The Conceptual Site Model:
An Effective Framework for Advancing Clarity, Transparency, Consistency, Value and Understanding in the Mining Industry
The Conceptual Site Model: An Effective Framework for Advancing Clarity, Transparency, Consistency, Value and Understanding in the Mining Industry

EXECUTIVE SUMMARY

Mine projects are complex engineering endeavors that focus on the efficient and economical recovery of natural resources. Managing the environmental concerns associated with mine projects is also complex, and it requires a corresponding level of effort in terms of definition, parameterization, and understanding. This paper delves into conceptual site models (CSM) and describes their utility in unraveling the complex environmental systems surrounding mineral extraction. At their core, these models attempt to simplify complex systems and highlight the most important system features that must be thoroughly understood and managed to prevent environmental impacts and to ameliorate ongoing concerns caused by legacy mine activities.

The ARCADIS approach to environmental restoration has always begun with the construction of a CSM that integrates geology, hydrogeology, geochemistry, and risk assessment; this approach is borne out of our pioneering work on in situ strategies for groundwater restoration. The CSM serves as the platform for important decisions about site restoration, literally “grounding” the decision makers to one shared understanding of the situation in the field. Even more important, in situ innovation focused on the subsurface and in aquifer systems, waste rock piles, pit lakes, and tailings storage facilities requires that a good framework be assembled before advancing into uncharted territory. A strong CSM provides this framework and helps guide the way.

Those who are averse to CSMs posit the following: a) that CSM development is an exercise that is inherently expensive and of limited usefulness; b) that CSMs apply only to remediation sites and are not applicable to mining; and c) that CSMs are used only as the foundation for numerical models. We posit that none of these beliefs are true, and we will show that good CSMs are often the foundation for project success. We trust that you will find these insights from the ARCADIS mining practice to be useful, and we welcome further discussion of this topic.

THE bottom line

1. A conceptual site model (CSM) is an operating hypothesis against which mining site observations can be compared to provide meaningful qualitative or quantitative analysis at any stage of the mining life cycle.

2. Not all CSMs are comprehensive. Tailoring the CSM is fundamental to meeting the needs of the project, and choosing the right components provides cost efficiencies, flexibility, and agility.

3. Common misconceptions of the CSM hinder the utilization of this tool. Companies that employ CSMs gain a clear vision of the interwoven complexities of their mine site, facilitating informed and sound decisions.
A CSM can be defined as a working description (written, pictorial, graphical, analytical) of an environmental system and the processes that control the interaction of each component within that system.

There are numerous variations on this definition but, in essence, a CSM is an operating hypothesis against which site observations can be compared. Data gathering will either validate that hypothesis or identify the deficiencies, data gaps, deviations from expected behavior, or uncertainties of the hypothesis. The CSM provides meaningful understanding of a system, which is a prerequisite to any meaningful qualitative or quantitative analysis.

The Mine Life Cycle is separated into phases described by the primary activities being conducted during each phase; specifically, Discovery and Exploration, Assessment and Approval, Development, Operations, and Reclamation and Closure. The complexity of the CSM will generally increase as a project advances through these phases and additional site-specific information is obtained. CSMs can be developed during any of these phases, but early incorporation into the mine plan provides a foundation for key activities such as Monitoring Plans, Predictive Modeling, Risk Assessment, and Materials Management.
CSMs can range from a simple graphical illustration that depicts site features and processes to much more sophisticated comprehensive documents, depending on the project objectives. ARCADIS develops CSMs that range from comprehensive (updated, refined, and adapted as a project advances) to discrete (addressing a specific feature or component of a system or project). Both provide a framework to help communicate ideas, concepts, and an understanding of site conditions in an effective manner to all stakeholders.

Typically, CSMs include three principal elements: sources, migration/exposure pathways, and receptors. At mine sites, sources can be both natural, such as undisturbed mineralization, and associated with mining activities, such as waste rock, pit wall rock, tailings, and heap leach residues. Constituents released from sources can be transported through environmental media (i.e., groundwater, surface water, soils, sediment, air and biota) to potential environmental receptors (human and ecological). Some pathways for transport of constituents associated with mining operations include:

- Leaching into groundwater
- Runoff from surface facilities (e.g., waste rock or lean ore storage facilities) into nearby surface-water bodies
- Partitioning between water and sediments
- Uptake and transfer via biological pathways
- Windblown to workers and surrounding users

