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Oct. 1978

STABILIZATION AND RECLAMATION

CLINTON CREEK MINE

R. M. Hardy & Associates Ltd.,

October, 1978

R.M.HARDY & ASSOCIATES LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

File No. K4232

September 28, 1978.

Mr. L. E. Garinger, P. Eng.,
Controller of Water Rights,
Northern Affairs Program,
200 Range Road,
WHITEHORSE, Y.T.
Y1A 3V1

Dear Mr. Garinger:

This letter accompanies six copies of a report presenting the current status of our work for the Yukon Water Board relative to the rehabilitation plan for the Cassiar Asbestos Corporation Mine at Clinton Creek.

The report presents the backup information for recommendations presented in our letter of July 31, 1978. The additional analyses which we have carried out have indicated that there is a need for some further planning by the mine to accommodate any major failure in the northern lobe of the tailings pile.

We have not commented in the report on the most recent results of asbestos fiber content tests on water samples from the various sampling stations. This is because the data that was forwarded to us by telex indicated that some of the tests are being rerun and we will wait until the final test results are available before assessing them. I have also not included the photo documentations on the most recent field trips as all the prints are not back from the photographer. I will include the appropriate photographs which I took on our last field trip as well as those obtained by Dr. Hollingshead on his recent reconnaissance and will send them in one document for your records.

I believe that there should be an inspection made of the mine before freeze-up i.e. within the next 2-3 weeks. I would also recommend that a further inspection be made in the spring immediately prior to breakup.

.../2

910, 205 - 5 AVENUE S.W., P.O. BOX 9237, BOW VALLEY SQUARE 2, CALGARY, ALBERTA T2P 2W5 PHONE (403) 265-7793
GEOTECHNICAL, MATERIALS & METALLURGICAL ENGINEERING; ENVIRONMENTAL, MATERIALS & CHEMICAL SCIENCES
BURNABY CALGARY DAWSON CREEK EDMONTON GRANDE PRAIRIE LETHBRIDGE PRINCE GEORGE RED DEER WINNIPEG

If you have any questions concerning the attached report, please do not hestitate to contact me at your convenience.

Yours very truly,

R. M. HARDY & ASSOCIATES LTD.,

Per: Anna L. Burwash

for J. I. Clark, Ph.D., P. Eng.,
Vice-President, Technical Services.

JIC:ikm
Encls. (6)

INTRODUCTION

This report presents the current status of our assessment of rehabilitation plans for the waste pile and tailings pile at the Cassiar Asbestos Company Mine at Clinton Creek, Y.T. The report expands on our letter of July 31, 1978 (Appendix A), and presents the results of stability analyses which take into account potential seismic loading and excess pore pressure from thaw consolidation of the permanently frozen soil beneath the waste pile. In addition, recommendations are presented for a program of continued monitoring and for the development of a contingency plan by the Company to deal with a major failure of the tailings pile.

CLINTON CREEK (Waste Pile)

The training works designed for Clinton Creek rely on a moderate amount of maintenance to accommodate movement of the waste pile. If movement continues at the same rate that it has over the past year (about 4 ft./yr) maintenance requirements could be high. Observations over a relatively short period of time indicate a trend to a decrease in rate of movement. There is, however, considerable spread in data over the observation period and the average annual rate of movement may not have significantly changed.

Monitoring of movements must be continued. If there is no significant decrease in movement within the next two years, it is likely that implementation of additional stabilization measures will be required. The surface movement hubs which have been installed are considered adequate for monitoring movements. Readings should be continued on a monthly basis until a definite trend is established, the frequency of readings could be reduced at that time.

WOLVERINE CREEK (Tailings Pile)

The training works for Wolverine Creek rely on the tailings pile being stable. Recontouring of the slope has been undertaken to enhance the stability. The mechanics of the failures which have occurred, as analyzed by Golder Associates are predicated on a buildup of pore pressure in a soil stratum which is classified as a fluvial-lacustrine deposit and which overlies bedrock. This soil layer appears to be approximately 40 feet which at the top of the slope and it decreases in thickness downslope until it pinches out entirely toward the bottom of the slope. The analysis carried out by Golder Associates (July 1978) is based on the assumption that the failure which occurred in 1974 and the failures which occurred at the frontal part of the cave to the north of the 1974 failure are due to buildup of excess pore pressure in the fluvial-lacustrine soil when it thaws and then refreezes during winter. This may be the case; however, we are of the opinion that the failure may not be due to excess pore pressure development in the overburden soil for the following reasons:

(1) The soils are described on the logs as "gravel with clay, silt and sand - fluvial lacustrine". These soils tend to have a relatively high permeability when thawed.

(2) No evidence of ice is recorded in the overburden fluvial-lacustrine soil. On the contrary, ice was recorded in the weathered argillite and in one test hole a three inch thick lens was recovered.

(3) If the overburden soil was the main source of the stability problem, failure should have occurred when the steep tails were at the top of the slope and beginning to creep downslope. The heaviest (i.e. thickest) loading at the frontal portion of the lobe would occur in the early stages of tailings disposal. The glacial-lacustrine soils are thickest at the top. The 1974 failure occurred six years after disposal commenced and after a considerable amount of creep downslope had taken place i.e. when the fluvial-l-lacustrine soil was thin or had pinched out.

In our opinion, the fluvial-lacustrine soils rather than being the source of the problem, provide a stable foundation until the tails have crept downslope to a point where the overburden is not of sufficient thickness to provide adequate strength. At this point the strength properties, ice content, and rate of thaw of the underlying weathered argillite would govern the stability of the tailings pile.

