ABANDONED CLINTON CREEK ASBESTOS MINE

REPORT

ON

1990 SITE INSPECTION

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1.0 INTRODUCTION

The abandoned Clinton Creek area was visited on September 29 and 30, 1990, in the company of Mr. H.F. McAlpine. The previous geotechnical inspection was undertaken in June 1988 and the observations made are contained in our report dated November 1988. Detailed documentation of main geotechnical aspects of this area and a brief review of the historical behaviour of mine pits and dumps is presented in our Review Report dated December 1986.

Relicts of past mining activities, such as underground conduits, crusher, storage tanks, remnants of a power plant, and sewage treatment plant are unpleasant features and represent potential hazards to animals and, possibly, visitors. Landslide blockages of Clinton, Wolverine and Porcupine Creek valleys present more significant threats to people and the environment.

Ground surveys and monitoring of previously installed benchmarks was discontinued in 1986. Consequently, the rating of deformations and movements observed during the current site visit is qualitative only. Some of the photographs included in this report were taken from locations similar to those selected for photographing during previous visits. This allows for comparison of current terrain features with previous documentation.

We have also included previously compiled sketches of main surficial features of the waste dump and highlighted the areas of the apparent greatest activity.

The U.S. Geological Survey conducted an investigation of the hazards associated with natural valley blockages forming lakes. J.E. Coste and R.L. Schuster published the study results in the Geological Society of American Bulletin in July 1988 (The Formation and Failure of Natural Dams). During the U.S.G.S. study, the formation and/or failure of approximately 225 natural dams was compiled and categorized. The results encouraged us to revise our brief review of case histories (presented in our 1986 report), as well as the evaluation of possible future behaviour of these valley blockages.

2.0 CLINTON CREEK WASTE DUMP

The major portion of overburden rock from the Porcupine open pit was dumped over the slope which forms the south wall of the Clinton Creek valley. The uppermost segments of the valley wall have gradients up to some 30 degrees. The dump started to slide into the valley during the very early stages of mining. As the toe of the dump reached the valley floor, it began to spread over the low shear strength, presumably ice-rich alluvial soils comprising the valley bottom. As more waste material was placed on the dump, the dump continued to spread until the entire valley bottom was blocked. The valley blockage formed a lake (Photo 1), now known as Hudgeon Lake. Discharge from the lake currently passes through four, 1.5 m diameter culverts into the Clinton Creek channel which flows across the waste dump along the north side of the valley. The channel has incised a trough bounded by waste material on the south while the north bank is mostly bedrock-controlled. The channel has an overall gradient across the dump of about 4.5 percent.

2.1 WASTE DUMP - OBSERVATIONS

Fresh cracks, scarps and fissures were observed in the upper segment of the waste dump and are indicative of recent and ongoing movement of wastes placed on the south slope of the Clinton Creek valley. The headscarp area has retrogressed upslope from the waste dump limit and localized segments of natural ground have become unstable. The dump toe has apparently advanced into the creek channel.

The main observations made during the site visit and our interpretation of the movements which have occurred since the 1988 site visit are summarized below:

- The uppermost section of the dump (Photo 2) exhibits a series of steep and fresh-looking scarps, ranging in height from 100 to 600 mm. The uppermost slope gradient ranges from 40 to 45 degrees.

- The retrogressive character of the movement is indicated by ongoing vertical displacement and cracks extending beyond the upslope dump boundary. One scarp is about 2 m high.

- Fissures caused by the sliding of the Porcupine pit north wall extended into the waste dump (Photo 3). The rate of dump movement into the pit has possibly increased.

- A section of the dump forming the shore of Hudgeon Lake does not exhibit significant changes in the ground configuration along the shore line (Photo 4).

- Tension cracks running parallel to the Clinton Creek channel and traversing the access road are fresh and indicative of recent movements.

These features, schematically outlined on Figure 1, indicate that the dump movements continue to be pervasive.

Water level marks indicate that the water level in the lake was down by about 0.3 m below the prevailing lake elevation just prior to the site visit.

2.2 CREEK CHANNEL - OBSERVATIONS

There are no apparent terrain changes at the lake outlet area. The volume of timber and other debris, partially obstructing the culvert inlets, is larger than in 1988.

The armoured section of the creek channel between the lake outlet and the drop weir (Photo 7) exhibits only minor changes since the 1988 site visit. Minor downcutting of an incised channel upstream from the weir continues. A gravel bar deposited along the north bank upstream from the weir appears to be stable. Erosion of the south abutment at the drop weir continues without major impact on the weir.

The channel downstream from the weir to a point approximately half way across the waste dump area has also been relatively stable since 1988. This channel section has a constant gradient (upstream from point A on Photo 8) and contains a series of small steps across the channel bottom. Erosion of the south bank is minor. Similarly, the channel downcutting and erosion of the north bank has slowed downstream from point A.

The south bank, comprised of mine waste, is eroding and the steep bank is sliding (Photo 9). There is obvious loss of material and dump movement into the creek channel.

The downstream segment of the creek channel shows very little visually recognizable changes since 1988. Boulder pavement of the channel bottom is more consistent in this sector than further upstream. The bedrock forming the north side of the channel comprises thinly-bedded and jointed shale with some calcareous sandstone, locally. However, the bank morphology and the channel pattern is almost the same as observed in 1988 (Photo 10).

