STRATUM: Corporate Case Study

Copper Leach Classification & Guidance Improvement

July, 2023

STRATUM AI

STUDY CASE
COPPER DEPOSIT

Large Copper Porphyry in the United States

THE DEPOSIT

- Mine has a production history of over 45 years
- Has over ~300,000m drillhole assays, ~90,000 blasthole, ~70,000 blastholes reserved for reconciliation
- Mill cutoff grade of 0.17% Cu, leach cutoff grade of 0.08% Cu

STUDY CASE
COPPER DEPOSIT

Large Copper Porphyry in the United States

PROBLEM

The mine struggles with predicting leach contained metal on a quarterly and block-basis, complicating plans to integrate leach ore into mine plan and expand leach processing

OBJECTIVE

Better predict leach tonnage on a quarterly basis and leach grade on a block basis

OUTCOME

A better resource model that accurately predicts leach ore creates value by ensuring minimal leach ore in mine plan reconciles as waste.

SOLUTION

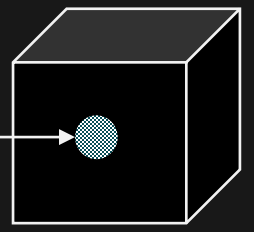
AI outperforms Kriging by learning geological patterns from 390k samples worth of historical drillholes, blastholes to **determine which blocks are mill, leach, or waste**

COPPER MODELLING
INPUT DATA

RECONCILIATION TEST SET

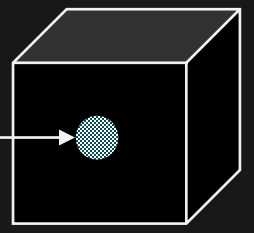
Testing Dataset with Larger Grid Size

2021 – 2022 Data



Reconciliation Test Set

Pre-2021 Data



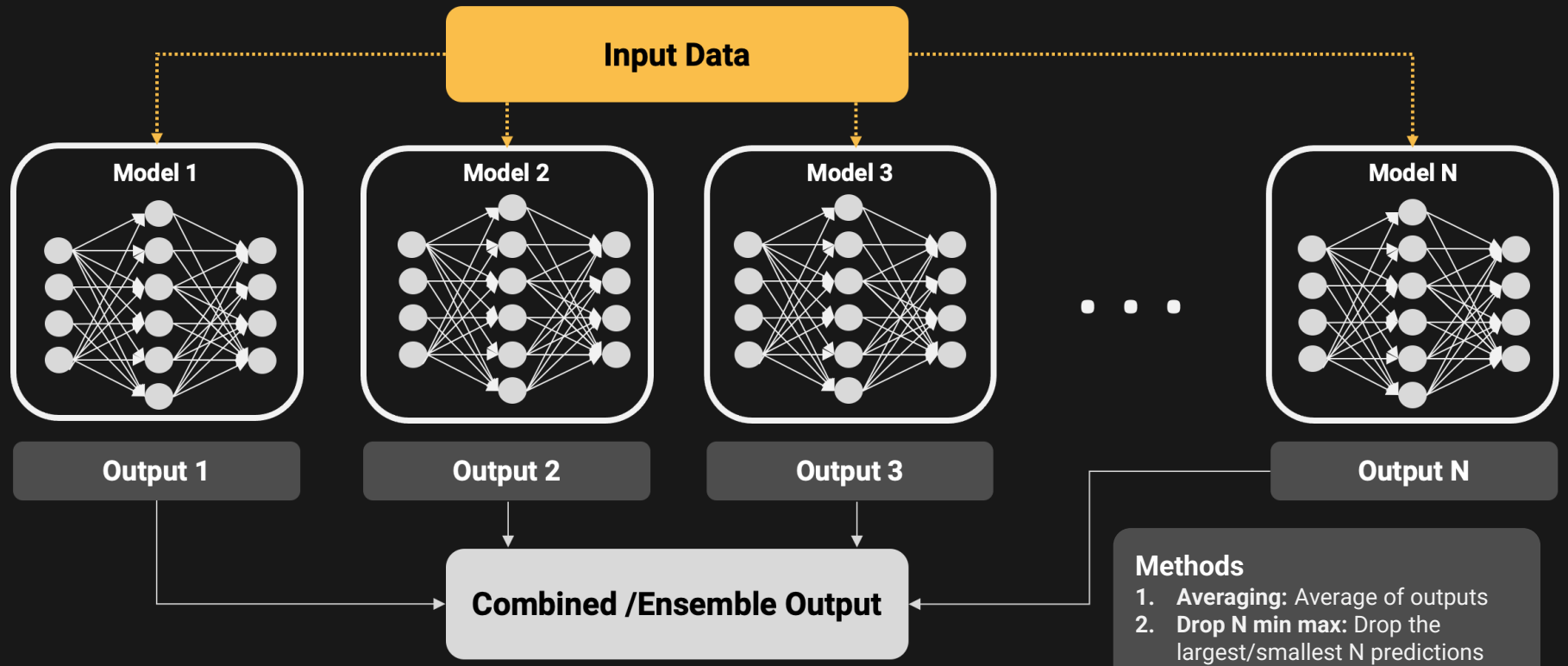
Input Data

All models will **only have access** to data before Jan 2019 as input

STRATUM MODELS
AI MODEL STRUCTURE

ENSEMBLE NETWORKS

Ensemble Networks:
Combining the outputs of multiple learning models together usually creates more accurate models. We create separate models from different input features and then combine them through an ensemble network. This includes Kriging!



Methods
1. **Averaging:** Average of outputs
2. **Drop N min max:** Drop the largest/smallest N predictions for each block and average the middle predictions

STRATUM MODELS
AI MODEL STRUCTURE

MODELS IN ENSEMBLE

Top 10 Models + Kriging

We combine a diverse set of 10 AI models as well as existing Kriging model into an ensemble

Legend:

- Special learning method in training
- Additional metals inputs channel)
- Sample (1-2) Composite (3) and Range (4) methods
- GEO — Geological info input channel

MODEL 1 INPUTS
Diamond Drillholes & Blastholes

MODEL 2 INPUTS
Diamond Drillholes & Blastholes
Cu-As

MODEL 3 INPUTS
Diamond Drillholes & Blastholes
Cu-Mo

MODEL 4 INPUTS
Diamond Drillholes & Blastholes
Cu-Fe

MODEL 5 INPUTS
Diamond Drillholes & Blastholes
1
Cu-As

MODEL 6 INPUTS
Diamond Drillholes & Blastholes
1
Cu-Fe

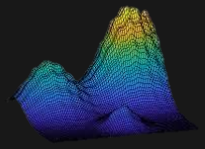
MODEL 7 INPUTS
Diamond Drillholes & Blastholes
2
Cu-As

MODEL 8 INPUTS
Diamond Drillholes & Blastholes
3
Cu-As

MODEL 9 INPUTS
Diamond Drillholes & Blastholes
4

MODEL 10 INPUTS
Diamond Drillholes & Blastholes
GEO

KRIGING MODEL



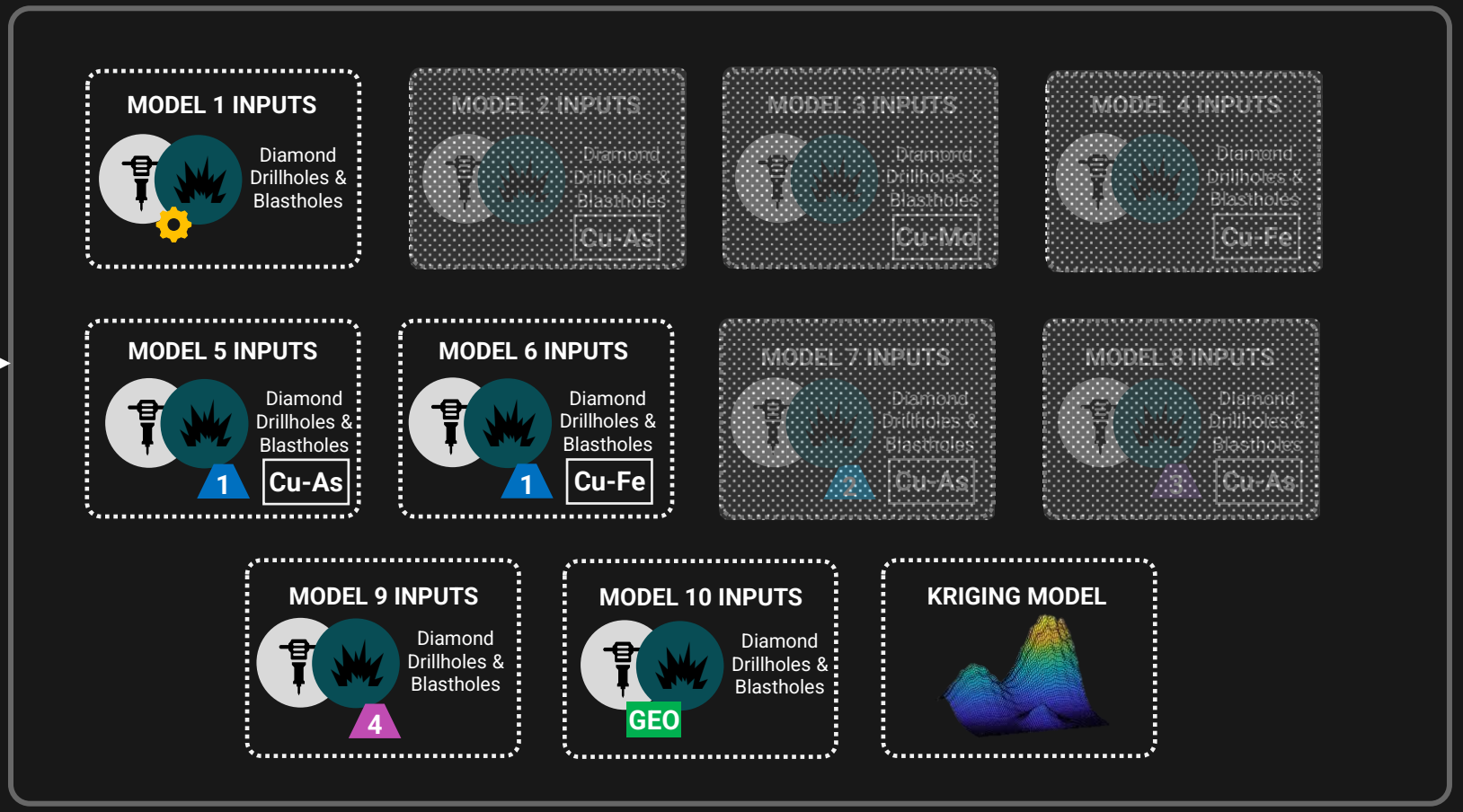
STRATUM MODELS
AI MODEL STRUCTURE

MODELS IN ENSEMBLE

Ensemble selection

We remove models from the ensemble that do not contribute to increased performance on target metrics.

Models best combined via: **Averaging**



Legend:

- Special learning method in training
- Additional metals inputs channel)
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COPPER MODELLING
F1 RECONCILIATION

QUARTERLY DEVIATION
Mill cutoff = 0.17%
Leach cutoff = 0.08%

2019 Models vs Blastholes 2019-2022		Kriging 2019	Ensemble 2019
Quarterly Total Tonnage Deviation	All BLH (Cu lbs)	4.97%	**3.16%**
Quarterly Mill (>0.17% Cu) Tonnage Deviation	All BLH (Cu lbs)	9.28%	**4.07%**
	All BLH (MT ore)	7.70%	**6.71%**
Quarterly Leach (0.08% < Cu < 0.17%) Tonnage Deviation	All BLH (Cu lbs)	31.55%	**17.97%**
	All BLH (MT ore)	31.81%	**19.11%**

- Ensemble models perform better than standalone kriging by leveraging the advantages of machine learning pattern recognition and human geological interpretation.
- The biggest improvements on an absolute basis are with leach ore (MT & Cu lbs) ore and on a relative basis with mill tonnage (Cu lbs).

COPPER MODELLING
RECONCILIATION

BLOCK-WISE RESULTS
Mill cutoff = 0.17%
Leach cutoff = 0.08%

2019 Models vs Blastholes 2019-2022		Kriging 2019	Ensemble 2019
Missed Mill Ore (mill ore predicted as leach or waste)	**All BLH (Cu lbs)**	33.55 Mlbs Cu	**28.92 Mlbs Cu**
	All BLH (MT ore)	**7.08MT (12.2%)**	7.10MT (12.1%)
False Positive Mill Ore (leach/waste predicted as mill ore)	**All BLH (MT waste/ leach)**	7.02MT (12.3%)	**6.13 MT (10.6%)**

- Ensembles excels in ensuring that minimal mineralization is left behind – zones predicted as waste actually being mill ore. The model correctly identified 4.6Mlbs of additional mill ore where Kriging expected waste.
- The model predicts an additional 15Mlbs of these zones in-situ within 4 benches from surface. Given the mine is satisfied with the existing realized strip ratio, reducing missed mill ore is more economically beneficial than reducing false positive mill ore as the potential value of finding previously missed mill ore is higher than potential savings of blasting ~5% less waste.

COPPER MODELLING
LEACH RECONCILIATION

BLOCK-WISE RESULTS
Mill cutoff = 0.17%
Leach cutoff = 0.08%

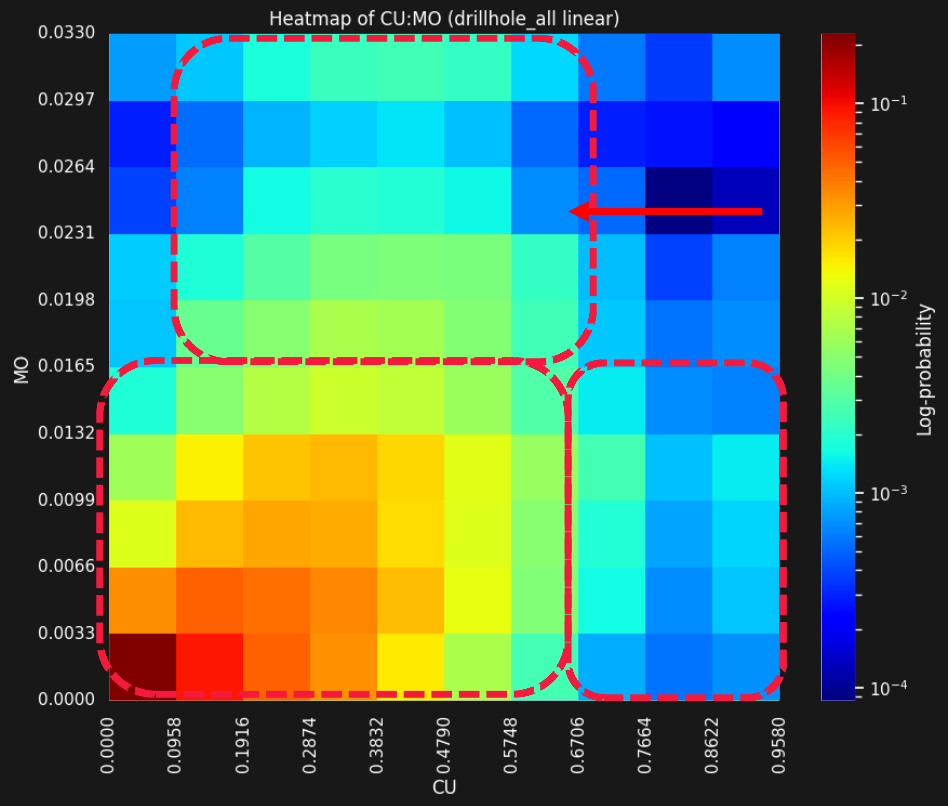
2019 Models vs Blastholes 2019-2022		Kriging 2019	Ensemble 2019
Missed Leach Ore (leach ore predicted as waste)	**ICP BLH (Cu lbs)**	1.28 Mlbs Cu	2.16 Mlbs Cu
	ICP BLH (MT ore)	0.61MT (16.9%)	1.02MT (28.6%)
Waste In Leach Ore (waste predicted as leach)	**ICP BLH (MT ore)**	1.05MT (35.2%)	**0.28 MT (11.4%)**

- Kriging's difficulty in meeting guidance with leach grade material manifests as 35.2% of predicted leach being reconciled as waste. Ensemble-1 contains a minimal 7.4% of leach estimates reconciled as waste and Ensemble-3 has 23.1% of leach estimates reconciled as waste. Ensemble-1 is a more constrained model so it misses 1Mlbs more of leach ore while Ensemble-3 misses 0.1Mlbs less leach ore.
- Given that leach is already marginal ore, it is typically beneficial to be more constrained, meet guidance, ensure leach predictions contain minimal waste rather than attempting to minimize missed leach ore. Ensemble-1 and HG-Detector both achieve these objectives.

