Typeface selection
As part of Cardno's brand standards, when using Microsoft products please use Arial as the standard typeface.

Color Usage
Please use the pre-programmed color palette in support of all Cardno brand standards. If there are concerns or questions about color usage please consult Section 5 of the Cardno brand standards manual.

Imagery
Use related and relevant imagery that addresses the client(s) you're presenting to. If photos are unavailable, please use the images provided.

Front and back cover instructions
Trim Sizes
For 8.5x11 covers, please use the inner-set of vertical crop marks. For 9x11 covers, please use the outer-set of vertical cropmarks.
Mining

Solutions customized to your challenges

The challenges mining operations face become more complex every year, despite global demand for coal, industrial minerals, aggregates and metal increasing every year. Public scrutiny and regulatory requirements increase, and to supply increase in demand, we must evaluate and mine sites with geological challenges, among other complexities. Ultimately, obtaining return on your investments and operating profitable mining ventures can themselves become challenges.

To cost-effectively address or manage the challenges you face, your operations need to be properly planned, effectively designed, and run with efficiency. Cardno can work with you to develop integrated, site- and project-specific solutions by applying leverage to our in-depth industry experience, seamlessly delivering multidisciplinary services, and providing advanced engineering technologies to:

- Predict the potential profitability or risk associated with new ventures and acquisitions
- Earn and maintain a social license to operate in harmony with communities around the world
- Quickly obtain required permits to keep projects on schedule and within budget
- Plan, design and develop efficient infrastructure including water supply, water treatment, transportation, and power
- Accurately estimate, manage, and maximize mineable resources and reserves
- Comply with regulations while minimizing operational costs
- Assess, mitigate and minimize environmental, health and safety risks and insurance loss
- Restore mined land to a natural state or economically usable purpose

When you work with Cardno, you gain access to a network of professionals who listen to you and identify your needs. Our staff analyses opportunities from multiple perspectives, prevents problems, and delivers sustainable, best-practice mining solutions to mining projects around the world.

Cardno has delivered tangible value to mining projects in nearly every country. We operate offices in over 85 countries and throughout the Americas to locally deliver our expertise with regional regulations, markets, geologies and environments.
Full project lifecycle support
Cardno addresses challenges from multiple angles to identify alternatives that bring tangible value to your projects. We understand that you need experienced problem solvers who apply expert regulatory advice, provide economically feasible solutions, and assist in managing sustainable operations and growth. We provide integrated services and customized solutions throughout your mining operation’s full project lifecycle, from exploration to closure.

Hands-on industry experience that matters
Cardno has been serving as our clients’ trusted advisor on projects since 1945. Our mining engineers, geologists, civil engineers, hydro-geologists, environmental scientists, geotechnical engineers, planners and regulatory experts are both highly accredited within their professions and directly experienced within the mining industry.

Cardno applies leverage to our hands-on mining industry experience and knowledge to deliver innovative, sustainable solutions to your projects. We have worked with clients who mine a variety of resources including:

> Coal
> Industrial minerals and aggregates
> Metal ores
Coal

Cardno provides comprehensive capabilities and decades of experience servicing international coal markets, and is a leading consulting firm in the United States working in the coal and coal-bed methane industries. We have worked with hundreds of private mining operations, and as coal production has become more and more centralized, we work with entities as they go public. Our growth within the coal industry is based on a commitment to applying and developing advanced engineering and scientific technologies, and hiring and retaining talented staff.

Our staff comprises a mix of coal mining professionals with extensive industry experience that have transitioned into consultants to serve as your trusted advisors. Our multi-faceted expertise allows us to develop cost-effective, sustainable coal mining solutions. Some of the challenges we can help you overcome include:

> **Examine potential profitably in complex markets** including economies and governments undergoing significant change

> **Quantify coal resources** and ultimately define the reserve that can be extracted profitably through our expert reserve evaluations and competent person resource reports

> **Assess profitability** of various qualities of coal resources, from high-grade metallurgical coal to lignite, by developing project cash flow models using multiple market assumptions as to how your coal can be sold

> **Determine coal-bed methane levels** to provide pre-mining degasification or proper mine ventilation design and improve mine safety

> **Accurately determine subsurface conditions** at mine horizons to safely advance mines around difficult geological or hydrogeological obstacles while mitigating potential impacts to the environment

> **Design and permit coal refuse disposal facilities** that are innovative, efficient, and incorporate the best available engineering technologies to address sensitive environmental issues

> **Safely mine difficult coal seams** including seams that are under deep cover or contain high levels of methane

Cardno has simplified and delivered some of the most challenging coal mining projects in the world. We have brought modern, state-of-the-art mining technologies, methods, equipment and practices to artisan operations and regions with historically less-stringent regulations that increase operational risks. Cardno has helped operations expand and even double coal production within short periods of time to meet market needs. We have travelled to countries around the world to perform geologic and engineering studies, ad hoc market studies, create financial models, and research local environmental laws, rules and regulations.
Industrial mineral and aggregates

Production of mined industrial minerals and aggregates is typically more regional than other mining operations due to the high transportation costs associated with those materials. Cardno delivers regional expertise to facilitate our clients’ success around the world. We have served as a trusted advisor for clients who mine a wide range of industrial minerals and aggregates including:

- Phosphate
- Potash
- Limestone
- Heavy mineral sands
- Diamonds
- Uranium
- Granite
- Mica

We listen to our clients to identify their needs, and then provide our industry-leading mine engineering and regulatory expertise. Our professionals work hand-in-hand with our clients’ personnel to complement their strengths and needs. Cardno can help you add additional resource capacity, or provide you with industry experts’ on-call, around-the-clock, or even working fulltime from your own facilities.

**Comprehensive water supply capabilities:** Industrial mineral and aggregate mining operations commonly entail mineral processing techniques that require significant water supplies to refine mined resources into saleable product. However, sometimes those water supplies are not readily or economically available where you need to operate.

