

3 Eagle Project Geology

Appendix C contains a report by Rossell and Coombes (2005) that describes the regional Precambrian geology and geology of the Eagle deposit. The EIA contained in Volume II of this *Mining Permit Application* provides a detailed description of the Quaternary geology and hydrogeologic characteristics of the local Precambrian and Quaternary formations relevant to the assessment of potential environmental impacts. Appendix C also contains geotechnical reports prepared by Golder Associates Ltd. (2005a and 2006) that present detailed analyses on the geotechnical characteristics of the bedrock conditions at the site relevant to the design and stability of the underground mine workings and prevention of surface subsidence.

4 Mining Plan

This section contains information presenting the proposed mining operations pursuant to R 425.203, including descriptions of general mining activities, surface and underground facilities and the overall mining plan. In reviewing the figures in this document, the reviewer will notice that both English and Metric units are used to describe units of measurement. The site plan is in UTM Zone 16 coordinates in meters. Thus planimetric elevation and horizontal coordinate appears in metric units of meters. Additional data with respect to topography and certain engineering details have been converted and/or presented in more common English units.

4.1 Project Development

The Eagle Project development will include surface and underground facilities required for the mining of the ore body. Figure 4-1 is an existing conditions map showing the location of the surface facilities and ore body. Figures 4-2 through 4-3 show the proposed Eagle Project surface facilities on a planimetric map and aerial photograph. The total surface area required for the project development is approximately 145 acres (fenced facility boundaries and access road). The project facility area (disturbed area) as shown on Figure 4-1 is approximately 92 acres. The location of the surface facilities was selected based upon:

- ♦ Proximity to the ore body,
- ♦ Minimizing disturbance to sensitive surface features and water bodies,
- ♦ Minimizing visual impacts from local roads,
- ♦ Accessibility to county and state roads, and
- ♦ Maintaining the natural topographic configuration of the property during operations and post-reclamation periods.

The proposed Eagle Project site includes the following facilities collectively referred to as the mine site.

- ♦ The main surface facilities that support the mine operation are located in the NW ¼ of Section 12, T50N, R29W and include the following:
 - Assay Lab
 - Maintenance Shop and Compressor Plant
 - Generator Plant
 - Propane Storage and Mine Air Heater
 - Laydown Area for Mining Supplies
 - Contact Water Basins # 1 and # 2 (CWBs)
 - Non-Contact Water Infiltration Basins # 3, # 4 and # 6 (NCWIBs)
 - Loading Dock/Warehouse
 - Emergency Response Facility
 - Fuel Storage Area
 - Temporary Development Rock Storage Area (TDRSA)
 - Coarse Ore Storage Area (COSA)
 - Crusher Ramp, Crusher, Conveyor and Crushed Ore Storage Bins
 - Mine Portal
 - Septic System
 - Mine Dry/ Office Buildings
 - Wastewater Treatment Plant (WWTP)

- Treated Water Infiltration System (TWIS)
 - Potable Water Supply Well
 - Non-Potable Water Storage Tank
 - Visitor and Employee Parking Area
 - Truck Wash
 - Truck Scale
 - Gate House
 - Access Road
 - Construction Staging Area
 - Soil Stockpile Area
 - Storage buildings for explosives
- ◆ The backfill facility located in the NE ¼ of Section 11, T50N, R29W includes the following:
 - Covered Aggregate Raise and Feed Hopper
 - 110-ton Fly Ash Silo
 - 110-ton Cement Silo
 - Aggregate Storage Area
 - Aggregate Raise
 - Lined Binder Borehole
 - NCWIB # 5
 - Exhaust Fan Housing

The ore body is located in the N½ of Section 11, T50N, R29W. Total rock excavation including mineable resource and development rock is estimated at approximately 4,100,000 tonnes.

Except for the water treatment facilities, the entire project development from construction through operations and closure is expected to take approximately 11 years depending on ore production rates. Closure of the WWTP will occur in year 17. The overall project timeline is presented on Figure 4-4.

4.1.1 Schedule for Construction

The schedule for the major activities involved in surface construction and underground development will take approximately 2 years. This schedule brings the mine on line in year 2 with full mine production occurring in year 3. The major construction activities for the Eagle Project are as follows:

Phase 1 Surface Facilities Construction

- ◆ Construction of perimeter fence;
- ◆ Preparing the construction staging area and soil stockpile areas;
- ◆ Clearing, grubbing and stripping and stockpiling of topsoil;
- ◆ Construction of the mine site access road;
- ◆ Construction of the TDRSA;
- ◆ Construction of the WWTP;
- ◆ Construction of CWBs #1 and #2;
- ◆ Construction of the TWIS, and
- ◆ Construction of the NCWIBs.

Phase 2 Surface Facilities Construction

- ♦ Construction of the generator plant and installation of the generators;
- ♦ Construction of the compressor plant and installation of the compressors;
- ♦ Construction of the maintenance shop, warehouse and office buildings;
- ♦ Construction of the COSA;
- ♦ Improvements to Triple A Road and CR 510;
- ♦ Construction of the surface crusher, crusher ramp and dump, conveyor and crushed ore storage bins;
- ♦ Construction of surface backfill system facilities and power line to the generator plant; and,
- ♦ Construction of miscellaneous remaining facilities, including the truck wash, scales, and fuel storage area.

Subsurface Facilities Construction

Figure 4-5 shows an overall cross-section of the underground mine workings. The sequential order of subsurface facilities construction will include:

- ♦ Constructing the portal, established at approximate 444 m (meters above MSL).
- ♦ Constructing the main decline from surface to level 263 m,
- ♦ Constructing the backfill plant and lower levels of the main exhaust rise,
- ♦ Developing the main exhaust raise from the surface to the 263 m level,
- ♦ Developing the main decline from the 263 m to the 143 m level,
- ♦ Developing the 248 m level exhaust drift,
- ♦ Developing the 233 m, 203 m, 188 m, 173 m and 143 m level drifts,
- ♦ Constructing the aggregate raise and cement boreholes,
- ♦ Installing the emergency escape elevator,
- ♦ Developing the sump and pump stations at the 188 m and 143 m levels,
- ♦ Developing the interlevel return air raises below the 263 m level.

4.1.2 Operations Production Rates and Mining Methods

The selected mining method proposed for the Eagle Project consists of 30 m (~98 ft) high by 10 m (~33 ft) wide and 15 m (~49 ft) high by 10 m (~33 ft) wide blasthole stoping. The length of the stope is based upon the ore cut-off grade. A small portion of the ore deposit may be mined using the blind bench mining technique. This method will be used to recover small high-grade zones outside of the designed blasthole stopes. The key criteria considered in the selection of the mining methods are as follows:

- ♦ Use bulk-mining methods to maintain maximum productivity;
- ♦ Maintaining high recovery rates of high grade ore;
- ♦ Minimize overall dilution rates due to the cost associated with transportation of crushed ore off-site for processing;
- ♦ Use a mine and backfilling process that is planned and designed to eliminate any measurable surface subsidence.

Based on an evaluation of the stope sequencing, a nominal production rate of 2,000 tonnes per day (t/d) is expected. The estimated annualized production rates are presented in Table 4-1.

Table 4-1
Annual Production Schedule

Facility Development Year	Operating Days	Annual t/yr	Daily t/d
2	63	66,024	1,048
3	251	457,271	1,822
4	250	499,982	2,000
5	250	500,000	2,000
6	250	503,862	2,015
7	251	502,000	2,000
8	250	501,287	2,005
9	250	389,027	1,556
Totals	1,815	3,419,453	1,884⁽¹⁾

g/t = grams per tonne, t/yr = tonnes per year, t/d = tonnes per day

Source: Adapted from McIntosh Engineering

⁽¹⁾ 3,419,455 t/yr/1815 days = 1883.9 t/d

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Checked by: JOS1

4.1.3 Employment Schedule

The projected personnel requirements during operations are based on an operating schedule of eleven hours per shift and two shifts per day. It is estimated that the mine will operate about 250 days per year considering holidays and snow days. On-site personnel requirements during operations are expected to begin at about 87 employees during the initial year of production with an anticipated increase to about 110 employees at full production. Table 4-2 shows the maximum expected number of employees for the Eagle Project for various professional classifications.

Table 4-2
Projected Employment

	Mining	Clerical/Accounting	HR	HSE	GM	Total
Salary	24	7	2	10	2	45
Hourly	65	--	--	--	--	65
Totals	89	7	2	10	2	110

HR – Human Resources

HSE – Health Safety and Environment

GM – General Management

Source: Adapted from McIntosh Engineering

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Checked by: JOS1

4.2 Development Activities

Surface activities associated with the mine development include stripping and stockpiling of soils, and development of the TDRSA, CWBs, TWIS, and other surface facilities.

4.2.1 Topsoil Stripping, Stockpiling and Stabilizing

The initial construction activities for the surface facilities will in general consist of the following:

- ♦ Installing erosion control devices such as siltation fences;
- ♦ Where necessary for facility construction, removal of marketable timber by a contractor;
- ♦ Removal of remaining trees and brush that will be chipped and stockpiled on-site for use in landscaping and reclamation of the mine site;
- ♦ Grubbing of roots and stumps that will be chipped or burned on-site;
- ♦ Stripping of the upper organic soil horizons (topsoil) from the area for reclamation, and
- ♦ Stockpiling and stabilizing the topsoil for later use in site landscaping and reclamation.

Based on the soil borings completed on the mine site, the average topsoil thickness is approximately three inches. The quantity of topsoil to be stripped from the site is estimated at approximately 28,600 cubic yards (yd³).

The clearing, grubbing, topsoil stripping and stockpiling will be completed using conventional earth-moving equipment such as bulldozers, scrapers, graders and off-road trucks. Topsoil will be stockpiled in a controlled manner in the topsoil stockpile area. Topsoil and other soil stockpiles will be surrounded by silt fencing or similar erosion control devices to prevent soil erosion. In addition, topsoil stockpiles will be seeded with a Michigan Department of Transportation (MDOT), 2003 Standard Specification for Construction (MDOT, 2003) Temporary Seed Mixture 24+ (TSM 24+). TSM 24+ includes a 50/50 mixture of Perennial Ryegrass and Spring Oats. The rye and oats will quickly establish vegetation on the stockpile(s) and mitigate soil erosion and dusting until the topsoil is needed for site reclamation.

4.2.2 Facility Grading Plan

Upon completion of clearing and grubbing the area will be roughly graded as shown on Figure 4-6. The grading plan was designed to separate surface water runoff into zones for the main operations area and non-contact areas. The main operations area is the area of the facility that would be directly affected by mine activities. As such, storm water runoff from these areas will be collected in the CWBs. Non-contact areas are those areas which are not affected by mining activities associated with ore and development rock handling activities. Storm water runoff from these areas will be routed to the NCWIBs as shown on Figure 4-2. After rough grading is completed excavation for the TDRSA, CWBs, NCWIBs and other structures will be completed.

4.2.3 Excavation, Stockpiling and Earthwork Balance for Surface Structures

The preliminary earthwork balance is based on the design of the primary environmental protection structures that include the TDRSA, CWBs, NCWIBs and the TWIS. Note that grading for the other buildings and structures for the Eagle Project is considered incidental since these structures will, for the most part, be constructed at grade. Also, excavated rock during the mine development is not included in the earthwork balance since development rock will be temporarily stored in the TDRSA and eventually used as backfill in the mine stopes.