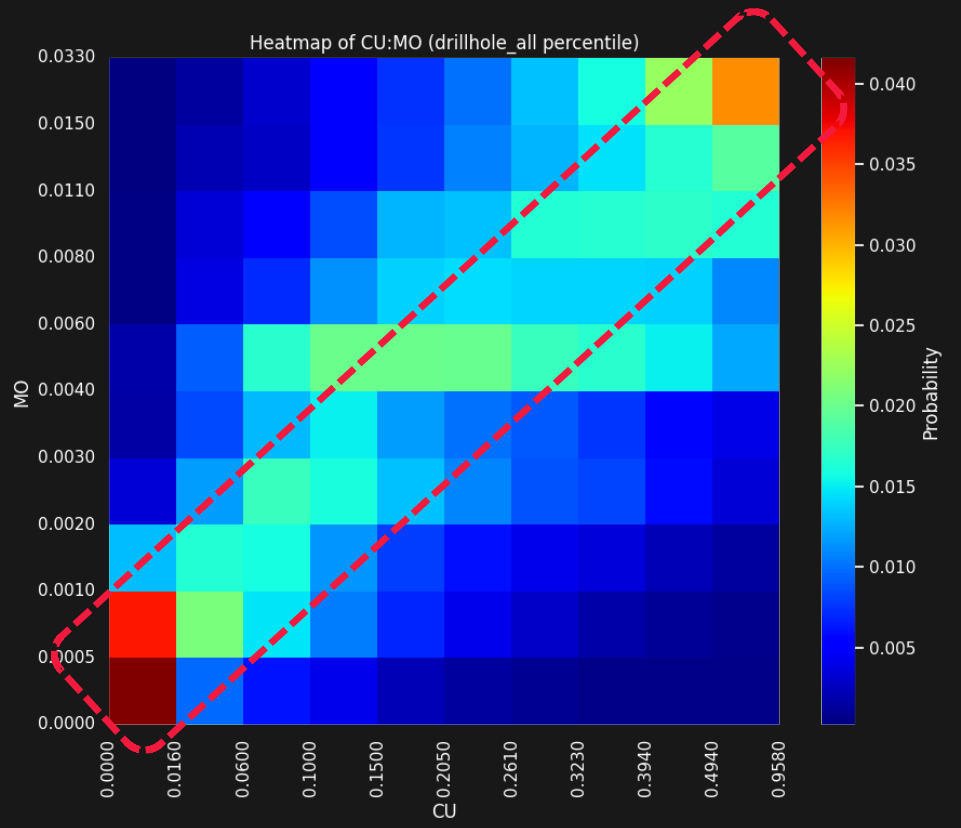
COPPER MODELLING
MULTIVARIATE ANALYSIS

COPPER & MOLYBDENUM (MO)

Straightforward linear trend on percentile data that initially implies that Mo assays contains little unique information



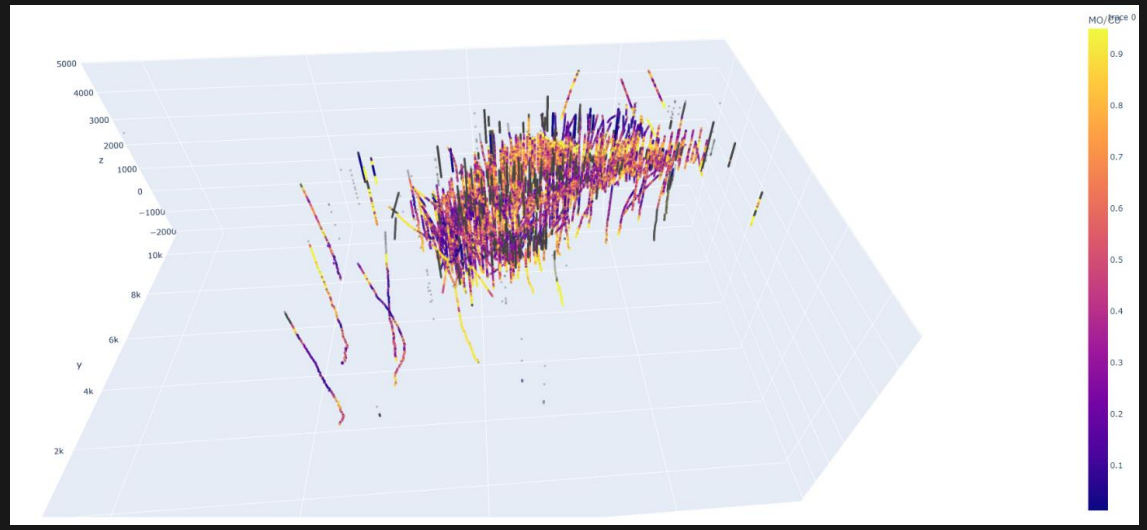
Linear Scaling

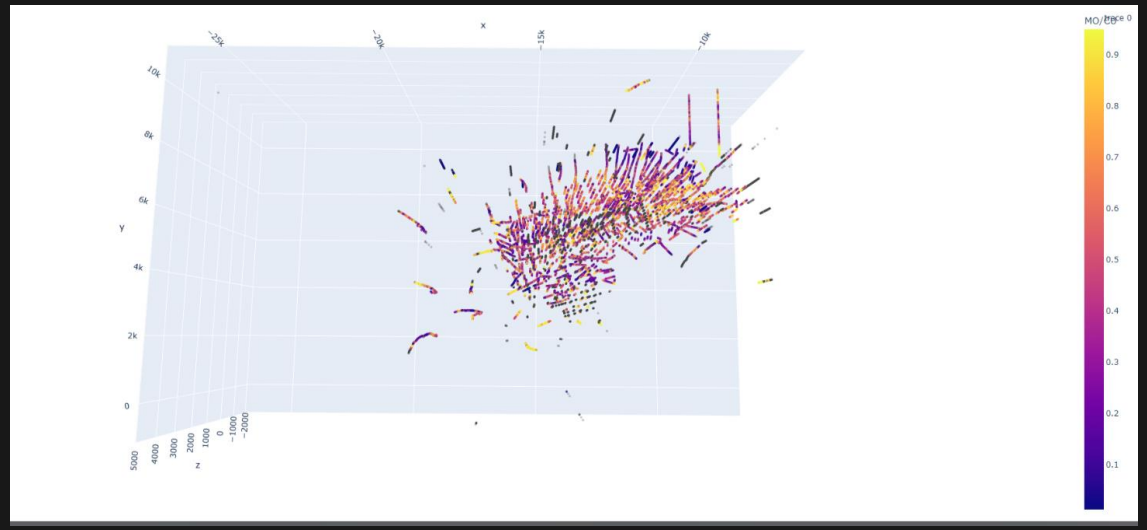


Percentile Scaling

COPPER MODELLING
SPATIAL ANALYSIS

COPPER & MOLYBDENUM (MO)





Comments:

Deconstructing linear trend spatially reveals distinct areas of i) high Cu, low Mo ii) mid Cu high Mo iii) low Cu, low Mo.

This implies that the Mo, Cu relationship is substantially more complex than multivariate analysis initially implies

Value to Ensemble:

Mo assays are valuable inputs for predicting Cu grades around the grade boundaries (0.06% -0.20%). In particular, Ensemble with Mo models excel in reducing missing ore, leach ore.

COPPER MODELLING
MULTIVARIATE ANALYSIS

COPPER & IRON (FE)

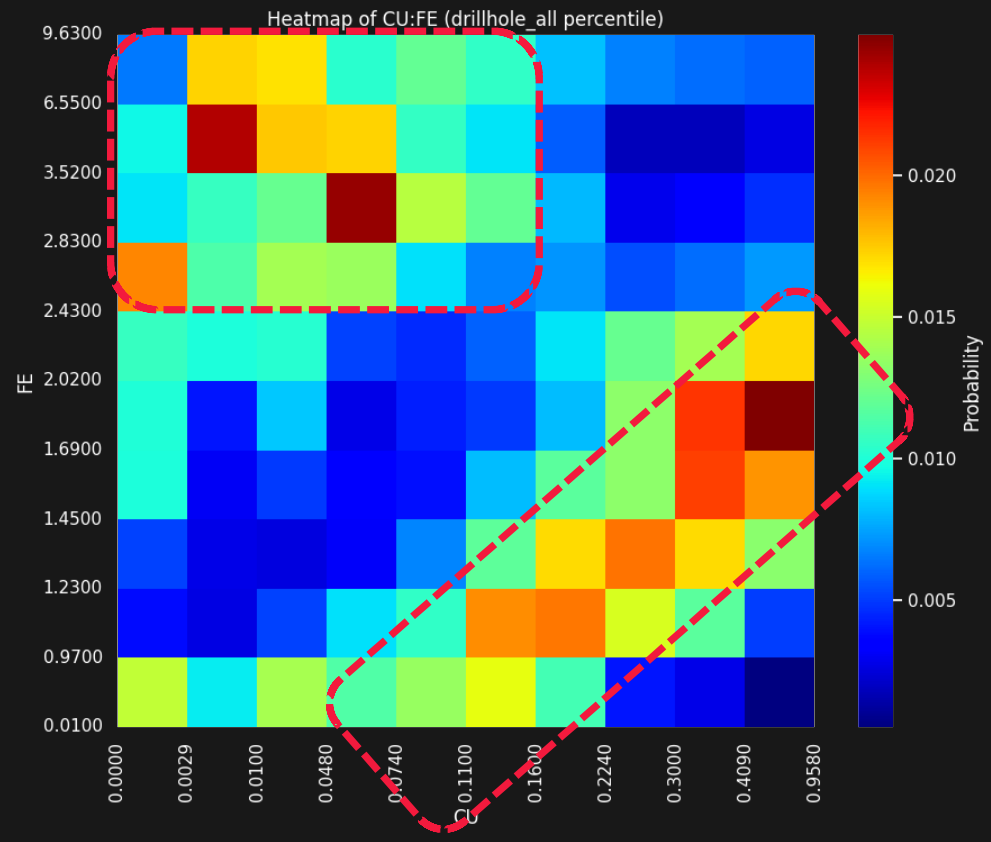
Value to Ensemble:

Fe assays provide value input for identifying high grade (>0.45%) areas. Both for reducing false positive HG areas and reducing missed HG ore.

All models designed for HG detection include Fe as part of ensemble.

Accuracy Through Consensus

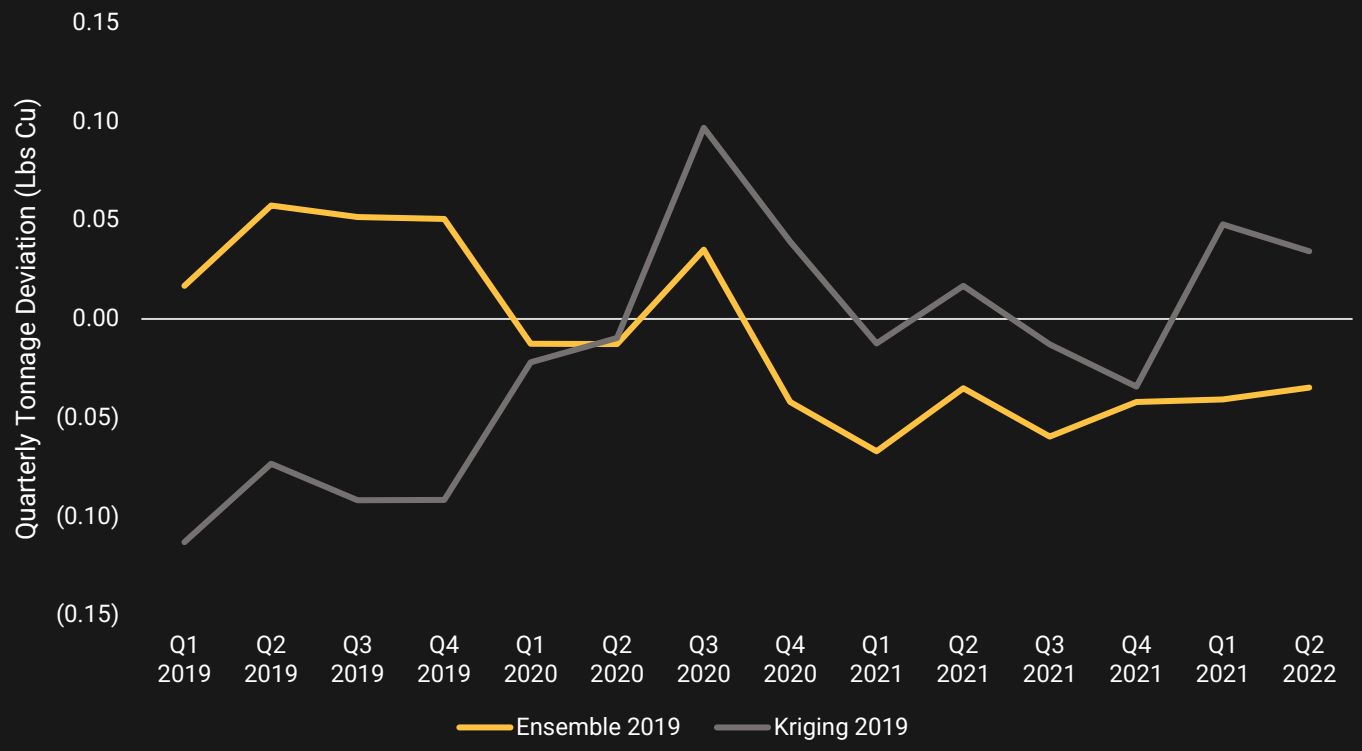
Ensembles designed for guided drilling for HG heavily depend on consensus to achieve targeting performance. If multiple models using different data predict HG, there is substantially higher chance a region is actually going to be HG than if just 1 or 2 models predicted HG.



Percentile Scaling

COPPER MODELLING
F1 RECONCILIATION

QUARTERLY TONNAGE DEVIATION

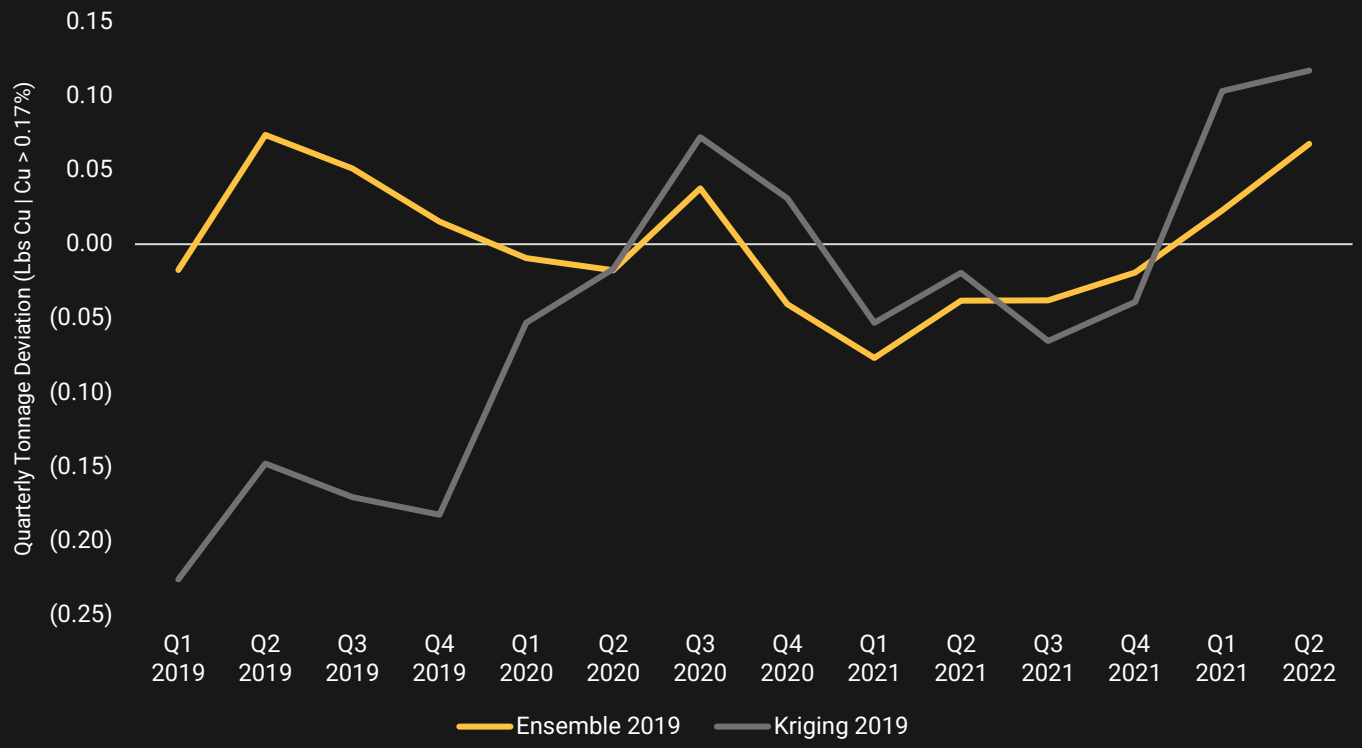


Ensemble model more accurately predicts the quarterly tonnage deviation of mine with 19.8% less error.

