Edge Protector Financial Assessment

for **Safescape Pty Ltd**

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Executive Summary

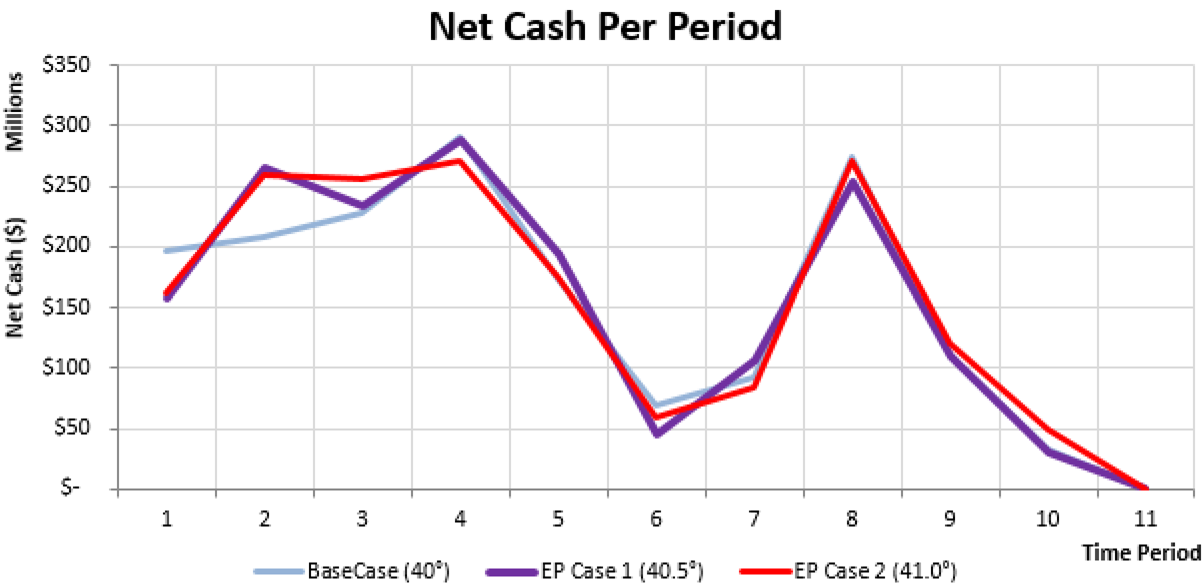
Safescape Pty Ltd has developed a product that allows open pit haul-road width to be reduced without reducing safety performance. This allows the mean slope used in pit design to be increased, which has a financial benefit to the mining operation.

To assess the financial benefit of the product, three cases were examined; a base case with a pit slope of 40.0°, an improved case with an Edge Protector that reduces haul road width by 2.4m, allowing a mean pit slope of 40.5° and a second improved case that reduces haul road width by 5.0m, allowing a mean pit slope of 41.0°.

An indicative Copper-Gold ore body and associated mining operation was modelled using the Geovia Whittle software package. A pit was sized for each of the two cases and then an optimised mining, stockpiling and processing schedule was produced using the SIMO function in Geovia Whittle.

The Net Present Value (NPV) of the three cases is the primary measure of the benefit of Edge Protector, as it takes into account the time-value of money. The NPV of the second Edge Protector case exceeded the NPV of the base case by $18.6M or 3.7%.

	Base Case (40°)	EP Case (40.5°)	EP Case (41.0°)	Difference EPC1	Difference EPC2
Mining Costs	-$ 803.5	-$ 798.6	-$ 815.2	$ 4.9	-$ 11.7
Processing Costs	-$ 1,489.4	-$ 1,485.7	-$ 1,507.5	$ 3.7	-$ 18.1
Revenue	$ 3,395.5	$ 3,401.3	$ 3,450.4	$ 5.8	$ 54.9
EP Costs	$ -	-$ 6.4	-$ 6.5	-$ 6.4	-$ 6.5
Capital	-$ 600.0	-$ 600.0	-$ 600.0	$ -	$ -
NPV	$ 502.5	$ 510.6	$ 521.1	$ 8.1	$ 18.6



An alternative to reducing ramp width is to use Edge Protector to allow a fleet of larger trucks to be used. In an indicative case examined for a mine at the end of its fourth year of operation, where the unit mining cost is reduced by 16.7% when using larger trucks, this yielded an extra $47.5M in NPV.

While each mining operation should be assessed on a case-by-case basis, this report gives an indication of the level of financial return that might be expected from the use of Edge Protector.

Introduction

Safescape has developed Edge Protector, a concept for improved edge protection in open cut mines. The structure allows open pit haul roads road to occupy a lesser width while retaining the same or better safety characteristics.

The system consists of a series of filled polyethylene shells which secure together in a row along the edge of an open pit road. The wall acts to support a bund of loose rock giving a vertical face. Edge Protector is designed so as to prevent trucks' tyres from rolling up the bund. Instead, in the event of a collision the truck either deflects off the bund or is slowed as the bund absorbs the truck's momentum. The product is also designed for simple transportation, handling and re-use on site.

Safescape is working with mathematicians from UWA to model the effectiveness of the bunding system. On-site testing of different bunds materials and heights is also planned for model calibration.

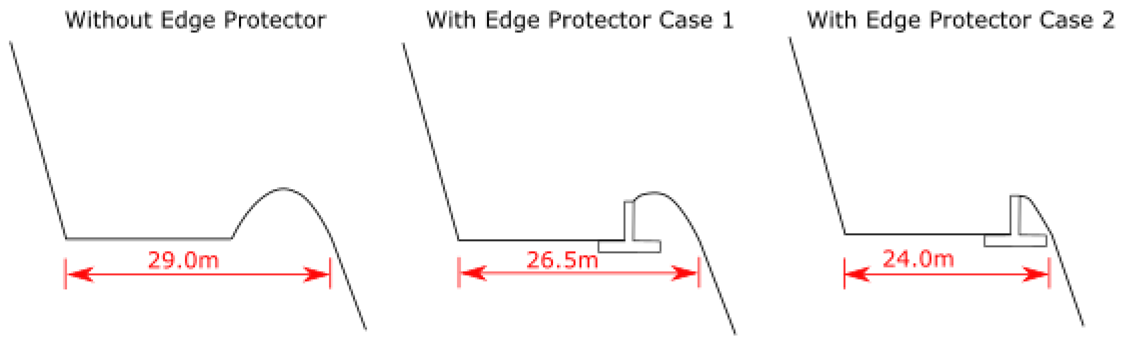


Figure 1: Comparison of haul road width with and without Edge Protector. The base case assumes a 6.3m wide truck (CAT® 785C) multiplied by a two-way factor of 3.5, plus 7m for the berm plus drain. The product can save 2.4m width by removing one horizontal portion of the bund. In case 2 there is an additional width saving from reducing the total height and spread of the bund.

A reduction in haul road width allows the total pit slope used in mine planning to be steeper without compromising safety. A steeper pit slope typically has financial benefits arising from a reduction in waste stripping, an associated benefit that additional ore at the bottom of the pit becomes economic, and potentially the ability to access deeper ore earlier in the life of the mine (when mining rate is the limiting factor).

Whittle Consulting carried out an investigation to assess the financial effect of using Edge Protector on a mining operation. This report summarises the findings.

Testing Methodology

Three cases are examined:

- Base Case: No Edge Protector
- EP Case 1: 2.4m Edge Protector
- EP Case 2: 5.0m Edge Protector

Mining Operation

All mining operations are different and any benefits from using Edge Protector will vary from case to case. Rather than attempting to assess Edge Protector against a large range of mines, this report assesses Edge Protector against a single mining operation to provide an indication of the magnitude of financial benefit.