Table 4-3 provides the earthwork balance for the facility construction as displayed on Figure 4-2. The cut needed to prepare the grades for the major facilities will be used to cover the TWIS and construct the soil berms. Excess soil from the site development will be placed in berms around the facility as shown on Figure 4-2. The soils placed in the berms will be used during the reclamation phase to return the mine site area to the reclamation grades. Also, if building and other structures need fill for the final design grades, this material can be removed from the stockpiled berms.

Table 4-3
Earthwork Balance

Structure	Cut (-) ⁽¹⁾(yd³)	Required Fill⁽²⁾ (+) ⁽¹⁾(yd³)	Net (+/-) ⁽¹⁾(yd³)	Comments
Stripping/Stockpiling				
Topsoil	28,600 ⁽³⁾	11,400	+17,200	Refer to Note #3- Excess topsoil will be stockpiled
CWB #1 ⁽⁴⁾	28,800	1200	+27,600	--
CWB #2 ⁽⁴⁾	28,800	1200	+27,600	--
NCWIB #3 ⁽⁴⁾	15,700	1200	+14,500	--
NCWIB #4 ⁽⁴⁾	8,500	800	+7,700	--
NCWIB #5 ⁽⁴⁾	4,800	700	+4,100	--
NCWIB #6 ⁽⁴⁾	1,300	400	+900	--
TWIS ⁵	-----	29,800	-29,800	Five foot cover over infiltration piping
TDRSA	134,800	2,600	+132,200	--
Berms	-----	202,000	-202,000	See Figure 4-2
Total	251,300	251,300	0	

Notes:

CWB- Contact Water Basin

NCWIB- Non-Contact Water Infiltration Basin

TDRSA- Temporary Development Rock Storage Area

TWIS- Treated Water Infiltration System

⁽¹⁾ Cut, Fill and Net volumes are in cubic yards. Multiply cubic yards (yd³) by 0.7646 to get cubic meters (m³)

⁽²⁾ Cut/Fill volumes are rounded to the nearest one hundred yd³.

⁽³⁾ Topsoil quantity assumes an average of three inches across the mine and surface backfill sites. Also assumes that 40% of the total quantity will be used on-site during construction to revegetate the disturbed areas.

⁽⁴⁾ Assumes that CWB and NCWIB include a two-ft high berm around their perimeters, except the inlets, to prevent surface water run-on.

⁽⁵⁾ Five feet of cover soils placed over TWIS distribution piping.

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4.2.4 Development Rock Excavation and Storage

Prior to extraction of the ore, KEMC must remove rock from portals, drifts, raises, and ramps that are developed to access the ore body. This rock is referred to as development rock.

Excavation of the subsurface mine facilities begins at the mine portal located on the west side of the rock outcrop as shown on Figure 4-2.

Development rock excavated to access the ore body will be hauled to the surface using low-profile haul trucks and placed in the TDRSA and amended with limestone. Table 4-4 lists the estimated quantities in metric tons (tonnes) of development rock that will be produced during mine development and mining. Column 7 – *Backfill Rock Balance* – lists the annual rock balance based upon the backfill requirements for development rock. Excess development rock will be stored in the TDRSA for approximately 7 years. For the first 3 years of facility development, no stope backfilling is planned or required due to the sequential primary/secondary stope backfill plan which will maintain mine stability during this period. The peak tonnage of development rock to be stored in the TDRSA occurs in year 3, totaling 378,914 tonnes. Beginning with year 4, stored rock in the TDRSA will be reduced with mine backfilling.

Table 4-4
Annual Development Rock Balance – Tonnes

(1) Facility Development Year	(2) Excavated Development Rock	(3) Underground Road Bed Requirements	(4) Subtotal Development Rock Balance	(5) Cumulative Totals	(6) Secondary Backfill Requirements	(7) Backfill Rock Balance ⁽¹⁾ (Col 7 + Col 4 – Col 6)
1	147,557	2,819	144,738	144,738	0	+144,738
2	178,359	3,796	174,563	319,301	0	+319,301
3	60,462	849	59,613	378,914	0	+378,914
4	72,811	840	71,971	450,885	143,599	+307,287
5	45,047	712	44,335	495,220	111,092	+240,530
6	63,171	1,295	61,876	557,096	189,435	+112,971
7	79,872	1,712	78,160	635,256	146,409	+44,722
8	22,055	475	21,580	656,836	136,496	-70,194
9	6,591	88	6,503	663,339	209,388	-273,079
Totals	675,925	12,586	663,339		936,419	-273,079

Source: Adapted from McIntosh Engineering

1 tonne (metric ton) = 1.102 ton (short ton)

⁽¹⁾ Backfill deficit will be supplied by importation of aggregate

Prepared by: REM

Checked by: JOS1

4.2.5 Geology and Ore Resources

The Eagle nickel-copper sulfide mineralization is hosted in a 480-meter long, east-west-trending, ultramafic body which intrudes Proterozoic siltstones, sandstones, greywackes and slates. These sediments dip shallowly to the northeast and have been thermally metamorphosed in a 2-meter to 10-meter aureole around the ultramafic. Sediment-intrusive contacts are reasonably sharp and regular.

The intrusive is predominantly peridotite, dips sub-vertically or steeply northwards and is covered by unconsolidated fluvial-glacial till and outwash. It tapers from 100 m (~328 ft) wide at surface to a 5 m (~16 ft) to 10 m (~33 ft) wide dyke at the base. No major faults have been identified that offset the intrusive. Oxidation is negligible and primarily confined to a few tens of meters below the Quaternary sediments. A 3D representation of the deposit is shown in Illustration 4-1.

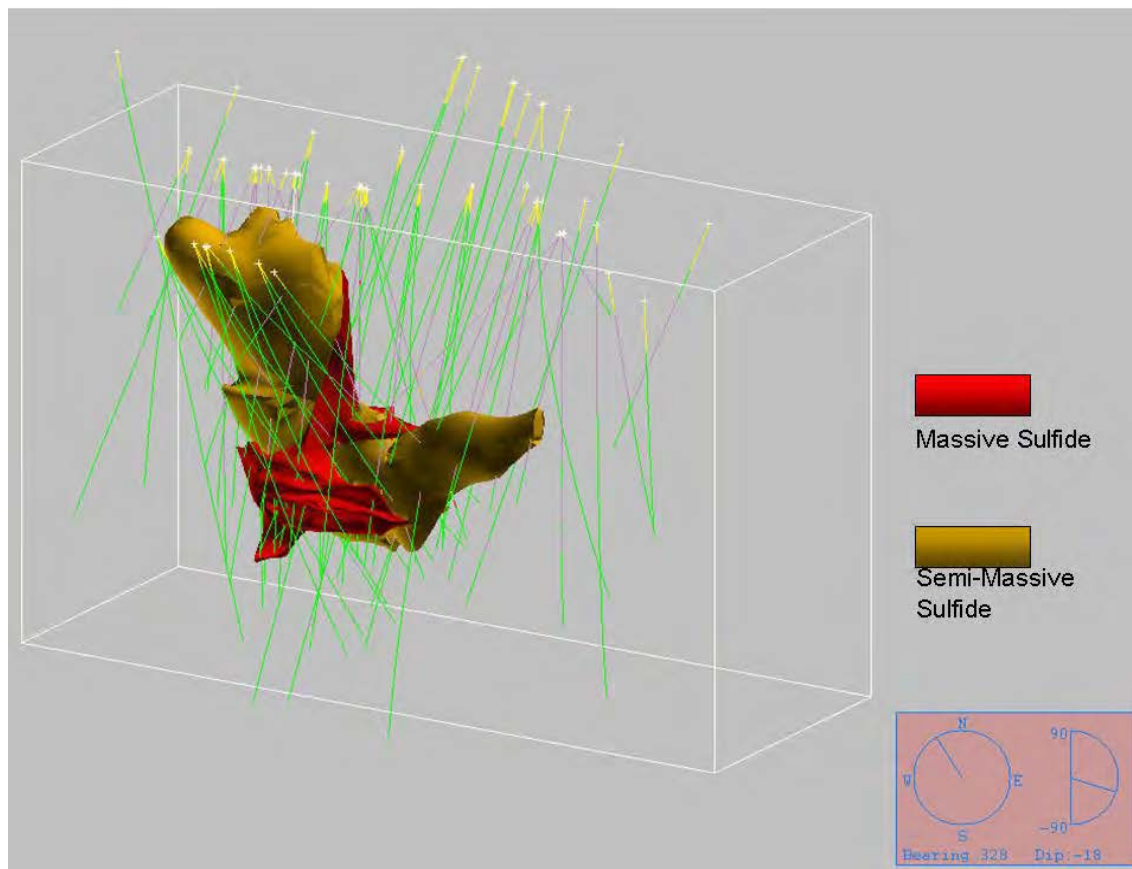


Illustration 4-1
3D Representation of the Section through Deposit looking North

Source: Kennecott Minerals Company.

The sulfide mineralization is divided into massive (>80% sulfide), semi-massive (30-80% sulfide) and disseminated (<30% sulfide) types. The massive sulfide and semi-massive sulfide are distinct phases of mineralization.

The geologic resource model is based on information from exploration drill holes, and uses separate wire-framed bodies for the massive sulfide, the semi-massive sulfide and the ultramafic intrusion. Metal grades and densities were interpolated using an inverse-distance-squared (IDS) averaging routine. The total geologic resources based upon this modeling are shown in Tables 4-5 and 4-6. The projected mineable resource as presented in Table 4-1 is 3,419,453 tonnes which is approximately 42% of the total geologic resource (peridotite) and approximately 84% at the massive and semi-massive sulfide units.

Table 4-5
Geologic Resource by Zone

Zone	Tonnes (million)	Cu %	Ni %	Au g/t	Co g/t
Massive Sulfide	1.477	4.15	6.11	0.32	0.17
Semi-Massive Sulfide					
Western Zone	1.914	2.33	2.09	0.28	0.05
Eastern Zone	0.659	1.80	2.18	0.23	0.06
Total Semi-Massive Sulfide	2.573	2.19	2.12	0.27	0.06
Total MSU and SMSU	4.050	2.91	3.57	0.28	0.10
 Peridotite	 8.064	 0.41	 0.54	 0.05	 0.02

g/t = grams per tonne, % = percent
Source: Kennecott

Prepared by: REM
Checked by: JOS1

Table 4-6
Geologic Resource by Class

Class	Tonnes (million)	Cu (%)	Ni (%)	Au (g/t)	Co (%)
Indicated	3.585	3.00	3.75	0.29	0.10
Inferred	0.465	2.20	2.21	0.22	0.06
Total	4.050	2.91	3.57	0.28	0.10

g/t = grams per tonne, % = percent
Source: Kennecott

Prepared by: REM
Checked by: JOS1

4.2.6 Geochemistry of Ore, Waste Rock and Peripheral Rock

A detailed description of the geochemistry of the Eagle deposit is provided in the Eagle Project Phase I and Phase II geochemistry reports prepared by Geochimica, Inc. (2004 and 2005). Copies of these reports are provided in Appendix D. Descriptions of the geochemical analysis of the water pumped from the mine and TDRSA during operations, and post-reclamation underground water quality in the reclaimed mine are also provided in Appendix D.