KRIGING 2019	**4.99%**
AI 2019	**3.98%**

COPPER MODELLING
F1 RECONCILIATION

QUARTERLY MILL TONNAGE DEVIATION
(Cu lbs | Cu > 0.17%)

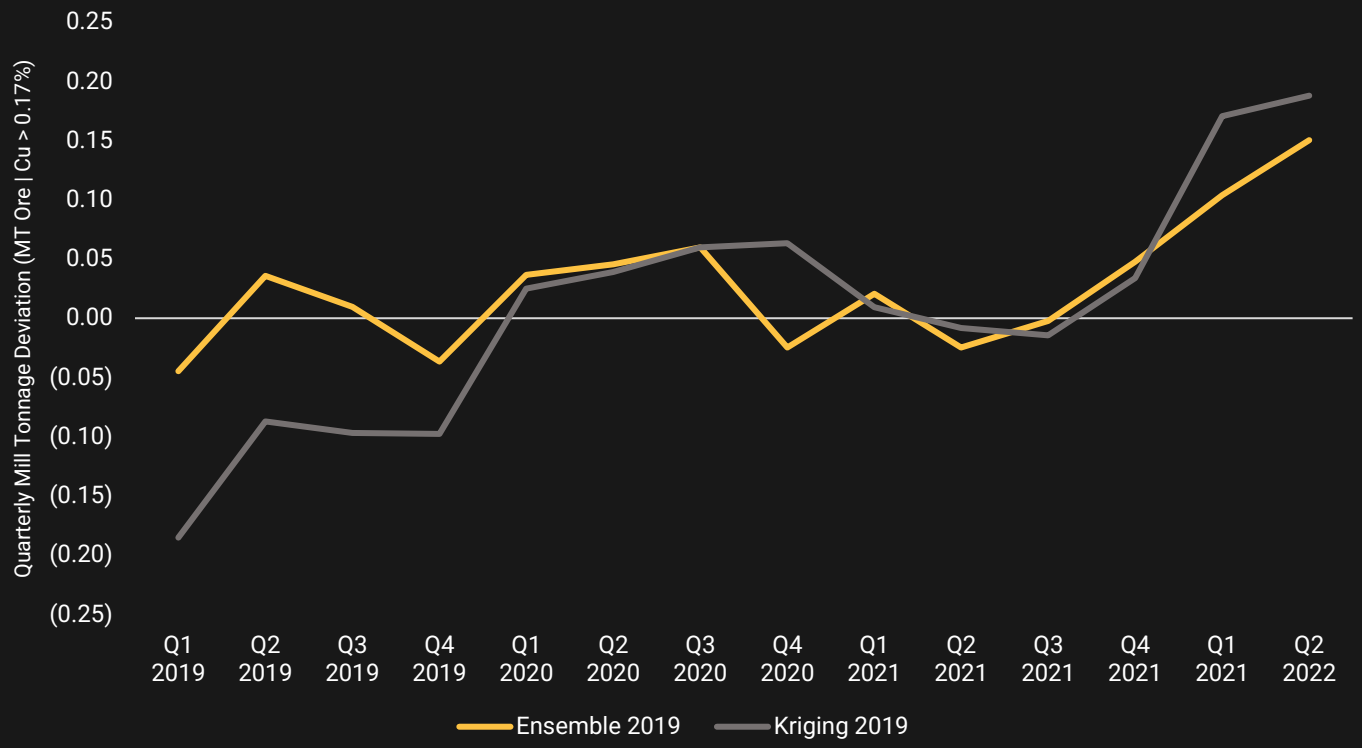


Ensemble model more accurately predicts the quarterly mill tonnage deviation (Cu lbs) of mine with 59.5% less error.

KRIGING 2019	**9.28%**
AI 2019	**3.76%**

COPPER MODELLING
F1 RECONCILIATION

QUARTERLY MILL TONNAGE DEVIATION
(MT Ore | Cu > 0.17%)

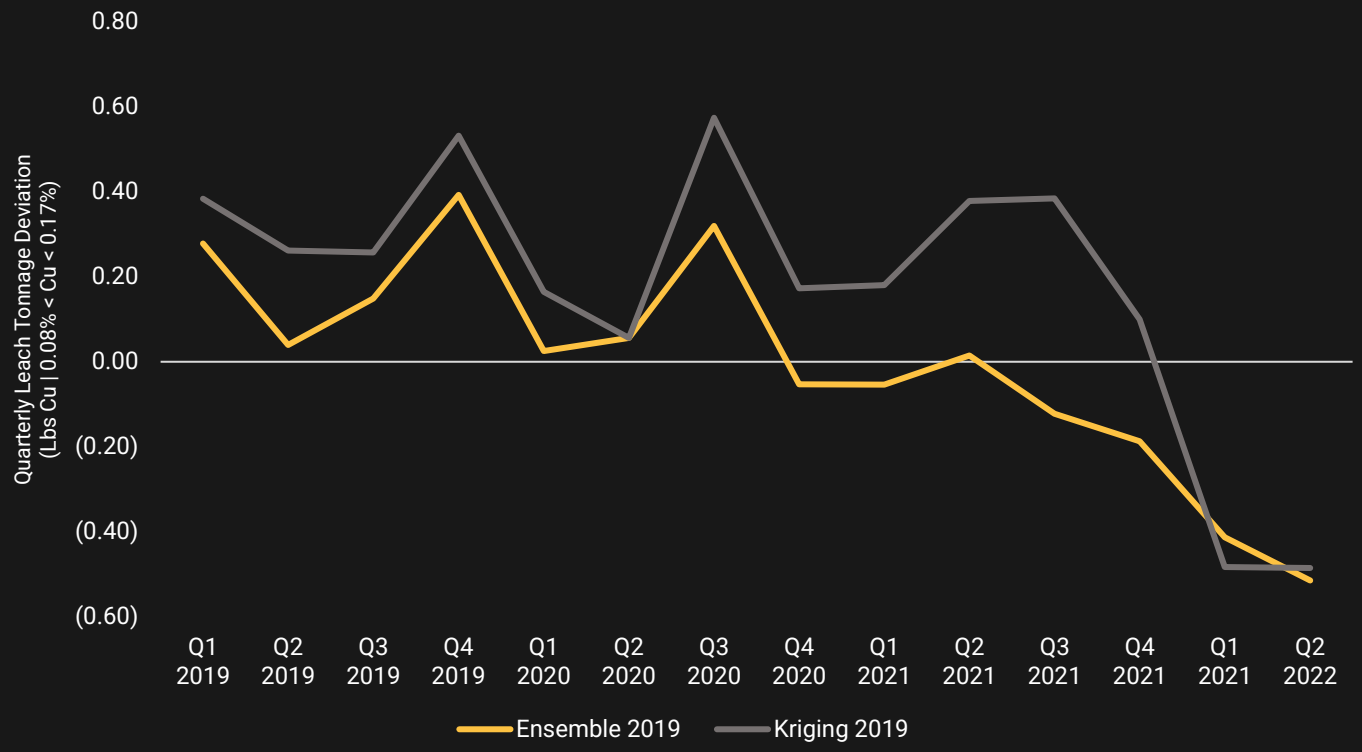


Ensemble model more accurately predicts the quarterly mill tonnage deviation (MT ore) of mine with 40.4% less error.

KRIGING 2019	**7.70%**
AI 2019	**4.59%**

COPPER MODELLING
F1 RECONCILIATION

QUARTERLY LEACH TONNAGE DEVIATION
(Cu lbs | 0.08% < Cu < 0.17%)

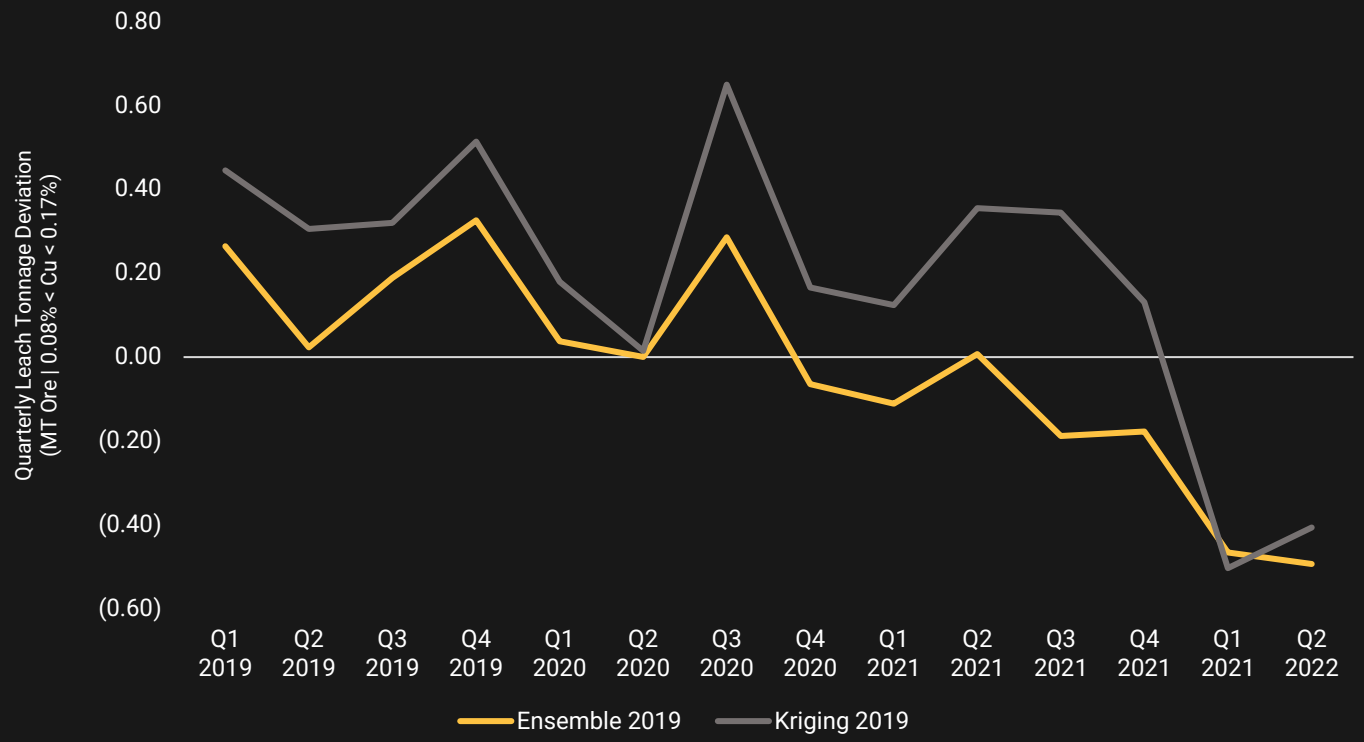


Ensemble-1 model more accurately predicts the quarterly leach tonnage deviation (Cu lbs) of mine with 40.7% less error.

KRIGING 2019	**31.55%**
AI 2019	**18.71%**

COPPER MODELLING
F1 RECONCILIATION

QUARTERLY LEACH TONNAGE DEVIATION
(Cu MT | 0.08% < Cu < 0.17 %)



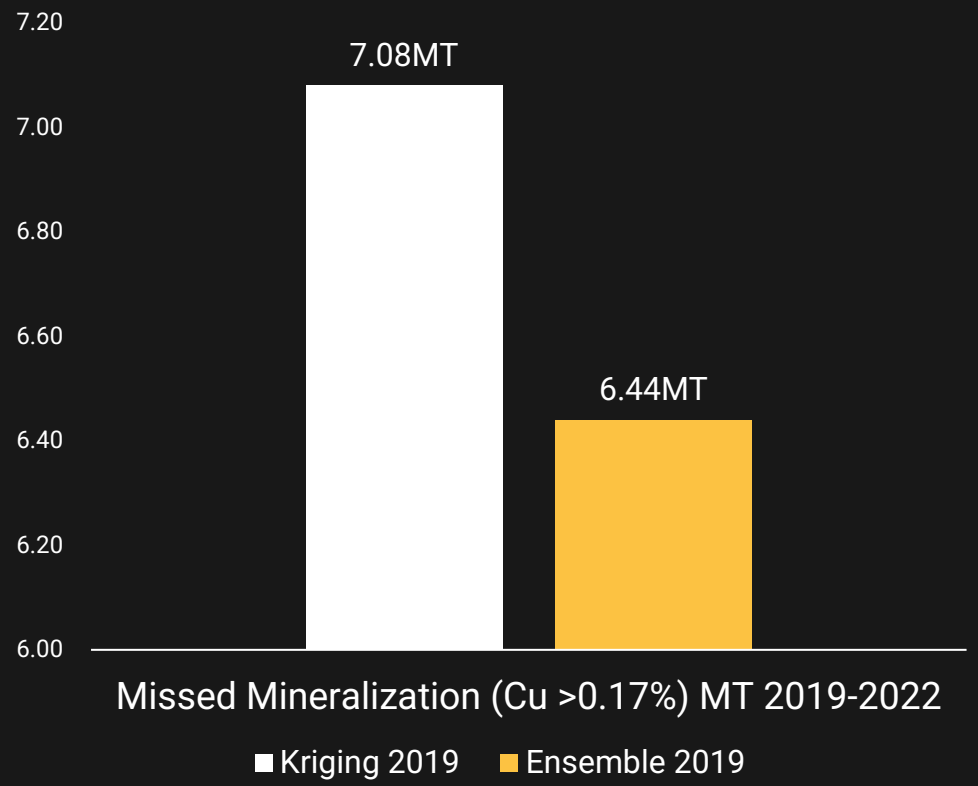
Ensemble-1 model more accurately predicts the quarterly leach tonnage deviation (MT ore) of mine with 40.9% less error.

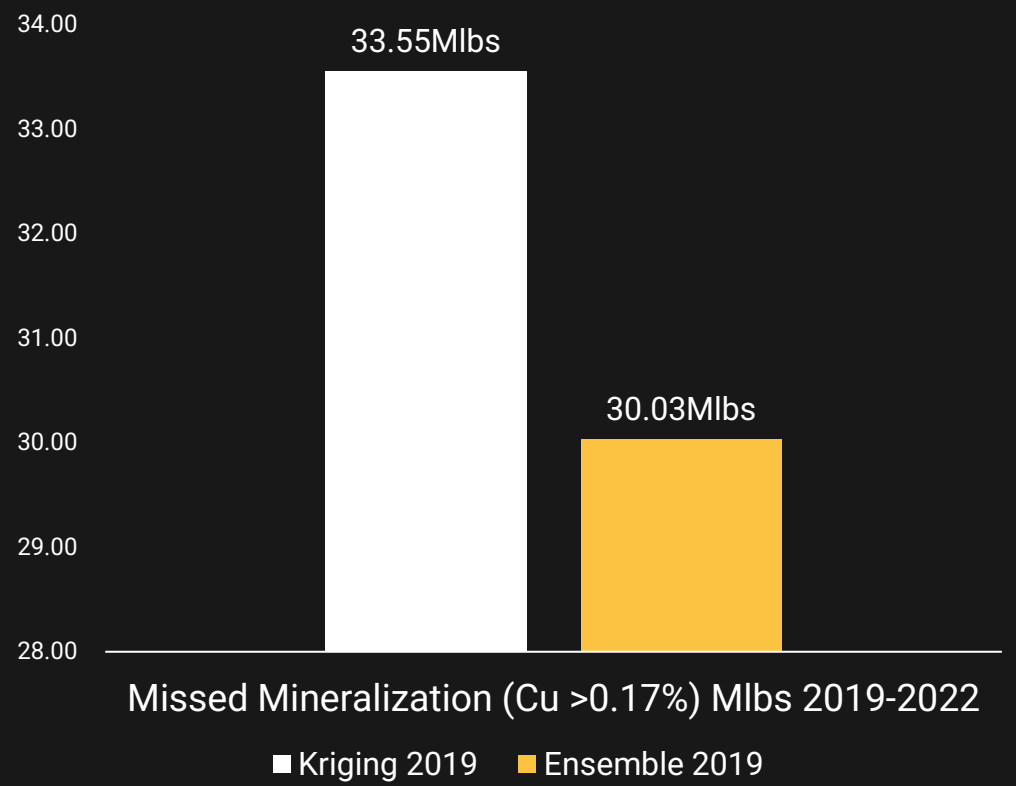
KRIGING 2019	**31.81%**
AI 2019	**18.79%**

COPPER MODELLING
RESULTS

MISSED MILL ORE
(>0.17% Ore Predicted as <0.17%)

Ensemble-1 reconciled over 3.5 years correctly predicts 3.52Mlbs (0.64MT) additional mineralization (net) from zones kriging models as waste.
An additional 15Mlbs unique mineralization zones remain in-situ 4 benches from surface in 2022.