The ore body used is the Marvin ore body. This is a realistic copper-gold ore body created over a decade ago by geologist Norm Hanson for use in case studies. Marvin has high gold grade at shallow elevations and a high copper grade at deeper elevations. The model used has a block size of 20m x 20m x 20m.

A single open pit with four phases was sized for each case using the Geovia Whittle software package and a set of basic processing assumptions. In each case the Skin Analysis technique was used to choose the shell with the highest expected NPV.

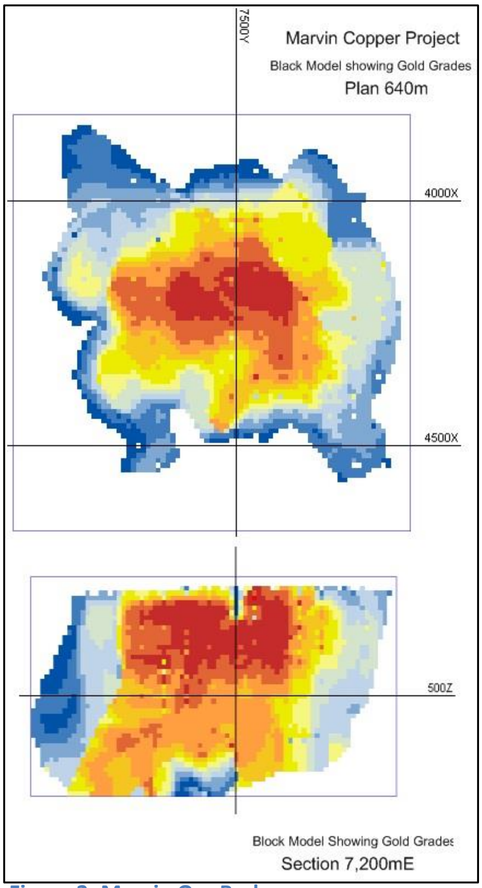


Figure 2: Marvin Ore Body

A calculation was completed to estimate the increase in pit slope that is possible through the use of Edge Protector. This found that, for a pit approximately 440m deep and accessed by a haul road descending at 1:10 slope, Edge Protector allows the mean design slope to increase from 40.0° to 40.5° in Case 1 and 41.0° in Case 2. The calculation can be seen in Appendix A – Slope Calculation.

Schedule Optimization

The full benefit of reducing the haul road width and increasing pit design slope cannot be assessed only by looking at the size of the pit shells and ore reserves contained within. Even a small change in one part of a mining operation can affect the optimal operation of all other parts of the enterprise (cut-off grades, stockpiling, plant settings etc.). Therefore, a whole-system approach is required to estimate the effect of a change. This approach must also take into account the time-value of money; the most common approach is to discount future cash flows to produce a Net Present Value (NPV) that can be directly compared between different cases.

Whittle Consulting's enterprise optimization methodology is used for this purpose. The whole mining operation from Resource to Market is modelled. While the pit and phase shapes are created in Geovia Whittle, the rest of the enterprise is modelled using Prober, a proprietary optimization algorithm that optimizes for NPV.

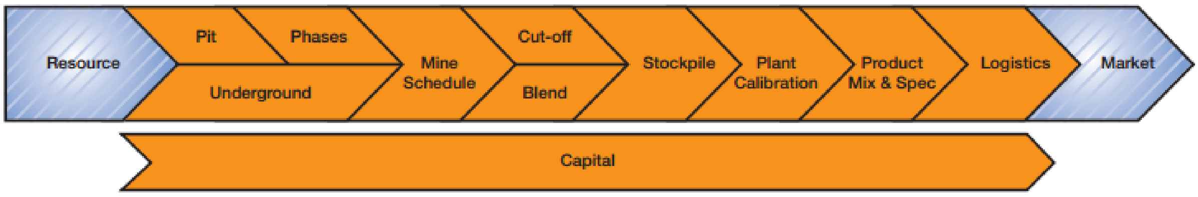


Figure 3: Whittle Consulting Enterprise Optimisation process.

While Whittle Consulting uses the most recent version of Prober, "Prober C", an earlier version of the software is available through the Simultaneous Optimizer (SIMO) function within Geovia Whittle. For this case study, SIMO was used to create an optimal 10-year mine schedule for each of the two cases. This means that any and all effects of Edge Protector on mining schedule, cut-offs, stockpiling, plant settings, product and logistics are measured.

A full list of settings used is provided in Appendix B - Mining Enterprise Model Settings. The cost of the Edge Protector product is included in the EP Case and is calculated in Appendix C – Edge Protector Cost Calculation.

Results

SIMO results for the three cases were collated and analysed. NPV is the primary measure to compare between the cases, while other impacts on pit inventories and cash flow are also measured. The material movements for each case are shown in Figure 4, Figure 5 and Figure 6.