Another factor which must be taken into account in assessing the long-term stability of the tailings pile is the seismic loading which may occur in the event of an earthquake. In order to assess this potential hazard, we obtained a seismic risk study for the site from Mr. W. G. Milne, Chief Scientist, Pacific Geoscience Centre. The data in Appendix B indicates that Clinton Creek is about border-line between zone 2 and zone 3 and should be considered as zone 3 for engineering design and stability analysis. The loading factor to apply is a complicated decision; however, on the basis of previous work in permafrost areas with which we have been associated, we would suggest that it would not be overly conservative to apply a factor of 0.1g to 0.15g in analyzing the stability of the tailings slope. If the slope being analyzed or designed presented a potential hazard to life, a value of 0.3g would be used.

In order to test our hypothesis of excess pore pressure in the weathered argillite (due to thawing) as being the main reason for the stability problems several slope analyses were carried out. These are summarized on Figure 1 and 2 at the end of the report and the methodology is described in Appendix C. The factor r_u is the ratio of the pore pressure to the overburden pressure. If the soil is very permeable, such as a clean gravel, r_u would equal zero. If the soil had a low permeability and if it contained ice lenses which thawed rapidly, r_u would approach 1. The higher the value of r_u, the lower the strength. Analyses were carried out for seismic loadings of 0 and 0.1g with r_u factors of 0.05 and 0.17 (they could be much higher) and with seismic loading of 0.1 and 0.15g and ru = 0. By assuming the failure to be occurring at the interface of the weathered argillite and of fluvial-lacustrine soil, a factor of safety of one for the critical slip surface is reached when the natural soils have an r_u factor of 0.17. When seismic loading of 0.1g is applied, the factor of safety is below 1 for all failure surfaces considered. Case four demonstrates that even for a very low r_u factor (0.05) the factor of safety is less than 1 for the critical surface and close to 1 for all surfaces considered. Table 2 demonstrates that for no seismic loading and failure within the fluvial-lacustrine soil, an r_u factor of approximately 0.33 is required for a factor of safety of 1 for the critical surface.

This appears to be very high for this soil type. For a failure zone within the weathered argillite and zero pore pressure in the fluvial-lacustrine soil an r_u factor of approximately 0.2 in the argillite is required for a factor of safety of 1 at the critical surface. In view of the relatively high ice content recorded for this material, this is not an unrealistic value. The analysis carried out with seismic loading of 0.1 and 0.15g and no pore pressure indicated factors of safety below 1.

CONCLUSIONS

1. Our conclusions and recommendations regarding Clinton Creek and the Clinton Creek waste pile are not changed from those presented in our letter of July 31, 1978 (Appendix A).

2. The tailings pile has been recontoured but the grades are not known. It is possible that the factor of safety against failure due to excess pore pressures in the weathered argillite may not be adequate if earthquake loading is not considered. The results of the analysis carried out suggest that even a recontoured slope would have a factor of safety of less than 1 if it were subjected to an earthquake loading of 0.1g. If some excess pore pressure due to thaw consolidation existed at the same time, the factor of

safety would be even lower. Thus a large mass could fail rapidly and bury Wolverine Creek similar to the 1974 failure but over a much larger section.

RECOMMENDATIONS

1. The mining company should be requested to produce a contingency plan which would illustrate the rehabilitation plan for Wolverine Creek in the event of a massive failure of the north lobe. The Yukon Water Board should seek a commitment from the Company to implement the plan in the event of a failure within a time frame to be negotiated. A period of 20 years is recommended.

2. Monitoring of the Clinton waste pile should be carried out at monthly intervals for the next year. The frequency required thereafter would be determined at that time.

3. Surface monitors on the tailings site which have been disturbed by recontouring should be re-established and monitoring should be carried out at the same frequency as for the Clinton dump.

4. The recontoured waste pile should be surveyed and a topographic plan produced.

5. Stability analysis should be carried out for the tailings pile as it now exists.

Respectfully submitted,

R. M. HARDY & ASSOCIATES LTD.,

Per: Anna L. Burwash

for J. I. Clark, Ph.D., P. Eng.,

Vice-President, Technical Services.

JIC:ikm

R.M.HARDY & ASSOCIATES LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

File No. K4232

July 31, 1978.

Mr. L. E. Garinger, P. Eng.,
Controller of Water Rights,
Northern Affairs Program,
200 Range Road,
WHITEHORSE, Y.T.
Y1A 3V1

Dear Mr. Garinger:

Re: Stabilization and Reclamation
Clinton Creek Mine

This letter will confirm our discussions and recommendations presented to the Yukon Water Board at the meeting of July 25, 1978.

My recommendations are presented relative to the proposals put forward by the mining company for stabilization and stream channel rehabilitation at Clinton Creek and Wolverine Creek. These recommendations are contained in a report prepared by Golder & Associates dated July, 1978. In addition, the results of analyses of asbestos fibers in water reported to the Board by B. H. Levelton & Associates Ltd. were reviewed.

As discussed at the meeting, it is not possible to designate an acceptable level of asbestos fibers in water since no standards exist. However, we agreed that the objective of the reclamation work should be to minimize the amount of asbestos fiber entering Clinton and Wolverine Creek. Other sediments should also be minimized but they do not present a serious problem.

The plan put forward by the mine is outlined in Golder & Associates' report. The scheme relies on the successful stabilization of the tailings pile in order to eliminate asbestos fiber from entering Wolverine Creek and it also relies on a continued reduction in the rate of movement of the waste pile in order to stabilize Clinton Creek. I have concerns about the assumption that the waste pile is slowing down. I do not believe that the observation record is long enough to draw this conclusion. An examination of the data

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presented in our previous report show that there is considerable fluctuation in rate of movement in both the waste and tailings pile. I am also concerned about the feasibility of stabilizing the tailings pile but the work that is planned will certainly improve the stability. With these reservations and on the strength of the data that we have examined and in the context of the objectives outlined above, I have the following recommendations:

1) The proposal for the weir, and armoured length of channel in Clinton Creek should be accepted. I have serious reservations about concentrating all of the protection works over a length of only 150 feet and am concerned that subsequent erosion immediately downstream could jeopardize this work. I would prefer to see velocity barriers also placed at other parts in the stream, but, if in fact, the movement of the waste pile is slowing rapidly, then this scheme could work and would be the most economical for the mine. I would therefore recommend that you approve this installation but that you condition the approval with the requirement for continued monitoring and maintenance for a minimum period of five years. If the stream course and waste pile is not stable after a five-year period, it will be necessary to continue maintenance and monitoring beyond that time.

