# UNSUPERVISED LEARNING FOR THE CHARACTERIZATION OF ESTIMATION DOMAINS IN MINERAL DEPOSITS: AN EPITHERMAL GOLD CASE STUDY

Isabella Buitrago & José González.

# AGENDA

OBJECTIVES AND PROPOSAL

TECHNICAL DETAILS OF THE SOLUTION

EXAMPLE OF APPLICATION

CONCLUSIONS

# OBJECTIVE

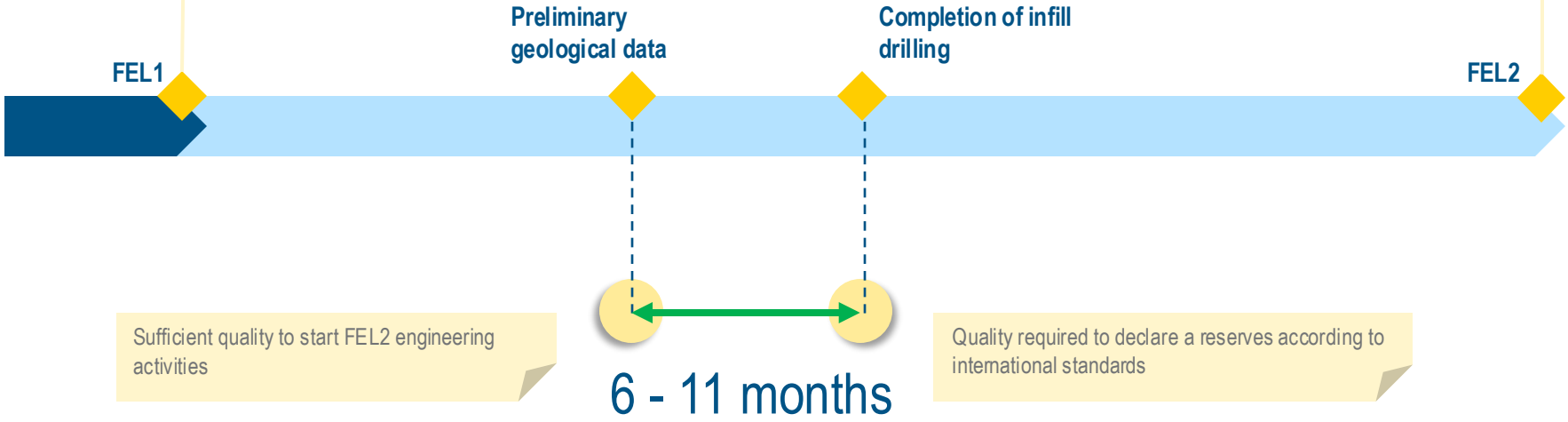
**How can we enhance early-stage mineral estimation, enabling faster and more reliable geological insights that reduce project development time?**

# CONTEXT OF THE PROJECT CONTRIBUTION

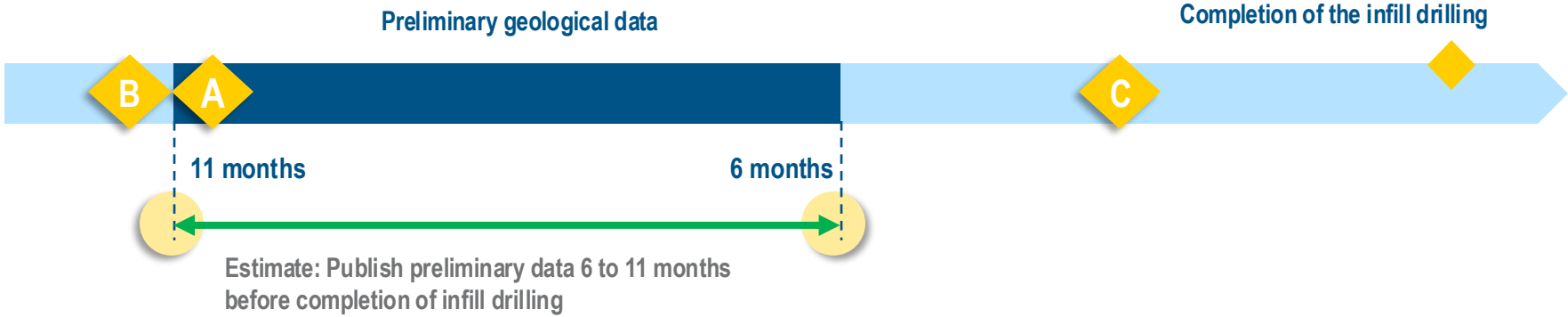
**PNR-000119**
Global Guide to the Management of Mineral Resources and Reserves

The project must be supported by at least 50% of Indicated Mineral Resources and/or Measured Mineral Resources and 50% or less of Inferred Mineral Resources.