4.2.7 Plans to Limit Access to the Facility

Access to the facility will be limited by the following design features:

- ♦ The Eagle Project surface facilities will be surrounded by a 8-foot high chain link fence.
- ♦ A single access road is proposed for the main surface facility that is gated and has a gatehouse manned during facility operation.

- ♦ The main surface facility is obscured from view by a tree covered rock outcrop and other tree covered areas;
- ♦ The excess soil berms constructed around the majority of the facility will further obscure the facilities from view and restrict site access.

4.3 Surface Facilities and Operations

The surface facilities required to support the mining operations are shown on Figure 4-2 and are discussed in the following sections. Figure 4-6 shows the pre-construction-site grading plan for the surface facilities. Additional surface facilities may be added during operations if required to support mining or other operational needs.

4.3.1 Site Access, Parking and Roads

Access to the Eagle Project will be via Triple A Road. The main access road will be surfaced with gravel for all-weather use. Entrance to the mine facilities will only be permitted through the main entrance gate as shown on Figure 4-2. At the main entrance will be a gate house with visitor parking. Employee parking is provided adjacent to the office/mine dry building.

On-site access to the surface facilities will be provided by all-weather gravel roads. Construction of access roads will be conducted using road grading equipment such as scrapers and dozers. Initially trees and vegetation will be grubbed. Topsoil will then be stripped from the roadways and stockpiled for future use. Once the road subgrade has been leveled, proof-rolling will be conducted to densify subsoils and identify potential loose/soft areas. If loose/soft areas are identified, weak materials will be removed and/or crushed stone will be compacted into the subgrade for added stability. Excess soil from grading will be stockpiled for future site reclamation. The main haul road from the portal to the COSA will be surfaced with 4 inches of bituminous concrete to permit efficient management of ore particulate that could drop from the ore carriers leaving the mine.

4.3.2 Buildings and Structures

The surface facilities will include the building and structures as shown on Figure 4-2. Planned major surface buildings are listed in Table 4-7.

Table 4-7
Proposed Major Surface Facility Buildings

Building	Area	
	m²	(ft²)
Mine Dry/Office (2 floors)	1,263	(13,600)
Truck Wash	368	(4,000)
Assay Lab/Core Storage	316	(3,400)
Generator Plant	427	(4,600)
Mine Air Heater	269	(2,900)
Maintenance Shop/Compressor Plant	687	(7,400)
Coarse Ore Storage	1,394	(15,000)
Water Treatment Plant	500	(5,380)
Crusher Building	549	(5,810)
Total	5,764	(62,020)

Prepared by: JOS1
Checked by: SVD1

Final sizes of the buildings may change when the building designs and operational needs are finalized. It is expected that most buildings will be steel framed with either concrete block or steel siding.

The main facility staging area is shown on Figure 4-2. This area will be used to stockpile topsoil and temporarily store materials and equipment such as piping and vehicles.

4.3.3 Truck Wash and Scales

All vehicles leaving the main operations area, as shown on Figure 4-2, will be required to go through a truck wash before they leave the area. The main operations area is that part of the mine site that contains truck, excavation and other equipment associated with the mine operations. The truck wash will be an enclosed system that recycles the wash water. Water that is not recyclable due to excessive sediment loading will be routed to the water treatment plant for processing.

The truck scale (see Figure 4-2) is included on the truck access road within the fenced area. The primary function of the scales will be to weigh the ore in the trucks before the ore is shipped off-site for processing.

4.3.4 Mine Portal

The Eagle Project portal will be positioned at the western face of the rock outcrop at the main surface facility. The portal will have a span of 7.2 meters (~24 ft) and a rise of 5.8 meters (~19 ft) as shown on Figure 4-7. The first 37 meters (~122 ft) will be constructed of a pre-fabricated steel arch, socketed into competent bedrock at the outcrop. Note that the actual portal entry into the bedrock is below existing land surface (Figure 4-7). The portal grade will be approximately 15%. To prevent icy conditions during winter months, the portal will be heated using generator exhaust heaters and propane-fired heaters as necessary.

4.3.5 Ore Conveying and Crushing

A generalized cross-section of the overall mine process is shown on Figure 4-8. The general ore flow process is as follows:

- ♦ On the lower mine levels ore will be remotely loaded from the stopes using Load-Haul-Dumps (LHDs) which will deliver the ore to low profile production trucks near the decline.
- ♦ On the upper mine levels ore will be remotely loaded using LHDs and delivered to a centrally located coarse ore grizzly. Ore will drop down a 3.0 m (~10 ft) by 3.0 m (~10 ft) ore pass to the 263 level, loading the low profile production trucks.
- ♦ Once loaded the low profile production trucks will proceed up the decline to the 3,000 m³ (3,924 yd³) COSA as shown on Figure 4-2. The COSA will have a nominal 5,000 tonnes storage capacity.
- ♦ The decline design includes passing bays which will be developed every 300 m (~984 ft) for vehicles and personnel bypass. It is estimated that two production trucks will be required to support the approximate 2,000 tonnes/day (2200 tons/day) production rate.
- ♦ From the COSA front end loaders will transfer ore to the enclosed grizzly feeding the crusher process. The grizzly openings will measure approximately 0.5 m x 0.5 m (20 in x 20 in). The grizzly will be equipped with a stationary rock breaker to process oversized ore. The ore will pass through a vibrating grizzly feeder to remove undersized material (less than six inches). This material will by-pass the crusher and be fed directly to the transfer conveyor to be routed to the crushed ore bins.
- ♦ Grizzled ore (6 in to 20 in size) will feed to a single-toggle jaw crusher having a 150 hp electric motor. Crushed ore drops onto the transfer conveyor to be routed to the crushed ore bins. The crusher will be equipped with a wet-type dust collector equipped with a 25,000 cfm fan and silencer.
- ♦ A crusher building will enclose crushing related equipment. The building will have an overhead bridge crane for installation and maintenance of equipment. In addition to the dust collection at the crusher, the building will be equipped with a baghouse to further reduce dust emissions from activities inside the building. The crusher building and process is illustrated on Figures 4-9 and 4-10.
- ♦ Crushed ore exits the crusher building on a covered transfer conveyor equipped with a walkway for inspection and maintenance. The conveyor transfers the ore to the top of two 300 tonne (330 ton) capacity crushed ore bins. The bins are equipped with chutes at the base to perform truck loading. The crushed ore bins and building are illustrated in Figure 4-11.

4.3.6 Coarse Ore Storage Area

The coarse ore storage area (COSA) will be an approximately 3,000 m³ (~3,924 yd³) building for storage of approximately 5,000 tonnes of ore. The COSA will measure approximately 1394 m² (~15,000 ft²) and be approximately 7 m (~23 ft) tall. The building will be metal framed and have metal siding enclosed on three sides. The floor of the building will be reinforced concrete 0.3 m (~12 in) thick sloping toward a collection sump. The collection sump will collect contact water from stockpiled ore for pumping into the CWB for treatment.

4.3.7 Ore Transportation

Ore transport from the underground mine will include a number of different processes. LHD's will deliver ore to low profile production trucks. Production trucks will proceed up the decline to the COSA. From the COSA, the ore will be moved by front-end loader to the crusher feed. Ore that passes through the crusher will charge the transfer conveyor. The transfer conveyor will feed a second transfer conveyor which charges two crushed ore bins. From the crushed ore bins approximately 50 tonne capacity ore trucks will be loaded for transport to the railhead. It is expected that approximately 40 truck loads per day will be required to transport the ore to the railhead. During transport the ore will be covered with secured caps. All ore trucks will be washed at the truck wash before exiting the main operations area. Presently KEMC plans to use the following approved trucking route to the railhead:

- ◆ East on Triple A Road, 9 miles to CR 510,
- ◆ East on CR 510, approximately 3 miles to CR 550,
- ◆ South on CR 550 approximately 20 miles to a railhead in the vicinity of Marquette.

KEMC is continuing to study transportation routes and railhead locations, and the final transportation plan may change from that described above. The railhead facilities will include an enclosed bulk ore storage building(s) and enclosed conveyor/rail car loading equipment. All ore handling processes will be within enclosed structures to prevent release of ore.

4.3.8 Ventilation Shaft

Intake air to the mine workings will be provided via the main decline. The mine exhaust raise measuring approximately 4.3 m (~14 ft) in diameter will be located at the surface backfill facility as shown on Figure 4-2. At the exhaust raise a 600-hp exhaust fan will be installed for pulling air (induced draft) through the mine workings. The ventilation system design was completed by McIntosh Engineering based upon a minimum air flow requirement of 150 cfm per worker and equipment demand. A schematic of the main exhaust fan is displayed in Figure 4-12. Modifications of the exhaust fan system may be required based upon final design and fabrication. Further discussion of the mine ventilation system is provided later in Section 4.5.2.

4.3.9 Temporary Development Rock Storage Area

The TDRSA will be constructed for the temporary storage of development rock. The size of TDRSA will be approximately 5.9 acres providing 219,925 m³ (~285,000 yd³) of storage capacity, based upon 378,914 tonnes of planned excess development rock. The location of the TDRSA with relation to other mine surface facilities is shown on Figure 4-2.

The design of TDRSA was completed pursuant to R 425.203 and R 425.409. The TDRSA will incorporate a geomembrane cover, a contact water collection system, a composite base liner system, and a leak detection system. Combined, these systems will minimize the generation of contact water. The leak detection system constructed below the base liner will allow for monitoring and collection (if needed) of percolation through the composite base liner system. Detail design concepts of the TDRSA are provided in Section 5 of this report.

Contact water will be collected at the base of the TDRSA using a granular soil collection medium and geocomposite drainage fabric sloping towards a collection sump. Liquid in the sumps will be pumped via a submersible pump through a side-slope riser to the CWBs for storage and eventual treatment by the on-site WWTP.

In addition, the development rock that is placed in the TDRSA will be amended with approximately 7,800 tonnes of limestone. As described in Appendix D-3, the addition of readily-available high-calcium limestone will:

- ♦ Provide acid-neutralizing capacity to the TDRSA that will prevent the generation of low pH water.
- ♦ Raise the pH of the water collected in the TDRSA thereby reducing the concentrations in the contact water of pH-sensitive metals such as copper and stabilizing the ferric hydroxide that will precipitate and absorb other trace metals.

4.3.10 Storm Water Management Systems

The Eagle Project Site has been designed so that non-contact storm water runoff is collected and treated separately from storm water runoff from the operational area. Storm water systems for the project site are divided into two general areas as shown on Figure 4-2. Operations area storm water runoff will be routed to the lined CWBs for storage and eventual treatment at the WWTP prior to discharge at the TWIS. The operations area includes that portion of the mine site that will contain ore and ore-related process handling equipment and storage facilities. Within the operations area is an approximate 4.2 acre bituminous lined area. This bituminous area includes the main production haul road from the portal to the COSA and crusher area and is intended to provide effective surface management of this area during operations. The lined operations area is also shown on Figure 4.2. The lined areas will consist of 4-inches of bituminous concrete supported by 12-inches of road aggregate. Details of the lined operations area is shown on Figure 4-13.

