

# Saving Money and Improving Data Collection When Drilling for Mining Projects

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## Abstract

Drilling provides critical data for multiple mining disciplines, yet programmes are often executed independently, leading to duplicated drilling and increased costs. This paper presents a case study where over 5,000 exploration boreholes captured only geological information, requiring additional drilling for hydrogeological, geotechnical and geochemical studies. The results show that simple multi-disciplinary observations during routine drilling could have improved data coverage and reduced follow-up drilling. An integrated drilling approach is proposed, combining early coordination, multi-disciplinary logging and shared data systems to improve efficiency, reduce costs and support more informed mine planning.

## Introduction

Drilling is a primary source of data throughout the life of a mining project. Exploration, geotechnical design, hydrogeological characterisation, geochemical risk assessment, sterilisation and metallurgical testing all rely on information obtained from boreholes. Despite this shared dependency, drilling programmes are commonly planned independently by different departments, each focusing on its own objectives. This results in missed opportunities to collect useful information across disciplines during the same drilling campaign, leading to duplicated drilling, increased cost and time delays.

Exploration drilling is typically conducted at a large scale to define an ore resource, but is often limited to lithological logging. Later in the project, additional boreholes are drilled for hydrogeology investigations, geotechnical investigations or geochemical sampling, frequently in areas that have already been drilled. The issue is therefore not the availability of drilling, but how it is planned and utilised across disciplines.

The aim of this paper is to demonstrate the benefits of an integrated approach to drilling, where each borehole contributes to multiple disciplines. Using a case study

from a large mining operation in Africa, the paper illustrates how thousands of exploration holes were drilled without capturing key hydrogeological, geotechnical and geochemical data, and how this resulted in additional drilling at later stages. Practical measures to improve coordination and the role of shared data systems and digital tools are also discussed.

## Data requirements and case study

Different technical disciplines rely on drilling data at various stages of a mining project. Exploration geologists focus on lithology and mineralisation, geotechnical engineers require rock mass properties, hydrogeologists depend on groundwater-related observations, and geochemists require samples for assessing acid-generating potential. Although these requirements differ, they are closely related and often depend on the same boreholes.

Fig. 1 illustrates a typical sequence of model development in mining projects. While logical from a modelling perspective, this sequence often translates into discipline-specific drilling campaigns. Each discipline tends to initiate drilling only after the preceding phase has been completed, rather than identifying opportunities to collect shared data earlier.

As a result, exploration drilling is often limited to geological logging, while hydrogeological, geotechnical and geochemical investigations are carried out later through additional boreholes. In many cases, these are drilled in areas already covered by exploration, leading to duplication and increased cost. The issue is therefore not a lack of drilling, but a lack of integration in how drilling is planned and executed and what information is collected. Early integration of such datasets is widely recognised as important for reducing uncertainty in mine planning and environmental assessment (ICMM, 2019).

A case study from a large mining operation in Africa highlights the practical implications of non-integrated drilling. During the exploration phase, 5,072 boreholes were drilled to define the mineral resource. These holes provided a dense spatial dataset of lithological information across the site (Fig. 2).

Despite this extensive coverage, no hydrogeological, geotechnical or geochemical data were systematically recorded. No measurements of water levels or water strikes were taken, and observations such as weathering, fracture frequency or drill-fluid loss were not captured. Similarly, basic geotechnical parameters and geochemical indicators relevant to early AMD assessment

were not recorded, despite the importance of early geochemical characterisation in mine planning (INAP, 2014).

Additional drilling was later required to support hydrogeological, geochemical and geotechnical studies. Approximately 35 boreholes were drilled for hydrogeological testing and about 8 for environmental geochemical assessment, while more than 100 additional boreholes were later drilled for geotechnical investigations. In several instances, these were located close to existing exploration holes.

The number of additional boreholes was constrained by available budgets rather than what would ideally be required to characterise a site of approximately 18 × 4 km and up to 600 m depth. Even partial integration of hydrogeological and geochemical observations within the exploration programme could have provided broader coverage and reduced reliance on a limited number of dedicated boreholes. This would have provided a broader dataset to better assess groundwater conditions, AMD risk and geotechnical stability, thereby reducing uncertainty in the overall project assessment.

