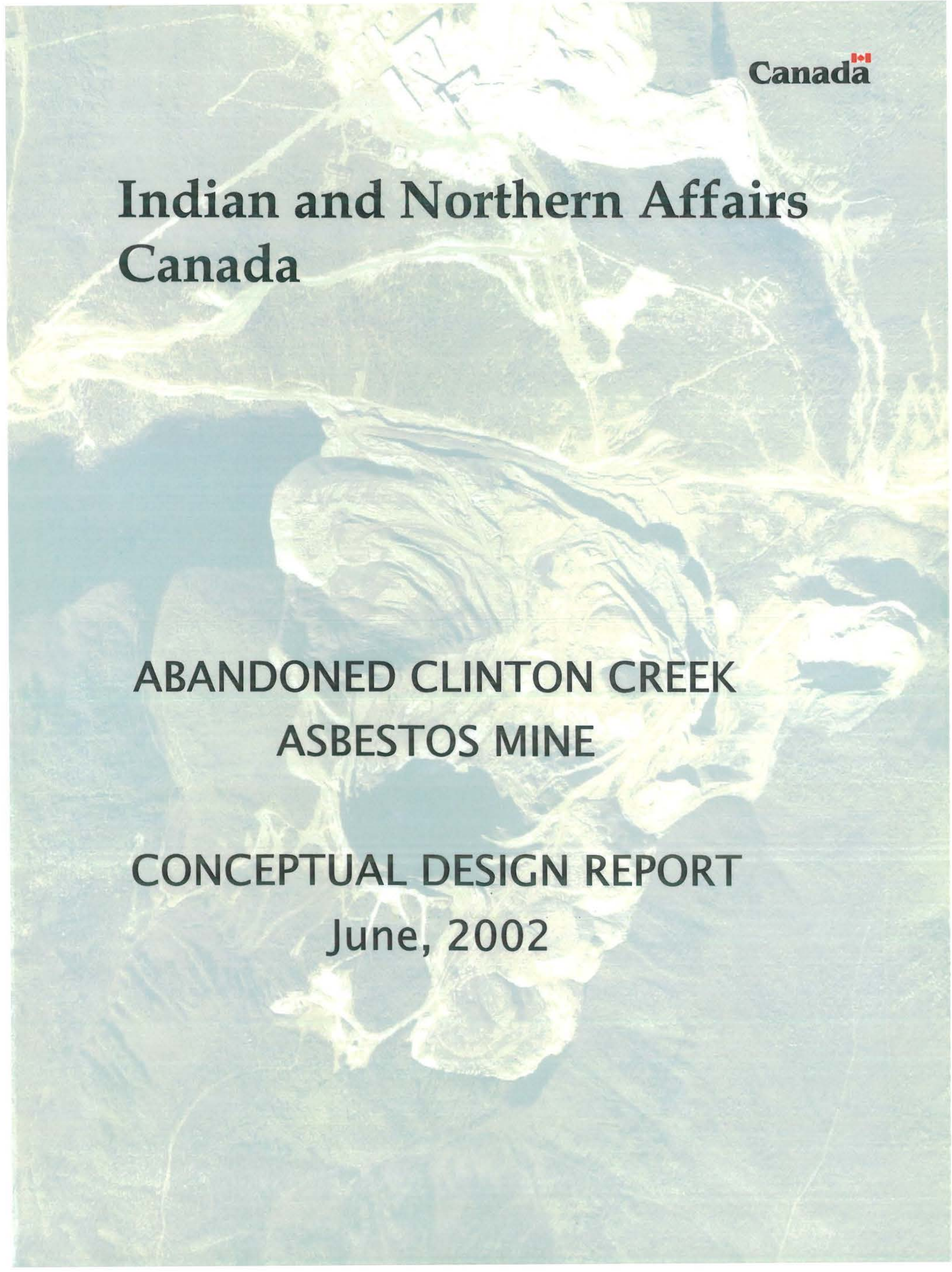

Canada

Indian and Northern Affairs Canada

ABANDONED CLINTON CREEK ASBESTOS MINE

CONCEPTUAL DESIGN REPORT

June, 2002

Canada

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ABANDONED CLINTON CREEK ASBESTOS MINE

CONCEPTUAL DESIGN REPORT JUNE 2002

Originally Submitted in Draft: November 2000
Final Submission, With Minor Revisions: June 2002

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Our File: 41 01 4440 038 02

June 11, 2002

Indian and Northern Affairs Canada
345 - 300 Main Street
Whitehorse, Yukon
Y1A 2B5

Attention: Mr. Brett Hartshorne

Dear Sir:

Reference: Abandoned Clinton Creek Asbestos Mine
Conceptual Design Report

Attached is our report summarizing the conceptual design of remedial measures to mitigate the hazards associated with a breach of the waste rock dump at the abandoned Clinton Creek Asbestos Mine. A review of the performance of the waste rock dump, previous geotechnical investigations and survey information collected since 1976 has been completed in preparing this report. A range of technically feasible options is presented to provide an indication of the capital costs associated with the implementation of remedial works. Recommendations are also provided for the investigations considered necessary to proceed with detailed design should the implementation of remedial work proceed. Should you have any questions or require any additional information, please contact Ken Skaftfeld, P.Eng.

Yours truly,

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1.0 INTRODUCTION

This report summarizes the results of our conceptual design of remedial measures to mitigate the hazards associated with a breach of the waste rock dump at the abandoned Clinton Creek Asbestos Mine, Yukon Territory. The terms of reference for the project are outlined in our letter to Indian and Northern Affairs Canada (INAC) dated August 16, 2000.

A significant hazard has been identified associated with continued degradation of the Clinton Creek channel through the waste rock dump (UMA Risk Assessment Report, April, 2000). Of particular concern are potential risks to human life and property downstream of the mine associated with a sudden breach of the channel blockage. In areas with significant relief such as the Clinton Creek valley, flooding from failures of channel blockages can be especially dangerous and unrelated to precipitation events that would normally be expected to produce flooding conditions. Although the potential exists for a sudden release of water upstream of where the mill tailings have obstructed Wolverine Creek and upstream of the Porcupine Creek waste rock dump, the consequences of failures at these locations are less significant by comparison. For these reasons, the conceptual design of remedial measures focuses on the waste rock dump instabilities and degradation of the creek channel where it passes through (over) the waste rock.

A review of the performance of the waste rock dump, previous geotechnical investigations and survey information collected since 1976 has been completed in preparing this report. A range of technically feasible solutions are discussed to provide an indication of the level of effort and capital costs associated with the implementation of remedial works. Recommendations are provided for follow-up work should the implementation of remedial work proceed.

2.0 BACKGROUND

2.1 Historical Summary

The abandoned Clinton Creek Asbestos Mine is located about 100 km northwest of Dawson City in the Yukon Territory, 9 km upstream of the confluence of Clinton Creek with the Forty Mile River (Figure 2-1). The mine consists of three open pits (Porcupine, Creek and Snowshoe), two waste rock dumps (Porcupine and Clinton Creek) along the south side of Clinton Creek, and a tailings pile on the west side of Wolverine Creek. From 1968 until depletion of economic reserves in 1978, the Cassiar Mining Corporation extracted approximately 12 million tonnes of serpentine ore from the bedrock.

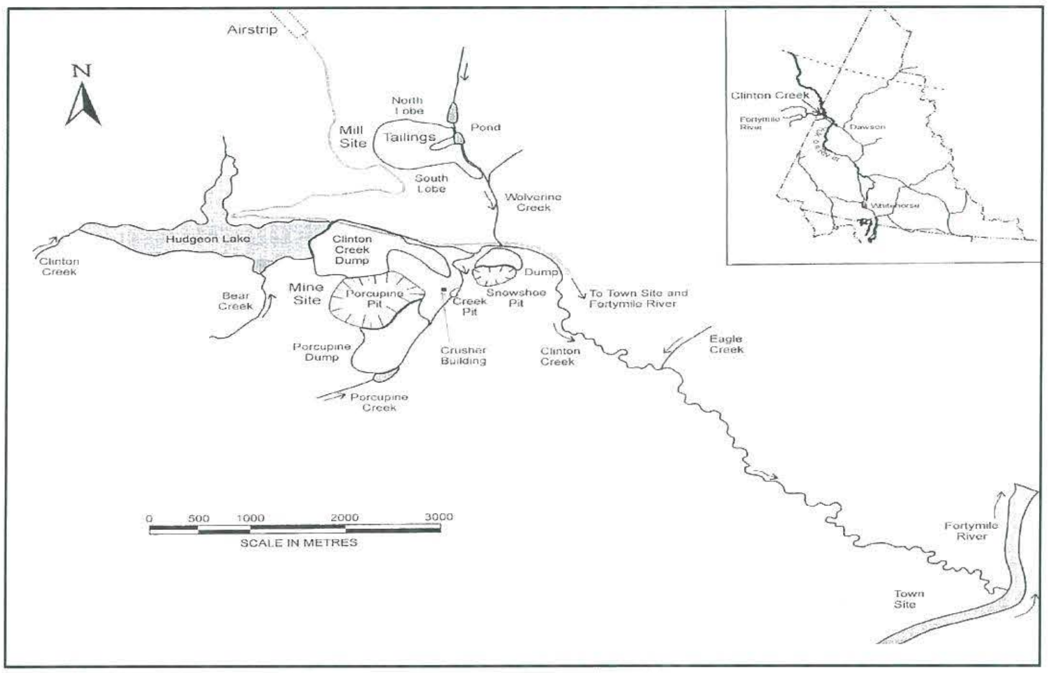

Figure 2-1
Location Plan (Royal Roads University, 1999)

Over 60 million tonnes of waste rock from the open pits was deposited over the south slope of the Clinton Creek valley at what is referred to as the Clinton Creek waste rock dump. The ore was transported by an aerial tramway to the mill located on a ridge along the west side of Wolverine Creek, a tributary of Clinton Creek. Over the same period of time, about 10 million tonnes of asbestos tailings from the milling operation were deposited over the west slope of the Wolverine Creek valley (Wolverine Creek tailings piles). Since closure of the asbestos mine, concerns have been raised with respect to the physical condition of the site, in particular downstream hazards associated with channel blockages resulting from landslides of the Clinton Creek waste rock dumps and Wolverine Creek tailings piles.

As early as 1970 or 1971, instabilities of the waste rock dump were evident (Figure 2-2). A significant slope failure of the waste rock dump into the Clinton Creek valley occurred in 1974 and the resulting landslide dam blocked natural drainage through the valley creating a 74 ha lake (Hudgeon Lake) as seen in Figure 2-3. A new creek channel was subsequently formed along the interface between the landslide material and north valley slope, some 25 metres above the original valley bottom at the Hudgeon Lake outlet. Within the area now occupied by the waste rock dump, the creek channel is approximately 700 m long with a gradient ranging from 3 to 5.5 percent compared to its natural gradient of approximately 0.075 percent.

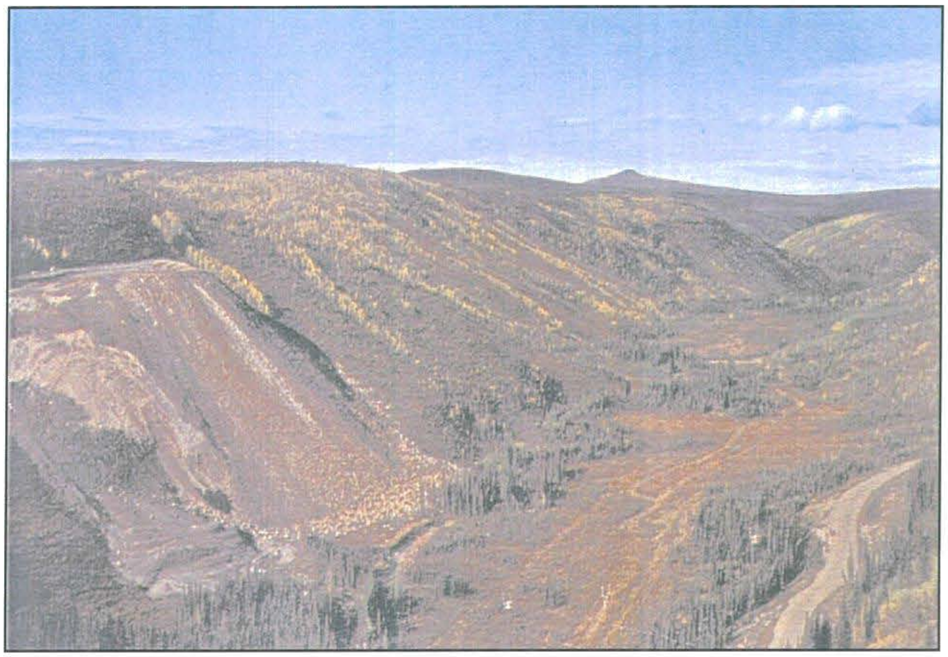

Figure 2-2
Waste Rock Dump in 1970/1971 (View Upstream)

Monitoring of waste rock movements was carried out on an annual basis beginning in 1977 and ending in 1986. Over this period it was concluded that while downslope movements of the Clinton Creek waste rock dump were continuing, the movement rates were decreasing (Klohn, 1987). Channel erosion protection measures were constructed between 1979 and 1984, including a rock weir and channel armouring just downstream of the Hudgeon Lake outlet. These erosion control works have since proven to be largely unsuccessful and were almost completely destroyed in the spring of 1997. Since that time, degradation of the channel, in particular, down-cutting near the Hudgeon Lake outlet has occurred. Up to 3 metres of down-cutting has occurred immediately downstream of the outlet where the channel bed is bounded to the south by waste rock and to the north by colluvial soils overlying bedrock on the valley slope (Figure 2-4). Farther downstream, less down-cutting is evident. This may be a result of less erodible exposed bedrock bounding the channel at lower elevations and/or sediment deposition.

Figure 2-3
Waste Rock Dump in 1974 (View Downstream)

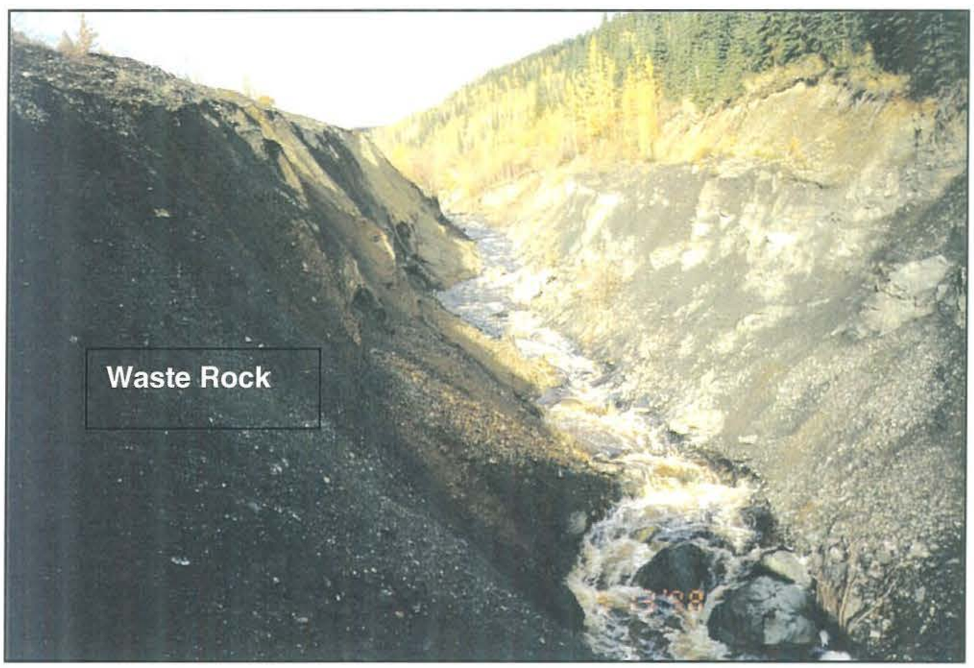

Figure 2-4
Clinton Creek Channel Over Waste Rock Dump (view upstream)

2.2 Background Information

A considerable amount of information regarding the waste rock dump is contained in reports, correspondence and drawings filed at INAC's Whitehorse office. Information was extracted related to geotechnical issues, previous remedial strategies and any additional information regarding the nature of the waste rock instabilities. In chronological order, relevant information from these reports is summarized in the following sections. Anecdotal comments by the writer are provided in Italics.

- The natural topography beneath the waste rock pile slopes at slightly greater than 30 degrees. The waste pile was developed in a series of benches by end dumping and pushing material over the crest. The measured angle of repose for the waste overburden is 37 to 38 degrees. Back scarps were evident on the upper regions of the dump in the early stages of development. Toe regions had evidence of cracking and differential movements in vertical and horizontal directions (Golder 1974, pg2).

- The toe of the waste rock dump had crept northward blocking the natural drainage course of Clinton Creek by 1974 when Hudgeon Lake was about 40 to 50 feet deep (*probably about elevation 1305 feet or so*). A channel had been excavated along the northern edge of the waste dump to drain the lake. The western side of this channel showed active soil movement, as did the surface of the toe regions of the waste rock dump above the channel. The bottom of the channel appeared to have been raised above the level of the lake by earth movements within the toe region of the waste rock dump (Golder 1974, pg3).