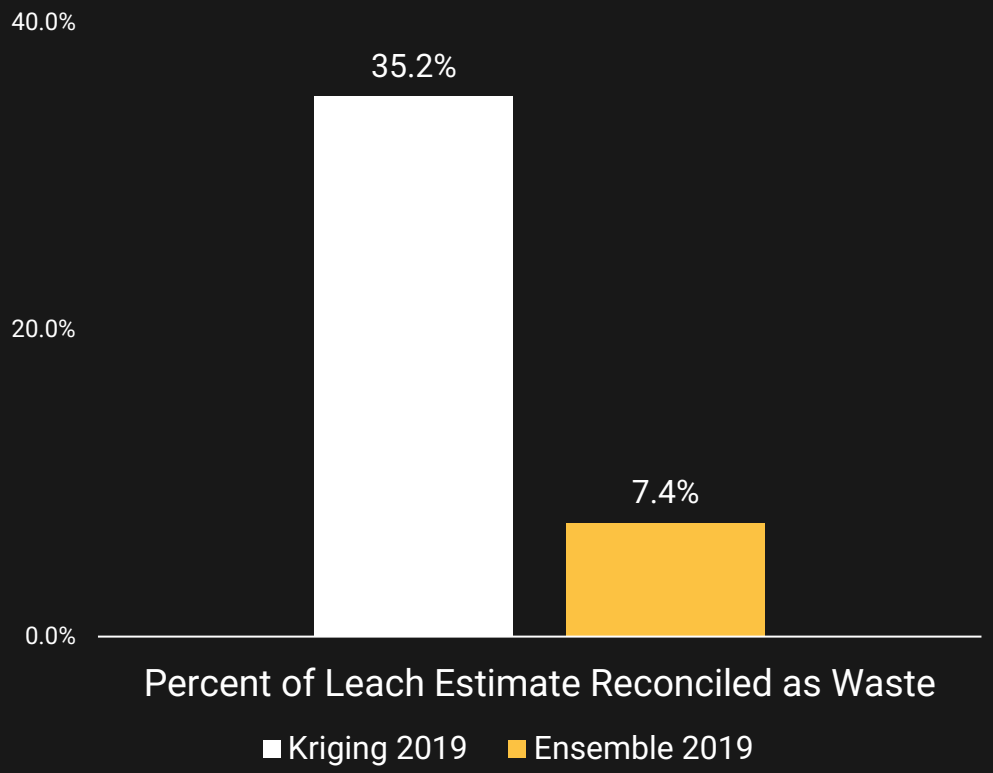


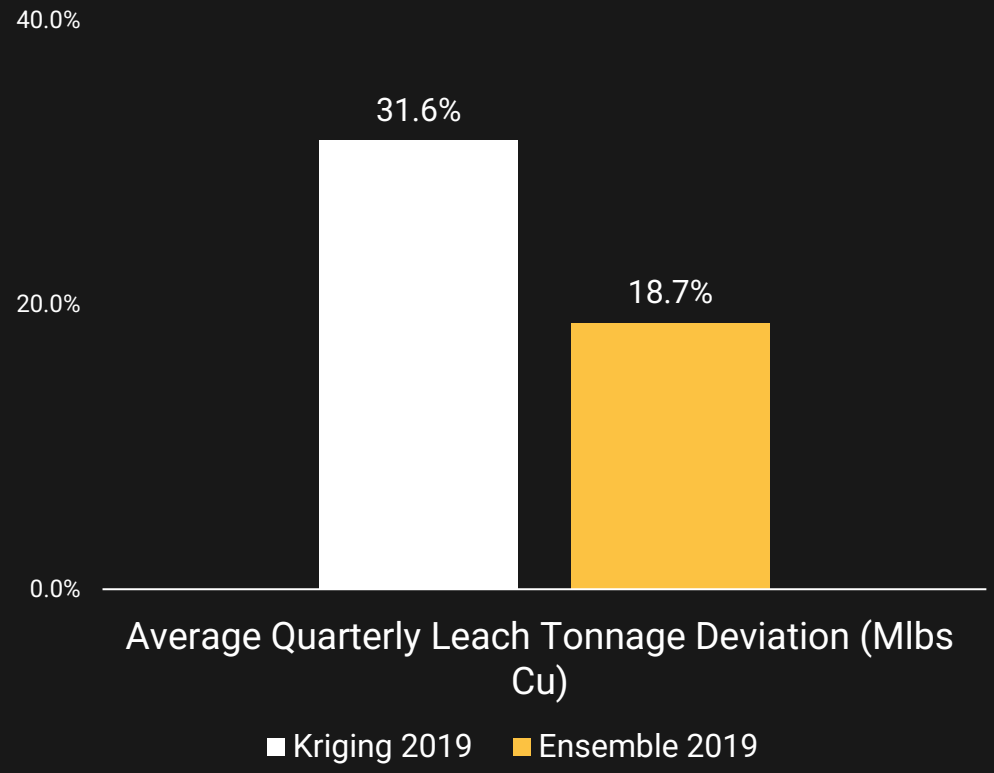
3Mlbs and 0.58MT represent the net missed economic (Cu >0.17%) mineralization over 3.5 years reconciliation. Please note that kriging generally tends to miss higher grade areas than the Ensembles.

COPPER MODELLING
RESULTS

WASTE IN LEACH ORE
(WASTE PREDICTED AS LEACH ORE)

Ensemble better estimates leach guidance (40.8% less error) by accurately constraining leach estimates – model has 78.9% less waste reconciled in leach block estimates over 1 year reconciliation





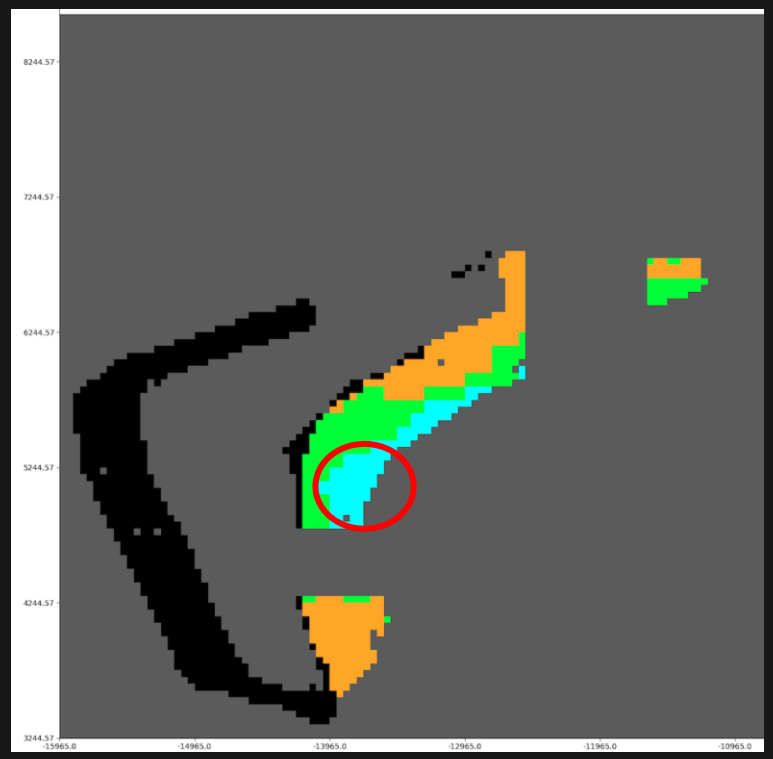
Cross Sections

Reconciliation Blastholes 2019-2022

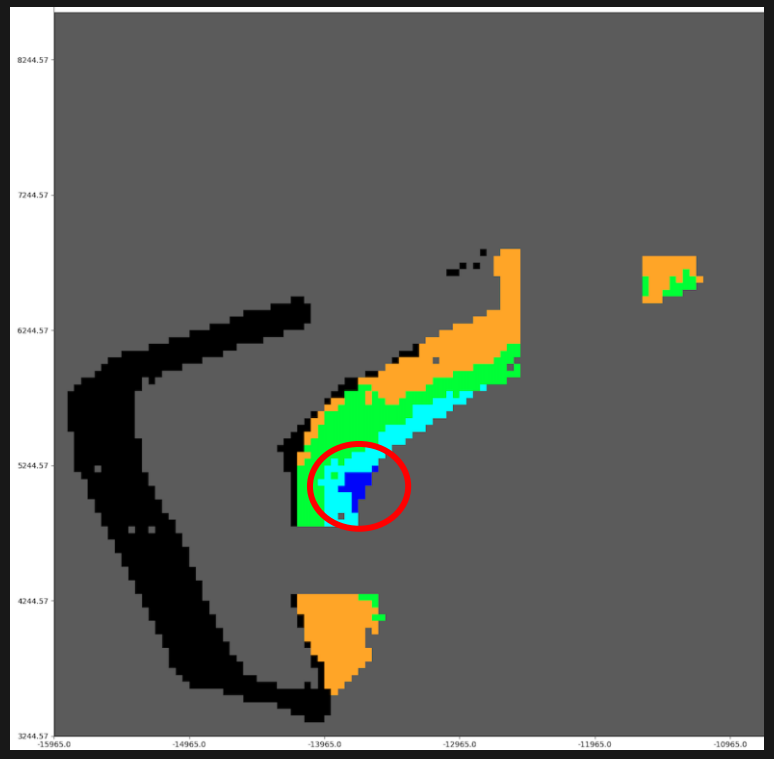
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 3245.8750 ft

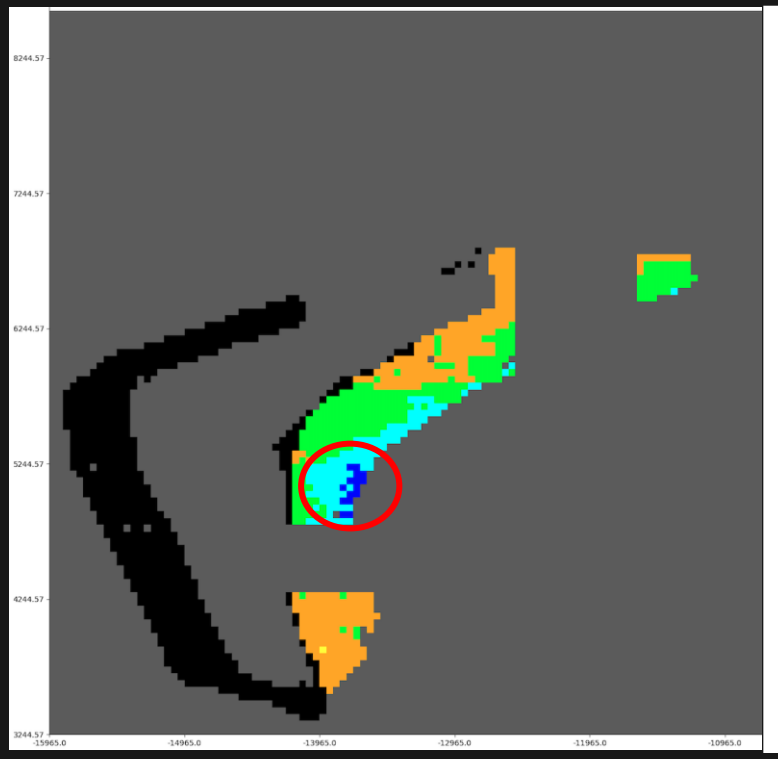
Kriging 2019



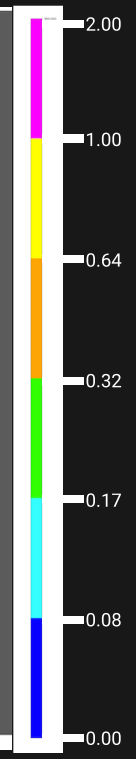
Ensemble 2019



Blastholes
2019-2022



Block Size (50x50x45)

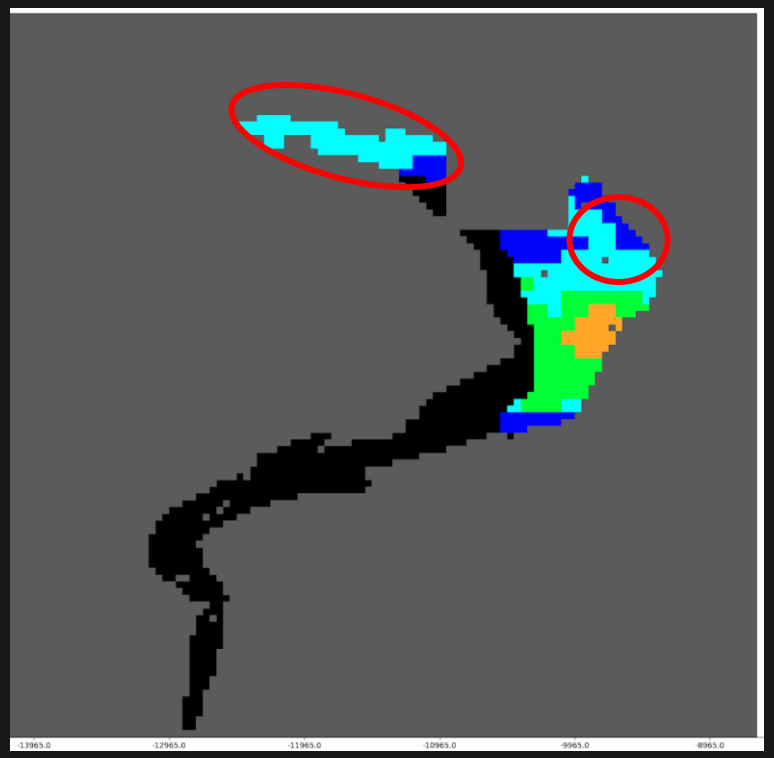


Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves pit design.

COPPER MODELLING
CROSS SECTION ANALYSIS

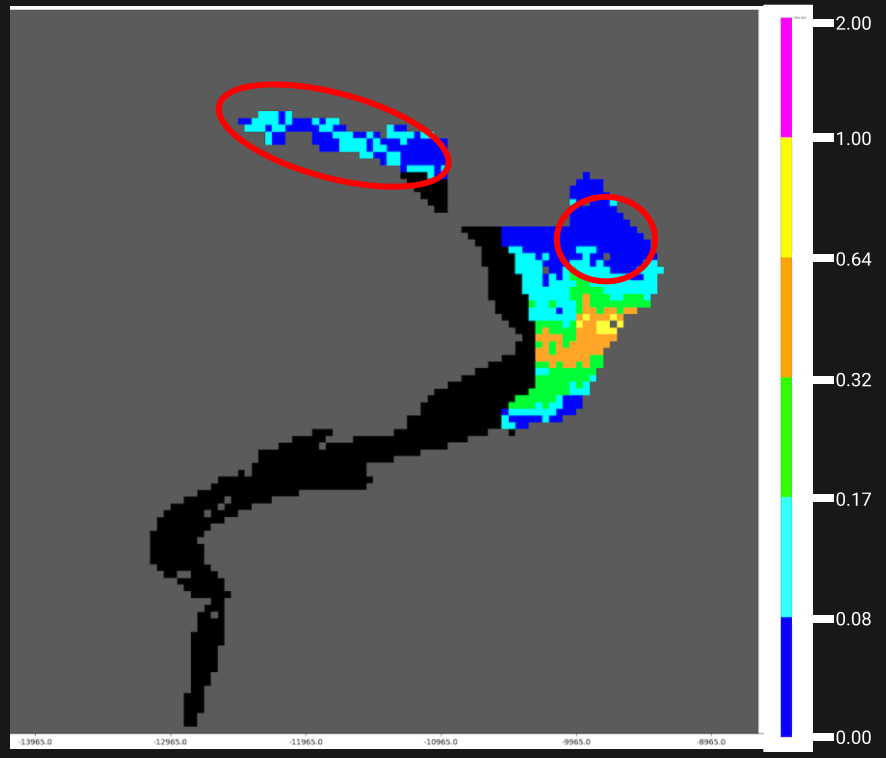
BENCH VIEW
Z = 4010.8750 ft

Kriging 2019



Ensemble 2019

Blastholes
2019-2022



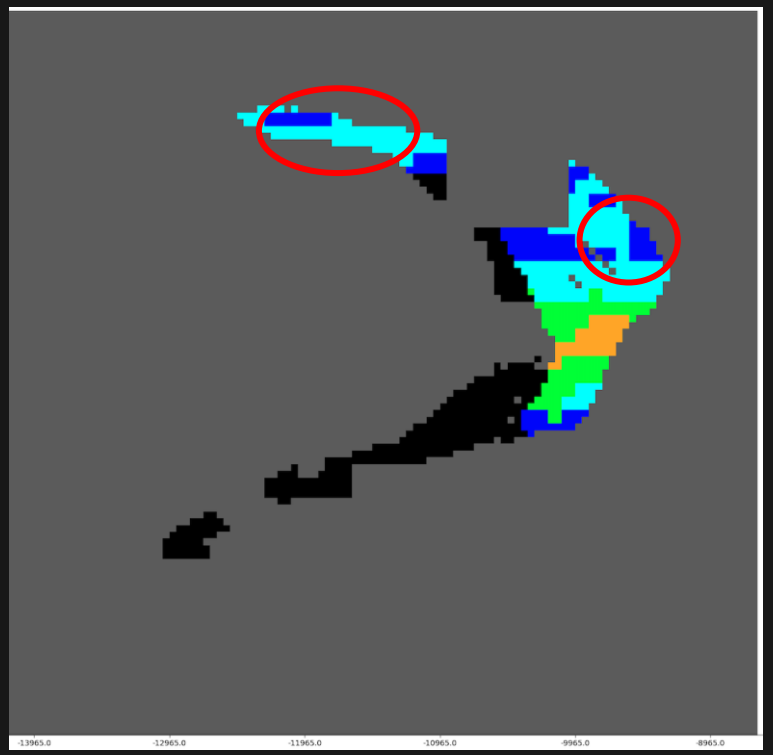
Block Size (50x50x45)

Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves pit design as it should not have been mined in the first place (contains little to no ore in benches under it).