From identifying water resources using geological and geophysical investigations to right-of-way acquisition to mechanical, electrical and structural construction services, Cardno provides you with the multidisciplinary expertise necessary to develop, permit, design and construct water supply systems that provide you with the water you need, where you need it. We can deliver innovative solutions to remove scarce groundwater from granite bedrock, reuse discharge water, develop multiple-source water supply systems, and ultimately make the most efficient use of your available resources.

**Regional regulatory experience:** Operating an industrial mineral or aggregate mining operation in today’s regulatory climate means that you face a multitude of regulations administered from various local, state and federal government agencies. Failure to comply with health, safety and environmental regulations and standards can result in human injury, penalties, negative public perception, and liability associated with impacts to communities or environments.

Cardno professionals are active members of regional regulatory and industry associations, committees and organizations, and have helped establish various practical regulations and requirements around the world. We maintain functional, long-term relationships with regulatory agencies and their staff, including the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, state environmental departments, and various local agencies. Our active involvement in regulatory compliance allows us to negotiate permitting requirements and subsequently streamline your projects or operations.
Metal ores

Due to their multitude of useful properties, metals have played an important role throughout human history. As we have grown, so has our demand for metal ores. This includes both precious metals, such as silver and gold, and base metals including iron, copper and lead. Subsequent to the ever-increasing demand for metals, the metal ore mining industry in the U.S. and around the world has grown from smaller operations into large, complex operations. These large mining operations can create significant impacts to both the environments and societies surrounding them, and therefore regulations and public interest in metal ore mining have also increased.

By providing multidisciplinary teams of industry-leading professionals, combined with use of state-of-the-art science and technologies, Cardno delivers accurate assessments and in-depth understanding of how your operations impact communities, landscapes, ecologies, economies, geology, infrastructure, and soil, air and water quality. We can work with you to develop ways to manage and mitigate these impacts while respecting your operational objectives and budget.

Earning and maintaining a social license to operate: At the onset of the 21st century, emerging economies in Asia, Africa and Latin America began to play the lead role in metal ore mining. The production of metal ores including iron ore, platinum, silver, aluminium, copper and nickel are now led by developing countries around the world, and to no surprise, mining and mineral processing operations are spending more and more every day on exploration and development programs within emerging markets.

Traditionally, the mining development approach has put permitting ahead of gaining community support, commonly referred to as the "social license." This can create conflict and dead-ends after significant investment because projects within emerging markets have area-specific social concerns that require a unique understanding of local needs and opportunities. To increase project success, Cardno establishes open communication between communities and mine operators. We apply best practices from our worldwide development experience to the local context, and proactively work with communities. Ultimately, we help you develop viable projects by earning and maintaining a social license.

Assessing and reducing impacts to the environment: Even though the mining industry has an exceptional record of protecting the environment while extracting the resources necessary to sustain economies, the public still views the industry as environmentally irresponsible and metal ore mines and processing facilities face stringent regulations that address environmental impacts.

Cardno is uniquely situated to offer environmental and engineering services to assist clients with these responsibilities in a cost-effective manner, optimizing the use of the mine operators’ internal professional resources on higher priority objectives. With a skilled staff of environmental scientists, biologists, hydrologists, wetlands specialists, foresters, engineers and geologists experienced from both regulatory and operational perspectives, Cardno has created a team that can accurately assess and mitigate environmental impacts, and provide post-mining management and reclamation needs to efficiently expedite bond release.
Integrated services seamlessly delivered
Cardno integrates the services you need to provide the right support for your projects. We offer comprehensive capabilities in the following disciplines:

> Construction services and owner’s engineer
> Engineering and design
> Expert witness and litigation support
> Geology
> Geographic information systems (GIS) and mapping
> Health and safety
> Hydrogeology
> Investment and insurance support
> Mineral transportation
> Operations management
> Permitting and compliance
> Reclamation and mine closure
> Social impact management
> Water management

Construction services and owner’s engineer
Keeping construction on track and executing your projects in a timely fashion is crucial to your budget and business plans. Cardno is committed to verifying that your projects are constructed in accordance with approved plans, specifications, applicable codes and the highest quality of workmanship, while ensuring those projects are brought in on time and within budget. Our staff is familiar with all applicable construction codes including:

> American Society for Testing and Materials (ASTM)
> American Concrete Institute (ACI)
> American Welding Society (AWS)
> American Institute of Steel Construction (AISC)
> American Association of State Highway and Transportation Officials (AASHTO)
> Modern building codes from Building Officials and Code Administrators International (BOCA)

Our construction testing and inspection services include earthwork, concrete, non-shrink grout, and structural masonry construction and verification. We help clients face a wide variety of challenges including utility coordination, materials testing and inspection, air quality, stormwater management, sediment control, and use of low-impact construction techniques.

Cardno also understands project success depends on maintaining complete, accurate records of contractor work, payment, field sampling and testing. Our records are available for client review and we provide periodic reports to comply with both client needs and contract requirements. Cardno construction administration professionals work proactively to resolve technical issues as they develop to minimize claims and meet schedules.

Hidden Valley Gold Mine Electrical and Instrumentation Design
Cardno provided design that included a diesel power station consisting of 19 x 1.5MW generators, a processing plant, crushing areas, grinding, flotation, refinery and miscellaneous loads. In addition to electrical engineering services, Cardno provided project scheduling, progress reports, client meetings, vendor data reviews, cost reporting and site commissioning.

Bid Package Development for Greenfield Coal Mine
On behalf of the International Coal Group, Cardno developed construction details and a contractor’s bid package to support the client’s request for bids for the civil site works associated with development of the Leer mining complex, a greenfield longwall metallurgical coal mine in West Virginia.
Engineering and design
Cardno mining engineers are seasoned industry professionals. We have extensive experience in mining operations that equates to understanding your needs, and we deliver the technical ability to meet those needs. A majority of our senior mining engineers have master's degrees or Ph.D.'s from major universities, and we employ professional engineers (P.E.'s) registered in major mining states around the country. Our teams deliver expertise in various disciplines including mine design, rock mechanics, mine ventilation, mineral economics and environmental reclamation.