The non-contact area of the project site is that portion of the project site that will not contain any ore processing or related storage facilities. Storm water runoff in the non-contact area will not contain any mining related constituents and will be routed to NCWIBs where it will be allowed to infiltrate into the subsurface. The storm water runoff management design calculations are provided in Appendix E.

The storm water runoff management facilities have been designed such that runoff will not leave the site. Both the CWBs and NCWIBs are sized to store the largest of the following storm events:

- ◆ A 100-year 24-hour rainfall event.
- ◆ A 50-year combined rainfall and snowmelt runoff event.

Appendix E provides documentation of the methodology used for sizing the storm water storage basins (operations area and non-contact area) at the Eagle Site. As described in Appendix E, the hydrology used to size the runoff storage basins includes standard TR-55 methods to determine the peak 100-year rainfall runoff volumes, and a hydrologic procedure to estimate the runoff expected from a combined 50-year rainfall and snowmelt event. The calculations show that the 50-year combined rainfall and snowmelt event generates larger runoff volumes than the 100-year 24-hour rainfall event and, therefore, results in a more conservative design.

The methodology used as a basis of design is a very conservative approach to sizing the storm water runoff basins so that overtopping is not likely to occur, even under severe runoff conditions. For the CWBs, contingencies (see Section 8) for routing to other mine areas will prevent off-site flow of water from the main operations area. Similarly, storm water release from the NCWIBs will be limited to very infrequent runoff events. These releases from the NCWIBs, if they occur, will be permitted with an Industrial Storm Water Permit.

4.3.10.1 Operations Area Storm Water

Figure 4-2 shows the main operations area. Storm water runoff from the main operations area will be conveyed to, and collected in, the two CWBs, prior to treatment at the WWTP. Figure 4-2 shows the general configuration and size of the CWBs. The 100-year, 24-hour rainfall and 50-year combined event (rainfall and snowmelt) will produce approximately 4,700,000 gallons and 7,800,000 gallons, respectively. The design of the CWBs is based upon the more critical event having a combined operating capacity of 7,800,000 gallons. During winter months an agitator or other devices may be installed in the CWBs to prevent ice build-up.

4.3.10.2 Non-Contact Storm Water

Non-contact areas are disturbed areas of the site which will not come in contact with development rock or ore. Figure 4-2 shows the proposed non-contact areas. Non-contact storm water runoff will be conveyed to, and collected in, one of four NCWIBs, as shown on Figure 4-2. The NCWIBs are designed to retain storm water runoff allowing it to infiltrate to the subsurface. Four NCWIBs will be provided to accommodate runoff. One basin will be located in the northwest area of the main surface facility and will receive runoff from the construction staging/soil storage area. The second and third basins will be located southeast of the main site along the access road and will receive runoff from the office/warehouse and employee parking lot areas. The fourth basin will be located at the backfill surface facility and will receive runoff from the clean backfill surface facility. Figure 2 in Appendix E shows the conceptual design cross section of the NCWIBs. The areas associated with each basin, the calculated precipitation event, and the basin design capacities are summarized in Table 4-8.

Table 4-8
Design Capacity Non-Contact Water Infiltration Basins

			100-yr rain event (gallons)	50-yr combined event (gallons)	Basin Design Capacity (gallons)
	Area				
NCWIB #3	Southeastern portion of the main surface facility	9.85 acres	900,000	3,500,000	3,500,000
NCWIB #4	Northwestern portion of the main surface facility	6.03 acres	430,000	2,100,000	2,100,000
NCWIB #5	Backfill facility site area	3.05 acres	250,000	1,000,000	1,000,000
NCWIB #6	Main access road	3.03 acres	220,000	1,000,000	1,000,000
Total		21.96 acres			7,600,000

Prepared by: JOS1
Checked by: SVD1

4.3.10.3 Soil Erosion and Sediment Control Plan

A separate Part 91 soil erosion and sediment control (SESC) permit is not required for the Eagle Project. Rule 425.203 (c)(xxii) requires that an SESC plan that meets the requirements of Part 91 of NREPA be incorporated into the *Mining Permit Application* as presented herein. This section describes the SESC plan components for the Eagle Project to effectively reduce soil erosion and sedimentation that may impact the surrounding area. The goal of the SESC plan is to incorporate methods into the design and operation such that soil erosion due to surface activities will be mitigated.

The site erosion control features will be maintained daily during construction. Permanent soil erosion control measures will be established as soon as possible after grading work has been completed, to augment or replace the temporary measures installed during construction. The SESC plan includes the following information:

- ♦ Construction phase erosion control plans showing areas and extent of disturbance (Figure 4-14);
- ♦ Operation phase erosion control plans (Figure 4-15)
- ♦ Reclamation plans (described in Section 7)
- ♦ Details of the Best Management Practices (Figures 4-16 and 4-17).

4.3.10.4 Soil Erosion and Sediment Control Plan During Construction

The site erosion and sediment control plan to be implemented during construction is shown on Figure 4-14. The following is a list of the earth work and other grading activities that are part of the construction phase. Each activity is followed by a description of the Best Management Practice that will be implemented to minimize soil erosion and site runoff. Materials and methods specified in the MDOT, 2003 Standard Specification for Construction (MDOT, 2003), where available, were used for specification of the materials proposed for soil erosion control.

KEMC staff will be certified as construction and industrial storm water operators to complete the required inspections and coordinate repairs and maintenance during construction.

Surface Water Diversion - Diversion of surface water run-on to the mine site surface facilities will not be necessary since areas around the surface facilities are generally very flat with slopes less than 0.5%. In addition, the subsoils are clean sands that have a high infiltration rate which will limit run-on.

Land Clearing - Land clearing is the removal of woody and herbaceous plant material and consists of two components: clearing which is the cutting and removal of trees and grubbing which is the removal of stumps and roots. Marketable timber will be removed from the site and sold. Unmarketable timber, herbaceous plants, dead wood, stumps and other vegetation will be chipped and stockpiled on-site for use in reclamation. Stumps that are too large to be chipped will be stockpiled and burned on-site. The soil and erosion control practices that are proposed include:

- ♦ Clearing marketable and non-marketable trees;
- ♦ Completing the grubbing and removal of tree harvesting remains in a single operation to minimize disturbance; and,
- ♦ Construction of silt fence downgradient of the areas to be cleared and grubbed prior to the start of earth disturbance. Refer to Figure 4-14 for the approximate locations where silt fence will be installed. Details of erosion control methods are provided on Figure 4-16 and 4-17.

Topsoil Stripping and Stockpiling - Following land clearing and grubbing, topsoil will be stripped from the mine site area as shown on Figure 4-14. Topsoil is defined as the A-horizon of the soil in which organic matter accumulates. The topsoil thickness over the mine site is typically less than three inches thick and is non-existent at many locations. A 3-inch thickness has been used to size the topsoil stockpiles.

Prior to stripping the topsoil additional silt fence will be constructed downgradient of the disturbed areas. Topsoil and any excess soil will be stockpiled in the previously prepared stockpile area with maximum side-slopes of 3 horizontal to 1 vertical (3H:1V). Silt fence will also be constructed around the soil stockpiles. Topsoil and excess soil will be stockpiled with conventional earth-moving equipment. Prior to seeding, the stockpile soil surface will be “track walked” (i.e. driving a bulldozer up and down the slope to leave a pattern of track imprints parallel to the slope contours) to create a rough surface. This rough surface will enhance the ability of the soil to withstand erosion until vegetation has developed. The stockpiles will be seeded with a mixture typically used on sandy soil for roadside restoration projects as specified in the MDOT, 2003 Standard Specifications for Construction (MDOT, 2003). Seed mixtures will include temporary species such as oats or perennial rye grass that germinate quickly and act as a nurse crop until the perennial species germinate and develop.

Site Excavation and Grading - The site will be rough-graded to the grades as shown on Figure 4-6, prior to excavation of the TDRSA, NCWIBs and CWBs. As part of the final site grading design, diversion berms and ditching will be used to separate the main operations and non-

contact areas. Excess soil will be used to build berms around the facility as shown on Figure 4-15. Once the surface facilities are under construction, disturbed areas will be seeded as soon as possible.

4.3.10.5 Soil Erosion and Sediment Control Plan During Operations

The site erosion control and sediment control to be implemented during operations is shown on Figure 4-15. Once the surface facilities are constructed and vegetation has been re-established, the main component of the SESC plan will be to maintain the storm water conveyance and storage basins as designed and constructed. This will require regular inspections after precipitation or snow melt events. Areas that show erosion or rutting will be repaired as soon as practical by filling with topsoil and seeding, as described in the previous section. The NCWIBs will be inspected for siltation which could reduce the infiltration capacity of the basins.

Planned operation and maintenance activities for the facility storm water and erosion control structures are listed in the table provided on Figure 4-15. This includes maintenance and repair of the storm water conveyance system and erosion control features described above during construction. KEMC will designate one of the technical staff to be a certified storm water operator to complete the regular inspections and coordinate repairs or maintenance during operations.

4.3.11 Site Utilities

The site utilities for the Eagle Project surface facilities will include electrical, heating, telephone, water and sanitary systems. A utility water system will be provided for operation needs including the crusher system and underground drilling equipment, etc. A fire water system will also be provided that will distribute water to the mine and surface facilities at designated locations for fire protection.

4.3.11.1 Electric Service

Facility electric power is provided by a set of three diesel generators, each capable of delivering 1825 kW of power. Each generator will be equipped with selective catalytic reduction (SCR) units installed on individual exhaust stacks. SCR units will reduce the concentration of NO_x in the generator exhaust.

Three generators will be provided, however, only two will be operating at all times. This provides redundancy and regular periods of downtime for maintenance. The generators will be operated equally throughout the year with equal loading, barring malfunction. The maximum routine power needed during full mine operation will be approximately 2.63 mW. The generators will be fueled with No. 2 diesel fuel with a sulfur content of less than 0.5%. The electrical distribution system will provide power to the main surface facilities, the backfill surface facilities, the potable well, and underground facilities.

4.3.11.2 Mine and Surface Facilities Heating

Captured generator exhaust heat will heat the portal to a temperature above 32° F. Four propane heaters having a combined capacity of 16,000,000 Btu/hr will also be provided to augment heating needs to keep the portal above 32°F. Combustion by-products from the propane heaters

will be vented through stacks or will be directly vented into the mine through duct work to the portal.

Electrical base board heaters will be provided in office spaces and other surface facilities requiring heat.

4.3.11.3 Telephone Service

Currently, landline telephone service is not available to the Eagle Project site. During all phases of the project, communications will be provided through the use of satellite telephones or other means.

A separate communication system will be provided for underground operations employing a base station with a multi-channel system for both voice and data communication.

4.3.11.4 Potable Water

A potable water system will be provided to supply potable water to the site buildings, the lab, and to the mine. A well, pump, potable water tank, and distribution system will be provided for potable water. KEMC plans to use well QAL011D (see Figure 4-1) as a potable well for the project and will apply for a *Type II Non-Transient Non-Community Water Supply Permit* from the Marquette County Health Department.

