Cut-off Grade
The Impact of Getting it Right

Presentation

Prepared for:

CIM 2019 Convention, Montreal, QC

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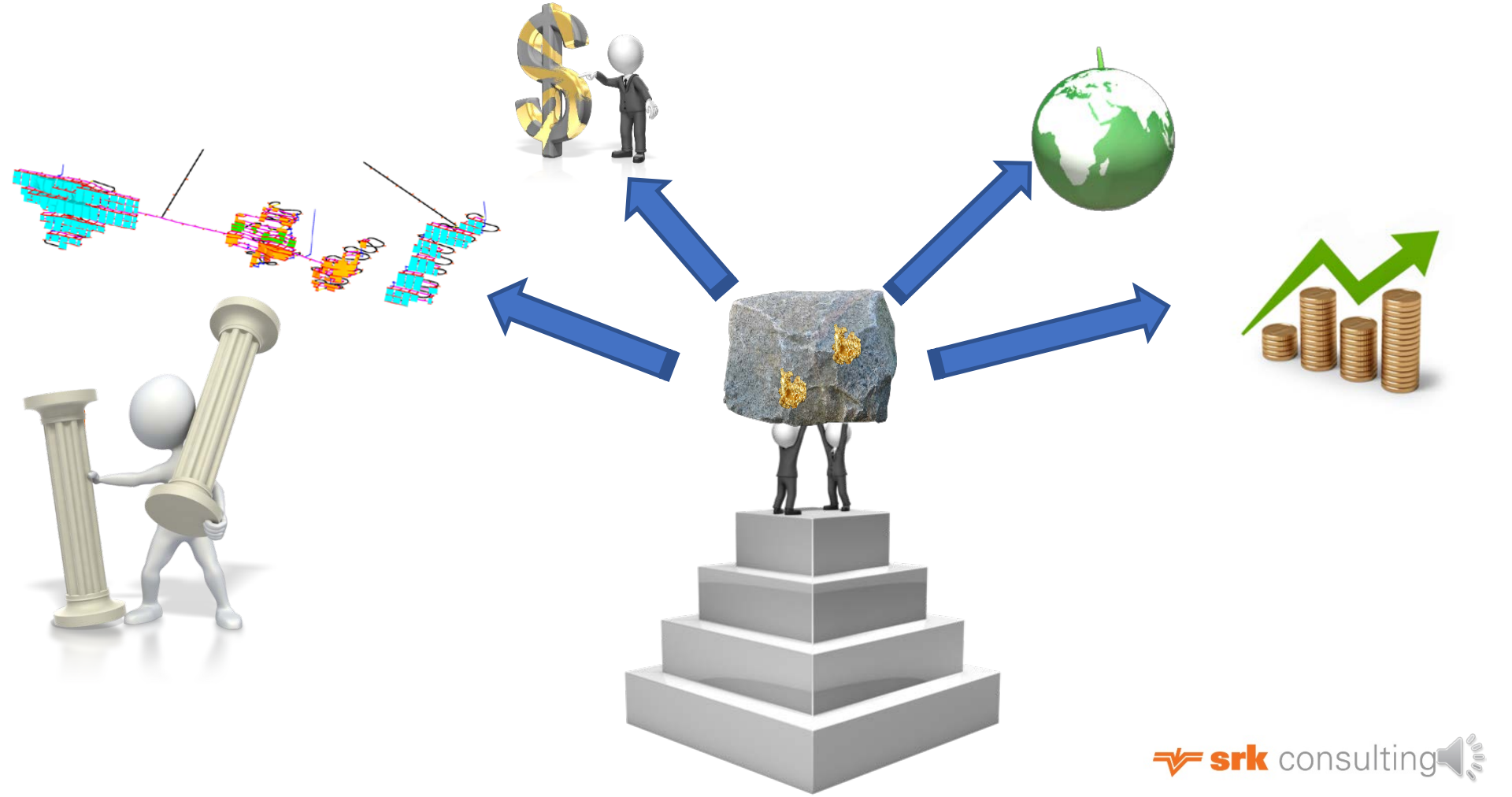
Talking Points

- Cut-off Grade (COG) Calculation
- Inputs/Modifying Factors into COG Calculation
- Effects of chosen inputs into the COG
- Industry wide Survey – Best Practices
- Corporate Objective for COG Determination
  - Value (NPV, IRR)
  - Other Considerations
- Provide a Case Study Example
- Incremental Materials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What is COG/COV?

Decision Point -

Ore?...

…or

…Waste?

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“Every tonne mined as ore pays for itself and (generates the greatest value and meets your corporate objectives).”

Ore

Waste

Break-even

Corporate Objectives

- Mineable Deposit size
- High Ounces
- Production Profile Consistent

Maximize NPV
Maximize IRR
Short Payback

- Continuity of Deposit
- Maximize Mine Life
- High Cashflow up front
- Short term Cash flow
- Consistent Mill Feed
- Robustness to operating cost
- Robust to changing gold prices

Break-Even COG – is different

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Break-Even COG

The grade at which revenue obtained is equal to the cost to produce that revenue.

BECOG =

Upstream Costs

Revenue

+ Profit Margin

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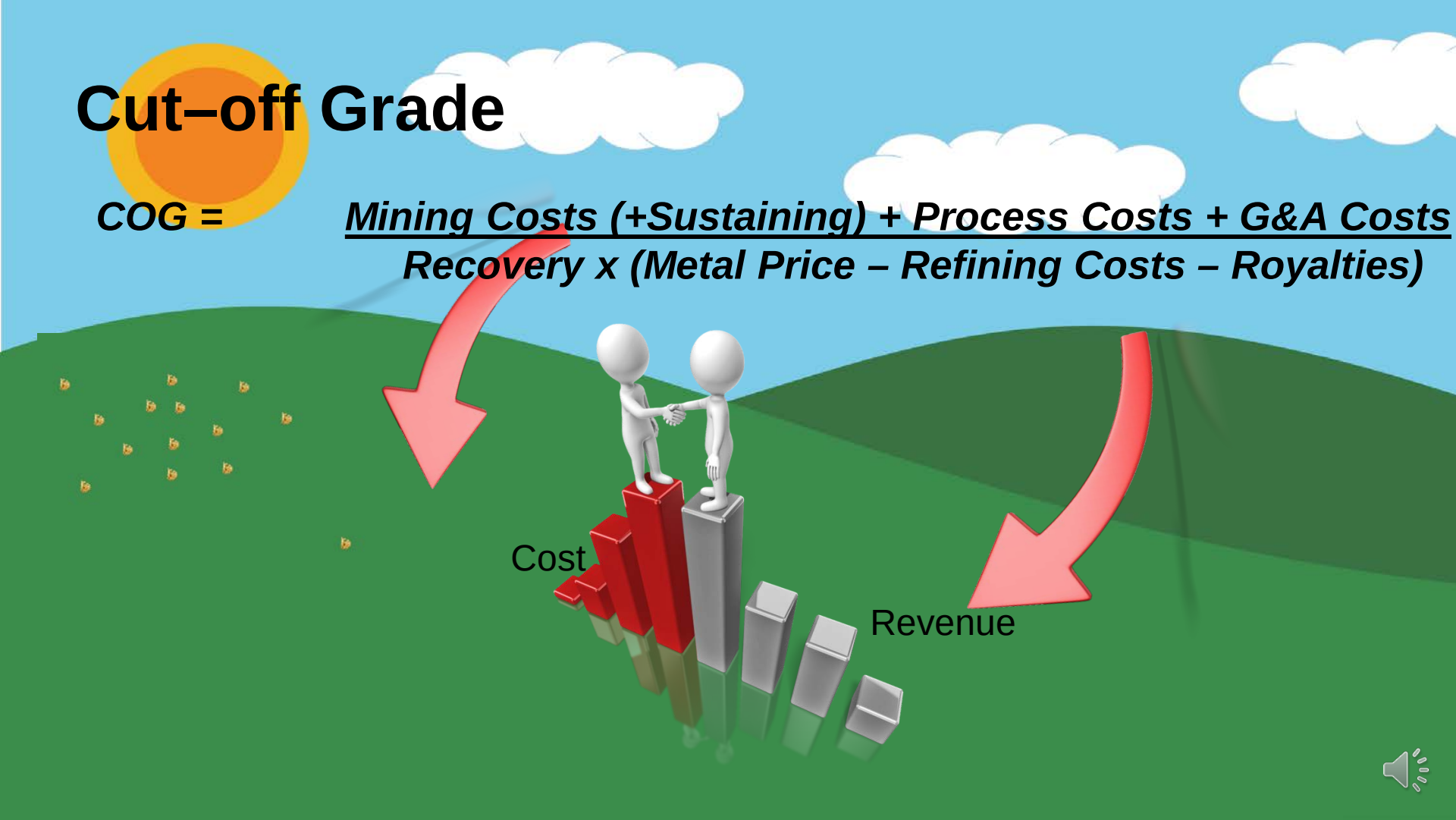
Cut–off Grade

