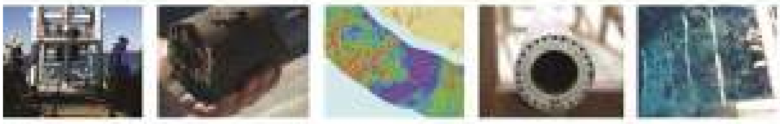

PRE-FEASABILITY STUDY

OFFSHORE IRON SANDS PROJECT

July 10th 2013	PFS	ST/TC/MB/AS/DD/RT/MK	ASt	TC
Date	Designation	Writers	Checked by	Approved
Revision		2		
Document Number		TTR-01-REP-001		

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Glossary of Terms

AHT: Anchor-Handling Tug

AHV: Anchor Handling Vessel

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

EEZA: Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012

FMP: Flow Moisture Point

FOOS: First Ore on Ship

FPSO: Floating Production, Storage and Offloading Vessel

FSO: Floating Storage and Offloading Vessel

HAZOP: Hazard and Operability Study

HFO: Heavy Fuel Oil

HPF: Hyperbaric Pressure Filter

IMS: Intermediate Magnetic Separation

IMS: Intermediate Magnetic Separators

ITP: Inspection and Test Plan

JORC: Joint Ore Reserves Committee Code

LARS: Launch and Recovery System (for SMT)

LIMS: Low Intensity Magnetic Separator

MIMS: Medium Intensity Magnetic Separator

MCC: Motor Control Centre

NPV: Net Present Value

NZDS: New Zealand Diving and Salvage Limited

OGV: Ocean Going Vessel

OPEX: Operating Expenditure

PFD: Process Flow Diagram

PFS: Preliminary 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

SMT: Sea floor Mining Tool

SOLAS: Safety of Life at Sea

SONAR: Sound Navigation and Ranging

SOP`s: Standard Operating Procedures

TSHD: Trailer Suction Hopper Dredge

TTR: Trans-Tasman Resources Limited

VTM: Vanadium Titano-magnetite

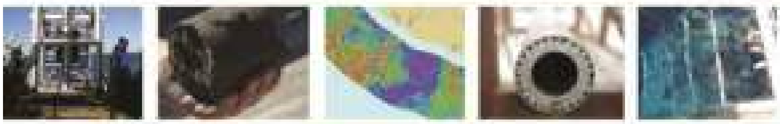
VTS: Vertical Transport System (ROM Hoses to SMT)

WBS: Work Breakdown Structure

STB: South Taranaki Bight

SSC: Suspended Sand Concentration

SSED: Submerged Sediment Extraction Device



1. EXECUTIVE SUMMARY

The technical and financial evaluation in this Preliminary Feasibility Study ("PFS") has concluded, based on the information currently available, that the project is economically viable and robust and that further project development is justified. The current set of current productivity assumptions, (Module 1), deliver a project post-tax Net Present Value ("NPV") of US$339 million at a 10% discount rate, based on a discounted cash flow model. Trans-Tasman Resources Limited (TTR) is currently working with its technology provider IHC to improve these assumptions and take new higher productivity assumptions as the basis of design for the Bankable feasibility Study (BFS). Should these assumptions be realised the NPV could increase to US$582-632 million for module 1.

The project is potentially highly profitable with a discounted payback (based on NPV) in approximately 6.5 years.

The financial analysis, (Module 1), of the project yields the following[1]:

- Project capital cost of US$576 million;
- Operating costs estimated at approximately US$35/t (rounded, excluding freight costs) on average over first 10 years of operations;
- Total revenue estimated at US$3.1 billion (rounded) in the first 10 years;
- Total direct operating costs (including overheads but excluding marketing costs, royalties and freight costs) are estimated at US$1.2 billion(rounded) in the first 10 years;
- EBITDA estimated at US$1.38 billion (rounded) in the first 10 years; and
- Net Profit after Tax estimated at US$519 million (rounded) in the first 10 years.

The financial outcomes detailed above reflect the results of the implementation of a single integrated vessel. The project solution detailed within this PFS has the potential to be scaled by adding additional integrated vessels.

[1] 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 Pre-Feasibility Report has been compiled by a select TTR team presenting a viable option for a project accomplishing the extraction and processing of iron ore deposits in tenements located off the West coast of New Zealand's North Island. This report details the technical and economic evaluation of an integrated mining solution over the existing multiple vessel solution as presented by Technip in an earlier report. In order to maintain continuity and consistency this report uses and refers to information within the submitted Technip PFS report. The Executive Summary of the previous Technip report has been included as Appendix 19.1 of this report.

2.1 Purpose of the report

In April 2013 TTR, after the receipt of increased indicative Capex and Opex costs, concluded that the multi vessel solution as presented by Technip did not constitute a viable project. It became apparent that an integrated solution whereby the mining or extraction component together with the tailings management solution had to be incorporated into a single processing platform. TTR then embarked on an intense, focussed assessment of mature feasible extraction technologies and after a structured evaluation procedure decided on the IHC crawler technology as employed by De Beers Mining off the coast of Namibia.

This report has been prepared to outline the key technical and economic findings of the Pre-Feasibility Study work (PFS) undertaken directly by TTR in the evaluation of the integrated vessel solution. The PFS report has been prepared in recognition of the Australasian Code for reporting of Exploration Results, Mineral resources and Ore Reserves, The JORC Code 2012 Edition. In addition, the reporting requirements pursuant to the listing rules of the ASX and Regulatory Guidelines of the Australian Securities and Investments Commission (ASIC) require mining companies comply with JORC.

2.2 Sources of information

The sources for the information contained within this report have been extracted from equipment designers and manufacturers, internationally recognised independent consulting and local engineering companies as engaged by TTR. The integrity and quality of the previous Technip study is recognised and as such relevant, verified information has also been retained and used from the previous Technip PFS report.

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 test work
- ASR – Environmental Study and Opinion letter
- Beca – Engineering Design and Verification Services.
- Canadian Shipping Lines (CSL) – Trans-Shipping Proposal
- DEME
- Fugro – Aeromagnetic Survey
- Golders Associates – Mineral Resource and Geology

- IHC Merwede – Mining Technology Design Support
- MTI – Dredging and Tailings Management
- Principia – Mooring Stability Study (Contracted directly by TPM)
- Sea Transport – Naval Architects - Engineering Design and Verification Services.
- Seabulk – Transhipment, Warehousing and De-watering
- Technip – Previous PFS Report
- Tennant Metals Pty. Ltd. – Marketing Report
- Transfield Worley – Risk Management and cost controlling

TTR has made all reasonable effort 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. Please see appendix 19.2– Verification Report.

All resource estimates and statements have been prepared by employees of Golder Associates Pty Ltd., who are totally independent of TTR.

2.3 Qualification and Experience

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

The key members were:

- Tim Crossley, CEO TTR,
- Andrew Stewart, CFO TTR,
- Shawn Thompson, Project Director TTR,
- Matt Brown, General Manager Exploration TTR,
- Andy Sommerville, General Manager - Environment and Approvals TTR,
- Rhys Thomas, Offshore Operations Manager TTR,
- Andre Mouton, Process Metallurgist TTR,
- Mahesh Khupse, Project Research Assistant TTR,
- Alvin Hung, Juniper Capital Partners
- Dr. John Feenan, Director IHC Mining,
- Laurens de Jonge, Manager IHC Mining,
- Ross Ballantyne, Manager Naval Architect Sea Transport,
- Albert Sedlmeyer, Senior Naval Architect Sea Transport
- Dave Debney, Capital Risk Specialist Transfield Worley,
- Chris Lee, Senior Process Engineer Beca.

Curriculum Vitae of the above personnel are provided in Section 19.3 of this report.

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 CAPEX and OPEX 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 resource (as reported by Golders Associates),
- It is reasonable to expect that the stated metallurgical yield can be achieved using the proposed mining method and process,
- It is reasonable to expect that if implemented, the proposed mining method has the capability of mining 39Mtpa of sediment (dry basis),
- It is reasonable to assume that if expected yields are achieved, the proposed processing facility is expected to produce 4Mtpa of iron ore 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 test work 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 4Mtpa production of concentrate grading 56% to 57% Fe, the estimated NPV is US$339 million for a Capex of US$576 million. The projected average FOB cash cost average over the first 10 years is estimated at approximately US$35/t of concentrate.

3. PROJECT SUMMARY

3.1 Project Description

TTR (TTR) is a privately owned New Zealand company, established in September 2007 to explore assess and uncover the potential of the rich offshore iron ore deposits off the west coast of the North Island of New Zealand. TTR's ambition is to provide Asian markets with a reliable supply of low cost iron ore and build mutually beneficial strategic long term partnerships with steel manufacturers. TTR is committed to conduct all its activities in a safe and environmentally sustainable manner and to proactively engage with the local communities on all relevant economic, environmental and social issues.

The aim of this pre-feasibility study is to estimate and economically evaluate selected techniques and methods for:

- The mining and processing of the offshore iron ore which could feed multiple blast furnaces to produce a Vanadium Titano-magnetite (VTM) concentrate at 56-57% Fe.
- The shipment to world markets of this VTM concentrate.
- Provision of a Capex estimate at +/- 30% accuracy.

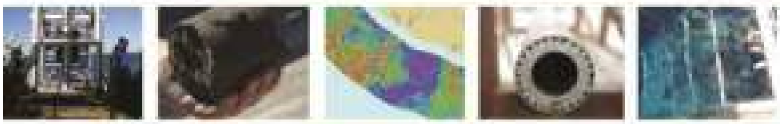
3.2 Option Overview

In addition to the dredging option review commissioned during the initial PFS study (see appendix 19.17) that evaluated different dredging options, different extraction/mining system options were evaluated during the later IHC workshop in order to identify the most suitable solution for TTR's activities. Mining systems were weighted on a system level not on specific included equipment. Mining systems evaluated include: crawler, trailer suction hopper dredge (TSHD), drill, Ro-Ro, and point suction dredge and measured against mining efficiency, depth from 30-45 m, capacity, mining flexibility, logistic complexity, and tailings dispersal parameterss.

Parameterss	Weight Factor	Crawler	TSHD	Drill	Ro-Ro	PSD
Mining Efficiency	7	9	8	5	4	6
Depth (30-45 m)	10	10	10	0	8	10
Capacity	10	9	10	4	8	10
Mining Flexibility (sediment thickness, direction, location, depth soil conditions, etc.)	8	9	9	9	7	5
Logistic Complexity Integrated vessel multi system	7	9	5	9	5	8
Tailings	10	9	5	9	5	9
Total (Sum of Rating x Factor)		478	413	300	329	428

Table 3-1 Option Decision Analysis

Results from the structured decision analysis indicated that the drill, Ro-Ro, and PSD were not viable options.



The TSHD, as detailed within the initial version of the PFS report and the integrated crawler as detailed within this latest version of the PFS were found to be the best two options for TTR's mining operations. Main differences between the two systems include: scalability, tailing dispersal, operation logistics, and mineral processing. The TSHD is easily scalable, whereas, the crawler is reaching its limits with regards to operational size. In regards to tailings dispersal, a TSHD system cannot control the tailings dispersion and has the ability to generate large plumes. On the other hand, crawlers, by their intensive extraction will allow the return of the tailings 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 on another vessel, whereas, the crawler can be incorporated into an integrated production vessel.

It is TTR's conclusion that an integrated sediment extraction device, i.e. a crawler system, provides the best overall mining solution particularly because it facilitates an acceptable tailings management strategy.

An integrated sediment extraction system such as the assessed sea bed crawler will be lowered to the sea bed and controlled remotely from the surface support vessel. The crawler is typically fitted with highly accurate acoustic sea bed navigation and imaging system, and extracts sediment by systematically advancing along a pre-determined 'lane'. Unconsolidated surface sediment is pumped to the vessel for further processing or beneficiation. These extraction devices are capable of achieving a more thorough coverage of the target area, thus avoiding the need for re-mining. The integrated mining vessel will employ a dynamic mooring system, i.e. using multi-anchor systems to locate itself precisely over a specified extraction area.

3.3 Project Geology

Titano-magnetite iron sand forms Quaternary[2] onshore beach and dune deposits and offshore marine deposits along 480 km of coastline from Kaipara Harbour 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 titano-magnetite mineral is sourced from the Quaternary volcanic rocks of western Taranaki and the volcanic rocks of the Taupo Volcanic Zone, transported to the coast by rivers, along the coast by shallow marine long shore currents, and subsequently concentrated by wave and wind 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 dunes that were constructed at a time of lower sea level. These paleo-dune features where part of an ancient river system in which dunes formed contemporaneous at the mouth of the river(s) and the coast line. The rivers are locally controlled by active faulting with the iron sands within the river channels and dunes partially reworked by currents and long shore drift and are re-deposited along the shore lines of the transgressing sea.

[2] 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.

3.4 Exploration Summary

TTR have undertaken extensive exploration activities within its tenement areas, and in particular within the identified mining area. Exploration activities included, aeromagnetic surveying, 2D seismic surveying, multiple programmes of shallow and deep drilling, and bulk metallurgical sampling. From these exploration activities TTR has been able to delineate a JORC compliant resource, using drilling methods that have been independently technically verified to enable representative sampling at depth of the titano-magnetite resource.

	Head Analysis		DTR Analysis	
	Drill Holes	Samples	Drill Holes	Samples
Area 2	497	2620		
Koitiata	44	205		
Proposed Mine Area			83	643

Table 3-2 Resource Model Area Data

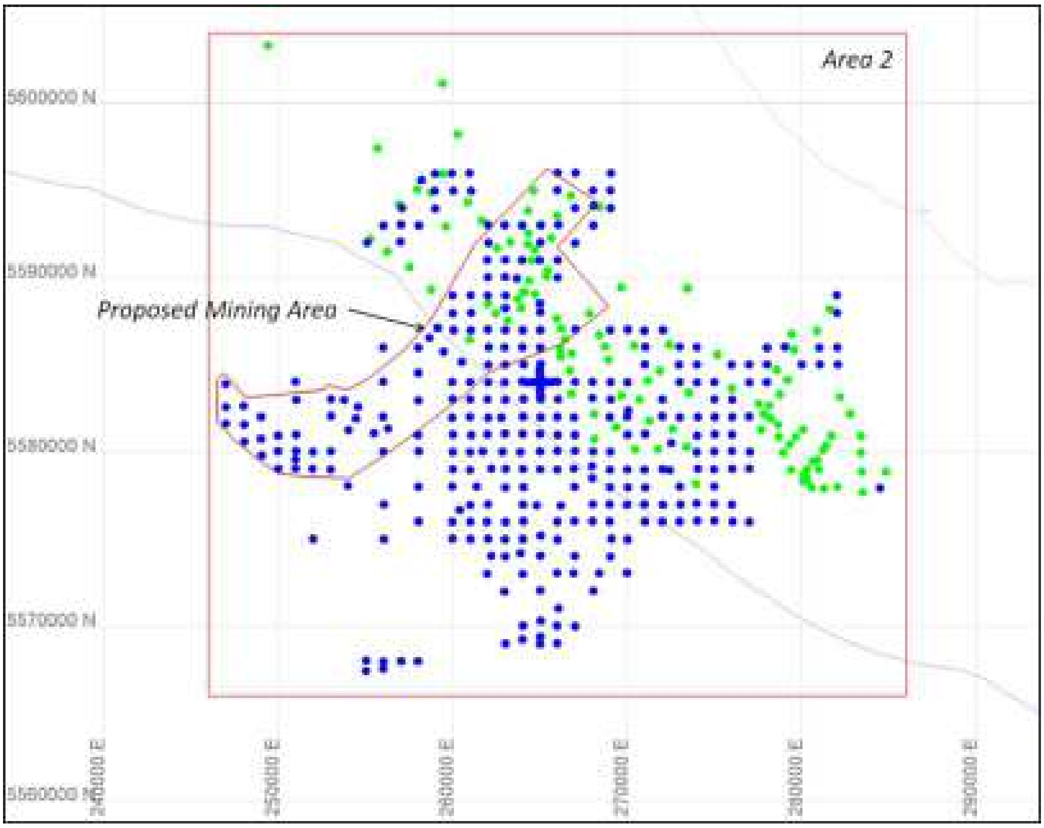


Figure 3-1 Drilling Locations

3.5 Mineral Resource Definition

Golder Associates Pty Ltd (Golder) was initially commissioned by TTR assist with the development of TTR's iron sand project in New Zealand in 2009. In November 2009 an in-situ maiden resource of 1040 Mt at 5.88% Fe was defined. Golder (2009) In July 2011, after additional drilling, the resource was updated to 2121 Mt at 5.64% Fe (Golder, 2011).

The TTR resource estimates were classified in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC, 2012) as Indicated and Inferred based on drill holes available as of 20 November 2012 and:

- The physical recovery has been applied to the models;
- Head grades and tonnages are for all material less than 2 mm in diaMetre;
- Concentrate grades are for the magnetically recoverable portion of the sample;
- Concentrate tonnage is calculated from the head tonnage and DTR;
- The *in situ* resource model has been reported at a 3.5% DTR cut-off grade where DTR analyses are available within the proposed mining area. 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.

TTR's Mineral Resource estimate is presented below in Table 3-3. The Mineral Resource is not believed to be materially affected by any known environmental, permitting, legal, title, taxation, socio-economic, marketing, political or other relevant factors.

Category	***In situ* Concentrate Tonnes**	**Fe%**	**P%**	**SiO_2%**	**Al_2O_3%**	**Ti**
Indicated	47.4	57.35	0.108	3.46	3.64	5.10
Inferred	32.5	57.00	0.111	3.85	3.68	5.08
Total	**79.9**	**57.21**	**0.109**	**3.62**	**3.65**	**5.09**

Table 3-3 Summary of the JORC *in situ* mineral resource at a cut-off grade of 3.5% DTR

At time of the PFS write up a review of the "*in situ*" bulk density[3] was undertaken. TTR believes that the "*in situ*" bulk density used to estimate the mineral resource has potentially under estimated the bulk density by approximately 8% to 10%. This updated assumption on density will be assessed and if ascertained will be corrected and reported in late Q3 as part of the company releasing a new JORC compliant Resource Statement and Ore Reserve.

3.6 Metallurgical Test work

[3] Bulk density implies the density of extractable volumes of sediment inclusive of voids. The in-situ density includes the void and grain boundary water present in the sediment in its natural state. Whilst the latter is important for estimation of the tonnage of material to be moved during mining, for resource estimates, however, dry bulk density is required, Lipton, I. T. 2001, Measuring of Bulk Density for Resource Estimation, Aus MIM

The metallurgical test work was conducted in two phases:

- Stage 1 – Preliminary test work
- Stage 2 – Pilot plant test work

The purpose of the preliminary test work was to investigate the viability of upgrading the ore using conventional mineral sands processing methods and to determine the base parameterss required for the design of the process flow sheet. The purpose of the test work 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.

Initial test work focused on gravity separation as is commonly used at many existing mineral and iron sands operations. This initial test work 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.

The pilot plant test work concentrated on investigating the beneficiation of the ore using this magnetic separation approach. This report will focus on the test work conducted on the pilot plant.

3.7 Operational Description

3.7.1 Integrated System

The selected integrated solution is based on a single FPSO, (Floating, Production, Storage and Offloading vessel) that will contain the mining, processing and tailings deposition mechanisms and a single Floating Storage and Offloading Vessel (FSO) that will trans-ship the concentrate from the FPSO onto standard commercial bulk cape-size vessels for delivery to end users.

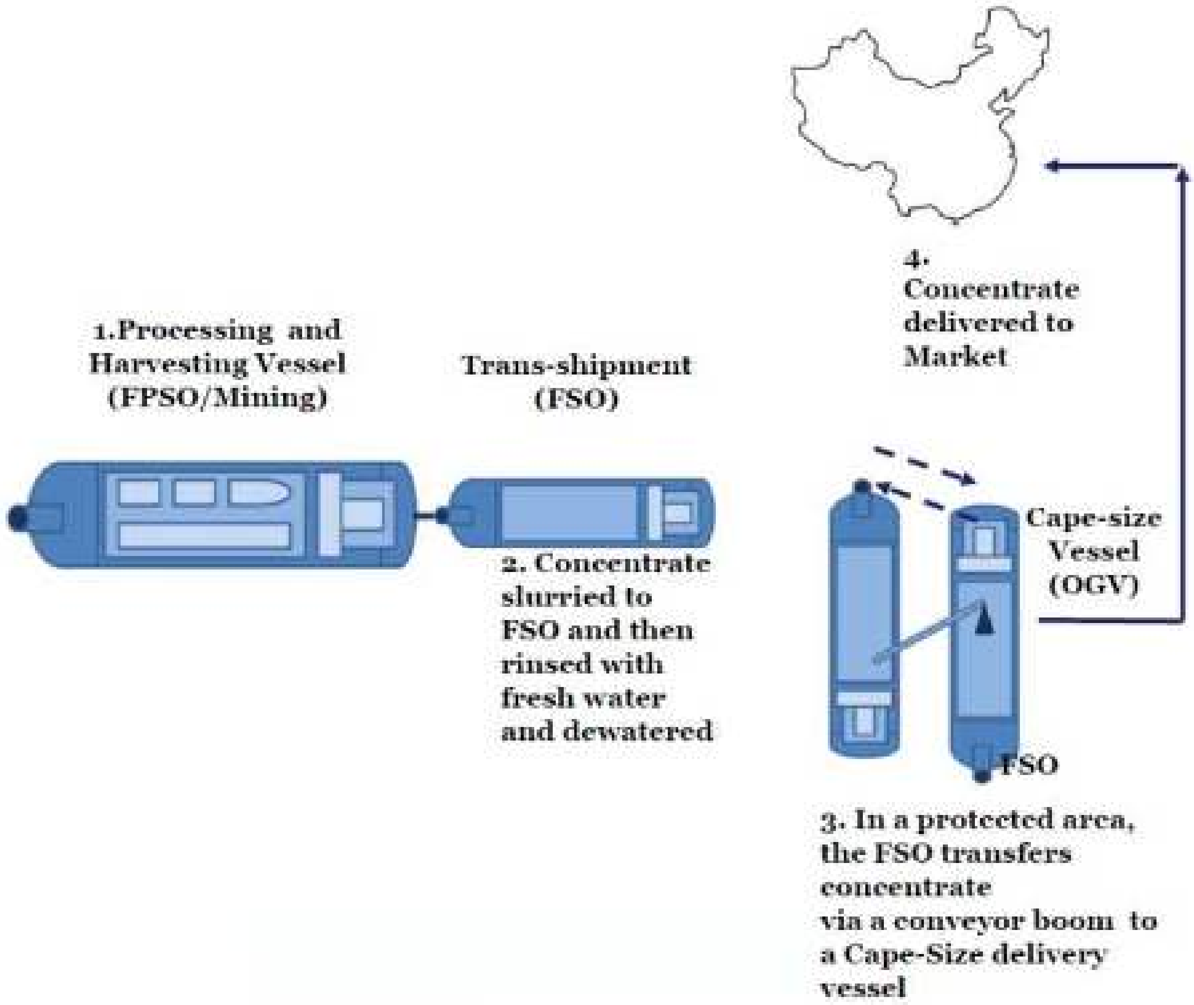


Figure 3-2 Offshore Operations

3.7.2 Sediment Extraction

A mobile subsea sediment extraction device (SSED) was selected as the preferred sediment extraction methodology to be integrated into the FPSO vessel.

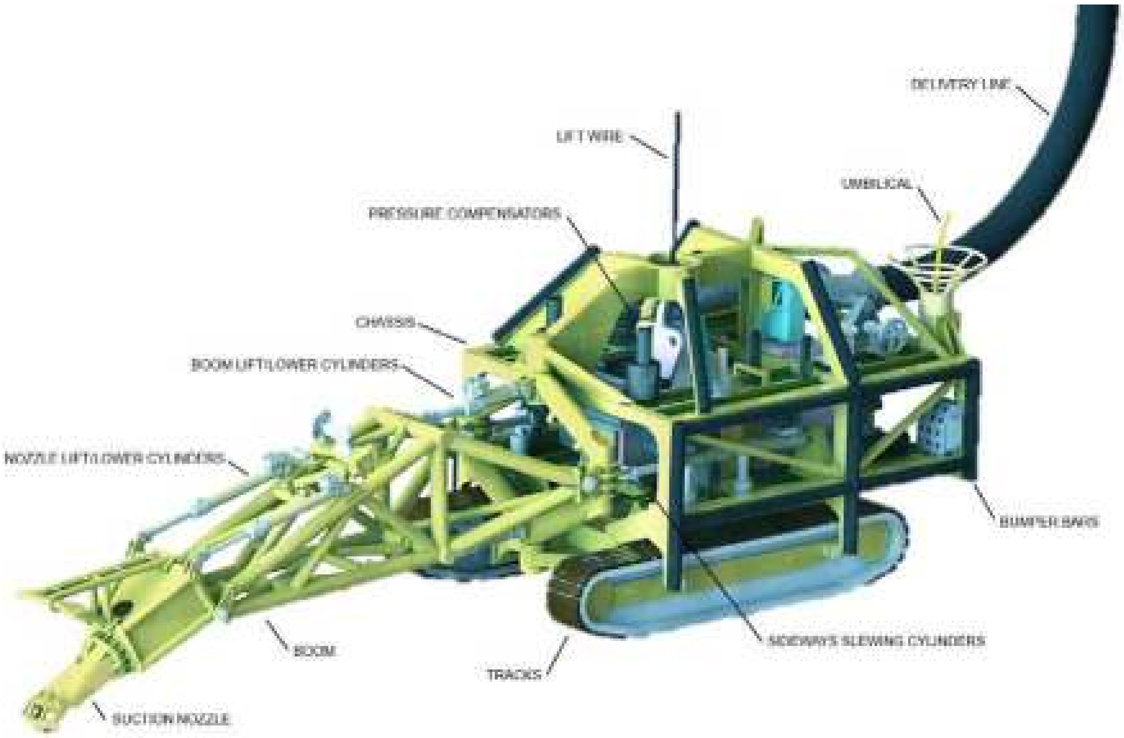


Figure 3-3 Subsea Sediment Extraction Device

During extraction operations the SSED is lowered onto the sea bed 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 m. At the end of each run the SSED will turn 180° and work the adjacent run, see Figure 3-4 below. The total width of the planned run of the SSED boom is 10 Metre wide allowing for a 1 Metre overlap on both sides of the run to minimize spill (losses).

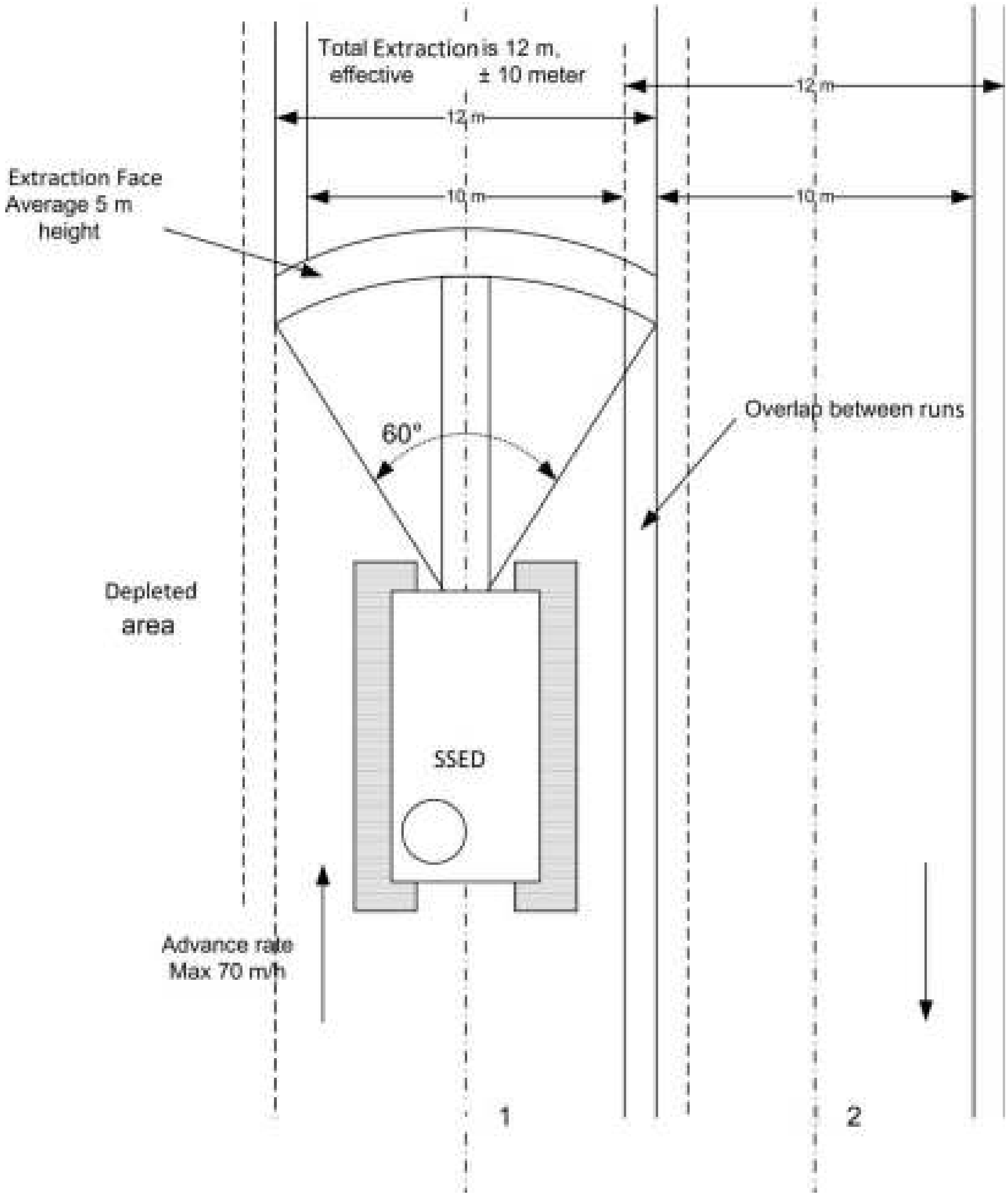


Figure 3-4 Typical SSED Run

The FPSO will follow the SSED at the advance rate of 70 m/hr, a 300x300 m block will typically be depleted in around 5 days, and thus the mooring system will normally span a 600x300m area, see Figure 3-5, allowing a period of 10 days between each mooring move.

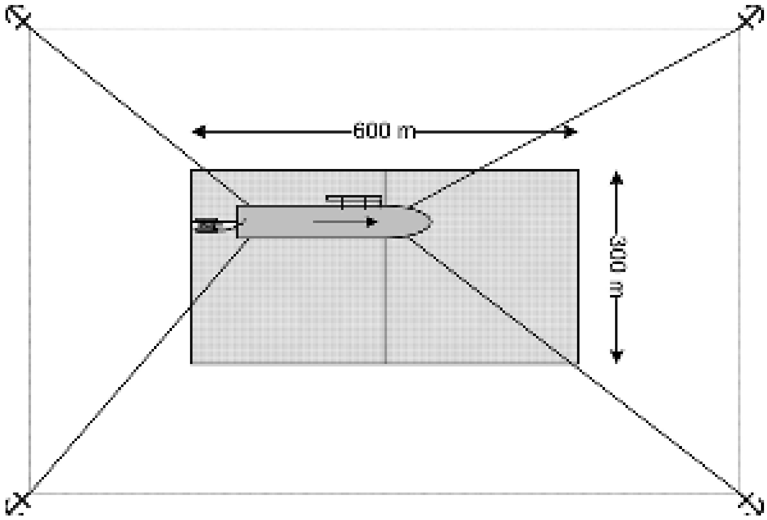


Figure 3-5 Mooring Layout

3.7.3 Processing Module

The metallurgical test work programmes demonstrated that the TTR Project deposits are required to 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 FPSO via an 800 mm ID rubber hose connected to the SSED. The design delivery rate of the SSED is 6,500 t/h solids. 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 4 mm such that the effective screen size of the ROM will be ~2 mm. 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 -2 mm 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].

[4] Gangue is the commercially worthless material that surrounds, or is closely mixed with, a wanted mineral.

- First Stage Grinding. The feed to the first stage (~1,420 t/h) will be ground to a P80 of nominally 130 µm, requiring a grinding energy of 15 kWh/t. It is envisaged that the first stage grinding duty will be accomplished using six 3 MW IsaMills™.
- 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.
- Second Stage Grinding. In the second stage grind the feed to the IsaMills™ will be ground from 130 µm to 75 µm in order to liberate the titano-magnetite sufficiently to achieve the final product specification on a consistent basis.
- 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 32,000 t. 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 60,000 t concentrate and return to the FPSO. Once the FSO is on station, it will connect to the FPSO via a floating slurry line.
- On-board the FPSO 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 fresh water tanks) to form a 50% by solids slurry. The fresh water is required to wash the concentrate, i.e. to reduce the chloride 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.
- During offloading of concentrate the process plant will continue to operate to produce the balance of the 60,000 t FSO cargo. Offloading to the FSO therefore will occur at double the production rate of the process plant (~1600 t/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 from the sea bed. The tailings waste water will be discharged via a second pipe along the tailings deposition pipe slightly higher than the solids discharge.

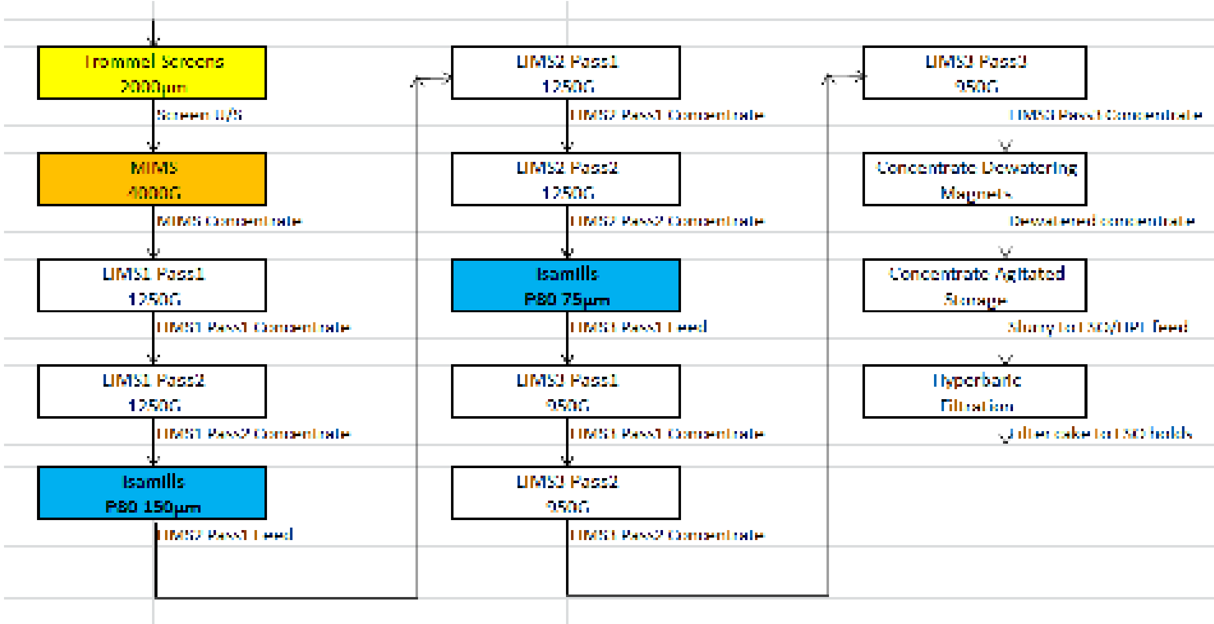


Table 3-4 Process Description

3.8 Auxiliary Services

3.8.1 Power Generation

The TTR project has specified 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 Heavy Fuel Oil (HFO).

The units also have:

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

Figure 3-6 FPSO Example

This vessel shown above in Figure 3-9 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 light-weight, high-efficiency, heavy-duty industrial gas turbine. Its special design features are high reliability and fuel flexibility. It is also designed for 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 TTR project has specified 10 separate containerised Reverse Osmosis plants, each with a production capacity of three thousand (3000) 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.

The sea water desalination component for the TTR project is detailed further in section 8.2 of this report.

3.9 Environmental

Before TTR can remove any material for any of its activities it will require authorisation from both the relevant legislation i.e. EEZ and Crown Minerals Act. TTR has exploration permits (as at the time of writing, one granted and three under application) to give it access to ironsand within NZ's territorial waters and one licence to prospect in NZ's exclusive economic zone (EEZ). These are all now managed under the Crown Minerals Act.

TTR's initial proposed mining area straddles the 12nm territorial boundary.

Any party wishing to undertake an activity within the territorial boundary requires environmental 'consents' under the Resource Management Act (**RMA**); and for activities outside the territorial boundary will require 'marine consents' under the Exclusive Economic and Continental Shelf (Environmental Effects) Act (**EEZA**). It is probable that initially TTR will only obtain environmental consents for activities in the EEZ. In that case there will be no activities within NZ's territory so there will be no requirement for RMA consents.

Both the RMA and EEZA are 'effects based' pieces of legislation. Effects based legislation requires that applicants for consents demonstrate that the activities will have low level of effect on the environment.

In order to be able to predict the effects of TTR's initial mining activities on the environment, it has had the environment in the South Taranaki Bight extensively studied. This work was designed to fill in the gaps of the existing knowledge. This work has entailed benthic, pore water chemistry, beach profile, noise, marine mammal aerial and visual sediment plume studies and also wave, current and sediment transport measurement. In order to establish the actual effects computer models of sediment plumes and waves have been built. Put together these will enable appropriate experts to determine the effects of the proposed activities on waves, shoreline erosion and the area's ecology, and determine the visual effects.

The timeframe for the consenting processes includes approximately 2 years of field work and reporting, of which the majority is already complete, followed by 7 to 12 months of consent processing work depending on the pathway followed.

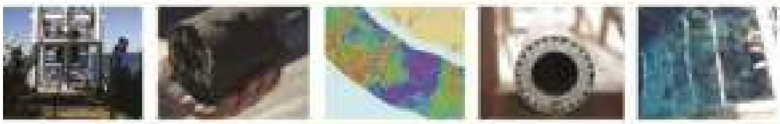
3.10 Capital Costs

Capital costs were estimated by TTR supported by various technical consultants and equipment providers. The estimates are summarised in Table 14-2CAPEX Breakdown and should be considered to be ±30% order of accuracy current at the second quarter of 2013.

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 will be evaluated during the BFS phase.

The following key assumptions have been made in regards to the capital cost.

- Contracted transfer and marine support operations;
- Owner processing;
- 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 as 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.



3.11 Operational Costs

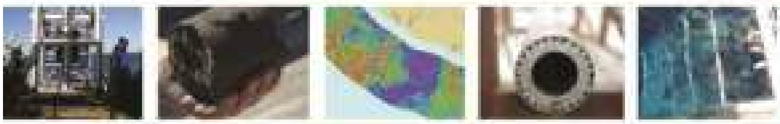
Operating costs have been estimated on the basis that all primary mining operations will be carried out by TTR. All transfer and support operation will be contracted out to third parties. Average operating cost (excluding freight) is estimated to be approximately US$35 per tonne to produce 57% Fe saleable product delivered FOB. A summary of operating costs elements are shown below under section 15.

3.12 Project Schedule

It is estimated that the project duration will be 22 months from project decision to mine (DTM). The major key elements of the project schedule are tabled below.

Task Name	Start	Duration	Finish
TTR-01-SS-001-R1 (WBS 130508)	**Wed 6/02/13**	**825 days**	**Mon 4/04/16**
Project Management	Mon 3/06/13	741 days	Mon 4/04/16
Project Management And Control	Mon 3/06/13	741 days	Mon 4/04/16
Project Operations	Mon 3/06/13	240 days	Fri 2/05/14
Maritime Operations & Licensing	Mon 3/06/13	220 days	Fri 4/04/14
Project Artefacts/Documents	Mon 3/06/13	320 days	Fri 22/08/14
Basis of Design (Early Confirmation)	Mon 3/06/13	81 days	Mon 23/09/13
BFS Report	**Thu 26/06/14**	[redacted]	**Thu 26/06/14**
Decision to Mine	**Fri 25/07/14**	[redacted]	**Fri 25/07/14**
Execution	**Mon 28/07/14**	**441 days**	**Mon 4/04/16**
Procurement	Mon 28/07/14	441 days	Mon 4/04/16
FSO Supply	Mon 20/10/14	12 mo	Fri 18/09/15
AHT Supply	Mon 20/10/14	12 mo	Fri 18/09/15
FPSO - Hull/Plant	Thu 5/02/15	81 days	Thu 28/05/15
Mining ROM	Mon 3/11/14	231 days	Mon 21/09/15
Process Plant	Fri 10/10/14	267 days	Mon 19/10/15
Power generation	Mon 28/07/14	261 days	Mon 27/07/15
Desalination	Thu 8/01/15	203 days	Mon 19/10/15
HDF - Concentrate Onloading	Mon 4/05/15	241 days	Mon 4/04/16
Construction	**Fri 6/03/15**	**282 days**	**Mon 4/04/16**
FPSO - Hull/Plant	Fri 6/03/15	190 days	Thu 26/11/15
FPSO Integration	Wed 1/04/15	264 days	Mon 4/04/16
Handover	**Mon 4/04/16**	[redacted]	**Mon 4/04/16**

Table 3-5 Project Schedule



3.13 Financial Analysis

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

The base-case key economic outcomes were:

- A NPV estimate of US$339 million;
- Total operating costs of approximately US$35/tonne (excluding freight costs) of product grading 57% Fe delivered free on board ("FOB"); and
- Capital discounted payback of approximately 6.5 years.

The financial outcomes from the studies of the TTR Offshore 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 60kt "Panamax" sized vessel.
- Flow-sheet has been compiled from laboratory test data and shall be confirmed by pilot plant 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 IsaMills™. designs.
- IsaMil™l grinding media assumption 330 g/t.

3.15 Forward Work Program

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 Test Works

A larger representative bulk sample in the order of 1500kg is required to undertake additional test works to confirm process equipment and PFDs and evaluate the concentrate product's sintering and pelletizing properties.

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

3.15.2 Minerals Processing Test Works

In addition to the minor recommendations contained within each of the PFS verification reports the following activities will be included within the next phase test work:

- Confirmation of optimum grind size for each grinding stage;
- Grinding circuit optimisation: 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 test work and pilot plant trials. The impact on product grade will be closely monitored. Also included under this program will be further grindability test work 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. A pilot scale IsaMill™ will be used for this purpose. The final concentrate produced will be provided to potential customers for sintering pot test work.
- 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 flow-sheet will be scheduled, including the use of sea water that will be used throughout the process plant.

In order to optimize the current flow-sheet 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;
- Evaluate the merits of installing a screen to scalp out the oversize (+300 μm) material from the IsaMill™ feed;
- Investigate different separation options for removing of the +2mm fraction;
- Materials handling test work: Samples will be collected at various stages of the pilot flow sheet for materials handling test work (TUNRA test work), including hydraulic conveying testing (slurry parameterss), and material flow property and related tests. This work is needed to determine the key slurry parameterss 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 FPSO 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 test work 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 TDS and other elements in the concentrator plant;
- In addition to the test work above, a continuous pilot plant run will be considered in order to de-risk the final process flow sheet. Additional bulk sample 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; and
- TTR has engaged LFJ Consulting to undertake a “Value in use Model” for the concentrate produced from the bulk sampling test works.

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 appreciate how this occurred and how the land and sea has 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 the constituent 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 off-shore, 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.

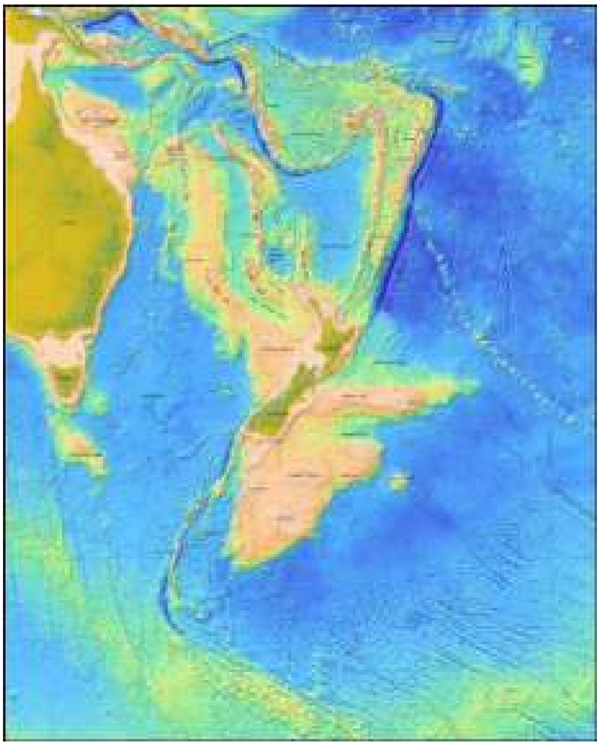


Figure 4-1New Zealand’s continental shelf and tectonic setting within the Australian and Pacific Plate

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. Titano-magnetite iron sand forms Quaternary onshore beach and dune deposits and offshore marine deposits along 480 km of coastline from Kaipara Harbour 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 titano-magnetite 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 long shore currents, and subsequently concentrated by wave and wind 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 titano-magnetite, orthopyroxene[5], clinopyroxene, horneblende[6] 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 titano-magnetite, 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 4-2Mt Taranaki volcano, the most recent feature of the Taranaki volcanics.

[5] The **pyroxenes** are a group of important rock-forming minerals found in many igneous and metamorphic rocks.

[6] Hornblende is a common constituent of many igneous and metamorphic rocks. Very dark brown to black hornblendes that contain titanium are ordinarily called basaltic hornblende

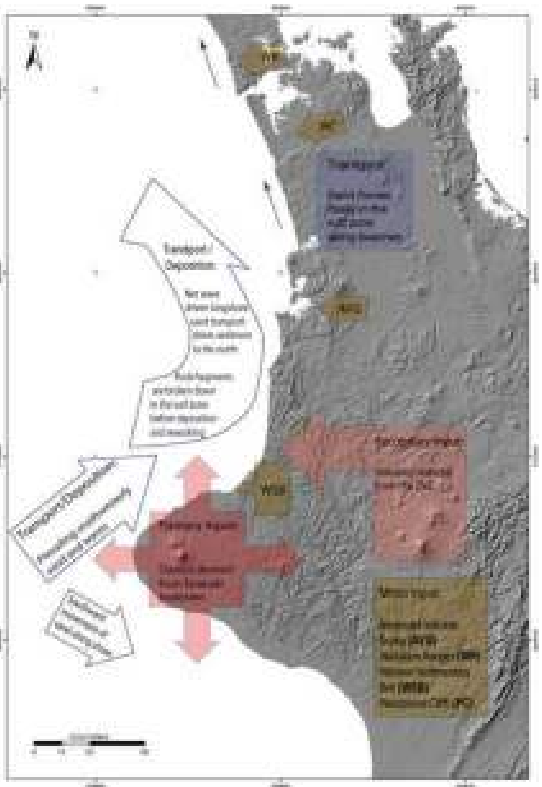


Figure 4-3The dominant controls on western coastal beach sand provenance and dispersal off the North Island (after Laurent, 2000).

The New Zealand offshore occurrence of iron sand have 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.

4.1.3 Iron sand Distribution

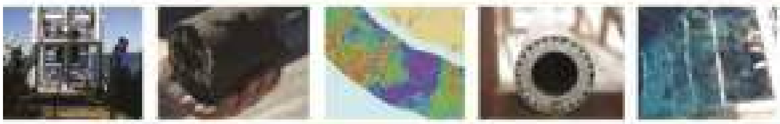
The highest reported surficial marine iron sand concentrations are typically associated with the inner shelf, shore-connected, Holocene muddy sand wedge that tapers seaward. This wedge offlaps onto an older gravelly sand unit, which is interpreted as a coarse grained transgressive lag deposit that ranges in thickness from about 2 to 5 m. The coarse grain sediments were deposited during the last marine transgression as the shoreface connected wave abrasion zone swept landwards during rising sea level. 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 stabilis ation of post glacial sea level some 7000 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 " 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 think. 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 titano-magnetite and Holocene marine sands and muds. However within areas of the mining area there are occurrences of iron sand which has 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 at a time of lower sea level. 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 coast line. The rivers are locally controlled by active faulting with the iron sands within the river channels and dunes partially reworked by currents and long shore drift and are re-deposited along the shore lines of the transgressing sea. Figure 4-4 shows a schematic of how the offshore high grade deposits formed and subsequently were preserved and reworked.

Figure 4-4The south Taranaki coastline with iron sand concentrate at river / stream mouth. Tidal, wave and longshore drift enhancing the concentration of the beach deposit.



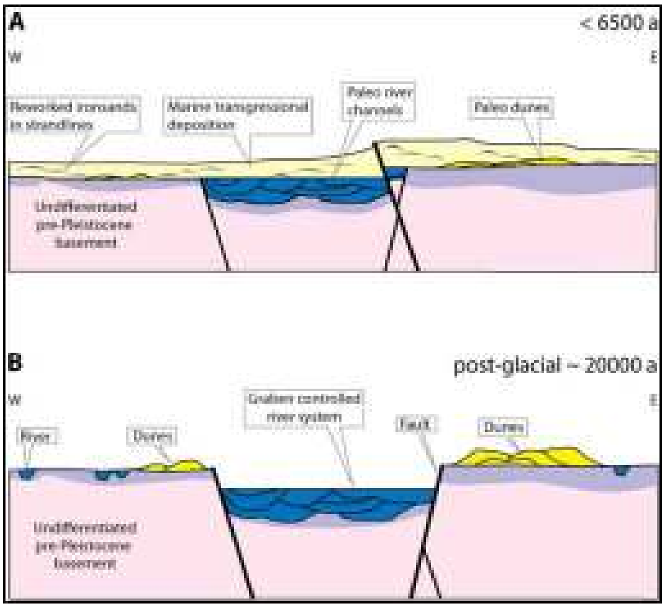


Figure 4-5Geological model of the offshore Titano-Magnetite mineral resource within the mining area

4.2 Tenements

TTR tenements are located on the west coast of the North Island of New Zealand to the north and south of Cape Egmont. TTR has been granted Exploration Permit *(EP) 54068* which covers part of the previous Prospecting Permit *(PP) 50383* off shore from Wanganui. The remainder of *(PP) 50383* is now covered by *(EP) 54270*, *(EP) 54271* and *(EP) 54272* currently awaiting approval by the New Zealand Petroleum and Minerals.

New Zealand approvals for the Prospecting, Exploration and Mining of Crown owned minerals resources is administered by New Zealand Petroleum and Minerals, (Ministry of Business, Innovation and Employment). TTR's mineral rights are assessed and granted under the Crown Minerals Act 1991, for the areas within the offshore 12 nautical mile limit, and the Continental Shelf Act 1964, which is outside the 12 nautical mile limit.

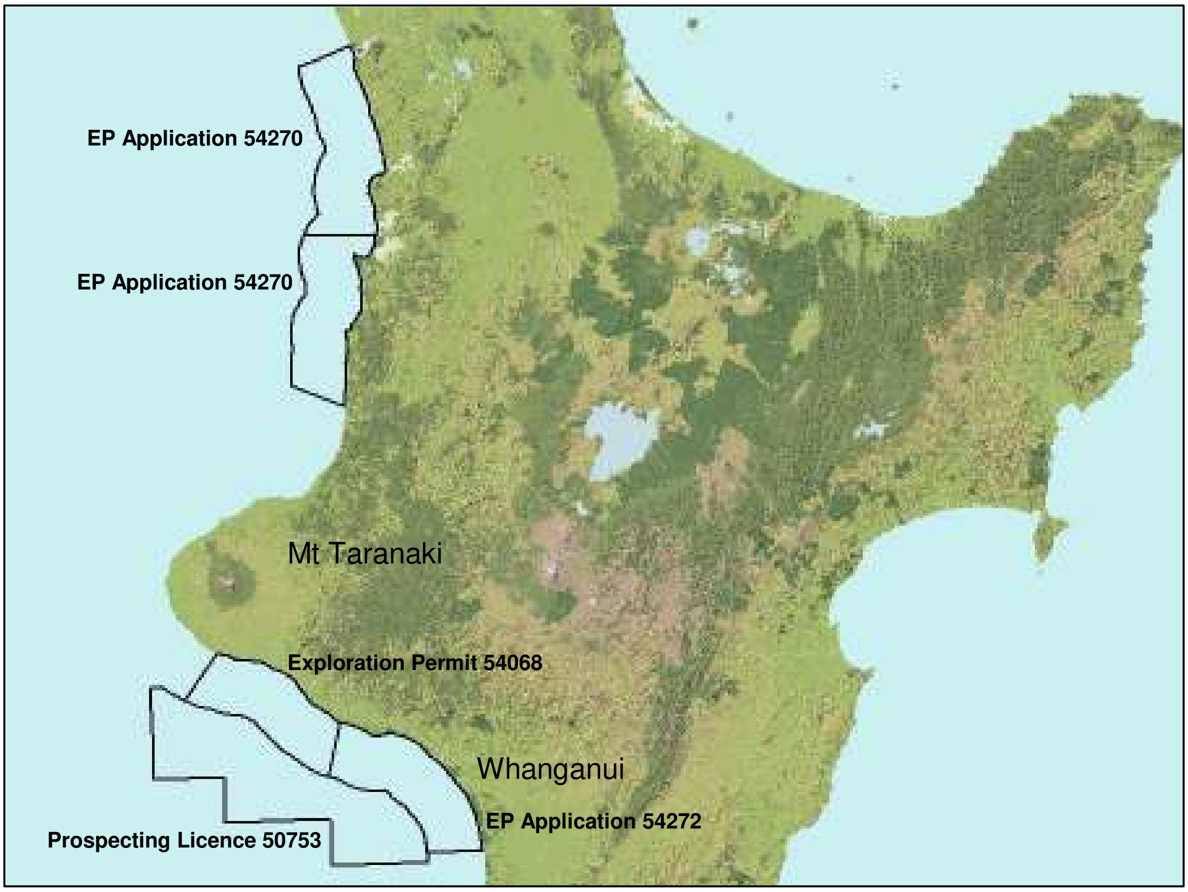


Figure 4-6Location of TTRs mineral exploration permits and licence

Prospecting Permits allow for more detailed investigation of the tenements to be undertaken. They are only applicable within the 12 nautical mile limit around New Zealand. Beyond this limit the Continental Shelf Act applies and a different licence must be applied for. TTR holds Continental Shelf License 50753 immediately south of *(EP) 54068* and *(EP) 54272*.

The table below lists the details held for each permit. The areas relating to the Pre-Feasibility Study relates to exploration permit *54068* and Continental Shelf Licence *50753*. Full license / permit documents for

CSA 50753 and *(EP) 54068* are appended. An overview of New Zealand's regulatory regime is included within Approvals Section of this study.

Number:	50753	54068	54270	54271	54272
Commodity:	MINERALS	MINERALS	MINERALS	MINERALS	MINERALS
Type:	Continental Shelf Licence	Exploration Permit	Exploration Permit	Exploration Permit	Exploration Permit
Owners:	TTR	TTR	TTR	TTR	TTR
Location:	Taranaki	Taranaki	Waikato	Waikato	Taranaki
Operation Name:	Offshore Taranaki	Patea	Waikato North	Taharoa South Offshore	Koitiata
Status:	GRANTED	GRANTED	SUBMITTED	SUBMITTED	SUBMITTED
Granted:	17-12-10	19-12-12			
Commenced:	17-12-10	19-12-12			
Received:			12-03-12	12-03-12	12-03-12
Duration:	4 years	5 years	5 years	5 years	5 years
Expires:	16-12-14	18-12-17			
Area:	3314 SQKM	143070 HECTARE	176770 HECTARE	156320 HECTARE	158760 HECTARE

Table 4-1 Permit Details from New Zealand Petroleum and Minerals (NZ Gov.) website

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 long shore 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 was deposited on these features. The sub surface iron sands located further offshore are that 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.

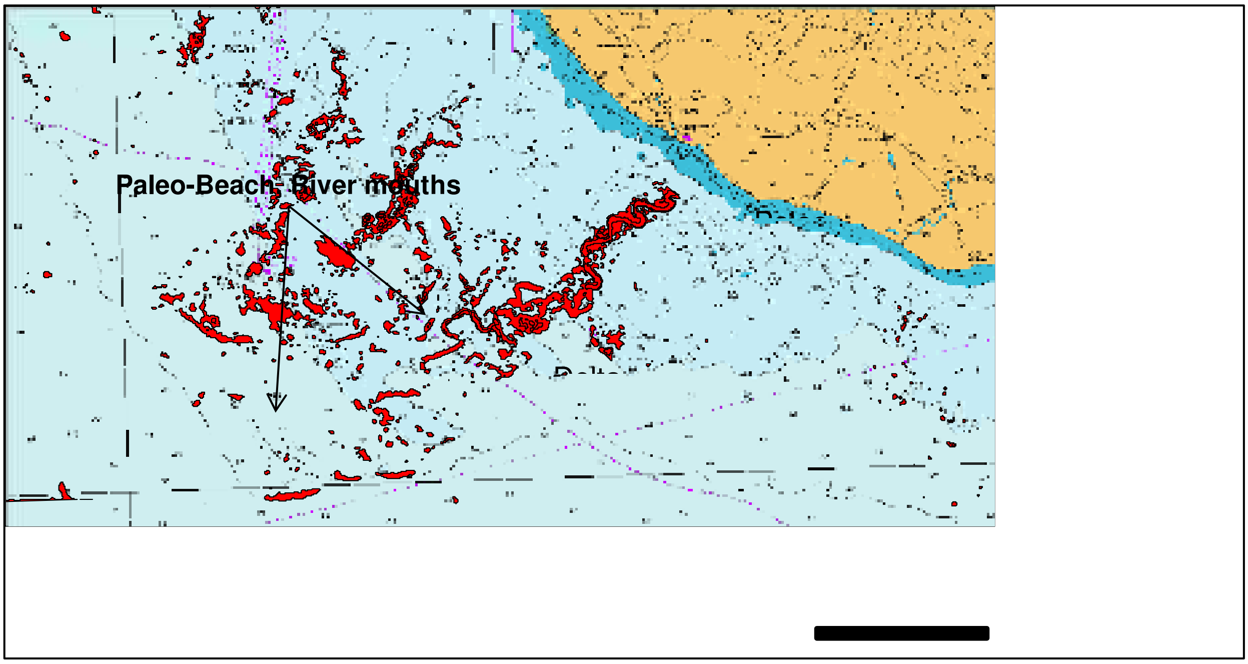


Table 4-2. The red areas highlight the magnetic anomalies over the South Taranaki Bight.

4.3.2 Drilling

Early in the company's life, TTR investigated different drilling and sampling methods. Globally nothing was considered to be a cost effective drilling technology that could meet all of TTR requirements. TTR therefore, 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 as the preferred method of recovering representative samples from below the sea floor. Samples are taken as composites over 1 m 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 it in water depth of up to 60 m (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 2nd tube, which in turn creates a venturi effect. The venturi lifts the slurry up the centre 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 Metre 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 4-7Trans-Tasman Resources 11m shallow rig on display at the sample warehouse

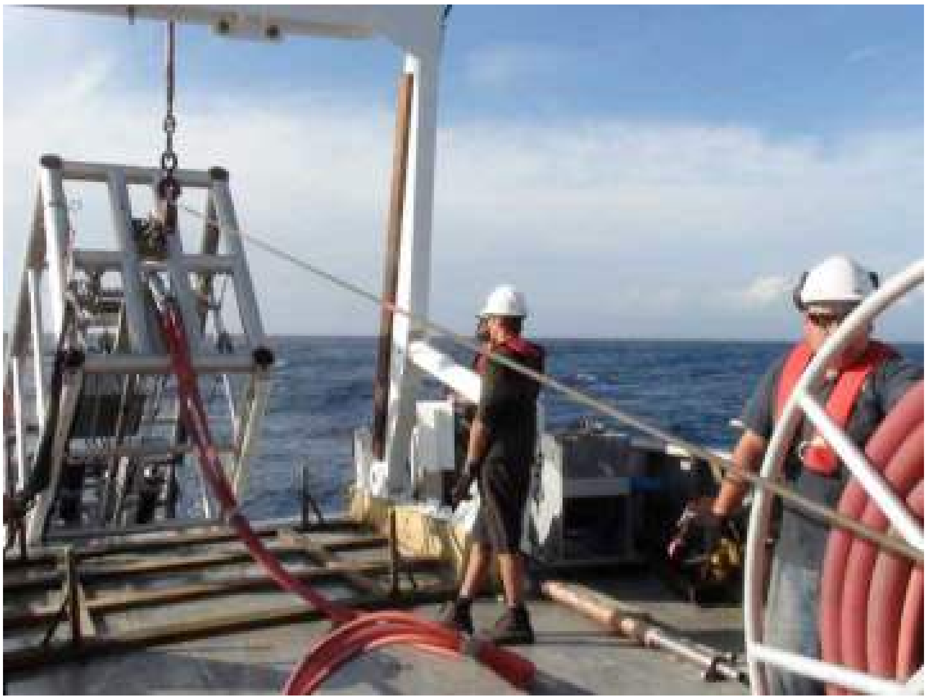


Figure 4-8Launching of the 11m shallow drill rig from the Island Leader II (2011 shallow drilling programme)

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 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 4-9Deep drilling rig and LARS on the PMG Pride during the 2013 deep drilling programme.

Figure 4-10Raising of the LARS off the PMG Pride during the 2013 deep drilling programme

Figure 4-11Collection of drill samples from deep drilling

Figure 4-12Diver preparing for deep drilling

4.3.5 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 ~30–55m. 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 4-5m 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.
- 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 practise 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 header.

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 are vastly improved after processing, as can be seen in the figure 4.13.

On some profiles, the processing resolved seismic horizons below the primary multiple. The first 5-8 ms 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 10 m.

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 30-35 m).

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.

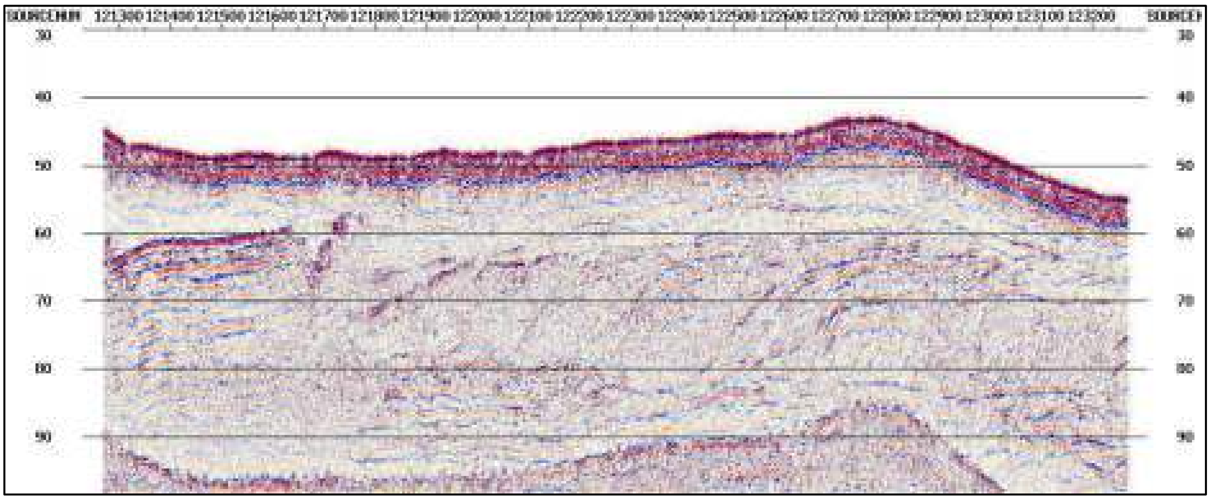


Figure 4-13Processed seismic line 107 profile showing sub-surface infilling of a paleochannel

4.4 Mineral Resource Estimation

Golder Associates Pty Ltd (Golder) was initially commissioned by TTR (TTR) to assist with the development of TTR's iron sand project in New Zealand in 2009. In November 2009 an *in situ* maiden resource of 1040 Mt at 5.88% Fe was defined. Golder (2009) details the data analysis and geological interpretation supporting the resource. In July 2011, after additional drilling, the resource was updated to 2121 Mt at 5.64% Fe (Golder, 2011).

Appended to this study is the current resource estimation report which details the latest update of the resource and includes drilling results, QAQC and statistical analysis of the drill data reported by Golder Associates. Only a few additional drill holes have been added to the resource model area since the previous estimate. The main update to the data set is the addition of Davis Tube Recovery results and concentrate assays for the proposed mining area.

Golder has been delivering technical solutions to the global mining sector for over 50 years, providing a comprehensive suite of integrated mining services, from concept study to mine closure. Golder has extensive practical experience in all aspects of design, planning and operation of open pit, underground and strip mines, enabling clients to realise the maximum value from mining projects.

4.4.1 Analytical Reporting

The TTR resource is a titano-magnetite iron sand deposit. Titano-magnetite 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.

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

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

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, 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.

4.4.2 Drilling

TTR has undertaken a program of offshore sampling using the services of New Zealand Diving and Salvage (NZDS). The sampling program has included sediment sampling onshore and offshore. 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 6 m of the sea bed. The 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 upgraded and can now drill to a maximum depth of 9 m, and most recently to 11m. 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 25 m 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 65 m water depth.

The original diver supported 6 m 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 9 m system.

In 2012 a new rig was developed and deployed with the ability to drill up to 42 m. 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 umbilicals. 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 boat.

Drilling is weather dependant. The tenements are exposed to the storms of the ‘roaring forties’ that come across the Tasman. During the worst storms even Wanganui harbour is unsafe.

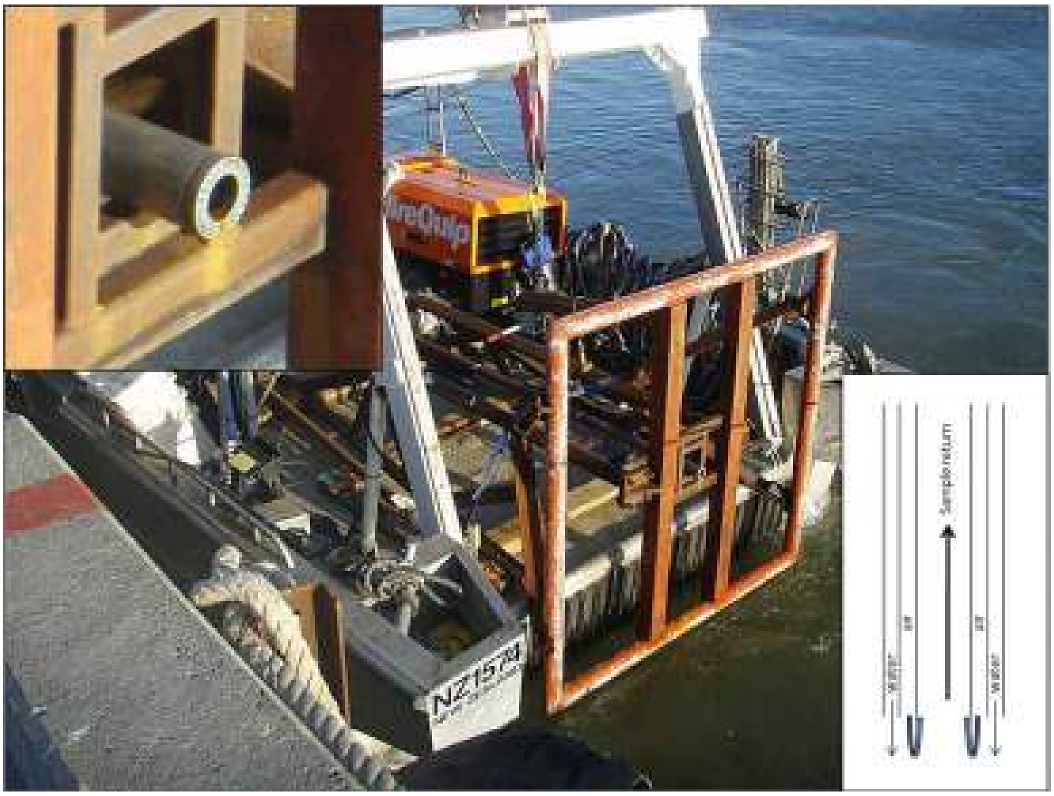


Figure 4-14 Drill Rig on The Shoman. Inset - Bit Detail and Circulation Diagram

Figure 4-15 Drilling is Diver Operated and Monitored from the Boat

Figure 4-16 Cyclone and Sample Collection

4.4.3 Site Visit

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 75.75 mm OD bit and 75 mm OD pipe (approximately NQ). The drill used a single rod with a 6 m 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 sands 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 not should 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 focussing on the DTR samples. In both instances the laboratory was observed by Golder to be performing as expected.

Figure 4-17 Deep Drill Rig TTR Yard Porirua

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 logging sample was sent to the National Institute of Water and Atmospheric Research (NIWA). Samples are now logged by TTR geologists.

The laboratory screens the sample to remove all material greater than 2 mm in diametre 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.

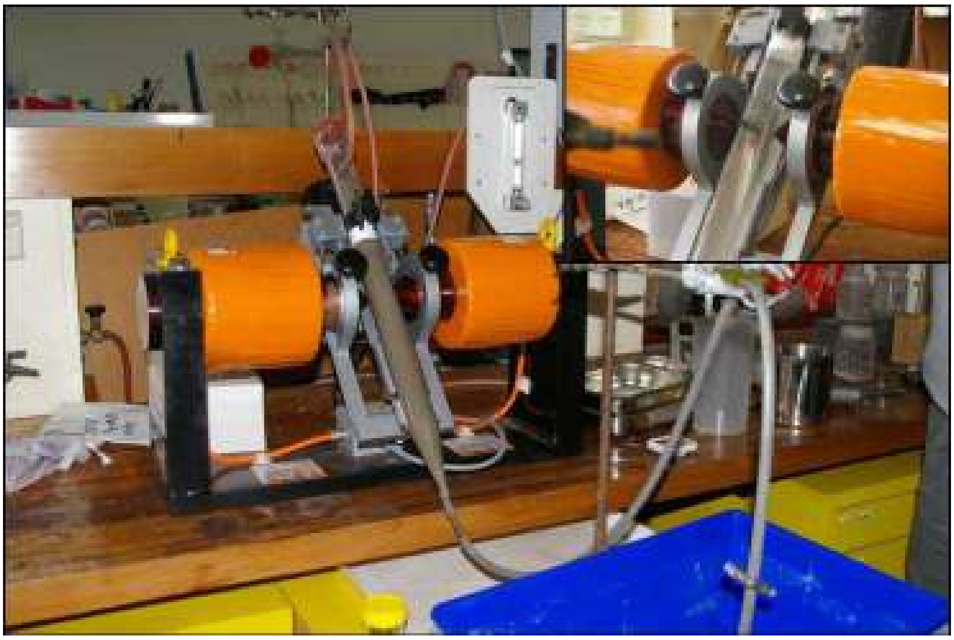


Figure 4-18 Davis Tube

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, is located at the Porirua warehouse. Multiple bulk samples have been collected from the proposed mining area for the pilot plant test work. The sample was obtained using the exploration drill rig. The pilot plant screens the sample at +20 mm then +2 mm with the sub-2 mm 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 53 µm (P80) and run through LIMS three times producing a final concentrate. JORC (2004) in defining a Mineral Resource requires that "there are reasonable prospects for eventual economic extraction". The successful production of concentrate by the pilot plant demonstrates that it is possible to recover titano-magnetite from the TTR iron sand deposits. Golder was provided with a 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

The November 2012 resource update is based on 606 drill holes containing valid analytical results for 3284 samples representing 3296 m of drilled material. The diagram below illustrates the locations of all drilling used in the resource estimate highlighted by drilling season. Holes drilled during the recent 2013 drilling programme and the 2012 programme in the northern tenement are not shown.

Within the proposed mining area 83 drill holes have had samples re-analysed for Davis Tube Recovery and the recovered concentrate analysed by XRF. The table below summarises the number of drill holes and samples available to each resource model estimate.

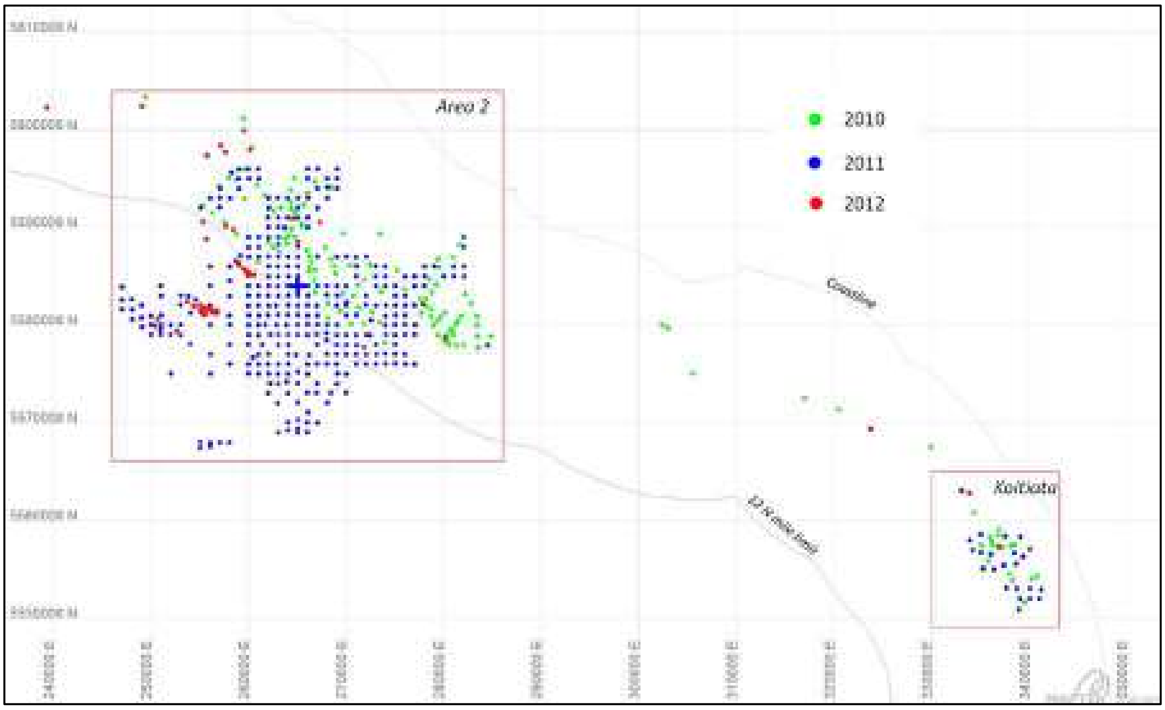


Figure 4-19Drilling Locations - TTRs Iron sand Deposit

	Head Analysis		DTR/DTC Analysis	
	Drill Holes	Samples	Drill Holes	Samples
Area 2	497	2620		
Koitiata	44	205		
Proposed Mine Area			83	643

Table 4-3Model Area Data

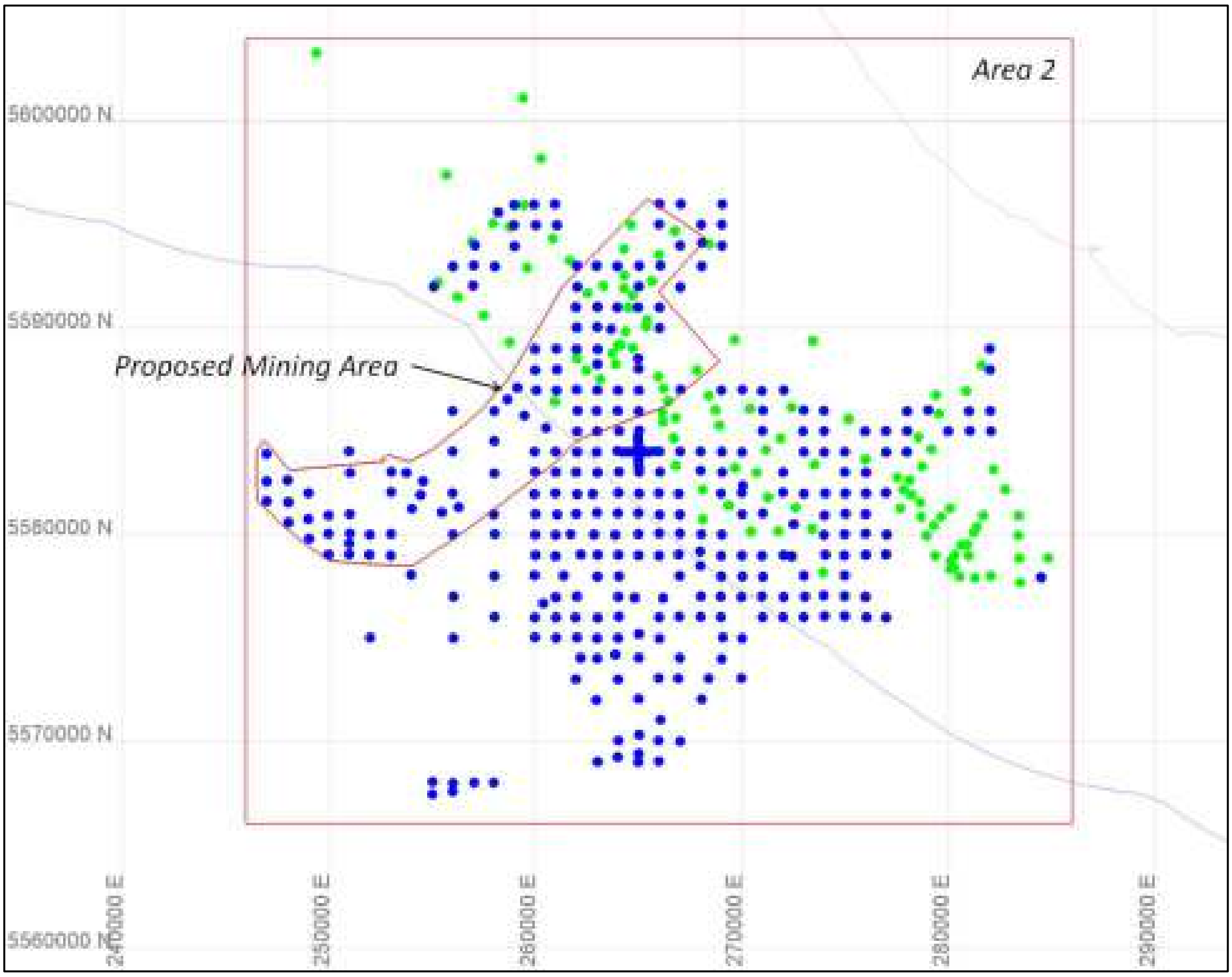


Figure 4-20Drill Holes in the Proposed Mining Area

4.4.7 Density

Mineral Resource and Ore Reserves, although typically stated in terms of grade and tonnage, are estimated in terms of three parameterss: 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.

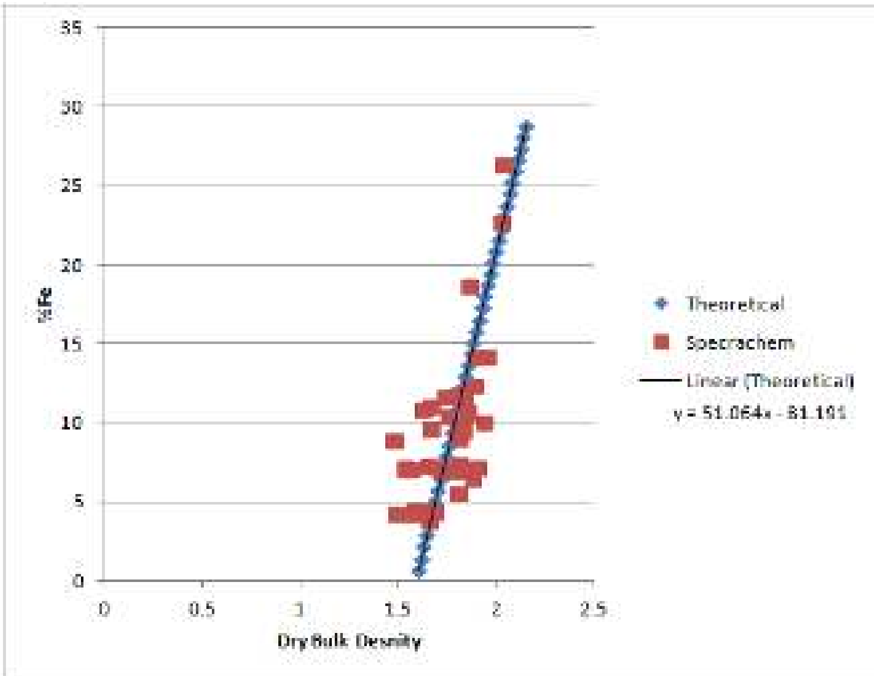


Figure 4-21 Dry Bulk Density Regression against Fe

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 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 under estimated the bulk density by approximately 8% to 10%. This updated assumption on density will be assessed and if ascertained will be corrected and reported in late Q3 as part of the company 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 analyses by TTR now provide recoverable resource figures for the proposed mining area. The pilot plant work, when complete will provide 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 titano-magnetite (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 titano-magnetite.

The mineralogy and chemical analysis suggest that most of the Fe content of the sands is in the titano-magnetite. FeO, Fe_2O_3 and TiO_2 are only available for a limited number of samples. Plotting the FeO:Fe_2O_3:TiO_2 ratios identifies the mineral species as a titanium enriched magnetite.

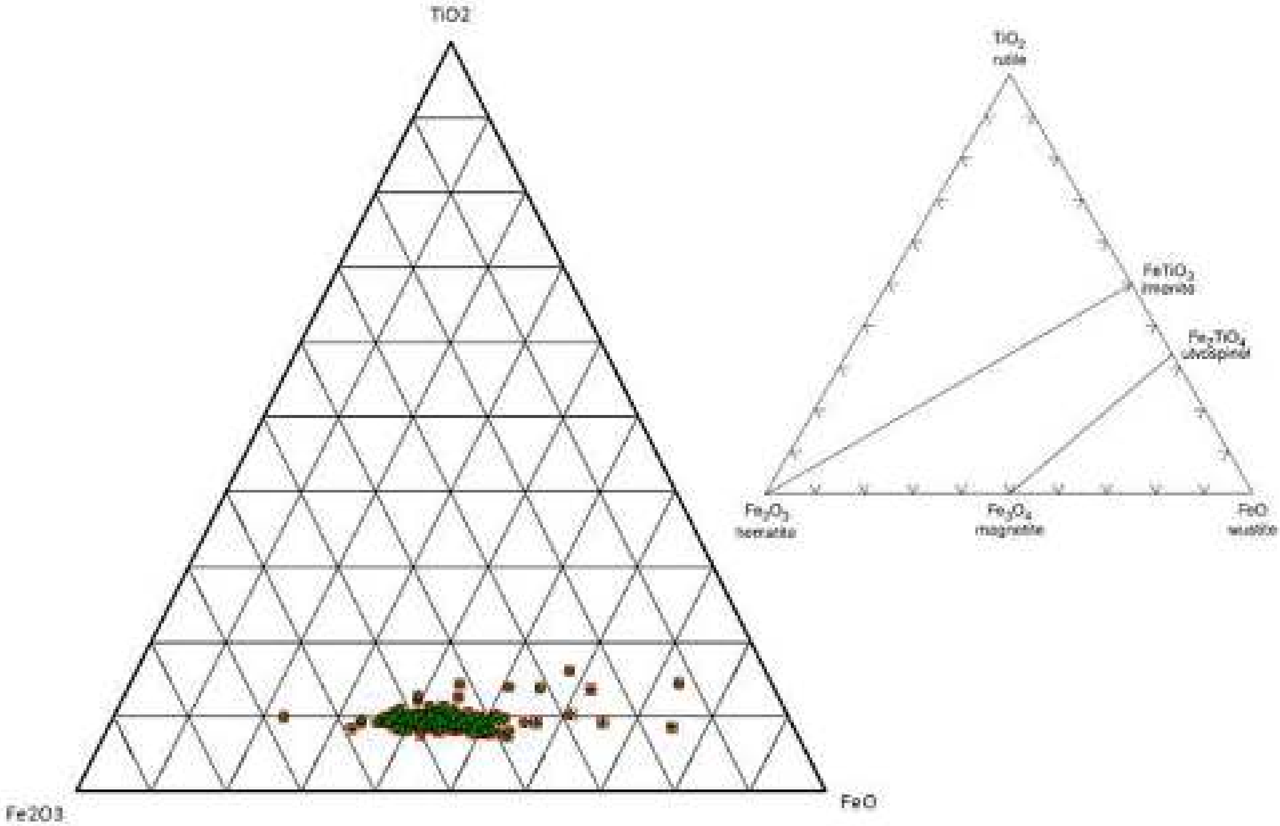


Figure 4-22: Fe_2O_3-Feo-TiO_2 Ternary Plot

4.5.1 Geological Model

The original geological model used to target drilling assumed higher grade 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 grade samples where the geophysical survey showed higher magnetic values.

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

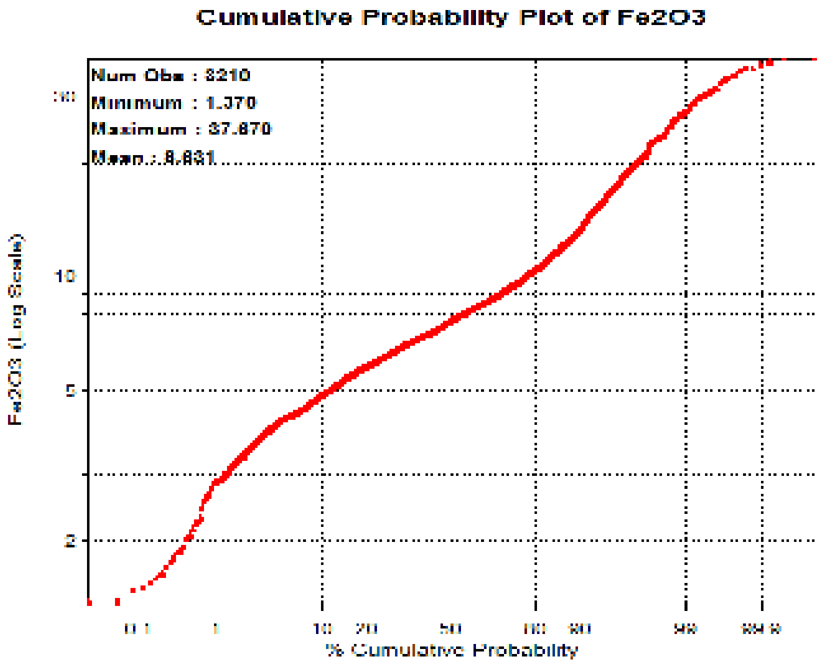


Figure 4-23 Fe2O3 - All Drill Holes

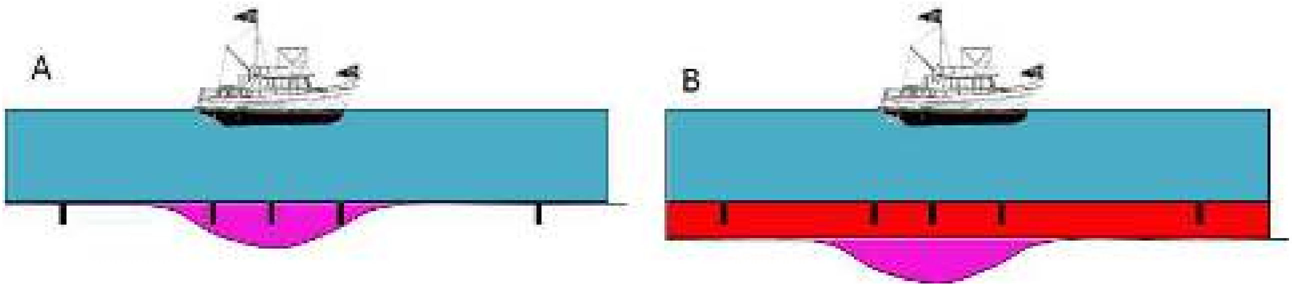


Figure 4-24 Geological Model

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 recent deep drilling has shown the sands to be up to 30 m thick but 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 off shore in Domain 9 are interpreted as slumps. The remaining northern areas are defined as deltas and Koitiata as paleo beach.

The domains were further refined to limit the extent of the influence of any particular drill hole to approximately 1000 m horizontally. This was done in order to stop an unreasonable volume of material receiving an estimated grade in the block model. The 1000 m extrapolation is based on the drill spacing of 2000 m required for an Inferred Resource in this deposit.

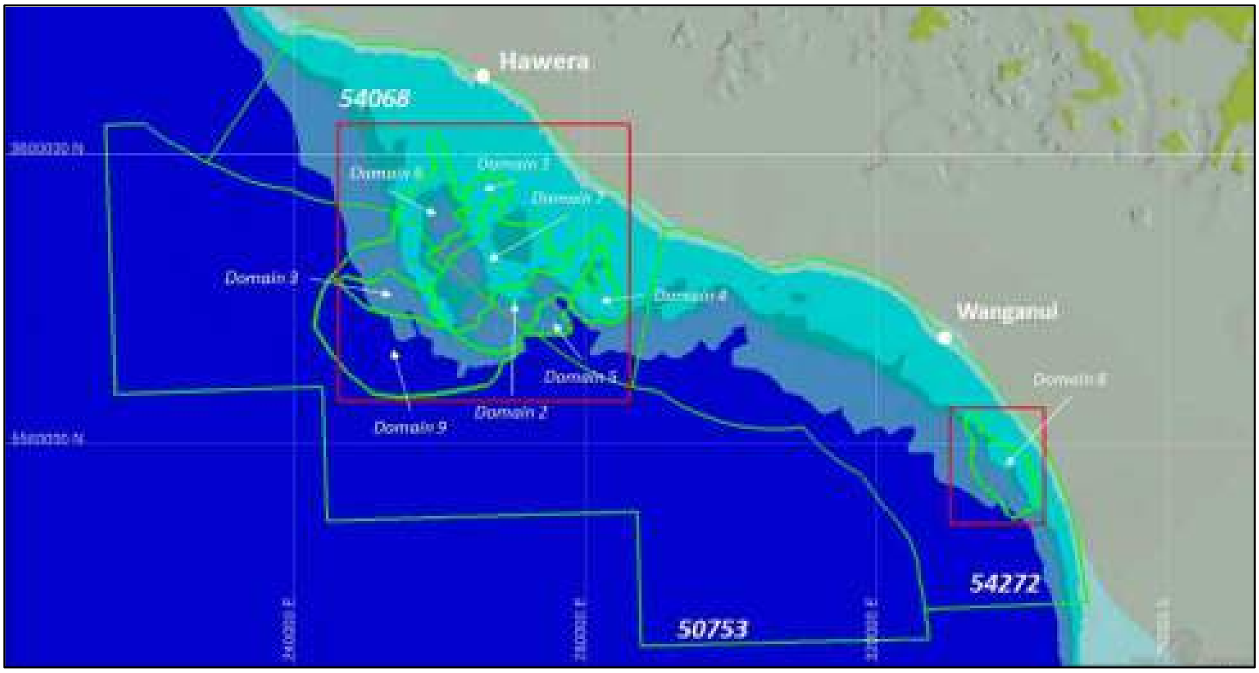


Figure 4-25 Domains of the offshore titano-magnetite Mineral Resource

The cumulative log probability plots for domains in the Area 2 (the larger red box) 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.

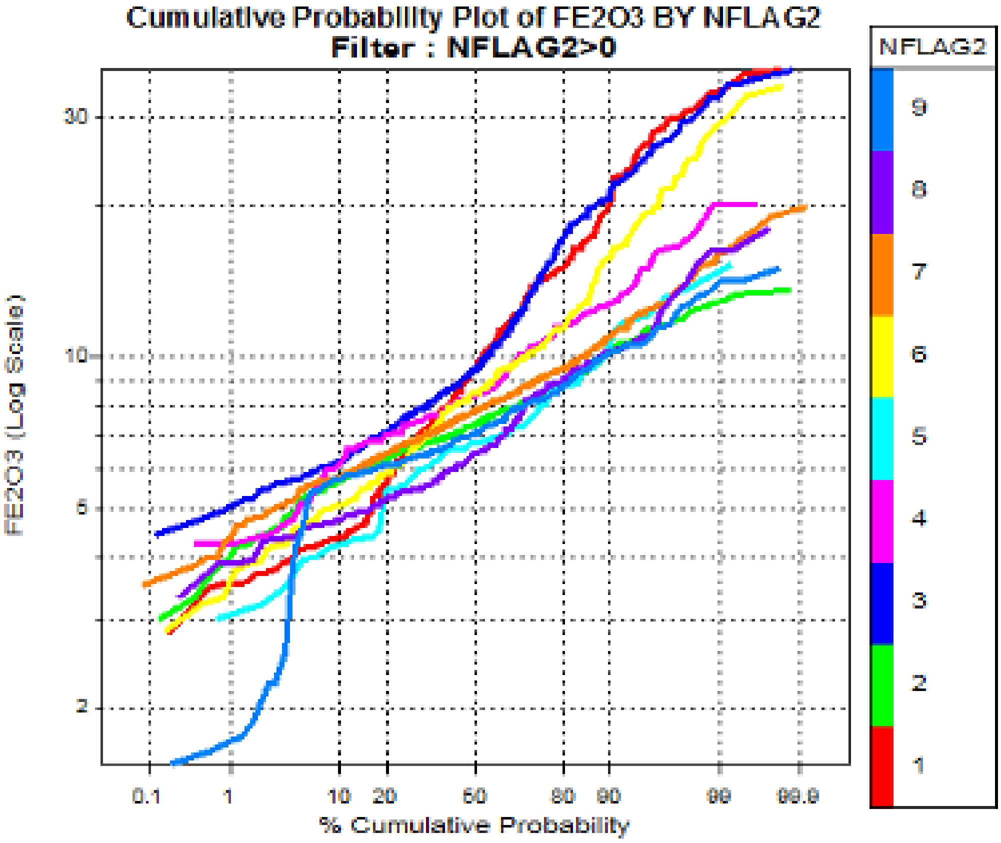


Figure 4-26 Cumulative Probability for Fe203 by Domains for the Area 2 and Koitiata Deposits.

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 2 m 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 offshore iron sand resource estimates are reported in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC, 2004). The resource estimates have been prepared by employees of Golder Associates Pty Ltd. Golder and its employees are independent of TTR.

The resource estimates were classified in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC, 2004) as Indicated and Inferred based on drill holes available as of 20 November 2012.

The physical recovery has been applied to the models. Head grades and tonnages are for all material less than 2 mm in diaMetre. 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 proposed mining area. 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.

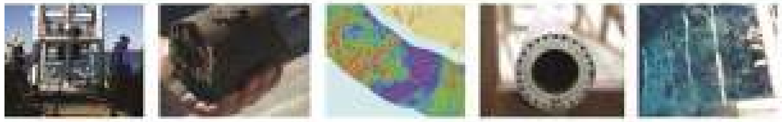


Table 4-4: Head Grades (%) - Proposed Mine Area - 3.5% DTR Cut-Off Grade

Class	Domain	Mt	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	P_2O_5	CaO	K_2O	MgO	MnO	LOI	DTR	REC
Indicated	1	98.9	10.54	10.50	55.41	1.07	0.177	10.46	1.08	5.14	0.18	3.08	7.10	93.24
	3	358.2	12.82	12.28	50.49	1.29	0.263	11.06	1.10	5.59	0.22	2.03	8.96	98.27
	6	81.8	10.67	11.46	55.84	1.10	0.200	9.49	1.19	4.48	0.17	2.59	7.16	95.46
	7	41.6	9.25	12.51	51.68	0.93	0.231	12.28	1.14	5.24	0.18	3.57	5.43	89.92
	9	3.6	8.23	14.16	53.71	0.82	0.232	11.18	1.20	4.60	0.17	2.55	4.10	98.25
Total Indicated		584.1	11.85	11.89	52.18	1.20	0.237	10.83	1.11	5.33	0.20	2.40	8.11	96.43
Inferred	1	93.3	16.68	10.27	47.42	1.69	0.276	10.88	0.99	6.34	0.25	2.63	8.27	94.67
	3	111.6	11.33	13.11	51.13	1.14	0.261	11.04	1.17	5.19	0.20	2.36	8.75	97.23
	6	192.6	10.14	13.34	52.26	1.03	0.241	11.09	1.16	4.89	0.18	2.46	6.21	95.01
	7	49.5	12.45	9.07	45.56	1.20	0.234	16.30	0.75	7.18	0.24	4.86	6.18	86.64
Total Inferred		447.0	12.06	12.17	50.22	1.21	0.253	11.61	1.08	5.52	0.21	2.74	7.27	94.56
Indicated + Inferred		1031.1	11.94	12.01	51.33	1.20	0.244	11.17	1.10	5.41	0.21	2.54	7.75	95.62

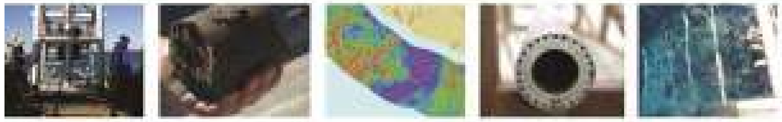


Table 4-5: Concentrate Grades (%) - Proposed Mine Area - 3.5% DTR Cut-Off Grade

Class	Zone	Mt	Fe	Al_2O_3	SiO_2	Ti	P	CaO	K_2O	MgO	Mn	LOI
Indicated	1	7.0	58.42	3.57	2.48	5.06	0.096	0.80	0.07	3.18	0.52	-3.21
	3	32.1	57.09	3.65	3.69	5.12	0.112	1.00	0.11	3.25	0.51	-3.05
	6	5.9	57.76	3.61	3.09	5.10	0.104	0.88	0.09	3.19	0.51	-3.14
	7	2.3	56.83	3.73	4.01	5.05	0.103	1.07	0.12	3.32	0.51	-3.07
	9	0.1	54.95	3.77	6.04	5.03	0.120	1.36	0.19	3.40	0.51	-2.90
Total Indicated		47.4	57.35	3.64	3.46	5.10	0.108	0.96	0.10	3.24	0.51	-3.08
Inferred	1	7.7	57.29	3.71	3.60	5.06	0.106	0.95	0.12	3.24	0.51	-3.10
	3	9.8	56.97	3.66	3.85	5.12	0.115	1.01	0.12	3.24	0.51	-3.03
	6	12.0	56.60	3.70	4.27	5.07	0.113	1.08	0.13	3.24	0.51	-3.01
	7	3.1	57.93	3.61	2.91	5.04	0.099	0.89	0.08	3.23	0.52	-3.17
Total Inferred		32.5	57.00	3.68	3.85	5.08	0.111	1.01	0.12	3.24	0.51	-3.05
Indicated + Inferred		79.9	57.21	3.65	3.62	5.09	0.109	0.98	0.11	3.24	0.51	-3.07

5. MINE PLAN

TTR have identified an initial mining area, which contains four areas of higher grade iron sand. These areas were identified and delineated by aeromagnetic data and subsequent shallow and deep drilling. These high grade areas are identified as Xantia, Xantia Extension (X2), Christine and Dianne and are located within an area of 130.5 square kilometres, extending from 13 km to 35 km off the South Taranaki coastline. The mining area encapsulates the high grade areas both inside and outside the 12 nautical mile limit and can be described as an offshore submarine aeolian/alluvial/marine accumulation of iron sand in paleo channels, strandlines and dunes.

In determining the recoverable material form the *in situ* resource TTR undertook a testing programme of the drill hole samples obtained within the identified mining area and involved samples tested using DTR, which therefore has permitted the modelling of the recoverable concentrate and associated grades. This was then used as the basis of the mine schedule.

5.1 Definition of initial mining area

In May 2013 Golder Associates, updated the mineral resource model and completed a resource estimate, which was based on the drilling results up to 20 November 2012. From this a mining model regularised to a consistent block size of 250 m × 250 m × 1 m was developed. This model was used as the basis for the mine schedule created by Golder Associates Mine Engineer.

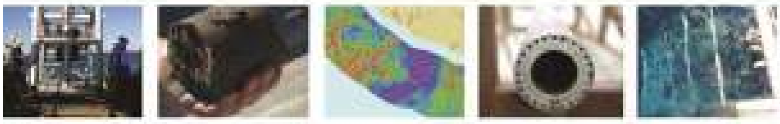
When delineating the mining area a number of factors such as, but not limited to, *in situ* head grade, bulk density, Davis Tube Recovery, metallurgy, depth of mineralization, mining method, water depth, regulatory consideration, meteorological and ocean conditions, tailings disposal, environmental effects and mine scheduling are key considerations and inputs.

The nature of the resource dictated how to effectively extract the iron sand resource, with TTR identifying two options that are considered technically feasible. The mining method options reviewed include the use of a TSHD (Trailer Suction Hopper Dredge) and a sea floor crawler or SSED (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.

5.2 Mine Blocks Overview

Mining blocks have been calculated and positioned within the minable resource within areas of the cut-off grade (as described in Section 5.9) with iron sand concentration varying in thinkness from two to ten metres below the ocean floor. Two scenarios have been studied, one the TSHD option the other is the sea floor crawler.

The only major difference of the mining blocks in relation to the different mining method is that of the orientation of the Christina Block. The orientation of the mining



blocks take into consideration prevailing environmental constraints such as current and wind direction.

For the dredging option, two large trailing suctions hopper dredges (TSHD) will 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 (FPSO), 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 nine years.

For the SSED or Crawler option, the crawler will be located on the sea floor, connected to the FPSO via an umbilical delivery tube. A winching system will be used to locate the FPSO relative to the crawler which will be mining 300 m × 300 m blocks from the base of the mineralisation, in a predetermined sequence. Based on current estimates, a remote crawler unit will have an annual throughput capacity of about 41 Mtpa.

The crawler option indicates annual tonnage movements of 41 Mtpa of *in situ* material with annual concentrate production of 2.9-4.8 Mtpa. A ten year schedule was developed, however there are still resources available for mining by the crawler beyond 10 years.

Concentrate production in both scenarios varies with the feed grade and feed recovery factor. The FPSO 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 Licence / Permit, and potentially enabling lower grade sediment (below current cut-off grade) to be mined in the future.

Mining Block Name	Area (sq km)	Average Fe Head Grade	Concentrate (MT)	Ave Mine Block Thickness (m)	Depth of Water (m)
Xantia	**14.98**	**9.75**	**10.8**	**3.3**	**17 - 32**
X2	**4.96**	**12.78**	**7.7**	**7.5**	**25 - 38**
Dianne	**15.53**	**10.41**	**19.9**	**8.4**	**21 -41**
Christina	**15.16**	**8.75**	**15**	**7.8**	**35 - 42**

Table 5-1Mining Blocks over a scheduled 10 year mining life

An overview of the mining area is outlined in the table above with the figures taken from Schedule Run 15 (Golder Associates**).**

5.3 Mine Plan Schedule

TTR commissioned Golder Associates to undertake a mining schedule over the defined mining area using a regularised mining model. This model is based on the recent resource block model, also completed by Golder Associates. From the mining model, extraction schedules where generated, utilising assumptions and key inputs to derive the yearly run of mining and grades.

The schedule also identifies area where a "royalty" applies. This is used to distinguish the resource which is situated within the 12 nautical mile limit. This is only used to distinguish between resource that inside versus outside the 12 nautical mile boundary, as they operate under different mineral tenement regimes, not for the financial model.

The mining methods used to determine the schedule rates is that of trailing suction hopper dredges (TSHD) or a remote crawler system. The modelled mineralised zone varies 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 centres to equate to the depth of the block centre below the ocean floor.

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 10-11% Fe.

For the dredging option, two large trailing suctions hopper dredges (30K m3 hopper capacity) will extract the material from the sea floor to fill the hopper on the dredge. This material will then be transported to the FPSO, where it will be processed. Based on current estimates, each dredge will have an annual throughput capacity of 30-35 Mtpa

For the dredging option, it is assumed that both of the waste fractions (+2 mm and -2 mm) will initially be pumped from the FPSO into a designated waste disposal area on the ocean floor adjacent to the FPSO. It may be possible for the FPSO to be relocated onto the mined out areas, to backfill these mined out areas when they become available.

For the remote crawler option, it is assumed that both of the waste fractions will be pumped from the FPSO into the mined out areas as part of the remote crawler/FPSO operating sequence.

Initial information SSED supplier indicated that the integrated FPSO system would require a minimum operational 30m depth of water. The total amount of minable resource reported from the model in 30m depth or more is 148.8 Mt or 27% of the scheduled tonnes. The sediment in the shallow areas could be extracted using a lower draft dredge system scheduled within relatively benign seasonal weather periods. The full Golder Associates scheduling report is appended to this report.

Note that the golders analysis and mine plan are based on employing existing technology. TTR plans to scale up that capacity to process up 8000 tph with an annual throughput capacity of up to 50 Mtpa, as discussed in section 7.

Mining Block

For this study, a mining block model *north_acc_12_02_2013_min.bmf* was created from the updated geological model by;

- Deleting geological model fields not required by running a Vulcan script file (*delete_variable.csh)*
- Set default values to zero, except *dt_loi* field using Vulcan Script (*set_defaults.csh)*
- To calculate the density of all material in a block, a calculated *in situ* density (isg) field was added, using the formula: *isg* = (sg*rec/100) + 1.5*(1-rec/100)

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 1.5 t/m^3.

This mining model is a sub-blocked model with the same block model dimensions and variables as the geological model.

5.4 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 will be calculated by summing the blocks that have the block centroid within an area.

- Vulcan reblocking definition file - *north_acc_2013_250.bdf*
- Vulcan regularised model -- *north_acc_2013_250.bmf*
- During the reblocking procedure, a new *fillpc* field is created. This field represents the proportion of the original blocks within the regularised model blocks. The *fillpc* field was used to adjust the *isg*, *sg* and *sg_rec* fields to correct the reported tonnages from the regularised model. Adjusted fields *isg_adj*, *sg_adj* and *sg_rec_adj* were added to the model, using the Vulcan script file - *adj_densities.csh.*
- The *Mine* field was updated by coding the area (Mine = 1) inside the revised mining boundary string file *Mining_Area_Rev02* supplied by TTR. The default code for areas outside the mining area was 0. Note Mining_Area_Rev1 was used for the Resource estimations.

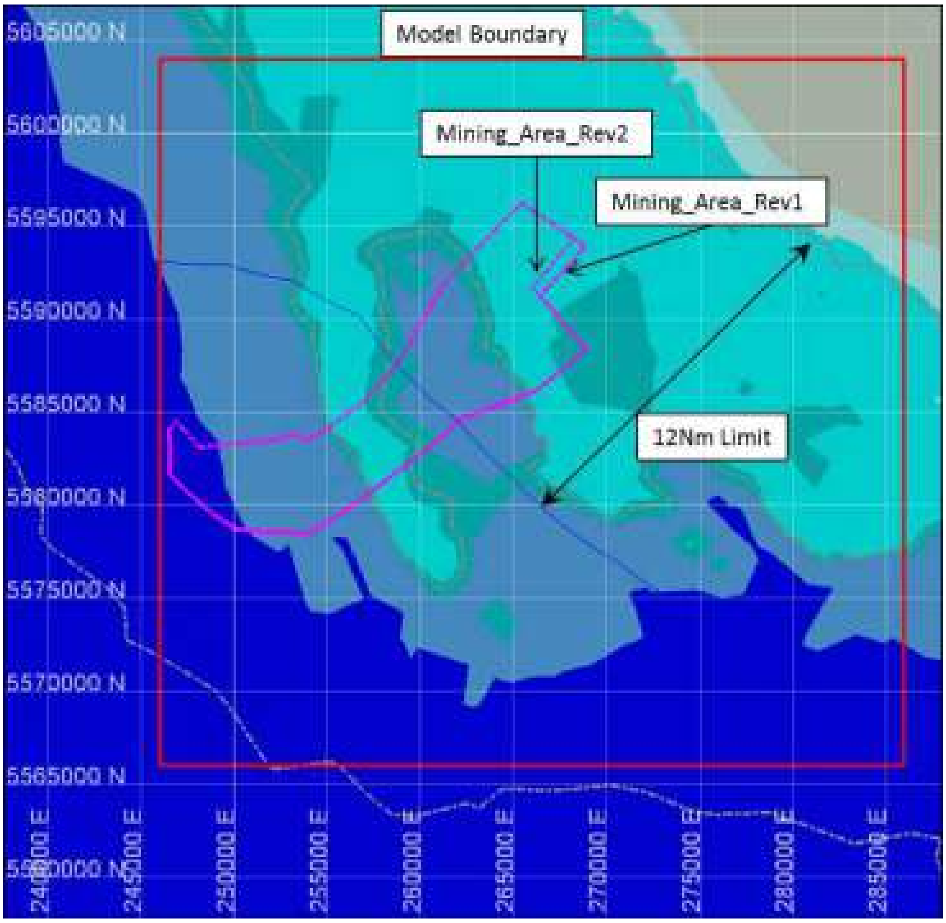


Figure 5-1 Proposed Mining Areas and the 12 Nm Limit

Below are the details of the position and dimensions of the regularised block model.

Area 2	Model Dimensions (m)						Block Dimensions (m)		
	x min	y min	z min	x max	y max	z max	x size	y size	z size
parent block	246 000	5 566 000	-110	286 000	5 604 000	0	250	250	1

Table 5-2Regularised Model Dimensions (north_acc_2013_250.bmf)

A summary of the *in situ* tonnage reported from the geological and the regularised mining models within the proposed mining boundary *Mining_Area_Rev02* are given in No cut-offs have been applied.