It is recommended that the project be supported only by Mineral Reserves and the payback supported by Proven Mineral Reserves.



# RESULTS OBTAINED FROM THE ANALYSIS OF PROJECTS




## A Project A

- **Approx. 11 months** before completion of the infill drilling

## B Project B

- **Approx. 12 months** before the completion of the infill drilling

## C Project C

- No data have been obtained that represent a stage of grid densification.

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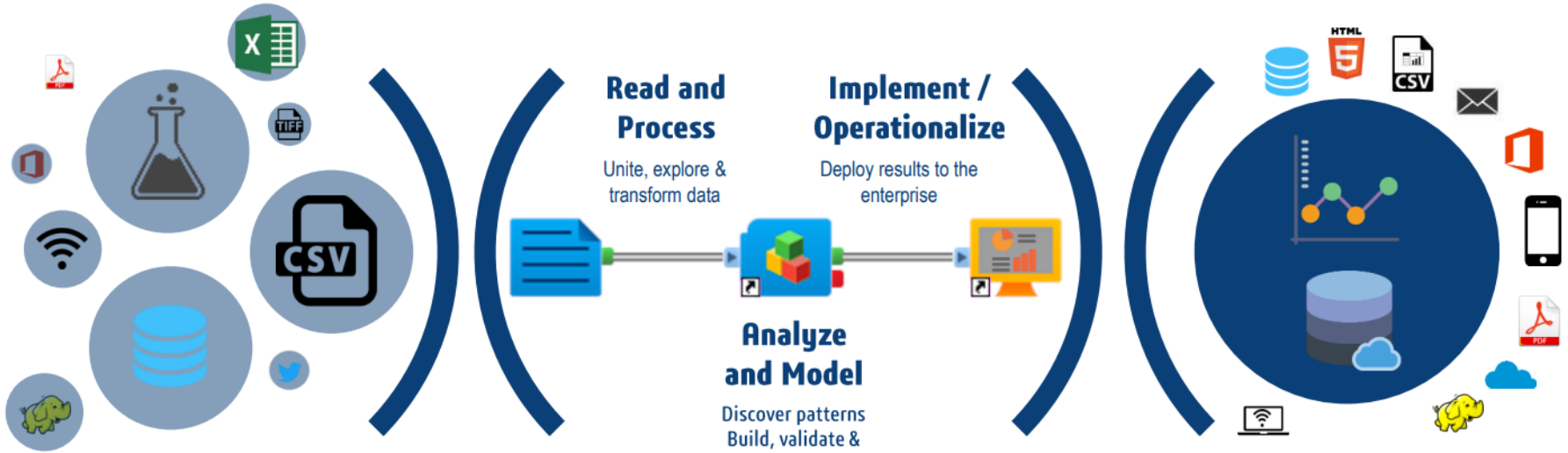