$$COG = \frac{\text{Mining Costs (+Sustaining)} + \text{Process Costs} + \text{G\&A Costs}}{\text{Recovery x (Metal Price} - \text{Refining Costs} - \text{Royalties)}}$$



$$COG = \frac{Costs}{Revenue} = \frac{\$102.00/t}{\$34.00/t}$$

Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

Cost (1 tonne of ore)		
Description	**Unit**	**Total**
Mining	$/t	$42.00/t
Mill	$/t	$20.00/t
Administration(G&A)	$/t	$25.00/t
Sustaining	$/t	**$15.00/t**
Total Opex + Sustaining	$/t	**$102.00/t**
COG – Report - Mill Feed (Head Grade)		**3.0 (Au gpt)**
Dilution	**%**	**10%**
COG –Insitu- Mine Design)		**3.3 Au gpt**

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What to Include in a COG

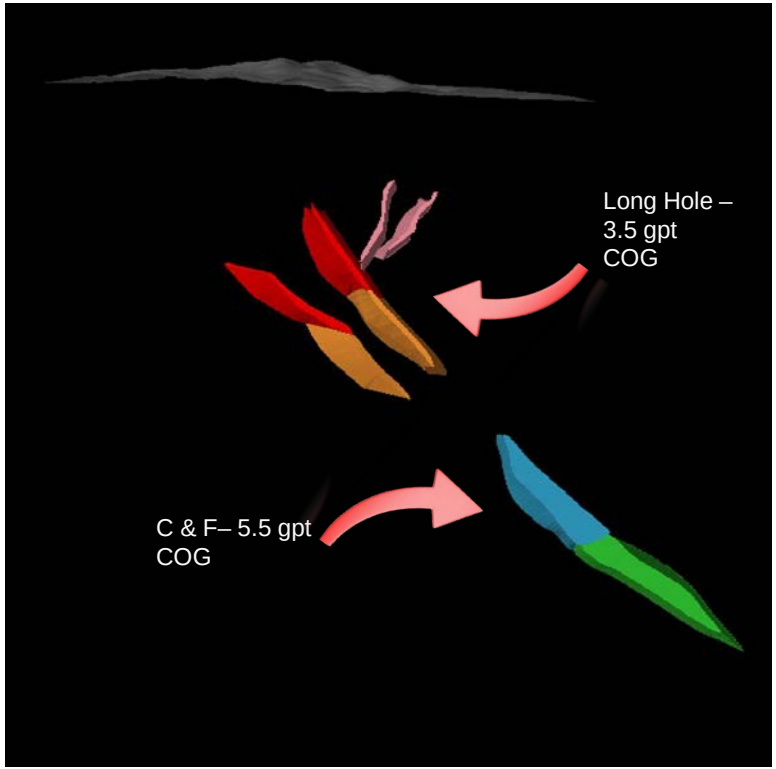
CIM guidance – “reasonable prospects” (Resources) •

Implies a judgment call by the QP in respect of the technical and economic factors likely to influence the prospect of eventual economic extraction •

The basis for determining “reasonable prospects” needs to be clearly stated.


Metal Price
TR/RC
Transportation/Selling
Penalties
Recovery
Royalties
REVENUE
Capex - Sustaining
Mine Opex
G & A
Opex Development
Mill Opex
Profit Margin
Dilution
Corporate G&A
Capex - Project
COST
Unique By Zone

Mining Method and Zone Specific COG



In some circumstances, a single COG applied to the full deposit may result in over generalization that ultimately impacts value by removing profitable material or subsidizing low value zones.

May require separate COG for:

- Different Mine Zones
- Geo-Metallurgical Zones
- Operational Aspects – Mining Methods

Modifying Factors -Industry use (%)

Revenue			
Metal Price ($)	✓		
Mill Recovery (%) (Fixed)	✓		100%
Payable Metal (%)		✗	
Treatment and Refinery ($)		✗	
Transportation ($)		✗	
Royalties (%)		✗	
Mill Recovery (Variable)		✗	

Upstream Cost			
Mining Cost	✓		
Milling Cost	✓		100%
G&A		✗	
Dilution		✗	
Sustaining Capital		✗	
Corporate G&A		✗	
Profit Margin		✗	
Project Capital		✗	

Modifying Factors -Industry use (%)

Revenue

Metal Price ($)	✓	
Mill Recovery (%) (Fixed)	✓	
Payable Metal (%)	✓	85%
Treatment and Refinery ($)	✗	
Transportation ($)	✗	
Royalties (%)	✗	
Mill Recovery (Variable)	✗	

Upstream Cost

Mining Cost	✓	
Milling Cost	✓	
G&A	✓	90%
Dilution	✗	
Sustaining Capital	✗	
Corporate G&A	✗	
Profit Margin	✗	
Project Capital	✗	

Modifying Factors -Industry use (%)

Revenue

- Metal Price ($) ✓
- Mill Recovery (%) (Fixed) ✓
- Payable Metal (%) ✓
- Treatment and Refinery ($) ✓
- Transportation ($) ✗
- Royalties (%) ✗
- Mill Recovery (Variable) ✗

80%

Upstream Cost

- Mining Cost ✓
- Milling Cost ✓
- G&A ✓
- Dilution ✓
- Sustaining Capital ✗
- Corporate G&A ✗
- Profit Margin ✗
- Project Capital ✗

70%

Modifying Factors -Industry use (%)

Revenue

Metal Price ($)	✓	
Mill Recovery (%) (Fixed)	✓	
Payable Metal (%)	✓	
Treatment and Refinery ($)	✓	
Transportation ($)	✓	75%
Royalties (%)	✗	
Mill Recovery (Variable)	✗	

Upstream Cost

Mining Cost	✓	
Milling Cost	✓	
G&A	✓	
Dilution	✓	
Sustaining Capital	✓	55%
Corporate G&A	✗	
Profit Margin	✗	
Project Capital	✗	

