SNOWDEN

Final

TNG Limited: Mt Peake Scoping Study
Project No. 2017

February 2011

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1 Findings

Snowden Mining Industry Consultants has completed a Scoping Study for TNG Limited's (TNG) Mt. Peake vanadium-iron-titanium project. Metallurgical data has been provided for use in the study by Mineral Engineering Technical Services (METS). This data has included recoveries, operating and capital costs associated with a conceptual 2 Mtpa and 5 Mtpa capacity hydrometallurgical plant producing a calcined V_2O_5-TiO_2-Fe_2O_3 concentrate.

Given the nature of the Inferred Resource model and financial analysis, Snowden assign a level of accuracy of +/-50% to this study. Any reference to "ore" is as a generic term and implies no economic significance as defined in the Australasian Code for the Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2004 edition (the JORC Code).

Optimisation

Snowden has conducted resource optimisations on an Inferred Resource Model, estimated by Snowden in 2010. These optimisations have examined 2.5 Mtpa and 5 Mtpa processing throughput scenarios, using mining and concentrate transport operating costs estimated by Snowden and process operating costs estimated by METS. METS has advised a mass concentrate yield for the plant feed of 36% of the material processed reporting to concentrate.

Projected product prices have been advised by METS and TNG Limited for a calcined concentrate.

Table 1.1 Summary product prices

Product	Units	Value
V_2O_5	$USD/lb	8.00
Fe_20_3	$USD/mt	200.00
TiO_2	$USD/mt	155.60

The result of this exercise is a mining inventory of some 176 Mt for both cases (refer Table 1.2). The identical size of the mining inventory is partially controlled by the common operational costs associated with both cases and partially controlled by the limits of the current Inferred Resource Model.

Table 1.2 Summary mining inventory

Scenario	Total	Waste	Inventory	V_2O_5	TIO_2	FE	Mine life
	Mt	Mt	Mt	%	%	%	yrs
2 Mtpa	176.4	69.4	107.1	0.33	6.04	25.39	54
5 Mtpa	176.4	69.4	107.1	0.33	6.04	25.39	21

Strategy

Capital expenditure for both plant configurations has been estimated by METS and these estimates have been incorporated into a preliminary technical cashflow model by Snowden.

The preliminary technical cashflow model results show that the NPV is significantly affected by an extended mine life for a 2 Mtpa process capacity.

To improve the NPV, a likely strategy was selected that contemplates an initial 2 Mtpa operation, followed by expansion to a 5 Mtpa operation after 5 years from project commencement. A two year pre-production period is devoted to capital construction of the plant and pre-strip of the mineralisation.

Technical cashflow model

The preliminary technical cashflow model does not take into account cost or source of capital, hedging, tax, depreciation, rehabilitation and salvage, to produce a EBITDA[1] cashflow and is consistent with a Scoping Study level of examination.

Using a mine production and process schedule developed from the strategy outlined above, the project produces an indicative NPV of AUD$904.6 M and an indicative IRR of 42% over a 26 year project life, from commencement of construction.

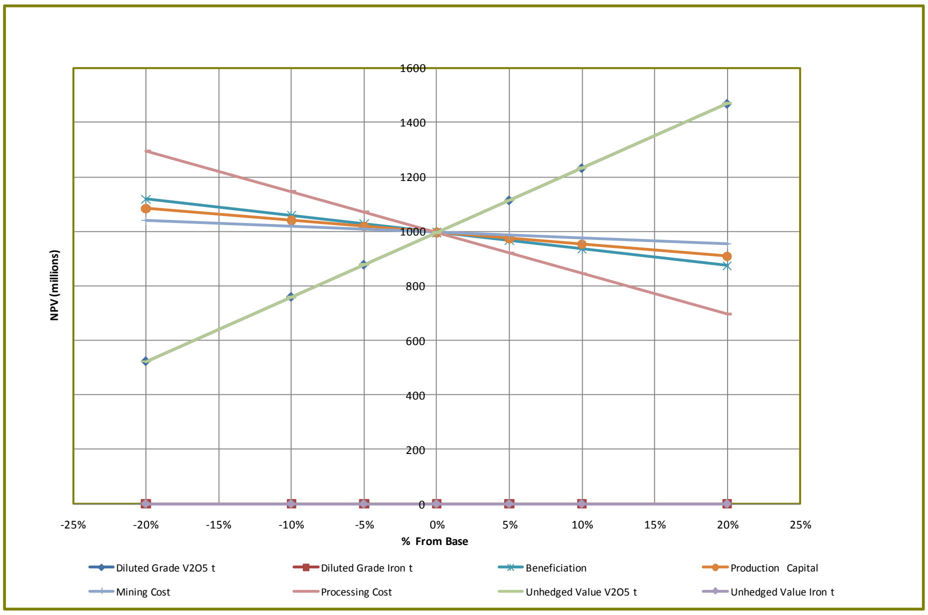
Table 1.3 Preliminary technical cashflow model summary

Measure	Units	Value
Discount rate	%	10
IRR	%	42
NPV	AUD$ M	904.6
CASH	AUD$ M	3,506
Prestrip CAPEX	AUD$ M	17.1
2 Mtpa CAPEX	AUD$ M	370.3
Expansion CAPEX	AUD$ M	307.6
Conceptual mine life	Years	23.63

Sensitivity

The project is sensitive to product grade and prices, particularly V_2O_5 (refer Figure 1.1).

Figure 1.1 Summary preliminary sensitivity analysis



[1] *Earnings Before Interest, Tax, Depreciation and Amortisation*

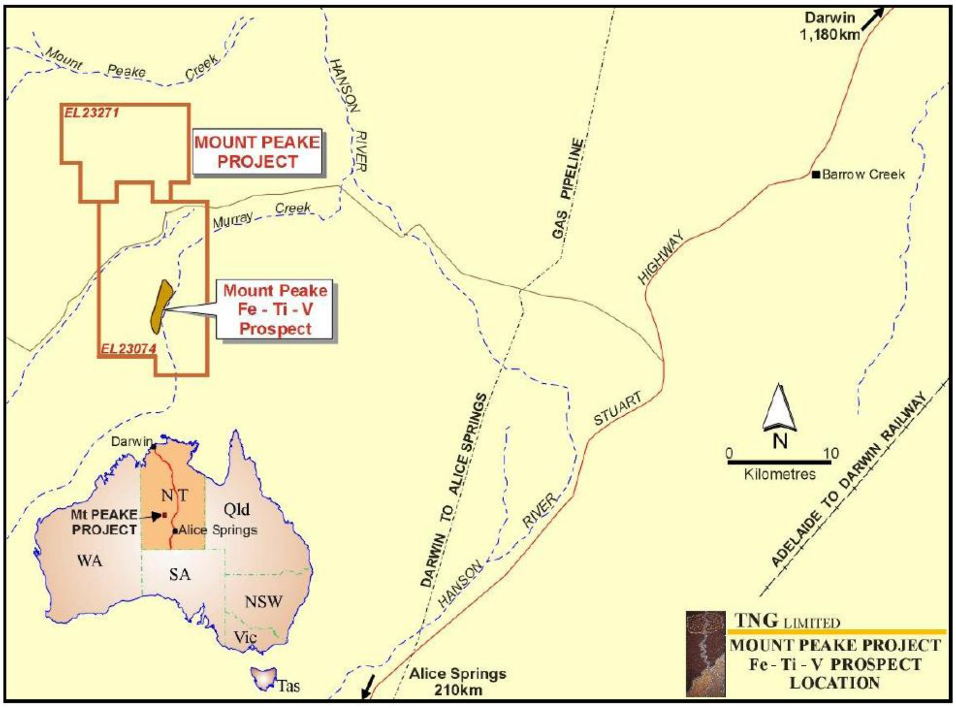
2 Introduction

TNG Limited (TNG) has requested that Snowden Mining Industry Consultants (Snowden) complete optimisations and a preliminary mine design and technical cashflow model for the Mt Peake V-Ti-Fe deposit as a Scoping Study. This exercise follows a previous optimisation[2] and a re-estimation of the resource for the deposit[3] following an extensional resource drilling programme.

