National Exams May 2010

98-MMP-A5, Mine Management and Systems Analysis

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK exam. Any non-communicating calculator is permitted.

3. Appendix A with discounted cash flow tables is attached.

4. A complete paper consists of answers to five (5) questions clearly indicate the questions you want graded if not indicated the first five questions listed will be marked.

5. Each answer will count equally toward the final grade; ie., each is worth 20%.

98-MMP-A5 Mine Management and Systems Analysis

National Exam

May, 2010

Time limit for exam is 3 hours.

Answer any 5 questions so that the total number of marks equals 100. If more than 5 questions are attempted, clearly indicate the 5 questions that are to be graded.

Appendix A with discounted cash flow tables is attached.

Total number of pages is 6.

Question 1 - Project Scheduling. 20 Marks

For the following mining project development schedule, generate a Gantt Chart showing the dependency and duration of tasks. What is the expected project duration if all tasks are completed within the planned duration? What tasks are not critical for the project to remain on schedule and why?

Task	Description	Duration (Months)	Dependent on Task #
1	10 km access road to minesite	8	none
2	15 km rail link to main CN line	12	none
3	Hoist and headframe installation	6	1
4	Collaring of shaft	2	3
5	Shaft sinking to Phase 1 depth	19	4
6	Ramp development to initial development levels	24	4
7	Construction of surface buildings (offices, warehouses, workshops, permanent dry rooms)	16	3
8	Shaft lining/guides, installation of cage and skip	10	5
9	Construction of surface crusher, ball mill	48	2
10	Construction of concentrator	48	2
11	Construction of flotation mill	60	2
12	Construction of underground crusher station	6	8
13	Excavation of initial 2 development levels	24	8
14	Excavation of initial ore passes	6	12
15	Construction of level 2 refuge station & garage	8	6,13
16	First production excavation (final step)	N/A	9,10,11,14,15

Question 2 - Feasibility Study and Financial Analysis. 20 Marks

This question is based on economic analysis of the mining project described in a recent press release:

> ***Bannerman to go ahead with Etango feasiblity study***
> *By: Creamer Media Reporter, 14th December 2009*
>
> *Australia-Namibia-Toronto listed uranium exploration and development company Bannerman Resources on Monday said it had received board approval to proceed with a definitive feasibility study on its 80%-owned Etango project, in Namibia, following positive results from the preliminary feasibility study.*
>
> *The preliminary feasibility study indicated a pre-tax internal rate of return of 22% for flotation concentrate leaching, and a pay-back period of three to four years, based on a long-term uranium price of $70/lb uranium oxide. The expected capital costs were $555-million to facilitate flotation concentrate leaching. Expected operating costs for flotation concentrate leaching were $38/lb uranium oxide in the first five years, with an average life-of-mine cost of $41/lb uranium oxide.*
>
> *The company said production was estimated to start in late 2013, with modelled output of five-million to seven-million pounds of uranium oxide a year over 16-year mine life. Bannerman also said it was on schedule for lodgement of a mining licence application by the end of the year. The definitive feasibility study was scheduled for completion in early 2011.*

.Conduct a before-tax discounted cash flow analysis of this project, **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 the press release and your justified assumptions, determine:

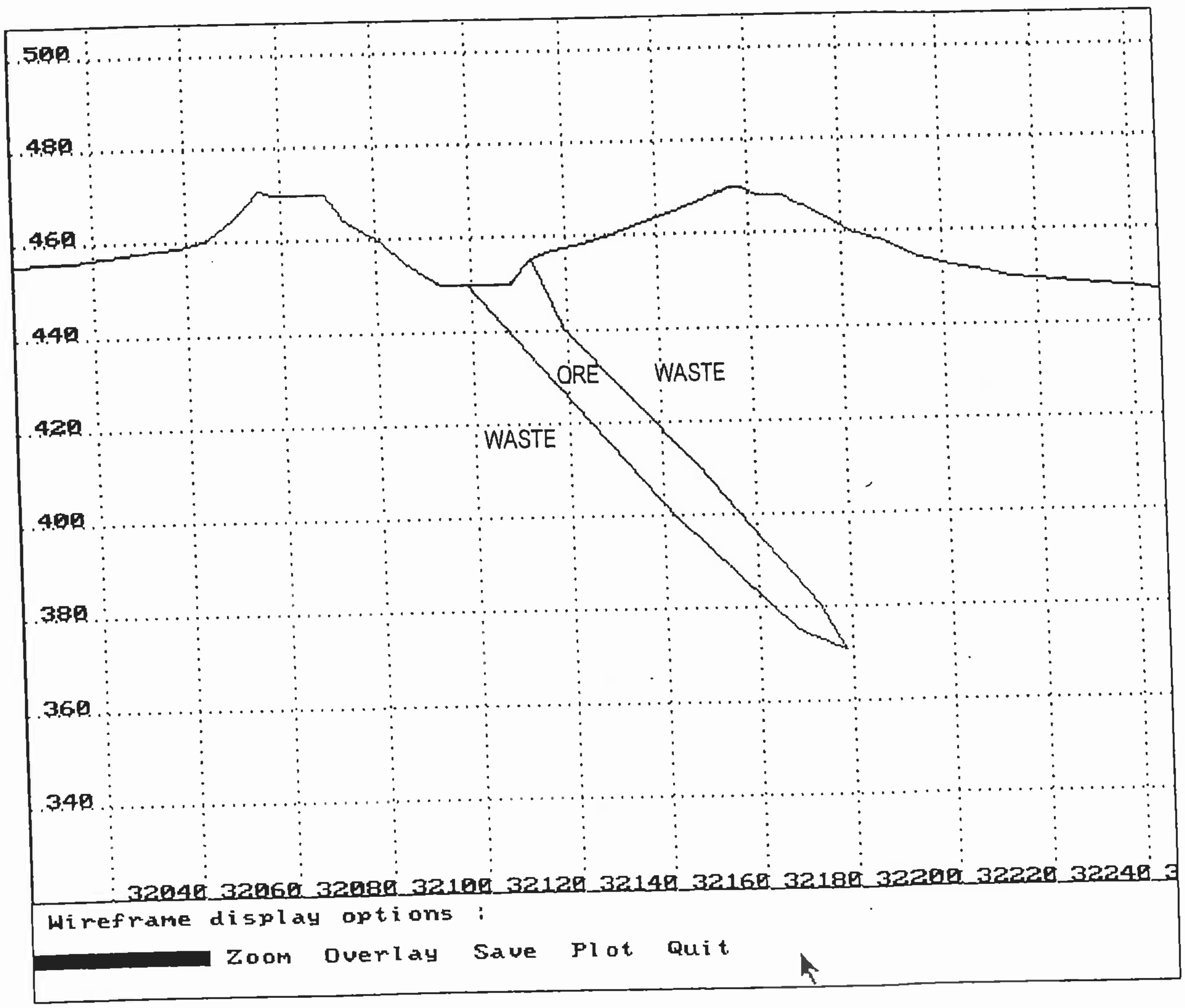
i. The gross value of ore per tonne and operating costs per tonne.
ii. Net Present Value and Present Value Ratio at a discount rate of 10% on a before-tax basis
iii. Conduct a Sensitivity Analysis from the base-case of item (ii) by varying the price of Uranium from $50/lb to $90/lb and analysing using standard graphical methods.

Question 3 – Open Pit Limits and Development Planning. 20 Marks

On the provided geological section, determine the open pit boundaries which satisfy an overall stripping ratio of 2.0 ± 0.1 waste to ore and maximize the amount of ore mined. Note that the floor of the final pit must be horizontal and have a minimum width of 20 m. Use this info in your calculations:

$$\rho_{ore} = \rho_{waste} = 2700 \text{ kg/m}^3$$
$$\text{max slope angle} = 45°$$

Propose separate phased mine development plans that i) maintain and approximately constant stripping ratio, and ii) involve alternating mining and stripping phases.



Question 4 – Equipment Selection. 20 Marks

A medium scale underground mine in Nova Scotia is being planned which will have 2 years of pre-production development followed by 5 years of production. The mining company is considering two different equipment options:

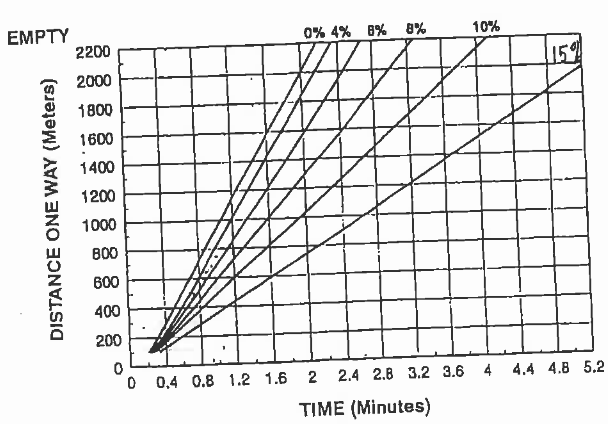
A) Lease all mining equipment from an equipment supplier in Halifax at a cost of $1 M/year during mine development and $2 M/year during production. All lease expenses must be written-off against taxable revenue in the year in which it is paid and cannot be carried forward to future years.
B) Purchase some of the needed equipment at a cost of $3 M at the start of development and then purchase the remaining equipment at a cost of $6 M at the start of production (all from the same supplier as ption A). All equipment capital costs can be assigned at the end of the year in which they are incurred, but depreciation (25% straight-line) does not begin until the end of the first year of production (i.e. no carried losses). The salvage value for all equipment at the end of the mine life is 10% of the initial purchase price and should be treated as a revenue.

