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CONSULTING ENGINEERING & PROFESSIONAL SERVICES

CLINTON CREEK MINE

REVIEW REPORT ON WASTE DUMP AND TAILINGS PILE CONDITIONS

PREPARED FOR:
INDIAN AND NORTHERN AFFAIRS
YUKON WATER BOARD

PREPARED BY:
GEO-ENGINEERING (M.S.T.) LTD.
on behalf of
HARDY ASSOCIATES (1978) LTD.

CG10075
MARCH, 1985
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1.0 INTRODUCTION

This report summarizes the 1984 conditions and events relating to the waste and tailings piles of the closed Clinton Creek (Cassiar Asbestos) Mine.

The work, undertaken within Contract No. Y3WA-13, included:

- site visit on June 14 and 15, 1984
- presentation of field inspection results to the mining subcommission of the Water Board
- review of remedial measures for the Hudgeon Lake outfall
- discussions with mining company consultants regarding stabilization and other rehabilitation measures
- review of rehabilitation measures for the waste dump area and preparation of June 1984 report
- review of rehabilitation measures for the Wolverine Creek tailings pile, contained in Hardy Associates report of 1984
- review of proposed abandonment procedures as outlined in Brinco Mining Limited's letter of January 9, 1985 and Klohn Leonoff reports of January 16, 1984 and February 28, 1985.

2.0 BACKGROUND INFORMATION

The main objective of the studies and investigations undertaken during the past several years was to advise the Water Board members and Northern Affairs personnel about technical merits or shortcomings of various stabilization and rehabilitation measures undertaken by the mining company. The ultimate goal was, in my view, to develop and implement abandonment and reclamation measures ensuring that the mining operation will be discontinued in an environmentally acceptable manner and that there would be no serious impacts on surface waters downstream from the mine.

In accordance with accepted practise, the mining company was striving to stabilize the dumps and stream channels with the objective to revegetate (or to allow for natural revegetation of) disturbed lands. This approach is in keeping with established practise and government environmental policies.

Mining operations commenced in 1968 at which time waste material was dumped at the top of the south slope of the Clinton Creek Valley. The waste material consisted of broken argillite with minor serpentine and asbestos fibre inclusions. The waste dump failed during the early stages of the mine operation, likely due to failure of foundation materials.

The moving waste debris forced the Clinton Creek channel northward across the valley and up onto the north slope and dammed the valley impounding so-called Hudgeon Lake. The deepest point of this lake is in the order of 16 m (85 ft.).

Tailings were dumped from the mill into the Wolverine Creek valley. A major failure occurred in 1974 and the Wolverine Creek channel was moved eastward by the sliding mass and partially blocked. A rock-lined channel was installed in 1978 to convey Wolverine Creek over the extreme southern portion of the tailings pile in the valley bottom. This portion of the tailings pile is called the south lobe.

From 1974 to 1978, tailings were deposited further north from the failed section into a heap which is now known as the north lobe. Attempts to stabilize the dump (by partial regrading), made mainly in 1978 and 1979, were unsuccessful.

Virtually all waste and tailings embankments show signs of instability, including those sections which were recontoured in 1978 and later. Results from the monitoring programs (since 1977) suggest that the slope movements are not decreasing at any significant rate. Conversely, the south lobe of the tailings pile exhibits accelerated movement and has reached the valley bottom, displacing the existing lobe. The Clinton Creek channel downstream from the armoured outfall (from the lake) continues to downcut and erode the banks which are oversteepened. It is my opinion that there is sufficient evidence to conclude that previous stabilization efforts (by recontouring of piles) did not stabilize the embankments. Similarly, existing armouring of lake outfalls does not ensure maintenance free and permanent control of affected stream sections.

At the request of the Water Licensing Department of Indian and Northern Affairs, Hardy Associates (1978) Ltd. reviewed in 1984 other possible rehabilitation measures for the dumps. Several concepts of stabilization were considered and outlined. The most preferable approach appeared to involve construction of a substantial toe support for affected embankments and conveyance of the streams across the waste via reinforced channels.

Brinco Mining Limited, in their letter of January 9, 1985, declined to pursue the suggested stabilization concepts, essentially on the grounds that costs would render it uneconomical to implement such design concepts. The company and their consultant expressed reservations regarding some technical aspects of the considered measures as well.

The opinion of the mining company regarding further work on the dumps and abandonment of the waste piles, as presented in Brinco's January 1985 letter, can be summarized as follows:

(a) Clinton Creek Dump

The mining company considers that the waste dump is safe against catastrophic failure involving sudden release of water from Hudgeon Lake. Furthermore, the channel of Clinton Creek is being armoured by large rock fragments, which are being eroded from the waste dump. This gradual, on-going erosion can be expected to occur for a number of years, with more armouring of the creek bed resulting; thus preventing rapid downcutting of the stream bed.

