PROJECT MANAGEMENT SERIES

PRE-FEASIBILITY STUDY

ON

A NEW MINE DEVELOPMENT

FACILITIES AND INFRASTRUCTURES

A PAPER FOR GENERAL DISCUSSIONS

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TABLE OF CONTENT

PART 1

GENERAL OVERVIEW ON NEW MINE DEVELOPMENT

PART 2

FACILITIES AND INFRASTRUCTURES FOR A NEW MINE DEVELOPMENT PROJECT

STUDY KICK-OFF

The Civil/Structural/Architectural Discipline Group – The CSA Group

General Arrangements of the Project

General topography of the planned lease area
The planned open pit area

The Explosive Yard

Mine Operations Compound

Truck Shop
Mine Warehouse
Truck Wash
Mine Administration Building
Mine Change House
Electrical Sub-Station
Parking
Haul Roads – From Pit to Primary Crushing

A Concentrator to process the raw ore from primary crushing to finished concentrates

Crushing
Milling
Flotation
Regrind
Concentrate Thickening
Filter
Drying
Shipping

The Concentrator Building

Associated Facilities Required Supporting the Concentrator's Operations

A Service and Maintenance Shop
A Change House
An Administration Building
An Emergency Respond Center

The Tailings Dams

The Main Access Road from the Mine Site to the Inlet

The Stockyard

A Ship Loader Export Wharf and General Service Wharf

Facilities required at the Export/Service Wharf Site

A central control house for ship loading operations
A change house for workers
A service and maintenance shop
A warehouse
A truck shop for concentrate delivery hauls trucks
A tire shop
A re-fueling station
An administration building
An emergency respond center

TRANSITIONING – FROM STUDY TO PLANNING

The Main Access Road

Employee Villages

Near the Concentrator area
Near the Export wharf area

PLANNING THE INFRASTRUCTURES TO SUPPORT THE NEW MINE DEVELOPMENT

Water

The Mine and Concentrator Areas
The Export Wharf and General Service Wharf Area

Power

Wind Farm

Other infrastructures required to support the operations at the new mine development:

Sewage collection and treatment

The Mine and Concentrator areas
The Employee Village near the Concentrator area
The Export Wharf Area
The Employee Village near the Export Wharf area

Wastewater treatment

Communications systems

Fencing and Gates – Site Security and Control

Sea Plane Mooring Jetty

CONSTRUCTION MANAGEMENT AND CONSTRUCTION EXECUTION PLANNING

FINAL COORDINATION WORKSHOP

TOPICS TO BE INCLUDED IN A PRE-FEASIBILITY STUDY REPORT (A GENERIC SAMPLE ONLY)

PART 3

LESSONS LEARNED

LESSONS LEARNED:

Mining

Concentrator and Mineral Processing

Tailings Management Facility

Site Services and Infrastructures to support the Operations of the Mine and Concentrator:

For the Mining Operations
For the Concentrator Operations
For the Tailings Management Facility's Operations

Main Access Road:

A Port Site for Exporting and Importing Purposes:

Environmental
Technical

Employee Villages:

Village One:
Village Two:

Pre-Construction Works Program – A Construction Wharf

PART 4

CONCLUSIONS

Difficult

Complex

Expensive

Risks

PART 5

EXPERIENCES ON MINING PROJECTS

PART 1

GENERAL OVERVIEW ON NEW MINE DEVELOPMENT

INTRODUCTION

Mining is not a recent human activity; some 11,000 years ago human living in Ancient Egypt and Near East discovered copper. As they learned to refine the metallurgy on copper, they evolved from Stone Age to Bronze Age about 6,000 years ago. Approximately 1,000 years later, people living in the Mesopotamia Valley also discovered iron in their region and they learned to use it to make tools, swords and even on wheel assembling.

Since the arrival of the 19th century, both science and technology have advanced in their fastest pace ever. Consequentially, human lives much better and longer as well due to better health care, advanced medical diagnoses, cleaner drinking water and healthier food available for consumption. As a result there is a spike in human population. To support that huge jump in population, basic life demands such as food, shelter and transport must also be increased to fill the gaps. All these mean endless demand of raw materials to field downstream productions. Most of those raw materials, both metals and non-metals come from mining industries. Entering the 21stcentury, the electronic and digital revolutions created another and even higher demands on new raw materials including rare earth elements. The mining industry is once again high on demand to supply those new materials.

Today, Canada is one of the most skillful countries in the world on development of mining operations mainly because Canadian mining companies own and operate a large number of mines in the world. The ever demand of mineral elements, since the industrial revolution, has created opportunities for mining companies to explore and develop new approaches in mining technology as well as metallurgical processing science to extract minerals from raw ore forms to finished products.

Each type of mineral is mined and processed differently and there is no 'one set fits all' approach to them. Minerals are formed, in different stages, during the formation of the planet earth. As a result, some are located closer to the surface of the earth and others are deeply buried below ground level. The size and shape of the mineral reserve also varied from source to source. As a result, the mining operations are generally carried out in four (4) different forms, namely:

- **Surface mining** – for mineral located very close to the surface of the earth, large hydraulic dredger will be used to excavate the raw ore. It will then either load the raw ore onto large rock trucks for delivery to the processing plant; or sometimes mixing the ore into a slurry in a nearby pond and pumps it to the processing plant through a pipeline system depending on the nature of the raw ore
- **Open pit mining** – for those mineral deposits located within reasonable depth below the surface of the earth, the overburden (soil covering the ore body) will be removed and a large pit excavated around the ore body. The pit gradually moved downward through drilling and blasting, in a spiral formation, until reaching the bottom of the ore body. The raw ore will be excavated with a huge hydraulic excavator and loaded onto huge (200+ tons) rock haul trucks to be delivered to the Primary Crusher to start their treatment processes
- **Underground mining** – when the ore body is located deep below the surface of the earth, the costs of stripping of the overburden is no longer considered economical, the method of mining

changes from open pit to underground operations. A large operating shaft, located near the ore body, will be sunk to a depth below the bottom of the ore body. Horizontal tunnels will be constructed from the bottom of the shaft towards the ore body. From there, grids of caves will be created and the miners will drill upwards and blast, allowing the ore to drop to the floor of the tunnels (*This is one of the technology used in underground mining known as block-cave mining chosen to illustrate underground mining methods*). The ore will be collected and loaded onto an underground train system to be delivered to the Primary Crushing system for processing into smaller rock fragments. After passing through Primary Crushing, the rock will be delivered to a skip through conveyor systems. The skip will lift the raw ore to the surface for further crushing and milling followed by metallurgical processing. The underground mining operations required a number of infrastructures to be built underground for support. They include:

- The main working shaft equipped with a large cage to deliver miners to and from the underground location. It also serves to deliver equipment and materials to the underground areas. Ready-mixed concrete mixes, including gunite mixes required to stabilize the walls and ceilings in the underground locations, will be delivered to a location through a vertical pipe where they will be re-mixed before application. De-watering piping system will also be mounted on the side of the working shaft to bring up ground water from the underground locations
- A separate working shaft for the skip to bring the raw ore up to the surface
- Ventilating shafts to exhaust and to deliver fresh air to the underground areas. At an elevation of 5,000 feet below ground, the temperature on the rock surface can be as high as 80 degree Centigrade. For that reason, several ventilation shafts are required to vent the hot air and at the same time to provide refrigerated air to the underground locations
- An escape tunnel and safe quarters near the bottom for emergency evacuation purposes
- A workshop located underground to service equipment
- A small warehouse besides the workshop to store spare parts and materials
- A workers' dry/lunch room
- An office with communication systems
- An electrical room complete with emergency generator
- A rail dumper connected to the Primary Crusher located underground
- Re-claim conveyors to deliver the raw ore after passing through the Primary Crusher to the skip
- The skip and hoisting system

***NOTE**: Some mineral deposits are located inside mountains. In those cases, instead of sinking shafts to each the ore body, Mining Engineers chose to drill a tunnel from ground surface to the ore. When they reach the ore, they will drill and blast to extract the raw ore and load them onto a train of open box cars to be brought to the surface for further treatments.*

- **Solution or in-situ mining** – some minerals located deep underground can be extracted by an alternative method known as solution mining or in-situ leaching. A number of 'pairs of wells', one for delivery of solvent to the ore body and one for extraction, are drilled and installed from the surface to the ore body. Solvent, such as steam, hot water or chemicals is delivered to the ore body through the well to dissolve the ore. Camera will be used to check on the development of the ore body. When the ore is soft enough and fluidized, it will be pumped to the surface for further treatment

The methodology chosen to extract the raw ore is the responsibility of a qualified Mining Engineer who had carried out detailed due diligence on the type and nature of the mineral to be extracted. The Mining Engineer works very closely with the Geologist to arrive at the final decision on the methodology to be used based on the results of economic modeling.

THE DEVELOPMENT OF A NEW MINE

The development of a new mine takes on the following phases, namely:

- Identification
- Concession Permitting
- Initial exploration drilling
- Scoping study
- Pre-feasibility study
- Permitting
- Bankable feasibility study
- Project execution
- Commissioning, start-up and production

Identification

Throughout the years, ground movements, erosions, weathering and/or climate change causing glaziers to recede will expose some fragments of the mineral deposits. A Professional Geologist, perhaps from a junior exploration company, trained to examine the rock formations for possible mineral deposits, is usually the first one on the ground to scour the land looking for signs of existence of minerals. When he/she finds adequate samples in a location known as "*prospects*", he/she will bring them back to an established commercial laboratory to have them examined and analyzed in greater details.

In the laboratory, the samples from the "*prospects*" will be crushed; ground to a fine powder, heat fused or dissolved in acid and then studied and analyzed using special analytical methods and/or scientific instruments. The results will **identify** the proportions of metallic and/or non-metallic elements from the

"*prospects*" samples and an early indication of the potential value of a mineral or ore body. This process of analyzing is known as 'Assay'.

Packed with an assay report, the junior exploration company will approach and make a business offer to a mining company on possible interest to work together to develop a project on that location.

All the works carried out at this phase are considered confidential by all parties.

Concession Permitting

Before a private company can lease a piece of public land to explore and develop a new mining operation, they have to apply to the government agencies, having jurisdiction on that piece of public land, for "mining concession" to do so. The rules and requirements vary from government to government.

By definitions, a "mining concession" refers to: *an area allocated by a government for the extraction of mineral(s). Concession is used as a general term for licenses, permits and/or other contracts that confers rights to a private company to manage and extract mineral(s) from public land and includes minerals and mining permits, tenures, licenses and other terms.*

A new mine development project requires a very large piece of land lease (hundred thousands of hectors), usually located within public land, to accommodate access to the proposed lease areas, to mine the ore body, roads for transporting the raw ore to the processing plant, areas for the processing plant and its supporting infrastructures, the location for the tailings management facilities and, in many cases, an area at the nearest coast to accommodate the construction of a ship-loading terminal together with a general cargo terminal to export the final products to their customers and to support the mining operations.

Before the company is able to carry out initial exploration drilling, they will have to apply to appropriate government agencies for the "mining concession". This will take time to process. When the concession is granted to the applicant, they can start organizing the land survey on the overall lease, mobilize a drilling team to start the initial exploration drilling program.

NOTE: In Canada, during the application of a "mining concession", the applicant must also check out if any part(s) of the proposed lease (the land) may have been in the process of being returned to the First Nation's people. If that is the case, then the applicant must negotiate with the First Nation's people to obtain their firm agreements to support and co-operate on the scope of the Project before proceeding further.