Modifying Factors -Industry use (%)

Revenue		
Metal Price ($)	✓	
Mill Recovery (%) (Fixed)	✓	
Payable Metal (%)	✓	
Treatment and Refinery ($)	✓	
Transportation ($)	✓	
Royalties (%)	✓	75%
Mill Recovery (Variable)	✗	

Upstream Cost		
Mining Cost	✓	
Milling Cost	✓	
G&A	✓	
Dilution	✓	
Sustaining Capital	✓	
Corporate G&A	✓	25%
Profit Margin	✗	
Project Capital	✗	

Modifying Factors -Industry use (%)

Revenue		
Metal Price ($)	✓	
Mill Recovery (%) (Fixed)	✓	
Payable Metal (%)	✓	
Treatment and Refinery ($)	✓	
Transportation ($)	✓	
Royalties (%)	✓	
Mill Recovery (Variable)	✓	20%

Upstream Cost		
Mining Cost	✓	
Milling Cost	✓	
G&A	✓	
Dilution	✓	
Sustaining Capital	✓	
Corporate G&A	✓	
Profit Margin	✓	10%
Project Capital	✗	

Modifying Factors -Industry use (%)

Revenue

Metal Price ($)	✓	
Mill Recovery (%) (Fixed)	✓	
Payable Metal (%)	✓	
Treatment and Refinery ($)	✓	
Transportation ($)	✓	
Royalties (%)	✓	
Mill Recovery (Variable)	✓	20%

Upstream Cost

Mining Cost	✓	
Milling Cost	✓	
G&A	✓	
Dilution	✓	
Sustaining Capital	✓	
Corporate G&A	✓	
Profit Margin	✓	
Project Capital	✓	10%

Industry Best Practice

Revenue

- Metal Price ✓
- Mill Recovery (%) ✓
- Payable Metal (%) ✓
- Treatment and Refinery ✓
- Transportation ✓
- Royalties ✓
- Mill Recovery (Variable) ✓

Upstream Cost

- Mining Cost ✓
- Milling Cost ✓
- G&A ✓
- Dilution ✓
- Sustaining Capital ✓
- Corporate G&A ✓

Profit Margin ?

Project Capital ✗

…reflect cashflow model inputs

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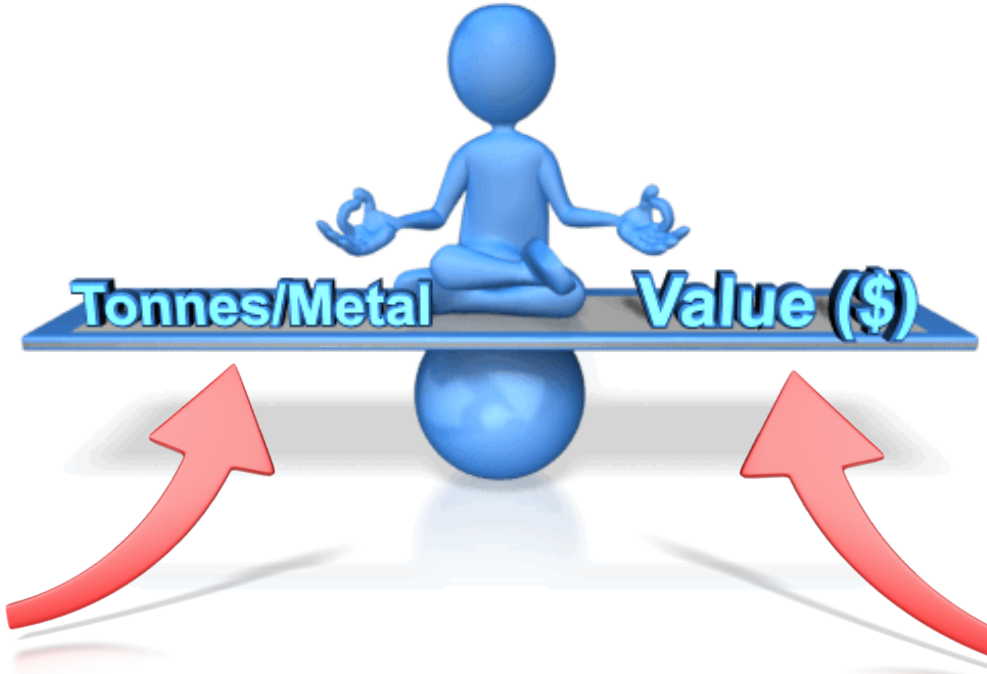

High Ounces/Metal
High Tonnes
Long Mine Life

Less Ounces/Metal
Less Tonnes
Short Mine Life
Higher Value?

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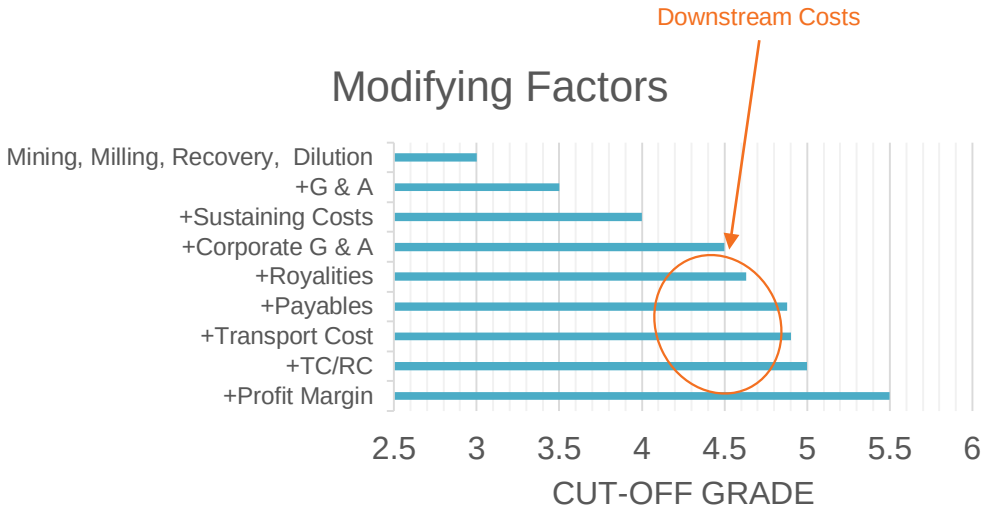
Case Study

- Created various COG scenarios by including and excluding common modifying factors.