With the possible exception of removal of the culverts at the outlet of Hudgeon Lake, the Company considers the abandonment plan for Clinton Creek to be completed.

(b) Wolverine Creek Tailings Pile

The Company still believes that the most practical approach in dealing with the tailings material is to maintain the channel of Wolverine Creek until movement of the tailings pile has stabilized sufficiently so that a permanent channel can be made. Insofar as the stability of the north lobe of the tailings pile is concerned, the

Company instructed Klohn Leonoff to do a stability analysis of the present dump configuration to see what steps can be taken in order to reduce the risk of catastrophic failure. In addition, Klohn Leonoff was also asked to undertake a sediment transport analysis to consider the effects of possible downstream sedimentation.

I had the opportunity to discuss the results of these later studies with Mr. P. Lighthall, P.Eng. (of Klohn Leonoff) on March 19, 1985 and my understanding of their findings and conclusions is summarized below:

- The risk of sudden failure for the lower portion of the southern lobe will not continue indefinitely as the lobe will begin to buttress itself against the opposite valley wall within the next few years.

- There are uncertainties with the pile regrading for reducing the rate of movement because the mechanism of failure is not properly understood. Fill redistribution on the tailings piles has been tried before and the results were inconclusive. Klohn Leonoff does not recommend further pile regrading.

- A sudden or rapid slide failure of the tailings piles into Wolverine Creek could result in significant bed aggradation in lower Wolverine and upper Clinton Creeks. Over the long term, no significant accummulation of sediment is anticipated in lower Clinton Creek or the Forty Mile River over and above existing natural processes.

- Continued gradual downslope movement of the tailings pile will probably result in some aggradation of gravel in upper Clinton Creek but only minor local depositions of tailings in other reaches.

- If a major failure of the south lobe occurs, the existing small lake would be displaced to increase its volume significantly. When the water level reaches the top level of the failed tailings, the lake will overflow and Wolverine Creek will begin to form a new channel across the tailings without the benefit of the grade control presently provided by the lower rock-lined channel. A failure of the rock-lined channel, regardless of rates of movement of the tailings piles, could also result in a new unlined channel being formed across the tailings.

  The new channel would progressively erode down through the tailings. Initial rates of erosion and downcutting in the new unlined channel will be rapid but may decrease with time as the channel becomes armoured with larger tailings gravels. During high flow periods the rates of transport of all sizes of tailings away from the tailings pile will be much higher than would occur under the gradual tailings pile movement.

Insofar as the stability of the Clinton Creek channel (within the waste dump area) is concerned, it has been agreed that:

- the waste dump movement is continuing at a relatively slow rate (30 to about 70 cm per year)

- the rip-rap apron and channel armouring downstream of the Hudgeon Lake outlet could be, especially if not maintained, undercut and destroyed. This, in turn, would result in partial erosion of the valley blockage and release of an undetermined amount of water from the lobe.

- The creek channel downstream from the lake outfall is becoming gradually protected by more competent rocks which could eventually contribute (acting as velocity barriers) to its greater stability.

3.0 NATURAL PROCESSES AND THEIR IMPLICATIONS

In order to evaluate the probable consequences of allowing the natural process to take it's course (i.e. gravitational movement of the waste mass, eroding power of the stream and gradual lining of the channel by durable rocks locally embedded within the waste), case histories on slide-formed lakes were reviewed.

There is a number of instances in which a slide temporary blocked the valley forming a lake. The barrier was usually breached. Among others, the following are examples of such events:

- In 1893, a large rockfall occurred in the upper reaches of the River Ganges in the Himalayas forming a 7 km long lake. The valley blockage collapsed next year (Q. Zaruba, V. Mencl, 1976).

- Several rockfalls (associated with earthquakes) temporary blocking the Murpals River valley (1911) and the Narym

River valley (1946) were reported in Russia. The blockages were eroded away within a period of several months.

- In the USA, many major slides have blocked river valleys, resulting in valley constriction but very seldom in the formation of permanent lakes. A typical example is the Farmer's Union Dam, Rio Grande, Colo. (W.G. Atwood, 1918 and R.F. Legget, 1962).

- The Huascaran debris avalanche (1970) temporarily blocked the Rio Santa in Peru. The blockage failed the same year and produced a debris flow for a distance of some 160 km (N.A.C. 1978).

- Two major slides occurred sometime in the geologic history about 20 km southwest of Bragg Creek, Alberta. Terraces concordant with the height of the debris in the more northerly slide indicate the debris dammed the Elbow River. The river now flows northwestwards through a steep sided canyon cut in very coarse slide debris. (Cruden, 1976).

