

How to Estimate the Cost of Portal Construction for an Underground Mine

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Introduction

This discussion on how to estimate the cost of portal construction for an underground mine will include the excavation, drilling and blasting, and the required ground support for safety measures. This type of construction requires substantially more analysis than a simple quantity takeoff utilizing standard unit rates. In order to maintain brevity and clarity the sample estimate provided excludes setup, owner Indirects, contractor Indirects, material delivery, supervision, and sales taxes in the direct costs. The sample estimate includes Indirect, contractor Indirect, material delivery, and supervision, in the indirect items below the line. The sample estimate completed to an SEP design development (level three) level of detail.

Master Format 2014

Main CSI Division

- Division 01- General Requirements
- Division 02 - Existing Conditions
- Division 03 - Concrete
- Division 31 - Earthwork

Main CSI Subdivisions

- Subdivision - 032000 - Concrete reinforcing
- Subdivision - 033000 - Cast-in-Place Concrete
- Subdivision - 312200 - Grading
- Subdivision - 315113 - Excavation Support and Protection

Brief Description

The preliminary portal design prepared in 2014 is the basis for the portal construction estimate. The estimate includes steel arch sets plus rock bolts, mesh, and shotcrete extending approximately 70 ft into the rock face. The high wall above the portal utilizes slope reinforcement with rock bolts; mesh, and shotcrete, Steel sets clad with corrugated steel extend approximately 20 ft outward.

The surface operations of the mine, plan to construct a road and refractory ore storage pad are immediately adjacent to the portal site. This work will also include the rough excavation of the portal site.

Types and Methods of Measurements

Portal construction in most Countries utilizes the metric system. The sample estimate contains Imperial measurements. The quantity surveys for the discussion are a Lump Sum item. (Typically based on Owner preference), it is important to have sufficient supporting cost item details. The detail should ensure that the unit rate applied to the established metric is adequately capturing the potential cost exposure. For costing Purposes, the quantity survey includes a count of each (EA), measurement of length in linear feet (LF), and measurement of an area in square feet (SF). Derived units of measure include weight, in pounds (LBS) or tons (TN), and volume, in cubic feet or cubic yards (CF or CY). Square foot measurements are also often derived from linear foot measurements.

Specific factors

As with any mining or earthwork project, there are a considerable amount of factors to review when establishing quantities and unit rates.

Bid Documents & Site Familiarity

At the Start of the process, there should be a comparison to determine if the amount of information provided is adequate to complete the estimate. The question “Can the level of detail as defined in the (SEP) guidelines be met based on the drawings and specifications provided by the owner. During the review, there may be evidence that the documentation has some discrepancies between the drawings and the specifications. In this case, the allowances for unforeseen conditions may need to be increased. The estimator's familiarity with a given site may also help to provide a comfort level and provide the opportunity for reduced contingencies. A discussion of any additions or reductions of these types should take place with management before making that assumption. When making assumptions, the notes section of the document should carefully explain all the factors, to facilitate full understanding of the estimate. It is important to evaluate the full extent of work required at the portal location.

Existing Conditions

First in evaluating the existing conditions, one will need to survey the location and understand the soil conditions. Certain types of soil may require additional labor, specialized tools, or more stringent safety control measures. For example, excavation started in wet ground

conditions will have special requirements, at the other end of the spectrum extremely dry sandy conditions could require extensive laybacks or the addition of extensive shoring. A complete review of the geotechnical report and recommendations should be completed as a priority item as the report will become a major part of the portal bases of estimate (BoE).

Schedule

The estimator should review the anticipated schedule with the Owner before finalizing the estimate. A more detailed schedule may be required to determine if shiftwork is required. The estimate referenced in this discussion is one shift per day. Portal Construction is usually of high importance as the portal provides critical access to mine infrastructure. In most cases the portal becomes a critical path item in the schedule. One should remember that most if not all mining operations operate on a twenty- four seven-work schedule. The schedule should be thoroughly evaluated for feasibility, to establish accurate prices and expectations from all parties. The estimate provided for the portal will also become the portal basis of schedule (BoS).