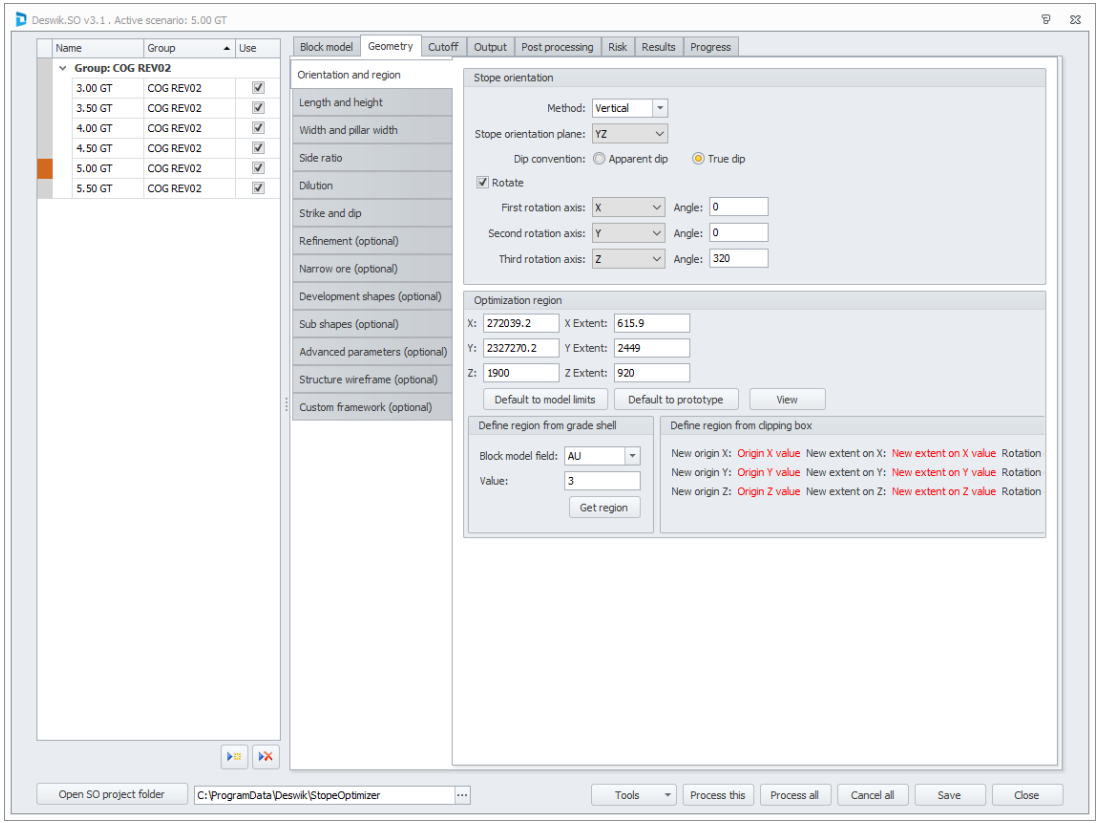


Modifying Factors	Units	Value
Metal Price	USD/oz	1,250
Payable Metal	%	99
Treatment & Refining	USD/oz	1.30
Transportation	USD/oz	4.00
Royalty	%	5
Mill Recovery	%	92
Mining Cost	$/t	80
Milling Cost	$/t	27
G & A	$/t	25
Corporate G & A	$/t	2
Sustaining Capital	$/t	15
Profit Margin	$/t	15
Dilution	%	15

Case Study

Modifying Factors	COG Scenario
Profit Margin	5.50
Downstream Costs	5.00
Corporate G & A	4.50
Sustaining Costs	4.00
G & A	3.50
Dilution	3.00

Parameter	Value
Level Spacing	25 m
Strike Length	20 m
Minimum Width	3 m
Minimum Dip	55°



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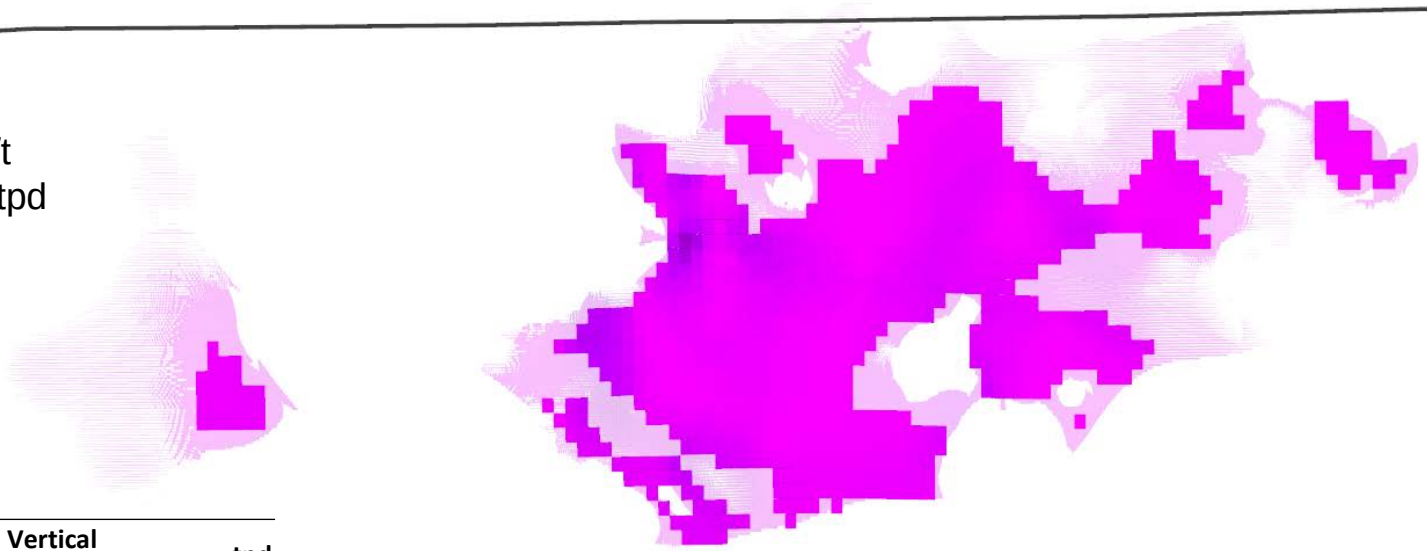
Mining, Milling, Recovery, Dilution = 3.0 gpt

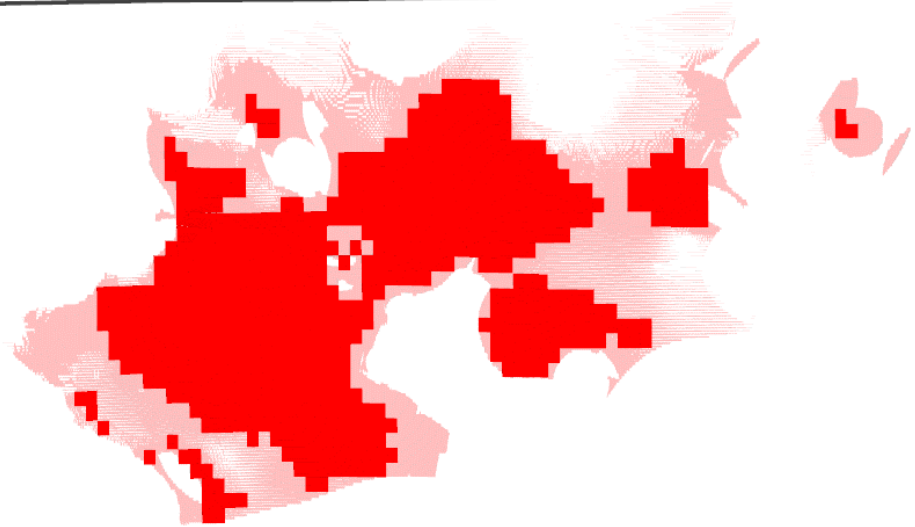
COG 3.0 g/t
Total Tonnes = 6.9M
Average Grade = 4.52 g/t
Production Rate = 2400 tpd



COG	Tonnes	Vertical Metres	tpd
3.00	6,901,787	775	2,400
3.50	5,116,866	750	1,800
4.00	3,915,709	675	1,600
4.50	3,140,989	625	1,400
5.00	2,095,061	550	1,000
5.50	1,396,578	475	800