**Inputs**

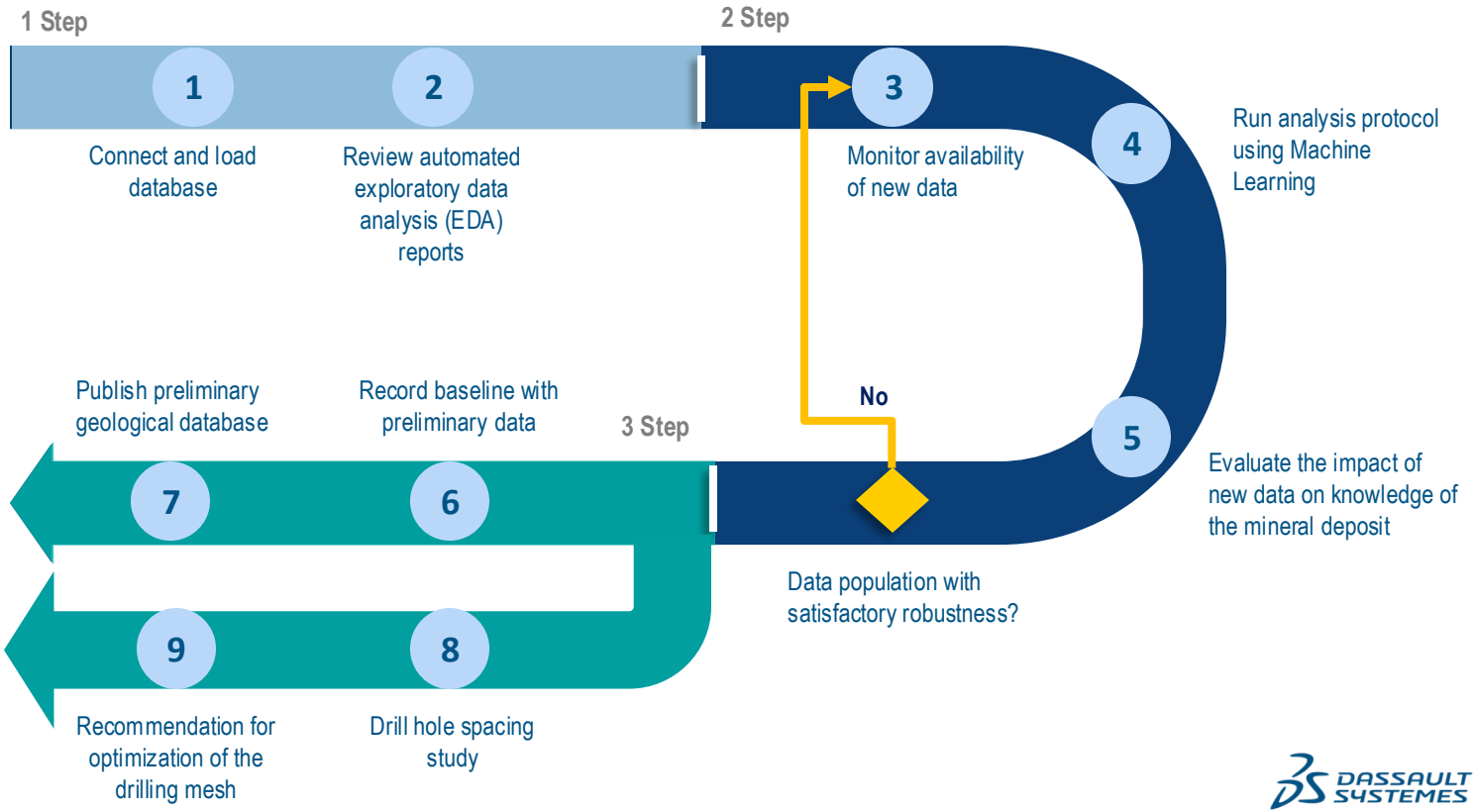
Connect to any data source or scour the web to create new data sources

**Outputs**

Visualizations, transformed data or protocol embedding in devices and web services

# PROPOSED PROCESS

**Input:**
- Geological database from previous campaigns
- Production rate
- Total expected reserves




**Output:**
- Preliminary geological database
- Assessment of data representativeness and reliability
- Recommendation for optimization of the drilling mesh