Documentation Requirements

Before estimating, the cost of a portal one should understand the importance of the documentation required, for permits, inspections, and certifications. For Portals constructed out of the country, the importance of understanding the government regulations of the host country

are critical to the estimate. Due to substandard safety regulations in foreign countries the estimator should use the US. Safety guidelines when doing a Portal estimate in a foreign country. Using the Mine Safety and Health Administration (MSHA) guidelines is highly recommended. Proper documentation can accelerate the construction process and avoid costly delays associated with discrepancies and safety issues.

Geographic and Fiscal Market Factors

In any construction work and business, in general, there are important market conditions both current and future to consider when establishing unit costs. In the construction of most portals, the work is on a designated Mine site. The rule of thumb is that the owner should provide the labor and equipment rates for the estimate. On a green field project where these rates are not available, the estimator could utilize the Mine and Mill cost guidelines. These are available and include most labor and equipment rates for countries that have active mining operations. Availability of manpower in various countries can contribute significantly to increased project costs and delayed schedules. The required materials to construct the portal in an offshore environment should include an analysis of the freight and scheduling cost. Additionally, an agreement on the foreign currency exchange should be part of the criteria and assumptions. The sample estimate uses 2016 US dollars.

Seasonal Effect on Work

Since the entire scope of work for portal construction takes place in an outdoor environment, typical seasonal factors will play a significant role. Areas with poor weather conditions may see an increase in pricing during the winter. Conversely, excessive heat on

projects in desert regions requires additional cost for worker protection. Examples of this protection would include reduced or modified work schedules and the inclusion of night work. These add factors will have a negative effect on the productivities and the effective available working hours for the work force. Using the Mine Safety and Health Administration (MSHA) guidelines for worker safety is highly recommended. The sample estimate includes seasonal working conditions in the State of Nevada.

Overview of Labor, Material, Equipment, and Approach to Mark-ups

In an estimate utilizing CSI Master- Format, the owners will receive a document that includes a list of quantities and unit rates to support the estimated cost. For mining construction, the direct cost unit rates will include direct costs only. The remaining costs values include indirect costs, and mark-ups added below the line. The primary factors in establishing a viable unit cost are labor, material, equipment, and a subcontractor if necessary. The indirect costs and marked-ups go below the line.

Labor Rates

The Labor rates established by the owner of the project are for each level of billable employees (e.g. Miner vs. Laborer). These rates are normally calculated to include the full cost of the employee's take-home pay, taxes, workman's compensation, social security, Medicare, and benefits, which include things like health insurance, holiday pay and paid time off.

In the mining industry, there are also added production bonuses and safety bonuses. However, in most foreign countries the rate of compensation and benefits are substantially lower than that of the US. There are two exceptions Argentina and Chili, which have some of the highest compensation packages. The estimator should review the Labor rates on a typical project

annually to accommodate inflation and tax changes. Mining and portal construction rates regulated by long-term contracts between the mine operator and the local governments are common. The contract accounts for the owner supplied rate. Depending on the provisions of the contract, labor is calculated (based on 24 hours a day seven- day schedule), there are no premium time rates for night-work or shift-work. These items are part of the bonus program. The sample estimate uses the owner provided labor rate. In this case, the owner has only provided one labor for all labor activities.

Material Rates

Material rates are established using historical data and current market trends. Lead-time and expediting fees are included in the unit rates. Material costs should include all facets of cost to get the material to the required location. The rates should include sales tax (unless the project is tax exempt), shop drawings, design fees, mounting hardware, freight to the job site, storage on-site or offsite. Most mining projects are tax exempt; therefore, there are no taxes included in the sample estimate. For items that have inherent waste factors, such as steel and concrete, the established unit rates should cover the expense of anticipated waste.

Equipment Rates:

For equipment that is owned by the mine, the initial cost, maintenance costs, and depreciation are all included in the rate provided by the owner. For equipment, provided by the owner's contractor the estimator should obtain a rental rate or a quote for the rental rates provided. The sample estimate provided uses contractor provided rental rates.

Indirect Costs

The direct unit cost does not include any Indirect Costs. Direct costs items include all miscellaneous items required for a complete installation covered under General Conditions. These typically consist of things like small tools, consumable goods like nails and screws; in mining, they included in the direct cost.

The Owners Indirect includes supervision, management, and other general overhead items necessary to complete the project. Contractor Indirects are additional costs added to the contractor work items to cover the contractor's management and additional overhead. The sample estimate includes fifteen percent (15%) for owner Indirect and an additional ten percent (10%) for contractor Indirects.

