Klohn Crippen Berger

Mine waste, geosciences and engineering design
Total mine water management solutions
Socio-environmental and consultation
Environmental guidance for design and permitting
Resource Infrastructure

GLOBAL LEADER IN THE MINING INDUSTRY

MINE SERVICES
ABOUT US

Klohn Crippen Berger Ltd. (KCB) is an international engineering, geoscience and environmental consulting firm with its head office in Vancouver and eight offices in strategic locations in Canada, Peru and Australia. We are registered and have an ongoing presence in the United States, United Kingdom, Papua New Guinea, Indonesia, Mauritania, Mongolia and Brazil. We have a strong reputation for quality service and technical expertise in a range of services including: Mining, Environmental, Water, Power, Transportation, and Oil and Gas. Since forming in 1951, we have a long history of participation in local projects, as well as a strong international reputation. We are working on some of the largest, most challenging engineering projects, both nationally and internationally.

Team Leaders

Bob Chambers, Vice President, is a geotechnical engineer with over 30 years of experience in site assessment, design and environmental aspects of tailings, mine rock and water management for mining and water resource projects.

Harvey McLeod has more than 40 years of experience in all aspects of mine waste management including major studies for more than 100 mining projects internationally.

Howard Plewes, Staff Consultant, is a civil engineer with more than 30 years of experience in dam engineering and mine waste management on some of the largest tailings facilities in the world.

Neil Singh, Regional Manager, BC Mining Environmental Group, is a geological engineer with over 20 years of experience with dam design, natural hazards, and geotechnical engineering.

Dan Etheredge, Regional Manager, South America, has more than 20 years of experience in environmental consulting and construction management.

Lawrence Clelland, Regional Manager Ontario has more than 25 years of experience in the study, design and construction supervision of major civil engineering projects.

Scott Crozier has more than 15 years of experience in infrastructure for heavy civil projects including hydroelectric, tunnels and mining.

Arvind Dalpatram has more than 30 years of civil engineering experience relating to water resources and infrastructure developments in Canada and overseas.

Rick Friedel is a geotechnical engineer with 10 years experience in the design and layout of tailings impoundments, waste dumps, construction monitoring, site investigation and slope stability analyses.

Greg Noack has more than 20 years of experience with all aspects of mine water management.

Graham Parkinson has more than 25 years' experience in a wide variety of projects in the mine development and engineering and environmental sectors.

Mary-Jane Piggott is a water resources engineer with over 18 years of experience in investigation, design and project management of civil and water resources.

Lindsay Robertson is an environmental soil chemist with 10 years of experience in geochemical assessments for mine waste management.

José Sánchez is a civil geotechnical engineer with over 10 years of experience in the design of tailings dams, alternative waste storage facilities and environmental studies.

Orlando Bravo is a civil engineer with over 7 years of experience in geotechnical engineering, road surface design, soil mechanics, and quarry and environmental studies.
The Mining Environmental Group provides comprehensive services for environmental and engineering management of mine development projects with a focus on mine waste management and environmental stewardship. We have worked on hundreds of mining projects worldwide, including some of the largest mining projects developed. Our designers cover all aspects of tailings transfer and waste rock from mill to impoundment, characterization and management of solids and water storage, and water reclaim or delivery of water to treatment for discharge. We are qualified in tailings dam design and have designed hundreds of dams, some up to 300 m high. Our integration with environmental and social design drives our continued development as a leading-edge provider of these services to major clients worldwide.

Our clients include:

Aurelian Ecuador SA (Kinross Gold)  
Barrick Gold  
BC Hydro  
BHP Billiton  
Boliden Ltd.  
Brigus Gold  
Chieftain Metals  
Compania Minera Antamina SA  
Compania Minera Minaspampa Sac  
Compania Minera Miski Mayo Sac  
Evolution Mining  
Gibraltar Mines  
Goldcorp Canada  
Guyana Goldfields  
Hidden Valley Mine JV (Harmony Gold & Newcrest Gold)  
Highland Valley Copper  
Howe Sound Pulp & Paper Corporation  
Iluka Resources  
Invicta Mining  
Ivanhoe Mines  
Kirkland Lake Gold  
Liberty Mines  
Mantaro Peru  
Marengo Mining  
Millennium Minerals  
Minera Barrick Misquichilca SA  
Minera Pampa De Cobre SA  
Minera Panama (Inmet Mining)  
Minto Explorations (Capstone Mining)  
Newcrest Mining  
Newmont Canada  
Northgate Minerals  
Ok Tedi Mining  
Origin Energy Resources  
Oyu Toigoi LLC  
Pacific Booker Minerals  
Pilbara Iron Company (Rio Tinto)  
Pluspetrol  
Queensland Water Commission  
Rainy River Resources  
Resolution Copper Mining (Rio Tinto)  
Sagittarius Mines (Tampakan Project)  
Sandspring Resources  
Seabridge Gold  
Selwyn Chihong Mining  
Shougang Hierro Peru Saa  
Silvercorp Metals  
Sona Resources  
Teck Coal  
Teck Metals  
Treasury Metals  
Vale Canada  
Wafi-Golpu Mine JV (Harmony Gold & Newcrest Gold)  
Woodlark Mining Ltd.  
Xstrata Copper  
Xstrata Mount Isa Mines  
Xstrata Zinc  
Yukon Zinc
Tailings Technologies
Designs to improve water management and reduce project footprints using dewatered, paste and thickened tailings. Alternative technologies using co-disposal with waste rock, cells to limit evaporation losses, cycloning and thickening of select tailing streams and combinations of conventional tailings storage and new technologies.

Dam Design
Geotechnical design of major dams, considering seismicity, seepage control, stability, natural hazards, and water management.

Environmental Design
Integration of limiting environmental factors, such as water quality, seepage, water treatment / discharge, and social concerns.

Waste Management

Pit Slope Design
Geotechnical design of open pit mine slopes and design of open pit dewatering systems. Development of structural geology logging data collection, rock mass assessment and structural domain assessment to optimize pit slope design. Groundwater investigations and pit dewatering and depressurization design for slope stability and groundwater control.

Construction
Focused on building a project that works for the client, QA / QC services, construction supervision / monitoring and cost control.

Waste Rock and Water Management
Geotechnical and environmental design of waste rock dumps. Water balance, water management and hydraulic structures associated with dams, waste dumps and open pits.

Risk and Benefit Assessment
Risk assessment and risk management plans for mine waste and water facilities. Benefit assessment to balance and mitigate potential risks.

Closure
Design for long-term sustainable closure of dams, tailing impoundments and waste dumps.

International Reputation
We have been trusted with some of the largest, most challenging tailings dams, and some of our clients have been with us for over 35 years.
Large Copper Projects
Design of tailings storage facilities for some of the largest copper mines in the world. Recent and active international projects include: Resolution Copper (USA), La Granja Copper (Peru), Oyu Tolgoi (Mongolia), Tampakan (Philippines), and Ok Tedi (Papua New Guinea). Canadian projects include: Kerr-Sulphurets, Morrison, Gibraltar, and Highland Valley Copper. Designs for production rates ranging from 30,000 tpd to 240,000 tpd, include different combinations of cycloned sand dams, waste rock dams, high density thickening, tailings desulphidization and co-disposal of ARD waste rock with tailings. Dam heights range from 80 m to 300 m in height.

Oil Sands
KCB is the designer of record for many of the large oil sand tailings facilities located in northern Alberta. The projects range up to 240,000 tpd and integrate evolving technologies for management of mature fine tailings. Recent and active projects include: Syncrude, Suncor, Fort Hills and Albion.

Massive Sulphide and Nickel Mines
Design and management of numerous facilities in Canada and worldwide, including many of the Vale Inco nickel mines in the Sudbury basin. Massive sulphide mines in western Canada include: Yukon Zinc, Tulsequah Chief, Sellwyn. Peruvian mines have included: Andaychagua, Huaron, Cobriza and others.

Uranium and Rare Earth Metals
Projects include design of the tailings facility for a confidential mine in Australia and a Tantalum-Niobium mine in British Columbia.