- Some tree cutting was undertaken in 1974 in the flooded area to remove standing timber. The cut material drifted to the outlet and a large amount of standing timber remained along the lakeshore and bottom. "This will soon become a sea of snags" (Bowie, 1974, pg11). *Based on Photo 5 in Bowie's report, the waste rock had already reached the north side of the valley.*

- Placement of an additional 3 million tonnes of waste rock was planned over the lower regions of the dump in the summer of 1974. It was recommended that this placement could destabilize the lower portion of the waste rock dump and further elevate the creek channel, although it would improve the overall stability (Golder 1974, pg3&4). Any additional waste material (beyond the 3 million tonnes) was to be placed on the east side of the waste dump. *Concerns remained however about the shear strength and displacement of the organic mantle beneath the waste rock already placed and the planned dump extension to the east* (Golder 1974, pg5). Golder Associates proposed to evaluate the presence of permafrost and if necessary strip the organic soil, allow the active layer to freeze and place 10 feet of waste rock as an insulating layer to prevent permafrost degradation. *It is not known if this recommendation was followed.* The waste rock dump in 1975 is illustrated on Figure 2-5. *Note North South Orientation of Cracks.*

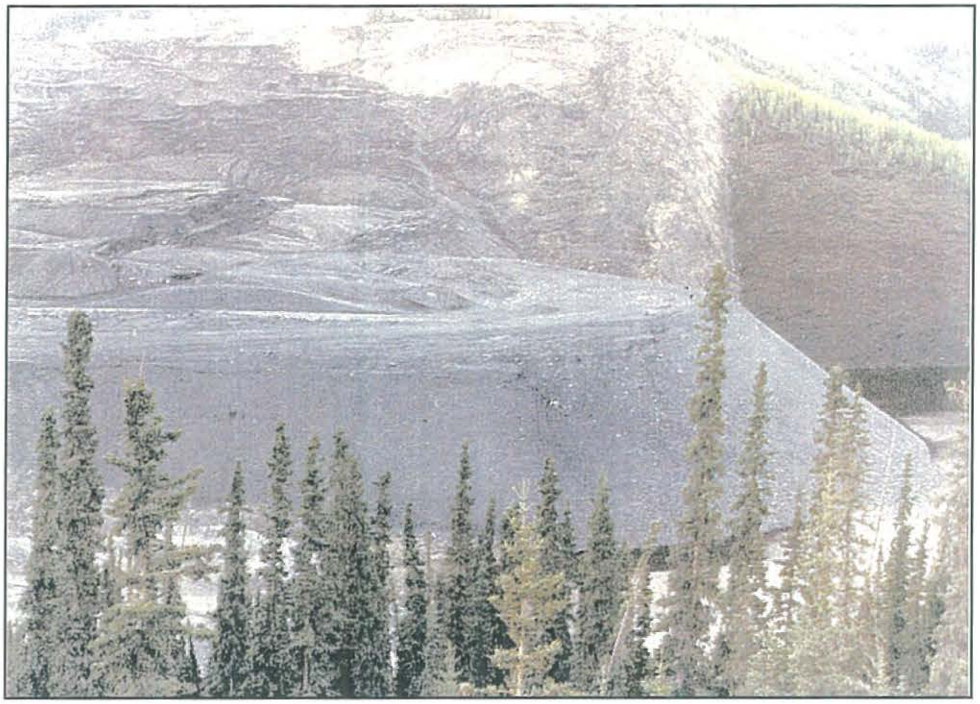

Figure 2-5
Waste Rock Dump in 1975

- The slope at the toe of the dump along the creek was trimmed to 2.75H:1V in the summer of 1976 to control erosion and sloughing (Golder 1977, pg2). The water depth in Hudgeon Lake was reported to be 120 feet (Hardy, 1977, pg13). *This depth is overstated.*

- It appears that little to no fill was placed on the active dump beyond about 1974 after which time, waste material was being dumped northwest of Snowshoe pit (Golder 1977, V77016 pg2). Large cracks believed to be a result of grabben development still existed in a north-south alignment in the toe area above the road in 1976/77 (Golder 1977, V77016 pg8). Changes in the physical condition of the waste rock dump between 1975 and 1976 can be seen in Figures 2-5 and 2-6. *Note evidence of slumping of into Hudgeon Lake by 1976.*

- Large movements were continuing in the Waste Rock Dump in 1977, but the rate of movement was decreasing progressively with time, from approximately 4 ft/year in 1978 to about 1.5 ft/year in 1985/86. "In the toe region of the dump, there is evidence to suggest that the major component of the movement is parallel to the valley direction, i.e. the valley confinement itself may be preventing further large across-valley movement" (Golder 1977, V76083, pg1).

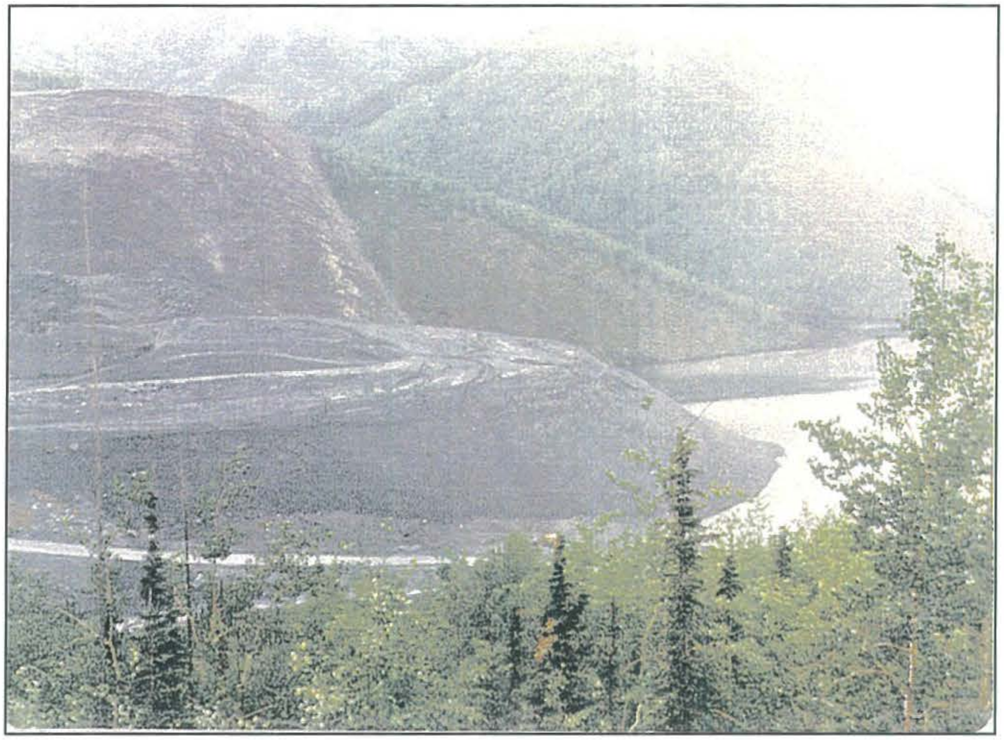

Figure 2-6
Waste Rock Dump in 1976

- Flattening of local slopes in the waste dump adjacent to the creek valley and construction of energy dissipaters in the channel were recommended in 1977 (Golder 1977, V76083, pg1 and V77016, pg10).

- A Site Rehabilitation and Abandonment Plan for the Yukon Territory Water Board was prepared in 1977 (Hardy, 1977). The main points in this report were:

  - The waste rock dump failure assumed 2 modes: 1) flow within the mass and 2) foundation failure (pg10).
  - Bulging at toe is visible in 1970 aerial photos.
  - The first mention that excess pore water pressure in the foundation material was possible and responsible for the failure (pg10).
  - Temporary regression of permafrost could be a contributing factor. Water from Hudgeon Lake could be degrading the valley bottom (pg11).
  - A large flow, estimated to be 1,000 cfs occurred in 1977, eroding the toe and leaving a boulder-paved bank (pg12).
  - A number of investigations were proposed to evaluate the properties of the soils and condition of the permafrost. This was necessary to evaluate if permafrost was moving up into the waste rock or degrading below the base. It was considered essential to evaluate possible long-term thermal equilibrium and its influence on dump stability (pg26).
  - Stability improvement by recontouring the waste pile was mentioned, as was an alternative plan to extend the dam and raise the elevation of the channel and run

the creek through natural soils. Concrete lining and energy dissipaters might be required (pg29). A revegetation plan was also recommended (pg31).

- "Cracks up to 3 feet and 10 feet deep were observed in the upper portion of the dump. The cracks in the upper portion of the dump are oriented roughly east west i.e. parallel to the contours of both the dump surface and the original ground surface. These cracks appear to be scarps caused by vertical shear as the dump material gradually crept downslope" (Golder 1977, V76083, pg5).

- "In the lower part of the dump, most of the cracks are aligned approximately north-south, i.e., in the across-valley direction, and there is evidence of graben development (downward movement of a block of material, relative to the blocks on either side). Some of the north-south cracks extend almost to the creek, i.e., across the main road from the town site. In some areas near the crest of local slopes in the lower portion of the dump, cracks have developed parallel to the crests of lower slopes" (Golder 1977, V76083, pg5). Cracks in the lower portion of the waste rock dump are shown in Figure 2-7.

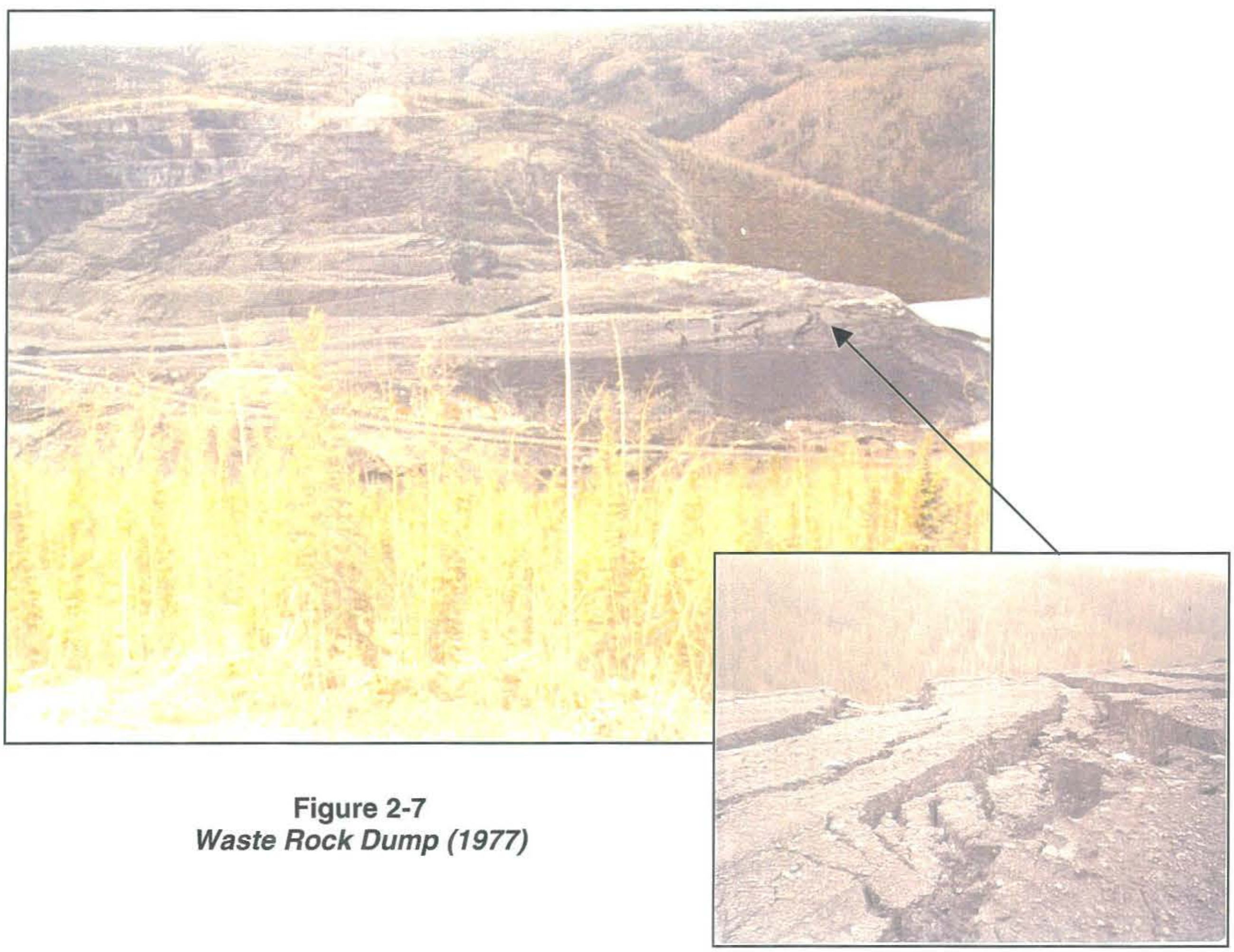

Figure 2-7
Waste Rock Dump (1977)

- Waste rock deposition stopped in 1977/78.
- Golder Associates carried out geotechnical investigations in 1978. Report highlights are summarized as follows:
  - The depth of Hudgeon Lake is 85 feet with surface movements radially outward from the central portion of the dump. Movements are occurring into Hudgeon Lake (Figure 2-8).
  - Rates of horizontal movements are greater near the perimeter than they are within the central portion of the dump. Rates of horizontal movements decrease in a downstream direction.

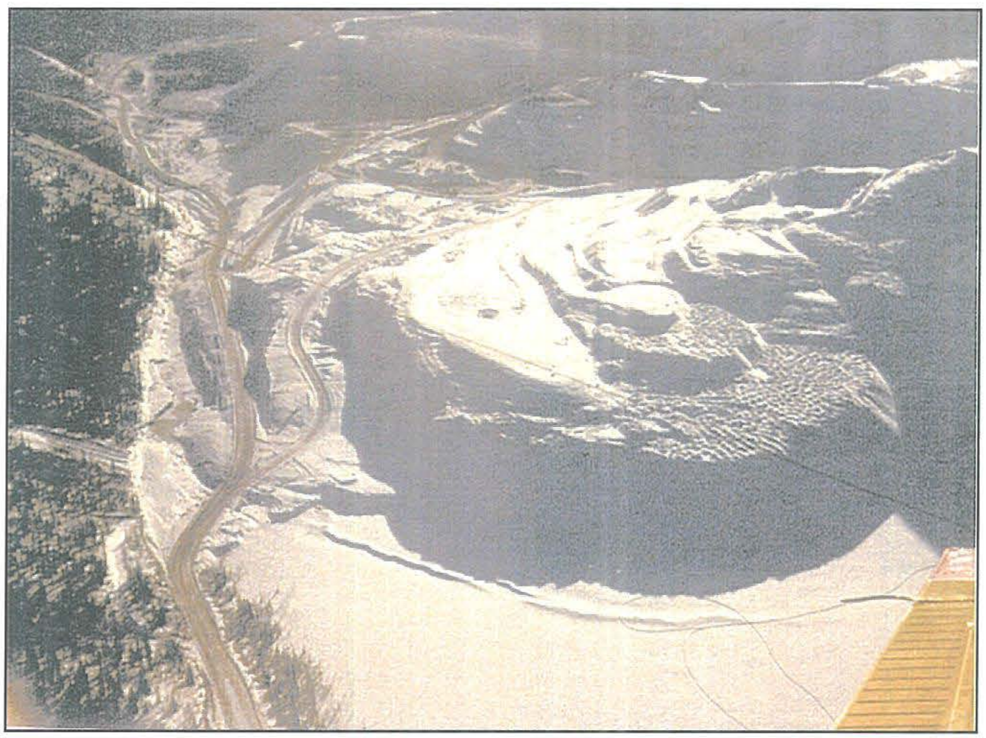

Figure 2-8
Pressure Ridge on Hudgeon Lake Ice Surface (March, 1978)

- Monitoring Points 66, 67 and 68 located between the creek and the toe of the north valley wall show upward movement toward the north with the development of horizontal movements. Movement vectors ranged from 6 to 12 degrees from horizontal that was reported to be approximately parallel to the valley slope at this location. *Our 1999 survey indicates #68 has dropped in elevation by about 8* *feet, an observation likely related to localized movement of the waste rock dump along the creek channel.*

- Upward vertical movements were also noted for the cross channel reference line points which were moving at 3.6 ft/yr. *Our 1999 survey could not confirm this, as we have been unable to locate historical coordinates for these points.*

- The geometry of the dump and angle of internal friction for waste rock material (40 degrees) precludes the possibility the movements are occurring as a result of shearing within the dump materials. " The dump is sliding on its base as a result of shear displacements within the in situ native foundation soils beneath the base of the dump."

- The waste rock serves as an insulator, which isolates the foundation from ambient temperatures. More importantly, groundwater seepage from Hudgeon Lake provides a continuous source of heat. As a result, the permafrost beneath the dump is melting.

- The melting permafrost generates high pore water pressures within the foundation soils.

- In 1980, it was concluded *(after a review of 1978 monitoring data)* that the entire dump was unstable and the degree of activity varies seasonally. Existing information was considered insufficient to determine the cause of seasonal variation (Hardy 1980, pg9).

- In 1981, Hardy concluded that the main dump segment and the eastern portion of the dump had not reached an equilibrium condition. Fresh tension cracks noted uphill and behind the uppermost reaches of the dump may have been associated with open pit wall instabilities (*This observation is consistent with UMA's in 2000*) Fresh tension cracks were visible along the access road in the downslope dump segment (Hardy 1981, pg2). Cross channel reference lines showed continued movement into the creek channel with the movements being greater in the summer.

- The rocks forming the weirs downstream of the outlet were being undermined and displaced as early as 1981 (Hardy 1981, pg5). Cassiar planned at this time (1981) to repair the weirs.

- In 1982 Hardy noted that the surface characteristics of the waste rock dump demonstrated sufficiently clearly the ongoing instability and continued movement of the dump (Figure 2-9). The channel weirs constructed in the fall of 1981 were now by-passed by the stream, which was undercutting and eroding the natural side slope (Figure 2-10).

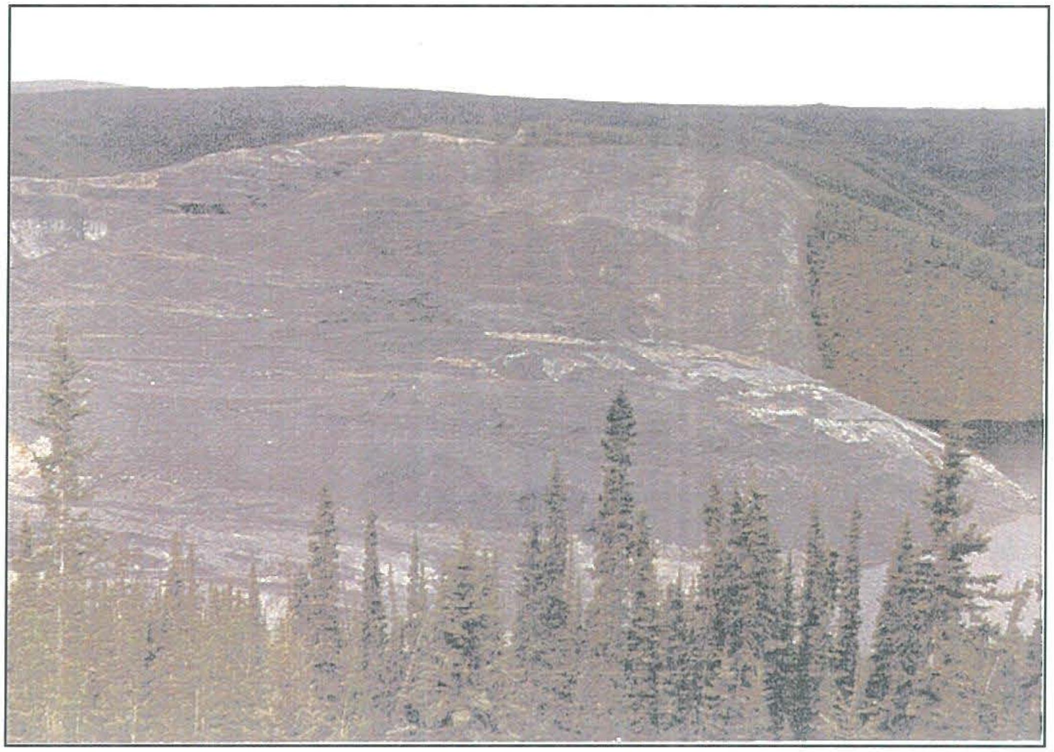

Figure 2-9
Waste Rock Dump (1982)

Figure 2-10
Channel bypassing weirs (1982)

- Remedial work to repair the channel where it had escaped the rock weirs was recommended in 1983 (Klohn 1984, pg2). The work, consisting of a rip rap plug with a geotextile lining at the upstream end of the erosion channel was initiated in November 1983 and completed in 1984. It was further recommended that the channel be widened at the upstream plug to allow for squeezing by future dump movements.

- In 1984, the channel down cutting had not increased significantly and the channel was becoming increasingly protected by large rock fragments, which remained following erosion of the waste rock. It was speculated that the 1984 construction program, when completed, would have sufficient flexibility to eventually reach an equilibrium condition and allow the waste dump to be finally abandoned. (Klohn 1984, pg3).

