

Development – Cost for Miners

Understanding and Managing Mine Costs

Prepared for:

CIM Connect
May 13, 2024

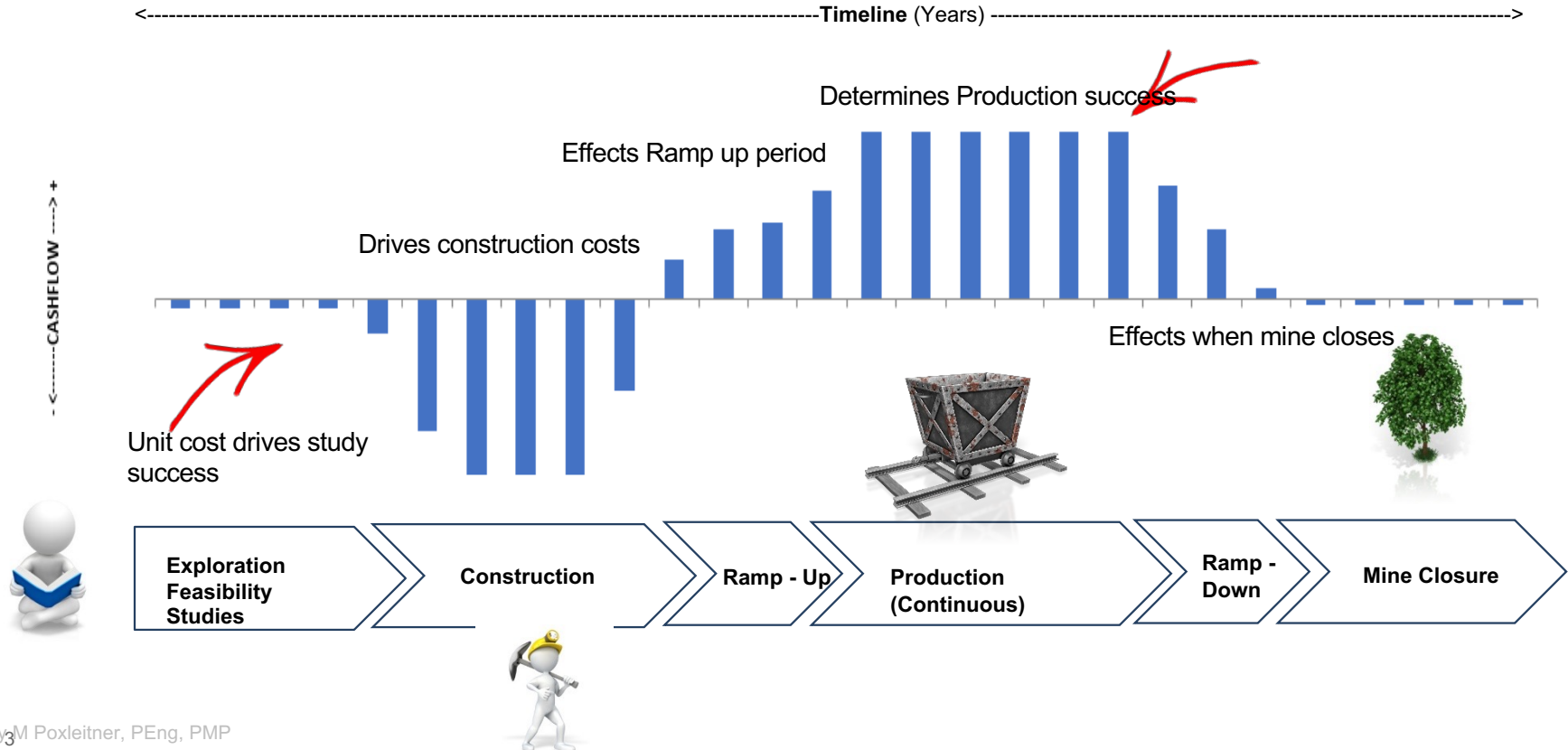
Prepared by:

Gary M Poxleitner, PEng, PMP
Practice Leader, SRK Consulting (Canada) Ltd





Lateral Development Drives Production

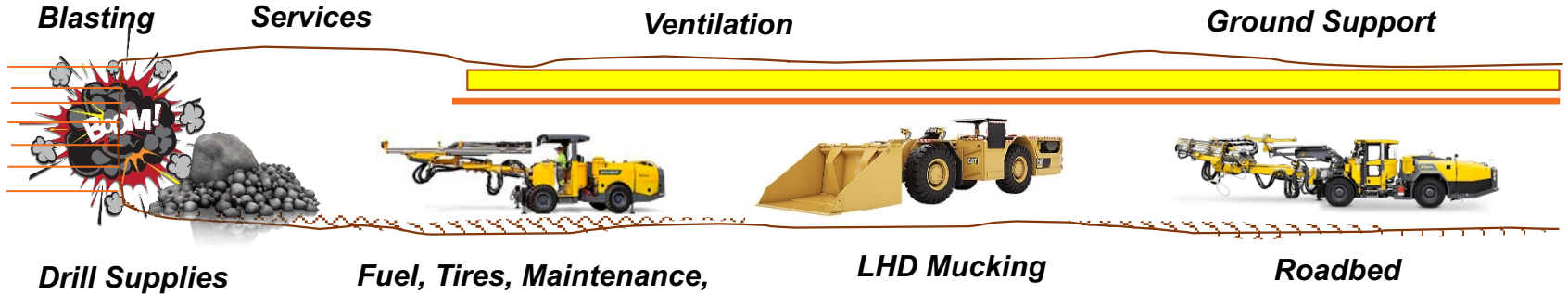


Development Round

Labour



-3.6 m Round
- Cost/m (C\$)



Materials (Drill/Blast, Ground Support, Muck/Services)

Development Cost Includes

Physicals:

- **Consumables:** bits, steel, explosives, bolts, shotcrete, screen, misc allowances
- **Mobile Equipment:** parts wearable, fuel, lube, tires, buckets, power
- **Labour:** Operator

Timeline:

- **Consumables:** life of parts in hours
- **Mobile Equipment:** total cost per hour of use
- **Labour:** Cost per person per shift (round up)

Cost:

- **Consumables:** Cost per round (e.g. 3.2 m) – cost per metre
- **Mobile Equipment:** Total hours required per round – cost per metre
- **Labour:** Operator: shifts to complete round - roundup to end of shift for one round

Development Cost Assumptions

The following cost were provided by various actuals expenditures from numerous operating mines, then normalized within a range. The selected a mean average.

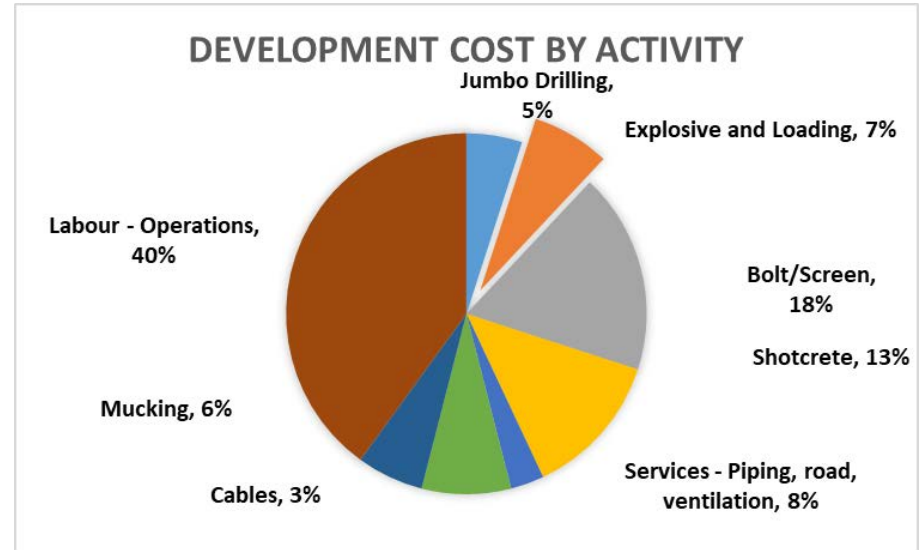
Cost then can be re-created on a first principal basis to use in other applications.

Assumptions include:

- *Single heading drives of 3.6m drilled 3.5m broken*
- *Based on effective hours available*
- *Based on operating mines*

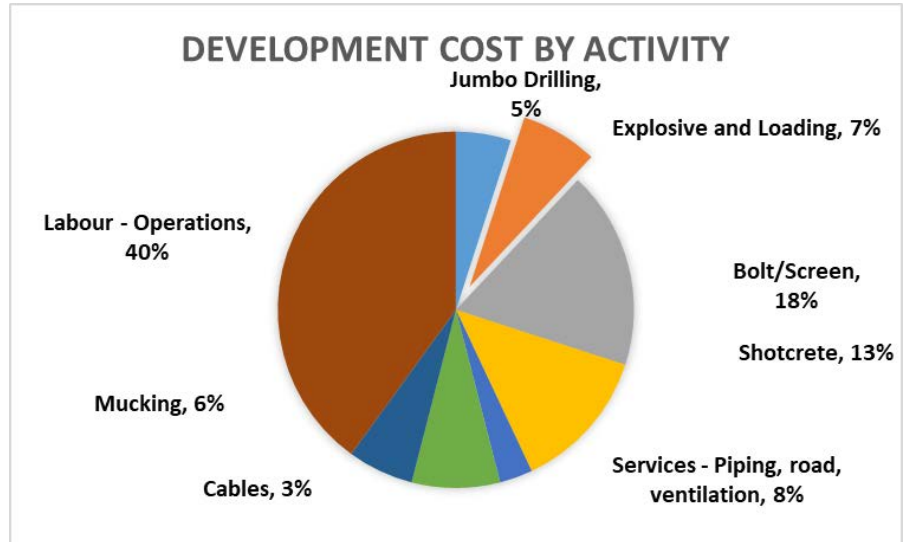
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