Tailings Technologies
KCB has integrated evolving tailings technologies into the dewatered tailings at Greens Creek (Alaska), paste tailings at Myra Falls (British Columbia), tailings desulphidization at Ok Tedi (Papua New Guinea), and cycloning and thickening of cyclone overflow at Albion (Alberta).
WATER MANAGEMENT
MANAGING WATER SAFELY, FROM EXPLORATION TO POST-CLOSURE

Services

Geochemistry and Predictive Water Quality Modelling

Water Balance and Water Management
Optimizing water recovery in arid climates and improving storage, treatment and release of water in wet climates.

Mine Dewatering
Design of mine dewatering systems that manage both quantity and quality of mine water. Design of depressurization systems for pit wall stability.

Water Supply and Water Rights
Groundwater and surface water supply and storage assessment of mine water supply.

Hydraulic Structures
Design and construction of diversion structures, diversion channels, spillways, sediment ponds and decant systems. Assessment of hypothetical “dam break” and “tailings run-out” effects to support emergency preparedness planning (EPP).

Environmental Design
Water quality modelling to integrate facility engineering design with limiting environmental factors in the receiving waters, such as aquatic life or downstream water use.

Groundwater
Groundwater plume modelling, including dispersion modelling and absorption / attenuation models. Groundwater monitoring programs and the design and construction of groundwater remediation systems.

Wetlands
Design and construction of wetlands to mitigate water quality and / or to enhance aquatic habitat.
Experience

**Antamina Mine, Peru**
Design and construction of an engineered wetland at 4000 m elevation and sediment and water treatment ponds for runoff from the mine waste rock dumps.

**Lihir Gold Mine, Papua New Guinea**
Development of a mine water, sediment and acid rock drainage plan for a mine located on an island formed around five volcanoes.

**Vale Inco Mine, Ontario, Canada**
Conceptual design, detailed design and construction monitoring of a site-wide Water Management System to reduce hydraulic overload at the central Waste Water Treatment Plant. The system services 60 km² of Canadian Shield watershed and features 21 ponds, reservoirs and lakes connected by fibre optic monitoring, and remote control discharge systems.

**Quintette, BC, Canada**
Mine surface and groundwater management, water quality mitigation strategies, site water balance, hydrogeology studies, waste dump design, and tailings facility design. Quintette is a formerly-producing coal mine undergoing a feasibility study to return it to production.

**KSM Project, BC, Canada**
Feasibility design for water management facilities for this proposed gold mine located in steep mountainous terrain. Works included diversion tunnels, channels, dam and a water storage reservoir for treatment of mine runoff. The designs considered the topography and high rainfall, snowfall and natural hazards.

**Water Balance and Flood Design**
Water management for all of the active tailings projects being carried out by KCB, including design of spillways, decant systems, erosion protection works and diversions.

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**Dam Break Assessments**
As part of the new Canadian Dam Safety Guidelines, dam break analyses are carried out for all tailings and water supply dams to classify key characteristics, to formulate design criteria, and to assess downstream flood impacts. KCB has carried this out for the 150 m high Highland Valley Copper tailings dam in British Columbia and other projects.

**Jabal Sayid Copper Project, Saudi Arabia**
Geochemical characterization of tailing and waste rock for ARD / ML prediction. The work will be used to support a waste and water management plans for this proposed large open pit underground copper mine and proposed open pit expansion.

**Ok Tedi Mine, Papua New Guinea**
Design of pit dewatering system for a 300 m deep pit extension in a high-rainfall (10 m/yr) environment.
Regulatory Management and Advisory Services
Developing strategies that advance the review and regulatory approval processes. KCB has experience with federal, provincial and territorial processes in Canada and International Finance Corporation standards, World Bank guidelines, Equatorial Principles, and numerous country specific processes worldwide.

Stakeholder and Aboriginal / Indigenous Peoples Consultation
Facilitating understanding, involvement, and information exchange during all project stages through use of a variety of tools and techniques.

Communications and Consultation Plans and Materials
Developing and implementing project-specific plans and supporting communications materials, including culturally appropriate materials.

Socioeconomic Baseline and Impact Assessments
Characterizing pre-project social and economic conditions in the potential area of influence of a project; assessing the potential short, medium and long-term effects on people, communities and economies; and developing mitigation, enhancement and monitoring strategies in concert with stakeholders and First Nations.