In addition, reducing the need for separate drilling campaigns can lower the amount of fieldwork required, which may contribute to improved safety outcomes and

### FLOW DIAGRAM SHOWING CONTRIBUTION OF EACH MODEL TO FINAL DEWATERING DESIGN MODEL (After A.R. Guest 2005)

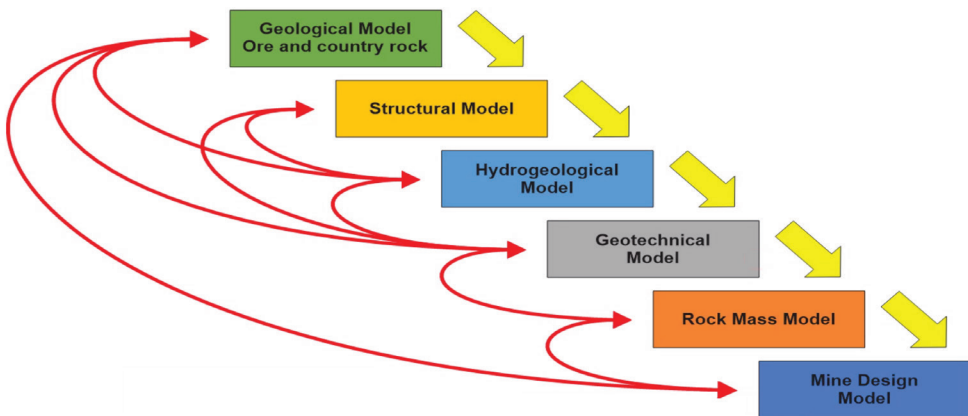


Figure 1 Typical sequential development of mine design models (adapted from Guest, 2005, as cited in Morton, 2025).

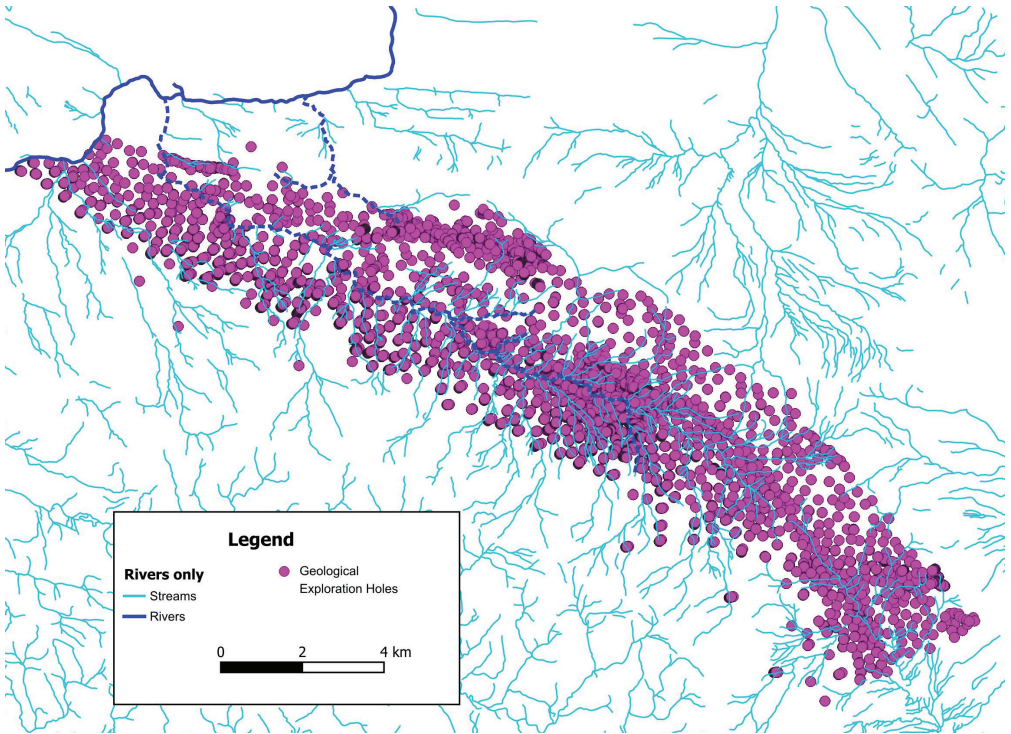


Figure 2 Project site and distribution of the drilled exploration holes.