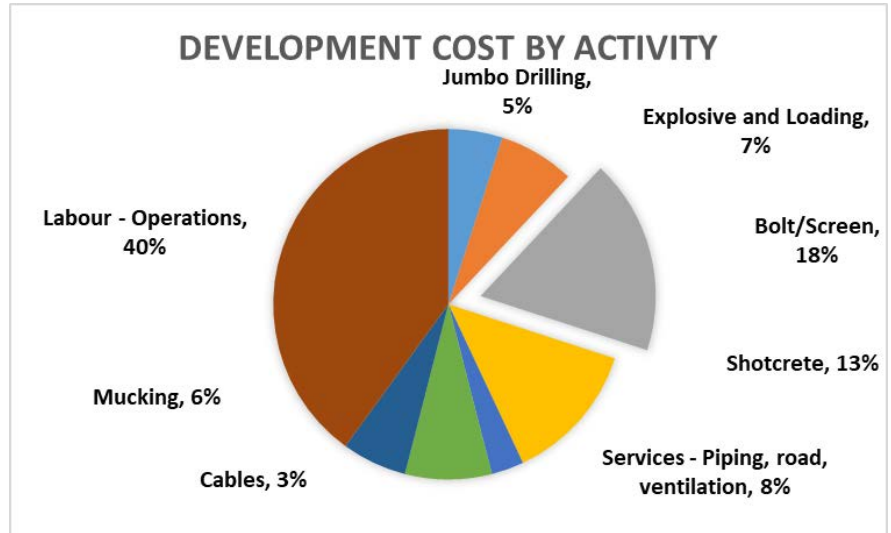
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



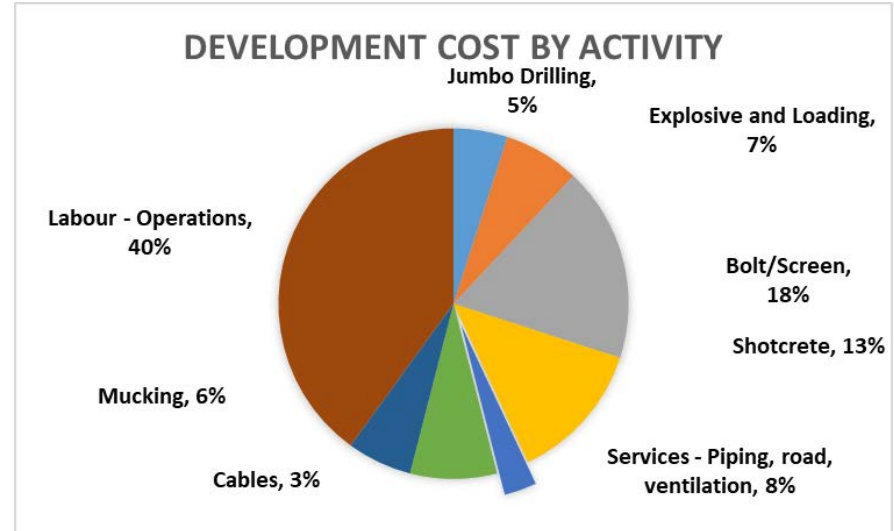
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