2.1 Location

The Mt Peake project is located approximately 280 km northwest of Alice Springs in the Northern Territory of Australia and is approximately 70 km from the Adelaide to Darwin railway and 1200 km by road train from Darwin. The location of the deposit is shown in Figure 2.1.

Figure 2.1 Location map (TNG 2009a)



2.2 Scope of work

The current scope of work contemplates:

- a pit optimisation
- a conceptual design
- a preliminary technical cashflow model

[2] *Snowden Project 499, August 2009*
[3] *Snowden Project 734, May 2010*

Data from metallurgical scoping studies was supplied by Metallurgical Engineering Technical Services (METS[4]) for use in the Scoping Study. Operating costs and pit slope angles relating to mining have been estimated by Snowden to a Scoping Study level of accuracy (implied at +/-50%).

The size of the open pit and the mine life has been assessed from pit optimisations performed using Whittle software. The results of these optimisations have been used to construct a preliminary mine design and site layout and provide input data to the preliminary technical cashflow model.

All currency in this report is quoted in Australian dollars, unless otherwise noted and tonnes are quoted as dry tonnes. Any reference to "ore" is as a generic term and implies no economic significance as defined in the Australasian Code for the Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2004 edition (the JORC Code).

[4] *METS assign a +/-35% level of accuracy to capital and operating cost estimates*

3 Resource optimisation studies

3.1 Block Model preparation

The resource model used in the study was prepared by Snowden5 and populated with waste and cut to the surrounding topography. All the mineralisation within the block model has been categorised as Inferred material, using the guidelines of the JORC Code (1994). The Mineral Resource at a 0.1% V_2O_5 cut-off grade is tabulated in Table 3.1.

Table 3.1 February 2010 Mt Peake Mineral Resource at 0.1% V_2O_5 cut-off grade[5]

Category	Tonnes (Mt)	V_2O_5 %	TiO_2 %	Fe %	SiO_2 %	Al_2O_3 %
Inferred	139.07	0.29	5.34	23.66	32.50	8.18

For the optimisation studies, the oxide and fresh material were tagged inside a mineralised envelope that was generated by Snowden following magnetic susceptibility interpretation of the geology. The model was tagged with the following ore types.

- mineralised oxide
- unmineralised oxide
- mineralised fresh
- unmineralised fresh

In the resource estimation, the potential waste blocks were assigned uneconomic V_2O_5, TiO_2 and Fe grades.

Snowden mining engineers performed basic checks to confirm the validity of the Resource model before import into the optimisation software.

3.2 Optimisation inputs

Blocks in the resource model were tagged as lying within or outside the mineralised zone, restricting the optimisation to selection of material from the interpreted mineralised zone only. This material attracts a greater geological confidence regarding tonnes and grade, based on geological interpretation of the magnetic susceptibility envelope. The mineralised material is associated with iron oxide, which demonstrates a significantly greater susceptibility to the effect of magnetism than the unmineralised waste rock.

3.2.1 Metallurgical parameters

Snowden has not provided metallurgical input to the Scoping Study and has relied upon advice from TNG's metallurgical consultant, METS.

Studies by METS have been undertaken in parallel with the current optimisation, as part of the overall Scoping Study. The following summarises Snowden's understanding of the process and relevant costs, as applied to the optimisation and technical cashflow model.

[5] *Snowden Project 734, TNG Limited: Mt Peake Fe-V-Ti Project, Resource Model Update, February 2010*

Products

The current METS metallurgical work is a reassessment of the work completed by METS for the 2009 Scoping Study and contemplates a 2 Mtpa plant designed to produce a calcined vanadium pentoxide (V_2O_5)- titanium dioxide (TiO_2)-iron oxide (Fe_2O_3) concentrate. This concentrate is to be trucked to a conceptual railhead near Barrow Creek on the Alice Springs to Darwin railway line (approximately70km) and then railed to Darwin (approximately 1,180km) for shipping.

Throughput

Initial optimisation work by Snowden quickly indicated that the Net Present Value of the project is dependent on the processing rate. Consequently, METS was asked to provide a preliminary capital and operating cost estimate for a 5 Mtpa plant, as well as the 2 Mtpa plant contemplated by the current Scoping Study.

The application of Taylor's Rule[6] indicates that the optimal size of plant is around 5.3 Mtpa. For the purposes of this Study, Snowden has assumed a maximum plant capacity of 5 Mtpa.

The loader at the port of Darwin is reportedly[7] currently limited to a 2 Mtpa capacity. Given the estimated preliminary metallurgical mass pull of around 36% the Mt. Peake plant size is therefore limited to around 5 Mtpa. A greater throughput will require a significant capital expansion of the Darwin loading facility.

Process Recoveries

The proposed primary process contemplates, for the recovery of all minerals, of coarse cobbing of the ROM ore, followed by crushing and grinding and magnetic separation.

The second stage is proposed to be a hydrometallurgical process to recover TiO_2 and V_2O_5 as a calcined concentrate.

Process recovery factors, as applied to the optimisations and technical cashflow model, are listed in Table 3.2.

Snowden has been advised by METS that the calcined concentrate will attract a negligible moisture content and Snowden has not applied a moisture content to subsequent calculations relating to the concentrate.

Table 3.2 Metallurgical recoveries[8]

Parameter	Overall Recovery
Mass yield	36.0%
V_2O_5	82.3%
Fe_2O_3	58.2%
TiO_2	85.4%

Process operating costs

Process operating costs have been advised by METS (refer Table 3.3) and incorporated into the optimisations. Operating costs have been estimated at being essentially the same for both the 2.5 Mtpa and 5 Mtpa cases.

[6] *Taylor's Rule is a generally used empirical formula for estimating optimum plant throughput. Refer: Taylor, H.K., 1986, Rates of working mines; a simple rule of thumb: Transactions of the Institution of Mining and Metallurgy, v. 95, section A, p. 203-204.*
[7] *METS/TNG advice*
[8] *As advised by METS, 2010*

In each case, METS advise that a ± 35% level of accuracy applies to the operating cost estimates.

Table 3.3 Estimate of process cost[8]

Parameter	Value
Labour	$5.97
Power	$7.81
Consumables	$1.05
Maintenance	$3.68
Reagent	$24.99
Contingency	$2.19
Grade control	$0.20
Total plant cost	**$45.89**

Concentrate transport costs

Concentrate transport costs have been estimated on the basis of truck transport of calcined plant product to a railhead on the Adelaide/Darwin railway at Barrow Creek, a distance of approximately 70km. From Barrow Creek, the product is railed to Darwin.

Costs for the roadtrain leg have been estimated at $0.13/tkm (tonne kilometre), based on similar contracts elsewhere. Costs for the rail leg have been estimated at $0.03/tkm, based on current rail freight costs for mines railing concentrate from Mt. Isa to Townsville.

Costs relating to port handling and shipping were advised in the 2009 Study as being $2.77/wt and $5.54/wt[9] and these figures have been retained.