- Options considered in 1985 (Hardy, 1985) are summarized as follows:

  - Three different positions were presented: 1) Restoration of stability of the terrain and streams or 2) Allowing natural processes to take place 3) Allow for uncontrolled erosion, slope movements etc. but construct small flow and sediment controlling structures just downstream of the mine, in effect, create selected condemned valley segments to protect downstream reaches (pg 11 and 12).

3.0 GEOTECHNICAL PROPERTIES

The geotechnical properties of the waste rock and foundation soils necessary to complete stability analysis include their general engineering properties (shear strength, unit weight), permafrost conditions and piezometric levels. The geotechnical properties of the waste rock have been previously researched, providing some information with respect to shear strength (friction angle) of the material. Information on the properties of overburden soils however, is nearly non-existent since test holes in the dump area did not penetrate through the waste rock. Data on permafrost conditions and piezometric levels is limited. Based on previous geotechnical reports, supplemented by observations made in recent reconnaissance trips, the available information with respect to geotechnical properties is summarized as follows:

3.1 Bedrock

The Porcupine Pit ore body (serpentine) strikes NE and dips to the NW at approximately 45 degrees (Golder 1977, V76083, pg1). The mine site is located within the unglaciated Yukon-Tanana Upland Region. Bedrock in the area consists of black argillite that was exposed to periglacial weathering and near-surface material is heavily fractured and weathered. It is also possible that thin bedding planes of graphitic material may exist in the bedrock (personal communication, Dr. N. Morgenstern).

3.2 Waste Rock

The waste rock is primarily sand and gravel sized argillite particles with occasional durable cobbles and boulders throughout (Golder 1986, pg3, Hardy, 1977, pg12). The argillite rock fragments are generally weak and break down relatively easily, in particular upon point-to-point contact. Direct shear tests were conducted in the 1970's to measure peak and residual friction angles. Peak friction angles of 40 degrees for an effective stress range of 0 to 170 kPa (0 to 25 psi) and 33.5 degrees for an effective stress of 1,380 kPa (200psi) were reported from tests on 6mm (1/4 inch) minus fraction material (Golder 1978, pg15). The observed angle of repose of the waste rock dump face of 35 to 40 degrees indicates good agreement with lab results for tests at the low stress range. A residual friction angle of 23 degrees was also reported (Hardy, 1977, pg12).

3.3 Overburden

Very little information is available regarding the nature of the overdurden soils within the Clinton Creek valley. Colluvium is visible above the weathered argillite on the north valley slope. Interpretation of aerial photography from the 1970's indicates a relatively shallow colluvium and ice-rich permafrost on the south wall of the valley in the area of the future waste rock dump (M. Stepanek, March 5, 2001). Ice rich alluvial material would be expected in the bottom of the valley although the nature, depth and properties of the alluvial materials are not known. The presence of layers of fine grained material in the alluvium as a result of deposition of eroded parent rock (argillite) resulting from historical valley blockages downstream of the mine site cannot be ruled out. Such blockages may have formed a temporary lake allowing the deposition of these materials to occur.

3.4 Permafrost

Very little site specific information exists with respect to permafrost conditions beneath the waste rock dump. Previous research indicates the area consists of wide spread permafrost distribution up to 200 feet thick (Golder 1978, pg6). The mean annual temperature is –2.5 degrees C, ranging on average from 15 degrees C in the summer to –32 degrees C during the winter (Golder 1978, pg6). Discussions with site personnel and observations downstream of the mine indicate the foundation soils were ice-rich (Golder 1978, pg16). The active layer was reported to be 12-18 inches but this appears inconsistent with vegetation in the area (Hardy, 1977, pg15).

Thermistor strings were installed at 4 locations within the waste rock dump in April 1978 (Golder, 1978). Each string has 9 points spaced at 1.5m (5 ft) intervals. Instrumentation was targeted at locations where the waste rock had been in place for at least 4-5 years and the depth of waste rock was less than 24 m (80 ft), which was the length of drill rod available for the investigation. Monitoring was conducted from April until July 1978. The entire data set for each string is plotted on a logarithmic scale on Figure 3-2, 3-4, 3-6 and 3-8 respectively. Temperature profiles were then plotted for data obtained immediately after installation, the minimum temperatures (May) and the last readings (June) on Figures 3-1, 3-3, 3-5 and 3-7. Test hole logs from the thermistor string installations are included in Appendix A. The monitoring results from each installation are summarized as follows:

<u>**Thermistor Strings T1 and T2**</u>

Thermistors T1 & T2 are located on the southern edge of the dump (well away from the creek channel and flood plain) as shown on Drawing 01.

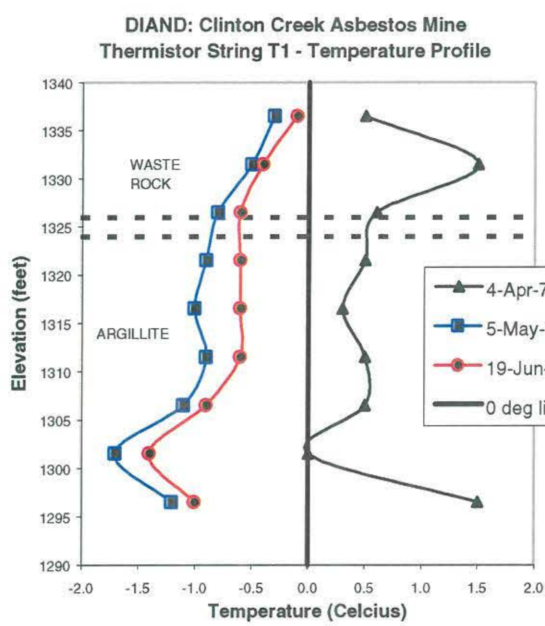

Figure 3-1
Temp. Profile – Thermistor String T1

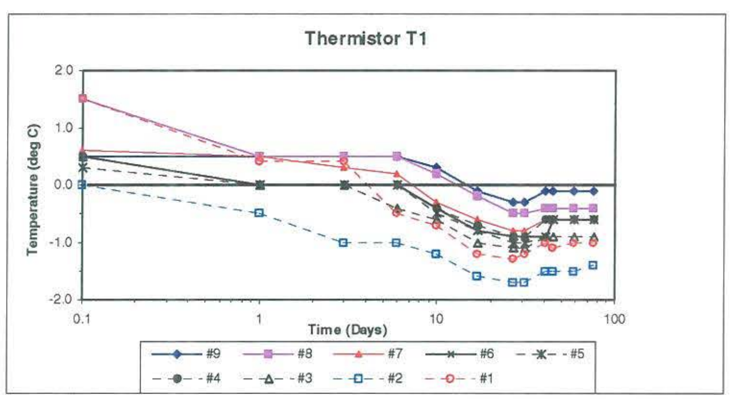

Figure 3-2
Temp. Vs. Time – Thermistor String T1

Points installed within the waste rock and foundation were below 0 degrees C indicating permafrost had advanced into the waste rock. Temperatures range from close to 0 degrees at the top of the string (within the waste rock) to –1 to –1.5 degrees in the foundation (argillite). Ice chips were noted on the test hole logs within the argillite for Thermistor T1 (BH1) and T2 (BH2).

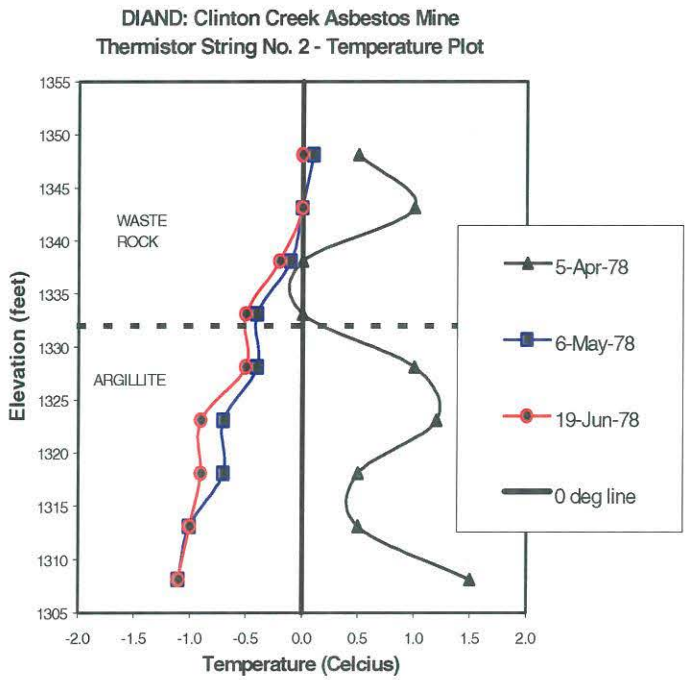

Figure 3-3
Temp. Profile – Thermistor String T2

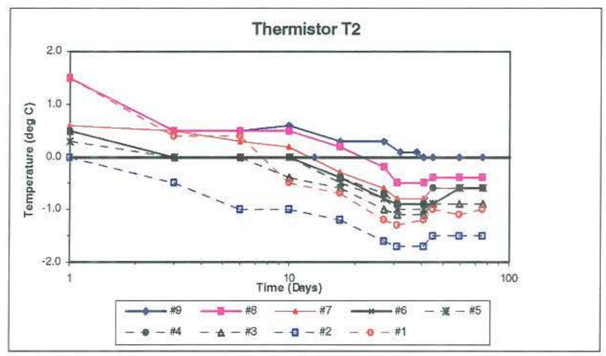

Figure 3-4
Temp. Vs. Time – Thermistor String T2

<u>Thermistor String T3</u>

Thermistor T3 is located farther to the west within the waste rock dump but still some distance from the creek. The results indicate the ground temperatures are above 0 degrees (about +0.5 degrees) for a depth of 30 feet below the original ground surface. At the location of T3, the ground surface formed part of a north aspect and quite likely was underlain extensively by permafrost. It appears therefore that the permafrost may have degraded to a depth of 30 feet in this area of the waste rock dump. No ice chips were observed during installation of the Thermistor T3 (BH4).

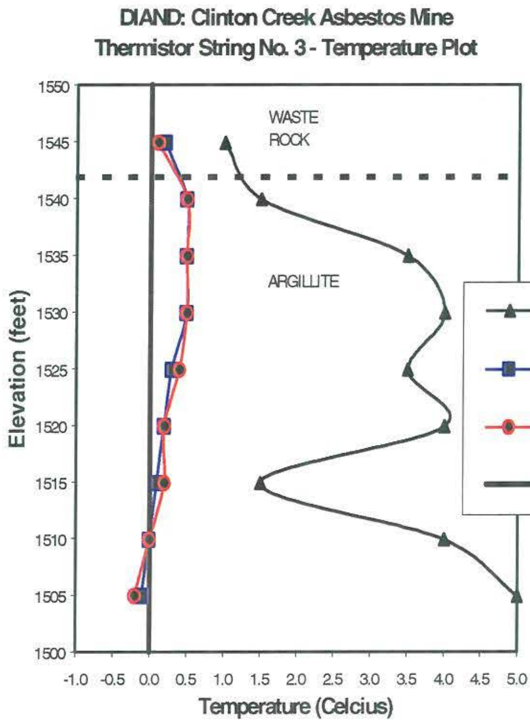

Figure 3-5
Temp. Profile – Thermistor String T3

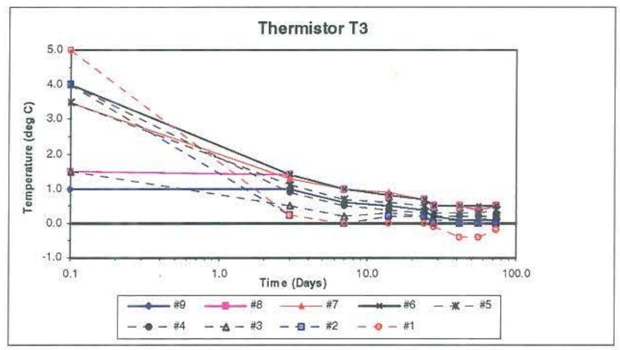

Figure 3-6
Temp. Vs. Time – Thermistor String T3

Thermistor String T4

Thermistor T4 is located near the northern edge of the waste rock dump along the access road adjacent to Clinton Creek, approximately coincident with the original toe of the north valley slope. Unfortunately, the base of the waste rock dump was not reached with the borehole and sloughing prevented the installation of the string to the base of the hole. Golder Associates concluded that the measurements reflected the temperature of seepage water within the base region of the dump. Based on the temperature profile, it was speculated that the phreatic surface was at approximately elevation 396m (1300 ft).

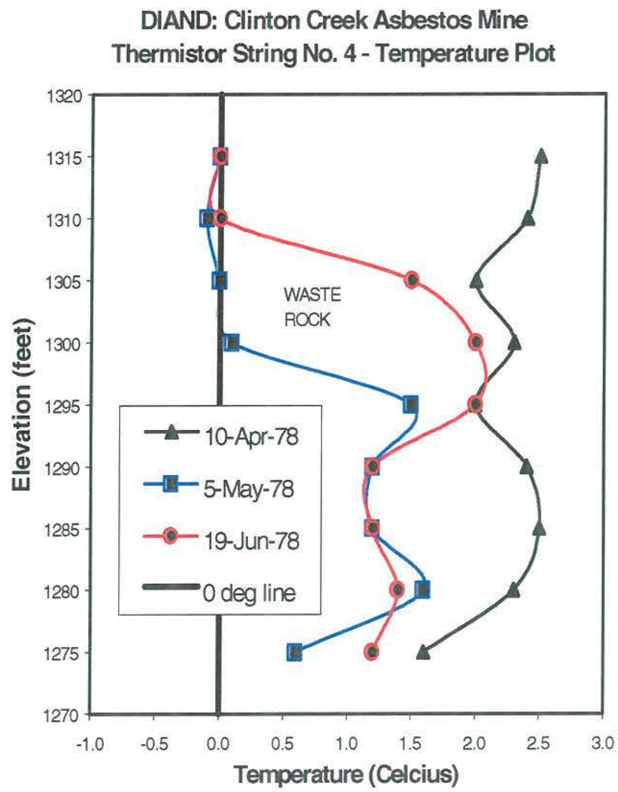

Figure 3-7
Temp. Profile – Thermistor String T4

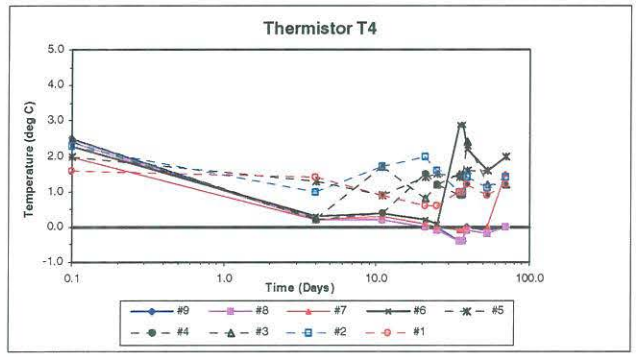

Figure 3-8
Temp. Vs. Time – Thermistor String T4

3.5 Piezometric Elevations

Five standpipe (Casagrande) piezometers (P1 to P5) were installed along the south side of the creek channel in 1978. Test hole logs for these installations are included in Appendix A. After installation in 1978, none of the piezometers were functioning properly and the installations did not yield any useful data (Golder 1978, pg14). All piezometers were located and monitored by UMA in 1999 with the results summarized in Table 3-1. It is possible that lateral movement of the waste rock material caused the observed blockages or breaks in the riser pipes for piezometers P3, P4 and P5 at the depths indicated in Table 3-1. The remaining piezometers appear to be functioning.

TABLE 3-1
STANDPIPE PIEZOMETER DATA (1999)

Piezo No.	Ground Elev (estimated)	Stick-up	Intake Elev (m)	Piezometric Elev	Comments
P1	415.4m (1363 ft)	2.0m (6.4 ft)	402.9m (1322 ft)	409.4m (1343 ft)	Bottom of Pipe at 11.6m below grade. Installation Depth= 11.6m below grade.
P2	417.0m (1368 ft)	1.6m (5.4 ft)	405.2m (1329 ft)	408.8m (1341 ft)	Bottom of Pipe at 10.4m below grade. Installation Depth= 12.8m below grade. Sediment in Bottom of Pipe.
P3	415.7m (1364 ft)	1.3m (4.4 ft)	400.6m (1314 ft)	413.5 (1357 ft)	Kink in Pipe at 2.1m below grade. Blockage at 3.8m below grade.
P4	397.8m (1305 ft)	1.3m (4.3 ft)	379.5m (1245 ft)	Dry	Pipe sheared or obstructed at 1.8m below grade.
P5	387.7m (1272 ft)	1.3m (4.3 ft)	366.6m (1203 ft)	Dry	Pipe sheared or obstructed at 7.0m below grade.

4.0 WASTE ROCK MOVEMENTS

Background performance monitoring reports have been combined with information from UMA's 1999 survey data to evaluate historical and current movement trends and magnitudes. Waste rock movements were monitored from 1976 until 1986 after which no surveys were undertaken until 1999. Although information on waste rock movements has been discussed in a number of reports dating back to 1974, the coordinates of monitoring target points are not always provided; The data is often reported as the rate of movement only. As best as possible, movement plots have been compiled by systematically combining historical and recent (1999) data and the following plots have been generated for operational targets:

- Northing and Easting coordinates measured at each survey to determine the direction of horizontal movement.
- Movement rates (horizontal distance vs. time).
- Elevation and rate of vertical movement vs. time.

The results are presented in tabular and graphical form in Appendix B. In general, the 1999 survey data is in good agreement with the movement trends identified in 1986. The direction of total horizontal movement since 1976 (in some cases extrapolated) and total vertical movement since 1981 (in most cases, missing data did not allow vertical movements from 1976 to 1981 to be determined) are illustrated on Drawing 01. Since 1976, approximately 10m of horizontal movement have occurred throughout the waste rock dump. In general, the movements are occurring radially outward from the central upper portion of the dump in the vicinity of 109,750N and 106,250 E (just NW of Thermistor T3). Since 1981, downward vertical movement (settlement) of the waste rock pile ranging from 2.0 to 3.8m has occurred. It was not possible to reconcile the vertical movements back to 1976. Horizontal and vertical movements, which have occurred from 1986 to 1999, are summarized in Tables 4-1 and 4-2 respectively with minimum and maximum values highlighted.

Table 4-1
Summary of Horizontal Movements

Movement Monitor	**Horizontal Movement 1986-1999**	
	Magnitude	Rate - cm/yr (ft/yr)
81-1	0.70m (2.28 ft)	5.3 (0.175)
81-2	0.80m (2.62 ft)	1.6 (0.054)
19	**1.89m (6.20 ft) max**	**14.5 (0.477 ft)**
20/20A	**0.28m (0.93 ft) min**	**2.2 (0.071)**
21/21A	0.47m (1.53 ft)	3.6 (0.117)
22/22A	1.06m (3.48 ft)	8.1 (0.267)
68	1.04m (3.42 ft)	7.9 (0.26)
AVERAGE	***0.89m (2.92 ft)***	***6.2 (0.203)***

Table 4-2
Summary of Vertical Movements

Movement Monitor	Vertical Movement 1986-1999	
	Magnitude	Rate - cm/yr (feet/yr)
81-1	**1.04m (3.42 ft) min**	**7.9 (0.26)**
81-2	1.05 (3.43 ft)	7.9 (0.26)
19	1.86m (6.09 ft)	14.3 (0.47)
20/20A	1.14m (3.73 ft)	9.1 (0.30)
21/21A	1.78m (5.85 ft)	13.7 (0.45)
22/22A	**2.35m (7.70 ft) max**	**17.9 (0.59)**
68	1.59m (5.20 ft)	12.2 (0.40)
AVERAGE	***1.54m (5.06 ft)***	***11.9 (0.39)***

Plots of movement data are illustrated in Figures 4-1 to 4-3 using Movement Monitor #68 as an example. Movement vectors are generally consistent throughout the observation period i.e. the direction of movement is consistent (Figure 4-1). Current (1999) horizontal movement rates appear to have reduced significantly from those observed prior to 1986 (Figure 4-2). Over the same period, however, settlement rates have remained about the same, currently at a magnitude about double that of the horizontal movement (Figure 4-3). It therefore appears that while the horizontal movement has slowed down considerably or may have ceased, settlement of the waste rock is continuing at a more or less constant rate.

