have no material adverse impact on marine mammals, whales, dolphins, fish, reefs, coastal areas beaches or food gathering (kaimoana seafood). The seabed is continuously rehabilitated, with full recolonisation occurring in under two years. The environmental effects are managed by a comprehensive set of Environmental Protection Authority (EPA) approved 109 operating conditions and detailed management plans, ensures sustainable resource use, high environmental accountability and safeguards and protection from any permanent adverse effects.

With regards to carbon intensity, the proposed TTR extraction and recovery of iron ore concentrate from STB's iron sand deposits places TTR in the bottom quartile of CO^2 emitters for iron ore producers globally, with an estimated 62kg CO^2/t of VTM compared to an international average of 125 to 250kg CO^2/t iron ore concentrate.

TTR, now a subsidiary of Australian Securities Exchange listed Manuka Resources Limited (ASX:MKR), has reported 3.2 billion tonne (Bt) JORC Indicated and Inferred Mineral Resources of VTM grading 10.17% Fe_2O_3, 1.03% TiO_2 and 0.05% V_2O_5 in the Cook, Kupe and Tasman deposits offshore from Pātea in the STB. 1,881Mt of the reported VTM iron sand deposit is within TTR's granted Mineral Mining Permit MMP55581, outside the 12Nm limit, within New Zealand's

Exclusive Economic Zone (EEZ), Pilot plant processing and Davis Tube Recovery (DTR) of the magnetic fraction shows the resource produces concentrate grades of around 56% to 57% Fe, 8.4% TiO_2 and 0.50% V_2O_5.

The 3.2Bt VTM Indicated and Inferred mineral resource contains 1.6Mt vanadium pentoxide ranking the deposit as one of the larger drilled vanadium deposits globally.

The Pre-feasibility Study (PFS) is based on extracting and processing approximately 1Bt of VTM iron sands over 20 years from the reported resource within MMP55581 in the EEZ. The Company has defined and reported additional VTM mineral resources of 2.2Bt within MMP55581 and MEP54068 in the STB. At the proposed extraction rates these additional VTM resources, subject to future permitting and environmental approvals, could add a further 40 years of VTM processing and concentrate exports to the life of the project.

TTR plans to extract 50Mt of titanomagnetite ore and produce circa 4.9Mt of VTM iron ore concentrate per annum, which will be processed aboard an Integrated Mining Vessel (IMV). The iron ore concentrate from the IMV will then be transferred to floating storage and offloading (FSO) vessels for transhipment in a slurry form, where it will be dewatered and stored, ready for transfer to bulk carrier vessels for shipping to overseas markets. This is a common transshipment model used by several bulk commodity projects globally.

These vessels will be supported by a mid-sized Anchor Handling Tug (AHT) that will assist with the provisioning of the vessels, transfer of equipment, connecting the IMV to the FSO during transhipment, the berthing of the FSO to the conventional bulk cargo vessels, and IMV anchor and mooring relocation. The AHT will also provide refueling assistance. An environmental monitoring and research vessel (EMV) and a geotechnical drilling and grade control survey vessel (GSV) will undertake monitoring, testing and survey support activities for the Project.

TTR envisages contracting a third-party company for bunker fuel supply, which will have a facility in New Plymouth employing approximately six people.

TTR will directly employ over 300 employees in Taranaki comprising 180 crew to operate both the IMV and FSO vessels and a further 50 plus staff in supporting engineering, environmental monitoring and fuel bunkering roles. There will also be 35 general administration staff for the day-to-day operation of the Project. TTR plans to establish its New Zealand head office in New Plymouth, which will add 35 marketing and corporate management roles.

Indirectly the Project will generate 1,125 new skilled jobs in mining, services, logistics and support in the Taranaki region.

The technical and financial evaluation of the project as defined above and detailed in this PFS concludes that the project is economically viable and robust, and that further project development is justified.

The current set of VTM concentrate production and financial assumptions, delivers a project post-tax Net Present Value (NPV) of US$1.26 billion (NZ$2.2B) at a 10% discount rate, based on a discounted cash flow model. TTR is currently working with its technology providers to improve these assumptions and take new higher productivity assumptions as the basis of design for the Bankable Feasibility Study (BFS).

The project is potentially highly profitable with a modelled discounted capital payback (based on NPV) in approximately seven years with an initial project life of 20 years based on the reported mineral resource within MMP55581.

The discounted cash flow financial analysis of the project yields the following:

- Annual VTM concentrate production of 4.9Mt
- Project capital cost of US$602.2 million (NZ$1B);
- Operating costs are estimated at approximately US$27.20 tonne (NZ$47/t) (rounded, excluding freight costs);
- At current commodity prices generate annual contrate exports of earnings of US$495 million (NZ$854M);
- Total revenue estimated at US$9.9 billion (NZ$17B) (rounded) over the 20-year life of the project;
- Total direct operating costs (including overheads but excluding marketing costs, royalties and freight costs) are estimated at US$2.67 billion (NZ$4.61B) (rounded) over the 20-year. life of the project;
- EBITDA estimated at US$6.23 billion (NZ$10.78B) rounded) over the 20-year life of the project; and
- Net Profit after Tax estimated at US$3.70 billion (NZ$6.40B) (rounded) over the 20-year life of the project.

The financial outcomes detailed above reflect the results of the implementation of a single IMV production and processing vessel together and the sale of titanomagnetite concentrate and the separable recovered vanadium pentoxide.

The project solution detailed within this PFS has the potential, in the future, to be scaled by adding additional integrated vessels and revenue credits for the contained titanium dioxide in the concentrates.

The PFS results are based on existing resource estimates, broker consensus, mid-point iron ore pricing (Section 15) and market conditions and consequently, market fluctuations, varied logistics or production costs or recovery rates may render the results of past and future project studies uneconomic and may ultimately result in a future study being very different.

2 INTRODUCTION

This release of the 2025 Pre-Feasibility Study (PFS) builds on the foundation laid in Revision 2, released in July 2014, with significant advancements across multiple project areas. The latest updates reflect years of dedicated work, discoveries, and refined strategies to enhance both project viability and sustainability. Key updates include the following:

- Cutting-edge process and engineering advancements developed and defined between 2014 and 2017, shaping a stronger foundation for innovation and efficiency.
- **Vanadium Recovery Circuit Integration**:

  Incorporating a separable vanadium pentoxide (V_2O_5) recovery circuit, informed by comprehensive testwork conducted by TTR between 2018 and 2023. This addition metal recovery enhances resource efficiency and economic potential.
- **Environmental Management Alignment:**

  Incorporating the environmental conditions and detailed management plans developed in collaboration with stakeholders and the Environmental Protection Authority (EPA). These conditions and management plans were formalised during the approval of marine and discharge consents in August 2017, ensuring regulatory compliance and environmental stewardship.
- **Mineral Resource Definition**

  Incorporating the latest JORC Mineral Resource Statement block model and mineral estimation for iron, vanadium and titanium metals completed and reported on 1 March 2023.
- **Mine Plan**

  The mine plan has been refined to incorporate changes in mining scheduling, extraction methodologies, and sequencing of mineral resources within MMP55581 located in the EEZ.
- **Market Study Update:**

  Revisiting and updating the marketing study to reflect current market dynamics, demand trends, and strategic opportunities for iron ore concentrates and including metal credits for vanadium and potentially, in the future, titanium.
- **Revised Capex and Opex Estimates:**

  Updating capital and operating expenditure estimates to incorporate the latest cost structures, industry benchmarks, and project specifications.
- **Financial Model Refresh:**

  Enhancing the Discounted Cash Flow (DCF) financial model with updated inputs to provide a clearer, more accurate picture of the project's economic performance and outlook.

This revised PFS delivers a more robust and forward-looking analysis, positioning the project for informed decision-making and future success. The PFS presents a viable approach for extracting and processing iron ore deposits within TTRs tenements located off the west coast of New Zealand's North Island. It reflects advancements in resource estimation, project planning, environmental management, monitoring and operating conditions, financial modeling, and market analysis.

The exploration summary includes an updated review of drilling data, while the mineral resource definition has been revised to incorporate the latest mineral resource block model and JORC Mineral Resource Statement of March 2023. Metallurgical testwork has also been updated with the most recent reviews, providing an improved understanding of vanadium and titanium metal recoveries and value-added ore processing characteristics. The mine plan has been refined to incorporate changes in mining scheduling, extraction methodologies, and sequencing. Updates to the process plant include the integration of the DRA report findings.

Environmental considerations have been revised to reflect the latest regulatory conditions, legislative changes, and permitting timeframes. The environmental studies, permitting, and social impact assessment section now includes the latest full set of EPA approved marine and discharge consent conditions and detailed set of management and operating plans, along with an updated timeline for the approvals and consenting processes.

The capital costs for the project have been updated to reflect the impact of various external and market-driven factors. Adjustments were made based on the origin of key project elements, taking into account differences in labor costs, material availability, and regional economic conditions. Market fluctuations, including changes in commodity prices and currency exchange rates, were incorporated to provide a more accurate cost baseline. Inflation adjustments were applied in line with the latest industry indices to capture the rising (or in some cases, falling) costs of materials and services, particularly in sectors such as ship construction, mining process equipment and industrial equipment procurement. Supply chain challenges, including delays and increased freight costs, have been factored into the revised estimates, given their significant influence on lead times and overall project expenditure. As a result, the project schedule and financial analysis have been recalibrated to align with these cost revisions, ensuring that contingency allowances and risk assessments are updated to reflect current market conditions and potential future scenarios.

Market studies have been revised, with updates to iron ore concentrate pricing forecasts, marketing strategy, and long-term demand expectations, including the role of new market opportunities and credits for the vanadium metal recoveries. The iron ore price assessment has been updated, with revised projections reflected in key figures and market analysis tables.

The financial evaluation section includes updates to vanadium and titanium market assessments, revised operating cost estimates, and an updated DCF model, ensuring alignment with current economic assumptions. The risk assessment has also been reviewed, with revised risk considerations and an updated basic schedule.

Finally, outdated reports have been removed from the appendices, and revised CVs have been incorporated. Updates to the TTR PFS reflects the most up-to-date information available. This revision provides a comprehensive foundation for progressing the project Bankable Feasibility Study (BFS) towards Decision to Mine (DCM), financing and development, ensuring alignment with industry best practices, financial expectations, and regulatory frameworks.

2.1 Purpose of the Report

In August 2022, Manuka Resources Limited (Manuka), an Australian Securities Exchange (ASX) listed company, entered into a binding terms sheet to acquire New Zealand registered TTR. The acquisition by Manuka aimed to diversify Manuka's portfolio by adding TTR's VTM iron sands project in New Zealand to its assets. Following the acquisition, TTR became a wholly-owned subsidiary of Manuka, with TTR's directors, joining Manuka's board. The acquisition was completed in November 2022, marking a significant expansion for Manuka into the New Zealand mining sector.

This updated PFS reflects the latest commercial, technical, permitting, environmental and natural resource project approval changes since the earlier release. This revised version incorporates new data and insights, ensuring a more accurate and comprehensive evaluation of the project's feasibility. The updates highlight adjustments in project scope, cost estimates, technical methodologies, and environmental considerations, permitting and project consenting regime, providing stakeholders with a clearer understanding of the project's current status and future economic performance and outlook.

TTR conducted an in-depth assessment of extraction technologies. This structured evaluation led to the selection of the IHC crawler technology, successfully employed by De Beers Marine SA off the coast of Namibia, as the preferred extraction method. The mine plan has since been refined to incorporate updates in mining scheduling, extraction methodologies, and sequencing of the reported mineral resources within MMP55581 in the EEZ.

The PFS integrates the latest mineral resource block model and 2023 mineral resource estimation, along with updated metallurgical testwork to enhance the understanding of ore processing characteristics. Environmental considerations have been revised to align with the 2017 EPA approved marine and discharge consents, current regulatory conditions, legislative changes, and permitting timeframes.

Financial updates account for market fluctuations, inflation, and supply chain challenges affecting key components such as ship construction, mining equipment, and procurement. The project schedule and financial analysis have been adjusted accordingly, with an updated DCF model and the revised risk assessment.

This PFS has been prepared in accordance with the Australasian Code for Reporting of Exploration Results, Mineral Resources, and Ore Reserves (JORC Code, 2012 Edition) and complies with ASX Listing Rules and the regulatory guidelines of the Australian Securities and Investments Commission (ASIC).

2.2 Sources of Information

Where relevant, the information and sources for the 2014 PFS have been retained. Appendix 19.1 of the document outlines the areas where information has been updated to reflect the updated developments from the previous 2014 PFS version. The sources for the information that are contained within this report have been provided by equipment designers and manufacturers, as well as internationally recognised independent consulting and local engineering companies engaged by TTR.

A full listing of the principal sources of information used in both this version and previous versions of the PFS report is available and a summary of the sources is provided below:

- Amdel-Bureau Veritas Australia – Metallurgical laboratory testwork;
- NIWA – Environmental Impact Assessment;
- Mitchell Daysh – Environmental Planning Approvals, Operating Conditions and Management Plans;
- Beca – Engineering Design and Verification Services;
- Canadian Shipping Lines (CSL) – Trans-Shipping Proposal;
- Fugro – Aeromagnetic Survey;
- Golders Associates – Previous Mineral Resource Statements, Geology and QA/QC JORC Seabed Drilling Technology and Sample Compliance;
- Siecap NZ Ltd – Mineral Resource Estimation, Metallurgical Testwork and Technical Overview;
- IHC Merwede – Mining Technology Design Support;
- MTI – Dredging and Tailings Management;
- Sea Transport – Naval Architects - Engineering Design and Verification Services;
- Seabulk – Transhipment, Warehousing and Dewatering;
- Tennant Metals Pty. Ltd. – Marketing Report;
- Transfield Worley – Risk Management and Cost Controlling;
- Upstream Technologies SA (previously De Beers Marine SA and Ignite);
    - Operational Advice and Support
    - Design Review and Recommendations:
    - In-depth Analysis and Feedback
        - The IMV Crawler System;
        - Launch and Recovery System (LARS);
        - Mooring and Dynamic Positioning Systems; and
        - BFS Work Program, Scheduling and Execution.
- DRA – Process Plant Design;
- Vuyk Rotterdam – Naval Architects; and
- AMS – American Bureau of Shipping Marine Classification.

TTR has made all reasonable efforts to verify and establish the completeness, accuracy and authenticity of the information provided and where appropriate identify potential risks or uncertainties that would affect either technical or economic models. Refer to Section 19 of this PFS.

2.3 Qualification and Experience

For this study, which crosses several technological areas including mineral exploration and resource reporting, subsea engineering, vessel mooring systems and mineral ore beneficiation, subject matter experts and experienced qualified professionals from various consultants have been integrated to form the study team.

2.4 Key Findings

The following key findings have been identified; these findings are subject to the stated risks and assumptions detailed in Section 16 and 3.14 respectively:

- The proposed integrated mining methodology and technical aspects of the project are technically sound and appropriate for the project;
- The Project capital (Capex) and operational (Opex) cost estimates (within +/-30% accuracy) are based on appropriate and reasonable assumptions;
- It is reasonable to expect that the proposed mining method is suitable for the geological characteristics of the VTM mineral resource (as reported by TTR 1 March 2023);
- It is reasonable to expect that the stated metallurgical yields can be achieved using the proposed mining method and process (Siecap Report: Recovery of Vanadium from Taranaki VTM Project February 2025);
- It is reasonable to expect that if implemented, the proposed mining method has the capability of mining 39Mtpa of sediment (dry basis) (50Mtpa wet basis);
- It is reasonable to assume that if expected yields are achieved, the proposed processing facility is expected to produce 4.9Mtpa of iron ore VTM concentrate, taking into account mining losses and dilutions;
- The basic schedule covering further studies and development of the project as outlined is reasonable;
- Results of the metallurgical testwork undertaken by Amdel Bureau Veritas appear to be reasonable and have been prepared using appropriate techniques and in accordance with applicable industry standards; and
- For the base case of approximately 4.9Mtpa production of VTM concentrate grading 56% to 57% Fe, 8.4% TiO_2 and 0.50% V_2O_5 the estimated NPV is US$1.263 billion for a Capex of US$602 million. The projected average Opex FOB cash cost over the first 20 years is estimated at approximately US$27.20t tonne of concentrate.

3 PROJECT SUMMARY

3.1 Project Description

Incorporated in September 2007 New Zealand registered company Trans-Tasman Resources (TTR) was established to explore, assess and uncover the potential of the offshore titanomagnetite iron ore deposits along the west coast of the North Island of New Zealand. TTR's ambition is to provide a reliable supply of low-cost iron ore concentrate, containing valuable vanadium and titanium metal credits, and build mutually beneficial strategic long-term partnerships with mineral processing facilities and steel manufacturers. TTR is committed to conducting all its activities in a safe and environmentally sustainable manner and to proactively engage with existing interests, local and regional authorities, iwi groups and local communities on all relevant economic, environmental, cultural and social issues.

The aim of this PFS is to present the proposed operational process, along with an economic evaluation of the selected ore recovery and mineral processing techniques and methods, to achieve the following objectives.

- **Run-of-Mine Extraction:** The offshore iron ore will be extracted from the identified and reported mineral resources using efficient and environmentally responsible mining techniques.
- **Concentrate Washing and Logistics**: The VTM concentrate will be processed and beneficiated on a dedicated Integrated Mining Vessel (IMV), washed in fresh water to a Floating and Storage Offloading Vessel (FSO), dewatered and transferred to bulk Capesize vessels at sea for export to a third-party processing plant for further treatment and final metal recoveries.
- **Ore Beneficiation:** The extracted VTM ore grading 10.17% Fe_2O_3, 1.03% TiO_2 and 0.05% V_2O_5 will undergo a mineral beneficiation process to increase the iron content, producing a VTM concentrate with an iron grade of 56-57% Fe with vanadium grade of 0.5% V_2O_5 and titanium of 8.4% TiO_2.
- **Vanadium Extraction:** At the processing plant, advanced metallurgical methods will be applied to extract the recoverable vanadium from the VTM concentrate.
- **Iron Ore for Steelmaking:** The remaining iron ore, after vanadium extraction, will be delivered to a steelmaking facility where it will serve as feedstock for blast furnace operations.
- **Market Shipment:** A VTM concentrate suitable for international markets will be prepared and shipped to global customers.
- **Capital Cost Estimate**: A capital expenditure (Capex) estimate with an accuracy level of ±30%.

This study provides a comprehensive overview of the entire value chain including engineering and environmental management solutions, mineral extraction and beneficiation to product shipment and export, value-added processing and economic feasibility.

3.2 Option Overview

In the previous revision of the PFS (Revision 2, 2014), several mining system options were thoroughly reviewed and evaluated. Initially, a simple dredging option was commissioned during the early stages of the study. However, a subsequent workshop held with IHC in the Netherlands explored a broader range of options to identify the most suitable and sustainable solution for TTR's operations. The options assessed included integrated crawler systems, trailer suction hopper dredges (TSHD), drill ship recovery (Drill), roll-on/roll-off (Ro-Ro) systems, and point suction dredges (PSD). These systems were evaluated based on key performance indicators such as resource optimization and mining efficiency, operational ocean depth (20m to 50m), capacity, flexibility, logistical complexity and tailings dispersal management and marine environmental impact.

The structured decision analysis revealed that the Drill, Ro-Ro, and PSD systems were not viable options due to limitations in efficiency, flexibility, and environmental performance. The results identified two promising candidates: the TSHD, as detailed in the initial PFS report, and the integrated mining vessel and crawler system (IMV) similar to the proven and operating design used by De Beers Marine of South Africa now for over 30 years.

While the TSHD demonstrated scalability, it posed significant challenges regarding tailings dispersal. Its operation could create large sediment plumes due to limited control over tailings return. In contrast, the IMV crawler system, with its precise and (based on grade control drilling) targeted extraction process able to avoid zones of high (>2%) silt, and controlled return of the de-ored sediments (tailings) to the seafloor, minimises plume generation. By employing a tailings pipe and pressure diffuser to around 4m above the seabed, the system will return sediment to the seabed in a controlled manner, reducing the suspended sediment impact in the surrounding water column.

Based on these findings, it was clear that utilising proven IMV seabed crawler technology offered the lowest project risk along with the most effective and environmentally responsible mining solution, particularly given its superior tailings management capabilities.

The seabed crawler will be remotely operated from a surface support vessel and equipped with advanced acoustic navigation and imaging systems to ensure precise, systematic extraction along pre-defined grade controlled lanes. It will pump the unconsolidated surface sediment to the IMV vessel for processing and beneficiation. The high-precision nature of the crawler's operation ensures comprehensive coverage of the target area, able to avoid areas of high silt loads, eliminating the need for re-mining and enhancing overall efficiency. The mining vessel will employ a dynamic positioning system with multiple anchors to maintain accurate placement during ore extraction and redeposition of tailings onto the seafloor, ensuring safe and effective operations across the designated mining zones.

3.3 Project Geology

Titanomagnetite iron sand forms Quaternary[1] onshore beach and dune deposits and offshore marine deposits along approximately 480 kilometres of coastline from Kaipara Harbour in the north, south to Wanganui on the west coast of the North Island, New Zealand. The onshore deposits include the present beach and dune sand, and older coastal sand deposits that have been preserved by uplift due to faulting and/or lowering of sea level.

The titanomagnetite mineral is sourced from the Quaternary volcanic rocks of western Mount Taranaki and the volcanic rocks of the Taupo Volcanic Zone, transported to the coast by rivers, along the coast by shallow marine longshore currents, and subsequently concentrated by wave, wind and tidal action into beach and dune lag deposits.

From the interpretation of the exploration information, the geological model of the offshore iron sand deposits can be represented as areas, consisting of remnant coastal beach and dune lag deposits that were constructed, in the same geological process as the current onshore dune deposits, at a time of lower sea levels of around 30m to 50m during the last glaciation from around 15,000 to 9,000 years ago. These paleo-dune features were part of an ancient river system in which dunes formed contemporaneously at the mouth of the river(s) and the coastline. The rivers are locally controlled by active faulting with the iron sands within the river channels and dunes partially reworked by currents and longshore drift then inundated and reworked by the rising and transgressing seas over the last 7 to 8,000 years.

3.4 Exploration Summary

TTR have undertaken extensive exploration activities within its tenement areas, and in particular within the proposed mining area within MMP55581. Exploration activities have included, high resolution aeromagnetic surveys, high resolution 2D seismic surveys, multi beam sonar bathymetry surveys, ROV video surveys of seafloor, multiple programs of shallow and deep drilling, bulk metallurgical sampling and pilot plant processing. From these exploration and processing activities TTR has been able to report a JORC Mineral Resource Statement using drilling methods that have been independently technically verified to enable representative sampling at depth of the seabed titanomagnetite resource.

[1] The **Quaternary Period** is the most recent of the three periods of the Cenozoic Era in the geologic time scale, and spans from 2.588 ± 0.005 million years ago to the present. This relatively short period is characterized by a series of glaciations.

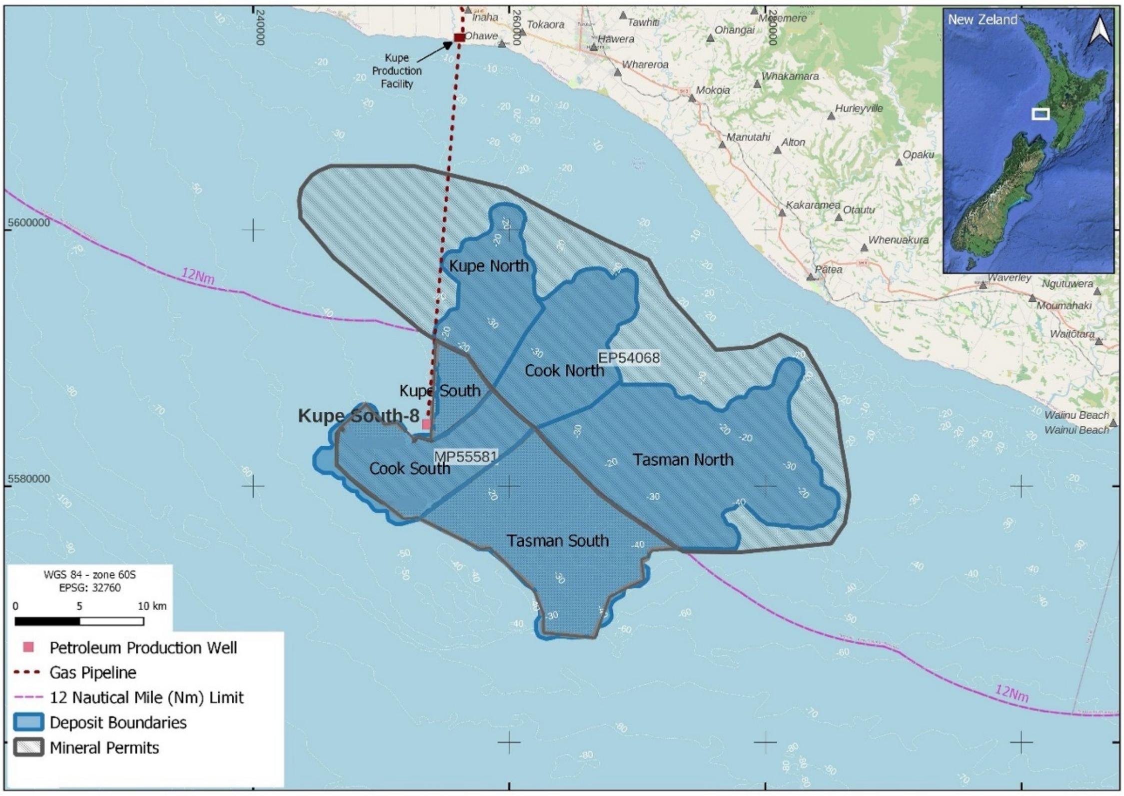

Figure 1 Location of the TTR VTM Project (Resource Blocks and Mineral Permits)

3.5 Mineral Resource Definition

On 1 March 2023 TTR reported the mineral resource estimates for its Taranaki VTM[2] iron sand project located in the STB off the west coast of the North Island, New Zealand (Figure 1)

The 3.2Bt Indicated and Inferred mineral resource of 10.17% Fe_2O_3, 1.03% TiO_2 and 0.05% V_2O_5 contains 1.6Mt vanadium pentoxide ranking the deposit as one of the larger drilled vanadium deposits globally.

Three contiguous resource deposits, the Cook, Kupe and Tasman VTM deposits that make up the Taranaki VTM project, are separately reported. The mineral resource and Davis Tube Recovery (DTR) concentrate estimates reported, based on all available assay data as of 1 January 2015, include iron oxide and iron (Fe_2O_3 & Fe), titanium dioxide (TiO_2) and vanadium pentoxide (V_2O_5) mineral resource estimates.

The mineral resource estimates for Cook, Kupe and Tasman deposits, have been reported separately for each of the North Blocks inside the 12Nm limit within Mineral Exploration Permit MEP54068 [Resource Management Act (RMA) approval area] and the South Blocks outside the 12Nm limit within Mineral Mining Permit MMP55581 [Exclusive Economic Zone (EEZ) approval area].

The mineral resource estimates are prepared and classified in accordance with the 2012 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore

[2] Vanadiferous titanomagnetite ($Fe_{2.74}Ti_{0.24}V_{0.02}O_4$).

Reserves (JORC Code 2012).

The 2023 Taranaki VTM Mineral Resource Statement is presented in Appendix 19.16.

Summary

The Taranaki VTM iron sand project has a total reported combined Indicated and Inferred mineral resource of 3,157Mt @ 10.17% Fe_2O_3, 1.03% TiO_2 and 0.05% V_2O_5 at a 7.5% Fe_2O_3 cut-off grade (Figure 1; Table 1).

The reported mineral resource estimate for the contiguous Cook, Kupe and Tasman North deposit Blocks has an Indicated and Inferred mineral resource of 1,275Mt @ 10.44% Fe_2O_3, 1.05% TiO_2 and 0.05% V_2O_5 inside the 12Nm limit (within MEP54068) and 1.881Bt @ 9.99% Fe_2O_3, 1.01% TiO_2 and 0.05% V_2O_5 for the South Blocks, including the initial mining area, outside the 12Nm limit (within MMP55581).

A DTR and Concentrate Grade estimation has been reported for the Cook North and South Blocks and the Kupe North and South Blocks using a 3.5% DTR cut-off grade (Table 1).

The mineral resource estimate for the Cook North and South Blocks reports a combined Indicated and Inferred recoverable mineral resource of 1,188.6Mt @ 11.17% Fe_2O_3, 1.14% TiO_2 and 0.05% V_2O_5 generating 84.0Mt concentrate at a grade of 56.18% Fe, 8.36% TiO_2 and 0.51% V_2O_5 at a 3.5% DTR cut-off grade.

The mineral resource estimate for the Kupe North and South Blocks reports a combined Indicated and Inferred recoverable mineral resource of 688.5Mt @ 10.80% Fe_2O_3, 1.12% TiO_2 and 0.05% V_2O_5 generating 46.1Mt concentrate at a grade of 56.82% Fe, 8.38% TiO_2 and 0.51% V_2O_5 at a 3.5% DTR cut-off grade.

Additional Taranaki VTM mineral resource estimates for the Tasman North and South Blocks have been reported using a 7.5% Fe_2O_3 (head) cut-off grade. At this cut-off grade the Tasman North and South Blocks have a combined Indicated and Inferred mineral resource of 1,279.6Mt @ 8.91% Fe_2O_3, 0.88% TiO_2 and 0.05% V_2O_5 at a 7.5% Fe_2O_3 cut-off grade.

Taranaki VTM Resource Estimates Summary									
	Indicated and Inferred Mineral Resources					DTR Concentrate			
MEP54068 Inside 12Nm (RMA)	**Cut-Off Grade**	**Mt**	**Fe_2O_3%**	**TiO_2%**	**V_2O_5%**	**Mt**	**Fe%**	**TiO_2%**	**V_2O_5%**
Cook North Block	3.5% DTR*	274	11.90	1.19	0.06	21	57.19	8.12	0.52
Kupe North Block	3.5% DTR*	417	11.48	1.21	0.06	31	57.07	8.35	0.51
Tasman North Block	7.5% Fe_2O_3	585	9.02	0.88	0.04				
Total VTM Resource (RMA)		**1,275**	**10.44**	**1.05**	**0.05**				
MMP55581 Outside 12Nm (EEZ)									
Cook South Block	3.5% DTR*	914	10.95	1.12	0.05	63	55.84	8.45	0.50
Kupe South Block	3.5% DTR*	272	9.76	0.98	0.05	16	56.33	8.43	0.50
Tasman South Block	7.5% Fe_2O_3	695	8.81	0.89	0.04				
Total VTM Resource (EEZ)		**1,881**	**9.99**	**1.01**	**0.05**				
Taranaki VTM Resource Total		**3,157**	**10.17**	**1.03**	**0.05**				

DTR is Davis Tube Recovery of the magnetic fraction of the sample

Table 1 JORC Reported Mineral Resource, Concentrate Tonnage and Grades

The JORC classification of Indicated and Inferred resource categories for the reported 1.881Bt VTM resource for the Cook, Kupe and Tasman South Blocks, outside the 12Nm limit within MMP55581, are presented in Table 2. The 1.881Bt resource comprises 1,418Mt, or 75%, Indicated and 463Mt, or 25%, Inferred resource categories.

Taranaki VTM Resource Classification MMP55581						
	Indicated and Inferred Mineral Resources					
VTM Deposit MMP55581	**Cut-Off Grade**	**Mt Ind**	**Mt Inf**	**Mt Total**	**% Ind**	**% Inf**
Cook South Block	3.5% DTR*	864.9	49.6	914.4	95%	5%
Kupe South Block	3.5% DTR*	238.2	33.6	271.8	88%	12%
Tasman South Block	7.5% Fe2O3	315.0	380.1	695.1	45%	55%
Total VTM Resource		**1,418**	**463**	**1,881**	**75%**	**25%**

Table 2 MMP55581 JORC Reported Indicated and Inferred Mineral Resources

3.6 Metallurgical Testwork

TTR has reported JORC mineral resource estimates for its VTM iron sand project located in the South Taranaki Bight of combined Indicated and Inferred mineral resource of 3.2Bt @ 10.17% Fe_2O_3, 1.03% TiO_2 and 0.05% V_2O_5 at a 7.5% Fe_2O_3 cut-off grade containing 1.6Mt of vanadium pentoxide (V_2O_5)[3].

Vanadium is present as a co-product in the TTR VTM concentrate resource and would be a substantial source of the metal, or its compound, from future processing. The TTR Siecap metallurgical study[4] summarised the laboratory-scale metallurgical test-work and process flow sheet development to recover iron, vanadium and titanium metals. A one (1) tonne per hour (tph) pilot plant, and a preliminary economic and environmental assessment to evaluate scalability, efficiency, and sustainability of the metal recoveries is proposed to be complete as part of the final definitive BFS. The testwork completed since 2018 has been very encouraging and demonstrates pathways to capturing these critical metals as a separate product stream using conventional technology.

The metallurgical testwork was conducted in two phases:

Stage 1 – Preliminary testwork

Stage 2 – Pilot plant testwork

Stage 3 – Vanadium and titanium recovery testwork

The purpose of stage 1 and 2 testwork was to investigate the viability of upgrading the ore using conventional mineral sands processing methods and technology to determine the base parameters required for the design of the metallurgical process flow sheet. The purpose of the testwork was to design a process flow sheet that is capable of producing a saleable iron ore concentrate whilst maximising recovery of the valuable titanomagnetite component in the primary ore resource.

Initial testwork in Stages 1 and 2 focused on gravity separation as is commonly used at many existing mineral and iron sands operations. This initial testwork proved that this approach was not viable and steered the process flow sheet design towards conventional magnetite processing which is based primarily on magnetic separation.

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[3] Manuka Resources Limited ASX Announcement 1 March 2023

[4] Metallurgical Review: Recovery of Vanadium from Taranaki VTM Project New Zealand; TTR and SieCap Consultants 4 February 2025

In 2023 TTR commenced Stage 3 testwork and commissioned metallurgical testwork into advanced mineral processing techniques to optimise the extraction and separation of vanadium and titanium from TTR STB sourced titanomagnetite VTM iron sands concentrate.

Testwork conducted by the University of Canterbury and Callaghan Innovation confirmed the viability of sodium salt roasting-water leaching process for the sustainable recovery of vanadium from the VTM concentrate. The sodium salt – water leaching process not only achieved high recovery rates of vanadium (77%) but also exemplified a model that balanced economic viability with environmental stewardship. This dual focus ensured that vanadium extraction aligned with TTR's sustainable development goals.

Vanadium and titanium are listed as critical minerals in MBIE's report "A Critical Minerals List for New Zealand" released on 31 January 2025 by the Minister for Resources. Also released by the Minister on 31 January 2025 MBIE's report "A Minerals Strategy to 2040 for New Zealand" identified vanadium and titanium bearing iron sands in the South Taranaki Bight as a growth minerals development opportunity to contribute to doubling New Zealand's mineral exports to NZ$3B by 2035.

Vanadium is a strategic mineral vital for strengthening steel, use in rebar, construction and structural steel, aerospace, and renewable energy technologies and now the emerging demand for utility storage vanadium redox[5] flow batteries (+50Mw VRFBs) used for large-scale energy storage. Titanium is widely used in spacecraft, paints, paper, plastics, white goods, alloys, satellites, electronics, medical implants, building products and solar storage.

Global demand continues to outpace supply, emphasizing vanadium and titanium's critical role in decarbonization and energy resilience resulting in their inclusion on several countries, critical metals lists including the EU, UK, USA, Canada and Australia's.

The recent testwork and subsequent study concluded that the salt roasting and water leaching process holds significant promise for extracting vanadium from TTR's iron sands especially when operating conditions were carefully optimised. Achieving a remarkable 77% vanadium recovery rate under laboratory conditions underscored the process's viability.

Siecap NZ Ltd's 2025 Metallurgical Review: Recovery of Vanadium from Taranaki VTM Project New Zealand is presented in Appendix 19.17.

3.7 Operational Description

3.7.1 Integrated System

The selected integrated solution is based on a single IMV that will contain the seabed crawler mining system (SBC), the mineral processing, beneficiation and tailings deposition mechanisms and a single Floating Storage and Offloading Vessel (FSO) that will transship and dewater the concentrate from the IMV onto standard commercial Capesize bulk vessels for export and delivery to mineral processor end users.

[5] Redox batteries are fire safe and present minimal safety risks compared to solid state batteries

Figure 2 TTR Taranaki VTM Project IMV

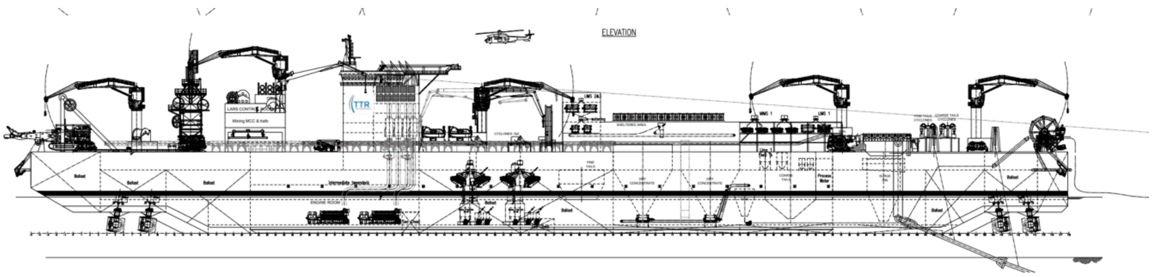


Figure 3 TTR Taranaki VTM Project IMV Elevation Plan

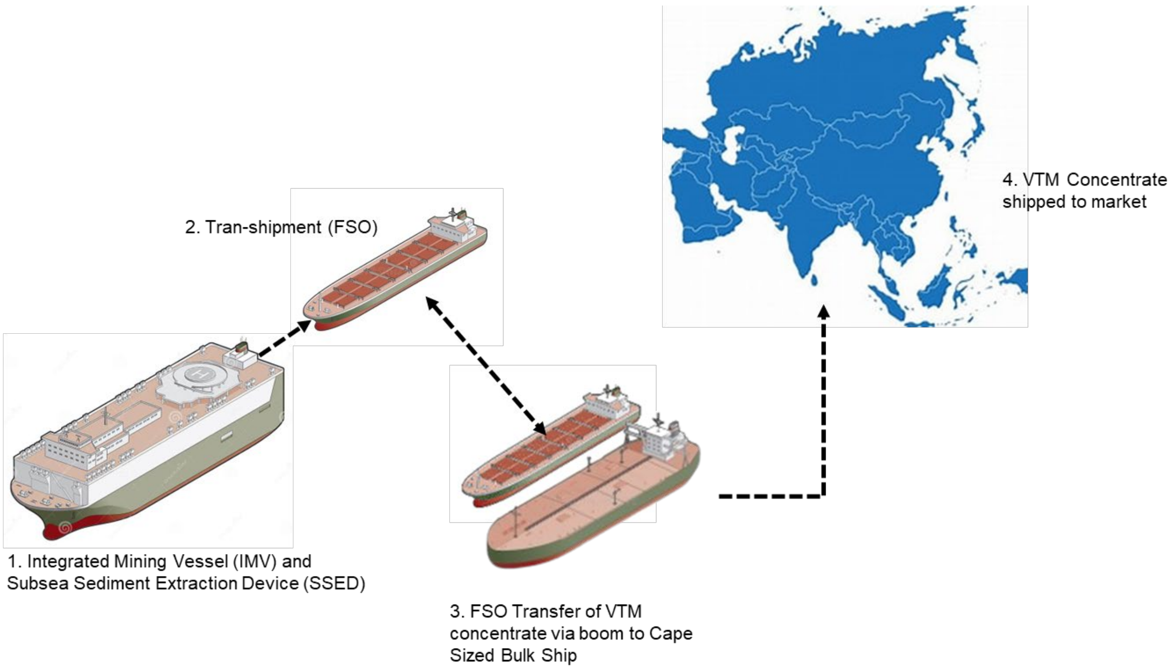


Figure 4 TTR Taranaki VTM Project - Operations

3.7.2 Seabed Mineral Resource Recovery

A mobile seabed crawler (SBC) was selected as the preferred sediment extraction technology to be integrated into the IMV. This proven and tested technology is very similar to the De Beers Marine extraction equipment operated offshore Namibia now for over 30 years.

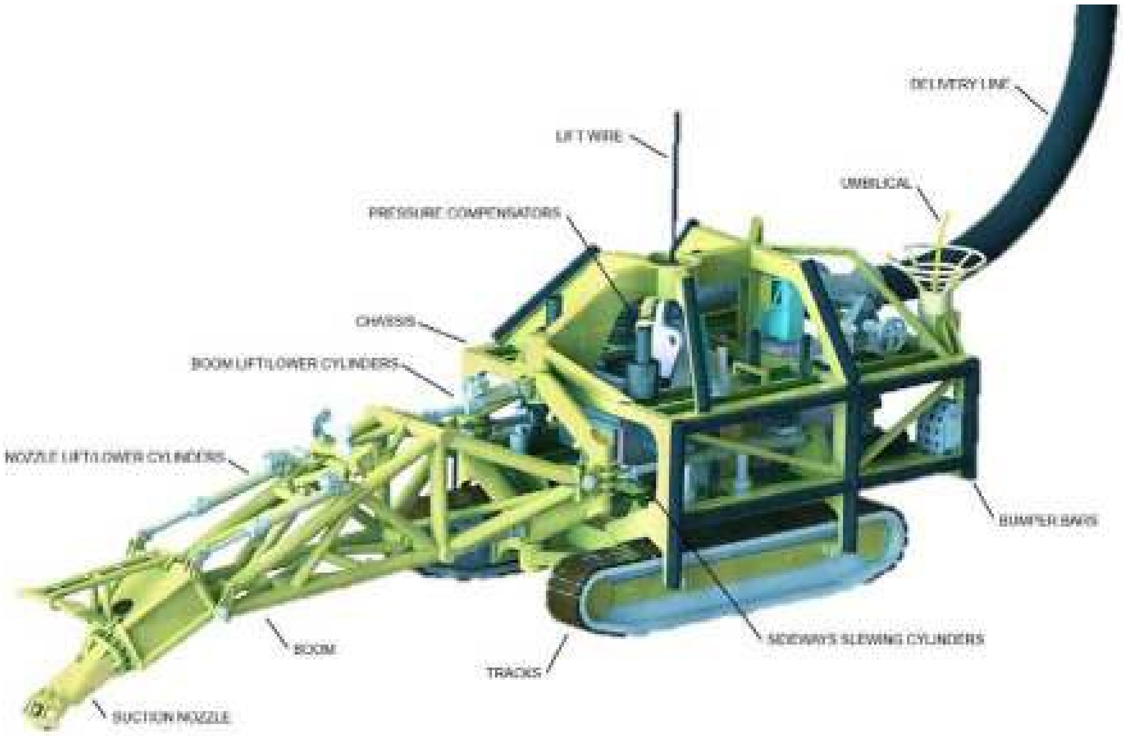


Figure 5 Seabed Crawler Technology (SBC)

During extraction operations the SBC is lowered onto the seabed by the launch and recovery system (LARS), together with the discharge hose and umbilical. Around 2-3 sections of the discharge hose will be floating on the water allowing for flexibility in the movement of the subsea device.

To accommodate the deposition of the tailings into an already depleted area, because of the location of the tailings deposition pipe on the bow of the vessel, the length of each extraction run will be a function of the vessel length, e.g. 300 metres. At the end of each run the SBC will turn 180° and work the adjacent run, see Figure 4 below. The total width of the planned run of the SBC boom is 10 metre wide allowing for a 1 metre overlap on both sides of the run to minimize spill (losses).

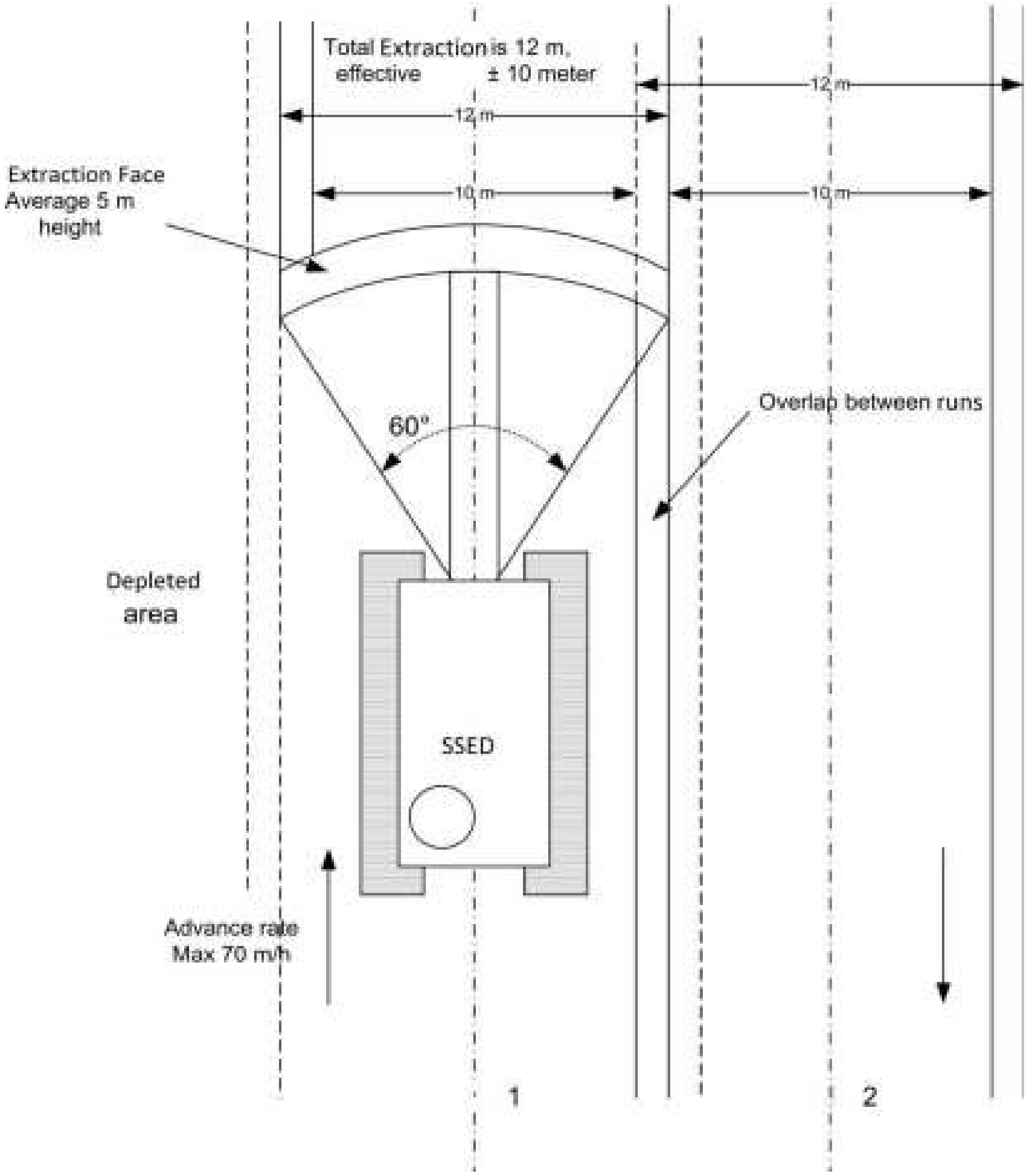


Figure 6 Typical SBC Extraction Run

The IMV will typically follow the SBC at the advance rate of 40 metres an hour. A 300m x 300m block will typically be depleted in around 10 days, and the mooring system will normally span a 900m x 300m area, see Figure 5, allowing a period of 30 days between each mooring move.

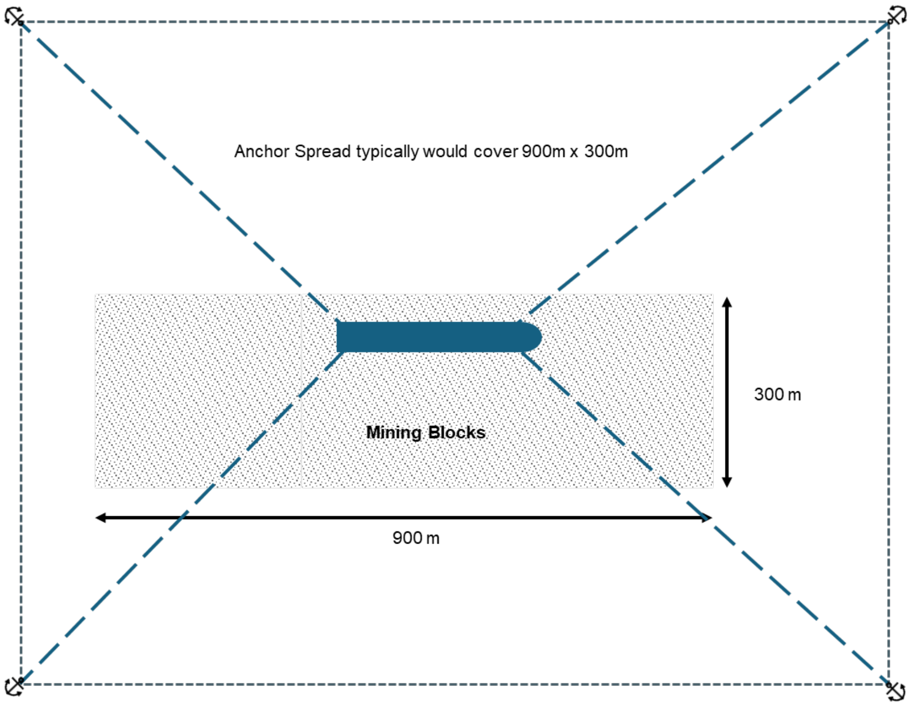


Figure 7 IMV Mooring Layout

3.7.3 Metallurgical Processing Module

The metallurgical test work programs demonstrated that the TTR VTM Project mineral resources can be beneficiated using conventional classification, i.e. magnetic separation followed by grinding and a final magnetic separation to produce a 56-57%Fe product (typically 75µm) with mass yields in the order of 10%.

A summary of the proposed processing facility is detailed in the Process Flow Diagram detailed in Section 7 of this report and is broadly described as follows:

- Extracted sediment will be delivered to the IMV via an 800mm ID rubber hose connected to the SBC. The pump will allow the transport of the sediment slurry at a rate of 8,000 tonnes per hour resulting in a slurry velocity in the hose of around 6.5m/s. The suction velocities directly at the nozzle entry will typically be around 1.5 to 2m/s and will decrease rapidly as the distance increases from the nozzle face. The estimated intake velocities 1m away from the nozzle will be a maximum of 0.5m/s. The run of mine (ROM), ore will be directed into a boil box from where it will be directed into two intermediate distribution sumps. Process water will then be added to reduce the slurry density to approximately 31.5% solids by weight before the slurry is fed to 10 trommel screens at main deck level. The screen aperture will be 4mm such that the effective screen size of the ROM will be ~2mm. Spray water on the screens will reduce the slurry density further to approximately 30% solids. The screen undersize is fed under gravity to 10 water agitated storage tanks directly below the screen area. The oversize will be fed via a chute to the tailings handling area.
- The -2mm ore will then be pumped from the agitated storage tanks to the first stages of magnetic separation. The purpose of the rougher magnetic separation (RMS) will be to capture both the liberated and locked magnetic particles whilst rejecting the majority of the gangue[4].

- Grinding – The feed to the first stage (~1,420t/h) will be ground to a P80 of nominally 130μm, requiring a grinding installed energy of 3.5kWh/t[6]. It is envisaged that the first stage grinding duty will be accomplished using 2 x 3,000HP Vertimills® in parallel.
- Intermediate Magnetic Separation (IMS) – The IMS section will comprise of 12 units arranged into two clusters of six separators each. Approximately 30% of the IMS feed will be rejected to tailings. The IMS concentrate will be gravity fed to the second stage grind feed tanks and the tailings will be gravity fed via a chute to the tailings handling area.
- Cleaner Magnetic Separation – The cleaner magnetic separation (CMS) section will consist of eight triple drum co-current magnetic separators at an intensity of 950 gauss, arranged in two clusters of four each. The CMS concentrate will then be gravity fed to a set of dewatering drum magnets to reduce the concentrate moisture to ~10%.
- Final Concentrate Handling – The dewatered concentrate will be stored in two hoppers. The hoppers were sized for a buffer capacity of 40h or approximately 32,000t. This will allow enough time for the FSO to sail a distance of maximum 70 nautical miles to a sheltered area (if required by weather conditions), offload its entire load of 60,000t concentrate and return to the IMV. Once the FSO is on station, it will connect to the IMV via a floating slurry line.
- On-board the IMV dewatered concentrate will be extracted from the bottom of the storage hoppers onto a conveyor belt. It will be elevated to the top of a constant density (CD) agitator tank with a sandwich conveyor. In the CD tank the concentrate will be slurried with fresh water from the desalination plant (from two intermediate freshwater tanks) to form a 50% by solids slurry. Fresh water is required to wash the concentrate, i.e., to reduce the chloride (salt) level of the product. The slurry will then be pumped to the FSO and filtered to a low moisture content of less than 6.5% using four hyperbaric pressure filters on the FSO.
- During offloading of concentrate the process plant will continue to operate to produce the balance of the 60,000t FSO cargo. Offloading to the FSO therefore will occur at double the production rate of the process plant (~1,600t/h).
- Tailings Handling – In order to minimise the environmental impact of the tailings, it will be dewatered before disposal via a set of hydro-cyclones. The coarse and fine tailings will be dewatered separately to approximately 75 to 80% solids before being discharged under gravity via the tailings deposition pipe. The deposition pipe will be controlled using sonar such that the discharge occurs at a constant height 4m from the seabed. The tailings wastewater will be discharged via a second pipe along the tailing's deposition pipe slightly higher than the solids discharge.

[6] Taken from the DRA March 2014 Process Review Report

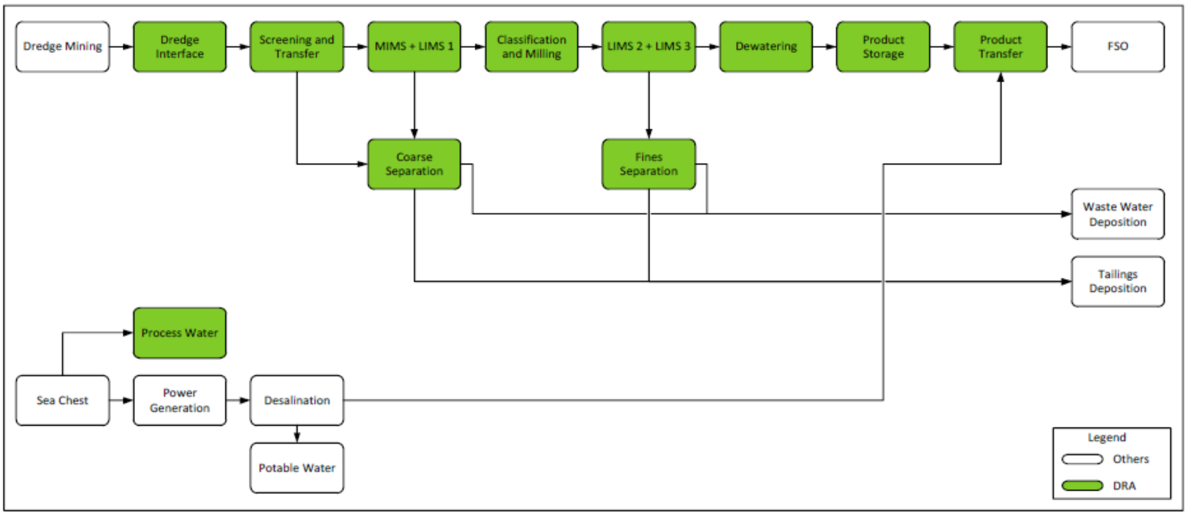


Figure 8 Mineral Recovery and Process Description

3.8 Auxiliary Services

3.8.1 Power Generation

The Project has specified on the IMV four (4) Siemens SGT-500 gas turbine generator sets for a total installed power capability of 80MW.

The SGT-500 set was selected because of its multi-fuel capability on a range of gas and liquid fuels specifically that of Intermediate Fuel Oil (IFO).

The units also have:

- The ability to accept a wide range of load application / rejection;
- The ability to accept a 6MW step load increase in a single step;
- The ability to shed load from 11MW to zero in a single step;
- The ability to shed load from full load to 2MW in a single step;
- The ability for on-line turbine washing;
- Low NOx emissions – 350ppmv without water injection, 50ppmv with water injection;
- Low noise emissions – 85dB(A) @ 1m;
- Low lube oil consumption; and
- Low footprint and weight.

Figure 9 FPSO Example

This vessel is shown above in Figure 7. is a typical oil and gas FPSO (Floating Production, Storage and Offloading) vessel. The power on board is provided by two SGT-500 gas turbines.

The SGT-500 is regarded in industry as a lightweight, high-efficiency, heavy-duty industrial gas turbine. Its special design features are high reliability and fuel flexibility. It is also designed for a single lift, which makes the unit suitable for all offshore applications.

The modular, compact design of the units also facilitates onsite modular exchange. (Source: Siemens Westinghouse)

The power generation component for the TTR project is detailed further in Section 8.1 of this report.

3.8.2 Sea Water Desalination

The project has specified 10 separate containerised Reverse Osmosis plants, each with a production capacity of three thousand (3,000) cubic metres per day.

Splitting the plant up in this way reduces risk as in the case of a breakdown in one plant, nine others are still available. It is also advantageous from a maintenance downtime perspective: with only 10% capacity offline at any one time, production is hardly interrupted for scheduled servicing. Spare parts are common across all plants, further reducing costs of stocking critical parts and components.

This aspect of the project is detailed further in section 8.2 of this report.

3.9 Environmental Regimes and Permitting Status

The Taranaki VTM project has undergone extensive environmental investigations and permitting processes. In 2017, TTR were granted marine and marine discharge consents by EPA Decision Making Committee (DMC) under New Zealand's Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act).

The EPA's decision was appealed to the High Court by environmental advocacy groups, some fishing interests and iwi representatives. The court process and outcomes, that subsequently included appeals to the Court of Appeal (CoA) and Supreme Court (SC), on points of law are summarised in Section 13.5 of this PFS.

Finally, the Supreme Court's decision, issued in September 2021, provided new guidance on the correct application of provisions in the EEZ Act by the DMC.

The Supreme Court judgment held that the DMC had made some errors of law in granting the consents. The SC referred the consents back to the DMC for reconsideration in light of the SC decision. The Court judgment stated, "Given the complex and evolving nature of the issues involved, it would not be appropriate to deny TTR the opportunity to have the application(s) reconsidered" and "TTR should be able to remedy matters if it can."

Importantly, the SC judgment provided a summary of the legal deficiencies of the original consent grants and the legal framework to address these when the grants are reconsidered by the reconvened DMC.

The EPA appointed a new decision-making committee to reconsider the applications in accordance with the SC appeal outcomes, and reconsideration hearings began in March 2024.

In anticipation of the NZ government's new Fast Track Approvals process, TTR withdrew its application for reconsideration by the reconvened DMC at the end of March 2024.

Between March and December 2024, the New Zealand Government developed the Fast Track Approvals Act 2024 (FTA Act), the purpose of which is to improve the delivery of projects with significant economic benefits. The FTA Act became law on 23 December 2024 and provides a streamlined process for such projects, with bespoke legal tests that give more weight to regional and national economic benefits than under the EEZ Act. At TTR's request, the New Zealand Government has listed TTR's project in the FTA Schedule 2[7], which means the project has already been approved to apply for final consents under the FTA process. This enables TTR to make an application for the project without first having to obtain additional ministerial support. TTR is now preparing its FTA application, which will reflect the new FTA legal tests.

TTR's EPA approved comprehensive set of consent operating conditions and detailed management plans mandate at least two years of baseline pre-mining commencement environmental monitoring and data collection, continuous operational monitoring over the 20 years of mining and five years of post-production environmental monitoring and review to address any unforeseen adverse impacts. TTR remains responsible for demonstrating ongoing compliance with these conditions to the regulator, the EPA, with oversight from independent technical reference groups including regional authorities, commercial fishing, oil and gas, iwi fishing forum representatives and cultural advisory panels to ensure environmentally responsible operations and stakeholder involvement throughout the project's lifespan.

3.9.1 Environmental Impact Assessment

For a detailed analysis of the updated Environmental Impact Assessment (EIA), including the most recent findings on sediment plume dynamics, marine ecology, and other key environmental factors, please refer to Appendix 19.21. This appendix contains the

[7] https://www.manukaresources.com.au/site/pdf/e2c94ac0-59d0-469d-a14d-fc1ce85ababb/TTR-Taranaki-VTM-Project-included-in-new-FastTrack-Approvals-Act-in-NZ.pdf

comprehensive assessment prepared by the National Institute of Water and Atmospheric Research (NIWA), which incorporates new data, updated modelling scenarios, and insights relevant to the ongoing environmental monitoring and environmental management strategies for the project. The information presented provides critical context for understanding the potential environmental impacts and the measures implemented to mitigate these risks.

3.10 Capital Costs

Capital costs (Capex) were estimated by TTR supported by various technical consultants and equipment providers. The Capex estimates are detailed in section 14.1 of this PFS and should be considered to be ±30% order of accuracy current at the first quarter of 2025.

The capital costs for the project have been updated to reflect the impact of various external and market-driven factors. Adjustments were made based on the origin of key project elements, considering differences in labor costs, material availability, and regional economic conditions. Market fluctuations, including changes in commodity prices and currency exchange rates, were incorporated to provide a more accurate cost baseline. Inflation adjustments were applied in line with the latest industry indices to capture the rising costs of materials and services, particularly in sectors such as ship construction, mining process equipment, and industrial equipment procurement. Supply chain challenges, including delays and increased freight costs, have been factored into the revised estimates, given their significant influence on lead times and overall project expenditure. As a result, the project schedule and financial analysis have been recalibrated to align with these cost revisions, ensuring that contingency allowances and risk assessments are updated to reflect current market conditions and potential future scenarios.

The total project Capex is estimated at US$602.183 million (NZ$1 billion). This figure encompasses a wide range of cost elements including project management, consultancy efforts (both BFS and execution), travel and accommodation, and extensive procurement activities. The procurement segment alone covers major components such as the IMV hull and superstructure, piping, machinery, the SBC, a geotechnical drilling and grade control survey vessel (GSV) and a variety of specialized equipment and installation costs. Each element has been meticulously evaluated to ensure that the overall estimate reflects both the scale and complexity of the project.

A critical aspect of any Capex estimate is the inclusion of a contingency reserve to address uncertainties and mitigate potential risks. The contingency, for this Capex estimate amounts to US$84.4 million (NZ$120M) or 14% of the total Capex.

The updated Capex estimate now also includes an allocation of NZ$2 million for the establishment of a dedicated employee training facility in Hāwera, aimed at enhancing workforce competency and supporting operational excellence. This facility will provide specialized training programs tailored to the project's manning needs, ensuring compliance with industry standards and best practices. Additionally, a NZ$3.9 million allowance has been incorporated for the acquisition of a suitable environmental monitoring and research vessel (EMV) I, monitoring equipment and technology and the necessary port infrastructure. This investment underscores the project's commitment to environmental stewardship, enabling continuous monitoring of marine ecosystems and ensuring adherence to regulatory requirements. These additions strengthen the project's long-term sustainability and operational resilience while aligning with best practices in environmental and workforce development.

Opportunities to reduce TTR's capital outlay through contracting with third parties to provide key elements of the project include potentially the project water supply and power infrastructure and auxiliary services. These will be evaluated during the BFS phase.

The following key assumptions have been made in regard to the capital cost:

- Contracted concentrate transfer and marine support operations;
- Owner run of mining, mineral processing, concentrate dewatering and environmental compliance and monitoring;
- Contracted vanadium recovery operations;
- A capital allowance has been made for an on-shore pilot vanadium recovery plant;
- Outside of the above, no capital allowance has been made for on-shore facilities as these are assumed to be covered by the respective entities providing services to the project at an operating cost; and
- The processing plant capital estimate has been based on suitable equipment sized from preliminary metallurgical test-work and flow sheet development. The processing plant is also based on a modularised construction strategy allowing (where practical) assembly and testing off site with reduced on-site construction effort and risk.

3.11 Operational Costs

Operating costs (Opex) have been estimated on the basis that all primary mining operations will be carried out by TTR. All transfer and support operations will be contracted out to third parties. The Opex estimates are detailed in section 14.2 of this PFS and should also be considered to be ±30% order of accuracy current at the first quarter of 2025.

The detailed Opex framework provides an in-depth analysis of the operational costs, amounting to US$27.20 (NZ$47.00) per tonne of VTM concentrate. This cost structure not only highlights the complexity and scale of the offshore mining operation but also identifies key cost drivers and opportunities for improving efficiency. Each component of the operation contributes uniquely to the overall expenditure, reflecting the logistical and technical demands of offshore mining while underscoring strategic areas for cost optimisation.

3.12 Project Schedule

It is estimated that the project duration will be 24 to 30 months from project Decision to Mine (DTM). The major key elements of the project schedule are shown in the table below:

Task Name
Project Management
Project Management and Control
Project Operations

Maritime Operations & Licensing
Project Artefacts/Documents
Basis of Design (Early Confirmation)
BFS Report
Decision to Mine
Execution
Procurement
FSO Supply
AHT Supply
IMV - Hull/Plant
Mining ROM
Process Plant
Power generation
Desalination
HDF - Concentrate Onloading
Construction
IMV - Hull/Plant
IMV Integration
Handover

Table 3 Project Schedule

3.13 Financial Analysis

The evaluation of the TTR Offshore Taranaki VTM Project was completed using discounted cash flow analysis (DCF) with a discount rate of 10%.

The base-case key economic outcomes were:

- A NPV estimate of US$1.263 billion (NZ$2.185B);
- Total operating costs of approximately US$27.20 (NZ$47.00) per tonne (excluding freight costs) of VTM concentrate product grading 57% Fe. 0.5% V_2O_5 and 8.4% TiO_2 delivered free on board (FOB); and

- Capital discounted payback of approximately 7 years based on 40% equity and 60% debt model.

The financial outcomes from the studies of the Project are shown below under Section 15.

3.14 Pre-Feasibility Assumptions

In the frame of this Preliminary Feasibility Study, the following main assumptions have been made in order to determine the most appropriate offshore scheme with regards to the logistical aspects.

- All equipment cost estimate accuracy is +/-30%;
- The FSO sizing has been based on a 60,000 tonne “Panamax” sized vessel;
- Flow-sheet has been compiled from laboratory test data and shall be confirmed further testing in the BFS phase;
- Assumed that the target specification for residual moisture of the final product is minimum 9%, to be confirmed by filtration test and FMP (Flow Moisture Point) for transportation of the iron concentrate;
- Preliminary grinding test results have to be confirmed by additional tests especially for the closed-circuit mill control (future consideration) and Vertimill® designs; and

3.15 Forward Work Programme

There are several areas that will require additional focus during the next phase (BFS) of the Project. These works are summarised below:

3.15.1 Bulk Concentrate Testwork

A larger representative bulk sample in the order of 1,500kg VTM concentrate is required to undertake additional testworks to confirm process equipment and PFDs and evaluate the concentrate product’s sintering and pelletizing properties.

A total of approximately 20t bulk sample is currently available for further testwork. Supervised trials will be conducted on the pilot plant with sample analysis carried out in local laboratories and in Australia. The following testwork is planned for the BFS phase.

3.15.2 Minerals Processing Testwork

In addition to the minor recommendations contained within each of the PFS verification reports the following activities will be included within the next phase of metallurgical testwork.

- Confirmation of optimum grind size for each grinding stage;
- Grinding circuit optimization – The potential for reduction of the grinding duty by closing the grinding circuit and having material at the target product size bypass the grinding will be investigated. This will include both laboratory sighter testwork and pilot plant trials. The impact on product grades will be closely monitored. Also included under this program will be further grindability testwork in order to provide accurate data for grinding mill sizing and Project power consumption;

- Once the grinding and magnetic separation circuits are optimised, the balance of the bulk samples will be processed according to the final flow sheet. The final concentrate produced will be provided to potential customers for sintering pot testwork;
- Magnetic separation circuit optimisation: The potential to reduce the number of MIMS units will be investigated. The impact on overall Fe recovery, Mag Fe recovery and product grade will be closely monitored;
- A mathematical concentrate grade from the Davis Tube Recovery (DTR) on each sample should be done and then compared to the DTR of the sample and also compare this with actual pilot run results; and
- A continuous pilot run with representative ore and a pilot plant configuration similar to the proposed flowsheet will be scheduled, including the use of sea water that will be used throughout the process plant.

In order to optimise the current metallurgical flowsheet TTR will:

- Evaluate options to determine if it will be viable to install separation equipment on the LIMS 1 concentrate to remove the target size material in the feed to the first grinding stage and similarly on LIMS 2 concentrate. This could have a positive impact on the grinding circuit by removing feed tonnage to the mills;
- Investigate different separation options for the removal of the +2mm fraction;
- Materials handling testwork- Samples will be collected at various stages of the pilot flow sheet for materials handling testwork (TUNRA testwork), including hydraulic conveying testing (slurry parameters), and material flow property and related tests. This work is needed to determine the key slurry parameters such as settling velocity, yield stress and viscosity. Wear rate of slurry pipeline materials will also be determined. The material flow properties of the final concentrate at the moisture level stored on the IMV as well as the FSO will be tested to provide critical data for bin and conveyor design. The transportable moisture limit will also be determined;
- Sea water trial – All pilot plant testwork to date has been carried out using potable water. A trial will be conducted to compare the pilot plant operation with sea water as opposed to freshwater to determine the extent of the influence of sea water on the process:
- Determine the dilution method, factor and effect of the process water (e.g. sea water);
- Develop a water management strategy that includes possible recycling of the filtrate from the FSO system helping in the dilution of the high total dissolved solids (TDS) and other elements in the concentrator plant; and
- In addition to the testwork above, a continuous 1tph pilot plant run will be considered in order to de-risk the final process flow sheet. Additional bulk samples will be required for a continuous run. This material could potentially be collected during tests to determine the free-flowing properties of the in-situ ore.

4 GEOLOGY

4.1 Geological Setting

New Zealand lies in the southwest of the Pacific Ocean astride a distinct belt of volcanic and earthquake activity that surrounds the Pacific Ocean. This is the Pacific Mobile Belt or "Ring of Fire" and the activity results from the structure of the Earth's crust. New Zealand straddles the boundary between the Pacific and Indian-Australian plates. To the north of New Zealand and beneath the eastern North Island, the thin, dense, Pacific plate moves down beneath the thicker, lighter Indian-Australian plate in a process known as subduction; within the South Island the plate margin is marked by the Alpine Fault and here the plates rub past each other horizontally; while south of New Zealand the Indian-Australian plate is forced below the Pacific plate. Plate movement results in volcanic activity in the North Island and in earthquakes that are felt throughout the country.

To understand New Zealand’s current geological setting and geographical features the past is the key to appreciating how this occurred and how the land and sea have diverged greatly during the geological past. The present-day shape of New Zealand is well recognised, however millions of years ago the relative positions of land and sea were quite different. Some hundreds of millions of years ago a super-continent (Gondwanaland), which included the present-day continents of South America, Africa, Australia, India, and Antarctica, existed in the southern hemisphere surrounded by sea.

The New Zealand area was situated on the edge of Gondwanaland. Since that time, movements from within the Earth have caused continents to break away from one another and move to their present positions - a process which is still continuing. The original super-continent was not stationary; it too responded to forces from within the Earth so that it was in different positions with respect to the Earth's poles at different times. Thus, at various times the fossil record and the rocks may show evidence of cold, temperate, or tropical climate.

The very oldest sedimentary rocks in New Zealand were deposited in basins lying offshore from the landmass of Gondwanaland. Subsequently the sediments were disrupted by tectonic movements and pushed up to form land that eventually became parts of Australia, Antarctica, and New Zealand. Later, an extensive series of depositional troughs developed offshore, which collected sediment eroded from adjacent continents for nearly two hundred million years. Here the "greywacke" rocks that now make up the main ranges of New Zealand were formed. This era came to a close about 110-120 million years ago when tectonic plate movements uplifted the sediments to form new land. A period of quiescence followed when erosion reduced much of the mountainous land to a low-lying, almost level plain. It was during this time that the split between Australia and New Zealand occurred.

As the land was reduced in height, low-lying swampy areas developed, which are now the sites of major coalfields. Eventually the sea started to cover the land, firstly depositing sediments in marginal basins, and later over most of the New Zealand area. Then, about 15 million years ago, the mainly quiet period ended, and New Zealand once again experienced tectonic activity, mountain building and widespread volcanic activity. In more recent geological times, the effects of rises and falls of sea level, due to alternating glaciations and warmer intervals, were superimposed on the tectonic events.

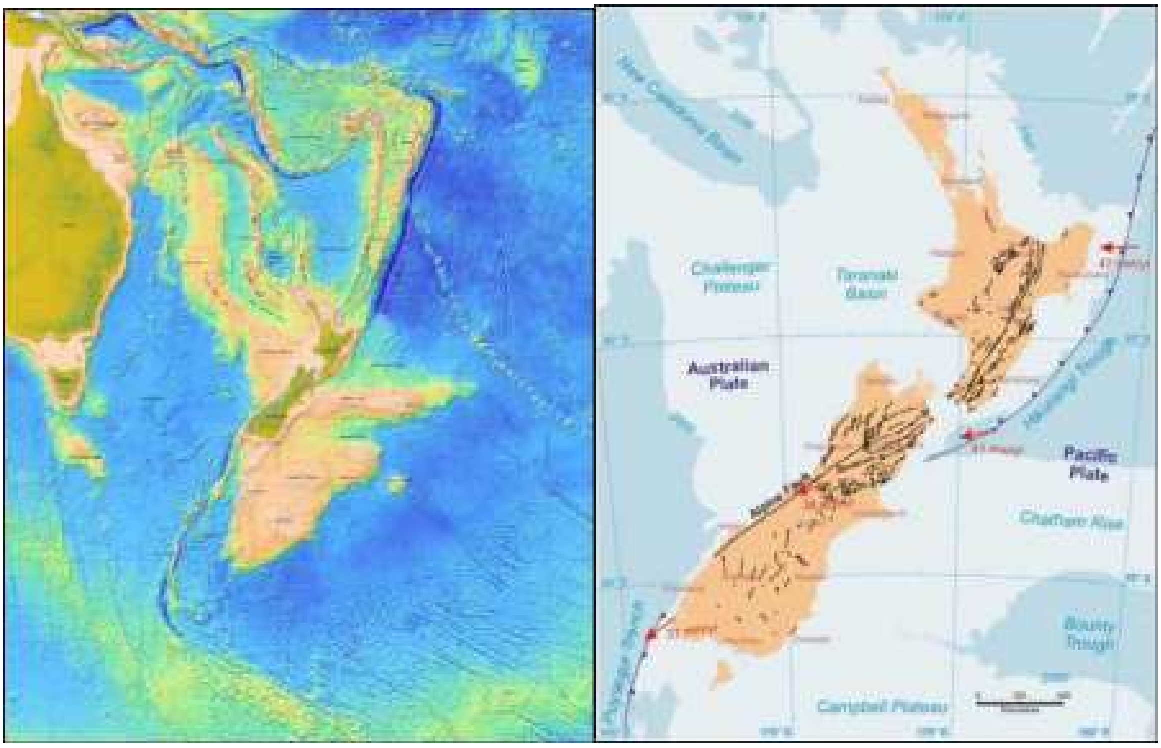


Figure 10 New Zealand's Continental Shelf and Tectonic Setting

4.1.1 Iron Sands Deposits

The nature, extent and provenance of New Zealand's onshore iron sand deposits have been well researched and investigated. Titanomagnetite iron sand forms Quaternary onshore beach and dune deposits and offshore marine deposits along approximately 480km of coastline from Kaipara Harbour in the north, south to Wanganui on the west coast of the North Island. The onshore deposits include the present beach and dune sand, and older coastal sand deposits that have been preserved by uplift due to faulting and/or lowering of sea level. This is evident with black sand beaches and dune systems along this coastline. The deposits have been well defined and in recent years attention has been given to the nature and extent of the offshore iron sand resource potential.

4.1.2 Source of Iron Sands

The liberated titanomagnetite mineral contained in iron sand deposits has been eroded from the Quaternary andesitic volcanic rocks of western Taranaki and, to a lesser degree from the rhyolitic volcanic rocks of the Taupo Volcanic Zone, transported to the coast by rivers, along the coast by shallow-marine longshore currents, and subsequently concentrated by wave, wind and tidal action into beach and dune lag deposits. Laurent (2000) investigated the dispersal and origin of the iron sands along the North Island's western coast using petrographic techniques. Shallow core samples were taken from multiple locations along the western coast in which the key tracer minerals analysed were titanomagnetite, orthopyroxene5, clinopyroxene, horneblende6 and volcanic lithics. It was ascertained that the main provenance was from the Taranaki volcanics, with the Taupo Volcanic Zone, providing a secondary input. A limited amount of material contributed also from localized, generally older volcanic outcrops and sediments. From the south to the north of Mt Taranaki, the primary variation was reflected by a decrease in the abundance of rock fragments, and an increase in the abundance of titanomagnetite, clinopyroxene and horneblende minerals. Winnowing of individual minerals was noted to happen over a short distance with a fining of grain size north and south of the primary source

Figure 11 Mt Taranaki volcano, viewed from the South Taranaki Bight, Looking North

The New Zealand offshore occurrence of iron sand has been known since the early 1960's, but estimates of the mineral resource are poorly constrained and to date remain unexploited. Scientific investigations have obtained a general understanding of the concentration and distribution of the offshore iron sand, through surface sampling. In 1980 Dr Lionel Carter presented iron sand concentration maps that show sediments containing >5% iron sand which are spatially restricted to the inner and middle shelves off Auckland, Taranaki and Whanganui. Elsewhere the iron sand concentrations are low, with the sediments concentrated under littoral (coastal) conditions that existed on the continental shelf during the Holocene transgression.

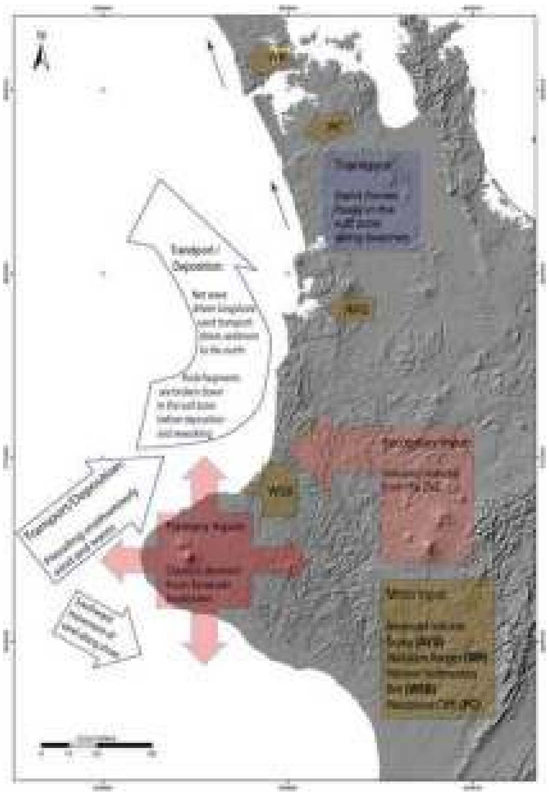


Figure 12 The Provenance and Dispersal Iron Sands off the North Island (Laurent, 2000)

4.1.3 Iron Sand Distribution

The highest reported surficial marine iron sand concentrations are typically associated with the inner shelf, shore-connected, Holocene muddy sand wedge that tapers seaward. This wedge offlaps onto an older gravelly sand unit, which is interpreted as a coarse-grained transgressive lag deposit that ranges in thickness from about 2 to 5m. The coarse grain sediments were deposited during the last marine transgression as the shoreface connected wave abrasion zone swept landwards during rising sea levels. This unit has not been covered everywhere by Holocene sediment but is subject to sediment reworking under the present wave climate. The shore connected sand wedge has accumulated largely since the stabilisation of post glacial sea level some 7,000 years ago. This unit is strongly influenced by waves and currents in the present littoral zone. Dr Alan Orpin and others describes, in a paper titled “Resource evaluation, exploration and current prospecting interests of west coast iron sands, North Island, New Zealand” the Whanganui Bight area as an area where active faults have created localized sea floor deformation and synsedimentary coarse grained post glacial infill of up to 20m thick. Generally, the distribution of the subsurface iron sands along the west coast of New Zealand is defined and their distribution and concentration influenced by a number of factors, such as current and littoral conditions, bathymetric relief and distance from the primary source.

4.1.4 Geological Model of Iron Sand Concentration within TTR Mining Area

Initial exploration targets were defined by concentrating on the higher magnetic anomaly areas and establishing the *in-situ* Fe grades through shallow and deep drilling. Drilling to date over the entire permit area has shown that the occurrence of higher grade (with an average 10% Fe head grade) iron sand to be patchy, and that a significant part of the permit area is generally covered by a "blanket" of lower grade sediment. This blanket is a combination of reworked titanomagnetite and Holocene marine sands and muds. However, within areas of the mining area there are occurrences of iron sand which have higher concentrations from the sea floor to depths of up to 11 metres.

From the interpretation of the exploration information, the geological model can be represented as an area, consisting of remnant coastal dunes that were constructed, in the same geological process as the current onshore dune deposits, at a time of lower sea levels of around 30m to 50m during the last glaciation from around 15,000 to 9,000 years ago. These paleo-dune features are part of an ancient river system in which dunes formed contemporaneous at the mouth of the river(s) and the coastline. The rivers are locally controlled by active faulting with the iron sands within the river channels and dunes partially reworked by currents and longshore drift inundated and reworked by the rising and transgressing seas over the last 7 to 8,000 years. Figure 11 shows a schematic of how the offshore high-grade deposits formed and subsequently were preserved and reworked.

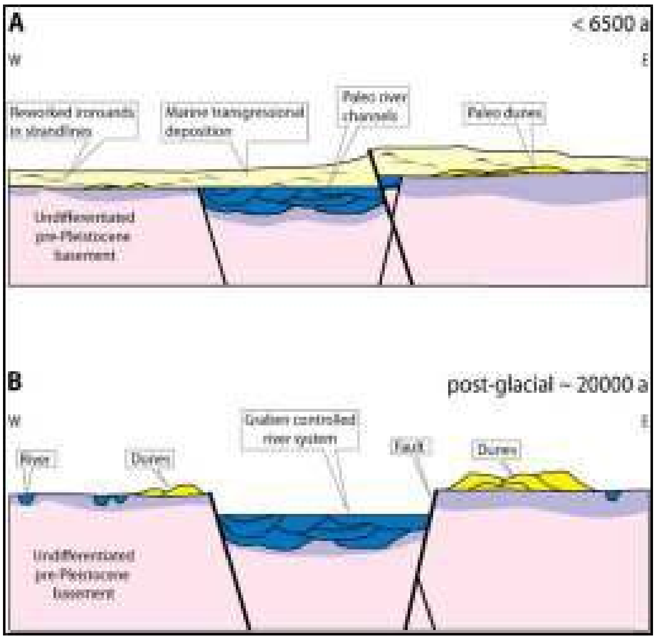


Figure 13 Geological Model Offshore Iron Sand Mineral Resource within Mining Area

Figure 14 The STB Coastline with Iron Sand Concentrate at River / Stream Mouth

4.2 Tenements

Trans-Tasman Resources have held a number of offshore mineral tenements along the western coast of the North Island, both within the South Taranaki Bight and to the north offshore Waikato. TTR were granted an offshore Continental Shelf Licence in 2014. Since the original PFS, TTR have undertaken strategic rationalisation of its permit holdings and currently has two offshore mineral permits, Mineral Mining Permit MMP55581 covering 24,257 hectares (242.57km^2) outside the 12Nm limit in the EEZ and Mineral Exploration Permit MEP54068 covering 63,504 hectares (635.04km^2) inside the 12Nm limit within the Coastal Management Area (CMA).

New Zealand approvals for the Prospecting, Exploration and Mining of Crown owned minerals resources is administered by New Zealand Petroleum and Minerals, (division of Ministry of Business, Innovation and Employment or MBIE). TTR's mineral rights are assessed and granted under the Crown Minerals Act 1991.

In January 2025, the New Zealand Government released its Minerals Strategy to 2040, in which it outlines the guiding principles and outcomes for the development of critical minerals. As a critical mineral, TTR's development of the vanadiferous titanomagnetite iron sands concentrate meets the current New Zealand Government Minerals Strategy, of ensuring a stable and secure supply of vanadium, for which the New Zealand Government have identified as crucial for supporting infrastructure development and advancing energy storage technologies, particularly as New Zealand transitions to cleaner, more sustainable energy sources.

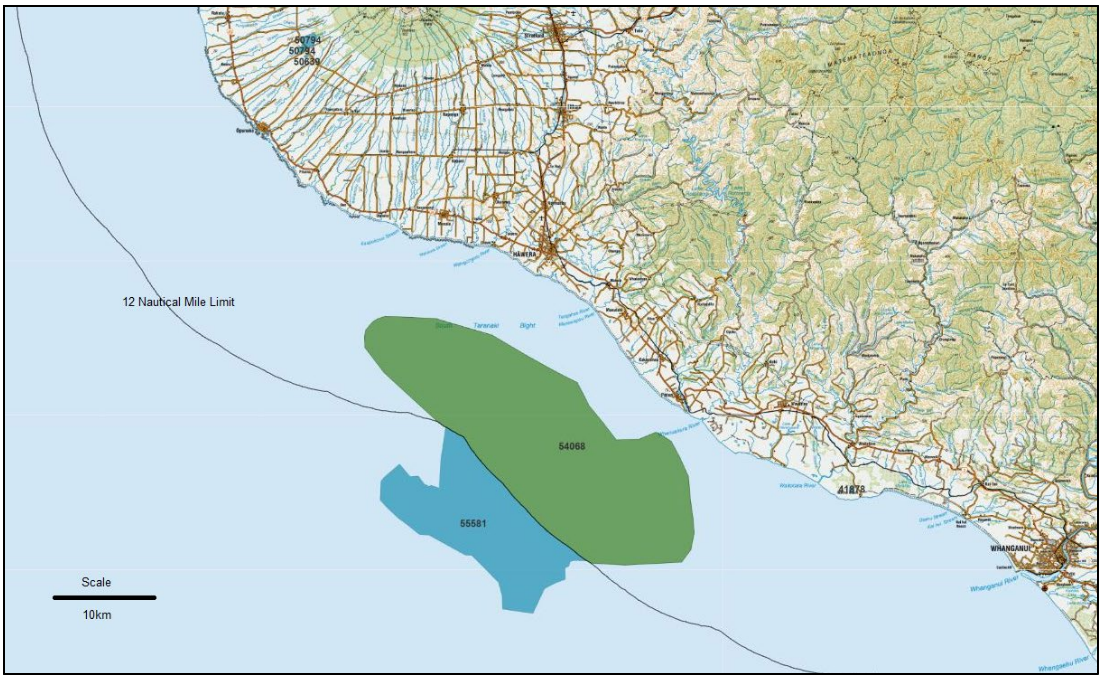


Figure 15 Location of TTRs Mining and Exploration Permits

Table 23 below lists the details held for the two permits held by TTR. Full license permit documents for MMP55581 and MEP54068 are presented in Appendix 19.15. An overview of New Zealand's regulatory regime is included within Section 13 of this report.

Number:	55581	54068
Commodity:	Minerals	Minerals
Type:	Mining Permit	Exploration Permit
Owners:	Trans-Tasman Resources Ltd	Trans-Tasman Resources Ltd
Location:	Taranaki	Taranaki
Operation Name:	Offshore Taranaki	
Status:	Granted	Granted
Granted:	2/05/2014	19/12/2012
Duration:	20 years	13 years
Expires:	1/05/2034	18/12/2025
Area:	24257 Ha	63503.647 Ha

Table 4 TTR Permit Details from New Zealand Petroleum and Minerals (NZ Government)

4.3 Mineral Resource Exploration

4.3.1 Airborne Magnetic Survey

Fugro Airborne Services were commissioned by TTR to undertake an extensive airborne magnetic survey. From this survey, over 55,000-line kilometres of aerial magnetic data was acquired. Fugro Airborne Geo-services then undertook filtering and interpretation of this data to target sub-surface sampling locations.

The aeromagnetic data clearly shows paleo-geomorphological features, such as channel, river mouth, beach dune deposits and possibly river deltas. From this data it is modelled that during the period of low sea levels, ancient river channel and river mouth systems were the locality for iron sand concentration. Further concentration occurred in this setting through longshore drift and tidal action, with dunes placed and potentially sorted through aeolian accumulation. With the marine transgression, the encroaching surf zone would have partially destroyed these dune systems. Eventually silt, sand and reworked iron sand were deposited on these features. The sub surface iron sands located further offshore are those of discrete locations that coincide with the paleo shorelines (during periods of stand still circa 7k yBP and 9K yBP) and the migration of the shoreline, due to marine transgression to the current sea level.

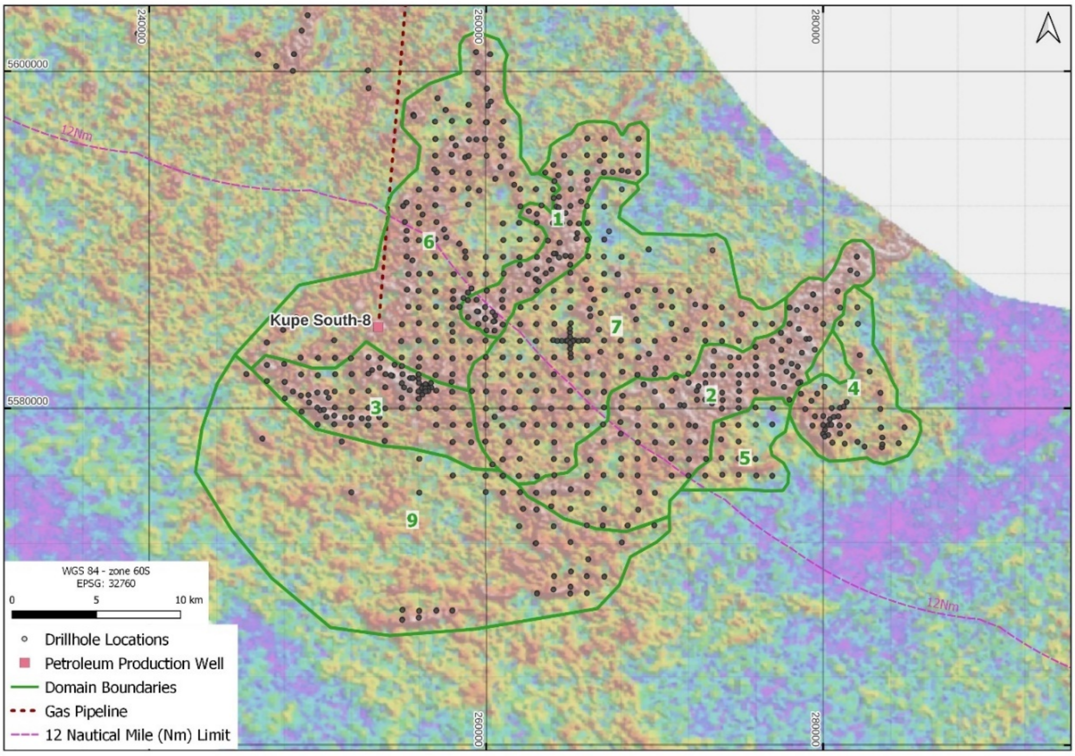


Figure 16 Airbourne Magnetic Anomalies Over the Taranaki VTM Project Area

4.3.2 Drilling

Early in the company’s life, TTR investigated different drilling and sampling methods for seabed drilling. Globally nothing was considered to be a cost-effective drilling technology that could meet all of TTR requirements. TTR began a long and innovative process of design, construction and development of proprietary drilling technology. With the input from an experienced offshore drilling contractor, TTR now has the technology to rapidly obtain cost- effective and representative samples at depth. This has enabled a JORC resource to be defined within TTR’s permits.

Two different submersible rigs have been developed to obtain the sample, a shallow system (<9 m drill string) and a deep drilling system (up to 42 m) with their applications depending on the number of holes required, water depth, and desired target depth. Both drilling rigs have a purpose-built LARS (Launch and Recovery System) to ensure safe launching and retrieval of the rig.

4.3.3 Shallow Drilling

The shallow drilling rig is controlled remotely from a vessel using a system of electric and hydraulics. The shallow drill system utilises a passive (non-mechanical cutting drill head)

Reverse Circulation (RC) drilling is the preferred method of recovering representative samples from below the sea floor. Samples are taken as composites over 1 metre intervals.

A hydraulic ram is used to control the descent of the drill string and again to pull the drill string from the hole. The whole process is monitored by two cameras stationed on the rig. As this rig does not require diver support it can be deployed in water depths of up to 60m (with the ability to go deeper if necessary). This is a single pass drilling system, so the maximum penetration depth is 11m below the sea floor.

The drill works using a triple tube system, with high pressure water, up to 500psi, pumped down the outer tube, which jets out of the end disturbing the sand and creating slurry. High pressure air between up to 220psi (350cfm) is pumped down the second tube, which in turn creates a venturi effect. The venturi lifts the slurry up the center tube and into a cyclone diffuser on the deck of the vessel, where it is collected in marked poly-weave bags.

The driller watches the drill penetrating the sea floor and directs the crew collecting the sample when to change bags (as each meter mark passes by).

This rig is extremely fast and cost-effective on a shallow resource, consistently drilling up to 8 holes to 9m depth in a 12-hour day. The rig also provides an effective bulk-sampling tool (<3 tonnes), having the capacity to collect several tonnes in a matter of hours.

Figure 17 TTR 11m Shallow Rig on Display at the Sample Warehouse

Figure 18 Launching of the Shallow Drilling Rig, 2011 Drilling Programme

4.3.4 Deep Drilling

As with the shallow drilling, the deep drilling rig has also been built as a Reverse Circulation (RC) drill. RC is the preferred drilling method, as this method can be carried out more effectively and potentially quicker than other drilling methods.

The deep drilling rig, developed in 2012, uses a combination of compressed air, drill fluid injection, rotation and downward pressure to retrieve slurry of sample from below mud line (BML). The bottom hole assembly (BHA) is a tri-cone roller bit, which allows penetration through alternating layers of sediment. The slurry sample travels from the rig to a cyclone diffuser on the vessel, via a return sample hose. The depth BML is monitored by the diver and the expert driller on the vessel with samples taken at 1 metre intervals.

The drilling is physically controlled by a diver on the drill platform who is directed by an expert drill supervisor located on the vessel, watching and communicating with them through standard SSBA communication equipment. Drilling is limited to dive time, which can be increased if decompression chambers are used.

Figure 19 Deep Drilling Rig on the PMG Pride During the 2013 Deep Drilling Programme

The deep drill rig was developed and deployed with the ability to drill up to 42m. This rig is diver operated on the sea floor. The rig uses a similar system to a land-based RC drilling rig carrying six removable drill rods in a carousel.

The deep drill rig and divers are connected to the service vessel by umbilical. The drill rig compressor and pump are on the service vessel and all samples are returned by bull hose to a cyclone on the deck. The system includes full video contact between the sea floor rig and the boat. Divers also have video and audio contact with the surface crew. Drilling is monitored by a drill supervisor on the service vessel.

4.3.5 SPT Drilling

In March 2013, TTR undertook geotechnical drilling in the Cook North area to determine the insitu geotechnical characteristics of the seabed material, at depth. This was required to determine the dredging effort required to extract the seabed sediment. TTR engaged OCEL Consultants Limited and NZDS to provide a reliable SPT N value to assist with the crawler design and breach testing. The investigation and report determined that the seabed material was considered dense to very dense, and that cutting action would be required with the SBC design. The report is appended to this PFS.

Figure 20 Deep Drill Rig on PMG Pride During the 2013 Drilling Programme

Figure 21 Collection of Drill Samples from Deep Drilling

Figure 22 Diver Preparing for Deep Drilling

4.3.6 2D Seismic Survey

TTR sought to gain better understanding of the geometry and geology of the sedimentary wedge within which iron sand-rich deposits occur. This sediment wedge overlies the massive siltstone/bioclastic, limestone and pebble sandstone unit of the Whenakura Group (locally called *papa* or basement). The basal contact of the sedimentary wedge with this massive mud/siltstone is a critical contact and was believed to be a strong reflector which would allow TTR to determine the true thickness of the sand wedge, allowing a more definitive volumetric assessment of any potential resource.

Two surveys have taken place, the first in August 2011 on NIWA's 14 m catamaran, RV *Ikatere*. This boomer study consisted of 20 seismic profiles, cumulating to total length of approximately 140-line kilometres, acquired over 28 hours of survey time. The water depth across the survey area ranged between ~30 to 55m. The data acquisition for the second seismic survey was completed on the 28th of February 2013, for an additional 20 lines at a total of approximately 140-line kilometres.

For both surveys the seismic source was a 300 Joule Applied Acoustics AA201 Boomer plate mounted on a CAT200 catamaran. For completeness, two receiver arrays were used: a Geoeel digital streamer and a Benthos analogue streamer. The Geoeel consists of 16 channels with a 1.5625m group interval, and 2 hydrophones per group. The horizontal offset between source and the Geoeel first channel was set to 10m. The Benthos 15/10S single-channel array was towed 4 to 5m directly behind the boomer source. The Benthos array consists of 8 hydrophones with a 300mm spacing connected in series.

Seismic processing was undertaken using Globe Claritas software. The processing routine included trace editing, quality control, source-receiver geometry setting, de- convolution, de-spiking, swell and band-pass filtering, staking, and post-stack de- convolution

The data was not tide corrected. Tide correction is usually only required when true depth below the sea surface is needed and was not required for this pilot study.

Swell filters were applied to all profiles following a protocol developed in house, as follows:

- Reflector was digitised on screen. Overall, the seismic surveys have successfully demonstrated the potential of high-resolution boomer seismic to provide valuable geological information, such as the sub-sea floor geometry of sedimentary units and the spatial extent of deposits;
- A 1-D time-series filter was applied using a window of 35–55 traces (equivalent to 25-40m filter length) to the digitised sea floor function. Different filter lengths were tested; and
- The residual function generated was applied as a static shift to each trace.

In some cases, swell corrections were applied twice when deemed necessary. Rare spikes and extremely high amplitude, low-frequency noise, in seemingly random places of the time section, required the application of a de-spiking algorithm to all shots. This is common practice and proved efficient. The final processed data were saved in standard SEG-Y format, with the trace relative position expressed as shop-peg in position 17-20 in the 240 bytes trace.

Processing was extremely beneficial to the quality of the seismic sections. The raw data are dominated by a very high frequency content that masks some useful signal indicative of geological reflectors. Although the processed data did not show better penetration, the overall resolution, coherence and clarity of the seismic profiles vastly improved after processing, as can be seen in the Figure 21.

On some profiles, the processing resolved seismic horizons below the primary multiple. The first 5-8ms immediately below the sea floor are often masked by the seismic-source signature, evident as a very-high amplitude and low frequency sea-bottom reflector. A ghost reflection also occurred within the first 10m.

Penetration (resolution at depth) and resolution of geological reflectors is usually very good down to the primary sea floor multiple, i.e. approximately 40ms below sea floor for most lines (which equates to approximately 30-35m).

Typically, seismic resolution of coherent reflection is often masked by the apparition of the very strong primary sea floor multiple within the first 40ms below the sea bottom reflection, depending on the water depth. However, for the current survey some lines (107, 117, and 118) yielded better resolution below the primary multiple, which indicates that strong coherent reflectors immediately below the primary multiple can be resolved with the present acquisition/processing settings. Some of these deeper reflectors could be geologically useful.

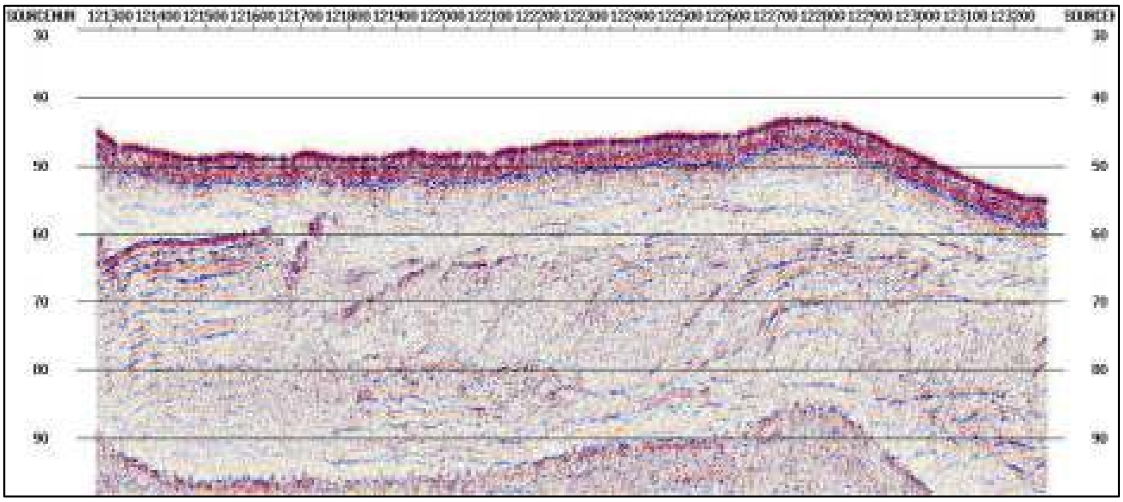


Figure 23 Processed Seismic Line Showing Sub-surface Infilling of a Paleochannel

4.4 Mineral Resource Estimation

Golder Associates Pty Ltd (Golder) was initially commissioned by TTR (TTR) to assist with the development of TTR's Taranaki VTM project in New Zealand in 2009. In 2010 an *in-situ* maiden resource of 1,040Mt at 8.40% Fe_2O_3 was defined. Since the in-situ maiden resource TTR has released five resource estimation updates, which reflected the ongoing drilling, advancements of the drilling technology and pilot plant processing and sample analysis used to define and update the mineral resource block model.

TTR's Taranaki VTM Project Mineral Resource Statement dated 1 March 2023is presented in Appendix 19.16 which details the latest updated mineral resource estimate and includes drilling results, QAQC and statistical analysis of the drill data reported. The main update to the original sample analysis and data set is the addition of Davis Tube Recovery results and concentrate assays for the proposed mining blocks.

Golder Associates undertook the independent analysis of TTRs drilling technology, sample collection and sample analysis procedures, to ensure that TTR can report in accordance with the JORC Code 2012. Golder provided practical experience in all aspects of ongoing design, planning of the TTR mineral exploration and mineral resource estimation, from which it was able to build its working resource block model.

4.4.1 Analytical Reporting

The TTR resource is a vanadiferous titanomagnetite ($Fe_{2.74}Ti_{0.24}V_{0.02}O_4$) iron sand deposit. Titanomagnetite is $Fe^{2+}(Fe^{3+},Ti)_2O_4$ pure magnetite is Fe_3O_4. The analysis process reduces all compounds to oxides and reports these. For head samples standard analyses return iron results as Fe_2O_3 (hematite), Fe is calculated from the stoichiometric ratios of Fe to O in the Fe_2O_3. For Davis Tube Concentrate sample analysis iron grades are reported as Fe.

TTR has estimated and reported the Fe_2O_3 content for the head grades and Fe for the DTC grades of the deposit based on the analytical results.

In historical documentation TTR have reported TiFe. The TiFe (Titanomagnetite) content of the deposit can be back calculated from the Fe_2O_3 content based on the assumptions and stoichiometric formula.

4.4.2 Site Visits

Representatives from Golder Associates visited the TTR project from 28 to 31 January 2010 and in July 2011. The purpose of the visits was to review the project status, drilling technology and sample recovery, audit the analytical laboratory and review the pilot plant operation.

In 2012 Stephen Godfrey and James Farrell (Associate, Senior Geologist) visited the TTR Wellington office and Porirua warehouse from 24 to 27 July.

4.4.3 Drilling

TTR has undertaken a number of offshore sampling programs using the services of New Zealand Diving and Salvage (NZDS). The programs have included sediment grab sampling, resource drilling (using the 5, 9 and 11m drilling rigs), bulk sampling and geotechnical drilling. Preliminary investigation commonly involved lowering a magnet to the sea floor to identify the presence of magnetic minerals. Within the Permit areas the return of magnetic sands from this process is almost ubiquitous. These grab samples, however, are non-representative of the deposit and so they have not been used in any analyses or estimations.

In partnership with NZDS, TTR developed a drill sampling system capable of sampling the first 5 to 6 metres of the seabed. The initial drill rig was diver operated on the sea floor. The drilling employs a passive triple tube reverse circulation system. In December 2010 the system was upgraded enabling it to be hydraulically controlled from the surface with diver support if necessary. In September 2011 the system was further upgraded and can now drill to a maximum depth of 9 metres, and in 2014 extending drill capabilities to 11 metres. The drilling rig is transported to the drill site by service vessel and lowered to the sea floor.

The original system was diver operated and restricted to operating in less than 25m of water. Below this depth decompression is required for the diver to return to the surface. The service vessels do not carry decompression chambers. The upgraded system can operate in deeper water, with the deepest hole to date at 65m water depth.

The original diver supported 6m system was used to drill the first 148 holes. A further 364 holes have been drilled with the diver-less system. The remaining drill holes in 2011 were drilled with the upgraded 9m system.

In 2012 a new rig was developed and deployed with the ability to drill up to 42m. This rig is diver operated on the sea floor. The rig uses a similar system to a land-based RC drilling rig carrying six removable drill rods in a carousel. Six holes have been drilled with this system.

The drill rig and divers are connected to the service vessel by umbilical. The drill rig compressor and pump are on the service vessel and all samples are returned by bull hose to a cyclone on the deck. The system includes full video contact between the sea floor rig and the boat. Divers also have video and audio contact with the surface crew. Drilling is monitored by a drill supervisor on the service vessel.

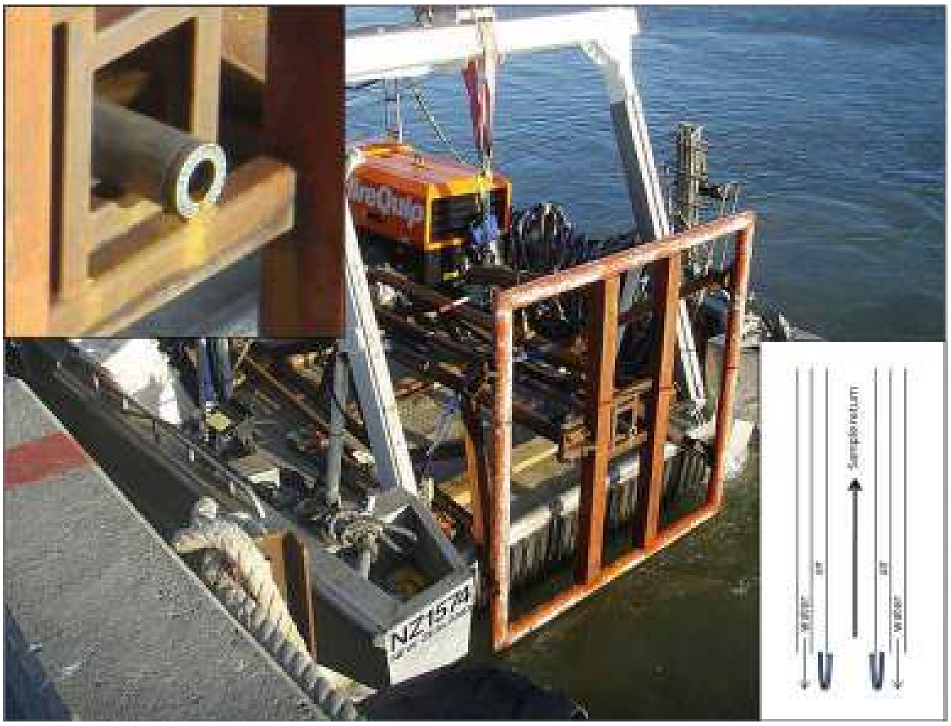


Figure 24 Drill Rig on The Shoman. Inset - Bit Detail and Circulation Diagram

Figure 25 Cyclone and Sample Collection

The complete drilling and sampling system has been constructed by NZDS. In order to ensure the effectiveness of the drill system and the veracity of the samples, in 2010 a Golder representative spent a day on the service vessel the *Shoman* and observed the drilling of three holes in the Graham Banks area.

The drill system uses a 75.75mm OD bit and 75mm OD pipe (approximately NQ). The drill used a single rod with a 6m stroke. On the sea floor the diver releases the drill rod which penetrates under its own weight with most of the work being done by the hydraulic cutting action of the bit. Water is pumped down the outer tube and air down the inner tube with angled jets creating both a cutting and venturi-type effect to raise the sample. Drilling through sand is quite smooth and effective. If the drill encounters shell beds penetration may be physically stopped. Originally, a blast of air was used to get through shell beds however, this resulted in abnormally large samples as the blast created a cavity which then collapsed.

Golder advised that these air blast samples should be flagged in the database and not used for any resource analysis work. The system later employed a hand operated winch and now uses a hydraulic system to exert down force on the drill rod to assist in penetrating shell beds.

The returned samples were collected from the base of a cyclonic separator. The size of the samples is normally consistent with the size of hole being drilled. When the downward progress of the drill is stopped the system returns clean water to the cyclone indicating there is no contamination from material inflow and that the drill is returning only material from the drill hole.

The drill system will have some issues with larger particles not returning in the system as there is no cutting bit to break them up. These larger particles make up a very small proportion of the material being sampled and should not have a significant impact on the resource. The envisaged dredging/processing system that would mine a deposit like this would screen out anything larger than 2 mm, so any contained mineralisation has no material impact on the resource.

The Spectrachem laboratory was visited in 2010 and 2012. The sample processing and analysis system was inspected during both visits, with the 2012 visit focusing on the DTR samples. In both instances the laboratory was observed by Golder to be performing as expected.

Figure 26 Mobilisation of the Deep Drill Rig

4.4.4 Sampling

Samples are bagged, labelled clearly and stored on deck until the return to harbour. A preliminary log of the samples is made while at sea and a magnetic susceptibility reading taken.

All samples are temporarily stored in Wanganui Port before being transported to the TTR Porirua warehouse. At the warehouse the samples are dried and split into eight. One split is sent for chemical analysis and another for geological logging. A field magnetic susceptibility reading is taken from chemical analysis sample. The remaining splits are re- bagged and stored.

Chemical analysis (head sample) is sent to Spectrachem for XRF analysis and returns the analysed suite to TTR. For the 2010-2011 drilling the drill samples were logged by the National Institute of Water and Atmospheric Research (NIWA). Subsequently, all drill samples have been logged by TTR geologists.

The laboratory screens the sample to remove all material greater than 2mm in diameter and records the percent recovery. This material is predominantly shells and pebbles and is regarded as barren. The laboratory analysis is performed on the sub-2 mm material. The final model results need to take this into account. The model estimates the full volume and tonnes of the deposit so the estimated grades need to be diluted by the recovery.

In 2012 selected samples were sent for Davis Tube Recovery (DTR) Analysis. The selected samples were from existing and any new drill holes in the proposed mining area. DTR analysis determines the magnetically recoverable portion of the sample by passing the sample through a high intensity magnetic field. The recovery is sensitive to the equipment set-up including particle size and magnetic intensity. The overall set-up is designed to emulate the eventual processing plant recovery but is at a laboratory scale. Some scale up factor may eventually be required in estimating an ore reserve. The recovered magnetic concentrate undergoes XRF analysis and returns the analyte suite as listed in the resource estimation tables. Note that the concentrate iron analysis returns Fe and the head analysis Fe_2O_3.

Figure 27 Davis Tube Device

4.4.5 Pilot Plant

As part of the resource validation process the metallurgical pilot plant was observed operating during Golder's 2012 site visit. The pilot plant, a scaled down version of the anticipated final processing plant, was located at the TTR Porirua warehouse. Multiple bulk samples have been collected from the proposed mining area for the pilot plant testwork. The samples were obtained using the exploration drill rig. The pilot plant screens the sample at +20mm then +2mm with the sub-2mm fraction going through a first pass Medium Intensity Magnetic Separation (MIMS) and Low Intensity Magnetic Separation (LIMS).

The recovered concentrate is ground by ball mill to 53μm (P80) and run through LIMS three times producing a final concentrate. JORC Code 2012 in defining a Mineral Resource requires that "there are reasonable prospects for eventual economic extraction". The successful production of concentrate by the TTR pilot plant demonstrates that it is possible to recover titanomagnetite from the TTR South Taranaki Bight iron sand deposits.

Golder was provided with comprehensive GIS data set and the geological drill hole database. Topographic and bathymetric data was extracted from the GIS data set along with miscellaneous geographical information, e.g. coastlines, rivers and place names. The GIS data set also included magnetic geophysical imagery. TTR also provided documentation for their drilling, sampling and database procedures.

4.4.6 Drilling for Mineral Resource Estimation

On 1 March 2023, TTR updated its mineral resource statement and released it to the ASX including a maiden vanadium resource. The updated resource estimated was based 689 drill holes, with the analysis of 4,237 head samples, 1716 Davis Tube Recovery (DTR) and Davis Tube Concentrate (DTC) analysis. The diagram below illustrates the locations of the drill holes used in the resource estimate.

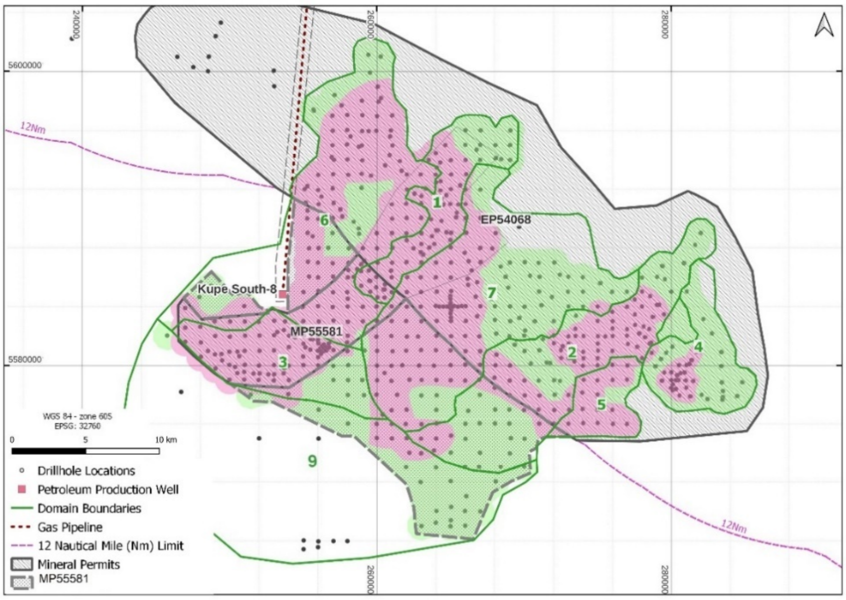


Figure 28 Drilling Locations - TTRs VTM Iron Sand Deposit

The 2023 resource estimate updated the naming convention for the TTR resource in the South Taranaki Bight. This was to reflect the updated mining permit area and reflect the boundary of the identified resource. Figure 26 shows Inferred (green area) and Indicate (pink area) resources.

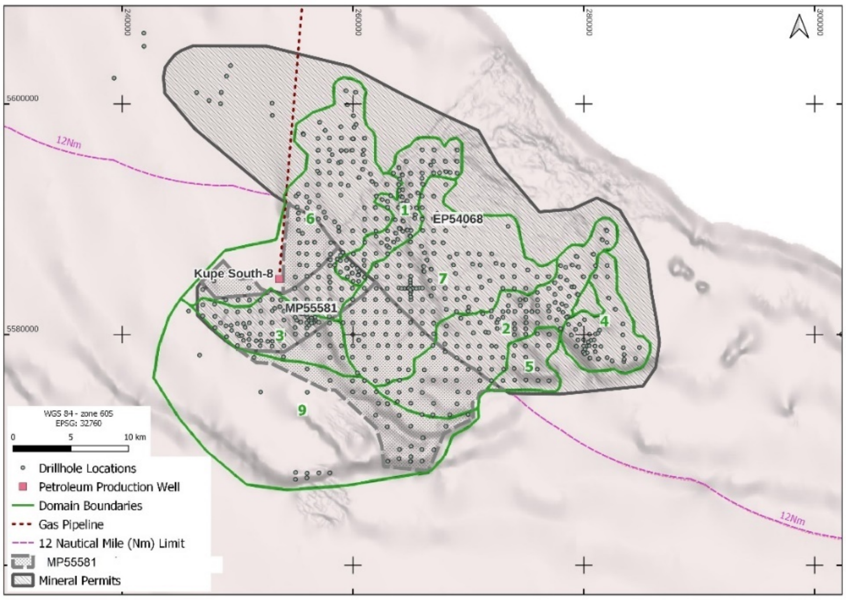


Figure 29 Domains Used in the 2023 Resource Estimation

Area	Drill Holes	Head Samples	DTR Samples
Cook North	121	1100	1000
Cook South	90	450	256
Kupe North	58	342	228
Kupe South	19	170	155
Tasman North and South	401	2175	77
Total	**689**	**4237**	**1716**

Table 5 Overview of the Drilling Used in the Mineral Resource Estimation Model

4.4.7 Density

Mineral Resource and Ore Reserves, although typically stated in terms of grade and tonnage, are estimated in terms of three parameters: grade, volume and density. Tonnes are the product of volume and density so for good estimation of the resource tonnes a reliable density value must be used for the deposit being evaluated. For a resource estimate the *in situ* dry bulk density is required to estimate the *in-situ* tonnage of the deposit. A detailed analysis of the available density data was undertaken previously by Golder in 2010. From this work the *in-situ* bulk density was defined using the Fe regression developed from the calculated theoretical bulk density corrected for measured results. The dry bulk density is calculated by the formula $((Fe_2O_3 *0.6994)+81.191)/51.064$ where Fe_2O_3 is 69.94% Fe.

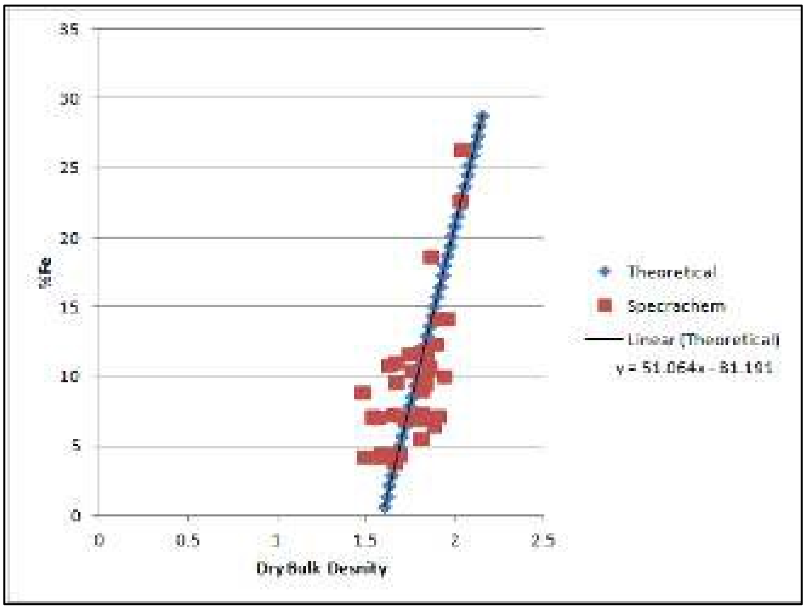


Figure 30 Dry Bulk Density Regression Against Fe

With consideration of the potential compaction of the sand and minerals other than quartz making up the non-magnetic portion of the sand Golder considers these bulk densities are likely to be slightly conservative. At the time of the PFS write up a review of the *in-situ* bulk density was undertaken. TTR believes that the *in-situ* bulk density used to estimate the mineral resource has potentially underestimated the bulk density by approximately 8% to 10%. This updated assumption on density will be assessed and if ascertained will be corrected and reported as part of the company completing the BFS and releasing a new JORC compliant Resource Statement and Ore Reserve.

4.4.8 Metallurgical Recovery

In the mineral sand industry, the mineralogy and quality can be secondary considerations to the recoverable percentage of heavy mineral. Magnetite and mineral sand deposits are commonly reported with a recovery. For deposits containing magnetically recoverable minerals DTR analysis provides this information. The recent DTR analysis by TTR now provides recoverable resource figures for the proposed mining area. The TTR pilot plant work provided plant recovery and efficiency figures.

4.5 Mineralisation

Iron sand deposits of New Zealand are comprised principally of silica sand with minor dark green clinopyroxene, black orthopyroxenes, hornblende and titanomagnetite (Orpin, 2010). In addition to the sands the samples commonly contain up to 15% shells and pebbles. Work to date has indicated that the only magnetic mineral present is titanomagnetite.

The mineralogy and chemical analysis suggest that most of the Fe content of the sands is in the vanadiferous titanomagnetite ($Fe_{2.74}Ti_{0.24}V_{0.02}O_4$). Plotting the FeO:Fe_2O_3:TiO_2 ratios identifies the mineral species as a titanium enriched magnetite.

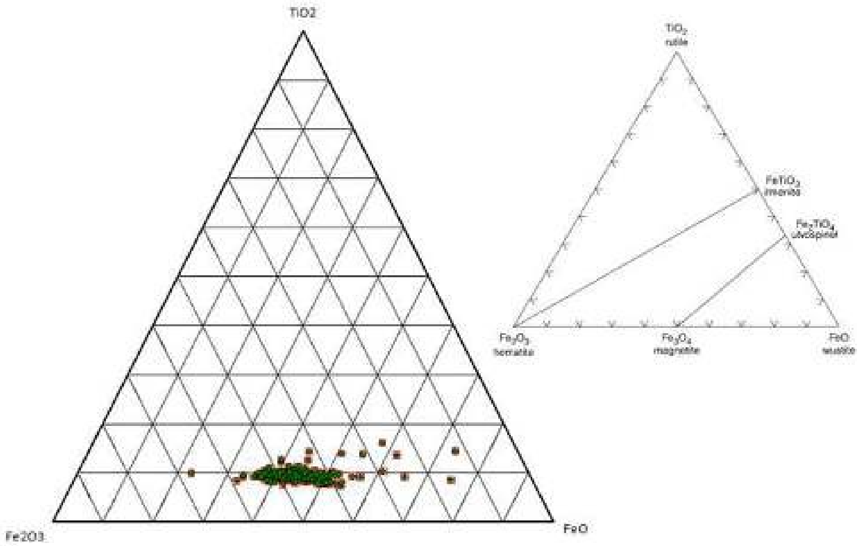


Figure 31 Fe_2O_3-FeO-TiO_2 Ternary Plot

4.5.1 Geological Model

The original geological model used to target drilling assumed higher grade VTM material would be intersected where the geophysics showed a higher magnetic response.

Statistical and visual analysis of the drill hole sample data showed that the samples were relatively consistent across most locations with only a small high-grade population. This conflicted with the anticipated result of getting higher Fe grade samples where the geophysical survey showed higher anomalous magnetic responses.

The geological model was revised to include a layer of overburden covering magnetic the features being observed in the geophysical survey imagery. A blanket of reworked sands explains the relatively consistent results from the shallow drilling.

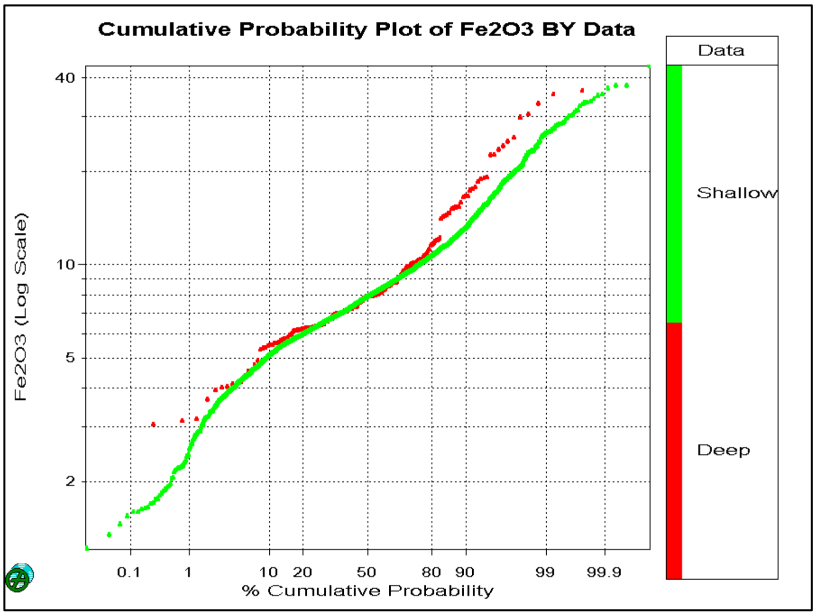


Figure 32 Fe_2O_3 - All Drill Holes

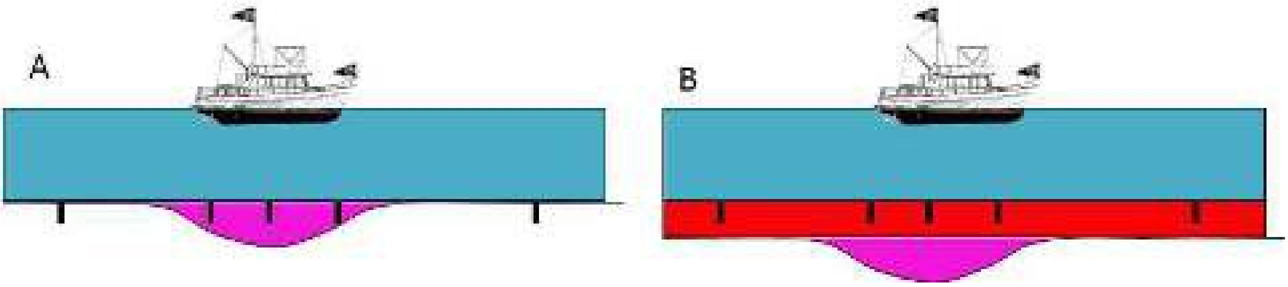


Figure 33 Geological Model

Statistical analysis also showed that the total population had an average grade in excess of that defined by TTR as the minimum grade required by the preliminary business model. This being the case a resource model was constructed to determine quantitatively the potential of the 'overburden'.

The deep drilling has shown the sands to be up to 30m thick, however, the limited dataset does not assist with the geological modelling.

4.5.2 Domains

The geological model has defined an overburden layer of sand which is different to the underlying geomorphological features. However, these overburden sands are reworked from the material making up these underlying features. Based on this, a series of broad domains were defined over the area sampled by the drilling. These are illustrated below. The old river channels are defined as fluvial zones, Graham Banks is defined as dunes and the linear features further offshore in Domain 9 are interpreted as slumps. The remaining northern areas are defined as deltas and Koitiata as paleo beaches.

The domains were further refined to limit the extent of the influence of any particular drill hole to approximately 1,000m horizontally. This was done in order to stop an unreasonable volume of material receiving an estimated grade in the block model. The 1,000m extrapolation is based on the drill spacing of 2,000m required for an Inferred Resource in this deposit.

The cumulative log probability plots for domains in Area 2 (the larger red box, in Figure 33) in the deposit and shows that there are statistical differences between the domains supporting the approach taken. Koitiata (Domain 8) is a single geographically separated from the Area 2 domains.

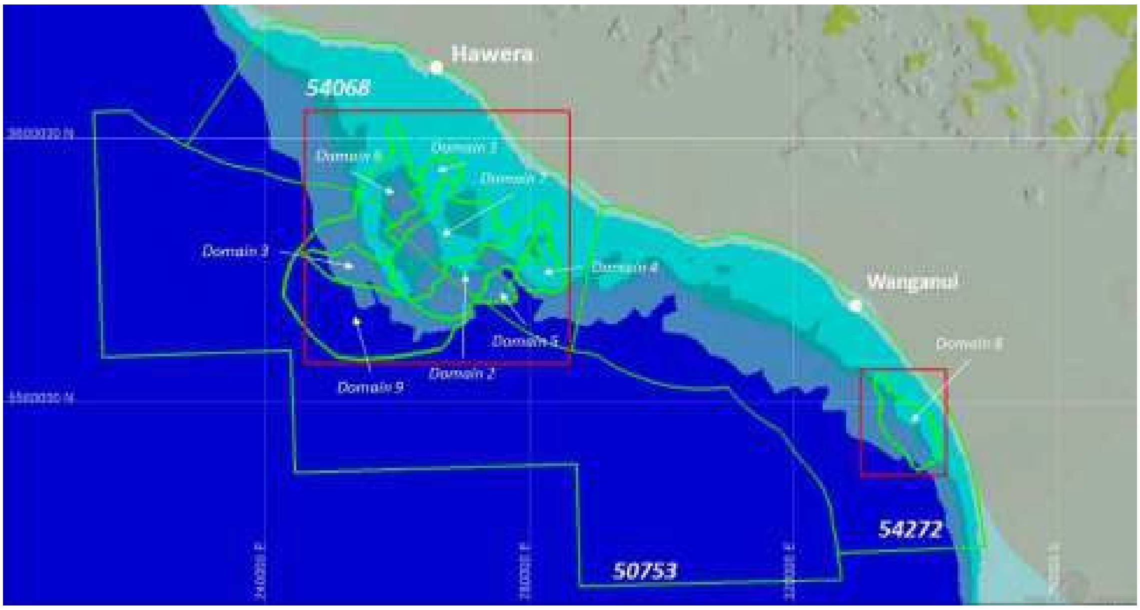


Figure 34 Resource Domains Defined by Golder Associates

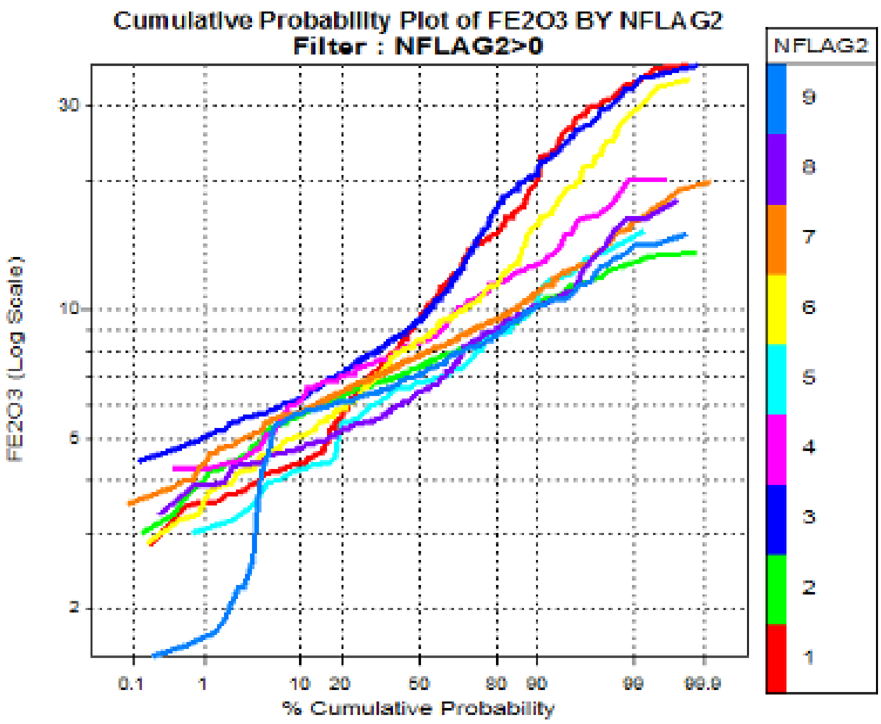


Figure 35 Cumulative Probability for Fe_2O_3 by Resource Domains

In addition to the geomorphological (spatial) domains, a mineralised zone was applied where all samples greater than or equal to 4% Fe_2O_3 were included in the mineralised zone. The break in the population at 4% can be seen in the above graph. To define the lower boundary of the mineralisation an intersection selection method was used to generate composites of the drill hole sample database using a 4% target with a maximum of 2m internal waste. As the proposed mining method of dredging will not be removing waste separately, overburden was blended into the selection. Multiple intersections were manually assessed to determine where to define the base of mineralisation by either incorporating the subgrade material or raising the base of mineralisation.

4.5.3 Resource Estimation

The TTR VTM offshore iron sand resource estimates are reported in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC, 2012). The latest 2023 mineral resource estimate was prepared by employees of Siecap NZ Ltd and Trans-Tasman Resources. The 2015 (updated by TTR and Golders) and 2023 resource estimation used MicroMine software, using the Golder Associates parameters for the basis of the modelling, i.e. base of mineralization, domains and cutoff grades.

The most significant difference between the previous models and reporting and 2023 models is the reporting of the vanadium and titanium resource estimates, the area extension of land for Mineral Mining Permit MMP55581 and the delineation and reporting of the Cook, Kupe and Tasman VTM deposits separately for each of the North Blocks inside the 12Nm limit within

Mineral Exploration Permit MEP54068 (RMA approval area) and the South Blocks outside the 12Nm limit within Mineral Mining Permit MMP55581 (EEZ approval area). The March 2023 Mineral Resource Statement is presented in Appendix 19.16.

The resource estimates were classified in accordance with JORC Code 2012 as Indicated and Inferred based on drill holes available as of 2015. The Indicated and Inferred mineral resources for the Cook, Kupe and Tasman north and south blocks are presented in Table 5.