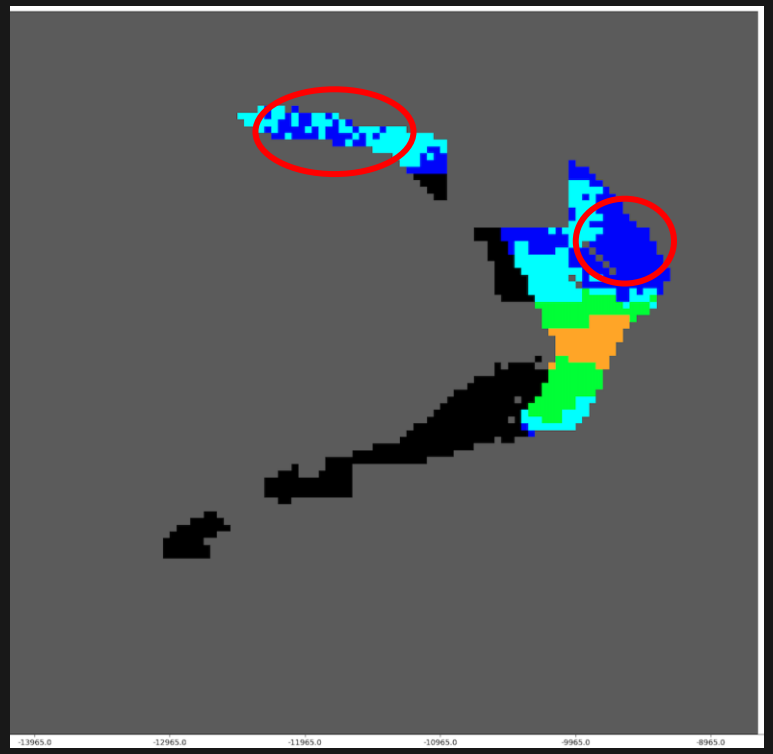
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 4055.8750 ft

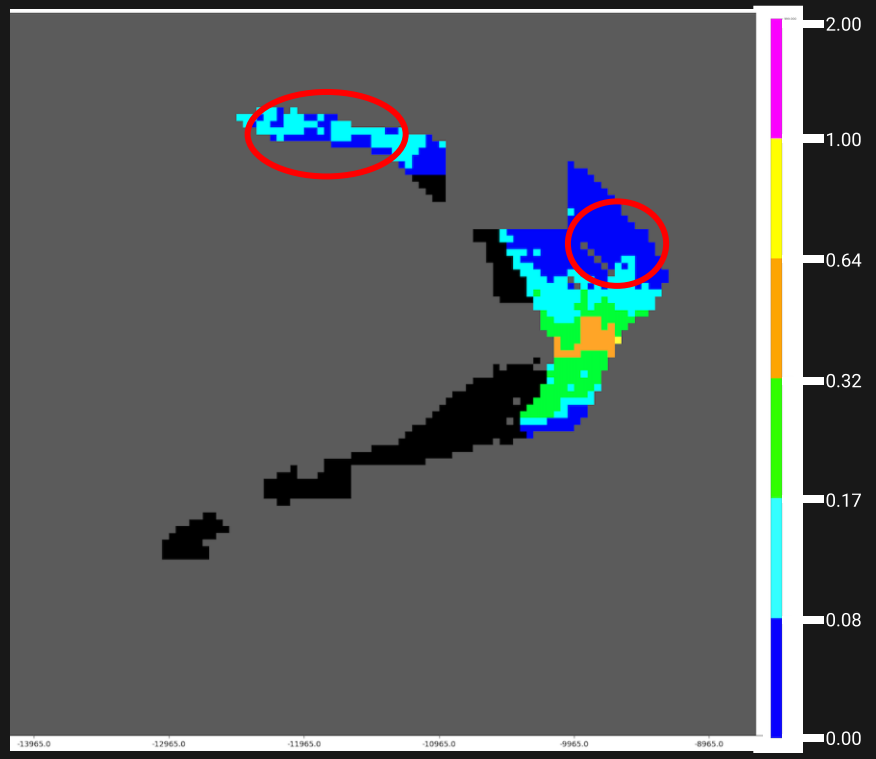
Kriging 2019



Ensemble 2019



Blastholes
2019-2022



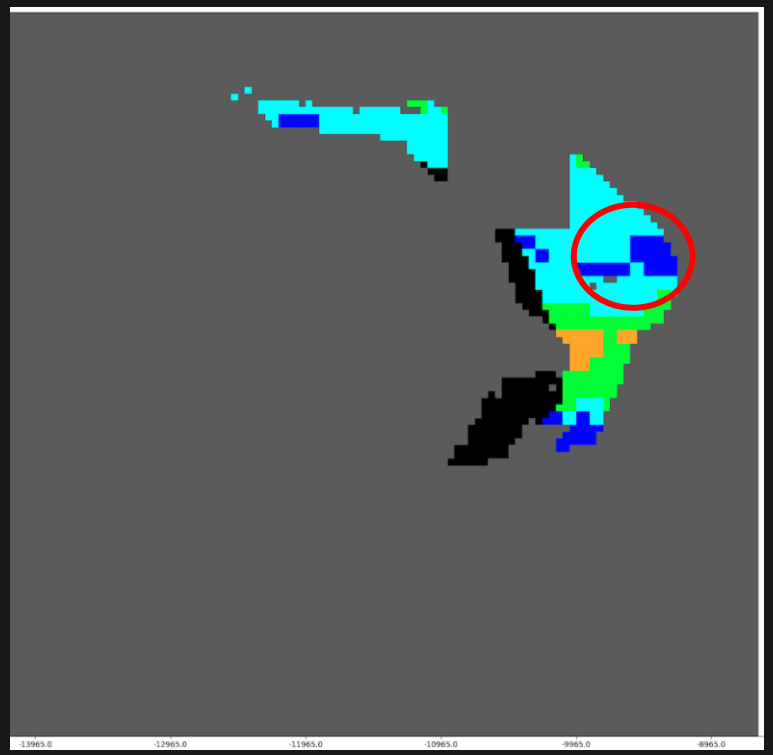
Block Size (50x50x45)

Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves pit design as these benches should not have been mined in the first place (contains little to no ore in benches under it).

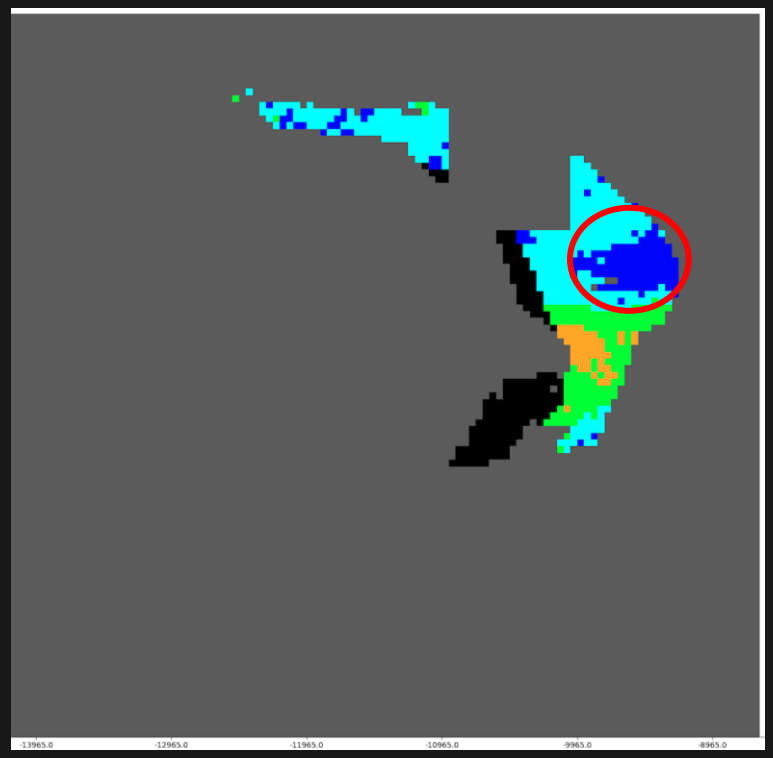
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 4145.8750 ft

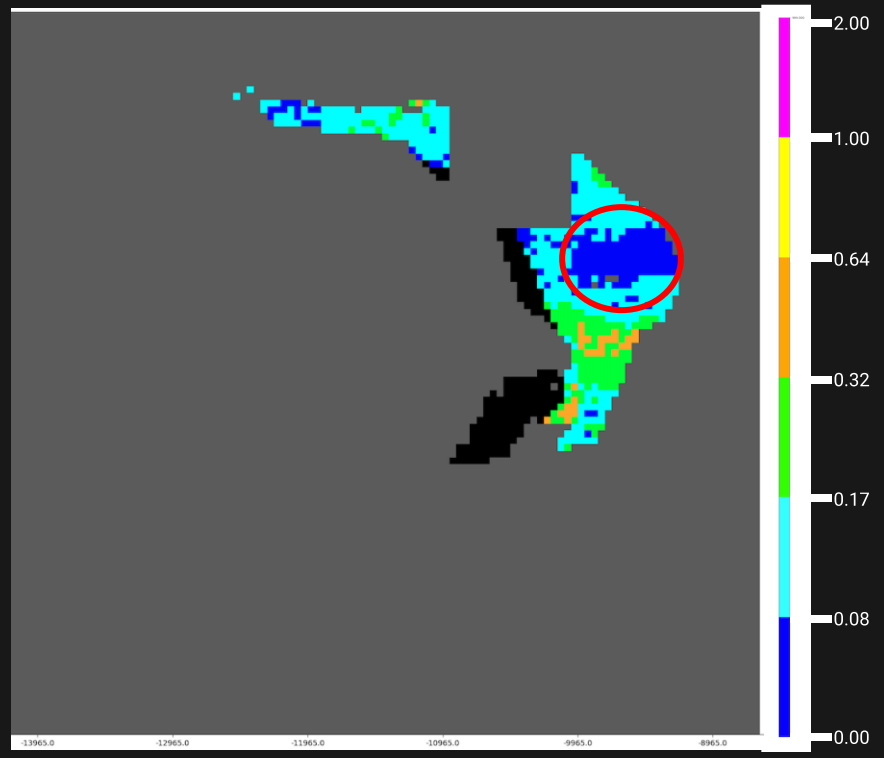
Kriging 2019



Ensemble 2019



Blastholes
2019-2022



Block Size (50x50x45)

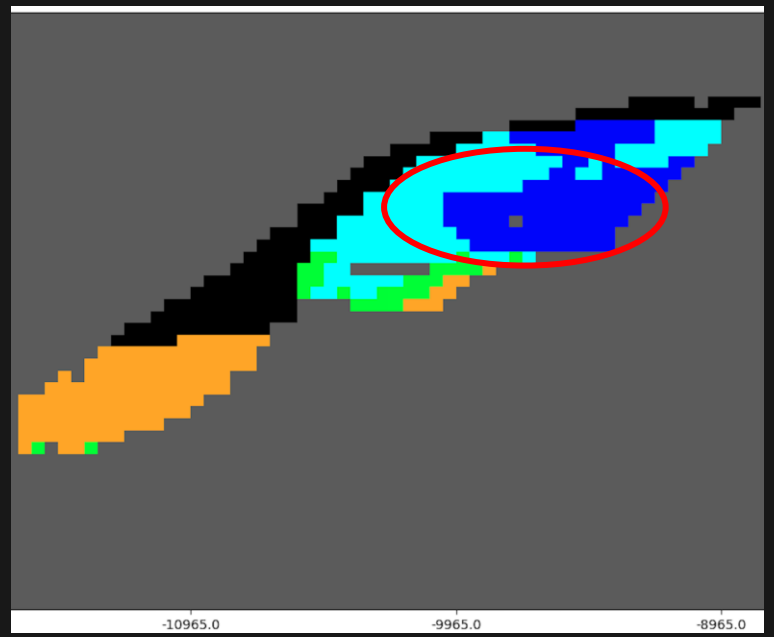
Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and dilution (through blast shape delineation).

COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
NORTH = 6694.5700 ft

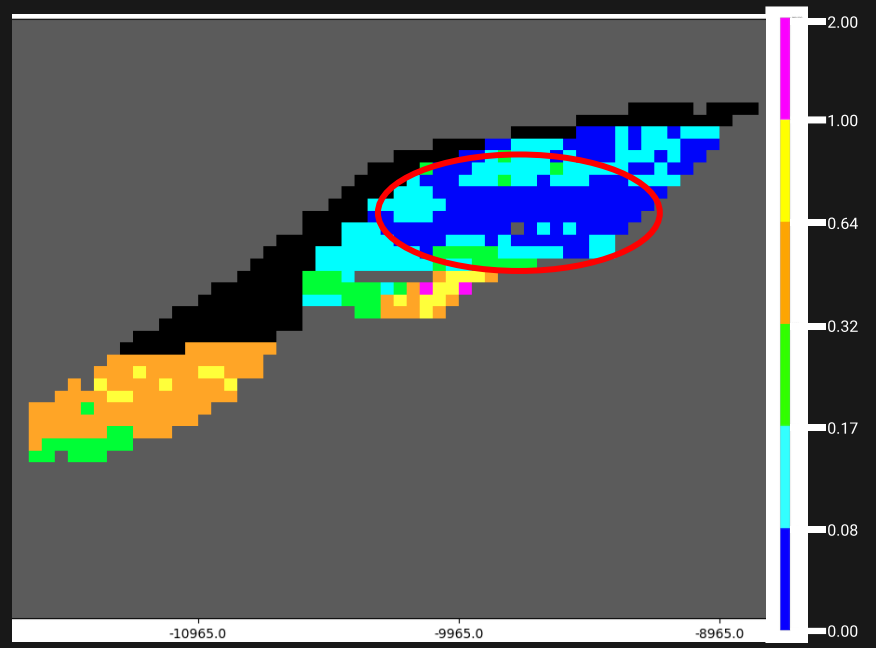
Kriging 2019

Ensemble 2019



Blastholes
2019-2022

Block Size (50x50x45)



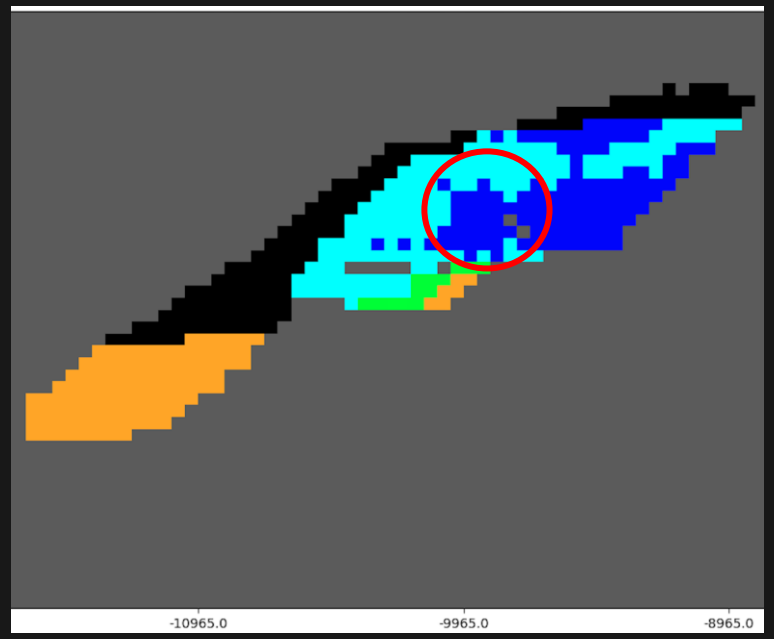
Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and dilution (through blast shape delineation).

COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
NORTH = 6744.5700 ft

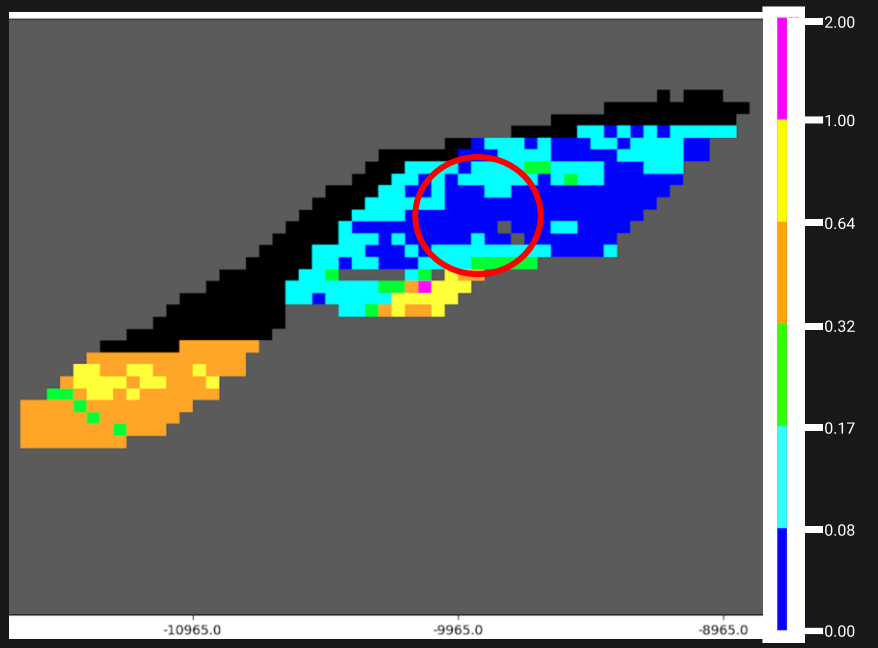
Kriging 2019

Ensemble 2019



Blastholes
2019-2022

Block Size (50x50x45)

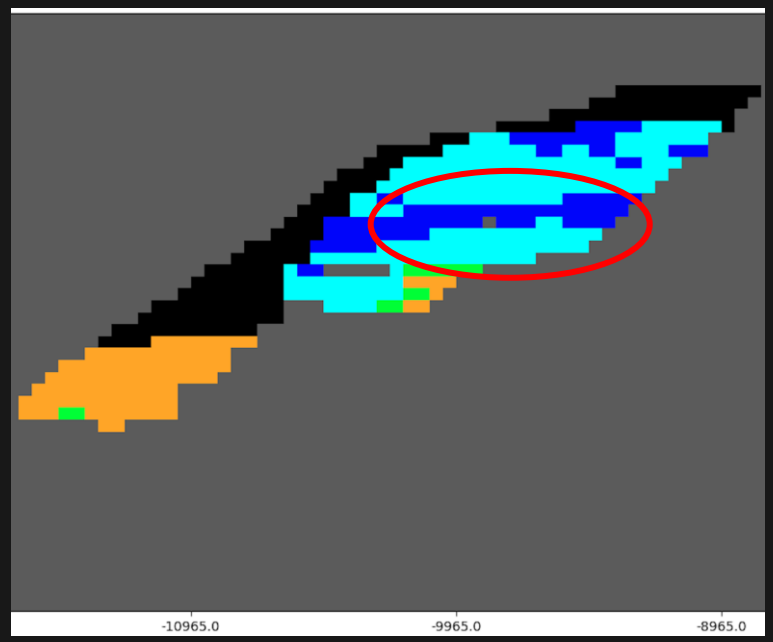


Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves mine scheduling.

