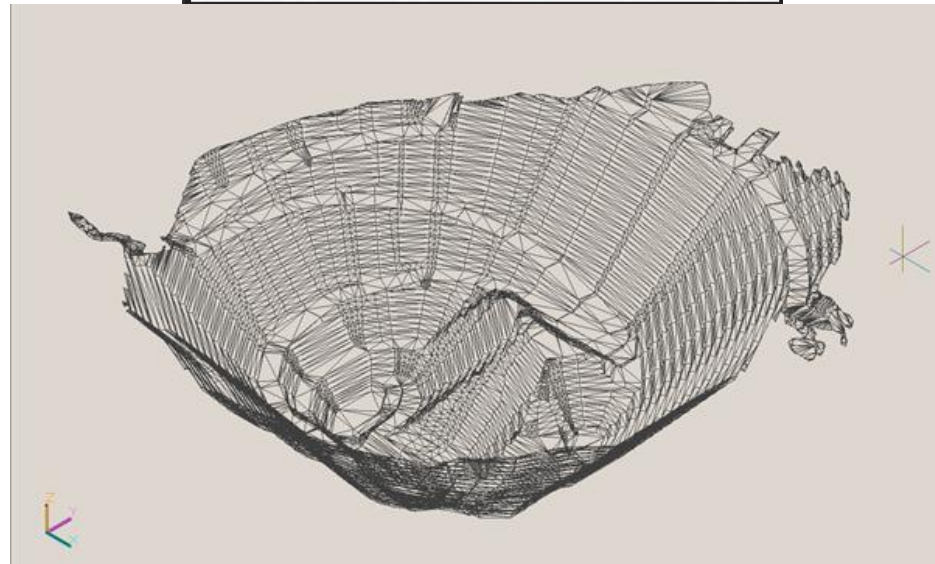


# Enterprise Optimization and Grind-Throughput-Recovery for the Avanti Kitsault Project

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# A Review- Enterprise Optimization

A holistic study methodology of the mining business, resource to market.

- Activity-based Costing and Theory of Constraints
  - Model cost behavior
  - Focus on production bottleneck in the business system
  - Create a net value model
- Ten step methodology
  - Additional sustainability and uncertainty steps 11-12
- Powerful NPV-driven optimizing engine- Prober
  - Jeff Whittle

# Activity-based costing

Model cost behavior, this is not GAAP accounting  
Costs reallocated to attributable and period cost

## Mine

Operating Costs	Unit	Type
General Mine Expense	C\$000/yr	Period Cost
Drilling	C\$/t	Attributable Cost
Blasting	C\$/t	Attributable Cost
Loading	C\$/t	Attributable Cost
Hauling	C\$/t	Attributable Cost
Support	C\$000/yr	Period Cost
Rehandle	C\$/t	Attributable Cost
Snow mining	C\$/t	Attributable Cost
<b>Total Attributable Component</b>	C\$/t	Attributable Cost
<b>Total Period Component</b>	C\$000/yr	Period Cost

## Process

Operating Costs	Unit	Type
General Plant Expense	C\$000/yr	Period Cost
Plant Labor	C\$000/yr	Period Cost
Power	C\$/t	Attributable Cost
Reagent	C\$/t	Attributable Cost
Oxygen	C\$/t	Attributable Cost
Refining	C\$/t	Attributable Cost
<b>Total Attributable Component</b>	C\$/t	Attributable Cost
<b>Total Period Component</b>	C\$000/yr	Period Cost

# Theory of Constraints

- All complex systems have a controlling rate
- It is typical for a mining business to be limited by the milling and processing plant (the bottleneck)
- How do you maximize the value through the bottleneck? This is an opportunity:
  - Design for extra capacity downstream, like a flotation circuit and downstream hydraulic capacity
  - Allow operational flexibility in terms of changing grind size or con grade
  - Apply period costs as opportunity cost

# Prober- Optimizing Engine

- Written by Jeff Whittle in the early 80s
- Pit optimizer commercialized with Geovia (formerly Gemcom)
- SIMO (steps 1-6) released by Geovia late 2012, single plant single mine
- Ad hoc components held by Whittle Consulting, used for Enterprise Optimization Studies
  - Fortran code, hyper-cubes, over 100 processors
  - This is not a GUI interface code

# Twelve Step Program

As applied in a study

1. Variable Cut-off Grade
2. Stockpiling
3. Schedule
4. Pit Design- constraint
5. Phase Design- constraint
6. All of the above simultaneously
7. Processing policy (grind size)
8. Product policy (con grade)
9. Logistics
10. Incidental Capital (i.e. two more trucks)
11. Sustainability (modeled in terms of economic efficiency)
12. Uncertainty Assessment (Monte Carlo)

# Avanti Kitsault Moly Project

## Kitsault, BC Canada

- Greenfields site, but mined, reclaimed, and closed in the 80s.
- AMEC Feasibility Study 2010 and FS Update 2013
- EO study to improve NPV and validate project
- Mining:
  - Maximum mining rate of 45.9 Mt per annum
  - 36 Mt permitted stockpile space
  - 14 year mine life
- Processing
  - 16.6 Mtpa processing rate
  - SAG and ball mill
  - Flotation circuit