Mark-up

Unit costs for lower tier subcontracts should be inclusive of their contract value, including mark-up. The Contractor's mark-up (Margin) should be carried "below the line" as a percentage of the total cost of construction. In the absence of adequate historical data for a given work item, or as a check number, there are numerous places to find standard unit rates for almost every work item imaginable. Mining Cost Services are the primary sources for published unit pricing, accessed with a paid subscription. When in doubt, the supplier of the material in question needs to provide current pricing and expected labor productivity rates. The sample estimate includes fifteen percent (15%) for contractor Margin

Engineering Procurement and Construction Management (EPCM) Allowance

The engineering component of EPCM is an allowance for detail engineering drawings and issued-for-construction drawings that are prepared for the construction of the facilities

identified. The sample estimate includes the following EPCM items; an allowance of six percent (6%) applied to all cost items for the engineering work.

Procurement services costs are an allowance for the purchase of equipment, traveling to manufacturer's plants, and miscellaneous costs incurred during the purchase of both fixed and mobile equipment. An allowance of two percent (2%) is applied to all cost items for procurement of materials and equipment as necessary

The construction management costs and the size of the team vary on an annual basis, depending on the amount of construction work scheduled. An allowance of ten percent (10%) applies to all construction items for construction management. The total add-on for the (EPCM) work to construct the portal is eighteen percent (18%)

Contingency

The contingency provides additional project capital for expenditures that are anticipated, but not defined, due to the level engineering detail in the estimate. A capital contingency of 20% assessed against the total Contractors and Owners costs.

Special Risk Considerations

Construction activities, in general, are hazardous; work on portal construction is arguably one of the most important. The portal is critical for accessing the underground mine. The portal is for ingress and egress for the Mine. The portal is also a major part of the ventilation system that provides airflow to and from the underground operations

Contractors must be conscious of the risks at all times, as failure to properly ensure ground support and safety measures during drilling and blasting could result in the loss of life.

This constant onus of safety will typically result in lower productivity, coupled with costly safety implementation.

The estimator should consider the two following rules of thumb when evaluating costs and risk associated with shoring and dewatering. First, the maximum practical depth for sheet piling in cohesive soils is approximately 60 feet (18m). In granular soils, the depth is usually not more than 40 feet (12m). Second standard well points systems use suction (vacuum) lift and the practical limit for lowering the ground water are normally about 16 feet (5m). Typically, the second stage of well points will be required to lower the ground water further. (Hard Rock Miner's Handbook)

Ratios and Analysis

Ratios and Analysis – Metrics and Review for Proper QA/QC:

Portals constructed in many different countries and climates; historical data will be available for comparison of the Portal estimate. A simple cost per lineal foot comparison may be a helpful benchmark provided the previous projects are similar portal size. However, a more accurate benchmark would be a typical cost per type and size of the portal. For example, the historical cost of a new portal constructed in Arizona could compare to the cost per location from the current portal estimate located in Nevada. Both have similar Soil types and climates. In comparison, benchmarking against the same size portal constructed in Alaska is not recommended due to the difference in climate and ground conditions.

A secondary approach to validating the current portal estimate would be to consider the use of work force logic. In this case, the estimator would review the approved schedule and the labor required to meet that schedule. Instead of costing the portal using unit rates, the costing could be completed by considering the material and labor cost separately. The material takeoff