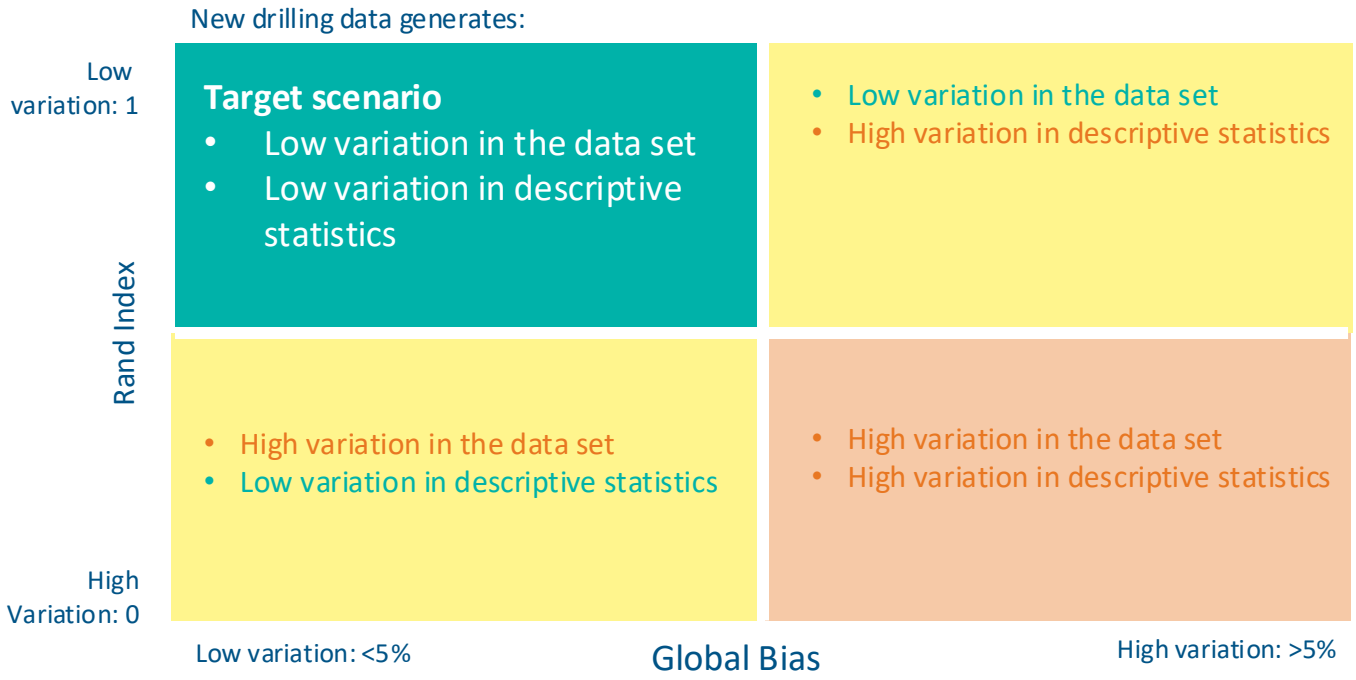
# PROPOSED PROCESS: QUESTION TO BE ANSWERED

**Data population with satisfactory robustness?**

# DATA POPULATION WITH SATISFACTORY ROBUSTNESS?

**Step 1: Identify impact of new drilling data**

**Step 2: Evaluate the difference between variograms**



# DATA POPULATION WITH SATISFACTORY ROBUSTNESS?

**Step 1: Identify impact of new drilling data** | Step 2: Evaluate the difference between variograms

To contrast the different domains from each campaign, we apply **Geoestatistical Clustering** that considers the variogram function in the dissimilarity metrics.

- Variogram: $\gamma(\mathrm{h}) = \frac{1}{2} E\{[z(x+\mathrm{h}) - z(x)]^2\}$
- Mahalanobis distance: $d(z_i, z_j) = (z_i - z_j)\Sigma^{-1}(z_i - z_j)^T$
- Geostatistical Mahalanobis Distance:

$$d(z_1, z_2)^2 = [\mathrm{z}(x_1) - \mathrm{z}(x_2)]^T \, \Gamma(x_1 - x_2)^{-1} [\mathrm{z}(x_1) - \mathrm{z}(x_2)]$$

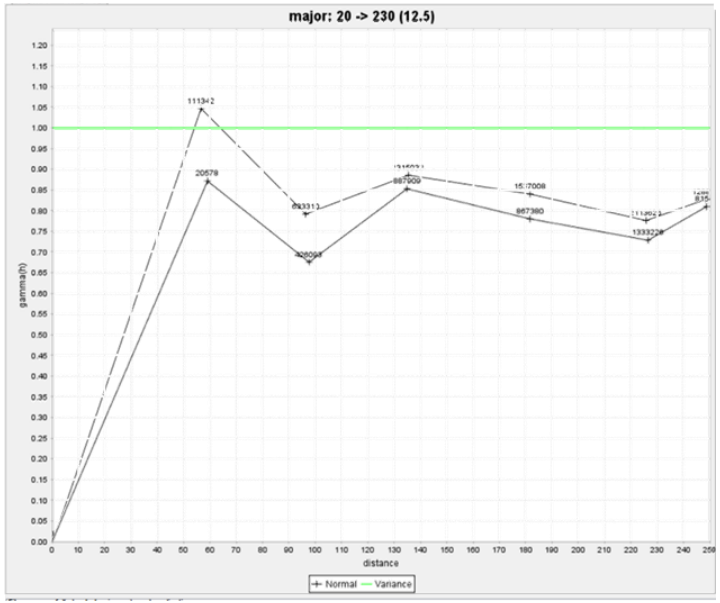
$$d_{12} = \frac{(z_1 - z_2)^2}{\gamma(x_1 - x_2)}$$