Taranaki VTM Resource Classification						
	Indicated and Inferred Mineral Resources					
VTM Deposit	**Cut-Off Grade**	**Mt Ind**	**Mt Inf**	**Mt Total**	**% Ind**	**% Inf**
Cook North Block	3.5% DTR*	225.9	48.3	274.2	82%	18%
Cook South Block	3.5% DTR*	864.9	49.6	914.4	95%	5%
Kupe North Block	3.5% DTR*	134.4	282.3	416.7	32%	68%
Kupe South Block	3.5% DTR*	238.2	33.6	271.8	88%	12%
Tasman North Block	7.5% Fe_2O_3	294.9	289.6	584.5	50%	50%
Tasman South Block	7.5% Fe_2O_3	315.0	380.1	695.1	45%	55%
Total VTM Resource		**2,073**	**1,083**	**3,157**	66%	34%
Cook	3.5% DTR*	1,090.7	97.8	1,188.6	92%	8%
Kupe	3.5% DTR*	372.6	315.9	688.5	54%	46%
Tasman	7.5% Fe_2O_3	609.9	669.6	1,279.6	48%	52%
Taranaki VTM Resource Total		**2,073**	**1,083**	**3,157**	**66%**	**34%**

Table 6 Taranaki VTM Project Reported Indicated and Inferred Mineral Resources 2023

The JORC classification of Indicated and Inferred resource categories for the reported 1.881Bt VTM resource for the Cook, Kupe and Tasman South Blocks, outside the 12Nm limit within MMP55581, are presented in Section 3.5, Table 2. The 1.881Bt resource comprises 1,418Mt, or 75%, Indicated and 463Mt, or 25%, Inferred resource categories. The physical recovery has been applied to the models. Head grades and tonnages are for all materials less than 2mm in diameter. Concentrate grades are for the magnetically recoverable portion of the sample. Concentrate tonnage is calculated from the head tonnage and DTR.

The resource model has been reported at a 3.5% DTR cut-off grade where DTR analyses are available within the identified resource block areas. Outside this area a cut-off grade of 7.5% Fe_2O_3 has been used based on the statistical relationship between Fe_2O_3 and DTR.

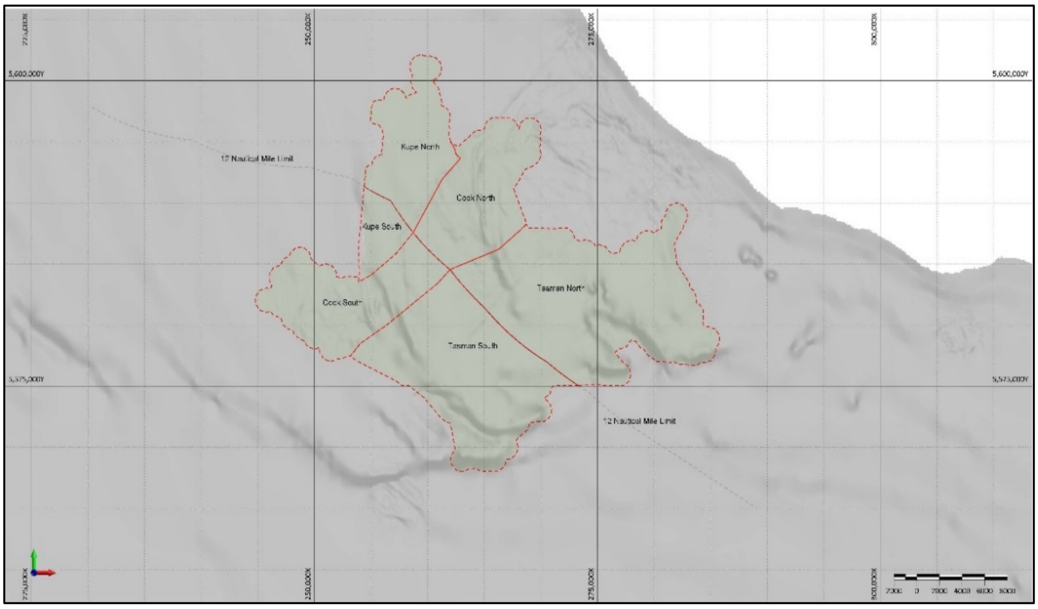


Figure 36 TTR 2023 - Mineral Resource Blocks

Taranaki VTM Resource Estimates Summary									
	Indicated and Inferred Mineral Resources					DTR Concentrate			
MEP54068 Inside 12Nm (RMA)	**Cut-Off Grade**	**Mt**	**Fe_2O_3%**	**TiO_2%**	**V_2O_5%**	**Mt**	**Fe%**	**TiO_2%**	**V_2O_5%**
Cook North Block	3.5% DTR*	274	11.90	1.19	0.06	21	57.19	8.12	0.52
Kupe North Block	3.5% DTR*	417	11.48	1.21	0.06	31	57.07	8.35	0.51
Tasman North Block	7.5% Fe_2O_3	585	9.02	0.88	0.04				
Total VTM Resource (RMA)		**1,275**	**10.44**	**1.05**	**0.05**				
MMP55581 Outside 12Nm (EEZ)									
Cook South Block	3.5% DTR*	914	10.95	1.12	0.05	63	55.84	8.45	0.50
Kupe South Block	3.5% DTR*	272	9.76	0.98	0.05	16	56.33	8.43	0.50
Tasman South Block	7.5% Fe_2O_3	695	8.81	0.89	0.04				
Total VTM Resource (EEZ)		**1,881**	**9.99**	**1.01**	**0.05**				
Taranaki VTM Resource Total		**3,157**	**10.17**	**1.03**	**0.05**				

Table 7 Reported Mineral Resource and Concentrate Tonnage and Grades

5 MINE PLAN

In 2014, Golder Associates conducted a high level mining scheduling review for TTR, which resulted in a maiden ore reserves statement, and has provided a basis for the PFS and ongoing mining evaluation of the TTR resource.

5.1 Updated Basis for Mine Planning

The 2014 mine plan study by Golders was confined to the resource defined under Mining Permit 55581 and Exploration Permit 54086. At the time of this study MMP55581 covered an area of 65.8 square kilometres, outside the 12Nm limit. In 2022, New Zealand Petroleum and Minerals granted TTR an extension of land, expanding MMP55581 to its current area of 242.57 square kilometres. Given this expansion, along with an increase in the mineral resource estimation (TTR, 2023) and updated modifying factors, the mine plan will need to be revised as part of the Bankable Feasibility Study (BFS). However, for the purpose of this Pre-Feasibility Study (PFS), the mining schedule relates to the originally granted area of MMP55581, and the modifying factors that were taken into consideration, at that time.

We do not expect any material change to any modifying factor when assessing the increased mining resource during the BFS phase.

5.2 SBC Mining Area

When delineating the mining area, several factors were taken into consideration:

- Fe head grade %;
- Bulk density;
- Davis Tube Recovery:
- Metallurgy;
- Depth of mineralization;
- Mining method;
- Water depth;
- Regulatory consideration;
- Meteorological and ocean conditions;
- Mining Permit area for MMP55581 (Note Mining Permit area and contained reported mineral resource has increased from the 2014 PFS);
- Tailings disposal, environmental effects; and
- Mine scheduling considerations.

5.3 Mine Blocks Overview

This section of the PFS evaluates two potential extraction methods:

1. Trailing Suction Hopper Dredge (TSHD).
2. Seabed Crawler (SBC) with an integrated mining vessel (IMV).

The report compares both methods, assessing their technical feasibility, mining efficiency, and suitability for offshore iron sand extraction. It ensures that the selected approach aligns with operational and environmental considerations. The findings confirmed that the VTM mineral resource can be converted to an Ore Reserve which the development of an extraction schedule.

The nature of the resource dictated how to effectively extract the iron sand resource, with TTR initially identifying two options that were considered technically feasible. The mining method options reviewed included a TSHD (Trailer Suction Hopper Dredge) or a sea floor crawler or SBC (Subsea Sediment Extraction Device), similar to that used offshore in Namibia for marine diamond mining. The methods have been reviewed and described within this study, but in terms of the effect the two mining methods have on the overall area and the mining blocks, this is considered minimal.

The mining blocks were defined by the resource block model with iron sand concentration varying in thickness from two to ten metres below the ocean floor. Two scenarios were considered when an external party provided the Ore Reserves Statement, one the TSHD option the other is the sea floor crawler.

In review of the two mining methods, the only major difference of the mining blocks is that of the orientation of the Christina Block. The orientation of the mining blocks takes into consideration prevailing environmental constraints such as current and wind direction.

For the dredging option, two large trailing suctions hopper dredges (TSHD) would extract the material from the sea floor to fill the hopper on the dredge. This material will then be transported to the Floating Production Storage and Offloading Vessel (IMV), where it will be processed. Based on current estimates, each dredge will have an annual throughput capacity of 30-35 Mtpa. The dredging option, with two dredges scheduled, indicates annual tonnage movements of 60-69 Mtpa of *in-situ* material with annual concentrate production of 3.7-7.4 Mtpa. The resources in the mining area are depleted in approximately 10 years.

For this PFS TTR has abandoned the dredging option and will develop the proven low environmental impact Seabed Crawler and integrated IMV production and processing option.

For the Seabed Crawler (SBC) option, the crawler will be located on the sea floor, connected to an IMV (Integrated Mining Vessel) via an umbilical delivery tube. A winching system and dynamic positioning system will be used to locate the IMV relative to the crawler which will be mining 300m × 300 m blocks to the base of the mineralisation, in a predetermined sequence. Based on current estimates, a remote crawler unit will have an annual throughput capacity of up to 50Mtpa of VTM ore.

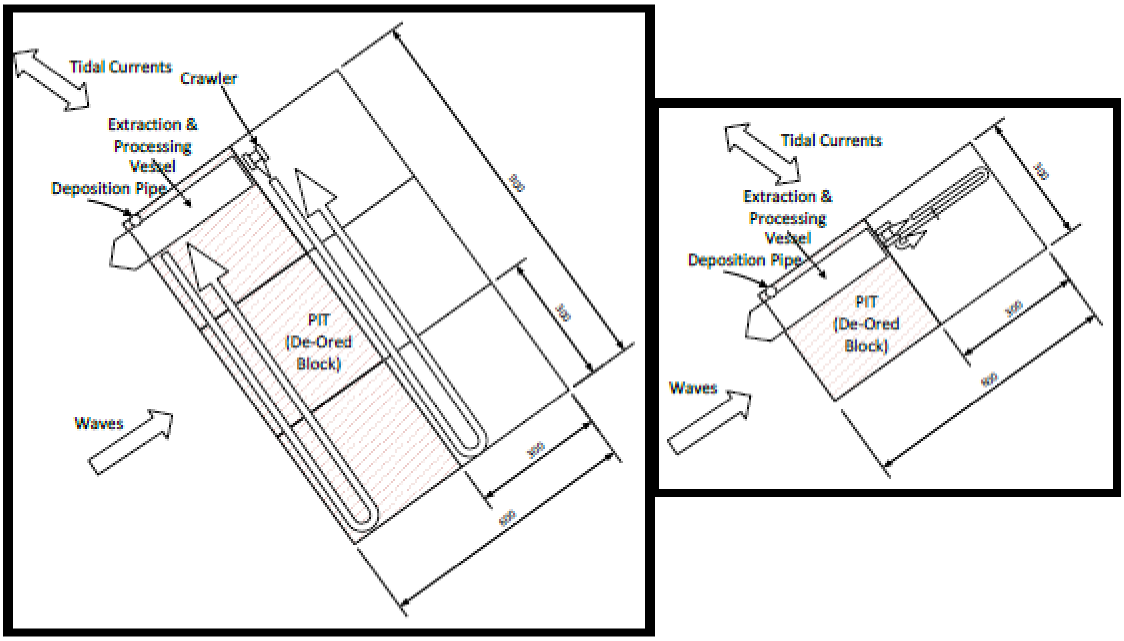


Figure 37 IMV and SBC Movements Over Mine Blocks

The SBC crawler option indicates annual tonnage movements of up to 50Mtpa of material with annual concentrate production of up to 5Mtpa. A ten-year mining schedule was originally developed; however, the updated 2023 Mineral Resource model highlights additional resources now available for mining by the crawler within MMP55581 for up to 20 years at the planned rate of extraction.

Concentration production in both scenarios varies with the feed grade and feed recovery factor. The IMV plant will be required to cope with these variations.

The extent of the resource within the mining area is shallow but widely dispersed. Areas between the higher-grade resources are retained within the mining area to ensure continuity between the areas for the purpose of maintaining this area as a single Mining Permit and potentially enabling lower grade sediment (below current cut-off grade) to be mined in the future.

5.4 Mine Plan - Schedule

The Golder Associates report was undertaken to develop a mining schedule over the defined mining area using the 2013 TTR resource block model. From this mining model, extraction schedules were generated, utilising assumptions (modifying factors) as well as key inputs to derive yearly run of mining and grades. Note these grades are based on DTR sampling.

Golder assessed the resource using two different mining methods, a trailing suction hopper dredge (TSHD) or a remote crawler system. The report had been used to determine the preferred mining method. Golder modelled the mineralised zone from two to ten metres below the ocean floor. For this scheduling study, the regularised block model has been “flattened” by adjusting the model block centers to equate to the depth of the block centre below the ocean floor.

5.5 Dredging

To minimise the dredging of the lower grade Fe material, higher grade areas in the proposed mining area were defined to target an average plant head-feed grade of 10 to 11% Fe. This higher cutoff grade is based on the previous financial model and now with the metallurgical upgrade of obtaining vanadium, and potentially titanium, credits this mine plan will need to be updated and defined in the BFS.

5.6 SBC - Seabed Crawler Operation

For the remote seabed crawler (SBC) option, it is assumed that both of the waste fractions will be pumped from the IMV into the mined-out areas as part of the remote crawler and IMV operating sequence.

Initial information from De Beers Marine SA and Royal IHC from Rotterdam, designers, builders and operators of the SBC indicated that the integrated IMV system would potentially require a minimum operational of 20m depth of water.

Note that Golders analysis and the mine plan are based on employing existing technology. Subsequent TTR engineering studies identified the capacity to process up to 8,000tph with an annual throughput capacity of up to 50Mtpa, as discussed in Section 7, of this PFS.

5.7 Mining Blocks

For this study, a mining block model was created from the updated geological model. The SG field in the geological model is the calculated density of the -2 mm or plant head feed material. The +2 mm fraction was discarded and a recovery field recorded. For this study, the density of the +2 mm oversize material is assumed to be 1.5t/m^3. This mining model is a sub-blocked model with the same block model dimensions and variables as the resource block model.

5.8 Mining Model Regularisation

For this study, the mining model was regularised to a consistent block size of 250 m × 250 m × 1 m. Bench tonnages for the proposed mining areas were calculated by summing the blocks that have the block centroid within an area. Note Figure 36, below, shows the outline of these regularised blocks, which were constrained due to the Mining Permit boundary at the time of that study. Refer to Section 4.2 for an overview of the current TTR mineral tenements.

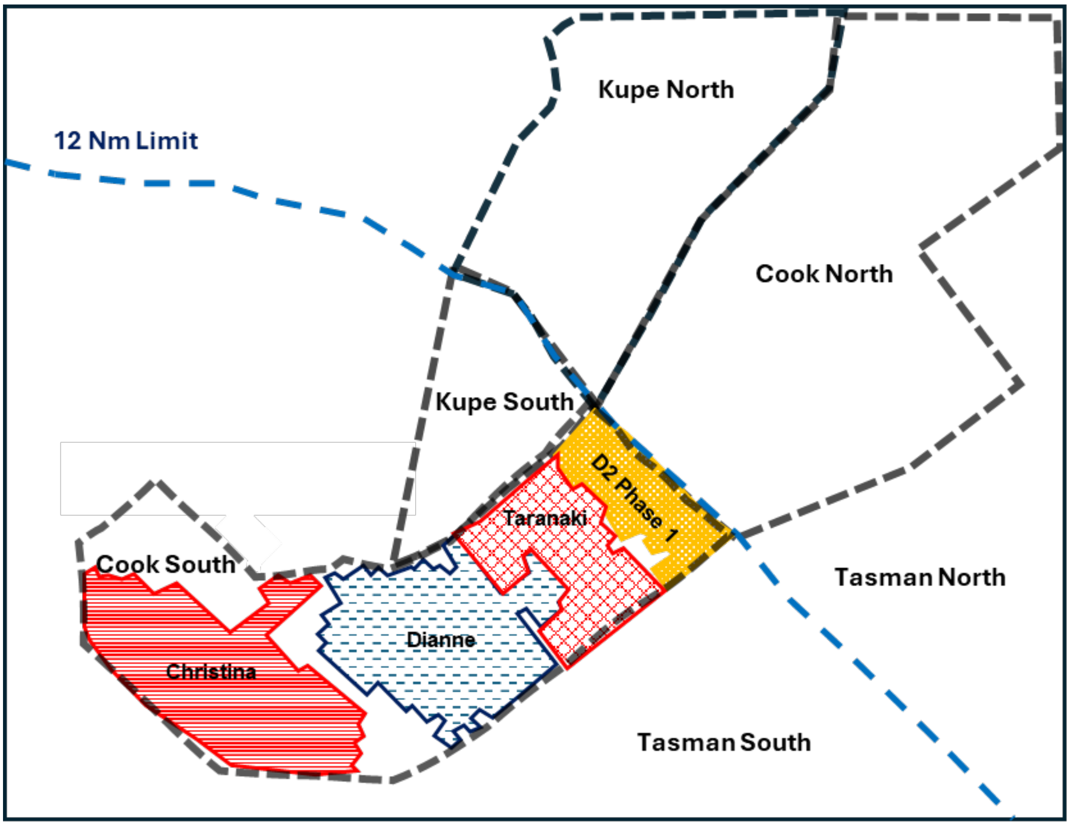


Figure 38 Defined Mining Areas and Mineral Resource Blocks MMP55581

5.9 The Effect of Model Regularisation

Regularising the model has reduced the total reported tonnages by 1.7% with only minimal changes to the modelled grades. These changes are considered to within acceptable limits.

5.10 Scheduling Block Model

It is assumed that the remote SBC crawler system will be used to mine the material below the gently sloping ocean floor.

For this scheduling study, the regularised block model has been “flattened” by adjusting the model block centers to equate to the depth of the block centre below the ocean floor.

A *depth* field was added to the mining model, and a java script (*rmg_block_depthbelsurf.java)* run to calculate the depth of the block centre below the ocean floor. The model blocks were exported to a csv file, manipulated by transferring the block *zcentre* field to a new field *b_centriod_z*. The *depth* field was then copied to the *zcentre* field. The modified csv file was imported into the scheduling model *north_acc_2013_250_flat.bmf.* This model has the same block dimensions and parameters as the regularised mining model.

This flattened scheduling model was used as the basis of the tonnages and grades for scheduling.

5.10.1 Grade and Tonnes Analysis

To define these higher-grade areas, a grade tonnage analysis of the blocks within the proposed mining area was done. The results, using DTR_Est grade as a cut-off are shown below.

DTR_Est Cut-Off %	DTR_Est %	Tonnes (Mt)	Fe_2O_3 %	Fe %
3	7.72	1103.6	11.81	8.26
4	8.51	928.6	12.61	8.82
5	9.65	723.4	13.69	9.57
6	10.84	563.7	14.81	10.36
7	11.76	465.9	15.66	10.95
8	12.73	380.2	16.54	11.57
9	13.48	323.1	17.27	12.08
10	14.38	263.9	18.09	12.65
11	15.33	211.9	19	13.29
12	16.45	164.3	20.07	14.04
13	17.5	130.1	20.96	14.66
14	18.31	108.3	21.72	15.19
15	19.4	84	22.71	15.88
16	20.64	63.6	23.67	16.55
17	21.56	52.1	24.62	17.22
18	22.17	45.3	25.16	17.6
19	23.14	35.5	25.97	18.16
20	24.06	28.6	27.01	18.89

Table 8 Grade Tonnage Report Based on DTR_Est Cut-Of

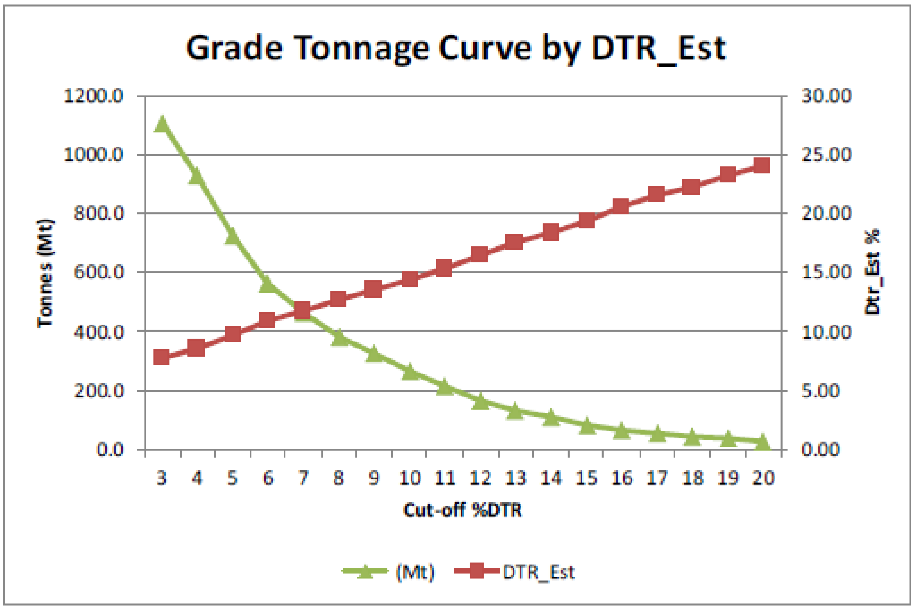


Figure 39 Grade Tonnage Curve - Based on DTR_Est%

This analysis indicates that a 7% DTR_Est grade cut-off would result in a plant head feed tonnage of 466Mt with an average grade of 10.95% Fe. However, it should be noted that the grade tonnage curve does show the best scenario as with any grade cut-off the curve assumes continuity of the concentration and every block is considered as equally available to be mined. That is why schedule planning was undertaken in this study to normalise the ROM grade and the tonnages expected within the mining blocks.

5.11 Integrated Mining Option (SBC and IMV)

For the integrated option, using a submerged seabed crawler, it is now proposed to have the SBC and the IMV both aligned along the SW - NE mining direction. The SBC will be located on the sea floor, connected to the IMV via an umbilical delivery tube. A winching system will be used to locate the IMV relative to the SBC which will be working 300m × 300m blocks in a predetermined sequence.

This alignment direction is parallel to the prevailing wind/wave direction (facing into the waves/wind) and perpendicular to the prevailing current direction.

5.12 Integrated Option (SBC) - Scheduling Blocks

The 7% DTR Est cut-off grade shell of the block model was used to define the blocks for the Crawler option. The dredging strip bench plans were utilised for D2 Phase 1, Taranaki, and Dianne but the Christina bench plans were rotated to align with the other areas and the prevailing wind/wave direction.

A bench height of one metre has been used but it is assumed that the crawler will operate at the base of the defined “ore body” and cut/dredge the full depth face (approximately 3 to 10 metres) during the scheduling sequence.

An *area2* field was added to the scheduling model north_acc_2013_250_flat.bmf. This field was coded with the area name and strip number.

5.13 SBC - Scheduling Parameters

Golder used the scheduling parameters for the SBC option which were provided by TTR following initial workshop discussions and meetings between TTR, Royal IHC (IHC) and DeBeers Marine SA the suppliers and operators of SBC type systems. Note these parameters were set at an early stage of the project feasibility, with subsequent analysis showing up to 50Mtpa as the mining extraction rate.

The original Golder scheduling assumptions were based on the 6,900tph crawler extraction rate. These assumptions, based on the updated SBC design, have now been upgraded to 8,000tph ore extraction rate:

1. Seabed Crawler throughput = 8,000tph
2. Annual operation hours = 6,326hrs
3. Calculated scheduling rate = 8,000tph × 6,326hrs pa = 50.0Mtpa.
4. Based on 72% SBC and IMV production utilisation rate and 28% downtime for servicing, weather events and breakdowns.

5.14 SBC Assumptions and Scheduling Parameters

For this scheduling scenario, it was assumed:

- TTR will utilise the SBC and IMV mineral extraction, processing and production technology SBC capable of achieving the above production rates after the initial ramp up period;
- The first 3 years are scheduled in six-month periods, then annual scheduling periods;
- Recovery of the sediment < 2 mm is based on the modelled field “rec”;
- Fe% = Fe_2O_3% × 0.6994;
- Mining recovery of *in situ* and feed tonnages = 100% (TTR request);
- Typical Process Recovery = 92%;
- Concentrate tonnage = Feed tonnage × DTR_EST% × Process Recovery;
- Indicated and Inferred resource classes have been used in the scheduling block tonnages and a Fe_2O_3 grade cut-off has not been applied;
- Each area is scheduled with strips being mined from the SE to the NW; and
- All areas can be accessed by the SBC crawler and IMV system.

5.15 High Level SBC Scheduling Results

The integrated SBC IMV scenario schedule assumes a ramp up period of six to twelve months with a single large plant.

A high level Mining Schedule based on the updated 2023 Mineral Resource estimation provides the basis for a 20 year mining life within MMP55581. The production average is based on producing 4.9M tonnes of concentrate per year with the averaged ROM and concentrate grade. The BFS will provide detailed scheduling on year by year basis, however the tables demonstrate that there is a mineral resource to establish a life of mine for at least 20 years.

The reducing rates in the final 3 to 4 years of the 20 year schedule will require further drilling to determine a DTR and DTC resource.

Table 9, shows that the overall mineral resource mining factor, required to min e for 20 years, with Table 10 shows the 20 life of mine resource availability.

Permit	Resource Block	Total Resource Mt	20 Year Minable Resource Mt	DTR Mt
MMMP55581	Cook South	914	686	63
	Kupe South	272	204	16
	Tasman South	695	146	**19***
	Total	**1,881**	**1,036**	**98**

Table 9 Summary: Available and Mineable Resources for 20 Year Mine Life

*Further drilling and DTR sampling are required to determine the Tasman Block DTR resource.

Year	ROM Mt	Resource Block	Resource Depletion Mt	Concentrate Mt	Ave DTC Fe % Concentrate Grade
1	50	Cook South	636	4.9	55.84
2	50	Cook South	586	4.9	55.84
3	50	Cook South	536	4.9	55.84
4	50	Cook South	486	4.9	55.84
5	50	Cook South	436	4.9	55.84
6	50	Cook South	386	4.9	55.84
7	50	Cook South	336	4.9	55.84
8	50	Cook South	286	4.9	55.84
9	50	Cook South	236	4.9	55.84
10	50	Cook South	186	4.9	55.84
11	50	Cook South	136	4.9	55.84
12	50	Cook South	86	4.9	55.84
13	50	Cook South/Kupe	240	4.9	55.90
14	50	Kupe	154	4.9	56.33
15	50	Kupe	104	4.9	56.33
16	50	Kupe	54	4.9	56.33
17	50	Kupe / Tasman	150	4.9	56.33
18	50	Tasman	100	4.9	TBC
19	50	Tasman	50	4.9	TBC
20	50	Tasman	0	4.9	TBC

Table 10 Twenty Year Mine Schedule. DTC = Davis Tube Concentrate

6 EXTRACTION METHODOLOGIES

Several extraction/mining methodologies have been assessed in both this and the previous versions of the PFS in order to evaluate the most practical and cost-effective solution given the stringent environmental conditions encountered in the proposed mining area as well as the large amount of sediment extracted from the seabed.

6.1 Seabed Crawler

The basis for this PFS concept is a mobile device with a submersible dredge pump and slewing boom configuration. The concept is based on many years of actual operational experience of the mining and dredge processes, and the designing of offshore mining/dredge systems, submerged pumps, dredge components and subsea tracked vehicles within the De Beers Marine SA group.

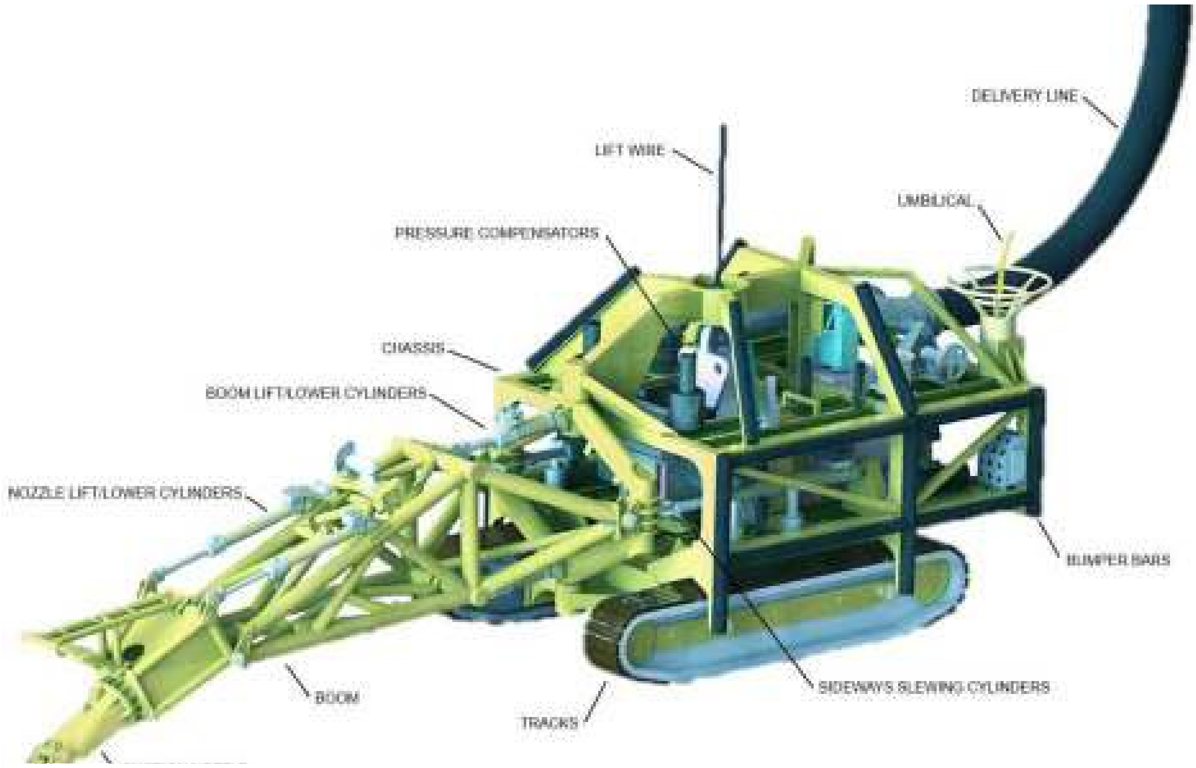


Figure 40 Seabed Crawler

After a rigorous selection process, TTR's concluded that the SBC or seabed crawler provided the best overall mining solution particularly because it facilitates an acceptable tailings management strategy.

The mining system has been defined at an 8,000 tonnes per hour nameplate capacity. The mining system consists of two crawlers, crawler launch and recovery system(s) (LARS), the electrical distribution system for the mining system, the mooring system and the de-ored sediment redeposition system. The weight of the crawler is currently estimated at 420 tonnes and will have a maximum rating of 70 metres water depth. The crawler will be fitted with a highly accurate acoustic seabed navigation and imaging system and will extract sediment by systematically advancing along a pre-determined 'lane'. The pump fitted on the crawler will allow the transport of the sediment slurry at a rate of 8,000 tonnes per hour resulting in a slurry velocity in the hose of around 6.5m/s. The suction velocities directly at the nozzle entry will typically be around 1.5 to 2m/s and will decrease rapidly as the distance increases from the nozzle face. The estimated intake velocities 1m away from the nozzle will be a maximum of 0.5m/s.

The crawler is designed for continuous operation with routine planned maintenance taking place once a week with at least one major maintenance shutdown biannually. Only one of the two crawlers will ever be in operation at any one time, conditions permitting.

The Launch and Recovery System (LARS) is the system that:

- Lifts the SBC off the Mining Vessel and lowers it onto the seabed during the launch phase; and then
- Lifts the SBC off the seabed and recovers it onto the IMV during the recovery phase. Refer to Section 9 of this document for detailed description of the IMV

During the operational scenario, the Seabed Crawler will be lowered onto the seabed and controlled remotely from the surface support vessel. The Seabed Crawler is fitted with highly accurate acoustic seabed navigation and imaging system, and extracts sediment by systematically advancing along a pre-determined 'lane'.

The SBC is the starting point of the extracted sediment slurry transport and comprises a suction head, pump system and a delivery line or STS. The suction head engages the seabed, fluidising the material and effecting the extraction. The slurry system is built up from standard and commonly used dredging equipment.

- Suction head Suction Line;
- Suction head (including jetwater nozzles if required);
- Pump System;
  - Dredge pump, and
  - Dredge pump electric motor.
- Slurry Transport System (STS).

6.1.1 SBC Slurry Transport System (STS)

The STS enables the transport of slurry from the SBC to the processing plant aboard the support vessel. The STS allows for quick deployment and retrieval as well as mining at variable mining depths.

The STS consists of the following components:

- The coupling between the sea floor mining tool and the first riser segment;
- A riser hose string consisting of individual riser hose segments; and
- A coupling between the riser and the plant connection.

The riser hose string consists of riser hose sections, with integrated floatation as required, and be stored on board the vessel through the use of a riser train handling system. The riser train consists of framed rollers, allowing the riser string to be stored on the vessel. The riser train includes several riser tensioners, used to launch and recover the riser string. The hose connects to the plant through the use of a ball joint connection, allowing for simple connection and disconnection during operations.

Figure 41 Riser Hose Handling

6.2 Sediment Breaching Test

In November 2013 MTI Holland B.V undertook breach testing of bulk samples taken from the TTR VTM project area. The testing was undertaken to evaluate the breaching behavior of iron sand sediment under different soil conditions. The study aimed to support the development of a crawler-based mining system by assessing breaching production under natural and active conditions, with and without water jets. Tests were conducted on both loose and dense iron sand of varying grades using a controlled tank setup. Key parameters measured included head wall velocity, porosity, permeability, and suction pipe velocity. The results showed that breaching production was highly dependent on porosity, with increased suction pipe velocity leading to slope instability and spillage. However, water jets improved breaching efficiency and stability. Additionally, a loose top layer accelerated the breaching process through an avalanche-like erosion effect, which was not yet included in theoretical models.

The study found discrepancies between theoretical predictions and experimental results, requiring correction factors in production calculations. Spillage was identified as a key challenge, with increased production speeds leading to material buildup behind the suction pipe, potentially obstructing operations. The report recommended further field characterization to refine porosity estimates, investigating erosion at greater breach heights (above 5 meters), and developing strategies to manage spillage. The findings from this testing provided crucial insights for optimising breaching production and improving the design of a crawler-based mining system.

Figure 42 Breach Tank Used in Testing Seabed Sediment

7 PROCESS PLANT

7.1 Metallurgy

7.1.1 Testwork Overview

The metallurgical testwork was conducted in three phases:

- Stage 1 – Preliminary testwork
- Stage 2 – Pilot plant testwork
- Stage 3 – Vanadium recovery testwork

The purpose of the testwork in stages 1 and 2 was to investigate the viability of upgrading the ore via conventional mineral sands and/or magnetite processing and to determine the base parameters required for the design of the process flow sheet. The ultimate objective of the testwork was to design a process flow sheet that is capable of producing a saleable iron ore concentrate whilst maximising recovery of the valuable component in the ore.

This testwork focused on gravity separation as is commonly practiced at mineral and iron sands operations. This testwork was largely unsuccessful and steered the process flow sheet design towards conventional magnetite processing based on magnetic separation. This report will focus on the testwork conducted on the pilot plant.

In 2023 TTR commenced stage 3 testwork and commissioned metallurgical testwork into advanced mineral processing techniques to optimise the extraction and separation of vanadium from New Zealand sourced vanadiferous-titanomagnetite (VTM) iron sands concentrate.

Testwork conducted by the University of Canterbury and Callaghan Innovation confirmed the viability of sodium salt roasting-water leaching process for the sustainable recovery of vanadium from the TTR VTM concentrate. The sodium salt – water leaching process not only achieved high recovery rates of vanadium (77% to 79%) but also exemplified a model that balanced economic viability with environmental stewardship. This dual focus ensured that vanadium extraction aligned with TTR's sustainable development goals.

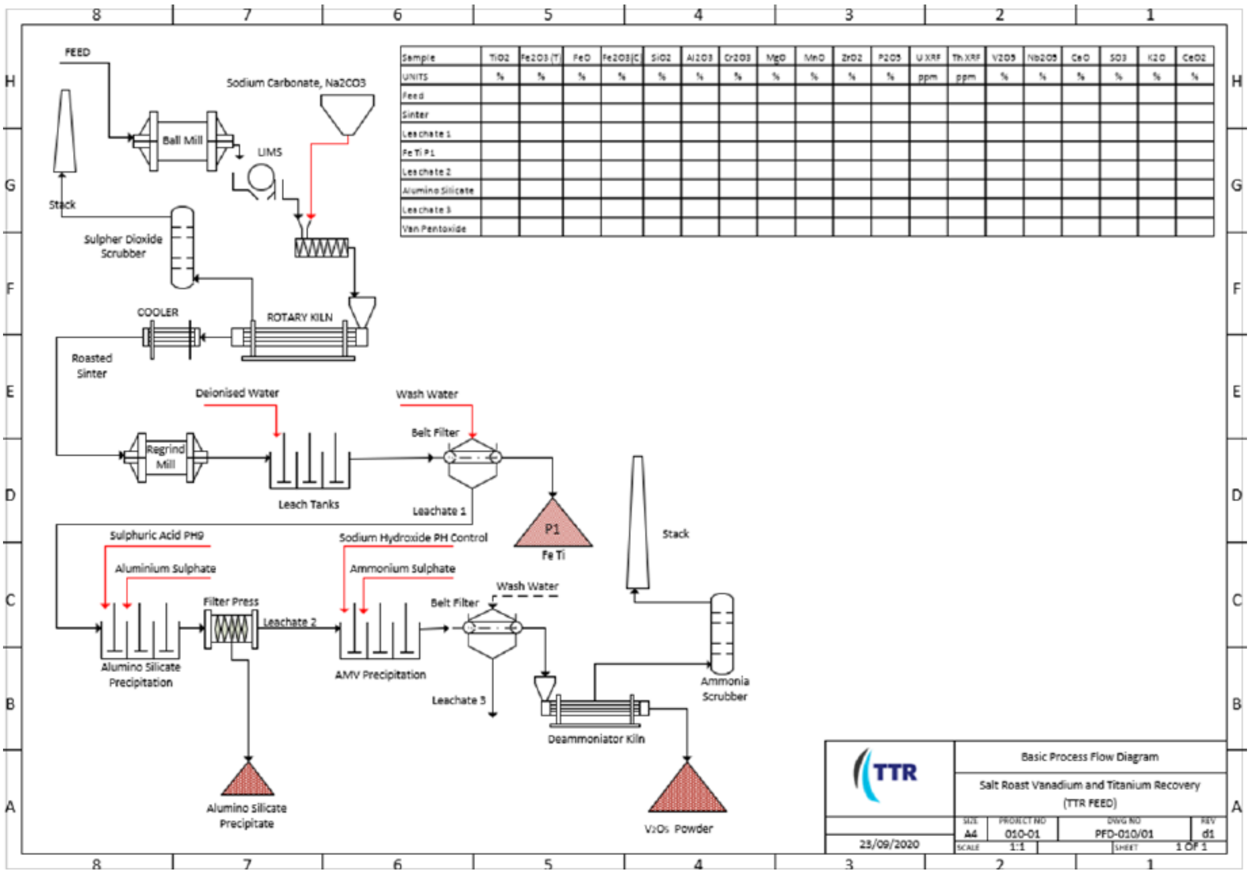


Figure 43 Vanadium and Titanium Recovery Flowsheet

7.2 Stage 1 and 2 Testwork – VTM Beneficiation

7.2.1 Ore Characterisation Qemscan

A composite head sample originating from the Xantia mining area was analysed by QEMSCAN (Quantitative Evaluation of Minerals by Scanning electron microscopy), an automated technique for quantitative mineralogical analysis of ores (Amdel report N3994QS11, 7th of April 2011). Qemscan identified the following minerals present in the ore:

	Description
Magnetite	Includes Magnetite and trace Hematite and Goethite
Rutile / Anatase	Includes Rutile / Anatase (>95% TiO2)
Ilmenite	Includes all TiO2 phases from Luecoxene to Ilmenite (50% TiO2 - 95% TiO2)
Titano-Hematite	Includes Titano-Hematite (50% TiO2 - 20% TiO2)
Titano-Magnetite	Includes Titano-Magentite (<20% TiO2)
Quartz	Includes Quartz
Calcite	Includes Calcite and CaCO3 from shell fragments
Feldspar	Includes K-Feldspar
Epidote	Includes Epidote
And/Sill/Kyan	Includes Al Silicate phase from the Andalusite/Sillimanite/Kyanite series
Tourmaline	Includes Tourmaline
Hornblende	Includes Hornblende
Pyroxene-En-Fs	Includes Pyroxene from the Enstatite/Ferrosilite series
Garnet	Includes Garnet phases, predominantly Almandine
Other Silicates	Includes all other silicate phases not listed above
Phosphates	Includes Apatite
Others	Includes all phases not listed above and occurring in trace form

Figure 44 Minerals Present as Identified by Qemscan

According to the QEMSCAN analysis, titanomagnetite is the dominant mineral in the -180 +106 µm size fraction. Silicate minerals hornblende and epidote are dominant in the -500 +180 µm size fraction. The QEMSCAN analysis has indicated that a high proportion (~36%) of the Fe is present in gangue minerals (epidote, tourmaline, hornblende and garnet). The recoverable Fe is contained mainly in titanomagnetite and magnetite with only minor quantities present as hematite.

	-1000/+250	-250/+180	-180/+125	-125/+90	-90/+0	Total
Magnetite	0.44	1.76	1.60	0.33	0.32	**4.44**
Rutile / Anatase	0.00	0.00	0.00	0.00	0.00	**0.00**
Ilmenite	0.00	0.03	0.00	0.00	0.00	**0.04**
Titano-Hematite	0.03	0.28	0.14	0.03	0.02	**0.51**
Titano-Magnetite	1.26	24.37	26.49	5.68	2.59	**60.39**
Epidote	0.28	1.94	0.22	0.01	0.01	**2.47**
Tourmaline	1.24	14.17	0.86	0.06	0.14	**16.47**
Hornblende	0.74	10.61	0.48	0.02	0.05	**11.90**
Garnet	0.36	2.62	0.24	0.03	0.03	**3.28**
Other Silicates	0.01	0.05	0.01	0.00	0.00	**0.06**
Others	0.19	0.19	0.03	0.00	0.01	**0.42**

Table 10. Deportment of Fe to Different Species

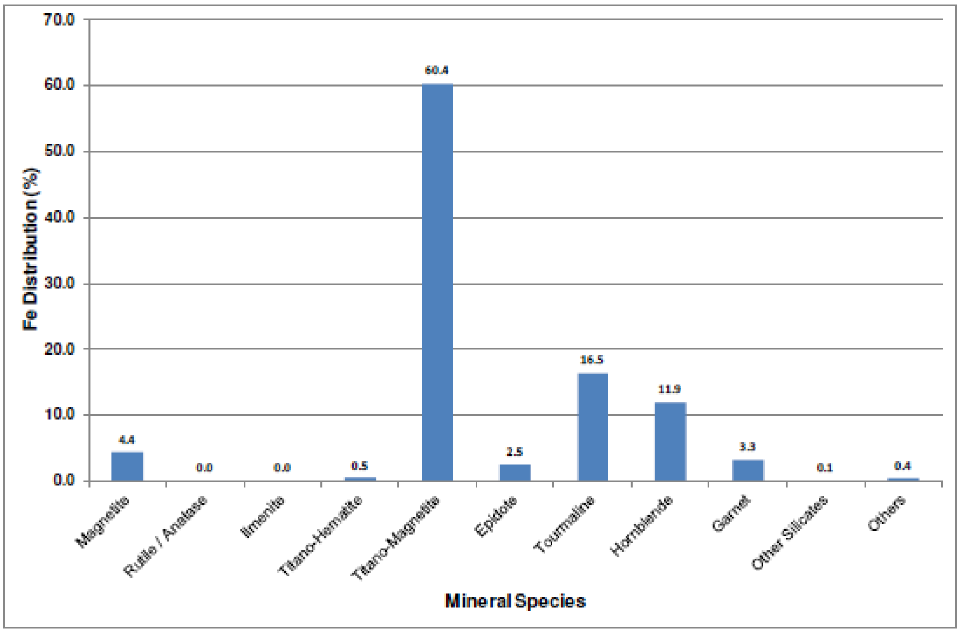


Figure 45 Deportment to Mineral Species

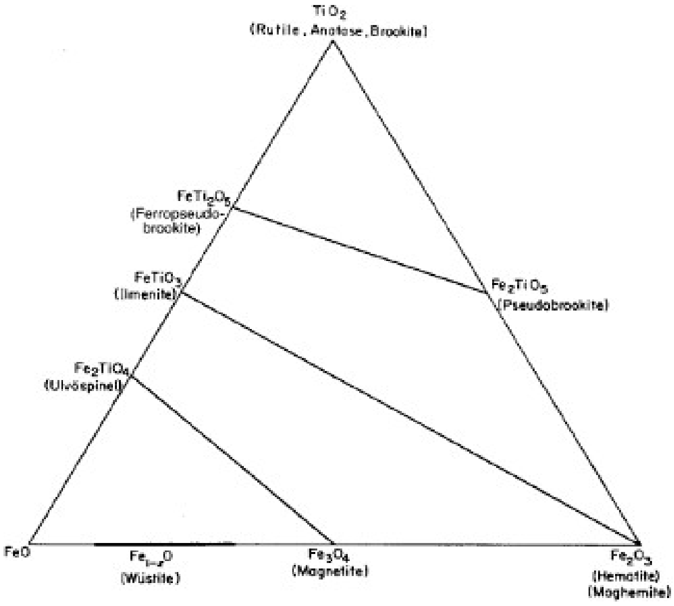


Figure 46 The FeO, Fe_2O_3, TiO_2 Ternary Phase Diagram

7.2.2 Davis Tube Recovery (DTR)

In 2012 a Davis tube testwork programme was launched to characterise the magnetic component of the ore and to quantify the maximum recoverable magnetic concentrate. In total, around 450 samples were tested. The DTR methodology that was developed had the specific aim of avoiding overgrinding of the sample which tends to lead to low concentrate grades and poor recoveries. All samples were stage pulverised and dry screened to avoid any oxidation of the sample during drying. The staged pulverisation typically produced a DTR feed with a P80 of 65 to 75µm. A magnetic field intensity of 3000 Gauss was used throughout.

The sample head Fe is plotted against the DTR weight recovery in Figures below. The DTR weight recovery quantifies the relative proportion of magnetic material in the sample which is equivalent to the maximum weight recovery that can be expected at a given Fe head grade.

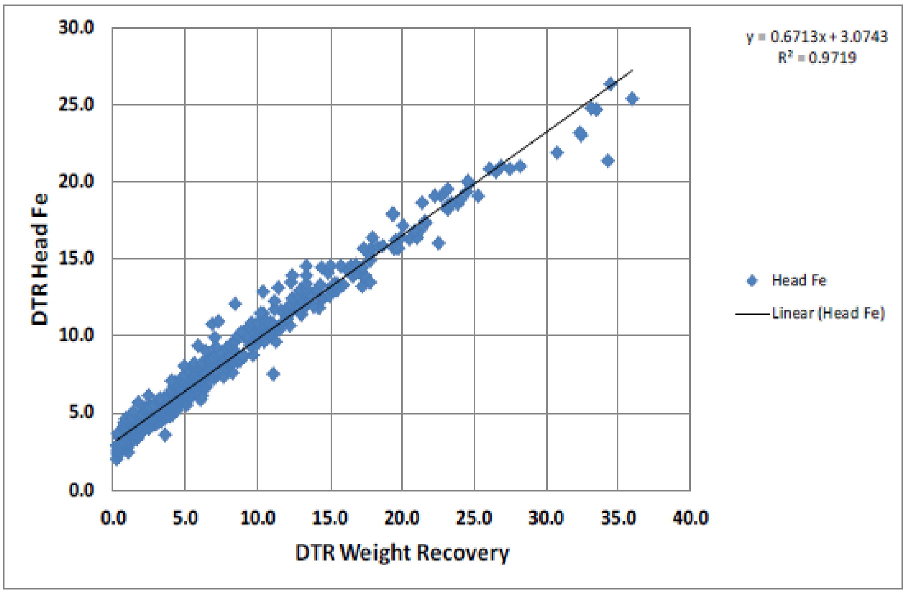


Figure 47 DTR Head Grade Fe vs Weight Recovered

The Fe recovery achieved with the Davis tube is plotted against Fe head grade in the Figure below. Although there is significant scatter in the data, the indication is that the Fe recovery drops below 40% from about 7% Fe. It also indicates that Fe recoveries ranging from 40 to 65% can be expected at a head grade of 10% Fe, with the average Fe recovery at 55%. No cut-off grade has been considered in this case.

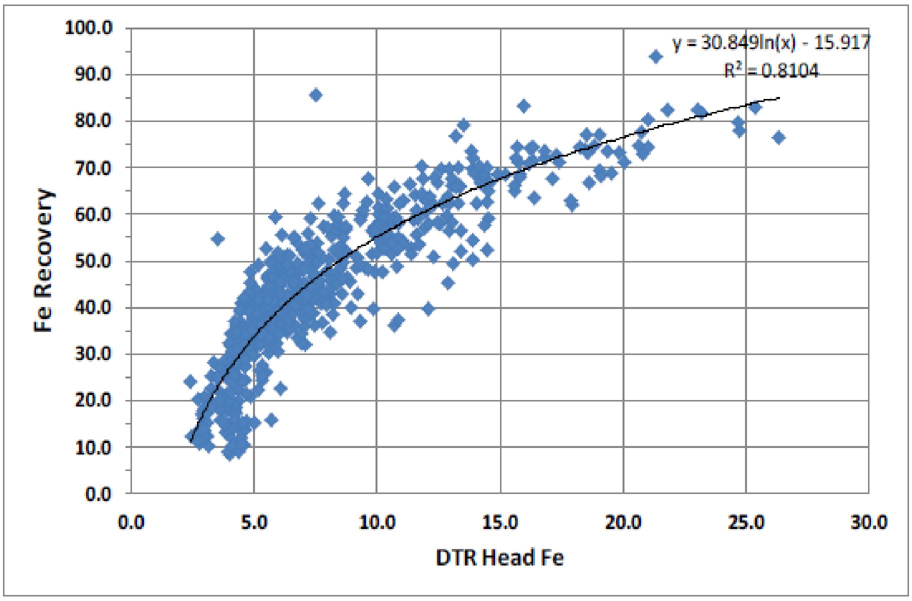


Figure 48 DTR Fe Recovery vs Fe Head Grade

The Fe – SiO2 relationship is depicted below. The Y-axis intercept is 60.7%, indicating the theoretical maximum Fe of the concentrate. The Fe content is substantially lower than that of pure magnetite (72.4% Fe) due to the displacement of Fe in the magnetite matrix by Ti, but also by Al and V.

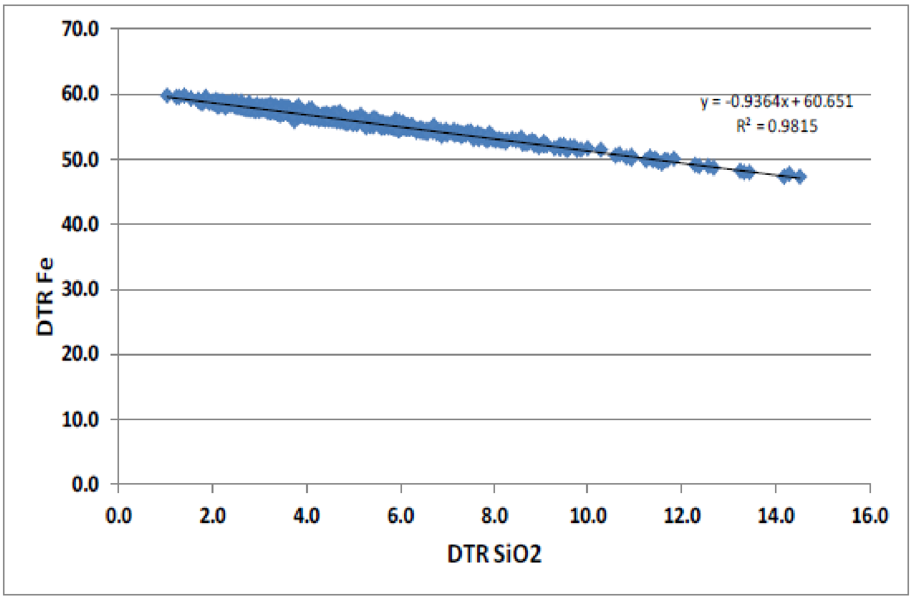


Figure 49 Fe -SiO_2 Relationship

The relationship between the DT Mag Fe (i.e. DT Concentrate Fe grade x DT Weight Recovery) and Head Fe is given in Figure 58 below, again illustrating the fact that a significant proportion of the Fe in the ore is non-magnetic and hence not recoverable.

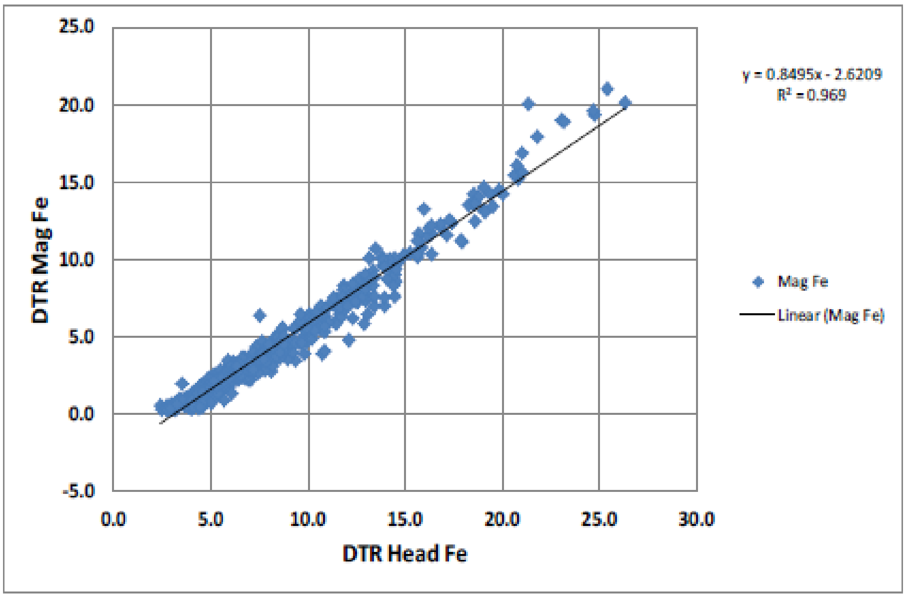


Figure 50 DTC Mag Fe vs DT Head Fe

7.2.3 Pilot Test Plant Work

In 2012 TTR pilot plant was constructed in New Zealand in order to test bulk sample from the initial mining areas and to develop a viable flow sheet for the recovery of the titanomagnetite from the run of mine (ROM) ore. The initial pilot plant flow sheet was set up as depicted in Figure 59.

After drying and removal of large pebbles and shells, the sample was homogenised in a tumble mixer and screened at 2mm. The material was then slurried in an agitator tank and subjected to medium intensity magnetic separation (MIMS) at 3,300G for a single pass followed by three passes through a low intensity magnetic separator (LIMS) at 1,250G. The primary LIMS concentrate was subsequently ground in a 500L ball mill using a mixture of 50 and 30mm ceramic balls. The aim grind size was 80% passing 53µm. Samples were periodically taken from the ball mill to collect data for grind establishment. The ground pre-concentrate was finally processed through a secondary LIMS for three passes at 1,050G. Grab samples of feed and product streams were taken and analysed at ALS Metallurgy in Perth. All feed and product streams were also weighed. All streams after the MIMS were weighed wet and the dry weights were determined by conducting moisture tests on the particular stream.

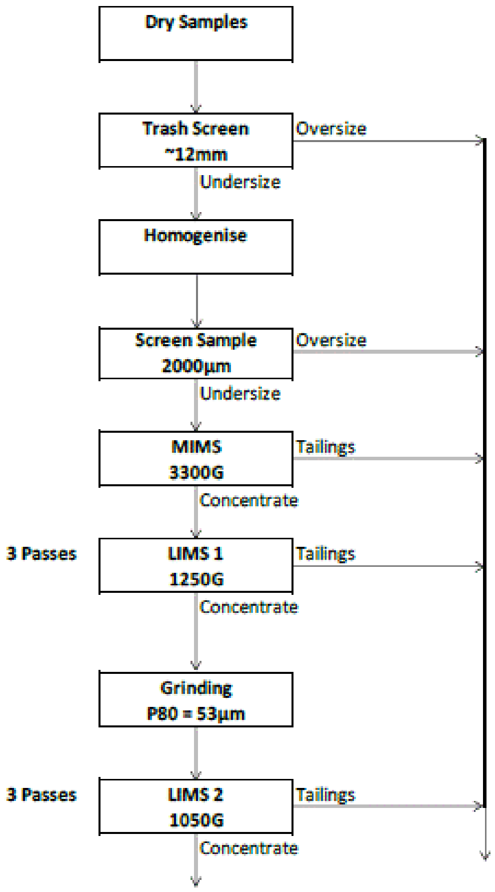


Figure 51 Initial Pilot Plant Flow Sheet Block Flow Diagram

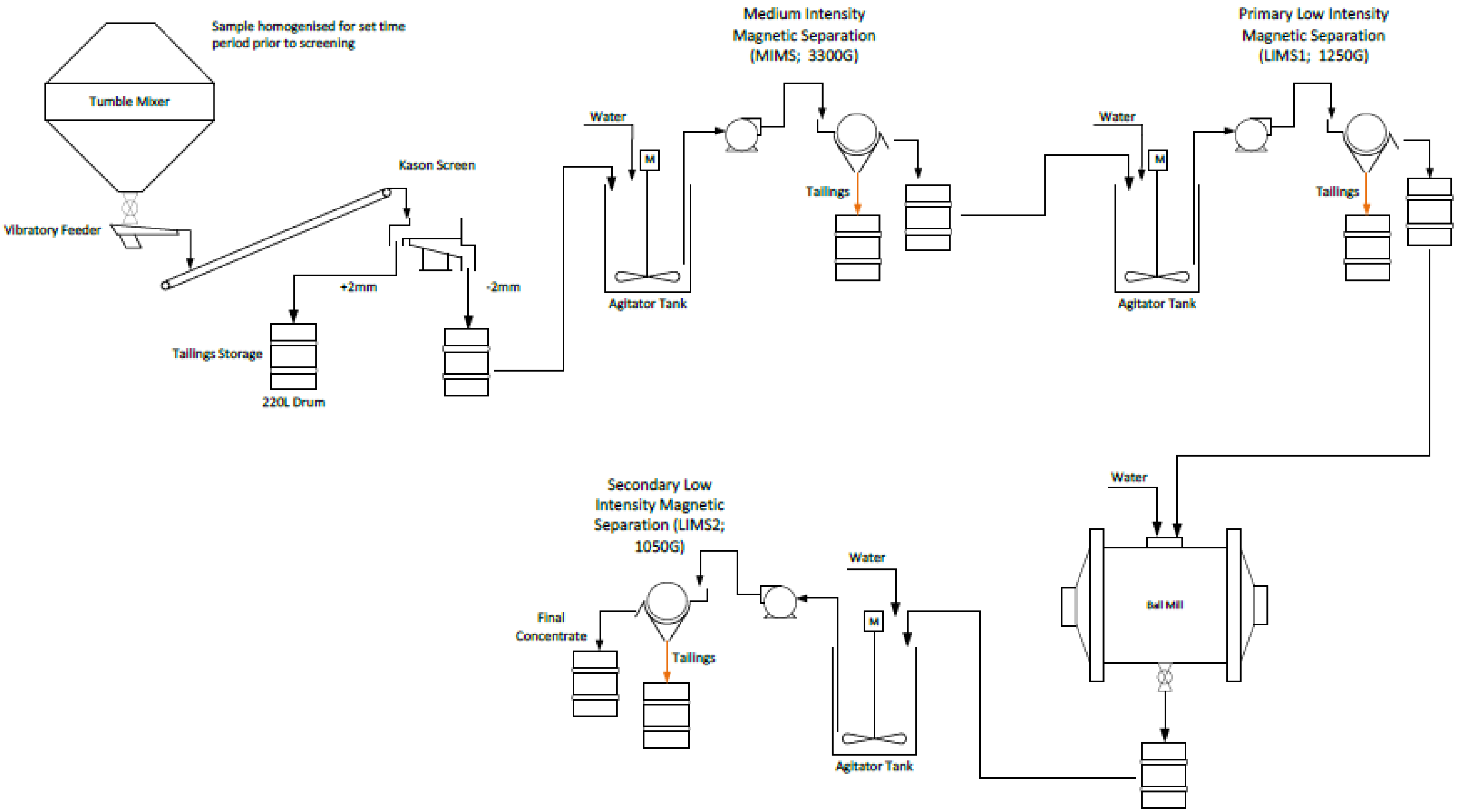


Figure 52 Pilot Plant Process Flow Diagram


Figure 53 Pilot Plant LIMS-1 Concentrate


Figure 54 Pilot Plant Ball Mill

After the first five runs, it became evident that there is an opportunity to discard a significant amount of tailings at a grind of approximately 150 µm. The pilot flow sheet was thus altered to introduce a two-stage grind with intermediate magnetic separation (refer Figure 63). For the second two stage grind run (Bulk 501), the field intensity on the MIMS was increased to 4300G in order to increase the initial Fe recovery on lower grade material.

The results from one sample, X039, were discarded due to operational problems during the run. Good magnetic Fe (Mag Fe) recoveries were obtained for all runs except Bulk 501. The reason for this is the low LIMS2 Fe recovery. It is not clear what the cause of this was. All the Davis tube wash (DTW) samples also returned relatively low Fe recoveries. However, it is clear that the flow sheet maximises both Fe recovery and final product grade. The recovery of magnetic Fe is evidenced by the MIMS/LIMS1 Fe recovery being constantly higher than the DT Fe recovery.

			Fe Recovery					
Sample ID	Head Fe	Mag Fe	MIMS& LIMS1/1	LIMS2	LIMS3	O/All Fe Recovery	DT Fe Recovery	Mag Fe Recovery
X450	7.8	3.5	48.6		83.4	43.3	45.0	96.3
X439	9.6	5.2	60.5		85.5	51.7	53.8	96.2
Bulk501	10.5	4.8	45.0	90.0	97.6	39.5	43.7	90.5
B456	13.9	8.9	66.3		92.7	61.6	62.7	98.3
X451Y	13.8	8.7	66.9	96.7	97.6	63.2	63.3	99.7
X438	21.1	16.4	76.9		91.2	71.9	74.4	96.7

Table 11 Pilot Plant Results – Fe Recoveries

	Weight Recovery			
Sample ID	MIMS& LIMS1	LIMS2	LIMS3	O/all
X450	12.0		46.0	5.7
X439	16.1		55.7	8.5
Bulk501	14.9	53.9	86.9	6.8
B456	20.4		64.0	12.9
X451Y	21.8	79.9	86.6	14.9
X438	34.9		68.8	23.4

Table 12 Pilot Plant Results – Weight Recoveries

	Fe Grade			
Sample ID	MIMS& LIMS1	LIMS2	LIMS3	LIMS2
X450	15.9	30.8		55.9
X439	18.8	34.2		56.3
Bulk501	14.3	29.7	49.4	56.9
B456	25.4	40.2		58.2
X451Y	26.1	40.9	51.8	57.8
X438	28.1	42.0		58.2

Table 13 Pilot Plant Results – Fe Grades

The pilot plant Fe recovery is plotted against mag Fe and DTR Fe recovery in Figure 64. It is clear that the pilot plant Fe recoveries fall well within the bounds predicted by the DTR work. Similarly, the pilot plant weight recoveries compared well with that achieved with the Davis tube.

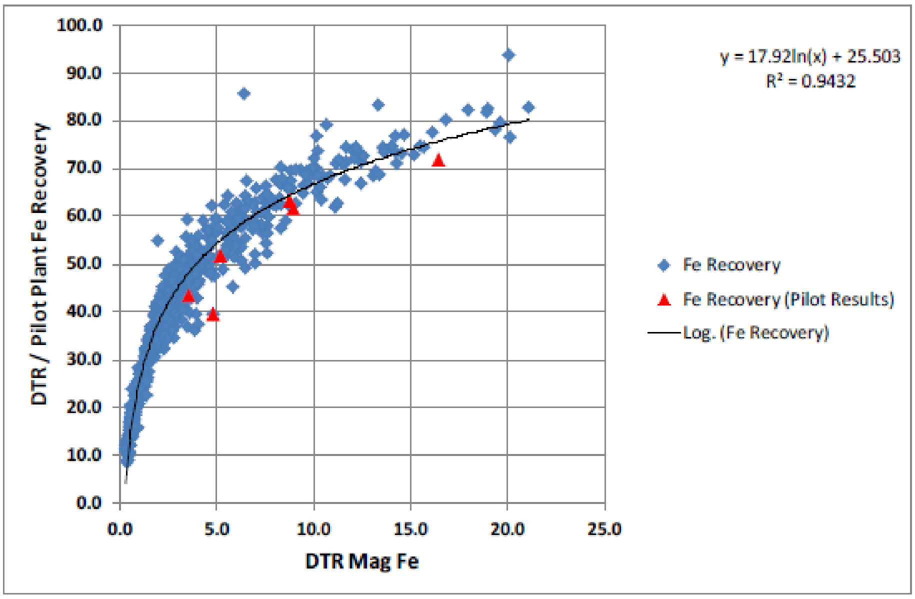


Figure 55 Pilot Plant and DTR Fe Recovery vs Mag Fe

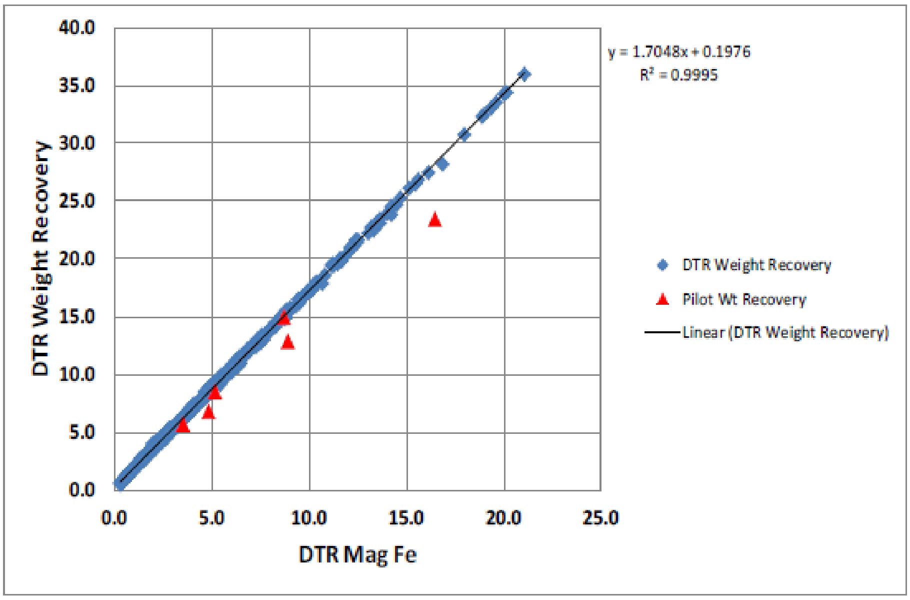


Figure 56 Pilot Plant and DTR Weight Recovery vs Mag Fe

7.2.4 Final Product Grade and Grind Determination

The Qemscan and other testwork have confirmed that the TTR iron sands are immature in respect of its liberation from associated gangue silicates. It is therefore necessary to grind the ore in order to achieve liberation, increase the product grade and maximise the Fe recovery. Initial grind establishment work on medium grade near shore material from the Xantia area indicated a liberation grind size of 53µm. However, this is deemed too fine a size from a marketing perspective. Grind establishment curves were generated for the pilot plant samples by taking samples at different stages during grinding in order to assist in determination of the optimum grind size. Each of these samples was subjected to Davis tube wash (DTW) at 3000G.

In Figure 66 the pilot plant Fe – SiO_2 relationship from DTW on grind samples is plotted showing a similar result compared to the DTR results from the drill samples. This would suggest that the final product SiO_2 must be reduced to less than 5% in order to have a Fe grade of more than 55%.

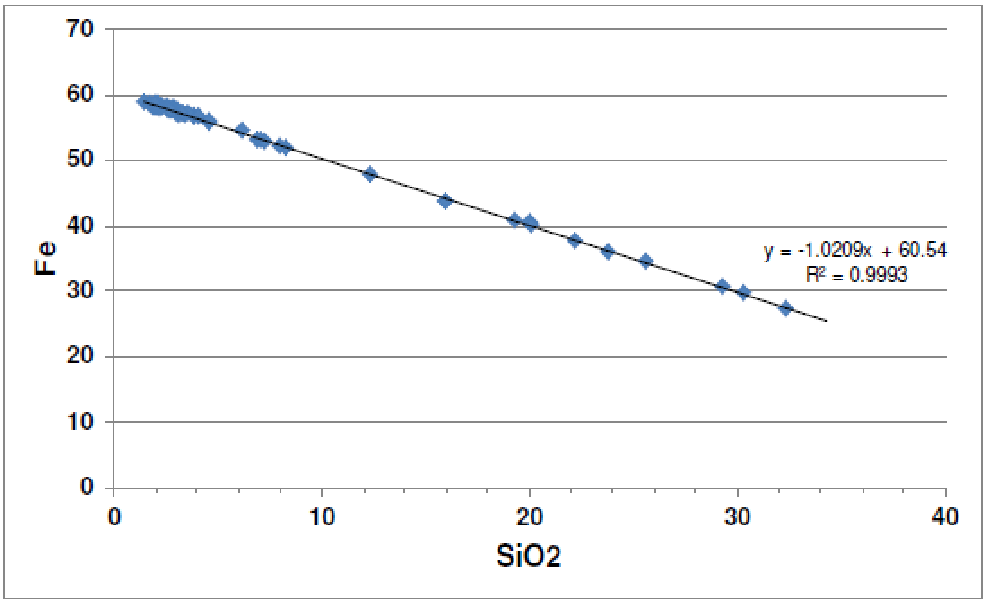


Figure 57 Pilot Plant DTW Results – Fe vs SiO_2

The pilot plant DTW data for Fe and P are plotted as a function of grind size and for samples ground to a P_{80} of 150 µm in Figure 67. The data sets were further split into low, medium and high grade according to head Fe. The low-grade data is most relevant as it best corresponds to the average ROM grade as determined by the mining schedule, i.e. 10.5% Fe. From the graph it can be seen that the low grade DTW Fe trend line intersects 55% Fe at a grind size (P_{80}) of 110 µm. However, the grade achieved with the LIMS will always be somewhat lower than that of the Davis tube.

An allowance of at least 1 to 2% Fe should be made in order to cater for plant inefficiency and product grade variation. With this in mind, the graph indicates a product specification of 55% could be guaranteed at a grind size of around 90µm and a specification of 56% Fe at 75 µm. A grind size of 90 µm corresponds to a product specification of 0.17% P maximum and 75µm to 0.16%P.

The final grind size will be confirmed during ongoing pilot testwork as well as negotiation with key product off-take customers. For the purpose of this Study, the plant grind circuit was designed for a grind size of 75µm.

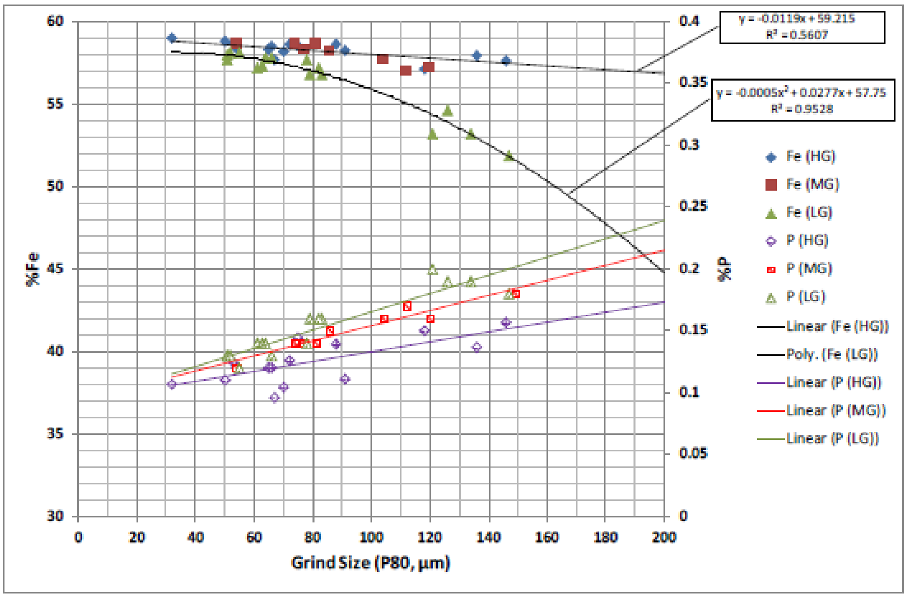


Figure 58 Pilot Plant DTW Results – Fe and P vs Grind Size

The proposed final product specification for a concentrate at a grind size (P_{80}) of 75 µm is given in 3, below.

Fe (min)	P (max)	SiO_2 (max)	Al_2O_3 (max)	TiO_2 (max)	V (min)	CaO (max)	S (max)	MgO (max)	K_2O (max)	Na_2O (max)	Zn (max)	Cl (max)
56.0	0.160	3.9	4.2	8.9	0.28	1.00	0.01	3.2	0.15	0.20	0.085	0.029

Table 14 Product Specification – 75µm Concentrate

7.2.5 Grindability Testwork

Under the DRA Process Review work A bulk sample from TTRs pilot plant was provided to Metso for conducting standard Jar Mill testwork data to assess the milling requirements to achieve the target grind and provide a Vertimill® sizing for the marine duty.

Several magnetic separation concentrates were progressively milled using the Levin- Method; which is effectively fine grinding in a standard Bond laboratory mill at known energy inputs. Milling tests were also conducted in laboratory scale UFG (ultrafine grinding) mills (Isa mill) on concentrates, and so a comparison between each technology and ball size effect can be made.

It has been possible to determine the grinding characteristics of the iron concentrate samples tested and therefore establish the probable milling performance of various milling options.

Levin Progressive Milling

The same breakage function was used throughout, and the grinding rates were manipulated to ascertain the best fit. From low energy grinding simulations show that there is a gradual improvement in milling rates with applied power.

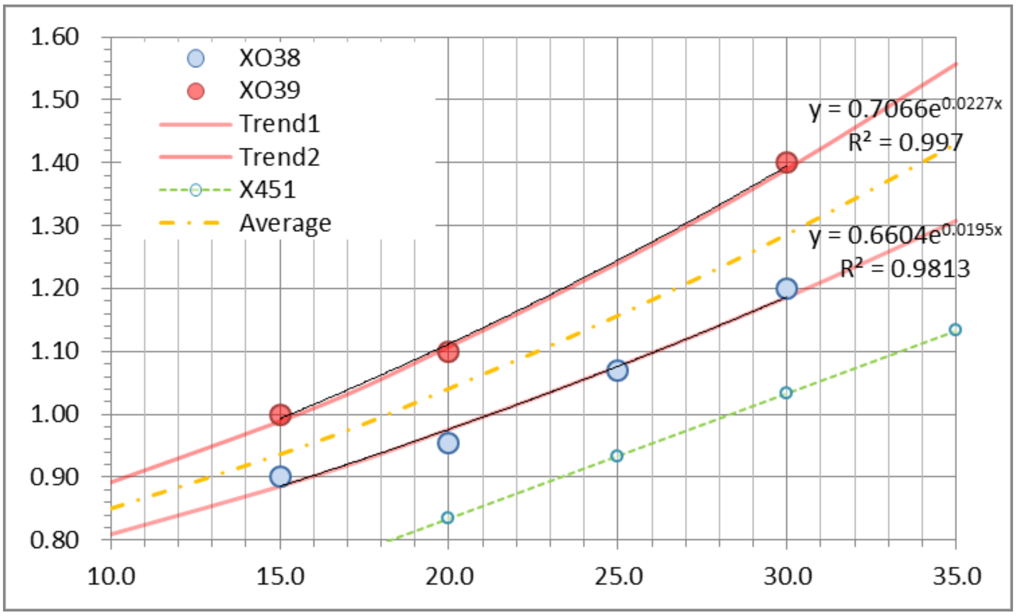


Figure 59 Levin Test – Typical Milling Rates with Applied Power

The testing undertaken by DRA / Metso showed that the breakage rates are less than conventional milling, despite improved particle breakdown, suggesting the smaller media size is more inefficient. Therefore, it was recommended that the use of Tower Mills be investigated. The grinding rates obtained were similar at low energies, 3.465*t/kWh* and were significantly higher than both Levin and IsaMills™, by *at least* a factor of two, and significantly more at the lower energy inputs. These results were subsequently used for simulating a full-scale mill.

Using the data from the Jar Mill test it was possible to estimate the performance of the full-scale unit, taking feed PSD and closed-circuit milling into consideration. The resultant simulations estimate that two VTM3000-WB units, in closed-circuit with two 33"Ø *gMax* or equivalent hydrocyclones, should cover the milling duty. However, it is strongly advised to consider a third standby unit, because the observed improvement in milling rates may not be fully realised with a seasoned charge on scale-up, and no derate factor has been used.

The estimated power requirement is between 3.3~3.5kWh/t.

7.3 Stage 3 Testwork – Vanadium Recovery

Laboratory testing was conducted by the University of Canterbury and Callaghan Innovation to validate the sodium salt roasting-water leaching process, optimise key parameters, and highlight areas for further testing and analysis associated with recovery from VTM.

In 2021, the University of Canterbury (UC) and Callaghan Innovation (CI) conducted lab-scale testing on the VTM concentrate sourced from three New Zealand locations, including TTR concentrate. The TTR sample and a second sample (Labelled as "PC" to maintain confidentiality, as its identification is restricted due to commercial sensitivity) shared nearly identical major oxide compositions, leading to comparable performance during testing. In contrast, the third sample exhibited a significantly different composition and performed notably worse in the testing program, highlighting the impact of ore variability on extraction efficiency.

The TTR and PC samples are iron sand concentrates while the VRC sample (Labelled as "VRC" to maintain confidentiality, as its identification is restricted due to commercial sensitivity) was a pyrometallurgical product i.e. vanadium enriched slag which understandably performed differently.

Sample	Name	Fe_2O_3	MnO	TiO_2	CaO	K_2O	P_2O_5	SiO_2	Al_2O_3	MgO	Na_2O	V_2O_5
1	TTR	82.90	0.68	8.60	0.74	0.09	0.29	2.42	3.79	3.09	0.11	0.57
2	PC	84.30	0.63	7.96	0.51	0.05	0.09	2.16	3.79	2.84	0.07	0.60
3	VRC	32.11	10.39	13.84	2.86	0.01	0.09	17.56	1.55	1.13	0.13	13.72

Table 15 Sample Major Oxide Compositions

The testing program explored the potential of the Salt Roasting and Water Leaching process, described in the previous section, the method favoured for its simplicity, established performance, and adaptability to local resources. The laboratory-scale testing evaluated and optimised the process for vanadium recovery from New Zealand iron sands.

The study evaluated roasting conditions, leaching solvents, and pre-treatment steps, and aimed to identify optimum operational parameters while addressing challenges such as byproduct management and environmental impacts.

The study concluded that the Salt Roasting and Water Leaching process holds significant promise for extracting vanadium from New Zealand's iron sands, especially when operating conditions were carefully optimised. Achieving a remarkable 77% vanadium recovery rate under laboratory conditions underscored the process's viability. However, challenges such as managing byproducts, addressing environmental impacts, and accommodating variations in sand composition were identified as hurdles to industrial-scale implementation. To advance this work, the study recommended future efforts focus on reducing wastewater and gas emissions, further enhancing the process's environmental sustainability, and conducting pilot-scale tests to confirm its commercial feasibility.

7.3.1 Experimental Procedure

The experimental procedure detailed in the report outlines the steps taken to evaluate the Salt Roasting and Water Leaching process for vanadium extraction from the iron sand samples. Key steps included the following.

Sample Preparation

- The samples were homogeneously mixed with sodium salts (e.g., sodium carbonate or chloride) using a ball mill for 60 minutes to ensure even distribution.

Roasting

- The prepared mixtures were roasted in a furnace equipped with temperature control to explore various roasting conditions, including temperature and duration; and
- After roasting, the samples were cooled to room temperature and ground to ensure uniformity.

Leaching

- The roasted materials were leached using distilled water or acidic solvents under controlled conditions; and
- Residual solids were separated using centrifugation and washed three times with distilled water to remove any remaining salts or impurities.

Analysis

- The composition of the roasted and leached samples was analysed using X-ray fluorescence (XRF) to determine metal content; and
- The leachate was further analysed using inductively coupled plasma mass spectrometry (ICP-MS) to quantify the vanadium and other elements extracted.

Process Optimisation

- Experiments were conducted to optimise pre-treatment, roasting, and leaching parameters. These included varying temperatures, roasting times, sodium salt compositions, and leaching solvents.

This methodical approach provided critical insights into the conditions that would maximise vanadium recovery, laying the foundation for further refinement and scalability of the process.

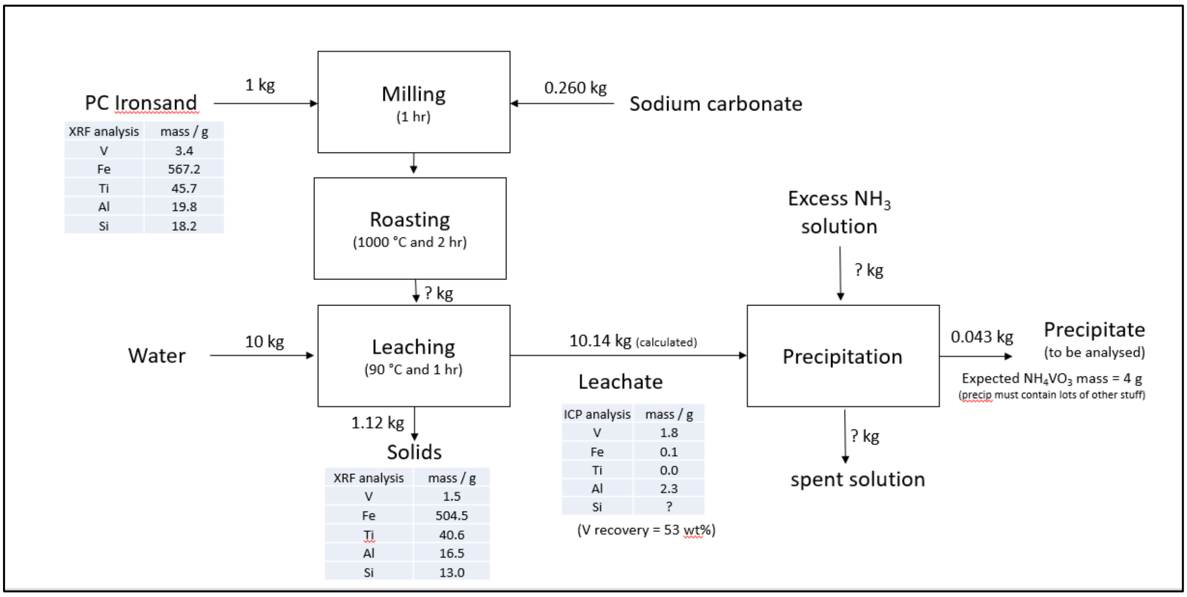


Figure 60 Mass Balance, University of Canterbury Laboratory Testing

7.3.2 Analysis of the Results

The third sample (VRC) was excluded from the Siecap conducted analysis due to its differing composition compared to the TTR and the second (PC) sample. While the TTR and PC samples shared similar major oxide compositions and demonstrated comparable performance, the VRC sample's distinct chemical makeup resulted in a vanadium recovery rate of only 9% under the baseline processing condition. As such, this analysis study focused on the two representative samples to provide meaningful insights into optimising vanadium extraction.

7.3.2.1 Average Vanadium Extraction Across Samples (Baseline Test)

The study evaluated vanadium recovery from the representative samples under identical baseline roasting and leaching conditions (roasting a 20g sample with 5g of sodium carbonate at 1000°C for 2 hours, followed by leaching at 90°C with distilled water for one hour). Under these baseline conditions, the results revealed varying levels of vanadium recovery.

On average, the baseline testing yielded a vanadium recovery rate of approximately 55% across the two representative sand samples.

7.3.2.2 Optimisation of Vanadium Extraction

The study then systematically investigated the effect of various parameters on vanadium extraction.

- Whilst the UC/Callaghan Innovation testwork references a coarse leach it does not elaborate on what defined the coarse leach. However, research papers detail the impact of a coarse leach on vanadium recovery and clearly defined the effect of the particle size distribution (PSD) i.e. D100 of 1000 μm and D90 of 25 μm, in which case the pulp density and pH were kept constant at 65 m/m% and 7.8, respectively. The results show that the best vanadium extraction was generally achieved when the coarser material (D100 of 1000 μm) was used as feed.
- Pre-treatment: Air roasting the sand prior to sodium salt roasting improved vanadium recovery from 55% to 65%.
- Roasting Conditions:
  - Temperature: Vanadium recovery increased with roasting temperature, peaking at 1000 °C.
  - Duration: Recovery improved with time, reaching a maximum of 56% after 4 hours. However, the difference in recovery between two and four hours was minimal, suggesting diminishing returns with extended roasting times.
  - Sodium Salts: Sodium carbonate and a mixture of 50 wt.% sodium chloride and 50 wt.% sodium carbonate both achieved comparable recovery rates.
- Leaching Conditions:
  - Time: The leaching duration had a marginal effect, with vanadium recovery stabilizing at 57% after two hours.
  - Solvent: Acidic solvents demonstrated superior performance compared to distilled water, achieving up to 65% vanadium extraction. However, the use of acidic solvents presents several adverse environmental impacts that must be carefully managed. Acidic solvents are inherently more reactive and, if not handled properly, can pose risks to soil and water quality through potential leakage or improper disposal. These solvents may produce hazardous by-products or residues, requiring robust waste management systems to prevent contamination of ecosystems.

7.3.2.3 Vanadium Extraction under Optimum Conditions

The detailed composition analysis showed efficient recovery of vanadium alongside other elements such as iron (Fe) and titanium (Ti). This demonstrates the effectiveness of an optimised process.

Combining optimal parameters (air roasting at 800 °C for 2 hours, sodium carbonate roasting at 1000 °C for 2 hours, and water leaching for two hours), on a coarse leached representative sample the testwork achieved an average vanadium recovery of 77%.

A slight increase in the vanadium recovery i.e. 79% was achieved using an acidic leach. The additional handling and storage protocols that are demanded by the use of acidic solvents would preclude its use in a full-size plant.

7.3.2.4 Challenges Identified

The process identified the following challenges.

- Formation of stable solid compounds during roasting, particularly with silicon (Si) and aluminium (Al), reducing vanadium availability;
- Generation of high-salinity ammonium-rich wastewater during vanadium precipitation, increasing treatment costs; and
- Emission of harmful kiln gases, requiring advanced gas scrubbing systems to minimise environmental impacts.

7.4 Process Overview

The TTR Taranaki VTM Project is designed to deliver 4.7 Mtpa titanomagnetite concentrate. The iron sands will be mined using two Seabed Crawlers, one operating and one standby. The ROM will be delivered to an IMV where it will be screened, magnetically separated and ground before final magnetic separation to produce a clean concentrate. All processing will be done wet using sea water throughout the process. The final concentrate will be dewatered to ~10% moisture and stored temporarily on the IMV before being slurried with fresh water from a reverse osmosis (RO) desalination plant. The slurry will be pumped to a floating storage and offloading vessel (FSO) where it will be dewatered and stored in the FSO holds. Once fully loaded, the FSO sails to a sheltered area (if required by prevailing weather conditions) where it offloads the cargo to an ore carrier, typically a Capesize vessel.

Tailings will be disposed in real time via a fall pipe extending forward off the port side of the IMV such that the tailings are deposited as far as possible from the face of mine. The tailings disposal fall pipe will be of similar design as a trailing suction hopper dredge drag arm. The tailings will first be dewatered via hydro cyclones with the wastewater disposed of separately along the tailings fall pipe.

7.4.1 Design Criteria

The design criteria for the process plant are listed in the table below. The reference key for the criteria is as follows:

1 Client supplied data.

2 Testwork data

3 Calculated

4 Design assumption

Item	Unit of Measure	Value	Ref	Comment
1. Overview				
ROM slurry density	vol.%	30	3	
Slurry volume mined	m3/h	11,348	3	
Solids density in situ	t/m^3	2.35	2	
ROM Feed	t/h (db)	8,000	3	
ROM Feed	t/a	48,002,734	5	
Product %Fe	%	56-57	2	
Process plant weight Recovery	%	9.6%	2	
Process plant weight Recovery	%	90.0%	2	
VTM Concentrate Production	t/h	765.0	3	
VTM Concentrate Production	t/a	4,590,261	3	Design to increase to 4.9Mtpa
2. Operating Schedule				
Annual operating days	d/y	365	4	
Daily operating hours	h/d	24	4	
Dry docking	d/y	12	4	56 days every 5 years for 15
Refuel	d/y	0	4	Refuelling will take place
Anchor spread	d/y	0	4	
Maintenance	d/y	26	4	
Days lost		38		Base case: Total 38 days lost (26 for maintenance), 12 days
IMV Availability	%	92%	3	
Mining efficiency	%	85%	4	
Weather uptime	%	90%	4	
	%	68.5%	3	

Total Operational Availability				
Operating time	h/y	6,000	3	
3. Ore Characteristics				
+2mm fraction	%	4.0	2	
-63μm fraction	%	0.6	4	
Concentrate SG	t/m^3	4.75	2	
Feed specific gravity	t/m^3	3.2	2	
Water Density	t/m^3	1.03	4	
Ore in situ density (wet)	t/m^3	2.35	4	
Ore in situ density (dry)	t/m^3	1.9	4	
Concentrate bulk density (dry)	t/m^3	2.36	4	
4.ROM Head Grade				
Fe	%	10.1	2	
SiO_2	%	48.9	2	
Al_2O_3	%	11.5	2	
TiO_2	%	1.4	2	
CaO	%	11.7	2	
MgO	%	6.0	2	
V	%	0.1	2	

Table 16 Project Design Criteria – Process Plant

7.4.2 Mass and Water Balance

The process plant mass and water balance were developed based on the design criteria and the pilot plant testwork results. The main inputs and outputs for the beneficiation plant are given below.

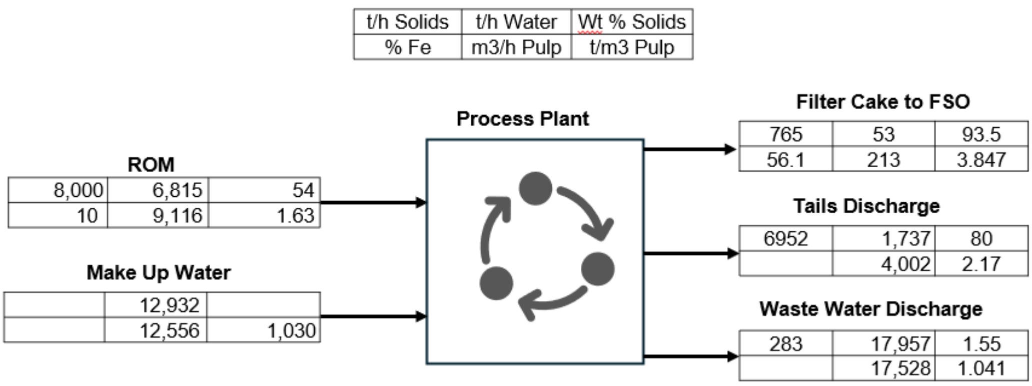


Figure 61 Process Plant High Level Mass and Water Balance

7.5 Process Description

7.5.1 Process Overview

In March 2014, DRA Global undertook a review of the process design for the TTR Taranaki VTM Project. DRA undertook the review while embedded into the TTR PFS design team to facilitate information and IP sharing. DRA's review identified a number of opportunities in terms of the installed power savings as well as alternate concepts and recommendations. These key findings and recommendations are.

- **Process Design Review**
  - Screening & Surge Tanks - The report recommends replacing trommel screens with double-deck vibrating screens to reduce footprint, mass, and power consumption.
  - Milling Circuit - The initial design proposed 4,500HP Vertimill®, but test results indicate 3,000HP Vertimill® may be sufficient.
  - Dewatering System - Recommended additional dewatering tests to ensure the target 10% moisture content is achieved in the final product.

- **Potential Power Savings**
  - Identified process modifications could lead to significant power savings (estimated at 10,250kW), including:
  - Using a pressure splitter instead of a boil box.
  - Optimising the coarse tailings disposal system to reduce pumping requirements.

- **Process Test-work Recommendations**
  - Additional pilot testwork is required, particularly for 7-10% Fe head grade samples, as this represents 60% of the resource.
  - Dewatering tests to confirm the effectiveness of the dewatering magnet.
  - Material flowability tests for product storage bins on the IMV.
  - Rheological testwork to optimise slurry pumping and flow characteristics.

- **Next Steps**
  - A dynamic simulation study is recommended to evaluate the IMV process plant availability and utilization.
  - Further layout optimization to integrate proposed changes.
  - Supply chain impact analysis to ensure smooth mining-to-processing-to-shipment flow.

The DRA revised process flow diagram for the beneficiation plant is provided in Figure 72.

7.5.2 ROM

ROM ore will be delivered to the IMV via an 800mm ID rubber hose connected to the SBC. The design rate of ROM delivery is 8,000t/h solids. The ROM ore will be directed into a boil box from where it is directed into two intermediate distribution sumps. Process water is added to reduce the slurry density to 31.5% solids by weight before the slurry is fed to 10 trommel screens at main deck level. The screen aperture will be 4mm such that the effective screen size of the ROM will be ~2mm. Spray water on the screens will reduce the slurry density further to 30% solids. The screen undersize is fed under gravity to ten water agitated storage tanks directly below the screen area. The oversize will be fed via a chute to the tailings handling area.

7.5.3 Screening and Surge Tanks

The TTR flowsheet allowed for 4 trommel screens to remove the oversize material (+3.5mm). This oversize material is then passed over a static screen, discharging the +25 mm material into a waste bin.

DRA reviewed the use of double deck vibrating screens. The primary deck would be to replace the duty of the static grizzly located on the boil box. The secondary deck would be to remove the +3.5mm material.

The advantages of using vibrating screens are:

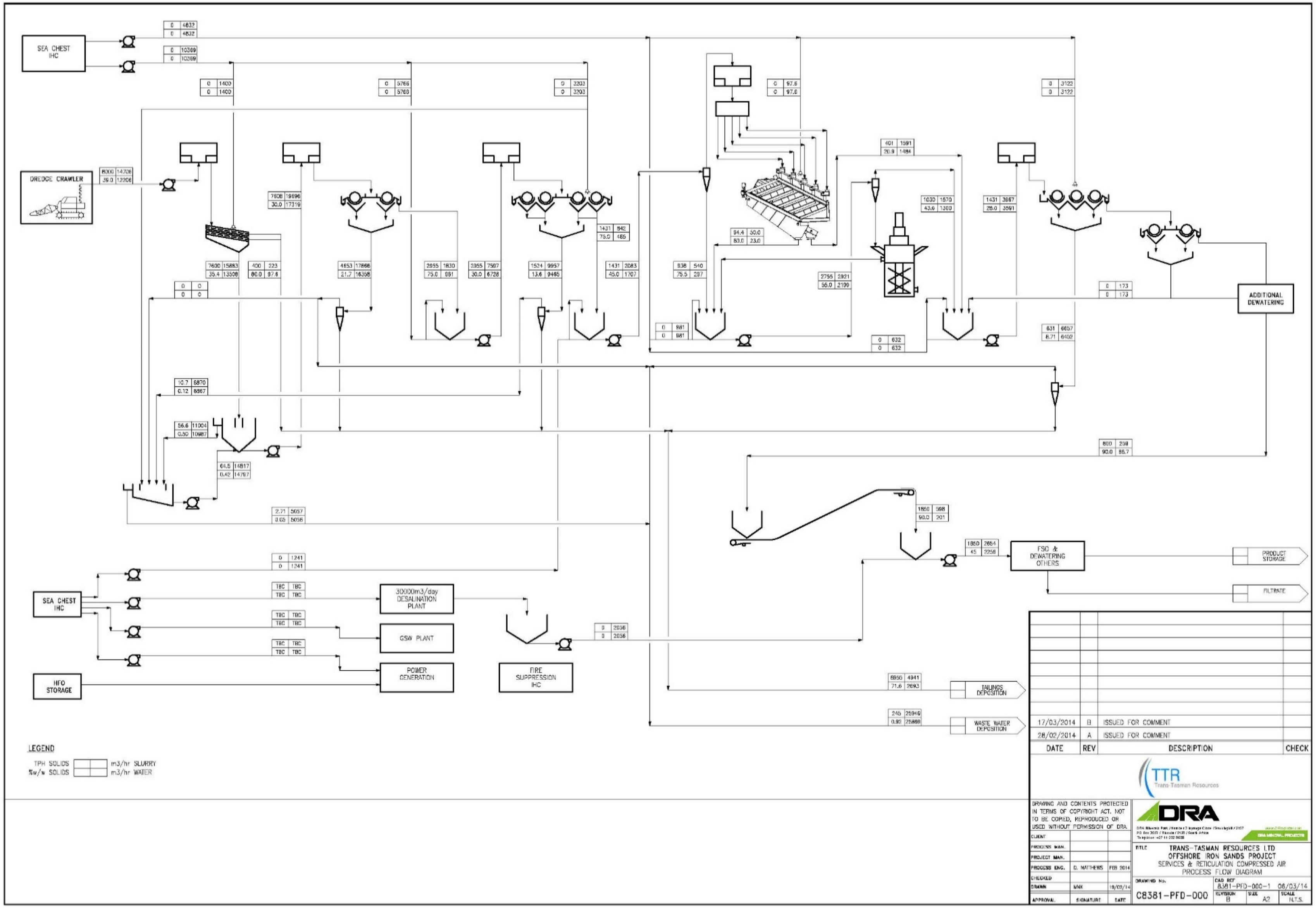
- reduced mass (30 tons per screen compared to 220 tons per trommel);
- reduced footprint;
- reduced Capex; and
- reduction in installed power.

The disadvantage of installing double deck vibrating screens are reduced operator visuals and maintenance access to the bottom deck. Due to the fine nature of the material and overflow entrainment, the overflow of the surge tanks directly to wastewater, which may result in a significant loss of Fe from the process. DRA recommended that a separate (motive water) tank be installed to capture the overflow from the surge tanks and reintroduce this water (and solids) into the surge tanks as motive / agitation water. It was also recommended that an elutriator type design be incorporated into the surge tanks to minimise the solids overflow to the motive water tank.

7.5.4 Rougher Magnetic Separation

The -2mm ore is pumped from the agitated storage tanks to the first stages of magnetic separation. The purpose of the rougher magnetic separation (RMS) is to capture both the liberated and locked magnetic particles whilst rejecting the majority of the gangue. This will be accomplished using single drum MIMS and double drum LIMS in series. The slurry is first pumped to the MIMS section located on the first level which will consist of 60 single drum units. The MIMS units will be split into ten clusters of six each, corresponding with the number of agitated storage tanks. The MIMS drums will have a magnetic field intensity of 4,500 G and consist of 3 m wide by 610mm dia. stainless steel drums

Figure 62 DRA Updated PFD



Due to the susceptibility of standard grade 304 stainless steel to pitting corrosion, grade 316 stainless steel was specified for the magnetic separator drums. The MIMS concentrate (approximately 41% of the feed) will be fed under gravity to the LIMS-1 feed tanks at main deck level. Process water will be added to reduce the concentrate slurry density from ~60 to 30% solids. The tailings will be gravity fed via a chute to the tailings handling area.

Figure 62 Magnetite Concentrate Exiting a Wet Drum Magnetic Separator

The MIMS concentrate will be pumped to the rougher LIMS distributors located on the second level. The rougher LIMS section will consist of 16 double drum units operating co-currently at an intensity of 1,250G. The units will be arranged in four clusters with four units each. Each unit has two 3.6m wide by 1.22m dia. drums in series. The weight recovery to concentrate is ~ 45%. Thus, in the RMS section, approximately 82% of the feed is rejected to tailings. The Fe upgrade ratio is 3.2. The RMS concentrate will gravitate to the first stage grind feed bins. Magnetite concentrate from LIMS units are typically at the required solids density required for grinding and no dewatering of the concentrate prior to grinding is required. The tailings will be gravity fed via a chute to the tailings handling area.

7.5.5 Milling

TTR reviewed various mill options and configurations, namely ball mills, ISA mills and Vertimill®. The comminution circuit proposed in the Rev 2 PFS had a two-stage grind with intermediate magnetic separation (IMS) to remove liberated gangue and reduce grinding energy in the second stage grind. Rev 2 also proposed grinding stages proposed M10,000 Isa Mills™ (Xstrata), because of its lightweight design and superior energy efficiency.

Following the DRA process review it was determined that two Metso Vertimill®, in parallel, provided the ability to complete the grinding circuit as a single pass grind. The post PFS process flowsheet had identified that two VTM 4500 mill were specified, however during the DRA review TTR completed special jar mill grindability testing with Metso, in South Africa. From these results DRA undertook a simulation and determined that two smaller VTM3000 units, in closed circuit could, could be utilised and meet the process design. It was noted that given the variability of the ore, additional detailed design would be required.

Description	Mill Specifications as per Basis of Design	Mill Specifications as per Mill Testwork
Mill Description	2 x VTM 4500	2 x VTM 3000
Installed Power	2 x 3 375kw	2 x 2 250kw

Table 17 DRA summary of the mill specifications

Figure 63 Metso Vertimill

7.5.6 LIMS 2 - Intermediate Magnetic Separation

The IMS LIMS units will be identical to the RMS LIMS units. Ground RMS concentrate will be diluted to 30% solids in the IMS feed tanks and pumped to the IMS section (LIMS-2) distributors on the second level. The IMS section will comprise 12 units arranged into two clusters of six separators each. Approximately 30% of the IMS feed is rejected to tailings. The IMS concentrate will be gravity fed to the second stage grind feed tanks. The tailings will be gravity fed via a chute to the tailings handling area.

7.5.7 LIMS 3 - Cleaner Magnetic Separation

The cleaner magnetic separation (CMS) section will consist of eight triple drum co- current magnetic separators at an intensity of 950G, arranged in two clusters of four each. Typical triple and double drum wet magnetic separators are shown in Figure 76. Ground IMS concentrate will be diluted to 30% solids in the CMS feed tanks and pumped to the CMS section (LIMS-3) distributors also located on the second level. The weight recovery to concentrate in the CMS section is expected to be 90% with the concentrate having a Fe grade of more than 56% Fe and SiO_2 less than 3.9%.

Figure 64 Triple and Double Drum Magnetic Separators

The CMS concentrate will be gravity fed to a set of dewatering drum magnets to reduce the concentrate moisture to ~10%. The purpose of these drums is to reduce the level of sea water in the concentrate to aid in reduction of final product chloride levels. Dewatered concentrate will be gravity fed into the concentrate storage hoppers directly below the CMS area. Water removed from the concentrate is recycled to the CMS feed tank.

7.5.8 Final Concentrate Handling

The dewatered concentrate will be stored in two hoppers. The hoppers were sized for a buffer capacity of 40h or approximately 32,000t. This will allow enough time for the FSO to sail a distance of maximum 70Nm to a sheltered area (if required by weather conditions), offload its entire load of 60,000 t concentrate and return to the IMV. Once the FSO is on station, it will connect to the IMV via a floating slurry line. Dewatered concentrate will be extracted periodically from the bottom of the storage hoppers onto a conveyor belt. It will be elevated to the top of a constant density (CD) agitator tank with a sandwich conveyor. In the CD tank the concentrate will be slurried with fresh water from the RO plant (from two intermediate freshwater tanks) to form a 50% solids slurry. Fresh water is required to wash the concentrate, i.e. to reduce the chloride level of the product. The slurry is subsequently pumped to the FSO and filtered to a low moisture content of less than 6.5% using four hyperbaric pressure filters.

Figure 65 Hyperbaric Pressure Filter

These units were chosen for their much smaller footprint relative to conventional filtration units, both from an operational and maintenance perspective. The residual moisture content attainable is also much lower than that of conventional filtration with the added benefit that the minimum moisture is transported to the final destination. The HPF units will operate at an elevated pressure of 6 bar. The filter cake is discharged from the units via a double gate valve system onto conveyors which will deposit the concentrate in the FSO holds. Filtrate from the FSO will be discharged below surface.

During offloading of concentrate the process plant will continue to operate to produce the balance of the 60,000t FSO cargo. Offloading to the FSO therefore will occur at double the production rate of the process plant (~1,600t/h).

7.5.9 Tailings Handling

No chemicals will be used anywhere in the beneficiation process. As a result, the tailings produced by the process plant will be inert. The only physical alteration of the ore is the size reduction during the grinding process. In order to minimise the environmental impact of the tailings in terms of plume formation, it will be dewatered before disposal via a set of hydro-cyclones (refer to Figure 78). Coarse tailings from the RMS area will be treated separately from fine tailings from the IMS and CMS areas. Water removed from the coarse tailings will be recycled to the process water tank at a rate of 15,000 t/h, thus accounting for approximately 52% of the process water requirement. Water from the fine tailings dewatering will contain too high level of suspended solids to be used as process water and will be discharged.

The coarse and fine tailings will be dewatered separately to approximately 75 to 80% solids before being discharged under gravity via the tailings deposition pipe. The deposition pipe will be controlled using sonar such that the discharge occurs at a constant height from the seabed. The tailings wastewater will be discharged via a second pipe along the tailings deposition pipe slightly higher than the solids discharge.

Figure 66 Hydrocyclone Cluster

8 AUXILLIARY SUPPORT SERVICES

8.1 Power Generation

For the purposes of the PFS study the project has specified four (4) Siemens SGT-500 gas turbine generator sets for a total installed power capability of 80MW.

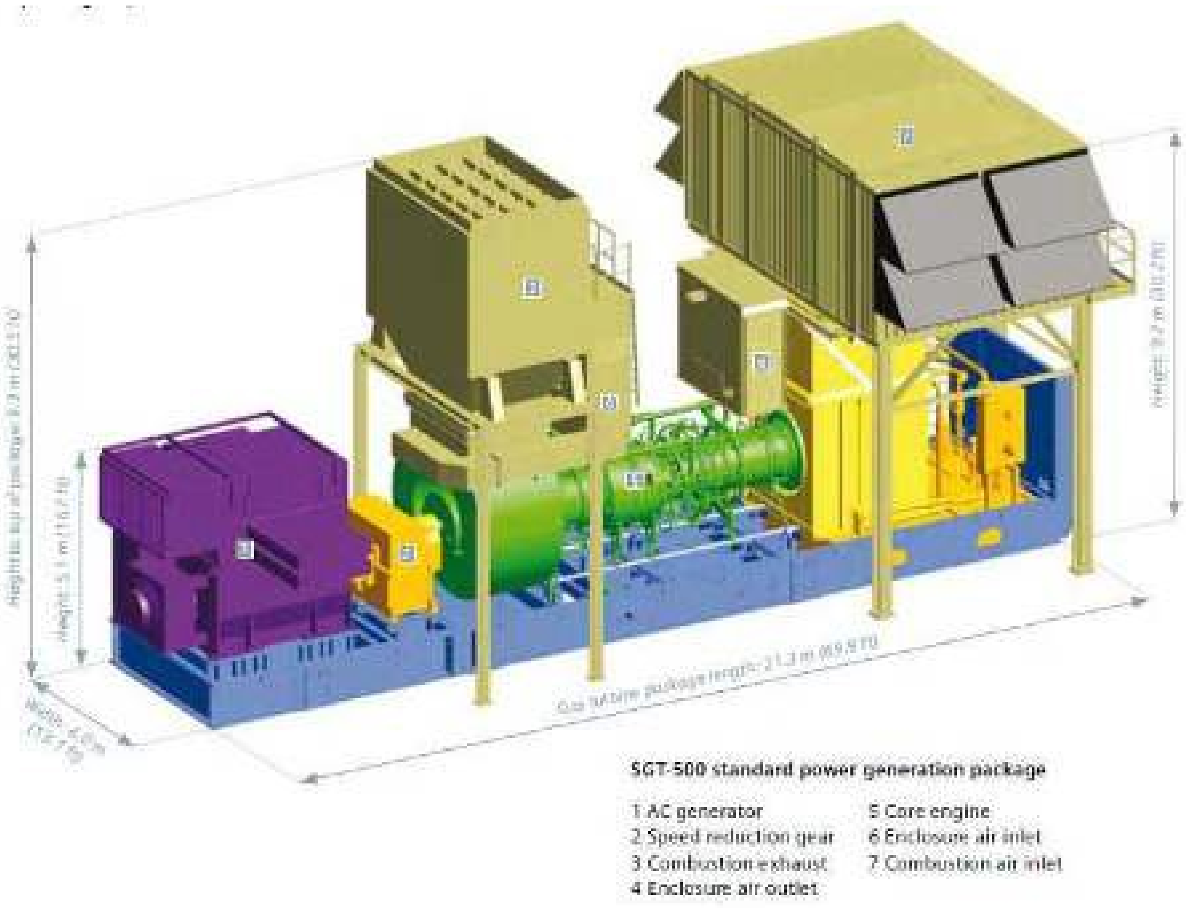


Figure 67 SGT-500 Power Generation Package

The SGT-500 is one of the few gas turbines which have the capability to operate on IFO, something normally associated with diesel engines. Siemens has shown that the SGT 500 can operate continuously on liquid fuels with viscosity corresponding to IF700 with no requirements for blending with diesel oil.

The project acknowledges that there is an opportunity to rationalise the power installation and add considerable value to the project. The feasibility phase value engineering exercise will investigate fitting the IMV with two turbines, along with four medium speed diesel generator sets giving the total installed power of around 80MW. The power generated will meet the ship's demand for energy, which includes the propulsion motors, mining, processing, desalination and low-voltage requirements for lighting and sockets.

Typical medium speed diesel engines for marine applications are rated from around 1MW in small vessels to 10MW in large vessels. Installations of four, six or eight engines are commonplace with 2MW to 7MW being a popular power range. The engines are invariably multi-cylinder units in either in-line or V configuration.

By implementing this dual concept, electric power will be provided by several synchronous alternating current generators operating in parallel. The generators will be connected to switchboards by way of circuit breakers that will allow the generators and loads such as thrusters, service transformers and motors to be connected and disconnected as required.

The advantages of this envisaged concept will include:

- ability to provide large amounts of power for activities other than propulsion;
- ease with which power can be distributed for auxiliary systems;
- modular designs allowing maintenance to continue during operations;
- flexibility in engine assignment; and
- good power plant efficiency.

8.1.1 BFS Power System Studies

Apart from the value engineering exercise, several other power related studies will be commissioned during the feasibility phase to support the design of the IMV power system including the following.

- **Short circuit calculations**: This study will be performed to verify the proposed switch gear will be able to withstand the force generated by the worst-case short circuit current. It will also be used to verify the circuit breakers are able to interrupt that level of fault current. When calculating the contribution to short circuit current it will be necessary to consider the contribution from all motors and certain types of drives in addition to the fault current delivered by the generators.
- **Protection co-ordination study**: This study will be performed to determine the various protection settings necessary to ensure that faults are isolated as close to source as possible.
- **Load balance**: This study will be performed to show the power consumed under various operating conditions, which may include dynamic positioning (DP), transit and harbour with variations for summer and winter operation if appropriate.
- **Harmonic analysis**: This study will be used to verify that levels of harmonic distortion fall within acceptable levels under all expected operating conditions. Excessively high levels of harmonic distortion have been known to cause equipment malfunction exceeding worst case failure design intent.
- **Transient stability study**: This study will be performed to verify the ability of the generators in the power system to maintain synchronism when subjected to a severe transient disturbance such as a fault, sudden loss of generating capacity or large load rejection. It will also be used to ensure that motors can restart and that generators can

restore voltage.

8.1.2 Distributed Control System

The IMV will be provided with a comprehensive vessel management system that will manage the functions of control, monitoring and alarm management of all machinery required to control the functions installed on the IMV including engine and propulsion auxiliary systems, fluid and cargo systems and other ancillary systems

8.1.3 Power Requirement Simulation Model

Due to the complex nature of the operating environment, TTR commissioned a simulation, (See Appendix 19.3), to examine the consequences of wave height, ROM grade variability, buffer sizes and maintenance shuts on the production rate and hence the instantaneous power consumption of the IMV.

A process mass balance model was constructed using the IDEAS modelling software to deliver modelling results for one year's operation at two production input rates of 6,700 tonnes per hour and 8,000 tonnes per hour respectively using actual historic variability in wave heights and observed variability of ROM ore grades based on site sampling surveys.

In addition to modelling the processing module, the model also accounted for:

- The power requirements of the IMV's DP system (DP), influenced by wave height;
- The production by reverse osmosis of desalinated water; and
- Routine fortnightly shuts of the plant for maintenance.

	Scenario 1	Scenario 2
	6700t/h ROM Solids	8000t/h ROM Solids
Real Time for Model	366.4 days	366.4 days
kWh/tonne (ROM)	8.8 kWh/tonne	8.4 kWh/tonne
Peak MW	82MW	82MW
ROM Average Feed Rate t/h	6300 t/h	6700 t/h

Table 18 TTR Power Simulation Results

8.2 Sea Water Desalination

As the processing circuit will be using sea water there is a requirement to provide a fresh water rinsing step into the process. At levels above 300 to 350ppm chlorides begin to pose challenges to steel mills. Chloride forms a white plume during the smelting process as halide formation with potassium (K) and sodium (Na) occurs. High levels of chloride fed into sinter plants can also act as catalysts for the formation of dioxins.

This rinsing requirement will be accomplished using desalinated sea water to transfer the ore in a slurry form from the IMV to FSO. This processing step will require the production of 30 000m^3 of fresh water per day.

The process of reverse osmosis is based on the fact that in all salt solutions an osmotic pressure arises whose magnitude is proportional to salt concentration. When a semi-permeable membrane is placed between two solutions of different concentrations and osmotic pressures, the difference in osmotic pressures will result in a flow of solvent (and a tiny part of the solute) through the membrane, from the less concentrated solution to the more concentrated one. In the process of reverse osmosis, the direction of the solvent flow is reversed by exerting external pressure, higher than the difference in osmotic pressures, on the more concentrated solution.

The typical reverse osmosis plant consists of a bundle of membranes placed in a pressure chamber, a high-pressure pump, a turbine for recovering energy from the high concentration brine which is discharged from the plant, and a system for the pre- treatment of the feed water and the product water.

In the TTR process the sea water will enter, via the sea chest, a pre-treatment system which will contains sand filters, micron filters and a system for chemical dosing. The purpose of this pre-treatment system will be to protect the membranes from fouling by dirt and biological deposits. The feed pump will generate sea water flow at pressures of 55– 80 bar through the membrane system. The discharged brine will be returned to the sea via the submerged tailings pipe. A secondary system used for periodical cleaning of the membranes is installed in each reverse osmosis plant.

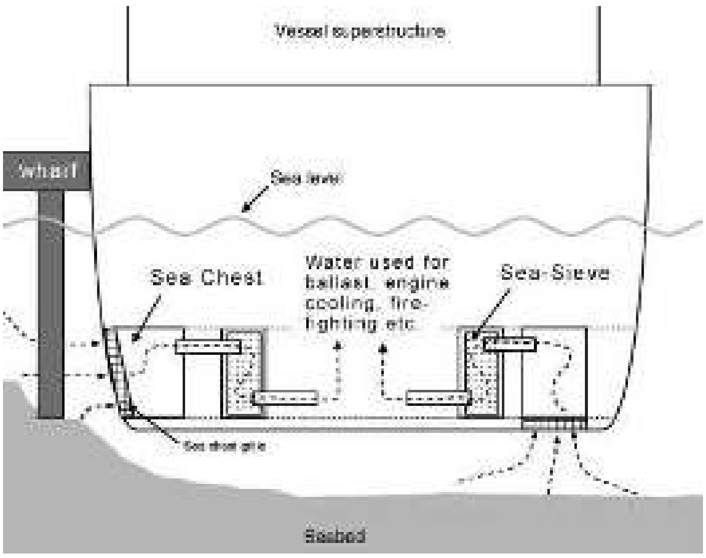


Figure 68 Vessel Sea Chest

The TTR project has specified 10 separate containerised Reverse Osmosis plants, each with a production capacity of 3000 cubic metres per day.

Modularising the plant in this way reduces risk, in the case of a breakdown in one plant, nine others are still available. It is also advantageous from a maintenance downtime perspective: with only 10% capacity offline at any one time, production is hardly interrupted for scheduled servicing. Spare parts are common across all plants, further reducing costs of stocking critical parts and components.

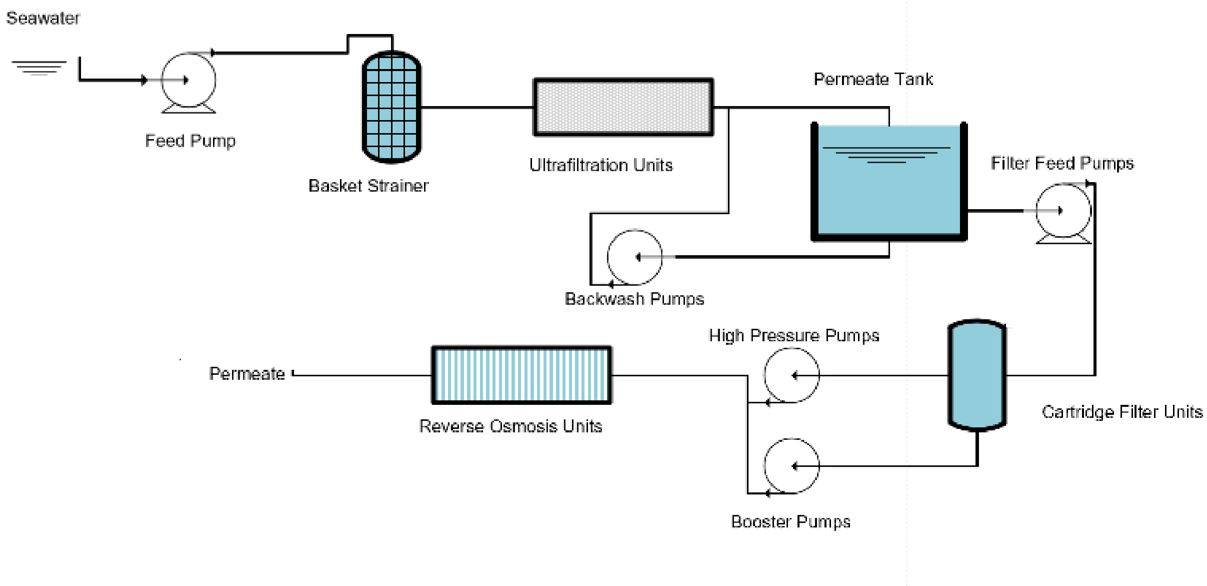


Figure 69 Typical Desalination Process

9 OFFSHORE FACILITIES & SHIPPING CYCLES

In order to fulfil the requirement for producing around 5Mtpa of concentrate, the integrated vessel solution requires several unique vessels to be permanently mobilised, each having a specific function.

9.1 Offshore Personnel levels

The personnel levels for the IMV have been developed based on the personnel arrangements on oil and gas FPSOs that have operated in the Taranaki Area. The crews of both vessels are employed under separate employment contracts, some collective and some individual. These contracts are a progression from the original IMV employment contracts developed for the 'Whakaropai' which was operated by Shell Todd Oil Services Limited in the Maui field from the mid 1990's to the mid 2000's.

9.1.1 Offshore Working Rosters

It is envisaged that TTR will employ the same 14-day on and 14-day off roster as per the current IMVs. This is a typical employment condition in the offshore oil and gas industry and results in two crews being engaged for each vessel.

Furthermore – the respective employment agreements will provide for six weeks annual leave and in order to meet the roster patterns a small number of relievers will be engaged to cover the disciplines when the core crew is taking these leave periods. The relievers are either sourced from onshore contractors or employed as casual permanent relievers.

9.1.2 Where Crew Reside Onshore

There are no employment restrictions as to where crew need to reside in New Zealand. As a natural result of Taranaki being the energy province of New Zealand, a number of crew will be sourced locally in Taranaki, whilst others from other New Zealand regions. For the 'Umuroa' the current figures are 54% Taranaki residents, elsewhere in 46% NZ, the 'Raroa' is similar.

9.1.3 Nationality of Crew

There are currently plans to incentivise the use of either New Zealand citizens or New Zealand residents as crew on all operational vessels.

9.2 IMV Offshore Operations

The IMV will be a large vessel designed to accommodate the extraction module at its rear, with the processing, operating and utility modules integrated above deck (Refer to Diagram 83). The vessel and its ancillary systems will be designed to support the interrupted extraction and processing up to a 4m significant wave height. When the captain of the vessel deems it necessary or when forecasts indicate conditions approaching that would exceed this wave height limit, the crawler will be lifted on deck and processing will be adjusted to accommodate this interruption and in extended periods of inclement weather even halted.

The vessel will be designed in accordance with the rules and regulations of ABS as a special purpose mining vessel for site- specific mining activities according to ABS classification rules and regulations with the Flag State for this vessel being New Zealand.

With regards to the design and construction of the IMV the following ABS rules and regulations will apply:

- ABS Rules for Building and Classing Offshore Support Vessels 2014;
- ABS Rules for Building and Classing Steel Vessels 2014;
- Code of Safety for Special Purpose Ships, 2008 adopted by IMO MSC 266(84);
- Rules for Building & Classing Mobile Offshore Drilling Units, 2014; and
- ABS Guide for the Classification Notation Thruster-Assisted Mooring (TAM, TAM (Manual)) for Mobile Mooring Systems, 2014.

The IMV is also required to comply with the following Rules and Regulations:

- IMO International Convention for the Safety of Life at Sea, 1974 (SOLAS), Consolidated Edition 2004 with latest amendments;
- IMO International Convention for the Prevention of Pollution from ship (MARPOL 73/78) with the latest amendments;
- IMO NOx regulations (MARPOL Annex VI);
- IMO International Convention on Load line 1966 including Protocol of 1988;
- IMO International Convention on Preventing Collisions at sea (COLREG 1972) including amendments of 1981 and 1987;
- IMO International Convention of Tonnage Measurement of ships 1969;
- Radio Rules of the International Telecommunication Convention, 1976 and 1979 incl. GMDSS;
- Global Maritime Distress and Safety (GMDSS) requirements for sea areas A1+A2+A3;
- International Labour Conference (ILO) Marine Labour Convention 2006; and
- International State and Port Security (ISPS).

The IMV will also be designed in compliance with the following international codes, standards and guidelines as far as applicable:

- IMO MSC/Circ.645: Guidelines for the design and operation of dynamically positioned Vessels;
- Common Structural Rules for tankers and bulk carriers;
- IMO Resolution A.468 (XII), 1981 Code on noise levels on board ships;
- ISO 6954 Guidelines for overall evaluation of vibration in merchant ships (1984);

- International Electrotechnical Commission (IEC), Publication no. 92 for electrical installations on-board ships;
- IEEE 45-2002 Recommended Practice for Electrical Installations on Board of Ships;
- Electromagnetic compatibility of electrical and electronic installations on ships, IEC 533;
- CAA – Rules and regulations for helicopter operation on UK sector (CAP 437) – latest edition;
- IMCA M 103 – Guidelines for the design and operation of dynamically positioned ships;
- IMCA M 404
- OCIMF for ship to ship transfer of fuel oil;
- American Petroleum Institute (API); and
- American Welding Society (AWS).

The Flag State for the IMV will be New Zealand and as such will comply with all the applicable Flag State marine rules and regulations.

Critical to the design of the mooring system is the specification of the maximum environmental conditions. TTR has used verified local Met Ocean data compiled over a period of two decades

To allow for potential future additional weight to be installed on-board the IMV, a 200,000tdw vessel has been considered for the mooring dynamic analysis in the rest of the study.

Figure 70 Integrated Mining Vessel (IMV)

9.2.1 IMV Mooring Analysis

As part of the IHC Crawler evaluation, a preliminary conceptual mooring study and dynamic analysis was performed on the IMV in order to confirm the ability of the proposed four- point mooring to cope with the environmental conditions. The loadings identified in the initial commissioned Principia mooring study, provided IHC with the baseline loading cases for the preliminary conceptual four-point mooring study.

The proposed mooring system will consist of a four-point mooring with an equal spread. The vessel will be able to operate in an anchor spread of 900m by 300m with a water depth of 20 to 65 metres. Refer to the appendix for the full report.

9.2.2 IMV Personnel Levels

The total personnel complement required for the IMV will be 139 personnel, this includes an allowance for relief during holiday periods. The detailed IMV personnel requirement is detailed in Appendix 19.5 of this document

9.3 FSO Offshore Operations

TTR commissioned CSL to provide a transhipment system consisting of a purpose-built self-unloading, trans- shipment vessel with a cargo capacity of 60,000 Mt. The loading system aboard the transhipment vessel consists of a dewatering plant and a mechanical, deck conveying system.

Product will be slurried with fresh water and pumped via floating hoses from the IMV to the transhipment vessel. The dewatering plant will consist of a number of hyperbaric disc filters. The machine consists of discs divided into segments, each of which is fitted with a ceramic filter. The water discharged from the hyperbaric filter on the vessel will not contain any “hard won” concentrate sediment particles. The hyperbaric disc filters on the FSO will make use of ceramic vacuum disc filters to dewater the iron sand slurry. The construction and operation principle of ceramic disc filters is similar to the conventional disc filters, but the difference is that the filter cloths are replaced by microporous ceramic segments with a pore diameter of 10µm. The verified analysis of the produced concentrate particle size distribution shows no particle below 20µm. The specified segments will provide a dewatered concentrate with a moisture content of less than 8%.

Once fully loaded, the transhipment vessel will sail to the area designated for “dry” transfer onto ocean going cargo vessels. The “dry” cargo discharge system on the proposed transhipment vessel is gravity based; a proven system widely used across CSL’s global fleet of vessels.

The dewatered iron ore flows through gravity feeder gates at the bottom of the transhipment vessel’s cargo holds, depositing cargo onto an inclining tunnel belt that will elevate the cargo to the main deck of the Transhipment Vessel. The cargo is then deposited onto two separate incline conveyors, each feeding a ship-loader located fore and aft. The ship-loaders can slew, luff and telescope and are capable of loading and trimming ocean going cargo vessels of up to 57m beam.

	FSO Specifications
Length (meters)	230
Width (meters)	32
Summer Draft (meters)	13
Air draft in ballast condition (meters)	34
Class and flag	IACS class society and flag to be determined.
Propulsion	• Main propulsion and rudder system designed for optimum maneuverability. • Powerful bow thrusters, allowing double-bank operation independent of tugs. • Further analysis required to determine maneuverability requirements during loading, including requirement for full Dynamic Positioning capability
Accommodations	25 people
Self-Unloading / Material Handling System	• Hopper shaped cargo holds lined with Ultra- high-molecular-weight polyethylene (UHMW) • Hydraulic mass flow gates • Gravity fed inclining conveyors • 2 x ship-loaders, each 4,000tph (peak 8,000tph; average 6,000tph)

Table 19 FSO Specification

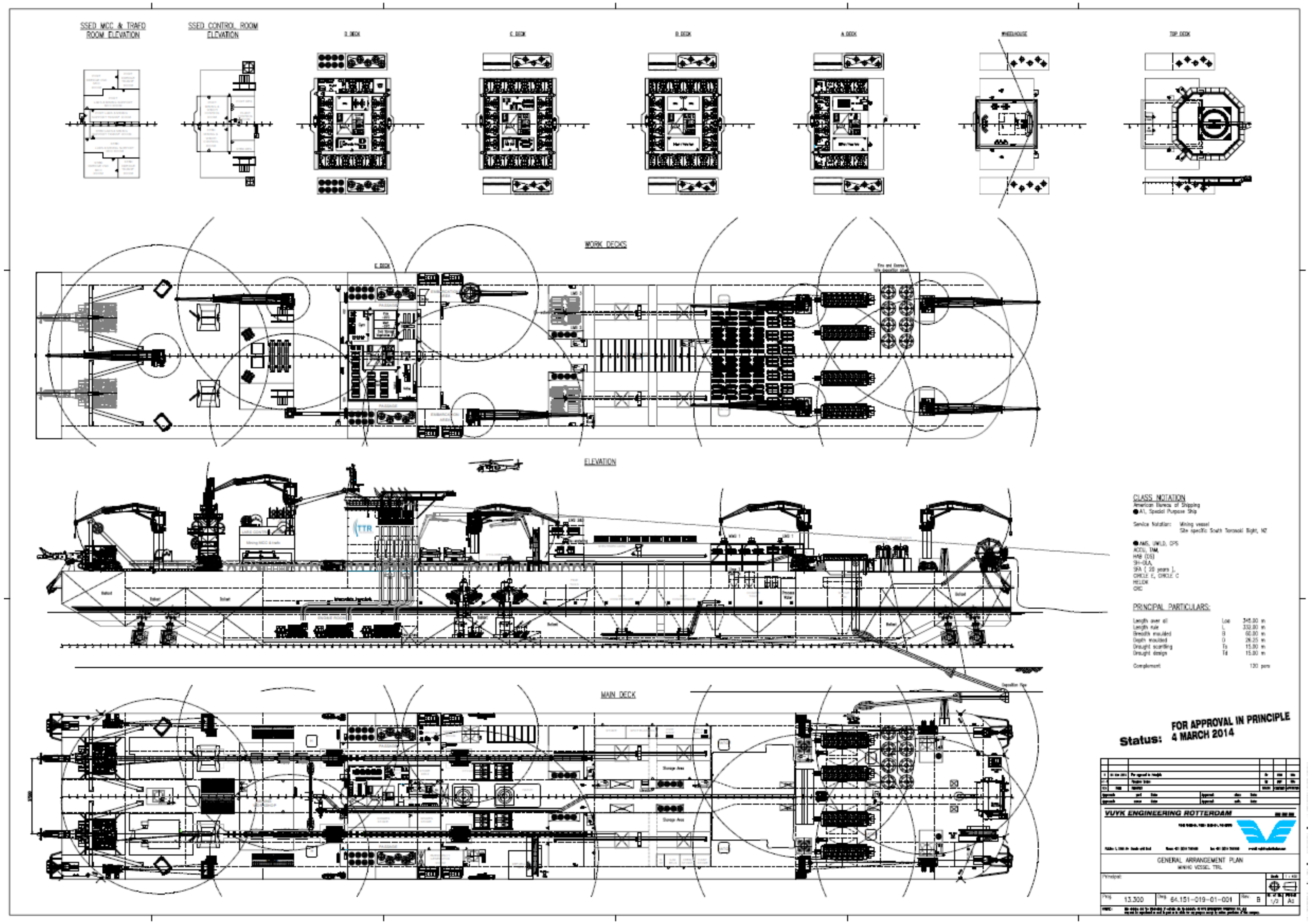


Figure 71 IMV General Arrangement

9.3.1 FSO Loading System

This loading system will consist of a dewatering plant and a mechanical deck conveying system.

The dewatering of the ore will be achieved by four hyperbaric filtration units each with a throughput of 450 tons/hr, providing a total dewatering capability of 1,800 tons/hr.

The slurried ore will be transferred from the IMV to the FSO through flexible hoses. Once the FSO is fully loaded with concentrate (60,000t), it can unmoor from the IMV and sail to an awaiting export Capesize vessel which will be located in a calm area off the South Island, approximately 70Nm from the mining location.

9.3.2 Cargo Vessel (Capesize) Loading system

The cargo discharge system on the proposed FSO will be gravity based and is wildly used across self-unloading bulk carriers and transhipment systems. The company approached during the completion of the PFS, i.e. CSL, had three gravity FSOs in operation and nine self-unloading bulk carriers under construction (or newly completed) utilizing the same core technology as the proposed TTR FSO.

9.3.3 Transhipment Cycle

The overall cycle duration of the Floating, Storage and Offloading vessel.

Activity	Time (h)
Total positioning time	5.0
Loading IMV to FSO	53.6
Average time for draft survey	0.2
Transit to Anchorage	5.8
Unload FSO (trans-shipping)	7.5
Shifting	0.5
Transit to IMV	5.8
Total time per FSO (hours)	**78.4**
Total time per FSO (days)	**3.3**

Table 20 FSO Shipping Cycle

The overall shipping cycle duration for the FSO is thus approximately 78.4 hours, putting the FSO on the critical path of the overall production cycle.