- Jonas Creek Slide (crossed by the Banff-Jasper Highway) flowed across the Sunwapta River and formed a shallow, temporary lake. The slide comprises quartzite blocks, probably of the Gog Group. The river re-opened its channel and now flows through a stretch of rapids (Cruden, 1976).

- Mount Kitchener Slide, located about 6 km north of the Columbia Icefield and comprizing massive limestones and dolomites, temporarily blocked and dammed the Sunwapta River. The river now flows through a steep-walled canyon of slide debris over 50 m deep (Cruden, 1976).

- One case of a larger slope failure forming a temporary lake occurred on April 25, 1974 in the Mantaro River Valley in Peru. The slide debris comprised sandstone blocks and the volume of slide was estimated in the order of 109 m^3. After 44 days, the debris dam was overtopped and in two days washed away. (Kojan and Hutchinson, 1974).

On the other hand there are lakes which were formed by a slide and some of them retain water quite well.

- In the Carpathians, a large rock-fall occurred east of Georgheni in Rumania in 1818. The limestone blocks dammed the valley creating a lake (Lacul Rosu) which still exists (Q. Zaruba, 1976).

- In the Rockies, slides formed lakes (such as Moraine Lake, Maligne Lake etc.) which remain in place.

While the geomorphological characteristics of slides forming lakes described in the previous paragraphs may not be entirely typical for the conditions existing in the Clinton and Wolverine Creek valleys, they are believed to be of assistance when predicting the likelihood of future behavior of valley blockages in these areas. The significant aspects are summarized below:

- Lake barriers formed by slides, and which were not eroded away, appear to be located on grounds which have sufficient permeability to convey inflows, i.e. the barriers are not overflown.

- The most common type of destabilizing effect is that caused by rivers or streams eroding side slopes or valley blockages.

- The erosion of man-made slopes by streams is a major cause of land instability.

4.0 REVIEW OF OPTIONS AND DISCUSSION

The site rehabilitation and abandonment plan is normally prepared prior to or in the early stages of mining and is aimed at leaving the mined area in a stable condition, consistent with the natural surrounding landforms and vegetation or having the potential to achieve a vegetative cover consistent with the end land use. The end land use is normally determined by the government agency responsible for the administration of the land and is highly dependent upon the land use prior to mining.

The mining was discontinued earlier than originally anticipated and no formal abandonment plan was developed.

At this point, it is too late to produce a normal rehabilitation plan as decisions have been made and implemented which are economically irreversible.

It is my opinion that what can be done now is to develop a rehabilitation and protection scheme for selected valley segments which would be acceptable to the government, compatible with existing conditions and the desired land use and, at the same time, be within reasonable limits.

Currently, there are two different positions regarding the abandonment of these mine waste dumps:

- restoration of stability of the terrain and streams, or
- allowing natural processes, i.e. material movement, erosion and sediment transport, to take place.

It appears to be the Owner's position that the stabilization costs are in the order of magnitude which precludes their implementation. Consequently, the authorities have to decide whether the area downstream from the mine dumps could be condemned and left exposed to the devastation by landslides and transported sediments or, at least, partially protected.

I have serious reservations about the mining company position that the waste and tailings piles will stabilize themselves and that abandonment of these piles in their present state is ecologically and socially acceptable.

It is my opinion that there is a third option to the expensive stabilization or to uncontrolled natural processes:

- The scheme proposed would allow for uncontrolled erosion, slope movements and sediment transport within selected ("condemned") valley segments and endeavour to protect or minimize the impacts on lands and streams located in the valley beyond a certain distance from the mine.

This arrangement would include construction of small flow and sediment controlling structures (weirs and dykes) at a distance of some 500 m downstream of the confluence of the Clinton and Wolverine Creeks. These structures would facilitate sedimentation of water transported materials during catastrophic or flood events and allow for more or less unobstructed flow and sediment transport during normal flow conditions.

These measures, schematically illustrated on Fig. 1 and 2, have been used on a number of European streams (to control sediment transport and facilitate navigation during low flow conditions) since the last century.

5.0 CONCLUSIONS AND RECOMMENDATIONS

It is not believed that the current state of the Clinton Creek waste dump ensures reasonable stability of the lake, its outfall and immediately adjacent stream channel. As illustrated by Figure 3, the rate of the waste dump movement has been relatively constant since 1982. While a catastrophic failure of the dump or a sudden breach of the valley blockage is not expected, the erosion of the dump will continue for many years. This, in my opinion, will eventually lead to the failure of the lake outfall structure, to partial removal of the waste dump which, in turn, will cause a temporary acceleration of waste dump movement and deposition of large quantities of materials further downstream. This process could repeat itself several times until an equilibrium condition is achieved.