2) The mine should be directed to revegetate the waste pile. The decomposed argillite bedrock appears to be a good substrate for vegetation. Revegetation will occur naturally but it will take a long period of time for it to be effective in preventing erosion of the surface materials to the water courses. Revegetation will require a certain amount of recontouring in order to provide an appropriate surface for plant growth but it should not be excessive. In our previous report we presented our recommendations regarding the application of fertilizers and seeding. It is likely that the most appropriate seed mixture would include creeping red fescue, blue grass, clover and perhaps crested wheat grass. This will produce a fibrous root mat which will stabilize the surface against erosion and also will act as a nurse crop to accelerate the establishment of the native species.

3) The scheme proposed for Wolverine Creek is acceptable except that tailings should not be used as part of the fill material under the elevated stream bed. The use of tails in this area would only perpetuate and may even

exacerbate the problem. I therefore recommend that weathered waste rock be used for fill. The objective here is to ensure that the running water does not have contact with the tails. Although the waste rock does have some asbestos fiber in it, the test results that we have been able to see to date suggest that the fiber concentration is at least one-sixth of the amount of fibers that are contained in the tails. In keeping with our overall objective of minimizing the amount of asbestos fiber gaining access of the water, we recommend that argillite be used for fill.

4) The report indicates that no measures are required to protect the tailing pile from wind or water erosion since the surface has developed a crust. A crust is forming over sections of the pile that have not been disturbed, but we know very little about the porosity and durability. There is no information to indicate as to whether or not it provides an impermeable layer, what the nature of the binding is, whether it is a transient condition or one that will improve with time. I therefore recommend that the mining company be directed to investigate the use of a surface sealant for the waste pile. Such a material would improve the runoff and prevent rainfall and snowmelt from penetrating the pile and thus eventually reaching the water course with a heavy asbestos fiber load. A surface seal would also reduce the amount of air blown asbestos fiber in the area. Considering the state of art with respect to revegetation of serpentine tails as we now know it, we do not recommend that revegetation be undertaken at this time. We do not know if it would require, for example, one foot or five feet of waste rock material to provide a proper substrate for vegetation which would not be affected by the toxic elements in the tails. We also recognize that it may not be practical to use a sealant but we feel that until more is known about the crust being formed that the mine should investigate the practicality of using a surface sealant. If a durable sealant is available, it should be applied in the concentration required to provide an impermeable bonded surface.

The above recommendations were discussed at the Water Board meeting on July 25, 1978 and also they were discussed with Mr. Brian Fletcher, P. Eng. of Golder Associates at a meeting in Calgary on July 28. I will be presenting a separate report in due course that will summarize in detail the concerns and the basis for those concerns as well as presenting documentation of our recommendations and the basis for them. This report will also include what we consider to be the monitoring required by the mine company in order to assess the performance

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of their physical work and any monitoring over and above that which the Water Board may wish to initiate to provide a data base for the future decisions concerning ongoing maintenance requirements. We will also present the photo documentation from our field trip in order that they will form part of the record of our investigation and review work for the Board. I expect that report to be finished in approximately one month's time.

Yours very truly,

R. M. HARDY & ASSOCIATES LTD.,

Per:

J. I. Clark, Ph.D., P. Eng.,
Vice-President, Technical Services.

JIC:ikm

Energy, Mines and Resources Canada
Science and Technology

Énergie, Mines et Ressources Canada
Science et Technologie

Your file Votre référence

Our file Notre référence 4215-12SRA

August 21, 1978.

R.M. Hardy and Associates,
Box 9355,
310, Bow Valley Square 2,
205 - 5 Avenue, S.W.,
Calgary, Alberta,
T2P 2W5

Attention: Miss Gretchen Minning.

Dear Miss Minning,

The seismic risk studies for Clinton Creek are enclosed. The acceleration attenuation curve obtain from more recent data have been used. The data file to the end of 1975 is the basic information for the analysis.

Sincerely,

W.G. Milne, Chief Scientist,
Pacific Geoscience Centre.

WGM:dc

encls.

Pacific Geoscience Centre
9860 West Saanich Road
P.O. Box 6000
Sidney, B.C.
Canada
V8L 4B2

Centre géoscientifique du Pacifique
9860, chemin Saanich ouest
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THIS IS AN ESTIMATE OF THE EARTHQUAKE PROBABILITY OF A SITE NEAR

CLINTON CREEK

THE GEOGRAPHICAL CO-ORDINATES OF THE SITE ARE
64 DEGREES 27 MIN NORTH LATITUDE
140 DEGREES 43 MIN WEST LONGITUDE

EARTHQUAKES BETWEEN 1899 AND 1975 INCLUSIVE ARE INCLUDED IN THE ANALYSIS.

DURING THIS PERIOD THERE ARE 1265 EARTHQUAKES IN THE EARTHQUAKE CATALOGUE FOR THIS REGION. THERE WERE 63 EARTHQUAKES WHICH COULD HAVE BEEN FELT AT THIS LOCATION DURING THIS 77 YEAR PERIOD

THIS SITE HAS EXPERIENCED A MAXIMUM ACCELERATION OF 3. PERCENT GRAVITY
OR A MAXIMUM INTENSITY OF VI

TABLE 1 IS A LIST OF THE EARTHQUAKES WHICH REACHED AN INTENSITY OF II OR GREATER AT THIS SITE. ALL OF THE EVENTS IN THIS LIST MAY HAVE BEEN FELT.