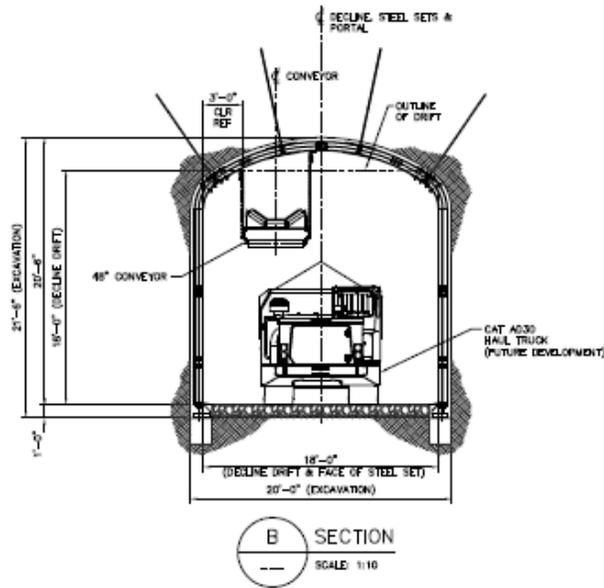
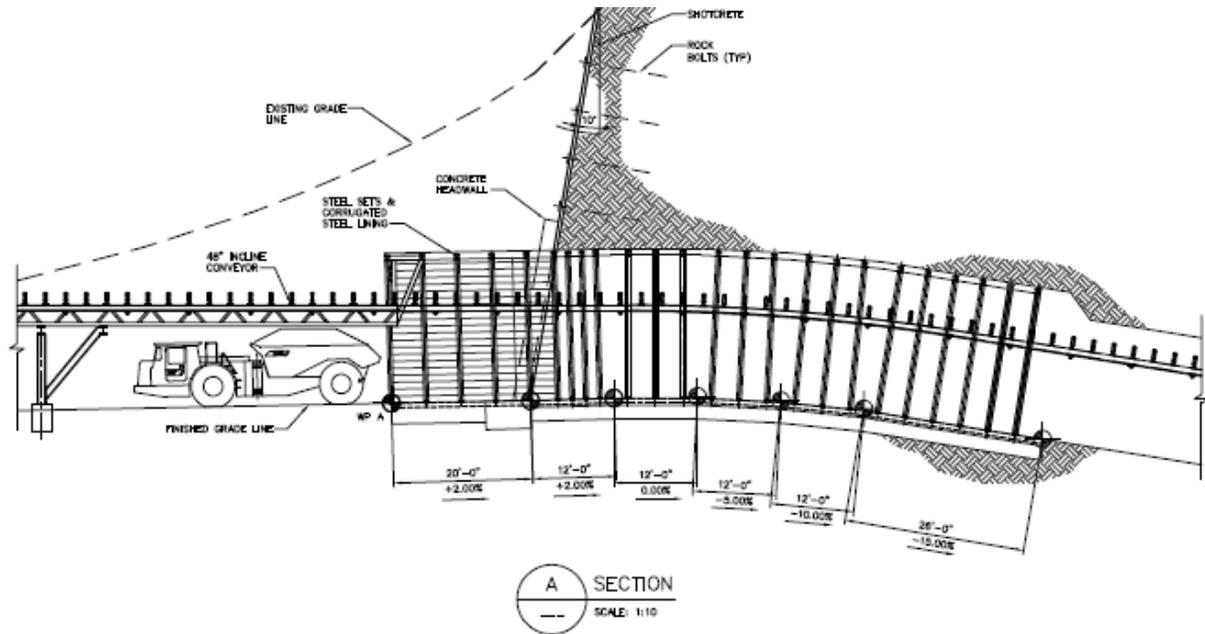
should provide a reliable quantity for material pricing. Secondly, the estimator would evaluate the number of miners (and laborers, etc.) that would be required to complete the project in the allotted time. Finally, the estimator would evaluate if the lump sum construction costs were satisfactory to cover: the full cost of the labor equipment and materials for the total duration of the project. On projects of this nature, it is likely that there will be significant unproductive time, caused by unexpected ground conditions, and changes to safety requirements.

Miscellaneous Pertinent Information

Based on the project delivery method, lump sum, time and materials, or guaranteed maximum prices, unit costs and allowances may need to be adjusted. The previous discussion is about a lump sum contract. A portal completed on a time and materials basis, has no adjustments for inefficiencies, because unproductive time would be billable to the client. The time and material delivery method can be beneficial for projects on an accelerated schedule. The owner is motivated to cooperate in order to expedite access to areas of work and reduce waiting times. To a proactive owner, this method could result in cost savings as it minimized the risk to the contractor.