	In Situ Tonnes	Fe_2O_3	AL_2O_3	SIO_2	TIO_2	P_2O_5	CaO	K_2O	MgO	MnO	LOI
	Mt	%	%	%	%	%	%	%	%	%	%
Geomodel	**1471.5**	**10.69**	**12.30**	**52.82**	**1.09**	**0.23**	**10.78**	**1.17**	**5.02**	**0.19**	**2.7**
Reblocked Model	**1446.5**	**10.72**	**12.29**	**52.76**	**1.09**	**0.23**	**10.82**	**1.17**	**5.04**	**0.19**	**2.7**
% Difference	**(1.7)**	**0.3**	**(0.1)**	**(0.1)**	**(0.2)**	**(0.2)**	**(0.3)**	**(0.3)**	**(0.4)**	**(0.3)**	**(0.1)**

Table 5-3 In Situ Tonnage and Grade Reports and the Effect of Model Regularisation

5.5 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.

5.6 Scheduling Block Model

It is assumed that both the TSHD or a remote 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 centres to equate to the depth of the block centre below the ocean floor.

A *depth* field was added to the mining model, and a lava script (*rmg_block_depthbelsurf.lava)* 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 parameterss as the regularised mining model.

An additional field *b12nm* was added to the model to code material within the 12 nautical mile limit as royalties are payable on products from within this zone..

This flattened scheduling model *north_acc_2013_250_flat.bmf* was used as the basis of the tonnages and grades for scheduling.

5.7 Initial Dredging Areas

Initial dredging areas were defined covering most of the proposed mining area *Mining_Area_Rev02.* These initial areas are shown in the figure below and a summary of tonnages and grades reported from each area is shown in Table 5-4.

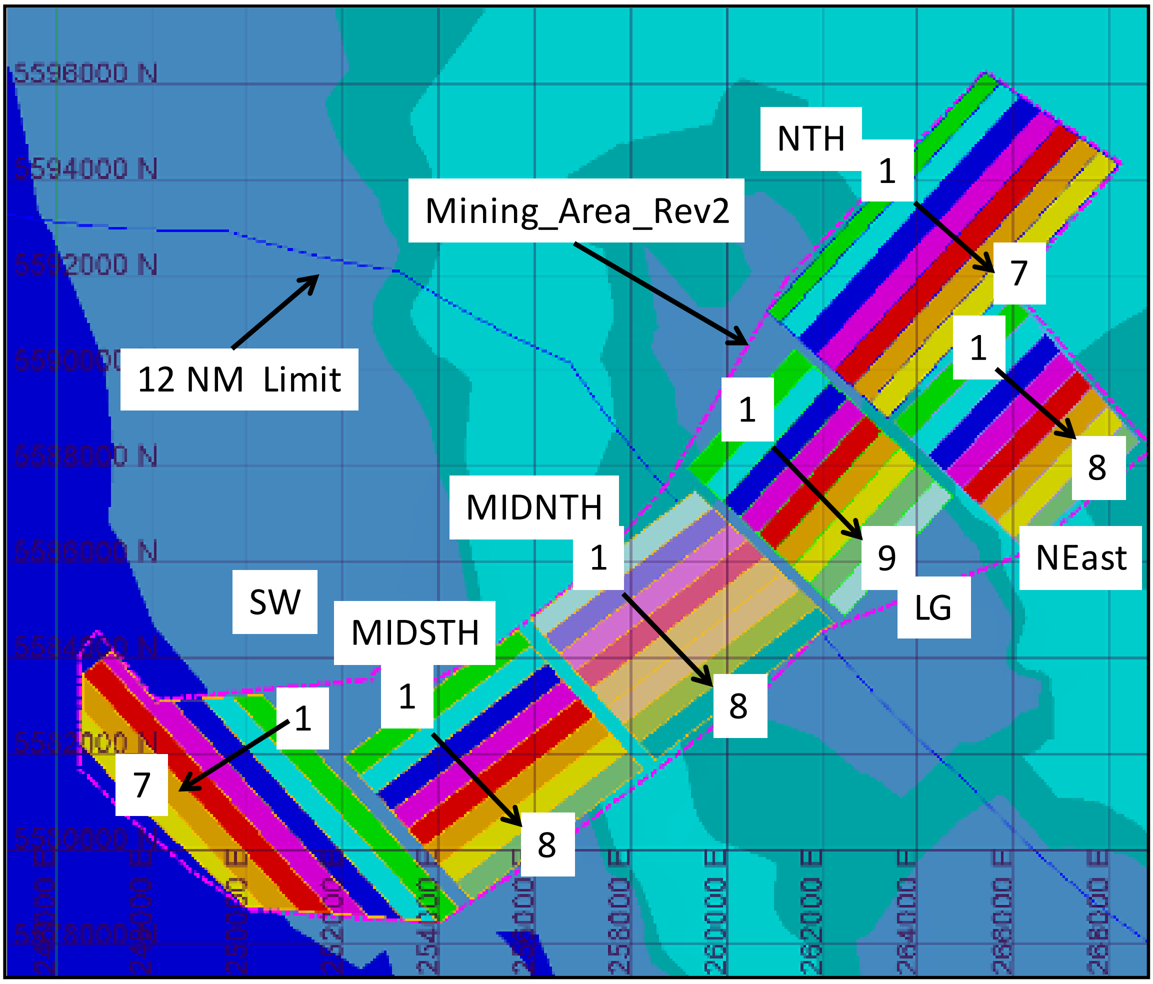


Figure 5-2Proposed Initial Dredging Areas

Initial scheduling of these areas indicated that there were a significant number of lower grade blocks within the defined areas. These lower grade blocks were having an effect on concentrate production and therefore increased the dredging capacities required to achieve TTR concentrate targets.

Feed tonnes are the plant feed tonnes after initial screening removes the +2 mm oversize material.

To minimise the dredging of the lower grades blocks Fe, it was proposed to dredge the higher grade areas in the proposed mining area with the aim of achieving an average plant head-feed grade of 10 to 11% Fe.

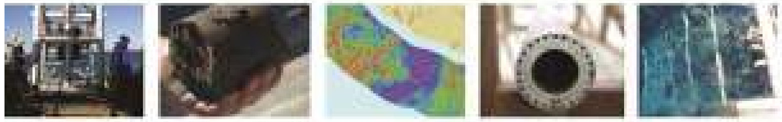
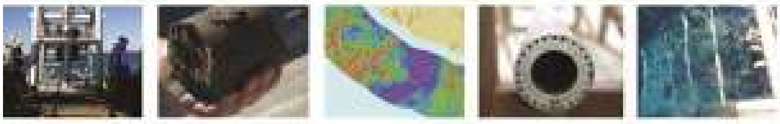


Table 5-4Initial Dredging Areas - Tonnages and Grades

Area	*In Situ* Tonnes	Feed Tonnes	F_Fe_2O_3	F_Al_2O_3	F_SiO_2	F_TiO_2	F_P_2O_5	F_CaO	F_k_2O	F_Mgo	F_Mno	F_LOI	F_dtr	F_rec	Conc Tonnes
	Mt	Mt	%	%	%	%	%	%	%	%	%	%	%	%	Mt
Nth	148.6	139.9	11.10	10.23	56.82	1.15	0.16	8.88	1.12	4.77	0.18	3.02	7.17	93.96	10.0
NEast	89.1	77.2	12.20	9.31	48.08	1.19	0.22	14.83	0.80	6.75	0.23	4.31	7.12	86.64	5.5
MidSth	259.1	250.4	13.04	12.36	49.55	1.32	0.27	11.33	1.09	5.55	0.22	2.29	9.31	96.28	23.3
MidNth	266.7	251.0	10.86	13.38	52.09	1.11	0.26	10.55	1.25	4.95	0.19	2.27	6.66	94.23	16.7
SW	323.0	315.6	10.95	12.99	52.32	1.11	0.25	10.76	1.18	5.13	0.20	2.06	6.78	97.52	21.4
LG	105.1	92.6	6.31	11.20	59.38	0.65	0.15	10.02	1.30	3.86	0.13	4.26	2.23	88.27	2.1
Grand Total	1191.5	1126.8	11.12	12.19	52.50	1.13	0.23	10.82	1.15	5.14	0.19	2.61	7.01	94.56	79.0



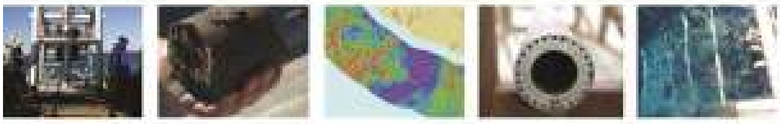
5.8 High Grade Areas

5.8.1 Grade Tonnage Analysis

To define these higher grades 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 is shown below.

DTR_Est	DTR_Est	Tonnes	Fe_2O_3	Fe
Cut-Off %	%	(Mt)	%	%
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	84.0	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	17.60
19	23.14	35.5	25.97	18.16
20	24.06	28.6	27.01	18.89

Table 5-5 Grade Tonnage Report Based on Dtr_Est Cut-Off



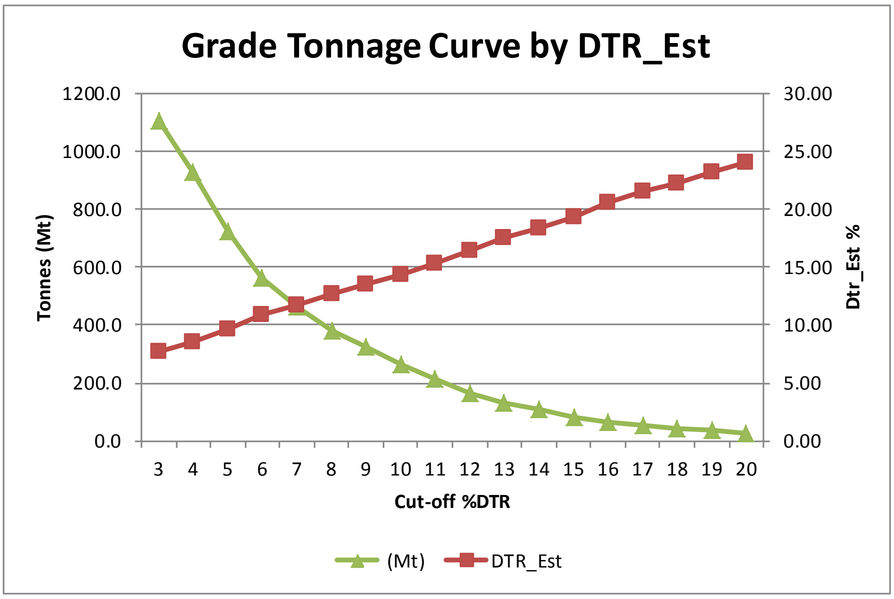


Figure 5-3 Grade Tonnage Curve - Based on DTR_Est%

This analysis indicates that a 7% DTR_Est grade cut-off would result in a plant head feed tonnage of 466 Mt 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.

5.9 Dredging Option

For the initial dredging option, two large TSHD would extract the material from the sea floor to fill the hopper on the dredges. This material would then be transported to the FPSO where it would be offloaded for processing.

Based on estimates, each dredge would of had a capacity 30 to 35 Mtpa.

5.10 Dredge Scheduling Blocks

A grade shell of the block model was created in Vulcan to define the blocks above the 7% DTR_Est cut-off. This grade shell was then used to digitise the higher grade dredging strips on each bench. A bench height of one metre has been used.

The outline of the pit shell on the ocean floor, and the area/strip naming convention is shown below.

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

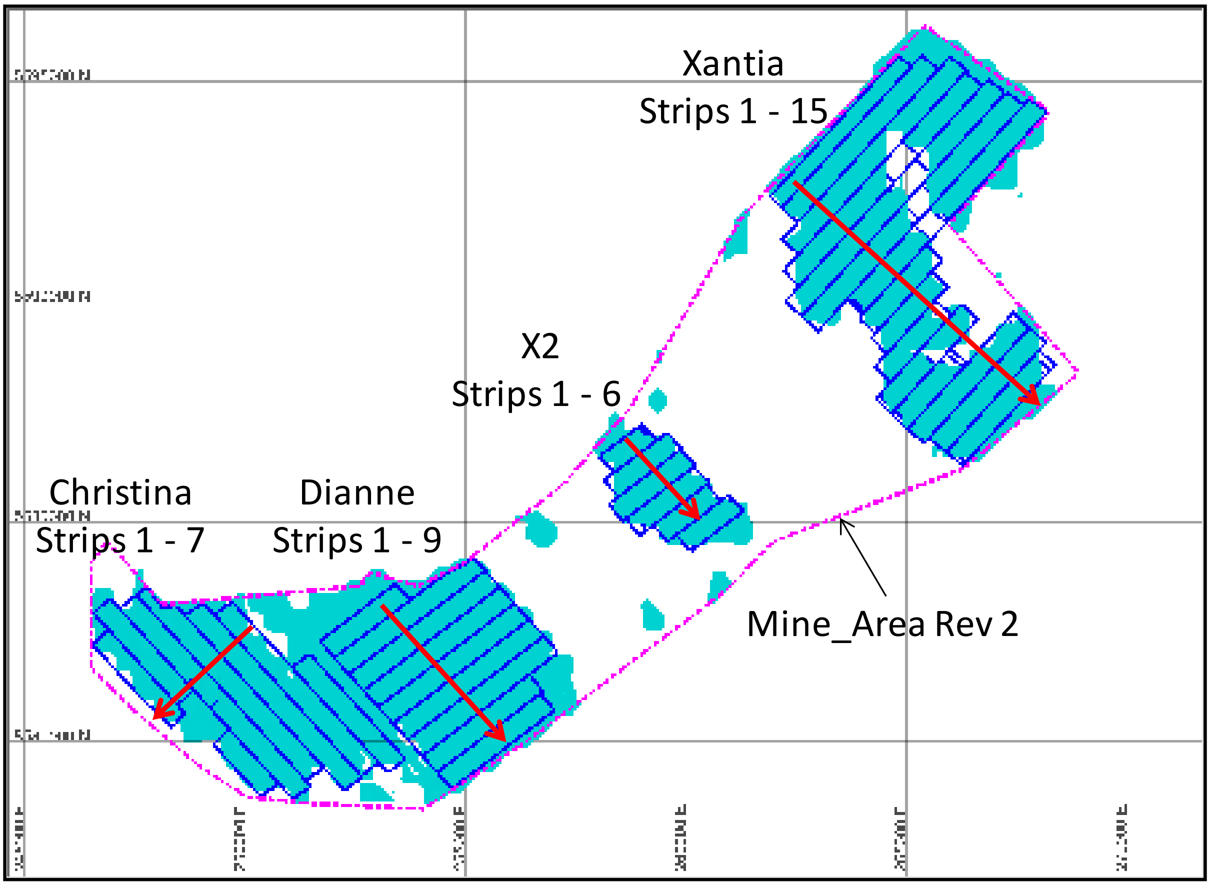


Figure 5-4Proposed High Grade Dredging Areas - 7% DTR_Est Pit Shell Outline and Strip Naming Convention

Dredging areas are generally aligned parallel to the SW - NE wave and wind direction for the area. This is the preferred alignment for directional control of the dredge. The Christina area is roughly perpendicular to the wave/wind direction and would have to be dredged in calm weather conditions. Generally, the prevailing tidal current is in SE-NW alignment. Current direction is also substantially affected by wind conditions.

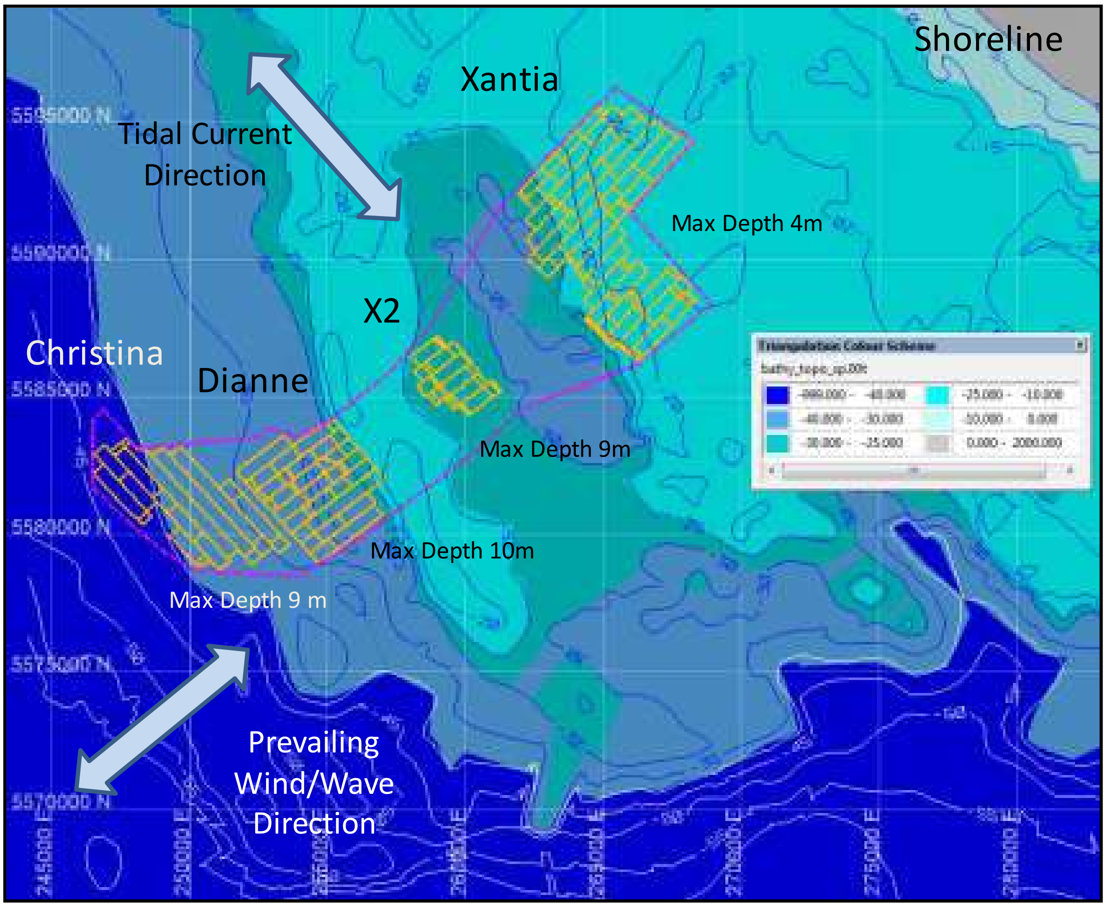
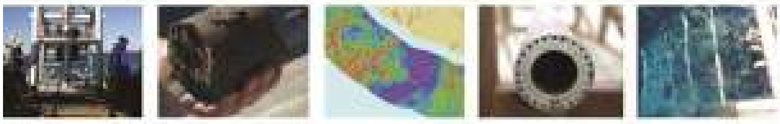


Figure 5-5 Dredging Option Areas - Wind and Tidal Directions

The Xantia area has up to 4 benches, while the other three areas are deeper and have 9 or 10 benches.

The north-eastern edge of the Xantia area has been excluded as there are no block concentrate grades for this area within the current model, due to lack of sample data.

Some low grade blocks are included in the digitised strips as these blocks will have to be dredged to access lower levels. The top 4 metres of Christina is mainly low grade material. This lower grade material will have to be dredged to access the deeper higher grade (HG) material.



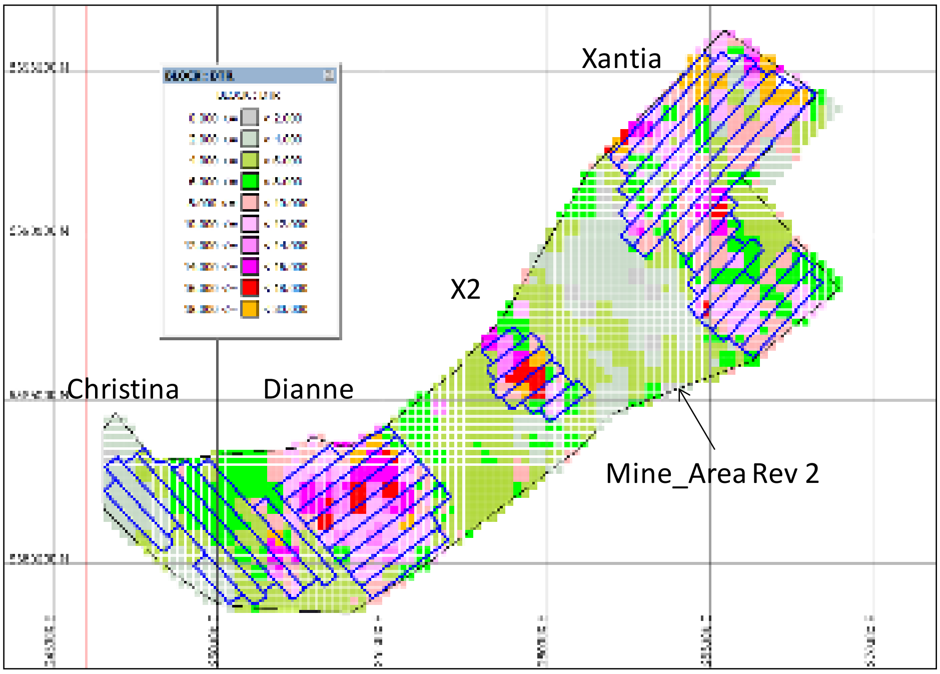


Figure 5-6HG Dredging Areas- Top Metre showing DTR_Est Grades

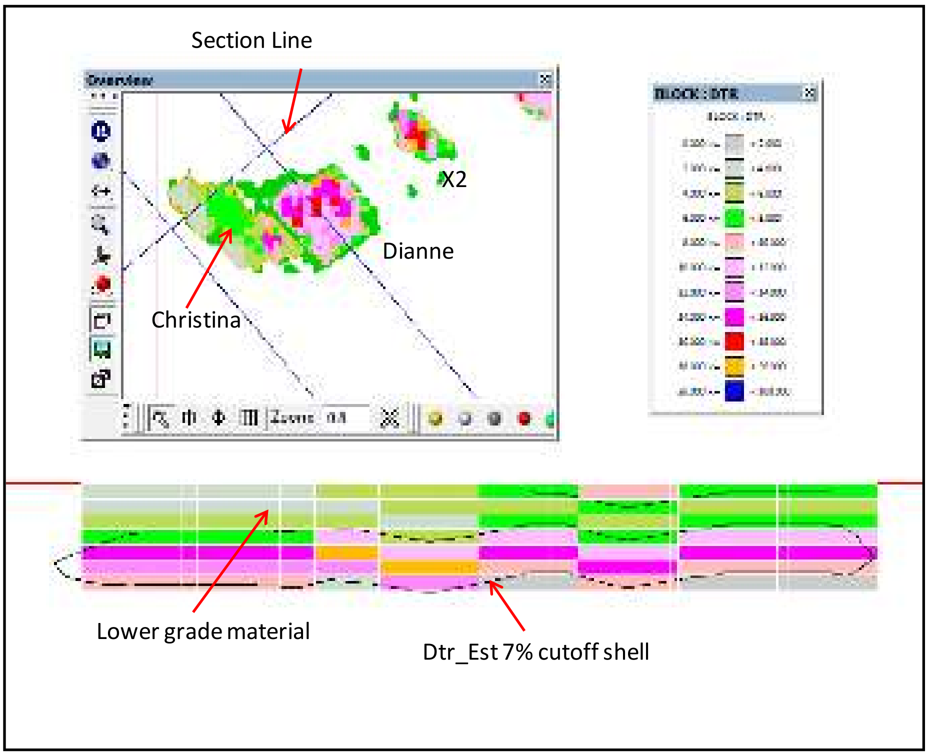


Figure 5-7Christina Section - Low Grade Material in Scheduled Blocks from Normalised Model

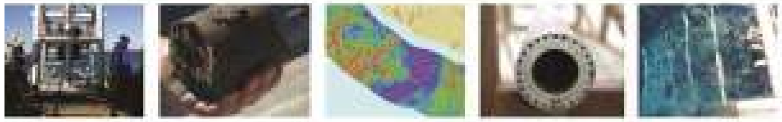


Table 5-6HG Dredging Areas - Tonnages and Grades

Area	*In Situ* Tonnes	Feed Tonnes	F_Fe_2O_3	F_Al_2O_3	F_SiO_2	F_TiO_2	F_P_2O_5	F_CaO	F_K_2O	F_Mgo	F_Mno	F_LOI	F_dtr	F_REC	Conc Tonnes
	Mt	Mt	%	%	%	%	%	%	%	%	%	%	%	%	Mt
Xantia	122.9	113.5	13.94	9.27	50.37	1.39	0.20	12.03	0.88	6.13	0.23	3.54	9.54	92.55	10.8
X2	60.6	58.8	18.18	10.37	45.88	1.84	0.32	11.39	0.95	6.98	0.28	1.44	13.74	97.00	8.1
Dianne	180.9	176.3	14.88	11.84	48.48	1.50	0.28	11.13	1.04	5.70	0.23	2.09	11.30	97.07	19.9
Christina	199.4	195.8	12.25	12.31	50.80	1.22	0.26	11.36	1.06	5.66	0.22	1.99	7.99	98.00	15.7
Grand Total	563.8	544.4	14.09	11.31	49.43	1.41	0.26	11.43	1.00	5.91	0.23	2.28	10.01	96.46	54.5

5.11 Dredge Scheduling Parameterss

With regards to the previous version of the PFS report, advice from Technip Oceania Pty Ltd (Technip) the PFS Study Managers and dredging experts from the Dredging, Environmental and Marine Engineering Group (DEME), was that the dedicated processing FPSO could be located in a minimum of 50 m of water.

Other DEME provided assumptions (within the previous version of the PFS) were:

- Tailings were not to be handled by dredges,
- SPT 24 (Standard PenetroMetre Test) - i.e. free digging material
- Optimal overflow - minimum ore losses to fill the hopper
- Pumping distance from TSHD to FPSO would be 150 m
- 50 weeks/year, 90% operational workability, 81% weather workability
- Coupling/uncoupling time is 60 min/trip.

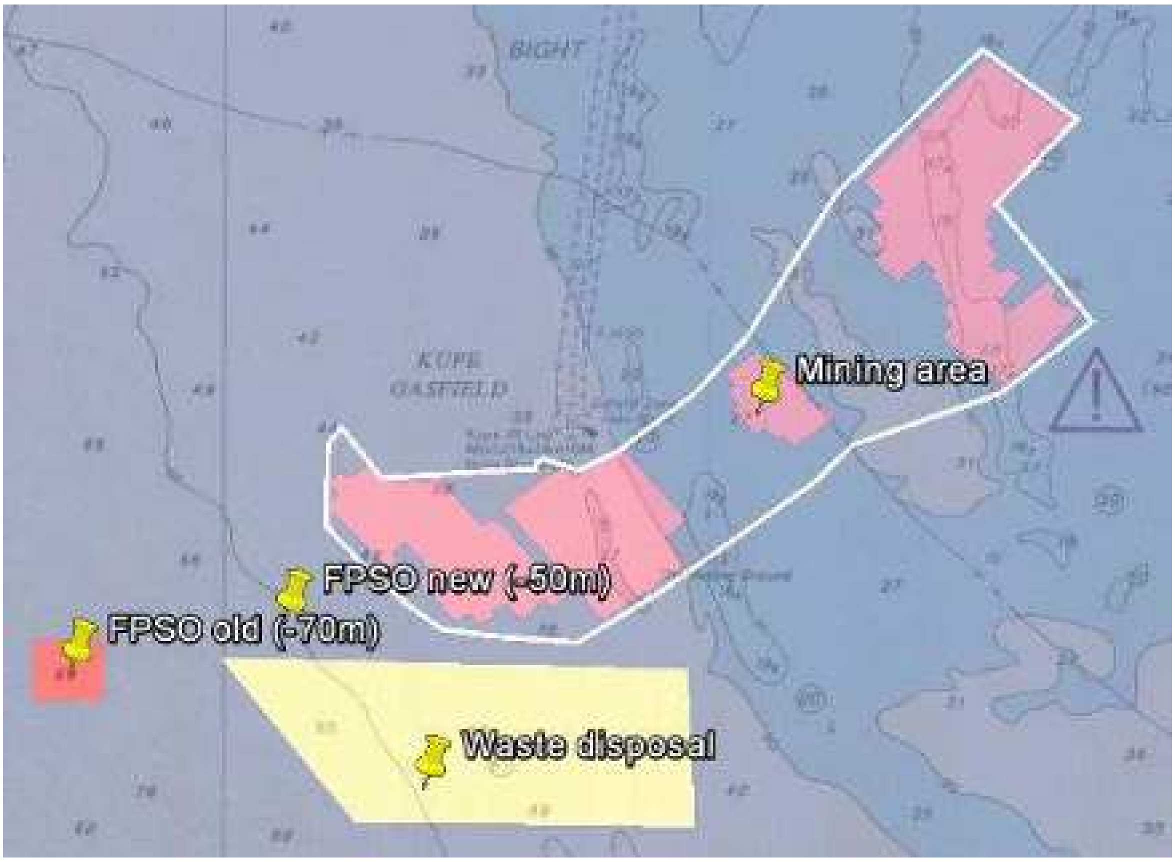


Figure 5-8 Proposed FPSO Location and Mining Area Layout

Area	Sailing Distance	Av DTR	Annual Sediment TDS
	nm	%	Mt TDS/yr
Christina	**3**	**6.74**	**33.2**
Christina	**3**	**11.50**	**33.5**
Dianne	**5.4**	**6.74**	**34.2**
Dianne	**5.4**	**11.50**	**34.6**
X2	**8.6**	**6.74**	**31.9**
X2	**8.6**	**11.50**	**31.8**
Xantia	**12.5**	**6.74**	**29.8**
Xantia	**12.5**	**11.50**	**30.4**

Table 5-7Dredge Scheduling Parameterss Provided by DEME

Note: TDS = Tonnes of Dry Sediment

Golder used the higher annual sediment estimates for this study.

5.12 Dredge Assumptions and Scheduling Parameter's

For the initial dredge scheduling study, it was assumed that:

- TTR would source two trailing hopper suction dredges and a FPSO capable of achieving the above production rates after initial ramp up periods;
- First 3 years were scheduled in 6 month periods, then annual scheduling periods;
- Recovery of the sediment < 2 mm was based on the modelled field "rec";
- Fe% = Fe_2O_3% × 0.6994;
- Mining recovery of *in situ* tonnages 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;
- In general each area was scheduled on an area/bench sequence, with strips being mined from the NW to the SE. This mining direction was not strictly applied when two dredges were scheduled in the same area at the same time.

- Scheduling Rates
    - Dianne = 34.6 Mtpa
    - X2 = 31.8 Mtpa
    - Xantia = 30.4 Mtpa
    - Christina = 33.5 Mtpa

Note: These rates were averaged when multiple areas were scheduled in one period.

5.13 Dredge Scheduling Results

The dredge scenario scheduled was that of one dredge for 6 months, with a second dredge starting in the second half of Year 1.Both dredges at maximum capacity, with one large plant.

The scenario was developed using an Excel spreadsheet template.

On advice from DEME, it was assumed both dredges were able to operate within one area at the same time.

Period	Dredge 1	Dredge 2
Y1	Dianne	Dianne
Y2	Dianne	Dianne
Y3	Dianne	Dianne+ X2
Y4	Xantia	X2 + Xantia
Y5	Xantia	X2 + Xantia
Y6	X2 + Xantia	X2 + Xantia + Christina
Y7	X2 + Christina	Christina
Y8	Christina	Christina
Y9	Christina	Christina

Table 5-8Dredging Scenario - Areas as Scheduled

The dredging, Processing Plant Feed and Concentrate Product Tonnages and grades are summarised below.

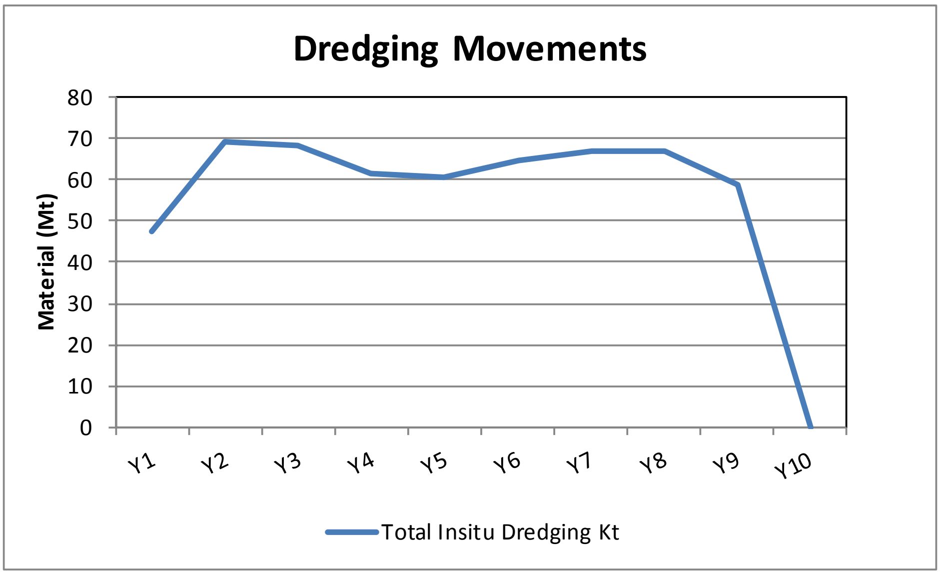


Figure 5-9 Dredging Schedule - Dredging Tonnage

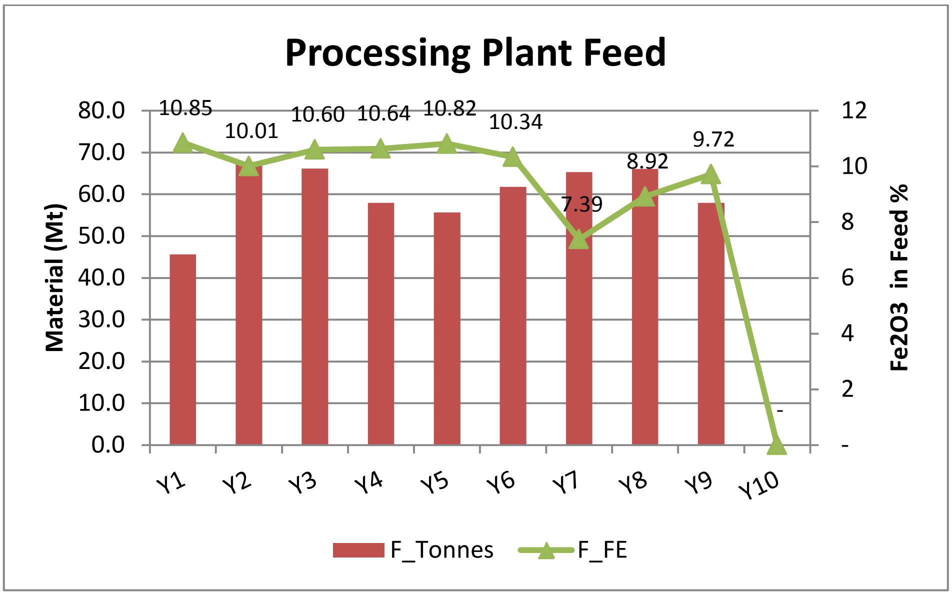


Figure 5-10Dredging Schedule - Processing Plant Tonnages and Fe Grades

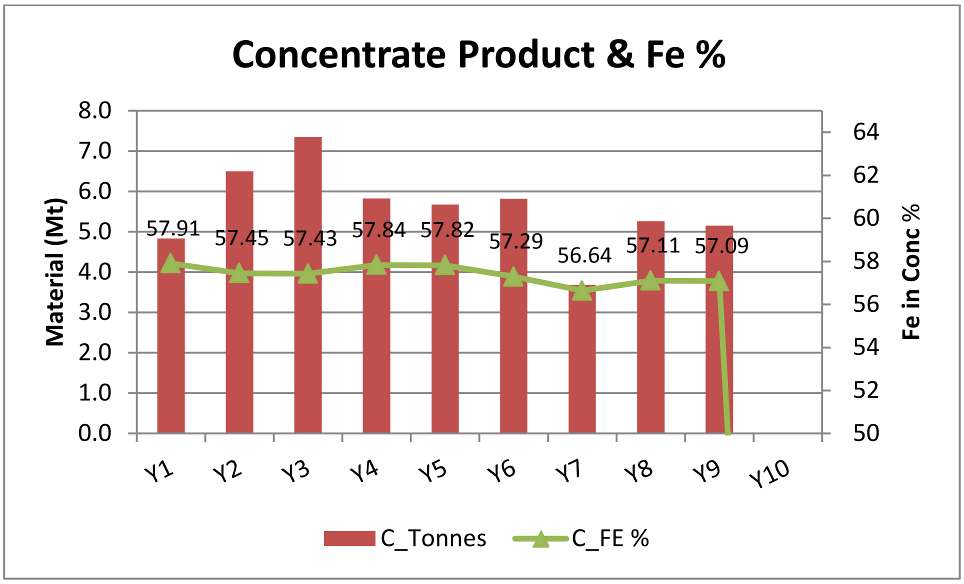


Figure 5-11 Dredging Schedule - Concentrate Tonnes and Fe Grades

Regardless of the selected extraction method, Dianne will be exploited first as this is the highest grade area outside the 12 nautical mile limit. In the case of the initial dredge option, both dredges were scheduled to work in this area for the first 3 years. Xantia and X2 would then be utilised, with both dredges scheduled in each area to attempt to even out the overall plant feed grades.

Christina would then start to be utilised late in Year 6 and with the majority of tonnes from Year 7 on, coming from Christina. The plant feed grades would fall as the upper lower grade Christina material was scheduled. From Year 8, both dredges were scheduled in the Christina area and plant feed grades would of improved a little as the dredging depth increased.

Average plant feed grades of over 10% Fe would be maintained for the first 6 years, but then fall as the lower grade Christina material, is mined.

A maximum concentrate production of 7.4 Mtpa would be achieved in Year 3 with average concentrate grades relatively consistent until the lower grade Christina material and the lower benches of X2 are scheduled in Year 7.

At the scheduled dredging rates, with two dredges operating, the high grade resources in the mining area would be depleted in nine years.

Royalties are payable on concentrate produced from within the 12 nm limit under the crown Minerals Act.

Table 5-9Dredging Scenario Schedule - Two Dredges One Plant

Period	Dredging Tonnage			Processing Feed				Concentrate Production							Waste_Tonnes		Royalty
	Dredge 1	Dredge 2	Total Dredging	F_Tonnes	F_Fe	F_DTR	F_REC	C_Tonnes	C_Fe	C_Al_2O_3	C_SiO_2	C_Ti	C_P	C_LOI	+2 mm	-2 mm	Tonnes
	Mt	Mt	Mt	kt	%	%	%	Mt	%	%	%	%	%	%	Mt	Mt	Mt
Y1	32.3	15.0	47.3	45.7	10.85	11.51	96.89	4.8	57.91	3.54	2.79	5.19	0.11	-3.12	1.6	40.8	
Y2	34.5	34.5	69.0	67.8	10.01	10.43	97.88	6.5	57.45	3.62	3.27	5.15	0.11	-3.04	1.2	61.3	
Y3	34.5	33.8	68.3	66.2	10.60	11.99	96.29	7.4	57.43	3.68	3.29	5.13	0.11	-3.06	2.1	58.8	
Y4	30.0	31.5	61.5	58.0	10.64	10.93	94.54	5.8	57.84	3.64	3.00	5.05	0.10	-3.15	3.5	52.1	4.4
Y5	30.0	30.5	60.5	55.6	10.82	11.09	92.27	5.7	57.82	3.65	3.02	5.05	0.10	-3.15	4.9	50.0	3.9
Y6	32.5	32.0	64.5	61.8	10.34	10.23	95.65	5.8	57.29	3.66	3.60	5.08	0.11	-3.11	2.7	56.0	2.1
Y7	33.5	33.5	67.0	65.3	7.39	6.12	97.35	3.7	56.64	3.64	4.20	5.12	0.11	-3.03	1.7	61.7	
Y8	33.5	33.5	67.0	66.1	8.92	8.67	98.36	5.3	57.11	3.64	3.74	5.10	0.11	-3.07	0.9	60.8	
Y9	33.5	25.3	58.8	58.0	9.72	9.66	98.37	5.2	57.09	3.67	3.76	5.08	0.11	-3.06	0.8	52.8	
Y10																	
Total	**294.3**	**269.5**	**563.8**	**544.4**	**9.86**	**10.00**	**96.47**	**50.1**	**57.43**	**3.64**	**3.37**	**5.10**	**0.11**	**-3.09**	**19.4**	**494.3**	**10.3**

5.14 Integrated Option (SSED)

For the integrated option, using a submerged sediment extraction device (SSED), it is now proposed to have the SSED and the FPSO both aligned along the SW - NE mining direction. The SSED will be located on the sea floor, connected to the FPSO via an umbilical delivery tube. A winching system will be used to locate the FPSO relative to the SSED which will be working 300 m × 300 m 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.

5.15 Integrated Option (SSED) - 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 same digitised dredging strip bench plans were utilised for Xantia, X2 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.

The digitised the high grade crawler strips on each bench are given in Appendix D.

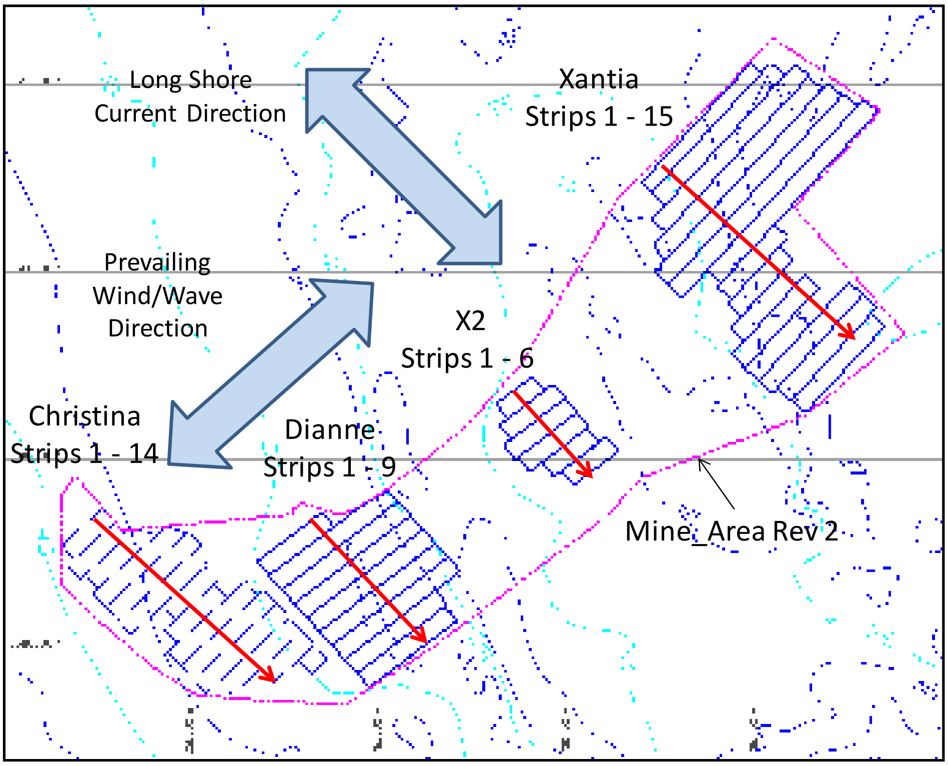


Figure 5-12 Proposed High Grade SSED Areas - Strip Naming Convention

For the integrated option, using a SSED, all areas are generally aligned parallel to the SW - NE wave and wind direction for the area. This is preferred alignment for directional control of the FPSO and the preferred alignment of the SSED advance direction to potentially minimise tails disposal onto the un-extracted areas.

Generally, the prevailing tidal current is in SE-NW alignment. Current direction is also substantially affected by tidal conditions.

The Xantia area is up to 4 metres in depth, while the other three areas are deeper and are up to 9 or ten metres in depth.

Some low grade blocks are included in the digitised strips as these blocks will have to be mined to access the lower levels.

In order to start the schedule in the highest grade area X2, the approximately 3 Mt of X2 material within the 12 nautical mile area has been removed from the schedule. It is assumed that this material will not be able to be mined once the adjoining areas have been backfilled with tails.

Table 5-10 HG SSED Option - Tonnages and Grades

Area	*In Situ* Tonnes	Feed Tonnes	$F\_Fe_2O_3$	$F\_Al_2O_3$	F_SiO_2	F_TiO_2	$F\_P_2O_5$	F_CaO	F_K_2O	F_Mgo	F_Mno	F_LOI	F_dtr	F_REC	Conc Tonnes
	Mt	Mt	%	%	%	%	%	%	%	%	%	%	%	%	Mt
Xantia	122.9	113.5	13.94	9.27	50.37	1.39	0.20	12.03	0.88	6.13	0.23	3.54	9.54	92.55	10.8
X2	57.5	56.0	18.27	10.38	45.79	1.84	0.32	11.39	0.95	6.99	0.28	1.42	13.83	97.05	7.7
Dianne	180.9	176.3	14.88	11.84	48.48	1.50	0.28	11.13	1.04	5.70	0.23	2.09	11.30	97.07	19.9
Christina	188.8	185.3	12.37	12.24	50.72	1.24	0.26	11.36	1.06	5.68	0.22	2.00	8.10	97.91	15.0
Grand Total	550.1	530.9	14.16	11.28	49.38	1.42	0.26	11.43	1.00	5.92	0.23	2.30	10.08	96.40	53.5

5.16 SSED - Scheduling Parameterss

Basic scheduling parameterss for the SSED option have been provided by TTR following initial workshop/discussions and meetings between TTR and IHC Merwede (IHC), the suppliers of SSED type systems.

Scheduling Assumptions:

- SSED throughput = 6900 tph
- Annual operation hours = 6000 hrs
- Calculated scheduling rate = 6900 tph × 6000 hrs pa = 41.4 Mtpa.

5.17 SSED Assumptions and Scheduling Parameterss

For this scheduling scenario, it has been assumed:

- TTR will source a SSED and FPSO capable of achieving the above production rates after initial ramp up period.
- First 3 years are scheduled in 6 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.
- All areas can be accessed by the crawler/FPSO system.

5.18 SSED Scheduling Results

The integrated SSED scenario schedule assumes a ramp up period of six months with a single large plant.

The scenario was developed using an Excel spreadsheet template. Each area was scheduled (SE to NW direction) until completed.

The minimum and maximum depths to the top and the bottom (from the ocean surface - 0 m RL) of the mined “ore” zone, and the minimum and maximum depths of the ore zone are also indicated in the table below.

Period	SSED	Min Depth	Max Depth	Ore Depth	
				Max	Min
Y1	X2	-26	-38	8	8
Y2	X2 + Dianne	-25	-42	9	5
Y3	Dianne	-21	-42	10	8
Y4	Dianne	-21	-40	10	8
Y5	Dianne	-23	-41	10	9
Y6	Dianne + Xantia	-18	-41	9	3
Y7	Xantia	-17	-28	4	2
Y8	Xantia	-18	-32	3	2
Y9	Xantia + Christina	-18	-45	7	3
Y10	Christina	-34	-49	9	7

Table 5-11 SSED Scenario - Areas as Scheduled

The SSED, processing plant feed and concentrate product tonnages and grades are summarised below.

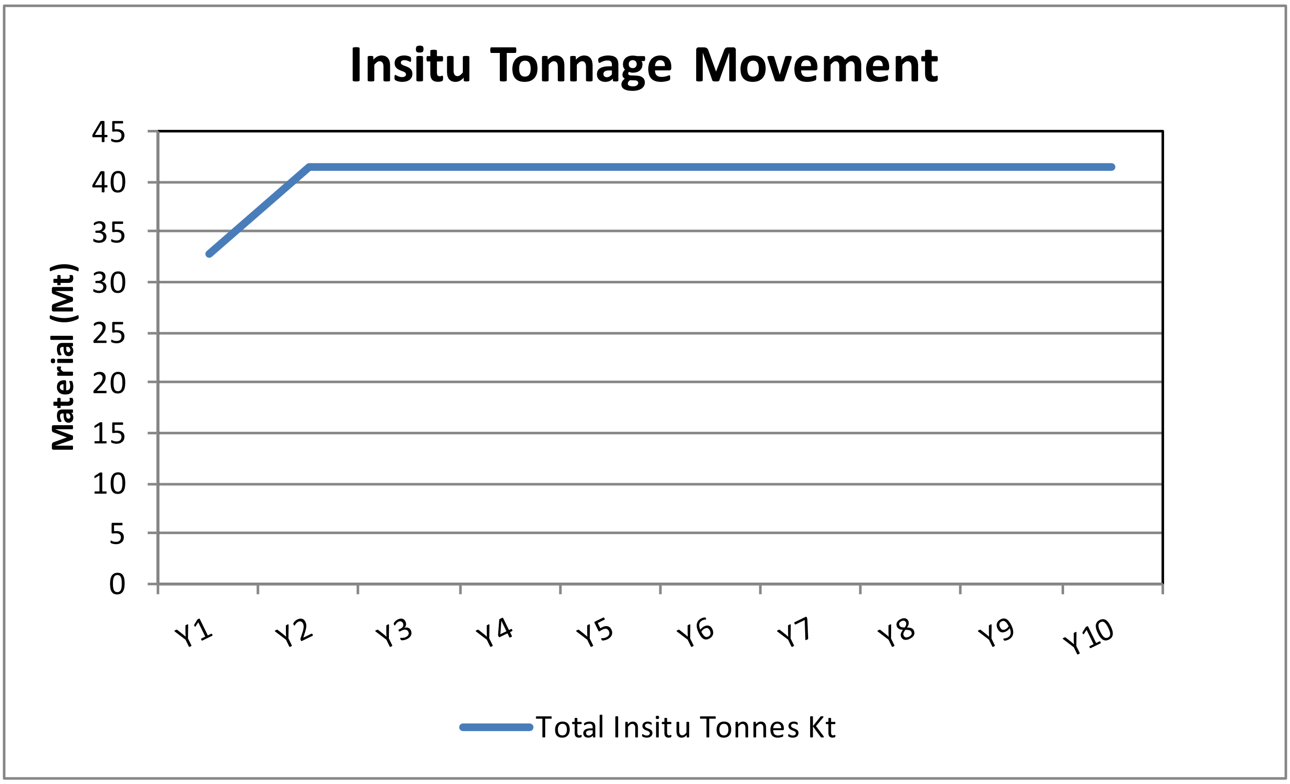


Figure 5-13 SSEDSchedule - In Situ Tonnes Mined

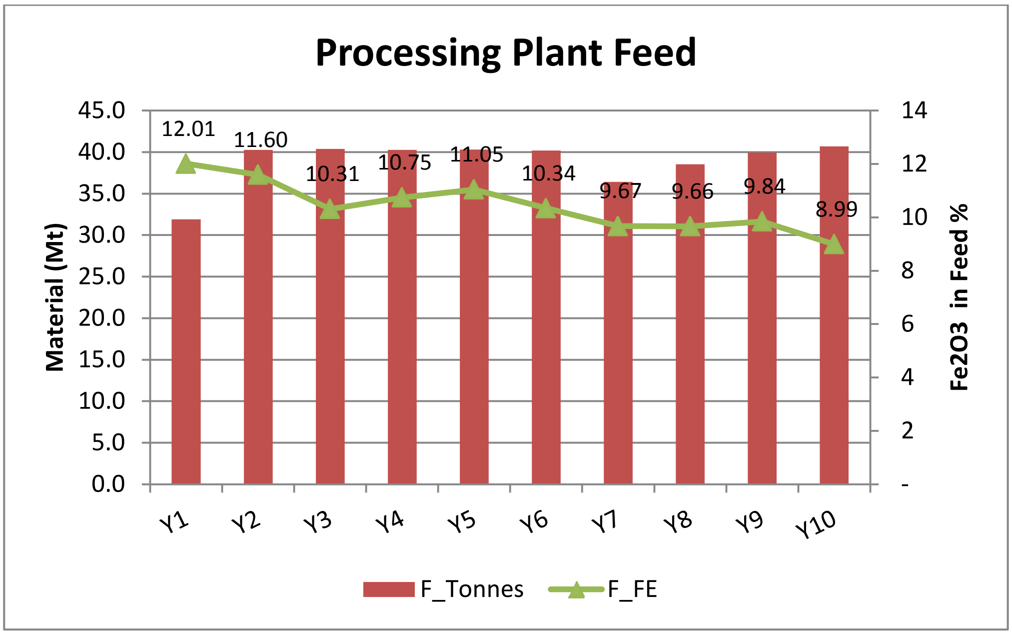


Figure 5-14 SSED Schedule - Processing Plant Feed Tonnes and Fe Grades

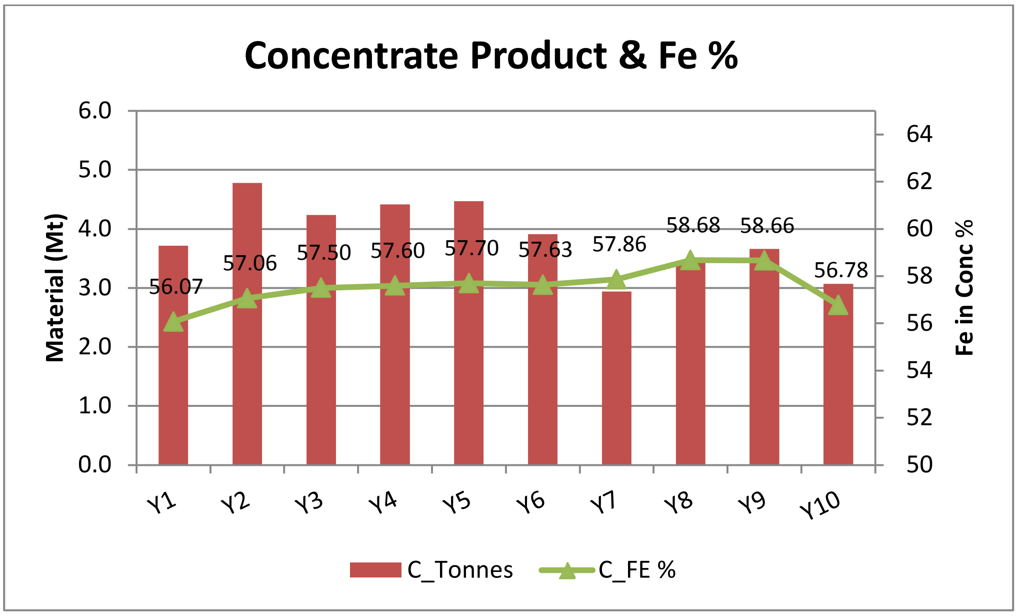


Figure 5-15 SSED Schedule - Concentrate Tonnes and Fe Grade

X2 has been scheduled first as this is the highest grade area. The X2 material within the 12 nm limit was removed from the schedule.The sequence is then to mine Dianne, Xantia and finally Christina. Due to the reduced scheduling rate in this scenario (41.4 Mtpa) only three of the defined area/strips are scheduled from Christina in late Year 9 and then in Year 10.

Average plant head feed grades of over 10% Fe are maintained for the first 6 years, but then feed grades fall as the lower grade material from Xantia and Christina are mined. Concentrate grades increase while Xantia is being mined but then decrease as Christina is mined. Concentrate tonnages start to decrease as the lower quality Xantia material is mined but then decrease further as Christina material is mined. The Xantia area has a higher trash content as indicated by the low recovery percentage, whereas the Christina material is a lower grade material.

A maximum concentrate production of 4.8 Mtpa is achieved in Year 2. The average concentrate grades are relatively consistent after Year 1, then increase while Xantia is being mined, then decreases further as Christina is scheduled.

At the scheduled crawler rates, the high grade resources in the mining area are not depleted at the end of the ten year schedule. The remaining Christina material would have an average Fe feed grade of less than 10%.

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 to be extracted from the sea bed.

6.1 Submerged Sediment Extraction Device Methodologies

The basis for this 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 IHC Merwede group.

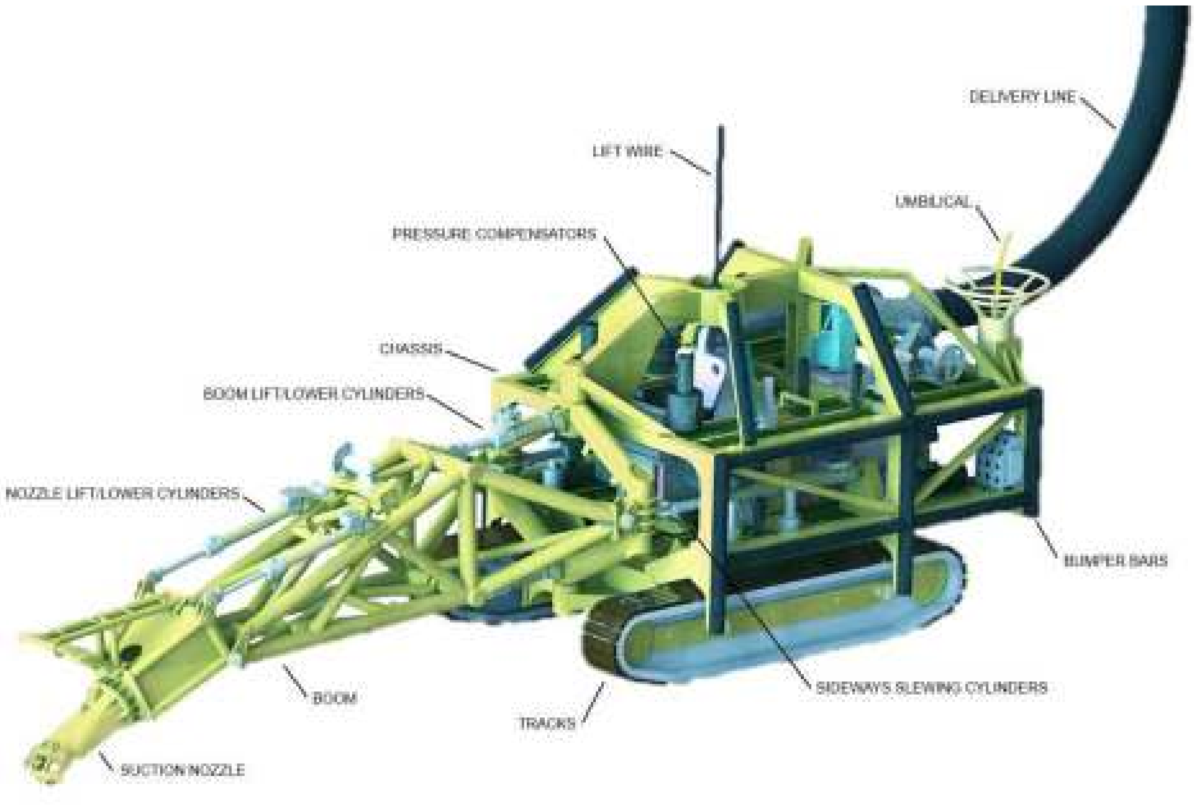


Figure 6-1 Submerged Sediment Extraction Device

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

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

The SSED 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 sea bed, eroding and 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 SSED Slurry Transport System (STS)

The STS enables the transport of slurry from the SSED 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 6-2 Riser Hose Handling

6.2 Dredging methodologies

The dredging methodology was amongst the best two options considered for TTR's sediment extraction operations. Within the dredging arena, the following dredging based methodologies were considered by both the Technip and TTR teams:

- Use of Airlift methodology,
- Use of a Trailing Suction Hopper Dredger (TSHD),
- Use of Plain Suction Dredger (PSD).

A general description of the different mining methodologies as well as the motivations for their selection (or not) are presented in the following paragraphs.

6.2.1 Airlift

Airlift operates by the injection of compressed air into the water inside of a discharge pipe, at a point below the water level. The injection of the air results in a mixture of air bubbles, water and fine particles of sand, which being lighter in weight than water outside the discharge the working principle of air lift method.

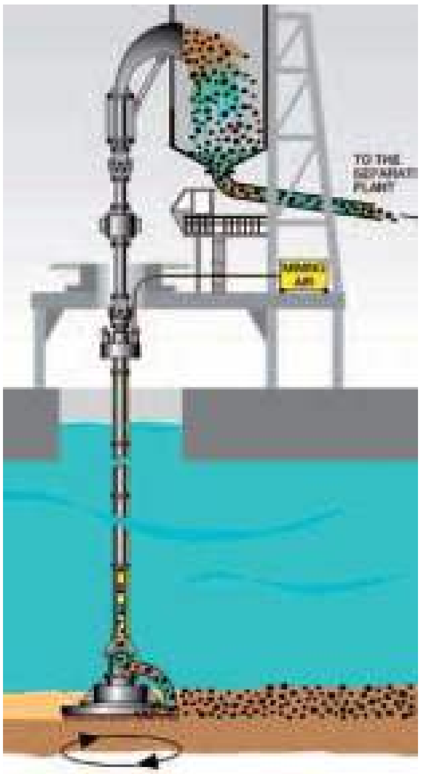


Figure 6-3 Airlift Methodology

The two critical factors in airlift pumping method are the submergence of the airline as well as the size of the discharge line. Submergence always means the depth of airline below the pumping level, rather than the static water level in the well. Best performance occurs when approximately 60% of the airline is submerged. If the submergence is too low, the system will not work.

With regards to its working principle and limitations, the use of airlift methodology was not progressed as a viable option because of the relatively high power consumption due to the requirement for pressurised air. Moreover, a restrictive and complex pressurised air management system is required to achieve the required production rate and simultaneously control the topside air expansion.

Also erosion induced by pumping the ore sands at relatively high pressures compared to other methodologies may be of concern and cause additional OPEX while drastically reducing the dredging operability.

6.2.2 Plain suction dredger

Compared to a TSHD, the main characteristic of a plain suction dredger is that it is a stationary (anchored) dredger, consisting of a vessel or barge equipped with a suction pipe, as represented on the drawing herein 6.4.

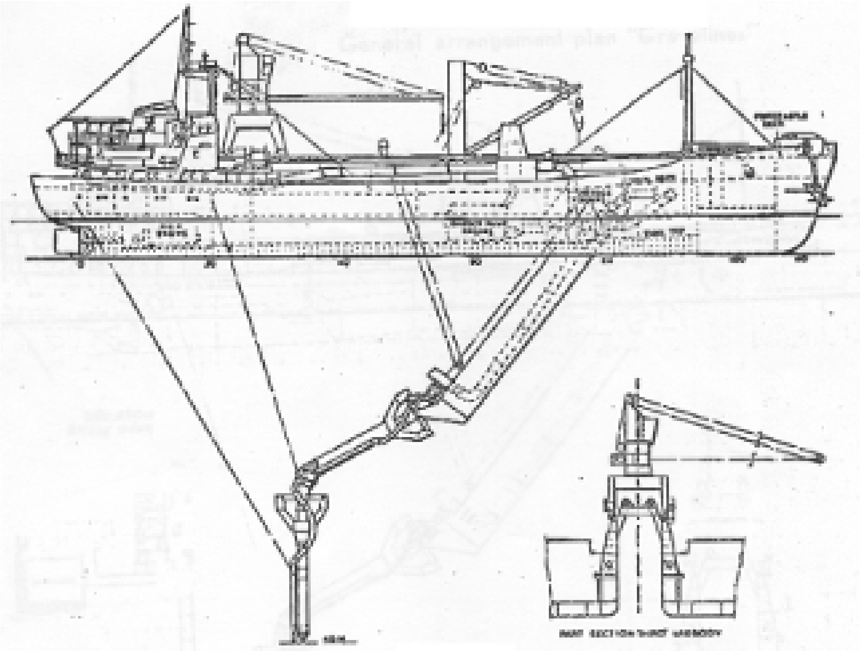


Figure 6-4 Plain Suction Dredger methodology

Material excavation is achieved by means of a jet stream and/or the suction flow of the dredge pump. During sand excavation, the dredger is moved slowly forwards by a set of winches acting on its anchoring lines. In order to increase the amount of dredged material flowing towards the suction mouth, a water jet is often directed onto the breach/bank. In this case, the jet pipe is often mounted above the suction pipe.

The pictures below describe the suction pit geometry obtained using a Plain Suction Dredger when slightly moved around its anchoring position.

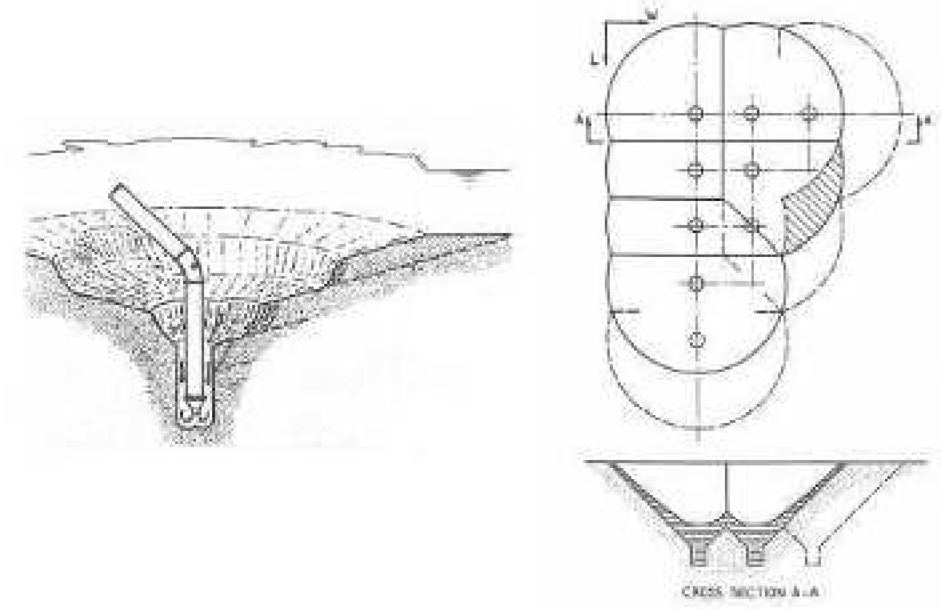


Figure 6-5 Suction pit geometry

Resulting from an extensive technical and economical comparison between the PSD and TSHD methodologies, the Plain Suction Dredger has proved to be less active for this specific application with regards to the environmental conditions, together with the high expected production rates, compared to the option using a TSHD.

6.2.3 Trailing Suction Hopper Dredger

With regards to dredging methodologies, the use of a TSHD was retained as a viable alternative to the SSED for the recovery of iron sands considering its operational performance, delivery and reliability of the dredge cycle for the four parts of the process, i.e. the dredging of sediment, sailing to the point of discharge, the connection and offloading of the sediment as well as the sailing time back to the mining location to continue dredging operations.

The sketch below in figure 6.6 represents a typical arrangement of a TSHD as well as the offshore dredging operation concept.

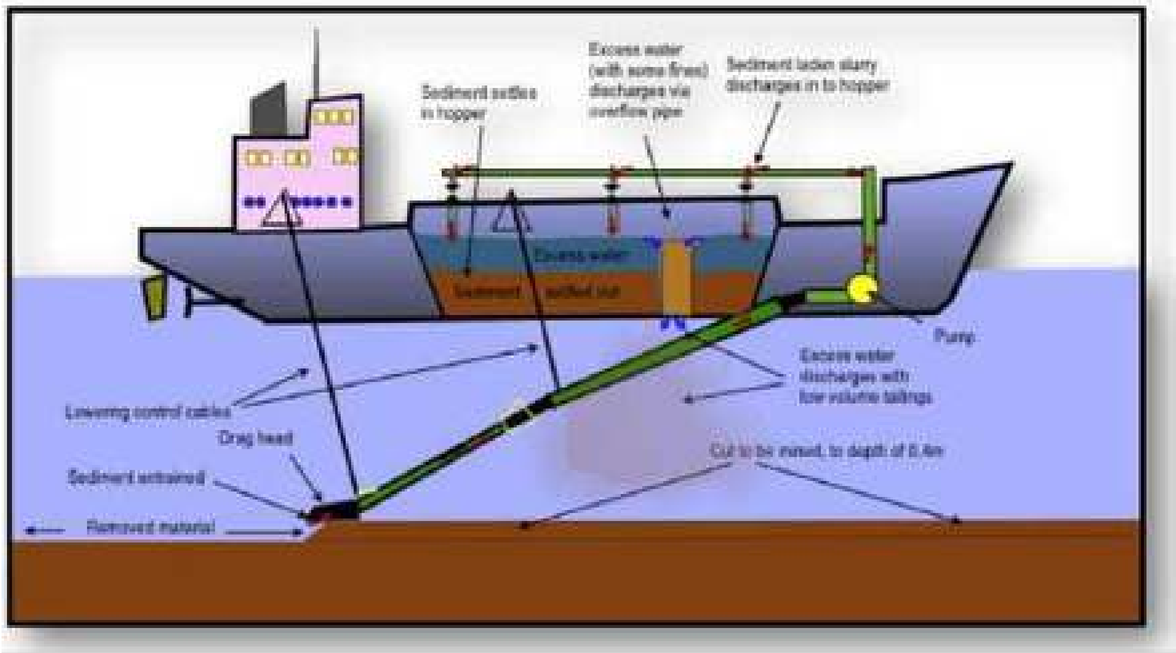


Figure 6-6 Typical section of the TSHD

In evaluating the TSHD over the SSED it was found that while the TSHD is easily scalable, the TSHD system cannot control the tailings dispersion and has the potential to generate large plumes. On the other hand SSED using their intensive extraction allows the return of the tailings material back on to the original location in a controlled way, and avoids the need to return to an extracted area. Operation logistics between the two systems are also different. The TSHD system must have the processing plant located on another vessel, whereas, an SSED can be incorporated into an integrated production vessel.

7. PROCESS PLANT

7.1 Metallurgy

7.1.1 Test work overview

The metallurgical test work was conducted in two phases:

- Stage 1 – Preliminary test work
- Stage 2 – Pilot plant test work

The purpose of the test work was to investigate the viability of upgrading the ore via conventional mineral sands and/or magnetite processing and to determine the base parameter's required for the design of the process flow sheet. The ultimate objective of the test work 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.

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

7.1.2 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% TiO_2)
Ilmenite	Includes all TiO_2 phases from Luecoxene to Ilmenite (50% TiO_2 - 95% TiO_2)
Titano-Hematite	Includes Titano-Hematite (50% TiO_2 - 20% TiO_2)
Titano-Magnetite	Includes Titano-Magentite (<20% TiO_2)
Quartz	Includes Quartz
Calcite	Includes Calcite and $CaCO_3$ 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

Table 7-1 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

[$CaNa(Mg,Fe)_4(Al,Fe,Ti)_3Si_6O_{22}(OH,F)_2$ or $(Ca,Na)_{2.3}(Mg,Fe,Al)_5Si_6(Si,Al)_2O_{22}(OH)_2$] 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 titano-magnetite 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 7-2 Deportment of Fe to Different Species

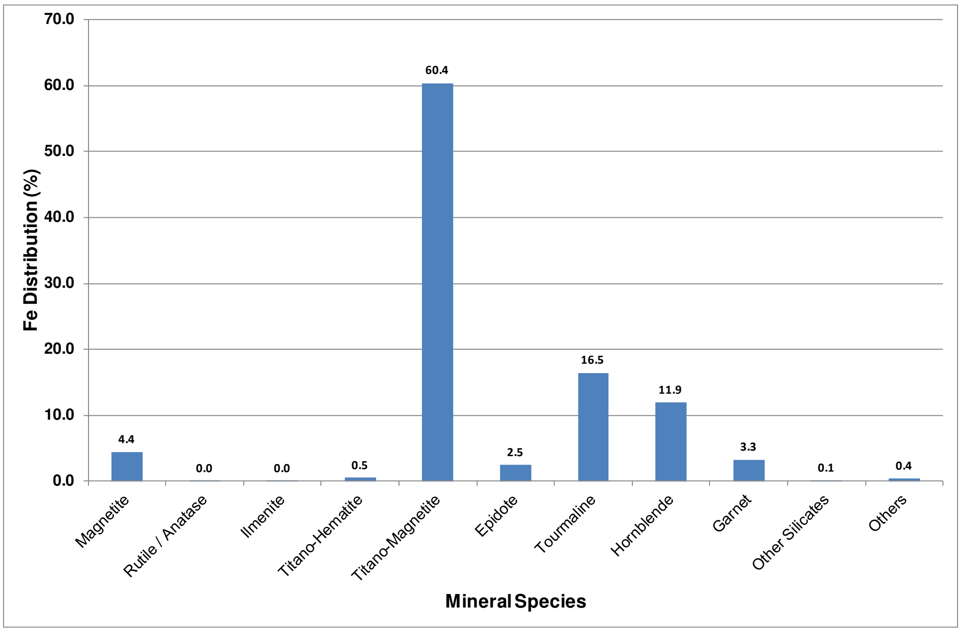


Figure 7-1: Fe Deportment to Mineral Species – Xantia Composite Sample

The Fe is therefore primarily present as titanomagnetite, which is a solid solution of ulvöspinel and magnetite. Pure ulvöspinel has a TiO_2 content of 35.7% and is non-magnetic. The TTR titanomagnetite typically has a TiO_2 content of around 8.5% and is therefore much closer to the magnetite side of the solid solution series refer (The FeO

Fe2O3 TiO2 ternary phase diagram). As a result the TTR titano-magnetite is highly magnetic and would therefore be amenable to beneficiation by magnetic separation.

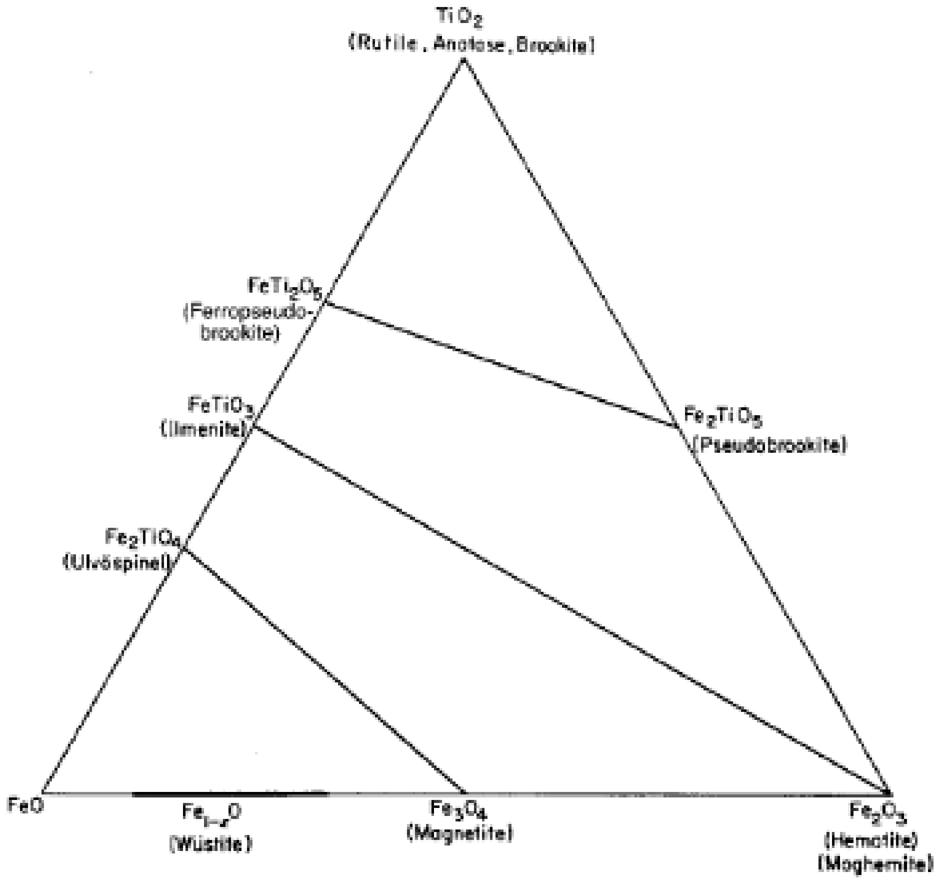


Figure 7-2: The FeO Fe2O3 TiO2 ternary phase diagram

7.1.3 Davis Tube Recovery (DTR)

In 2012 a Davis tube test work 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 Figure 7-3 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.

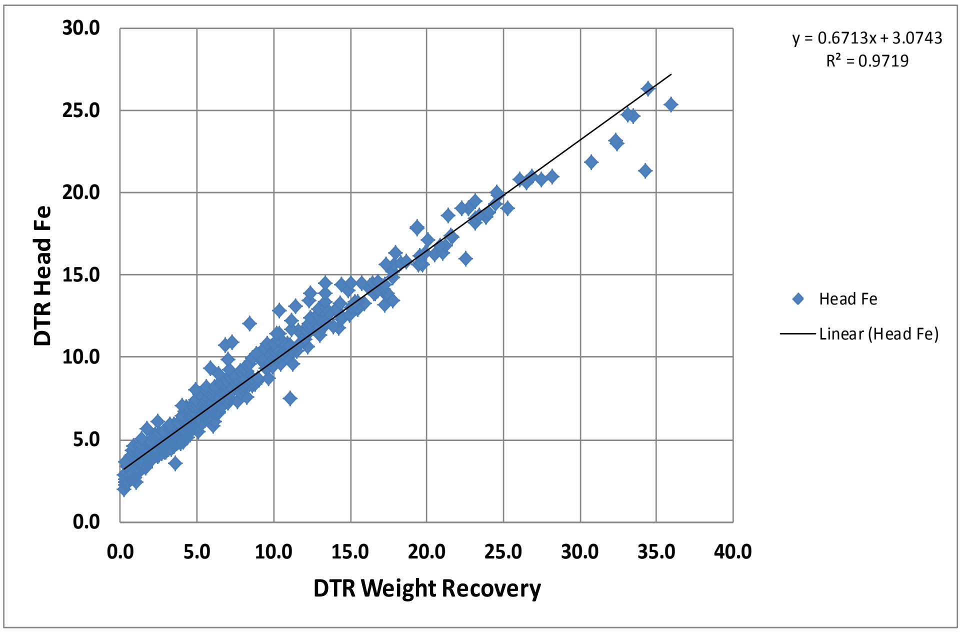


Figure 7-3: DTR Head Fe vs. Weight Recovery

The Fe recovery achieved with the Davis tube is plotted against Fe head grade in Figure 7-4. 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.

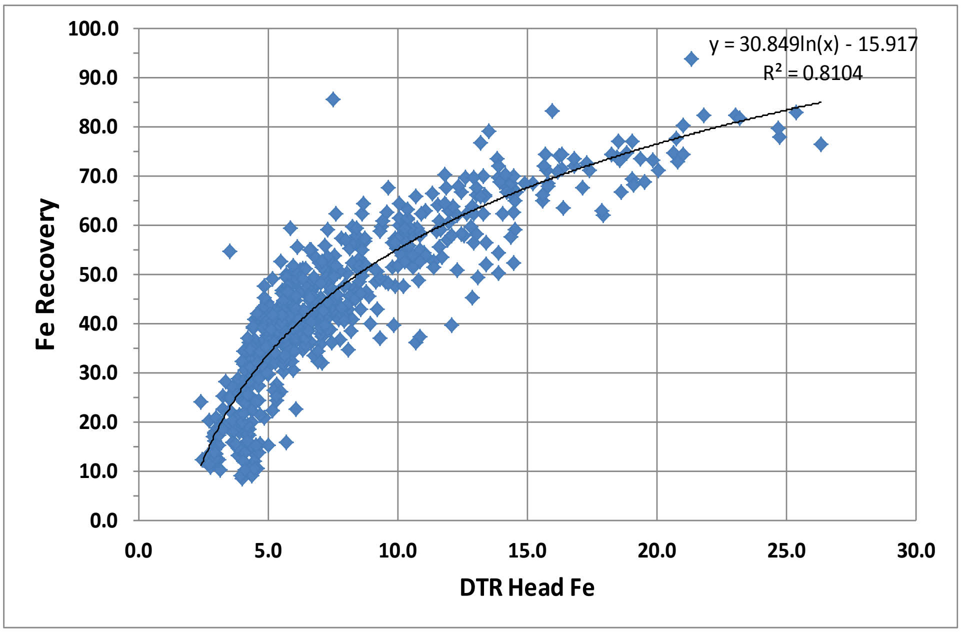


Figure 7-4 DTR Fe Recovery vs. Fe Head Grade

The Fe – SiO_2 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.

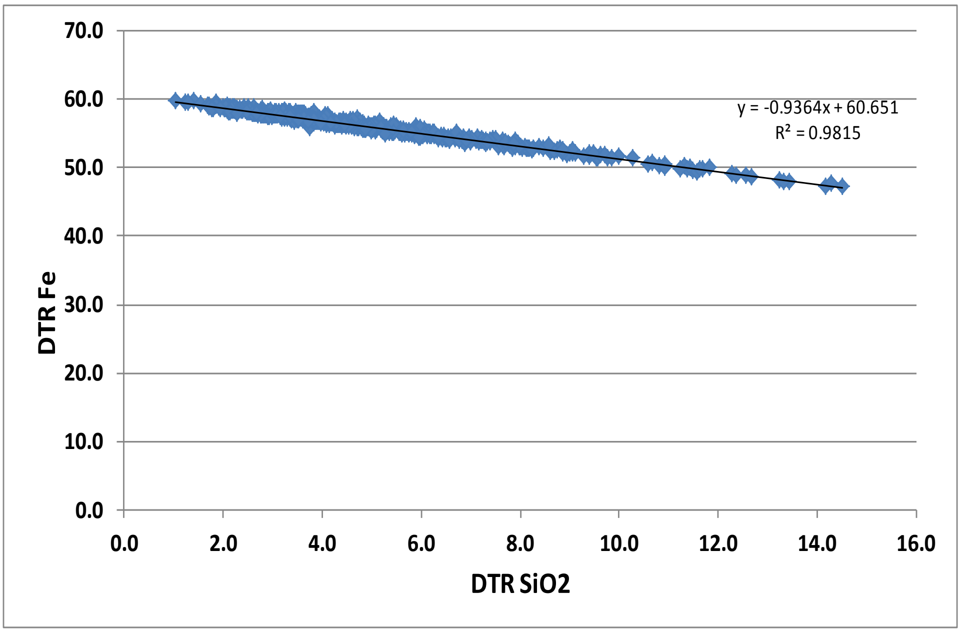


Figure 7-5 Fe – SiO_2 Relationship

The relationship between the DT Mag Fe (i.e. DT Concentrate Fe grade x DT Weight Recovery) and Head Fe is given in Figure 7-6 below, again illustrating the fact that a significant proportion of the Fe in the ore is non-magnetic and hence not recoverable.

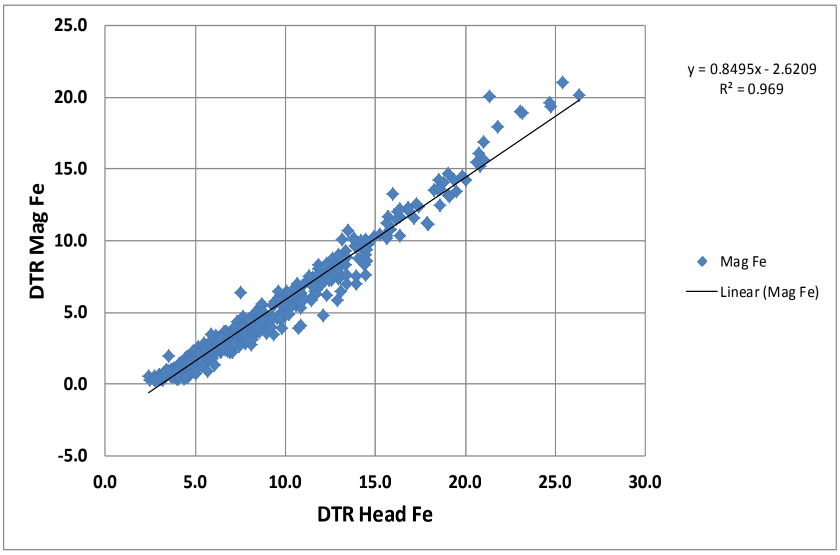


Figure 7-6 DT Mag Fe vs. DT Head Fe

7.2 Pilot Plant Test Work

In 2012 a 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 7-7 and Figure 7-8.

After drying and removal of large pebbles and shells, the sample was homogenised in a tumble mixer and screened at 2 mm. The material was then slurried in an agitator tank and subjected to medium intensity magnetic separation (MIMS) at 3300 G for a single pass followed by three passes through a low intensity magnetic separator (LIMS) at 1250 G. The primary LIMS concentrate was subsequently ground in a 500 L ball mill using a mixture of 50 and 30 mm ceramic balls. The aim grind size was 80% passing 53 µm. 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 1050 G. 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.

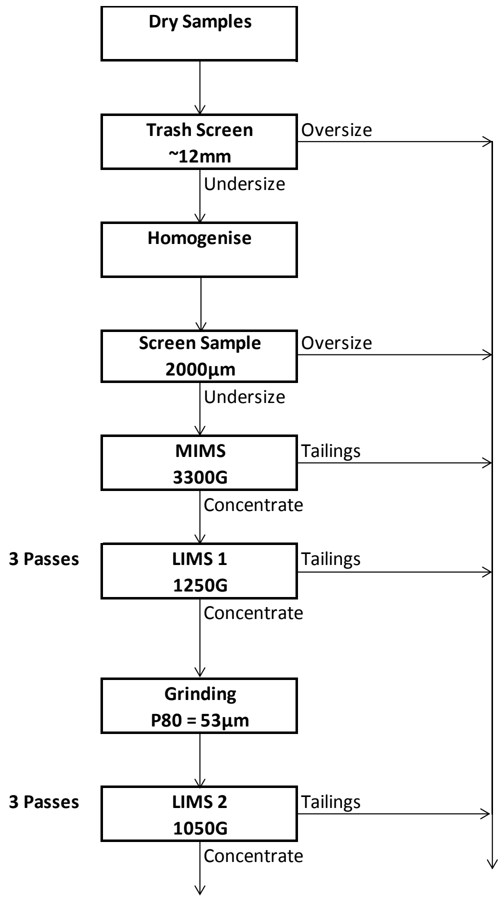


Figure 7-7 Initial Pilot Plant Flow Sheet Block Flow Diagram

Figure 7-8 Pilot Plant Process Flow Diagram

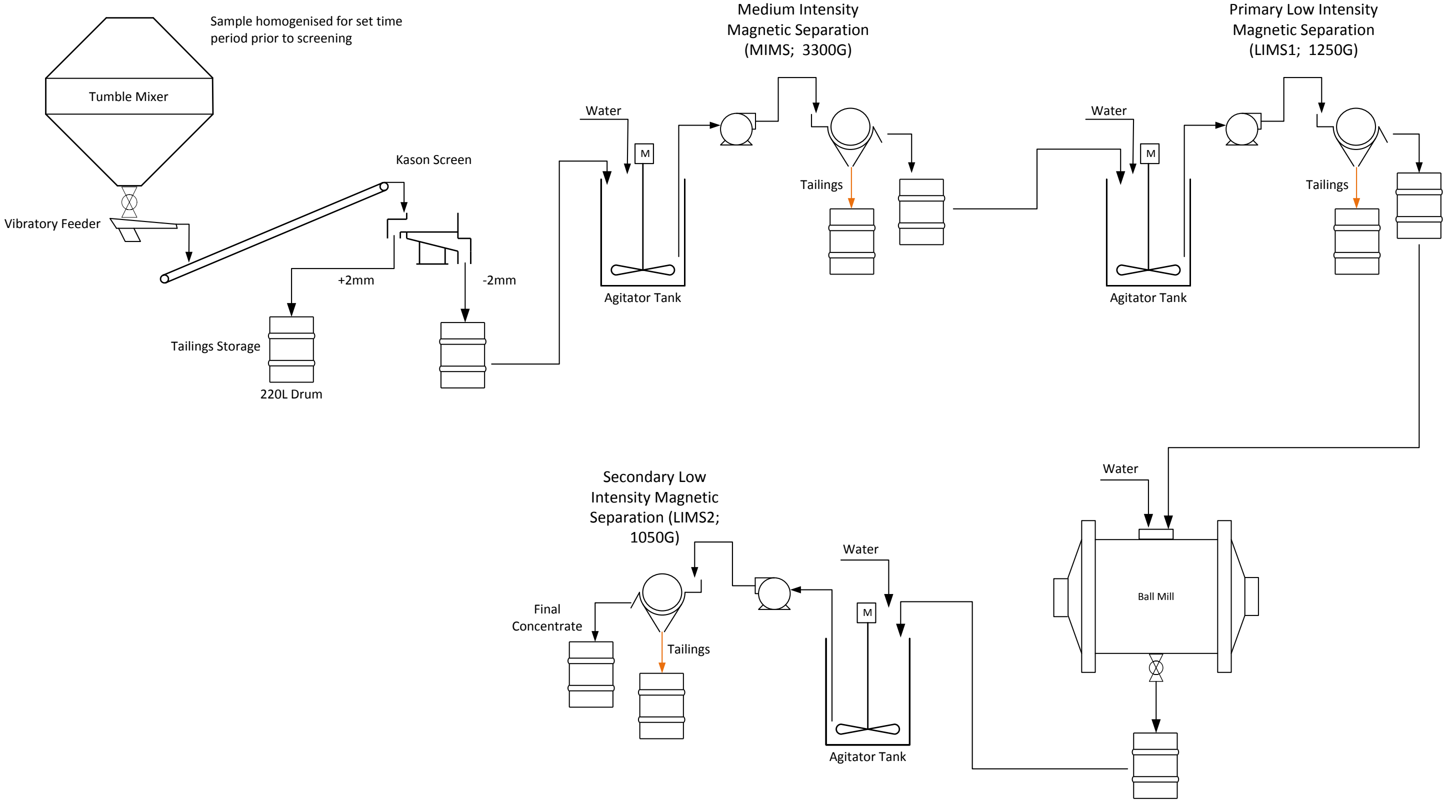
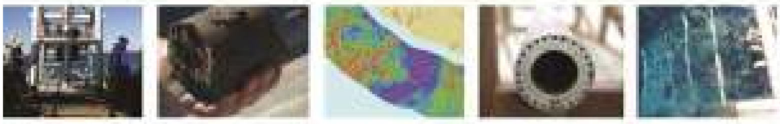


Figure 7-9 Pilot Plant LIMS-1 Concentrate

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 7-11). 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.

Figure 7-10 Pilot Plant Ball Mill



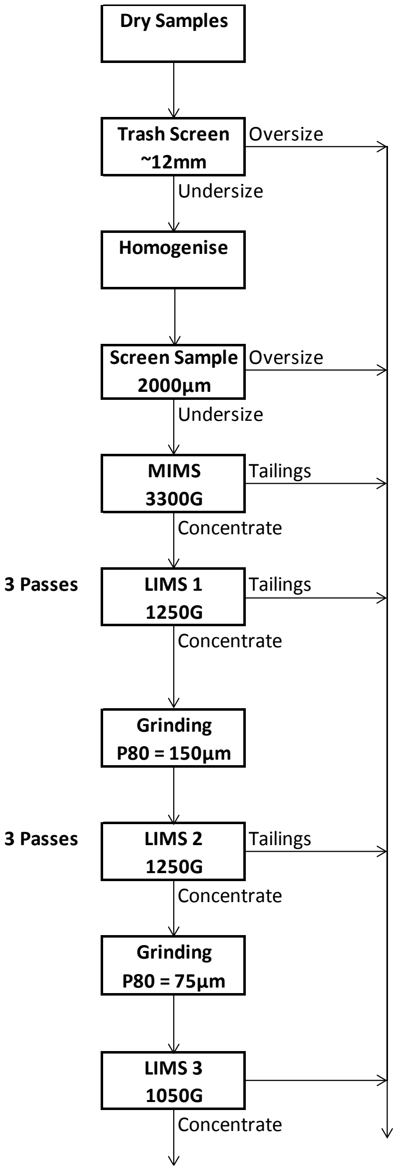


Figure 7-11 Two Stage Grinding Flow Sheet

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 7-3 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 7-4 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 7-5 Pilot Plant Results – Fe Grades

The pilot plant Fe recovery is plotted against mag Fe and DTR Fe recovery in Figure 7-12. 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.

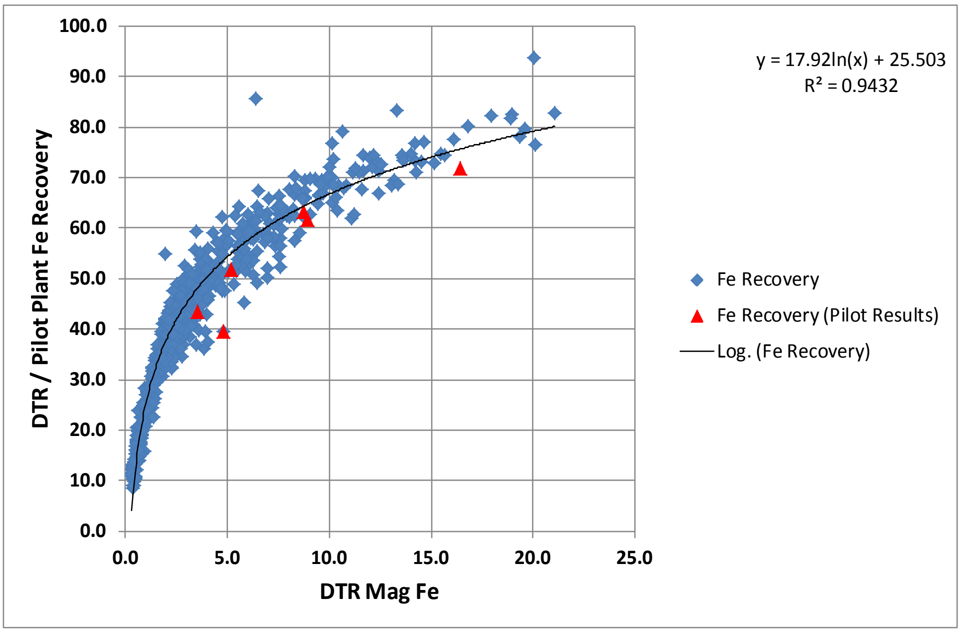


Figure 7-12 Pilot Plant and DTR Fe Recovery vs. Mag Fe

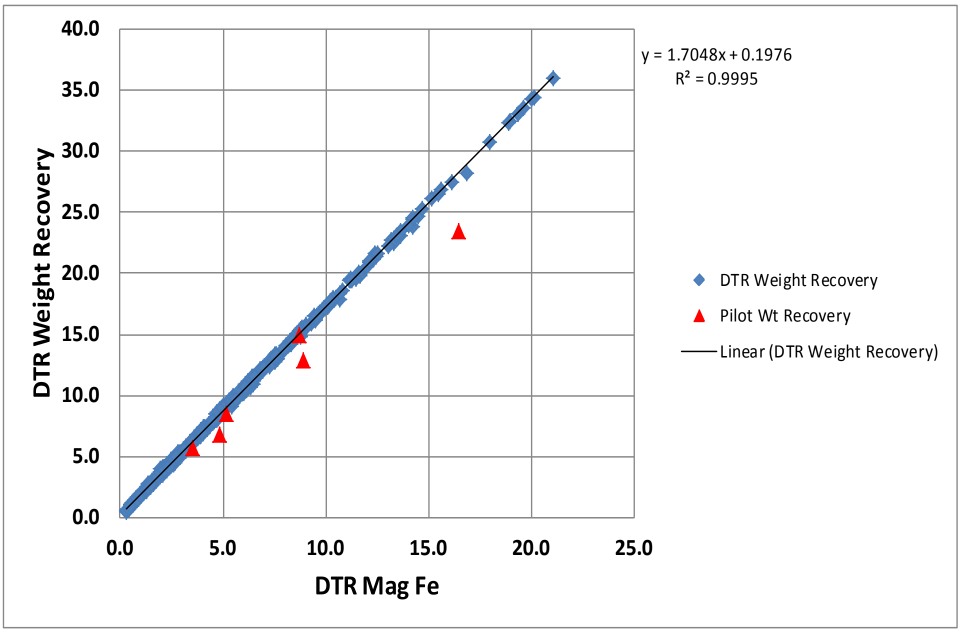


Figure 7-13 Pilot Plant and DTR Weight Recovery vs. Mag Fe

7.2.1 Final Product Grade and Grind Determination

The Qemscan and other test work 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 3000 G.

In Figure 7-14 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 (refer Figure 7-5). This would suggest that the final product SiO_2 must be reduced to less than 5% in order to have an Fe grade of more than 55%.

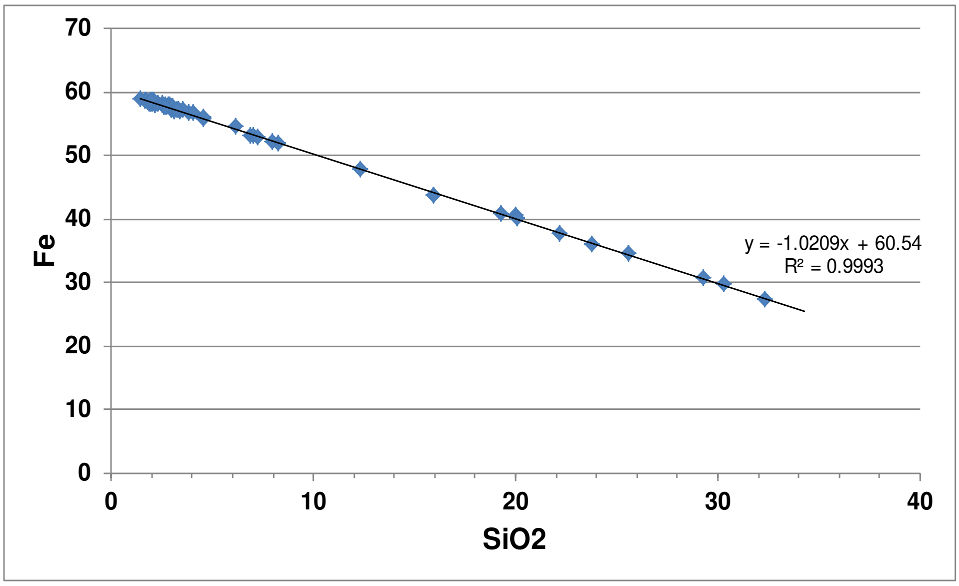


Figure 7-14 Pilot Plant DTW Results – Fe vs. SiO_2

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 7-15. 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 90 µm 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 75 µm to 0.16%P.

The final grind size will be confirmed during ongoing pilot test work 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 75 µm.

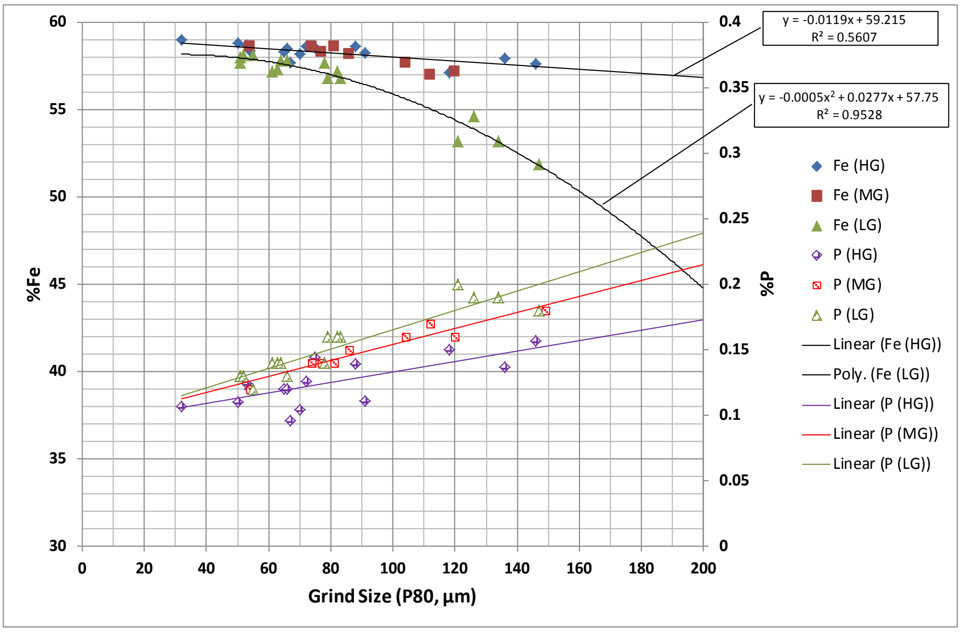


Figure 7-15 Pilot Plant DTW Results – Fe and P vs. Grind Size

The proposed final product specification for a concentrate at a grind size (P_{80}) of 75 µm is given in Table 7-6.

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 7-6 Product Specification – 75µm Concentrate

7.2.2 Grindability Test Work

Three sets of grindability test work were conducted. Samples from Xantia Extension (X038 and X039) were used for Levin test work and two sets of IsaMills™. signature plot work were subsequently carried out (X438 and X451). The IsaMills™. signature plot work is the most applicable due to the equipment choice. Due to problems experienced on the first signature plot work, this data could not be used. The most reliable data set is the most recent plot performed on X451. Unfortunately this sample was quite fine with a feed size (F_{80}) of 208 µm. It has however allowed a preliminary estimate of power requirements and sizing of the grinding mills by the mill vendor

Xstrata. The grinding energy required for the first stage grind will be approximately 15 kWh/t (P80 = 130 µm) and the second stage 17 kWh/t (P80 = 75 µm). The signature plots for the first and second stage grinds are given in Figure 7-16 and Figure 7-17 respectively.

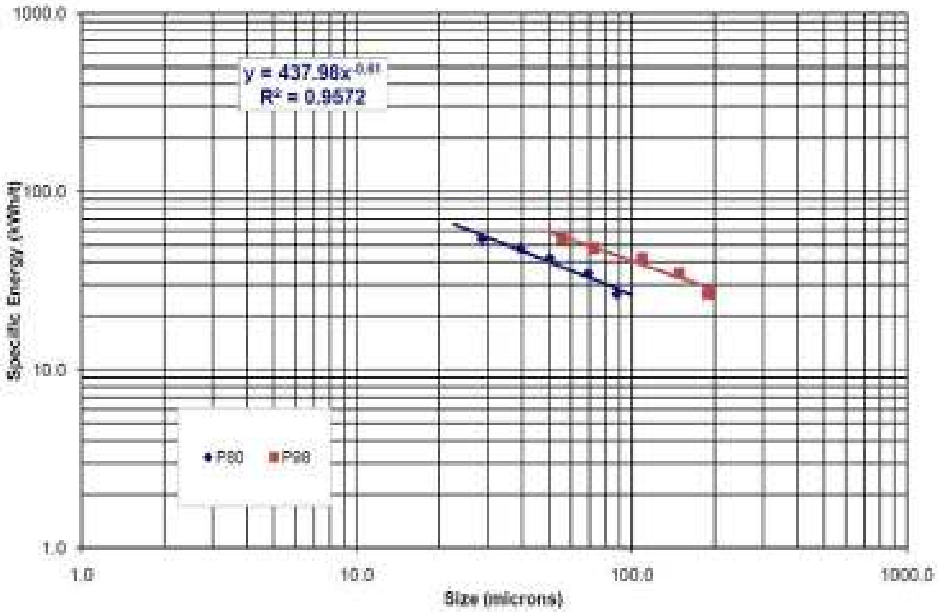


Figure 7-16 Signature Plot – First Stage Grind

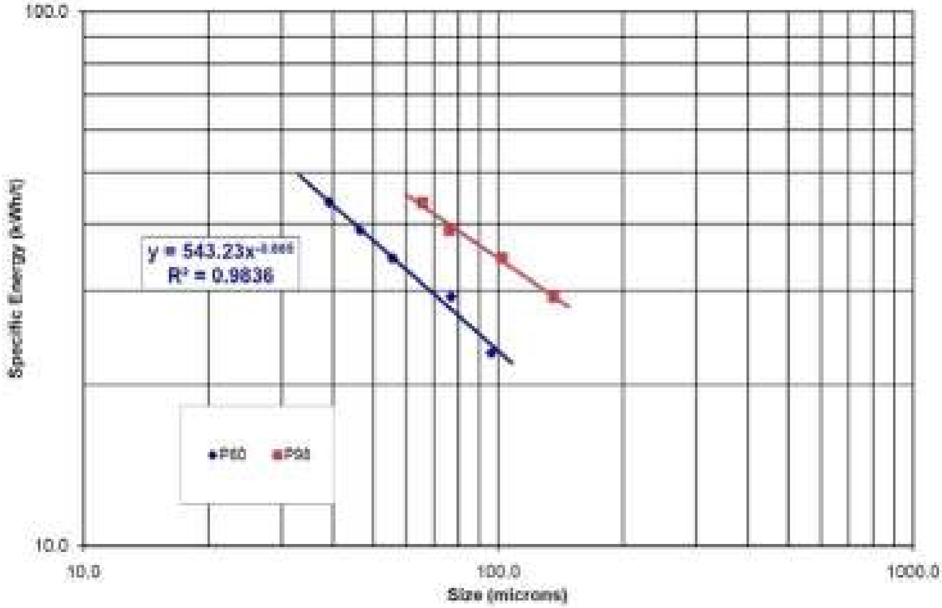


Figure 7-17 Signature Plot – Second Stage Grind

7.3 Process Overview

The TTR Iron sands Project is designed to deliver 4.7 Mtpa titano-magnetite concentrate. The iron sands will be mined using two SSED`s, one operating and one standby. The ROM will be delivered to a FPSO 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 FPSO 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 cape-size vessel.

Tailings will be disposed in real time via a fall pipe extending forward off the port side of the FPSO such that the tailings is deposited as far as possible from the mine face. 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 waste water disposed of separately along the tailings fall pipe.

7.3.1 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	Test work 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	
	t/a	48,002,734	5	
Product %Fe	%	56-57	2	
Process plant weight recovery	%	9.6%	2	
Process plant mag Fe recovery	%	90.0%	2	
VTM Concentrate Production	t/h	765.0	3	
VTM Concentrate Production	t/a	4,590,261	3	
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 years, then every 3 years thereafter
Refuel	d/y	0	4	Refueling will take place without any loss to production
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

				for buffer
FPSO Availability	%	92%	3	
Mining efficiency	%	85%	4	
Weather uptime	%	90%	4	
Total operational Availability	%	68.5%	3	
Operating time	h/y	6,000	3	
3. Ore Characteristics				
+2mm fraction	%	4.0	2	
-63µm fraction	%	0.6	4	
Concentrate specific gravity	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	
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 7-7 Project Design Criteria – Process Plant

7.3.2 Mass and Water Balance

The process plant mass and water balance was developed based on the design criteria and the pilot plant test work results. The main inputs and outputs for the beneficiation plant is given below.

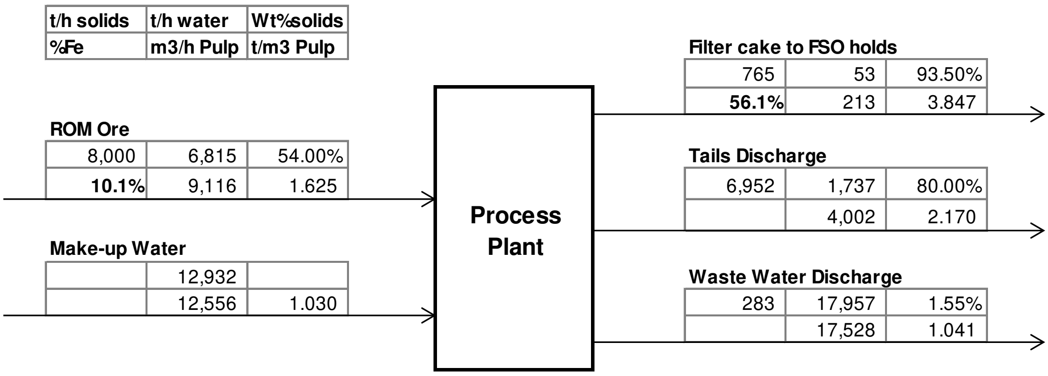


Figure 7-18 Process Plant High Level Mass and Water Balance

7.4 Process Description

7.4.1 ROM Receipt

The process flow diagram for the beneficiation plant is given in Figure 7-19 and Figure 7-20 (also refer Section 19.6 for FPSO general arrangement). ROM ore will be delivered to the FPSO via an 800 mm ID rubber hose connected to the subsea mining vehicle. The design rate of ROM delivery is 8,000 t/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 4 mm such that the effective screen size of the ROM will be ~2 mm. Spray water on the screens will reduce the slurry density further to 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.

7.4.2 Rougher Magnetic Separation

The -2 mm 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 10 clusters of six each, corresponding with the number of agitated storage tanks. The MIMS drums will have a magnetic field intensity of 4500 G and consist of 3 m wide by 610 mm dia. stainless steel drums.