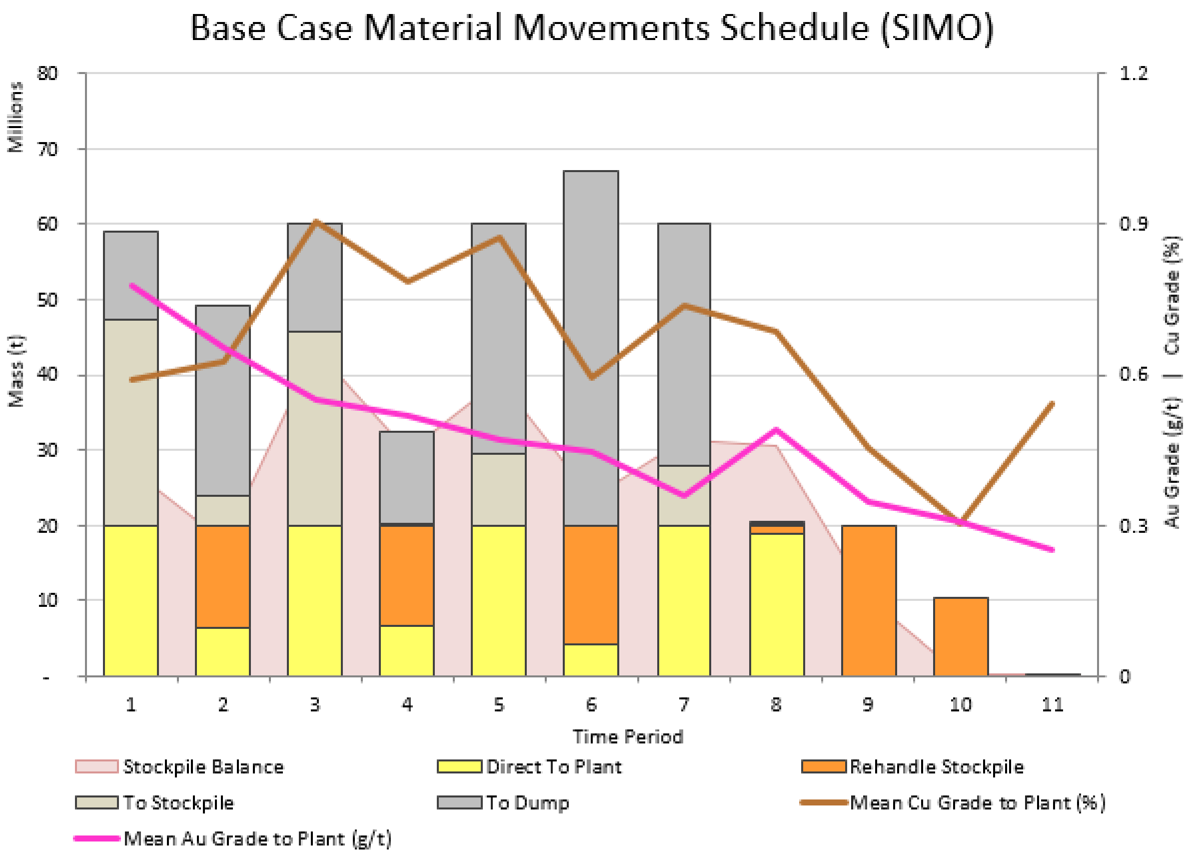


Figure 4: Material movements for optimized schedule using Base Case pit

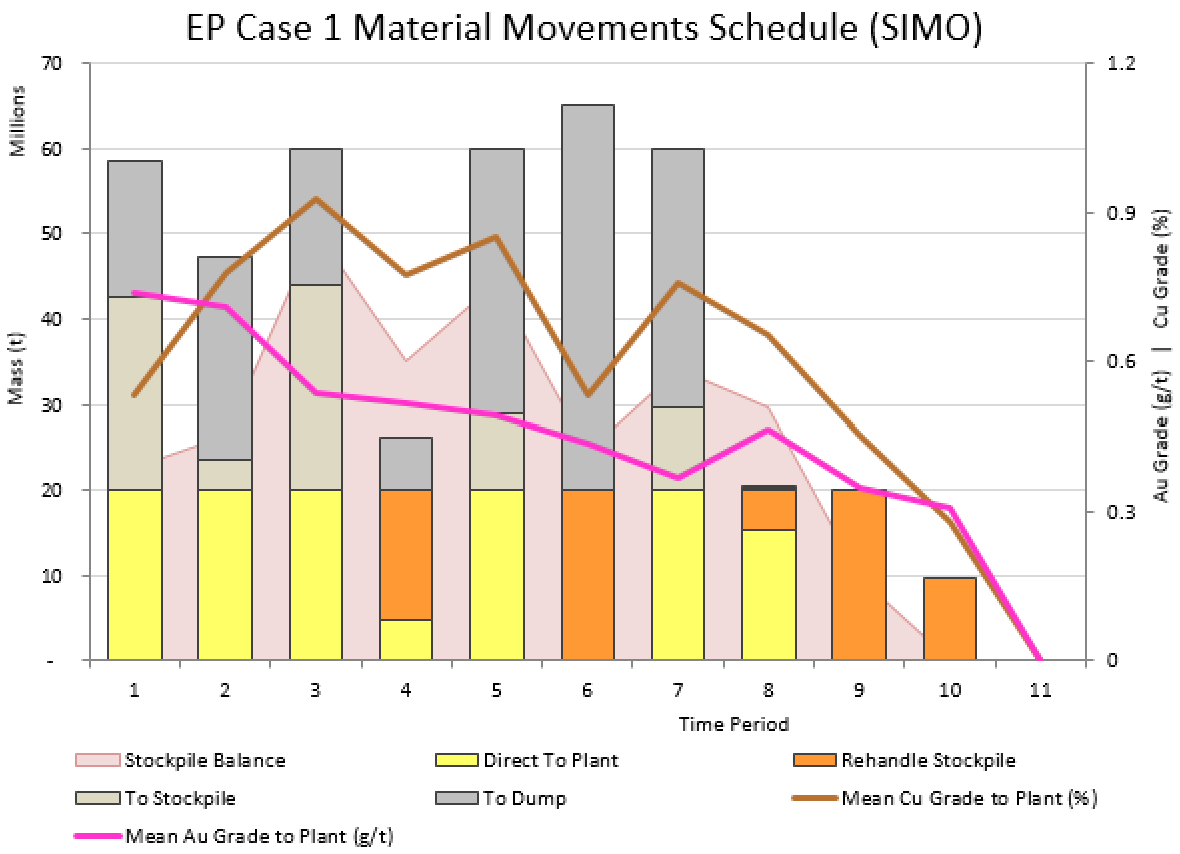


Figure 5: Material movements for optimized schedule using EP Case 1 pit.

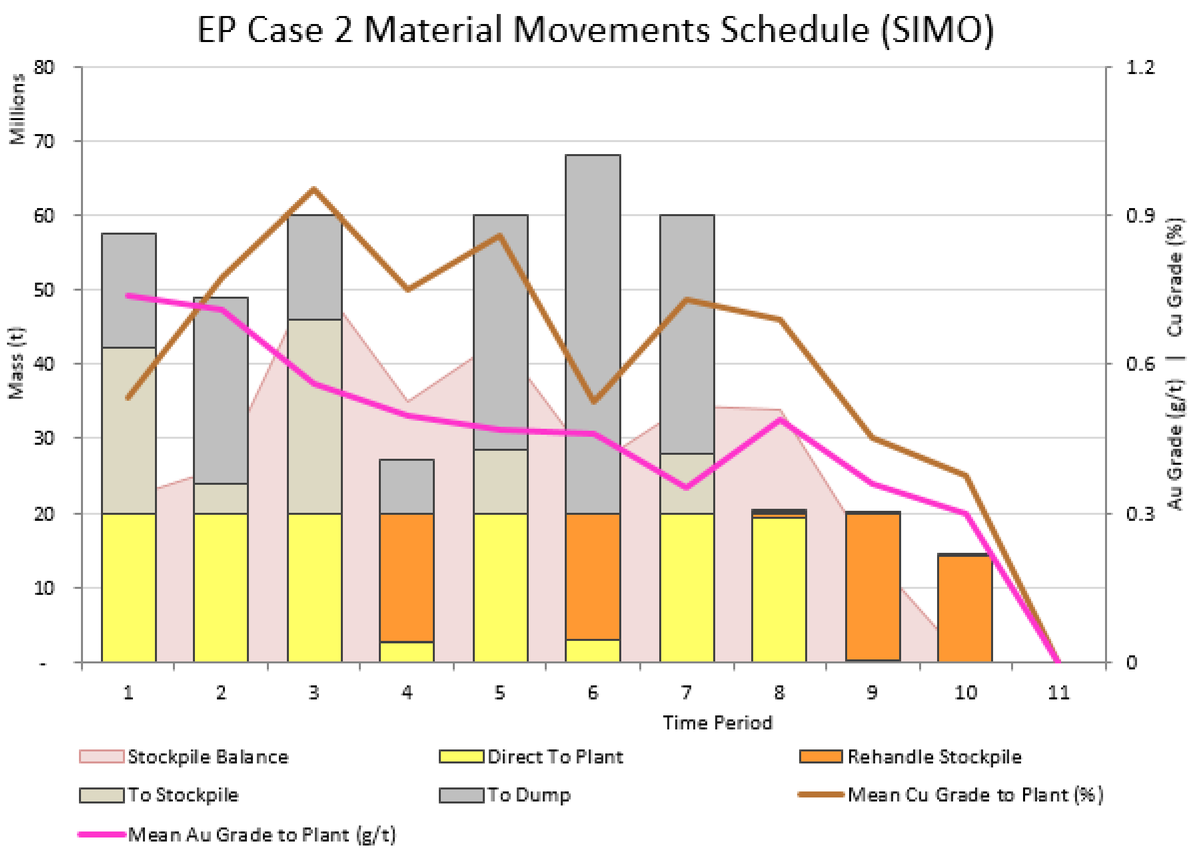


Figure 6: Material movements for optimized schedule using EP Case 2 pit.