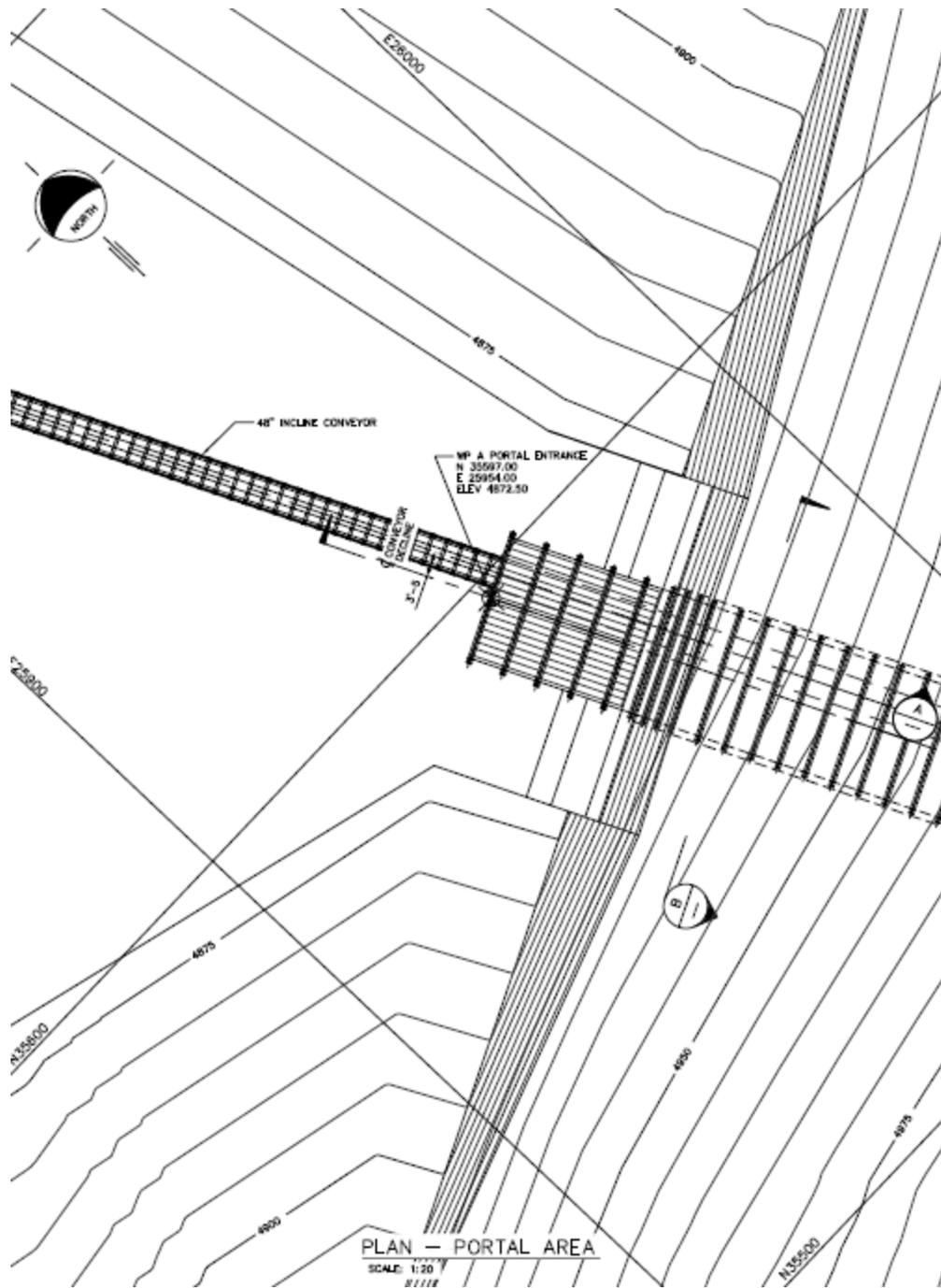
Sample Sketch

The following are a few examples of relevant documents.



PRELIMINARY NOT FOR CONSTRUCTION

The sections above represent the typical details used for the discussion estimate. The conveyor is excluded and covered by the material handling document.



The above topo represents what a typical portal layout would look like at the toe of a hillside after mass excavation had taken place.