Capacity Building
Training, skills development and capacity building for local communities and First Nations / Aboriginal groups.

Traditional Use and Traditional Ecological Knowledge
Incorporating traditional use and traditional ecological knowledge into socioeconomic and environmental baseline and impact assessment studies.

Corporate Social Responsibility and Sustainability
Working with clients to integrate social, economic, and environmental considerations into corporate decision making.

Health and Safety
Development of Health & Safety programs and integration of safety into project design.

Joint Ventures
IEG Consultants Ltd. and IEG Nunasi Consultants Ltd. are joint ventures between KCB and the Inuvialuit Development Corporation and Nunasi Corporation, respectively. Dedicated to the communities and people of northern Canada, the joint ventures deliver quality environmental and engineering services to industry, government and aboriginal organizations.
Experience

Minto Mine Phase IV-VI Expansion, Yukon, Canada
Socio-economic assessment and traditional knowledge study as part of the Minto Mine’s Yukon Environmental and Socio-economic Assessment Board application to extend the life of the mine. As the mine is located on Selkirk First Nation Category A Settlement Lands, KCB worked closely with the community and Minto to conduct several project activities and products.

Hidden Valley Mine Advisory Committee, Papua New Guinea
KCB was appointed as AC members for a period of four years in 2009. The AC provided high level review, recommendations and general advice addressing mine site waste and environmental management strategies, general riverine impacts and social issues covering a range of community and government stakeholders.

Ok Tedi Mine Community Relations, Papua New Guinea
The Ok Tedi Mine community relations team is responsible for gaining and maintaining the company’s license to operate covering a demographic of over 100,000 people. The team has a current staffing level of 40 with varying levels of qualifications and experience. KCB has been commissioned to undertake a CR capacity review, develop a strategic CR management plan and, facilitate training programs aimed at updating the present skills base.

Tampakan Copper Mine, Philippines
KCB completed a Social Impact Assessment and Community Consultation Program for a mine access road. Using IFC performance standards we worked closely with local consultants and experts from the local university to complete the project.

Fenix Nickel Mine, Guatemala
Working with a team of local consultants, KCB developed a baseline and complete socio-environmental impact assessment for the reopening of a mining and milling operation.

Mica Units 5 and 6, BC, Canada
Socio-environmental assessment for this project located in the overlapping traditional territory of 25 First Nations. We also advised and supported the client in consultation and regulatory activities, undertook an alternatives assessment and worked with First Nations to involve them in project studies.

Antamina Mine, Peru
KCB managed a team of consultants that undertook a social baseline study and consultation for a mine closure plan in accordance with Peruvian law. KCB developed a plan to monitor the effectiveness of social programs.
Services

**Environmental Baseline Studies**
Characterizing pre-project environmental conditions in the potential project area of influence, such as climate, aquatic and terrestrial biology, water quality, hydrology, hydrogeology, noise, visual terrain, soils. Working with First Nations to incorporate traditional ecological knowledge into the baseline.

**Environmental Impact Assessment**
Assessing potential short, medium and long term environmental effects of a project including developing mitigation, enhancement, compensation, and monitoring plans.

**Aquatic Biology**
Fisheries and fish habitat assessment including inventory, impact assessment, mitigation and compensation planning.

**Terrestrial Biology**
Wildlife inventory surveys, terrestrial ecosystem mapping, identification and management of species at risk, vegetation assessments, monitoring, and management plans.

**Water**
Hydrology, hydrogeology, and geochemistry baseline and impact assessment.

**Permitting**
Guidance and support for permitting throughout the EIA stage, construction, operations and closure.

**Monitoring and Evaluation**
Developing monitoring and evaluation programs and undertaking monitoring during construction, operations and closure.

**Environmental Management Plans**
Preparing EMPs for construction and operations.

**Environmental Audits and Risk Assessment**
Assessments of existing operations or acquisition targets. Conducting risk assessment workshops and preparing risk management plans.