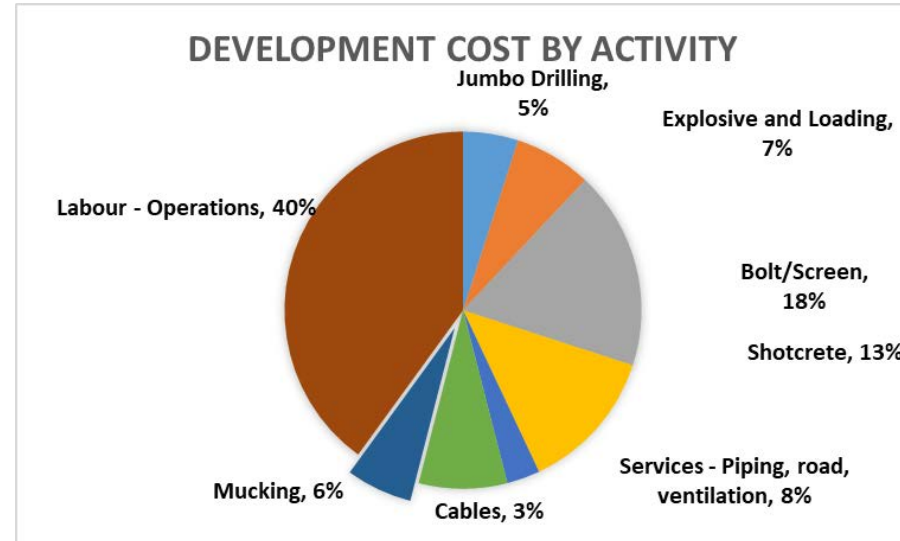
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



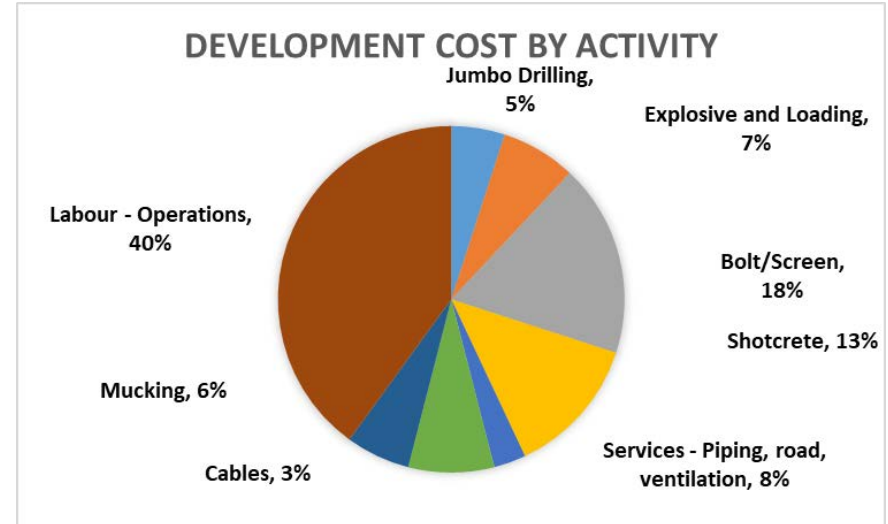
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



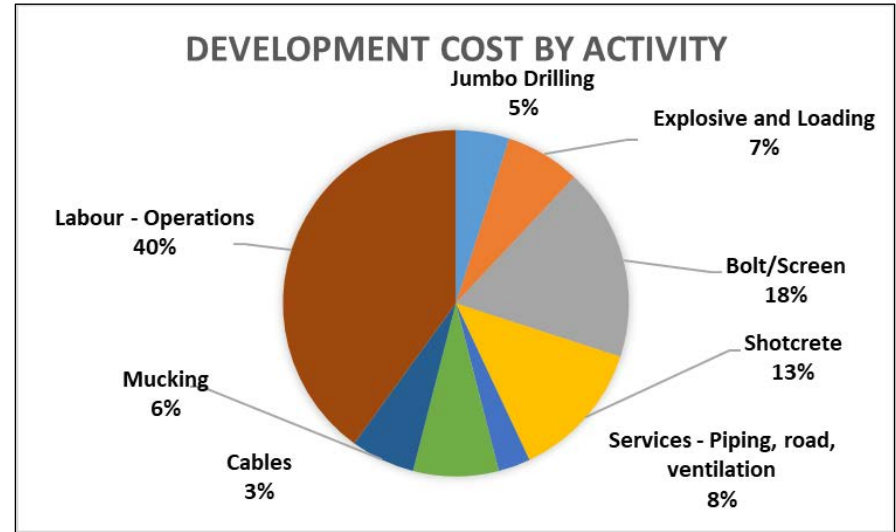
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