Sample Take-off and Costing Sheets

General Information Sheet Provides Quantities

CLIENT: ASPE		MADE BY: RDG		DATE: 06/13/16	
SEARCH CODE: 0		CHECK BY:			
ITEM: EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR				SHEET: 2 of 3	
COST AREA: GENERAL INFORMATION					
CLEAR AND GRUE 3457.78 SQUARE FT					
DOZER	5,438	SQUARE FT/HR		DURATION:	1.74 HRS
		CREW	1	MS	0.17
RIPPABLE MATERIAL REMOVAL 1030.35 CUBIC YARDS					
STOCKPILE DIST.		0.25	MILE		
740 HAUL TIME LOADED		3	MIN	TK CAPACITY	31.4 CY
740 HAUL TIME EMPTY		3	MIN	LOADS	35 EA
SPOT/LOAD/DUMP TIME		3.5	MIN	DURATION:	6.65 HRS
		CREW	3	MS	1.30
DRILL & BLAST GOOD GROUND					
MAX DEPTH		21.60	FT		
AVERAGE DEPTH		10.8	FT		
AREA BLASTED		144	FT LONG	20	FT WIDE
AREA BLASTED		2880	SQUARE FT		
PRESPLIT HOLES		2	FT CENTERS	156	EACH
BLAST HOLES		4	FT CENTERS	180	EACH
TOTAL DRILL HOLES		336	EACH		
TOTAL DRILL FT		3628.8	DRILL FT		
INSITU VOLUME		1152	CY		
SWELL		40%			
BROKEN VOLUME		1612.8	CY		
POWDER FACTOR - PRE SPLIT HOLES		1	LB/CY	1152	LBS
POWDER FACTOR BLAST HOLES		4	LB/CY	4608	LBS
BOOSTERS		2	PER HOLE	672	EACH
CORD		5532.36	FT		
BLAST WIRE		2500	FT		
DRILL		336	HOLES	7.7	MIN/HOLE
				DURATION:	51.74 HRS
		CREW	2	MS	3.856
LOAD/BLAST		336	HOLES	4	MIN/HOLE
				DURATION:	4.48 HRS
		CREW	6	MS	2.56
MUCK	LOADS	52	EA		DURATION: 3.88 HRS
		CREW	3	MS	2.82
SUPPORT					
AREA SUPPORTED		3542.4	SQ FT		
BOLTS		3	CENTERS	334	BOLTS
BOLTS		12	FT	4728	DRILL FT
BOLTS WITH MESH		8.2	MIN/BOLT	1	DRILLS
				DURATION:	64.38 HRS
		CREW	4	MS	24.53
MESH		10%	OVERLAP	3897	SF
SHOTCRETE		0.33	FT THICK	43.73	CY WITHOUT REBOUND
SHOTCRETE REBOUND		25%		54.67	CY WITH REBOUND
SETUP/TEAR DOWN:		20	MINS		
PERFORMANCE:		4.0	CY/HR		DURATION: 14.07 HRS
		CREW	3	MS	4.02
0					
CLIENT: ASPE		MADE BY: RDG		DATE: 06/13/16	
SEARCH CODE: 0		CHECK BY:			
ITEM: EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR				SHEET: 3 of 3	
COST AREA: GENERAL INFORMATION					
AVAILABLE TIME/DAY					
HR/SHIFT		10.5	HRS	ACTUAL HR/SHIFT	12 HRS
SHIFT/DAY		1	SHIFTS	WORK DAYS/MONTH	30.25 DAYS
MIN/HR		50	MIN		
MIN/DAY		525	MIN/DAY		

Performance for Excavation Items

CLIENT:	ASPE	MADE BY:	RDG	DATE:	06/13/16
SEARCH CODE:	0	CHECK BY:			
ITEM:	EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR			SHEET:	4 of 9
COST AREA:	PERFORMANCE				
<hr/>					
ACTIVITY		MS		DURATION (HRS)	
CLEAR AND GRUB/CLEAR AND GRUB		0.17		1.74	
RIPPABLE MATERIAL REMOVAL		1.90		6.65	
DRILL & BLAST GOOD GROUND		12.42		56	
MUCK		2.82		10	
BOLTS WITH MESH		24.53		64	
SHOTCRETE		4.02		14	
<hr/>					
TOTALS		46 MS		153 HRS	
TOTAL DURATION (DAYS)				14.57 DAYS	
<hr/>					
OVERALL PERFORMANCE RATE		PERCENT	UNIT	DURATION (DAYS)	
QUANTITY	1 LS	100%	1 LS	14.57	
<hr/>					
	TOTAL DURATION:			14.57 DAYS	
	RATE:			0.07 LS/DAY	