**Closure and Sustainability**
Incorporating environmental and social factors into the final land and water use planning for the mine. Design for closure to optimize opportunities and minimize long-term risks.
Experience

Morrison Copper / Gold, BC, Canada
Environmental and geochemical assessment of potential effects on aquatic life in Morrison Lake and its tributaries and completed the conceptual fish habitat compensation plan.

Oil Sands “end of pit” Lakes Research Study, Alberta, Canada
KCB is part of a team carrying out a full scale pilot program to test the potential for reclamation of oil sand open pit mines with a sustainable lake. The work will include a worldwide research program and construction of a full scale prototype “End Pit Lake” in a completed open pit area.

Molejon Gold, Panama / Tassawini Gold, Guyana
Socio-economic and environmental impact studies for these projects. Studies included preparing field protocols for baseline data collection by national consultants; due diligence field assessments; and preparation of the Social Environmental Assessment to International Finance Corporation standards.

Antamina Mine, Peru
KCB received an award of merit from the Consulting Engineers of BC and the Canadian Consulting Engineering Award for our innovative work on this mine located high in the Andes. These highest-altitude wetlands were constructed to treat seepage water from the mine waste rock dumps. We also carried out the detailed closure plan.

Silvertip Mine, BC, Canada
KCB is responsible for leading the environmental assessment and permitting project for this silver, lead, zinc property in northern British Columbia.

Victor-Capre Project, Ontario, Canada
The Victor-Capre Project pre-feasibility study investigated the potential to expand an existing Brownfield advanced exploration site to accommodate an additional shaft and ramp development. KCB provided support in identification of permit requirements, permitting workplans and schedule, EA identification, and waste and water management.

New Afton Mine, BC, Canada
KCB has completed updating the 5 year Closure Plan and cost estimate for the New Afton Mine. The Closure Plan and cost estimate included decommissioning of brownfield infrastructure and progressive reclamation of previously disturbed land to meet Closure Plan end land use objectives.
GEOSCIENCES

Services

Hydrogeology
KCB has a large and diverse hydrogeology team with a broad range of international mining experience. We offer full range hydrogeological services from field program management and organization, data management and assessment, to a variety of technical assessments. We have in house specialist modellers experienced in 2D and 3D saturated and unsaturated modelling using a variety of platforms, as well as GIS, geological modelling and spatial data management services.

Services include:
- Hydrogeological field services
- Monitoring networks
- Hydrogeological conceptualization
- Water balance
- Regulatory compliance
- Groundwater modelling

Groundwater supply
- Mine dewatering
- Managed aquifer recharge
- Mine closure
- Geochemistry
- Hydrogeological modelling

Slope Stability
- Development of geological, structural and rock mass models for the project area and pit sectors
- Computer modelling of pit, rock slope and soil or dam and waste dump stability
- Stability analysis and determination of bench face inter-ramp, and overall pit slope configurations for each design sector (including kinematic and overall stability analyses)

Seismic Hazard Assessment
- Seismicity, seismo-tectonic setting, regional geology and geological structure assessment
- Probabilistic and deterministic seismic hazard assessment
- Seismic response

Geohazards
- Geological conditions that involve long / short term geological processes such as landslide, rockfall, over-pressured zones, shallow gas accumulation, volcanoes, earthquakes
- Corridor assessment
- Landslide, rockslide and debris flow assessments
- Risk and decision analysis
Experience

KSM Project, BC, Canada
Site investigations and design of water management structures at this proposed major copper-gold mine in Northwestern BC. Geoscience services ranging from regional structural and geotechnical mapping for tunnel route selection, assessment of tailings, waste dump and water dam foundations.

Rovina Project, Romania
Open pit design for this proposed gold mine based on geotechnical drilling, mapping and in-situ and laboratory testing. Limit equilibrium modelling was used to assess slope stability.

Granisle Project, BC, Canada
Pre-feasibility geotechnical assessment for two copper-gold porphyry open pits located in Northern BC. Mine planning tasks were integrated with the pit design work. Site work included pit wall mapping using conventional methods and photogrammetry.

Seymour Falls Dam, BC, Canada
KCB managed the baseline and impact assessment and was retained for the screening level studies, preliminary design, final design and construction supervision for the seismic upgrade. As part of design, KCB carried out review of the seismic hazard assessment and generated time histories matching the target spectra for seismic analyses.