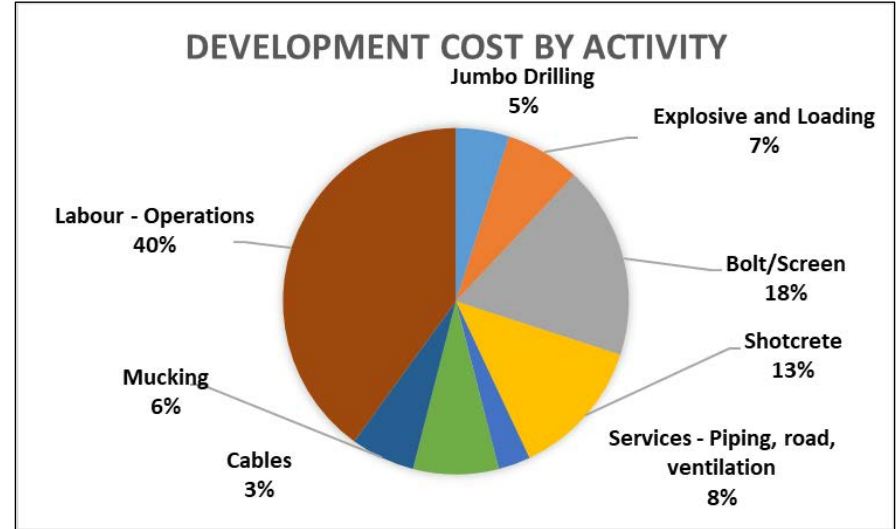
Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



Development Cost Summary

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



Ground Support

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, road, ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	



Ground Support

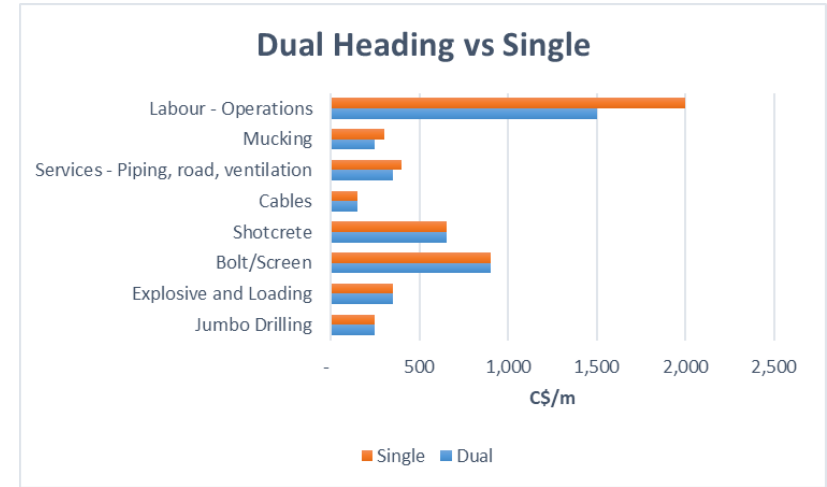
Activity	C\$/m Good Grd	C\$/m Poor Grd
Jumbo Drilling	250	275
Explosive and Loading	350	385
Ground Support	1,700	2,685
-Bolt/Screen	900	1,530
-Shotcrete	650	975
-Cables	150	180
Services - Piping, Road, Ventilation	400	520
Mucking	300	260
Labour - Operations	2000	4,000
Total - All -In	5000	8,125
Labour- Maintenance	800	950
Indirects – Admin., Training, Utilities	850	750
Total - All -In	6,650	9,825

Ground Standard	\$/m
Type A	603
Type B	878
Type C	987
Type D	1418
Type E	1873
Type F	3,065

- Labour also increases with more development
- And so does everything else since the cycle time is longer

Single Heading vs. Multiple

Activity	Dual Heading	Single Heading	C\$/m
Jumbo Drilling	200		250
Explosive and Loading	315		350
Ground Support	1,425		1,700
-Bolt/Screen	750		900
-Shotcrete	550		650
-Cables	125		150
Services - Piping, Road, Ventilation	380		400
Mucking	275		300
Labour - Operations	1,805		2000
Total - All -In	4,400		5000
Labour- Maintenance	700		800
Indirects – Admin., Training, Utilities	700		850
Total - All -In	5,800		6,650



Cost savings primarily on Labour with 2 or three headings per crew

Capital Development vs Operating

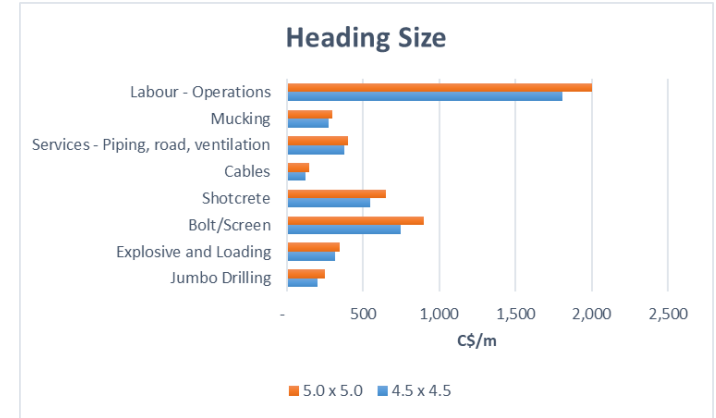
Activity	C\$/m Capital	C\$/m Opex
Jumbo Drilling	275	250
Explosive and Loading	385	350
Ground Support	1,955	1,700
-Bolt/Screen	1,035	900
-Shotcrete	750	650
-Cables	170	150
Services - Piping, Road, Ventilation	435	400
Mucking	250	300
Labour - Operations	2,200	2000
Total - All -In	5,500	5000
Labour- Maintenance	800	800
Indirects - Admin, Training, Utilities	850	850
Total - All -In	7,150	6,650