A similar, but more devastating scenario is conceivable for the Wolverine Creek tailings pile area. The rates of movement recorded suggest that the south tailings lobe is moving in a "caterpiller-like" manner. As a lower segment fails, toe support for the section above it is removed and the failure gradually progresses up the slope with the amount of horizontal movement decreasing in the upslope direction. The toe of the dump is rising and gradually blocking the creek channel. This could possibly result in forming a new channel (across the temporary blockage) outside of the present rock lined spillway. The unlined channel could erode easily through the tailings accelerating the instability.

Horizontal movements of the toe of the north tailings pile lobe have accelerated over the past few years and are presently in the order of 30 m per year (100 ft/year). If the present trends continue, (Figure 4), it is predicted that a major failure of the north lobe would occur within this or the next year, i.e. in 1985 or 1986.

Such an event would form a temporary blockage of the valley and a larger lake than the present one. The blockage would be eventually overflown, likely outside of the present spillway. The tailings would be eroded progressively down resulting in lowering of the lake level, flooding of the downstream valley section and transportation as well as deposition of large quantities of fine to coarse tailings particles throughout the Wolverine and Clinton Creek valleys. Again, this event may re-occur several times until an equilibrium between the erosion rate and tailings pile movement is achieved. It is expected that such a condition would exist if a new creek channel is cut to a gradient approximately corresponding to the original slope of the Wolverine Creek valley in this area.

Studies undertaken by Hardy Associates in 1984 and by Klohn Leonoff in 1984 and early 1985 indicated that there are uncertainties associated with stabilization efforts and that there is no measure which would guarantee successful and maintenance free stabilization. In addition, high costs are indicated for the implementation of these measures.

Since severe losses of property and life are unlikely to occur, it is recommended to consider the abandonment of slide and slide-prone areas in their present state and to allow natural processes to take place. This may involve declaration of this area "off limits" for hunting, prospecting and other activities.

It is also recommended to evaluate the merits and costs of constructing a system of weirs and sedimentation cells controlling flow and depositional process downstream of the Wolverine and Clinton Creek confluence. The objective of these measures would be to provide a passive protection of the lower portions of the Clinton Creek valley and the Forty Mile River.

Further analysis and design is required to evaluate this scheme. It is considered to construct the flow and sediment control structures using mostly local material, i.e. timber and earth compacted dykes. Stream and bank protection may require gabion mattresses or baskets.

Since these structures will be relatively small, not exceeding a height of some 2 to 3 m, they could be infilled with transported materials during a relatively short period of time (i.e. several years). Material revegetation could then be enhanced using conventional reclamation (seeding and fertilizing) procedures.

The current program of inspections and unspecified maintenance will not resolve existing problems. However, the monitoring data are extremely useful for the evaluation of possible courses of action. They confirm that large downhill displacements of both piles are possible under present conditions with a low static Factor of Safety. The existing data also enables one to estimate potential future extent of the movements. Consequently, the monitoring of the dumps and creeks should continue.