For the purposes of the optimisation, these figures have been modified by application of the estimated plant yield of 36% to produce a transport figure of $19.03/t plant feed (as summarised in Table 3.4).

Table 3.4 Concentrate transport costs

Transport	Cents/tkm	Distance km	$/t
Rail	3.0	1180	35.4
Roadtrain	13	70	9.10
Port handling			2.77
Shipping			5.54
Plant yield			36%
Total per tonne plant feed			**19.03**

Administration costs

Total administration costs (mine and plant) have been added to the overall processing cost per tonne plant feed in the optimisation.

METS has estimated plant administration costs as $0.88/t plant feed for the 2 Mtpa plant option and $0.88t/t plant feed for the 5 Mtpa option. A figure of $0.88/t plant feed has been applied to the optimisation and technical cashflow model.

[9] *As advised by TNG, 2009*

Mine administration costs have been estimated by Snowden at $1.00/t plant feed for all cases, covering the cost of a geology/survey department and engineering and mine management department at an annual cost of around $1.00 M each.

3.2.2 Mining parameters

The nature and location of the deposit indicates that the orebody should be mined using conventional drill and blast with truck and shovel open pit mining methods. Preliminary optimisations clearly indicate that the mining strategy should be to commence mining with a "starter pit" to access higher grade, low stripping-ratio ore to feed the initial 2 Mtpa plant. This pit is then expanded after a nominal period of three years to feed the expanded 5 Mtpa operation.

This scenario contemplates a two-year pre-production period, during which the plant is constructed and overburden pre-stripped, with this cost capitalised.

The indicative strip ratio is less than one (around 0.65), which is consistent with a large open pit low-grade deposit.

Mining cost

Snowden has assumed that the project will, at least initially, operate as a contract mining operation. Further study is required to assess the economics of owner-operator mining. Open pit mining costs have been estimated by Snowden from figures related to an operating Northern Territory iron ore mine, utilising an hourly-hire mining contract.

Snowden estimate a base mining cost of $2.34/t mined for ore and waste at the surface, with an additional $0.05 for each successive 10m bench. The average mining cost for the deposit is estimated to be $2.60.

METS has applied a grade control cost to the process operating cost for plant feed.

These costs have been applied to both the 2 Mtpa and 5 Mtpa phases of the operation.

Wall angles

Overall wall angles were not calculated due to a lack of geotechnical testwork on the existing core.

Snowden understand that the structure of the fresh rockmass is not well understood. However, the limited data does not reveal a structural anomalies of faulting, voids and weak materials that requires the implementation of shallow overall wall angles.

On this basis, an average wall angle of 45 degrees was applied in the optimisation. The model block size was not conducive to the nominated wall angles so the model was reblocked for the optimisation.

3.2.3 Financial aspects

The following factors were applied to both the optimisations and the technical cashflow model.

Product prices

Snowden does not advise on metal prices and has relied on advice from METS for projected product pricing (Table 3.5). Snowden notes that no modification has been made for the nature of any concentrate and that the Fe_20_3 price incorporates a factor for sale of at least part of the product as pigment.

Table 3.5 Summary projected product prices

Product	Units	Value
V_2O_5	$USD/lb	8.00
Fe_20_3	$USD/mt	200.00
TiO_2	$USD/mt	155.60

Royalty

No definitive Northern Territory Government royalty has been agreed upon for this exercise and TNG has agreed that a royalty allowance of 2.5%/t plant feed be applied to all exercises.

Exchange rate

TNG has agreed to the use of an exchange rate of 0.85US$ = 1$AUD.

Discount rate

TNG has agreed to the use of a discount rate of 10%.

4 Optimisation results

Snowden has considered three cases for optimisation, collecting revenue from a calcined V_2O_5 -TiO_2-Fe_2O_3 -concentrate:

- 2 Mtpa plant throughput
- 5 Mtpa plant throughput

The results of the optimisations are based on an Inferred Mineral Resource.

4.1 Optimisation scenarios

Preliminary optimisations indicated that the mine life for the 2 Mtpa case is excessive, with the cashflow significantly eroded by the discount rate. This provided the case for an expansion to 5 Mtpa, as incorporated in the technical cashflow model.

In each case, mining and processing costs were uniform, resulting in identical mining inventories, but significant differences in NPV.

The results of the optimisations are presented in Table 4.1.

Table 4.1 Optimisation results, exclusive of capital

Scenario	Total	Waste	Inventory	V2O5	TIO2	FE	Mine life	NPV[10] Discounted
	Mt	Mt	Mt	%	%	%	yrs	$ M
2 Mtpa	176.4	69.4	107.1	0.33	6.04	25.39	54	1,273.5
5 Mtpa	176.4	69.4	107.1	0.33	6.04	25.39	21	2,347.3

4.2 Final optimisation

The result of the 5 Mtpa optimisation was chosen for the purposes of the technical cashflow model and indicative pit design and scheduling. Note that the mining inventory remains the same in both cases, due to the uniform operating costs relating to mining and processing and the limitations of the Inferred Resource model.

Capital, interest, tax, royalties and depreciation have not been considered in this optimisation. Similarly, the strategy of a staged approach to the operation, with a plant expansion from 2 Mtpa to 5 Mtpa after three years' operation, has not been considered within the optimisation. Capital and an estimate of royalties have been incorporated in the preliminary technical cashflow model and can be included and developed in future optimisations, as the Mt. Peake development strategy and costs are further assessed.

The result of this optimisation is summarised in Table 4.2.

[10] *Exclusive of capital*

Table 4.2 5 Mtpa process scenario optimisation results

Optimisation output	Units	value
Mine Life	years	21.4
Total tonnes	Mt	176.4
Waste tonnes	Mt	69.4
Processed tonnes	Mt	107.1
Processed tonnes fresh	Mt	96.1
Processed tonnes transition	Mt	5.5
Processed tonnes oxide	Mt	5.5
V2O5 grade to process	%	0.33
V2O5 grade fresh	%	0.33
V2O5 grade transition	%	0.29
V2O5 grade oxide	%	0.29
TiO2 grade to process	%	6.04
TiO2 grade fresh	%	6.06
TiO2 grade transition	%	5.73
TiO2 grade oxide	%	5.87
FE grade to process	%	25.39
FE grade fresh	%	25.87
FE grade transition	%	21.16
FE grade oxide	%	21.23
V2O5 tonnes output	kt	349.0
V2O5 tonnes fresh	kt	317.0
V2O5 tonnes transition	kt	16.1
V2O5 tonnes oxide	kt	15.9
TiO2 tonnes output	kt	6,463.6
TiO2 tonnes fresh	kt	5,826.0
TiO2 tonnes transition	kt	315.9
TiO2 tonnes oxide	kt	321.7
FE tonnes output	kt	27,182.0
FE tonnes fresh	kt	24,851.9
FE tonnes transition	kt	1,166.6
FE tonnes oxide	kt	1,163.6
Strip Ratio Wt:Ot	t/t	0.65
Mining cost	$M	466.1
Average mining unit cost	$/t	2.64
Process cost	$M	7,150.2
Average process cost	$/t	66.8
Income total	$M	12,142.3
Income V2O5	$M	7,528.2
Income TiO2	$M	984.9
Income Fe	$M	3,629.3
Undiscounted cashflow	$M	4,526.0
Discounted best cashflow	$M	2,347.3
Discounted worst cashflow	$M	1,854.1

The *discounted best case* cashflow is a function of the optimisation algorithm that represents shell by shell mining. Similarly, the *discounted worst case* cashflow represents bench by bench mining. Neither case is entirely practical in reality. The discounted 75% cashflow recognises that staged pit designs will usually result in a discounted cash flow between the best and worst cases and seeks to approximate this situation.