Net Present Value

Assuming $600M of capital, the Base Case NPV is $502.5M and the EP Case 2 NPV is $521.1M, an improvement of $18.6M or 3.7%.

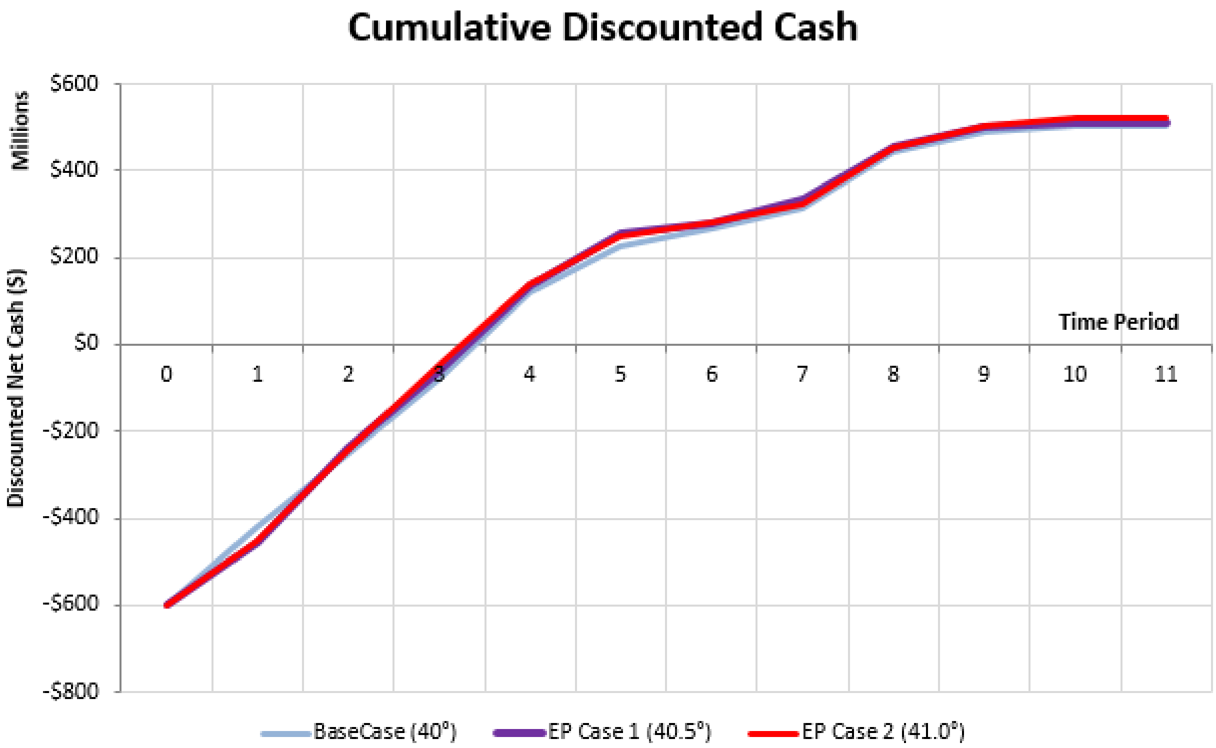


Figure 7: Discounted Cash of EP Case against Base Case.

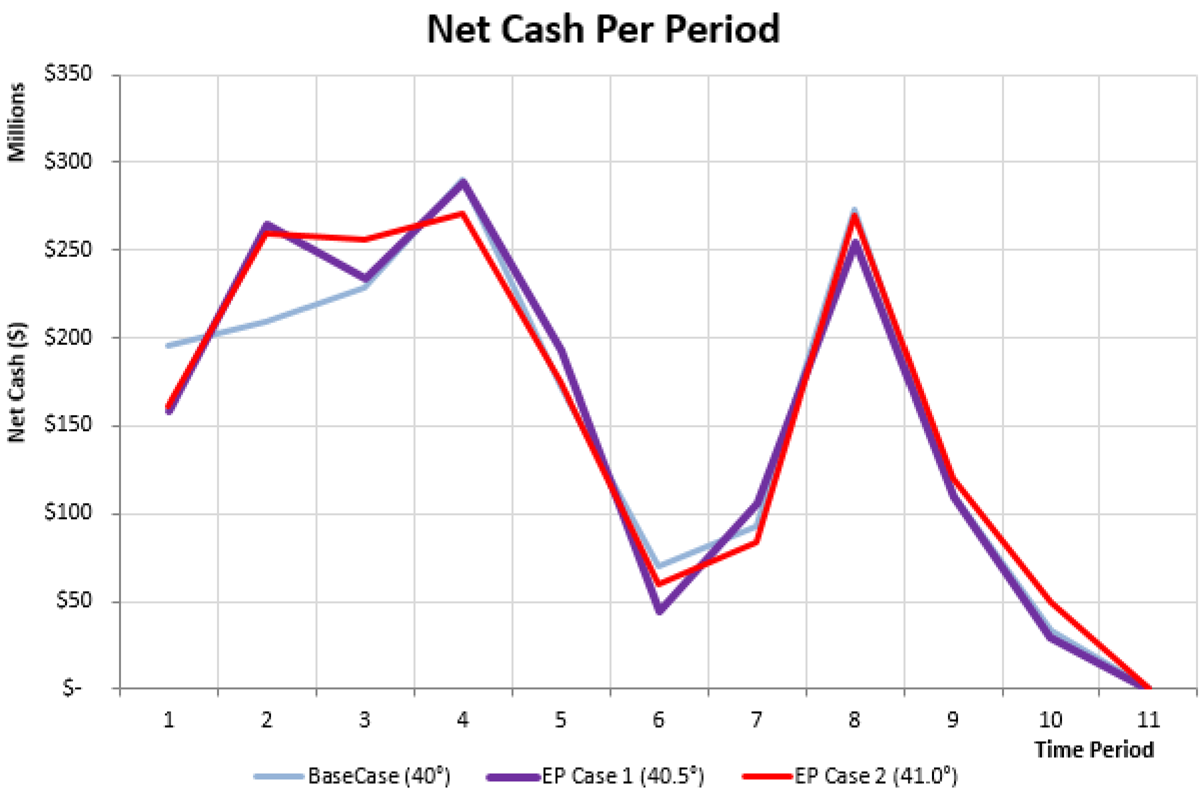


Figure 8: Net Cash. This shows where the optimised EP Case schedule differs from the optimised Base Case schedule.

It was expected that the EP Cases would mine less material in the initial part of the pit and then also mine additional ore at the bottom of the pit. Both of these outcomes were observed in the optimization result, albeit only to a small extent.