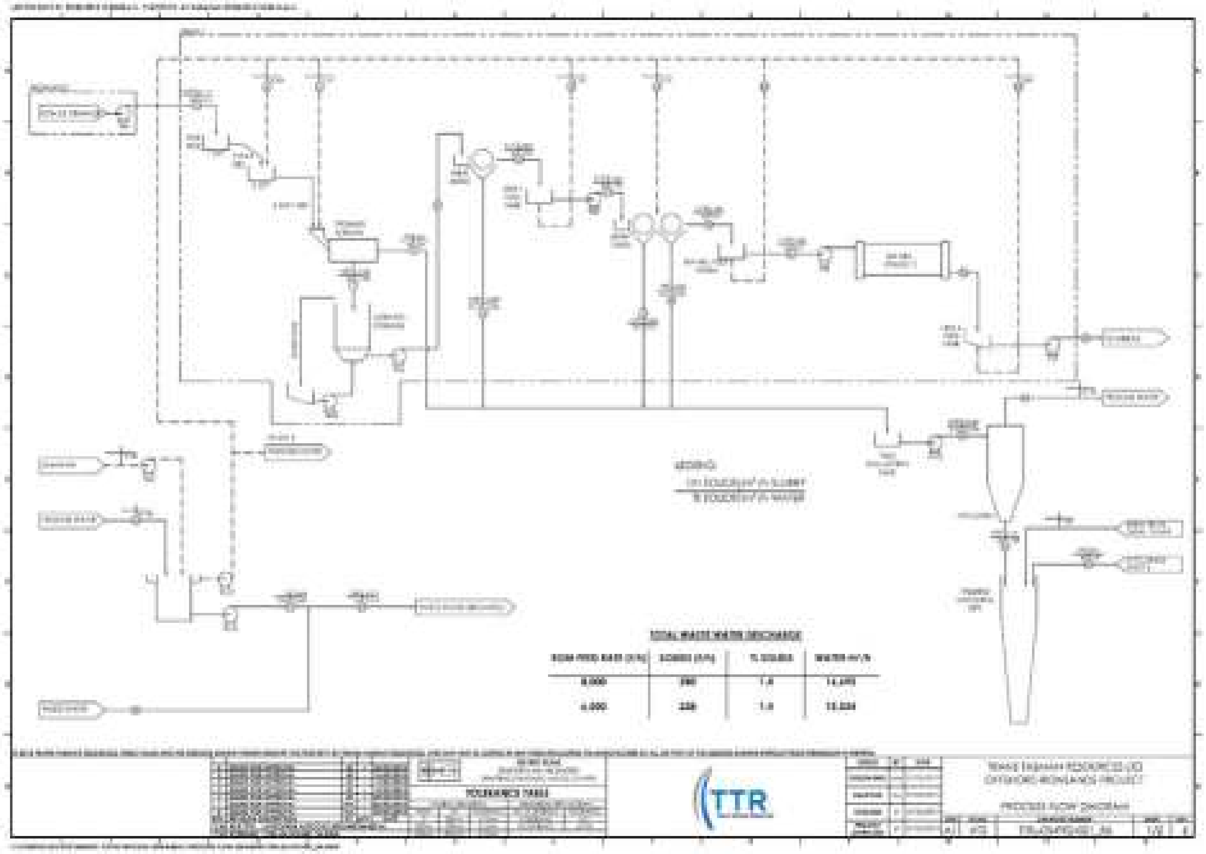


Figure 7-19 Process Plant PFD (Sheet 1)

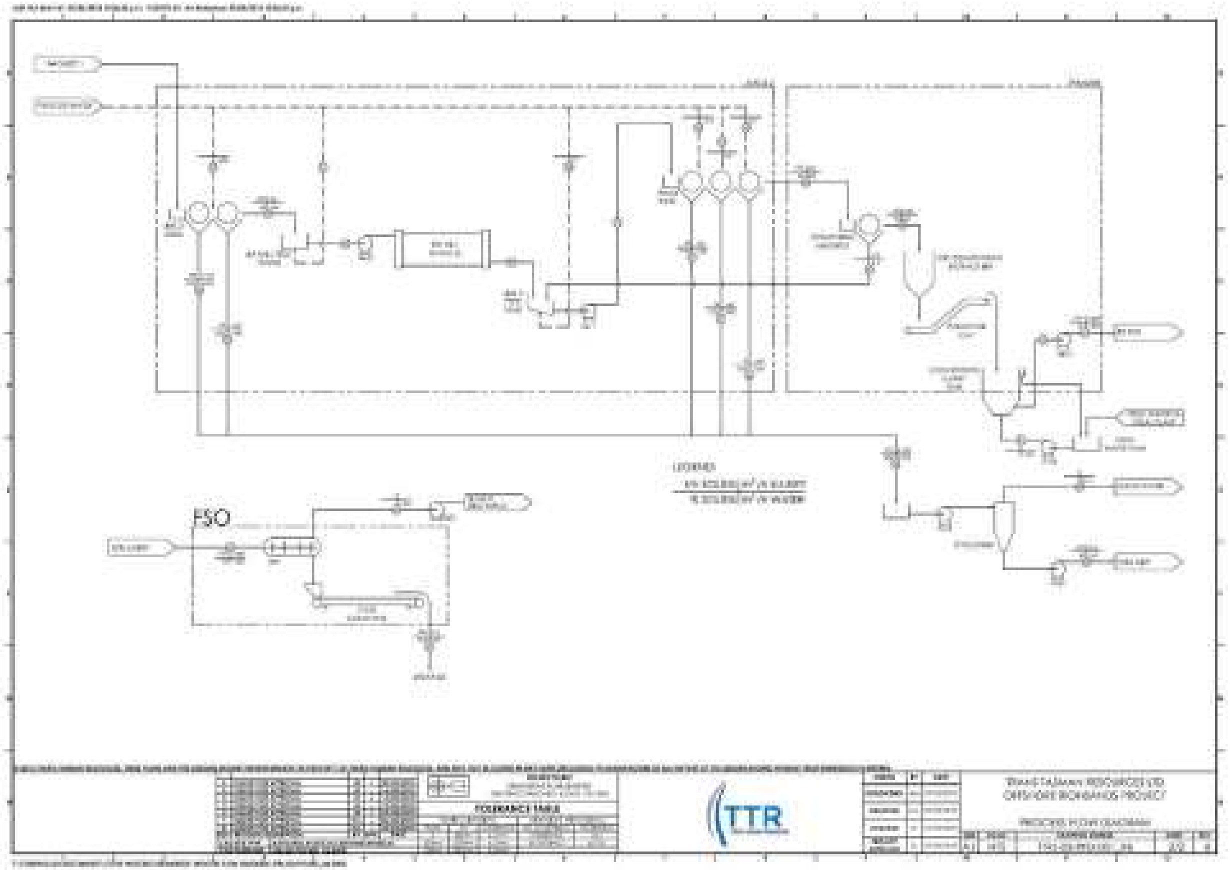


Figure 7-20 Process Plant PFD (Sheet 2)

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 7-21 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 1250 G. The units will be arranged in four clusters with four units each. Each unit has two 3.6 m wide by 1.22 m 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 IsaMills™. 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.

7.4.3 First Stage Grinding

The comminution circuit proposed for the Project consists of a simple two stage grind with intermediate magnetic separation (IMS) to remove liberated gangue and reduce grinding energy in the second stage grind. Both grinding stages will consist of M10,000 IsaMills™ (Xstrata), chosen for its light weight design and superior energy efficiency. The IsaMills™ will operate in open circuit. The feed to the first stage (~1,420 t/h) will be ground to a P_{80} of nominally 130 µm, requiring a grinding energy of 15 kWh/t. It is envisaged that the first stage grinding duty can be accomplished in six 3 MW IsaMills™

Figure 7-22 M10,000 IsaMills™. Installation, South Africa

7.4.4 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.

7.4.5 Second Stage Grinding

In the second stage grind the feed to the IsaMills™ are ground from 130 µm to 75 µm in order to liberate the titano magnetite sufficiently to achieve the final product specification on a consistent basis. Both the first and second stage grinding will be inert, i.e. ceramic grinding media will be used to avoid product contamination. The grinding energy required will be 17 kWh/t with the grinding duty performed by another six M10,000 (3 MW) IsaMills™

7.4.6 Cleaner Magnetic Separation

The cleaner magnetic separation (CMS) section will consist of eight triple drum co-current magnetic separators at an intensity of 950 G, arranged in two clusters of four each. Typical triple and double drum wet magnetic separators are shown in Figure 7-23. 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 an Fe grade of more than 56% Fe and SiO_2 less than 3.9%.

Figure 7-23 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.

7.4.7 Final Concentrate Handling

The dewatered concentrate will be stored in two hoppers. The hoppers were sized for a buffer capacity of 40 h or approximately 32,000 t. 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 60,000 t concentrate and return to the FPSO. Once the FSO is on station, it will connect to the FPSO 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 fresh water 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 (HPF; refer Figure 7-24).

Figure 7-24 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 60,000 t FSO cargo. Offloading to the FSO therefore will occur at double the production rate of the process plant (~1600 t/h).

7.4.8 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 Figure 7-25).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 sea bed. The tailings waste water will be discharged via a second pipe along the tailings deposition pipe slightly higher than the solids discharge.

Figure 7-25 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.

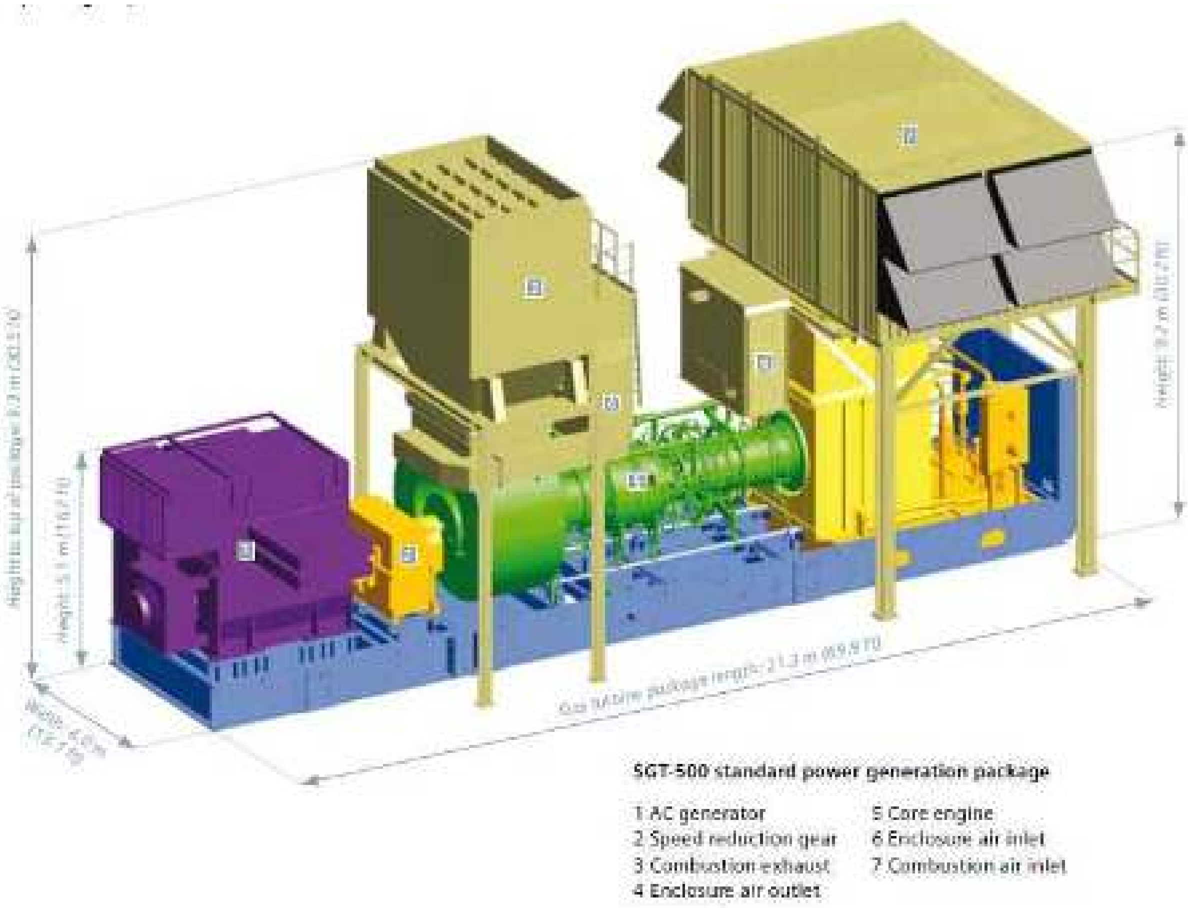


Figure 8-1 SGT-500 Power Generation Package

The SGT-500 is one of the few gas turbines which have capability to operate on HFO, 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 FPSO 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 ships' 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.

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;
- 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 FPSO power system including:

- **Short circuit calculations**: This study will be performed to verify the proposed switchgear will be able to withstand the forces 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 FPSO 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 FPSO 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 model, (See Appendix 19.6), 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 off-shore floating production, storage and off-loading vessel (FPSO).

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 6500 tonne per hour and 8000 tonne 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 FPSO's DP system (DP), influenced by wave height;
- The production by reverse osmosis of desalinated water;
- Routine fortnightly shuts of the plant for maintenance.

	Scenario 1 6,500 t/h ROM Solids	Scenario 2 8,000 t/h ROM Solids
Real Time for Model	366.4 days	366.4 days
kWh/tonne (ROM)	8.845 kWh/tonne	8.635 kWh/tonne
Peak MW	~ 66 MW	~ 79 MW
ROM Average Feed Rate t/h	6065 t/h	7465 t/h
ROM Total Tonnes	53.34 million tonnes	65.65 million tonnes

Figure 8-2 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. The 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 FPSO 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 the 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.

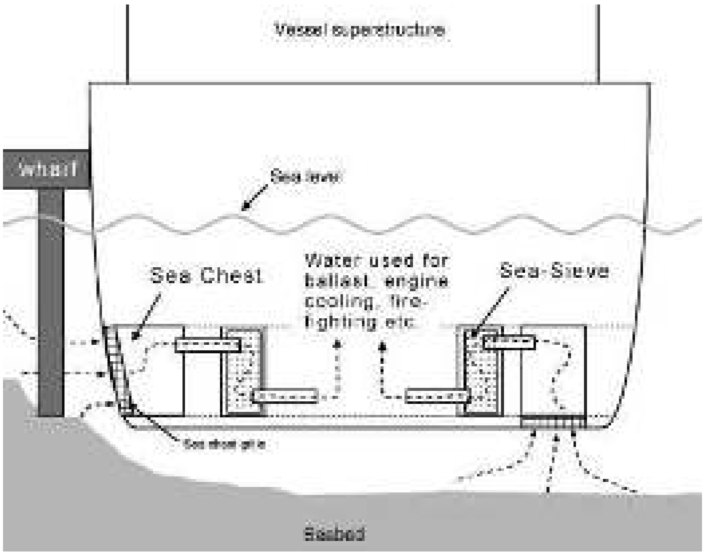


Figure 8-3 Vessel Sea Chest

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 up 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.

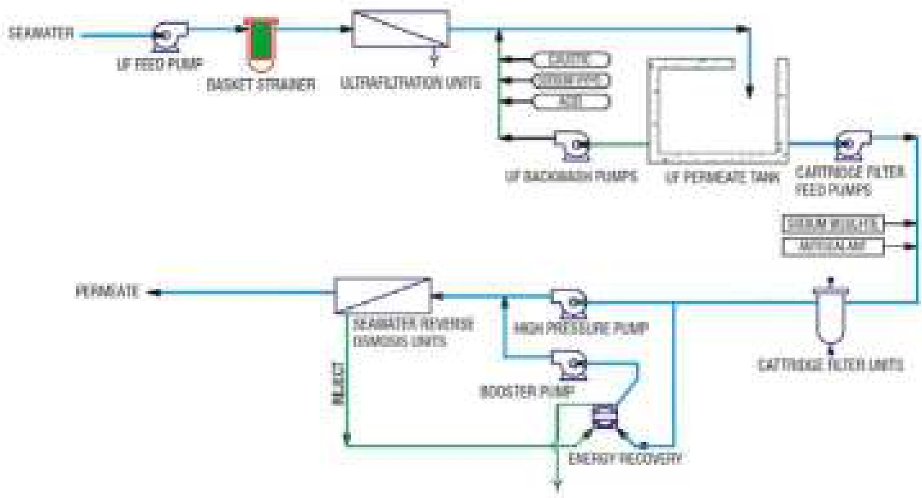


Figure 8-4 Typical Desalination Process

9. OFFSHORE FACILITIES & SHIPPING CYCLES

In order to fulfil the requirement for producing 4-5 Mtpa 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 FPSO has been developed based on the personnel arrangements on FPSOs currently operating in the Taranaki Area. There are currently two FPSOs operating in the Taranaki offshore oil fields, and these have been operating since 2007.

The crews of both vessels are employed under separate employment contracts, some collective and some individual, these contracts are a progression from the original FPSO employment contracts developed for the ‘FPSO Whakaropai’ which was operated by Shell Todd Oil Services Limited in the Maui field from the mid 1990’s to the mid 2000’s. (See Appendix 19.9)

9.1.1 Offshore Working Rosters

It is envisaged that the TTR will employ the same 21 day on and 21 day off roster as per the current FPSOs. 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 when 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 have been sourced locally in Taranaki, whilst others from other New Zealand regions. For the FPSO ‘Umuroa’ the current figures are 54% Taranaki residents, elsewhere in 46% NZ, the FPSO ‘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 FPSO – Offshore Operations

A FPSO, will extract sediment from the sea bed, process the sediment (ROM) and return the tailings to a previously mined area whilst moored on a temporary 4 point, DP assisted, mooring.

The table below summarises the calculated size required for the FPSO.

Duty	Weight (t)
Crawlers & LARS	3,651
Process Plant Equipment	4,388
Process Buffers:	
Rom Buffer	32,000
Material in Process	14,828
Process Water	15,000
Fresh Water (desal)	10,000
Tails Buffer	5,524
Concentrate Buffer	34,000
Process Plant Structure, Pumps & Electrical	5,188
Ship Mooring System, Propulsion Pumps & Electrical	745
Ship Fit-out, Consumables & Tanks (Incl Fuel)	14,750
Ship Hull & Superstructure	33,200
TOTAL	173,184

Table 9-1: FPSO Size

Note: the amount of fuel required has been calculated based on an installed power generation capability of 80MW.

In order to fit with this requirement and also allow for potential future additional weight to be installed on-board the FPSO, a 200,000 tdw vessel has been considered for the mooring dynamic analysis in the rest of the study.

9.2.1 FPSO Mooring Analysis

As part of the IHC Crawler evaluation, a preliminary conceptual mooring study and dynamic analysis was performed on the FPSO in order to confirm the ability of the proposed 4 point mooring to cope with the environmental conditions. The loadings identified in the initial commissioned Principia mooring study, see appendix 19.23, provided IHC with the baseline loading cases for the preliminary conceptual 4 pint mooring study.

The proposed mooring system will consist of a 4 point mooring with an equal spread. The vessel will be able to operate in a mining grid of 600 m * 300 m with a water depth of 20 Metres. (see Appendix 19.16)

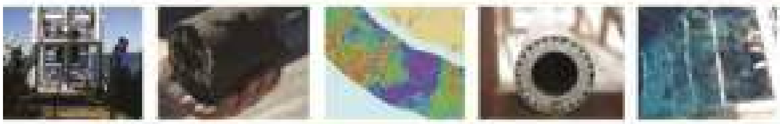
9.2.2 FPSO Personnel Levels

The total personnel complement required for the FPSO will be 139 personnell, this includes an allowance for relief during holiday periods. The detailed FPSO personnel requirement is detailed in Appendix 19.8 of this document

9.3 FSO – Offshore Operations

The FSO, i.e. Floating Storage and Offloading vessel, will be used in the overall production cycle to temporarily store the iron ore product before shipping and offloading onto the cape size vessels round tripping to export market.

The proposed FSO transhipment system will consist of a built-for-purpose, self-unloading vessel with a cargo capacity of 60,000 tons.



	Specifications
Length *(meters)*	230
Width *(meters)*	32
Summer Draft *(meters)*	13.0
Air draft in ballast condition *(meters)*	34.0
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 requirement during loading, including requirement for full Dynamic Positioning capability
Accommodations	25 people
Self-Unloading / Material Handling System	Hopper shaped cargo holds lined with UHMW Hydraulic mass flow gates Gravity fed inclining conveyors 2 x ship-loaders, each 4,000 TPH (peak 8,000 TPH, average 6,000TPH
OGV Limitations	Must be gearless and free of deck obstructions Max beam: 57m Max freeboard (waterline to hatch coamings): 21m Min hatch sizes to be determined

Table 9-2 FSO Specification

There will be two cargo handling systems on the FSO:

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 4 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 FPSO to the FSO through flexible hoses. Once the FSO is fully loaded with concentrate (60,000t), it can unmoor from the FPSO and sail to an awaiting export cape size vessel which will be located in a calm area off the South Island, approximately 70 nautical miles from the mining location (Table 9-3).

Upon arrival at the South Island, the FSO will moor to the cape size vessel and offload the concentrate for export.

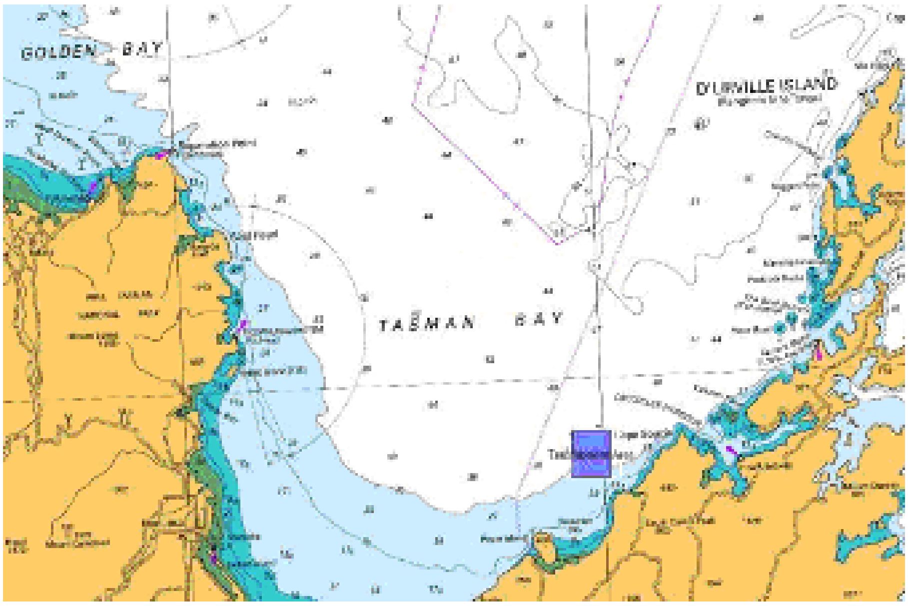


Table 9-3: Trans-shipment location off Southern Island

9.3.2 Cargo Vessel (Cape-size) 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, has currently 3 gravity FSOs in operation and 9 self-unloading bulk carriers under construction (or newly completed) utilizing the same core technology as the proposed TTR FSO.

9.3.3 Trans-shipment Cycle

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

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

Table 9-4: 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.

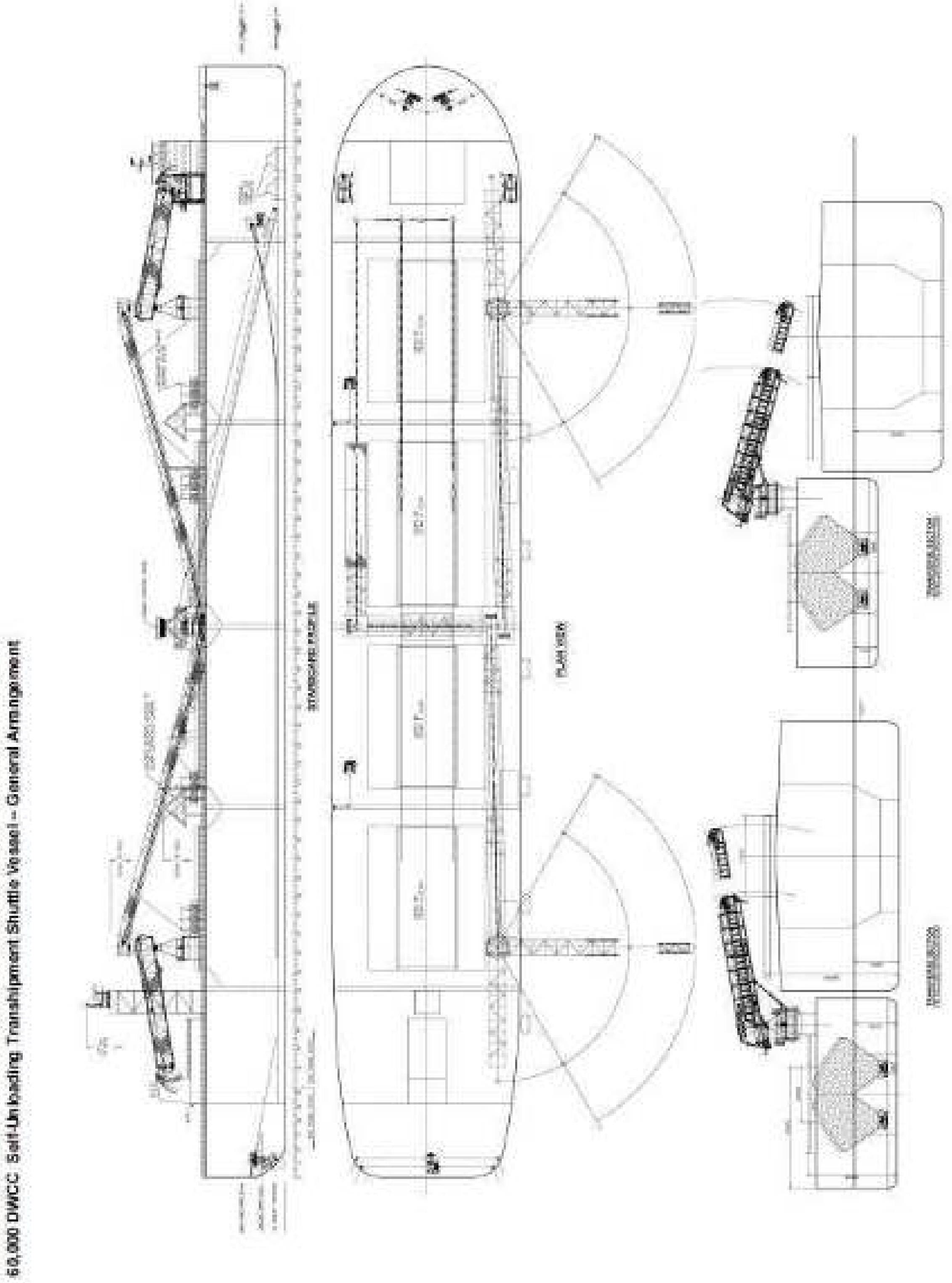


Figure 9-1 FSO General Arrangement

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 (AHT)

The TTR project has made provision for a 80te bollard pull Anchor Handling Tug (AHT) to assist with the provisioning of the FPSO and FSO, assistance with the connection of floating hoses and anchor moving.

The AHT will also provide refuelling assistance and be equipped to assist in case of any fuel spillage and fire.

9.4.1 AHT Personnel Levels

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

9.5 Iron Concentrate Export to China

The final iron ore product will be exported to China by means of standard cape size 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)	382.0	15.9
Unload	140.0	5.8
Sail to New Zealand (Ballast)	369.0	15.4
TOTAL	1126.3	46.9

Table 9-5: Cape Size Vessel shipping cycle

10. OFFSHORE OPERATIONS

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

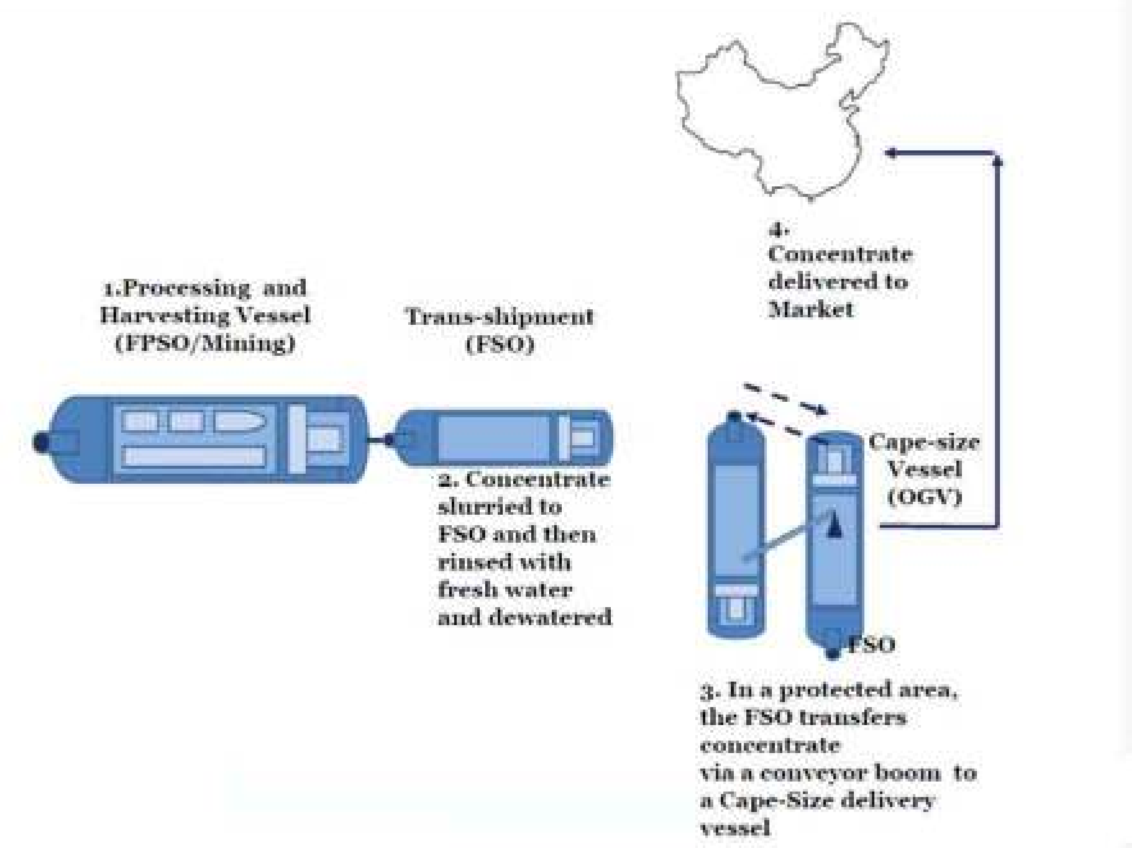


Figure 10-1Offshore Operations

10.1 Anchor Relocation

A 300x300 m mining block will typically be mined out in around 5 days, thus the mining block selected is 600x300 m requiring an anchor shift operation every 10 days.

With the FPSO in a DP assisted state, the AHT will move 2 (least loaded) adjacent anchors to their new position whilst the FPSO remains over its existing mining area. Once the FPSO has raised the mining crawler, moved over the new mining area and lowered the crawler the AHT will resume the relocation of the two remaining anchors.

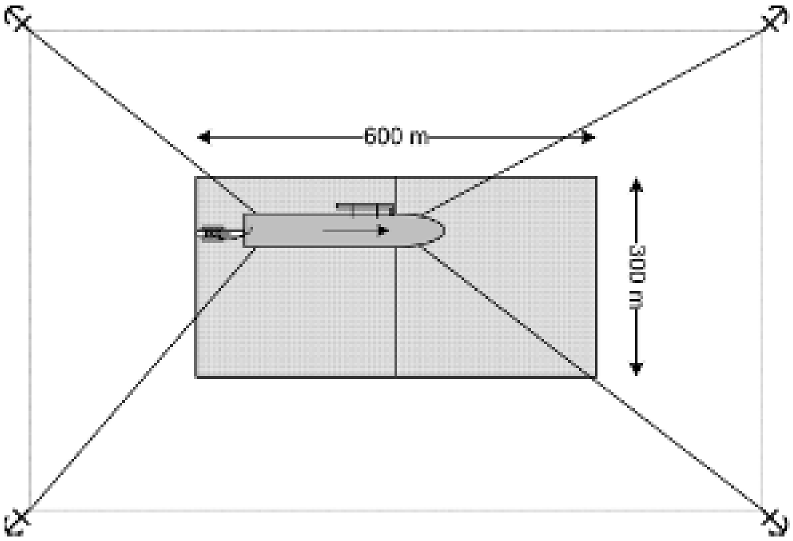


Figure 10-2 Anchor Spread

10.2 Iron Ore Unloading

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

This iron ore unloading operation will require the FPSO 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 FPSO and the FSO for safe unloading operations varies between 70 and 110 metres. 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 Cape Size Vessels Loading

The transhipment from the FSO to the cape size 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 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 manoeuvrability, shorter cycle times and improved safety. This will also allow the FSO to operate without tug assistance.

Figure 10-3 Gravity Transhipment Shuttle Vessel CSL Whyalla transhipping iron ore in South Australia

Figure 10-4 Cape Size Vessel Loading

10.4 Heavy Fuel Oil (HFO) Supply & Transfer

HFO is still the standard grade of fuel for ocean going vessels and is readily available from Singapore, with a smaller supply also available from the New Zealand Marsden Point refinery. All of the operations on the FPSO will be powered by generators using HFO, at full production this will consume around 7,500T of HFO per month.

10.4.1 RAS (Replenishment at Sea)

The most efficient refuelling 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 FPSO to continue operation during the fuelling process.

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

Figure 10-5 Typical Refuelling Configuration

The jackstay wire rope is fastened to the receiving vessel above the refuelling 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 HFO available around the world with Singapore being the nearest large supply, however the Marsden Point Refinery in New Zealand also produces a certain amount of HFO per year. During Summer, the supply and

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[7] The **significant wave height** (H_s) is defined traditionally as the mean wave height (trough to crest) of the highest third of the waves.

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 practise 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;

FPSO

- 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
- 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 FPSO or FSO via deck cranes
- Moving the anchors of the FPSO

FSO

- Deployment, connection & Emergency release of slurry hoses to FSO
- Loading between the FSO & cape size 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 (SOP's) & maintenance schedules with hazards and work plans associated to each.

A HAZOP will be undertaken before commissioning.

11.4 Submerged Sediment Extraction Device (SSED)

The SSED 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 SSED on deck
- Emergency lift procedures
- Loss of vessel position
- Umbilical tendering - steel wire lifting cable; slurry hose; high voltage power supply subsea & on deck
- Maintenance procedures on the SSED

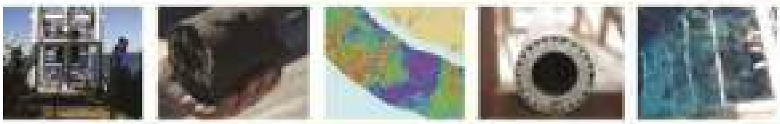
An advantage is that the crawler is mature technology which has established its use at sea, so previous experience of H&S procedures developed can be used and updated to exceed international expectations.

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 on shore power plants.

The FPSO 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 cables
- 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
- Class protection of equipment established



11.6 HFO Fuel Handling & Transfer

The fuel being used on the project will be Heavy Fuel Oil (HFO), 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;

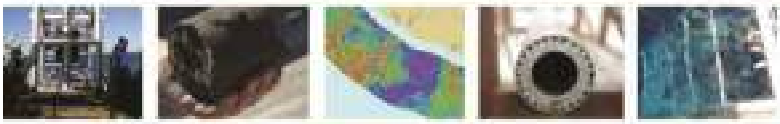
- a safe and controlled surface transfer system – this system should have an automated mating / coupling system
- Transfer in daylight hours only
- A safety management system documenting all procedures to take place to allow the safe transfer of fuel oil
- Strict protocols in place for spill control
- 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 crews 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. Our H&S procedures should be similar to other manned production platforms such as the Raroa and Umoroa (Existing New Zealand offshore FPSO's). Some of the key H&S policies will be around;

- Physical health
- Dealing with accidents & 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
- The proper training is provided in offshore survival; first aid & fire fighting

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 specialist, some of the considerations will be;

- Security
- Communications
- Cold water survival training
- Weather parameterss
- Fire fighting capability
- 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, these include adherence to Civil Aviation Rules; Safety Case methodology, Risk & impact assessments.

12. MARKET STUDIES AND CONTRACTS

12.1 Introduction

TTR engaged the services of an independent global iron ore consultant Tennant Metals Pty Ltd to assist in determining the potential value, penalties and market opportunities of the beneficiated fines and to provide marketing input for the PFS, (Ref: Appendix 277).

Amongst other things the study considered the relative pricing of a 57% product compared with the PFS product specification of 60% Fe product in order to provide the foundation for a cost benefit analysis to be carried out in due course for the production of a higher grade Fe product at a likely lower overall process recovery.

The shipped iron ore fines product from the TTR Project is forecast to produce a 57% Fe contact with the remaining chemistry within the acceptable range for steel plant consumption. The 60% Fe iron ore fines product is well suited for the Asian market and at a production capacity of 4-5 Mtpa will be easily consumed by steel plants.

The relative Value in Use (VIU) of the 57% Fe iron ore fines compared to the Platts 62% Fe index was calculated using the Slag Volume Index (SVI) method. This index measures the amount of waste material required to be processed to obtain one tonne of iron. Using the SVI method it is forecast that the 57% Fe iron ore fines would attract a discount on a dmtu basis compared to the Platts 62% Fe index to provide the similar VIU based on the iron ore fines chemistry. It is assumed that the size distribution will have no impact on sinter plant productivity. This assumption will be tested in due course by laboratory-scale sinter pot test work program at an internationally recognised laboratory.

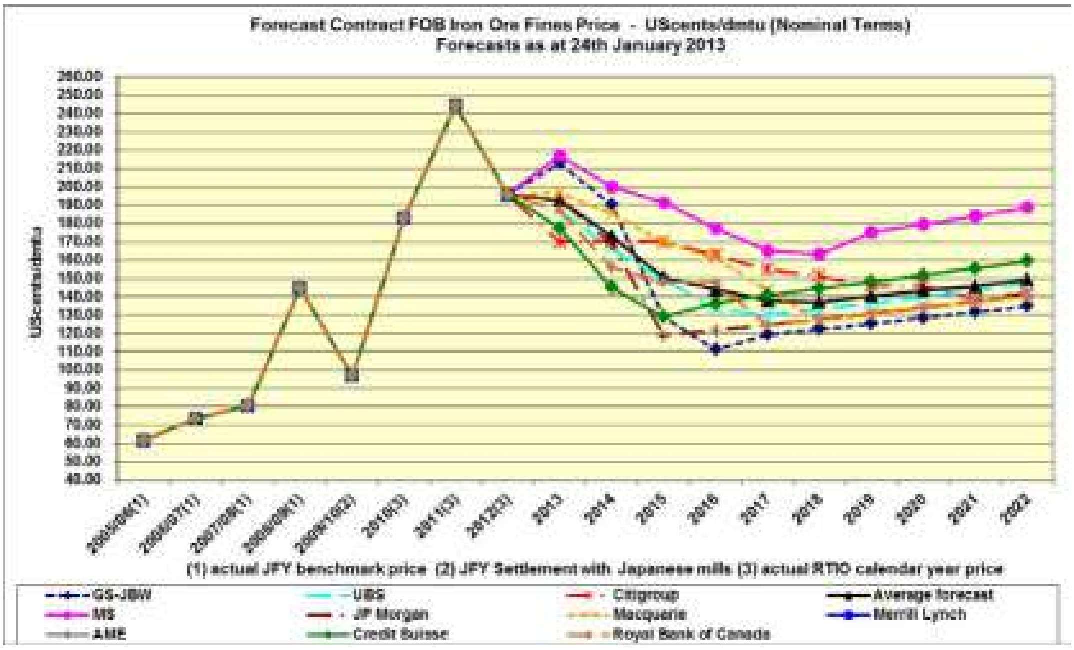


Table 12-1: Tennant Metals mid to long term price forecast consensus.

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 Mtpa.

Iron Ore	TTR 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 12-2: 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 parameterss within the market contracted specifications between TTR and the customer.

12.4 Marketing Summary

Worldwide steel consumption is being driven by Asia's rampant demand for metallurgical raw materials such as iron ore, coking coal, manganese etc. China is the largest consumer of iron ore and will maintain this consumption demand for many years to come. There are however a number of other increasing markets, specifically the Middle East and the Indian Sub-Continent whose requirements for higher quality ores becomes more a necessity as base load steel capacity modernised and hence should not be ignored into the future.

Japan, Taiwan, Korea & Europe remain steady consumers of iron ore and other metallurgical commodities, but 2003 marked the commencement of the China era, and it is from this period that China became the dominant buyer. It is expected that China will be the 'base load country' for the TTR Vanadium Titanium Magnetite (VTM) concentrate product with other demand driven countries to follow suite, via a deliberate marketing and diversification strategy.

The TTR marketing strategy will be structured into a four phase plan as follows:

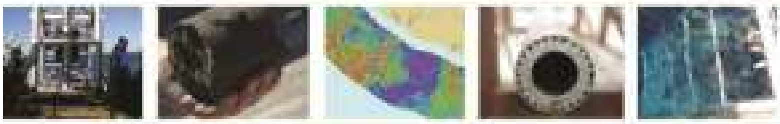
- Phase One: Development of the Chinese market.
- Phase Two: Development of other mature Asian buyers such as Japan, Korea and Taiwan.
- Phase Three: Development of new capacity buyers such as the Middle East and India.
- Phase Four: Development of mature markets of Europe etc.

All of the above is relative to modulated expansion of TTR's concentrate production moving forward.

Each phase has its individual subset development. For the purpose of this marketing strategy and the fact that China will be the base load customer for the project in the initial production development phase being around 4 to 5 million dry metric tonnes of processed VTM concentrate , this initial strategy will be specific to the Chinese phase one. Phase's two to four will be embarked upon following the achievement of a satisfactory outcome in China. The time line for the remaining phases will be relative to the project reaching world class capacity (around the 20 to 50 million tonnes per annum for a single operation) via modulated ramp up in production.

Phase one will consist of the following sub phases:

- Pre-introduction phase: The TTR VTM project has been well introduced by the Tennant Metals Beijing office & TTR management. This has occurred with tier one & tier two dedicated VTM consumers and traditional blast furnace users of similar ranking.



- Introduction phase: To date, several high profile conferences (CISA Iron Ore Conference on three occasions & other investment forums in China) have been used to present detailed concepts and the project dynamics to a large iron ore and investment specific audience. In addition, several road shows were conducted in which detailed presentations were given to prospective off-taker, funders and end user/buyers. This led to several Letters of Intent being signed, aimed at long term off-take for TTR's VTM concentrate.
- Broader marketing phase: This phase is aimed at reducing the potential off-takers to a smaller pool, all of whom ideally contribute something back to TTR (equity/debt funding, strategic benefits, and/or market related off-take terms). To date, an initial portion of future offtakes have been negotiated and signed, and a tranche of equity investment secured from an offtaker. These have assisted the spread of the product through the market, allowing mills not familiar with VTM ores to become inquisitive. Others have appreciated the potential of the project and show a real path to production which is half the battle for new miners.
- Initial consummation phase: Final off-take negotiations (in some cases renegotiation of current off-take to fall in line with economics confirmed via the PFS) and execution of sales contract leading into First Ore On Ship (FOOS) and the commissioning phase have been executed

There is an excellent technical and economic case for using VTM concentrates as a substitute to traditional iron ores feeds, particularly if vanadium credits can be allocated on a positive basis.

The current VTM supply is limited on a Seaborn basis but there are significant quantities consumed domestically within China. As much as the Seaborne market is limited there is significant scope for this to increase.

In the short term, there is a substantial market accessible to TTR's product that is estimated to be circa 20 million metric tonnes specific to TTR VTM feed. This is based on a combination of traditional blast furnace capacity using small amounts of VTM concentrate in the pre burden sinter matrix (somewhere between 3% to 5% with the constraints allowing higher blends being the elevated titania (TiO_2) and Phos (P), while seaborne supply for dedicated VTM consumers would be 100% reliant on dedicated VTM feed material.

In the medium to long term, there is potentially for a much larger market for VTM concentrates if integrated steel mills can be encouraged to convert traditional Blast Furnace capacity to dedicated VTM use during new construction of blast furnaces or that of modifications to traditional capacity. This larger capacity is relative to future iron price outcomes and the continuation of TTR's cost of recovery sits favourable on the cost curve which would allow circa 100 million tonnes per annum circa 5 to 10 years.

The failure of new capacity coming on line from magnetite (Fe_3O_4) hard rock pier competition that has a cost of recovery well above US$70 (Free on Board basis) a tonne will assist by the significant CAPEX in hard rock processing and significant cost to deliver a logistics corridor to ships rail, the modulated and organic logistic solution for the TTR project gives it a significant advantage, in realisation of this new capacity constraint the mid to long term potential for VTM's and TTR look excellent.

12.5 Pricing Strategy

Baosteel has traditionally led a negotiation table consisting of members of the top tier one steel mills and traders. This single negotiation approach used to start around November each year, and continue through to March of the following year. This period was always known as the “mating season”. These negotiations were then strained when the China Iron & Steel Association (CISA), which is an association of steel producers in China and acts as a quasi-semi-governmental organisation, was given the role to secure more favourable terms for the Chinese steel mills for JFY 09/10 this led to a total breakdown in the yearly benchmark.

From this period miners and buyers ended up pricing off a range of indices these indices have become much matured. The main Indices are as follows:

- Platts (published by Mcgraw Hill Financial). They publish the following range of indices:
  - IODEX 62% Fe CFR North China.
  - 63.5/63% Fe CFR North China.
  - 65% Fe CFR North China.
  - 58% Fe* CFR North China.
  - 52% Fe CFR North China.

*Al = 4.0% max

- The Steel Index (TSI.. TSI was purchased outright last year by Mcgraw Hill Financial). They publish the following range of indices:
  - 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.
  - 63.5/63% Fe fines, 3.5% Al, CFR Qingdao port

Miner and buyers agreed to a quarterly price outcome which was derived from the previous quarters Platts or TSI as the indices take into account the CFR landed basis so C3 (Brazil to North China) and C5 (West Australia to North China) whereas the previous yearly benchmark was on a Free on Board (FOB Incoterms 2000) basis. After a period of price volatility with many mills either deferring or defaulting the quarterly in arras still exist for larger buyer (particularly from Vale) a significant amount of tonnes are now driven by very narrow quotation period or are derived based on future price setting (M+1 or M+2 ad description of this is in section of pricing methodology).

12.6 Market Price forecast.

12.6.1 Current price assessment

The market price of the iron ore had stabilization in the first two weeks of February 2013 ($150-US$155 per dry metric tonne CFR China – 62% Fe Australian fines) and was followed by a negative trend in the second half of Q1, as spot prices rolled down to $US133-135 per dry metric tonne level. This trend continued into April and has continued onto US$120 or thereabouts for May.

According to the major market players and industry experts, the price decline was caused by weaker demand (Chinese consumers cut their purchases drastically after re-stocking) and better availability of material (there were seasonal difficulties with iron ore shipments from Australia at the beginning of the year). In early Q2, the situation in the Chinese steel worsened further. The following three facts demonstrate the Fe surplus currently affecting the market:

- Steel production in China gained 11% y-o-y in January-February 2013, reaching 50% of the total global production for the first time ever;
- Apparent consumption of steel products in the country increased by 10% y-o-y in the same period;
- China's PMI published in early April showed a drop of 14 points, reflecting Chinese consumers' negative expectations from Q2 in general.

As a result, the leading investment banks and industry analysts started to update their short- and medium-term forecasts for iron ore as well as other raw materials, revising the change direction again.

Several forecasts of iron ore price prepared after the beginning of 2013 are provided below. Many analysts will update their forecasts by late Q2 2013. Tennant runs its own mid to long term pricing model but has not updated its forecasts

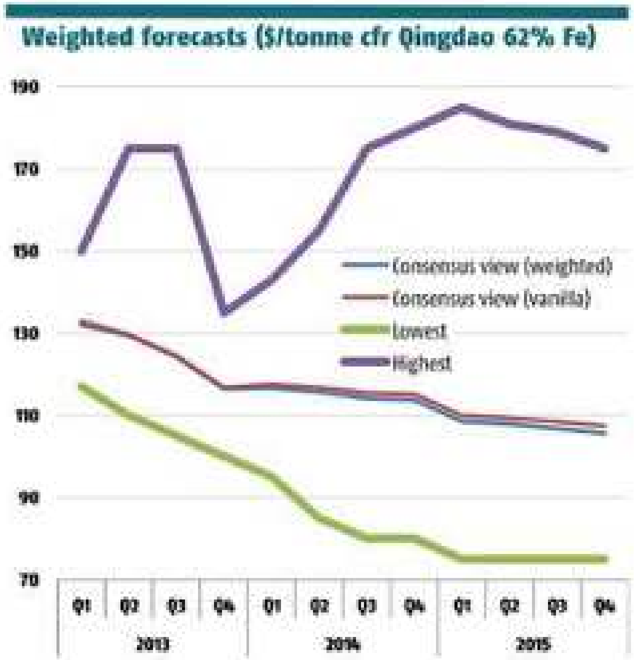


Figure 12-1 Weighted Forecasts

Date	Analyst/Desk	2013 Q1	2013 Q2	2013 Q3	2013 Q4	2014 Q1	2014 Q2	2014 Q3	2014 Q4	2015 Q1	2015 Q2	2015 Q3	2015 Q4
21/01/13	ABN AMRO, Casper Burgering	130	130	130	130	116	116	116	116	112	112	112	112
20/11/12	BAML, Michael Widmer	117	110	108	108	110	110	110	110	100	100	100	100
17/01/13	Citigroup	135	120	110	115	125	122	122	120	125	122	122	120
15/01/13	CLSA, Ian Roper	125	110	105	100	95	85	80	80	75	75	75	75
03/01/13	Credit Suisse, Andrew Shaw	130	125	115	110	105	100	100	95	90	90	90	90
08/01/13	Deutsche Bank, Daniel Brebner	140	130	120	110	115	115	115	115	110	110	110	110
15/01/13	INTL FCStone, Edward Meir	150	135	130	125								
12/01/13	Jefferies, Chris Lafemina	130	130	130	130	120	120	120	120	105	105	105	105
01/09/12	Macquarie	131	121	121	111	120	120	110	110	105	105	105	105
14/01/13	Metal Bulletin Research*	140	120	105	105	120	120	105	110	100	100	100	100
15/01/13	Numis	140	135	130	125	125	120	118	116	115	113	111	109
04/01/13	RBCCM, Chris Drew	130	130	120	120	105	105	105	105	100	100	100	100
14/01/13	TDSecurities, Bart Melek	130	140	145	135	129	129	129	129				
04/01/13	UBS, Tom Price	131	133	123	118	118	118	111	106	108	109	101	96
17/01/13	Westpac, Justin Smirk	135	175	175	110	143	155	175	180	185	181	179	175

	2013 Q1	2013 Q2	2013 Q3	2013 Q4	2014 Q1	2014 Q2	2014 Q3	2014 Q4	2015 Q1	2015 Q2	2015 Q3	2015 Q4
Consensus view (weighted)	132	129	124	116	117	116	114	114	108	108	107	106
Consensus view (vanilla)	133	130	125	117	118	117	115	115	110	109	108	107
Lowest	117	110	105	100	95	85	80	80	75	75	75	75
Highest	150	175	175	135	143	155	175	180	185	181	179	175
% Vanilla to weighted	0.7%	0.1%	0.2%	0.3%	0.8%	0.9%	1.1%	1.2%	1.4%	1.1%	1.6%	1.7%

Figure 12-2 Source: MetalBulletin Index Iron Ore Forecasts Q1 2013

12.7 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 off take 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 12-3 Marketing Related Risks

13. ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL IMPACT

13.1 Introduction

This section describes the regulatory permit regime applying to the TTR (TTR) iron sand mining operation in the South Taranaki Bight project.

This section also describes the broad environmental characteristics of TTR's area of interest along with associated environmental risk factors. Information is presented on the investigations undertaken by TTR to provide information in support of applications for consents. In conclusion an anticipated consenting timeline is presented.

It is written on the basis that TTR's proposed mining activities will be both within and beyond New Zealand's (NZ) territorial boundary, in the exclusive economic zone and it addresses the legislative requirements for these activities.

Some aspects of NZ's legislation are expected to change in the near future and these expected changes are noted where relevant.

13.2 Mining Permit Regime

13.2.1 Legislation

Mining approvals required for TTR's project will require mining permit/s under the Crown Minerals Act (**CMA**) for extraction activities both within and beyond the 12 nautical mile (nm) limit[8].

13.2.2 Mining Applications under Crown Minerals Act 1991

TTR is working to obtain a mining permit under section 23 of the CMA, which covers the allocation of the Crown's mineral resources. The Mining Permit can be granted for up to 40 years and will be subject to the prevailing royalty regime. Permit applications will be lodged with NZ Petroleum and Minerals, a section of the Ministry of Business Innovation and Employment. Applications will be made in the prescribed form and will contain the following information:

- *Applicant and permit holder details*
- *Location details and permit area sought.*
- *A statement of the technical qualifications and financial resources of the applicant.*
- *A map of the permit area.*
- *A report that sets out the evidence for an exploitable mineral deposit or mineable resource sufficient to support a mining permit, that includes –*

  a) *estimates of the mineable mineral resource, which may include –*

- [8] The 12 nautical mile limit delineates the boundary of the Territorial Sea. The Territorial Sea is a belt of coastal water extending from the shoreline to the 12-nautical mile (22-kilometre) limit. The Exclusive Economic Zone (EEZ) is a belt of water from the territorial sea's 12-nautical mile limit to the 200-nautical mile (370-kilometre) limit.

i. inferred, indicated, and measured mineral resources; and

ii. probable and proved reserves;

b) a map showing the size and location of the deposit;

c) a description of the geology of the deposit; and

d) if applicable, a description of the type of coal and its properties.

- *A statement of the proposed work programme [for full duration of permit] that provides an overview of how the permit area will be worked that includes –*

a) the size, nature, extent, and siting of the proposed mining operations;

b) the proposed mining methods to be used;

c) the proposed mining and production schedule;

d) the expected production and long-term mining scheme for the mineable resource;

e) the proposed start date for production;

f) any proposed prospecting or exploration work in relation to the permit area;

g) the proposed expenditure under the permit; and

h) if applicable, the point of valuation for royalty purposes.

The Ministry assesses the application, its plan, description and work programme and also forward a copy of the application to local iwi (Māori) as part of the Crown's consultation obligation.

The timing of the iwi consultation, obtaining of the agents report and internal assessment varies depending on current policy of the Ministry. Generally they run in parallel. The Ministry sets conditions on permits and if all matters are satisfied the Minister of Energy and Resources grants the permit. Other than the iwi consultation, there is no public participation process under the CMA.

Environmental aspects are addressed under the Resource Management Act 1991 (**RMA**) or the EEZA for activities within and beyond the 12 nautical mile (nm) limit respectively.

13.3 Environmental Permitting Regime

13.3.1 Legislation

Currently, approvals required for TTR's project can be broadly categorised as follows:

Environmental approvals, including:

a) <u>Marine consents</u> under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (**EEZA**) for activities beyond the 12 nm limit.

b) <u>Resource consents</u> under the Resource Management Act 1991 (**RMA**) for activities (including discharges) within the 12 nm limit.

c) Marine discharge consents under the EEZA or Discharge Management Plans under the Maritime Transport Act 1994 (**MTA**) for discharges beyond the 12 nm limit.

The environmental regulatory regime relating to TTR's areas of operation is presently undergoing changes as illustrated in table 13-1. In particular, environmental approvals for discharges from ships in the area beyond the 12 nm limit will come under the EEZA and this is expected to come into effect by late 2013.

Location	Category	Present	Future
Within 12 nm (No Change)	Environmental/discharges	RMA	RMA
Beyond 12 nm (Significant change)	Environmental (excluding discharges)	Continental Shelf Act	EEZA
Beyond 12 nm (Significant change)	Discharge from ships	MTA	EEZA

Table 13-1 Pending Changes in TTR's Environmental Regulatory Regime

In general, NZ's environmental legislation is effects and not standards based. In effects based legislation, the applicant must demonstrate the expected effects of its proposed activities and that these meet the requirements of the policy documents or will not have any more than minor effects. In the EEZA, if the information supporting the applications is inadequate or uncertain the decision maker must favour caution and environmental protection and an adaptive management approach could result or, in the worst case, an application could be declined.

13.4 Status of TTR's Proposed Activities

Depending on where they occur in relation to the 12 nm limit, TTR's activities will require consents under either the EEZA or the RMA. Requirements relating to each area are discussed as follows.

13.5 Marine Consents under EEZA

The following TTR activities (beyond the 12 nm limit) will potentially require a marine consent under the EEZA.

TTR Project Element – EEZA Activities	Activity Category needing Marine Consent
Permanent and semi-permanent mooring blocks and structures	Structures on or under the sea bed

TTR Project Element – EEZA Activities	Activity Category needing Marine Consent
Extraction operation	Removal of non-living natural material from sea bed
De-ored sand deposition	Deposit of anything on, or under the sea bed
Extraction and deposition of de-ored sand	Destruction, damage, or disturbance of the sea bed.
FPSO, mooring structures	Construction, mooring or anchoring long-term, placement, alteration, extension, removal, or demolition of a structure or part of a structure in the waters of the EEZ.
FPSO operations – milling, power generation and other operations	Causing of vibrations (other than vibrations caused by the normal operation of a ship) in a manner that is likely to have an adverse effect on marine life.

Table 13-2 EEZA Activity Category Descriptions

The EEZA was passed in 2012 and came into force on 30 June 2013 when the required regulations will be promulgated.

13.6 Marine Discharge Permits under Maritime Transport Act 1994

The MTA currently regulates the discharge of harmful substances beyond the territorial sea. This is expected to change towards the end of 2013 with the enactment of the Marine Legislation Act and new regulations, which will bring mining-related discharges under the EEZA.

13.7 Resource Consents under RMA

If TTR's operations are within the territorial waters (12 nm limit), the following TTR activities will potentially require resource consent under the RMA (unless they are deemed to be permitted activities or already authorised by a designation where no consent application is required). If these are already permitted a certificate of compliance will be sought.

TTR Potential Project Element – RMA Activities	Activity
Freshwater storage pond and ancillary equipment – includes noise and other land-related controls.	Land use
Freshwater pipeline; end-of-pipe structure for freshwater off take; power cable	Structures on or under the foreshore and sea bed
Installation of freshwater pipeline; power cable, extraction	Disturbance of foreshore and sea bed where adverse effect on foreshore or sea bed
Occupation of sea bed and exclusion of other users by pipeline and power cable.	Occupy any part of the common marine and coastal area
Discharges arising from mining on sea bed	Discharge of a harmful substance from a ship or offshore installation Discharge water into water from any ship or offshore installation
Extracting of the sea bed and deposition of de-ored sand	Disturbance of foreshore and sea bed where adverse effect on foreshore or sea bed Deposit any material on the sea bed in a manner that is likely to have an adverse effect on the sea bed Destroy damage or disturb the sea bed in a manner that has an adverse effect on plants and animals or their habitat
Noise	Every occupier of land (including coastal marine area) and every person carrying out an activity in the coastal marine area shall adopt the best practicable option [9] to ensure that the emission of noise ... does not exceed a reasonable level.

Table 13-3 RMA Activity Category Description

13.8 Information to be provided with applications

The information requirements for the relevant environmental legislation are described in the following.

---

[9] **best practicable option**, in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to—

a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and
b) the financial implications, and the effects on the environment, of that option when compared with other options; and
c) the current state of technical knowledge and the likelihood that the option can be successfully applied

13.8.1 Impact Assessment under EEZA

Section 38 of the EEZA requires that applications for marine consents to undertake a discretionary activity, such as activities associated with mining, must be made in the prescribed form; fully describe the proposal; and include an impact assessment prepared in accordance with Section 39 of the EEZA. Section 39 states that:

1. *An impact assessment must:*
   a) *describe the activity for which consent is sought; and*
   b) *describe the current state of the area where it is proposed that the activity will be undertaken and the environment surrounding the area; and*
   c) *identify the effects of the activity on the environment and existing interests (including cumulative effects and effects that may occur in New Zealand or in the sea above or beyond the continental shelf beyond the outer limits of the exclusive economic zone; and*
   d) *identify persons whose existing interests are likely to be adversely affected by the activity; and*
   e) *describe any consultation undertaken with persons described in paragraph (d) and specify those who have given written approval to the activity; and*
   f) *include copies of any written approvals to the activity; and*
   g) *specify any possible alternative locations for, or methods for undertaking, the activity that may avoid, remedy, or mitigate any adverse effects; and*
   h) *specify the measures that the applicant intends to take to avoid, remedy, or mitigate the adverse effects identified.*
2. *An impact assessment must contain the information required by subsection (1) in—*
   a) *such detail as corresponds to the scale and significance of the effects that the activity may have on the environment and existing interests; and*
   b) *sufficient detail to enable the Environmental Protection Authority and persons whose existing interests are or may be affected to understand the nature of the activity and its effects on the environment and existing interests.*
3. *The impact assessment complies with subsection (1)(c) and (d) if the Environmental Protection Authority is satisfied that the applicant has made a reasonable effort to identify the matters described in those paragraphs.*
4. *The measures that must be specified under subsection (1)(h) include any measures required by another marine management regime and 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.*

Section 6 of the EEZA defines “effect” as follows:

1. *In this Act, unless the context otherwise requires, effect includes—*

a) *any positive or adverse effect; and*
b) *any temporary or permanent effect; and*
c) *any past, present, or future effect; and*
d) *any cumulative effect that arises over time or in combination with other effects; and*
e) *any potential effect of high probability; and*
f) *any potential effect of low probability that has a high potential impact.*

2. *Subsection (1)(a) to (d) apply regardless of the scale, intensity, duration, or frequency of the effect.*

13.8.2 Effects Assessment under RMA

Section 88 of the RMA sets out that

1) *A person may apply to the relevant consent authority for a resource consent.*
2) *An application must—*
   a) *be made in the prescribed form and manner; and*
   b) *include, in accordance with Schedule 4, an assessment of environmental effects in such detail as corresponds with the scale and significance of the effects that* the activity may have on the environment.

Schedule 4 outlines a specific list of matters an assessment of environmental effects (AEE) should include (subject to any additional information requirements of any relevant policy statement or plan). Requirements are set out as follows:

1. *Matters that should be included*
   a) *a description of the proposal*
   b) *where significant adverse effects are likely, any possible alternative locations or methods for undertaking the activity*
   d) *assessment of actual or potential effects on the environment of the proposed activity:*
   e) *hazards – where the activity includes the use of hazardous substances and installations, an assessment of any risks to the environment which are likely to arise from such use*
   f) *where the activity includes the discharge of any contaminant, a description of*
      i. *the nature of the discharge and sensitivity of the receiving environment to adverse effects;*
      ii. *any possible alternative discharge methods*
   g) *a description of the mitigation measures (safeguards and contingency plans where relevant) to be undertaken to help prevent or reduce the actual or potential effect:*
   h) *identification of the persons affected by the proposal, the consultation undertaken, if any, and any response to the views of any person consulted:*

i) where the scale or significance of the activity's effect are such that monitoring is required, a description of how, once the proposal is approved, effects will be monitored and by whom.

1AA To avoid doubt, clause 1(h) obliges an applicant to report as to the persons identified as being affected by the proposal, but does not—

a) oblige the applicant to consult with any person; or

b) create any ground for expecting that the applicant will consult with any person.

1A Matters to be included in assessment of effects on environment

An assessment of effects on the environment for the purposes of section 88 must include, in a case where the activity for which a resource consent is sought will, or is likely to, have adverse effects that are more than minor on the exercise of a protected customary right, a description of possible alternative locations or methods for the exercise of the proposed activity (unless written approval for the proposed activity is given by the protected customary rights group).

2. *Matters that should be considered when preparing an assessment of effects on the environment*

Subject to the provisions of any policy statement or plan, any person preparing an assessment of the effects on the environment should consider the following matters:

a) any effect on the neighbourhood and wider community (including socio-economic and cultural effects)

b) physical effects on locality (including any landscape and visual effects)

c) any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity:

d) any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural, or other special value for present or future generations:

e) any discharge of contaminants into the environment, including any unreasonable emission of noise and options for the treatment and disposal of contaminants:

f) any risk to the neighbourhood, the wider community, or the environment through natural hazards or the use of hazardous substances or hazardous installations.

Section 3 of the RMA defines effect as follows:

3. Meaning of effect

In this Act, unless the context otherwise requires, the term effect includes—

a) any positive or adverse effect; and

b) any temporary or permanent effect; and

c) any past, present, or future effect; and *d) any cumulative effect which arises over time or in combination with other effects— regardless of the scale, intensity, duration, or frequency of the effect, and also includes—*

e) any potential effect of high probability; and

any potential effect of low probability which has a high potential impact.

13.9 TTR Applications

Environmental consenting in NZ is an 'effects based' rather than standards based approach. Consequently, an applicant has to supply information on the expected effects of its proposed activities. In order to do this, TTR is required to provide information on all the matters identified in the applicable parts of Section 13.7 as detailed above such as the existing environment, the proposed activities and an evaluation of the effects or impacts of the activities on the environment.

The following sections of this report provide a general overview of the existing environment at the project site, and outline the various investigations commissioned by TTR to address all associated effects.

13.10 Environmental Characteristics of the TTR Area of Interest

13.10.1 Background

The "area of interest" in relation to the TTR project is the northern part of the South Taranaki Bight (STB). In this area, the water shoals gradually inshore from about 125 m deep in the west into the coastal shallows. Please note that the area outlined in Figure 13-2 will include only that portion shown in the EEZ ie. beyond the territorial boundary.

The geology of the area is discussed further in Section 4 of this PFS.

13.10.2 Coastal Physical Characteristics

The coast adjacent to the TTR area of interest lies on the southern flank of the Cape Egmont 'mega-headland', on a very exposed and energetic coast. This coast has seen continual tectonic uplift and erosion over the past 15,000 years, producing almost continuous near-vertical, 30 – 50 m tall cliffs along about 70% of the coastline. As the cliffs have retreated, they have left behind a hard shore platform on which sandy beaches have developed at the base of the cliffs (See Figure 13.1).

Figure 13-1 Hawera Beach showing high cliffs and typical profile

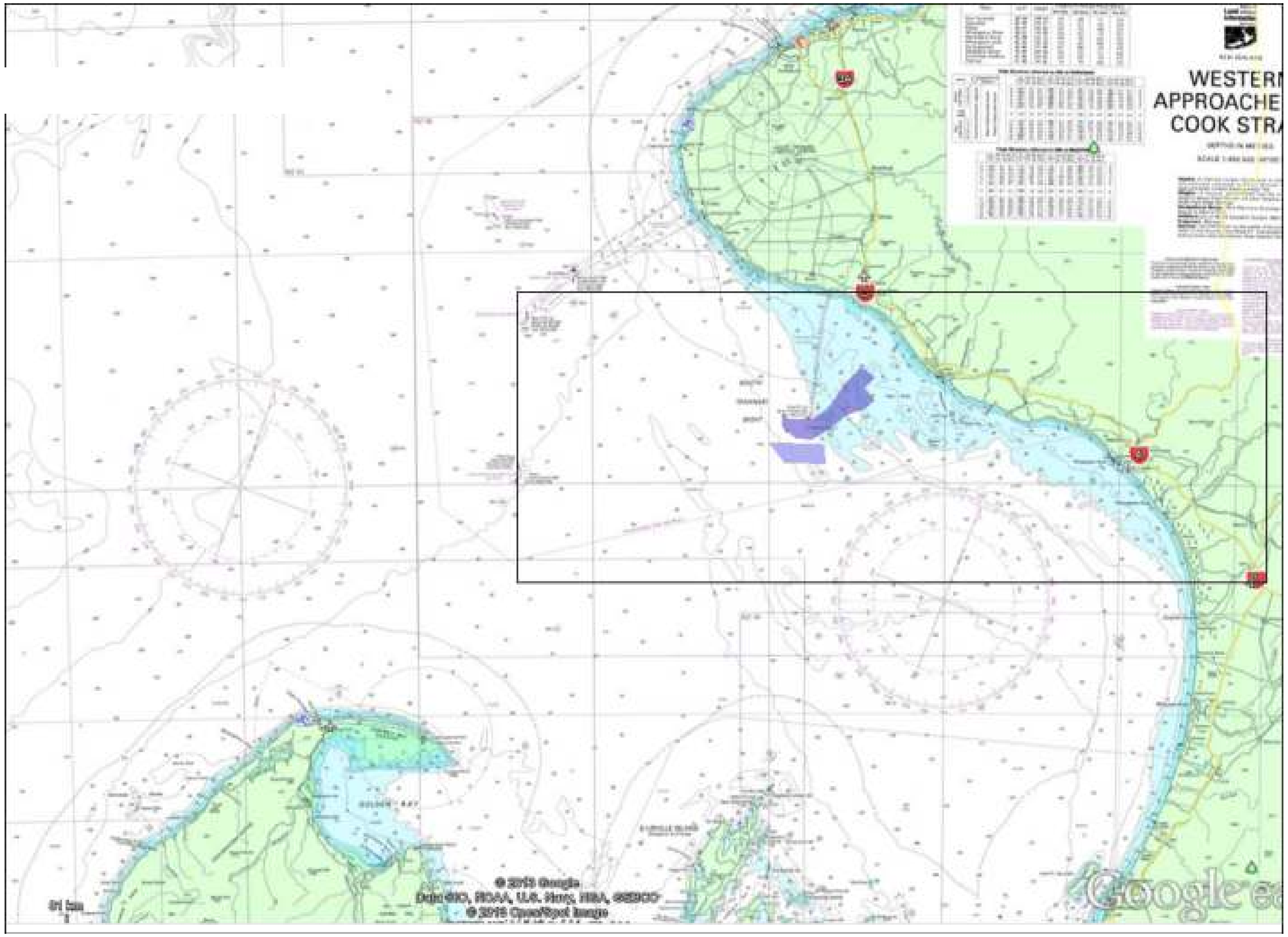


Figure 13-2Location of TTR “Area of Interest” relative to broader South Taranaki Bight.

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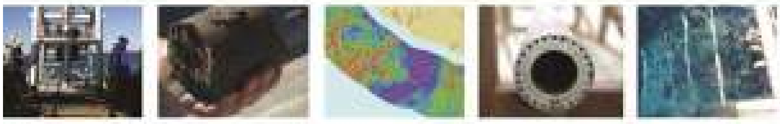


The beaches form in places where shallow embayments in the coast and headlands provide shelter from waves. Along a section of coast without cliffs (from the Patea River to about Waiinu), the beaches are backed by fore-dunes, landward of which transgressive dunes, now stabilised by farm pasture, have formed where sand picked-up from the beach by strong winds is blown far inland to smother low lying topography and rising ground.

Cliff erosion supplies sediment to the beaches. Sand is also transported into and through the area from alongshore by waves. Transport can be particularly large at times of storms when large waves create a surf zone and corridor for sand transport more than 500 m wide. Under these conditions sand is moved in pulses or slugs along the shore, which are visible in the beach profile records.

The net change in beach volume varies greatly, from erosion at some sites to accretion at others. There is no pattern of change in erosion and accretion along the shore. The overall picture seen for the South Taranaki Bight is one of high variability in beach morphology, erosion and accretion throughout the year, small net storage of sand on the beaches and large quantities of sand passing through the beach systems. With the exception of the sand stored in the transgressive dunes, the sand storage on beaches is rather transient in a system of highly connected sand storage units.

13.10.3 Physical Oceanography

Currents

Tidal currents account for 40-73% of the measured currents at all sites in TTR's area of interest, with wind driven current accounting for the remainder.

The peak ebb or flood current speed of the main twice-daily lunar (M2) tide, which is an average tide, ranges between 0.13 m/s and 0.25 m/s. Some-what higher and lower tidal speeds occur on spring and neap tides respectively. At all sites the M2 tide was oriented in the SE–NW direction (parallel with the coastline). The presence of such tidal current speeds well offshore in the STB arises from the alternate flow of water over the extensive, relatively-shallow, shoals off Hawera and Patea.

Currents in the STB are also affected by wind conditions. Large current speeds of around 1 m/s were measured on a number of occasions during periods of high winds. Winds blowing from the W and the SE sectors had the most pronounced influence on currents. Moderate to strong winds not only increased current speeds but also greatly altered current direction. During strong winds, currents could set in a constant direction for more than 24 hours; during calm conditions, currents reversed approximately every 6.2 hours with the tides re-asserting dominance.

At most sites during periods of light winds, the prevailing current drift was towards the SE This is consistent with the influence of the d'Urville Current, which sweeps past Farewell Spit and turns around in the STB to head south. However, current drift directions were significantly altered by moderate to strong SE winds which reversed the drift towards the NW. During times of moderate to strong W to NW winds, the prevailing SE drift was considerably enhanced.

Wave Characteristics

The 20-year average of significant wave height for all output locations is plotted in Figure 13.3 [Left]. This shows that the largest wave heights are found off the western end of the Taranaki Peninsula, decreasing further south with increasing shelter from prevailing SW swell.

This pattern is also seen in the corresponding average of wave energy flux (Figure 13.3 [Right]), which is a vector quantity reflecting the magnitude and direction of energy transfer by the waves. This shows relatively strong energy transfer, principally from the WSW, at the northern end of the STB, while further south, the more southerly energy components become blocked.

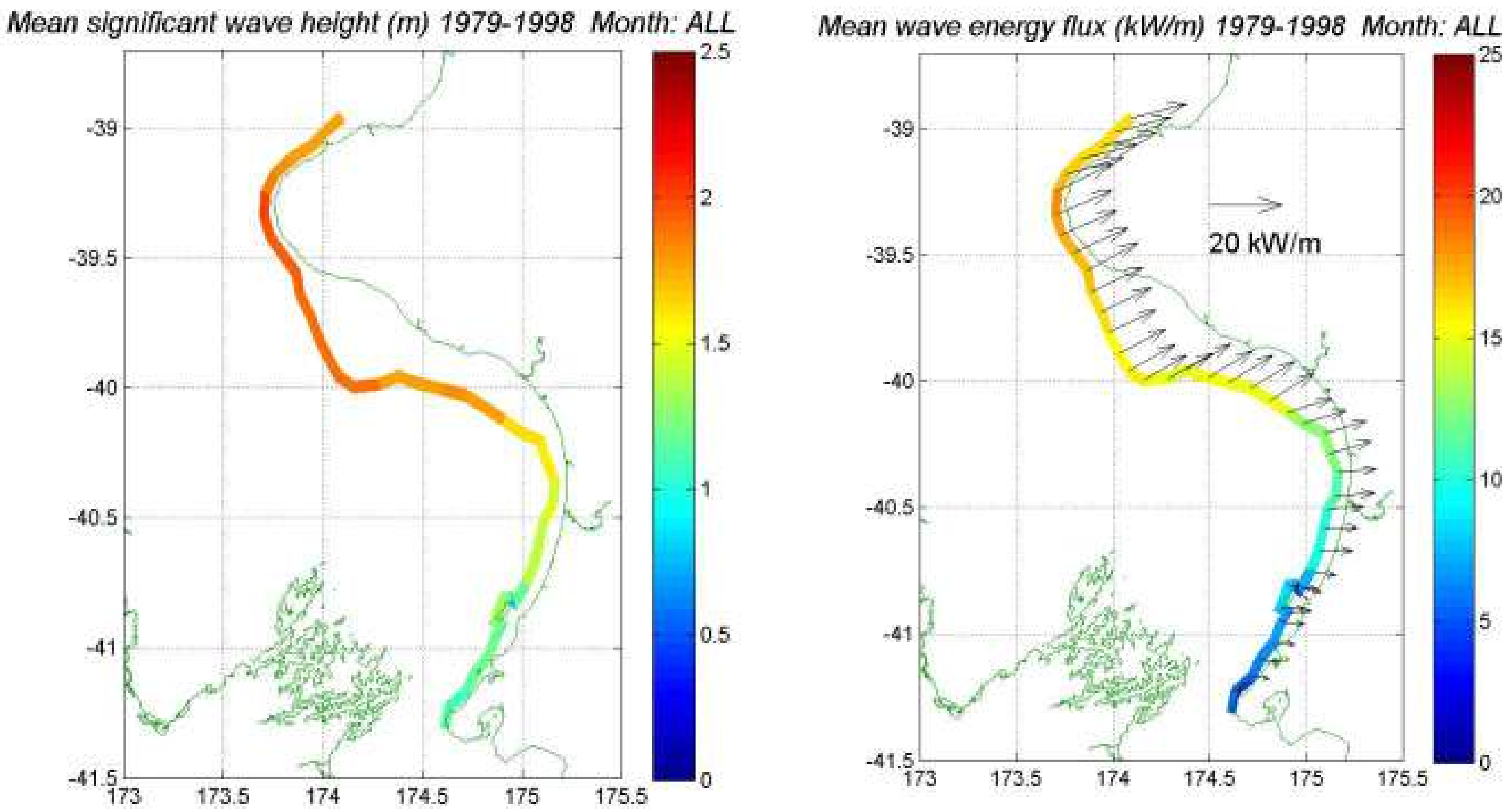
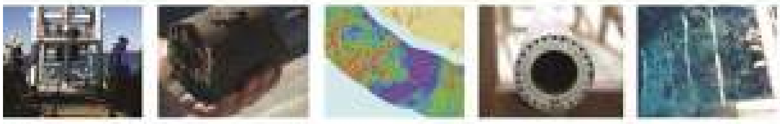


Figure 13-3 Wave Data

Left : Spatial distribution along the 50m isobaths of mean significant wave height averaged over a 20 yr hindcast record.

Right: Spatial distribution along the 50m isobaths of mean wave energy flux, averaged over a 20 yr hindcast record. Colour scale shows the mean of the magnitude of the energy flux, while the arrows show the vector averaged flux.



Water Quality

TTR has undertaken a range of water quality investigations in the STB in relation to TTR's area of interest. Preliminary findings are as follows:

Temperature and salinity measurements show that the water column in the STB was generally well mixed with only small vertical differences in temperature and salinity. Slightly lower salinity is likely to be found in the vicinity of major rivers in the STB (e.g., Patea, Waitotara and Whanganui).

Concentrations in the water column of suspended sands and suspended fine sediments (clays, silts and muds) were made at several sites and heights above the sea bed within the STB.

In the near-surface waters, maximum suspended-fine-sediment concentrations (*SSCm*) were very low. At some sites *SSCm* varied over the deployment period, with peaks in *SSCm* tending to occur during or just after periods of significant rainfall. At these times it is likely that rivers were discharging fine sediments into the STB, which were then transported in suspension through the measurement site. Some of the peaks in *SSCm* also coincided with times of large waves.

When there was any sand in suspension, suspended-sand concentration (*SSCs*) close to the sea bed was typically much greater than *SSCm*. The largest suspended-sand concentration very close to the sea bed was 1.9 grams/litre. At all sites, periods of increased sand concentration coincided with periods of large waves, thus highlighting the importance of waves in re-suspending sand from the sea bed in the STB. During calm periods, no sand was found to be in suspension.

Over the duration of the largest sediment-transport event, 3355 kg of sand per metre width of sea bed was transported in suspension by currents. This equates to a volume of 2.1 m^3 of sand transported per metre width of sea bed.

13.11 Ecological Characteristics

13.11.1 Benthic Ecology

TTR commissioned investigations into the benthic flora and fauna (macrobenthos through to meiobenthos) in the STB, in the vicinity of the TTR's permit areas, in order to characterise faunal communities across naturally occurring gradients.

At the macro scale, the Benthic Ecology of the STB is typical of the range of benthic ecology found inshore around much of the North Island (See Figures 13-4 and 13-5).

Preliminary findings of TTR's investigations indicate that the sandy habitats, including the proposed mining areas, to have relatively low abundance and species richness. This is a pattern typical of highly disturbed habitats and is in contrast to sites in the deeper, less sandy, part of the study area.

Overall there was no evidence within the data to suggest that the proposed extraction or de-ored sand deposit areas are "unique" with respect to macrofauna collected/observed during the survey. Importantly, the investigations found no significant relationship between iron concentration and community structure.

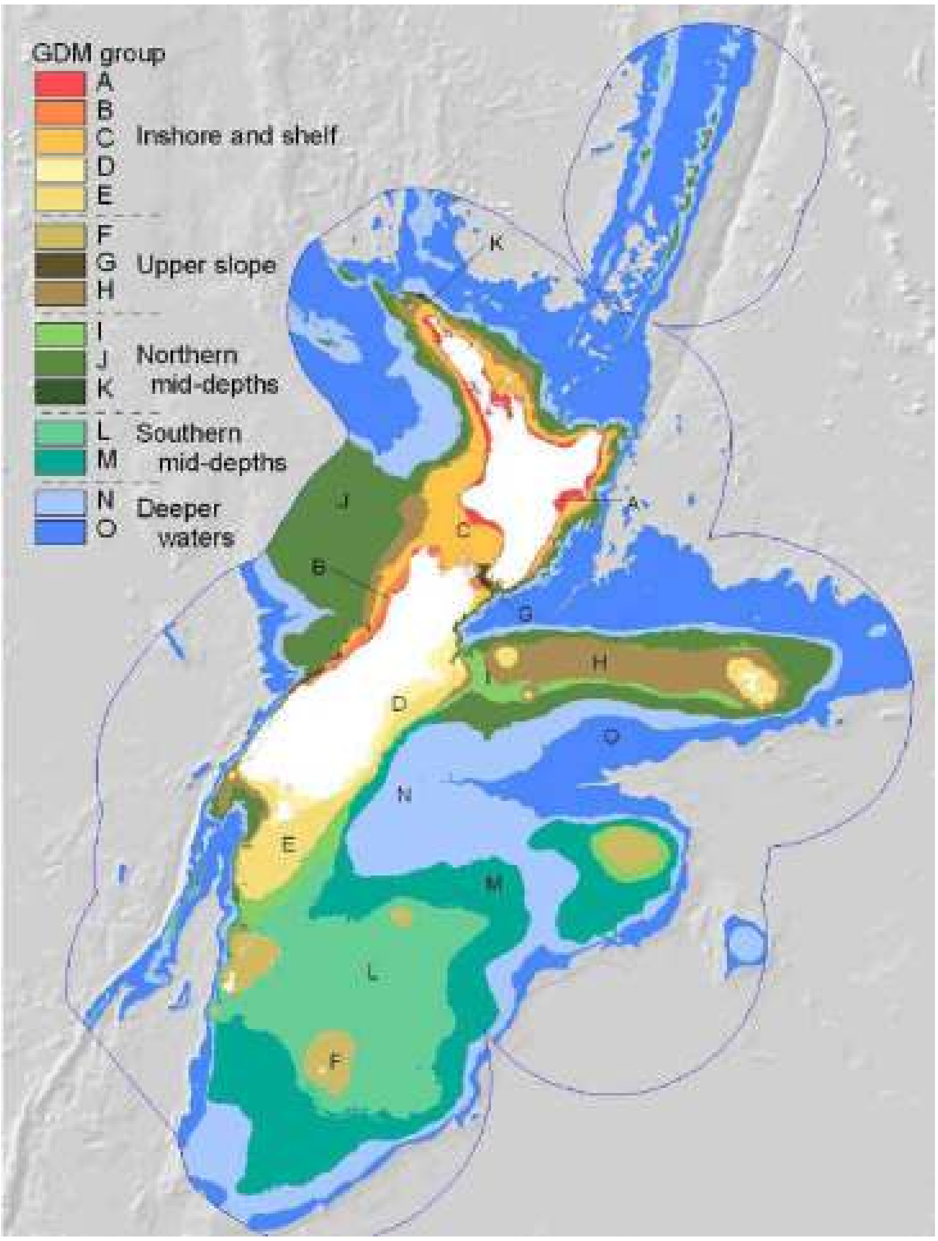


Figure 13-4 Geographic distribution across eight taxonomic groups of benthic species (from: Leathwick et al 2009 "Benthic-optimised marine environment classification for New Zealand Waters".

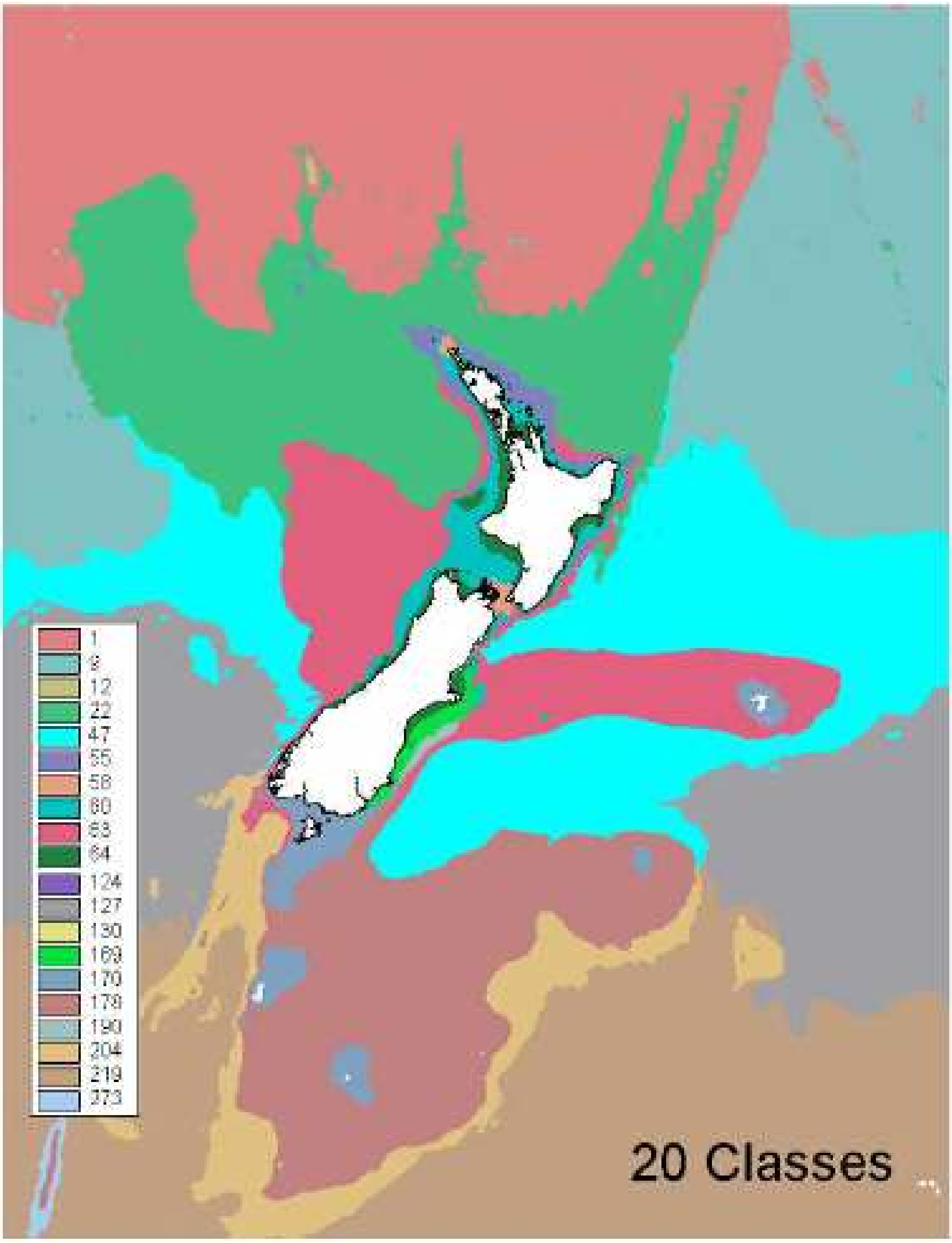
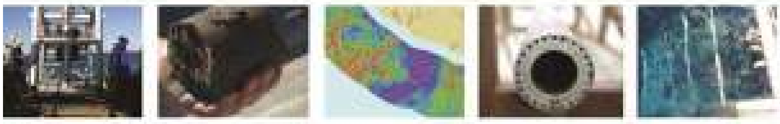


Figure 13-5 Marine Environment Classification – "The New Zealand Marine Environment Classification" NZ Ministry for the Environment 2005



13.11.2 Plankton

Complex optical conditions are prevalent in the broader STB area. Particulate and dissolved terrigenous material are frequently advected into the region from the Marlborough Sounds, west coast of the South Island and from the Cook Strait. Phytoplankton blooms appear to peak in springtime, with an origin off-shore to the west of the study region, and apparent advection of the bloom through the study region and into the Cook Strait. River inputs of terrigenous material along the Taranaki coastline are frequent but sporadic. Massive resuspension of bottom sediments, presumably wind-driven, occasionally causes the entire region to appear bright and turbid. Chlorophyll values at those sites deemed to be least compromised by terrigenous inputs range from 0.02 to 4.4 mg m-3, with blooms occurring regularly during October, and no significant autumn bloom. Apparent median chlorophyll values are relatively high throughout the year all across the broad STB, with an overall range of 0.02 to 32 and median 0.57 mg m-3. This compares to values typically < 0.1 mg m-3 in clear blue waters. No significant decadal trends were observed in apparent chlorophyll concentration.

The broader STB is biologically productive in terms of mesozooplankton, and the area may represent a breeding ground for zooplankton, which in turn promotes aggregations of larger mobile predatory species, particularly squid. The mesozooplankton species composition is neritic (nearshore) and is strongly influenced by the physical oceanography of the region, including the upwelling events off Cape Farewell and the D'Urville Current.

13.11.3 Fish

The STB has a moderately diverse reef fish fauna with only 38 of the 72 species modelled by Smith (2008) New Zealand wide predicted to occur on reefs within SCUBA diving depth range in the region.

Many of the reef fish are predicted to occur on the off-shore shoals and on coastal rocky reefs, which will not be influenced by TTR's extraction activities.

Moderate numbers of demersal fish species occur in the region. Most species are common within a restricted depth range.

Commercial fishing operations within the broader STB area have been dominated in recent years by bottom trawling (for a variety of species), midwater trawling (mainly for jack mackerel), and set netting (mainly for rig, blue warehou, and school shark). Together these methods have accounted for 95% of all fishing events recorded with position.

The highest levels of fishing effort (mainly bottom trawling and set netting) were relatively close to the shore between New Plymouth and Cape Egmont (well north of TTR's area of interest), and between Hawera and Whanganui near the 50 m contour.

13.11.4 Birds

The STB supports a relatively modest seabird assemblage. Many of the species occurring in the area are relatively coastal in their distributions. Such species include blue penguin, shags, gulls and terns, although these latter taxa can extend to more offshore areas. By contrast, and although some species have been observed from and relatively close to the coast, albatross and petrel species tend to be more pelagic and wide-ranging in their distributions and will likely occur anywhere throughout the area.

The area does not support large breeding colonies for any species but a number of estuarine sites are of significant value to coastal, shore, wading, and migratory bird species. These include the Waikirikiri Lagoon, and the Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei river estuaries.

13.11.5 Marine Mammals

Relatively few sightings of cetaceans have been made within TTR's area of interest. However, two endangered species are reported to occur in the area: the killer whale, and southern right whale.

In addition, the Maui's dolphin is reported to occur to the north and south of TTR's area of interest, generally within 7 nm of the shore.

13.12 TTR's Environmental Application Strategy

13.12.1 Consenting Risks

Based on an evaluation of data on the existing environment in the STB, TTR has identified three key consenting risks as follows:

TTR intends to extract up to 50 million tonnes (or 25 million m^3 per year). This is a large volume by international standards and is comparable with some of the largest individual dredging projects undertaken to date internationally. For example, around 30-40 million m^3 is dredged annually from waterways in the Netherlands; and two of the larger recent dredging programmes, the London Gateway Project and the Wheatstone Project in Australia, involve total dredged volumes of around 32 and 35 million m^3 respectively over the life of each project, or around 7 million m^3 per year.

TTR's preliminary modelling studies anticipate that the tailings and water discharge operation will cause a sediment plume. In particular, the modelling presently predicts relatively high levels of suspended sediments arising from the extraction and discharge operations within the 12 nautical mile limit. This can primarily be attributed to the shallower water and proximity to the coast. This could lead to associated effects on water clarity and marine biology (including effects on benthic organisms, plankton and fish). In addition the large volume discharged could result in adverse effects arising from the deposition of fine sediments on the sea floor and subsequent re-suspension by wave action. Extracting sediment from outside the 12 nm limit presents less of a sediment plume risk, although a plume will still result. This plume will at times extend to within the 12 nm area.

Various stakeholders such as iwi and others have expressed an interest in the project. Some, such as "Kiwis Against Sea bed Mining" (**KASM**), have expressed opposition to the proposal. TTR will take all reasonable steps to avoid adverse environmental effects which may exacerbate any stakeholder concerns.

The Maui's dolphin is a consenting risk largely due to the precarious state of the population with an estimated 55 adult dolphins remaining. The Maui's dolphin is endemic to New Zealand and is considered to be the world's rarest dolphin species. There has been recent interest in the measures to protect the species with the Government releasing a review of the Maui's dolphin threat management plan. Whilst the dolphin has never been recorded as such in TTR's area of interest it has been noted further south, implying that it has moved through the general area in the past. This dolphin is generally recognised to have a near-shore habitat preference, and it will be important to give attention to potential interactions with these dolphins and with other marine mammals.

13.12.2 TTR's Risk Mitigation Approach

TTR's approach to mitigating consenting risks involves adopting a flexible approach, incorporating if necessary, staging to initially avoid areas with an associated high and unacceptable risk.

Analysis indicates that only 15% of the identified ore resource occurs inside the 12 nautical mile limit. Preliminary analysis indicates potentially high consenting risk for extraction inside this limit as a consequence of predicted higher suspended sediment levels from extraction operations closer to shore.

TTR is adopting a staged approach involving application for all EEZ Activities (mining and other as noted above) with a later RMA mining component (thereby reducing the risk). A subsequent application for sediment extraction in the RMA areas not previously applied for would be lodged at a later date.

In addition, as described below, TTR has commissioned an extremely wide range of environmental investigations to provide a sound scientific basis for evaluation of effects associated with the project.

13.13 Environmental Studies

13.13.1 Introduction

In recognition of the need to identify environmental risks identified in relation to the project, TTR has undertaken a wide range of environmental investigations. These have focussed on ecology; coastal processes, physical oceanography, social impacts, landscape matters, noise, shipping and maritime transport.

In undertaking these studies, TTR has convened a team of leading environmental specialists to provide input, with expertise covering the following subject areas:

- Shore line monitoring
- Coastal stability

- Surf break effects
- Fish and fisheries
- Wave modelling
- Biomass, species composition in the South Taranaki Bight
- Natural drivers of meso-zooplankton in the South Taranaki Bight
- Antifouling
- Plume modelling
- Cetacean habitat modelling
- Benthic survey – near shore and offshore
- Colonisation experiment
- Seabird distribution and abundance in the South Taranaki Bight
- Effects of ships lights on fish, squid and seabirds
- Water quality effects - Characterisation of suspended sediments and ground truth of satellite imaging of surface waters
- Noise effects
- Social impact assessment
- Marine mammals
- Pore water chemistry and toxicology
- Maritime and shipping
- Recreational and tourism
- Commercial fishing
- Sediment size distribution
- Statutory planning
- Landscape and visual effects
- Economic effects assessment
- Marine geotechnical – sediment behaviour
- Consultation and iwi liaison
- Cultural impact assessment

13.13.2 Ecological and Physical Oceanographic Studies

Particular focus has been given to detailed ecological and physical oceanography studies in a wide range of subject areas as described in Table 13-4 below.

Table 13-4: TTR Investigations commissioned 2011-2013.

Topic	Scope of Investigation
Wave modelling and surf effects	Develop SWAN nearshore wave model Determine sensitivity of model for detecting mining sea bed effects on waves/ shoreline. Shoreline stability modelling Develop worse-case scenarios for mounds and holes and incorporating into bathymetry. Identify and describe surf breaks potentially impacted. Determine range of wave and wind conditions that result in surfable conditions at each site. Assess impacts at the 10 m bathymetry offshore of each of the 10 surfing breaks.
Plume modelling	Estimate sediments concentrations and deposition rates arising from planned activities, incl. dredging, loading and dumping. Sensitivity analysis. Establish sediment release scenarios – including separate near field modeling to establish inputs to far field model Simulate sediment plumes Establish up to 3 sediment release scenarios (i.e. combinations of sediment sources) with input from client. Undertake laboratory analysis to determine optical properties of finest (<30 µ) sediments from TTR cores. Simulate sediment plumes, including optical response. Undertake sensitivity studies of up to 3 additional release scenarios.
Field instrumentation	Field investigations into ocean physical parameterss: Currents Waves

Topic	Scope of Investigation
	Salinity Temperature Suspended sediments Methods: Optical and Acoustic Backscatter Sensors (OBS and ABS). Subsurface salinity and temperature mooring buoy. Datawell 70 cm wave rider directional wave buoy at an offshore location (approximately 40O 00’S, 174O 05’E, 50m depth), to record wave statistics. Dobie pressure sensors. Acoustic Doppler Current Profiler (ADCP).
Shore line monitoring	Desktop analysis of historical profile data Field reconnaissance to determine sites for beach survey profiles Ten monthly profile surveys and in addition one survey following a storm event. Beach sediment samples collection and grain size analysis along each profile during one of the monthly profile surveys
Offshore benthic	Fieldwork between September 2011 and May 2013 The sampling was carried out in three phases: Benthos the initial survey of the north-eastern end of the proposed mining area and surrounding area; Deepwater, an extension to the survey to include an expansion of the proposed mining area and Initial proposed site for de-ored sand New proposed site for de-ored sand. Three different sampling gear types were used: NIWA’s CoastCam, a video and still imaging system; a small Agassiz dredge and a sediment corer. 144 sites were observed using the CoastCam video

Topic	Scope of Investigation
	116 sites were dredged and 331 sediment cores were collected from 103 sites. Fifteen different habitats were identified, most of which were sandy (e.g. sand with ripples, sand with waves, sand and shell). Results are presented as distribution plots which, with few exceptions, show the sandy habitats, including the proposed mining and de-ored sand deposit areas, to have relatively low abundance and species richness. Recolonisation study - experiment, using treatments of iron-rich and de-ored sand - experiment out at two sites, Mahanga Bay and Evans Bay. Multivariate analyses of the data showed significant differences in benthic community structure between sites but little effect of iron concentration, which explained less than 4 % of the variation in species composition despite the highly contrasting iron-ore treatments. There was also no significant interaction between site and treatment. Further analysis showed that the relatively small differences in sediment properties among treatments had a larger influence on community structure than the very large differences in the concentration of iron.
Inshore benthic sampling	Characterisation of the inshore benthic macro-fauna and macro-algae, and collection and analysis of surficial sediments Field sampling benthic macro-fauna and macro-algae (Camera plus some dredging): 25 near-shore stations from Hawera in the west to south of Wanganui in the east where sediment plume modelling indicates possible occurrence of high concentrations of near-bottom suspended sediments and 5+ mm of deposited sediment. 10 stations along proposed route for Whanganui pipeline extension. Small van veen grab - samples of surficial sea floor sediments at each of the 35 sites where benthos is sampled. Analyse all sea floor camera transects to characterise the

Topic	Scope of Investigation
	habitat at each site sampled. For each sample of surficial sediment characterise its particle size-frequency distribution using methods appropriate for each size class of particle.
Cetacean habitat modelling.	Whales and dolphins habitat modelling – Habitat (environmental) modelling analysis of New Zealand wide data of Killer whale -Orcinus orca, Maui’s Dolphin - Cephalorhynchus hectori maui, and Southern Right whale - Eubalaena australis.
Suspended sediments.	Characterisation of suspended sediments and ground truth of satellite imaging of surface waters Collect 30 surface water samples from distinct bodies of water during other field sampling. Collect near sea-floor samples of water near optical back-scatter sensor on at least three occasions. Collect 5 sea bed samples. Laboratory analysis of grain size of the sea bed samples Laboratory analysis of optical properties of at least 30 water samples. Laboratory analysis of suspended sediments in at least 30 water samples. Deploy Wetlabs EcoTRIPLET device to provide increased spatial coverage of chlorophyll fluorescence, CDOM fluorescence and particulate backscatter across distinct water bodies. Derive surface distributions of phytoplankton, detritus, dissolved substances such as land-derived humic acids, and inorganic particulates from satellite imagery using a range of published algorithms. Quantitatively validate satellite estimates using field data. Estimate background levels of surface distributions of phytoplankton, detritus, dissolved substances such as land-derived humic acids, and inorganic particulates and their seasonal variation.
Sediment	Particle frequency distribution of samples from core

Topic	Scope of Investigation
characterisation.	horizons provided by TTR
Fish and fisheries	Reef fish report Demersal fish report Commercial fisheries report
Coastal stability	Effects of climate change on coastal processes Effects on the landform and geomorphic character of the beach Effects on the deposition of substances to the foreshore and sea bed Effects on public access to the marine environment Effects on physical drivers and processes that cause coastal change incl. sea level rise How long will the effects of dredging last Effects of reduction in the supply of sand to the nearshore and littoral drift system Incorporate information from wave modelling studies into the coastal stability report.
Seismic survey	Seismic survey across parts of the resource area to establish the geology of the sub sea bed layers
Sidescan/Multibeam survey	Sidescan survey of deep sediment habitats Multibeam bathymetry over extension of Wanganui outfall pipeline, oceanographic instrument mooring, FPSO vessel mooring site, tailing dump site and all proposed mining areas.
Optical and suspended sediment concentrations.	Field investigations to characterise the background near-shore optical and SSC levels Static deployment of instruments at 6 near-shore sites (~10 m water depth) along the STB to measure the near-surface optical backscatter (from which beam attenuation and SSC levels can be derived). Undertake 2 synoptic boat surveys to measure near-surface optical backscatter (SSC) and beam attenuation along 18 shore-normal transects. The transects will be ~

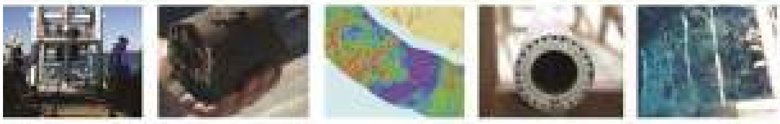
Topic	Scope of Investigation
	3.2 km long, and along each transect 8 spot measurements will be taken. In addition to these measurements, at up to one-third of the 144 measurement sites (18 transects x 8 spot measurements) water samples will be collected and analysed to yield SSC, light absorption and the size distribution of the suspended particles. On a single occasion collect and measure the size distribution of the sea bed surficial sediments from the 6 static sites and from 12 of the 18 synoptic boat survey transects.
Cetacean aerial surveys	Aerial surveys out to 22 nautical miles over a period of 2 years.
Pore water chemistry	Laboratory experiments to investigate the water-column effects of re-suspension of anoxic iron sands. Provide a detailed description of important properties of the target sediment: particle size distribution, water content, organic matter content, acid volatile sulphide content. Evaluate the release of trace metals (Cadmium, Copper, Lead, Nickel, Zinc) from suspensions of subsurface, anoxic iron sands with a series of elutriate tests (certification unavailable, but carried out subject to EPA 503/8-91/001 protocols). Evaluate the effects of iron sand resuspension on dissolved oxygen, pH, and turbidity with laboratory trials. Evaluate the potential for the release of toxic materials to the water column from grinding of sand particles.

13.14 Consenting Timeline

The proposed consenting timeline is set out in Figure 13.6.

Target dates for the TTR consenting programme have been developed in terms of a "Best" Case, "Base" Case, and "Delayed" Case, with broad assumptions for each case summarised as follows:

Case Scenario	Broad Assumptions
"Best" Case	Field data collection and analyses completed early; Timely delivery of project design information; Efficient handling of applications by regulators.
"Base" Case	Allows for some weather downtime; Timely delivery of project design information; Efficient handling of applications by regulators.
"Delayed" Case	Adverse weather with associated downtime; Slow delivery of Project information; Inefficient handling of application materials by the regulators.



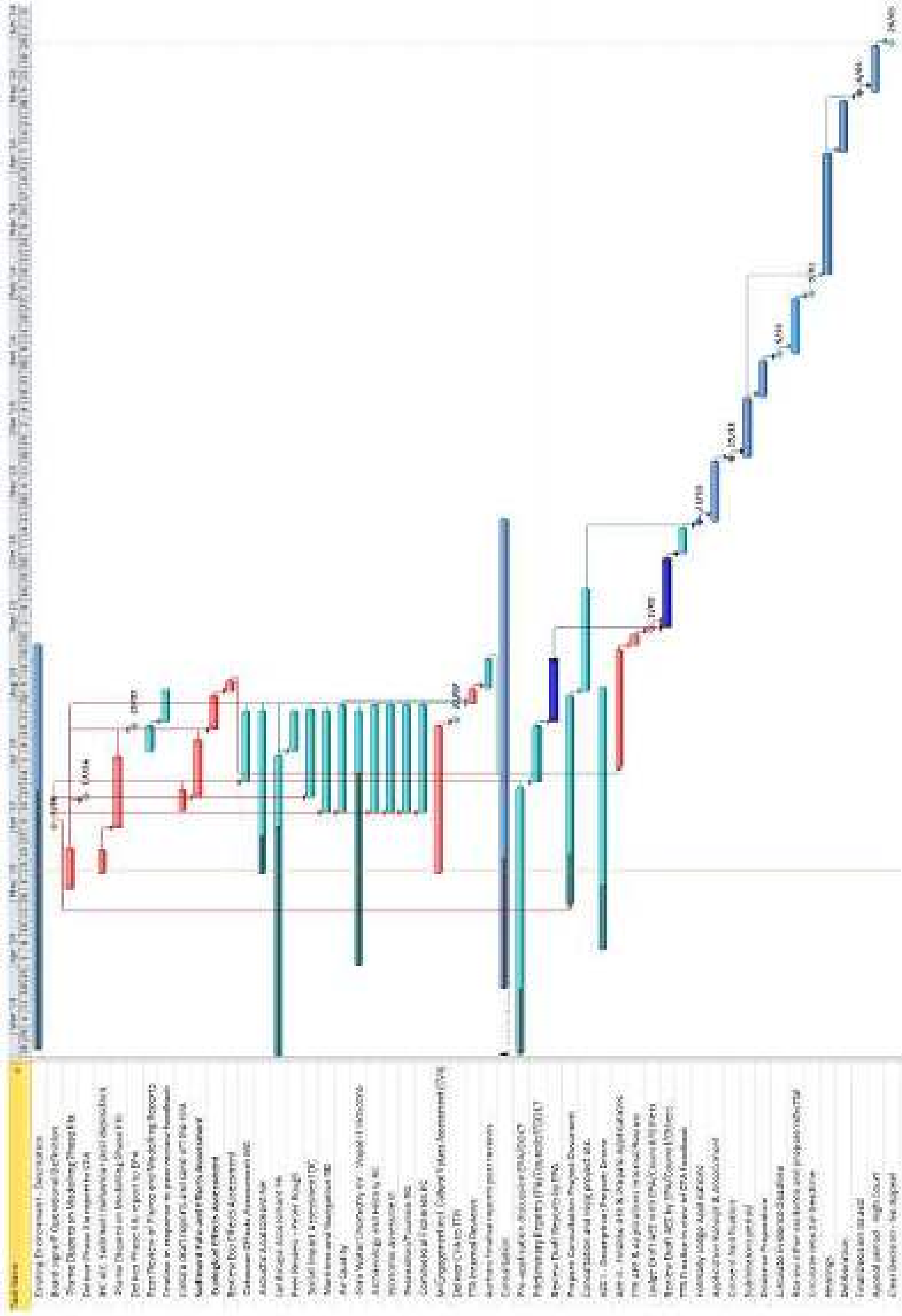


Figure 13-6 Consenting Timeline

14. CAPITAL AND OPERATING ESTIMATES

14.1 Capital Expenditure Estimate

As part of the PFS study TTR has calculated and assigned a level of contingency to the capital cost estimate for the TTR Offshore project, and also identified a prioritised list of risk factors affecting the capital cost estimate. The results are presented in the form of a cumulative S-curve showing project budget cost against probability and level of confidence and a register of ranked cost risk factors. These risk factors form the basis of the Risk Management Plan, i.e. significant risks that need to be controlled and managed throughout the project.

14.2 CAPEX Risk Model

The CAPEX cost risk model was developed in @Risk for Excel (version 6). The risk variables have been modelled as triangular distributions, using a 3-point estimate of their likely range of uncertainty. Thus, the least likely minimum (P10), the most likely (P50), and the least likely maximum (P90) are identified. The switches are modelled as discrete distributions, simply using the likelihood of their occurrence.

The @Risk model was analysed using Monte Carlo simulation (10,000 simulation runs were performed). Using risk analysis, the capital cost contingency is defined as the ***provisional*** sum required to bring the base estimate to the P50 probability. That is, the contingency is added to the base estimate so that the total cost budget has an equal chance of performing either over or under. The accuracy of the estimate is then defined as the P10 and P90 points on the cumulative curve, meaning that there is an 80% chance that the project capital cost will fall within that range. In order to produce a register of ranked cost risk factors, sensitivity analysis is performed on the risk factors, by ranking the factors in terms of contribution to the overall contingency.

14.3 Summary Scope of Work

Capital costs have been prepared based on the PFS documentation and 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 8000 tph
- Installed Power Generation of 80MW
- Sea Water Desalination capacity of 30,000 m^3/day

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

- Working capital

- Insurances
- Escalation

14.4 Capital Estimate Basis

The capital cost estimate has been prepared based on the detailed project scope developed during the PFS. The basis for the majority of the estimate is component cost ratios. A comprehensive equipment list was produced from which supply costs were then compiled, from historical information and by solicited budget quotations. Actual industry norms were extracted from published sources and applied to determine estimated costs of all activities associated with each equipment item. This included: equipment installation, piping material and labour, electrical material and labour, instrumentation, field expenses and project management including engineering. This enables a total capital cost to be calculated.

Budget prices have been received from pre-qualified OEM's/vendors for the major engineered/process equipment, namely the trommel screens, IsaMills™, magnetic separators, pumps, power generation units and the water desalination plant. These items currently represent approximately 65% of the total estimate value.

The historical norms used in the estimates were based on industry standards within the defined scope. The project has endeavoured to compile a reasonable level of basic engineering to facilitate the allocation of applicable norms, finalisation 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
- 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%. This percentage was calculated using the completed risk analysis. The capital cost contingency is defined as the ***provisional*** sum required to bring the base estimate to the P50 probability.

14.4.1 Normed Estimates

The normed estimates of the project, were compiled using the 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 14-1 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.
- The factoring of associated equipment and service costs to calculate the final estimated capital cost.

14.4.2 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 the 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 (P50), the maximum pessimistic (P90) and minimum optimistic (P10) 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 accuracy margin and contingency.

14.4.3 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 detail engineering increases, as does the cost to undertake the higher level studies. Therefore it is common for detailed engineering to be conducted in the full feasibility study after the project concepts have been fully optimised.