For the purposes of the Scoping Study and degree of accuracy implied, the pit shell that corresponds to the optimal *Best Case* has been used for the technical cashflow model and subsequent pit design and scheduling. This is justified by the behaviour and limitations of the geological model under the optimisation conditions.

A graphical representation of the optimisation results is provided in Figure 4.1 and a picture of the optimal pit shell (Shell 28) is provided in Figure 4.2. A sectional view of the geological block model has been overlaid inside the shell in Figure 4.2.

Figure 4.1 5 Mtpa optimisation

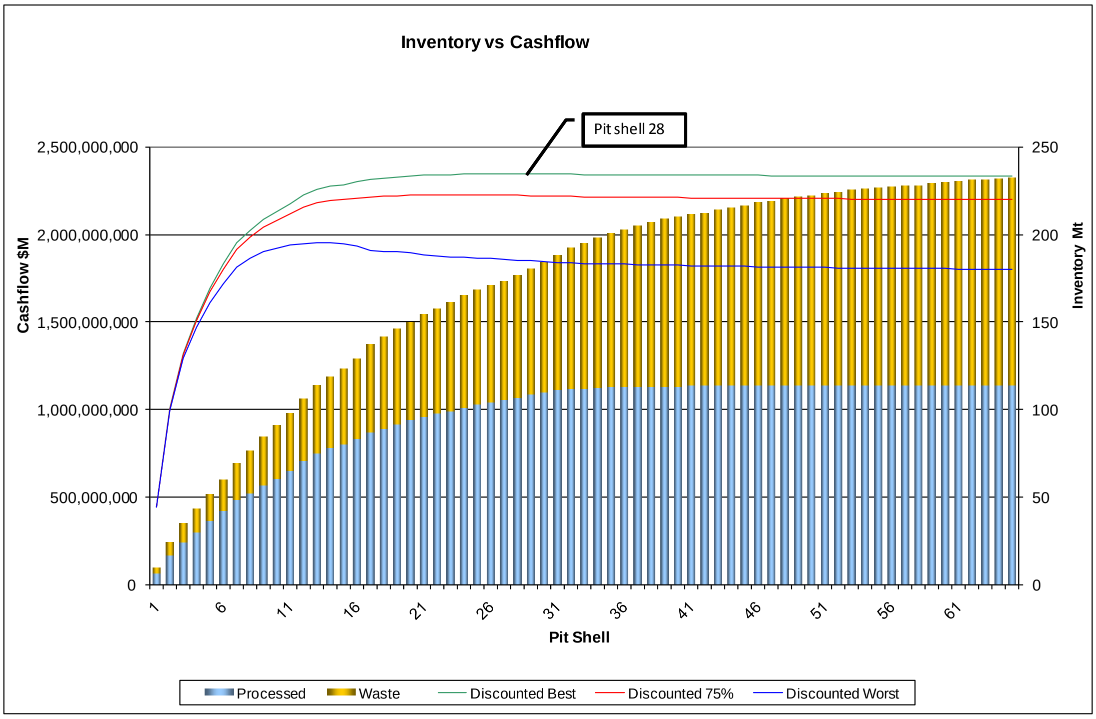
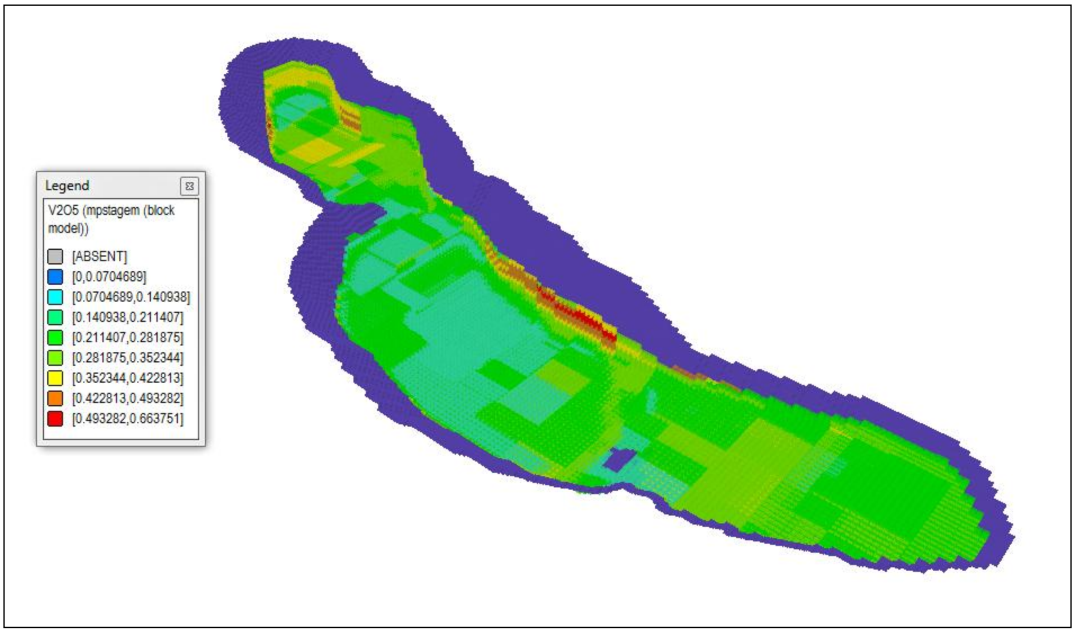


Figure 4.2 Pit shell 28



Cut-off grade

The optimisation algorithm applies an economic cut-off grade to each ore parcel it encounters to determine if the parcel is profitable to process or should be directed to a waste dump. In practise, the cut-off grade for V_2O_5 is calculated on a block by block basis using Equation 4.1.

Equation 4.1 Cut-off grade calculation

$$COG\% = \frac{P_{cost}}{(P_{rev} - R_{roy}) * \mathrm{Re}\,c}$$

Where:

COG% = V_2O_5 % cut-off grade

P_{cost} = processing cost ($/t ore)

P_{rev} = V_2O_5 price per ten kilograms ($/10kg)

R_{roy} = Ore royalty/refinery cost per ten kilograms ($/10kg)

Rec = V_2O_5 metallurgical recovery (%)