G & A = 3.5 gpt

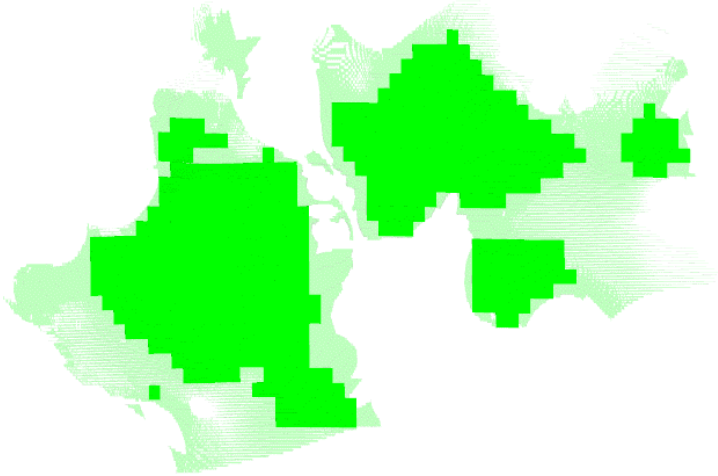
COG 3.5 gpt
Total Tonnes = 5.0M
Average Grade = 4.95 g/t
Production Rate = 1800 tpd



COG	Tonnes	Vertical Metres	tpd
3.00	6,901,787	775	2,400
3.50	5,116,866	750	1,800
4.00	3,915,709	675	1,600
4.50	3,140,989	625	1,400
5.00	2,095,061	550	1,000
5.50	1,396,578	475	800

Sustaining Capital = 4.0 gpt

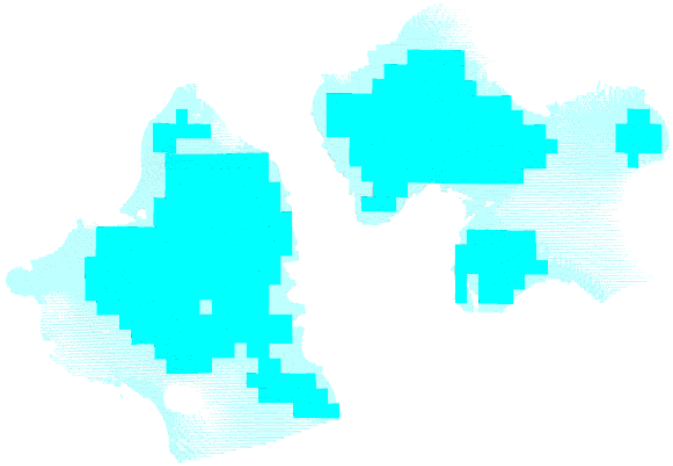
COG 4.0 gpt
Total Tonnes = 4.0M
Average Grade = 5.34 g/t
Production Rate = 1600 tpd



COG	Tonnes	Vertical Metres	tpd
3.00	6,901,787	775	2,400
3.50	5,116,866	750	1,800
4.00	3,915,709	675	1,600
4.50	3,140,989	625	1,400
5.00	2,095,061	550	1,000
5.50	1,396,578	475	800

Corporate G & A = 4.5 gpt

COG 4.5 gpt
Total Tonnes = 3.0M
Average Grade = 5.61 g/t
Production Rate = 1400 tpd



COG	Tonnes	Vertical Metres	tpd
3.00	6,901,787	775	2,400
3.50	5,116,866	750	1,800
4.00	3,915,709	675	1,600
4.50	3,140,989	625	1,400
5.00	2,095,061	550	1,000
5.50	1,396,578	475	800

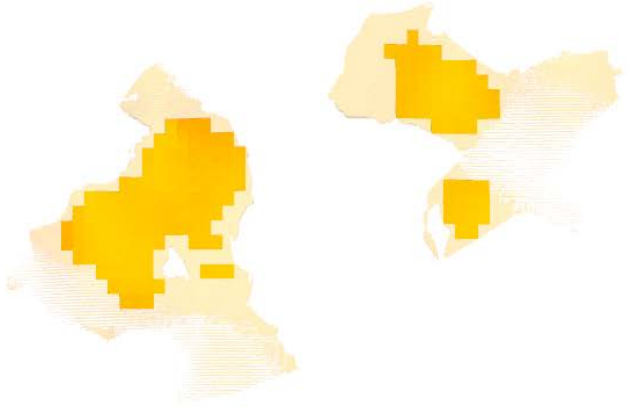
Downstream Cost = 5.0 gpt

COG 5.0 gpt
Total Tonnes = 2.0M
Average Grade = 6.03 g/t
Production Rate = 1000 tpd

COG	Tonnes	Vertical Metres	tpd
3.00	6,901,787	775	2,400
3.50	5,116,866	750	1,800
4.00	3,915,709	675	1,600
4.50	3,140,989	625	1,400
5.00	2,095,061	550	1,000
5.50	1,396,578	475	800

Profit Margin = 5.5 gpt

COG 5.5 gpt
Total Tonnes = 1.4M
Average Grade = 6.44 g/t
Production Rate = 800 tpd



COG	Tonnes	Vertical Metres	tpd
3.00	6,901,787	775	2,400
3.50	5,116,866	750	1,800
4.00	3,915,709	675	1,600
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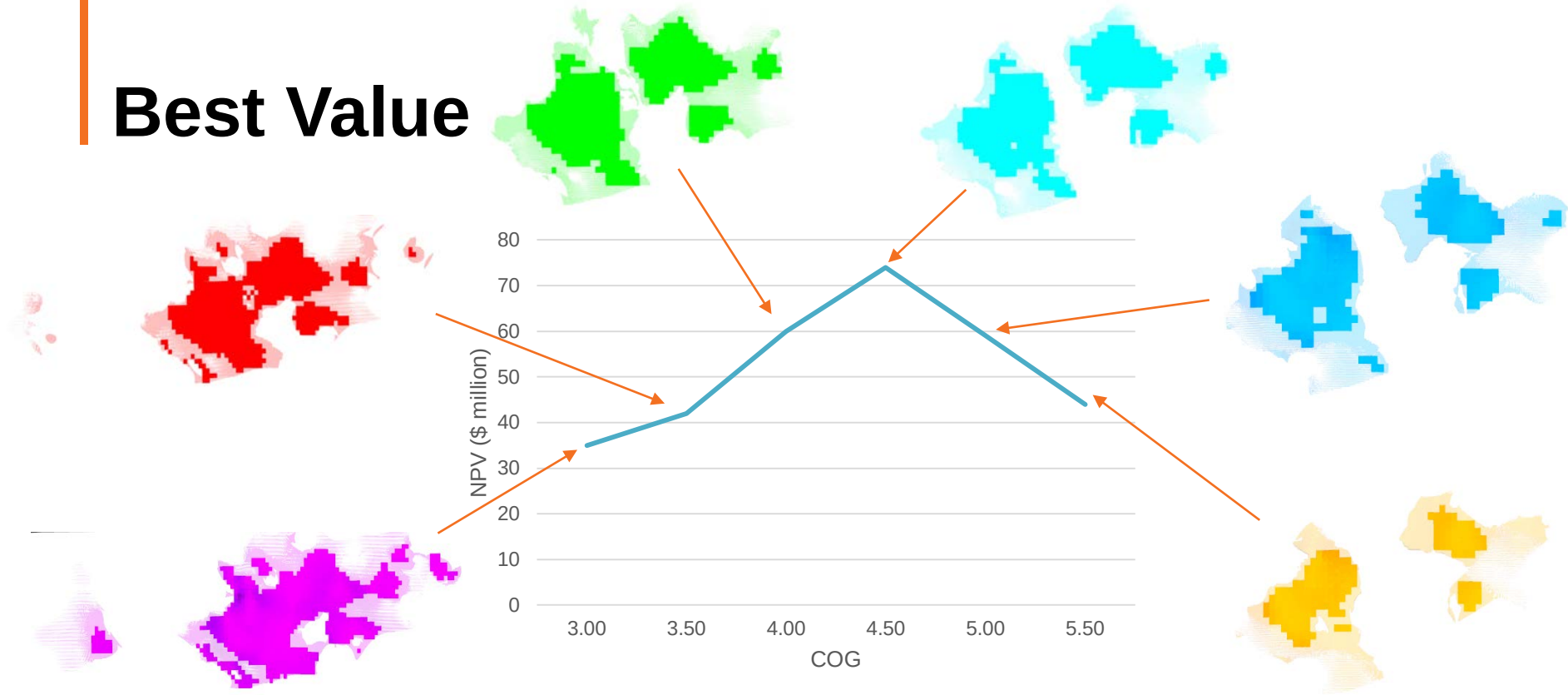
5.00	2,095,061	550	1,000
5.50	1,396,578	475	800