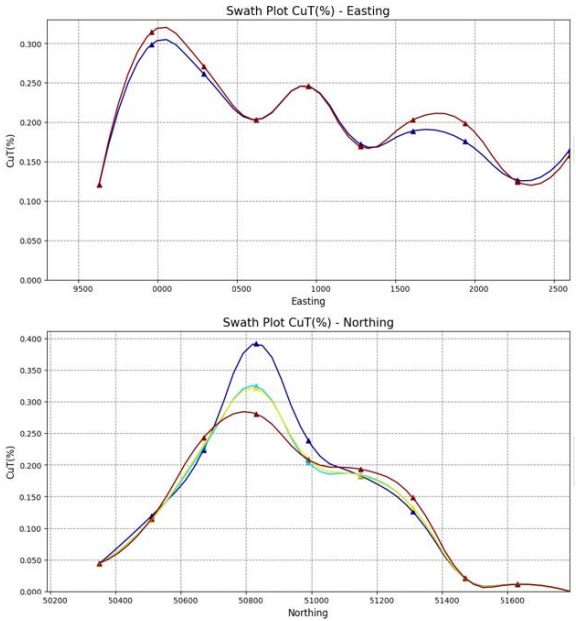
**Equation 1** : Geostatistical Mahalanobis distance function formulated by Fustos (2017).

# DATA POPULATION WITH SATISFACTORY ROBUSTNESS?

**Step 1:** Identify impact of new drilling data

**Step 2:** Evaluate the difference between variograms and swath-plots



# DATA POPULATION WITH SATISFACTORY ROBUSTNESS?

## How does the new drilling data impact on the data population?

### Metric: Adjusted Rand Index

### Use of Metric:

Comparison of automatically generated groups of data (clusters) before and after the incorporation of the new drilling data.

### Reference values:

- 1: Data sets before and after are identical
- 0: Sets are completely different

## What impact does the new drilling data have on descriptive statistics?

### Metric: Global Bias

### Use of Metrics:

Comparison of global bias in composited and ungrouped data to assess the sensitivity of the mean when entering new survey data.

### Reference values:

- >5%: Relevant variation between before and after incorporating new data
- <5%: Non-relevant variation between before and after incorporating new data

## What is the impact on spatial representativeness?

### Graphical analysis: Variogram and swath plots

### Use of the graphics:

Comparison of thresholds, amplitudes and nugget effect between variograms

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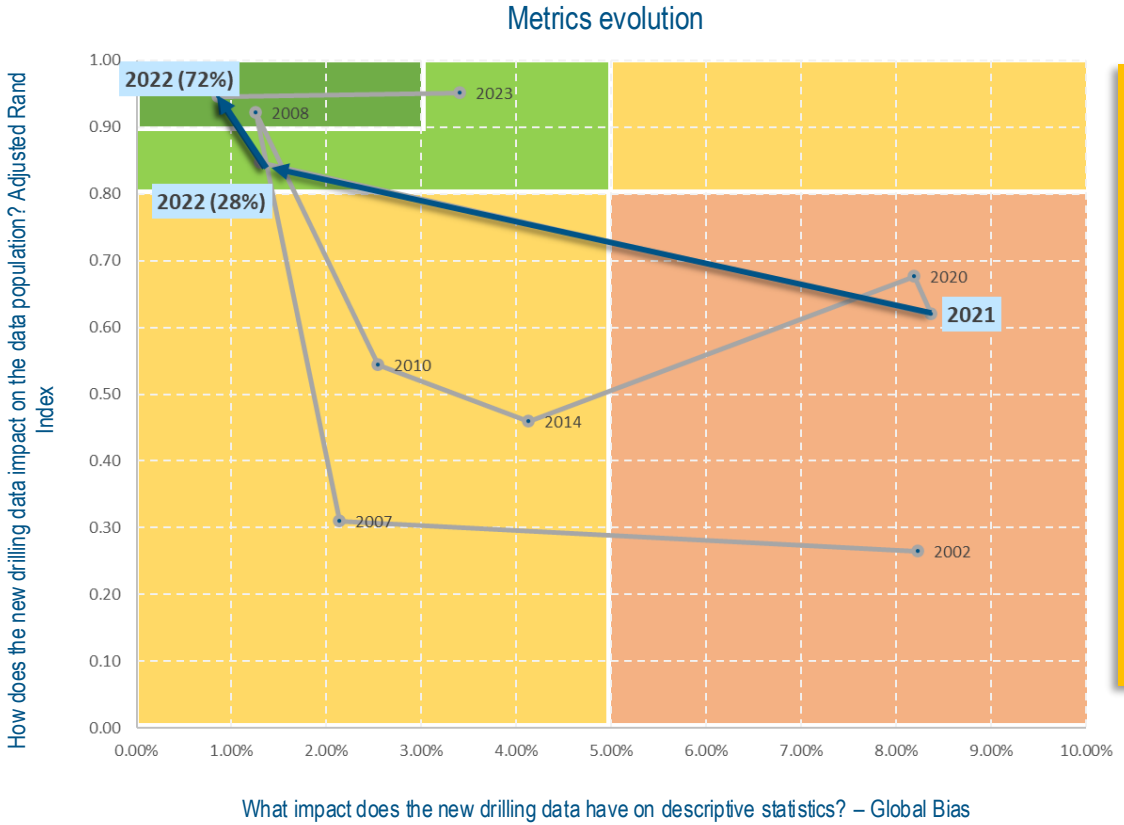
# DRILLING HISTORY: PROJECT A