Capital such as ramp development typically has control blasting techniques, less headings available and more ground support



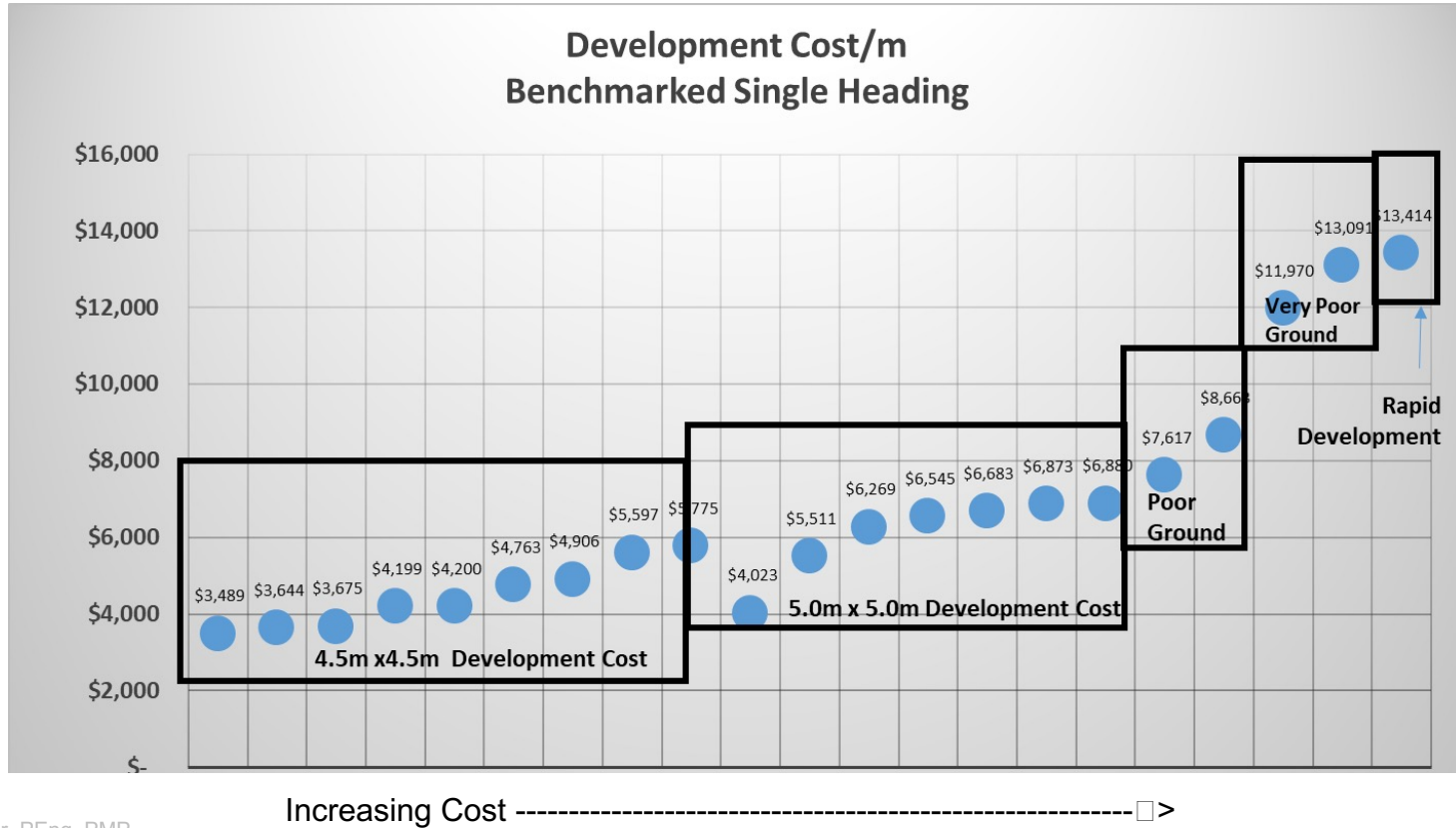
Heading Size 4.5 m vs. 5.0 m

Activity	Opex 4.5 x 4.5	Opex 5 x 5
Jumbo Drilling	200	250
Explosive and Loading	315	350
Ground Support	1,425	1,700
Bolt/Screen	750	900
Shotcrete	550	650
Cables	125	150
Services - Piping, Road, Ventilation	380	400
Mucking	275	300
Labour - Operations	1,805	2000
Total - All - In	4,400	5000
Labour- Maintenance	700	800
Indirects – Admin., Training, Utilities	700	850
Total - All - In	5,800	6,650