Equipment Rental

PROJECT:	ASPE			MADE BY: RDG	DATE: 06/13/16
AREA:	-			CHECK BY:	
ITEM:	EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR			SHEET: 7 of 9	
COST AREA:	EQUIPMENT RENT				

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST	RENT %	MONTHLY COST
Drill Jumbo, Single Boom, Electro/Hy	1	EA	\$1,078,607	\$1,078,607	4.00%	\$43,144
Telehandler, Diesel, Underground	1	EA	\$179,584	\$179,584	4.00%	\$7,183
Shotcrete Placer Truck	1	EA	\$821,988	\$821,988	4.00%	\$32,880
Tracked Dozer - 150 HP-Surface	1	EA	\$485,188	\$485,188	4.00%	\$19,408
Surface Loader - 8.0 cy	1	EA	\$1,206,970	\$1,206,970	4.00%	\$48,279
Muck Truck - Surface	1	EA	\$832,585	\$832,585	4.00%	\$33,303
Air Track Drill w/Compressor	1	EA	\$250,000	\$250,000	4.00%	\$10,000
						\$0.00
						\$0.00
TOTAL MONTHLY COST:						\$194,197
TOTAL EQUIPMENT COST PER DAY:				30.25 DAY/MONTH		\$6,420
TOTAL EQUIPMENT RENT UNIT COST:						\$93,507.75

Services and Supplies

PROJECT:	ASPE	MADE BY:	RDG	DATE:	06/13/16	
AREA:	-	CHECK BY:				
ITEM:	EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR			SHEET:	9 of 9	
COST AREA:	SERVICES AND SUPPLIES					
<hr/>						
EXPLOSIVES:		QTY/LS	UNIT	COST	WASTE	COST/UNIT PER LS
<hr/>						
Emulsion-Bulk		5760.00	/pound	\$ 0.57	5%	\$ 3,447.36
0.5 lb Cast Booster		672.0	/ea	\$ 1.95	5%	\$ 1,375.92
Nonelectric Delay Detonator		336.0	/ea	\$ 2.24	5%	\$ 790.27
Electric Delay Detonator		2.0	/ea	\$ 1.92	5%	\$ 4.03
Cordex		5593.0	/ft	\$ 0.12	5%	\$ 704.71
MISC	10.0%					\$ 632.23
SUBTOTAL EXPLOSIVES):						\$ 6,954.53
<hr/>						
DRILLING:						
<hr/>						
Air Track Drill w/Compressor		3628.80	DF	\$5.00	5.00%	\$19,051.20
Drill Jumbo, Single Boom, Electro/Hydraulic Drill(Roc		4728.00	DF	\$1.33	5.00%	\$6,595.42
SUBTOTAL DRILLING:						\$ 25,646.62
<hr/>						
SERVICES:						
<hr/>						
SUBTOTAL SERVICES:						\$ -
<hr/>						
MISCELLANEOUS						
<hr/>						
Small Tools	45.85 MS/LS	1.00	LOT	\$ 14.50		\$ 664.64
SUBTOTAL MISCELLANEOUS:						\$ 664.64
<hr/>						
SUBTOTAL:						\$ 33,265.78
<hr/>						
TOTAL SERVICES & SUPPLIES UNIT COST:						\$ 33,265.78