TABLE 2 IS A LIST OF THE PREDICTIONS FOR THIS SITE. PLEASE READ THE FOLLOWING REMARKS BEFORE USING THE DATA.

THE VALUES FOUND IN TABLE 2 ARE BASED UPON A STATISTICAL ANALYSIS OF THE EARTHQUAKES WHICH HAVE OCCURRED OVER THE ABOVE INTERVAL OF TIME. THIS IS TOO SHORT A PERIOD OF OBSERVATION FOR ACCURATE PREDICTIONS ABOUT TECTONIC ACTIVITY. HOWEVER, THE DATA HAVE BEEN PROCESSED TO PROVIDE AN ESTIMATE OF THE POSSIBLE LEVEL OF EARTHQUAKE ACTIVITY IN THE NEAR FUTURE ASSUMING A CONTINUATION OF THE STATISTICAL PATTERN OF THE PAST YEARS. ALTHOUGH PREDICTIONS CAN BE MADE FOR MANY RETURN PERIODS, THE NUMBERS GIVEN FOR RETURN PERIODS GREATER THAN 100 YEARS ARE MORE LIKELY TO BE ALTERED BY CHANGING PATTERNS OF EARTHQUAKE ACTIVITY.

THE EXTREME VALUE METHODS OF STATISTICS ARE USED FOR THESE CALCULATIONS. THE SLOPE OF THE CURVE IS FOUND BY A LEAST SQUARES SOLUTION OF THE DATA FOR THE YEARS WHEN THERE WAS ACTIVITY ABOVE A FIXED THRESHOLD LEVEL. THE CURVE IS REPRESENTED BY THE EQUATION

$$LOG(ACC) = MODE + K(-LOG(-LOG(P)))$$

WHERE NATURAL LOGARITHMS ARE USED. P IS THE PROBABILITY THAT ACC WILL NOT BE EXCEEDED IN 1 YEAR. R IS THE RETURN PERIOD (IN YEARS) OF ACCELERATION AMPLITUDE LOG(ACC) AND EQUALS 1/1-P .

FROM THIS THE ACCELERATION AMPLITUDE IS

$$ACC = EXP(LOG(ACC))$$

AND THE INTENSITY

$$I = 3 LOG10(ACC) + 4.5$$

I IS THE INTENSITY BY THE MODIFIED MERCALLI INTENSITY SCALE OF 1931. IN THE TABLES THE VALUE IS ROUNDED TO THE NEAREST INTEGER AND PRINTED IN ROMAN NUMERALS. ACC IS THE ACCELERATION AS A PERCENTAGE OF GRAVITY.

THE VALUES OF ACCELERATION LISTED IN TABLE 2 ARE FOR FIRM SOIL. OTHER TYPES OF FOUNDATION MATERIAL MAY ALTER THE VALUES BY AT LEAST ONE UNIT OF I.

THE SEISMIC ZONING MAP IN THE NATIONAL BUILDING CODE OF CANADA (1970)
USES THE ACCELERATION AMPLITUDES WITH RETURN PERIODS OF 100 YEARS AS THE
CRITERIA FOR ZONE BOUNDARIES. THIS IS CALLED ACC100. THE FOLLOWING ARE
THE ZONE BOUNDARIES IN THE 1970 CODE.

```
ZONE 0             ACC100 < 1.     R = 0
ZONE 1   1. <=     ACC100 < 3.     R = 1
ZONE 2   3. <=     ACC100 < 6.     R = 2
ZONE 3   6. <=     ACC100 <        R = 4
```