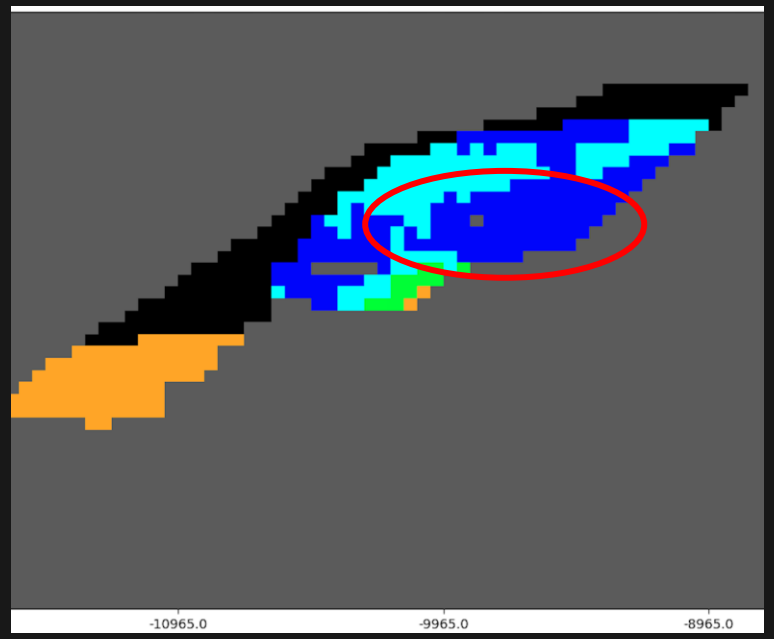
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
NORTH = 6794.5700 ft

Kriging 2019

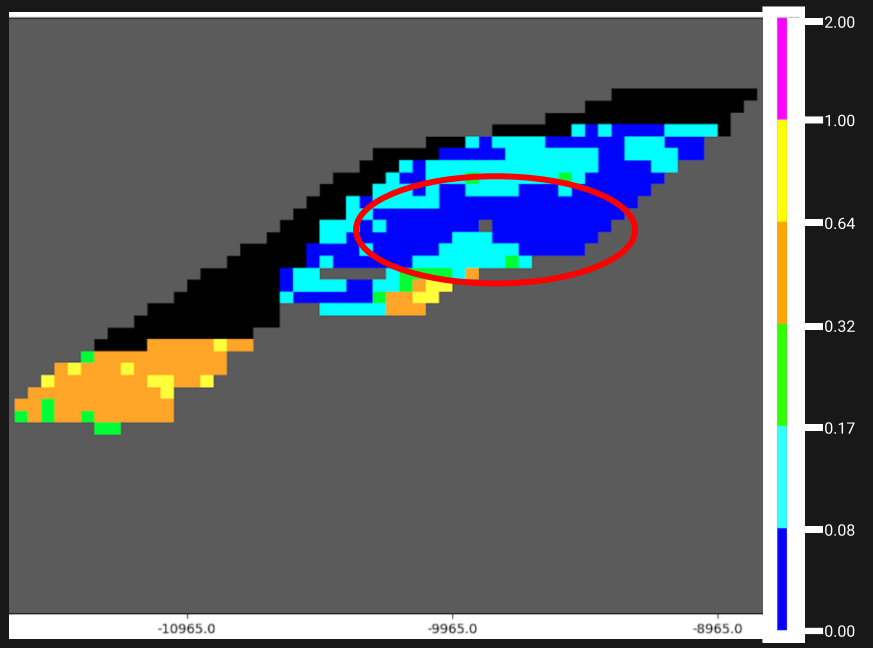


Ensemble 2019



Blastholes
2019-2022

Block Size (50x50x45)

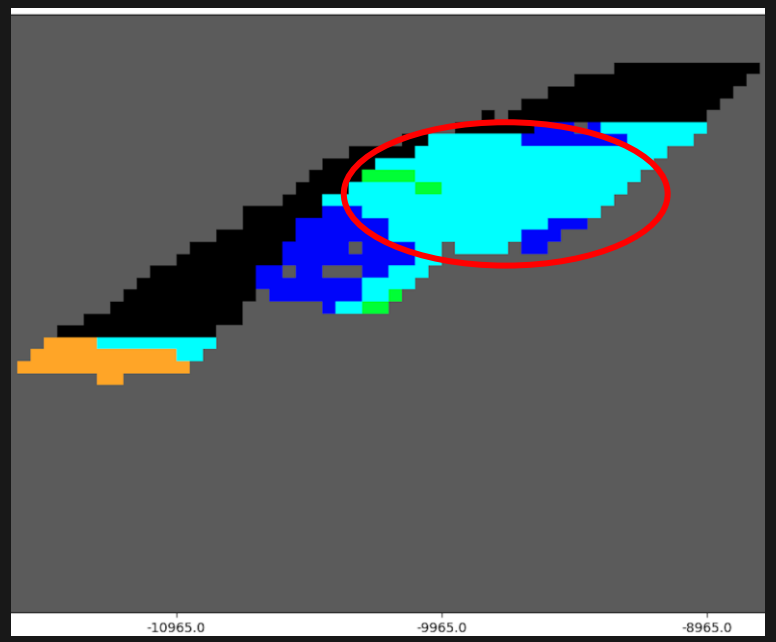


Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves mine scheduling.

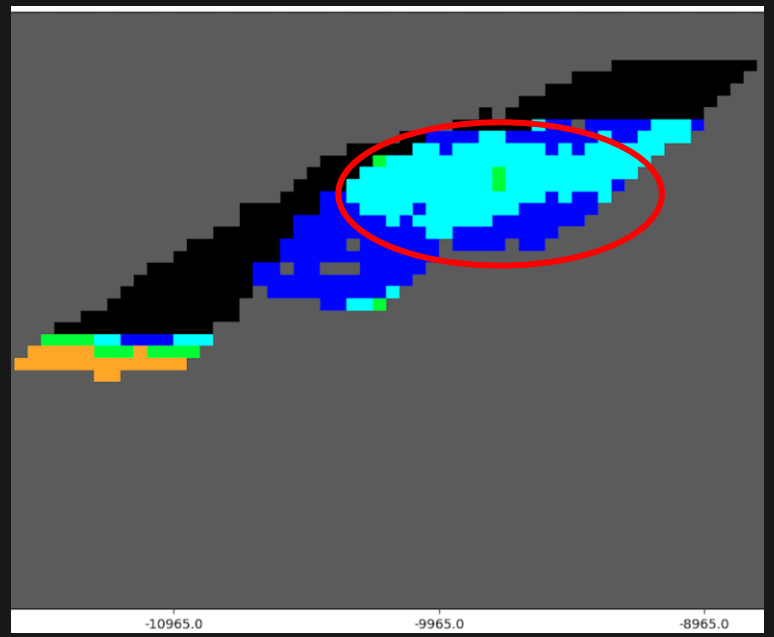
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
NORTH = 6944.5700 ft

Kriging 2019

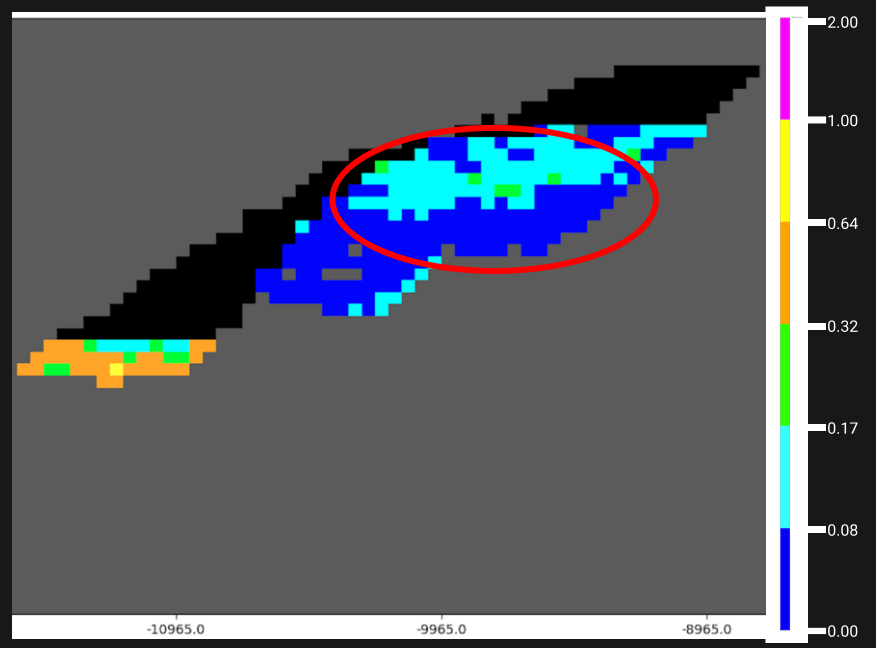


Ensemble 2019



Blastholes
2019-2022

Block Size (50x50x45)

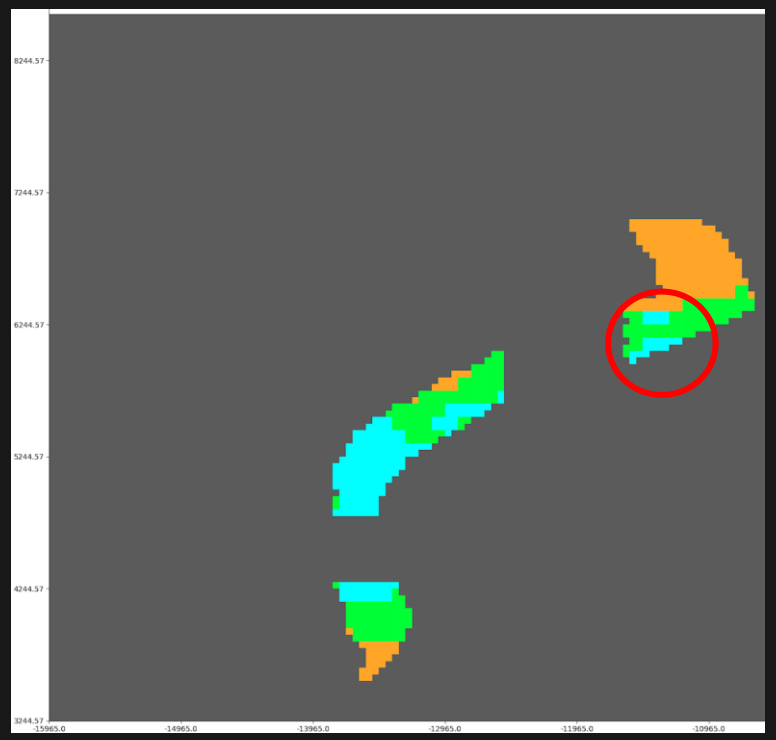


Ensemble identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves pit design as it should not have been mined in the first place (contains little to no ore in benches under it).

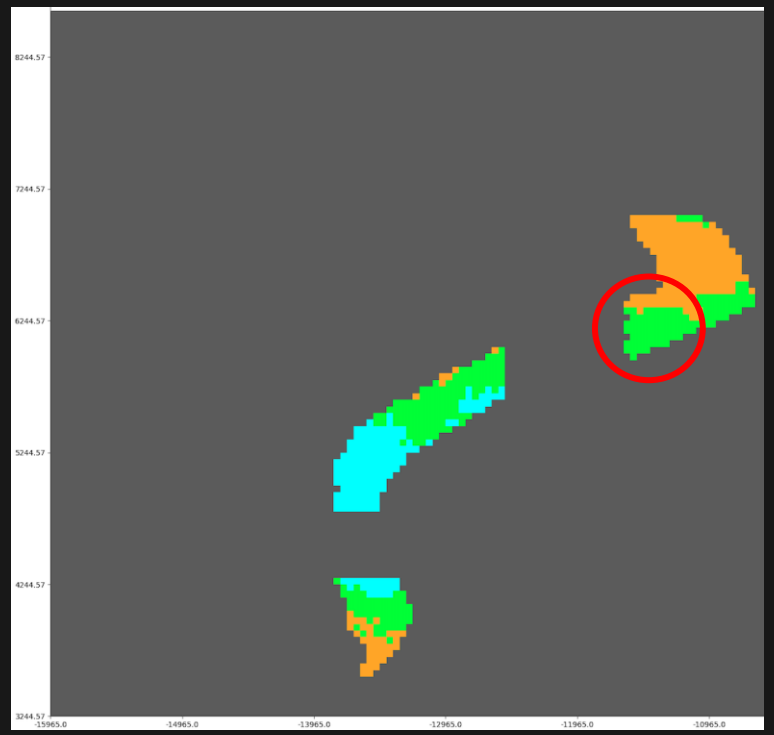
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 3515.8750 ft

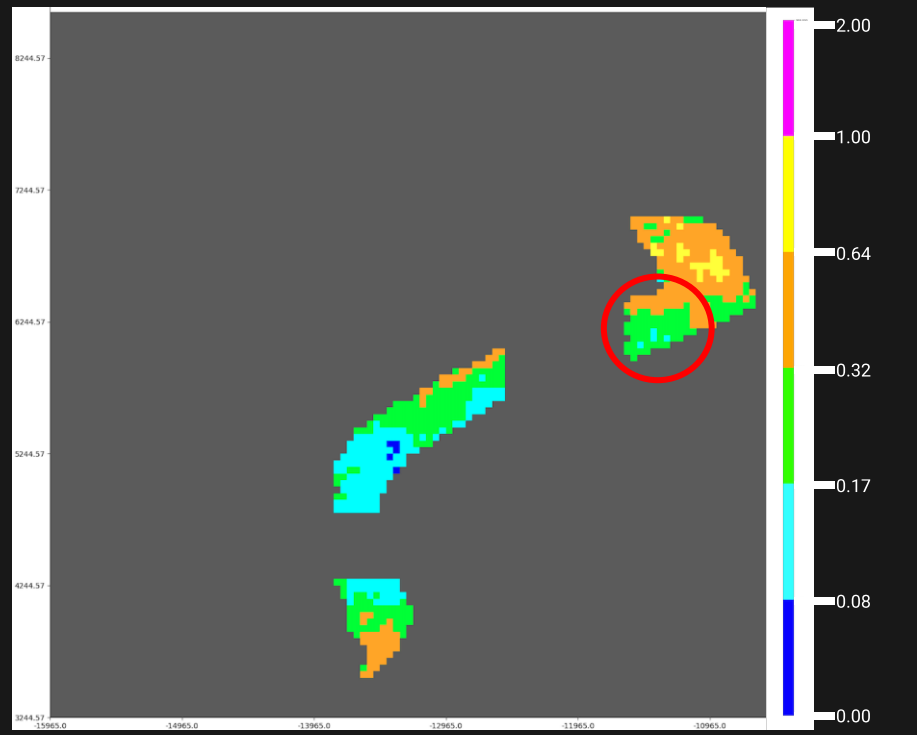
Kriging 2019



Ensemble 2019



Blastholes
2019-2022

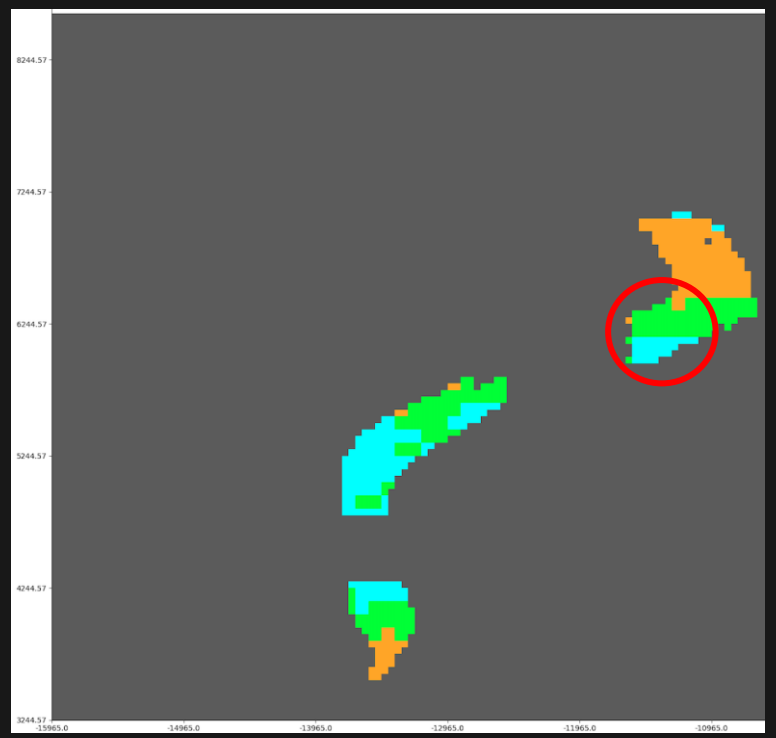


Ensemble identifies mill area correctly where kriging predicts waste. Demonstrates ability of model in correctly identifying otherwise missed mineralization. Model identifies 15Mlbs more unique mill ore within 4 benches from surface.