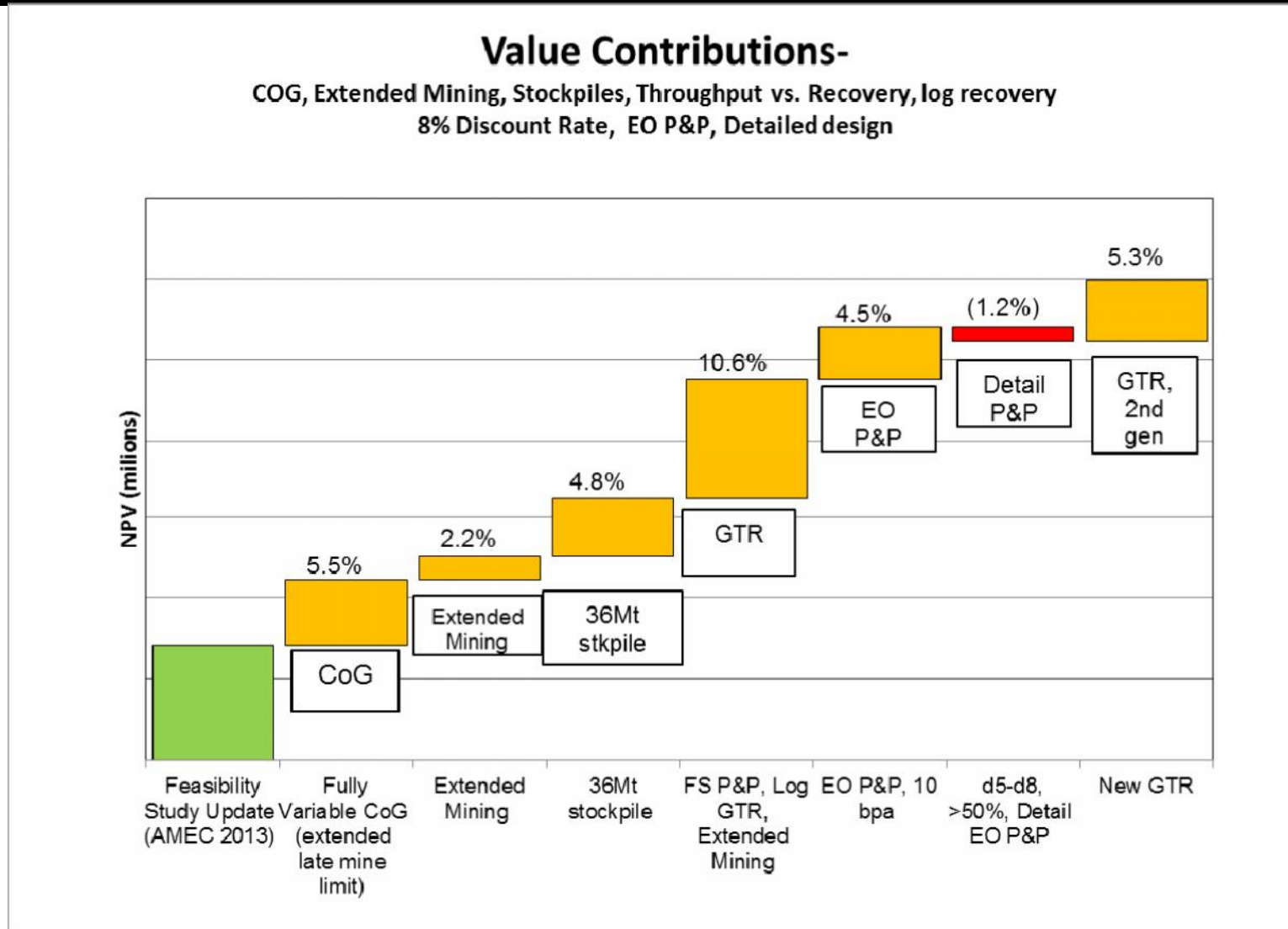
# Avanti Kitsault Moly Project

## Kitsault, BC Canada

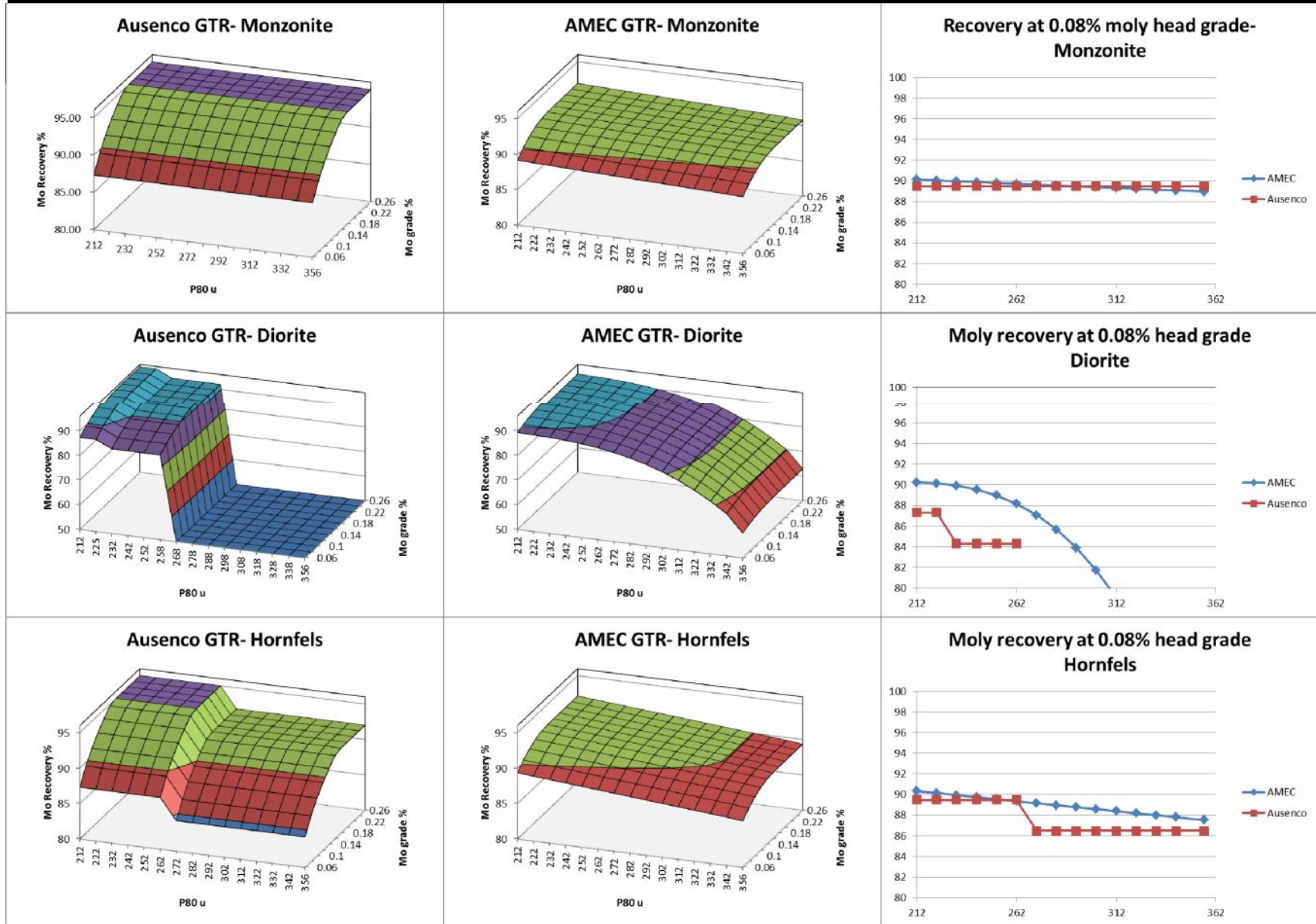
- Three rock types-
  - Monzonite, phaneritic igneous rock
  - Diorite, phaneritic igneous rock (more mafics)
  - Hornfels, metamorphic sedimentary rock
- 52% Moly con non-negotiable for sales
- Silver at 39-40% recovery included in revenue
- AMEC mine planning and metallurgical work in FS update