Initial Exploration Drilling

The management group, within the mining company, will study and review the assay report presented to them. Should they find the information provided by the report to be attractive, based on their company's business objectives, they will make arrangements with the junior exploration company to carry out further processes of identification, to ensure the early indication of the potential value of the mineral or the ore body is reliable.

To begin with, they will create a new joint-venture company (**The Company**) to manage the project. This new company will stakeout a swart of land and enters into a lease agreement with the Crown (or Local Government Agencies). Thereafter, The Company will apply for applicable permits for a mineral exploration program. During this process, they will retain a Legal Land Surveyor to prepare a map with some topographical data showing the boundaries of the lease. The surveyor will also establish some basic survey control points, such as temporary bench marks (for elevations) and control grid lines (for establishment of drill hole coordinates), inside the lease for future references.

When the permits are approved, The Company will go to markets to raise some venture capitals to start the exploration program. This program will include the mobilization of a drilling team to the designated location, within the lease, to drill and take core samples at the same time with a specially designed drill bit. Depending on the location of the lease, the initial part of the exploration program can be very expensive, especially if the lease is located in a totally remote and isolated area and with difficult access to the lease. The drill team will have to construct a safe, temporary, access for the drilling equipment to mobilize, a temporary mobile camp to accommodate the drilling crew and logistics for delivery of supplies including fuel and food. They will also have to establish a proper 'core shack' to store and handle the core samples. Therefore, the initial exploration program may only include the drilling of a small number of holes at chosen locations. The final depths of the holes will depend on what was revealed from the cores extracted from the drilling operations. The Company will again send the mineral impregnated cores samples to an independent commercial laboratory to have them assayed by qualified professionals and to generate a report for the stakeholders' information. If the report shows promising results, more holes may be drilled to further verify the size of the reserve. Or, if the price of the commodity is not favorable at the time, further drilling may be delayed and The Company will take the data shown in the report to form part of their reserve (asset), to shore up future chances on raising more venture capitals. It is not unusual that the exploration program can stay on and off for many years, even decades, before the next step will be taken to further study the feasibility of the prospect.

Depending on the mining company's creditability, capacity and business policies, some mining companies may choose to keep the exploration active on a continuing base just to keep the project alive; at the same time trying to find a joint-venture partner willing to bring the project to the next phase – to come up with "Project Definitions" or Scoping Study, to prepare for the application of a mining concession permit on the leased property.

Scoping Study

When the results from the Initial Exploration Drilling Program showed the potential ore body can be of reasonable size (due to limited number of bore holes drilled at the time) that will amount to a real mineral discovery, based on their in-house data and past experiences on similar projects, The Company will retain an outside consultant to conduct a Scoping Study to come up with some preliminary definitions for the project for future considerations.

Scoping Study for a proposed new mine is defined as: *an initial appraisal carry out early in the life of a resource project. It is based on a set of initial drilling records and informed assumptions. It is also common for the study to include a preliminary mining plan and concluded with recommendations on how much further pre-development efforts are warranted. The conclusion from the scoping study will not be accurate enough (+/-50%) to allow the stakeholders to carry out meaningful comments on the economic viability of the project, but it should determine and clearly highlights key project risks for the stakeholders' attentions. However, results from the scoping study will provide The Company with reasonable parameters of 'project definitions' to form the bases for the next phase works – pre-feasibility study.*

Scoping study can be part of the requirements, by some government agencies, in the application of a new mining concession or upon renewing an existing concession.

Pre-feasibility Study

When The Company is ready to move forward beyond the Scoping Study phase (sometimes the gap can be decades apart or never getting to proceed) and onto its next phase – Pre-feasibility Study, The Company will invite well established and reputable engineering consultants, with strong expertise in mining development experiences, to submit their proposal on an "Expression of Interest" format. The Company will receive, review and analyze the proposals carefully before engaging one candidate to proceed with the Pre-feasibility Study.

A Pre-feasibility Study (**PFS**) is an early stage analysis of a potential mining project. The study is designed to give The Company's stakeholders the very basic information they needed to consider proceeding with the project to the next phase or to choose alternate between investment options. The PSF gives an overview on the proposed project's logistics, capital investment, key challenges and other information that are considered important to their decision making process, such as: whether the mining operations should be open-pit or underground. It also includes some information on, but not necessarily limited to: preliminary geological modeling and mine design, potential impacts on local community issues, environmental and safety issues, geographic obstacles, permit challenges, preliminary metallurgical processing designs and description of mining operations, early capital costs and operating costs estimates, potential risks and multiple options to overcome challenges. During the PFS and as a 'rule of

thumb', the consultant will have to produce approximately 6-8% Front End Engineering in order to support their findings and to generate the required costs estimates with an accuracy of +/-25%.

The PFS is preceded by adequate mineral exploration works including drilling and sampling to support the production of a Mineral Resource Report, a potential model of the ore body and a Scoping Study.

The PFS is also intended as a potential Investment Report before considering spending more money on acquiring permits or researching on mining and metallurgical processing equipment. When The Company is ready and the market prospect is favorable on the target mineral, they may choose to move the project forward to the next phase, which is Feasibility Study. Timing is the critical mover.

Permitting

After the completion of a PFS, The Company will have a reasonably good idea whether the project is feasible or not and what are the main risks associated with it. When they think that the project is feasible within the confine of their company's business objectives, they might choose to start contacting the various government agencies and to obtain a feel of how long it takes to apply for the permits required. The longest one will likely be the federal government's environmental assessment process which could take up to over a year to obtain, if everything went well. They will also have to apply for permits from provincial government agencies. While they are working with government agencies, they must also check with local First Nations who might have jurisdictions over the resources rights.

Bankable Feasibility Study (BFS)

When The Company decided to move the project forward to the Bankable Feasibility Study (**BFS**) phase, they will either re-call the consultant who prepared the PSF for them or to solicit for a new "Expression of Interest", depending on the time lapse between the PFS and the plan to proceed with the BFS.

The BFS is an in-depth study on the proposed project based on the data and contents stipulated in the PFS. It is intended to evaluate the estimated mine reserve calculations to see if it can be extracted effectively and profitably, based on the proposed mining plan, and, using it as the basis to determine the total capital expenditures (CAPEX) and the overall economic viability of the project. In order to achieve those objectives, it will require a lot more resources to conduct the study. For example, the study team has to produce at lease 12-15% Front End Engineering to generate better estimates on work quantities, during the study; provide the Procurement Group with clear definitions on the permanent equipment so they can approach the suppliers for non-committed quotations. These activities will give the Cost Engineers confidence in their CAPEX calculations to arrive at an accuracy of +/-15% and the Engineering

Economist to create proper financial models, such as using Nat Present Value (NPV), to justify the capital investment.

The contents in the BFS will include economic, legal, and operation; as well as schedule issues, technical feasibility and capital costs, complete with a detailed project execution plan, all in accordance with how operations work and when it can complete. It will also have a section on market research covering the prospects on the target mineral product.

The BFS is a very important document for all the investors and investment bankers to understand the opportunities and risks carried by the proposed project. Therefore, the language, data, figures, tables and attached reference documents in the final published study report must be clear, precise, transparent and with no room for miss-interpretation, misunderstanding or miss-leading. Therefore, the stock exchange regulations require each section of the final version of the BFS to be signed-off by Qualified Person(s) before it is made available to the public.

At this phase of the project, The Company has invested a very large sum of money and a drive to see the project through to completion. The successful completion of the BFS will give The Company a good overview on how to reduce risks and address other possible issues that may cause complication when it comes to the execution of the project. The BFS will also be a helpful reference document for government agencies having jurisdictions on the project and the environment analysts.

Project Execution

The final Bankable Feasibility Study report will boost interest and confidence to both the investors and the investment bankers to provide financial support to the project, allowing The Company to move the project to its next phase, which is – Project Execution.

For the Project Execution Phase, The Company will retain an experienced and reputable Engineering, Procurement and Construction Management (**EPCM**) contractor to handle the execution of the project. This contractor is a very special one in the engineering-construction industry. It is well established, has a large contingent of experienced professional engineers and supporting technologists, and other disciplines of human resources in-house capable of handling most of the nominal engineering, procurement and construction management functions to execute large and complex industrial type projects, especially those located in remote and isolated northern regions.

Time is of the essence on the project.

When the project is awarded and with instructions to proceed from The Company, the **EPCM** contractor will move quickly to mobilize and set up a project team to manage the various disciplines. The engineering team will begin with a ‘gap’ study on the BFS to make sure no gaps existed before they started with Basic Engineering design. They will create two teams, in parallel, to serve the project. The

main engineering team will carry out the Basic Engineering Design works, while a second smaller team works to assist the Construction Management Team to prepare engineering documentation for permit applications to start the Pre-Construction Program.

The Procurement Team will also have a two team's setup similar to the engineering arrangements. One team will prepare documentation for tendering on all permanent equipment and structures. A second team will work closely with the Construction Management Team to procure materials and equipment to support the Pre-Construction Program.

The Construction Management Team will immediately organizes a Pre-Construction Program team to handle initial mobilization, initial site access facilities, site preparation, on-site temporary site services (power, fuel, water, sewage, fire protection, etc.) as required, a fully operating temporary construction camp, kitchen, dining and recreation facilities complete with catering services. They will prepare a large laydown area with a temporary covered warehouse ready to receive deliveries of materials and equipment. The team will also set up temporary site offices for themselves and serviced spaces prepared for the subcontractors to use.

Most importantly, a secured telecommunication system set up, on-site, to provide voice, video and data communications transmission with the outside communities and regions.

An efficient and effective on-time completion of the Pre-Construction Program will allow the Full Balance of Plant Construction Program to mobilize without complications and delays.

The Full Balance of Plant Construction Program of a new mine development is usually divided into five (5), and in some project six (6), silos. Each silo represents a major component of the whole project and is managed by a separate construction management sub-team, under the directions of a Silo Superintendent who reports directly to the Construction Manager or his/her designate. They are:

1. Mining
2. Concentrator
3. Tailings Management
4. Main Access Road
5. Employee Village(s)
6. Ship Loading Port (optional, only if required)

Each silo will have its defined scope of work, a construction schedule and a budget for the team to manage the works. The Construction Manager will have a Project Coordinator appointed to the site organization, to ensure that all permanent site services connections are properly coordinated and installed before each silo declares 'Mechanical Completion'.

When a silo declares 'Mechanical Completion', the Silo Superintendent and his/her team will inspect the works carried out by subcontractors and prepares a list of deficiency for them to correct and make good before releasing them. When the Silo Superintendent is satisfied that the major deficiencies are properly corrected, he/she will submit request for pre-commissioning of the equipment and infrastructures.

Pre-commissioning will be carried out by EPCM contractor's Pre-Commissioning Manager. He/she, supported by field engineers, construction workers and equipment vendors, will follow a set of established procedures to check out the installations of all permanent equipment shown on the latest revision of the engineering drawings. Pre-commissioning will use only water and air to test the operating systems without introducing real feed stock materials.

When the Pre-Commissioning Manager is fully satisfied with the installations, he/she will inform the Commissioning Manager from The Company to take over the silo and to begin with their own commissioning process.

