Underground Strategic Planning

Kristina Huss

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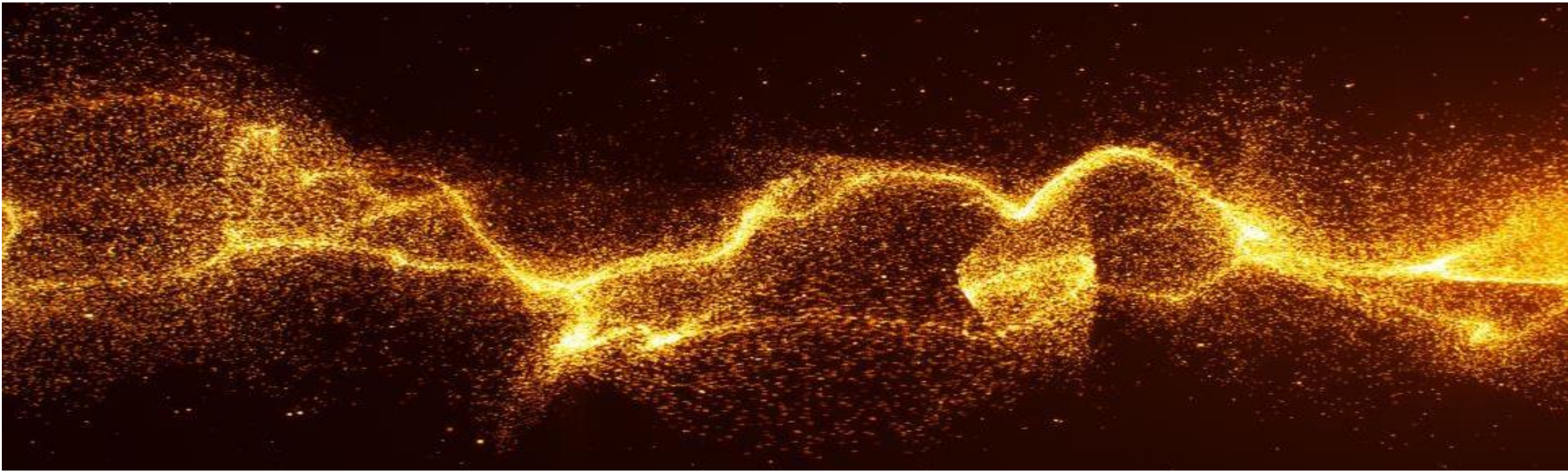


What is Strategic Planning?

Which resource should be mined?

What is the correct size of the operation?

When and at ***What*** rate should the resource be mined and processed?

How should we mine & process the resource? ***How*** should we reclaim & close the operation?

Deliver reliable, sustainable strategic mine plans.

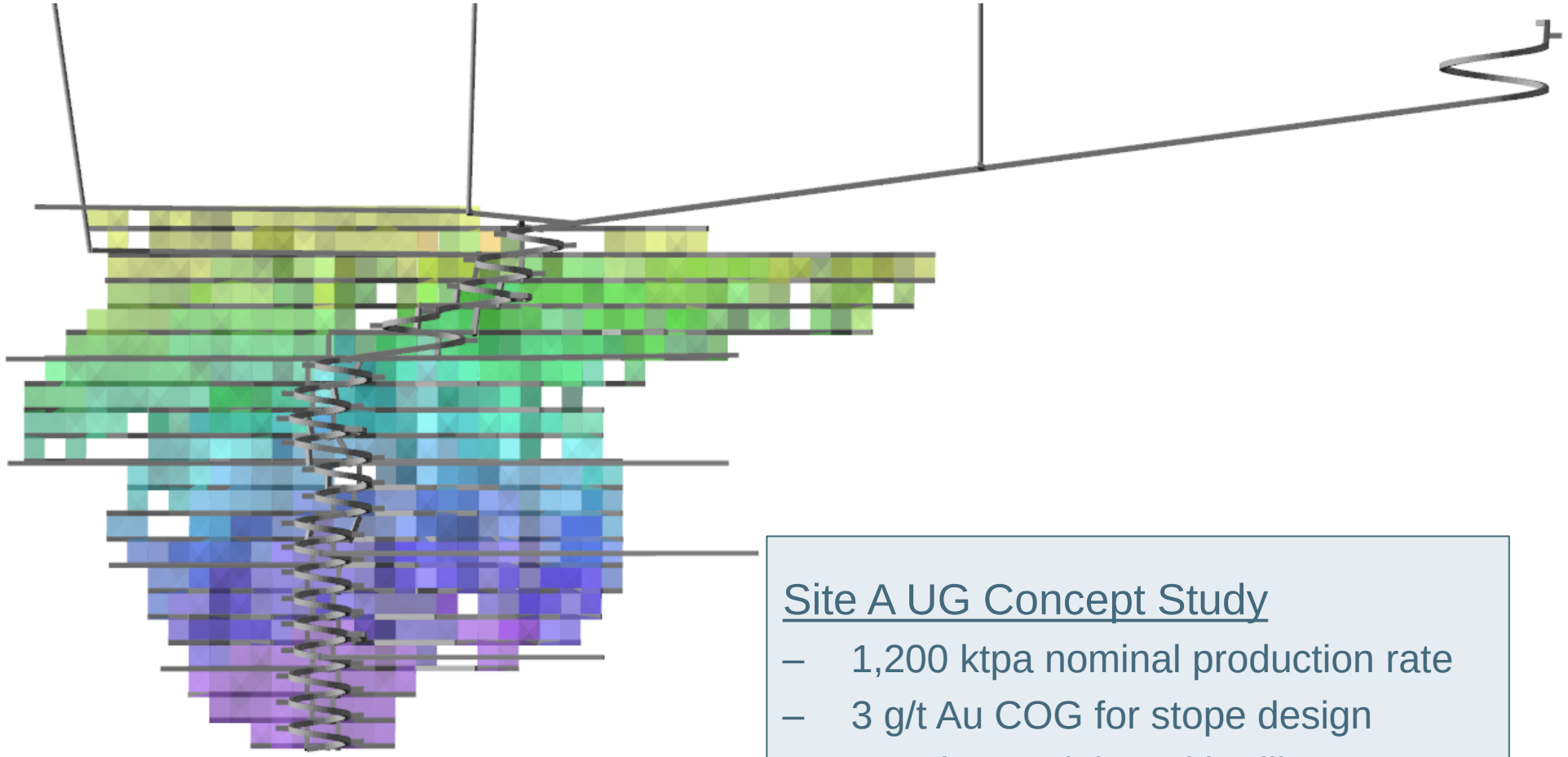
Strategic Planning :Open pit vs. Underground