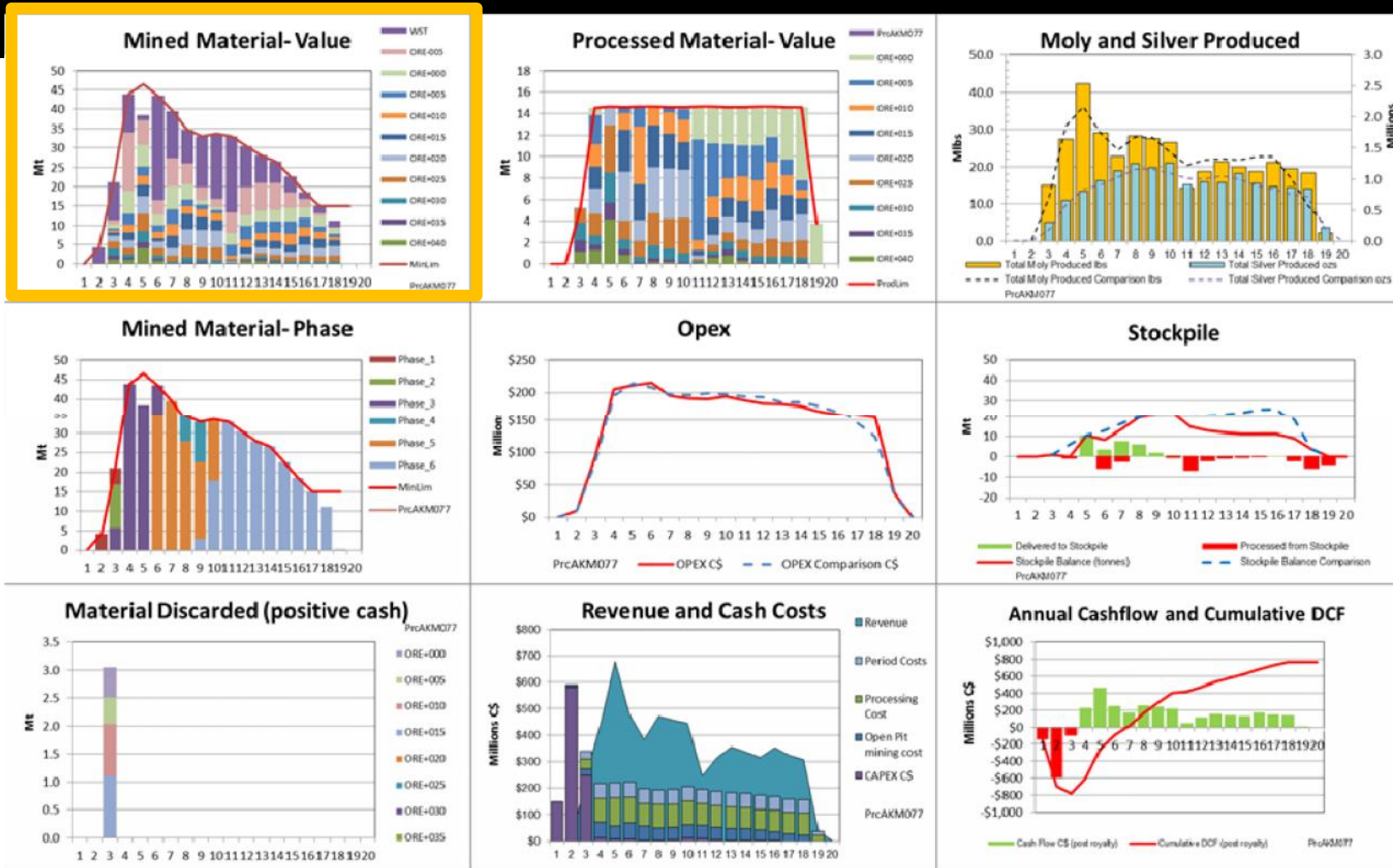
# Project Waterfall Graph



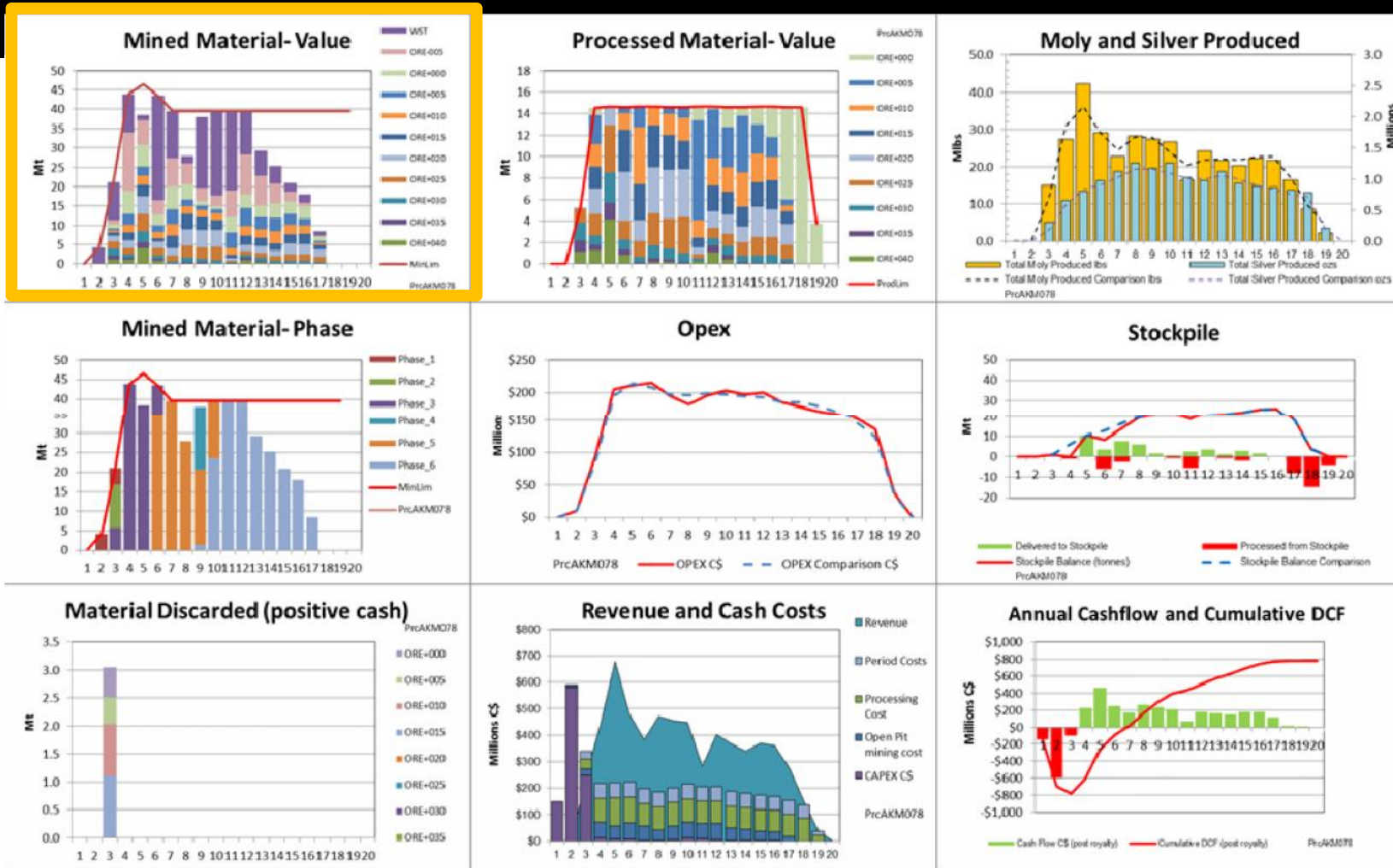
# GTR Surface Graphs



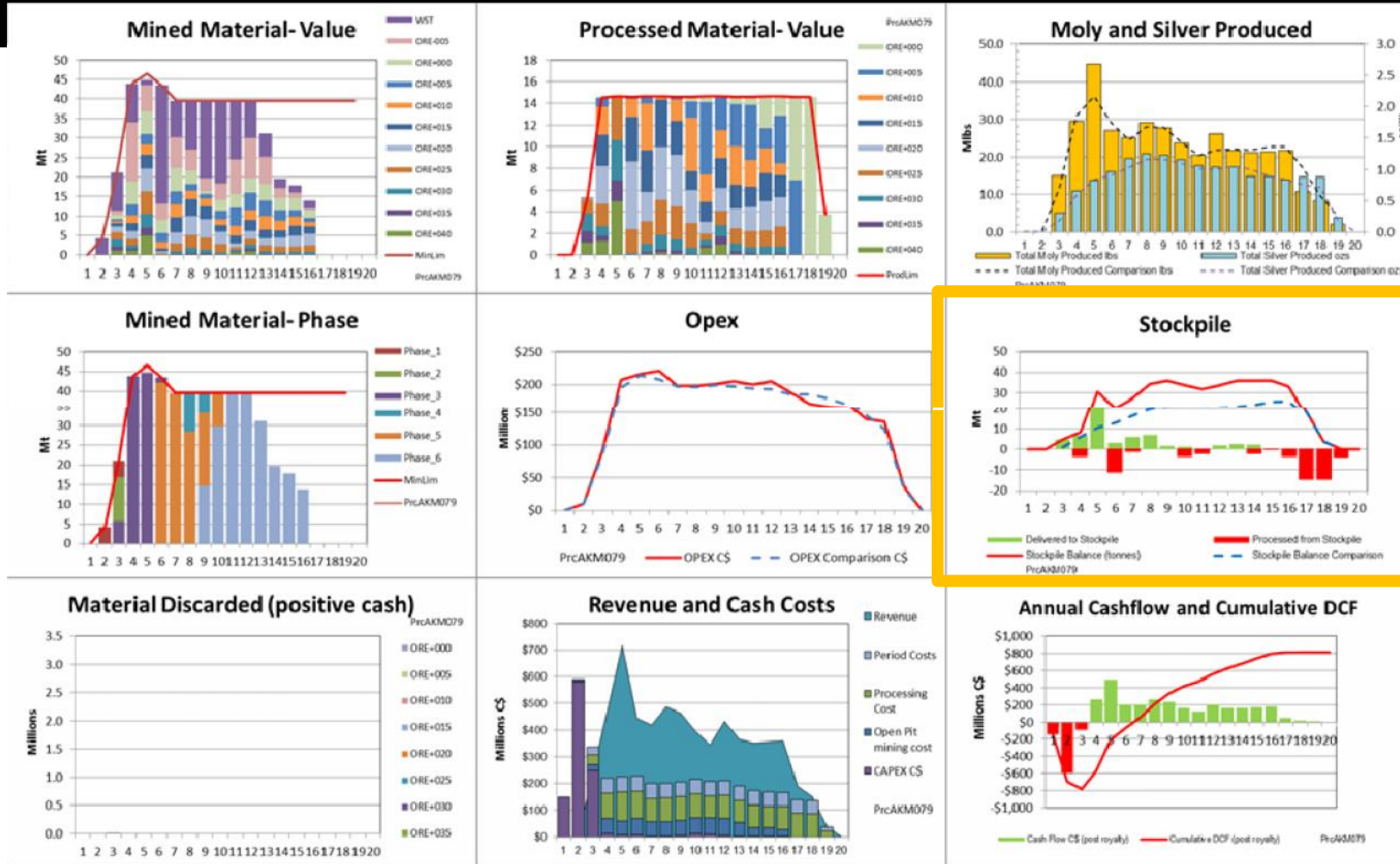
# Variable CoG +5.5%



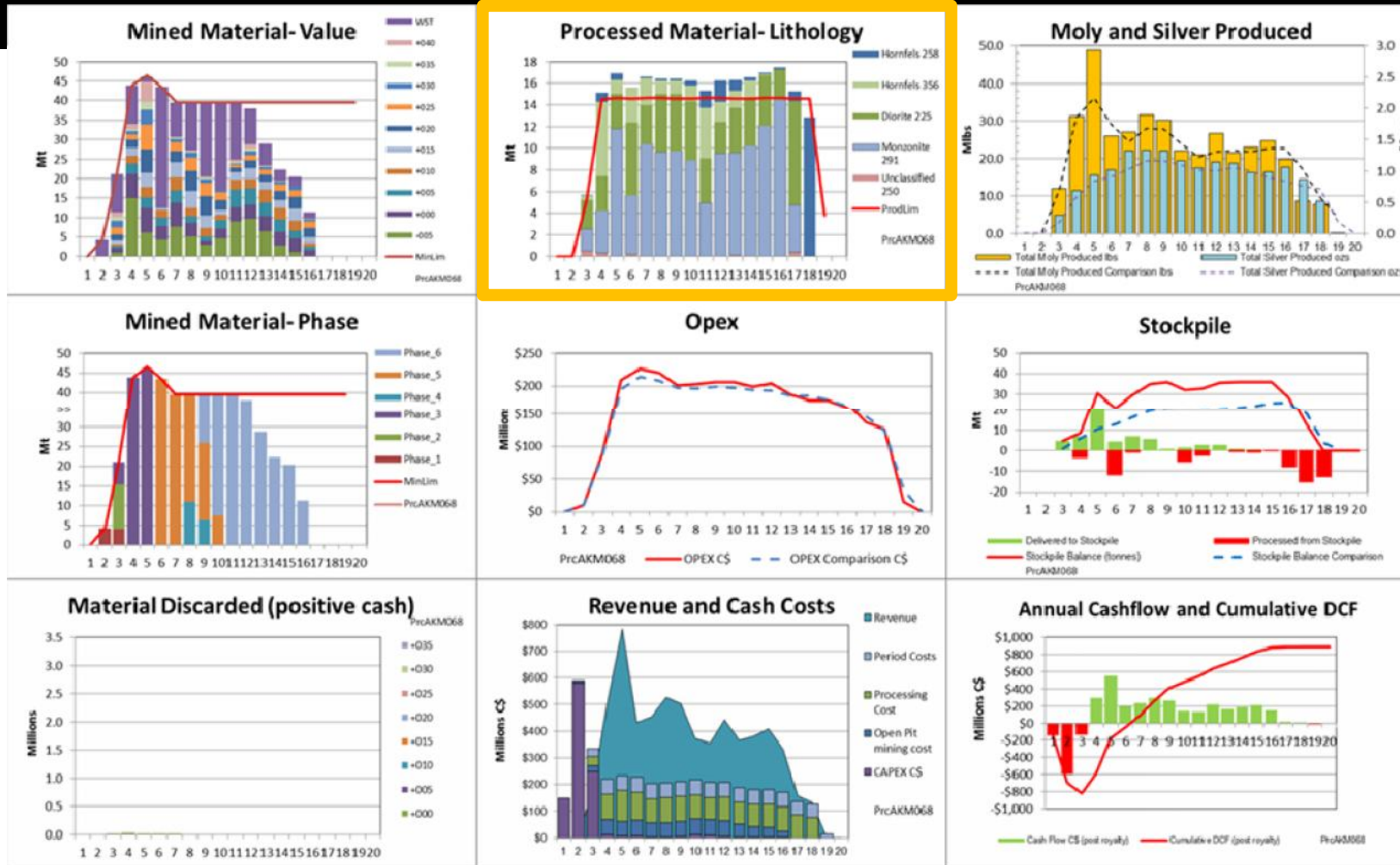