Geotechnical engineering
Cardno’s in-depth understanding of geological and hydrogeological conditions allows us to provide specialized services to assess, reduce or eliminate hazards and impacts to the earth’s surface, man-made structures, perennial streams, aquifers, large impoundments, and public facilities. Some specific geotechnical services we provide include:

> Subsidence prediction, mitigation, remediation and reclamation
> Pillar and roof support design
> Ground control and rock mechanics

Mine ventilation design, evaluation and computer simulation
Effective mine ventilation begins with design of the system. Cardno applies an integrated approach, combining the characteristics of reserve geology with practical, experience-based solutions to mine ventilation problems. The result is an effective ventilation system design that cost-effectively supports the mining operation, meets safety and production goals, and complies with the appropriate laws and regulations.

We apply the same integrated approach when evaluating existing ventilation systems. Through examinations of the mine airways and ventilation controls, in conjunction with pressure and quantity surveys, we determine system characteristics and identify future needs or potential improvements to the mine ventilation plan. Our documentation and reporting of the findings assist with system improvements or planning new or expanded operations.

Cardno engineers employ state-of-the-art computer software, such as VNet PC™, to evaluate future ventilation system needs. We provided a clear picture of mine planning, capital expense, and operating provisions required, resulting in the most effective ventilation system for that mine. Our teams have provided mine ventilation system evaluation, planning, and computer simulation services for both domestic and foreign mining operations, and we can provide them independently or as part of an integrated overall mine plan or feasibility study.

Mine seal design
Cardno has worked with Minova USA, Inc. to design seals made of Minova Tekseal® cementious material to satisfy the requirements of the U.S. Mine Safety and Health Administration’s (MSHA’s) Emergency Temporary Standard (ETS) issued under Section 101(b) of the Federal Mine Safety and Health Act. The Act was a result of mine explosions in 2006 that resulted in more than thirteen...
fatalities. To date, Cardno has assisted Minova in obtaining eight different seal approvals. These are:

50 psi Approved Seal Designs:
> Main Line Seal in a Stable Entry - MSHA Approval No. 50-75.336.1.07.04.1
> Main Line Seal with Convergence - MSHA Approval No. 50-75.336.1.07.05.1
> Gob Seal in a Stable Entry - MSHA Approval No. 50-75.336.1.07.06.1
> Gob Seal with Convergence - MSHA Approval No. 50-75.336.1.07.07.1

120 psi Approved Seal Designs:
> Main Line Seal in a Stable Entry - MSHA Approval No. 120-75.336.1.07.15.1
> Main Line Seal with Convergence - MSHA Approval No. 120-75.336.1.07.16.1
> Gob Seal in a Stable Entry - MSHA Approval No. 120-75.336.1.07.13.1
> Gob Seal with Convergence - MSHA Approval No. 120-75.336.1.07.14.1

Currently, we are working with clients to install the Minova plug-type seal in difficult mining conditions, such as where the immediate roof of entries has caved, filling the entry and often leaving an irregular opening atop the cave. Cardno addresses these conditions by designing programs to stabilize the fill allowing the seal to be constructed atop the cave. The Minova plug-type seal is easily modified to irregularly shaped openings. Cardno’s engineers verify the application of the seals to specific locations in the mine, and act as the P.E. on behalf of the company, supervising the construction and installation of the seals, and completing the necessary verification documents.

Coal refuse handling, storage and disposal facilities
Cardno maintains current knowledge of the refuse disposal permitting process and interfaces routinely with the federal and state agencies and individuals responsible for the review and issuance of permits. Our geotechnical engineering experience combined with our knowledge of the permitting process delivers significant value during the design of coal refuse handling, storage and disposal facilities. Ultimately, we deliver cost-effective, functional designs that can be permitted quickly and efficiently.

Electrical engineering
Cardno has proven capabilities across all aspects of:
> **Power generation**: Whether increasing power capacity, maximizing efficiency or designing a power station, we deliver innovative solutions to your project.
> **Power systems**: We provide total engineering services for your network and routinely set industry standards with our system designs.
> **Control systems**: We quickly evaluate your process and its variables, and then apply our knowledge to optimize response to changing conditions.

Our capabilities span all aspects of electrical, instrument, control, communications and power generation with a dedicated team of engineers, technicians, programmers, draftspersons and site support staff.
Expert witness and litigation support
Cardno has a proven track record as expert witnesses in both state and federal courts. Our professional geologists and engineers routinely provide expert witness services for both private industry and state and federal government agencies. We have provided depositions, court exhibits, and testimony to assist with case presentations in the areas of:

- Hydrogeology
- Mineral property evaluations
- Mining
- Mineral condemnation

Cardno engineers have provided expert witness testimony in cases involving:

- Lost resource claims
- Fatalities and serious injuries
- Blasting damage
- Water loss damage
- Subsidence damage
- Mine fires and explosions
- Equipment loss
- Roof collapse
- Reserve estimation
- Longwall entrapment
- Business interruption
- Mine property damage
- Legal suits and labour costs
- Mineral condemnation

We can develop court exhibits including video productions, sophisticated 3D graphics and animation, and perform still frame photo editing. Using cutting-edge technology in software and hardware, we can produce broadcast-quality video and photo-realistic, computer-generated animation and still frames. Our professionals deal with complex scientific and engineering issues in a manner that facilitates understanding the factors involved and the basis for conclusions.

Geology
Cardno provides a full range of geological services and industry-leading, professional geologists including geotechnical engineers and hydro-geologists. Cardno has become one of the most respected geological and engineering consulting firms in the United States, with extensive experience providing geological services to mining projects around the world.