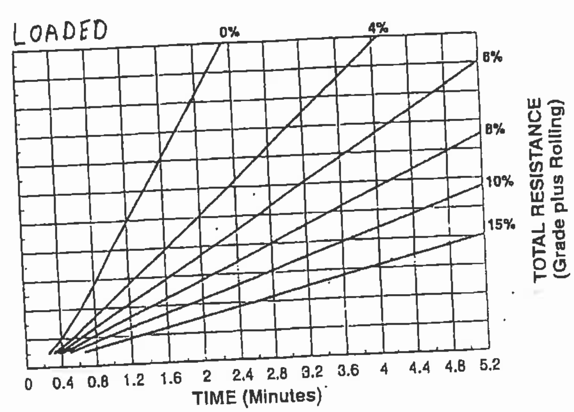
Tax is a flat 35% of taxable net revenue and the cost of capital is estimated at 12%. Equipment operating costs for both options would be the same since the identical equipment fleet would be used for each. Also, it is expected that production revenues will be sufficient to fully utilize the tax write-offs that would be available from either equipment option.

What are the after-tax cash flows associated with each option? Which option would be the best from economic and investment points-of-view?

Question 5. Shovel-Truck Fleet Analysis. 20 Marks

For a particular working area of the mine, the haul route from the shovel to the crusher is i) 100 m of level in-pit haulage, ii) climbing through 150 m of elevation change up a 10% ramp, and iii) traveling a horizontal distance of 650 m to the crusher. The rolling resistance of all road surfaces is 6%, downhill speed limits of 30 km/h are imposed, and average loading and dumping times are each 2.5 minutes. Using the truck performance charts below, determine (a) the expected truck cycle time, and (b) the optimum number of trucks to assign to a single shovel.





Question 6 - Mineral Resource Block Modelling and Pit Limits. 20 Marks

The 2-D geological block model shown below gives composite ore grades for a polymetallic deposit in percent. For this deposit, a grade cutoff of 1.5% is used to differentiate between ore and waste. Use the criteria listed in Table 1, answer the following questions:

a). Determine the net value of each block and fill-in the block value in the corresponding location in the 2-D economic block model.

b) Conduct a 2-D Lerchs-Grossman or Floating Cone analysis to determine the most profitable open pit outline. You can show this on the figures below.

Table 1. Geological Block Model parameters.

Block dimensions are 10 m East by 10 m North by 20 m Elev
Ore and waste densities are both 2300 kg/m^3
Net processed mineral value (including NSR and transportation charges) is $1500/tonne
Mine recovery is 100%
Mill recovery is 95%
Combined mining costs are $20/tonne
Combined milling costs are $15/tonne
Combined overhead costs are $15/tonne

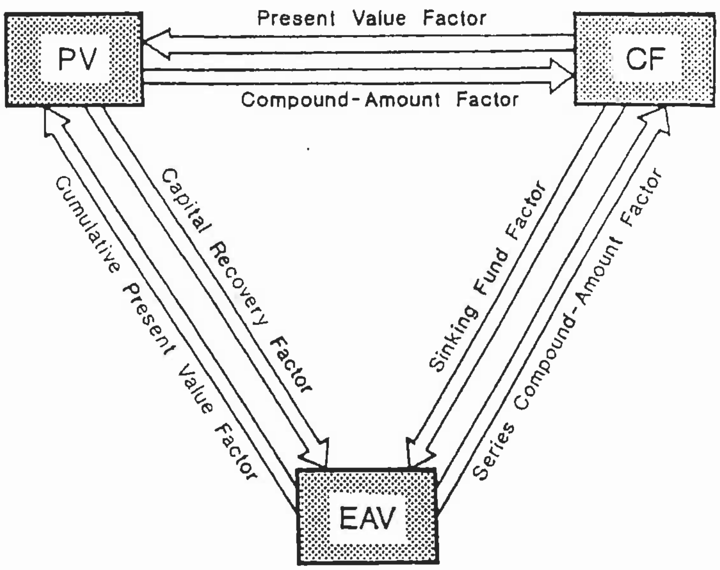
Geological Block Model (Composite mineral grade in percent):

0	0	2	3	0	0	0	0
0	0	1	4	4	0	0	0
0	0	1	4	2	0	0	0
1	1	1	2	6	1	0	0
0	1	1	2	2	1	2	0

Economic Block Model ($):

Optimum Pit Outline:

Appendix A – Discounted Cash Flow Analysis Tables and Charts



	PVF				CPVF				SFF			
years	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