Table 1 Indicative comparison between conventional and integrated drilling approaches.

Item	Conventional Approach	Integrated Approach
Exploration boreholes	5,072	5,072
Hydrogeological boreholes	35 additional holes	Reduced requirement
Geochemical boreholes	8 additional holes	Reduced requirement
Geotechnical boreholes	>100 additional holes	Reduced requirement
Mobilisation campaigns	Multiple	Fewer
Spatial data coverage	Limited by specialist drilling	Broader site-wide coverage
Overall drilling effort	Higher	Potentially reduced

reduce repeated disturbance to landowners and surrounding communities.

The impact of non-integrated drilling is reflected in cost, data coverage and technical uncertainty. Using a typical cost of USD 50,000 for a 100 m hydrogeological borehole, the additional groundwater investigations alone represent an expenditure exceeding USD 1 million, excluding testing and supervision costs. While such drilling is necessary, some of this cost could have been reduced if relevant data had been collected earlier.

Data coverage is also affected. Exploration drilling provides wide spatial distribution, whereas later investigations rely on relatively few boreholes. This can limit representativeness, particularly in heterogeneous settings. From a modelling perspective, fewer data points may require additional iterations to refine interpretations. Similar challenges related to limited data coverage and model uncertainty have been widely documented in groundwater studies (Anderson *et al.*, 2015). Table 1 summarises the practical differences



between the conventional and integrated drilling approaches discussed in this paper.

### Integrated drilling approach

An integrated drilling approach aims to maximise the value of each borehole by aligning the data requirements of multiple disciplines before drilling begins. Rather than treating drilling as a discipline-specific activity, it is considered a shared resource that can support geological, hydrogeological, geotechnical and geochemical investigations simultaneously. The objective is not to replace specialised drilling programmes, but to ensure that routine drilling - particularly during exploration - contributes useful information to subsequent studies.

Table 2 illustrates the difference between a conventional sequential drilling workflow and a more integrated approach. In the conventional model, drilling programmes are initiated independently by each discipline, often at different stages of the project, resulting in repeated mobilisation and uneven data coverage. In contrast, the integrated approach begins with joint planning, followed by exploration drilling that incorporates multi-disciplinary logging, supported by a shared database and targeted follow-up drilling only where additional detail is required.

The first step in implementing this approach is early coordination. Prior to commencing a drilling campaign, representatives from relevant disciplines should review their data requirements and identify which

parameters can be reasonably collected during exploration drilling. This typically includes low-effort observations such as recording water strikes, measuring water levels where feasible, logging weathering profiles and fracture frequency, and collecting representative samples for preliminary geochemical screening. These additions generally require only minor adjustments to logging practices rather than changes to drilling equipment or methodology.

A key component of the approach is the use of a standardised logging template that incorporates inputs from multiple disciplines. For example, an exploration log sheet can be expanded to include sections for hydrogeological observations (e.g. water strikes, fluid losses), geotechnical parameters (e.g. rock quality designation (RQD), core recovery, weathering class), and geochemical indicators (e.g. sulfide presence, visual oxidation, sample intervals). This allows field teams to capture additional information in a structured manner without increasing logging time.

Roles and responsibilities also need to be clearly defined. In many cases, exploration geologists or logging technicians can record basic multi-disciplinary observations with minimal additional training, while more specialised measurements - such as packer testing or detailed geochemical analyses - can still be conducted in selected boreholes as required. The approach therefore focuses on capturing broad, site-wide datasets during

Table 2 Integrated drilling workflow compared to conventional approach.

Current / Sequential Approach	Proposed Integrated Approach
Exploration drilling	Joint planning (all disciplines)
↓	↓
Resource definition (infill) drilling	Exploration, resource definition (infill) and sterilisation drilling
↓	(multi-disciplinary logging)
Hydrogeology drilling	↓
↓	Shared database
Geotechnical drilling	↓
↓	Targeted follow-up drilling (only where needed)
Sterilisation drilling	↓
↓	Integrated dataset (site-wide, multi-disciplinary coverage)
Multiple datasets (separate, uneven coverage)	



exploration, complemented by targeted investigations where greater detail is needed.

