Comprehensive services for the mining industry

From prospect through production to closure

BARR®

National and global experience in the mining sector

About Barr's mining services

Since its incorporation in 1966, Barr Engineering Co. has been assisting mining and minerals processing clients around the world with complex projects of all scales. We use our comprehensive knowledge of the mining process; extensive engineering, environmental, and operational experience in the industry; and project-based solutions to help clients develop new projects, construct new mining and minerals-processing facilities, and modify existing operations.

With over 1000 employees, Barr offers clients one source for the technical and regulatory services needed to take projects from conceptual studies and environmental assessments through detailed facility design, construction, operations, and closure. Integrating engineering and environmental expertise yields a streamlined project approach—one that improves efficiency, communication, and understanding of both small project details and the big picture.

To learn more about Barr Engineering Co. and our mining services, visit: **www.barr.com/sector/mining**.

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Mine engineering services

Barr's mining engineers support active operations, as well as greenfield and brownfield project development. We create optimized mine designs that assist in developing executable mine plans, sequences and schedules.

Our mine engineering services include:

- Project evaluation and due diligence
- Technical reporting: NI 43-101, SK 1300, and JORC
- Conceptual, prefeasibility, and feasibility studies
- Mining and facility support for NEPA studies and other permitting needs
- Strategic life-of-mine design and planning
- Short- and long-range production scheduling
- Cost estimation and economic analysis
- Reserve estimation
- Paste backfill system design
- Waste rock storage and tailings disposal design
- Equipment selection and optimization
- Operations auditing and benchmarking
- Reclamation, closure design, and planning

Barr's staff has decades of experience in an array of commodities, including:

- Base metals
- Industrial minerals
- Oil sands and oil shale
- Phosphate and potash
- Borates
- Uranium
- Industrial sands
- Precious metals
- Coal
- Rare earth elements
- Trona
- Cobalt
- Lithium
- Aggregates, sand, and gravel

Battery minerals project development

Barr is assisting with mine development, mineral concentration, metals refining, tailings management, and facilities design for a project in Missouri to produce multiple metals important to the growing U.S. electric vehicle and lithium-ion battery industry. The project will reprocess historic tailings and process ore from several underground mines at the site. The beginnings of one of the underground mine access declines is pictured above. A small concentrator was developed to reprocess the historic tailings by regrinding and froth flotation; a new concentrator, sized for the mine feed, will be developed based on this basic flowsheet.

Graphite One feasibility study

On Alaska's rugged Seward Peninsula, Barr is performing a feasibility study for the Graphite Creek mining project. Graphite One Inc. is aiming to become a primary U.S. producer of high-grade anode material, chiefly for use in lithium-ion batteries that power electric vehicles.

Geotechnical engineering services

Barr's geotechnical and mining engineers work closely with clients to understand geotechnical risks and develop practical, operational-based solutions collaboratively for safely achieving the mine plan. Our mining geotechnical staff have experience at surface and underground operations with active mining areas and support facilities, including tailings storage facilities, heap leach facilities, waste rock/spoil storage facilities, impoundments, and various infrastructure elements.

Our geotechnical engineering services include:

- Geotechnical and hydrogeological investigations
- Laboratory testing coordination
  - Material characterization
- Geological exploration and mapping
- Seismic analyses
- Mine pit shell assessment for pre-feasibility and feasibility level studies
- Highwall stability analyses
- Subsidence evaluations and monitoring
- Dewatering studies and system design
- Tunnel design
- Underground excavation and support system design
- Mine backfill design
- Shallow and deep foundation design
- Tailings management and engineer of record (EOR) services
- Lined facility design
- Heap leach design
- Near-real time instrumentation monitoring and data visualization
- Fatal flaw analyses
- Operational audits and independent reviews
- Dam safety reviews (DSRs) and independent technical reviews (ITRs)

Pinto Valley Mine geotechnical assessment

Barr conducted a third-party geotechnical assessment at Capstone Copper's Pinto Valley Mine in Arizona. Our study included an on-site inspection of two slope instabilities, tailings storage facilities, and waste rock storage facilities, as well as a review of geotechnical monitoring data. Our observations provided on-site staff with practices for safely assessing and executing concurrent remediation activities.

Underground mining services

Barr assists with underground mine inspections and monitoring using our staff's extensive operational experience. We plan investigations and perform ground support studies, including installed support and pillar geometry.

Engineering design services

Barr offers a full range of engineering services for mining and minerals processing plants, including the associated facilities and infrastructure. We assist our clients with conceptual studies through final design, construction and operation for both existing and retrofitted facilities.