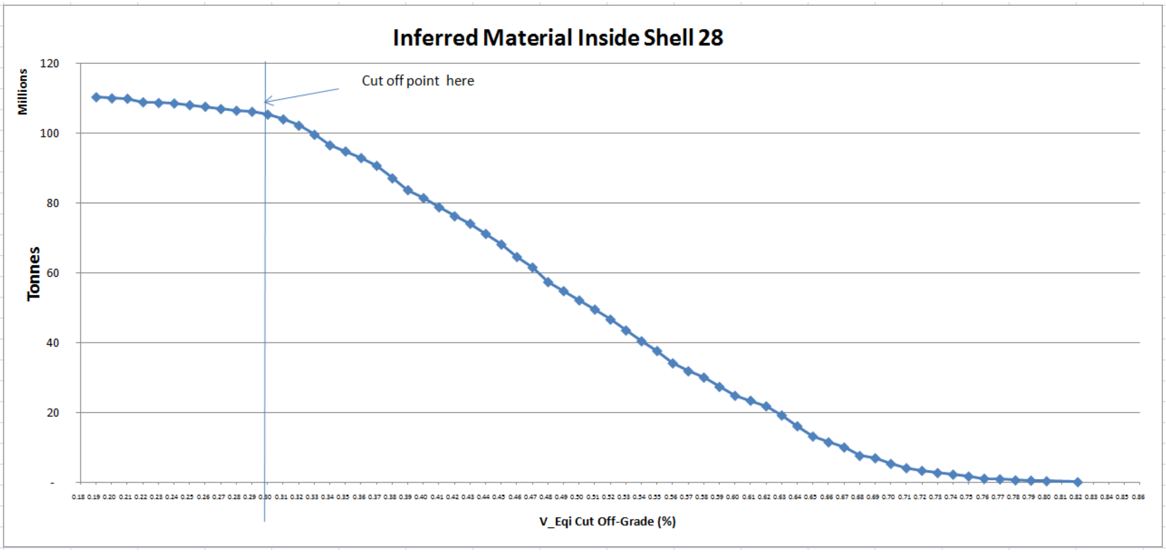
A preliminary and simplistic V_2O_5 equivalent cut-off grade has been calculated for all products. This cut-off grade is indicative only and requires further refinement as recoveries and prices for each product become apparent.

Equation 4.2 Preliminary equivalent cut-off grade calculation

Veq = V_2O_5 + 0.0091 x TiO_2 + 0.0048 x Fe

The grade-tonnage curve (refer Figure 4.3) indicates that the vanadium equivalent cut-off grade is 0.30% V_2O_5.

Figure 4.3 V_2O_5 grade/tonnage curve



5 Conceptual mine design

A conceptual pit has been designed around the 5 Mtpa optimisation pit shell to provide waste and plant feed volumes for the preliminary technical cashflow model. This design contemplates two phases, as indicated by the performance of the project as a whole in the optimisations and the technical cashflow model.

The first phase contemplates the pre-stripping of waste in a two-year mine pre-production period before progressing to exploit shallow, high-grade material to feed the initial 2 Mtpa plant for three years. The second phase expands the pit to its limits, as indicated by the optimisations, with volumes adjusted to feed a 5 Mtpa plant.

5.1 Pit design

Design considerations

The pit was designed with consideration for:

- an overall slope angle of 45 degrees
- confirmation of the overall mining inventory
- clarification of the mining inventory by stages

Design parameters

The parameters used for pit design are as below:

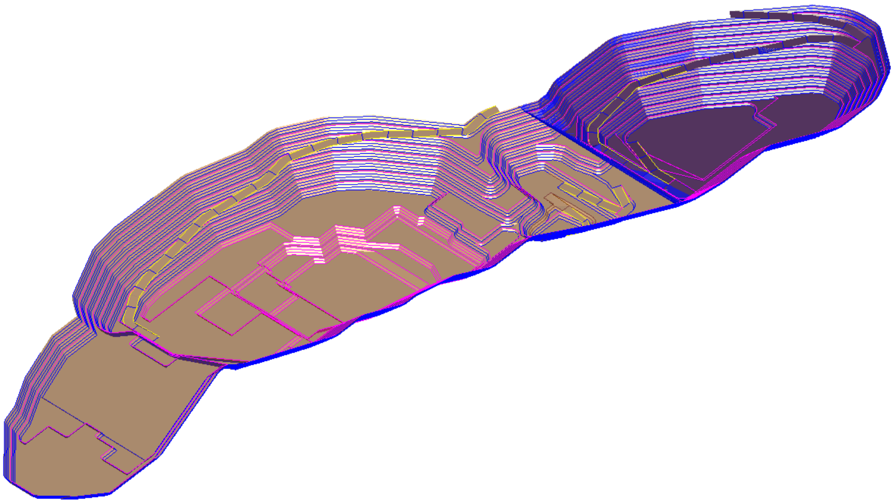
- bench height: 15m
- batter angle: 60 degrees
- ramp width (dual lane): 20m
- ramp width (single lane): 12m
- berm width: 5m
- ramp gradient: 1 in 10

Pit design

The preliminary pit design consists of two mining stages (Figure 5.3 – the initial mining phase is coloured dark purple). The first phase of mining encompasses a pre-strip of 7.3 Mt of predominantly oxide waste material in Years -2 and -1 of the operation and the subsequent production of 2 Mt of ore annually over the next three years, for around 5.3 Mt annual waste movement.

The second phase of the pit produces 5 Mt of pre annually for the remaining life of the project, at a strip ratio of 0.58. Including the pre-strip, the overall strip ratio is 0.64.

Figure 5.1 Mt. Peake conceptual pit design



5.2 Waste dump design

A conceptual waste dump design is illustrated by Figure 5.2. No allowance has been made at this stage for the encapsulation of deleterious waste or the separation of inert oxide and fresh material for dump facing. This is an exercise that will require further examination at a later stage, when enough information is available to classify the waste material.

A simplistic approach has been taken, with no scheduling or staging of the dump development. Similarly, specific costs have not been applied for dump construction or rehabilitation in the optimisation parameters or the technical cashflow model, these costs being assumed to constitute a component of the overall operating mining cost.

Design considerations

The waste dump was designed with consideration for:

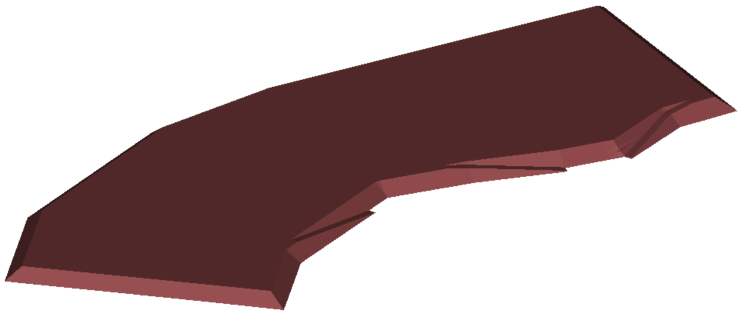
- determination of a conceptual location of a dump footprint
- determination of conceptual dump volume
- proximity of the dump in relation to the pit ramp exit

Design parameters

The parameters used for waste dump design are as below:

- batter angle: 37m
- ramp width: 20m
- ramp gradient: 1 in 10

Figure 5.2 Conceptual waste dump design

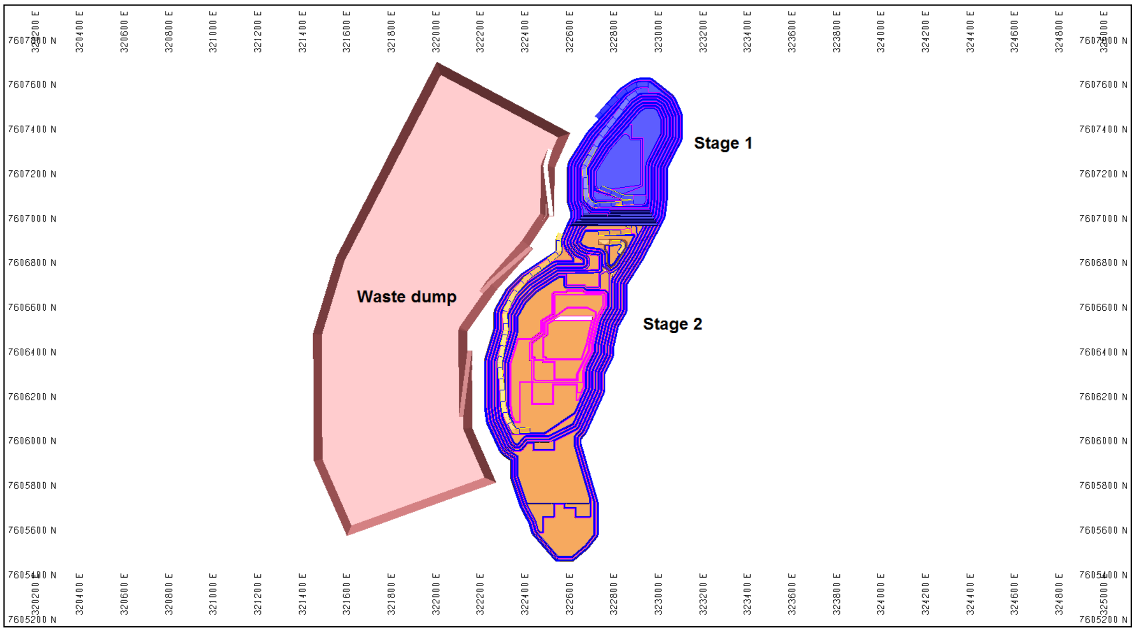


5.3 Conceptual mine layout

A simplistic mine layout has been prepared by combining the staged pit design with the conceptual dump design. This layout has been influenced by the topography of the operation and assumes that the area to the northeast of the pit provides the likely location for the plant, infrastructure and tailings storage facility.

The conceptual mine layout is illustrated in Figure 5.3.

Figure 5.3 Conceptual mine layout



5.4 Conceptual life of mine schedule

A conceptual life of mine (LOM) schedule has been prepared for inclusion in the preliminary technical cashflow model (Table 5.3). This schedule incorporates the two phases (Table 5.4) indicated by the preliminary technical cashflow model and the optimisations and is a bench schedule that indicated conceptual gross annual movements only.

Total mining inventory

A pit design will necessarily depart from the optimal pit shell for practical reasons relating to the incorporation of the pit haul ramp, pit stages and the geometry of the mineralisation. In general, the geometry of the mineralisation indicated by the geological block model allows a good correlation between the conceptual pit design and the optimal shell.

Table 5.1 compares the inventories of the conceptual pit design and the optimal shell.

Table 5.1 Comparison of pit design and optimisation inventory

ROCKT1	Model	Waste	Inventory	V_2O_5	TIO_2	FE	SIO_2	AL_2O_3
	Mt	Mt	Mt	%	%	%	%	%
Pit design	181.2	75.1	106.1	0.33	6.05	25.43	30.88	7.30
Optimal shell	176.9	69.9	107.1	0.33	6.04	25.39	30.91	7.31
Variance	2.44%	7.52%	-0.87%	0.21%	0.22%	0.14%	-0.12%	-0.14%

The total mining inventory by stages and tonnage is summarised in Table 5.2.

Table 5.2 Total mining inventory summary

	Total	Waste Quantity	Inventory	V_2O_5	TIO_2	FE	SIO2	AL_2O_3
	Mt	Mt	Mt	%	%	%	%	%
Stage 1	49.5	21.9	27.6	0.37	6.99	26.39	29.04	7.24
Stage 2	131.8	53.2	78.5	0.31	5.72	25.09	31.53	7.32
Total	**181.2**	**75.1**	**106.1**	**0.33**	**6.05**	**25.43**	**30.88**	**7.30**

Table 5.3 Conceptual mine schedule

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Total
Strip Ratio	(waste:ore)	48.95	2.94	2.62	2.58	1	1	0.88	1	0.95	1.21	0.85	0.73	0.45	0.42	0.3	0.31	0.33	0.28	0.25	0.14	0.13	0.13	0.06	0.03	0.01	**0.71**
Total Movement																											
Total Quantity	t	7.3	7.3	7.3	7.3	10.0	10.0	10.0	10.0	10.0	10.0	9.2	8.6	7.2	7.1	6.5	6.6	6.7	6.4	6.2	5.7	5.6	5.6	5.3	5.1	0.1	181.2
Total Volume	bcm	3.9	3.8	3.4	3.2	3.6	3.8	4.1	4.6	4.3	4.1	3.2	2.8	2.3	2.2	2.1	2.1	2.1	2.0	2.0	1.8	1.8	1.8	1.7	1.6	0.0	68.1
Waste Movement																											
Waste Quantity	t	7.2	5.4	5.3	5.3	5.0	5.0	4.7	5.0	4.9	5.5	4.2	3.6	2.2	2.1	1.5	1.6	1.7	1.4	1.2	0.7	0.6	0.6	0.3	0.1	0.0	75.1
Waste Volume	bcm	3.8	2.9	2.6	2.5	2.1	2.2	2.3	2.6	2.3	2.3	1.5	1.2	0.7	0.7	0.5	0.5	0.5	0.4	0.4	0.2	0.2	0.2	0.1	0.0	0.0	32.5
Ore Movement																											
Ore Quantity	t	0.1	1.9	2.0	2.0	5.0	5.0	5.3	5.0	5.1	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.1	106.1
Ore Volume	bcm	0.1	1.0	0.8	0.7	1.6	1.6	1.8	2.0	2.0	1.8	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.0	35.5
Ore Movement by Rock type																											
Ore Quantity _ Oxide	t	0.1	0.7	0.1	0.1	0.0	0.1	0.4	1.7	1.3	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
Ore Quantity _ Transitional	t	0.0	1.0	0.6	0.1	0.0	0.0	0.0	0.2	0.6	1.7	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2
Ore Quantity _ Fresh	t	0.0	0.1	1.3	1.9	4.9	4.9	4.9	3.1	3.2	2.0	4.2	4.8	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.1	95.5
Insitu Grade																											
V2O5	%	0.23	0.28	0.33	0.35	0.41	0.38	0.39	0.34	0.32	0.32	0.34	0.34	0.36	0.36	0.33	0.34	0.36	0.34	0.33	0.3	0.29	0.27	0.22	0.2	0.19	**0.33**
TIO2	%	5.27	6.12	6.9	7.17	7.86	7.21	7.12	6.33	5.94	5.94	6.4	6.47	6.82	6.71	6.09	6.21	6.51	6.08	5.78	5.32	5.07	4.7	3.98	3.67	3.45	**6.05**
FE	%	19.09	21	23.3	24.21	29.03	27.87	27.37	24.2	23.64	23.06	24.56	24.89	26.42	26.3	25.45	25.97	27.31	26.81	26.47	25.91	25.55	24.98	23.09	22.62	21.76	**25.43**
SIO2	%	39.85	35.06	30.55	29.33	26.7	28.02	27.97	30.98	31.87	32.22	31.66	31.48	29.7	29.65	29.65	29.48	29.06	30.19	30.98	31.69	32.14	32.82	34.82	35.56	36.23	**30.88**
AL2O3	%	10.04	8.52	7.39	7.08	6.19	6.97	7.07	7.81	7.92	7.46	7.58	7.66	7.41	7.41	7.45	7.33	7.02	7.1	7.15	6.68	6.77	6.98	7.6	7.92	8.78	**7.3**