# Extended Mining +2.2%



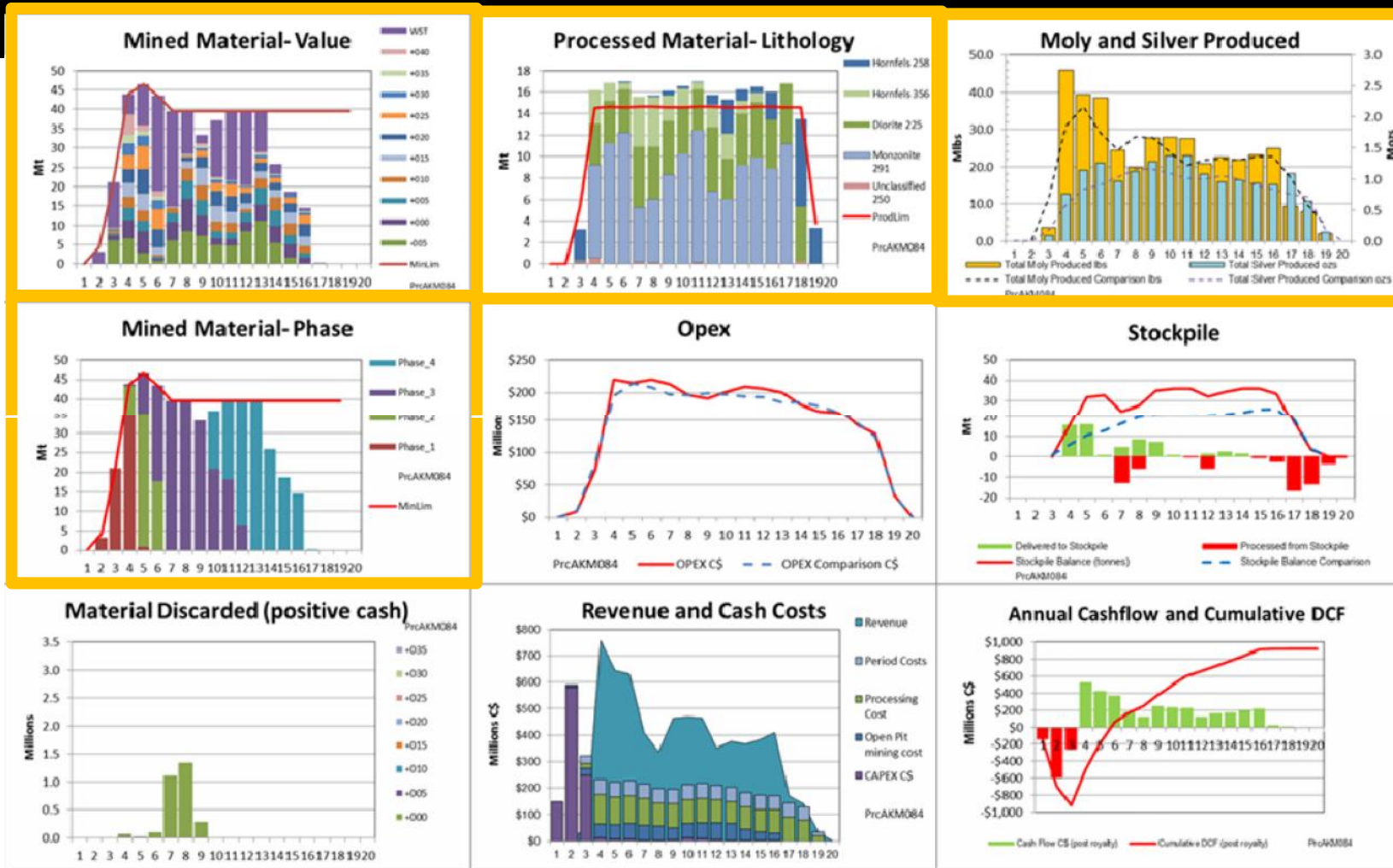
# Stockpile Max 36Mt +4.8%



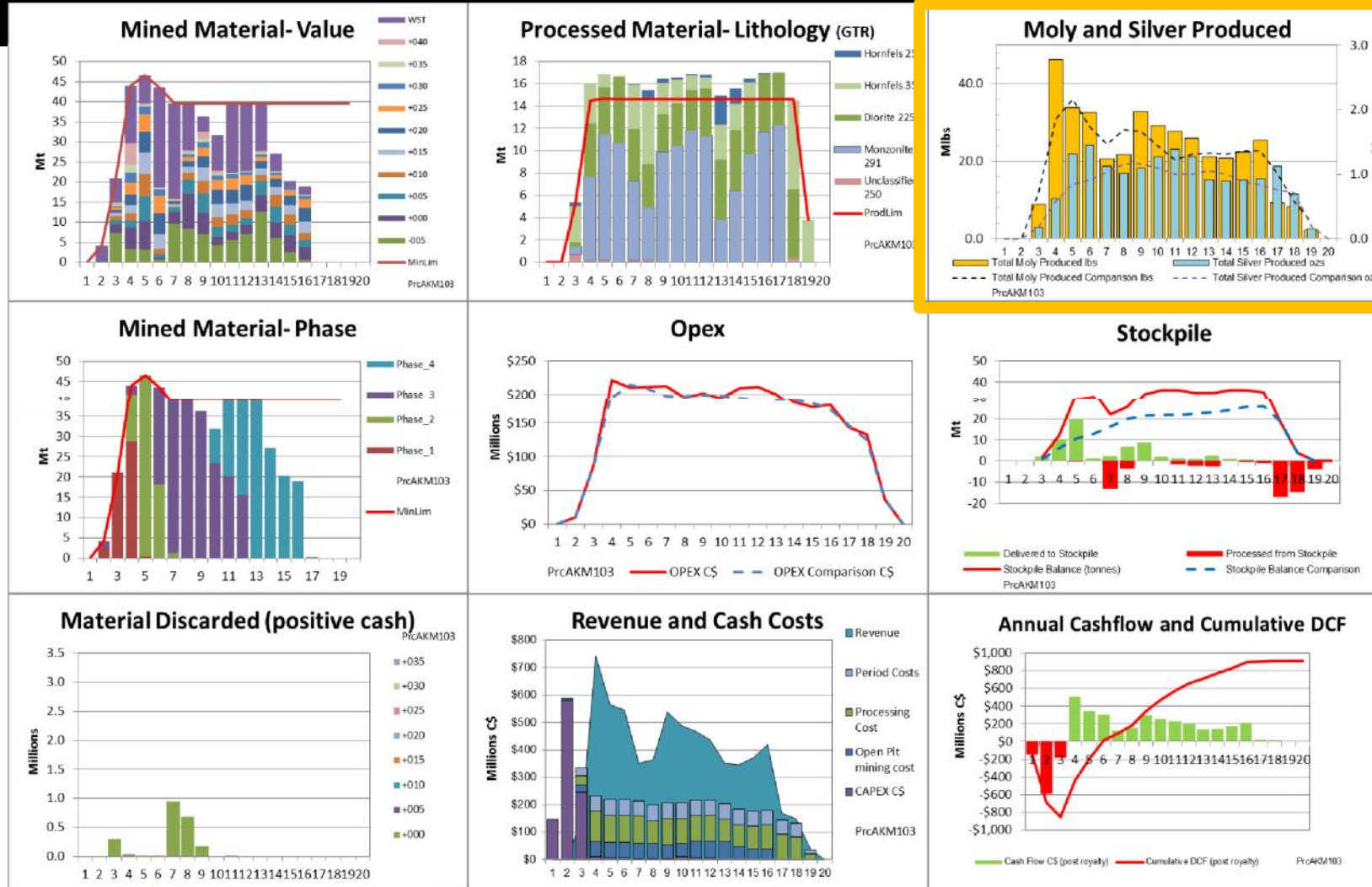
# GTR- First Generation +10.6%



# EO Pit and Phase Design +4.5%

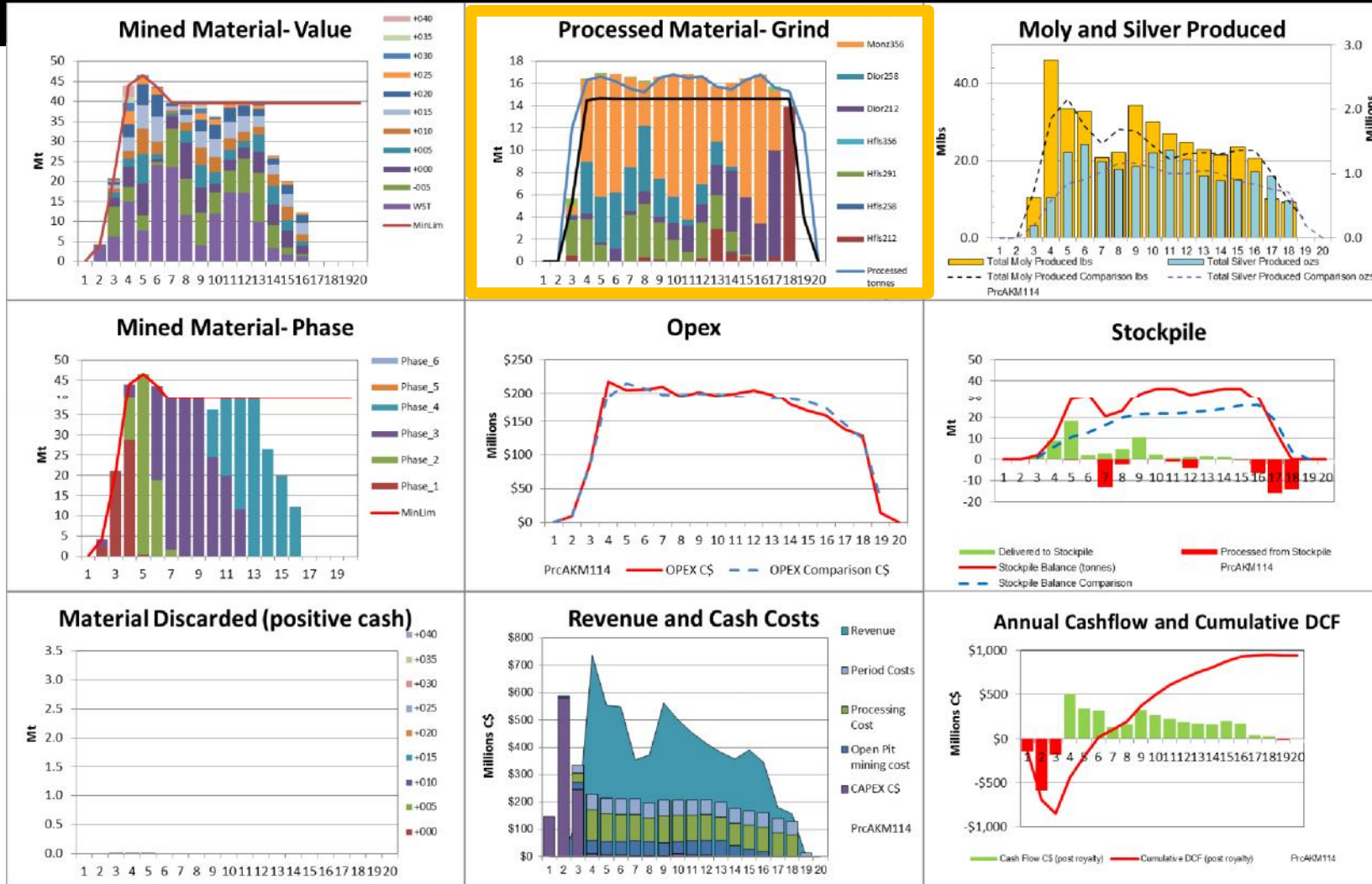


# Detailed design -1.2%



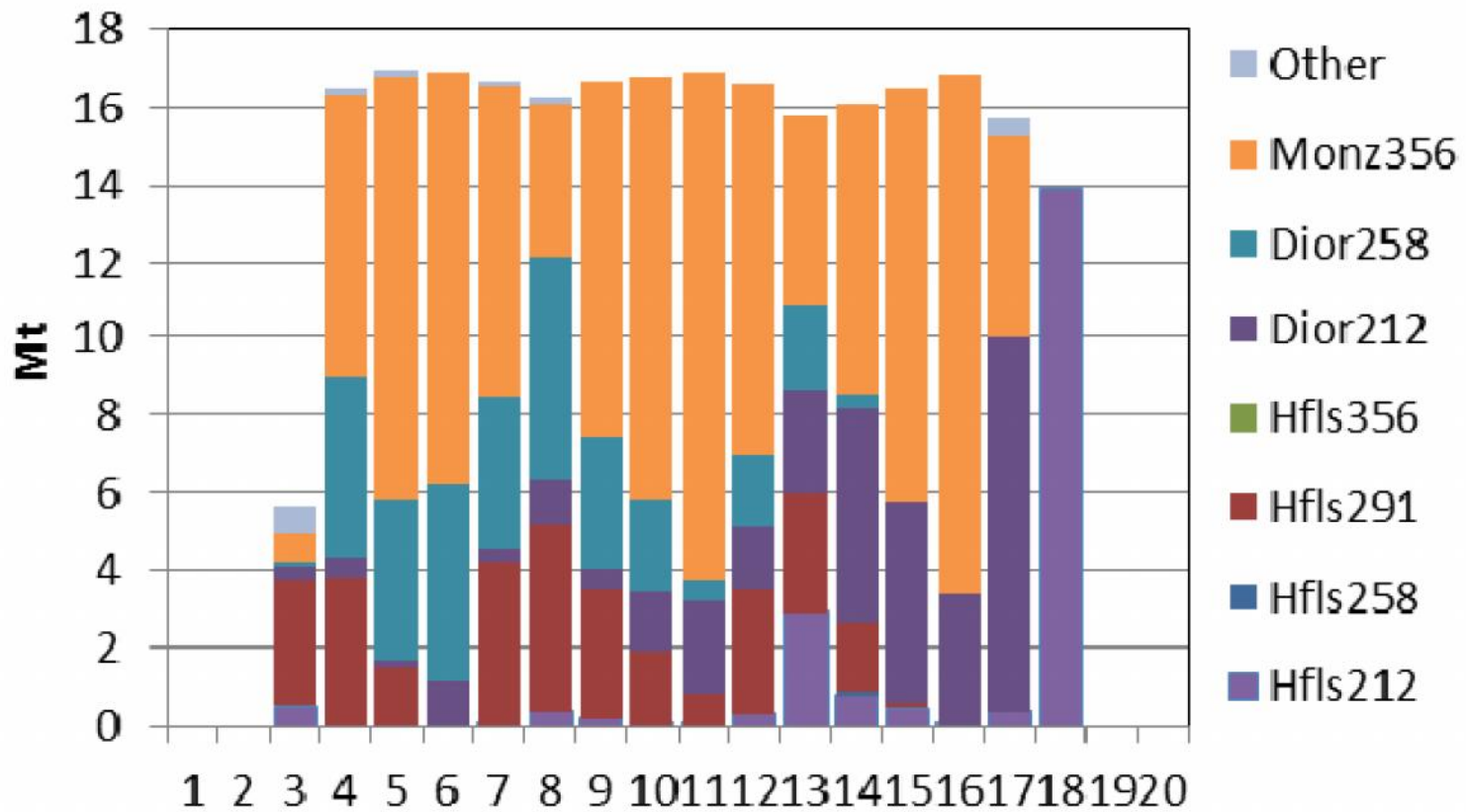