Respectfully submitted,

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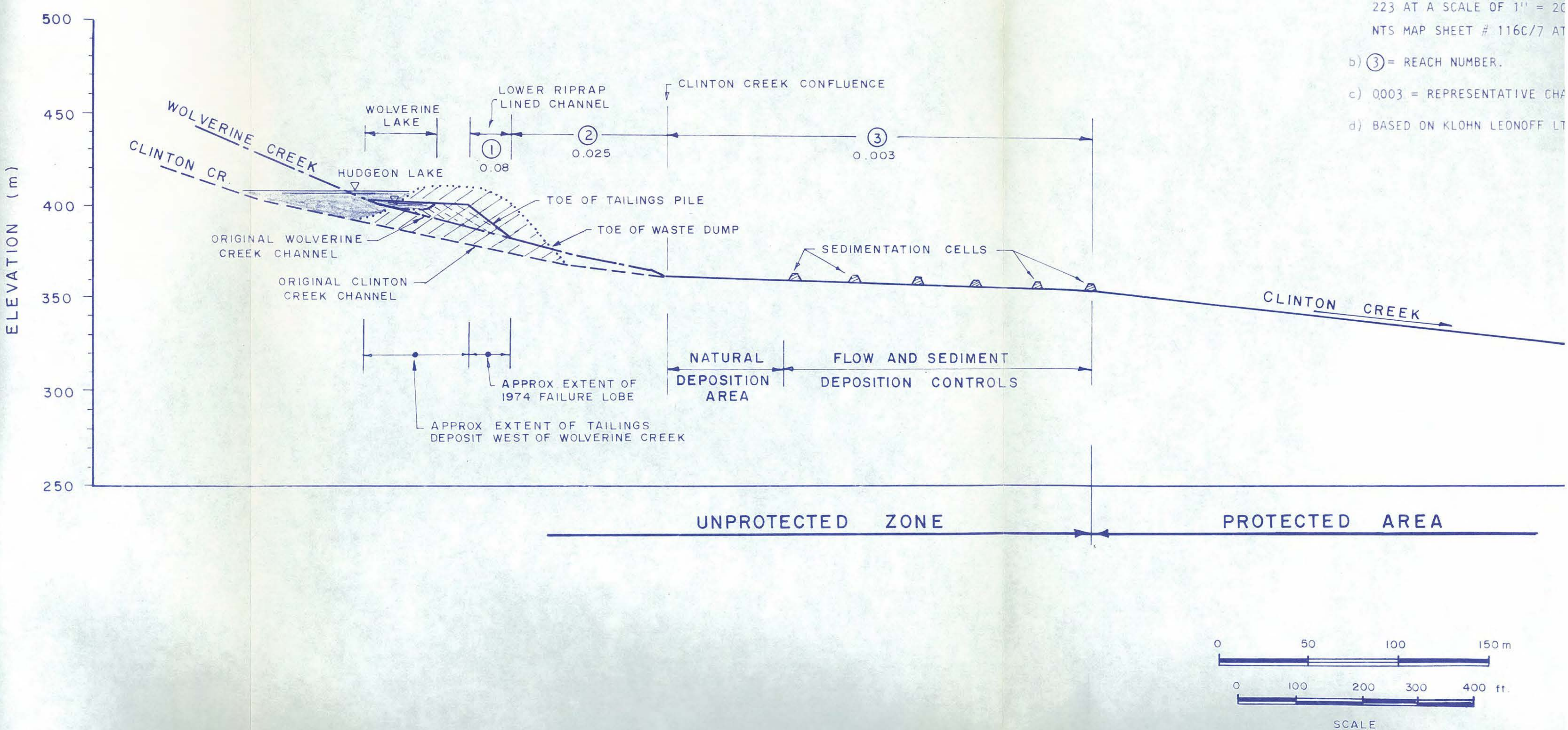


NOTES:

a) ELEVATIONS AND CHANNEL SL
CONFLUENCE TAKEN FROM CAS
223 AT A SCALE OF 1'' = 20
NTS MAP SHEET # 116C/7 AT

b) (3) = REACH NUMBER.

c) 0.003 = REPRESENTATIVE CHA

d) BASED ON KLOHN LEONOFF LT

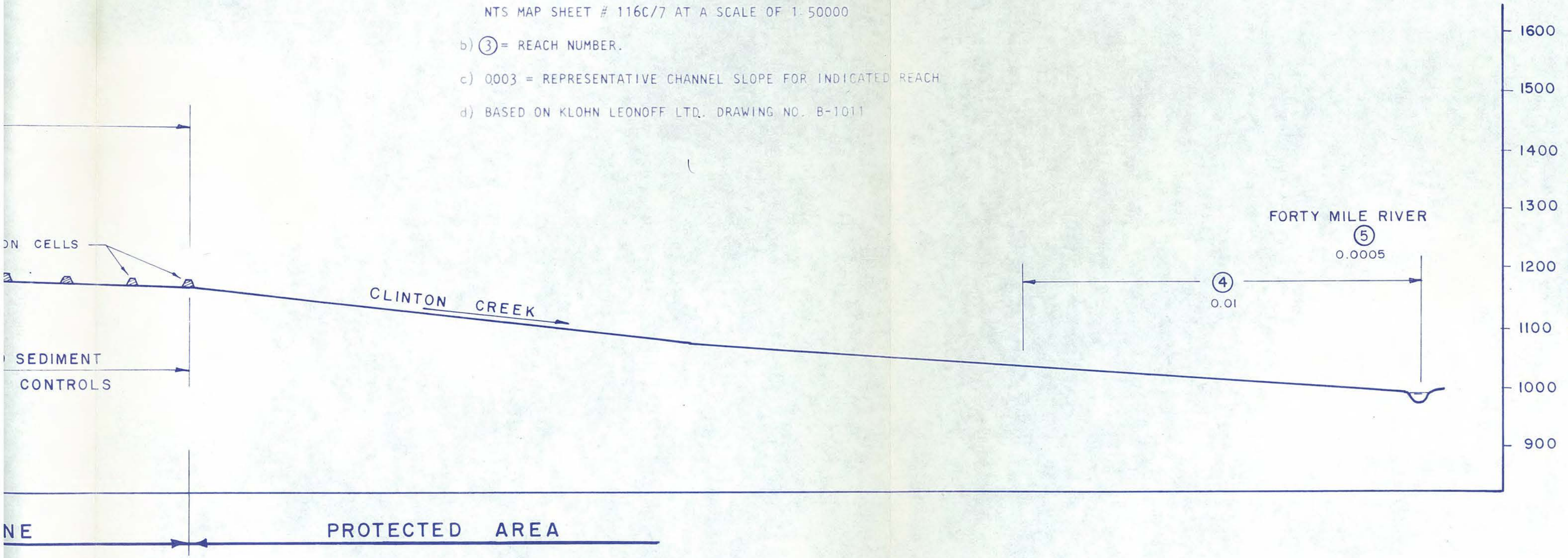
NOTES:

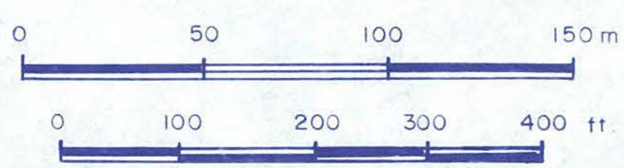
a) ELEVATIONS AND CHANNEL SLOPES UPSTREAM OF CLINTON/WOLVERINE CONFLUENCE TAKEN FROM CASSIAR ASBESTOS CORP. LTD. SHEET NO. 223 AT A SCALE OF 1" = 200". DOWNSTREAM SLOPES ESTIMATED FROM NTS MAP SHEET # 116C/7 AT A SCALE OF 1:50000

b) (3) = REACH NUMBER.

c) 0.003 = REPRESENTATIVE CHANNEL SLOPE FOR INDICATED REACH

d) BASED ON KLOHN LEONOFF LTD. DRAWING NO. B-1011





SCALE

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CLINTON CREEK MINE

WOLVERINE AND CLINTON CREEK PROFILE

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FIGURE 1

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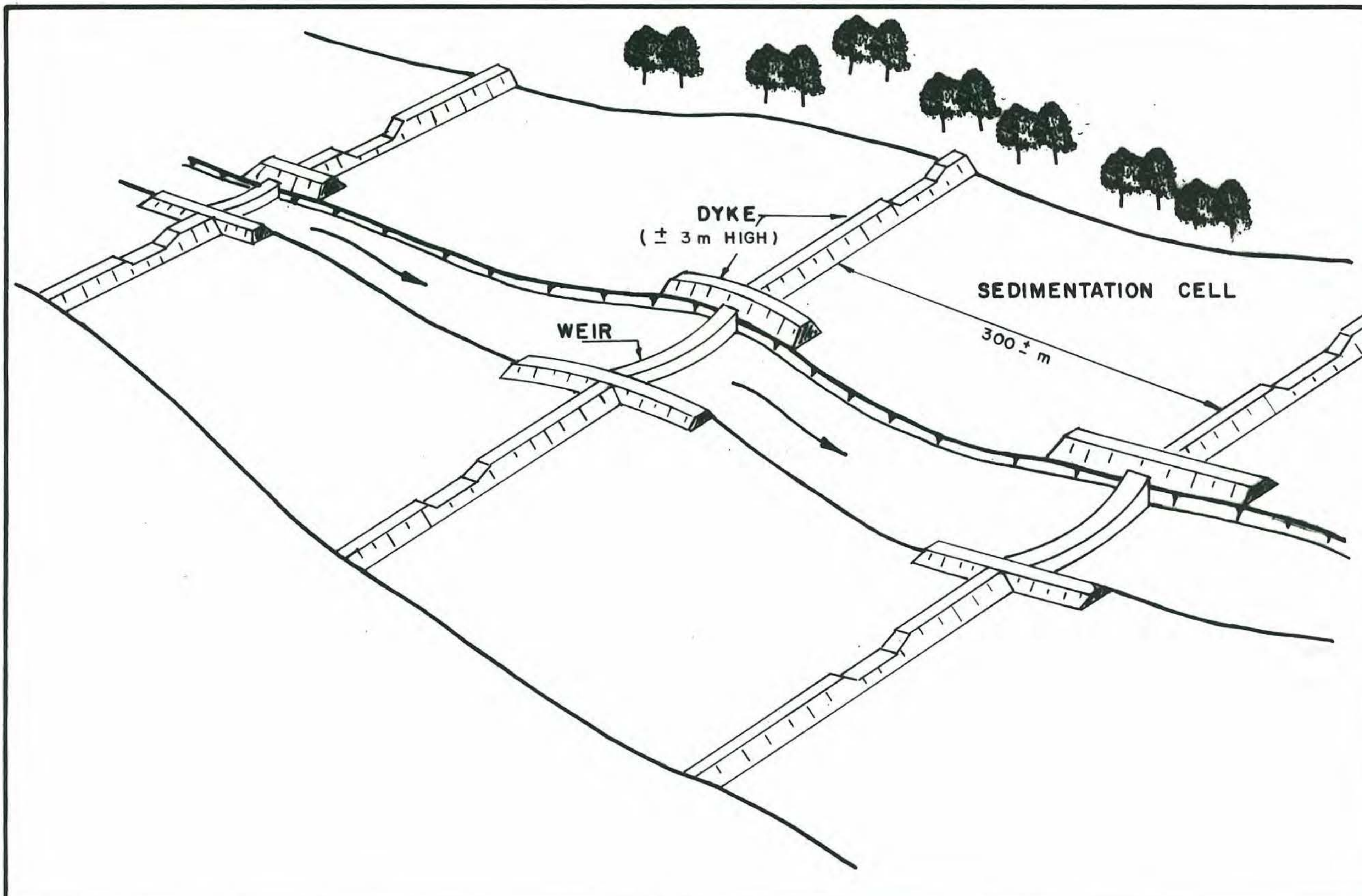