	Open Pit	Underground
Concepts	• Mining direction and geometry shape constrained • Can schedule block model blocks	• Unlimited directionality • Stope shapes and designs are required
Tools	• Commercial packages available to quickly produce an array of options	• Some programs for aspects of design and scheduling are commercially available
Result	• **Many scenarios evaluated**	• **Limited or select scenarios evaluated**

Strategic Planning : An Underground Approach

To advance underground strategic planning by integrating operations research algorithms with novel ways of using commercial software

Case Study : Context

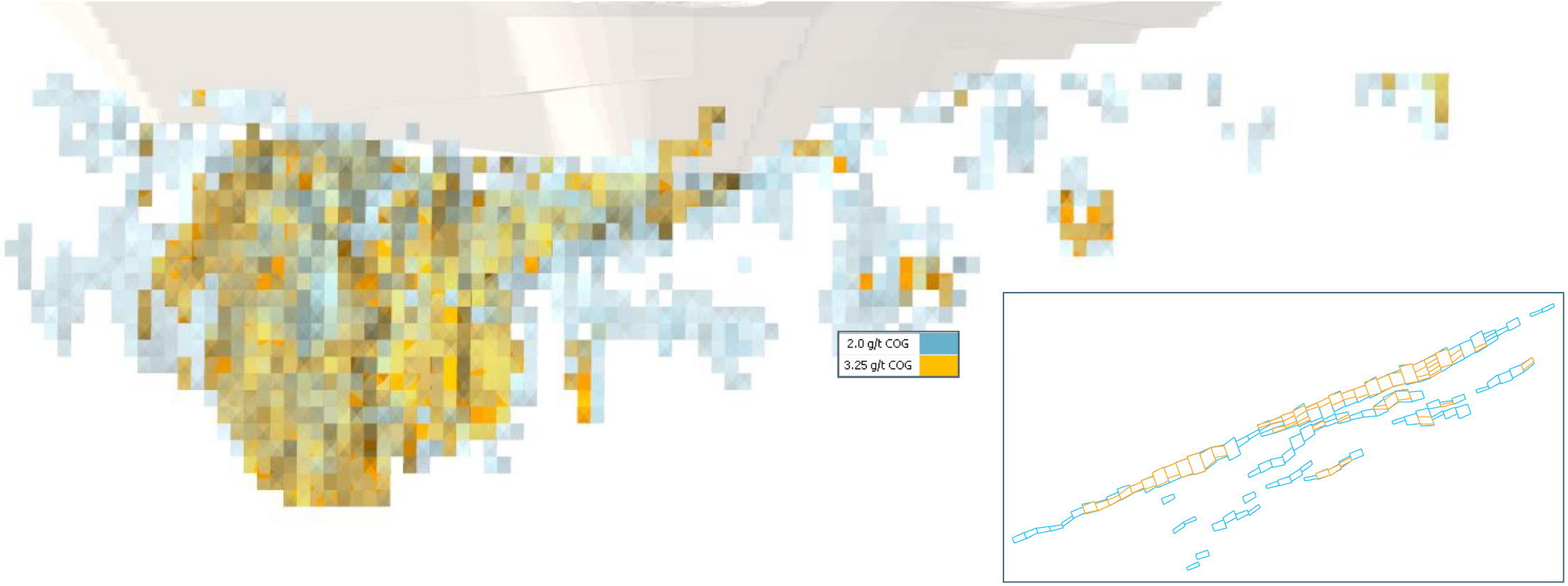


Site A UG Concept Study

- 1,200 ktpa nominal production rate
- 3 g/t Au COG for stope design
- Top-down mining with pillars at a <80% extraction ratio

Strategic Planning Problem

- Trade off mining method – sequence vs. extraction vs. cost
- Evaluate correlations between cut-off grade, production rate and value



Plan view section through deposit

Methodology: Tools

- Mine planning package (Deswik)
  - Stope optimizer used to generate stope shapes at a range of cut-off grades
  - Rule-based dependencies generated for inter-stope relationships
  - LG used to determine economic limits based on designs, dependencies and costs
  - Used to compile and visualize schedule results
- Scheduling Algorithm (SA)
  - Used to generate schedules based on scenarios created in planning package
  - Uses a combination of activity production rates and targets