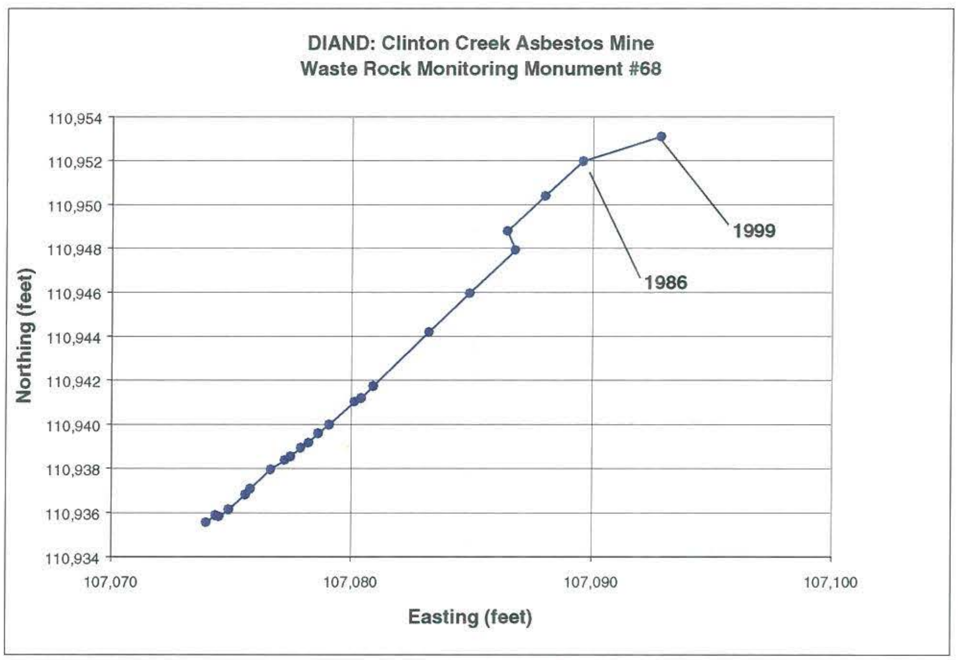

Figure 4-1
Target Coordinates

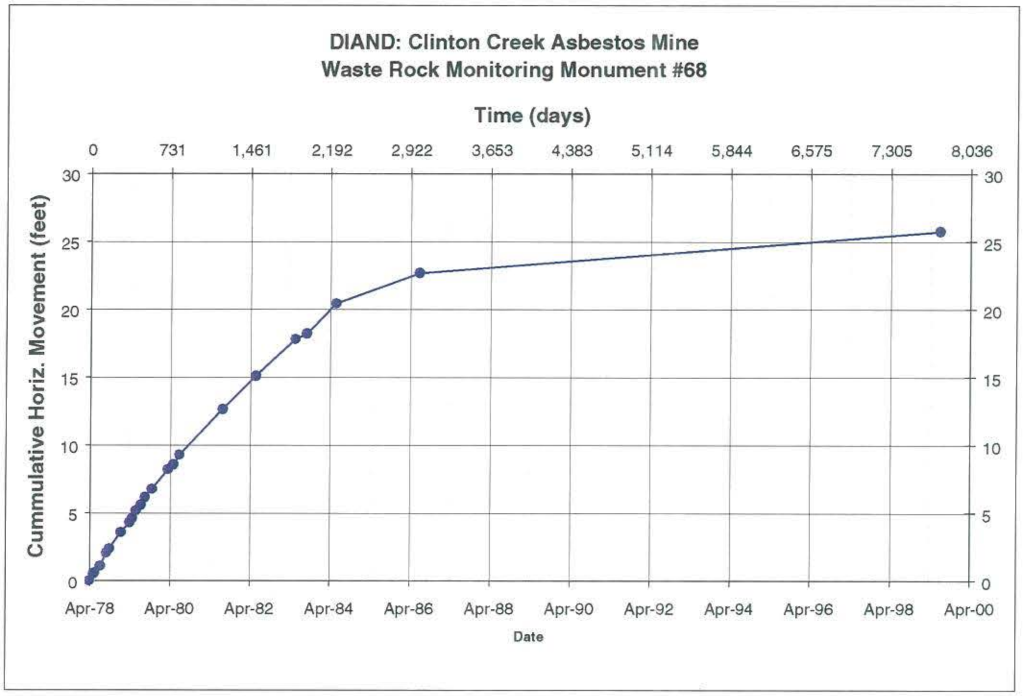

Figure 4-2
Horizontal Movements

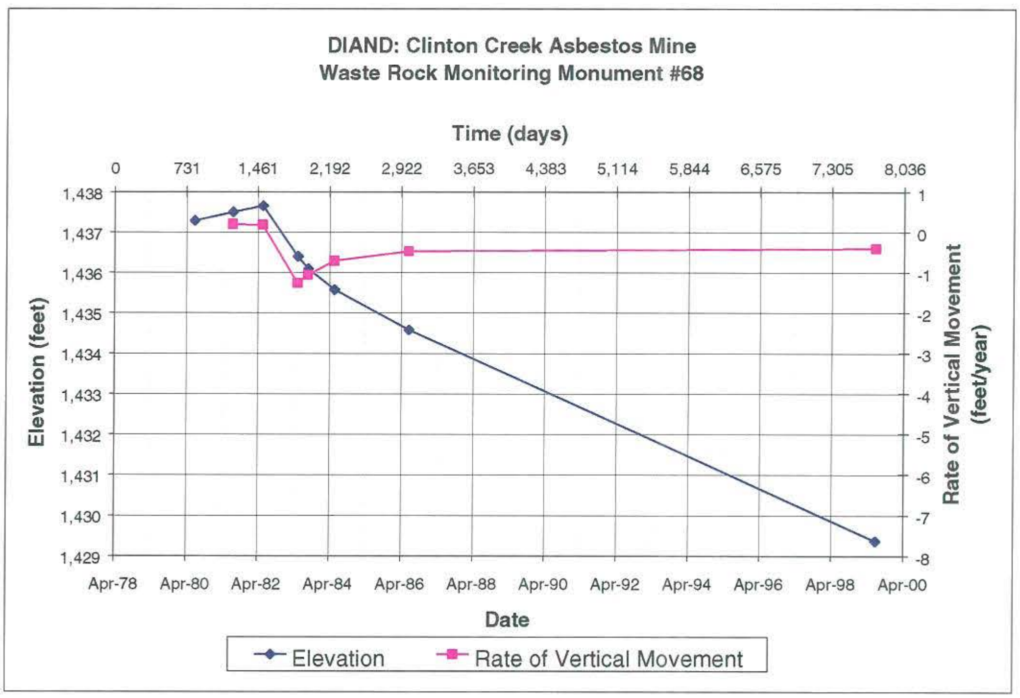

Figure 4-3
Vertical Movements

The ability to combine the 1999 Channel Closure Section survey results with previous surveys has been limited. Of the 6 channel closure sections, coordinates from previous (1983) surveys are only available for Sections J and K (Drawing 01). Of these 2 sections, there is an inconsistency in the position of prism KK on the valley slope (reason unknown). Therefore, interpretation is only possible for Section J, located at the Hudgeon Lake outlet. From 1983 to 1999, about 2.1m (7 ft) of channel closure occurred at Section J with only about 0.2m (0.7 ft) of settlement. Although the horizontal movement is consistent with what was recorded at the waste rock monitors over the same period as the waste rock monitors, the vertical movement is significantly less, possibly as a result of a thinner layer of compressible foundation material at this location. It is also possible that the waste rock is riding up onto the valley slope as it moves across the valley, compensating in part, for the downward vertical settlement. Although the magnitudes of channel closure further downstream since 1983 cannot be quantified, continued erosion of waste rock material indicates continued encroachment of waste rock into the creek channel is occurring. This observation is supported by historical monitoring data that identified the largest horizontal displacements occurred at Sections A, B, G and F which are all farther downstream from Section J.

5.0 WASTE ROCK STABILITY

5.1 Initial Waste Rock Dump Failure

The failure mechanism associated with the initial slide may be unique to that event i.e. the mechanism may be different than that associated with the subsequent movements. The difference could be associated with the thermal regime early in the development of the dump compared with the long term equilibrium (steady state) condition eventually reached after termination of mining activities. It is reasonable to assume that the most critical time period would be the first few years of development when waste rock was being actively placed over the valley slope and the initial disturbance to the thermal regime occurred. This is the time period when the rate of thaw might have been the fastest if ice-rich surficial soils were present.

Evidence of slumping at the toe of the waste rock dump seen in the 1970 aerial photograph (Figure 2-2) was likely the first sign of the impending problem. At this time (1970) there was no water impounded i.e. the time before the formation of Hudgeon Lake. Assuming permafrost existed at shallow depths there may have been zones of varying strength within the waste rock and foundation soils at the time of the failure as follows:

- The waste rock fill, the strength characteristics of which have been measured,
- The upper portion of the foundation soil immediately below the toe of the waste rock which may have previously thawed and consolidated, thus regaining some strength,
- The foundation material near the thaw front where shear strengths may be significantly reduced by increased pore water pressures associated with the slow drainage of thaw-water, and
- The still frozen bedrock or foundation material, which would represent an impenetrable boundary. It cannot be ruled out that there is a possibility of the frozen layer being underlain by a weaker thawed zone.

The resistance to sliding within the frozen foundation soil at the toe of the dump and along the valley slope would be expected to decrease if the drainage of water from the thawing permafrost affected soil is restricted. To investigate the parameters necessary to cause an initial foundation failure of the waste rock, the pre-failure dump geometry was generated from historical surveys and photographs. Two representative cross sections (E and K) were chosen for the slope stability back analysis that assumes the factor of safety (FS) at the time of failure was unity (Drawing 02).

The failure surface was assumed to be within a weak layer of the weathered argillite at a shallow depth in the foundation soil across the valley floor. The resisting forces in the rock fill were excluded in the analysis by forcing the failure through the weathered argillite. The piezometric level within the weak foundation soil is assumed to be coincident with the top of the original creek bank (valley floor). Sensitivity analyses were then carried out to determine the influence of pore water pressures and friction angles for the argillite. A friction angle in the weathered argillite of 33.5 degrees (close to the direct shear testing results) was then selected to determine the pore water pressures necessary to achieve a FS of 1.0, as illustrated in Figures 5-1 and 5-2.

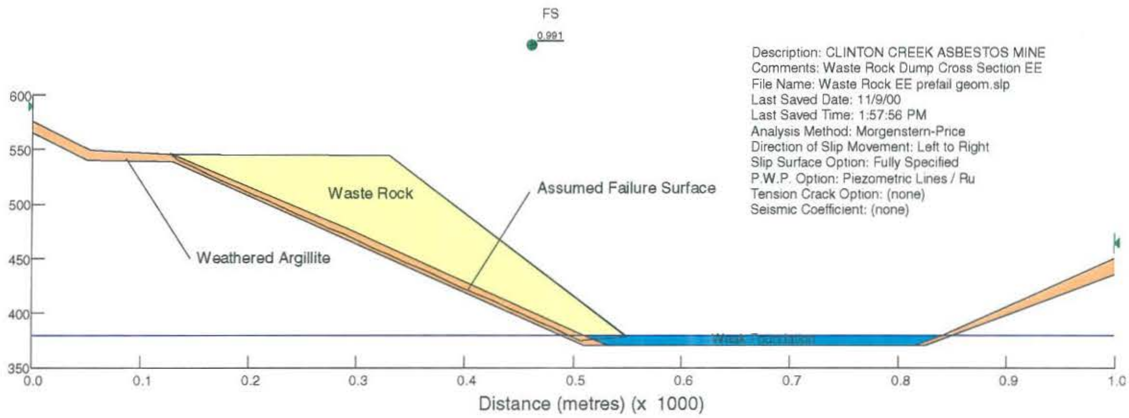

Figure 5-1
SECTION E – Initial Failure

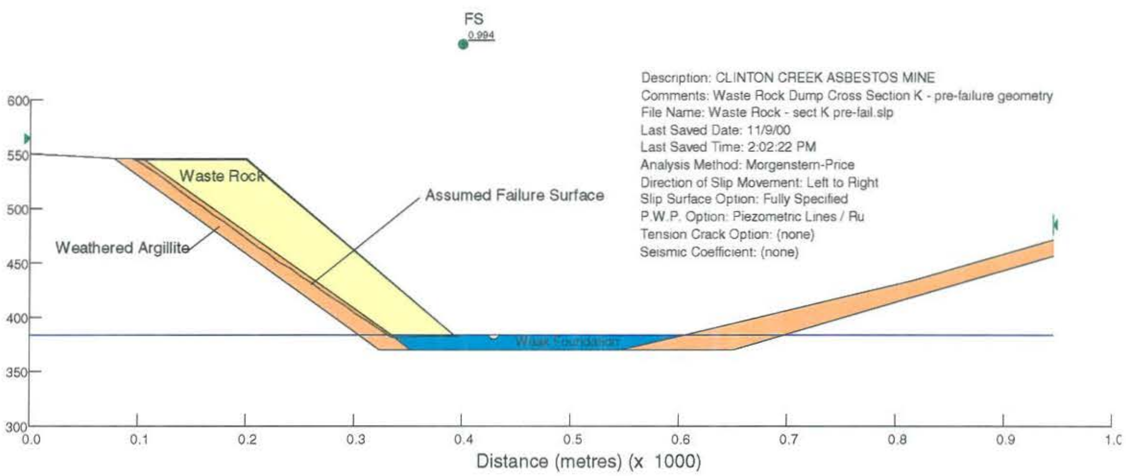

Figure 5-2
SECTION K – Initial Failure

5.2 Existing Stability

Continued movements of the waste rock dump since the initial failure indicates the presence of a weak layer within the foundation soil. The strength of this layer may be dependent on a number of factors including the ice content, the type of soil and the relationship between the rate of thawing and dissipation of excess pore water pressures.

A back analysis was carried out to determine approximate operating soil strengths and piezometric levels necessary to satisfy a FS of 1.0. The analysis assumes a residual friction angle for the waste rock of 23 degrees based on direct shear testing results. Combinations of strengths for the foundation soils (alluvium) and argillite were used under varying piezometric levels to determine combinations of parameters necessary to satisfy a FS of unity as illustrated in Figures 5-3 and 5-4.

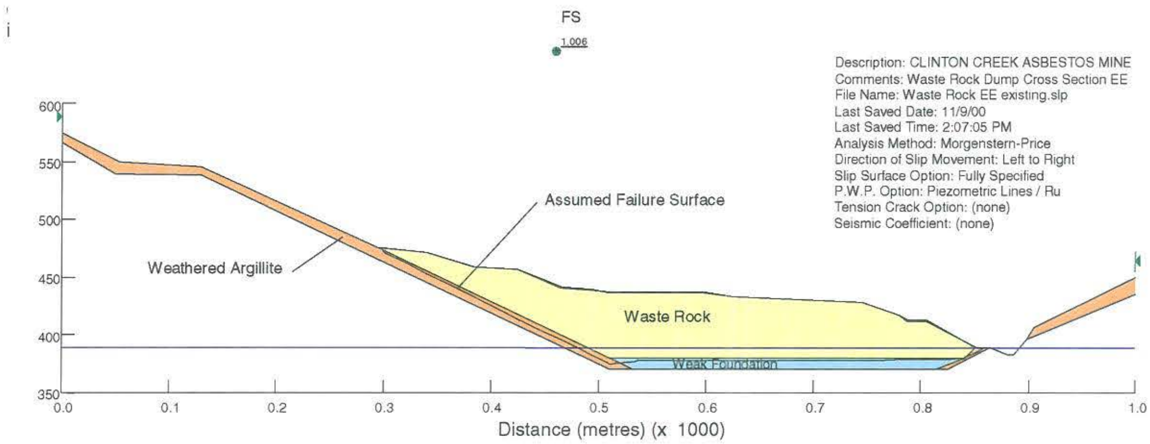

Figure 5-3
SECTION E – Existing Geometry

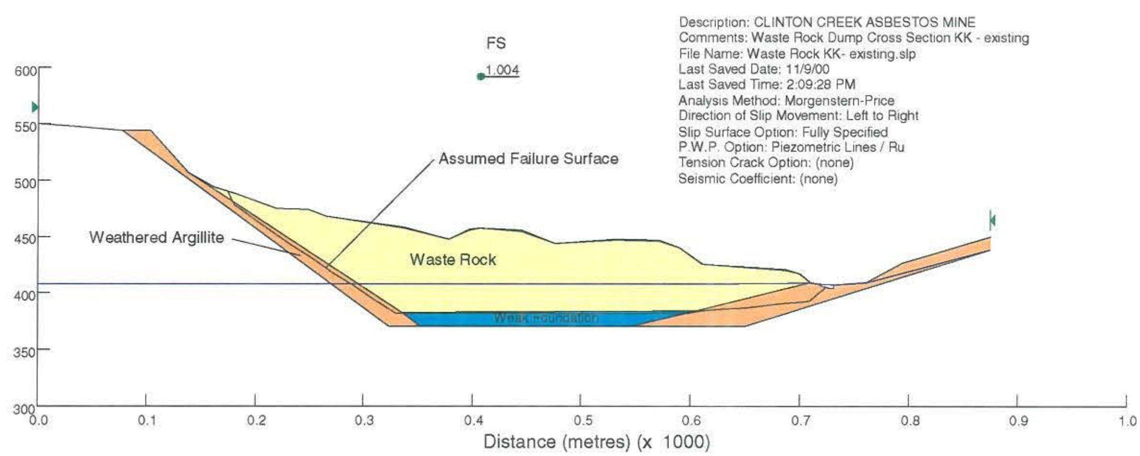

Figure 5-4
SECTION K – Existing Geometry

The analysis indicated that a combination of very low shear strengths and high pore-water pressures in the foundation material are required to achieve a FS of unity. It can therefore be concluded that unique geological conditions, in particular a very weak foundation layer, are responsible for continued movement of the waste rock pile. Almost certainly, disturbance of the thermal regime, in particular thawing of the permafrost resulting from filling of the upstream reservoir (Hudgeon Lake) has been a contributing factor. Penetration of the thaw front will likely be downward below the lake and laterally (downstream) into the waste rock and foundation soil. Detailed knowledge of the thermal changes that occurred during mining and after mine closure, however, are not known and these changes may be continuing i.e. equilibrium may not have been reached. Given the limited site specific geological information, there is considerable uncertainty in the absolute values or combinations of values calculated from the back analysis. The model however, is considered sufficient to comment on and assess the relative improvement available through remedial options for the purposes of comparing alternatives for remediation (stabilization) and selecting a preferred long term strategy for the same.