Owner's Readiness and Commissioning

Approximately six (6) months before the first silo declares "Mechanical Completion", The Project Manager from the EPCM team will inform his/her counterpart at The Company of the project's progress and requested that The Company should start putting their operations team together and be ready to take over from the EPCM team to begin with their commissioning program.

Owner's readiness means that The Company's Operations Manager will have to start hiring workers for the operations, maintenance staffs and kick-off with training programs to ensure their operations personnel are familiar with all the processing equipment installed at the facilities. They will have to learn and order all the necessary parts and spares required for commissioning and start-up, especially with all the specific lubricants and oils to replace the 'first fills' after commissioning. They will have to order all the tools and minor equipment for their shops and warehouse operations.

The most important part of Owner's readiness in a new mine development is that their mine development program* has to be readied, commissioned and has stockpiled adequate amount of raw ore materials that meet specifications, such as: hardness, sizes, moisture content, etc. This raw ore stockpile is required as feed stock for the commissioning program and the start-up on production after commissioning.

***NOTE**: As a rule of thumb, in a new mine development project, the actual mine development part of the scope is excluded from the EPCM contract. It is handled directly by the Owner's own mining team.*

Commissioning, Start-up and Production

Commissioning, in a new mine development project, is a process to be carried out by the Owner's commissioning team. After receiving notifications from the EPCM contractor's Pre-commissioning Manager that the silo is ready to be transferred to the Owner, the Owner's commissioning team will

take over the completed silo and begins with their commissioning program, with the EPCM contractor on standby to assist. Real feed stock will be fed to the equipment to check out their performances and the operating systems to see if they meet design criteria, production rates, etc. Minor changes or modifications maybe required during commissioning, but major changes requested by the Operations team will not be considered and accepted at this stage. Those changes will be incorporated into their future Operations budget.

After the Commissioning team is fully satisfied with the results from the check out on the equipment and systems, they will turn the silo over to the Operations team for them to start-up and to bring the silo into production mode with gradual ramp-up.

PART 2

FACILITIES AND INFRASTRUCTURES

FOR

A NEW MINE DEVELOPMENT PROJECT

INTRODUCTION

From the descriptions shown in Part 1 above, we learn the complex processes of taking on a new mine development project.

Majority of new mine development sites are located in remote and/or isolated regions. Existing utilities facilities and infrastructures from 'outside boundaries areas', readily available for connections, are few and far in between. As a result, permanent facilities and infrastructures, required to support the operations of the "new mine development", have to be considered and their construction costs included in the Capital Expenditures budget during the pre-feasibility study phase.

The term "new mine development" is used only as a general description of a proposed mining project. Each project is truly ***unique***, due to the type of targeted mineral(s) to be mined, the mining plan, metallurgical processing design, shipping and exporting the final products. More importantly, the physical conditions of the site play an important part in the planning of the development. Therefore, there is no 'one-size-fits-all' approach to the planning of the facilities and infrastructures required for the project.

Let us use the example of a "new mine development" project mentioned in Part 1 and to examine the types of facilities and infrastructures required more closely in details.

A New Mine Development Project

> *A large ore body of copper mixed in with some visible gold, silver, magnesium and some minute traces of other non-ferrous metals was discovered in the Northwestern part of the Province of British Columbia, Canada in 1978 by a junior exploration group. They entered into a joint-venture agreement with a Canadian junior mining company and were able to obtain a concession and a lease from the Government Agencies to carry out further exploration drilling on the lease. In 2002, the company retained a reputable Canadian Engineering Consultant to conduct a pre-feasibility study on the project for the purpose of finding a partner with strong financial background and experiences to move the project into the next phase – to carry out a Bankable Feasibility Study.*
>
> *According to Environment Canada, the project site area is classified to have a 'humid continental climate' with an annual precipitation of approximately 2,000mm, mostly in the form of snow. Even though it is located in the northwestern part of the Province of BC, the averaged minimum temperature in the winter months is about -7 degree C.*
>
> *The proposed mine site is located approximately 85Km inland from a water access point inside a deep water inlet, where there is an existing and established village with approximately 200 residents. The inlet, being influenced by warm Pacific Ocean current, does not freeze during the winter months. As a result, the inlet is open to shipping year round. The village has an existing slip for supply barges to tie-down and a seaplane landing ramp to service its residents.*

The Developer engaged our company, a reputable engineering consultant with solid background in new mine development projects, to carry out a pre-feasibility study on the proposed Project.

The Scoping Study Report, available from the client, included a very preliminary Process Block Flow Diagrams and some general site layout drawings as part of the attached documents. Those general site layout drawings did show some, but not all, permanent facilities and infrastructures intended to serve and support the operations on mining, metallurgical processing of the ore and shipping the concentrates to market.

PERMANENT FACILITIES AND INFRASTRUCTURES COMMONLY REQUIRED TO SUPPORT THE OPERATIONS OF A NEW MINE

For the purpose of this paper, it will focus the discussions on the permanent facilities and infrastructures areas only during the preparation of a pre-feasibility study program.

In order to plan the necessary supporting facilities and infrastructures properly for a new mine development project during the pre-feasibility study phase, the consultant's team will take on a two prongs approach, at the very start of the study program, to achieve their goal. They are:

1. Site visit
2. Block Flow Diagram

Site Visit

Before starting the Pre-feasibility Study, the consultant's Study Manager, together with the Procurement Lead, a Marine/Harbor Engineer and the Construction Specialist will conduct a site visit to have a better understanding of the *physical site conditions* and to identify potential risks that the project have to manage and/or mitigate. The key physical site conditions and potential risks include, but not necessarily limited to the following:

- Exact location of the proposed mine site
- Existing general topography of the lease
- Year round weather conditions at the site
- Main access to the site
- Logistical issues and challenges
- Sources for power, water and tele-communication

In order for the study team to carry out their planning correctly and to prepare a proper project execution schedule to guide the Capital Cost estimate, they need to have good and firsthand knowledge on all those key physical and natural site conditions mentioned above. A helicopter was chartered to fly

the team to take pictures over the proposed site areas. The post site visit de-briefing session and their subsequent detailed Site Visit Report are both important information and references to the study team.

Block Flow Diagram

While the site visit was being conducted, the Process Engineering group will start off with the preparation of an upgraded Block Flow Diagram showing the flow of the Project's operations from the mining operation to the raw ores going through metallurgical processing to the transporting of the concentrates to a shipping outlet for delivering the concentrates to market, in the form of a pictorial diagram. The purpose of the Block Flow Diagram is to provide an easy understanding to all the disciplines within the study team on the overall scope of works destined for the project. A copy of the Block Flow Diagram will be included in the final Pre-feasibility Study Report, as general project information, for other project stakeholders as well as investors to see.

STUDY KICK-OFF

Upon the return from the site visit, the Study Manager calls a pre-feasibility study kick-off meeting with the presence of the whole study team – both teams from the client and the study group.

Immediately after introducing the team to the purpose and scope of the study, the Study Manager moves the agenda to discuss the Block Flow Diagram followed by the Site Visit Report. The presentation of those two items generates useful discussions and information for the team to form their engineering concepts on the project and parameters to kick-start the study.

At the end of the kick-off meeting and armed with a copy of detailed Minutes of Meeting, each discipline group will begin with their study program. Regular progress meetings will be conducted for engineering coordination purposes and to make sure there is no "gaps" missing in the Master Planning.

The Civil/Structural/Architectural Discipline Group – The CSA Group

A new mining development is a very complicated engineering project. It involves a large team of professional engineers and specialists from multi-disciplinary groups and the CSA is one of the groups within the team's organization. However, among other civil, structural and architectural scope of works in the study, the CSA group does have one important task – to study what facilities and infrastructures are required to support every step of the operations in the proposed development. They will form a sub-group specifically assigned to study them.

As a starting point, they will study the *general arrangements* of the project as proposed in the Scoping Study Report which provides them with good basis on *'project definitions'* for references. From there, they will consult, co-operate and collaborate with other disciplines before arriving at a clear and concise scope of work that directs them into more in-depth studies to achieve the goals for each general arrangement.

General Arrangements of the Project

The Scoping Study Report provided 8 initial general arrangements of the proposed project which include:

- General topography of the planned lease areas
- The planned open pit area (Open pit mining method proposed in the Scoping Study Report)
- A concentrator to process the raw ore from primary crushing to finished concentrates ready for shipping and delivery to customers
- The tailings dams
- The main access road from the mine site to the coast
- A stockyard at the export wharf area
- A ship loading export wharf and a general service wharf located on the inlet
- Two employee's villages

General topography of the planned lease area

During the Scoping Study, the consultant used existing published survey maps, as overlay for their initial general arrangement layouts, to show the locations of the proposed facilities included in the project. Up to date topographic survey will be carried out at the start of the Pre-feasibility Study phase.

Once the updated topographic maps are available, the CSA Group begins to study them to map out a strategy for a site grading plan to fit the required facilities. The purpose of this planning is twofold:

1. To map out a master site preparation plan in order to establish a balanced cut and fill estimate
2. To establish the 'finished floor elevation' at the Concentrator (an important step because finished floor elevations for all other facilities will be related from this *datum*). This will provide the basis to the overall site drainage scheme

The planned open pit area

The Scoping Study, based on the exploration drilling logs, proposed an open pit mining operations for the project and mapped out an approximate area for the pit. Further post-Scoping Study exploration

drillings logs, including some coming from 'condemnation drill holes' confirmed the planned size of the pit is reasonable.

From the review of that information, the CSA Sub-group begins to make plans to support the open pit mining operations. The first set of facility required on site will be:

The Explosive Yard

- A fenced-in, secured compound for storage and mixing of explosive materials. It will include a pre-engineered steel building to house the operations. This facility has to be located, under Canada's Explosive Act, at least 1.5Km away from other operations, preferably in a spot behind the pit. Warning signs will be posted at the entrance access to the site
- Access road, power, lighting, ventilating, water supply and fire protection have to be installed in this facility to support the storage and mixing operations. Power generators, fuel tanks and water storage tank will be included in the planning for this facility
- In a separate location, approximately 1.0Km away, also completes with a fenced-in, locked and secured magazine is designated as the storage facility for the blasting caps

Once the Explosive Yard is established, the CSA Sub-group moves on to review the facilities requirements for the Mining Operations.

Mine Operations Compound

The Mining Group will require an operations compound complete with supporting facilities and infrastructures to manage their daily operations. This compound will be located in a prepared, flat area away from the edge of the ultimate open pit. It will include the following facilities on the compound:

<u>Truck Shop</u>

An open pit mining operations requires a substantial number of large mobile equipment to support its operations. As a result, a well-equipped, custom designed truck shop of structural steel construction has to be established on site not far from the mine pit. This truck shop, together with several related facilities, will be located in a prepared, flat area away from the edge of the pit. The size and height of this shop has to be large enough to maintain and service those huge rock haul trucks. A well-stocked lubricant and oil center will be attached to the truck shop. A large, well compacted gravel surfaced apron will be built besides the truck shop to serve as 'Ready Line' for the trucks. A well-equipped tire shop will be set up at the other end of the 'Ready Line' to handle tire changes and tire repairs. Standard building services will also be incorporated into both buildings.

Mine Warehouse

To support the mining operation and the maintenance and service of all the mobile equipment, an enclosed warehouse has to be built besides the truck shop to stock up on parts, spares and consumable materials. This warehouse will be a regular pre-engineered building including a section to store highly weather sensitive materials. Full building services will be incorporated into the warehouse building for use by the mine operations personnel.