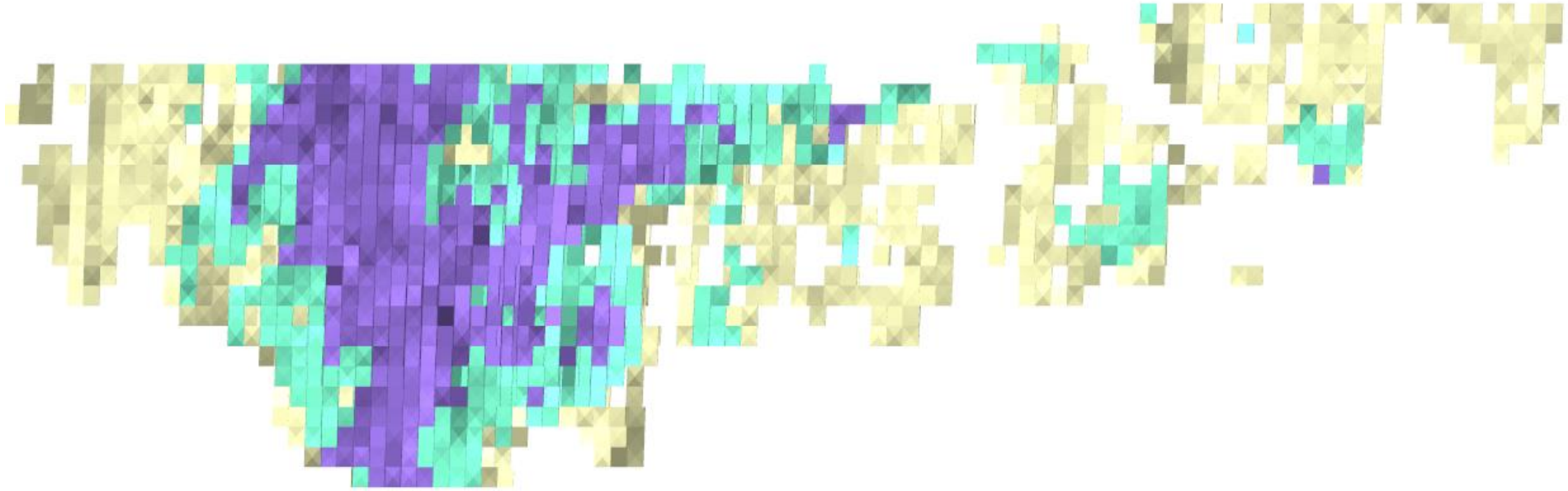
Methodology: Testing Parameters

- Production Rate
  - 600 to 1,800 ktpa in 200ktpa increments
  - Development capped at 8,000m per annum
- Sequence
  - Top down with pillars : 75% extraction
  - Bottom up with full extraction : 100% extraction
  - Bottom up with sill pillars: 100% extraction, sill pillars – 60%
- Cut Off Grade
  - 1.5 to 5.0 g/t Au

Methodology: Workflow

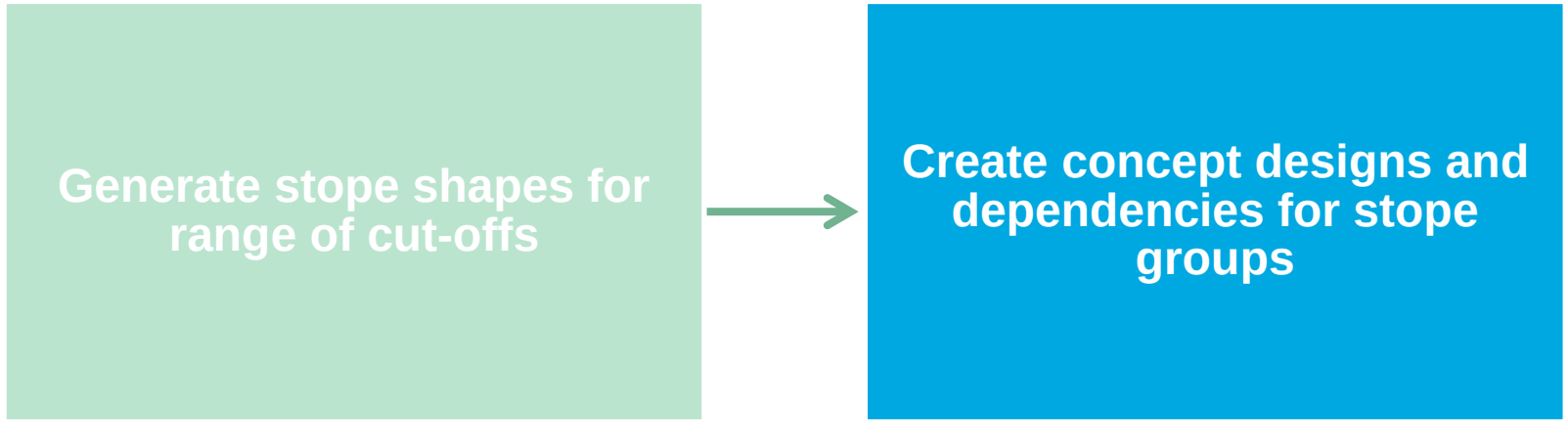
Generate stope shapes for range of cut-offs