2.3 ASSESSMENT

The waste dump volume is estimated at about 35 million m^3. The valley bottom in this area used to be flat and about 240 m wide. The length of the dump in the valley bottom exceeds 700 m. It is believed that the dump triggered a deep-seated failure extending below the valley floor. This resulted in an upward movement and eventual displacement of the creek channel towards the north valley side. This valley blockage (or landslide dam, according to Coste J.E. and Schuster, R.L.) is more than 50 m high in the center of the valley and created a lake having a surface area about 72 ha (0.7×10^6 m^2) and a depth of water of about 26 m. It is estimated that the total volume of impounded water is in the order of 15×10^6 m^3. Table 1 summarizes some documented examples of other landslide dams and includes parameters of this valley blockage.

During the initial inspection (Hardy 1977), it was recognized that the long-term stability of this landslide dam depends on the stability of the lake outlet and channel. While the waste material is heterogeneous and poorly-consolidated, a failure, due to piping or collapse of the blockage, was not considered to be possible. Approximate transverse sections of this landslide dam, a large earth fill dam (Oroville, California) and a large moraine dam (Nostetuko, British Columbia) are compared on Figure 2. The Hudgeon Lake landslide dam is nearly as wide as the other dams, while its height is considerably smaller.

Concerns regarding the stability of the Clinton Creek channel across this dam prompted the mine company to construct, in 1981, a rock-lined section and weirs near the upstream end of the channel. The creek by-passed this channel in 1982 and eroded a new course. The newly-eroded channel was backfilled and a single weir with armoured banks was constructed in 1983. The armoured channel and the weir were affected by some erosion and deposition of materials, especially shortly after construction was completed. There have been only minor changes since 1988, and the performance of the armoured section has been good. However, there has not been a major flood since that time.

TABLE 1

Examples of Landslide Dams Formed by Slumps (According to Costa and Schuster)

Landslide Class and Name	Year	Dammed River	State/ Country	Landslide Volume (m^3)	Blockage Dimensions			Lake Dimensions		Dam Failed?
					Height (m)	Length (m)	Width (m)	Length (km)	Volume (m^3)	
Deixi Landslide	1933	Min River	Sichuan, China	150×10^6	255	400	1,300	17	400×10^6	Yes
Lower Gros Ventre Landslide	1925	Gros Ventre River	Wyoming, U.S.A.	38×10^6	70	900	-2,400	6.5	80×10^6	Yes
Tsao-Ling Rockslide	1941-1942	Chin-Shui-Chi River	Taiwan	250×10^6 (two slides)	217	1,300	2,000	?	157×10^6	Yes
Cerro Condor-Sencca Rockslide	1945	Mantaro River	Peru	5.6×10^6	100	250	580	21	300×10^6	Yes
Madison Canyon Rockslide	1959	Madison River	Montana, U.S.A.	21×10^6	60-70	500	1,600	10	?	No
Thistle Earthslide	1983	Spanish Fork River	Utah, U.S.A.	22×10^6	60	200	600	5	78×10^6	No
Hudgeon Lake	1974	Clinton Creek	Yukon, Canada	35×10^6	50	700	300	2.2	15×10^6	No
Wolverine Lake	1974	Wolverine Creek	Yukon, Canada	0.5×10^6 (a)	24	200	150	0.3	0.01×10^6	Yes (b)

NOTES: (a) Estimated volume of the south lobe blocking the valley bottom only. Total volume of tailings is about 7×10^6 m^3.

(b) The failure occurred prior to the construction of an armoured spillway.

A temporary blockage of the overflow channel, due to localized accelerated sloughing of the waste material, resulting in a temporary rise of the lake level and subsequent increased erosion, was considered a possible mechanism releasing large volumes of water and material (Geo-Engineering Review Report, 1986). During the past ten years, the volume of material sliding from the waste dump into the channel has been relatively consistent and, with the exception of gravel-sized and larger aggregates, readily transported further downstream. This experience validates predictions made by Klohn Leonoff (Abandonment Plan, 1986) regarding the waste dump movement and sediment transport through the overflow channel for flow events experienced to-date.

In summary, the large mass of the valley blockage, its shape and composition of the dam material provides, in our opinion, significant protection against its rapid failure. The highest risk to the stability of this landslide dam is breaching and erosion of the armoured upstream segment of the overflow channel.

3.0 PORCUPINE CREEK WASTE DUMP

The displacement of the mine waste deposited into the Porcupine Creek valley continues. The main instability features and drainage conditions are schematically shown on Figure 3.

Steep, fresh-looking scarps outlining the upper limit of the slide area encompass the entire waste dump. The southern half of the dam appears to be considerably more active than the northern one (Photo 11). The slide toe also exhibits discernable changes since 1988.

The valley blockage caused by a relatively narrow slump, combined with ground heave, did not significantly change since 1988 (Photo 12). However, the lake inlet leading to this blockage appears to be somewhat narrower. Its width ranges from about 5 to 15 m. At the narrowest point, the slide lifted up glaciolacustrine material originally covering the valley bottom. Water from this inlet seeps through the waste rock.

The secondary (western) outlet from the lake has been restored since 1988. This is likely due to the somewhat higher lake level than in 1988. The flow infiltrates into the dump.