Nullagine Gold Project, Australia
The Millennium Minerals Nullagine Gold Project is located in the Pilbara region of north-western Australia. KCB was commissioned to undertake a range of hydrogeological investigations at the site from feasibility to providing on-going services during mine production.

Mount Isa Mines, Australia
KCB has been providing hydrogeological consulting support to XMIM since 2010, and has developed a thorough understanding of the hydrogeological setting of the mine site and relevant infrastructure.

Origin Project, Australia
Hydrogeological field supervision services for the installation of a network of regional groundwater monitoring bores throughout Origin’s existing gas producing operations and pilot facilities.
RESOURCES INFRASTRUCTURE

Services

We integrate engineering, science and socio-environmental consultation to study, design, build and close projects in the mining and energy sectors. Our engineering is supported by environmental, permitting, social and consultation teams.

Hydroelectric Power Generation
- Large hydro-electrical projects to run-of-river small and large hydro
- Kaplan, Bulb, Francis & Pelton turbines & generators
- Gates, stoplogs, trash racks and turbine valves
- Hydraulic control systems

Process, Pipelines and Mechanical
- Slurry pipelines and pumps
- Water supply and reclaim systems
- Drainage and irrigation

Electrical, Power and Instrumentation
- Generators
- Transmission lines
- Power distribution and load studies
- Transformers and switchyards
- Instrumentation and control systems
- Excitation and SCADA systems

Bridges, Tunnels and Structures
- Pre-fabricated truss stream crossings to internationally recognized cable stay bridges
- Swing and floating spans
- Hard rock and cut / cover tunnels
- Retaining walls and rock fall protections

Ports and Transportation
- Container terminals
- Drydocks
- Wharves
- Mining access roads to highway interchanges

Cranes, Lifting Equipment and Conveyors
- Bridge, container, hammerhead, and level luffing cranes
- Ship unloaders
- Marine loading ramps
- Drydock equipment
Experience

Highland Valley Copper Mine, BC, Canada
The life of this large copper / molybdenum mine has been extended to 2035, requiring raising of the tailings dam. KCB is performing the civil / structural / architectural and mechanical / piping engineering for the new cyclone building that will extract sand from tailings slurry to provide material required for dam construction.

The multiplate overpass allows loaded Cat 797B mining trucks access from the main pit to the new rock dump facility northeast of the Mill. The multiplate arch has a 15 m span, a 6.6 m maximum clearance and is 58 m long.

In Pit Pumping System, Canada
KCB designed a land-based intake to transport thin mature fine tailings. The land-based intake was configured as an economical alternative to a barge system where difficult soil conditions made launching a barge impractical.

Shell Thickened Tailing Drying, Alberta, Canada
Electrical, instrumentation and communication systems, tie-ins and upgrades for this project. The facility includes a muskeg reclamation stockpile, tailings delivery and discharge pipelines, modular e-houses and pump-houses and systems return lines.

Antamina Mine Water Pump-back System, Peru
Due to potential changes in the mine development plan, KCB was retained to design a new pump back system to accommodate the low-grade ore stockpile. The surface water management system is composed of a system of lined ponds, ditches, pump back stations, and sodium hydroxide dosing to control the quality of surface water released to the environment.

Suncor PAW Pond Pump Station, Alberta, Canada
KCB designed a large wastewater pump station for the Process Affected Water (PAW) Pond which collects seepage and surface run-off water from the South Tailings Pond (STP) at Suncor’s oil sands mine north of Fort McMurray. The pump station was designed for staged construction to handle the increasing operating head and flow requirement associated with progressive dyke lifts that result in both a higher pump discharge elevation and a larger catchment area.

Vale Inco, Ontario, Canada
A pre-feasibility study was prepared to assess different options to improve the reliability of the reclaim pumping system that supplies water to the Upper Pond.

Votorantim Metais Goethite Pumping System, Peru
Votorantim Metais operates a zinc refinery in Peru. The former goethite pumping system consisted of slurry pumps with limited capacity that could not deliver the slurry to a new pond located at a higher elevation.
Down to Earth.
Up to the Challenge.

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