4.3.11.5 Sanitary System

The Eagle Project on-site septic system (OSS) is designed based upon expected operation loading and will be permitted through the Marquette County Health Department. The design flow for the OSS is based on the number of employees. From Table 4-2, the total project employment will be 110. From Table 1 of the *Michigan Criteria for Subsurface Sewage Disposal*, the design flow for an employee at an industrial facility is approximately 35 gallons per day (gpd). Therefore, the peak design flow based upon the State of Michigan criteria for the OSS is 3,850 gpd.

The OSS includes the following components as discussed below:

- ♦ Septic tank
- ♦ Dosing pumps
- ♦ Soil absorption system

The septic tank system will provide a total of 4,000 gallons capacity. The volume will be split into 2 or 3 tanks or compartments. The first compartment will be a minimum of 2,000 gallons. The multiple compartment design will provide improved solids separation and treatment.

The design flow for the OSS exceeds 2,000 gpd and as such is required by state code to use dosing pumps for septic tank effluent distribution. Therefore, two dosing pumps will be provided to operate on an alternating basis. The dosing pumps will be located in a separate tank with septic tank effluent flowing into the dosing tank.

The soil absorption system will consist of distribution piping placed in a shallow gravel trench. The trench width will be three feet and the trenches will be spaced with four feet between the

trench walls. The distribution piping will be 1.5-in. diameter PVC or HDPE pipe with perforations typically five feet apart. The dosing pumps will provide adequate pressure to force equal flow through each perforation.

The infiltration rate of site soils has been measured as approximately 60 ft/d (Foth & Van Dyke, 2006). The loading rate (gpd/ft²) is determined based on soil types. Based upon the *Michigan Criteria for Subsurface Sewage Disposal Section IX, C, 5* the design loading rate for this type of soil is 0.5 gpd/ft².

The area required for a design flow rate of 3,850 gpd is 7,700 ft² of trench. With trenches three feet wide and spaced four feet between trenches, the total area required for soil absorption is 18,000 ft². Additional space is needed for the septic tanks and dosing pump chamber. The distribution system will be designed with three cells. Each cell will have a shut-off valve to allow one cell to rest or be repaired while the other cells are in operation.

A reserve area is required to provide a replacement of the soil absorption system without using the initial system. Figure 4-2 shows the location at the OSS. The area identified for the OSS is adequate for the initial soil absorption system and, if necessary, replacement of the soil absorption system.

During initial site development, the construction contractor will be responsible for providing temporary facilities during construction until the OSS system and the sanitary sewer piping to the OSS is operational.

During the mine operation the septic tanks will be pumped on an annual basis to remove excess solids. The dosing pumps will be inspected and maintained on a regular basis. The distribution system will be inspected several times during the year and cells rested each year. This system along with routine maintenance will provide effective sanitary wastewater treatment and disposal at the mine site.

4.3.12 Water Usage, Treatment and Discharge

The Eagle Project will have an extensive water management program. Figure 4-2 shows the locations of the main water management facilities including the CWBs, the WWTP, and the TWIS. Water requiring treatment will be generated during construction, operation, and closure of the Eagle Project. Each of the major sources of mine water is discussed in more detail below. The design of the facilities to be used for collection, treatment, and disposal of these wastewaters is also discussed below. A more detailed description of the water sources and treatment and discharge systems is provided in the *Groundwater Discharge Permit Application* (Foth & Van Dyke, 2006).

4.3.12.1 Wastewater Sources and Characteristics

The following is a summary of the different wastewater sources that will be treated by the WWTP.

Mine Drainage - Sources of water inflow to the mine will include groundwater infiltration into the mine, water vapor contained in ventilation air entering the mine, treated water pumped to the mine for use in mining operations, and water contained in the mine backfill material.

The mine drainage water will primarily consist of a composite of groundwater that infiltrates into the mine and treated water used in the mine (utility water) for dust suppression and for operation of mining equipment and operating the backfill plant. Drainage from the mine backfill material is anticipated to be negligible and is not included in the water balance. The mine drainage water will be collected in underground sumps and will be pumped to the CWBs.

Two sources of groundwater are anticipated to be encountered during development and operation of the mine. The primary source will be groundwater that flows from the upper bedrock regions into the upper mining levels. The upper bedrock water that is expected to be encountered during both the mine development and mine operation phases, will represent the bulk of the water pumped from the mine and is low in total dissolved solids (TDS). The second source of groundwater is water that is stored within the weakly connected fractures of the lower bedrock and which is expected to be encountered during initial development when the stored water in the rock drains to the mine sumps. The deeper bedrock water is more saline than the upper bedrock groundwater.

The chemical characteristics of the groundwater in the area of the Eagle Project were estimated based on background groundwater sampling and analysis work conducted by Golder Associates, Ltd. (2005b) and Golder Associates, Inc. (2006). Analysis of groundwater samples from exploration holes open to the upper bedrock and yielding non-saline water were used to determine the chemical characteristics for the upper bedrock groundwater. Groundwater samples from testing of deep exploration holes were used to determine the chemical characteristics of the water stored in fractures of the deeper bedrock. The chemical characteristics of the composite mine drainage water will depend on the background characteristics of the groundwater that infiltrates into the mine and on the impact of groundwater contact with the mine workings. The mine drainage water will contain readily soluble substances, mineral oxidation products, and colloidal materials that will result from the short-term reactions between water and materials within the mine. The incremental increases in the concentrations of the various constituents in the groundwater infiltrating into the mine, due to contact with the mine workings, are provided in Appendix D-4. The *Groundwater Discharge Permit Application* (Foth & Van Dyke, 2006) describes the methodology for combining background bedrock groundwater quality data and geochemical predictions to estimate the chemical characteristics of the mine drainage water pumped from the mine during operations.

Although ammonia and nitrates are not anticipated to occur in the groundwater in significant concentrations, they will be present in the mine drainage water as byproducts from blasting operations. Ammonia and nitrate concentrations in the mine drainage water were estimated based on information supplied by Kennecott from other representative mines. The estimated mine drainage water characteristics are provided in Table 4-1 of the *Groundwater Discharge Permit Application* (Foth & Van Dyke, 2006).

Temporary Development Rock Storage Area - Water coming in contact with the stored development rock amended with limestone may contain readily soluble substances and colloidal materials. The water will have a neutral pH. The chemical characteristics of the TDRSA contact water are provided in Appendix D. The geomembrane cover which will be installed over the TDRSA will further reduce the generation of contact water requiring treatment.

Storm Water - During construction and operation of the mine and surface facilities, storm water runoff will be collected and managed within the facility. The storm water runoff from the operational area will be collected in the CWBs and treated at the WWTP. Non-contact surface water runoff will be managed separately by NCWIBs and is not part of the influent water to the WWTP. For WWTP design purposes, operational surface water runoff from the main operations area was conservatively estimated to have the same water chemistry as the combined contact water (mine drainage water and TDRSA contact water).

Miscellaneous Sources of Wastewater - Wastewater will also be generated from the laboratory and shops. The wastewater generated in the laboratory will include small amounts of laboratory chemicals used in ore analysis and in analysis of wastewaters. Wastes generated in the laboratories will be disposed off-site by a qualified contractor or will be discharged to the CWBs and processed.

Wastewater generated in the shops will include small amounts of grease and oil, metal shavings, other particulate materials, and wash water. Most of the grease will be captured in traps. These wastewaters will be discharged to the CWBs and treated by the WWTP. Small quantities of wastewater from the truck wash and crusher system will also be discharged to the CWBs and treated by the WWTP.

4.3.12.2 Water Balance

Two water balance models have been prepared for the Eagle Project. The first water balance model (Figure 4-18A) evaluates the system water balance based upon the design basis groundwater inflow and maximum annual precipitation. For WWTP design purposes a design basis of 250 gpm of groundwater inflow was assumed. This design basis exceeds the upper bound groundwater inflow estimated of 215 gpm. The groundwater inflow modeling is provided in the EIA in Volume II of this *Mining Permit Application*. The second water balance model (Figure 4-18B) evaluates the system water balance using expected groundwater inflow (75 gpm) and average annual precipitation. The water balance determines the water inputs, water uses, and water discharges associated with the mine and the main operations area.

Potable water for sanitary uses will be obtained from an on-site well. Sanitary wastewater will be collected and disposed separately in a septic system.

The *Groundwater Discharge Permit Application* (Foth & Van Dyke, 2006) contains additional discussions on the design basis of the WWTP and the development of the water balances in Figures 4-18A and 4-18B.

4.3.12.3 Wastewater Treatment System

The WWTP will treat wastewater collected and stored in the CWBs and is designed to produce a treated effluent which will meet the effluent standards for discharge to groundwater by way of the TWIS. The WWTP will be designed to provide a level of treatment to comply with MDEQ groundwater quality standards.

The water treatment system includes the following processes:

- ♦ CWBs
- ♦ Main wastewater treatment process
- ♦ Concentrate reduction process
- ♦ Evaporation/Crystallization process
- ♦ Sludge handling process
- ♦ TWIS

Detailed descriptions of these processes are provided in the *Groundwater Discharge Permit Application* (Foth & Van Dyke, 2006).

All wastewater generated at the Eagle Project, with the exception of sanitary wastewater, will be routed to, and temporarily stored in CWBs No.1 and No.2. Appendix E provides the design capacity of the CWBs. A cross section and details of the CWBs are shown on Figure 4-19. These basins will provide wastewater storage and equalization capacity. Wastewater will be pumped from these basins to the WWTP.

The main wastewater treatment process will include a base treatment system and an advanced treatment system. The base treatment system will include pH adjustment, metals precipitation, and filtration to substantially reduce the mass of dissolved solids present in the raw wastewater. The advanced treatment system will include a reverse osmosis system and pH adjustment as a polishing step to further reduce the concentrations of dissolved solids in the base treatment system effluent. The discharge streams from the final wastewater treatment process will include treated water, metals precipitation sludge, and reverse osmosis concentrate. The treated water will be suitable for discharge to groundwater the TWIS. The TWIS consists of series of distribution piping connecting to five subsurface infiltration cells. Within each infiltration cell will be 1.5-in diameter perforated PVC discharge piping covered with 5 ft of select soils, then topsoiled and seeded. The metals precipitation sludge will be routed to the sludge handling process for dewatering. The reverse osmosis concentrate will be routed to the concentrate reduction process (CRP) for treatment and volume reduction.

The CRP will be provided to maximize the water recovery for the WWTP and correspondingly minimize the volume of concentrate treated by the evaporator/crystallizer process. The CRP will treat the concentrate from the main wastewater treatment process reverse osmosis system. The treatment processes proposed for this system include breakpoint chlorination, softening/metals precipitation, microfiltration, pH adjustment, reverse osmosis, and ion exchange. The discharge streams from the concentrate reduction process will include treated water, microfiltration sludge, and reverse osmosis concentrate. The treated water will be suitable for discharge to groundwater by way of the TWIS. The microfiltration sludge will be routed to the sludge handling process for dewatering. The reverse osmosis concentrate will be routed to an evaporation/crystallization process for volume reduction or incorporated with the cemented mine backfill.

The sludge handling process will dewater sludge from the main wastewater treatment process metals precipitation/sedimentation system and sludge from the concentrate reduction process microfiltration system. A plate and frame filter press will be used for sludge dewatering. Filtrate from the filter press will be routed back to the head end of the concentrate reduction process for

treatment. The dewatered sludge from the filter press will be managed in accordance with applicable regulations.