Smaller Heading has some savings to supplies and labour

Development Cost Benchmark



Advance Rates

Elephant in the room – low advance rates

- Based on sustainable advance rates 6 months to 1 year
- Historically rates decreasing not increasing
- Increase unit \$/m
Increases labour cost
- Unable to cycle in a shift



Cost Management

Activity	C\$/m Single Heading	% of Total
Jumbo Drilling	250	5
Explosive and Loading	350	7
Ground Support	1,700	34
-Bolt/Screen	900	18
-Shotcrete	650	13
-Cables	150	3
Services - Piping, Road, Ventilation	400	8
Mucking	300	6
Labour - Operations	2000	40
Total - All -In	5000	100
Labour- Maintenance	800	
Indirects – Admin., Training, Utilities	850	
Total - All -In	6,650	

Ground Support – Control Overbreak

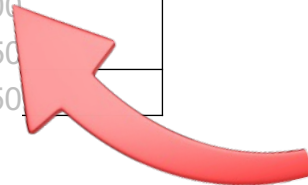
- Good drill/blast techniques
- Avoid excessive explosives (i.e. pf)
- Ground support for purpose apply correct system
- Incentive system that supports bolting effectively
- Remote Bolting Application work safer and increase seat time

Labour

- Increase equipment availability
- Improve operating hours
- Improve face time
- Use simulation modeling to determine bottlenecks and cycle effectively

How Low can we go (C\$/m)?

Activity	Ideal Heading	Base Case
Jumbo Drilling	200	250
Explosive and Loading	350	350
Ground Support	600	1,700
-Bolt/Screen	600	900
-Shotcrete	0	650
-Cables	0	150
Services - Piping, Road, Ventilation	300	400
Mucking	250	300
Labour - Operations	1,300	2000
Total - All -In	3,000	5000
Labour- Maintenance	600	800
Indirects – Admin., Training, Utilities	600	850
Total - All - In	4,200	6,650



Smaller Heading has some savings to supplies and labour

Advance Rates Case Study - Labour

Hours per Shift (Portal to Portal)	Units	12.00
Less		
Line-Up and Safety Talk	hr/sft	0.50
Travel - In	hr/sft	0.84
Pre-Op Checks	hr/sft	0.17
Lunch/Breaks (travel to lunchroom)	hr/sft	0.75
Wash and grease at end of shift	hr/sft	0.17
Operator unavailable and other interference	hr/sft	0.25
Vehicle loading/Pick-up Area	hr/sft	0.42
Refuelling	hr/sft	0.17
Travel - Out	hr/sft	1.00
Total Non-Operating Time	hr/sft	4.27
Total Operating Time	hr/sft	7.73
Utilization of shift time	hr/sft	64%
Availability (Scheduled Maintenance/Breakdowns)	%	80%
Average available hours per shift	hr./sft	6.18
(Mob)	hr	0.50
(Demob)	hr	0.50

Development - Cycle Summary 3.8 m advance		Cycle
Activity		hr/rnd
Drilling		1.8
Blasting		1.3
Grd Support - A		14.4
Grd Support - B		14.4
Grd Support - C		9.9
Grd Support - D		18.2
Ground Support - Combined		14.06
Mucking		2.7
Shotcrete & Cable bolts		3.6
Services		2.0
Total Development		25.4
Cycle time 7 hrs/shift out of 12 hours		2
Cycle time		1.9

Source: Northern Ontario Hard rock mine

Cost Build Up – i.e. Jumbo Drill

A. Drill Parameters – total equipment hrs/rnd

- Set-up time
- Drill Pattern/number of holes/depth
- Time to move from one hole to another
- Drill time/re-drilling/cleaning hole time

B. Labour

- Operator Time – hrs/rnd
- Maintenance Time – maintenace time /operating hour

C. Consumables

- Usage Time – hrs/rnd
- Steel, shanks, couplings, bits, etc. replacement life x unit cost