Truck Wash

When the raw ore is being loaded onto the rock haul trucks, it is always mixed in with some native soil. The moisture content of the soil may cause the soil to stick to the bottom of the truck's bed. When that happens, the truck has to go through a truck wash facility to clean out the bed thoroughly. A truck wash is a specially designed steel building equipped with high pressure water jets to wash the trucks. An air compressor room is included in the building layout. The waste water is collected and directed to a pond located besides the building to allow the water to be filtered for re-use. The soil particles settled at the bottom of the pond will be clean out periodically and disposed off-site. Standard building services will also be incorporated into this building.

Mine Administration Building

A mine administration building will be included in the compound to provide office spaces for the engineering and administrative personnel to work and manage the mining operations. It will be a 2-story building with an assay laboratory to be located on the main floor. This building will be a pre-engineered building complete with architectural finishing and all building services.

Mine Change House

A mine change house is a facility for the mine workers to prepare themselves for the start and at the end of a shift. There will be large shower and dry rooms, with separate entrances for male and female, in this facility for after shift clean-up and change. The shower and change room is 2-story high. On one side of the change house, it is lined with lockers, shower stalls and washroom fixtures. On the other side, baskets hung from the roof with rope attached for raising and lowering the baskets. This allows the mine workers to put their washed clothes in the basket and their work coverall hung underneath. The basket is then raised up high to allow the clothing to dry and be ready to wear in the next shift. Lockers are installed inside the change house for workers to store their personal things while at work. This part of the building is well heated and ventilated to keep out the dampness in the room. Other standard building services are also incorporated into the building.

Electrical Sub-Station

An electrical sub-station will be installed on the Mine Operations Compound to receive high voltage electrical power from the Main Power House, located near the Concentrator area. It will have proper transformers and switchgears to step down the power to meet the requirements of the services they intern provides to the buildings and operating equipment. A small steel building will be used to house the switchgears, bus bars, motor control centers and power distribution panels.

Parking

A parking area, complete with yard lighting and electrified hitch railings, is provided inside the compound for personnel parking and buses to transport workers to and from the Employee's Village.

Haul Road – From Pit to Primary Crushing

Extra wide gravel haul roads, leading from the open pit to the primary crushing plant, is an important infrastructure to be built to support the mining operations. These roads are designed to accommodate those huge rock haul trucks to deliver the raw ores to the primary crusher. Due to the size of those trucks large radii turning curves have to be considered and incorporated into the road design. It is prudent to note that those huge haul trucks drive on the wrong side of the road.

A Concentrator to process the raw ore from primary crushing to finished concentrates

The current preliminary Block Flow Diagram shows the metallurgical processing flow from raw ore to shipping of finished products, giving the CSA Sub-group the basic definitions to map out the facilities and infrastructures required to support the Concentrator's operations. They study each "block" on the Block Flow Diagram carefully, in consultations with the other engineering disciplines, before they start with their planning approach.

The following descriptions showed their understanding of the metallurgical processes and how they would provide facilities and infrastructures to support them effectively and efficiently.

Crushing

Metallurgical treatments to the raw ore begin at the primary crusher. After the raw ore is drilled, blasted and loaded onto the rock haul trucks, they are delivered to the primary crusher to be further broken down by a rock breaker mounted above ground, besides the grizzly grill and on top of the

primary crusher. The primary crusher, either a jaw crusher or a gyratory crusher, is housed inside a structure constructed of reinforced concrete and structural steel. A feed hopper is mounted on top of the primary crusher and below the grizzly grill to receive the raw ore rocks that passed through the grillage. The primary crusher crushes the ore rock into smaller pieces so that they can be transported by overland conveyor to the screening and secondary crushing stream.

The screening and secondary crushing steam consists of a screening plant and a series of cone crushers set up in a closed circuit arrangement. The initially crushed ore rocks will be sent to the screening plant. The undersize will be sent directly to the milling plant while the oversize will pass through the first set of cone crushers followed by routing it through the screening plant again. The oversized rock will be returned to the other set of cone crusher to be further crushed down. The undersize rock will be sent to the next stream which is milling. During crushing process, magnets are usually mounted on the conveyors to remove any ferrous type metals (steel/iron particles broken from rock breaking or crushing) before sending the product to milling.

Milling

The milling stream consists of SAG mills (or rod mill) and Ball mills. The ore bearing rock is milled down to a fine powder through the actions of those two types of mills. A system of cyclones (centrifugal separators) is used to separate the oversized particles from the undersized ones. The oversized ones returned to further milling to bring them to the specific sizes before sending the milled products to the next stage of metallurgical treatments, which is flotation.

Flotation

Flotation is a metallurgical treatment process to separate the different types of metals contained in the ore that has been milled to a fine particle. The processes are based on the different surface wettability property of materials. It is a “sink and float” where the specific densities of the different materials with respect to the ‘mediums’ (reagents) used will separate. It is a wet process. Flotation cells are used to carry out this treatment where water, medium and air bubbles are introduced to float hydrophobic particles that adhere to the bubbles with respect to the hydrophilic ones that sink. There are several steps in this treatment such as: rougher/scavenger flotation and cleaner flotation. In each case different types of flotation cells are used. The water used in this processes can be re-used after a separate treatment process.

The principal objective on this project is to recover as much as possible the targeted copper, gold and silver from the ore. Other materials that are not economical to recover will be sent to, and stored, in the Tailings Management Facility.

To support the flotation processes, a separate storage and dispensing facility for the mediums (reagents) and another air compressor station have to be built outside the concentrator building and next to the flotation section.

Regrind

After the ore has passed through the rougher/scavenger flotation process, the ore particles are once again sent through to a cyclone system to separate the ore by sizes. The undersized ones will be sent directly to the cleaner flotation but the oversized ones will be sent to a vertical mill for regrind before returning to rougher/scavenger flotation for subsequence treatments.

Concentrate Thickening

The particles after passing through the cleaner flotation are now called ‘concentrates’. They will be sent through separate concentrate thickening process to remove the free water attached to the particles.

Filter

The concentrates after passing through the thickening process will be sent to a filter system to grade the particles before sending them to the dryer.

Drying

The wet concentrate will be sent through a dryer after filtering and sent to a stockpiling facility ready to be shipped out.

Shipping

After the drying process, the copper concentrates will be loaded onto haul trucks to be sent to a stock yard located on the export wharf area, located on the coast, to be re-loaded onto ships for delivery to market.

The gold and silver concentrate will be sent to a rough refinery on site to be melted and cast into bars before sending to customer for further refining.

The Concentrator Building

The metallurgical processing, to recover concentrates from raw ore, as mentioned above shows that a huge building has to be built to house all those processes. The building is a steel building with wide spans to accommodate the setting arrangements of the processing equipment. However, one of the main challenges presented to the structural engineer is on the design of the roof.

For a project such as the one mentioned above, located in a *humid continental climate* region with very heavy annual snow fall, the snow loading on a large roof will be huge. One concept to overcome this challenge is to design a steep slope and un-insulated roof, relying on the heat generated from the processing equipment inside the concentrator to prevent the snow from accumulating on the roof surface. However, what will happen should the mine be shut down during low commodity prices and shortage on demand? The unheated roof may collapse under heavy snow accumulation. Therefore, the structural engineers must plan well and taking that risk into their design consideration.

The size of this building is so big that an architect from the CSA Team has to study and analyze the fire/hazard safety evacuation planning, to ensure they meet the current Building Codes requirements.

The Concentrator building will be fully equipped with all necessary building services, including:

- Power
- Lighting
- Domestic water supply
- Heating and ventilation
- Sewage disposal
- Fire protection systems
- Communications, and
- Make-up water supply required for metallurgical treatment processes

Associate Facilities Required Supporting the Concentrator's Operations

<u>A Service and Maintenance Shop</u>

A fully equipped Service and Maintenance Shop will also be established besides the Concentrator Building. This shop will have machines, such as: metal lathes and heavy drill presses and other tools required to service and maintain operating equipment at the Concentrator and an electrical shop to service electrical and instrumentation components. A warehouse to store spare parts, supplies and consumables is attached to this facility. This shop will be a large pre-engineered steel building complete with all necessary building services.

A Change House

A Change House, similar in design to the one located on the Mine Operation Compound and located besides the Concentrator Building, will provide locker rooms, washrooms, shower rooms and dry rooms for the peoples working inside the Concentrator during shift changes.

An Administration Building

A fully furnished Administration Building will be located near the entrance to the Concentrator to provide office spaces for the engineering and administrative personnel to work and manage the metallurgical processing operations of the ore. It will also be a 2-story building with a laboratory located on the main floor. This building will be a pre-engineered building complete with architectural finishing and all building services. A parking lot complete with yard lighting and electrified hitch railings will be located in front of the Administration Building.

An Emergency Respond Center

Due to the remoteness of both the mining and concentrator sites, it is important to include an Emergency Respond Center on that area. This facility will include the following:

- A fully equipped and stocked medical first-aid center complete with qualified first-aid attendants and registered nurses in resident
- To handle emergency health safety issues on site including evacuation, if necessary
- An approved Heli-Pad complete with a service hanger and fuel storage to accommodate a helicopter on standby, to assist evacuation when required

This Emergency Respond Center will have direct communication capability with the Emergency Respond Center located on the Export Wharf site. This set up helps to coordinate and to manage any emergency situation happened on either ends.

The Tailings Dams

After the ore went through the Rougher/Scavenger Flotation process, only the 'target minerals' will be extracted and sent for further treatments. Other materials, considered to be not worthy of recovering/waste (known as tailings) will be sent to the Tailings Management Facility for storage.

The Tailings Management Facility consists of two earth-filled dams located in a valley near the Concentrator. The upper dam is designed for storage of the tailings and the lower dam is for controlling of spilling from the upper dam.

The tailings, mixed in with the solution from the flotation cells are pumped to the upper dam for storage through a pipeline. A specially designed floating barge, complete with pumps; sits inside the upper dam pumps and returns the liquid solution to the Concentrator for reuse in the flotation processes.

The Tailings dams are earth-filled dams, built using suitable waste rock/soil materials from the mining operations. Initially, they are built as 'starter dams' and gradually rise in height as the storage of tailings rises/filling up behind the upper dam.

A combined shop and warehouse structure complete with offices and work stations for maintenance and services personnel to manage the equipment on the Tailings Management Systems. Site services, such as power sub-station, domestic water storage tanks and a sewage treatment facility will be required and brought onto the site.

An access road from the Concentrator to the Tailings dams has to be included in the planning to service the dams.

The Main Access Road from the Mine Site to the Inlet

According to the project scenario mentioned above, the actual mine and concentrator site is located approximately 82 Km from a water access point located inside an inlet. As a result, a main access road designed to handle heavy hauls has to be built to connect those two facilities. This Main Access Road will be equipped with two (2) emergency shelters for drivers in case of heavy snow fall. Repeaters for voice communication with the Administration Office on the Concentrator site are also installed along the full length of the road. Run away lanes will be incorporated into the road's vertical alignment, where the gradient is considered too "steep" for winter trips, to provide safe emergency exit for the driver.

The Stockyard

The large quantity of copper concentrates produced at the Concentrator will be transported to a Stock Yard, by trucks, located at a chosen spot besides the Ship Loading Export Wharf at the inlet. The concentrates will be reloaded by a reclaim system and deliver to the ship loaders, by transfer conveyors, to load ships that carry the concentrates to market.