To ensure that the additional data are effectively utilised, they should be stored in a shared database accessible to all relevant teams. This enables different disciplines to make use of exploration data during early stages of analysis and reduces the need for separate data collection campaigns. Ongoing coordination during drilling can further support this process by allowing teams to refine data collection priorities based on preliminary findings.

When applied consistently, even partial multi-disciplinary data collection can provide broader spatial coverage than a limited number of dedicated boreholes. Over time, this can reduce the extent of follow-up drilling required and improve the efficiency of project development.

Sterilisation drilling is commonly undertaken to confirm the absence of economically viable ore in areas planned for infrastructure such as tailings storage facilities, waste rock dumps, processing plants, offices and housing. Although these drilling programmes are typically focused on geological assessment, the same areas often require geotechnical characterisation and an understanding of groundwater conditions to support infrastructure design, stability assessments and environmental management. Incorporating additional observations during sterilisation drilling can therefore provide valuable multi-disciplinary information with minimal additional effort.

### **Organisational challenges and data integration**

While the technical aspects of integrated drilling are relatively straightforward, implementation is often constrained by organisational and communication factors within mining operations. In many cases, drilling programmes are not integrated because departments operate independently, each with its own objectives, budgets and performance targets. Exploration, hydrogeology, geotechnical engineering and environmental teams typically plan and execute their work for their respective scopes, even though they rely on the same underlying data source - drilling.

Although regular meetings are held within departments to track progress, structured coordination between disciplines is less common, particularly at the level of detailed technical planning. Senior management may encourage collaboration, but they are not always involved in the day-to-day decisions that shape drilling programmes. As a result, integration is often left to departmental managers, who are primarily focused on meeting short term targets.

This structure can unintentionally discourage integrated planning. From a departmental perspective, it is often more efficient to design drilling programmes that meet immediate needs rather than coordinate with other teams and accommodate additional data collection. However, at the project level, this leads to duplication of drilling, increased costs and fragmented datasets. Improving integration therefore requires deliberate coordination mechanisms. Digital tools and shared data systems can further enhance accessibility of information across teams, but their effectiveness depends on active collaboration. Ultimately, integrating drilling programmes requires both systems and mindset - treating drilling as a shared resource rather than a discipline-specific activity, and aligning teams early to maximise the value of collected data.

Data integration is essential for maximising the value of drilling. In many operations, datasets are stored separately, limiting accessibility. Shared data platforms can allow information to be used across disciplines, improving planning and reducing duplication.

Digital tools, including artificial intelligence, can support this process by identifying patterns and extracting insights from large datasets. Their effectiveness, however, depends on collaboration between teams. Technology supports integration, but does not replace the need for communication. Integrated data systems are increasingly recognised as essential for modern mining operations (McKinsey & Company, 2020), and AI applications in geoscience are expanding rapidly (Nature Reviews Earth & Environment, 2022).



## Conclusions

Drilling is widely used across mining disciplines, yet is mostly planned independently. This paper shows that the lack of integration can lead to duplicated drilling, increased cost and limited data coverage. The case study demonstrates that large exploration datasets may not fully support later studies if key observations are not recorded.

An integrated approach allows drilling to serve multiple purposes, improving data coverage and reducing reliance on additional boreholes. Achieving this requires both technical adjustments and improved coordination between departments, supported by shared data systems. In addition to these primary benefits, improved integration can contribute to better safety outcomes by reducing the extent of fieldwork, shortening project timelines, and providing a more comprehensive dataset to support decision-making. It can also reduce administrative and operational effort associated with managing multiple, separate drilling programmes.

Based on the findings of this study, several practical measures can be adopted to improve

the integration of drilling programmes in mining projects:

- Plan drilling collaboratively across disciplines
- Expand exploration logging to include key multi-disciplinary observations
- Collect samples for early geochemical screening
- Use standardised logging templates to collect the many forms of data
- Maintain shared databases
- Encourage regular interdepartmental coordination
- Use digital tools to support integration

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