

National Exams May 2019

**09-MMP-B8 Mine Management & Systems Analysis**

**3 hours duration**

NAME: \_\_\_\_\_

DATE: \_\_\_\_\_

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ANSWER ALL 5 QUESTIONS FOR A TOTAL OF 100 MARKS.

APPENDIX A WITH DISCOUNTED CASH FLOW TABLES IS ATTACHED.

THIS IS A CLOSED BOOK EXAM - ONE OF TWO CALCULATORS IS PERMITTED - ANY CASIO OR SHARP APPROVED MODEL.

CLEARLY STATE AND JUSTIFY ANY ASSUMPTIONS THAT YOU MAKE.

PARTS OF QUESTIONS 4 AND 5 CAN BE ANSWERED DIRECTLY ON THESE SHEETS - ANSWER OTHER QUESTIONS AND SECTIONS IN THE BOOKLETS PROVIDED.

RETURN ALL 7 PAGES WITH YOUR EXAM BOOKLETS.

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**Question 1 - Mining Stages. (15 Marks)**

- a) Name and describe the 5 stages in the life of a mine. (10 Marks)
- b) Describe the 5 stages in terms of typical cash flows and sketch the corresponding cash flow diagram. (5 Marks)

**Question 2 – Mining Project Financial Analysis and Feasibility. (25 Marks)**

Evaluate the mining project described in the edited press release given below and answer the financial analysis questions that follow.

*TORONTO, ONTARIO - (February 15, 2018) - McEwen Mining Inc. announces results of the updated Feasibility Study for its 100% owned Gold Bar Mine in Nevada. Construction has started on the Gold Bar Mine with a planned completion date in late 2018, and commercial production beginning in 2019. Oxide ore will be mined from three open pits and transported by 100-ton haul trucks to be crushed, screened, conveyed and agglomerated. The feasibility study assumes the use of a contract mining fleet. Ore will be conveyor-stacked at a rate of approximately 8,000 tons per day on a conventional heap leach pad. An adsorption-desorption recovery (ADR) carbon plant will produce a final gold-silver doré product. Details of the 7 year mine production schedule, capital costs, and operating costs are given in the attached Tables 1,2 and 3.*

Conduct a discounted cash flow analysis of this project (as outlined below) **clearly stating and justifying all of the economic factors that you interpreted from the press release.** Note that DCF tables are provided in the attached Appendix A. From this information, determine:

- a) The gross and net value of ore per tonne for \$1250, \$1300 and \$1350 USD/oz gold.
- b) Net Present Value and at a discount rate of 10% and payback period on a before-tax basis for the 3 gold values given in (a).
- c) Based on your analysis, would you recommend this project as an investment opportunity? Justify your recommendation.

*Table 1. Summary mine production schedule. Gold ore mined in Year 0 (preproduction period) will be stockpiled and processed in Year 1 (first production year). LoM are Life of Mine totals.*

Year	Ore Tons (000's tons)	Gold Grade (oz/t)	Contained Gold (000's oz)	Recovered Gold (000's oz)	Waste Tons (000's tons)	Strip Ratio
0	265	0.020	5.2	0	4,370	16.5
1	2,038	0.035	70.7	55.1	14,369	7.1
2	2,773	0.032	87.6	74.2	14,137	5.1
3	2,742	0.030	82.9	68.0	16,193	5.9
4	2,752	0.025	70.0	58.6	13,437	4.9
5	2,665	0.027	71.2	57.2	13,815	5.2
6	2,749	0.029	80.9	66.4	9,082	3.3
7	513	0.032	16.5	18.2	1,065	2.1
LoM	16,497	0.029	485.0	397.7	86,468	5.2

Table 2. Summary of Year 0 capital costs in 2018 USD.