We combine the collective skills, knowledge and expertise of our staff with state-of-the-art technologies. Cardno uses network-based computer systems throughout geological investigations to assist with database management, resource and reserve mapping and tabulations, graphic displays, computer-aided drafting and design (CADD), strip ratio analyses, and scanning and analysis of preferred fracture orientations. Our software platform includes Vulcan™, Carlson Mining™, ArcCAD, and ArcView, providing clients with the latest in evaluation technology. We maintain proprietary data management software and can output information in a variety of formats, allowing for transfer and incorporation of the geological information into other systems such as GIS and mineral assets management.
Mineral resource and reserve estimation

Cardno resource evaluations are highly regarded in the industry for presenting complex geological data in a concise and understandable presentation format. We go beyond determining basic volumes or tonnage assessments of mineral deposits, and address the geological factors that control quality and mining conditions. By establishing scientific cause-and-effect relationships, our geologists reliably predict the potential productivity of a mining venture and classify reserves based on their economic viability.

Geophysical logging services

Cardno maintains fully digital, state-of-the-art equipment in various suites for specialized environmental, geotechnical, hydrogeological and coal-bed methane applications. Cardno has a fleet of all-terrain vehicles equipped with computer technology for presentation and processing, and some of the advanced tools and logs we can provide include:

- Acoustic televiewers
- Borehole deviation
- Borehole video cameras
- Calipers
- Electromagnetic (EM) flow meters
- Fluid conductivity
- Fluid temperature
- Gamma-gamma density (high resolution or compensated)
- Induction
- Natural gamma ray
- Neutron
- Full waveform sonic tools for cement bond logs (CBL)
- Fluid sampler
- Various resistivity logs

Our personnel help you determine the logging suites best suited to your specific application. We generate all suites in fully digital form, and send data to a central processing unit (CPU) located in a logging vehicle and to a disk for storage. This allows for re-plotting at a later date or transcribing to an ASCII, CSF, or AutoCAD® drawing file (.DWG) format. Some of the specific applications our geophysical logging capabilities can be used for include stratigraphic investigations and fluid movement investigations.

Field exploration

Cardno’s depth of experience in planning, permitting, and managing field exploration projects saves you time and money and gains the best results. Additional benefits our exploration services provide include:

- Accurately estimate the cost of an exploration program, including such factors as initial project planning, permitting, drilling fees, road construction, quality analysis, and core processing
- Select the best locations to maximize proven reserves and minimize drilling footage, access road construction and reclamation costs
- Incorporate available geologic data from existing reports or published information to aid in exploration planning
- Work with local, state, and federal agencies to obtain exploration permits
> Describe in detail the various lithologic units penetrated and their geotechnical characteristics

> Complete descriptions of core samples in the field, at Cardno’s core laboratory, or another site at your request

When core drilling is complete, we provide digital database files of the entire borehole, including sections logged in detail by the geologist. We can then insert the data as an interpretive geologic column on the geophysical log in AutoCAD™.

Geographic information systems (GIS) and mapping

Our professionals use cutting-edge technology to accurately measure field conditions and map those conditions for design and analysis. For example, by using handheld global positioning systems to electronically tag and map field resources within GIS, our staff can provide clients with web-based interactive tools that foster real-time decision-making.

**Advanced GIS capabilities**

Our highly-trained GIS consultants are experienced in data integration and evaluation, and provide innovative GIS solutions that drive informed decision-making. The benefits of our GIS services include:

> Assessing multiple layers of complex data to determine site and environmental constraints (e.g. evaluating biological, cultural, and archaeological resources against terrain data)

> Managing assets across large geographic regions in real-time

> Simplifying complex data into presentable formats for stakeholders

> Integrating GIS data into modelling software

> Bridging the gap between geologic evaluation and tax assessment, working with land owners to accurately and authoritatively evaluate assets for filing taxes

Our staff records detailed data in the field, and then uses tools such as our ArcGIS Server to present geospatial data in an interactive web-based format and easily present complex data sets and offer broad user access.

**Laser mapping and modelling**

Cardno uses state-of-the-art, laser-equipped total stations to provide detailed surveying of objects and topography. Laser scanning showcases visible items and features that have been digitally recorded by distance, vertical angle and azimuth. Some laser surveying/scanning applications we provide include:

> Stockpile inventory measurement with same-day results

> Topographic scanning of areas

> Conventional surveying

> GPS surveying (RTK-real time measurements)
Equipment alignment
Laser scanning with ability to view scanned objects in 3D
Preparation of “as-built” drawings

We also interpret acquired data points into digital images. With image quality directly proportional to the number of data points, we can use a very high number of data points to deliver accuracy as high as 1/1000 of an inch.

Health and safety
At Cardno, health and safety is paramount. An integral part of Cardno and how we work with clients is our Zero Harm policy. We seek to continually improve safety, take responsibility for safety in our daily activities, and extend our value for safety to all parties potentially impacted by our projects: our staff, your staff, consultant teams, equipment, the environment and communities.

To help you meet your health and safety objectives, we offer a wide range of services, including:

- Providing a comprehensive hazard analysis and mitigation plan for all client-identified activities
- Creating a safe work environment free from drugs and alcohol for all employee and contractor workforces through pre-employment and client required pre-mobilization screening and reasonable suspicion testing
- Communicating to all consultant and contractor personnel the right and responsibility to use “Stop Work” authority
- Ensuring any contracted work meets your safety performance goals for injury rates
- Conducting site inspections for compliance with safety regulations and implementing corrective actions in the field

Health and safety training
Cardno delivers innovative, results-driven environmental, health and safety training programs for a wide variety of organizations around the world. As your training resource, we teach you how to identify, assess, and mitigate hazards while you earn certification maintenance credits. We maintain an unparalleled list of state and federal training accreditations, and set ourselves apart from the competition by tracking complex and continually-changing regulations and translating them into effective programs.

Hazardous materials and waste
Cardno is committed to helping our clients comply with regulatory requirements associated with hazardous materials and waste. Our teams are always on call to perform emergency response or perform industrial hygiene exposure studies. We
manage projects from start to finish, minimizing potential health and environmental risks and protecting our clients every step of the way.

We offer a dynamic set of services because our teams include certified hazardous materials managers, engineers, and scientists with experience in personnel training and auditing industrial properties. Our goals are to meet your expectations while ensuring sound hazardous materials management, and ultimately, to protect you from risk.