The most common applications of CSMs to the mine life cycle include their use as the basis for analytical or numerical groundwater flow models and pit lake-water quality predictions, or for identifying receptors for human health and ecological risk assessments. Mining-related CSMs can be used to:

- Guide sampling and analysis efforts
- Test and refine conceptual scenarios, such as mitigation measures
- Share information about the project with field staff, clients, regulatory agencies, communities, and other stakeholders
- Identify data gaps and uncertainty and provide ways to address them
- Recognize when additional expertise may be required
- Identify potential health and safety hazards associated with investigation and/or mining operations

**CSM Graphical Foundation**

Interface of potential surface-water: groundwater Interaction throughout the mine cycle
The key components of a mining CSM include many of the most fundamental aspects of a generalized mining project. Additional components may be included depending on the specific project and the unique aspects of that project.

A fully comprehensive mining CSM may include qualitative and quantitative descriptions of each individual aspect of the project at discrete points within the mine life cycle, serving to unite each of these different components within an integrated, consistent whole.

**Site Description**
This component of the CSM includes the details describing overall site conditions and may include the physical location of the project site, a timeline of activities, development of the project area and surrounding areas over time, modifications to the site over time, historical operations (including activities under different owners), materials used and wastes disposed of at the facility. The site description is a key component of the CSM; it helps to define the project site boundaries, guides the regulatory framework, and provides a foundation for the other model components.

**Geology, Stratigraphy, and Topography**
Geology, stratigraphy, and topography play an important role in all aspects of a mine life cycle, from the identification of mineralogical resources, to development and closure. This component of the comprehensive CSM includes a review of geologic maps/aerials (e.g., USGS quadrangle maps and aerial imagery), topography, cross sections, and possibly the mine block model itself. The information scale varies from regional to highly local. As site-specific information on the geology and extent of mineral resources is obtained through mine development, the CSM may be updated and refined. This information is important not only for understanding resource extent, but also for informing the hydrogeological and geochemical aspects.

**Climate**
This component includes meteorological data, such as precipitation, evaporation, temperature, wind speeds, and solar radiation, as well as information on how these parameters vary seasonally and relate to site location, elevation, and topography. This component is important as it relates to geological, hydrological, and geochemical aspects of the mine project; specifically, informing surface weathering rates and water fluxes (inputs, outputs, and flow) within and across the site.

**Hydrogeology**
The hydrogeology component describes the status and movement of water within the stratigraphic and geologic system as it flows within and across the project boundary, as well as its relationship to other physical components, such as surface-water bodies and project-specific components (e.g., underground workings and open pits). A clear understanding of hydrogeology is important throughout the mine life cycle; for example, it defines the feasibility of (and strategy for) dewatering during mining operations, as well as the behavior of water after mining operations are complete. This component may include qualitative inferences on water movement based on water levels and geology, or a summary of more quantitative local/regional groundwater flow evaluations and transport models developed for the area. It is also an important component of mine operation water-balance models.

**Water Balance**
Water balance is a critical component of a mining CSM because it describes climate-driven and hydrogeology-driven controls on the flow of groundwater, surface water, and precipitation, as well as the mine-operation-driven sourcing, movement, and disposal of water across the site.
Geochemistry
Simply put, the geochemical component of a CSM includes a description of the key chemical constituents present within the project boundary, such as the elements and minerals contained in rocks, dissolved constituents in ground and surface water, and chemical components added as part of mining operations – as well as their forms, dynamics, and mutual interactions. For example, as it relates to resource identification and mine development, a CSM may include the geochemical processes leading to ore body deposition. As it relates to water quality and solute transport factors during and following mine operation, a CSM may include mineral precipitation/dissolution reactions, redox transformations, pH modification, and a host of other aqueous- and solid-phase chemical reactions that may occur in response to a geochemical disturbance (e.g., saturation or de-saturation, introduction of dissolved oxygen, exposure of rock surfaces by excavation). Geochemistry ultimately controls how mineralogical resources are derived, how the system responds to mining activities, and how a system exhibiting environmental impacts may be treated. Accordingly, the geochemical component of the CSM is important at all stages of the mine life cycle.