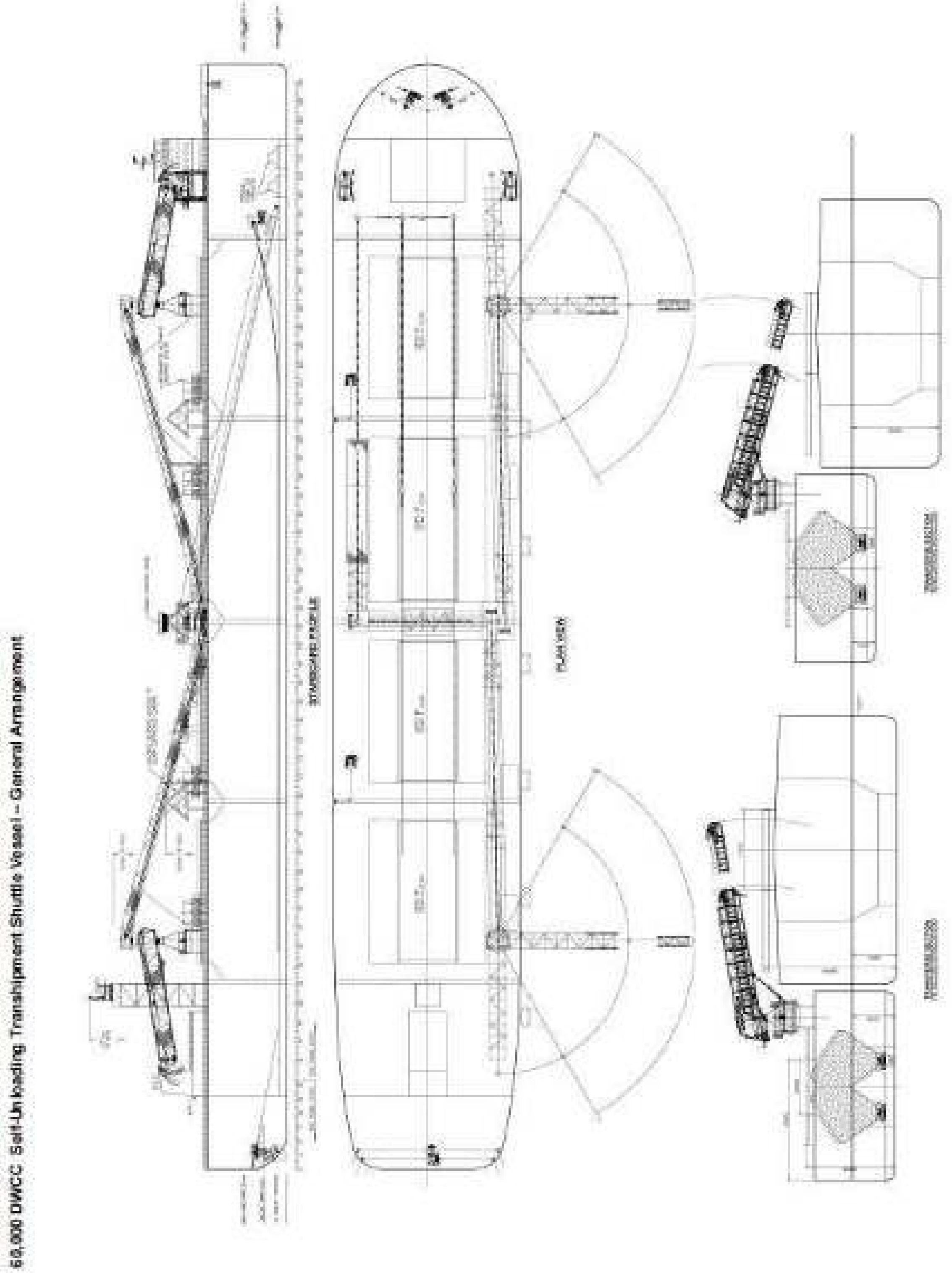


Figure 72 FSO General Arrangement

9.3.4 FSO Personnel Levels

The total personnel levels, including holiday relief, for the operation of the FSO will number 34 and will be sufficient to operate and maintain the filtration modules provided they are given the relevant training.

9.4 Operational Support

9.4.1 Anchor Handling Tug (AHT)

The TTR project has made provision for an 80te bollard pull Anchor Handling Tug (AHT) to assist with the provisioning of the IMV and FSO, assistance with the connection of floating hoses and anchor moving. The AHT will also provide refueling assistance and be equipped to assist in case of any fuel spillage and fire.

9.4.2 AHT Personnel Levels

The total personnel levels, including holiday relief, for the operation of the AHT will number 24.

9.4.3 Environmental Monitoring Vessel (EMV)

TTR has proposed deploying an Environmental Support Vessel (EMV) as a key component of its offshore iron sand extraction operations. The EMV would be dedicated to conducting comprehensive environmental testing and monitoring throughout the project's duration. Equipped with advanced oceanographic and environmental sensors, the vessel would collect real-time data on water quality, marine ecosystems, and sediment dispersion. This proactive approach ensures compliance with environmental monitoring requirements.

Continuous monitoring would allow for timely responses to any deviations from environmental performance expectations, minimizing risks to marine habitats. By integrating state-of-the-art monitoring technology with scientific oversight, TTR aims to uphold responsible resource development while maintaining the health of New Zealand's offshore environment.

9.5 Iron Concentrate Export to China

The final iron ore product will be exported to China by means of standard Capesize vessels, chartered by either TTR or their customers. The overall export cycle is detailed in the table below.

Activity	Duration (h)	Duration (d)
Load time 180kt	235.3	9.8
Sail to Qingdao (Cargo)	382	15.9
Unload	140	5.8
Sail to New Zealand	369	15.4
TOTAL	**1126.3**	**46.9**

Table 21 Capesize Vessel Shipping Cycle

10 OFFSHORE OPERATIONS

The integrated solution features a single IMV, that will contain the mining, processing and tailings deposition mechanisms, a single FSO that will trans-ship the concentrate from the IMV onto standard commercial bulk Capesize vessels for delivery to end users.

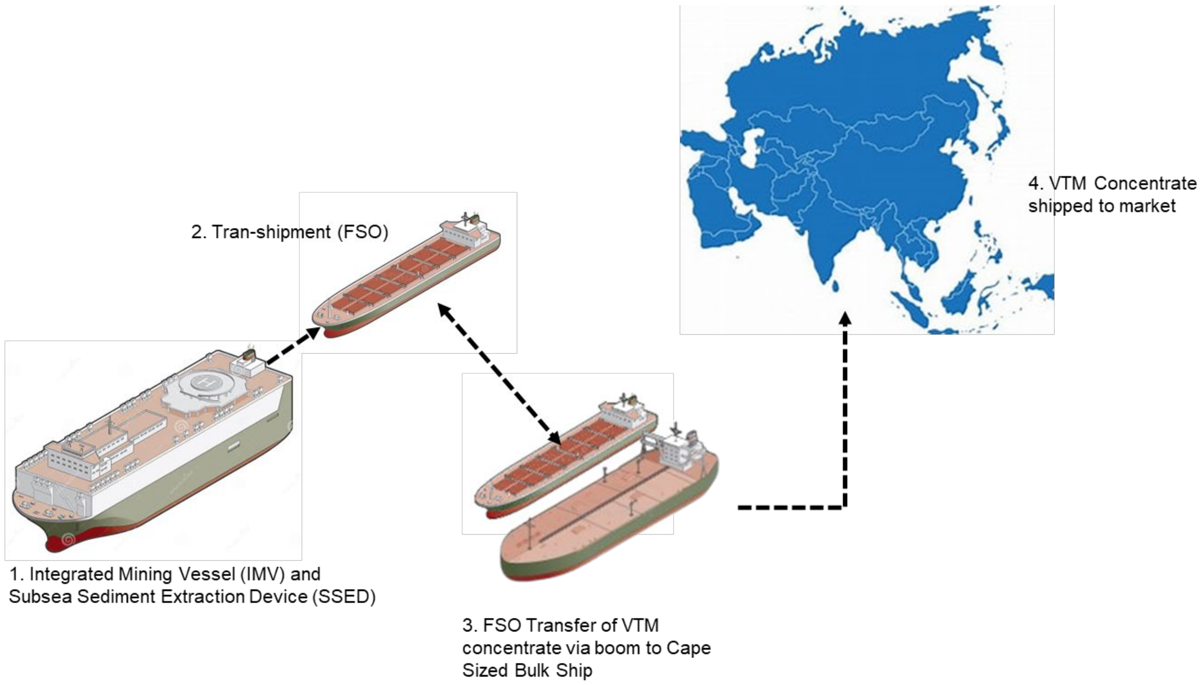


Figure 73 Offshore Operations

10.1 Anchor Relocation

A 300 x 300m mining block will typically be mined out in around five days, therefore a mining block selected 900 x 600m (anchor spread) would require requiring an anchor shift operation approximately every thirty days.

With the IMV in a DP assisted state, the AHT will move two (least loaded) adjacent anchors to their new position whilst the IMV remains over its existing mining area. Once the IMV has raised the mining crawler, moved over to the new mining area and lowered the crawler, the AHT will resume the relocation of the two remaining anchors.

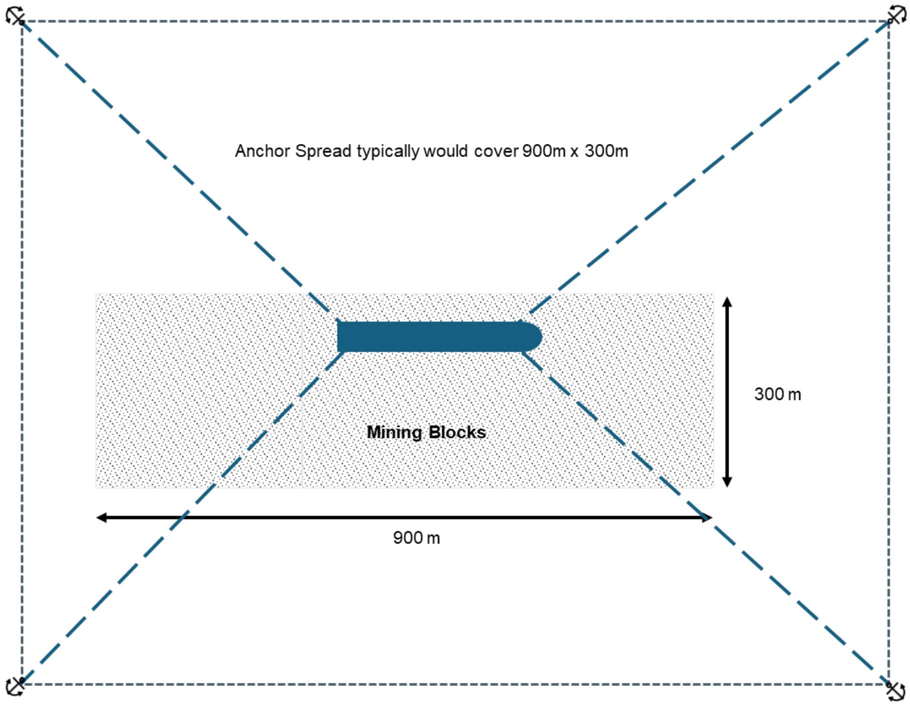


Figure 74 IMV Anchor Spread

10.2 Iron Ore Unloading

Once beneficiated the iron ore will be unloaded to a FSO used for storage and transfer to Capesize vessels for export.

This iron ore unloading operation will require the IMV to be equipped with a bow offloading system to be connected to the bow of the FSO by floating, flexible hoses.

The average distance required between the IMV and the FSO for safe unloading operations varies between 70m and 110m. The FSO will need to be equipped with some dynamic positioning capability in order to enhance operability and facilitate transfer operations whilst not disrupting mining operations.

The offloading system must offer the advantage of storing the flexible hoses on dedicated storage reels, in order to avoid leaving them at sea where they are subjected to waves and current which will induce wear, tear and fatigue damage of the lines.

10.3 CapeSize Vessels Loading

The transhipment from the FSO to the Capesize vessel will be performed by means of dedicated belt conveyors which will be installed below the FSO holds which slope has been modified in order to allow removal of the ore by gravity (no additional equipment required for ore transfer).

The iron ore will flow through gravity feeder gates at the bottom of the FSO cargo holds, depositing cargo onto an inclining tunnel belt that will elevate the cargo to the main deck of the vessel. The cargo will then be deposited onto two separate incline conveyors, each feeding a “ship- loader” located fore and aft. The ship-loaders can slew, luff and telescope and are capable of loading and trimming cargo vessels up to 57m across. No additional mechanical trimming will be required.

The distance between the two ship-loaders and the slewing capability will facilitate an optimized cargo vessel loading sequence with little or no shifting of the FSO along the cargo vessel.

The FSO will be fitted with an optimised mooring systems and an azimuth propulsion system, allowing for a higher degree of maneuverability, shorter cycle times and improved safety. This will also allow the FSO to operate without tug assistance.

Figure 75 Transhipment Shuttle Vessel CSL Whyalla Iron Ore in South Australia

Figure 76 Capesize Vessel Loading

10.4 Intermediate Fuel Oil (IFO) Supply & Transfer

Heavy Fuel Oil (IFO) is a broad term used to describe a range of residual fuels derived from crude oil refining, typically characterised by high viscosity and density. Within this category, different grades exist based on their specific properties and intended applications. One of the most common grades is Intermediate Fuel Oil (IFO) 380, which falls under the IFO classification.

The designation "IFO 380" refers to its maximum viscosity of 380 centistokes at 50°C, making it a widely used marine and industrial fuel. While IFO encompasses various formulations, IFO 380 is essentially a standardised variant within this group, sharing the same fundamental characteristics and applications as other heavy fuel oils. IFO 380 is still the standard grade of fuel for ocean going vessels and is readily available from Singapore. All of the operations on the IMV will be powered by generators using IFO 380, at full production this will consume around 7,500T of IFO 380 per month.

10.4.1 RAS (Replenishment at Sea)

The most efficient refueling system would be a RAS system. This is proven technology and used widely around the world, including all major Navies. Its biggest advantage is the ability for the IMV to continue operation during the fueling process.

The process would involve a tanker vessel sailing directly from the supply point to the TTR mining area and refueling would take place as shown below.

Figure 77 Typical Refueling Configuration

The jackstay wire rope is fastened to the receiving vessel above the refueling point, the fuel hose is then deployed and is guided to the reception manifolds, where the fuel probe self-locates and locks in place, once secure fuel can be transferred.

This system is capable of operating in up to 4m significant wave height[7].

10.4.2 Logistics

There is a large supply of IFO 380 available around the world with Singapore being the nearest large supply. During Summer, the supply and demand are relatively equal, during the Winter the requirement drops significantly and there is a surplus which needs to be exported. TTR would contract a company to provide a turnkey solution providing a consistent fuel supply per month directly to the operating vessels via a RAS or similar system.

11 HEALTH AND SAFETY

11.1 Summary

There are a number of Health & Safety (H&S) considerations when carrying out such a large offshore project, TTR will be requiring the companies who are supplying all of the equipment to provide relevant H&S guidelines for use. The information provided will be assessed against the best practice in industry and improved where possible to ensure TTR is providing the safest work environment available. Below are the high-level obligations TTR would have to cover when undertaking the mining operation:

11.2 Vessel Operations

All of the vessels involved in the mining operation will follow the International Safety Management Code (SOLAS) for vessel operations, Maritime Transport Act and Maritime NZ Marine Protection Rules. Each vessel will also have tailored H&S systems based on the unique normal day-to-day deck-based operations. There will be specialist operations which the vessels take part in which will need specific H&S guidelines developed for them as follows;

IMV:

- Deployment, connection & Emergency release of slurry hoses to FSO;
- Vessel proximity procedures (based on dynamic positioning capability);
- Safe sea state operating conditions;
- On deck crawler operations;
- Power plant operations;
- Crane operations;
- Anchoring operations; and
- Port Operations (handled by Pilot) – This will be specifically covered due to the size of the vessel.

Anchor Handling Tug (AHT):

All of the anchor handling operations will be dependent on the met ocean conditions

- Loading and unloading supplies to the IMV or FSO via deck cranes; and
- Moving the anchors of the IMV.

FSO:

- Deployment, connection & Emergency release of slurry hoses to FSO; and
- Loading between the FSO & Capesize export vessel.

11.3 Process

The process area will be treated in the same way as a high-level production plant onshore, with each piece of machinery assessed and assigned Standard Operating Procedures (SOPs) & maintenance schedules with hazards and work plans associated to each.

A HAZOP will be undertaken before commissioning.

11.4 Seabed Crawler (SBC)

The SBC or Seabed Crawler is an extremely large machine and will have similar H&S requirements around its handling as onshore mining equipment of the same size. Some of the unique requirements will be;

- Operating the Seabed Crawler on deck;
- Emergency lift procedures;
- Loss of vessel position;
- Umbilical tendering - steel wire lifting cable; slurry hose; high voltage power supply subsea & on deck; and
- Maintenance procedures on the Seabed Crawlers.

An advantage is that the crawler is mature technology which has established its use at sea, so previous experience of H&S procedures developed can be used and updated to exceed international expectations.

11.5 Power Generation

Due to the large amount of power being generated for the various processes on the vessel and the environment it is being used in, the H&S requirements will be of the highest standard and can be modelled on procedures used by onshore power plants.

The IMV will have an integrated power system which will control, monitor and regulate the power being sent to each piece of plant, this will allow TTR to automate the safety systems for faster and more efficient deployment. Specific attention will also be applied to:

- Security & treatment of on deck power cable;
- Integrity of areas where power is generated;
- Electrical isolation of plant & emergency stop of whole process;
- Monitoring of fumes & gases;
- Electrical safety plans;
- High voltage safety;
- Emergency power requirements; and
- Class protection of equipment established.

11.6 Fuel Handling & Transfer

The fuel being used on the project will be IFO 380, this fuel is not as refined as other fuels and is more toxic than refined fuel. Specific H&S risks are associated with this fuel necessitating a need to reduce the exposure to zero where possible. If exposure is necessary, then strict protective equipment would be specified and supplied.

Bunkering at sea is regulated under the Maritime Transport Act, Marine Protection Rules & MARPOL, the following H&S practices need to be followed;

- A safe and controlled surface transfer system – this system should have an automated mating coupling system;
- Transfer in daylight hours only;
- A safety management system documenting all procedures to take place to allow the safe transfer of fuel oil;
- Strict protocols in place for spill control; and
- The vessel transferring to have spill control and dispersants available and ready.

11.7 Personnel

Maintaining the health of all personnel working within this operation is paramount. The crew will be working on a rotation basis such as three weeks on, three weeks off, while they are on the vessel they will work every day on 12-hour shifts every day. TTR's H&S procedures will be similar to other manned production platforms such as the Raroa (existing New Zealand offshore FPSO. Some of the key H&S policies will be around.

- Physical health;
- Dealing with accidents and injuries;
- Promotion of a healthy lifestyle on board;
- Physical properties of fine iron sand and associated hazards;
- Mental Health;
- Fatigue;
- Isolated working environment;
- Adherence to strict procedures and practices;
- Active participation in promoting a safe work environment; and
- Providing proper training is provided in offshore survival; first aid and firefighting.

11.8 Helicopter Operations

These operations are some of the most dangerous and will have to be carried out regularly to transfer crews & emergency / specialist supplies. The safety precautions that need to be taken are very specific and require a number of trained specialists. Some of the considerations will be:

- Security;
- Communications;
- Cold water survival training;
- Weather parameters;
- Firefighting capability; and
- Rescue capability.

New Zealand has a major helicopter port based in New Plymouth which carries out a number of flights each day to New Zealand offshore installations. They have strict H&S standards and procedures which allow them to operate around and land on oil installations, these same standards will be applied to TTR's offshore operations, including adherence to Civil Aviation Rules, Safety Case methodology, Risk & impact assessments.

12 MARKET STUDIES AND CONTRACTS

12.1 Introduction

Siecap NZ undertook an update of the Market conditions and outlook, which was reviewed by independent commodities trader Tennant Metals Pty Ltd.

Tennant Metals have a comprehensive understanding of the global metals market, including miners, producers, smelters and refineries. Tennant Metals produced the 2014 PFS market study report for the PFS.

This Section of the PFS provides an analysis of the iron ore market, focusing on historical pricing structures, current market dynamics, and future price forecasts for 2025. It examines the evolution of iron ore pricing mechanisms, from the traditional benchmark system to the modern index-based structure, highlighting key influences such as Chinese steel demand, supply constraints, freight rates, and environmental policies.

A key aspect of this Section is the assessment of product variability and quality control, ensuring alignment with market specifications through a Total Quality Management Plan. The report also explores the strategic opportunities presented by co-products such as titanium and vanadium, particularly in jurisdictions where these minerals are classified as critical.

Additionally, this market study outlines recent price trends, including fluctuations observed in Q4 2024 and early 2025, and provides a forecast for the remainder of the year. It offers insights into the impact of global economic conditions, infrastructure spending, and the shift towards low-emission steel production on iron ore demand and pricing.

The findings and recommendations in this report aim to support strategic decision-making, optimize market positioning, and enhance commercial outcomes for stakeholders engaged in iron ore production and trade.

12.2 Product Specification

The TTR Iron sands has been identified as a material which can be mined and processed to produce a product of a quality that can be sold in the current market. The forecast mine life is 20 years plus at a production capacity of 4.9Mtpa.

Iron Ore	**VTM Iron Sand**
Type	**Concentrate**
Fe	56.70%
Fe^{3+}	66.70%
Fe^{2+}	33.30%
FeO	24.30%
Fe_2O_3	54.00%

SiO_2	3.40%
Al_2O_3	3.70%
CaO	0.94%
MgO	3.14%
Mn	0.53%
P	0.15%
S	0.01%
TiO_2	8.40%
V_2O_5	0.50%
Na_2O	0.15%
K_2O	0.12%
H_2O^+	0.00%
H_2O^-	6.50%
Total	99.40%
Ultrafines (for fines)	100.00%

Table 22 TTR's VTM Expected Typical Specification.

12.3 Product Variability Targets

It is anticipated that the product variability will be within the range required for the market. This is based on the assumption that a total quality management plan will be implemented with mining and scheduling. The operational focus will be aimed at maintaining all key parameters within the market contracted specifications between TTR and the customer.

12.4 Marketing Summary

12.4.1 Historical Pricing Structure of Iron Ore and its Evolution

Before 2009, the annual benchmark system was the primary mechanism for negotiating iron ore prices between major miners and steel producers, particularly in China, Japan, and South Korea. The system involved long-term contracts between the world's largest iron ore producer Vale, Rio Tinto, and BHP Billiton and major steelmakers, with Baosteel traditionally representing China's interests. Although this annual benchmark system was a mechanism developed between the world's three largest producers and their Asian customers, the pricing methodology was largely adopted by iron ore producers and their steel mill customers globally.

Additionally, initial pricing was straightforward, with payables based only on the iron ore content of the negotiated parcel less any penalty items. The range of those penalty items were quite detailed with clear contractual limits which once exceeded would reduce the total amount to be paid. It was however unusual for a seller to be entitled to additional credits in the event of the presence of a recoverable and valuable co-product like vanadium. This was in stark contrast to the base metals concentrate markets where additional credits were due and payable for those metals in existence above certain minimum amounts.

Following a shift from the yearly benchmark system in 2010, iron ore pricing in China transitioned to index-based mechanisms, significantly maturing over the past years, with the changes again being adopted broadly by producers and steel mills in the various geographical markets. The primary indices used in today's market include:

- Platts (S&P Global Commodity Insights)
  - IODEX 62% Fe CFR North China;
  - 63.5/63% Fe CFR North China;
  - 65% Fe CFR North China;
  - 58% Fe CFR North China; and
  - 52% Fe CFR North China (with max 4.0% Al content).
- The Steel Index (TSI) (Acquired by S&P Global Commodity Insights)
  - 62% Fe fines, 3.5% Al, CFR Tianjin port;
  - 58% Fe fines, 3.5% Al, CFR Tianjin port;
  - 62% Fe fines, 2% Al, CFR Qingdao port; and
  - 63.5/63% Fe fines, 3.5% Al, CFR Qingdao port.

Figure 78 Iron Ore 62% Fe, CFR China (TSI) – 7 February 2025

Today, iron ore contracts are primarily priced on a quarterly, monthly, or spot basis, with many deals based on average price settlements derived from Platts or TSI indices.

It is also important to note that the continued reference to Chinese ore preferences and pricing methodologies set out further in this summary, is due to their prevailing influence on global iron ore markets. (It is not the intention of TTR to specifically pursue a Chinese off-take relationship. The fact that both titanium and vanadium are listed as critical minerals in the USA, the EU, Canada, Australia and now New Zealand, provides offtake, marketing and strategic opportunities in numerous geographical locations).

12.4.2 Current Market Structure and Price Forecast – 2025

The iron ore pricing landscape in 2025 reflects a well-established index-based structure, with price fluctuations driven by Chinese steel demand, supply constraints, freight rates, and decarbonisation policies. It is now an accepted practice for parcels of iron ore with valuable co-products to receive either a direct credit (a direct and percentage based monetary payment for the attached co-product) or an implied credit (a higher payable than the prevailing percentage of iron ore contained) in price negotiations. With the shift towards lower-emission steel production, the demand for high-grade iron ore and magnetite is expected to remain strong, as will those ores with valuable co-products, while lower-grade ores may face discounts due to environmental concerns.

The role of futures trading continues to grow, adding complexity and flexibility to price negotiations.

12.4.3 Market Trends and Price Assessment

In this first quarter of 2025, iron ore prices have experienced volatility driven by global economic factors, shifts in Chinese steel demand, and supply constraints in major production regions such as Brazil and Australia.

- Q4 2024 Price Overview: Prices fluctuated between $115-$125 per dry metric tonne (dmt) CFR China (62% Fe fines) amid concerns over slowing steel demand and production curbs in China;
- January-February 2025: A slight price recovery was observed, reaching $130-$135/dmt CFR China, driven by;
  - Infrastructure spending increases in China post-stimulus measures;
  - Supply disruptions in Brazil due to seasonal heavy rains; and
  - Rising freight costs impacting CFR prices.
- Forecast for 2025:

- Analysts project an average price of $100/dmt[8] CFR China for 62% Fe fines throughout 2025, with potential downward pressure in Q3 due to global economic slowdowns.[9]
- High-grade ores (65% Fe) are expected to trade at a premium of $15-$20/dmt due to increased demand from low-emission steelmakers.

	Current (November 8)	2024 YTD	2020	2021	2022	2023	2024f	2025f	2026f	2027f	2028f
BMI	96	105	105	156	113	114	110	100	95	92	90
Bloomberg Consensus	na	na	na	na	na	na	109	95	90	88	90

Figure 79 BMI - Iron Ore Price Forecast (USD/Tonne) – 15 November 2024

12.4.4 Key Market Drivers in 2025

12.4.4.1 Chinese Steel Demand and Government Policy

- China remains the largest iron ore consumer, importing over 1 billion tonnes annually.
- The Chinese government continues its “Dual-Carbon policy, enforcing steel production cuts to reduce emissions.
- Demand for high-grade iron ore (65% Fe and above) and magnetite has increased due to decarbonisation initiatives and the increasing adoption of Direct Reduced Iron (DRI) processes.

12.4.4.2 Global Supply-Side Factors

- Brazil (Vale): Seasonal disruptions and logistics constraints have led to intermittent supply tightness.
- Australia (Rio Tinto, BHP, FMG): Expansion projects continue, but ESG concerns, and regulatory hurdles may impact future growth.
- New entrants: African projects (e.g., Simandou in Guinea) are expected to contribute to supply post-2025.

12.4.4.3 Freight and Logistics Impact on Pricing

- The cost of shipping iron ore from key exporters (Brazil and Australia) to China remains a significant factor in CFR pricing.

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[8] https://editorial.northernminergroup.com/wp-content/uploads/2024/11/BMI-Iron-Ore_-Price-Weakness-To-Continue-Into-2025-Upside-Contingent-On-Mainland-Chinese-Stimulus-15-Nov-2024.pdf

[9] https://www.nasdaq.com/articles/iron-ore-price-forecast-top-trends-iron-ore-2025

- Freight indices, particularly C3 (Brazil-China) and C5 (Australia-China), influence landed costs.

12.4.4.4 Futures Market and Hedging Strategies

- Dalian Commodity Exchange (DCE) and Singapore Exchange (SGX) iron ore futures play a pivotal role in price discovery and risk management.
- Increased hedging activity by steel mills and traders to mitigate price volatility.

12.5 Hematite and Magnetite - Iron Ore Pricing and Supply to China

12.5.1 Hematite vs Magnetite in the Iron Ore Market

Hematite (Fe_2O_3) and Magnetite (Fe_3O_4) are the two primary iron ore types used in steelmaking. While hematite dominates the global seaborne trade, magnetite has been gaining importance due to its energy efficiency, improved pelletising and sintering performance and lower impurities.

12.5.1.1 Hematite Ore Characteristics:

- Direct Shipping Ore (DSO).
- Lower processing costs but generally lower Fe content (58%-62%).
- Requires sintering before use in blast furnaces.

12.5.1.2 Magnetite Ore Characteristics:

- Requires beneficiation (crushing, grinding, magnetic separation)
- Higher Fe content post-processing (typically 65%-72% Fe).
- Lower impurities (phosphorus, sulphur and alumina).
- The reduction of magnetite to metallic iron is exothermic, meaning it releases heat, whereas hematite reduction is endothermic (absorbs heat).
- Suitable for pellet production and Direct Reduced Iron (DRI) steelmaking.

12.5.2 How Magnetite is Priced in China

Unlike hematite, which is mostly priced based on Platts IODEX (62% Fe) and TSI indices, magnetite pricing follows a different structure due to its beneficiation process and higher Fe content.

12.5.2.1 Magnetite Pricing Mechanisms

- Premium Pricing for Higher-Grade Ores.
    - Magnetite concentrates and pellets (65%-72% Fe) generally trade at a premium over the benchmark 62% Fe fines.

- The premium typically ranges from $15-$25/dmt above the Platts IODEX 62% Fe CFR China price.
- Platts 65% Fe index is used as a pricing benchmark for magnetite concentrates.

- Index Referencing.
  - Prices for magnetite concentrates (64%-67% Fe) are referenced to Platts 65% Fe fines CFR China.
  - Pellet prices are based on Platts Atlantic Pellet Premium or negotiated on long-term contracts.
- Discounts for Impurities.
  - If magnetite contains high sulphur (S) or phosphorus (P), discounts apply.
  - Some magnetite ores require further refining, leading to processing cost adjustments.

12.5.3 Market Positioning of Magnetite in China

China's Dual-Carbon policy (carbon peaking by 2030, neutrality by 2060) has increased demand for high-grade iron ores such as magnetite due to its lower energy requirements in steel production.

Magnetite is gaining prominence in China due to its higher Fe content, energy efficiency, and alignment with low-carbon steelmaking. Suppliers in New Zealand and Australia can leverage this demand by offering high-grade magnetite concentrates and pellets. Positioning magnetite as a premium, low-carbon alternative will be key to capturing future market opportunities in China's evolving steel industry.

12.5.3.1 Key Demand Drivers in China

- Energy Efficiency & Lower Emissions.
  - Magnetite is preferred for Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) steelmaking, which aligns with China's push toward low-emission steelmaking.
  - Using pellets made from magnetite reduces coke consumption and CO_2 emissions.
- Pelletisation for Low-Emissions Steel.
  - Magnetite is often processed into pellets, which are directly used in blast furnaces and DRI plants.
  - Pellet demand is rising as China restricts sintering activities to control pollution.
- Steel Mill Preferences.
  - Large steelmakers (Baosteel, China Baowu, HBIS) increasingly favour magnetite-based pellets and concentrates.

- Many integrated steel plants are modifying blast furnaces to accommodate high-grade magnetite-based feedstocks.

12.5.4 Supply Considerations for NZ and Australian Suppliers

12.5.4.1 Australia's Magnetite Position

- Australia holds significant magnetite reserves, with key projects in Western Australia (WA), South Australia (SA), and Tasmania.
- Major players include.
  - Fortescue Metals Group (FMG): Developing magnetite operations at Iron Bridge.
  - Grange Resources: One of Australia's largest magnetite producers (Savage River).
  - Gindalbie Metals/Karara Mining: A major supplier of magnetite concentrate to China.

12.5.4.2 New Zealand's Magnetite Potential

- NZ's iron sand deposits (e.g., Taranaki, Waikato) contain vanadiferous titanomagnetite ("VTM"), which is exported for steelmaking.
- Challenges: Historically higher titanium content has limited use in traditional blast furnaces, but advancements in processing technology, as well as the increasing value of vanadium has expanded the marketability of certain of these VTM ores.
- Opportunities: Vanadium is a relatively easily recovered metal with steel strengthening qualities, as well as grid storage battery applications. Current global supply of iron sands ores are sporadic in nature with varying grades and quantities. A single large scale VTM producer (annual production volumes of 3.0 – 5.0Mtpa) offering consistent supply and grades will be of significant interest to a number of steel mills in a range of geographical locations including Asia.

12.5.4.3 Recommended Strategy for NZ and Australian Suppliers

- Target High-Grade Magnetite Market.
  - Position NZ & Australian magnetite for DRI & EAF steelmaking in China.
  - Negotiate contracts with steel mills transitioning to low-carbon processes.
- Target Steel Mills in specific locations.
  - Both vanadium and titanium are deemed to be critical minerals in many major first world countries and regions with numerous producing steel mills of significant scale
  - Vanadium recovery generates a high value by-product within steel production.
- Leverage Pellet Demand.

- If feasible, invest in pelletising infrastructure to meet growing demand in China.
- Engage with Chinese steel mills looking for low-impurity pellet feedstocks.

- Optimise Logistics and Freight.
    - CFR China contracts can be advantageous for securing buyers.
    - Freight cost analysis (C3 Brazil-China vs. C5 Australia-China) can help position magnetite competitively.

12.6 The Role of 58% Fe VTM in Iron Ore Pricing and Supply to China

12.6.1 VTM vs Hard Rock Magnetite and Hematite in the Iron Ore Market

Vanadiferous Titanomagnetite (Fe_3O_4 with vanadium and titanium content) is a distinct iron ore type that differs from traditional hematite (Fe_2O_3) and hard rock magnetite (Fe_3O_4). While hematite remains dominant in seaborne trade, both hard rock magnetite and vanadiferous titanomagnetite have been gaining importance due to beneficiation potential and specialised steel applications.

12.6.1.1 Hematite Ore

- Direct Shipping Ore (DSO), requiring minimal processing.
- Lower processing costs but typically 58%-62% Fe content.
- Requires sintering before use in blast furnaces.

12.6.1.2 Hard Rock Magnetite Ore

- Typically found in igneous and metamorphic rock formations, often requiring significant mining and crushing.
- High iron content (typically 60–70% Fe) but contains silica (SiO_2) and other gangue materials that require beneficiation.
- Common sources: Australia, Canada, Sweden, Brazil.
- Preferred for pelletisation and DRI (Direct Reduced Iron) processes.

12.6.1.3 Vanadiferous Titanomagnetite Ore (58% Fe)

- Derived from eroded volcanic rock and deposited in coastal or riverine environments.
- Lower iron content (~56–58% Fe) but naturally occurs in fine particles, reducing the need for extensive crushing.
- Contains titanium (TiO_2) and vanadium (V_2O_5), which impact processing but offer valuable by-products.
- Requires upgraded processing techniques due to titanium impurities.
- Can be used in specialty steel production and blended feeds for Chinese mills.

12.6.2 How 58% Fe Vanadiferous Titanomagnetite is Priced in China

VTMs (58% Fe) presents both challenges and opportunities in the Chinese iron ore market. While historical trades have been at a discount to standard hematite fines, its standard form, specialty steel applications, blending potential, and strategic positioning in the decarbonisation trend make it a viable export commodity.

12.6.2.1 Pricing Mechanisms for 58% VTMs

- Discounted Pricing Compared to Standard 62% Fe Fines.
  - VTMs (58%) historically have been priced at a discount of $5-$15/dmt (10-15% discount/dmt) relative to 62% Fe fines (Platts IODEX).
  - The underlying discount today depends on the titanium and vanadium content and low grade ores (52-54% Fe) can even trade at a premium to the 62% price depending on the contained percentages of vanadium pentoxide (V2O5) within the ore.
- Index Referencing with Adjustments.
  - Contracts reference Platts 58% Fe fines CFR China or Mysteel 58% Fe pricing indices.
  - Some trades apply penalty adjustments for TiO_2 content beyond 1.5%.
- Blended Pricing Structures.
  - Chinese steel mills blend low-grade titanomagnetite with higher Fe ores (e.g., Pilbara fines, Brazilian fines).
  - Prices are negotiated based on desired Fe yield post-blending.

12.6.2.2 Market Positioning of Vanadiferous Titanomagnetite in China

China's Dual-Carbon policy (carbon peaking by 2030, neutrality by 2060) influences iron ore preferences. Higher Fe ores are favoured, but titanomagnetite remains a viable option under specific conditions.

12.6.2.3 Key Demand Drivers in China for Vanadiferous Titanomagnetite

- Use in Specialty Steel Production.
  - Some mills utilise vanadium-rich titanomagnetite for high-strength steel applications, i.e. Panzhihua Iron and Steel (Pangang) Group, Xinjiang Da'an Special Steel Co., Ltd.
  - Demand is growing for low-alloy steels incorporating vanadium-enhanced

feedstocks[10].

- Blended Feed for Blast Furnaces.
    - Chinese mills blend vanadiferous titanomagnetite with hematite fines or Brazilian high-grade ores.
    - Helps optimise costs and furnace efficiency.

12.6.2.4 Supply Considerations for NZ and Australian Suppliers

- Australia's Titanomagnetite Position.
    - Australia has limited titanomagnetite reserves, but South Australia and Tasmania contain deposits with 58%-60% Fe content.
    - Major titanomagnetite players are focused on niche steel applications.
- New Zealand's Vanadiferous Titanomagnetite Potential.
    - New Zealand iron sands (e.g., Taranaki, Waikato) contain significant titanomagnetite resources.
    - Challenges: High titanium content can limit traditional blast furnace use but offers potential for value-added processing.

12.6.2.5 Recommended Strategy for NZ and Australian Suppliers

- Target Blended Market Opportunities.
    - Engage with Chinese steel mills seeking lower-cost blending feedstocks.
    - Establish supply partnerships for specialty vanadium-rich steel production.
- Enhance Processing and Beneficiation.
    - Explore upgraded beneficiation techniques to reduce TiO_2 content.
    - Consider developing low-cost pelletisation facilities to meet Chinese sinter plant requirements.
- Optimise Freight and Logistics for Cost-Effective Delivery.
    - CFR China contracts may improve competitiveness.
    - Utilise existing bulk export infrastructure to reduce shipping costs.

12.7 New Zealand's Critical Minerals List

New Zealand's Critical Minerals List, released in January 2025, identifies 37 minerals essential to the country's economy and technological development. Among these are vanadium and titanium, which play significant roles in various industries and particularly with regards to the

[10] https://www.spglobal.com/en

decarbonisation of both the steel and energy sectors.

12.7.1 Geopolitical Importance of Vanadium and Titanium.

Both vanadium and titanium are crucial for a range of applications, including aerospace, energy storage, and advanced manufacturing. Their strategic importance is further demonstrated by the fact that nations such as Australia, the United Kingdom, the United States, Canada, and the European Union also classify them as critical minerals, highlighting the role these elements play in national security, economic stability, and technological leadership.

In recent years, concerns over supply chain vulnerabilities have heightened the geopolitical significance of these minerals. China dominates global vanadium production, accounting for approximately 68% of output, while Russia contributes around 18%. Similarly, Russia is a major producer of titanium sponge, a material essential for aerospace manufacturing.

This concentration in just two countries presents supply risks, as geopolitical tensions or policy shifts could disrupt access. The worsening tariff disputes between the USA, Canada, Mexico, China, and the European Union are further exacerbating concerns over mineral security, as trade barriers and retaliatory tariffs threaten to increase costs and restrict the free flow of critical resources between key markets.

To mitigate these risks, countries are actively working to diversify their supply sources. Strategies include expanding domestic production, forming partnerships with allied nations, and investing in recycling and alternative materials research.

12.7.2 Geopolitical Importance of Vanadiferous Titanomagnetite

Despite the inclusion of vanadium and titanium on New Zealand's Critical Minerals List, it is notable and disappointing that New Zealand's iron sands were overlooked. Vanadiferous Titanomagnetite is a significant local resource containing viable quantities of vanadium and titanium, and its primary magnetite component could itself be considered a critical resource. With growing global concerns over supply chain vulnerabilities and geopolitical risks in mineral sourcing, the importance of iron and steel to the world economy cannot be overstated. Given the strategic value of domestic steel production and iron ore supply chains, the absence of New Zealand's titanomagnetite from the critical minerals list represents a missed opportunity to strengthen economic resilience and develop a more self-sufficient and strategically positioned domestic resource base.

12.8 The Role of New Zealand Iron Sands in Green Steel Initiatives

12.8.1 Introduction

The steel industry is a major contributor to global carbon emissions, responsible for around 7% of CO_2 output. As demand grows for low-emissions alternatives, hydrogen-based direct reduction is emerging as a key solution. New Zealand's VTM iron sands have strong potential to support this transition. With demonstrated compatibility with hydrogen reduction processes and opportunities for energy-efficient sintering, iron sands could play an important role in reducing the carbon footprint of steel production.

12.8.2 Green Steel

Green steel refers to steel produced with minimal or no carbon emissions, primarily through alternative reduction methods. The hydrogen-based direct reduced iron (DRI) process is a particularly promising approach, replacing traditional carbon-intensive methods with hydrogen, which emits only water vapour instead of CO_2. New Zealand's iron sands are well suited to this technology.

12.8.2.1 Hydrogen Reduction Potential

Research shows that New Zealand iron sands can be effectively reduced using hydrogen, making them compatible with emerging green steel technologies such as HYBRIT and MIDREX's hydrogen-based DR processes. Conventional blast furnaces struggle with titanomagnetite (TTM) iron sands due to their high titanium content, but shifting to hydrogen reduction could overcome these limitations and open up new pathways for sustainable steelmaking.

12.8.2.2 Pelletisation and Sintering Efficiency

For iron sands to be used in DR processes, the fine iron ore particles must be pelletised to improve their reducibility. Studies[11] have shown that iron sands pellets sintered at 1200°C achieve high compressive strength, making them suitable for direct reduction feedstock. '

12.8.3 Green Steel Market Opportunities

12.8.3.1 Supplying the Growing Green Steel Market

The global green steel market is projected to exceed NZ$145 billion by 2032, growing at an annual rate of nearly 21%. Countries such as Australia, Sweden, Germany, and Japan are investing heavily in hydrogen-based steel production, creating increasing demand for high-quality, direct reduction-compatible iron ores. New Zealand has an opportunity to position itself as a key supplier in this expanding market.

12.8.3.2 Partnering with Green Steel Innovators

New Zealand's iron sands industry could explore partnerships with firms leading the shift towards low-emissions steel production to secure supply agreements and collaborate on research and development.

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[11] NZ Paper

12.8.3.3 Attracting Sustainable Investment

Governments worldwide are introducing policy measures to decarbonise heavy industries. The European Union's Carbon Border Adjustment Mechanism (CBAM) and the United States' clean hydrogen tax credits under the Inflation Reduction Act could create favourable conditions for green steel feedstocks. By aligning with these policies, New Zealand's iron sands industry could attract foreign investment and position itself as a sustainable supplier.

12.9 Marketing Risks

Given the forward-looking nature of market analysis, there are several risks highlighted below that are addressed under the broader project risk management protocols.

Marketing Related Risks	Description
Market downturn	The GFC of 2008/2009 was largely unpredicted by the broader market until it was "almost upon us", it is not possible to predict a re-occurrence of this type of global event in the future.
Project delay	Speed to market is a key factor in the success of obtaining long-term offtake agreements, should the project be delayed, these agreements will become more difficult for TTR to establish.
Pricing volatility	With price forecasts there is always a risk of incorrect prices (either high or low). Prices used by TTR in the evaluation of the project would be considered to be within the mid to upper range of the current range of estimates available.
Inaccurate sampling and analysis	Poor sampling techniques may result in lower revenue than anticipated.

Table 23 Marketing Related Risks

13 ENVIRONMENTAL REGIMES AND PERMITTING STATUS

13.1 Introduction

The previous revision of the prefeasibility study provided an overview of the broad environmental characteristics of Trans-Tasman Resources (TTR) area of interest within the South Taranaki Bight (STB). It highlighted the associated environmental risk factors and the extensive investigations undertaken by TTR to support the successful marine consent application. The updated Environmental Impact Statement is appended to this PFS (Appendix 19.21)

This revision of the PFS updates the environmental permitting status, emphasising the legal challenges encountered and the project's inclusion in New Zealand's Fast Track approvals process. The project's inclusion in the Fast Track approvals process signals its potential economic value and commitment to best practice environmental management. An overview of the

13.2 Marine Consent Approval

In August of 2017 TTR was granted marine consents and marine discharge consents under sections 62(1)(a) and 87F(1) of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act).

The consents permitted the extraction and processing of iron sand within the STB for 20 years. Under these consents, TTR was granted consent to extract up to 50 million tonnes of seabed material annually, with approximately 10% processed into 5Mt VTM concentrate for processing and export.

13.3 Environmental Impact Assessments

The marine consent process involved a comprehensive assessment of the potential environmental impacts of the proposed mining operation. The key areas evaluated included:

- Sediment Plume Dynamics - Assessment of the generation, dispersion, and optical impacts of sediment plumes, with modelling conducted under various scenarios to predict worst-case outcomes;
- Benthic Ecology - Studies indicated that benthic organisms within the mining site would be significantly impacted; however, natural recolonisation is expected over time;
- Marine Life - Evaluations of potential impacts on fish, shellfish, marine mammals, and seabirds, considering factors like noise, sediment dispersion, and food web interactions;
- Ecotoxicity and Biosecurity - Analysis of the potential bioaccumulation of heavy metals and the risks posed by marine biosecurity threats.; and
- Human and Environmental Health - Consideration of potential impacts on air and water quality and health risks to nearby coastal communities.

Refer to Appendix 19.21 for detailed environmental studies and findings in the Environmental Impact Assessment.

13.4 Regulatory Principals and Decision Framework

The EPA's decision-making Committee applied the EEZ Act's information principles, ensuring that the best available information was used to assess potential impacts. The decision-making process involved expert conferencing, public submissions, and independent technical reviews to evaluate the data provided. The Committee granted the consents, concluding that it had sufficient information to make a decision, and that granting consents, with appropriate conditions, would meet the EEZ Act's purpose.

13.5 Legal Challenges and Court Proceedings

The EPA's decision was appealed to the High Court by environmental advocacy groups and iwi representatives. They argued there were many errors of law in the decision. The High Court found there was one error, that the consents applied a prohibited "adaptive management" approach, and for that reason it quashed the EPA's decision and referred the applications back to the EPA to reconsider.

The High Court's decision was appealed to the Court of Appeal. The Court of Appeal disagreed with the High Court that the consents applied an adaptive management approach but found that there were other errors of law in the EPA's decision. So, for different reasons than the High Court, it upheld the outcome of the High Court's decision: the applications were referred back to the EPA to reconsider.

The Court of Appeal's decision was appealed to the Supreme Court, the highest court in New Zealand's legal system. The Supreme Court's reasoning differed from the Court of Appeal's, yet it reached the same outcome, finding that there were errors of law in the EPA's decision, and referring the applications back to the EPA for reconsideration. The Supreme Court's decision, issued in September 2021, provided new guidance on the correct application of provisions in the EEZ Act.

The EPA appointed a new decision-making committee to reconsider the applications in accordance with the appeal outcomes, and reconsideration hearings began in March 2024.

In anticipation of the Fast Track Approvals process, TTR withdrew its applications at the end of March 2024, bringing the reconsideration to an end.

13.6 Inclusion in the Fast Track Approvals Process

Between March and December 2024, the New Zealand Government developed the Fast Track Approvals Act 2024 (the FTA Act), the purpose of which is to improve the delivery of projects with significant economic benefits. The FTA Act provides a streamlined process for such projects, with bespoke legal tests that give more weight to regional and national economic benefits than under the EEZ Act. At TTR's request, the New Zealand Government has listed

TTR's project in Schedule 2 of the FTA Act, which means the project has already been approved to use the FTA process. This enables TTR to make an application for the project without first having to obtain additional ministerial support. TTR is preparing its application, which will reflect the new FTA legal tests.

13.7 Consent Conditions and Compliance Requirements

In August 2017, the Environmental Protection Authority (EPA) granted TTR a marine and marine discharge consents under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012, allowing the extraction of iron sand from the seabed in the South Taranaki Bight. Consent is subject to strict conditions ensuring environmental protection, stakeholder engagement, and ongoing monitoring. These are summarised below with the full set of conditions provided in Appendix 19.25.

13.7.1 Scope of the Consent

- Permits the extraction of up to 50 million tonnes of seabed material annually, with an operational limit of 8,000 tonnes per hour.
- Authorises the discharge of de-ored sediment back into the marine environment, subject to compliance with sediment dispersion limits.

13.7.2 Environmental and Operational Conditions

- Environmental Monitoring: Pre- and post-extraction assessments must be conducted to measure the impact on benthic ecosystems, water quality, and sediment dispersion.
- Noise and Marine Mammals: Underwater noise levels must comply with 120 dB re 1μPa limits to mitigate impacts on marine mammals. A soft start procedure must be followed before operations begin to ensure marine mammals are not in proximity.
- Benthic Recovery: Ongoing monitoring is required to assess the recovery of marine habitats post-extraction.
- Seabird and Marine Mammal Management: A management plan must be implemented to protect local marine biodiversity.

13.7.3 Reporting and Compliance

- Quarterly and Annual Reports: TTR must submit reports to the EPA, covering:
    - Extraction volumes.
    - Sediment plume modelling.
    - Environmental monitoring results.
    - Complaints received and remediation actions taken.

- Technical Review Group (TRG): An independent group will oversee the monitoring programme, review data, and provide recommendations on additional parameters that may need assessment.

13.7.4 Stakeholder and Community Benefit

Stakeholder Engagement and Community Benefit

- Tangata Whenua Consultation: Regular engagement with iwi representatives and integration of mātauranga Māori into monitoring and decision-making.
- Fishing Industry Coordination: TTR must hold six-monthly meetings with commercial fishing representatives to address concerns and coordinate activities.
- Community Fund: A $50,000 per annum fund (inflation-adjusted) is allocated for local community projects in South Taranaki.
- Training and Employment: A training facility in Hāwera will be established to develop local workforce skills in marine and process operations.

13.7.5 Risk Management and Compliance

- Biosecurity Measures: All vessels must comply with New Zealand's ballast water treatment regulations to prevent invasive species introduction.
- Oil Spill Contingency: Comprehensive oil spill response plans must be in place and reported to Maritime New Zealand.
- Kupe Oil and Gas Field Protection: A 500m exclusion zone around wellheads and a 1.5km protection zone around the Kupe Well Head Platform must be maintained to prevent conflicts with existing petroleum operations.

13.7.6 Review and Lapse Conditions

- The consent is valid for 10 years, with a requirement for continuous review to adapt to emerging environmental concerns.
- If operations do not commence within this period, the consent will lapse.

The EPA's approval of the TTR marine consent reflects a balanced approach between economic development and environmental stewardship. The strict monitoring, compliance, and engagement frameworks ensure the operation aligns with sustainable marine resource management principles.

13.8 Mineral Permit Regime

13.8.1 Legislation

Mining approvals required for TTR's project require mining permits under the Crown Minerals Act for extraction activities both within and beyond the 12Nm limit.

13.8.1.1 Mineral Permits under Crown Minerals Act 1991

TTR has been granted a mining permit (MMP55581) under section 25 and 29A of the Crown Mineral Act 1991, which covers the allocation of the Crown's mineral resources. The Mining Permit has been granted 20 years and is subject to a royalty regime and a set of work program conditions.

Permits are administered by NZ Petroleum and Minerals, a section of the Ministry of Business Innovation and Employment. In addition to the mining permit TTR also have an exploration permit 54068, which is situated within the 12Nm limit offshore, and is directly adjacent to, and contiguous with, MMP55581. Details of these permits are in Section 4.2 of this PFS document and are appended to this document (Appendix 19.15).

13.8.2 Section 59(2)(l) – Any Other Applicable Law

When considering both the marine consents and marine discharge consents, the EPA was required to take into account any other applicable laws that are relevant to the TTR application.

The following are the relevant statutes:

- Biosecurity Act;
- Continental Shelf Act;
- Crown Minerals Act;
- Fisheries Act 1996 ("**the Fisheries Act**");
- HSW Act;
- HSNO Act;
- *Heritage Act;*
- MCA Act;
- Marine Mammals Protection Act 1978;
- Marine Reserves Act 1971;
- Maritime Transport Act;
- RMA;
- Resource Management (Marine Pollution) Regulations 1998;
- Submarine Cable Act; and
- Wildlife Act 1953 ("Wildlife Act").

13.8.2.1 Biosecurity Act

The Biosecurity Act was enacted to reform the law relating to the exclusion, eradication, and effective management of pests and unwanted organisms. The 2012 reform also added Part 8A to the Biosecurity Act which extends the existing provisions to the EEZ. This was in response to increased economic activity in the EEZ.

Sections 24E to 24K of the Biosecurity Act deals with Craft Risk Management Standards and specifies requirements to be met for the effective management of risks that are associated with the entry of foreign craft into the EEZ and New Zealand territory.

All TTR project related vessels will be required to comply with the requirements of Part 3 – Importation of Risk Goods, including the Craft Risk Management Standards and Import Health Standards, and Part 4 – Surveillance and Prevention under the Biosecurity Act.

Further biosecurity risks associated with the project may potentially arise through the management of ballast waters and vessel biofouling associated with the operation of the vessels. As part of standard operational requirements, TTR will implement controls and procedures that identify how these risks are managed primarily through the requirement for vessels to comply with the requirements of the BMP.

Consent conditions can be imposed as part of any marine consent granted, requiring ballast water and hull biofouling to comply with the requirements of the Biosecurity Act and conventions guidelines for the management of ballast water and hull biofouling. The proposed consent conditions have included conditions of this nature.

TTR is committed to continue to engage with the Ministry of Primary Industries on matters of biosecurity under the Biosecurity Act during the course of the project and this has been provided for through the BMP requirements.

There are no Pest Management Strategies prepared under the Biosecurity Act that are relevant to the project. For completeness, it is noted Pest Management Strategies have been prepared by the TRC and the Horizons Regional Council; however, these pest management strategies relate to management of pests on land and are not relevant to the EEZ area to which the project relates.

It is considered that the project will comply with the provisions of the Biosecurity Act and any regulations made under that Act.

13.8.2.2 Continental Shelf Act

The Continental Shelf Act vests all rights that are exercisable in New Zealand with respect to the continental shelf and its natural resources (defined as mineral and other non-living resources of the seabed and subsoil of those submarine areas that extend beyond 12Nm to 200Nm, and in some areas to the outer edge of the continental margin (the extended continental shelf)) for the purpose of exploring the shelf and use those resources.

Prior to 24 May 2013, the Continental Shelf Act provided for the granting of licences for prospecting and mining on the continental shelf, including imposition of conditions on any licences granted. On 24 May 2013, the Continental Shelf Amendment Act 2013 inserted a new Section 5AA into the Continental Shelf Act which provided for matters related to the mining of minerals on the continental shelf.

Section 5AA specified that the Crown Minerals Act and any regulations made under that Act, as far as they are applicable and with any necessary modifications, apply to mining activities for minerals other than petroleum in the seabed or subsoil of the continental shelf. In effect, this meant that any new applications or subsequent mining licences would be processed under the Crown Minerals Act as if the Continental Shelf Licence was a prospecting or exploration permit under the Crown Minerals Act.

TTR held a Continental Shelf Licence (No. 50753) for minerals prospecting over 3,314 km^2 of the continental shelf under the Continental Shelf Act. The licence was granted and commenced on 17 December 2010 for a period of four years which expired on 16 December 2014.

On 26 July 2013, TTR applied for a new mining permit, that includes the project area for these consents, which is located within the area over which the now expired Continental Shelf Licence 50753 covered. As detailed in Section 4 of this PFS the mining permit (Mining Permit No. 55581) has since been granted under the Crown Minerals Act.

Further to the above, the Continental Shelf Act enables safety zones to be created to protect existing offshore installations. The project area borders the identified Kupe Safety Zone attached to the existing Kupe Natural Gas Platforms (refer to Figure 92) however, the project area does not impede this area.

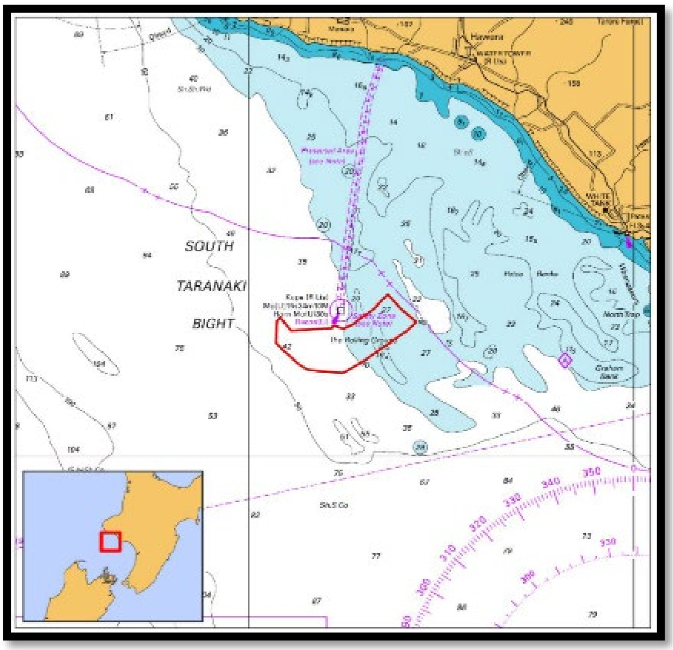


Figure 80 Kupe Safety Zone as Identified Under the Continental Shelf Act 1964

13.8.2.3 Crown Minerals Act

As identified above, following the May 2013 Continental Shelf Act amendment, the management of activities relating to prospecting, exploration and mining of Crown-owned mineral resources within the EEZ was transferred to the Crown Minerals Act. As such, approvals for the prospecting, exploration and mining of Crown-owned minerals resources are now administered by New Zealand Petroleum and Minerals, a branch of the Ministry of Business Innovation and Employment.

TTR's Crown Minerals Act tenements are located off the west coast of the North Island of New Zealand to the north and south of Cape Egmont, which the project area falls within. TTR was granted an Exploration Permit (No. 54068) for five years commencing on 17th December 2012, which expires on 18 December 2017. Also adjacent to the project area is Prospecting Licence 50753, which was granted to TTR on the 17th of December 2010 and expires on the 16th of December 2018. This licence was granted under the Continental Shelf Act.

The Crown Minerals Act sets out the reporting regulations for active Tier 1 mining permits. The purpose of the report is to ensure TTR operates in accordance with good industry practice and is tracking the resources and reserves in accordance with a recognised reporting code. TTR will be reporting to the Joint Ore Reserves Committee (2012) standard. Mine plans are also required to be submitted annually. This includes an outline of the extraction operations to occur for the following year along with an extraction schedule. These matters have been further provided for through the proposed consent conditions by way of an annual Operational Assessment Report.

13.8.2.4 Fisheries Act

The Fisheries Act establishes a framework for managing customary, recreation and commercial fishing, in New Zealand. The Fisheries Act is administered by the Ministry of Fisheries.

The Fisheries Act manages the allocation of rights to go fishing, the creation of taiapure (local customary fishery covering estuarine and littoral waters - Part IX) and mataitai areas (Maori customary fishing areas - section 186), and the recovery of costs from the commercial fishing industry.

TTR's project will occur in 'New Zealand fisheries waters' as defined in the Fisheries Act. The majority of the provisions of the Fisheries Act deal with quota management and access to fisheries under different fishery management regimes established in accordance with the provisions of the Fisheries Act.

Fishing interests are recognised by the EEZ Act as lawfully established existing activities which are 'existing interests'. These 'interests' need to be taken into account by the EPA when determining applications for marine consents and marine discharge consents, in accordance with section 59(2) of the EEZ Act.

Customary Fishing

The Maori Fisheries Act 2004 implements the agreements made under the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992.

Measures include the establishment of a Kaimoana Monitoring Programme to provide ongoing information about the fish and shellfish stocks of relevance to Maori within the STB coastal areas. It is expected that this programme will provide valuable information to Maori and assist in the long-term management of the customary kaimoana stocks.

Recreational Fishing

The project area was found to be a very low use recreational setting, which may be used only rarely for recreational marine fishing due to being so far offshore. There is the potential for some minor and localised effects at the iron sand extraction sites due to the exclusive use of the extraction zone, turbidity effects and short-term effects on habitat in the recently mined seafloor. However, due to the distance offshore and the low recreational fishing activity, the public notification of working mining areas and the ability for recreational fishers to avoid any mining areas, there are unlikely to be any adverse effects on recreational fishing at a local, regional or national scale.

Commercial Fisheries

TTR has undertaken extensive consultation with the commercial fisheries representatives and the outcomes of this process resulted in the inclusion of consent conditions that provide for regular ongoing meetings between TTR and representatives of the commercial fishing industry. The purpose of the meeting is to establish and provide for a co-ordinated approach between the iron sand extraction activities and commercial fishing activities.

The consultation process also identified the value of Admiralty Bay to New Zealand's aquaculture sector. In order to protect the existing interests within this area TTR agreed to include conditions of consent that exceed current regulatory requirements and has voluntarily prohibited the discharge of any ballast water or other materials within Admiralty Bay as well as restricting use of the area to only sheltering during storm events other than in emergency situations.

The requirements to meet regularly with aquaculture interests and the restrictions on use of Admiralty Bay have been incorporated into the proposed consent conditions.

Provided the proposed consent conditions are adopted, it is considered that any effects on the existing interests of commercial fisheries will be avoided, remedied or mitigated.

13.8.2.5 HSW Act

Section 39(4) of the EEZ Act states:

"…any measures required by or under the Health and Safety in Employment Act 1992 that may have the effect of avoiding, remedying, or mitigating the adverse effects of the activity on the environment or existing interests."

It is noted that the HSW Act has superseded the Health and Safety in Employment Act 1992 which is referred to in section 39(4) of the EEZ Act. The HSW Act has implications on how TTR manages the project operations, but it does not have a direct impact on the effect of avoiding, remedying, or mitigating the adverse effects of the activity on the environment or existing interests.

Notwithstanding this, there are many operational health and safety considerations to be taken into account for the project and TTR has developed a comprehensive set of health and safety initiatives which will address the health and safety matters of the project.

Further to its initiatives and policies, TTR is liaising with MNZ and Worksafe New Zealand in respect of developing a suitable approach for the overarching health and safety management for the project. As part of this approach and prior to the commencement of any operations, TTR will be required to identify and evaluate all hazards that have the potential to cause major accidents and, subsequently, identify suitable control measures to address these hazards. However, to reiterate, these are not related to the effects of avoiding, remedying or mitigating the adverse effects of the activity on the environment or existing interests.

13.8.2.6 HSNO Act

The HSNO Act sets out controls on the use of hazardous substances and came into effect in two stages. Provisions relating to new organisms took effect in July 1998, and provisions relating to hazardous substances came into force on 2 July 2001. The HSNO Act is administered by the EPA.

In TTR's case the substances that fall under the HSNO Act jurisdiction are:

- IFO 380 and diesel; and
- Residual Clean-in-Place chemicals from reverse osmosis system

Storage and handling of IFO and diesel on all project related vessels will be managed to ensure compliance with requirements under the HSNO Act for the avoidance of unintended ignition and for the segregation of incompatible substances. Further, TTR will implement a Spill Contingency Management Plan to provide for any unplanned spill events that may occur.

All Clean-in-Place chemicals used in the reverse osmosis system will be collected and retained for onshore disposal by approved contractors.

Storage and handling of all potentially hazardous substances will be managed to ensure safe practices consistent with requirements under the HSW Act, and the HSNO Act.

13.8.2.7 Heritage Act

The *Heritage Act* prohibits the modification or destruction of an archaeological site unless an Archaeological Authority for the modification or destruction is obtained from Heritage New Zealand. This Authority is in addition to any resource consents required under the RMA for the modification or destruction of the heritage feature.

An archaeological site is defined in the Heritage Act as follows:

"any place in New Zealand, including any building or structure (or part of a building or structure), that—

(i) was associated with human activity that occurred before 1900 or is the site of the wreck of any vessel where the wreck occurred before 1900; and

(ii) provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand; ...”

It is noted that the meaning of “archaeological site” refers to “a place in New Zealand,” including any place within the territorial limits of New Zealand, including the EEZ.

13.8.2.8 MCA Act

The MCA Act repealed the Foreshore and Seabed Act 2004 and restored any customary interests in the common marine and coastal area that has been extinguished by that Act. The CMCA extends from the line of mean high-water springs to the outer limits of the territorial sea but does not include land in the CMA already in private ownership or that held by the Crown as a conservation area, a national park or a reserve. No part of the project area is located within the territorial sea being an area not exceeding 12Nm from the low water mark of the coast.

The MCA Act also provides for the recognition and protection of protected customary rights. As a general rule, a consent authority must not grant a consent for an activity in a protected customary rights area if the activity has, or is likely to have, adverse effects that are more than minor on the exercise of a protected customary right.

The MCA Act also restores the right to Maori to seek customary marine title which recognises property rights of Maori that have continued since or before acquisition of Crown sovereignty to the present day. It also protects existing uses and rights, including navigation and fishing rights, and resource consents granted before the MCA Act commenced. It is important to note that the MCA Act does not affect Crown ownership of nationalised minerals.

In accordance with the EEZ Act, a ‘protected customary right’ or ‘customary marine titles’ as defined under the MCA Act are deemed as an ‘existing interest’ in the EEZ Act and shall be taken into account by the EPA when determining applications for marine consents and marine discharge consents, in accordance with section 59(2)(b) of the EEZ Act.

It is also noted that section 45(1) of the EEZ Act requires the EPA to serve a copy of any application for a marine consent on ‘customary marine title groups’ and ‘protected customary right groups’.

The MCA Act defines ‘customary marine title groups’ and ‘protected customary right groups’ as follows:

customary marine title group –

(a) means an applicant group to which a customary marine title order applies or with which n agreement is made and brought into effect; and

(b) includes a delegate or transferee of the group if the delegation or transfer is made accordance with tikanga.

protected customary right groups –

(a) means an applicant group to which a protected customary rights order applies or with which an agreement is made; and

(b) includes a delegate or transferee of the group if the delegation or transfer is made in accordance with tikanga.

At the time of writing there were no customary rights or customary marine titles, nor are there applications for titles, under the MCA Act relating to the project area. It is noted that Ngāruahine has lodged an application for customary title for the CMCA between the Taungatara and Waihi Rivers however, this area is outside the project area.

13.8.2.9 Marine Mammals Protection Act

The Marine Mammals Protection Act provides for the conservation, protection and management of marine mammals. The Marine Mammals Protection Act is administered by DOC and applies to the coastal marine environment's waters within the territorial sea and beyond the EEZ.

Under the Marine Mammals Protection Act, a permit from the Minister of Conservation is required for anyone to "hold" or "take" a marine mammal, whereby "take" is defined to include any actions that harm, harass, injure and attract a marine mammal.

Section 3(a) of the Marine Mammals Protection Act gives specific responsibility to DOC for the administration and management of marine mammals and marine mammal sanctuaries. Further, conservation management strategies establish objectives for the integrated management of marine mammals under the Marine Mammals Protection Act (section 3(c)). The purpose of these conservation management strategies is to establish objectives for management of marine mammal sanctuary(s) (section 3(d)).

The Minister of Conservation may also approve a 'population management plan' in respect of one or more species, being threatened species or other species of marine mammal (section 3(e)).

Section 22 deals with the Ministers powers to define, by notice in the Gazette, any place and declare it to be a marine mammal sanctuary. In defining and declaring a sanctuary, the Minister may specify the activities that may or may not be engaged in within the sanctuary and may impose restrictions in respect of the sanctuary.

There are currently six marine mammal sanctuaries in New Zealand including the West Coast North Island sanctuary, shown in Figure 93 below, which is the only sanctuary within the general vicinity of this project.

Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008

The issuing of this notice created a marine mammal sanctuary along the northern part of the west coast of the North Island. The explanatory note states that the notice "creates a marine mammal sanctuary along part of the west coast of the North Island, and restricts seismic surveys in the whole of the sanctuary and mining activities in part of the sanctuary. The sanctuary includes areas where Hector's dolphin are found."

The boundaries extend alongshore from Maunganui Bluff in Northland to Oakura Beach, Taranaki in the south. The sanctuary's offshore boundary extends from mean high-water springs to the 12Nm territorial sea limit. The total area of the sanctuary is approximately 1,200,086ha and covers 2,164km of coastline, as shown in Figure below.

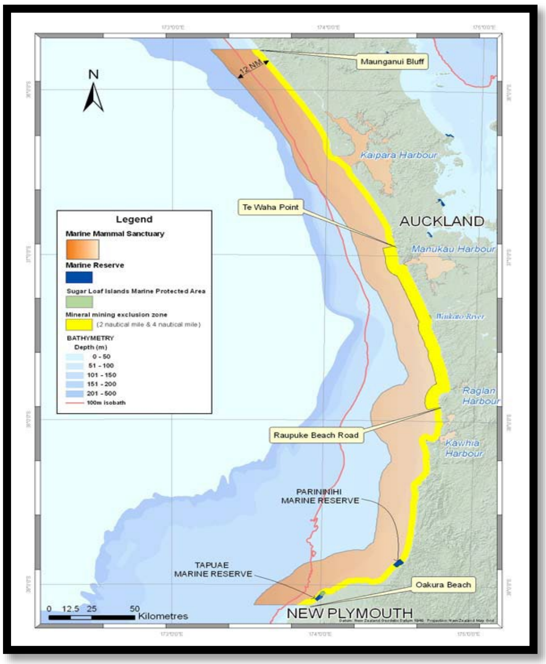


Figure 81 Boundaries of Marine Mammals Protection, West Coast North Island

Within the sanctuary boundaries there are restrictions on seabed mining activities and acoustic seismic survey work. The NZ Gazette notice for a marine mammal sanctuary specifies the areas in which these restrictions apply.

The project area is located approximately 100 km south of this sanctuary and is therefore not subject to any restrictions imposed within this area.

Other Mammal Effects

In summary, the potential key effects of the project are:

- Noise effects - it has been concluded that there is not expected to be a more than minor temporary alteration to the behaviour of marine mammals in the immediate vicinity of the extraction area. Further, given the low numbers of marine mammals observed in the area any effects of noise generated by extraction activities are expected to be no more than minor. Additionally, 'soft-start' and other operating procedures will be implemented to minimise the potential noise effects on marine mammals; and

- Risk of collision with operational vessels - it is concluded that overall, given the low vessel speeds during excavation, and the low number of operational vessels proposed in addition to those already using the STB, that the additional risk to any marine mammals that may be present in the project area is extremely low. Operational procedures will be implemented through management plans to further minimise the potential for any effects on mammals. These measures include observers and video recordings on each vessel, and the requirement of avoidance measures when mammals are encountered when the vessels are in motion.

TTR has included various mitigation measures and operational controls, including the provisions of a Marine Mammal Management Plan, in the proposed consent conditions for the project. These conditions are considered to further avoid, remedy or mitigate any potential adverse effects on marine mammals that occur as a result of the project. The proposed consent conditions as they relate to marine mammals have been prepared in consultation with, and generally accepted by, DOC through the pre-lodgement consultation process.

13.8.2.10 Marine Reserves Act

The Marine Reserves Act provides for the establishment of marine reserves over specified areas of the foreshore and territorial sea. Section 3(1) of the Act states "the provisions of this Act shall have effect for the purpose of preserving, as marine reserves for the scientific study of marine life, areas of New Zealand that contain underwater scenery, natural features, or marine life, of such distinctive quality, or so typical, or beautiful, or unique, that their continued preservation is in the national interest."

Within marine reserves, a range of activities are prohibited including fishing, removal of material, dredging, discharging or dumping of any matter, construction or any other direct human disturbance.

There are two Marine Reserves in the Taranaki area, Parininihi and Tapuae Marine Reserves. Both are located to the north of project area:

(i) Parininihi Marine Reserve protects a 1,800ha portion of the subsea environments located in the southernmost reaches of the Taranaki Bight and protects an isolated offshore reef in the shadow of the White Cliffs/Parininihi. Within the reserve boundaries, all marine life, habitat, objects and structures are protected. The reserve is managed by a Joint Advisory Committee of Ngāti Tama Iwi and DOC; and

(ii) Tapuae Marine Reserve is located on the Taranaki coast close to New Plymouth. The 1,404 ha reserve adjoins the Sugar Loaf Island Marine Protected Area where a complexity of caves, canyons and crevices, boulder fields, mud and sand hosts a diverse and flourishing range of sea life.

The project-related activities will not take place within or in close proximity to either of these identified marine reserves, identified under the Marine Reserves Act.

13.8.2.11 Maritime Transport Act

The Maritime Transport Act and associated Marine Protection Rules previously regulated the discharge of harmful substances from ships or offshore installations, and the dumping of waste or other matter, beyond the territorial sea. However, as of 31 October 2015, as a result of the EEZ Act and the Maritime Transport Act amendments passed in 2013, there has been a transfer of responsibility for regulating these activities from MNZ to the EPA through the EEZ Act. Therefore, as of 31 October 2015, Part 200 (which previously provided for discharges) was revoked and Part 131 entered into force.

Further to the discharges, Part 131 of the Marine Protection Rules is relevant to the project.

Maritime New Zealand Marine Protection Rules, Part 131: Offshore Installation – Offshore Installations – Oil Spill Contingency Plans and Oil Pollution Prevention Certification

The purpose of Part 131 is to ensure that offshore installations operating in New Zealand continental waters and in the internal waters of New Zealand have marine oil spill contingency plans that will support an efficient and effective response to an oil spill.

Part 131 also ensures that certain pollution prevention equipment and arrangements on board installations meet international performance standards and in-service maintenance requirements.

Part 131, in conjunction with the EEZ Regs 2015, gives effect to the provisions of the MARPOL and the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 in respect of offshore installations.

Offshore installation is defined under Part 131 to include:

"(a) any artificial structure (including a floating structure that is not a ship) used or intended to be used in or on, or anchored or attached to, the seabed for the purpose of the exploration for, or the exploitation or associated processing of, any mineral, oil or gas.

The IMV is by this definition an "installation" because it is an "artificial structure …intended to be used in or on, or anchored or attached to, the seabed for the purpose of … the exploitation or associated processing of, any mineral, oil or gas".

Under Subpart A, 131.21, a person must not operate an offshore installation, in this case the IMV or other operational vessels, without the MNZ Director's written approval of an oil spill contingency plan containing the matters prescribed in Part 131 that are appropriate to the operation of that installation. Further, rules under Part 131 set out the process for approval, consultation, amendment etc. with regard to any such plans.

TTR is committed to preparing and implementing a Spill Contingency Management Plan for the project prepared in accordance with the requirements of Part 131, and in consultation with MNZ, and submitted for approval to the Director of MNZ. This has been further provided for through inclusion in the proposed consent conditions.

13.8.2.12 RMA

In accordance with section 59(2)(a) of the EEZ Act, the EPA is required to take into account effects that may occur outside of the EEZ - including areas that are within the jurisdiction of the RMA. Further section 59(2)(h) of the EEZ Act requires the EPA to take into account 'the nature and effect' of the RMA when considering marine consent and marine discharge consent applications.

The provisions of the RMA apply both on land and extend seaward to the outer limits of the CMA - being the extent of the 12Nm limit. The jurisdictional boundaries of the TRC or the STDC are shown in Figure 95 below.

The proposed compliance monitoring that is detailed within the BEMP and the EMMP will take place both within the EEZ and the CMA. The location of the permanent monitoring stations that will be placed within the CMA will be within the jurisdictional waters of the TRC. Even though the specific details have not been confirmed as to the mooring configuration and surface buoy arrangement, TTR is aware that a coastal permit (likely to be a discretionary occupational consent) will be required from the TRC prior to the BEMP commencing.

A resource consent application and supporting assessment of environmental effects will be submitted to the TRC for processing as soon as the relevant mooring and buoy details are confirmed. TTR note that the application for the placement of the moorings and surface buoys will be submitted in accordance with the relevant rules of 'Regional Coastal Plan for Taranaki' in adherence to the RMA 1991. No moorings will be placed within the CMA without prior resource consent approval.

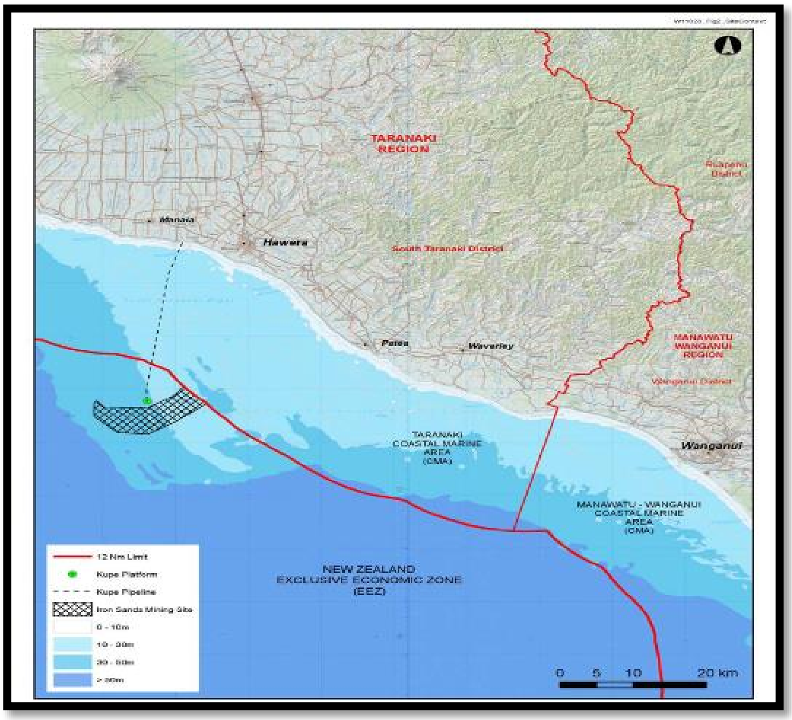


Figure 82 Site Context and Governance Boundaries of the Regional & District Councils

Purpose and Principles of the RMA

Section 5 of RMA sets out the purpose of the RMA, which is to “promote the sustainable management of natural and physical resources...”

The application of Section 5 of the RMA involves a ‘broad overall judgement approach’ as to whether an activity will promote the sustainable management of natural and physical resources. It is, however, noted that the definition of sustainable management does differ between the EEZ Act and the RMA, and the definition of the ‘environment’ in the EEZ Act is limited to the natural environment values.

Section 6 of the RMA states, in achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall “recognise and provide for…” the relevant matters of national importance. Consideration is given to relevant matters from section 6 of the RMA in Table 7.3 below.

Section 7 (Other matters) of the RMA, states in achieving the purpose of the RMA, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall “have particular regard to” specified relevant other matters.

13.8.2.13 New Zealand Coastal Policy Statement

The NZCPS is a national policy statement under the RMA and came into effect on 3 December 2010. The purpose of the NZCPS is to achieve the purpose of the RMA in relation to the coastal environment of New Zealand. The NZCPS is to be applied by persons exercising functions and powers under the RMA.

As previously identified, no part of the project area is located within the CMA. However, some potential effects arising from the project may occur in the CMA and wider coastal environment, as defined by Policy 1 of the NZCPS.

The NZCPS has only been assessed to the extent which the potential effects arising from the project operations can occur within the coastal environment and the CMA (as defined by the RMA).

Overall, it is concluded that the project is not inconsistent with the relevant provisions of the NZCPS.

13.8.2.14 Regional Policy Statement for Taranaki

The Regional Policy Statement for Taranaki (“**RPST**”) became operative on 1 January 2010.

The boundary of the Taranaki region extends to the seaward limit of the CMA adjoining the Taranaki region and does not include any of the project area.

The RPST identifies “High quality or high value areas of the coastal environment”. The coastal areas listed are identified in the Inventory of Coastal Areas of Local or Regional Significance in the Taranaki Region (2004). This inventory identifies important areas in the CMA and in adjacent land within the coastal environment.

The RPST also notes the coastal areas identified are not necessarily an exhaustive selection and on occasion, other parts of the coast may have natural, ecological or cultural values that are regarded as important to the region. The areas identified in the RPST that may experience potential effects arising from the project are as follows:

- Ohawe Beach;
- Waihi Beach;
- Manawapou-Tangahoe River Mouths and Cliff Tops;
- Kakaramea Beach;
- Patea Beach and River Mouth;
- Whenuakura Estuary;
- Waipipi Iron sands;
- Waverley Beach;
- Waiotara Estuary and Dunes;
- Waiinui Beach and Reef; and
- North and South Traps.

Further, the RPS states, “Taranaki is recognised nationally and internationally for its surfbreaks. Surfbreaks depend on the presence of a combination of suitable seabed shape, swell direction and power, swell corridors that allow swells to arrive at the surfbreak and wind direction and force. High quality or high value surfbreaks in Taranaki attract surfers from throughout New Zealand and overseas as well as locally. The surfbreaks have been identified using the Council’s inventory of Coastal Areas of Local or Regional Significance in the Taranaki Region (2004), the Surfing Guide (2004) published by Wavetrack and by consultation with local surfers.”

- Waiinui Reef; and
- The Point / Fences.

13.8.2.15 Regional Coastal Plan for Taranaki

The Regional Coastal Plan for Taranaki became operative on 1 October 1997 and applies to the CMA adjoining the Taranaki Region extending from mean high-water springs out to the 12Nm limit.

Management Areas for the CMA in Taranaki

The Plan identifies four coastal management areas for the CMA in Taranaki.

Areas of outstanding coastal value:

- Estuaries within the CMA that are permanently open to tidal movements;
- Port Taranaki being a highly modified environment; and
- The open coastline.

Areas where Amenity Values are of Regional importance

Policy 3.2 of the Regional Coastal Plan identifies areas where amenity values are determined to be of regional importance. The Regional Coastal Plan includes three areas that may be potentially affected by the project, as follows:

- Ohawe Beach;
- Waverley Beach; and
- Waiinu Beach.

Areas of Outstanding Coastal Value

Policy 4.1 of the Regional Coastal Plan identifies areas of outstanding coastal value that shall be managed in a way that gives priority to avoiding adverse effects on the outstanding coastal values of each area. There are five sites that may be potentially affected by the project as follows:

- Waitotara Estuary;
- Waiinu Reef;
- Waverley Beach;
- North and South Traps; and
- Whenuakura Estuary.

13.8.2.16 South Taranaki District Plan

The South Taranaki District Plan was made operative in December 2004. South Taranaki District Plan has jurisdiction over the South Taranaki District to the landward edge of the mean high water springs mark. STDC has no jurisdiction over the CMA.

The primary management technique used in the South Taranaki District Plan is zoning. Five zones cover the district, being Rural, Residential, Commercial, Industrial and Rural Industrial Zones.

Coastal Protection Areas

The South Taranaki District Plan identifies Coastal Protection Areas, being areas defined along the coastline by location, landscape and topography as part of the natural environment which is particularly susceptible to damage from the adverse effects of activities. These areas are also identified as being potentially most affected by coastal processes including erosion of the coastal cliffs.

TTR's project has no direct effect on the area or zones of jurisdiction of the South Taranaki District.

13.8.2.17 Wanganui District Plan

The Wanganui District Plan was made operative in 2004. The Wanganui District Plan covers the management of the land within the Wanganui District. The Wanganui District Plan has jurisdiction over the Whanganui District to the landward edge of the mean high water springs mark. Whanganui District Council has no jurisdiction over the CMA.

Resource Management (Marine) Pollution Regulations 1998

These regulations control the dumping and discharges from ships and offshore installations within the CMA boundary. The regulations deal with the dumping of waste and discharges from vessels including oil, sewage, garbage and ballast water.

Aside from those matters provided for under the EEZ Act, there will be no dumping of waste or discharge from vessels into the CMA, arising from the project.

13.8.2.18 Submarine Cable Act

The Submarine Cable Act governs the management of submarine cables (both electricity and communications) and gas and fuel pipelines. The Submarine Cable Act is administered by the Ministry of Transport and provides for the protection for submarine cables and pipelines by allowing for the creation of cable protection areas or cable protection zones. Within these cable protection zones, it is an offence for a ship to anchor or to conduct most types of fishing.

The Submarine Cable Act also lists offences against the Act, which include causing damage to submarine cables and pipelines.

The Ministry of Transport website records there are 11 cable protection areas (commonly known as Cable Protection Zones ("CPZ")) established around the country. The following CPZs are located in the STB:

- Area 8: Oaonui;
- Area 10: Maui A and B; and
- The Pohokura Protection Area (no number).

The project area is outside any of the CPZs identified above therefore, the project will not impact on the cable protection areas identified under the Submarine Cable Act.

14 CAPITAL AND OPERATING ESTIMATES

14.1 Capital Expenditure Estimate

The total project Capex is estimated at approximately US$602.183 million. This figure encompasses a wide range of cost elements including project management, consultancy efforts (both BFS and execution), travel and accommodation, and extensive procurement activities. The procurement segment alone covers major components such as the IMV hull and superstructure, piping, machinery, the SBC, a geological drilling and grade control survey vessel (GSV) and a variety of specialized equipment and installation costs. Each element has been meticulously evaluated to ensure that the overall estimate reflects both the scale and complexity of the project.

A critical aspect of any Capex estimate is the inclusion of a contingency reserve to address uncertainties and mitigate potential risks. The contingency, for this Capex estimate amounts to US$84.4 million or 14% of the total Capex.

The updated Capex estimate now also includes an allocation of NZ$2 million for the establishment of a dedicated employee and contractor Training facility in Hāwera, aimed at enhancing workforce competency and supporting operational excellence. This facility will provide specialised training programs tailored to the project's manning needs, ensuring compliance with industry standards and best practices. Additionally, a NZ$3.9 million allowance has been incorporated for the acquisition of a suitable environmental monitoring and research vessel (EMV), monitoring equipment and technology and the necessary port infrastructure. This investment underscores the project's commitment to environmental stewardship, enabling continuous monitoring of marine ecosystems and ensuring adherence to regulatory requirements. These additions strengthen the project's long-term sustainability and operational resilience while aligning with best practices in environmental and workforce development.

The estimate is composed of several major segments.

- Project Management
  - Consultancy Costs.
  - Travel & Accommodation.
  - Additional Set-Up Costs: A set-up expense for the TTR Charitable Trust is also included, reinforcing the administrative and preparatory elements of the project.
- BFS & Engineering/Design
  - BFS Components: Include resource definition, beneficiation, metallurgy, pilot plant development, permits, approvals, environmental initiatives, community engagement, and training facility setup. These items ensure that both operational readiness and regulatory compliance are thoroughly addressed.
  - Engineering and Design: Specifically related to the IMV, two estimates (Part A

and Part B) from Europe contribute to the design and integration of the offshore unit.

- **Procurement**

  The procurement section represents the bulk of the expenditure, covering:

  - IMV Elements - Costs for the hull, equipment, superstructure, piping, machinery, electrical systems, equipment fittings, firefighting, and navigation systems which will be predominantly sourced from China and integration in Singapore.
  - Two SBC units – Costs for pumps, crawler, controls and LARS systems.
  - Specialised Process Equipment - This includes items such as the Vertimill® units, with significant contributions from the USA, as well as equipment sourced from Europe.
  - Process Plant - This area covers equipment like pumps, dewatering systems, and screening equipment;
  - Power generation and desalination equipment sourced in Europe and US;
  - Installation, Norms, and Contractors Fees - These ensure proper assembly and commissioning; and
  - BFS, Project management and EMV vessel in New Zealand

- **Risk-Based Contingency**

14.1.1 Contributions by Source Country

The design and construction phase of the project is truly global, drawing on world-leading technology and best-in-class providers for both services and equipment. This international collaboration brings together a carefully selected network of experts who ensure every element of the project adheres to the highest standards. South African contributions are particularly noteworthy, with De Beers expertise in advanced seabed mining technologies setting a benchmark for innovation and efficiency. Complementing this, China's renowned shipbuilding industry delivers state-of-the-art vessel construction capabilities, while Singapore's specialised maritime systems integration services provide seamless coordination in complex offshore environments. Together, these global inputs exemplify the project's commitment to excellence and cutting-edge performance.

- **China (52%)**

  China is the dominant contributor, supplying the majority of procurement elements such as the hull, piping, machinery, electrical systems, and various process plant components. The extensive reliance on Chinese manufacturing and equipment procurement is a key driver of the overall Capex.

- **Europe (3%)**

  European contributions are evident in several areas:

- Engineering and design work, including parts of the IMV.

- **South Africa (16%)**

  South African contributions are evident in several areas:

  - Engineering and design work, including parts of the IMV and LARS; and
  - SBC design, components and controls.

- **USA (11%)**

  The USA contributes significantly with specialized processing equipment, most notably the Vertimill® units, which represents a major capital investment in the processing technology for the project.

- **Singapore (9%)**

  Singapore plays a crucial role in the vessel integration process. This is vital for the successful assembly and operational readiness of the IMV unit.

- **New Zealand (NZ) (6%)**

  New Zealand's input is focused on project management and BFS-related efforts. This includes consultancy, travel, and specialised local projects like the vanadium recovery pilot plant, BFS, permitting, and community/environmental initiatives and EMV.

- **International (3%)**

  A small fraction of the costs is attributed to international sources, primarily reflecting the risk-based contingency allocation and minor cross-border contributions.

- **Australia (0.1%)**

  Australia's overall contribution is limited to beneficiation and metallurgical testing during the BFS phase.

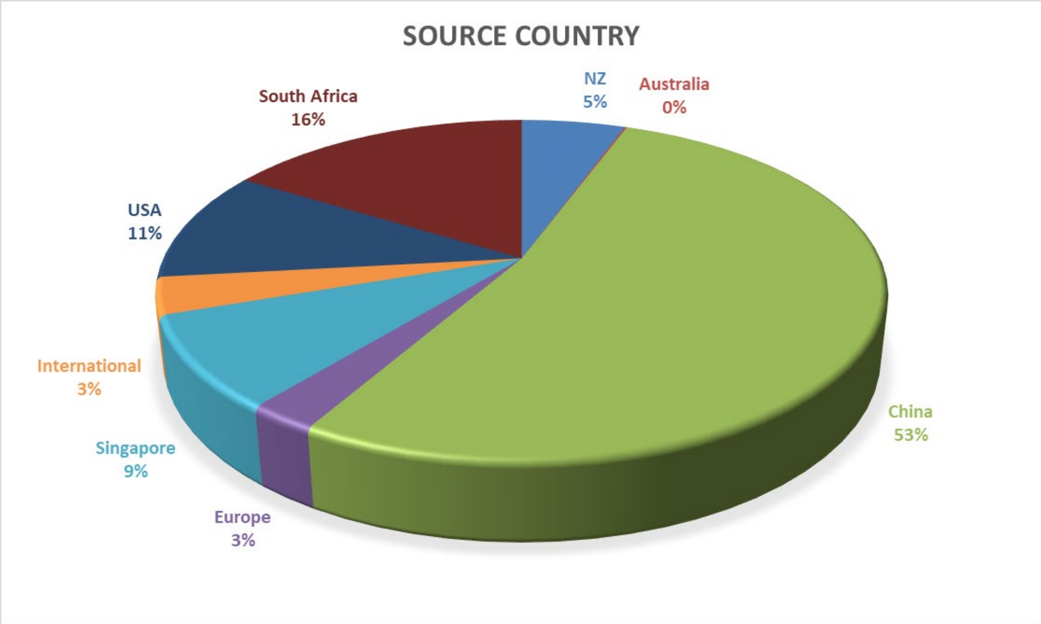


Figure 83 Project Element Source Country

14.1.2 Capital Estimate Revision Process

The capital cost estimates for the Taranaki VTM Project have been updated through a process that began with identifying the intended sources of each key project element. This involved a review to determine whether materials, equipment, and labour resources were to be sourced domestically or internationally, taking into account supplier locations, logistical pathways, and potential geopolitical impacts.

With the sourcing origins clearly defined, the next step was the application of relevant industrial and national price indices to adjust costs. The Producer Price Index (PPI) was employed to reflect changes in manufacturing and wholesale prices across various sectors, while the Consumer Price Index (CPI) was consulted to capture broader trends. Additionally, industry-specific indices were referenced, particularly for ship construction, mining process equipment, and industrial equipment procurement.

Incorporating market-driven factors was a critical part of the methodology. This process began with data collection from reputable industry reports, government publications, and economic research papers. Key factors considered included:

- Commodity Price Fluctuations - Historical and forecasted trends were analysed to anticipate changes in raw material costs.
- Currency Exchange Rates - Data from the Reserve Bank and financial institutions.
- Supply Chain Dynamics - Insights from logistics providers and recent case studies were used to estimate freight costs; and
- Labour Market Trends - National employment data and industry wage reports provided

insights into wage growth and productivity variations across regions.

Inflation adjustments were applied using the most up-to-date data available to ensure that material and service costs reflect current market conditions accurately. Supply chain challenges, including increased freight rates and extended delivery times, were integrated into the revised estimates to account for potential delays and cost overruns.

14.1.3 Capex Model

The project's capital expenditure (Capex) estimate was developed using "@Risk", a Monte Carlo simulation tool that models the uncertainties inherent in project costs. The process involved defining cost elements with probability distributions to reflect potential variability, informed by historical data, industry benchmarks, and expert input. Through multiple simulation iterations, "@Risk" generated a probability distribution for the total Capex, providing insights into the range of potential outcomes and highlighting key cost drivers.

As part of this process, the maximum Capex value was selected to determine an appropriate base contingency. This approach ensured a high level of confidence that the estimated Capex would be sufficient to cover expected variations.

In addition to this statistical contingency, a risk-based contingency was applied, derived from the project risk register. The risk register outlined identified project risks along with their likelihood and potential cost impacts, allowing for a contingency that accounted for both historical cost variability and project-specific risk factors. This combined approach provided a robust and defensible CAPEX estimate for the project.

14.1.4 Summary Scope of Work

Capital costs have been prepared based on the work breakdown structure (WBS) for the execution phase of the Project. Estimated costs have been broken down into the main areas of mining, processing and logistics.

The overall capital cost estimate includes the following scope:

- Project capital includes all development work;
- Processing plant for the screening and beneficiation of iron sands based on 8,000tph;
- Installed Power Generation of 80MW; and
- Sea Water Desalination capacity of 30,000 m^3/day.

The following items are excluded from the overall capital cost estimate:

- Working capital;
- Insurances; and
- Escalation.

14.1.5 Capital Estimate Basis

The capital cost estimate has been prepared based on the detailed project scope developed during the PFS.

Budget prices were received from pre-qualified OEM's/vendors for the major engineered/process equipment, namely the trommel screens, mills, magnetic separators, pumps, power generation units and the water desalination plant. These items currently represent approximately 58% of the total value.

The historical norms used in the estimates were based on industry standards within the defined scope. The project has endeavored to compile a reasonable level of basic engineering to facilitate the allocation of applicable norms, finalization of project scope and verify aspects of constructability and understanding of risk associated with the implementation of the works.

The value of "normed" works is approximately 21% of the total estimate value. The total Capex estimate comprises the following break-up:

- 5% Fixed Prices;
- 60% Budget prices;
- 21% Normed estimates; and
- 14% Provisional Prices.

The project management and engineering requirements have been quantified using a resource-based schedule, reflecting current industry standards and historical data for this type of project. Incidental and non-labour costs such as travel, third party consultants, etc. have been included on expected activities for the project.

The current overall contingency applied to the bottom line of the estimate (total base estimate excluding sunk costs) is 12%.

14.1.6 Normed Estimates

The normed estimates of the project were compiled using a Cost Ratio method, which relates directly to equipment cost. The Cost Ratio method is particularly suited to preparing Pre-Feasibility estimates, where there is not a lot of detail available with regards to associated equipment, facilities and services.

```
1.  Purchased equipment costs from references
    and on current index basis .......................$000,000
2.  Equipment installation
    (0.17 to 0.25 times Item 1).......................$000,000
3.  Piping,material and labour, excluding service
    piping (0.13 to 0.25 times Item 1)................$000,000
4.  Electrical,material and labour, excluding
    building lighting (0.13 to 0.25 times Item 1).....$000,000
5.  Instrumentation (0.03-0.12 times Item 1) .........$000,000
6.  Process buildings, including mechanical services
    and lighting (0.33 to 0.50 times Item 1) .........$000,000
7.  Auxiliary buildings,including mechanical services
    and lighting (0.07 to 0.15 times Item 1) .........$000,000
8.  Plant services,such as fresh water systems,sewers,
    compressed air etc.(0.07 to 0.15 times Item 1)....$000,000
9.  Site improvements, such as fences, roads,
    railroads etc.(0.03 to 0.18 times Item 1).........$000,000
10. Field expenses related to construction management
    (0.10 to 0.12 times Item 1) ......................$000,000
11. Project management including engineering and
    construction (0.30 to 0.33 times Item 1)..........$000,000

12. Fixed capital = (Sum of 1+2+3+4+5+6+7+8+9+10+11)..$000,000
      Costs
```

Figure 84 Historical Norms

Using this method to project an estimated capital cost required the following actions:

- The preparation and verification of plant flow-sheets involving all major items of equipment, for each of the options considered;
- The calculation of equipment sizes using knowledge of the estimated plant mass balance;
- The costing of individual equipment items; and
- The factoring of associated equipment and service costs to calculate the final estimated capital cost.

14.1.7 Range

The estimate for the TTR Project was developed in the usual manner using vendor quotations, contractor estimates and rates applied to a defined scope of work. Therefore, the cost risk of planned work includes the risks associated with scope definition, quantity take-offs and rate estimation (i.e., the basis of the estimate). For each item in the estimate, three-point range estimates consisting of the likely, the maximum pessimistic and minimum optimistic values were determined for each of these risk factors.

These ranges were determined by key project team members based on factors such as the stage of scope development, the source of rate information and the level of complexity associated with the estimated item and applied in the form of an accurate margin and contingency.

14.1.8 Accuracy

The accuracy margin applied to the base estimate is the amount by which an estimate is corrected to allow for inherent uncertainties brought about by the extent of analysis and design undertaken to quantify risk elements enabling costs to be determined to the prescribed level of accuracy.

Therefore, the level of accuracy margin applied depends on the nature of the information supplied to vendors or suppliers and the information received from these same vendors or suppliers.

As the level of detailed engineering increases, as does the cost to undertake the higher-level studies. Therefore, it is common for detailed engineering to be conducted within the full feasibility study after the project concepts have been fully optimised.

14.1.9 Contingency

Contingencies are the amounts of money allocated to the project to provide for uncertainties in project definition and technology, and risks associated with execution of the project. A quantitative risk analysis was used to determine the most likely project cost outcome and estimate accuracy.

14.1.10 Capital Benchmarks

No specific benchmarking of capital costs has been completed as part of the PFS study given that the process for determination of the capital costs used current market data as the basis of the project estimation. During the PFS study a number of processes have been adopted to assist in determining the optimum capital necessary for the project. From the outset of the PFS study it was expected to achieve a high level of front-end loading. Extensive consideration of execution planning, engineering definition, and understanding site-specific factors have been the basis of the work completed by the PFS study team. In the course of progressing the study a number of Value Improving Practices have been followed, including:

- Formal technology selection;
- Simulation modelling;
- Customised standards and specifications;
- Constructability reviews; and
- Risk assessments.

14.1.11 Verification

Due to the lack of detail engineering within the Pre-Feasibility stage, the verification of the accuracy of estimates and assumptions used in creating these estimates was regarded as essential to the potential success of the Project.

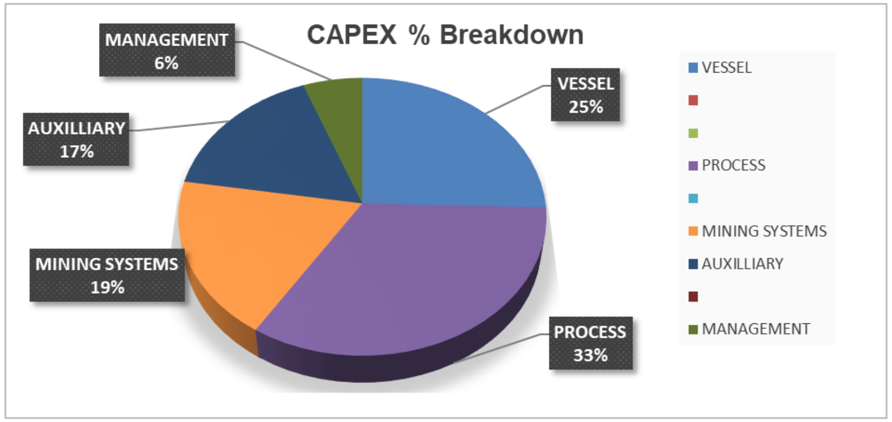
Experienced consultants in each of the different technology areas, namely mineral sands mining, concentration and beneficiation/comminution, were retained to independently evaluate the integrity of the specifications and assumptions.

14.1.12 Capex Cost Estimate

Based on the operational tools and equipment required to achieve a production target of 4.9Mtpa of final iron sands concentrate, the risk analysis estimates a Capex budget of US$602.183 million (circa NZ$1 billion).

PROJECT ELEMENT		CAPITAL ESTIMATE							ELEMENT TOTALS	PFS TOTAL
		IMV	FSO	AHT	ENVIRO MON	PM & ENG	UNCERTAINTY	RISK		
VESSEL	HULL	$ 42,221,692.89		$5,683,724.65	$1,900,000.00		$ 7,185,812.63	$ 4,222,169.29	$ 153,298,229.34	$ 61,213,399.47
	EQUIPMENT	$ 31,630,003.83					$ 3,163,000.38	$ 3,163,000.38		$ 37,956,004.60
	INTEGRATION	$ 45,107,354.39					$ 4,510,735.44	$ 4,510,735.44		$ 54,128,825.28
PROCESS	PROCESS PLANT	$163,393,883.51					$16,529,388.35	$ 3,940,880.48	$ 201,932,946.14	$183,864,152.33
	DEWATERING		$15,459,730.28				$ 1,545,973.03	$ 1,063,090.50		$ 18,068,793.81
MINING SYSTEMS	CRAWLERS/LARS ETC	$ 86,711,224.00				$ 5,621,583.47	$10,820,910.00	$ 8,799,470.00	$ 111,953,187.47	$111,953,187.47
AUXILLIARY	POWER GENERATION	$ 66,036,828.55					$ 6,603,682.86	$ 1,839,386.82	$ 100,575,468.37	$ 74,479,898.22
	DESALINATION	$ 21,929,050.54					$ 2,192,905.06	$ 1,973,614.54		$ 26,095,570.15
MANAGEMENT	PM&E	$ 23,287,615.97				$ 8,783,724.17	$ 1,164,380.80	$ 1,187,472.81	$ 34,423,193.75	$ 34,423,193.75
	Totals	$480,317,653.69	$15,459,730.28	$5,683,724.65	$1,900,000.00	$14,405,307.64	$53,716,788.55	$30,699,820.25	$ 602,183,025.07	**$602,183,025.07**
	% of Total	79.8%	2.6%	0.9%	0.3%	2.4%	8.9%	5.1%		100%

Table 24 CAPEX Breakdown



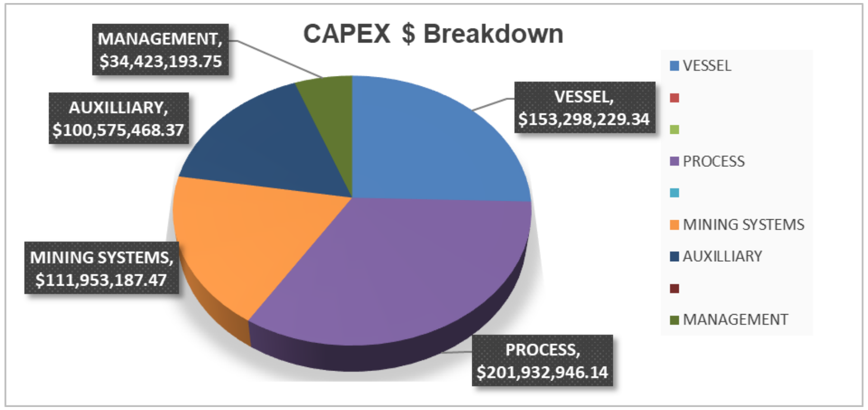


Figure 85 Capex Breakdown

14.1.13 Capex Analysis Results

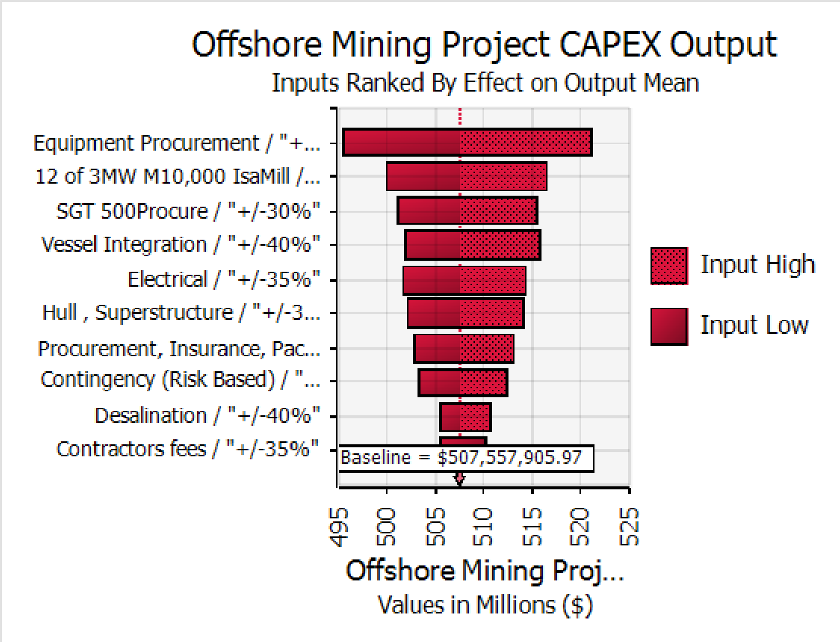


Figure 86 Capex Sensitivity Analysis

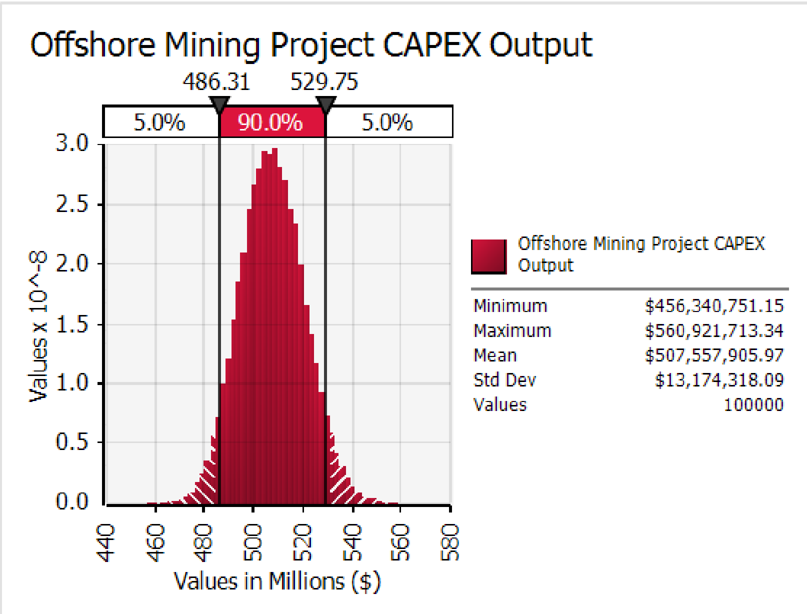


Figure 87 Capex Distribution

14.2 Operational Expenditure

The detailed Opex framework provides an in-depth analysis of the operational costs, amounting to US$27.20 (NZ$47.00) per tonne of concentrate. This cost structure not only highlights the complexity and scale of the offshore mining operation but also identifies key cost drivers and opportunities for improving efficiency. Each component of the operation contributes uniquely to the overall expenditure, reflecting the logistical and technical demands of offshore mining while underscoring strategic areas for cost optimisation.

The seabed crawler (SBC) with its impressive capacity of 8,000tph, exemplifies operational efficiency, contributing just US$1.29t of VTM concentrate to the total cost. This low unit cost is a testament to the crawler's robust design and high throughput capability. At the other end of the spectrum, the Integrated Mining Vessel (IMV) stands out as the most significant cost driver, accounting for US$15.34t of concentrate or over half of the total Opex. This high cost is primarily due to the vessel's multifaceted role, encompassing sediment extraction, mineral processing, and energy-intensive operations including 80MW power generation and seawater desalination. Notably fuel consumption, which is a critical factor in the IMV's operation, represents US$8.12t of concentrate, roughly 30% of the total Opex, underscoring the importance of efficient power generation and energy management.

The Floating Storage and Offloading (FSO) Vessel adds a further US$7.72t to the Opex, driven largely by leasing costs of US$7.00t. While the FSO provides essential storage and transshipment capabilities, its leasing arrangement introduces a fixed cost that scales directly with production. Ancillary services, including the Anchor Handling Tug (AHT) (US$1.85t) and the EMV vessel (US$1.00t), provide vital operational support, with the latter reflecting the project's commitment to ongoing environmental stewardship and strict regulatory compliance.

A deeper breakdown of Opex reveals further operational complexities. Labour costs account for US$6.27t of concentrate, reflecting the highly skilled workforce required to manage offshore operations. Repairs and maintenance costs total US$2.04t, essential for maintaining equipment reliability and minimising downtime. Insurance (US$0.57t) protects operational assets against marine and environmental risks, while miscellaneous expenses (US$2.20t) cover consumables, logistics, and unforeseen operational requirements. Importantly, the US$1.00t allocated for environmental monitoring and training not only ensures ongoing regulatory compliance but also enhances workforce capability, strengthening long-term operational resilience.

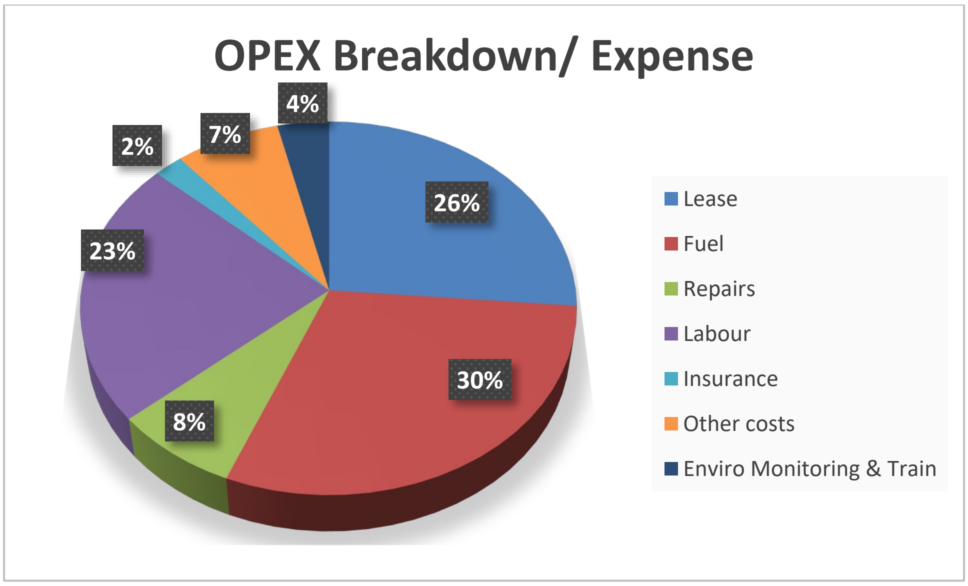


Figure 88 Opex Operational Breakdown

Summary Opex Costs	**US$t Concentrate**
8,000 tph Seabed Crawler	US$ 1.29
Integrated Mining Vessel	US$ 15.34
Floating Storage and Offloading Vessel	US$ 7.72
Ancillaries (AHT)	US$ 1.85
Environmental Monitoring Vessel	US$ 1.00
Total	**US$ 27.20**

Table 25 Opex Costs by Element

Summary Opex Costs	**US$t Concentrate**
Leasing Costs (FSO)	US$ 7.00
Fuel	US$ 8.12
Repairs & Maintenance	US$ 2.04
Labour	US$ 6.27
Insurance	US$ 0.57
Other Costs (Misc.)	US$ 2.20
Environ Monitoring & Training	US$ 1.00
Total	**US$ 27.20**

Table 26 Opex Costs by Area

14.2.1 Benchmarking Against Iron Sand Land Operations

When benchmarked against conventional iron sand land operations, which typically operate at approximately US$25.00-28t, the offshore operation's Opex of US$27.20t remains competitively positioned, particularly when considering the added complexities of marine-based mining. While land-based operations benefit from simpler logistics, lower fuel dependency, and reduced environmental monitoring costs, they also face significant challenges, such as land use constraints, regulatory pressures, and community engagement hurdles.

Land-based mining often contends with strict zoning laws, complex environmental regulations, and public opposition related to land disturbance and ecosystem impacts. Coastal and rural communities frequently raise concerns about the environmental footprint of large-scale mining operations, leading to time-consuming consent processes and potential operational delays. Additionally, engagement with Māori iwi and local stakeholders is essential in maintaining a social licence to operate, adding another layer of complexity to land-based projects.

Offshore mining offers several strategic advantages with access to higher-grade deposits, with minimal overburden removal, thus allowing for more consistent head grades and potentially higher metallurgical yields. Furthermore, the environmental footprint of seabed mining, when managed responsibly, can be more contained compared to the land disturbance associated with large-scale excavation, offering long-term sustainability benefits.

14.2.2 Closing the Cost Gap: Pathways to Greater Efficiency

Targeted initiatives aimed at reducing fuel consumption such as optimising power generation systems or integrating hybrid energy solutions could yield substantial savings. Similarly, increasing crawler and plant throughput would dilute fixed costs across higher production volumes, directly lowering the unit Opex.

Continuous refinement of the mining plan to minimise grade variability will further stabilise production rates and improve processing efficiency. Investment in advanced process control systems and real-time monitoring technologies could also enhance operational stability, reduce downtime, and improve overall cost management.

In the long term, the offshore model's flexibility and capacity for scaling production, combined with strategic efficiency improvements, offer cost advantages over land-based operations, positioning the project to remain competitive in the global iron sand market while aligning with New Zealand's environmental and regulatory standards.

15 FINANCIAL EVALUATION

This section summarises the financial and operating parameters of the TTR Taranaki VTM project for the first 10 years of operations, as well as the Capex and Opex with an accuracy of +/- 30% as defined in the scope of work set out in the pre-feasibility study.

15.1 Business Model

The business plan has been elaborated by TTR in the above section in particular with regard to the marketing approach in terms of pricing and sales. TTR and its various consultants have also collectively contributed to the necessary inputs in relation to the Capex and Opex estimates for the project for the purpose of economic evaluation.

There is a compelling technical and economic case for using VTM concentrates as a substitute for traditional iron ore, particularly when the valuable vanadium is recovered as a by-product.

The Taranaki VTM Project has significant upside scalability that can be deployed on a modularised basis following successful investment and deployment of its first production unit. TTR has a vast amount of resource potential (only 9% of its tenement has been explored to date) providing significant expansion opportunities to become a major, low-cost supplier of VTM iron ore concentrates.

15.2 Key Inputs and Assumptions

In performing financial evaluation of the project, the following assumptions have been considered for the base case scenario:

- Run-of-mine sediment mining tonnage and anticipated head grade based on proposed mine plan prepared by Golders Associates for first five years as follows and thereafter assuming average head grade of 9.5% based on average of year eight to ten;
- Metallurgical yield estimated based on analysis of results from samples tested through the pilot plant and Davis Tube Recovery results and adjusted by the Fe recovery of the pilot plant and then compared against the proposed mine plan;
- Product Fe grade of 57%;
- Production projected for 20-years, thereafter assuming same level of grade and yield on an ongoing basis with terminal value;
- Crawler cycle time of 260 net operating days or 6,326 hours (72% utilization rate);
- Crawler dredging capacity of 8,000tph throughput;
- IMV requires Dry Docking of 56 days every 5 years for the first 15 years, and every 3 years thereafter;
- IMV is powered by Intermediate Fuel Oil (IFO380) converted to power cost on kwh per ton of IFO used basis based on estimated conversion factor;
- Power usage based on estimated average power consumption from engineering modelling conducted during the pre-feasibility study (PFS);
- Estimated personnel required and estimated labour costs;

- Estimated repair and maintenance costs based on industry norms;
- Estimated insurance and other ancilliary support costs;
- Sales, general and admin costs as a dollar per ton of concentrate estimate;
- Marketing costs as a percentage of sales;
- Royalties based on higher of ad valorem or accounting profit basis;
- Sale price based on nominal 62% Fe CFR China benchmark price, adjusted for 57% Fe product grade discount, and thereafter applying sale discounts and/or adjustments as applicable;
- FSO on a fully outsourced basis, charged on a fixed cost plus a variable per ton charge;
- Estimated freight cost from New Zealand to China; and
- Estimation of other ancillary costs such as anchor support vessel, grade control drilling, community development, exploration, environmental research and monitoring, etc.

15.2.1 Key Inputs

15.2.1.1 Long-Term Consensus Iron Ore Price Forecast

The selection of $90/metric ton as the long-term iron ore price forecast is based on a balanced assessment of historical price trends, market fundamentals, expert forecasts, and industry dynamics.

The justification for this assumption is outlined below:

a) Alignment with Long-Term Market Forecasts

Industry analysts and market researchers, including Fitch Solutions, Australia's Office of the Chief Economist (OCE), and Macquarie, provide long-term iron ore price forecasts ranging from $70 to $100/metric ton for the period leading up to 2030. While some projections indicate a downward trend toward $70-$80/metric ton, others suggest prices could stabilize closer to $90-$100/metric ton due to supply constraints and cost inflation in mining operations. Selecting $90/metric ton represents a reasonable midpoint of these projections while maintaining a conservative yet realistic outlook.

b) Historical Price Trends and Market Cycles

Iron ore prices have historically fluctuated due to supply-demand imbalances, global economic cycles, and geopolitical factors. Over the past decade, prices have generally ranged between $80 and $120/metric ton, with occasional spikes and dips. The $90/metric ton assumption reflects a sustainable long-term average, accounting for both cyclical downturns and potential future upswings driven by supply constraints and infrastructure-driven demand.

c) Cost Support and Marginal Production Economics

The cost of production for major iron ore producers, such as Rio Tinto, BHP, and Vale, generally ranges between $40 and $55/metric ton, depending on location and grade.

While some low-cost mines in Australia and Brazil can operate profitably at lower prices, the marginal cost of production for higher-cost producers (e.g., in China, India, and West Africa) typically sits around $70-$90/metric ton. This suggests that prices are unlikely to fall below $90/metric ton for extended periods without prompting supply reductions, reinforcing the assumption of $90/metric ton as a sustainable long-term benchmark.

d) Structural Demand Drivers and Supply Constraints

China's Transition to Higher-Quality Steel Production: While China's steel demand may slow, its increasing preference for high-grade iron ore (to reduce emissions and improve efficiency) may support a price floor around $90/metric ton for high-quality ore.

Infrastructure and Decarbonization Investments: Demand from emerging markets, renewable energy projects, and infrastructure development in India, Southeast Asia, and Africa will offset some of the declines in China's steel consumption.

Supply-Side Challenges: Future supply risks, including regulatory constraints, environmental policies, and operational challenges in new mining regions (e.g., Simandou in Guinea), could lead to temporary shortages and price resilience above $90/metric ton.

e) Inflation and Currency Effects

Mining input costs, including labor, energy, and logistics, continue to rise due to global inflationary pressures and supply chain disruptions. A long-term price assumption of $90/metric ton accounts for the cost-push inflation effect, ensuring that the forecast remains economically viable in real terms.

15.2.1.2 Long-Term Forecast for IFO 380 CST Fuel Oil

a) Historical and Current Market Pricing Trends

As of early 2025, the price of IFO 380 CST in Singapore is approximately $499 per metric ton (bunkerindex.com).

Over the past decade, IFO 380 CST has experienced price fluctuations between $300 and $700 per metric ton, largely influenced by crude oil prices, supply-demand dynamics, and regulatory changes.

A $500 per metric ton long-term estimate aligns with historical average prices, providing a reasonable middle ground rather than an overly optimistic or pessimistic projection.

b) Regulatory and Market Influence on Long-Term Prices

The IMO 2020 sulfur cap significantly reduced demand for high-sulfur fuel oils, shifting demand toward low-sulfur alternatives. However, ships equipped with scrubbers still support a steady demand for IFO 380 CST.

Looking forward, while stricter environmental regulations could reduce demand, the availability of scrubber-equipped vessels and regional price arbitrage (e.g., Singapore vs. China's Zhoushan) ensures continued usage of IFO 380 CST.

The price of IFO 380 CST tends to correlate with global crude oil trends. If crude oil prices stabilise in the $70–$90 per barrel range over the long term, bunker fuel prices will likely remain within a proportionate range, supporting a $500 per metric ton assumption.

c) Inflation and Cost Adjustments in Long-Term Modeling

A $500 per metric ton assumption accounts for inflationary pressures on crude oil production and refining costs, ensuring that the forecast remains realistic over a 10-year horizon.

While some alternative fuels (e.g., LNG, biofuels) may gain market share, their high infrastructure investment requirements could delay mass adoption, maintaining stable demand for traditional fuels like IFO 380 CST.

15.2.1.3 Vanadium Pentoxide Price Long-Term Forecasts

a) Historical Price Trends and Market Stability

The 2024 average price of vanadium pentoxide (V_2O_5) was reported by the USGS at $5.45 per pound, down from $7.50 per pound in 2023. This suggests a stabilization of prices following recent fluctuations. Given that market corrections have occurred and recent price levels reflect equilibrium conditions, assuming the $5.45 price point for long-term forecasts is reasonable and aligns with historical price adjustments.

b) Supply and Demand Considerations

Vanadium supply is influenced by production from primary mining sources and as a byproduct of steel production. The global demand for vanadium, driven primarily by steel alloying and energy storage applications, remains steady. While demand for vanadium redox flow batteries (VRFBs) could increase in the long term, any significant price surge is likely to be met with supply-side responses. The $5.45 price reflects a balance between supply resilience and demand growth, making it a stable long-term assumption.

c) Cost Structure and Production Viability

Global production costs, particularly in China, Russia, and South Africa, suggest that a price floor of approximately $5.00 per pound supports sustainable mining and refining operations. A long-term price forecast at $5.45 ensures cost coverage for producers while maintaining competitive pricing for consumers, thereby avoiding significant supply shocks.

d) Inflation and Commodity Price Trends

While inflationary pressures could push nominal prices higher, the real price of vanadium pentoxide—adjusted for inflation—has remained relatively stable over time. Commodity price trends indicate that metals typically trade within long-term ranges unless structural supply or demand changes occur. A $5.45 price forecast incorporates reasonable expectations of inflation-adjusted stability.

15.2.1.4 Shipping Allowance for Transporting Iron Ore from the West Coast of New Zealand to China – US$ 10.00/metric ton

The selection of a $10 per metric ton shipping allowance for transporting iron ore from the West Coast of New Zealand to China is based on an analysis of historical and current freight rates, voyage distances, and prevailing market conditions. The key factors supporting this assumption are outlined below.

a) Benchmarking Against Dry Bulk Freight Rates

Iron ore is typically transported using Capesize or Panamax bulk carriers, depending on shipment volumes and port constraints. Historical freight rates for comparable routes provide a strong reference point:

- Australia to China (Pilbara–Qingdao): Shipping rates for Capesize vessels have ranged between NZD $9.60–$21.82 per metric ton, depending on market conditions.
- Brazil to China: Due to the significantly greater distance, rates are higher, typically around NZD $18.70 per metric ton.
- New Zealand to China: Given the shorter distance relative to Brazil but longer than Australian routes, a reasonable estimate falls between NZD $8–$12 per metric ton for Capesize shipments.

The $10/t assumption aligns with these rates while allowing for fluctuations.

b) Voyage Distance and Fuel Costs

The shipping distance from Westport, New Zealand, to Northern China (e.g., Qingdao) is approximately 4,800–5,400 nautical miles, placing it between the distances from Australia (approx. 3,000Nm) and Brazil (approx. 11,000Nm).

Given current marine fuel prices and bunker consumption for a Capesize vessel, the fuel cost component supports a $10/t rate estimate.

c) Port and Handling Considerations

New Zealand's West Coast ports have limited bulk export infrastructure, requiring additional handling costs or transshipment.

Loading rates and potential delays could affect final costs, but these are generally offset by the shorter shipping route compared to Brazil or South Africa.

d) Market Volatility and Risk Allowance

The dry bulk freight market is subject to fluctuations driven by factors such as fuel price variations, seasonal demand shifts, and geopolitical influences.

Baltic Dry Index trends reflect the volatility of bulk shipping rates.

The recent Capesize freight rates for iron ore transport from Australia to China have ranged from NZD $9.60 to $21.82 per metric tonne.

15.3 Economic Impact Assessment

TTR engaged New Zealand Institute of Economic Research (NZIER) to update the economic impact assessment of the Taranaki VTM Project. NZIER are an independent economic consultancy, who provide services to both the public and private sectors, and were commissioned to undertake the economic impact study, capturing the direct and the flow-on impacts of the Project's capital investment and 20-year operation in New Zealand on the local, regional and national economies.

15.3.1 Economic Impact Summary

The economic impact assessment report was modelled on the PFS capital (Capex) and operating expenditure (Opex) estimates to conduct its economic analysis. The NZIER economic impact assessment for TTR's Taranaki VTM Iron Sands Project highlights the project's significant contributions to the New Zealand economy, with a NZ$1 billion capital investment, approximately NZ$55 million will be spent within New Zealand, primarily on project setup, environmental initiatives, and infrastructure. This investment is expected to create 459 new jobs nationally, with 211 regional and 86 local jobs. Once operational, the project will inject NZ$238 million annually into the economy, generating 1,365 jobs nationwide, including 1,123 in the Taranaki and Whanganui region and 224 at the local level.

The project is estimated to earn NZ$854 million per year in export earnings, with NZ$658 million from iron ore and NZ$196 million from vanadium pentoxide. It will contribute NZ$36M to NZ$54M in annual royalties and NZ$91M to NZ$136M in corporate taxes to the New Zealand government. Sensitivity analysis indicates that iron ore prices significantly impact export earnings and royalties, while exchange rate fluctuations and fuel costs have less influence on the project's overall financial performance. Refer to Appendix 19.24 for the full report.

15.4 Project Discounted Cash Flow

STB Vanadium Titanomagnetite Iron Sands Project

20 YEAR LIFE OF MINE

		High Level DCF	x US$1,000,000		OPEX/US$t	27.20																			
		US$M	Yr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
NOTE: PRICE IS CURRENT SPOT PRICE		Conc m/t avg sales				4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
90.0	US$/t North China	*Revenue (FeX Earnings)*	*(58% disc to 62%CFR)*			380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6	380.6
13.7%	62% Fines Discount 57%Fe																								
5.45	US$/lb V_2O_5 less 50% costs	0.50%	0.77	50.00%		113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3	113.3
2,080.00	US$/$TiO_2$	8.50%	0.77	0%		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100.79	*Revenue/tonne US$/t*	*Total Revenue*				*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*	*493.9*
-	US$/t	V_2O_5 & TiO_2 Roast 50% revenue (cost 50% revenue row 10)				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
27.2	Fixed	Direct and GA costs avg	*(IFO $500/t US$75/bbl)*			133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3
10.0	US$/t	Freight				49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0
37.2	*Cost/tonne US$/t*	*Total Costs*				*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*	*182.3*
63.59	*EBITDA/tonne US$/t*	EBITDA				*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*	*311.6*
		Interest				17.5	15.4	13.1	10.7	8.2	5.6	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-
602.18		Depn / Amort (DA)	EOL 7yrs. SL Depn			86.0	86.0	86.0	86.0	86.0	86.0	86.0													
		Fe, V_2O_5 & TiO_2 Royaltie	2% AVR / 10% APR			20.8	21.0	21.2	21.5	21.7	22.0	22.3	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2
		NPBT				*187.3*	*189.2*	*191.2*	*193.4*	*195.6*	*198.0*	*200.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*	*280.4*
28%		Tax	Corporate tax rate. No loss C/fwd			-	5.4	53.5	54.1	54.8	55.4	56.1	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
		NPAT				*187.3*	*183.8*	*137.7*	*139.2*	*140.8*	*142.5*	*144.3*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*
		Cash Flows																							
		NIAT-DA				273.3	269.8	223.7	225.3	226.9	228.6	230.3	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9
602.18	Capex	Asset		125.0	477.2																				
		Financing Principal repayments			421.5	(43.0)	(45.1)	(47.4)	(49.8)	(52.3)	(54.9)	(57.6)	(60.5)	-	-	-	-	-	-	-	-	-	-	-	-
		CF	1,204.3	(125.0)	(55.7)	230.3	224.7	176.3	175.5	174.6	173.7	172.7	141.4	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9	201.9
		Disc % /yr		1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.1
0.1	Discount factor excl inflation	**DCF**	1,263.0	*(119.2)*	*(48.2)*	*181.5*	*161.0*	*114.8*	*103.9*	*94.0*	*85.0*	*76.8*	*57.2*	*74.2*	*67.5*	*61.3*	*55.8*	*50.7*	*46.1*	*41.9*	*38.1*	*34.6*	*31.5*	*28.6*	*26.0*
		IRR	37.7%	*(125.0)*	*(477.2)*	*273.3*	*269.8*	*223.7*	*225.3*	*226.9*	*228.6*	*230.3*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*	*201.9*

Table 27 TTR's Discounted Cash Flow Model

16 RISK & UNCERTAINTIES

TTR commissioned Transfield Worley to specifically undertake a Marine Operations Risk Review on the proposed operations as outlined in the PFS. TTR undertook a HAZID workshop, to not only identified risks associated with the following operational activities, but to assist in any Marine approvals.

- Mining and processing;
- Marine vessel operations including those of the IMV, FSO, export vessel, anchor handling tugs, and replenishment vessel;
- Transfer operations from the IMV to FSO, FSO to export vessel, and fuel transfer;
- Biosecurity and operational discharges including sewage/garbage, de-ored sand and brine, brackish fresh water from the ore washing process, oil products, and other hazardous materials;
- Navigational impacts and maritime safety of the project including marine traffic and activities, proximity to other mining operations, other TTR operational vessel movements, and Automatic;
- Identification System issues;
- IMV (terminology updated to IMV) exclusion; and
- Anchor Handling.

The full report is appended to this PFS. In summary the following operational risk ratings were identified as follows:

Hazard Risk	Before Mitigation and Control Measures	After Mitigation and Control Measures
Extreme	15	0
High	14	3
Moderate	13	23
Low	5	21

Table 28 TTR Marine Operations HAZID Risk Ranking (Transfield Worley)

Project Risks

- The resource is located in an area that is subject to severe sea states, although these have been factored into the dynamic model there is a risk that down time due to inclement weather is higher than allowed;
- The mineable grade is based on an annual mining schedule, as more detailed schedules are applied loss and dilution factors will need to be applied;
- Assumptions on process plant iron units recovered prove to be overly aggressive;
- Capital estimates are based predominantly on supplier estimates, industry "norms" have been used to calculate fabrication and integration costs and hence there is a risk that our allowances have been aggressive;
- Operating costs have been built up using a combination of suppliers budget estimates,

estimated personnel numbers, estimates on consumables and industry “norms” for maintenance. There is a risk our estimates have been aggressive;

- Production estimates have been based on IHC estimates with caveats on further work to understand the “dig-ability” of the sands to be dredged. This was addressed in the IHC report on the dredging / breach testing;
- The crawler solution current operating model restricts its depth to c.25 m, hence shallow areas in the RMA zone cannot be mined requiring, if a crawler operating solution cannot be found higher mining costs will be incurred, this is not expected until after year five;
- The project does not get environmental approvals are appealed or the approvals are granted with conditions what make the Project uneconomic, refer to Section 13 of this PFS document;
- The Company is not in a position to make early commitments to long-lead procurement items with consequential delays to first commercial ore production;
- Mineable grades are materially worse than assumed;
- The Project is subjected to protest vessels that stop/slow operations;
- Assumptions on tailings are worse than allowed for and result in significant amounts of ROM dilution increasing unit costs;
- Assumptions on plume models and overall environmental effects are materially worse than allowed for requiring cost imposts to mitigate on the project that have not been allowed for;
- Revenue assumptions prove to be aggressive.
- Capital estimates prove to be conservative with significant savings identified and materialised through BFS and execution;
- Operating costs prove to be conservative with significant savings identified through BFS and executed through operations, a key driver of Opex will be IFO demand (linked to power demand) and IFO 380 price;
- Mining production rate proves to be conservative and is materially exceeded driving higher sales revenue and lowering unit costs;
- Mineable grades prove to be conservative and are exceeded driving higher revenue through higher sales and lower unit costs;
- Assumptions on process plant iron units recovered prove to be overly conservative;
- Revenue assumptions prove to be conservative;
- Schedule assumptions prove to be conservative allowing for an early start up of operations.
- Further testwork is required to determine the Process Flow Sheet for the optimal recovery of vanadium pentoxide, this relates to the marketing of the VTM Concentrate, and not the IMV processing.

16.1 Updated Risk

The TTR project has undergone a recent risk review, identifying several updated project risks that could impact its progress. Key updates include regulatory and environmental compliance challenges due to evolving legislation and heightened stakeholder scrutiny. Technical risks have also been revised, particularly concerning offshore extraction methodologies and sediment plume management, requiring further validation through modelling and independent assessments.