During periods when cemented backfill is not generated, the evaporation/crystallization process is provided for volume reduction of the reverse osmosis concentrate from the CRP. Distillate from the evaporator will be discharged through the TWIS along with treated water from the main wastewater treatment process. Brine solids from the crystallizer will be managed in accordance with applicable regulations.

4.3.13 Backfill Aggregate Stockpiles

The backfill aggregate stockpile area located near the backfill raise is shown on Figure 4-2. Also present near the aggregate stockpile and backfill raise will be a 110-tonne capacity fly ash silo, and a 110-tonne capacity cement silo. During full production it is estimated that approximately 200 tonnes per day of aggregate will be required for mine backfilling operations. Clean aggregate will be supplied from a local vendor. Aggregate from the stockpile will be moved via front-end loader to the aggregate hopper feeding the 2.4 m (~8 ft) diameter aggregate raise. Surface water drainage from the aggregate stockpiles will be controlled via perimeter ditching, draining to NCWIB #5 as shown on Figure 4-2.

4.3.14 Security and Access Control

Security and access control will be maintained at all times at the Eagle Project. Surrounding the facility will be an 8-foot high chain link fence. Access to the facility will only be allowed via the main facility entrance off Triple A Road. Vehicles entering or leaving the facility must pass through the main gate. An attendant will be present at the gate house to control facility entry. In addition, the excess soil berm constructed around the facility boundary will also limit unauthorized access.

4.3.15 Aesthetics and Landscaping

The Eagle Project will be naturally obscured by the existing trees and the rock outcrop at the main surface facility. In addition, a berm of excess soil will be placed directly around the boundary of the facility to limit visibility of the site. KEMC may selectively plant trees to further obscure the mine facilities from Triple A Road. Near the entrance road landscaping will blend with the natural flora to develop a balanced natural appearance.

4.3.16 Fuel Handling and Chemical Storage

Fuel handling at the facility will include diesel to power the generators, regular unleaded gasoline for light equipment and propane for heating. The fuel storage facility will be located within the fenced and secured area shown on Figure 4-2, and will contain three diesel fuel storage tanks each having an approximate capacity of 20,000 gallons (for a total of 60,000 gallons) located within a roofed secondary containment system. One smaller tank for regular unleaded gasoline will also be provided within the containment area. Leak testing of the tanks will be conducted by the vendor upon installation to verify tank tightness.

Diesel-fueled generators to supply facility electric power will be located south of the fuel storage tanks. Propane storage of an approximate capacity of 24,000 gallons will be located within the

secure area of the mine property adjacent to a building that will contain a propane-fired air heating system for the mine.

Fuel truck unloading will be conducted on a concrete or asphalt pad with spill protection provisions consisting of a small catch basin which drains into the secondary containment area via double walled piping. The unloading pad area will be roofed to minimize collection and treatment of precipitation. Underground fuel lines from the storage tanks that feed the electrical generators will be double walled with leak detection provisions. A discussion of the SPCC Plan is provided below. It is anticipated that diesel fuel consumption will be approximately 5,000 gallons per day. It is expected that 6 tanker trucks or approximately 30,000 gallons of diesel fuel will be delivered each week to the site. The fuel tanks will be designed in compliance with all federal, state and local requirements. A designated fueling station will be established for fueling underground vehicles using a tanker vehicle.

4.3.17 Blasting Materials Handling and Storage

The blasting and cap magazine buildings will be located at a secure location within the mine facility. The blasting and cap magazine buildings will be constructed of reinforced concrete following Mining Safety and Health Administration (MSHA) requirements. The building will have explosion proof air handling and moisture control systems. Entry into these buildings will only be allowed by certified blasting material handlers. KEMC will obtain a permit from the Bureau of Alcohol, Tobacco and Fire Arms for storage and use of the explosives for the project.

4.3.18 Spill Prevention and Countermeasures Plan

A SPCC Plan will be prepared for the fuel storage area that will incorporate the provisions set forth in 40 CFR 112. The SPCC Plan will be prepared prior to the commencement of operations at the facility. The SPCC Plan will be reviewed and certified by a Professional Engineer, maintained at the facility and reviewed and revised as required by federal, state, and local regulations. Pursuant to the SPCC Plan and regulatory requirements, tanks and secondary containment will be designed to contain a potential spill. Storage tanks and containment areas will also be installed such that prevention measures for all fuel handling and storage are incorporated into the design, including techniques that will be used to contain potential spills during loading and off-loading of vehicles.

In addition to the federal SPCC requirements, all aboveground storage tanks containing flammable or combustible materials must be in compliance with the Michigan Fire Prevention Code statute at 1941 PA 207. The statute applies not only to tanks that store liquid petroleum products, but also to storage of compressed gases, including propane. Design plans for affected storage tanks will be submitted to the MDEQ Waste and Hazardous Materials Division for approval.

In addition to the above requirements, the facility will also comply with R 324.2001 through 2009. These rules require preparation of a PIPP to address potential spillage of fuel, salt and other “polluting materials” listed under Rule 324.2009. While a portion of these rules contain requirements that are similar to the federal SPCC rules, the regulations also contain requirements to cover salt and any listed “polluting material” that is above indicated Threshold Reporting Quantities. The listed materials include numerous metal compounds, including copper and nickel. The rules state that if these materials are in solid form, they shall be stored such that they

are “enclosed, covered, contained or otherwise protected to prevent run-on and runoff”. Design provisions for all storage facilities at the site contain adequate measures to meet this requirement.

To ensure that an overall cohesive spill prevention and pollution control plan is prepared for the site, it is anticipated that the PIPP will incorporate all requirements of the SPCC Plan as well as requirements for other regulated chemicals at the site. The PIPP will be prepared prior to commencement of operations at the site. Once the written PIPP is prepared, notice will be provided to the state and other emergency agencies that the PIPP is available. The PIPP will then be provided upon request. In accordance with state regulations, the PIPP will be reviewed every 3 years.

4.4 Underground Mine Description

The basic design concept for the underground mine will be to employ transverse blasthole stoping with blind benching. The mine design is based upon extracting 2,000 tonnes per day of ore. Total mineable reserves are approximately 3,419,453 tonnes. An overall section of the mine is shown in Figure 4-5.

4.4.1 Mine Design and Layout

The mine design is based upon 10 production levels as shown on Figure 4-5. Mining will progress from mine level 143 m upward to mine level 353 m. Mine level 383 m will be selectively mined based upon further geotechnical analysis conducted on the crown pillar as mining progresses upward. The geotechnical analysis conducted by Golder Associates has determined that the proposed mining plan will be stable. A copy of the Golder Associates geotechnical reports are provided in Appendix C. Additional geotechnical analysis will be conducted as part of continuous rock mass assessment performed during each level development. The mine design is based upon: 1) maintaining economic production levels by incorporating bulk-mining methods, and 2) preventing surface subsidence due to underground mining. The geotechnical analysis presented in Appendix C has determined there will be no measurable subsidence at ground surface due to the underground mine. A 3-dimensional schematic of the underground mine is displayed on Illustration 4-2.

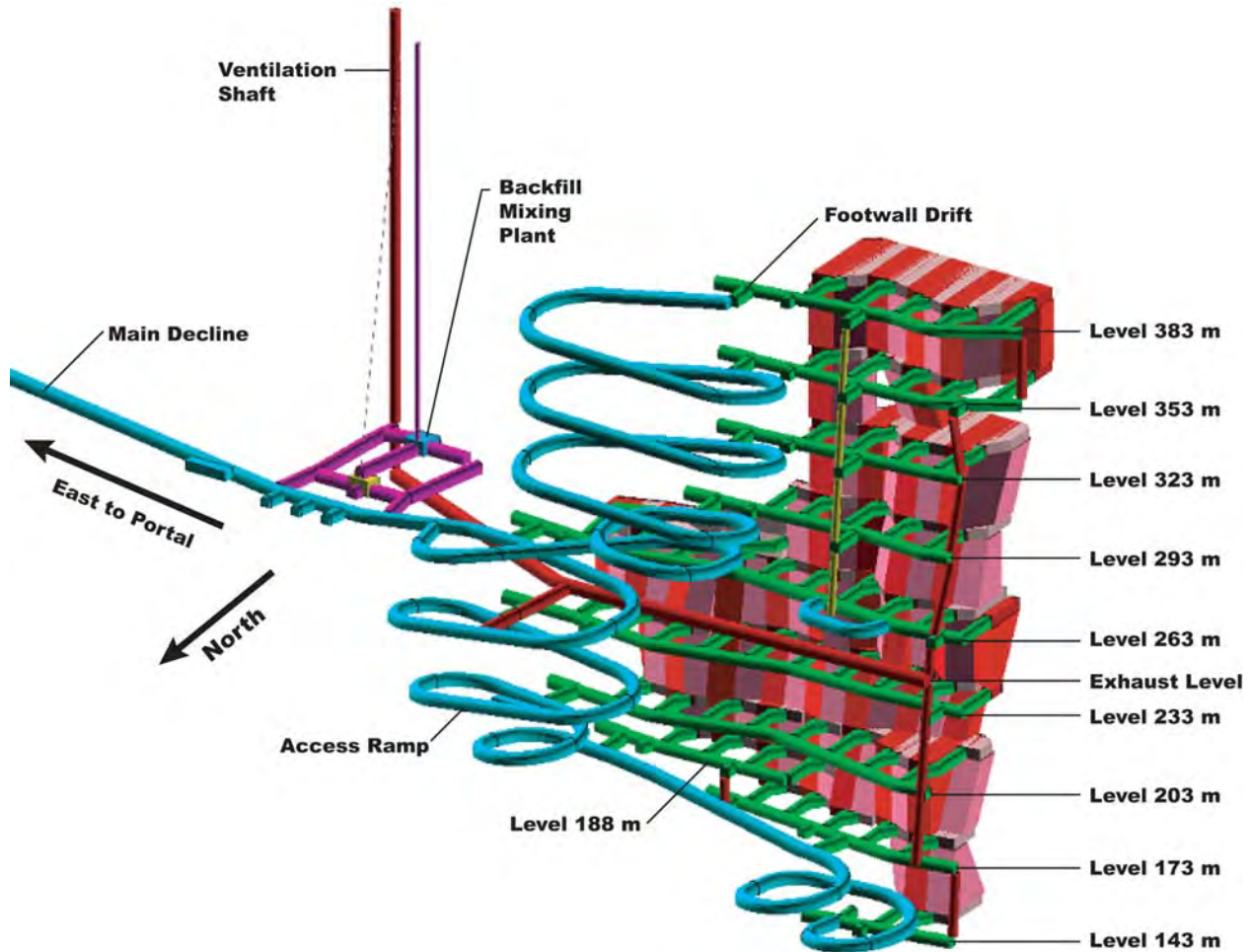


Illustration 4-2
3D Schematic of Underground Mine

Source: Kennecott Minerals Company.