**Exposure reconstruction and human health risk assessments**
Cardno can evaluate a wide range of metals of interest to the mining industry such as lead, mercury, arsenic, nickel, cadmium, cobalt, and beryllium. Our scientists’ hands-on experience equates to understanding the special considerations that must be made when evaluating metals, including:

- Adsorption, bioavailability, and bio accessibility
- Speciation of certain metals
- Particle size
- Toxicity vs. essentiality
- Background levels in the environment
- Source contribution
- Metal allergy/skin or lung sensitizations

We have published more than 100 papers that address metals exposure health effects, and have completed more than 300 risk assessments. Cardno can accurately model exposure to comprehensively evaluate the potential health effects of a single metal or combinations of metals when present in soil, groundwater, drinking water, workplace air, ambient air, and homes.

**Hydrogeology**
Cardno’s hydro-geologists accurately evaluate the complex interactions between underground or surface mining and the hydrogeological regime. We facilitate understanding of the hydro geologic framework to provide a basis for assessing probable hydro geologic consequences and anticipate mining conditions. Our teams investigate the stratigraphic, structural, and geotechnical controls influencing the subsurface hydro geologic system to determine the nature and degree of interaction between that system and mining. Specific applications of our hydro geologic investigations include:

- Pre-mining assessment of hydro geologic impact for permitting and hydro geologic reclamation planning purposes
- Assessment of probable mining conditions beneath stream valleys, and impact of mining upon streams
- Post-mining evaluation of stream crossing impacts
- Assessment of impact to domestic water supplies
- Evaluation of conditions to be encountered in shaft and slope construction

**Community Mercury Exposure Near a Gold Mine in Peru**
Cardno developed an activity pattern-based exposure model for elemental mercury. We coupled cumulative and acute exposure assessments across numerous microenvironments with modeled emission rates and indoor/outdoor air concentrations.

**Groundwater Characterization of an Underground Mined Area**
Cardno conducted a geological and hydrogeological study of the area to characterize the groundwater regime and circulation and determine the stability and monitor ability of the mine cavity for disposal of plant refuse slurry.

**Leer Mine Hydrogeological Investigation**
Cardno conducted detailed geologic mapping, delineation of aquifers and aquitards, exploratory drilling and aquifer testing to identify utilization of groundwater across 27 square miles.
> Remediation of drainage impacts from flooded underground workings and surface disturbed areas
> Water supply development
> Mine inflow and control
> Monitoring of mine, quarry or construction impact on hydrogeology
> Acid mine or metal-rich drainage prevention
> Stream and wetland mitigation and restoration

To deliver detailed, accurate hydrogeologic investigations, we apply leverage to our advanced geophysical logging capabilities including acoustic televiewers, borehole video cameras, and fluid conductivity and temperature probes. Our professionals can subsequently map a site’s hydrogeology, identifying structural influences and potential fracture traces that may increase hydrogeologic interactions with the mine.

Cardno maintains in-house drilling, aquifer testing and well installation equipment, and our drillers are certified in both water well and monitoring well construction. We use monitoring wells and piezometers to confirm ground water flow paths, horizontal and vertical gradients, and degree of intercommunication between horizons. We can also evaluate aquifers and construct flow nets and hydrogeologic models to provide you with an accurate depiction of the hydrogeologic regime, and the effects of mining upon that regime.

**Investment and insurance support**

Whether you are evaluating a potential mining operation or an existing operation for sale, acquisition, investment or associated risk, Cardno provides you with the industry experience needed to facilitate sound decisions and achieve success in competitive markets. Our teams integrate mining engineering, geological, environmental, financial, and economic expertise to provide a comprehensive understanding of your potential ventures, and their associated risks.

We provide technical studies and reports to major international producers, local mining operations, power generation companies, private equity firms and other investors, and insurance companies, adjusters, and brokerage providers. Some of the values we provide include:

**Feasibility studies**
> Delivering accurate depictions and understanding of subsurface conditions
> Planning mines to take advantage of favourable mining conditions
> Minimizing the impact of adverse mining conditions
> Designing multiple alternatives for mines and access sites
> Maximizing the productivity and minimizing the impact of operations
> Providing accurate estimates of resources and reserves

**Hydrogeological Analysis of a Limestone Mine**

Cardno characterized a complex hydrogeological regime to develop an understanding of the karst relationships and water sources for use in mine planning.

**Greenfield Coal Mine Prefeasibility**

Cardno demonstrated that the coal mineral of interest has the potential to be mined successfully using longwall mining techniques despite numerous gas and oil wells, and areas of irregularly configured property control.

**Valuation of Mining Assets**

Cardno made key assumptions related to the capital and operating costs when preparing the cash flow models in order to accurately estimate the indicative values of the proposed mines.
Estimating mining capital and operating costs
Developing cost-effective processing methods and plans
Assessing infrastructure needs and costs

**Valuations of reserves, property, plants, and equipment**
- Estimating the fair market value of the mineral ownership
- Determining the value of a mineral property
- Presenting fair market value for processing and related facilities
- Evaluating all types of surface and underground mining equipment

**Due diligence**
- Completing Phase 1 Environmental Site Assessments (ESAs)
- Auditing resources and reserves
- Delivering dynamic, ad hoc market studies
- Reducing or eliminating events that can negatively affect acquisitions
- Reviewing or independently estimating end-of-mine closure (reclamation) liabilities

**Risk mitigation and insurance loss control surveys**
- Assessing safety and loss-control programs
- Reaching fair and equitable settlements for business interruption losses
- Reviewing MSHA accident and safety compliance history and state environmental compliance history

Cardno takes a proactive approach to completing technical studies, deploying our teams to perform site visits and collaborate directly with your staff, or the management of the mine being studied. We have a long history of completing large surveys in short times, and present our reports, summaries and recommendations in easy-to-understand formats to empower our clients.

**Mineral transportation**

Well planned infrastructure is critical to meet the increasing world demand for minerals. The development of mines in remote locations and emerging markets can make the delivery of your product to your customers a significant challenge.