There is a significant amount of seepage discharged at the north end of the dump. This seepage is dispersed over a relatively wide zone and does not have any adverse impact on this dump sector (Photo 14).

The flow from the dump and surface drainage paralleling the east side of the dump traverses a small waste dump and descends into the valley bottom. This dump is progressively failing.

Since the Porcupine Creek watershed upstream from the dump is less than 2.5 km^2 and the valley blockage is wide (relative to the lake head and volume), the risk of a mass wasting failure combined with flooding is believed to be very small or negligible.

4.0 SNOWSHOE PIT WASTE DUMP

This dump, deposited on the south slope of the Clinton Creek valley, has a low volume. Its crest is only about 400 m long and 20 m wide. It rests on about a 25 degree slope and the dump surface gradients range from 37 degrees (west and center segments) to 42 degrees (eastern portion). The toe of the dump is located well above the valley bottom (Photo 15). Its position shows very little chance since 1986.

The dump is unstable, as evidenced by fresh headscarps along its crest and tension cracks, namely across its eastern segment. It appears that the toe of the dump, in its center and eastern segments, acts as a passive wedge controlling the movement of the upper portion of the dump.

Some portions of this dump should eventually fail. However, the impact on the Clinton Creek channel could be low because of the small volume of materials which would be involved.

5.0 WOLVERINE CREEK TAILINGS PILE

The tailings (approximate total volume of 7 x 10^6 m^3) were placed over the valley slopes dipping at an average angle of about 16 to 17 degrees to the valley bottom. The subgrade of the tailings pile, comprised of overburden soils and argillitic bedrock, was frozen and reportedly contained segregated ice.

The tailings have been stacked in two piles, referred to as the north and south lobes. The south lobe was deposited from start-up until 1974, when a segment of the pile moved downslope and blocked the valley bottom forming a small lake. The valley blockage was breached and a large volume of tailings was washed down covering the valley bottom. Following the failure, a rock-lined outfall channel was constructed to control erosion and convey the creek across the valley blockage.

The south tailings pile lobe temporarily blocked (apparently for a short period of time) the Wolverine Creek channel a short distance downstream from the lake outlet again in 1986. Water seeped underground and was discharging along the toe of the north hillside, outside of the lined spillway. This blockage was breached and surface flow restored in 1987.

The north lobe reached the valley bottom in 1985 and temporarily blocked the creek flow in 1987. The original valley bottom was "bulldozed" up and against the east valley wall. This created another small lake. The flow from this lake overtopped easily erodible tailings and cut a new channel through the toe of the north lake.

5.1 FIELD OBSERVATIONS

Wolverine Creek, downstream from the tailings pile weir, has cut its channel through tailings and has now reached its original (1973) level. Tailings forming creek banks are eroded only during larger flow events.

The general appearance of both south and north pile lobes is similar to that observed in 1988 (Figure 4). The pile movements continue and their rates are apparently irregular, reflecting the displacement of individual dump segments. For example, when a lower block moves, the adjacent upslope segment accelerates and the failure gradually progresses to the top of the pile.

It is difficult to estimate the rate of movement. The displacement is significant since some markers which used to be on the top of the pile toe have been displaced into the creek channel. It is our judgment that the rate of horizontal movement of the southern lobe is several meters per year, and of the northern lobe, ten or more meters per year.

The toe of the south lobe has expanded northward and its height above the channel has increased significantly. Prevailing fissures in the toe area are oriented perpendicularly to the creek channel (Photos 16 and 17). Pieces of argillite and chunks of till found on the surface are indicative of a deep-seated nature of this failure. The toe is eroding and steep banks (ranging from 40 to 60 degrees) have been formed (Photo 18). The creek channel has been pushed up and against the east valley wall, which is also eroding. The downstream segment of the channel is cut within the argillaceous bedrock. More resistant rock blocks and fragments pave the channel bottom through this area (Photo 19).

Continuing dump movement and its affect on the channel bottom resulted in an historically high lake level. This level exceeded the lake elevation caused by a temporary blockage of its outlet in 1986.

The height of the toe of the north pile lobe is increasing (Photo 21). This, in turn, has caused heaving of the original valley bottom along its east side. It is estimated that this terrain was lifted up by about 3 m. This lobe is also spreading upstream, pushing away and raising the original ground. The creek has cut its channel through the blockage within tailings, which are obviously more erodible than overburden or bedrock. The west bank, formed by tailings, is approximately 5 m high.

There is only a low head between the lower and upper lake levels. However, the size of the upper lake is increasing.

The middle and upper segments of the pile continue to slide downhill. Some slide segments descended and obliterated terraces cut into this slope in 1978. It is estimated that the middle segment of the north pile was displaced laterally by at least 120 m since that time.

5.2 ASSESSMENT

The Wolverine Creek valley is blocked with the southern lobe of the tailings pile. The size of the blockage and volume of stored water is small, relative to other landslide dams listed in Table 1. The volume of tailings currently blocking the valley bottom (i.e. the toe of the southern lobe) is about 1/14 of the total mass of tailings sliding into the valley. This process could eventually form a bigger blockage and a larger lake.

The ongoing downslope movements of both tailings pile lobes and tailings eroded from the north lobe may fill the lower lake and form a single, relatively wide blockage. It is expected that the stream will flow across the top of this "dam", probably confined along the east valley wall.