Table 5.4 Conceptual mine development

Location		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25
Stage 1	Ore	0.1	1.9	2.0	2.0	4.9	4.9	4.9	3.1	2.9	0.9															
	Waste	6.1	4.4	1.9	1.6	3.0	2.3	1.2	0.5	0.6	0.2															
	Total	6.3	6.3	3.9	3.6	7.9	7.3	6.1	3.6	3.5	1.1															
Stage 2	Ore			0.0	0.1	0.0	0.1	0.4	1.9	2.2	3.7	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.1
	Waste	1.0	1.0	3.4	3.6	2.1	2.7	3.5	4.5	4.3	5.3	4.2	3.6	2.2	2.1	1.5	1.6	1.7	1.4	1.2	0.7	0.6	0.6	0.3	0.1	0.0
	Total	1.0	1.0	3.4	3.7	2.1	2.7	3.9	6.4	6.5	8.9	9.2	8.6	7.2	7.1	6.5	6.6	6.7	6.4	6.2	5.7	5.6	5.6	5.3	5.1	0.1
Total	Ore	0.1	1.9	2.0	2.0	5.0	5.0	5.3	5.0	5.1	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.1
	Waste	7.2	5.4	5.3	5.3	5.0	5.0	4.7	5.0	4.9	5.5	4.2	3.6	2.2	2.1	1.5	1.6	1.7	1.4	1.2	0.7	0.6	0.6	0.3	0.1	0.0
	Total	7.3	7.3	7.3	7.3	10.0	10.0	10.0	10.0	10.0	10.0	9.2	8.6	7.2	7.1	6.5	6.6	6.7	6.4	6.2	5.7	5.6	5.6	5.3	5.1	0.1

6 Technical cashflow model

A simple, preliminary technical cashflow model has been prepared, that does not account for cost or source of capital, hedging, tax and depreciation. Similarly, no provision has been made for salvage or mine closure costs. This is consistent with a Scoping Study level of accuracy. The model produces a raw NPV and IRR based on a 10% discount rate and has been optimised for these factors.

6.1 Preliminary capital estimate

The preliminary estimated capital cost for a 2Mtpa plant is $370.3 M (refer Table 6.1) and for a 5 Mtpa plant is $677.8 M (refer Table 6.2). For the purposes of the Scoping Study and the preliminary technical cashflow model, Snowden has contemplated an operation that initially processes 2 Mtpa, with an expansion to 5 Mtpa after three years' production. The increased capital cost associated with the 5Mtps plant has been incrementally applied to the technical cashflow model without modification.

This "expansion" approach significantly improves the NPV of the project by reducing the mine life from a figure in excess of 37 years to a more realistic 26 years and approximates the strategy that would realistically be applied to such an operation.

In all cases, METS have advised that a ± 35% order of accuracy applies to the Capex estimates.

Table 6.1 2 Mtpa plant capacity capital cost estimate[8]

Area	A$ Million
Direct cost	
Crushing	13.8
Beneficiation	2.3
Leaching and CCD	32.5
Metal extraction and purification	24.1
Vanadium precipitation, drying and packing	12.3
Acid regeneration and precipitation of iron oxide	131.2
Reagent and utilities	26.9
Direct cost sub-total	**243.0**
Indirect cost	
Field indirects	29.2
EPCM	36.4
Vendor reps	1.8
Capital spares	6.0
Commissioning spares	1.8
Insurance	3.7
Indirect cost sub-total	**79.0**
Total cost	
Contingency	48.3
Grand total	**370.3**

Table 6.2 5 Mtpa plant capacity capital cost estimate[8]

Area	A$ Million
Direct cost	
Crushing	25.2
Beneficiation	4.2
Leaching and CCD	59.4
Metal extraction and purification	44.2
Vanadium precipitation, drying and packing	22.5
Acid regeneration and precipitation of iron oxide	240.1
Reagent and utilities	49.2
Direct cost sub-total	**444.8**
Indirect cost	
Field indirects	53.4
EPCM	66.7
Vendor reps	3.3
Capital spares	11.2
Commissioning spares	3.3
Insurance	6.7
Indirect cost sub-total	**144.6**
Total cost	
Contingency	88.4
Grand total	**677.8**

6.2 Technical cashflow model strategy

The result of the 5 Mtpa optimisation has been entered into SMC *Mining Pro* mine evaluation software. For the purposes of this Scoping Study, tax, hedging, debt finance and other financial factors have been ignored and a simple NPV has been calculated, based on the application of a discount rate to cashflows and simple gross capital outlays. Operating cost estimates are the same as those used in the optimisation exercise.

For the purposes of this exercise, the mine development schedule contemplates a two-year pre-production period in which the 2 Mtpa plant is constructed and waste pre-stripped, with the cost of this exercise capitalised. Capital expenditure has been spread such that $123.4 M is spent in Year -2 and $246.8 M is spent in Year -1, the sum of which matches METS' capital estimate of $370.2 M for a 2 Mtpa plant.

The 2 Mtpa plant operates for three years, with $153.78 M being spent during each of Years 2 and 3 to expand the plant capacity to 5 Mtpa. This total of $307.566 M represents the difference between METS capital estimate for a 2 Mtpa and 5 Mtpa plant.

6.3 Preliminary technical cashflow model results

At a 10% discount rate, the preliminary technical cashflow model, using the strategy outlined in Section 6.2 above, indicates an internal rate of return (IRR) of 42%, for an NPV of $904.6 M (refer Table 6.3). The indicative mine life associated with this scenario is around 24 years from commencement of development.

Table 6.3 Preliminary technical cashflow model results

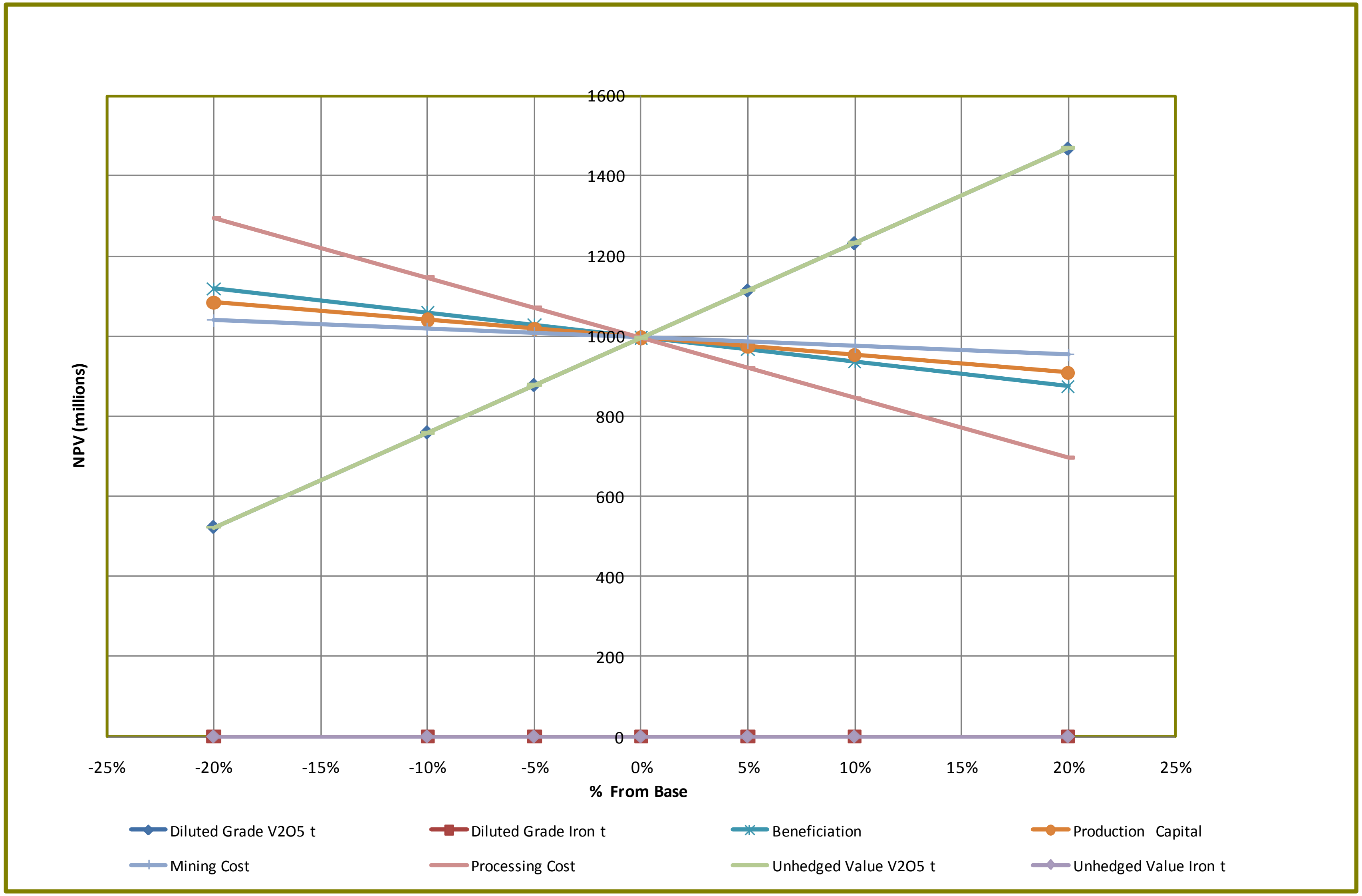
Measure	Units	Value
Discount rate	%	10
IRR	%	42
NPV	AUD$ M	904.6
CASH	AUD$ M	3,506
Prestrip CAPEX	AUD$ M	17.1
2 Mtpa CAPEX	AUD$ M	370.3
Expansion CAPEX	AUD$ M	307.6
Conceptual mine life	Years	23.63