Example Stope Shapes

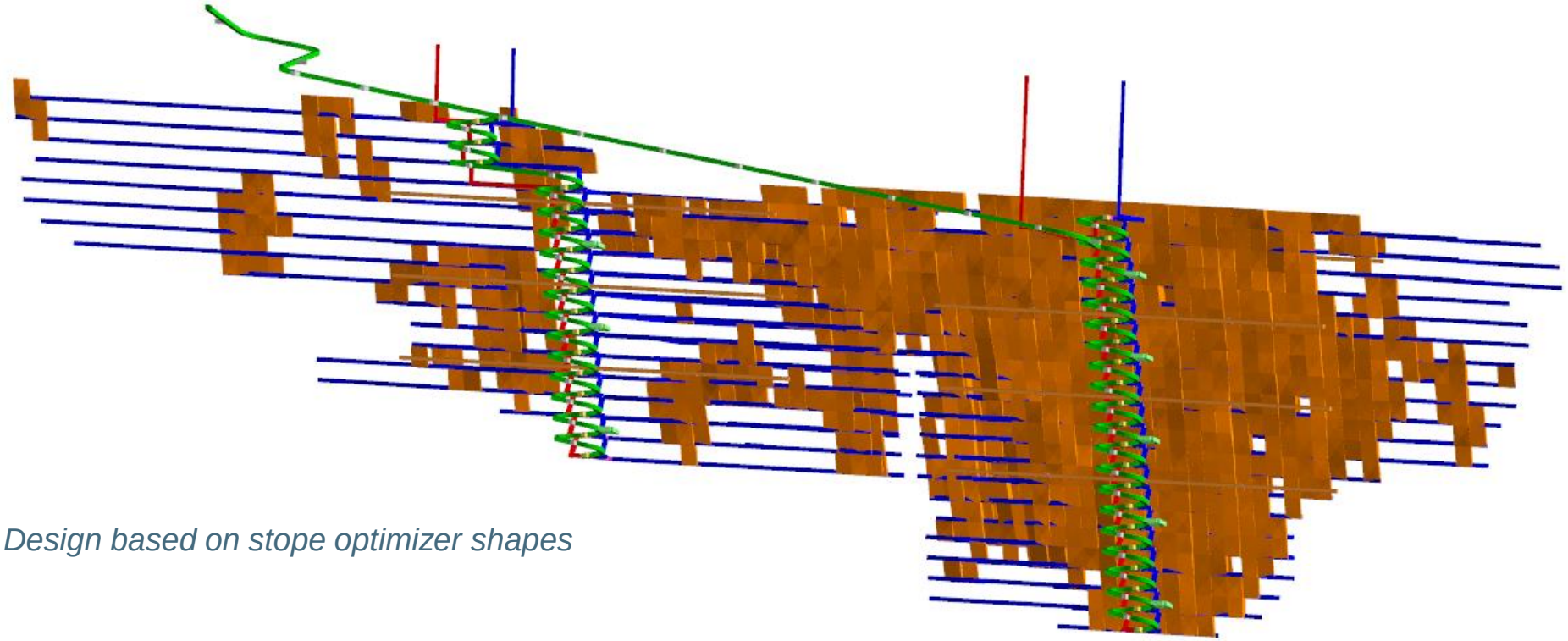


Stope optimizer output at 1.5, 3.0 and 4.5 g/t Au cut-off

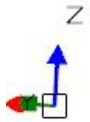
Methodology: Workflow



Pre-LG Mine Limits

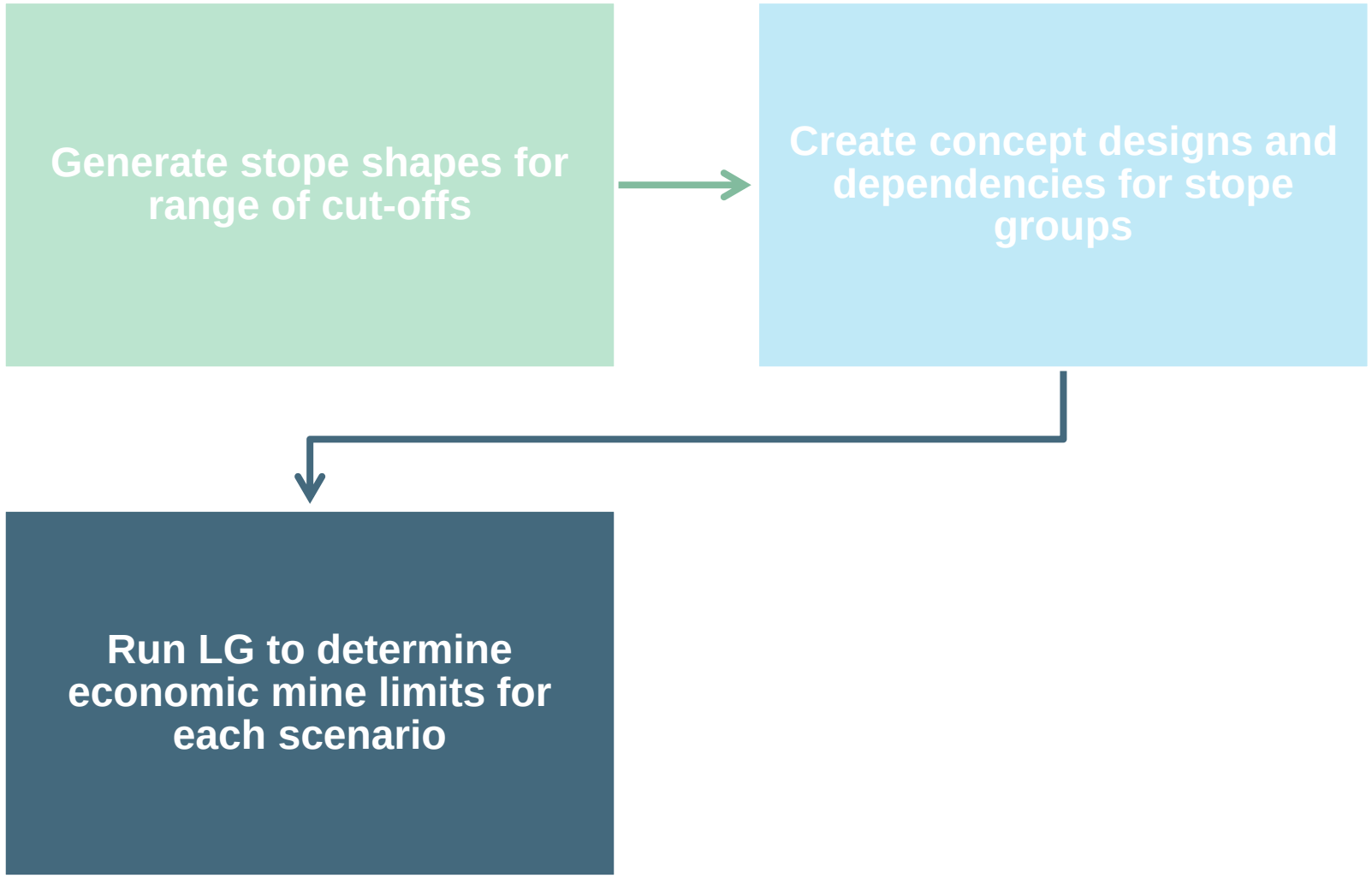


Design based on stope optimizer shapes