Capital Items	Cost (\$ millions)
Site General	3.6
Mobile Equipment	1.3
Crushing & Agglomeration	4.8
Leach Pad Stacking	3.9
Heap Leach Pad & Ponds	13.6
Solution Transfer Systems	2.9
ADR Plant	6.1
Refinery	2.0
Water Systems	4.7
Power Generation & Distribution	4.4
Reagent Systems	1.1
Laboratory	2.2
Warehouse	0.4
Administration	0.8
Fuel Station	0.5
Freight	2.1
Trends	1.4
<b>Direct Cost</b>	<b>56.7</b>
Indirects (EPCM, mobilization, demobilization, and commissioning)	8.4
Contingency	4.6
County Sales Tax	1.2
<b>Plant and Infrastructure Total</b>	<b>70.9</b>
Owners Costs	6.4
Mine Development and Pre-Stripping	3.4
<b>Total Capital Cost</b>	<b>80.8</b>

Table 3. Summary of Year 1 to Year 7 operating costs in 2018 USD, including mining, processing and overhead (general and administration) on a per ton basis.

	Cost per Ton of Ore Processed	Cost per Ounce Produced
Mining	\$11.75	\$487
Process	\$5.23	\$217
G&A	\$1.59	\$66
<b>Total Cash Cost<sup>(5)</sup></b>	<b>\$18.57</b>	<b>\$770</b>

**Question 3. Shovel-Truck Fleet Analysis. 20 Marks**

For the McEwen Mining project described in a Question 2, the open pit furthest from the process mill will have a working area where the route from the loading shovel to the primary crusher is i) 100 m of level in-pit haulage, ii) climbing through 125 m of elevation change up a 10% ramp, and iii) traveling a horizontal distance of 1950 m to the crusher. The rolling resistance of all ramp and road surfaces is expected to be approximately 6% and downhill speed limits of 30 km/h are imposed. Time study data for loading and dumping times are given in Fig. 3.1 and the truck performance charts are given in Fig. 3.2. Using these data, determine (a) the expected range of truck cycle times, and (b) the optimum number of trucks to assign to the shovel at this working area. Clearly justify any assumptions you make regarding the use of the provided data.

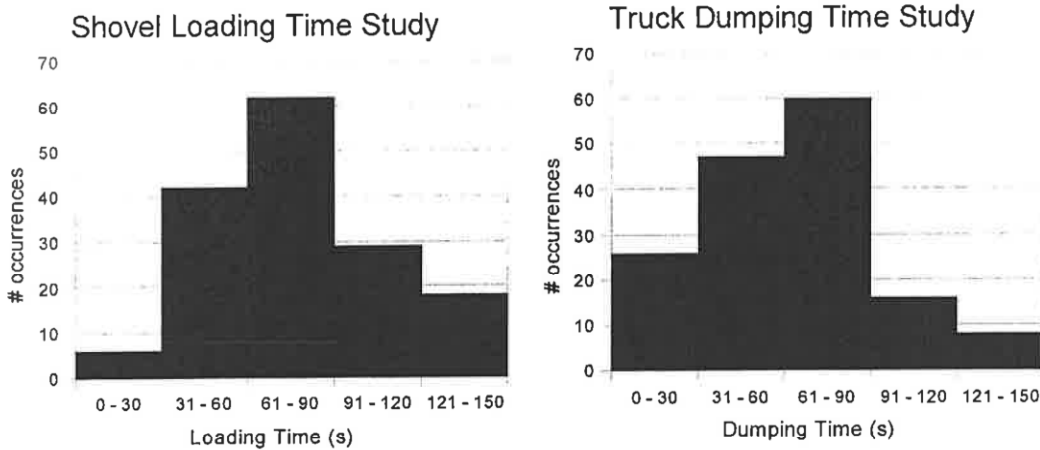


Fig. 3.1 Histograms of shovel loading and truck dumping times.