Since the tailings are readily erodible, it is quite possible that the blockage will be breached, stored water partially released and eroded material transported downstream. The assessment of a probable breach configuration, flows and sediment transport was made by Klohn in 1987 (Report on Downstream Hazard Assessment). This analysis has shown that downstream flows would rise significantly for a distance of several kilometers from the tailings pile. The bulking and debulking of flood water with sediment as such flow moves down the valley represents an unsolved problem. Consequently, the sediment transport analysis (as presented in the Klohn report) should be considered as an illustration of the possible outcome of this dam failure. Unfortunately, consequences of flow bulking could be very significant.

It is our opinion that the landslide dam formed by the tailings is inherently more erodible than the Clinton Creek blockage (comprised of waste rock and overburden material) and considerably less stable than a constructed dam. The length of the valley blockage, in this case, may not represent any advantage insofar as its stability is concerned; it may simply supply more material for transport downstream.

The flood hazard and its impacts has been, to a degree, limited by relatively low runoff from a catchment area, which is estimated to be only 21.6 km^2.

Since the armoured spillway channel does not extend into the outlet from the lake, it could be by-passed by a larger flow and possibly destroyed. This would lead, in our opinion, to retrogressive erosion and, in turn, the transportation of significant volumes of tailings downstream.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the 1990 site visit and in consideration of available monitoring data and analyses, the following conclusions are presented:

- Waste dumps in the Porcupine Creek valley and at the Snowshoe Pit are unstable, but the risk of significant failure causing mass wasting or flooding is believed to be very small to negligible.

- Valley blockages (landslide dams) in the Clinton Creek and Wolverine Creek valleys, if breached, could have a significant impact on natural conditions of the downstream sectors of these streams. A combined effect of flood conditions and breach of a channel blockage may present a hazard to human life.

- The rate of the Clinton Creek waste dump movement is relatively slow. Providing that the lake outlet remains stable, the probability of a sudden failure of this valley blockage is believed to be low.

- The Wolverine Lake tailings pile movement continues at a significant rate and further changes of the Wolverine Creek blockage are expected. The probability of breach failure of the tailings-formed dam, including destruction of the existing armoured spillway, is rated as high.

While inexpensive measures, which would control these events, are not available, it is recommended to consider the following actions:

- Removal of culverts and placement of rip-rap across the Hudgeon Lake outlet.

- Maintenance of the control weir at the outlet of Hudgeon Lake. This should include improvement of the weir stability and placement of additional rip-rap along the armoured channel.

- Visual monitoring of main dumps and creek channels (preferably twice a year) by a geotechnical specialist, as required.

- Maintenance of the water gauge on Clinton Creek.

- Installation and monitoring of water gauges in both lakes.

- Installation of reference points within the Clinton Creek channel and their yearly survey.

- Installation of survey prisms at selected areas of the Wolverine Creek waste dump and their yearly survey.

- Installation of properly-designed warning signs along the access road and at the creek channels.

Respectfully submitted,

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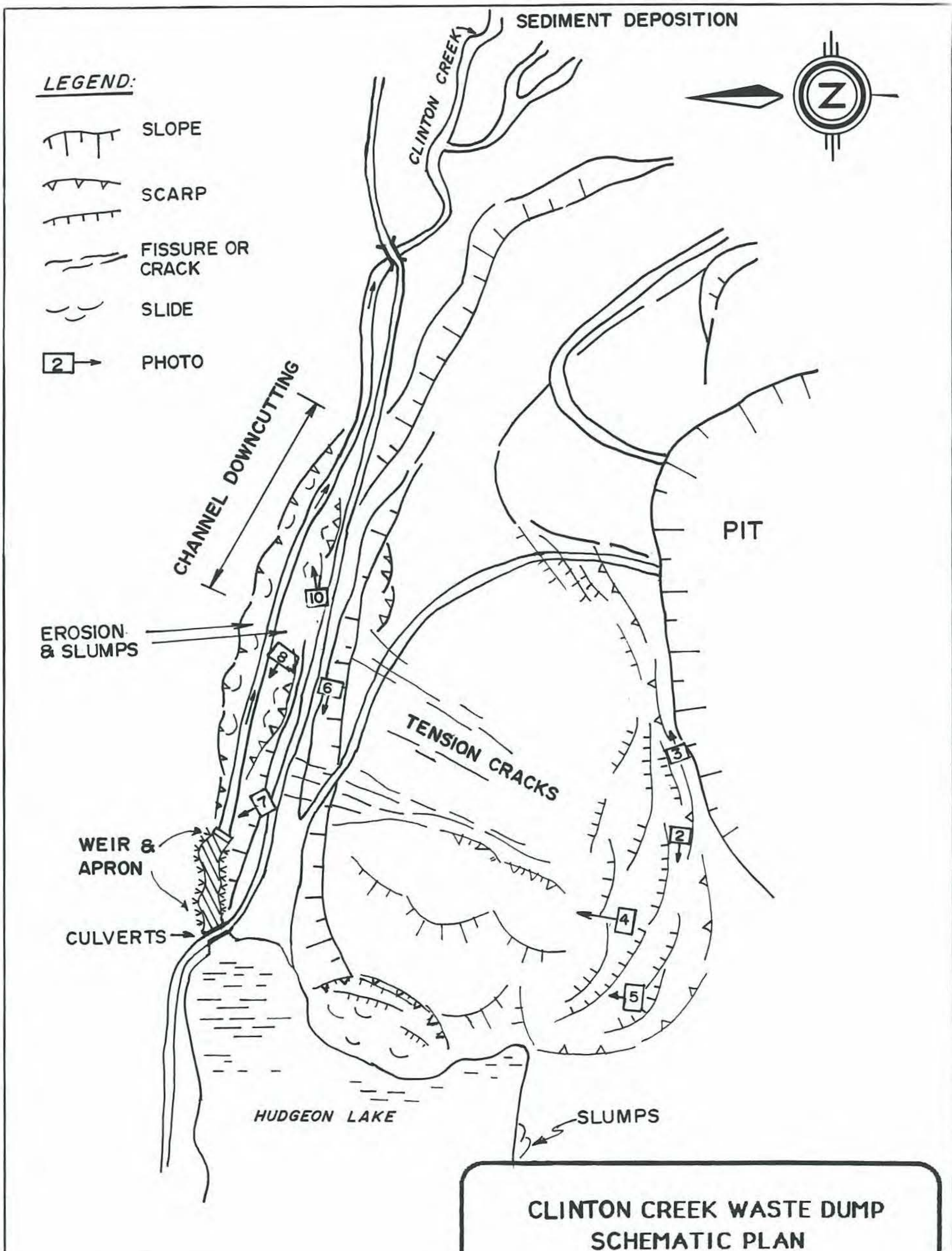
APPENDIX A