Water Quality and Solute Transport
Water quality and solute transport are intimately tied to the other components of the CSM described above, particularly the hydrogeological and geochemical components. Specifically, the water quality and solute transport component describes changes in water quality as a result of hydrogeological and geochemical factors. It is also often modeled concurrently with water flows within the water balance model. Examples of water quality CSM components include the chemistry of groundwater moving into or out of below-ground mine features, water seeping from ore and waste rock storage facilities, the evolution of pit lake chemistry, and impacted groundwater expressing to surface water. This component is arguably most important during the mine development, operation, and closure stages, although an in-depth understanding of baseline water quality and the factors controlling it are equally as important to the ability to understand and predict water-quality changes in response to early site activities.

Potential Receptors and Exposure Pathways
Changes to soil and water quality and the disruption of surface ecological habitats have the potential to impact human and ecological receptors. Human receptors may include industrial, residential, and recreational users of the area, while ecological receptors may include threatened or endangered species as well as non-threatened or -endangered populations in the area. When human and ecological risks are identified, risk assessments are performed to evaluate specific receptors and exposure pathways; these serve as the basis for the risk components of the mining CSM. Development of this component of the CSM serves to tie these risk assessments to the larger site framework, particularly the water quality, geochemistry, and hydrology components.

Identification of Data Gaps and Uncertainty
Accurate and complete development of the CSM components described above can be used to identify knowledge and data gaps, as well as the sources and magnitude of parameter uncertainties. This in itself serves as an important component of the mining CSM because it drives additional data collection efforts and is the tool by which updates and refinements are made. It further highlights the fact that the CSM is a living document, concisely summarizing current understanding of a mine site. As data gaps are bridged, updates to the CSM are made, and additional data gaps can be identified.
TYPES OF MINING CONCEPTUAL SITE MODELS

It is important to note that a mining CSM does not need to include all components of a comprehensive CSM nor does it need to follow a rigid set of rules to provide tremendous value to a project. The CSMs applicable to mining projects may vary widely in complexity and detail, and may take the form of a written report, a series of PowerPoint slides, or a single flow diagram. In addition, a CSM may be developed to focus on only a few or even a single component of the mine system or life cycle. For example, a geochemical CSM may focus on water quality and solute mass flux components of a mining project, while a hydrogeological CSM may be developed to link groundwater/surface-water flows and site-wide water balances. Such component-specific CSMs may stand alone or may be merged with other component-specific CSMs at a later date to form a more comprehensive CSM.

Keeping in mind that a primary purpose of the CSM – to provide clarity, transparency, self-consistency, and value to all members of a mining project – will help to maintain flexibility and avoid rigidity and needless expense in CSM development.

COMMON MISCONCEPTIONS ABOUT MINING CONCEPTUAL SITE MODELS

Companies that see beyond the misconceptions associated with CSMs and employ them gain a clear advantage: they better understand the interwoven complexities of their mine site and are better able to make informed and sound decisions.

“CSM development is an exercise that is inherently expensive and of limited usefulness.”
Development of a formal, stand-alone CSM may represent an additional project expense, but the benefits described herein clearly outweigh the cost. The CSM compiles and interprets information that is already being developed as part of the mining project, synthesizing that data in a transparent, consistent, easily digestible manner. The actual cost of development can be kept to a necessary minimum by properly adjusting the scope of the CSM to the project needs, keeping in mind that comprehensiveness of the CSM should be dictated by project needs.

“CSMs are used for remediation sites and are not applicable for mining projects.”
Although it is true that CSMs are commonly and historically used to guide remediation projects, the principles of CSM development have important applicability to – and usefulness in – the mining sector. The use of CSMs in the mining industry is on the rise as leaders come to recognize their value in quickly and clearly communicating project information and understanding to team members and stakeholders.

“CSMs are used only as precursors to numerical models.”
Although this is an important use of the CSM, it is not the only use. The development of a CSM should be viewed as a tool for the synthesis, communication and understanding of a project, even if numerical models are not required or have already been developed.
APPLYING CSMs TO ACHIEVE OPTIMAL ENVIRONMENTAL MANAGEMENT STRATEGIES AND PROJECT ADVANCEMENT

The preceding sections have provided an introduction to CSMs as they apply to the mine life cycle, as well as a review of the types of CSMs and their key components. This section delves into two project examples that illustrate the benefits of a developing CSM for selecting optimal environmental management strategies and advancing a project forward.

The ARCADIS approach is to focus on what is known about a mine project and to illustrate this information through conceptual illustrations and a synthesis and summary of quantitative environmental data. This approach often identifies gaps in our understanding of processes or interfacial phenomena (e.g., at the groundwater-to-surface-water discharge point), leading to a field effort based on science (with data obtained specifically to answer key questions).