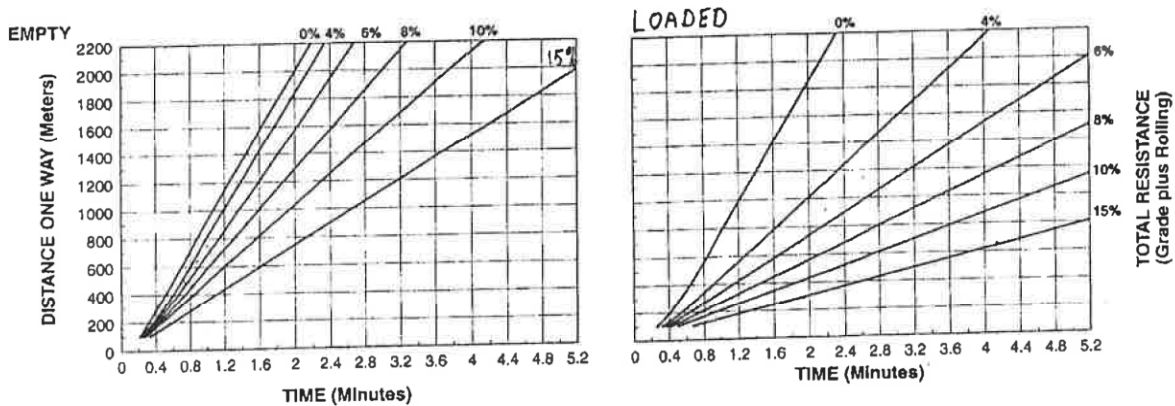


Fig. 3.2 Haul truck performance charts.



**Question 5 – Open Pit Limits. 20 Marks**

The 2-D geological block model shown below gives ore grades for a disseminated mineral deposit in percent, where a cutoff grade of 1.5% differentiates between ore and waste. For this model, the block volumes are 1000 m<sup>3</sup> and both ore and waste have an average density of 2.5 tonnes/m<sup>3</sup>. Combined mining, milling, and overhead costs are \$50/tonne and the net processed mineral value is \$2800/tonne. From this data, use the 2-D Lerchs-Grossman method to determine the most profitable pit outline.

Geological Block Model (% grade):

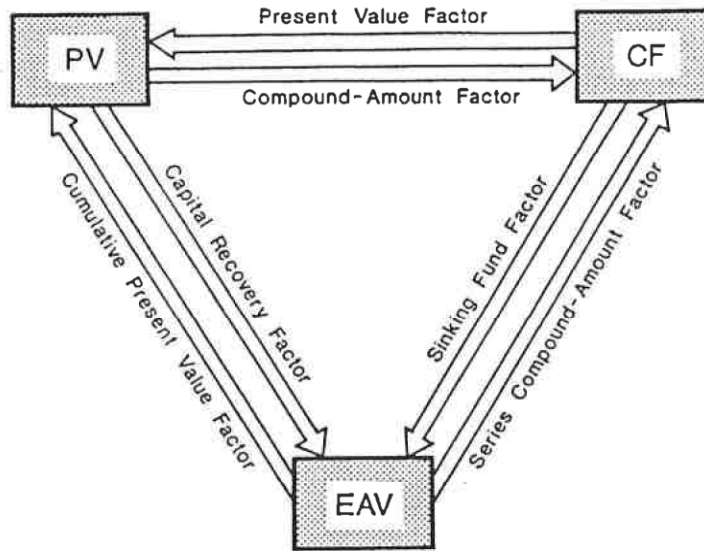
0	0	2	3	4	3	1	1
0	0	1	4	4	0	1	0
0	0	1	4	2	3	0	0
1	1	1	2	3	1	0	0
0	1	1	2	2	1	0	0

Economic Block Model (\$):


Cumulative Block Model:


Profit Block Model:


Appendix A – Discounted Cash Flow Analysis Tables and Charts



years	PVF				CPVF				SFF			
	10%	20%	30%	40%	10%	20%	30%	40%	10%	20%	30%	40%
1	0.9091	0.8333	0.7692	0.7143	0.9091	0.8333	0.7692	0.7143	1.0000	1.0000	1.0000	1.0000
2	0.8264	0.6944	0.5917	0.5102	1.7355	1.5278	1.3609	1.2245	0.4762	0.4545	0.4348	0.4167
3	0.7513	0.5787	0.4552	0.3644	2.4869	2.1065	1.8161	1.5889	0.3021	0.2747	0.2506	0.2294
4	0.6830	0.4823	0.3501	0.2603	3.1699	2.5887	2.1662	1.8492	0.2155	0.1863	0.1616	0.1408
5	0.6209	0.4019	0.2693	0.1859	3.7908	2.9906	2.4356	2.0352	0.1638	0.1344	0.1106	0.0914
6	0.5645	0.3349	0.2072	0.1328	4.3553	3.3255	2.6427	2.1680	0.1296	0.1007	0.0784	0.0613
7	0.5132	0.2791	0.1594	0.0949	4.8684	3.6046	2.8021	2.2628	0.1054	0.0774	0.0569	0.0419
8	0.4665	0.2326	0.1226	0.0678	5.3349	3.8372	2.9247	2.3306	0.0874	0.0606	0.0419	0.0291
9	0.4241	0.1938	0.0943	0.0484	5.7590	4.0310	3.0190	2.3790	0.0736	0.0481	0.0312	0.0203
10	0.3855	0.1615	0.0725	0.0346	6.1446	4.1925	3.0915	2.4136	0.0627	0.0385	0.0235	0.0143
11	0.3505	0.1346	0.0558	0.0247	6.4951	4.3271	3.1473	2.4383	0.0540	0.0311	0.0177	0.0101
12	0.3186	0.1122	0.0429	0.0176	6.8137	4.4392	3.1903	2.4559	0.0468	0.0253	0.0135	0.0072
13	0.2897	0.0935	0.0330	0.0126	7.1034	4.5327	3.2233	2.4685	0.0408	0.0206	0.0102	0.0051
14	0.2633	0.0779	0.0254	0.0090	7.3667	4.6106	3.2487	2.4775	0.0357	0.0169	0.0078	0.0036
15	0.2394	0.0649	0.0195	0.0064	7.6061	4.6755	3.2682	2.4839	0.0315	0.0139	0.0060	0.0026
16	0.2176	0.0541	0.0150	0.0046	7.8237	4.7296	3.2832	2.4885	0.0278	0.0114	0.0046	0.0018
17	0.1978	0.0451	0.0116	0.0033	8.0216	4.7746	3.2948	2.4918	0.0247	0.0094	0.0035	0.0013
18	0.1799	0.0376	0.0089	0.0023	8.2014	4.8122	3.3037	2.4941	0.0219	0.0078	0.0027	0.0009
19	0.1635	0.0313	0.0068	0.0017	8.3649	4.8435	3.3105	2.4958	0.0195	0.0065	0.0021	0.0007
20	0.1486	0.0261	0.0053	0.0012	8.5136	4.8696	3.3158	2.4970	0.0175	0.0054	0.0016	0.0005
21	0.1351	0.0217	0.0040	0.0009	8.6487	4.8913	3.3198	2.4979	0.0156	0.0044	0.0012	0.0003
22	0.1228	0.0181	0.0031	0.0006	8.7715	4.9094	3.3230	2.4985	0.0140	0.0037	0.0009	0.0002
23	0.1117	0.0151	0.0024	0.0004	8.8832	4.9245	3.3254	2.4989	0.0126	0.0031	0.0007	0.0002
24	0.1015	0.0126	0.0018	0.0003	8.9847	4.9371	3.3272	2.4992	0.0113	0.0025	0.0006	0.0001
25	0.0923	0.0105	0.0014	0.0002	9.0770	4.9476	3.3286	2.4994	0.0102	0.0021	0.0004	0.0001
26	0.0839	0.0087	0.0011	0.0002	9.1609	4.9563	3.3297	2.4996	0.0092	0.0018	0.0003	0.0001
27	0.0763	0.0073	0.0008	0.0001	9.2372	4.9636	3.3305	2.4997	0.0083	0.0015	0.0003	0.0000
28	0.0693	0.0061	0.0006	0.0001	9.3066	4.9697	3.3312	2.4998	0.0075	0.0012	0.0002	0.0000
29	0.0630	0.0051	0.0005	0.0001	9.3696	4.9747	3.3317	2.4999	0.0067	0.0010	0.0001	0.0000
30	0.0573	0.0042	0.0004	0.0000	9.4269	4.9789	3.3321	2.4999	0.0061	0.0008	0.0001	0.0000