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Enhancing Dam Safety Inspections Using a Digital Knowledge Base

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ABSTRACT

Industry guidelines for tailings management emphasize the need for an integrated, interdisciplinary knowledge base. Traditional methods of data collection and reporting, often reliant on static documents, GIS platforms, and fragmented databases, cause challenges in data accessibility, interpretation, and integration. Recent advancements in geospatial digital knowledge bases offer a transformative approach to managing earth science and engineering data by integrating several data sources such as instrumentation data, site investigation data, imagery, design lines, and field data such as dam inspections and observations into a dynamic, near-real-time system.

Traditionally, dam safety inspections (DSIs) were conducted using paper-based methods, and while some digital form applications have improved field data collection, they often lack integration with broader site datasets, particularly when operating without internet connectivity. By leveraging a geospatially integrated platform, engineering teams can dynamically analyse observed changes in condition parallel to supporting datasets and historical records, improving understanding of underlying conditions that may contribute to the changes observed at site.

This article presents how the Cambio™ software platform was used as a digital knowledge base to enhance DSIs and transition tailings management from static, fragmented reporting to an integrated digital workflow that supports long-term site safety.

INTRODUCTION

In response to several notable tailings facility failures, the Global Industry Standard on Tailings Management (GISTM, 2020) was released in 2020 to provide guidance on responsible tailings management practices. The regulatory landscape is evolving, and conformance to standards such as the GISTM requires operators to develop and maintain an interdisciplinary knowledge base of social, environmental, economic, and technical data to inform decisions throughout the tailings facility lifecycle. The GISTM requires such a knowledge base to include available data and knowledge relevant to the facility, is accessible and regularly updated, and promotes a culture of knowledge sharing across disciplines and organizations.

This article highlights a case study of how a geospatial digital knowledge base supplemented dam safety inspections (DSIs) by enabling the EoR team immediate access via a central location to past observations, inspection records, and other relevant data during the inspections (such as design lines, historical imagery, instrumentation, and borehole logs). The digital knowledge base provided

efficient and intuitive access to key project information and allowed the team to contribute new observations from the field. In addition, it streamlined communication of changed conditions between the EoR team and the owner. While initially used to support post-DSI documentation and communication, the digital knowledge base can be leveraged for routine dam inspections by either the EoR or the owner. Furthermore, it offers significant value for knowledge sharing and onboarding new team members by providing immediate context and visibility into the project's history and evolving conditions.

BACKGROUND

Historically, project information and data management have relied on reports, drawings, and fragmented Geographic Information Systems (GIS) platforms. While essential for documentation and regulatory compliance, this traditional approach often leads to static or siloed data representations that can be challenging to interpret. Engineers and owners often rely on multiple data sources presented in reports, software platforms, and other communications (such as email or verbal) to gain a complete understanding of on-site activities and conditions.

Large quantities of data are produced throughout a mine's lifecycle by various stakeholder groups including engineers, owners, and contractors. As data volumes grow, effective and efficient management and analysis of the data becomes more challenging. Years of routine inspections, site photographs, and other routine data can become lost and underutilized if not managed properly. Instead, digitizing, georeferencing, and integrating with automated monitoring data enables teams to monitor hazards, evolving conditions, and potential non-compliance in near real-time. A proper digital knowledge base continuously integrates near-real-time data with historical records, offering a dynamic and evolving view of the tailings facility.

Challenges with Data Collection and Communication

Relying on static reference materials, such as printed maps or inspection sheets, to locate and document observations can lead to uncertainty, as it can be hard to match on-the-ground location and observations with these static reference materials. This may impact the precision, traceability and value of the field observations, especially when trying to compare observations through time or communicate information to other team members or operators.

Communication of field observations to team members or owners can also be challenging using traditional approaches. Photos and notes collected in the field are often detached from the broader geographic context of the dam. As a result, it can be difficult for non-field personnel to interpret the significance of an observation: the precise location, its spatial extent, its proximity to critical infrastructure, and its relation to historical issues, creating a disconnect between those in the field and those who are not.