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CLINTON CREEK MINE

FLOW SEDIMENT CONTROLS

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FIGURE 2

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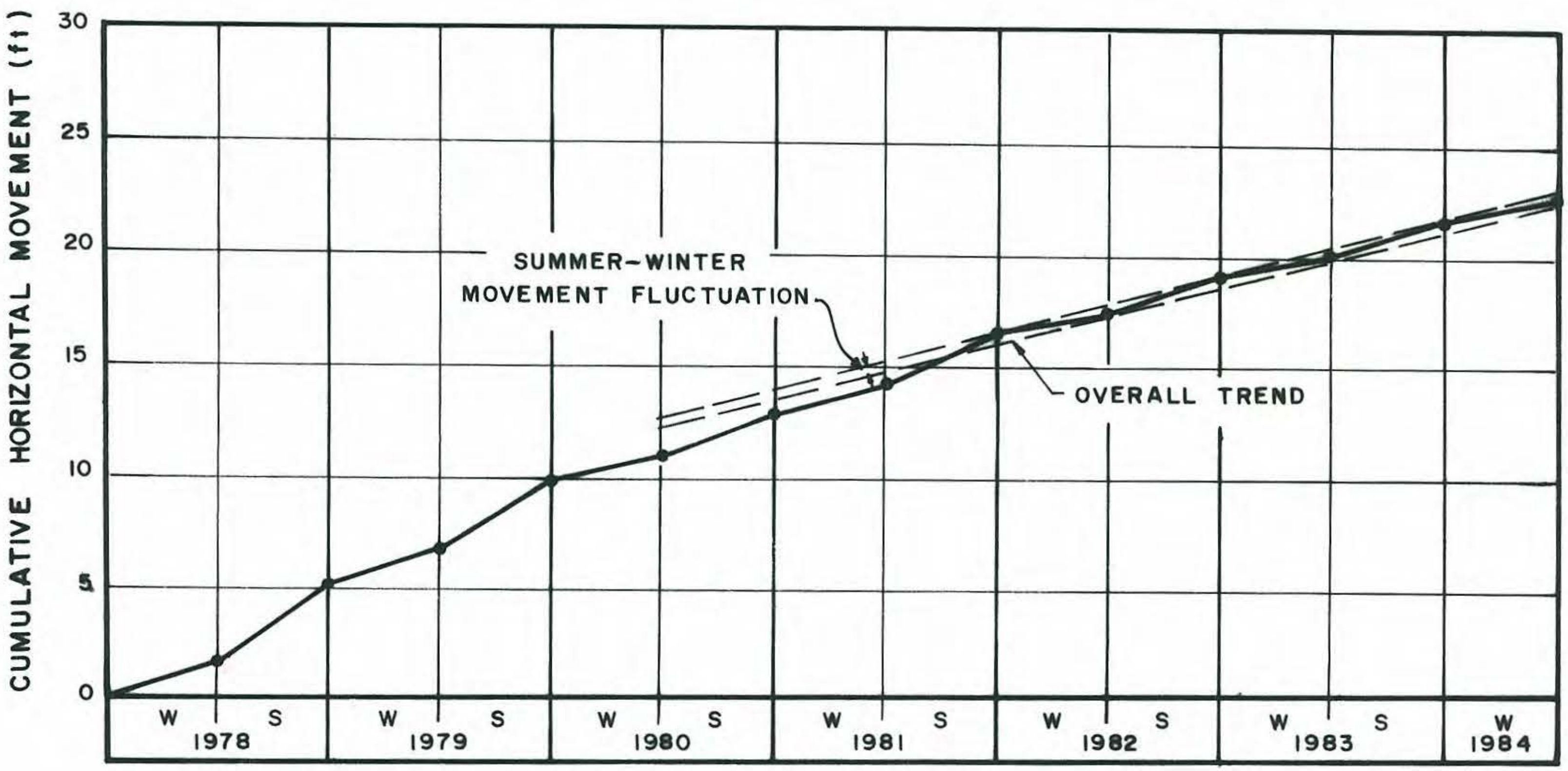