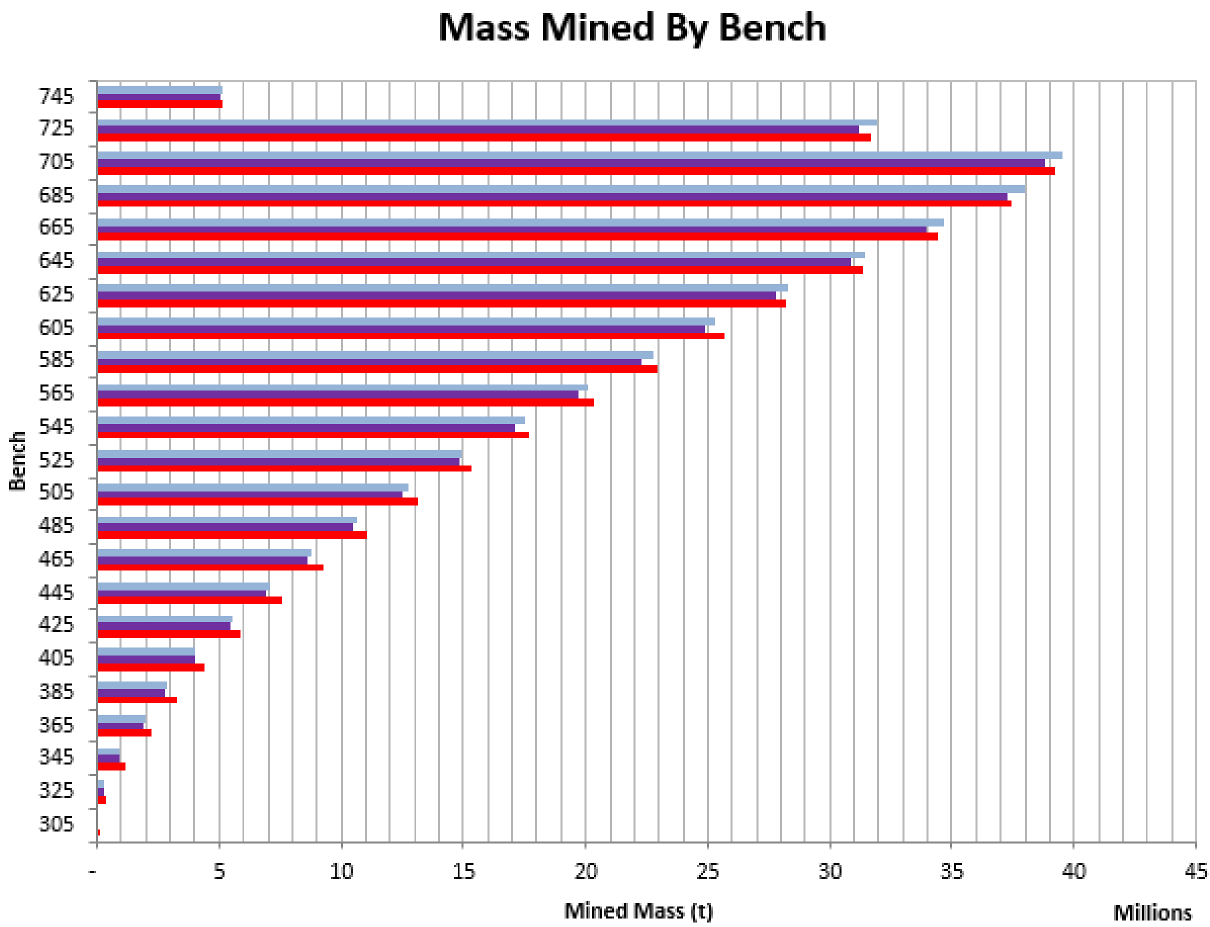


Figure 9: Both EP case pits contain less material in benches closer to the surface than the base case. The EP Case 2 also mines material to a deeper level than the Base Case, indicating that ore that was previously uneconomic has become economic.

The effect on pit inventories can be seen in Figure 10, which also shows the full financial analysis of the cases.

The EP Case 1 pit is smaller than the Base Case pit by 6.6Mt and has slightly less ore (0.7Mt) with no change in copper or gold grade. The main effect of the 2.4m Edge Protector is to allow the lowest bench of the pit and also each phase to be reached while mining significantly less waste, which saves some cost. It allows acceleration through the ore-body such that although total cash revenue over the mine’s life is less than the base case, that revenue comes earlier and therefore has a greater discounted value.

The EP Case 2 pit add value over EP Case 1 and the Base Case primarily through accessing additional ore. The pit is larger and both discounted mining costs and discounted processing costs are greater than in the base case. However, this is outweighed by a larger increase of $54.9M discounted revenue. That it is better economically to reduce waste when moving from the Base Case to EP Case 1, but then more advantageous to instead increase the ore (and waste) tonnage mined from EP Case 1 to EP Case 2, is simply a function of the ore body itself.

The Life of Mine is not significantly affected as the amount of ore produced from the EP Case pits is almost the same as the Base Case, so the Plant runs for a similar length of time.

The Edge Protector costs are also discounted as these are purchased throughout the life of the operation and can be reused in outer phases (see Appendix C – Edge Protector Cost Calculation).

	Base (40°)	EPC1 (40.5°)	Diff. EPC1	EPC2 (41.0°)	Diff. EPC2
Pit Contents					
Mass (Mt)	364.3	357.7	- 6.6	367.6	3.3
Cu (kt)	1,447.6	1,440.9	- 6.7	1,474.8	27.3
Mean Cu grade (%)	0.397%	0.403%	0.006%	0.401%	0.004%
Au (kTr.Oz)	3,464	3,455	- 10	3,516	52
Mean Au grade (g/t)	0.296	0.300	0.005	0.298	0.002
Mining Costs ($M)	*-$ 1,184.1*	*-$ 1,162.4*	*$ 21.6*	*-$ 1,194.8*	*-$ 10.8*
Mining Costs (Disc. $M)	*-$ 803.5*	*-$ 798.6*	*$ 4.9*	*-$ 815.2*	*-$ 11.7*
EP Costs					
EP Costs ($M)		*-$ 8.4*	*-$ 8.4*	*-$ 8.8*	*-$ 8.8*
EP Costs (Disc. $M)		*-$ 6.4*	*-$ 6.4*	*-$ 6.5*	*-$ 6.5*
Ore					
Mass (Mt)	190.37	189.6	- 0.7	194.2	3.8
Cu (kt)	1,282.1	1,277.8	- 4.3	1,307.4	25.3
Mean Cu grade (%)	0.673%	0.674%	0.000%	0.673%	0.000%
Au (kTr.Oz)	3,066	3,061	- 5.4	3,115	48.8
Mean Au grade (g/t)	0.501	0.502	0.001	0.499	-0.002
Stripping Ratio	0.914	0.886	-0.028	0.893	-0.020
Processing Costs ($M)	*-$ 2,379.1*	*-$ 2,369.6*	*$ 9.5*	*-$ 2,426.3*	*-$ 47.2*
Processing Costs (Disc. $M)	*-$ 1,489.4*	*-$ 1,485.7*	*$ 3.7*	*-$ 1,507.5*	*-$ 18.1*
Product					
Cu (kt)	794.4	790.6	- 3.8	811.5	17.0
Au (kTr.Oz)	2,386	2,381	- 5.0	2,425	38.5
Revenue (Less Sell Costs)					
Revenue ($M)	*$ 5,239.9*	*$ 5,222.0*	*-$ 18.0*	*$ 5,338.1*	*$ 98.2*
Revenue (Disc. $M)	*$ 3,395.5*	*$ 3,401.3*	*$ 5.8*	*$ 3,450.4*	*$ 54.9*
Capital					
Capital ($M)	*-$ 600.0*	*-$ 600.0*	*$ -*	*-$ 600.0*	*$ -*
NPV	$ 502.5	$ 510.6	$ 8.1	$ 521.1	$ 18.6

Figure 10: The full impact of Edge Protector on the mining operation analysed. The $18.6M improvement in NPV from EP Case 2 can be seen as ΔNPV = MiningCostReduction + (RevenueIncrease – ProcessingCostIncrease) – EPcost .

In general, the first benefit of increasing the slope of the pit via Edge Protector is a reduction in mining costs. This is particularly important early in the mine life while the discounted cash value of the mining costs is high.