Sensitivity

A simple sensitivity analysis was performed using the SMC software and varying input parameters by increments of 5%.

The project demonstrates greatest sensitivity to unhedged metal prices, particularly iron and vanadium (Figure 6.1).

Figure 6.1 Preliminary sensitivity analysis



7 Project risks

Snowden comments on the following risks associated with a Scoping Study level mining inventory and technical cashflow model:

- The parameters used to assess the Mt. Peake project viability have been based on limited data.
- The economic evaluation of the optimisation is preliminary and based on an Inferred Mineral Resource and preliminary economic assumptions. This presents a risk to the understanding of the grade continuity within the deposit. There is a risk that the grade variability could be high and this needs to be understood so the true tonnes and grade are reflected in the model and the likelihood of blending and any differing ore types is known. The economics of the project is sensitive to grade.
- As there has been no logging of the core for geotechnical data there may be a risk of wall instability.
- Metallurgical testwork is at a Scoping Study level and will need to be representative of the ore type that will make up most of the feed. If the testwork is not comprehensive the true recovery may not be correctly estimated. The robustness of the metallurgical recovery to changes in the grade needs to be assessed.
- The metallurgical capital and operating costs are preliminary and there is a high risk that these will change. If these costs increase significantly, this may present a risk to the project economics.
- The project has the potential to supply a significant proportion of current world vanadium requirements.
- Approvals, leases and required licences may be slow to acquire and transport of the product may be subject to stringent environmental restrictions.
- Snowden understands the price of vanadium is susceptible to market fluctuations and has demonstrated that the project operating cashflow is very susceptible to vanadium price in this study.
- The capacity of the Port of Darwin may change and affect the project economics.

8 Conclusions and recommendations

8.1 Conclusions

Optimisation

Snowden has used an Inferred Resource model to conduct Scoping Study-level optimisations on TNG Limited's Mt. Peake vanadium project. These optimisations have examined 2.5 Mtpa and 5 Mtpa processing throughput scenarios using mining and concentrate transport operating costs estimated by Snowden and process operating costs estimated by METS.

Product prices have been advised by METS and TNG Limited.

The result of this exercise is a mining inventory of some 176 Mt for both cases (refer Table 8.1). The identical size of the mining inventory is partially controlled by the common operational costs associated with both cases and partially controlled by the limits of the current Inferred Resource Model.

Being the product of an Inferred Resource and Scoping Study-level analysis, these figures in no way constitute a mining reserve under any definition.

Table 8.1 Summary mining inventory

Scenario	Total Mt	Waste Mt	Inventory Mt	V2O5 %	TIO2 %	FE %	Mine life yrs
2 Mtpa	176.4	69.4	107.1	0.33	6.04	25.39	54
5 Mtpa	176.4	69.4	107.1	0.33	6.04	25.39	21

Strategy

Capital expenditure for both plant configurations has been estimated by METS and these estimates have been incorporated into a preliminary technical cashflow model by Snowden.

The preliminary technical cashflow model indicates that a 2 Mtpa plant implies an excessive mine life, with a deleterious effect on the NPV. A likely strategy was selected that contemplates an initial 2 Mtpa operation, followed by expansion to a 5 Mtpa operation after 5 years from project commencement. A two year pre-production period is devoted to capital construction of the plant and pre-strip of the mineralisation.

Technical cashflow model

The preliminary technical cashflow model is rudimentary and does not take into account cost or source of capital, hedging, tax, depreciation, rehabilitation and salvage. Using a conceptual schedule developed from the strategy outlined above, the project produces an indicative NPV of AUD$904.6 M and an indicative IRR of 42%.

Table 8.2 Preliminary technical cashflow model summary

Measure	Units	Value
IRR	%	42
NPV	$ M	904.6

Sensitivity

The project is sensitive to product grade and prices, particularly vanadium.

8.2 Recommendations

- Preliminary modelling indicates that the economics of deposit is most sensitive to commodity prices and Snowden recommends that TNG Limited seeks advice on projected prices and demand, particularly for vanadium.
- Preliminary modelling indicates that the economics of deposit is sensitive to grade and Snowden recommend further resource drilling within the existing mineralised envelope to define high-grade sections amenable to mining early in the project to improve the early cashflow.
- Snowden recommends further infill drilling to increase the confidence in the Resource from an Inferred category to an Indicated category so that potential Ore Reserves can be assessed.
- Further process recovery testwork and confirmation of process flows should be undertaken to improve the level of accuracy from a Scoping Study level. The effectiveness of the recovery at the low cut-off grade of should be further tested, given that the optimisation results are most sensitive to grade.
- The process capital and operating cost needs to be further developed, particularly in relation to the strategy of constructing a 2 Mtpa operation and then expanding to 5 Mtpa.
- The mining cost needs to be substantiated by vendor "budget price" quotation. Snowden recommends that, given the mine life, owner/operator mining could be considered.
- The financial analysis will need to be developed to consider royalty, tax and depreciation. Indicative royalties should be sourced from the Northern Territory Government Treasury Department.
- A perfunctory sub-study was performed to investigate the effect of producing a ferrovanadium product (FeV). This exercise contemplates the three-product concentrate being produced as above and railed to Darwin, where the V_2O_5 fraction is extracted and reacted in a separate plant to produce FeV. The process will entail reaction with scrap steel and aluminium. The perfunctory study indicated considerable upside, related to a high-value product and Snowden recommends that TNG investigate this avenue further.
- The limitations of the Port of Darwin (reportedly 2 Mtpa) form a potential bottleneck to expansion and Snowden recommends that TNG investigate either current plans for expansion by the Port Authority or scope for expansion.

9 References

Snowden 2009. *Resource Model*, (unpubl. internal report, project 459 for TNG Limited).

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