INCREASING CONSEQUENCE		INCREASING PROBABILITY				
		A Rare	B Unlikely	C Moderate	D Likely	E Almost Certain
	0 None	0	0	0	0	0
	1 Slight	0	0	0	1	0
	2 Minor	0	0	2	4	3
	3 Moderate	1	1	2	15	5
	4 Major	0	0	2	3	2
	5 Catastrophic	0	2	2	4	1

Key:

- Low
- Moderate
- High
- Extreme

Figure 89 TTR Updated Project Risks

Issue	Risk Status	Description of Impact	Risk Category	Risk Reduction / Mitigation Plan	Current Priority
Information is deemed uncertain or inadequate, Marine Consent delayed or not granted	In Progress	inability to mine, impact on capital recovery timeframe	Environment	Consultation, Verification Process & Legal	Extreme
Tank overflow or pipe rupture	Identified	Vessel lists uncontrollably. Engine room and electrical switch room flooded, immobilising the vessel.	Safety	Water tight bulkheads installed. Layout, controls, supervision Provision of sumps and bilge systems	Extreme
Fire	Identified	Personal injury or equipment damage	Safety	Detailed design and materials selection Maintenance procedures, hot work permits	Extreme
Plant not suited to ROM variability	Identified	Short fall in annual production Long or short term deviation from specification	Financial	Good quantification of resources. Measurement/sampling detection on mining vessel Mill control/recirculation system Alternate market available for off-specification product Detailed design & review processes Equipment selection	Extreme
Inadequate BFS engineering / FEED	Identified	Cost overrun during construction. Plant does not perform as expected	Financial	PFD to be verified. Contracting strategy to be developed during BFS. FEED and operability reviews by experienced parties. Benchmark off other projects	Extreme
Rewetting of iron sand post the drying step making the product structurally unstable	Identified	Potential for liquefaction, formation of beaches causing hazard of capsizing	Safety	Design to remove (or manage) presence of free-water in cargo	Extreme
20yr on-water life requires insitu overhauls	Identified	Short fall in annual production due to extended outage periods	Financial	Detailed design to account for in-situ overhauls Streams and crossovers to be includes Maintenance procedures, equipment selection, spares holdings, proven technologies. Preventative maintenance , maintenance schedule - Commonality of spares/parts - Maintenance philosophy	Extreme
Get declined for Environmental Consent or restrictive operational conditions on consents i.e. smaller operation	In-Progress	Unable to progress with Project	Environment	Engage SME, Comprehensive Study & mitigation plans	Extreme
Third party will appeal positive Consent/License award	In-Progress	Delay to achieving Marine Consent	Environment	Consultation, Engaging Legal resources	Extreme
Uncontrolled movement of heavy loads on a moving vessel	Identified	Personal injury or equipment damage	Safety	Detailed design to consider maintenance requirements (e.g. crawl beams)	Extreme
High energy requirements on the vessel	Identified	Energy costs greater than anticipated	Financial	Detailed design to reduce power demand	Extreme
Price of iron ore drops significantly - project becomes uneconomic	Identified	Project is not viable	Financial	Robust margins/Allowances, ID Lower cost options CAPEX & OPEX	Extreme
Insufficient contingency allowance applied to budget pricing	Identified	Actual cost of procured items differs from estimate, because point of purchase is 12 months after BFS budget is set	Financial	Procurement Processes, RFQ, Verification Processes,	Extreme
Restricted access to NZ ports	Identified	Unable to address urgent break-fix	Performance	Berthing procedures, Vessel Design	Extreme
Power required is nominal, BFS estimate has insufficient allowance for power generation	Identified	Power Inadequate	Performance	Design Verification, Detailed modelling	Extreme
Increase in Shipping costs	Identified	Potential for significant Increase in FOB/CFR determinations	Financial	Early Notification, Mod of Shipping arrangements	Extreme
Cracking of hull caused by vibration	Identified	Vessel lists uncontrollably. Engine room and electrical switch room flooded, immobilising the vessel.	Safety	Detailed design to isolate vibrations, on going monitoring of equipment operation. Fatigue analysis in design phase	High

Table 29 Updated Risk Register, Highlighting the Highest Project Risks

17 BASIC SCHEDULE

The basic development schedule for the future stages of the TTR project is proposed in the schedule shown below:

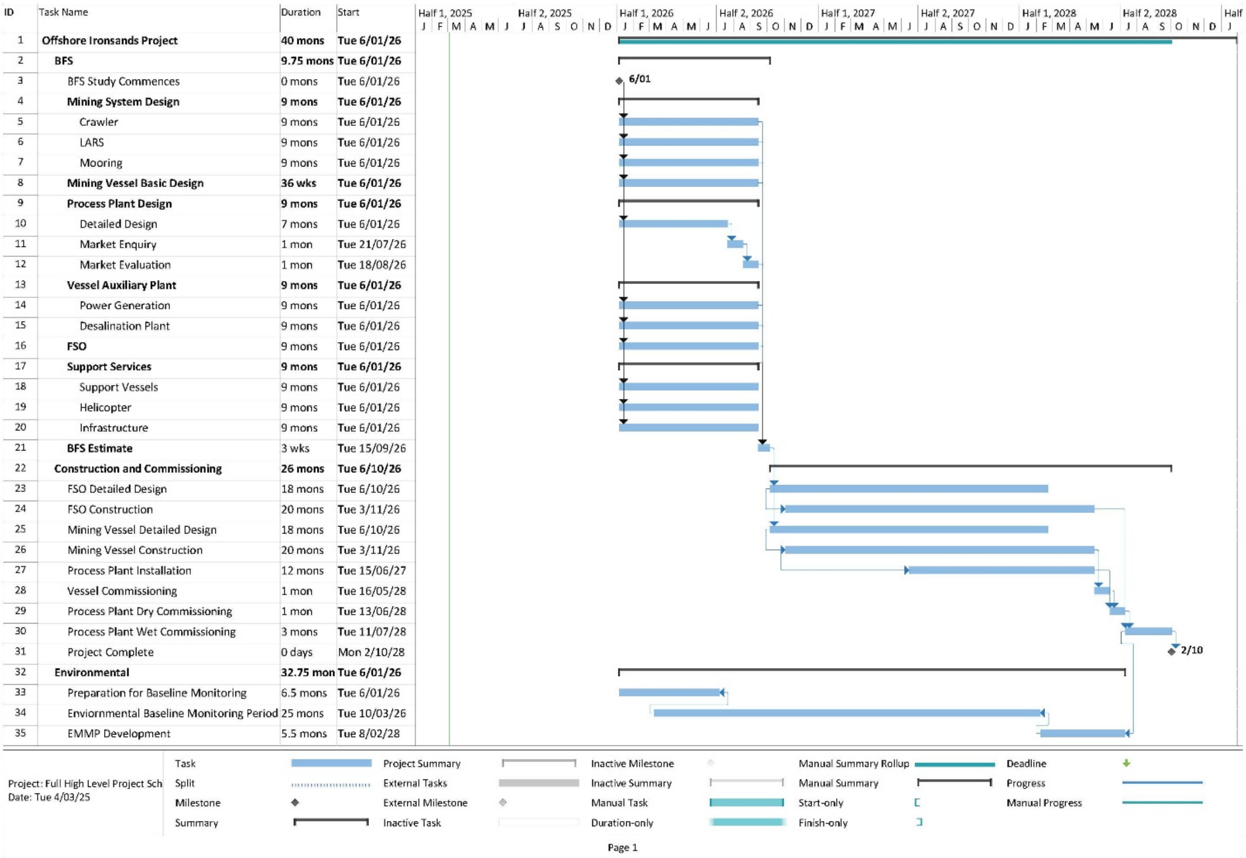


Figure 90 Basic Schedule of Detailed BFS Study

18 BANKABLE FEASIBILITY STUDY

A Bankable Feasibility Study (BFS) is one that will be suitable to enable TTR to negotiate project financing from typical lending sources. The bankable document will satisfactorily provide all the technical / economic information and auditing necessary for a banker (and the banker's independent engineer) to determine that the project risks are acceptable and that the project is indeed viable on a stand-alone project financing basis.

The scope of work for this phase will be to carry out detailed project definition and planning to produce a BFS. This will include:

- General arrangements & P&IDs;
- Lists of required mechanical & electrical equipment;
- Estimate +/- 10% and Schedule that meets TTR's business case; and
- Materials take off lists in support of Capital Cost Estimate.

From this point should the project meet the TTR's business case, and the "green light" is given to proceed, the project will then enter the Execution stage.

Completion of the BFS requires development of preliminary engineering drawings and other documentation. Equipment quotations will be solicited competitively, material take-offs will be prepared, and a direct field cost estimate supported in its entirety by competitive bids will be prepared.

18.1 BFS Strategy

There are two generic strategies that could be implemented to execute the TTR offshore project. The first strategy, i.e. "Project Management by Owners Team", will require that TTR assume full responsibility for the management and engineering of the project, forming a TTR led team that comprises hired or seconded individuals and engaged organisations, each retained for a distinct portion of work or responsibility.

The second strategy, "Project Co-ordination by the Owners' Team" approach is the preferred option, as it ensures strategic oversight while representing the shareholders' interests. By appointing a Project Management and Engineering company as the prime contractor, this model enables effective project execution, with the contractor managing sub-consultants, schedules, budgets, and deliverables, ensuring alignment with project objectives while minimising direct operational involvement by the owners' team.

18.1.1 Project Management by Owners Team

With this strategy, TTR will organise the study and assemble the final BFS report. Various tasks and specialized contributions to the report will be subcontracted to outside consultants and could include the following:

- Exploration drilling;
- Specialised geotechnical investigations;
- Environmental baseline studies and investigations;

- Continued metallurgical test-work; and
- Detailed engineering design and material take-offs.

TTR will co-ordinate all the geological assessments and modelling, mine design and planning, production scheduling, flow-sheet development and estimating of both capital and operating costs. The developed WBS will be used to define all the tasks required, and then a decision will be made as to which tasks could be carried out with internal resources.

These internal tasks could include geologists, mining engineers, mechanical, civil and electrical engineers, metallurgists, legal resources, and purchasing, construction and marketing experts.

A formal project will be developed, with the necessary internal people assigned responsibilities for budgets, deliverables and schedules.

All externally contracted parts of the study will have a very well-defined scope and definition of work, including the contractual basis for carrying out the work and the required dates for completion.

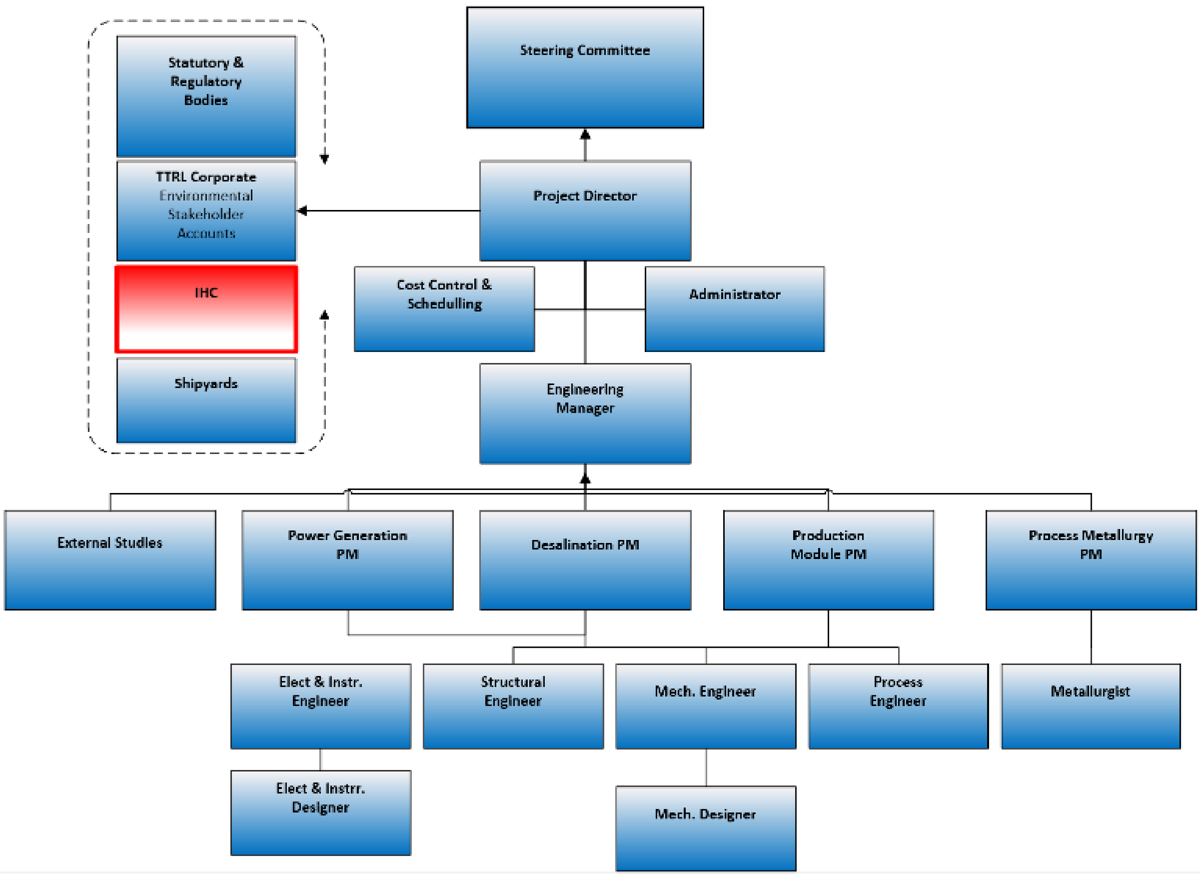


Figure 91 Organisation Chart: BFS Project Managed by Owners Team

18.1.2 Project Co-Ordination by the Owners Team

The second preferred strategy, “Project Co-ordination by the Owners’ Team”, involves establishing a lean but highly capable team representing the shareholders' interests. This team operates at a strategic oversight level, ensuring that project execution aligns with the shareholders' objectives while minimising direct involvement in day-to-day operations.

A key element of this approach is the appointment of a Project Management and Engineering company to act as the prime contractor, assuming responsibility for engaging and supervising all sub-consultants. This firm will manage the full project lifecycle, ensuring schedules, budgets, and deliverables remain on track while maintaining alignment with the project's overarching objectives.

18.1.3 Role of the Prime Contractor

Once engaged, the prime contractor will take ownership of the following critical responsibilities:

- Coordination of Sub-Consultants – Managing all engineering, operational, and regulatory sub-consultants to ensure an integrated and cohesive approach to project delivery.
- Final Bankable Feasibility Study (BFS) Report – Taking full responsibility for compiling and delivering the BFS, ensuring all technical, financial, and environmental aspects are robustly addressed.
- Schedule and Budget Adherence – Implementing rigorous project controls to monitor performance, mitigate risks, and ensure timely and cost-effective execution.
- Technical and Operational Oversight – Providing expert engineering input to optimise project design and execution, particularly in complex offshore environments.

This structured approach leverages the expertise of an experienced project management and engineering firm while allowing the owners' team to focus on high-level governance, risk management, and strategic decision-making.

18.1.4 Alignment with Upstream Technology

Given the nature of the project, appointing a prime contractor with proven expertise in offshore mining i.e. Upstream Technology (formerly De Beers Marine and Ignite), will be instrumental in driving project success. Upstream Technology, with its background in diamond offshore and land-based mining solutions, possesses the necessary technical and operational experience to oversee the execution of such a project.

The previous collaboration between TTR and Upstream Technology positioned Upstream as a leading advisory and operational partner, providing expertise in:

Engineering design input and operational strategies;

Integration of key offshore mining components, including the crawler system, mooring setup, and process equipment on a marine-based platform;

Ensuring regulatory and environmental compliance for operations in New Zealand’s Exclusive Economic Zone (EEZ); and

By integrating Upstream Technology’s global expertise in offshore mining solutions into the project structure, the prime contractor model ensures that best-in-class marine resource extraction techniques are adopted. This also aligns with TTR’s strategic objective of resuming project development through the Fast Track approvals process, which underscores the need for an experienced and well-structured project execution framework.

18.1.5 Strategic Benefits of Project Co-Ordination

- Reduced Operational Risk – With a highly skilled prime contractor managing technical execution, the owners' team can focus on governance and shareholder interests.
- Improved Project Execution – Leveraging Upstream Technology's offshore mining expertise ensures efficient operations, integrating novel solutions to mitigate technical and environmental challenges.
- Enhanced Stakeholder Confidence – A structured governance model, combined with a globally recognised offshore engineering partner, strengthens the project's credibility with regulators, investors, and the broader industry.

By adopting a Project Co-ordination by the Owners' Team approach, supported by an experienced prime contractor such as Upstream Technology, the project benefits from world-class operational expertise while maintaining shareholder-driven oversight. This model ensures that all technical, financial, and environmental objectives are met, laying the foundation for a successful and sustainable offshore mineral extraction operation in New Zealand.

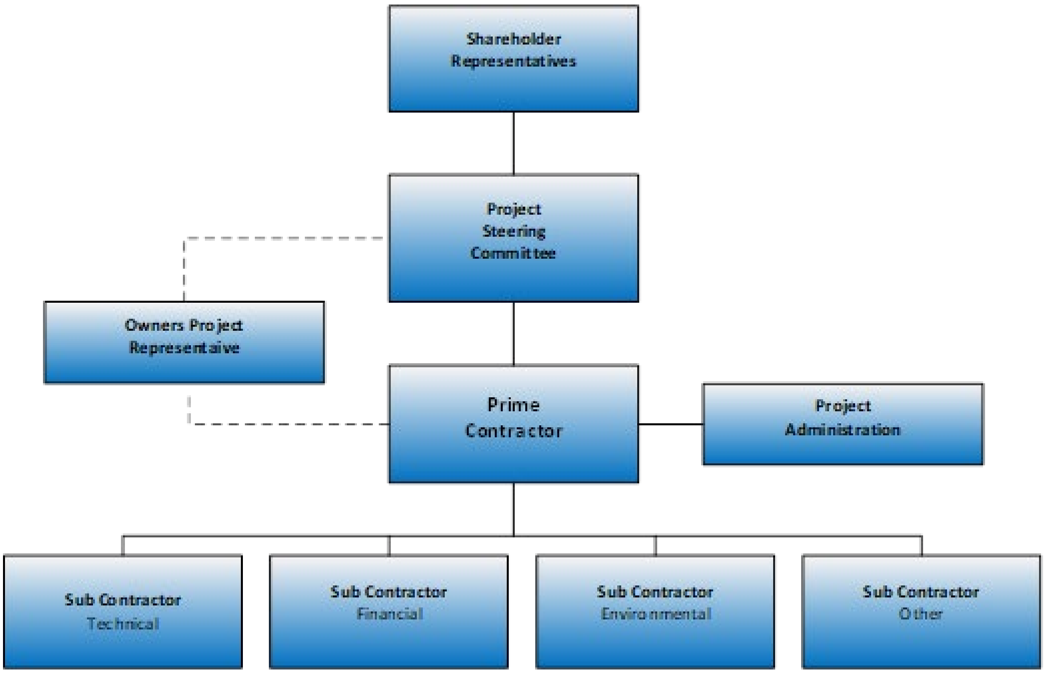


Figure 92 Organisation Chart: BFS Project Co-Ordination by Owners Team

18.2 BFS Capital Cost Estimate

18.2.1 BFS Contracting and Procurement Strategy

Choosing the right suppliers that can deliver value for money outcomes is the core principle underpinning TTR's strategy for the development of the BFS capital cost estimate of the

Offshore Iron sands Project. This means that TTR will need to be satisfied that the best possible outcome has been achieved taking into account all the relevant costs and benefits over the whole of the procurement/project cycle.

With regards to competitive costing processes for this project are, the procurement and contracting processes adopted will be designed to:

- Encourage competition to deliver the most favorable submission;
- Ensure that rules and procedures adopted do not limit competition by discriminating against any one supplier;
- Enable suppliers to develop reliable, informed and competitive proposals which assist in making informed decisions as to the preferred supplier; and
- Ensure contractual compliance.

The procurement of services and equipment for this project will require a number of strategies to be employed depending upon the nature and type of contract or purchase required. In identifying and managing the chosen strategy those directly involved in the process will be required to adhere to the following key requirements:

- Impartiality, whereby potential suppliers are treated equally and have the same opportunity to access information and advice;
- Consistency and transparency of process so that requests are evaluated in a systematic manner against explicitly predetermined evaluation criteria;
- Security and confidentiality of processes for receiving and managing supplier information to ensure the security and confidentiality of intellectual property and proprietary information;
- Identification and resolution of any actual or perceived conflict of interest prior to undertaking any tender evaluation; and
- Contractual compliance.

Adherence to the above behaviours will provide surety that TTR is undertaking procurement and contracting in a professional and transparent manner and consistent with contractual requirements.

18.2.2 Selection of TTR Preferred Suppliers

In general, competitive tenders will be sought with both local and international suppliers and manufacturers who will be given full, fair and reasonable opportunity where possible.

Where Sole Sourcing is proposed, a Sole Source Justification will be required to be submitted to the TTR Board for approval.

Recommended suppliers will be determined having assessed their submission on the basis of compliance with the contractual requirements of the tender, the below mentioned selection criteria and price.

The tender selection process will address the following:

- Health and Safety;

- Industrial relations policies and practices;
- Quality (AS/NZ ISO 9000.2000);
- Technical capabilities;
- Contractor capabilities;
- Available resources;
- Deadlines and timeframes;
- Key personnel;
- Environmental impacts;
- Commitment to local employment opportunities; and
- Local (New Zealand) content.

Preferred suppliers may also be asked to provide references for similar work undertaken so that these can be used to assess the capabilities of the company to meet the project deliverables.

Specific emphasis will be placed on contractor safety records, and recent and previous experience with a similar project. All selected suppliers will be required to demonstrate an understanding of the safety requirements, submitting an overview of their proposed management process for the safe implementation and management of the contract.

18.2.3 Risk Management

Prior to accepting any offer, TTR will conduct a risk analysis/due diligence to identify potential problems, the likelihood that these risks could occur and their consequences. As part of the risk management process a criticality assessment shall be completed to identify the level of mitigation required for the "purchase". Following this a specific risk management/mitigation strategy will be put in place.

Risk assessments will be carried out at regular intervals of the contracting process, not just in the initial procurement planning stage. This will assist in identifying and monitoring risk factors as they arise or change but also will assist in managing the total procurement and contracting risk.

18.2.4 Contracting and Procurement Legal Advice/Services

TTR retained counsel and lawyers will be engaged during the contract formation, tender assessment and contract negotiations stages to provide advice on contractual requirements, form of contract required and supplier conformance with the Terms and Conditions of the contract. They will also assist in ensuring that TTR fulfils its legal and contractual obligations in terms of the BFS tender process.

18.2.5 Contracting and Procurement Document Control

During the procurement and contracting process all documents (both electronic and hardcopy) will be collected and filed together, thereby providing a record of procurement activities and how they have been conducted. The records will facilitate an understanding of the reasons for the procurement, the process that was followed and all relevant decisions, including approvals and authorisations. The filing system has already been established by TTR for the purpose of this project.

A contracts/procurement control database will be maintained during the project life cycle to communicate status information for Contracts/Purchase Orders and other related packages. This will be controlled within the Document Control Management System.

Document Control is a centralised process, and a dedicated person will be charged to manage, collate and record all incoming and outgoing correspondence.

18.3 Value Engineering

As part of the BFS phase both internal and external reviews will be scheduled to assess all aspects of the project to ensure that process documents will be carried out, addressing materials of construction, surge and design safety factors, adherence to general philosophy, and completeness etc.

18.4 Detailed PFS Recommendations

Based on the findings of this 2025 updated Pre-Feasibility Study (PFS) for the Taranaki Vanadiferous Titanomagnetite (VTM) Project, the following recommendations are proposed to advance the project towards development and operational execution:

Project Development and Execution Strategy

- Establish a dedicated project team to oversee all aspects of BFS execution.
- Initiate detailed engineering studies as part of BFS to refine project specification and optimise capital allocation.
- Conduct a strategic review of project phasing to assess risk and provide mitigation measures.

Regulatory and Environmental Compliance

- Continue engagement with the Environmental Protection Authority (EPA) and relevant stakeholders to ensure full compliance with the Fast Track Approvals (FTA) process.
- Implement the updated Environmental Management Plan (EMP) to address sediment plume control, marine biodiversity monitoring, and community impact mitigation.
- Plan the two-year baseline environmental monitoring program prior to operational commencement, followed by continuous monitoring during the project lifecycle.

Mining and Processing Optimisation

- Confirm the suitability of the Integrated Mining Vessel (IMV) and Submerged Sediment Extraction Device (SBC) technology through additional engineering and third-party verification.
- Update the Mineral Ore Reserves and mining schedule
- Optimise the processing flow sheet to maximize vanadium and titanium recovery, ensuring alignment with industry best practices.
- Expand metallurgical testwork on the sodium salt roasting-water leaching process to improve vanadium recovery beyond the current laboratory results.

Infrastructure and Logistics Planning

- Finalise procurement strategies for critical infrastructure, including the IMV, Floating Storage and Offloading (FSO) vessel, and associated power generation systems.
- Develop strategic partnerships with shipping and logistics providers to streamline iron ore concentrate export operations.
- Evaluate potential cost reductions by outsourcing auxiliary services such as desalination, power supply, and fuel logistics to third-party providers.

Market Positioning and Commercial Strategy

- Conduct further market analysis to refine sales and offtake agreements, particularly with steel producers in China and other key markets.
- Explore opportunities for product differentiation by leveraging the project's contribution to green steel initiatives and critical mineral supply chains.
- Establish long-term agreements with vanadium and titanium buyers to ensure stable revenue streams and project viability.

Financial and Risk Management

- Update the financial model to incorporate new Capex and Opex estimates, adjusted for inflation and supply chain risks.
- Secure funding commitments for the BFS phase, with a focus on engaging strategic investors and government support mechanisms.
- Conduct scenario analysis on price fluctuations, operational costs, and regulatory changes to ensure financial resilience.

Workforce Development and Community Engagement

- Commence planning for a training facility in Hāwera to develop local workforce capabilities and support operational readiness.
- Strengthen community engagement initiatives to address cultural, social, and economic concerns, fostering positive relationships with local iwi and stakeholders.
- Implement a corporate social responsibility (CSR) strategy that aligns with regional development priorities and environmental sustainability goals

19 APPENDICES

No	Updated PFS No	Document	Source	Date	Updated PFS
1		PFS Rev 1	Technip	2012	Removed
2		CVs of Key Personnel	TTR	2013	Removed
3	19.1	Basis of Design	TTR	2013	Retained
4	19.2	Process Flow Diagram	TTR	2013	Retained
5	19.3	Simulation Model	BECA	2013	Retained
6	19.4	IMV GA Drawings	TTR	2013	Retained
7	19.5	IMV Personnel Assessment	TTR	2013	Retained
8	19.6	Maritime and Navigational Report	RN Barlow	2015	New
9	19.7	Mechanical Equipment List	CSL	2013	Retained
10		Process Plant GA	TTR	2013	Removed
11		Grinding Media Calcs/ Costs	TTR	2013	Removed
12		Marketing Report	Tennant Metals	2013	Removed
13	19.8	Crawler Viability Report	IHC Merwede	2013	Retained
14	19.9	Tailings Plume Assessment	HR Wallingford	2013	Retained
15		Dredging Concept Study	MTI	2011	Removed
16		South Taranaki Mineral Resource Report	Golder Associates	2012	Removed
17	19.10	Mining Schedules	Golder Associates	2013	Retained
18	19.11	Transhipment Study	Seabulk Systems	2010	Retained
19		Environmental Opinion	ASR	2010	Removed
20	19.12	Metallurgical Lab Testwork	Amdel Bureau Veritas	2011	Retained
21		Airbourne Magnetic Survey	Fugro	2010	Removed
22		FPSO Mooring Feasibility Study	Technip	2011	Removed
23	19.13	IHC Mooring Analysis	IHC Merwede	2014	New
23	19.14	ST 500 Gas Turbine Specifications	Siemens	2013	Retained
24	19.15	TTR Mineral Mining & Exploration Permits	NZPaM	2025	Updated
25	19.16	TTR Mineral Resource Statement 1 March 2023	TTR	2023	Updated
26	19. 17	Metallurgical Review: Recovery of Vanadium from Taranaki VTM Project	Siecap NZ	2025	New
27	19.18	Breach Testing Report	IHC Merwede	2014	New
28	19.19	SPT Drilling Report	OCEL Consultants Ltd	2013	New
29	19.20	Marine Operations Risk Review	Transfield Worley	2013	New
30	19.21	Updated Environmental Impact Assessment	NIWA / Mitchell Daysh	2025	New
31	19.22	TTR 2025 DCF Model	TTR	2025	New
32	19.23	Process Plant Review	DRA	2014	New
33	19.24	Economic Impact Study	NZIER	2025	New
34	19.25	EPA Approved Marine Consent Conditions 2017	EPA	2017	New

Table 30 List of Updated Documents Appended from Rev 2

Appendix 19.1 - Basis of Design - SSED

BFS Assumptions Register

Page - 900 Crawler

Original Data Source: Shawn Thompson 5 Nov 2013, File: "Crawler Advance Rate Comparison and Time Usage 5 Nov"

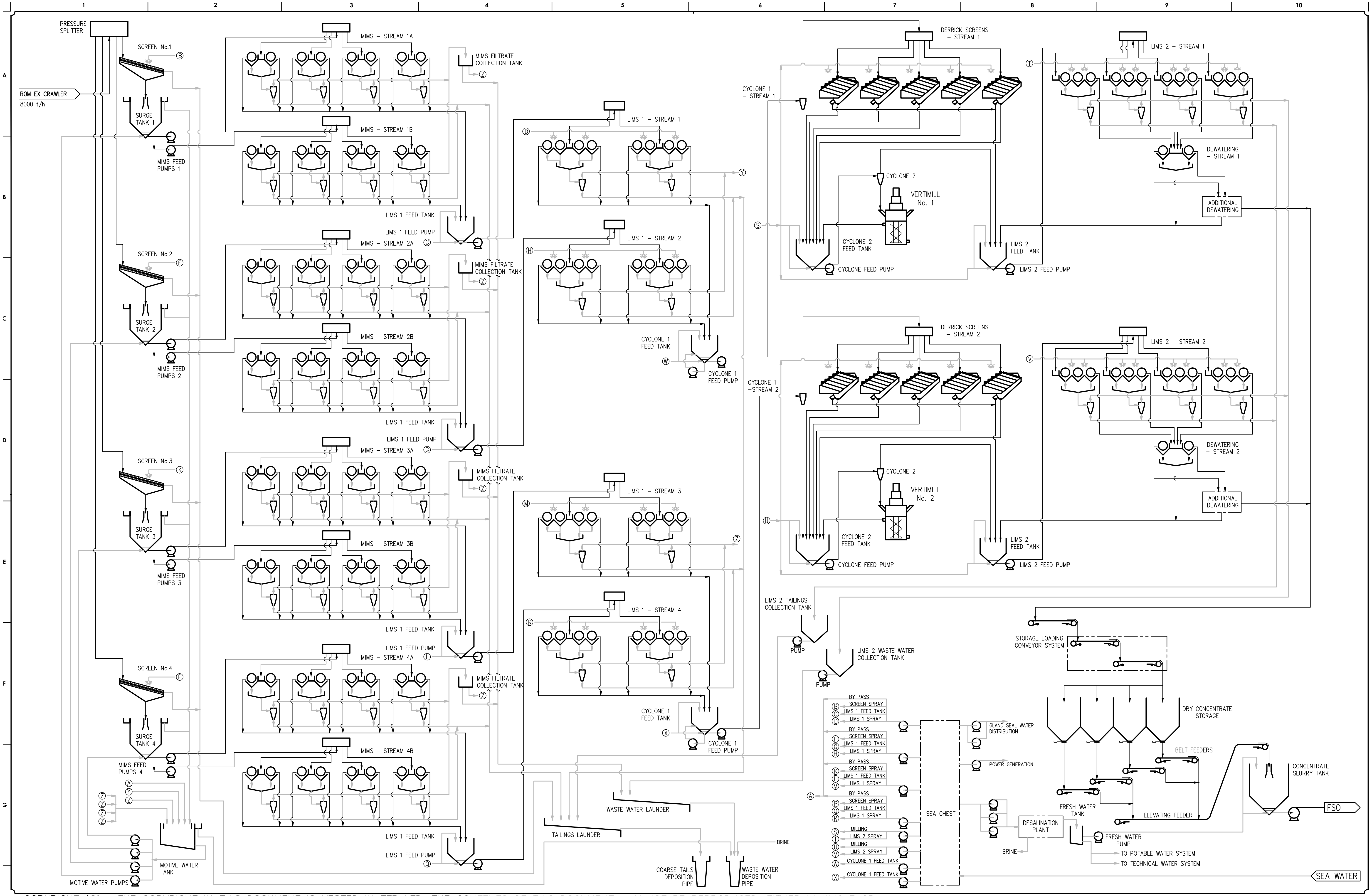
Revision Date: 8 November 2013
Revised By: Thomas Zink

Modified and reconfigured the table to ensure all inputs were visible. Changed the calculation for "Time Required to Mine Block". It had included a subtraction of reversing time, now has an addition of all crawler delay time.

Parameter	Value	Units	Comments
Block Width	300	m	
Block Length	300	m	
Average Mining Depth	5	m	
Block Volume m^3	450,000	m3	
Ave. SG of ROM	1.90		IHC Figure
Ave. mining rate	8,000	tph	IHC Figure - crawler/pump design rating
Weight of Average Block	855,000	tonne	
Number of Mining Lanes	15		Based on a 20m lane width
Ave. Time to Mine Block @ 8000tph	106.88	Hrs	Extraction Time
Crawler Extraction Delay Per Block	11.62	Hrs	Non-extraction time (refer calc below)
Time Required to Mine Block	118.49	Hrs	
Time for Extraction Per Lane	7.54	Hrs	Less positioning and reversing time
Ave. Forward velocity	39.78	m/hr	
Ave. Forward velocity	1.10	cm/s	Refer V_{wall} in pg 2 of 4 IHC Breach Memo
Total time allowed for sweeping per lane	7.13	hrs	Extraction time
Time per sweep	1.43	min	
Sweep length	24	m	IHC Figure
Velocity of Sweep m/hr	1,011	m/hr	
Velocity of Sweep m/min	16.84	m/min	Crawler Max Sweep velocity 30 m/min
Days per Block	4.94	days	

Crawler Extraction Delay Calculation	**Value**	**Units**	
Time to Position at Start per Lane	5	mins	Assumption
Position Operations Per Block	14		
Delay Due to Positioning Per Block	1.17	hr	
Reversing Speed	1.00	km/hr	IHC figure
Time to Reverse per Lane	18	mins	
Reverse Operations Per Block	14		
Delay Due to Reversing Per Block	4.20	hr	
Length of Forward Step	1	m	IHC Figure
Number of Sweeps per lane	300		One forward step per sweep
Time for step	5	sec	IHC Figure
Time to step forward per lane	0.42	hrs	
Delay Due to Step Per Block	6.25	hrs	
Position at start of lane	0.98%		Per block
Reversing	3.54%		Per block
Step	5.27%		Per block
Total	9.80%		Based on time that crawler is deployed on sea bed

Appendix 19.2 - DRA Process Flow Diagram



Notes

FOR INFORMATION ONLY
26/03/14

Drawing No.	Title
–	–
	Reference Drawings

Rev.	Description	Date	Drawn	Chkd	Eng	Appr	Client
0A	ISSUED FOR INFORMATION	03/14	TW	KP	–	TZ	ST

Client: TTR Trans-Tasman Resources

Project: OFFSHORE IRON SANDS PROJECT

Title: TRANS–TASMAN RESOURCES LTD
IRONSAND WET PROCESSING PLANT
SCHEMATIC

Project No. –
A1 Scale: NTS
Drg No. TTRL–05–DWG–52100
Sht. 01 of 01
Rev. 0A

Appendix 19.3 - BECA Operational Simulation Model

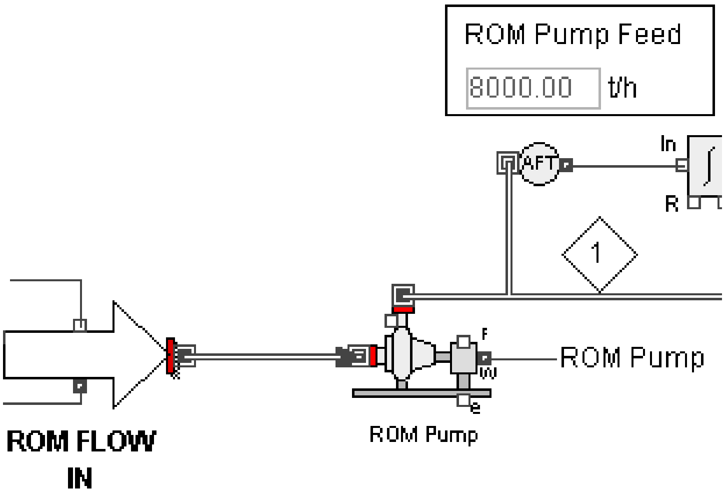
Report

Process Simulation Model: Offshore Iron Sands Project Feasibility Study

Prepared for Trans-Tasman Resources Ltd (Client)

By Beca Ltd (Beca)

5 March 2014



Revision History

Revision Nº	Prepared By	Description	Date
A	Suzanne Hay	Issue to TTRL	21/2/14
B	Chris Lee	Issue final to TTRL	26/2/14
C	Suzanne Hay	Issue final to TTRL	5/3/14

Document Acceptance

Action	Name	Signed	Date
Prepared by	Suzanne Hay	Suzanne Hay	5/3/14
Reviewed by	Chris Lee	pp Suzanne Hay	5/3/14
Approved by	Lee Roberts	pp	5/3/14
on behalf of	Beca Ltd		

Summary

This report presents the results of process scenarios from an IDEAS^{TM} process simulation model of a proposed offshore iron sand mining vessel to be located in the South Taranaki Bight, as part of a bankable feasibility study being undertaken by Trans-Tasman Resources Limited (TTRL).

The main process simulation starts with the ROM (Run Of Mine) sand feed from the Crawler and includes all major unit operations through to the FSO (Floating Storage and Offloading vessel) storage.

The model can be run in steady state, at a single rate of production to give a single power consumption answer. A number of scenarios were run in this mode to test the sensitivity of the power consumption to different variables. The alternative is to run the model stochastically (dynamically) with input variables varying in time according to defined probability distributions to predict the varying power requirements over time.

It is recommended that power consumption, and therefore fuel consumption, is critical to the financial viability of the project. Opportunities for process optimisation that significantly reduce overall power demand in the process plant were identified by TTRL during the course of the modelling work and the model outputs for the 8000 t/h case yielded the following results:

- Predicted peak power of 67.3 MW
- Predicted average power of 46.9 MW
- Predicted kWh/t ROM of 6.97

However, based on the information provided to Beca at the commencement and through the course of the modelling work, the total predicted power consumption results are as follows. (Note that figures have been rounded in some cases to better reflect the accuracy of these predictions).

For steady state production cases:

- 55 – 61MW at 6700t/h dry ROM feed, with 7.0 – 12.2% Fe
- 61 – 69MW at 8000t/h dry ROM feed, with 7.0 – 12.2% Fe

With stochastic (changing) input variables and a “most likely” mining rate of 6700t/h dry ROM feed, the power consumption required for the operation is:

- Predicted total power consumption peaks at 82MW
- Predicted total power consumption averages 55MW
- Average ROM feed rate achieved is 6300t/h (dry basis)
- The predicted kWh/t ROM is 8.8

In comparison, the stochastic case when the “most likely” mining rate is 8000t/h dry ROM feed, results in power consumption as follows:

- Predicted total power consumption peaks at 82MW
- Predicted total power consumption averages 57MW
- Average ROM feed rate achieved is 6700t/h (dry basis)
- The predicted kWh/t ROM is 8.4

It should be noted that there are a number of uncertainties in the variables used in constructing the model (specific mention of these are made in the body of this report) and in some cases these could

contribute quite significantly to the overall power requirements of the process. For this reason, while the results of this modelling provide a good basis for comparing options, the absolute values need to be viewed with caution.

Also note that the model does not currently incorporate any capacity limitations for individual unit operations and it is therefore possible that during stochastic modelling a combination of high mining rate and high ore grade produces product flows which may exceed the final design capacity of a particular unit operation and also reports power consumption in excess of the installed motor capacity.

Table of Contents

Appendices

1 Introduction

This report details the results from a process simulation model of a proposed offshore iron sand mining vessel in the South Taranaki Bight, for the Offshore Iron Sands Project undertaken by Trans-Tasman Resources Limited (TTRL).

TTRL is undertaking a confidential study into an off-shore iron sand mining operation off the west coast of the North Island, New Zealand. A process model of the proposed iron sand concentration process was constructing using IDEAS™ software for the prefeasibility study (PFS) in May 2013. The model took into account factors such as wave heights and sand grades. The project is currently in bankable feasibility study (BFS) phase and the process design has been developed further requiring the model to be updated. The process simulation determines expected power consumption for the process. Work was also started on a model which would provide a check on the storage capacity sizing at several key points in the process.

2 Model Description

A picture of the model and the process flow diagram (PFD) it is based on are included in Appendix A.

The main process simulation starts with the ROM (Run Of Mine) sand feed from the Crawler and includes all major unit operations through to the FSO (Floating Storage and Offloading vessel) storage, as follows:

- Mining vessel, positioning and mooring systems
- Power requirements for ship accommodation and services
- ROM Pump and Crawler hydraulic and jetting systems
- ROM Boil Box
- Trommel Screens
- MIMS (Medium Intensity Magnetic Separators) and associated feed tank
- LIMS1 (Low Intensity Magnetic Separators) and associated feed tank
- Cyclones 1 and 2 and feed tanks
- Vertimill
- LIMS2 and feed tank
- LIMS3 and feed tank
- Derrick Screens
- Dewatering Magnets
- Dry Concentrate Storage
- Concentrate Slurry Tank
- HBF (HyperBaric Filter) Dewatering
- FSO (Floating, Storage and Offloading vessel) Storage
- Desalination plant
- Process water tank
- Recycle process water, including coarse and fine tails collection

The simulation was constructed in IDEAS™ software.

The model can be run in steady state give a single power consumption answer. In this mode, a number of scenarios can be run to test the sensitivity of the power consumption to different production rates and different grades of the ROM feed.

The alternative is to run the model with input variables varying in time according to defined probability distributions. With sufficient variables the model is essentially stochastic and begins to simulate actual production albeit in a simplified way.

In this mode, a range and likelihood are given for certain key variables and the model randomly chooses a figure for each variable at a predetermined frequency. To reduce instabilities in the model and make the changes reasonably realistic the model ramps the parameters from the previous value to the new value all the while calculating instantaneous power requirements as the flows and compositions change through the process in response to the new conditions.

The variables in this mode of simulation are:

- ROM production rate
- ROM grade Fe content
- Wave height
- Wind speed
- VertiMill power consumption

Note that the ROM production rate and the ROM grade are ramped from one value to the next and when the plant is stopped the ROM rate is simply set to 0. The ramping combined with some delays through the remainder of the model result in buffering-like behaviour. However, the model does not make buffering decisions in the sense of allowing tank levels to rise and fall in accordance with what is happening downstream or upstream from the tank.

The model also introduces a maintenance schedule which simulates most of the plant stopping for 24 hours every two weeks.

Detailed comments on the stochastic modelling are provided in Table 9 in Appendix B.

3 Input Data and Assumptions

The simulations assume the maximum limit for normal production is 8500 t/h dry ROM feed material.

- Table 8, Appendix B lists the input data provided by TTRL.
- Section 7, References lists the reference documents used.

The distribution of iron content with mined grade changes considered in the simulation is shown in Figure 1.

The triangular distributions of mining rates considered, centred on “most likely” rates of 6700 t/h (ROM rate, dry basis) and 8000 t/h (ROM rate, dry basis), are shown in Figure 2 and Figure 3 respectively. “Most likely” being the apex of the triangular distribution.

The figure that inputs into the model of 6700 t/h ROM feed represents a longer term average mining rate, taking into account production operating delays and crawler extraction delays (refer to Reference 5, Time Usage Assumptions). Other reasons for not achieving design rate, including non-production due to planned maintenance, unplanned breakdowns, anchor relocation, sailing to a new location, are incorporated into a single recurring variable called the “maintenance” production stop in the model. The actual production rate that the model calculates is a result of operating at 6700 t/h when the plant is available and there is no stop in production.

Note that the mean rate is different from the "most likely" rate if the triangular distribution is skewed to one side or another (as it is in both these cases). The mean for each of these distributions will tend more toward the centre of a triangular distribution, resulting in:

- For the "most likely" 6700t/h ROM feed case, the mean rate will be 7066t/h
- For the "most likely" 8000t/h ROM feed case, the mean rate will be 7500t/h

The wave height and wind speed probability distributions used in the model to determine ship positioning power requirements are shown in Figure 4 and Figure 5 respectively.

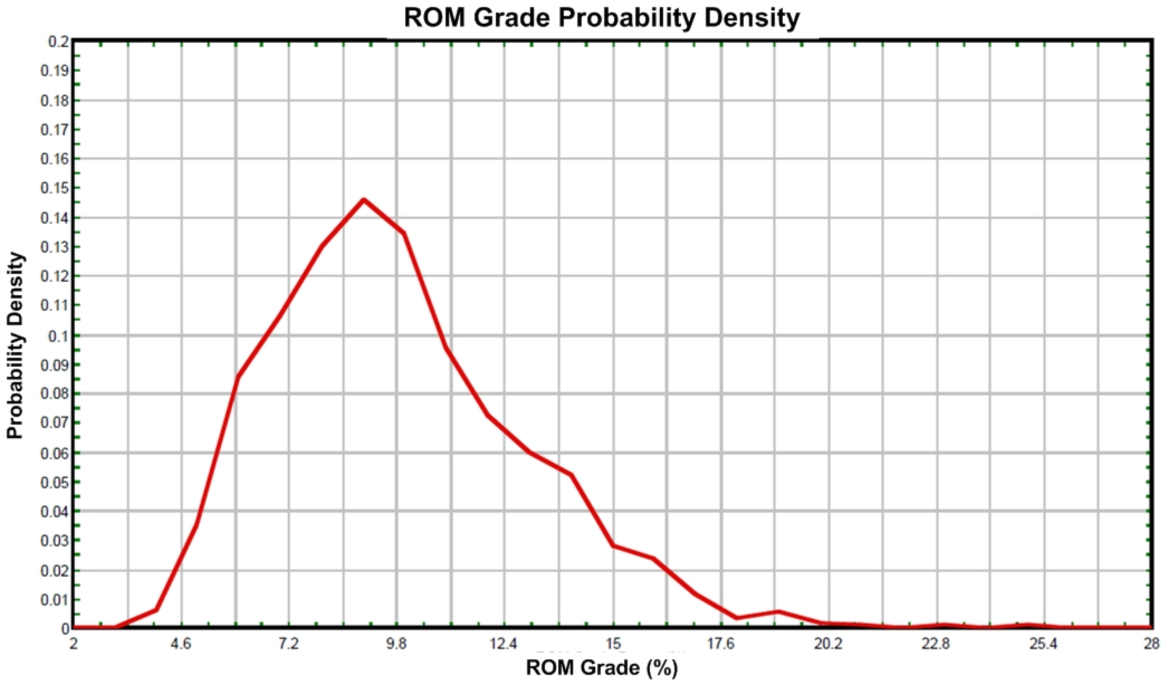


Figure 1: The distribution of the iron content in the mined sand used in the process simulation, showing ROM grade range in mass% Fe versus probability. Reference 6.

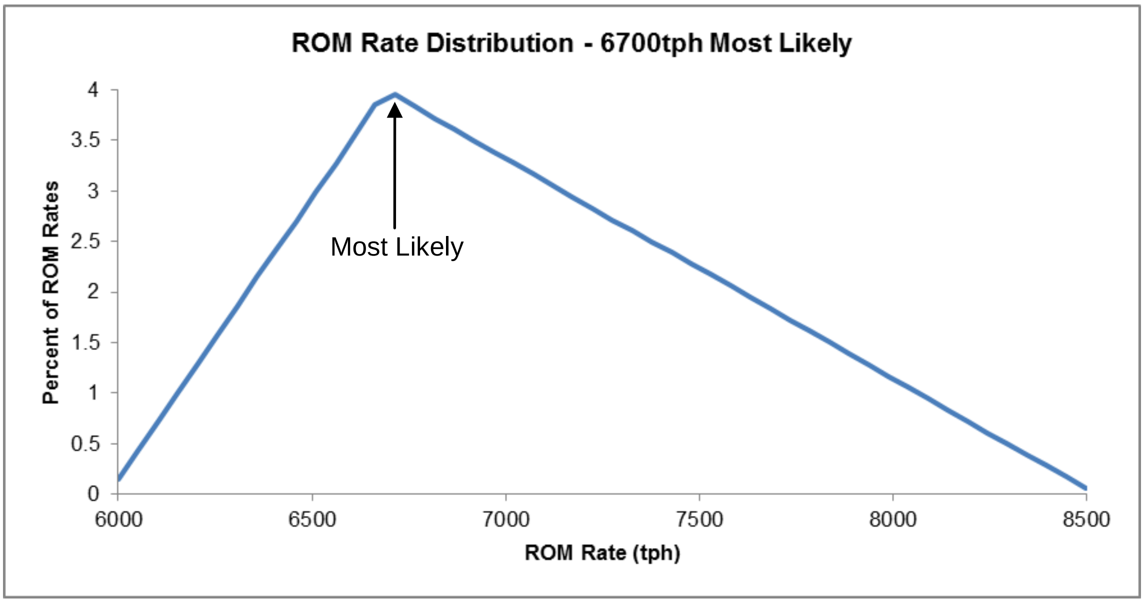


Figure 2: The distribution of the mining rate used in the process simulation when centred on a most likely 6700 t/h, showing ROM feed rate range in t/h dry basis versus probability, sample size one million.

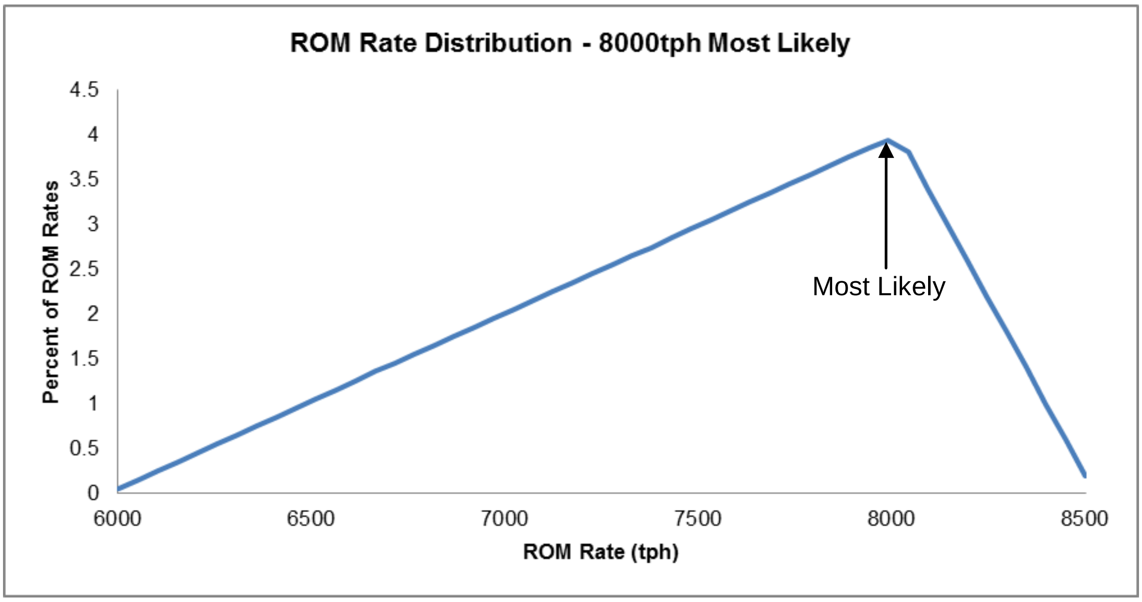


Figure 3: The distribution of the mining rate used in the process simulation when centred on a most likely 8000 t/h, showing ROM feed rate range in t/h dry basis versus probability, sample size one million.

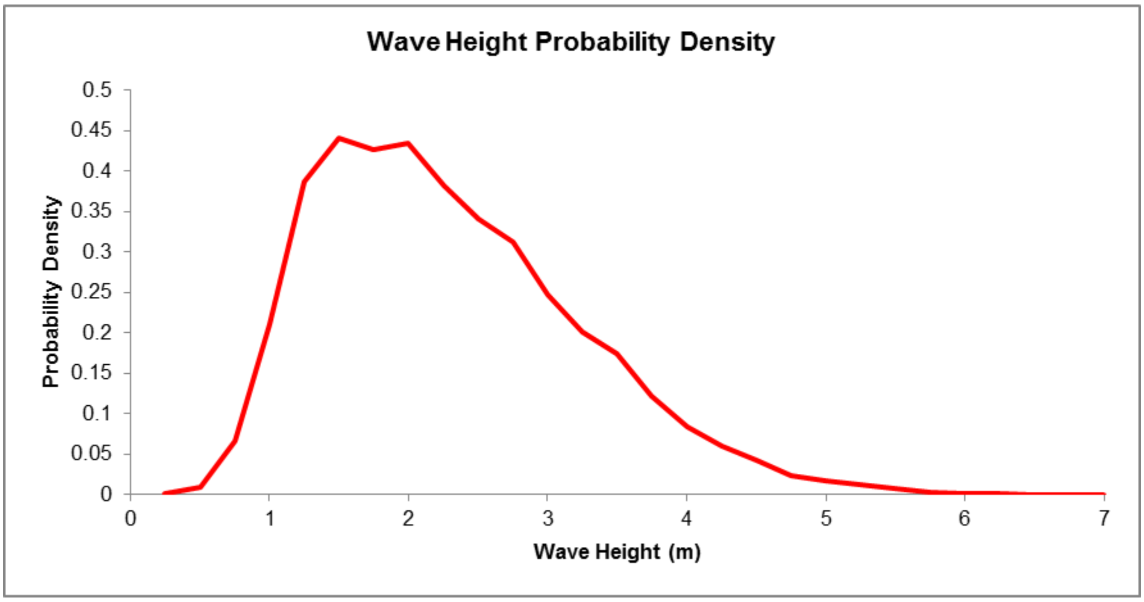


Figure 4: The wave height distribution used in the process simulation, showing Wave Height in m versus probability. Reference 10, Table 6.6.

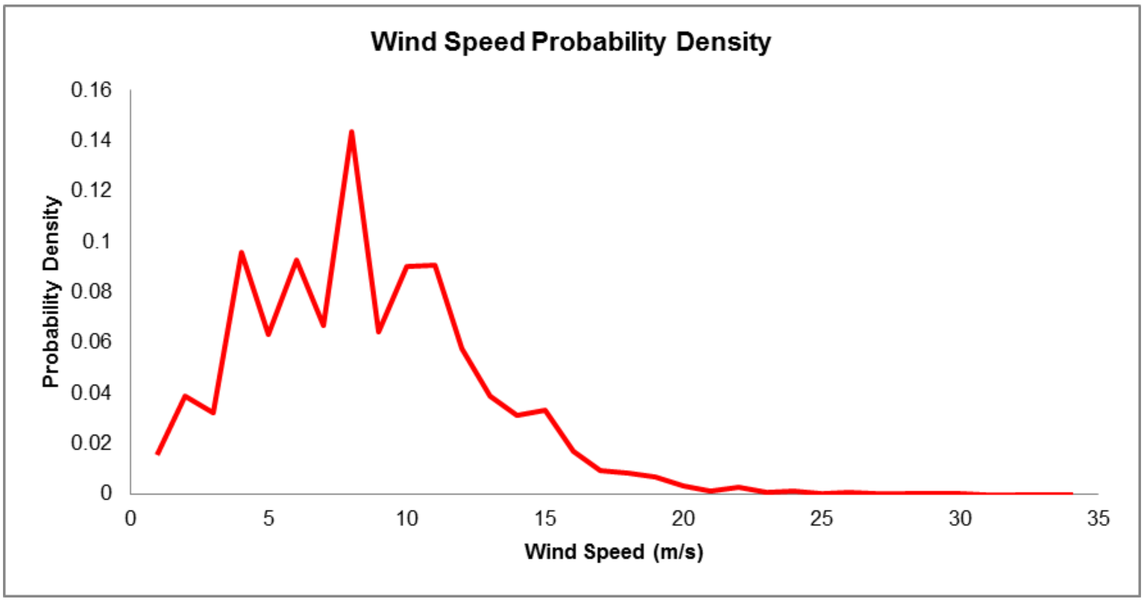


Figure 5: The wind speed distribution used in the process simulation, showing Wind Speed in m/s versus probability. Reference 10, Table 5.5.

As the wave height or wind speed increase (refer to Figure 4 and Figure 5 for distributions), the power consumption of the ship positioning system will also increase. The model currently stops the process while the significant wave height is equal to or greater than 4.0 metres. Exact details of how weather will affect operations are still to be confirmed. Current assumptions are detailed in Table 8, Appendix B.

3.1 Pump Power Calculation Method

When a stream is pumped, IDEAS^{TM} calculates the pumping power from first principles using the:

- Volumetric flow rate of the stream
- Stream density
- Differential pressure for the pump
- Overall efficiency

The first two parameters are calculated in the model "on the fly". The last two parameters are set in the pump object according to information provided by TTRL.

The model calculates material flows, compositions, and densities based on the information provided by TTRL:

- The starting parameters of ROM feed rate and composition
- The solids concentrations at each stage of the process, and the separations of solids and recoverable iron at each stage of the process

In the IDEAS^{TM} model, the ROM composition has been assembled from a small set of individual materials available from the suite of materials provided by IDEAS. At each stage in the process the density of the mix of materials can be determined from the composition of the stream. The density will not be an exact match for the actual material at that point because a small number of components have been chosen to approximate the ROM material.

IDEAS^{TM} also has a dynamic pump object (not used in this model) which can incorporate actual pump curves. This object is used in pressure-network models which are also modelling pipes and tanks.

3.2 Other Power Consumers

Other power consumers that are included in the model are:

- Vertimills
- Magnetic Separators
- Conveyors
- Reverse Osmosis plant
- Vessel Positioning System
- Accommodation
- Services

Refer to Table 8 in Appendix B for details on how these were modelled.

4 Process Scenarios

4.1 Steady State Cases

Six steady state cases were run to include:

- 6700 and 8000 t/h ROM feed rate
- 7.0, 10.3 and 12.2% Fe due to changes in grade composition

Two mining rates were modelled, the design rate of 8000 t/h ROM feed (dry basis) and a comparison at 6700 t/h ROM feed. The figure of 6700 t/h ROM feed represents a longer term average mining rate, taking into account production delays and crawler delays.

In each differing iron content case, the separation of water, solids and iron content was changed with the input %Fe. Outputs for the six steady state cases are detailed in Table 1 through to Table 6 on the following pages.

From these cases, the model was refined and corrected to accurately reflect the expected outcomes before it was run in stochastic mode (with the various probability distributions switched on). Based on the current assumptions, Vertimill grinding is the largest single power consumer. Other significant power consumers include the ship positioning system, the coarse tails cyclone pumping system, the reverse osmosis plant, the trommel screens and the crawler system.

Total predicted power consumption ranges are:

- 54.8 – 60.8MW at 6700t/h dry ROM feed, with 7.0 – 12.2% Fe
- 61.4 – 68.8MW at 8000t/h dry ROM feed, with 7.0 – 12.2% Fe

The water pumps and coarse tails cyclone pumps use minimum power at 10.3% Fe compared to the 7 and 12.2% Fe cases. This is a result of the TTRL mass balance separation efficiencies for the three different grades (Reference 3).

Table 1: Outputs for 6700 t/h ROM feed rate and 7.0% Fe in feed.

							IDEAS Total	TTRL Installed	
	Grade	7.0	%				Power	Power	Difference
	ROM Rate	6700	tph				MW	MW	MW
							54.75	61.34	6.59
Group	**Label**	**Area**	**Stream No.**	**Solids Flow t/h**	**Flow t/h**	**Density kg/m³**	**Power kW**	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**10594**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4357	5050	693
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					5557	6290	733
Variable Loads: Pumps Modelled in IDEAS							**14065**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	6700	16969	1444	1141	1420	279
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	6426	21422	1327	2838	3600	762
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	2448	9168	1275	956	1260	304
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	790	1083	2314	154	320	166
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	2186	3972	1763	1015	1800	785
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	116	647	1184	160	220	60
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	673	3163	1214	693	900	207
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	387	861	1553	226	930	704
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	5904	23191	1265	4567	4000	-567
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	408	5607	1075	789	1000	211
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	12854	1020	1527	1800	273
Variable Loads: Other							**18830**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					4612	5507	895
Other Process Equipment	VertiMill Power	Grinding	32	673	1451	1576	7718	6800	-918
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 2: Outputs for 8000 t/h ROM feed rate and 7.0% Fe in feed.

							IDEAS Total	TTRL Installed	
	Grade	7.0	%				Power	Power	Difference
	ROM Rate	8000	tph				MW	MW	MW
							61.35	61.34	-0.01
Group	**Label**	**Area**	**Stream No.**	**Solids Flow t/h**	**Flow t/h**	**Density kg/m³**	**Power kW**	**Power kW**	**Power kW**
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**12156**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6522	6290	-232
Variable Loads: Pumps Modelled in IDEAS							**16706**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1444	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7674	25579	1327	3388	3600	212
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	2923	10946	1275	1141	1260	119
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	943	1295	2311	185	320	135
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	2612	4755	1760	1215	1800	585
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	139	770	1184	190	220	30
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	804	3773	1214	827	900	73
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	463	1028	1553	270	930	660
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	7049	27237	1270	5363	4000	-1363
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	487	6687	1075	940	1000	60
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15348	1020	1823	1800	-23
Variable Loads: Other							**21222**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	804	1741	1572	9215	6800	-2415
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 3: Outputs for 6700 t/h ROM feed rate and 10.3% Fe in feed.

							IDEAS Total Power MW	TTRL Installed Power MW	Difference MW
	Grade	10.3	%						
	ROM Rate	6700	tph						
							58.29	61.34	3.05
Group	**Label**	**Area**	**Stream No.**	**Solids Flow t/h**	**Flow t/h**	**Density kg/m^3**	**Power kW**	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**10104**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4357	5050	693
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					5068	6290	1222
Variable Loads: Pumps Modelled in IDEAS							**14191**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	6700	16969	1441	1141	1420	279
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	6438	21461	1331	2843	3600	757
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	2828	9454	1315	985	1260	275
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1214	1665	2306	237	320	83
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3295	5993	1755	1532	1800	268
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	200	716	1303	177	220	43
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1014	3377	1318	740	900	160
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	671	1491	1551	392	930	538
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	5476	18570	1315	3657	4000	343
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	552	6807	1081	957	1000	43
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	12877	1025	1530	1800	270
Variable Loads: Other							**22729**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					4612	5507	895
Other Process Equipment	VertiMill Power	Grinding	32	1014	2190	1571	11617	6800	-4817
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 4: Outputs for 8000 t/h ROM feed rate and 10.3% Fe in feed.

							IDEAS Total Power MW	TTRL Installed Power MW	Difference MW
	Grade	10.3	%						
	ROM Rate	8000	tph						
							65.91	61.34	-4.57
Group	**Label**	**Area**	**Stream No.**	**Solids Flow t/h**	**Flow t/h**	**Density kg/m^3**	**Power kW**	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**11712**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6078	6290	212
Variable Loads: Pumps Modelled in IDEAS							**17003**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1441	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7679	25600	1331	3391	3600	209
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3384	11310	1315	1179	1260	81
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1455	1998	2304	285	320	35
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3946	7173	1751	1833	1800	-33
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	240	858	1303	212	220	8
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1216	4051	1318	888	900	12
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	804	1788	1551	470	930	460
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	6533	22396	1310	4410	4000	-410
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	663	8162	1081	1148	1000	-148
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15361	1025	1825	1800	-25
Variable Loads: Other							**25936**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	1215	2622	1573	13929	6800	-7129
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 5: Outputs for 6700 t/h ROM feed rate and 12.2% Fe in feed.

							IDEAS Total Power	TTRL Installed Power	Difference
	Grade	12.2	%						
	ROM Rate	6700	tph				MW	MW	MW
							60.79	61.34	0.55
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**10857**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4357	5050	693
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					5821	6290	469
Variable Loads: Pumps Modelled in IDEAS							**15442**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	6700	16969	1440	1141	1420	279
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	6437	21454	1329	2842	3600	758
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3021	11368	1273	1185	1260	75
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1312	1927	2136	275	320	45
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3437	6248	1747	1597	1800	203
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	255	910	1304	224	220	-4
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1059	4117	1265	902	900	-2
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	834	1854	1551	487	930	443
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	5378	20882	1266	4112	4000	-112
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	488	8158	1063	1147	1000	-147
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	12872	1024	1529	1800	271
Variable Loads: Other							**23226**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					4612	5507	895
Other Process Equipment	VertiMill Power	Grinding	32	1057	2282	1575	12114	6800	-5314
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 6: Outputs for 8000 t/h ROM feed rate and 12.2% Fe in feed.

							IDEAS Total Power	TTRL Installed Power	Difference
	Grade	12.2	%						
	ROM Rate	8000	tph				MW	MW	MW
							68.75	61.34	-7.41
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**12576**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6941	6290	-651
Variable Loads: Pumps Modelled in IDEAS							**18450**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1440	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7687	25616	1328	3393	3600	207
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3607	13571	1273	1415	1260	-155
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1565	2299	2136	328	320	-8
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	4101	7454	1744	1905	1800	-105
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	304	1088	1304	268	220	-48
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1262	4903	1265	1074	900	-174
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	997	2215	1551	582	930	348
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	6423	25030	1265	4929	4000	-929
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	581	9724	1063	1367	1000	-367
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15368	1023	1825	1800	-25
Variable Loads: Other							**26458**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	1261	2721	1575	14451	6800	-7651
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

4.2 Stochastic Cases

Two production rate distributions were used to create two stochastic runs. The distributions are depicted in Figure 2 and Figure 3 above.

In addition to the varying production rate, the model had an allowance for scheduled maintenance as described in Section 2. Overall, the duration and frequency of this allows for stopped production due to planned and unplanned maintenance, sailing times, and crawler repositioning.

A separate switch is used to model production stops due to excess significant wave height

Refer also to Reference 5, Time Usage page, and to Table 8 in Appendix B.

4.2.1 6700 t/h ROM Feed Dynamic Case

The power consumption for major groups of users and the total power required for the operation is shown in Figure 6 when the most likely mining rate is 6700t/h dry ROM feed:

- Predicted total power consumption peaks at 82.0MW (black trace).
- Predicted total power consumption averages 55.2MW.
- Total power consumption is broken down into mining (red trace), onship processing (green trace), mooring etc. (purple trace) and RO (blue trace) power requirements.
- Average ROM feed rate is 6266t/h (dry basis). The average rate is less than the “most likely” due to the triangular distribution chosen to represent the variation in mining rate and the production stoppages during the simulation.
- Although the model was run for 8760 hours (one year), the traces are for three months for clarity of the plot.

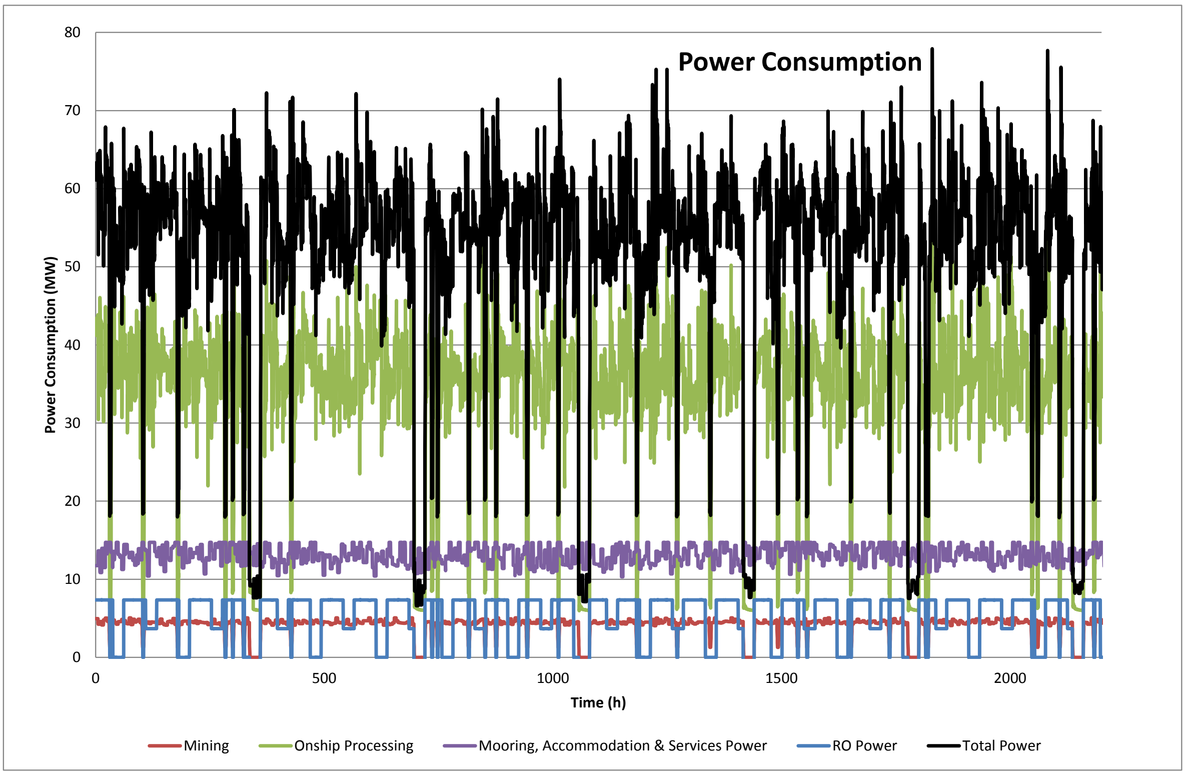


Figure 6: Predicted power consumption at a most likely mining rate of 6700t/h dry ROM feed.

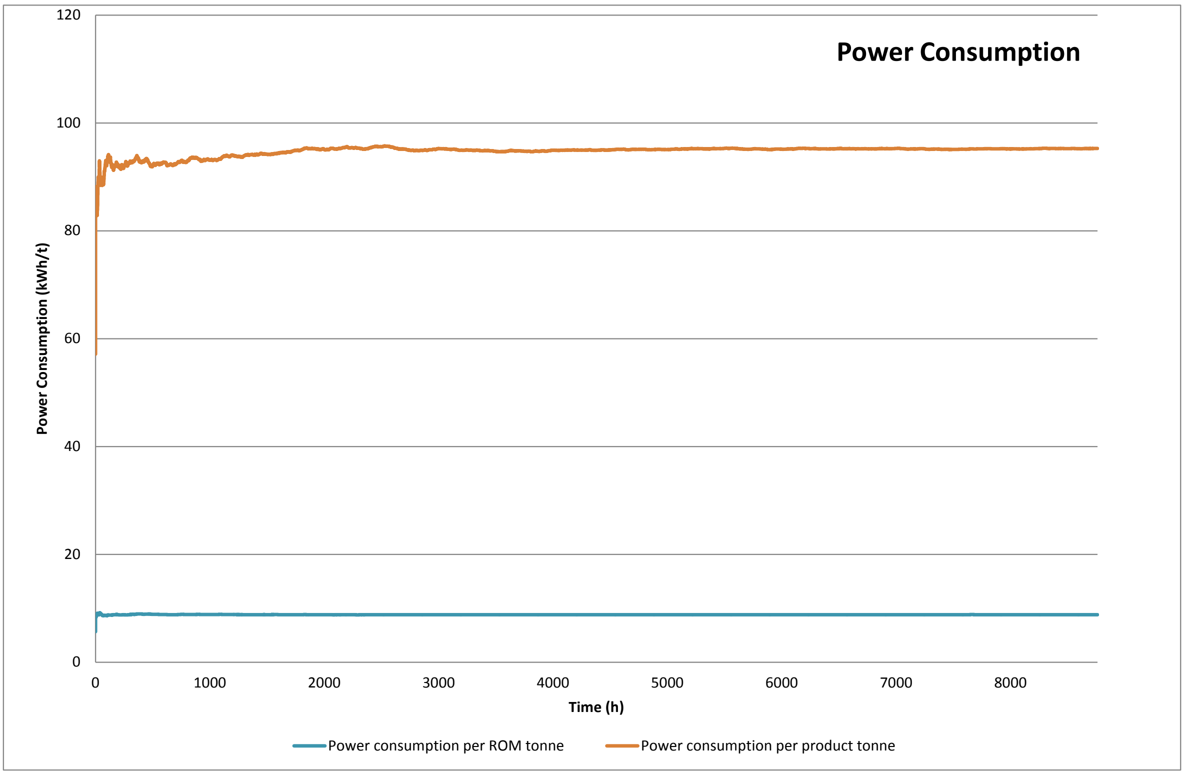


Figure 7: Predicted power consumption per tonne of (i) ROM feed and (ii) product at a most likely mining rate of 6700t/h dry ROM feed.

Power consumption per tonne of mine feed (blue trace) and product (orange trace) is shown in Figure 7:

- Per tonne of ROM feed, power consumption peaks at 9.18kWh/t and averages at 8.81kWh/t.
- Per tonne of product, power consumption peaks at 95.74kWh/t and averages at 94.73kWh/t.
- The plot shown is for the full 8760 hours (one year) of data.

A stacked plot of changing input variables and total power consumption is shown in Figure 8 in order to see how the variables affect power consumption:

- The plot shown is for the first three months of the simulation for clarity of the plot.
- ROM feed rate averages at 6266t/h with a maximum of 8418t/h (dry basis, blue trace).
- Product rate averages at 580t/h with a maximum of 1444t/h (dry basis, trace not shown).
- The average grade is 10.19%Fe in this simulation and ranges between 7 and 12.2%Fe (red trace).
- Wave height averages at 2.26m (green trace) and there are 440 hours over the year of simulation where wave height exceeds 4m, with a maximum of 5.99m (green trace).
- The frequency of plant stoppages have increased since the recent change from 4.5m to 4m for acceptable wave height for plant operation (wave height is green trace, ROM feed is blue trace). Refer to the prefeasibility study report, Reference 15.
- Wind speed averages at 8.5m/s with a maximum of 25.8m/s (purple trace).

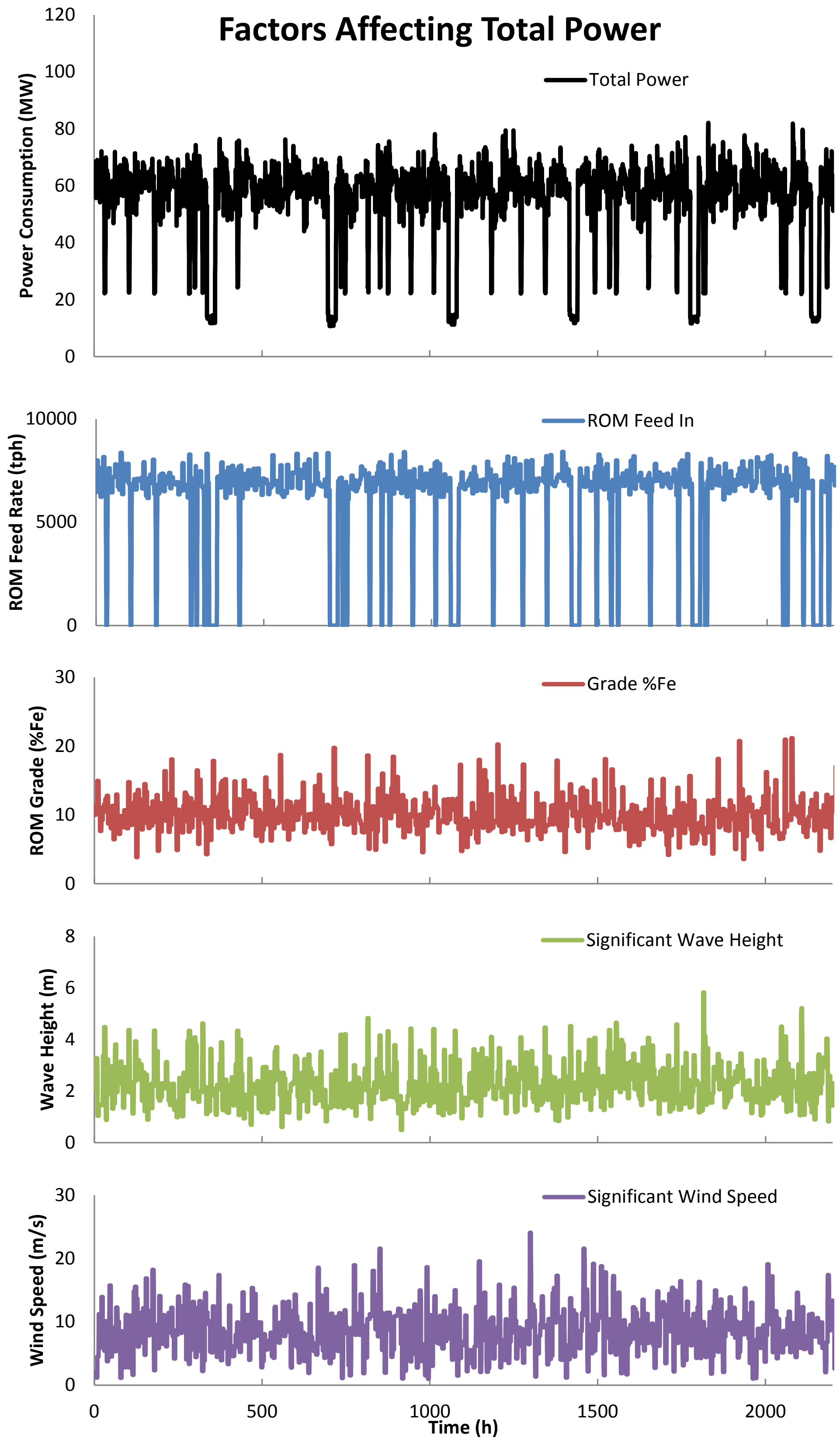


Figure 8: Stochastic variables influencing total power consumption at a most likely mining rate of 6700t/h dry ROM feed.

4.2.2 8000 t/h ROM feed Dynamic Case

The major users power consumption is shown in Figure 1 when the most likely mining rate is 8000t/h dry ROM feed:

- Predicted total power consumption peaks at 82.3MW (black trace).
- Predicted total power consumption averages 56.5MW.
- Total power consumption is broken down into mining (red trace), onship processing (green trace), mooring etc. (purple trace) and RO (blue trace) power requirements.
- Average ROM feed rate is 6702t/h (dry basis). As with the previous case, the average rate is less than the “most likely” due to the triangular distribution chosen for mining rate and the production stoppages.
- Although the model was run for one year, only three months of data are shown for plot clarity.

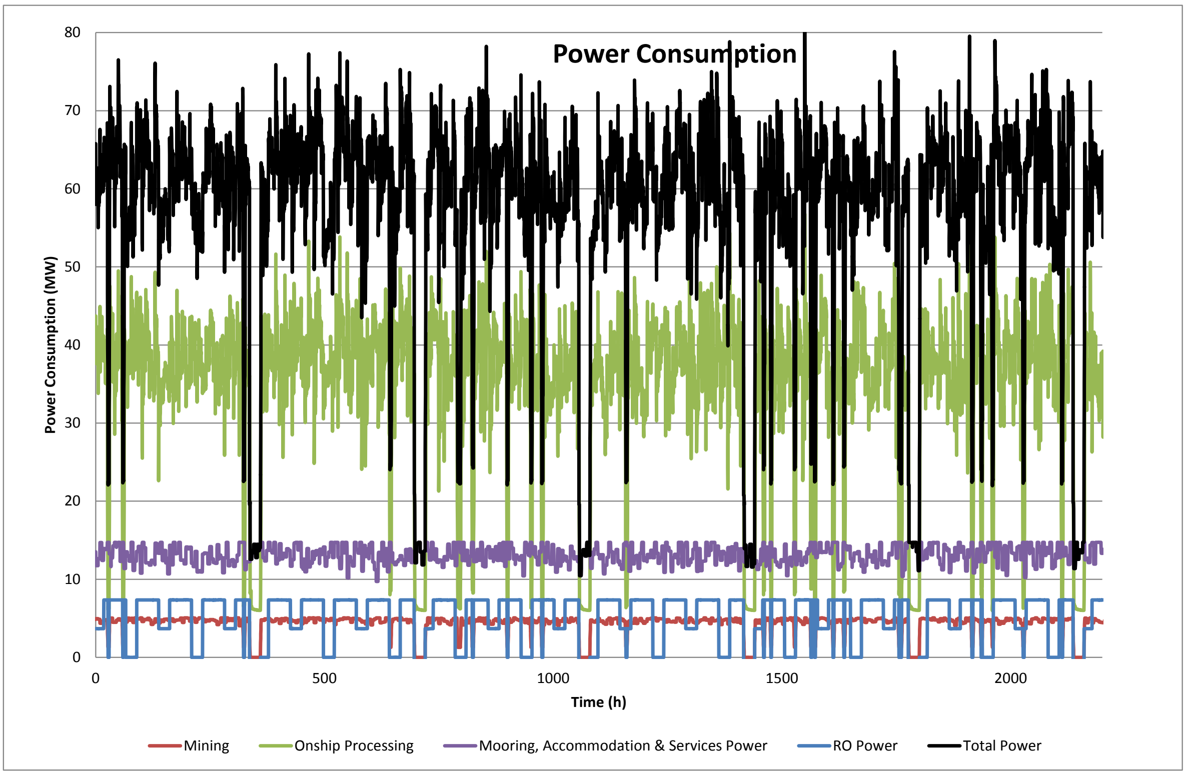


Figure 9: Predicted power consumption at a most likely mining rate of 8000t/h dry ROM feed.

Power consumption per tonne of mine feed (blue trace) and product (orange trace) is shown in Figure 10:

- Per tonne of ROM feed, power consumption peaks at 8.86kWh/t and averages at 8.41kWh/t.
- Per tonne of product, power consumption peaks at 93.50kWh/t and averages at 91.73kWh/t.
- The plot shown is for the full 8760 hours (one year) of data.
- Compared to the 6700t/h case, the power consumption per tonne has reduced slightly due to the base fixed power load being shared over a higher production rate.

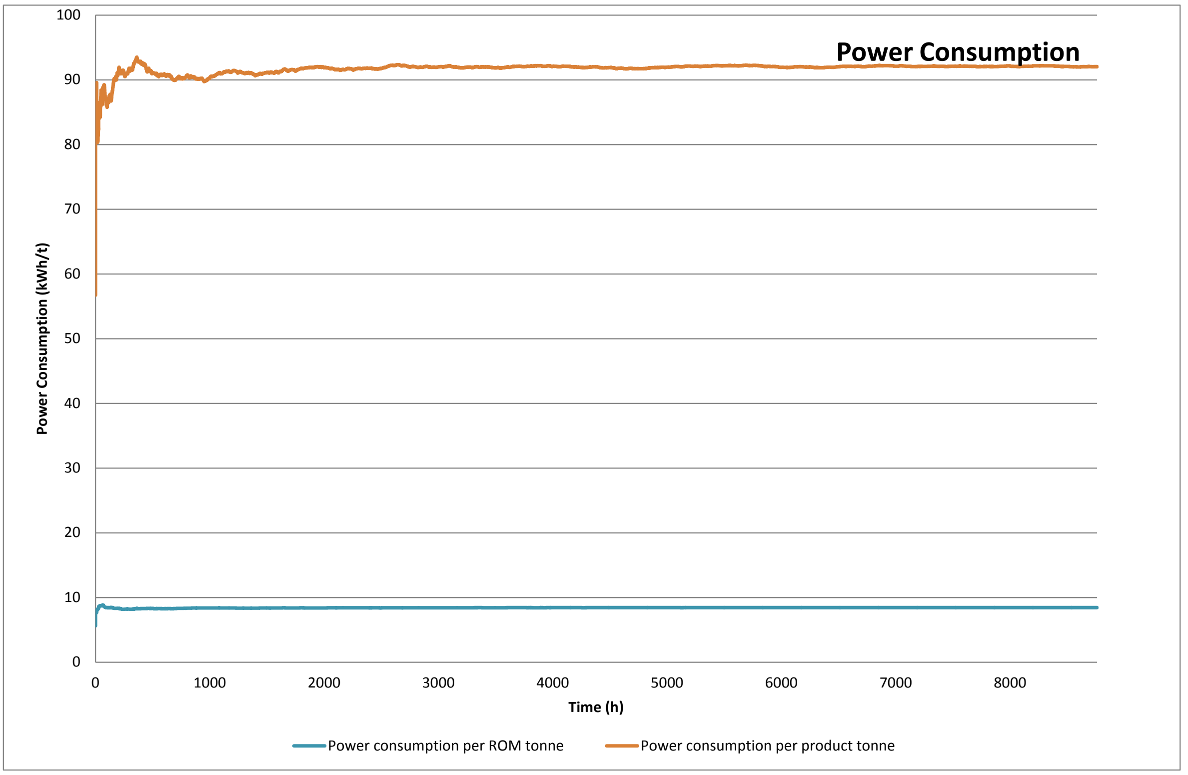


Figure 10: Predicted power consumption per tonne of (i) ROM feed and (ii) product at a most likely mining rate of 8000t/h dry ROM feed.

A stacked plot of changing input variables and total power consumption is shown in Figure 11 in order to see how the variables affect power consumption:

- The plot shown is for the first three months of the simulation for clarity of the plot.
- ROM feed rate averages at 6702t/h with a maximum of 8485t/h (dry basis, blue trace).
- Product rate averages at 614t/h with a maximum of 1514t/h (dry basis, trace not shown).
- The average grade is 10.04%Fe in this simulation and ranges between 7 and 12.2%Fe (red trace).
- Wave height averages at 2.30m (green trace) and there are 397 hours over the year of simulation where wave height exceeds 4m, with a maximum of 6.16m (green trace).
- The frequency of plant stoppages have increased since the recent change from 4.5m to 4m for acceptable wave height for plant operation (wave height is green trace, ROM feed is blue trace). Refer to the prefeasibility study report, Reference 15.
- Wind speed averages at 8.9m/s with a maximum of 27.4m/s (purple trace).
- Slight variation in average grade %Fe, wave height and wind speed can be expected compared to the 6700t/h case due to the method of generating random numbers within a given distribution during any simulation.

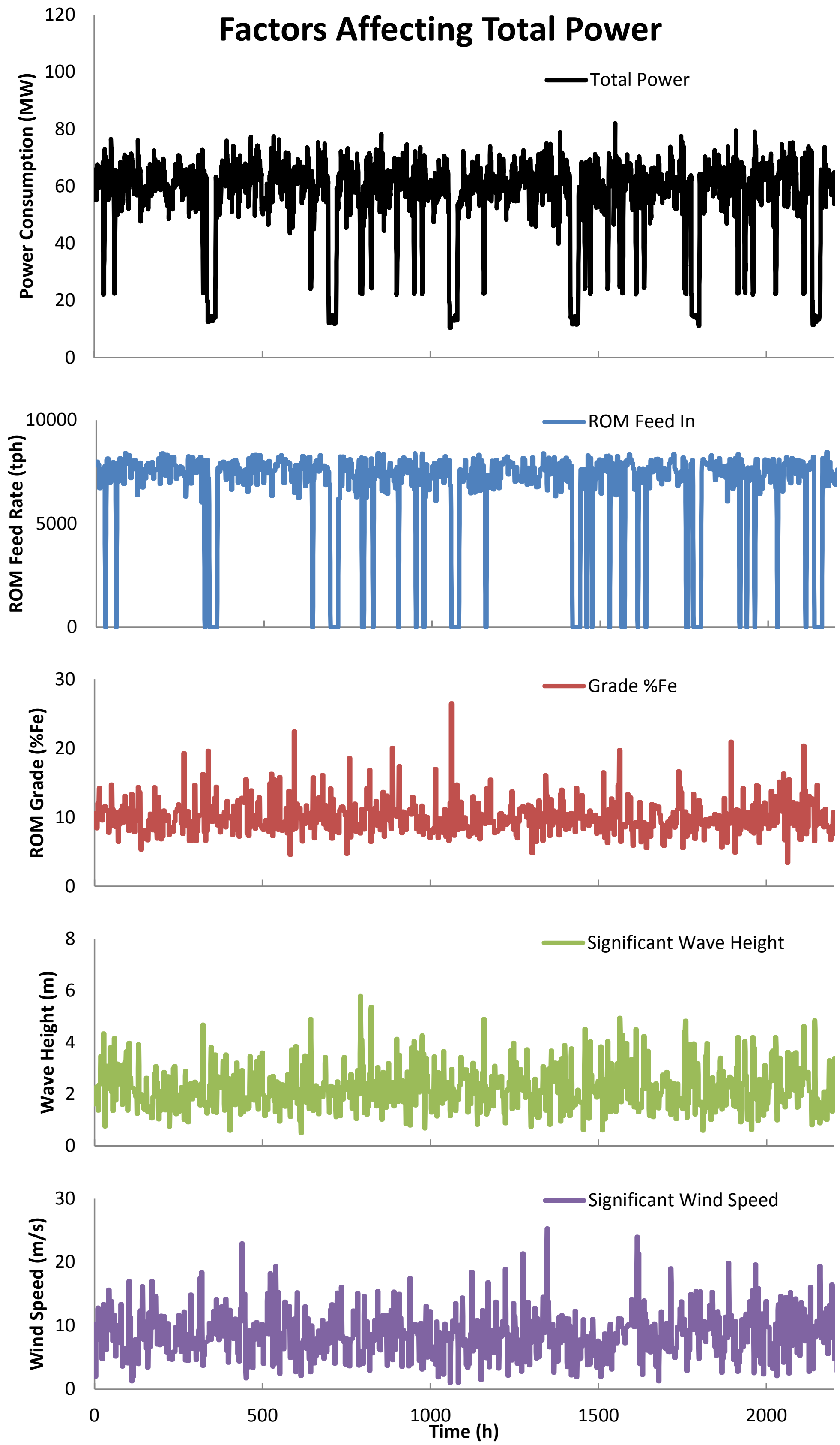


Figure 11: Stochastic variables influencing total power consumption at a most likely mining rate of 8000t/h dry ROM feed.

4.2.3 Scenario: 8000 t/h ROM feed with reduced power consumption by the Vertimills and Trommel Screens

A scenario was run where the following two variations were made:

- TTRL has advised that the Vertimill power consumption per tonne of milled material is being reviewed and is likely to reduce substantially. At present, the model output for the Vertimill exceeds the "installed" power. For example, for the primary design case of 8000t/h ROM at 10.3% grade the calculated power required for the Vertimill was approximately 4800 kW more than the "installed" power of 6800 kW in the current design. For this scenario the Vertimill power consumption for steady state was reduced from 11.46 kWh/t to 3.5 kWh/t.
- TTRL has also advised that the Trommel Screens may be replaced with vibrating screens and that the power requirements for the vibrating screens will be significantly less than for the Trommel Screens. For this scenario the power consumption for steady state was reduced from 4500 kW for four Trommel Screens to 400 kW for four Vibrating Screens.

Outputs for the steady state scenario are shown in Table 7. Total power consumption has reduced to 52MW from nearly 66MW with the previous Vertimill and Trommel Screen conditions.

Table 7: Steady state outputs for the reduced power scenario

	Grade	10.3	%				IDEAS Total Power	TTRL Installed Power	Difference
	ROM Rate	8000	tph				MW	MW	MW
							52.00	61.34	9.34
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**7164**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					400	4500	4100
Variable Loads: with Production							**11644**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6009	6290	281
Variable Loads: Pumps Modelled in IDEAS							**16935**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1441	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7679	25596	1331	3391	3600	209
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3385	11315	1315	1179	1260	81
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1456	1999	2304	285	320	35
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3948	7178	1749	1835	1800	-35
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	240	859	1303	212	220	8
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1216	4052	1318	888	900	12
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	805	1789	1551	470	930	460
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	6531	22039	1316	4340	4000	-340
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	663	8165	1081	1148	1000	-148
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15357	1025	1824	1800	-24
Variable Loads: Other							**16262**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	1216	2625	1572	4255	6800	2545
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

The major users power consumption is shown in Figure 12 when the most likely mining rate is 8000t/h dry ROM feed:

- Predicted total power consumption peaks at 67.3MW (black trace).
- Predicted total power consumption averages 46.9MW.

- Total power consumption is broken down into mining (red trace), onship processing (green trace), mooring etc. (purple trace) and RO (blue trace) power requirements.
- Average ROM feed rate is 6700t/h (dry basis). As with the previous case, the average rate is less than the "most likely" due to the triangular distribution chosen for mining rate and the production stoppages.
- The model was run for three months.

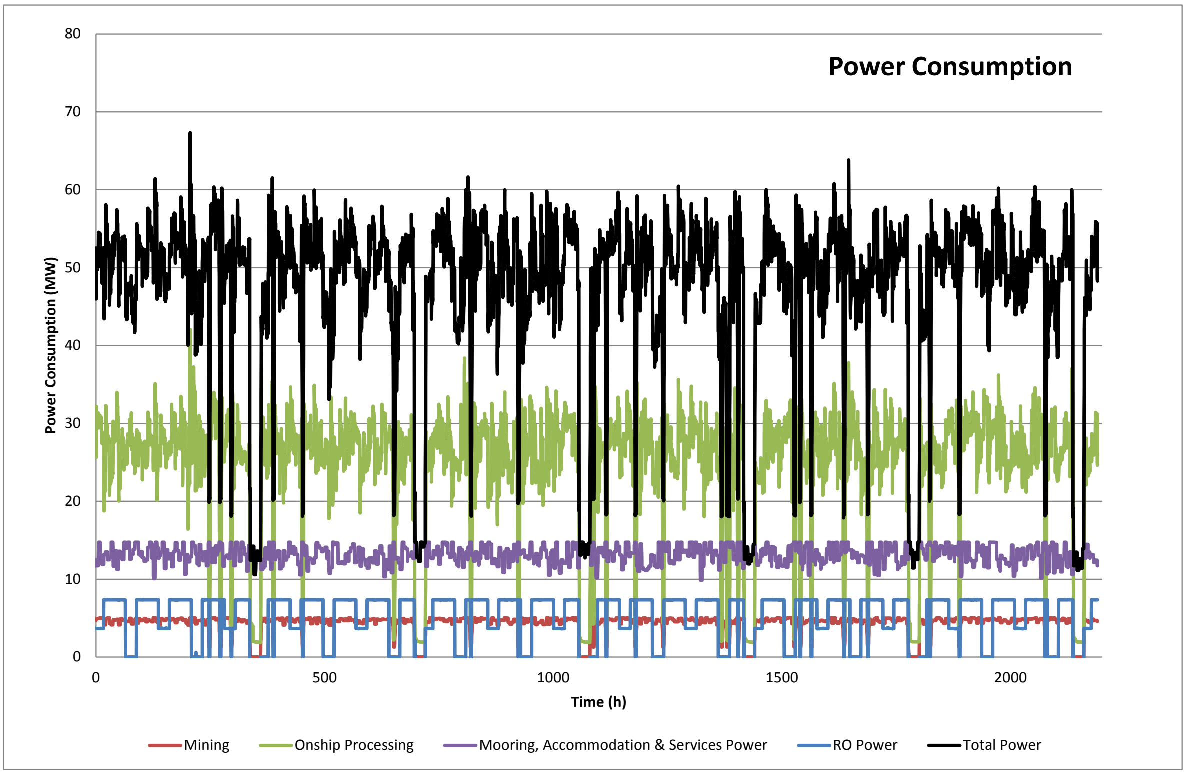


Figure 12: Predicted power consumption for the reduced power scenario.

Power consumption per tonne of mine feed (blue trace) and product (orange trace) is shown in Figure 13:

- Per tonne of ROM feed, power consumption peaks at 7.03kWh/t and averages at 6.97kWh/t.
- Per tonne of product, power consumption peaks at 94.89kWh/t and averages at 75.23kWh/t.
- The plot shown is for the three months.

Compared to the higher power 8000t/h case, the differences are quite significant although there is little difference in peak power demand.

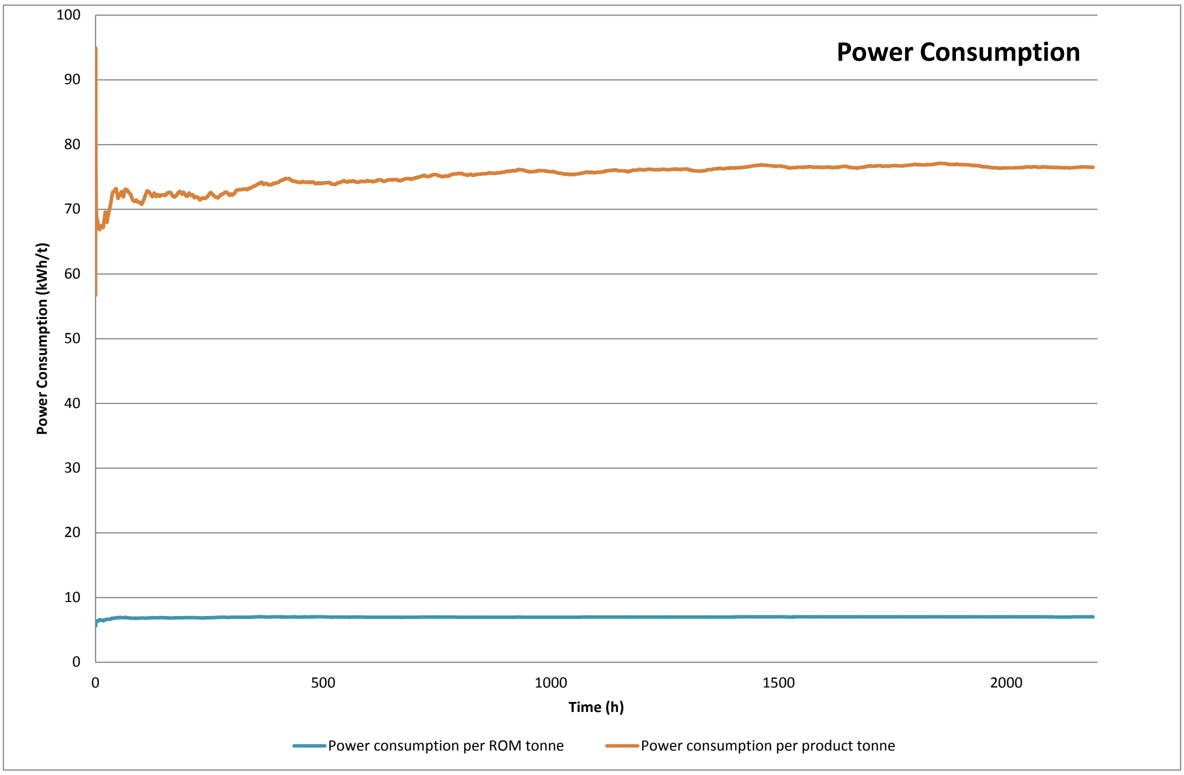


Figure 13: Predicted power consumption per tonne of (i) ROM feed and (ii) product for the reduced power scenario.

A stacked plot of changing input variables and total power consumption is shown in Figure 11 in order to see how the variables affect power consumption:

- ROM feed rate averages at 6700t/h with a maximum of 8493t/h (dry basis, blue trace).
- Product rate averages at 614t/h with a maximum of 1597t/h (dry basis, trace not shown).
- The average grade is 10.03%Fe in this simulation and ranges between 7 and 12.2%Fe (red trace).
- Wave height averages at 2.30m (green trace) and there are 94 hours over the 3 months of simulation where wave height exceeds 4m, with a maximum of 5.55m (green trace).
- The frequency of plant stoppages have increased since the recent change from 4.5m to 4m for acceptable wave height for plant operation (wave height is green trace, ROM feed is blue trace). Refer to the prefeasibility study report, Reference 15.
- Wind speed averages at 8.5m/s with a maximum of 28.4m/s (purple trace).

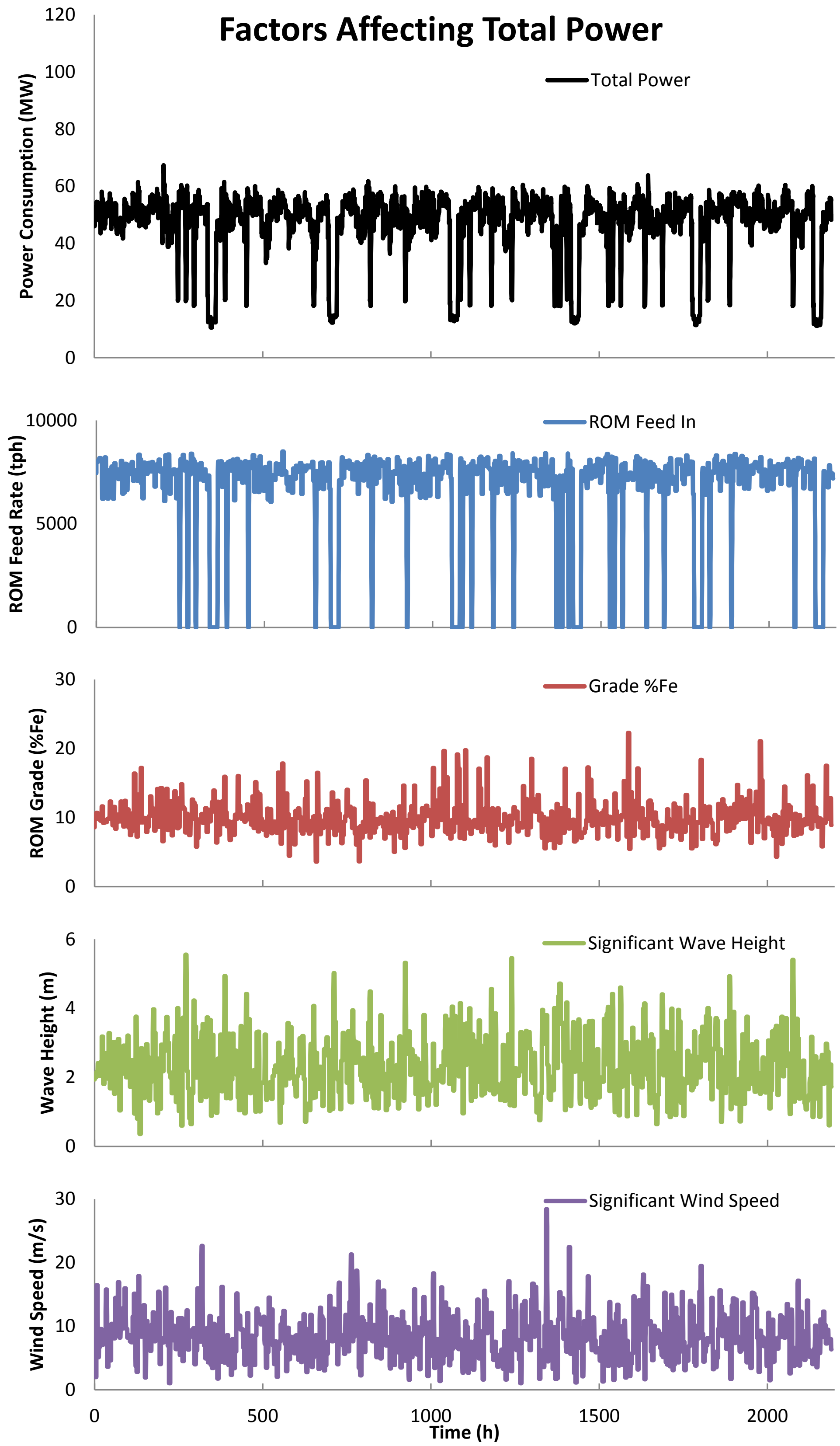


Figure 14: Stochastic variables influencing total power consumption for the reduced power scenario.

5 Modelling Limitations

5.1 Overall

The model incorporates the current process design, calculating power requirements using the information supplied by TTRL. However, there are a few provisos which we need to record:

- The process is currently being independently verified by TTRL and is therefore subject to change.
- Although we have used separation efficiencies provided by TTRL, there are some differences between our results and the TTRL calculations which should be examined in more detail.
- Some further work is desirable on separation efficiencies so that the model can properly address very low and very high grade feeds.
- Recycle streams may well be required in real life to balance flows around the plant and these have not been considered but may have some effect on required pumping capacities.
- Some of the major power consumers (positioning system, ROM pump, accommodation and services, and VertiMill) are either not modelled in a dynamic way or require refined modelling due to their contribution to the overall power demand. In particular:
  - The positioning power calculation does not consider any sort of relationship between wave height and wind speed (or between these and sea currents and ship's heading) and is also based on a preliminary interpretation of what might be required. As such, the positioning calculation can only be regarded as a preliminary first estimate.
  - The pump calculations are based on TTRL's estimate of discharge head and take no account of changes in dynamic head due to slurry flow or composition changes.
- The model does not have any cap on the capacity of unit operations downstream of the ROM pump. This means that combinations of high mining rate and high ROM grade may result in production rates which exceed the final design capacity of some unit operations.

5.2 Steady State Modelling

The mass balance results from the steady state modelling do not exactly match the results from TTRL's mass balance and it is most likely that this is caused by:

- Small offsets in some of the control loops used to converge the model
- Possible inaccuracies of some of TTRL's figures in a recycle situation

More work and collaboration between TTRL and Beca would be required to nail down the reasons for these variances.

The model also starts generating error messages for the low production rates with low grades and this is probably due to inaccuracies in the separation efficiencies for some of the fringe cases.

Ideally, it would be nice to have separation efficiencies provided as a function of the grade of the feed to the unit operation and also as a function of feed rate. However, we understand that these details are difficult to establish.

5.3 Stochastic Modelling

The stochastic modelling gives some idea of the variability of the instantaneous power demand and provides a calculation for the long run power requirement per tonne of ROM or product. However, the model in its present form is not capable of dynamically calculating friction losses and pump efficiencies as a function of flow rate and nor does it have a robust representation of separation efficiencies (as noted above).

6 Future Work

6.1 Inclement Weather

If further discussions with the ship builder yielded new or different information about the expected power consumption for ship positioning at different wind speeds and wave heights, then the simulation could be updated to see the effect on power consumption.

However, a realistic analysis of the effects of inclement weather on mining vessel operations and power consumption would need to involve temporal modelling of wind, waves, and current combined with management strategies for ship’s heading.

These sorts of issues also bear on the transfer operation between the mining vessel and the FSO and also the product transfer from the FSO to the Cape Size vessel.

6.2 Other Production Cases

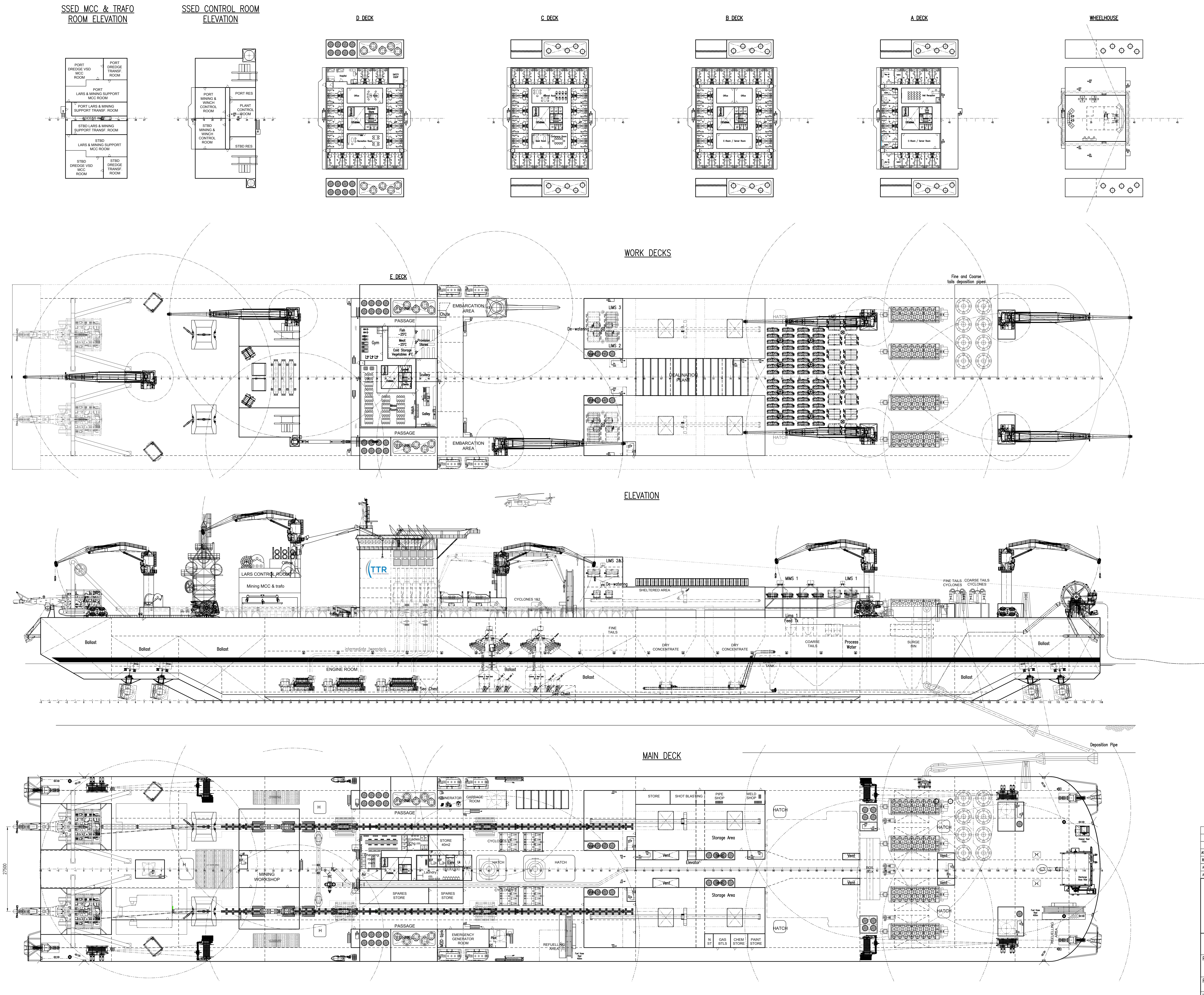
Other cases which could be simulated to improve the accuracy of the expected power consumption:

- New or better information on Vertimill power consumption.
- Desalination plant running and not running.
- Random equipment failures affecting one train or part of one train.
- Start up and shut down sequencing.
- More complex representation of product transfer to the FSO, the effect of FSO availability on production, and the effect of Cape Size availability on FSO availability.
- Updated process design following the impending process verification by an independent party.

7 References

1. TTRL-05-PFD-10002, rev 0E, Iron Sand Wet Processing Plant PFD – average flow
2. TTRL-05-DWG-52000, rev 0C, Iron Sand Wet Processing Plant Schematic
3. TTRL Grade Impact Overview spreadsheet rev P4
4. TTRL-04-BOD-12000 BFS Assumptions Register R6 20 Nov 2013 (KP) spreadsheet, FSO cycle tab
5. TTRL-04-BOD-12000 BFS Assumptions Register R5 15 Nov 2013 spreadsheet, Tabs: Design and Interface, Time Usage, 900 Crawler
6. TTRL-13-MEM-12000 Memo on ROM Grade Variation, 5 Nov 2013
7. TTRL-05-BOD-12000-R1 Bankable Feasibility Study Basis of Design, 3 Dec 2013
8. TTRL-04-CLC-13000-RO – Pump and Line Sizing Calculation spreadsheet, 29 Nov 2013
9. TTRL-05-SCH-13000, rev 5, Major Equipment Summary, Pump List
10. TTRL-13-EXT-05000, rev 0, Kupe Metocean Design Criteria
11. TTRL-13-BOD-00001, rev 0, Mining Resource Schedule, 20 Oct 2013
12. 2932288-PF-001, rev A, Desalination Plant PFD
13. NZ1-8221576-TTRL, rev A, Desalination Scoping Study – Motor List
14. TTRL-BFS-BFD, rev 0, Mass and Water Balance 22 Nov 2013
15. NZ1-7456818-3 0.3 Simulation Model TTRL Offshore Project Report, Prefeasibility Study, 23 May 2013

Appendix 19.4 - Intergrated Mining Vessel GA Drawings



CLASS NOTATION

American Bureau of Shipping
✠ A1, Special Purpose Ship

Service Notation: Mining vessel
Site specific South Taranaki Bight, NZ

✠ AMS, UWILD, CPS
ACCU, TAM,
HAB (OS)
SH–DLA,
SFA (20 years),
CIRCLE E, CIRCLE C
HELIDK
CRC

PRINCIPAL PARTICULARS:

Length over all	Loa	345.00 m
Length rule	L	332.00 m
Breadth moulded	B	60.00 m
Depth moulded	D	26.25 m
Draught scantling	Ts	15.00 m
Draught design	Td	15.00 m

Complement 120 pers

Status: FOR APPROVAL IN PRINCIPLE 4 MARCH 2014

REV.	DATE	REMARKS	DRAWN	CHECKED	APPROVED
B	04 Mar 2014	For approval in Principle	Dlr	DSM	SBo
A1–6		Progress issues	Dlr	RdV	SBo

Approved:	yard	Date:	Approved:	class	Date:
Approved:	owner	Date:	Approved:	auth.	Date:

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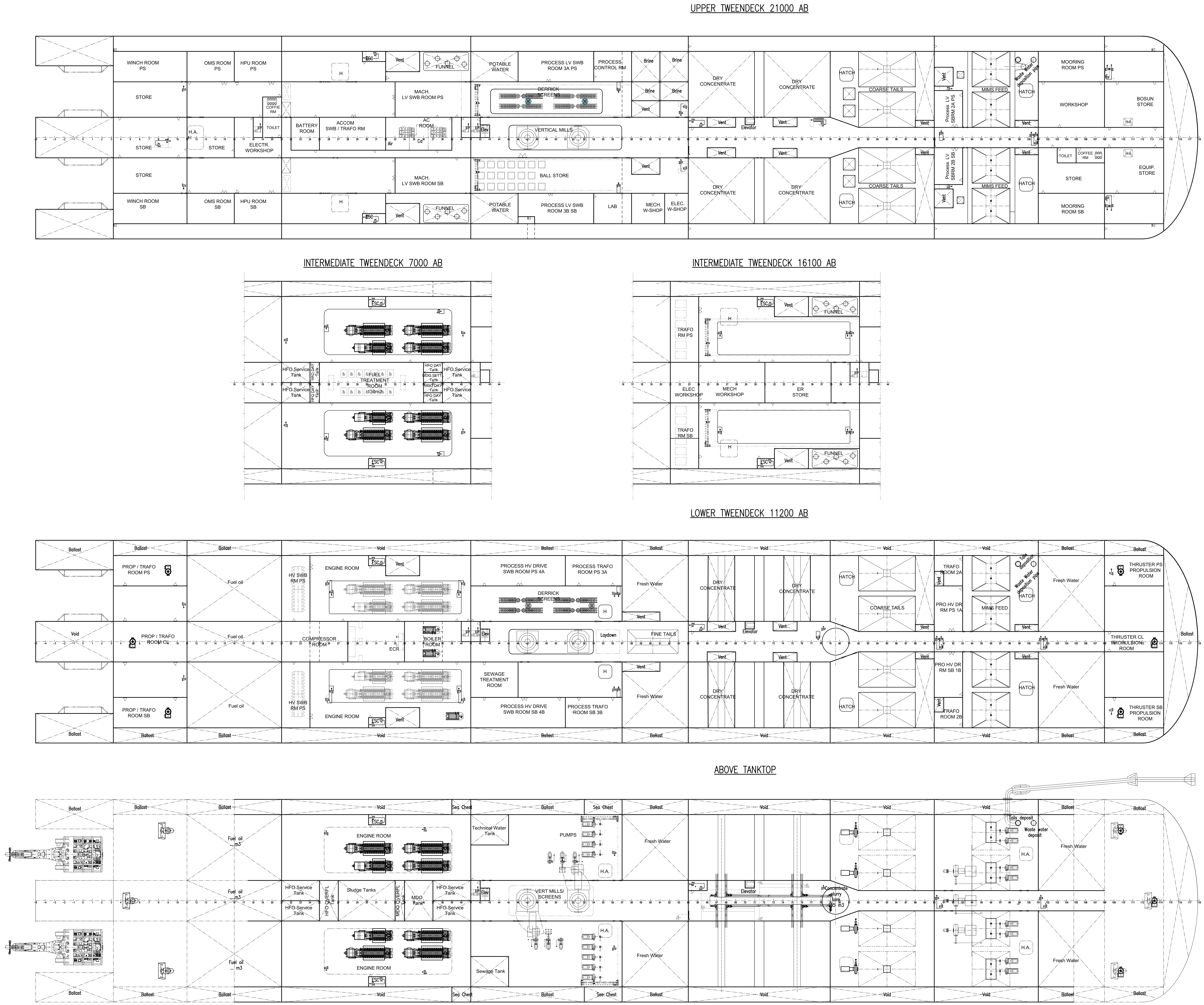
GENERAL ARRANGEMENT PLAN
MINING VESSEL TTRL

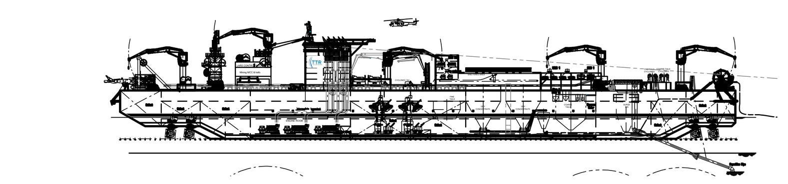
Principal:

Scale 1 : 400

Proj.	Dwg.	Rev.	Nr. of Sh.	Format
13.300	64.151–019–01–001	B	1/2	A0

N:\Projects\2013\13300 TTRL Mining vessel\Drawings\020 General arrangement\64.151-019-01-001 General arrangement.dwg, 3/4/2014 4:30:19 PM, bot, A0 (1189.00 x 841.00 MM), 1:1





Status: **FOR APPROVAL IN PRINCIPLE 4 MARCH 2014**

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Approved:	yard	Date:	Approved:	class	Date:
Approved:	owner	Date:	Approved:	auth.	Date:

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GENERAL ARRANGEMENT PLAN
MINING VESSEL TTRL

Principal:

Scale 1 : 400

Proj. 13.300 | Dwg. 64.151–019–01–001 | Rev. B | Nr. of Sh. 2/2 | Format A0

Appendix 19.5 - Trans Tasman Resources Ship Personnel Assessment

Marine personnel per shift. (Two shifts required).

Level	Grade #1		Grade #2		Grade #3		Grade #4		Grade #5		Grade #6		Per vessel per shift	Total
Experience	15+ years, Marine Certification	No.	10+Years, Marine Certification	No.	10+, Technical Degree/Diploma, Marine Certification	No.	10+, Trade/Tech Qual , Marine Certification	No.	5+ years, + Trade/Qual + Marine Certification	No.	2+years, Certification	No.		
Operational Job Description	MV Captain	1	MV Mining Superintendant	1	Utility Engineer	1	MV Laboratory technicians	1	MV Medic	2	MV Cargo Operator (Deck Hand)	2		
	MV Installation Manager	1	MV Process Superintendant	1	Maintenance Engineer	1	MV Utility Operator	2	MV Camp Boss/Day Cook	1	MV Crane Driver	2		
			Marine H&S Officer	1			MV Utility Operator	2			MV Night Cook	1		
							MV Crawler Pilot	2			MV Steward	2		
							MV Crawler Relief Pilot	1			MV Steward	2		
							MV Plant operator (Feed & Mag Sep)	2			MV Kitchen Hand	2		
							MV Plant operator (Grinding)	2			MV Kitchen Hand	2		
							MV Relief operators	2			MV Trade Assistant	2		
							MV C&I Technician	2			MV Trade Assistant	2		
							MV C&I Technician	2						
							MV Electrical Tech	2						
							MV Electrical Tech	2						
							MV Hydraulic Tech	2						
							MV Snr. Cargo Operator (Deck Hand)	2						
							MV Mechanical Fitter/Welder	2						
							MV Mechanical Fitter/Welder	2						
	TOTAL IMV	2		3		2		30		3		17	57	114
	AHT Captain	1	AHT 1st Mate	1	AHT Second mate	1	AHT Able Body Seaman	2	AHT Steward	2	AHT Junior Engineer	2		
			AHT Chief Engineer	1	AHT First Engineer	1	AHT Second Engineer	2			AHT Cook	1		
					AHT Electrical Engineer	1	AHT Marine Electrician	2						
	TOTAL AHT	1		2		3		6		2		3	17	34
	TS Captain	1	TS 1st Mate	1	TS Third mate	1	TS Able Body Seaman	2	TS Steward	2	TS Junior Engineer	2		
			TS 2nd Mate	1	TS First Engineer	1	TS Able Body Seaman	2			TS Cook	1		
			TS Chief Engineer	1	TS Electrical Engineer	1	TS Utility Operator	2						
							TS Utility Operator	2						
							TS Second Engineer	2						
							TS Marine Electrician	2						
	TOTAL TS	1		3		3		12		2		3	24	48
	Geo Captain	1	Geo First mate	1	Geo Chief Engineer	1	Geo Drill Support Crew	1	Geo Tech Support	1	Geo Tech Support	1		
					Geo Geologist	1	Geo Drill Support Crew	1						
	TOTAL Geo Exp	1		1		2		2		1		1	8	16
	GRAND TOTAL	**5**		**9**		**10**		**50**		**8**		**24**	**106**	**212**

Appendix 19.6 - RN Barlow Maritime Operations Review

R. N. Barlow and Associates Limited

Trans-Tasman Resources Limited

South Taranaki Bight

Offshore Iron Sand Extraction and Processing Project

Report on the Maritime and Navigational Impacts of the Project

November 2015

Prepared by Captain R N Barlow Master Mariner MNI

In November 2015 I was provided with a summary of additional scientific work commissioned by TTR since 2014. The conclusions from my report dated August 2013 remain valid in light of TTR's additional information.
Ray Barlow 11 November 2015

Contents

Appendices

Appendix 1 **South Taranaki Bight Marine Traffic Study, Marico Marine (NZ) Ltd**

Appendix 2 **Import Health Standard for ships ballast water from all countries' issued under Section 22 of the Biosecurity Act 1995**

Appendix 3 **Ballast Water Declaration**

Appendix 4 **Craft Risk Management Standard (CRMS) for Biofouling on Vessels arriving to New Zealand' issued under section 24G of the Biosecurity Act 1993.**

Appendix 5 **R N Barlow Experience**

Glossary

AIS	Automatic Identification System
BWM Convention	International Convention for the Control and Management of Ships Ballast Water and Sediments
DP	Dynamic Positioning - a system of maintaining a required position or heading
FPSO	Floating Production Storage and Offloading Vessel
FSO	Floating Storage and Offloading Vessel
HFO	Heavy Fuel Oil 380 Cs
IACS	International association of Classification Societies
IMO	International Maritime Organisation
MARPOL	International Convention for the Prevention of Pollution From Ships
MEPC	Maritime Environment Protection Committee of the IMO
SOLAS	Safety of Life at Sea Convention
SSMS	Safe Ship Management System
TTR	Trans-Tasman Resources Limited
UNCLOS	United Nations Convention on the Law of the Sea

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1. Executive Summary

Navigation Impacts of the project

The mining site in the South Taranaki Bight for which approval is sought is removed from regular marine traffic routes and activities and should not be in conflict with other marine traffic and activities in the area.

Exclusion Zone FPSO Operations

It is intended to apply to Maritime New Zealand to establish an exclusion zone (or an equivalent) around the FPSO when anchored on the mine site to safeguard other ocean users, members of the public and project vessels from harm.

The exclusion zone around the FPSO is unlikely to affect recreational opportunities in the mining area, the Marine Traffic Study indicates that the area is very lightly used by any vessels and the mine site, because of the nature of the sea bed material, is unlikely to support much marine life which would be of interest to recreational fisher or divers. The site is well removed from recreational boating launching and mooring sites.

Maritime Safety

All the major vessels employed on the project will be classed by a member of International Association of Classification Societies (IACS) and be compliant with the Safety of Life at Sea Convention (SOLAS) and all other International Maritime Organisation (IMO) Conventions as well as the Laws of New Zealand, any other smaller vessels will be registered under the New Zealand Safe Ship Management System (SSMS).

Bio security

Ballast Water and Biofouling

Bio security issues associated with the project essentially revolve around the management of ballast water and hull fouling of vessels arriving in New Zealand. All vessels arriving in New Zealand are required to make a ‘Ballast Water Declaration’ and comply with the ‘Import Health Standard for ships ballast water from all countries’ issued under Section 22 of the Biosecurity Act 1995 (Appendix 2)

In addition, arriving vessels will be required to meet the ‘Craft Risk Management Standard (CRMS) for Biofouling on Vessels arriving to New Zealand’ issued under section 24G of the Biosecurity Act 1993. (Appendix 4)

Operational discharges

Normal vessel operational discharges

Operational discharges will comprise of sea water used for cooling machinery and products of combustion from engines and turbines. Sewage and Garbage will be dealt with as required under MARPOL Annex IV and V.

Mining operational discharges from the FPSO

FPSO mining operational discharges will comprise of de-ored sand being replaced on the seabed in areas that have been mined and brine, which is a by-product of the reverse osmosis plant operation, this will be co-mingled with the de-ored sand.

Process operational discharge from the FSO

Process operational discharge from the FSO will comprise of brackish fresh water from the ore washing process.

Oil and oil products

All oils will be retained on board for disposal ashore at an approved facility.

Hazardous materials

Any hazardous materials will be retained on board for disposal ashore at an approved facility.

Ports

The project is likely to use a number of different ports to support the vessels engaged in the project depending on the services required and the method of delivering them. The ports of Wanganui, New Plymouth and Nelson are the closest to the mine site in that order and each may offer the project support in different ways according to their capabilities.

Personnel

TTR intends to incentivise the use of New Zealand citizens or New Zealand residents as employees of the company and its contractors to service the project.

It is envisaged that around 200 positions will be available to operate on marine vessels associated with the project.

It is envisaged that around 50 positions will be available to directly manage and operate TTR's projects on shore. There will be other direct employment effects resulting from TTR's project should it be approved. These will include maintenance and supply operations for the vessels.

2. Navigation Impacts of the project

2.1. Marine Traffic in South Taranaki Bight

A comprehensive study was commissioned from Marico Marine NZ Limited (Marico) into vessel movements in the South Taranaki Bight to establish the impact of the proposed mining project on vessel activity in the area. This is attached as Appendix A.

The study analysed 12 months of Automatic Identification System (AIS) data for the area extending from Cook Strait to Kahurangi Point and Cape Egmont including Tasman Bay.

AIS was developed primarily as a collision avoidance tool. Vessels that carry an AIS transponder broadcast at regular intervals key information such as their position, identity, type, speed, course, etc. AIS exists in two forms, Class A and Class B: the former is fitted in all vessels so mandated by International Maritime Organisation (IMO); the latter on a voluntary basis by non-SOLAS vessels such as recreational craft.

Regulation 19 of SOLAS Chapter V4 - sets out the navigational equipment to be carried on board ships according to ship type. AIS is required to be carried on:

- All ships of 300 and greater gross tonnage and engaged on international voyages;
- Cargo ships of 500 and greater gross tonnage not engaged on international voyages; and
- All passenger vessels irrespective of size.

The Marico study concluded that, the mining area proposed by Trans-Tasman Resources Limited in the South Taranaki Bight is well separated from the nearest regular shipping routes and commercial fishing grounds and should have 'very little impact, if any, on the safety of navigation in the adjacent areas'.

Figure 1 below shows the cumulative plot of all vessel types over 12 months monitoring of AIS data.

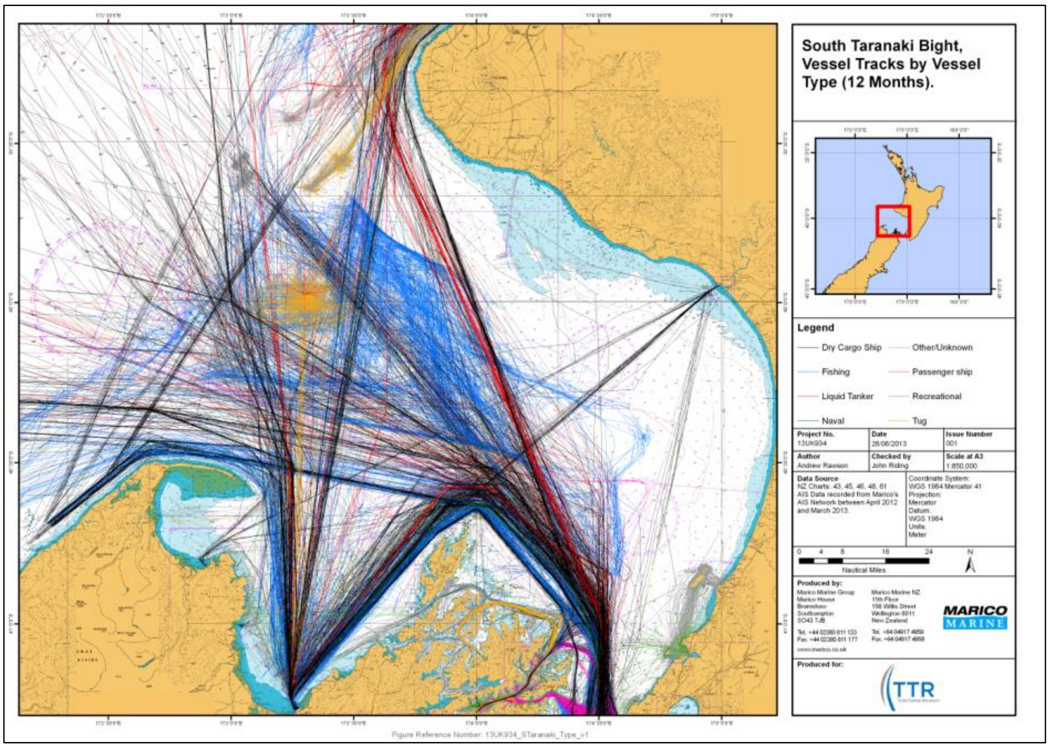

Figure1: cumulative plot of all vessel types over 12 months monitoring of AIS data

2.2. Proximity to Kupe Well Head Platform

The mining operations proposed by TTR will be adjacent and to the south east of the unmanned Kupe Well Head platform, but outside the exclusion zone around this installation and its associated pipelines. Marine activities associated with the platform will be easily accommodated by the mining operations and should not be in conflict.

2.3. TTR vessels' presence

The presence of TTR's manned vessels in the area will supplement the shore based surveillance of the platform's exclusion zone and add to the security of the Kupe operation. TTR's vessels will be equipped with Radar, AIS and an extensive communications suite to detect and communicate with vessels in the area.

2.4. Impacts on Other Marine Operations

Marine traffic in the areas that the project will be conducting these operations is very light, the areas relatively small and the impacts will be minor, if any.

3. Marine Vessel Operations – General Principles

The vessels, management, contractors and crews operating in mining, transporting and supporting the project will be compliant with IMO conventions and New Zealand Law.

It is intended that in addition to being fully compliant, 'best practice' will be the project's operating mantra.

3.1. Marine Vessel Operations – the FPSO

3.1.1. The mining and processing operations are planned to be undertaken continuously 24 hours per day, based on the FPSO which will be moored on a four anchor spread extending up to one nautical mile from the vessel, supplemented by a Dynamic Positioning system to ensure the loads on the mooring system do not exceed design limits.

3.1.2. The FPSO will show the lights and shapes for a vessel restricted in its ability to manoeuvre when at anchor, as required by the Maritime Rule 22.27. Working lights will also be very obvious to other marine traffic as required by Maritime Rule 22.30.

3.1.3. The FPSO will contain significant quantities of HFO. The FPSO's HFO tanks will meet international standards and will comply with the Maritime NZ's and the respective classification society's rules for the containment of fuel, particularly in regard to double containment.

3.1.4. The FPSO will be fitted with an AIS transmitter /receiver to alert traffic to its presence and for the officer of the watch to monitor nearby traffic. The AIS transmission gives position data sourced from GPS and can be monitored from the shore and if combined with mining logs will demonstrate that the vessel's location is in compliance with the consents

3.1.5. The position of each anchor will be marked by a buoy, which will be lit at night.

3.1.6. It is intended that an exclusion zone of one nautical mile radius be set up around the FPSO. This exclusion zone will move to the new location as the FPSO is moved.

3.1.7. The FPSO will move within the anchor pattern as mining and deposition of de-ored sand proceeds and the anchor pattern will be re-laid as extraction is completed in an area.

3.2. Marine Vessel Operations - the FPSO – FSO

3.2.1. The FSO will operate as the transfer vessel between the FPSO and the Export vessel.

3.2.2. The FSO will station itself by dynamic positioning (DP) adjacent to the bow of the FPSO and connect the product transfer hoses to receive the ore slurry.

3.2.3. Whilst approaching and when within the exclusion zone around the FPSO, the FSO will be restricted in its ability to manoeuvre and will show the lights and shapes as required by Maritime Rule 22.27 and 22.30.

3.3. Marine Vessel Operations – the FSO and Export vessel

3.3.1. The transfer operation between the FSO and the export vessel will take place with the export vessel at anchor and the FSO either moored to it or under dynamic positioning in close proximity to the export vessel.

3.3.2. The export vessel will show the lights and shapes required for a vessel at anchor under Maritime Rule 22.30 (1) and (2). The FSO, when transferring cargo and under dynamic positioning will show the lights required by Maritime Rule 22.27, otherwise the lights for a vessel at anchor as required under Maritime Rule 22.30.

3.4. Marine Vessel Operations - Anchor Handling Tug (AHTS)

3.4.1. The AHTS will be used to deploy and move the anchors of the FPSO as required, when doing so it will exhibit the lights of a towing vessel as required by Maritime Rule 22.24.

3.4.2. The AHTS may also be used to transfer stores and equipment to and from other vessels and the shore.

3.5. Marine Vessel Operations – Replenishment vessel

3.5.1. The replenishment vessel will be used to re-fuel the FPSO and the FSO with Heavy Fuel Oil, and supply other stores and spare parts; the fuel transfer will normally be undertaken whilst dynamically positioning alongside these vessels using the RAS method. The AHTS may undertake all or some of these functions.

3.5.2. The replenishment vessel's HFO tanks will meet international standards and will comply with the Maritime NZ's and the respective classification society's rules for the containment of fuel, particularly in regard to double containment.

3.5.3. Whilst replenishment is being undertaken, the replenishment vessel will be restricted in the way it can manoeuvre and show the lights and shapes as required under Maritime Rule 22.27.

3.5.4. Comprehensive operating manuals will be drawn up to manage the fuel transfer operation and a Project Oil Spill Response Plan submitted for approval to Maritime New Zealand.

4. Maritime Safety

4.1. General

4.1.1. All the major vessels employed on the project will be classed by a member of IACS (International Association of Classification Societies) and be compliant with the Safety of Life at Sea Convention (SOLAS) and all other International Maritime Organisation (IMO) Conventions as well as the Laws of New Zealand, any other smaller vessels will be registered under the New Zealand Safe Ship Management System (SSMS).

4.1.2. The vessels will be equipped with navigation equipment, (including charts both electronic and paper) as required by the IMO Conventions and New Zealand Maritime Rules.

4.1.3. The vessels will be equipped with Radar, AIS and an extensive communications suite to detect and communicate with other vessels in their proximity and the shore.

4.1.4. The vessels will be fitted with life-saving equipment as required by the SOLAS Convention and New Zealand Maritime Rules, the crews will be fully trained and competent to operate the life-saving equipment.

4.1.5. The presence of the project vessels in the South Taranaki Bight will be an asset to and enhance any search and rescue operations in the area.

4.1.6. The project will also be serviced by helicopter, which may be available to supplement the current rescue helicopter services in times of emergency.

4.2. Exclusion Zones

4.2.1. It is intended to apply to Maritime New Zealand to establish an exclusion zone, or an equivalent, around the FPSO when anchored on the mine site to safeguard other ocean users, members of the public and project vessels from harm.

4.2.2. The exclusion zone applied for will extend in a circle with a radius of approximately one nautical mile from the FPSO to extend beyond the extremities of the anchor pattern and cover the area where support vessels are manoeuvring and/or are constrained in their ability to manoeuvre.

4.2.3. It is intended that the exclusion zone will be monitored and all movements within the zone will be authorised by the Officer of the Watch on the FPSO.