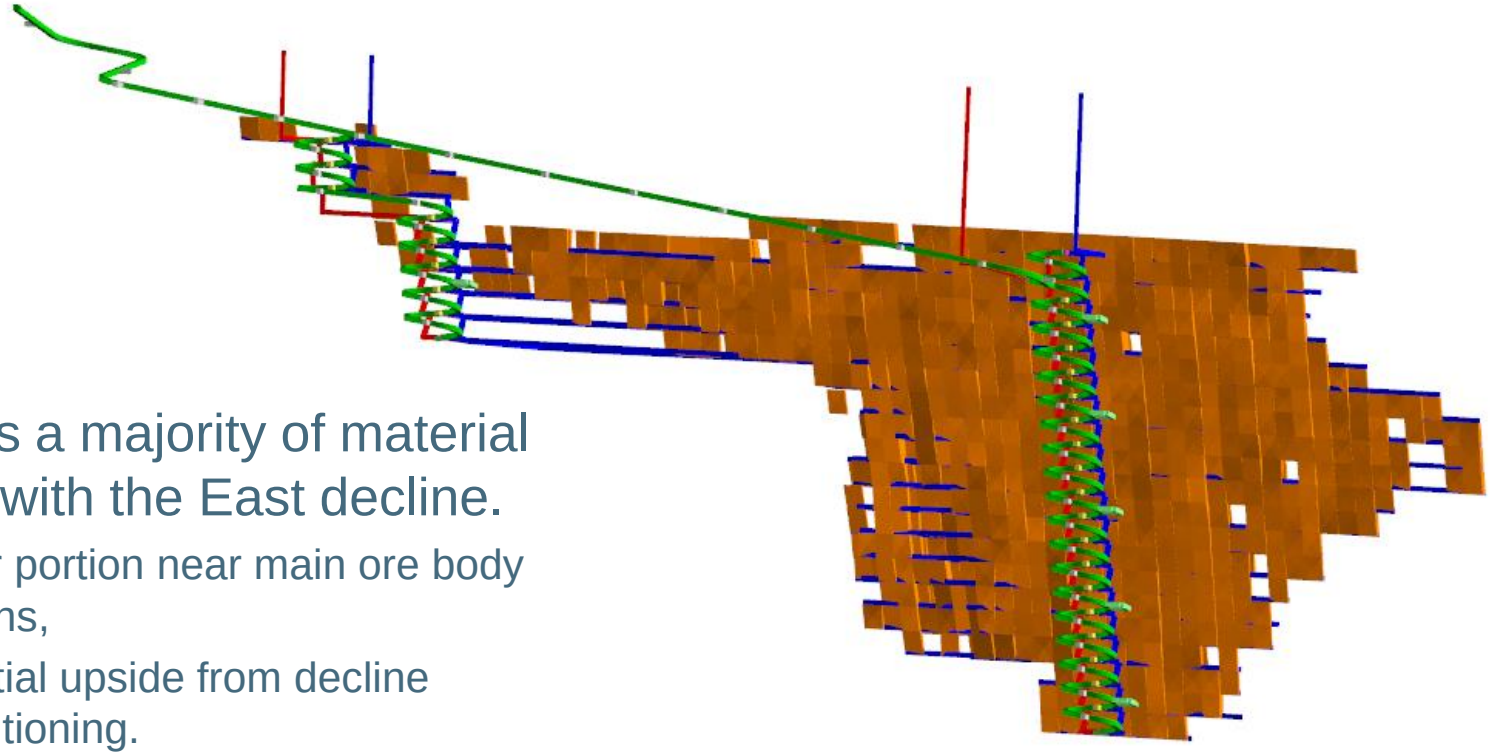


2.25 g/t Au COG all stopes

Methodology: Workflow



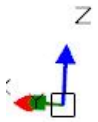
Post-LG Mine Limits



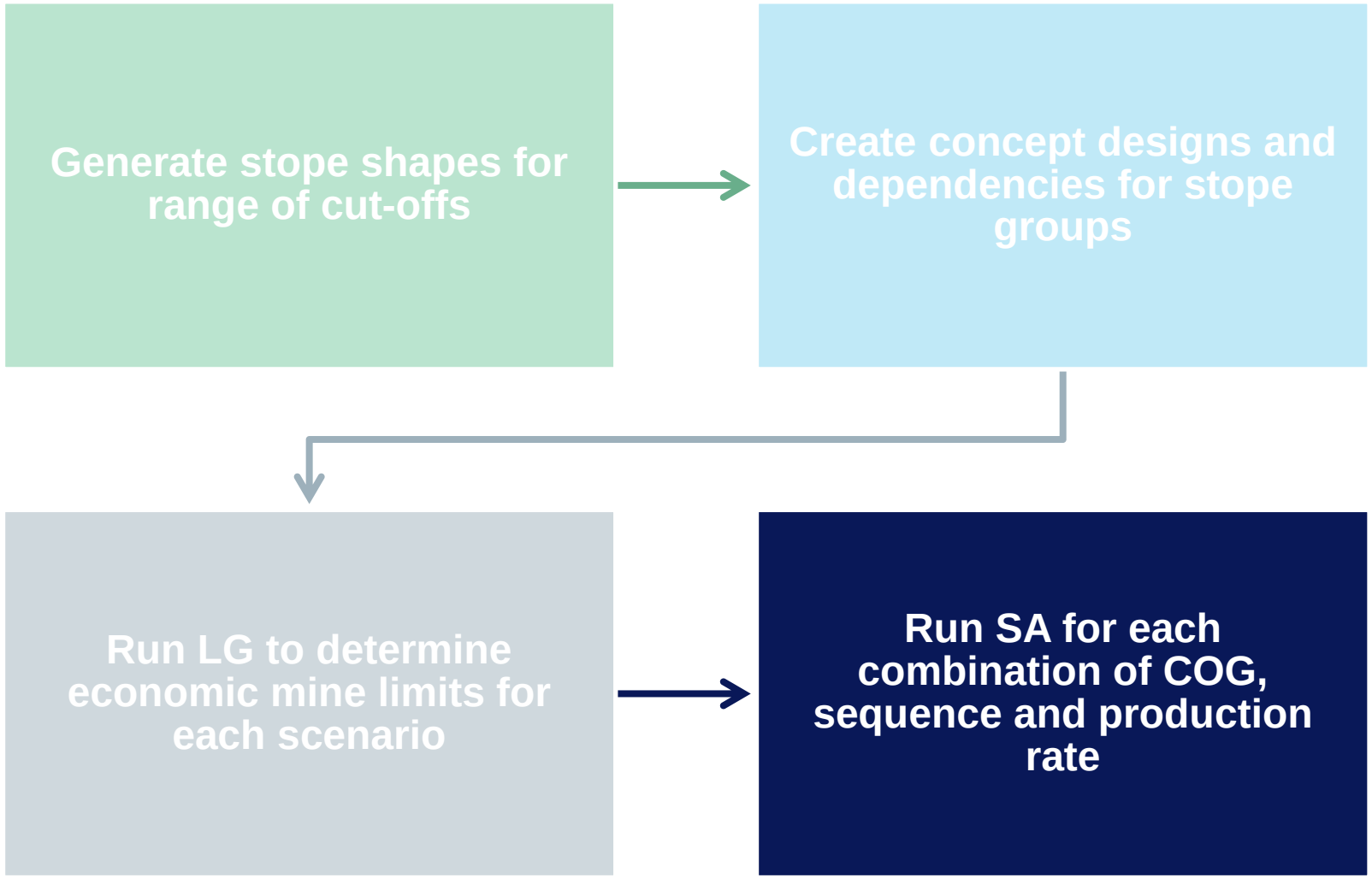
LG removes a majority of material associated with the East decline.