FIGURES



CLINTON CREEK WASTE DUMP
SCHEMATIC PLAN

N.T.S.

FIGURE 1.

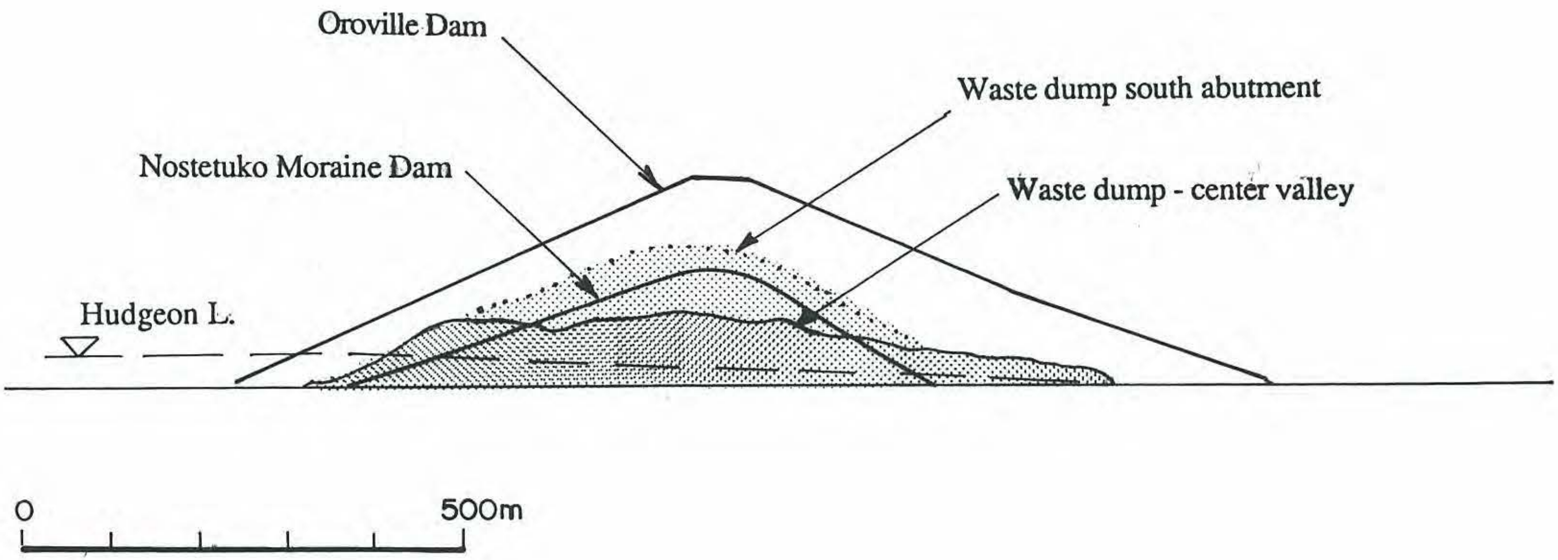
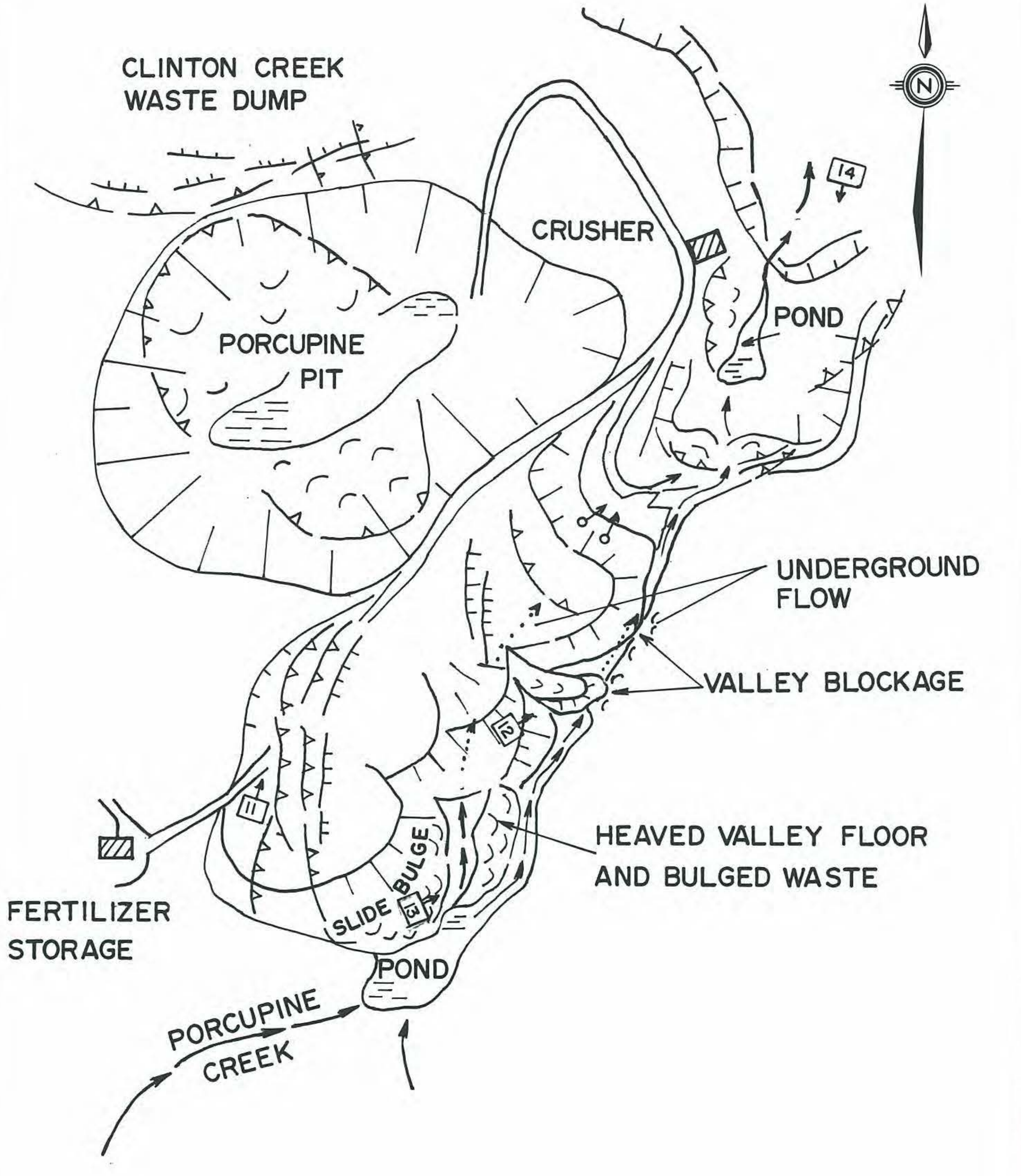