| Target area | Year | Total drill holes in the campaing | Total accumulated drill holes | Condition |
|---|---|---|---|---|
| "unique" | 1998 | 14 | 14 | New area |
| | 2002 | 14 | 28 | |
| | 2007 | 9 | 37 | |
| | 2008 | 22 | 59 | |
| | 2010 | 9 | 68 | |
| | 2014 | 3 | 71 | |
| | 2020 | 38 | 109 | Grid densification |
| | 2021 | 66 | 175 | |
| | 2022 | 65 | 240 | |
| | 2023 | 7 | 247 | |

# EXAMPLE OF APPLICATION: PROJECT A

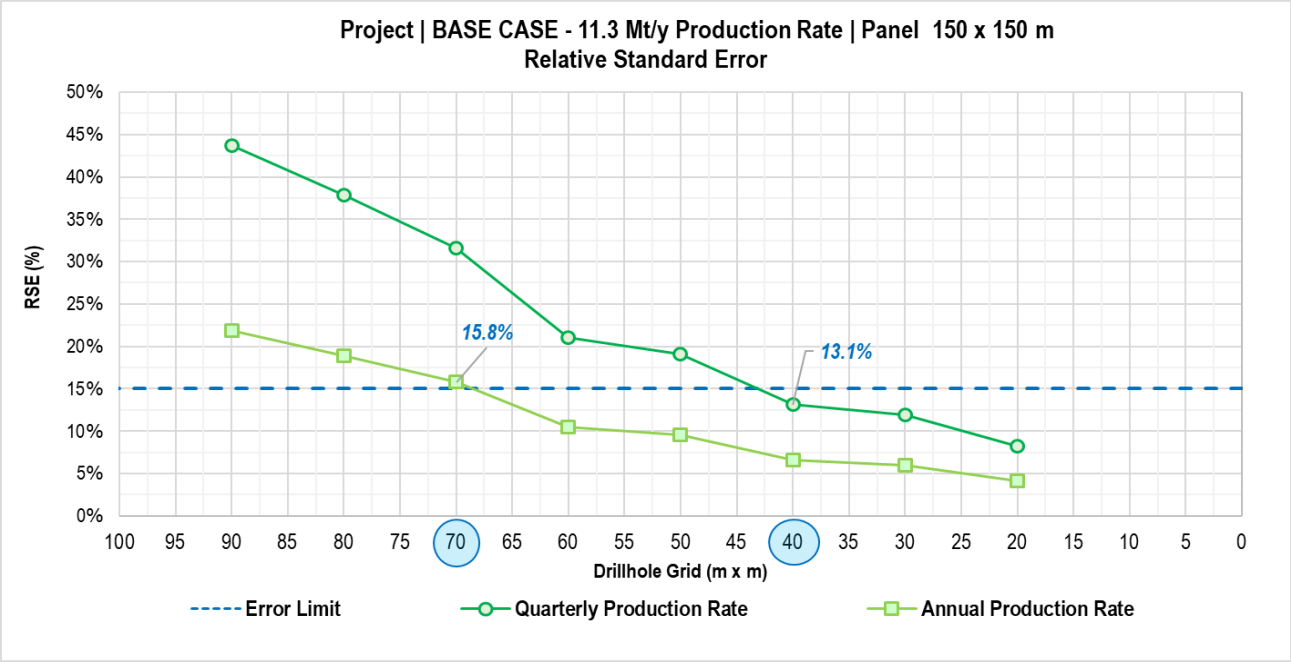



**From 28% of the data from the 2022 campaign, the new drilling data does not generate significant variation.**

- Historic total: **247** drill holes
- 2022 campaign: 65 holes
  - 2022 (28%) : 18 drill holes