The Stockyard consists of a large open, well consolidated flat area capable of withstanding the weight of the planned stockpile of copper concentrates without excessive settlements. It will be surrounded by a large drainage ditch for storm drainage control. Local drainage ditches are also installed complete with settling ponds to filter the contaminated storm water before discharging into the inlet.

Yard lighting is provided to facilitate 24 hours operations on the Stockyard.

A Ship Loader Export Wharf and General Service Wharf

As mentioned in the project scenario, there is an existing village located at the inlet with approximately 200 residents; the site selected for the ship loading Export Wharf should be farther away (in this case, it is set up at a location 6 kilometers west of the village) to avoid causing unnecessary pollutions and harm to the village and its residents. The pollutions include, but not necessarily limited to:

- Noise
- Lights
- Dust
- Traffic

One of the main criteria on the planning of the Export Wharf is the ability to accommodate the loading of 50,000 ton bulk cargo ships during low tide. Besides having the ship loaders to fulfill its functions, it will also have a General Service Wharf area sitting next to it to serve the operations' needs at the mine, the concentrator and the ship loading facilities. The General Service Wharf will have proper mooring and tie-down slips for large barges/ships to deliver materials, equipment and supplies, either in bulk or in shipping containers. A large crane will be stationed at the service wharf to handle the loading and unloading of goods.

One of the main commodities to be stored at the General Service Wharf is fuels for power generations and for operating equipment. Large field erected steel tanks will be set up on the General Service Wharf complete with berms and liners to control fuel from spilling. A specially designed jetty, complete with pumping systems and fire protection system, will accommodate fuel carrying tankers to off-load fuels into the tanks located on land.

A pipeline complete with several intermediate pumping stations will deliver the fuels from the tank farm on the General Service Wharf to the one located at the Concentrator site. The pipeline will be laid along the inside of the main access's alignment.

Facilities required at the Export/Service Wharf Site

Both the Export and General Service wharfs will require facilities to support their daily operations. These facilities will include:

- A central control house for ship loading operations
- A change house for workers
- A service and maintenance shop
- A warehouse
- A truck shop for concentrate delivery haul trucks
- A tire shop
- A re-fueling station

- An administration building
- An emergency respond center

A Central Control House for Ship Loading Operations

To control the ship loading operations from reclaiming at the Stock Yard to loading the concentrates onto ships, a Central Control House will be located near the ship-loaders so the operators can monitor and control the processes properly, both visually and electronically.

The Central Control House will be a single story steel building completely fit-up with architectural finishing and all necessary building services.

A Change House for Workers

This Change House for the workers operating on the Wharf Site is similar to the one planned and set-up on the Mine Operations Compound, but smaller in size.

A Service and Maintenance Shop

This facility is required on the Wharf Site because of the amount of maintenance and services work required on the equipment located on both the Stockyard and on the Wharf site. It will be a pre-engineered steel building complete with all building services.

A Warehouse

To support the operations of the service and maintenance shop and the Truck Shop, a covered warehouse will be built besides the shop to stock up on parts, spares, tools and consumables. An open laydown area will be provided immediately adjacent to the warehouse to store non-weather sensitive equipment and materials. The warehouse will be a pre-engineered steel building complete with all building services.

A Truck Shop for Concentrate Delivery Hauls Trucks

The finished concentrates are hauled directly from the concentrator's load-out facility to the Stockyard by concentrate delivery hauls trucks. These trucks are much smaller than those huge rock haul trucks at the pit. Often, after they off-loaded the concentrate, they discover that the truck requires services before they can safely return to the Concentrator site. For that reason, a Truck Shop will be set up, not

far from the warehouse, to handle those circumstances. This Truck Shop will also handle services and maintenances on other types of vehicles and mobile equipment used on the Wharf Site.

A Tire Shop

A Tire Shop specially equipped to change or repair tires on the concentrate haul trucks, will also be located besides the Truck Shop to provide those services. Spare tires will be stored in the laydown area.

A Re-Fueling Station

A Re-Fueling station will be set up besides the Truck Shop to re-fill the haul trucks before their return trip to the Concentrator area, if required.

An Administration Building

To manage the operations from the Stockyard to Export Wharf and the General Service Wharf, an Administration Building will be required to house the administrative and engineering staffs working on those sites. It will also serve as the main communication hub between the Mine Administration Office and the Administration Office on the Concentrator site with the outside world because it is located only 6 Km from an existing village with a secured telephone land line. An arrangement can be made with the telephone company to upgrade the existing switching station at the village to meet the needs of the new mine development and to install a new fiber-optic cable from the switching station to the telephone room located inside this Administration Building.

An Emergency Respond Center

Due to the remoteness of the ship loading Export Wharf site, it is important to include an Emergency Respond Center on that site. This facility will include the following:

- A fully equipped and stocked medical first-aid center complete with qualified first-aid attendants and registered nurses in resident
- To handle emergency health safety issues on site including evacuation, if necessary
- An approved Heli-Pad complete with a service hanger to accommodate a helicopter on standby to assist evacuation when required

This emergency respond center will have direct communication capability with the emergency respond center located not far between the mine operations compound and the concentrator site. This set up helps to coordinate and to manage any emergency situation happened on either ends.

TRANSITIONING – FROM STUDY TO PLANNING

The project definitions, as shown above, illustrated the complexity on scope of work for a new mine development and the challenges for the CSA Sub-group to make the project a success.

The CSA Sub-group, learning from past experiences, sets up separate files on each general arrangement to collect information in-puts received from all other disciplines during progress meetings and inter-disciplinary meetings. They have to be patient, because information on process equipment has to come from Vendors. As the pre-feasibility study does not offer a commitment to purchase of the equipment, vendor's interest is not expedient. Yet, the Process Engineers, the Mechanical Engineers and the Electrical Engineers have to have that information to complete their parts of the study before they can pass on their plans to the CSA Group to do their parts – to study and plan the necessary facilities and infrastructures to support the different areas in a totally coordinated approach to be economically feasible. *[Sizes of buildings and equipment foundations requirements]*

Time is of the essence. Since the CSA Sub-group is the last one to receive the engineering decisions from members of the other disciplines, they took a strategy to perform their part by adopting *lessons learned* from past projects and start preparing general layouts for each file while waiting for information. They are prepared to make continuous up-dating to the layouts, where necessary, in order to meet their assigned schedule.

They will start off with the planning of the Main Access Road file and the Employee Villages file which fall into the parameters of their discipline. When they have arrived at a final layout for each of those two general arrangements, they will pass them onto their peers at the Sub-group, to allow them to start with their planning on the required infrastructures.

The Main Access Road

The CSA Sub-group, using the latest topographic maps provided by the Land Surveyors, will study and determine the route alignments of the Main Access Road from the port site to the mine site. When they are satisfied with their plan, they will pass it onto the CSA Sub-group to plan the storm drainage control system, crossings over stream and river, turn-out allowances, locations for communication transmission towers/poles, and the fuel pipeline right-of-way. The CSA Sub-group will also plan the location and facilities for road maintenance and snow removal facilities along the route.

The Main Access Road will be constructed as a gravel surfaced road. It will be 10 meter wide with drainage ditches on both sides where applicable. Cross culverts will be installed at specific locations to handle the storm drainage to prevent washout. Stone rip-raps will be placed at both the culvert's entrance and exit ends to reduce erosion in the ditches. Since the site is located in a region with heavy snow fall, all culvers will come with a piece of re-bar welded onto one end. The purpose of this piece of re-bar is to facilitate the maintenance crew to attach a portable heater onto the re-bar, to warm up the culvert, melting the snow/ice built-up to prevent plugging from inside.

The planned Main Access Road alignments include two major crossings: one crosses a wide stream and another one crosses a small river. The CSA Sub-group planned to use multi-plates heavy duty culverts for those two crossings. For the one crossing at the river, Gabion baskets will be used at the inlet end to train the river and as headwalls structure for the inlet end.

The planning of this Main Access Road will include, somewhere near the middle of the route, a road maintenance shed. This shed arrangement will include a room to accommodate the maintenance crew to rest and/or stay over, a spot to store salt-sand mixtures under a roof and a spot for a grader, a loader and salting truck to park. All those materials and equipment are required to maintain the road surface and for snow removal during the winter months.

Due to the heavy snow fall during the winter months, two more sheds with similar arrangements will be located: one at the concentrator site and the other at the export wharf site. With three crews working at the same time, it will help to clear the Main Access Road faster to keep traffic flowing without delay.

Communication towers, mounted with micro-wave dishes and repeaters, installed along the Main Access Road will provide communication connections between the Concentrator site and the Export Wharf site.

Employee Villages

The Owner planned to build two Employee Villages, one near the Concentrator area and another one near the Wharf area, to accommodate their employees working on the operations of the project.

The CSA Sub-group received instructions from the Study Manager to select the sites and to start their planning based on the specifications provided by the Owner which includes the numbers, unit types, sizes, supporting facilities, etc.

Near the Concentrator area

The Architect, a member of the CSA Sub-group, studies the general topography around the Concentrator area and chose a site located in a valley approximately 2 Km from the Concentrator area for the Employee Village. This site is shielded from noise and lighting from the Concentrator by a range of low hills. The gentle slope of the land offers good storm drainage and has little chance of impact from possible avalanche.

Due to the heavy snow fall each winter, the Architect proposed a series of eight (8), three-story high apartment type buildings to accommodate a total of 400 single status employees working on the Mine and in the Concentrator. These 8 buildings will be of modular type with steep metal roof to allow the snow to slide off. Arctic corridors will connect all 8 buildings leading to a central kitchen/dining facility and a separate building for recreation. Complete catering services will be provided to all residents. A

small commissar is included in the recreation area to provide some basic items for the residents to purchase.

Each suite will be approximately 18.6 square meters in size, fully furnished, complete with a private washroom. A common laundry room is located on the ground floor in each building. A separate central laundry room for oily clothing is located besides the recreation facility.

The Employee Village will be fully equipped with building services:

- Electricity for power, lighting, heating/ventilation/cooling
- Hot and cold domestic water supply
- Fire protection system
- Communications system for phone, internet and TV reception

Locally drilled wells will supply the raw water required for the Village and a water treatment plant to produce domestic water

A modularized sewage treatment to be located in the Employee Village is included in the planning.

A large parking lot complete with electrified hitch railing and yard lighting is also included in the planning. Buses will be used to transport workers to and from work. A service road, approximately 9.0 meter wide connects the Employee Village to the Concentrator area.

Near the Export wharf area

For the Employee Village planned for the employees working on the Export Wharf and General Service Wharf area, the Architect selected a site located approximately 3 Km away where noise and lighting generated from the wharfs operations will be greatly reduced.

On this site, the Architect also plan to have three (3), three-story high apartment type buildings to accommodate a total of 150 single status employees working on the Port

All the building type design and associated facilities are similar to the one on the Concentrator area. All building services will be included in the planning and residents are provided with full catering services.

The Architect also included 24 single family houses, each one measured 72 square meters in size, for senior management staffs that may have their spouses living on site with them. A 15-room Guest House is also included in the planning for visitors to the development.

A small supermarket style shop will be established on site to provide vegetables, meat, and other food stuffs for the household residents. This facility will be managed by the Catering Contractor on-site.

A 9.0 meter wide service road will connect the Employee Village to the General Service Wharf.