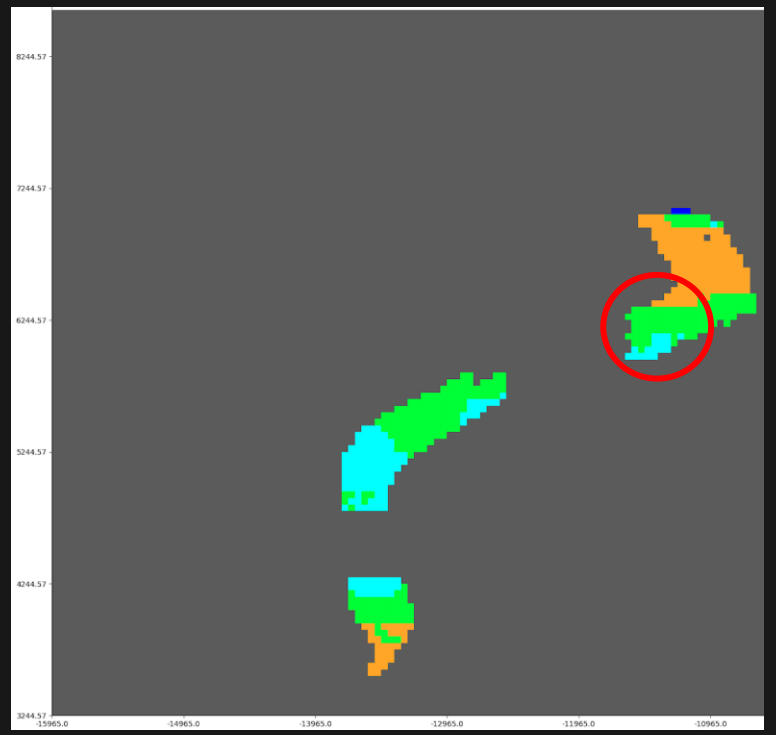
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 3560.8750 ft

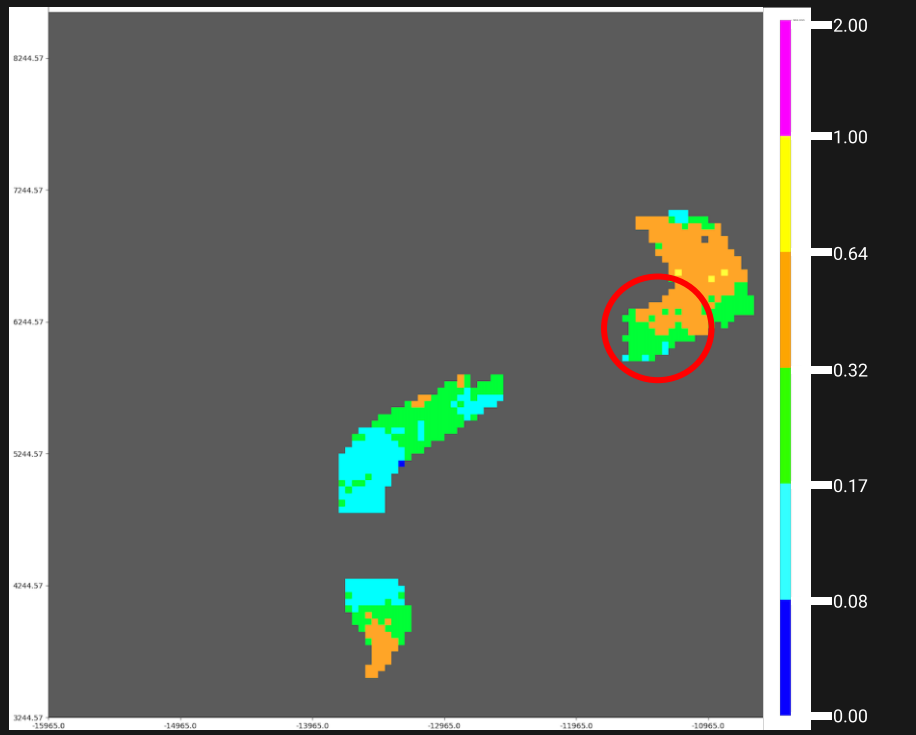
Kriging 2019



Ensemble 2019



Blastholes
2019-2022



Ensemble identifies mill area correctly where kriging predicts waste. Demonstrates ability of model in correctly identifying otherwise missed mineralization. Model identifies 15Mlbs more unique mill ore within 4 benches from surface.

Leveraging ML for High Grade Detection

HG Detection for NPV Maximization

COPPER MODELLING
RECONCILIATION

BLOCK-WISE HG RESULTS
HG cutoff > 0.45%

2019 Models vs Blastholes 2019-2022		Kriging 2019	Ensemble 2019
Missed HG Ore (mill ore predicted as LG / waste)	**All BLH (Cu lbs)**	76.65 Mlbs Cu	**70.00 Mlbs Cu**
	All BLH (MT ore)	6.64MT (58.2%)	**5.92MT (53.4%)**
False Positive HG Ore (LG / waste predicted as mill ore)	**All BLH (MT waste/ leach)**	2.51MT (35.1%)	**1.88 MT (26.7%)**

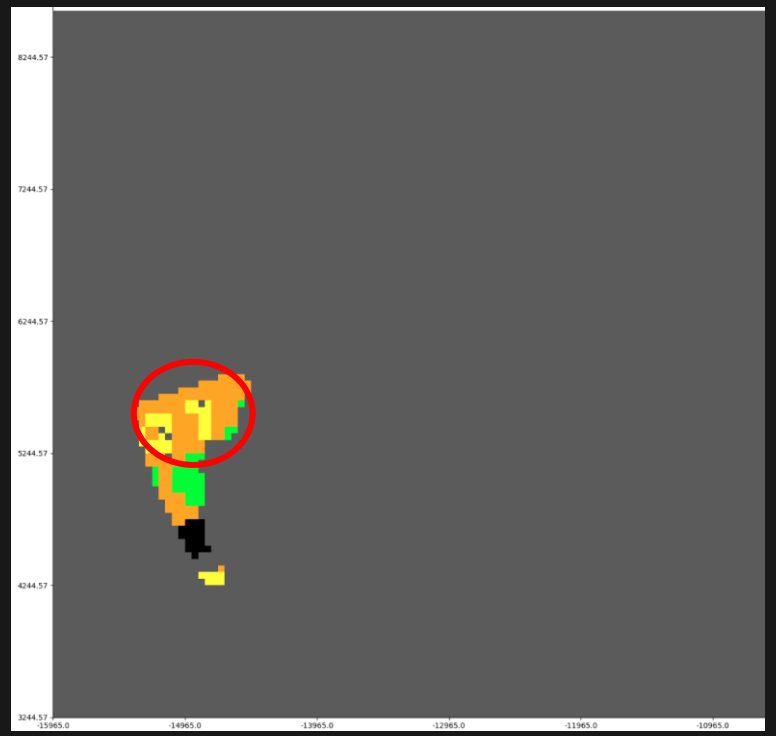
Resource Definition Drilling

- Reconciliation yields **23.9%** ((35.1-26.7)/(35.1) lower probability any predicted block is LG/W when mined while missing **6.6Mlbs** less of HG ore.
- Model also identifies **22Mlbs** of HG mineralization in areas where Kriging models LG / Waste within 4 benches of surface which creates **ideal targets for NPV maximizing resource definition drilling**.

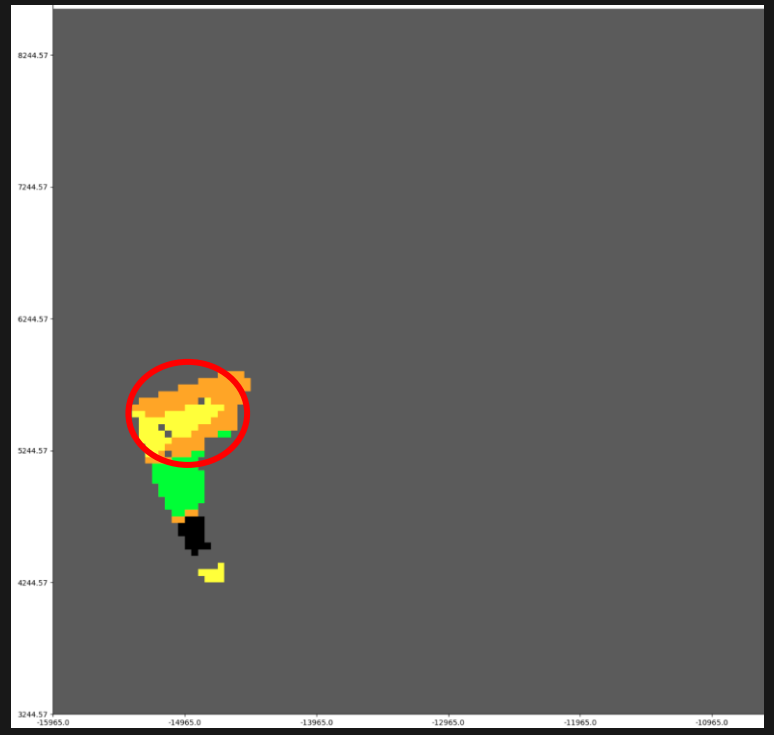
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 2750.8750 ft

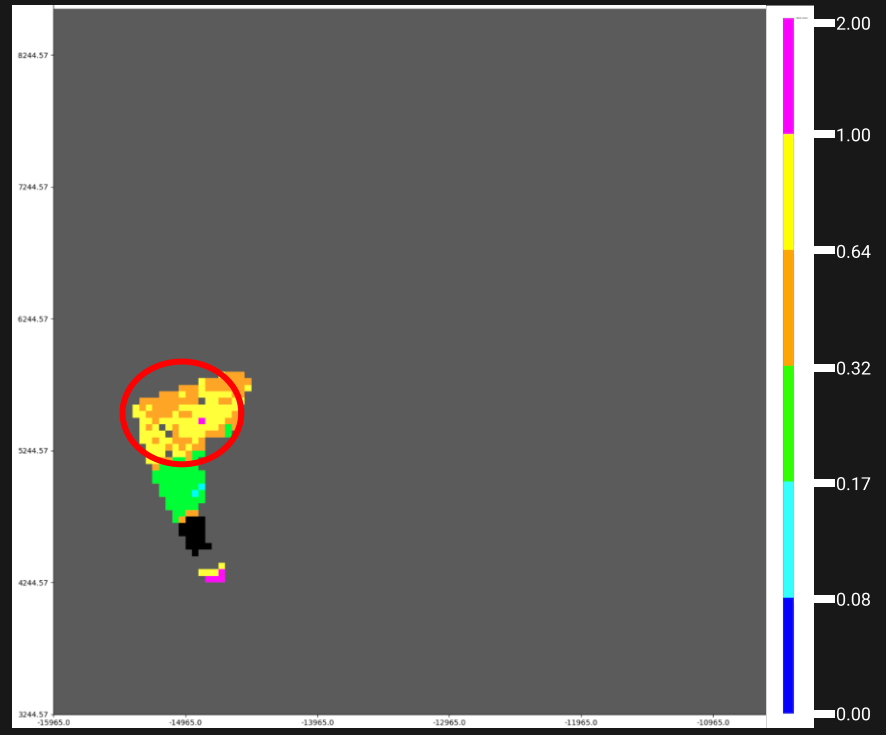
Kriging 2019



Ensemble 2019



Blastholes
2019-2022



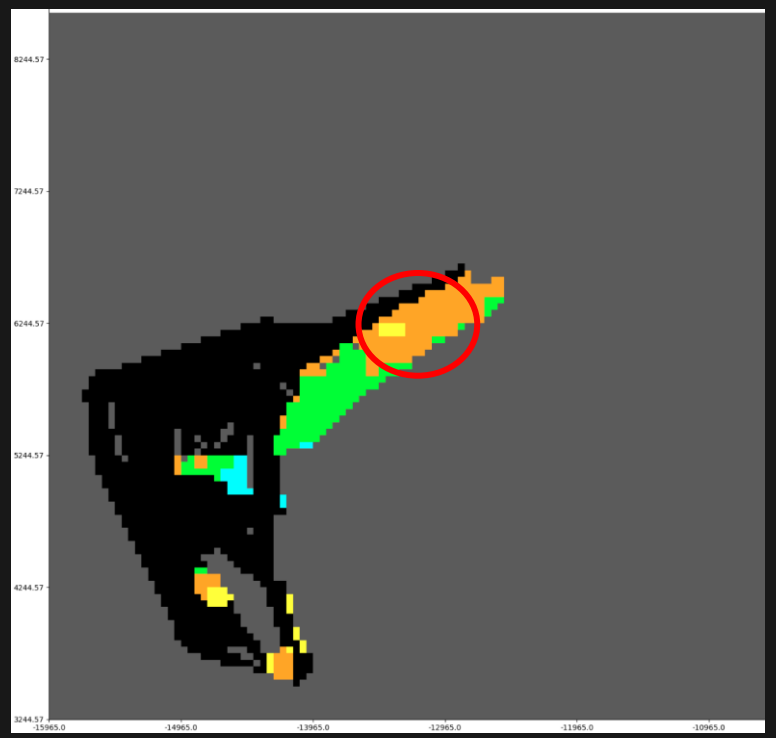
Block Size (50x50x45)

Ensemble successfully identifies large continuous HG region that should be heavily prioritized in the mine plan. Predicting this bench correctly earlier in mine life would improve realized NPV as it would prioritize mine design to reach it sooner.

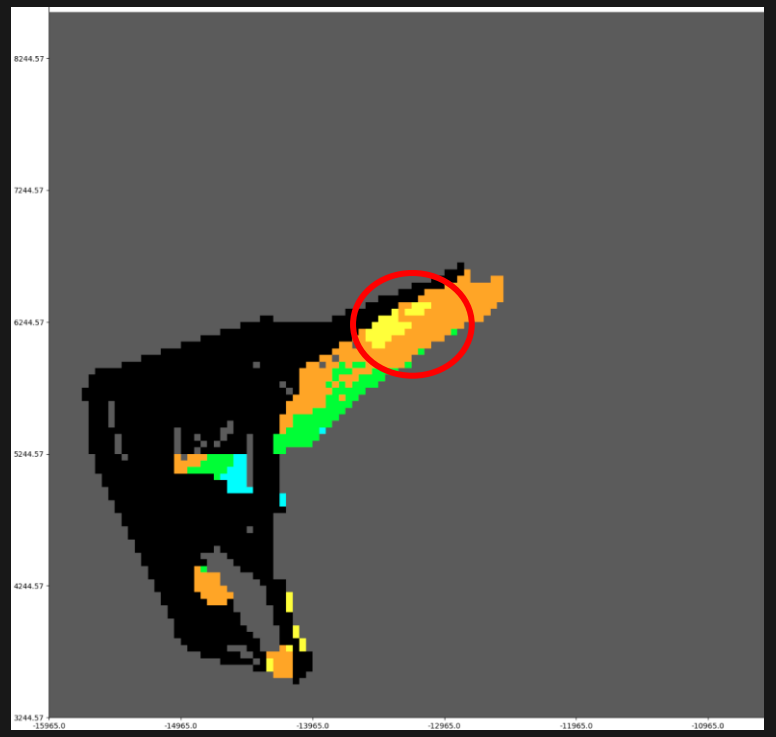
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 3110.8750 ft