Our site design services include:

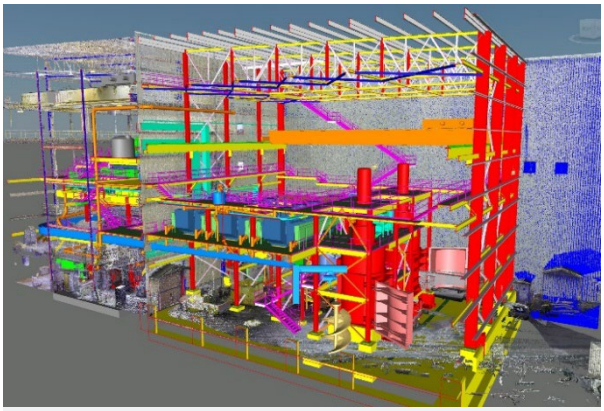
- Site characterization, foundation evaluation, and stabilization design
- Surveying
- Grading, drainage, and site preparation
- Planning and design for infrastructure including:
  - Roads, bridges, and railroad tracks and yards
  - Truck and rail loading and unloading systems
  - Port facilities
  - Utilities (water, fuel, power, and communications)

Our facility design services include:

- Conceptual through feasibility studies
- Process modeling and plant design
- Plant general-arrangement design
- Process flow diagrams, piping and instrumentation diagrams, process hazard analyses, and hazard and operability analyses
- 3D scanning and integrated 3D design
- Process equipment specifications and integration design
- Facility structural steel, equipment installations, and piping supports
- Building and equipment foundations
- Bulk materials-handling systems
- Water supply, treatment and distribution systems
- Emission control and wastewater treatment systems
- Electrical power supply, distribution, monitoring and control systems
- Process controls, communications, instrumentation, and lighting systems
- Materials and equipment selection, specifications, and procurement assistance
- Preparation, review, and administration of construction plans, specifications, and contract documents

Loadout conveyor replacement

Barr completed detailed engineering design and construction assistance for a product loadout conveyor replacement. Our design approach minimized total downtime and project costs.



Plant retrofits

Barr completes plant retrofit projects, from scoping and feasibility studies through detailed design, for process improvements or production of new, value-added products. We can provide engineering for all disciplines and construction and commissioning support.

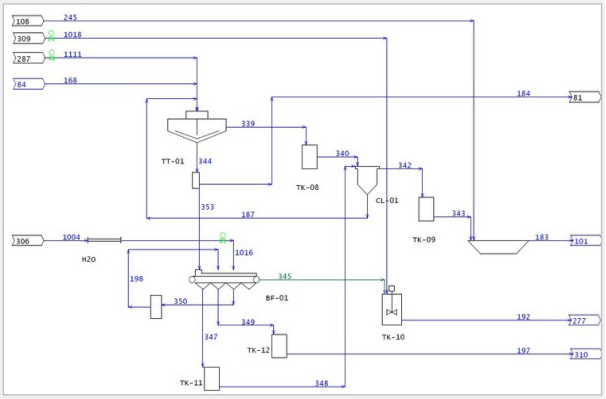
Mineral and metallurgical processing services

Barr provides conceptual, basic, and detailed engineering for mineral and metallurgical processes including:

- Ore sizing, crushing, and screening
- Stockpiling and material handling and distribution
- Milling, grinding, and classification
- Calcining and roasting
- Gravity, magnetic, and hydraulic separation and concentration
- Flotation
- Leaching and dissolving
- Evaporation and crystallization
- Solid/liquid separation
- Agglomeration and induration
- Concentrate handling, storage, and loadout
- Tailings processing and tailings basin management
- Reclaim and scavenging

Barr assists mineral processing facilities to integrate process improvements that boost efficiency and profitability and strategically expand facilities to increase production with:

- Options analyses
- Process sampling and test work
- Liberation studies and detailed metallurgy
- Material and energy balance studies
- Plant audits and updated process documentation
- Detailed process design
- Debottlenecking studies and equipment performance improvements
- Energy audits and greenhouse gas footprint evaluations
- Tailings reprocessing
- Process hazard analyses



Modeling for design and process optimization

Barr uses computer modeling programs such as METSIM to help design and optimize mineral processing systems. METSIM calculates process mass and energy balances, simulates and tracks particle-size distributions, and models kinetics and equilibrium-based processes. It can simulate steady-state, batch, and dynamic operations from a single unit to an entire plant. The simulation outputs provide critical data used in developing flowsheets, specifying equipment, and estimating labor.