14.4.4 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.

14.4.5 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
- Risk assessments

14.4.6 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. The projects verification plan has been included in Appendix 19.2 of this document.

14.4.7 CAPEX Cost Estimate

Considering the operational tools and equipment requested to reach the production of 4-5 Mtpa of final iron sands concentrate, the risk analysis indicates a CAPEX budget estimate of US$ 576 million.

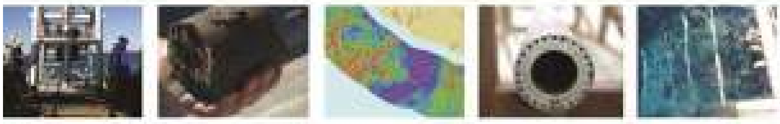
CAPEX Risk Analysis Results		
Least Likely Minimum	**Most Likely Cost**	**Least Likely Maximum**
P10	**P50**	**P90**
US$ 555 Million	US$ 576 Million	US$ 597 Million

Table 14-1CAPEX Risk Analysis Results

PROJECT ELEMENT		CAPITAL COST					TOTAL
		FPSO	FSO	AHV	PM & ENG.	CONTINGENCY	
VESSSEL	HULL	$52,084,340		$6,000,000			$58,084,340
	EQUIPMENT	$39,018,518					$39,018,518
	INTEGRATION	$45,000,000					$45,000,000
PROCESS	PROCESS PLANT	$173,228,799				$4,980,767	$178,209,566
	DEWATERING	$0	$17,035,800			$1,062,000	$18,097,800
MINING	CRAWLER	$97,862,279				$11,189,989	$109,052,268
AUX SYSTEM	POWER GENERATION	$78,767,500				$1,837,500	$80,605,000
AUX SYSTEM	DESALINATION	$26,555,900					$26,555,900
MANAGEMENT	PM&E	$3,096,200			$16,683,407	$973,790	$20,753,397
TOTAL		$515,613,536	$17,035,800	$6,000,000	$16,683,407	$20,044,046	$575,376,789
% OF TOTAL		89.61%	2.96%	1.04%	2.90%	3.48%	100.00%

Table 14-2CAPEX Breakdown

As expected the integrated production platform represents the major portion (90%) of the estimated total CAPEX.



14.5 CAPEX Risk Analysis Results

Simulation Summary Information	
Workbook Name	580349-SCH-X0003-RA (Model as basis of
Number of Simulations	1
Number of Iterations	10000
Number of Inputs	728
Number of Outputs	2
Sampling Type	Latin Hypercube
Simulation Start Time	5/06/2013 14:28
Simulation Duration	00:01:03
Random # Generator	Mersenne Twister
Random Seed	1

Summary Statistics for Offshore Mining Project Single Crawler Case Output Cost to First O				
Statistics			**Percentile**	
Minimum	$	526,862,079.58	**5%**	$ 549,832,265.32
Maximum	$	634,253,397.05	**10%**	$ 554,893,905.72
Mean	$	575,789,726.41	**15%**	$ 558,914,951.91
Std Dev	$	16,037,537.22	**20%**	$ 561,915,649.79
Variance	2.57203E+14		**25%**	$ 564,637,019.94
Skewness	0.086414368		**30%**	$ 567,122,070.02
Kurtosis	2.83794671		**35%**	$ 569,365,376.92
Median	$	575,698,033.89	**40%**	$ 571,551,335.30
Mode	$	569,201,978.78	**45%**	$ 573,713,932.03
Left X	$	549,832,265.32	**50%**	$ 575,698,033.89
Left P	5%		**55%**	$ 577,686,901.09
Right X	$	602,896,044.60	**60%**	$ 579,749,049.00
Right P	95%		**65%**	$ 581,844,951.65
Diff X	$	53,063,779.28	**70%**	$ 584,050,012.81
Diff P	90%		**75%**	$ 586,465,806.62
#Errors	0		**80%**	$ 589,248,432.06
Filter Min	Off		**85%**	$ 592,378,155.94
Filter Max	Off		**90%**	$ 596,963,914.97
#Filtered	0		**95%**	$ 602,896,044.60

Change in Output Statistic for Offshore Mining Project Single Crawler Case Output Cost to				
Rank	**Name**	**Lower**		**Upper**
1	Equipment Procurement / Budget Price	$	561,726,468.09	$ 592,182,986.31
2	Procure / Budget Price	$	565,463,888.61	$ 587,414,309.92
3	12 of 3MW M10,000 IsaMill / Budget Price	$	565,311,063.27	$ 587,053,811.36
4	Integration / Provisional Price	$	566,039,295.36	$ 586,765,907.18
5	HULL , SUPERSTRUCTURE, PAINT / Budget Price	$	567,377,669.94	$ 585,708,246.91
6	Procurement, Insurance, Packing, Shipping / Normed Price	$	571,125,351.02	$ 581,631,357.53
7	Desalination / Provisional Price	$	571,139,662.94	$ 580,590,010.79
8	MIMS / Budget Price	$	572,393,590.66	$ 579,360,514.06
9	Electrical / Normed Price	$	573,078,874.62	$ 579,833,338.53
10	MACHINERY / Budget Price	$	572,814,849.60	$ 578,778,403.34
11	Equipment / Budget Price	$	573,712,013.48	$ 578,335,144.87
12	One year Operating Spares / Normed Price	$	574,261,855.44	$ 578,115,983.13
13	Instruments / Normed Price	$	574,065,385.08	$ 576,994,313.48
14	Trommel screen/chutes / Fixed Price	$	574,700,251.56	$ 577,498,318.62

Table 14-3Simulation Summary

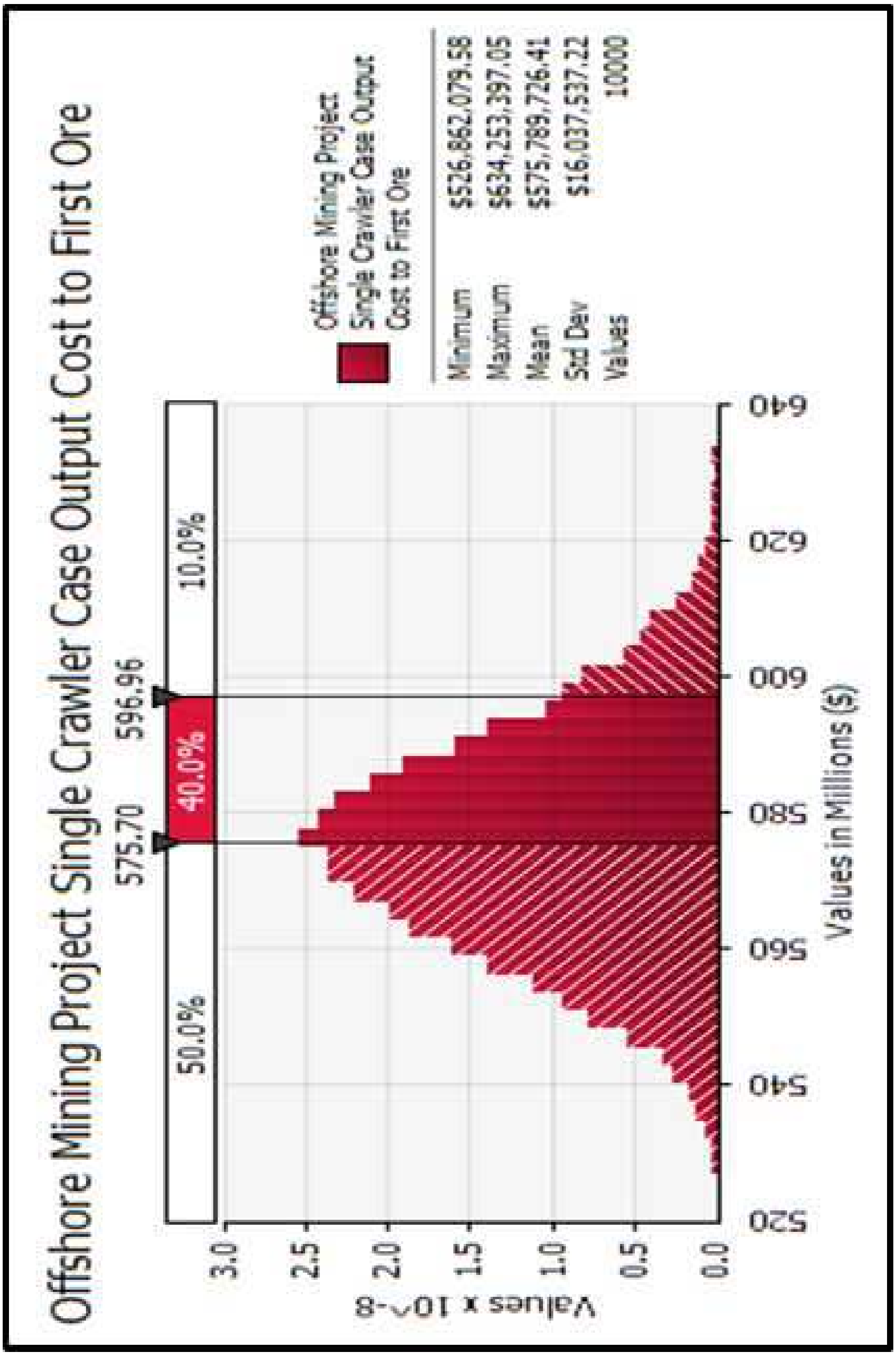


Figure 14-2 Estimate Distribution

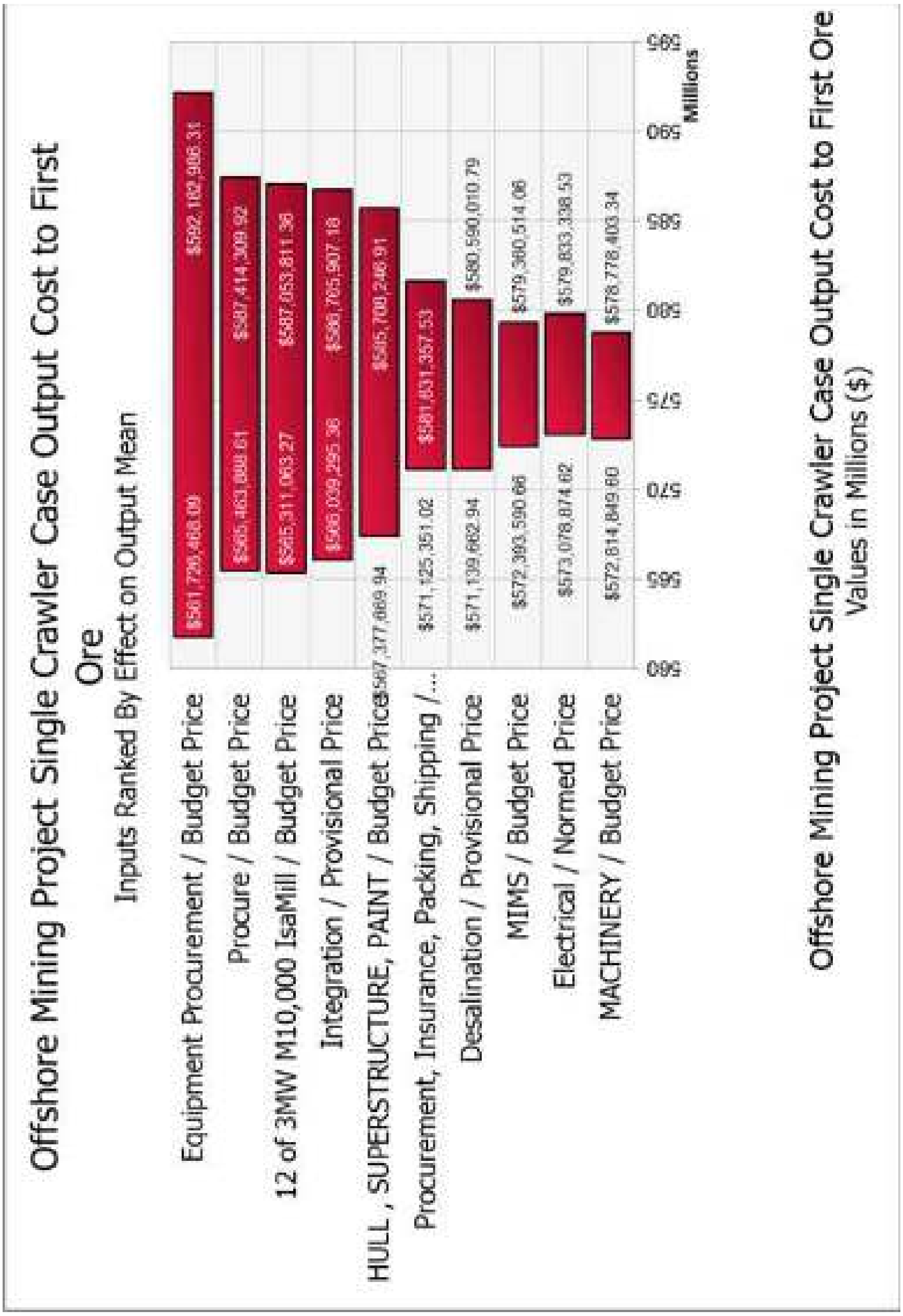


Figure 14-3 Estimate Tornado Chart Risk Ranking

Task Name	Cost	Installed	Piping	Electrical	Instruments	Structural Steel	Contractors fees	Procurement, Insurance, Packing, Shipping	Construction and Commissioning Spares	One year Operating Spares	Capital Spares	Contingency	
Overall Price Breakdown	81.7%	1.1%	1.5%	4.4%	0.6%	0.3%	1.6%	3.3%	0.3%	1.3%	0.8%	3.2%	
Process Plant Price Breakdown		2.9%	4.4%	6.4%	1.7%	0.9%	4.6%	5.0%	0.2%	1.1%	0.7%	1.1%	
Mode Applied		14%	8%	10%	5%	14%	7.5%	7.5%	0.5%	2.5%	1.5%	0.25	
Standard Deviation Applied												0.05	TOTAL
Offshore Mining Project	$464,816,793	$8,184,974	$7,983,043	$20,051,957	$4,676,126	$2,236,541	$7,384,468	$24,975,664	$1,669,241	$8,346,209	$5,007,725	$20,044,046	$575,376,789
Project Management	$8,204,917	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$969,590	
Project Management And Cor	$8,204,916.67												
BFS	$8,478,490.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	
Resource Definition	$592,600.00												
Beneficiation and Metal	$519,166.67												
Permits and Licences	$2,476,834.17												
Consenting and Appro	$3,078,128.33												
Environment and Comi	$1,811,780.83												
Engineering and Design	$3,096,200	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$4,200	
FPSO - Hull/Plant													
Part A Estimate Receive	$82,600.00											4,200	
Estimate for Part B	$3,013,600.05											0	
Procurement	$445,037,186	$8,184,974	$7,983,043	$20,051,957	$4,676,126	$2,236,541	$7,384,468	$24,975,664	$1,669,241	$8,346,209	$5,007,725	$19,070,256	
Procurement - FPSO - Hull	$136,102,858.00											0	
Procurement - Mining ROV	$93,249,920.00								512,484	2,562,422	1,537,453	11,189,989	
Procurement - Process Pla	$115,351,074.48	7,512,374	7,629,043	9,845,957	4,499,128	2,236,541	7,384,468	12,998,684	590,757	2,953,787	1,772,272	4,980,767	
FPSO Transfer Hose	$433,333.33			0					2,600	13,000	7,800		
Procurement - Power gene	$81,250,000.22	0	0	8,125,000	0		0	8,085,000	367,500	1,837,500	1,102,500	1,837,500	
Procurement - Desalinatio	$20,650,000.00	0	0	2,065,000	0		0	2,725,800	2,725,800	2,725,800	2,725,800	0	
Procurement - FSO Concentrate Onloading	$12,000,000.00	672,600	354,000	2,016,000	177,000	0	0	1,168,200	72,000	360,000	216,000	1,062,000	
AHT Procurement	$6,000,000.00												

Table 14-4 Capital Estimate

15. FINANCIAL EVALUATION

This section summarises the financial and operating parameters of the TTR 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.

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	
PRODUCTION												
Head Grade		12.0%	11.0%	10.3%	10.8%	10.0%	11.1%	9.7%	9.7%	9.7%	9.7%	
Metallurgical Yield		58.2%	57.8%	55.0%	50.5%	61.5%	55.7%	55.7%	55.7%	55.7%	55.7%	
Fe Product Grade		57.0%	57.0%	57.0%	57.0%	57.0%	57.0%	57.0%	57.0%	57.0%	57.0%	
												Average
Sediments Mined	Mtpa	30.00	30.00	30.00	30.00	34.11	30.00	30.00	30.00	30.00	34.11	30.82
Fe Concentrate @ 57% Fe	Mtpa	4.00	4.40	3.84	4.10	3.87	3.72	3.48	3.48	3.48	3.04	3.81
SALES												
Nominal 62% Fe CFR China Price	$/t	108.50	108.50	108.50	108.50	108.50	108.50	108.50	108.50	108.50	108.50	
Fe % Adjusted Product Price	$/t	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.75	99.75	
Offtake Price	$/t	79.80	79.80	79.80	79.80	79.80	79.80	79.80	79.80	79.80	79.80	
Market Sale Price	$/t	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	81.00	
COSTS	$M											
Crawler												
Repairs		6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	
FPSO												
Repairs		14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	
Labour		14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	
Insurance		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Power		38.4	38.3	38.2	38.2	33.4	38.2	38.2	38.2	38.2	33.4	
		70.3	70.2	70.1	70.1	65.3	70.1	70.1	70.1	70.1	65.3	
FSO (Outsourced)		34.4	33.8	32.5	33.1	32.6	32.3	31.7	31.7	31.7	30.7	
Ancillaries Support		5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
Others												
Sales G&A		7.8	7.3	6.4	6.8	6.5	6.2	5.8	5.8	5.0	5.1	
Others		2.2	2.1	1.3	1.4	1.4	1.3	1.2	1.4	1.6	1.5	
Marketing		7.5	7.0	6.1	6.6	6.2	6.0	5.6	5.6	5.6	4.9	
Freight		48.8	44.0	38.4	41.0	38.7	37.2	34.8	34.8	34.8	30.4	
Royalty		11.6	9.9	6.3	7.9	6.7	2.7	2.5	3.8	5.5	4.3	
		75.7	70.3	58.5	63.8	59.5	53.4	49.8	51.4	53.2	46.1	
												Average
Total Opex per ton (TOC)	$/t	31.20	32.36	35.14	33.64	33.75	35.05	37.07	37.52	38.04	40.09	35.46
Total Opex per ton (CFR)	$/t	41.20	42.36	45.14	43.64	43.75	45.05	47.07	47.52	48.04	50.09	45.46
FINANCIAL SUMMARY	$M											
												Total
Revenue		329	357	312	333	315	303	283	283	283	247	3,054
Direct Costs		117	116	115	115	110	114	114	114	114	109	1,136
Other Costs		76	70	59	64	59	53	50	51	53	46	582
EBITDA		187	171	139	154	145	135	119	117	116	91	1,375
Profit before Tax		105	90	56	71	61	49	31	75	104	82	720
Profit after tax		75	64	41	51	44	35	22	53	75	58	519
CAPEX	$M	575										
NET PRESENT VALUE @ 10%	$M	339										

15.1 Business Model

The business plan has been elaborated by TTR in the section above in particular with regards 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 to traditional iron ore, particularly when the valuable vanadium is recovered as a by-product.

In the short term, there is a substantial market accessible to TTR's product that is estimated to be in excess of 50 Mtpa, which is based on a combination of traditional blast furnaces using initially small amounts of VTM concentrates and also existing heavy VTM concentrate users looking to source their VTM concentrates from the seaborne market. This market is substantial and unlikely to be swamped by the competing VTM hopefuls from the Philippines and Indonesia which have small mineral resources compared to TTR.

TTR's business plan assumes that its project can readily capture 4-5 Mtpa of the existing VTM market. Currently TTR has secured framework agreements for an initial portion of its products.

In the medium term, there is the optionality for TTR to supply VTM concentrates to integrated steel making facilities located in New Zealand, China, as well as other Asian countries. The combination of a TTR supply of VTM concentrates and a dedicated steel making facility would enjoy total cost leadership on a worldwide basis. There are a number of possible combinations that TTR could deploy to capture this market.

In the longer term there is potentially a much larger market for VTM concentrates, amounting to few hundred million tons per annum, as dedicated facilities are developed and as existing steel mills start using 'heavy blends' of VTM concentrates (which require some operational adjustments but no substantial investments). This market is very lumpy as each individual blast furnace would require large amounts of VTM product, at least 2-10 Mtpa. As a result this market is only accessible to VTM producers that have a very large mineral resource, in excess of 150 Mt of VTM concentrate.

TTR's key strategic advantage compared to other VTM hopefuls is that TTR has potentially a vast mineral resource that enables steel mills to envisage customized steel making activities (through 'heavy blending' or the development of dedicated facilities) that would have a strong economic edge compared to traditional steel mills sourcing their iron ore supply from the majors (Vale, Rio Tinto and BHP). Additionally the low capital intensity and operating cost of TTR's project is a key strategic proposition to iron ore users. It is critical that TTR leverage this structural advantage when looking for trade sale or funding opportunities.

TTR's 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 5 years as follows and thereafter assuming average head grade of 9.5% based on average of year 8 to 10 ;

Grade 1 Fe Head Grade	12.0%
Grade 2 Fe Head Grade	11.6%
Grade 3 Fe Head Grade	10.3%
Grade 4 Fe Head Grade	10.8%
Grade 5 Fe Head Grade	11.1%
Grade 6 Fe Head Grade	9.5%

- 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;

Year	Fe Yield
Y1	59.17%
Y2	57.58%
Y3	55.78%
Y4	58.57%
Y5	61.46%
Y6	58.92%
Y7	54.69%
Y8	54.53%
Y9	53.59%
Y10	43.80%
Weighted Average	**55.73%**

- 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 250 net operating days or 6,000 hours;
- Crawler dredging capacity of 6,500 tph throughput;
- FPSO requires Dry Docking of 56 days every 5 years for first 15 years, and every 3 years thereafter;
- FPSO is powered by Heavy Fuel Oil (HFO) converted to power cost on kwh per ton of HFO used basis based on estimated conversion factor;

- Power usage based on estimated average power consumption from engineering modelling conducted during pre-feasibility study;
- 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, 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;
- Estimation of other ancillary costs such as anchor support vessel, community development, exploration, environment, etc.

15.3 Operating Costs

The Opex breakdown is set out below:

COSTS	$M											Average
Crawler												
Repairs		6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	
FPSO												
Repairs		14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	14.9	
Labour		14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	
Insurance		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	
Power		38.4	38.3	38.2	38.2	33.4	38.2	38.2	38.2	38.2	33.4	
		70.3	70.2	70.1	70.1	65.3	70.1	70.1	70.1	70.1	65.3	
FSO (Outsourced)		34.4	33.8	32.5	33.1	32.6	32.3	31.7	31.7	31.7	30.7	
Ancillaries Support		5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	
Total Direct Costs		**116.7**	**115.9**	**114.6**	**115.2**	**109.9**	**114.4**	**113.8**	**113.8**	**113.8**	**108.0**	
Others												
Sales G&A		7.8	7.3	6.4	6.8	6.5	6.2	5.8	5.8	5.8	5.1	
Others		2.2	2.1	1.3	1.4	1.4	1.3	1.2	1.4	1.6	1.5	
Marketing		7.5	7.0	6.1	6.6	6.2	6.0	5.6	5.6	5.6	4.9	
Freight		46.6	44.0	30.4	41.0	30.7	37.2	34.8	34.8	34.8	30.4	
Royalty		11.6	9.9	6.3	7.9	6.7	2.7	2.5	3.8	5.5	4.3	
		75.7	70.3	50.5	63.8	51.5	53.4	49.8	51.4	53.2	46.1	
Total Opex per ton (FOB)	$/t	31.26	32.36	35.14	33.64	33.75	35.05	37.07	37.52	38.04	40.69	35.45
Total Opex per ton (CFR)	$/t	41.26	42.36	45.14	43.64	43.75	45.05	47.07	47.52	48.04	50.69	45.45

Table 15-1Opex Breakdown

The Opex per ton is a function of production tons hence the head grade and metallurgical yield variabililty will have significant impact on the unit operating cost. Moreover, the Opex estimation has been calculated taking into account the %Fe content in the iron concentrate in order to be able to make a direct correlation with the sale price defined by the %Fe (dmtu on dry basis). Therefore a direct relation exists between the grade of Fe in the sediment, the metallurgical yield and the unit cost.

As most of the operating cost compoments are largely fixed with minimal variability with increased production, increased crawler and plant throughput can also have a direct positive impact on reducing unit operating cost on a per ton of concentrate basis. The key component of operating costs on the FPSO would be power generation and therefore fuel consumption, which represents approximately 1/3 of the total direct operating costs.

As such, the key to managing opex would be to minimize grade variability and improve crawler/plant throughput. The following have been and will continue to be further considered:

- A mining plan which will take into account of the grade variation of the 3 lips (already planned) in order to minimise the Fe standard deviation of the ROM which will be by definition a guaranty of the iron concentrate quality;
- Further exploration and test work which will drive accuracy of the mining operations;
- Further engineering studies to investigate potential of increasing crawler throughput capacity; and
- Study and planning to achieve operational optimization with the aim to improve mining efficiency and reduce operating hours loss.

15.4 Scenario Analysis

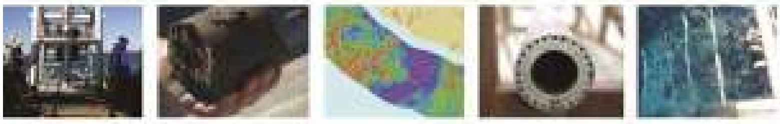
The following operating scenarios and the corresponding key financial parameters have been considered:

	$M NPV	Mt Prod Avc 1st 6 yrs	$M Capex	$/t FOB Opex Avc 1st 6 yrs
1-CRAWLER 6500 tph / 6000 hrs < BASE CASE >	339	4.17	576	33.2
1-CRAWLER 8000 tph / 6000 hrs	582	5.04	576	31.2
1-CRAWLER 8000 tph / 6224 hrs	632	5.21	576	30.9
2-CRAWLER 8000 tph / 6224 hrs	593	5.21	637	30.5

Table 15-2 Operating Scenarios

The financial results of the base case operating scenario of 6,500 tph crawler throughput at 6,000 operating hours has a post-tax project NPV of US$339 million. Higher operating throughput scenario both in terms of crawler throughput and operating efficiency will be considered in the next stage engineering studies, with the aim to achieve higher production rate to maximise designed specification. The higher throughput scenarios are set out above, which has post-tax NPV of US$582 – 632 million.

The sensitivity analysis of the various key parameters of the base case scenario is set out below:



BASE CASE	1-CRAWLER	6500 tph / 6000 hrs	Product Grade 57%

SENSITIVITY ANALYSIS

Iron Ore Benchmark Price ($/t) 62% Fe China CFR			$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	30%	141	823	4.2	576	36.3
	20%	130	681	4.2	576	35.2
	10%	119	509	4.2	576	34.2
BASE CASE		108.5	339	4.2	576	33.2
	-10%	98	176	4.2	576	32.4
	-20%	87	8	4.2	576	31.9
	-30%	76	-173	4.2	576	31.5

Uncommitted Sale Volume: Price Discount (applicable to on-market sale volume)		$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	26%	219	4.2	576	32.6
	24%	249	4.2	576	32.7
	22%	279	4.2	576	32.9
	20%	309	4.2	576	33.0
BASE CASE	18%	339	4.2	576	33.2
	16%	369	4.2	576	33.4
	14%	399	4.2	576	33.6
	12%	428	4.2	576	33.8
	10%	460	4.2	576	34.0

Crawler Throughput (tph) 6500			$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	10%	7150	445	4.6	576	32.1
BASE CASE		6500	339	4.2	576	33.2
	-10%	5850	232	3.8	576	34.7

HFO Price ($/t) 610-608-606 (2016, 2017, 2018 and after)			$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	30%		277	4.2	576	35.7
	20%		298	4.2	576	34.8
	10%		318	4.2	576	34.0
BASE CASE			339	4.2	576	33.2
	-10%		359	4.2	576	32.4
	20%		380	4.2	576	31.6
	30%		400	4.2	576	30.8

Power Usage (MW) 39.4 (average power usage on FPSO)			$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	30%	51.2	277	4.2	576	35.7
	20%	47.3	298	4.2	576	34.8
	10%	43.3	318	4.2	576	34.0
BASE CASE		39.4	339	4.2	576	33.2
	-10%	35.5	359	4.2	576	32.4
	-20%	31.5	380	4.2	576	31.6
	-30%	27.6	400	4.2	576	30.8

Discount Rate
10%

		$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	12%	217	4.2	576	33.2
BASE CASE	**10%**	**339**	**4.2**	**576**	**33.2**
	8%	523	4.2	576	33.2

Capex ($m)
576

		$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	30%	208	4.2	748	32.9
	20%	252	4.2	691	33.0
	10%	296	4.2	633	33.1
BASE CASE		**339**	**4.2**	**576**	**33.2**
	-10%	382	4.2	518	33.4
	-20%	425	4.2	460	33.5
	-30%	467	4.2	403	33.7

Freight Rate ($/t)
10

			$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	30%	13.0	279	4.2	576	32.9
	20%	12.0	299	4.2	576	33.0
	10%	11.0	319	4.2	576	33.1
BASE CASE		**10.0**	**339**	**4.2**	**576**	**33.2**
	-10%	9.0	359	4.2	576	33.4
	-20%	8.0	379	4.2	576	33.5
	-30%	7.0	398	4.2	576	33.6

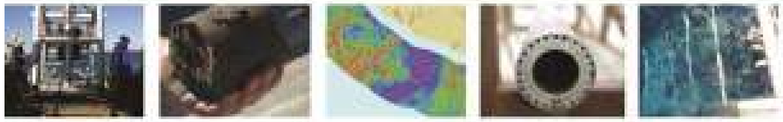
Head Grade
12.0% - 11.6% - 10.3% - 10.8% - 11.1% - 9.5%
(Yr 1-5, and thereafter average of Yr 8-10 grade)

		$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	10%	598	5.5	576	28.3
	5%	463	4.8	576	30.5
BASE CASE		**339**	**4.2**	**576**	**33.2**
	-5%	222	3.6	576	37.1
	-10%	111	3.1	576	42.2

Metallurgical Yield
59.17%-57.58%-55.78%-58.52%-61.46%-55.73%
(Yr 1-5, and thereafter weighted average)

		$M NPV	Ave 1st 5 yrs Mt Prod	$M Capex	Ave 1st 5 yrs $/t FOB Opex
	10%	473	4.6	576	31.3
	5%	406	4.4	576	32.2
BASE CASE		**339**	**4.2**	**576**	**33.2**
	-5%	272	4.0	576	34.3
	-10%	204	3.8	576	35.7

Table 15-3 Sensitivity Analysis



15.5 Project Discounted Cash Flow

DCF Valuation

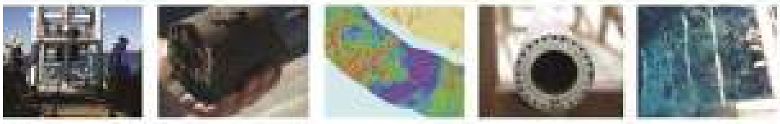
US$m

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
EBIT	-	-	105	89	56	71	61	49	31	73	104
add back depreciation/amortisation	-	-	82	82	82	83	85	86	88	44	12
EBITDA	-	-	187	171	139	154	145	135	119	117	116
less Capital Expenditure	(114)	(462)	-	-	-	(12)	(12)	(12)	(12)	(12)	(12)
Working Capital Movement	-	-	-	-	-	-	-	-	-	-	-
Tax on EBIT	-	-	(29)	(25)	(16)	(20)	(17)	(14)	(9)	(20)	(29)
Free Cash Flow for Enterprise	(114)	(462)	157	146	123	123	117	110	99	85	75
Terminal value											
Year No	1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1	11.1
Discount Factor (Value Date)	0.90	0.82	0.74	0.67	0.61	0.56	0.51	0.46	0.42	0.38	0.35
Present Value	(102)	(377)	117	99	75	69	59	51	41	33	26
Project NPV	338.85										

Year	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	Terminal cash flows
EBIT	82	104	104	104	104	82	104	104	82	104	
add back depreciation/amortisation	12	12	12	12	12	12	12	12	12	12	
EBITDA	93	116	116	116	116	93	116	116	93	116	
less Capital Expenditure	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	(12)	
Working Capital Movement	-	-	-	-	-	-	-	-	-	-	
Tax on EBIT	(23)	(29)	(29)	(29)	(29)	(23)	(29)	(29)	(23)	(29)	
Free Cash Flow for Enterprise	59	75	75	75	75	59	75	75	59	75	75
Terminal value											750
Year No	12.1	13.1	14.1	15.1	16.1	17.1	18.1	19.1	20.1	21.1	
Discount Factor (Value Date)	0.31	0.29	0.26	0.24	0.21	0.20	0.18	0.16	0.15	0.13	0.13
Present Value	18	21	19	18	16	11	13	12	9	10	100

Assumptions

WACC	10.00%	Calculated	10.00%
Terminal growth rate	0.00%	Valuation date	15/5/13



16. RISK & UNCERTAINTIES

In addition to the detailed risks identified on the Project Risk Register, other general risks and uncertainties associated with this project are discussed below.

- 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. A dig – ability test program is proposed for the PFS. There is a risk the estimates used have been aggressive;
- 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 5;
- The project does not get Resource consents, consent are is appealed or the consents are granted with conditions what make the Project uneconomic;
- 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 HFO demand (linked to power demand) and HFO 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.

16.1 Deposit and associated process

The main risks regarding the deposit and the process are:

- Some significant grade (%Fe) variation which increases the yearly ROM requisition, and thus the Opex with an immediate impact on profitability.
- The modification of mineral grain size into the particles which may require a very fine grinding during processing.
- The proposed flow sheet is based on the original Xantia samples; it is therefore necessary to confirm the results by means of pilot plant tests on material from new representative samples collected in the 3 promising (lips) areas.
- A significant upside exists if the full mining plan can be based on high grade material. As the mineralisation is open at depth in most cases, it is reasonable to assume that additional high grade material exists. This would allow for the continued use of only two dredging vessels and substantially reduce the cost base. This upside has not been taken into account at this stage and will be assessed when further deep drilling has been completed.

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	3	1
2 Minor	0	0	2	6	4
3 Moderate	1	1	5	17	9
4 Major	0	0	1	0	1
5 Catastrophic	0	0	1	0	0

Key:

- **Low** (green)
- **Moderate** (yellow)
- **High** (orange)
- **Extreme** (red)

Figure 16-1 Number of Current Risks by Assessment

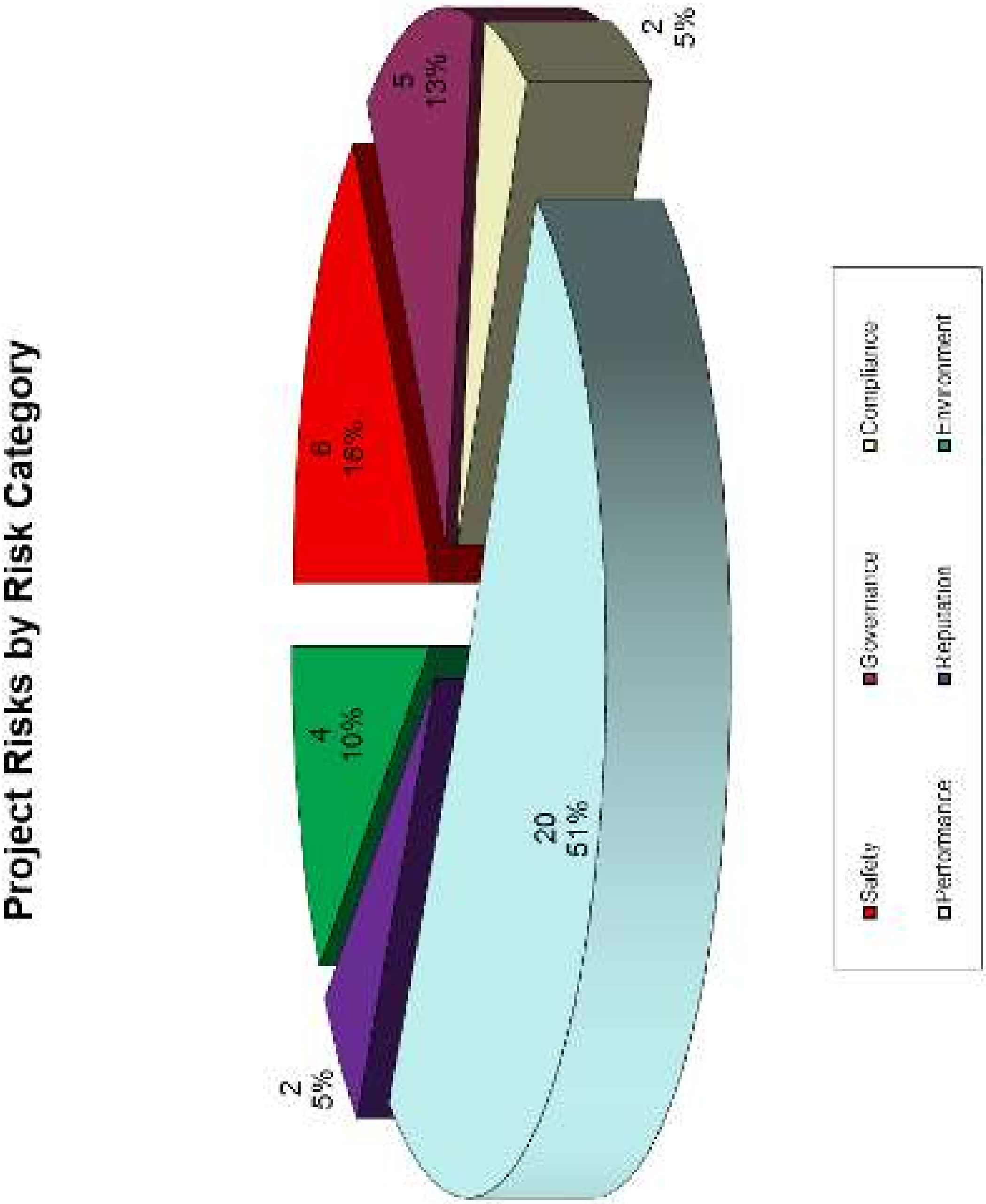


Figure 16-2 Project Risks by Category

Issue	Current Priority	Mitigated Priority
Rewetting of iron sand post the drying step making the product structurally unstable	Extreme	Low
Third party will appeal positive Consent/License award	Extreme	High
Price of iron ore drops significantly - project becomes uneconomic	Extreme	High
Insufficient contingency allowance applied to budget pricing	Extreme	Moderate
Restricted access to NZ ports	Extreme	High
Power required is nominal, BFS estimate has insuffucient allowance for power generation	Extreme	Moderate
Get declined for Environmental Consent or restrictive operational conditions on consents i.e. smaller operation	Extreme	High
Increase in Shipping costs	Extreme	High
Oil spills during transfer at sea	Extreme	High
Insufficient Fresh Water	Extreme	High
Extreme Weather event during Operations	Extreme	High

Table 16-1 Risk Register (Extreme)

17. BASIC SCHEDULE

The basic development schedule for the future stages of the TTR project is proposed in the schedule shown below:

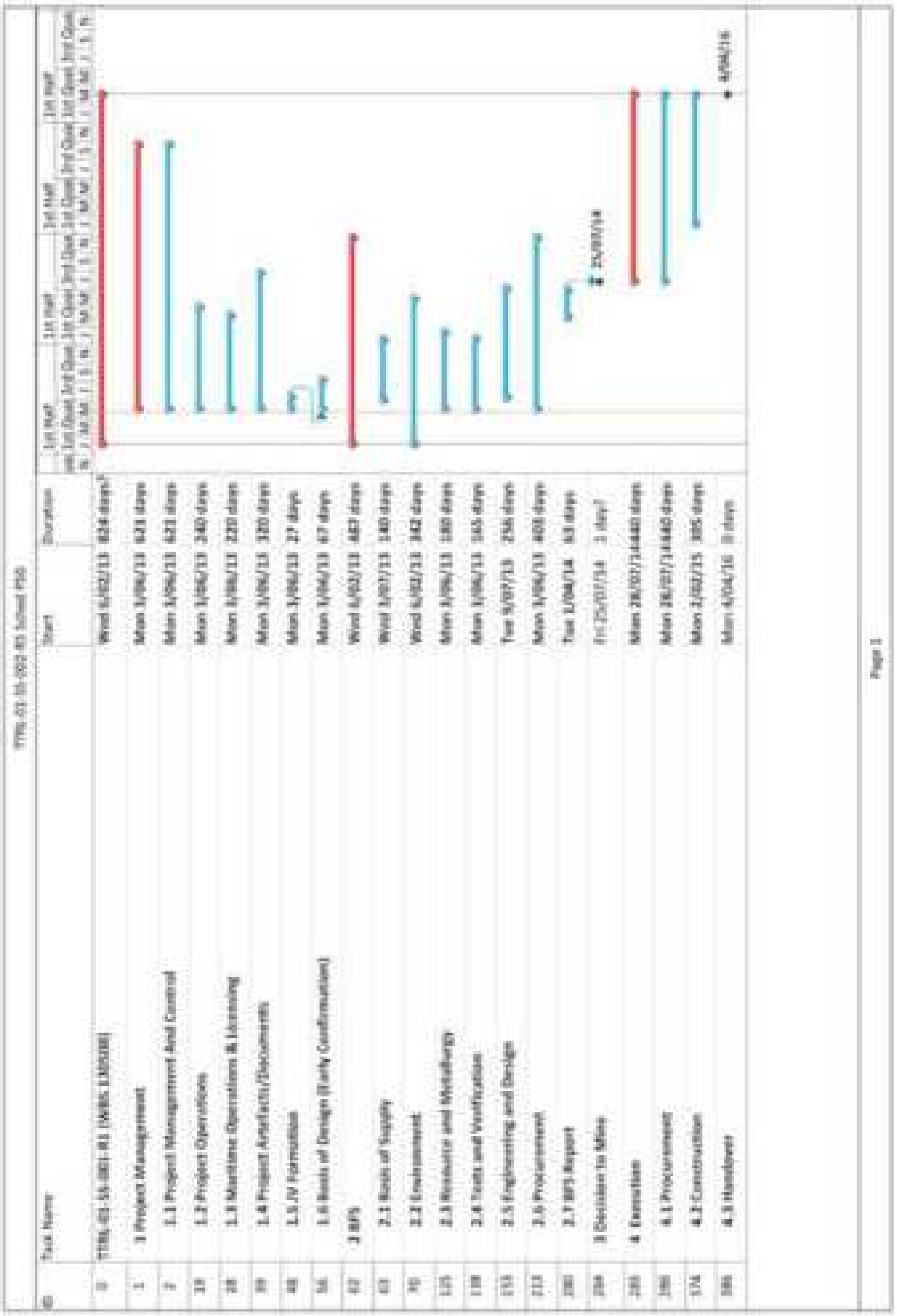


Figure 17-1 Basic Schedule

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
- 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, i.e. "Project Co-ordination by Owners Team", requires a smaller owners team that after the contracting of suitable vendors or in this case a consortium or Joint Venture, will concentrate on the management of the contract and it's deliverables.

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,
- Specialized geotechnical investigations,
- Environmental baseline studies and investigations,

- Possibly metallurgical test-work,
- Detailed engineering design and material take-offs.

TTR will co-ordinate all the geological assessment 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 organisation 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.

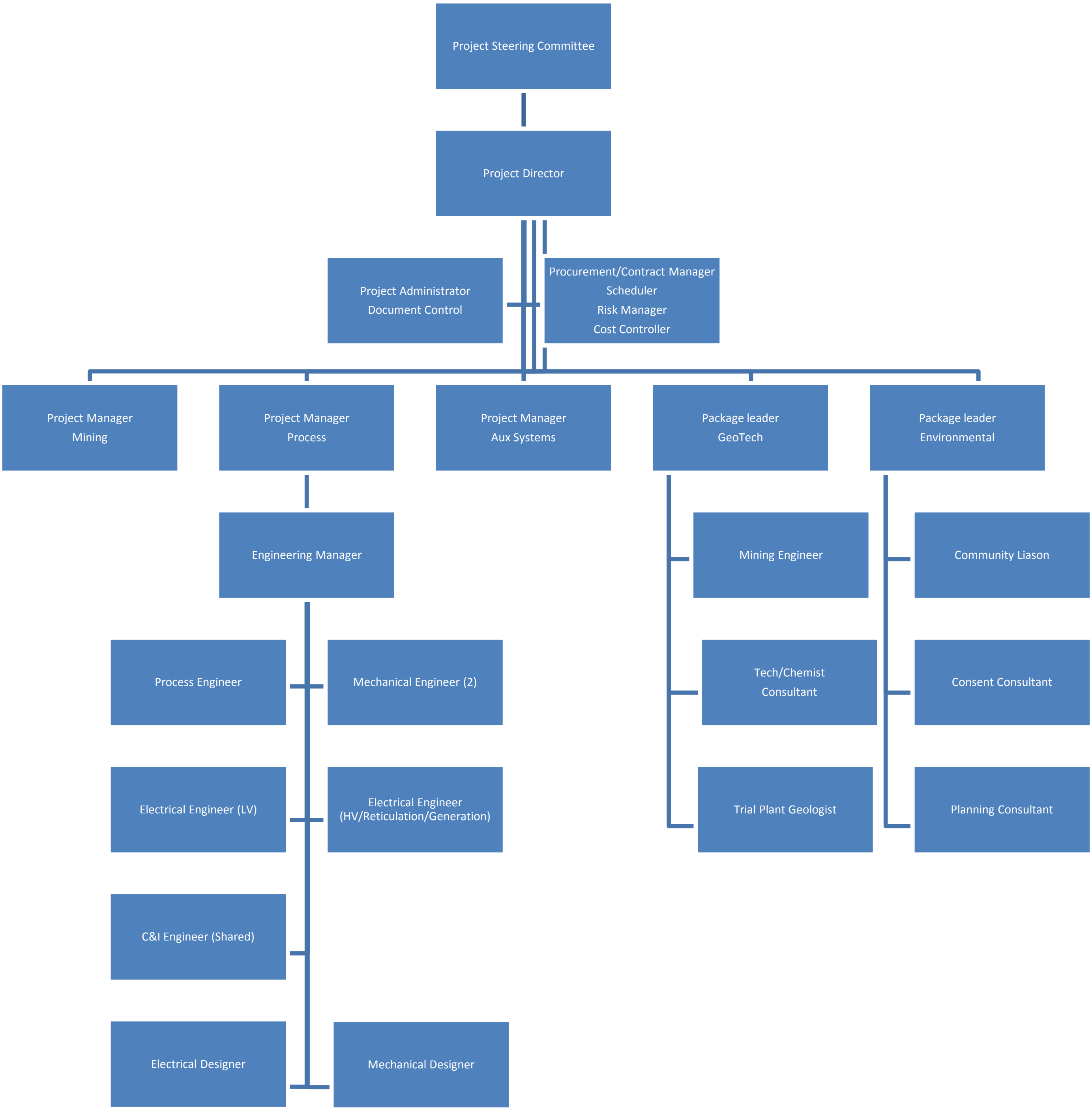


Figure 18-1 Proposed Owners Team Organisation Chart

18.1.2 Project Management by Consultant/PME Contractor

The main consideration for this strategy is the requirement that the independent opinion of a major engineering company will be needed to provide project credibility. In the application of this strategy, TTR will retain the responsibility for “owner's” concerns, i.e. environmental consents, property titles, legal matters, financing arrangements and product marketing.

The appointed Project management and engineering company will act as the “prime contractor”, supervise all the sub-consultants and take responsibility for assembling and preparing the final report, ensuring that schedules and budgets are adhered to. Typically, sub-consultants would be required for the following work:

- Geotechnical studies.
- Ore reserve calculations
- Tailings system design.
- Metallurgical test work

In the application of the second strategy, it is TTR's view that the diverse capabilities required to prepare the BFS describing the management, engineering and construction of the TTR Floating Production Storage and Off-take vessel (FPSO) will require an association of capabilities, formed under the basis of a Joint Venture (JV) (or consortium or association) with the individual entities each providing specialist services.

The ideal joint venture, consortium or association will be one that brings together partners with complementary skills and resources. TTR accept that such complementarity cannot be narrowly confined to complementary technologies of the participants but should also encompass other capabilities that are deemed valuable to all partners, such as experience in operating within JV's, specific market access, etc.

TTR envisions the JV as comprising of a leading Project Management and Engineering (PM&E) partner, mining technology partner and a local constructor each of which will be awarded a reimbursable contract for the completion of the Bankable Feasibility Study (BFS). The PM&E partner will act as the lead on all or some of the JV activities and hold specific responsibility for project management and engineering, with responsibilities for detail design shared with the other joint venture partners.

Project Management & Detail Eng.

- PM Responsibility, Complete or for defined portions;
- Complete JV Engineering Responsibility;
- Co-ordination of the vessel Fit-out/Integration in a TTR defined shipyard;
- Power Generation Specification and Integration into the vessel hull and systems;
- Desalination Specification and Integration into the vessel hull and systems;

- Process Unit Integration into the vessel hull and systems;
- Electrical Reticulation Detail Design & Integration into the vessel hull and systems;
- Control & Instrumentation Detail Design & Integration into the vessel hull and systems;

Construction and Support

- Process Unit Detail Design &Fabrication
- Mining Component Fabrication. TTR envisages that this partner will provide local construction support to the Mining Technology provider.

MINING TECHNOLOGY

- Mining Unit Supply & Integration
- Mooring System Supply & Integration
- Dynamic Positioning System Supply & Integration

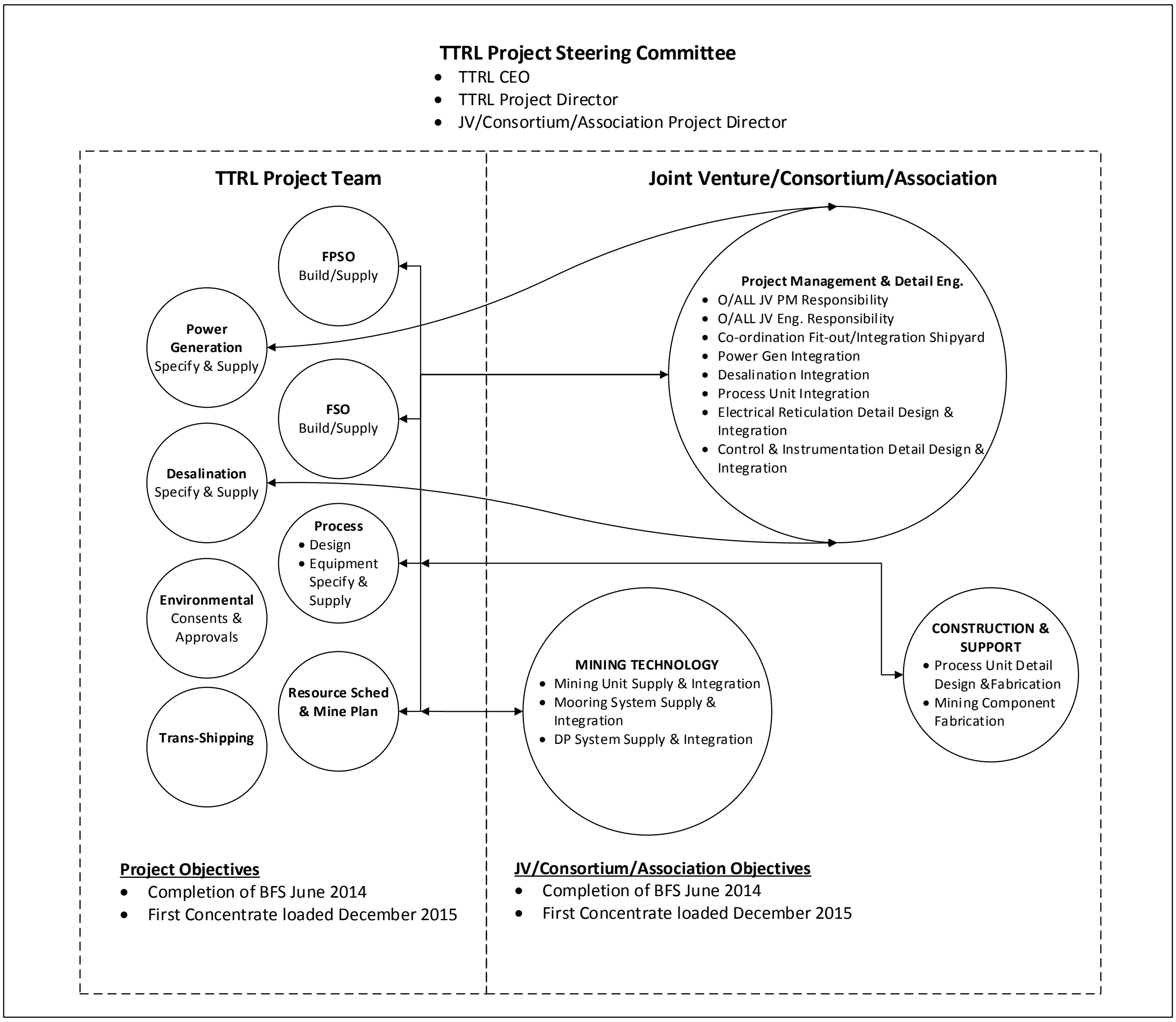


Figure 18-2 BFS Joint Venture/Consortium/Structure

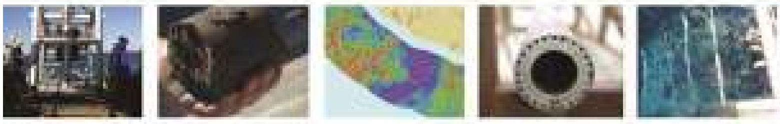
18.2 BFS Capital cost estimate

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 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 favourable submission;



- ensure that rules and procedures adopted do not operate to 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 dependent 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 CEO 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 Confidentiality

Submissions will be required to be submitted in sealed packages and be delivered to TTR by the nominated tender closing date. Specific procedures have been established for this purpose.

18.2.4 Probity

When calling for tenders or expressions of interest, TTR will maintain effective probity of the decision-making and procurement and contracting processes.

Conflicts of interest will be managed and staff associated with potential suppliers will not take part in the decision-making process for that procurement or contract. Members of the TTR selection panel will be required to sign a Declaration of Confidentiality and Interest form prior to assessing the submissions.

18.2.5 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.

18.2.6 Contracting and Procurement Legal Advice/Services

TTR retained counsel and lawyers from Bell Gully will be engaged during the contract formation, tender assessment and contract negotiations stages to provide advice of 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.

18.2.7 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 of 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

In the previous version of the PFS study,Technip recommended the following additional works in order to confirm some of the key assumptions made in the study:

- To improve the knowledge of each prospective mining area via infill-drilling and deep drilling as required.
- To elaborate a robust mining plan which will allow an estimation of the reserves (quantity, quality: associated standard deviation). This mining has to be elaborated with the dredging company in order to take into account of all the technical specificities of the dredger.
- The pre-concentrates and concentrates obtained during the 2012 pilot tests, as well as at least 100kg of sediment should be sent to the main equipment suppliers (magnetic separation, coarse and fine grinding, filtration) in order to:
- Improve the final design (number, size and power requirement) of their equipment, especially for the grinding steps and the filtration units,
- Confirm if an open circuit is enough for the coarse grinding or if a closed circuit has to be installed,

Collect acute engineering data such as:

- Specific gravity, bulk densities per type of material (sediment, pre-concentrate, tailings, concentrate before and after filtration),
- Slopes of material in holds, on conveyors,
- Work indexes (grinding and wear index),
- Grinding media consumptions,
- Filtration index (in ton/h/m^2).

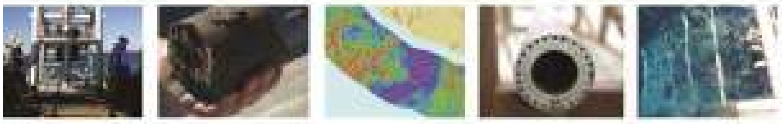
During the pilot plant erection, it will be advisable to repeat the ore characterisation (mainly the size of the mineral grains inside the particles) and to confirm the former best laboratory tests with the same settings.

FMP (Flow Moisture Point) in order to avoid the liquefaction of iron concentrate during the transportation from New Zealand to China.

Fresh Water Supply: A detailed technical and economic analysis of the potential fresh water sources and buffering method shall be performed t determine the most appropriate option.

Vessels Sizing: an independent study focusing on a preliminary feasibility and associated cost of retrofitting a large VLOC to be used as a process plant in stringent met-ocean conditions shall be performed.

Standard Penetration Test (SPT) measurements in mining areas can be scheduled by TTR at a later time, as they will only be required if a deep drill hole reveals the existence of a thick, high grade resource. This may change the economics of a point suction dredge pending SPT results.



19. APPENDICES

19.1 PFS (TECHNIP REVISION) Executive Summary

Technip Mines	**TTR – NEW ZEALAND**	TTR
	PROJECT TANGAROA	

EXECUTIVE SUMMARY

PREFEASIBILITY STUDY ON TTR OFFSHORE IRON SANDS PROJECT TANGAROA

	6 February 2012	PFS	PhE/AM/HCC/ThR	PhG	ThR
	Date	**Designation**	**Writers**	**Checked by**	**PM**

0061	TTR Project – NEW ZEALAND	0061 005
N° study	**Project**	**Report reference**

19.2 PFS Verification Plan

VERIFICATION PLAN

Project Title: TTRL Offshore Project **PFS** | Project Director: Shawn Thompson

Doc Number: TTRL-01-PLN-003 Rev. 1 | Project Stage: PFS

Design Item Description	Designer (Name in Print)	Complexity	Maturity	Consequences	Design Risk	Verification Method Used (see legend below)	Verifier (Name in Print)	Verifier's Signature	Date
PROJECT SCOPE	S.Thompson	0	0	4	4	REVIEW	T. Crossley	Completed	15/5/13
DECISION ANALYSIS MINING TECH.	T.Crossley S.Thompson	1	1	4	6	REVIEW	D.Debney (TW)	Completed	17/5/13
BASIS OF DESIGN	A.Mouton M. Brown	1	1	4	6	REVIEW	S.Thompson	Completed	17/5/13
PROCESS FLOW DIAGRAM (PFS) MASS & WATER BALANCE	A.Mouton	2	3	3	8	SME	BECA (IDEAS)	Completed	17/5/13
PROCESS SCHEMATIC (PFS)	A.Mouton	2	3	3	8	SME	BECA	Completed	17/5/13
PRODUCTION MODULE GA	A.Mouton	1	2	2	5	Senior Eng.	S.Thompson	Completed	17/5/13
SAFETY PLAN (PFS)	S.Thompson R.Thomas	1	2	3	6	CEO	T. Crossley	Completed (Included in PFS)	22/05/13
ENVIRONMENTAL SCHEDULE	A.Sommerville O.Venus	1	2	3	6	SME	BECA	Completed	22/05/13
PROJECT EXECUTION PLAN (PFS)	S.Thompson	1	1	2	4	CEO	T. Crossley	Completed	22/05/13
DYNAMIC MODEL (IDEAS)	CL	2	2	2	6	Senior Eng. BECA	BECA	Completed	23/05/13
GRINDING CIRCUIT REVIEW (XSTRATA)	A.Mouton	1	1	4	6	SME	FLUOR	Completed	23/05/13
TAILINGS STUDY(NEAR FIELD)	A.Sommerville	2	3	3	8	SME	MTI/IHC	Completed	17/5/13

Rev 1 at 4/06/13
Page 1 of 3

VERIFICATION PLAN

Design Item Description	Designer (Name in Print)	Complexity	Maturity	Consequences	Design Risk	Verification Method Used (see legend below)	Verifier (Name in Print)	Verifier's Signature	Date
PROD. MODULE EQUIPMENT LIST	A.Mouton	2	1	3	6	Senior Eng.	S.Thompson	Completed	17/05/13
MAG. SEPERATION CIRCUIT REVIEW	A.Mouton	2	1	3	6	Supplier	Steinert	Completed	17/05/13
POWER GENERATION REQUIREMENT	A.Mouton	2	1	3	6	Senior Eng.	(IDEAS)	Completed	17/05/13
RISK REGISTER	D. Debney	1	1	4	6	Senior Eng.	S.Thompson	Completed	22/05/13
BASIS OF ESTIMATE	D. Debney	2	2	2	6	CFO	A.Stewart	Completed	22/05/13
WBS STRUCTURE	S.Thompson	2	2	2	6	CFO	A.Stewart	Completed	22/05/13
CLASS 3 ESTIMATE	S.Thompson	1	3	4	8	Auditor	PWC	Completed	23/5/13
FINANCIAL MODEL	JUNIPER	1	3	4	8	Auditor	KPMG	Completed	22/05/13
OVERALL SCHEDULE	S.Thompson	2	2	2	6	Senior Eng.	Project Team	Completed	22/5/13
CONSTRUCTION SCHEDULE	S.Thompson	2	2	2	6	Senior Eng.	Project Team	Completed	22/5/13
MINE PLAN	M. Brown/Golders	2	1	4	7	SME		Completed	4/6/13
MINE SCHEDULE	M. Brown/Golders	2	1	4	7	SME		Completed	4/6/13
LOW GRADE RECOVERY	A.Mouton	2	1	3	6	Geologist	M.Brown	Completed	4/6/13

Design Verification Methods: (A) Alternate Calculations; (T) Trials/Tests; (C) Compare with Existing Design; (D) Designed to New Zealand or ISO Standards; (E) Minuted Meeting.

VERIFICATION PLAN

Design Verification Guide For each of the three characteristics listed in the following tables, (a) Design Process Complexity, (b) Design Maturity, (c) Consequence of Design error, the value in the right hand column should be selected from each table that best represents the level of the design. The sum of those three values is then to be called the "Design Risk". This design risk is then used in table (d) Verification Requirement, to establish the most appropriate level of verification.

(a) Design Process Complexity

	Value
Minimal design effort and simple	0
Significant design effort but simple	1
Significant design effort but some complexity	2
Extensive design effort or complex	3
Extensive design effort and complex	4

(b) Design Maturity

	Value
Proven design available	0
Proven design elements for a similar application	1
Modify proven design for different application	2
Redesign existing item for different application	3
New design	4

(c) Likely Consequence of Design Error

Personnel Impact	Environmental Impact	Production or Plant Loss	Value
Minor Injury (eg cuts, bruises, minor burns)	Minor Pollution Brief transient pollution. Not noticeable to the public/media. Not required to inform the EPA. Relatively easy to clean up.	Minor Event Less than $10,000	1
Significant Injury (eg major burns, broken bones, severe bruises, cuts) Gassing causing nausea, headaches.	Significant Pollution Transient release. May attract some public or media attention. Required to inform the EPA. Some clean up costs.	Significant Event Greater than $10,000 Less than $100,000	2
Serious Injury (eg serious burns to large parts of body, major internal injuries, serious skull injuries) Gassing requiring hospitalisation.	Serious Pollution Significant release of pollutants. Attracts public and media attention. High likelihood of EPA fine or court action. Fine ($500). Significant clean up costs.	Serious Event Greater than $100,000 Less than $1,000,000	3

(c) continued

Fatality	Major Environment Event Major release of pollutants. Public and media concern outside local area. Significant costs for PR, courts, EPA, remediation. Fine ($100,000). Company reputation damaged.	Major Event Greater than $1,000,000 Less than $10,000,000	4
Multiple Fatalities	Catastrophic Environmental Event Major environmental damage. Public and media outrage (national coverage). Major costs for PR, courts, EPA, remediation. Fine ($1,000,000). Public pressure to curtail operations.	Catastrophic Event Greater than $10,000,000	5

For each of the three characteristics, the appropriate description and corresponding value should be selected.

Design Risk = value of (a) Design Process Complexity + value of (b) Design Maturity + value of (c) Likely Consequence of Design Error.

The level of experience and the expertise of the person nominated to conduct the design verification is to be appropriate to the assessed Design Risk, in accordance with the table at (d) Verification Requirement below.

(d) Verification Requirement

Design Risk	Verifier Requirement	Minimum Verification Requirement
>6	A suitably experienced qualified engineer who is independent of the design team. SME (Subject Matter Expert)	Prior to commencement of the activity, review of the design approach, criteria and parameters. Upon completion of the activity, separate calculations using an alternative approach where possible, and/or appropriate trials/tests.
4-6	A suitably experienced qualified engineer other than the original designer.	Upon completion of the activity, checking of original calculations, comparison with an existing design, and/or appropriate trials/tests. Calculations checks must include the challenging of loadings and any assumptions made.
1-3	The original design engineer if an independent person is not available.	Upon completion of the activity, design review, and/or appropriate trials/tests.

Note that the above table contains the minimum requirements, and that more rigorous verification may be applied when deemed necessary.

19.3 Curriculum Vitae

19.3.1 Tim Crossley, CEO TTR

B.AppSc (Hons) Dip.AiCD

Former COO of Gloucester Coal, an ASX listed diversified coal company producing around 5 Mtpa of coal.

Was the President and Chief Operating Officer with BHP Billiton's West Australian iron ore business and previously held senior positions in BHP Billiton's manganese and metallurgical coal divisions.

Has extensive experience in the carbon steel raw materials sectors where he has managed large complex operations with sensitive environmental requirements.

19.3.2 Andrew Stewart, CFO TTR

MBA, BCA, CA (ICANZ)

Brings over 20 years of experience in senior management roles in petroleum exploration and production, aviation and fund management

Was Chief Financial Officer with New Zealand Oil & Gas Limited where he contributed to the growth of the company through the development of Tui oil, Kupe gas and the IPO of Pike River Coal Limited.

19.3.3 Shawn Thompson, Project Director TTR

I.Eng, MSc, MIMechE, MIED, MASME

A professional Engineer and Project Manager with sound design, manufacturing and proven project management and leadership experience, all associated with the improvement, development and installation of major process plant.

Extensive project experience gained in the heavy industrial and mining industries with a wide international experience focused on project delivery throughout the entire project life cycle from the concept, pre-feasibility, feasibility and execution phases of major projects, managing projects through each of the required process toll gates

Experienced in managing and leading multi-disciplinary project teams in the engineering, procurement, construction and commissioning phases of various projects in South Africa, Saudi Arabia and New Zealand all which have been completed with excellent safety records .

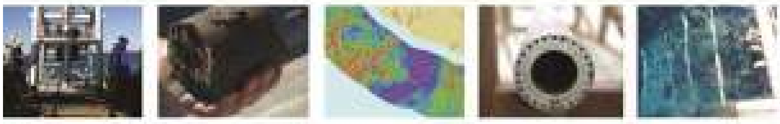
EMPLOYMENT HISTORY

TTR., Project Director

PERIOD: April 2012 TO Present

Engaged as the Project Director tasked delivering the Offshore Project within schedule and budget.

Transfield Worley Ltd., Divisional Manager Auckland



PERIOD: Jun 2012 TO April 2012

Tasked with building a known and trusted industrial service organisation that consistently delivers positive results ensuring that TW and especially the Auckland Division was synonymous with Innovation, Expertise, Experience and Efficiency.

Senior Project Manager

As a senior member within the Auckland regional office, Shawn was been tasked with leading the Mining and Metals service offering as well as being the Regional Project Management Lead.

Feb 2009 – Apr 2010 United Group Ltd, Senior Project Manager

Managed major capital projects (+$50 million) including the alliance of strategic partners tasked with increasing the capacity at the Owens Illinois Plant in NZ.

Apr 2005 - Feb 2009 Beca Carter Hollings & Ferner Ltd

Taharoa Mine Manager

Responsible for 50 staff comprising the Production, Technical, Maintenance, Administration functions as well as the project team, who were working to implement the “Taharoa 2010” project.

Managed the mine through a controversial sale process.

Project Manager

The "Taharoa 2010" project involved increasing the current capacity of the operation, by implementing a “Dry Mining” concept, from 1 Million tons of Primary Concentrate to 2.7million tons of fully beneficiated product with an increased Fe content of 59.5%.

Engineering Manager

Involved leading an engineering team of 15 engineers and support staff, initially preparing and submitting the Pre-Feasibility study and then the ensuing Feasibility study.

EPCM Leader/Project Manager, New Zealand Steel, Glenbrook.

Worked on various maintenance and capital projects

Appointed Project Director responsible for a group of projects and associated Project Managers, basically ensuring that good project governance was undertaken at all stages within the project’s lifecycle and that all possible risks had been identified, rated and where required, mitigation had been implemented

19.3.4 Matt Brown, Exploration Manager TTR

MSc (Geology), PGDip (Bus) MAusIMM

Over 10 years experience in the coal and industrial metals industry

Experience in offshore iron-sand exploration

Key government experience as Manager of The Ministry of Economic Development's Crown minerals department (now New Zealand Petroleum and Minerals, part of the Ministry of Business, Innovation & Employment)

19.3.5 Andy Sommerville, Environmental and Approvals Manager TTR

B.Eng

Mechanical Engineer with 17 years experience related to gaining and managing resource consents under the Resource Management Act (RMA);

Was Senior Environmental Advisor at Contact Energy Limited, and prior to this he was based for 16 years in New Plymouth working for ECNZ at the New Plymouth Power Station;

Provided input into the original Resource Management Bill in 1989, and contributed to the development of RMA policy.

19.3.6 Rhys Thomas, Offshore Operations Manager TTR

B.Acc (Hons)

Qualified commercial diver with over five years experience in New Zealand waters on a variety of different projects. Brings a unique skill set which enables him to plan, manage and actively participate in all marine operations, new build projects, and sample control and analysis. Rhys is tasked with:

- Managing the development of new drilling technology and successfully implementing into the field;
- Planning large offshore drilling campaigns utilising in-house expertise mixed with relevant qualified contractors, an emphasis was placed on safety, results & budget control;
- Designing and managing the sample preparation process, monitoring results; building working relationships with contractors;
- Developing and integrating a new Health & Safety system throughout the company

19.3.7 Andre Mouton, Process Metallurgist TTR,

CONSULTING METALLURGIST

QUALIFICATIONS: Bachelor of Engineering (Metallurgy), University of Pretoria, South Africa, 1992

EXPERIENCE:

Oct 2010 - Present PYROMET CONSULTING PTY LTD, PERTH *(Private Metallurgical Consultancy)*

DIRECTOR AND PRINCIPAL CONSULTANT

Apr 2000 – Sep 2010 PROMET ENGINEERS PTY LTD, PERTH *(An Engineering Consulting Firm Specialising in Magnetite Ore Processing)*

PRINCIPAL PROCESS ENGINEER

Oct 1995 – Nov 1999 COLUMBUS STAINLESS, MIDDELBURG, RSA *(A Mid-sized. Stainless Steel Producer with 1800 Employees)*

PROCESS METALLURGIST

Dec 1991 – Oct 1995 ISCOR, PRETORIA WORKS, RSA *(A 560,000 tpa mild steel producer with 2000 employees.)*

METALLURGICAL ENGINEER, SLAB TECHNOLOGY

19.3.8 Dr. John Feenan, Director IHC Mining,

PhD, MSc, BSc (Hons), Dip. Applied Finance

Director, Mining Advisory Services Asia Pacific September 2012 – Present

IHC Mining (www.ihcmerwede.com)

Dr.John Feenan Leads IHC Mining's consulting and advisory services business in the Asia-Pacific. IHC's Mining Advisory Service supports existing and new miners to develop successful technical solutions and business investments in the marine and dredge mining sector.

Consultant March 2009 – August 2012

JPF Global Pty Ltd (Personal consulting company) Sydney

Chief Operating Officer May 2005 - February 2009

NEPTUNE MINERALS Plc Sydney (www.neptuneminerals.com)

Managing Consultant Australasia March 2003 - April 2005

WOOD MACKENZIE Sydney (www.woodmacresearch.com)

Commercial Manager January 2001 - January 2003

WOODSIDE Melbourne (www.woodside.com.au)

Senior Business Analyst October 1994 - March 1998

WOODSIDE (North West Shelf Venture) Perth (www.woodside.com.au)

Senior Geologist & Business Analyst November 1992 - October 1994

WOODSIDE Perth (www.woodside.com.au)

Exploration Consultant July - October 1992

COMMAND PETROLEUM Sydney

Oil & Gas Broking Analyst February - May 1992

MACQUARIE BANK EQUITIES RESEARCH Sydney (www.macquarie.com.au)

Exploration Geologist November 1989 - December 1991

AMOCO (UK) EXPLORATION London

Exploration Geologist February 1985 - September 1988

19.3.9 Laurens de Jonge, Manager IHC Mining,

Manager Design and Estimating – Deep Sea Mining

Education and training:

1983 - 1989 : VWO, Stedelijk Gymnasium Nijmegen

1991 - 1999 : Master of Science in Mechanical Engineering, Technical University Delft

Affiliations:

- KIVI-Niria - Royal Institute of Engineers

Employment:

- IHC Merwede - IHC Mining BV 2008 – 2012, Manager Design and Estimating – Deep Sea Mining
- IHC Merwede - IHC Dredgers BV 2005 – 2008, Lead Engineer for Dredge Components
- IHC Merwede - IHC Parts & Services BV 2004 – 2005, Manager Workshop and Services
- IHC Merwede – MTI BV 2002 – 2004, Research Engineer – Project Manager
- NAMCO – Namibian Minerals Corporation – Offhsore Diamond Mining 2000 – 2002, Mechanic – Crawler Operator
- Technical University Delft 1999 – 2000, Researcher

19.3.10 Ross Ballantyne,Manager Naval Architect Sea Transport,

Summary of Qualifications and Achievements

- Master Class 5 Unrestricted (Skippers Ticket) : June 2010
- MED 3 Unrestricted (Marine Engine Driver Ticket): June 2010
- STCW95 – Australian Maritime College: August '09
- B Eng (Honours) Naval Architecture - Australian Maritime College: Feb '02 - Nov '05
- Coxswains Training Course - Cairns, QLD Jan '04
- Senior First Aid Certificate and Shipboard Safety - TAFE Brisbane, QLD Feb '05
- Advanced Fire Fighting - Consolidated Training Systems, Inc. (DNV Certified Firm)

Papers/Presentations

- Co-Author of RINA Technical Note. Trans RINA, Vol 154, Part A2, Intl J Maritime Eng, Apr-Jun 2012. "AN EXPERIMENTAL STUDY ON THE RELATIVE MOTIONS BETWEEN A FLOATING HARBOUR TRANSHIPPER AND A FEEDER VESSEL IN REGULAR WAVES"
- The Royal Institution of Naval Architects (RINA) Paper & Presentation at Military Support Ships Conference (London, U.K) 13th to 14th November 2007 - "Stern Landing Vessels"
- RINA Technical Meeting Presentation (QLD, Australia Division) September 2006 – "Design Optimisation and Hull Development"

Research Area

Supervisor of research & development at STS, with testing conducted at the Australian Maritime College Ship Hydrodynamic Research Centre (AMCSHRC), Launceston, Tasmania Australia.

- Motion studies of transhipping for patented Floating Harbour Transhipper (FHT)
- Shallow Water/Hydrodynamic Lift Analysis of Sub-critical/Trans-critical & Super-Critical speeds in varying Froude Depth numbers for a 41m high speed semi-SWATH
- Seakeeping motion reduction tests using a systematic series of Bow forms for a 68m RoPax Catamaran including initial hull design.
- Research & Development of a patented 3-axis tugboat/barge coupling system for a 35m Ocean Going Pusher Catamaran Tugboat
- LCB & LCF Separation/ Longitudinal Pitch Gyradius/ Above Hull Flare optimisation for reducing pitch & heave RAO's & vertical accelerations for a 17m Semi-SWATH.

Professional Memberships

Associate Member - Royal Institution of Naval Architects

Education

B Eng (Honours) Naval Architecture - Australian Maritime College, Newnham, TAS, Australia.

19.3.11 Albert Sedlmeyer, Senior Naval Architect Sea Transport

Career Summary	Designing commercial ships, Australia, 1992 to now. Designing commercial and pleasure yachts, New Zealand, 1975-1992. Designing commercial buildings, Germany, 1965-1975. Cabinetmaker apprenticeship, Germany, 1962-1965
Qualifications	Practical career path through ownership of a Marine Design Consultancy 1978-1992 B.A. (Theology), Major in Relationships, 1992 Kaiser Schule, Architectural Draughting, 1967
Professional Membership	Member of The Society of Naval Architecture and Marine Engineers, 1980 to present Member of the Australian Society of Authors, 2009 to present Member of the professional committee of The Naval Architecture Society (New Zealand), 1987-1992 Founding Co-director of the Maritime Referral Group Ltd, 1990-1992
Professional Experience	Sedlmayer Associates Pty Ltd, Director, Naval architect, 2012 to present: Under contract to Sea Transport Solutions Pty Ltd, for commercial vessel design Developing super-yacht design concepts Sea Transport Corporation Pty Ltd, Senior Naval Architect, 1992 to 2012:

Designing a variety of commercial ships, particularly catamaran ROPAX ferries, stern landing vessels and Self-discharging bulkers among other.

Innovative design solutions of on-board materials handling, deep sea mining operations, lifting vehicle-decks and ramps, tug-barge couplings and efficient hull shapes and ship structures

Sedlmayer Associates (NZ), Principal Partner, 1978 to 1992:

Running my own consultancy, designing pleasure and commercial, mono and multihull power and sailing yachts in wood, fibreglass, steel and alloy

Jim Young Marine Ltd. Draughtsman, Boat builder 1975-1978

General boatbuilding of wood and fibreglass, racing and pleasure yachts and power cruisers

Project Achievements	Lead Naval Architect on 110m 'WUNMA' and 80m 'ABURRI' self-discharging bulker design projects in Australia Developed the design of a 42m sail-training Barquentine in Australia Developed low-drag, easy-build catamaran hull shapes in Australia and New Zealand Pioneered CAD/CAM applications in small-craft design and manufacture in New Zealand

19.3.12 Dave Debney, Capital Risk Specialist Transfield Worley,

Experience in strategic business planning, leadership, team mentoring and moderation of business processes. Successful in the development of business processes, delivery of business requirements and growth of operational capability.

AREAS OF EXPERTISE

- Financial reporting capabilities.
- Project and engineering management and a good understanding of business unit management.

- Mentoring of project managers and development of manpower resource management practices.

QUALIFICATIONS

- Master of Business Administration, University of Auckland
- Graduate Diploma in Business (Engineering Management), University of Auckland
- NZCE (Electronics and Computer Technology), Auckland Institute of Technology

PROFESSIONAL AFFILIATIONS

- New Zealand Society of Risk Management,
- Australia and NZ Institute of Insurance and Finance,
- Scrum Alliance

EXPERIENCE

May 2012 – Present Transfield Worley Limited

Project Manager (Capital Risk) and Project Controls Manager

Feb 2011 – May 2012 Transfield Worley Limited

Contracts Manager, Refining NZ

May 2007 – Feb 2011 Vero Insurance

Project Manager

May 2006 – May 2007 Otis Elevator Company Ltd

Construction Manager

Feb 2004 – May 2006 Fuelquip Limited

Projects and Installation Manager

Jun 2002 – Feb 2004 Glidepath Limited

Project Manager

Apr 2000 – Jun 2002 Fleet Engineering Centre, Royal New Zealand Navy

Project Officer

Apr 1999 – Apr 2000 United Nations Truce Supervision Organisation

Jan 1992 – June 2002 Royal New Zealand Navy

Weapon Engineer Officer

19.3.13 Mahesh Khupse, TTR Project Research Assistant

MEng PM, BEng

May 2013 – Present TTR

Dec 2012 – Jan 2013: Summer Intern at Core Builders and Composites, NZ

Jun – July 2012: Project Intern at Transfield Worley Limited, NZ

Sep 2012 – May 2013: Brand Ambassador at Auckland Transport, NZ

19.3.14 Chris Lee, Senior Process Engineer Beca,

BE (Hons) (Chemical) (Cant)

Dip AppSci (Computer Science) VUW

New Zealand Dairy Research Institute Graduate Training Programme

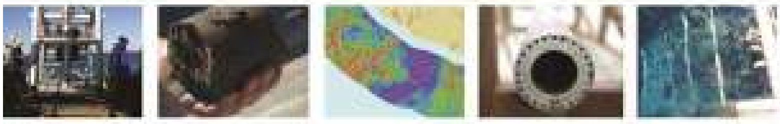
Industry experience or exposure in:

- Pulp and paper
- Industrial chemicals
- Dairy products
- Brewing
- Meat products
- Pip fruit packing
- Ethical pharmaceuticals
- Seed cleaning (papaver somniferum)
- Oilsands mining
- Utilities upgrades in dairy, pulp and paper, pharmaceuticals, mining, and nickel smelter operations

Experience – Information Technology and Software

- Process simulations using IDEAS™ and Extend™:
- Dynamic simulation of spill options for sewage digester overflows
- Groundwood Mill mass balance
- Screen room mass balance
- Digester “multistage” washing simulation
- Steady state simulations for various water reticulation networks and steam reticulation options
- Steady state simulations for various processes including pulp drying, press washing, and screening
- Maintenance and redevelopment of software for brewery simulation

- IDEASTM training
- ExtendTM programming for brewery modelling
- High fidelity process modelling of a pulp dryer’s white water system
- “Macro” model for a mill wide water system.



19.3.15 Thierry Rousseau, Technip

Thierry ROUSSEAU

Chief Engineer / Projects Director

January 2010
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Born	1963
Nationality	French
Education	Graduate geologist engineer from « Ecole Nationale Supérieure de Géologie » in Nancy, France 1988 DESS – Option Valorisation des Ressources du sous-sol
Languages	French, English

PROFILE

More than 20 years of experience in mining engineering projects (geology and process) and mining operation (open pit and beneficiation plant).

Audits: technical and financial audits of various mining projects

Engineering: for both existing and new mining projects (coal, iron ore, lime stone, phosphate, uranium, …)

Mining operation: full responsibility of mine site operation and management

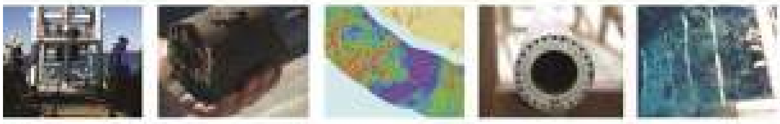
EXPERIENCE SUMMARY

In charge of geological and mining operation feasibility studies, development studies for existing and new deposits and technical/financial audit of mining sites as well.

For new mining projects, Project Manager in charge of ore and mine optimisation and development, ore preparation and transport for all mining facilities studies both at pre-feasibility and feasibility stages.

As a Project Manager for an international arbitration regarding an iron ore mining project in West Africa with the responsibility of ensuring the technical and financial audit of the feasibility study carried out (technical, financial and market) and preparing all the files for a lawyer firm (defendant).

Technip



19.3.16 Henry Caudron de Coquereaumont

Henri CAUDRON de COQUEREAUMONT

Project Manager

Février 2010
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Born	1949
Nationality	French
Education	Graduate Engineer of the Ecole Nationale Supérieure de Géologie Appliquée et de Prospection Minière de Nancy, France with specialization in mining and beneficiation
Languages	French, English

PROFILE

Thirty five years experience across mining, beneficiation or process design as process engineer, production engineer or project manager.

Basically geological engineer (mining and beneficiation, with experience in open pit mining, and a main experience in lead-zinc, manganese, iron and phosphate beneficiation.

EXPERIENCE SUMMARY

Major assignment during the last decade were :

- Project manager for the extension of an Iranian Iron Mine : crushing 12 Mt/year design of a new line 2 Mt/year,
- Project engineer for studies, erection and commissioning of a phosphate beneficiation plant (in Syria), revamping of a phosphate beneficiation plant in Jordan.

WORK HISTORY WITH SOFREMINES / TECHNIP MINES (SINCE1981)

<u>HEAD OF MINERAL PROCESSING ENGINEERING DEPARTMENT</u> (SINCE 1999)

19.3.17 Jean Pascal Biaggi

TECHNIP Subsea Innovation Management
PROFESSIONAL RESUME

Technip

Name:	Jean-Pascal Biaggi
Position:	Vice President, T-SIM
Date of Birth:	16 October 1951
Nationality:	French
Qualifications:	Ecole Nationale Supérieure de Techniques Avancées (ENSTA) - Paris Institut d'Administration des Entreprises (MBA) – IAE - Paris

Summary of Experience:

Jean-Pascal Biaggi has thirty years international experience in the energy field and more particularly in the oil and gas industry.

He worked as engineer, senior offshore engineer and project manager for subsea pipelines development projects and operation in the North Sea. This experience was complemented by involvement in conceptual engineering for field development projects on a world wide basis. Jean-Pascal then spent ten years in the LNG industry as managing director of a leading gas naval engineering company specialised in containment systems for LNG storage and maritime transportation.

In addition to business unit management skills, other specific areas of expertise include :

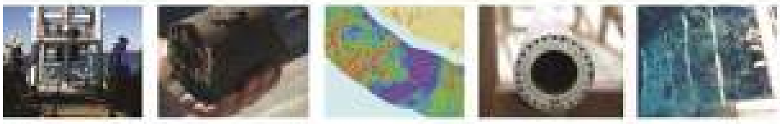
- subsea pipelines design, construction and operations
- LNG carriers design, building and operations
- floating LNG facilities (FPSO/FSRU) feasibility studies
- natural gas market and LNG trades
- project management
- economic analyses and market surveys, business development
- relationships with Authorities and Classification Societies

Jean-Pascal joined the Technip-Coflexip Group (CSO Branch) in June 2001 to set up and develop the French branch of Genesis in Paris.

Details of Experience:

TECHNIP — **APRIL2011 – PRESENT**

Creation, development and management of the new Subsea Innovation Management Department within the Technip Group Headquarters in Paris



19.3.18 Antoine Marret

TECHNIP Subsea Innovation Management
PROFESSIONAL RESUME

Name:	Marret Antoine
Position:	Subsea Project Engineer
Date of Birth:	20 October 1984
Nationality:	French
Qualifications:	Université de Technologie de Compiègne (UTC) - Compiègne Cranfield University – Cranfield, UK

Summary of Experience:

Antoine Marret has nearly five years experience in the energy field and more particularly in the oil and gas industry.

He worked as mechanical engineer and project engineer for subsea pipelines development projects and operation in the Oil & Gas industry, including Liquefied Natural Gas. This experience was complemented by involvement in conceptual engineering for field development projects on a world wide basis but also in the renewable energies area.

In addition to project management skills, other specific areas of expertise include :

- subsea pipelines design, construction and operation
- subsea and offshore structures design and installation
- riser design, configuration and installation
- design and installation of offshore renewable energy devices
- dredging operations

Antoine joined the Technip Group in September 2008 to work as Project Engineer.

Details of Experience:

TECHNIP – PROJECT ENGINEER — **SEPTEMBER 2008 – PRESENT**

Involvement in the development and promotion of the Technip's Cryogenic Pipe-in-Pipe for Liquefied Natural Gas transportation, including:

- welding and repair procedures development and qualification
- Non Destructive Examination procedures development and qualification
- monitoring philosophy by fibre optics development
- realisation of feasibility study including thermal and mechanical design of the lines, fabrication and installation methodologies assessment, cost estimate for different Clients such as Total, Woodside Ltd, Bechtel/Brass consortium, Rabaska consortium

Involvement in the bid submission for two Invitations To Tender for Cryogenic Pipe-in-Pipe projects (Brass LNG and Gate LNG) as a project engineer.

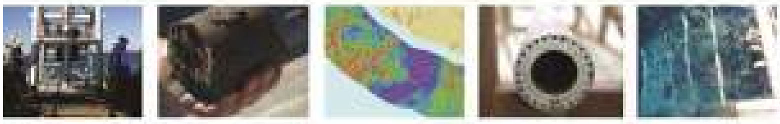
Involvement in the development and promotion of the Technip's Electrically Trace Heated Pipe-in-Pipe, including:

- heat trace cables suppliers screening and audit
- mechanical, electrical and thermal design of the lines
- realisation of feasibility study including thermal, electrical and mechanical design of the lines, fabrication and installation methodologies assessment, cost estimate for different Clients.

Project Manager on a Feasibility Study for the implementation of the ETH-PiP technology on a marginal Field in the Pre-Salt area (Brazil) – Client: Repsol Sinopec Brazil

CRANFIELD UNIVERSITY - THESIS — **FEBRUARY 2008 – JULY 2008**

Development and realisation of procedures for testing and qualifying an offshore renewable energy device, including a reliability and risk analysis.



19.3.19 Philippe Espinasse

TECHNIP Subsea Innovation Management
PROFESSIONAL RESUME

Technip

Name:	**Philippe Espinasse**
Position:	**Deputy General Manager, T-SIM**
Date of Birth:	**September 19th 1964**
Nationality:	**French**
Qualifications:	**Mechanical Engineer , E.N.I. Metz**
	Bilingual French/English, Fluent Portuguese

Summary of Experience:

Philippe Espinasse has thirty years experience in deep water offshore projects, including offshore operations, flexible pipe and umbilical design and manufacturing as well as research and development work for the oil and gas offshore industry. He has lived and worked extensively overseas in Brazil and the USA. He has worked on all phases of design developments, from conceptual studies through to offshore installation and commissioning.

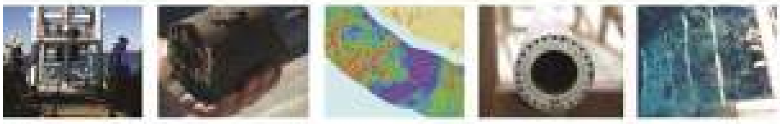
He holds 30 patents covering flexible pipe design and components, manufacturing processes as well as installation methods for both steel and flexible pipe (equipment and riser configurations), LNG platforms, FPSO turrets, offloading and export systems, subsea mining equipment and layouts.

From April 2011, Philippe has transferred to the newly created Subsea Innovation Group as Deputy Manager, responsible for the subsea engineering and innovation function (UFL/SPS).

Details of Experience:

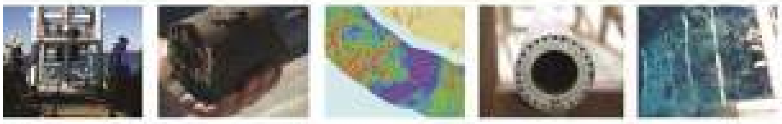
TECHNIP — **APRIL2011 – PRESENT**

- Subsea and Substructures Manager in charge of a conceptual and engineering studies Group for subsea development projects :
- Development of a novel side by side liquefied gas offloading system for FLNGs
- In charge of the R&D effort on subsea mining applications
- Author of OTC paper **22704**: **The Spiral Stack Turret, an Enabling Technology for High Volume, High Pressure Field** Developments with FPSOs (2011)

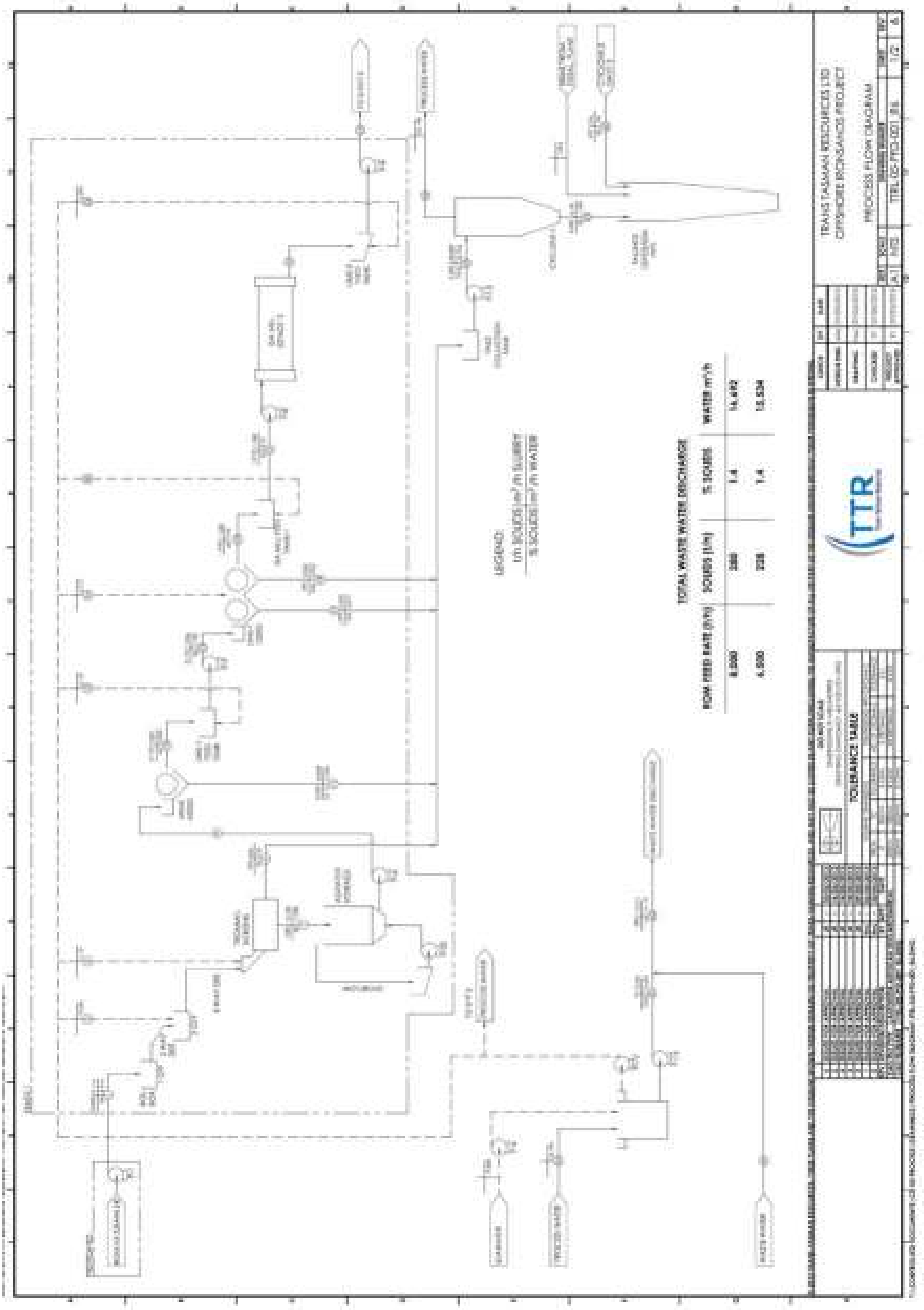


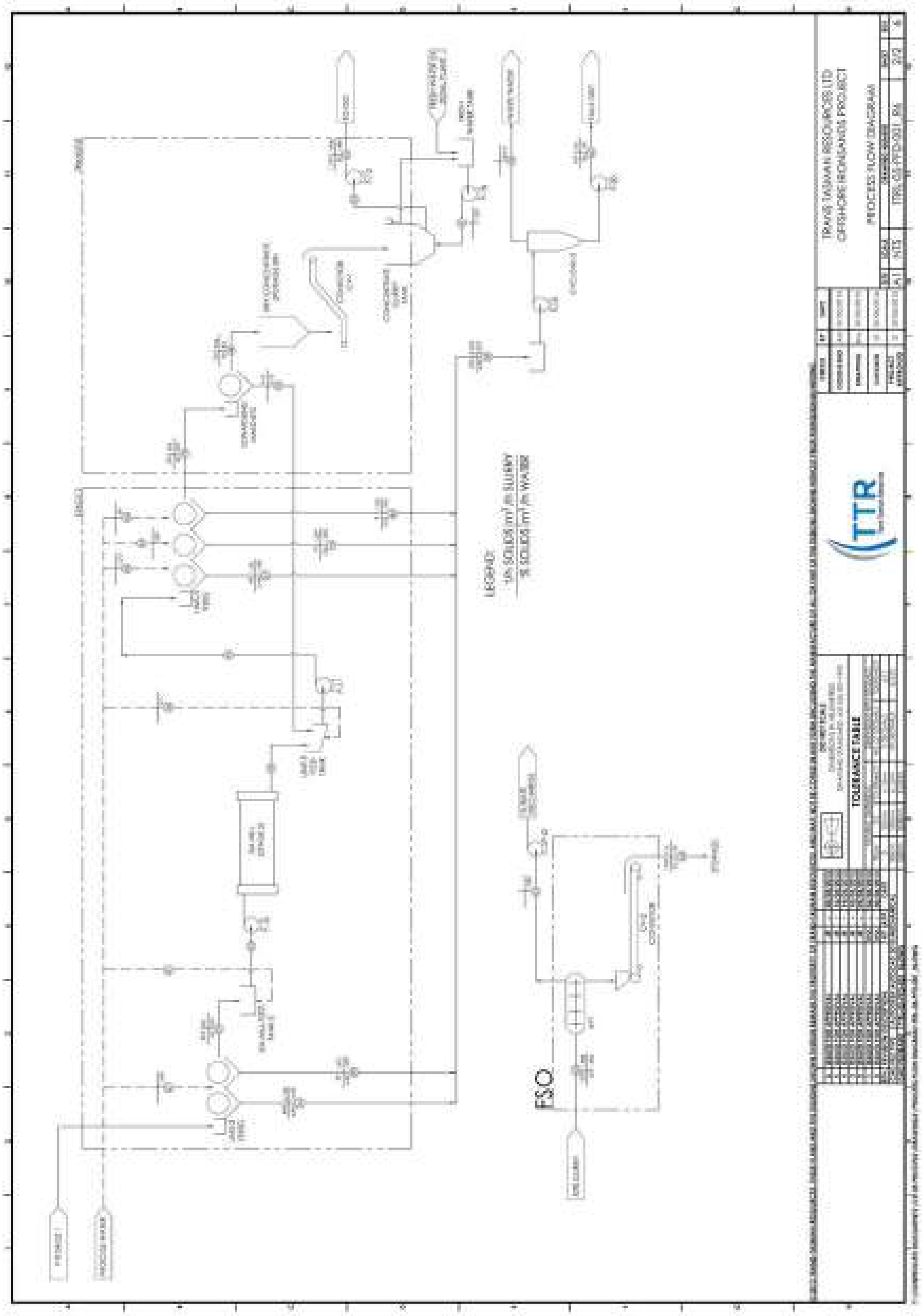
19.4 Basis of Design: Single Crawler 6000 tph

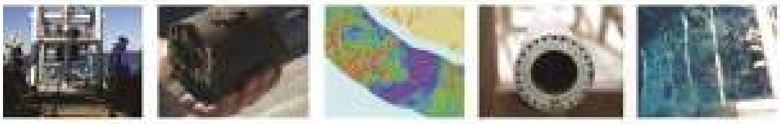
Item	Unit of Measure	Value	Reference	Comment
1. Overview				
ROM slurry density	vol.%	30	IHC	
Slurry volume mined	m3/h	11,300	IHC	
Solids density in situ	t/m³	2.35	2	
ROM Feed	t/h (db)	7,967	3	
	t/a	47,801,723	5	
Product %Fe	%	57.0	4	
Process plant weight recovery	%	9.8%	2	
VTM Concentrate Production	t/h	780.7	3	
VTM Concentrate Production	t/a	4,684,569	3	
2. Operating Schedule				
Annual operating days	d/y	365	4	
Daily operating hours	h/d	24	4	
Dry docking	d/y	12	4	Dry docking 60d per 2 years
Refuel	d/y	5	4	IHC
Anchor spread	d/y	0	4	IHC
Maintenance	d/y	12	4	IHC
Days lost		29		
FPSO Availability	%	92%	3	
Mining efficiency	%	88%	4	Adjust to reach 6000 h/a
Weather uptime	%	85%	4	
Total operational Availability	%	68.5%	3	
Operating time	h/y	6,000	3	
3. Ore Characteristics				
+2mm fraction	%	4.0	2	
-63µm fraction	%	0.6	4	
Concentrate specific gravity	t/m³	4.75	2	
Feed specific gravity	t/m³	3.2	2	
Water Density	t/m³	1.03	4	
Ore in situ density (wet)	t/m³	2.35	4	
Feed sizing				
Wt Distribution (µm)				
2000	%	4	2	
1000	%	1.1	2	
710	%	1.4	2	
500	%	3.9	2	
355	%	7.8	2	
250	%	21.1	2	
212	%	15.1	2	
150	%	32.0	2	
125	%	8.6	2	
106	%	2.9	2	
90	%	1.0	2	
63	%	0.6	2	
45	%	0.2	2	
38	%	0.1	2	
-38	%	0.3	2	
Cumulative % passing				
2000	%	96	2	
1000	%	94.9	2	
710	%	93.6	2	
500	%	89.7	2	
355	%	81.9	2	
250	%	60.8	2	
212	%	45.7	2	
150	%	13.7	2	
125	%	5.1	2	
106	%	2.2	2	
90	%	1.2	2	
63	%	0.6	2	
45	%	0.4	2	
38	%	0.3	2	
-38	%	0.0	2	
D50	µm	222.8	2	
D80	µm	345.5	2	
Feed Slurry Density from TSHD	%w/w	50	4	
Grinding Energy	kWh/t	11	*	F80 230µm; P80 150µm
Grinding Energy	kWh/t	9.5	*	F80 150µm; P80 75µm



19.5 Process Flow Diagram




FSO



19.6 Report: Power Requirement Simulation Model

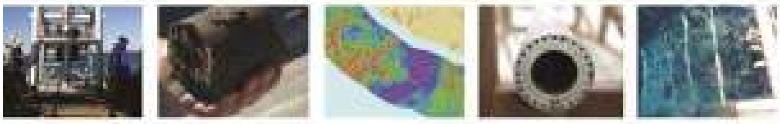
Report

Simulation Model TTRL Offshore Project

Prepared for Trans-Tasman Resources Ltd

By Beca Ltd (Beca)

23 May 2013



Revision History

Revision N°	Prepared By	Description	Date
C	Chris Lee		22/5/2013

Document Acceptance

Action	Name	Signed	Date
Prepared by	Chris Lee	[signature]	23/5/13
Reviewed by	Adrian Dickison	[signature]	23/5/13
Approved by	Lee Roberts	[signature]	23/5/13
on behalf of	Beca Ltd		

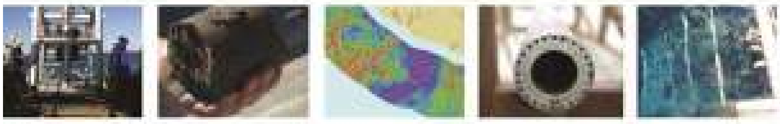


Table of Contents

Appendices:

Executive Summary

This document reports on the results of the mass balance simulations for the pre-feasibility study (PFS) which has been undertaken by TTRL for their offshore project.

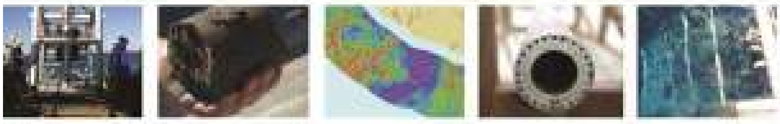
The simulation has used the modelling software "IDEAS" supplied by the Automation Solutions division of Andritz Inc, Decatur, Georgia, USA.

The modelling simulated a year's running of the process plant for two cases being 6,500 t/h and 8,000 t/h of ROM solids. The simulation included allowances for grade variability, scheduled maintenance, and significant wave height.

Plots of the results are in the appendix of this report.

Based on the available data and the modelling methodology employed the simulation found the following:

	Scenario 1 6,500 t/h ROM Solids	Scenario 2 8,000 t/h ROM Solids
Real Time for Model	366.4 days	366.4 days
kWh/tonne (ROM)	8.845 kWh/tonne	8.635 kWh/tonne
Peak MW	~ 68 MW	~ 79 MW
ROM Average Feed Rate t/h	6065 t/h	7465 t/h
ROM Total Tonnes	53.34 million tonnes	65.65 million tonnes
Product Buffer Size	30,000 tonne capacity is inadequate at this rate	30,000 tonne capacity is marginal at this rate



1 Introduction

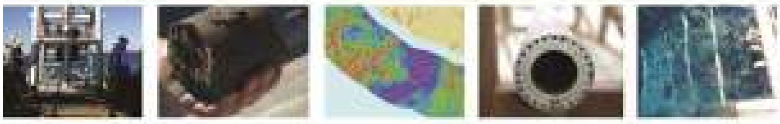
Trans-Tasman Resources Ltd has undertaken a pre-feasibility study (PFS) as a first step in preparing a bankable feasibility study (BFS) for the off-shore mining and processing of magnetite in the South Taranaki Basin.

The objective of the simulation is to examine the effects of wave height, ROM grade variability, buffer sizes and maintenance shuts on the production rate and hence the power consumption of an off-shore floating production, storage and off-loading vessel (FPSO).

They have identified a key issue in their operating expenditure estimates (OPEX estimates) to be the power requirements for the process and they have opted to determine electricity usage and power consumption per tonne of run of mine (ROM) material by using process simulation with variable inputs for grade change in the ROM recoverable iron ore.

Beca has been engaged to construct a process mass balance simulation using the modelling software IDEAS and to deliver modelling results for one year's operation at the two ROM input rates of 6,500 tonne per hour and 8,000 tonne per hour with historic variability in wave heights and observed variability of ROM ore grades based on site sampling surveys.

The engagement commenced on the 6th of May 2013 and has been on-going to the date of this report.



2 Simulation Model Description

2.1 Basic Function

The IDEAS model is constructed primarily from "macro" blocks which calculate fluid flows and material separations using mathematically-based calculations.

The power consumption of various process consumers of power, namely: pumps, magnetic separators, ISA grinding mills, trommels, etc. are either calculated based on the flow through the item of equipment or are given a power consumption based on vendors' information.

2.2 Extent of Model

The simulation model is based on the process flow diagram (PFD) which evolved in parallel with the model development.

Due to time constraints, the water supply and tailings disposal systems on the PFD were not modelled and in these cases an allowance was made for the power consumption based on vendor supplied figures.

In addition to modelling the process itself, the model also accounts for:

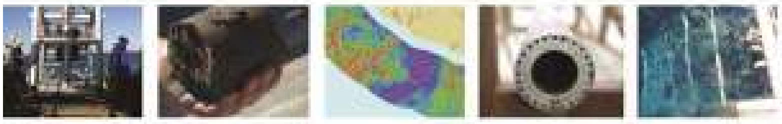
- The power requirements of the FPSO's dynamic positioning system (DP), which is affected by wave height;
- The production by reverse osmosis of desalinated water;
- Routine fortnightly shuts of the plant for maintenance.

2.3 Modelling Components

The IDEAS process modelling system supplies a set of component data which enables individual components to be selected to "build" a ROM material feed composition.

For this process the components are ferric oxide (Fe_3O_4), silica (SiO_2), water and salt (in aqueous solution) (NaCl). Iron (Fe) was added to the component set as a high density modifier to enable the density of the modelled fluid to closely match the expected density of the actual ROM material. However, the yield of iron (Fe) is based solely on Fe_3O_4 and the other two solid components (SiO_2 and iron) are simply separated as "other material".

An alternative approach would have been to construct a special "other" material. However, this would have created issues with quickly devising an appropriate material with the correct density.

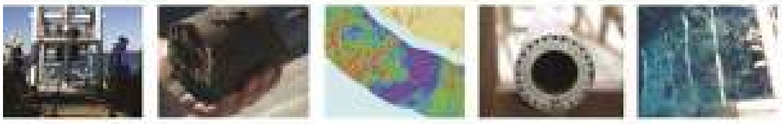


3 Data Inputs

The simulation model has been built and operated using information summarised in Table 1. As such, the assumptions used and accuracy of the information provided apply to the results of the model:

Table 1 - Summary of Inputs

Process Flow Diagram	The process flow diagram (PFD) was developed by Andre Mouton, Consulting Metallurgist, and was substantially completed by the commencement of the modelling. However the PFD has been undergoing progressive refinement ever since with the latest version issued as recently as 21/5/2013.
Mass Balance	The static mass balance was also developed by Andre Mouton and is based on experimental results from TTRL's pilot scale laboratory. All the material separations in the model are taken from this static mass balance. This document has also been evolving during the time of the modelling. However, most of the changes have not affected the primary process streams which have been the focus of the model.
Equipment List	The Equipment List has evolved along with the Process Flow Diagram and the Mass Balance and details on the power requirements of different items of equipment have been included as vendors have responded to information requests. Andre Mouton has also created this document and has generally taken the installed power to also be the operating power. The use of this data is discussed elsewhere in this report.
Wave Height Data	The wave height data has been supplied by Rhys Thomas of TTRL from two sources, ASR Ltd and NIWA. There is a discontinuity of 1 year and 21 days between the two sets of data and this was ignored when the data was merged. Overall the data covered a period from 1/2/1997 to 31/8/2010 for ASR data and 21/9/2011 to 23/4/2012 for NIWA data. When a subset of the combined data was selected this discontinuity was deliberately avoided. The NIWA data had figures for wave heights taken twice an hour. To match the 3 hourly ASR data the NIWA data was simply pruned to one reading every third hour. The key figure in the wave height data is 4.5 metres. Above this wave height TTRL advise that the processing would cease and the figure of 4.5 also provided the step change for the DP system from 6 MW to 9MW as per the Vuyk model.
Pump Discharge Heads	The pump discharge heads were provided by TTRL from the preliminary specifications sent to pump suppliers. In



	some cases these numbers have been increased because the tanks used in the model were controlled at a level of 5.5 metres which provided a reasonably significant static suction head which offset some of the discharge head.
ROM Grade Variability	The ROM grade variability was obtained from Matt Brown, Exploration GM for TTRL. This information has been derived from sampling surveys and was entered into the model as an empirical probability distribution. During model execution the grade probability distribution is sampled on a 4 hourly basis and the new grade is applied to the model via a ramp function.
Maintenance Schedule	TTRL has specified a maintenance schedule of 24 hours every calendar fortnight for the PFS
Dry Docking Schedule	TTRL had requested the inclusion of a 56 day dry docking schedule every 5 years. However, the effect of this on an annual basis can be calculated by recalculating the overall power consumption and applying it to a longer period.