CLINTON CREEK

64 27 140 43

TABLE 1 DATA

DAY	MONTH	YEAR	MAG	LAT	LONG	DISTANCE MILES	KMS	ACCELERATION PERCENT G	INTENSITY	
4	9	1899	8.20	60.00	-142.00	310	499	2	VI	2.32
10	9	1899	7.80	60.00	-140.00	308	496	2	V	1.57
10	9	1899	8.60	60.00	-140.00	308	496	3	VI	3.47
9	10	1900	8.20	60.00	-142.00	310	499	2	VI	2.30
15	5	1908	7.00	59.00	-141.00	376	606	1	IV	0.54
18	6	1912	7.00	59.00	-143.00	383	617	1	IV	0.53
7	7	1920	6.00	60.20	-138.00	306	492	0	III	0.27
16	11	1920	6.50	72.50	-128.00	639	1029	0	II	0.16
24	10	1927	7.10	57.50	-137.00	495	797	0	III	0.41
19	9	1933	5.50	60.00	-138.00	319	514	0	II	0.15
6	7	1935	6.00	59.00	-139.00	380	612	0	II	0.20
18	9	1939	6.00	58.00	-136.00	472	759	0	II	0.15
28	1	1940	5.20	61.75	-137.50	211	340	0	II	0.20
29	5	1940	6.20	66.60	-132.70	272	439	0	III	0.38
5	6	1940	6.50	67.00	-135.50	230	370	1	IV	0.65
12	6	1942	5.70	61.00	-138.00	253	407	0	III	0.26
3	2	1944	6.50	60.50	-137.50	291	469	0	IV	0.47
30	4	1947	6.30	59.00	-139.00	380	612	0	III	0.27
22	8	1949	8.00	53.75	-133.25	783	1261	1	IV	0.52
31	10	1949	6.70	56.00	-136.00	605	974	0	II	0.21
9	3	1952	6.00	59.50	-136.00	374	602	0	II	0.20
15	6	1952	5.50	65.70	-134.50	200	322	0	III	0.29
11	1	1953	6.50	65.30	-133.20	227	366	1	IV	0.66
28	8	1953	4.50	64.00	-142.00	49	79	1	IV	0.74
10	1	1954	4.50	65.50	-136.50	142	230	0	II	0.18
1	3	1955	6.60	65.30	-132.90	236	380	1	IV	0.69
22	10	1955	5.00	67.00	-136.00	221	355	0	II	0.16
7	1	1956	6.50	65.50	-133.50	222	358	1	IV	0.68
1	8	1956	5.80	66.00	-133.50	234	377	0	III	0.32
3	11	1956	5.70	61.00	-139.00	244	393	0	III	0.27
4	11	1956	5.40	61.00	-139.00	244	393	0	II	0.20
30	1	1957	5.80	65.00	-134.00	201	324	0	III	0.39
9	12	1957	5.70	65.50	-133.00	236	380	0	III	0.29
10	12	1957	5.70	65.50	-133.00	236	380	0	III	0.29
10	7	1958	7.90	58.60	-137.10	421	677	1	V	1.13
31	8	1958	6.20	63.00	-144.50	152	246	1	IV	0.86
24	9	1958	6.20	59.50	-143.50	353	569	0	III	0.27
19	4	1959	5.00	66.50	-142.50	150	242	0	III	0.27
17	10	1959	5.60	60.00	-138.50	315	507	0	II	0.17
26	2	1960	4.00	64.50	-142.50	53	85	0	III	0.41
25	3	1962	4.60	65.00	-135.70	152	245	0	II	0.18
27	10	1962	4.60	65.00	-135.00	172	278	0	II	0.15
17	6	1963	5.40	60.50	-140.80	272	439	0	II	0.17
3	2	1964	4.40	64.00	-136.75	123	198	0	II	0.19
28	3	1964	8.40	61.10	-147.60	317	510	3	VI	2.73
4	10	1965	5.00	65.30	-134.00	205	330	0	II	0.17
5	10	1965	5.20	65.30	-134.00	205	330	0	II	0.21
23	12	1965	5.80	60.60	-140.70	265	428	0	III	0.27
22	1	1966	4.60	62.15	-141.10	159	256	0	II	0.17
7	3	1966	4.10	65.83	-140.00	97	157	0	II	0.20

26	3	1966	5.00	65.00	-133.50	216	347	0	II	0.16
24	4	1966	4.80	66.00	-136.50	162	261	0	II	0.20
20	5	1966	4.60	66.33	-142.17	136	219	0	II	0.21
21	6	1967	5.00	64.00	-144.00	103	166	0	III	0.45
15	11	1969	3.40	64.89	-139.89	39	62	0	III	0.34
19	12	1970	3.80	64.60	-138.94	53	86	0	III	0.33
26	3	1971	5.80	60.33	-140.94	284	458	0	III	0.24
10	6	1972	5.20	61.58	-140.25	198	319	0	III	0.22
30	7	1972	7.60	56.77	-135.91	554	892	1	IV	0.57
1	7	1973	6.10	57.84	-137.33	470	756	0	II	0.16
3	7	1973	6.00	57.98	-138.02	455	733	0	II	0.15
22	9	1974	4.30	65.22	-141.26	55	89	1	IV	0.52
3	9	1975	4.70	64.66	-138.51	67	107	1	IV	0.60

TABLE 2

64 27 140 43

MODE FOR THIS SITE = -2.36
K FOR THIS SITE = 0.91

ACC100 FOR THIS SITE = 6.2 PERCENT GRAVITY

PROBABILITY OF ACC BEING EXCEEDED IN ONE YEAR.	ACC IN PERCENTAGE GRAVITY	INTENSITY (MODIFIED MERCALLI)	EQUIVALENT RETURN PERIOD
0.333	0	II	3.
0.100	1	IV	10.
0.033	2	V	30.
0.020	3	VI	50.
0.010	6	VII	100.
0.005	12	VIII	200.