Best Value



What COG should I Use?

What to do?

Industry Best Practice…

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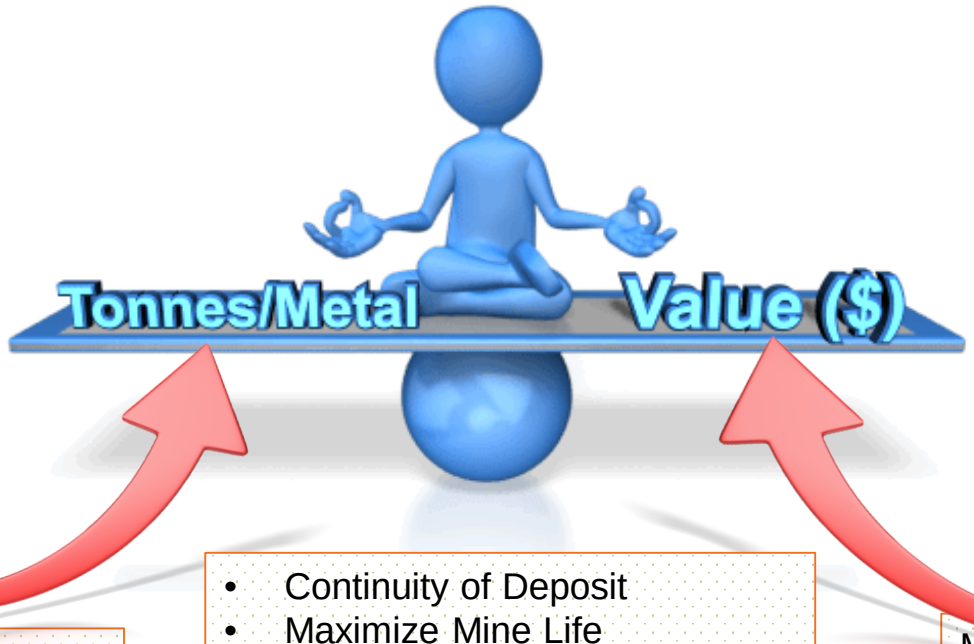
Same as any evaluation?

- Open pit vs Underground?
- Mining Method?
- Material Handling System?

Trade-Off Study

What Cut-off Grade to use?

Step 1 – Define your COG Objective



- Mineable Deposit size
- Long Mine Life
- High Ounces
- Production Profile Consistent

- Continuity of Deposit
- Maximize Mine Life
- High Cashflow up front
- Short term Cash flow
- Consistent Mill Feed
- Robustness to operating cost
- Robust to changing gold prices

Maximize NPV
Maximize IRR
Short Payback

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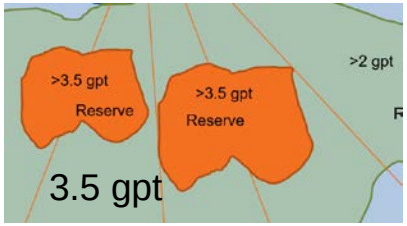
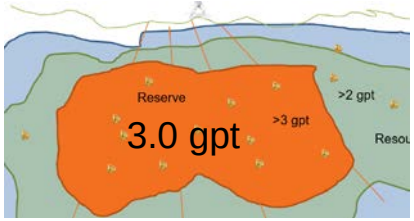
Step 2 – Generate a Base case BCOG

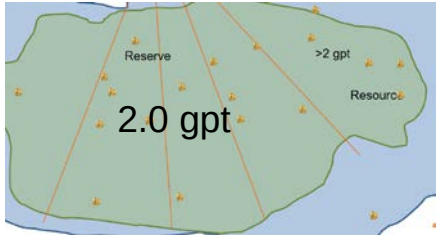
Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

Cost (1 tonne of ore)		
Description	**Unit**	**Total**
Mining	$/t	$42.00/t
Mill	$/t	$20.00/t
Administration(G&A)	$/t	$25.00/t
Sustaining	$/t	**$15.00/t**
Total Opex + Sustaining	$/t	**$102.00/t**
COG – Report - Mill Feed (Head Grade)		**3.0 (Au gpt)**
Dilution	**%**	**10%**
COG –Insitu- Mine Design)		**3.3 (Au gpt)**

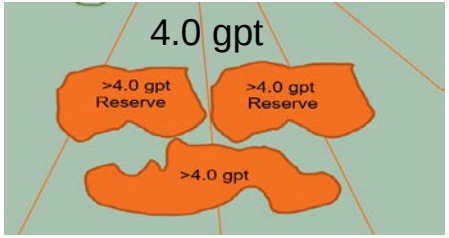
Step 3 – Select Range and Increments of COGs

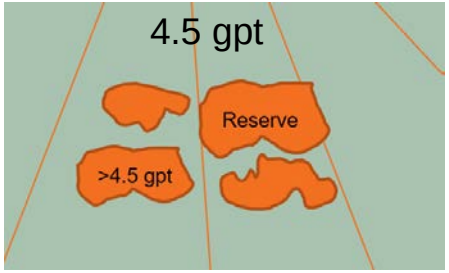






Range: 2.0 gpt to 5.0 gpt
Increments of 0.5 gpt





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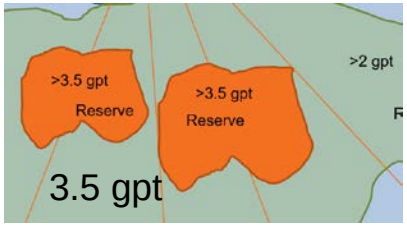
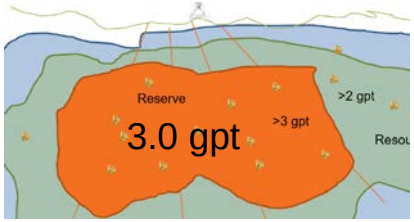
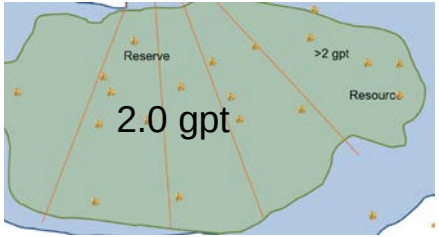
Step 4 – Select Mining Method, Material Handling System and Generate a Mine Plan for Each Scenario



