INDUSTRY LAB REPORT

Triple Performance Mine

An experiment in integrated mine design.

Hosted by

CEEC International · GMG

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1. The Lab — Concept and Purpose

Mines are still designed in sequence rather than as systems. Production is optimised first; environment, water, closure, safety, community relationships, and decarbonisation are bolted on afterwards, once the pit shells are fixed and the technology selections are made. The cost of that sequence shows up later — in permitting delays, contested water licences, deferred rehabilitation that never gets caught up, and trust deficits that the next crisis exposes.

CEEC International and GMG built the Triple Performance Mine lab as a way for mining professionals to practice integrated design before they have to do it on a real project. Three teams of six played the leadership of a hypothetical mining company developing Snow Apple Mine — a $4B capital build, 40-year life operation, open pit transitioning to underground, a water-stressed catchment, three Indigenous rights-holder communities, a regional town 15 km away, and a heritage-listed ridge. Teams made foundational design and technology decisions in Round 1 and then faced challenge cards across the simulated life of the asset, with environmental, water, community and economic consequences arriving as direct feedback to choices made in the first hour. It is deliberately a game: the simulation gives participants permission to make decisions they would not normally make, to surface assumptions they would not normally name, and to see what their own design choices look like under stress.

Our purpose in developing the lab is twofold: to give mining professionals a tangible experience of what an interdisciplinary, non-siloed approach to mine design actually feels like and produces; and to surface, in the industry's own words, the barriers to working this way and the changes that would make it possible.

Value to participants

The strongest theme from participants was the value of being in a room with people they would not normally make these decisions with. Several said it was the first time they had been around a table with that mix of disciplines, and the experience changed how they understood their own work.

> *"It helped to illuminate the things that I didn't realise I didn't know. I'm thinking I'm innovative, but I'm not bringing together a group of people like this ever. So I think I'm innovative, but I am not. And today reminded me of that in a very healthy way."*

A second theme was the recognition that different teams were defaulting to different approaches — some leaning into technical specificity, others leading with relationships — and that real projects need both. As one participant observed, "in reality, that's also how it happens in our industry. You probably need to mix both. Sometimes the technical stuff, you start with the jargon, all that, people are really in mining... but other people are more on the community side... I don't know what the hell he's talking about, but these people are bringing me along."

A third theme was the surfacing of blind spots in a safe space. Two of the three teams realised — only at the self-assessment stage — that they had not discussed caribou habitat at all in their Round 1 design, despite the orebody sitting in caribou range. One of those teams realised the word "carbon" had not entered their conversation until the scorecard either. These were not failures of expertise; they were a demonstration of how easily even experienced teams default to a familiar subset of considerations under time pressure. That demonstration is the lesson.

Finally, the lab generated appetite for follow-on collaboration. Several participants spoke about explicitly making space for this kind of cross-disciplinary work back in their own organisations: "We will set aside this many hours to work together each month."

2. How the Day Ran

The day ran in three acts:

- Act 1 — Design the mine. Mixed-discipline teams of six opened a sealed company kit (orebody, site map, water licence, capital budget, regulatory and community profile), sketched a high-level layout, made binding selections in six technology areas (underground method, surface fleet, processing route, tailings, energy, and ore sorting), and recorded three design principles. The downstream consequences of their elections were not revealed.
- Act 2 — Four challenge-card rounds. Year 2 (contested water licence and permitting), Year 4 (geotechnical and environmental surprise), Year 8 (commodity price crash with an organisational cost-cutting demand), Year 12 (opportunity to acquire a neighbouring tenement). Each card carried additional triggers that activated only for teams whose Round 1 choices matched, so teams discovered, in real time, that the situations they were responding to had been created by their own earlier decisions.
- Act 3 — Self-assessment and barriers. Teams assessed their mine across economic, environmental and social dimensions, naming both strengths and what they had missed. The top industry-wide barriers to integrated design were discussed and a final 20-minute sprint translated one of those barriers into a concrete change. Each participant left having written a personal integration commitment on the back of their name card.

3. The Three Teams

Each team took a recognisably different path through Snow Apple — and each ended the day having learned something different about how their own discipline shows up under integrated design conditions.

ROUND 1 · TECHNOLOGY

Common ground and divergences

KEY PATTERN

Every team converged on dry-stack tailings and ore sorting — but underground method, energy supply and processing route diverged sharply, with downstream consequences that surfaced in Rounds 2–5.

Election	Table 1	Table 2	Table 3
Underground	Block cave / sub-level cave	Block cave (Yr 9+)	Open pit Yr 1–8, block cave Yr 9+
Surface fleet	Alt material movement	Manned electric fleet	Hybrid manned electric + AHS u/g
Processing	Option B (oxide → flotation)	Conventional flotation	Conventional flotation
Tailings	Hybrid (dry stack + paste)	Dry stack + wet AG lens	Dry stack
Energy	Renewable hub + SMR	Grid + hybrid renewable	Hydro grid
Ore sorting	Hybrid (bulk + grade eng.)	Bulk ore sorting	Bulk ore sorting

Team 1 — The integrators with a documentary crew

Identity-first integration: small footprint, optionality, and co-design referenced explicitly in every round.