4 Summary of Simplifications Used in the Model

The following table summarises and discusses some of the simplifications used to develop the model. These range from some technical aspects associated with the workings of the model to some of the high level parameters which have been taken as part of the input constraints and/or used in the modelling.

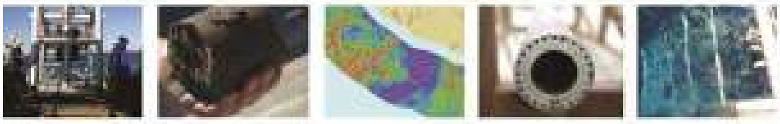
Table 2 - Summary of Model Simplifications

Fe(s) as heavy fraction	Fe(s) component	This material was included as one of the components to enable the density of ROM material in the model to be matched to the expected actual ROM density. This Fe is a separate component from the Fe_3O_4 and does not participate in the yield and recovery calculations in the model.
Wave Height Cut-off	4.5m Hs (significant wave height)	This figure is provided by TTRL and will be subject of review in the BFS. It may transpire that different aspects of the mining, operation, and off-loading will be influenced by different wave heights.
Timeframe of wave height data	1 year	The total actual modelling time per scenario (approximately 16 hours) and memory limitations have limited each modelling run to one year of real time. (How representative this one year slice of historic wave height data has not been analysed for this PFS stage and more sensitivity to wave height variation should be a part of the BFS).
Yield Calculations	10% recoverable Fe in the static mass balance	The model calculates yields for all grades based on the yields given in the static mass balance for a grade of 10% recoverable Fe. This does not model real-world variability in achievable recovery in that is probably overstates recovery from low grade ore and understates recovery from higher grade ore.
Pumping power calculations	Based on theoretical flow and total discharge head calculations and a standard pump efficiency of 75%	These calculations are dependent on the total discharge head figures provided by TTRLwhich includes an allowance for entry, exit, and friction losses. A friction loss check could not be made at this stage and this will be an important component of the BFS phase in relation to the pumps. The power for the ROM pump system (which also has power requirements for the on-board hydraulic system and jet sluicing pump) was developed in discussion with Shawn Thompson, Project Director of TTRL.

5 Model Outputs

5.1 Scenarios

The basic model has been copied into two separate models to model the two scenarios of 6,500 t/h and 8,000 t/h of ROM material fed to the process.



For both these cases the model simulates a year to determine the annual process power consumption (in kWh per tonne of ROM feed) and instantaneous power in MW.

In both cases the same set of wave height data has been used and the model has started from the same point in this data.
As discussed in the Inputs section, the wave data is historical and was selected to provide a reasonably fair representation of the wave data over a period of 3 years. In the event, some modelling time restrictions have limited the period to the first year of this data.

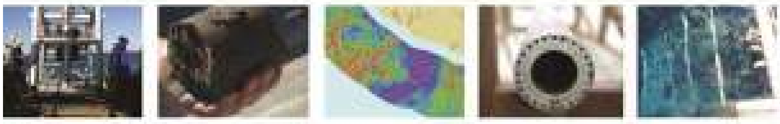
For both models the other variable is ROM grade (although the model is also capable of modelling variations in overall plant availability).
The grade variability has a direct effect on the yield at the first set of medium intensity magnetic separators (MIMS) and this affects the flow through the remainder of the plant. However, the yield calculations at the MIMS (and subsequent low intensity magnetic separators LIMS) are constants based on the separation efficiencies used in determining the original static mass balance for the 8,000 t/h scenario. Separation efficiencies related to ore grade would be highly desirable for the BFS phase of the project as the fixed figures may be understating the yield from high grade ores and, to some extent, overstating the yield from low grad ores.

The model also accounts for a fortnightly maintenance shut in production for 24 hours although it maintains a base power consumption of approximately 10 MW for power to equipment such as the DP system and the Desalination Plant.

5.2 Subjective Observations on the Model Outputs

Over the duration of a year the average values for both MW and kWh/tonne become quite stable and shorter modelling periods would probably suffice to test sensitivity to different variables or at least identify which of those variables is worthy of closer examination.

As far as pump power is concerned, the total discharge head for each pump has been provided as an input to the modelling and these will obviously require closer scrutiny in the next phase of this project to ensure friction losses in pipes and gravity discharges are both accounted for more accurately.



6 Summaries of Modelling Results

- Scenario 1: 6,500 tonne/h ROM feed to the plant
- Scenario 2: 8,000 tonne/h ROM feed to the plant

6.1 Summary Scenario 1: 6,500 tonne/h ROM feed to the plant

Table 3 - Scenario 1 Input Parameters

Plant Production	6,500 t/h ROM. (Grade variations mean that the ROM material density changes which introduces some variability into the actual feed rate to the plant).
Maintenance Time	Maintenance time in the model was as specified as by TTRL.
Grade Variation	Derived from the random number generator
Graphical results	Refer to the Appendix

Table 4 – Scenario 1 Results Summary

	Scenario 1 6,500 t/h ROM Solids
kWh/tonne (ROM)	8.845 kWh/tonne
Peak MW	~ 66 MW
ROM Average Feed Rate t/h	6065 t/h
ROM Total Tonnes	53.34 million tonnes
Product Buffer Size	30,000 tonne capacity is inadequate at this rate

6.2 Summary of Scenario 2: 8,000 tonne/h ROM feed to the plant

Table 5 - Scenario 2 Input Parameters

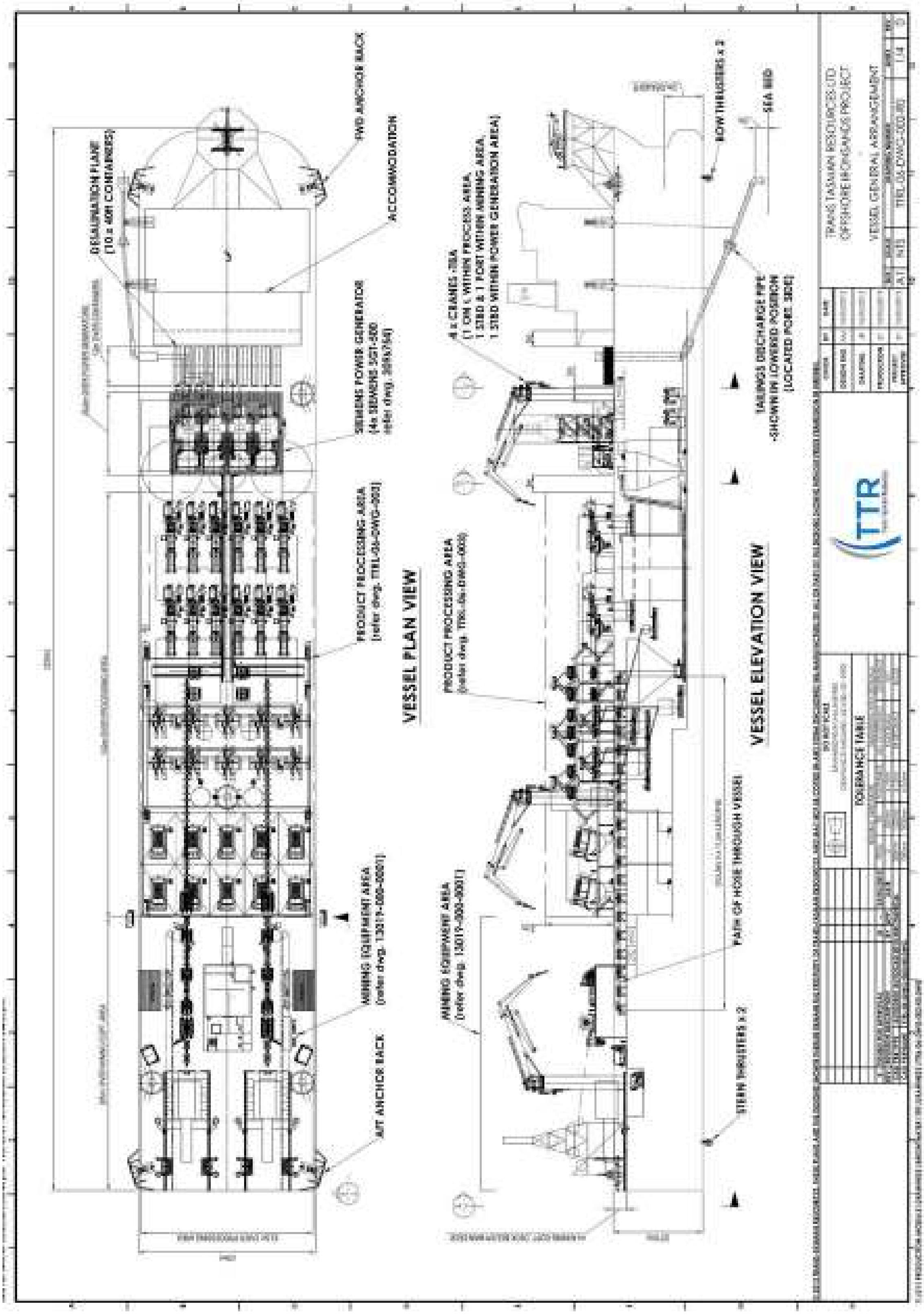
Plant Production	8,000 t/h ROM. (Grade variations mean that the ROM material density changes which introduces some variability into the actual feed rate to the plant).

Maintenance Time	Maintenance time in the model was as specified as by TTRL.
Grade Variation	Derived from the random number generator
Graphical results	Refer to the Appendix

Table 6 – Scenario 2 Results Summary

	Scenario 2 8,000 t/h ROM Solids
kWh/tonne (ROM)	8.635 kWh/tonne
Peak MW	~ 79 MW
ROM Average Feed Rate t/h	7465 t/h
ROM Total Tonnes	65.65 million tonnes
Product Buffer Size	30,000 tonne capacity is marginal at this rate

19.7 FPSO General Arrangement



19.8 FPSO Personnel Assessment

Vessel Manning	No men	Remarks
FPSO Installation Manager	1	
Marine Safety Superintendant	1	
Snr. Cargo Operator (Deck Hand)	1	Concentrate Transfer/Fuel Loading/Service Vessel
Cargo Operator (Deck Hand)	1	Concentrate Transfer/Fuel Loading/Service Vessel
Medic	1	
Crane Driver	1	Service Vessel/Maintenance/Shut Assist
Camp Boss/Day Cook	1	
Night Cook	1	
Steward	2	
Kitchen Hand	2	
SUB TOTAL (per shift)	12	
Number of shifts	4	
Total men	48	
Utility Plant Manning	No men	
Utility Engineer	1	Shut Assist
Operator	2	Power Plant & Desal Operator (Interchange, No relief), Shut Assist
SUB TOTAL (per shift)	3	
Number of shifts	4	
Total men	12	
Mining Plant Manning	No men	
Mining Superintendant	1	
Pilot	1	Shut Assist
Relief Pilot	1	Shut Assist
SUB TOTAL (per shift)	3	
Number of shifts	4	
Total men	12	
Processing Plant Manning	No men	
Process Superintendant	1	Shut Assist
Plant operator (Feed & Mag Sep)	1	Shut Assist
Plant operator (Grinding)	1	Shut Assist
Relief operators	1	Shut Assist
Laboratory technicians	0.5	Day Shift Only/Mine Scheduling/Reconciliation
SUB TOTAL (per shift)	4.5	
Number of shifts	4	
Total men	18	
Plant Maintenance Manning	No men	
Maintenance Engineer	1	Shut Lead
C&I Technician	2	Shut Assist
Electrical Tech	2	Shut Assist
Hydraulic Tech	1	Shut Assist
Mechanical Fitter/Welder	2	Shut Assist
Trade Assistant	2	Shut Assist/Deck Hand
SUB TOTAL (per shift)	10	
Number of shifts	4	
Total men	40	
Total	130	
Holiday Cover	139	
Special Resources Flown In on Shut		

19.9 Report: Personnel of Current FPSOs

R. N. Barlow and Associates Limited

P O Box 6169

Moturoa

New Plymouth 4310

New Zealand

13/12/2012

Report on Management and Manning of the two FPSO's currently operating in the Taranaki Area for Trans Tasman Resources Limited.

Background

TTR have engaged RN Barlow and Associates to provide details on manning arrangements on FPSOs operating in the Taranaki Area.

There are currently two FPSOs operating in the Taranaki Offshore Oil fields, Tui and Maari, they have been in place since 2007 and 2009 respectively. The vessels are operated by two different companies.

The 'FPSO Umuroa' (above) moored on the Tui Field is owned and operated by BW-Prosafe.

The 'FPSO Raroa' on the Maari field is now operated by Modec (having recently changed from Tanker Pacific).

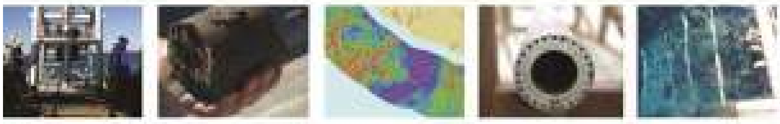
The crews of both vessels are employed under separate employment contracts, some collective and some individual, these contracts are a progression from the original FPSO employment contracts developed for the 'FPSO Whakaropai' which was operated by Shell Todd Oil Services Limited in the Maui field from the mid 1990's to the mid 2000's

Response to Specific Questions

1.0 Crewing Numbers (both total numbers and numbers onboard at any time)

The current crewing arrangements for the FPSO 'Umuroa' and FPSO 'Raroa' are presented in tables in Annex A. Of note is the slightly different manner in which positions are classified and the numbers engaged for the respective positions. This is ultimately derived from the different management system philosophy of the two vessel owners/operators and in particular the manner in which they address planned maintenance. Both organisations engage onshore engineering support contractors from time to time with the need driven by vessel survey and maintenance programmes.

2.0 Offshore Working Rosters



Both FPSOs operate a 21 day on and 21 day off roster. This is a typical employment condition in the offshore oil and gas industry and results in two crews being engaged for each vessel. Therefore total numbers in the tables need to double if wishing to identify total personnel required to ensure 24/7 365 day operations.
Furthermore – the respective employment agreements provide for six weeks annual leave and to meet the roster patterns a small number of relievers are also 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.

3.0 Where crew reside when 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 have been sourced locally in Taranaki, whilst others have been sourced from other New Zealand regions. For the 'Umuroa' the current figures are Taranaki residents 54%, elsewhere in NZ 46%, the 'Raroa' is similar.

4.0 Nationality of crew (numbers of which)

The engaged crew represent a collection of nationalities however all personnel are either New Zealand citizens or New Zealand residents.

5.0 **Personnel qualifications and brief background requirements** are inserted in Tables under Annex A.

19/12/12 20:37 +13:00

X Ray Barlow

Ray Barlow
I approve the document.

CoSign

Captain Ray Barlow

Principal

ANNEX A

FPSO 'UMUROA' – Traditional employment positions onboard

Positions	Classification	Qualification/Background
MANAGEMENT		
1	Offshore Installation Manager (OIM)	Extensive experience and qualification endorsement of offshore facility management. Generally qualifications emanating from an engineering, electrical or nautical background (Class 1 Master Foreign Going or Class 1 Chief Engineer unlimited)
Total 1		
PRODUCTION DEPARTMENT		
1	Production Superintendent	Degree level engineer with appropriate offshore experience in hydrocarbon production including gas lift systems and maintenance
4	Production Operator	Engineer and/or hydrocarbon production operator
Total 5		
MAINTENANCE DEPARTMENT		

1	Senior Maintenance Specialist	Engineers with extensive facility management
1	Maintenance Superintendent	Engineer with extensive facility management
2	Maintenance Fitter	Fitter and turner
1	Electrical & Instrument Lead	Electrical and Instrument engineer with HV endorsement
2	Electrical and Instrument	Electrical and Instrument engineer with HV endorsement
2	Utilities Operator	Mechanical Engineer or Fitter Turner
Total 9		
OPERATIONS DEPARTMENT		
1	Marine Safety Superintendent	Extensive offshore facility/ship experience. Generally nautical qualification as Class 1 Master Mariner (MFG) with tanker endorsement
1	Senior Cargo Operator	Extensive offshore facility/ship experience. Generally nautical qualification as Class 1 Master Mariner (MFG) or Class 2 (Chief Officer) with tanker endorsement
2	Cargo Operator	Extensive offshore facility/ship experience. Generally nautical qualification as Class 1 Master Mariner (MFG) or Class 2 (Chief Officer) with tanker endorsement
1	GP Operator Lead	Usually has a trade qualification or some sea going certification/experience
2	GP Operator	Usually has a trade qualification or some sea going certification/experience

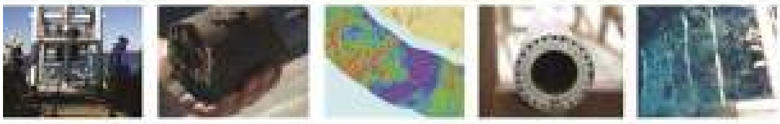
1	Crane Driver	Certified crane operator with offshore endorsement
Total 8		
ADMINISTRATION DEPARTMENT		
1	Material Planner and Coordinator	Usually trade qualified with material planning and logistics experience
1	Medic and administrator	Certified offshore medic (usually a registered nurse or paramedic)
Total 2		
CATERING DEPARTMENT		
1	Camp Boss/Day Cook	Offshore experience with Chefs qualifications
1	Night Cook	Offshore experience with Chefs qualifications
1	Steward	Offshore experience
1	Kitchen Hand	Offshore experience with kitchen background
Total 4		
Total onboard compliment of 29		

6

PSO 'RAROA' Traditional employment positions onboard

Positions	Classification	Qualifications/Background
MANAGEMENT		
1	Offshore Installation Manager	Extensive experience and qualification endorsement of offshore facility management. Generally qualifications emanating from an engineering, electrical or nautical background (Class 1 Master Foreign Going or Class 1 marine Chief Engineer unlimited)
Total 1		
PRODUCTION		
1	Production Team Leader	Degree level engineer with appropriate offshore experience in hydrocarbon production including gas lift systems and maintenance
1	Senior Cargo Operator	Extensive offshore facility/ship experience. Generally nautical qualification as Class 1 Master Mariner (MFG) or Class 2 (Chief Officer) with tanker endorsement
2	Control Room Operator	Engineer and/or hydrocarbon production operator
2	Area Operator	Engineer and/or hydrocarbon production operator
2	Boiler Operator	Engineer and/or hydrocarbon production operator
Total 8		
MAINTENANCE		
1	Maintenance Team Leader	Engineers with extensive facility management and/or Certificate of Competency as a Class 1 marine Chief Engineer with tanker experience and tanker endorsement
2	Electrical and Instrument Technician	Certified electrical and instrument technician
2	Maintenance Technician	Registered engineer with facility experience
1	Heavy Volt Electrician	Electrician with HV certification
Total 6		

MARINE & SECURITY		
1	Operations Team Leader	Extensive offshore facility/ship experience. Generally nautical qualification as Class 1 Master Mariner (MFG) with tanker endorsement
1	Crane Operator	Certified crane operator with offshore endorsement
4	Deck and Tank Hands	Usually has a trade qualification or some sea going certification/experience
Total 6		
ADMINISTRATION AND MEDICAL		
1	Medic & Administrator	Certified offshore medic (usually a registered nurse or paramedic)
1	Materials and Logistics	Usually trade qualified with material planning and logistics experience
Total 2		
CATERING SERVICES		
1	Camp Boss	Offshore experience with Chefs qualifications
1	Night Cook	Offshore experience with Chefs or Cooks qualifications
2	Steward	Offshore experience
Total 4		
Total onboard compliment of 27		



19.10 CSL Trans-Shipment Clarification

TTR Responses and further questions to CSL Transhipment proposal

dated

01 May 2013

1. We note that CSL have allowed for 2*60 kt TSV vessels, TTR would like CSL to undertake some sensitivity work around what would be the tipping point in terms of TSV loading rate that would tip to a one vessel TSV operation. As further background, currently TTRs designs are assuming operating up time of our full production process of between 6000 – 6300 hours per year at a concentrate production rate of between 750 -850 tph.

   Only 1 x 60k TSV has been allowed for in the indication. As discussed yesterday, we will look to increase the dwt capacity to 90k. Ross will be able to give you an indication on dimension based on our proposed vessel for African Minerals.

2. As a left field alternative what do CSL think of the concept of the export vessels being direct loaded from the FPSO, each export vessel having its own filtration units (would require a dedicated fleet of vessels)? Or ships that can accept the slurry as a slurry and dewater on voyage, i.e Taharoa operation?

   I think this would be an expensive option and limit your output if the dedicated vessels were unavailable or delayed on return from delivery of cargo due to congestion at the discharge port. The new Taharoa vessel was reported to cost in excess of $100m which makes them an expensive option.

   If you were to look at the blending option, then possibly two dedicated vessels delivering product to the blending vessel may be an option but we would need to look at the location of the blending operation and the cycle time for return so as not to stop production.

3. What test work would CSL require to satisfy them selves on flowability?

   Tunra tests on the filter cake would be required to check flow characteristics, arching dimensions and clean off angle. I can have the technical department send a full list of tests.

4. We note that CSL are allowing for 26 – 30 month delivery times for the TSV, TTR would like to understand what the opportunities are to shorten this? Our current time lines had assumed 18 -20 months, although it is not clear yet what the build time for the FPSO would be. (this has since been answered)

5. What manning levels would be on each TSV and would this manning be available and have capacity to operate and maintain the Hyperbaric filtration modules?

   Vessel currently has a manning of 16. There would be sufficient crew to operate and maintain the filtration modules provided they are given the relevant training.

6. What installed power have CSL allowed on the vessel and does this cover the power requirement for the filtration units? These units require installed power of 800 Kw per unit with power demand estimated at 1.6Kw hrs per tonne.

   Final installed power has not taken into account the filtration units. We will need to revise for the 90k version and will add in the power requirements for the 4 filtration units.

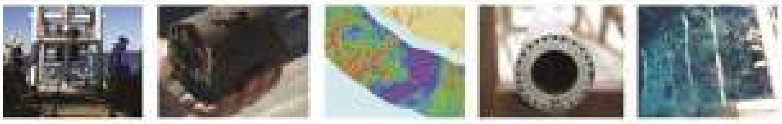
7. Could CSL undertake a high level operability study that identifies the connection/disconnection to the FPSO taking into consideration its 4 – 6 point mooring system? Taking also into consideration that TTR will have available a large (c. 8000 hp) anchor handling tug. Would CSL be interested in owning and operating the anchor handling tug? If so what would be the budget annualised charge?

   To undertake the study, we will need the layout of the mooring arrangement. As discussed yesterday, there are a number of companies which have already developed this technology and may be able to be adapted for this application.

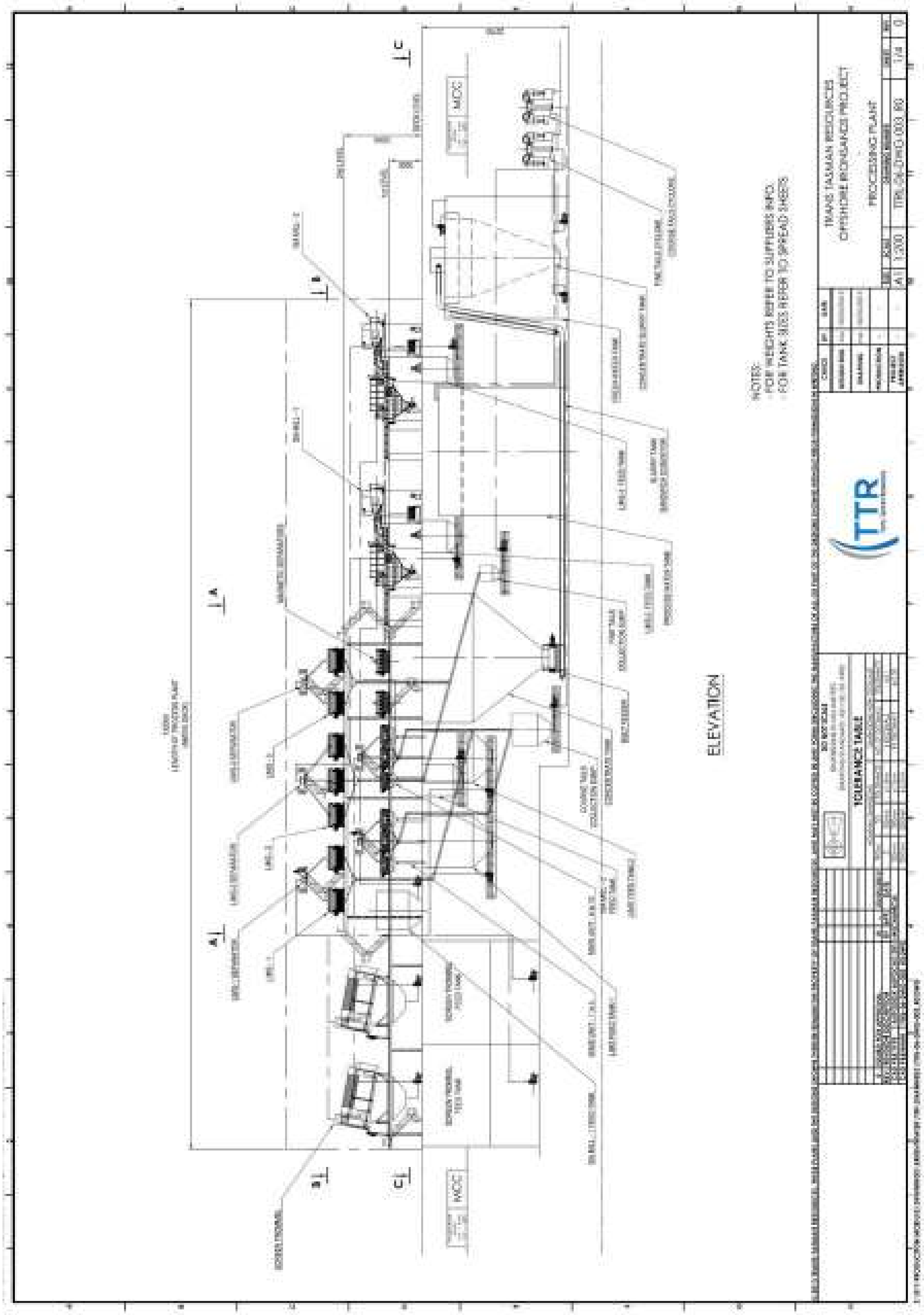
   CSL would be interested in the tug operation and will need to revert with budget numbers. We would also consider the FPSO operation as an integrated unit with the TSV.

8. We now provide (attached) Met ocean data, please advise whether this in any way would materially alter the proposal costings and workability.

   The Met ocean data supplied will not effect the costings and workability.



19.11 Processing Plant General Arrangement



19.12 Grinding Media Calculations

Grinding Media cost estimation

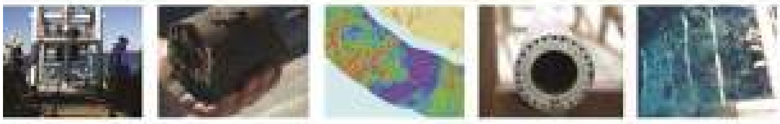
Grinding media cost estimation	Ball Mills	ISA Mills	TOTAL
Dry flow rate (t/h)	1497	276	
Grinding Media consumption (kg/t)	0,2	0,35	
Hourly Grinding Media consumption	299	97	
Operating hours (h/y)	6960	6960	
Grinding Media consumption (kg/y)	2 083 824	672 336	
Unit Grinding Media cost ($/kg)	1,5	10	
Yearly grinding Media cost ($/y)	3 125 736	6 723 360	9 849 096

19.13 Equipment List & Required Power

Description		In Operation	Number Installed	Design Total Flow		Power	Installed Power
		No	No	solid t/hr	m3/hr	kW	kW
Mining							
	Crawler Unit	1	2	8,000	9,116		
	Crawler Unit	1	2	8,000	9,116		
	ROM Pump	1	2	8,000	9,116	3000	6000
	Hydraulic unit	1	2			750	1500
	Jetwater pump	1	2			750	1500
	Anchor spread winch	4	4			0.75	3.00
	ROM Surge Tank	1	2	8,000	9,116		
Process Plant							
	Trash screen - 10mm	1	1	8,000	9,116		
	ROM agitated storage tanks	10	10	8,000	19,472		
	Overflow sump	10	10		4,868		
	ROM agitation pump	10	10		4,868	75	750
	3mm Trommel Screens	10	10	8,000	20,625	100	1000
	Trommel Screen Feed Chute	10	10	8,000	20,627		
	Trommel Screen Under Pan	10	10	7,680	19,798		
	Trommel Screen U/S Chute	10	10	7,680	19,798		
	Trommel Screen O/S Chute	10	10	320	825		
MIMS							
	MIMS Feed Sampler	5	5			**2.5**	13
	MIMS feed pump	10	10	7,680	19,798	400	4000
	Feed Distributor	10	10	7,680	19,798		
	MIMS	**60**	60	7,680	19,798	**7.5**	450
	MIMS Feed Chute	60	60	7,680	19,798		
	MIMSTails Launder	10	10	4,508	16,848		
	MIMS Cons Launder	10	10	3,172	2,827		
	MIMS Area Sump	5	5	384	990		
	MIMS Area Sump Pump	5	5	384	990	22.0	110
	Area Hoist	2	2				
						-	
LIMS1						-	
	LIMS1 Feed Sampler	2	2			**2.5**	5
	LIMS1 Feed Tank	2	2	3,172	7,906		
	LIMS1 Feed Pump	4	4	3,172	7,906	250	1000
	Feed Distributor	4	4	3,172	7,906		

	LIMS1	**16**	16	3,172	7,906	15	240
	LIMS1 Feed Chute	16	16	3,172	7,906		
	LIMS1 Cons Launder	4	4	1,418	1,240		
	LIMS1 Tails Launder	4	4	1,754	9,623		
	LIMS1 Area Sump	2	2	159	395		
	LIMS1 Area Sump Pump	2	2	159	395	22.0	44
Stage 1 Grinding (~300 to 135µm)							
	IsaMills™. Feed Tank	**2**	2	1,418	1,240		
	IsaMills™. Feed Pump	6	6	1,418	1,240	75	450
	IsaMills™. Feed Pump VSD	6	6				
	IsaMills™. M10,000	**6**	6	1,418	1,240	**3000**	18000
	IsaMills™. Gearbox	6	6				
	IsaMills™. Media Handling System	6	6				
	IsaMills™. Discharge Tank	2	2	1,418	1,240		
	IsaMills™. Discharge Pump	2	4	1,418	1,240	350	1400
	IsaMills™. Discharge Pump VSD	2	4				
	IsaMills™. Gland water tank	6	6				
	IsaMills™. Gland water pump	6	6		60	0.55	3
	IsaMills™. Area Sump	2	2	142	124		
	IsaMills™. Area Sump Pump	2	2	142	124	11.0	22
	IsaMills™. Area Crane	2	2				
LIMS2							
	LIMS2 Feed Sampler	2	2			**2.5**	5
	Feed Distributor	2	2	1,418	3,535		
	LIMS2	**12**	12	1,418	3,535	15	180
	LIMS2 Feed Chute	12	12	1,418	3,535		
	LIMS2 Cons Launder	2	2	855	821		
	LIMS2 Tails Launder	2	2	563	4,385		
	LIMS2 Area Sump	2	2	71	177		
	LIMS2 Area Sump Pump	2	2	71	177	11.0	22
Stage 2 Grinding (~135 to 75µm)							
	IsaMills™. Feed Tank	**2**	2	855	821		
	IsaMills™. Feed Pump	6	6	855	821	45	270
	IsaMills™. Feed Pump VSD	6	6				
	IsaMills™. M10,000	**6**	6	855	821	**3000**	18000
	IsaMills™. Gearbox	6	6				
	IsaMills™. Media Handling	6	6				

	System						
	IsaMills™. Discharge Tank	**2**	2	855	821		
	IsaMills™. Discharge Pump	2	2	855	821	180	360
	IsaMills™. Discharge Pump VSD	2	2				
	IsaMills™. Gland water tank	6	6				
	IsaMills™. Gland water pump	6	6		60	0.55	3
	IsaMills™. Area Sump	2	2	86	124		
	IsaMills™. Area Sump Pump	2	2	86	124	7.5	15
LIMS3							
	LIMS3 Feed Sampler	2	2			**2.5**	5
	Feed Distributor	2	2	855	2,132		
	LIMS3	**8**	8	855	2,132	22.5	180
	LIMS3 Feed Chute	8	8	855	2,132		
	LIMS3 Cons Launder	2	2	765	656		
	LIMS3 Tails Launder	2	2	90	3,996		
	LIMS3 Area Sump	2	2	43	107		
	LIMS3 Area Sump Pump	2	2	43	107	5.5	11
Dewatering Magnets							
	Dewatering Magnets	**4**	4	765	656	7.5	30
	Feed Chute	4	4	765	656		
	Dry Concentrate Chute	2	2	765	244		
	Waste water chute	2	2		413		
Concentrate Handling FPSO							
	Concentrate Sampler	2	2			**2.5**	5
	Dry concentrate hopper	2	2	765	244		
	Hopper discharge feeder	2	2	765	244		
	Wet Concentrate Conveyor	1	1	1,530	488	150	150
	Sandwich / pipe conveyor	1	1	1,530	488	100	100
	Concentrate slurry tank	1	1	1,530	1,808		
	Concentrate slurry pump	1	2	1,530	1,808	350	700
Tailings Handling FPSO							
	Coarse tails cyclones	24	24	6,582	28,988		
	Coarse tails cyclone feed pump	8	8	6,582	28,988	400	3200
	Tails agitated storage tank	1	1				
	Fine tails cyclones	8	8	653	8,793		
	Fine tails cyclone feed pump	4	4	653	8,793	250	1000



	Fine tails cyclone underflow pump	1	1	653	376	110	110
	Tails cyclone Area Sump	4	4	362	208		
	Tails cyclone Area Sump Pump	4	4	362	208	11.0	44
Plant Services							
	Process water tank	2	3		15,000		
	Process water make-up pump	4	5		19,863	500	2500
	Process water feed pump	4	5		23,612	850	4250
	Desalination plant						
	Containerised Desal Unit	1	1			3000	3000
	Desal Feed Pump	2	2		2,254	132	264
	Fresh water pump	1	1		1,360	110	110
	Fresh Water Tank	2	2		1,360		
	Brine discharge pump	2	2		4,508	55	110
	FPSO Analytical Laboratory	1	1				
	Cooling Water Pump	2	3		1,280	75	225
	Fire Water Pump Electric	2	2		640	37	74
	Fire Water Pump Diesel	2	2		640		
	Fire Water Jockey Pump	2	2		32	3	6
	Gland Water Package	2	4		1,280		
	Gland Water Pump	2	4		1,280	75	300
	Services Area Sump	4	4		2,478		
	Services Area Sump Pump	4	4		2,478	75	300
	Density Gauges	10	10				
	Flow Metres	10	10				
	Reagent Flow Metres	5	5				
Ancillary Equipment FPSO							
	Dynamic Positioning	1	1			12000	12000
Concentrate Filtration FSO							
	Hyperbaric Pressure Filters	4	4	1530	1530	800	3200
	Filter Cake Conveyor	1	1	1,530	106	50	50
	Final concentrate sampler	1	1				
	Filtrate discharge pump	1	1		1,424	37	37
	FSO Analytical Laboratory	1	1				

Electrial MCC							
Electrical Switchroom							
							87,306

19.14 FSO power balance estimation

Technip Mines

ENERGY CONSUMPTION ESTIMATE FOR EACH FSO

N° Technip Mines 0061 000052 — Rev.: B

N° Client — Date: 23/03/12

SUMMARY — FOR 1 FSO BOAT

Annual energy consumption Loading
23 862MWh 17 777Mvarh
(without power factor compensation)

Annual energy consumption Unloading
1 944MWh 1 458Mvarh
(without power factor compensation)

Annual energy consumption
25 806MWh 19 235Mvarh
(without power factor compensation)

Max demand (Loading)
8,7MW 6Mvar 11MVA
(according to power balance)

Max demand (Unloading)
1,4MW 1Mvar 2MVA
(according to power balance)

Working hours

2 750h/year for loading
1 380h/year for unloading

DETAIL OF ENERGY CONSUMPTION PER TYPE OF EQUIPMENT

		Installed power		Energy consumption	
1	Filter	9 144Kw	85%	23 617MWh	92%
2	Handling	1 600Kw	15%	2 189MWh	8%
TOTAL		10 744Kw	100%	25 806MWh	100%

Note: The second FSO energy consumption is identical.
The annual energy consumption must then be doubled for 2 FSO

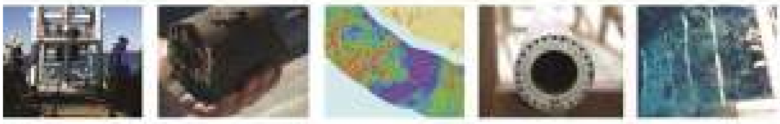
19.15 Marketing Strategy

Progressive Marketing Strategy For TTR VTM Concentrate

20th of May 2013

Author: Justin Boylson, General Manager Bulk Commodities & W.A.

Confidential Document



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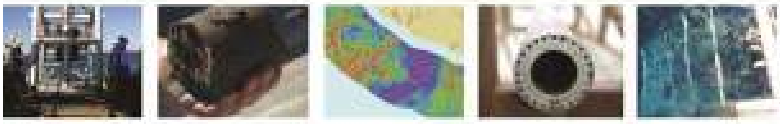


Initial Marketing Strategy for TTR VTM Concentrate.

- Trans Tasman Resources (TTR) VTM concentrate has excellent technical and economic case as a substitute to traditional iron ores feeds, particularly if vanadium credits can be allocated on a positive basis.
- Traditional blast furnace capacity to be targeted in the short to mid-term allowing small amounts of VTM concentrate in the pre burden sinter matrix (somewhere between 3% to 5%). Continued market development in changing new capacity during new construction and steel mills long term refurbishment program to convert to dedicated VTM users.
- Market penetration of TTR VTM concentrate to the dedicated VTM users to underpin the commissioning of 4 to 5 million tonnes in stage one of production along with the soft blend buyers (3% - 5%).
- TTR's lack of expensive logistics corridor CAPEX and lower cost of recovery relative to hard rock pier ores will allow sustainable operation overt the life of mine.
- Value-In-Use modelling portrays this as an acceptable substitution when compared with tier one competitive base load ores such as Pilbara Blend Fines. Further VIU on a more robust basis to occur along with sinter pot test work to allow more profitable price realisation justification.
- Propose a three pronged approach to the market:
    - a) Target dedicated VTM concentrate users with emphasis on negotiating positive Vanadium credits.
    - b) Targeting the pre sinter feed sector for non-dedicated VTM users via soft blend in the pre- burned matrix (3% - 5%) facilitating significant market diversification and considerable access to market capacity.
    - Targeting new capacity at a design phase or pursuing major operational adjustment to use a heavy blend of TTR VTM within the traditional blast furnace sector.
- Market currently in a technical inflection point (supply is meeting demand) with price volatility continuing until 2015 and then a technical floor price kicking in (Chinese based magnetite production) with proposed additional capacity either being delayed or cut. Long term consensus currently at US$93 a tonne but post 2015 this should steady to above US$100 a tonne as lower quality ores from marginal assets start to shut down along with marginal domestic production.
- Staged development of the Chinese market as China is forecast to be the base load buyer of TTR's ore in its initial production of 4 to 5 million tonnes.
- Tennant Metals Pty Ltd (TMPL) continues to develop the market and is in the process of addressing implied discount clawback.

1. Summary

Worldwide steel consumption is being driven by Asia's rampant demand for metallurgical raw materials such as iron ore, coking coal, manganese etc. China is the largest consumer of iron ore and will maintain this consumption demand for many years to come. There are however a number of other increasing markets, specifically the Middle East and the Indian Sub-Continent whose requirements for higher quality ores becomes more a necessity as base load steel capacity modernised and hence should not be ignored into the future.

Japan, Taiwan, Korea & Europe remain steady consumers of iron ore and other metallurgical commodities, but 2003 marked the commencement of the China era, and it is from this period that China became the dominant buyer. It is expected that China will be the 'base load country' for the TTR Vanadium Titanium Magnetite (VTM) concentrate product with other demand driven countries to follow suite, via a deliberate marketing and diversification strategy.

It is recommended that the TTR marketing strategy be structured into a four phase plan as follows:

- **Phase One:** Development of the Chinese market.
- **Phase Two:** Development of other mature Asian buyers such as Japan, Korea and Taiwan.
- **Phase Three:** Development of new capacity buyers such as the Middle East and India.
- **Phase Four:** Development of mature markets of Europe etc.
  All of the above is relative to modulated expansion of TTS's concentrate production moving forward.

Each phase has its individual subset development. For the purpose of this marketing strategy and the fact that China will be the base load customer for the project in the initial production development phase being around 4 to 5 million dry metric tonnes of processed VTM concentrate , this initial strategy paper will be specific to the Chinese phase one. Phase's two to four will be embarked upon following the achievement of a satisfactory outcome in China. The time line for the remaining phases will be relative to the project reaching world class capacity (around the 20 to 50 million tonnes per annum for a single operation) via modulated ramp up in production.

Phase one will consist of the following sub phases:

- **Pre-introduction phase:** The TTR VTM project has been well introduced by the Tennant Metals Beijing office & TTR management. This has occurred with tier one & tier two dedicated VTM consumers and traditional blast furnace users of similar ranking.
- **Introduction phase:** To date, several high profile conferences (CISA Iron Ore Conference on three occasions & other investment forums in China) have been used to present detailed concepts and the project dynamics to a large iron ore and investment specific audience. In addition, several road shows were conducted in which detailed presentations were given to

prospective off-taker, funders and end user/buyers. This led to several Letters of Intent being signed, aimed at long term off-take for TTR's VTM concentrate.

- **Broader marketing phase:** This phase is aimed at reducing the potential off-takers to a smaller pool, all of whom ideally contribute something back to TTR (equity/debt funding, strategic benefits, and/or market related off-take terms). To date two off-takes have been negotiated and signed (Rockcheck and CMC), and 1 tranche of equity investment secured (Rockcheck). These have assisted the spread of the product through the market, allowing mills not familiar with VTM ores to become inquisitive. Others have appreciated the potential of the project and show a real path to production which is half the battle for new miners.
- **Initial consummation phase:** Final off-take negotiations (in some cases renegotiation of current off-take to fall in line with economics confirmed via the PFS) and execution of sales contract leading into First Ore On Ship (FOOS) and the commissioning phase have been executed

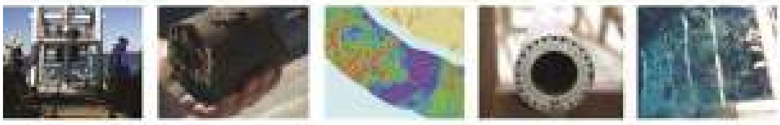
There is an excellent technical and economic case for using VTM concentrates as a substitute to traditional iron ores feeds, particularly if vanadium credits can be allocated on a positive basis.

The current VTM supply is limited on a Seaborn basis but there are significant quantities consumed domestically within China. As much as the Seaborne market is limited there is significant scope for this to increase.

In the short term, there is a substantial market accessible to TTR's product that is estimated to be circa 20 million metric tonnes specific to TTR VTM feed. This is based on a combination of traditional blast furnace capacity using small amounts of VTM concentrate in the pre burden sinter matrix (somewhere between 3% to 5% with the constraints allowing higher blends being the elevated titania (TiO_2) and Phos (P), while seaborne supply for dedicated VTM consumers would be 100% reliant on dedicated VTM feed material.

In the medium to long term, there is potentially for a much larger market for VTM concentrates if integrated steel mills can be encouraged to convert traditional Blast Furnace capacity to dedicated VTM use during new construction of blast furnaces or that of modifications to traditional capacity. This larger capacity is relative to future iron price outcomes and the continuation of TTR's cost of recovery sits favourable on the cost curve which would allow circa 100 million tonnes per annum circa 5 to 10 years.

The failure of new capacity coming on line from magnetite (Fe_3O_4) hard rock pier competition that has a cost of recovery well above US$70 (Free on Board basis) a tonne will assist by the significant CAPEX in hard rock processing and significant cost to deliver a logistics corridor to ships rail, the modulated and organic logistic solution for the TTR project gives it a significant advantage, in realisation of this new capacity constraint the mid to long term potential for VTM's and TTR look excellent.



2. Introduction to Vanadium Titanium Magnetite Concentrates

Vanadium Titanium Magnetite (VTM) Concentrate is a sub family of iron ore which can be sold as either a Direct Ship Ore (DSO) or a concentrate derived from iron rich sediment that is used mainly for production of hot metal smelting. VTM concentrates have mid to high levels of iron (Fe) and Vanadium (V) which can in some cases be recovered from the steel making process.

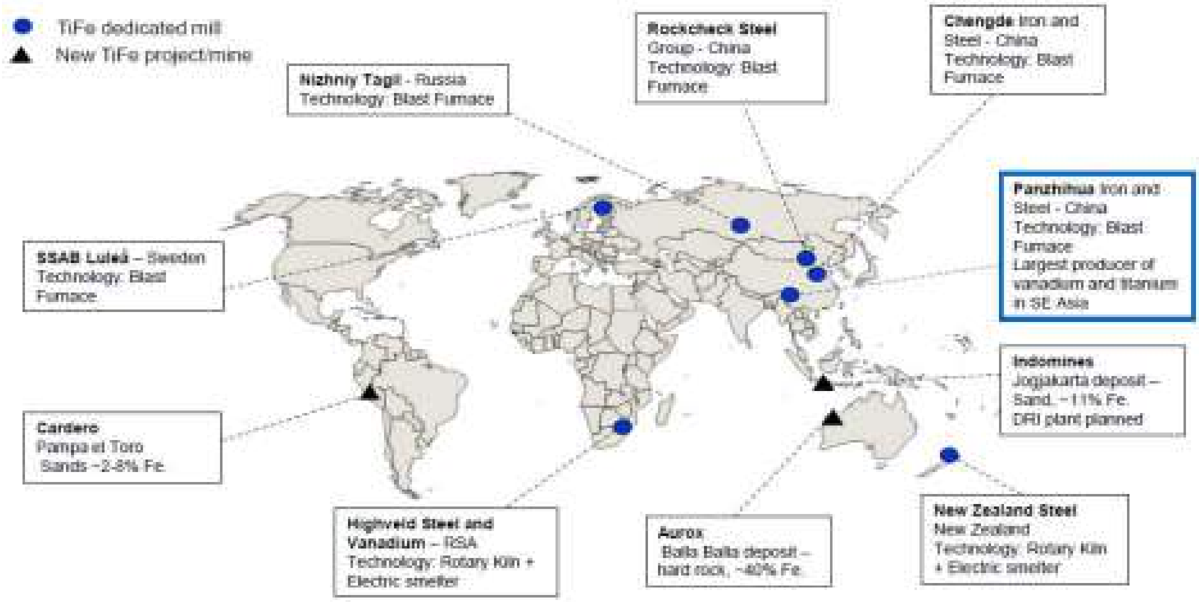
VTM concentrates are typically derived from iron sands or hard rock deposits. In order for VTM's to be recognised as an economic resource they need to be amenable to becoming either a sinter feed/pellets or blast furnace direct charge (Massive VTM lump) that may be used as light feed/blend in either the pre burden sinter matrix or the direct feed blast furnace matrix.

Although large integrated steelmaking operations using VTM's as their base load feedstock have existed in both China and Russia for the last 40 years, the seaborne VTM market is relative small to the rest of the market. Current domestic VTM capacity in both China & Russia exists due to significant in situ resources that are integrated into hot metal production.

Current seaborne capacity is assessed at somewhere between an annual 4 to 6 million tonnes (this varies according to information source). This capacity is currently being sourced from New Zealand and the well-known New Zealand Steel's Taharoa VTM mine and other suppliers from Philippines and Indonesia.

There are substantial VTM resources in China particularly in China's Sichuan province where VTM concentrates are produced locally and used by local steel mills, including Panzhihua which is also recovering titania (the author is unsure of this process but believes it via some form sponge recovery process),. Other provinces also include Hebei where Ghengde Steel & Vanadium Plant recovers vanadium via a dedicated BOF scaping system taking Vanadium rich slag from the top of the converter. It should be noted that the large Russian (Siberia) and Chinese VTM integrated steel mills are all conventional blast furnaces set up for dedicated VTM feed and are located on or near- to hard rock VTM deposits.

Figure 19-1:Main world-wide users & deposits.



3. Potential VTM Market Accessible Projections

VTM concentrates can be used in traditional or customized steel-making operation and as such are a substitute to traditional iron ore supplied either from the domestic or sea born market. So analyst are predicting that by 2017 China will be importing 854 million tonnes of seaborne DSO & concentrates and other feed stocks. In 2015 it is expected that total consumption of domestic & Seaborne DSO will be around 1340 million tonnes (on an ore basis). Therefore the estimate of static China Accessible market taking into consideration that 40% of steel mills in China are landlocked such that TTR VTM's concentrates cannot be economically accessible is as follows:

- **Light Blend for traditional blast furnace**. Any steel mill can use 3% - 5% VTM concentrate in the blast furnace with minimal operation adjustments or deleterious effects. This market is immediately accessible and the estimated size is 1340 x 0.6 x 0.06 = **48 million tonnes per annum.**

- **Heavy blend for coastal Chinese steel mills.** Typical Chinese steel mills can blend on a heavy basis between 30% -40% VTM concentrate via their sinter lines or direct charge VTM pellet feed. This market need significant development work and is only available to the current dedicated VTM users but thru operational adjustments taking into consideration of new capacity being constructed and 20 year furnaces relining and being retro fitted for dedicated VTM use the estimated market size is 1340 x 0.60 x 0.3 X 0.8 = **190 million tonnes per annum.**

- **Existing VTM Chinese steel mills.** There are three large VTM dedicated steel mills in China mentioned elsewhere in this report but the estimated latent demand = **10 million tonnes per annum.**

4. Current Market Analysis.

Iron ore comes from a variety of different suppliers and regions however the two main producing regions; Brazil accounts for 30% of market share and Australia accounting for 38% of market share (as per 2011). Within this, these two regions are dominated by three companies being Vale, Rio Tinto and BHPB. They are viewed as tier one suppliers, and there also remains a vibrant second and third tier (driven by the rampant demand curve and not delivering on their true VIU rating of their ore) group of producers. These include in the tier two categories Anglo American, FMG (which with its quantum increases in capacity will soon move into the tier one stratosphere), Citi Pacific Sino Iron (expected production of 24 million tonnes) from these two regions, and in the tier three category Atlas Iron, Mount Gibson and others. However there is expected additional capacity to come on line from West Africa and continued cost constrained Chinese domestic coarse grain magnetite.

Vale during 2011 produced in excess of 323 million tonnes followed by Rio Tinto producing 220 million tonnes (and who has publicly stated that it wants to increase production output to 360 million tonnes per year by 2015, and BHPB producing 150 million tonnes. India was a major supplier of spot cargo ore in lump and fines and 2009 exports peaked at around 120 million tonnes of ore however production has collapsed due to increase in tariffs and bans on illegal domestic production on the west coast with exports in 2012 at 63 million tonnes. This Indian capacity is expected to continue to decline over the next two to three years.

Figure 19-2: Chinese iron ore and steel data & forecast 2008 -2013, quarterly

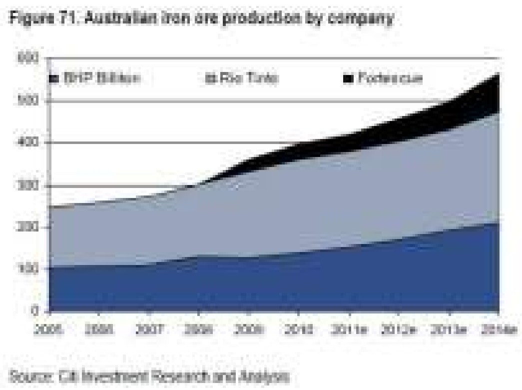
kMotons	Chinese Domestic Iron Ore Production	Chinese Iron Ore Imports (63% Fe)	Chinese Iron Ore Port Inventory Change	Chinese Steel Production	Chinese Iron Ore Demand (63% Fe)	Domestic Iron Ore Production at 63% Fe	Chinese Iron Ore % Fe
2008 Q1	167,309	110,690	18,280	124,960	179,942	87,532	33%
2008 Q2	225,243	115,550	1,850	138,015	198,747	81,047	23%
2008 Q3	188,974	116,230	11,700	127,318	183,338	78,808	26%
2008 Q4	201,294	97,630	-12,910	108,391	156,083	45,543	14%
2009 Q1	167,148	131,420	6,500	126,934	182,785	57,865	22%
2009 Q2	209,613	165,790	1,990	139,455	200,815	37,015	11%
2009 Q3	238,951	173,350	3,040	153,836	221,524	52,214	14%
2009 Q4	258,909	158,700	-6,020	148,652	214,059	49,339	12%
2010 Q1	204,066	156,010	4,120	155,883	224,472	73,582	23%
2010 Q2	280,674	154,400	-720	164,587	237,005	81,885	18%
2010 Q3	280,713	148,797	1,410	151,665	218,398	71,011	15%
2010 Q4	289,290	161,054	1,950	151,675	218,412	59,308	13%
2011 Q1	240,672	177,173	5,980	173,594	249,976	78,783	21%
2011 Q2	324,247	157,077	13,320	179,209	258,061	114,304	23%
2011 Q3	372,016	173,824	-510	174,752	251,643	77,309	13%
2011 Q4	378,057	178,011	3,600	156,720	225,677	51,266	8%
2012 Q1	256,395	187,460	2,800	174,197	250,844	66,186	17%
2012 Q2	342,065	178,740	-1,590	182,022	262,112	81,782	15%
2012 Q3	361,520	185,010	-2,500	178,546	256,618	60,908	12%
2012 Q4 F		178,790					
2013 Q1 F		195,609					
2013 Q2 F		199,625					
2013 Q3 F		194,702					
2013 Q4 F		194,814					

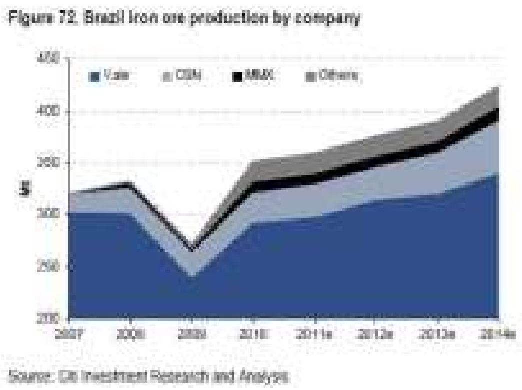
Note: Chinese Iron Ore Demand = Chinese Steel Production*1.6*90%   90% is the share of Chinese steel produced from BOS

Source: BIMCO, China Customs, Morgan Stanley, National Bureau of Statistics of China

Below is a quick summary of the main iron ore consumers define by country and the market dynamics relative China as the main base load consumer.

Figure 19-3: Top iron ore producers.





4.1.China & Iron Ore

China is the largest consumer of sea-born iron ore. The country is quickly maturing in its steel intensity Chinese steel consumption will not peak until 2025. Standard Charter indicates that, China's annual steel consumption growth has already peaked and will slow to less than 1% between 2021 and 2025.

Standard Chartered also states that “even with flatter future growth than the past decade, the additional consumption in volume terms remains substantial due to a high base. For example, total steel consumption will increase by 155mt between 2013 and 2025 (+23%). Between 2014 and 2025, their base-case scenario suggests average growth of 1.3% y/y. There will be virtually no increase in steel consumption in the peak year of 2025."

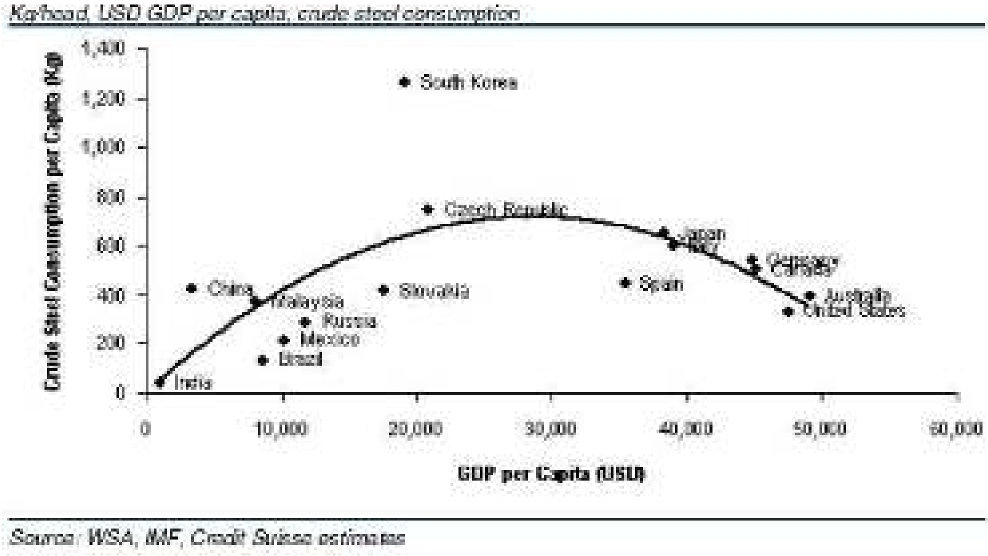
Part of the reason for this belief stems from three basic assumptions on the part of the bank:

1. The future path of China's per-capita steel consumption will track the trajectory of major economies.
2. China's long-term real GDP growth will gradually trend down and stabilise at 4% y/y towards 2030.
3. Standard Chartered uses the UN estimates for China's population. Population growth is forecast to decelerate in the years leading up to 2030, reaching 1.46bn people by 2030.

But, while these assumptions all point to lower growth, they also point to a very robust base of demand.

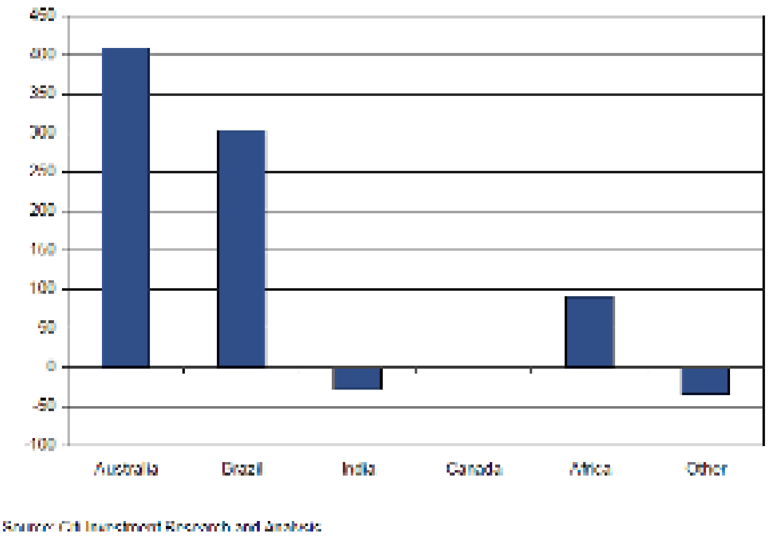
The bank published the following statement “the trajectory for China's per-capita steel consumption derived from our regression analysis of various countries shows that 2012 consumption, at 487kg, is already close to the peak of 569kg we forecast between 2022 and 2023. Our analysis also suggests that between 2012 and 2020, per-capita consumption will increase by 16%. But between 2020 and 2025, there will be virtually no growth in per-capita use, while total steel consumption will continue to rise on the back of population growth in its Steel intensity which provides considerable scope to increase the ratio of steel consumption to national GDP," it says.

Figure 19-4: Chinese steel consumption / GDP per capita rates.



Standard Chartered believes this continued, albeit slower demand for steel in China, as well as the restructuring of the sector that must accompany it, will support iron ore demand in the longer-term. The bank believes that iron ore demand from the Asian giant will peak at 775mt (measured by Fe content) in 2020 (there are other peak numbers indicated within this report reflecting a consensus view) But, it says, imports should peak at 989mt (rock weight) in 2025.

Figure 19-5: Expected mine supply until 2020.



China's total consumption of iron ore imports (seaborne) for 2012 hit a record of 743.6 million (CIQ data), rising 8.4 percent from a year earlier.

As indicated this production of domestic magnetite means that a large number of steel mills use magnetite in their pre-sinter feeds hence allowing for a TTR TiFe concentrates to become an integral component of their pre feed stock piles.

4.2. Chinas domestic magnetite production

Currently 60% of China's iron ore requirements arrive as seaborne DSO and concentrates, and are mainly imported from Brazil, Australia. The remaining 40% is locally produced iron ore of which a large proportion is coarse grain magnetite in nature and at a 63.5% basis. This local capacity is produced by marginal assets which carry an average head grade of around Fe 25% and declining (circa 22% 2013). If we look at even lower grader operations with in ground head grades of 20% these will decline to 18% by 2020, which implies over 4 tonne of ore processed per one tonne of final 62.5% product, a mass yield of 25%. Higher processing volumes entail higher electricity, personnel, fuel, consumables (e.g. steel grinding bodies) costs.

Figure 19-6: Chinese domestic iron ore costs-average low grade with Fe at 19%.

Total Costs		2011	2012E	2013E	2014E	2015E	2016E	2017E	2018E	2019E	2020E
Key Grinding Costs	$/t	12.0	12.6	12.9	13.2	13.6	13.9	14.3	14.6	14.7	14.9
Electricity Costs (ex-grinding)	$/t	37.3	39.6	41.7	43.7	45.4	47.2	48.9	50.1	51.3	52.6
Personnel Costs	$/t	24.2	27.7	31.4	35.3	39.3	43.6	48.1	52.5	57.3	62.4
Fuel Costs	$/t	6.3	7.3	7.5	6.5	7.0	7.5	8.0	8.4	8.9	9.4
Royalty/Tax	$/t	6.4	6.6	6.8	7.0	7.1	7.2	7.2	7.2	7.2	7.2
Other Materials Cost	$/t	17.6	19.2	20.8	22.5	24.4	26.3	28.3	30.2	32.1	34.1
Rail Costs	$/t	10.0	10.3	10.5	10.8	11.0	11.3	11.6	11.9	12.2	12.5
Total Costs	$/t	**113.8**	**123.1**	**131.6**	**139.0**	**147.7**	**157.0**	**166.4**	**174.9**	**183.6**	**193.2**
YoY %	%		8%	7%	6%	6%	6%	6%	5%	5%	5%

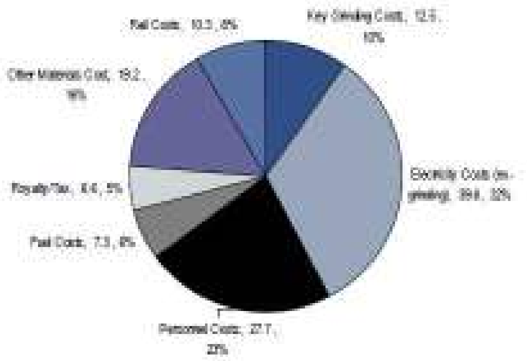
Source: Citi Investment Research and Analysis

Consensus price forecast imply the Chinese capacity begins to decline in 2014/15 and could be eliminated by 2017/18. This decline would commence with the highest of marginal producer and with low cost Chinese capacity exiting a decade later.

Applying conservative assumptions to the cost component iron ore cash cost for the average low-grade Chinese mine is around US$120 per Dry Metric Tonne. Higher cost operations do exit in the region US$140 per Dry Metric Tonne with Fe grades of 15-16%.

China's capacity to buy sea-borne iron ore is a combination of supply and demand factors, and their ability to produce domestic magnetite production. This ability is only competitive when prices are high; however as price decline, in the event supply increases to meet demand (inflection point) local capacity becomes uneconomic and is either suspended or closed. This is the fundamental concept of the floor price for iron ore at US$120 per dry Metric Tonne.

Figure 19-7: Cash cost breakdown of Chinese domestic iron ore production at US$119.



Source: Citi Investment Research and Analysis

5. China and its Market Dynamics

5.1.Background of the Benchmark (reference price)

Baosteel has traditionally led a negotiation table consisting of members of the top tier one steel mills and traders. This single negotiation approach used to start around November each year, and continue through to March of the following year. This period was always known as the "mating season". These negotiations were then strained when the China Iron & Steel Association (CISA), which is an association of steel producers in China and acts as a quasi-semi-governmental organisation, was given the role to secure more favourable terms for the Chinese steel mills for JFY 09/10 this led to a total breakdown in the yearly benchmark.

From this period miners and buyers ended up pricing off a range of indices these indices have become much matured. The main Indices are as follows:

- Platts (published by Mcgraw Hill Financial). They publish the following range of indices:
    - IODEX 62% Fe CFR North China.
    - 63.5/63% Fe CFR North China.
    - 65% Fe CFR North China.
    - 58% Fe* CFR North China.
    - 52% Fe CFR North China.

      *Al = 4.0% max
- The Steel Index (TSI.. TSI was purchased outright last year by Mcgraw Hill Financial). They publish the following range of indices:

- 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.
- 63.5/63% Fe fines, 3.5% Al, CFR Qingdao port

Miner and buyers agreed to a quarterly price outcome which was derived from the previous quarters Platts or TSI as the indices take into account the CFR landed basis so C3 (Brazil to North China) and C5 (West Australia to North China) whereas the previous yearly benchmark was on a Free on Board (FOB Incoterms 2000) basis. After a period of price volatility with many mills either deferring or defaulting the quarterly in arras still exist for larger buyer (particularly from Vale) a significant amount of tonnes are now driven by very narrow quotation period or are derived on future price setting (M+1 or M+2 ad description of this is in section of pricing methodology).

5.2. Market Price forecast.

5.2.1. Current price assessment

The market price of the iron ore had stabilization in the first two weeks of February 2013 ($150-US$155 per dry metric tonne CFR China – 62% Fe Australian fines) and was followed by a negative trend in the second half of Q1, as spot prices rolled down to $US133-135 per dry metric tonne level. This trend continued into April and has continued onto US5123 or thereabouts for May.

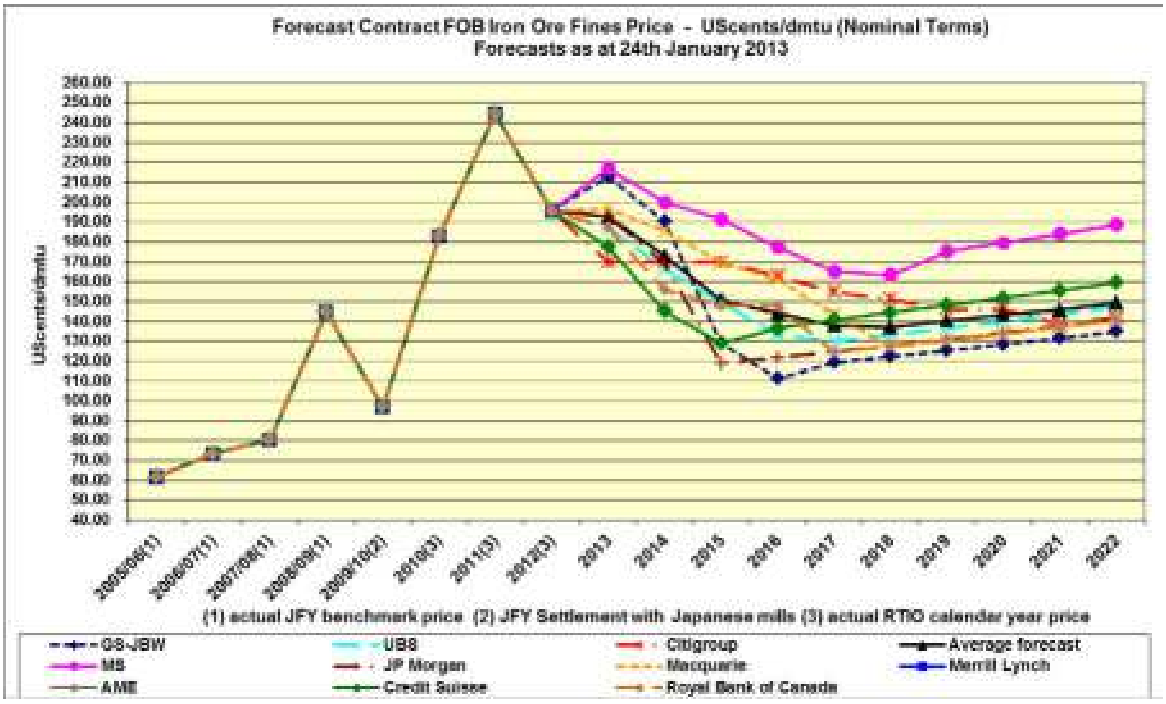
According to the major market players and industry experts, the price decline was caused by weaker demand (Chinese consumers cut their purchases drastically after re-stocking) and better availability of material (there were seasonal difficulties with iron ore shipments from Australia at the beginning of the year). In early Q2, the situation in the Chinese steel worsened further. The following three facts demonstrate the Fe surplus currently affecting the market:

- Steel production in China gained 11% y-o-y in January-February 2013, reaching 50% of the total global production for the first time ever;
- Apparent consumption of steel products in the country increased by 10% y-o-y in the same period;
- China’s PMI published in early April showed a drop of 14 points, reflecting Chinese consumers’ negative expectations from Q2 in general.

As a result, the leading investment banks and industry analysts started to update their short- and medium-term forecasts for iron ore as well as other raw materials, revising the change direction again.

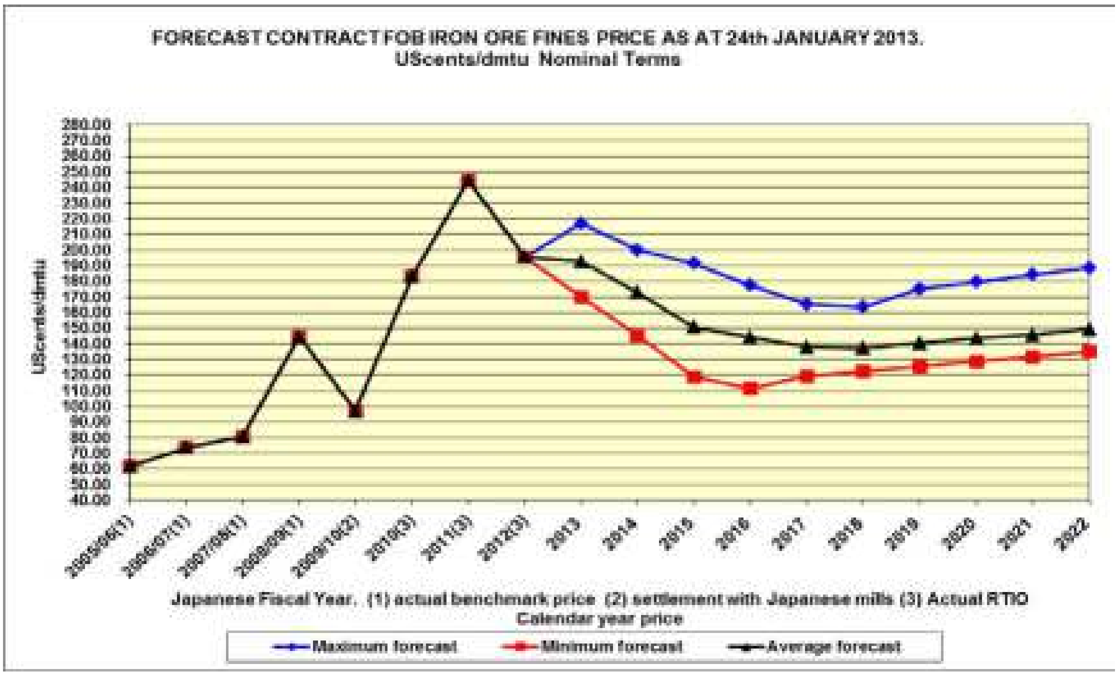
Several forecasts of iron ore price change prepared after the beginning of 2013 are provided below. Many analysts will update their forecasts by late April into May; Tennant runs its own mid to long term pricing model but has not updated its forecasts.

Figure 19-8: Tennant Metals mid to long term price forecast consensus.



Tennant Metals

Figure 19-9: The maximum and minimum assessment & the applied average trend line.



Tennant Metals

Figure 19-10: Global iron ore forecast by industry & financial companies .

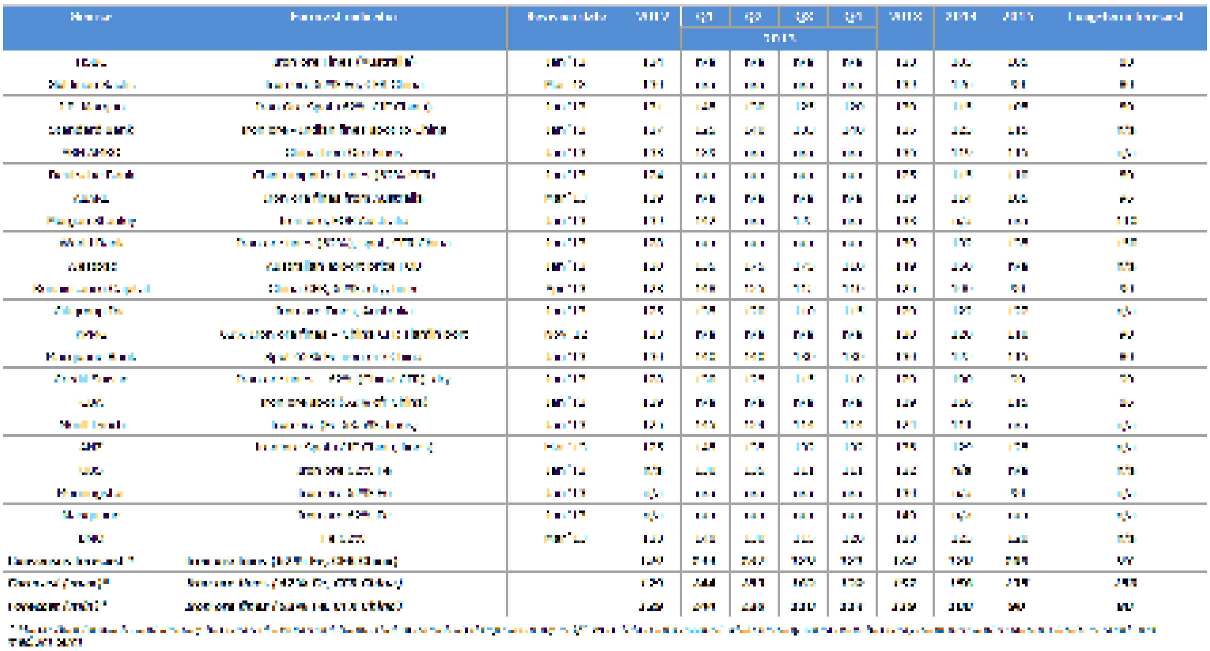


Figure 19-11: Forward iron ore swaps using FIS COB London prevailing bids.

Freight Investors Services.

Figure 19-12: Iron ore stockpiles at Chinese major ports Cal 12-13.

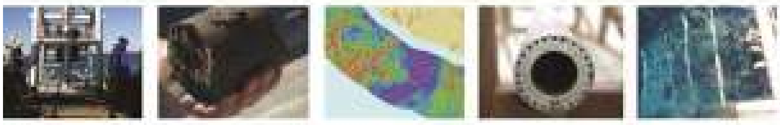
CLARKSONS

6. Technical Discussion TiFe (VTM) Concentrate.

6.1.Origins of New Zealand TiFe

Offshore titano-magnetite (TiFe) off the west coast of New Zealand's North Island, originates from onshore volcanic activity where the host rock contained 20% TiFe by weight. As the host rock is transported downstream by rivers, the rock is weathered and eroded. TiFe concentrates in mass in river beds that were once above the current sea level. This migration via the riverbeds deposited the TiFe in the surrounding Ocean's where further liberation of the TiFe took place. This finalised with concentration on beach lines, dune systems and paleo rivers.

Due to sea levels historically being much lower (less than 25 Metres around 9000 years ago, and less than 55 Metres lower 14000 years ago) old river systems (paleo river beds) and coast dune system now exist as the current sea bed.



6.2.TiFe Geology

TiFe grains are liberated from the host rock containing both phosphorus and alumina. A review of previous geological work has indicated that phosphorus (P) was contained in discrete apatite grains, and can thus be removed during beneficiation. However current metallurgical testing and pilot plants results have indicated that indeed the P is a part of the crystalline structure and that expected VTM concentrate will be elevated in P.

Alumina is partly contained in the spinal structure of the TiFe, and the alumina content can be lowered by ensuring that mixed grains are minimised

6.3.VTM Concentration Beneficiation

The beneficiation process has been ongoing via laboratory pilot plant work. The following appears to be the typical specification:

Figure 19-13: TTR's VTM Expected Typical Specification.

Iron Ore	TTR 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%

6.4.VTM Concentrate Use

VTM concentrates can be used as a primary iron ore feed or a blend for most traditional blast furnaces operations. Although there are some necessary operational adjustments required to avoid deleterious effects due to the elevated levels of Titania and other deleterious element in the VTM concentrate. These operational adjustments are well documented technically and do not typically required any significant investment from the steel maker.

Derived from past and current Value in Use Modelling on a robust and appropriate substitution within the pre sinter matrix Chinese steel mills can be economically incentivized to partially or completely substitute traditional ores with VTM concentrate. The economics of VTM concentrates become overwhelming in the case where the steel maker can recover Vanadium however it is debatable whether Chinese mills will offer a credit for the vanadium or whether it is held as a neutral credit to TTR (this will be one of the main marketing challenges and major focus for the future marketing effort). This Vanadium “by-product” (via scaping the top of a second BOF) does require additional processing to maximise this advantage. It must also be noted that high levels of VTM are needed in the blend to make this occur.

6.5.Technical constrains on VTM ores in blast furnace bases steel mills.

In September 2009, TTR engaged Hatch Bellows, an independent consultant with world class expertise in steel- making to replicate TTR’s VTM concentrate & confirm that TTR’s product can be used. The specification implied from 2009 to the current 2013 specification will have specific differences relative to each mills use on a substitution basis but the methodology of differencing blends will be the same and can be summarised as follows:

(a) A typical Chinese blast furnace can operate with VTM concentrates with minor productivity losses provided the operation parameterss of the blast furnace are correctly adjusted.

(b) In order to compensate for the productivity loss of the blast furnace, and without taking into account the benefits of recovering the by- products, an appropriate discount is required determined in part from VIU (see VIU) for the substitution of VTM’s to be economically indifferent .

(c) Any traditional blast Furnace can operate with a 3% to 5% VTM concentrate in the pre burden sinter matrix. The restraint is at the sintering stage with degradation in sinter strength caused by the elevated Titania. This blending range is known as a light blend and will bring customer diversification away from the dedicated VTM users & Buyers.

(d) With specific operational adjustments but no investment, a typical blast furnace can blend 20% to 40% of VTM concentrate in the iron ore feed. In this case, the Vanadium may be recovered at relative cost. The issue here is at what point mills see vanadium as a positive credit. This comes solely to negotiation as to where a mill has the capacity to actually recover the Vanadium. Dedicate VTM users such as Chende Steel & Vanadium have this capacity.

The exact tolerance for VTM concentrates in the iron ore pre burden matrix is a complex function of the global raw materials basket which is specified to each steel mill. Simplistically, for a conventional Chinese blast furnace, located on the coast and using mainly imported ores, the tolerance is 30% to 40% VTM concentrates in the iron ore feed. For land locked blast furnaces using domestic ores, the tolerance is 20% to 25% VTM concentrate in the blast furnace feed. This market is the "heavy blend" market and this is the primary interim conversion for steel mills that can adjust their operation running in a hearth re lining and driven by a reliable feed stock and competitive advantage

(e) With specific operational adjustments and investment significant modification can be made to shape and lining of the blast furnace to take 100% VTM direct charge material. This process needs to occur at design and forward engineering stage for new capacity coming on line or at a reline of the hearth lining of a Blast furnace which occurs every 15 to 20 years.

The technology to use a dedicated VTM feed was developed by Russian steel maker Evraz Holdings and was implemented by Nizhniy Tagil in 2006. Dedicated VTM can "mode" change between dedicated VTM and traditional direct charge feed where as a traditional Blast furnace cannot.

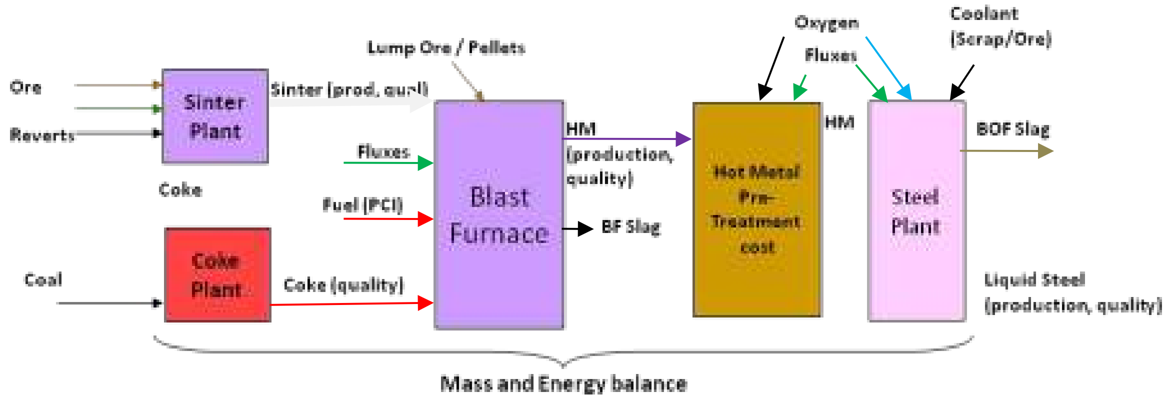
6.6.TiFe Concentrate Value In Use (VIU)

The Value In Use (VIU) describes the price point (or range of price points) where a steel maker will derive benefit from using a specific raw material. VIU model takes into account the whole steel making production process to ensure that the steel mill is cost neutral or better when switching to a new raw material.

The following factors impact VIU the most:

- Freight rates
- Coal (coke) prices
- Specific operating practises at the mill (dependent on raw materials qualities and operating philosophies)

Figure 19-14: Value In Use flow chart in steel production.



Tennant Metals

The trend to date in the market has been a rerating of lower quality iron ore products in particular fines and magnetite ore. It is expect that this will reverse over the coming years given the margin compression and lower profitability that has occurred in the steel industry.

Under this scenario Chinese mills would resort to optimizing their operations and focusing on quality of product. At this juncture the 'value in use' argument comes into play, which bodes well for those iron ore miners producing the best quality iron ore and not so well for those that currently benefit from strong pricing but actually sell an inferior product. Creative Process Innovation Pty Ltd conducted a Marx VIU model on the 28th of March. This took into consideration TTR concentrates as a small percentage ore replacement in a traditional blast furnace in which two scenarios compare a coastal Asian Steel Mill and a Chines Inland Steel Mill.

The following Scenarios were calculated as follows:

Comparison of the VIU of TTR product in a coastal Asian mill. VIU is US$/dmtu in plant. Premium calculated relative to Pilbara Blend Fines (61.50% Fe, US$2.07 / dmtu CFR North China). Slag alumina <15% in all cases.

Ore	Cost Cutting (Case 1)			High Productivity (Case 2)		
	VIU (US$/t)	VIU (US$/dmtu)	Premium	VIU (US$/t)	VIU (US$/dmtu)	Premium
PB Fines Nov 2012	$ 127.17	$ 2.07	100%	$ 127.17	$ 2.07	100%
TTR Cons	$ 104.32	$ 1.84	89%	$ 91.75	$ 1.62	78%
Taharoa Ironsand	$ 102.72	$ 1.79	87%	$ 90.95	$ 1.58	77%

Creative Process Innovation Pty Ltd

Comparison of the VIU for Trans Tasman Resources products in an inland Chinese mill. VIU is US$ / dmtu in plant. Premium calculated relative to Pilbara Blend fines (61.5% Fe, US$2.07 / dmtu CFR North China. All cases are run with floating slag alumina.

Ore	Cost Cutting (Case 3)			High Productivity (Case 4)		
	VIU (US$/t)	VIU (US$/dmtu)	Premium	VIU (US$/t)	VIU (US$/dmtu)	Premium
PB Fines Nov 2012	$ 127.17	$ 2.07	100%	$ 127.17	$ 2.07	100%
TTR Cons	$ 113.67	$ 2.00	97%	$ 115.34	$ 2.03	98%
Taharoa Ironsand	$ 110.84	$ 1.93	93%	$ 111.67	$ 1.95	94%

Creative Process Innovation Pty Ltd

Frome the above VIU analysis Creative Process Innovation Pty Ltd delivered the following finding:

Quote:
The highest VIU for TTR cons is calculated for inland Chinese mills under the high productivity operating scenario. This high VIU, almost equivalent to Pilbara Blend fines on a $ / dmtu basis, is due to the high MgO and Mn content on the TTR cons. The inland Chinese markets segment is less sensitive to the alumina content of raw materials. There are several negative factors, however, which cannot be quantified using the Marx VIU model but need to be considered in Technical Marketing of TTR cons. *Approximately 5% replacement may be the limit for TTR addition to the sinter blend based on the sinter TiO2 content. The VIU model calculates an increase in the TiO2 of 0.38%, which may increase sinter RDI by 9.5% based on published sinter quality relationship. This would be a concern to most iron makers, and needs to be measured by carrying out sinter pot test on the TTR cons.*

- *Iron makers limit the total alkali (Na2) plus (K2) load on their blast furnace to less than 1- 1.5kg / tonne hot metal. A 5% replacement of Pilbara Blend fines with TTR cons in sinter would increase the alkali load by 0.16 kg / tonne of hot metal. Depending on the Alkali load from other sources, this may be a concern for some iron makers and may limit the proportion of the TTR cons they will use in their blast furnace.*

- Considering only the effect of chemistry on the sintering process productivity and fuel rates, TiFe concentrates can be considered to be worth 15% discount to fines iron ore reference price if no optimisation is made. When TiFe concentrates are used in moderate quantities in a blend, the valuable Vanadium can be recovered from the hot metal as a by-product, and this significantly increases the value in the ore.

Higher usage amounts can increase the Titanium content in the blast furnace slag to economically recoverable concentrations, and this further enhances the value of the concentrate.

Unquote:

The author understand the Marx VIU uses a traditional single substitution basis and understands that the single substitution basis (Rio PB) is the way the BHP models VIU while I do not have an issues with this I would question further the "Robustness " of the results. I would also question the substitution of Pilbara Blend ores being one of the cheaper base loads of the pre burden sinter matrix. I would like to see alternative ores from Brazil and West Coast Indian ores as an example that price similarly to that of TTR VTM concentrates (West Coast Indian) to also be used on a substitution basis. There for as a continuation of the marketing effort and alongside further sinter pot test work a dedicated VTM VIU should be constructed and further alternatives should be substituted into the model.

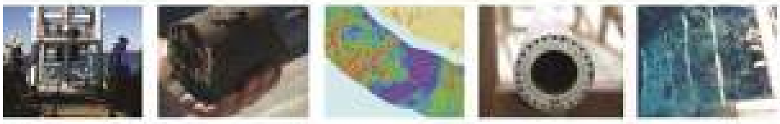
7. TTR VTM Pricing Methodology

The means by which TTR's VTM should be prices is relative in part to VIU and each specific off-take/sales agreement and will be different for fixed tonnes to that of spot. Many different pricing formulas exist with different outcomes. TTR already has an agreed pricing structure with its current off-take partner's and indicative ones via the current Letters of Intent. However for future negotiation the following should be taken into consideration.

TSI or Platts 62% basis should be used on head grade adjusted basis. TSI & Platts do correlate over the last few years with Platts being US$2 to US$3 higher than that of TSI however in 2013 this differential has narrowed with it currently differential being as little as $0.20 a tonne difference (as at 23rd of May 2013). The best means to price on a landed CFR basis is to use the indices via a head grade adjustment.

This head grade adjustment is a simple reconciliation of price to Fe units or Dry Metric Tonne basis from this any Fe unit can be priced. The formula for this is simple TSI 62% price / 62 = DMTU x TTR VTM head grade – applied discount. The use of Quotation Period (QP's) which is becoming more common in the iron ore market is the norm in the base metals industry where the month of shipment ("M") or M +1 Month of shipment plus one month) or M +2 dependent on the specific agreement. This QP methodology can be used against a hedge and can also be used as an "option" as part of price negotiations.

Figure 19-15: Historic Iron Ore Pricing one year actual.



Most Chinese buyers are currently wanting to buy fixed with the seller taking a floating price the price variability between the two is covered by an over the counter swap. There is current more and more liquidity in the swaps market now allowing physical tonnes to be covered.

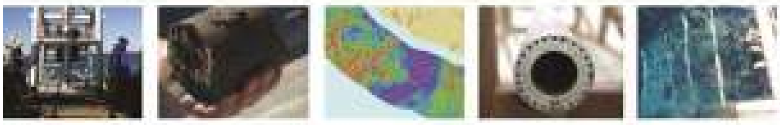
The implied discount will be relative to a variety factors and will be different for Dedicated VTM users and that of traditional blast furnace users they include but not limited:

- VIU outcomes relative to “light blend”, “Heavy Blend”& “Dedicated User”.
- New production asset (this discount can be clawed back over a period of time) and relates to reliability of supply mills adapting there hot metal production to consist supply but also consistent quality & grade.
- The current assumption that Phos will be 0.15% where traditional penalties kick in at between 0.09 % (PB fines) and 0.100%. Phos is an increasing element in future iron ore supply.
- The current assumption that Titania will be 8.40% for traditional blast furnace user is elevated but not as high say at Forge Mining’s Balla Balla deposit that has TiO_2 level of 14%. The implied discount for this is relative to traditional blast furnace user.

8. Customer Diversification.

The Chinese market is extensive and varied with many different sectors within the steel sector. Relative to this there are two types of buyers:

- Steel Mills.
- Traders.



8.1.Steel Mills.

Steel mills can be divided in three categories as follows:

- Tier one steel mills consist of mainly State Owned Enterprises (SOE) and large private mills that have import licenses and mainly deal on Long Term Contract (off-take) with the major miners. These are the base load customers of the steel industry.
- Tier two steel mills are relatively smaller SOE mills and larger private steel mills. These mills vary on whether they have an import license or not and are part reliant on either tier one mills selling imported ore or purchasing seaborne DSO from traders. They are also more reliant on domestic magnetite's.
- Tier three steel mills are producing less than 2 million tonnes and are mainly private steel mills that are normally totally reliant on others to supply their Seaborne iron ore requirements. They are normally dictated by domestic supply particularly if they are an inland mill.

8.2.Traders.

Domestic traders that are Chinese based and not internationally owned import a large quantity of ore and most have import licenses, or agreements with license holders. The smaller steel mills in the tier three categories or mills that do not have licenses depend in large part on the traders to supply their seas bore iron ore requirements.

Traders offer diversification of customer base and offer liquidity to mills that struggle to purchase cargo outright. The trader also offers the ability to divert tonnage to alternative buyers should a sector of manufacture stall or a particular buyer is unable to buy due to a force majeure event as an example.

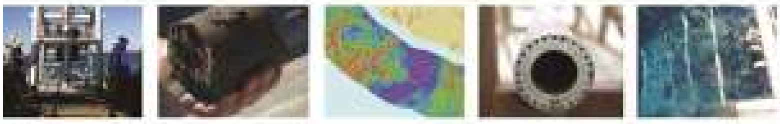
8.3.Customer ratios.

It is preferred for off-takes to be placed directly with dedicated TiFe users and larger non dedicated TiFe users. A proportion of this should also be placed with Chinese based traders to assist with customer and risk diversification.

9. Tennant Metals Pty Ltd

Tennant Metals is a diversified, Australian owned and Australian domiciled multi-commodity trading house. Tennant Metals, as one of Australia's oldest trading houses with an existence dating back to 1966, is the leading mid-tier trading company in this region.

Tennant has a significant foot print of offices in China, Taiwan, India and Turkey and domestic capability with the corporate office based in Sydney with the bulk commodity desk manages out of Perth, Western Australia.



9.1.Tennant Metals Strategic Benefits.

Tennant Metals strengths and strategic benefits are as follows:

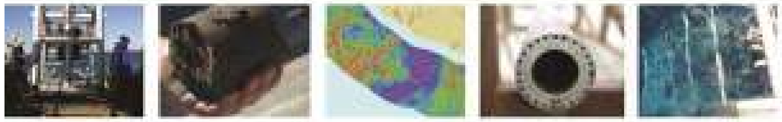
- Tennant Metals is the only Australian operated trading company that acts as principal in the vast majority of all its counterparty transactions, irrespective of the transactional magnitude hence offering low counter party risk.
- Tennant Metals maintains a mid-tier focus to the vast majority of its commercial relationships due to the cultural similarities which flow within this approach (it should be noted that TMPL does transact with many of the world's largest producers and end-using refineries, smelters and mills but our core relationships are with those companies below this particular stratosphere).
- Tennant Metals fully understands the Australian/New Zealand way of doing business and can ensure TTR has a smooth transition from an explorer to producer supplying the challenging Asian markets.
- Tennant Metals has treasury, corporate finance and logistical skills in-house which it will make available to its relationship partners.
- Tennant Metals has a comprehensive understanding of the international commodity landscape and is well positioned to assist it partners accordingly.

10. TTR & Tennant Metals Off-Take

TTR & Tennant Metals signed an off-take on the 31st of August 2009. This agreement allows Tennant Metals to secure 50% of all TiFe production for a 10 year period and an exclusive agreement to secure the first 5 million tonnes of production of TiFe concentrate.

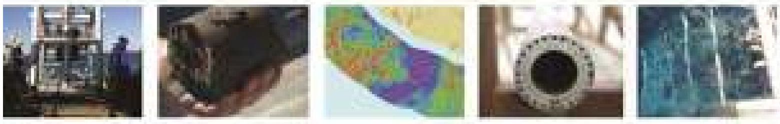
This approach was agreed to in order to facilitate a managed introduction into the Chinese market, minimising any conflict of effort from other interest parties. The issue of adopting a strategy of "more parties involved the better" is wrong and will devalue the cargo and the project. By allowing Tennant to develop the market as identified in this strategy paper TTR can control the deliberate development of the market. Having several parties competing with potential buyers/users have the reserves effect as a buyer will leverage better terms between the two parties.

Multi representation can lead to confusion in the market as different parties have different agendas hence the potential for misrepresentation can cause corporate as well legal issues.



11. Tennant's previous market development.

NN	Name	Type	Tonnage	Option	Duration	Suggested Price	Comment
1.	Rockcheck	Steel mill	2.0	0.5	15	TSI (58%) *(1-30%)	Off-take signed
2.	China Mining Association	Diversified Group	1.2	0.0	15	PLATTS 62% CFR*(1-30%) –(62-60)*Fe diff IODEX	Off-take signed
3.	Jiangsu Yonggang Group	Steel mill	0.5	0.5	8	PLATTS 62% CFR*(1-30%) –(62-60)*Fe diff IODEX – port discount	Update needed
4.	Shunshun Dvlpmnt	Steel mill	1.0	0.0	15	PLATTS 62% CFR*(1-30%) –(62-60)*Fe diff IODEX	Commercial negotiations ongoing
5.	Shanxi Jianbang	Steel mill	0.3	0.2	15	PLATTS 62% CFR*(1-30%) –(62-60)*Fe diff IODEX	Update needed
6.	Ningbo Iron & Steel Co. Ltd	Steel mill	0.3	0.2	15	PLATTS 62% CFR*(1-30%) –(62-60)*Fe diff IODEX	MOU sent out, waiting for response
7.	CCRE/Ocean Glory Enterprises Ltd	Diversified Group	1.0	0.0	20	PLATTS 62% CFR cents/dmtu ***Fe%***(1-30%)	MOU signed on CCRE side, price to be corrected as above
8.	Rizhao Wanbao	Trader	2.0	1.0	15	(PLATTS CFR 62 % USD/dmtu*(1-25%)	MOU
9.	Shandong Yaochang Group Co., Ltd	Steel mill	1.0	1.0	15	(PLATTS CFR 62 % USD/dmtu*(1-25%)	MOU
10.	Jangsu province Binxin Special Steel Material	Steel mill	0.6	0.0	15	(PLATTS CFR 62 % USD/dmtu*(1-25%)	MOU
11.	Beijing Jianlong Heavy Industry Group Co., Ltd	Steel mill	2.0	0.0	15	(PLATTS CFR 62 % USD/dmtu*(1-25%)	Off-take
12.	Qingdao Jiahe International Trade Co., Ltd	Trader	0.6	0.0	15	(PLATTS CFR 62 % USD/dmtu*(1-25%)	MOU
13.	Chengde	Steel mill	?		15	(PLATTS CFR 62 % USD/dmtu*(1-25%)	MOU
TOTAL			12.5	3.4			

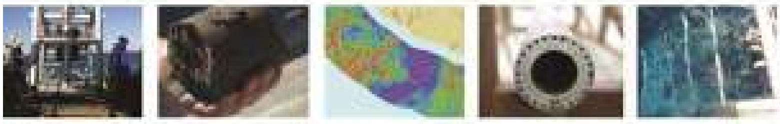


J

General Manager Bulk Commodities

Tennant Metals Pty Ltd

Date: 20th of May 2013



19.16 IHC Crawler Report

IHC Mining B.V.

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Date	Reference	Status	Taco de Boer
23 May 2013	M10.002	FINAL	

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)

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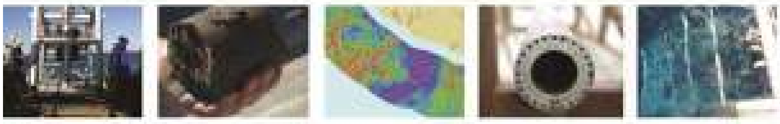

Date	Reference	Status
23 May 2013	M10.002	FINAL

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

Disclaimer

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Date	Reference	Status
23 May 2013	M10.002	FINAL

This document is dated 23 May 2013.

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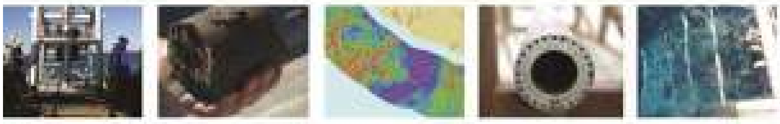

Date
23 May 2013

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M10.002

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FINAL

Content

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Date	Reference	Status
23 May 2013	M10.002	FINAL

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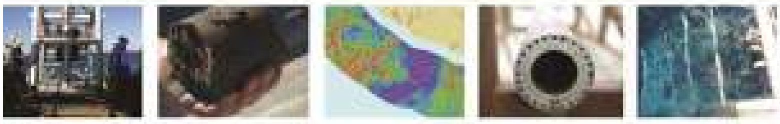


1 Executive Summary

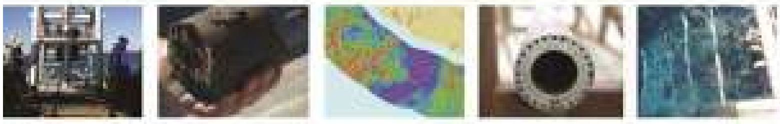
The Crawler Viability Workshop provided an opportunity for Trans Tasman Resources Limited (TTRL) to rapidly assess the key parameters and levels of confidence to deploy IHC Merwede's technology for iron sands mining in New Zealand. Both parties understood that within a limited timeframe there was a need 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.

TTRL Question 23 April 2013
Please elaborate on the assumption of rolling stones on the seabed?

IHC Response 25 April 2013
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.

TTRL Response 30 April 2013
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.

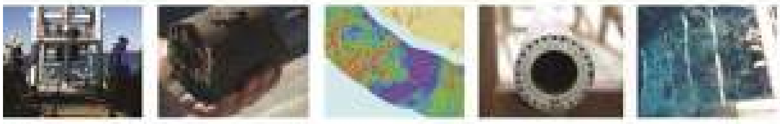
The basis for the concept is a tracked vehicle with a submersible dredge pump and slewing boom configuration. The concept is based on many years of experience of the mining and dredge processes, and the designing of offshore mining/dredge systems, submerged pumps, dredge components and subsea tracked 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:



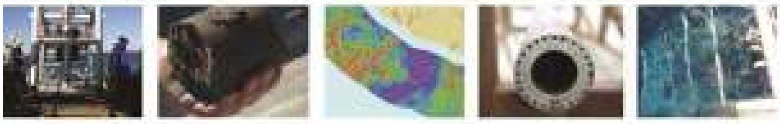
- a track system;
- the slewing boom configuration with the suction head and the slurry system;
- and lift wire, umbilical and riser connection.

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 +6m . 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.

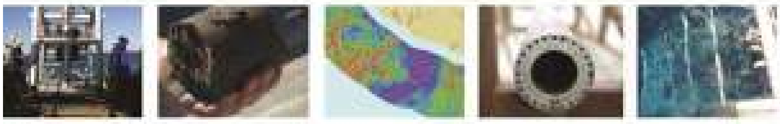
4.1.4 Suction head

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.

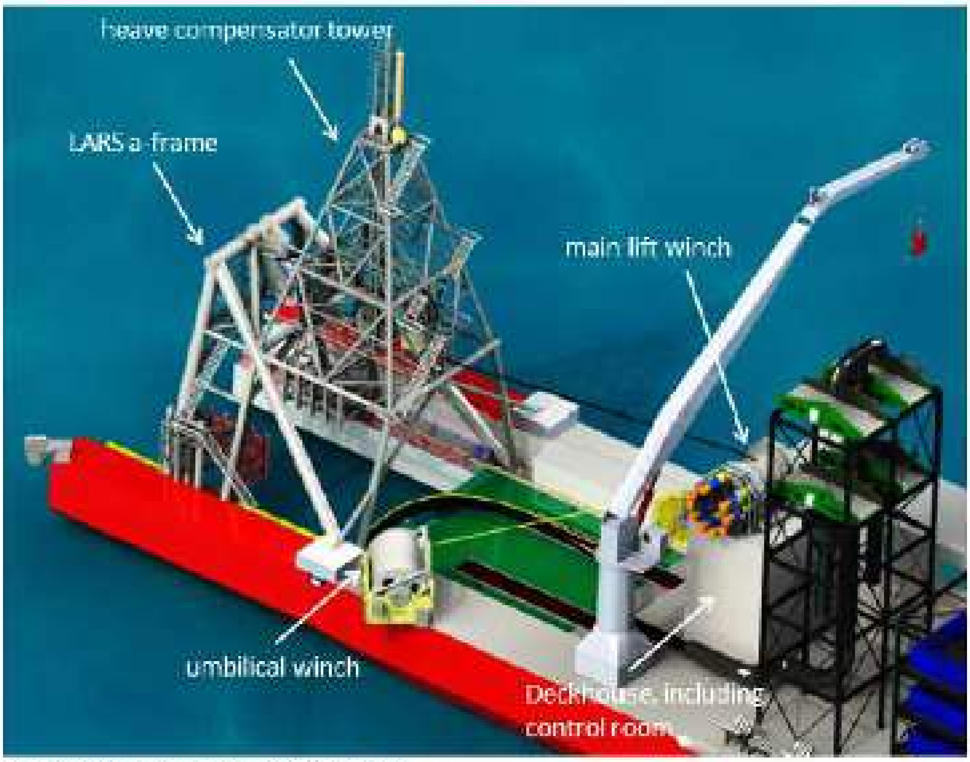


Figure 4-4 Typical isometric view of a MSV aft deck layout.

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.

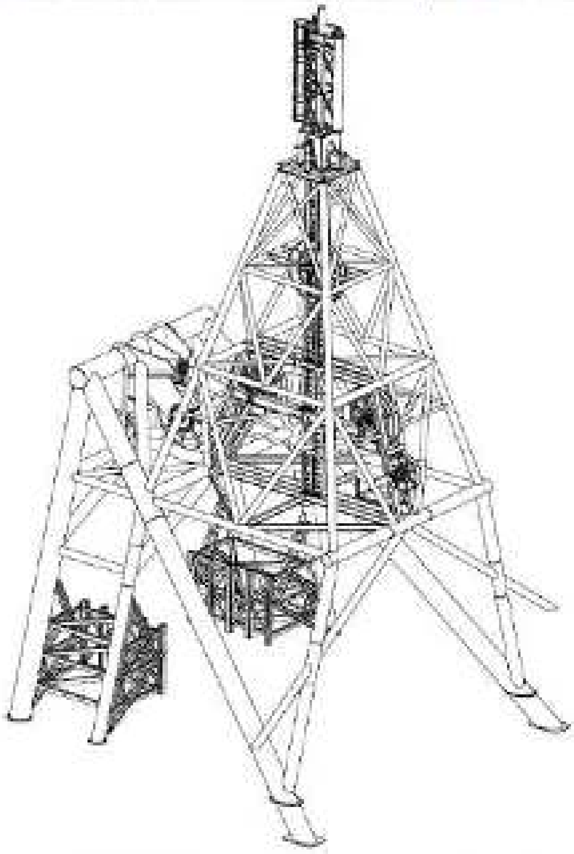


Figure 4-5: Typical isometric view of an A-Frame and Heave Compensation Tower

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:

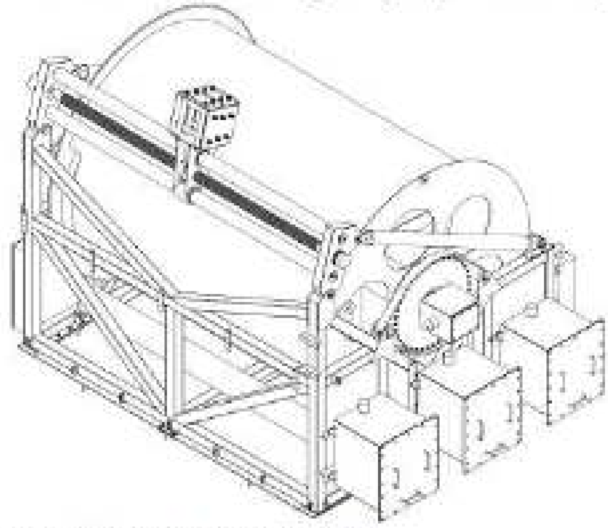


Figure 4-6: Typical isometric view of an Umbilical Winch

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.

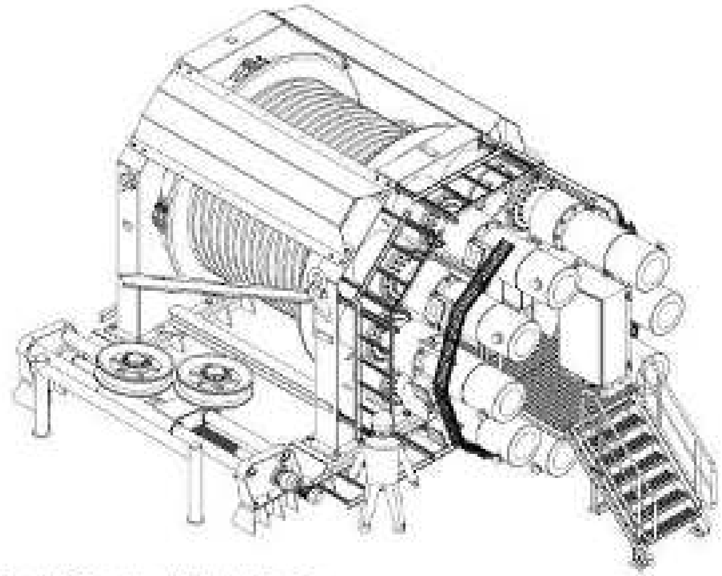


Figure 4-7: Typical isometric of a Main lift winch.

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.

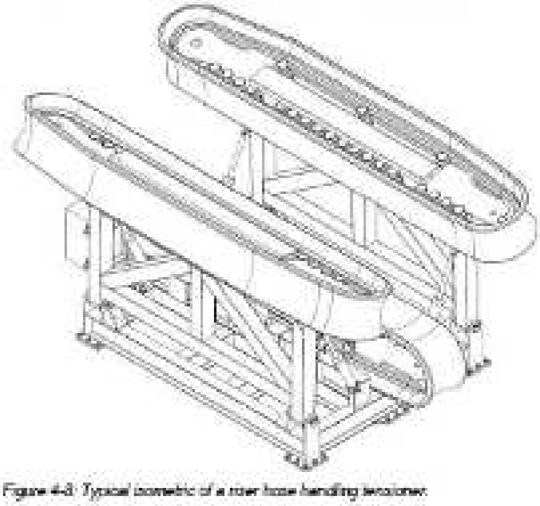


Figure 4-8: Typical isometric of a riser hose handling tensioner.

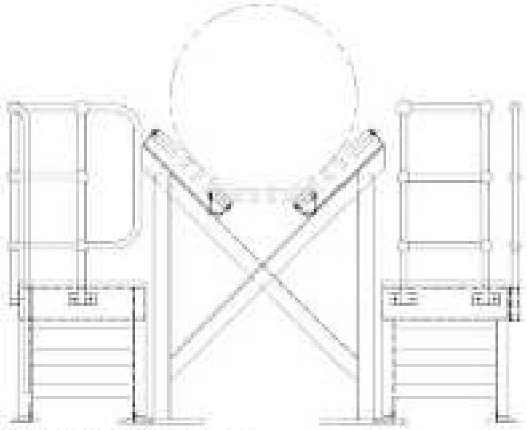


Figure 4-8: Typical Riser train layout.

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

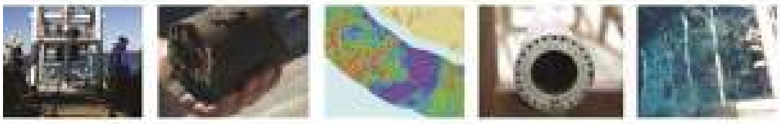
All figures in this table are based on field experience for the availability and efficiency under similar circumstances as the TTRL operation. However each operation has its own characteristics and all steps in the specific overall logistic mining chain will have their own availability and influence 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.