Cost Summary of the Excavation and Support Items

CLIENT:	ASPE			MADE BY: RDG	DATE: 06/13/16
SEARCH CODE:				CHECK BY:	
CON / OWN	CONTRACTOR				
HEADING					
ORE / WASTE					
ITEM:	EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR			SHEET: 1 of 9	
ESTIMATE CODE					
FILE:	C:\Users\bgriesinger\Documents\ASPE\Tech Paper Sub\Portal.xls\servsupp				
DESCRIPTION:	EXCAVATE/SUPPORT PORTAL IN GOOD GROUND - CONTRACTOR				
INCLUDES:					
	EXCAVATION				
	SUPPORT	8 FT SUPER SWELLEX BOLTS			
		3 FT CENTERS			
		100% MESH			
		0.33 FT SHOTCRETE			
	DRIFT SIZE	21.6 FT HIGH	20 FT WIDE		
	DECLINE	15%			
	EXCAVATION FACTOR	1			
	RIPPABLE DEPTH	5 FT			
	RIPPABLE ANGLE	30%			
		1 SHIFT PER DAY			
EXCLUDES:	SETUP, OWNER INDIRECTS, CONTRACTOR INDIRECTS, MATERIAL DELIVERY, SUPERVISION, SALES TAXES				
QUANTITY:	1 LS				
ADVANCE RATE:	0.00 LS/DAY	MAN SHIFTS	DAILY	UNIT COST	TOTAL COST
SUMMARY COMPONENTS		/LS	MANPOWER	/LS	/LS
LABOR					
SALARY		0.00	0	\$ -	\$ -
HOURLY		667.82	46	\$ 33,090.75	\$ 33,090.75
LABOR TOTALS		667.82	45.85	\$ 33,090.75	\$ 33,090.75
PERMANENT MATERIALS (LESS Ground Support)				\$ -	\$ -
PERMANENT MATERIALS (Ground Support)				\$ 37,808.59	\$ 37,808.59
EQUIPMENT - DIRECT CHARGE				\$ -	\$ -
EQUIPMENT RENT				\$ 93,507.75	\$ 93,507.75
EQUIPMENT - OPERATING COST (LESS DIESEL)				\$ 10,880.48	\$ 10,880.48
EQUIPMENT - OPERATING COST (DIESEL)				\$ 6,117.40	\$ 6,117.40
SERVICE AND SUPPLIES				\$ 33,265.78	\$ 33,265.78
SUBCONTRACTS				\$ -	\$ -
SUBTOTAL:				\$ 214,670.76	\$ 214,670.76
SALES TAX:			0%	0	\$ -
TOTAL COST:				\$ 214,670.76	\$ 214,670.76

Total Capital Cost Estimate

ASPE			
ACCESS PORTAL			
CAPITAL COST ESTIMATE			
June 2016			
			Total
Item Description	Quantity	Unit	Total Cost
GENERAL ACTIVITIES			
Mobilize Contractor	1	Lump Sum	\$ 103,247
Contractor Surface Setup	1	Lump Sum	\$ 40,109
Teardown Contractor Plant	1	Lump Sum	\$ 15,000
Demobilize Contractor	1	Lump Sum	\$ 80,326
PORTAL CONSTRUCTION			
Support Bank Above Headwall	1	Lump Sum	\$ 32,748
Excavate Lift #1 and Presplit Drill and Blast	1	Lump Sum	\$ 20,304
Support Lift #1	1	Lump Sum	\$ 20,030
Excavate Lift #2	1	Lump Sum	\$ 6,980
Support Lift #2	1	Lump Sum	\$ 19,795
Excavate Lift #3	1	Lump Sum	\$ 12,575
Support Lift #3	1	Lump Sum	\$ 22,130
Excavate Lift #4	1	Lump Sum	\$ 11,839
Support Lift #4 (100%)	1	Lump Sum	\$ 16,768
Excavate Portal (Sample Estimate Provided)	1	Lump Sum	\$ 214,670
Headwall Foundations	1	Lump Sum	\$ 296,793
Plate Arch Foundations and Installation	1	Lump Sum	\$ 235,586
Headwall Concrete	1	Lump Sum	\$ 154,178
Sub Total Direct Cost			\$ 1,303,081
Contractor Indirects	10%		\$ 130,308
Contractor Margins	15%		\$ 215,008
Owner Indirects	15%		\$ 247,260
EPCM	18%		\$ 341,218
Contingency	20%		\$ 447,375
Total Direct and Indirect Cost			\$ 2,684,251

Glossary/ Acronyms

BoE	basis of estimate
BoS.....	basis of schedule
CapEx.....	capital expenditure
CIM.....	Canadian Institute of Mining, Metallurgy and Petroleum
EPCM.....	engineering, procurement, and construction management
IRS	intact rock strength
LOM.....	life-of-mine
MSHA	Mine Safety and Health Administration
MTO.....	material takeoff
NPV.....	net present value
QA.....	quality assurance
QC.....	quality control
RMR.....	rock mass rating
RQD	rock quality designation
ToPo.....	topographical Data

References

Hard Rock Miners Hand Book (Rules of Thump) Edition 4, 2015