APPENDIX C

Clinton Creek Mine Stability Analyses

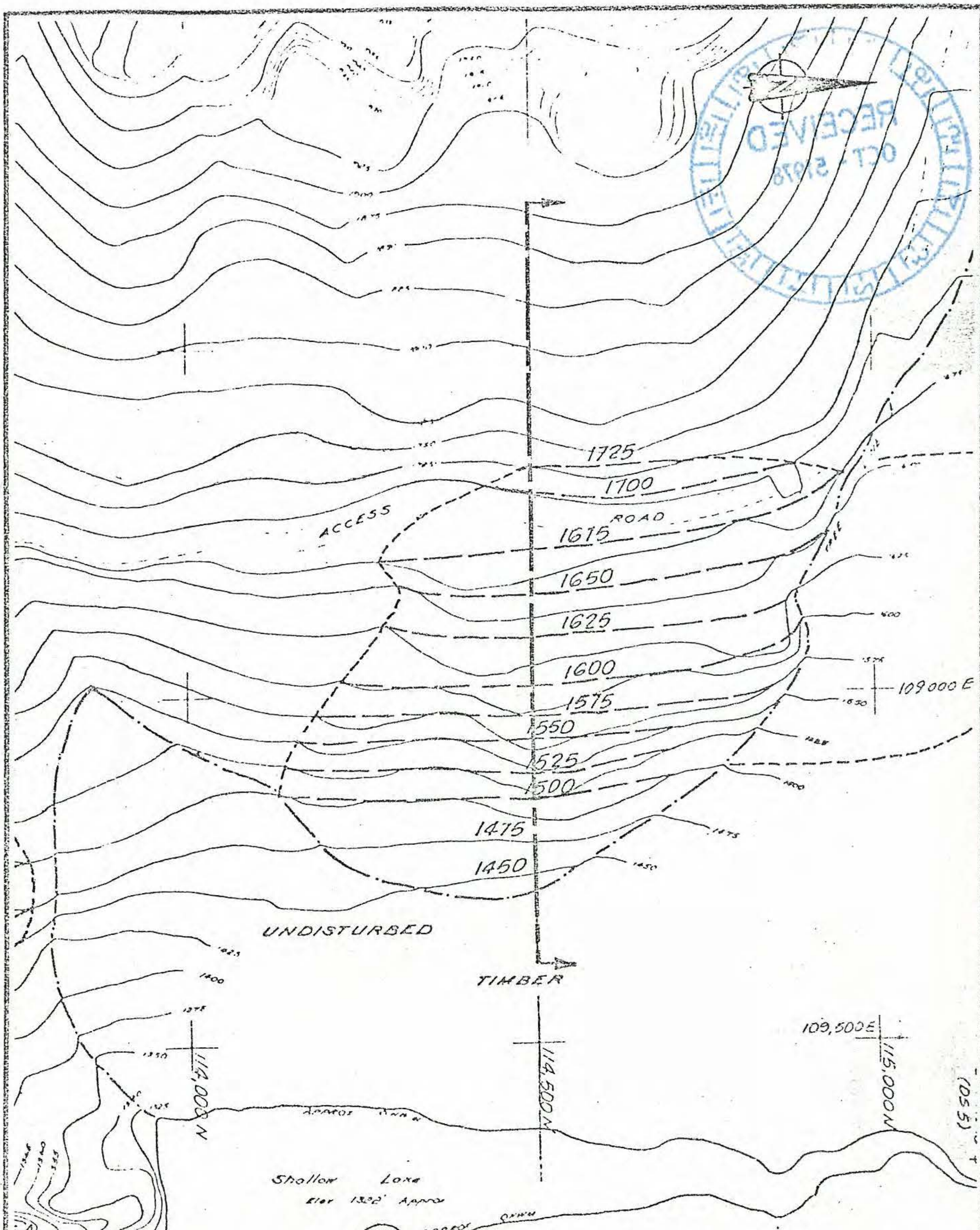
A section cutting through the north lobe of the tailings pile is analyzed. The location and the profile of the section are shown in Figs. 1 and 2 respectively. The elevations of original ground surface below the tailings are obtained from Fig. 8 of Golder & Associates' report (July 1978). Since there is no bore hole drilled at the section location, the thicknesses of "fluvial lacustrine (Golder report)" and weathered argillite strata are estimated from the information gathered in the vicinity.

The analyses are performed with SLOPE (Fredlund, 1974) program using the simplified Bishop method. The mid-plane of the fluvial lacustrine layer and the interface of weathered and competent argillites have been assumed as the possible slip planes. A set of three slip surfaces which intersect each one of these planes are analyzed. The locations of these non-circular slip surfaces are shown in Fig. 2.

In the analyses, the situations of the soils at thawing or completely thawed states are considered. From the seismic information obtained, it is indicated that Clinton Creek is about borderline between seismic zone 2 and zone 3.

Hence several analyses are performed with the consideration of seismic loading effects.

Table 1 is a summary of the analyses performed for the case where interface between weathered and competent argillites is a slip plane while Table 2 is for the mid-plane of fluvial lacustrine.



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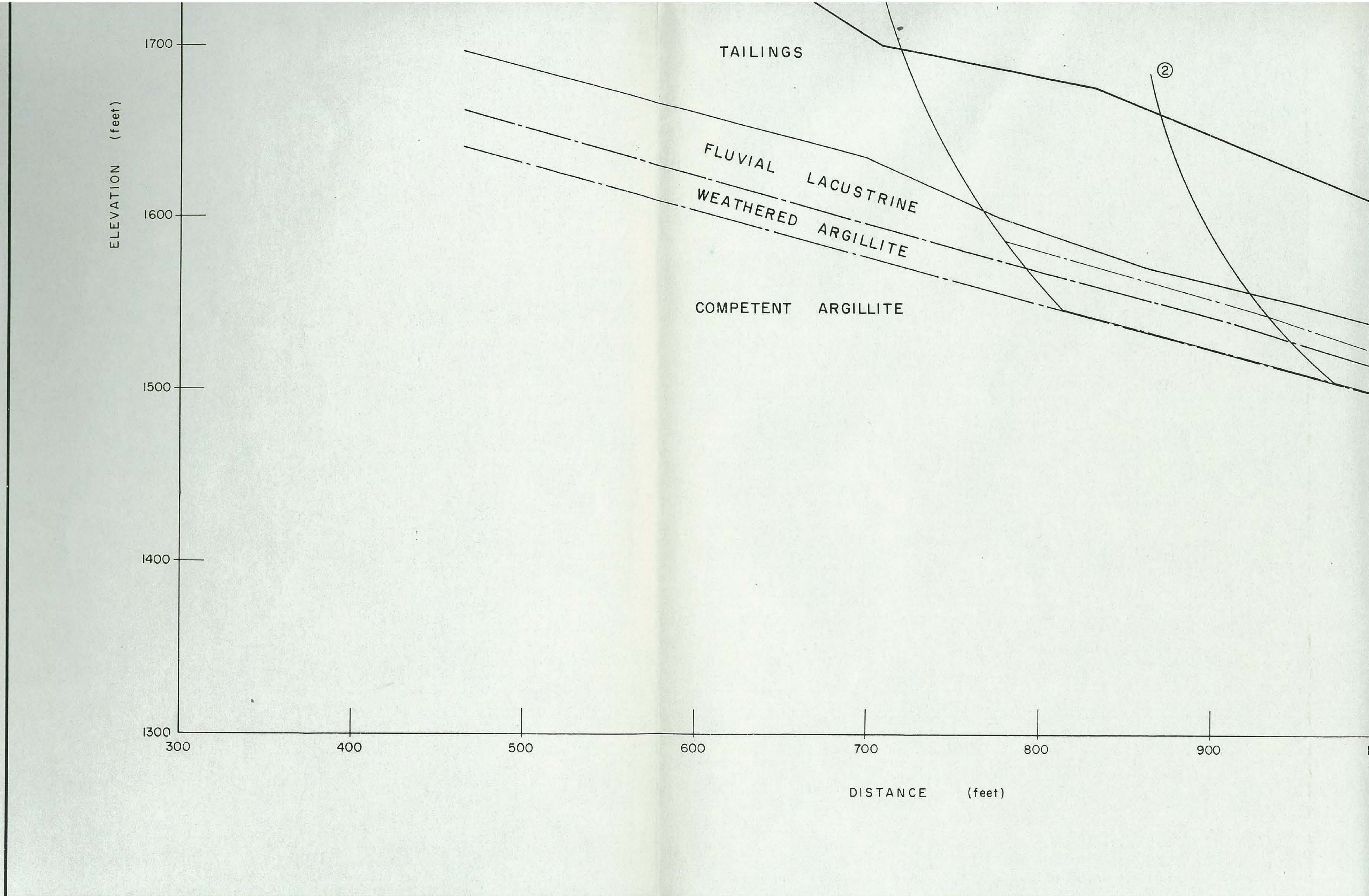
CLINTON CREEK MINE
LOCATION OF ANALYSED SECTION