- Upper portion near main ore body remains,
- potential upside from decline repositioning.

LG Details – 2.25 g/t Au COG using bottom up mining and low throughput costing.

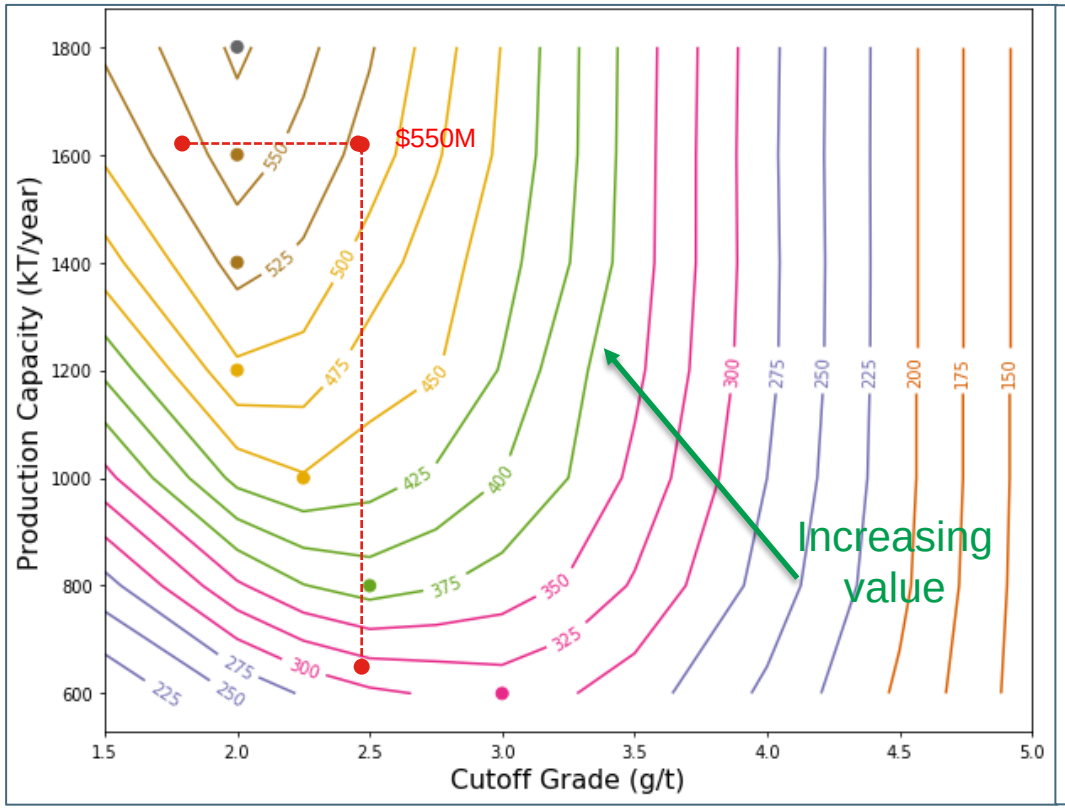


Methodology: Workflow

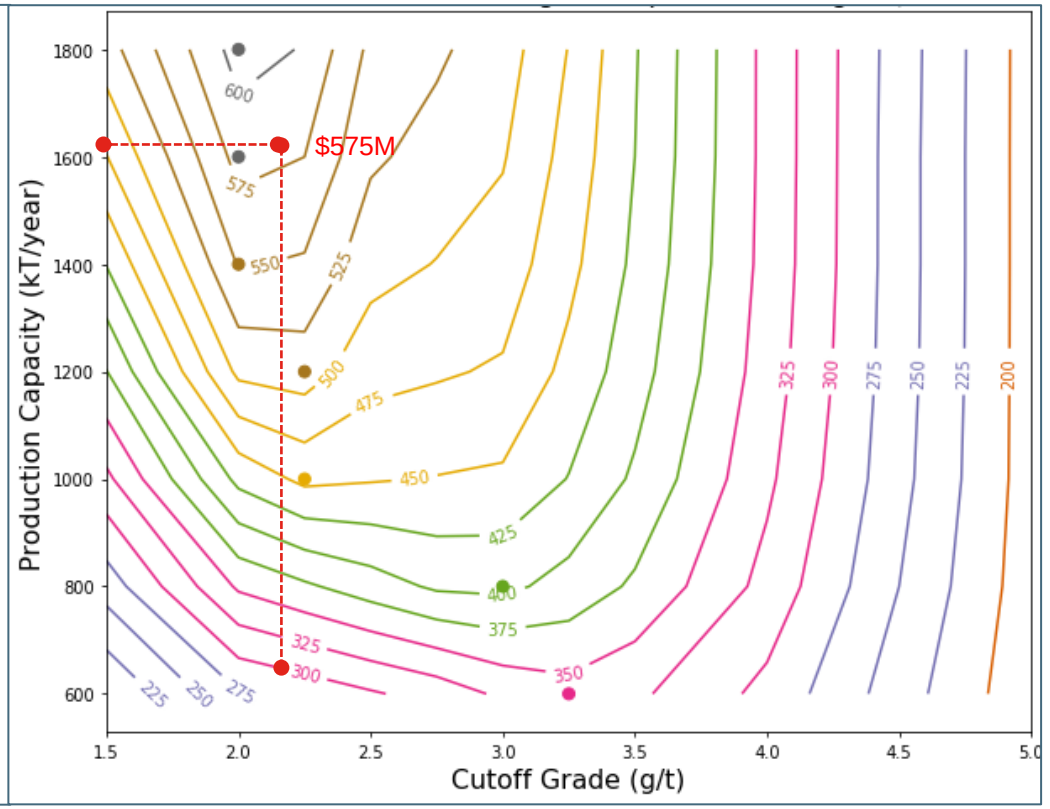


Value Ranges – Mining Methods

Top Down Mining