Almost all CSMs related to mine projects must answer questions related to two topics that encompass a wide range of scales:

1. Natural large-scale processes that may be altered by construction of the mine
2. Small-scale changes at the water-rock interface

An assessment of the former includes changes in surface and groundwater behavior upon mine construction. This requires that geotechnical, hydrologic, hydrogeologic, and mine engineering aspects of a project be identified. The latter may include changes in the geochemical environment of overburden rock and the ore body, resulting in greater mobility of trace elements. A full assessment at this scale involves hydrology, hydrogeology, mineralogy and geochemistry expertise. Two examples are provided here to illustrate construction of the CSM and its utility in advancing project goals.

Example 1: Conceptual Geochemical Model for Acid Rock Drainage Generation at a Mining-Impacted Site

Residuals from mining introduced into the natural environment from past activities can serve as long-term sources of acidity and metals in soils due to geochemical weathering reactions. These reactions can be accelerated in oxic environments, specifically if the residuals include iron sulfide minerals (e.g., pyrite) that release sulfuric acid when oxidized. The natural buffering capacity of soils may be able to neutralize the effects of oxic weathering; however, this capacity is limited. Once the buffering capacity is overcome, trace metals that dissolve under acidic conditions can migrate away from the source. An attractive environmental management strategy is to augment the buffering capacity that may have been depleted.
Coupled with passivation of the weathering reactions, this can provide a sustainable solution. Prior to implementing this type of strategy, however, and due to the geochemical complexity of mining residuals, a robust understanding of the site conditions must be obtained. This level of understanding was developed for a site in the United States that was engaged in the production of phosphate fertilizers during the late 19th century. The primary constituents at the site were lead (Pb) and arsenic (As) that were associated with the phosphate ore, sulfide ore feedstock for making sulfuric acid, and sludge from Pb-lined acid storage tanks. In addition, the soil and groundwater were acidic due to previous site operations. While mitigation was initially scoped to be the construction of a costly groundwater pump-and-treat system to maintain hydraulic control on the constituents, a better solution was found after construction of a CSM for the site.

The complexity of the environment (the site borders a wetland), as well as the highly localized nature of constituent distribution, made development of a thorough understanding of constituent mobilization and immobilization mechanisms a challenge. A geochemical CSM was developed based on an understanding of sources and the general behavior of As and Pb (Figure 1). The geochemical CSM was constructed through focused site investigations and involved the use of non-routine geochemical analyses.

![Figure 1](image)

**Figure 1**

Geochemical CSM describing mechanisms for release and sequestration of As, Pb, and acidic pH. (Zone 3 is not shown because it was initially identified as the zone in which As and Pb mobilization occurred under sub-oxic conditions and was not found to be prevalent at the site.)
Based on the investigation results, three geochemical zones were identified at the site, described in Table 1. The mechanism responsible for the release of As and acidity from the slag (Zone 1) was identified as oxidation of the partially roasted pyrite (releasing sulfuric acid and As), and As desorption from iron oxyhydroxides that comprised the majority of the slag. Pb was predominantly associated with the mineral anglesite and was effectively sequestered by natural soil minerals outside of source zones.

Table 1. Geochemical CSM, natural control mechanisms for constituent mobility, and investigation methods used to verify the presence of natural controls.