Team 1 declared integration their identity in the first hour. Their three design principles — small footprint, optionality, and co-design — were referenced explicitly in every subsequent round. Co-design had real teeth: shared value, shared ownership with Indigenous and local community partners, and shared impact responsibility.

Their Round 1 elections formed a deliberate system: oxide heap leach to start (small footprint, faster cash) transitioning to conventional flotation, with copper-only processing and gold deferred; a hybrid renewable energy hub flagged as a critical anchor delivering social, economic and environmental wins together; bulk ore sorting plus grade engineering; and a hybrid manned-then-autonomous fleet. Block cave was on the table but contingent on First Nations protocols.

When the Year 2 reagent challenge landed, the team had been quietly excited about a new low-environmental-footprint gold-leaching reagent but had not properly briefed the regulators. Rather than fight, they asked their First Nations partners to write to the regulator requesting a co-convened discussion — and explicitly framed it as a capacity-building moment for the recent-graduate regulator who had raised the concern. If the 60-day window did not close, they would run copper-only and defer gold.

Year 4 found them well-prepared because they had built optionality into the design. The processing facility was modular; the heritage trigger was reframed as an old settler cottage tied into a community theme park the team had been developing as part of an ongoing documentary series. Cost: roughly $15M. At Year 8 they pushed back hard on a $120M cost-cut demand — German sustainability-focused banks were already in conversation about refinancing the original high-interest project loan on the strength of the renewable energy hub's carbon story, and cutting the community team would collapse both the co-design model and the bank deal. By Year 12 the team was running an energy hub, a tech hub producing batteries, and a manufacturing arm; UBC had opened a campus near the operation; and the First Nations partners were already exploring shifting majority ownership to the community for the back end.

> *"We didn't really keep running the numbers, so we probably built a very expensive mine."*

In self-assessment, Team 1 graded themselves around eight out of ten across all three dimensions, with a clear-eyed caveat: they had been deliberately qualitative on numbers.

Team 2 — Block-cave first, then redesign the impact

Technology elections first, principles named afterwards — and a striking late realisation about caribou.

Team 2 took the opposite route to their design principles. They made their technology elections first and only afterwards realised that, in doing so, they had committed themselves to a set of principles they then named explicitly: maximise early returns and pre-fund closure; mitigate-manage-offset with caribou habitat as the charismatic anchor; community engagement early and often, and a 200-year structure of shared ownership with the three nations — explicitly aspirational, openly caveated, but committed to.

The orebody sat under a caribou park and Indigenous territory. They proceeded with a 22 Mt/yr block cave and two pits, planning to close as an amusement park and tourist lake, referencing a precedent diamond mine in Africa. On waste and tailings the team made life harder on purpose: 100% of waste rock and 20% of tailings assumed acid-generating; waste rock underwater in pits and underground; filter-stacked tailings as a structural cell with acid-generating tailings contained as a wet slurry in the centre. They eliminated cyanide, redirected the capital into bulk ore sorting after crushing, and added pyrite flotation to sequester a PAG tail separately.

At Year 2 they invested in both monitoring and water-recycling capex with a contingency trigger to defer capital later. At Year 4 they slowed underground, split the cave into two panels — one outside the heritage subsidence zone, one to wait for clearance — redirected the $80M into a closed water-treatment plant, and named clearly that geological surprises tend to repeat. Year 8 was the round in which Team 2 famously fired their CFO: “We don’t quite see the strategic vision. We believe in the long-term buoyancy of copper in the era of the energy transition.” They restructured to delivery-focused management, deferred remaining underground capital, brought forward the final pit-stage bench progression, and protected the cheap, visible parts of community engagement. At Year 12 they bought the neighbouring tenement but deferred development to coincide with the exhaustion of the original reserve.

In self-assessment, Team 2’s most striking realisation was a confession: they had not talked about caribou at all in their first-round design — only at the scorecard. They had played with diverting the creek and dropped the idea unresolved. The scorecard discussion was, for them, the first time the word “carbon” entered the conversation. Around 3/5 on economic, stronger on tails and waste-rock chemistry, 4/5 on social with the caveat that early-life community investments needed to extend well beyond the early years.

Team 3 — Water-first, with the world’s biggest open pit

Built the mine from the water envelope inward; coherence paid out in later rounds.

Team 3 built the mine from the water envelope inward. Their first design principle was water — scarcity, licence constraints, and the implications for every other technology selection. Their second was a low-cost mining method, combining a large-bench open pit with a block cave on the same orebody; selectivity, which the mining method could not provide, would come from ore sorting on the shovels and on the conveyor down the decline. Their third was community consideration: manned electric fleet to anchor early local employment, dry-stack tailings to reduce footprint and water demand, and co-investment with First Nations from the start.