The second benefit from increasing the slope is an increase in revenue from processing additional ore that can be economically accessed in the EP Case pit. In this case study both EP Cases produce greater discounted revenue than the base case, with the increase in discounted revenue particularly notable in EP Case 2.

	Base Case (40°)	EP Case (40.5°)	EP Case (41.0°)	Difference EPC1	Difference EPC2
Mining Costs	-$ 803.5	-$ 798.6	-$ 815.2	$ 4.9	-$ 11.7
Processing Costs	-$ 1,489.4	-$ 1,485.7	-$ 1,507.5	$ 3.7	-$ 18.1
Revenue	$ 3,395.5	$ 3,401.3	$ 3,450.4	$ 5.8	$ 54.9
EP Costs	$ -	-$ 6.4	-$ 6.5	-$ 6.4	-$ 6.5
Capital	-$ 600.0	-$ 600.0	-$ 600.0	$ -	$ -
NPV	$ 502.5	$ 510.6	$ 521.1	$ 8.1	$ 18.6

Figure 11: A simple summary of the differences in discounted cash between the cases.

Alternative Approach – Larger Trucks

An alternative to narrowing the haul roads is to instead use the road width freed by Edge Protector to run a larger truck fleet. Larger trucks typically incur a lower material movement cost per tonne, which in some cases is worth more than the cost of modifying infrastructure and any additional capital or period costs.

While it is possible with a greenfield project that Edge Protector may sway the optimal choice of haul truck from one model to another, the more potentially valuable case is the introduction of Edge Protector to an existing open pit mine. It is not usually practicable to widen an existing in-pit haul road in order to switch to a fleet of larger trucks, however implementing Edge Protector makes this option available.

Any mining operation considering changing to a different trucking fleet would need to take into account a large number of factors such as ownership model (owner-operator vs contract), availability, capital, maintenance, existing infrastructure and machinery (excavators etc). However, if the cost savings are large enough then the switch may be justified.

A case is considered here against the previously described Base Case, where Edge Protector allows the CAT® 785C fleet (6.3m wide, 136t payload) to be replaced with a fleet of CAT® 793C (7.4m wide, 223t payload). A contract fleet is in use and the contractor is able to provide the larger trucks. Any cost saving achievable through this change will vary from operation to operation; in this case study it is assumed that the truck change reduces the mining unit cost by 16.7%[1], from $3.25/t to $2.71/t. It is assumed that the mine has already operated for four years and mining has progressed as per the Base Case. For simplicity it is assumed that the pit shape and schedule are *not* re-optimised for the revised mining cost. It is also assumed that the EP installation and truck fleet switch does not significantly disrupt production.

For comparison to previous cases, the NPV of this EP Case 3 (with all dollar figures discounted to Period 0) is $555.0M, an improvement of $47.5M over the base case. This improvement consists of a reduction in Mining costs of $52.5M, less the Edge Protector cost of $5.0M. An operation considering this decision in period 4 would be more interested in the improvement in NPV discounted to Period 4 dollars; this figure is $69.5M.

[1] https://www.linkedin.com/pulse/what-drives-innovation-mining-industry-existing-new-projects-miller

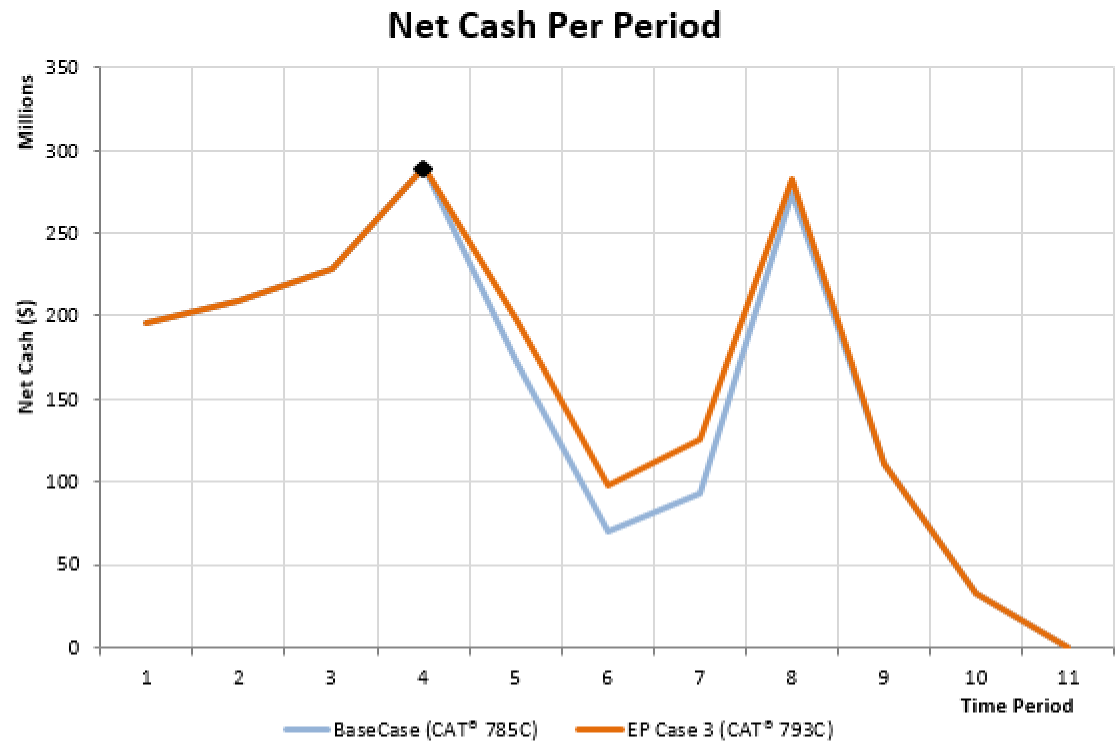


Figure 12: After switching truck fleet at the end of Period 4, mining costs are lower for EP Case 3 in the remaining periods, which contributes to an improvement in net cash per year. EP costs are subtracted at the start of year five.