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CLINTON CREEK WASTE DUMP
TOE OF MAIN DUMP SEGMENT

AVERAGE HORIZONTAL MOVEMENTS

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FIGURE 3

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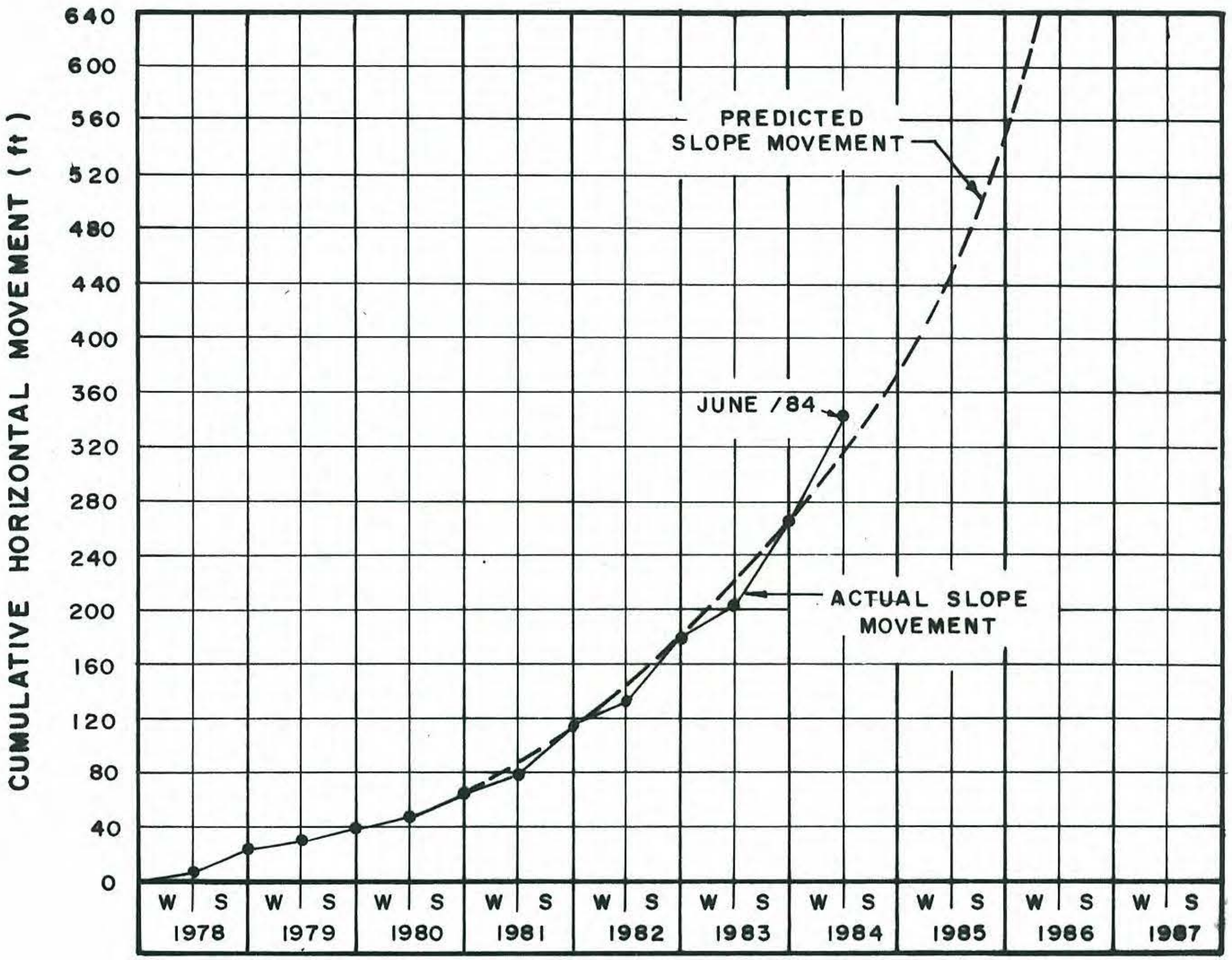

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WOLVERINE CREEK TAILINGS PILE
TOE OF NORTH LAKE
AVERAGE HORIZONTAL MOVEMENTS

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FIGURE 4

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