4.2.4. If authorised by Maritime New Zealand this exclusion zone will be promulgated through Notices to Mariners and noted on Marine charts. Up to date position information of the FPSO will be promulgated to mariners through the vessel's AIS transmissions.

5. Transfer operations

5.1. FPSO to FSO

The FSO will station itself by dynamic positioning (DP) adjacent to the bow of the FPSO and connect the ore/fresh water slurry transfer hoses to receive the ore slurry. The mining operation will continue as the slurry is transferred.

5.2. FSO to Export Vessel

5.2.1. The transfer site for loading the export vessel will be chosen by the Master of the FSO in conjunction with the Master of the export vessel. The transfer site will be contingent on weather conditions at the time and the immediate forecast. It would be expected that the master of the FSO will be pre-eminent in this decision because of better local knowledge.

5.2.2. The transfer site nominated will be advised to Maritime New Zealand by the master of the FSO and a radio navigation warning issued to all vessels of the activity with a request to keep clear. All updates of position and notifications of completion of the operation to Maritime New Zealand will be the responsibility of the FSO master.

5.3. Fuel Transfer

5.3.1. Procedures for fuel transfer operations at sea will be as approved by Maritime New Zealand.

5.3.2. The commencement and completion of fuel transfer operations at sea will be notified to Maritime New Zealand by the Master of the replenishment vessel as required by Maritime Rule 103.

5.3.3. If this is to take place in a Harbour the relevant Harbour Authority will issue a fuel transfer permit as required by their by-laws.

6. Bio security

6.1. General

Bio security issues associated with the project essentially revolve around the management of ballast water and hull fouling.

6.2. Ballast Water

Since the introduction of steel hulled vessels around 120 years ago, water has been used as ballast to stabilize vessels at sea. Ballast water is pumped-in to maintain safe operating conditions throughout a voyage. This practice reduces stress on the hull, provides transverse stability, improves propulsion and manoeuvrability, and compensates for weight lost due to fuel and water consumption.

While ballast water is essential for safe and efficient modern shipping operations, it may pose serious ecological, economic and health problems due to the multitude of marine species carried in ships' ballast water. These include bacteria, microbes, small invertebrates, eggs, cysts and larvae of various species. The transferred species may survive to establish a reproductive population in the host environment, becoming invasive, out-competing native species and multiplying into pest proportions.

Preventing the transfer of invasive species and coordinating a timely and effective response to invasions requires cooperation and collaboration among governments, economic sectors, non-governmental organizations and international treaty organizations. The UN Convention on the Law of the Sea (UNCLOS) provides the global framework by requiring States to work together "to prevent, reduce and control human caused pollution of the marine environment, including the intentional or accidental introduction of harmful or alien species to a particular part of the marine environment."

The International Convention for the Control and Management of Ship's Ballast Water and Sediments 2004 (BWM convention) was adopted by consensus at a Diplomatic Conference held at IMO Headquarters in London on 13 February 2004. NZ is in the process of ratifying the BWM convention with Ministry of Transport and expect the process will be completed in about mid-2014.

The BWM convention requires all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. Parties to the BWM convention are given the option to take additional measures that are subject to criteria set out in the BWM convention and to IMO guidelines.

The vessels employed by the project will arrive in New Zealand from an overseas port and will be fully compliant with the requirements of the BWM convention with 'clean' water ballast and 'clean' tanks. In practice the vessels will have exchanged their ballast water in the tropics in deep water as recommended by IMO.

There will be operational ballasting and de-ballasting undertaken by project vessels in the EEZ and in the New Zealand Territorial Sea but this will be exchanging clean New Zealand ballast water.

All vessels arriving in New Zealand are required to make a 'Ballast Water Declaration' and comply with the 'Import Health Standard for ships ballast water from all countries' issued under Section 22 of the Biosecurity Act 1995.

All TTR's export vessels will arrive in New Zealand with compliant water ballast and 'clean' tanks. Ballast water will be pumped out of the export vessel when cargo is loaded as a normal operational discharge as is the case for most vessels loading cargoes in New Zealand waters.

6.3. Hull Biofouling

Vessels arriving in New Zealand will be required to comply with the IMO Biofouling Guidelines 2011 (Resolution MEPC 207(62), '2011 Guidelines for the Control and Management of ship's Biofouling to minimise the transfer of invasive aquatic species'. These guidelines will be enforced through the bio-fouling regulations which are currently being developed by the Ministry for Primary Industries.

The Guidelines include advice on the vessel's Biofouling Management Plan, Biofouling Record Book, Choosing the anti-fouling System, installing, and repairing the anti-fouling system, in water inspection, cleaning and maintenance

In addition arriving vessels will be required to meet the 'Craft Risk Management Standard (CRMS) for Biofouling on Vessels arriving to New Zealand' issued under section 24G of the Biosecurity Act 1993.

These standards will also apply to the export vessels and will be a pre-requisite for vessels uplifting cargoes from the project.

TTR's locally operated vessels will comply with the newly released "Controls for antifouling paints" put out by the EPA

7. Sewage

Sewage wastes will be treated on board the vessels in an approved manner and shipped ashore for treatment and disposal at an approved facility as detailed in the vessels' sewage management plan.

8. Garbage

Garbage will be treated on board the vessels in an approved manner and shipped ashore for treatment and disposal at an approved facility as detailed in the vessels' garbage management plan.

Appendix 1 South Taranaki Bight Marine Traffic Study

Supplied separately from this report.

Appendix 2

IMPORT HEALTH STANDARD FOR SHIPS' BALLAST WATER FROM ALL COUNTRIES

Issued pursuant to Section 22 of the Biosecurity Act 1993 Dated: 13 June 2005

1. REVIEW

The original standard was issued by Ministry of Fisheries in May 1998. It was reviewed to include improved procedures and transition to the format of Biosecurity New Zealand, Ministry of Agriculture and Forestry (MAF) in June 2005.

2. APPLICATION

This import health standard (IHS) applies to ballast water loaded within the territorial waters of a country other than New Zealand and intended for discharge in New Zealand waters. The IHS does not apply to: ballast water that will not be discharged in New Zealand waters; ballast water loaded in New Zealand waters; or emergency discharge of ballast water.

3. GENERAL CONDITIONS

It is the responsibility of the Master of the vessel to ensure that the ballast water and any associated sediment, intended for discharge in New Zealand, comply with the conditions in the standard. Ballast water that does not comply with the conditions must not be discharged in New Zealand waters.

Compliance with these controls must be consistent with the safety of the crew and the vessel. Nothing in these controls is to be read as relieving the Master of their responsibility for the safety of the vessel.

4. DEFINITIONS

Ballast water - water, including its associated constituents (biological or otherwise), placed in a ship to increase the draft, change the trim or regulate stability. It includes associated sediments, whether within the water column or settled out in tanks, sea-chests, anchor lockers, plumbing, etc.

Internal waters - means:

- harbours, estuaries, and other areas of the sea that are on the landward side of the baseline of the territorial sea of a coastal state; and
- rivers and other inland waters that are navigable by ships.

Inspector - an inspector appointed under section 103 of the Biosecurity Act, 1993

Nothing in this standard is to be read as relieving ship masters of their responsibility for the safety of the vessel, passengers and crew.

New Zealand waters - means:
• the internal waters of New Zealand; and
• the territorial sea of New Zealand.

Territorial sea – For New Zealand this is the sea within 12 nautical miles of the seaward side of the baseline of the territorial sea. (See section 3 of the Territorial Sea, Contiguous Zone and Exclusive Economic Zone Act, 1977 for definition of New Zealand baseline)

5. REQUIREMENTS FOR BALLAST WATER

5.1 No ballast water may be discharged into New Zealand waters without the permission of an inspector.

5.2 An inspector will only permit ballast water to be discharged if satisfied that the Master has met one of the criteria in section 6 below.

5.3 Part I of the Vessel Ballast Water Declaration approved by the Ministry of Agriculture and Forestry must be completed for all vessels. It should be completed before arrival in New Zealand and sent accompanying the Advance Notice of Arrival to the Ministry of Agriculture and Forestry Quarantine Service (MAFQS) office at the ship's first port of arrival.

5.4 For vessels indicating intention to discharge ballast in New Zealand, Part 2 of the Ballast Water Declaration must also be completed, except for the columns under Question 3 for Ballast Water Discharged. This should be sent to MAFQS before arrival in New Zealand, along with Part 1, in order for a vessel to be granted permission to discharge ballast water or be granted an exemption.

5.5 Permission to discharge ballast water is granted when an inspector approves the discharge, signs the 'Discharge of ballast permitted' form, and sends this back to the ship. Discharge of ballast is denied when an inspector does not approve the discharge, signs the 'Discharge of ballast denied' form and sends this to the ship.

5.6 Before the ship leaves New Zealand the original of Part 2 must be completed with details of the discharge in New Zealand. The original signed declarations must be kept on board while in New Zealand. In addition the copy faxed or emailed from MAFQS to the ship detailing the MAFQS direction to the vessel must also be retained. These are uplifted by MAFQS at the last port of call in New Zealand.

5.7 Sediment which has settled in ballast tanks, ballasted cargo holds, sea-chests, anchor lockers or other equipment must not be discharged into New Zealand waters. If the ship needs to discharge sediment in New Zealand, the sediment must be landed and taken to a landfill approved by an inspector.

6. OPTIONS FOR SATISFYING AN INSPECTOR

Option 1

Demonstrating the ballast water has been exchanged en route to New Zealand in areas free from coastal influences, preferably 200 nautical miles from the nearest land and in water over 200m in depth. Accepted techniques are either emptying and refilling ballast tanks/

Import Health Standard *Ships' Ballast Water From All Countries* June 2005 Page 2 holds with an efficiency of 95% volumetric exchange or pumping through the tanks a water volume equal to at least three times the tank capacity. Tanks should be pumped no more than two at a time and, if two tanks are pumped together, they should be a symmetrical pair of tanks to ensure the safety of the vessel.

Option 2

Demonstrating the ballast water is fresh water (not more than 2.5 parts per thousand sodium chloride).

Option 3

Ballast water has been treated using a shipboard treatment system approved by MAF.

Option 4

Ballast is discharged in an onshore treatment facility approved by MAF.

Note - there are presently no treatment systems or facilities approved by MAF for the purposes of options 3 and 4.

7. EXEMPTIONS

It is accepted that in some circumstances exchange may not be possible. Exemptions are granted by the same process as granting permission to discharge. An exemption will generally be granted when it can be demonstrated that:

Exemption 1

- The weather conditions on the voyage in combination with the construction of the vessel have precluded safe ballast water exchange; and
- the ballast water was not loaded in any area listed in Annex 1.

Exemption 2

- The construction of the vessel has precluded ballast water exchange; and
- the ballast water was not loaded in any area listed in Annex 1.

In the case of weather conditions or vessel construction precluding the safe exchange of ballast water from Annex 1 areas, the vessel must either redistribute the ballast water around the ship's ballasting spaces in order to load cargo or, if this is not possible to accomplish with a suitable margin of safety, the ship must leave New Zealand without loading some, or all, intended cargo.

Exempted vessels are asked to discharge the least amount of ballast water possible and discharge as far offshore as practicable.

8. COSTS

The costs of inspection, analysis, identification, delays, and any other costs associated with this standard are the responsibility of the owner and/or charterer. These costs shall be actual, fair and reasonable.

Import Health Standard *Ships' Ballast Water From All Countries* June 2005 Page 3

9. ENQUIRIES

Unless indicated to the contrary on communications, enquiries concerning this IHS should be addressed to:
Team Manager, Border Standards
Biosecurity New Zealand
Ministry of Agriculture and Forestry
PO Box 2526
Wellington
NEW ZEALAND
FAX: 64 - 4 - 498 9888

10. OFFENCES AND PENALTIES

Providing incorrect information to an inspector is an offence under the Biosecurity Act, 1993 section 154(b). It carries a penalty for individuals of up to 12 months imprisonment and/or a fine not exceeding NZ$50,000, and for corporations a fine not exceeding NZ$100,000. Failure to obey the directions of an inspector is an offence under section 154(o). It carries a penalty for individuals of a fine not exceeding NZ$5,000, and for corporations a fine not exceeding NZ$15,000.

11. OBTAINING INFORMATION

Ship masters should communicate with MAFQS inspectors prior to their arrival in New Zealand waters to determine requirements or discuss their options if permission has been denied (these may include carrying out an exchange and resubmitting a new declaration). Communications should be directed to the MAFQS office at the intended port of arrival or one of the following: MAF Quarantine Service
CPO Box 39
Auckland
Phone - (09) 303 3423
FAX - (09) 303 3037
Group Leader – 0272 924 820

MAF Quarantine Service
PO Box 3042
Wellington
Phone - 04) 473 8996
FAX - (04) 473 2079
Operations Manager 0274 361 345

MAF Quarantine Service
Private Bag 4765
Christchurch
Phone - (03) 328 7166
FAX - (03) 328 7186

Appendix 3 BALLAST WATER DECLARATION

BALLAST WATER DECLARATION: PART 1

TO BE COMPLETED FOR ALL VESSELS ARRIVING IN NEW ZEALAND

Vessel's Name:	Arrival Date:	Arrival Port:	Inspector's Name:

BALLAST WATER			
1	**Are you carrying ballast water?**	☐ YES ☐ NO	**If NO go to question 5**
2	**List any tanks loaded with ballast water in Port Phillip Bay, Victoria or Tasmania.**		**List Each Tank Number and Type (see codes below):**
3	**How will you comply with NZ's ballast water controls. (See NZ Import Health Standard for Ballast Water from all Countries.) Check the box indicating how you will comply**		**(A, B or C) below.**
	A. Not discharging any ballast water in New Zealand waters.	☐	
	B. Exchanging the ballast water mid-ocean in all tanks that are to be discharged in New Zealand waters. Indicate whether flow-through or empty/refill technique was used. Note: Flow-though requires 3 times the tank capacity to be pumped through the tank.	☐	**Flow-through ☐ or Empty/refill ☐**
	C. Discharging only fresh water. State when and where the water was loaded.	☐	**Date loaded: Port or Position:**
4	**If you cannot comply, check the box (A &/or B) indicating the reason(s). Give details.**		
	A. Vessel is not physically capable of either empty/refill or flow-through exchange	☐	**Specify Details:**
	B. Exchange would have caused unacceptable risk to crew or vessel due to weather conditions	☐	**Specify Details:**
CLEANING: SEDIMENTS			
5	**Do you intend to discharge sediment or other debris from ballast tanks/holds (excluding normal deballasting), anchors, chains or chain lockers in New Zealand waters? If YES, state when and where.**	☐ YES ☐ NO	**Date: Port or Position:**
	Please note that sediments must be discharged into an approved landfill.		
CLEANING: HULL FOULING			
6	**When and where was the vessel last dry-docked and cleaned?**		**Date: Port or Position:**
7	**Has the vessel been laid-up for 3 months or more since it was last dry-docked and cleaned? If YES, state when and where.**	☐ YES ☐ NO	**Date: Started: Date: Finished: Port or Position:**
8	**Do you intend to clean the hull of the vessel in New Zealand? If YES, state when and where.**	☐ YES ☐ NO	**Date: Port or Position:**

Ballast tank codes: Upper=U, Lower=L, Forepeak=FP, Aftpeak=AP, Double Bottom=DB, Deep Tank=DT, Wing Tank=WT, Topside=TS, Cargo Hold=CH, Other (specify), Port=P, Starboard=S, (eg 3UWTP):.

MASTER'S NAME AND SIGNATURE:	**MAF's directions to vessel:-**	**INSPECTOR'S SIGNATURE:**		
	☐ **Vessel not discharging** (Contact MAF if intentions change)	☐ **Discharge of ballast permitted**	☐ **Discharge of ballast denied** (Contact MAF to discuss options)	☐ **Exemption granted** (This voyage only)

New Zealand Ministry of Fisheries. Pursuant to section 22 of the Biosecurity Act 1993. Revised April 2004

BALLAST WATER DECLARATION: PART 2

TO BE COMPLETED FOR ALL VESSELS DISCHARGING BALLAST WATER IN NEW ZEALAND

1. VESSEL INFORMATION	Vessel's Name:	IMO Number:	Vessel's Call Sign:
Flag:	Vessel's Owner:	Vessel's Agent: PHOENIX SHIPPING	Gross Tonnage (MT):
Type of Vessel: ☐ Bulk ☐ Container	☐ Tanker ☐ RORO/Cars ☐ Fishing	Other(specify) Date Built:	Ballast pumping capacity : Pump A Pump B
Total Number of Ballast Tanks On Board Vessel:	Total Ballast Capacity (specify units):		
2. THIS VOYAGE	Date of Arrival in New Zealand:	Arrival Port:	Last Overseas Port:
	Date of Departure from New Zealand:	Departure Port:	Next Overseas Port:
Total Number of Tanks in Ballast on Arrival in New Zealand:		Total Ballast Volume on Arrival in NZ (specify units; m3, MT):	

3. BALLAST WATER DISCHARGED IN NEW ZEALAND (If none, go to bottom of page) TICK HERE IF THIS SECTION IS A CONTINUATION OF ANOTHER FORM ☐

IMPORTANT:
List the original **BALLAST WATER SOURCE(s)** for ballast taken on in countries other than **New Zealand**.
All tanks discharged in New Zealand that contained any ballast from another country prior to any exchange must be listed. Detail each ballast management operation for tanks listed.

TANK NO. and TYPE (see codes below)	BALLAST WATER SOURCE AT COMMENCEMENT OF VOYAGE				BALLAST WATER EXCHANGED E/R = Empty then Refill F/T = Flow Through					BALLAST WATER DISCHARGED		
	DATE LOADED (DD/MM/YY	PORT or LAT./LONG.	VOLUME LOADED (specify units)	FINAL VOLUME IN TANK (specify units)	E/R or F/T	START DATE FINISH DATE (DD/MM/YY)	START TIME FINISH TIME (HH:MM)	START LAT. LONG FINISH LAT. LONG.	VOLUME FLOWED THROUGH or being EXCHANGED (specify units)	DATE DISCHARGED	PORT or LAT./LONG.	VOLUME DISCHARGED (specify units)

Ballast tank codes: Upper=U, Lower=L, Forepeak=FP, Aftpeak=AP, Double Bottom=DB, Deep Tank=DT, Wing Tank=WT, Topside=TS, Cargo Hold=CH, Other (specify), Port=P, Starboard=S, (eg 3UWTP).

MASTER'S NAME AND SIGNATURE:

New Zealand Ministry of Fisheries. Pursuant to section 22 of the Biosecurity Act 1993. Revised April 2004

Appendix 4 CRAFT RISK MANAGEMENT STANDARD

Craft Risk Management Standard
For Vessel Biofouling
Short Name: CRMS - BIOFOUL

Issuing Authority

This standard is issued under section 24G of the Biosecurity Act 1993 (the Act).

It commences in four years on the day and month of signature below*.

Dated at Wellington this day of 20 _ _

Peter Thomson

Director, Plants, Food and Environment
Standards Branch, Ministry for Primary Industries (MPI)
(Issued under delegated authority)

* The four year lead-in period before commencement of enforcement of this standard is intended to allow shipping, and other vessel operators, time to make any adjustments needed to their hull maintenance regimes. It is also expected that during this time other jurisdictions will implement clean hull requirements and also that technology for acceptable in-water hull cleaning and provision of hull cleaning services will have developed to the extent that most vessels will be compliant when it comes in to force. Towards the end of the four year period, MPI will review the current hull maintenance practices and other factors to check that the expected improved environment for enforcing the standard has eventuated.

Voluntary compliance is encouraged during the lead-in period. MPI will monitor indicators of each arriving vessel's hull cleanliness through mandatory questions in the advance arrival information. These questions must be answered and false declaration can lead to prosecution under the Act. The information collected will used for the review.

Note: see Guidance Document for explanatory information

Ministry for Primary Industries
P.O Box 2526, Wellington 6011
New Zealand

For all matters relating to the interpretation, review and amendment of this standard, please contact:

Biosecurity and Environment Group
Ministry for Primary Industries
PO Box 2526
Wellington 6011
New Zealand

Phone: 0800 008333

Email: standards@mpi.govt.nz

For all matters relating to the operation of this standard, including inspections, audits and treatments, please contact MPI at your port of arrival. See listed at

http://www.biosecurity.govt.nz/regs/ships/ports-first-arrival

This Standard is accessible on: (*hyperlink to be inserted*)

www

Amendment record:

Table of Contents

INTRODUCTION

Vessel biofouling is a major pathway for the introduction of non-indigenous marine organisms into New Zealand territorial waters, some of which may be harmful to New Zealand resources, economy, environment, and/or people's health and well being. This CRMS manages the risk of introduction into NZ territory and surrounding waters of harmful organisms associated with arriving vessels.

BIOSECURITY REQUIREMENTS – VESSELS ARRIVING TO NEW ZEALAND

This standard applies to any vessel, which arrives into New Zealand territory, meaning a vessel that will anchor, berth or be brought ashore after a voyage originating outside New Zealand's Territorial Sea.

The risk to be managed is the introduction into New Zealand of harmful organisms carried as biofouling on the submerged or periodically submerged parts of the hull.

Outcome Statement:

The outcome of this standard is **to minimise the entry into New Zealand of those harmful organisms that constitute vessel biofouling[1] or are harboured in the biofouling[2].**

Requirements:

A vessel must arrive in New Zealand with a 'clean hull'.

'Clean hull' means that no biofouling of live organisms is present other than within the thresholds below.

'Clean hull' thresholds:

The following criteria are used in assessing whether a vessel has a 'clean hull' according to vessel category. There are two different vessel categories and applicable biofouling allowances – for 1) long-stay vessel and 2) short-stay vessel. The vessel category applies to a vessel for its entire visit to New Zealand (from time of arriving to time of departing NZ territory.

The meaning of 'hull' (including various hull parts in Table 1 and 2) is given in the Appendix.

a) 'Long-stay vessels' means those vessels intending to remain in New Zealand for 21 days or longer and/or visit areas other than those designated under section 37 of the Act as 'Places of First Arrival'.

Table 1: Biofouling Allowances for Long-Stay Vessels

Hull part	Allowable biofouling
All hull surfaces	Slime layer;

[1] Such as algae, barnacles, mussels and oysters
[2] Such as free living worms, sea-stars, fish or shrimps

	Goose barnacle

b) ‘Short-stay vessels’ means those vessels intending to remain in New Zealand for 20 days or less and to only visit places designated under section 37 of the Act as ‘Places of First Arrival’. These vessels generally remain under ‘biosecurity surveillance’ while in New Zealand territory rather than becoming fully cleared of risk goods.

Table 2: Biofouling Allowances for Short-Stay Vessels

Hull part	Allowable biofouling
All hull surfaces	Slime layer; Goose barnacles.
Wind and water line	Green algae growth of unrestricted cover and no more than 50 mm in frond, filament or beard length; Brown and red algal growth of no more than 4 mm in length; Incidental (maximum of 1%) coverage of one organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ isolated individuals or small clusters; and ▪ a single species, or what appears to be the same species.
Hull area	Algal growth occurring as: ▪ no more than 4 mm in length; and ▪ continuous strips and/or patches of no more than 50 mm in width. Incidental (maximum of 1%) coverage of one organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ isolated individuals or small clusters that have no algal overgrowth; and ▪ a single species, or what appears to be the same species.
Niche areas	Algal growth occurring as: ▪ no more than 4 mm in length; and ▪ continuous strips and/or patches of no more than 50 mm in width. Scattered (maximum of 5%) coverage of one organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ widely spaced individuals and/or infrequent, patchy clusters that have no algal overgrowth; and ▪ a single species, or what appears to be the same species; and Incidental (maximum of 1%) coverage of a second organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ isolated individuals or small clusters that have no algal overgrowth; and ▪ a single species, or what appears to be the same species.

Refer to the guidance document for illustrations and photo examples of the biofouling allowances.

ACCEPTABLE MEASURES FOR MEETING THE STANDARD

One of the following measures must be applied to achieve the outcome:

i. Cleaning before visit to New Zealand (or immediately on arrival in a facility approved[3] by MPI within 24 hours of arrival) – All biofouling must be removed from all parts of the hull and this must be carried out less than 30 days before arrival to New Zealand.

ii. Continual Maintenance using best practice including:- regular application of antifoul coatings; operation of marine growth prevention systems on sea-chests; and in-water inspections with biofouling removal as required. Following the IMO Biofouling Guidelines[4] is recognised as an example of best practice.

iii. Application of Approved Treatments[5]. Treatments are approved and listed under the Approved Biosecurity Treatment Standard MPI-STD- ABTRT

As an alternative a vessel operator may submit, for MPI approval, a Craft Risk Management Plan (which includes steps that will be taken to reduce risk to the equivalent degree as meeting the requirements of this standard).

Refer to the Guidance Document for information on: how to apply for approval of treatments, requirements for approval of treatments, and list of generally available approved treatments and for examples of evidence of measures i to iii that can be presented on arrival to expedite clearance.

COMPLIANCE

An operator, or the person in charge of a vessel, must take all reasonable steps to comply with this standard. Any vessel that does not meet the requirements of this standard is likely be directed under section 32 or 33 of the Act to take action to mitigate the risk and, if mitigation measures cannot be taken, is likely to be directed to leave New Zealand.

Deliberate non-compliance with the requirements of this standard or negligence leading to non-compliance will lead to increased intervention regimes (e.g. inspections or audits) and/or serving of a compliance order and/or prosecution of liable parties under the Act.

BIOFOULING INFORMATION

The following information is to be provided to MPI prior to arrival (via the Advanced Notice of Arrival)

- Intended length of stay within New Zealand territory and intentions in respect of places to be visited

[3] Means approved as a transitional facility under section 39 of the Act
[4] The current version, including templates for biofouling management plans and records, can be read on MPI's website here http://www.biosecurity.govt.nz/files/enter/ships/2011-imo-biofouling-guidelines.pdf. The Guidelines are available for purchase from the IMO. The English language version has the following reference: I662E ISBN 978-92-801-1545-1
[5] 'Approved Treatment' includes any treatment or other means for meeting the outcome of standard that has received MPI approval.

- Whether the vessel has spent an extended period mainly stationary in a single location. If so, the location and duration of the most recent occurrence of such a stay.
- If the vessel is coming in to undergo biofouling cleaning on arrival, any formal arrangement for cleaning or treatment that will be undertaken immediately upon arrival
- What measures have been or will be used to meet the requirements of the standard, or
- Whether the operator has chosen to operate an MPI approved Craft Risk Management Plan (CRMP) as an alternative to meeting the requirements of the standard (See section 2.5, Approved Treatments, in the Guidance Document for explanation of CRMPs).

The following information (if relevant) must be held on the vessel and provided to MPI in an appropriate form if requested. (This is in addition to information to be provided prior to arrival).

- Information on the antifouling regime and any marine growth prevention systems used. If applying the IMO Biofouling Guidelines, a biofouling management plan showing the hull maintenance and inspection regime and the records kept, preferably consistent with the template in the IMO guidelines[6].
- If applicable to the vessel, its latest International Anti-fouling System Certificate or International Anti-fouling System Declaration,
- Date and reporting from the latest hull biofouling inspection (undertaken either on land or in-water) that was initiated by the vessel operator.

Appendix - TERMS & DEFINITIONS

The following terms and definitions apply to this Standard. Other terms used are as per the Biosecurity Act 1993.

algal growth
Growth of algae that is visible to the naked eye. Algae may be either single celled filamentous forms or multi-celled macroalgae (seaweed) species and includes coralline algae.

biofouling
The accumulation of aquatic organisms such as micro-organisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment.

goose barnacles
Also called stalked barnacles or gooseneck barnacles, goose barnacles are ubiquitous foulers of tropical, subtropical and temperate seas, with a wide oceanic distribution that includes attachment to drift wood, floating plant debris and vessel hulls, as well as turtles and whales.

[6] The current version, including templates for biofouling management plans and records, can be read on MPI's website here http://www.biosecurity.govt.nz/files/enter/ships/2011-imo-biofouling-guidelines.pdf. The Guidelines are available for purchase from the IMO. The English language version has the following reference: I662E ISBN 978-92-801-1545-1

harmful organisms
Organisms that may cause unwanted harm to natural and physical resources or human health in New Zealand

hull
The immersed (including occasionally immersed) surfaces of a vessel including the following three parts. Includes pontoons.

> **hull area**
> The immersed surfaces of a vessel excluding niche areas and wind/water line.
> **niche areas**
> Areas on a vessel hull that are more susceptible to biofouling due to different hydrodynamic forces, susceptibility to coating system wear or damage, or being inadequately, or not, painted, e.g., sea chests, bow thrusters, propeller shafts, inlet gratings, dry-dock support strips, etc. Includes appendages.
> **wind and water line**
> The area of the hull that is subject to alternating immersion due to a vessel's movement or loading conditions (also known in shipping as the Boot-top).

IMO
International Maritime Organisation

New Zealand's Territorial Sea
Is the sea bounding New Zealand out to 12 nautical miles from an internal baseline as described in the Territorial Sea, Contiguous Zone, and Exclusive Economic Zone Act 1977

slime layer
A layer of microscopic organisms, such as bacteria and diatoms, and the slimy substances that they produce.

vessel or sea-craft
Is a subset of 'craft' as defined by the Act and means every description of boat or other craft used in water navigation, whether or not it has any means of propulsion; also includes: a barge, lighter, hovercraft or floating drilling rig. It does not include aircraft.

vessel operator
Operator of a vessel, either the master or skipper or a land-based ships' operations manager.

Appendix 5

Captain Ray Barlow MNI

Qualifications

Master Mariner (1st Class) Certificate

Experience

Port Operations Management
Successfully operating a surge affected port
Pilotage
Towage
Contracting
Nautical Advice
HSE Management in Port and Marine environment
HR and Industrial Relations
Specialties:

Petro chemical terminals
Offshore support operations
Dynamic under keel clearance
Waterfront labour relations
Oil Spill Response planning
Harbour Towage
Tug and Launch design choice and construction supervision
Container Terminal development and management
Port Planning and optimisation
Ship motions and their affects on safe operations in shallow water
Port and Marine Safety Management

Positions Held

Chairman Global Air And Water Limited

May 2011 – Present (2 years 4 months)

Infection Control and bio security programmes
Health and Phyto sanitary solutions. Food Safety Solutions

Principal R N Barlow and Associates Limited

April 2010 – Present (3 years 5 months)

Advisory services in transport, marine and engineering sectors
Governance positions in engineering, logistics, infection control and bio security solutions

Director Engineering Taranaki Consortium

June 2010 – July 2012 (2 years 2 months) New Plymouth NZ

Independent Director

Operations Manager at Port Taranaki Limited
September 1988 - April 2010 (21 years 8 months)
Deputy Chief Executive, responsible for all operations, engineering and procurement.
Marine
Services – pilotage, towage, launches, moorings, hydrography.
Engineering Design and Maintenance. Container Terminal Operations, Petro-chemical terminal operations, Security. Statutory compliance.
Harbourmaster Port Taranaki at Taranaki Regional Council
September 1988 - December 2009 (21 years 4 months)
Responsible for management of safety of navigation at Port Taranaki. Development and implementation of Marine Oil Spill response plan
Relief Pilot and Loading Master at NZ Steel Mining Ltd
January 1980 - December 1995 (16 years)
Acting as relief pilot and loading master at the Taharoa Marine Terminal for the export of ironsands in slurry form into bulk carriers up to 135,000 dwt through an SBM moored in the Tasman Sea
Harbour Pilot at Taranaki Harbours Board
October 1970 - August 1988 (17 years 11 months)
Harbour Pilot, Tugmaster, Dredgemaster

Recent Projects

Review of New Zealand's Oil Spill Preparedness and Response Capability

Work as part of a team with Thompson Clarke Shipping Limited to review and report on NZ's oil spill preparedness and...View

Review operating parameters for pilotage of vessels entering and departing the Port of Gisborne

Full review of berthing criteria applying qualitative risk assessment techniques and recommendations on weather parameters

Value for Money Review Maritime New Zealand

Part of a team of industry players assisting MNZ to evaluate its performance and identify where value for money could be better spent

Review of New Zealand's Oil Spill Preparedness and Response CapabilityEditRe-order section

November 2010 – February 2011

Work as part of a team with Thompson Clarke Shipping Limited to review and report on NZ's oil spill preparedness and response capability

Safety Management system for Port Otago and Otago Regional Council

Assist development of a Safety Management system in compliance with the NZ Port and Harbour Safety CodeView

Marine advice to ALARP review of Wire lining at Kupe Offshore Platform Origin Energy

Acted as marine advisor to Operational safety review of proposed well maintenance procedures on Kupe Offshore platform

Marine advisor project to extend pipelines and relocate SBM at Taharoa Offshore Loading Terminal NZ

1. Marine advice for launching 450m triple pipeline at Port Taranaki NZ 2. Marine advice for 70nm bottom tow to Site

Report on Future Towage requirements for the Port of Gisborne

Review existing towage arrangements and forecast shipping arrivals. Report on requirements to meet current and future

Marine Advisor to Trans Tasman Resources Ltd Marine Advisor for Consenting

Provide advice on the effects of proposed marine operations in preparation of evidence for resource consent applications for mining ironsands

Project to improve Mooring Safety at Port Taranaki

Development of Port Numerical Wave Model to describe current wave climate under storm conditions and test various mooring

Project to advise on depth required for future operations at Eastland Port NZ

Project to assess depth required for future operations at Eastland Port to assist in Resource Consent application for dredging

Memberships

Member of the Institute of Directors

Member of the Nautical Institute

Past President of the New Zealand Maritime Pilots Association

Appendix 19.7 - DRA Equipment List

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
	PFD NO: C8381-PFD-20-110	**ROM & SCALPING**								
20-PU-1102	Dredge Booster Pump	Weir	750MCM	14706	m³/hr					
20-PU-1118	Stream #1 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-PU-1218	Stream #2 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-PU-1318	Stream #3 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-PU-1418	Stream #4 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-SC-1106	ROM Scalping Screen #1	Vibramech		2000	tph					
20-SC-1206	ROM Scalping Screen #2	Vibramech		2000	tph					
20-SC-1306	ROM Scalping Screen #3	Vibramech		2000	tph					
20-SC-1406	ROM Scalping Screen #4	Vibramech		2000	tph					
20-CH-1112	ROM Scalping Screen #1 Underpan									
20-CH-1212	ROM Scalping Screen #2Underpan									
20-CH-1312	ROM Scalping Screen #3 Underpan									
20-CH-1412	ROM Scalping Screen #4 Underpan									
20-TK-1110	Elutriator #1			3971	m³/hr					
20-TK-1210	Elutriator #2			3972	m³/hr					
20-TK-1310	Elutriator #3			3973	m³/hr					
20-TK-1410	Elutriator #4			3974	m³/hr					
20-DB-1104	Feed Pressure Splitter			14706	m³/hr					
20-CH-1108	Screen #1 Oversize Chute									
20-CH-1208	Screen #2 Oversize Chute									
20-CH-1308	Screen #3 Oversize Chute									
20-CH-1408	Screen #4 Oversize Chute									

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Revision	Rev B
Date	17-Mar-14
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Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-PU-1120	Stream #1 & #2 Spillage Pump	Weir								
20-PU-1220	Stream #3 & #4 Spillage Pump	Weir								
	PFD NO: C8381-PFD-20-210	**MIMS - STREAM 1**								
20-PU-2102	MIMS Stream 1 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2104	MIMS Stream 1 - Feed Distributor									
20-MS-2112A	MIMS Stream 1 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2112B	MIMS Stream 1 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2122A	MIMS Stream 1 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2122B	MIMS Stream 1 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2132A	MIMS Stream 1 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2132B	MIMS Stream 1 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2142A	MIMS Stream 1 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2142B	MIMS Stream 1 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2114	MIMS Stream 1 - MagSep #1 Underpan									
20-CH-2124	MIMS Stream 1 - MagSep #2 Underpan									
20-CH-2134	MIMS Stream 1 - MagSep #3 Underpan									
20-CH-2144	MIMS Stream 1 - MagSep #4 Underpan									
20-CY-2116	MIMS Stream 1 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2126	MIMS Stream 1 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2136	MIMS Stream 1 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2146	MIMS Stream 1 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-220	**MIMS - STREAM 2**								
20-PU-2202	MIMS Stream 2 - Feed Pump	Weir	350MCU	2462	m³/hr					

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Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-DB-2204	MIMS Stream 2 - Feed Distributor									
20-MS-2212A	MIMS Stream 2 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2212B	MIMS Stream 2 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2222A	MIMS Stream 2 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2222B	MIMS Stream 2 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2232A	MIMS Stream 2 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2232B	MIMS Stream 2 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2242A	MIMS Stream 2 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2242B	MIMS Stream 2 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2214	MIMS Stream 2 - MagSep #1 Underpan									
20-CH-2224	MIMS Stream 2 - MagSep #2 Underpan									
20-CH-2234	MIMS Stream 2 - MagSep #3 Underpan									
20-CH-2244	MIMS Stream 2 - MagSep #4 Underpan									
20-CY-2216	MIMS Stream 2 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2226	MIMS Stream 2 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2236	MIMS Stream 2 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2246	MIMS Stream 2 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-230	**MIMS - STREAM 3**								
20-PU-2302	MIMS Stream 3 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2304	MIMS Stream 3 - Feed Distributor									
20-MS-2312A	MIMS Stream 3 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2312B	MIMS Stream 3 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2322A	MIMS Stream 3 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

TTR Trans-Tasman Resources

DRA

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-MS-2322B	MIMS Stream 3 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2332A	MIMS Stream 3 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2332B	MIMS Stream 3 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2342A	MIMS Stream 3 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2342B	MIMS Stream 3 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2314	MIMS Stream 3 - MagSep #1 Underpan									
20-CH-2324	MIMS Stream 3 - MagSep #2 Underpan									
20-CH-2334	MIMS Stream 3 - MagSep #3 Underpan									
20-CH-2344	MIMS Stream 3 - MagSep #4 Underpan									
20-CY-2316	MIMS Stream 3 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2326	MIMS Stream 3 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2336	MIMS Stream 3 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2346	MIMS Stream 3 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-240	**MIMS - STREAM 4**								
20-PU-2402	MIMS Stream 4 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2404	MIMS Stream 4 - Feed Distributor									
20-MS-2412A	MIMS Stream 4 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2412B	MIMS Stream 4 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2422A	MIMS Stream 4 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2422B	MIMS Stream 4 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2432A	MIMS Stream 4 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2432B	MIMS Stream 4 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2442A	MIMS Stream 4 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-MS-2442B	MIMS Stream 4 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2414	MIMS Stream 4 - MagSep #1 Underpan									
20-CH-2424	MIMS Stream 4 - MagSep #2 Underpan									
20-CH-2434	MIMS Stream 4 - MagSep #3 Underpan									
20-CH-2444	MIMS Stream 4 - MagSep #4 Underpan									
20-CY-2416	MIMS Stream 4 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2426	MIMS Stream 4 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2436	MIMS Stream 4 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2446	MIMS Stream 4 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-250	**MIMS - STREAM 5**								
20-PU-2502	MIMS Stream 5 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2504	MIMS Stream 5 - Feed Distributor									
20-MS-2512A	MIMS Stream 5 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2512B	MIMS Stream 5 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2522A	MIMS Stream 5 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2522B	MIMS Stream 5 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2532A	MIMS Stream 5 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2532B	MIMS Stream 5 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2542A	MIMS Stream 5 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2542B	MIMS Stream 5 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2514	MIMS Stream 5 - MagSep #1 Underpan									
20-CH-2524	MIMS Stream 5 - MagSep #2 Underpan									
20-CH-2534	MIMS Stream 5 - MagSep #3 Underpan									

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-CH-2544	MIMS Stream 5 - MagSep #4 Underpan									
20-CY-2516	MIMS Stream 5 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2526	MIMS Stream 5 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2536	MIMS Stream 5 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2546	MIMS Stream 5 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-260	**MIMS - STREAM 6**								
20-PU-2602	MIMS Stream 6 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2604	MIMS Stream 6 - Feed Distributor									
20-MS-2612A	MIMS Stream 6 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2612B	MIMS Stream 6 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2622A	MIMS Stream 6 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2622B	MIMS Stream 6 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2632A	MIMS Stream 6 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2632B	MIMS Stream 6 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2642A	MIMS Stream 6 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2642B	MIMS Stream 6 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2614	MIMS Stream 6 - MagSep #1 Underpan									
20-CH-2624	MIMS Stream 6 - MagSep #2 Underpan									
20-CH-2634	MIMS Stream 6 - MagSep #3 Underpan									
20-CH-2644	MIMS Stream 6 - MagSep #4 Underpan									
20-CY-2616	MIMS Stream 6 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2626	MIMS Stream 6 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2636	MIMS Stream 6 - Cyclone #3	Multotec		558	m³/hr					

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Revision	Rev B
Date	17-Mar-14
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TTR Trans-Tasman Resources

DRA

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-CY-2646	MIMS Stream 6 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-270	**MIMS - STREAM 7**								
20-PU-2702	MIMS Stream 7 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2704	MIMS Stream 7 - Feed Distributor									
20-MS-2712A	MIMS Stream 7 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2712B	MIMS Stream 7 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2722A	MIMS Stream 7 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2722B	MIMS Stream 7 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2732A	MIMS Stream 7 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2732B	MIMS Stream 7 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2742A	MIMS Stream 7 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2742B	MIMS Stream 7 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2714	MIMS Stream 7 - MagSep #1 Underpan									
20-CH-2724	MIMS Stream 7 - MagSep #2 Underpan									
20-CH-2734	MIMS Stream 7 - MagSep #3 Underpan									
20-CH-2744	MIMS Stream 7 - MagSep #4 Underpan									
20-CY-2716	MIMS Stream 7 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2726	MIMS Stream 7 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2736	MIMS Stream 7 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2746	MIMS Stream 7 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-280	**MIMS - STREAM 8**								
20-PU-2802	MIMS Stream 8 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2804	MIMS Stream 8 - Feed Distributor									

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Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
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Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-MS-2812A	MIMS Stream 8 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2812B	MIMS Stream 8 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2822A	MIMS Stream 8 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2822B	MIMS Stream 8 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2832A	MIMS Stream 8 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2832B	MIMS Stream 8 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2842A	MIMS Stream 8 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2842B	MIMS Stream 8 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2814	MIMS Stream 8 - MagSep #1 Underpan									
20-CH-2824	MIMS Stream 8 - MagSep #2 Underpan									
20-CH-2834	MIMS Stream 8 - MagSep #3 Underpan									
20-CH-2844	MIMS Stream 8 - MagSep #4 Underpan									
20-CY-2816	MIMS Stream 8 - Cyclone #1	Multotec		558	m^3/hr					
20-CY-2826	MIMS Stream 8 - Cyclone #2	Multotec		558	m^3/hr					
20-CY-2836	MIMS Stream 8 - Cyclone #3	Multotec		558	m^3/hr					
20-CY-2846	MIMS Stream 8 - Cyclone #4	Multotec		558	m^3/hr					
	PFD NO: C8381-PFD-20-310	**LIMS - STREAM 1**								
20-TK-3102	LIMS 1 Stream 1 - Feed Tank									
20-PU-3104	LIMS 1 Stream 1 - Feed Pump	Weir	350MCU	1899	m^3/hr					
20-DB-3106	LIMS 1 Stream 1 - Feed Distributor									
20-MS-3112A	LIMS 1 Stream 1 - MagSep #1A	Steinert	single - 1s - 1250G							
20-MS-3112B	LIMS 1 Stream 1 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3112C	LIMS 1 Stream 1 - MagSep #1C	Steinert	single - 1s - 1250G							

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-MS-3112D	LIMS 1 Stream 1 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3122A	LIMS 1 Stream 1 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3122B	LIMS 1 Stream 1 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3122C	LIMS 1 Stream 1 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3122D	LIMS 1 Stream 1 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3114	LIMS 1 Stream 1 - MagSep #1 Underpan									
20-CH-3124	LIMS 1 Stream 1 - MagSep #2 Underpan									
20-CY-3116	LIMS 1 Stream 1 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3126	LIMS 1 Stream 1 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-320	**LIMS - STREAM 2**								
20-TK-3202	LIMS 1 Stream 2 - Feed Tank									
20-PU-3204	LIMS 1 Stream 2 - Feed Pump	Weir	350MCU	1899	m³/hr					
20-DB-3206	LIMS 1 Stream 2 - Feed Distributor									
20-MS-3212A	LIMS 1 Stream 2 - MagSep #1A	Steinert	single - 1s - 1250G							
20-MS-3212B	LIMS 1 Stream 2 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3212C	LIMS 1 Stream 2 - MagSep #1C	Steinert	single - 1s - 1250G							
20-MS-3212D	LIMS 1 Stream 2 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3222A	LIMS 1 Stream 2 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3222B	LIMS 1 Stream 2 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3222C	LIMS 1 Stream 2 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3222D	LIMS 1 Stream 2 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3214	LIMS 1 Stream 2 - MagSep #1 Underpan									
20-CH-3224	LIMS 1 Stream 2 - MagSep #2 Underpan									

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-CY-3216	LIMS 1 Stream 2 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3226	LIMS 1 Stream 2 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-330	**LIMS - STREAM 3**								
20-TK-3302	LIMS 1 Stream 3 - Feed Tank									
20-PU-3304	LIMS 1 Stream 3 - Feed Pump	Weir	350MCU	1899	m³/hr					
20-DB-3306	LIMS 1 Stream 3 - Feed Distributor									
20-MS-3312A	LIMS 1 Stream 3 - MagSep #1A	Steinert	single - 1s - 1250G							
20-MS-3312B	LIMS 1 Stream 3 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3312C	LIMS 1 Stream 3 - MagSep #1C	Steinert	single - 1s - 1250G							
20-MS-3312D	LIMS 1 Stream 3 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3322A	LIMS 1 Stream 3 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3322B	LIMS 1 Stream 3 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3322C	LIMS 1 Stream 3 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3322D	LIMS 1 Stream 3 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3314	LIMS 1 Stream 3 - MagSep #1 Underpan									
20-CH-3324	LIMS 1 Stream 3 - MagSep #2 Underpan									
20-CY-3316	LIMS 1 Stream 3 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3326	LIMS 1 Stream 3 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-340	**LIMS - Stream 4**								
20-TK-3402	LIMS 1 Stream 4 - Feed Tank									
20-PU-3404	LIMS 1 Stream 4 - Feed Pump	Weir	350MCU	1899	m³/hr					
20-DB-3406	LIMS 1 Stream 4 - Feed Distributor									
20-MS-3412A	LIMS 1 Stream 4 - MagSep #1A	Steinert	single - 1s - 1250G							

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-MS-3412B	LIMS 1 Stream 4 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3412C	LIMS 1 Stream 4 - MagSep #1C	Steinert	single - 1s - 1250G							
20-MS-3412D	LIMS 1 Stream 4 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3422A	LIMS 1 Stream 4 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3422B	LIMS 1 Stream 4 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3422C	LIMS 1 Stream 4 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3422D	LIMS 1 Stream 4 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3414	LIMS 1 Stream 4 - MagSep #1 Underpan									
20-CH-3424	LIMS 1 Stream 4 - MagSep #2 Underpan									
20-CY-3416	LIMS 1 Stream 4 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3426	LIMS 1 Stream 4 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-410	**CLASSIFICATION & MILLING STREAM 1**								
20-TK-4102	Stream 1 - Cyclone #1 Feed Tank									
20-PU-4104	Stream 1 - Cyclone #1 Feed Pump	Weir	250MCU	1042	m³/hr					
20-PU-4106	Stream 1 - Sheer Pump	Weir	250MCU	1042	m³/hr					
20-CY-4108	Stream 1 - Cyclone 1	Multotec		1042	m³/hr					
20-DB-4110	Stream 1 - Derrick Screen Feed Distributor									
20-DB-4112A	Stream 1 - Derrick Scalping Screen 1 Feed Distributor									
20-DB-4112B	Stream 1 - Derrick Scalping Screen 2 Feed Distributor									
20-DB-4112C	Stream 1 - Derrick Scalping Screen 3 Feed Distributor									
20-DB-4112D	Stream 1 - Derrick Scalping Screen 4 Feed Distributor									
20-DB-4112E	Stream 1 - Derrick Scalping Screen 5 Feed Distributor									
20-SC-4114A	Stream 1 - Derrick Scalping Screen 1	Derrick								

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-SC-4114B	Stream 1 - Derrick Scalping Screen 2	Derrick								
20-SC-4114C	Stream 1 - Derrick Scalping Screen 3	Derrick								
20-SC-4114D	Stream 1 - Derrick Scalping Screen 4	Derrick								
20-SC-4114E	Stream 1 - Derrick Scalping Screen 5	Derrick								
20-TK-4116	Stream 1 - Cyclone #2 Feed Collection Tank									
20-PU-4118	Stream 1 - Cyclone #2 Feed Pump	Weir	250MCU	1460	m³/hr					
20-CY-4120	Stream 1 - Cyclone 2	FLSmidth		1460	m³/hr					
20-VM-4122	Stream 1 - Mill	Metso	VTM-3000-WB Vertimill®							
20-SC-4124	Stream 1 - Mill Discharge Screen									
20-PU-4188	Stream 1 - Mill Discharge Sump Spillage pump	Weir			m³/hr					
	PFD NO: C8381-PFD-20-420	**CLASSIFICATION & MILLING Stream 2**								
20-TK-4202	Stream 2 - Cyclone #1 Feed Tank									
20-PU-4204	Stream 2 - Cyclone #1 Feed Pump	Weir	250MCU	1042	m³/hr					
20-PU-4206	Stream 2 - Sheer Pump	Weir	250MCU	1042	m³/hr					
20-CY-4208	Stream 2 - Cyclone 1	Multotec		1042	m³/hr					
20-DB-4210	Stream 2 - Derrick Screen Feed Distributor									
20-DB-4212A	Stream 2 - Derrick Scalping Screen 1 Feed Distributor									
20-DB-4212B	Stream 2 - Derrick Scalping Screen 2 Feed Distributor									
20-DB-4212C	Stream 2 - Derrick Scalping Screen 3 Feed Distributor									
20-DB-4212D	Stream 2 - Derrick Scalping Screen 4 Feed Distributor									
20-DB-4212E	Stream 2 - Derrick Scalping Screen 5 Feed Distributor									
20-SC-4214A	Stream 2 - Derrick Scalping Screen 1	Derrick								
20-SC-4214B	Stream 2 - Derrick Scalping Screen 2	Derrick								

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	DRIVES Duty (kW)	DRIVES VSD	DRIVES S/By Unit	Comments
20-SC-4214C	Stream 2 - Derrick Scalping Screen 3	Derrick								
20-SC-4214D	Stream 2 - Derrick Scalping Screen 4	Derrick								
20-SC-4214E	Stream 2 - Derrick Scalping Screen 5	Derrick								
20-TK-4216	Stream 2 - Cyclone #2 Feed Collection Tank									
20-PU-4218	Stream 2 - Cyclone #2 Feed Pump	Weir	250MCU	1460	m³/hr					
20-CY-4220	Stream 2 - Cyclone 2	FLSmidth		1460	m³/hr					
20-VM-4222	Stream 2 - Mill	Metso	VTM-3000-WB Vertimill®							
20-SC-4224	Stream 2 - Mill Discharge Screen									
20-PU-4288	Stream 2 - Mill Discharge Sump Spillage pump	Weir			m³/hr					
	PFD NO: C8381-PFD-20-510	**LIMS 2 - Stream 1**								
20-TK-5101	LIMS 2 Stream 1 - Feed Tank									
20-PU-5102	LIMS 2 Stream 1 - Feed Pump	Weir	350MCU	1984	m³/hr					
20-DB-5104	LIMS 2 Stream 1 - Feed Distributor									
20-MS-4112A	LIMS 2 Stream 1 - MagSep #1A	Steinert	single - 1s - 950 G							
20-MS-5112B	LIMS 2 Stream 1 - MagSep #1B	Steinert	single - 1s - 950 G							
20-MS-5112C	LIMS 2 Stream 1 - MagSep #1C	Steinert	single - 1s - 950 G							
20-MS-5122A	LIMS 2 Stream 1 - MagSep #2A	Steinert	single - 1s - 950 G							
20-MS-5122B	LIMS 2 Stream 1 - MagSep #2B	Steinert	single - 1s - 950 G							
20-MS-5122C	LIMS 2 Stream 1 - MagSep #2C	Steinert	single - 1s - 950 G							
20-MS-5132A	LIMS 2 Stream 1 - MagSep #3A	Steinert	single - 1s - 950 G							
20-MS-5132B	LIMS 2 Stream 1 - MagSep #3B	Steinert	single - 1s - 950 G							
20-MS-5132C	LIMS 2 Stream 1 - MagSep #3C	Steinert	single - 1s - 950 G							
20-MS-5142A	LIMS 2 Stream 1 - MagSep #4A	Steinert	single - 1s - 950 G							

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-MS-5142B	LIMS 2 Stream 1 - MagSep #4B	Steinert	single - 1s - 950 G							
20-MS-5142C	LIMS 2 Stream 1 - MagSep #4C	Steinert	single - 1s - 950 G							
20-CH-5116	LIMS 2 Stream 1 - MagSep #1 Underpan									
20-CH-5126	LIMS 2 Stream 1 - MagSep #2 Underpan									
20-CH-5136	LIMS 2 Stream 1 - MagSep #3 Underpan									
20-CH-5146	LIMS 2 Stream 1 - MagSep #4 Underpan									
20-CY-5118	LIMS 2 Stream 1 - Cyclone #1	Multotec		832	m^3/hr					
20-CY-5128	LIMS 2 Stream 1 - Cyclone #2	Multotec		832	m^3/hr					
20-CY-5138	LIMS 2 Stream 1 - Cyclone #3	Multotec		832	m^3/hr					
20-CY-5148	LIMS 2 Stream 1 - Cyclone #4	Multotec		832	m^3/hr					
20-MS-5106A	LIMS 2 Stream 1 - Dewatering Magnet #A	Steinert	single - 1s - 6000G							
20-MS-5106B	LIMS 2 Stream 1 - Dewatering Magnet #B	Steinert	single - 1s - 6000G							
20-CH-5107	LIMS 2 Stream 1 - Dewatering Magnet Underpan									
20-SC-5109A	LIMS 2 Stream 1 - Dewatering Screen #1	Derrick								
20-SC-5109B	LIMS 2 Stream 1 - Dewatering Screen #2	Derrick								
20-SC-5109C	LIMS 2 Stream 1 - Dewatering Screen #3	Derrick								
20-SC-5109D	LIMS 2 Stream 1 - Dewatering Screen #4	Derrick								
	PFD NO: C8381-PFD-20-520	**LIMS 2 - Stream 2**								
20-TK-5201	LIMS 2 Stream 2 - Feed Tank									
20-PU-5202	LIMS 2 Stream 2 - Feed Pump	Weir	350MCU	1984	m^3/hr					
20-DB-5204	LIMS 2 Stream 2 - Feed Distributor									
20-MS-4212A	LIMS 2 Stream 2 - MagSep #1A	Steinert	single - 1s - 950 G							
20-MS-5212B	LIMS 2 Stream 2 - MagSep #1B	Steinert	single - 1s - 950 G							

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-MS-5212C	LIMS 2 Stream 2 - MagSep #1C	Steinert	single - 1s - 950 G							
20-MS-5222A	LIMS 2 Stream 2 - MagSep #2A	Steinert	single - 1s - 950 G							
20-MS-5222B	LIMS 2 Stream 2 - MagSep #2B	Steinert	single - 1s - 950 G							
20-MS-5222C	LIMS 2 Stream 2 - MagSep #2C	Steinert	single - 1s - 950 G							
20-MS-5232A	LIMS 2 Stream 2 - MagSep #3A	Steinert	single - 1s - 950 G							
20-MS-5232B	LIMS 2 Stream 2 - MagSep #3B	Steinert	single - 1s - 950 G							
20-MS-5232C	LIMS 2 Stream 2 - MagSep #3C	Steinert	single - 1s - 950 G							
20-MS-5242A	LIMS 2 Stream 2 - MagSep #4A	Steinert	single - 1s - 950 G							
20-MS-5242B	LIMS 2 Stream 2 - MagSep #4B	Steinert	single - 1s - 950 G							
20-MS-5242C	LIMS 2 Stream 2 - MagSep #4C	Steinert	single - 1s - 950 G							
20-CH-5216	LIMS 2 Stream 2 - MagSep #1 Underpan									
20-CH-5226	LIMS 2 Stream 2 - MagSep #2 Underpan									
20-CH-5236	LIMS 2 Stream 2 - MagSep #3 Underpan									
20-CH-5246	LIMS 2 Stream 2 - MagSep #4 Underpan									
20-CY-5218	LIMS 2 Stream 2 - Cyclone #1	Multotec		832	m³/hr					
20-CY-5228	LIMS 2 Stream 2 - Cyclone #2	Multotec		832	m³/hr					
20-CY-5238	LIMS 2 Stream 2 - Cyclone #3	Multotec		832	m³/hr					
20-CY-5248	LIMS 2 Stream 2 - Cyclone #4	Multotec		832	m³/hr					
20-MS-5206A	LIMS 2 Stream 2 - Dewatering Magnet #A	Steinert	single - 1s - 6000G							
20-MS-5206B	LIMS 2 Stream 2 - Dewatering Magnet #B	Steinert	single - 1s - 6000G							
20-CH-5207	LIMS 2 Stream 2 - Dewatering Magnet Underpan									
20-SC-5209A	LIMS 2 Stream 2 - Dewatering Screen #1	Derrick								
20-SC-5209B	LIMS 2 Stream 2 - Dewatering Screen #2	Derrick								

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-SC-5209C	LIMS 2 Stream 2 - Dewatering Screen #3	Derrick								
20-SC-5209D	LIMS 2 Stream 2 - Dewatering Screen #4	Derrick								
	PFD NO: C8381-PFD-20-600	**PRODUCT HANDLING, PRODUCT STORAGE, TRANSFER**								
20-CH-6102	Stream 1 Product Diverter Chute									
20-CH-6202	Stream 2 Product Diverter Chute									
20-CV-6104	Product Transfer Conveyor #1	DRA								
20-CV-6204	Product Transfer Conveyor #2	DRA								
20-CH-6106	Bin 1 - Bin 2 Diverter Chute									
20-CH-6206	Bin 3 - Bin 4 Diverter Chute									
20-CV-6108	Product Storage Bin #2 Feed Conveyor	DRA								
20-CV-6208	Product Storage Bin #4 Feed Conveyor	DRA								
20-CH-6110	Bin 1 Distribution Chute									
20-CH-6210	Bin 2 Distribution Chute									
20-CH-6310	Bin 3 Distribution Chute									
20-CH-6410	Bin 4 Distribution Chute									
20-BN-6112	Product Storage Bin #1									
20-BN-6212	Product Storage Bin #2									
20-BN-6312	Product Storage Bin #3									
20-BN-6412	Product Storage Bin #4									
20-CH-6114	Product Storage Bin #1 Discharge Chute									
20-CH-6214	Product Storage Bin #2 Discharge Chute									
20-CH-6314	Product Storage Bin #3 Discharge Chute									
20-CH-6414	Product Storage Bin #4 Discharge Chute									

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-CV-6116	Product Belt Feeder #1	DRA								
20-CV-6216	Product Belt Feeder #2	DRA								
20-CV-6316	Product Belt Feeder #3	DRA								
20-CV-6416	Product Belt Feeder #4	DRA								
20-CH-6118	Product Belt Feeder #1 Head Chute									
20-CH-6218	Product Belt Feeder #2 Head Chute									
20-CH-6318	Product Belt Feeder #3 Head Chute									
20-CH-6418	Product Belt Feeder #4 Head Chute									
20-CV-6120	Product Conveyor	DRA								
20-TK-6122	Product Dilution Tank									
20-PU-6124	Product Transfer Pump	Weir	350MCU	2654	m³/hr					
20-PU-6126	Product Storage Spillage Pump #1	Weir			m³/hr					
20-PU-6128	Product Storage Spillage Pump #2	Weir			m³/hr					
20-PU-6130	Product Storage Spillage Pump #3	Weir			m³/hr					
	PFD NO: C8381-PFD-20-700	**PROCESS WATER - SEA CHEST**								
20-TK-7002	Motive water tank									
20-FL-7100	Stream #1 Process Water Supply Filter									
20-FL-7200	Stream #2 Process Water Supply Filter									
20-FL-7300	Stream #3 Process Water Supply Filter									
20-FL-7400	Stream #4 Process Water Supply Filter									
20-PU-7102	Stream #1 Process Water Supply	Weir	350MCU	2592	m³/hr					
20-PU-7202	Stream #2 Process Water Supply	Weir	350MCU	2592	m³/hr					
20-PU-7302	Stream #3 Process Water Supply	Weir	350MCU	2592	m³/hr					

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-PU-7402	Stream #4 Process Water Supply	Weir	350MCU	2592	m³/hr					
20-FL-7110	Stream #1 Process Water Supply Filter									
20-FL-7210	Stream #2 Process Water Supply Filter									
20-PU-7112	Stream #1 Process Water Supply	Weir	350MCU	2416	m³/hr					
20-PU-7212	Stream #2 Process Water Supply	Weir	350MCU	2416	m³/hr					
20-FL-7220	GSW Filtration Supply Pump Filter									
20-PU-7222A	GSW Filtration Supply Pump	Weir	150MCU	460	m³/hr					
20-PU-7222B	GSW Filtration Supply Pump - Standby	Weir	150MCU	460	m³/hr					
20-FL-7130	Stream #1 HP Process Water Supply Filter									
20-FL-7230	Stream #2 HP Process Water Supply Filter									
20-PU-7132	Stream #1 HP Process Water Supply	Weir	150MCU	621	m³/hr					
20-PU-7232	Stream #2 HP Process Water Supply	Weir	150MCU	621	m³/hr					
20-FL-7240	Desalination Plant Feed Pump #1 Filter									
20-PU-7242A	Desalination Plant Feed Pump #1	Weir	250MCU	1562.5	m³/hr					
20-PU-7242B	Desalination Plant Feed Pump #2	Weir	250MCU	1562.5	m³/hr					
20-PU-7242C	Desalination Plant Feed Pump Standby	Weir	250MCU	1562.5	m³/hr					
	PFD NO: C8381-PFD-20-710	**PROCESS WATER DISTRIBUTION**								
	PFD NO: C8381-PFD-20-715	**PROCESS WATER DISTRIBUTION**								
	PFD NO: C8381-PFD-20-720	**GSW DISTRIBUTION**								
20-FL-7202	GSW Filter									
20-TK-7204	GSW Collection Tank									
20-PU-7206A	GSW Feed Pump	Weir			m³/hr					
20-PU-7206B	GSW Feed Pump Standby	Weir			m³/hr					

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

TTR Trans-Tasman Resources

DRA

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
	PFD NO: C8381-PFD-20-800	**TAILINGS AND WASTE WATER**								
20-TK-8007	LIMS 2 Waste Water Collection Tank									
20-TK-8027	LIMS 2 Tailings Collection Tank									
20-PU-8012	LIMS 2 Waste Water Transfer Pump	Weir		6300	m³/hr					
20-PU-8032	LIMS 2 Tailings Transfer Pump	Weir		460	m³/hr					
20-LA-8017	Waste Water Collection Launder									
20-CH-8022	Waster Water Disposal Pipe									
20-LA-8037	Tailings Collection Launder									
20-CH-8042	Tailings Disposal Pipe									
	PFD NO: C8381-PFD-20-010	**COMMON SERVICES**								
20-AC-0102	Compressor - Engine Air									
20-AC-0202	Compressor - Workshop Air									
20-FL-0104	Compressed Air Filter / Strainer									
20-FL-0204	Compressed Air Filter / Strainer									
20-AR-0106	Air Receiver - Engine Air									
20-AR-0206	Air Receiver - Workshop Air									
	PFD NO: C8381-PFD-30-100	**SERVICES AND RETICULATION, DESALINATION**								
30-TK-1102A	Desalinated Water Storage Tank #1									
30-TK-1102B	Desalinated Water Storage Tank #2									
30-TK-1102C	Desalinated Water Storage Tank #3									
30-TK-1102D	Desalinated Water Storage Tank #4									
30-PU-1104	Product Transfer Dilution Pump	Weir	350MCU	2056	m³/hr					
	PFD NO: C8381-PFD-40-100	**SERVICES AND RETICULATION, POWER GENERATION**								

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
40-HX-1002	Generator Heat Exchanger									

Appendix 19.8 - IHC Merwede Crawler Report

IHC Mining B.V.

P.O. Box 9, 2960 AA Kinderdijk
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www.ihcmerwede.com

Date	Reference	Status	
23 May 2013	M10.002	FINAL	Taco de Boer

Crawler Viability Workshop Report

Titano-Magnetite Resource Project
For
Trans Tasman Resources Limited

Client: Trans-Tasman Resources Limited
Document no: IHC IMAS-NS01
Version: Final
Date: 23 May 2013
Prepared by: T. de Boer; L.J. de Jonge; C. Jermyn
IHC Mining Advisory Services (IMAS)

The technology innovator.

Date	Reference	Status
23 May 2013	M10.002	FINAL

This report has been reviewed and approved in accordance with the policies of IHC Merwede.

Prepared:	Ir. T. de Boer		
		Signed	Date
Prepared:	Ir. L.J. de Jonge		23 May 2013
		Signed	Date
Reviewed:	Dr. J. Feenan		23 May 2013
		Signed	Date
Approved:	Mr. R. Norman		
		Signed	Date

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This document is dated 23 May 2013.

List of figures

List of tables

Date	Reference	Status
23 May 2013	M10.002	FINAL

Content

1 Executive Summary

The Crawler Viability Workshop provided an opportunity for Trans Tasman Resources Limited (TTRL) to rapidly assess the key parameters and levels of confidence to deploy IHC Merwede's technology for iron sands mining in New Zealand. Both parties understood that within a limited timeframe there was a need to focus attention upon the key technology issues in order to seek out any potential showstoppers, and if there were no showstoppers then what are the levels of confidence in the system and associated costs to deliver and operate to the required performance criteria.

IHC Merwede committed its senior Mining and Advisory personnel to the workshop and brought in naval architect and environmental engineering expertise as required. A lot of productive thinking and work was undertaken during the workshop with the key findings that crawler mining technology represents:

1. A viable technical solution for TTRL's iron sands project;
2. An opportunity to achieve minimum requested production levels for iron concentrate once the known parameters of a "DeBeers scale" system are fully engineered for increased capacity;
3. A viable process to deliver "at site" backfill of tailings to avoid the need for multiple transhipments of materials; and
4. A level of system flexibility to optimise mining operations and account for local conditions that is not possible with standard dredging technologies.

All mining projects have unique characteristics that will only be fully assessed through detailed feasibility engineering and studies. Further learning will also occur once the mining system is installed and brought into production. The benefit of working closely with an Original Equipment Manufacturer in IHC Merwede is that we are available to work closely with the project operator, understand the project issues and if new operating information means new challenges, then to find a successful engineering solution to keep the project working at optimum performance.

IHC Merwede brings a long history of successful crawler operations to the market, technology that is unmatched, and IHC rightly seeks to protect that intellectual property as the basis for its future success in marine mining projects. However, IHC Merwede acknowledges that successful mining projects also require collaboration between different project participants and always works actively to manage project collaboration and relationships to the benefit of the mining project and the mining client. Our commitment to this Crawler Viability Workshop reflects the passion to achieve success and to work closely with our clients as a partner through the mining lifecycle. IHC Merwede welcomes the opportunity and challenges to bring TTRL's project from a viable concept to a successful reality.

2 Introduction

As part of a value improvement review requirement of the Pre Feasibility Study (PFS) phase, Trans-Tasman Resources have requested IHC Merwede to assist in the evaluation of the crawler mining system as employed by DeBeers Marine off the coast of Namibia. As the designers of the DeBeers mining system IHC are best placed to provide both a technical viability and financial assessment of the crawler mining system in the TTRL scenario.

The assessment was accomplished by way of a rigorous seven day workshop attended by senior project and technical personnel from TTRL and the IHC divisions of Deep Sea Mining, Mining Advisory Services and MTI Holland. The workshop was held at the IHC Merwede premises in Kinderdijk, The Netherlands between Wednesday 3rd April to Friday 12th April 2013. Q&A discussions with TTRL subsequent to the Workshop have been included in this Final version of the report.

TTRL		**IHC**	
Name	*Position*	*Name*	*Position*
Tim Crossley	CEO	Rodney Norman	PMC Director Deep Sea Mining
Shawn Thompson	Project Director	Taco de Boer	Sr. Consultant IMAS
Matt Brown	GM Exploration	Laurens de Jonge	Manager Design & Engineering DSM
Andre Mouton	Process Lead	Henk van Muijen	PMC Director IMAS
		John Feenan	Director Asia Pacific
		Courtney Jermyn	Project Engineer IMAS

Additional subject matter experts were also included to review specific applications of the crawler mining system. These SME's included:

- Naval Architect, Marc Oele from Vuyk Engineering — Mooring Analysis
- Environmental Engineer, Aleyda Ortega — Tailing Plume Analysis

The terms of reference for the workshop were provided by TTRL to ensure that the workshop focussed on the major issues, assessing the most serious likely impacts and identifying any fatal flaws. In order that the value opportunity was properly assessed TTRL required that the assessment be largely a quantitative exercise using both established and verified data.

The timing of this value improvement initiative has enabled TTRL to consider detailed risks and challenges inherent within the current PFS configuration, risks and challenges that unless mitigated is carried over into the next project phase i.e. BFS. It is envisaged that the recommendations emerging from this workshop will be able to be incorporated into the project PFS.

3 Design Basis

3.1 Starting points for the workshop

Before the start of the workshop specific starting points and objectives were defined by TTRL, which were described in the Terms of Reference as attached in Appendix A: Pre-Workshop Terms of Reference TTRL.

Additionally some general starting points were defined at the beginning of the workshop:

- The crawler mining system should be based on existing technology, not on new concepts.
- Tailings management is very important with respect to environment and should be incorporated in the mining solution. Backfilling is required in the mined out area with minimum impact on ecology.
- The total mining solution should have as minimum transhipments as possible
- The targeted concentrate production of the total mining system should be 5.000.000 tds. per annum
- Recoverable yield: 9,8%

3.2 Deposit characteristics

The most important iron sands deposit characteristics with respect to the crawler mining operation are listed below. These figures have been supplied by TTRL as an input for the workshop and these were used to size and forecast production levels of the crawler mining system:

Deposit type	: Iron Sands, flat lying deposit
Thickness deposit	: Average 5 meter Maximum 12 meter Minimum 2 meter
Deposit characterisation	: Sediment is assumed to be of free flowing nature, some clay lenses are present but not taken into account during evaluation
Sediment average specific gravity	: 3,2 t/m³
Sediment in situ density (wet)	: 2,35 t/m³
Sediment bulk density (dry)	: 1,9 t/m³
Seawater density	: 1,03 t/m³
Average particle size distribution	: see table below

(µm)	%Dist (-2mm)	%Passing (-2mm)	**%Dist (ROM)**	**%Passing (ROM)**
2000			4	96
1000	1.13	98.87	1.1	94.9
710	1.42	97.46	1.4	93.6
500	4.02	93.44	3.9	89.7
355	8.12	85.32	7.8	81.9
250	21.96	63.36	21.1	60.8
212	15.77	47.58	15.1	45.7
150	33.34	14.24	32.0	13.7
125	8.97	5.27	8.6	5.1
106	3.02	2.25	2.9	2.2
90	1.01	1.23	1.0	1.2

(µm)	%Dist (-2mm)	%Passing (-2mm)	**%Dist (ROM)**	**%Passing (ROM)**
63	0.60	0.64	0.6	0.6
45	0.23	0.41	0.2	0.4
38	0.05	0.36	0.1	0.3
-38	0.36	0.00	0.3	0.0
			100.0	

Table 3-1: Average particle size distribution Iron Sands sediment

3.3 Site conditions

The most important site conditions with respect to the mining area are listed below:

- Water depth between 30-45 meter.
- Weather conditions and sea state according to data used in the prefeasibility study of Taharoa project. The conditions are very similar to offshore conditions in Namibia, where crawler mining systems are operational currently.
- Mining Area is on average 15 Nm from coastline.
- Presence of rolling stones on the seabed.

<u>TTRL Question 23 April 2013</u>
Please elaborate on the assumption of rolling stones on the seabed?

<u>IHC Response 25 April 2013</u>
2.1: In the MTI Holland report MB94 entitled “TTRL Iron Sands Dredge Mining Concept Study” in paragraph 2.3 Wave currents and climate, it was mentioned that rolling stones, rocks or boulders occur in this area. These rolling stones may have a negative influence on the mining efficiency of the crawler. To what extent it influences the mining efficiency should be taken into consideration in the BFS phase.

<u>TTRL Response 30 April 2013</u>
No rolling stones, rocks or boulders have been observed in any of the areas demarcated within our mine plan.

3.4 Exclusions

Due to the limited period of time available during the workshop, some parts of the entire logistic mining system were outside the scope, these include:

- Transshipment of concentrate from Mining Support Vessel (MSV) to FSO and further on
- Processing of iron sands onboard
- Sizing of processing buffer capacities onboard
- Re-fueling of the Mining Support Vessel
- Other support vessel operations (such as tugs)
- Mining support vessel sizing
- Port maintenance and offloading facilities

It should be noted that the mining system and operation, although evaluated separately in this workshop, cannot be seen as an standalone system, but forms an integral system with the other parts of the logistic chain, especially with the processing plant and the transshipment between the Mining Support Vessel and the FSO.

4 Crawler mining system

The following section is intended to describe, at a high level, the breakdown of a crawler based system for mining iron sands.

4.1 Seafloor Mining Tool

The concept design of the seafloor mining tool (SMT) which will extract the iron sands from the seafloor is described below. It is purely based on existing technology readily available from operational diamond mining systems, with limited extrapolation and adaptation due to the limited time available within the workshop for concept development and engineering.

The basis for the concept is a tracked vehicle with a submersible dredge pump and slewing boom configuration. The concept is based on many years of experience of the mining and dredge processes, and the designing of offshore mining/dredge systems, submerged pumps, dredge components and subsea tracked vehicles within the IHC Merwede group.

Figure 4-1 shows the selected SMT concept. The respective parts constituting the SMT, as well as equipment and systems located on the SMT, are detailed below. The installation to power, operate and control the SMT will be located on the mining support vessel.

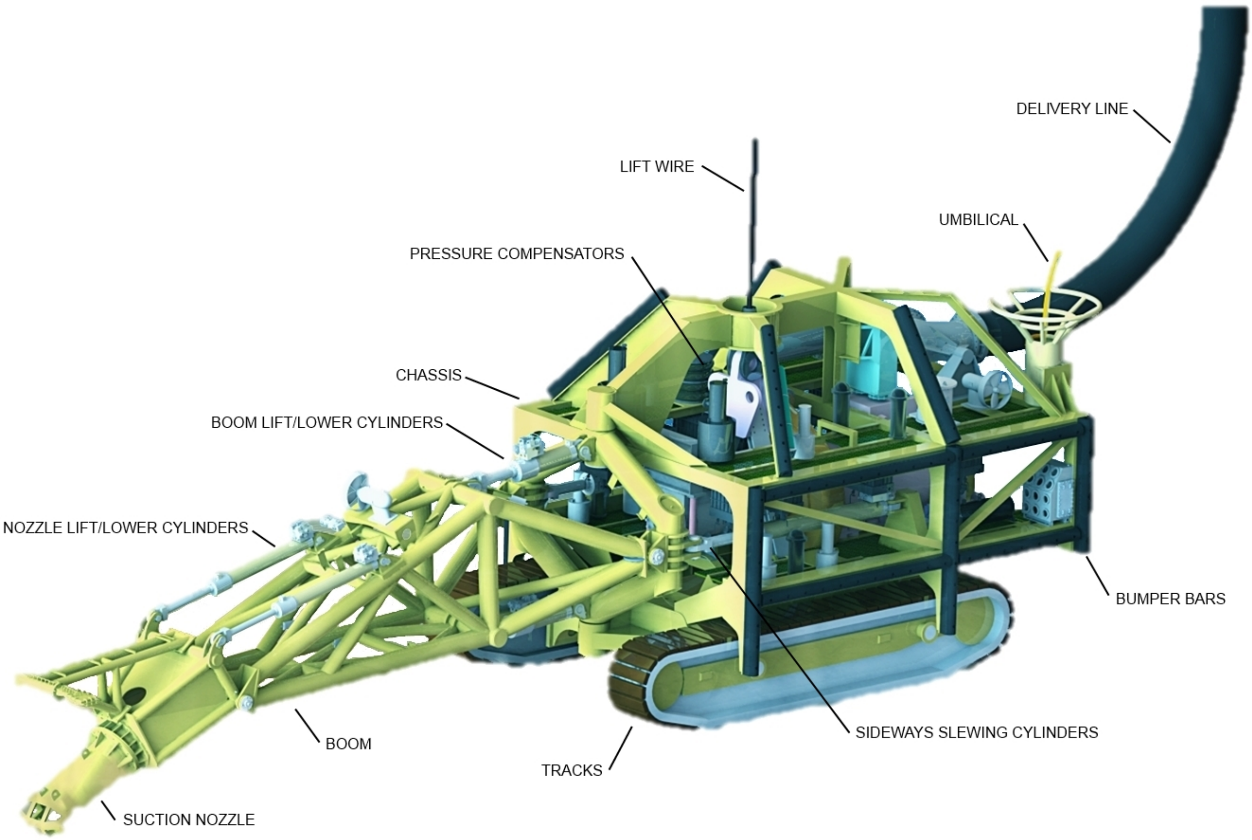


Figure 4-1: Seafloor mining tool (SMT) concept.

4.1.1 General Arrangement

The SMT structure comprises a box girder construction chassis to which the following are attached:

- a track system;
- the slewing boom configuration with the suction head and the slurry system;
- and lift wire, umbilical and riser connection.

Figure 4-2 Seafloor Mining Tools

4.1.2 Slewing boom configuration

The suction head of the slurry system is located at the end of a slewing boom configuration attached to the chassis with a gimbal. The gimbal allows the boom configuration to slew left to right and up and down with hydraulic cylinders. With a boom length of 12m and 30 degree sideway angles it can reach a mining window of approximately 12m width by -1m to +8m . The boom needs to reach below the tracks to be able to dig itself down into the seafloor. Effectively this will allow for a lane width of approximately 10m.

The length and reach of the slewing boom configuration is limited due to limitations in the balancing of all digging and other forces. In comparison with a spud on a cutter suction dredge, the tracks on the crawler need to transfer all cutting and slewing forces to the seafloor. The combination of track type and seafloor conditions determines the balance.

Depending on the required mining face, cleanup and below track capabilities a knuckle can be attached to the boom allowing for a more flexible up and down reach of the suction nozzle and a better alignment with the seafloor.

For a high density production with this configuration it is required to have free flowing material that breaches into the suction head. The suction nozzle can then be positioned right at the bottom of the face allowing the material to flow in slowly slewing side to side.

If the material does not breach then the suction nozzle needs to be slewed along the face side to side. Starting at the top moving down with each slew in approximately 1 meter steps. Obviously this will require much longer time to mine the full face, limiting the maximum achievable densities and production. Furthermore allowance can be made to attach an active cutting tool like a wheel cutter head.

4.1.3 Slurry System

The slurry system is the starting point of the slurry transport and comprises a suction head, pump system and delivery line. The suction head engages the sea bed, eroding and fluidising the material and effecting the entrainment. The slurry system is built up from standard and commonly used dredging equipment.

Suction head Suction Line

- Suction head (including jetwater nozzles if required);
- Waste gate valve;
- Flexible hose section in the gimbal;
- Expansion joint;
- Inspection piece; and
- Jet-water pump and electric motor.

Pump System

- Dredge pump; and
- Dredge pump electric motor.

Delivery Line

- Expansion joint
- Dump valve; and
- Turning gland.

4.1.4 Suction head

The suction head forms the starting point of the slurry suction line which is connected to the dredge pump. It can use jet to fluidise and entrain the soil. The suction head can erode the material but works best with free flowing material allowing high density flows.

The production efficiency of the suction head is the ability of the mining / excavation method to achieve the optimum velocity to entrain the material. It is inevitable that during the mining process; losses could occur that would influence the ability to effectively entrain the material. This could be due to the ineffective ability of the mining / excavation method to positively engage the seabed.

4.1.5 Jet-water

Jetwater can assist in to allow fluidising of the soil matrix when eroding. The jet pump is driven by a submersible electrical motor.

TTRL Question 23 April 2013
Is Jet water taken into consideration when evaluating concentration?

IHC Response
No. Jet water is not taken into consideration when evaluating concentration as it would take empirical analysis to determine the varying effects of jet water upon concentration.

4.1.6 Waste Gate Valve
In case of a blockage, by clay for instance, the waste gate valve allows water to enter the suction line thus relieving the vacuum and prevents the slurry flow from stopping. The valve is by the suction pressure transmitter.

4.1.7 Flexible hose section
A flexible hose section allows the slewing boom gimbal cylinders to position the boom horizontally and vertically from the seabed.

4.1.8 Expansion Joint
An expansion joint in the suction and delivery line will isolate pump vibrations, preventing transfer to the rest of the slurry system. Any effect due to thermal expansion and contraction will also be absorbed by the joint.

4.1.9 Dredge Pump
The dredge pump is driven by a submersible electric motor and provides the flow and pressure to allow slurry transport to the MSV.

4.1.10 Dredge Pump Submersible Electric Motor
The submersible electric motor provides the power for driving the dredge pump. The dredge pump is directly coupled to the electric motor and is pressure compensated to prevent water entering the housing. The electric motor is supplied via the umbilical by a variable speed drive, located on the MSV.

4.1.11 Dump Valve
The dump valve is located in a bend of the delivery line. The valve is hydraulically actuated and allows slurry to be drained from the riser string in case of unplanned stoppages.

4.1.12 Turning Gland
A turning gland between the flexible riser and SMT delivery line allows the riser to rotate freely around the longitudinal axis. A second turning gland, mounted to a pivot arm on the SMT chassis, provides swivel in the lateral direction, allowing the flexible riser string freedom during launch and recovery. This configuration allows the crawler to make turns.

4.1.13 Chassis
The chassis is fabricated from high strength steel using a simple but strong box girder construction. The main chassis structure is connected to the tracks which are located on either side on the SMT. The slurry system is located above the chassis, including the suction line, dredge pump and delivery line.

A secondary structure is located above and integrated into the main chassis, providing mounting areas for all the associated equipment and instrumentation, such as the subsea electronics pod, hydraulic power unit (HPU), valve tanks, junction boxes and the lift umbilical termination for the control and monitoring system as well as launch and recovery. The secondary structure also comprises a bumper bar system for guiding the

SMT onto the vessel during launch and recovery. Cameras and sonar for surveillance of subsea mining operations are mounted in appropriate locations.

Hydraulic hoses and harnesses are routed externally on the upper surfaces of the vehicle, aiming to provide the best compromise between protection and accessibility for maintenance, inspection and repair.

4.1.14 Tracks

The hydraulic driven tracks are bolted to the chassis of the SMT and allow for driving and steering the vehicle. The tracks also need to transfer all digging and slewing forces to the soil. The soil needs to provide for enough bearing capacity and friction to allow traction and slewing. Spill, clay and loose soil can limit the slewing force and speed.

4.1.15 Hydraulic System

The hydraulic system is composed of motors, pumps, filtration units, hydraulic cylinders, flexible hoses and instrumentation. In general flexible hoses with SAE 3000 series stainless steel fittings are used for all connections between the valve tanks, intermediate couplings and hydraulic cylinders. The design will generally minimise the number of connections to improve integrity. A key feature of the hydraulic design is provision to minimise the effect on the operation of the remainder of the vehicle through a hose failure or leak at any individual function.

4.1.16 SMT Control system

Equipment on the SMT is fitted with the required instrumentation to facilitate the monitoring and control of the complete mining system in a safe manner. The control system architecture is based on distributed networked nodes controlled from central processing units, using an industry standard PLC (Programmable Logic Controller) platform, distributed I/O (Input/Output) and SCADA (Supervisory Control and Data Acquisition) system. Incorporating these industry standard technologies allows for a reliable and open system that is easily maintainable.

The SMT is remotely controlled and powered via the umbilical by means of fibre optic connection, from the surface equipment, located on the mining support vessel.

4.1.17 Instrumentation

Equipment on the SMT is fitted with the required instrumentation to facilitate the monitoring, control and operation of the unit in a safe manner, whilst maximising system availability.

Instrumentation catered for would include amongst others:

- LVDT's (Linear Voltage Displacement Transducers);
- ICT's (In Cylinder Transducers);
- Angular Encoders;
- Pressure Transmitters;
- Temperature Transmitters;
- Accelerometers;
- Water Ingress Sensors; and
- Subsea Proximity Sensors.

In order to facilitate the safe and efficient operation of the mining system, the following positioning and visualisation equipment is fitted to the SMT:

- Gyro (including pitch, roll, yaw and heave);
- Submersible Cameras and lights;

- Pan and Tilt Units for cameras and lights where applicable;
- Multi-beam Sonar;
- Sound velocity probe;
- Altimeter; and
- USBL Transponder.

4.2 Vertical Transport System

The VTS enables the transport of slurry from the SMT to the MSV. The VTS allows for quick deployment and retrieval as well as mining at variable mining depths.

The VTS consists of the following components:

- The coupling between the seafloor mining tool and the first riser segment;
- A riser hose string consisting of individual riser hose segments; and
- A coupling between the riser and the plant connection.

The riser hose string consists of riser hose sections, with integrated floatation as required, and be stored on board the vessel through the use of a riser train handling system. The riser train consists of framed rollers, allowing the riser string to be stored on the vessel. The riser train includes several riser tensioners, used to launch and recover the riser string. The hose connects to the plant through the use of a ball joint connection, allowing for simple connection and disconnection during operations.

Figure 4-3 Riser hose handling

4.3 Mining Support Vessel

The Mining Support Vessel (MSV) provides the platform from which the SMT will be operated (note TTRL use the acronym FPSO for Floating Production Storage Offtake vessel). The MSV houses the SMT Launch and Recovery System (LARS), Vertical Transport System (VTS), Power generation, Propulsion, System support infrastructure (workshops/stores/cranes etc.), Accommodation, Auxiliary equipment.

The mining system service and auxiliary equipment on board the MSV generally comprises of the following major components:

- LARS structure with integrated A-Frame and sheaves;
- Passive heave compensator;
- Bumper bars;
- Umbilical winch and umbilical cable;
- Main lift winch and wire rope;

- The on-board hydraulic power unit;
- Deckhouses facilitating the required workshops, electrical equipment, hydraulic power units control rooms;
- Electrical equipment;
- Control equipment; and
- The vertical transport system.

The hydraulic and electrical auxiliary services supply equipment are housed in deckhouse areas, located on the aft deck of the MSV. The deckhouses also incorporate the control rooms for the mining system, including the LARS. The isometric view of the aft deck model shown as *Figure 4-4* provides a typical representation of the aft deck layout.

Typically an area of 45x24m would be required to house all the equipment excluding the aft sponsoons and the length required for the riser train.

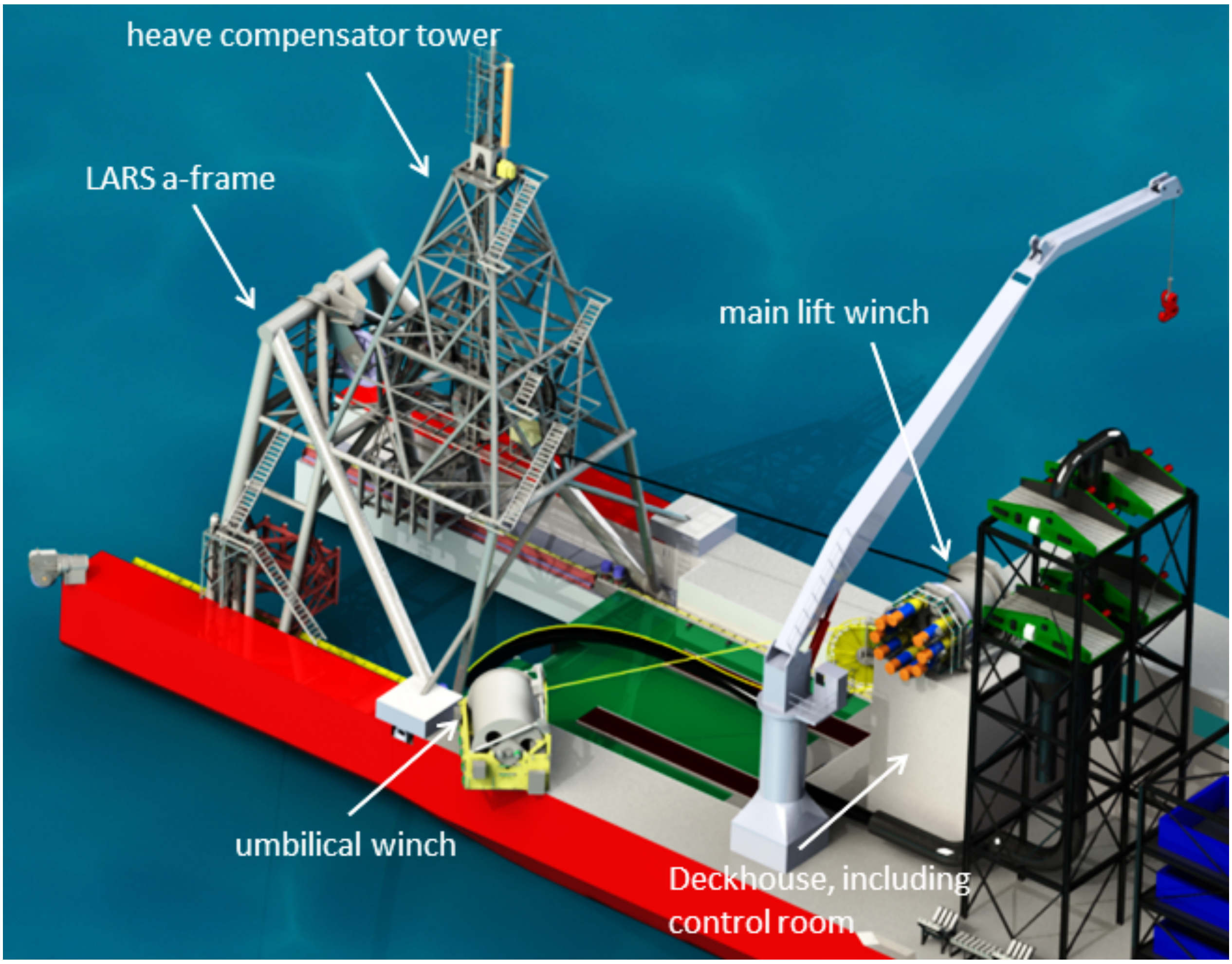


Figure 4-4 Typical isometric view of a MSV aft deck layout.

4.3.1 Launch and Recovery A-Frame

The static A-frame is fabricated using high strength steel, allowing for a reduction in self-weight, resulting in reduced deck loadings. The A-Frame structure incorporates the passive heave compensator structure and swivelling sheave. The design would take cognisance of the load paths required to reduce stresses imposed on the vessel structure. The main structural members will be designed to be integrated into the vessels deck structure, reducing the need for under-deck or above-deck stiffening. The A-Frame and Compensator Tower will have sufficient access and walkways for inspection and maintenance.

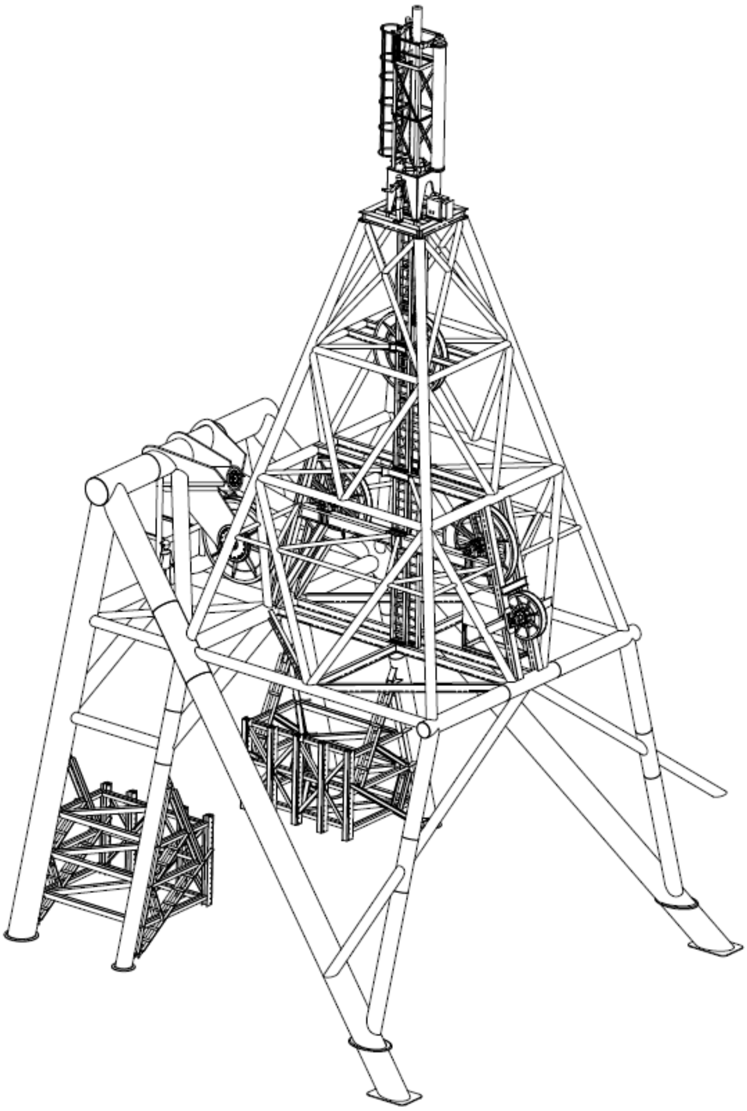


Figure 4-5: Typical isometric view of an A-Frame and Heave Compensation Tower

4.3.2 Passive Heave Compensator

The passive heave compensator is required to compensate for sea swells during operations. The passive heave compensator system provides a constant tension in the main lift wire rope through a system of fixed sheaves.

4.3.3 Sliding Door

In SMT is located on a sliding door located beneath the A-Frame and compensating tower on the aft deck of the vessel. The sliding door facilitates the launch and recovery of the SMT. The main lift wire rope lifts the SMT off the sliding door, the door is retracted and the SMT is launched into the water.

In addition to the launch and recovery purposes, the sliding door also allows for the SMT to be effectively moved to a safe maintenance position on the aft deck.

4.3.4 Umbilical Winch System

The umbilical winch is located on the aft deck, adjacent to the SMT deck. The umbilical is routed through a powered sheave, taking up the slack between the sheave and the umbilical winch.
The umbilical winch system would generally comprise of the following major components:

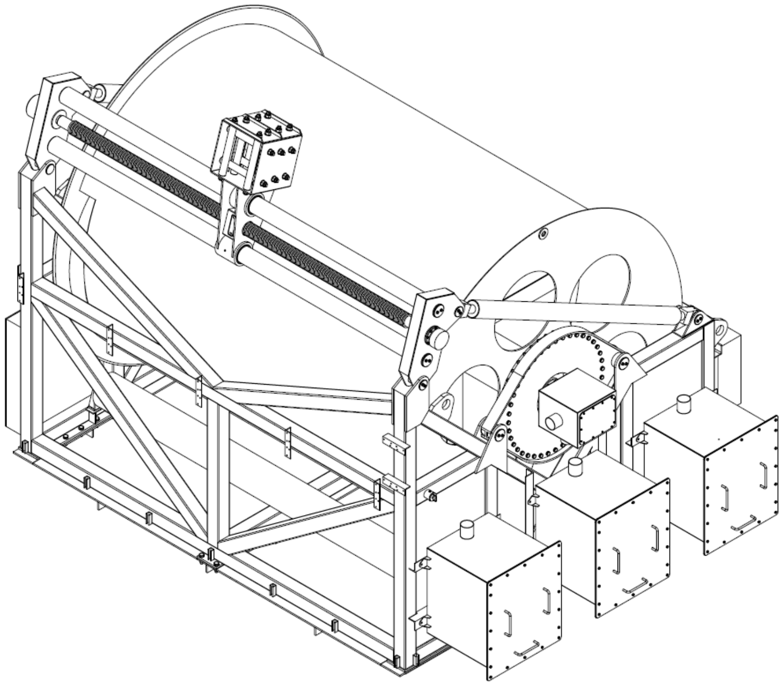


Figure 4-6: Typical isometric view of an Umbilical Winch

4.3.5 Main Lift Winch

The main purpose of the main lift winch is to power and control launch and recovery operations of the SMT. The lift winch consists of a drum with grooved sleeve (for accurate spooling and storage of the wire rope), a structural support frame and a spooling device. Electric motors, reduction gearboxes and a ring gear and pinion system provide power to the winch drum and spooling system.

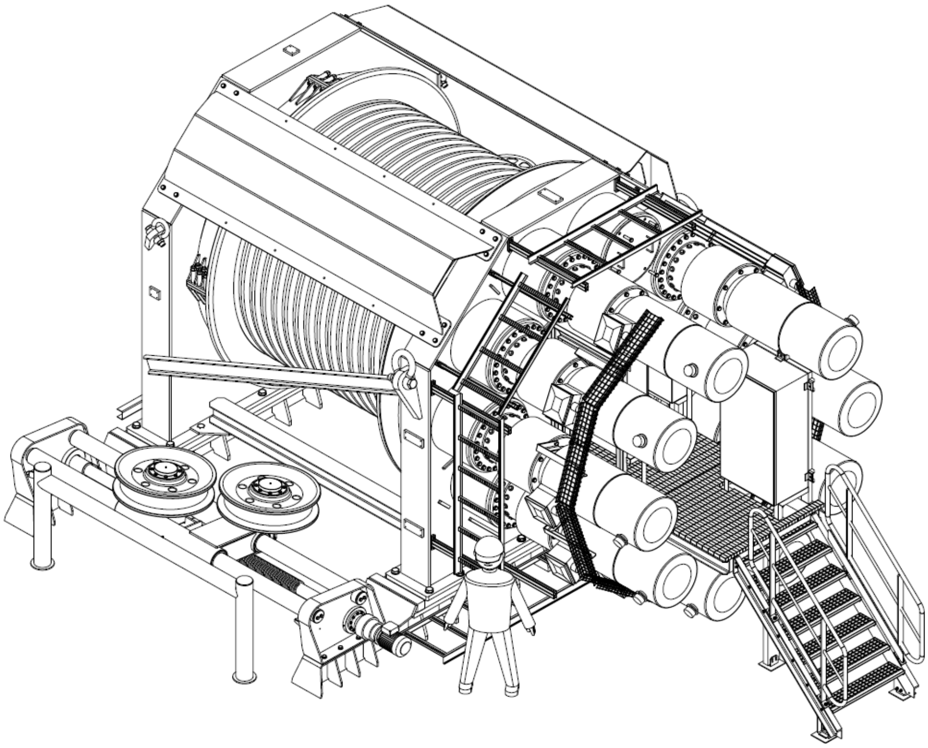


Figure 4-7: Typical isometric of a Main lift winch.

4.3.6 Hose Handling

Whilst on deck, the riser hose string is stored in the riser train consisting of rollers mounted on frames routed throughout the vessel. The riser train handling system would consist of multiple riser tensioner units positioned along the riser train. The riser tensioners would assist with the launch and recovery of the riser string. Any excess or spares lengths is stored in a dedicated riser hose storage rack and would typically be handled by either an overhead gantry crane or ships utility crane.

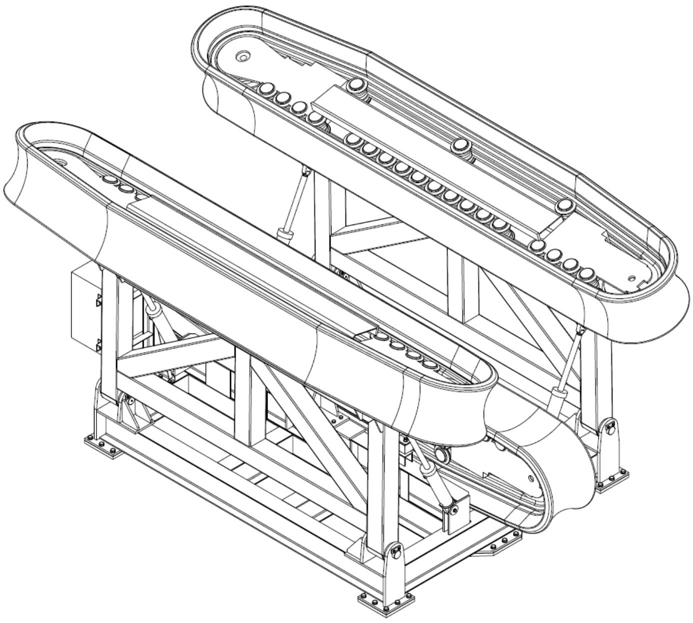


Figure 4-8: Typical isometric of a riser hose handling tensioner.

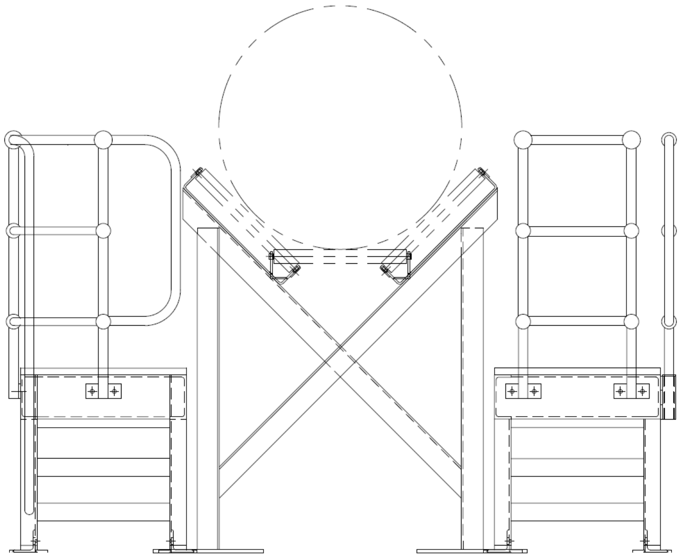


Figure 4-9: Typical Riser train layout.

4.3.7 Electrical System

Typically the electrical components and equipment is located in the following areas on board the mining support vessel:

- Mining system transformer room;
- Mining system MV switchgear room;
- Mining system LV switchgear room; and
- Mining system control room.

All SMT supplies are independently switchable at the surface and protected against:

- Overloads;
- Line insulation faults; and
- Earth continuity faults.

4.3.8 Control and Instrumentation System

The operator is able to control the mining system in its selection of modes from an operator control console, located inside the control cabin. The control cabin is designed to provide a comfortable environment for the operators incorporating good ergonomic practice regarding layout and seating, etc. Typically two stations is provided, one for the Pilot and one for the Co-Pilot. All SMT, LARS and riser train handling functions will be controlled and monitored from the control stations located inside the control cabin.

Operator system monitoring and control is achieved through a combination of SCADA and HMI (Human Machine Interface) systems. The operator will be able to obtain information regarding equipment functions such as hydraulic actuators, cameras, lighting, instrumentation and survey equipment. A typical layout of an operator control console, located inside the control cabin is provided in figure 11.10 below.

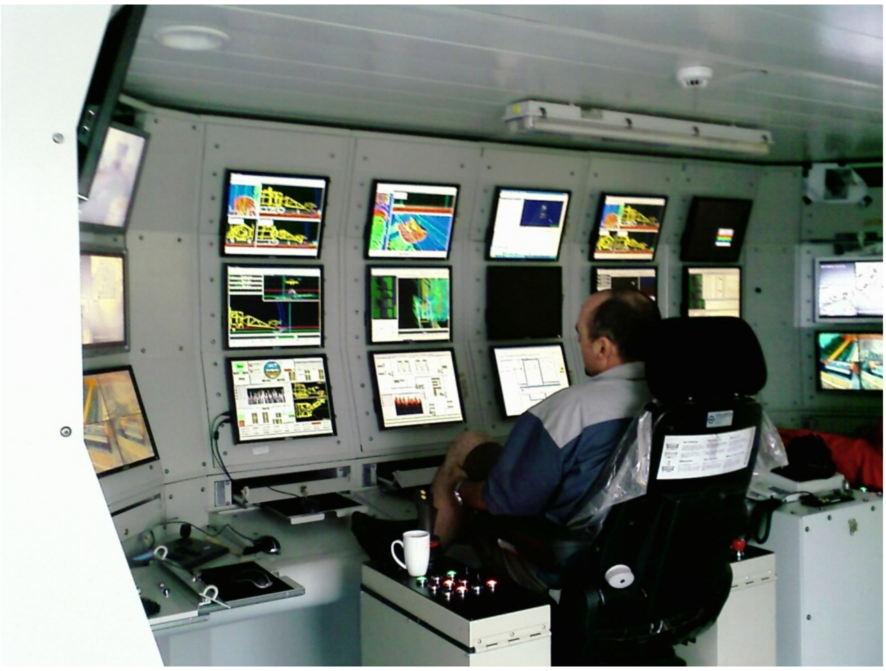


Figure 4-10: Typical operator control console.

4.3.9 Deck Cranes

The MSV should be equipped with enough crane capacity to allow for independent offshore and in port maintenance. The aft deck crane for the Mining system is typically located on the aft deck in a position determined by the crane reach and the positions of deck equipment and the SMT.

4.3.10 Mining Support Vessel Requirements

The mining support vessel should be classed for worldwide operations in accordance with the relevant maritime class requirements. The mining support vessel must meet the following requirements:

- Capable of station keeping and tracking during mining operation;
- Capable of supporting and housing the mining system, launch and recovery system, vertical transport system and auxiliary services;
- Capable of supporting and housing a treatment plant;
- Capable of buffering and stockpiling slurries and concentrates to allow for a continuous process;
- Capable to offload tailings;
- Capable to offload concentrate to a FSO;
- Capable of supplying sufficient power to drive the mining system, launch and recovery system, vertical transport system and auxiliary services;
- Capable of providing sufficient office space and accommodation for the mining system operational staff complements; and
- Capable of supporting a helideck in order to facilitate personnel transfer.

4.4 Double Crawler System

The crawler mining system as described in the above paragraphs has been based on existing systems consisting of a single crawler. To meet higher production requirements or if full redundancy is required a two crawler system has been investigated at a very high level. Basically it implies placing two complete independent systems next to each other on the aft deck.

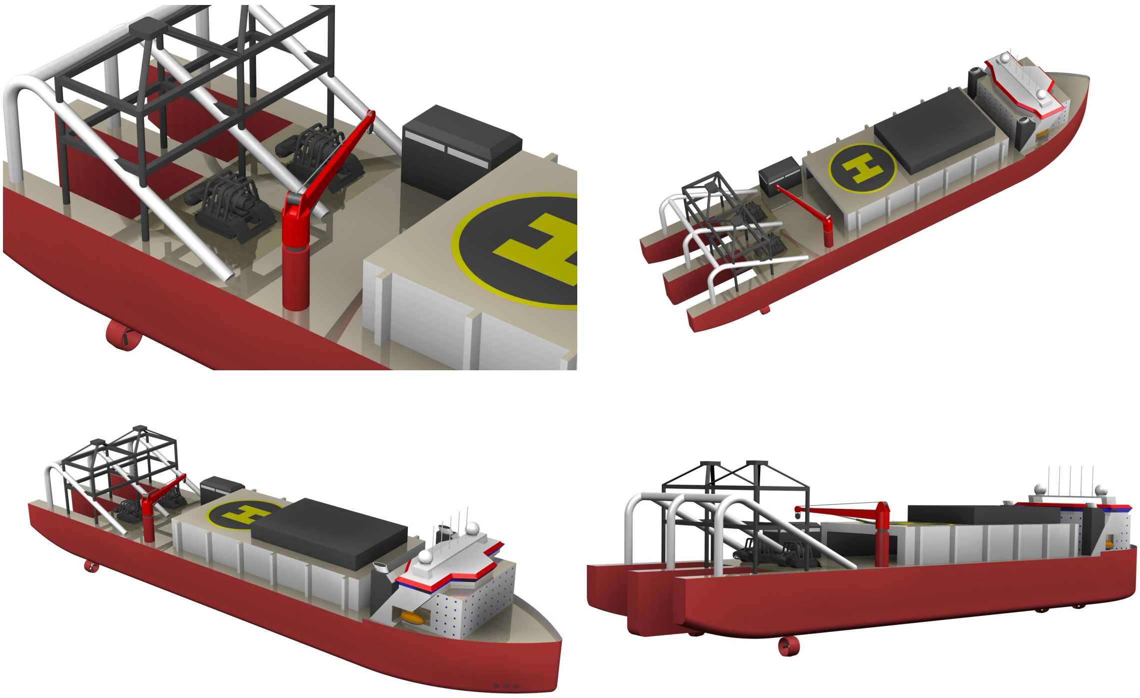


Figure 4-11: Artist impression of double crawler system vessel configuration

It requires a footprint of at least 45x45m and the MSV needs to be able to support the mass and operation of two systems. Technically the crawler systems are very similar to a single crawler system, however the operational viability of the systems needs to be fully investigated and engineered. A double crawler system of this size has no operating predecessor.

At a minimum following items need to be considered:

- Launching and recovering of two crawlers close to each other
- Operation of two crawlers next to each other, the independency of the operation, advance rates, mobility and manoeuvrability,
- Influence on mine plan: turning and rotating two crawlers is either difficult or will take a long time therefore long parallel lanes seem better for continuous production
- Full DP favourable of 4 point mooring:
    - Increased production requires more anchor handling
    - Long lanes v. block mining
    - Might give a slightly higher weather uptime, depending on DP system
- Two crawlers does not imply double production:
    - no full face for at least one of the crawlers
    - advance rate needs to be equal
    - less flexibility in crawler operating mobility

    - Alignment of two crawlers
- Weather uptime probably lower:
    - Crawlers off-centre therefore maximum accelerations in less seastate
    - Less offset allowed between vessel heading and crawlers
    - Launch and recovery of 2 crawlers more hazardous in higher seastates

4.5 Building confidence of a two crawler system [post workshop evaluation]

The current known technology for a crawler based mining system is a unit with a 700 x 650 Dredge Pump and a 650 mm ID slurry discharge line. Increasing this to a crawler with an 800 x 800 Dredge Pump and an 800 mm ID slurry discharge line represents an increase in size of 50%. To build confidence in a single crawler operation with an 800 x 800 Dredge Pump and 800 mm ID slurry discharge line will require further engineering during the BFS to ensure that there are no fatal flaws, which cannot be foreseen at this stage.

This will include but is not limited to:

- Is there an umbilical available which is able to supply the required power to the crawler.
- Design a flexible hose with 800 mm ID and sufficient buoyancy.
- Specify and select the pump and electric motor. Determine the auxiliary requirements (depth compensator and gland water pump) and the mass of all components.
- Specify and select the slurry train components. Determine the mass of all components.
- Design the crawler boom, suction nozzle and frame.
- Select the tracks required for the crawler.
- Determine the mass of thel crawler with all its components.
- Carry out initial FEA and fatigue analysis on the crawler.
- Is there a wire rope available which can handle 400 tonnes, the initial estimate of the mass, to lift/lower the crawler. With a rope safety factor of 6 this means a MBL of 2 400 tonnes.
- Investigate the exact power requirements of the crawler (pump + jet pump + tracks).
- Initial design and sizing of the launch & recovery system. This will include initial FEA work.

For a two crawler system additional engineering will be required to:

- Investigate the impact of having a two crawler systems outside the centerline of the vessel (more movements) and redefine workability.
- Investigate detection sensors and automation for a two crawler operation.
- Initial design and sizing of the double launch & recovery system. This will include initial FEA work.

Besides this, the operation of the two crawler system will have to be investigated as there are no current operations with 2 crawlers next to each other. The operating limitations will have to be defined, such as:

- Safe operating distance between the two crawlers
- Design of cuts and mine plan
- Prediction of mining face processes and production rate
- Advance rate of the two crawler operation
- Turning with two crawlers at the end of the lane
- Operating flexibility between vessel and crawler at given water depths.

In short it means a lot of work has to be done in the design of the system to increase the level of confidence and we reckon that this will take an additional 6-8 months of engineering. The upside potential of a single crawler 800 ID slurry delivery crawler has been evaluated and further upside on both the single and double crawler options could be pursued during the engineering required for the BFS.

5 Crawler mining operation for TTRL

A crawler mining operation off the coast of New Zealand has some different constraints than the diamond mining operation in Namibia. The main differences are:

	Diamond Mining operation	**TTRL operation**
Area	Namibia	New Zealand
Material	All materials, clay, shell, gravel, boulders to cemented sands	Free flowing sands
Mineral	Diamond mining	Iron Sands
Water depth	90-200m	35-45m
Mining	Precision cleanup mining	Bulk mining
Production measure	Square M of cleaned seabed	M3 of mined bulk
Required production	Estimated 600m2 per hour	8000 tph dry solids
Concentrate transhipment	Helicopter	FSO offload every 3 days
Buffer requirements	Limited	ROM, Processing plant buffers, Tailings buffers, Concentrate buffers
Processing Plant	Large	Probably larger

5.1 Minimum operating depth crawler, risks and mitigation [post workshop evaluation]

The crawler in itself has no minimum working depth limitations. However, as the crawler is working very close to the Mining Support Vessel (MSV) and possibly partly under the vessel, a safe distance should be taken into account between the draught of the vessel and the crawler. The crawler height of the PIA is around 6 meters. Furthermore, the thrusters for the DP system underneath the MSV will increase the draught of the vessel. Another item is that the distance between the seabed and the keel of the vessel should have a safe distance as well. When considering a significant wave height of 4,5 meter, that means the maximum wave height can be 2.5 to 3 times this height.

During the workshop TTRL was considering a vessel draught of 12-15 meters. Suppose the water depth is 20 meter, than the vessel can hit the seabed only due to the sea-state. Once the real dimensions of the vessel are known, Vuijk can calculate what the minimum safe water depth is for the vessel to operate in and when considering a crawler operation.

Another consideration is the freedom of motion and maneuverability of the crawler with such a reduced length of hoisting wire, hose and umbilical. With the possible motions of the vessel taken into account a significantly reduced workability due to weather and an increase in downtime due to unforeseen damage of these items can be expected.

At this status and considering the dimensions of the vessel used in the workshop, a minimum water depth of 30 meter will be required for safe operation of the crawler.

5.2 Annual mining efficiency

For comparison the annual mining efficiency of several systems is shown in *Table 5-1*. The 700mm crawler system is fairly close to existing technology (650mm for PIA of DeBeers Diamond Mining Crawler) to have a high confidence level in the engineering feasibility of such a system. The 800mm system is a step beyond existing technology and requires further engineering regarding:

- mass of the crawler and tracks

- power and umbilical
- delivery hoses
- including all interfaces and other systems

All figures in this table are based on field experience for the availability and efficiency under similar circumstances as the TTRL operation. However each operation has its own characteristics and all steps in the specific overall logistic mining chain will have their own availability and influence on the separate systems. Therefore these figures are only indicative and can only be used with great care and no guarantee. The overall system availability and productivity needs to be assessed during BFS and finally in the field.

Mining crawler system (Slurry system ø in mm)		**700**	**800**	**800**	**2x 700**	**2x 800**
Annual Efficiency		**Anchor spread single**	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Annual operating days	d/y	365	365	365	365	365
Daily operating hours	h/d	24	24	24	24	24
Port Visits (incl. Dry Docking)	d/y	30	30	30	30	30
Transhipment Constraints	d/y	12	12	12	12	12
Anchor spread handling	d/y	18	18	0	0	0
Maintenance	d/y	26	26	26	26	26
Mining crawler system (Slurry system ø in mm)		**700**	**800**	**800**	**2x 700**	**2x 800**
		Anchor spread single	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Days lost		86	86	68	68	68
Mining system availability	%	76%	76%	81%	81%	81%
Mining efficiency	%	80%	80%	80%	75%	75%
Weather uptime	%	90%	90%	90%	85%	85%
Total operational Availability	**%**	**55,0%**	**55,0%**	**58,6%**	**51,9%**	**51,9%**
Operating time	**h/y**	**4.821**	**4.821**	**5.132**	**4.544**	**4.544**

Table 5-1: Annual mining efficiency

In *Table 5-1* following items are defined as:

-	Annual operating days	Year days, 365 in total
-	Daily operating hours	Daily hours, 24 in total
-	Port Visits (incl. Dry Docking)	Based on dry docking and port calls for emergency or maintenance
-	Transhipment Constraints	Time reserved for delays due to issues with FSO transhipment, re-fuelling and all other ship-to-ship transfers
-	Anchor spread handling	Time required for repositioning of anchors
-	Maintenance	Time required for regular maintenance of the crawler system
-	Days lost	Total of days lost
-	Mining system availability	Percentage of time the Crawler Mining system is ready and available for pumping
-	Mining efficiency	Percentage of time the mining system will do 100% production, inefficiencies due to no full face, turning, hoisting, etc.

-	Weather uptime	Percentage of time the weather allows the crawler system to work
-	Total operational Availability	Percentage of time the crawler mining system is operational available
-	Operating time	Equivalent of full production hours

Remarks:
1. the 700 system is put in for comparison reasons
2. the double systems are only considered on DP operation
3. all systems need to be compared on many more aspects like: CAPEX, OPEX, operational workability, risks, etc.

TTRL Question 23 April 2013
Are we not double counting with Mining system availability and Mining Efficiency?

IHC Response 25 April 2013
2.5: There is a distinct difference between the mining system availability and the efficiency. The availability of the mining system includes the hours the crawler is available for operation and could be pumping sediment (ROM) from the seabed. In the table in this memo these hours have now been calculated and included. Taking into account the weather delays gives a reduction on this availability.

The mining efficiency is the efficiency of the crawler system while available. In theory the crawler system is capable to mine sediment at a 100% production rate all the time. However, in practice the crawler is not producing at a 100% efficiency all the time. Inefficiencies included in this factor are amongst others:
- manoeuvring and positioning of the crawler, turning – advancing – aligning
- seabed/ore conditions, full or half face – face conditions – spill – variations in face
- mine plan and operational philosophy, lane efficiency – grades – sediment variations – tailings philosophy
- operational skill level, spill – slewing – pumping – manoeuvring.

In effect, multiplying the mining efficiency with the available mining system hours will result in the effective number of hours the crawler is operating at full capacity.

5.3 Production capacity considerations

In practice the achievable production is not only calculated availability but also a balance between more factors that come into play. Limiting it to the activities on the seafloor a balance needs to be found between:

1. Production efficiency -> to achieve the highest possible production per hour;
2. Mining efficiency -> to achieve the highest use of the equipment and taking all of the ore out, this means a proper mining plan;
3. Spill (loss of ore) -> reducing mining and production efficiency due to inefficient operation, but also limiting the traction of the crawler;
4. Tailings management -> the best method for return of tailings to the mined out area for both environment and minimize dilution of ore sediments.

To determine this balance is a trade-off that partly can be engineered and designed for but also needs to be determined in day to day practice, operation and ongoing training of operators.

5.4 Pump production

On the mining crawler a hydraulic transport system is installed which consists of a suction mouth with jet water nozzles, a suction pipe, a flexible delivery pipe and a centrifugal pump which transports the dredged sediment from the seabed to the mining support vessel and delivers it to the feed intake of the processing plant onboard.

For determination of the required pump production and pump power, the following starting points were used:

- Particle size distribution as stated in the design basis
- Specific gravity of the grains 3,2 t/m³
- In situ density sediment 2,35 t/m³
- Dry bulking density sediment ± 1,9 t/m³
- Dredging depth 45 m
- Geodetic height 20 m above the sea level for discharging the ROM
- Discharge pipeline configuration 100 m, considered with 10x 90° bends (1.5D)
- No limitations on suction production (30-35% vol. sediment concentration)
- Maximum velocity in pipeline is restricted to 6,5 m/s to prevent excessive wear.

This results in the following output for two types of crawlers:

Description	Unit	700 mm ID HRMD pump	800 mm ID HRMD pump
Average concentration	%	30% by volume	30% by volume
Required Power on pump shaft	kW	2011	2525
Production sediment	dry tonnes/h	5000 tph	6440 tph
Slurry volume	m³/h	8.770 m³/h	11.300 m³/h

For both scenarios 700 mm and 800 mm, a centrifugal dredge pomp type HRMD with 4 bladed impeller is selected. This centrifugal pump will be directly driven by a submerged electric motor with frequency drive to control the flow with varying conditions. Depending on the suction production the concentration can be higher, which results in a lower mixture velocity in the pipeline or a lower concentration, in which the mixture velocity increases. This can be prevented by installing a pump speed limiter.

TTRL Question 23 April 2013
When extracting as a slurry, is using the dry bulk density (1.9 t/m3) to calculate the mass flow rate of solids mined justifiable? Should not the SG be used?

TTRL query the calculation in 5.3.2. For the calculation of the slurry vol.% solids the dry bulk density has been used instead of the SG. Using the SG, the vol % solids for the dry solids equivalent (6,440t/h) in the IHD calculation is only 17.8%. Increasing the solids vol.% back to 30% gives 10,850 t/h solids (57.1 wt% solids; slurry density 1.68 t/m3). Please review these calculations also with respect to the pump capacity.

IHC Response 25 April 2013
2.2: In the IHC standard calculations of pump productions the in-situ volume is used for production. In the dredging industry this is the main acknowledged way of calculating productions. Dry solids

calculations are more common in the mining industry. Dredging equipment is always extracting volumes and not tonnages.

In the pump calculations, the 30% concentration by volume is defined as the mined volume (in situ) is 30% of the mixture flow with an in-situ density of 2,32 t/m3. This corresponds to a dry bulk density of 1,9 t/m3 (= same volume, but taking out the water, but still considering the voids in the material).

The in-situ production of the crawler is calculated at 3390 m3/h. This results in a dry solids production of 6441 tph and the mixture density of the slurry feeding the plant will be 1,401 t/m3.

Appendix A Production Calculation shows the calculations for the 30% scenario.

<u>TTRL Response 30 April 2013</u>
Due to conflicting sources, TTRL continue to query the use of “Dry Bulk Density” against that of the “Specific Gravity” or even the “Wet Bulk Density” when calculating the production limits of the proposed system.

<u>IHC Response (email to Andre Mouton) 1 May 2013</u>
Please find enclosed my adaptions to your calculations (attached pdf: TTRL ROM Density Calcs P4). The reason we have started with the 30% vol of situ material, as it is the standard way of calculating in the dredging industry and this situ value is of great importance when considering the suction production of the crawler and the related advance rate.

Of course within a mining operation only the tonnes solids are of interest, so we have to be convert these figures into solids delivered to the plant and this is around 17,1%, when considering only true solids with a specific gravity of 3,2 t/m3 (This volume only accounts for about 60% of the total situ volume).

<u>TTRL Question 23 April 2013</u>
The limiting settling velocity of the slurry will also be affected. TTRL calculations for a slurry with 30 vol% TTR ROM the limiting settling velocity becomes 6.47m/s.

<u>IHC Response 25 April 2013</u>
2.4: The critical velocity of a solid – liquid mixture is defined as the velocity below which particles are starting to settle out in the pipeline. Above this velocity all particles will stay in suspension within the turbulent flow.

This critical velocity in the pipeline depends on:

- The internal diameter of the pipeline (800 ID)
- The mixture concentration (30%vol in situ)
- The particle size distribution (d50 = 230 micron)
- and the specific gravity of the particles (3.2 t/m3)

For an 800 ID pipeline system the settling velocity of particles with average specific gravity of 3,2 t/m3 is around 4,9 m/s. With 6,5 m/s velocity in the pipeline this is well above the critical velocity.

<u>TTRL Response 30 April 2013</u>
The critical velocity has been calculated using Durand’s equation with the parameter F_L of 1.1 (d50 of 200micron). The TTRL calculation yields 6.46 m/s far in excess of the IHC value of 4.9 m/s.

IHC Response (telecom)
Recommend using Wilson's equation for this parameter. However further review of the properties of iron sands may be required to justify the preference of the equation used.

5.5 Assessment of upside potential of crawler operation [post workshop evaluation]

TTRL has requested IHC to assess the upside potential of the single crawler operation to determine what the maximum annual production capacity can be for this mining system. IHC believes there is a significant upside potential of the crawler mining alternative. Appendix B shows the results of this short assessment done by IHC Mining.

- The total effective production time has an upside potential of 5949 hours or a total operational availability of 67,91%.
- The suction production of the crawler has an upside potential of 6870 tonnes dry solids per effective pump hour.
- Combining these two figures results in an upside potential for the ROM production of ± 40,87 Mt per annum.

It should be noted that part of the upside potential lies in the non-availability of the other parts of the complete mining and transport system, which results in non-availability of the crawler system as well. A significant portion of this upside potential is related to operations and lies with TTRL.

The upside potential of the crawler mining operation is to be confirmed during a BFS stage.

5.6 Suction production

The suction production of the crawler depends on the soil properties, the deposit characteristics, the crawler operation and the design of the suction mouth. The most important parameters to be considered are:

- Free flowing material (This means that the material is not packed and will flow easily to the suction mouth)
- Swing speed (This is the speed of the boom of the crawler swinging from left to right and vice versa, normal practice of crawlers is around 30 m/min)
- Width of cut (This is the width of a total swing of the crawler suction boom, normally 30° to both sides)
- Step size (forward movement of the crawler after each cut or advance rate)
- Sediment bed thickness (This can be considered as the entire bench height of the mining face in front of the crawler.)

The suction production is the product of the width of cut times the bed thickness times the step size. To meet the pump production, this production should be the same or higher than the pump production. In other words enough sediment should be presented at the suction mouth. If more production is presented than this results in spillage. The crawler operation should be adapted in such a way that the suction production and the pump production are balanced by varying swing speed and step size. The use of jet water nozzles on the suction mouth supports the loosening of the soil (create free flowing material) and the slurrification.

When considering a crawler boom length of 12 meter and 60 degrees swing angle, the width of cut is ± 12 meter. Some overlap between the cuts is required to minimize losses and therefore the effective width of cut will be around 10 meter. When considering an average bed height of 5 meter the advance rate of the crawler will be 70 m/h to reach the pump production of 6500 tph. When considering some spillage (15-20%) during suction the advance rate will be even higher. When the thickness of the deposit varies, the advance rate of the crawler should be adapted accordingly.

Best practices on suction production in similar thickness layers and free flowing material with plain suction dredgers justify the above production figures. In case the material is not free flowing the suction production will be less.

5.7 Mooring system for Mining Support Vessel (MSV)

The current crawler operations in Namibia use a four point mooring system with mining blocks of 300x300m. Unlike the TSHD mining system with the single point moored FPSO configuration, which is a static operation, the MSV is actively following the crawler and the MSV is continuously moving. Although at first sight similar to the crawler operation in Namibia, there are some significant differences for the TTRL project:

Location	New Zealand	Namibia
Water depth	30-45 m	90-200m
MSV size	LxB = 250x40 or 300x45	LxB = 175x24
Mining blocks	600x300m	300x300m

Limited by rope diameter (90mm) and length (2500m) (and hence winch size) and experience of operational limitations of these systems it is envisaged that a combined 4 point mooring and DP system is required for the safe operation of the MSV.

IHC Merwede subsidiary Vuyk Engineering performed a preliminary investigation on the feasibility of such a combined system and preliminary results are presented in the report (ref. 30481JBe13059) in Appendix B: Vuijk Report on Mooring and DP

Some important results:

- Minimum mooring wire length for self-handling of the Anchor Spread is 4000m so an anchor handling tug is most probably required
- For Mining operations the required DP power is 3.0+6.4 = 9.4 MW
- Minimum required installed DP power is 35MW

This shows that in all cases a significant DP system is required and running. A trade-off between a 4 point mooring + DP system and a Full DP system on the CAPEX, OPEX, Mining and operational practices is recommended. Operational considerations could be:

- More flexible mine layout → longer lanes or larger mining blocks
- No anchor handling
- Fuel consumption – refueling
- Longer on station with incoming bad weather

On a double crawler mining system it is recommended to use a full DP system. A 2 crawler system with higher productions would imply more anchor handling and less mining efficiency. With a full DP system mining over longer, double lanes is possible, which improves the mining efficiency.

5.8 Description of dedicated crawler mining operation

The crawler is first lowered onto the seabed by the launch and recovery system (LARS), together with the discharge hose and umbilical. Around 2-3 sections of the discharge hose will be floating on the water to allow for flexibility of the crawler.

The most ideal mining operation for the crawler are long cuts. In this way the crawler can continue mining for a long time. At the end of each cut with a single crawler system the crawler will have to turn 180° and mine the adjacent cut the other way, see figure below. The total mining cut of the crawler boom is 12 meter, however the effective cut will be only 10 meter wide, this allows for 1 meter overlap on both sides of the cut to minimize spill (losses). This spill is created because of free flowing sediment flowing outside the reach of the crawler.

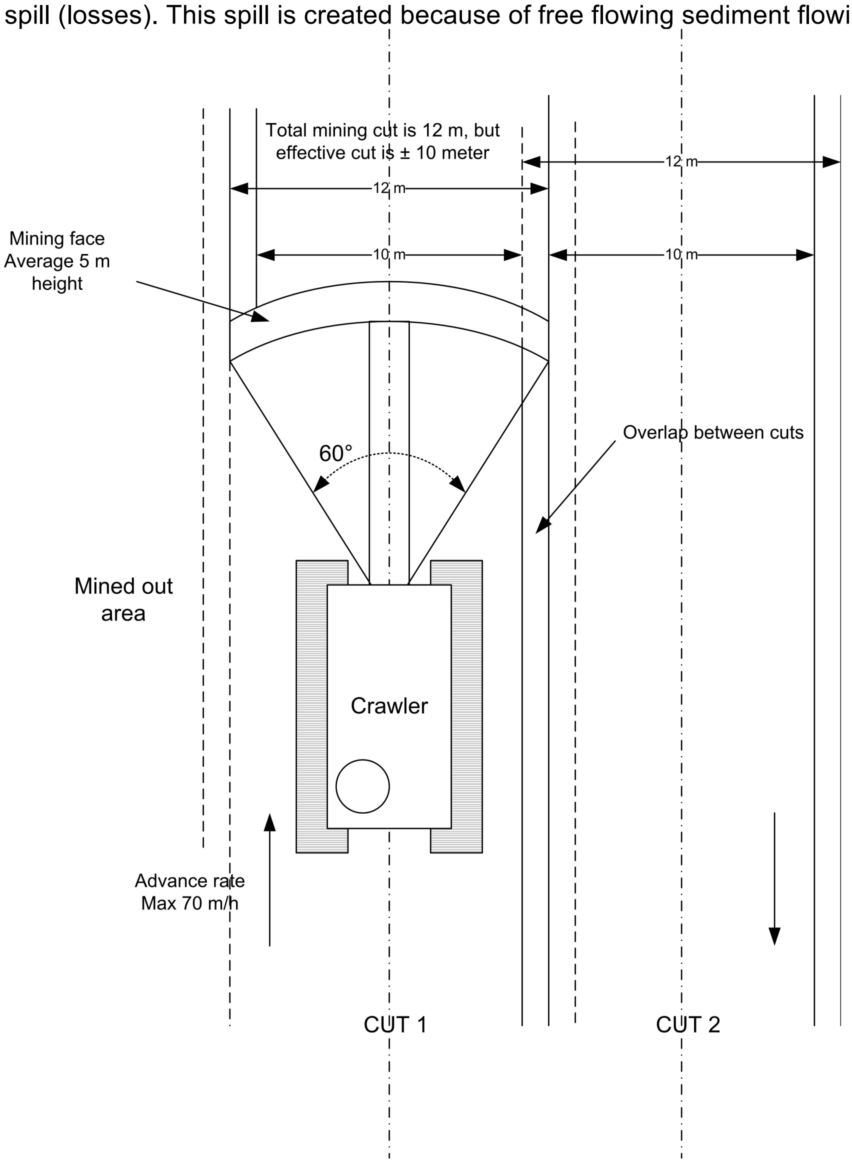


Figure 5-1 Mining lanes

When considering an average bed height of 5 meter and a production rate of 6500 tph, the advance rate of the crawler will be 70 m/h to match with the pump production. In total ±700 m² (70x10m) of seabed is mined per effective pump hour. One swing of the boom of the crawler will take around 25-30 seconds including deceleration and acceleration in the corners of the cut. This means that after each swing the crawler needs to move forward by 0.5 meter.

It should be noted that the flow of the material is the driving force for the suction production. Sediment should be free flowing and the suction mouth should be kept at the foot wall. In case the material is not free flowing, the boom will need multiple swings at various heights to mine the material. This will significantly reduce the suction production and advance rate of the crawler. When the thickness of the deposit varies, the advance rate of the crawler should be adapted accordingly.

The Mining Support Vessel (MSV) will need to follow the crawler with the same advance rate. When considering a four point mooring system the maximum length of the cut will be limited. De Beers was using a 300x300 meter mining block and also the mooring spread had the same dimensions. On average De Beers needed around 10 days to mine out the complete block, before the anchors had to be shifted. For TTRL a 300x300m mining block will be mined out in around 5 days, thus the mining block selected is 600x300 m and accordingly the mooring spread. As the water depth is much less in the TTRL case, this is possible. The cut of the crawler will than be 10x600m.