Figure 2: Cross section of Clinton Creek valley blockage, Nostetuko Moraine Dam and Oroville Dam (modified from Lee and Duncan, 1975).

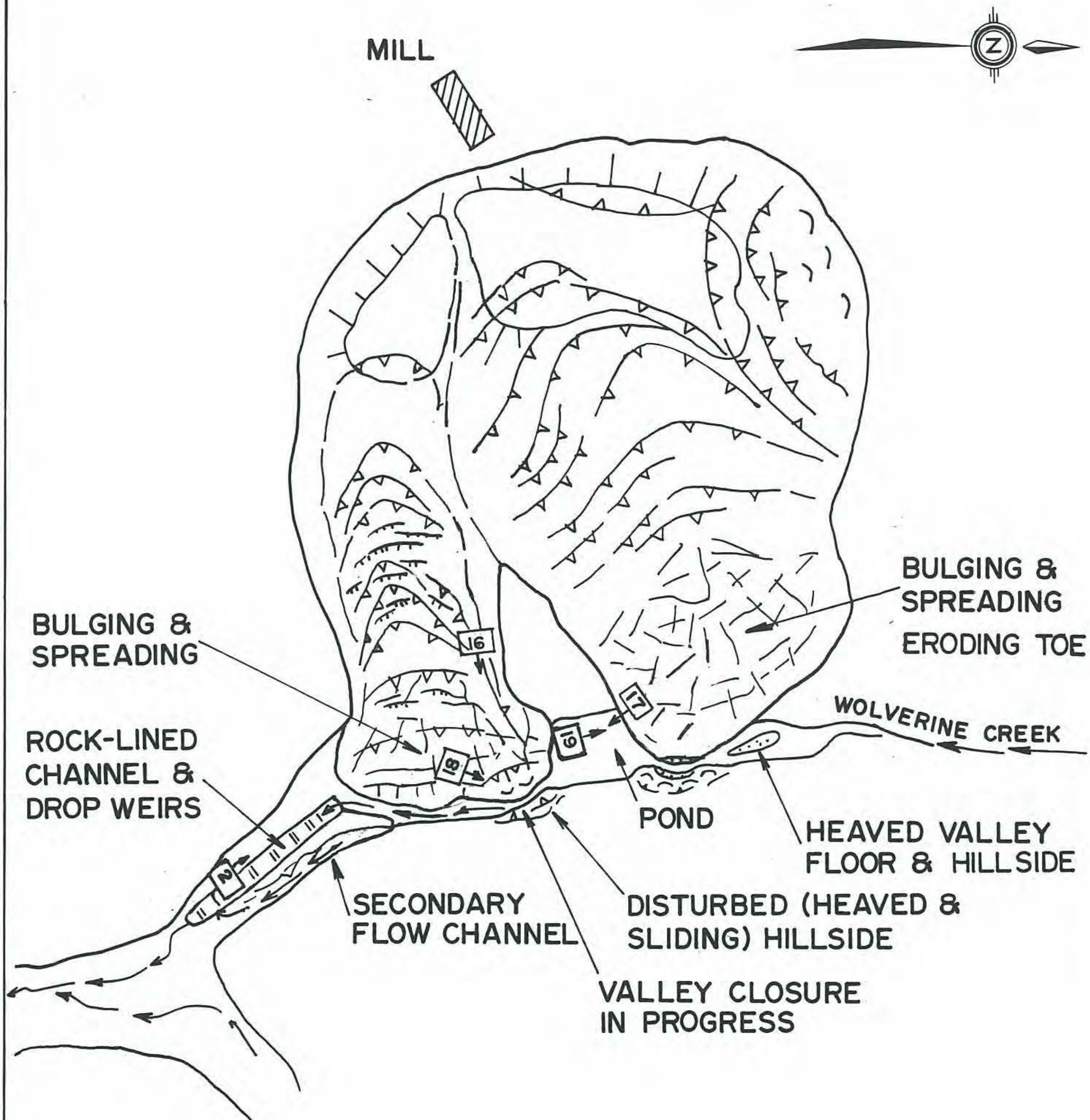


NOTE: LEGEND ON FIG. 1

PORCUPINE CREEK WASTE DUMP
SCHEMATIC PLAN

N.T.S.

FIGURE 3



NOTE: LEGEND ON FIG.1

WOLVERINE CREEK
TAILINGS PILES
SCHEMATIC PLAN

N.T.S.

FIGURE 4

APPENDIX B

PHOTOGRAPHS

Photo 1: View of the Clinton Creek waste dump. Note small slumps along the lake shore upstream from the dump.

Photo 2: Fresh cracks along the waste dump headscarp.

Photo 3: Unstable ridge bordering the north wall of the Porcupine pit. Refer to Photo 2 of the 1988 report.

Photo 4: View of the western segment of the waste dump and the lake outlet. Refer to Photo 3 of the 1988 report.

Photo 5: Prominent slide ridges parallel the toe of the hillside in the western segment of the dump.

Photo 6: Uneven surface of the access road paralleling the Clinton Creek channel is indicative of ongoing movements.

Photo 7: View of the armoured section of the Clinton Creek channel. Refer to photos 5 and 6 of the 1988 report.

Photo 8: Clinton Creek channel downstream from the armoured segment. Refer to photos 7 and 8 of the 1988 report.

Photo 9: View of the middle segment of the creek channel. Note sloughing of the bank formed by the waste material.

Photo 10: Downstream segment of the Clinton Creek channel does not exhibit major changes since 1988. Refer to photos 9 and 10 of the 1988 report.