# GTR- Second Generation +5.3%



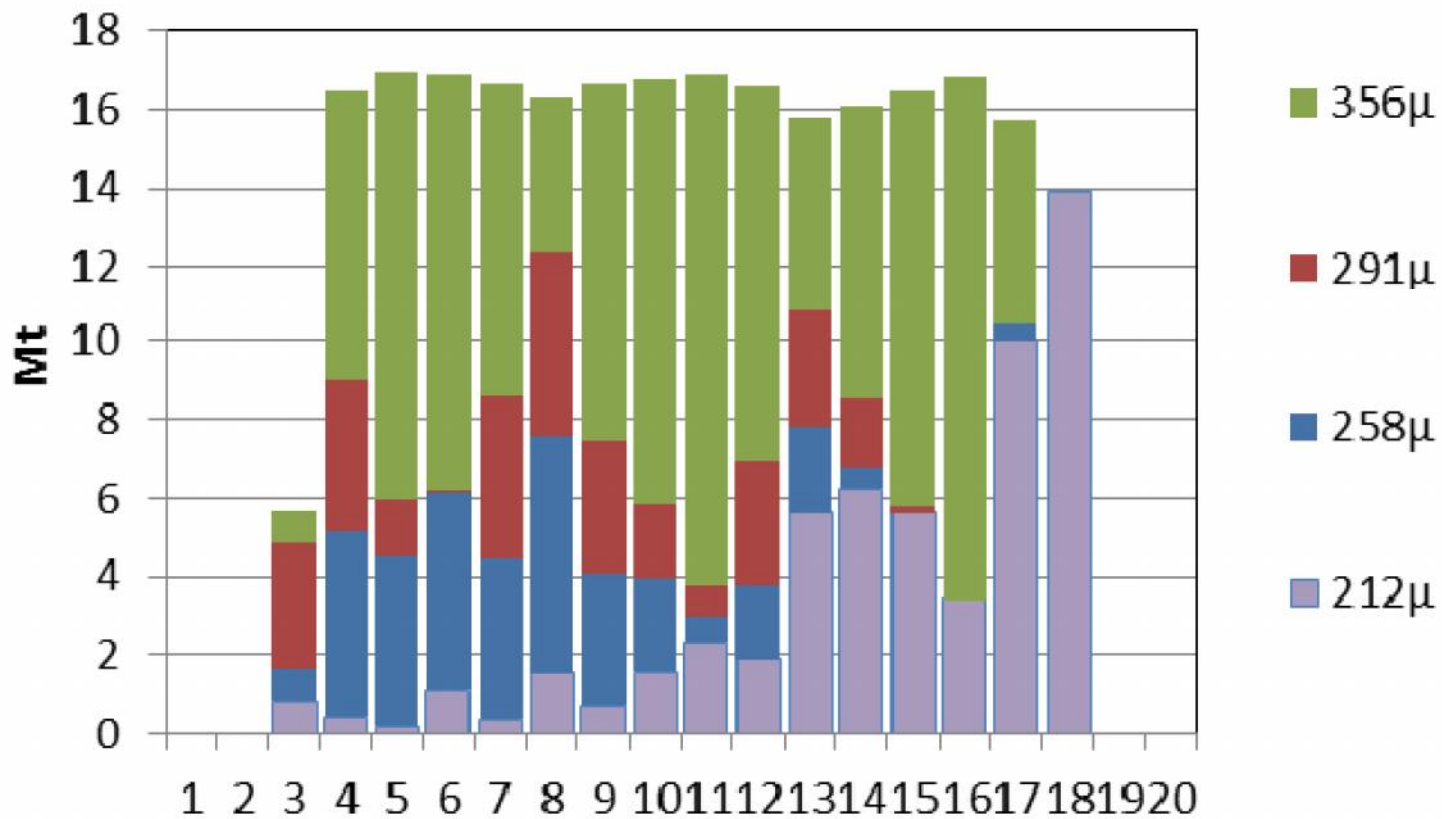
# Grind per rock type

## Processed Material- Rock by Grind



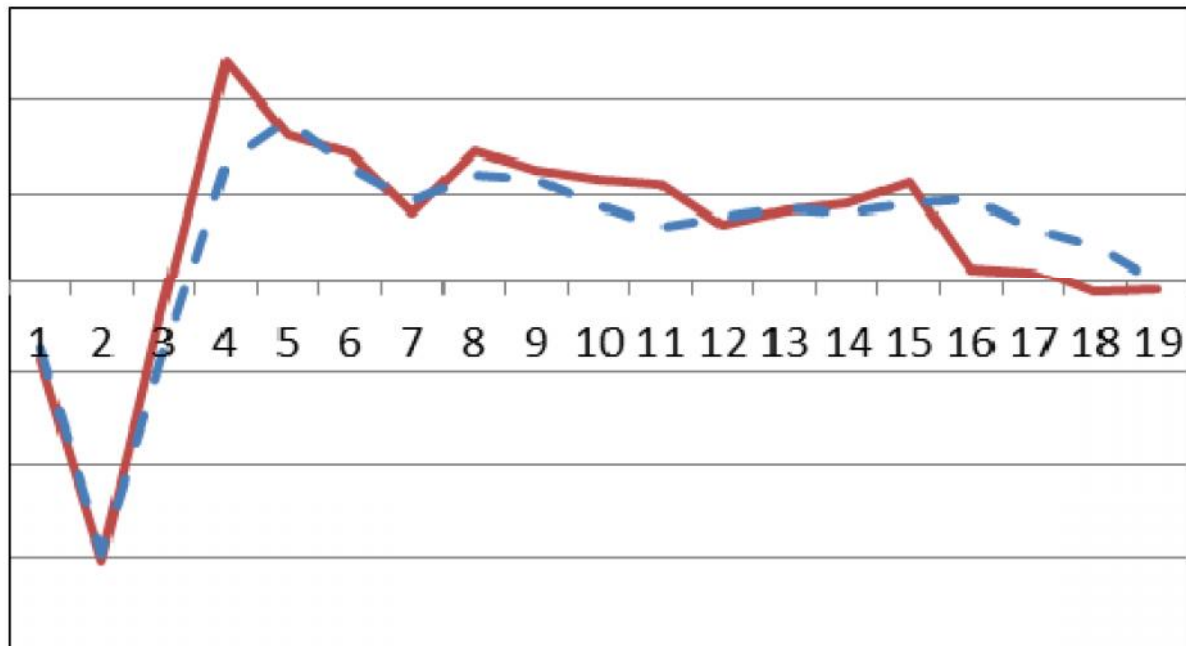
# Grind per Period

## Processed Material- Grind



# Red Line Blue Line

## Cash Flow



— Cash Flow CS (post royalty)

- - - Cash Flow Comparison CS

# Outcomes

- The Enterprise Optimization Study added significantly to the project NPV, above what is considered a good FS study.
- Grind Throughput Recovery was a significant portion of this value, adding more than half of the value.
- Scheduling, cut-off grade, and stockpiling to the maximum permitted volume also added value.
- Additional value was added by deferring capital based on the Prober schedule not utilizing mining capacity at the start.
- AMEC Mine Planner implemented the “path through the ore body” very well.
- AMEC process consultants took initial Ausenco EO GTR estimates and recommended additional test work, and improved the curves.
- A great team effort!

Questions,

and Thank you!



Be safe out there.