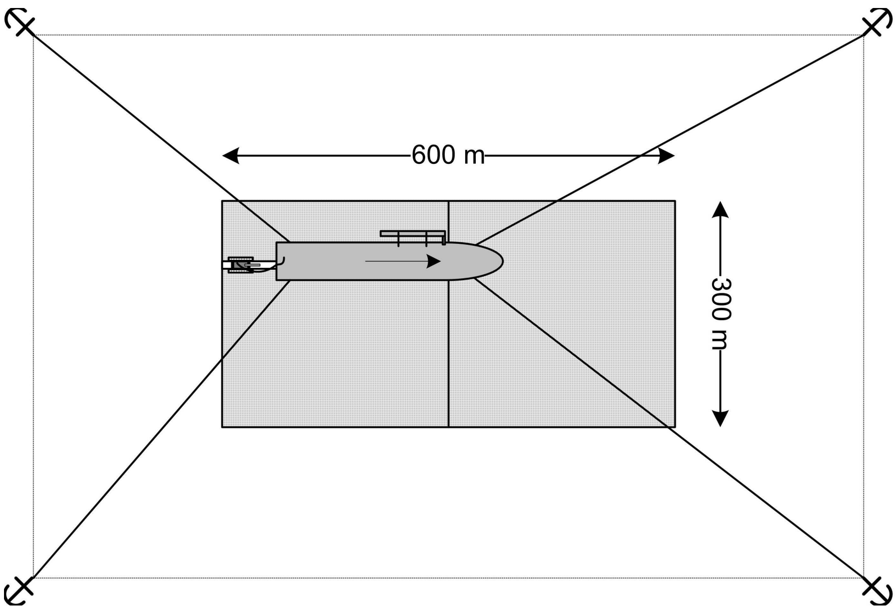


Figure 5-2: Anchor spread

Some considerations on the dedicated crawler mining operation:

- When using full DP system, the mining block could be even larger as there is no restriction by anchors. This results in lower changes of crawler direction.
- The layout of the mining blocks and direction of cuts need to be in such a way that the MSV is positioned with her bow against the dominant swell.
- In the situation where the length of the MSV is 300m, one could consider mining blocks of 300x300m. If the tailings are discharged at the front of the vessel and the vessel is behind the crawler, the tailings will always be discharged in the previously mined out area. However the crawler needs to turn more often, this results in slightly lower efficiency.
- In case of a double crawler operation, two parallel cuts will be made. The crawlers will need to keep up with each other with respect to the advance rate. For safety reasons, some berm should be left between the two cuts, possible the width of a cut. In the return, this berm could be mined by one of the crawlers. However this operation needs more investigation in a next phase.

TTRL Question 23 April 2013
The dry bulk density was also used to calculate the advance rate. For the advance rate should the in situ density not be used? At this time the best estimate for the in situ density is the wet bulk density of 2.35 t/m3. Hence the advance rate also needs to be recalculated in view of the comment above. Also the implications for the size of the mining blocks need consideration.

IHC Response 25 April 2013
2.3: Both the dry bulk density and the in situ density can be used for calculation of the advance rate. This rate is determined by the volume mined. The volume mined for the in situ density is the same as the volume mined for the dry bulk density. The dry bulk density only considers the tonnes dry solids in the volume, whereas the in situ density also takes the weight of the water in the pores into account.

TTRL Response 30 April 2013
Advance rate will be affected by (the decision to use Dry Bulk Density, Wet Bulk Density or Specific Gravity when calculating the production limits).

5.9 Tailings management

One of the most important issues on the mining operation is the handling of the tailings from the processing installation. It is envisaged that roughly 90% of the mined material will end up in the tailings.

Due to strict legislation set by the government, TTRL needs to backfill these tailings in the mined out area in a controlled manner. Therefore a backfilling system for the tailings is required.

For this system two important considerations have to be taken into account:
- The backfilling of the tailings needs to take place as close as possible to the seabed to minimize plume dispersion.
- The tailings will be backfilled in the mined out area, but should not disperse in such a way that they are diluting the virgin iron sands, which the mining crawler still needs to mine.

5.9.1 Tailings backfilling system requirements

In order to fulfill the above mentioned considerations and to handle the offshore conditions, there are several requirements set to the system:
1. The system must be operational in water depths ranging from 30 to 45 m.
2. The solids concentration of the tailings should be as high as possible and the velocity at the end of the pipe should be as low as possible.
3. The system should be capable of compensating for the vessel movements due to the sea state and maintain at a constant depth and distance to the seabed.
4. The end of pipe should be designed for best control at depth.
5. The system should be capable of handling 6000 tph solids.

5.9.2 Trade off backfilling system

Three different systems were evaluated for the backfilling of the tailings.

1 Flexible Hose

The flexible hose is used in normal dredging operations, but is not a viable option if the tailings are to be discharged close to the seabed. The hose will be difficult to control with respect to discharge location and positioning. On top of that the sea state will put a lot stresses in the hose and it will be easily destroyed by the sea state.

Figure 5-3: Flexible hose

2 Fall pipe through the ship

The fall pipe system is used normally for covering a pipeline on the seabed with rocks or sand, to protect the pipeline against other activities at sea, such a fishing with nets. It consists of a vertical large diameter pipeline to which pipe sections can be added or removed depending on the water depth. For accurate positioning of the outflow of the pipe an ROV is used with thrusters, see figure below. Technology may be difficult to handle in 40m water depth as it is a dynamically challenging area, deeper than 100m is no problem.

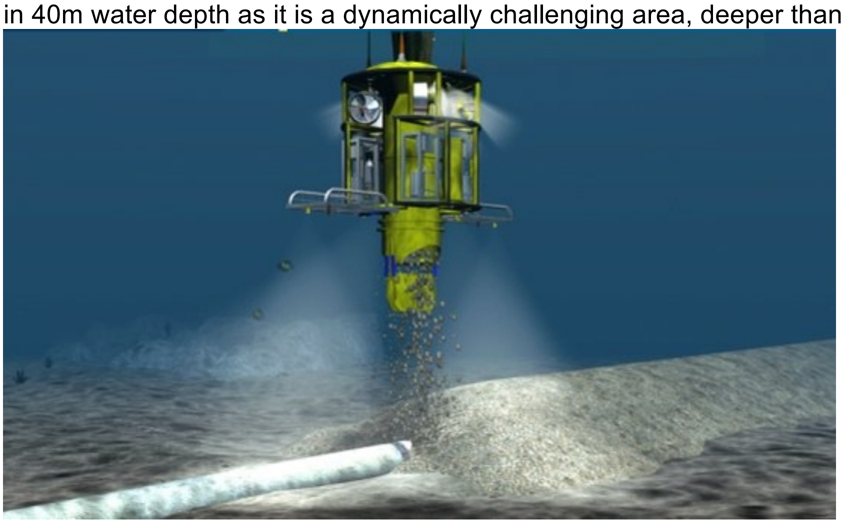


Figure 5-4: Fall pipe ROV

3 Modified suction tube of a TSHD

The normal suction tube of a TSHD can be modified in such a way that backfilling can be executed via the suction tube. This technology is used for covering pipelines with sand in water depth less than 100 m. The system consists of a rigid inclined pipeline with flexible connections and a draghead at the end of the pipe. The suction tube is put overboard along the side of the vessel with gantries. Depending on the water depth the pipe can be lowered or elevated. For accurate disposal of the backfilling material the suction tube is equipped with positioning sensors and an angle measurement system.

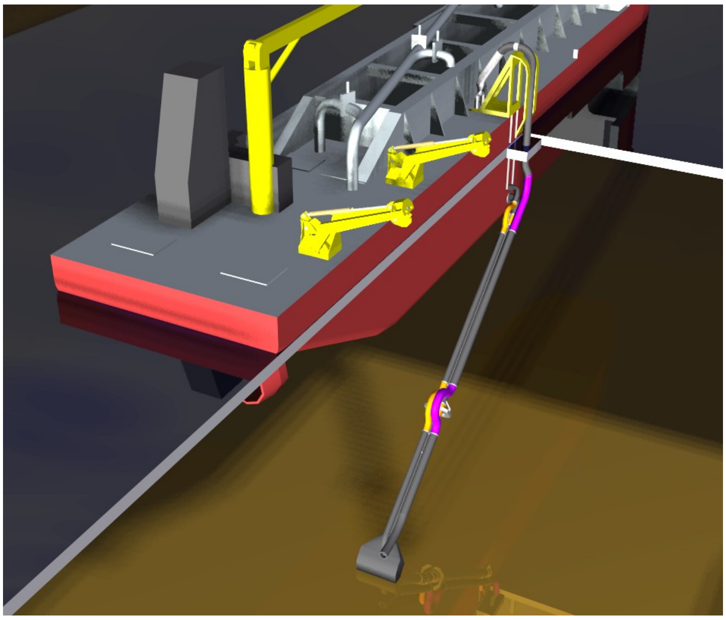


Figure 5-5: Modified suction tube of TSHD

The modified suction tube system is the most suited system for the TTRL backfilling operation of tailings, due to its ability to operate in shallow depths. Furthermore as the system is installed at the side of the vessel the distance between the cut of the crawler, which is in the centerline of the vessel and the outflow of the pipe is larger compared with a fall pipe. This can be seen in the figure below for a vessel width of 45 meter.

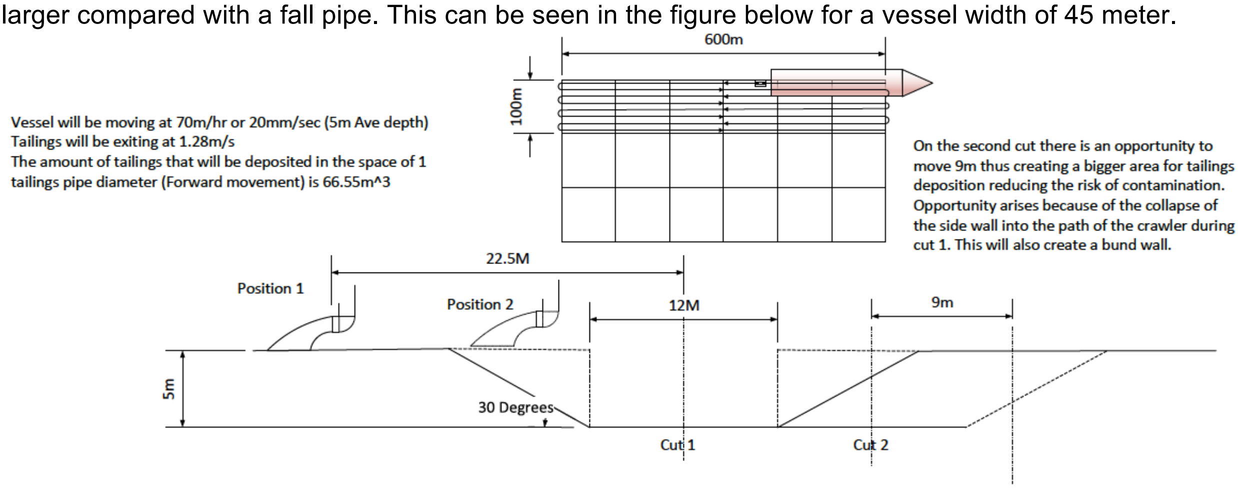


Figure 5-6: TTRL Mine & Tailings Plan

5.9.3 Plume modelling model

The control of the backfilling of the tailings is essential to minimize the dispersion of the material. To gain a better insight in this dispersion of the tailings, a first rapid assessment was carried out during the workshop and a CFD-model was developed and run. Below figure gives an preliminary result of the dispersion of the tailings as a first order estimate, when considering a current of 0,5 m/s (worst case scenario). The total results of this rapid assessment are enclosed in Appendix F: MTI Report: Rapid assessment of TTRL-tailings.

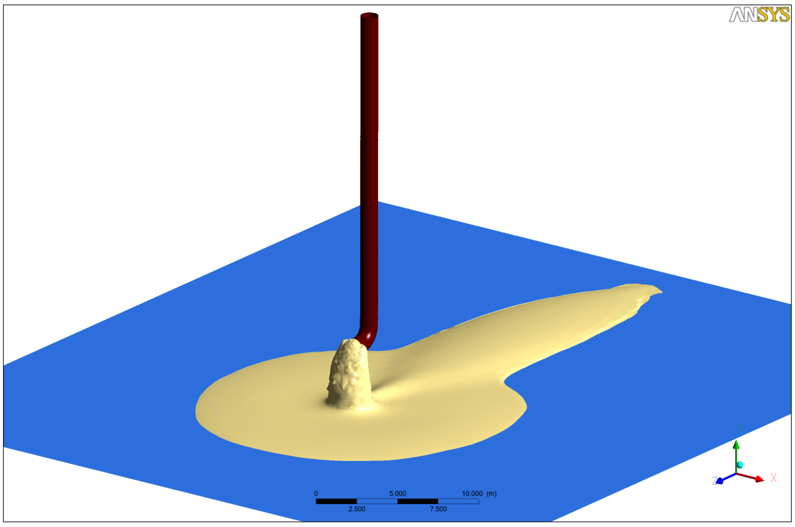


Figure 5-7: Dispersion of tailings

In a next study phase it is recommended to build a more sophisticated dispersion model as this requires more computational time and input parameters.

5.9.4 Adaptation of the tailings plume model [post workshop evaluation]

The rapid assessment of the tailings plume modelling was done to obtain a first insight into the behaviour of the tailings when deposited close to the seabed. This model did not incorporate vessel movement and assumed the Mining Support Vessel to be stationary. The difference between long mining runs and shorter block mining cannot be derived from this model at this stage.

It is possible to develop a more dynamic model for the tailings dispersion. However this would require extensive modelling, which cannot be achieved in the two weeks available. It is advised to do this modelling during the BFS stage.

6 Crawler mining system viability

In this chapter the viability of the Crawler Mining system is checked against other systems and the stationary FPSO concept.

6.1 Static FPSO mining system and proposed crawler mining system

How does the crawler mining system compare to the static FPSO mining system?

Crawler Mining System:

- Mining support vessel including crawler mining system, processing plant, tailings disposal and four point mooring system with DP
- Transhipment using FSO vessels.

Static FPSO system with TSHDs

- Trailing suction hopper dredgers
- Static FPSO with processing plant with single point mooring
- Transhipment using FSO vessels
- Tailings disposal using barges.

Assuming the FSO vessel operation is the same, the crawler mining system offers a significant reduction in the number of vessels in operation by combining mining, processing and tailings management in one single vessel. The logistic chain can be shortened with less transhipments, however this might imply a reduction in capacity.

Because the static FPSO becomes a sailing Mining Support Vessel, it becomes a fully operational maritime vessel including sailing crew and requirements for docking, port accessibility, class etc. This also implies the owner becomes a maritime operator.

6.2 High level system trade off Crawler / TSHD

IHC and TTRL compared different mining systems in order to identify the most probable solution for TTRL's activities. Mining systems were weighted on a system level not on equipment. Mining systems evaluated include: crawler, TSHD, drill, Ro-Ro, and PSD and measured against mining efficiency, depth from 30-45 m, 6500 tph capacity, mining flexibility, logistic complexity, and tailings dispersal parameters (*Table 6-1*).

Parameters	**Weight Factor (0-10)**	**Crawler**	**TSHD**	**Drill**	**Ro-Ro**	**PSD**
Mining Efficiency	7	9 63	8 56	5 35	4 48	6 42
Depth (30-45m)	10	10 100	10 100	0 0	8 80	10 100
Capacity (6500tph)	10	9 90	10 100	4 40	80 80	10 100

Parameters	**Weight Factor (0-10)**	**Crawler**	**TSHD**	**Drill**	**Ro-Ro**	**PSD**
Mining Flexibility (sediment thickness, direction, location, depth soil conditions, etc)	8	9 72	9 72	9 72	7 56	5 40 - not accurate
Logistic Complexity – Integrated vessel multi system	7	9 63 - FSO connection is more complicated in combination with mooring	5 35	9 63	5 35	8 56
Tailings (get it to the bottom with the most control and less disturbance)	10	9 90	5 50 - different than crawler, tailings will not act the same	9 90	5 50	9 90 -limited sediment depth
Total		**470**	**413**	**300**	**329**	**428**
		- puts material back in place Bearing capacity is the only problem out of these parameters	- dredgers don't have processing on board	- Relocation is an issue, very limited not designed for bulk	- more complex than TSHD	- dependent on free flowing material

Table 6-1: Mining System Comparison Matrix

Results from the comparison indicate that the drill, Ro-Ro, and PSD are not a viable option. The drill is discarded as an option because it is not applicable for extracting bulk sediments and working at shallow depths. Its design function is to extract rock in deep waters. The drilling system is also difficult to relocate and is of very limited in use. Ro-Ro system did not produce a strong weight because of its complexity over the TSHD suction tube and its ability to operate under TTRL's conditions. The PSD system was weighted high but the sediment depth is too limited. In addition, PSD system is not accurate and is dependent on free flowing material. As a result of the sensitivity of the TTRL environment and the importance of accurate and efficient production, PSD was removed as an option.

In further discussion the option of a dustpan dredge was considered. This is a wide suction mouth stuck forward directly into the soil and mainly in use on the Mississippi River. A general concern with this system is the limitation in suction width when the sides of the suction mouth are filled with clay and stuck. In those cases only a limited width is left and it will be very hard to move the dustpan forward. First option considered was a direct attachment to the MSV. This was discarded considering the high seastates and the danger of rocking the dustpan to disintegration. Second option considered an attachment to the crawler. This was discarded considering the inflexibility of the system to changing seabed circumstances and the danger of getting stuck.

The TSHD and crawler systems were found to be the best two options for TTRL's mining operations. The TSHD comprises different capabilities than the crawler. Main differences between the two systems include: scalability, tailing dispersal, operation logistics, and mineral processing. The TSHD is easily scalable, where as, the crawler is reaching its limits in individual size. In regards to tailings dispersal, a TSHD system cannot control the tailings dispersion and can generate a large plume. Conversely, crawlers can return the material back to the original location in a controlled way. Operation logistics between the two systems are also different; the TSHD system must have the processing plant located off site, whereas, the crawler vessel can have everything on board.

IHC and TTRL concluded that the crawler provided the best overall mining solution because it has better tailings management, coverage and accuracy. It should be noted that the crawler is not without difficulties. Free flowing material is essential and the bearing capacity of the soil was found to be the main problem considering all the parameters. Therefore, further evaluation and engineering is required to realize the best crawler system configuration.

6.3 Crawler mining systems evaluation

In the preceding chapters several crawler mining systems have been investigated. In the following table these different systems are evaluated:

Yield (Concentrate from Sediment)			*9.8%*			
Target Concentrate tpa			*4,500,000*			
Mining crawler system (Slurry system ø in mm)		**700**	**800**	**800**	**2x 700**	**2x 800**
Annual Efficiency		**Anchor spread single**	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Annual operating days	d/y	365	365	365	365	365
Daily operating hours	h/d	24	24	24	24	24
Port Visits (incl. Dry Docking)	d/y	30	30	30	30	30
Transshipment Constraints	d/y	12	12	12	12	12
Anchor spread handling	d/y	18	18	0	0	0
Maintenance	d/y	26	26	26	26	26
Days lost		**86**	**86**	**68**	**68**	**68**
Mining system availability	%	76%	76%	81%	81%	81%
Mining efficiency	%	80%	80%	80%	75%	75%
Weather uptime	%	90%	90%	90%	85%	85%
Total operational Availability	%	**55.0%**	**55.0%**	**58.6%**	**51.9%**	**51.9%**
Operating time	h/y	**4,821**	**4,821**	**5,132**	**4,544**	**4,544**

Mining crawler system (Slurry system ø in mm)	**700**	**800**	**800**	**2x 700**	**2x 800**	
Annual Efficiency		**Anchor spread single**	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Production Crawler (First)	t/hr	5000	6500	6500	5000	6500
Production Crawler (Second)	t/hr				3000	3300
Yearly production of dry solids ROM	t/a	24,105,600	31,337,280	33,359,040	36,352,800	44,532,180
Recoverable concentrate	t/a	2,362,349	3,071,053	3,269,186	3,562,574	4,364,154
Shortfall to Target Concentrate Production	t/a	-2,137,651	-1,428,947	-1,230,814	-937,426	-135,846
Confidence of Success						
Crawler Success		100%	80%	80%	90%	80%
LARS Success		100%	90%	90%	70%	60%
Operating Success		90%	90%	90%	60%	60%

Table 6-2: Crawler mining systems evaluation

In the table the target production is compared to the indicative production levels for the different systems and the level of confidence in the success of these systems. The confidence of success is directly related to the level of new technology, unknowns in deposit/environmental conditions/logistic chain and the unpredictable operational workability of the complete mining system.

Remarks:

- The lower production of the double crawler accounts for the smaller face and spill due to free flow of the middle lane.
- The single systems are on top of output.
- The double systems have a higher level of uncertainty regarding the operation of a dual system. However they offer as well more ability to improve and possibly increase the production levels.

6.4 Risks / opportunities / mitigation

IHC and TTRL evaluated risks, impacts, and mitigation strategies for the crawler mining operations. Components of the mining operations evaluated includes:

System Function	**Risks**	**Impacts**	**Mitigation**
Anchor Mooring	Limited with sea state	-unsecured vessel, loss of crawler, loss of production	DP & Mooring multi-system
Crawler	- Suction Capacity and advance rate to achieve 6500tph -Unexpected downtime for port maintenance - no soil bearing capacity figures to configure tracks	- heterogeneous flow and inefficient processing -loss of production and project value - tracks cannot function, may sink, can't gain traction	- mine operation planning - production simulation inputs to design. - can put a limit on the crawler to control plant -spare crawler at port ready for a switch - CPT analysis inputs

			to design
Crawler Production Hose	- geometry of hose	- failure through too much tension on hose	-load test engineering
Crawler LARS	- umbilical size and stresses - location of crawler launch - mass of crawler vs max. load of a single wire rope	-Power failure - inefficient with operations - crawler cannot be mobilized by LARS - loss of equipment	-Engineering design - keep LARS at aft
Production Rate	-material is not free flowing	- affects advance rate and production	- Take field and lab measurements
Product Transfer at Sea between FPSO and FSO	-FSO connection to unload material creates high risk of collision -FSO slurry transfer fails in heavy seas -56% availability reduced by unexpected down time in transfer operations	-loss of life or damages - production delay -lowers production and project value	- Thorough investigation planning and engineering. - slurry pipe simulation tests - Engineering design and modeling of working conditions and operations
Tailings	-recirculation of tailings -adverse environmental impact from dispersion	- inefficient production and loss of product -breach of environmental license conditions stops production	- mining plan and tailings modeling. -plume simulation and design engineering
Refueling at sea	- fires -lost mining time via connection failures - oil spill	-loss of life and/or property -lowers production and project value - breach of environmental license conditions stops production	-Consider MDO-MGO - Engineering design -oil spill modeling and equipment deployment planning
Local Port Facilities	-unable to use local port for routine or unplanned maintenance	-lowers production and project value -no port available.	- vessel designed access New Plymouth harbour and docks
Dry Dock Port Facilities	-Only remote ports available	-long steaming time and loss of production	- vessel designed to suite local dry docking facilities

Table 6-3: Risks

7 Capex Mining System

The capital cost estimate covers the cost for the mining system as detailed in the desktop study.

7.1 Accuracy of Estimate

The accuracy of the estimate has been compiled in accordance with the requirement of ± 30%. An overall project contingency of 10% for the Mining system and items as mentioned in this list has been allowed for.

Due to the limited time and no allowance for engineering all prices are based on estimates and assumptions from previous projects.

DISCLAIMER: Due to the limited time allowed all CAPEX figures are not based on actual quotes nor on detailed calculations or engineering. CAPEX figures are also prepared without a clear scope of work, demarcation and battery limits with the client. Therefore the CAPEX figures as presented are only indicative and can only be more detailed during the BFS.

7.2 Base Date, Base currency and Exchange Rates

The base date of this capital estimate is April 2013. The estimate does not allow for escalation. The base currency are EUROS €, all figures in this estimate have been converted to US$ Dollars for your convenience at the following exchange rate:

Currency	US $ (USD)
1 Euro €	1.30

7.3 CAPEX breakdown on Single crawler system

Project Activity / Item Designation	Main item	Final costs EUROS		Final costs DOLLARS	
SMT Engineering services, Project Management and Travel	Project Management & Engineering	€	4,450,000.00	$	5,785,000.00
LARS Engineering services, Project Management and Travel					
Installation support and commissioning (not the actual installation)					
Seafloor Mining Tool (SMT)	Seafloor Mining Tool 2x	€	21,000,000.00	$	27,300,000.00
Spare Seafloor Mining Tool (SMT)					
LARS System	LARS, VTS + control systems	€	28,250,000.00	$	36,725,000.00
Lift Winch					
Lift Rope					
Heave compensator					
A-frame					
Sliding door					
Vertical Transport System					
Hoses					
Plant connection					
Hose tensioners					
Umbilical and Umbilical Management System					
Umbilical					
Umbilical Winch					
Guiding Sheaves and systems					
Electrical System					
Hydraulic System					
Control System					
SMT					
LARS					
Mooring system	4 point Mooring System	€	10,000,000.00	$	13,000,000.00
Mooring winches					
Mooring cables					
Mooring anchors					
Tailings system	Tailings system 2x	€	4,000,000.00	$	5,200,000.00
Pipe					
Gantries					
Heave compensation					
Spare package	Spare parts package	€	5,000,000.00	$	6,500,000.00
Mooring cables					
Lift Wire					
Umbilical					
VTS Hoses					
Slurry train wear parts (pump, piping)					
Hydraulic and electrical					
Miscellaneous – Shipping, duties etc.	Miscellaneous – Shipping, duties etc.	€	1,900,000.00	$	2,470,000.00
	Total	**€**	**74,600,000.00**	**€**	**96,980,000.00**
10%	Contingency	€	7,460,000.00	€	9,698,000.00
	Grand Total (± 30%)	**€**	**82,060,000.00**	**$**	**106,678,000.00**

TTRL Question 23 April 2013
Does the CAPEX numbers include an allowance for a limited DP capability in addition to the winch system?

IHC Response 25 April 2013
2.6: In none of the CAPEX figures is the DP system is taken into account. This is because for any of the systems a full DP system is required and is considered as an integral part of the mining vessel. Only if the 4 point mooring system is deployed the DP system can work in a reduced mode. Also in the OPEX figures the DP system is not taken into account.

TTRL Response 30 April 2013
TTRL confirm that within the base case, the FPSO will make use of a 4 point winch mooring “assisted” by DP system and specialised anchor handling tug/vessel. TTRL will include this within the vessel supply scope.

7.4 CAPEX breakdown on Double crawler system

Project Activity / Item Designation	Main item	Final costs EUROS	Final costs DOLLARS
SMT Engineering services, Project Management and Travel	Project Management & Engineering	€ 7,175,000.00	$ 9,327,500.00
LARS Engineering services, Project Management and Travel			
Installation support and commissioning (not the actual installation)			
Seafloor Mining Tool 1 (SMT)	Seafloor Mining Tool 2x	€ 42,000,000.00	$ 54,600,000.00
Spare Seafloor Mining Tool (SMT)			
LARS System	LARS, VTS + control systems	€ 56,276,768.00	$ 73,159,798.40
Lift Winch			
Lift Rope			
Heave compensator			
A-frame			
Sliding door			
Vertical Transport System			
Hoses			
Plant connection			
Hose tensioners			
Umbilical and Umbilical Management System			
Umbilical			
Umbilical Winch			
Guiding Sheaves and systems			
Electrical System			
Hydraulic System			
Control System			
SMT			
LARS			
Mooring system	4 point Mooring System	€ -	$ -
Mooring winches			
Mooring cables			
Mooring anchors			
Tailings system	Tailings system	€ 4,000,000.00	$ 5,200,000.00
Pipe			
Gantries			
Heave compensation			
Spare package	Spare parts package	€ 7,000,000.00	$ 9,100,000.00
Lift Wire			
Umbilical			
VTS Hoses			
Slurry train wear parts (pump, piping)			
Hydraulic and electrical			
Miscellaneous – Shipping, duties etc.	Miscellaneous – Shipping, duties etc.	€ 2,850,000.00	$ 3,705,000.00
	Total	**€ 119,301,768.00**	**€ 155,092,298.40**
	10% Contingency	€ 11,930,176.80	€ 15,509,229.84
	Grand Total (± 30%)	**€ 131,231,944.80**	**$ 170,601,528.24**

TTRL Question 23 April 2013
Should the CAPEX cost of crawlers be less? We only need a 3rd crawler not 4.

IHC Response 25 April 2013
2.6: For a two crawler system 2 spare crawlers are taken into account. When an exchange system is adopted two are required. Take into account as well that no critical spares for the crawlers are taken into account as the spare crawlers are considered spares. If the second spare crawler is taken out, a similar amount of spare parts will need to be put in.

8 OPEX mining system

This section describes the input for the OPEX calculations and results for mining system only.

Since the OPEX of the crawler mining system is part of the complete Mining Platform only those components of the OPEX are presented that need to be added to TTRL's financial model for OPEX of the complete system:

- Power Consumption of Mining system;
- Extra personnel for operation of Mining System only;
- Critical spares for the Mining system

8.1 Accuracy of Estimate

The OPEX estimate has been compiled based on high level estimates and accuracy cannot be guaranteed. Some aspects of the OPEX are depending on the operational philosophy of the entire operation and can be best determined by TTRL.

DISCLAIMER: Due to the limited time allowed all OPEX figures are not based on actual quotes nor on detailed calculations or engineering. OPEX figures are also prepared without a clear scope of work, demarcation and battery limits with the client. Therefore the OPEX figures as presented are only indicative and can only be more detailed during the BFS.

8.2 OPEX for single crawler system

Following items need to be included in the TTRL Financial model:

8.2.1 Power Consumption

Only the power requirements for continuous operation of the crawler and its slurry pump are taken into account. This does NOT include peak power requirements!!

System	Type	Installed power MW
Crawler Power requirement	Continuous	5MW
4 point Mooring System Power requirement	Continuous	0.5MW
DP during Mining (high level estimate)	Continuous	5MW (Peak 10MW)

Table 8-1 Power consumption for single crawler system

8.2.2 Mining System Personnel

The following table represents personnel breakdown.

Personnel	Qty per 12 hr shift	Shifts per 24 hr period	Total crew per operational rotation	Total compliment
Operating Staff				
Mining System Superintendent	1	1	1	2
Mining System Supervisor	1	1	1	2
SMT Pilot	1	2	2	4
SMT Co-Pilot	1	2	2	4
Sub Total			**6**	**12**
Maintenance Staff				
A&I Technician	1	2	2	4
Electrical Technician	1	2	2	4
Hydraulic Technician/Fitter	1	2	2	4
Mechanical Fitter	1	2	2	4
Boilermaker/Artisan	1	2	2	4
Sub Total			**10**	**20**
Total			**16**	**32**

Table 8-2: Personnel for single crawler system

Excluded from this list but assumed to be included in the Mining Platform personnel are (but not limited to):

- Mine manager
- Geologists
- Mine Planners
- Surveyors
- Complete Marine crew
- Processing plant operating and maintenance crew

8.2.3 Critical spares

In the CAPEX a certain figure is allowed for critical spares. Maintenance and repair is dependent on the operational philosophy and the production requirements. System redundancy, preventive maintenance and stock of critical spares determine the overall uptime of the system and the sensitivity of the complete mining operation to incidents and showstoppers. Occurrence and impact of these risks needs to be taken into account.

The following items are expected to be replaced regularly:

- VTS riser hoses is expected to be replaced regularly, it is estimated the interval be every 6 months;
- Umbilical cable is expected to be replaced regularly, it is estimated the interval be every 12 months.
- Mooring Wires is expected to be replaced regularly, it is estimated the interval to be every 12 months;
- Life expectancy of a crawler system is expected to be 6 years, depending on the wear and tear and fatigue related weakening of the structure.
- Slurry systems wear and tear is hugely dependent on the type of soil and operational parameters. A BFS should determine the life expectancy of the slurry lines and the requirements for special wear resistant materials.

Yearly operational expenditure on critical spares is estimated at: **€ 5.000.000 or 6.500.000 USD** consisting of:

- VTS hoses
- Umbilical cable
- Mooring wires
- Main slurry wearing parts

8.2.4 Maintenance, Repairs, Spares and Consumables

Additionally all other maintenance, repairs, spares and consumables can be shared with the are determined as the average percentage of the CAPEX used for high density technology items.

8.3 OPEX for double crawler system

Following items need to be included in the TTRL Financial model:

8.3.1 Power Consumption

Only the power requirements for continuous operation of the crawler and its slurry pump are taken into account. This does NOT include peak power requirements!!

System	Type	Installed power MW
Crawler Power requirement	Continuous	8MW
DP during Mining (high level estimate, NOT BASED ON ANY CALCULATION)	Continuous	12MW

Table 8-3: Power consumption for double crawler system

8.3.2 Mining System Personnel

The following table represents personnel breakdown.

Personnel	Qty per 12 hr shift	Shifts per 24 hr period	Total crew per operational rotation	Total compliment
Operating Staff				
Mining System Superintendent	1	1	1	2
Mining System Supervisor	1	1	1	2
SMT Pilot	2	2	4	8
SMT Co-Pilot	2	2	4	8
Sub Total			**10**	**20**
Maintenance Staff				
A&I Technician	2	2	4	8
Electrical Technician	2	2	4	8
Hydraulic Technician/Fitter	2	2	4	8
Mechanical Fitter	2	2	4	8
Boilermaker/Artisan	2	2	4	8
Sub Total			**20**	**40**
Total			**30**	**60**

Table 8-4: Personnel for double crawler system

Excluded from this list but assumed to be included in the Mining Platform personnel are (but not limited to):
- Mine manager
- Geologists
- Mine Planners
- Surveyors
- Complete Marine crew
- Processing plant operating and maintenance crew

8.3.3 Critical spares
In the CAPEX a certain figure is allowed for critical spares. Maintenance and repair is dependent on the operational philosophy and the production requirements. System redundancy, preventive maintenance and stock of critical spares determine the overall uptime of the system and the sensitivity of the complete mining operation to incidents and showstoppers. Occurrence and impact of these risks needs to be taken into account.

The following items are expected to be replaced regularly:
- VTS riser hoses is expected to be replaced regularly, it is estimated the interval be every 6 months;
- Umbilical cable is expected to be replaced regularly, it is estimated the interval be every 12 months.
- Mooring Wires is expected to be replaced regularly, it is estimated the interval to be every 12 months;
- Life expectancy of a crawler system is expected to be 6 years, depending on the wear and tear and fatigue related weakening of the structure.
- Slurry systems wear and tear is hugely dependent on the type of soil and operational parameters. A BFS should determine the life expectancy of the slurry lines and the requirements for special wear resistant materials.

Yearly operational expenditure on critical spares is estimated at: **€ 5.000.000 or 6.500.000 USD** consisting of (all for 2 crawlers):
- VTS hoses
- Umbilical cable
- Main slurry wearing parts

8.3.4 Maintenance, Repairs, Spares and Consumables
Additionally all other maintenance, repairs, spares and consumables can be shared with the are determined as the average percentage of the CAPEX used for high density technology items.

8.4 Excluded Items
Following components are excluded as they are assumed to be calculated by the Client as part of their overall OPEX estimates:
- Overall mining platform Fuel consumption and Cost;
- All other Personnel required; Indirect support staff and costs (catering / housekeeping etc);
- Depreciation and Interest for the complete Mining Platform including the Mining System;
- Insurance for the complete Mining Platform including the Mining System
- Concession sampling and evaluation;
- Geological testing;
- Environmental impact studies;
- Personnel transportation and logistics (helicopter/boat) for crew change;
- Training;
- Insurance;

- Licensing;
- All overhead (shore based staff, hire of offices, electricity, communications, computers, copiers, emergency evacuation costs, technical department, lubricants, water, laying up and idle time, mobilization and demobilization, modifications, cost of flights, food, hotel and work permit if any required);
- Land based workshop for vessels (containers, water truck, compressor, generator, light set, fuel, chief workshop, workers, consumables etc);
- Land based warehouse for Spare Crawler system and all other spares and consumables; and
- No survey vessel / crew change (helicopter or boat) / emergency vessel.

9 Workshop conclusions

- The crawler mining system is a viable technical option for mining the iron sands tenements of TTRL. It can be deployed in a single or a double configuration.
- The single crawler configuration is a well known mining operation, however on its technological limits at 800mm ID.
- The double crawler configuration is not known in operation, however it has many opportunities for improvement on operational production performance.
- The expectation is that with additional detailed engineering the level of confidence in technology and operations will be significantly improved.
- Crucial for the production performance is the assumption that the Iron Sands are free flowing material once fluidised. It is recommended to undertake laboratory testing, site soil investigation and bulk sampling activities.
- The crawler mining system was evaluated during the workshop independent of the complete mining system integration; by combining mining, processing, offloading and tailings disposal on one vessel it is recommended to perform a Total Mining System Assessment to optimize system integration and interfacing.

9.1 Post Workshop Evaluation Conclusions

The main conclusions that can be drawn from the upside potential assessment:

- The minimum required water depth for the crawler operation is 30 meter. This is more dependent on the Mining Support Vessel draught and the sea states than on the crawler itself
- There is an upside potential to 40,87 Mt per annum for a single crawler with an 800 ID delivery line. However this figure is to be confirmed during a BFS stage.
- To bring the double crawler mining operation to an acceptable level of confidence requires about 6-8 months of engineering to ensure that there are no fatal flaws.

Appendix A: Pre-Workshop Terms of Reference TTRL

TERMS OF REFERENCE

TTRL/IHC Viability Workshop 2 – 12 April

Trans Tasman Resources have requested IHC to assist in the evaluation of a specific mining solution.

TTRL require that the Viability analysis be largely a quantitative exercise. A solid data base using established and verified data and solutions is to be utilised.

The aim of workshop is to determine whether the proposed alternative is technically viable and, if it is, whether it is the best alternative. The ideal scenario for the TTRL project is an alternative that fulfils all the objectives with the smallest possible risk and challenges. ***It must be stressed that even though an alternative best accomplishes the objectives but still carries severe risks and challenges it will not regarded as the best choice.***

The priority of the workshop will be to first perform a viability analysis on the "Crawler Mining" option against a fixed list of imperatives (Must haves!), then to compare it against any other identified alternatives including the current PFS alternative.

1 Imperatives (MUST HAVES)

1.1 Total Capex intensity for the whole project including FSO (50kt-80kt) type vessel and transhipment vessel (Capesize 180kt) must be ≤ USD$100 per tonne of annualised concentrate capacity

1.2 Opex costs per tonne of concentrate loaded into export vessel (FOB) have to be less or comparable to the current PFS solution.

1.3 Integrated Tailings Management. The continuous deposition of tailings on the seabed behind the progressing mining unit is to be an essential component of any successful alternative. This will require mining down to full depth of mineralisation (basement level) in each mining location prior to moving forward to the next anchor location. This is important to ensure a void is created to allow continuous discharge of tailings behind the mining operation.

1.4 Production of ≥ 5mtpa Concentrate. This will require the extraction of 8000tph of ROM material. (50mtpa ROM)

1.5 High Mining Utilisation of at least 80%. Able to work in conditions 3-4m Hs

1.6 High Certainty with regards to both CAPEX and OPEX estimates (90%). This can only be accomplished with the reference to actual historical data.

2 Wants

No	Description	Priority	Weighting
2.1	Minimum environmental effects, i.e. plumes		
2.2	Reduced operational risks		
2.3	Reduced Marine operations Less vessels, reduced interdependencies		
2.4	Reduced Power Requirements		

3 Deliverables

3.1 A viability report for the "crawler mining option" detailing the process of analysis, identified risks and mitigations and the estimated associated CAPEX and OPEX.

3.2 Sufficient verified information to facilitate a detailed comparative analysis between the Crawler Option and the Trailer Hopper Suction Dredge.

Questions to be addressed:

- What is a realistic production rate for a single dredge/FPSO and is the dredge scaleable and or able to be duplicated?
- What is the best solution for continuous discharge of tailings without contaminating future mining areas?
- What is the best solution for transferring concentrate to an FSO?
- What is our fresh water solution?

General Comments:

- Size of the FPSO and FSO will be critical drivers to capex
- Build an operating cost model and NPV model to allow a transparent comparison to the Technip process. Must be able to be integrated into a "combined" PFS!
- Why do we really need 170 kt FSO's? based on 5mtpa concentrate production we would be producing c.15000 tpd con. , I think we are better off with a smaller FSO vessel (panamax size?) shuttling concentrate and water on a 3 -4 day cycle? back to a permanently moored large floating dock/barge in a safe anchorage location. Concentrate is then transferred to this dock which then re-handles to export vessels as they arrive. Vale have built one of these systems recently off the coast of Malaysia.

Appendix B: Vuijk Report on Mooring and DP

Naval architects, Marine Engineers, Consultants

CALCULATION NOTE

To: IHC Mining
Origin: JBe
Chkd: DBr, MNo
Distr:
Date: 10-Apr-2013
Project: TTR Mining **Ref.no.:** 30481JBe13059
Subject: Mooring estimation

Introduction
IHC Mining requested Vuyk Engineering Rotterdam B.V. to perform a preliminairy DP and mooring analysis for two possible vessel designs that could be used for the TTRL mining project at the coast of New Zealand. All calculations are based on limited information and are performed in a very short time window, for this reason it is advised to use the results for information only. For the design of the final mooring spread, more detailed calculations are required.

Input and Assumptions

Vessel properties
The following properties for the two possible vessel designs are used. This data is partly based on representative reference vessels.

	250 m vessel	300 m vessel
Length [m]	250.0	300.0
Breadth [m]	40.0	45.0
Max Draught [m]	12.0	16.0
Wind area front [m^2]	1400.0	1575.0
Wind area side [m^2]	6250.0	7500.0

Used coefficients

Wind	1.00	[-]
Current front	0.30	[-]
Current side	0.90	[-]
Wave side	0.044	[-]
Wave front	0.063	[-]

Typical transmission ratio azimuthing thruster: 0.16 kN/kW

Mooring layout
The mooring system consist of a 4 point mooring with an equal spread. The vessel should be able to operate in a mining grid of 600 m * 300 m with a water depth of 50 meters.

The used mooring wire has the following properties:

Diameter [mm]	88.9
Weight [kg/m]	33.8
MBL [kN]	5520
EA [MN]	378

A safety factor of 2.0 on the MBL is used in the calculations. This is according GL-ND.

Environmental condition
In the calculations the following environmental condition is considered:

Wind speed [m/s]	15.0
Sig. wave height [m]	4.5
Current speed [m/s]	0.5

Based on a reference vessel, the maximum expected 1st order wave motion offset is 4.5 m for an environmental direction of 30 deg.

The speed of the crawler is estimated to be 0.5 m/s. This speed needs to be added to the wind and current speed to calculate the environmental load when operational at the by the client specified environmental condition.

Results

Environmental loads for station keeping
Based on the calculations, the total environmental loads are given in the table below. This includes the wind, current, and second order mean wave drift load:

	250 m vessel		300 m vessel	
Env. dir. [deg]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]
Front, 0	627.8	0.0	706.2	0.0
Side, 90	0.0	4581.5	0.0	5497.7
30	502.1	1592.6	564.8	1911.1

Minimum required thruster capacity for full DP
Based on the environmental loads the estimated minimum required total DP capacity of the thrusters is presented. This calculation does not take into account any DP-class requirements.

	250 m vessel	300 m vessel
Env. dir. [deg]	Power [MW]	Power [MW]
Front, 0	3.92	4.41
Side, 90	28.63	34.36
30	10.44	12.45

The actual overall installed power for the thrusters will be higher, this to cover different failure modes, different environmental conditions etc.

Minimum required mooring line lengths
Based on the operational grid, vessel dimensions and the environmental loads, the mooring layout is determined. The mooring lines are at an angle of 45 deg relative to the vessel coordinate system, with an offset of 1500 m from the corners of an ‘box shaped area’ of 300 m + vessel breadth * 600 m + vessel length. This to be able to cover the operational grid of 600 m * 300 m. The diagonal of this ‘boxed area’ is close to 1000 m. This results into a minimum effective line length on the winch of 2500 m. If the vessel deploys and retrieves the anchors by itself, a length of 1500 m + 1000 m + 1500 m = 4000 m is required.

When moving the centre of the vessel to the corners of the ‘boxed area’, the angles in the spread change. For this position the environmental loads are introduced on the vessel at an angle of 30 deg of the bow, and 30 deg of the stern. In this position on the grid one of the lines will almost have the same direction as the environmental load, therefore it will take a large contribution in counteracting the environmental load.

Quasi static load calculation
The calculated environmental loads are for a mean static condition. Due to first order wave motions it is assumed that there will be an inline dynamic offset of 4.5 m (amplitude) in the mooring line This causes an increase in the line loads. (Quasi static approach). This effect should not exceed the maximum allowable tension in the mooring line.

For the determination of the maximum catenary shape the maximum allowed load in the mooring line is used: MBL / Safety factor, 2760 kN. The line length in is 1500 m un-stretched in a water depth of 50 m. Applying a load of 2760 kN results in a total line length of about 1510 m. During maximum loading the horizontal distance will be about 1509 m between the anchor and winch.

To determine the maximum allowable static load on the catenary, the horizontal offset is subtracted from the 1509 m (without changing the mooring line length), resulting in a horizontal distance between the anchor and winch of approx. 1504.5 m and a reduced line load of 1750 kN. This tension of 1750 kN is the maximum allowable static load on the highest loaded line, without the 1st order wave motions.

Additional required DP power for mooring assist
The maximum allowable static tension of 1750 kN is lower than the tension due to the calculated environmental loads, and therefore additional DP power is required to reduce the tension in the mooring line. In the table below the required DP thrust is calculated:

	250 m vessel	300 m vessel
	Tension [kN]	Tension [kN]
Max static line load due to environmental loads	1890.1	2239.5
Max allowable static line load	1750.0	1750.0
Required additional DP thrust	140.1	489.5

Based on the additional required DP thrust the required DP power to counteract the 1st order wave motions is given:

	250 m vessel	300 m vessel
	Power [MW]	Power [MW]
Required DP power	0.88	3.06

Anchor capacity
The maximum load on the mooring line will be 2760 kN, therefore the anchors should have an identical or higher holding capacity. When assuming the usage of the Flipper Delta anchor type, an anchor with a weight of 15 ton or larger is required for sandy soils. For clay a minimum weight of 20 ton is required.

Additional required DP power for crawling
When crawling, it is assumed the vessel will move with a speed of about 0.5 m/s. The extra load due to this speed is calculated by adding 0.5 m/s to the wind and current speed.

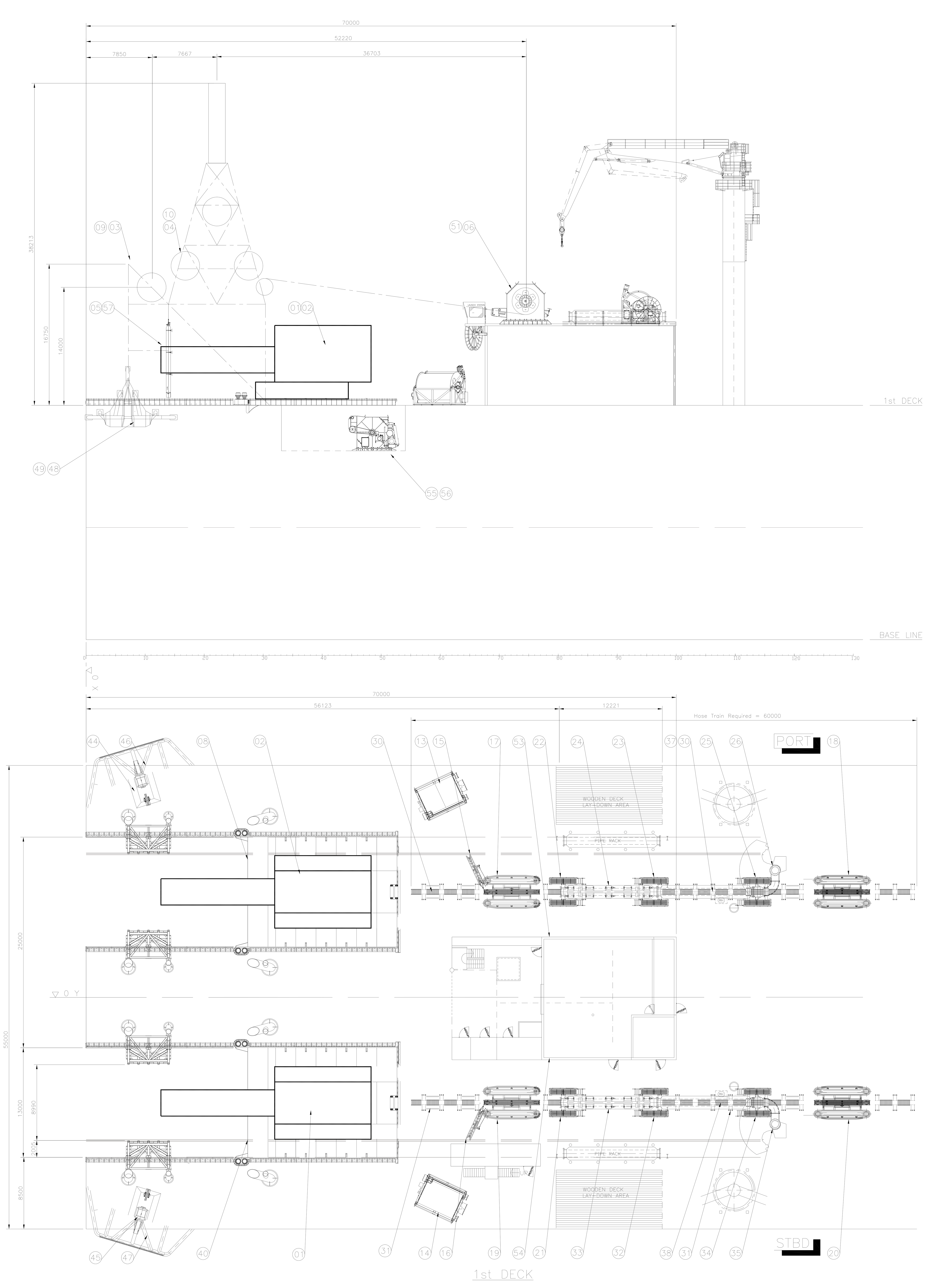
This speed cannot be guaranteed by the winches, because the maximum allowable load on the wire is already reached. Therefore the DP system is required to move the vessel. The results of this calculation is given in the table below:

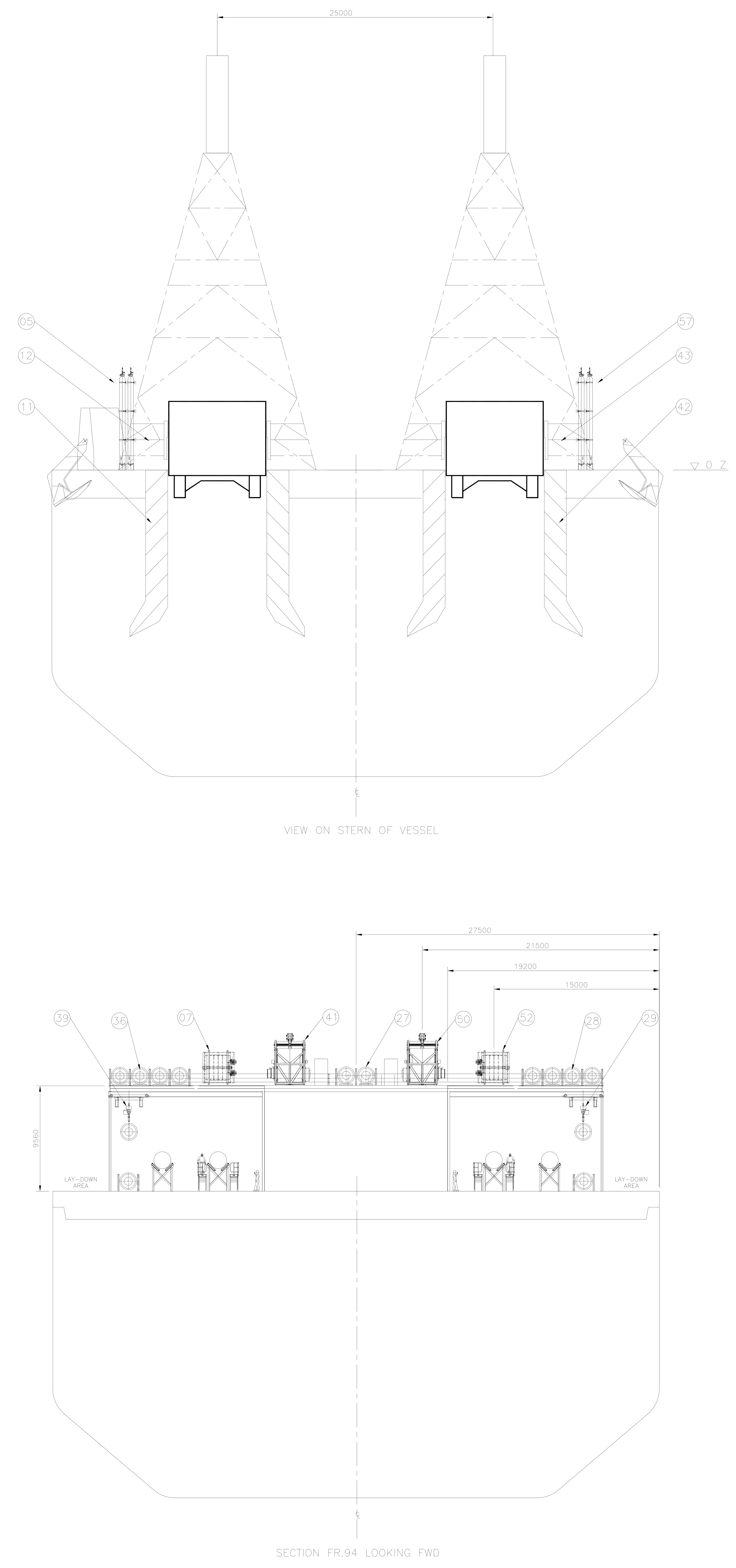
	250 m vessel	300 m vessel
DP Thrust [kN]	851.8	1024.1
DP Power [MW]	5.32	6.40

Remarks

- When the operational grid is reduced in size, the angles of the mooring spread will become closer to 45 degrees, this will result in lower line loads. This also means when the vessel is operating more to the centre of the field, the loads on the mooring lines will reduce.
- Due to the relative shallow water depth, the effect of the catenary of the mooring line is limited. This results in a relatively stiff mooring system, causing high loads due to dynamic offsets (1^{st} order wave motions).
- In the calculations line lengths of 500 - 1000 m or more are in contact with the seabed. Due to the manoeuvring over the grid, the lines will be dragged transversely over the seabed. This will result in bellies in the mooring wire, which could at once release during manoeuvring, causing unexpected offsets of the vessel.

Appendix C: Mining System – Aft Vessel Drawing





DO NOT SCALE - IF IN DOUBT, ASK

REFERENCE DOCUMENTS

DOCUMENT NUMBER	TITLE

REVISION TABLE

REV	BY	DATE	DESCRIPTION

GENERAL TOLERANCES

MACHINING	FABRICATION
0 to 100 ± 0,2	0 to 500 ± 2
100 to 500 ± 0,4	500 to 2500 ± 3
500 to 1000 ± 0,6	2500 to 5000 ± 4
Above 1000 ± 1,0	Above 5000 ± 5

GENERAL NOTES
UNLESS OTHERWISE NOTED

1. MASSES IN TONNES
2. DIMENSIONS IN METRES
3. X IS TAKEN LONGITUDINALLY FROM VESSEL STERN
4. Y IS TAKEN TRANSVERSE FROM VESSEL CENTERLINE. (P–PORT, S–STB'D)
5. Z IS TAKEN VERTICALLY FROM 1ST DECK
6. ESTIMATED MASSES AND COG's: ±30% ACCURACY

ITEM	DESCRIPTION	MASS	X	Y	Z
57	NITROGEN STORAGE BOTTLES (STB'D)	60	10.6	S6.7	5.3
56	MOORING WINCH AFT (ø80 X 2000M) (PORT)	125	34	P4.5	–3
55	MOORING WINCH AFT (ø80 X 2000M) (STB'D)	125	34	S4.5	–3
54	DECKHOUSE EQUIPMENT STBD (EXCLUDING STRUCTURAL STEELWORK)	50	56.7	S3.6	6.0
53	DECKHOUSE EQUIPMENT PORT (EXCLUDING STRUCTURAL STEELWORK)	50	56.7	P3.6	6.0
52	SPARE ROPE + STORAGE WINCH (ø141 x 300m) (STB'D)	55	66.6	S12.5	11.4
51	MAIN HOIST WINCH + ROPE (ø141 x 300) (STB'D)	220	52.2	S12.5	12.1
50	SPARE UMBILICAL STORAGE WINCH (STB'D)	20	65.5	P5.9	11.8
49	ANCHOR (AFT STB'D)	15	6.0	S26.4	2.3
48	ANCHOR (AFT PORT)	15	6.0	P26.4	2.3
47	ANCHOR RACK (AFT STB'D)	4	6.7	S27.0	–0.5
46	ANCHOR RACK (AFT PORT)	4	6.7	P27.0	–0.5
45	FAIRLEADER + SUPPORT STRUCTURE + BEND SHEAVES (STB'D)	45	7.7	S13.2	4.0
44	FAIRLEADER + SUPPORT STRUCTURE + BEND SHEAVES (PORT)	45	7.7	P13.2	4.0
43	CRAWLER RESTRAINING SYSTEM (UPPER) (STB'D)	15	7.5	S12.5	2.8
42	CRAWLER RESTRAINING SYSTEM (LOWER) (STB'D)	30	7.5	S12.5	–4.2
41	SPARE UMBILICAL STORAGE WINCH (PORT)	20	65.5	S5.9	11.8
40	LONGITUDINAL SLIDING DOOR (STB'D)	90	27.7	S12.5	0.3
39	SPARE HOSE HANDLING GANTRY & GANTRY CRANE (PORT)	28	63.0	P20.5	6.8
38	HOSE ON RISER TRAIN (STB'D)	24	74.3	S12.5	2.3
37	HOSE ON RISER TRAIN (PORT)	24	74.3	P12.5	2.3
36	SPARE HOSES + STORAGE RACKS (PORT)	24	63.0	S18.6	10.5
35	HOSE CLAMPING SWIVEL (STB'D)	10	81.4	S12.5	1.9
34	HOSE CLAMPING PLATFORM (STB'D)	1.5	79.6	S12.5	1.0
33	RISER HOSE ROTATION SYSTEM (STB'D)	10	62.0	S12.5	1.6
32	BOLTING STATION PLATFORM NO.2 (STB'D)	1.5	67.4	S12.5	1.0
31	RISER TRAIN (STB'D)	12	43.2	S12.5	1.3
30	RISER TRAIN (PORT)	12	43.2	P12.5	1.3
29	SPARE HOSE HANDLING GANTRY & GANTRY CRANE (STB'D)	28	63.0	S20.5	6.8
28	SPARE HOSES + STORAGE RACKS (STB'D)	24	63.0	P18.6	10.5
27	SPARE HOSES + STORAGE RACKS (CENTRE)	12	63.0	–	10.5
26	HOSE CLAMPING SWIVEL (PORT)	10	81.4	P12.5	1.9
25	HOSE CLAMPING PLATFORM (PORT)	1.5	79.6	P12.5	1.0
24	RISER HOSE ROTATION SYSTEM (PORT)	10	62.0	P12.5	1.6
23	BOLTING STATION PLATFORM NO.2 (PORT)	1.5	67.4	P12.5	1.0
22	BOLTING STATION PLATFORM NO.1 (PORT)	1.5	56.6	P12.5	1.0
21	BOLTING STATION PLATFORM NO.1 (STB'D)	1.5	56.6	S12.5	1.5
20	RISER TENSIONER 2 (STB'D)	21	89.7	S12.5	1.5
19	RISER TENSIONER 1 (STB'D)	21	50.5	S12.5	1.5
18	RISER TENSIONER 2 (PORT)	21	89.7	P12.5	1.5
17	RISER TENSIONER 1 (PORT)	21	50.5	P12.5	1.5
16	POWERED UMBILICAL SHEAVE (STB'D)	6	46.2	S15.0	7.6
15	POWERED UMBILICAL SHEAVE (PORT)	6	46.2	P15.0	7.6
14	UMBILICAL WINCH (STB'D) + UMBILICAL	30	42.0	S23.9	2.2
13	UMBILICAL WINCH (PORT) + UMBILICAL	30	42.0	P23.9	2.2
12	CRAWLER RESTRAINING SYSTEM (UPPER) (PORT)	15	7.5	P12.5	2.8
11	CRAWLER RESTRAINING SYSTEM (LOWER) (PORT)	30	7.5	P12.5	–4.2
10	COMPENSATOR SYSTEM (STB'D)	120	13.6	S12.5	18.8
09	A–FRAME (STB'D)	130	8.9	S12.5	9.5
08	LONGITUDINAL SLIDING DOOR (PORT)	90	27.7	P12.5	0.3
07	SPARE ROPE + STORAGE WINCH (ø141 x 300m) (PORT)	55	66.6	P12.5	11.4
06	MAIN HOIST WINCH + ROPE (ø141 x 300) (PORT)	220	52.2	P12.5	12.1
05	NITROGEN STORAGE BOTTLES (PORT)	60	10.6	P6.7	5.3
04	COMPENSATOR SYSTEM (PORT)	120	13.6	P12.5	18.8
03	A–FRAME (PORT)	130	8.9	P12.5	9.5
02	750 SUBSEA CRAWLER (PORT)	400	25.7	P12.5	4.7
01	750 SUBSEA CRAWLER (STB'D)	400	25.7	S12.5	4.7

PARTS LIST

IHC MARINE AND MINERAL PROJECTS (Pty) Ltd

MERWEDE

PROJECT	TTRL IRON SANDS NEW ZEALAND
TITLE	TTRL VESSEL CONCEPT - MINING EQUIPMENT
DRAWN	HNE
DATE	2013/05/09
TYPE	GENERAL ARRANGEMENT
APPROVED	

3RD ANGLE PROJECTION U.O.N

DRAWING NUMBER	REVISION
13019-000-0001	D

SIZE	A0	SCALE	1:100	SHEET NUMBER	1 of 1

Appendix D: ROM Density Calculations

In Situ

	SG (t/m3)	Volume (m3)	Weight (t)	Vol%	Wt%
Solids SG	3.20	0.594	1.90	59.4	82.0
Water in pores SG	1.03	0.406	0.42	40.6	18.0
In Situ		**1.00**	**2.32**	**100.0**	**100.0**

As Mined Vol% solids (IHC calc)

ROM Vol% solids	**30.00**				
	SG (t/m3)	Volume (m3)	Weight (t)	Vol%	Wt%
Solids SG	**3.2**	**0.178**	0.57	17.8	40.2
Water in pores SG	**1.03**	**0.122**	0.13	12.2	8.9
Situ Solids SG	2.32	0.300	0.70	30.0	49.1
Seawater SG	1.03	0.700	0.72	70.0	50.9
ROM Slurry		**1.00**	**1.417**	**100.0**	**100.0**

Alternative Case:

As Mined Vol% solids

ROM Vol% solids	**17.10**				
	SG (t/m3)	Volume (m3)	Weight (t)	Vol%	Wt%
Solids SG	3.20	0.171	0.55	17.1	39.1
Seawater SG	1.03	0.829	0.85	82.9	60.9
ROM Slurry		**1.00**	**1.401**	**100.0**	**100.0**

		1 Crawler (800 ID)
Slurry volume	m3/h	11,771
Slurry weight	t/h	16,674
Seawater weight	t/h	9,965
Seawater volume	m3/h	9,674
Solid weight	**t/h**	**6,709**

Actual Vol % true solids 17.8% by SG

solids t/h	t/h	6500
solids density	t/m3	1.9
Effective cut width	m	10
Face height	m	5
Advance Rate	m/h	68.4
Hose ID	mm	800
Area	m2	0.503
Slurry Velocity	m/s	6.50

		1 Crawler (800 ID)	
Slurry volume	m3/h	11,771	11,771
Slurry weight	t/h	16,492	16,492
Seawater weight	t/h	4,721	10,051
Seawater volume	m3/h	4,583	9,758
Solid weight	**t/h**	**6,441**	**6,441**

Actual vol % solids 17.1% by SG

solids t/h	t/h	10,850
solids density	t/m3	2.35
Effective cut width	m	10
Face height	m	5
Advance Rate	m/h	92.3
Hose ID	mm	800
Area	m2	0.503
Slurry Velocity	m/s	6.50

Appendix E: ROM Production Calculations

PRODUCTION CALCULATIONS FOR CRAWLER 800 ID OPERATION

In situ material (ROM)

Average density solids	3,200	t/m3
Density water	1,030	t/m3
Voids (porosity)	40,63%	vol
Dry Bulk density	1,900	t/m3
Wet bulk density ROM (incl moisture)	2,318	t/m3
Moisture in ROM	18,05%	wt
True Operating Hours per year	4821	hrs
Feed production	3390	m³/h

Output figures

Description	m3/h	t/h	m3/y	t/y
Production in situ	3390	7860	16.343.190	37.890.665
True solids production delivered	2013	6441	9.703.769	31.052.061
Production water	1377	1419	6.639.421	6.838.604

Cv true solids in situ	**59,38%**
Cm true solids in situ	**81,95%**
Check volumes	OK

PUMP PRODUCTION

			critical vel	
Diameter discharge pipe dredge	800	mm		
Diameter suction pipe dredge	800	mm		
Mixture velocity in dicharge pipeline	6,50	m/s	*4,85*	m/s
Mixture velocity in suction pipeline	6,50	m/s	*4,85*	m/s
Duty point (DAS)	3,270	m3/s		
Cv in situ (DAS)	30%			
Total mixture flow	11771	m3/h	16492	t/h
Production in situ material (theory)	3531	m3/h	8187	t/h
Transport factor	0,96			
Mixture density in pipeline	1,401	t/m3		

Output figures

Description	m3/h	t/h	m3/y	t/y
Production in situ delivered	3390	7860	16.343.190	37.890.665
True solids production	2013	6441	9.703.769	31.052.061
Production water	9758	10051	47.043.418	48.454.721
Total mixture flow	11771	16492	56.747.188	79.506.782

Cv true solids	**17,10%**
Cm true solids	**39,06%**
Cv in situ (del)	**28,80%**
Cm in situ	**47,66%**
Check volumes	OK

Appendix F: Crawler Potential Upside Production Assessment

Base Case: Single Crawler with 800mm ID Slurry Delivery Line

Rev.: 0 **26-apr-13**

Variable	**Unit**	**Base case**	**Upside potential IHC**	**Proposed Value TTRL**	**TTRL Rationalisation**	**Upside Potential Responsibility**	**Upside Potential Comments**
Annual operating days	days	365	365	365			
Port visits (incl. dry docking)	days	30	15	15	TTRL has confirmed that a new vessel requires a dry docking every 5 yrs. to inspect the hull and propulsion.	TTRL	TTRL to ensure that: (i) the vessel will be designed to access the local port. (New Plymouth), (ii) the 15 day allowance per annum is sufficient allowance for dry docking and transit to and from the nearest dry dock facility and (iii) Classification Society Rules and Regulatioons are adhered to. **Note:** The 15 day allowance assumes no dry docking or port call for unforeseen breakdowns.
Maintenance	days	26	26	12	TTRL consider the availability of the second crawler, either on deck or at the local port will significantly reduce the number of days lost to unscheduled maintenance delays.	IHC	IHC advises that an allowance of 26 days per annum should be made for regular maintenence. This includes weekly maintenance of the crawler on deck and swopping out the crawler in-port once per annum. **Note:** The 26 day allowance assumes no dry docking or port call for unforeseen breakdowns.
Transhipment Constraints	days	12	0	0	TTRL has confirmed the methodology and operation of transhipment transfers with an experienced shipping operator. All transfers will be accomplished without the interruption of the mining operation.	TTRL	Downtime is not dependent on crawler operation. TTRL has full responsibility for he consequences of any downtime related to concentrate transshipment, refueling of MSV and transhipment of supplies and crew changes.
Anchor Spread Handling	days	18	0	0	TTRL has indicated that an anchor handling tug can shift the anchors during mining operation and that DP will take over	TTRL	A combined four point mooring system together with DP will allow anchor handling days to be reduced by the use of an anchor handling tug. TTRL has full responsibility for the consequences of any downtime rellated to anchor handling and must ensure the full DP system is available during anchor handling.
Mining System Availability	**days**	**279**	**324**	**338**			
	hours	**6696**	**7776**	**8112**			
		76,44%	**88,77%**	**92,60%**			
Weather uptime		90%	90%	90%		TTRL	
Mining Efficiency		80%	85%	85%	The IHC value has been selected based on experience with the MV Peace In Africa diamond mining operation. The mining efficiency is a factor which has to be taken into consideration for the inefficiencies during the crawler operation, which include: creating a first face (digging in), no full face, spill, turning at the end of a cut and irregularities in the soil.	IHC	IHC believes there is a potential to increase the mining efficiency due to the larger block size and lane length. This needs further investigation during the BFS as it depends on the abilities of the final mooring system chosen, the mine plan and the skill level of the operators.
Total effective production time	**days**	**201**	**248**	**259**			
	hours	**4821**	**5949**	**6206**			
		55,04%	**67,91%**	**70,84%**			
Maximum Slurry Velocity		6.5 m/s	6.05 m/s	7.5 m/s	The IHC value has been selected as an average velocity, based on experience in other dredging operations. A slurry feed is never completely constant as mixture concentration changes and these are strongly dependent on each other. When concentration goes down velocity will go up and if concentration goes up velocity will go down.	IHC	The pump system is not the limiting factor nor is the slurry velocity in the pipeline. Higher velocity does not directly result in more production, the limiting factor is the amount of soil which can enter the suction mouth and this is dependent on the deposit characteristics (free flowing, thickness and stratification) and the advance rate of the crawler. This, however, needs further field testing and investigation during the BFS as this parameter and average sediment concentration are inter-related and depend on the variables mentioned above.
Sediment Concentration (vol) Average		30%	35%	40%	The IHC value has been selected based on experience with the similar dredging operations in free flowing sands with jetting. TTRL believe there is an opportunity to raise this average concentration when extracting the less cohesive iron sands and also by using mechanical assists such as jetting or mechanical feeding. It is interesting to note that the Taharoa operation achieves far higher slurry concentrations in their dredging operations.	IHC	IHC sees the potential for optimising the slurry velocity and sediment concentration. This, however, needs further field testing and investigation during the BFS as this parameter and slurry velocity are inter-related and depend on the variables mentioned above.
Total effective production	**hours**	**4821**	**5949**	**6206**			
	tph	**6441**	**6870**	**9909**			
	tpa	**31.052.834**	**40.867.157**	**61.492.083**			

Appendix G: MTI Report: Rapid assessment of TTRL-tailings

Memo

To
T. de Boer

From
A. Ortega
Z. Sulaiman

Copy to
E. Munts

Date	Reference
April 12, 2013	M013-103

Subject
Rapid Assessment TTR-Tailings

Mining Advisory Services has requested MTI-Sustainability and CFD to make a rapid assessment of the tailings return behaviour as currently being planned by TTR.

The main question was *"how the tailings from iron-sands mining will fall and initially disperse in the near-bed environment, as a first order estimate?"*

Input parameters

• Pipe diameter	1100 mm
• Specific gravity sand	3
• D50 (mean diameter)	250 μm
• Fines content (<63 μm)	5%
• Flow velocity pipe outflow	1.28 m/s
• Distance from seabed	4 m
• Mass concentration of solids	70%
• Sea water temperature (bottom)	4-5 °C
• Ambient current velocity	0.5 m/s

Initial dispersion model

Setting up a 3D-CFD model was the best approach as a pipe outflow is initially investigated. For the CFD calculations, "ANSYS-CFX" software package was used. A flat bed was assumed as well as a uniform ambient velocity. For a presentation of the model grid and the position of the pipe with respect to the seabed and the point of interest (from 16.5 m right of the pipe outflow) refer to Figure 1.

Parameters used in the model:

- Mixture density: based on input (sand and water density) an estimated mixture density of 1904 kg/m^3 was used. Volume fraction was calculated as 44%.
- Grain size: mean diameter (D50) was used. Fines content was not used because of increased complexity of the model and increased computational time.
- Flow velocity pipe outflow.
- Ambient current velocity (near seabed).
- Pipe, layout, diameter and location from seabed.

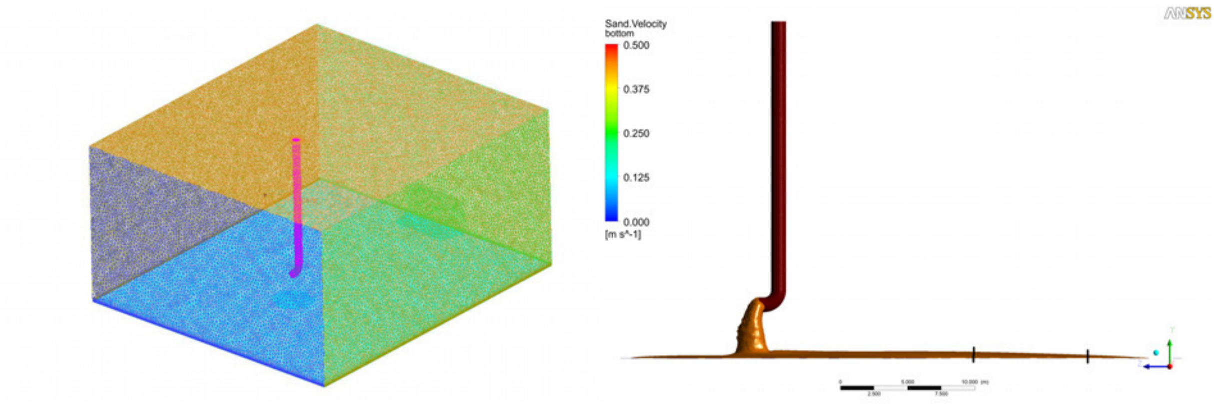


Figure 1 Computational domain and model set up

Initial results: rapid assessment CFD model

For the computation the ambient velocity (perpendicular to the pipe –worst case scenario) and the velocity at the outflow of the pipe are used. Figure 2 shows the velocity field, magnitude and direction around the pipe. At the right side of the pipe velocity magnitude reduces whereas at the left side the ambient current is affected by the outflow increasing in magnitude to approximately 1.6 m/s. It should be noted that this computation is done for a steady-state case and therefore the results are not time-dependent. This velocity magnitude influences the dispersion of sediment towards the point of interest.

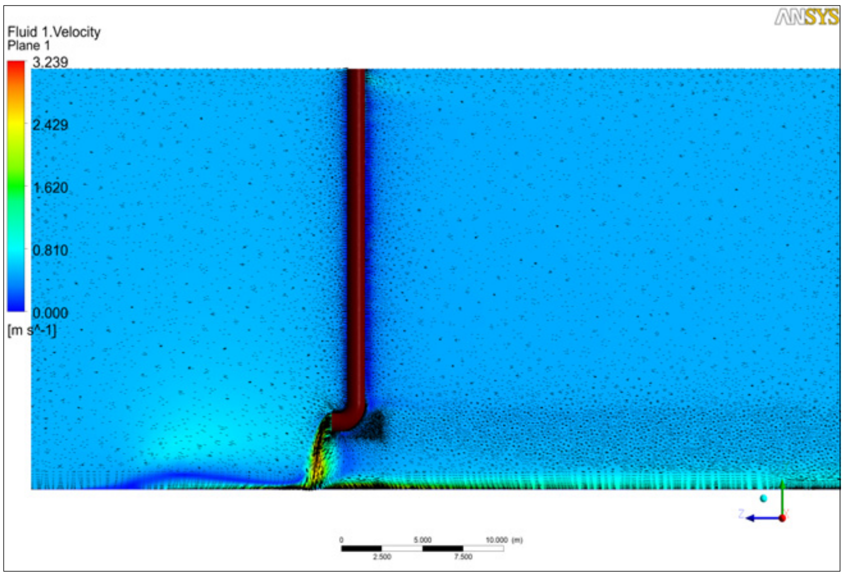


Figure 2 Tailings return near-seabed. Velocity magnitude and direction

Figure 3 shows the sediment dispersion around the pipe and near-seabed. Considering that the ambient current velocity is approaching perpendicular to the pipe, it can be concluded that the sediment dispersion is influenced by the outflow velocity (radial dispersion) and the ambient current (towards the left side of the pipe) in the direction of the point of interest. Figure 4 shows the density field in the surroundings of the pipe.

The result of the simulation is an estimation of the steady flow field pattern around the pipe. This means that the result is given for the moment where flow patterns are stabilised.

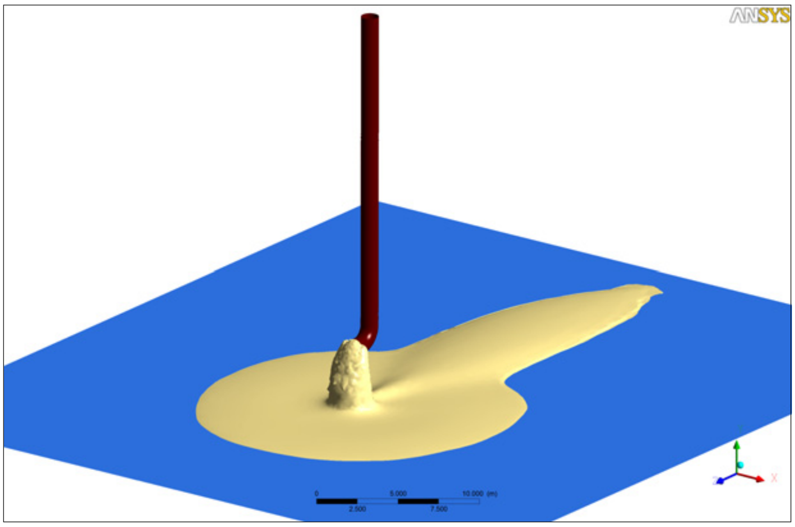


Figure 3 Sediment dispersion around the pipe and near-seabed

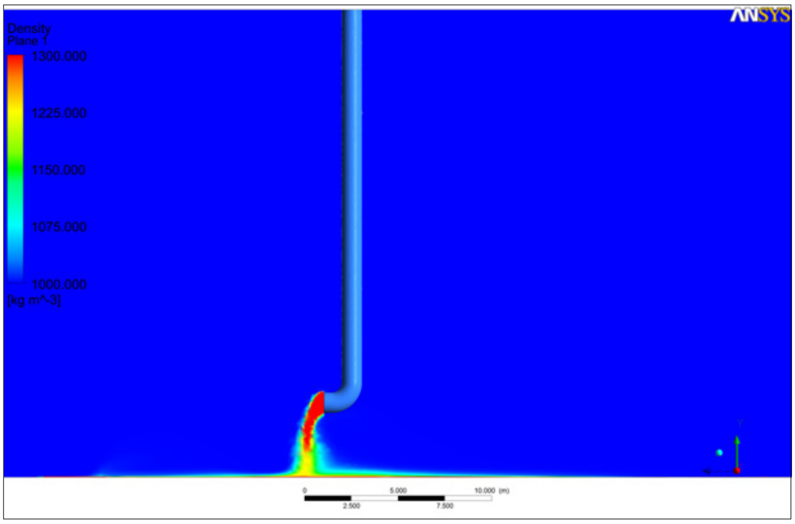


Figure 4 Density field pipe outflow and near-seabed

Recommendations for further investigation

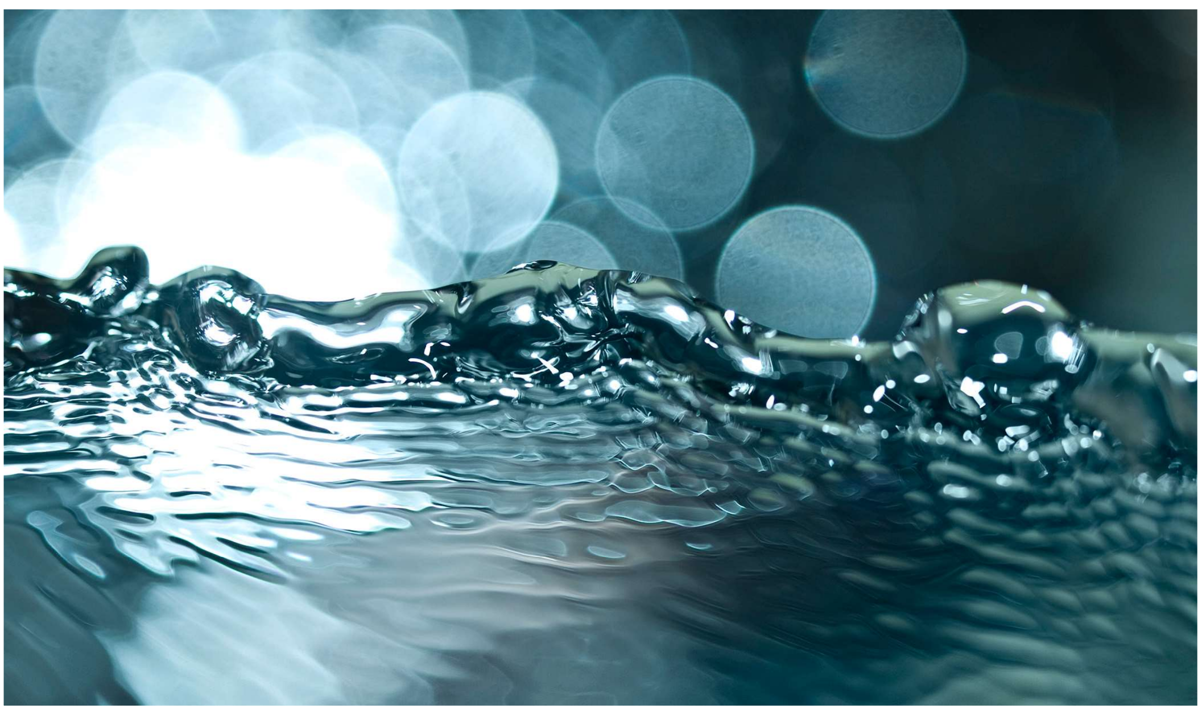
- For more accurate CFD calculations a mesh convergence study is recommended. This will reduce uncertainty of the results caused by mesh dependency.
- These computations were done for a steady-state case because of time-constraints, for inclusion of time-dependent solutions, “Transient case” is recommended. However, this will certainly increase the computational time.
- CFD calculations serve to schematise the sediment source coming from discharges (e.g., tailings pipe). For this study only the main grain size is used (D50). A multi-flow computation for different sediment fractions could be implemented in CFD, these type of computations require a more detailed model set up and require longer computational times. Alternatively, a separate study for the outflow behaviour of the fines’ fraction could be performed.
- CFD computations do not include factors such as erosion and resuspension which affect the formation and dispersion of a sediment plume. This has to be done by means of hydrodynamic and sediment dispersion models (e.g., Delft3D). The sediment source used for a near and far field dispersion model could be estimated by means of accurate CFD calculations.

Appendix 19.9 - HR Wallingford Tailings Plume Review

HR Wallingford
Working with water

Support to Trans-Tasman Resources

Independent review of plume modelling



DDM7316-RT001-R01-00

August 2014

Document information

Document permissions	Confidential - client
Project number	DDM7316
Project name	Support to Trans-Tasman Resources
Report title	Independent review of plume modelling
Report number	RT001
Release number	R01-00
Report date	August 2014
Client	Trans-Tasman Resources
Client representative	Shawn Thompson
Project manager	Tom Matthewson
Project director	Dr Mike Dearnaley

Document history

Date	Release	Prepared	Approved	Authorised	Notes
15 Aug 2014	01-00	AMM	MPD	MPD	

Document authorisation

Prepared	Approved	Authorised
A. J. Manning	M.P. Dearnaley	M.P. Dearnaley

Contents

1. Introduction

1.1. Background

Trans-Tasman Resources Ltd (TTR) plans to extract titanomagnetite sand (ironsand) from an area in South Taranaki Bight. As input to the Environmental Impact Assessment (EIA) for the proposed mining project, NIWA was commissioned by TTR to investigate the potential environmental impacts of the proposed extraction operation.

Following the refusal of consent by the Decision Making Committee in June 2014, TTR are re-assessing their scientific case as background for a possible appeal and re-hearing. One issue that has arisen is the need to re-assess the degree of uncertainty and conservatism in the sediment plume modelling. In July 2014 TTR commissioned HR Wallingford to review the plume modelling work undertaken by NIWA.

1.2. Scope of review

This review concentrates on the NIWA studies pertaining to the assessment of effects from sediment plumes, focussing on the following documents:

- NIWA (2013) South Taranaki Bight Iron Sand Extraction Sediment Plume Modelling , Phase 3 studies, report for Trans-Tasman Resources Ltd, October 2013.
- NIWA (2014) South Taranaki Bight Sediment Plume Modelling: the Effect of Revised Source Particle-Size Distributions, report for Trans-Tasman Resources Ltd, March 2014.

Where relevant to the assessment of effects from sediment plume modelling the following documents will also be referred to:

- MTI (2013a) Assessment of sediment deposition and re-suspension behaviour of tailings, report for Trans-Tasman Resources Ltd, Report DZ 57, June 2013.
- MTI (2013b) Assessment of sediment deposition and re-suspension behaviour of tailings, Phase 2: influence of surface waves, Report DZ 58, July 2013.
- NIWA (2012) South Taranaki Bight Iron Sand Mining: Oceanographic measurements data report, report for Trans-Tasman Resources Ltd, August 2012.
- NIWA (2013) Optical effects of an iron-sand mining sediment plume in the South Taranaki Bight region, report for Trans-Tasman Resources Ltd, October 2013.

1.3. Report structure

The remainder of this report comprises a further 7 sections. In Section 2 the source terms used for the modelling are considered. The near bed processes associated with the release of the sediment from the mining operation are reviewed in Section 3 including results of our own near field modelling using our SEDTRAIL model. The flow model used to drive the sediment plume modelling is discussed in Section 4. Consideration of the sediment properties used for the sediment plume modelling is provided in Section 5. The calibration and application of the sediment transport model is commented upon in Section 6. The key findings of our review are discussed in Section 7 and conclusions arising from this review are provided in

Section 8. Two Appendices accompany this review report: Appendix A describes the SEDTRAIL model and Appendix B the background to the potential for mixing of an initial near bed suspension into overlying waters

2. Source-terms

2.1. Suitability of the source terms used for sediment release

There is no description in NIWA (2013a, 2014) regarding evidence for the productivity used in the NIWA assessment (removal of 1.195 m^3/s of in situ material, Section 3.2.3, NIWA 2013a). This productivity is however within the bounds of what could reasonably be expected given the methodology and plant proposed to undertake the works. It is noted that this productivity relies on achieving a relatively large velocity (~5.75m^3/s) and density (~1,300 kg/m^3) in the suction pipe. It is assumed that this productivity has been supplied to NIWA by TTR.

Given the productivity of 1.195 m^3/s of in situ material (2200 kg/s) then the returns to the bed of around 2000 kg/s are appropriate with about 10% of the in situ material recovered. It is however noted that there is a typographical error in the NIWA sediment plume modelling report (p33, Section 3.2.3 paragraph 2 of NIWA, 2013a) **–** the <u>dry</u> density is 1860 kg/m^3 (not the <u>bulk</u> density as stated in the report). The true bulk density is 2272 kg/m^3. The dry density of 1860 kg/m^3 gives a volume concentration of 0.6 which is consistent with typical sand deposits (e.g. Soulsby, 1997).

There are some apparent differences in the figures given for in situ fines content in the resource. Table 3-7 of NIWA (2013a) provides an indication of the particle size distribution of seabed material adjacent to the area being mined. This indicates that around the resource the fines content (<63 microns) in the bed is about 2.2% (1.6% less than 38 microns and about half of the 1.2% of material in the 38 to 90 micron fraction).

Table 3.2 of NIWA (2013a) provides the estimates of the particle size distribution and release rates for the predominantly fine material released from the hydrocyclone (about 87kg/s of material less than 63 microns). Table 3.3 of NIWA (2013a) presents similar information for the predominantly sandy material released from the de-ored sand (about 34kg/s of material less than 63 microns). On the basis that the in-situ material is removed at 2,200kg/s then the total fines released from the mining (~ 121kg/s)is equivalent to about 6% of the in-situ mass. Of this release rate about 32kg/s is assumed to be less than 8 microns in size and 23kg/s between 8 to 16 microns.

We understand that these numbers were provided to NIWA by TTR and that there is considered to be conservatism in these numbers in terms of inclusion of some mud layers within the resource in the average fines content. We understand from TTR that in practice the mining of the resource will be managed so as to avoid significant removal of muddy areas of the bed. We also note that if the samples used for providing the information in Table 3-7 are surface samples rather than samples over the top 5 to 10m of the bed then they are likely to have a higher fines content consistent with the large waves experienced in the area which will tend to winnow out fine sediment from the surface of the bed.

Table 3.4 of NIWA (2013a) summarises the assumption that NIWA make as to how much of the fine material released from the hydrocyclone and from the return of de-ored sand is available in suspension for introduction as a source in the plume modelling. This assumption is informed by the results of the MTI modelling where it is demonstrated that some of the coarser fines is deposited along with the sand fraction. We discuss this further in Section 3. Based on NIWA (2013a) the rate of fines less than 63 microns introduced into the model is about 113kg/s whilst this was reduced to 82kg/s in subsequent testing reported in NIWA (2014). These rates of release are substantially higher than the rates of release of fines associated with typical aggregate dredging activities in the UK (order 10kg/s) (HR Wallingford, 2011). Note also that typical aggregate dredging activity would have an intermittent release at the dredge site with the dredger spening time away from the site sailing to and fro to a port to discharge the materials arising.

2.2. Comparison with river inputs

In the sediment transport modelling NIWA assume (Section 3.1, NIWA2013a) that all the material input from the eleven rivers they include in their inner model is fine (less than 63 microns). The combined mean annual sediment release rate from these rivers is equivalent to an average of 373kg/s with a combined mean discharge of 593m^3/s.

NIWA suggest that there will be a linear relationship between river discharge and suspended sediment concentration. NIWA also assume that 50% of the river discharge is in the size range 4 to 16 microns.

The release of fines (both less than 63 microns and less than 16 microns) from the mining activity is about one-third of the assumed average fine sediment input from the rivers. In their modelling NIWA include a time varying discharge from the rivers to represent this average discharge.

3. Near-field modelling

3.1. Introduction

The plume modelling does not account for the near-field behaviour of the released sediment immediately after release. This can be an acceptable simplification of the sediment transport if the near-field behaviour does not lead to a significant difference in plume behaviour and if the focus of the investigation is far-field and longer term. This section considers what will happen in reality and whether this simplification is valid.

This review will consider both the scenario as modelled of releases of sediment at 10m above the bed and 4m above the bed, and also the revised methodology (*pers.comm.,* Shawn Tompson, TTR, Telecon 4/07/2014, UK time) of a single release at 4m above the bed.

3.2. Description of near-field processes

For both releases the released sediment discharge will form a negatively buoyant plume which will accelerate towards the bed under the effect of gravity. As the plume accelerates downwards it will entrain adjacent sea water, increasing the diameter of the plume and diluting the plume concentration, and also reducing the speed of the plume and its rate of acceleration (Chu and Goldberg, 1974, Fischer et al, 1979, Lee and Cheung 1990). Given the water depth at the site the plume will impact on the bed within a few seconds of release from the discharge pipe. During these several seconds the plume will dilute by an order of magnitude or more. The result will be the creation of a density current which will collapse over the sea bed under the action of gravity, expanding outwards and reducing in thickness as this expansion continues. The expansion will continue until the sediment in the density current settles out of suspension or the density current mixes into the overlying waters. This process is well known as an important feature of the physical processes of disposal of dredged sediment (e.g. Brandsma and Divoky, 1976; Johnson et al, 1993; Dankers, 2002; Saremi et al, 2014). As the density current settles the sand grains will displace the fine particles and this process will tend to leave a layer of fine sediment on top of a layer of sandy sediment (Amy et al, 2006). Generally this discharge and spreading will occur within a previously excavated resource area with dimensions of order 300m by 300m and depth of up to 11m below the ambient sea level.

3.3. Scenario as modelled

The scenario modelled by NIWA involves the release of 113 kg/s of fines (NIWA, 2013a), now revised down to 82 kg/s of sediment (NIWA, 2014a) in a discharge of 8.8 m^3/s, at 10 m above the bed and a release of 1900 kg/s in a discharge of 1.4 m^3/s at 4 m above the bed.

We used our numerical model SEDTRAIL-RW, developed to reproduce the near-field mixing of sediment releases from dredging and mining activities, to investigate the mixing from these two releases (Spearman, 2003, 2007 – now further developed to include axisymmetric, or stationary, releases as well as those from moving releases. The relevant part of the model is explained in Appendix A).The lower, larger and (predominantly sand) discharge will descend under gravity, entraining surrounding water as it does so, and collapse over the bed as a slurry with an initial concentration of around 45 kg/m^3, initially a few metres deep, which will then collapse over the bed as a result of being heavier than the surrounding water. As it does so it will entrain further water at the head of the expanding density current. The sand will settle out leaving a near bed suspension of fines about 0.5m deep with a concentration of fines of around 140 mg/l.

The upper (predominantly fine sediment) discharge will also descend to the bed (due to gravity and the initial momentum of the release)and collapse over the bed as a slurry, but with a much lower initial concentration of around 4 kg/m^3. As before, additional entrainment will further dilute the density current. The density current will initially be a few metres deep but will collapse to around half a metre in thickness. The sand will settle out leaving a near bed suspension of fine sediment of around 750 mg/l.

In practice these two releases will interact and combine into a single body of water with the mass of sediment being additive because one plume will be entrained into the other. This would result in a concentration of around 900 mg/l in a near bed layer about 0.5m thick. Such a concentration is likely to remain as a concentrated suspension near the bed. This is because while in general the waves are sufficient to re-erode this sediment (e.g. using the equations for wave orbital velocity and wave shear stress presented in Soulsby,1997) and prevent it from depositing, the stirring effect of waves on the sediment is largely confined to the wave boundary layer (Soulsby, 1997) and waves (in this case) only augment to a small extent the ability of currents to diffuse the sediment upwards (Soulsby and Clarke, 2004). The turbulence generated by waves and currents in this case is insufficient, or at best marginal, to mix such a near bed suspension into the overlying waters. This is explained in detail in Appendix B. Note also that for much of the time the suspension created will be contained within the previously excavated area. In the latter stages of filling each previously excavated area the fine suspension may be able to spread over a larger area and may be proportionately more readily entrained into the water column by the action of waves.

Broadly speaking this result is supported by the results of the CFD modelling (MTI, 2013a, 2013b). The MTI modelling only considers the lower release and predicts that the vast majority of sediment left in suspension at a distance of 100m from the release is within the bottom 2m of the water column. This is even for the most energetic conditions of peak current speeds of 0.5 m/s and 4 m waves with a period of 10 seconds. This is a similar result to the argument made above and in Appendix B but resulting in a somewhat thicker near bed suspension. It is noted that the CFD model does not take additional account of the upper release and that the CFD modelling does not allow the radial collapse of the density current (MTI, 2013a, 2013b) and hence will over-estimate the thickness of the near bed suspension.

As near bed suspensions continue to be generated near the release, without mixing into the overlying waters, three additional effects will happen:

- fining of the substrate will start to occur and this will cause the bed to become smoother. The turbulence generated at the bed will reduce. This may lead to deposition of fine as well as coarse sediment;
- the concentrations of near bed fine sediment will increase locally, the vertical gradient of density will increase and this also will lead to the "damping" or reduction in turbulence (Munk and Anderson, 1948; Toorman, 2000) and further deposition of fine sediment;
- the more fine sediment deposited on the bed or trapped in a near bed suspension, the less fine sediment that will be available to be advected as a plume mixed into the water column.

These effects will occur regardless of whether the suspension of fines is confined well within a previously excavated pit or has effectively spilt out of a confined pit in the latter stages of the filling of an individual pit.

3.4. Revised scenario

The scenario now proposed by TTR involves the combined release of the upper and lower sources – i.e. release of 1974 kg/s in a discharge of 10.2 m^3/s, at 4 m above the bed with an additional discharge of hyper-saline brine. At present we do not know the volume of brine discharge but we assume that any such discharge will be small compared to the overall mixture discharge and small compared to the volume of water entrained into the plume.

A re-run of SEDTRAIL-RW indicates that the discharge will collapse over the bed as a slurry with an initial concentration of around 120 kg/m^3, initially a few metres deep, which will then further collapse over the bed as a result of being more dense than the surrounding water. As it does so it will entrain further water at the head of the expanding density current. The sand will settle out leaving a near bed suspension of fines about 0.25m deep with a concentration of fines of around 800 mg/l. As stated above such a concentration is likely to remain as a concentrated suspension near the bed.

3.5. Other factors influencing near-field processes

A factor that could result in additional fines being made available from the near bed suspensions described above would be the effects of disturbance from propeller wash. For a typical trailer suction dredger undertaking overflow in modest water depths then the action of propeller wash on the recently formed near bed suspension can substantially mix that material into the water column and lead to increased quantities of fines to be dispersed into the far-field.

For the TTR method of production the FPSO will generally move over the site controlled by anchors. This will significantly reduce the potential for enhanced release of fines from the near bed suspension. Other vessel movements will be less frequent and will have limited effects on resuspension of fines from the near bed suspension.

4. Flow modelling

4.1. Introduction

The flow model forms an important input to the plume impact assessment since it controls:

- The direction of the movement of the plume;
- The shear dispersion of the plume – i.e. the mixing caused by spatial differences in currents;
- The mixing of sediment through the water column (via turbulence);
- The deposition and resuspension of sediment from the bed (via shear stress).

However, it should be realised that once a model has been validated against measurements of currents and water levels with reasonable care any uncertainty in the flow model prediction will be smaller than the uncertainty in the source terms (Section 3) or due to sediment properties (Section 5). It should be recognised that error in the flow model will always exist – no flow model is perfect – but in our experience as long as the model can provide confidence that it can predict current strength and direction with reasonable accuracy it will be sufficient to identify the extent of plume impacts.

4.2. Flow model performance

The flow model performance is measured by decoupling the currents caused by tidal forcing and the residual currents (referred to as "subtidal" in NIWA (2013a)). The performance of the model in reproducing the tidal currents is measured using parameters such as semi-major axis, eccentricity, inclination and phase of the tidal ellipse. The performance of the model in reproducing the residual currents is measured by comparing the same parameters but additionally including mean magnitude and mean direction of the residual current. These comparisons show that the model performs well overall with tidal currents being particularly well reproduced. Residual currents are also on the whole well reproduced with directions mostly predicted within 10 degrees and within 2 cm/s. Exceptions to this occur for small (~0.01 m/s) residual currents near the bed, which are more susceptible to noise in the ADCP measurement, and also at location 10 where the flow model consistently predicts residual current directions 14 - 23 degrees northward of the measured easterly/south-easterly residual currents. The time series of comparisons of residual flow (Appendix C of NIWA 2013a) also indicate that the model reproduces the general fluctuation in residual flow well.

The assessment of flow model performance would be improved by adding a measure of the root-mean-square or mean-absolute error in current speed and direction (i.e. which are more normal parameters used to measure flow model performance). The parameters used in the report tend to reflect mean overall properties rather than a measure of the ability of the model to predict currents at any particular time. An attempt to capture this is made using the correlation coefficient *r* but this is an opaque parameter to grasp in this context.

The flow model is validated against ADCP data at 5 locations with three of these locations (5, 6, 7) being compared against 5 months of data (06/09/2011 to 09/02/2012 excepting a week between deployments) and two (locations 8 and 10) being compared against a little over 2 months of data (24/04/2012 to 01/07/2012). It is not known how this validation was undertaken – if the model was initially calibrated against the data from location 5, 6 and 7 and then validated (without further parameter adjustment) against the later data from locations 8 and 10, then the model could reasonably be said to perform well against the whole data set representing 10 months of the year.

4.3. Sensitive sites

Where there are sensitive sites in the vicinity of a mining area and the potential impacts at these sites are critical to the licensing of the mining, it is obviously more important for the model to predict the currents well in the vicinity of these areas and in the area between the mining and these areas. This needs to be considered in the light of the tendency for residual currents at Location 10 to be predicted more northwards of the real residual current direction. This introduces some (albeit modest) uncertainty as to the potential for the plume to extend over Graham Bank or OB site 155 (see Figure 4.1). Ideally this uncertainty would be reduced through better calibration of the flow model. However, if this option is impractical given the constraint of the appeal process, a thorough examination of the potential for any of these sites to experience the plume (when they are not predicted to experience the plume) or to more directly experience the plume or to experience the plume more frequently should be examined. This exercise will be helpful if it can be clearly reasoned that, even allowing for uncertainty in the model, sensitive areas cannot possibly experience the plume. It may be that it is helpful to use the measured ADCP data in this respect.

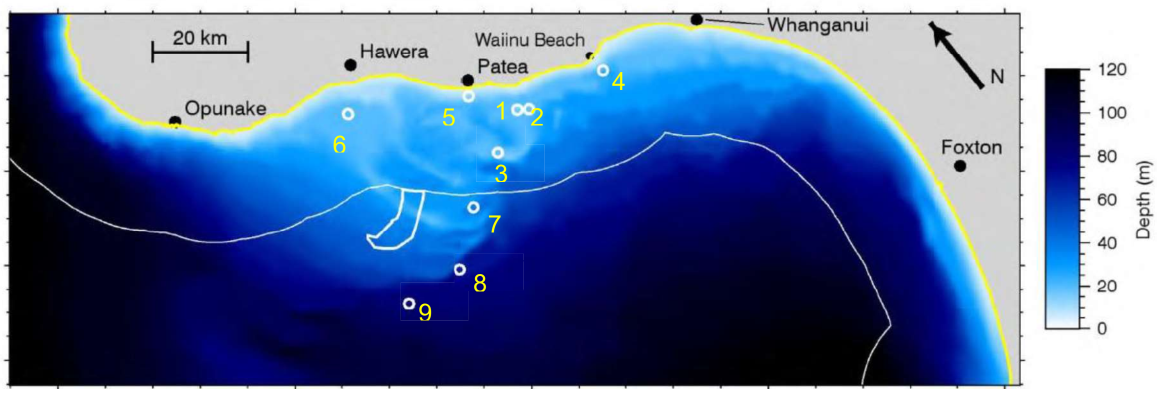


Figure 4.1: Locations of ecologically sensitive areas in the vicinity of the proposed mining

Source: NIWA (2014b). Numbered locationsare as follows: 1: North Trap. 2: South Trap. 3: Graham Bank. 4: Wainu Reef. 5: Patea Reef. 6: Four mile reef. 7: OB site 155. 8: OB site 113. 9: OB site 130. Mining area is shown as a polygon white a thin white border.

4.4. Oceanographic inter-annual variation

It can often be the case with environments strongly influenced by oceanic currents that currents may vary from year to year or even over longer periods such as those caused by El Nino events. It is a useful exercise to examine existing data or existing oceanographic models for conditions from other years to see if the ocean currents influencing Taranaki Bight change significantly – particularly if they (from time to time) fall outside of the range of behaviours modelled in the plume study. If there are potentially conditions which would result in a significant change in the movement of the plume nearer to sensitive areas (see Figure 4.1) then these conditions should be included in the sediment plume assessment along with the reasoning why these particular conditions are important and how they were selected.

4.5. Conclusions regarding flow model performance

Overall the flow model compares well with the measured flows **–** with slightly more northward currents predicted in the vicinity of the mining area. This model performance is considered to be satisfactory for the proposed studies but there needs to be some additional thought as to whether the small amount of uncertainty in the residual current direction at the mining site or inter-annual variation in oceanic currents could result in the plume moving to ecologically sensitive sites which are not predicted to be affected at present.

5. Sediment properties

Assumed sediment properties for riverine inputs and in-situ sea bed material are presented in Table 3.1 of NIWA (2013a). NIWA select a minimum settling velocity of 0.1mm/s for the finest material (4-16 microns) on the basis that this material can flocculate in the marine environment. For the remaining fine material (16 to 63 microns) and the coarser sand fractions they calculate a settling velocity assuming non-cohesive sediment properties based around the mid-point grain size of each class band.

The assumed sediment properties for the sediment released back into the marine environment from the mining operations are presented in Table 3.4 of NIWA (2013a). Sediment with a size less than 8 microns is assumed to have a settling velocity of 0.01mm/s. That with a grain size of between 8 to 16 microns 0.1mm/s and that of the coarser size fractions assuming non-cohesive sediment behaviour. NIWA state (Para 1 of Section 3.2.1, NIWA 2013a) that the mining derived sediment is not expected to flocculate as readily as natural sediment. The basis of this statement should be clarified with NIWA. NIWA also estimated critical erosion thresholds for the different size fractions based on published literature and assumed a minimum level of 0.1 Pa characteristic of the unconsolidated muds.

NIWA also estimated critical erosion thresholds for the different size fractions based on published literature and assumed a minimum level of 0.1 Pa characteristic of unconsolidated muds.

5.1. Flocculation and salinity

Fine grained sediments, in particular clay particle surfaces have ionic charges creating forces comparable to or exceeding the gravitational force, and these cause the clay particles to interact electrostatically. The cohesive forces exerted between two clay particles depends both on the mineralogy of the clay, and on the electro-chemical nature of the suspending medium. Most of the individual clay particles, made up from the common clay minerals, have a negative charge on the face of each platelet mainly due to the exposed oxygen atoms in the broken bonds of the crystal lattice. The mutual forces experienced by two or more clay particles in close proximity, are the result of the relative strengths of the repulsive and attractive forces (see van Olphen, 1977; Manning, 2001).

In fresh water suspensions (containing very few positive ions or low electrolyte concentration), the repulsive forces between the negatively charged particles dominate and the particles will repel each other. The particles thus tend to settle as individuals.

In saline water the attractive forces dominate due to the abundance of sodium ions forming a cloud of positive ions (cations in a high electrolyte concentration) around the negatively charged clay particles resulting in the formation of flocs (e.g. Krone, 1962).Consequently, the sediment particles do not behave as individual particles, but tend to stick together. This process is known as flocculation, and the aggregates formed are referred to as flocs, whose size and settling velocity are much greater than those of the individual particles, but whose overall floc density is significantly less. Krone (1963) found that flocculation quickly reaches an equilibrium situation at a salinity of about 5-10ppt, which is much smaller than that of sea water (~35ppt). The potential for fine particles to flocculate is partly governed by their cohesion and this can vary with mineralogy and the electrolytic level of the suspending fluid. Inevitably flocculation is controlled by a series of inter-related kinetics that tend to be site specific in nature (Mikeš and Manning, 2010). In terms of gauging the importance of salt flocculation, engineering practice (as a simple rule-of-thumb) categorises this behaviour in terms of NaCl concentration. Critical salinity for coagulation of three common clays (expressed in parts per thousand or milliequivalents per litre) are (Winterwerp and van Kesteren, 2004):

- Kaolinite 0.6 ppt or 10 mEq.L^{-1};
- Illite 1.1 ppt or 19 mEq.L^{-1};
- Smectite (or Montmorillonite) 2.4 ppt or 36 mEq.L^{-1}.

In predominantly seawater environments (e.g. for marine dredging operations) it could be expected that these critical values of salinity are greatly exceeded. On that basis the role of salt flocculation should not be one that induces a clay mineral dependency. Dredging operations in brackish environments could however lead to slight dependency of mineral type of the clays present.

Within a mixed sediment environment, the degree of cohesion between the various sediment fractions tends to increase with the content of fine clay minerals within the sediment, and starts to become significant when the sediment contains more than 5-10% of clay by weight (Whitehouse et al, 2000, van Ledden, 2003).

It is also increasingly recognised that there is strong mediation of the physical behaviour of particles and flocs by the biological components of the system. Mineral cohesion effects are further enhanced by the presence of extra-cellular polymeric substances (EPS; e.g. Tolhurst et al., 2002), such as mucopolysaccharides produced by microphytobenthos. For example, epipelic diatoms (e.g. Paterson and Hagerthey, 2001) secrete EPS as they move within the sediments. EPSs are regarded as highly effective stabilisers of muddy sediments (e.g. de Brouwer et al. 2005; Gerbersdorf et al. 2009; Grabowski et al., 2011) and can significantly enhance inter-particle cohesion. Smith and Friedrichs (2011) state that a dredge plume produced in a microbiologically active environment (e.g. Ayukai and Wolanski, 1997; van der Lee, 2000; Fugate and Friedrichs, 2003) is likely to experience faster rates of flocculation than in less biologically active environments. In general, flocs held together by polymers are stronger than those held together solely by electrostatic London-van de Waals forces (Kitchener, 1972).

5.2. Potential mixed sediment fraction interactions / effects

When modelling sediment transport, it is common practice to assume a single representative sediment type, such as a non-cohesive sand or cohesive mud. Modelling single sediment types would typically be a pre-cursor to any more complex modelling of mixed sediment types and fractions. This is due to the well-documented transport formulae developed for solely muddy or sandy sediments.

Sediment mixtures may behave either in a segregated way, or may interact through flocculation. The phenomenon of mud:sand segregation considers the mud and sand to operate as two independent suspensions (van Ledden, 2002). When a segregational regime dominates, there is very little bonding and flocculation interaction between the fine fraction and the larger non-cohesive sediment fractions is non-existent. Mixed sediment experiments have shown that fine sediment particles and sand grains which behave in a segregated manner, settle simultaneously (but at different speeds) at the bed/water interface, thus forming two well-sorted layers (Ockenden and Delo, 1988; Migniot, 1968; Williamson and Ockenden, 1993, Torfs et al., 1996).

However, where the fine fraction and the larger non-cohesive sediment co-exist as a single mixture (Mitchener et al., 1996) this creates the potential for these two fractions to combine and exhibit some degree of interactive flocculation (Manning et al., 2009, 2013). Whitehouse et al. (2000) describe a process whereby cohesive sediments mixed into a predominately cohesionless sandy region can create a 'cage-like' structure which can fully encompass the sand grains, thus trapping the sand within a clay floc envelope.

In terms of flocculation kinetics (Overbeek, 1952), the macroflocs (typically parameterised as D > 160 μm; Manning, 2001 ; Manning and Dyer, 2007; Soulsby et al., 2013) tend to control the fate of purely muddy sediment in an estuary (Mikeš and Manning, 2010), because the smaller microflocs generally settle at less than 1 mm/s, whereas macroflocs settle in the 1-15 mm/s range, enabling them to deposit to the bed (Pouët, 1997). However, when mixed sediment flocculation effects occur, the microflocs (D < 160 μm) can potentially demonstrate settling velocities comparable to those of the macroflocs (Manning et al., 2010).

It should be noted that any mixed sediment flocculation effects and intra-fraction interaction can only be truly demonstrated empirically through rigorous laboratory settling experiments.

5.3. Comments on flocculation resulting from dredging operations

Based on dredging plume monitoring in San Francisco Bay, Smith and Friedrichs (2011) showed that flocs represented 68% of the suspended sediment mass and comprised over three quarters of the vertical mass transport; whilst fine sand (D < 100 μm) only comprised a small fraction of the plume (this implies either that only a small fraction of fine sands passed over the weir and the bulk was, in this case, retained in the hopper, or few are entrained outside the dynamic plume).

Trailing suction hopper dredges, through: hydraulic removal and transport of sediment to the hopper; turbulent conditions within the hopper; and turbulent stresses during overflow (Land and Bray, 1998; van Raalte, 2006) are likely to break bed aggregates into small fragments. Additionally, hopper dredges may preferentially retain larger bed aggregates within the hopper (Smith, 2010). Smith and Friedrichs (2011) observed that the remainder of sediment entrained into the water column within 20-minutes of passing out of the dredger overflow already existed in a highly flocculated state and this suggests that flocculation occurs within the high-concentration slurry within the hopper and/or very rapidly soon after overflow. Similar effects can be anticipated associated with the discharge and the creation of the near bed suspension for the TTR case.

From particle size and floc analysis, Smith (2010) found the presence of at least two distinctly different sediment size classes within a dredge plume. For estuarine dredging he observed a smaller, but denser particle fraction in the form of bed aggregates and a less dense floc population. From further analysis, Smith and Friedrichs (2011) found that the denser bed aggregates (typically comprising consolidated, dense bed fragments) demonstrated time invariant size and velocity, whereas both floc sizes and their respective settling velocities tended to increase with time within a dredge plume and therefore they recommended the use of a time-dependent flocculation function and also a multiple-class model when modelling dredge plumes. Milligan and Hill (1998), Mikkelsen and Pejrup (2000), and Winterwerp (2002) all have suggested that time-variant flocculation effects must be included in sediment transport models for assessing potential environmental impacts within coastal zone regions. Importantly, Smith and Friedrichs (2011) state that denser bed aggregates may also interact with the less dense floc population (see earlier Section 5.2 on mixed sediment floc interactions). Although the ambient conditions in San Francisco Bay are most probably muddier than the South Taranaki Bight, this illustrates how important flocculation can be within a dredging plume.

For example, Hayter et al. (2012) used the SEDZLJ sediment bed model (Jones and Lick, 2001) to investigate sediment transport processes relating to short- to mid-term dredge material management strategies for the Federal Navigation Project at Grays Harbor, Washington. The SEDZLJ can be divided into multiple layers to represent existing sediment bed as well as new bed layers that form due to deposition during model simulations. Based on an analysis of available data, six sediment grain sizes (i.e. 10, 22, 222, 375, 750 and 4,000 µm) were deemed necessary to adequately represent the wide range of sediment within the SEDZLJ model domain (Hayter et al., 2012). Of these six fractions, two of these size classes (i.e. 10 and 22 µm) were used to represent the erosion, transport and settling of the fine-grain sediment placed at the dredge matertial placement sites. The 10 µm cohesive class was used to represent the flocs whose settling speeds were measured using the Particle Imaging Camera Sysem - PICS (Smith and Friedrichs, 2011), whilst the 22 µm cohesive class was used to represent the bed aggregates. A mean settling velocity of 0.35 mm/s for flocs was determined using PICS data, and a mean settling velocities of bed aggregates of 1.1 mm/s.

The NIWA model includes a number of size fractions (as available in the ROMS model set-up). The properties of these materials are given in Tables 3.1 and 3.4 of NIWA 2013a (see Section 5.1). It is our view that the settling velocities of these smaller size classes are significantly underestimated with fall velocities of 0.1 and 0.01mm/s and would not represent true fall velocities if these fractions flocculated(NIWA, 2013a).

The flocculation process is dynamically active which is directly affected by its environmental conditions, primarily being dependent on a complex set of interactions between sediment, fluid and flow within which the particles aggregation plays a major role (Manning, 2004). A conceptual model which attempts to explain the linkage between floc structure and floc behaviour in an aquatic environment is provided by Droppo (2001). As a result of dynamic inter-particle collisions, floc growth implies large variations in the sediment settling flux with direct implications on the vertical distribution of fine sediment throughout the water column. Flocculation is therefore a principle mechanism which controls how fine sediments are transported within many aquatic environments.

In order for flocculation to occur, suspended particles must come into contact with each other and then stick together. Particles in suspension collide due to a variety of different mechanisms, and the frequency of contact depends on the mechanism that brings about the contact, as well as on the particle size and the concentration of the particles. There are three principle mechanisms of collision:Brownian motion; differential settling; and turbulent shear principally created by velocity gradients generated within the fluid. The latter is the most significant collision mechanism in natural waters (Van Leussen, 1988) and would be the most applicable for dredging related operations.

The flocculation process requires turbulent mixing in order for particles to collide and flocs to grow (Krone, 1962; van Leussen, 1994; Manning, 2004; Winterwerp and van Kesteren, 2004). Turbulence creates inter-particle collisions and stimulates flocculation (McAnally and Mehta, 2001). Too much turbulence though can break flocs apart (Eisma, 1986; Dyer, 1989). Turbulent energy is transferred to decreasingly smaller eddies and this energy is dissipated by viscosity (van Leussen, 1997). These small eddies are defined by the Kolmogorov microscale of turbulence (Kolmogorov, 1941a,b). McCave (1984) found that turbulence determines the maximum floc size in tidally dominated estuaries.

Flocs released by the dredging process may originate either from any low-density muddy surficial sediment layer or those formed during the dredging process (high-concentration and low-moderate turbulence within hopper dredges are favourable to floc formation; Smith, 2010).

The hydrodynamics stresses produced during dredging operations can greatly exceed the typical, natural stresses exerted in natural aquatic environments. If we examine the hydrodynamic conditions produced during the proposed dredging operations, during the tailings release the pipe outflow velocity is calculated to be 1.522 m/s (MTI, 2013a). This fast discharge speed from a 1.1m diameter release pipe (MTI, 2013a), could potentially create a very high level of turbulent shear and create disruption to the flocculation process at the point of discharge. This hydraulic stress would limit floc growth and these ambient conditions would favour smaller, denser aggregates and possibly stronger microflocs, all with slow floc settling velocities. As the distance increases between the fine sediment fraction and the release pipe in the near bed sus[pension formed by the release processes the turbulence level would decay to a level more conducive for macrofloc formation. However, flocculation is not an instantaneous process and requires time to occur. This is referred to as the flocculation time (e.g. van Leussen, 1994), and is a function of shear stress and suspended sediment concentration.

5.4. Comments on settling velocity used in the MTI studies

In the assessment of sediment deposition and resuspension behaviour of tailings during their first phase of near field studies (MTI, 2013a), flocculation is assumed to occur in the two smaller size fractions ($1^{\#}$ is 0<d<38μm and $2^{\#}$ is 38μm<d<63μm). Representative floc diameters of 95 μm and 250 μm, have been attributed settling velocities of 1.2 mm/s and 7.3 mm/s respectively in MTI (2013a). These nominal floc settling rates were calculated using Winterwerp's (1999) mud floc formula. Although these floc settling velocities appear within a realistic range, it should be noted that the various Winterwerp floc settling velocity equations (e.g. Winterwerp, 1999; Winterwerp et al., 2006) are based on fractal physics. Fractal theory is dependent on the successive aggregation of self-similar flocs producing a structure that is independent of the scale considered. This is similar to Krone's (1963) order of aggregation. In fractal geometry different floc structures are characterised by distinctly different fractal dimensions, nf (Kranenburg, 1994).

Fractal dimensions of 1.4 are representative of low effective density, fragile structured aggregates, whilst values of 2.5 indicate strongly bonded, less porous flocs. However, in order to make a fractal based model solvable analytically within a numerical simulation, an average nf value is requires and this ignores important floc density variations (Dyer and Manning, 1999). Furthermore, a single primary particle size (d_p) needs to be selected, however in reality flocs may be composed from a much wider range of primary particles. The fractal geometry then calculates the resultant floc diameter and the corresponding settling velocity based in part on these nf and d_p values.

No flocculation is assumed to occur for fractions between 63um and 2.8mm, and settling velocities were calculated using Van Rijn (1993). This therefore suggests that it is assumed that these larger fractions do not directly interact with the small, flocculating fraction.

In subsequent investigations (MTI, 2013b) did not continue with the use of these settling velocities for the finest material. NIWA did not pick up and use these settling velocities in their far-field modelling.

6. Sediment transport model

6.1. Calibration of the sediment transport model

The calibration/validation of the sediment transport model for baseline conditions presented in Section 4 of NIWA (2013a) is primarily undertaken by comparing against near-shore measurements of fine sediment concentration 3m below the surface and against the ABS measurements of suspended sand concentration.

The comparison with measured fine sediment concentrations indicates that the model over-predicts suspended sediment concentration by around a factor of 2. During the period of comparison there is a significant peak in observed concentrations which the model generally significantly over predicts. It will be important to understand what data has been used to calibrate the observations as this may be less applicable to this period of peak observations. The model over-prediction in the near surface waters may be as a result of the choice of settling velocity parameters (see Section 7.2) but the model may also require further work in a more general choice of sediment parameters.

The comparison with ABS measurement of sand concentrations presented in Section 4.3 of NIWA 2013a is, at least partially, a result of coarse vertical resolution near the bed in the model. It may be prudent to model the sand first in a 1DV model to understand how the 3D model needs to be modified in order to achieve a better result.

These two measures of baseline model performance do not invite confidence in the baseline sediment transport model and it would be prudent to improve the calibration of the sediment transport model particularly for the fines fractions which are so important for the assessment of optical effects (NIWA 2013b).

A demonstration of the ability of the model to reproduce the observed vertical distribution of fine sediment through the water column under a range of conditions near the mining site and in the vicinity of the closest sensitive receptors would be valuable. The available offshore measurements in and around the mining site (NIWA 2012) indicate that near surface fine suspended sediment concentrations were in the range 10 to 25 mg/l and that near bed suspended sediment concentrations were in the range 10 to 80 mg/l. It is not clear why this data has not been used for comparison with the baseline modelling.

6.2. Sand transport – patch sources

NIWA have simulated a scenario which represents a condition after one year of productivity (Section 5.5 of NIWA 2013a). The scenario represents the situation where a patch of seabed 2km by 3km has been backfilled with de-ored sediment. This is then used as a source in the model to predict the fate of this material over the next 800 days.

In the NIWA simulations the assumption is that the patch is a homogenous mixture of all the material (including about 0.4% fines less than 63 microns) released by the mining process that has not dispersed in the initial plume created at the time of release of the fines (see Section 3.2.3 of NIWA 2013a). The surrounding bed is characterised as having about 2% fines.

We consider that this approach may need to be reviewed if it can be demonstrated (see Section 3 above) that rather less of the fines is released into the plume at the time of initial discharge because this would tend to imply the development of layers of muddier material overlying less muddy sand in the patch areas. If more mud remains in the de-ored areas in the form of patches of mud or muddier material overlying a sand deposit it is possible that the first more extreme wave events that each patch receives after completion will lead to localised sources of greater fines content than is presently the case.

It may be possible to manage the placement of the de-orded material back onto the sea bed using sand spreading technology to promote mixing and/or burial of the finest material into the bed to recreate a deposit more similar to the adjacent areas of seabed.

7. Key findings of review

7.1. The implications of near-field mixing

The assessment of near-field modelling (Section 3) identifies that the release of sediment is likely to lead to a near-bed suspension which will not readily mix into the water column. These processes are not in the ROMS sediment transport model. Instead the ROMS model represents the upper release as releasing 15m below the surface and the lower release 1.5m above the bed. The ROMS model has a grid resolution of 1000 m and a vertical layer resolution defined by having 20 layers in the vertical. The vertical layers do not have equal spacing. We estimate from the information provided in Appendix A of NIWA 2013a that in a water depth of about 20m the sediment is released into a layer of between about 1m and 1.5m thickness and in a water depth of 40m the sediment is released on to a layer of about 2 to 3m thickness. Therefore in the ROMS model the sediment released from the two sources is immediately, upon release, mixed into a total volume of at least 2,500,000 m^3. This serves to artificially mix the plume in the cell where the release takes place and essentially precludes any of the near-field processes discussed in Section 3 because the concentrations are immediately diluted upon release. The sensitivity tests on a 500 m grid model would result in mixing into a volume of at least 625,000 m^3. In any case the ROMS model (as used in this study) is not designed to reproduce the complexity of mixing of near bed suspensions as the vertical resolution is insufficient to represent the gradients in velocity and density.

Were it not for the fact that the near bed suspensions caused by the release do not readily mix into the overlying waters as a result of the action of waves and currents, the ROMS model could have still been entirely appropriate for the plume dispersion study in the longer-term in the far-field. This is because over these larger scales the nature of the origin source of sediment becomes unimportant in plume dispersion (Fisher et al, 1979). However, Section 3 has shown that the near-field mixing turns out to be significant in terms of the fate of fine sediment in the mining release and is likely to significantly reduce the release of fine sediment from the mining site compared to what has been used in the NIWA model.

7.2. The implications of the choice of settling velocity

Consideration of whether flocculation will occur in the fine sediment fractions released during the mining process is discussed in Section 5.

In the NIWA ROMS Sediment Plume model both the natural River and Seabed fractions listed in Table 3.1 have had their settling velocities capped at just 0.1 mm/s(NIWA, 2013a). This value was used as it was meant to be representative of some flocculation effects occurring (flocculation is discussed in Section 5). This is potentially a significant under-estimation of a flocculation setting velocity. This very slow settling velocity is typically representative of either small, low order flocculi aggregates (e.g. microflocs of nominally only 10-20 μm in diameter), and this would be an under-estimate if floc growth occurs. Flocculation of this size fraction would potentially increase the settling velocity of these fines (when in a floc formation) by at least an order of magnitude, or even more (potentially within the range of 1 to 5 mm/s; the absolute value would be governed by the level of flocculation achieved). There is also further potential for the fines to flocculate and then interact with the slightly larger size fractions of material and include a portion of these within their floc matrix; this would ultimately be a factor of the relative particle bonding potential.

The effect of this is two-fold:

- Under calmer conditions when flocculated fine sediment could settle to the bed, thereby reducing the suspended sediment concentrations in the water column, the model will not represent the finer fractions as settling.
- The fine fractions will normally, especially as in this case where current speeds are not high, form higher concentrations near the bed and reduced concentrations near the surface. This phenomenon reduces the attenuation of light in the water column and contrasts with the assumptions used by NIWA that flocculation does not occur to the mining discharges which results in near uniform distributions of the finest sediment fractions included in the through the water column with disproportionate effects on light attenuation within the water body influenced by the plume.

Thus the choice of settling velocity results in an over-estimate of the turbidity in the water column, particularly in the upper part of the water column and hence results in an overestimate of impact on light reduction.

8. Conclusions

From our review process we draw the following conclusions:

1. The flow model used to drive the sediment transport models is fit for purpose.
2. Further information is required to be presented to support the validation of the baseline sediment transport model. Comparisons against measured near surface and near bed observations should be presented.
3. The source terms provided by TTR to NIWA for use in the modelling are understood to be conservative (original tests indicated ~6% fines in the resource compared to 2% fines in the adjacent area) but may benefit from being presented or justified in further detail with supporting evidence to demonstrate that they are conservative. There may be a justification for sensitivity testing with a reduced source to illustrate a more representative scenario. Albeit some testing of a reduced source (~4%) has already been undertaken.
4. Near-field process modelling has been undertaken by MTI for NIWA to assist in providing source terms for the NIWA sediment plume modelling. Further assessment and schematisation of these source terms will be required to better represent the effect of turbulent damping creating a near bed suspension of fine material at the discharge site and thereby reducing the amount of fines available for dispersion in the NIWA plume modelling. As a consequence the amounts of fine material generally being dispersed from the mining activity are likely to be over-estimated.
5. The settling velocities for the fine material in the NIWA modelling are too low and do not adequately represent the processes of flocculation that will be occurring. In addition there is no justification for the finest fraction of the mining derived fines having a settling velocity an order of magnitude lower than that of naturally derived fines.
6. The under estimate of settling velocities will lead to a more uniform distribution of fine material through the water column and consequential effects on light attenuation and associated deposition rates at times of low wave and flow energy.

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Appendices

A. SEDTRAIL-RW model

<HOLD – This will be provided in a future release of the report>

B. Potential for mixing of initial near bed suspension into overlying waters

Turbulence becomes insufficient to mix a fluid when the gradient Richardson number, $Ri_g = \frac{g\frac{\partial\rho}{\partial z}}{\rho_w\left(\frac{\partial v}{\partial z}\right)^2}$ exceeds a value of around 0.25 (Turner,1973; Monin and Yaglom,1971). We will use this result to show that the currents in the vicinity of the mining area are insufficient, or at most barely sufficient to mix the near-bed fine sediment suspensions resulting from release.

Section 5 of the main text indicates that the release of sediment will lead to a layer in the region of 0.5m thick with a concentration of 1 kg/m^3. We use the gradient Richardson number result, along with some assumptions about the value of $\frac{\partial\rho}{\partial z}$ and $\frac{\partial v}{\partial z}$ to investigate whether this layer can mix into the overlying waters given the hydrodynamic conditions.

Firstly we approximate $\frac{\partial\rho}{\partial z}$ by $\frac{\rho_{plume}-\rho_w}{h_{plume}}$ where ρ_{plume} and ρ_w are the densities of the plume and seawater, respectively, and h_{plume} is the thickness of the plume upon forming a near bed suspension.

We estimate $\frac{\partial v}{\partial z}$ in two ways. The first is by using figure C-2 of Appendix C of NIWA (2013a). At locations 7 and 10 the value of $\frac{\partial v}{\partial z}$ in the lower 2m of the water column can be estimated as 0.1 s^{-1} for a depth-averaged current of about 0.3 m/s. For a higher current speed of 0.5 m/s this value can reasonably be expected to be (assuming linear scaling) about 0.17 s^{-1}. The second method is by using the theory developed by Soulsbv and Clarke (2004).Soulsby and Clarke develop a framework for the interaction of currents and develop a formula for the velocity profile outside of the wave boundary layer,

$$v(z) = \frac{u_{*m}^2}{\kappa u_{*e}} ln\left(\frac{\delta}{z_0}\right) + \frac{u_{*m}}{\kappa} ln\left(\frac{z}{\delta}\right) \quad (1)$$

which leads to

$$\frac{dv}{dz} = \frac{u_{*m}}{\kappa z} \quad (2)$$

Soulsby and Clarke give u_{*m} as ,

$$u_{*m} = \frac{1}{2a}\left[(b^2 + 4a\bar{V})^{1/2} - b\right] \quad (3)$$

Where a and b are given by,

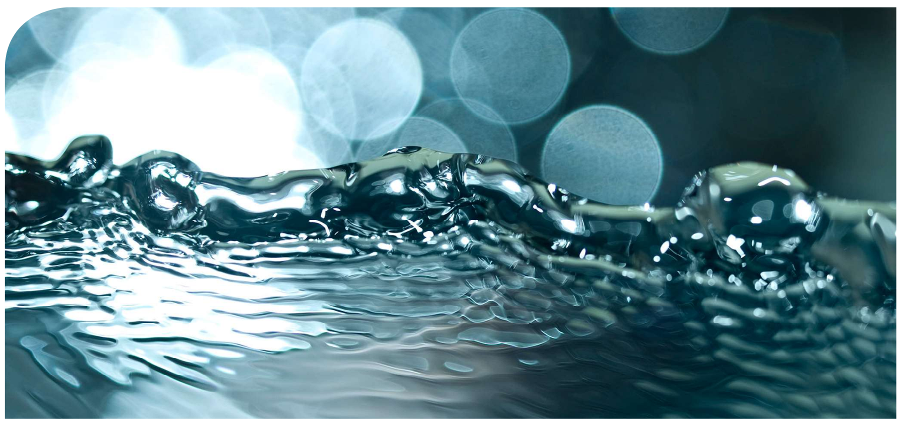
$a = \frac{1}{\kappa u_{*m}} ln\left(\frac{\delta}{z_0}\right)$ and $b = \frac{1}{\kappa} ln\left(\frac{h}{e\delta}\right)$, h is the water depth, δ is the thickness of the wave boundary layer, e is the value 2.718 and z_0 is the physical roughness, in this case taken to be 0.0004 m.

This method gives similar values for $\frac{dv}{dz}$ as figure C-2.

Taking values of $\rho_{plume} - \rho_w = 0.67$ kg/m^3, and $h_{plume} = 0.5$ and $\bar{V}$ = 0.3 m/s gives a value for u_{*m} of 0.017 m/s and a value for Ri_g of 0.6-0.9. This indicates the plume will not mix. For $\bar{V}$ = 0.5 m/s you get a value of 0.4-0.6 which is still above the threshold for mixing.

These calculations are approximate but suffice to show that a near bed suspension of 1 kg/m^3 will not readily mix. It should also be noted that this calculation is conservative since there will be a density gradient in the sand suspension which will also act to reduce turbulence.

HR Wallingford
Working with water



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Appendix 19.10 - Golder Associates Mine Reserve and Schedule Report

30 May 2014 Project No. 137641046-003-L-Rev0

Matt Brown
GM Exploration
Trans-Tasman Resources Limited
Level 13, 342 Lambton Quay
WELLINGTON NZ 6143

ORE RESERVES STATEMENT – SOUTH TARANAKI IRONSAND PROJECT – AREA 2

Dear Matt

Golder Associates (Golder) has completed an ore reserves estimate update for Area 2 of the Trans-Tasman Resources Ltd (TTR) South Taranaki Ironsand Project which comprises a sub-sea titano-magnetite deposit. The ore reserves estimates are based on all available mineral resources data available as of 25 November 2013.

The mineral resource estimates were prepared and classified in accordance with the Australasian Code for the Reporting of Identified Mineral Resources and Ore Reserves (JORC Code, 2012).

1.0 ASSUMPTIONS AND METHODOLOGY

This Ore Reserves estimate is based on a number of factors and assumptions:

- The Davis Tube Concentrate (DTC) samples have analyses for Fe, Al_2O_3, P, SiO_2, Ti, CaO, K_2O, MgO, Mn and LOI (magnetic concentrate grades).
- Vertically, the Mineral Resource is constrained by a mineralisation envelope defined by a nominal 4% Fe_2O_3 edge cut-off grade.
- The Mineral Resource was estimated using an Ordinary Kriging algorithm. Head grades were estimated using samples weighted by recovery.
- Head grades were estimated for Fe_2O_3, Al_2O_3, P_2O_5, SiO_2, TiO_2, CaO, K_2O, MgO, MnO, LOI, Recovery and DTR. DTC grades were estimated for Fe, Al_2O_3, P, SiO_2, Ti, CaO, K_2O, MgO, Mn and LOI.
- The Mineral Resource estimates have been classified as Indicated Resource where the drill spacing is on a 1000 m by 1000 m grid or closer, and Inferred Resource where the deposit is less systematically drilled but geological continuity can be interpreted.
- No Inferred material has been included within the Ore Reserves estimate.

2.0 MODEL VALIDATION

The 2013 mineral resource model was used to prepare the Mineable Resource Model for use in a mineable schedule. The mineral resource model was first 'flattened' such that block centres equated to the depth below the ocean floor.

A *depth* field was added to the mining model, and then a lava script (*rmg_block_depthbelsurf.lava)* was run to calculate the depth of the block centre below the ocean floor. The model blocks were exported to a csv file, manipulated by transferring the block *zcentre* field to a new field *b_centroid_z*. The *depth* field was then copied to the *zcentre* field. The modified csv file was imported into the scheduling model *sia_dtr_est_post_a_TRANS.bmf.* This model has the same block dimensions and parameters as the resource model.

An additional *mine* variable was added to the block model to flag the model according to the planned mining region. The variable was flagged using the code 1=Outside of 12 nautical mile (NM) but inside Mining Area revision 2, 2=Inside of the 12NM limit and inside of the Mining Area Revision 2, -99 outside of the Mining Area Revision 2 boundary.