<u>TTRL Question 23 April 2013</u>

Are we not double counting with Mining system availability and Mining Efficiency?

<u>IHC Response 25 April 2013</u>

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.

<u>TTRL Question 23 April 2013</u>
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.

<u>IHC Response 25 April 2013</u>
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.

TTRL Response 30 April 2013
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.

IHC Response (email to Andre Mouton) 1 May 2013
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).

TTRL Question 23 April 2013
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.

IHC Response 25 April 2013
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.

TTRL Response 30 April 2013
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.

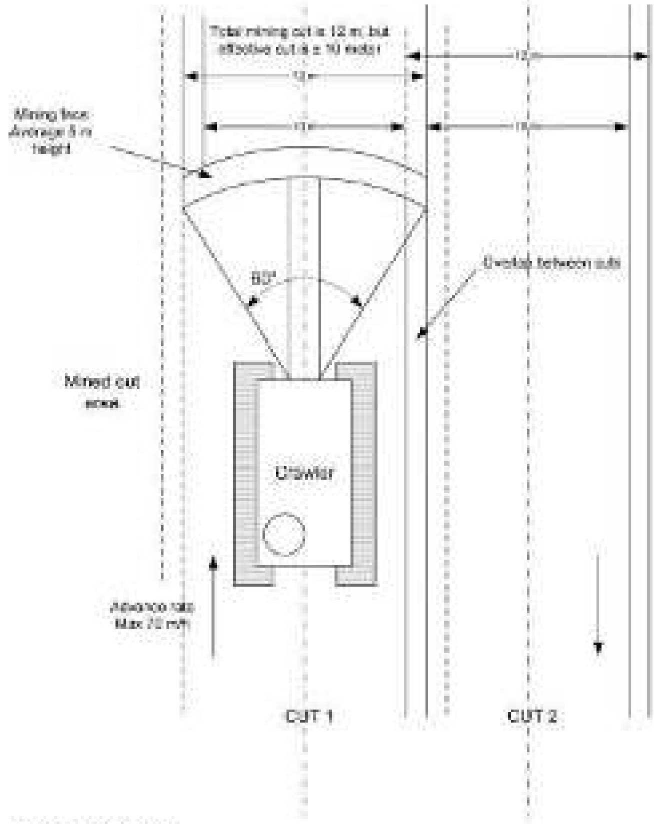


Figure 5-1 Mining lanes

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 m^2 (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.

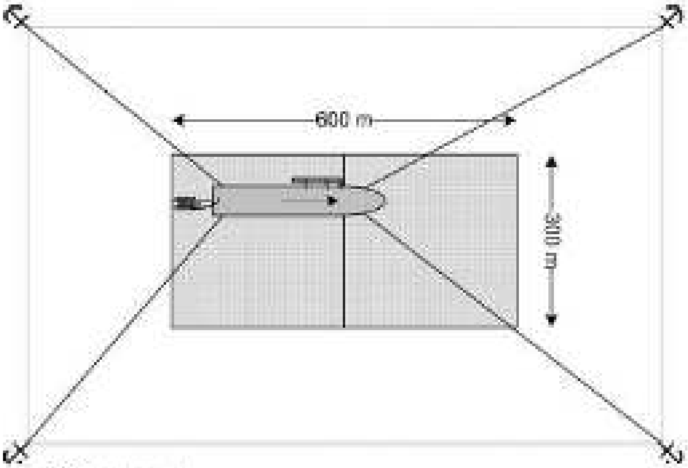


Figure 5-2: Anchor spread

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.

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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.

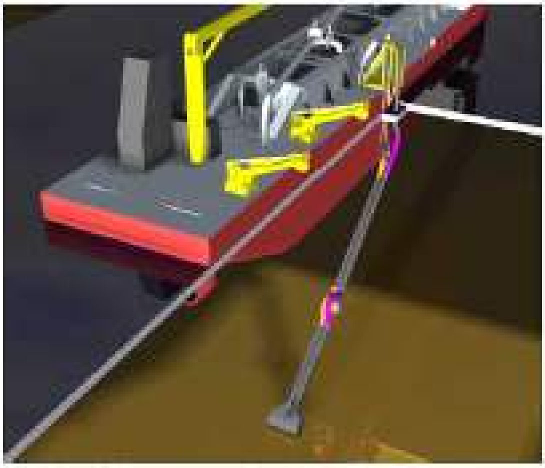


Figure 5-5: Modified suction tube of TSHD

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.

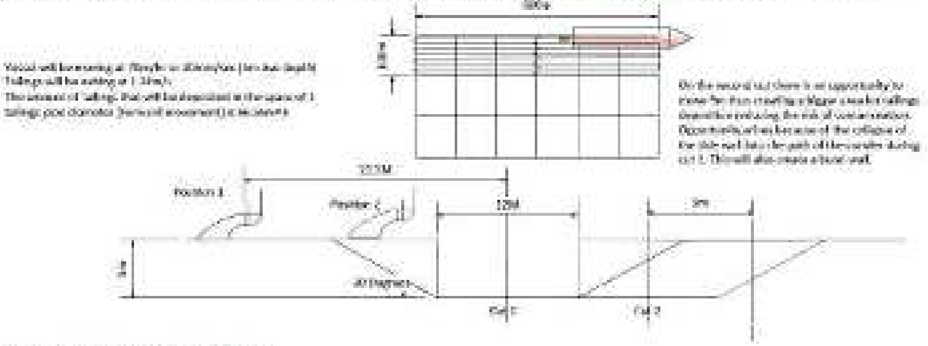


Figure 5-6: TTRL Mine & Tailings Plan

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.

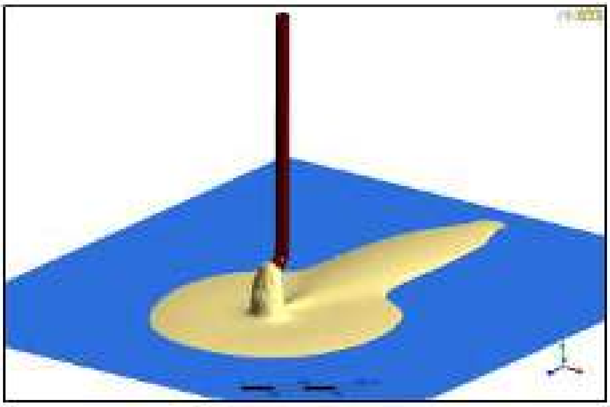


Figure 5-7: Dispersion of tailings

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.

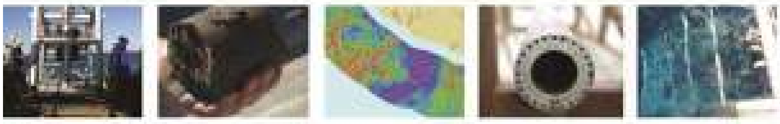
The TSHD and crawler systems were found to be the best two options for TTRL's mining operations. The TSHD comprises different capabilities than the crawler. Main differences between the two systems include: scalability, tailing dispersal, operation logistics, and mineral processing. The TSHD is easily 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.

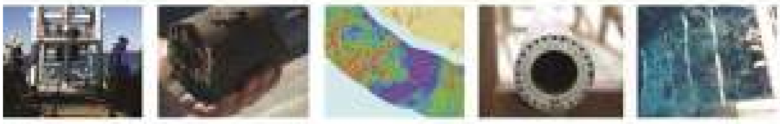
6.4 Risks / opportunities / mitigation

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.

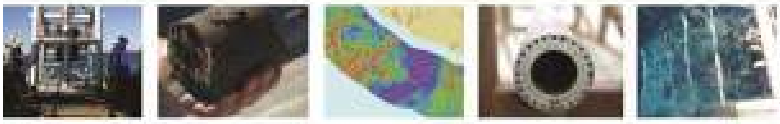
Due to the limited time and no allowance for engineering all prices are based on estimates and assumptions from previous projects.

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



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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

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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.

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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

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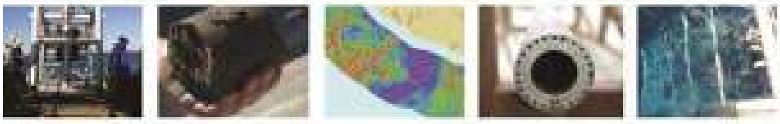

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<u>TTRL Question 23 April 2013</u>

Should the CAPEX cost of crawlers be less? We only need a 3rd crawler not 4.

> <u>IHC Response 25 April 2013</u>
>
> 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

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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.

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Appendix A: Pre-Workshop Terms of Reference TTRL

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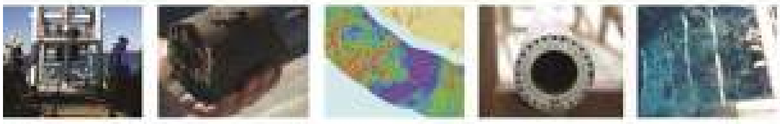

TERMS OF REFERENCE

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 $\leq$ 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 $\geq$ 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		

TERMS OF REFERENCE

TTRL/IHC Viability Workshop 2 – 12 April

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.

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Appendix B: Vuijk Report on Mooring and DP

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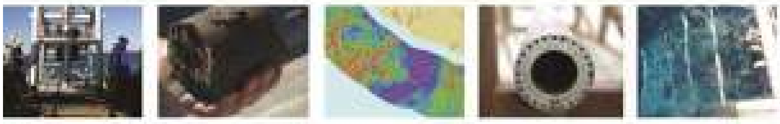


VUYK ENGINEERING ROTTERDAM

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

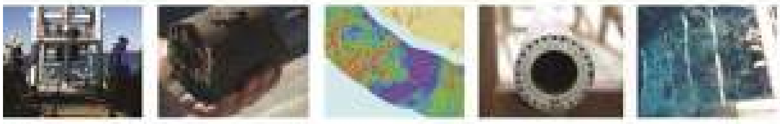
Mooring layout

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 1[st] 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:

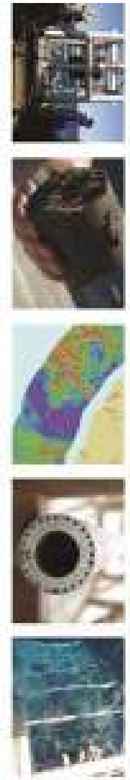
	250 m vessel	300 m vessel
DP Thrust [kN]	851.8	1024.1
DP Power [MW]	5.32	6.40

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 (1st 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

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

		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

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	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	3300	m³/h

Output figures

Description	m3/h	t/h	m3/y	t/y
Production in situ	3300	7960	14.343.190	37.930.625
True solids production delivered	2013	6441	9.703.769	31.052.061
Production water	1277	1419	6.639.421	6.838.604

Cv true solids in situ	59,38%
Cm true solids in situ	81,95%
Check volumes	Ok

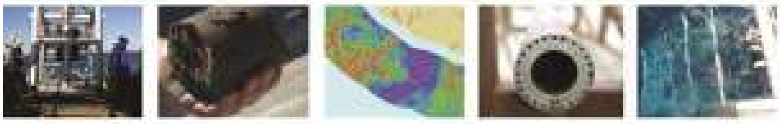
PUMP PRODUCTION

			critical vel
Diameter discharge pipe dredge	800	mm	
Diameter suction pipe dredge	800	mm	
Mixture velocity in discharge pipeline	6,50	m/s	4,21 m/s
Mixture velocity in suction pipeline	6,50	m/s	4,21 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	0,38		
Mixture density in pipeline	1,401	t/m3	

Output figures

Description	m3/h	t/h	m3/y	t/y
Production in situ delivered	3300	7960	16 343 190	37 800 683
True solids production	2013	6441	9 703 769	31 052 061
Production water	9758	10051	47 043 419	48 456 721
Total mixture flow	11771	16492	56 747 188	79 508 782

Cv true solids	17,10%
Cm true solids	39,06%
Cv in situ (del)	28,00%
Cm in situ	47,69%
Check volumes	Ok



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Appendix F: Crawler Potential Upside Production Assessment

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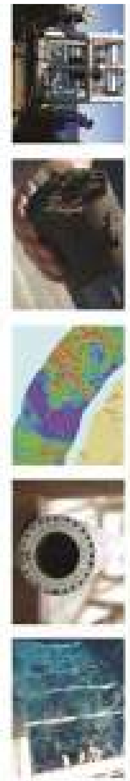

Base Case: Single Crawler with 800mm ID Slurry Delivery Line

Rev.: 0

25-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 Regulations are adhered to. Note: The 15 day allowance assumes no dry docking or port call for unforeseen breakdowns.
Maintenance	days	20	20	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 20 days per annum should be made for regular maintenance. This includes weekly maintenance of the crawler on deck and swapping out the crawler in port once per annum. Note: This 20 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 the consequences of any downtime related to concentrate transhipment, 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 related 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		93%	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 operation.
Total effective production time	days	201	248	259			
	hours	4821	5949	6208			
		55,04%	67,91%	70,86%			
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 believes 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	6208			
	tph	5447	6870	9908			
	tpa	21,050,836	40,867,187	61,482,062			

IHC MERWEDE

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Appendix G: MTI Report: Rapid assessment of TTRL-tailings

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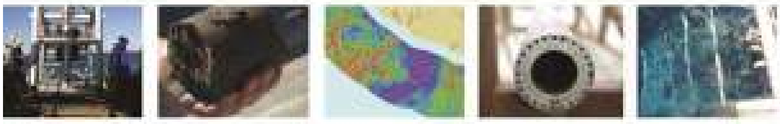


MTI Holland B.V.

Memo

To
T. de Boer

From
A. Ortega
Z. Sulaiman

Copy to
E. Munts

Date	Reference
April 12, 2013	M013-303

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.

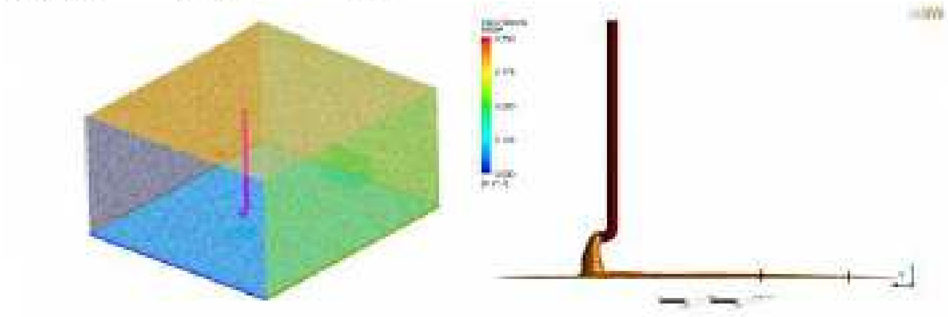


Figure 1 Computational domain and model set up

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.

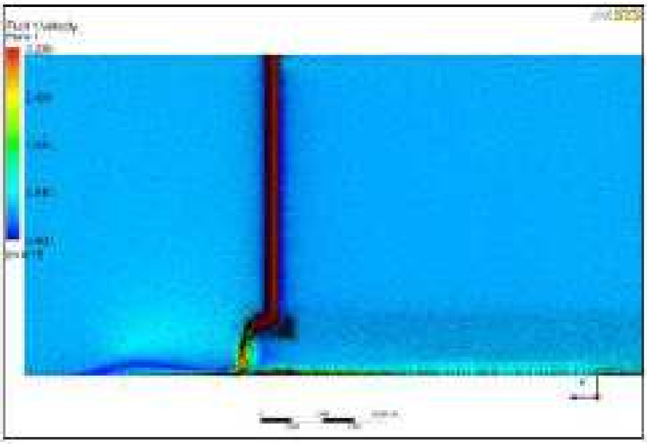


Figure 2 Tailings return near-seabed. Velocity magnitude and direction

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.

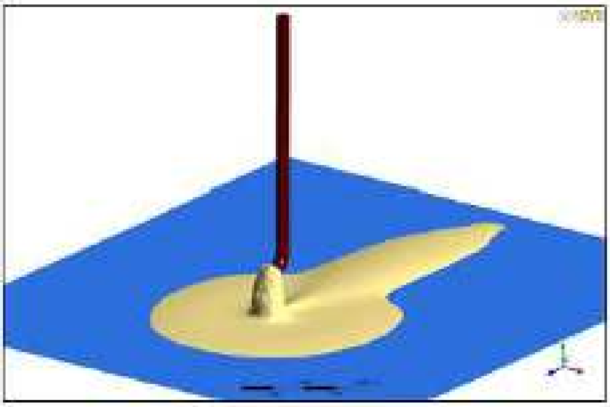


Figure 3 Sediment dispersion around the pipe and near-seabed

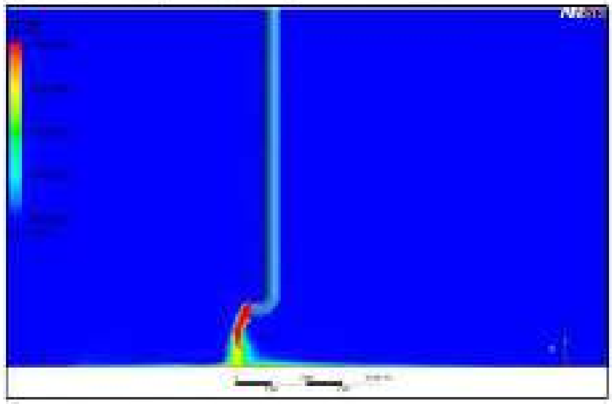
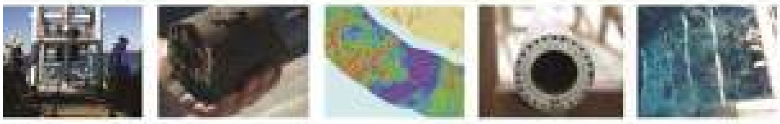


Figure 4 Density field pipe outflow and near-seabed

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.



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Appendix H: Post Workshop – MTI Plume Modelling Report

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19.17 MTI – Dredging and Tailing Management

MB-094

TTRL Iron Sands Dredge Mining Concept Study

Client	:	TTRL
Order number	:	55062
Report date	:	30-8-2011
Keywords	:	TTR Iron sands
Prepared by	:	Hanraets, P
		Higler, R
		Paauw, J

Date
30 August 2011

Quality control

This report has been reviewed and approved in accordance with the policies of MTI Holland BV.

Prepared:	P. Hanraets	Signed	Date 30 August 2011
Reviewed:	R. Higler	Signed	Date 30 August 2011
Approved:	S. Wezemer	Signed	Date 30 August 2011

Disclaimer

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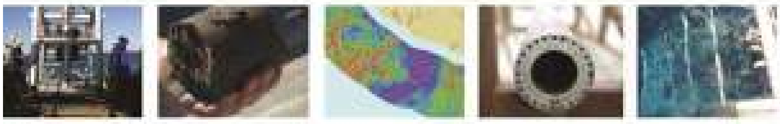
This document is dated 30-8-2011

Date
30 August 2011



Date
30 August 2011

Abstract

MTI intends to provide an unbiased comparison of dredging methods for dredge mining iron sands from the southern TTRL tenements. Numerous dredging options were evaluated with the aid of a weighted multi criteria analysis. It followed that a trailing suction hopper dredger (TSHD) and a plain suction dredger (PSD) would probably yield the most successful dredge mining concepts. After further elaboration and production calculations it is concluded that a PSD based option is not economically feasible compared to a TSHD based option. The soil is harder packed than initially anticipated which limits breaching- and therefore dredge production. This in term requires a large number of vessels to meet TTRL's production requirements. It was concluded that application of permanent floating and sinker dredging pipe lines is not possible due to ambient conditions. This requires that sediment, waste, and concentrate transport should be performed by barges. Mooring vessels to each other or to rigid structures should be avoided at all times under the wave climate present. Therefore position of barges and TSHDs in relation to the FPSO should be kept with the aid of dynamic positioning.

	€/yr	€/tds TiFe
Operational expenditure PSD	125,710,353	13.2
Exploitation cost PSD	204,082,512	21.4
Operational expenditure TSHD	59,707,188	7.59
Exploitation cost TSHD	91,425,652	11.62

Operational and exploitation cost estimates of PSD and TSHD compared (not including processing- or overhead related costs)

Application of an ROV dredger has been considered as well. The South Taranaki Bight has complex bottom topography, and includes areas of shoaling at water depths as little as 15-20 m, up to 35 km offshore [ref. 8] which is unfavourable for the use of ROV's. Launch and recovery of an ROV large enough to facilitate sufficient sediment production will prove difficult under the ambient conditions present. The expected increase in workability over a standard TSHD (approximately 20%) will be undone for the largest part by the lower mechanical availability of a ROV dredger. A (modified) TSHD can most likely be applied with success. However large ocean swells and strong currents will prove difficult to handle especially when it is not possible to sail perpendicular to the swell direction. It should not be overlooked that a sea state with H_s of 2.5 m in South Taranaki Bight cannot be compared to a sea state with H_s of 2.5 m in the North Sea, because of different wave periods. It is expected that large benefits can be obtained by modifying a TSHD with one or several options as proposed here under paragraph 3.3.4.

Date		
30 August 2011		

1 Introduction

Trans-Tasman Resources Limited (TTRL) is a privately owned New Zealand company with the ambition to provide Asian markets with a reliable supply of low cost iron ore. TTR has obtained a prospecting permit granting exclusive mineral rights over 6319 km2 of seabed located off the west coast and 3319 km^2 located off the south coast of the north island of New Zealand. TTR has completed an aeromagnetic survey covering a large portion of its tenements and has successfully deployed a series of shallow drilling campaigns. Over 150 core samples of the seabed have been collected to date and a JORC compliant mineral resource of a significant scale is being finalised by an independent geological consultant, Golders Associates.

The maiden non-JORC compliant mineral resource, based on an independent report by Fugro Geophysics, is currently equivalent to at least 4000 MTon of concentrate @ 60% Fe in weight. This initial mineral resource is based only on a portion of the tenements of TTR and is expected to increase substantially as the exploration program unfolds. The mineralogical and chemical analysis performed on the seabed samples reveals the presence of large amounts of titano-magnetite (TiFe) in the sediment. Initial beneficiation test work indicates that TTR should be able to obtain a good quality TiFe concentrate with Fe grades from 58%-61% using a combination of gravity and magnetic separation (no crushing required). The typical TiFe concentrate contains 60%Fe, 7%-8% of TiO2 and ~0.55% of V2O5 and is similar to the TiFe concentrates used in the Sichuan province in China and by a number of dedicated TiFe steel mills. The benefits of using TiFe concentrates for a Chinese steel mill could be very substantial, given the opportunity to recover the valuable by-products (vanadium and titanium oxides) as well as the potentially high discounts which could be provided for these types of low cost ores compared to traditional Australian ores. The scale and quality of the resource is such that TTR can supply any volume of production to a partner steel mill customer for the full life of the steel making plant.

Figure 1: Southern TTRL tenements

The present study aims to present TTRL with the most promising concepts for dredge minging TiFe sediment from the southern tenements (figure 1). A stationary and a free sailing solution are investigated and production- and cost estimates are made. The processing plant and storage facilities will be based on a floating production, storage, and offloading unit (FPSO). Design of the concentrate processing plant is outsourced to Technip and is excluded from this study.

1.1 Scope of work

This study is limited to the dredge mining part of the TTRL iron sands project. In essence the removal of sediment from the TTRL tenements and transporting it to a FPSO or primary sediment buffer with an average capacity sufficient to produce 6 MT TiFe concentrate per year.

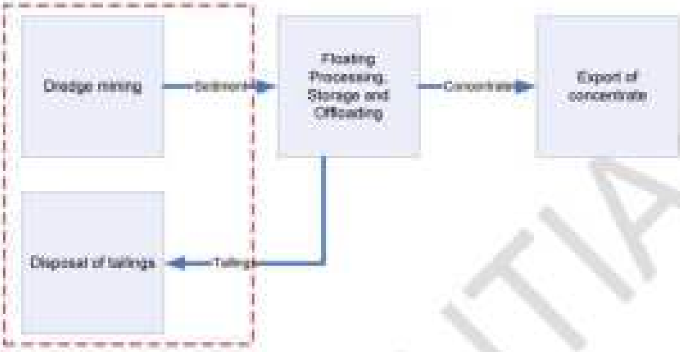


Figure 2: Iron sands mining operation. The scope of this report is limited to the processes inside the red rectangle

MTI intends to provide an objective and accurate technical- and economical analysis of a stationary- and a free sailing dredge mining method. Concepts of both these principal methods will be presented and analyzed in terms of technical feasibility for both alternatives. The most promising alternatives will be developed up to concept stage. This entails providing:

- Approximate dimensions and tonnage of the equipment
- CAD sketch of the concepts
- Diameters of slurry pipes and, if required, dimensions of hopper space
- Indication of installed power
- Estimate of production capacity and dredging efficiency
- Operations per dredging cycle and cycle time
- Estimates of workability and availability
- Capital- and operational expenditure analysis

After concept development and analysis conclusions and recommendations will be made regarding the most promising concepts to develop further and how to proceed to a feasibility design stage of the TTRL dredge mining operations.

2 Available project data

2.1 TTRL tenements

TTRL has completed an aeromagnetic survey of its tenements in 01/2010. The iron sands are very magnetic and clear Palaeolithic geological features, (beaches, rivers, dunes) are obvious. The survey covers over 4000 km2 and shows a large concentration of iron sands over massive areas. Over 150 seabed samples to a depth of 5 m were collected by TTRL. The straight average for the concentration of iron sands in the sediment of all the core samples is approximately 12%. The economic volumetric cut off grade is estimated at 6% concentrate, but 8% is conservatively used for mineral resource definition.

Cut off grade (%Magnetite)*	Depth Slice	Volume at Cut off (m^3)	Average grade contained within volume (%Magnetite)	Estimated Bulk Tonnage (metric tonnes) Density=2.4 t/m³	Estimated Tonnage of magnetite (metric tonnes)	Estimated Contained tonnes of Fe based on stochiometry ratio of Fe_3O_4	TiFe tonnes @ 60% Fe content
[illegible]	0 to 5m	[illegible]	8.2	[illegible]	[illegible]	[illegible]	[illegible]
10	0 to 5m	[illegible]	14.7	[illegible]	[illegible]	[illegible]	[illegible]
15	0 to 5m	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	0 to 5m	[illegible]	25.8	[illegible]	[illegible]	[illegible]	[illegible]

Table 1: Resource estimates of the southern TTRL tenement as function of cut off grade. [Ref. 1]

TTRL has indicated that the current concept design study should be based on mining the southern tenements. Mining area "Xantia" located on the 12 nm territorial waters border was used to serve as a representative design case. This Mining area follows a paleo-river with high TiFe grades running approximately to the south west.

Property	Value	Unit
Minimum depth	-18.00	m
Latitude of center	39°55'20.37"	° S
Longitude of center	174°18'32.09"	° E
Maximum depth	-35.00	M
Average depth	-27.70	m
Perimeter	28.30	km
Area	24.76	km2
Average sailing distance to FPSO	9.20	nm
Average mineable stratum >12 nm	13.0	m
Average mineable stratum < 12 nm	8.0	m
Average Tife grade <12 NM zone (Xantia)*	8	% wt
Average Tife grade >12 NM zone (Xantia)*	23.75	% wt
Average TiFe grade*	11	% wt

Table 2: Specifications of mining area "Xantia"

From table 1 it can be concluded that TTRL possesses sufficient TiFe resources to continue operation for multiple decades. Therefore it will be beneficial to use customized dredge mining solutions as, in general, these will yield lower operational costs compared to standard dredging vessels.

*Based on grade values X002 – X039 from "20110729_TIFE_minmasPV.xls"

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30 August 2011

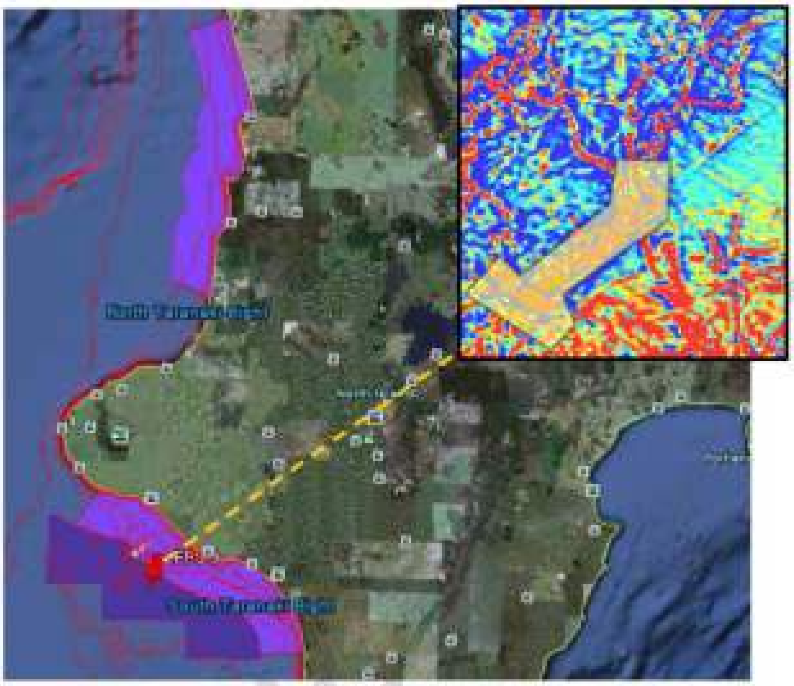


Figure 3: TTR tenements. Insert: Magnetics of mining area "Xantia" located on top of a paleo-river with high TiFe grades.

Since no specific dumping area has been indicated to dispose the waste (sediment with concentrate extracted) it is proposed to use deeper waters in between FPSO and mining area Xantia.

2.2 Soil mechanical properties

Three principle aggregates are encountered during the dredge mining part of the project which are:

- Concentrate:
  The typical TiFe concentrate contains 60%Fe, 7%-8% of TiO_2 and ~0.55% of V_2O_5 TiFe.

- Sediment:
  Soil containing the concentrate. Sediment in the TTRL tenements typically contains 8-30% wt of concentrate.

- Tailings:
  Waste product consisting of the sediment with the concentrate fraction extracted

Based on the geology of the southern tenements it was expected that the paleo rivers contain well graded relatively coarse soil. This is confirmed by the sample descriptions and particle size distributions made available by TTRL [ref. 2, ref. 3]

2.2.1 Density

For the dredge mining concepts described in this report the following grain- and bulk densities where used:

Property	Value	Unit
Bulk density concentrate	2.36	t/m3
Particle density concentrate	4.72	t/m3
Bulk density tailings	1.57	t/m3
Particle density tailings	2.73	t/m3

Table 3: Grain- and bulk densities [ref. 3]

The in-situ densities depend heavily on the weight percentage of TiFe present. Golders [ref. 4] has provided the following approximations valid for the southern TTRL tenements:

Property	Value	Unit
Dry density, compacted	1.803 + 1.063 x % wt TiFe	t/m3
Wet density, compacted	2.210 + 1.046 x % wt TiFe	t/m3
Particle density	3.049 + 1.653 x % wt TiFe	t/m3

Table 4: Dry and wet in-situ sediment density

Considering nearby recorded SPT-values [ref. 2] and the geology of the area it is assumed here that the in-situ sediment density can be approximated by the wet compacted density.

2.2.2 SPT values

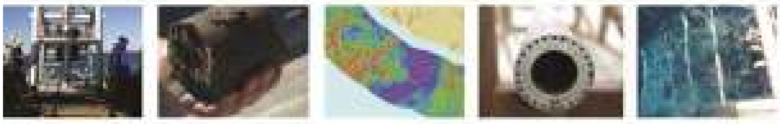
The SPT values mentioned in report '070606 Report on Geotechnical Survey Work" (table 2 on page 10) [ref. 2] are N1.70 values which are corrected for submergence and overburden. The correlations used by IHC to derive the angle of internal friction and the permeability are based on N1.60 and therefore the N1.70 values are normalized to a 60% blow efficiency by:

$$N_{60} = N_{70} * 70/60 \quad [1]$$

This results in higher SPT values as shown in the table below.

Depth [m]	N under water	0.83	(N)70 abov	(N1)70	1.167	(N1)60
0	16		13	13		15
1	26		22	22		25
1.5	33		27	27		32
3	>50		50	50		58
5.8	60		50	50		58
8.8	13		11	11		13
11.8	31		26	26		30
14.8	>50		50	50		58
17.8	>50		50	50		58

Table 5: SPT values as function of depth



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30 August 2011

Based on values found at the Momoho well site [Ref. 2] it was assumed for the TSHD production calculations that the top 2 meters of sediment in mining area Xantia has an SPT N_{60} value of 24. This classifies the soil as medium dense to dense. The deeper layers (2m<layer depth<13m) are assumed to have an average SPT N_{60} value of 58 which can be classified as very dense soil.

For the PSD option an average SPT N1.60 of 41 is used over the whole height of the breach. This corresponds to a SPT N1.70 value of 35.
Since at present only one SPT measurement has been recorded these values should be treated with care.

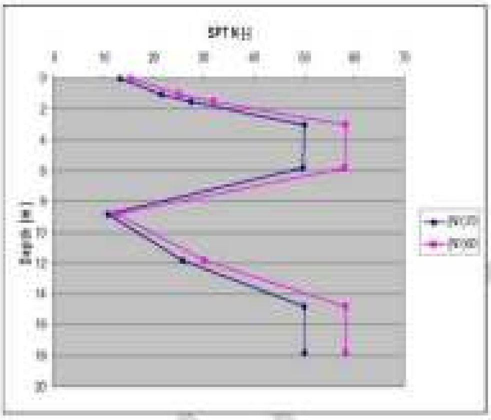


Figure 4: SPT values over depth

2.2.3 Particle size distributions

Based on an average concentrate content of 15% a particle size distribution as pictured in figure 5 was found.
The soil encountered is well graded with a significant coarse fraction. In several cases some silt was encountered as well. D_{50} was found to be 0.356 mm. MTI classifies a D_{50} of 0.236 mm as "medium sand" and 1.304 mm as "coarse sand" [ref. 3]

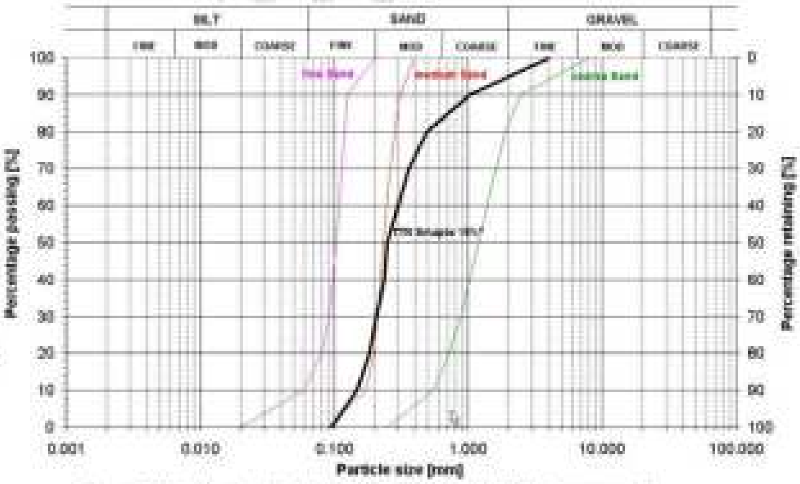


Figure 5: Particle size distribution of sediment with 15% wt concentrate.

D_m is an average grain diameter and is calculated as:

$$D_m = \frac{D_{10} + D_{20} + ... + D_{90}}{9} \qquad [2]$$

2.2.4 Angle of internal friction

For the correlation between SPT and angle of internal friction many correlations exist. A relation for N1.70 is given in the report '070606 Report on Geotechnical Survey Work" which is based on work by Bowles et al. Within IHC the correlation of Miedema is used which is based on N1.60 and also takes into account the influence of the grain shape. Angular grains have a higher angle of internal friction than rounded grains. In this report the correlation of Miedema is used. The sensitivity of the production calculations for the internal angle of friction is investigated for the stationary option by using sub rounded and very angular grains.

2.2.5 Permeability

In the literature many correlations are available for D10, D50, D60/D10 and permeability. The relation of Beyer is used since this relation also takes the SPT values into account. For determining the permeability a D60/D10 of 2 and a D10 of 150 μm have been used.

2.3 Wave climate, wind, and currents

2.3.1 Wave climate

The wave climate at both TTRL tenements can be considered harsh. From Argos satellite measurements [ref. 5] the year-average significant wave height (H_s) over 1993 to 2005 is approximately 2 m.

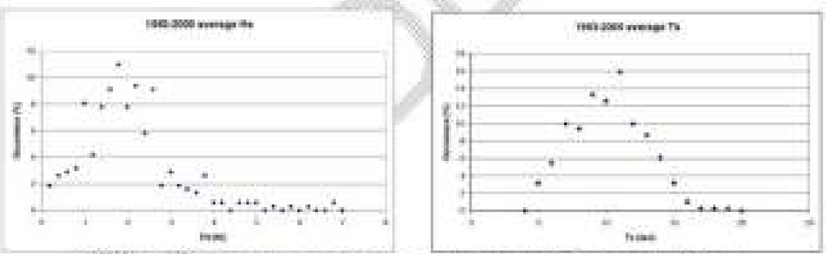


Figure 6: Significant wave height H_s (m) (left) and period Tp (s) (right). [ref. 5]

Swell direction ranges from south to northwest but is predominantly from the south west.

2.3.2 Wind

Wind direction is predominantly from the west. On average wind speeds of 15 knots are to be expected however the region is prone to 30+ knot gales. Over the years 1960-1980, some 22 tropical cyclones passed over or near the South Taranki Bight [ref.6, 8]

2.3.3 Currents

Ocean currents in the South Taranaki Bight will be predominantly from the North West, typically around 0.2 m/s. Tidal currents are more powerful, frequently with velocities over 0.3 m/s to the North West with rising tide and south-east with falling tides.

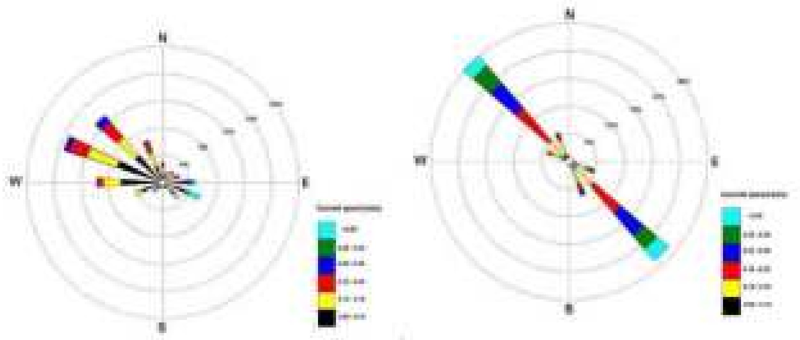


Figure 7: Ocean currents (left) and tidal currents (right) [ref. 8]

Extra: Wave induced currents

Considering the relatively shallow mining areas and high swells, question arose regarding the magnitude of wave induced current. Estimates were made to predict wave induced water velocities over depth. Using a deep water regular wave length (λ_0) approximation from Journée et al [ref. 7]:

$$\lambda_0(m) = \frac{g}{2\pi} T(s)^2 \qquad [3]$$

From which iteratively the shallow water wave length can be found by:

$$\frac{d}{\lambda_0} = \frac{d}{\lambda} \cdot \tanh\left(\frac{2\pi d}{\lambda}\right) \qquad [3]$$

It follows that typical wavelength near area "Xantia" will be in the order of 130-155 meters. Journée et al. also state a method to estimate water velocities resulting under a regular wave:

$$u(m/s) = \left(\frac{\pi H}{T}\right) \cdot \frac{\cosh\left(\frac{2\pi(y+d)}{\lambda}\right)}{\sinh\left(\frac{2\pi d}{L}\right)} \cdot \cos(2\pi(x/\lambda - t/T)) \qquad [5]$$

$$v(m/s) = \left(\frac{\pi H}{T}\right) \cdot \frac{\sinh\left(\frac{2\pi(y+d)}{\lambda}\right)}{\sinh\left(\frac{2\pi d}{L}\right)} \cdot \sin(2\pi(x/\lambda - t/T)) \qquad [6]$$

Using the approximations above it is estimated that the magnitude of average wave induced currents will be between 0.3 m/s close to the water surface to about 0.12 m/s at the sea bed. Since waves with Hs of 5 m are not uncommon wave induced currents in the South Taranaki Bight can be as high as 0.7 m/s in the shallow sections of the TTRL tenements.

Based on this paragraph two conclusions regarding the use of dredging pipelines can be made;

- The wave climate does not allow for permanent floating pipelines
  The constant movement and flexing as a result of wave action will cause rapid degeneration of the pipeline elements. Floating pipelines can be used when they are reeled in after the transfer process.

- As indicated by Technip during the TTRL-Technip-MTI conference call [ref 9] previous experience in the Taranaki area rules out the use of long sea floor based pipe lines due to strong currents and rolling boulders at the sea floor.

2.4 Ecology and environment

Dredging operations will impact the environment to a certain extent. Increased turbidity and changes to the bathymetry of the sea bed will affect the local eco system. TTRL has contacted ASR Marine consulting and research to investigate the impact TTRL's operations will have on local marine environment [8]. ASR is of the opinion that the ecological impacts of extracting seabed materials from locations >5 km offshore of the southern Taranaki coast would likely be minor, shorter term and localized.

- The area is a high-energy environment with consistently high waves and winds that create a very active seabed environment (i.e. seabed sediments are regularly mobilized and moved around)

- Existing data of seabed organisms in the area indicate that the existing seabed communities are not particularly sensitive to disturbance (as would be expected in a highly energetic environment)

Turbidity during dredging and dumping is most likely the primary impact factor on local marine life. Measures to minimize turbidity and therefore the impact of the iron sands mining operation on the environment are:

- Dredging using a so called "green valve" in the TSHD hopper overflow will limit overflow related turbidity up to 80%.

- Using a short tail pipe to limit mixing and suspension of fines when dumping material.

- Using a distributed mining pattern which limits the length of exposure of a certain part of the marine eco system.

Furthermore it would be advisable to apply water-based hydraulic actuators where possible. This technology is already being applied in mining and, apart from environmental, also offers performance benefits.

2.5 Production requirements

TTRL intends to produce 6 MT per year of TiFe concentrate. It is assumed that operations will continue year round. Furthermore it is assumed that the FPSO has a primary sediment buffer with sufficient capacity to continue dredging in case the processing plant has to be stopped. In essence: the average dredge mining capacity can be equal to average required concentrate production. Below resulting weekly dredge productions are given based on an average plant recovery percentage of 90%:

Required concentrate production	6.00	MT/y
Plant recovery grade	0.90	-
Weeks per year	52.14	wk/y
Required concentrate dredging	**127,854**	**Tds/wk**

Table 6: Required weekly production

The amount of sediment which needs to be dredged to attain this concentrate production depends on sediment grade and therefore upon mining location. For the Xantia area a split up in average grade is made which equals an area perpendicular to the dominant wave direction for the TSHD option with a grade percentage of 11% and an area parallel to the wave direction for the PSD option with a grade percentage of 23.75 %. The area parallel to the wave direction has a negative impact on the operation hours of the TSHD and therefore this area is assigned to the PSD. The split up in area is indicated in figure 8 below.

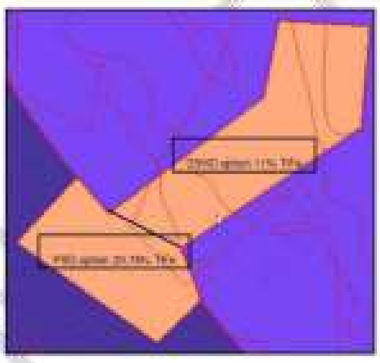


Figure 8: Allocation of dredging area for the PSD and TSHD option.

For both cases the required production capacity and tailings production is given in the table below:

	11% TiFe	23.75% TiFe	
Required sediment dredging	1,162,308	538,332	tds/wk
Required sediment dredging	583,284	255,360	m3/wk
Production tailings	1,034,454	410,478	tds/wk
Production tailings	653,180	255,859	m3/wk

Table 7: Required sediment dredging and tailings removal at 11% and 23.75% sediment grade.

3 Dredge mining iron sands

3.1 Concept selection

When existing dredge mining methods are analysed the following diagram of options results:

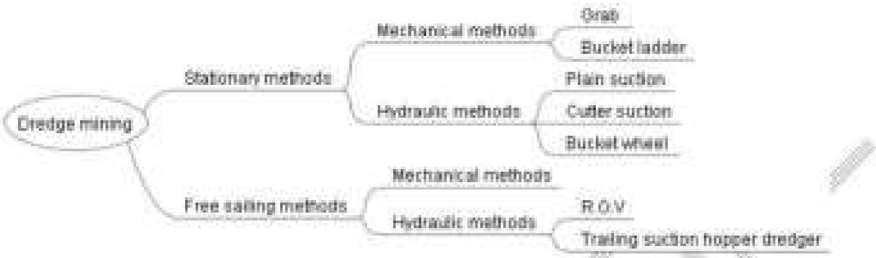


Figure 9: Overview of dredge mining options

MTI DAS reviewed the dredging mining options above using a weighted multi criteria analysis. All options where assessed for five criteria on a scale of -2 to +2. A double negative score excludes an option. Each criterion has a specific weight assigned out of a total distributable weight of 10.

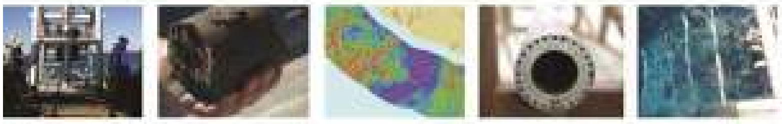
Dredge type	Unit capacity	Workability	Reliability	Unit Capital costs	Unit operational costs	Weighted Score
Grab dredge	--	+	++	+	+	**Excluded**
Bucket ladder dredger	--	-	+	-	-	**Excluded**
Plain suction dredger	0	+	+	+	++	**10**
Cutter suction dredger	+	--	+	+	++	**Excluded**
Bucket wheel dredger	+	--	+	+	+	**Excluded**
R.O.V. dredger	+	++	0	-	-	**3**
Trailing suction hopper dredger	++	+	++	0	+	**13**
Criterion weight	**3**	**2**	**1**	**1**	**3**	

Figure 10: Weighted multi criteria analysis of dredging options

- Unit capacity:
  A higher capacity means the total spread requires less capital and operational expenditures. It also indicates the overall system complexity is lower due to lower equipment numbers.

- Workability:
  Has significant influence on unit capacity.

- Reliability:
  Expresses the expected probability of equipment failure



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3.2 Stationary plain suction dredger concept

One of the production methods to be evaluated is a stationary suction dredger. The cutter suction dredger, bucket wheel dredger and plain suction dredger are all types of stationary dredgers. The bucket wheel and the cutter suction dredger are typically used in soil types that are cohesive or compact and hard. These types of equipment exert a force on the soil after which it is cut loose and transported. The dredging depth of 45 m requires a heavy construction and the waves enforce movement of the equipment which results in high forces at the bucket wheel and cutter head. The plain suction dredger is further analysed.

3.2.1 Description of operations

The plain suction dredger (PSD) will be positioned in the dredging area by means of 5 anchor lines. The length of the lines determines the area that can be mined before the anchors have to be shifted. The forward speed of the PSD and the width of each cut are dependent on the soil properties and the height of the breach. For the sub rounded / sub angular material with an average SPT of 35 the forward speed is around 5 m/hr. In case of a cut length of 600 m each week one cut can be completed. During the first cut the material on both sides of the PSD is undisturbed which results in optimal breach productions. During the second cut alongside the first, one side of the breach is already disturbed which reduces the production level. The distance between the cuts depends on the allowed drop in production together with the allowed loss of material that cannot be economically excavated anymore. In case of a cut width of 50 m; 12 cuts can be made within one anchor position. This means that every 3 months the PSD has to shift anchors.

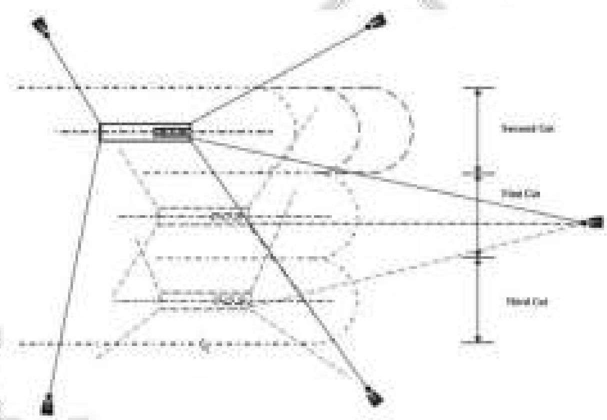

Figure 11: Anchoring and movement of the PSD

The production level of the PSD is quadratic dependent of the breach in front of the suction mouth and therefore the suction tube of the PSD has to be positioned on maximum allowed dredging depth as quickly as possible. As soon as the breaching process is activated it is very important to create a stable continuous process. Discontinuities in the dredging process will result in a stalling breaching process and requires extra time for start-up. To prevent stalling the process during coupling and/or waiting, it may be necessary to continue dredging and pumping in a temporary storage depot within the dredging location. The material in this storage will be loosely packed and therefore easily dredged with high productions in a later stage.

Hydraulic transport from the PSD to the storage location has not been investigated in this study. Floating pipelines are considered to be vulnerable for the local wave climate. Sinker lines on the seabed are disqualified as a result of rolling rocks which are transported over the seabed by the currents.

Loading through a short flexible floating line which is coupled to the bow of the barge is a known technique but is in the current design limited in workability by the couple boat. To increase the workability, couple techniques used within the offshore oil and gas industry seem to be suitable but need further investigation.

In case of the use of loading arms the mooring position of the barge can be aside the PSD fixed on winches or independently on dynamic positioning (DP) near the PSD. The wave climate together with the length and weight of the barge in comparison to the PSD makes it less favourable to moor the barge at the PSD. The loading of the barges is done by means of a heave compensated loading arm with the barge positioned on DP underneath it. In this way the pieces of equipment can move independently from each other and no high forces need to be controlled by winches during moving the barge under the loading arm. To minimize the movement between the barge and the loading arm, the arm is heave compensated. To sail the barge from and to the dredger, fairleads are used to bring the side line wires on a sufficient depth below the water level that the barge can sail over the wires.

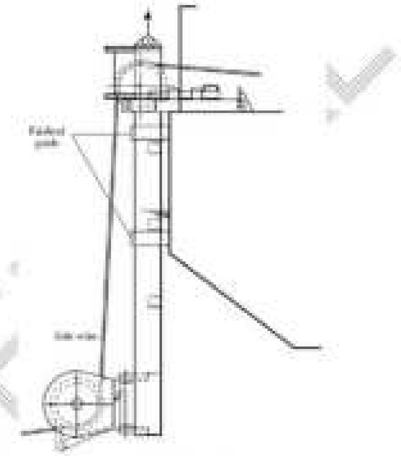

Figure 12: Fairleads

3.2.2 Required equipment

The specifications of the equipment are dependent of the breach production. The breach production is quadratic dependent on the breach height and on different soil characteristics as the angle of internal friction and permeability of the soil. Based on the given particle size distribution and the SPT values of the available borehole an indication of both parameters is determined with the discussed correlations.

The productions have been calculated for several SPT values with a breach of 15 m. This gives an indication in variation of the production level as a function of the SPT. Beside the production for free flowing sand (N1.70=5) also the production for medium compacted (N1.70=25) and highly compacted (N1.70=50) sand have been calculated. Because different SPT values occur over the whole borehole the production level will be in between the most extreme productions. The average SPT N1.70 is 35 and the corresponding production levels are also mentioned. The productions mentioned are the most optimal productions based on a stable breaching process with constant soil characteristics over the whole height and width of the breach. Disturbance layers like for example clay or silt have a negative impact on the production level. Also the overlap between two cuts has a negative influence on the production level.

The calculation of the breach production is very sensitive. Deviations in the used angle and permeability have great influence on the production level. To give an indication of the variation in the production level the effect of grain shape is shown for the divers SPT values. Variations in grain shape can result in 20% to 40% variations in production level.

		SPT N1.70			
		5	25	35	50
Grain Shape	very angular	4,000	1,400	900	500
	sub rounded / sub angular	5,000	2,000	1,300	850

Table 8: Optimal breach production [situ m^3/hr]

The variation in breach production has its consequences for the specifications of the equipment. As the dredging location is located downstream of the Paleo-river it is assumed that the grain shape is sub rounded / sub angular. The highest production level requires the most extreme equipment specifications. Therefore the production level of 5000 m^3/hr in free flowing sand with sub rounded / sub angular grain shape is used. Due to the movement of the suction tube not all the material from the side slopes will reach the suction mouth and spillage will occur. A dredging efficiency of 90 % is taken into account in the calculation of the cycle production.

Plain suction dredger

The production level of the PSD is besides the soil properties dependent on a stable suction process. The suction mouth has to be positioned at a constant level during the whole process. To guarantee this in heavy sea states heave compensation is necessary. IHC has experience with building heave compensated PSD's and a possible solution like the hereafter presented Jumbo PSD. This design is based on a maximum allowed significant wave height of 5.0 m. Tropical storms are excluded.

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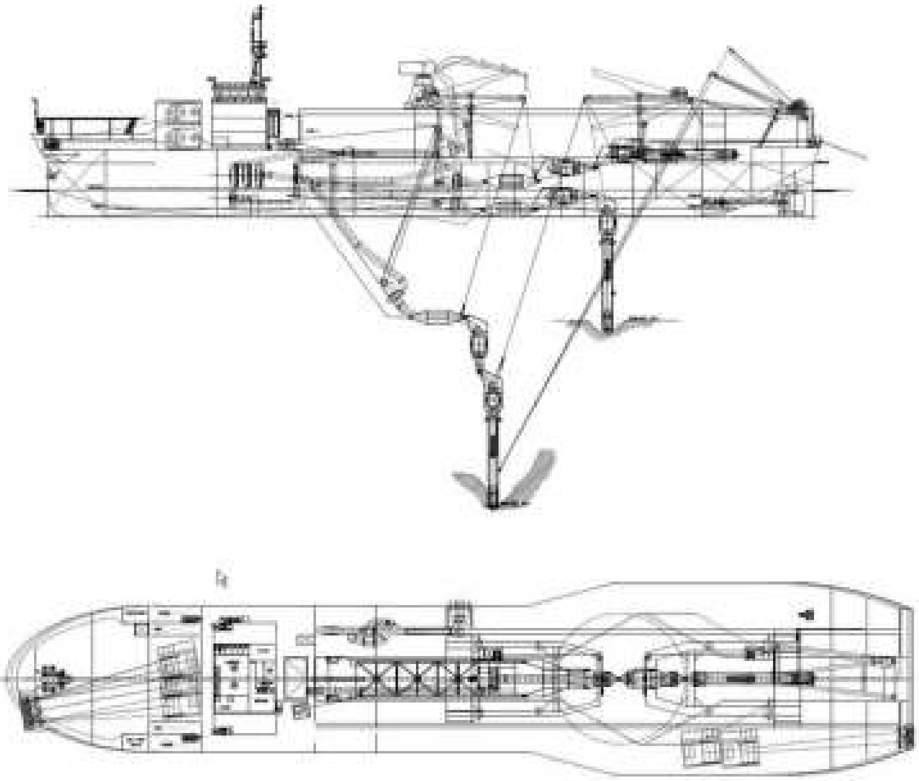


Figure 13: Swell compensated PSD

Property	Value	Unit
Light ship weight:	6000-8000	ton
Length overall:	145	m
Breadth:	31	m
Depth:	10	m
Draught / average freeboard:	5	m
Suction pipe diameter:	0.9	m
Dredging depth max:	60	m
Dredging depth min:	25	m
Total installed diesel power:	8700	kW
Total installed dredge pump power:	3000	kW
Power available for propulsion:	3000	kW

Table 9: PSD specification

Barges

The barges that transport the material from the PSD to the storage depot must be able to be loaded by means of loading arms even during heavy sea states. This means that the hopper must be freely accessible and that they must be positioned by DP since mooring is not possible. An even spread of the load can be realized by moving the barge during the loading process. The barge must be able to discharge the loaded sediment by means of pump(s) to the storage depot and dump the received tailings at the dump location. For the pumping process a self emptying line is necessary and for dumping bottom doors are required. The required barge is therefore basically a TSHD without the loading system (suction pipe(s) and loading lines above the hopper) and a clean good accessible hopper. The size of the barges is determined in such a way that the necessary weekly production is realized with one PSD and two barges with a minimum of waiting time in free flowing sand with a SPT of 5. This results in barges with 13000 ton carrying capacity which are able to work till a significant wave height Hs of 3 m.

Property	Value	Unit
Displacement at dredge mark:	20600	ton
Length overall:	134	m
Breadth:	23	m
Draught at dredging mark:	9	m
Carrying capacity:	13100	ton
Max hopper volume:	8700	m³
Length hopper:	55	m
Width hopper:	16	m
Discharge pipe diameter:	1.0	m
Total installed diesel power:	10500	kW
Total installed dredge pump power:	2900	kW

Table 10: Barge specification

Figure 14: Barge [from www.Deme.be]

Loading arms
Loading barges through a loading arm is a proven technology. Not only barges moored along side the dredgers can be loaded through a loading arm but also barges positioned with DP near the dredgers. The last technique was, for example, used by the Al Wassl Bay in the beginning of the 80's. The 1250 m3 barges used in combination with the Al Wassl Bay were able to be kept on position with a accuracy of one meter in weather conditions with wind speeds up to 65 km/h and wave heights to 4,5 m.

Figure 15: Al Wassl Bay [From www.dredgers.nl]

According to the latest technique high accuracy station-keeping can be realized in any weather condition at the expense of power consumption and exposure to wear and tear. To minimize the losses during loading in bad weather the loading arm can be heave compensated.

3.2.3 Dredging cycle

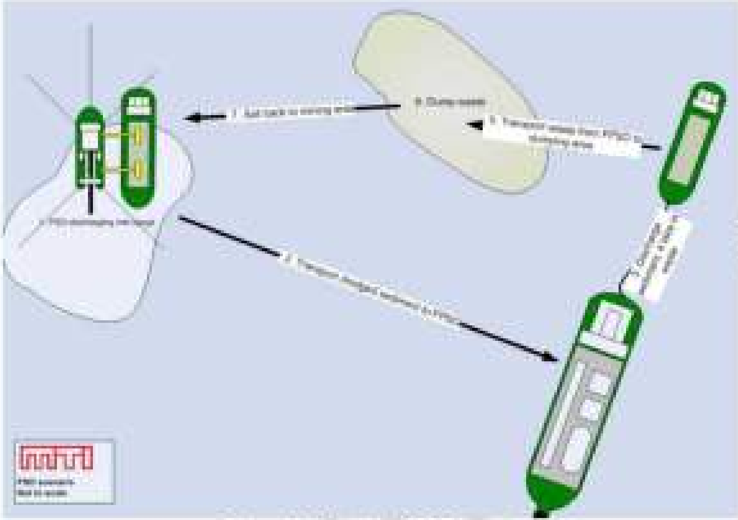


Figure 16: Overview of PSD concept

The steps of the dredging cycle are indicated by numbers in figure 14. Below are descriptions of each step.

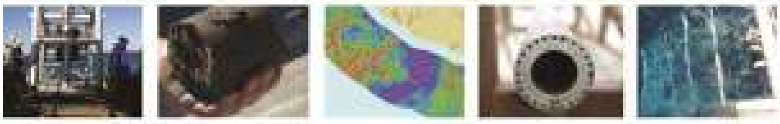
1: PSD discharging into barge
The PSD dredges sediment with the aid of one heave compensated suction tube. The loading process will require approximately 4.3 hours.

2: Transport dredged sediment to FPSO
After finishing loading the barge will sail to the FPSO, which according to Technip [ref. 10], will be located approximately 9.2 nautical miles from mining area Xantia. An average sailing speed of 9.8 knots has been taken.

Property	Value	Unit
Average sailing speed loaded	9.8	kn
Sailing distance loaded	9.2	nm
Sailing time loaded	0.94	h

Table 11: Transport dredged sediment to FPSO

3: Discharge sediment
Once the barge has arrived at the FPSO it is estimated that it takes 15 minutes to couple the transfer lines. The barge will maintain position facing the stern of the FPSO using DP. Sediment will be transferred by slurry pipeline to the stern of the FPSO. This will take approximately 0.73 hours.



4: Take in waste

After the barge has been emptied the FPSO will pump back the processed sediment to the barge by using the still connected transfer pipe line. This will take approximately 0.63 hour excl. unmooring time of 0.25 hour.

5, 6,7: Transport waste from FPSO to dumping area, dump waste and sail back to mining area

After loading the waste the barge sails to the dump site. The barge will dump its load and will sail back to the PSD.

Property	Value	Unit
Sailing filled with tailings		
Average sailing speed loaded	9.8	kn
Sailing distance loaded	4.6	nm
Sailing time loaded	0.47	h
Dumping tailings		
Dumping	0.17	h
Sailing empty		
Average sailing speed empty	10.3	kn
Sailing distance loaded	4.6	nm
Sailing time loaded	0.45	h

Table 12: Transport waste, dump waste and sail back

3.2.4 Workability

The availability is estimated to be 83.3 % (140 OH/wk). The workability of the barges is determined by the size of the barge and by the possibility to stay positioned under the PSD loading arms. The significant wave height of 3 m is used as maximum significant wave height and results in a workability of 87.7%. Availability and workability together result in 123 operational hours on average per week. The PSD is not limiting the operational hours per week because it is designed to work till significant wave heights of approximately 5 m which results in a workability of 98%. Tropical storms are excluded.

3.2.5 Production estimates

As previously discussed the breaching production is very dependent on the soil to be dredged. For the sub rounded / sub angular type of material with different SPT values the cycle production of one spread existing out of one PSD with one or two barges is calculated. Also the number of spreads necessary to achieve the weekly output of 128000 Tds concentrate is calculated. The specifications of the equipment used for the calculations are described in paragraph 3.2.1. The results are presented below.

				Average				
Type of material SPT N1.70	**5**	**25**		**35**		**50**		**-**
Breach production	5000	2000		1300		650		m3/hr
Number of barges per spread	2	1	2	1	2	1	2	-
Loading production	75	30	30	20	20	13	13	m3/min
Operation hours per week	123	123	123	123	123	123	123	oh/wk
Weekproduction Concentrate per spread	128,000	44,000	87,000	36,000	61,000	28,000	41,000	tds conc/ wk
Weekproduction Tailings per spread	423,264	145,000	289,000	119,000	203,000	94,000	135,000	tds tail/wk
Waiting time PSD	110	220	20	210	5	190	0	min
Waiting time per Barge	0	10	0	0	90	0	250	min
Number of spreads necessary	1	3	2	4	3	5	4	-
Total weekproduction Concentrate	128,000	132,000	174,000	144,000	183,000	140,000	164,000	tds conc/ wk
Total weekproduction Tailings	423,264	435,000	578,000	476,000	609,000	470,000	540,000	tds tail/wk

Table 13: Sub rounded / sub angular material with a SPT N1.70

A detailed split up of the cycle production is given for the sub rounded / sub angular material with a SPT N1.70 of 35. This is executed for a spread consisting of one PSD with one or two barges. In appendix 2 the cycle times and quantities are mentioned for each type of equipment. On the left a split up of one PSD with 2 barges is shown and on the right one PSD with 1 barge.

The load per barge per cycle is 10370 Tds situ material which results in 2463 Tds concentrate and 8153 Tds tailings. All the cycle times of the successive steps result together in a cycle time excluding waiting of 506 minutes for each barge and 594 minutes for the PSD. Because the PSD needs more time to load two barges than a single barge needs to complete one cycle, the barges need to wait each cycle for 88 min. The loads per barge and the cycle time of the whole spread result in a cycle production of the whole spread, which together with the operational hours per week result in week productions. Week productions are mentioned in sediment m^3/wk, sediment Tds/wk, concentrate Tds/wk and tailing Tds/wk.

By taking one barge out of the spread, the waiting time of the barge reduces to zero but instead the PSD has to wait 209min. This has a negative effect on the cycle production and weekly production, which can be seen in the table on the right. If the PSD has to wait for the barges, the PSD will continue dredging and will pump the material in a temporarily under water depot or it will stop its operations. Stopping the operations will stop the breaching process as well, which will result in reduced productions at start-up. The material pumped in the temporary depot will have a loose packing and can be dredged in a later stage at high production levels. Both effects are not taken into account within the presented calculations.

In this particular example the size of the barges is based on breaching productions in material with a SPT of 5 although they are deployed in material with lower productions. This results in waiting time for the barges. Reducing the waiting time by reducing the size of the barge is possible but will result in a lower cycle production and together with a reduced workability in lower week productions. To guarantee the necessary weekly output this may result in an extra spread. If the productions become temporarily higher as the production on which the size of the barges is based this will result in waiting times for the PSD. In that case the size of the barges is limiting the cycle production.

3.2.8 Expenditure analysis

Based on data from CIRIA [ref. 11] the following CAPEX and OPEX figures where derived for the principal required vessels. The beneficiation plant, bulk carrier, dewatering and desalinisation systems are excluded in all scenarios. The capital expenditure is for new built acquisition. The capital costs per year are given with an economic life of the equipment of 18 year with a residual value of 10% and the mean rate of interest during economic life is estimated at 7%. The operational expenditure is mentioned per year. This is an accumulation of the fuel cost, repair and maintenance, crew and insurance. These are present values. Overhead (office, etc) is not taken into account. The exploitation cost a year of the equipment is the accumulation of the capital cost a year and the operational expenditure a year. In table 17, 18, and 19 all the costs are given for respectively 1 PSD, 1 barge, and the required spread of 3 PSD and 6 barges based on a presumed SPT N1.70 value of 35.

PSD	Value	Unit
Capital expenditure	150,000,000	€
Capital costs a year	14,470,701	€/yr
Fuel costs	5,179,402	€/yr
Repair and maintenance	6,755,284	€/yr
Crew costs (double shift)	3,600,000	€/yr
Insurance costs	1,875,000	€/yr
Operational expenditure	**17,409,687**	**€/yr**
Exploitation cost	**31,880,388**	**€/yr**

Table 14: Cost estimates for a PSD

Barge	Value	Unit
Capital expenditure	60,398,000	€
Capital costs a year	5,826,676	€/yr
Fuel costs	3,177,245	€/yr
Repair and maintenance	4,714,662	€/yr
Crew costs (double shift)	3,600,000	€/yr
Insurance costs	754,975	€/yr
Operational expenditure	**12,246,882**	**€/yr**
Exploitation cost	**18,073,558**	**€/yr**

Table 15: Cost estimates for a barge

Spreads (3 x PSD+ 6 x Barge)	Value	Unit	€/Tds TiFe
Capital expenditure	812,388,000	€	
Capital costs a year	78,372,159	€/yr	8.24
Fuel costs	34,601,676	€/yr	3.64
Repair and maintenance	48,553,824	€/yr	5.10
Crew costs (double shift)	32,400,000	€/yr	3.40
Insurance costs	10,154,850	€/yr	1.07
Operational expenditure	**125,710,353**	**€/yr**	**13.21**
Exploitation cost	**204,082,512**	**€/yr**	**21.45**

Table 16: Cost estimates for three spreads based on SPT value of 35 TDS concentrate/week (excluding processing and overhead related costs)

3.3 TSHD concept

A trailing suction hopper dredger (TSHD) is a vessel with an internal sediment storage hopper and a loading system consisting of a drag head which loosens the soil, a suction tube which transports the soil water mixture from the drag head to the hopper, and one or several dredge pumps which pump the soil-water mixture from the sea floor though the suction tube to the hopper. A TSHD can unload by connecting to a (floating) pipeline and using dredge pumps to empty the hopper, by jetting soil-water mixture though a nozzle located on the bow ("rainbowing"), or alternatively by opening doors in the bottom of the hopper ("dumping"). Modern TSHD are often equipped with dynamic positioning (DP1) and advanced monitoring- and tracking software which enables accurate dredging of selected area

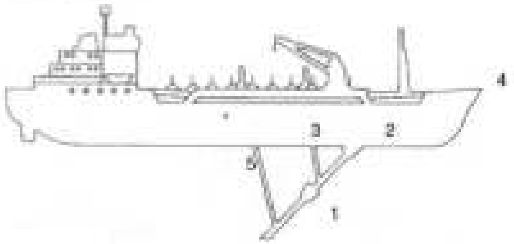


Figure 17: Typical TSHD. 1: Suction tube with drag head, 2: Dredge pumps, 3: Hopper, 4: Bow coupling, 5: Bottom doors

Typically a TSHD performs the following actions during a dredging cycle:

1. Sail to dredging location
2. Deploy suction tube with drag head from storage on deck

3. Lower suction tube and start pumping
4. Sail to discharge location upon completion of hopper loading
5. Discharge sediment and restart cycle

3.3.1 Description of operations

For dredge mining the TTRL Xantia tenement a concept is proposed which requires two 30.000 m^3 TSHDs with the hopper laterally divided in two compartments. The TSHDs will dredge sediment in parallel directions with the dominant swell direction. Swell direction will usually be in SW - NE which is favourable since this corresponds with the orientation of mining area Xantia. Considering the very considerable screening-area required no pre-screening of sediment is applied at the TSHD. After the TSHD has filled it's hopper with sediment it sails to the FPSO. Due to the FPSO details not being available at time of writing it is assumed that the FPSO will transfer a cable to the TSHD and deploy a floating pipe Ø1300 mm along the cable which connect to the TSHDs bow coupling. The TSHD will transfer sediment to the FPSO. After unloading the FPSO will pump processed sediment back in to the TSHD. After filling both hopper compartments with waste material the TSHD disconnects from the FPSO and sails to the dumping area. Once arrived the TSHD will deposit waste by opening its bottom doors. To prevent excessive turbidity by sediment suspension the TSHD should be stationary while dumping. When dumping is complete the TSHD will set sail for the mining area and restart the dredge mining cycle.

Alternatively the possibility of using split barges for waste transport from the FPSO has been investigated. When using similar barges as in the PSD concept from § 3.2 one barge will provide sufficient waste removal capacity. Smaller TSHDs can be used. Smaller TSHDs however have a lower workability. The addition of overflow and DP-systems make the barge expensive. The result yields no significant reduction in operational expenditures while total system complexity is increased. This option is therefore not elaborated further.

3.3.2 Required equipment

To meet TTRL's production requirements of 6 MTDS of TiFe concentrate per year two TSHD are required when the average sediment TiFe grade is 11% in weight. Each TSHD will have the following specifications:

Property	Value	Unit
Total installed power	23.200	kW
Hopper capacity	30.000	m3
Loading capacity	58500	ton
Length over all	168,0	m
Breadth	38,0	m
Draught	12,2	m
Speed (loaded)	16,6	Knots
Suction tubes	2 x 1.300	mm
Dredging depth short conf.	36,0	m
Dredging depth long conf.	56,0	m
Dredging depth optional	100,0	m

Table 17: TSHD specification

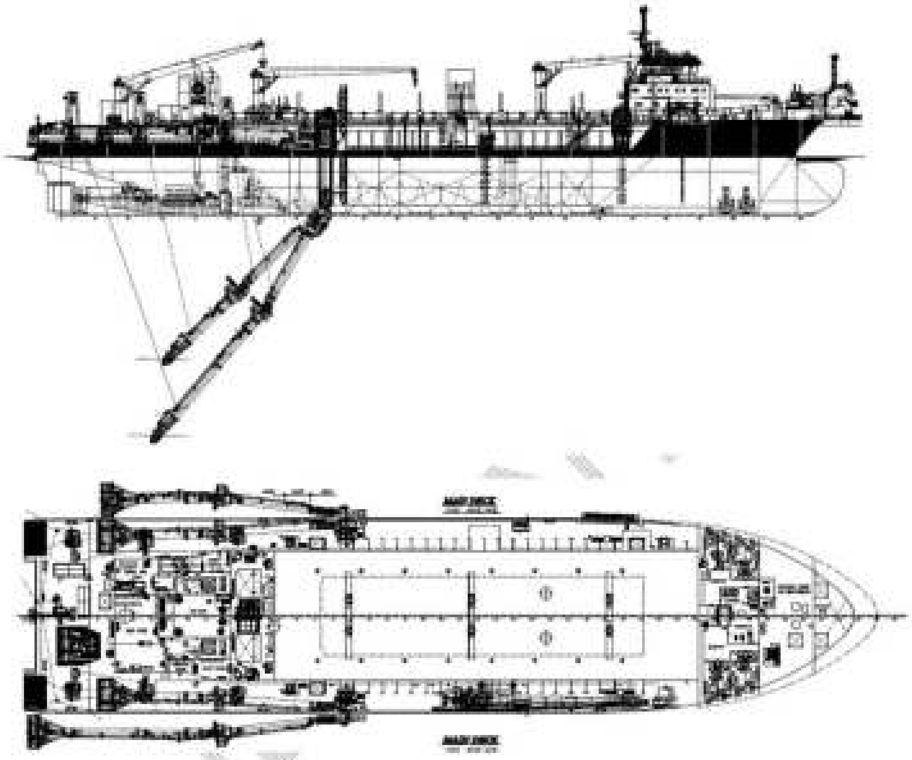


Figure 18: A large state-of-the-art TSHD: The "Congo River" operated by DEME

Further more several modifications are proposed which drastically increase the vessels workability under heavy seas. These modifications are described under paragraph 3.3.4: "Workability"

3.3.3 Dredging cycle

The steps of the dredging cycle are indicated in by numbers in figure 17. This paragraph lists details of each step of the dredging cycle

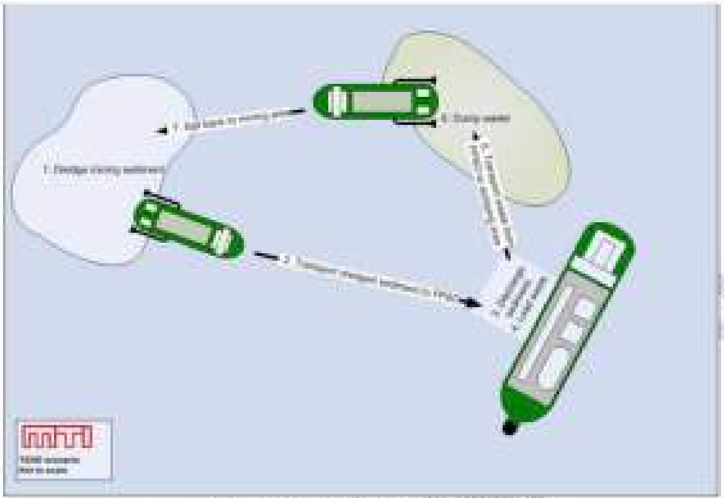


Figure 19: Overview of TSHD concept

1: Loading sediment

The TSHD dredges sediment with the aid of two suction tubes. The loading process will require approximately 1.80 hours. The table below lists the principal loading process parameters:

2. Transport dredged sediment to FPSO

After finishing loading of the hopper the TSHD will sail to the FPSO which, according to Technip will be located approximately 9.2 nautical miles from mining area Xantia. Sailing speed determined during the sea trials cannot be used as the average speed during the lifespan of the trailing suction hopper dredger. On top of that the ship needs to accelerate and decelerate. Therefore a velocity is 70% of the deep-water sea trail velocity is taken.

Property	Value	Unit
Average sailing speed loaded	11.6	kn
Sailing distance loaded	9.2	nm
Sailing time loaded	0.8	h

Table 18: Sailing to FPSO

3. Discharge sediment to the FPSO

Once the TSHD has arrived at the FPSO it is estimated that approximately 0.7 hours are needed to couple the transfer line. Meanwhile the TSHD will maintain position facing the stern of the FPSO using dynamic positioning. Sediment will be transferred by slurry pipeline to the back of the FPSO. This will take approximately 2.0 hours.

4. Taking in waste from the FPSO

After the hopper has been emptied the FPSO can pump-back the processed sediment to the TSHD by using the still connected transfer pipe line. This will take approximately 1.6 hour excl. unmooring time of 0.2 hour.

5, 6, 7 Transport sediment to dumping location an dump waste

After taking in waste the TSHD will sail to one of the dump sites. Close to the FPSO and approximately en route to the mining site are several deeper sections where waste material can be dumped. Natural erosion due to strong (tidal) currents will probably distribute dumped material in limited time.

Property	Value	Unit
Sailing filled with tailings		
Average sailing speed loaded	11.6	kn
Sailing distance loaded	4.6	nm
Sailing time loaded	0.40	h
Dumping tailings		
Dumping	0.25	h
Sailing empty		
Average sailing speed empty	14.5	kn
Sailing distance empty	4.7	nm
Sailing time empty	0.32	h

Table 19: Sailing to dumpsite, dumping waste, and sail to mining site

3.3.4 Workability

Workability indicates the percentage of time a vessel can continue normal operation in a certain wave climate. From experience, mostly gained in the relatively confined North Sea and Gulf regions, it is known that trailing suction hopper's workability is eventually limited by:

1. The bow-coupling process (if required) which involves a small work boat which connects winch lines to the floating pipeline and transfer this to TSHDs bow coupling. This procedure is usually limited to significant wave heights (H_s) lower than 2.5 m
2. The process of deploying and recovering the suction tube. When ship motion is too severe the suction tube will smash into the hull of the ship, causing damage to both. In bow waves this process is limited to H_s of 2.5 meters
3. Ship motions which result in backward movement of the drag head. The drag head will be moved aft ward and large forces will be exerted on the suction tube damaging joints and drag head. This limit is reached at H_s of around 3 meters in bow waves.
4. Limited stroke length of the drag head swell-compensator, resulting in lifting of the drag head.

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Above order of workability limits should be treated as an indication only which is applicable to a large modern TSHD

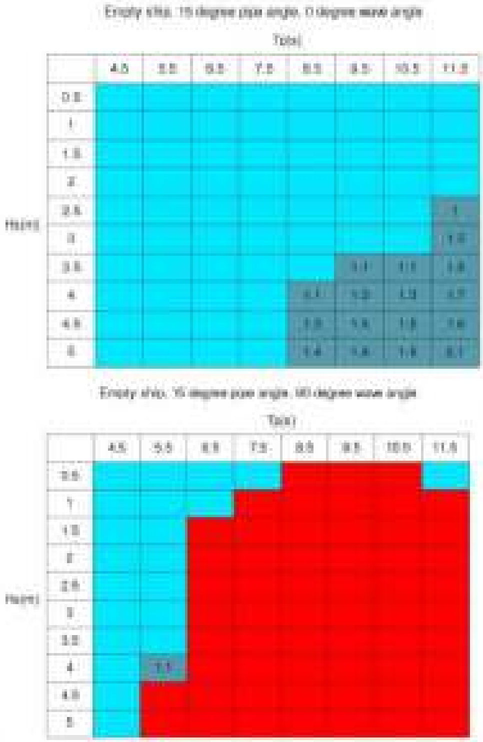


Figure 20: Theoretical workability limit of a TSHD in regular head waves (top) and in perpendicular regular waves (bottom). Grey blocks indicated a required mining trailing speed to prevent damage to the drag head, red blocks indicate the swell compensator is limited or insufficient sailing speed can be obtained.

As can be seen from the figures above, for regular bow or stern waves, workability for a large modern TSHD is high. For instance: Bow waves with H_s of 3 (m) and T_s of 11.5 (sec) require a 1.3 knot minimum trailing velocity to prevent damage from negative drag head velocities. In reality waves consist of many superimposed regular waves and wave directions. This will result in an actual workability which is lower than what one would expect when looking at workability diagrams calculated for regular bow waves. Another fact which is often overlooked is the importance of wave period (T_s). Many dredge contractors know from experience gained in the North Sea or Gulf that dredging with modern TSHDs suffers little up to significant wave heights of about 2.5 (m). Wave periods in the North Sea are rarely over 8 seconds. However much longer wave periods typically around 10-11 seconds are experienced in the South Taranaki Bight which have a more pronounced effect on ship dynamics. Since the FPSO has a limited sediment buffer size it is of great importance for TTRL's profit to ensure that TSHD operations can continue despite unfavourable sea states.

Therefore several options have been studied to increase TSHD workability and reliability. The most feasible concepts are:

1. Use a drag head swell compensator with at least 3 meters of stroke. This will help raising limit 4. DEME's Congo River is already equipped with a 3 meter stroke swell compensator.

2. Use fast (approximately 25 m/min) winches for lowering and raising the suction tube limiting the critical period the suction tube is suspended next to the vessel. This will help raise workability limit 2.

3. Reinforce the front suction tube guide rails.

4. Addition of a short telescopic section to the suction tube near the drag head. 0.5 meter of stroke will prevent damage due to negative drag head velocities up to more than 3.5 meter significant wave height at wave periods of 11 seconds. This will help raise workability limit 3. (Appendix 4)

5. Add suction tube retaining clamps so the suction tube does not need to be recovered and deployed during each dredging cycle. This will help raise workability limit 2.

6. More workable alternatives for slurry transfer systems are available such as the Aker-Pusnes offloading system. This will help raise workability limit 1.

Figure 21: Aker-Pusnes off-loading solution using guide wire and reeled slurry pipe line. [source: http://www.akersolutions.com]

With the modifications proposed in this paragraph it is expected that an overall workability of at least 85% can be attained. Without adaptations overall workability will be around 66%. Tropical storms are excluded from these figures.

3.3.5 Production estimates

In paragraph 2.5 the required production was found to be approximately 127854 Tds concentrate per week. Below principal production estimates are given for different sediment grades. When grades reach 20% wt. or higher the required annual concentrate production can be obtained with one 30.000 m^3 TSHD. Lower grades require two TSHD's.

Sediment grade % wt	8	11	14	17	21	Unit
Total cycle time	8.2	8.1	8.0	7.9	7.8	h
Tds concentrate per cycle	3,446	4,760	6,084	7,420	9,216	Tds
Tds tailings per cycle	42,075	41,038	39,984	38,914	37,463	Tds
Operation hours per week	128.5	128.5	128.5	128.5	128.5	oh/wk
Week production concentrate per TSHD	54,163	75,623	97,716	120,446	151,741	Tds/wk
Week production tailings per TSHD	661,358	652,020	642,135	631,687	616,853	Tds/wk
Number of TSHD's required	3.00	2.00	2.00	2.00	1.00	-
Total week production concentrate	162,489	151,245	195,432	240,891	151,741	Tds/wk
Total week production tailings	1,984,074	1,304,040	1,284,270	1,263,374	616,853	Tds/wk

Table 20: Production estimates as function of grade, SPT N_{10} = 24

The influence of SPT on (cutting) production was investigated as well. It turned out that even for high SPT values of 50 drag head jet penetration was sufficient to allow close to the nominal cutting depths of 40 centimetres. Up to SPT values of 35 Jet penetration allowed nominal cutting depth and the models used therefore predict equal productions.

Type of material SPT N1.70	5	25	35	50	Unit
Total cycle time	8.1	8.1	8.1	8.4	h
Tds concentrate per cycle	4,760	4,760	4,760	4,760	Tds
Tds tailings per cycle	41,038	41,038	41,038	41,038	Tds
Operation hours per week	128.5	128.5	128.5	128.5	oh/wk
Week production concentrate per TSHD	75,623	75,623	75,623	73,047	Tds/wk
Week production tailings per TSHD	652,020	652,020	652,020	629,809	Tds/wk
Number of TSHD's required	2.00	2.00	2.00	2.00	-
Total week production concentrate	151,245	151,245	151,245	146,093	Tds/wk
Total week production tailings	1,304,040	1,304,040	1,304,040	1,259,619	Tds/wk

Table 21: Production estimates as function of SPT, Grade = 11% wt.

Availability and workability have a linear relation with production. Mechanical availability is estimated at 85% when assumed that dockings and repairs are scheduled in June to August as much as possible when sea states are most unfavourable.

3.3.6 Expenditure analysis

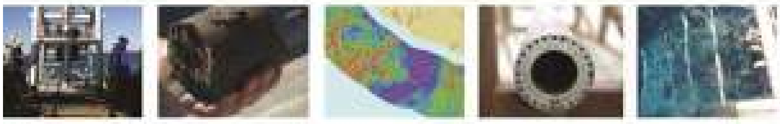
The capital costs per year are given with an economic life of the equipment of 18 year with a residual value of 10% and the mean rate of interest during economic life is estimated at 7%. The operational expenditure is given per year. This is an accumulation of the fuel cost, repair and maintenance, crew and insurance. These are present values. Overhead is not taken into account. The exploitation cost per year of the equipment is the accumulation of the capital cost per year and the operational expenditure per year. In table 28 all the cost of one TSHD is given. In table 29 costs of both the TSHD's are mentioned. Additionally the cost per Tds concentrate for this concept is stated in the last column.

TSHD	Value	Unit
Capital expenditure	164,393,190	€
Capital costs a year	15,859,232	€/yr
Fuel costs	10,159,247	€/yr
Repair and maintenance	11,639,432	€/yr
Crew costs (double shift)	6,000,000	€/yr
Insurance costs	2,054,915	€/yr
Operational expenditure	**29,853,594**	**€/yr**
Exploitation cost	**45,712,826**	**€/yr**

Table 22: Cost estimates for one TSHD

Spread (2 TSHDs)	Value	Unit	€/Tds TiFe
Capital expenditure	328,786,380	€	
Capital costs a year	31,718,464	€/yr	4.03
Fuel costs	20,318,494	€/yr	2.58
Repair and maintenance	23,278,864	€/yr	2.95
Crew costs (double shift)	12,000,000	€/yr	1.52
Insurance costs	4,109,830	€/yr	0.52
Operational expenditure	**59,707,188**	**€/yr**	**7.58**
Exploitation cost	**91,425,652**	**€/yr**	**11.61**

Table 23: Cost estimates for two TSHD's producing 151,245 TDS TiFe/week



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4 Conclusions and recommendations

4.1 Conclusions

- It is concluded that a plain suction option is not economically feasible compared to a TSHD based option. The soil is harder packed than initially anticipated which limits breaching production and therefore dredge production. This in term requires a large number of vessels to meet TTRL's production requirements.

	€/yr	€/tds TiFe
Operational expenditure PSD	125,710,353	13.2
Exploitation cost PSD	204,082,512	21.4
Operational expenditure TSHD	59,707,188	7.59
Exploitation cost TSHD	91,425,652	11.62

Table 24: Operational en exploitation costs of PSD and TSHD compared

- Application of an ROV dredger has been considered as well. The South Taranaki Bight has complex bottom topography, and includes areas of shoaling at water depths as little as 15-20 m, up to 35 km offshore [ref. 8]. Launch and recovery of an ROV large enough to facilitate sufficient sediment production will prove difficult under the ambient conditions present. The expected increase in workability over a standard TSHD (approximately 20%) will be undone for the largest part by the lower mechanical availability of an ROV dredger.

- A TSHD can most likely be applied with some degree of success. However large ocean swells and strong currents will prove difficult to handle especially when it is not possible to sail perpendicular to the swell direction. It should not be overlooked that a sea state with H_s of 2.5 m in South Taranaki Bight cannot be compared to a sea state with H_s of 2.5 m in the North Sea. It is expected that large benefits can be obtained by modifying a TSHD with one or several options as proposed in paragraph 3.3.4.

- It is concluded that floating pipelines can not be applied in a permanent application. Fatigue of the internal load bearing wires will destroy sections of pipe line in less than a month. Furthermore Technip has indicated that, based on experience obtained in the region, sinker pipelines also get damaged in a very short time span and should not be used. This rules out the option of a direct feed from PSD to the FPSO or waste disposal from the FPSO by pipeline.

4.2 Recommendations

- A stationary option enables dredging of high sediment lenses grade (+30% wt lenses have been found in the southern tenements) which is attractive since grade has a very strong influence on almost all project costs. However a cutting tool is required which in term requires anchoring means with high stiffness to provide the required cutting forces (F.I. spud poles). Another possibly interesting alternative might be to develop a very large and heavy cutter suction dredger based on a platform which is insensitive to wave action.

- Further research is required into the attainable workability levels of a TSHD and how to improve these is required.

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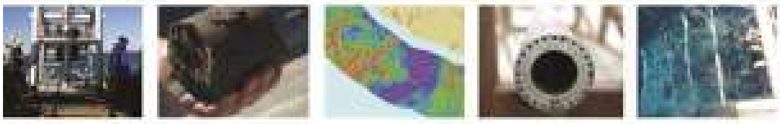
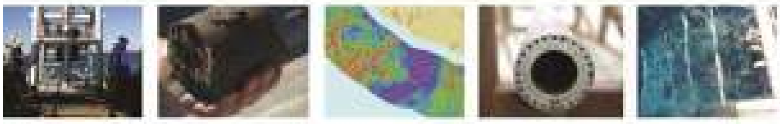


Nomenclature and abbreviations

DP	Dynamic Positioning
DWT	Dead Weight Tonnage
FPSO	Floating Production Storage and Offloading vessel
MDO	Medium Diesel Oil
PSD	Plain Suction Dredger
ROV	Remotely Operated Vehicle
Tds	Tonnes dry solids
TSHD	Trailing Suction Hopper Dredger

C_{vc}	Volumetric concentration in-situ soil	(-)
g	Gravitational constant	(m/s^2)
d	Local depth in	(m)
H_s	Significant wave height in meters (av. trough to crest height of 1/3 largest waves)	(m)
T, T_p	(Dominant) wave period	(s)
u	velocity in positive x-direction	(m/s)
v	velocity in positive y-direction	(m/s)
λ	Wave length in meters	(m)



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Appendix 1: Wave climate

	lower	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
lower	upper	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	total
0.0	0.2	0	0	0	0	0	0.3	0	1.0	0	0	0.3	0	0.3	0	0	0	0	1.9
0.2	0.4	0	0.3	0	0.3	0.3	0	0.3	0	0.3	0	1.0	0	0	0	0	0	0	2.6
0.4	0.6	0	0.3	0	0.3	0	0	0.3	0.3	0.6	0.6	0	0.3	0	0	0	0	0	2.9
0.6	0.8	0	0.6	0.3	0.3	0	0	0	0.6	0.3	0.6	0	0.3	0	0	0	0	0	3.2
0.8	1.0	0	0.6	0.6	0.6	0	1.9	0.6	1.0	0.6	0.6	0.6	0.3	0	0	0.3	0.3	0	8.1
1.0	1.2	0	0.6	0.3	0	0.6	1.0	0	0.3	0.3	0	0.6	0.3	0	0	0	0	0	4.2
1.2	1.4	0	0.6	0.6	1.0	0	1.0	[illegible]	1.0	0.6	0.3	0.3	0.3	0	0	0	0	0	7.8
1.4	1.6	0	0	1.9	1.0	1.3	0	1.3	1.3	0	0	1.3	1.0	0	0	0	0	0	9.1
1.6	1.8	0	0	0.3	1.0	0.6	1.6	[illegible]	1.9	1.3	0.6	0.3	0.6	0	0.3	0	0	0	11.0
1.8	2.0	0	0	0.6	[illegible]	0.6	0.3	1.0	1.0	0.6	0	0	0	0	0	0	0	0	7.8
2.0	2.2	0	0	0.6	1.9	[illegible]	0.6	0.6	1.0	0.6	0.3	0.6	0	0.3	0	0	0	0	9.4
2.2	2.4	0	0	0	0	0.6	1.6	0	1.3	1.3	0.6	0	0	0.3	0	0	0	0	5.8
2.4	2.6	0	0	0	0	[illegible]	1.6	1.9	1.9	0.3	0.3	0.3	0	0	0	0	0	0	9.1
2.6	2.8	0	0	0	0	0	1.0	0.6	0	0.3	0	0	0	0	0	0	0	0	1.9
2.8	3.0	0	0	0	0	0	1.0	0.3	0.3	0.3	0.6	0	0	0	0	0	0	0	2.9
3.0	3.2	0	0	0	0	0	0.3	0	0.3	0.6	0.6	0	0	0	0	0	0	0	1.9
3.2	3.4	0	0	0	0	0	0.3	0	1.0	0	0.3	0	0	0	0	0	0	0	1.6
3.4	3.6	0	0	0	0	0	0.3	0.6	0	0.3	0	0	0	0	0	0	0	0	1.3
3.6	3.8	0	0	0	0	0	0	0.6	0.6	0.3	0.6	0.3	0	0	0	0	0	0	2.6
3.8	4.0	0	0	0	0	0	0.3	0	0.3	0	0	0	0	0	0	0	0	0	0.6
4.0	4.2	0	0	0	0	0	0	0	0	0	0.3	0.3	0	0	0	0	0	0	0.6
4.2	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
4.4	4.6	0	0	0	0	0	0	0	0.3	0.3	0	0	0	0	0	0	0	0	0.6
4.6	4.8	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0.6
4.8	5.0	0	0	0	0	0	0	0	0	0.3	0.3	0	0	0	0	0	0	0	0.6
5.0	5.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5.2	5.4	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0.3
5.4	5.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
5.6	5.8	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0.3
5.8	6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6.0	6.2	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.3
6.2	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6.4	6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
6.6	6.8	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0.6
6.8	7.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
total		0.0	3.2	5.5	10.0	9.4	13.3	12.6	15.9	10.0	8.7	6.1	3.2	1.0	0.3	0.3	0.3	0.0	100.0

Table A1: Scatter table of H_s and T_z as found for the South Taranaki Bight [ref. 5]

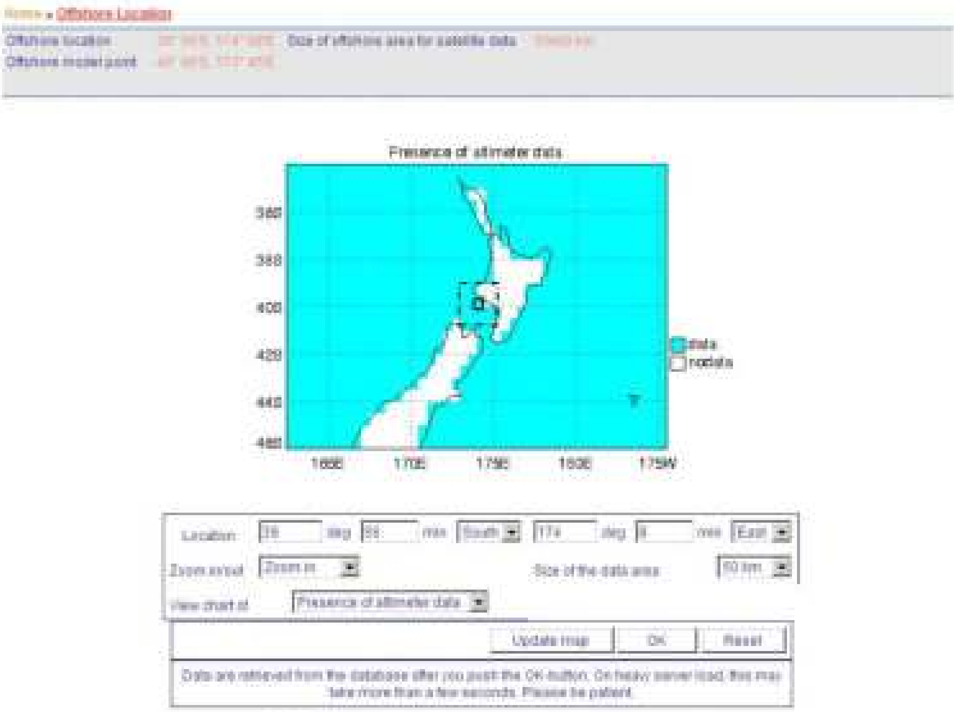


Figure A1: Scatter table location [ref. 5]

Date		
30 August 2011		

TTR DEME

Appendix 2: Detailed PSD production calculations

Option 1300 m3/hr with 2 barges			PSD	Barge 1	Barge 2
Loading	min	barge1	257	257	
	min	barge2	257		257
Load	situ m3			4,919	4,919
Load	situ tds			10,370	10,370
Load	tds conc.			2,463	2,463
Change barge	min	barge1	15	15	
	min	barge2	15		15
Sailing empty	min			27	27
Sailing full	min			57	57
Mooring at FPSO	min			15	15
Unloading sediment	min			44	44
Loading tailings	min			38	38
Load tailings	tds			8,153	8,153
Un-mooring FPSO	min			15	15
Sailing full tailings	min			28	28
Unloading tailings	min			10	10
Pipecheck	min		51		
SUB TOTAL	min		594	506	506
Waiting	min		0	89	89
TOTAL	min		594	594	594
Efficiency	OH		123	123	123
Number of cycles per week	-		12		
Cycle production	situ m3/hr		993	497	497
Week production	situ m3/wk		122,111	61,055	61,055
Cycle production	situ tds/hr		2,094	1,047	1,047
Week production	situ tds/wk		257,426	128,713	128,713
Cycle production TiFe	tds con/hr		497	249	249
Week production TiFe	tds con/wk		61,139	30,569	30,569

Production Tailings

Cycle production Tailings	tds tail/hr		1,646	823	823
Week production Tailings	tds tail/wk		202,401	101,201	101,201

1 Spread	1	PSD
	2	Barges

Number of spreads required	3.00	-

Table A2a: Production calculations for a spread consisting of 1 PSD and 2 Barges

Date
30 August 2011

Option 1300 m3/hr with 1 barges			PSD	Barge 1	Barge 2
Loading	min	barge1	257	257	
	min	barge2			
Load	situ m3			4,919	
Load	situ tds			10,370	
Load	tds conc.			2,463	
Change barge	min	barge1	15	15	
	min	barge2			
Sailing empty	min			27	
Sailing full	min			57	
Mooring at FPSO	min			15	
Unloading sediment	min			44	
Loading tailings	min			38	
Load tailings	tds			8,153	
Un-mooring FPSO	min			15	
Sailing full tailings	min			28	
Unloading tailings	min			10	
Pipecheck	min		26		
SUB TOTAL	min		297	506	
Waiting	min		209	0	
TOTAL	min		506	506	
Efficiency	OH		123	123	
Number of cycles per week	-		15		
Cycle production	situ m3/hr		584	584	
Week production	situ m3/wk		71,763	71,763	
Cycle production	situ tds/hr		1,230	1,230	
Week production	situ tds/wk		151,286	151,286	
Cycle production TiFe	tds con/hr		292	292	
Week production TiFe	tds con/wk		35,930	35,930	
Production Tailings					
Cycle production Tailings	tds tail/hr		967	967	
Week production Tailings	tds tail/wk		118,948	118,948	

1 Spread	1	PSD
	1	Barges

Number of spreads required	4.00	-

Table A2b: Production calculations for a spread consisting of 1 PSD and 1 Barge

Date
30 August 2011

Appendix 3: TSHD detailed production calculations

Sailing empty	0.3	hr
Loading sediment	1.80	hr
Sailing full	0.8	hr
Mooring	0.7	hr
Unloading sediment	2.0	hr
Average time loading tailings	**1.6**	**hr**
Un-mooring	0.2	hr
Sailing full tailings	0.4	hr
Average time unloading tailings	0.22	hr
Total cycle time	8.1	hr
Cycle production sediment (situ) m3	2,684	m3/hr
Cycle production sediment (situ) tds	5,349	tds/hr
Cycle production concentrate (TiFe) tds	588	tds/hr
Cycle production tailings tds	5,073	tds/hr
Mechanical availability	0.9	
Workability	0.85	
Available hours TSHD	128.5	hr/wk
Cycle production sediment (situ) m3	345,000	m3/wk
Cycle production sediment (situ) tds	687,479	tds/wk
Cycle production concentrate (TiFe) tds	**75,623**	tds/wk
Cycle production tailings tds	**652,020**	tds/wk

Table A3: Detailed production calculation of the TSHD for 11% grade and SPTN$_{60}$ = 24

Appendix 4: Effects on workability of a telescopic suction tube section

Ship dynamic simulations for a novel telescopic suction tube.
Some ship dynamics simulations were performed to test a novel conceptual suction tube design. One remark about these simulations should be made here: the simulations are coarse and limited, hence specific numbers in graphs have no strict meaning. The simulations are more about trends in the results. The simulations were performed using the DoDo program. [1]

Figure 1 presents a standard 3 part suction tube design. One of the limitations of such a design is any pitching motion of the ship will result in forward of backward motions of the drag head. If the relative backward velocity becomes bigger than the forward velocity of the ship, the total drag head velocity becomes negative, which is highly undesirable for the dredging process.

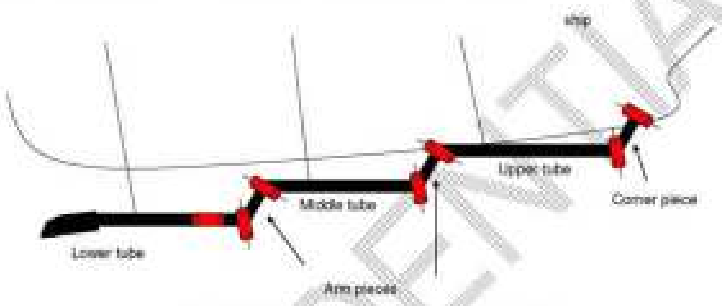


Figure A4 1 Standard 3-part suction tube configuration

The main reason that ship pitch motions give large relative drag head motions is that: the whole suction tube is kinematically constrained. Therefore a solution seams to allow for some extra drag head motion by using a telescopic suction tube as illustrated in figure 2.
The stiffness of the pre tensioning spring is highly non-linear: very stiff when the suction tube is pulling strongly, very flexible when the forces in the tube become compressive.

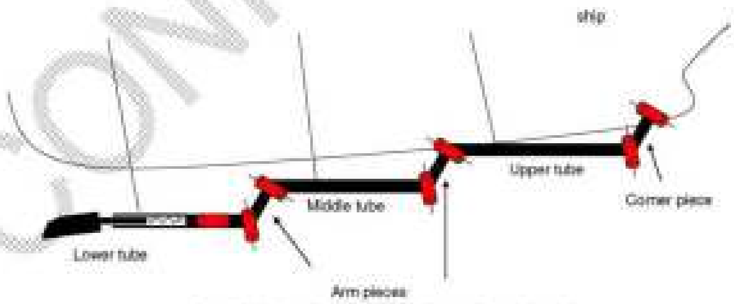


Figure A4 1 Novel concept with telescopic suction tube

For the simulation a hopper with a capacity of over 30000 m^3 was used. The model is about 150 meters long. The suction tube was lowered to about 40 meters. In that case one finds the results in figure 3. All

[1] For a (very) short description of the DoDo program, see the end of this document.

speeds that are more negative that -0.5 m/s are problematic, because in that case the forward speed of 1 knot is not enough for keeping a total positive forward velocity.

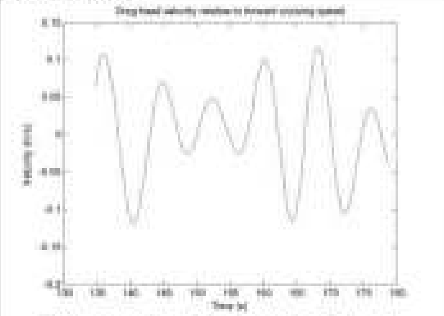
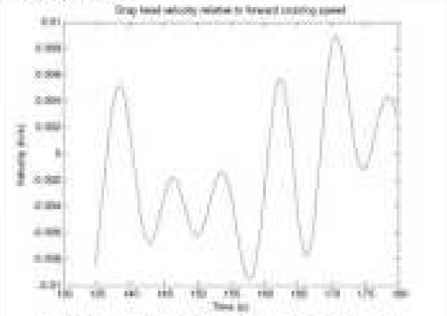
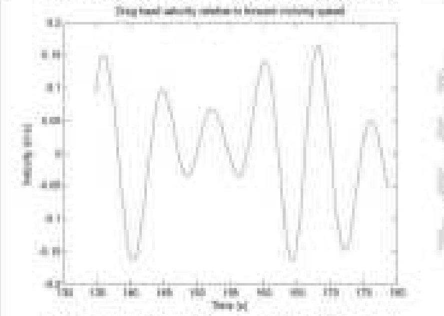
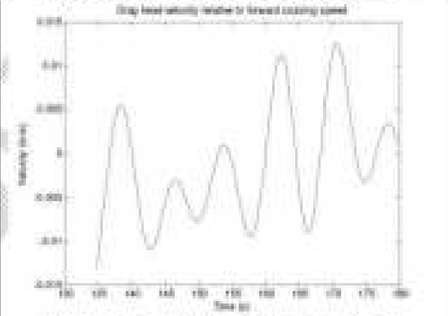
	Standard Hopper	Novel concept
Hs = 2.5 meter	 Most negative relative velocity is -0.12 m/s	 Most negative relative velocity is -0.01 m/s
Hs = 3.5 meter	 Most negative relative velocity is -0.20 m/s	 Most negative relative velocity is -0.015 m/s

Figure A4 2 Drag head velocities for several situations

In figure 4 the required stroke of the telescopic motion is shown. A stroke of about 0.5 meter seems to be required for these waves.

All simulation were performed with a wave generated using a JonSwap spectrum and a time window of 200 seconds, only a part of the results is shown because the starting up transient of the simulation is uninteresting. The peak period in the time window was 9 seconds.

From the simulations it is clear that the concept can have a positive effect on workability for higher seas.

However it should be noted that this was a preliminary study, therefore forces on the telescopic part were not studied. Also the cutting force was simulated as simple velocity dependent force, instead of the more advanced cutting models available in Dodo. Als only a short wave was shown, due to the statistical properties of waves, all values are underestimated, however the trend is clear.

Date 30 August 2011		

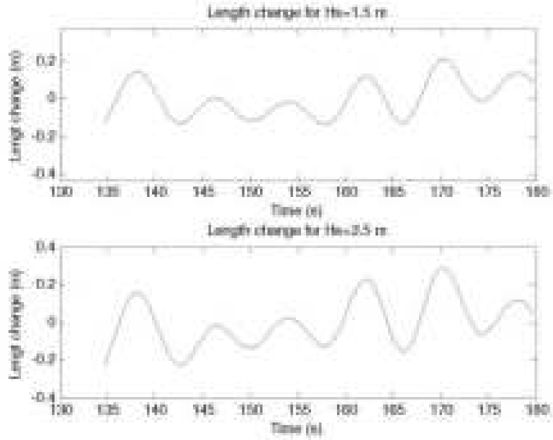


Figure A4 3 Stroke of the telescopic part

The workability of the original ship without telescoping suction tube is shown in Figures 5 and 6. Where the following procedure was used:

A situation is said to be not workable if:

1. The stroke of the heave compensator exceeds 3 meters
2. The speed of the heave compensator exceeds 1.75 meters per second
3. The speed of the drag head becomes negative, for a ship speed of 1 knot.

If criterion 3 is reached, the necessary ship speed to prevent a negative drag head speeds is determined. If it is below three knots this speed is listed, if it is above three knots the situation is said to be not workable. This leads to the following colour definitions for the workability diagrams:

	Workable
1.2	Workable if ship speed is increased to the listed speed in knots
	Not workable because necessary ship speed is above 3 knots
	Not workable because either heave compensator stroke or speed is exceeded

Empty ship, 15 degree pipe angle, 180 degree wave angle

Tp(s)

Hs(m)	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
0.5								
1								
1.5								
2								
2.5								1.1
3							1	1.3
3.5							1.2	1.6
4						1.1	1.4	1.8
4.5					1	1.3	1.5	2
5					1.2	1.4	1.7	2.2

Figure A4 4 Workability of the ship with classic suction tube configuration

Empty ship, 15 degree pipe angle, 0 degree wave angle

Tp(s)

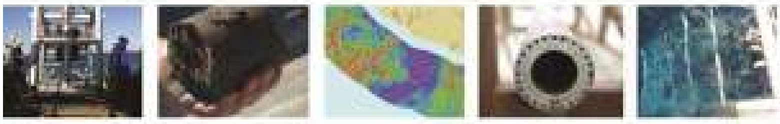
Hs(m)	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5
0.5								
1								
1.5								
2								
2.5								1
3								1.3
3.5						1.1	1.1	1.5
4					1.1	1.3	1.3	1.7
4.5					1.3	1.5	1.5	1.9
5					1.4	1.6	1.6	2.1

Figure A4 5 Workability of the ship with classic suction tube configuration

What is DoDo?

In order to reach the goal of the DODO project, three traditionally more separated disciplines are combined in one simulation package:

- Multibody dynamics
- Hydrodynamics,
- Soil mechanics.



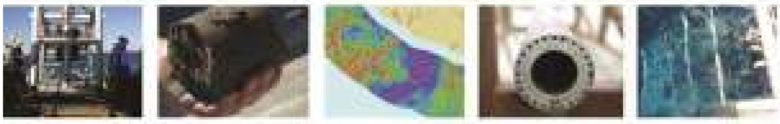
Multibody dynamics, needed for modeling the motion of the dredger parts and soil mechanics are the expertise of IHC Holland - MTI and are therefore implemented by the DoDo project team. The multibody dynamics code has been implemented in Matlab.

Hydromechanics is the expertise of the research institute Marin, therefore their codes will be used as basis for the hydrodynamic parts of DoDo. This used hydrodynamic suites of MARIN consists of two parts:

- A hydrodynamic coefficient computation code, Diffrac
- A non-linear time integration code for ship dynamics, AnySimPro

The hydrodynamic coefficients have to be computed once of a ship before coupled DoDo simulations are performed. Diffrac stores the coefficients such that they can be used by the DoDo and AnySim programs

The soil mechanics code has been implemented in Matlab directly based on the Cudyn code for cutters and the Miedema/Vercruijse model for hoppers.



MTI Holland B.V.

Memo

From
Harraets, P.W.

Date
9 November 2011

Reference
55092 - TTRL concept study 2

Subject

Addendum to TTRL Iron Sand Dredge Mining Concept Study

Introduction

In the document "Clarifications on Dredge Mining Concept Report – 21/10/2011" Technip posed several questions regarding the concept study (MB094 , 08/2011) executed by MTI Holland's Dredging Advisory Services (DAS) in cooperation with Dredging International (DI) Asia for Trans Tasman Resources ltd. (TTRL). The questions where examined and some of the figures in the report recalculated accordingly. Below Technip's questions are repeated (printed in black) followed by MTI's response.