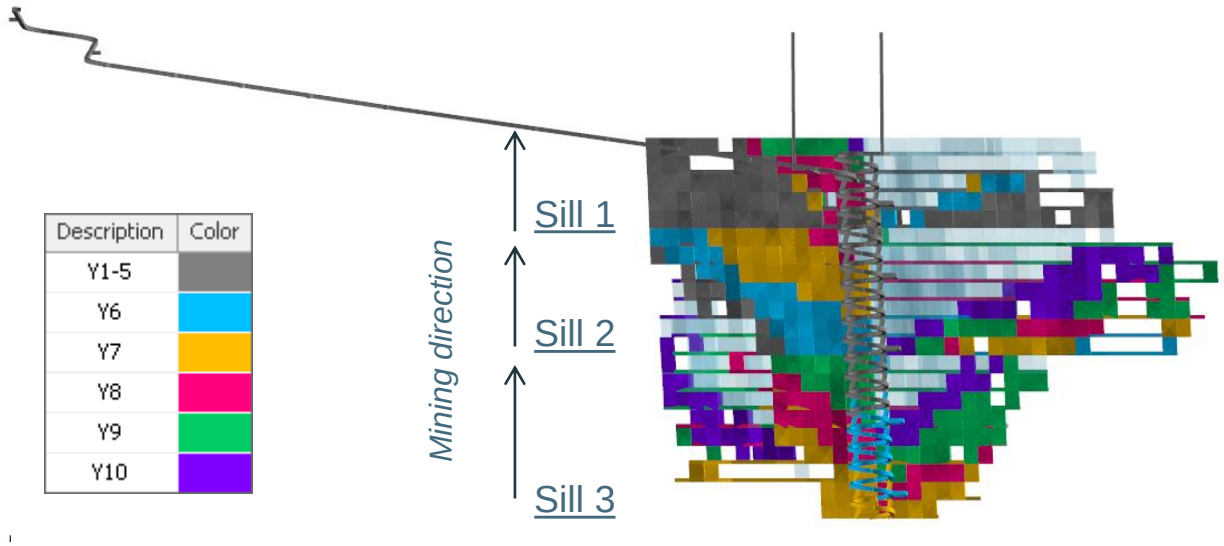


Bottom Up Mining w/sills

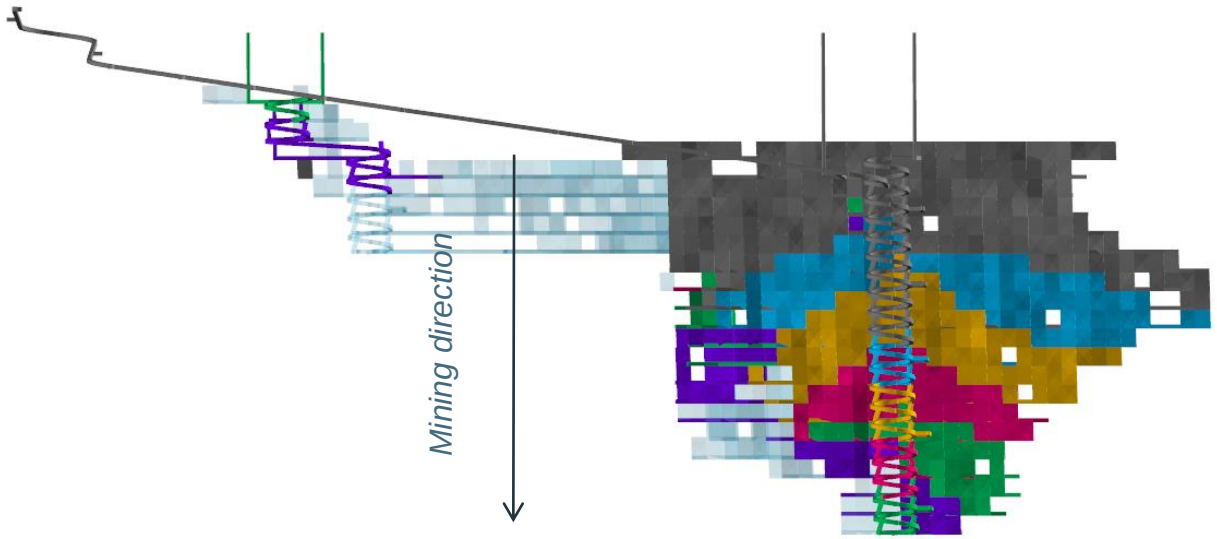


- For both methods, consider raising production rate
- Diminishing returns with increasing cut-off grade
- Bottom up w/sills drives higher value for same COG and rate (+25M NPV)

What's Driving Value?