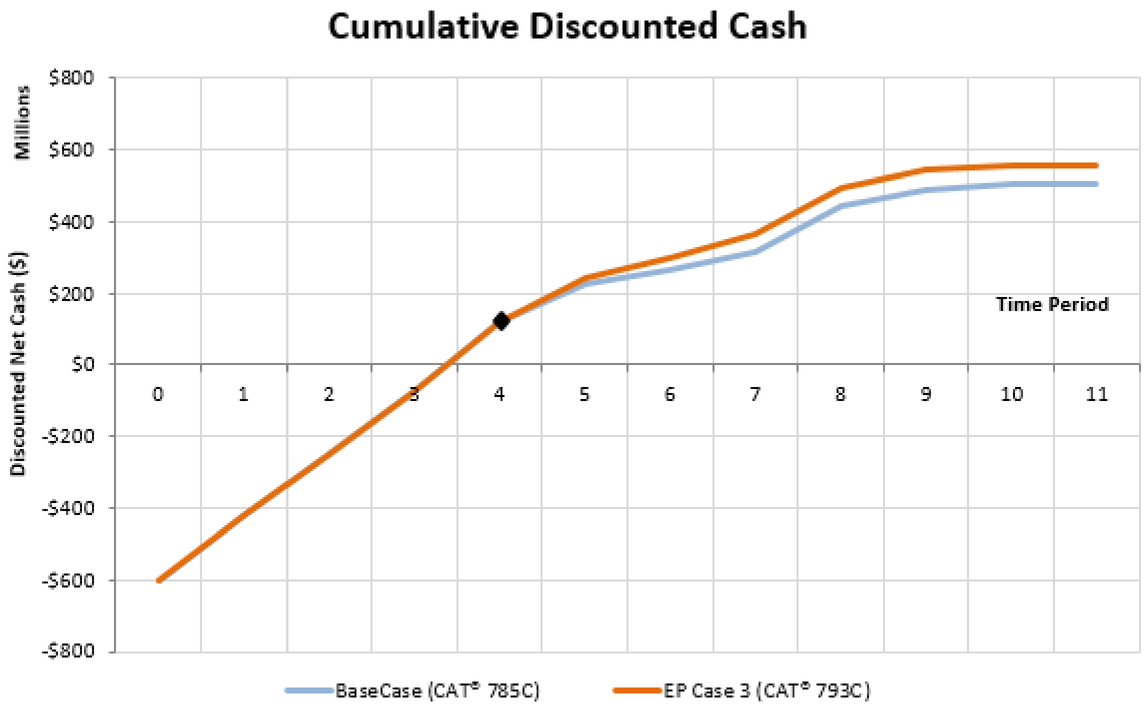


Figure 13: Cumulative discounted net cash of the two cases, with EP Case 3 having an NPV of $555.0M, an improvement of $47.5M over the base case (in Period 0 dollars).

Conclusion

Although the increase in pit slope possible through the use of Edge Protector is small, in the cases examined in this report it provides a significant improvement in Net Present Value of $8M-$18M. This benefit is achieved by reducing the waste stripping required to reach ore, saving mining costs, and also by making extraction of additional ore economically justified such that production and revenue are increased.

Any benefits to increasing the pit slope will vary between mining operation and by pit, so must be assessed on a case-by-case basis.

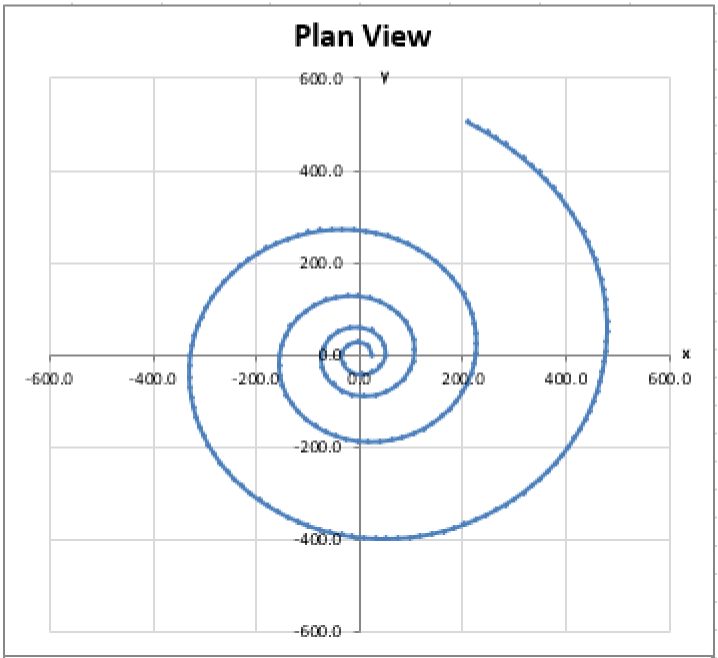
Edge Protector also makes available to existing mining operations the option to switch to a fleet of larger trucks instead of narrowing the haul road. The practicality and economics of this are more contingent upon the specifics of the operation than the road-narrowing option, however with the assumptions used in this case study the cost savings also yielded a larger NPV improvement.

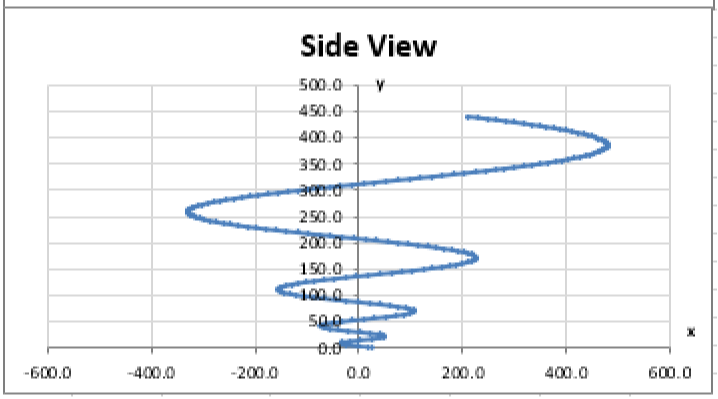
Appendix A – Slope Calculation

Edge Protector saves 2.4m/5.0m of pit radius per 360° haul road loop.

As the Marvin pit is near-conical, a spiral descending down a cone at a constant slope of 1:10 was used to estimate the number of haul road loops required to reach the bottom.

Just over four loops are required to reach the base of the pit (where a box cut would be performed).