Iron ore concentrator design

Our mineral processing experts provided fast-track design services for an iron ore concentrator in Venezuela.

Tailings management services

Barr has over 100 professionals who routinely work on tailings storage facilities (TSFs) across North America and abroad. This large group allows us to build teams based on facility-specific needs. Our expertise spans the TSF life cycle, including permitting, concept development, design, construction and operation, monitoring, and closure.

We have experience with slurry, thickened, paste, and filtered tailings, and assist our clients in selecting evaluating alternatives based on site-specific considerations.

Our experts actively engaged in various industry organizations and are well-versed in the Global Industry Standard on Tailings Management (GISTM), as well as Mining Association of Canada (MAC), Canadian Dam Association (CDA), and International Commission on Large Dams (ICOLD) guidelines.

Our tailings management services include:

- Concept planning and feasibility studies
- Tailings pumping and piping system design
- Tailings deposition and beach slope studies
- Filtered and thickened tailings analysis and design
- Mine backfill analysis and design
- Engineer of record (EOR) services
- Water balances, hydrology, and hydraulics
- Geotechnical investigations and characterization
- Liquefaction and seismic hazard analyses
- Seepage and groundwater modeling
- Tailings storage facility (TSF) and dam design
- Seepage cutoff wall, liner, and collection design
- Instrumentation monitoring and TARP development
- Construction management, startup, and operations assistance
- Dam breach and runout analyses
- Emergency action plan (EAP) development
- Closure, reclamation, and landform design
- Dam safety reviews (DSRs) and independent technical reviews (ITRs)
- Risk assessments

Trona TSF management and seepage cutoff

Barr provides tailings management, annual dam safety reviews, permitting, water balance, dam design, and groundwater interceptor-system evaluation and design services for a confidential Wyoming client that operates and maintains a tailings storage facility covering approximately 4,500 acres. The facility includes a series of cells with perimeter and interior impoundment dams and groundwater interceptor systems. The total length of the dams is approximately 20,000 feet with the tallest dam exceeding 60 feet. Shown here is the construction of a seepage cutoff through fractured-rock foundation design by Barr.

TSF engineer of record (EOR) services

Six TSFs at Canadian potash mines rely on Barr for EOR services and ongoing engineering and technical assistance. Since 2010, we have assisted these facilities with concept planning, geotechnical analysis, water management planning, expansion designs, and groundwater controls. We have developed monitoring programs and been active in operational assistance and managing the risk of these facilities— efforts that have improved capital planning, improved operations, and reduced risk.

Mine-water management services

Today's modern mines understand that responsible management of water is paramount to having sustainable operations and maintaining a social license to operate. We help our clients manage water safely and responsibly through all phases of the mine life cycle. By integrating engineering and environmental expertise, we offer clients one source for addressing their needs.

Our mine-water management services include:

- Baseline environmental studies
- Permitting assistance
- Water balance studies
- Water management planning
- Climate variability simulations
- Mine rock geotechnical and mineralogical characterization
- Metal leaching and acid rock drainage evaluations
- Water quality modeling for permitting and design
- Hydraulic modeling of natural streams and engineered flows
- Tailings and water dam breach analyses
- Emergency action plan (EAP) development
- Tailings and sediment transport and deposition modeling
- Hydrogeologic characterization, including aquifer and water quality testing
- Groundwater flow modeling
- Contaminant transport modeling
- Pumping and piping systems
- Hydraulic structures
- Stormwater management and infrastructure design
- Water supply systems and well fields
- Dewatering systems
- Seepage cutoffs and liner systems
- Source control measures
- Aquatic invasive species control systems
- Active and passive water treatment systems

Waste-characterization plan

Barr designed and implemented a waste-characterization plan (including humidity-cell testing) and performed geochemical modeling for water-quality predictions for a proposed new mine.

Field characterization for model development

Barr geologists and hydrogeologists characterize porous media and fractured bedrock systems using a variety of drilling, testing, and monitoring methods. We use the results of field characterization programs to develop groundwater flow and contaminant transport models.

Environmental services

From conducting baseline studies to minimizing the environmental impacts associated with an operation, Barr provides a variety of environmental services to the mining industry for new or expansion projects, existing operations, and closed sites.

We regularly perform permitting and mine development concurrently with our multidisciplinary teams. Our engineering and environmental teams collaborate to help your facility meet permit and operational objectives.