Some digital form applications allow for data input but lack integration with other site information while offline, potentially leading to missed information or a lack of cohesion with historical or key data. The implementation of a fully integrated digital knowledge base with web and mobile applications can significantly enhance these aspects of DSIs.

CASE STUDY

The following section will describe a use case of a digital knowledge base to support communication of observations and documentation during recent DSIs at the Flin Flon Tailings Impoundment System (FFTIS), a site owned by Hudbay Minerals Inc. (Hudbay) in central Canada. The FFTIS was commissioned over ninety years ago, and as such, the history and development of many containment structures are not well documented. Observations that deviate from expected performance is not uncommon because of gaps in historical documentation and information regarding the underlying conditions. For this case study, the EOR team chose to use the Cambio™ platform as the digital knowledge.

Cambio was first developed by BGC Engineering Inc. (BGC) over 20 years ago to help pipeline clients centralize their data in a standardized format, similar to the needs of the project. FFTIS, like most mining projects was looking for a way to collect structured, repeatable inspections, with real-time data integration, and actionable insights to enhance site safety and compliance. Cambio integrates several data sources which are viewable as interactive layers on a geospatial map. In addition, Cambio includes forms to input and store data, and displays tabular information that can be filtered and exported. This functionality increases the efficiency of both the annual DSI and routine inspections completed by the owner. The ease of access to several data sources through the Cambio platform also helps reduce the barriers of historical knowledge sharing between new and developing staff. Additionally, due to connectivity limitations at some locations on-site the ability for Cambio to be taken offline on mobile devices and later accessible on the web-based made it an appealing solution for the project.

During the field component of recent DSIs. the EoR team was able to access “Observation Points” that had been added during previous inspections at the FFTIS, which appear as flagged locations on the plan view map (Figure 1). The user can visualize their current location on site (using the built in GPS functionality) relative to Observation Points to better orient themselves, understand what data is available for a particular structure, and document a changed condition. In Cambio, an Observation Point can be opened to view photos and comments describing the feature at that location (Figure 1). Over reoccurring inspections, new observations can be made at existing Observation Points so that a series of photos and comments spanning multiple years becomes compiled at that location, making it easier to track and monitor changes over time.