PLANNING THE INFRASTRUCTURES TO SUPPORT THE NEW MINE DEVELOPMENT

When the CSA Sub-group received enough information from all other disciplines within the pre-feasibility study team, they begin to conduct in-depth study on their requirements for each facility and to start with planning to up-date their general arrangement layouts in each file.

To support a new mining development project, located in a remote/isolated region without *outside boundary* utilities for connections, the CSA Sub-group knew that there are two (2) main sources of infrastructures that have to be planned from the very beginning. They are:

- Water
- Power

The proposed development has two inter-connected operations: the wharfs and the mine and they are 82 Km apart. That means two separate sets of infrastructures have to be provided to service the need of the two operations.

Water

From the Site Visit Report, they learned that there is a very large fresh water mountain lake located approximately 2 Km from the Concentrator area. Local hunters informed the site visiting team that the lake does not freeze throughout the winter months. So that should provide the source of sustainable raw water supply needs for both operations at the mine and at the concentrator. The Site Visit Report also indicated another smaller fresh water lake located approximately 0.5 Km from the wharf site; which is also a good source of raw water for the wharfs' operations.

Based on that information, the CSA Sub-group begins to formulate a master plan on water supply to meet demands on the project.

<u>The Mine and Concentrator Areas</u>

A large water pumping station will be located and established besides the edge of the large fresh water mountain lake near the Concentrator area complete with a water intake structure extended further into the deeper part of the lake to draw water. The pumping station will deliver the raw water, via 2 steel pipelines, to 4 large surge/storage tanks. These three tanks will be located at a high point near the Concentrator. The raw water from those 4 tanks will flow, by gravity, and distribute the raw water to the raw water storage tanks: three located at the Concentrator area and the other one located at the Mining Operations Compound. Each one of these tanks will serve as the reservoir to provide water services to the operations.

At the Mining Operations Compound, its reservoir will have a 3-ways distribution piping system:

1. To supply raw water to a water treatment plant to produce domestic water required to service: the Change House; washrooms and coffee stations located at each facility on site
2. To supply raw water to feed the fire protection systems at each facility and the fire loop and hydrants around the compound
3. Raw water for the Truck Wash

At the Concentrator area, its reservoirs will have a 4-ways distribution piping system:

1. Raw water to meet the requirements for 'make-up' water
2. To supply raw water to a water treatment plant to produce domestic water required to service: washrooms and coffee stations located at each facility within the Concentrator area; the Change House, and the eye washing stations located inside the Concentrator
3. To supply raw water to feed the fire protection systems at each facility and the fire loop with hydrants around the Concentrator area
4. To supply raw water to the Employee Village for their fire protection system and also water to the water treatment plant to produce domestic water, as required, to service the Employee Village's facilities

<u>The Export Wharf and General Service Wharf Area</u>

The raw water supply system is similar to the one for the Mine and Concentrator areas but to a smaller scale because the demand is smaller with fewer facilities on site.

A water pumping station will be located and established besides the edge of the fresh water lake near the Wharfs area complete with a water intake structure extended further into the deeper part of the lake to draw water. The pumping station will deliver the raw water, via 2 steel pipelines, to 2 large surge/storage tanks. These two tanks will be located at a high point near the Wharf site. The raw water from those 2 tanks will flow, by gravity, and distribute the raw water to the raw water storage tanks: one located at the Wharfs area and the other one located at the Employee Village. These tanks will serve as the reservoir to provide water services to the Wharf operations and the Employee Village.

At the Wharfs' area:

1. To supply raw water to a water treatment plant to produce domestic water required to service: the Change House; washrooms and coffee stations located at each facility on site
2. To supply raw water to feed the fire protection systems at each facility and the fire loop with hydrants around the port area

At the Employee Village:

5. To supply raw water to a water treatment plant to produce domestic water required to service the Employee Village's facilities
6. To supply raw water to feed the fire loop with hydrants around the Employee Village

Power

The region, where the development is located, has proven meteorological records showing that wind farm is a feasible facility to generate 'green, renewable' power to support the operations of heavy industrial type projects. For the purpose of this Pre-feasibility Study, the Electrical Engineers proposed to adopt a *renewable 'green' energy policy* for power supply to all the facilities located in the new mine development.

Realistically, until **all** the mobile equipment, used on a new mine development, can be switched over to 'green fuel' operated type equipment, they are still operating on diesel fuel.

The Study Manager made the decision, in consultation with the Owner, to adopt both 'green' and fossil fuel in this Pre-feasibility Study. On that basis, the CSA Sub-group's scope of study on power will be limited to the planning of a large diesel fuel tank farm to be located behind the off-loading area, on the General Service Wharf. The tank farm will sit on a firm ground covered with liners and with a high berm around the tank farm for spillage control. Large field erected tanks will be installed inside the berm area. A similar fuel tank farm will be located near the Mining Operation Compound.

The Mechanical Engineering Group will plan the infrastructures required to off-load fuel from a large fuel barge berth at the General Service Wharf and the pipelines to deliver the fuel to the tanks at the tank farm. The Material Handling Engineering Group will plan the pipeline and pumping stations required to connect the fuel tank farm at the General Service Wharf site to the one located near the Mining Operations Compound. Their plans include two (2) refueling stations: one located near the tank farm on the General Service Wharf site and the other one located near the tank farm on the Mining Operations Compound to refuel trucks and mobile equipment at each location.

<u>Wind Farm</u>

The Electrical Engineering Group in collaboration with other disciplines will study and make plans on the wind farm installations.

The CSA Sub-group will be responsible for the planning of the steel structures for the power houses, based on the specifications provided by the Electrical Engineering Group. There will be five (5) power houses to be included in the planning. They include:

- One at the Export Wharf site

- One at the Employee Village near the Export Wharf site
- One at the Concentrator area
- One at the Employee Village located near the Concentrator area
- One at the Mine Operations Compound

A properly sized diesel fuel operated emergency generator set together with a diesel fuel storage tank is planned to sit beside each of the 5 power houses to provide essential power supply in case of power failure at the wind farm.

Other infrastructures required to support the operations at the new mine development

After the water and power issues are settled and their planning in progress, the CSA Sub-group begins their study on other infrastructures required to support the operations of the new mine development. They include:

- Sewage collection and treatment
- Wastewater treatment
- Communications systems

Sewage collection and treatment

By law, raw sewage generated from washrooms, coffee stations and especially from Change House facilities have to be collected and delivered to a sewage treatment plant for proper treatment before the effluent can be discharged into waterway. The CSA Sub-group begins their study and planning as follow:

<u>The Mine and Concentrator areas</u>

A network of underground sewer lines is planned at the Mine Operations Compound to collect the raw sewage generated from all facilities on site and drain them by gravity to a large underground holding chamber.

A similar network of underground sewer lines is also planned at the Concentrator area draining the raw sewage by gravity to another large underground holding chamber.

Lift pumps are planned and located at each underground sewer storage chamber to deliver the raw sewage to a large sewage treatment plant located at a point between the two chambers and not far from an existing waterway. The sewage treatment plant will be a multi-stage treatment unit to ensure the effluent meets the legal standards before being discharged. A small laboratory will be included at the treatment plant to sample and test the effluent on a daily basis.

The Employee Village near the Concentrator area

Since this Employee Village is designed to house 400 residents including full catering and recreation services on site, their sanitary sewage discharges will have peak and low periods, based on shift change hours established by both the Mining and Concentrator operations. Therefore, the village will have their own sewage collection systems from each facility leading to a main sewage treatment facility where modular sewage treatment plants will handle the first and seconds stage of treatments before sending the effluent to a sewage lagoon for third stage treatment before discharging the effluent into natural waterways.

The Export Wharf Area

The Export Wharf area, being located on the inlet and far away from the other operations located inland will require a separate set of sewage collection and treatment plan. It will be very similar to the one planned for the Mine Operations Compound.

A network of underground sewer lines is planned to collect the raw sewage generated from all facilities on site and drain them by gravity to a large manhole. From the large manhole, a lift pump will deliver the raw sewage to a sewage treatment plant for treatment before discharging the clear and harmless effluent directly into the inlet.

The Employee Village near the Export Wharf area

This Employee Village is designed to house 150 single status employee, 45 single family housing and a 15 rooms hotel style facility for visitors; their sanitary sewage discharge volume will again be different from the one on the Export Wharf site. Therefore, they will have a similar sewage treatment facility arrangement as the Employee Village up by the Concentrator except smaller in size and capacity.

Wastewater treatment

One of the facilities located at the Mine Operations Compound is a Truck Wash. This facility generates large quantity of wastewater from washing those huge rock haul trucks. The wastewater, contaminated by a mixture of soil and petrochemical product (lubricating oil) is harmful to the environment if discharged directly into a water way. The CSA Sub-group planned to collect the waste water from floor drains into a large pond located besides the Truck Wash. That pond will have 2 un-equal compartments: a larger one for settling the soil particles followed by a smaller one to have the oil in the water to be removed by a floating skimmer pump before the water is returned to the Truck Wash for re-use.

Communications systems

Clear and effective communication is important to all industrial operations. In this case, where the mine is located in a remote and/or isolated area, it is even more important to maintain good communications system between the various operations. The CSA Sub-group meets with a specialist from the region's communication carrier to discuss the various options available. The specialist suggested that:

- Between the mining crew working in the pit, the rock haul truck drivers and the mining administration office, a high, multi-frequency radio system will be used. A separate frequency will be dedicated specifically for use by the blasting gang only, for safety reasons. Another separate frequency will be dedicated for emergency communications
- A specially designed cellular phone system via satellite will be installed near the Concentrator area to provide secured communication between the Mining Operations Compound, the Concentrator and its associated facilities, and the future Employee Village located near the Concentrator area
- Microwave dishes and repeaters mounted on towers/poles will be installed along the Main Access Road connected to a switching terminal installed at the Export Wharf area to provide a communication corridor along the Main Access Road
- The switching terminal will be able to connect to the nearest cellular tower in the region to complete the transmission process. This technology will provide voice, data and internet transmission for the proposed new mine development

A special arrangement will be made with the telephone company that provides land phones to the residents in the existing village to expand their existing telephone terminal and to have a fiber-optic cable installed to connect the terminal to a telephone exchange located at the Administration Building located at the Wharf area. This arrangement will provide reliable and secured communications between the Project and the outside world which is important to the success of the operations.

Fencing and Gates – Site Security and Control

Since the Project is located in an isolated location, on-site security and control is important for the safety of the operations and their personnel. The CSA Sub-group planned to include fencing and gates at each of their operation sites to control unwanted intrusions of wild animals and movements of personnel in and out of the operation areas. Gate house(s) will be incorporated at each location for the security teams to operate and monitor. All gate houses will be fitted up with building services and communications system.

Sea Planes Mooring Jetty

The Project in the scenario mentioned above is located inside an inlet and the only way of access is by sea planes. The existing village has a terminal for sea plane operations, but the Project's operations will overwhelm the capacity of that terminal to properly service their customers.

For that reason, a special jetty designed for sea planes to moor, to off-load and to re-load passengers and goods will be included in the planning, in a location just past clear the Service Wharf.

When the planning is complete, the CSA Sub-group finalizes all the general arrangement files and updated the general arrangement drawings to be submitted as part of their preliminary Pre-feasibility Study Report. At the same time, the engineers will carry out quantity surveying on each general arrangement files to provide the Estimating Group with information needed for budgeting purposes.