The mining method selected for the majority of the Eagle deposit will be primarily transverse blasthole stoping with cemented and uncemented backfill. A small percentage of mining may be performed by blind benching methods. Transverse blasthole mining was chosen for the following reasons:

- ♦ Blasthole stoping with cemented backfill is a proven mining method.
- ♦ The deposit is generally vertical in nature and relatively regular along the footwall (FW) (north side) thereby allowing for greater vertical spacing between mining levels.
- ♦ The deposit averages approximately 35 m (~115 ft) in horizontal thickness and seldom measures less than 15 m (~50 ft) in horizontal thickness. Maximum horizontal thickness of the deposit measures approximately 75 m (~246 ft).
- ♦ The strength of the ore mass is competent thereby allowing for stopes to be opened up and bulk mining methods to be incorporated.
- ♦ The deposit is relatively thick, hanging wall (HW) to footwall (FW), allowing for the incorporation of transverse longitudinal methods.

- ♦ There is an availability of backfill material on-site for use in secondary stopes for uncemented backfill.

4.4.2 Mine Access

The mine design includes the following access developments:

- ♦ Portal
- ♦ Main Decline
- ♦ Footwall Drift
- ♦ Emergency Escape

Construction of these developments may employ the use of cement and bentonite based grout for localized control of water inflow to the mine workings.

Portal

The portal facility is located on the west side of the bedrock outcrop shown in Figure 4-2. The portal will be constructed with steel arches having a 7.2 m (~24 ft) span and 5.8 m (~19 ft) rise. The steel arch sets will extend out from the rock face approximately 37.0 m (~121 ft). The rock cut will be backfilled with compacted engineered fill after the steel plates are set. A concrete headwall will secure the steel arch plates into the bedrock. Details of the portal are shown on Figure 4-7.

Main Decline

Mine access is gained through the main decline. The decline will be at 5.5 m (~18 ft) wide by 5.0 m (~16 ft) high sloped 15.0% for 120 m (~39 ft) then reduced to -12.0%. The decline is slightly steeper initially in order to quickly access the bedrock thereby minimizing the volume of alluvium excavated and required support. Dimensions of the main decline are based on clearance criteria of the low profile production haul trucks as well as maximum ventilation velocities in the decline.

Footwall Drift

FW drifts will measure 4.5 m (~15 ft) wide by 4.5 m (~15 ft) high. The largest equipment expected to enter the FW drifts are the 5.4 m³ (~7 yd³) production LHDs. FW development is designed to maintain a minimum 20 m (~66 ft) offset from the stope FW. The FW drift provides access to the transverse blasthole stopes, sump, mine load center, exhaust raise, etc.

Emergency Escape

Emergency escape will be provided by an elevator installed in the main exhaust raise. The bottom of the elevator is located at mine level 248 m and exits the raise on surface at an air lock-off the exhaust fan housing. The elevator is installed on the wall of the raise. The elevator, shown in Figure 4-12, has a design capacity of 545 kg or approximately 5-6 persons.

A manway will also be installed in the return air raise between mining levels. The manway will have platforms spaced every 7.0 m (~23 ft). The emergency escape routes are shown on Illustration 4-3.

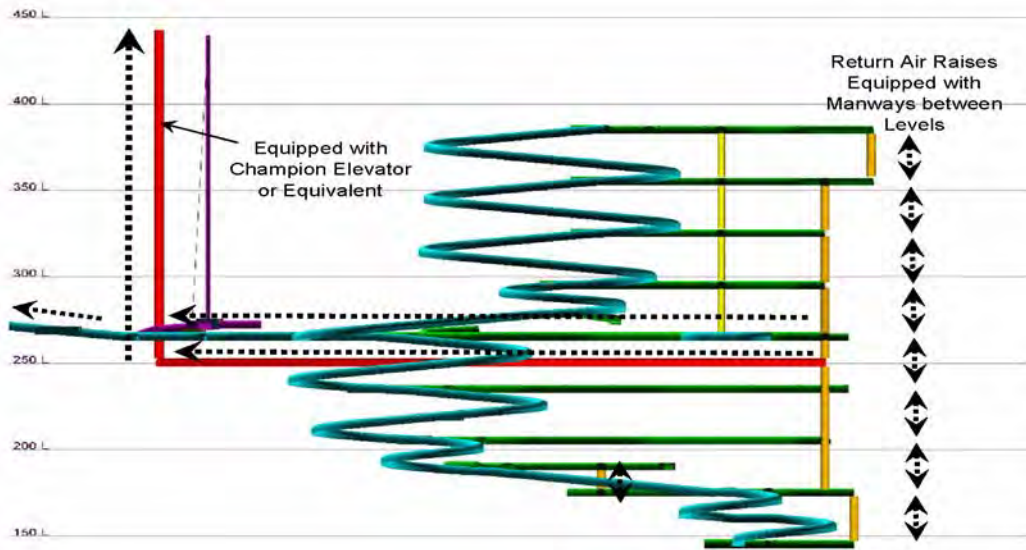


**Illustration 4-3
Emergency Escape Routes**

Source: Adapted from McIntosh Engineers

4.4.3 Transverse Blasthole Stoping

Two sizes of transverse stopes were developed, 30 m (~98 ft) high (sill to sill) and 15 m (~49 ft) high (sill to sill). All transverse stopes measure 10 m (~33 ft) wide, regardless of their height. The 30 m (~98 ft) high stopes have lengths, (HW to FW) ranging from approximately 15 m (~49 ft) to 70 m (~230 ft). The 15 m (~49 ft) high stopes have lengths (HW to FW) ranging from approximately 15 m (~49 ft) to 40 m (~131 ft). The 15 m (~49 ft) high stopes were designed to increase recovery. Each stope includes a top cut (or drill level) at the top of the stope and an undercut (or production level) at the bottom. Top cut and undercut levels are developed by drifting from the FW to the HW, then slashing the stope to the full 10 m (~33 ft) width. Actual stope limits will be identified by stope definition drilling and sampling programs during operations. Current stope designs have both HW and FW planes that best follow the ore body within the capabilities of the production drills. This allows for the design of inclined HW and FW stope limits, thereby reducing waste and increasing ore recovery.

Once stope development is complete, a slot raise is developed. Slot raise cut holes are planned at 0.76 m (~30 in) in diameter, then opened up to 2.4 m (~8 ft) by 2.4 m (~8 ft). Smaller diameter slot raise cut holes are developed using the 115 mm (~4.5 in) production drill blast holes. The slot is drilled and shot in a two-row blast to the full 10 m width of the stope. The slot is designed at 4.5 m (~15 ft) long HW to FW. Illustration 4-4 shows this sequence for a typical 30 m (~98 ft) stope.

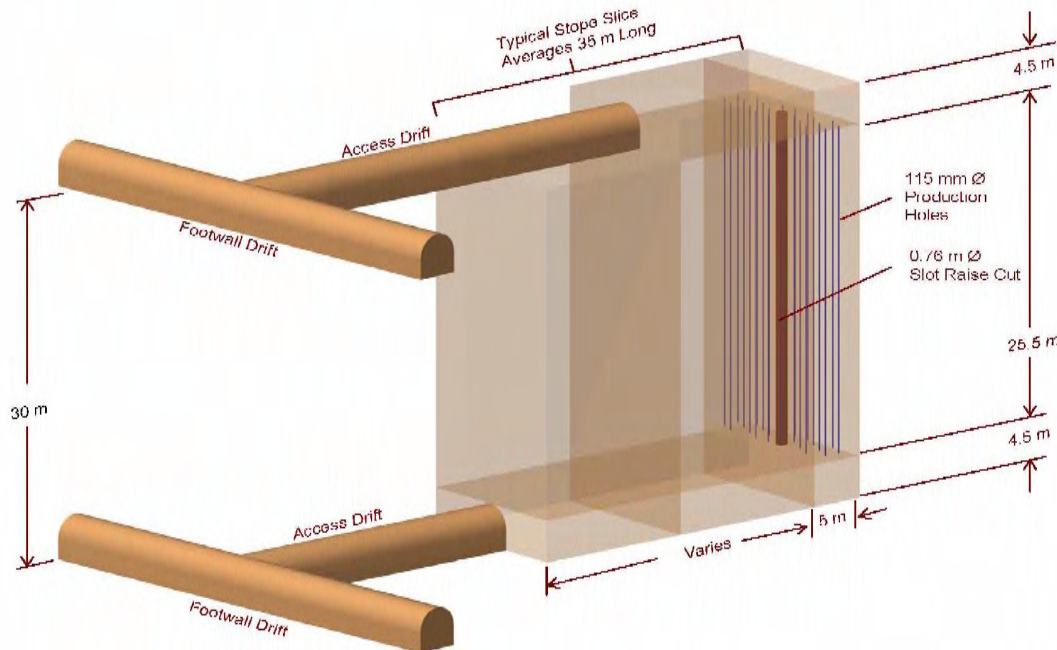


Illustration 4-4
Typical Stope Development Plan

Source: Adapted from McIntosh Engineers

4.4.4 Production Drilling and Blasting

4.4.4.1 Production Drilling

Production drilling will be performed by track-mounted drill rigs capable of drilling 89 mm (~3.5 in) to 165 mm (~6.5 in) diameter holes up to 100 m (~328 in) in length. The drills are powered using high pressure air. Typical production drilling will have the drill holes staggered in a diamond pattern alternating between four holes and three holes per row. Blasthole burden and spacing distances are estimated to be approximately 2.3 m (~7.5 ft) and 3.0 m (~9.7 ft), respectively.

4.4.4.2 Production Blasting

Production blasting will be accomplished using emulsions produced and delivered by a local explosive supplier. The maximum explosive density that can be used in 115 mm (~4.5 in) holes is 1.27 g/cc. Based upon the burden and spacing design, blasthole powder density will be 1.2 g/cc. The ability to use a higher density explosive in the future could allow for expanding the drilling pattern and therefore ultimately reducing the cost per tonne of drilling by reducing the number of holes drilled. As an alternative to emulsion, ANFO can be used. KEMC crews will perform production emulsion loading. All loading will be performed using a bulk emulsion loading system.

4.4.5 Level Development and Stope Sequence

As shown on Figure 4-5 the Eagle Project will be developed with 10 levels. Figures 4-20 through 4-30 illustrate plan views of each level development. As discussed in Section 4.4.1,

mine level 383 m will be selectively mined based upon further geotechnical analysis of the crown pillar and evaluation of the appropriate mining method.

Level development will begin at the lowest mining levels, progressing vertically to the upper levels. Initial production is scheduled to start on mine level 143 m and mine level 173 m. Mining during the first three and a half years will be limited to production at or below mine level 263 m. Upper mine levels will be brought on line once production below mine level 263 m declines.

The mining method entails development of primary and secondary stopes. A series of four-panel production units are designed to mine 10 m (~33 ft) wide by 30 m (~98 ft) high transverse stopes with minimum ground support. The stoping sequence is illustrated in Figure 4-31. The primary stopes will be filled with engineered cemented aggregate backfill prior to mining the secondary stopes. Once the primary stopes are backfilled, mining the secondary stopes will commence. Secondary stopes will be backfilled with uncemented limestone-amended development rock. Production stopes within each level were designed to sustain a consistent production rate of 2,000 t/d once full production is achieved. The production of each of the active stopes is estimated to be 500 t/d to meet the total 2,000 t/d nominal production.

Production is expected to begin in year 2, with two active stopes in production during the ramp-up period. Full production will be achieved in the middle of year three when two additional active stopes are brought on line. The production rate of 2,000 t/d will be sustained until the third quarter of year nine. Production at the Eagle Project is expected to be completed near the end of year nine.