<table>
<thead>
<tr>
<th>Conceptual Geochemical Zone</th>
<th>Control Mechanism for Constituents</th>
<th>Investigation Data Used to Verify Mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>• The major source of Pb and As at the site is waste material from the pyrite (FeS$_2$) roasting process&lt;br&gt;• The Fe minerals desorb the attached Pb and As at acid pH&lt;br&gt;• Pb dissolution from lead sulfate mineral phases</td>
<td>• Elevated acid generation potential of source soils&lt;br&gt;• Presence of significant concentration of crystalline iron oxides and iron sulfide in source soils&lt;br&gt;• Predominant association of As with sulfide phases&lt;br&gt;• Identification of anglesite by XRD</td>
</tr>
<tr>
<td>2 Immobilization of constituents under Toxic conditions</td>
<td>• Amorphous iron oxyhydroxides bind As as the pH moderates&lt;br&gt;• Pb becomes associated with phosphate mineral phases outside the source zone</td>
<td>• Moderation in pH, As, and Pb away from source&lt;br&gt;• Significant fraction of the iron present in amorphous forms.&lt;br&gt;• Predominant association of As with amorphous iron.&lt;br&gt;• Identification of lead phosphate by XRD</td>
</tr>
<tr>
<td>4 Immobilization of constituents under anoxic conditions</td>
<td>• Sulfate-reducing conditions and organic matter in wetland serve to stabilize As with sulfide mineral phases</td>
<td>• Sequestration profile strongest in wetland&lt;br&gt;• Significant fraction of iron present as iron sulfide&lt;br&gt;• Predominant association of As with iron sulfide and organic matter</td>
</tr>
</tbody>
</table>
The CSM was used to guide additional investigation to validate the understanding of source and immobilization mechanisms. The analysis of an expanded analyte list for groundwater, as well as advanced soil and rock analyses (including sequential selective extraction, x-ray diffraction, electron microscopy and x-ray spectroscopy), provided the data required to fully understand As, Pb and pH behavior at the site. A complete understanding of site geochemical conditions and the current behavior of constituents provided for the development of a management approach that was compatible with site conditions and will be sustainable over the long-term.

This involved:

1. Excavating the more highly impacted source soil from Zone 1 locations
2. Harnessing the natural sequestration capacity of site soils for As using soil amendments and pH buffers to counter the acidity in other Zone 1 locations
3. Excavating saturated zone soil and emplacing clean fill with amendments and pH buffers to sequester constituents in groundwater
4. Providing residual treatment capacity so that downgradient locations (Zone 4) can function more effectively and stabilize constituents in solid mineral phases

The approach used at this site is applicable to other sites with similar concerns and geochemical complexities and hinges on a well-formulated CSM that focuses on the water-rock interactions. With a firm understanding of geochemical controls for metals, the outcome was a strategy with minimal perturbation to the site that harnessed existing geochemical conditions for maximum benefit.

Example 2: Evaluation of the Presence of Arsenic in Groundwater Prior to the Start of New Mining – A Coupled Hydrogeological and Geochemical CSM

Prior to mining activities, the development of a CSM provides a useful means to document existing conditions (undisturbed or prior disturbances), understand the presence of constituents and their fate in past mining (through data collection) and future mining (through a CSM), and find sound technical and cost-effective solutions that address environmental issues in all phases of the mine life cycle.

Past mining activities at a gold-bearing property in the western United States had resulted in accumulation of historical mine waste from the recovery of precious metals. The mine wastes were a concern to state regulators, local government officials, regional water and air quality boards, and federal entities, with specific concerns related to elevated concentrations (above regulated concentrations) of As in groundwater beneath the project site. The mineral deposits that had been mined historically in the area are hosted in a volcanic sequence of rhyolite porphyries, quartz latites, and bedded pyroclastics. Precious metal mineralization is associated with steeply dipping epithermal fissure veins in faults and fracture zones that cross cut the rock units. The veins are contained within siliceous envelopes of lower-grade material that form the bulk of the mineral resources. The mineralization extends to depths below the water table of the surrounding regional alluvial aquifer, the volcanic sequences are present at depth and are likely contributors to the geochemical characteristics of the groundwater. A CSM that shows the mineralogical association of As with various environmental compartments, including the surficial environment, historical tailings, and As at depth below the regional water table, was assembled and is shown on Figure 2. (on the following page)
A comprehensive ore, waste rock, tailings and soil sampling and analysis program, as well as hydrogeological studies, formed the basis for the CSM. Similar to Example 1 discussed above, advanced chemical analyses (leach testing and ion-beam microprobe analysis) were used and focused on the mineralogical form of As and trace elements in ore, rock, and surface soil downwind of historical tailings piles. Groundwater characterization wells were developed and sampled for major cations and anions, As, and other trace elements. This work was focused on the goal of understanding As and its chemical form and environmental stability.

Groundwater in the vicinity of the project is characterized by naturally elevated pH, alkalinity, total dissolved solid (TDS), and As concentrations. Groundwater in the region also has elevated TDS and alkaline pH (>8) and contains characteristically high As concentrations. A hydrogeological CSM was constructed to evaluate the potential for migration of water from the ground surface, through historical tailings, previously mined areas and waste rock, to the underlying aquifer. The CSM used a conceptualized stratigraphy beneath the tailings, as well as site-specific soil properties supplemented with data from other applicable sources. Climatic data such as precipitation and evaporation were also included in the CSM.
The CSM consisted of a vertical column that extended from the tailings to the approximate depth of the regional water table. Model simulations were performed to predict the migration of tailings seepage through the timeframe from early mining to the present and approximately 30 years into the future. Model results showed that a seepage front reaches a depth of only 50 feet after 70 years, which is approximately 200 feet above the regional water table, and indicated that tailings seepage would not have impacted groundwater and is unlikely to affect groundwater quality in the future.