LHOS



SLC



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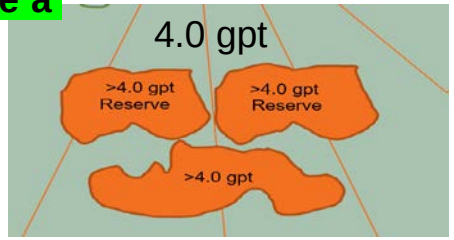

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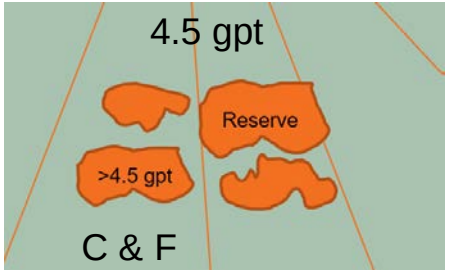
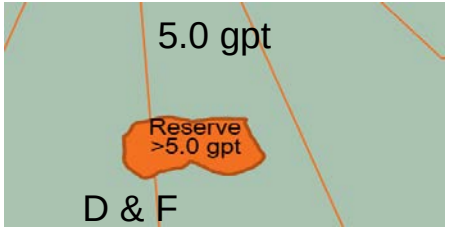
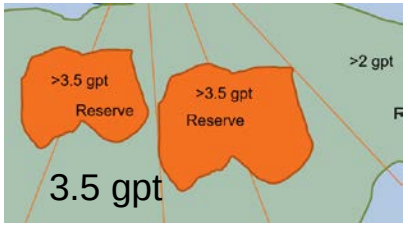




Step 5 – Generate a Cashflow Model for each Scenario



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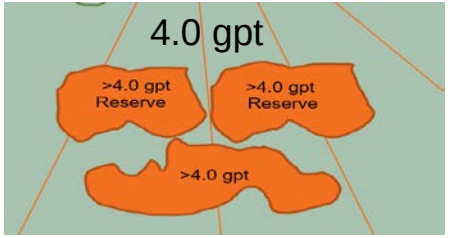

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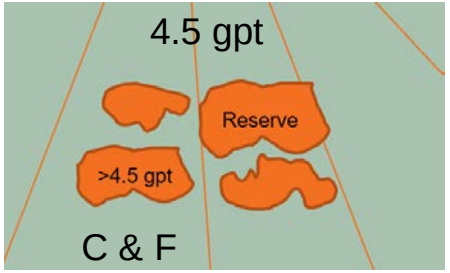

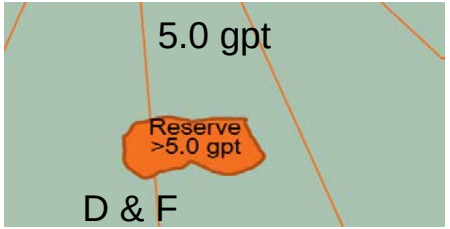

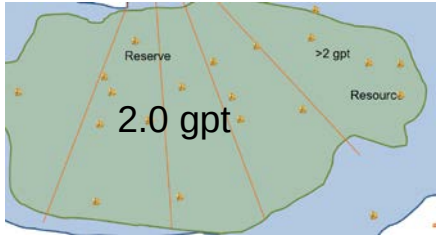

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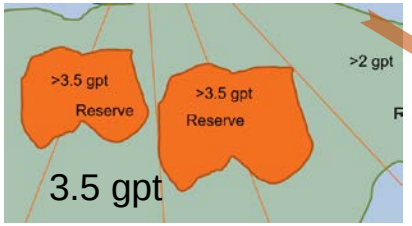
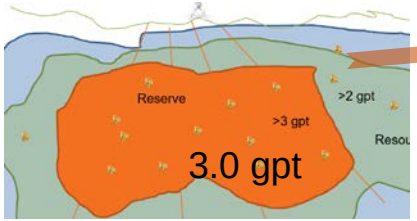
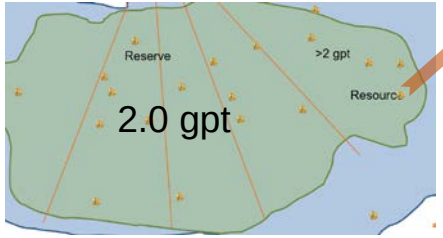
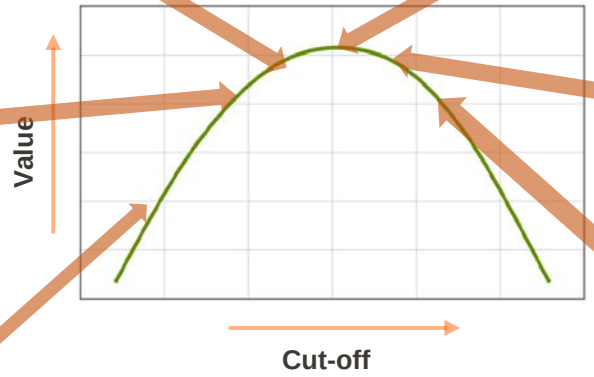
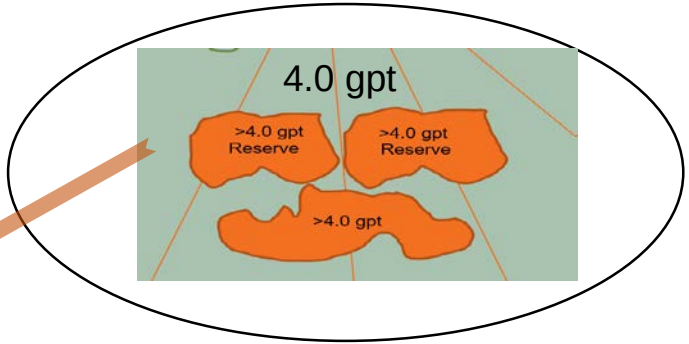
Step 6 – Summarize the Results (e.g. NPV)

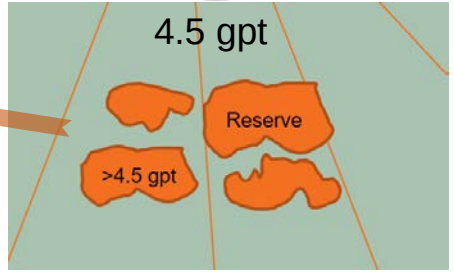


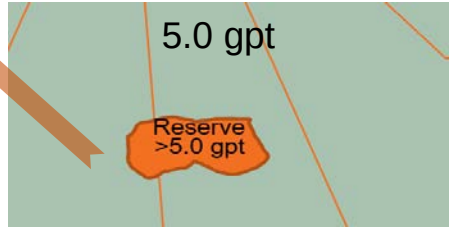












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Step 7 – Summarize the Objectives and Value

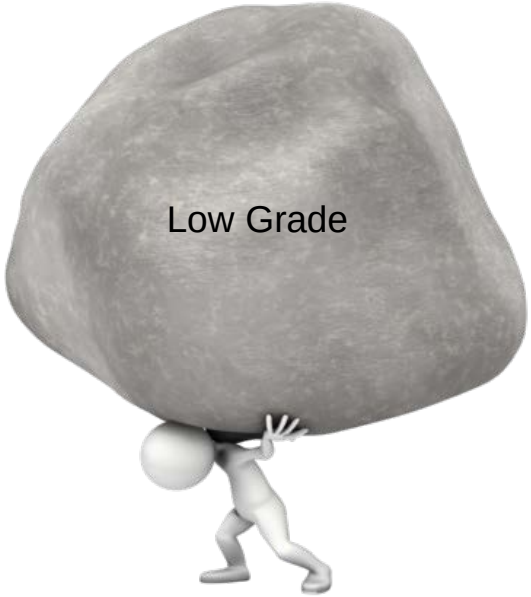
The PUGH Matrix (Decision Strategy Template) is a useful tool to select a COG that produces a mine plan that is best aligned with corporate goals.