CONSTRUCTION MANAGEMENT AND CONSTRUCTION EXECUTION PLANNING

Besides all the engineering planning during the process of the Pre-Feasibility Study, the section on Construction Management and Construction Execution Planning is also a critical part to be included in the final report. It is important to note that in the development of a new Greenfield mining project, the construction budget can take up to at least 60% of the total Capital Expenses. Therefore, a detailed study into the Construction Management component followed by a thought through Construction Execution Plan, complete with a critical path schedule and a realistic budget, are very important parts to be included in the Pre-Feasibility Study Report for all the stakeholders to know.

Construction Management in a Project, such as the one mentioned above, will take four (4) phases:

1. Pre-construction planning
2. Pre-construction mobilization and execution
3. Balance of Plant construction
4. Pre-commissioning and turn-over

Each phase must be very carefully planned before their execution, to make sure that their sequencing and transition are smooth and without 'gaps' or 'conflicts'.

Construction of a Greenfield mining project located in a remote and isolated location is challenging, to say the least. That was the reason why the Construction Specialist was included in the early site visit team, to make sure all physical and natural site conditions were observed and recorded. All that information will be incorporated into the risk register as references for the entire study team to manage and possibility of turning them into opportunities.

The most important topic in the Construction Execution Plan is the Pre-construction mobilization and execution. The Construction Specialist will prepare a draft on a preliminary conceptual schematic diagram for the engineering groups to include into their design – the establishing of a safe and effective pioneer access to site, and an efficient construction wharf to off-load equipment and materials, complete with all temporary site services for pre-construction mobilization. All these activities and costs will be added into and form parts of the Master Schedule and the total Capital Cost Budget Estimate.

FINAL COORDINATION WORKSHOP

When all the disciplines have submitted their preliminary Pre-feasibility Study Report, the Study Manager will organize a final coordination workshop. The purpose of this workshop is to gather the whole study team together with the Owner's team, in one place, to review the contents of all the preliminary reports submitted. One of the themes in this workshop is to feature the 3-D visual presentations prepared by each discipline's Layout Technologists. Those visual presentations will provide the whole team a chance to view the ***whole*** development's layouts with all the facilities planned to support the development's operations; to generate discussions to ensure no gaps are present and that: reliability, accessibility, maintainability, constructability, operability and safety issues have all been taken into consideration in their planning.

It is important to remember, a Pre-Feasibility Study only commits to approximately 6-8% Front End Engineering and the accuracy of the Capital Costs estimates generated from those engineering for the planned development is only +/-24%. Still, the Owner expects a reasonably well planned scheme with the entire project definitions included in the planning.

A detailed Minutes of Discussions will be recorded throughout the workshop and all disciplines will update their planning based on the Minutes before submitting their final general arrangements to the Study Manager for the preparation and compilation of the final Pre-Feasibility Study Report.

TOPICS TO BE INCLUDED IN A PRE-FEASIBILITY STUDY REPORT (A GENERIC SAMPLE ONLY)

- Executive Summary
- Introduction
- Property Location and Description
- Accessibility, Climate, Local Resources, Infrastructure, Physiography
- History
- Geological Setting and Mineralization
- Deposit Types

- Exploration
- Drilling
- Sample Preparation, Analysis and Security
- Data Verification
- Mineral Processing and Metallurgical Testing
- Mineral Resource Estimate
- Mineral Reserve Estimate
- Mining Methods
- Recovery Methods
- Project Infrastructures
- Market Study and Contracts
- Environmental Studies, Permitting and Social or Community Impacts
- Capital and Operating Cost Estimate
- Economic Analysis
- Adjacent Properties
- Other Relevant Data and Information
- Interpretation and Conclusion
- Recommendations
- References
- Signature Page and Certificates
- Appendices and Attachments

PART 3

LESSONS LEARNED

LESSONS LEARNED:

As we can see from the above study's descriptions, planning for the development of a new mine is a very complex and challenging task for the engineers. Both the Owner's in-house team and the Consultant's team have to work very closely together during the study phase in order to achieve the most economical model, through sharing effective and efficient methodologies from Owner's past experiences to make the Project a successful business venture.

Mining:

The methodology to be applied on mining is determined by the size and location of the ore body and its depth below the overburden. In the above described case, the thickness of the overburden layer falls within the economics for an open pit mining operations. Thus, the open-pit mining method was chosen by the Mining Engineer in the study. The Geologists**, assisting the Mining Engineers, will carry out detailed study on rock mechanics to achieve safe designs on slope stability for the mine pit as well as an effective solution to handle mine pit dewatering.

**NOTE: The Geologists involved in the study will include the following disciplines within their group:

- Geo-physics
- Geo-chemistry
- Hydrogeology

Concentrator and Mineral Processing:

The Lead Process Engineer, equipped with detailed information from laboratory on the mineral's grinderbility and floatation test results designs the metallurgical processes to treat the raw ore from Primary Crushing to final Drying before Load-Out and Shipping the concentrate and other by-products to be delivered to customers. The Process Engineering Group will be supported by a number of other engineering disciplines, including:

- Civil
- Structural
- Architectural
- Mechanical
- Material Handling
- Piping
- Electrical – High, Medium and Low Voltages
- Instrumentation and Controls
- Communications
- Other Technology Package Vendors and Suppliers

Tailings Management Facility:

When the raw ore is being processed in the Concentrator, some of the wastes or unwanted materials will be extracted and sent to the Tailings Management Facility for storage and future disposal through a transfer pipeline system. The Civil Engineer will have to plan and design a system of earth-filled dams to contain the Tailings, allow the solids to settle behind the upper dam and the water to be pumped back to the Concentrator to be used as part of the make-up water for the floatation cells. Here again, the engineering becomes complicated and involves several different disciplines including:

- Geo-technical
- Civil/Structural/Architectural
- Mechanical
- Piping
- Electrical
- Instrumentation and Controls

The Civil Engineer will plan the dam system construction in two (2) stages:

1. A starter dam system for the initial start-up operations
2. Raising the height of the dam system in later stages throughout the life of the mineral processing operations

Site Services and Infrastructures to support the Operations of the Mine and Concentrator:

Both the Mine, Concentrator and Tailings Management Facility are located 85 Km inland and in isolated locations, every and all necessary site services and infrastructures have to be planned and provided for, in order to support the operations of those operations.

<u>For the Mining Operations</u>

- Power supply and distributions
- Yard lighting
- Both raw and domestic water supply, including water treatment
- Sanitary sewage collection and treatment
- Fire protection system
- Truck wash facility
- Truck shop – to maintain, service and repair trucks
- Tire shop
- Warehouse and laydown area
- Explosive production and storage yard
- Blasting caps storage facility
- Lunch room

- Change house facility and office complex
- Communications system
- First Aid Trailer
- Core shack
- On site roads

For the Concentrator Operations

- Power supply and distributions
- Site lighting
- Concentrator building
- Both raw and domestic water supply, including water treatment
- Make-up water supply and storage
- Sanitary sewage collection and treatment
- Fire protection system
- Machine shop
- Light vehicles services center
- Warehouse and laydown area
- Lunch room
- Change house facility
- Administration office
- Communications system
- Emergency medical treatment facility
- Heli-pad and maintenance shop
- Reagents and other chemicals storage facilities
- Laboratory - metallurgy
- Solid waste management facility
- On site roads and parking
- Employees village
- Borrow pit(s) to produce rocks, gravel and concrete aggregate
- A concrete batch plant and associated equipment

For the Tailings Management Facility's Operations

- Power supply
- Site lighting
- Domestic water storage and distribution
- Sanitary sewage collection and treatment
- Floating barge to operate return water pumps
- Equipment yard for earth work equipment
- Shop and warehouse
- Communication system

- Lunch room
- On site roads
- First Aid station

Main Access Road:

Ordinarily, people would think of the engineering on the Main Access Road is a simple and straight forward task. However, when it comes to the development of a new mine in a northern region and 85 Km from the Export Port site, the task on engineering the Main Access Road becomes a challenge. During the early exploration stage, the driller will develop a very narrow and winding dirt road to reach the proposed mine site for use by their equipment only.

When it comes to the planning on the ultimate Main Access Road for the Project, the Civil Engineer will have to consider many issues, such as:

- The protection and preservation of existing indigenous relics and historic sites. This means an early detailed study and consultations with local First Nations to identify and mark all those possible sites before the road's horizontal alignment can be finalized
- A good "Mass Haul" study to determine and achieving a balanced 'cut and fill' approach to the road design
- Slope stability study on all 'cut and fill' areas
- Environmental considerations to minimize the unnecessarily cut down of old growth trees
- Safe vertical alignments proviso for heavy haul tracks travel especially during winter and icy road conditions. Run-away lanes have to be considered and included in the planning where the road grades are steep
- Provision of adequate storm drainage along the road alignment with properly designed culvert systems to prevent road washout during heavy rainfall seasons
- Design of bridge(s) and/or large multi-plates culvert(s) to cross over river(s) and stream(s) for heavy haul trucks use, including provisions for river training and bank protection in those locations
- Provision of space on the inside of the roadway to accommodate the installation, servicing and maintenance of the fuel delivery pipeline and the communication pole line
- Provision of "turn-outs" for safe truck passing
- Provision of good and clear road signs along the road alignment
- Establishing road maintenance and snow removal facility along the road alignment to maintain the road surface: regular dust control, regular filling in pot-holes and re-grading, snow removal and de-icing during winter months
- Development of borrow pit(s) to produce and stockpile crushed gravels to maintain a good and safe travel surface for heavy haul trucks

A Port Site for Exporting and Importing Purposes:

All finished product and by-products from the Concentrator have to be shipped to their customers via some form of transportation equipment and associated facilities. Since the Project has no access to such existing facilities in the immediate vicinity of the Concentrator area, the engineers have to plan and include a Wharf site, connected to the Concentrator via the Main Access Road, in the Project scope to accommodate the exporting of the products and importing of goods and materials necessary to support the operations throughout the life of the Project's operations.

The decisions on the selection of a proper location for such a Wharf site are subject to the followings criteria:

Environmental

- Far away enough from existing village/town to avoid issues such as: noise, dust, lights and traffic that cause unnecessary environmental damages and life safety to that community
- Area sensitive to certain marine habitats

Technical

- The proposed Wharf site should have adequate and constant water depth (draft) to accommodate the type and size of ships coming in for loading and unloading without costly dredging operations
- Sedimentation impacts, at the proposed Wharf site, from nearby streams and/or rivers
- Meeting meteorological and oceanographic data such as:
    - Rainfall
    - Wind
    - Squalls
    - Visibility
    - Tidal levels
    - Offshore wave conditions
    - Nearshore wave climate
    - Extreme wave conditions
    - Tidal current regime

Even though the proposed wharf site is located inside a supposed deep water inlet, actual data required for a wharf design is not published and available to public. In order to confirm that the proposed Wharf site mentioned in the Scoping Study Report is the correct choice, the Study Manager invited an engineer from the Marine/Harbor Engineering Consultant to join them at the initial site visit, to carry out a firsthand due diligent at the proposed site location.