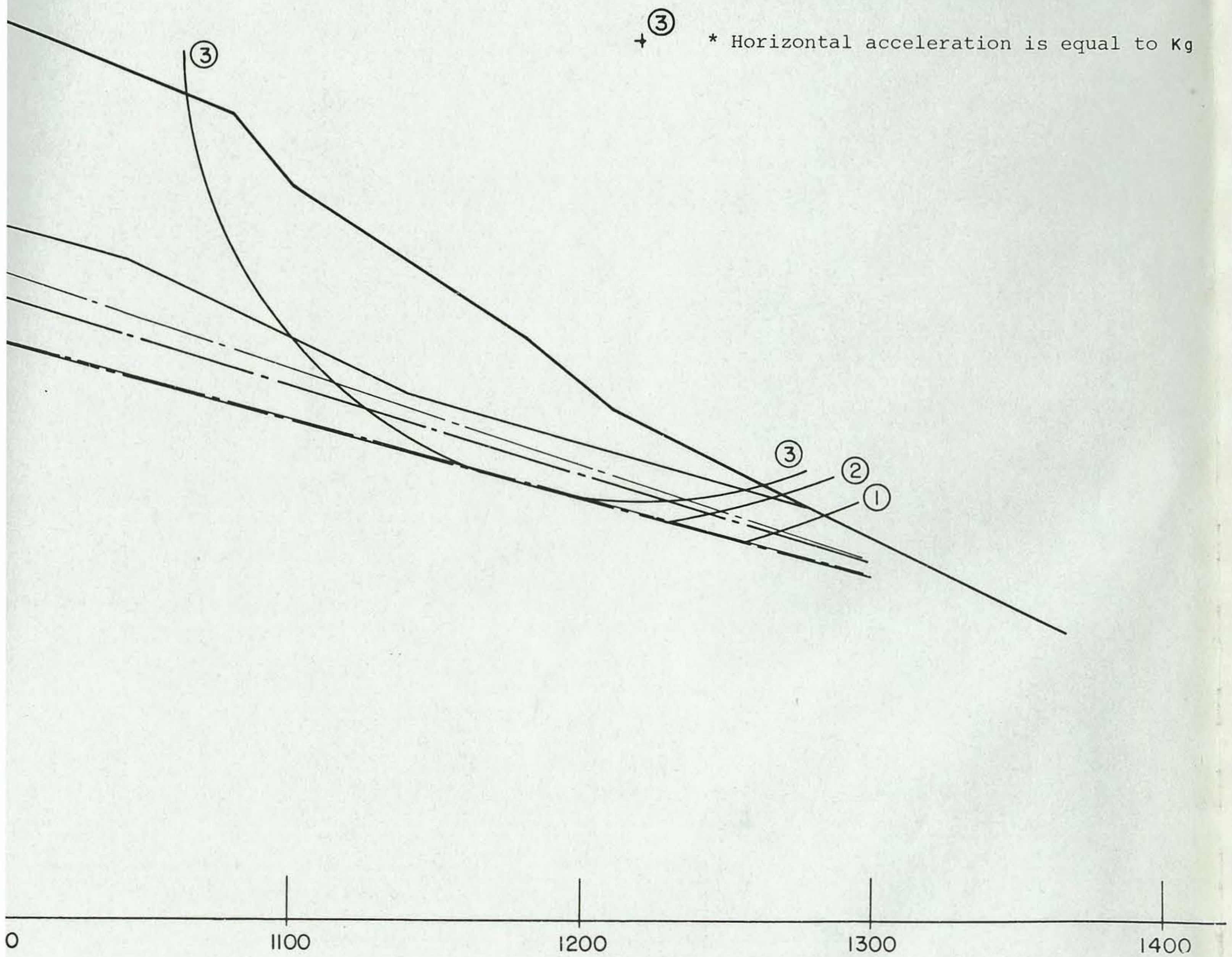
Figure I



TAILINGS
②
FLUVIAL LACUSTRINE
WEATHERED ARGILLITE
COMPETENT ARGILLITE
ELEVATION (feet)
1700
1600
1500
1400
1300
300
400
500
600
700
800
900
DISTANCE (feet)

				(r_u)	(K)*	Critical Slip Surface 1	2	3	
1	Tailings Fluvial Lacustrine	135 138	40 33	0 0.17	0 0	1.48	1.35	1.23	In order to obtain F.S.=1 for slip surface No. 3, it is estimated that r_u for fluvial lacustrine should be 0.33
2	Tailings Fluvial Lacustrine	135 138	40 33	0 0.41	0 0	1.01	0.94	0.89	

* Horizontal acceleration is equal to Kg



No.	REVISION	DATE	BY

REFERENCES

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CLINTON CREEK MINE

STABILITY ANALYSIS

SCALE As shown DATE Sept., 1978 MADE B.T. CHKD S.L. APPD.