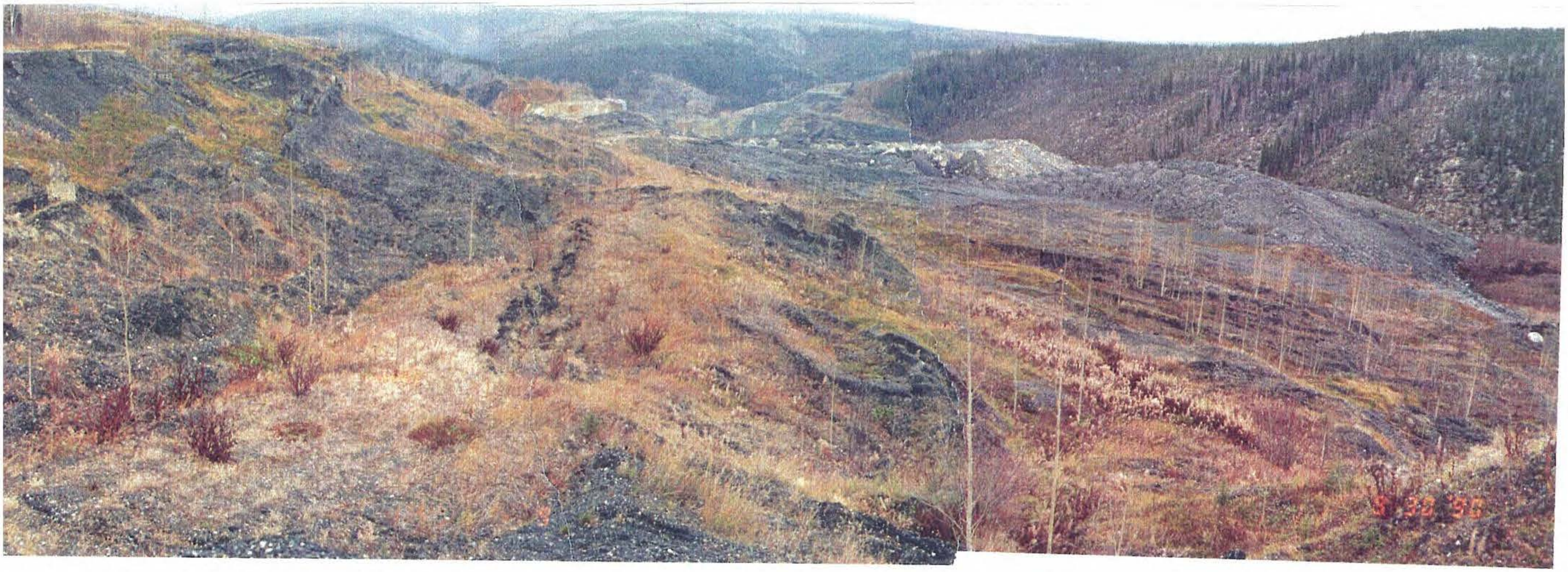


Photo 11: Oblique view of the Porcupine Creek waste dump, looking north. Fresh appearance of the cracks in the headscarp area is indicative of current and ongoing movements. Refer to Photo 4 of the 1988 report.

Photo 12: Eastern lobe of the pond formed by the sliding Porcupine dump appears to be narrower than in 1988. Refer to photo 12 of the 1988 report.

Photo 13: View of the western discharge channel. Water from this channel infiltrates into the waste, and further downstream, the channel is dry.

Photo 14: Underground flow is discharged at several locations from the northern toe of the Porcupine dump. This seepage apparently contributes to the instability of the dump on the left.

Photo 15: View of the Snowshoe waste dump. Fresh cracks exist along the crest of the dump and at its toe.