The Marine/Harbor Engineer took a number of actions during the site visit. They include:

- Spoke with local fishermen at the village to get their knowledge on the weather and tide conditions at the site

- Arranged a boat with a crew from the village to sail up to the site, taking pictures along the way
- Did some very rough sounding measurements close to the shoreline in front of the site location
- Walked the beach along the site to get a firsthand impression on the existing ground conditions
- Spoke with the sea-plane pilot to get information on weather conditions in the area

Immediately after the site visit, the Marine/Harbor Engineer collected as much other meteorological and oceanographic data from government agencies on and near the site area to map a base case for the study. He also submitted a request to the Study Manager for the following:

- A preliminary Bathymetric Survey in front of the site
- A couple of bore holes at the sea bed to obtain basic geotechnical information on existing soil classifications and characteristics

Once these two parcels of information are available, they can start with their technical reviews and planning on the pre-feasibility study.

Employee Villages:

When the Project reaches the stage of operational readiness, it will require a large team of operators, service and maintenance personnel and administration staffs to work onsite to learn the operational processes and to manage the business. Since the Project is located in a remote area (85 Km inland), an Employee Village built to provide comfortable accommodations to the employee is important and essential. On that basis, an Architect on the CSA Sub-group was assigned to prepare a basic plan and some schematics sketches to allow the team to arrive at a reasonable budget estimate to be included in the Capex calculations.

The scope of works in this proposed Project is a complex one. A smaller part of its operation is on the inlet side while the major part is located 85 Km inland. The Project is also located on a region with heavy snow fall in the winter seasons. As a result, the Architect proposed a two (2) separate Employee Village scheme to be included in the Project's scope of works:

- Village One – a large village located near the Concentrator site
- Village Two – a smaller village located near the Wharf site

Village One:

It is a large village with capacity to house 400 employees working on the Mine, the Concentrator, the Tailings Facility and part of the Main Access Road maintenance. This village will be designed, mainly catered to single status employees due to its location and harsh environment. This village will be fully self-contained with all the site services provided. It will be located about 2 Km from the Concentrator area and connected to the Concentrator with a good and safe access road. Such a location will provide

the residents with the feeling of being away from their work area and with reduced pollutions from noise, light and dust. Good catering services will be provided to all residents complete with a well-equipped recreation center for their use. A high quality communication system will be installed on site to provide access to TV, internet and cell phone services. A well-equipped health clinic is also included near-by to provide treatments and emergency evacuation if necessary. Buses will be used to deliver majority of employees to and from work.

Village Two:

This is a smaller village with capacity to house 150 employees working on the Export Wharf site. It will have three types of accommodations available:

- 150 rooms for single status employees
- 45 single family housing for married employees, and
- A 15 room hotel style facility for visitors

This village is intended to provide accommodations to employees working on the Wharf's operations and some of those employees working on the Main Access Road maintenance program. It will be located approximately 3 Km away from the Port site, on a fully serviced lot, to avoid pollutions such as noise, lights and dust generated from Port Operations. It also provides an impressions of being close to an existing community and yet far away enough without creating an overwhelming feeling to the residents living in the existing village. This village will also provide full catering services and recreation facilities to the residents. They will also have full access to a good communication system to connect with the outside world. A fully equipped health clinic and a supermarket are also incorporated into the planning.

Pre-Construction Works Program – A Construction Wharf

In general, many of the Greenfield mining projects are located in isolated and/or remote areas. As a result, construction of those projects becomes really challenging to manage. The project scenario used as example in this discussion paper is no exception. For that reason, the Construction Specialist together with an engineer from the Marine and Harbor discipline had to visit the site before the Project's kick-off; to obtain a clear and precise view of the sites and to gather as much information on both their physical and natural conditions, so they can prepare a good report for the engineering teams and the logistic team to refer to, and as basis for their Pre-construction works planning.

The Construction Specialist in this study team is a seasoned senior construction manager with many years of working on mining projects – in both new developments and up-grading ones. In his Pre-Construction Planning submittal, he requested that before the project mobilizes, the following should be planned and developed. They are:

- Two (2) pioneer access ramps to accommodate landing crafts to off-load medium heavy construction equipment to land on shore to develop the borrow pit, to build roads and laydown areas on site
- A pioneer access ramp to accommodate passenger boats to off-load and re-load workers arriving and returning from works. These workers live on a floating camp anchored near by
- A borrow pit to produce stones, gravel and concrete aggregates as soon as the construction and crushing equipment can be delivered (assuming the proposed pit is located inland)
- A temporary jetty to allow the mooring of a power generation barge and a fuel barge required to generate temporary power for the Wharf site
- A permanent jetty for the mooring of large fuel deliver barge/ship complete with piping and pumping system to deliver fuel to field erected tanks located on shore
- A permanent jetty for the mooring of large barges/ships to deliver heavy construction equipment and materials. This jetty will be designed to handle RO-RO deliveries of mobile equipment
- A permanent jetty for float plane tie-down as float planes are used to deliver and pick-up workers including light cargoes for this Project
- A permanent jetty fully equipped for the delivery of cement in bulk. A 6,000 tons capacity cement silo complete with a facility to generate dry compressed air attached to the silo
- A ready-mix concrete batching plant capable of producing 80 cu. meters per hour to be installed besides the cement silo

All these facilities will take time to design, procure and install. Until all these facilities are in place, forming a well thought through construction wharf, pre-construction mobilization cannot proceed efficiently. These facilities are also costly to build. Therefore, a budget for these works has to be estimated and incorporated into the overall Capital Cost Budget Estimate.

All those permanent facilities will be designed in such a way that they can be incorporated into, forming parts of the Service Wharf.

PART 4

CONCLUSIONS

In conclusion, we come to learn that planning the development of a new Greenfield mining project is a difficult, complex and very expensive venture that carries high risks due to so many internal and external influencing factors.

Difficult

Mining projects are usually located in isolated and difficult areas. Because of those particular reasons, the physical and natural conditions at the site location post huge challenges to the engineers on planning those projects to make them economically feasible to develop. Many projects, even though they have proven to have good size reserves may not be economically feasible to develop due to lack of access to ports to export the products. For example:

> *Five mining projects with good proven reserves located within the same region could not proceed due to the lack of an export port facility. Building a new port individually is extremely expensive.*
>
> **Solution:** The author proposed to them to raise capital, jointly, and apply to the government to build an export port together, at the nearest coast location, complete with a properly designed stockyard to ship their product to their clients.

Complex

All mining projects are complex by design due to the processes from extraction to metallurgical treatments before the product can be shipped out to an export port equipped with a large stockyard and a deep draft to handle the off-loading onto Panamax size bulk carriers. The requirements of on-site services, facilities and infrastructures necessary to support the project's operations are huge as shown in the above discussions.

Expensive

The development of a new Greenfield new mine is very costly. Besides the capital expenditure costs on all the production equipment and the facilities to house them, the project also have to include the development of at least one employee village at/near the production site to house all the operators, engineers, scientists and administration personnel. The reasons for such village(s) are mainly social issues. The project will require approximately 400 – 500 peoples working on site. The project's location and environment do not offer favorable living conditions for permanent residents in existing community. As a result an alternative location has to be considered. From a good corporate citizen's point of view, the project should not be a cause of social issues to the nearby existing community with a sudden addition of 400 – 500 people arriving and overwhelming the peace and quiet lives of the community.

A project, as described above, would have to have two villages, one at the mine/concentrator site and the other on the wharf site. Each village will have to have municipal services to service the village(s). To build all those site services facilities and infrastructures from scratch are extremely expensive and time consuming. Large amount of pre-construction works including many temporary facilities such as:

- Power supply – temporary power generation
- Fuel supply, storage and dispensing to support power generation. To date, there is no simple clean/green power generation equipment available for temporary power supply purposes
- Temporary water supply, both raw and domestic
- Temporary sewage treatment
- Pioneer camp and catering services followed by temporary construction camp and catering to last through the entire construction period
- Pioneer access and temporary off-loading facility, including temporary laydown areas
- Logistics on deliveries of materials and equipment required to build all the permanent facilities

Mining projects, such as the one mentioned above, are usually located in isolated area and often without any existing facilities or infrastructures to support its development program. Everything required to develop the project has to start from scratch, especially on initial access issues. A new mining development project requires huge amount of equipment and materials to build and to operate. The primary access(s) to deliver all those equipment and materials becomes a challenge to the execution of the project. Some of the equipment is huge in size and very heavy. Therefore, a carefully and thought through planning to create a pioneer construction access facility (such as a well planned construction wharf for the project mentioned above) during the study phase is a must in order to be cost effective and easy to accomplish.

Risks

Development of a new Greenfield mining project carries many risks, for example:

- Permit approvals by government agencies – a new mine development requires many different types of permits from government agencies ranging from environmental assessment to accesses to construction. In some cases, the government's approval can be challenged by local environmental groups causing long delays
- The worst case scenario happened in the Province of British Columbia back in 2007 when a group called 'Mine Watch' challenged the Federal Government's approval of the environmental in court and won. As a result, a total of seven (7) new mine developments were suspended indefinitely pending further reviews. One of the projects had already purchased $18,000,000.00 worth of long delivery process equipment and construction of the main access road was also in progress. That delay resulted from that judgement eventually brought that one developer to bankruptcy

- Commodity prices vary from time to time. Many outside factors can have influences on the commodity planned for the project resulting in either abandoning or keeping the project on the book as part of the company's reserve
- Economic environment may cause difficulty raising financing for the project. Investors' mood have major impacts on the financial market
- Geo-political and/or political uncertainty/unrest in some places where the mines are located
- Other risks beyond the developer's control

Therefore, many new mining projects took years to study and re-study and never brought to conclusion that the project is feasible.

PART 5

EXPERIENCES ON MINING PROJECTS

PROJECT	OWNER
CONSTRUCTION OF MINING FACILITIES	
Copper concentrator and support facilities in Stewart, BC	Newmont Gold Corp
Re-open and upgrade 12,000 tons per day molybdenum mine, tailings management facilities and town-site, Kitsault	Amex Corporation
Asbestos mine expansion in Cassiar, BC	Cassiar Asbestos Corp
Concentrator and leach pads for Rain Gold Mine in Nevada	Newmont Gold Corp
Upgrading of concentrator at Gold Bar Mine in Nevada	Atlas Precious Metals
Ruby Creek Molybdenum Mine, Atlin, BC	Adanac Molybdenum Corp
Ona Phosphate Mine and supporting facilities in Florida, USA	Mosaic Phosphates
Allan Potash Mine major shut down in Allan, Saskatchewan	Potash Corp of Canada
Legacy Potash Mine (solution mining) Bethune, Saskatchewan	K + S Potash Canada

PROJECT STUDY (SS, PFS, FS) AND PROJECT EXECUTION PLANNING

Meekatharra Gold Mine Project in south Sumatra, Indonesia

Simandou Iron Ore Project in Guinea, West Africa

Potash One Potash Mine Project in Bethune, Saskatchewan, Canada

Burr Potash Mine Project near Saskatoon, Saskatchewan, Canada

Isua Iron Ore Project in Greenland

Donlin Creek Gold Mine Project in Alaska, USA

Detour Lake Gold Mine Project, Northern Ontario, Canada

Izok Lake Zinc Mine Project, Northwest Territories, Canada

Kvanefjeld Uranium and Rare Earth Project, Greenland

Baffin Lake – Mary River Iron Ore Project, Nunavut, Canada

Resolution Copper Mine Project, Arizona, USA

Arturo Gold Mine Project, Nevada, USA

Blackwater Gold Mine Project, British Columbia, Canada

Yanacocha Gold Mine Waste Water Treatment Project, Peru

Bell Mine Waste Water Treatment Project – post-mining environmental management facility in Grinnell, British Columbia, Canada