No. K 4232

2

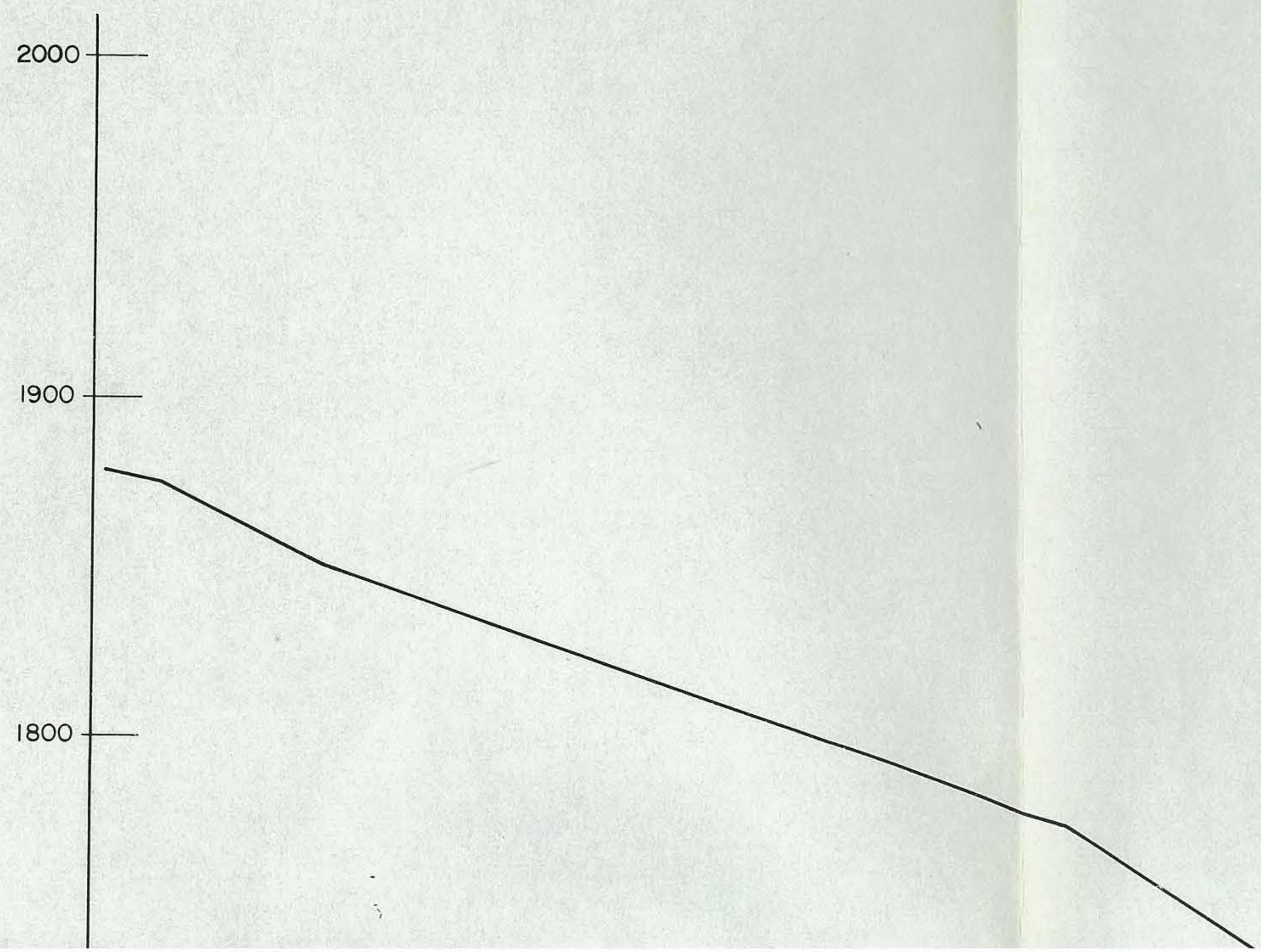
2000
1900
1800

TABLE 1

Case No.	Soil	Unit Weight (pcf)	Ø' (degree)	Pore Pressure Ratio (r_u)	Seismic Loading (K)*	F.S. for Slip Surface No. 1	2	Critical Slip Surface 3	Remarks
	Tailings	135	40	0	0				
1	Fluvial lacustrine	138	33	0	0	1.46	1.33	1.21	
	Weathered argillite	150	26	0	0				
	Tailings	135	40	0	0				
2	Fluvial lacustrine	138	33	0.17	0	1.19	1.09	1.00	
	Weathered argillite	150	26	0.17	0				
	Tailings	135	40	0	0.1				
3	Fluvial lacustrine	138	33	0.17	0.1	0.93	0.87	0.83	
	Weathered argillite	150	26	0.17	0.1				
	Tailings	135	40	0	0.1				
4	Fluvial lacustrine	138	33	0.05	0.1	1.08	1.02	0.95	
	Weathered argillite	150	26	0.05	0.1				
	Tailings	135	40	0	0.1				
5	Fluvial lacustrine	138	33	0	0.1	1.15	1.08	1.00	
	Weathered argillite	150	26	0	0.1				
	Tailings	135	40	0	0.15				
6	Fluvial lacustrine	138	33	0	0.15	1.03	0.98	0.92	
	Weathered argillite	150	26	0	0.15				

* Horizontal acceleration is equal to Kg

TABLE 2