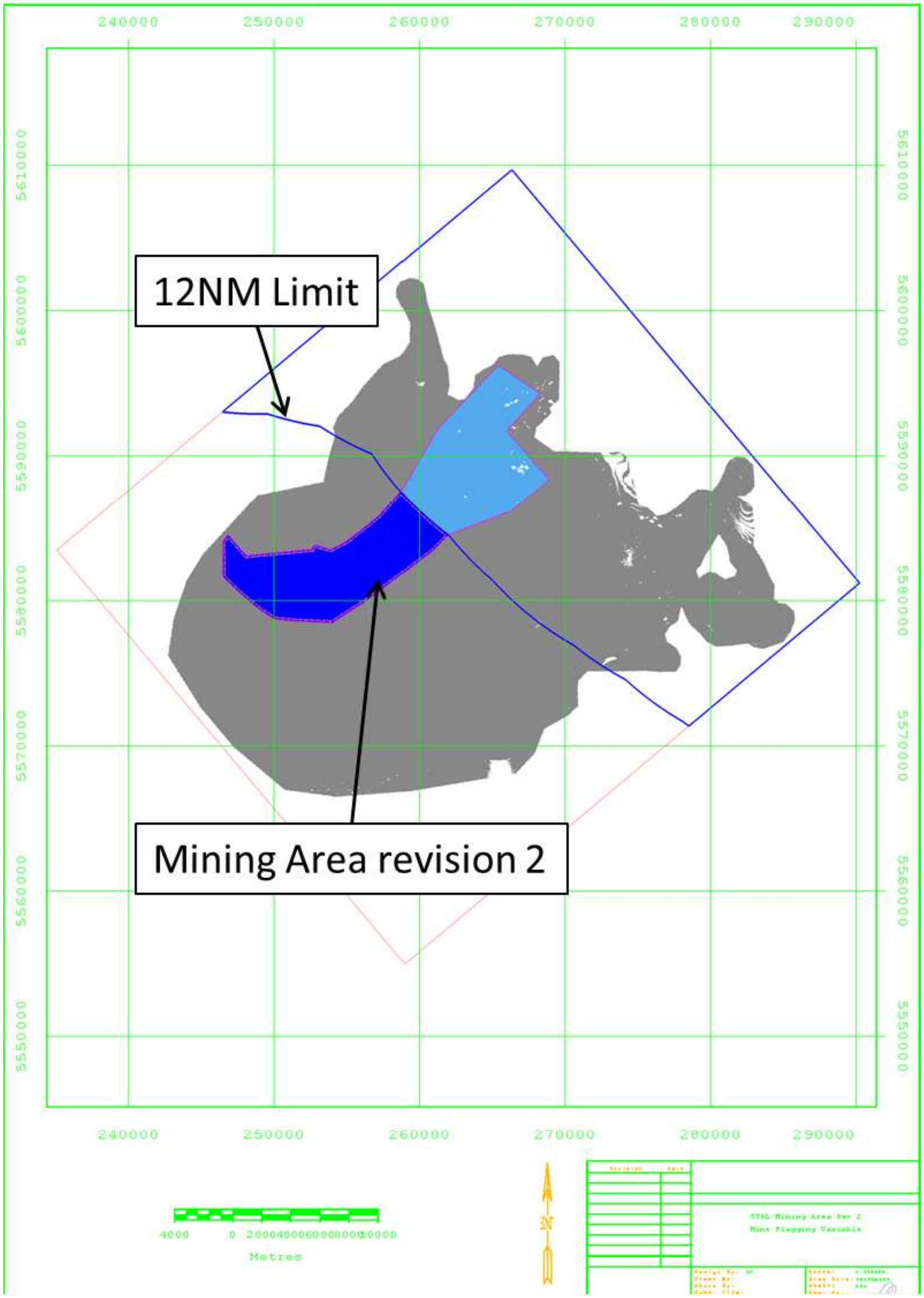

Figure 1: Mining Area Revision 2

The Mineable Resource Model was then used as the basis for tonnage and grade calculations.

3.0 SCHEDULING

3.1 Creation of mining regions

Within the boundary of Mining Area Revision 2 (MAR2), a grade shell representing areas above a 7% Davis Tube Recovery (DTR) grade was created. The creation of this 7% cut-off boundary enabled mining areas to be planned within the MAR2 region that targeted the maximum value of the contained resource. An initial cut-off of 7% DTR has been chosen in that it enables a potential balance between rapid return on investment without risking undue sterilisation of future mining potential. Following depletion of the 7% cut-off blocks, a subsequent lower grade mining region within the MAR2 has been scheduled to maximise resource extraction from the resource.

The MAR2 was separated by the 12NM boundary, as this will form a separation of two separate mining application permits. The initial mining application will focus on the area within MAR2 that is outside of the 12NM boundary, whilst the subsequent mining application will seek approval to mine the blocks within the 12NM boundary.

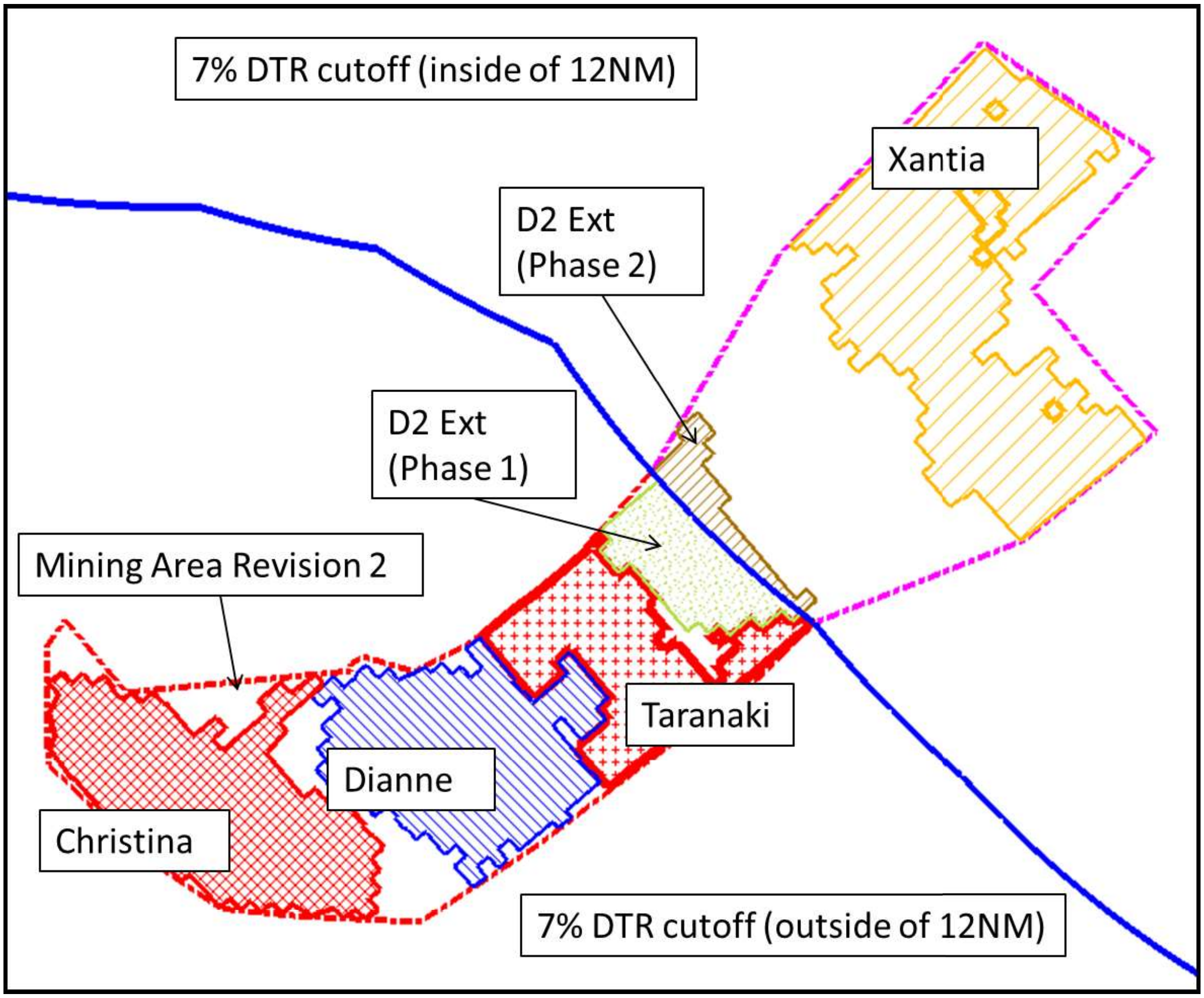

Figure 2: Mining Regions within MAR2

Within each of the mining regions, Christina, Dianne, D2 extension Phase 1 D2 extension Phase 2, and Xantia, mining panels of 300 m × 300 m were defined to enable the sub-sea crawler dredge and Integrated Mining Vessel (IMV) to operate. Based upon the current metocean data, the mining panels have been orientated to optimise the placement of the IMV.

3.2 Creation of mining panels

Within each of the mining regions, targeted mining strips and panels were defined. The mining strips represent the 300 m × 300 m wide ‘lanes’ of material that have been defined within the DTR cut-off grade. Each of the strips was then divided into individual mining panels that represent a practical mining area of 300 m × 300 m. The mining panel dimension assists in minimising anchor movements of the IMV. The crawler dredge unit will mine the 300 m × 300 m wide panels in 22 m wide ‘lanes’ giving an effective 20 m strip width with 1 m overlap on each side to ensure minimising ore losses. Vertical control is by a combination of sonar and positional monitoring equipment.

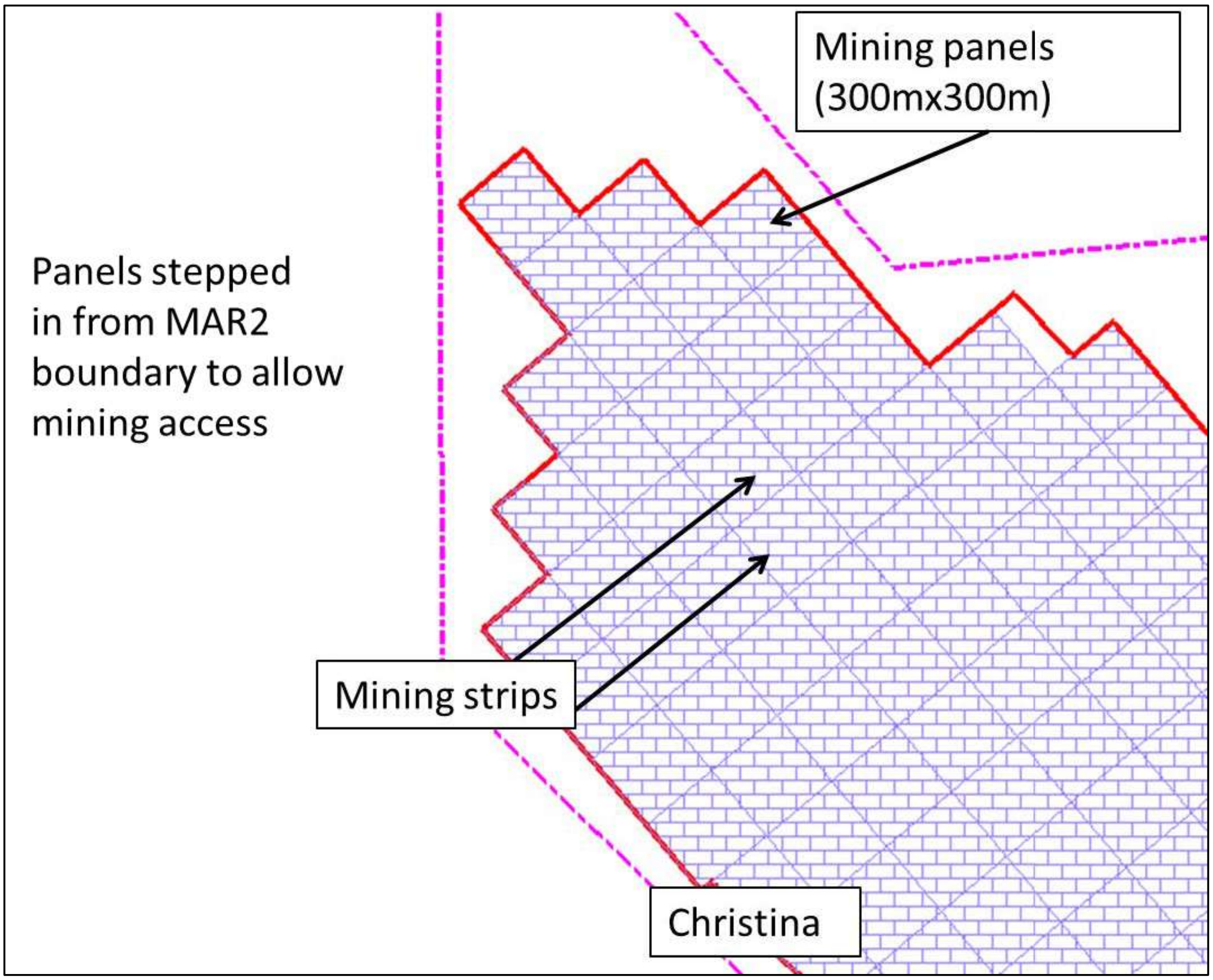

Figure 3: Mining Panels and Strips within a mining region

After creation of the mining strips and panels, the resource block model was interrogated against the defined areas to provide tonnage and grade estimates for each of the mining panels. The total for each of the mining regions was then compared against the total for the mining panels within each region.

The Mining regions would of necessity include areas that were not practical to include in a full mining panel. The total available resource tonnage within each of the mining regions equated to some 368 Mt above 7% DTR cut-off. With an additional 107 Mt being available at a 4% DTR cut-off for the Taranaki blocks, giving a total targeted resource tonnage of some 475 Mt.

Table 1: Resource tonnage per region

Mining Region	Resource Tonnes above Cut-Off
Christina	125.2
Dianne	123.3
D2ext Phase 1	37.4
D2ext Phase 2	6.7
Xantia	75.6
Taranaki	107.5
Grand Total	**475.7**

After allowing for potential ore losses at boundaries of the first block in a strip and possible horizon control errors for the crawler head an estimated 451 Mt of feed material will be available for processing by the IMV. The allowance of a 5% material loss has been advised by TTR, which was determined through recent breach testing (overseen by IHC Merwede B.V) as well as input from DeBeers Marine based on their operational experience. The use of the 5% material loss is the lower expected efficiency factor that could be expected from the crawler dredging unit. IHC are an international company that specialise in the design and construction of marine dredging solutions, with DeBeers Marine (an experienced marine mining operator) providing technical and operation advice to TTR. It is useful to note that a recent breach test carried out at TTR in Wellington demonstrated that extraction percentages in excess of 95% could be expected.

Table 2 below shows the tonnage within the mining panels for each of the mining regions and identifies the stage application for each of the regions.

Table 2: Mineable resource per stage and region

Mining Region	First Stage Tonnes (M)	Second Stage Tonnes (M)
Christina	118.9	
Dianne	117.1	
D2 extension – Phase 1	35.5	
D2 extension – Phase 2		6.4
Xantia		71.8
Taranaki (4% DTR Cut off)		102.1
Total	271.5	180.3
Grand Total Tonnes (M) at 7% DTR cut-off (except for Taranaki)	**451.8**	

The total grade and tonnage for each region is summarised below in Table 3 for the first stage application being the mining area outside of the 12NM limit.

Table 3: Grade and Tonnage for Stage 1 application

Stage 1	Tonnes (M)	DTR (%)	Fe (%)	Al_2O_3 (%)	LOI (%)	P_2O_5 (%)	SiO_2 (%)	TiO_2 (%)	CaO (%)	K_2O (%)
Christina	125	9.65	9.77	11.18	1.33	0.27	50.26	1.40	11.26	1.03
Dianne	123	10.44	9.63	12.26	2.31	0.27	49.23	1.41	11.22	1.07
D2 Ext – Ph 1	37	10.32	9.76	11.71	1.93	0.29	49.57	1.43	11.13	1.12
Total	285	10.07	9.71	11.71	1.82	0.27	49.73	1.41	11.22	1.06
Taranaki (4% DTR Cut-off)	107	5.12	4.65	13.73	2.49	0.26	51.62	0.95	11.97	1.15

For the second stage of mining, the remainder of the D2 extension resource and the Xantia mining region have been identified. The tonnage and grades for the mining areas within that stage are shown below in Table 4 all tonnes and grade relate to material above the specified 7% DTR cut-off.

Table 4: Grade and Tonnage for Stage 2 application

Stage 2	Tonnes (M)	DTR (%)	Fe (%)	Al_2O_3 (%)	LOI (%)	P_2O_5 (%)	SiO_2 (%)	TiO_2 (%)	CaO (%)	K_2O (%)
D2 Ext – Ph 2	7	8.32	7.15	10.96	2.48	0.23	54.46	1.04	10.70	1.18
Xantia	76	8.92	9.30	9.35	3.37	0.20	51.28	1.32	12.05	0.91
Total	82	8.87	9.13	9.48	3.30	0.21	51.54	1.30	11.94	0.93

3.3 Creation of scheduling resource

The defined mining panels were used as resource targets for the mining scheduling programme.
A scheduling model was created using the MineMax Scheduler that allowed each of the mining panels to be mined at a defined rate of extraction. The available hours per period for extraction were incorporated into the scheduler with a three month ramp up phase being applied in the first year of operation. The ramp up factors applied during the first three months of operation assumes that wet commissioning of the plant and crawler has occurred prior to first mining. The maximum allowable hours for the first month was set at 30% of available planned hours, with 80% being targeted for month two and 90% of planned hours for month three of the ramp up period.

The available time per year for use of the Crawler and IMV were supplied by TTR, and reviewed by DeBeers Marine, in terms of a minimum time usage model used by TTRL. The time usage model identifies some 6 326 hours per year available for production by the Crawler/IMV system at a stated throughput of 8 000 tonnes per hour.

The summary of the Time Usage Model is shown in Figure 4.

TTR Mining system time usage model		
Total available hrs per year	8760	
Deduct non work hours (Christmas day and boxing day)	0	24/7 operation
Deduct non production hrs to due inclement weather	438	Based on Metocean data <4mHs
Deduct non production hours due to planned maintenance	52	Time for raising and lowering Crawler to replace on breakdown
Deduct non production hours for crawler reversing and lane set up		Included in Crawler(See Extraction breakdown below)
Deduct non production hours due to operating delays	672	28 days (See Availability breakdown below)
Deduct non production hours due to anchor relocation	156	Contingency. Despite availability of AHT
Sail to new Location	120	10 Occurrences of Ship steaming to new location within mine plan
Sub Total	7322	System Availability
Deduct Crawler Extraction Delay	732	See Extraction breakdown below
Available production hours at design capacity	6590	
Deduct break downs (unplanned)	264	
Available production hours at design capacity	6326	

Figure 4: Time Usage Model

Factors used in the Scheduler model were supplied by TTR are listed below in Table 5. Dredge rate is the Basis of Design provided by IHC.

Table 5: Factors used in MineMax Scheduler model

Factor	Value
Process plant recovery efficiency	92%
Process cost	USD 24.81/tonne per tonne Fe concentrate processed
Dredge rate	8000 tph
Dredge system efficiency (incl. loss & dilution)	95%
Dredge Mining Cost	USD 1.97/tonne ROM
Fe Price of concentrate (FOB)	USD 70.00/tonne concentrate

The scheduling model is used to determine a practical mining sequence and allocates costs and revenue per process to determine a high-level financial assessment. The scheduler is not intended to replace a fully costed financial model, the primary purpose of the scheduling model is to provide a time dependant set of material physical properties that can be used to further assess the project viability.

The numbering (sequencing) of the mining panels has been set up to follow the ‘Z-Mining’ direction of the IMV/Crawler system in order to minimise anchor movements and sailing time between strips. At the completion of one strip the subsequent strip is mined in the opposite direction as shown in Figure 5.

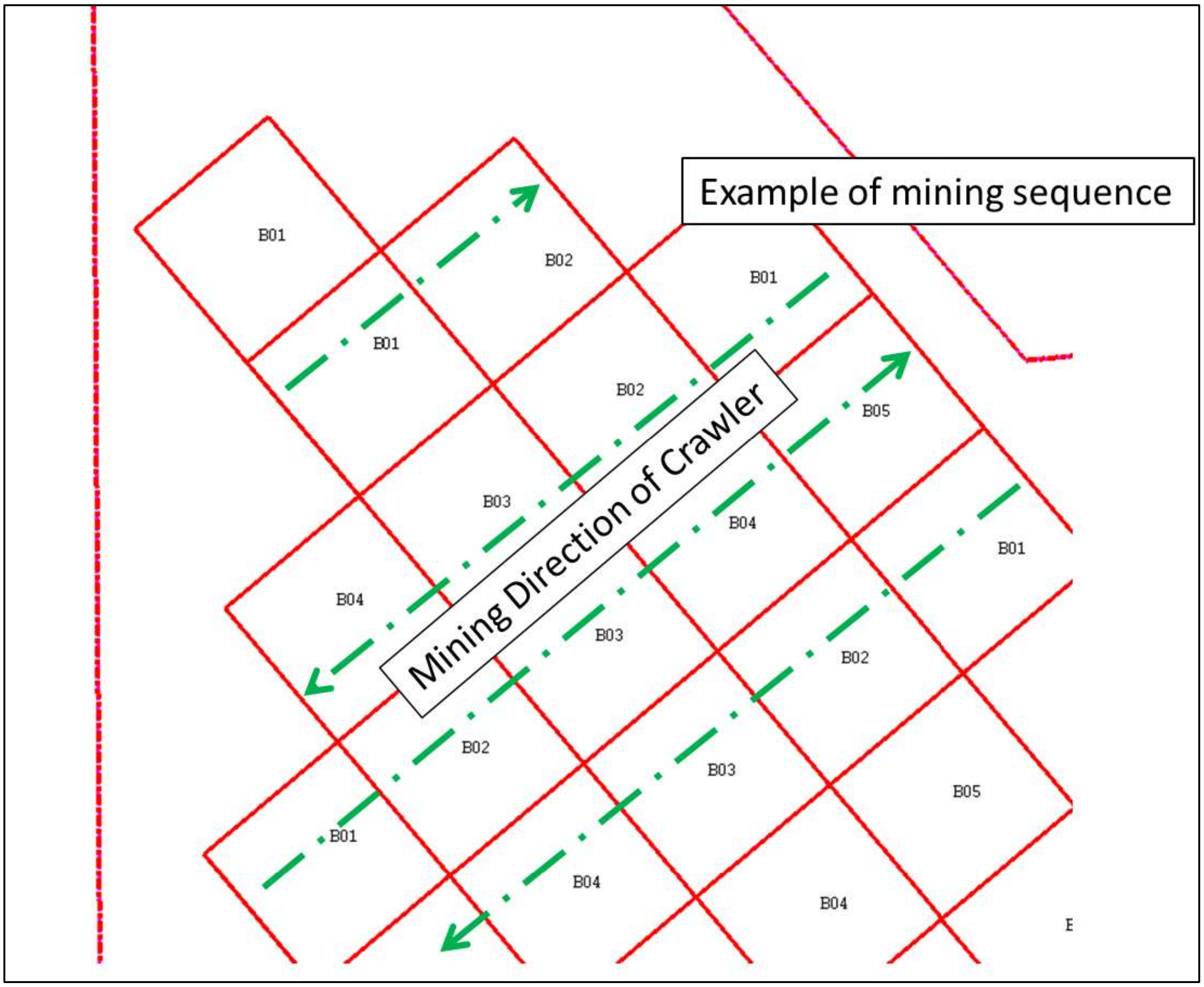

Figure 5: Mining Direction per strip

Within the first mining stage the scheduling model is configured to sequentially mine the regions in a defined sequence commencing in the higher grade Dianne region and then the D2 extension Phase 1 region before moving on to the Christina mining region. The subsequent stage (Stage 2) will mine the remainder of the D2 Extension region and then the Xantia mining region.

The scheduling constraints are assigned in terms of maximum permissible running hours per year, maximum recoverable concentrate tonnes, and maximum total material movement.

The maximum annual material movement is set to 50.6 Mt after the first year, the first year includes a three month phased build up and has been limited to 46.4 Mt. The recovered concentrate restriction is a function of the concentrate holding capacity on the IMV and the estimated time taken to transfer the concentrate to the FSO during rough sea conditions. The annual concentrate limit has been set to 5.068 Mt. Maximum system operating hours have been limited to 6326 hours after year 1, with the year 1 being constrained to 5797 to reflect ramp-up conditions.

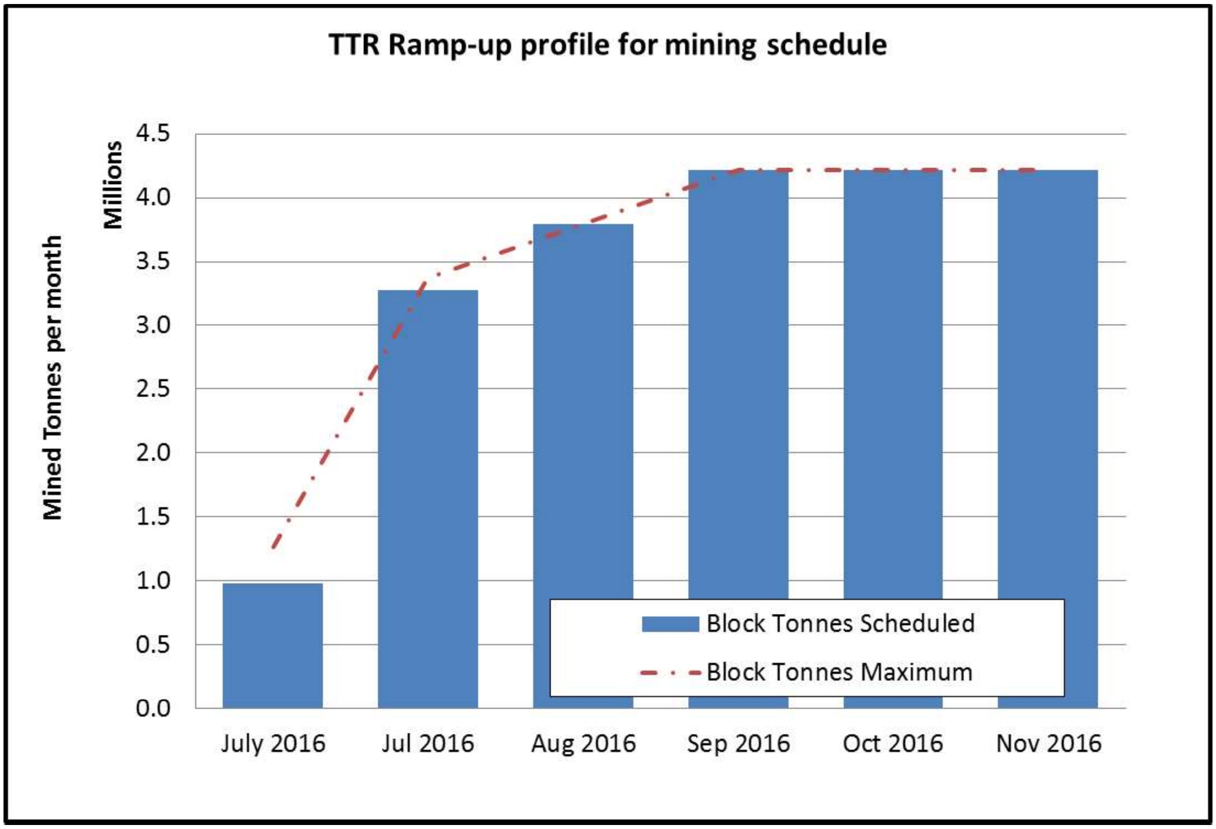

Figure 6: Ramp up profile applied to mining schedule

The scheduler sequence is then defined in terms of the strip mining and block sequence, with the aforementioned ‘Z-Mining’ direction being applied to the majority of the mining regions.

Volumes mined and concentrate product are constrained by either the available hours (volume mined) or storage capacity of the system (concentrate product). Both of these constraints have been applied to the logic of the scheduling tool with periods of high concentrate production then limiting the processing hours of the IMV. Figure 7 shows the annual process feed tonnes from the MAR2, the reduction in recovered concentrate tonnes towards the tail of the schedule is a reflection of the lower grade Taranaki blocks being mined.

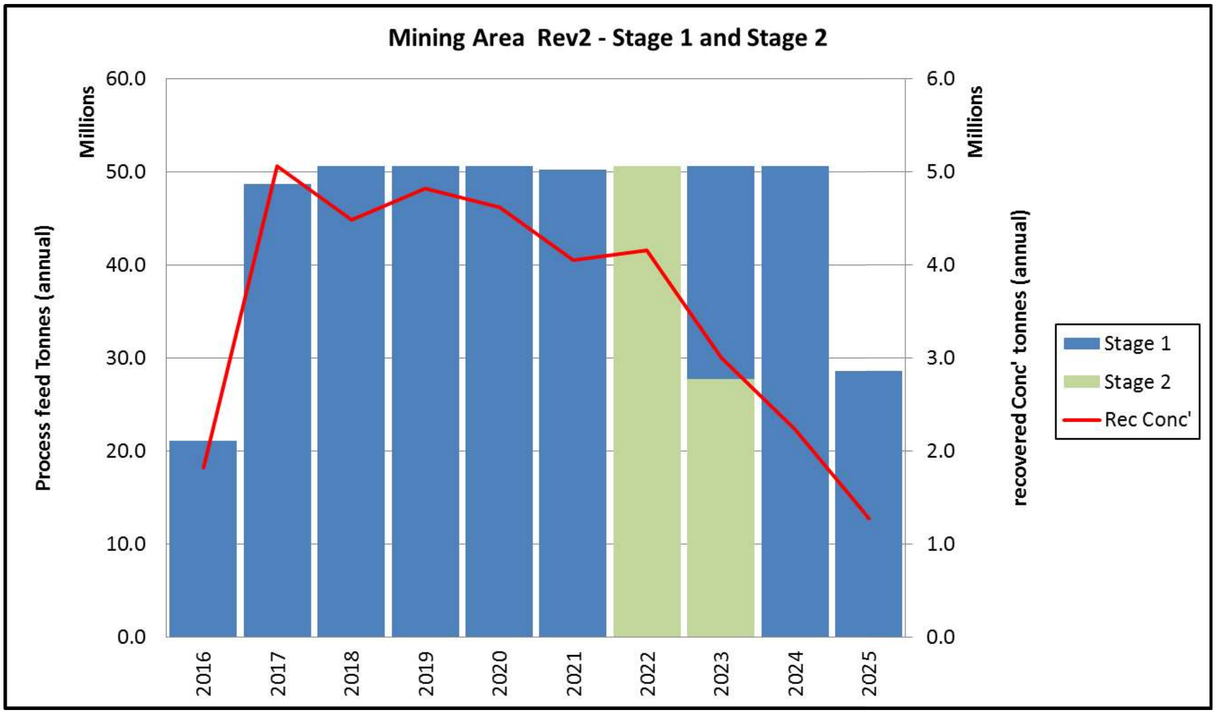

Figure 7: Ore mined versus Concentrate production for MAR2 stage 1

Ore Reserves estimated tonnage from the schedule has been broken into the two distinct stages represented by the separate mining lease applications and is reported by stage below (Table 6).

Table 6: Mining Area Revision 2 Resource tonnage

MAR2	Stage 1 tonnes (M)	Stage 2 tonnes (M)
Tonnes depleted	286	190
Process feed tonnes	267	172
Concentrate recovered	24.85	10.66

Concentrate product specification forecast from the schedule is as shown in the grade table below (Table 7).

Table 7: Concentrate product by stage

Mining Area	Stage 1	Stage 2	Total
Concentrate tonnes (Mt)	24.85	10.66	35.51
Fe %	57.04	57.31	57.12
SiO_2 %	3.75	3.64	3.72
Al_2O_3 %	3.65	3.65	3.65
Ti %	5.07	5.02	5.06
MgO %	3.26	3.23	3.25
K_2O %	0.10	0.10	0.10
CaO %	1.00	0.99	1.00
DTR* %	10.10	7.39	9.28
Fe Yield %	0.62	0.52	0.59
Mag Fe %	5.76	4.27	5.31
P %	0.11	0.10	0.11

*DTR is the estimate based analytical DTR and calculated DTR values.

4.0 ORE RESERVE STATEMENT

The Ore Reserve estimates were classified in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC Code, 2012).   .

The Ore Reserves are based on the block model *sia_dtr_est_post_a_TRANS.bmf* and applicable modifying factors.

The Ore Reserves have been reported at 7.0% DTR cut-off grade with only Indicated resource category material used in the generation of these reserves, there is no measured resource material within the mining lease application area at this time. There is an estimated 35.5 Mt of recoverable concentrate product (56% Fe) within the lease application areas that have been scheduled for mining and processing as shown in Table 8.

Table 8: Probable Ore Reserves for TTR Mining Area Revision 2

Mining Area	Concentrate Tonnes (M)	Fe (%)	SiO_2 (%)	Cut-Off Used
Stage 1	24.85	57.04	3.75	7% DTR
Stage 2*	10.66	57.31	3.64	7% DTR
Total	**35.51**	**57.12**	**3.72**	**7% DTR**

*Stage 2 includes Taranaki (4% DTR cut-off)

The physical recovery has been applied to the models. Head grades and tonnages are for all material less than 2 mm in diameter. Concentrate grades are for the magnetically recoverable portion of the sample. Concentrate tonnage is calculated from the head tonnage and DTR.

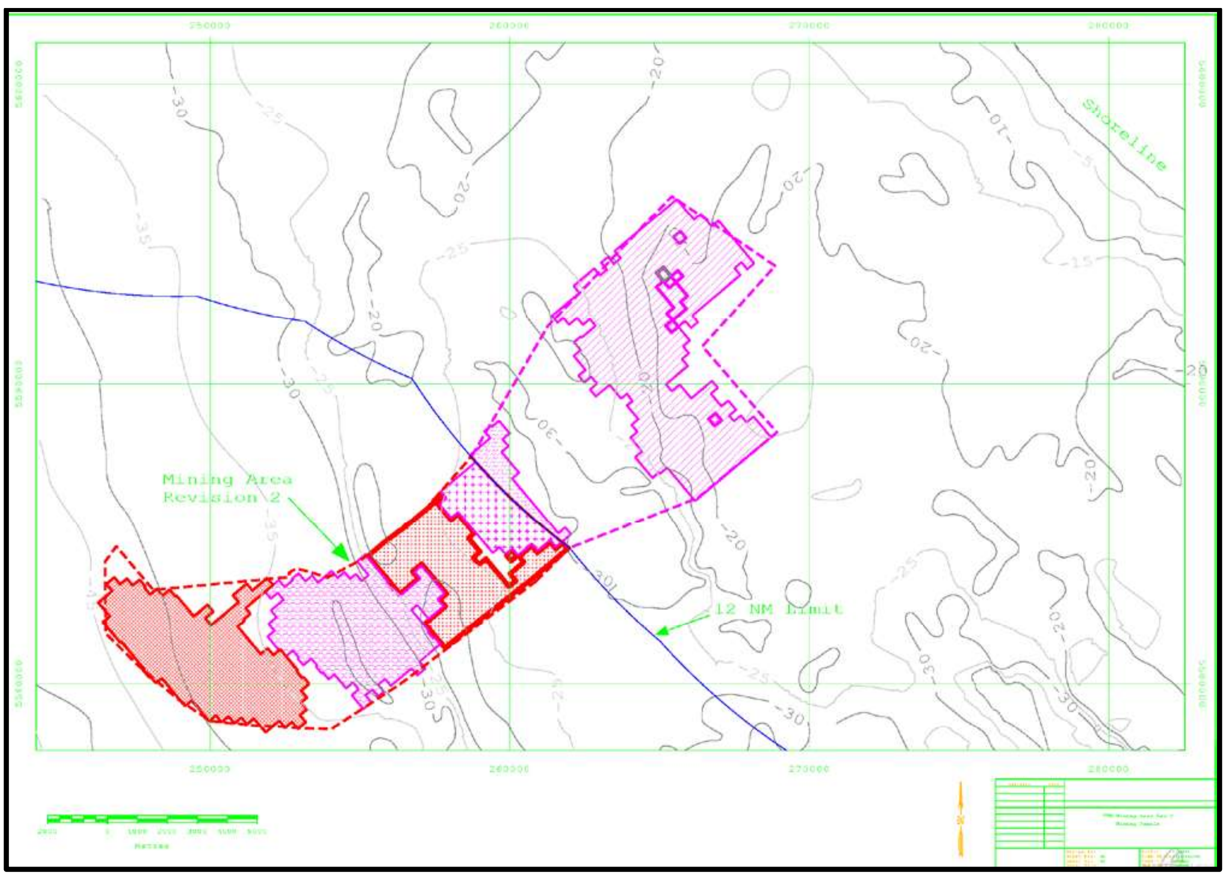

Figure 8: Mining Area Revision 2 location

The information in this report that relates to Ore Reserves is based on information compiled by Mr Glenn Turnbull who is a member of The Australian Institute of Mining and Metallurgy. Mr Glenn Turnbull is a full time employee of Golder Associates and has sufficient experience which is relevant to the engineering and economics of the types of deposits which are covered in this report and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2012 edition of the 'Australian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'.

Glenn Turnbull consents to the inclusion in this report of matters based on his information in the form and context in which it appears.

5.0 COMPLIANCE WITH THE JORC CODE ASSESSMENT CRITERIA

The JORC Code (2012) describes a number of criteria, which must be addressed in the documentation of Ore Reserves estimates, prior to public release of the information. These criteria provide a means of assessing whether or not parts of or the entire data inventory used in the estimate are adequate for that purpose. The Ore Reserves estimate stated in this document was based on the criteria set out in Table 1 of that Code.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Mineral Resource estimate for conversion to Ore Reserves	Description of the Mineral Resource estimate used as a basis for the conversion to an Ore Reserve. Clear statement as to whether the Mineral Resources are reported additional to, or inclusive of, the Ore Reserves.	The material being sampled is subsea sand originally deposited in marine and terrestrial environments. Indicated mineral resources of 35.5 Mt at 57.1% Fe concentrate have been identified across two mining area application regions. No inferred material is included within the TTRL planned mining area. The Mineral Resources are reported as wholly inclusive of the Ore Reserves.
Site visits	Comment on any site visits undertaken by the Competent Person and the outcome of those visits. If no site visits have been undertaken indicate why this is the case.	A site visit was made to the TTRL locality from the 23 November 2013 to the 27 November 2013 with Mr Matt Brown (TTR) and Mr Glenn Turnbull (Golder).
Study status	The type and level of study undertaken to enable Mineral Resources to be converted to Ore Reserves. The Code requires that a study to at least Pre-Feasibility Study level has been undertaken to convert Mineral Resources to Ore Reserves. Such studies will have been carried out and will have determined a mine plan that is technically achievable and economically viable, and that material Modifying Factors have been considered.	Previous onshore mining activities have been carried out in the Waipipi area, with shallow mineral exploitation having been abandoned in 1987 due to economic conditions. A Pre-Feasibility Study has been completed with the Ore Reserves part of this study.
Cut-off parameters	The basis of the cut-off grade(s) or quality parameters applied.	A 7% DTR cut-off grade has been used and was selected on the basis of $US80/t concentrate CFR (57% Fe) at an exchange rate of 0.82NZD:1USD.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Mining factors or assumptions	The method and assumptions used as reported in the Pre-Feasibility or Feasibility Study to convert the Mineral Resource to an Ore Reserve (i.e. either by application of appropriate factors by optimisation or by preliminary or detailed design). The choice, nature and appropriateness of the selected mining method(s) and other mining parameters including associated design issues such as pre-strip, access, etc. The assumptions made regarding geotechnical parameters (e.g. pit slopes, stope sizes, etc.), grade control and pre-production drilling. The major assumptions made and Mineral Resource model used for pit and stope optimisation (if appropriate). The mining dilution factors used. The mining recovery factors used. Any minimum mining widths used. The manner in which Inferred Mineral Resources are utilised in mining studies and the sensitivity of the outcome to their inclusion. The infrastructure requirements of the selected mining methods.	The method used to convert Mineral Resource to Ore Reserves is based upon a grade shell optimisation identifying the economic shell within which a practical mining design has been applied. The mining method chosen is a sub-sea crawler dredge feeding directly to an Integrated Mining Vessel (IMV), with the concentrate slurry being pumped to a Floating Storage and Offloading (FSO) vessel for transhipment to cargo carriers for export. The nature of the titano-magnetite deposit lends itself to dredge mining in defined lanes up to 11 m thick mining horizons. Several extraction lanes will be mined per mining block with a 1 m overlap at the edges of the lanes to ensure minimal material loss. A dredge system efficiency of 95% has been allowed for by allocating 5% of mineral depletion tonnes to losses. The operating design criteria have been provided by IHC. No specific mining dilution has been allowed for other than the combined losses allocated to the 5% system loss stated above. No Inferred material has been included within the mine design. The mining operation will require a purpose built sub-sea crawler dredge unit and dedicated mineral processing vessel.
Metallurgical factors or assumptions	The metallurgical process proposed and the appropriateness of that process to the style of mineralisation. Whether the metallurgical process is well-tested technology or novel in nature. The nature, amount and representativeness of metallurgical test work undertaken, the nature of the metallurgical domaining applied and the corresponding metallurgical recovery factors applied.	A dedicated purpose built process plant (IMV) is planned for the operation with the concentrate off loaded to a dedicated FSO vessel for transhipment for export. Bulk and laboratory sample tests have been carried out by Spectrachem/CRL with validation QA/QC samples carried out by Ultratrace (Perth). A process plant recovery of 92% of concentrate feed has been allowed based upon design criteria provided by TTR.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
	Any assumptions or allowances made for deleterious elements. The existence of any bulk sample or pilot scale test work and the degree to which such samples are considered representative of the orebody as a whole. For minerals that are defined by a specification, has the ore reserve estimation been based on the appropriate mineralogy to meet the specifications?	The Ore Reserve has been defined based upon an Iron concentrate product in excess of 56% Fe. Deleterious elements have been estimated as part of the processing stream with estimates for SiO_2, Al_2O_3, TiO_2, MgO, K_2O, CaO and P_2O_5 being included as concentrate product elements.
Environmental	The status of studies of potential environmental impacts of the mining and processing operation. Details of waste rock characterisation and the consideration of potential sites, status of design options considered and, where applicable, the status of approvals for process residue storage and waste dumps should be reported.	A Minerals Mining Permit was granted under the Crown Minerals Act (1991) on 2 May 2014 to undertake iron ore extraction and processing operations offshore from Patea in the South Taranaki Bight. In October 2013 TTR lodged a marine consent application under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act) to the Environmental Protection Agency (EPA). ArgoEnvironmental have advised that there are no foreseen material reasons for the applications to be withheld. All likely environmental effects associated with the project have, as far as have been identified, been addressed by TTR.
Infrastructure	The existence of appropriate infrastructure: availability of land for plant development, power, water, transportation (particularly for bulk commodities), labour, accommodation; or the ease with which the infrastructure can be provided, or accessed.	TTR have commissioned IHC Merwede a global leader in Dredging solutions to design the IMV and sub-sea crawler dredging units.
Costs	The derivation of, or assumptions made, regarding projected capital costs in the study. The methodology used to estimate operating costs. Allowances made for the content of deleterious elements. The derivation of assumptions made of metal or commodity price(s), for the principal minerals and co- products.	Capital costs have been estimated from equipment suppliers for the purpose built process plant and infrastructure costs have been provided from the process engineering consulting company employed on the feasibility study. Royalty has been estimated based on the NZ Governments formula for calculating mining royalties for material extracted inside and outside the 12 Nautical Mile exclusion zone.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
	The source of exchange rates used in the study. Derivation of transportation charges. The basis for forecasting or source of treatment and refining charges, penalties for failure to meet specification, etc. The allowances made for royalties payable, both Government and private.	Processing, dredging, maintenance and operating costs have been provided by TTR based upon operational experience and estimates reviewed by De Beers Marine.
Revenue factors	The derivation of, or assumptions made regarding revenue factors including head grade, metal or commodity price(s) exchange rates, transportation and treatment charges, penalties, net smelter returns, etc. The derivation of assumptions made of metal or commodity price(s), for the principal metals, minerals and co-products.	Head grade and metal content are derived from the Mineral Resource and modifying factors described above. The financial analysis in this report is based on an Iron concentrate (>56% Fe) and 0.82 exchange rate. The Iron slurry concentrate will be transhipped from the FSO to cargo carriers for export to Asia and the far East.
Market assessment	The demand, supply and stock situation for the particular commodity, consumption trends and factors likely to affect supply and demand into the future. A customer and competitor analysis along with the identification of likely market windows for the product. Price and volume forecasts and the basis for these forecasts. For industrial minerals the customer specification, testing and acceptance requirements prior to a supply contract.	Historical Iron concentrate price and forward looking estimates have been used for the iron concentrate price. Price flexing has been carried out to determine the robustness of the project viability.
Economic	The inputs to the economic analysis to produce the net present value (NPV) in the study, the source and confidence of these economic inputs including estimated inflation, discount rate, etc. NPV ranges and sensitivity to variations in the significant assumptions and inputs.	Inputs to economic analysis include factors described above including ore & metal quantities from mining/processing schedule, (incl. described recovery/processing parameters), cost quotes & estimates and price assumptions.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Social	The status of agreements with key stakeholders and matters leading to social licence to operate.	Applications for iron ore extraction and processing have been lodged with the New Zealand government and a decision is expected in early 2014. In July 2013 TTR applied for mining permit 55581 for the South Taranaki Bight Project. In October 2013 TTR applied for marine consents under the new Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 for this area.
Other	To the extent relevant, the impact of the following on the project and/or on the estimation and classification of the Ore Reserves: Any identified material naturally occurring risks. The status of material legal agreements and marketing arrangements. The status of governmental agreements and approvals critical to the viability of the project, such as mineral tenement status, and government and statutory approvals. There must be reasonable grounds to expect that all necessary Government approvals will be received within the timeframes anticipated in the Pre-Feasibility or Feasibility study. Highlight and discuss the materiality of any unresolved matter that is dependent on a third party on which extraction of the reserve is contingent.	TTR holds a Continental Shelf Act prospecting licence in the exclusive economic zone in the South Taranaki Bight and a Crown Minerals exploration permit offshore between Oeo and Patea. TTR has applied for subsequent offshore exploration permits under the Crown Minerals Act for iron sands between Patea and Santoft, and between the Waikato River and Awakino on the west coast of the North Island.
Classification	The basis for the classification of the Ore Reserves into varying confidence categories. Whether the result appropriately reflects the Competent Person's view of the deposit. The proportion of Probable Ore Reserves that have been derived from Measured Mineral Resources (if any).	Indicated Resources have been converted to Probable Ore Reserves. There are no Measured Mineral Resources within the Mining Area Revision 2 mining application area. The estimated Ore Reserves and mining method are in the opinion of the Competent Person appropriate for this style of deposit.
Audits or reviews	The results of any audits or reviews of Ore Reserve estimates.	All inputs to the estimation of Ore Reserves have been subject to internal reviews.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Discussion of relative accuracy/confidence	Where appropriate a statement of the relative accuracy and confidence level in the Ore Reserve estimate using an approach or procedure deemed appropriate by the Competent Person. For example, the application of statistical or geostatistical procedures to quantify the relative accuracy of the reserve within stated confidence limits, or, if such an approach is not deemed appropriate, a qualitative discussion of the factors which could affect the relative accuracy and confidence of the estimate. The statement should specify whether it relates to global or local estimates, and, if local, state the relevant tonnages, which should be relevant to technical and economic evaluation. Documentation should include assumptions made and the procedures used. Accuracy and confidence discussions should extend to specific discussions of any applied Modifying Factors that may have a material impact on Ore Reserve viability, or for which there are remaining areas of uncertainty at the current study stage. It is recognised that this may not be possible or appropriate in all circumstances. These statements of relative accuracy and confidence of the estimate should be compared with production data, where available.	The assessment of relative accuracy using statistical or geostatistical techniques is not considered appropriate. The local estimate of Ore Reserves available for technical and economic evaluation is 35.5 Mt of Iron Concentrate (>56% Fe). There are no additional factors or areas of uncertainty remaining to be disclosed which could have material adverse impacts on project viability.

The summary in Table 9 shows the probable Ore Reserves for the Mining Area Revision 2 for the first and second stage of mining.

Table 9: Probable Reserves – Mining Area revision 2 (Stage 1 – Outside of 12NM, Stage 2 – Inside of 12NM)

Mining Area	Conc' (Mt)	Fe %	SiO_2 %	Al_2O_3 %	Ti %	MgO %	K_2O %	CaO %	DTR* %	Fe Yield %	Mag Fe %	P %
Stage 1	24.85	57.04	3.75	3.65	5.07	3.26	0.10	1.00	10.10	0.62	5.76	0.11
Stage 2	10.66	57.31	3.64	3.65	5.02	3.23	0.10	0.99	7.39	0.52	4.27	0.10
Total	**35.51**	**57.12**	**3.72**	**3.65**	**5.06**	**3.25**	**0.10**	**1.00**	**9.28**	**0.59**	**5.31**	**0.11**

6.0 CONCLUSIONS AND RECOMMENDATIONS

The sub-sea titano magnetite deposit being considered by TTR for seaborne exploitation is an extension of the land based titano magnetite sands formerly worked at Waipipi.

Further exploration and sampling of the marine deposits in the South Taranaki bight would be expected to further increase the mineable potential of similar deposits in the vicinity.

7.0 LIMITATIONS

Your attention is drawn to the document "Limitations", which is included in Attachment A of this letter report. The statements presented in this document are intended to advise you of what your realistic expectations of this letter report should be, and to present you with recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this letter report are aware of the responsibilities each assumes in so doing.

GOLDER ASSOCIATES PTY LTD

Glenn Turnbull
Principal Mining Engineer

Iain Cooper
Associate, Principal Mining Engineer

GT/ILC/hsl

Attachments: A – Limitations

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ATTACHMENT A

Limitations

LIMITATIONS

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In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Golder's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

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Appendix 19.11 - CSL Trans-Shipment Review

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Ref. No.: 758-01-201005071

October 12, 2010

BY EMAIL

Trans-Tasman Resources Ltd
1139 Hay Street
West Perth, WA 6005
Australia

Attention: Paul Berend, Managing Director

**Re: Iron Sands Export System
Revised Updated Report**

Introduction

Trans Tasman Resources (TTR) proposes to mine offshore iron sands along the south and west coast of the North Island of New Zealand. Conceptually a dredge will be used to recover the iron sands from the sea bottom and the reclaimed sands will be concentrated and exported. Initial mining areas have been proposed in the southern and northern tenements, ***Appendix 1***.

This report briefly reviews the site wave climate, the export process and system components proposed to undertake the offshore mining. Additional details and indicative costs for the offshore slurry system and transshipping portion are included in the report. Also included are preliminary specification for the conversion of a bulk carrier to transshipper and an introduction to operating guidelines.

Site

The TTR tenements each range along over 100 km of coast line and extend offshore over 20 km with water depths ranging typically from 20 to 40 m in areas of high resource concentration. Both tenements are in water exposed to the heavy seas of the Tasman Sea. The sea state will have a major impact on the operability of the dredging and shipping activities, operation down time must be expected during the winter months. A preliminary assessment has been made based on wave data for sites nearby the tenements at Taranaki and Port Waikato, ***Figures 1 and 2***.

From the wave data preliminary, estimates of transshipper operability have been made and indicate that a vessel capable of operating in seas up to 2.5 metres significant wave height would be able to operate about two thirds of the time annually and would be able to exceed the target 5 Mt annual export tonnage. These preliminary figures are a positive statement for Seabulk's export system and make it candidate for further study.

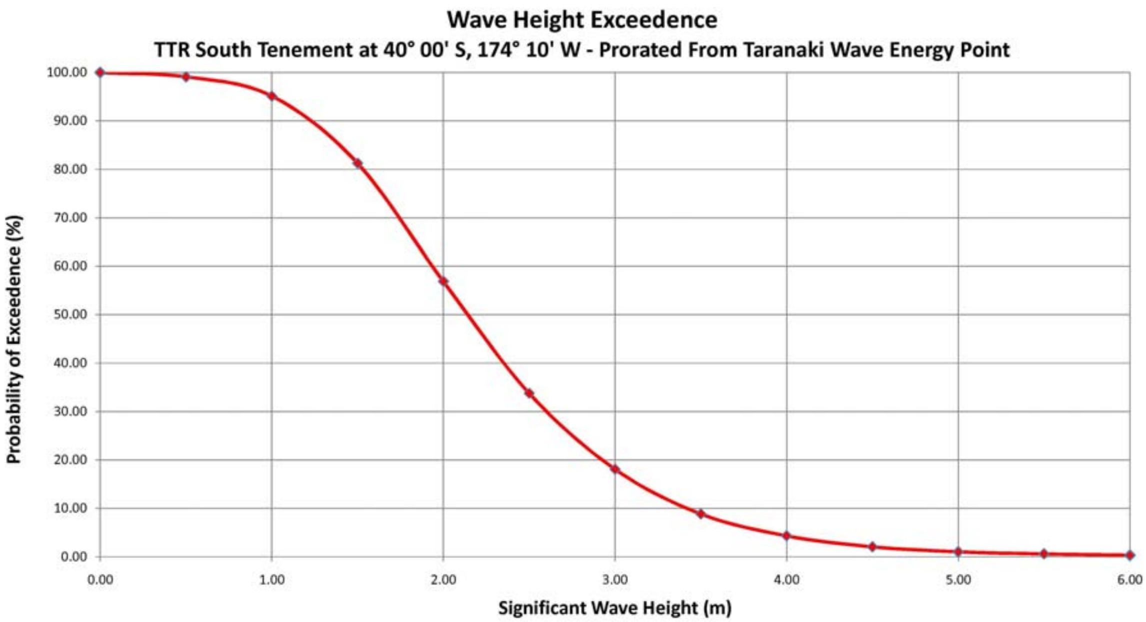


Figure 1: Wave height exceedence at Taranaki near TTR's south tenement

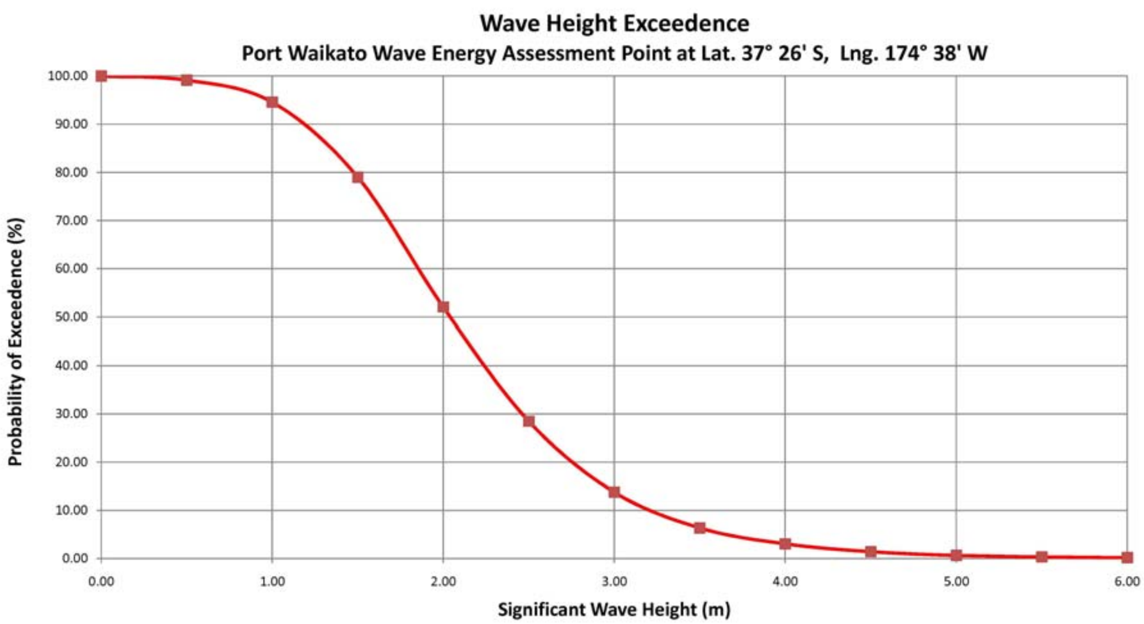


Figure 2: Wave height exceedence at Port Waikato near TTR's north tenement

System Overview

Seabulk's export system concept seeks to reduce the number of vessels operating at the site over that proposed in the terms of reference documents. The high sea state will require use of large export vessels such as cape size bulk carriers to attain the target annual export volumes given the available windows of operability. This has directed us to consider placing a part of the export operation on land which will have some obvious advantages over a sea based operation, including:

- easier access to fresh river or well water for slurry export and concentrator operation;
- ability to have relatively larger surge capacity using onshore storage;
- ability to process the commodity during rough sea conditions that might be precluded with sea based operation; and
- ability to operate at a larger scale and take advantages of the economy of scale that may provide.

The operation envisaged by Seabulk, outlined schematically in ***Appendix 2***, is comprised of the following major land based and offshore components:

- Trailer suction hopper dredger capable of operating in seas up to 2.5 m significant height;
- An import single point mooring (import SPM) for receiving inbound raw commodity from the dredger and conveying outbound process waste to the dredger for disposal at sea;
- A subsea pipeline to convey raw commodity from the import SPM to shore and to convey process waste from shore to the dredger;
- A shore based slurry processing and concentrating plant with storage ponds for raw commodity, concentrated commodity, recycled water, process waste and fresh water;
- A subsea pipeline to convey concentrate slurry to an export SPM;
- A recycle water pipeline to return water from the export SPM back to the shore based facilities for possible reuse in the process; and
- A dewatering transshipper with a minimum of 150,000 tonnes of surge capacity capable of loading slurry in up to 2.5 m seas, moored at the export SPM.

Trailer Suction Hopper Dredge

The dredger specifications would require operability in sea states of up to 2.5 m or possibly higher and have a dredging rate that would enable the recovery of the target 5 Mtpa iron sand during periods of operability. The unit would have to be able to discharge the cargo as slurry through hoses at the import SPM and have sufficient pumping power to covey the cargo through the import pipeline to shore. Southern tenement pipeline locations have been assumed for cost estimation purposes to be on a seabed area of low mineral concentration, ***Appendix 3***, however, the actual pipeline location and SPM positioning would have to be determined in consultation with the dredging contractor as the capabilities of their equipment may influence the SPM and pipeline location. The dredger is assumed to be owned and operated by a dredging contractor. An illustration of a trailer suction hopper dredger is shown in ***Figure 3***.

Figure 3: Trailer suction hopper dredge

Import Slurry Pipeline

The import system for the southern tenement would be comprised of the following major equipment:

- import SPM buoy with product swivel;
- hose strings with end couplings and pick up buoys;
- hose strings to connect the SPM to the pipeline end manifold;
- pipe line end manifold;
- subsea pipeline (estimated length for costing 15 km, southern tenement);

- upland pipeline (estimated length for costing 2 km, southern tenement); and
- corrosion mitigation for steel components as required

For purposes of scoping costs, the southern tenement import pipeline is assumed to terminate in the vicinity of the initial mining areas and the dumping area on about the 30 m depth contour and would have a length of 15 km offshore and perhaps 2 km onshore, ***Appendix 3***. The 30 m depth contour is assumed at this time noting that shallower depths closer to shore are possible, however, wave shoaling may preclude the use of these closer and shallower sites. Alternate SPM sites with shorter pumping distances to shore are possible as shown for the southern tenement, ***Appendix 1***.

The import pipeline is to be a single pipe that would have flow reversed for either importation of raw iron sand or export of concentrator waste.

It is noted that candidate materials for the pipeline materials are steel and plastic. Additional work on the physical properties of the raw iron sand would be required to assess pipeline wear rates and suitable pipe type.

Slurry Processing and Concentration

It is proposed that slurry processing and concentration be done on an upland site. The major functions of this system would be to flush salt out of the iron sands and concentrate them to the required specifications for export. Water and concentrator waste is stored and managed at the site. A conceptual process schematic for this system is presented in ***Appendix 2***.

Export Slurry Pipeline

The export system for the southern tenement would be comprised of the following major equipment:

- dynajet hydraulic reclaimer;
- slurry booster pump;
- upland slurry pipeline (estimated length for costing 2 km, southern tenement);
- upland water pipeline;
- subsea slurry pipeline (estimated length for costing 12 km, southern tenement);
- subsea water pipeline;
- pipe line end manifolds;
- hose strings to connect the pipeline end manifolds to the SPM;
- export SPM buoy with dual product swivel;
- hose strings with end couplings and pick up buoys; and
- corrosion mitigation for steel components as required.

For purposes of scoping costs, the export pipeline is assumed to terminate east south east of the import SPM on about the 30 m depth contour and would have a length of 12 km offshore and perhaps 2 km onshore, ***Appendix 3***. The 30 m depth contour is assumed at this time noting that shallower depths closer to shore would be possible, however, wave shoaling may preclude the use of these closer and shallower sites.

The export system is a dual pipeline system for outbound iron concentrate slurry and inbound water. As in the case of the import pipeline, candidate materials for the pipeline materials are steel and plastic. Additional work on the physical properties of the iron sand concentrate and recovery efficiency of the dewatering centrifuges would have to be determined to assess pipeline wear rates and suitable pipe type.

For both import and export systems, pipeline weighting for on bottom stability would be an important design consideration.

Dewatering Transshipper

The dewatering transshipper would be a conversion of an existing cape size bulk carrier, of about 150,000 DWT or larger capacity, to a transshipper capable of:

- receiving iron ore concentrate slurry
- dewatering the product on board
- storing the product in the vessel holds
- reclaiming the product by gravity; and
- transloading the product to the export vessel over ship loading booms.

The transshipment vessel would be moored offshore at a SPM buoy and would receive slurry through hoses connected at a forward manifold, ***Figure 4***.

Figure 4: Illustration of a dewatering transshipper with gravity reclaim and loading boom

Slurry surge storage would be in the forward hold of the vessel. The vessel would be equipped with dual hawser bow mooring arrangement pursuant to OCIMF (Oil Companies International Marine Forum) guidelines. On board slurry distribution and de-watering systems would include requisite pumps, pipelines and centrifuges to convey the product from the surge storage as slurry and deposit it as a dewatered bulk material in the transshipper holds for later reclaim. The dewatered bulk product would be reclaimed by a gravity reclaim system and conveyed over ship loading booms operating on one side of the transshipper for transloading of the product to the export vessel.

The materials handling system on the vessel will be designed to operate in the rough sea states of the site. Particular design aspects that would require attention include systems sensitive to vessel list and trim.

The weather cut-off criteria for transshipment operation is deemed to be a sustained wind speeds of 30 knots and/or significant wave heights exceeding 2.5m, however, the dewatering transshipper may be able to load slurry at higher wave heights. Studies will be required to affirm the wave height limit for slurry loading. At times when the weather conditions exceed safe operation limits, the dewatering transshipper would sail with the dewatered cargo to a safe transshipment anchorage site for transloading to the export vessel. It is deemed the transshipper would have a nominal discharge rate of 1,500 tph for the iron ore concentrate with an average bulk density of 3.60 t/m^3.

The conversion scope would include as required strengthening and upgrading of ship systems for robustness to enable operation in the rough environment, including:

- the general refurbishment of the vessel;
- refurbishment and/ or renewal and repositioning of mooring equipment;
- strengthening of hatch covers; and
- reinforcing deck areas where new equipment will be installed.

A preliminary outline specification for the conversion is presented in ***Appendix 4***.

Operation

The operation of Seabulk's iron sand export system, ***Appendix 2***, during operable seas conditions is visualized as follows:

1. The trailer suction dredger mines the seabed until loaded. This dredger design has the capability of partial separation and concentration using separate hoppers.

2. The dredger pulls up its dredging leg and connects to the import SPM hoses and pumps the raw sand commodity ashore.

3. After discharging its cargo, the import pipeline is used to convey process waste back to the dredger for discharge at sea.

4. The loaded dredger disconnects and proceeds to a waste site, dumps the waste material at the disposal site and returns to station to continue dredging.

5. On shore, the dredged sand is placed in a raw commodity storage pond. The sands are reclaimed as required, washed using river or well sourced fresh water, and concentrated and placed in a concentrated commodity storage pond. Waste material from the concentrator goes to a waste storage pond for subsequent disposal by pumping the material back out to the dredger for disposal at sea.

6. For export, the concentrate will be reclaimed from the surge pond and pumped as slurry to the offshore dewatering transshipper, using the export subsea pipeline and SPM. The dewatering transshipper will dewater the concentrate and return water to the shore plant where it will be stored in a recycled water pond. Depending on the salinity concentration in the recycled water, it may be used or refreshed for use in the concentration process.

7. When the dewatering transshipper is full, an export vessel will be brought alongside, moored and loaded. If the sea state for transloading exceeds operation limits, in the case of the southern tenement, the transshipper, being an operable ship, can cast off from the SPM and seek a more sheltered location such as the south side of Tasman Bay, or even Golden Bay for transloading to the export vessel. This latter operation will need to address issues relating to regional wilderness and fishing reserves and will need to be investigated before nominating a specific location for this off-site transshipment operation. The options for the northern tenement are not as obvious and a closer analysis will be required to determine a possible location for off-site transshipment.

Seasonality

The South Taranaki Bight Iron Sand Mining Baseline Environmental Study presents wave climate data in the vicinity of the southern tenement based on 20 years of modeling for the period 1979 to 1998. The wave climate shows clear seasonality as illustrated by the mean significant wave height, ***Table 1*** and ***Figure 3***.

For the case of data analysis site number 16, latitude 174.158°, longitude 39.996°, in the vicinity of the proposed initial mining areas:

- months November through April are distinctly calmer with monthly mean heights that below the annual mean significant wave height of 1.89 m, December, January and February being the calmest; and

- months May through October are distinctly rougher with monthly mean heights that are above the annual mean significant wave height.

August is the most severe month, however the six months from May through September inclusive have about the same severity.

Table 1: Mean Significant Wave Height by Month
For Data Analysis Site 16, Latitude 174.158°, Longitude 39.996°

Month	Mean Hs	Variation From Annual
Jan	1.53	-19%
Feb	1.50	-21%
Mar	1.73	-8%
Apr	1.84	-3%
May	2.15	14%
Jun	2.11	12%
Jul	2.14	13%
Aug	2.18	15%
Sep	2.12	12%
Oct	2.03	7%
Nov	1.76	-7%
Dec	1.56	-17%
Overall	1.89	0%

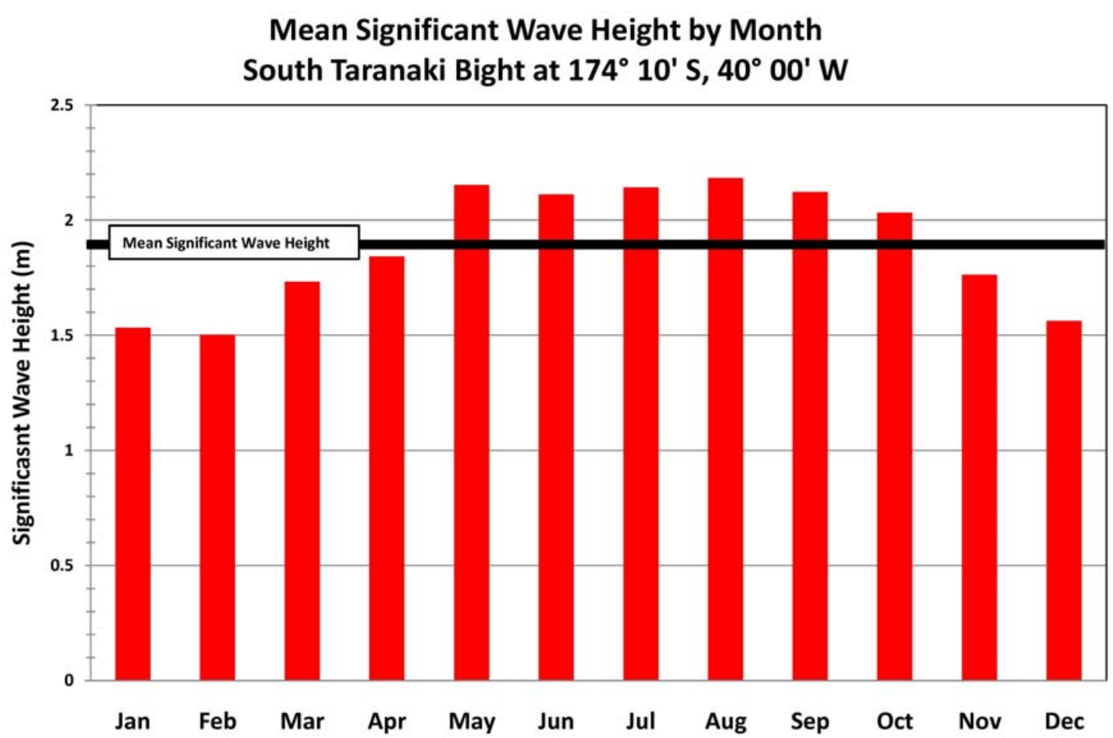


Figure 3: Seasonality of waves indicated by monthly variation in mean significant height

The data suggests that the month November through April would have higher operability whereas the months May through October would have lower operability. Further analysis will be required to assess the impact on operations and whether or not production would need to be adjusted seasonally.

Materials Handling

In order to achieve a high degree of operability in the transshipping mode, the dewatering transshipper should be able to rapidly discharge cargo and have a materials handling system that is relatively insensitive to vessel motion. Our concept is to utilize a gravity reclaim system and load the export vessel with a conveyor boom. Specific details on how to convey the export commodity to the conveyor boom, the number of booms and export vessel hatch coverage has yet to be worked out. Our preliminary logistics analysis suggests transshipping using grab cranes is unlikely to attain a high enough ship loading rate to avoid downtime due to low system thoughput. In addition, grab cranes are more likely to be impacted by vessel motion.

A very important investigative step is to determine the physical properties of the concentrate for material handling system design and to assess dewatering equipment performance. Samples should be tested early on in the investigation as the material properties direct design and equipment selection decisions on the transshipper. On board dewatering is not expected to be an issue. Deck mounted centrifuges will dewater the concentrate, but the number of centrifuges and centrifuge type will have to be determined through testing with the samples of the concentrate.

Logistics

The initial assessment indicates that the operation proposed can achieve an export level of 5 million tonnes per annum at both the southern and northern tenements. To fully assess the shipping logistics, detailed wave data for the area of the tenements, recorded by season would be required. If Trans Tasman Resources does not have site specific met-ocean data, then we advise that this should be acquired early on as it is requisite information to enable shipping logistics analysis to be completed. Our preliminary research has found that Metocean Engineers have undertaken a large number of studies in the area and would be a candidate firm from which to obtain information that may be required.

In addition, dredge equipment productivity needs to be understood to assess its capability to perform within operating windows. The scope of our investigation would include consultation with dredging companies on the performance of their equipment and its ability to meet the annual production. With our proposed concept, more than one dredge can operate through a single import SPM if required. Similarly, since loading of the transshipper will be possible in conditions exceeding the transshipment limit, more than one transshipper could use the export SPM and sail to sheltered water for the transfer operation. This possibility seems realistic for southern tenement but would require further investigation for the northern tenement.

Indicative Capital Cost

Indicative costs for the southern tenement offshore slurry export system have been prepared with reference to design proposals and projects of similar scope undertaken by Seabulk Systems. It is noted that no significant design has been undertaken at this time and that this would be necessary to develop accurate cost estimates. The scope for costing is illustrated in ***Figure 4*** and is summarized in ***Table 2***.

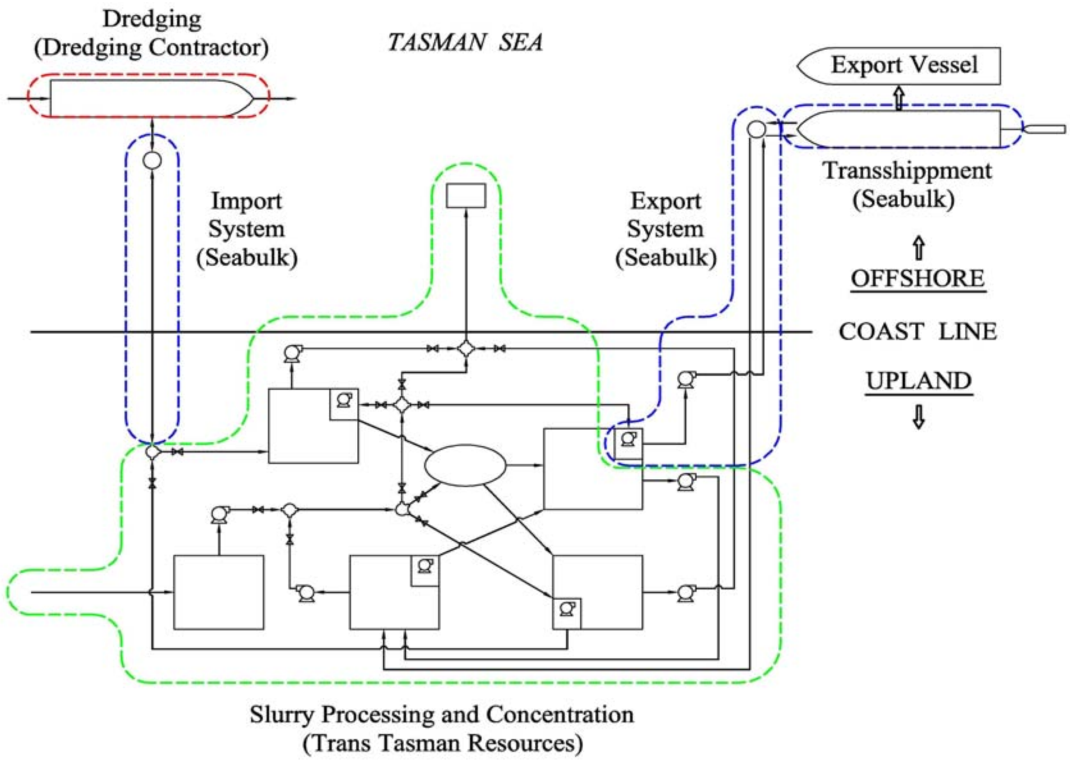


Figure 4: Illustration showing assumed responsibilities for iron sand export system

Table 2: Iron Sand Export System
Assumed Scope and Responsibilities

Description	Scope Details	Responsibility
Dredging	Trailer suction dredge and operation services	Dredging Contractor
Import System	Import SPM, hoses, couplings, PLEM, 15 km subsea pipeline, 2 km upland pipeline to interface at upland plant	Seabulk Systems
Slurry Processing and Concentration	Slurry storage, reclaim, concentration, water processing facilities, fresh water	Trans Tasman Resources
Export System	Slurry reclaim, pumping, 2 km upland pipeline, 12 km subsea pipeline, export SPM, hoses, couplings, return water pipeline	Seabulk Systems
Transshippment	150,000 DWT bulk carrier conversion with centrifugal dewatering, return water pumping, gravity reclaim system, ship loading booms	Seabulk Systems

With reference to the scope breakdown noted in ***Figure 4*** and ***Table 2***, indicative capital cost figures for items assumed to be supplied by Seabulk Systems are summarized in ***Table 3***.

Table 3: Iron Sand Export System
Indicative Capital Cost of Seabulk Systems Scope

Description	**Indicative Cost (M $USD)**	**Remarks**
Import Slurry Pipeline	$32	Single pipeline, flow reverses
Export Slurry Pipeline	$49	Dual pipeline, slurry out, water in
Dewatering Transshipper	$76	Vessel conversion, dewatering, gravity reclaim

It is noted that a hold back tug will likely be required for the operation of the transshipper, however, it is deemed that this equipment can be chartered and thus qualify as a system operating cost.

Indicative Operating Cost

Order of magnitude operating expense estimates have been prepared for the iron sand export system comprising the offshore slurry and return water pipeline systems and the dewatering transshipper, ***Figure 4***. We have not considered at this time the raw commodity dredging and import system as the scope and operating cost for this would largely be in the purview of the dredging contractor. We assume that TTR will estimate operating expenses for the slurry processing and concentration plant.

Estimated annual operating costs for 5 Mtpa export are summarized in ***Table 4***.

Table 4: Iron Sand Export System
Estimated Annual Operating Costs for 5 Mtpa Export

Cost Scope	**Cost Detail**	**Amount (M $USD)**
Export System	Slurry Reclaim and Pumping Energy	$1
Export System	Slurry System Maintenance and Operation	$2
Transshipper	Crew and Maintenance	$18
Transshipper	Fuel, Dewatering, Ship Loading	$4
Transshipper	Hold Back Tug	$2
	Estimated Annual Operating Cost:	**$27**

The slurry reclaim and pumping energy costs assumes a Metso Dynajet RJ-12 reclaimer and 1600 kW of centrifugal pumping at a power cost of $65 per MW*h. The slurry maintenance and operation cost is an allowance for periodic maintenance of the slurry reclaimer, pump and pipeline as these are wear items when subject to conveyance of iron sand concentrate slurry. These estimates are order of magnitude as concentrate testing would be required to accurately assess wear rate and maintenance requirements for these export system components.

The major operating cost is the crewing of the transshipper. We assume that New Zealand will have similar regulations as required in Australian territorial waters resulting in 2.4 crew members being hired for each position and at wage levels similar to Australia. These labour cost plus vessel provisioning and maintenance, based on our previous work for a similar transshipper in Australian territorial waters, is $18 M per annum. Since New Zealand wages are currently lower than Australian wages, it is conceivable that some savings in crew costs may be possible. However, a review of regulations that may affect crew size, hours of work, payroll taxes, etc. will be required before it can be stated with assurance that crew costs could be lower. The biggest saving in crew cost would result from permission to use an international crew with attendant wage levels. However, permission to use an international crew, provided they are paid the going rate for New Zealand, is also possible (This is our understanding of the Australian regulatory position) If so, when considering the cost of crew rotation, which will entail airfares to distant countries, there may be no savings.

The operation and maintenance of the transshipper's dewatering and gravity reclaim and ship loading system is estimated to be about $4 M per annum assuming IFO at US $ 500 per tonne and MDO at US $ 600 per tonne. Fuel costs include an assumed 6 trips per year across Tasman Bay to transship in a more sheltered location. System energy requirements include surge tank agitation, slurry pumping, dewatering, gravity reclaim conveying system and ship loading boom and return water pumping to shore. System energy is provided by generators on the transshipper that operate on MDO yielding an estimated power cost of about $100 per MW*h. The centrifuges are a wear item that have maintenance costs estimated as a fraction of capital cost. As was the case with the slurry pumping system, the estimates are order of magnitude as concentrate testing would be required to accurately assess wear rate and maintenance requirements for the centrifuges.

The annual operating costs include US $ 2 M for the occasional services of a hold back tug to keep the ocean going vessel and the transshipper in a favourable alignment with the seas during transloading operations. This is only an allowance, and the size of tug, availability and cost will all have to be further evaluated.

Amortization of the capital cost is a separate item that will obviously depend on how the project is financed. No capital cost recovery has been included in the numbers presented.

Additional Work

This report deals with a concept for the mining of iron sands, the concentration and subsequent export. Seabulk Systems has only addressed in any detail the items specific to our expertise. We assume that the selection of the dredging equipment and the concentrator plant design will be by others as part of an overall feasibility study. The overall feasibility study will also have to identify water sources, land availability, environmental impacts and associated costs.

Additional work would be required to move the iron sand export system proposal to bankable feasibility and implementation, for its inclusion in the overall study. A description of additional design, studies and investigation required follows:

Iron Sand Physical Property Testing: Physical properties will be determined to assess technology performance, in particular centrifuge dewatering efficiency, and to enable design of the slurry system and the gravity reclaim system in the transshipper. The scope of these tests would include flowability tests.

Slurry Rheology Study: This is required to determine the engineering properties of the iron sand slurry and confirm the hydraulic design of the slurry pipeline system.

Water Quality Investigation: This investigation will examine water quality and accumulation of salt concentration in the water recycling system. Findings will enable proper specification of corrosion resistant materials in the system and enable definition of fresh water use and management.

Offshore Geotechnical Study: This is required to provide definition of the seabed strata for the design and implementation of SPM anchorages. This programme may be able to utilize existing geophysical and magnetometer data obtained in the region.

Offshore Bathymetry and Geophysical Study: This is required to define the seabed along the pipeline corridor and for the marine operational radius around the import and export SPM. Existing bathymetry and geophysical data may be sufficient but would have to be reviewed for sufficiency.

Vessel Motion Study: This is required to better define the operability of the offshore transshipment operation as a function of sea state and wind conditions. It is noted that ship response to sea state is a complex function of wave height and period and vessel parameters. There are numerous analytical software packages that can be utilized for this investigation. The traditional approach of physical modeling of vessel motion will probably not be required. This study will help define sea state operation limits for the dewatering transshipper during loading and transloading.

Operability Analysis and Logistics: This study would take a more detailed look at the operation of vessels at the offshore terminal during sea state and weather events that are near or in excess of the operating criteria.

Risk Analysis: This study would identify and quantify risks associated with the iron sand export system. Issues investigated would include reliability of systems and equipment and impact of failure or downtime.

Met-Ocean Data Programme: This work would establish site specific marine weather and sea state data either by synthesis or acquisition through deployment of instrumentation. This data would enable seasonality to be defined and would provide key input to operability analysis and logistics.

Wave Refraction and Shoaling Investigation: This work would assess the effect of wave shoaling and refraction at the chosen import and export SPM locations. Being in transitional water depths, it is possible that wave shoaling and refraction may have an impact on operations. This investigation would enable issues to be identified such as bathymetric focusing of wave energy at the SPM sites.

Draft Operational Procedures: This work is intended to define how the iron sand export system would be operated in practice and address operational issues that could be expected. Dealing with practical issues such as use of tugs for berthing, mooring, cargo transfer, offsite transshipment, equipment breakdowns and maintenance would be included in the scope. Preliminary guidelines for operating a slurry transshipper at a single point mooring have been prepared by Seabulk, the introduction to the operating guidelines is attached as ***Appendix 5***.

Crewing and Manning Options: In order to obtain a better estimate of the crewing costs, an investigation will be required. The New Zealand Maritime Safety Authority sets out circulars on ship operations. Circular Part 31A, Crewing and Watch Keeping is a guide to the requirements. The Law will govern in case of conflict. Just how these regulations would be applied to a transshipper will have to be investigated. Next, the attitude of the maritime union will have to be considered. Adamant opposition to a crewing proposal may receive favourable consideration by the government, compelling Trans-Tasman to accept a less attractive option. To obtain a definitive quotation, once the rules have been established and the crewing levels set, requests can be submitted to ship managing companies.

Preliminary System Design: This work would provide a comprehensive definition of the system scope and deliver drawings showing the general arrangement of required equipment and infrastructure for the system. The level of detail would be sufficient for definition of material and resource requirements and cost estimation.

Detailed System Design: This would be an extension of the preliminary design work and provide remaining details to enable supply, tendering and construction of equipment and infrastructure.

Conclusion

We trust that this investigation provides a clear outline of our proposed strategy for iron sand export from Trans Tasman Resources northern and southern tenements. This document has expanded on our first report to include additional details. Perhaps our most important recommendation is to have the concentrate plant on land and reduce the floating components to the minimum. The sea conditions are such that, aside from the wear and tear on the equipment, staying on station will often be untenable for all but large or specialized vessels. In addition, crew costs in New Zealand are very high. Until we have had an opportunity to review crewing requirements, we would assume that they are the same as in Australia, which effectively requires the hiring of 2.3 crew members for every position on a vessel. The floating dewatering transfer station will be a fully manned ship, ready to cast off and seek shelter if necessary. This manning is a significant operating cost for the transshipment operation. Our concept calls for the dredge to come to a buoy to unload. This allows the use of a centrally located discharge point and a semi-permanent pipeline location. Unless land acquisition cost is prohibitive, we believe this will have lower capital and operating costs than an all floating alternative.

As a next step, in addition to the additional work we have listed, it would be useful to collaborate with a dredging contractor to determine what their specific requirements would be (e.g. size of pipeline from the dredge to the shoreline) and ascertain what their operability limits would be.

Sincerely,
SEABULK SYSTEMS INC.

Carlos Johansen, P.Eng.
Vice President, Marine

Enclosures: Appendices

Appendix 19.12 - Amdel Metallurgical Lab Test Work

REPORT N3994QS11

QEMSCAN ANALYSIS OF ONE IRON ORE SAMPLE SPLIT INTO 5 SIZED FRACTIONS

CLIENT: Martin van Wyk, Amdel (Perth)

CLIENT DETAILS

Company	Amdel (Perth)
Address	6 Gauge Circuit, Canning Vale WA
Contact	Martin van Wyk
Email	martin.vanwyk@au.bureauveritas.com
Telephone	Tel: +61 (0) 8 6218 5700

One iron rich sample with significant levels of Ti was submitted for mineralogical analysis using QEMSCAN. Of particular interest is the Ti and how it is associated with the Fe Oxide minerals in the sample. It was sized into 7 separate size fractions with the coarsest and finest sized fractions not submitted for QEMSCAN analysis. The weight distribution between the size fractions is displayed.

N3994QS11 Sizing Data				
Fraction	Mass (g)	wt%		
+1mm	114,493	15,4	15,4%	
-1 +500	51,6	7,0	7,0%	7,0%
-500 +212	474,21	64,0	64,0%	64,0%
-212 +106	94,79	12,8	12,8%	12,8%
-106 +75	2,72	0,4	0,4%	0,4%
-75+38	2,42	0,3	0,3%	0,5%
-38	1,04	0,1	0,1%	
Total Mass	741,27	100		84,6%

QEMSCAN Sample Preparation		
Size Fraction	**No. Blocks prepared**	**Analysis Mode**
-1mm +500um	2	FieldScan
-500um +212um	1	FieldScan
-212um +106um	1	PMA
-106um +75um	1	PMA
-75um +38um	1	PMA
Total	6	

Each sample was mounted in an epoxy resin for analysis by QEMSCAN. Graphite was added to the sample to aid in separation of the individual particles. Each block was coated with carbon prior to QEMSCAN analysis. The FieldScan method was used on the 2 coarsest size fractions and the Particle Mineralogical Analysis (PMA) method was used on the remaining sample blocks. The data was processed using iDiscover v.5.0.

Reported by:
Wade Hodgson
Senior Mineralogist - Pacific Zone
Bureau Veritas Australia Pty Ltd

MINERAL LISTS

Mineral lists are designed to display the results in the most appropriate format. The following mineral lists have been used to report the data for this project. A description of each mineral grouping, including the reports that each mineral list is used in, are indicated below.

Main Mineral List, used in all reports apart from Liberation, Locking, Surface Exposure and Theoretical Grade Recovery reports

	Description
Magnetite	Includes Magnetite
Hematite	Includes Hematite and minor Goethite
Rutile / Anatase	Includes Rutile / Anatase (>95% TiO2)
Ilmenite	Includes all TiO2 phases from Luecoxene to Ilmenite (50% TiO2 - 95% TiO2)
Titano-Magnetite	Includes Titano-Magentite (<50% TiO2)
Quartz	Includes Quartz
Calcite	Includes Calcite and CaCO3 from shell fragments
K-feldspar	Includes K-Feldspar
Epidote	Includes Epidote
And/Sill/Kyan	Includes Al Silicate phase from the Andalusite/Sillimanite/Kyanite series
Tourmaline	Includes Tourmaline
Hornblende	Includes Hornblende
Pyroxene-En-Fs	Includes Pyroxene from the Enstatite/Ferrosilite series
Garnet	Includes Garnet phases, predominantly Almandine
Other Silicates	Includes all other silicate phases not listed above
Others	Includes all phases not listed above and occurring in trace form

Liberation, Locking and Surface Exposure Mineral List

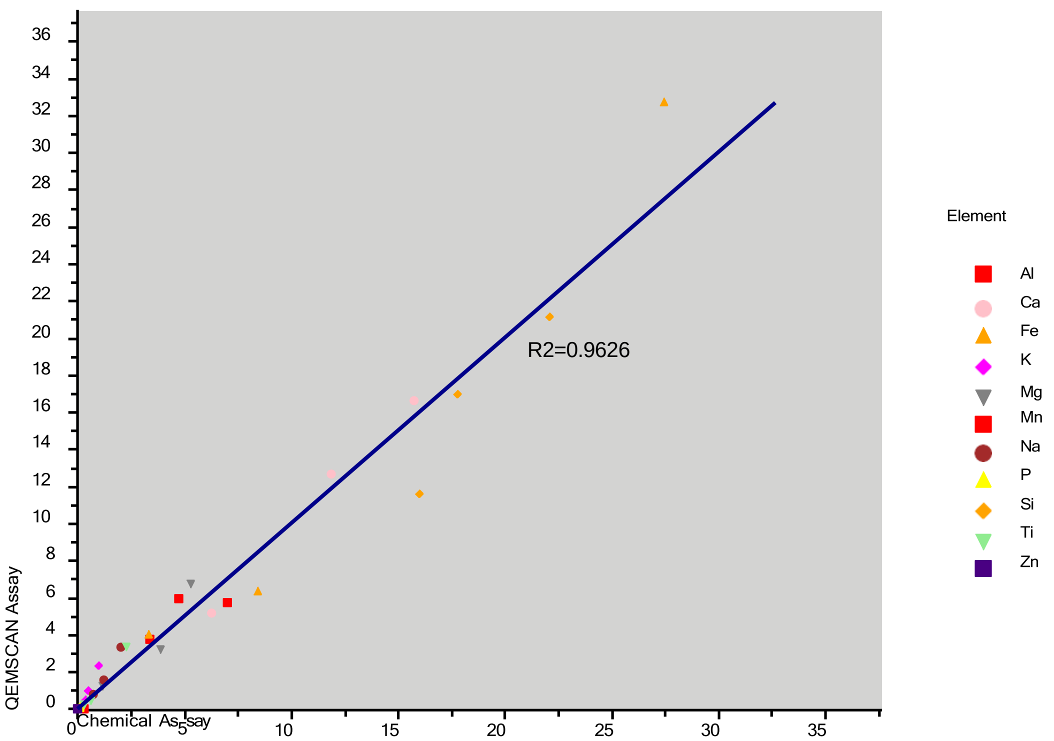
	Description
Magnetite	Includes Magnetite
Hematite	Includes Hematite and minor Goethite
Ti bearing minerals	Includes all TiO2 bearing mineral phases
Silicates	Includes all silicates
Carbonates	Includes all carbonates
Others	Includes all phases not listed above and occuring in trace form

DATA VALIDATION

QEMSCAN generates assays for each sample by using assigning each pixel analysed chemical values and S.G. Chemical assay are compared to the QEMSCAN generated assays to determine if the analysis is valid. There is a good correlation between chemical assays and the QEMSCAN generated assays. **Please note that there was insufficient sample mass to conduct chemical assays on the -106um and -75um fractions.**

Sample		-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Elemental Mass (%)	Al (QEMSCAN)	5,69	5,94	3,75	5,33	5,40
	Al (Chemical)	7,03	4,73	3,37		
	Ca (QEMSCAN)	16,58	12,67	5,17	8,87	9,74
	Ca (Chemical)	15,78	11,91	6,25		
	Fe (QEMSCAN)	3,94	6,26	32,68	17,01	14,83
	Fe (Chemical)	3,32	8,42	27,48		
	K (QEMSCAN)	2,30	0,98	0,47	1,34	1,37
	K (Chemical)	0,98	0,52	0,38		
	Mg (QEMSCAN)	1,26	6,75	3,27	3,67	3,74
	Mg (Chemical)	1,18	5,30	3,87		
	Mn (QEMSCAN)	0,00	0,00	0,00	0,00	0,00
	Mn (Chemical)	0,06	0,22	0,33		
	Na (QEMSCAN)	3,34	1,52	0,76	2,17	2,27
	Na (Chemical)	2,01	1,22	0,74		
	Si (QEMSCAN)	16,96	21,16	11,62	16,56	16,99
	Si (Chemical)	17,79	22,12	15,99		
	Ti (QEMSCAN)	0,30	0,48	3,39	1,91	1,74
	Ti (Chemical)	0,29	0,64	2,27		

Assay Reconciliation



MINERAL ABUNDANCE

The mineral abundance data for each analysed fraction is listed in the below table and shown graphically.

	Size Distr	8,2%	75,7%	15,1%	0,4%	0,6%
Sample		-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Mineral Mass (%)	Magnetite	0,10	0,17	1,67	0,94	0,71
	Hematite	0,15	0,32	2,44	1,26	1,22
	Rutile / Anatase	0,00	0,00	0,00	0,04	0,00
	Ilmenite	0,03	0,02	0,06	0,12	0,05
	Titano-Magnetite	2,39	5,47	48,67	22,72	19,47
	Quartz	2,05	2,25	4,46	1,80	1,57
	Calcite	24,88	4,10	0,70	3,46	4,67
	K-feldspar	23,00	9,80	4,68	13,36	13,71
	Epidote	34,89	17,74	5,96	23,33	26,09
	And/Sill/Kyan	0,13	0,37	1,73	0,58	0,32
	Tourmaline	2,18	4,16	2,90	4,17	4,03
	Hornblende	6,66	52,51	23,88	23,62	23,00
	Pyroxene-En-Fs	1,15	1,06	1,06	2,37	2,90
	Garnet	1,35	1,29	0,77	0,87	0,69
	Other Silicates	0,10	0,06	0,09	0,18	0,20
	Others	0,95	0,67	0,94	1,18	1,37
	TOTAL	100,00	100,00	100,00	100,00	100,00

ELEMENTAL DEPORTMENT OF Fe, Ti, Si and Al

The elemental deportment of Fe is displayed in the below table and graph.

	Size Distr	8,2%	75,7%	15,1%	0,4%	0,6%
	Sample	**-1000/+500**	**-500/+212**	**-212/+106**	**-106/+75**	**-75/+38**
Mineral Mass (%)	**Magnetite**	1,54	1,86	3,34	3,52	3,03
	Hematite	2,43	3,42	5,00	4,86	5,47
	Rutile / Anatase	0,00	0,00	0,00	0,00	0,00
	Ilmenite	0,22	0,12	0,07	0,24	0,10
	Titano-Magnetite	28,06	49,11	87,36	76,97	75,76
	Epidote	48,56	**17,76**	1,20	7,30	8,32
	Tourmaline	7,42	**8,63**	1,17	3,20	3,52
	Hornblende	2,88	**14,27**	1,24	2,36	2,64
	Garnet	6,12	**4,20**	0,51	1,06	0,86
	Other Silicates	0,25	0,09	0,03	0,10	0,13
	Others	2,53	0,55	0,07	0,38	0,17
	TOTAL	100,00	100,00	100,00	100,00	100,00

ESTIMATED AVERAGE GRAIN SIZE

QEMSCAN estimated average grain and particle sizes are displayed below.

	Sample	-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Mineral Mass (%)	**Average Particle Size**	508	262	155	72	41
	Magnetite	12	8	7	7	5
	Hematite	14	10	8	9	7
	Rutile / Anatase	11	7	9	75	5
	Ilmenite	16	12	12	23	10
	Titano-Magnetite	26	37	61	41	29
	Quartz	80	65	58	37	27
	Calcite	246	156	68	48	29
	K-feldspar	62	38	25	27	20
	Epidote	93	70	48	45	30
	And/Sill/Kyan	20	20	25	20	11
	Tourmaline	26	27	22	22	14
	Hornblende	95	126	92	52	33
	Pyroxene-En-Fs	19	23	24	25	20
	Garnet	16	9	8	9	6
	Other Silicates	12	8	6	6	5
	Others	16	11	10	10	9

NB regarding QEMSCAN size data: By definition, a particle is comprised of mineral grains. QEMSCAN average grain size is an estimate of the diameter of the particles in a population. The value is the diameter of a sphere of equivalent (ESD) volume to the average particle in the measured population. The calculation includes stereological correction that relies on the population being a set of random cross-sections through randomly-oriented particles. QEMSCAN size data is the diameter of an equivalent-volume sphere. Since particles are rarely spherical, the actual particles will be both larger (in some axis) and smaller (in some other axis) than the estimated size. Data is indicative only.

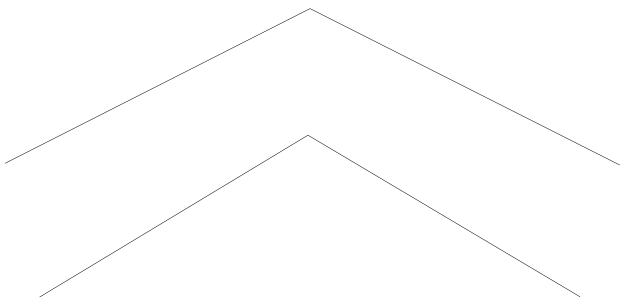
GRAIN SIZE DISTRIBUTION

QEMSCAN data can be used to display the grain size distribution curve of a mineral or group of minerals. The grain size distribution of the Magnetite and Hematite groups is displayed. These two groups have been combined due to the strong spatial association between these two groups and the issues associated

Fe Oxides

Mass Percent Fe Oxides		Fraction				
		-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Fe Oxide Grain Size Distribution	5	0,00	0,00	0,00	0,00	4,69
	10	0,00	4,34	0,80	4,08	21,89
	15	6,03	11,27	45,64	44,86	45,17
	20	0,10	42,84	40,72	29,20	20,63
	25	41,95	20,28	10,93	6,64	1,06
	30	40,87	21,27	1,66	6,02	0,00
	35	10,81	0,00	0,25	3,25	1,50
	40	0,00	0,00	0,00	1,79	0,00
	45	0,13	0,00	0,00	1,95	0,00
	50	0,10	0,00	0,00	0,00	2,00
	+50	0,00	0,00	0,00	2,21	3,07
	TOTAL	100,00	100,00	100,00	100,00	100,00

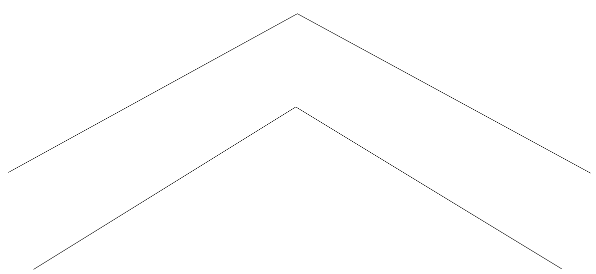
Fe Oxide Grain Size Distribution



Ti bearing minerals

Mass Percent Ti minerals		Fraction				
		-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Ti minerals Grain Size Distribution	**5**	0,00	0,00	0,00	0,00	0,58
	10	0,00	4,05	0,39	1,19	1,63
	20	26,16	7,15	3,71	6,59	12,99
	30	19,98	11,83	6,85	10,22	15,30
	40	15,33	7,85	4,41	9,51	18,71
	50	12,37	11,01	7,15	9,69	19,54
	60	7,66	8,33	6,54	13,25	12,58
	70	5,66	6,18	5,32	11,01	8,35
	80	3,28	1,19	4,71	12,96	6,46
	90	4,62	3,37	7,15	9,57	1,68
	100	1,65	3,06	6,21	6,90	0,00
	150	1,50	14,74	28,65	9,13	2,18
	200	1,80	9,63	14,40	0,00	0,00
	+200	0,00	11,60	4,52	0,00	0,00
	TOTAL	100,00	100,00	100,00	100,00	100,00

Ti bearing minerals Grain Size Distribution



IRON OXIDES, SILICATES AND TI MINERALS LIBERATION

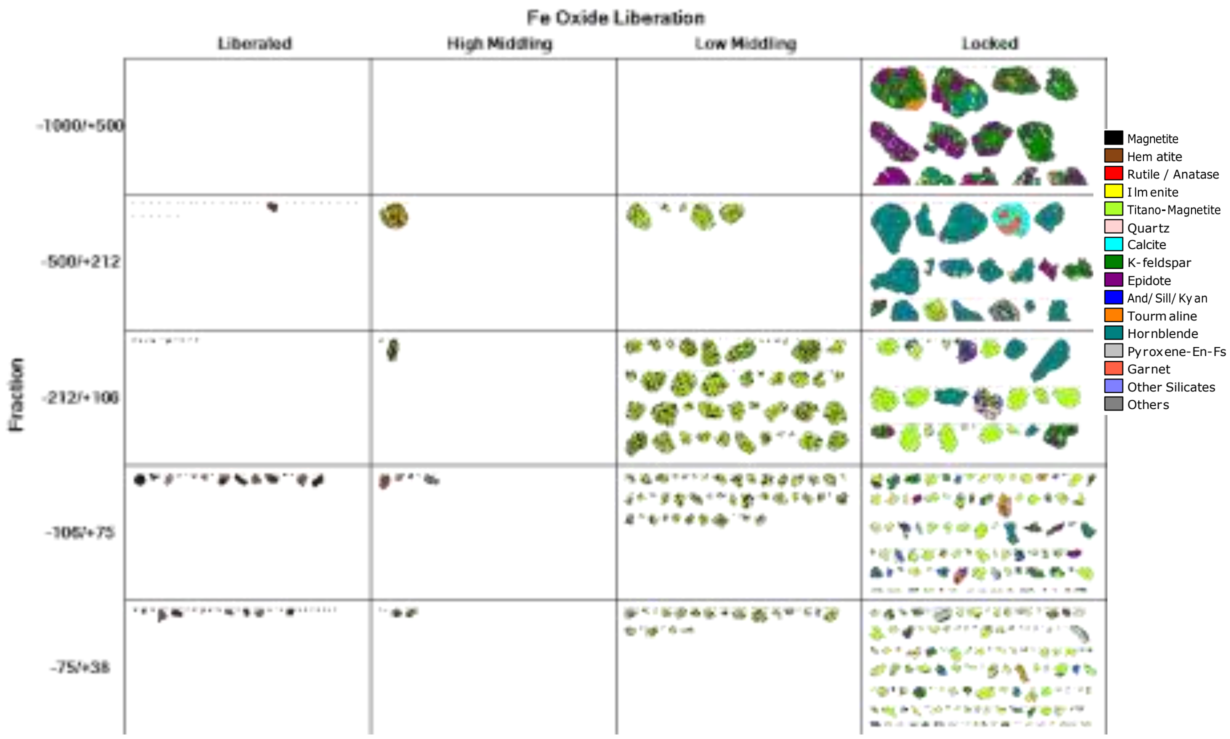
By using area percent, the liberation class of the Fe oxide mineral group (magnetite and hematite/goethite), silicates including quartz and Ti bearing minerals have been examined and quantified. The liberation criterion of each class is described below.

Code	Rule
Liberated	Area of target mineral is >90% of the particle's area
High middling	Area of target mineral is between 60-90% of the particle's area
Low middling	Area of target mineral is between 30-60% of the particle's area
Locked	Area of target mineral is <30% of the particle's area

Fe Oxide Liberation

Liberation was calculated by using the area percent of the Fe Oxide mineral group (magnetite and hematite/goethite). The liberation criterion of each class is described below.

	8,2%	75,7%	15,1%	0,4%	0,6%
Mass % Fe Oxides	**-1000/+500**	**-500/+212**	**-212/+106**	**-106/+75**	**-75/+38**
Liberated	0,00	2,91	0,23	13,13	17,81
High Middling	0,00	12,61	0,66	3,45	4,86
Low Middling	0,00	18,09	35,65	22,87	23,87
Locked	100,00	66,40	63,47	60,55	53,46
TOTAL	100,00	100,00	100,00	100,00	100,00

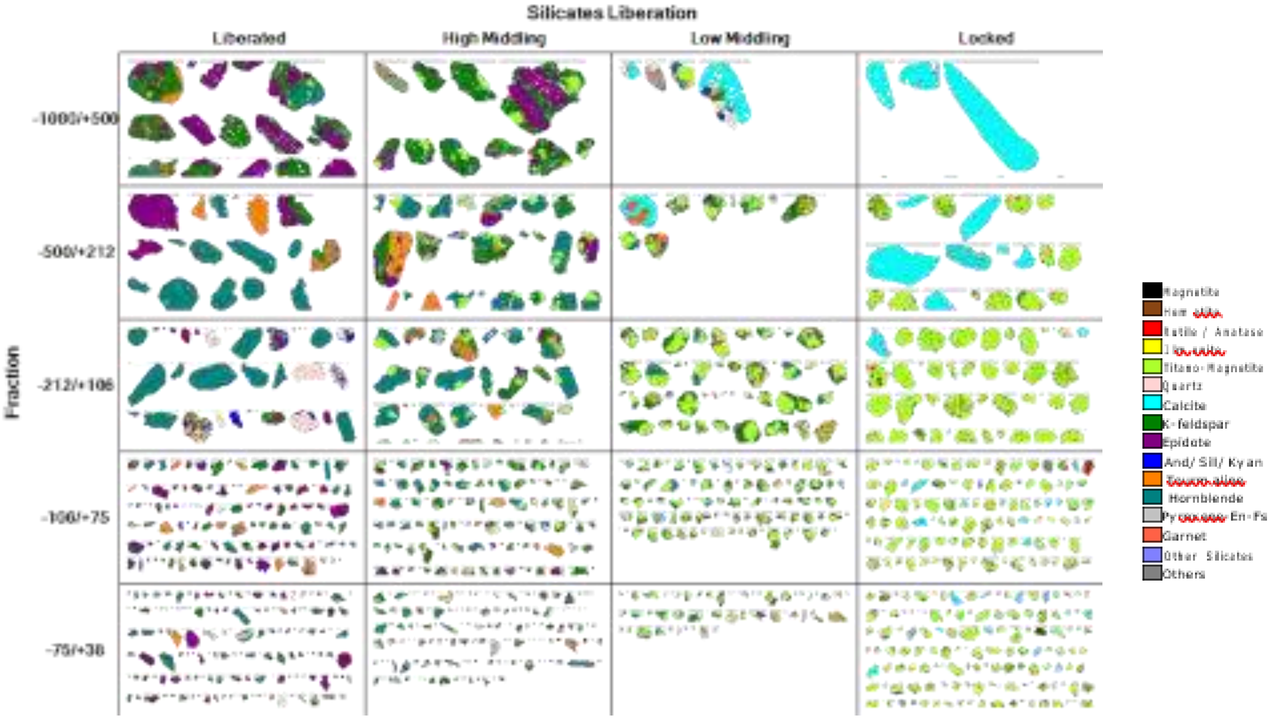


Silicates Liberation

Silicates have been grouped as per the mineral liberation and locking mineral list. The liberation criterion of each class is described below.

8,2% 75,7% 15,1% 0,4% 0,6%

Mass % Silicates	-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Liberated	94,69	95,51	92,02	94,84	96,54
High Middling	4,53	4,13	5,27	3,32	1,85
Low Middling	0,14	0,19	1,05	0,79	0,69
Locked	0,63	0,17	1,65	1,05	0,92
TOTAL	100,00	100,00	100,00	100,00	100,00

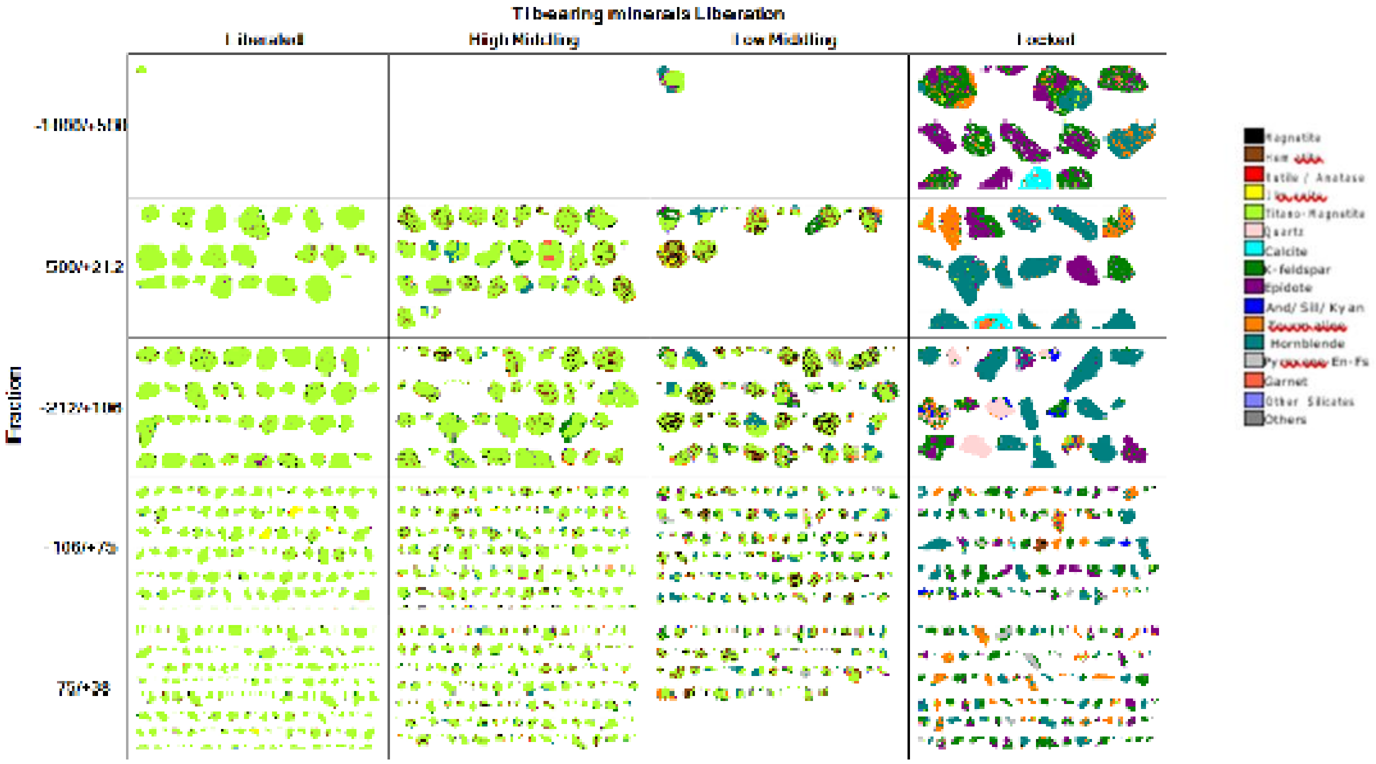


Ti bearing minerals Liberation

The Ti bearing minerals have been grouped as per the mineral liberation and locking mineral list. The liberation criterion of each class is described below.

	8,2%	75,7%	15,1%	0,4%	0,6%
Mass % Silicates	**-1000/+500**	**-500/+212**	**-212/+106**	**-106/+75**	**-75/+38**
Liberated	0,45	26,55	64,02	52,21	55,52
High Middling	0,00	26,55	28,86	36,73	34,02
Low Middling	1,81	5,02	4,76	6,79	7,38
Locked	97,74	41,88	2,36	4,26	3,08
TOTAL	100,00	100,00	100,00	100,00	100,00

Liberated	0,037	20,086	9,682	0,227	0,306	30,338
High Middling	0,000	20,089	4,364	0,159	0,188	24,800
Low Middling	0,149	3,799	0,719	0,029	0,041	4,738
Locked	8,047	31,684	0,357	0,019	0,017	40,124
TOTAL	8,233	75,658	15,123	0,434	0,552	

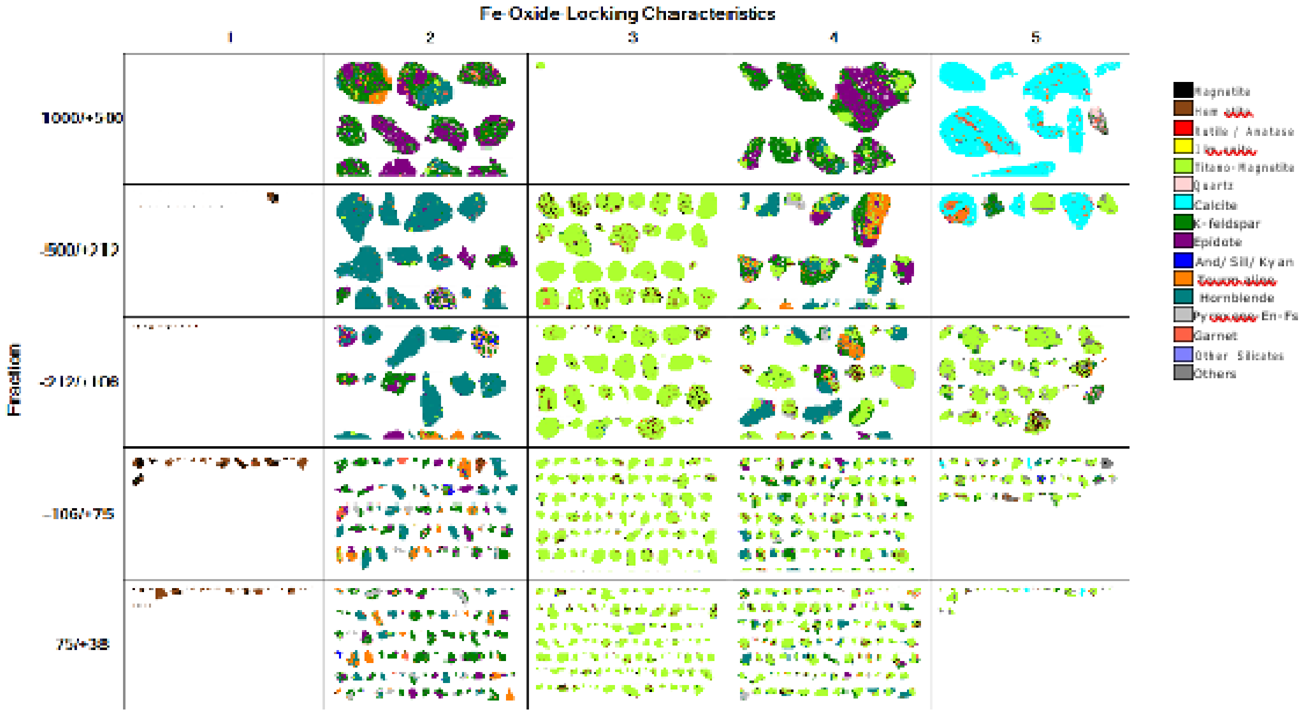


IRON OXIDE LOCKING

Hematite and magnetite/goethite have been group into a Fe Oxide group when calculating locking data.
Locking of the particular mineral has been calculated using the total area percent of the minerals and the association mineral of interest. The classification rules are displayed below.

Code		Description	Rule
1	Lib Fe Ox	Liberated Fe Oxide	Area percent magnetite + hematite/goethite >90
2	Bn Silicates	Binary with Silicates	Area percent magnetite + hematite/goethite + Silicates >90
3	Bn Ti minerals	Binary with Ti minerals	Area percent magnetite + hematite/goethite + Ti minerals >90
4	Tn Sil + Ti minerals	Ternary with Silicates and Ti minerals	Area percent magnetite + hematite/goethite + Silicates + Ti minerals >90
5	Complex	All other Fe Oxide bearing particles	Area percent magnetite + hematite/goethite >0

		8,2%	75,7%	15,1%	0,4%	0,6%
Code		-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
1	Lib Fe Ox	0,00	2,91	0,23	13,13	17,81
2	Bn Silicates	80,74	18,05	1,16	4,20	3,23
3	Bn Ti minerals	0,12	54,55	81,83	56,31	58,25
4	Tn Sil + Ti minerals	15,61	23,79	14,50	23,74	18,72
5	Complex	3,52	0,71	2,28	2,61	2,00
	TOTAL	100,00	100,00	100,00	100,00	100,00



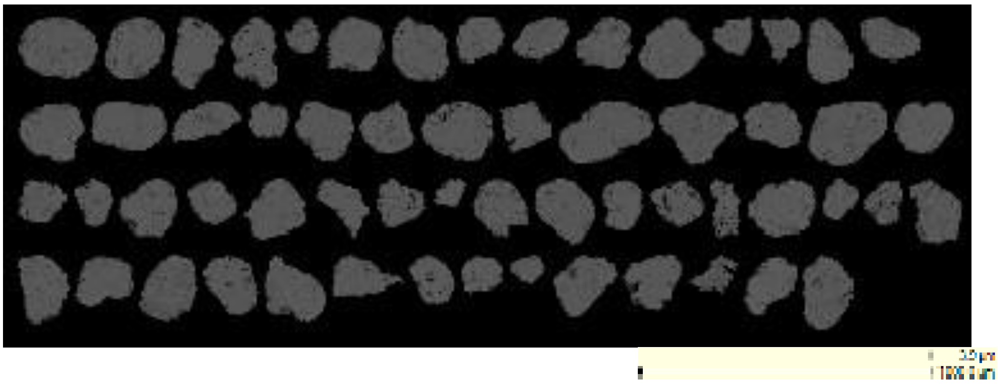
Binary with Ti minerals in detail

Selected particles from the +106um samples were chosen to highlight the binary with Ti mineral phase. From the particle images, it can be seen that there is a strong cross hatching texture within some of the particles. It is believed that this is due to Ti rich layers within the structure of the magnetite mineral possibly due to Ti enrichment along the cleavage lines within the magnetite/hematite minerals.

Particle images, as

the QEMSCAN

Back Sca



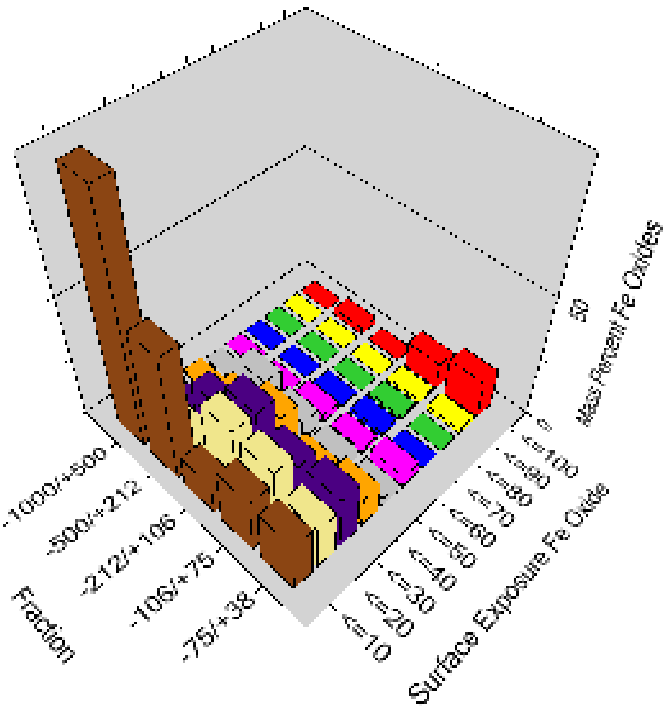
IRON OXIDE SURFACE EXPOSURE

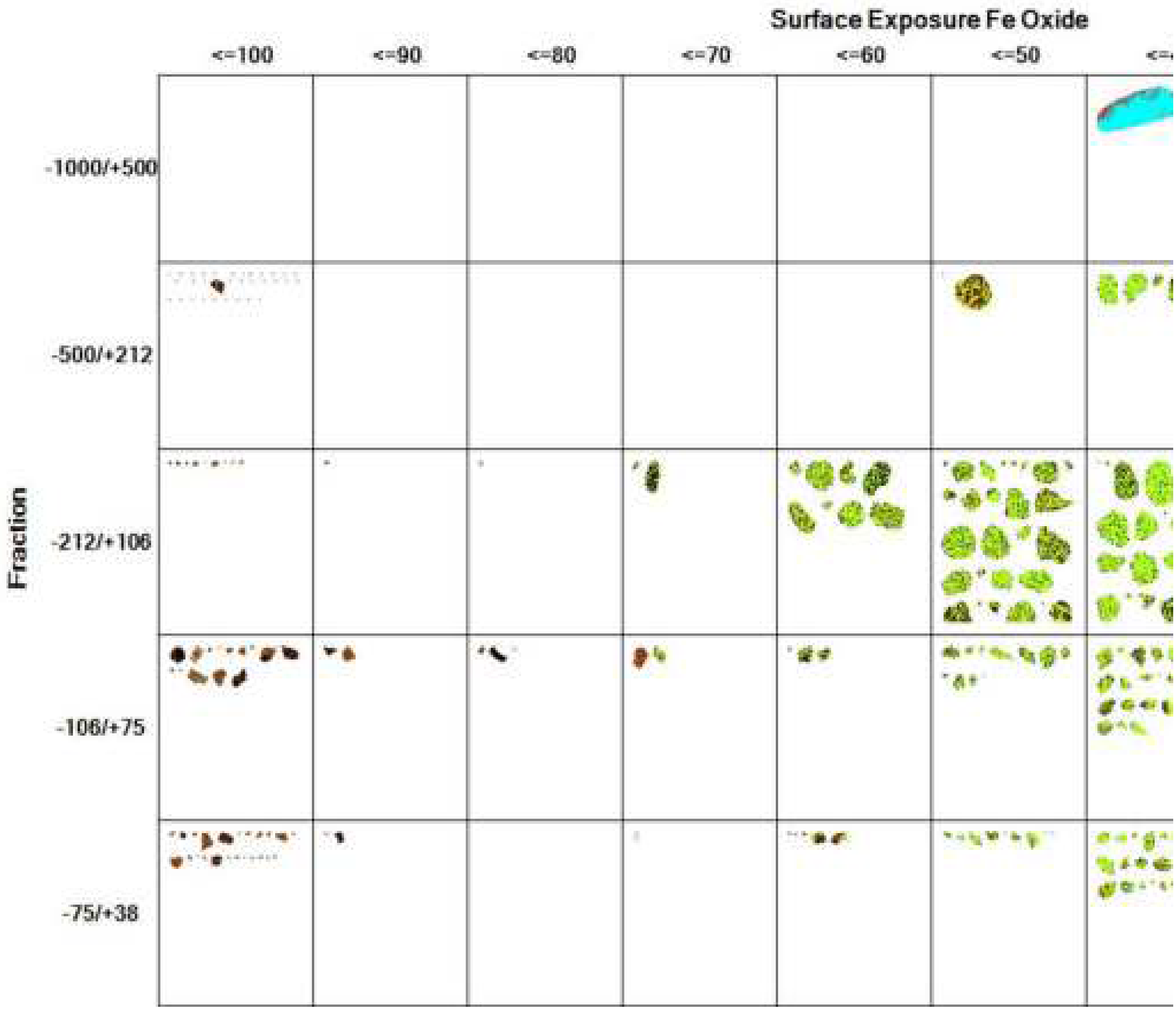
Surface Exposure of the iron oxide group (hematite and magnetite/goethite) has been calculated using the Surface Area Percent of iron oxide group in each iron oxide bearing particle. The classification rules are displayed below.

Code	Rule
<=10	Surface Area Percent magnetite + hematite/goethite is between 0% and 10%
<=20	Surface Area Percent magnetite + hematite/goethite is between 10% and 20%
<=30	Surface Area Percent magnetite + hematite/goethite is between 20% and 30%
<=40	Surface Area Percent magnetite + hematite/goethite is between 30% and 40%
<=50	Surface Area Percent magnetite + hematite/goethite is between 40% and 50%
<=60	Surface Area Percent magnetite + hematite/goethite is between 50% and 60%
<=70	Surface Area Percent magnetite + hematite/goethite is between 60% and 70%
<=80	Surface Area Percent magnetite + hematite/goethite is between 70% and 80%
<=90	Surface Area Percent magnetite + hematite/goethite is between 80% and 90%
<=100	Surface Area Percent magnetite + hematite/goethite is between 90% and 100%

Mass % Fe Oxides		Fraction				
		-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
Fe Oxide Surface Exposure	<=10	98,05	52,18	12,82	22,38	20,92
	<=20	0,00	7,51	28,71	26,62	18,13
	<=30	0,00	16,34	28,37	20,25	21,92
	<=40	1,95	8,43	18,10	8,24	12,54
	<=50	0,00	12,63	7,75	4,14	3,47
	<=60	0,00	0,00	3,34	1,89	5,02
	<=70	0,00	0,00	0,67	2,10	0,19
	<=80	0,00	0,00	0,02	1,71	0,00
	<=90	0,00	0,00	0,02	1,62	1,83
	<=100	0,00	2,91	0,20	11,04	15,98
	TOTAL	100,00	100,00	100,00	100,00	100,00

Surface Exposure Fe Oxide





Surface Exposure Fe Oxide
<=100
<=90
<=80
<=70
<=60
<=50
Fraction
-1000/+500
-500/+212
-212/+106
-106/+75
-75/+38

Appendix 19.13 - IHC Merwede - Vuyk Engineering Mooring Study

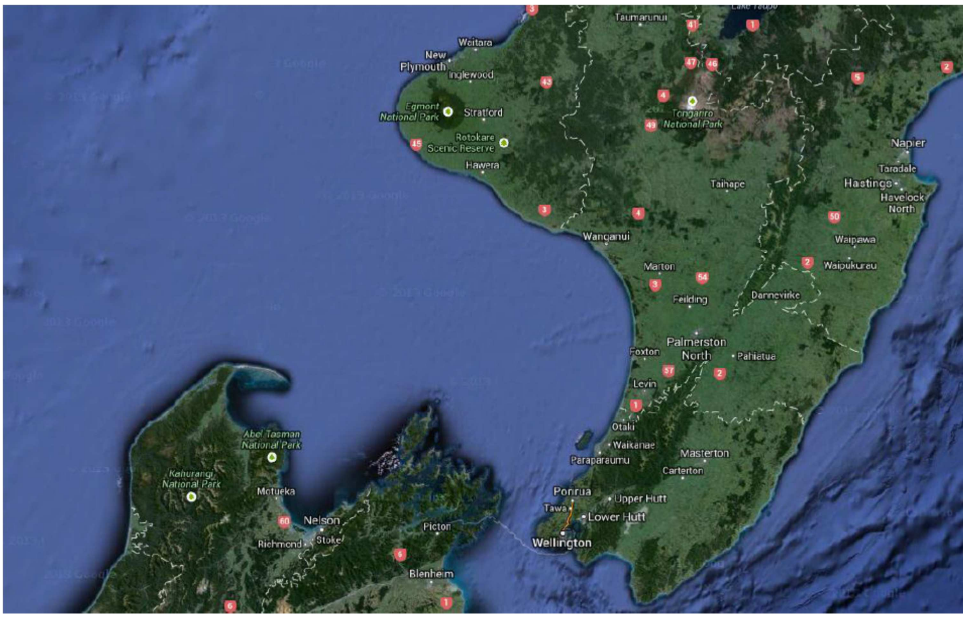
CALCULATION NOTE

To:	TTRL		
Origin:	BvdK		
Chkd:	SBo		
Distr:	SBo		
Date:	23-Jan-2014		
Project:	TTRL mining vessel	**Ref.no.:**	40082BvdK13300
Subject:	DP and mooring analyses		

INTRODUCTION

TTRL has requested Vuyk Engineering Rotterdam (VER) to perform an analysis on the station keeping of the mining vessel. The vessel will be used for the Offshore Iron Sands project and will be operating a crawler mining system in the shallow waters in New Zealand. Further to previous reports and calculation notes (13300-R02 and cnote 31897BvdK13300) and the latest set of environmental data the mooring lines, power demand and mining direction is elaborated. In this document the results of these analyses are presented.

The results should support further selection of:
- Final wire diameter in order to fix the mooring system and mooring winch specification
- Final line loads and anchor weights in order to select the correct anchor handling and supply tug
- Support the final mining direction and power demand



REFERENCES

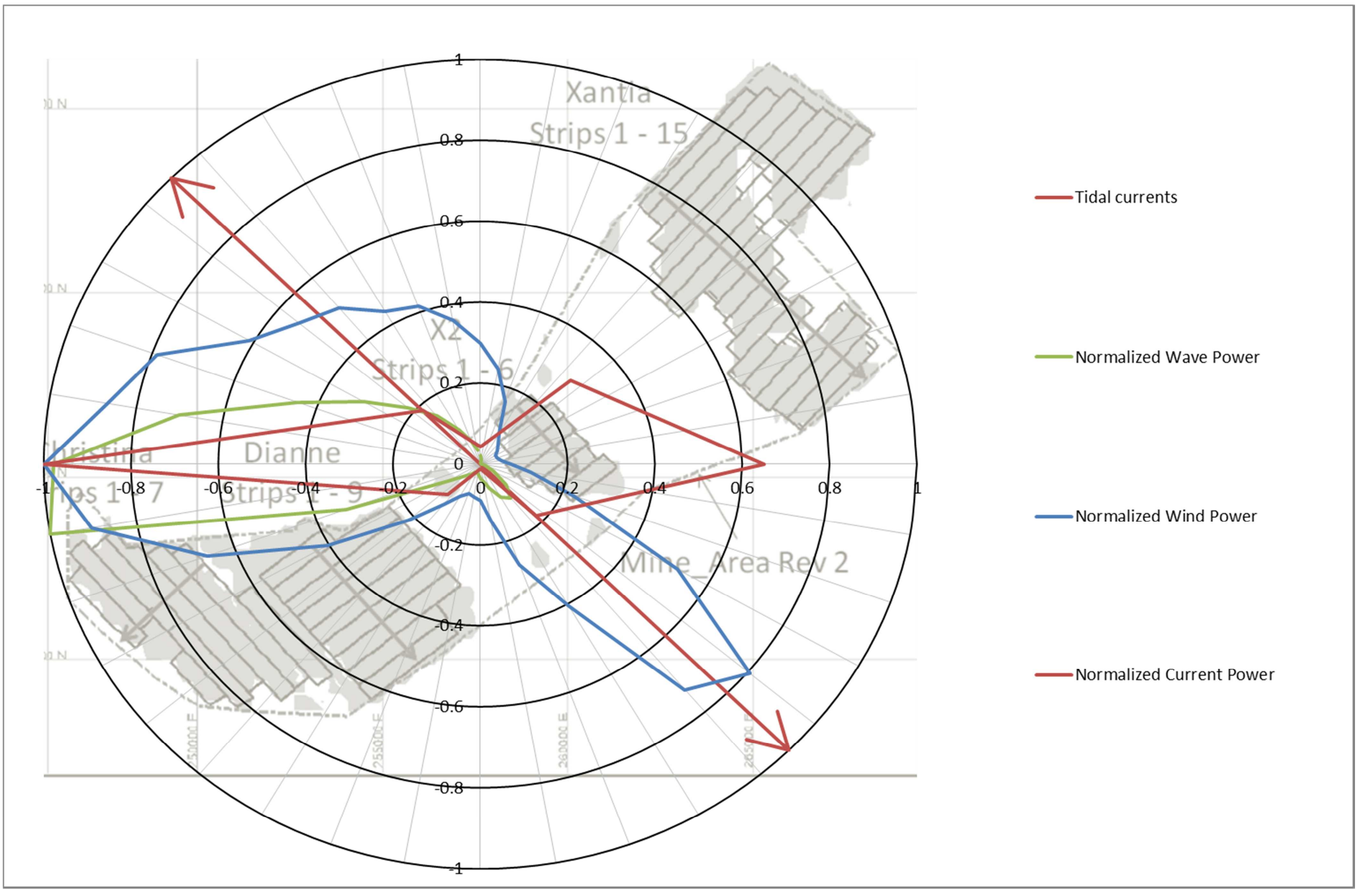
[01] Argoss wind and wave data for model output point 40° 00'S, 173° 45'E, www.waveclimate.com
[02] "Titan Oil Field Ropes", Usha Martin
[03] "0032-1 Guidelines for moorings", GL-Noble Denton, Dec 2010
[04] "Anchor manual 2010", Vryhof anchors

CALCULATION INPUT

The vessel main characteristics are presented in the table below.

Length over all	330.00	m
Breadth	60.00	m
Depth	26.00	m
Design draught	12.00	m
Block coefficient	0.84	-
Water depth	12.00	m
Mining block length	900	m
Mining block width	900	m

The maximum environmental condition during operations is stated by the client to be a significant wave height of 4.0 m. The corresponding wind and current conditions are 15 m/s and 1.1 m/s respectively. In total the station keeping system will be subjected by wind, current and mean wave drift loads. The 1st order wave loads are not considered. In the figure below, the dominant environment headings are presented, depending on the different components. Also the mining area is printed in the background.



A 4 point mooring system will be used. In the following calculations the results for two different line diameters will be presented. These will be **83 mm** and **108 mm** respectively [02]. The selection of the wire diameter will be decided by the feasibility of the winch design and the capacity of the anchor handler. A large wire diameter will result in a low power consumption but should be feasible to handle and operate. Hence the 2 options. The results will give sufficient support to verify the winch design feasibility and to investigate the available anchor handlers.

The DP system consists of 6 thrusters (three at the bow and three at the stern) of 5000 kW each. This corresponds to about 850 kN of thrust for each thruster.

RESULTS

Several different conditions are investigated, involving a 4 point mooring system, a thruster assisted mooring and a full DP situation. Note again that for the mooring lines, two line diameters were studied (83 mm and 108 mm).

4 point mooring

In this case a static mooring analysis is performed when the vessel is located in one corner of the mining area. This is considered the most severe case, as this results in one of the mooring lines being shortest. All round headings are investigated.

For each of the two mooring lines, the shortest catenary length was determined based on its submerged weight and MBL [02]. Also a 1st order motion was considered of about 3.2 m, to avoid anchor uplift. Note that according to GL-ND [03], a mooring line load safety factor of 2 is required over the line MBL. In the following table the results are presented. Also the maximum line length based on the mining area dimensions is presented.

	MBL [kN]	Allowable tension [kN]	Min. line length [m]	Max. line length (3x3) [m]	Max. line length (2x2) [m]
83 mm line	5512	2756	1550	2760	2340
108 mm line	8928	4464	1500	2711	2290

In terms of mooring line lengths the differences are small. However when it comes to the allowable environment, the differences are larger as indicated in the following table.