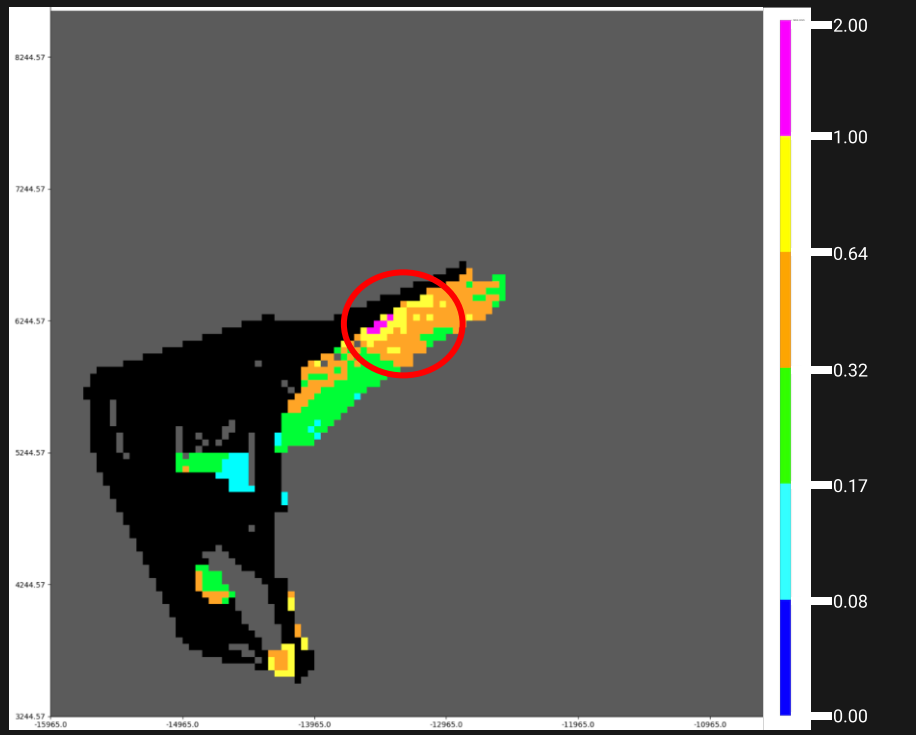
Kriging 2019



Ensemble 2019



Blastholes
2019-2022

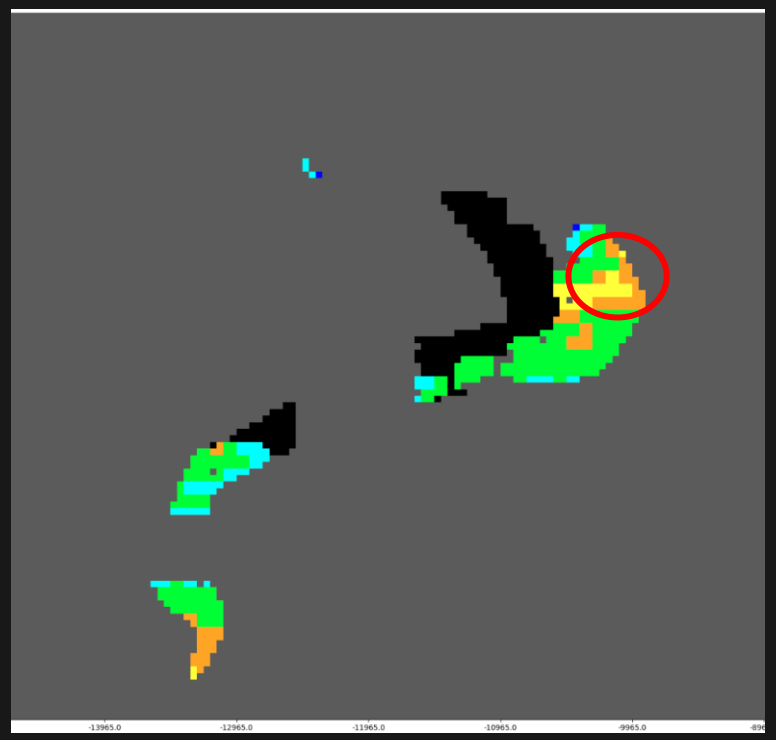


Ensemble successfully identifies large continuous HG region that should be heavily prioritized in the mine plan. Predicting this bench correctly earlier in mine life would improve realized NPV as it would prioritize mine design to reach it sooner.

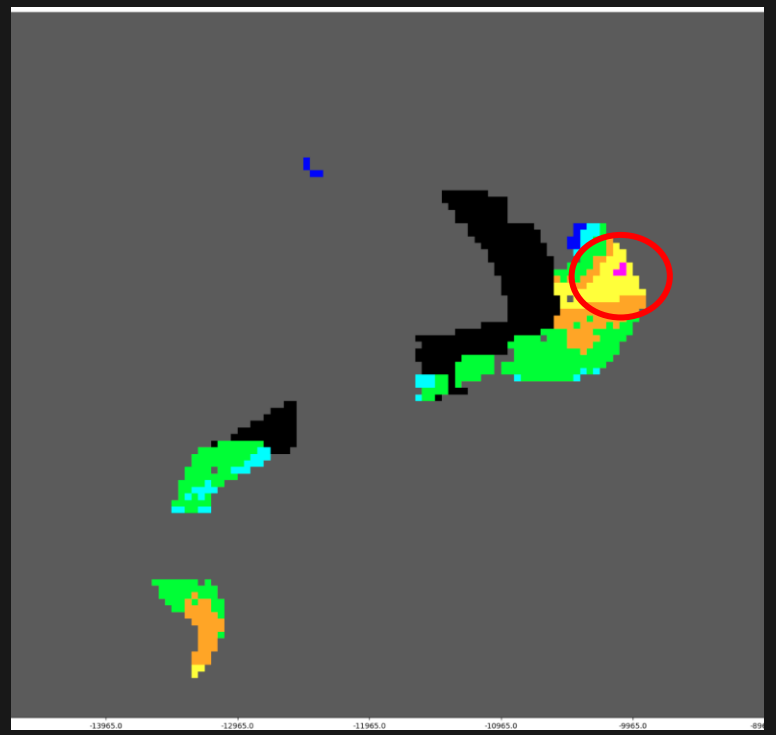
COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
Z = 3740.8750 ft

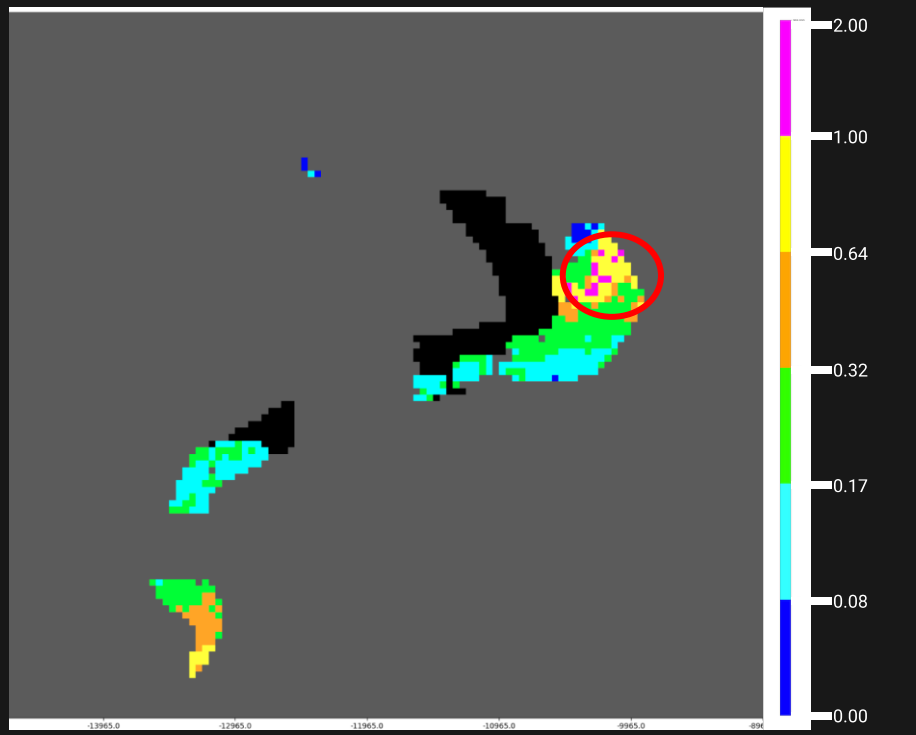
Kriging 2019



Ensemble 2019



Blastholes
2019-2022



Ensemble successfully identifies large continuous HG region that should be heavily prioritized in the mine plan. Predicting this bench correctly earlier in mine life would improve realized NPV as it would prioritize mine design to reach it sooner.

COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
NORTH = 6044.5700 ft

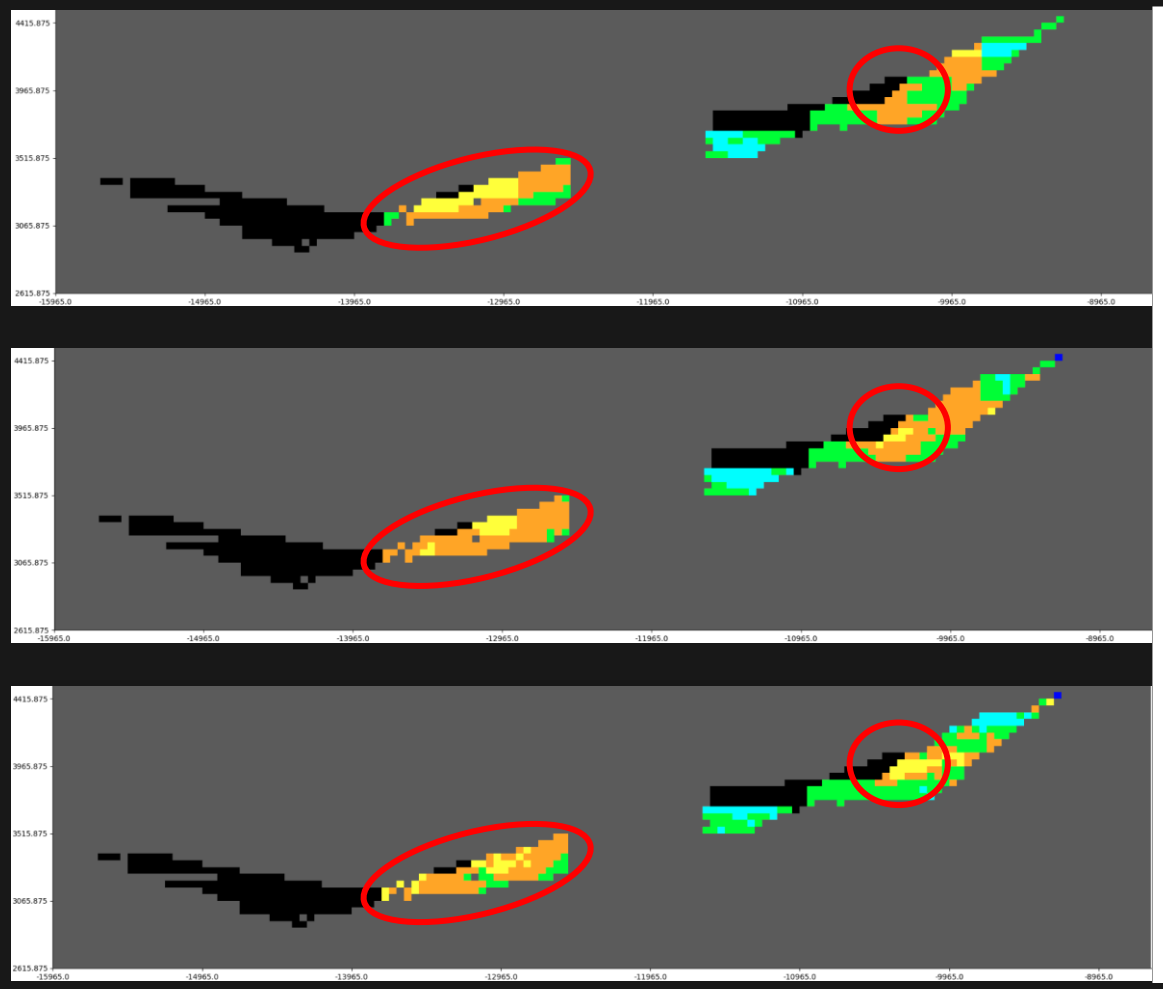
Ensemble successfully identifies large continuous HG region that should be heavily prioritized in the mine plan. Predicting this bench correctly earlier in mine life would improve realized NPV as it would prioritize mine design to reach it sooner.

Block Size (50x50x45)

Kriging 2019

Ensemble 2019

Blastholes 2019-2022



COPPER MODELLING
CROSS SECTION ANALYSIS

BENCH VIEW
NORTH = 6144.5700 ft

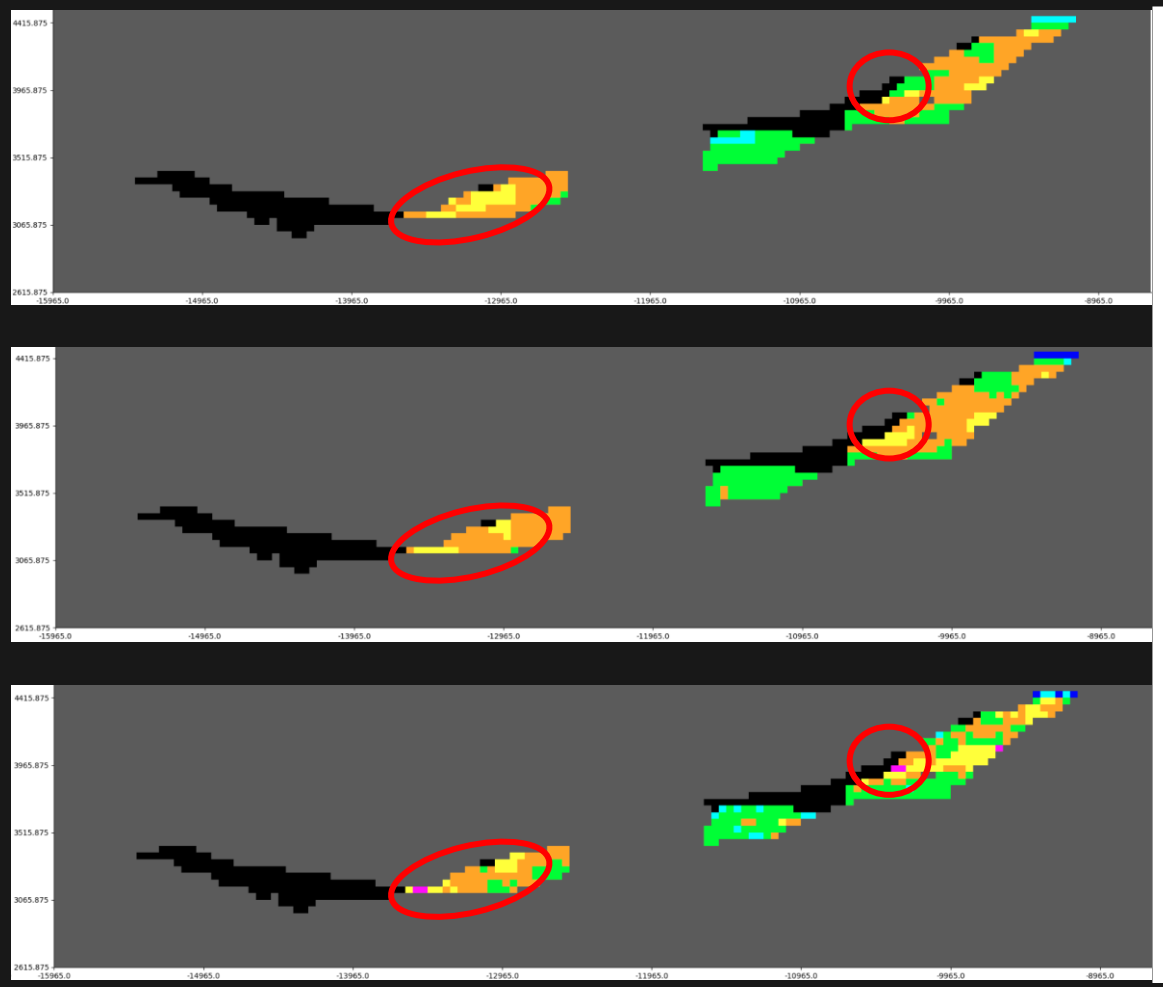
Ensemble successfully identifies area on left as being lower grade than expected by kriging and area on right as being higher grade than expected by kriging. This could improve NPV by prioritizing West area and deprioritizing East area.

Block Size (50x50x45)

Kriging 2019

Ensemble 2019

Blastholes 2019-2022



COPPER MODELLING
MODEL SUMMARY

RESULTS

Improve quarterly tonnage deviation (guidance)	**56%** improvement on quarterly mill tonnage deviation, **43%** improvement on leach tonnage deviation
Improve mining economics by reducing missed mill ore and false positive leach ore.	**73%** less waste where leach predicted, **4.6Mlbs** less missed mill ore in reconciliation 2019-2022.
Improve mine NPV by better detecting HG (>0.45%) ore early in mine plan.	**24%** less LG/W where HG predicted, **7.6Mlbs** less missed HG ore in reconciliation 2019-2022.

COPPER MODELLING
MODEL SUMMARY

ECONOMIC VALUE OF ADOPTION

56% improvement on quarterly mill tonnage deviation, **43%** improvement on leach tonnage deviation

Improved guidance allows for **de-risked** and practical use of leaching technology in mine planning, external mine guidance.

73% less waste where leach predicted, **4.6Mlbs** less missed mill ore in reconciliation 2019-2022.

Reduction in missed mill ore leads to **15Mlbs ($55M)** of unique in-situ mill ore near ore within 4 benches of 2022 surface

24% less LG/W where HG predicted, **7.6Mlbs** less missed HG ore in reconciliation 2019-2022.

Model identifies **22Mlbs ($80M)** unique HG ore within 4 benches of 2022 surface – confirmation via drilling would increase realized NPV by allowing mine to prioritize those benches in mine plan.

STRATUM

LOW RISK – HIGH YIELD – AI DRIVEN