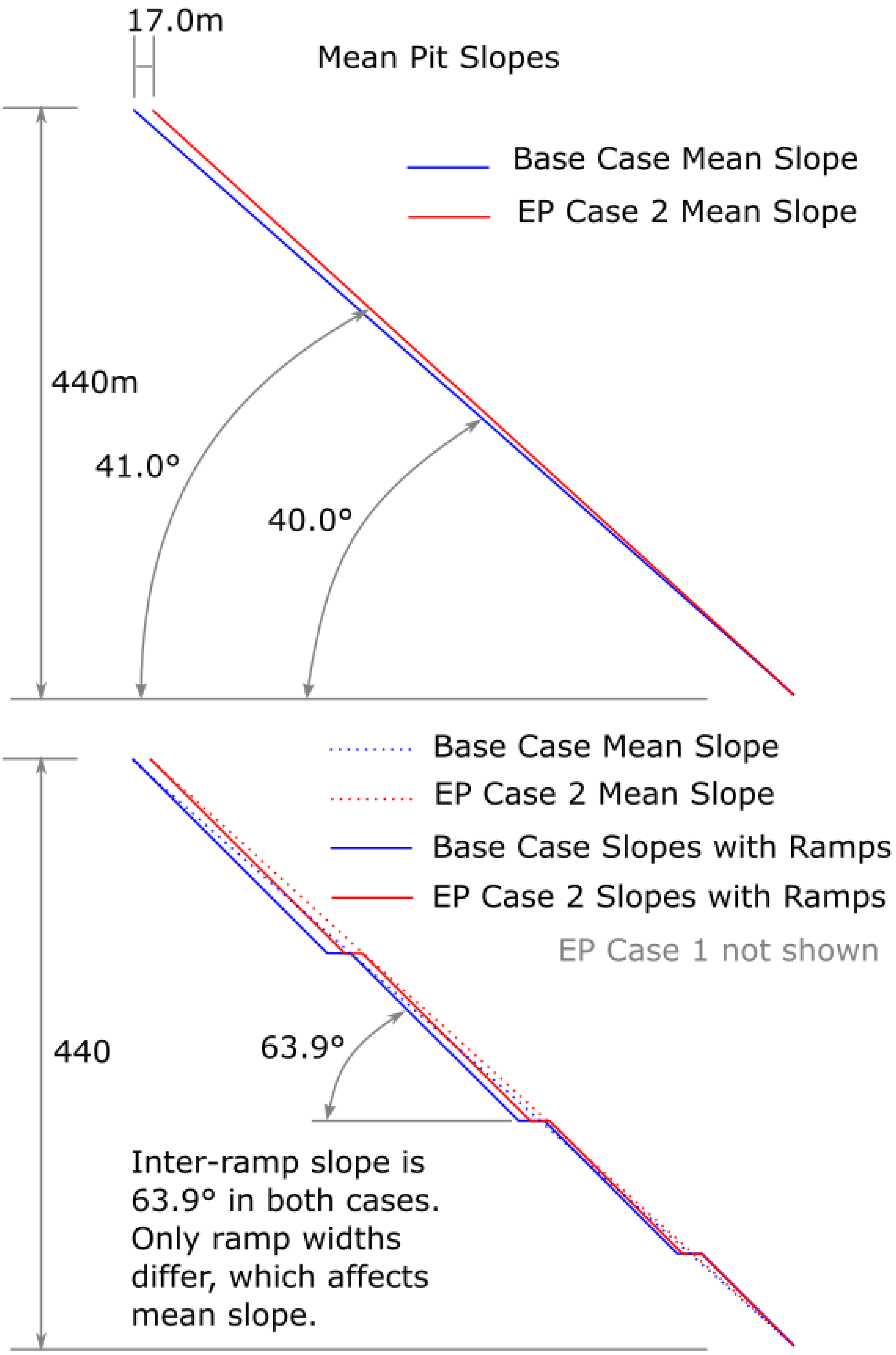




The reduction in pit radius in EPC1 would be 4.26 x 2.4 = 10.2m over the 440m descent, however this is offset slightly by an increase in the loops required to descend the cone. The slope is 41.0° for the second EP case. See diagram on following page.

Case	EP size (m)	Cone Depth (m)	Mean Slope °	Num Haul Loops	Cone radius (m)	Cone diameter (m)
Base Case		440	40.0	4.19	524.4	1049
EPC1	2.4	440	40.5	4.26	515.8	1032
EPC2	5	440	41.0	4.33	506.8	1014

Note: In both the base case and the edge protector case, the actual pit slope will be steeper at the top of the pit due to fewer haul roads per vertical metre, and less steep closer to the bottom of the pit due to a greater number of haul roads per vertical metre. Further investigation would be required to quantify this.


17.0m
Mean Pit Slopes
Base Case Mean Slope
EP Case 2 Mean Slope
440m
41.0°
40.0°
Base Case Mean Slope
EP Case 2 Mean Slope
Base Case Slopes with Ramps
EP Case 2 Slopes with Ramps
EP Case 1 not shown
440
63.9°
Inter-ramp slope is
63.9° in both cases.
Only ramp widths
differ, which affects
mean slope.

Appendix B - Mining Enterprise Model Settings

Geovia Whittle pit optimisation and SIMO settings.

All dollar figures are AUD.

Pit Slopes = Base Case: 40° with haul road width of 29.0m
EPC1: 40.5° with haul road width of 26.5m (as per Appendix A – Slope Calculation)
EPC1: 41.0° with haul road width of 24.0m (as per Appendix A – Slope Calculation)
Mining Cost = $3.25/t

Processing Cost = $12.50/t

Gold Recovery = Ox: 80%, Mx: 75%, Pm: 83%

Copper Recovery = Ox: 75%, Mx: 50%, Pm: 80%

Gold price = $1150/oz

Copper price = $5000/t

Gold Selling Cost = $36/oz

Copper Selling Cost = $1750/t

Capital Costs = $600M

Discount rate = 10%

Mining Limit = 60Mt

Processing Limit = 20Mt

Appendix C – Edge Protector Cost Calculation

Purchase Cost = $2000/m

Road slope = 1:10

The depth reached at each time period is from the SIMO run.

Note: Edge Protector can be re-used, so can be moved from inner phases to outer phases as mining progresses.

EPC1

			1	2	3	4	5	6	7	8	9	10	11
Depth (m)	Phase 1	745	645	485	485	485	485	485	485	485	485	485	485
	Phase 2	745	745	685	485	405	405	405	405	405	405	405	405
	Phase 3	745	745	745	745	705	385	365	365	365	365	365	365
	Phase 4	745	745	745	745	745	745	645	465	325	325	325	325
Exposed vertical (m	Phase 1		100	200	0	0	0	0	0	0	0	0	0
	Phase 2		0	60	260	300	0	0	0	0	0	0	0
	Phase 3		0	0	0	40	360	280	100	0	0	0	0
	Phase 4		0	0	0	0	0	100	280	420	420	420	420
EP in use (m)	Total	0	1000	2600	2600	3400	3600	3800	3800	4200	4200	4200	4200
EP purchased (m)	Total	4200	1000	1600	0	800	200	200	0	400	0	0	0
Cost ($)	Undiscounted $	$8,400,000	$ 2,000,000	$ 3,200,000	$ -	$ 1,600,000	$ 400,000	$ 400,000	$ -	$ 800,000	$ -	$ -	$ -

EPC2

			1	2	3	4	5	6	7	8	9	10	11
Depth (m)	Phase 1	745	645	485	485	485	485	485	485	485	485	485	485
	Phase 2	745	745	665	465	405	405	405	405	405	405	405	405
	Phase 3	745	745	745	745	705	425	365	365	365	365	365	365
	Phase 4	745	745	745	745	745	745	625	465	345	325	305	305
Exposed vertical (m	Phase 1		100	180	0	0	0	0	0	0	0	0	0
	Phase 2		0	80	280	300	20	0	0	0	0	0	0
	Phase 3		0	0	0	40	320	260	100	0	0	0	0
	Phase 4		0	0	0	0	0	120	280	400	420	440	440
EP in use (m)	Total	0	1000	2600	2800	3400	3400	3800	3800	4000	4200	4400	4400
EP purchased (m)	Total	4400	1000	1600	200	600	0	400	0	200	200	200	0
Cost ($)	Undiscounted $	$8,800,000	$ 2,000,000	$ 3,200,000	$ 400,000	$ 1,200,000	$ -	$ 800,000	$ -	$ 400,000	$ 400,000	$ 400,000	$ -

EPC3

			1	2	3	4	5	6	7	8	9	10	11
Depth (m)	Phase 1	745	605	505	505	505	505	505	505	505	505	505	505
	Phase 2	745	745	685	505	405	405	405	405	405	405	405	405
	Phase 3	745	745	745	745	705	445	405	385	365	365	365	365
	Phase 4	745	745	745	745	745	745	645	465	325	325	325	325
			745	745	745	745	745	745	745	745	745	745	745
Exposed vertic	Phase 1		140	180	0	0	0	0	0	0	0	0	0
	Phase 2		0	60	240	300	40	0	0	0	0	0	0
	Phase 3		0	0	0	40	300	240	80	0	0	0	0
	Phase 4		0	0	0	0	0	100	280	420	420	420	420
EP enabled			FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Length EP	Phase 1		0	0	0	0	0	0	0	0	0	0	0
(Can re-use)	Phase 2		0	0	0	0	400	0	0	0	0	0	0
Slope 1:10	Phase 3		0	0	0	0	3000	2400	800	0	0	0	0
	Phase 4		0	0	0	0	0	1000	2800	4200	4200	4200	4200
EP in use (m)	Total	0	0	0	0	0	3400	3400	3600	4200	4200	4200	4200
EP purchased (	Total	4200	0	0	0	0	3400	0	200	600	0	0	0
Cost ($)	Undiscounted $	$ 8,400,000	$ -	$ -	$ -	$ -	$ 6,800,000	$ -	$ 400,000	$ 1,200,000	$ -	$ -	$ -

Appendix D – Pit

Base case pit. EP Case pits looks very similar.