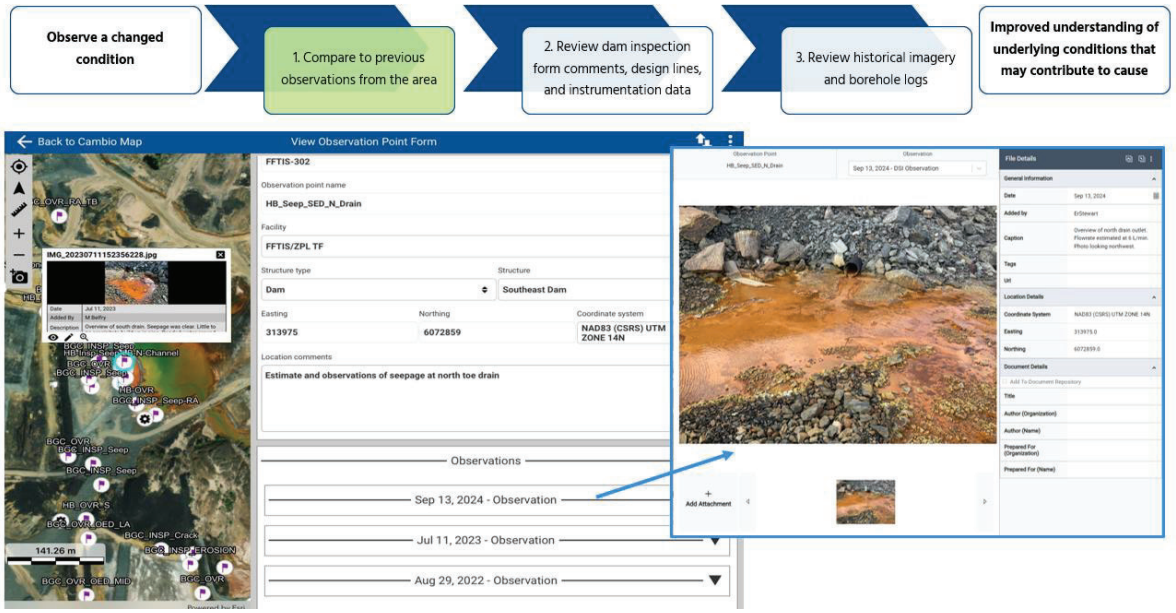

Figure 1 An Observation Point can be selected to view a series of observations (photos and captions) taken at a particular location over time

A dam inspection form was developed for the project in Cambio for use on the web and mobile platforms, to replace separate digital and paper collection methods. The form includes checkbox fields to capture typical inspection items along with the ability to add additional notes and comments as well as assign recommended follow-up actions, if required. By hosting a standardized inspection form in Cambio, reoccurring BGC and Hudbay inspections can become consistent and trends in observations over repeating inspections can be discerned more readily. To improve the quality of inspections and overall understanding of potentially changing site conditions, historical inspection forms and photographs were integrated into the Cambio platform and made available on the mobile app so that they could be easily referenced in the field. In addition, other information could also be viewed in parallel with the dam inspection form in Cambio, such as Observations, photos, design lines, and instrumentation data (Figure 2).

Figure 2 A view of the Cambio web platform showing a dam inspection form, Observation Points, instruments, and design lines

Additional information can be viewed on both web and mobile versions of Cambio, including site investigation locations, borehole logs and historical imagery (Figure 3). Immediate access to this information can inform field inspectors of potential causes of unexpected conditions, helping them recognize any additional in-field assessments or data collection that may assist with interpretations.

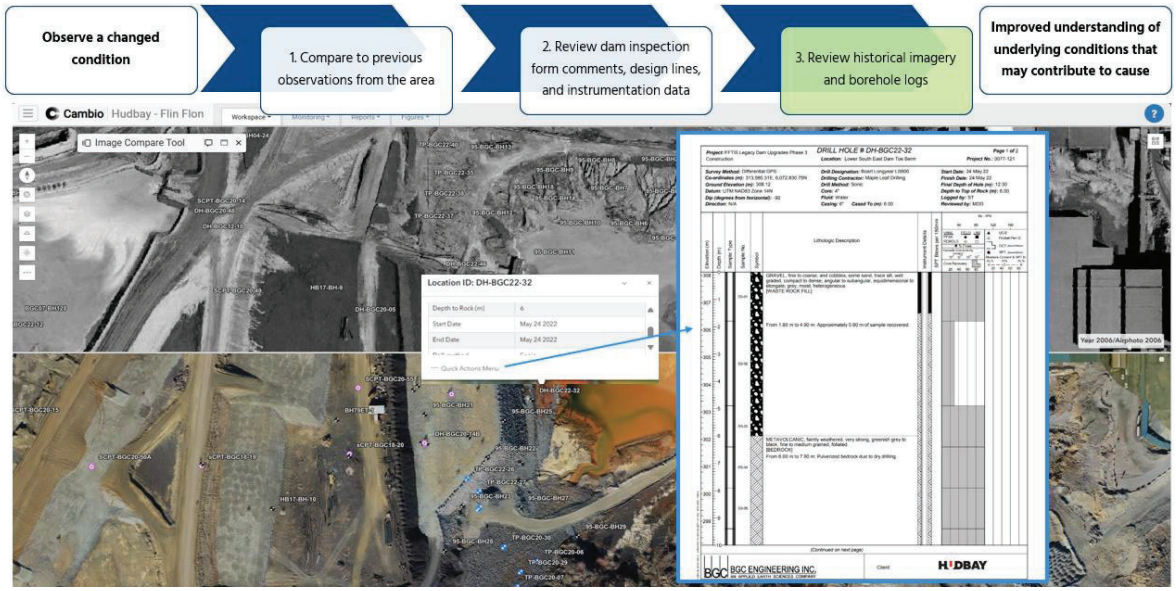

Figure 3 A view of the Cambio web platform showing a comparison of imagery, site investigation locations, and a borehole log