Cardno can help you deliver your product from mines and mineral processing facilities through our expert analysis, planning, design and development of transportation infrastructure. Cardno employs highly experienced professionals who have been responsible for the planning, design, construction management, and operations of major transportation infrastructure worldwide. We have helped with the handling of bulk commodities including alumina, bauxite, cement, coal, copper concentrate, fertilizers, gypsum, iron ore, limestone, and phosphate.
Cardno’s transportation and mining experience coupled with its expertise in economic analysis delivers accurate feasibility studies that determine the technical and economic viability of developing or upgrading mines or ports. We conduct site assessments, coordinate meeting with potential shippers and industries to determine future transportation needs in the region, and engage potential project stakeholders to get their support and reduce the risk and financial burden of transportation infrastructure development. Cardno has extensive experience working within emerging markets and will help you gain local, social license to operate your rail projects and obtain your objectives.

**Port services**
Cardno offers infrastructure planning, operational analyses, and management services to the port, marine transportation, cargo handling, and freight intermodal industries. We emphasize the analysis and planning of both the facilities required to meet projected cargo handling requirements and the equipment used to service those needs. We have completed facility and operational planning for numerous international and domestic ports and are dedicated to developing environmentally sensitive projects. Some of the particular experiences we have include:

- Strategic and master planning
- Feasibility studies
- Market analysis
- Operational analysis
- Material handling equipment selection and procurement
- Economic and financial forecasting
- Funding strategies and design
- Public-private partnership strategies
- Infrastructure and material handling system engineering and design
- Asset management
- Coastal, ocean, and estuarine numerical modelling
- Coastal protection facility design
- Environmental monitoring
- Dredging and land reclamation studies

The depth and breadth of our expertise results in unique planning and operational analysis specifically developed for the particular client’s needs and tailored to the physical limitations of each site.

**Operations management**
Cardno employs professionals that have more than 25 years of operations experience within the mining industry. We understand how mining operations work, analyse efficiency and utilization, and facilitate process improvements.

Our capabilities are best demonstrated by the diverse set of clients that have trusted us to provide our mining expertise. From reasonableness reviews of mining companies’ business plans to independent engineering services provided to banks, owners, lenders, and investors for a third-party perspective, our industry experience delivers value and gives our clients a competitive edge.

**Operation evaluations**
Our engineers and geologists listen to you to determine your objectives, and then gather detailed information regarding the parameters critical to the success of
your mining venture. We evaluate your operations from multiple perspectives to identify your strengths, and the weaknesses that need to be addressed.

As needed, Cardno singularly or collectively evaluates several areas of a mining operation, including:

- **Reserves**: audit existing reports and documentation or complete detailed evaluations to accurately determine reserve quantities
- **Quality parameters**: tabulate and categorize mineral or coal quality to determine the markets in which your coal or mineral product can be sold
- **Mining methods**: select the most technologically advanced methods and equipment based on site-specific attributes to cost-effectively extract reserves
- **Management and manpower**: analyse reporting systems, report content and context, chain of command, and personnel to determine production bottlenecks or cost inefficiencies
- **Mine plan assessment**: account for mining hazards, such as identifiable poor roof conditions or severe geologic anomalies, to succeed in today’s competitive environment
- **Operating costs**: analyse costs to determine the impact of productivity improvement or alternate operating scenarios
- **Supply contracts**: evaluate supply contracts to match with available coal reserves and production quality and achieve a balanced plan of low cost and contract compliance

Cardno also performs valuations for banks, financial groups, mining companies, and insurance companies. Our valuations are in accordance with the Uniform Standards of Professional Appraisal Practice, and where applicable, the Uniform Appraisal Standards for Federal Land Acquisition.

**Mine cost and cash flow analysis**

Cardno prepares economic analyses to determine the present value of the cash flow and rate of return on the investment. Based upon the physical parameters of the reserve, we prepare estimates of the productivity, production, manpower, capital requirements, and operating cost for proposed or on-going mining operations. Our professionals evaluate manpower costs, royalty, depreciation, depletion, and interest charges (cash flows are calculated on a pre- or post-tax basis).

We incorporate productivity parameters with manpower and supply costs into a unique spreadsheet model to generate comprehensive cost analyses. Cardno routinely performs analyses on indirect, direct and total costs, and earnings before income tax bases, including estimates of depletion and depreciation.

**Business solutions and risk management**

Cardno teams include credentialed Project Management Professionals (PMP) with expertise in construction project management, decision analysis, and risk management. Our combined experience and multidisciplinary capabilities drive
effective development, implementation, and refinement of program management and project controls. We identify the best possible strategies to manage our clients’ projects and capital, and implement those strategies as efficiently as possible. Some of the specific tools we can provide include:

> **Decision analysis**: Cardno uses a decision analysis framework to allow for the quantitative evaluation of the net present value cost of environmental compliance and potential liabilities. The framework can incorporate issues such as lease requirements, regulatory changes, product price changes, capital costs, operating costs, and closure costs into different scenarios. We can then compare the net present value of each scenario to determine which option provides the best value to shareholders. Cardno also uses a multi-criteria decision analysis (MCDA) framework to incorporate non-monetary criteria into scenario comparison.

> **Combined cost and schedule risk assessment (CSRA)**: Our CSRA process helps our clients address uncertainty in the budgeting and scheduling process. Using estimates and schedules from the client, Cardno facilitates workshops with project teams to identify and quantify risks, uncertainties and possible mitigations for cost and schedule elements. Following the workshops, we create an integrated cost and schedule simulation model that generates potential ranges for cost and schedule outcomes. In addition, we identify and quantify the major drivers of cost and schedule variation. Ultimately, the CSRA process allows clients to identify which project elements have the most potential to drive ranges to their high end so they can prioritize mitigations, monitor critical activities during execution, modify contract terms, and budget appropriately.

In addition to the innovative solutions mentioned above, Cardno offers a wide range of services to assist in improving overall program and portfolio performance – saving our clients time and money while improving communication and reducing variability.