We assist with:

- Federal, state/provincial, and local permitting
- Environmental review under National Environmental Policy Act (NEPA) and state/local programs
- Baseline monitoring and studies
- Tribal engagement
- Regulatory analysis and negotiations
- Regulatory compliance, environmental management systems, and ISO 14001 compliance
- Modeling and monitoring environmental impacts
- ESG and sustainability monitoring, reporting, and plan development
- Annual stack testing, including test-plan preparation, regulatory negotiation, sample collection, process-data
- monitoring and collection, lab-analysis coordination, data analysis and interpretation

We assess environmental resource areas including:

- Air and dust
- Odor and noise
- Surface water and hydrology
- Groundwater and hydrogeology
- Terrestrial ecosystems
- Aquatic ecology and aquatic invasive species
- Wetland delineation and compensatory mitigation planning
- Greenhouse gases and climate change
- Cultural resources
- Archaeological surveys
- Geochemical analyses

Analyses for mine expansion

Barr helped support a Utah mining client conduct baseline surveys in support of NEPA permitting for an expansion.

Driving sustainable value

Barr helps clients develop and implement environmentally responsible practices at all points in the extraction and processing life cycle by providing energy planning and alternative energy, life-cycle analysis, water-use minimization, and standards alignment and reporting (e.g., TSM, GISTM, GRI, SASB).

Barr offers verification services, performs gap analysis for those considering implementation, and helps develop programs in compliance with the Mining Association of Canada's "Toward Sustainable Mining" program requirements.

Closure and reclamation services

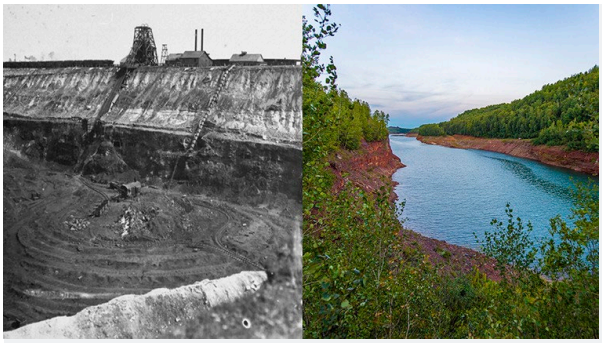
Barr provides reclamation and closure services for open pits, mine rock stockpiles, tailings storage facilities (TSFs), milling facilities, and other disturbed areas on operating and legacy mine sites to help clients manage residual risk and achieve desired end land uses.

We assist private and public clients across the full life cycle of the mine, from planning during greenfield development to post-closure monitoring of reclamation performance. Sustainable mine closure requires meeting the principles of physical, chemical, ecological, and social stability. When these principles conflict with each other, we help our clients identify and mitigate the challenges those conflicts pose.

Our multidisciplinary services follow a site-specific approach where goals, objectives, and criteria are developed strategically and purposefully based on the site conditions and the client's interests.

Our closure and reclamation services include:

- Reclamation and closure plans
- Closure studies and reclamation research
  - Baseline and current condition studies
  - Human health and ecological risk assessments
  - Closure options and reclamation alternatives analyses, including repurposing potential
  - Physical (geotechnical) stability analyses for stockpiles, tailings dams, and pit walls
  - Geochemistry for waste characterization and stabilization of acid rock drainage, metals leaching (ARD/ML) issues
  - Water balance and load determinations, including the effects of climate change
  - Aquifer impact / restoration studies and modeling
  - Biodiversity and ecosystem integration
- Design
  - Remediation to address physical instabilities or contaminant impact on the environment
  - Mine impacted water treatment systems – passive and active
  - Landforms – upland, lowland, wetland, and lake
  - Demolition of foundations and structures
- Closure and post closure monitoring
- Community engagement support, including plain language communications
- Reclamation Cost Estimating (RCE) for Bonding and Asset Retirement Obligation (ARO)



Mineland repurposing

Barr worked with Iron Range Resources and Rehabilitation and the city of Chisholm, Minnesota, on environmental planning, permitting, and conceptual design for the Redhead Mountain Bike Park, which includes over 35 miles of mountain bike trails traversing historic minelands.

Reclamation investigations

In Canada's Northwest Territories, a Barr environmental scientist kayaks through a wetland downstream of a former lead and zinc mine. As part of mine reclamation efforts, we are investigating hydraulic and chemical characteristics of the tailings facility to design a long-term closure option that is safe and protects the environment.

BARR®