6.0 REMEDIATION ALTERNATIVES

Monitoring data suggests the horizontal waste rock movements are abating while vertical displacements (settlement) are continuing at a constant rate. Remediation alternatives must therefore either accommodate the movements or include measures to stabilize the waste rock. Remedial strategies broadly fall into one of three categories:

i) Remove a sufficient volume of waste rock from the valley to completely drain Hudgeon Lake and restore natural creek drainage,

ii) Continue to convey water over the waste rock dump or,

iii) Convey water around the waste rock dump.

Each alternative is discussed in the following sections.

6.1 Design Objective

Stabilization measures are typically designed with an objective to achieve a factor of safety that reflects the level of confidence in the interpretation of site and geological conditions and the consequences of continued movement or a slope failure. Higher factors of safety are generally used if there is a high failure consequence or high uncertainty in parameters assumed for the analysis. In this regard, the consequences of any continued movements of the waste rock dump are small providing the channel stabilization measures can accommodate some deformation and if necessary, repairs could be completed. This observation is based on our interpretation of the recent survey data that suggests that large displacements of waste rock are not anticipated. A high degree of uncertainty exists however, with respect to the site and geological conditions.

A design objective of 1.25 has been used for the conceptual design and cost estimating of remedial measures. This will require that additional information on soil properties, permafrost and piezometric levels can be obtained through more detailed site investigations. Without this information, a FS of 1.5 should be applied for the design of remedial measures. The cost of these investigations can certainly be justified given the significant incremental increase in capital costs associated with achieving higher factors of safety i.e. construction costs could conceivably double if a FS of 1.5 is desired.

6.2 Valley Restoration – Draining Hudgeon Lake

Of the options considered, completely draining Hudgeon Lake by removing the waste rock blockage is the only alternative that restores natural creek drainage through the Clinton Creek valley. The work would have to be completed in stages to gradually lower lake levels as excavation work proceeded. A sufficient volume of waste rock would have to be removed to provide adequate hydraulic capacity through the valley and allow for sloughing of thawed valley slopes below the present water surface. The remaining waste rock would have to be flattened or terraced for long term stability. Considerable excavation would be required upstream of the waste rock where sub-aqueous slopes are likely much flatter and where sedimentation has occurred. Excavated material could likely be wasted in the open pit.

To provide for the meandering pattern typical to the Clinton Creek channel, a minimum valley width of 100 m was used to estimate the waste rock excavation volumes. Based on existing cross sections, approximately 10,000,000 m^3 of waste rock excavation would be required to achieve a stable geometry as shown on Drawing 05. The excavated material would be disposed of either in the open pit or at the east end of the waste rock dump. An additional 1,000,000 m^3 of regrading may be necessary to achieve a stable waste rock geometry on the south side of the valley. The estimated capital costs to implement this scheme are summarized in Table 6-1.

Table 6-1
Valley Restoration - Draining Hudgeon Lake
Cost Estimate

Description	Unit	Approximate Quantity	Unit Price	Amount
Mobilization & Demobilization	Lump Sum	1	$500,000	$500,000
Excavation	Cubic Metre	10,000,000	$2	$20,000,000
Dewatering	Allowance			$500,000
Regrading	Cubic Metre	1,000,000	$1	$1,000,000
Subtotal				$22,000,000
30% Contingency				$6,600,000
Total Estimated Cost				**$28,600,000**

6.3 Convey Water Over Waste Rock Dump

The long term success of continuing to convey water over the waste rock dump is contingent on the overall stability of the waste rock dump and the stability of the channel i.e. its ability to resist erosion. Although the survey data suggests horizontal movement rates have decreased significantly, the existing stability cannot be fully quantified without additional surveys and investigations. For the purposes of conceptual design, it has therefore been assumed that stabilization of the waste rock dump is required for this alternative. Conveyance of water over the dump could be achieved either along the existing channel alignment or along an alternative alignment through the center of the dump. Conveyance of water in buried culverts is not considered practical given the anticipated settlement of the waste rock and the potential for failure and/or blockages of the culvert.

6.3.1 Channel Stabilization

The significance of continued channel degradation on overall stability depends largely on the current state of equilibrium. Since this cannot be readily quantified, it is concluded that any option conveying water over the waste rock dump must include channel stabilization measures. These measures should include filling the channel to flatten the profile through the western (more active) portion of the waste rock dump, armouring the channel bottom and flattening the sideslopes on either side of the creek channel. The modified channel profile is illustrated on Drawing 03. The channel stabilization works should be compatible with any continued horizontal and vertical movements. In this regard, channel stabilization using cobbles and cobble filled gabion drop structures is recommended. Rigid structures e.g. concrete linings should be avoided due to the risk of cracking and subsequent failure.

Drop Structures

The drop structures would be constructed from 0.5 x 0.5 x 3.0m gabion baskets placed empty on a geotextile, tied together with wire and machine filled with cobbles. The gabions are placed as steps, which provides energy dissipation between each step as the water travels through the structure. The weir at the top of the structure creates a constriction that reduces the water surface draw-down immediately upstream of the structure to control the channel flow velocity along that length of channel. An end sill prevents a floor jet during high discharges. Using as many 0.5 m steps as required creates the desired hydraulic drop of approximately 35 m (Drawing 04).

As the weir and end sill are made of gabions, a part of the channel flow will pass through the gabions rather than over them. As a result, neither the weir nor the end sill will cause any significant ponding of water. In fact, during low flows, the water surface may be below the top of the gabions i.e. between the cobbles. Because there will be a small flow of water through the gabions most of the time, it is important that the gabions sit on a geotextile and gravel bedding layer to prevent the loss of fine grained material below the baskets. Some sand and gravel will be washed through the channel, in particular during spring runoff. The finer material will become trapped between the cobbles in the gabion baskets further stabilizing the structure.

Channel Lining

The entire channel through the waste rock dump (approximately 700 m) must be lined with granular material of sufficient size and gradation to resist anticipated velocities. For example, the permissible channel velocity for cobble lining is 2.5 m/s compared with 1.6 m/s for unprocessed material consisting of gravel and cobble sized material. Channel velocities in the proposed channel can be maintained within this range by adjusting the number, height and locations of the drop structures and the channel width and grade. For conceptual design, the drop structure locations required for both options are summarized in Table 6-2. Final determination of the drop structure profile and channel lining method would be deferred until detailed design.

Table 6-2
Drop Structure Profiles

Station (m)	Drop (m)		Comments
	Cobble Lined Channel (5m wide channel)	Channel Lined With Composite Material (7m wide channel)	
0+100	2.0	2.5	100m Downstream of Outlet
0+200	2.0	2.5	
0+300	2.0	2.5	
0+450	3.0	3.5	Grade Break
0+500	3.5	3.5	
0+550	3.5	3.5	
0+620	3.5	3.5	Grade Break
0+650	3.5	3.5	
0+680	3.5	4.0	
0+710	4.0	4.0	
0+750			Downstream End

Downstream Channel Hydraulic Considerations

As a result of the channel stabilization measures, the sediment transport will be reduced in the stabilized reach possibly resulting in downstream channel degradation. For this reason, the stabilization works should continue with drop structures as far as is practicable. Due to the amount of material that has been deposited in the Clinton Creek channel during decades of chronic erosion and channel degradation through the waste rock dump, channel instability and degradation can be expected downstream of the mine. The instability will be most noticeable just downstream of the Wolverine Creek confluence and least noticeable just upstream of the alluvial fan at the lower end of Clinton Creek (just upstream of the Clinton Creek Town site). The channel crossing the alluvial fan will remain unstable as this is an inherent condition. The estimated cost to stabilize either channel alignment is $1,500,000, exclusive of earthworks and dewatering associated with channel filling.

6.3.2 Waste Rock Pile Stabilization

Existing Creek Channel Alignment

Slope stability analyses were carried out to determine the necessary geometric modifications to the waste rock dump to achieve a minimum overall FS of 1.25. In general, this would be accomplished by regrading the waste rock and off-loading material from the upper portion of the waste rock dump to reduce the driving forces on the slide mass. Two unloading scenarios were evaluated; with the channel along its existing alignment and an alternative alignment through the middle of the dump. The modified channel profile illustrated on Drawing 03 was used for each case. The elevation of the upper portion of the waste rock pile was incrementally lowered until the design objective was met (Drawing 06).

Approximately 600,000 m^3 of waste rock would be excavated to achieve a stable waste rock geometry. Approximately half of this volume (300,000 m^3) would be used to fill the existing channel. The remainder (300,000 m^3) would be used for regarding the mid to lower sections of the dump or disposed of in the open pit area. The channel would be stabilized as described in Section 6.3.1. Depending on the time of year when construction is undertaken, it may be necessary to control discharge from Hudgeon Lake. This could be accomplished by drawing down the lake level prior to construction and/or constructing a cofferdam at the outlet and allowing lake levels to rise for the construction period.

Drawdown would have to be carefully controlled to minimize instabilities of the slopes around Hudgeon Lake. Assuming an average lake discharge of about 0.6 m^3/sec (20 cfs) during the summer and a pumping capacity of 75 m^3/min (20,000 gpm), approximately one month would be required to draw down the lake level by 2 m. If pumping at this rate were discontinued after 1 month, it would take about another month for lake levels to recover and begin spilling at the outlet. Conversely, the lake would be expected to rise by about 2 m per month if a cofferdam was constructed.

Placement of 300,000 m^3 of material to in-fill the channel would take approximately 60 days, assuming an average placement rate of 5,000 m^3/day, a window that could be accommodated by the lake discharge control measures described above. Construction of channel stabilization works would proceed as soon as possible during this operation. Regrading on the upper portion of the waste rock dump could continue during the channel stabilization work. This earth moving operation however is not weather dependent and construction could proceed into the winter months if required. The estimated costs for this option are summarized in Table 6-3.

Table 6-3
Waste Rock Stabilization With Existing Channel Alignment – Cost Estimate

Description	Unit	Approximate Quantity	Unit Price	Amount
Mobilization & Demobilization	Lump Sum	1	$500,000	$500,000
Dewatering	Allowance			$500,000
Excavation	Cubic Metre	600,000	$3	$1,800,000
Regrading	Cubic Metre	300,000	$1	$300,000
Channel Filling	Cubic Metre	300,000	$2	$600,000
Channel Stabilization	Allowance			$1,500,000
Subtotal				$5,200,000
30% Contingency				$1,600,000
Total Estimated Cost				**$6,800,000**

Alternate Channel Alignment

The option of excavating an alternate creek channel over the waste rock dump was also evaluated. This approach would allow for construction of the new channel to proceed in the dry while maintaining flow in the existing channel. The alternative channel profile would be similar to the one proposed for the existing alignment (Drawing 03). A portion of the waste rock excavated from the new channel would be temporarily stockpiled adjacent to the existing channel for subsequent filling. Waste rock from the upper portion of the waste rock dump would be off-loaded to improve the overall stability. Using parameters determined from the back analysis, the modified geometry necessary to achieve a FS of 1.25 is illustrated on Drawing 07 for Sections E and K.

Approximately 3,000,000 m^3 of waste rock would be excavated to achieve the required waste rock dump geometry, including about 1,500,000 m^3 for the channel excavation. Approximately 1,000,000 m^3 of the excavated waste rock would be used to fill the existing creek channel. Of the remaining 2,000,000 m^3, a portion (say 500,000 m^3) would be used for regrading and 1,500,000 m^3 would be disposed of in the open pit or east end of the waste rock dump. Once the channel has been lined with gabion drop structures, the flow would be diverted to the new channel and the existing channel could be filled. The estimated costs for this option are summarized in Table 6-4.

Table 6-4
Waste Rock Stabilization With Alternate Channel Alignment – Cost Estimate

Description	Unit	Approximate Quantity	Unit Price	Amount
Mobilization & Demobilization	Lump Sum	1	$500,000	$500,000
Excavation*	Cubic Metre	3,000,000	$2	$6,000,000
Dewatering	Allowance			$500,000
Channel Filling	Cubic Metre	1,000,000	$2	$2,000,000
Channel Stabilization	Allowance			$1,500,000
Regrading	Cubic Metre	500,000	$1	$500,000
Subtotal				$11,000,000
30% Contingency				$3,300,000
Total Estimated Cost				**$14,300,000**

* Includes disposal costs for portion not used for regrading

6.4 Convey Water Around Waste Rock Dump

The conveyance of water through a concrete lined tunnel or directionally drilled, steel or PVC lined tunnel constructed around the unstable waste rock dump was considered. This scheme would not require any stabilization of the waste rock dump other than filling in the existing creek channel once the tunnel has been constructed. The inlet structure for the tunnel should be located away from the active waste rock movement. In this regard, the most practical tunnel alignment would be an inlet just upstream of the existing Hudgeon Lake outlet on the north side of the valley to an outlet in the Wolverine Creek valley (Drawing 08). The total distance for this alignment is approximately 2,200m. Tunneling on the south side of the valley is not considered feasible given the unstable open pit slopes and required tunnel length.

The full supply level (FSL) would be set at 410m (approximately the current lake elevation) and the crown of the tunnel would be placed at the same level. The proposed FSL will provide a live storage of 1.5 m between the overflow crest at the tunnel inlet and the outflow level of the current channel (over the waste rock pile) to generate sufficient head for the tunnel flow. The channel over the waste rock pile will function as an emergency spillway in the event the tunnel entrance is blocked. To allow isolation of the tunnel for inspection and maintenance, a low-head sluice gate would be installed at the inlet. Once completed, flow would be diverted into the tunnel.

A minimum tunnel diameter of 2.3 m is required to convey the estimated 200-year flood (43 m^3/s). The appropriate design flood however, will require verification prior to detailed design. The estimated costs of tunneling (based on a conventional concrete lined tunnel) are summarized in Table 6-5.

Table 6-5
Conveyance of Water Around Waste Rock Dump – Cost Estimate

Description	Unit	Approximate Quantity	Unit Price	Amount
Mobilization & Demobilization	Lump Sum	1	$500,000	$500,000
Tunneling	Metre	2,200	$5,500	$12,100,000
Inlet and Outlet Structures	Allowance			$2,000,000
Channel Improvements (Wolverine Creek)	Allowance			$500,000
Regrade Clinton Creek Channel	Allowance			$500,000
Subtotal				$15,600,000
30% Contingency				$4,700,000
Total Estimated Cost				**$20,300,000**

7.0 CONCLUSIONS AND RECOMMENDATIONS

A review of the performance of the Clinton Creek waste rock dump, including previous geotechnical investigations and survey information collected since 1976 has been completed. The rate of horizontal waste rock movements appears to have significantly reduced although minor movements may be continuing. Vertical movements associated with settlement of the waste rock dump appear to be continuing at a constant rate. Additional monitoring of the waste rock dump is required to verify the interpretations made from 1999 survey data.

Stability analysis indicates a weak foundation material is contributing to the continued horizontal displacements following the initial failure of the waste rock dump. The loss of strength may be related to a number of geological conditions unique to the site including ice content, soil type and the relationship between the rate of thawing and dissipation of excess pore-water pressures. It is likely that disturbance to the thermal regime, in particular thawing of permafrost beneath the dump, has resulted from filling of the upstream reservoir (Hudgeon Lake). Insufficient information is available to further quantify parameters necessary to accurately model the existing waste rock stability. In this regard, a detailed geotechnical investigation will be required for the final design of remedial measures.

Based on our current understanding of the problem, several remediation alternatives were considered to mitigate the existing hazards associated with a breach of the waste rock blockage. Remedial strategies broadly fall into one of three categories:

i) Remove a sufficient volume of waste rock from the valley to completely drain Hudgeon Lake and restore natural creek drainage.

ii) Continue to convey water over the waste rock dump.

iii) Convey water around the waste rock dump via a tunnel.

Significant capital costs are associated with these options, ranging from $ 7,000,000 to stabilize the waste rock dump and existing creek channel alignment to $30,000,000 to remove a sufficient amount of the dump to restore natural creek drainage. It must be recognized that these options have been evaluated in concept only. Should the implementation of remedial measures be considered, the work completed to date and available information is only considered sufficient to select a preferred alternative. Upon the selection of the remedial repair alternative, a feasibility study including detailed field investigations is recommended to examine the technical feasibility of the preferred option and refine construction cost estimates. The level of detailed field investigations required will depend on the selected alternative.

Additional performance monitoring of the waste rock dump should be undertaken in 2001 to provide data needed to confirm the current waste rock movement trends. If continued monitoring confirms that movement rates are sufficiently small or if movements have terminated, the need to stabilize the waste rock dump should be re-evaluated. If based on additional surveys, it can be concluded that stabilizing the waste rock dump is not required, it may be possible to reduce the scale of the construction project to stabilize only the creek channel over the waste rock dump. Including a 30 percent contingency, the cost of stabilizing the channel alone is estimated to be in the range of $4,000,000.

The evidence of accelerated deterioration of the Hudgeon Lake outlet confirms that the likelihood of a breach is increasing. If it is determined that a risk management strategy is not sufficient to address the hazards associated with a breach scenario, then the implementation of remedial measures should proceed as soon as possible. Consideration could be given to armouring a short section of the Clinton Creek channel immediately downstream of the lake outlet until long term remedial repairs are implemented. It may be possible to incorporate such short term measures in the overall repair strategy.

Several recommendations have been made in this report with respect to additional work beyond what has already been implemented as part of an overall risk management strategy. In summary, these steps are:

- Monitoring of waste rock movements in 2001 and perhaps beyond.
- Development of a plan for the short term remedial measures at the Hudgeon Lake outlet.
- Selection of a preferred long term remedial repair alternative.
- Completion of a detailed field investigations required for the selected repair strategy.
- Preparation of a Function Design Report.
- Completion of Detailed Design and the Preparation of Construction Drawings and Specifications.

Should you have any questions or require any additional information, please contact the undersigned.

Respectfully Submitted,
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9-1-02

References

Golder Associates (1978). "Report to Cassiar Asbestos Corporation Ltd., Re: Mine Waste Dump and Tailing Pile, Clinton Creek Operations"

Golder Associates (1977). "Report to Cassiar Asbestos Corporation Limited on Stabilization Measures for Mine Closure"

Golder Associates (1977). "Second Report to Cassiar Asbestos Corporation Ltd. on Stabilization Measures for Mine Closure"

Golder Brawner Associates (1974). "Report to Department of Indian Affairs and Northern Deveopment on Waste Disposal Operations, Clinton Creek Mines Ltd."