On the web version of Cambio, a workspace containing relevant information can be created and shared as a link. For example, the workspace could include the Observation Point of interest, along with supporting data such as design lines, relevant instrumentation, and site investigation data. This makes it easy to share information with key stakeholders and ensure everyone is accessing and viewing the same information, improving communication and collaboration between various people on the project.

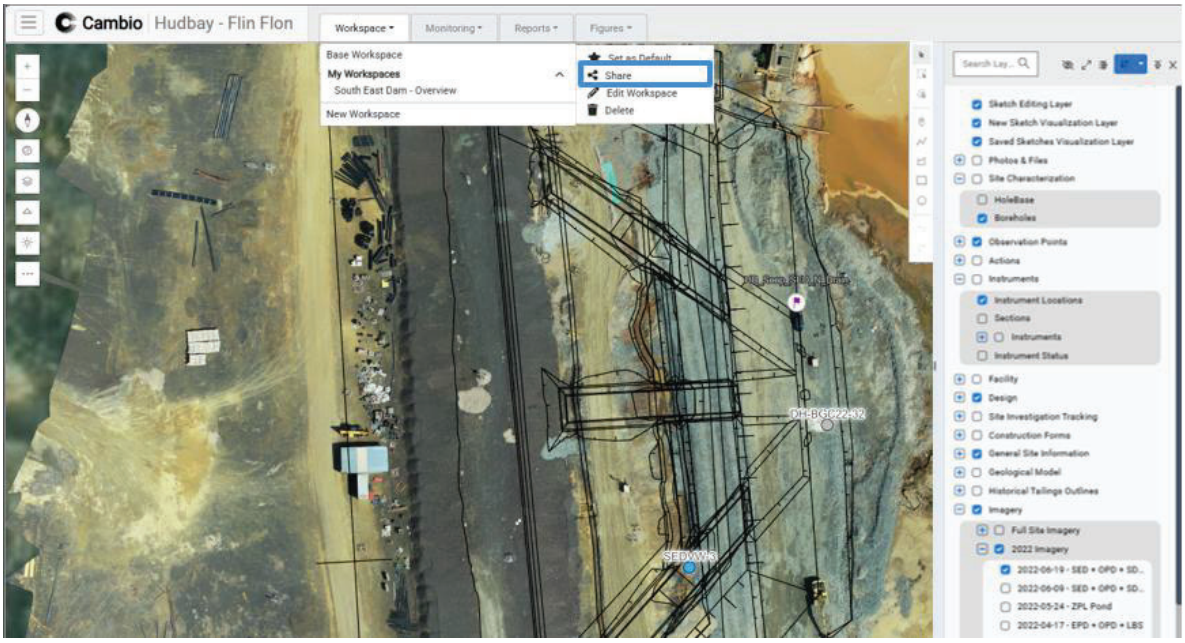

Figure 4 A view of a Cambio workspace and the "Share" feature

CONCLUSION

Using a digital knowledge base at FFTIS significantly enhanced the ability to share and retain institutional knowledge, reducing the barriers to transferring historical context and expertise to new and developing staff. By linking spatially referenced observations, historical inspection records, near-real-time monitoring data, and supporting design documentation, the platform transformed individual field observations into a shared and evolving knowledge base.

REFERENCES

International Council on Mining and Metals (ICMM), United Nations Environment Programme, Principles for Responsible Investment. (2020). *Global Industry Standard on Tailings Management.*