The coupled geochemical and hydrogeological CSM concluded that leaching of the host rock or historical tailings by natural processes does not influence groundwater quality in the area. The elements of the CSM are described as follows (Figure 2): As incorporated into pyrite within the ore deposit is stable [1], while As in the historical tailings is immobilized through sorption to iron hydroxides and incorporation into pyrite [2]. The combination of low precipitation, insufficient sulfur for acid generation, and 180 to 250 feet of unsaturated alluvial soils, with sorptive capacity for As, greatly inhibits the potential for development of acid rock drainage that could result in degradation to the quality of any receiving water at the site [3]. Groundwater in the region contains naturally elevated As concentrations, which are present due to the flow of high-TDS alkaline groundwater through natural mineralized zones in the subsurface, mobilizing As [4].

This work facilitated a detailed understanding of the existing site conditions and a projection of the environmental fate and bioaccessibility of trace elements present in ore, waste rock, leached residues, and the process solution used in gold and silver heap leach operations. This information was used to assist in the mine design and preliminary mine closure planning to meet existing and pending regulatory requirements. In addition, geochemical and mineralogical investigations were used to support hazardous air pollutant modeling and groundwater protection evaluations.

ARCADIS’ approach of using the science of mineralogy to develop a CSM for every phase of the project enabled a better understanding of the environmental and human health impacts that must be managed during the mineral extraction process. In turn, a sustainable mine development plan (which, in this case, involved managing historical tailings on the property, waste rock and heap leach residues, and aggregate production, and developing strategies to meet the state-mandated backfilling requirements) was developed that provided the following:

- Answers to stakeholder concerns relative to mining effects on past, present, and future groundwater quality
- A guide for mine waste management that uses an evaluation of trace element environmental behavior
- A firm footing to address new and changing mining environmental regulations

The CSM provided all stakeholders significant detail and understanding of current pre-mining conditions which generated strong cooperation to permit the mine.
CSMs synthesize complex information at a mine site into an understandable site narrative for all stakeholders. The two project examples presented in this paper demonstrate the utility of CSMs in helping to understand complex water-rock interactions at mine project sites, and their use as tools to communicate changes to the natural environment that have occurred, or may occur, due to mining. However, what is more significant is that both examples showed that the CSM process itself, thoughtful assembly of data, identification and in-filling of data gaps, and (when needed) compilation of non-routine data, identified opportunities that saved the project money and strengthened stakeholder relationships. This demonstrates that the outcome of the CSM not only supports project planning and execution but the process itself of assembling the required data can lead to significant benefits for the project.

In conclusion, activities related to the assembly of a CSM facilitate a greater project understanding. This is because the information and data required for a conceptual model for a mining project forces the project team to confront the quality of the available data, the quantity of the data required for decision-making, and gaps in project understanding. A tailored CSM can then be designed that meets the needs of the project and provides meaningful qualitative and quantitative analysis with a clear path forward to facilitate sound environmental decisions and develop cost-effective solutions.

This conversation continues at the Northwest Mining Association 119th annual meeting in Reno, Nevada on December 2-6, 2013 at the session titled “Conceptual Model Application through the Mine Life Cycle: A Tool for Getting Lost in the Weeds or Finding a Way Out?”

ARCADIS geochemist’s Patsy Moran and Michael Hay are organizing this session, which will focus will on case studies that demonstrate the application of CSMs to the mine life cycle. Here we will discuss the overall utility to successful mine planning, operation and closure. The conversation will focus on how to use conceptual models to enhance mine planning, facilitate stakeholder understanding, and provide for more efficient reclamation and closure.

Dr. Patsy Moran (Senior Scientist), Dr. Michael Hay (Project Geochemist), and Dr. Jeff Gillow (Principal Scientist) prepared this paper; this team works closely in collaboration with other technical experts in the ARCADIS mining practice to provide comprehensive well formulated solutions to meet client needs.

For more information on conceptual site models, contact Jeff Gillow at jeff.gillow@arcadis-us.com.