Hardy Associates (1978) Ltd. (1985). "Clinton Creek Mine Review Report on Waste Dump and Tailings Pile Conditions"

Hardy Associates (1978) Ltd. (1981). "Cassiar Asbestos Mine, Waste Dump and Tailings Pile Stability"

Hardy Associates (1978) Ltd. (1980). "Cassiar Asbestos Corporation Mine Review of Waste Dump and Tailings Pile Behaviours"

Klohn Leonoff Consulting Engineers (1984). "Report on 1984 Site Visit, Clinton Creek Mine Waste Dump and Tailings Piles"

R.M. Hardy & Associates Ltd. (1977). "Report on Requirements for Development of a Rehabilitation Plan, Clinton Creek Mine, Cassiar Asbestos Corporation"

W.B. Bowie Assistant Resource Management Officer, Dawson City (1974). "Inspections of Clinton Mine Operations"

APPENDIX A
TEST HOLE LOGS

RECORD OF BOREHOLE 1 (T-1)

LOCATION (See Figure 2)
BORING DATE April 4, 1978

BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1386.6' / 0.0'	WASTE ROCK - argillite - dry - grey - some asbestos fibres							
1370.6' / 16.0'	WASTE ROCK - argillite - dry - brownish grey - very fibrous.							
1364.6' / 22.0'	WASTE ROCK - argillite with some serpentine - dry to damp - grey to brown to green - some asbestos fibres Original Ground Surface							
1323.6' / 63.0'	ORGANICS - dark brown - moss, leaves etc. - ice chips							
65.0'	ARGILLITE - weathered - moist - grey brown - ice chips							
1306.6' / 82.0'	ARGILLITE - weathered - grey (brownish) - wet - ice chips							
1296.6' / 90.0'	End of Hole							Thermistor cable installed to 90' (9 units at 5' intervals)

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 2 (T-2)

LOCATION (See Figure 2)
BORING DATE April 5, 1978
BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P – W – W_L)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1398.1' / 0.0'	WASTE Rock - argillite - dark grey - damp							
1386.1' / 12.0'	WASTE ROCK - argillite - dark grey - damp		1	D.O				
			2	"				
			3	"				
1333.1' / 65.0'	Original Ground Surface / ORGANICS - dark brown							
66.0'	ARGILLITE - dark grey - weathered - ice chips		4	"				
1308.1' / 90.0'	End of Hole							Thermistor cable installed to 90 ft. (9 unit[s] at 5 ft. interva[ls]

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 3

LOCATION (See Figure 2)
BORING DATE April 6, 1978
BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_p W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	WASTE ROCK -argillite -dry -dark grey							
8.0'	WASTE ROCK -argillite -damp		1	D.O.				
			2	"				
52.0'	End of Hole							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 4 (T-3)

LOCATION (See Figure 2) BORING DATE April 7, 1978

BOREHOLE TYPE BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN. DATUM

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1559.9' / 0.0'	WASTE ROCK - argillite - dry - grey							
1541.9' / 18.0'	Original Ground Surface ARGILLITE - damp - dark grey - original rock		1	0.0.				
1504.9' / 55.0'	End of Hole							Thermistor cable installed to 55ft. (9 units at 5' intervals)

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBE

RECORD OF BOREHOLE 5

LOCATION (See Figure 2)
BORING DATE April 8, 1978
BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	WASTE ROCK - argillite - dry to damp - grey							
80.0'	End of Hole (hole collapsed at 80ft.)							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED E.B.F.

RECORD OF BOREHOLE 6 (T-4)

LOCATION (See Figure 2) BORING DATE April 10, 1978

BOREHOLE TYPE BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN. DATUM

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_p W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	WASTE ROCK - argillite - dark grey - dry - some asbestos fibre							
25.0'	WASTE ROCK - argillite - dark grey - damp							
50.0'	WASTE ROCK - argillite - wet - free water running into hole at 50.0' - some asbestos fibres - possible original ground surface at approx. 80'							Thermistor cable installed to 60' (9 units at 5' intervals) Borehole collapsed during installation preventing cable from reaching full depth in bore hole
82.0'	End of Hole							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 7 (P-4)

LOCATION (See Figure 2)
BOREHOLE TYPE
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE April 10, 1978
BOREHOLE DIAMETER 6 in.
DATUM

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_p — W — W_L)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1304.6'	WASTE ROCK -argillite -dry -dark grey -damp at 40'							
1241.6' 63.0'	End of Hole							Piezometer el. 1245.17'

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 8 (P-5)

LOCATION (See Figure 2)
BOREHOLE TYPE
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE April 10, 1978
BOREHOLE DIAMETER 6 in.
DATUM

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P — W — W_L)	PIEZOMETER OR STANDPIPE INSTALLATION; ADDITIONAL LAB. TESTING
1271.5' / 0.0'	WASTE ROCK - argillite - dry - dark grey							
1241.5' / 30.0'	ARGILLITE - dark grey - damp. ARGILLITE bedrock-weathered							Piezometer el. 1202.76'
1202.5' / 69.0'	End of Hole							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBE

RECORD OF BOREHOLE 9 (P-3)

Project No. KL2016

LOCATION (See Figure 2)
BORING DATE April 11, 1978

BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P — W — W_L)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1364.3'								
	WASTE ROCK - argillite - dry to damp - dark grey - moist at 45.0'							Piezometer el. 1314.19'
1301.3' / 66.0'	End of Hole							

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

Project No. _[illegible]_

RECORD OF BOREHOLE 10 (P-2)

LOCATION (See Figure 2)
BORING DATE April 11, 1978
BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_p — W — W_L)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1368.0' / 0.0'	WASTE ROCK - argillite - dry to damp - dark grey							
1330.0' / 42.0'	End of Hole							Piezometer el. 1329.4[illegible]

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 11 (P-1)

LOCATION (See Figure 2)

BOREHOLE TYPE

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE April 11, 1978

BOREHOLE DIAMETER 6 in.

DATUM

SOIL PROFILE									
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION	ADDITIONAL LAB. TESTING
1363.0' / 0.0'	WASTE ROCK - argillite - dry to damp - dark grey							Piezometer el. 1321.95'	
1345.0' / 38.0'	End of Hole								

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED

RECORD OF BOREHOLE 12 (T-5)

LOCATION (See Figure 6)

BOREHOLE TYPE

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE May 9, 1978

BOREHOLE DIAMETER 6 in.

DATUM

ELEV. / DEPTH	SOIL PROFILE – DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_p — W — W_L; 10 20 30 40)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
19452'	Surface of Tailing Pile							
0.0'	Tails							
1911.7' / 33.5'	Compact, light brown, sub-rounded, fine to med. GRAVEL with clay, silt and sand - fluvial lacustrine traces of organics at bottom of tails		1					Thermistor cable installed to 54 ft. (9 units at 5' intervals)
			2					
1891.2 / 54.0'	End of Hole							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

Project No. Y11016

RECORD OF BOREHOLE 13 (T-6)

LOCATION (See Figure 6)

BORING DATE May 9, 1978

BOREHOLE TYPE

BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

DATUM

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P, W, W_L) 10 20 30 40	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1880.6' / 0.0'	Ground Surface in Roadway Cut							
	Frozen, light brown sub-rounded fine to med. GRAVEL with clay, silt & sand fluvial lacustrines		1					
			2				~42	
			3				~32	
			4				~28	
1840.6' / 40.0'	End of Hole							Thermistor cable install to 40 ft. (9 units at 5' intervals

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 14 (T-7)

LOCATION (See Figure 6) | BORING DATE May 10, 1978

BOREHOLE TYPE | BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN. | DATUM

ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_p, W, W_L) 10 20 30 40	PIEZOMETER OR STANDPIPE INSTALLATION; ADDITIONAL LAB. TESTING
1741.0	Surface of Tailing Pile							
0.0'	Tails							
1696.0' / 45.0'	-Frozen - ice crystals - light brown - sub-rounded - fine to med. GRAVEL with clay, silt & sand. - fluvial - lacustrine		1 2					Thermistor cable installed to 74ft. (9 units at 5' intervals)
1667.0' / 74.0'	End of Hole							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN RP
CHECKED EBE

RECORD OF BOREHOLE 15 (ST-8)

LOCATION (See Figure 6)

BOREHOLE TYPE

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE May 11, 1978

BOREHOLE DIAMETER 6 in.

DATUM

ELEV. / DEPTH	SOIL PROFILE — DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_p — W — W_L; 10 20 30 40)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1607.2'	Ground Surface in Road Cut							
0.0' / 1607	-Frozen - light brown - sub rounded -fine to med. GRAVEL with clay silt & sand - fluvial lacus trines		1				⊙ (~6)	
	-Frozen - black -ARGILLITE weathered bedrock		2				⊙ (~12)	
1567.2 / 40.0'	End of Hole							

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 16 (T-8)

LOCATION (See Figure 6) | BORING DATE May 12, 1978
BOREHOLE TYPE | BOREHOLE DIAMETER 6 in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN. | DATUM

ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P — W — W_L) 10 20 30 40	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
1623.8 / 0.0'	Surface of Tailing Pile							
	Tails							
1560.8 / 63.0'	- light brown - sub-rounded - fine to med. GRAVEL with clay silt & sand. fluvial lacustrine		1				⊙ (approx. 13)	
1540.8 / 83.0'	End of Hole							Thermistor cable installed to 83.0 ft. (9 units at 5' intervals)

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED EBF

RECORD OF BOREHOLE 17 (D.S.-2)

LOCATION (See Figure 6)

BORING DATE May 16, 1978

BOREHOLE TYPE

BOREHOLE DIAMETER 6 in.

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

DATUM

SOIL PROFILE: ELEV. / DEPTH	SOIL PROFILE: DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT (W_P, W, W_L)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	Frozen dark brown organic silty SAND							
3.0'	Frozen dark brown PEAT							
5.0' / 7.0'	Frozen, light brown, sub-rounded, fine to med. GRAVEL with clay, silt & Sand (fluvial Lacustrine)							
	ARGILLITE - hard, dry unweathered							
19.0'	SERPENTINE, weathered frozen							
21.0'	ARGILLITE BEDROCK soft, weathered, frozen		1					
46.0'	ARGILLITE BEDROCK unweathered, frozen		2					
57.0'	End of Hole							

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.

CHECKED E.B.E.

Project No. 772019

RECORD OF BOREHOLE 18 (D.S-5)

LOCATION (See Figure 6)

BOREHOLE TYPE

SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.

BORING DATE May 17, 1978

BOREHOLE DIAMETER 6 in.

DATUM

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	Frozen, dark brown, organic silty, SAND.							
8.0'	Frozen, light brown, sub-rounded, fine to med. GRAVEL with clay, silt & sand (fluvial lacustrian)		1					
19.0'	ARGILLITE frozen, weathered (ice lens approx. 3in. thick recovered with sample)		2					
37.0'	ARGILLITE - frozen, becoming harder with depth, unweathered		3 4					
60.0'	End of Hole							

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED E.B.F.

RECORD OF BOREHOLE 19(D-S-6)

LOCATION (See Figure 6)
BORING DATE May 18, 1978
BOREHOLE TYPE
BOREHOLE DIAMETER 6 in.
SAMPLER HAMMER WEIGHT 140 LB. DROP 30 IN.
DATUM

SOIL PROFILE								
ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_p W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	Frozen, light brown sub-rounded, fine to medium GRAVEL with clay, silt & sand (alluvial)							
7.0'	Frozen Silt with layers of fibrous peat		1					
17.0'	Frozen, light brown sub-rounded, fine to medium GRAVEL with clay, silt and sand (fluvial lacustrine)							
20.0'	ARGILLITE frozen, weathered		2					
32.0'	ARGILLITE - frozen becoming harder with depth, unweathered		3					
60.0'	End of Hole							

VERTICAL SCALE
1 inch to 20 feet

Golder Associates

DRAWN R.D.
CHECKED E.B.F.

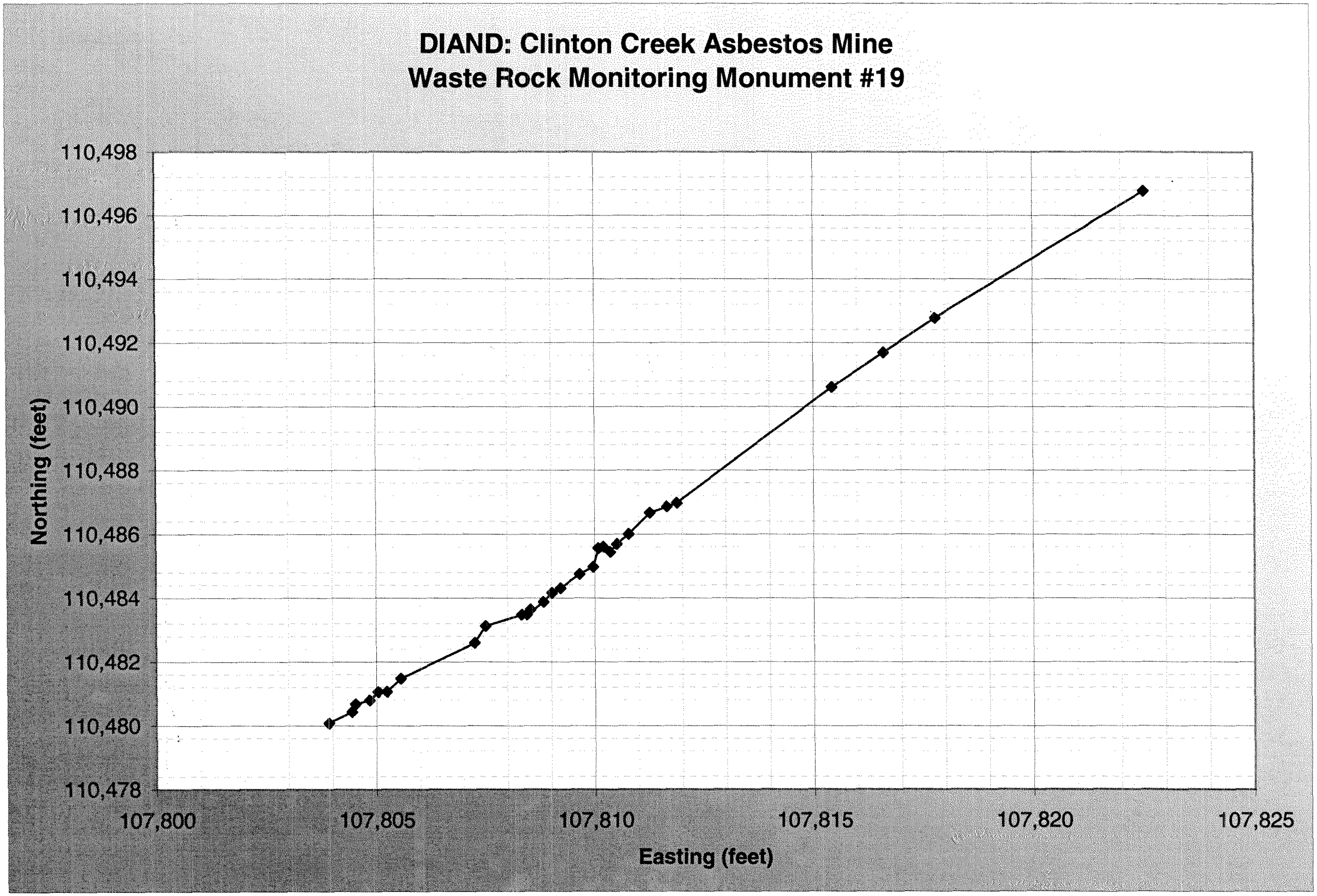
APPENDIX B
PERFORMANCE MONITORING RESULTS

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Point #19

Interpolated values

Monitoring	Northing	Easting	Elevation	Time		Horizontal Movement			Vertical Movement		
Date				Total	Incremental	total	incremental	rate	total	incremental	rate
	(feet)	(feet)	(feet)	(days)	(days)	(feet)	(feet)	(feet/year)	(feet)	(feet)	(feet / year)
24-Nov-76	110,480.08	107,803.92		0	0	0	0	0			
25-Jan-77	110,480.44	107,804.44		62.0	62.0	0.63	0.63	3.723	0.04	0.04	0.24
24-Feb-77	110,480.68	107,804.52		92.0	30.0	0.85	0.25	3.078			
23-Mar-77	110,480.80	107,804.84		119.0	27.0	1.17	0.34	4.620			
10-May-77	110,481.06	107,805.04		167.0	48.0	1.49	0.33	2.494			
24-May-77	110,481.06	107,805.24		181.0	14.0	1.64	0.20	5.214			
19-Jul-77	110,481.48	107,805.56		237.0	56.0	2.16	0.53	3.442			
18-Nov-77	110,482.60	107,807.25		359.0	122.0	4.18	2.03	6.066			
20-Jan-78	110,483.12	107,807.50		422.0	63.0	4.70	0.58	3.343			
20-Apr-78	110,483.48	107,808.32		512.0	90.0	5.56	0.90	3.632			
26-May-78	110,483.64	107,808.52		548.0	36.0	5.82	0.26	2.597			
6-Jun-78	110,483.48	107,808.44		559.0	11.0	5.66	0.18	5.936			
27-Jul-78	110,483.88	107,808.82		610.0	51.0	6.20	0.55	3.949			
22-Sep-78	110,484.16	107,809.02		667.0	57.0	6.53	0.34	2.203			
19-Oct-78	110,484.31	107,809.22		694.0	27.0	6.78	0.25	3.380			
1-Feb-79	110,484.75	107,809.65		799.0	105.0	7.39	0.62	2.139			
22-Apr-79	110,484.98	107,809.96		879.0	80.0	7.78	0.39	1.761			
16-May-79	110,485.57	107,810.08		903.0	24.0	8.25	0.60	9.157			
18-Jun-79	110,485.61	107,810.20		936.0	33.0	8.37	0.13	1.399			
1-Aug-79	110,485.45	107,810.35		980.0	44.0	8.38	0.22	1.819			
7-Sep-79	110,485.69	107,810.51		1017.0	37.0	8.65	0.29	2.845			
10-Nov-79	110,486.00	107,810.78		1081.0	64.0	9.06	0.41	2.345			
4-Apr-80	110,486.67	107,811.26		1227.0	146.0	9.86	0.82	2.060			
24-May-80	110,486.86	107,811.65		1277.0	50.0	10.28	0.43	3.167			
17-Jul-80	110,486.98	107,811.88		1331.0	54.0	10.53	0.26	1.754			
1-Sep-83	110,490.61	107,815.43	1422.64	2472.0	1141.0	15.60	5.08	1.624			
14-Jun-84	110,491.69	107,816.61	1422.09	2759.0	287.0	17.20	1.60	2.034		-0.55	-0.70
15-Jul-86	110,492.77	107,817.78	1420.69	3520.0	761.0	18.79	1.59	0.764		-1.40	-0.67
16-Jul-99	110,496.77	107,822.52	1414.60	8269.0	4749.0	24.99	6.20	0.477		-6.09	-0.47