1. A bulk density of 2.36 t/m^3 has been assumed for the concentrate. Technip agrees with this value, despite maybe a bit high (2.1 t/m^3 could be more relevant according to preliminary basis of design agreed).

   Answer: 2.36 t/m^3 was provided by Andre Mouton (TTRL) on 11/6/2011. We suggest keeping this value.

2. A primary sediment buffer storage has been considered in the report despite this is not technically feasible as it would lead to a loss of the fines particles in which the highest TiFe concentration has been observed. Technip is requiring MTI / DEME not to consider a subsea buffer tank and clarify the according consequences on the overall mining concept.

   Answer: Leaving out the buffers will greatly increase the required plant- and dredge mining capacities. Alternatively considerably longer loading times of bulk carriers should be allowed for resulting in more bulk carriers required. We believe that without sediment and concentrate buffers it is not possible to make the operation economically feasible without totally changing bulk carrier/ shuttle carrier loading frequency.

3. Environmental conditions have well documented in the report, nevertheless Technip is requesting for a detailed wind rose as an input for further analysis.

Date	Reference	Page
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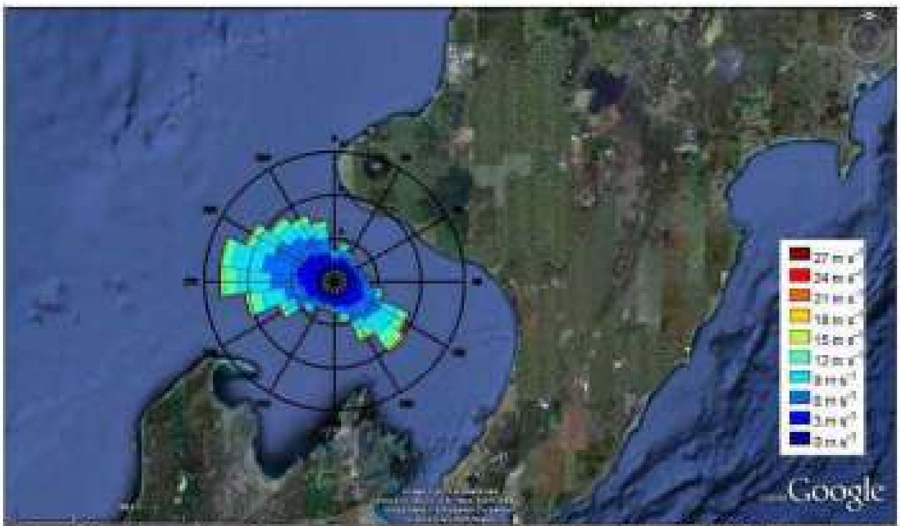


Figure 2.4 Rose plots of wind speed and direction for the period 1997-2009 at a location southwest of the southern tenement at latitude longitude -40° 173.5°.

Answer: Above is what MTI has available: Source: "South Taranaki Bight Iron Sands – Environmental Baseline Study" written by ASR 05/2010.

4. An overall operability of 76% was considered for the TSHD. When accounting for both the weather down-time as well as the maintenance operations, i.e. cleaning of the suction head, dry docks ... it is assumed that the overall operability of a TSHD in the Southern Tenement would be decreased down to 69%, report shall then be updated accordingly or the value of 76% of operability further documented.

   Answer: It is assumed that "operability" is defined as workability times (mechanical) availability. Availability depends heavily on the type- and state of the vessel and experience level of its crew. In literature typical availability values for a TSHD range from 66% to 90%. From experience of our customers we know that 80% availability is a good approximation for a large modern TSHD. Since we will have periods of weather-related downtime part of the repair and maintenance can be performed during these periods. We therefore have used 90% availability during potential operational hours. Workability is a more complex subject since it depends on sailing pattern as well. To arrive at the value of 66% as mentioned in our report we made the assumption that for our operation and wave type the maximum allowable significant wave height will be about 2.2 meters for a 30.000 m^3 twin suction tube TSHD for wave periods up to 15 seconds. Summing frequencies of occurrence in table A1 on page 38 yields the stated 66% workability. Above this wave height we are limited by lowering of the suction tube and negative drag head velocities due to too much pitching of the vessel. We propose several modifications to extend these limits. (by modifications to suction tube, winches, and guide rails as proposed). Calculations (Appendix 4) show that even at H_s of 4 meters in a Jonswap (North Sea) wave spectrum will not yield significant negative velocities at the drag head if a telescopic section with about 0.5 meter stroke vastly increasing workability. We therefore made the assumption that with modifications 2, 3, and 4 as proposed on page 32 of the report that work can continue up to at least H_s of 3 meters taking into account the longer wave periods near New Zealand. When once again using this value in table A1 on page 38 it can be found that workability will be approximately 85%.

This yields (in averages): 85% (workability) * 90% (availability during workable hours) = 76% (operability)

5. As a general comment regarding the estimated production rate, MTI has assumed that the TSHD is filled at 100% of its capacity at each cycle, which is probably too optimistic and shall be re-evaluated. In addition, Technip deems that a volume of 10% of sediment will remain in the TSHD tanks after offloading, the number of cycles shall be updated accordingly.

Answer: We used a recovery efficiency of 95% for the TSHD. Please note that we have incorporated a "clean up" part in the unloading process where unloading continues at lower capacity with added jet water to recover as much as possible of the hopper load. We are convinced that this number is already conservative for a modern TSHD and recommend against lowering it any further.

6. Production rate were estimated for 6 Mtpa. Technip is requiring a sensitivity analysis to be performed for 10 Mtpa.

Answer: If **exactly** 6 and 10 Mton concentrate is required at (for instance) 12% grade sediment the following cost figures will arise:

Production (TiFe):	**6**	**Mt/y**
Estimated sediment grade	12	%
Required spread (TSHD)	2	-
Average utilization rate	**0.72**	**-**
Capital expenditure	328,786,380	€
Capital costs a year	31,718,464	€/yr
Fuel costs	14,719,206	€/yr
Repair and maintenance	16,863,769	€/yr
Crew costs (double shift)	8,693,089	€/yr
Insurance costs	4,109,830	€/yr
Operational expenditure	**44,385,894**	**€/yr**
Exploitation cost	**76,104,358**	**€/yr**
Specific Exp. costs	**12.7**	**€/t (TiFe)**

Table 1: Costs recalculated for exactly 6 Mt/y concentrate

Production (TiFe):	10	Mt/y
Estimated sediment grade	12	%
Required spread (TSHD)	3	-
Average utilisation rate	0.80	-
Capital expenditure	493,179,570	€
Capital costs a year	47,577,696	€/yr
Fuel costs	22,078,809	€/yr
Repair and maintenance	16,863,769	€/yr
Crew costs (double shift)	13,039,633	€/yr
Insurance costs	6,164,745	€/yr
Operational expenditure	**58,146,956**	**€/yr**
Exploitation cost	**105,724,652**	**€/yr**
Specific Exp. costs	**10.6**	**€/t (TiFe)**

Table 2: Costs recalculated for exactly 10 Mt/y concentrate

As can be seen in table 1 and 2 specific exploitatin costs are higher than calculated in the report (9 €/t (TiFe). This is because we do not use different types of TSHD's to obtain the production goals and in the report the TSHDs are used at their nominal capacity. The approach in the report will yield **at least** 6 mt/year of concentrate (and possibly more depending on grade and vessel spread).

7. The minimum water depth encountered in the Xantia zone is 20m, would a PSD or TSHD be capable of operating in such shallow water (a minimum water depth of 25m is mentioned in the PSD specifications). As a general comment, clarifications are required regarding the operablity as a function of the water depth.

   Answer: For the TSHD 20 meters of water depth will not yield any problems since the maximum loaded draught is around 12.2 meters. The PSD needs a small modification to the lower suction tube to be able to dredge at 20 meters depth.

8. The Plain Suction Dredger concept is based on the use of barges for sediment transfer, basically being a TSHD without loading system. Technip is wondering if these barges need to be dynamic positioned and in this case if it has be accounted for in the CAPEX estimate.

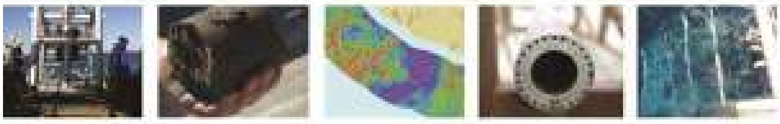
   Answer: DP1 is required to keep the barges in position underneath the PSD loading arms and included in the CAPEX of the barges.

9. The two concepts, either stationary or free sailing, show consequent discrepancies in the calculation of the overall dredging cycle, especially regarding the sediment offloading time to the FPSO. Realistic clarification is requirement on this point.

   Answer: We have thoroughly investigated and compared both dredging cycles (table below) and indeed two problems were found (marked in yellow) both discrepancies are clarified on the following page. However influence on the system capacity turned out to be small and the required spreads did not change.

Sailing empty	PSD	TSHD	
Averge sailing speed empty	10.3	14.5	Kn
Sailingdistance empty	4.6	4.6	Nm
Sailing time empty	26.8	19.0	min
Loading	256.5	107.2	min
Sailing full sediment			
Average speed used	9.8	11.6	kn
Sailingdistance full sediment	9.2	9.2	nm
Sailing time full sediment	56.5	47.5	min
Mooring			
Mooring	15.0	42.0	min
Pumping sediment			
Pumping sediment	44.3	122.7	min
Loading tailings			
Bulk volume	5082.0	25177.4	m3
Pumping tailings	38.2	107.7	min
Un-mooring			
Un-mooring	15.0	12.0	min
Sailing full tailings			
Average speed used	9.8	11.6	kn
Sailing distance full tailings	4.6	4.6	nm
Sailing time full tailings	28.3	23.8	min
Dumping tailings			
Dumping	10.0	15.0	min

Table 3: Dredging cycles compared



1. Mooring: TSHD requires almost 3 times more time to moor and connect to the FPSO transfer pipeline. This was found to be due to a different mooring procedure used between DAS engineers. The correct mooring procedure (dynamically keeping position and taking in the FPSO transfer pipeline floating connector) will take approximately 15 minutes for the TSHD's and PSD shuttle barges.
2. Pumping tailings: An error was found in the calculation of the loading of tailings by the FPSO to the PSD shuttle barges. Instead of bulk tailings density, in-situ sediment density was used. This problem has been corrected resulting in an increased tailings mixture capacity of 133 m^3/min. to 160 m^3/min. during the loading of tailings to the PSD barges.
3. Un-mooring: The PSD unmoors in 15 minutes while the TSHD unmoors in 12 minutes. This has been set to 15 minutes for both THSD and PSD for sake of consistency.

We have recalculated the tables provided in appendix 2 of the report and also made the units and layout more consistent. This results in table 2 and 3 below to replace tables A2a and A2b in the report.

Date	Reference	Page
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Option 1300 m3/hr with 2 barges			PSD	Barge 1	Barge 2
Sailing empty	min			27	27
Loading	min	barge1	257	257	
	min	barge2	257		257
	min	barge3			
	min	barge4			
Load	situ m3			4,919	4,919
Load	situ tds			10,379	10,379
Load	tds conc.			2,463	2,463
Change barge	min	barge1	15	15	
	min	barge2	15		15
	min	barge3			
	min	barge4			
Sailing full	min			57	57
Mooring at FPSO	min			15	15
Unloading sediment	min			51	51
Restload	situ m3			50	50
Loading tailings	min			32	32
Load tailings	tds			8,153	8,153
Un-mooring FPSO	min			15	15
Sailing full tailings	min			28	28
Unloading tailings	min			19	19
Pipecheck	min		81		
SUB TOTAL	min		594	506	506
Waiting	min		0	88	88
TOTAL	min		594	594	594
Efficiency	OH		123	123	123
Number of cycles per week	-		12		
Cycle production	situ m3/hr		983	492	492
Week production	situ m3/wk		120,870	60,435	60,435
Cycle production	situ tds/hr		2,094	1,036	1,036
Week production	situ tds/wk		254,809	127,405	127,405
Cycle production TiFe	tds con/hr		497	248	248
Week production TiFe	tds con/wk		60,517	30,259	30,259

Production Tailings

Cycle production Tailings	tds tail/hr		1,646	823	823
Week production Tailings	tds tail/wk		202,401	101,201	101,201

1 Spread	1	PSD
	2	Barges

Number of spreads required	3.00	-

Table 4: Replacement for table A2a

TSHD		
Sailing empty	min	19
Loading	min	107
Load	situ m3	22854
Load	situ tds	45748
Load	tds conc	6405
Sailing full	min	48
Mooring at FPSO	min	15
Unloading sediment	min	121
Restload	situ m3	1133
Loading tailings	min	92
Load tailings	tds	39984
Un-mooring FPSO	min	15
Sailing full tailings	min	24
Unloading tailings	min	13
TOTAL	min	453
Efficiency	OH	129
Number of cycles per week	-	17
Cycle production	situ m3/hr	2850
Week production	situ m3/wk	388231
Cycle production	situ tds/hr	6057
Week production	situ tds/wk	781416
Cycle production TiFe	tds con/hr	806
Week production TiFe	tds con/wk	103542

Production Tailings		
Cycle production Tailings	tds tail/hr	5294
Week production Tailings	tds tail/wk	680416

1 Spread	2	TSHD's

Number of spreads required	1	

Table 5: Replacement for table A2b

10. The expenditure analysis provided in the report has been reviewed by Technip. Given that dredging operations are not common at Technip, no comparison with internal costs can be done. Nevertheless, it is required to clarify if the crew cost is including the cost for personnel transport to New-Zealand.

    Answer: We have not included specific mobilization costs to- and from New Zealand in the present pre-feasibility stage.

With regards to the offshore operations aspect, Technip fully agree with MTI regarding the impossibility to use either floating flexible or subsea rigid pipeline for the sediments / tailings loading or offloading between the TSHD and FPSO due to harsh environmental conditions.

Finally, it is also stated in the report that mooring two vessels together for material transfer shall be avoided at all time due to these environmental conditions. Technip does not agree with this statement as it shall be a conclusion from a detailed dynamic analysis study.

Answer: This seems like a proper approach and we are interested in the results. However since we did not have a dynamic analysis of moored vessels available we've had to make this (perhaps conservative) assumption.

19.18 Golders Associates – Mineral Resources and Geology

REPORT

May 2013

TRANS TASMAN RESOURCES LIMITED

South Taranaki Ironsand Project Resource Report

Submitted to:
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Report Number. 107641018-028-R-Rev0

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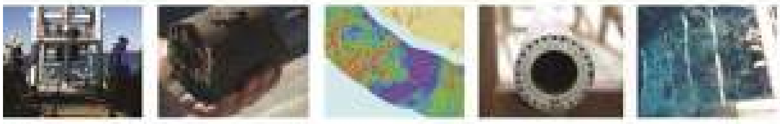


Executive Summary

This report details the resource update for the South Taranaki titanomagnetite deposit located offshore south west of the North Island of New Zealand. The resource estimates are based on all available assay data as of 20 November 2012.

The deposit is a submarine aeolian/alluvial/marine accumulation of ironsand in palaeo channels, strandlines and dunes. Geophysical surveys have identified strongly magnetic targets throughout the exploration area. The majority of drilling to date has penetrated 5 m or less into what is interpreted as a blanket of overburden sand covering the geophysical anomalies. Several deeper holes have defined the depth of sand as being up to 30 m.

Analysis of the available drilling data for the South Taranake project has resulted in the creation and estimation of a Mineral Resource for the blanket of sand. The underlying geophysical targets are as yet undefined by the drilling.

The resource was estimated using an Ordinary Kriging algorithm. The screened recovery (REC) has been applied to the models. Head grades and tonnages are for all material less than 2 mm in diameter. Davis Tube Concentrate (DTC) grades are for the magnetically recoverable portion of the sample. Head grades were estimated using samples weighted by REC. Estimations for concentrate grades were weighted by REC and Davis Rube Recovery (DTR). The weighting is applied in order to appropriately reflect the relationship between the REC and head assays for the head samples and REC, DTR and the DTC assays for the magnetic concentrate samples. Weighting was completed by calculating the accumulation (REC × Head Grade, Rec × DTR × DTC assay) and subsequently back calculating the head and DTC assay estimates by dividing by relevant estimated REC and DTR values. Concentrate tonnage is calculated from the head tonnage and DTR.

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. The DTR is a laboratory scale representation of the expected metallurgical recovery of the processing plant. DTC grades were estimated for Fe, Al_2O_3, P, SiO_2, Ti, CaO, K_2O, MgO, Mn, and LOI.

The resource estimates were classified in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC, 2004) as Indicated and Inferred. The recoverable Mineral Resource is reported from the block models *north_acc_24_11_2012.bmf (domains 1-7 and 9)* and *south_acc_24_11_2012.bmf (domain 8)*.

The models have been reported at 3.5% DTR cut-off grade where DTR analyses are available within the proposed mining area (Table A and Table B). 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 (Table C).

For comparison with previous resource estimates Table D reports the models at 5% Fe_2O_3 (head) cut-off grade.

Table A: Head Grades (%) - Proposed Mine Area - 3.5% DTR Cut-Off Grade

Class	Domain	Mt	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	P_2O_5	CaO	K_2O	MgO	MnO	LOI	DTR	REC
Indicated	1	98.9	10.54	10.50	55.41	1.07	0.177	10.46	1.08	5.14	0.18	3.08	7.10	93.24
	3	358.2	12.82	12.28	50.49	1.29	0.263	11.06	1.10	5.59	0.22	2.03	8.96	98.27
	6	81.8	10.67	11.46	55.84	1.10	0.200	9.49	1.19	4.48	0.17	2.59	7.16	95.46
	7	41.6	9.25	12.51	51.68	0.93	0.231	12.28	1.14	5.24	0.18	3.57	5.43	89.92
	9	3.6	8.23	14.16	53.71	0.82	0.232	11.18	1.20	4.60	0.17	2.55	4.10	98.25
Total Indicated		***584.1***	***11.85***	***11.89***	***52.18***	***1.20***	***0.237***	***10.83***	***1.11***	***5.33***	***0.20***	***2.40***	***8.11***	***96.43***
Inferred	1	93.3	16.68	10.27	47.42	1.69	0.276	10.88	0.99	6.34	0.25	2.63	6.27	94.67
	3	111.6	11.33	13.11	51.13	1.14	0.261	11.04	1.17	5.19	0.20	2.36	8.75	97.23
	6	192.6	10.14	13.34	52.26	1.03	0.241	11.09	1.16	4.89	0.18	2.46	6.21	95.01
	7	49.5	12.45	9.07	45.56	1.20	0.234	16.30	0.75	7.18	0.24	4.86	6.18	88.64
Total Inferred		***447.0***	***12.06***	***12.17***	***50.22***	***1.21***	***0.253***	***11.61***	***1.08***	***5.52***	***0.21***	***2.74***	***7.27***	***94.56***
Indicated + Inferred		**1031.1**	**11.94**	**12.01**	**51.33**	**1.20**	**0.244**	**11.17**	**1.10**	**5.41**	**0.21**	**2.54**	**7.75**	**95.62**

Table B: Concentrate Grades (%) - Proposed Mine Area - 3.5% DTR Cut-Off Grade

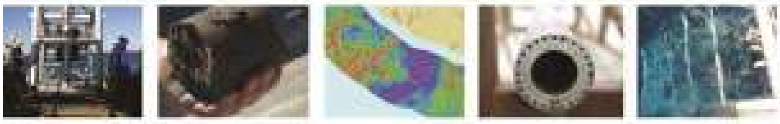
Class	Zone	Mt	Fe	Al_2O_3	SiO_2	Ti	P	CaO	K_2O	MgO	Mn	LOI
Indicated	1	7.0	58.42	3.57	2.48	5.06	0.096	0.80	0.07	3.18	0.52	-3.21
	3	32.1	57.09	3.65	3.69	5.12	0.112	1.00	0.11	3.25	0.51	-3.05
	6	5.9	57.76	3.61	3.09	5.10	0.104	0.88	0.09	3.19	0.51	-3.14
	7	2.3	56.83	3.73	4.01	5.05	0.103	1.07	0.12	3.32	0.51	-3.07
	9	0.1	54.95	3.77	6.04	5.03	0.120	1.36	0.19	3.40	0.51	-2.90
Total Indicated		*47.4*	*57.35*	*3.64*	*3.48*	*5.10*	*0.108*	*0.96*	*0.10*	*3.24*	*0.51*	*-3.08*
Inferred	1	7.7	57.29	3.71	3.60	5.06	0.106	0.95	0.12	3.24	0.51	-3.10
	3	9.8	56.97	3.66	3.85	5.12	0.115	1.01	0.12	3.24	0.51	-3.03
	6	12.0	56.60	3.70	4.27	5.07	0.113	1.08	0.13	3.24	0.51	-3.01
	7	3.1	57.93	3.61	2.91	5.04	0.099	0.89	0.08	3.23	0.52	-3.17
Total Inferred		*32.5*	*57.00*	*3.68*	*3.85*	*5.08*	*0.111*	*1.01*	*0.12*	*3.24*	*0.51*	*-3.05*
Indicated + Inferred		79.9	57.21	3.65	3.62	5.09	0.109	0.98	0.11	3.24	0.51	-3.07

Table C: Head Grades (%) Outside Proposed Mine Area - 7.5% Fe2O3 Cut-Off Grade

Class	Domain	Mt	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	P_2O_5	CaO	K_2O	MgO	MnO	LOI	REC
Indicated	2	92.0	8.85	13.16	48.96	0.89	0.253	14.21	1.14	5.53	0.20	4.00	84.12
	3	19.3	9.55	13.57	51.84	0.96	0.249	11.92	1.19	5.43	0.20	2.19	92.87
	5	32.9	9.54	13.90	50.03	0.94	0.274	12.91	1.16	5.99	0.21	2.09	82.86
	6	66.2	12.26	12.91	51.30	1.29	0.215	10.25	1.15	4.56	0.21	2.88	93.53
	7	260.6	8.85	14.10	51.56	0.88	0.247	12.16	1.25	5.20	0.19	2.40	89.07
	9	118.2	9.08	13.96	51.63	0.90	0.263	12.19	1.18	5.37	0.19	2.28	94.01
Total Indicated		*589.2*	*9.34*	*13.76*	*51.06*	*0.94*	*0.247*	*12.31*	*1.20*	*5.27*	*0.20*	*2.63*	*89.57*
Inferred	1	33.7	14.52	7.83	47.43	1.46	0.204	13.76	0.79	5.42	0.21	6.55	87.75
	2	192.9	8.79	13.66	49.27	0.89	0.240	13.57	1.21	5.05	0.19	4.08	85.13
	3	149.8	9.39	14.33	51.59	0.95	0.257	11.41	1.28	4.87	0.18	2.59	94.23
	4	139.0	9.55	11.09	45.37	0.91	0.237	17.32	0.88	6.22	0.21	6.08	83.60
	5	1.7	8.18	13.84	50.90	0.80	0.281	13.31	1.19	6.19	0.20	2.08	82.67
	6	263.0	11.27	12.36	52.10	1.16	0.214	10.92	1.14	4.91	0.20	2.97	93.55
	7	167.6	8.92	10.91	45.17	0.86	0.228	17.77	0.88	6.05	0.20	6.72	83.24
	9	201.3	8.92	14.48	51.60	0.88	0.270	12.23	1.22	5.57	0.19	1.78	91.01
	8	60.6	9.08	9.12	54.13	0.78	0.141	12.62	0.85	6.82	0.18	4.50	90.51
Total Inferred		*1209.6*	*9.70*	*12.53*	*49.74*	*0.97*	*0.234*	*13.47*	*1.09*	*5.46*	*0.19*	*3.96*	*88.97*
Indicated + Inferred		**1798.8**	**9.59**	**12.93**	**50.17**	**0.96**	**0.238**	**13.09**	**1.13**	**5.40**	**0.20**	**3.52**	**89.17**

Table D: Head Grades (%) Full Area Reported at 5% Fe2O3 Cut-Off Grade

Class	Zone	Mt	Fe_2O_3	Al_2O_3	SiO_2	TiO_2	P_2O_5	CaO	K_2O	MgO	MnO	LOI	REC
Indicated	1	131.3	9.65	10.71	56.14	0.98	0.171	10.41	1.13	3.30	4.86	0.17	92.21
	2	184.1	7.69	14.46	50.31	0.80	0.241	13.00	1.33	4.34	4.41	0.17	86.85
	3	426.8	11.98	12.72	51.18	1.21	0.259	10.87	1.16	2.14	5.33	0.21	98.06
	5	108.8	7.32	15.05	52.37	0.78	0.240	11.31	1.44	3.92	3.90	0.15	90.80
	6	220.7	8.88	12.54	55.52	1.03	0.197	9.48	1.25	2.71	4.17	0.17	94.96
	7	501.3	8.06	14.65	52.99	0.83	0.234	11.23	1.36	2.65	4.50	0.17	90.67
	9	150.5	8.65	14.20	52.21	0.87	0.248	11.88	1.22	2.36	5.05	0.18	94.69
Total Indicated		***1723.4***	***9.35***	***13.57***	***52.71***	***0.96***	***0.233***	***11.10***	***1.27***	***2.81***	***4.69***	***0.18***	***93.12***
Inferred	1	157.8	14.76	10.06	48.79	1.50	0.247	11.27	1.01	3.95	5.67	0.22	92.81
	2	429.4	7.65	14.31	49.86	0.80	0.227	13.38	1.30	4.91	4.17	0.16	86.86
	3	355.3	9.33	14.43	52.70	0.96	0.250	10.54	1.34	2.47	4.53	0.18	96.13
	4	212.1	8.55	11.01	44.61	0.82	0.225	18.26	0.89	7.57	5.70	0.19	83.40
	5	7.4	6.68	13.46	53.50	0.70	0.224	11.85	1.37	4.34	4.22	0.14	89.26
	6	617.4	9.63	13.16	53.86	1.00	0.215	10.21	1.26	2.91	4.45	0.17	94.74
	7	375.3	8.41	11.72	47.20	0.83	0.219	16.19	1.02	6.29	5.30	0.18	85.58
	8	191.6	7.04	9.68	56.77	0.64	0.141	11.65	1.01	5.45	5.11	0.14	90.83
	9	590.5	7.33	16.29	53.13	0.76	0.253	10.96	1.46	2.09	4.12	0.16	91.75
Total Inferred		***2936.8***	***8.71***	***13.38***	***51.38***	***0.89***	***0.227***	***12.36***	***1.23***	***3.98***	***4.66***	***0.17***	***90.79***
Indicated + Inferred		**4660.2**	**8.94**	**13.45**	**51.88**	**0.91**	**0.229**	**11.90**	**1.24**	**3.55**	**4.67**	**0.17**	**91.55**



19.19 Golders Associates – Mine Schedules

May 2013

REPORT

2013 MINING SCHEDULES

Trans-Tasman Resources Ltd

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Report Number. 107641018-027-R-Rev0

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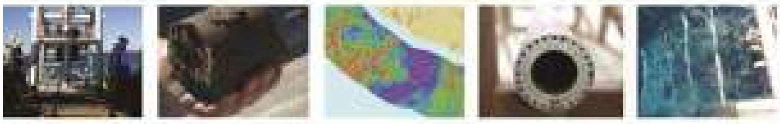


Executive Summary

This report details the mining schedules developed for the Prefeasibility Study of the Trans-Tasman Resources Limited (TTRL) South Taranaki titanomagnetic deposit, located offshore from Taranaki in New Zealand.

Golder updated the resource model and completed a resource estimate in May 2013, which was based on the drilling results up to 20 November 2012.

The deposit is a submarine aeolian/alluvial/marine accumulation of iron sand in palaeo channels, strandlines and dunes.

A mining model regularised to a consistent block size of 250 m × 250 m × 1 m was developed from the geological resource model.

A summary of the *in situ* tonnage reported from the geological and the regularised mining models within the proposed mining boundary *Mining_Area_Rev02* are given in the table below. No cut-offs have been applied.

***In Situ* Tonnage and Grade Reports and the effect of Model Regularisation**

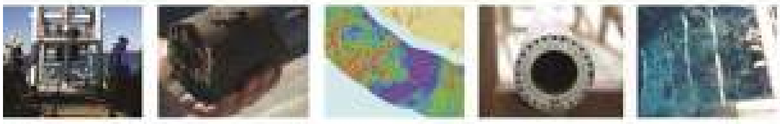
	In Situ Tonnes	Fe_2O_3	AL_2O_3	SIO_2	TiO_2	P_2O_5	CaO	K_2O	MgO	MnO	LOI
	Mt	%	%	%	%	%	%	%	%	%	%
Geological Model	1471	10.69	12.30	52.82	1.09	0.23	10.78	1.17	5.02	0.19	2.77
Reblocked Model	1446	10.72	12.29	52.76	1.09	0.23	10.82	1.17	5.04	0.19	2.77
% Difference	(1.7)	0.3	(0.1)	(0.1)	(0.2)	(0.2)	(0.3)	(0.3)	(0.4)	(0.3)	(0.1)

It is assumed that trailing suction hopper dredges (TSHD) or a remote crawler system will be used to mine the material below the gently sloping ocean floor. The modelled mineralised zone varies 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 centres to equate to the depth of the block centre below the ocean floor.

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 10-11% Fe.

For the dredging option, two large trailing suctions hopper dredges (TSHD) will 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 (FPSO), where it will be processed. Based on current estimates, each dredge will have an annual throughput capacity of 30-35 Mtpa.

For the remote crawler option, the crawler will be located on the sea floor, connected to the FPSO via an umbilical delivery tube. A winching system will be used to locate the FPSO relative to the crawler which will be mining 300 m × 300 m blocks from the base of the mineralisation, in a predetermined sequence. Based on current estimates, a remote crawler unit will have an annual throughput capacity of about 41 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 nine years.

The crawler option indicates annual tonnage movements of 41 Mtpa of *in situ* material with annual concentrate production of 2.9-4.8 Mtpa. A ten year schedule was developed. There are still resources available for mining by the crawler beyond 10 years.

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

For the dredging option, it is assumed that both of the waste fractions (+2 mm and -2 mm) will initially be pumped from the FPSO into a designated waste disposal area on the ocean floor adjacent to the FPSO. It may be possible for the FPSO to be relocated onto the mined out areas, to backfill these mined out areas when they become available.

For the remote crawler option, it is assumed that both of the waste fractions will be pumped from the FPSO into the mined out areas as part of the remote crawler/FPSO operating sequence.

Initial information from the remote crawler system supplier indicated that the Crawler/FPSO system required a minimum operational 30 m depth of water. The total amount of material reported from the model above the 30 m depth is 146.8 Mt or 27% of the scheduled tonnes. If the shallow areas cannot be mined with the crawler system there will be a significant reduction in the scheduled tonnages.

The schedule have been developed using optimistic assumptions.

Dredging Scenario Schedule - Two Dredges One Plant

Period	Dredging Tonnage			Processing Feed				Concentrate Production							Waste_Tonnes		Royalty
	Dredge 1	Dredge 2	Total Dredging	F_Tonnes	F_Fe	F_DTR	F_REC	C_Tonnes	C_Fe	C_Al_2O_3	C_SiO_2	C_Ti	C_P	C_LOI	+2 mm	-2 mm	Tonnes
	Mt	Mt	Mt	kt	%	%	%	Mt	%	%	%	%	%	%	Mt	Mt	Mt
Y1	32.3	15.0	47.3	45.7	10.85	11.51	96.89	4.8	57.91	3.54	2.79	5.19	0.11	-3.12	1.6	40.8	
Y2	34.5	34.5	69.0	67.8	10.01	10.43	97.88	6.5	57.45	3.62	3.27	5.15	0.11	-3.04	1.2	61.3	
Y3	34.5	33.8	68.3	66.2	10.60	11.96	96.29	7.4	57.43	3.68	3.29	5.13	0.11	-3.06	2.1	58.8	
Y4	30.0	31.5	61.5	58.0	10.64	10.93	94.54	5.8	57.84	3.64	3.00	5.05	0.10	-3.15	3.5	52.1	4.4
Y5	30.0	30.5	60.5	55.6	10.82	11.09	92.27	5.7	57.82	3.65	3.02	5.05	0.10	-3.16	4.9	50.0	3.9
Y6	32.5	32.0	64.5	61.8	10.34	10.23	95.65	5.8	57.29	3.68	3.60	5.08	0.11	-3.11	2.7	56.0	2.1
Y7	33.5	33.5	67.0	65.3	7.39	6.12	97.36	3.7	56.64	3.64	4.20	5.12	0.11	-3.03	1.7	61.7	
Y8	33.5	33.5	67.0	66.1	8.92	8.87	96.36	5.3	57.11	3.64	3.74	5.10	0.11	-3.07	0.9	60.8	
Y9	33.5	25.3	58.8	58.0	9.72	9.66	98.37	5.2	57.09	3.67	3.76	5.08	0.11	-3.06	0.5	52.8	
Y10																	
Total	**294.3**	**269.5**	**563.8**	**544.4**	**9.86**	**10.00**	**96.47**	**60.1**	**57.43**	**3.64**	**3.37**	**5.10**	**0.11**	**-3.08**	**15.4**	**494.3**	**10.3**

Crawler Scenario Schedule - Remote Crawler Option

Period	Dredging Tonnage		Processing Feed				Concentrate Production							Waste_Tonnes		Royalty
	Crawler 1	Total Dredging	F_Tonnes	F_Fe	F_DTR	F_REC	C_Tonnes	C_Fe	C_Al_2O_3	C_SiO_2	C_Ti	C_P	C_LOI	+2 mm	-2 mm	Tonnes
	Mt	Mt	kt	%	%	%	Mt	%	%	%	%	%	%	Mt	Mt	Mt
Y1	32.7	32.7	31.9	12.01	12.66	97.35	3.7	56.07	3.82	4.82	5.06	0.12	-2.98	0.8	28.2	
Y2	41.4	41.4	40.3	11.60	12.91	96.99	4.8	57.09	3.74	3.72	5.08	0.11	-3.06	1.1	35.5	
Y3	41.4	41.4	40.4	10.31	11.41	97.10	4.2	57.50	3.65	3.20	5.14	0.11	-3.07	1.0	36.1	
Y4	41.4	41.4	40.3	10.75	11.92	96.75	4.4	57.60	3.64	3.08	5.16	0.11	-3.09	1.1	35.8	
Y5	41.4	41.4	40.3	11.05	12.05	97.05	4.5	57.70	3.61	3.02	5.16	0.11	-3.07	1.1	35.8	
Y6	41.4	41.4	40.2	10.34	10.58	96.94	3.9	57.63	3.57	3.13	5.15	0.11	-3.04	1.2	36.3	0.1
Y7	41.4	41.4	38.4	9.67	8.78	88.37	2.9	57.86	3.59	2.97	5.04	0.10	-3.17	5.0	33.5	2.9
Y8	41.4	41.4	38.5	9.66	9.74	92.95	3.5	58.68	3.55	2.21	5.05	0.09	-3.23	2.9	35.1	3.5
Y9	41.4	41.4	40.0	9.84	9.96	96.47	3.7	58.66	3.53	2.26	5.08	0.10	-3.23	1.4	36.3	3.5
Y10	41.4	41.4	40.7	8.99	8.19	98.09	3.1	56.78	3.84	4.07	5.09	0.11	-3.04	0.7	37.6	0.0
Total	406.3	406.3	388.9	10.40	10.80	95.06	38.7	57.54	3.64	3.25	5.10	0.11	-3.09	16.4	350.2	10.0

19.20 Seabulk – Transhipment, Warehousing and De-watering

SEABULK SYSTEMS INC.
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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 transhipping portion are included in the report. Also included are preliminary specification for the conversion of a bulk carrier to transhipper 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

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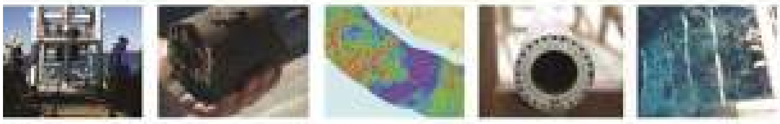


to exceed the target 5 Mt annual export tonnage. These preliminary figures are a positive statement for Seabulk's export system and make it candidate for further study.

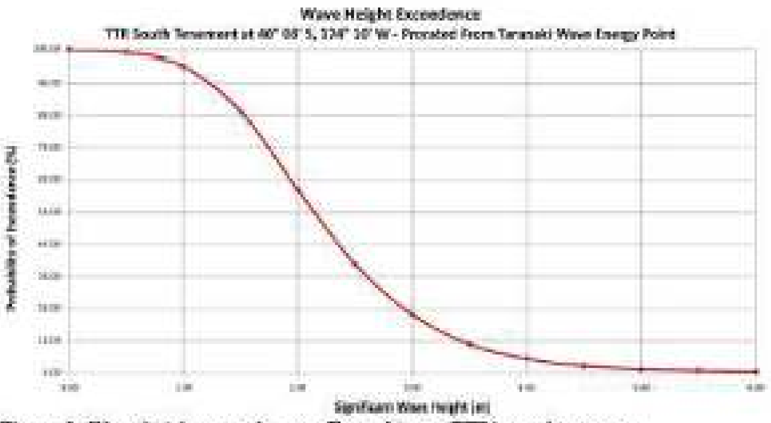


Figure 1: Wave height exceedence at Taranaki near TTR's south tenement

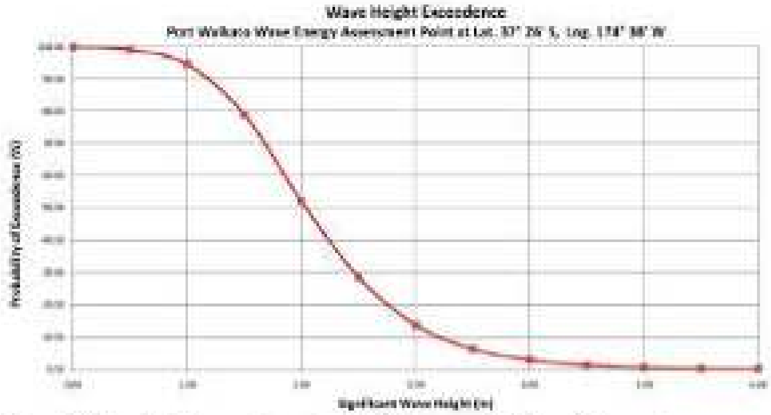
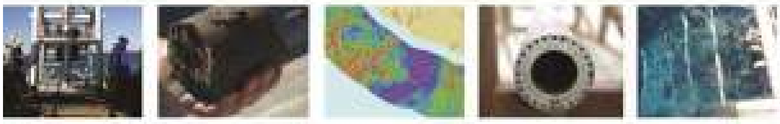


Figure 2: Wave height exceedence at Port Waikato near TTR's north tenement

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 off-shore 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 5*, 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*.

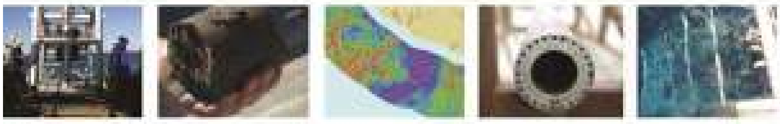
Operation

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%

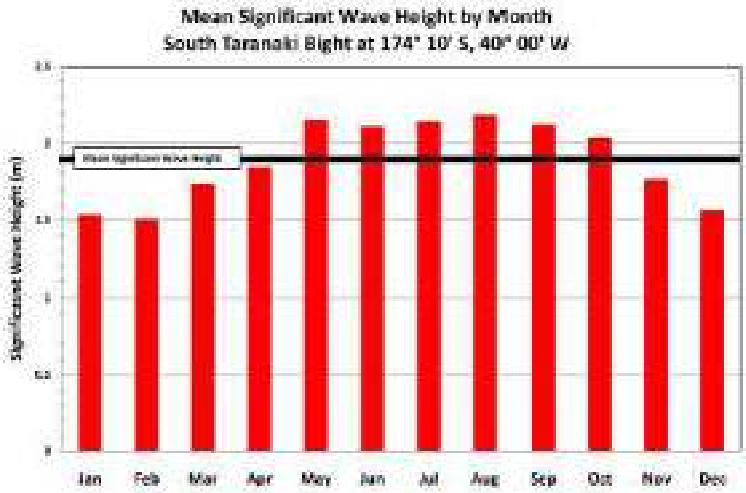


Figure 3: Seasonality of waves indicated by monthly variation in mean significant height

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.

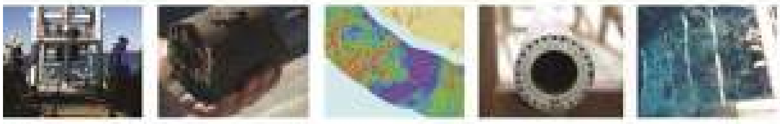
Logistics

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***.

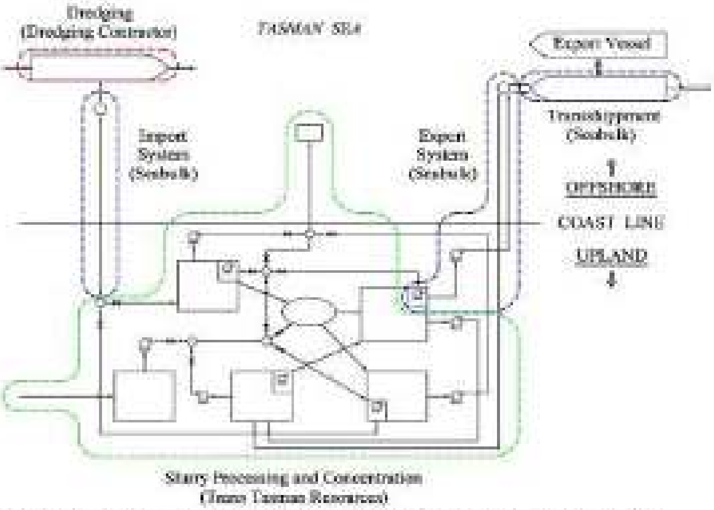
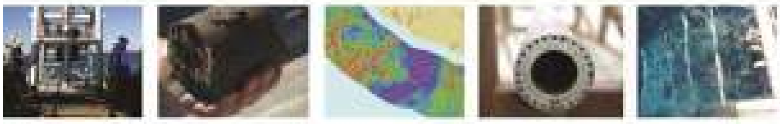


Figure 4: Illustration showing assumed responsibilities for iron sand export system

Table 2: Iron Sand Export Systems
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
Transshipment	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 tranship 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*.

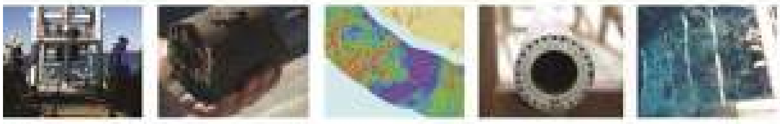
Crewing and Manning Options: In order to obtain a better estimate of the crewing costs, an investigation will be required. The New Zealand Maritime Safety Authority sets out circulars on ship operations. Circular Part 31A, Crewing and Watch Keeping is a guide to the requirements. The Law will govern 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



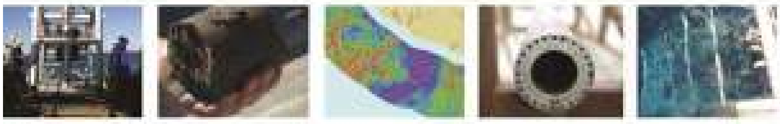
operating cost for the transshipment operation. Our concept calls for the dredge to come to a buoy to unload. This allows the use of a centrally located discharge point and a semi-permanent pipeline location. Unless land acquisition cost is prohibitive, we believe this will have lower capital and operating 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



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MULTI PURPOSE REEFS
COASTAL PROTECTION
ENVIRONMENTAL IMPACT ASSESSMENTS
HYDRODYNAMIC MODELING

28 April 2010

Paul Berend
Managing Director
Trans-Tasman Resources Ltd
1139 Hay Street
West Perth
WA 6005, Australia

Dear Paul

Re: Opinion on the Ecological Impacts of Seabed Ore Extraction in the Southern Taranaki Bight.

I have prepared a brief opinion of the likely ecological impacts of seabed ore extraction in the area of your southern tenement based on our existing knowledge of the area (from previous investigations associated with the Kupe and Maari oil/gas fields) and the existing body of knowledge with respect to ecological impacts of dredging.

It is noted that this opinion comes prior to the thorough seabed investigations planned for the area as part of exploration Resource Consent applications, and so there are unknowns with respect to the ecology of the entire tenement. However, based on what is known of the physical and biological aspects in this region they do provide insight to the likely findings.

Supporting information has been provided as the main body of this opinion letter. However, the findings are summarized in the final page.

The following factors suggest that the ecological impacts of extracting seabed materials from locations >5 km offshore of the southern Taranaki coast would likely be minor, short-term and localized:

- The area is a high-energy environment with consistently high waves and winds that create a very active seabed environment (i.e. seabed sediments are regularly mobilized and moved around);
- Existing data of seabed organisms in the area indicate that the existing seabed communities are not particularly sensitive to disturbance (as would be expected in a highly energetic environment);
- The operation only occurs once at each site, and;
- Management techniques such as those used for seabed extraction in other parts of New Zealand would ensure any sensitive or ecologically valuable areas would be protected.

Extraction Processes

In order to consider the potential ecological impacts, it is first important to understand the kind of extraction that could occur in the area, both for exploration and for mining. No

ASR ASR Marine Consulting and Research

extraction for either purpose will be undertaken closer than 5 km to the coast. Exploration extraction consists of:

- Bulk sampling of 2,000 tonnes (~1,000 m^3) of seabed material using an airlift suction dredge
- The extraction areas would be no more than 5-10 m deep (e.g. 5 m deep would impact on an area of <15 x 15 m in order to lift a 1,000 m^3 sample).
- The number of samples is likely to be 15-20, since there are no more than 10 types of seabed 'systems' within the area.

Mining operations would consist of:

- Extraction of 4-5 Mm^3/annum of concentrated ore material
- Areas targeted for extraction would likely contain >20% ore material
- 20-25 Mm^3 would be extracted, with 16-20 Mm^3 returned to the seabed (e.g. an extraction area of 2 x 2 km would be targeted, with initial extraction of 5 m depth, and 4 m of this material returned to the seabed via a tailings pipeline to reduce dispersion of fine materials).
- Note, the total volume of material removed over a year (~xx m^3/day during dredging operations)

Existing Physical Environment

The most relevant information at hand for physical and biological information of the subtidal seabed off the southern Taranaki area are investigations for the Kupe and Maari oil/gas fields (Figure 1). Physical and biological investigations have been undertaken for both of these projects – ASR, 2003; ASR, 2004a,b; ASR, 2005. Benthic and water column sampling around the site was undertaken for the Maari ecological investigations, while benthic surveys along the Kupe pipeline route from the nearshore of the well head were undertaken for Kupe, along with a marine mammal assessment for the area.

The Western Cook Strait/Southern Taranaki Bight area is known to be very dynamic, with a number of phenomena influencing the physical and biological regimes, including a highly energetic wave and wind climate, mesoscale features, areas of upwelling and regions with energetic tidal currents.

Wave and Wind Climate
TTR's southern tenament is located in a region that is known to be very energetic in terms of wave activity due to its exposure to long period waves originating in the Southern Ocean, as well as locally generated seas (particularly from the SE quarter). Most of the wave energy arrives from the west and southwest (the median wave direction is 245^{0}T) with peak spectral periods of 12-14 seconds. Storm conditions are expected to be characterised by a broad unimodal spectra, while the ambient conditions are frequently bimodal, typically exhibiting spectral peaks at sea and swell frequencies. The sea state is likely to bimodal for around 50% of the time, reflecting the influence of distantly-generated wave energy on the South Taranaki Bight sea conditions.

The prevailing wind direction for New Zealand is from the southwest-northwest, so that the New Zealand land mass presents a considerable obstacle, but with an opening at the Cook Strait. Regionally, the Strait tends to funnel and concentrate airflows and the resulting convergence leads to intensified wind speeds. Under southerly winds conditions, wind flows through the Narrows of the Strait in the form of a low-level jet, which maintains its integrity throughout the Greater Cook Strait into the Tasman Sea and creates high seas throughout the area.

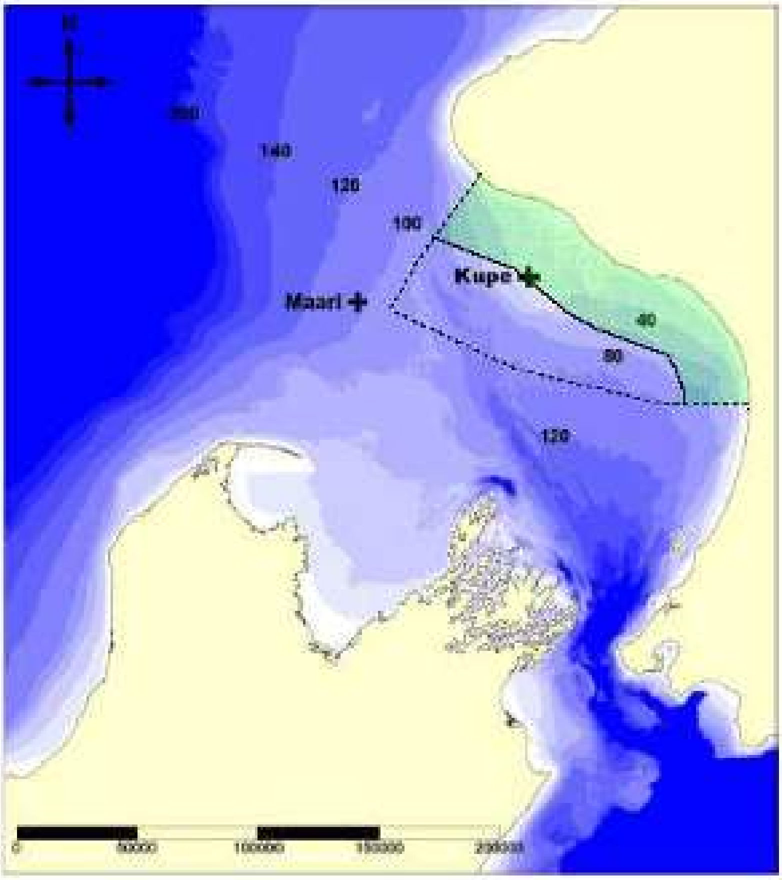


Figure 1. Bathymetric map of the Greater Cook Strait region showing the location of the Maari and Kupe Fields and the approximate location of the southern tenement.

Seabed Characteristics

The southern tenament straddles a zone of variable bathymetry, including an area known as 'The Rolling Ground', where the seabed morphology is characterised by a series of shore-parallel ridges (aligned NW-SE) (Figure 1 – in the area surrounding and inshore of the Kupe site). These ridges are up to 23 km long, 4 km wide, and rising 5-15 m above the surrounding topography. These are likely to represent relic coastal dunes formed during Late Quaternary sealevel regressions/transgressions. Indeed, it is probable that these ridges are the equivalent of the modern-day Farewell Spit, with an energetic wave climate driving a strong littoral sediment transport system and forming a migrating spit. At ~40 m depth, the spit has prograded offshore with each sealevel regression. The orientation of the ridges is consistent with a trend toward equilibrium alignment with the dominant wave approach, and the arcuate form of the SE tip of each ridge is consistent with the development of migrating spit from longshore sediment transport (directed SE). These littoral sediments are likely to be derived from the Taranaki Headland.

The seabed has a low overall gradient in the area, but features numerous undulations, which give rise to a fairly complex bathymetry. This complexity is likely to be due to the re-working of Late Quaternary sediments (sand and gravel) by littoral and aeolian processes. Overall these complex surficial features may be considered palimpsest in nature, having been formed under conditions of lower sealevel and subsequently modified by littoral and aeolian processes during transgression/regression events. Underlying the irregular bathymetric features of the Kupe Development area, the substratum consists of alternating marine sequences that are an extension of the Pleistocene lithology found on the coastal cliffs. This is likely to represent a wave-cut terrace.

Seabed Stability

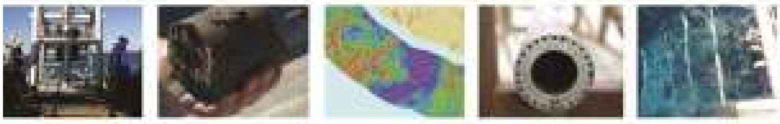
A mobile seabed that is exposed to waves and currents will not remain stable and has the potential to be worked into sedimentary structures termed bedforms. These structures have a large range of shapes and sizes, and the terms to describe them include bars, dunes, anti-dunes, ripples, sand-waves and ribbons. Sand ridges, sand ribbons, symmetrical megaripples and sand waves have all been previously identified in the South Taranaki Bight to depths of up to 60 m, indicating that the seabed in this area is very mobile, especially during storm events.

Theoretical calculations of the threshold for seabed mobility can give an indication of the potential of producing bedforms under different conditions at a range of water depths. The Hallermeier Outer Limit (HOL) has been calculated to estimate the maximum depths associated with sediment transport due to waves in South Taranaki Bight region (based on the reported surficial sediment grain sizes and the wave characteristics reported by Pickrill & Mitchell, 1979). From these data, it may be expected that the seabed sediment will be regularly mobilised by waves down to water depths of 60-70 m.

Existing Biology

Water Column

An interesting and somewhat unique aspect of the Western Cook Strait area is the presence of nutrient-rich upwelled plumes. Upwelled plumes, originating along the Kahurangi Shoal, are the salient parameter affecting the properties of the offshore water column in the area. These plumes are highly variable (both spatially and temporally) and



are comprised of cold, nutrient rich water that often becomes recruited into mesoscale eddies, which are shed off the tip of Cape Farewell. These eddies travel northwards towards the South Taranaki Bight and periodically migrate through the southern tenament. These eddies propagate northwards, becoming nutrient-depleted and phytoplankton-rich (as the entrained phytoplankton proliferate and mature). The high primary production subsequently affects the entire food chain within the Western Cook Strait. Episodic high concentrations of krill (*Nyctiphanes australis)* are often observed at the offshore oil fields in the area.

During the summer months, thermal stratification occurs over a large portion of the Western Cook Strait, with comparatively low levels of dissolved inorganic nutrients. A seasonal thermocline has been noted at the mid-water levels, which breaks down in the winter and spring months. Generally, the distribution of the stratification varies with the weather conditions, and is further modified by the upwelling pulses from the Kahurangi Shoals.

Benthic

Surficial sediment sampling and re-mote videoing have been used to investigate the benthos in the Maari and Kupe areas.

Towed-video images at the Maari site suggest the seabed consists of irregular mega-rippled bedforms with amplitude of approximately 0.1m, as well as some wave-induced ripples. Further, video observations and surficial sediment samples suggest active bioturbation of the upper sediments. A relatively low number of taxa and specimens were recovered from the surficial sediment samples. This may be a reflection of the sieve size on which the samples were washed (i.e. 1 mm), or a general paucity of organisms. Polycheates were found to dominate the macrobenthic community, but the single most abundant species found was the filter-feeding brittlestar. Statistical analysis of the benthic infaunal data suggests that there is little variability in the macrobenthic community over the area surveyed. No recognizably important or ecologically sensitive species were identified from the seabed grab samples.

Video and surficial sampling along the Kupe pipeline route found that the nearshore seabed exhibits a diverse range of environments, with a general trend of decreasing complexity with distance offshore, with a relatively low biological diversity, and no rare or threatened species have been identified along the pipeline route. This observation is broadly consistent with the expected reduction in volcanicast size with increasing proximity to the distal margin of the debris avalanche – i.e. hard substrates are likely to be found close to the coast. Within 1 km of the coast, low-relief reef with small sand-filled cracks and gutters is present, while 1-2.5 km offshore the seabed is composed of exposed mudstone, typically covered by a thin veneer of sand. The mudstone is characterised by a very flat and smooth surface, depauperate in marine life, and likely represents a relict wave-cut platform.

No large laminarian (kelp) or fucalean (bladderwrack) macroalgae were present at the in the nearshore to 3 km offshore. The lack of large macroalgae may be due to the high turbidity of the water in this coastal region. Hard substratum (cobbles, boulders and reef) areas supported dense patches of red and brown turfing algal communities and coralline algae (paint and turf). It is likely that that the turfing algal patches are ephemeral due to periodic cover by mobile sands (e.g. Figure 2), being more prevalent in summer months.. It is noteworthy that these algal complexes can tolerate and acclimate to very low light conditions and survive in the often very turbid waters of the nearshore South Taranaki Bight

Common sponges and ascidians on hard substratum inhabit patches of hard substrate in the nearshore area (Figure 2). Growth forms in the area were found to be predominantly encrusting, again probably due to the interplay of high wave action, sediment loading and associated scour, which is likely to preclude the growth of more erect species. Erect sponges were present in isolated patches further offshore, which may be a function of increasing depth with increasing distance offshore.

Low complexity soft sediment areas along the Kupe pipeline route were species-depauperate. The low biological diversity is ultimately due to the transient nature of the surficial sediments. It is likely that the infaunal species present in that study (e.g., amphipods, isopods crabs, gastropods, bivalves and polychaetes) will also occupy the soft sediment areas further offshore, and none of these species are considered rare or threatened.

Figure 2. Low cobble reef and surrounding mobile sand in the nearshore area of the Kupe pipeline.

Marine Mammals

There is minimal information surrounding marine mammals and their movements through the area of ocean that encompasses the South Taranaki Bight. This could be due to the lack of permanent viewing areas along the south Taranaki coast as most of the land is private farmland that prevents public access to the cliffs and rugged coast. Most of the information regarding marine mammals is collated from observations by fishermen and by the occasional stranding along the beaches.

Historically the embayment from Cape Egmont through to Kapiti was thought to have been a breeding ground for Southern Right Whales (*Eubalaena australis*), though sightings of these whales today are very rare. Southern Right Whales have been seen along New Zealand's coasts during winter when they come to breed and give birth to their young.

In the past the Maui offshore platforms, situated within the South Taranaki Bight, and associated support vessels have been involved in marine mammal monitoring throughout this area. The first accurate records of Blue whales (*Balaenoptera musculus*) in New Zealand waters were made from the Maui support vessel Northern Ranger (Kingett Mitchell, 2000).

Whales that have been observed off the New Zealand coast are usually on their seasonal journeys between their breeding grounds in temperate and sub-tropical areas and the rich feeding grounds of Antarctica. Research by the Department of Conservation (Suisted & Gibbs, 2003) indicates that a branch of the winter migration route of whales travels up the South Taranaki coast from the Cook Strait region to Cape Egmont.

The different species of cetaceans observed within the South Taranaki Bight include Humpback whales (*Megaptera novaeangliae*), Southern Right whales, Sperm whales (*Physeter macrocephalus*), Pygmy Sperm whales (*Kogia breviceps*), Beaked whales (Family *Ziphidae*), Pilot whales (*Globicephala melas, G. macrorhynchus*), Orca (*Orcinus orca*), and Common dolphins (*Delphinus delphis*). There are also scant records of observations of Hectors dolphins (*Cephalorhynchus hectori*) within this area. The North Island Hectors dolphin has just recently been recognised as a new sub-species, and is now known as the Maui's dolphin. Maui's Dolphins are generally found along the north-west coast of the North Island, between Taranaki and Dargaville, although the population is concentrated between Raglan and Manukau harbours.

Endangered Species

The South Taranaki Region falls under the Department of Conservation's (DOC) Wanganui Conservancy. No marine species are listed as threatened within this Conservancy. However, the Hector's Dolphin (*Cephalorhynchus hectori*) is listed as endangered by the DOC.

The International Union for the Conservation of Nature and Natural Resources (IUCN) is considered the world-authority on threatened and endangered species. The IUCN 'Red List' for endangered animals includes some 270 species in the New Zealand territories. Of these, a variety of whales are on the red list (e.g. Blue, Bryde's, Common Rorqual, Arnoux Beaked, Minke, Southern Right, Flatheaded Bottle-nosed, Pacific Pilot, Humpback). Endangered marine species that may sometimes be present in the Southern Taranaki Bight include Hector's Dolphin and the Great White Shark (*Carcharodon carcharias*). It is noted that several species that may be applicable to the Southern Taranaki region are listed as either 'data deficient' or 'nearly vulnerable' (e.g. Orca, Bronze-Whaler Shark).

Potential Impacts of Sand Extraction

A great deal of international studies of the effects of dredging (and trawling) have been undertaken; these can provide supplementary information on the biological impacts and seabed recovery time that would be expected due to extraction of seabed material proposed by TTR.

It is evident from the various sources of literature that the most important factors relating to the magnitude of the biological impacts and recovery times are,

- the intensity of the disturbance (i.e. dredging);
- the sediment type being disturbed, and;
- the amount exposure to natural disturbance (and thus sediment mobility) experienced at the dredge/trawl site.

As a general rule, *areas that are frequently dredged are more impacted than those that are only occasionally dredged/trawled.* However, the *magnitude of the impacts varies and is usually dependent on the complexity of habitat that is being dredged, and the sediment type at the site, which is also related to the level of natural disturbance. Fine muddy sediments are more affected than coarse sandy sediments, and the sediment grain size is often indicative of exposure to waves and currents.*

By relating these known impacts of dredging to existing environment in the southern tenement, an indication of the potential impacts of sand extraction can be gained. Although some organisms can go through the dredging process unharmed, in the present case, since after extraction the sand is 'sorted' and 90% of the sediment is returned to the seabed, it is considered that all organisms captured by the extraction process will be destroyed.

While it has been found that dredging/trawling can cause significant negative impacts to benthic biology, the following factors suggest that the ecological impacts of extracting seabed materials from locations >5 km offshore of the southern Taranaki coast would likely be minor, short-term and localized:

1. The area is a high-energy environment with consistently high waves and winds that create a very active seabed environment (i.e. seabed sediments are regularly mobilized and moved around, which is supported by the observed seabed formations in the area – mobility of sediment has been identified out to the Maari site, which is deeper than extraction tenament). Thus, the organisms living in these areas are adapted to sediment movement and the communities are robust to the impacts of disturbance.

2. Existing data of seabed organisms in the area indicate that the existing seabed communities are of low complexity, species-depauperate, and not particularly sensitive to disturbance (as would be expected in a highly energetic environment). The types of organisms present are common and it is likely that the infaunal species present in the area (e.g., amphipods, isopods crabs, gastropods, bivalves

and polychaetes) are widespread (none of these species are considered rare or threatened).

3. The operation only occurs once at each site, rather than frequent re-dredging of the same sites. While the organisms captured by the extraction process will be destroyed, once the sand without the ore content is returned to the seabed[1], it will quickly become re-colonized, both due to new settlement and immigration of organisms into the area. Past plankton sampling off the North Island, west coast has identified a large range of larval forms that can potentially re-colonize seabed areas following the extraction process, including decapods (crabs), gastropods, polycheate and bivalves. Recovery time of the benthos off the Mangawhai-Pakiri coast after dredging has been estimated to be fairly rapid (possibly faster than the 3-5 years suggested in the accompanying Assessment of Environmental Effects for the project), and that there are unlikely to be permanent changes to the fauna of the area. Recovery time could be expected to be faster in the southern tenement area due to the relatively much higher exposure of this coast.

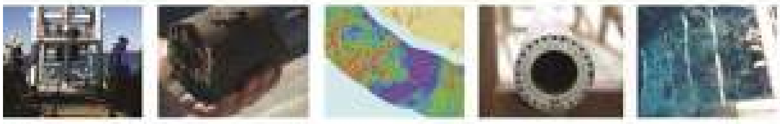
4. Management techniques such as those used for seabed extraction in other parts of New Zealand would ensure any sensitive or ecologically valuable areas would be protected. For example, as part of the Resource Consents for sand extraction from between 25-50 m depth off the Mangawhai-Pakiri coast, pre-dredging surveys are carried out to identify the substrate and habitat types within a selected area (e.g. 8 km2), using multi-beam survey, grab and tow sampling and remote video records). Important biogenic communities (e.g. *Atrina* beds) can be avoided and extraction not undertaken in such areas. This type of information will be collected during the baseline investigations proposed by TTR.

5. With respect to impacts on marine mammals and other mega-fauna that utilize the area, there are unlikely to be negative impacts on these species - they are able to move away from any extraction operations and few are benthic feeders. Even though the southern tenement is considered outside the normal range of Maui dolphins, impacts on this species are an important consideration since it is critically endangered. Maui dolphin are benthic feeders, however, being a relatively small mammal, they are mostly restricted to the nearshore area (< 5 km offshore) because they have a limited down-time. Together with the other factors such as the ability to avoid any operations and the recovery of the impacted areas, it unlikely that seabed extraction >5 km offshore of the southern tenement will have any negative impact on the Maui dolphin.

All of these features suggest that the biological impacts of seabed extraction in the area of the southern tenement will be low, localized and will not be persistent (temporary).

This opinion has been based on existing knowledge of the area and impacts of seabed extraction. The planned investigations by TTR will provide a far more definitive understanding of the area and potential impacts.

[1] The impacts of the plume caused during extraction and return of sediment to the seabed have not been considered with respect to ecological impacts. In relation to the turbidity of the waters along this coast, which is relatively high, the plume is considered very small and confined to the area of extraction.



Yours truly,

Dr. Shaw Mead
(Managing Director)

ASR Marine Consulting and Research

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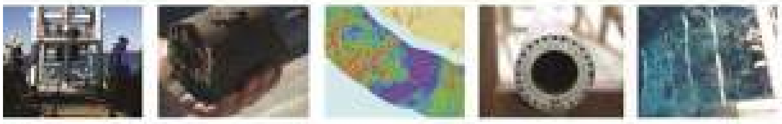
19.21 Amdel-Bureau Veritas Australia – Metallurgical laboratory test work

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

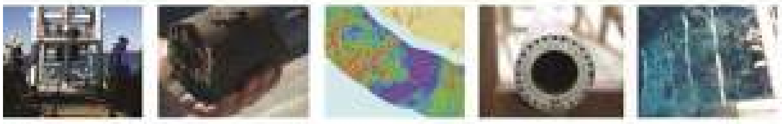
One iron rich sample with significant levels of Ti was submitted for mineralogical analysis using QEMSCAN. Of particular interest is the Ti and how it is associated with the Fe Oxide minerals in the sample. It was sized into 7 separate size fractions with the coarsest and finest sized fractions not submitted 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

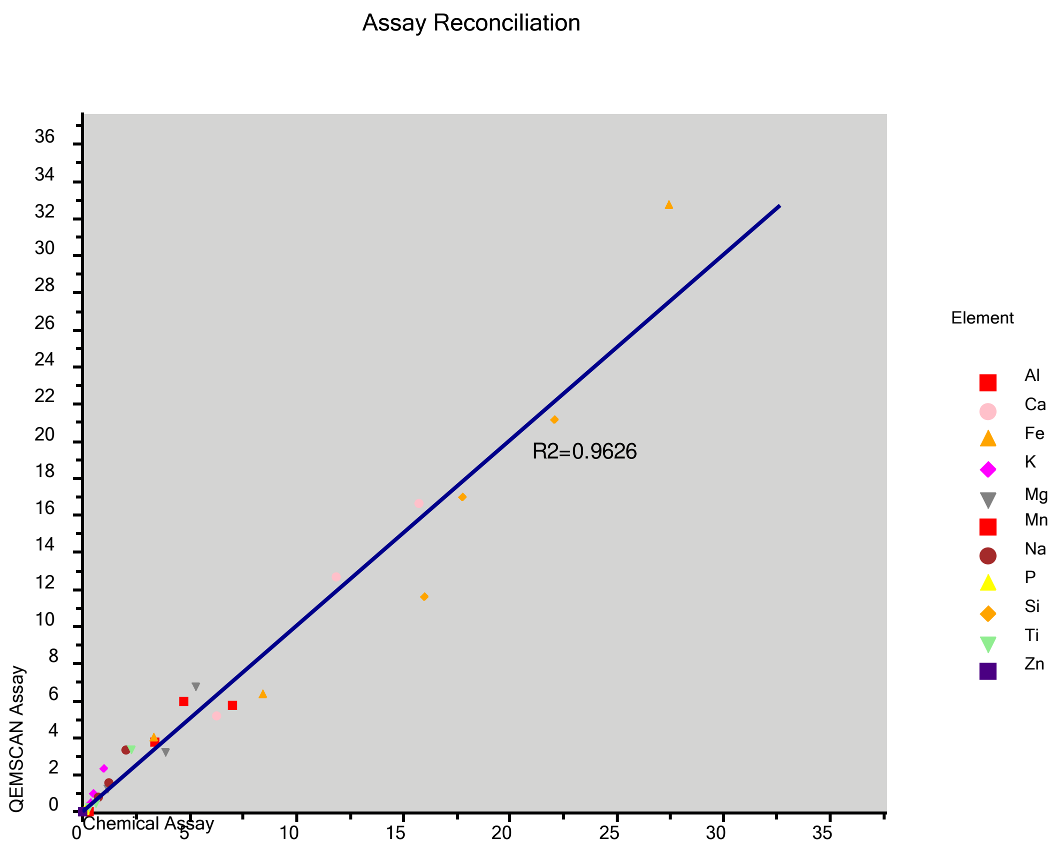
Liberation, Locking and Surface Exposure Mineral List

	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		



MINERAL ABUNDANCE

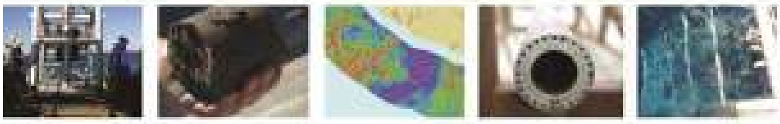
The mineral abundance data for each analysed fraction is listed in the below table and shown graphically.

	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

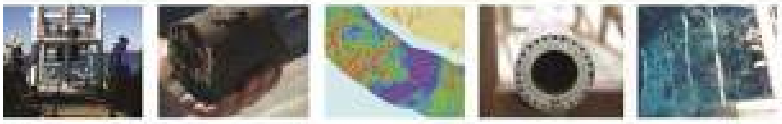


ESTIMATED AVERAGE GRAIN SIZE

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.



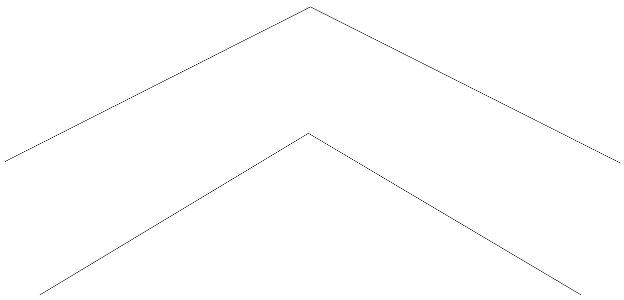
GRAIN SIZE DISTRIBUTION

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

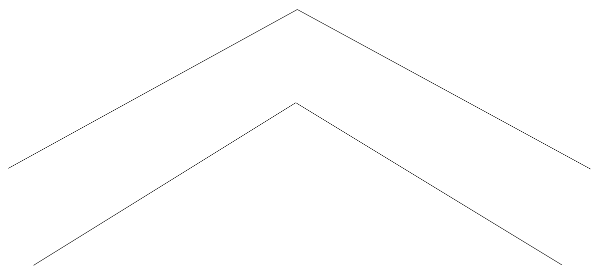
Fe Oxide Grain Size Distribution



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

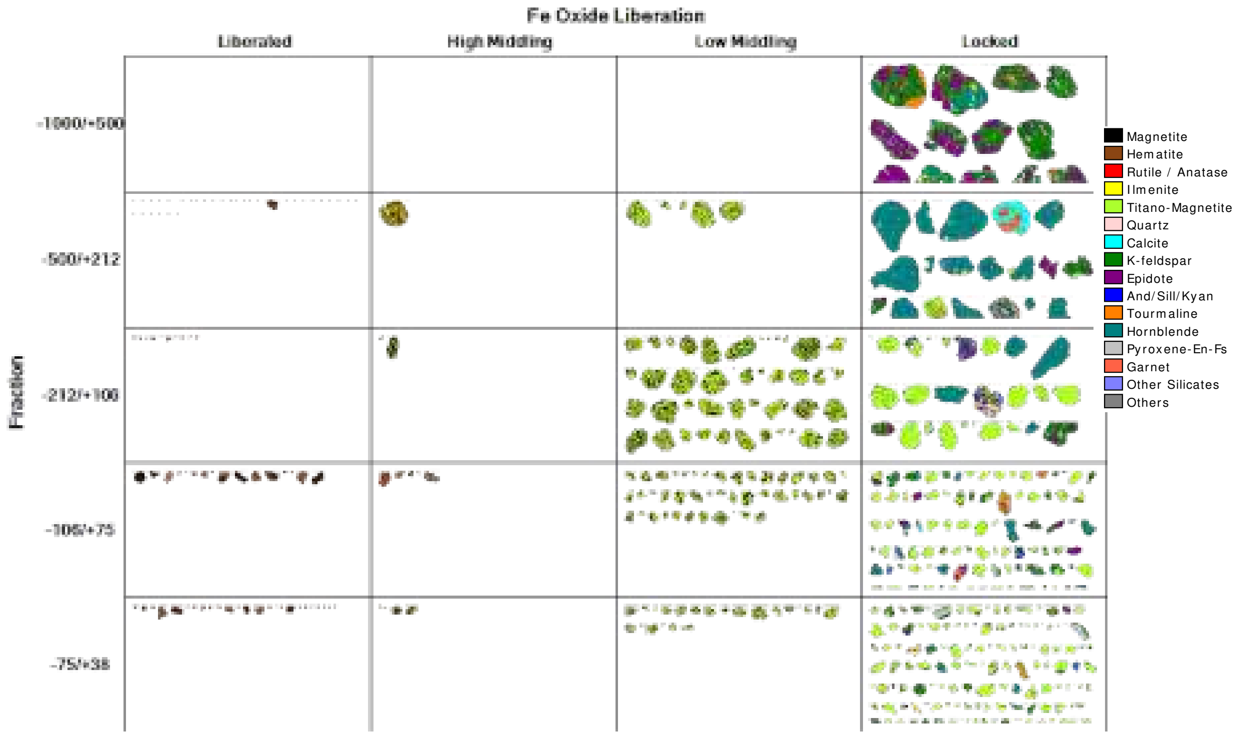
By using area percent, the liberation class of the Fe oxide mineral group (magnetite and hematite/goethite), silicates including quartz and Ti bearing minerals have been examined and quantified. The liberation criterion of each class is described below.

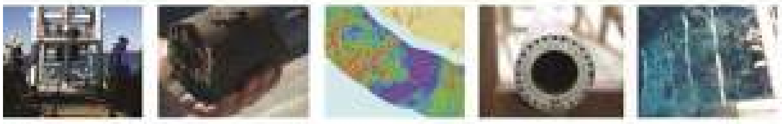
Code	Rule
Liberated	Area of target mineral is >90% of the particle's area
High middling	Area of target mineral is between 60-90% of the particle's area
Low middling	Area of target mineral is between 30-60% of the particle's area
Locked	Area of target mineral is <30% of the particle's area

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

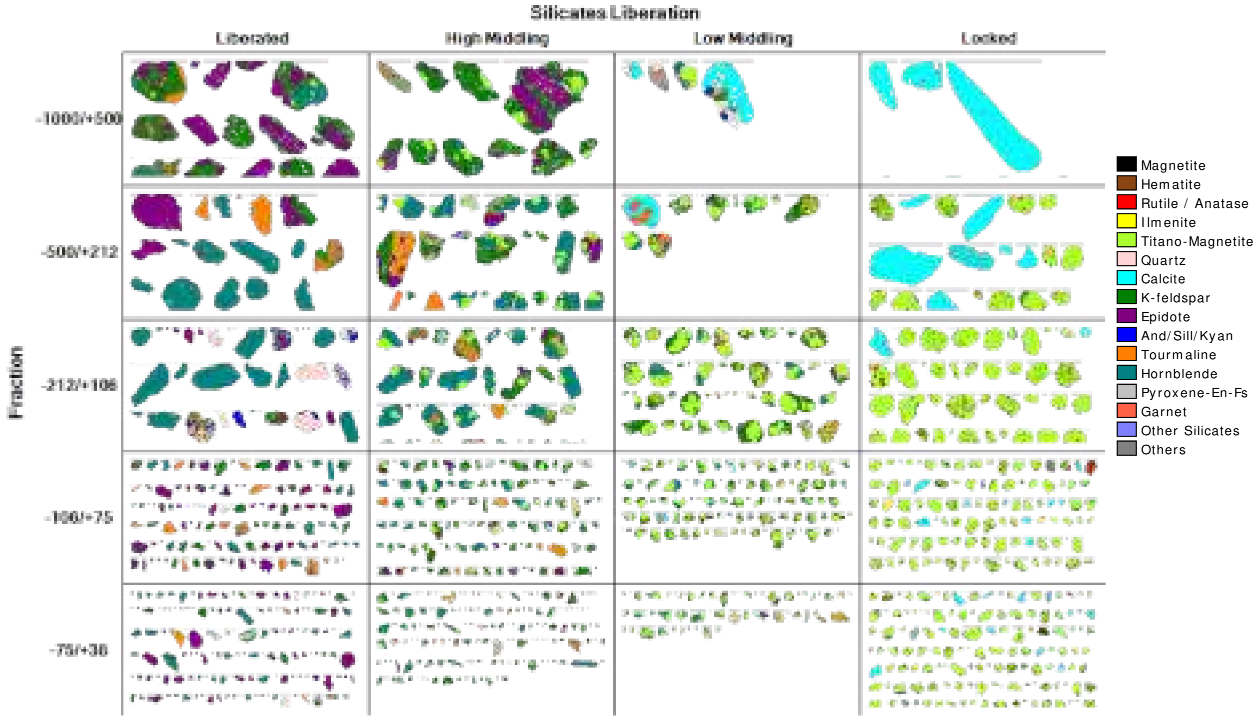


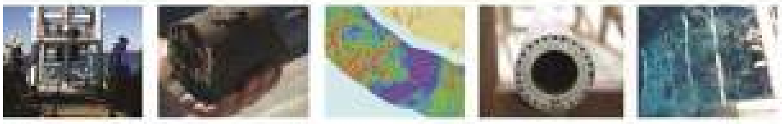


Silicates Liberation

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



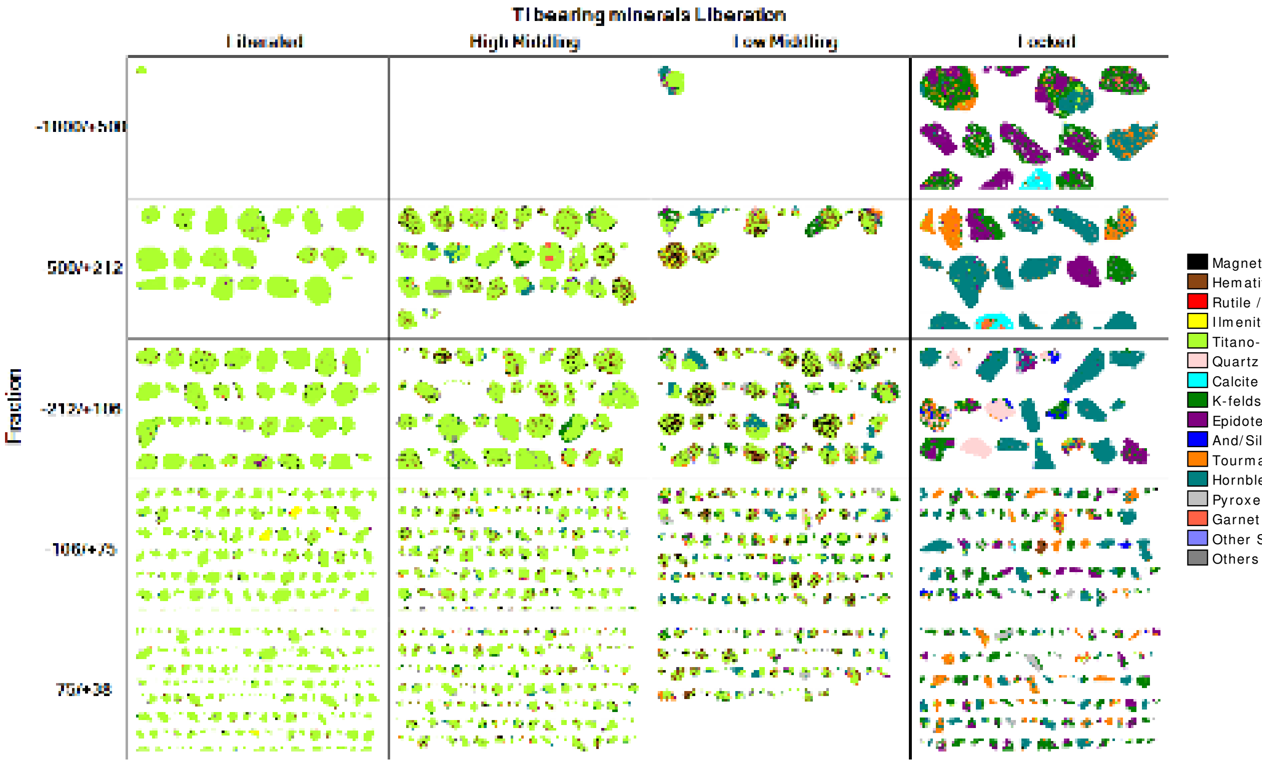


Ti bearing minerals Liberation

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	

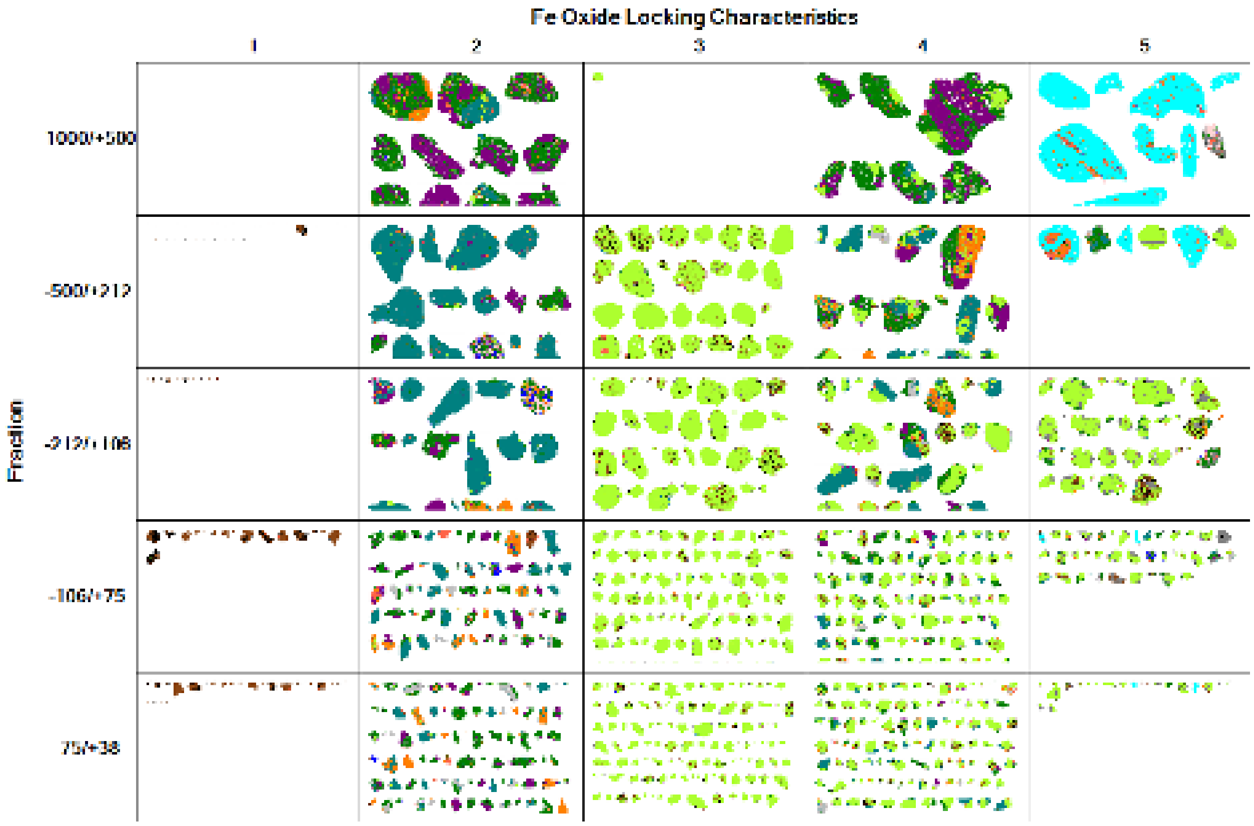


IRON OXIDE LOCKING

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

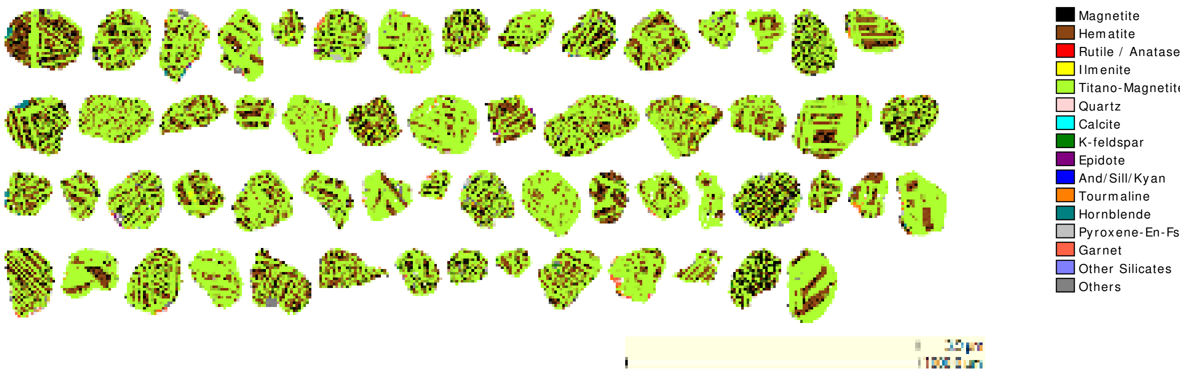
		8,2%	75,7%	15,1%	0,4%	0,6%
	Code	-1000/+500	-500/+212	-212/+106	-106/+75	-75/+38
1	Lib Fe Ox	0,00	2,91	0,23	13,13	17,81
2	Bn Silicates	80,74	18,05	1,16	4,20	3,23
3	Bn Ti minerals	0,12	54,55	81,83	56,31	58,25
4	Tn Sil + Ti minerals	15,61	23,79	14,50	23,74	18,72
5	Complex	3,52	0,71	2,28	2,61	2,00
	TOTAL	100,00	100,00	100,00	100,00	100,00



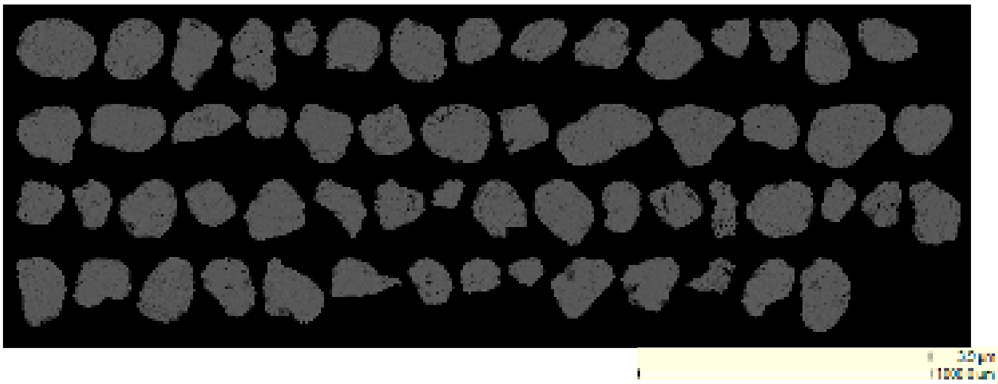
Binary with Ti minerals in detail

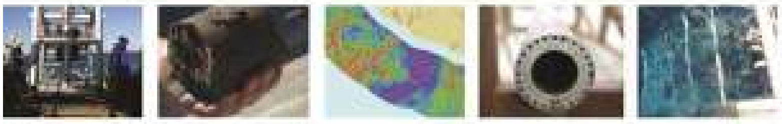
Selected particles from the +106um samples were chosen to highlight the binary with Ti mineral phase. From the particle images, it can be seen that there is a strong cross hatching texture within some of the particles. It is believed that this is due to Ti rich layers within the structure of the magnetite mineral possibly due to Ti enrichment along the cleavage lines within the magnetite/hematite minerals.

Particle images, as measured on the QEMSCAN



Back Scatter Electron (BSE) Image





Report:	N3994QS11
Client	Amdel (Perth)
Report Date:	7th April 2011
Tab	11 of 12

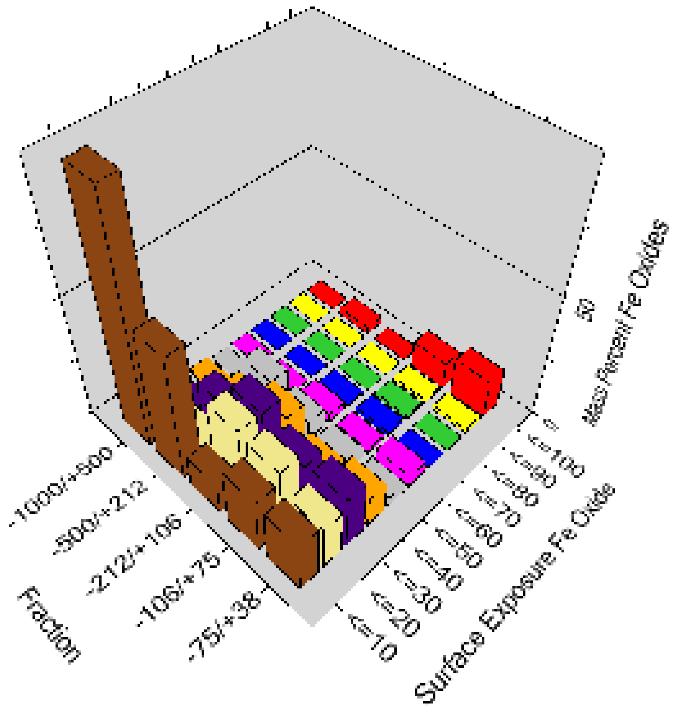
IRON OXIDE SURFACE EXPOSURE

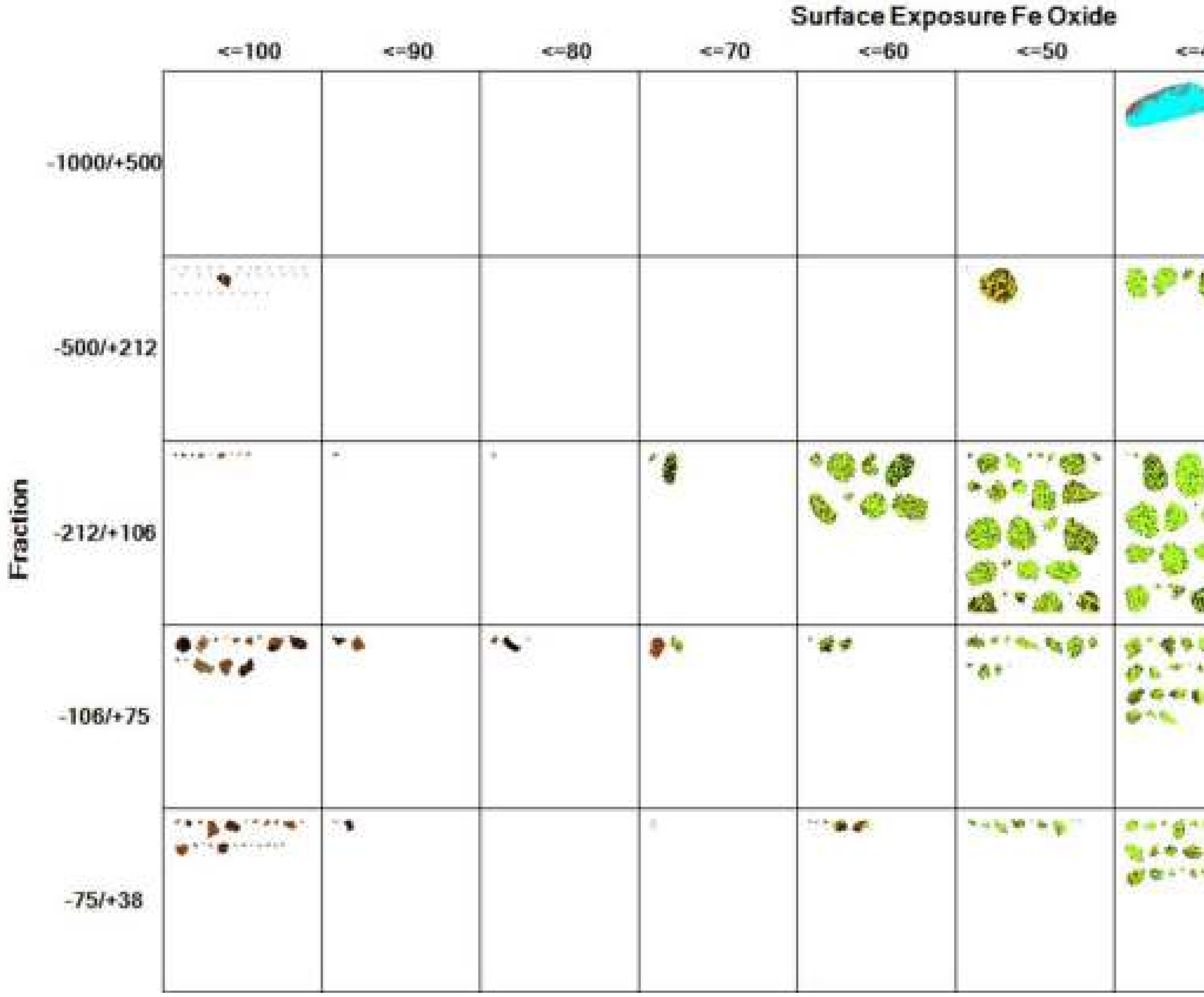
Surface Exposure of the iron oxide group (hematite and magnetite/goethite) has been calculated using the Surface Area Percent of iron oxide group in each iron oxide bearing particle. The classification rules are displayed below.

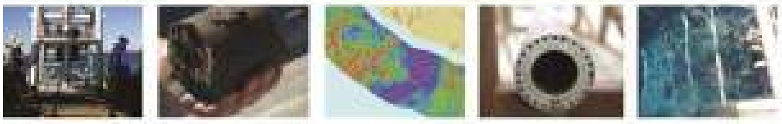
Code	Rule
<=10	Surface Area Percent magnetite + hematite/goethite is between 0% and 10%
<=20	Surface Area Percent magnetite + hematite/goethite is between 10% and 20%
<=30	Surface Area Percent magnetite + hematite/goethite is between 20% and 30%
<=40	Surface Area Percent magnetite + hematite/goethite 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

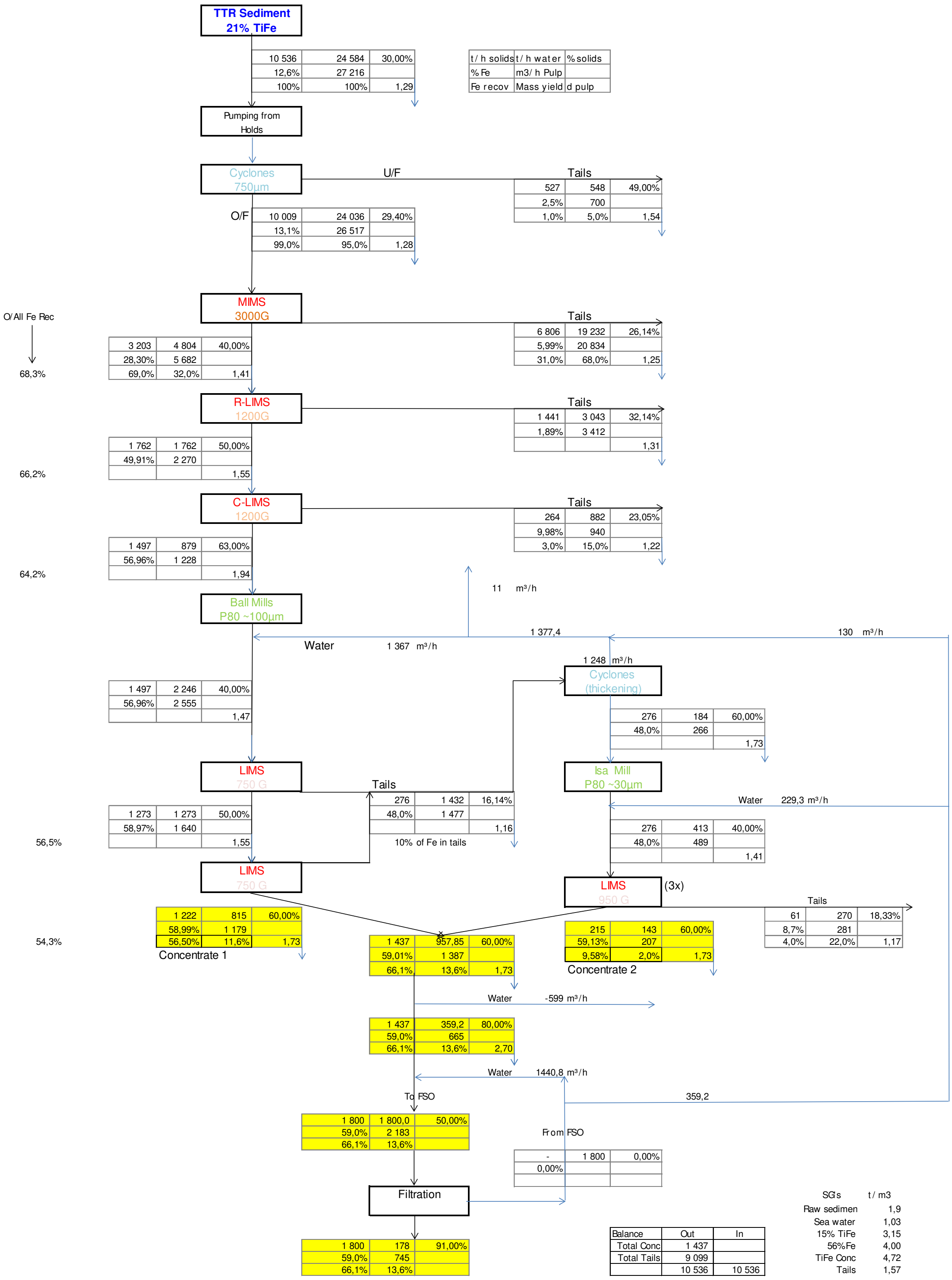
Surface Exposure Fe Oxide




Surface Exposure Fe Oxide
<=100
<=90
<=80
<=70
<=60
<=50
Fraction
-1000/+500
-500/+212
-212/+106
-106/+75
-75/+38



Flows and masse balances at every stage



19.22 Fugro – Aeromagnetic Survey

MEMORANDUM

To : Paul Vermeulen
Technical Director, Trans-Tasman Resources Ltd

From : Carlos Cevallos: Fugro Airborne Surveys (FAS)

Date : July 1st 2010

Subject : **Volumetric contained Fe and tonnage calculations assuming pure magnetite as source**

Northern Area

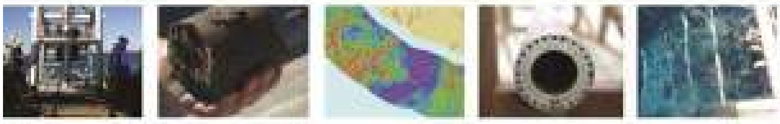
Cut off grade (% magnetite)	Depth Slice	Volume at cut off (m³)	Average % magnetite contained within volume	Estimated Bulk Tonnage (Tonnes)	Estimated Tonnage of magnetite (Tonnes)	Estimated Contained Fe Tonnage (Tonnes)
5	0 to 60m	12,368,955,000	8.5	27,211,701,000	2,312,994,585	1,673,687,045
5	0 to 6m	1,229,055,000	8.5	2,703,921,000	229,833,285	166,307,779
5	6 to 12m	1,227,660,000	8.5	2,700,852,000	229,572,420	166,119,016
5	12 to 18m	1,226,205,000	8.5	2,697,651,000	229,300,335	165,922,135
5	18 to 24m	1,225,230,000	8.5	2,695,506,000	229,118,010	165,790,204
5	24 to 30m	1,226,220,000	8.5	2,697,684,000	229,303,140	165,924,165
5	30 to 36m	1,229,760,000	8.5	2,705,472,000	229,965,120	166,403,175
5	36 to 42m	1,234,815,000	8.5	2,716,593,000	230,910,405	167,087,185
5	42 to 48m	1,243,710,000	8.5	2,736,162,000	232,573,770	168,290,799
5	48 to 54m	1,255,560,000	8.5	2,762,232,000	234,789,720	169,894,264
10	0 to 60m	2,904,435,000	13.9	6,389,757,000	888,176,223	642,685,914
10	0 to 6m	283,440,000	14.0	623,568,000	87,299,520	63,170,090
10	6 to 12m	283,230,000	14.0	623,106,000	87,234,840	63,123,287
10	12 to 18m	284,025,000	14.0	624,855,000	87,479,700	63,300,468
10	18 to 24m	285,195,000	14.0	627,429,000	87,840,060	63,561,226
10	24 to 30m	286,725,000	13.9	630,795,000	87,680,505	63,445,771
10	30 to 36m	288,990,000	13.9	635,778,000	88,373,142	63,946,965
10	36 to 42m	291,780,000	13.8	641,916,000	88,584,408	64,099,837
10	42 to 48m	295,320,000	13.8	649,704,000	89,659,152	64,877,524
10	48 to 54m	299,955,000	13.8	659,901,000	91,066,338	65,895,766
15	0 to 60m	699,015,000	20.1	1,537,833,000	309,104,433	223,668,524
15	0 to 6m	71,415,000	20.4	157,113,000	32,051,052	23,192,199
15	6 to 12m	71,010,000	20.4	156,222,000	31,869,288	23,060,674
15	12 to 18m	70,305,000	20.3	154,671,000	31,398,213	22,719,803
15	18 to 24m	69,900,000	20.3	153,780,000	31,217,340	22,588,923
15	24 to 30m	69,390,000	20.2	152,658,000	30,836,916	22,313,648
15	30 to 36m	69,180,000	20.1	152,196,000	30,591,396	22,135,989
15	36 to 42m	68,925,000	20.0	151,635,000	30,327,000	21,944,672
15	42 to 48m	69,015,000	20.0	151,833,000	30,366,600	21,973,326
15	48 to 54m	69,420,000	19.9	152,724,000	30,392,076	21,991,761

MEMORANDUM

20	0 to 60m	242,085,000	26.3	532,587,000	140,070,381	101,355,180
20	0 to 6m	25,365,000	26.7	55,803,000	14,899,401	10,781,233
20	6 to 12m	25,125,000	26.7	55,275,000	14,758,425	10,679,223
20	12 to 18m	24,810,000	26.6	54,582,000	14,518,812	10,506,838
20	18 to 24m	24,765,000	26.5	54,483,000	14,437,995	10,447,359
20	24 to 30m	24,420,000	26.3	53,724,000	14,129,412	10,224,068
20	30 to 36m	24,105,000	26.2	53,031,000	13,894,122	10,053,812
20	36 to 42m	23,760,000	26.1	52,272,000	13,642,992	9,872,094
20	42 to 48m	23,430,000	26.0	51,546,000	13,401,960	9,697,682
20	48 to 54m	23,250,000	25.9	51,150,000	13,247,850	9,586,168

Southern Area

Cut off grade (% magnetite)	Depth Slice	Volume at cut off (m^3)	Average % magnetite contained within volume	Estimated Bulk Tonnage (Tonnes)	Estimated Tonnage of magnetite (Tonnes)	Estimated Contained Fe Tonnage (Tonnes)
5	0 to 54m	4,163,460,000	8.2	9,159,612,000	751,088,184	543,488,762
5	0 to 6m	543,855,000	8.4	1,196,481,000	100,504,404	72,725,168
5	6 to 12m	533,265,000	8.4	1,173,183,000	98,547,372	71,309,056
5	12 to 18m	515,865,000	8.3	1,134,903,000	94,196,949	68,161,082
5	18 to 24m	492,735,000	8.3	1,084,017,000	89,973,411	65,104,922
5	24 to 30m	466,965,000	8.2	1,027,323,000	84,240,486	60,956,567
5	30 to 36m	440,100,000	8.2	968,220,000	79,394,040	57,449,670
5	36 to 42m	414,360,000	8.1	911,592,000	73,838,952	53,429,999
5	42 to 48m	389,970,000	8.0	857,934,000	68,634,720	49,664,207
10	0 to 54m	805,500,000	14.7	1,772,100,000	260,498,700	188,497,328
10	0 to 6m	111,990,000	15.0	246,378,000	36,956,700	26,741,935
10	6 to 12m	109,155,000	15.0	240,141,000	36,021,150	26,064,969
10	12 to 18m	104,070,000	14.9	228,954,000	34,114,146	24,685,057
10	18 to 24m	97,800,000	14.8	215,160,000	31,843,680	23,042,144
10	24 to 30m	90,885,000	14.7	199,947,000	29,392,209	21,268,255
10	30 to 36m	83,895,000	14.5	184,569,000	26,762,505	19,365,397
10	36 to 42m	76,245,000	14.4	167,739,000	24,154,416	17,478,179
10	42 to 48m	69,105,000	14.2	152,031,000	21,588,402	15,621,497



MEMORANDUM

15	0 to 54m	255,720,000	20.6	562,584,000	115,892,304	83,859,880
15	0 to 6m	37,755,000	21.1	83,061,000	17,525,871	12,681,752
15	6 to 12m	36,630,000	21.0	80,586,000	16,923,060	12,245,557
15	12 to 18m	34,245,000	20.9	75,339,000	15,745,851	11,393,726
15	18 to 24m	31,485,000	20.8	69,267,000	14,407,536	10,425,319
15	24 to 30m	28,305,000	20.6	62,271,000	12,827,826	9,282,238
15	30 to 36m	25,650,000	20.4	56,430,000	11,511,720	8,329,901
15	36 to 42m	22,725,000	20.2	49,995,000	10,098,990	7,307,647
15	42 to 48m	20,700,000	19.7	45,540,000	8,971,380	6,491,707
20	0 to 54m	100,890,000	25.9	221,958,000	57,487,122	41,597,785
20	0 to 6m	15,645,000	26.8	34,419,000	9,224,292	6,674,714
20	6 to 12m	14,955,000	26.7	32,901,000	8,784,567	6,356,528
20	12 to 18m	13,935,000	26.5	30,657,000	8,124,105	5,878,617
20	18 to 24m	12,690,000	26.3	27,918,000	7,342,434	5,312,998
20	24 to 30m	11,265,000	26.0	24,783,000	6,443,580	4,662,586
20	30 to 36m	10,005,000	25.5	22,011,000	5,612,805	4,061,436
20	36 to 42m	8,715,000	25.0	19,173,000	4,793,250	3,468,404
20	42 to 48m	7,440,000	24.5	16,368,000	4,010,160	2,901,759

Estimated Bulk Tonnage = Volume at cut off x Density (Density = 2.2 tonne/m^3)

Estimated Tonnage of Magnetite = Estimated Bulk Tonnage x Average Percentage Magnetite

Ratio of Fe within the magnetite mineral Magnetite Fe_3O_4 = 3 * 55.85 / ((3 * 55.85) + (4 * 16))

= 167.55 / 231.55

= 0.7236018

Estimated Contained Tonnes of Fe based on stoichiometry ratio of Fe_30_4

= Magnetite Tonnage of Magnetite x 0.7236018

The density value of 2.2 tonne/m^3 was provided by Trans-Tasman Resources.

Sincerely,
Carlos Cevallos
Senior Geophysicist

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19.23 Principia – Mooring Stability Study (Contracted directly by TPM)

Turret moored FPSO in Shallow water Offshore New Zealand for mining purpose

Mooring feasibility study

Technical Report

RET.11.4.483.02 13/12/2011	J. COGNARD	P. LE BUHAN	P. LE BUHAN	Including T-SIM comments
RET.11.4.483.01 02/12/2011	J. COGNARD	P. LE BUHAN	P. LE BUHAN	Issued for review
Document Number	**Prepared by**	**Checked by**	**Approved by**	**Designation**

Client	**TECHNIP France** **(on behalf Technip Mines)** 92973 Paris La Défense Cedex - France Contract Number : -
Contractor	**PRINCIPIA** Z.I. Athélia 1 – Voie Ariane 13705 LA CIOTAT cedex ☎ +(33) 04.42.98.11.80 - 🖷 +(33) 04.42.98.11.89 www.principia.fr / commercial@principia.fr
Project	**Shallow water Offshore New Zealand** **Mining purpose** Project Number PRINCIPIA D11.43.1159

Internal Diffusion	**External Diffusion**					
	Name	Qty	Firm	Name	Qty	Firm
Technical Manager Dossier Author(s)	A. MARRET	1	TECHNIP			

Nb Pages + Annexes: 40 | Confidentiality of the document: NC [X] CD [ ] CI [ ] DR [ ]

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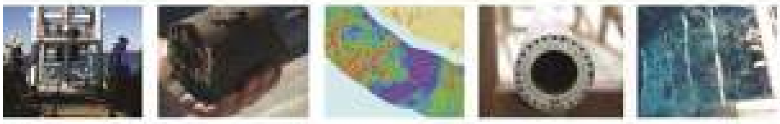


REVISION RECORD SHEET

N° Document	Date	List of updated / modified sections
RET.11.4.483.01	02/12/2011	Issued for review
RET.11.4.483.02	13/12/2011	Including T-SIM comments

EXECUTIVE SUMMARY

Introduction:

The Technip Subsea Innovation Management Department (T-SIM) has been contracted via the Technip Mines (TPM) Group to conduct a scoping and prefeasibility study for the development of an Offshore sand deposit (TiFe) processing plant, in shallow water offshore New Zealand (75 m constant water depth considered at mooring anchors location). Principia has been awarded to conduct a conceptual mooring study and dynamic analysis for the large anticipated FPSO on turret to be used for hosting the processing plant in the stringent environmental conditions encountered off the New-Zealand coasts.