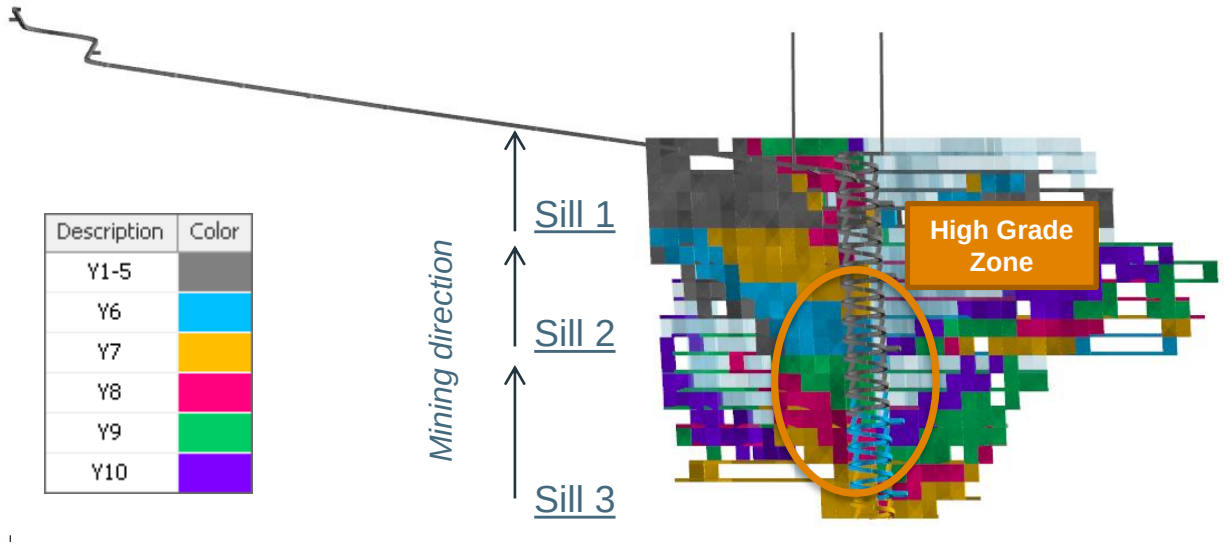


Bottom up with Sills (backfill stopes)
Year 6 to 10 – 1.6Mtpa, 2.25 g/t



Top Down with Pillars (open stopes)
Year 6 to 10 – 1.6Mtpa, 2.25 g/t

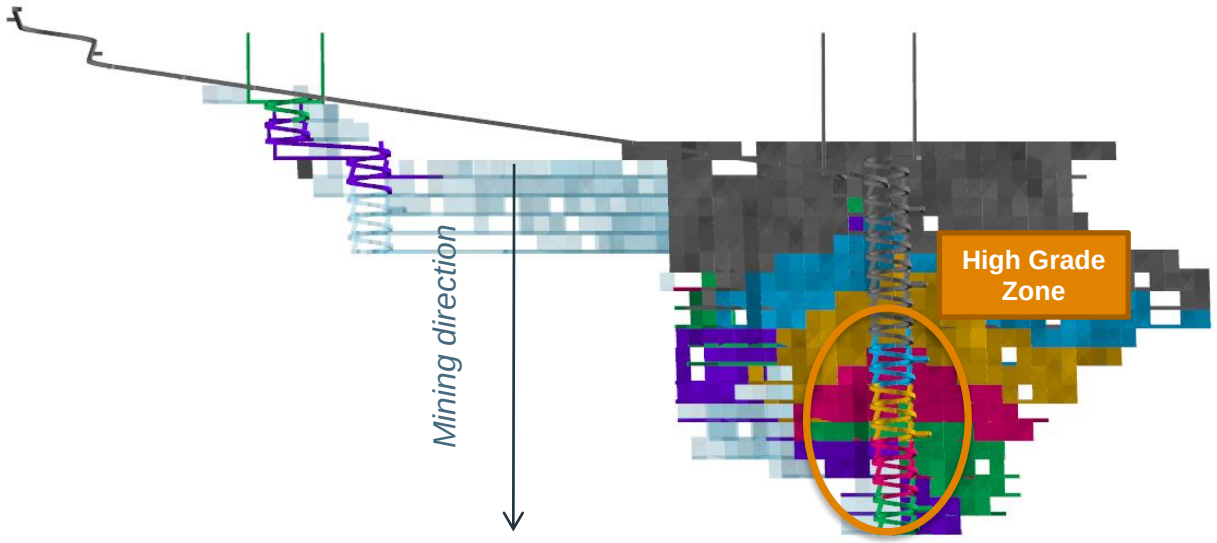
What's Driving Value?



Bottom up with Sills (backfill stopes)
Year 6 to 10 – 1.6Mtpa, 2.25 g/t

Opportunities from less constrained sequence

Higher extraction at a cost



Top Down with Pillars (open stopes)
Year 6 to 10 – 1.6Mtpa, 2.25 g/t

Faster ramp-up to production

Outcomes and Conclusions

- Scheduling algorithm allowed analysis of a range of options within a short period of time
- Assisted in understanding value drivers specific to the deposit
- Provided support for changing mining method and production rate going from concept to scoping study
- Assisted in infrastructure design decisions

Advantages	Caveats
Scheduling algorithm allows analysis of a range of options within a short period of time	Scheduling algorithm is not commercially available
Priorities can be cascaded to mine planners and integrated into Gantt schedules	Simplification of mining activities means scheduling is not at a tactical level

Tools and approaches are in development to empower underground mining engineers to spend more time thinking about “bigger picture” aspects and less time on design and scheduling tasks.

Thank you!