**Permitting and compliance**

Changing environmental laws and regulations and increasing constraints are challenging the mining industry more and more every day, even though the mining industry has an exceptional record of diligently protecting the environment while extracting the resources necessary to sustain our country’s economy.

Cardno helps you obtain the permits you need, maintain compliance with the most stringent regulations, protect valuable natural resources, and complete timely, efficient projects. We can also help you with sustainability planning and Global Reporting Initiative (GRI) G3 reporting and compliance. Our regulatory experts have decades of experience and even participate in establishing various practical regulations and requirements around the world. Our diverse staff allows us to integrate necessary testing, planning and design with our permitting and compliance services, passing on savings to you.

**Environmental permitting, assessments, and impact statements**

Cardno helps clients comply with all aspects of the U.S. National Environmental Policy Act (NEPA), state environmental policy acts, and specialized local and state permit requirements. We routinely work with federal agencies such as the
U.S. Environmental Protection Agency (EPA), Army Corps of Engineers, Office of Surface Mining, and Fish and Wildlife Service to complete:

- Environmental Impact Statements (EISs)
- Environmental Assessments (EAs)
- Categorical Exclusions (CEs)
- Findings of No Significant Impact (FONSI)

Our focus is to always provide you with strategic, proactive advice and service to guide you through NEPA compliance so you can successfully implement your project. Highlights of our services include:

- Air quality
- Biological resources
- Endangered Species Act compliance
- Environmental justice

Cardno has decades of experience preparing environmental assessments and impact statements for a variety of highly controversial projects. Our professionals prepare strong, defensible documents to address your project’s specific requirements. We offer valuable insights that reduce the schedule to complete documents and provide innovative approaches that meet your project’s needs.

**Surface Mining Control and Reclamation Act**

The Federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) requires that land disturbed by mining be restored to its pre-mining condition or an “equal or better” economic or public use. The permitting application requires detailed descriptions of the pre-mining conditions, mining activities, reclamation, and post-reclamation land use, and posting of a bond to cover the cost of reclaiming the site.

Cardno facilitates the permitting process by performing unique and site-specific reclamation assessments, taking into account structures, permit variances, drainage, and sediment control systems. We understand the issues specific to each state, permit, and operator, and evaluate with respect to the mine plan, the local geography and geology, and the post-mining land use. Our teams also consider financial impacts such as abatement of violations, water supply replacement, surface damage repair, perpetual water treatment and costs associated with restoration of the land to approximate original contour, and the successful establishment of the appropriate vegetative cover.

**Water quality**

Cardno professionals understand the critical regulations that drive the U.S. Clean Water Act and Safe Drinking Water Act. We have obtained permits for projects of all sizes around the U.S., and our expertise includes:

- **Local and state**: Cardno provides local and regional regulatory experts from our nationwide offices. We understand local conditions and state and municipal regulations, and are active members of regional regulatory and industry associations, committees and organizations. We also understand the
importance of engaging local communities early to address their concerns and streamline the permitting and compliance process.

- **Section 404**: Cardno manages all aspects of Section 404 permitting, from wetlands assessments to mitigation. We perform rigorous analyses to help clients determine if their projects have significant nexus to waters of the U.S. and require Section 404 permitting. To facilitate that permitting, we maintain working relationships with the U.S. Army Corps of Engineers and EPA, the federal agencies responsible for administering and enforcing Section 404. We also coordinate efficiently with states and tribes, who can assume administration of Section 404 permitting in certain waters within their jurisdictions.

- **National Pollutant Discharge Elimination System (NPDES)**: Our professionals have significant experience and provide integrated services to help clients obtain, maintain and update critical NPDES permits for mines and mineral processing facilities. We identify and resolve point-source pollution and will help you address consent decrees using the most efficient, cost-effective methods. We can provide direct or indirect sampling and analytical support as needed, and recommend “No Exposure” exemptions where applicable.

- **Stormwater Pollution Prevention Plans (SWPPPs)**: Cardno has obtained, prepared and implemented SWPPPs at hundreds of construction sites and locations where industrial runoff occurs. We address policy, planning, and pre-through post-construction activities. Our teams’ technical depth and breadth means we can review your site’s features, identify potential sources of contamination, and recommend Best Management Practices (BMPs) to control or mitigate stormwater. When your customized SWPPP is approved and implemented, our state-certified SWPPP designers and practitioners will provide inspection services to ensure on-going compliance.

- **Underground slurry injection investigation and permitting**: When the most practical method to dispose of coal waste is pumping coal slurry into abandoned underground mines, Cardno delivers the hydrogeologic expertise to prevent contamination of water supplies, and the regulatory experience to help you obtain your permit.

**Spill Prevention Control and Countermeasure (SPCC) Plans**
Cardno has decades of experience at providing expert contingency planning and spill response services. Our professionals can help you determine if your facility requires an SPCC Plan and work closely with you to reduce the likelihood of spills and costly clean-up.

We can help you design a plan that can be used in the event of an emergency or regulatory audit, and one that illustrates your commitment to environmental planning and pollution prevention. Cardno has developed a cost-effective SPCC Plan template that readily reflects compliance with all portions of regulations. We also customize plans to provide the most effective and economic methods for your specific facility. Our plans include a description of facility design, equipment operations and maintenance procedures, and ultimately help you:
Avoid spills
Minimize your liability and risk
Properly perform spill control, containment, clean up, and reporting
Reduce impacts of spills on public health and the environment

We include all required provisions for spill prevention, spill response, SPCC training, and quality assurance. When we prepare, revise or update your SPCC Plans, Cardno meticulously performs mandated quality assurance. Our professionals walk through and inspect your site to confirm locations, containers, quantity of liquids, release prevention equipment, topography, and that preventative equipment is functioning properly. We confirm your preventative maintenance logs and inspection records and provide a P.E. certified in your state to review the completed plan for compliance with requirements, including state-specific regulations.