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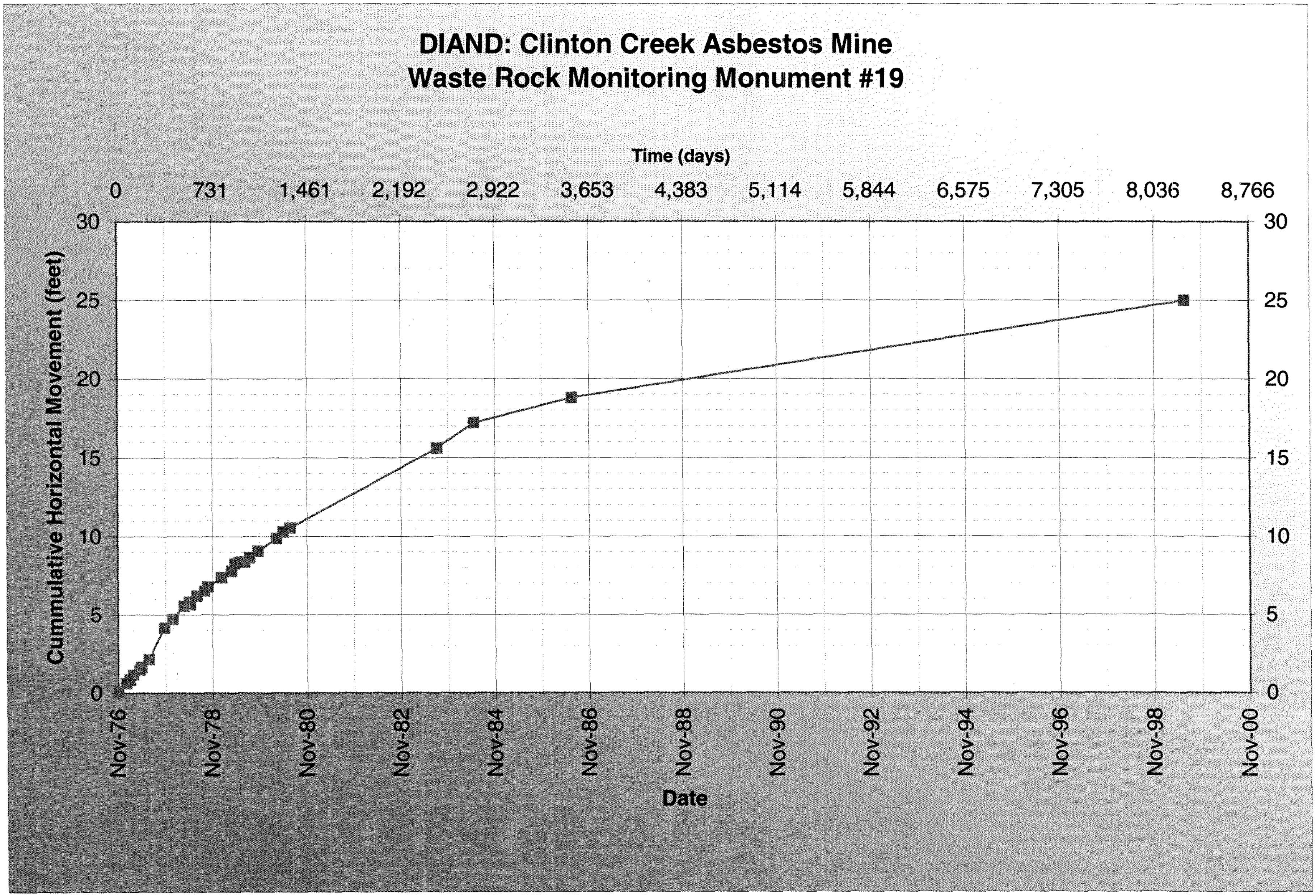
Date: 11/10/2000



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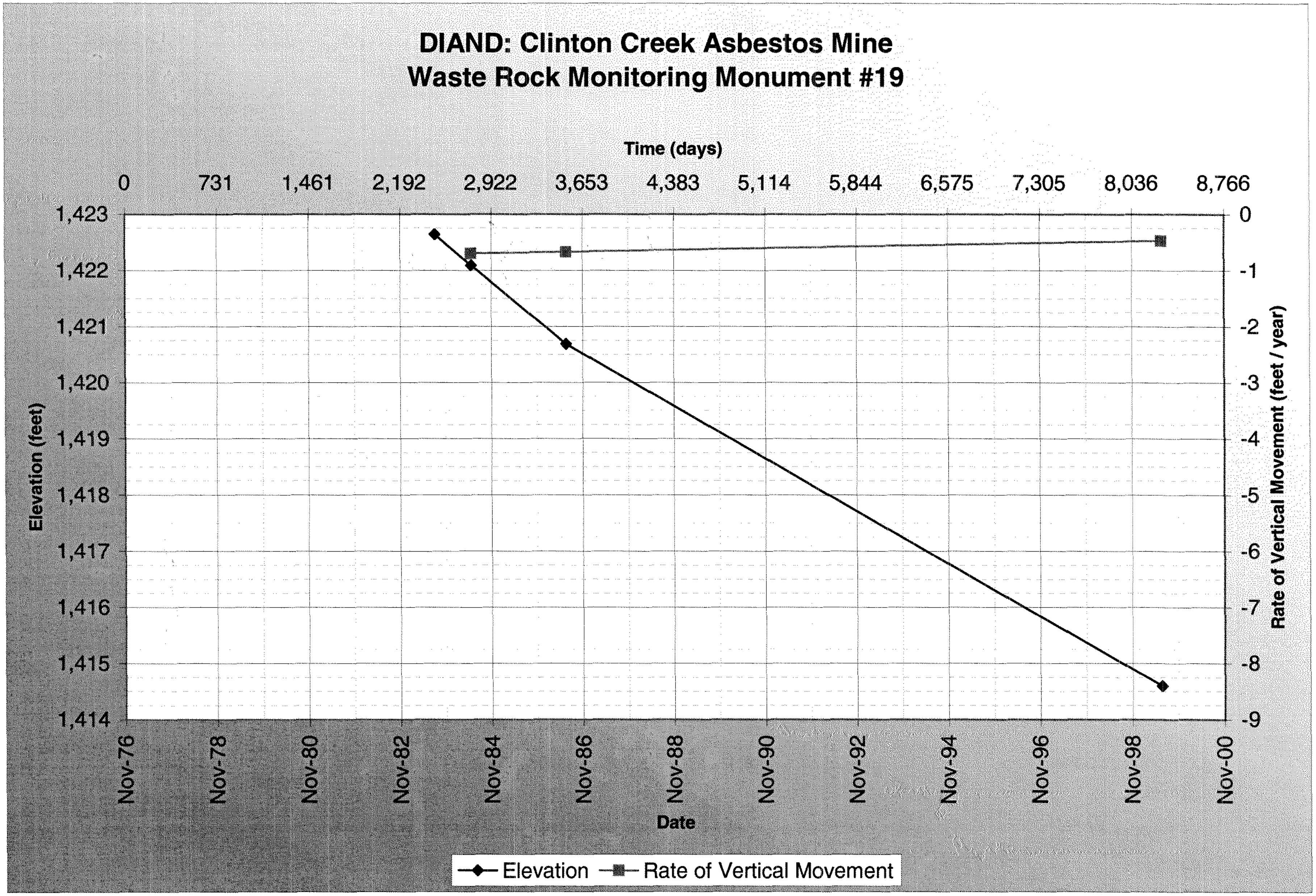
Date: 11/10/2000



File: monitoring data #19 Tab: #19-vert mvmnt

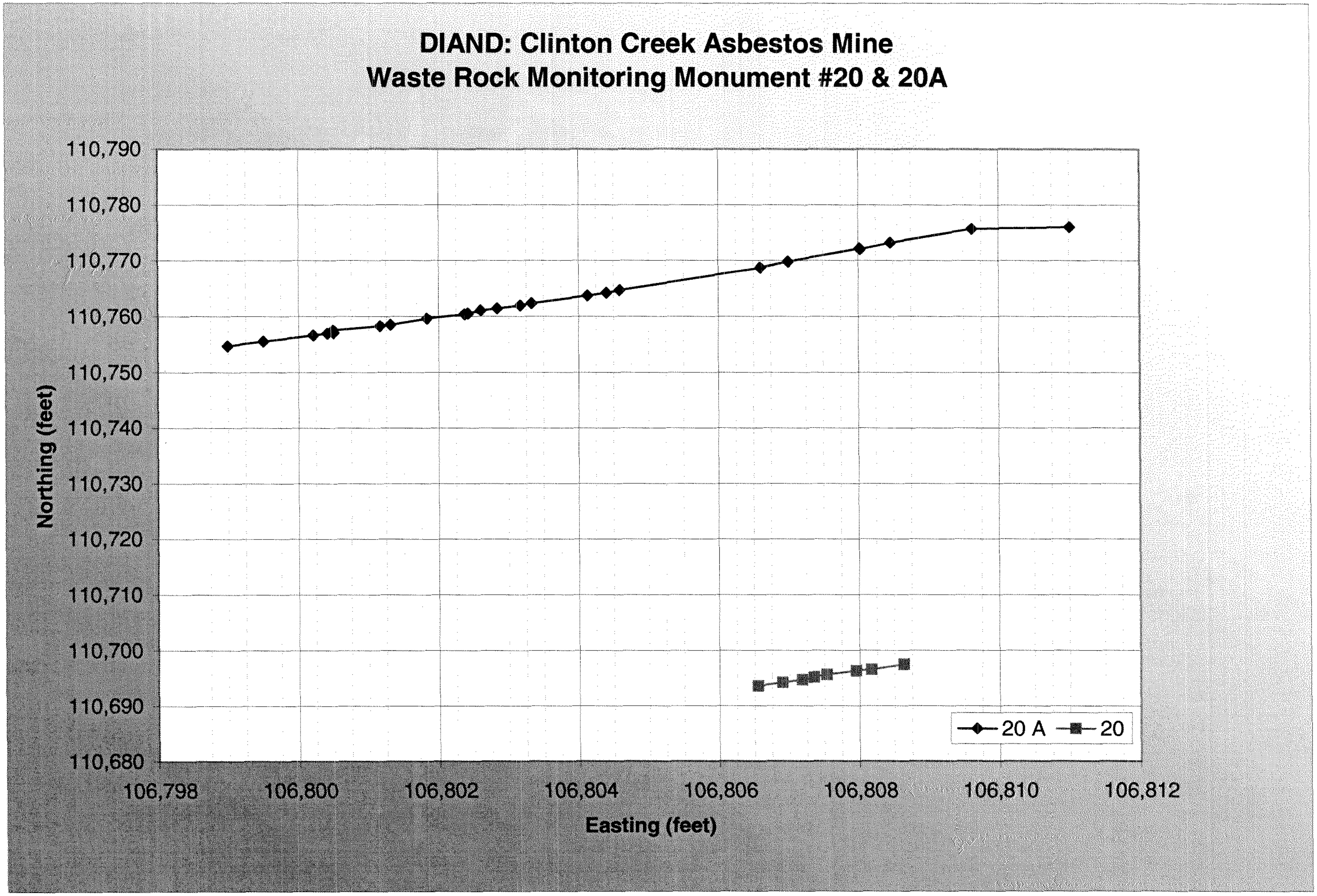
Date: 11/10/2000

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Point #20A

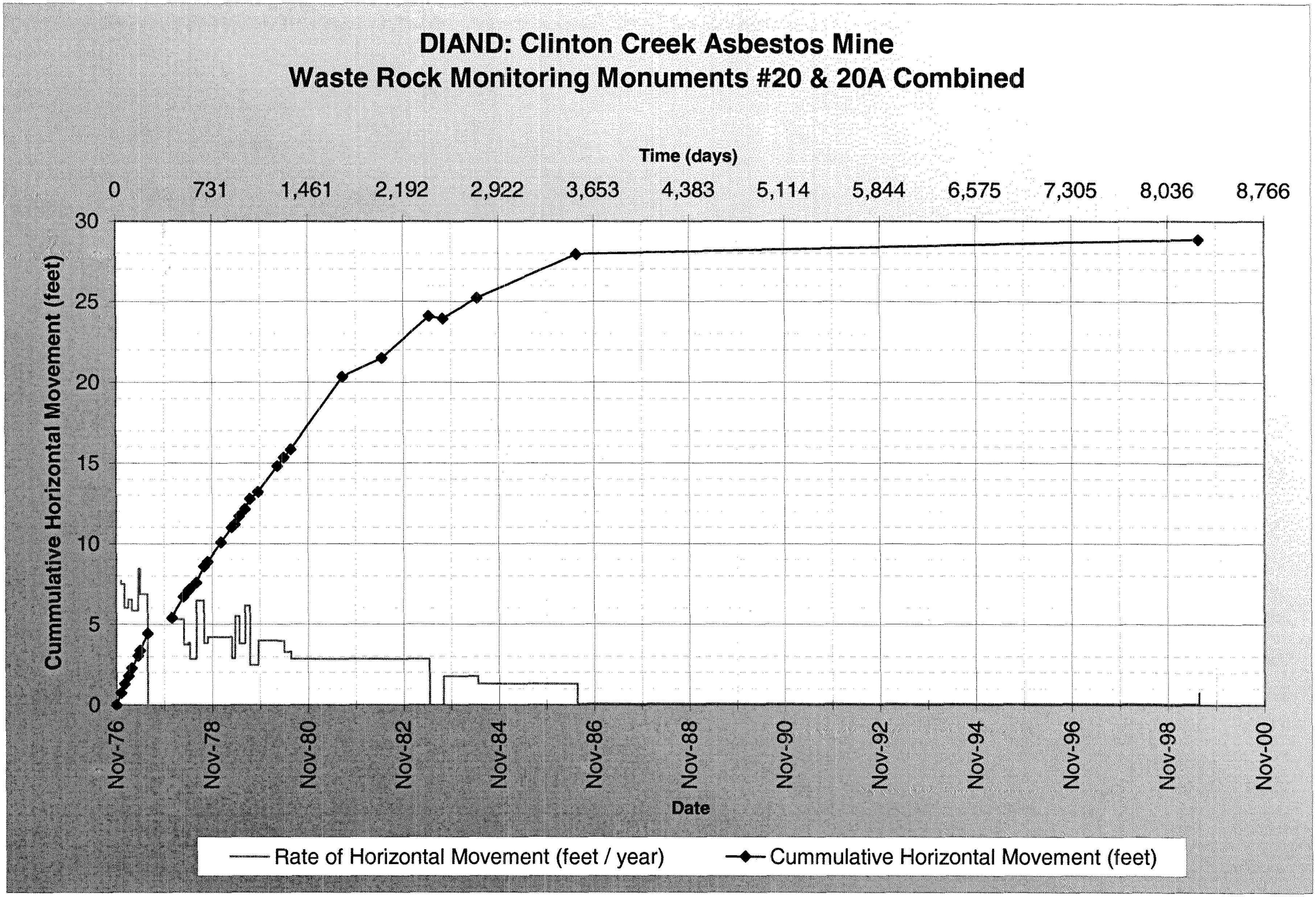
interpolated values

Monitoring	Northing	Easting	Elevation	Time		Horizontal Movement			Vertical Movement		
Date				Total	Incremental	total	incremental	rate	total	incremental	rate
	(feet)	(feet)	(feet)	(days)	(days)	(feet)	(feet)	(feet/year)	(feet)	(feet)	(feet / year)
#20											
24-Nov-76	110,693.60	106,806.55		0	0	0	0	0			
29-Dec-76	110,694.25	106,806.90		35.0	35.0	0.74	0.74	7.699			
25-Jan-77	110,694.73	106,807.18		62.0	27.0	1.29	0.56	7.512	0.22		
24-Feb-77	110,695.20	106,807.35		92.0	30.0	1.79	0.50	6.081			
23-Mar-77	110,695.65	106,807.53		119.0	27.0	2.27	0.48	6.552			
10-May-77	110,696.30	106,807.95		167.0	48.0	3.04	0.77	5.885			
24-May-77	110,696.55	106,808.17		181.0	14.0	3.37	0.33	8.682			
19-Jul-77	110,697.50	106,808.63		237.0	56.0	4.42	1.06	6.880			
#20A											
18-Nov-77	110,754.71	106,798.99		0	0	0	0	0			
20-Jan-78	110,755.53	106,799.50		63.0	63.0	0.97	0.97	5.595			
20-Apr-78	110,756.63	106,800.21		153.0	90.0	2.27	1.31	5.310			
26-May-78	110,756.94	106,800.41		189.0	36.0	2.64	0.37	3.740			
6-Jun-78	110,757.02	106,800.50		200.0	11.0	2.76	0.12	3.996			
27-Jul-78	110,757.49	106,800.49		251.0	51.0	3.16	0.47	3.364			
22-Sep-78	110,758.27	106,801.16		308.0	57.0	4.17	1.03	6.584			
19-Oct-78	110,758.51	106,801.31		335.0	27.0	4.45	0.28	3.826			
1-Feb-79	110,759.61	106,801.83		440.0	105.0	5.66	1.22	4.230			
22-Apr-79	110,760.36	106,802.37		520.0	80.0	6.58	0.92	4.217			
16-May-79	110,760.55	106,802.42		544.0	24.0	6.77	0.20	2.988			
18-Jun-79	110,761.02	106,802.60		577.0	33.0	7.27	0.50	5.567			
1-Aug-79	110,761.41	106,802.84		621.0	44.0	7.73	0.46	3.799			
7-Sep-79	110,761.94	106,803.17		658.0	37.0	8.35	0.62	6.159			
10-Nov-79	110,762.35	106,803.33		722.0	64.0	8.79	0.44	2.510			
4-Apr-80	110,763.73	106,804.13		868.0	146.0	10.38	1.60	3.988			
24-May-80	110,764.20	106,804.40		918.0	50.0	10.92	0.54	3.957			
17-Jul-80	110,764.65	106,804.59	1473.76	972.0	54.0	11.41	0.49	3.302			
15-Aug-81	110,768.70	106,806.60	1472.96	1366.0	394.0	15.93	4.52	4.189		-0.8	
15-Jun-82	110,769.80	106,807.00	1472.62	1670.0	304.0	17.08	1.17	1.405		-0.34	
9-Jun-83	110,772.19	106,808.02	1471.96	2029.0	359.0	19.67	2.60	2.642		-0.66	
23-Sep-83	110,772.00	106,808.03	1471.7	2135.0	106.0	19.51	0.19	0.655		-0.26	
14-Jun-84	110,773.22	106,808.46	1470.66	2400.0	265.0	20.79	1.29	1.782		-1.04	
15-Jul-86	110,775.69	106,809.62	1470.07	3161.0	761.0	23.52	2.73	1.309		-0.59	
17-Jul-99	110,776.00	106,811.01	1466.34	7911.0	4750.0	24.45	1.42	0.109		-3.73	
20 & 20A Combined											
24-Nov-76				0.1	0.0	0.00	0.00	0.000			
29-Dec-76				35.0	35.0	0.74	0.74	7.699			
25-Jan-77				62.0	27.0	1.29	0.56	7.510	-0.22		-1.3
24-Feb-77				92.0	30.0	1.79	0.50	6.024			
23-Mar-77				119.0	27.0	2.27	0.48	6.534			
10-May-77				167.0	48.0	3.04	0.77	5.849			
24-May-77				181.0	14.0	3.37	0.32	8.451			
19-Jul-77				237.0	56.0	4.42	1.05	6.873			
18-Nov-77				359.0							
20-Jan-78				422.0	63.0	5.39					
20-Apr-78				512.0	90.0	6.69	1.31	5.309			
26-May-78				548.0	36.0	7.06	0.37	3.740			
6-Jun-78				559.0	11.0	7.18	0.12	3.850			
27-Jul-78				610.0	51.0	7.58	0.40	2.856			
22-Sep-78				667.0	57.0	8.59	1.01	6.470			
19-Oct-78				694.0	27.0	8.87	0.28	3.826			
1-Feb-79				799.0	105.0	10.08	1.21	4.211			
22-Apr-79				879.0	80.0	11.00	0.92	4.199			
16-May-79				903.0	24.0	11.19	0.19	2.873			
18-Jun-79				936.0	33.0	11.69	0.50	5.496			
1-Aug-79				980.0	44.0	12.15	0.46	3.797			
7-Sep-79				1017.0	37.0	12.77	0.62	6.155			
10-Nov-79				1081.0	64.0	13.21	0.44	2.482			
4-Apr-80				1227.0	146.0	14.80	1.60	3.988			
24-May-80				1277.0	50.0	15.34	0.54	3.957			
17-Jul-80			1473.76	1331.0	54.0	15.83	0.49	3.279			
15-Aug-81			1472.96	1725.0	394.0	20.35	4.52	4.184		-0.8	-0.7
15-Jun-82			1472.62	2029.0	304.0	21.50	1.16	1.391		-0.34	-0.4
9-Jun-83			1471.96	2388.0	359.0	24.09	2.59	2.634		-0.66	-0.7
23-Sep-83			1471.7	2494.0	106.0	23.93	-0.16	-0.565		-0.26	-0.9
14-Jun-84			1470.66	2759.0	265.0	25.21	1.28	1.765		-1.04	-1.4
15-Jul-86			1470.07	3520.0	761.0	27.94	2.73	1.308		-0.59	-0.3
17-Jul-99			1466.34	8270.0	4750.0	28.87	0.93	0.071		-3.73	-0.3