Photo 16: View of the south lobe of the Wolverine valley tailings pile and the armoured spillway. Note that the prevailing cracks are perpendicular to the channel, indicating bulging of the toe area.

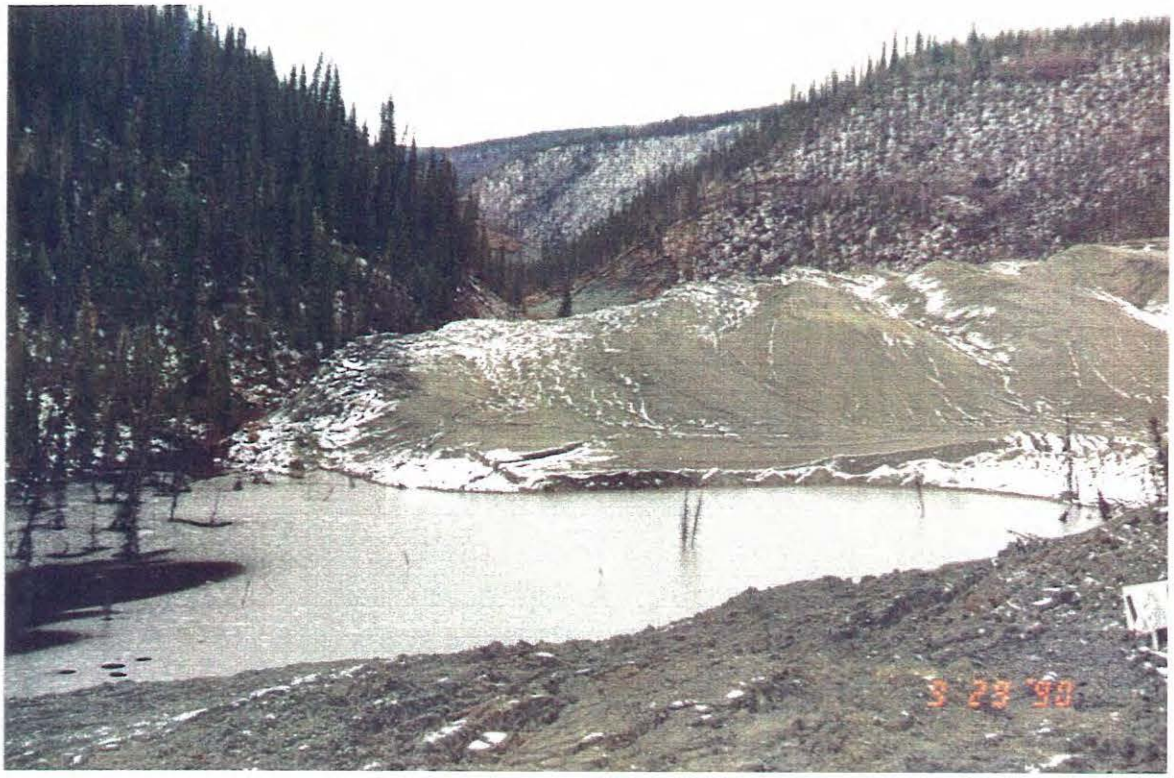


Photo 17: View of the upstream portion of the south lobe. Refer to photo 15 of the 1988 report.

Photo 18: Outlet from the south lobe is quite narrow. The valley slope is locally sliding.

Photo 19: View of the outlet channel through the south lobe. Refer to photos 20 and 21 of the 1988 report.

Photo 20: View of the armoured Wolverine Creek spillway. Refer to Photo 22 of the 1988 report.

Photo 21: View of the north lobe of the Wolverine valley tailings pile. Refer to photos 17 and 18 of the 1988 report.