		Hs [m]	V_wind [m/s]	V_curr [m/s]	Heading [deg]
83 mm	4 point mooring	2.3	6.5	1.1	all
	4 point mooring**	4.0	15.0	1.1	18
	4 point mooring (survival)	4.1	15.5	1.1	15
108 mm	4 point mooring	3.2	11.0	1.1	all
	4 point mooring**	4.0	15.0	1.1	39
	4 point mooring (survival)	5.2	21.0	1.1	15

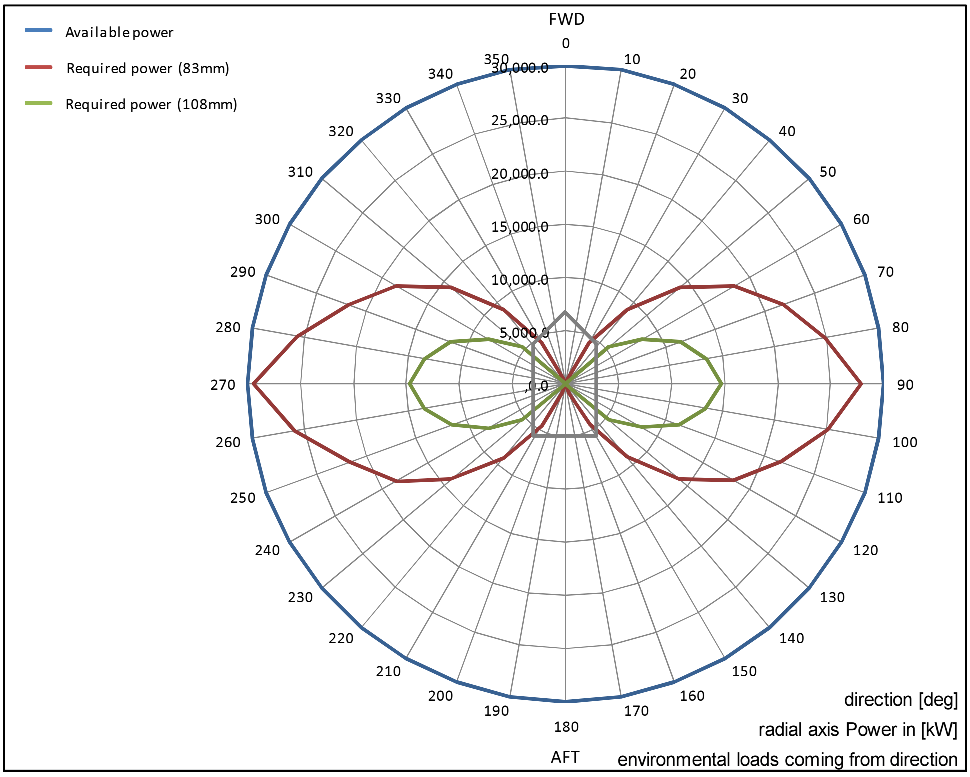
Note that the results indicated by the "**" in the table, correspond to the heading limitation studies for the stated maximum working condition.

The results in this table read that for the 83 mm line in all round headings, the maximum allowable significant wave height is 2.3 m. For the stated maximum working condition of 4.0 m significant wave height, the heading limit from head/stern seas is about 18 degrees. For a survival condition with a bow/stern heading limit of 15 degrees, the allowable significant wave height is 4.1 m. Analogously, the values for the heavier mooring line are determined.

Thruster assisted mooring

As indicated above, the lone mooring system does not allow for operations up to a significant wave height of 4.0 m. Therefore the thrusters are used in combination with the moorings to obtain this 4.0 m significant wave height.

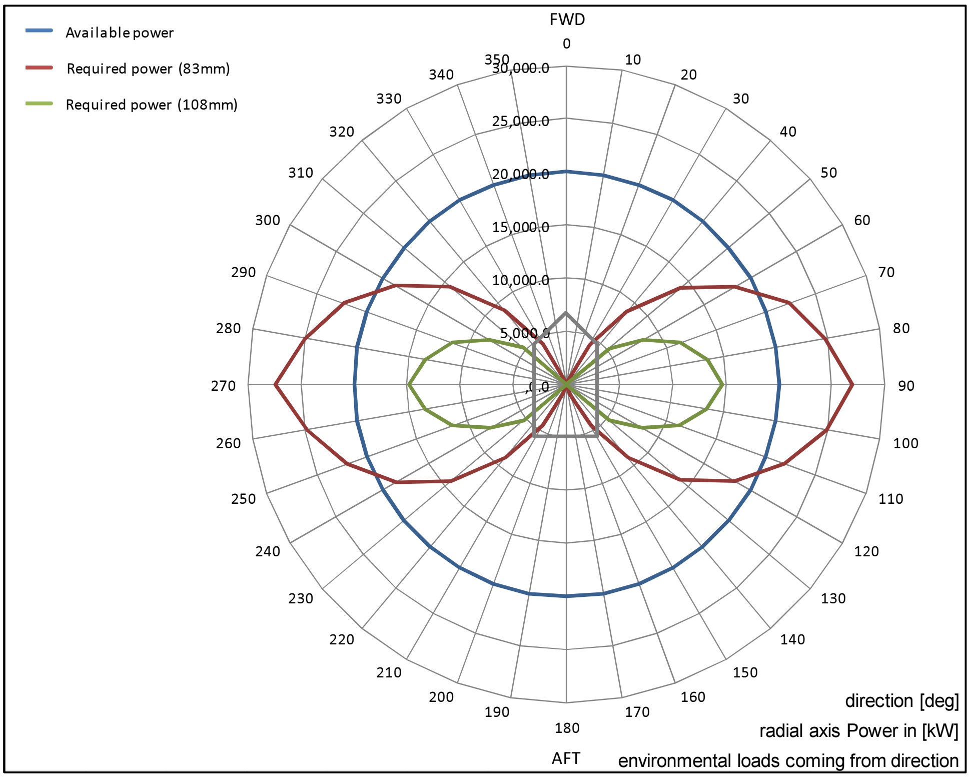
In the figure below, the required DP power to maintain station (including mooring lines) is presented compared to the available power of 30 MW (6 x 5000kW).



One can see that the maximum required power for a beam seas condition in case of an 83 mm mooring line is about 29500 kW, which is almost equal to the available power. Note that this is for all round headings in which the maximum load demand occurs in beam seas conditions. For the normal $\pm$ 30º heading for operation the required power will be about 5000 kW.

For the case with the 108 mm lines, the required power is about 14700 kW for a beam seas condition when the maximum load occurs. For the normal $\pm$ 30º heading for operation no thruster power is required. Only with a heading of about $\pm$ 50º thruster assist will be required.

Also a study was performed for the situation in which two thrusters had failed. Assumed was that one bow and one stern thruster lost power, so the amount of available power has reduced from 30 MW to 20 MW. In the graph below, the power requirements are presented.



In this figure one can see that the 83 mm mooring system is unable to achieve the operational conditions for all headings as the required power exceeds the available power in near beam seas conditions. This occurs for headings (from bow/stern) larger than about 64 degrees.
The 108 mm system on the other hand is capable of operating in the stated operational conditions. The maximum required power is about 14800 kW in a beam seas condition.

Weather vaning
The weather vaning option is studied as a survival condition. Without the aid of thrusters, the vessel will be moored form the bow on a single mooring line. This means that the allowable weather conditions are reached when the head seas environmental loads are equal to half the MBL [03] of the line. In the following table, the allowable environmental conditions are specified for both the the 83 mm line as well as for the 108 mm line.

	Hs [m]	**V_wind [m/s]**	**V_curr [m/s]**
83 mm line	5.6	23.0	1.1
108 mm line	6.3	26.6	1.1

As one can expect the larger line provides the highest allowable environmental conditions.

Storm riding
The final survival condition consists of only using the DP system to maintain head seas (smallest loads). This is calculated by means of a DP capability calculation in which no mooring line characteristics are included. In the table below, the maximum weather conditions for this storm riding case is listed.

	Hs [m]	**V_wind [m/s]**	**V_curr [m/s]**
Storm riding (full DP)	8.0	35.0	1.1

Effectively this means that the environmental loads above this condition become such that even at full power, the vessel cannot sail into the waves and starts to drift backwards. For these conditions, the vessel should look for shelter elsewhere.

CONCLUSIONS

In the following table, the allowable environmental conditions per station keeping system are listed.

Station keeping system (83 mm line)		Hs [m]	V_wind [m/s]	V_curr [m/s]	Heading [deg]	Power [MW]
1a	4 point mooring	3.2	6.5	1.1	all	--
1b	4 point mooring**	4.0	15.0	1.1	18	--
1c	4 point mooring (survival)	4.1	15.5	1.1	15	--
2a	Thruster assist (6 thrusters)	4.0	15.0	1.1	all	29.5
2b	Thruster assist failure (4 thrusters)	4.0	15.0	1.1	64	20.0
3	Weather vaning	5.6	23.0	1.1	--	--
4	Storm riding (full DP)	8.0	35.0	1.1	0	30.0

Station keeping system (108 mm line)		Hs [m]	V_wind [m/s]	V_curr [m/s]	Heading [deg]	Power [MW]
1a	4 point mooring	3.2	11.0	1.1	all	--
1b	4 point mooring**	4.0	15.0	1.1	39	--
1c	4 point mooring (survival)	5.2	21.0	1.1	15	--
2a	Thruster assist (6 thrusters)	4.0	15.0	1.1	all	14.7
2b	Thruster assist failure (4 thrusters)	4.0	15.0	1.1	all	14.8
3	Weather vaning	6.3	26.6	1.1	--	--
4	Storm riding (full DP)	8.0	35.0	1.1	0	30.0

In terms of anchor characteristics, these line loads will result in the following anchors [04]. Note that a class A anchor corresponds to a Stevpris anchor or similar and a class B/C anchor corresponds to a Flipper delta anchor or similar.

	Effectiveness "Class A"	Effectiveness "Class B/C"	MBL [ton]	Anchor weight "Class A"	Anchor weight "Class C"
83 mm line	35	20	281	10 ton	15 ton
108 mm line	35	20	455	15 ton	24 ton

From a power consumption point of view the 108 mm wire is the most optimal solution. In order to fix this it has to be feasible to design a winch with the following specification:

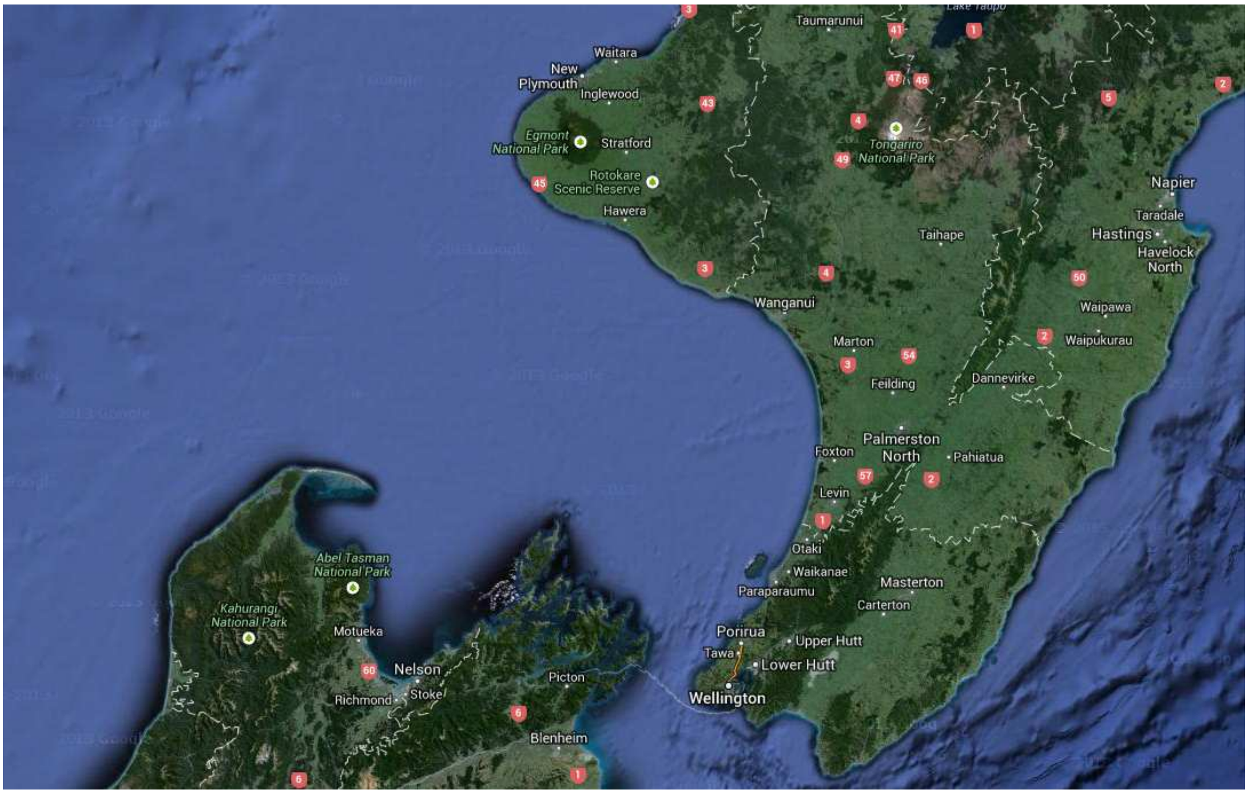
- Wire rope diameter: 108 mm
- MBL mooring wire 9000 kN
- Wire rope capacity of storage part: 3000 m
- Estimated speed on first layer (loaded): 10 m/min.
- Brake holding force: 4500 kN.

The anchor handling tug should be capable of dealing with an anchor of 24 ton with a holding capacity 450 ton. It should be provided with a secondary winch that is capable of storing a spare wire of 108 mm with a spooling capacity of 3000 m.

These starting points can be downgraded if either of the two requirements cannot be met but this will be at the cost of power consumption which can be estimated from the two mooring wire diameter results.

Outline / Preliminary Tender Specification

Mining Vessel TTRL



Prepared for:

Trans-Tasman Resources

Prepared by:

Vuyk Engineering Rotterdam B.V.

REVISION STATUS					
REV	REASON FOR ISSUE	ORIG.	CHECK.	APPR.	DATE
B	For approval in principle	SBo	DSM	MNO	11 Mar 2014

REVISION RECORD

REV	DATE	DESCRIPTION	CHKD	APPR
A1	30 Sept 2013	Progress issue Sept 2013	-	-
A2	7 Mar 2014	For internal review	MNO	SBo
B	11 mar 2014	For approval in principle	DSM	MNO

Address: Vuyk Engineering Rotterdam BV
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TABLE OF CONTENTS **Page**

0. GENERAL

001 Introduction

TTRL requested IHC Mining to design a mining Vessel with mining installation for the Iron Sands project. As subsidiary of IHC Mining Vuyk Engineering Rotterdam (VER) was requested to prepare the concept design of the mining Vessel by IHC Mining.

In this functional specification the operational requirements and starting points for the design of the Vessel are defined.

The design should meet following requirements:

- Mining in water depths of 20 to 50 m working in a four point mooring spread assisted by DP.
- Deploying and recovery of two (2) mining SSED's with flexible hoses and umbilicals, one will be operating and one will be standby.
- Carrying a process plant which is Owner furnished.
- Dumping tailings back on the sea bed
- Offloading the product to an FSO which will be positioned bow on to the vessel and then coupled to the vessel by means of a flexible discharge hose.
- Station keeping and dynamic tracking during mooring and assisted mooring operations.
- Accommodation of 120 persons, all in single cabins.
- Redundant design to allow for continuous operation, even in failure cases

001.1 Purpose of this document

The purpose of this document is to assist TTRL in the process of achieving an Approval in Principle from the Class Society and to go out for tender for the Vessel to shipyards. This document will present the description of the concept design and the requirements that the vessel has to meet with.

It is the intention to build the Vessel at the construction yard and to do all outfitting with process plant equipment and mining equipment at an outfitting yard where the process plant and mining installation will be commissioned. From there the vessel will sail to the mining location.

The construction yard will quote for the construction of the Vessel. This quotation will be based on the information of this specification, the light ship estimate data as provided in [5] and based on the maker's list that is presented in appendix A.

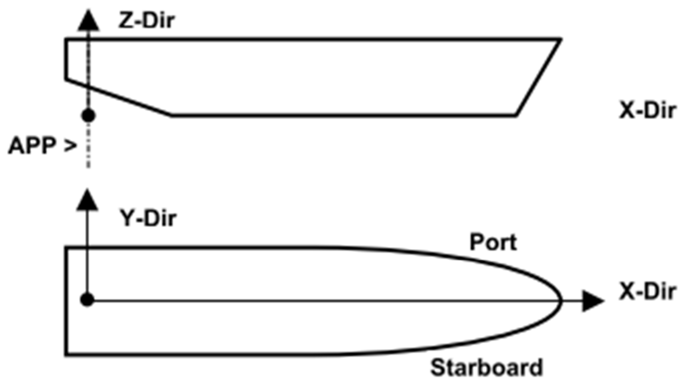
001.2 Reference documents

The following reference documents have been used for this specification:

[1] TTRL-01-REP-001 rev 1 Pre-feasibility study offshore Iron Sands project, 24 June 2013
[2] NIWA – South Taranaki Bight Iron Sand mining: Oceanographic measurements data report, August 2012
[3] TTRL Iron Sands - Basis of Design rev_0.1 final, IHC Mining B.V., Dec 2013
[4] 64.151-019-01-001 General arrangement plan
[5] 13.300-R05 Light ship weight report

001.3 *Definitions*

Definition of coordinate system for the Vessel design:



The SI metric system shall be used as the primary means to describe physical quantities. Common commercial designations, when used in a descriptive manner not involving calculations, may be expressed in the customary Vessels.

The following SI units, SI derived units and permissible non-SI units should be used in all drawings, specifications, etc.

Length	meter	m, mm
Time	second , minutes, hours, days, years	s, min, hr, d, y
Temperature	degree Celsius	°C
Volume	cubic meter	m3
Area	square meter	m^2
Mass	kilogram, tonne (1,000 kg)	kg, t
Plane angle	radian, degrees	rad, ° or deg
Speed (velocity)	meters per second, knots	m/s, kn
Power	Watt	W, kW
Angular velocity	radians per second	rad/s
Acceleration	meters per square second	m/s^2
Force	Newton	N, kN
Pressure	bar	bar
Density	kilogram or ton per cubic meter	kg/m3, t/m3
Rate of flow	cubic meter per second or hour	m3/s, m3/h
Electric current	Ampere	A
Electric voltage	Volt	V
Electric power	VoltAmpere	VA, kVA
Frequency	Hertz	Hz
Suction head	meter water column	mWc

001.4 *Abbreviations*

AC	Alternating current/Air conditioning
AHU	Air Handling Unit
ASME	American Society of Mechanical Engineers
CCTV	Closed circuit television
DC	Direct current
DP	Dynamic Positioning
DPU	Distribution Processing Unit
EER	Electric equipment room
ER	Engine room
ECR	Engine control room
FMEA	Failure Mode and Effect Analysis
FoS	Factor of safety

FRC	Fast Rescue Craft
FSS code	International code for Fire Safety Systems
FWD, fwd	Forward
GA	General Arrangement Plan
HPU	Hydraulic Power Unit
HVAC	Heating, Ventilation & Air Conditioning
Hs	Significant wave height
IIW	International Institute of Welding
I/O	Input / Output signal
IOPP	International oil pollution prevention
LARS	Launch and recovery system
LCD	Liquid Crystal Display
LED	Light emitting diode
LIMS	Low intensity magnetic separator
MCC	Motor control center
MCR	Maximum continuous rating or Machinery Control Room
MDO	Marine diesel oil
MGO	Marine gas oil (DMA)
ME	Main engine
MIMS	Medium intensity magnetic separator
MMI	Man machinery interface
OFE	Owner furnished equipment
OMR	Oil Management Room
PS	Portside
RO	Reverse Osmosis
RPM, rpm	Revolutions per minute
SB	Starboard
SDNR	Screw Down Non Return (valve)
SFOC	Specific fuel oil consumption
SG	Specific gravity
Solas	Safety of Life at Sea
SSED	submerged sediment extraction device
TBD	To Be Decided
UF	Utilization Factor
UMS	Unmanned machinery space
UPS	Uninterrupted power supply
VDU	Video display unit
VMS	Vessel management system
WT, wt	Watertight
WP	Working pressure

002 Rules and Regulations

002.1 Classification and class notation

The Vessel will designed in accordance with the rules and regulations of American Bureau of Shipping (ABS) with the following class notation:

Class notation: ✠ A1, Special Purpose Ship
service notation: “Mining Vessel”
20 years in South Taranaki Bight, New Zealand

✠ AMS,
UWILD, CPS,
ACCU, TAM,
SH-DLA
SFA (20 years)
CIRCLE E
CIRCLE C
HELIDK
CRC

As an option the HAB++ (OS) notation for crew habitability should be considered.

The Vessel will be a site specific design for the South Taranaki Bight before the coast of New Zealand. The Vessel will be designed for a lifetime of 20 years operation without any dry-docking.

The Flag State for this Vessel will be New Zealand.

002.2 Regulatory body rules and regulations

In addition to the ABS rules and regulations the Vessel shall also be in compliance with the Rules and Regulations as mentioned below, in as far as they are applicable:

- IMO International Convention for the Safety of Life at Sea, 1974 (SOLAS), Consolidated Edition 2004 with latest amendments
- IMO International Convention for the Prevention of Pollution from ship (MARPOL 73/78) with latest amendments
- IMO NOx regulations (MARPOL Annex VI)
- IMO International Convention on Load line 1966 including Protocol of 1988
- IMO International Convention on Preventing Collisions at sea (COLREG 1972) including amendments of 1981 and 1987
- IMO International Convention of Tonnage Measurement of ships 1969
- Radio Rules of the International Telecommunication Convention, 1976 and 1979 incl. GMDSS
- Global Maritime Distress and Safety (GMDSS) requirements for sea areas A1+A2+A3
- International Labour Conference (ILO) Marine Labour Convention 2006
- International State and Port Security (ISPS)

002.3 Applicable industry codes, standards and guidelines

The Vessel shall also be designed in compliance with the following international codes, standards and guidelines in as far as applicable:

- IMO MSC/Circ.645: Guidelines for the design and operation of dynamically positioned Vessels
- Common Structural Rules for tankers and bulk carriers
- IMO Resolution A.468 (XII), 1981 Code on noise levels onboard ships
- ISO 6954 Guidelines for overall evaluation of vibration in merchant ships (1984)
- International Electrotechnical Commission (IEC), Publication no. 92 for electrical installations onboard ships
- IEEE 45-2002 Recommended Practice for Electrical Installations on Board of Ships
- Electromagnetic compatibility of electrical and electronic installations on ships, IEC 533
- CAA – Rules and regulations for helicopter operation on UK sector (CAP 437) – latest edition
- IMCA M 103 – Guidelines for the design and operation of dynamically positioned ships
- IMCA M 404 – Appendices D&E
- OCIMF for ship to ship transfer of fuel oil
- American Petroleum Institute (API)
- American Welding Society (AWS)
- American National Standards Institute (ANSI)
- British Standards Institute (BSI)

002.4 Territorial rules and regulations

The Vessel will be operating in the coastal areas and territorial waters of New Zealand. The Vessel will comply with the applicable territorial rules and regulations.

003 Main Characteristics

The Vessel will have the following main particulars:

Length over all	:	345.00	m
Length rule	:	332.00	m
Breadth moulded	:	60.00	m
Depth	:	26.25	m
Design draught	:	12.00	m
Scantling draught	:	15.00	m
Complement	:	120	persons

004 Tank Capacities

004.1 Endurance

The Vessel will be designed for an endurance of 60 days, meaning that the Vessel will be able to operate without the supply of any provisions, stores and fuel for the indicated period of time.

004.2 Type of fuel

The Vessel will be operating on Heavy Fuel Oil, 380 Cst.

004.3 *Vessel tank capacities*

In order to operate the Vessel the following tank capacities will be required:

Heavy Fuel Oil capacity	:	20 000	m^3
Marine Diesel Oil capacity	:	450	m^3
Lubricating oil	:	t.b.d.	m^3
Potable water	:	1 200	m^3
Technical water	:	800	m^3
Ballast water	:	t.b.d.	m^3

004.4 *Operating tank capacities*

For the operation of the process plant the following tank capacities for integrated process tanks will be required:

Tank compartment	Content type	No of tanks	Volume m3	Specific density t/m3	Total Volume m3	Total Weight ton
Boil Box	Liquid	1	750	1.405	750	1054
Surge tanks	Liquid	4	2000	2.090	8000	16720
LIMS-1 feed tanks	Liquid	4	20	1.318	80	105.4
Cyclone 1 feed tank	Liquid	2	10	2.198	20	44.0
Cyclone 2 feed tank	Liquid	2	20	1.177	40	47.1
LIMS-2 feed tanks	Liquid	2	10	1.314	20	26.3
LIMS-3 feed tanks	Liquid	2	20	1.318	40	52.7
Dry concentrate hopper	Dry / liquid	4	4250	2.090	17000	35530
Wet concentrate hopper	Liquid	1	167	1.542	167	258
Course tails collecting tank	Liquid	4	2800	1.177	11200	13182
Fine tails collecting tank	Liquid	1	800	1.097	800	878
UF backwash tank	Liquid	1	250	1.000	250	250
UF filtrate tank	Liquid	2	250	1.000	500	500
RO backwash tank	Liquid	1	250	1.000	250	250
Fresh water tank	Liquid	4	6000	1.000	24000	24000
Process water tank	Liquid	1	2500	1.030	2500	2575

006 Deadweight

The Vessel is designed for the following loading capacity, based on all process plant tanks being 100% filled and including all stores, crew and effects and spares:

Total deadweight : approx. 120 000 ton

007 Environmental conditions

007.1 *Ambient conditions*

The Vessel will be designed for the following ambient conditions:

Outside air temperature	:	0 to 28	°C
Relative humidity	:	70	% RH
Sea water temperature	:	0 to 23	°C

The Vessel shall be operating in the following environmental design conditions:

Max operating significant wave height Hs	4.0	m
Wind speed	15	m/s
Combined current speed	1.1	m/s

007.2 Water depth

Within the exploitation area the water depth will range from 20 to 50 m. The Vessel shall be capable of working at the full range of water depths.

008 Operational profile

The Vessel will be capable of operating at the following sea states:

	Hs [m]	Period Tz [sec]	Wind [m/s]	Current [m/s]	Heading [deg]	Deadweight [ton]
Normal mode on 4 point mooring system	3.2	all	15	1.1	all	0-100%
Normal mode on 4 point mooring system	4.0	all	15	1.1	±39°	0-100%
Normal mode on 4 point mooring system with thruster assistance	4.0	all	15	1.1	all	0-100%
Weather vaning	6.3	all	26.6	1.1	-	0-100%
Survival	8.0	all	35	1.1	±15°	0-100%

For mining in 20 m water depth special conditions will be defined in terms of loading and trim of the vessel and in terms of environmental conditions in which the vessel will be capable of working in these very shallow water depths. As an option model testing may be considered to verify the analytical results of the workability anaylis.

008.1 Normal operating conditions

The Vessel will be capable of running the following operational modes under normal conditions:

a. *Normal mining mode on 4 point mooring system*

In normal operating conditions the Vessel will be mining with one SSED on the sea bed and will be operating at nominal capacity. The mining direction will be head on into the waves with a heading range of 30° from the bow. The Vessel will be moored with 4 anchors. Movement of the Vessel is achieved by hauling or reeving the mooring wires. Maximum load on the winches will be 90%.

The deadweight of the Vessel is dictated by the mining process which means that all feed tanks are considered full and the dry concentrate tanks are being filled up and shall therefore be considered empty or full. The Vessel will be able to operate in 20 m water depths with restricted stores up to a draught of 12 m and may be operating up to a draught of 15 m when water depths allows for this.

b. *Normal mining mode on 4 point mooring system with thruster assist*

When the sea state becomes higher the mooring will be assisted with thrusters with the environment coming from the more onerous directions. With the thruster assist the

Vessel will be capable of working up to a significant wave height of 4.0 m at all periods in all headings.

One SSED will be on the sea bed and will be operating at nominal capacity.

Movement of the Vessel is achieved by hauling or reeving the mooring wires. Maximum load on the winches and the thrusters will be 90% of the nominal thrust.

The deadweight of the Vessel is dictated by the mining process which means that all feed tanks are considered full and the dry concentrate tanks are being filled up and shall therefore be considered empty or full. The Vessel will be able to operate in 20 m water depths with restricted stores up to a draught of 12 m and may be operating up to a draught of 15 m when water depths allows for this.

c. *SSED launching and recovering*

SSED launching or recovery will be done on a regular basis when required for repositioning of the Vessel. This will be possible up to the design sea state of 4.0 m significant wave height with heading limitation.

The Vessel will be on the 4 point mooring system or mooring assist as described in modes a and b, depending on the sea state.

Deadweight of the Vessel at launching or recovery will depend on the filling rate of the dry concentrate tanks which can range for 0 - 100% and all feed tanks considered full.

d. *Vessel relocation*

The mooring system will be designed to allow for a constant mining of 9 mining blocks. After mining the 9 blocks the Vessel has to be relocated to a new set of mining blocks.

The anchors will be relocated by means of an anchor handling tug which is capable of deploying and retrieving the anchors up to a sea state of 4.0 m significant wave height. The Vessel will move to its new position using its thrusters. During this operation the SSED may be recovered on board.

Deadweight of the Vessel at launching or recovery will depend on the filling rate of the wet concentrate tanks which can range for 0 - 100% and all feed tanks considered full.

008.2 Vessel interfacing conditions

e. *Discharge of mining material*

During discharge of the mining material the discharge hose will be coupled to an FSO and all material from the wet concentrate tanks are discharged via the dry concentrate tank to the FSO in about 30 hours.

The mining process will continue with one (1) SSED on the sea bed and operating at nominal capacity.

The Vessel will be on the 4 point mooring system or mooring assist as described in modes a and b, depending on the sea state.

At the start of the discharge process all tanks including the wet concentrate tanks are full. After discharging the wet concentrate tanks are empty. In order to compensate the trim during discharging extra water ballast will be pumped to the fore ship.

f. *Refuelling*

The Vessel will be refuelled once a month. The refuelling station will be located at the fore end of the Vessel with a second refuelling option on the side of the Vessel if the bow connection is not available during off-loading.

The mining process will continue with one SSED on the sea bed operating at nominal capacity.

The Vessel will be on the 4 point mooring system or mooring assist as described in modes a and b, depending on the sea state.

Deadweight of the Vessel at refuelling will depend on the filling rate of the dry concentrate tanks which can range for 0 - 100% and all feed tanks considered full.

g. Vessel supply

The Vessel will be supplied with stores two (2) times a month. Supply of the Vessel will be done by a dedicated supplier at the supply area of the Vessel. During supply of the Vessel new provisions and stores will be taken on board and garbage containers will be disposed.

The mining process will continue with one (1) SSED on the sea bed and operating at nominal capacity.

The Vessel will be on the 4 point mooring system or mooring assist as described in modes a and b, depending on the sea state.

Deadweight of the Vessel during supply will depend on the filling rate of the wet concentrate tanks which can range for 0 - 100% and all feed tanks considered full.

008.3 Survival conditions

Beyond 4.0 m significant wave height no mining operation will take place. The SSED will be retrieved and stowed on board. In sea states above 4.0 m Hs the Vessel will be moored at 1 anchor and will be weather vaning. At severe weather conditions the Vessel will seek shelter.

008.4 Transit conditions

No transit conditions are foreseen except for the transit from the yard to the mining location. A transit will be carefully planned and prepared.

1. HULL

100 General

The Vessel shall be an all steel constructed hull made of high tensile strength steel with a minimum yield strength of 355 N/mm^2 in compliance with the material requirements of the Class Society and provided with approved certificates to demonstrate the quality. The Vessel shall be designed for a lifetime of 20 years for site specific mining activities.

100.1 Hull form and subdivision

The Vessel shall be capable of operating in shallow waters. At the fore and aft end of the Vessel a raised bottom is provided for the thrusters. In this way the thrusters will not protrude through the base line. The hull shape will allow for an effective thrust generation and as little obstruction for the thrusters as possible. The level of the raised bottom will allow for an in-water-overhauling of the thrusters, assisted with extra trimming of the Vessel if necessary.

The Vessel will be divided into the following main areas:
- aft ship in which the SSED is located with launch and recovery system and riser handling area
- engine room area in which the generator sets are located
- process plant area in which the third stage process plant equipment is located on deck and fresh water tanks and vertimills for the process plant are located below deck
- a discharge area in which the dry and wet concentrate tanks are located including all discharge equipment
- Surge tank area in which process plant first and second stage equipment is located on deck and surge tanks are located below deck.
- a fore ship where the forward thruster rooms are located including the tailings disposal equipment
- superstructure in which all accommodation is located

The Vessel will be provided with a double hull in compliance with Solas and Marpol regulations over nearly the entire length of the Vessel. Above upper tweendeck level the double hull will serve as main routing for cable trays. The double bottom will be sloped towards centreline to create a natural drain of eventual spoil in the cargo hold areas.

In longitudinal direction a longitudinal bulkhead at 6.00 m off centreline SB and PS is located, forming a natural separation between Starboard and Port Side equipment as a means of redundancy in process plant streams and related systems such as power supply and control stations. The central corridor which is created with these longitudinal bulkheads, is used for the third main cable routing.

At 16.50 m off centre line SB and PS a longitudinal bulkhead is located which is partly used as tank boundary and partly as wash- or open bulkhead for structural integrity.

In transverse direction a number of transverse bulkheads, including a collision bulkhead, are located according to the general arrangement plan. They form tank boundaries or the watertight boundaries in order to comply with the damage stability requirements.

100.2 *Steelwork and workmanship*

The construction of the Vessel shall be executed to the best practice of the shipbuilding industry and shall fulfil in every respect the requirements of the Class. Maintenance of high standards of workmanship will also be Yard's responsibility. Strengthening of the construction for the design loads shall be provided by optimal stiffening continuity in order to prevent stress concentrations and vibrations.

101 Materials

The hull is constructed of high tensile strength shipbuilding steel with a minimum yield stress of 355 N/mm^2. The design temperature for all materials shall be 0 °C. Frames and deck beams shall be made from bulb profiles and webs shall be built-up from plates with flat bars. In the deckhouse, the deck beams shall be bulb profiles and the girders and webs are heavy bulb profiles in general or built-up sections when required.

All structural steel used for the construction of the Vessel and machinery, including possible forgings and castings, shall be of shipbuilding and marine engineering quality, tested, inspected and certified by Classification Society and shall be physically and chemically in conformity with such requirements. All steel shall be free from cracks, lamination and similar defects. At locations where interface loads occur in the normal direction of the plate, Z-quality material shall be used to avoid laminar tear.

All structural steel plate and sections will be shot blasted and shop primed prior to any fabrication. All materials shall be acceptable to Inspector, Class or any other prevailing regulatory body. Asbestos and asbestos containing materials shall not be used.

All equipment and major components shall carry permanent identification stamped-in, cast-on or engraved plate, showing manufacturer's name or trade name, model, serial number, size and type rating.

102 Scantlings

Scantlings will be designed in compliance with Class requirements for the design lifetime of the Vessel. Strengthening of construction and scantlings shall be designed for

- Design draught of 12.0 m
- Scantling draught of 15.0 m

The size, arrangement and material of the various members of the hull structure are shown on the appropriate plans and in accordance with the applicable Rules and Regulations and to the approval of the Class.

102.1 *Owner's allowances*

The following process plant tanks will be integrated in the steel structure:

- Surge tanks
- Dry concentrate tanks
- Course tails tank
- Process water tanks

In addition to the required Class scantlings and corrosion allowances the following wear allowances will be applied:

Vertical plating of surge tanks	2 mm
Sloped plating of surge tanks	4 mm
Vertical plating of dry concentrate tanks	2 mm
Sloped plating of dry concentrate tanks	4 mm

102 Welding

103.1 General welding requirements

The Vessel shall be completely welded. Welding shall be of excellent quality and shall be carried out in accordance with the Rules of the Class Society. Welders shall have a Class approved Yard's welding certificate. Prior to construction the Yard shall prepare welding procedures in compliance with Class requirements which shall be submitted to and approved by the Owner before any welding is carried out.

Before welding, the edges of the material shall be straight, prepared in the correct way and completely clean. Plate edges are flame cut or sheered. The parts to be welded shall be dry and remain dry during welding.

At temperatures of the material and air lower than 0 °Celsius, it is only allowed to weld after approval by Owner's representative. If required, measures will be taken in order to avoid these low temperatures in the material and rapid fall of temperature. Sufficient protection means against snow, frost, wind, rain etc. shall be provided, when welding takes place in the open air.

Heavy parts and connections to cast steel will be preheated and annealed before and after welding, where necessary and/or required by Class. Connections shall be welded to fit properly with the correct welding gap. Too large welding gaps will be adapted in concert with the supervisors and if necessary replaced by new construction. Use of filling material such as for instance strips, bars, etc. is not allowed.

For all welding continuous welds will be used. Intermittent welding is only allowed inside the accommodation deckhouse in dry spaces. Overhead welding shall be avoided as much as possible. On the main hand-welded butt joints, ceramic material shall be used. A backing run will be welded after carefully cutting-out with the round chisel or gouging and grinding, as an alternative in concert with the supervisors. Gouged joints shall be reworked by grinding by means of special grinding discs, suited to that purpose. Crossing of welding seams will be avoided as much as possible. If this is not possible, the existing welding seam will be ground smooth. In way of crossings of section butts and seams, with stiffeners, butts shall be ground smooth in way of the crossing. In way of limbers and air-holes welds are continued around the edges.

Material of frames and other connected constructions in way of welding seams shall be removed as far as necessary to obtain continuous welding. In the construction of the Vessel's bottom and in tanks welding stops shall be applied. Edges shall be smooth, clean and dry before welding is started. Welding gaps will be secured by means of tack welds.

All welding shall be carried out with electrodes in absolute dry condition of an approved make and according to a method to be approved. Gas metal arc welding (GMAW) is allowed unless welding circumstances may affect proper shielding of the weld by the gas. Cracked tack welds will be ground before final welding. No edge undercut will occur. Head sides of profiles and edges of plates will be completely welded. Any stress concentration due to less than optimal welding will be corrected. Welding appearances shall be smooth and well-finished.

103.2 Non-destructive testing

Welding sections will be inspected visually to ensure proper penetration of the weld on its backing. X-ray photographs and/or ultrasonic tests will be made of the most important welding, the number of photographs in accordance with the Rules of the

Class. Moreover, by instruction of the Supervisors, additional welding (structure) will be examined by means of X-ray photographs or ultrasonic tests. If ultrasonic testing of a butt weld shows poor quality, the complete butt weld will be examined.

Defaults in welding will be repaired by gouging and repair welding (maximum one time) or otherwise be replaced by new constructions. Repaired welding will be examined again, according to the formerly applied method, for account of the Yard. Supplementary photographs and ultrasonic tests in addition to the number required by the Class will be charged at an extra price, unless a defect requiring repair is found. Repaired welds are re-examined for Yard's account.

Welding will be judged according to I.I.W. classification. Welds are examined according to ASME V (Art. 5) and judged according to ASME VIII (Div. I). ultrasonic testing and X-ray will be done by an independent institution. The average quality number of the X-ray photos shall be not higher than 3. If the number is higher, the necessary precautions are to be taken immediately to improve the quality of the welding work.

A complete welding code will be submitted for approval to the Supervisors and to Class before construction is started. This table will indicate the shape of the welding seams, the way of preliminary treatment, the dimensions of the weld and the electrodes to be used. On the construction drawings welding details and the welding sequence will be indicated.

110 Aft end

The aft ship will be designed to locate the two (2) SSED's with LARS and all other related equipment. Also the two (2) aft mooring winches will be located in this region. At the aft end of the Vessel two (2) recesses will be provided for lowering the SSED's. The structure will be designed to handle the maximum interface forces during all launch and recovery procedures and the mooring winch interface forces.

The main deck in this region will be designed for the following deck loads:

General deck load	8 ton/m^2
Laydown area for SSED equipment	12 ton/m^2

On the main deck a deckhouse will be provided which will contain control and electrical rooms. The main hoisting winches will also be mounted on this deck. The structure will be sufficiently strong and stiff to handle the main hoisting loads. At the forward corners the crane pedestals will be integrated into the deckhouse structure.

At the upper tween deck stores and propulsion rooms will be located.

The bottom will be raised in way of the thrusters. Provisions will be made to allow for in water overhauling or replacement of the aft thrusters with the Vessel in a trimmed condition when necessary.

120 Engine room

The engine room will be physically split in two engine room compartments with the longitudinal bulkheads at 6.00 m off centreline. Each generator set will be mounted on its own integrated foundation.

The sloped double bottom from the process plant area will be extended in the engine room area as well to allow for structural continuity in the Vessel.

The engine room will be provided with lower tween decks that will be designed according to the structural requirements from Class.

130 Process plant Vertimill area

In the aft end of the midship area the vertimills will be located. On the main deck all process plant equipment which requires gravity feed into the vertimills will be mounted. The deck structure will be designed to handle the maximum interface forces from the process plant equipment. Loss of strength at locations where gravity piping is penetrating the deck or where large hatches are provided, will be compensated. Special attention will be paid to the installation of the vertimills and their foundations because of the high gyroscopic loads.

The main deck in this region will be designed for the following deck loads:

General deck load	8 ton/m^2
Laydown areas for process plant equipment	12 ton/m^2

At centreline in the tanktop sumps will be provided with natural drainage towards the lowest points. Sump pumps as part of the process plant equipment will be provided to empty the sumps. The sumps will be designed to be large enough for the expected spillage washing capacity and will have a protruding depth into the double bottom in compliance with Solas requirements.

In order to optimize the drainage of spills and washing water all structures connected to the tanktop will be of a box shape connection to avoid collection of material.

135 Process plant discharge area

Forward of the vertimill area the discharge equipment of the process plant will be located. On the main deck the process plant equipment that require gravity feed into the dry and wet concentrate tanks and the course tails tanks will be mounted. The deck structure will be designed to handle the maximum interface forces from the process plant equipment. Discharge of processed material will be done by means of two (2) conveyor belts that will store the material in four (4) dry concentrate tanks through a large opening over each of these tanks. The openings can be closed watertight but will be open during operation. The loss of strength in these regions will be compensated.

The main deck in this region will be designed for the following deck loads:

General deck load	8 ton/m^2
Laydown areas for process plant equipment	12 ton/m^2

The four (4) dry concentrate tanks will be integrated into the construction of the Vessel. At the upper ends of each tank the longitudinal and transverse bulkheads of the Vessel will form the tank boundaries. The transverse lower parts of these tanks will be sloped with an angle of 60° and will end in a tapered discharge opening above a conveyor belt that will transport the material to the wet concentrate tank.

The scantlings will be on the outside of each tank. In longitudinal direction the tanks will be separated by means of an accessible cofferdam. The sloped plating will be covered with liners to prevent wear of the actual construction. The tanks will be provided with means of access to inspect and clean the tanks.

Design specific density dry concentrate tanks	2.09 ton/m^3

Forward of the dry concentrate tanks four (4) course tails tanks will be integrated into the construction of the Vessel. At the upper ends of each tank the longitudinal and transverse bulkheads of the Vessel will form the tank boundaries. At the lower end the longitudinal and transverse lower parts of these tanks will be sloped and will end in a tapered discharge area where the pumps will take suction to discharge the course tails to the tailings deposition installation.

Connected at the forward end to two course tails tanks is a process water tank. Water from the course tails tanks is able to overflow into the process water tank by means of overflow openings which may be valve controlled.

Design specific density course tails tanks 1.177 ton/m^3

The double bottom will be sloped to centreline to create a natural drainage towards bilge wells of sufficient size. At centreline in the tanktop sumps will be provided with natural drainage towards the lowest points similar as described for the vertimill area.

140 Process plant surge tank area

On the forward end of the main deck the boil box and trommel screens will be located. One (1) filling connection point will be provided to the boil box. From the boil box four (4) discharge connections will be provided, each supplying ROM to the four (4) main process streams. The scantlings will be on the outside of the tank except for the top of tank scantlings.

At the upper tween deck the control stations and workshops will be located.

The four (4) constant density surge tanks will be integrated into the construction of the Vessel. At the upper ends of each tank the longitudinal and transverse bulkheads of the Vessel will form the tank boundaries. The lower parts of these tanks will create a conical shape at a slope of 60° and will end in a tapered discharge area where the pumps will take suction.

The scantlings will be on the outside of each tank. In transverse direction the tanks will be separated by means of an accessible cofferdam. The sloped plating will be covered with liners to prevent wear of the actual construction. The tanks will be provided with means of access to inspect and clean the tanks.

Design specific density CD surge tanks 2.09 ton/m^3

The double bottom will be sloped to centreline to create a natural drainage towards bilge wells of sufficient size. At centreline in the tanktop sumps will be provided with natural drainage towards the lowest points similar as described for the vertimill area.

150 Fore end

The fore end of the Vessel will be designed to locate the processed material discharge system, the refuelling station and the mooring winches. The structure will be designed to handle the maximum interface forces of each piece of equipment.

The main deck in this region will be designed for the following deck loads:

General deck load 8 ton/m^2

At the upper tween deck the control stations and workshops will be located.

The bottom will be raised in way of the thrusters. Provisions will be made to allow for in water overhauling or replacement of the forward thrusters with the Vessel in a trimmed condition when necessary.

160 Foundations

All equipment shall be mounted on specially designed foundations of ample strength and stiffness. They shall allow for the positioning of sea-fastenings when required. Drip trays shall be incorporated in the foundation for equipment that may have a risk of oil spillage. The location of the equipment with foundation shall allow for proper mounting and service space of the equipment. The supports of each foundation shall be properly integrated into the Vessel construction to integrate the equipment load. Hard spots shall be avoided.

160.1 Crane pedestals

The Yard shall provide crane pedestals on which the cranes can be installed. Crane pedestals shall be designed for the design cranes loads and shall be properly integrated into the Vessel construction. The pedestals will be used for access and ventilation and the structure will allow for the openings that are required.

160.2 Vertimill foundation

Special attention shall be paid to the foundation of the vertimill due to the large gyration forces. The foundation shall be specially analysed and arrangement and structure shall be such that it minimizes the impact on the Vessel structure.

161 Fenders

Over the full length of the Vessel at tanktop level and lower tweendeck level a fender system will be provided. The fender will consist of wearing strips of 50 mm thickness.

At locations where regular interfacing with ships alongside the Vessel will take place, additional fendering consisting of wearing strips on the shell will be applied. Fendering or wearing strips for SSED launching and tailing disposal shall be specially considered.

165 Bilge keel

A bilge keel will be provided at each side of the Vessel to reduce the roll motions of the Vessel. The bilge keel will be a constructed structure, built from plating and round bar at the end. Inside the double bottom the bilge keel will be properly supported by internal stiffeners

170 Structural details

170.1 Manholes

Each tank shall be accessible through at least two (2) manholes in opposite corners close to the bulkheads with water tight covers and steel ladders with safety cages and platforms. Manhole covers shall be watertight and central bolted with stainless steel bolts. Manhole diameter shall be 600 mm or oval execution 600x400 mm. Further the vertical covers shall have one (1) handgrip on each side of the bulkhead. Manholes shall be marked with number of the tank.

170.2 *Drain plugs*

In each water ballast tank, for drainage, one (1) recessed stainless steel bottom plug shall be provided, size: 50 mm. Plugs in oil tanks of stainless steel, head shall be 50 mm hexagonal. Number of tanks shall be welded aside the plugs. Plugs with O-ring and shall be fitted flush with shell at the lowest point of the tank, but in such a way that they will be free from the dock blocks.

170.3 *Drip trays*

Utmost attention shall be paid to prevent leakage from any component of oil system in service conditions. Drip trays shall be provided to avoid spillage during inspections and changing filters.

170.4 *Bilge wells*

At appropriate places bilge suction wells shall be fitted. The wells shall be covered with a perforated top plate flush with the surrounding decks or tank top.

180 Superstructure

The accommodation deckhouse shall be located aft of the process plant area and will be arranged according to the General Arrangement Plan. The accommodation deckhouse comprises the following deck levels:

- Top Deck	52.85	m above base
- Wheelhouse deck	49.40	m above base
- A-deck	46.20	m above base
- B-deck	43.00	m above base
- C-deck	39.80	m above base
- D-deck	36.60	m above base
- E-deck	33.40	m above base
- Main deck	26.25	m above base

The outside bulkheads of the deckhouses shall be of a welded steel construction, suitably stiffened. Corners of the bulkheads shall be welded right angled. The deckhouse will form a rigid structure with a central steel staircase and cable duct for cable trays and ventilation. The web frames will be fitted in line with the web frames of the hull of the Vessel.
Inside bulkheads will have a thickness of at least 6 mm. The decks shall be executed with longitudinal deck beams and transverse girders. Decks shall be designed for a load as required by Class.

All places on open decks shall have ample drainage where water may collect. Doubler plates shall be provided under scuppers ending just above deck. Decks of the deckhouse will protrude the outside bulkheads. Grab rails shall be fitted to outside bulkheads where necessary.

181 Wheelhouse

The wheelhouse is arranged as shown on the General Arrangement Plan. The windows of all sides have an angle of approx. 15° to the vertical to minimise reflection. The thickness of the glass shall be according Class requirements. A sun protection visor is fitted all around the wheelhouse Top Deck. On the top deck the navigation mast and helicopter deck are mounted.

182 Funnel and deck houses

The Vessel will be provided with two (2) funnels. Special attention shall be paid to the support of the exhaust gas lines and the vibration towards the accommodation. Part of the funnel will be used for air intake to the engine rooms. Provisions will be made to allow for future installation of emission reducing equipment.

On top of the funnels a pipe rack will be provided to support the exhaust pipes. The pipes will be directed away from the flying route of the helicopter.

185 Helicopter deck

On top of the wheelhouse a helicopter deck will be mounted. The helicopter deck will be designed to carry a Bell 412 or similar. The diameter of the platform will be in compliance with the requirements of the CAP437. The deck will be of an aluminium construction and will be complete with at least the following:

- High friction deck.
- Recessed tie down points for anchoring the helicopter
- Landing net with fastening
- Helideck perimeter lighting
- Illuminated windsock
- Helideck floodlighting
- Walkways
- Fixed firefighting system
- Drainage gutter with drainpipes

The helicopter deck is supported by a steel structure to the deckhouse, consisting of round pipes and brackets. The supporting structure is capable of carrying the design loads from the helicopter at all possible locations for landing.

187 Process plant covering

The process plant is partly covered with a weather tight steel structure to protect the process plant equipment and to create a shelter. The structure will not be an integral part of the Vessel strength and proper precautions should be taken in the design to guarantee this.

The structure will contain stores as indicated on the General Arrangement Plan and will be provided with internal stairs and platforms to give access to process plant equipment.

The structure will also be designed to handle overhead crane loads.

190 Painting and preservation

190.1 Painting preparation

Surface preparation is in general in accordance with Swedish standard SIS 055900 (ISO 8501-1:1988) and Shipyard Quality Standard (QSI-003) and shall be painted with a suitable zinc-silicate shop-primer with a dry film thickness according manufacturer's standard.

The standard of second preparation shall in general be as follows:

Process	Alkyd Paint Bitumen Paint	Epoxy Mastic Epoxy	Solvent Free Epoxy Heat Resistant Paint	Phenolic Epoxy
Power tool cleaning	St 2	St 3		
Blasting	Sa 2	Sa 2.5 + Ss	Sa 2.5	Sa 2.5

- For ballast tanks and spaces where grit blasting is to be applied all blocks shall be blasted to Sa 2.5 except for special areas and fresh water tanks which shall be treated specially during the hull erection and construction process.
- For power tool cleaning, intact shop primer can be kept but shall be abraded with sandpaper.
- “Ss” means Sand Sweeping. Intact shop primer can be kept.
- Water ballast tanks shall be blasted and primed at the block stage.
  - Welding seams and damaged shop primer shall be treated to Sa2.5 and intact shop primer sand swept.
  - After erection, the damaged coats and block link up butts, seams and connections shall be power tool cleaned to St3 and repaired in accordance with the specified system.
- External Shell and Hull areas shall be blasted and primed at the block stage.
  - Welding seams and damaged shop primer shall be treated to Sa2.5 and intact shop primer sand swept.
  - After erection, the damaged coats and block link up butts, seams and connections shall be blasted and primed to Sa2.5 and repaired in accordance with the specified system.
- For special tanks and compartments, all surfaces and welds shall be blasted to Sa 2.5 after erection and all hot work completed.
- Hand welds, free and fraying edges and steel defects shall be treated prior to blasting and painting.

190.2 Painting scheme

The painting system shall be specially considered for the 20 years on site operation of the Vessel. The system shall be in compliance with PSPC rules and regulations. The underwater paint system and anti-fouling system shall be in compliance with the Class requirements for in water survey.

Final painting schemes and dry film thicknesses to be decided by paint supplier, make Hempel / International Paint / Jotun up to Owner’s choice. In general the following painting schemes shall be applied:

Primer	Coating	Anit-fouling	Location
Alkyd primer	Alkyd enamel		Technical enclosed spaces
Alkyd under coating	Alkyd enamel		Accommodation
Epoxy holding primer	Epoxy coating		Sea and fresh water tanks Hull above waterline
Epoxy holding primer	Epoxy coating	Anti-fouling	Under water hull

Painting must be executed in accordance with Shipyard Quality Standard (QSE-003) and the paint supplier's prescription, and in general according to this Specification.

For the hull and large outside surfaces only airless spraying will be used. Painting will not be done when raining, at too low temperatures, too high relative humidity, too intensive sunshine, but conditions and drying times as specified by the paint manufacturer will be respected. Following conditions apply to painting :
- steel temperature of more than 3 °C above dew point,
- relative humidity lower than 85 %.

For paint systems on outside decks a full stripe coat is applied for the first layer. After applying each different group of layers, the thickness will be controlled. Specified layer thickness is minimum Dry Film Thickness.

Galvanized items, stainless steels (except in accommodation) and other non-ferro items will be painted with the finish coating as specified for the surroundings, after applying a special primer if required.

The antifouling system is a Tin and TBT-free system.

Colour scheme will be to Owner's choice as well as finishing of the paint. This colour scheme also applies to all equipment supplied by third parties.

After final coating the total Dry Film Thickness (DFT) shall be measured and recorded. During painting works the Wet Film Thickness (WFT) and DFT may be monitored for reference. For inspection purposes, 90 percent of the readings taken in liquid holding tanks and on underwater areas must be greater than the specified DFT.

Paint adhesion tests shall be carried out at agreed quality “hold points” to ensure the quality of the complete paint, application and adhesion system.

196 Galvanizing

Where piping is specified to be galvanised the various sections and assemblies shall be completely finished with all flanges attached and hot dip galvanised after welding is completed.

All parts which are submitted to the influence of humidity and moist sea-air, like hand-rails, outside stairs, pipelines, ventilation-grates, parts of rigging, small forged iron pieces, railings, ladders, safety cages shall be hot dip galvanized according to ISO 1461 and EN 10240. Galvanized items shall be fastened by bolting. If this is not possible, welding is executed in such a way that the galvanizing shall be damaged as little as possible. Galvanized parts are painted as specified in above paint specification.

197 Cathodic protection

Final means of cathodic protection will be specially considered in view of the 20 years on site operation of the Vessel. Overall hull impressed current systems will be considered as well as conventional means of cathodic protection. For the latter option at least the following specification will be followed.

Sacrificial aluminium anodes will protect the underwater hull including seawater inlet chests, suction inlets and nozzles of thrusters against corrosion. Capacity generally shall be an average 15 mA/m^2 during a period of 24 months after delivery of the Vessel. Anodes shall be welded on doubler plates. The mounting shall be in compliance with the Class requirements for in water survey and shall be readily accessible for replacement by divers.

Each sea chest shall be provided with a marine growth prevention system based on Copper electrodes and made suitable for two (2) years operation. The electrodes shall be supplied from the Vessel’s electric system via transformer rectifiers. The mounting shall be in compliance with the Class requirements for in water survey and shall be readily accessible for replacement by divers.

2 OUTFITTING CARGO AREA

210 Hatches

210.1 *Main hatches*

The Vessel shall be provided with hatches for access and maintenance as shown in the General Arrangement Plan. Hatch coaming heights and free access dimensions shall be in compliance with Flag State and Class requirements. Coaming heights of hatches on main deck shall be at least 900 mm unless a flush hatch is required. At least the following major hatches will be provided on main deck:

- One (1) hatch to serve the SSED workshop store.
- Two (2) hatch covers to serve the engine rooms, suitable for transportation of a main generator.
- One (1) hatch to serve the aft vertimill, suitable to lower the vertimill
- One (1) extended hatch to serve the forward vertimill, suitable to lower the vertimill and to handle equipment from the laydown area at lower tweendeck
- Four (4) watertight closable opening to each dry concentrate tank of at least 5.0x5.0 m
- Four (4) watertight closable opening to each surge tank
- Two (2) service hatches above the discharge area, suited to handle pump parts
- Two (2) service hatches above the surge tank area, suited to handle pump parts
- Two (2) service hatches in the fore, suited to handle equipment parts in the fore ship

All weather exposed hatches and all clamps shall have stainless steel hinge pins and synthetic bushes with a collar in the hinges. Springs and toggles shall be stainless steel. Watertight hatches shall have UV resistant rubber seals.

At lower decks hatches as indicated on the General Arrangement Plan shall be provided.

210.2 *Escape and small hatches*

Escape hatches / doors will be fitted at the end of each escape trunk. Size and execution are to be in compliance with the Class requirements and SOLAS requirements.

220 Doors

220.1 *Watertight sliding doors*

Watertight sliding doors will be fitted at the following positions:
- Two (2) watertight sliding doors on the upper tween deck at centreline to allow for passage between the process plant areas
- Two (2) watertight sliding doors on tanktop at centreline to allow for passage between the process plant areas

The doors slide horizontally in rails at upper and lower side and will have a clear opening of 800 x 1800 mm. Each door shall be complete with its own hydraulic power pack, hydraulic cylinder, valves, limit switches, fittings, controls and alarm.

Local control, remote control and signalling of the doors will be in full accordance with the requirements of the Flag State Authorities and Class.

220.2 Steel doors

Single and double doors shall be placed according to the General Arrangement Plan. Entrance doors of accommodation shall be of steel box construction with one (1) handle. Doors are of standard construction with clear opening width of 750 mm. The top of all doorways is about 2100 mm above deck. A draft lobby is created by means of an extra interior door at all entrances of the accommodation.

Watertight doors will have one (1) central lever, four (4) dogs and two (2) adjustable hinges. The dogs are each connected to the lever with a bar. Watertight doors are provided with glued rubber packing. Packing shall be inserted in a channel on the door.

All weather exposed doors shall have two (2) stainless steel hinge pins and synthetic bushes with a collar in the hinges. Sill heights as far as prescribed shall be according to Flag State Authorities and Class's requirements. Each door has a non-corrosive hook to keep the door fully open.

Inside steel doors shall have a padlock, outside watertight doors are locked from the inside by means of a small bar.

Switchboard rooms shall be provided with a double door with crush bars to allow for removal of larger equipment.

221 Main hoisting cranes

The Vessel will be provided with deck cranes as per General Arrangement Plan. All cranes will be designed in compliance with Class requirements. In principle knuckle boom cranes will be provided but telescopic cranes are considered an alternative. In below specification SWL means safe working load under operating conditions, i.e. up to Hs=4.0 m as most extreme operating condition.

The hoisting requirements for the main hoists apply for a 360^{0} revolving crane. The working limit for which the crane will be designed, are:

Maximum off-lead angle:	3^{o}
Maximum side lead angle:	5^{o}

All cranes will be electrically driven from the board net and shall be fed from two [2] switchboards to have redundancy during operation.

The Vessel will be equipped with seven (7) identical offshore knuckle boom cranes for the following crane loads:

- Main hoist SWL	100	ton
- Main hoist outreach	40	m
- Auxiliary hoist	15	ton
- Hoisting speed	40	m/min at SWL

Two (2) cranes will be located in the SSED area to perform lifting activities for maintenance on the SSED's. One of the cranes shall be capable of lifting overboard to exchange SSED components, including the dredge pump with electric motor.

One (1) crane will be located on SB side near the vertimills to perform lifting activities for maintenance on the vertimills and the cyclones on deck. It can also serve the vertimill pump room with lifts to the laydown area on lower tween deck and assist during refuelling. The cranes shall reach at least 20 m outboard to lift or stow equipment from or onto the anchor handling and supply tug.

Four (4) cranes will be located on SB and PS in the fore ship to perform lifting activities for all process plant equipment on the fore ship. The forward cranes are also in reach of the mooring winches and the hose reels for discharging and refuelling. The cranes also serve the hatches that give access to the discharge area and the surge tank area to lift equipment from these areas. The cranes shall reach at least 20 m outboard to lift or stow equipment from or onto the anchor handling and supply tug.

The Vessel will be equipped with two (2) offshore knuckle boom cranes for the following crane loads:

- Main hoist SWL	30	ton
- Main hoist outreach	30	m
- Auxiliary hoist	10	ton
- Hoisting speed	40	m/min at SWL

One crane will be located on SB side next to the SSED control deckhouse to assist the risers and to serve the hatch to the engine room.

One crane will be located on PS in front of the accommodation and shall reach at least 15 m outboard to take in supplies from the anchor handling and supply tug or to stow waste containers onto the tug. For this reason the crane shall be provided with a heave compensation system.

222 Mining Vehicle , riser hose and LARS

The Vessel is fitted with 2 Owner Furnished Submerged Sediment Extraction Devices. In normal mining operations only one SSED will be mining.

In air weight of SSED	450	ton each
Name plate production capacity	8000	ton/hr
Size (lxbxH)	28x10.5x8.6	m
Installed power	5000	kW
Type of dredge system	900	mm ID pump connection
Pump power	3800	kW

The system will be delivered complete with the following equipment
- SSED's
- SSED restraining systems
- long sliding doors
- A-frames for Launch and Recovery
- Swell compensator towers with compensator system, including hydraulic system
- nitrogen bottles for swell compensator
- main hoist winch and wires incl spare wires
- spare rope storage winch and wire
- umbilical winches with umbilical and motorized umbilical sheaves
- spare umbilical storage winches
- riser with hose handling equipment and spare hoses
- booster station including booster pump
- tensioners for hose handling including working platforms
- Fixed piping system up to the boil box including coupling to the riser
- deckhouse equipment

The installation will be mounted on board at the outfitting Yard. The Yard has to provide all structural interfaces below the main deck.

230 Process Plant

The Vessel will be fitted with a process plant which is Owner Furnished. The plant shall be suited to operate in all operational sea states as defined in 008, including the corresponding motion accelerations and heel and trim angles. The processing of the ROM consists of the following stages:

- Extraction of the ROM from the seabed by means of one of the two SSED's
- Assembly of ROM into a boil box via a booster station aft of the accommodation
- Particle separation in the trommel screens. Undersize will be fed to the constant density surge tanks and the oversize will be fed to the course tails tanks
- The ore will be pumped to magnetic separators (MIMS and LIMS-1) for first stage separation. The separated material will be collected in the cyclone 1 feed tanks. The overshoot will be collected in the course tails tanks.
- First stage cylones, fed from a feed tank, will further separate the particles to 150 μm. The larger particles will be discharged to the second stage cyclone feed tanks and the overshoot will go to the derrick screens.
- Second stage cylones, fed from a feed tank, will further separate the particles to 125 μm. The larger particles will be discharged to the vertimills and the overshoot will go to the LIMS-3 feed tanks.
- Grinding of the larger particles (125 μm) will be done by means of two (2) Vertimills which discharge back into the cyclone 2 feed tanks.
- The derrick screens further separate the particles to a size of less than 150 μm which are then collected in the LIMS-2 feed tanks. The overshoot will go back to the cyclone 2 feed tanks.
- The LIMS-2 and LIMS-3 feed tanks will feed the LIMS-2 and LIMS-3 magnetic separators. The separated material will be lead through the de-watering magnets and will be stored in the dry concentrate tanks. The overshoot will be collected in the fine tails tanks.
- Transport of concentrated material for offloading will be done by means of sandwich conveyor belts to the wet concentrate tank.
- Fresh water from either of the four (4) fresh water tanks will be added to slurry the concentrate which will then be pumped to the offloading station from where it will be loaded into an FSO.
- Throughout the process flow process water (dedicated sea water) will be added to maintain the required density of the slurry.
- The course tails and the fine tails will be discharged through a dedicated tailings disposal system via cyclones that will separate the water. This water is also discharged via a dedicated waste water disposal system.

The installation on deck will be mounted on board at the outfitting Yard. The process plant equipment that will be inside the Vessel, will be installed by the Yard but will be commissioned at the outfitting yard. The Yard has to provide all structural interfaces below the main deck.

237 Tailing disposal system

Tailings are directly dumped overboard through an Owner Furnished tailings disposal system via the cyclones. The system will be separated in two parts; the particle disposal and the waste water disposal. In principle the system will consist of two deposition pipes running at PS of the Vessel. The pipe will be operated by means of gantries with electrical winches that will lift and lower the deposition pipes.

240 Desalination plant

On top of the shelter over the conveyor belts a desalination plant will be installed with a capacity of 30,000 m^3/day. The desalination plant will consist of reversed osmosis

units that are supplied with sea water that is warmed up from the cooling water of the main generators. They will discharge to:
- the fresh water tanks for discharging the dry concentrate material
- the potable water tanks after treatment of the generated fresh water as described in 870.1.
- the technical fresh water tank to serve the fire-fighting and deck wash system

The desalination unit shall be complete with filtration units. Integrated tanks for filtration and back-flushing will be provided. The brine that results from the fresh water generation from sea water will be collected in brine tanks made of stainless steel, quality 316LN

The sea water pumps will be considered as part of the desalination plant and will be Owner Furnished.

245 Process plant systems

For a proper functioning of the process plant the following systems will be provided.
- sea water system
- fresh water system
- gland system

All systems will be designed as part of the process plant with accompanying specifications. Process plant piping below freeboard deck and penetrations for the process piping shall be in compliance with Class requirements, including the application of (emergency) shut-off valves and monitoring. All piping of these systems below main deck shall be incorporated by the Yard during the building of the Vessel.

250 Off-loading Equipment

After the dry concentrate tanks are filled up the mined material will be discharged to an FSO.

The mined material will be transferred from the dry concentrate tanks to the wet concentrate tank where fresh water is added to slurrify the material. Discharge pumps will then pump the material to the FSO.

The FSO will be moored bow to bow with the Vessel and a floating discharge hose will be connected to the FSO. A hawser line is connected to the discharge hose which will be handled by the anchor handling tug. Tugger winches will be installed to assist the discharge operation.

The hose reel will be capable of storing the discharge hose of about 350 mm internal diameter. The reel will have sufficient storage capacity and the drum diameter will be large enough to allow for frequent reeving and spooling of the hose.

3 HULL OUTFITTING

320 Mooring arrangement

320.1 4 point mooring system

The Vessel will be provided with an Owner Furnished 4-point mooring system. The forward two (2) anchor winches will also serve as anchor winches as required by Class. An exemption for the anchor arrangement will be requested. The system will operate together with the thrusters which are standby in case of an overload on the mooring wires.

<Preferred winch system consists of a traction winch with storage reel. As alternative if the design proves feasible, a single winch with sufficient spooling capacity may be considered.>

The PS winches will be a mirrored-image of the SB winches. The winches shall be designed to comply with the following specification:

- Nominal pull after payout of 1250 m	4500	kN
- Nominal pull after payout of 2750 m	4500	kN
- Minimum speed at nom pull	17	m/min
- Maximum speed for anchor hauling and reeving	100	m/min
- Brake holding force:	6000	kN.
- Wire rope diameter:	108	mm
- MBL mooring wire	9000	kN
- Wire rope capacity of storage part:	3000	m
- No of safety windings	5	

Drums are executed with Lebus groove. Every drum is provided with a rope guiding and spooling system.

Each drum is provided with a remote operated brake system. The winch is suitable for free paying out, free fall, paying out with controlled brake force.

Each winch will be electrically driven and controlled by a VSD. The drive systems are supplied by the 6.6 kV main switchboard and transformed to a supply voltage of 690 V. The regenerative power of the mooring winch that is not hauling the wire will be supplied back into the electrical system by means of an active front end. The electric motors which are horizontally mounted with a front flange and are designed according to the following specification:

- Total output power	about 1750	kW
- Voltage	0-690	Volt
- Frequency	50	Hz
- Degree of protection	IP56	
- Duty cycle	S1	(continuously)
- class of insulation	F	
- Temperature rise	H	
- Cooling	water cooled	
- Anti-heat condensation	yes	

Each winch is provided with a combined speed and pay-out length measurement system with display in the wheelhouse. Measurement consists of proximity sensors detecting the drum movement. This measurement is also used to detect an overspeed of the winch.

Each winch is also provided with a wire load measuring system with display in the wheelhouse. The wire load reading is connected to the mooring PLC which will automatically start the thruster assistance in case of an overload of the mooring wire. Thruster assistance will start when a wire load exceeds 90% of the nominal pull.

The winches shall be provided with a quick wire disconnecting device which will allow a quick release of the wire from the drum in case of any emergency situation that requires a more rapid recovery of the mooring system than the anchor handling tug can allow for.

The winches are controlled from the wheelhouse. Local (emergency) control is installed at site.

320.2 Capstans

For handling of mooring ropes four (4) capstans will be provided, two fore and two aft. The warping head of each capstan is made of cast steel. Main characteristics of the warping head are:

- Number of warping heads	1	piece(s)
- Diameter	710	mm
- Nominal force	200	kN
- Nominal speed	10	m/min
- Slack rope speed	20	m/min

Each capstan is driven by means of planetary gearbox that is mounted inside a pipe construction. The electric motor is flange mounted to the gearbox. The main shaft is suspended in two spherical roller bearings. The capstan is provided with a disc brake. The main characteristics of the winch drive are:

- Output power	t.b.d.	kW
- Maximum torque	1.5x	nominal torque
- Voltage	415	Volt
- Frequency	50	Hz
- Degree of protection	IP56	
- Duty cycle	S2	
- class of insulation	F	
- Temperature rise	H	
- Cooling	water cooled	
- Anti-heat condensation	yes	

The capstans will be operated locally with an operating console mounted close to the capstans.

321 Anchors

Four (4) 15 ton Stevpris anchors will be used for the mooring. They are of the class A effectiveness drag type anchors. The forward two anchors will also serve as mooring anchors as required by Class as described under 320.

The anchors can be stowed on an anchor rack with seat to stow the anchor. The rack is constructed of thick walled pipes and attached to the hull with proper stiffening inside to avoid hard spots.

323 Fairleads, chocks and bollards

323.1 Fairleads

For the 4-point mooring system a self-adjusting swivel fairleader is fitted on deck for each anchor. The fairleader will consists of a sheave with roller, mounted in a swivelling housing. Sheave, roller, swivelling house are provided with ball or roller bearings. The necessary sheaves are installed for leading the anchor wires from this fairleader to the anchor winch. All sheaves will be executed with ball or roller bearings. The sheave diameter is at least 22 times the wire diameter.

323.2 Chocks and bollards

For the normal mooring on mooring wires Panama chocks and bollards will be provided as indicated on the General Arrangement Plan. For ship to ship operations recessed bollards shall be arranged in the side shell as indicated on the General Arrangement Plan.

The dimensions of the Panama chocks shall be based on the breaking strength of the mooring ropes and towing wire, prescribed and recommended by the Class. The deck construction in way of the Panama chocks shall be reinforced to withstand the full breaking strength of the rope wire.

The dimensions of the bollards shall be based on the breaking strength of the mooring ropes and towing wire, prescribed and recommended by the Class. Bollards are of welded construction with steel plate constructions. The deck construction in way of the bollards shall be reinforced to withstand the full breaking strength of the mooring ropes and/or tow line.

328 Towing and mooring lines

328.1 4 point mooring system wires

For the 4 point mooring system each anchor will be connected to a mooring wire with the following specification:

- Wire rope diameter:	108	mm
- MBL mooring wire	9000	kN

Each anchor is fitted to the mooring wire by a wire rope socket and shackle. Size of connecting equipment to be in compliance with the design loads on the mooring wire.

328.2 Regular mooring wires

The Vessel will be provided with the following mooring lines:

- Thirteen (13) polypropylene mooring ropes, length 200 m, breaking strength 736 kN, according to Class recommendations.
- Eight (8) lines on mooring winches; type, length and breaking strength according to Owner’s requirements.
- Six (6) throw lines, length 70 m.

Mooring ropes will be stowed in rope baskets made of pipe and located in the stores below main deck. Rope hatches will be provided to stow the mooring wires from the main deck into the rope baskets.

336 Personnel elevator

One (1) personnel elevator is installed, running from the main deck up to B-deck, having stop places at:

- B-deck
- C-deck
- D-deck
- E-deck
- Main deck
-

The elevator cage is suited for 350 kg or four (4) persons. The elevator cage is built in a steel elevator trunk. The elevator motor room is situated below Main Deck level.

For access to the process plant areas and transport of minor equipment two (2) personnel elevators are installed, running from main deck to the tanktop. The elevator cage will be suitable for 1000 kg and six (6) persons. The elevator cage is built in a steel elevator trunk. The elevator motor room is situated at Main Deck level.

340 Lifesaving and firefighting equipment

The Vessel shall be provided with all fire-fighting-, lifesaving and safety equipment necessary to comply with the requirements of the Flag State Authorities and Class Society for a complement of 120 persons. The location of the safety equipment will be indicated on the Safety Plans.

341 Lifeboats

341.1 Totally enclosed lifeboats

The Vessel will be equipped with four (4) totally enclosed lifeboats, suited for 60 persons each. Two (2) are fitted at each side of the Vessel. The lifeboats shall be provided with all fixed and loose inventory in accordance with the regulations in force. The name of the Vessel and port of registry are marked on each side of the lifeboat's bow.

Each lifeboat is equipped with a water cooled diesel engine, suitable for a speed in calm water of 6 knots, fully loaded.

Each lifeboats is provided with its own launch and recovery davit. The davits are of the gravity, “Single Pivot” type, placed inside the length of the boats.
The davits meet the requirements of the Authorities, and are complete with all necessary blocks, guide sheaves, wire ropes and fittings. The davits are complete with electrically driven winches, suitable for lowering of the fully manned lifeboats and to hoist the boats manned with the launching crew or the manned rescue boat.

341.2 Rescue boat

Furthermore the Vessel will be provided with two (2) fast rescue boats. The rescue boat is in Fibreglass Reinforced Polyester execution, and has a capacity of 10 persons. The rescue boat shall be in full compliance with Solas, Flag state and Class requirements.

For launching and recovery of the rescue boat an hydraulically actuated pivot davit with hydraulic winch is installed, designed for the required SWL. The davit shall be in compliance with the Flag state and Class requirements for the launching and recovery of a rescue boat.

342 Safety equipment

Sufficient life rafts and life buoys shall be provided in compliance with Solas and Class requirements. They shall be spread over SB and PS locations over the length of the Vessel to allow for safe operation for the crew over the full length of the vessel.

Four (4) certified sets of single fall davits for launching life rafts shall be supplied at the life raft locations.

Lifejackets and immersion suits shall be provided in each cabin with in accordance with the complement and Solas and Class requirements. Five (5) spare life jackets shall be stored in boxes near each muster station.

All other lifesaving appliances such as stretchers, lifebuoys, life throwing apparatus, immersion suits, SART, EPIRB, etc. to be provided and located / stored per SOLAS and other Regulatory Authority requirements. Forty Helicopter immersion suits in accordance with regulatory Authority requirements shall be provided. SART & EPIRB shall be provided for lifeboats and rescue boats.

One (1) set of rescue equipment for the Helideck in accordance with international rules for helicopter operations (as a minimum UK CAA CAP 437) shall be provided. Rescue equipment shall be stored in the nominated space on the Top Deck.

345 Fire protection and detection system

A fire detection and alarm system to Class requirements and in compliance with the international FSS code shall be provided with the main fire detection panel on the Wheelhouse and a repeater panel in the Engine Control Room. Switches for fire alarm shall be provided at the exits from the accommodation, machinery spaces, technical spaces, process plant spaces, SSED spaces and in control rooms. Alarm bells for fire alarm and general alarm, and flashing lights shall be provided in machinery spaces. The power supply for the alarm systems shall be provided by the 230 V emergency system and shall have a battery back-up.

The fire detecting system shall be of the 24 V automatic type covering accommodation as well as machinery, control rooms, SSED area, process plant area, winch and thruster rooms, stores, and workshops.

Combined smoke and heat detectors shall be installed in all cabins and all corridors and further in all spaces in which a fire might be expected to originate. A combination of thermal rate of rise temperature detectors, smoke/ionisation, flame flicker and manual release buttons shall be installed in the engine rooms. A combination of detector types shall be used in engine rooms and emergency generator room.

The complete fire detection system shall be installed in accordance with regulations and maker's recommendations with special attention to the loop and circuit wiring. Arrangement for manual stop of fans and pumps shall be arranged outside the engine rooms. The general alarm's signalling equipment shall be used also for the fire alarm signals.

Call points shall be installed throughout the accommodation spaces, service spaces and control stations, according to rules and regulations. Call point shall be located at each exit.

All information from the fire detection system shall be available to the VMS for display. Operation of a detector or call point shall be displayed at the VMS workstations.

346 Fire extinguishing system

Fire extinguishing systems and equipment shall be provided in accordance with Class and Flag state requirements and in compliances with the international FSS code. The necessary fire extinguishers, spare charges, hoses, reels, lockers etc. shall be delivered and installed.

For the engine room and all electrical rooms a marine type gaseous fixed fire suppression system shall be applied, make Novec or similar.

Portable fire extinguishers shall be provided in accordance with SOLAS and any other applicable regulations. Fire hydrants shall be fitted according to Regulations. The hydrants shall be made of an internationally approved type.

In the engine room, auxiliary generator room and separator room, a high pressure water spraying system is provided for the areas of the main engines, separators and oil-fired heater as per IMO Solas Reg II/2-10.5.6. The system consists of a water spraying system with pumps and piping working on technical fresh water. The system with its controls (manual and automatic release capabilities) will be of an approved type. Manual controls are arranged in the ECR.

The deep fryer in the galley is provided with a fixed fire extinguishing system, in full accordance with the requirements of the Authorities.

A suitable foam application system consisting of monitors or foam-making branch pipes capable of delivering foam to all parts of the helideck in all weather conditions in which helicopters can operate. The system shall be capable of delivering a discharge rate of 500 l/min for at least five minutes

Fireman's Outfit in accordance with Class and Flag regulations shall be provided and properly stored on a suitable, easily accessible place, each comprising:

* protective clothing
* gloves and boots
* helmet, safety lamp and axe
* a self-contained compressed air operated breathing apparatus
* a fireproof lifeline

350 Provision stores

The provision stores will consist of a dry provision area and a refrigerated provision area. The stores will be designed for the following design temperatures:

Dry provision compartment:	+12 ^{0}C design temperature
Cold compartment:	+4 ^{0}C design temperature
Freezing compartments:	-25 ^{0}C design temperature

351 Refrigerated provision stores

The refrigerated provision storerooms shall be located on E-Deck and shall be built-up of prefabricated panels. Insulation and the duty of the plant will be capable of maintaining below mentioned temperature at an outside temperature of 45° Celsius. The following refrigerated stores shall be provided:

Refrigerated space	Temperature	Approx. gross volume inside the room
Fish room	- 25 °Celsius	35 m³
Meat room	- 25 °Celsius	35 m³
Vegetable room	+ 4 °Celsius	35 m³

A complete marine refrigerating plant will be provided and installed to effect the refrigeration necessary to maintain the temperatures specified when working 18 hours per 24 hours. Two (2) air-cooled compressor units of ample capacity will be furnished, complete with compressor, integral piping, instrumentation, controls, etc. Each unit will be fitted with a fresh water-cooled condenser. Motor starters may be separately furnished for bulkhead mounting. Each unit will be sized to handle the entire refrigeration load.

One (1) unit will normally be in service and the second unit in a standby condition. Each unit will be provided with a filter-dryer and a moisture indicator. The refrigeration control panel will be bulkhead mounted and situated near the units for local control.

Each room is built up of a steel frame, insulated with polyurethane panels, the inside finished with stainless steel sheets, outside finished with painted galvanized steel sheets. Floors have a stainless steel covering fitted with water drains.
Doors and door frames are of polyester and insulated with polyurethane foam. Doors with heated seals.

The meat room will be fitted with suitable overhead meat rails made of stainless steel rods and some stainless steel racks against the wall. The fish room will have stainless steel racks. Stainless steel racks, shelving, retaining battens and wooden cargo battens against the wall shall be fitted in the cooling room. Below the racks wooden gratings are laying on the floor. Each chamber will be fitted with a reading dial thermometer, which will be hung in the galley.

352 Dry provision stores

The dry provision store room is situated on E-deck and equipped with:
- 150 m2 wooden racks (or steel racks with wooden shelves) divided over four tiers, height about 500 mm, maximum depth about 600 mm.
- 1 stainless steel sink with mixing tap.
- Sufficient free area for storing supplies on pallets.
- Beer locker, closed by means of wire mesh walls.
- A locker for bonded stores, with wooden racks.

The provision store is provided with a door giving straight access to the laydown area for provision supply.

The dry provision storeroom is ventilated by means of the AC system. The room is additionally cooled by means of a self-contained recirculation unit, installed inside the room. The store will be insulated and all crevices will be adequately moisture sealed with elastic or similar plastic compound.

360 Ventilation

The following Heating, Ventilation and Air Conditioning (HVAC) systems shall be installed:
- AC system for accommodation.
- Mechanical ventilation supply systems
- Mechanical ventilation exhaust systems
- Heating systems
- AC system for ECR
- AC system for Navigation Bridge
- AC system for control stations
- Individual AC systems for switchboard rooms
- Individual AC systems for the Thruster and Mooring Rooms
- Natural ventilation where appropriate

Back-up AC units shall be supplied and installed where required to ascertain continuity of the mining operation. Local control panels shall be provided as required and the system shall be suitable for remote control and monitoring from the VMS.

All calculations for AC and ventilation installations will be submitted to the Owner for approval. For accommodation spaces, the system is designed to ISO 7547-1985 and/or ISO 8861, except where hereafter more stringent conditions are specified.

These calculations will take into account the real circumstances such as :
- k-value
- sun radiation
- opening of doors
- heat radiated by equipment, lights (in contradiction with ISO 7547/8861, heat radiated by lights is to be taken into account, also for spaces with daylight), etc.
- persons in concerned spaces

Special attention shall be paid to the intake of air in relation to dust intake from the process plant. The air inlets for the engine room and electrical spaces are provided with Viledon type bag-filters, filtration grade G85. The filters are mounted in a steel box; the boxes shall be mounted with stainless steel bolts, nuts and washers. The capacity of the filters is such that the air speed through the filters, with all fans working, will not exceed 1.5 m/s (taking into account the net filter surface).

361 Air conditioning

361.1 Design conditions

The technical spaces will be provided with mechanical ventilation with sufficient air changes per hour. The maximum increase of air temperature will be 12.5º C. Special attention shall be paid to avoid hot spots. Engine room ventilation will be redundant.

In general the supply and exhaust systems will be provided by electrically driven axial flow fans or centrifugal fans, one or two speed as required and of the marine type.

The air conditioning units are designed for the following condition:

Outside temperature	:	+28	°C
Relative humidity outside air	:	80	%
Inside temperature	:	+20	°C

361.2 Air conditioning plant

The AC plant is to operate on a maximum of 50% re-circulated air. At least 50 m^3/hour per person is supplied to cabins and 25 m^3/hour per person is supplied to public spaces.

In addition to the accommodation spaces at least the following spaces will be provided with air conditioning:
- Wheelhouse
- Galley
- HV Switchboard rooms
- LV switchboard rooms
- Thruster / mooring winch drive / switchboard rooms aft
- Thruster / mooring winch drive / switchboard rooms fore
- Low Voltage switchboard room accommodation

- Engine control rooms
- High Voltage switchboard rooms
- Low Voltage switchboard rooms

- Process plant control rooms
- Process plant High Voltage drive / switchboard rooms
- Process plant Low Voltage drive / switchboard rooms

- Mining control rooms
- Mining High Voltage switchboard rooms
- Mining Low Voltage drive / switchboard rooms

Space	**Supply**	**Exhaust**
	air ch/h	air ch/h
Wheelhouse	15	
Converter room	8	
Offices	12	
Cabins	8 to12	
Recreation room	15	
TV room	15	
Mess room	15	
Gymnasium	15	
Galley	20	40
Sanitary spaces accommodation		15
Provision store	12	
Hospital	12	15
Hospital sanitary spaces		15
Process plant coffee canteen	12	15
Mining plant canteen	12	15
Control rooms	20	
HV switchboard rooms	20	
LV switchboard rooms	20	
Electrical workshops	15	
Laboratory	20	

362 Mechanical ventilation

The technical spaces and stores will be provided with mechanical ventilation with sufficient air changes per hour. The maximum increase of air temperature will be 12.5º C. The ventilation of the engine rooms will be in compliance with the ISO standard 8861. Special attention shall be paid to avoiding “hot spots”. Engine room ventilation will be redundant to guarantee continuous operation with the loss of one (1) fan per engine room.

In general the supply and exhaust systems will be provided by electrically driven axial flow fans or centrifugal fans, one or two speed as required and of the marine type. All air intakes or exhausts will be provided with louvers and watertight covers in compliance with IMO regulation.

Space	**Supply**	**Exhaust**
	air ch/h	air ch/h
Engine rooms	45*	
Separator room	60	65
Boiler room	20	
Hydraulic room	20	
Emergency generator room	45*	
Compressor room	15	
Incinerator room	20	
Garbage room	12	
Change room	12	
Laundry	12	
Vertimill room		10
Discharge pump room		10
Surge tank pump room		10
Derrick screen room		10
Ball storage room		10
Transformer rooms	20	
Drive rooms	20	
Mechanical workshops	15	
Stores	12	
Shot blasting room	12	15
Pipe shop		12
Welding shop	12	15
Paint store		15
Nuclear store		15
Gas bottle store		15
Chemical store		15

* The engine room and emergency generator room ventilation will be specially considered in compliance with the ISO standard 8861

370 Small steel work

370.1 Steel stairs and ladders and railings

Exterior stairs shall be of completely galvanised steel, bolted at top and bottom. Steps shall be anti-slip. Normal width between stringers is 800 mm. Free headroom shall be at least 2100 mm. The angle of inclination shall be limited to maximum 45° to the horizontal in compliance with the regulations for Special Purpose Ships.

Stairs in accommodation spaces shall be of steel construction. In general the clear width of the stairways is 900 mm. The steps shall be of steel plate. Free headroom shall be at least 2100 mm. Stairs in machinery spaces shall be of steel construction, flat bolted at top and bottom. In general the clear width of the stairways is 800 mm and at the back of the stairs light plate dust covers are fitted. The angle of inclination shall be limited to maximum 45° to the horizontal in compliance with the regulations for Special Purpose Ships.

Steel ladders are provided in tanks, below escape hatches, to funnel, masts, and where required for good accessibility for maintenance, repair and installation of equipment. Sides of these ladders of flat-iron, spaced 400 mm apart. Steps shall be of square-iron, spaced 300 mm apart protruding and welded to the sides. Ladders shall be kept 200 mm clear of the construction. A cage ladder shall be provided, where required for safety.

Galvanised steel railings shall be arranged at location that need to be protected to assure safety of personnel. Height of railings shall be at least 1000 mm above deck.

370.2 Floors, platforms and gratings

Floors and platforms shall be fitted in the engine room and pump room. Floor space for maintenance shall be provided for all machinery. Floor plates shall be made of 5 mm chequered plate. Floors in the engine room shall be fitted on a rigid channel bar type framework (Unistrut or equal) with vertical edges to form toe guards along openings in the floor. The framework shall be demountable. The plates shall be fastened by countersunk screws. The plating arrangement shall allow for proper access to valves and other equipment below floor level that regularly need to be used or checked.

Wherever necessary, local loose plates shall be provided in way of valves etc. located under floor level. Handrails shall be fitted around open spaces as a necessity to assure the safety of personnel. Top platforms or open gratings shall be provided with double handrails, lower levels shall be fitted with single handrails. Ladders and gratings shall be fitted in order to provide access to all machinery, control valves and flats. Gratings shall be of the anti-slip type and shall be galvanised.

In the process plant area platforms and walkway shall be made of a galvanised construction with GRE gratings.

374 Accommodation and pilot ladders

374.1 Accommodation ladder

Two (2) galvanised platforms for the accommodation ladder are fitted on Main Deck. The platforms can be canted to stow the platforms flush with the railing. An accommodation ladder can be connected to the platforms. The length of the ladder shall be sufficient to allow access onto the ladder from the lowest operating waterline with the gangway under a maximum angle of 60° to the horizontal.

The ladder is of seawater-resistant aluminium and is provided with folding railing and a platform with roll at lower end, stowed on a suitable place. Hoisting eyes shall be fitted with lifting bridle.

374.2 Pilot door

In the starboard shell a watertight pilot door will be provided with the door sill at about 16.0 m above base. The door will be hinged to open outboard and will have a clear opening of 1500 x 2500 mm. The door will be hydraulically operated and will be delivered complete with its own hydraulic power pack, hydraulic cylinder, valves, limit switches, fittings, controls and alarm.

Local control, remote control and signalling of the doors will be in full accordance with the requirements of the Flag State Authorities and Class.

374.3 Pilot ladder

Two (2) rope pilot ladders shall be provided on Main Deck, one (1) on SB and one (1) on PS, with rubber steps and anti-turning bar according to Class requirements, operated from a pilot ladder winch. The ladder will have sufficient length to reach at least 20 m below Main Deck. The pilot ladder winch shall be electrically driven and approved by the Flag State Authorities and Class.

A third pilot ladder will be provided at the pilot door room with the same execution but with smaller pilot ladder length.

380 Navigation mast

On the top deck the navigation mast will be located. The masts shall be complete with all rigging, wireless antenna fittings, navigation light brackets and survey antenna fittings. Cage ladders shall be provided, extending from the bottom to the top of each mast. Sockets, heavier plates and supporting construction where necessary for strength and vibration reasons shall be provided. A mast platform shall be provided for servicing and mounting of equipment.

Inside the mast house a battery room and an AC room for the wheelhouse is located.

383 Hull marks and nameplates

The Vessel’s name shall be indicated on the Vessel’s bow at SB / PS, made of 5 mm steel plates. The Vessel’s name and port of registry shall be marked in the same way on the stern. The net registered tonnage of the Vessel and the official IMO number shall be marked and permanently outlined in accordance with the requirements of the Flag State Authorities. On the outsides of the funnel the company’s emblem shall be fitted.

In general, hull marks shall be made of 5 mm steel plates. Tanks shall be marked according to the tank plan, by weld beads on the outside of the shell and tank top. Draft markings shall be marked on both sides of the Vessel at the stem, stern and amidships up to a draft one (1) metre higher than the maximum assigned draft.

The draft marks shall be indicated in Arabic numerals, 100 mm high in projection. These draft markings shall be accurately measured in respect of the underside of the flat keel amidships and shall be outlined by weld beads, and as fitted on drawing to report. Paint lines shall be marked with weld beats. The statuary deck line and assigned load line marks shall be accurately located on each side of the Vessel. The bow thrusters shall be marked as required by Flag State Authorities and Class. Marks shall be of welded plates and painted.

Nameplates shall be in the English language. Engraved brass nameplates shall be fitted on all valves to facilitate the handling of machinery and pump plant. Individual items of control equipment shall be identified with plastic nameplates. Storage and miscellaneous tanks shall be provided with a brass nameplate.
Each unit of deck machinery and each entrance of compartments shall be marked with a bolted brass nameplate. Stores with combustible goods will have red coloured lettering on a white plastic plate.

Accommodation and service spaces will have plastic nameplates and number plates on or near the entrances to the compartments. Stores with combustible goods will have red coloured lettering on a white plastic plate. On the entrance door of each cabin a nameplate with loose exchangeable lettering will be fixed. The deck numbers will be indicated inside the stair casing.

385 Hoisting facilities

385.1 Overhead travelling cranes

Electrically driven travelling overhead cranes with electric hoist are arranged as follows (Final lifting capacity is yet to be determined) :

- One (1) overhead crane in the mining workshop on main deck
- Two (2) overhead cranes in the riser corridors in the mining deckhouse to allow for hose handling and replacement
- Two (2) overhead cranes in the engine rooms, one at SB and one at PS over the main engines
- One (1) overhead crane in the fuel treatment room over the separators
- Two (2) overhead cranes in the vertimill area above the sea water pumps
- Two (2) overhead cranes, one at SB and one at PS over the LIMS 2 and LIMS 3 equipment
- One (1) overhead crane in the derrick screen room above the derrick screens
- One (1) overhead crane in the ball store

For travelling in longitudinal and transverse direction a rack and pinion system is fitted. The size and spacing of the main girders of each crane is such that a maximum area can be covered. The crane will be driven by electric motors. Lifting operations will be possible for all operational angles of heeling and trim of the vessel.

Operation shall be done via an electric wire hanging down from the crane with at its end a box with push-buttons. A safety protection against overload and by limit switches on all movements is provided. A fail-safe brake is activated in case of power failure. The steel wire for hoisting shall be galvanised.

Certificate
A “Certificate of Test and Thorough Examination of Lifting Appliances” in accordance with the Class and Flag State Authorities shall be delivered. The crane shall be entered in the “Register of Ship’s Lifting Appliances and Cargo Handling Gear”.

385.2 Lifting beams

Hoisting beams with electrically operated chain hoists shall be provided above all major equipment. The lifting capacity of each hoist shall be sufficient to handle the heaviest component of each piece of equipment. The length and arrangement of each hoisting beam shall allow proper lifting of each component and stowage at a laydown area that is within reach of a deck crane.

The trolleys will have chain-operated hoist and travel and will have a fastening device. The hoisting height, length and route shall be suited for the situation. Trolleys shall be self-braking and shall have demountable stoppers at ends.

385.3 Lifting lugs

For ease of handling and installation lifting eyes will be provided where necessary. All hoisting eyes on board will be tested on the safe working load (SWL) and marked with a colour code according to the Owner.

4 ACCOMMODATION

400 General

For the design and execution of the accommodation special attention shall be paid to the noise and vibration levels which shall be in compliance with Class requirements. In case the optional Class notation HAB++ (OS) will be applicable, the accommodation will be in full compliance with the regulations of this notation. The accommodation is suited for a complement of 120 persons. The following accommodation spaces will be arranged

A-deck
- 18 single cabins
- Helicopter reception
- Helicopter safety equipment room
- Electrical room / server room
- Locker
- Toilets

B-deck
- 36 single cabins
- Conference room
- Quiet room
- Internet room
- Locker
- Toilets

C-deck
- 36 single cabins
- two offices
- Electrical room / server room
- Locker
- Toilets

D-deck
- 30 single cabins
- hospital
- office
- TV room
- Recreation room
- Bonded store
- Safety equipment room
- Locker
- Toilets

E-deck
- Mess room
- Galley
- Scullery room
- Provision stores with cooling/freezing area
- Gymnasium
- Ladies toilets
- Man’s toilets

Main deck
- Male Change room

- Female change room
- Laundry room

<u>Upper tween deck deck</u>
Process plant area
- Sanitary room mining area
- Coffee room mining area
- Sanitary room process plant area
- Coffee room process plant area

<u>SSED deckhouse top deck</u>
- Offices

410 Interior requirements

410.1 Linings and partitioning bulkheads

All panels and insulation will be in compliance with the requirements of the Solas, Flag state and Class requirements. Special attention shall be paid to the noise and vibration levels in the accommodation. Colour scheme of the accommodation will be in compliance with owner’s requirement.

All partitioning bulkheads are executed with non-combustible panels with a fire rating in accordance with Class requirements. They shall be of a prefabricated system, consisting of a core of mineral wool covered on both sides with a PVC-coated steel sheet or glass-fibre reinforced plastic laminate or equal. The linings shall be of the same system, however with a reduced thickness.

Linings shall be applied at the following spaces:
- throughout the accommodation
- inside the accommodation staircase
- inside air conditioned or insulated technical spaces
- weather exposed outside walls with thermal insulation.

410.2 Ceilings

Ceilings shall be of prefabricated incombustible panels. Fire rating to be in compliance with SOLAS requirements. Ceilings shall be generally 2200 mm above the top of the flooring. Ceilings shall be fitted in the following locations:
- throughout the accommodation
- inside control stations
- inside offices

410.3 Floors

All floors inside the accommodation will in general consist of a priming system, insulating panels, a latex sub floor of suitable thickness and a covering layer according to owner’s requirement. The flooring system will be designed in such a way to minimize sound levels in the accommodation. If required extra damping layers will be provided in the flooring system.

410.4 Interior doors

All external and interior accommodation doors shall be in compliance with Solas, Flag state and Class requirements with respect to structural fire class rating and provisions, including locks, as well as with the requirements from the Loadline Convention with respect to sill heights. All outside doors of accommodation are steel weather tight doors. Entrances to the accommodation will be provided with an outer and an inner door to create an air lock.

Principle execution of doors shall be according the following table:

Door location	Clear opening	Top height above deck
Cabins	1800x700	2200
Sanitary Vessels	1800x560	2200
Hospital	1800x1500	2200

420 Furniture

The furniture shall be chosen in co-operation with the Owner. The dimensions, construction and appearance shall suit the location and shall be in close concert with Owner and the interior designer. Wooden construction normally means: plywood covered with hard plastic with wood like finish.

Loose standing furniture shall be provided with appliances for fixing to floors or bulkheads. Chairs can be fastened to tables by elastic straps.

Berths
All berths will have a dust tight bottom and shall be designed to provide a neat but adequate fit to the foam rubber mattress.
All berths in cabins shall be wooden construction with drawers underneath. The overall dimensions shall be (l x b) 2200x800 mm inside.

425 Accommodation spaces

The accommodation is arranged with single cabins only. Each cabin has a minimum area as required by the MLC-2006.

425.1 Cabins

All cabins shall be delivered complete with furniture, cupboards, refrigerator, bookshelves and a prefabricated sanitary unit consisting of shower, washing basin, water closet and sanitary equipment.

425.2 Other accommodation spaces

Offices and conference rooms shall be fitted with all equipment to facilitate meetings to Owner’s requirements.

The recreation and television room will be fitted with equipment to Owner’s requirements

The ship’s fitness room shall be fitted with fitness equipment to Owner’s requirements with a.o. fitness bikes, rowing machines, jogging machines, etc. Inside the fitness room facilities for showering will be provided.

The hospital shall be furnished with two (2) hospital berths, an examination table and all necessary furniture. A medical locker with a built-in domestic refrigerator for storage of special medicines will be provided. A sanitary unit will be provided inside the hospital which will be identical to other sanitary units, however fitted with a bath and a shower.

The galley will be provided with all galley equipment necessary for the preparation and disposal of food for the complement of 120 persons. Between the galley and the mess room a hatch will be provided to pass food and related items. On both sides of the hatch there will be a table with sufficient area for the service. The necessary cabinets, racks, hooks, drawers and shelves needed to store the kitchen utensils, pots and pans.
The range, table tops, shelves, etc. shall have retaining bars to keep equipment in place on a moving Vessel. A potable water tap is provided for cleaning purposes.

All cabinets, drawers, doors, racks, sinks, etc. shall be made of stainless steel.
The framework for tables, cabinets, etc. shall be made of stainless steel angles and/or pipes, bolted to supports welded on deck. All screws, bolts, nuts, washers, etc. necessary for fastening the items as mentioned above shall be of stainless steel.
A stainless steel exhaust hood shall be arranged above the range.

The change rooms shall be equipped sufficient lockers for 120 persons, divided over the ratio of men and women on board. Showers and washing basins will be provided as indicated on the general arrangement plan. Wooden banks, hooks for towels mirrors etc. will be provided.

The laundry shall be provided with all equipment necessary to handle the laundry of the complement of the vessel, complete with washing machines, drying tumblers, ironing equipment, etc.

426 Service spaces

The following service spaces will be provided.

Top deck
- AC room for wheelhouse

Main deck
- Garbage room
- Incinerator room
- Emergency generator room

Upper tween deck
- HPU room for the SSED SB and PS
- Oil management room for the SSED SB and PS
- Air Conditioning room
- Engine room
- Process plant laboratory

Lower tween deck
- Compressor room
- Boiler room
- Engine room
- Fuel treatment room
- Sewage treatment room
- Vertimill area and pump room
- Discharge area and pump room
- Surge tank area and pump room

Technical spaces will be provided with equipment that is adequate for the technical functionality of the space, in close consultation with the Owner.

426.1 Garbage disposal room

The Vessel will be provided with a central disposal room at main deck level, located close to the garbage disposal station. Garbage will be disposed from the Vessel two (2) times a month. The capacity of the garbage disposal station will be designed for the total number of persons on board and 20 days between disposals.

The system will consist of ten (10) 20 foot containers with different colours to indicate the type of waste and compactors to reduce the size of the waste. One (1) container will be a refrigerated container in which waste that may cause unpleasant smells can be refrigerated and contained.

The waste disposal installation shall consist of at least the following equipment with a capacity in compliance with the 20 days disposal period:

- garbage compactor
- bale compactor
- glass crusher
- can crusher
- shredder
- wet food waste processing plant, including pulpers and water pressers with a piping system to storage silos of sufficient size.

A waste disposal area will be provided close to the waste disposal room. The supply crane as indicated in 221 will dispose the waste to the supply Vessel.

430 Electrical spaces

Top deck
- Battery room

SSED deckhouse MCC and trafo deck
- Dredge VSD and MCC room SB and PS
- LARS and mining support MCC room SB and PS
- LARS and mining support transformer room SB and PS

SSED deckhouse control deck
- SSED winch control room SB and PS
- SSED plant control room
- Resistor rooms SB and PS

Upper tween deck
- Mooring room aft SB and PS containing the drives for the thrusters and mooring winches aft
- Accommodation Low Voltage switchboard room
- Engine room Low Voltage switchboard room SB and PS
- Battery room

- Process plant Low Voltage switchboard room aft SB (3B) and PS (3A)
- Process plant control room
- Process plant Low Voltage switchboard room forward SB (2B) and PS (2A)

- Mooring room forward SB and PS containing the drives for the thrusters and mooring winches forward

Lower tween decks
- Transformer room thrusters and mooring winches SB, centre and PS aft

- Engine room transformer room SB and PS
- Engine control room
- Engine room High Voltage switchboard room SB and PS

- Process plant High Voltage switchboard room aft SB (4B) and PS(4A)
- Process plant transformer room aft SB (2B) and PS(2A)
- Process plant High Voltage switchboard room forward SB (1B) and PS(1A)

- Transformer room thrusters and mooring winches SB, centre and PS fore

Switchboard rooms shall be provided with furniture and cabinets for adequate use of the switchboard rooms. Switchboard rooms that are air conditioned will be provided with linings and raised floors. The floor height will be sufficient to allow for proper routing of power cables below the floor. Oil resistant, insulating matting shall be provided in the front and back of switchboards.

450 Workshops and stores

The following workshops and stores will be provided.

Main deck
- SSED workshop
- Spares stores
- General stores as per General Arrangement Plan
- Shot blasting room
- Pipe shop
- Welding shop
- Nuclear store
- Gas bottle store (Ac/Ox bottles)
- Chemical store for the desalination plant
- Paint store

Upper tween deck
- SSED stores
- Process plant mechanical workshop
- Process plant electrical workshop
- Process plant workshop fore
- Equipment store
- Stores foreship

Lower tween deck
- Engine room mechanical workshop
- Engine room electrical workshop
- Engine room store

The workshops and stores shall be arranged with the following equipment:
- workbenches with drawers vices
- pipe bending machines and pipe clamps
- electrically driven screw cutting lathes
- electrically driven hack-saw machine
- electrically driven pillar drilling machines
- electrically driven milling machines
- double wheel grinders on pedestal
- electric welding rectifiers
- sufficient sets of welding equipment
- a cleaning table in way of the separators

- steel racks for storing of spare part boxes, etc
- cupboards and cabinets for storage of equipment and tools
- plastic boxes for small parts

460 Insulation

All spaces are insulated if required by Solas regulations concerning the fire integrity of bulkheads and decks. These boundaries are insulated with Rockwool panels of the required thickness, covered with wire gauge and finished with galvanized metal sheeting or panelling, depending on location.

The weather exposed outside walls and weather exposed decks and ceilings of cabins, mess rooms, recreation rooms, alleyways, offices, lockers, galley, change rooms, sanitary spaces, dry provision store, hospital, AC room, switchboard rooms, ECR are provided with thermal insulation by means of glass wool panels, fixed with clips, finished with panelling. Deck beams and stiffeners are clad with glass wool slabs. Wheelhouse walls up to the window level and the wheelhouse ceiling and walls down to window level are insulated in the same way.

The accommodation spaces are insulated against heat and noise with thermal and noise insulation and special deck covering. Specification of this deck covering will follow from the noise and vibration analysis. In way of insulated walls, a watertight strip is fitted in front of the insulation in such a way that liquids on the floor of the relevant space may not affect the insulation.

Heated tank surfaces within the engine room shall be insulated with glass wool between stiffeners, finished with galvanised sheet steel, all shall be compatible with fuel oil leakage.

5 ELECTRICAL INSTALLATION

501 Electrical Installation

The electric power generation plant will be designed in compliance with the Class requirements and will comprise:

- six (6) main generator sets of 12930 kVA
- two (2) main generator sets of 6500 kVA
- one (1) emergency generator sets of 1250 kVA

The power consumption will be based on the final load balance, taking the proper electrical efficiencies and load and diversity factors into account.

The following voltage systems will be applied on board:

- AC 6600 V power system for main power generation and transport
- AC 4160 V power system to supply the mining HV installation
- AC 690 V power system for all major power consumers
- AC 415 V system for auxiliary power consumers
- AC 230 V system for hotel duties and lighting
- DC 24 V system for alarm, control and navigation applications

The frequency on board will be 50 Hz.

An emergency source of power will be provided in accordance with Class requirements with a capacity that is sufficient to start the Vessel from “dead ship”.

501.1 Design conditions

The electrical installation will be designed for an ambient inside temperature of no more than 45 °C in accordance with the IEC regulations.

Insulation class of electrical machines and equipment is Class F or better.
Temperature rise however will never exceed the allowable rise for Class F.
Power rating of all electric machines and equipment is S1 Continuous Duty, unless otherwise specified.
Electrical equipment shall have the following enclosure, depending on the location, unless otherwise specified in this specification.

- On outside deck	IP 67
- Electric motors on outside deck	IP 56
- Inside the process plant area	IP 56
- Inside the Vessel	IP 44
- Inside the ECR, inside switchboard rooms	IP 23
- Inside the accommodation	IP 23
- Inside the emergency generator room	IP 44

Switchboards and panels or other electrical apparatuses according to enclosure IP44 or better will have completely closed bottoms, with eventually MCT cable passages.

The electrical installations shall be compatible with the recommendations of the International Electro-technical Commission (IEC), in particular publication No. 60092. Consideration shall be given in the design of all equipment to the environmental conditions of shipboard service, and proven marine components shall be employed.

Requirements in IEC 60533, “Electromagnetic Compatibility of Electrical and Electronic Installations in Ships” (EMC), shall be fulfilled as a minimum.
All Electrical equipment, instruments, regulators etc. shall not be interfered with by induced current or radiation from other electrical or electronic equipment fitted onboard.

All electrical equipment shall be designed and rated for a humid, salt laden marine atmosphere (with vibration and acceleration) under continuous tropical conditions. Particular emphasis shall be placed on the quality of power supplies and electrical interference effects. The electrical system, equipment, components and materials shall be designed, produced and installed in accordance with specification, proven marine practice, Class requirements, Authority requirements and furthermore with rules and regulations as stated in the general section.
The electrical installation shall be designed to ensure proper operations when the Vessel is inclined as specified by the Class and regulatory body requirements.

Consideration shall be given in the design and construction to reliability, safety, flexibility, redundancy, high quality and reduced maintenance and service requirements.

501.2 Electrical system design

A complete load analysis shall be prepared for the main and the ship's service plants for each of the Vessel's functional modes. The accuracy of the load analysis shall be confirmed by observing and recording electrical loads at steady state conditions during sea trials.

The Vessel electrical system will be designed with separated electrical systems for the vessel, the mining equipment and the process plant. In each of these systems sufficient redundancy shall be incorporated to allow for a continuous mining process in every aspect. This redundancy is arranged by separating the power generation in a Starboard and Portside engine room which each feed the two main switchboards.

The layout of the Vessel allows for separated routing of cables for each of these systems through the SB and PS corridors at the side shell on the upper tween deck. At centre line a third corridor is created for cable routing. Location of the propulsion and mooring related cabling shall be in compliance with the Class requirements for Special Purpose Ships.

Each of the two main switchboards is provided with three bus-ties and the main switchboards are interconnected by means of a double bus-tie. In principle the Vessel will be operating with these two bus-ties open. If required these bus-ties can be closed for load sharing. In a similar way sequential bus-ties in the main switchboards can be closed, provided the short circuits allow for this operation.

The high voltage mining and process switchboards and the low voltage Vessel switchboards are fed directly from the bus bar in the main switchboard. To create redundancy each of these switchboards is provided with a supply from the opposite switchboard. In normal operation the circuit breakers are open but when required due to a failure in the primary feed circuit they can be closed to allow for continuation of the operation. Capacities of each switchboard is based on this back-up function.

501.2.1 Harmonic distortion

Equipment producing transient voltage, frequency and current variations is not to cause malfunction of other equipment on board, neither by conduction, induction or radiation. In distribution systems the total harmonic distortion in voltage waveform shall not exceed 5%, nor shall any single order harmonics exceed 3%.

An analysis of the total harmonic voltage distortion on the 6.6 kV and 4.16 kV network and the 690 V network shall be performed when several harmonic sources are present, to confirm that no harmonic filters are required, due to the use of active front end supplies for azimuth thruster drives, mooring winch drives and mining equipment and process plant equipment drives.

Maximum acceptable levels on the 6.6 kV and 4.16 kV network shall be documented harmless for the connected equipment and the maximum acceptable levels on the 690 V network shall be less than 5%. On site measurement shall also be taken on board the Vessel, with all machinery and equipment running, during sea trials, for comparison with the total harmonic voltage distortion calculation.

501.2.2 Short Circuit analysis

A short circuit study shall be performed by the electrical installation supplier to determine the maximum symmetrical and asymmetrical fault levels developed in the electrical AC system. Protective device evaluation analysis shall also be performed which shall compare the making and breaking ratings of the protective devices (fuses, breakers, etc.) to the fault currents they need to withstand. This evaluation shall determine if the system's protective devices can withstand the available short circuit duties that the system can deliver. If problem areas are revealed, recommendations shall be made and for corrections to the system deficiencies before they are implemented.

The study shall be based upon the single line diagram provided for the electrical system. Bus, distribution board and branch number identifications shall be assigned to the system for easy reference between the one-line diagram and the computer printouts.

Faults shall be simulated starting from the 6.6 kV generator bus including the 4.16 kV busses, 690 V busses, 415 V busses, 230 V busses and AC distribution boards.
A data reduction program shall be used to calculate the per unit impedance of each element in the system (cables, transformers, motors, etc.). Motor contributions to faults shall be modelled in conformance with the IEC 60363 standard.

A summary of short circuits shall be listed on a single line diagram for easy review.

501.2.3 Voltage drop

The design of the electric plant including generators, motors and controllers shall be co-ordinated to insure that the voltage dip, when starting the motors with the highest inrush current shall not exceed 15 percent of the rated voltage.

A voltage drop analysis during start of large AC motors shall be performed, to ensure that voltage dip during the starting period of such motors shall not cause disturbance to other loads on the AC system and that the voltage dip is within the Class requirement.

The minimum conductor size for power and lighting circuits shall be 2,5 mm^2. The maximum voltage drop from main switchboard to final consumers shall stay inside the class rules but as minimum will not exceed 6% of the nominal voltage.

501.2.4 Battery sizing

A battery sizing study shall be performed to determine the required minimum capacity for the various 24 V DC battery systems installed. The study shall also include the recommended charging rate. The intention is to make the 24 DC when required as much as possible locally from the 415 V or 690 V supplies.

501.2.5 Illumination intensity

An illumination intensity calculation shall be performed, to verify the required quantity of light fittings and floodlights. Calculations shall be performed for accommodation and technical rooms and for open decks. The required illumination intensities are specified in 540.1.

502 Main generators

Six (6) identical and inter-exchangeable self-regulating, self-excited brushless AC generators are installed in the engine room. Each generator is driven by a main engine. The generators are suitable for supplying a system with large consumers powered via frequency converters.

Main particulars

-	Output	11640	ekW
-	Speed	750	r.p.m.
-	Voltage	3x6600	Volt
-	Frequency	50	Hz
-	Excitation	brushless	
-	Class of insulation	according to H or F	
-	Temperature rise	according to F or B	
-	Duty rating	S1	
-	Degree of protection	IP55	
-	Anti-condensation heating	230	Volt
-	Ambient air temperature	45	° Celsius
-	Cooling	closed air circuit, freshwater cooled with built-up air / water heat exchanger	

Two (2) identical and inter-exchangeable self-regulating, self-excited brushless AC generators of reduced power are installed in the engine room for flexibility in the power generation. Each generator is driven by a main engine. The generators are suitable for supplying a system with large consumers powered via frequency converters.

Main particulars

-	Output	5820	ekW
-	Speed	750	r.p.m.
-	Voltage	3x6600	Volt
-	Frequency	50	Hz
-	Excitation	brushless	
-	Class of insulation	according to H	
-	Temperature rise	according to F	
-	Duty rating	S1	
-	Degree of protection	IP55	
-	Anti-condensation heating	230	Volt
-	Ambient air temperature	45	° Celsius
-	Cooling	closed air circuit, freshwater cooled with built-up air / water heat exchanger	

The main generators are suited for load sharing operation and will be delivered with separate current transformers for control and measurement.
The main generators will be supplied complete with bearing oil cooling system with redundant pumps and oil storage tank. The main generators shall be arranged with a conical shaft end. They shall be vacuum impregnated.

All generator sets are provided with at least the following monitoring and Instrumentation;
- 6 PT 100 elements for winding temperature
- leak water detector;
- 1 PT 100 in air inlet duct;
- 1 PT 100 in air outlet duct;
- thermometer on air in- and outlet;
- 1 PT 100 in each bearing;
- 1 LO flow sensor for each sleeve bearing

Regulating equipment (i.e. Voltage regulation) is installed in the engine control room. A phase symmetry detection is installed, switching off the generator excitation. Generator excitation will always be switched off in case of detection of short circuit. The des-excitation circuit is provided with wire break detection with alarming.

The main generators and associated controls shall be suitable for short-time parallel operation to each other for take-over purposes. Generator, automatic voltage control equipment, prime motor and governor as installed for all normal conditions shall be designed as to limit terminal voltage variations to minus 15% and plus 10% and to maintain terminal voltage under steady conditions from no-load to full-load with plus / minus 2,5% of the rated value.

504 Emergency / harbour generator

One (1) self-regulating, self-excited brushless AC generator is installed in the emergency generator room. The generator is driven by the emergency diesel engine.

<u>Main particulars</u>

-	Output	950	ekW
-	Speed	750	r.p.m.
-	Voltage	3x690	Volt
-	Frequency	50	Hz
-	Excitation	brushless	
-	Class of insulation	according to H	
-	Temperature rise	according to F	
-	Duty rating	S1	
-	Degree of protection	IP55	
-	Anti-condensation heating	230	Volt
-	Ambient air temperature	45	° Celsius
-	Cooling	air cooled by means of shaft driven fan; air inlet and outlet with louvres	

For emergency duty the generator shall start automatically on power failure at the emergency / harbour switchboard. The generator capacity shall be capable to supply amongst others:
- engine room fans
- process plant fans
- emergency fire-fighting pump
- water mist fire-fighting pump
- emergency bilge pump
- fuel pumps
- starting air compressor
- external communication equipment
- nautical equipment according to Class requirements
- internal communication equipment according to Class requirements
- the emergency lighting according to Class requirements

Feedback through the bus-tie circuit breaker to the 690 V switchboard will be possible. Emergency generator is vacuum impregnated.

505 *Electric motors*

Electric motors, generators, starters, controllers, and associated equipment shall be designed in close co-operation between the respective suppliers in order to obtain an integrated system design. Electric motors for auxiliaries shall be generally of the totally enclosed, self-ventilated, squirrel cage type. All electric motors shall be suitable for marine service in tropics.

Motors shall be single-speed direct-on-line (DOL) starting, having low starting current (maximum 7 x I n) and starting torque as required for the service except for motors of special proposal except where conditions require otherwise.

Motors > 500 kW shall be rated 6600 V, 3-phase 415 V and will be frequency controlled.
Motors < 7.5 kW may be rated for single or 3-phase 415 V, 50 Hz, whichever is suitable for the condition involved.

Motors driven by a frequency converter will be of a winding insulation of 2200 V and of the “form wound” winding execution.

- Motors shall be provided with suitably sized terminal type connection boxes fitted with gland(s) as required located on top or at the side of the motors.
- Penetrations for windings to terminal box shall be sealed to limit the temperature in the terminal box.
- All motors shall be fitted with radio interference suppressors.
- Electric motors shall be provided with preloaded ball bearings.
- Electric motors used for frequency-control shall be selected 15% bigger than for normal application of electric motors.
- Motors rated > 5 kW, which are mounted in wet areas (on deck and in steering gear room) shall be fitted with anti-condensation heating.
- The electric motors rated from 30 to 90 kW shall be fitted with a switchable anti-condensation heating.
- Electric motors > 90 kW shall be fitted with an automatic switch for anti-condensation heating.
- Electric motors (power > 500 kW) and generators with ball/roller bearings are provided with connections for SPM measurement.
- All electric motors are provided with hoisting eyes
- Propulsion and thruster motors are vacuum impregnated

506 *Switchboards*

506.1 *General*

The main and auxiliary switchboards and main power distribution panels are installed in designated high voltage and low voltage switchboard rooms.

The switchboards shall be of the clad metal, drip proof type with circuit breakers and distribution switchgear in screened metal cubicles. Ample room shall be provided within the switchboards to give accessibility for maintenance and adjustments. The fronts shall have hinged panel doors and handrails and the rear side will have detachable panels.

A protection system shall be provided to disconnect non-essential consumers in the event of overload of generators. All switchboards are to be provided with sufficient spare breakers. A synchronizer panel will be built in the front of the cabinet with indication of the synchronizer status.

The power generating system is controlled and monitored in the engine control room by means of the alarm and monitoring system. The system provides the following indications and controls:

- Power rating indication for each main generator and each auxiliary generator:
    - voltage
    - frequency
    - power
    - current
    - cos (phi)
- status of each generator
- current and power rating for all relevant electrical equipment
- status of all relevant breakers (on, off, interlocked, tripped)

506.2 6600 V switchboard

The Vessel will be provided with two (2) 6600 V main switchboard which are fed by the main generators. They shall be of the free-standing, "dead front end" type, marine type, for indoor use, consisting of enclosed breaker cubicles for each section. The main switchboards shall be installed in the engine switchboard room SB and PS.

The main switchboards mainly consists of:
- four (4) incoming sections of main generators, including synchronising equipment
- three (3) bus-tie section / synchronization sections
- two (2) bus-tie section / synchronization sections between the SB and PS switchboard
- outgoing sections to consumers
- outgoing sections to 4160 V or 690 V transformers

The 6.6 kV switchboards shall be constructed in accordance with the requirements of the Classification Society and arranged with necessary bus-tie breakers to allow the switchboards to be split. The main switchboards shall be air insulated and designed for ship operation and equipped with motor operated draw-out type vacuum circuit breakers of the trip free type and controlled by VMS and a manual control switch. All circuit breakers on the switchboards shall be able to withstand the maximum short circuit current. One spare semi-equipped circuit breaker cubicle shall be provided on each switchboard. The bus-tie breaker operations shall be operated by the VMS system in addition to local manual control.

The switchboard shall be designed for free standing mounting on vibration dampers. Every cubicle shall be divided into various compartments for both power equipment (bus-bar, feeder, circuit breaker, VT-compartments) and for auxiliaries (instrument compartment, wiring ducts for interconnections, etc.), which shall be segregated by metal partitions.

The switchboards shall be air insulated and arc proof and shall be tested according to IEC and Class requirement. Connection of cables shall be from the bottom only.

Indication lights for each breaker shall be fitted on the switchboard fronts.
Steam, water or oil lines shall not be located over or close to the switchboards. Air from ventilation ducts shall not be discharged directly onto the switchboards.

Switchboards and internal components shall be capable of withstanding shipboard vibration without damage or faulty operation.

The Vessel will be provided with four (4) 6600 V switchboard for the process plant installation which are fed by the main switchboard. They shall be of the free-standing, “dead front end” type, marine type, for indoor use, consisting of enclosed breaker cubicles for each section. The switchboards shall be installed in the process plant HV switchboard room aft SB and PS and process plant HV switchboard room forward SB and PS. Execution will be similar to the main switchboards.

506.3 4160 V switchboard

The Vessel will be provided with two (2) 4160 V switchboards for the mining installation which are fed by the main switchboard via a transformer. They shall be of the free-standing, “dead front end” type, marine type, for indoor use, consisting of enclosed breaker cubicles for each section. The switchboards shall be installed in the crawler switchboard room SB and PS. Execution will be similar to the main switchboards.

506.4 690 V switchboard

In total twenty-four (24) 690 V switchboards will be provided, divided as follows:
- sixteen (16) 690 V switchboards for the Vessel installation
- four (4) 690 V switchboards for the mining installation
- four (4) 690 V switchboards for the process plant installation

The switchboards are installed in separate switchboard rooms with dedicated functionality as indicated on the General Arrangement Plan.

Each switchboard mainly consists of:
- one (1) incoming sections from the transformer
- one (1) incoming sections from opposite switchboard
- outgoing sections to consumers
- outgoing sections to 690 / 415 V transformer

The 690 V switchboards shall in general be of the “dead front end” type, drip-proof construction, well ventilated and provided with lifting eyes. The mooring winches shall be connected to an “active front end” switchboard which is capable of feeding back the brake energy from the winches into the electrical system. The switchboards shall be air insulated and designed for ship operation. They shall be constructed of self-supporting metal clad single bus-bar panels. The switchboard shall be designed for free standing mounting on vibration dampers.

The front will have hinged panel doors and handrails and the rear side will have detachable panels. All parts shall be accessible for inspection, maintenance or replacement.

The switchboards shall be equipped with motor operated draw-out type vacuum circuit breakers of the trip free type and controlled by VMS and a manual control switch. All circuit breakers on the switchboards shall be able to withstand the maximum short circuit current. One spare semi-equipped circuit breaker cubicle shall be provided on each switchboard.

The switchboards shall be connected by two motor operated bus-tie breakers, one located in each switchboard. The bus-tie breakers shall normally be open. Interlocks shall be arranged to prevent paralleling of the 6.6 kV generators through the transformers. Bus-tie breaker and main breakers from transformers shall be motor-operated air circuit breakers of draw-out type. All draw-out type circuit breakers shall be removable from the panel front without de-energising the main bus.

The switchboards shall be tested according to IEC and Class requirements. Connection of cables shall be from the bottom only.

506.5 415 V switchboard

In total six (6) 415 V switchboards will be provided for the process plant installation. The remaining small 415 switchboards are supplied from the 690 V switchboards. The switchboards are installed in separate switchboard rooms with dedicated functionality as indicated on the General Arrangement Plan.

Each switchboard mainly consists of:
- one (1) incoming section from the transformer
- one (1) incoming section from opposite switchboard
- outgoing sections to consumers
- outgoing sections to 230 V transformer

The 415 V switchboards shall be of dead front type, drip-proof construction, well ventilated and provided with lifting eyes. The switchboards shall be air insulated and designed for ship operation. They shall be constructed of self-supporting metal clad single bus-bar panels. The switchboard shall be designed for free standing mounting on vibration dampers. Further execution will be similar to the 690 V switchboards

506.6 230 V switchboard

In total ten (10) 230 Volt switchboards or distribution boards will be provided for the Vessel lighting. They shall be of the “dead front end” type, drip-proof construction, well ventilated and provided with lifting eyes. Further execution will be similar to the 415 V switchboards

506.7 UPS

A 230 V 50 Hz UPS system is provided for supply to all processors and computer systems. The UPS autonomy will be 30 minutes. A power balance for the UPS system will decide the final capacity of the UPS system. Switching to/from battery back-up, to/from static bypass has to be without any interruption in the power supply (i.e. floating switch-over).

The UPS system will be delivered complete with:
- rectifier-charger
- set of maintenance free batteries
- inverter
- main supply is from the 690 V switchboard
- back up supply from the 230 V ESB
- in case of failure or of overload of the UPS system, a static bypass is provided connecting the load directly to the back-up supply
- a mechanical bypass switch is provided for connecting the load manually to the main or bypass supply, enabling servicing the UPS system.
- alarm unit

Extra (free) sockets of the 230 V 50 Hz UPS system are provided :
- in the wheelhouse
- in the control rooms
- in the engine rooms for motor control systems
- in the mooring and propulsion rooms for motor control systems
- in the high voltage switchboard rooms

- in the low voltage switchboard rooms
- in the offices

Final number to be decided by the Owner

507 Transformers

All transformers shall be of the cast resin type. All power and lighting transformers shall be of the 3-phase marine type having insulation class H, temperature class F, IP 44 enclosure and designed for ambient temperature of 45°C. They shall be provided with an internal closed air circuit that is fresh water cooled by means of a built-up heat exchanger. They shall be installed in dry, clean and well ventilated rooms as indicated in the General Arrangement Plan.

Each transformer shall be delivered complete with monitoring equipment for temperature and leakage. All transformers shall be executed with 6x PT100 in each of the coils and 3x PT100 on the core hot spots.
Cable connection points shall be of copper. All transformers are provided with hoisting eyes.
The transformers' windings shall be vacuum pressure impregnated (VPI), shall resist moisture, sea air and oil vapours, and shall be braced to withstand the thermal and electromagnetic effects of short circuits.

Each transformer for distribution shall have capacity of 120% of the total load of the actual switchboard indicated in the electrical load analysis. No paralleling of transformers shall be allowed. The transformers shall be arranged with stand-still heating and automatic change over to standby transformer, should the supplying transformer fail. All transformers shall be approved by Class.

Two (2) amply sized transformers, 3x 6600 V / 3x 4160 V shall be provided for the supply to the crawler consumers.

Main particulars

- Output	6000	kVA
- Primary voltage	3x6600	Volt
- Secondary voltage	3x4160	Volt
- Frequency	50	Hz

Sixteen (16) amply sized transformers, 3x 6600 V / 3x690 V shall be provided for the supply to all 690 V consumers throughout the Vessel.

Main particulars

- Output	4000	kVA
- Primary voltage	3x6600	Volt
- Secondary voltage	3x690	Volt
- Frequency	50	Hz

Two (2) amply sized transformers, 3x 6600 V / 3x 690 V shall be provided for the supply to all 690 V consumers throughout the Vessel.

Main particulars

- Output	630	kVA
- Primary voltage	3x6600	Volt
- Secondary voltage	3x690	Volt
- Frequency	50	Hz

Four (4) amply sized transformers, 3x 6600 V / 3x 690 V shall be provided for the supply to the mooring system.

Main particulars

- Output	2000	kVA
- Primary voltage	3x6600	Volt
- Secondary voltage	3x690	Volt
- Frequency	50	Hz

Ten (10) amply sized transformers, 3x 690 V / 3x 230 V shall be provided for the supply to the 230 V lighting consumers throughout the Vessel.

Main particulars

- Output	approx. 40	kVA
- Primary voltage	3x690	Volt
- Secondary voltage	3x415	Volt
- Frequency	50	Hz

508 Starters

All motor starters shall be designed for marine application, withstanding the high moisture environment and normal shipboard vibration. All equipment in the motor starter shall be rated for an air temperature of 45º C.

All AC motor starters shall generally be of the direct-on-line type. Star/delta starters or “soft starters” with thyristors shall be used for large motors if the voltage drop on starting exceeds 15%.

Generally, starters shall contain:

- an isolating switch with locking device
- a magnetic contactor with auxiliary contacts
- a temperature compensated, thermal overload relay, with single phasing protection
- fault indication
- not ready for start indication
- stand still heating status indication
- necessary control relays
- a set of control fuses
- a control circuit step-down transformer
- control pushbuttons start/stop
- a running light
- a power indicating light
- a motor standstill heater on indicating light where applicable
- local-off-remote switch and suitable interface when the motor is controlled by the Vessel automation system
- an Am meter with operating scale indicating full load of the motor at 2/3 of the scale for each motor of 4 kW or more.

All AC motors starters shall be concentrated in motor control centres (MCC’s) as much as possible and practical.
Motor starters in MCC’s shall be the ‘draw-out’ type.
Where motors are controlled by MCC’s they shall be provided with local start/stop at the motor.

509 *Variable speed drives*

Various equipment (thrusters, mooring winches, pumps, etc) shall be driven by variable speed AC induction motors. Speed control of these motors shall be by means of Variable Speed Drives.
The drives shall be fresh water cooled, if not otherwise specified, and suitable for starting and speed regulation of the concerned electric motor. The speed controllers shall be complete with commutating reactors, surge suppression circuits, control relays, protection circuits, etc. The design of the speed controllers shall be such that harmonic distortion in the supply and torque pulsation in the motors is minimized.

Drives shall be mounted on shock absorbers in dedicated compartments as indicated on the General Arrangement Plan. The Variable Speed Drives shall be interfaced to the VMS showing all relevant parameters.

510 *Power Management System*

The power management system controls the availability of power for all processes on the vessel. Main priority of the PMS is the safe guarding of power availability to all the ship related systems. The second priority is to maintain the best economically operating solution under all circumstances.

The vessels generators are in automatic mode started and stopped and connected in such a way that the maximum short circuit capacity of the switchboard is never compromised.

The PMS also controls the power availability of power reduction to all systems and safeguards the interconnection of all HV and LV switchboards.

The PMS has three modes of operandi :
- Manual mode (safety signals and interconnections of the individual groups stay active).
- Semi-automatic where each power distribution setting needs to be approved and priorities can be adapted
- automatic mode where the system is deciding by itself based on pre-determined settings and limits what action is to do in order to maintain a safe vessel situation and economically operating process.

In case of power shortage the PMS will determine which systems will be switched of (non-preference) based on a prescribed list.

In case of a generator failure or unwanted disconnecting of a part of the main switchboard the PMS will make power available and restore power on that part of the switchboard unless that part of the switchboard is faulty in that case the PMS will restore as far as possible in the electric installation the power to the consumers on a LV level or HV drive level.

The PMS exists of two PLC systems (one mounted in the starboard halve and one mounted in the PS halve of the HV SWB) of which one is operating and one is hot stand by. All HV contactors, circuit breakers in the switchboard are executed with a protection relay and these are all connected together with the PLC systems in an closed Ethernet ring. Each bus bar connection and each generator connection is executed with a synchronizer and these are also controlled by the PMS

The PMS is also connected to the glass fiber ring of the vessel management system and via this to the Process management system and receives the operational power requests via this connection.

514 Auxiliary distribution system

514.1 Battery system

A 24 V DC lead acid battery system (maintenance free) with distribution board, supply rectifier with alarm contact for under voltage and charger failure connected to alarm system and battery charger shall be installed in the battery room to supply:

- diesel control, alarm and indication systems
- thruster emergency control
- alarm systems
- communication systems
- navigation aids
- miscellaneous small 24 V DC consumers

514.2 Shore supply

No shore supply connections will be provided. In case the vessel would need external power since it is not capable of generating its own power, separate generator sets will be installed on board which will be connected to the main switchboard.

515 Emergency distribution system

The main bus system of the emergency switchboard shall be supplied from the 690 V 50 Hz switchboard and from the emergency generator. The emergency switchboard shall provide power to all consumers as required by Class and shall allow for starting up the Vessel after dead ship. In addition to this one fan for the ventilation of the dry concentrate area will be added to the emergency switchboard.

516 Electric cables and cable trays

516.1 Cables

All cables shall be of an approved marine type in compliance with Class requirements. Cables shall be of one piece from starter to motor. Two or more identical three core cables in parallel may be used for the larger capacities.

All cables shall have cores of stranded copper, with ethylene propylene rubber (EPR) or cross-linked polyethylene (XLPE) insulation with protective cover. Supply cables to electric motors shall be at least 2,5 mm². Maximum conductor temperature shall be in accordance with Class and Flag regulations. For thyristor controlled motors special cables shall be installed.

All cables shall be colour coded and shall have the following properties in case of fire:

- Halogen free
- Flame retarding
- Low smoke generation.

All small and high power cables shall be of the armoured type, signal cables shall be of the armoured and screened type. Multi-core cables with more than four (4) conductors shall have one (1) spare conductor for each five (5) conductors in use.

Cables shall as far as practical not be installed in areas exposed to the weather, heat dissipating surfaces or inaccessible spaces. Exposed runs, where necessary, shall be kept as short as possible.

Where cables penetrate watertight bulkheads or decks, watertight penetrations shall be provided (MCT type). The MCT type cable passages shall have the required fire resistance rating. At deck penetrations kick plates shall be provided.

Penetrations of multiple cables through watertight bulkheads and decks shall be made by means of “multi cable transits” type Brattberg, Hawke or equivalent.

516.2 Cable trays

All cables are placed and fixed on cable trays. For fixing the cables, cable trays of the ladder type are used. Special attention will be paid to the running of the trays, concerning leakage from pipe systems, hoisting possibilities and maintenance areas. The cables on the cable trays will be mounted according to the cable class specifications. HV cables separate from LV cables and the LV cables classes (power 50Hz, signal 230 or lower, and digital connection cables) separated by at least 25cm. Outgoing cables of frequency converters to be mounted on separate cable trays. If not completely possible parallel running within 25 cm of frequency converter output cables with signal or digital cables for over more than 1 meter is not allowed

To support cable runs the following systems shall be used:
- ladder tray (main runs more than six (6) cables, maximum two (2) layers per tray)
- strip or rod type, galvanised perforated tray (auxiliary runs, maximum six (6) cables)
- galvanised steel pipes (on weather exposed areas and under floor plates)

The cable trays shall be fitted by welded hangers against beams or frames to allow for installation of the cables on top of the tray. Cable trays with a width exceeding 440 mm have rungs with angle bar section. Bending radii of the cable trays shall be sufficiently large to suit the size of the cables.
Cables shall in general be secured with ultraviolet resistant tie raps. Where required by Class additional stainless steel ties are provided. When cables are installed on vertical trays or under the tray they shall also be secured every meter with plastic covered buckle band.

In general cables must run underdecks. Cables on deck and cables needing mechanical protection are placed in galvanized, solid drawn steel pipes. To protect the cables running in cable pipes from damage, the ends of the pipes shall be fitted with PVC inserts. Cables running in oil polluted area’s shall have an oil resistant poly propylene outer sheet.
Crossing cable trays shall have different levels (at least 200 mm distance).

Measuring, network and control cables are fitted separately from power cables. PLC network cables are laid in galvanised steel pipes, also inside the Vessel, in order to protect the cable.

517 Distribution panels

Power consumers not directly connected to the main switchboard and emergency switchboard will be grouped and supplied from power distribution panels/motor control centres with manually operated breakers for outgoing groups. Distribution panels may also be installed in a part of another switchboard, in e.g. the auxiliary switchboards. In that case isolation switches are installed, for maximum 12 outgoing groups.

Distribution panels will be made of steel sheeting or reinforced synthetic materials, of the totally enclosed design, and will be provided with a main switch in the supply. The protection class will be at least IP 55 for spaces which are likely to be subjected to water washing and high pressure cleaning. For other spaces IP 23 will suffice.