DECISION MATRIX				Scenerios	Case 1	Case 2	Case 3	Case 4	Case 5
SELECT				Production (tpd)	4,000	3,500	3,000	2,500	2,000
				Mine Method	LH	LH	Narrow LH	Cut and Fill	Cut and Fill
				COG (g/t)	2.0	3.0	3.5	4.0	4.5
Item #	Weight	Parameter	Description	Ranking Criteria	SELECT				
					14	27	29	27	22
1	High	Net Present Value (NPV)	Maximized NPV		1	1	1	1	0
2	High	Reserve basis	The mineable orebody size		1	3	2	2	3
3	Medium	Mine life	Maximize Mine Life		0	2	2	1	3
4	High	Au Production	Sustainable and consistent Au Oz production		3	1	1	1	1
5	Low	Short term cash flows	Higher cash flows over the first 3 years.		0	1	2	2	0
6	Low	Mill feed	Achieve consistent mill throughput, with a head grade that does not significantly impact the process recovery.		1	1	1	1	1
6	High	Profit Margin	High Profit Margin ensures robustness in the mine design for potential long term profitability		1	1	1	1	1
7	Medium	Sensitivity to Au price	Impact of variations in Au price on the overall economics (upside and downside).		0	1	2	2	1
8	Low	Sensitivity to Operating Costs	Impact of variations in operating cost ($/t ore) on the overall economics.		0	2	2	2	1
9	Medium	Sensitivity to Fixed/Variable cost breakdown	Impact of variations in fixed and variable costs breakdown ($/t ore) on the overall economics.		2	3	3	0	0

Step 8 – Select the Best COG Value

DECISION MATRIX				Scenerios	Case 1	Case 2	Case 3	Case 4	Case 5
SELECT				Production (tpd)	4,000	3,500	3,000	2,500	2,000
				Mine Method	LH	LH	Narrow LH	Cut and Fill	Cut and Fill
				COG (g/t)	2.0	3.0	3.5	4.0	4.5
Item #	Weight	Parameter	Description	Ranking Criteria	SELECT				
					14	27	29	27	22
1	High	Net Present Value (NPV)	Maximized NPV		1	1	1	1	0
2	High	Reserve basis	The mineable orebody size		1	3	2	2	3
3	Medium	Mine life	Maximize Mine Life		0	2	2	1	3
4	High	Au Production	Sustainable and consistent Au Oz production		3	1	1	1	1
5	Low	Short term cash flows	Higher cash flows over the first 3 years.		0	1	2	2	0
6	Low	Mill feed	Achieve consistent mill throughput, with a head grade that does not significantly impact the process recovery.		1	1	1	1	1
6	High	Profit Margin	High Profit Margin ensures robustness in the mine design for potential long term profitability		1	1	1	1	1
7	Medium	Sensitivity to Au price	Impact of variations in Au price on the overall economics (upside and downside).		0	1	2	2	1
8	Low	Sensitivity to Operating Costs	Impact of variations in operating cost ($/t ore) on the overall economics.		0	2	2	2	1
9	Medium	Sensitivity to Fixed/Variable cost breakdown	Impact of variations in fixed and variable costs breakdown ($/t ore) on the overall economics.		2	3	3	0	0

“Lets mine that low grade stuff!!!!”



Below Cut-off???

In **Rare** situations it may make sense if…

- Capacity in the Mill.
- Capacity in the Mine.
- Does not displace planned COG Ore.
- Does not de-rail LoM Plan.
- It makes economic sense.

- Be sure there are processes in place for sign-off and approval.

There are circumstances where mineralized material, although below the stated LOM COG, may still be deemed economic.

Incremental Cut–off Grade

Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

Cost (1 tonne of ore)				
Description	**Unit**	**Fixed**	**Var.**	**Total**
Mining	$/t	~~20~~	20	20.00
Mill	$/t	~~9~~	9	9.00
Administration(G&A)	$/t	~~8~~	2	2.00
Sustaining	$/t	-	-	-
Total Opex + Sustaining	$/t			**31.00**
COG – Report - Mill Feed (Head Grade)	**gpt**			**0.90**
Dilution	**%**			**10%**
COG –Insitu- Mine Design)	**gpt**			**1.00**

$$ICOG = \frac{Variable\ Mining\ Cost + Variable\ Processing\ Cost + Variable\ G\&A\ Cost}{Process\ Recovery\ x\ (Metal\ Price - TCRC\ Cost - Royalties)}$$

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Development Cut-off Grade

Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

Cost (1 tonne of ore)				
Description	**Unit**	**Fixed**	**Var.**	**Total**
Mining	$/t	~~20~~	~~20~~	-
Re-Handling	$/t	~~-~~	5	5.00
Mill	$/t	~~9~~	9	9.00
Administration(G&A)	$/t	~~8~~	2	2.00
Sustaining	$/t	**-**	**-**	**-**
Total Opex + Sustaining	$/t			**16.00**
COG – Report - Mill Feed (Head Grade)	**gpt**			**0.50**

$$MCOG = \frac{Mine\ Rehandling\ Cost + Variable\ Processing\ Cost + Variable\ G\&A\ Cost}{Process\ Recovery\ x\ (Metal\ Price - TCRC\ Cost - Royalties)}$$

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Summary

- The COG/COV will set the course for your entire operation, choose it wisely.
- Include input parameters in your COG calculation that reflect what you would have in your cashflow model.
- Understand your project/mine corporate objectives.
- Complete a trade-off study on various COG to identify the COG that yields best value.
- Complete a decision matrix or other tool to select the preferred COG.
- Have various COG based on mine areas or zones if relevant.
- Balance value with effort when completing this exercise.
- Use Incremental “ore” in rare circumstances when there is capacity and you manage it well.

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Gary is involved in leadership within the mining consulting industry. Gary provides technical advice, mine and project reviews, due diligence and audits, cut-off grade analysis, operating cost estimation, mine design and economic and productivity improvement studies, as well as training and mentoring in all aspects of mine orebody extraction in the underground environment. This involves high level concept projects, PEA, PFS, Feasibility, project execution and operational assistance. He assists clients in providing innovative albeit practical solutions to complex problems.

Gary's technical experience covers a wide range of commodities, geographic and mining settings.

Gary is a professional engineer registered in Ontario and a professional project manager, he has previously held positions as Vice Chairman of Camiro, Membership Chair of the CIM Sudbury Branch, and is currently on the Canadian CIM Council and Chair of the CIM Underground Mining Society. Gary has a PEng in Mining Engineering and is a graduate from Laurentian University, Canada (1991).

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Joseph is a Mining Consultant with SRK Consulting based out of Sudbury. He recently transferred from SRK's UK office and brings technical expertise in mine planning and scheduling using Deswik software. He assists clients in all aspects of mine design and scheduling ranging from long range strategic planning right the way down to the implementation of short term scheduling solutions to help clients maximize the value of their assets.

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