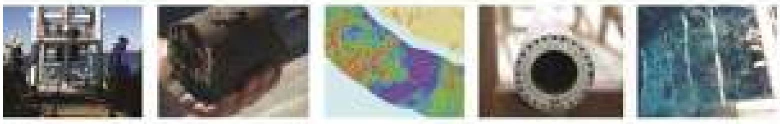
The initial mooring anticipated in this conceptual study is a conventional API. STL turret type with 12 moorings in four main bundles, and made of 140mm diameter chain, as initially proposed by T-SIM. In the project the 140mm chain characteristics have been considered initially, but by sake of conservatism, a degraded MBL corresponding to an equivalent 130mm chain was used for post processing.

A 200kDWT tender vessel have to be considered in tandem offloading, with reduced operating environments, while the FPSO alone is request to withstand up to the 100-year environmental return periods.

As a preliminary part of the project, main assumptions and input data are further discussed in the report. A reduced load case matrix with all environmental conditions being collinear is anticipated, and some conservatism is imposed to try to cover possible hardest loads with non-collinear events. Here after are given the main results, details on the inputs / assumptions are to be found in the main report, as well as some sensitivities / extra cases.

FPSO overview – 336m long, 60m breadth and 31m high

FSO tender for offloading overview 200 kDWT OCIMF generic tanker



Conclusion:

At this feasibility study stage and according the assumptions used, the 12 lines mooring configuration with 140mm chains proposed with APL STP turret system is acceptable for the FPSO alone in 100 years conditions. The Tandem offloading directly on the FPSO with a classical 200 kDWT tanker with yearly conditions provide acceptable criteria.

Only the provided damaged cases (one FPSO mooring line broken) are slightly above the common tolerance, but the following listed conservatism have been used and thus bring a sufficient level of confidence on the suitability of the proposed solution:

- 60% MBL criteria is considered and could be discussed with Class at a later stage of the project.
- Despite a 140mm chain is used, a 130mm MBL is considered, as an already used / corroded component.

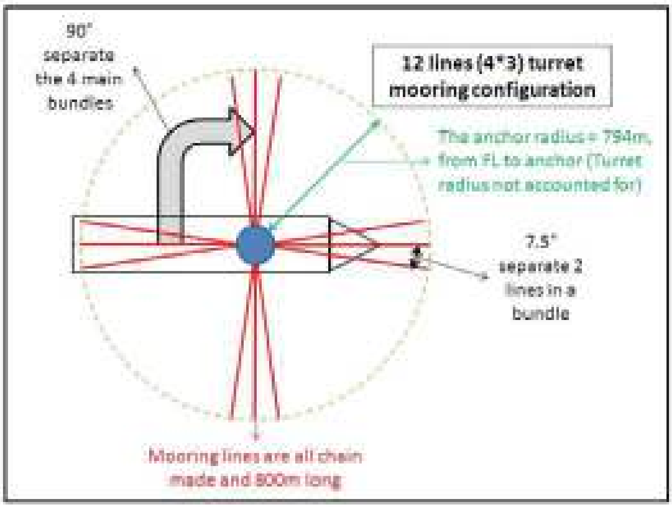
Imposed criteria:

- After discussions with Technip, a 8 to 10m offset is deemed acceptable.
- The maximum tension in mooring lines should not exceed 50% of the MBL for intact conditions, and 60% of the MBL for damaged conditions.

Note: This condition is more severe than the API recommendations, and 70% of MBL for damaged cases could possibly be considered. Here, a conservative 60% damaged criteria has been considered, to avoid as much as possible failure of a second mooring line, if a risk of collision with adjacent structure is present. If no risk of collision with adjacent anchored vessels, those criteria are considered to be very severe.

Mooring configuration / mooring analysis results:

The basic mooring configuration is with 7.5° between two lines in a bundle, and a 794 m anchor radius is considered, as illustrated below:



The table below is a summary of the mooring analysis results.

Mooring results summary		Max offset FPSO		Max tension ML		Max tension Hawser	
		m	% WD	Tons	% MBL	Tons	% MBL
Fully Loaded FPSO alone	Intact mooring	7.8	10.5	770.3	48.6	N/A	
	Damaged mooring (1 Line broken)	9.8	13.0	1126.4	71.0		
Fully Loaded FPSO in tandem with ballasted tender	Intact mooring	6.8	9.1	700.9	44.2	433.2	60.7
	Damaged mooring (1 Line broken)	9.1	12.1	1019.2	64.3	387.8	54.3

Mooring analysis results summary

The full tables of results are provided below:

Fully Loaded FPSO anchored alone results:

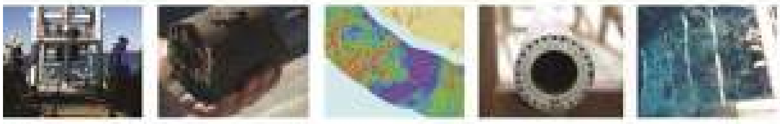
FPSO alone mooring analysis results						Max offset		Max tension	
Case	Mooring configuration	Current RP	Wind RP	Wave RP	Wave period	m	% WD	Tons	% MBL
Alone-1	In-line	100	10	10	Nominal - 20%	5.1	6.7	550.2	34.7
Alone-2					Nominal	5.2	6.9	564.8	35.6
Alone-3					Nominal +20%	5.2	7.0	572.1	36.1
Alone-4		10	100	10	Nominal - 20%	5.3	7.0	574.7	36.2
Alone-5					Nominal	6.3	8.4	684.9	43.2
Alone-6					Nominal +20%	5.3	7.0	574.3	36.2
Alone-7		10	10	100	Nominal - 20%	6.8	9.0	738.4	46.6
Alone-8					Nominal	7.0	9.3	770.3	**48.6**
Alone-9					Nominal +20%	6.5	8.6	709.6	44.7
Alone-10	In-between	100	10	10	Nominal - 20%	5.2	7.0	468.1	29.5
Alone-11					Nominal	5.3	7.0	466.1	29.4
Alone-12					Nominal +20%	5.2	6.9	473.5	29.9
Alone-13		10	100	10	Nominal - 20%	5.6	7.5	493.7	31.1
Alone-14					Nominal	6.2	8.3	542.7	34.2
Alone-15					Nominal +20%	5.7	7.6	500.7	31.6
Alone-16		10	10	100	Nominal - 20%	6.9	9.3	601.1	37.9
Alone-17					Nominal	7.8	**10.5**	683.7	43.1
Alone-18					Nominal +20%	7.1	9.5	623.1	39.3
Alone-19 - Damaged case - "Alone-8" case with ML-1 broken (2[nd] most loaded)						9.8	**13.0**	1126.4	**71.0**
Alone-20 - Damaged case - "Alone-17" case with ML-1 broken (most loaded)						9.0	12.0	877.1	55.3
Alone-19 - Damaged case - With 15° bundle separation and 792m radius						10.9	14.6	1001.5	63.1

Fully Loaded FPSO alone mooring analysis results

The condition leading to extreme results is the one governed by the wave:

- When the mooring is "in-line" with the wave direction, the tension is maximum (one line is facing environment), and is just below 50% of the chain corroded/second-hand MBL.
- When the mooring is "in-between" the wave direction, the offset is maximum (no line facing environment) and reaches an absolute value close to 8 m, which remains acceptable.

When damaged mooring is considered, the offset increases up to 10m and the tension in the line reaches 71% of the corroded/second-hand chain MBL.



Finally on this worst damaged case with a 15° angle between lines and a 792m reduced anchor radius, the maximum damaged tension decreases down to 63.1 % of the considered breaking load.

Note: If the MBL of the 140mm initial chain diameter is considered to be the one of a similar 134mm chain diameter (instead of 130mm here), the tension is 60% of the MBL as requested by the codes.

Fully Loaded FPSO in tandem with ballasted tender results:

Tender connected mooring analysis results (MAX)						FPSO offset		ML Tension		Hawser Tension	
Case	Mooring configuration	Current RP	Wind RP	Wave RP	Wave period	m	% WD	Tons	% MBL	Tons	% MBL
Tender-1					Nominal - 20%	3.8	5.1	437.1	27.6	287.1	40.2
Tender-2		10	1	1	Nominal	4.4	5.9	490.6	30.9	288.1	40.4
Tender-3					Nominal +20%	4.5	6.0	505.9	31.9	310.2	43.5
Tender-4					Nominal - 20%	4.5	6.1	503.7	31.8	352.7	49.4
Tender-5	In-line	1	10	1	Nominal	4.7	6.2	517.3	32.6	335.2	47.0
Tender-6					Nominal +20%	5.3	7.0	576.0	36.3	391.3	54.8
Tender-7					Nominal - 20%	6.5	8.6	700.9	44.2	424.3	59.5
Tender-8		1	1	10	Nominal	5.9	7.9	645.2	40.7	392.0	54.9
Tender-9					Nominal +20%	6.1	8.1	663.8	41.9	375.3	52.6
Tender-10					Nominal - 20%	3.9	5.2	381.9	24.1	277.0	38.8
Tender-11		10	1	1	Nominal	4.7	6.2	430.4	27.1	294.8	41.3
Tender-12					Nominal +20%	4.8	6.3	435.1	27.4	308.5	43.2
Tender-13					Nominal - 20%	4.7	6.2	431.7	27.2	336.7	47.2
Tender-14	In-between	1	10	1	Nominal	5.1	6.7	457.5	28.8	344.0	48.2
Tender-15					Nominal +20%	5.5	7.3	485.2	30.6	386.3	54.1
Tender-16					Nominal - 20%	6.8	9.1	589.1	37.1	433.2	60.7
Tender-17		1	1	10	Nominal	6.1	8.2	532.3	33.6	382.3	53.6
Tender-18					Nominal +20%	6.5	8.6	567.4	35.8	382.7	53.6
Tender-19 - "Tender-7" with ML-1 broken (2nd most loaded)						9.1	12.1	1019.2	64.3	387.8	54.3
Tender-20 - "Tender-16" with ML-1 broken (most loaded)						8.7	11.6	829.4	52.3	385.0	54.0
Tender-19 - With 15° bundle separation and 792m radius						9.4	12.5	811.4	51.2	375.9	52.7

Fully Loaded FPSO in tandem with ballasted tender mooring analysis results

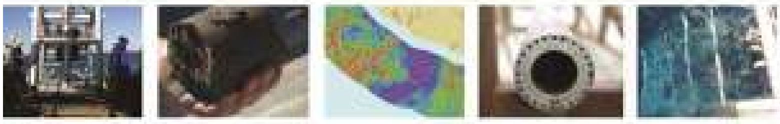
The condition leading to extreme results is the one governed by the wave:

- When the mooring is "in-line" with the wave direction, the tension is maximum (one line is facing environment) and is just below 45% of the chain corroded/second-hand MBL.
- When the mooring is "in-between" the wave direction, the offset is maximum (no line facing environment), reaching 7m, which is about 9% of the water depth and is deemed to be acceptable.

When damaged mooring is considered, the offset increases up to 9m and the tension in the line reaches about 65% of the corroded/second-hand chain MBL.

Finally, on this worst damaged case with a 15° angle between lines and a 792m reduced anchor radius, the maximum damaged tension decreases down to 51 % of the considered breaking load.

The tension in the hawser remains acceptable for the operational metocean conditions considered.



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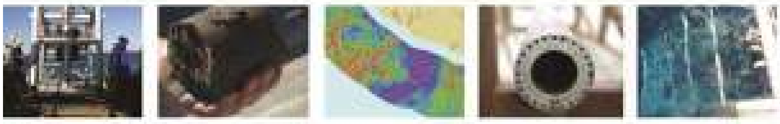


1 INTRODUCTION

1.1 SCOPE OF DOCUMENT

The Technip Subsea Innovation Management Department (T-SIM) has been contracted via the Technip Mines (TPM) Group to conduct a scoping and prefeasibility study for the development of an Offshore sand deposit (TiFe) processing plant, in shallow water offshore New Zealand (75 m constant water depth considered at mooring anchors location). Principia has been awarded to conduct a conceptual mooring study and dynamic analysis for the large anticipated FPSO on turret to be used for hosting the processing plant in the stringent environmental conditions encountered off the New-Zealand coasts.

One of the concerns is the capacity to safely moor the dedicated FPSO (and the tender) in the shallow water, according to the severe metocean conditions on site. In this context, Principia has been requested by T-SIM to perform:

- Task 1: A preliminary design of the mooring system for the turret moored FPSO,
- Task 2: A feasibility analysis to assess the capability to get the tender (200 Kdwt) moored in tandem.

1.2 REFERENCES

[1] Joint Industrial Project "CLAROM : Roulis des barges", final report.

[2] Prediction of wind and current loads on VLCCs, 2nd edition 1994, OCIMF.

[3] "A Lagally formulation of the wave drift force", Ledoux A., Molin B., Delhommeau G. et Remy F. 2006. Proc. 21st Int. Workshop Water Waves and Floating Bodies – Loughboroug.

[4] API Recommended Practice 2SK - Third edition, October 2005.

[5] Bureau Veritas Guidance note – "Quasi-Dynamic analysis of mooring systems using Ariane Software" – October 1997.

[6] Recommended Practice DNV-RP-C205, April 2007, Amended October 2008.

[7] Recommended Practice DNV-RP-E301, October 2008.

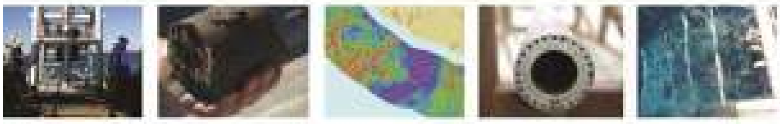
[8] PET.11.4.448.01 Principia document - 25/10/2011 – "Mooring feasibility of a dedicated turret moored FPSO for mining purpose in Shallow water Offshore New Zealand".

[9] Mail received from Antoine Marret (Technip) the 09/11/2011 – "RE: Project Mining New Zealand – Input data".

[10] Drawing from Technip "TIR conceptual study: FPSO hull preliminary design – General arrangement" – Rev.0 of 26/10/2011.

[11] Mail received from Antoine Marret (Technip) the 14/11/2011 – "RE: Project Mining New Zealand – Input data".

[12] Mail received from Antoine Marret (Technip) the 23/11/2011 – "TTR Study - Typical FSO Data".



2 GENERAL METHODOLOGY / ASSUMPTIONS

2.1 GENERALITIES

The Mooring design feasibility analysis is performed considering a classical quasi-dynamic approach (BV definition) of the dedicated FPSO, using Diodore™ software with the following steps:

- Hydrodynamic data base of the FPSO (from shape and mechanical data) to assess 1st order loads (diffraction / radiation) (requires a mesh of the FPSO).
- Mean current/waves/wind loads calculations (using OCIMF data or Principia's expertise).
- 2nd order wave diffraction loads calculations (wave drift and slow drift in horizontal Dof's).
- Determination of the initial number of legs, mooring layout and chain diameter / grade, and tuning of anchor radius or pretension to get acceptable offset.
- Quasi-dynamic extreme calculation in Diodore in intact and damaged mooring conditions (new loop to update the mooring if required).

A more precise description of the methodology is provided in appendix.

<u>Particular project assumptions</u>

For the initial hydrodynamic analysis, the following considerations were assumed:

- The FPSO draft is directly imposed, without any trim.
- The FPSO centre of gravity is imposed at the same horizontal location of the centre of buoyancy provided by Diodore™ from the hydrodynamic mesh.
- In a 2nd stage a second Diodore™ calculation will be performed when the tender floater for offloading is connected to the FPSO. The relative position between both vessels will be initially imposed for hydrodynamic interaction purposes.
- A Classical "diffraction/radiation" analysis without forward speed is considered.
- A 75m finite water depth is imposed and accounted into the waves forces.
- A discretisation in wave heading every 15°, with additional 5 and 10° heading from facing one (according to the weather weaning assumptions).
- The hydro-data base built covers waves' periods from 3 to 25 seconds Additional larger periods are also considered for low frequencies motions assessment.

For the time domain simulation the following considerations are assumed:

- The low frequency drift force is assessed using a Lagally formulation.
- Time domain simulations are performed on a 3-hour basis. 11,000 seconds simulations are performed, the first 200 seconds not being post-processed as possible transient part. A constant current is used, the wave is simulated through a Jonswap spectrum. The wind is also considered constant with the 3-second measurement imposed every time.
- Lines below the turret are modelled on the same top point (centre of the real lines departure) to avoid any blockage of the turret (the turret is free to rotate in reality).
- Wave frequency damping is imposed for the FPSO roll (and tender when present), based on a quadratic form as recommended by the Clarom (Ref. [1]). A period by period linearization is chosen.

- Low frequency damping is imposed for the FPSO horizontal motions (and tender when present), based on a linear form as recommended by the BV, for a vessel on an SPM (turret moored).
- FPSO is operated with a heading control thruster. In this feasibility study level we consider all environments collinear and facing FPSO. A larger low damping in yaw could be first consider to add a force opposite to the low frequency motions (for example three or five times the BV damping) if needed.
- Using selected information's on thrusters data, sensitivity with non collinear environmental conditions have also been done.

2.2 PRELIMINARY DESIGN CONSTRAINTS AND PHILOSOPHY

The work performed on this project is a mooring feasibility design approach. The objective is to design and check a mooring system with a given level of confidence and conservatism in line with the unknowns present at this stage of the project. The methodology used enables to quickly assess system limitations. As no detailed input data are generally provided at such level of prefeasibility study, we consider relevant reduce load case matrix to allow possible quick loops to potentially optimize the solution.

It has been decided to reduce the load case matrix by imposing collinear environments (FPSO with heading control). This allows to reduce the number of cases, but as non-collinear environments are possibly leading to highest forces (wind and current polars are giving more in-line forces around a 45° angle from facing ones, a more perpendicular wave increase the heave response, and the roll, even if here the lateral radius of chains is limited…), some conservatism should be applied to try to cover non considered events.

Some conservatism has so been considered in the study, both on the anticipated input data and on the environments combinations. The conservatisms are listed below:

- Wind and current Polars are generally based on considering provision by increasing shape coefficients and surfaces. Increases values of about 5-10% are applied, and the most severe approach is used when choice between different rough approaches is possible. Internal check on the magnitude of obtained loads compared other "similar" ships was assessed to avoid excessive conservatism.
- For the mooring chain, a 140mm is considered, but the post treatment is based on the MBL (Minimum Breaking loads) of a similar 130mm chain to assess possible corrosion, or second-hand material. At that level, this assumption is considered at least satisfactory, or even severe.
- Criteria are further detailed in this report, but the values finally retained are considered at least satisfactory, or even severe.
- A constant wind speed equal to the 3-sec maximum measurement is always considered. This approach seems severe as the maximum wind is always associated with the entire wave spectrum.
- Omni-directional data are considered collinear, and the maximum are combined (even if they have not real occurrence risk).
- For the wave simulated through a Jonswap spectrum, the nominal peak period is considered, and the periods at +/-20% from it are also simulated.
- The environment combinations are more severe than the general approach. For the FPSO alone condition, 100y event is combined with 10y other events (generally combined with 1y event). For the tender connected case, 10y event is combined with 1y events (generally 1y events are combined, or even 95% non-exceedance values are associated with 1y event). Also to be noted that 100y conditions are generally considered with long operations (20 to 30 years), while lighter conditions could be considered for shorter operations.
- For the tanker connected cases combinations of 1yr and 10yr conditions have been considered.

3 PROJECT INPUT DATA ANALYSIS

All the input data used for the analysis are detailed in this chapter, except the environmental data which are detailed in the next chapter.

3.1 GENERALITIES

The seawater density is equal to 1.025.
The considered water depth for mooring anchor points and hydrodynamic reference is 75m.

3.2 FPSO DATA

3.2.1 FPSO Hull mesh

Main dimensions of the FPSO are issued from Technip drawing in reference [10], and are given here after:

Main FPSO geometry		
FPSO total length	m	336
Length from FPSO aft to bow perpendicular	m	330
FPSO breadth	m	60
FPSO height (**)	m	31
Longitudinal turret center from bow perpendicular (going to the aft) (**)	m	80
Turret mooring attachments below the FPSO keel (*)	m	4
FPSO draft (*)	m	22
FPSO estimated displacement at above draft (*)	Tons	425000

(*) Data from reference [9]. - (**) Data from reference [11].

Table 3-1: Main FPSO geometry

Here after is illustrated the FPSO meshed used. Note that the turret below the hull is not considered, and a horizontal closed FPSO keel is assumed:

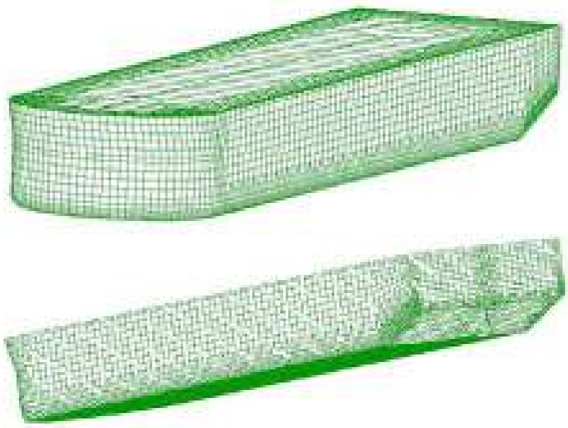


Figure 3-1: FPSO mesh for Diodore™ calculations (6814 wet elements)

3.2.2 FPSO mass and inertia

Horizontal centre of gravity and FPSO mass are deduced from the Diodore™ results (based on entered mesh, see section 0). The centre of gravity height is considered at 15m above the keel and so 7m below sea level (from reference [11], this value is 21.5 for light ship and 15m for fully loaded ship).

For the inertia, no specific data are available at that stage of the project and so the following classical assumption is used:

- Roll inertia radius : FPSO Breadth / 3.
- Pitch and Yaw inertia radii : FPSO Length / 4 (Lpp is the reference).
- The inertia is then equal to $M*R^2$, where R is the inertia radius, and M the FPSO mass.

Finally the following data are considered:

Main FPSO mass repartition at 22m draft		
Mass	Tons	428226
Longitudinal CoG from aft	m	164.9
Transverse CoG from middle	m	0
Vertical CoG from keel	m	15
Roll inertia	Tons.m²	1.7129E+08
Pitch / Yaw inertia	Tons.m²	2.9146E+09

Table 3-2: FPSO mass repartition for Diodore™ calculations

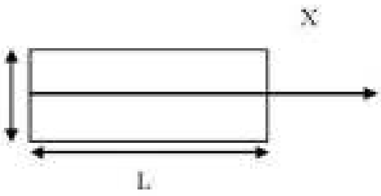
3.2.3 FPSO damping

As stated in section 0, both wave frequency quadratic damping in roll, and linear low frequency in surge, sway and yaw are imposed.

3.2.3.1 FPSO roll quadratic damping at wave frequency

Roll quadratic damping is estimated using the following CLAROM formulation (here, B_Q around X-axis):

$$B_Q = \frac{1}{2} \cdot \rho B^4 \cdot L \cdot Ca$$



With:

B_Q = Quadratic damping,
ρ = Seawater density,
B = Vessel breadth,
L = Vessel total length,
Ca = Hull shape dependent coefficient.

A Ca= 0.1 is used. (The value is so 2.232 E+11).

3.2.3.2 Surge, Sway and Yaw linear damping at low frequency

Linear damping terms are based on Bureau Veritas rules (Ref. [5]) for a tanker moored on an SPM:

MOORING SYSTEM	LINEAR DAMPING COEFFICIENT (1)		
	B_{xx} (2)	B_{yy} (2)	B_{nn} (2)
Barge or tanker on an SPM (3)	$0.01\,m\sqrt{\frac{g}{L}}$	$0.02\,m\sqrt{\frac{g}{B}}$	$0.083\,L^2\,B_{yy}$

Table 3-3: BV low frequency linear damping recommendations

(The values are so 7.317 E+05 in surge, 3.463 E+06 in sway, 3.245 E+10 in yaw).

3.2.4 <u>FPSO wind and current polar</u>

At this stage of the project, no data are available on such subject and a rough assessment is so performed:

- Above the deck, 30-m high modules are foreseen. No other information is available, such as the living quarters for example. 30-m high modules (blocks) have thus been considered all above the deck for exposed surface consideration. The final surface is finally multiplied by 1.1 to cover possible missing data and remains in a the conservatism side
- The API reference [4] is used as a basis for polar assessment.

3.2.4.1 Morison drag force calculation

The drag force can be computed using the Morison formulation given below:

$$F_d = \tfrac{1}{2}\,\rho\,C_d\,S\,V^2$$

With ρ the external fluid density (in kg/m^3, with seawater for current and air for wind), C_d the drag shape coefficient (data bases or experiments), S the surface seen by the flow (m^2), and V the fluid velocity (in m/s). Then the F_d is the drag force (in N), in the direction of the flow.

3.2.4.2 API data for FPSO current polar

For ship shaped hulls, the API formulation is similar to the Morison drag formulation, with basically a surface seeing the current times a coefficient shape factor. The coefficients are 2.89 for facing currents and 72.37 for the transverse currents.

Note: Those coefficients account for the "½*density" in the Morison formulation, so that the load is directly those coefficients, times the associated surface, times the square of the current speed.

The surface is in both cases described as the wetted surface area of the hull, including appendages. The wetted surface of the hull is considered to be twice the lateral and front surfaces, plus the bottom surface. Bottom surface would be the length (between perpendiculars) times the breadth, the front surface would be the breadth times the draft, the lateral surface is the length (between perpendiculars) times the draft.

A verification of the API data is performed, based on Morison formulation, with a drag shape coefficient applied on the surface seen by the current. A 0.65 coefficient is used for front surface coefficient (See section 8.4), and 1.05 for lateral consideration (1 from API with conservatism). Results are summarized here after:

Current data	API			Morison		
	Surface (m²)	API coeff	Force (Tons)	Cd	Surface (m²)	Force (Tons)
Facing current of 1m/s	36960	2.89	10.89	0.65	1320	44.82
Transverse current of 1m/s	36960	72.37	272.66	1.05	7260	398.25

Table 3-4: Basic API/Morison formulations for FPSO current polar assessment

As preliminary study, the most severe data based on the Morison formulation is selected. Drag forces on the lines linked to the FPSO are also considered. Below the turret are present:

- 12 mooring lines with chain 140mm diameter,
- 4 to 6 risers with 1m diameter.

So additional drag forces for all those elements are added to the hull drag for all directions. A 1.2 coefficient in Morison formulations is used, the drag on chain is considered with a doubled diameter, the maximum 6 risers number is considered. The length of each element is equal to 49m (the water depth minus the draft, and considering the turret 4m below keel). Same surface current is acting all along the lines. The moorings/risers additional force is finally 29 Tons for a 1m/s current speed. Half of this load is reported on the FPSO, as a current polar additional effect. For the moorings, a quick estimation of the validity of such an approach is detailed, see section 8.3.

The following forces due to front and lateral 1m/s current on the FPSO are finally considered:

Current force (Tons) for 1m/s speed	
Facing current of 1m/s	59.20
Transverse current of 1m/s	412.62

Table 3-5: 1m/s current speed – Equivalent forces on the FPSO in Diodore™

3.2.4.3 API data for FPSO wind polar

Wind forces acting on the FPSO are also computed based on the API reference [4] recommendations. It is then equivalent to Morison forces, with the surface seeing the current associated with a recommended drag coefficient. The FPSO and its super-structures are seen as a unique box, and a shape coefficient of 1 is then recommended; 1.05 is laterally used for conservatism, and 1.1 is considered for facing wind (possibility of several deck houses).

A height factor as the wind is not constant have also to be applied together with the above shape coefficient. Following data are recommended:

Wind force height coefficients		
Meters over not exceeding		Ch
0	15.3	1
15.3	30.5	1.18
30.5	46	1.31
46	61	1.4
61	Infinite	1.47

Table 3-6: API recommended height coefficient for wind forces assessment

As the surfaces are considered constant along the height, a mean coefficient is exhibited to account for the entire wind surfaces (Ch = Σ(Hi*Chi) / Σ(Hi)).

The surfaces are the height above sea, times the breath or the length (between perpendiculars) for respectively facing or transverse currents. 9m of hull is above the sea (22m draft), plus 30m of structures above the deck, and a 1.1 coefficient is additionally imposed on the surfaces. The air density is equal to 1.275 kg/m³. Finally the following is deduced:

Wind data	Surface (m²)	API coeff	Force (Tons)
Facing wind of 20m/s	2574	1.22	81.65
Transverse wind of 20m/s	14157	1.16	428.66

Table 3-7: 20m/s wind speed – Equivalent forces on the FPSO in Diodore™

3.2.4.4 API data for oblique wind and current

Oblique forces due to wind or current and acting on the FPSO are also computed based on the API reference [4] recommendations.

API RP 2SK for oblique direction	Formula	TERM	Definition	Unit
	$F\phi = Fx * [\,2.\cos^2(\phi) / (1+\cos^2(\phi))\,] + Fy * [\,2.\sin^2(\phi) / (1+\sin^2(\phi))\,]$	Fϕ	Force due to oblique environment	N
		Fx	Force on the bow due to a bow environment	N
		Fy	Force on the beam due to a beam environment	N
		ϕ	Direction of approaching environment	°
		Method "Vector" -> Fx and Fy are considered as vectors Method "Scalar" -> Fx and Fy are considered as values		

Table 3-8: API recommendations for estimation of oblique wind and current forces

The scalar method has been used as being more conservative. The obtained oblique force is then in the same direction as the oblique considered environment. Here after are traced the oblique forces obtained:

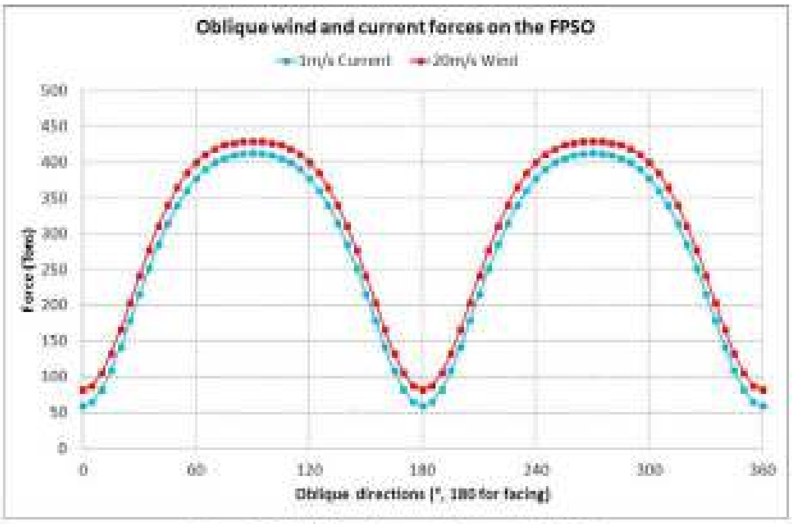


Figure 3-2: Wind and current forces on the FPSO

3.3 FPSO MOORING

The mooring system on the FPSO turret is detailed here based on data from reference [9]. 12 mooring lines are considered, with 4 bundles of 3 lines. A 90° angle has been used between each bundle. The angle between lines in a bundle and the pre-tension are further discussed in the preliminary mooring check, see section 6. The basic configuration is with 7.5° between two lines in a bundle, and a 794 m anchor radius is considered:

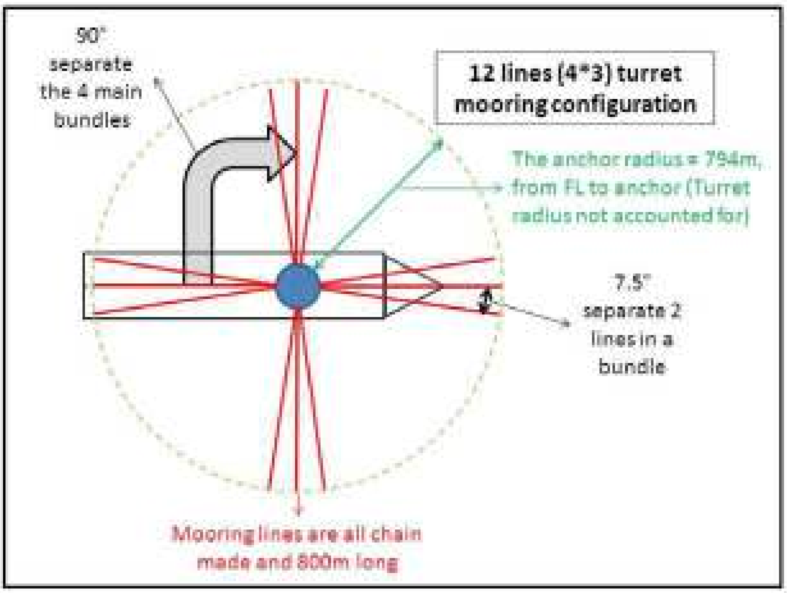


Figure 3-3: Main mooring configuration overview

Note: From results of fully loaded FPSO alone (see section 7), a 15° separation between two lines in a bundle, and a shorter radius (792m, perhaps 790m) helps reducing the maximum damaged tension in mooring lines. But the offset increases with the reduce radius / pre-tension.

Each line is made of 800m of chain. Considered chains are with 140mm diameter, and the considered breaking load is the one of a 130mm chain, to include some corrosion or second-hand chains. Considered chains here are 140mm R4K4 studlink chains, with the following properties:

Data	Unit	Value
Type	-	Studlink (R4K4)
Diameter	mm	140
Weight in air	kg/m	429.24
Weight in water	kg/m	373.14
Breaking Load (130mm)	kN	15 560
EA	N	1.28 E+09

Table 3-9: Mooring chain considered properties

In all cases, results are always given in Tons so that different chain MBL can be considered.

Here after is plot the top tension and the top vertical departure angle (0 for a vertical departure to 90° for an horizontal departure) in a mooring line, depending the radius between the fair-lead and its anchor:

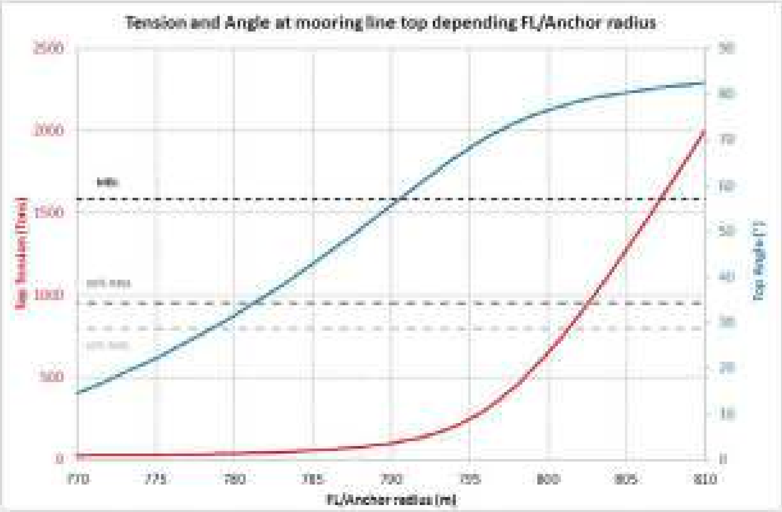


Figure 3-4: Mooring line top tension depending the anchor radius

Two different configurations are tested, as all environments will be collinear and supposed to be in front of the FPSO due to the weather weaning turret system. :

- "In-line", then the FPSO and so environment will face the middle of a bundle.
- "In-between", then the FPSO and so environment will face the middle of two bundles.

Details on both configurations are provided in the below sketch:

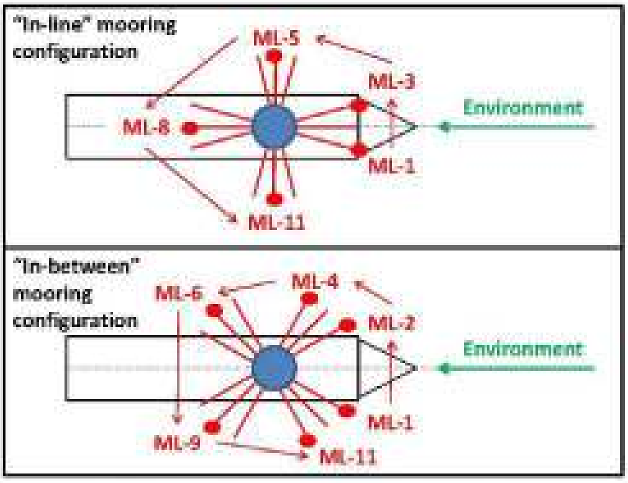


Figure 3-5: FPSO mooring configurations overview

3.4 TENDER OFFLOADING FSO DATA

The tender vessel is considered as a generic Capesize max OCIMF tanker. A generic mesh is adapted to the tanker real dimensions (according to its capacity), and wind and current polar coefficients are deduced from OCIMF database for the corresponding capacity (Diodore™ features). The same damping formulation as for the FPSO is followed with the updated dimensions. The mass repartition is assessed as for the FPSO at the imposed tender vessel draft.

Typical tender FSO data were provided by Technip in reference [12]. As very close to a 200 kDWT generic OCIMF tanker dimensions, the generic vessel is preferred here, as more accurate data are available, and in order to avoid excessive conservatism on this more classical / documented subject:

Data	Technip	200kDWT	% diff
LBP	285	310	8.80%
B	47.5	47.17	-0.70%
H	25	28.04	12.20%

Table 3-10: Typical foreseen FSO vs generic OCIMF tanker

The tender vessel used is a 200 kDWT capacity, in a ballast configuration, simulating the transfer start, with the Fully Loaded FPSO. Tanker dimensions estimations are provided below. The Center of Gravity is at around 2/3 of the hull height for this ballast case (equivalent as per the FPSO case):

Main Ballasted Tanker 200-kDWT geometry		
Length from Tanker aft to bow perpendicular	m	310
Tanker breadth	m	47.17
Tanker height	m	28.04
Tanker draft	m	5

Table 3-11: Ballasted Tanker geometry

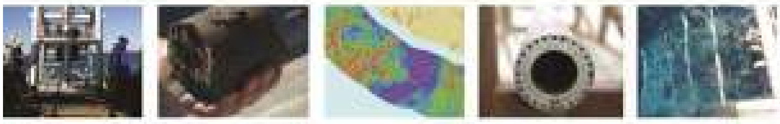
Main Tanker mass repartition at 5m draft		
Mass	Tons	58 786
Longitudinal CoG from aft	m	183.9
Transverse CoG from middle	m	0
Vertical CoG from keel	m	19
Roll inertia	Tons.m²	1.4533E+07
Pitch / Yaw inertia	Tons.m²	3.5308E+08

Table 3-12: Ballasted Tanker mass repartition

Dampings on ballasted tanker (SI units)			
Motion	Form	Freq	Value
Roll	Quadratic	WF	7.8654E+10
Surge	Linear	LF	1.0457E+05
Sway	Linear	LF	5.3617E+05
Yaw	Linear	LF	4.2767E+09

Table 3-13: Ballasted Tanker dampings

Polar are from OCIMF data bases. Loads are imposed at the tanker mid-length, at mid-draft for current, and at 2/3 of the hull above sea level for wind.



The mesh used is illustrated here after:

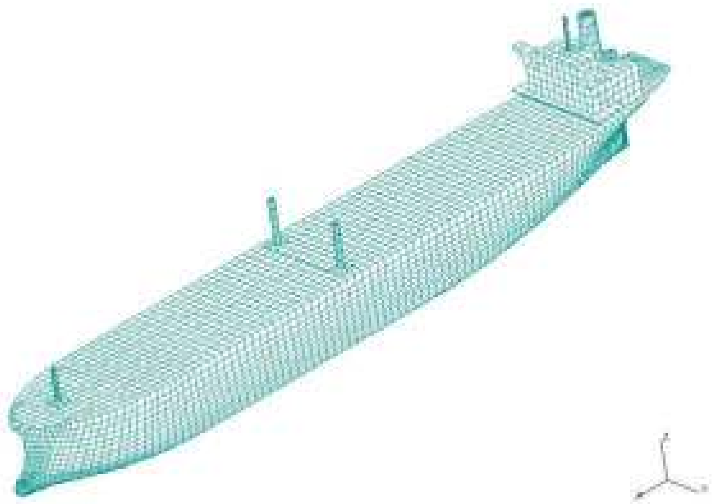


Figure 3-6: Generic tender overview

3.5 HAWSER DATA

The following arrangement is considered:

DESCRIPTION	UNIT	VALUE
Number of hawsers	-	2
Material	-	100% Nylon Double-Braided
Length of rope (*)	m	90
Circumference	inch	16
Breaking Strength per rope (estimated for 16'' circumference)	kN	3500 (7000 for the 2)

(*) Rope length does not account for 10m chafing chains. 10m is added to the assembly and assumed inextensible.

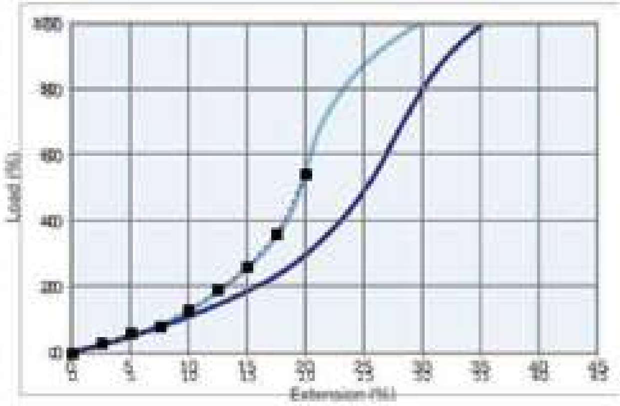
Table 3-14: Hawser properties

The equivalent non-linear load-extension curve of the assembly (including 10m chafing chain inextensible, and two parallel hawsers 90m long, with stiffer below "worked" curve) is given:

Tension (kN)	0	210	420	560	910	1330	1820	2520	3780
Length (m)	100	102.25	104.5	106.75	109	111.25	113.5	115.75	118

Table 3-15: Mooring hawsers load excursion tabulated values

The following classical nylon load / extension curve is used (reference (http://www.exsil.be/#/en/products/double-braided/))



Extension (%)	0	2.5	5	7.5	10	12.5	15	17.5	20
Load (% MBL)	0	3	6	8	13	19	26	36	54

Figure 3-7: Hawser nylon part - Load / Extension curve

3.6 BACK FORCE

The Capesizemax shuttle tanker being self propelled, we assume that a constant 300 KN back force is considered to maintain the hawser tensioned (could be achieved also by a tug if required). This load is applied in the tanker local axis system.

4 ENVIRONNEMENT – LOAD CASES - OUTPUTS

4.1 GENERALITIES

In this chapter are detailed the environments on the field, from the document "Kupe Meteocean Design Criteria" provided by "ASR Marine Consulting and Research".

All data given after for wind, wave and surface current are the maximum omni-directional values. Values for 1y, 10y and 100y return periods are provided. Following main combinations are conducted:

Combination	Extreme Current	Extreme Wind	Extreme Wave
Current	Extreme	Associated	Associated
Wind	Associated	Extreme	Associated
Wave	Associated	Associated	Extreme

Table 4-1: Environments basic combinations.

In this preliminary work, all the environments are considered collinear and facing the FPSO. (In a 2nd time in sensitivity cases, more severe combinations are done, to cover possible non-collinear events):

- Omni-directional data are considered and the maximum are combined (even if they have not real occurrence risk).
- For the FPSO alone conditions, a severe combination with 100y event associated with 10y other events are considered. (note: usually for detailed design phase, the 100y events are generally combined with other 1y)
- For the tender connected conditions, a severe combination with 10y event associated with 1y other events are considered. (note: usually for detailed design phase only the 1y combination are assumed)
- A constant current equal to surface speed is considered, a constant wind with the 3 seconds gust speed is used. The constant wind speed is expected severe and is preferred, as no wave trigger sensitivity are conducted
- For the wave simulated through a Jonswap spectrum, the nominal peak period is considered, and the classical sensitivity on periods (+/-20%) are also considered.

4.2 EXTREME ENVIRONMENTS

Here after are presented the maximum environments on the field:

CURRENT RP	1	10	100
Surface Speed (m/s)	0.98	1.31	1.62

WIND RP	1	10	100
1 minute wind (m/s)	28.67	34.94	40.48
3 second gust (m/s)	32.22	39.62	46.25
Ratio (1mn / 3sec)	1.12	1.13	1.14

WAVE RP	1	10	100
Hs (m)	5.49	7.33	9.27
Tp (sec)	8.82	10.66	11.72
Hmax (m)	10.21	13.64	17.24
Hmax / Hs	1.86	1.86	1.86
Gamma	2.972	2.538	2.748

Table 4-2: Extreme considered environments

4.3 LOAD CASES WITH FPSO ALONE

Here after are presented the load cases matrix considered for the FPSO alone cases:

FPSO alone Load Cases					
Case	Mooring configuration	Current RP	Wind RP	Wave RP	Wave period
Alone-1	In-line	**100**	10	10	Nominal - 20%
Alone-2					Nominal
Alone-3					Nominal +20%
Alone-4		10	**100**	10	Nominal - 20%
Alone-5					Nominal
Alone-6					Nominal +20%
Alone-7		10	10	**100**	Nominal - 20%
Alone-8					Nominal
Alone-9					Nominal +20%
Alone-10	In-between	**100**	10	10	Nominal - 20%
Alone-11					Nominal
Alone-12					Nominal +20%
Alone-13		10	**100**	10	Nominal - 20%
Alone-14					Nominal
Alone-15					Nominal +20%
Alone-16		10	10	**100**	Nominal - 20%
Alone-17					Nominal
Alone-18					Nominal +20%

Table 4-3: FPSO alone load cases

Two additional cases are considered with damaged mooring.

For the case above leading to the maximum tension, the second most loaded line is then considered permanently broken, to possibly assess the maximum damaged tension.

For the case above leading to the maximum offset, the most loaded line is then considered permanently broken, to possibly assess the maximum damaged offset.

A test on the environments relative directionality is finally performed on the worst intact case (higher lines tension), as recommended by the BV, reference [5]:

"The mooring system in either design or fatigue condition should be checked for at least eight wave incidences covering 360°. Directions of wind and current should be those associated with each wave incidence. Without relevant information about the relative direction of wind and current, the following combinations are at least to be verified for each wave incidence:

- *wind and current acting in the same direction as wave;*
- *wind acting in the same direction as wave, current crossing wave with an angle of ±22.5°;*
- *current acting in the same direction as wave, wind crossing wave with an angle of ±22.5°;*
- *parallel wind and current crossing wave with an angle of ±22.5°;*
- *wind and current crossing wave, each on one side with an angle of ±22.5°."*

4.4 LOAD CASES WITH CONNECTED TENDER VESSEL

All 1y conditions are first run for information. A test on the environments relative directionality is also performed on the worst intact case (higher lines tension), as recommended by the BV, see above section.

In the present preliminary part of the study, most severe combinations are tested to ensure conservatism in those early results. Here after are presented the load cases considered for the tender connected cases:

Tender connected Load Cases					
Case	**Mooring configuration**	**Current RP**	**Wind RP**	**Wave RP**	**Wave period**
Tender-1					Nominal - 20%
Tender-2		**10**	1	1	Nominal
Tender-3					Nominal +20%
Tender-4					Nominal - 20%
Tender-5	In-line	1	**10**	1	Nominal
Tender-6					Nominal +20%
Tender-7					Nominal - 20%
Tender-8		1	1	**10**	Nominal
Tender-9					Nominal +20%
Tender-10					Nominal - 20%
Tender-11		**10**	1	1	Nominal
Tender-12					Nominal +20%
Tender-13					Nominal - 20%
Tender-14	In-between	1	**10**	1	Nominal
Tender-15					Nominal +20%
Tender-16					Nominal - 20%
Tender-17		1	1	**10**	Nominal
Tender-18					Nominal +20%

Table 4-4: Tender connected load cases

<u>Two additional cases</u> are considered with damaged mooring.

For the case above leading to the maximum tension, the second most loaded line is then considered permanently broken, to possibly assess the maximum damaged tension.

For the case above leading to the maximum offset, the most loaded line is then considered permanently broken, to possibly assess the maximum damaged offset.

4.5 OUTPUTS

For each of the above cases, the following are given:

- The maximum offset at the FPSO CoG, in meters and in % of the 75m water depth,
- The maximum tension in each line, in Tons and in % of the breaking load.

The hawser maximum tension is also given in Tons when the tender is connected.

5 CRITERIA

The FPSO offset should be limited by the connected risers' capability to withstand will large displacements. After discussions, an 8 to 10m offset seems satisfactory.

For the maximum tension in the mooring lines, different codes are providing different criteria compared to the mooring lines MBL.

The recommendations from the API reference [4] are as follows:

API RP-2SK recommended maximum mooring tensions			
Mooring Condition	**Method**	**Tension Limit (% MBL**	**Equivalent Safety Factor**
Intact	**Quasi-Static**	50	2.00
	Dynamic	60	1.67
Damaged	**Quasi-Static**	70	1.43
	Dynamic	80	1.25

Table 5-1: Criteria on mooring tension from API

Following criteria are from the DNV reference [7], for quasi-static calculations. Note that the "class-2" is applied when a risk of collision with an adjacent platform (or moored vessel) is present.

DNV-OS-E301 recommended maximum mooring tensions			
Mooring Condition	**Class**	**Tension Limit (% MBL**	**Equivalent Safety Factor**
Intact	**1**	58.8	1.70
	2	40.0	2.50
Damaged	**1**	90.9	1.10
	2	74.1	1.35

Table 5-2: Criteria on mooring tension from DNV

Following criteria are from the BV reference [5]. Note that the "type-1" is applied when a risk of collision with an adjacent platform (or moored vessel) is present.

BV-NI 461 recommended maximum mooring tensions			
Mooring Condition	**Type**	**Tension Limit (% MBL**	**Equivalent Safety Factor**
Intact	**1**	45.5	2.20
	2	57.1	1.75
Damaged	**1**	57.1	1.75
	2	80.0	1.25

Table 5-3: Criteria on mooring tension from BV

Finally to be conservatism (and accounting the risk of collision with adjacent structures) , the maximum tension in mooring lines should not exceed 50% of the MBL for intact conditions, and 60% of the MBL for damaged conditions.

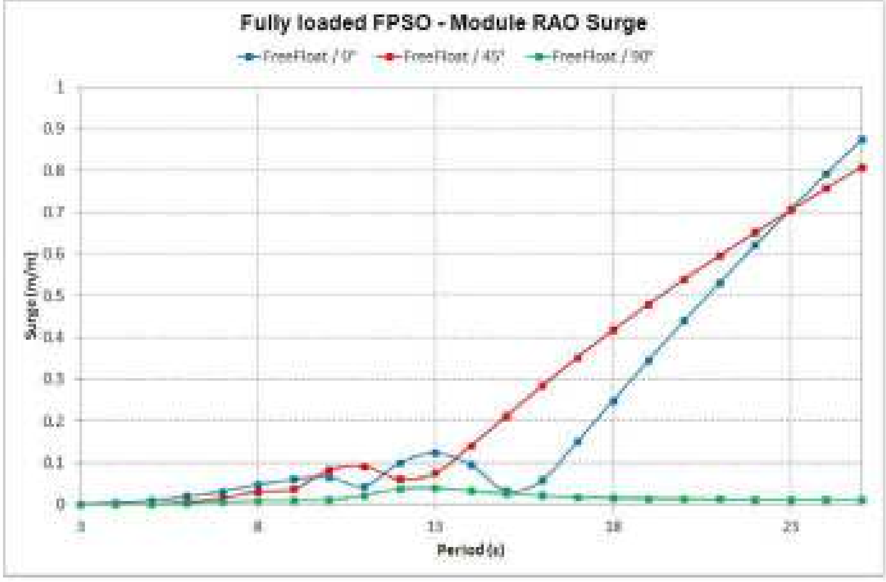
This condition is more severe than the API recommendations, and 70% of MBL for damaged cases could possibly be considered. Here, a conservative 60% damaged criteria is foreseen, to avoid as much as possible a second mooring failure, if a risk of collision with adjacent structure is present. If no risk of collision with adjacent anchored vessels, those criteria are severe and can be relaxed.

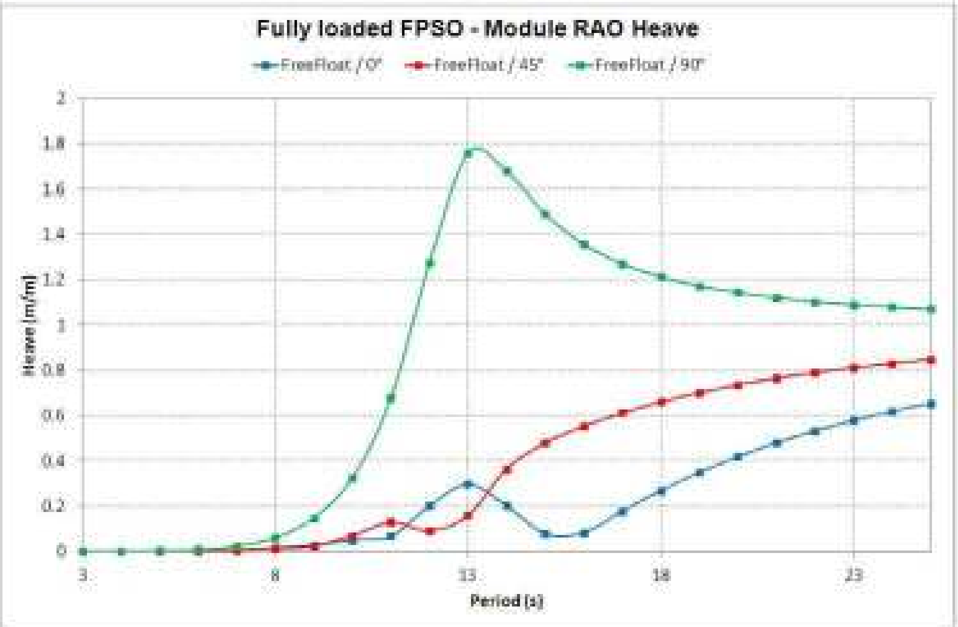
In all cases, results are always given in Tons so that different criteria or chain MBL can be assessed.

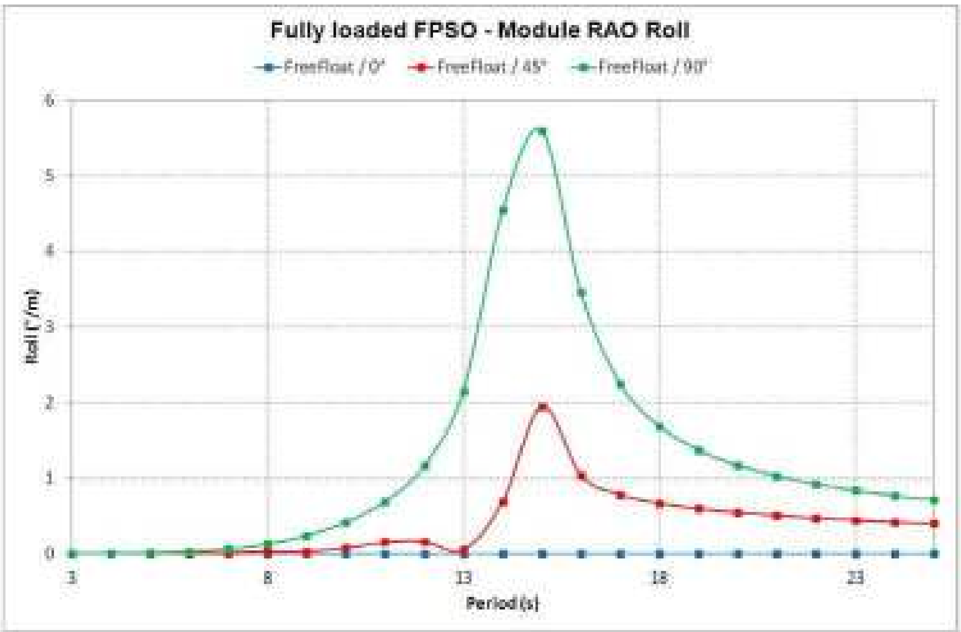
FULLY LOADED FPSO HYDRODYNAMIC RESULTS - FREE FLOATING

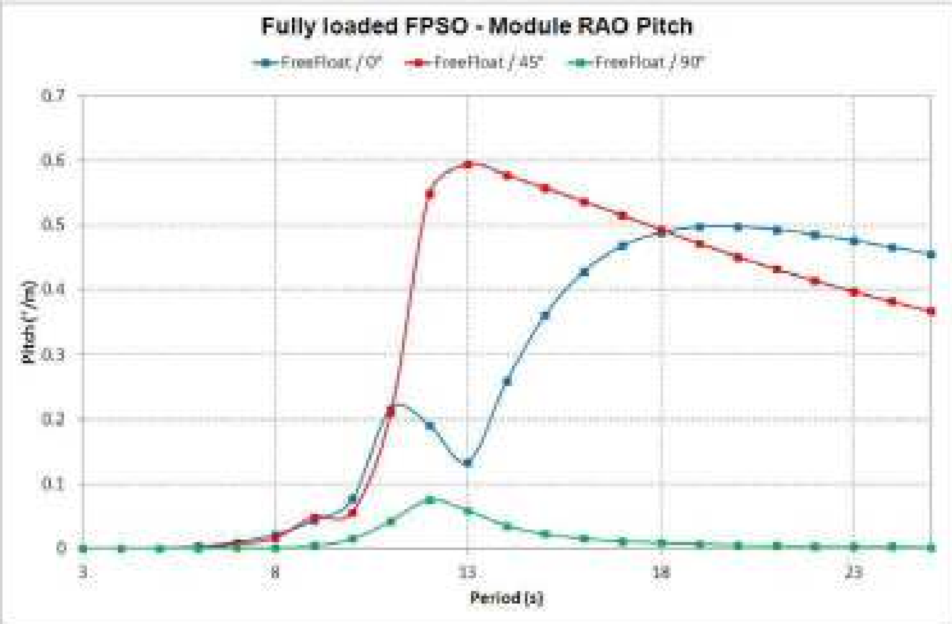
5.1 FULLY LOADED FPSO MOTION RAOS

The fully loaded FPSO is considered in free floating conditions and the motion RAOs modulus are given:




Fully loaded FPSO - Module RAO Heave
FreeFloat / 0°
FreeFloat / 45°
FreeFloat / 90°
Heave [m/m]
Period [s]


Fully loaded FPSO - Module RAO Roll
FreeFloat / 0°
FreeFloat / 45°
FreeFloat / 90°
Roll [°/m]
Period [s]



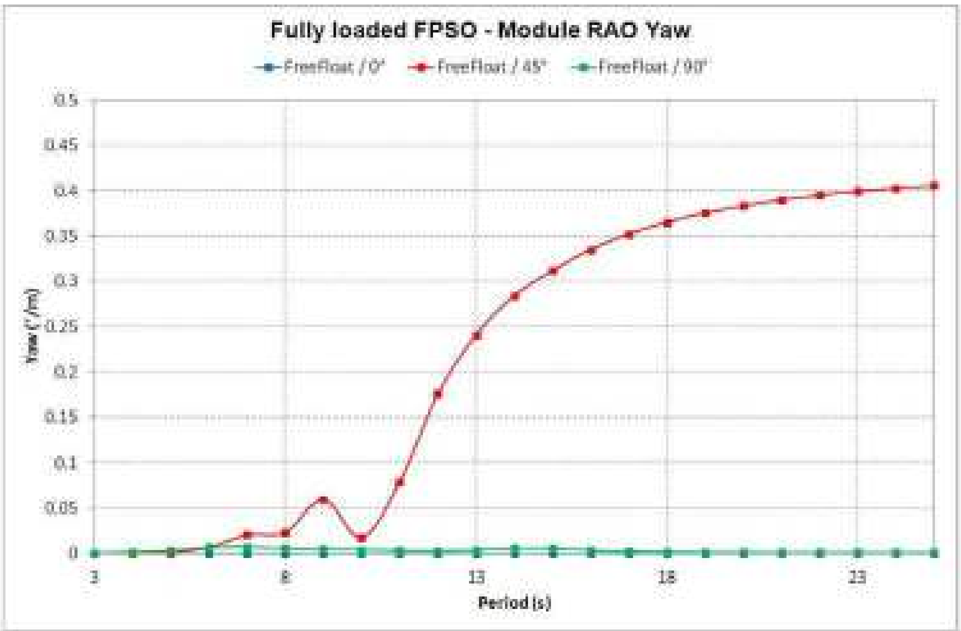


Figure 0-1: Fully loaded FPSO in free floating condition - Motion RAOs

5.2 FULLY LOADED FPSO HORIZONTAL DRIFT FORCES AND MOMENTS

The fully loaded FPSO is considered in free floating conditions and the horizontal drift forces and moments are given:

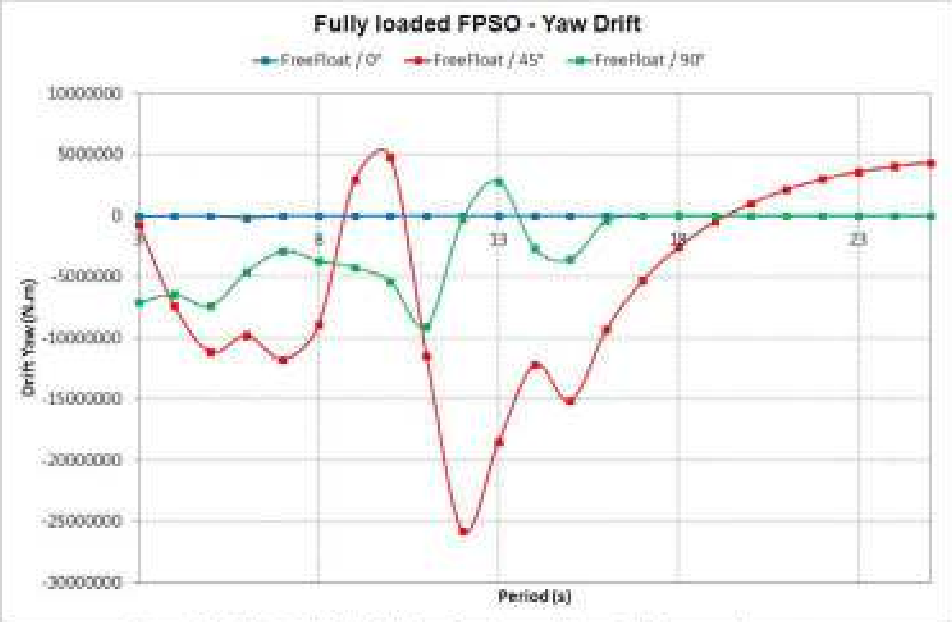


Figure 0-2: Fully loaded FPSO in free floating condition - Drift forces and moments

5.3 FULLY LOADED FPSO RESPONSE TO EXTREME WAVES

Here after are presented the response in Surge, Heave and Pitch of the fully loaded free floating FPSO facing the 1y, 10y and 100 y extreme waves. Values are provided at the FPSO Centre of Gravity in double amplitude:

Wave			Surge (m)		Heave (m)		Pitch (°)	
RP	Hs (m)	Tp (s)	Vs	Max-3h	Vs	Max-3h	Vs	Max-3h
1y	**5.49**	**8.82**	0.23	0.45	0.20	0.39	0.24	0.47
10y	**7.33**	**10.66**	0.46	0.89	0.73	1.40	0.81	1.56
100y	**9.27**	**11.72**	0.75	1.44	1.38	2.64	1.39	2.66

Table 0-1: Fully loaded FPSO in free floating condition facing waves – Extreme waves response at FPSO CoG

The motions and accelerations at the four FPSO corners, at the top of the topsides, and for those 1y, 10y and 100y waves are given here after.

Corners are so at +/-30m laterally from FPSO center, at the rear or front FPSO (336m total length considered), and at 61m above FPSO keel (deck is at 31m and then 30m more). The conventions are as follows:

- Point-1: FPSO rear and on Portside,
- Point-2: FPSO rear and on Starboard,
- Point-3: FPSO front and on Portside,
- Point-4: FPSO front and on Starboard.

The wave is considered facing the FPSO (180° in Diodore™), or at 15° from it (165°).

In the below table, for each case and motion, the following are given. Each motion parameter is given <u>in double amplitude (through to crest):</u>

- Vs: Significant FPSO motion,
- Max-3h: Maximum motion on a 3 hours duration,
- Acc: Significant value of the acceleration on this FPSO degree of freedom,
- Speed: Significant value of the speed on this FPSO degree of freedom.

Wave RP / Heading	FPSO Motion	Point-1				Point-2				Point-3				Point-4			
		Vs	Max-3h	Acc	Speed	Vs	Max-3h	Acc	Speed	Vs	Max-3h	Acc	Speed	Vs	Max-3h	Acc	Speed
1y - 165°	SURGE	0.394	0.768	0.177	0.256	0.376	0.734	0.167	0.244	0.393	0.766	0.177	0.256	0.376	0.733	0.167	0.243
	SWAY	0.433	0.846	0.207	0.292	0.433	0.846	0.207	0.292	0.271	0.531	0.138	0.188	0.271	0.531	0.138	0.188
	HEAVE	0.589	1.142	0.208	0.345	0.597	1.155	0.207	0.348	0.828	1.604	0.299	0.484	0.865	1.675	0.306	0.504
	ROLL	0.115	0.223	0.044	0.069	0.115	0.223	0.044	0.069	0.115	0.223	0.044	0.069	0.115	0.223	0.044	0.069
	PITCH	0.237	0.460	0.084	0.139	0.237	0.460	0.084	0.139	0.237	0.460	0.084	0.139	0.237	0.460	0.084	0.139
	YAW	0.111	0.216	0.055	0.076	0.111	0.216	0.055	0.076	0.111	0.216	0.055	0.076	0.111	0.216	0.055	0.076
1y - 150°	SURGE	0.377	0.736	0.170	0.246	0.377	0.736	0.170	0.246	0.376	0.734	0.170	0.246	0.376	0.734	0.170	0.246
	SWAY	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	HEAVE	0.625	1.209	0.214	0.362	0.625	1.209	0.214	0.362	0.841	1.628	0.299	0.492	0.841	1.628	0.299	0.492
	ROLL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	PITCH	0.242	0.469	0.086	0.142	0.242	0.469	0.086	0.142	0.242	0.469	0.086	0.142	0.242	0.469	0.086	0.142
	YAW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10y - 165°	SURGE	1.045	2.016	0.331	0.576	1.002	1.931	0.305	0.542	1.045	2.016	0.331	0.575	1.003	1.932	0.305	0.541
	SWAY	1.010	1.950	0.331	0.561	1.011	1.950	0.331	0.561	0.636	1.228	0.216	0.355	0.636	1.228	0.216	0.355
	HEAVE	2.053	3.948	0.586	1.079	2.017	3.883	0.592	1.076	2.851	5.480	0.804	1.491	3.043	5.845	0.839	1.573
	ROLL	0.463	0.886	0.112	0.224	0.463	0.886	0.112	0.224	0.463	0.886	0.112	0.224	0.463	0.886	0.112	0.224
	PITCH	0.821	1.578	0.233	0.430	0.821	1.578	0.233	0.430	0.821	1.578	0.233	0.430	0.821	1.578	0.233	0.430
	YAW	0.237	0.459	0.084	0.137	0.237	0.459	0.084	0.137	0.237	0.459	0.084	0.137	0.237	0.459	0.084	0.137
10y - 150°	SURGE	0.995	1.918	0.312	0.545	0.995	1.918	0.312	0.545	0.994	1.916	0.311	0.545	0.994	1.916	0.311	0.543
	SWAY	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000
	HEAVE	2.075	3.996	0.613	1.114	2.075	3.996	0.613	1.114	2.854	5.487	0.810	1.499	2.854	5.487	0.810	1.499
	ROLL	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	PITCH	0.811	1.561	0.235	0.431	0.811	1.561	0.235	0.431	0.811	1.561	0.235	0.431	0.811	1.561	0.235	0.431
	YAW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100y - 165°	SURGE	1.679	3.225	0.465	0.866	1.682	3.230	0.456	0.862	1.684	3.235	0.465	0.867	1.688	3.239	0.456	0.863
	SWAY	1.626	3.119	0.444	0.825	1.626	3.120	0.444	0.825	1.069	2.045	0.278	0.522	1.069	2.045	0.278	0.522
	HEAVE	3.576	6.839	0.878	1.735	3.420	6.548	0.863	1.685	4.999	9.567	1.241	2.450	5.449	10.425	1.338	2.639
	ROLL	0.886	1.692	0.201	0.418	0.886	1.692	0.201	0.418	0.886	1.692	0.201	0.418	0.886	1.692	0.201	0.418
	PITCH	1.430	2.736	0.353	0.697	1.430	2.736	0.353	0.697	1.430	2.736	0.353	0.697	1.430	2.736	0.353	0.697
	YAW	0.363	0.696	0.102	0.184	0.363	0.696	0.102	0.184	0.363	0.696	0.102	0.184	0.363	0.696	0.102	0.184
100y - 180°	SURGE	1.626	3.123	0.448	0.858	1.626	3.123	0.448	0.858	1.629	3.128	0.447	0.857	1.629	3.128	0.447	0.857
	SWAY	0.001	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.001	0.000	0.000
	HEAVE	3.522	6.752	0.922	1.768	3.522	6.753	0.922	1.768	4.983	9.542	1.258	2.463	4.983	9.541	1.258	2.463
	ROLL	0.001	0.002	0.000	0.000	0.001	0.002	0.000	0.000	0.001	0.002	0.000	0.000	0.001	0.002	0.000	0.000
	PITCH	1.299	2.662	0.355	0.690	1.299	2.662	0.355	0.690	1.299	2.662	0.355	0.690	1.299	2.662	0.355	0.690
	YAW	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 0-2: Extreme waves response at the four FPSO corners at the FPSO top sides top (61m above keel)

6 PRELIMINARY MOORING CHECK

6.1 FIRST SCREENING

A preliminary static check of the mooring is performed by considering both the 100y wind and current facing the FPSO for the two mooring configurations. Different anchor radiuses and angles between lines in a bundle are tested, the neutral line characteristics are given (tension and angle from vertical, 0 for vertical departure and 90 for horizontal departure), and finally the maximum tension and FPSO offset due to the environment are provided.

Mooring configuration				Max tension (% MBL)		Max offset (% WD)		Surge NP
Radius (m)	Neutral Top Tension (%MBL)	Neutral Top Angle (°)	Angle between lines in a bundle	In Line	In Between	In Line	In Between	sec
792	8.7	60.9	15	17.80	16.48	4.82	4.99	113.06
			5	17.72	15.35	4.79	5.02	
797	23.4	72.2	15	30.56	29.54	1.78	1.78	65.11
			5	30.56	28.79	1.78	1.78	

Table 6-1: Preliminary static 100y facing current and wind influence on mooring - Screening

As seen on the mooring curve section 3.3, moorings are working with high departure angles, near a straight tensioned line behavior. The stiffness is so important and the natural period of the FPSO is low.

The angle between lines in a bundle has a low influence on the results. The first tension gives "important" static offsets, near 5% of water depth. The second one limits offsets, but the surge natural period comes low and the pre-tension is important, so the maximum tension already reaches 30% of the MBL.

6.2 SELECTED MOORING

So the chosen mooring is intermediate:
- The anchor radius chosen is 794m,
- The angle between lines in a bundle is 7.5° (the three lines in a bundle have finally a 2*7.5=15° separation angle).

Results are presented here after:

Mooring configuration				Max tension (% MBL)		Max offset (% WD)		Surge NP
Radius (m)	Top Tension (%MBL)	Top angle (°)	Angle between lines in a bundle	In Line	In Between	In Line	In Between	sec
794	12.7	65.9	7.5	20.86	18.97	3.19	3.24	88.8

Table 6-2: Preliminary static 100y facing current and wind influence on mooring - Selected mooring

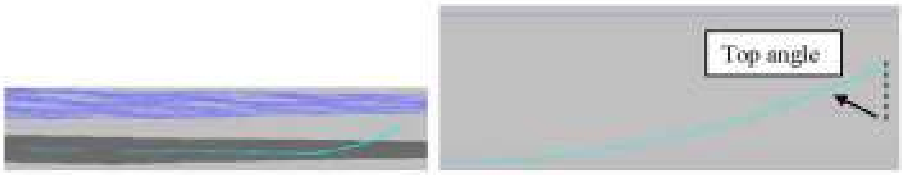


Figure 6-1: Mooring illustration at neutral position

7 MOORING ANALYSIS RESULTS

7.1 FULLY LOADED FPSO ALONE

7.1.1 Main results

Here after are presented the results from the mooring analysis performed on the Fully Loaded FPSO considered alone:

FPSO alone mooring analysis results						Max offset		Max tension	
Case	Mooring configuration	Current RP	Wind RP	Wave RP	Wave period	m	% WD	Tons	% MBL
Alone-1	In-line	100	10	10	Nominal - 20%	5.1	6.7	550.2	34.7
Alone-2					Nominal	5.2	6.9	564.8	35.6
Alone-3					Nominal +20%	5.2	7.0	572.1	36.1
Alone-4		10	100	10	Nominal - 20%	5.3	7.0	574.7	36.2
Alone-5					Nominal	6.3	8.4	684.9	43.2
Alone-6					Nominal +20%	5.3	7.0	574.3	36.2
Alone-7		10	10	100	Nominal - 20%	6.8	9.0	738.4	46.6
Alone-8					Nominal	7.0	9.3	770.3	**48.6**
Alone-9					Nominal +20%	6.5	8.6	709.6	44.7
Alone-10	In-between	100	10	10	Nominal - 20%	5.2	7.0	468.1	29.5
Alone-11					Nominal	5.3	7.0	466.1	29.4
Alone-12					Nominal +20%	5.2	6.9	473.5	29.9
Alone-13		10	100	10	Nominal - 20%	5.6	7.5	493.7	31.1
Alone-14					Nominal	6.2	8.3	542.7	34.2
Alone-15					Nominal +20%	5.7	7.6	500.7	31.6
Alone-16		10	10	100	Nominal - 20%	6.9	9.3	601.1	37.9
Alone-17					Nominal	7.8	**10.5**	683.7	43.1
Alone-18					Nominal +20%	7.1	9.5	623.1	39.3
Alone-19 - Damaged case - "Alone-8" case with ML-1 broken (2nd most loaded)						9.8	**13.0**	1126.4	**71.0**
Alone-20 - Damaged case - "Alone-17" case with ML-1 broken (most loaded)						9.0	12.0	877.1	55.3

Table 7-1: Fully Loaded FPSO alone mooring analysis results

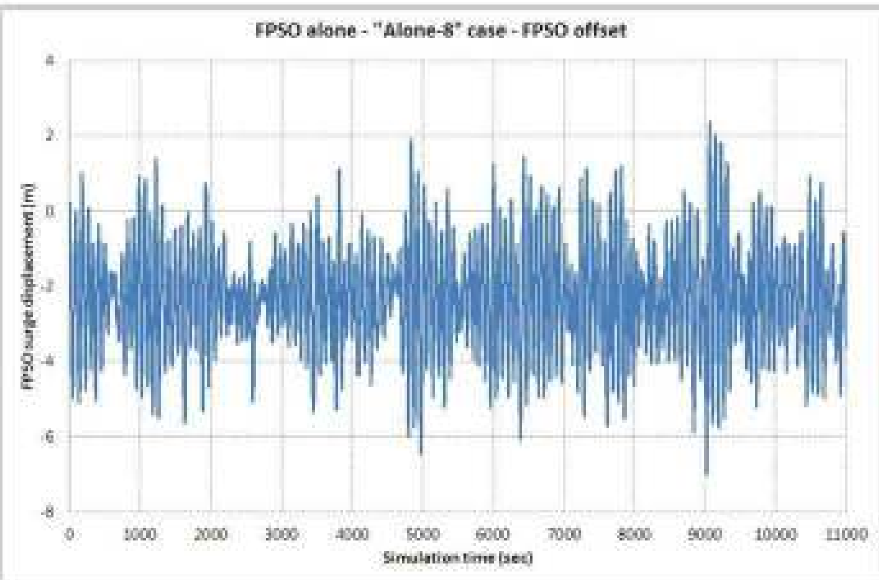
The condition leading to extreme results is the one governed by <u>the wave</u>:

- When the mooring is "in-line" with the wave direction, the tension is maximum (one line is facing environment), and is just below 50% of the chain corroded/second-hand MBL.
- When the mooring is "in-between" the wave direction, the offset is maximum (no line facing environment) and reaches an absolute value close to 8 m, which remains acceptable.

When damaged mooring is considered, the offset increases up to 10m and the tension reaches 71% of the corroded/second-hand chain MBL.

7.1.2 Illustration of the results

Here after are presented time histories of FPSO offset and maximum mooring line tension along the Diodore™ simulation. They are representative of the "alone-8" intact case (ML-2 is the most loaded):



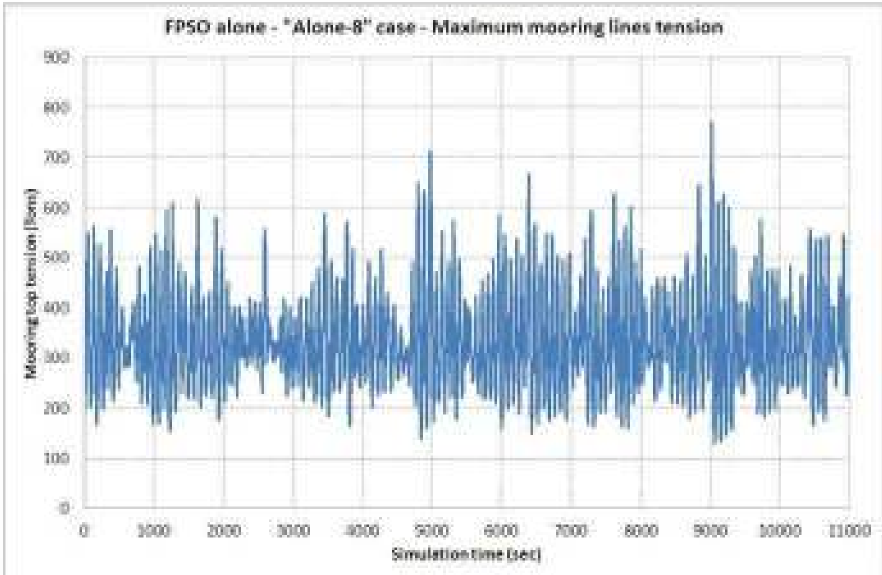
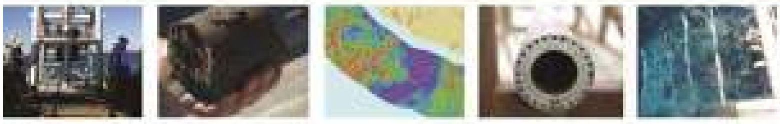


Figure 7-1: "Alone-8" case for fully loaded FPSO – Diodore™ time series samples



7.1.3 Worst damaged case sensitivities

The worst damaged case is additionally tested by changing the angle between two lines in a bundle, and the main anchor radius pre-tension:

Alone-19 - Damaged case - "Alone-8" case with ML-1 broken (2nd most loaded)					
Radius (m)	**Angle in bundle (°)**	**Offset (m)**	**Offset (%WD)**	**Tension (Tons)**	**tension (%MBL)**
794	5	9.9	13.2	1137.6	71.7
	7.5	*9.8*	*13.0*	*1126.4*	*71.0*
	15	9.5	**12.6**	1083.6	**68.3**
792	**15**	10.9	14.6	1001.5	**63.1**
794		*9.5*	*12.6*	*1083.6*	*68.3*
796		7.6	**10.1**	1101.9	69.5

Table 7-2: FPSO fully loaded and alone - Most severe damaged case sensitivities on mooring

Spacing the lines in a same bundle helps reducing a little the maximum tension in the lines. As seen in section 6, this modification of the separation angle in a bundle had reduce impact on the intact cases, even if it would have to be checked on the full load case matrix.

In the second test, a stiffer system (anchor radius increased) leads to reduced offsets, but higher tensions are encountered. So, if "large" offsets can be supported by the connected risers, reducing the line pre-tension can help reducing the loads.

Finally, with a 15° angle between lines and a 792m reduced anchor radius decreases the maximum damaged tension down to 63.1 % of the considered breaking load.

If the MBL of the 140mm initial chain diameter is considered to be the one of a similar 134mm chain diameter (instead of 130mm here), the tension is 60% of the MBL as requested by the codes.

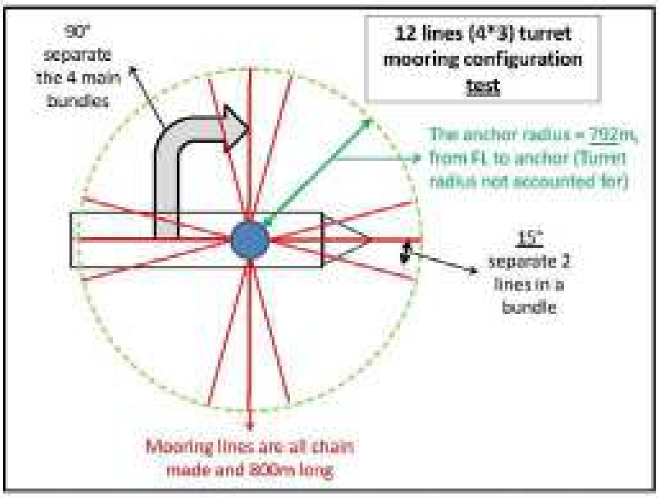


Figure 7-2: More efficient tested mooring on the worst damaged case

7.1.4 Sensitivity on the environments directions

The "Alone-8" case leading to the highest tension in mooring lines is chosen to perform a test on the environments directions, as presented in 4.3. For this purpose, the turret is here modeled and the fair leads are considered on an 8.5m radius. Note that it has been checked this modification does not significantly affects the precedent study results with aligned environments (maximum tension of 769.7 Tons, instead of 770.3 Tons). Results are given here after, offset are for the turret base center:

	Headings (°)			Max offset		Max tension		FPSO mean
	Current	Wind	Wave	m	% WD	Tons	% MBL	Heading (°)
Alone-8 basic case	180	180	180	7	9.3	769.7	48.5	0.0
	202.5	180	180	7.1	9.5	780.4	49.2	5.9
	180	202.5	180	7.5	10	824.8	52	11.5
	202.5	202.5	180	7.7	10.2	845.8	53.3	**14.4**
	202.5	157.5	180	**8.3**	11.1	**920.4**	58	-4.0

Table 7-3: FPSO fully loaded and alone - Most severe intact case sensitivities on directions

It can be noted that on the above most severe tension, by considering associated 1y wind and current (instead of 10y), the maximum tension decreases down to 796 Tons, nearly 50% of the 130mm chain MBL.

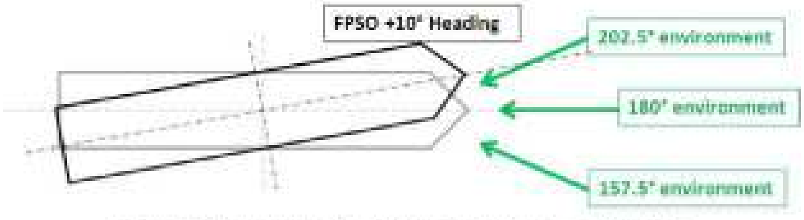


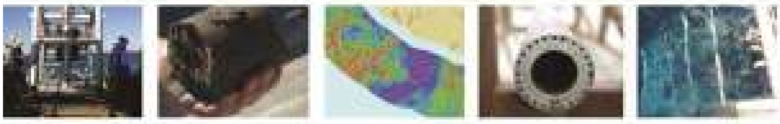
Figure 7-3: Illustration of the different given headings in above table

On the case leading to the maximum mean FPSO yaw, a test is conducted on the thruster capability. As provided by Technip on the thruster, 3 x 3.0 MW (3 x 50%) transverse thrusters installed in tunnel (3m diameter) have been considered at the stern. With two thrusters operational (100%), about 85 Tons lateral thrust will be available. So 82 Tons (conservative) lateral force at FPSO stern is additionally imposed to compensate the FPSO mean heading, in the relative FPSO reference frame. Results are given here below:

	Headings (°)			Thruster	Max offset		Max tension		FPSO mean
	Current	Wind	Wave		m	% WD	Tons	% MBL	Heading (°)
Alone-8 basic case	202.5	202.5	180	NO	7.7	10.2	845.8	53.3	**14.4**
				YES	8.3	11.1	923.6	58.2	**4.6**

Table 7-4: Thruster influence sensitivity

Lateral thrusters are influencing the FPSO main heading, and the relative angle with facing waves decreases from 14.4 to 4.6°. On the other hand, wave and current are then more lateral to the FPSO, and both offset and tension are increased.



7.2 CONNECTED BALLAST TENDER ON FULLY LOADED FPSO

7.2.1 All 1y collinear environments test

Here after are presented the results considering all 1y environments collinear:

Tender connected mooring analysis results – 1y environments						Max offset FPSO		Max tension ML		Max tension Hawser	
Case	Mooring configuration	Current RP	Wind RP	Wave RP	Wave period	m	% WD	Tons	% MBL	Tons	% MBL
1y-1	In-line	1			Nominal - 20%	3.6	4.9	424.2	26.7	279.3	39.1
1y-2					Nominal	4.4	5.8	488.2	30.8	287.4	40.3
1y-3					Nominal +20%	4.5	6.0	497.6	31.4	311.0	43.6
1y-4	In-between				Nominal - 20%	3.8	5.0	373.0	23.5	271.0	38.0
1y-5					Nominal	4.6	6.2	427.9	27.0	294.2	41.2
1y-6					Nominal +20%	4.7	6.3	431.2	27.2	308.4	43.2
1y-7 - "1y-3" case with ML-1 broken (2nd most loaded)						6.0	8.0	650.8	41.0	282.7	39.6
1y-8 - "1y-6" case with ML-1 broken (most loaded)						5.6	7.5	546.1	34.4	279.4	39.2

Table 7-5: Fully Loaded FPSO in tandem with ballasted tender – 1y environments test

7.2.2 All 1y environments - Sensitivity on the environments directions

The "1y-3" case leading to the highest tension in mooring lines is chosen to perform a test on the environments directions, as presented in 4.3. For this purpose, the turret is here modeled, and the fair leads are considered on an 8.5m radius. Note that it has been checked this modification does not significantly affects the precedent study results with aligned environments (maximum tension of 498 Tons, instead of 497.6 Tons). Results are given here after, offset are for the turret base center:

	Headings (°)			Max offset		Max tension ML		Max tension Hawser		Vessels Heading (°)	
	Current	Wind	Wave	m	% WD	Tons	% MBL	Tons	% MBL	FPSO	Tender
1y-3 basic case	180	180	180	4.5	6	498	31.4	311	43.6	0.0	0.0
	202.5	180	180	4.8	6.4	525.4	33.1	306.1	42.9	3.5	4.4
	180	202.5	180	5.2	7	560.6	35.3	**689**	96.6	16.1	12.6
	202.5	202.5	180	**6.1**	8.1	**656.2**	41.4	650.9	91.2	**18.0**	**16.4**
	202.5	157.5	180	5	6.7	555	35	314.4	44.1	-11.0	-10.3

Table 7-6: Fully Loaded FPSO in tandem with ballasted tender - Most severe 1y intact case sensitivities on directions

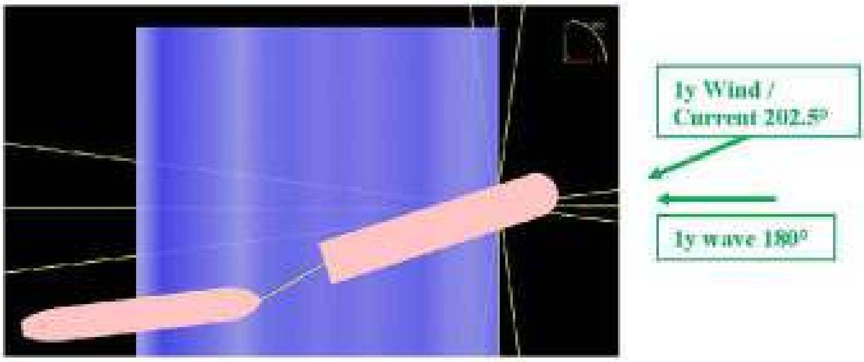
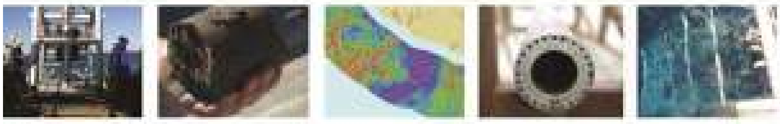


Figure 7-4: Illustration of above case with current and wind at 202.5° - Wave at 180°



7.2.3 Main results

Here after are presented the results from the mooring analysis performed on the Fully Loaded FPSO considered in tandem with a ballast tender:

Tender connected mooring analysis results (MAX)						FPSO offset		ML Tension		Hawser Tension	
Case	Mooring configuration	Current RP	Wind RP	Wave RP	Wave period	m	% WD	Tons	% MBL	Tons	% MBL
Tender-1	In-line	10	1	1	Nominal - 20%	3.8	5.1	437.1	27.6	287.1	40.2
Tender-2					Nominal	4.4	5.9	490.6	30.9	288.1	40.4
Tender-3					Nominal +20%	4.5	6.0	505.9	31.9	310.2	43.5
Tender-4		1	10	1	Nominal - 20%	4.5	6.1	503.7	31.8	352.7	49.4
Tender-5					Nominal	4.7	6.2	517.3	32.6	335.2	47.0
Tender-6					Nominal +20%	5.3	7.0	576.0	36.3	391.3	54.8
Tender-7		1	1	10	Nominal - 20%	6.5	8.6	700.9	44.2	424.3	59.5
Tender-8					Nominal	5.9	7.9	645.2	40.7	392.0	54.9
Tender-9					Nominal +20%	6.1	8.1	663.8	41.9	375.3	52.6
Tender-10	In-between	10	1	1	Nominal - 20%	3.9	5.2	381.9	24.1	277.0	38.8
Tender-11					Nominal	4.7	6.2	430.4	27.1	294.8	41.3
Tender-12					Nominal +20%	4.8	6.3	435.1	27.4	308.5	43.2
Tender-13		1	10	1	Nominal - 20%	4.7	6.2	431.7	27.2	336.7	47.2
Tender-14					Nominal	5.1	6.7	457.5	28.8	344.0	48.2
Tender-15					Nominal +20%	5.5	7.3	485.2	30.6	386.3	54.1
Tender-16		1	1	10	Nominal - 20%	6.8	9.1	589.1	37.1	433.2	60.7
Tender-17					Nominal	6.1	8.2	532.3	33.6	382.3	53.6
Tender-18					Nominal +20%	6.5	8.6	567.4	35.8	382.7	53.6
Tender-19 - "Tender-7" with ML-1 broken (2nd most loaded)						9.1	12.1	1019.2	64.3	387.8	54.3
Tender-20 - "Tender-16" with ML-1 broken (most loaded)						8.7	11.6	829.4	52.3	385.0	54.0
Tender-19 - With 15° bundle separation and 792m radius						9.4	12.5	811.4	51.2	375.9	52.7

Table 7-7: Fully Loaded FPSO in tandem with ballasted tender mooring analysis results

The condition leading to extreme results is the one governed by the wave:

- When the mooring is "in-line" with the wave direction, the tension is maximum (one line is facing environment), and is just below 45% of the chain corroded/second-hand MBL.
- When the mooring is "in-between" the wave direction, the offset is maximum (no line facing environment) and reaches 7m which is about 9% of the water depth and is deems to be acceptable.

When damaged mooring is considered, the offset increases up to 9m and the tension reaches about 65% of the corroded/second-hand chain MBL.

Finally on this worst damaged case and with a 15° angle between lines and a 792m reduced anchor radius, the maximum damaged tension reduces to 51 % of the considered breaking load for the environmental conditions.

The tensions in the hawser remains acceptable for the operational metocean conditions considered.

8 APPENDICES

8.1 APPENDIX 1 - GENERAL METHODOLOGY FOR ANALYSIS IN DIODORE^{TM}

Diodore^{TM} analysis needs first mesh of the vessel(s) to be entered.

Note: When different floaters are simultaneously given, Diodore^{TM} will automatically compute there reciprocal influence on the main wave flow, as it is solved everywhere in the model. Special user attention should then be focused on possible current and wind influence, to be considered through modified polars.

The mesh is based on nodes, linked by triangles and/or quadrangles elements. Mesh can be imposed directly at a given position, or an equilibrium can be requested if the floater mass and its location are given. In a first section, so-called "pre-processor", the mesh is read, and the volume and its associated point of application (Centre of Buoyancy, CoB) are output. If equilibrium is requested, Diodore^{TM} will automatically search the right volume and associated position to equilibrate the imposed mass. For particular problem, the stability analysis can be performed, and beam loads (bending and shear) can be asked for.

Once this first part is frozen, the second part of the Diodore^{TM} job is the so-called "hydrodynamic processor".

Note: The above hydrodynamic resolution of the problem is generally the longer part of the simulation. This part of the calculations needs the first equilibrium position of the vessel to be frozen, as any change would lead to different results.

The hydrodynamic simulation can account for different assumptions, such as floater forward speed, tanks/floater coupled analysis, detailed QTF formulation for drift forces, limited water depth influence… Each time, the main input for this calculations are a number of wave periods and headings. Given periods and headings should then be sufficient to cover all the environments to be further studied in the analysis. Diodore^{TM} then generates individual airy waves, with 1m height, for the different asked periods and headings, for the diffraction part of the efforts. Radiation of the floater at the different periods is also considered with unitary FPSO motions.

Finally, the last part of Diodore^{TM} calculations before output can be asked, is the so-called "mechanical processor". Here the mass and inertia are imposed at the correct floater location (Centre of Gravity, CoG), the different dampings on the floater are considered (possibilities for linear or quadratic damping, acting at wave and/or frequency motions…), and the polars for wind and current loads on the floater are detailed. Mechanical connections are also modelled here, with anchors with soil and/or connections between vessels (including fenders). The different environments (wave, wind, current) are also described here, and additional forces can be input (such as thruster or dynamic positioning concerns). Frequency domain and time domain analysis can be conducted, the method for drift forces assessment can be chosen.

8.2 APPENDIX 2 - DIODORE SOFTWARE DESCRIPTION

Hydrostatic analysis

- Intact or damaged stability
- Handle closed, open, or damaged tank
- Trim or Heel stability
- Wind heeling moment computed with OCIMF or USER coefficient

1st order Radiation Diffraction model

- Without forward speed, in finite or infinite depth
- With forward speed, in finite or infinite depth (several formulations)
- 2nd order 3D low frequency diffraction: full QTF with Hydrostar (Bureau Veritas)
- Multi structures and sub-structures handling
- Pressure, velocity, wave elevation in the fluid domain or on the mesh
- Tank analysis : eigen period – added mass – coupling with ship motion
- Wave resistance (Neumann-Kelvin formulation)
- Infinite domain

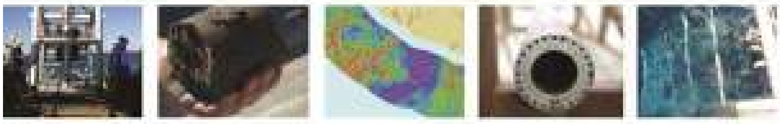
Potential calculation by integral method with Kelvin sources calculated thanks to Green functions. Influence coefficient matrix is solved with a Gauss algorithm

Linear mechanic (wave frequency domain, multi-structures)

- Motions, loads and pressures transfert functions (RAO)
- Quadratic and linear added damping, mass, stiffness
- Automatic linearisation of complex mooring system (lines, fenders…)
- Natural periods, critical damping,
- Drift loads
- Post-treated through spectral analysis
- Slamming occurences
- Deck wetting/ Green water occurences

Non linear time domain simulation

- Complex mooring modelisation: spring, chain, tether, fender
- Wind and current load defined with or USER coefficients
- Thruster loads (and soon DP model including *capability plots*)
- Foil and rudder with or without PID pilot
- Non linear hydrostatic loads
- Modification of the initial position (mean offset…)
- Damping with a large set of formulation (WF and LF global, on a bar element, on keel with Faltinsen formula…)
- Memory effects



8.3 APPENDIX 3 - DRAG ON MOORINGS CHECK

1- For one mooring line and as detailed in section 3.2.4.2, the reported load on the FPSO current polar, and due to a 1m/s surface current, would be 0.43 Tons.

2- A DeepLines model of this line is done. The line Cd is 1.2 and it is acting on the doubled chain diameter. Both current in the mooring plane (In-Line) or transverse to the mooring are tested. For a transverse current, lateral friction is also introduced.

3- For a 1m/s surface speed, all extreme currents are leading to a 0.9m/s current at mid depth (-37.5m) and 0.7m/s at soil (-75m). The mooring is from -26m to soil, and will see a current from 1m/s at top to 0.7m/s on soil. In DeepLines, both constant current of 1m/s and the above profile are tested.

4- The most realistic approach in DeepLines to compare to the initial load calculated is to consider the decreasing profile. As 12 lines are present, we can consider that 6 will see In-Line current and 6 transverse current. So for comparison, the concerned individual line have to combine both current directions. For the transverse direction, the intermediate lateral soil friction case is considered. Finally the load found is 0.39 Tons, and the proposed 0.43 Tons force is just a little conservative.

DeepLines calculations with 1 Mooring line - Current	Constant = 1m/s	From 1m/s to 0.7m/s
In Line Current	0.25	0.23
Transverse current – No Soil Friction	6.90	3.70
Transverse current – Lateral Soil Friction = 0.1	0.77	0.55
Transverse current – Lateral Soil Friction = 0.2	0.72	0.53
Used assumption	0.43	N/A
DeepLines mean result = (In Line + Transverse_0.1) / 2	0.51	0.39

Table 8-1: Drag on mooring assessment (Mooring Line was with 15° departure angle, 770m radius, 22.4 Tons top tension)

8.4 APPENDIX 4 - CD ON FPSO FOR CURRENT POLARS APPROACH

Data are issued from DNV reference [6]. The following coefficient for a current facing the FPSO is chosen. As L/D=5.5, a Cd=0.65 is considered.

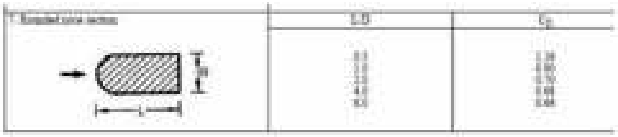


Figure 8-1: Reference for FPSO Cd when facing current

19.24 SGT-500 Gas Turbine Brochure

Siemens Gas Turbines (SGT)

SGT-500 Industrial Gas Turbine

Power Generation: (ISO) 17 MW(e) / Mechanical Drive: (ISO) 23,290 bhp (17.40MW)

The Siemens SGT-500 industrial gas turbine (*formerly known as the GT 35C*) is a light-weight, high-efficiency, heavy duty gas turbine in the 15MW to 20MW power range. The special design features and the fuel flexibility for lower cost fuels of the gas turbine make it suitable for economical base-load power generation.

The SGT-500 has many applications where continuous base-load power availability, ease of maintenance and fuel flexibility are important. Not only for industries, but also for utilities and for marine and offshore applications. The unit meets the exacting requirements of the oil and gas industry.

The modular, compact design of the SGT-500 facilitates easy servicing on-site, where complete modules can be swiftly exchanged.

Design particulars

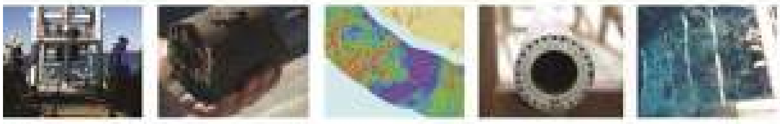
The SGT-500 has a twin-shaft compressor, one low and one high pressure compressor. The total number of compressor stages is 18. The three-stage power turbine speed is 3,600rpm for power generation and 3,450rpm for mechanical drive. Seven can-type combustion chambers are located in an annular space between the inner and outer combustion chamber casing.

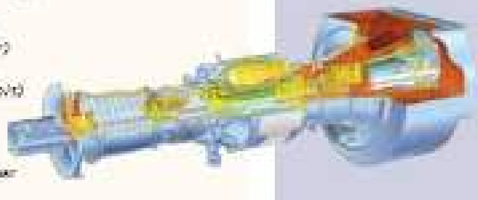
A blade tip clearance adjuster is connected between the power turbine stator and rotor in order to increase the efficiency.

All bearings are hydro-dynamic bearings of the tilting pad-type. An electrical starting motor is connected to the low pressure compressor rotor.

Power Generation

SIEMENS





Performance of SGT-500 at base load (ISO rating) on natural gas

	Power Generation Base load	Power Generation Peak load	Mechanical Drive
Output:	17.00MW(e)	18.60MW(e)	17.40MW (23,290 bhp)
Efficiency:	32.2%		32.8%
Heat rate:	11,180kJ/kW-hr (10,597 Btu/kW-hr)		10,979 [illegible] (7,760 btu/bhp-hr)
Pressure ratio:	12:1		12:1
Exhaust mass flow:	92.3kg/s (203.7 lb/s)		92.3kg/s (203.7 lb/s)
Exhaust gas temperature:	375°C (709°F)		375°C (709°F)
Turbine rotor speed:	3,600rpm		3,450rpm
Speed range:	1,500rpm / 1,800rpm		0–100%
Required gas pressure:	18.0 bar(a) ± 0.5 bar (261psi(a))		18.0bar(a) ± 0.5bar (261psi(a))

Low environmental impact

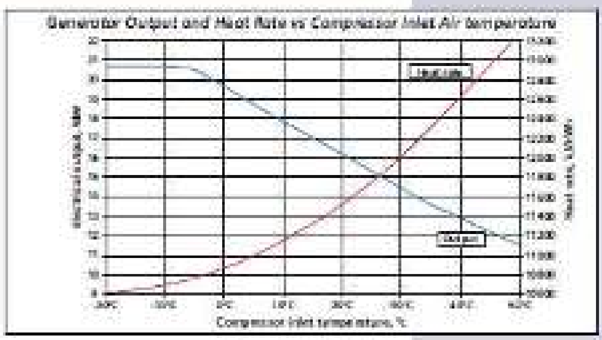
The SGT-500 runs quietly and cleanly. Roomy and well designed combustors ensure smoke-free combustion of most types of liquid or gas fuel.

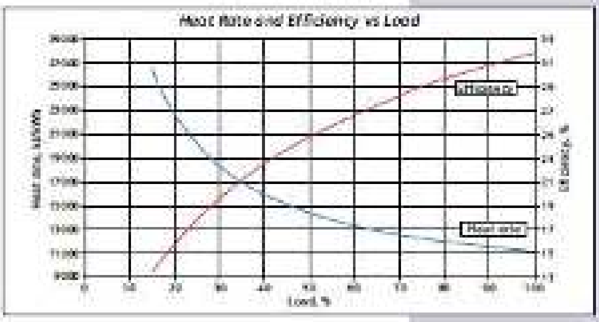
A dry low NO_x combustor system maintains emissions below 42ppmV on gas fuel. This means a NO_x level ten times lower than conventional burner techniques. Water or steam is injected into the combustor section to reduce the NO_x level when the gas turbine is running on liquid fuels. The SGT-500 satisfies stringent noise requirements and regulations for NO_x emissions.

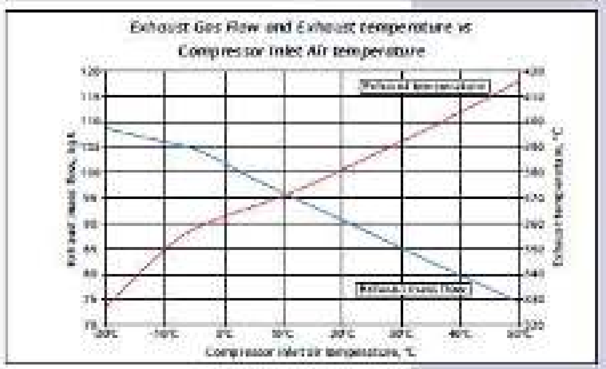
Robust SGT-500 combustor (right) compared with a common gas turbine combustor of similar type.

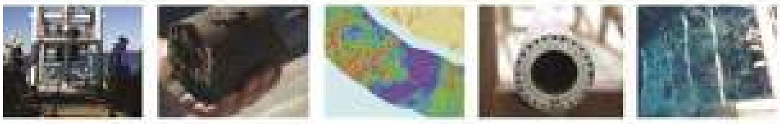
Conversion factors:

To convert	To	Multiply by
°C	°F	(°C x 9/5)+32
kg/s	lb/s	2.2046
kJ/kWh	Btu	0.949









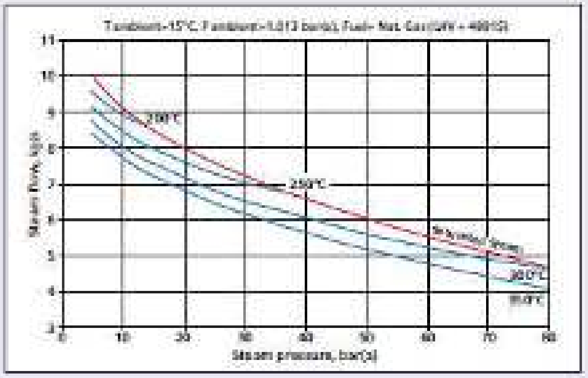
Power Generation

Nominal steam production capability in cogeneration and combined cycle

Intake losses:	*10 mbar (4" H_2O)*
Exhaust losses:	*25 mbar (10" H_2O)*
Relative humidity:	*60%*
Altitude:	*Sea level*

Conversion factors:

To convert	To	Multiply by
°C	°F	(°C x 9/5)+32
kg/s	lb/s	2.2046
kJ/kWh	Btu	0.949
bar	psi	14.5



Mechanical Drive

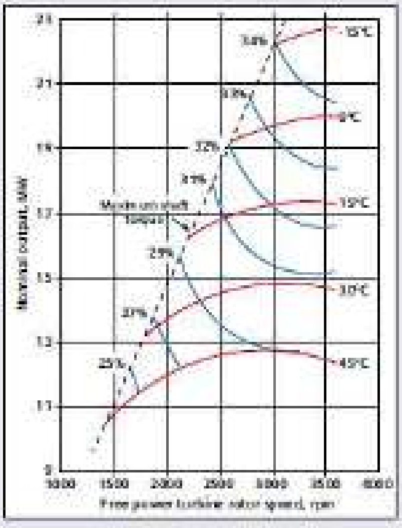
Nominal shaft power output and efficiency at various free power turbine rotor speeds

Reference conditions:

Inlet/outlet pressure drop:	*10 mbar (4" H_2O)*
Relative humidity:	*60%*
Altitude:	*Sea level*
Gaseous fuel LHV:	*46,798 kJ/kg*

Conversion factors:

To convert	To	Multiply by
°C	°F	(°C x 9/5)+32



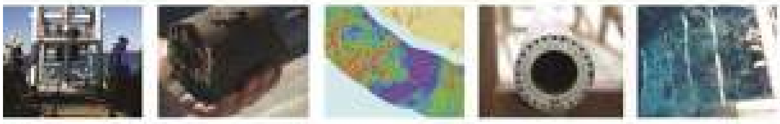
Sound emissions

Outdoor enclosure covering gas turbine and auxiliaries (roof over AC generator)

Standard: 85 dBA @ 1 m (3 ft) & 1.5 m (4.5 ft) above grade (average value)

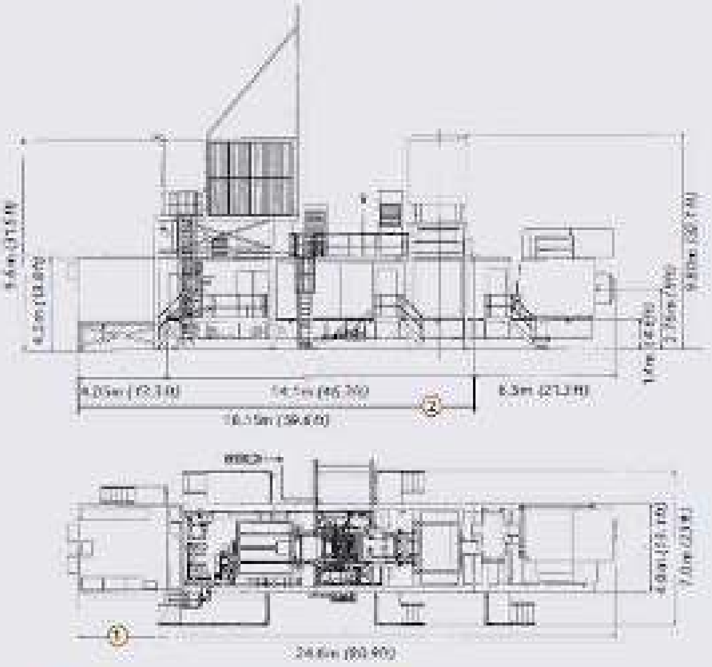
Option: 80 dBA @ 1 m (3 ft) & 1.5 m (4.5 ft) above grade (average value)

Far field
Standard: 65 dBA @ 100 m (300 ft)
Option: 55 dBA @ 100 m (300 ft)



SGT-500 Power Generation and Mechanical Drive Packages
A compact layout

The SGT-500 has the same footprint in the power generation and mechanical drive package except for the length of the generator and gearbox.



① *Total length in power generation* ② *Total length in mechanical drive*

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