4.5 Underground Facilities

Underground facilities to support the KEMC Eagle Project will include:

- ♦ Mine dewatering system,
- ♦ Ventilation and air heating systems,
- ♦ Communication system,
- ♦ Ore hauling system,
- ♦ Sanitation system,
- ♦ Electrical system,
- ♦ Compressed air system, and
- ♦ Emergency escape, and
- ♦ Emergency safe room with oxygen supplied, food and water.

The facilities are discussed in further detail in the following sections.

4.5.1 Mine Dewatering System

The mine dewatering system for the Eagle Project is designed to support a total of 600 gpm of pumping requirements during full production. Note that 600 gpm is not the rate of groundwater inflow to the mine. Based upon groundwater modeling the upper bound estimate of groundwater inflow is approximately 215 gpm. The groundwater inflow coupled with approximate operating service requirements results in a 600 gpm mine water pumping system.

The following Illustration 4-5 shows the dewatering system flow plan. Three main dewatering pump stations are included in the dewatering system design, one located near the mine bottom, the second at mine level 173 m, and the third at the main decline at mine level 300 m. The level 173 pump station will service the development requirements until the lower station (level 143 m) has been installed.

The mine level 143 m pump station will be equipped with two 58-hp pumps to pump groundwater to mine level 173 m. At mine level 173 m, two 125-hp pumps will be installed with a 10,000-gallon agitator tank. From mine level 173 m, water will be pumped to the 300 m level pump station also employing two 125 hp pumps with an agitator tank. From mine level 300 m, water will be pumped to the surface CWBs.

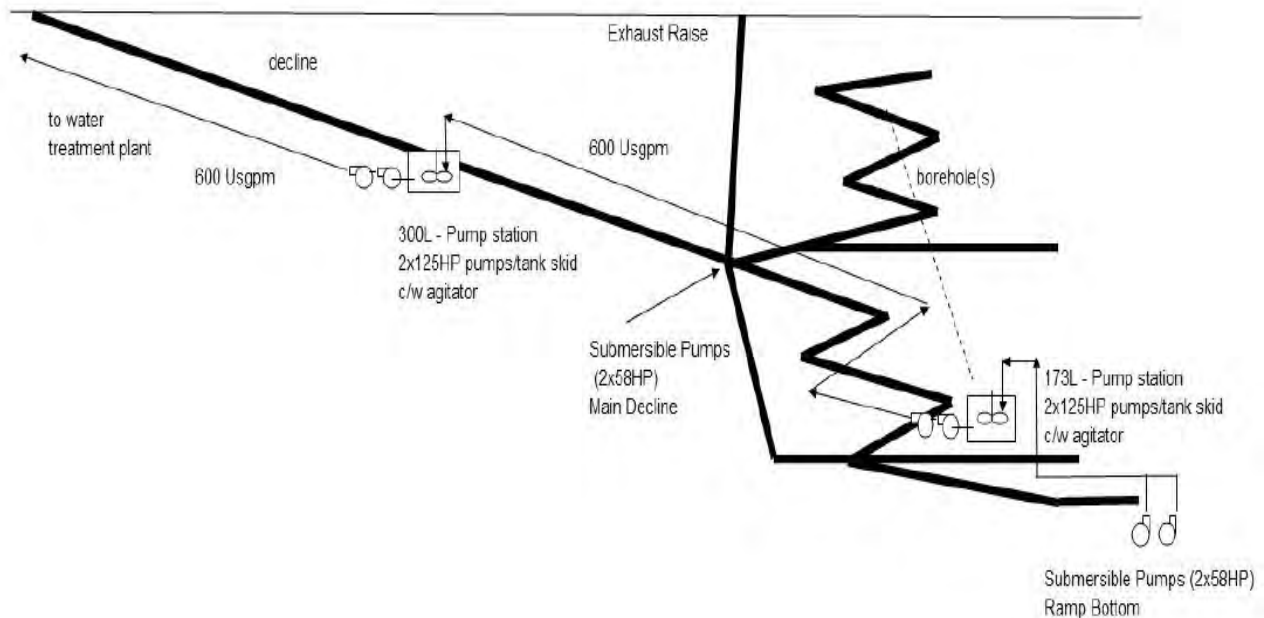


Illustration 4-5
Groundwater Dewatering System

Source: Adapted from McIntosh Engineers

4.5.2 Mine Ventilation Systems

The ventilation design is based upon providing sufficient airflow to the mine workings to maintain safe working conditions. A minimum airflow of 150 cfm per underground worker was used in the design. The total estimated ventilation requirements are 427,000 cfm including employee and equipment demand.

Intake air to the mine is provided via the main decline. Each mine level is ventilated from the decline to a dedicated return air raise. This system is referred to as single-pass ventilation which is well-suited for maintaining safe working conditions. Each return air raise will be connected to the exhaust drift on mine level 248 m.

The 600 hp main exhaust fan will pull air (induced draft) from the main decline to each operating level to achieve the ventilation requirements. Used air is then pulled through return air raises (RAR) to the exhaust drift and then to the exhaust raise. Figure 4-32 is schematic of the overall mine ventilation system.

4.5.3 Underground Ore Handling Systems

The underground ore flow process for the Eagle Project is as follows:

- ♦ On the lower mining levels, below and including mine level 263 m, ore will be remotely loaded from the stopes by production LHDs and delivered to low profile production trucks near the ramp access. If a production truck is not waiting to be loaded, the LHD dumps its bucket at an adjacent load bay and continues removing ore from the stope. When the truck arrives the LHD loads the truck from the loading bay.
- ♦ On levels above mine level 263 m, ore will be remotely loaded from the stopes by a production LHDs and delivered to a centrally located coarse ore grizzly off the FW drift. Remotely operated LHD's will be employed under these operational conditions to limit the operator's presence within the recently blasted stope. The operator will be able to safely operate the LHD outside of the stope using this remote system. Ore drops down the ore pass to mine level 263 m where it loads the low profile production trucks. The ore pass grizzlies are equipped with dust covers to prevent dusting on the levels as well as short circuiting the ventilation. Dust covers are equipped with electric winches and operated remotely by the LHD operators.
- ♦ Once loaded, the low profile production trucks proceed up the decline to the COSA. In the decline design, passing bays are included every 300 m (~984 ft) for vehicles and personnel to allow for the loaded trucks to pass.
- ♦ The COSA will have a capacity of 3,000 m³ (~3,924 yd³). The production trucks dump their loads and proceed back underground.

The underground ore handling system is based upon "best" facility economics. Because economics are constantly changing due to market conditions, changes to the underground ore handling system may be necessary to reflect future market conditions.

4.5.4 Communication Systems

Communications through the mine will be accomplished using a digital cable system. At each level and at other designated locations, wireless routers will be installed. The main control will be in the dispatch center on surface. The base station is multi-channel and used for both voice and data communication. A computer will be integrated with the system to manage data communication. Data communication is for vehicle dispatch systems. Voice communication will be hand held or vehicle mounted radios. The cable system will have multiple vehicle-mounted radios. A tag reading system will be installed at critical areas to ensure all persons are accounted for within the mine. In addition, a manual tag out system will also be used.

4.5.5 Sanitation Systems

Underground sanitation facilities will be provided in accordance with applicable requirements and may consist of portable toilets and sinks placed at several underground locations. Toilets will be periodically brought to the surface and cleaned or exchanged by a vendor.

4.5.6 Underground Electric Supply

Underground electrical demand will be provided by the three surface diesel generators. Only two generators will be running at any given time. The third generator will be used as back-up. Routine power needed during full mine operation will be approximately 2.63 MW. The largest loads for the Eagle Project will be from the exhaust raise fan, backfill plant and the dewatering pumps. Power will also be supplied to remote sites (backfill facility and potable well pump).

4.5.7 Compressed Air System

Compressed air is required for support of mining activities. Compressed air will be distributed from the surface air plant to mine workings using steel pipe. Compressed air requirement for the Eagle Project is 3,600 scfm based upon a line pressure requirement for equipment at 80 to 90 psig. The connection between mining levels will consist of 150 mm (~6.0 in) pipes installed in the main access ramps. Laterals across mining levels will be 100 mm (~4 in) pipes.

4.5.8 Mine Utility Water

Treated mine utility water will be supplied to both surface and underground facilities including the crusher, truck wash, drilling equipment and underground dust control equipment, etc. (see Figures 4-18A and 4-18B for water balance).

4.6 Mine Backfill

Mine backfilling will be conducted in mined out stopes concurrent with the mining of new stopes. The primary stopes will be backfilled using cemented aggregate. The secondary stopes will be backfilled either with limestone amended development rock or other aggregate fill material. The estimated amount of material for secondary backfilling is 936,419 tonnes (Table 4-4). Table 4-9 summarizes the total required primary and secondary backfill tonnage.

Table 4-9
Mine Backfill Requirements

Backfill Type	Quantity (tonnes)
Primary Backfill	1,766,867
Secondary Backfill	936,419 ⁽¹⁾
Total	2,103,288

⁽¹⁾ Excluding 12,586 tonnes placed as underground roadbed during mine operations
Adapted from McIntosh Engineering

Prepared by: JOS1
Checked by: SVD1

The backfill cement plant will be located near mine level 263 m. A 2.4 m (~8 ft) diameter raise will feed the aggregate silo. The capacity of the silo is approximately 800 tonnes. If needed, aggregate will be stockpiled at the surface near the raise.

Cement and fly ash storage silos will be located on the surface providing 110 tonnes of capacity each. Once the cement/fly ash is thoroughly blended, the mix will be discharged to an underground binder bin via a cased 250 mm (~10 in) diameter borehole, feeding a colloidal mixer. It is estimated that cement binder will be approximately 6% by weight. The binder mix is estimated to be a 50:50 proportion of cement and Class C fly ash.

The backfill plant will include an automatic colloidal slurry mixer which feeds a continuous backfill mixer. The mixer will be positioned to allow drive-through with the 40-tonne backfill trucks. The loaded 40-tonne trucks will then take the mix to the designated stope. Figure 4-33 illustrates the backfill plant flow diagram. Water requirements for the backfill mixing process are displayed in the water balance for the project (Figures 4-18A and 4-18B).

4.6.1 Mine Stability and Subsidence Prevention

Golder Associates conducted mine stability and ground surface subsidence modeling as documented in Appendix C. Both plastic and elastic deformation of the crown pillar rock mass were evaluated. Plastic deformation is defined as the collapse and subsequent unraveling and bulking of the displaced rock mass. Elastic deformation is the displacement of the rock mass by “bending” over a void space. Plastic and elastic deformation are both a function of the effectiveness of the backfilling plan. The analyses presented in Appendix C show that plastic deformation will not occur with the proposed stope backfilling plan. Plastic deformation of the crown pillar will be limited to no more than 2 cm at the bedrock/alluvial contact. Given this small displacement, movement at the ground surface will not be measurable. KEMC will conduct subsidence monitoring during operations and during the 20 year post-reclamation monitoring period.

The mine decline stability was also assessed by Golder Associates and determined to be stable without backfilling. As such, backfill of the mine decline will only occur at specific locations to prevent interconnection of different groundwater regimes as described in the reclamation plan in Section 7. As needed, rock support mechanisms such as roof bolting may be employed to stabilize the decline roof at discrete locations.