  - 2022 (72%) : 47 drill holes
- Drill holes proposed for preliminary publication:
  - Total = **193** boreholes (**78% of total boreholes**).
- **11 months** before completion of survey and **$1 MM in drilling costs** (considering drilling cost $160/m).

# CONTRIBUTIONS OF DRILL HOLE SPACING STUDY - PROJECT A

- Base Case – 11.3 Mt per year production rate




*(*) Under current industry standards for technical reports from publicly traded mining companies*

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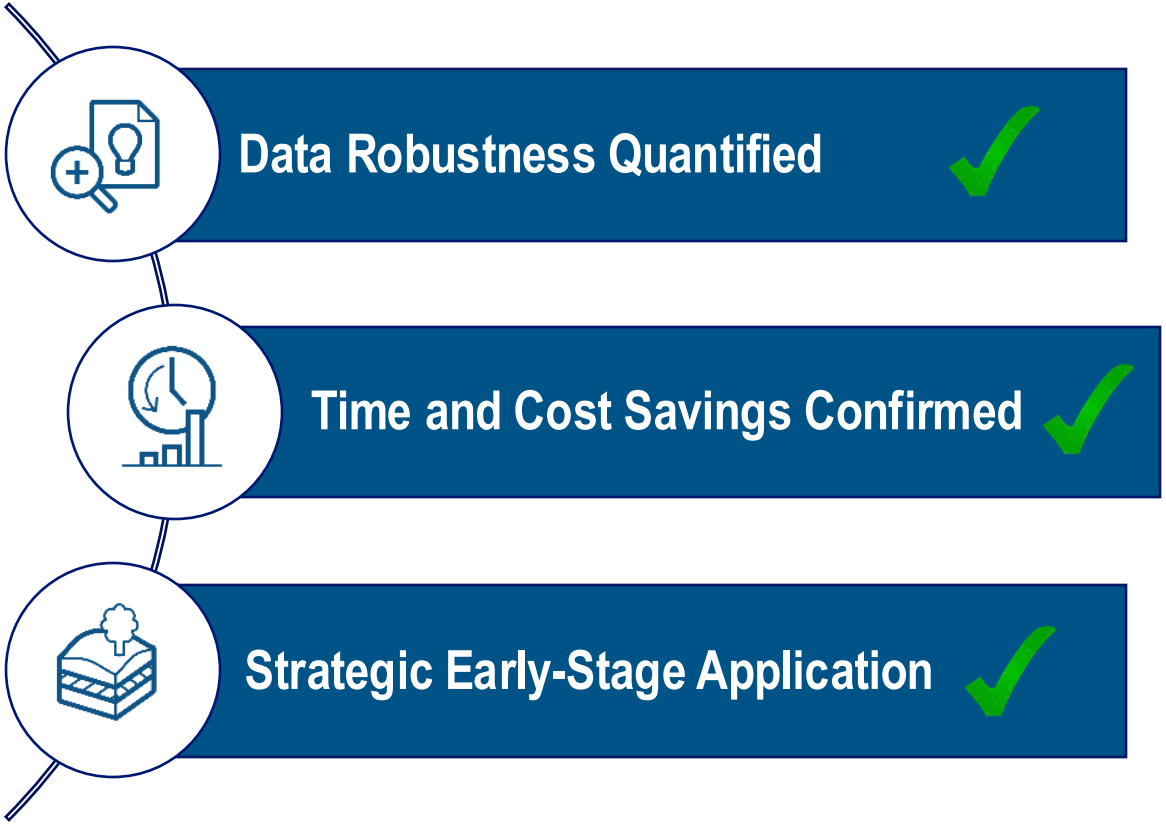
# MAIN CONCLUSIONS ON THE PROPOSED SOLUTION



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