When the Year 2 water challenge arrived, the team’s response was a closed-loop water recycling system as a future-proofing investment, structured with a deferral subject to interim-licence negotiation. At Year 4 they slowed underground development, reordered the pit mining plan to make room for fault-zone investigation, adapted the cave footprint for the heritage trigger, and named openly that part of the orebody might have to be sterilised. At Year 8 the team’s key cost-cutting lever was an ore-sorting set-point trick — with the concentrator at full tilt, they could adjust the sorter to send more metal into the tails short-term while high-grading mill feed, lowering variable cost per metal unit. They were entirely transparent that the trick destroyed long-term value: reserve would drop. “I’ll be retired by then,” one team member said, “so I leave that probably to younger people in the room to sort it out.” Year 12 was where the team’s earlier coherence paid out — the neighbouring tenement was accessible directly from the existing underground, ore sorter capital was reusable, and dewatering water from the fault since Year 6 could process the new ore without extending the water licence.

> *“We shouldn’t mine this area at all.”*

In self-assessment Team 3 named two clear blind spots: they had underestimated water impacts at the very beginning, and they had no caribou plan — fences had not even been raised in Round 1. The scorecard was the first time they used the word “carbon,” despite their ore-sorting choice having been reducing carbon per pound of metal the whole time. Around 3/5 on environmental and 4/5 on social, with the caribou question still open at the end of the day.

ROUNDS 2 – 5

How early choices echoed forward

YR 2

Permitting & water

Closed-loop water systems committed, monitoring frameworks negotiated. The team that chose heap leach had to convene regulators, First Nations and community on reagents within 60 days.

YR 4

Geotechnical surprise

Unmapped fault zone triggered a 9-month delay. Block-cave teams split the cave into panels to dodge the heritage ridge; conventional TSF teams faced seepage and front-loaded water treatment.

YR 8

Commodity crash, –28%

Range of moves: refinance off the renewable energy story, defer the underground capex tail, or adjust the ore-sorter set-point to high-grade short-term — with explicit acknowledgement of long-term value destruction.

YR 12

Life-of-asset extension

Adjacent tenement opportunity. Teams with early water investment and co-design relationships made the case credibly; the autonomous-from-day-one team had less goodwill to draw on.

4. What's Stopping Us?

The day lab wrapped up with a final exercise to identify the barriers restricting interdisciplinary, systems-level collaboration and co-work on site, and to dig in a bit on some of the prioritized issues that arose. Overall, all participants agreed this is a real issue and deserves much more attention and effort than it currently receives. Below are some of the key barriers and an agreed 3 steps we could take immediately.

PART 1 · BARRIERS

Why we don't already do it this way

1 Cultural inertia

The tanker analogy — large organisations resist change and have standardised processes that quietly enforce "how we've always done it".

2 Funding mindset

No budget line for cross-team integration discussions. Short-term financial framing crowds out long-horizon value.

3 The tyranny of NPV

Hammered into engineers, hostile to optionality and long-tail value. Closure costs discounted to invisibility.

4 Risk aversion

"Who else is doing it?" — the industry's first question on new technology, and the reason novel approaches stall before pilot.

5 Annual optimisation

Operations measured against this year's targets. Twenty-year design choices get whittled away one budget cycle at a time.

6 Skills transfer

Knowledge held tight as job security. Mentorship structures absent. The next generation is not being equipped to challenge the status quo.

PART 2 · FROM BARRIERS TO LEVERS

What teams pitched as concrete change

TOOL

Dynamic cash-flow modelling

Stochastic, optionality-valuing alternatives to NPV. The technique exists — the industry's standard training doesn't yet reach for it.

PEOPLE

Mentorship + capability sharing

Pair junior and senior, then publish internal capability statements. Make sharing knowledge the route to status, not a threat to it.

PROCESS

Time, ringfenced, for integration

Not aspirational "we should collaborate" — explicit hours each month, allocated, tracked, and protected from operational urgency.

> *The team that integrates economic, environmental and social thinking from the first decision outperforms those who bolt it on later — that's not a spoiler, that's the point.*

4. Next Phase

The Vancouver lab was a first run. It worked, not because the day was smooth (it was not, and we learned a great deal about pacing and where to compress) but because the underlying mechanism did what it was supposed to do. Mixed-discipline teams made early design decisions whose downstream consequences they then had to live with. They saw, in their own work, the patterns the industry has been describing in panel discussions for years: caribou habitat overlooked until late; the word "carbon" not appearing until the scorecard; community investment front-loaded; the temptation to optimise to annual production at the expense of the asset; the difficulty of valuing optionality and risk reduction inside an NPV frame.

The Snow Apple project has further potential as a structured workshop for use beyond this first cohort, refined where the materials need it, with a tighter dossier, and adjusted to be repeatable without losing the discovery quality that makes it work. The barriers-and-pathways segment, in particular, generated content worth its own thread: NPV alternatives that value optionality (dynamic stochastic cash-flow modelling came up directly), knowledge-transfer mechanisms across generations of mining professionals, and the cultural and incentive shifts that would let cross-disciplinary time be protected as a measurable input rather than an aspiration.

What the lab provides, and what conferences and panel discussions do not, is problem-based learning. Participants make the decisions, live with the consequences across a 20-year decision time-axis, and discover the integration patterns through their own work — rather than hearing them described from a stage. The next phase is to take that mechanism further: to more participants, more contexts, and more partners, with the goal of driving more inter-disciplinary mine planning and operation.

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