**Biological and ecological services**
Cardno can determine if high-value or sensitive natural resources, such as threatened or endangered species are present in your project area. Our team works with our clients to minimize or avoid adverse impacts to natural resources and valued species by careful consideration of project siting and operational alternatives. Cardno can also restore or enhance valued resources and sensitive habitats to promote threatened, endangered, or other high-value species.

**Mitigation**
When environmental impacts are unavoidable, Cardno can mitigate adverse effects by restoring or enhancing valued resources either on-site or off-site to ultimately help you obtain and maintain compliance with the permits you need to operate. Our environmental scientists and engineers will help you plan, design, implement and maintain projects to mitigate impacts to hydrogeology, streams and wetlands.

**Reclamation and mine closure**
Cardno is ideally situated to offer an array of environmental and engineering services to assist clients with expediting release of their mining bond in an efficient and cost-effective manner, optimizing the use of the mine operators' internal professional resources on higher priority objectives.

We restore function to impaired environments by combining comprehensive knowledge of ecosystems, engineering expertise, state-of-the-art technology, and over 30 years of environmental restoration and regulatory experience. Some specific post-mining activities we can assist you with include:

- Submit Phase I, II and III Bond Release Packages to various state regulatory agencies, including all forms, maps, supporting data, and documentation.
- Conduct field inspections on a routine basis to monitor ground cover along with tree/shrub survival and development.

**Amphibian Monitoring Project**
To assist the Mosaic Company, the world’s leading producer of concentrated phosphate and potash crop nutrients, Cardno developed a database to maintain amphibian call data from monitored wetlands. We also prepared a report summarizing the results that includes expectations and recommendations.

**CF Industries, Inc., Ecological Habitat Restoration**
To offset impacts caused by an expansion of phosphogypsum storage facilities, Cardno restored 1,900 acres of upland pasture to flatwoods, enhanced 680 acres of wetlands, restored 53 acres of wetlands, and created 139 acres of forested, herbaceous, and ephemeral wetlands.

**Creating Productive Forests on Previously Reclaimed Properties**
Cardno assisted the coal operator and landowner in creating productive forests on lands that had been inadequately reclaimed.
Perform or sub-contract with reclamation/tree planting crews to provide supplemental seeding or planting as needed to comply with post-mine land use criteria of forest land or fish and wildlife habitat.

Evaluate and identify any problems associated with a mine site including establishment of trees/shrubs, ground compaction issues, erosion, ground cover competition, and other site factors. Cardno will provide services to remediate those conditions in order to expedite the bond release process.

Perform or sub-contract with local construction crews the maintenance and repair of any sub-standard erosion control structure, regarded slopes or roads during the bond maintenance period.

Meet with inspectors and other regulatory personnel on behalf of the client regarding any post-mining issues.

Compile and submit NPDES monitoring reports.

Manage post-mining water quality treatment facilities (if applicable); collect and provide water quality data.

Provide sediment control structure and valley fill certifications, as required.

Cardno’s staff is always available to assist with active mine design, permitting, and reclamation services. We can also assist with the identification and placement of spoil material, grading techniques, and approved ground cover applications necessary to achieve optimum site conditions. This includes the successful establishment of trees and shrubs required for final bond release in accordance with the approved post-mining land use.

Social impact management
Mining projects invariably have impacts to the environment, economies, and communities in which they operate. For a mining operation to succeed, it must have acceptance or approval from the surrounding communities, a process often referred to as earning and maintaining a social license to operate.

Cardno’s coordinated and sustainable economic, social, and environmental approaches add value, protect investment, and enhance project security. We apply best practices in social development to help manage social, economic, and political risks. Our international development assistance and mining industry experience combine to provide you with invaluable expertise when implementing your projects. We earn and maintain your social license to operate by:

- Proactively engaging stakeholders and communities
- Assessing development needs, perceptions and expectations
- Designing appropriate social impact activities
- Building capacity for local government stakeholders and communities
- Creating local economic development initiatives and content development programs
We receive stakeholder input early to proactively address project concerns from start to finish. Our staff designs and implements community programs and determines the right communication strategy to reach diverse groups. For large-scale, programmatic efforts, we accurately track comments and responses to ensure your approach is defensible.

**Water management**

Water has become one of our most vital resource needs in the 21st century, and as the numerous uses for water compete for limited resources, sustainable management of water resources becomes critical. Cardno professionals provide strategic guidance to help you effectively manage water resources.

**Water supply**

Finding the water you need where your mining and mineral processing operations are located can be a complex challenge that can significantly affect your initial investments in infrastructure development and your operating costs. Cardno has hydrogeological, water resource engineering, design and regulatory experience that combines to give us a holistic approach to water supply and the ability to develop cost-effective and innovative solutions for water supply and reuse.

**Wastewater treatment services**

From conducting feasibility studies to performing final permit negotiations, Cardno protects human and environmental health while saving you money. We evaluate, install and modify treatment systems using various treatment technologies. Our familiarity with waste treatment chemicals allows us to select the most effective and cost-efficient chemical program. We evaluate and install water recovery systems for substantial reductions in water and energy use, as well as surcharge payments. We solve waste reduction, treatment, and disposal problems and supply ongoing monitoring and sampling to ensure compliance and keep operating costs at a minimum. Cardno delivers hands-on training to address system operations in addition to energy conservation, safety and management.

**Groundwater**

Cardno offers expertise in assessment, prediction, and mitigation of mine drainage issues involving underground mines and surface structures such as refuse areas and valley fills. Cardno has assisted the mineral extractive industry in pre-mining prediction of discharge water quality and designing mitigation to alleviate adverse impacts of drainage. Our specialized professional services pertaining to groundwater concerns include:

- Mine drainage characterization and remediation
- Assessment of acid mine drainage potential from underground mines
- Assessment of acid mine drainage from refuse areas and valley fills

We are adept in investigation and interpretation of water chemistry associations, and in applying those considerations to determination of drainage sources. Cardno is experienced and qualified in the use of such specialized techniques as tracers, discrete interval sampling, and geophysics to delineate subsurface flow paths and drainage sources.