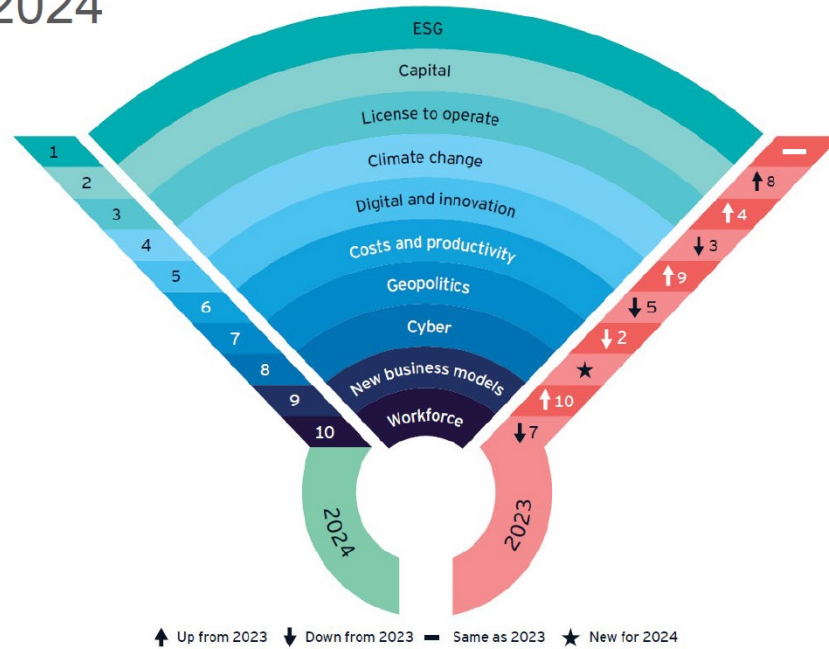
D. Mobile

- Run Time – hrs/rnd
- Incl. Fuel, Lube, Parts, Tires

Capture Fuel for Scope 1 Carbon Tax

Sustainable Mining

Top 10 business risks and opportunities for mining and metals in 2024



https://www.ey.com/en_gl/insights/energy-resources/risks-opportunities#:~:text=Summary,healthier%2C%20more%20attractive%20workforce%20culture.

Sustainable Mining

In Canada, we have a carbon tax of C\$ 80 per tonne and it will increase by C\$15 every year until 2030 when it will reach C\$170.

Opportunity to reduce with electrification.

Scope 1 “Direct GHG emissions occur from sources that are owned or controlled by the company”

Results in \$171/rnd direct development.

Scope 2: Accounts for GHG emissions from the generation of purchased electricity consumed by the company.

Scope 3: Is an optional reporting category that allows for the treatment of all other indirect emissions.

Fuel Usage	Fuel	Carbon Emissions	Carbon Tax	Carbon Tax
Activity	l/rnd	tCO2e	\$/t	\$/rnd
Drilling	25	0.07	80.00	5.44
Blasting	42	0.11	80.00	8.95
Grd Support	190	0.51	80.00	40.85
Mucking	289	0.78	80.00	62.17
Shotcrete & Cable bolts	66	0.18	80.00	14.12
Services	36	0.10	80.00	7.65
Other Support (Supplies)	147	0.40	80.00	31.72
Total	794	2.14	560.00	170.90

Source:Dhiren Naidoo SRK UK
 $((2681\text{CO}_2 \times 1 \text{ litres}) + (0.078\text{CH}_4 \times 28 \text{ litres}) + (0.022\text{N}_2\text{O} \times 265 \text{ litres})) / 1000000$



Summary

- Note development drives production – keep it as a focus
- Face time activity
 - Increase operational hours – remote between shifts
 - Keep equipment available or on stand-by
 - Remote activity when possible
- Maximize use of personnel with dual declines to make available headings possible
- Larger headings not always better
- Use best blasting practices – control perimeter
- Remote Face Loading (i.e. Avatel) in high stress ground
- Remote bolting (i.e. Epiroc Boltec M10 with ABR system potential for drilling between shifts?)
- Alternatives to conventional loading and blasting with explosives (Dr. Hani Mitri) *“Breaking rocks without explosives – a mine safety paradigm shift”*



About the Author



Gary M Poxleitner, PEng, PMP
Practice Leader/Principal Consultant
SRK Consulting (Canada) Inc.

<https://www.linkedin.com/in/gpoxleitner/>

gpoxleitner@srk.com

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, Gary has served as a Board Member of SRK, CIM Sudbury Board Membership Chair, Chair of the CIM UMS, Vice-Chair of Camiro and on CIM National Council.

Gary is a Practice Leader for SRK Consulting Ltd, Past Chair of the CIM Underground Mining Society, and Current Chair of the CIM National Guidelines, Standards and Leading Practice Directorate.