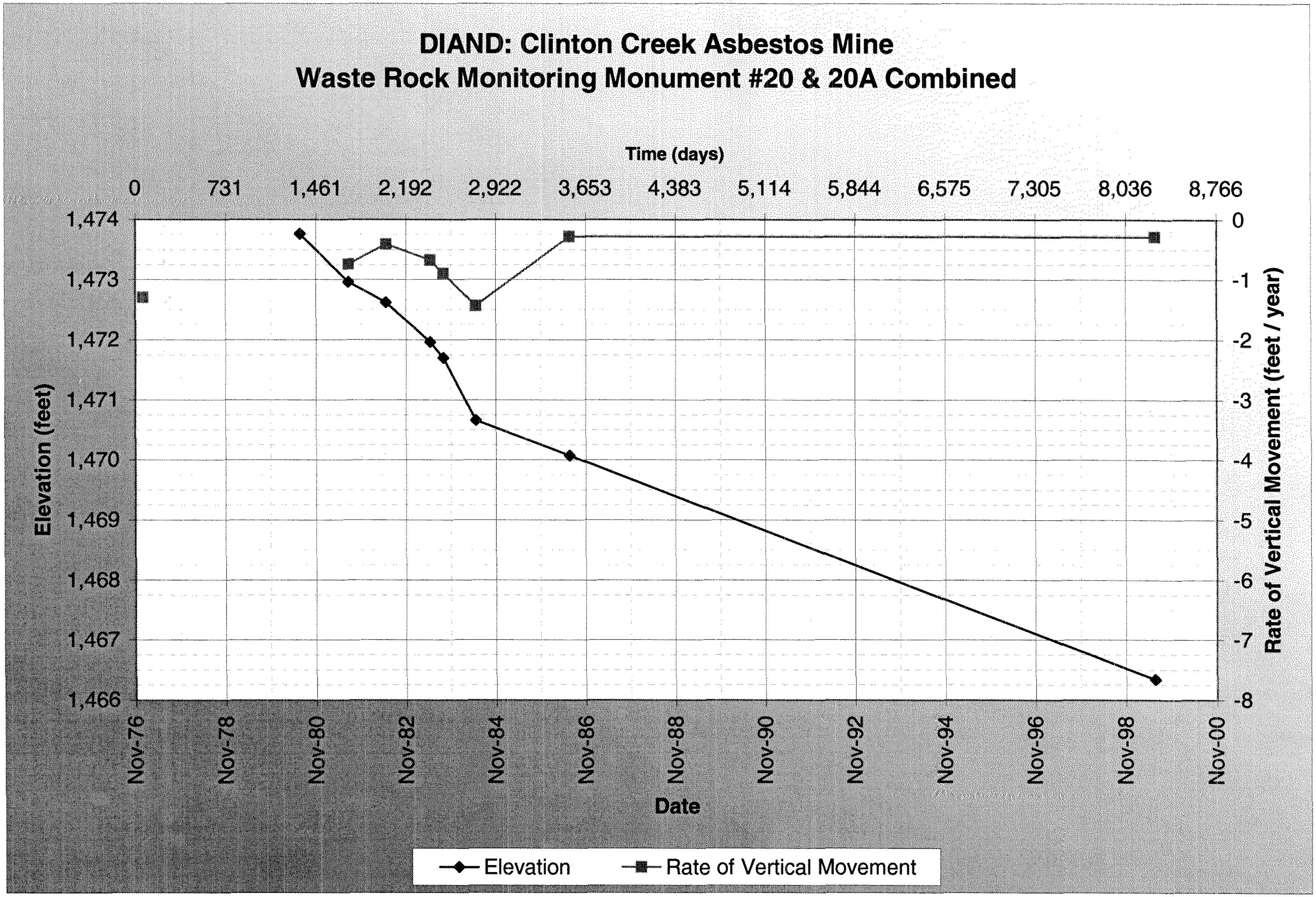
File: monitoring data #20A Tab: #20 & 20A-NE

Date: 11/10/2000



File: monitoring data #20A Tab: #20A-horiz mvmnt

Date: 11/10/2000



File: monitoring data #20A Tab: #20A-vert mvmnt

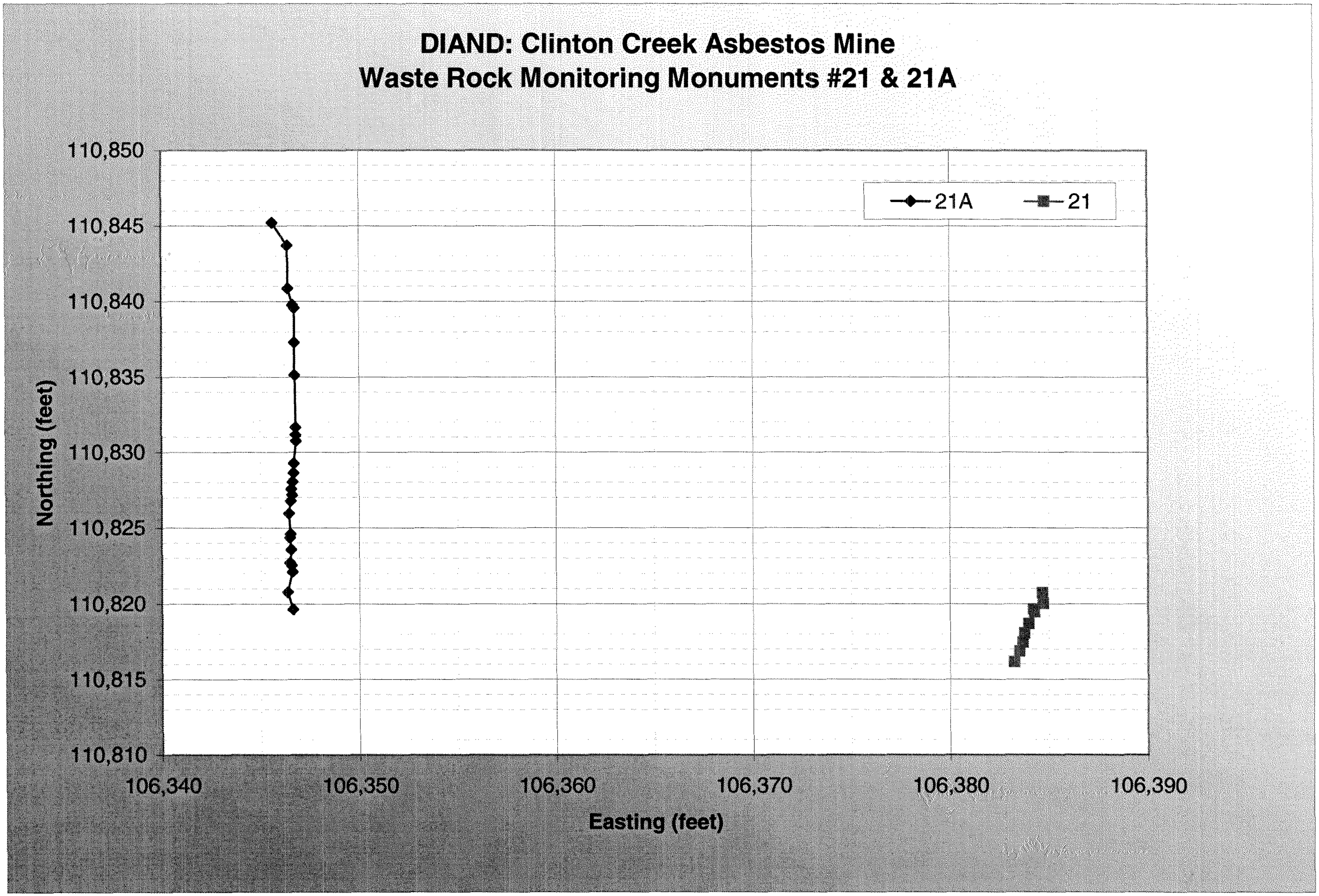
Date: 11/10/2000

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Points #21 & 21A

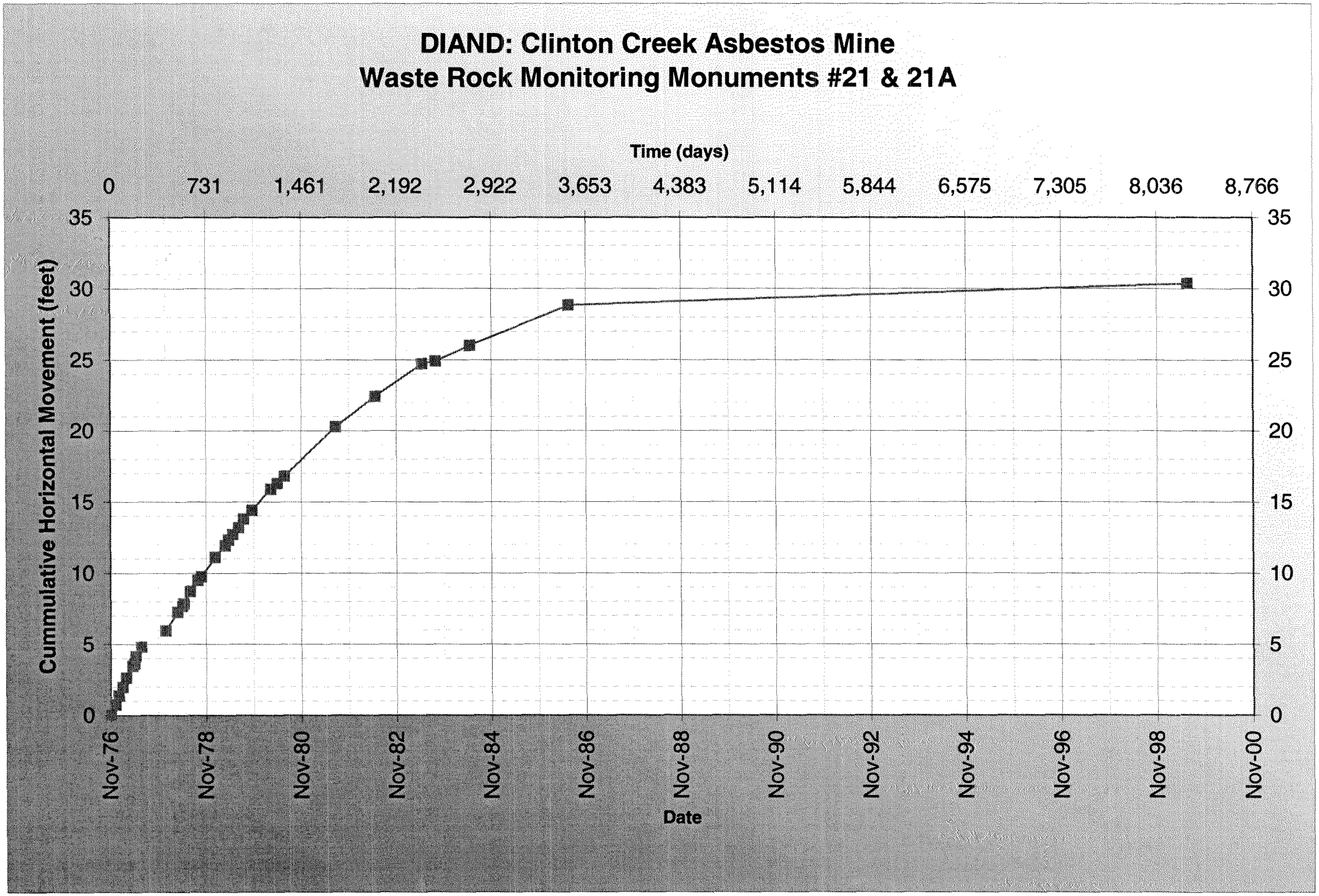
interpolated using survey and rates of movement

Monitoring Date	Northing (feet)	Easting (feet)	Elevation (feet)	Time: Total (days)	Time: Incremental (days)	Horizontal Movement: total (feet)	Horizontal Movement: incremental (feet)	Horizontal Movement: rate (feet / year)	Vertical Movement: total (feet)	Vertical Movement: incremental (feet)	Vertical Movement: rate (feet / year)
Monitor Point #20											
24-Nov-76	110,816.15	106,383.25		0	0	0	0	0			
29-Dec-76	110,816.86	106,383.51		35.0	35.0	0.76	0.76	7.885			
25-Jan-77	110,817.46	106,383.68		62.0	27.0	1.38	0.62	8.430	0.45		
24-Feb-77	110,818.06	106,383.76		92.0	30.0	1.98	0.61	7.365			
23-Mar-77	110,818.69	106,383.97		119.0	27.0	2.64	0.66	8.977			
10-May-77	110,819.48	106,384.26		167.0	48.0	3.48	0.84	6.399			
24-May-77	110,819.66	106,384.23		181.0	14.0	3.64	0.18	4.758			
3-Jun-77	110,820.02	106,384.73		191.0	10.0	4.14	0.62	22.488			
19-Jul-77	110,820.73	106,384.68		237.0	46.0	4.80	0.71	5.648			
Monitor Point #20 A											
18-Nov-77	110,819.65	106,346.63		0	0	0	0	0			
20-Jan-78	110,820.78	106,346.36		63.0	63.0	1.16	1.16	6.731			
20-Apr-78	110,822.12	106,346.59		153.0	90.0	2.47	1.36	5.514			
26-May-78	110,822.55	106,346.55		189.0	36.0	2.90	0.43	4.379			
6-Jun-78	110,822.71	106,346.47		200.0	11.0	3.06	0.18	5.936			
27-Jul-78	110,823.57	106,346.55		251.0	51.0	3.92	0.86	6.181			
22-Sep-78	110,824.35	106,346.49		308.0	57.0	4.70	0.78	5.009			
19-Oct-78	110,824.60	106,346.51		335.0	27.0	4.95	0.25	3.390			
1-Feb-79	110,825.95	106,346.43		440.0	105.0	6.30	1.35	4.701			
22-Apr-79	110,826.78	106,346.51		520.0	80.0	7.13	0.83	3.804			
16-May-79	110,827.18	106,346.60		544.0	24.0	7.53	0.41	6.235			
18-Jun-79	110,827.56	106,346.56		577.0	33.0	7.91	0.38	4.226			
1-Aug-79	110,828.04	106,346.63		621.0	44.0	8.39	0.49	4.024			
7-Sep-79	110,828.63	106,346.68		658.0	37.0	8.98	0.59	5.841			
10-Nov-79	110,829.25	106,346.69		722.0	64.0	9.60	0.62	3.536			
4-Apr-80	110,830.75	106,346.79		868.0	146.0	11.10	1.50	3.758			
24-May-80	110,831.15	106,346.79		918.0	50.0	11.50	0.40	2.920			
17-Jul-80	110,831.65	106,346.79	1478.79	972.0	54.0	12.00	0.50	3.380			
15-Aug-81	110,835.13	106,346.73	1477.77	1366.0	394.0	15.48	3.48	3.224		-1.02	-0.94
15-Jun-82	110,837.30	106,346.71	1477.09	1670.0	304.0	17.65	2.17	2.606		-0.68	-0.82
9-Jun-83	110,839.58	106,346.72	1,476.17	2029.0	359.0	19.93	2.28	2.318		-0.92	-0.94
23-Sep-83	110,839.78	106,346.64	1,476.17	2135.0	106.0	20.13	0.22	0.742		0	0.00
14-Jun-84	110,840.87	106,346.41	1,475.15	2400.0	265.0	21.22	1.11	1.534		-1.02	-1.40
15-Jul-86	110,843.70	106,346.38	1,474.25	3161.0	761.0	24.05	2.83	1.357		-0.9	-0.43
16-Jul-99	110,845.21	106,345.62	1,468.40	7910.0	4749.0	25.58	1.69	0.130		-5.85	-0.45
Monitoring Points 21 & 21A combined											
24-Nov-76				0.0	0.0	0.00	0.00	0.00	0	0	0
29-Dec-76				35.0	35.0	0.76	0.76	7.885			
25-Jan-77				62.0	27.0	1.38	0.62	8.417			
24-Feb-77				92.0	30.0	1.98	0.60	7.277			
23-Mar-77				119.0	27.0	2.64	0.66	8.965			
10-May-77				167.0	48.0	3.48	0.84	6.385			
24-May-77				181.0	14.0	3.64	0.16	4.287			
3-Jun-77				191.0	10.0	4.14	0.50	18.217			
19-Jul-77				237.0	46.0	4.80	0.65	5.195			
18-Nov-77				359.0	122.0						
20-Jan-78				422.0	63.0	5.96	1.16	6.731			
20-Apr-78				512.0	90.0	7.27	1.31	5.307			
26-May-78				548.0	36.0	7.70	0.43	4.368			
6-Jun-78				559.0	11.0	7.86	0.16	5.411			
27-Jul-78				610.0	51.0	8.72	0.86	6.131			
22-Sep-78				667.0	57.0	9.50	0.78	5.003			
19-Oct-78				694.0	27.0	9.75	0.25	3.371			
1-Feb-79				799.0	105.0	11.10	1.35	4.699			
22-Apr-79				879.0	80.0	11.93	0.83	3.777			
16-May-79				903.0	24.0	12.33	0.40	6.069			
18-Jun-79				936.0	33.0	12.71	0.38	4.206			
1-Aug-79				980.0	44.0	13.19	0.48	3.979			
7-Sep-79				1017.0	37.0	13.78	0.59	5.822			
10-Nov-79				1081.0	64.0	14.40	0.62	3.536			
4-Apr-80				1227.0	146.0	15.90	1.50	3.752			
24-May-80				1277.0	50.0	16.30	0.40	2.920			
17-Jul-80			1478.79	1331.0	54.0	16.80	0.50	3.379			
15-Aug-81			1477.77	1725.0	394.0	20.28	3.48	3.223		-1.02	-0.94
15-Jun-82			1477.09	2029.0	304.0	22.45	2.17	2.605		-0.68	-0.82
9-Jun-83			1,476.17	2388.0	359.0	24.73	2.28	2.318		-0.92	-0.94
23-Sep-83			1,476.17	2494.0	106.0	24.93	0.20	0.688		0.00	0.00
14-Jun-84			1,475.15	2759.0	265.0	26.02	1.09	1.503		-1.02	-1.40
15-Jul-86			1,474.25	3520.0	761.0	28.85	2.83	1.357		-0.90	-0.43
16-Jul-99			1,468.40	8269.0	4749.0	30.38	1.53	0.117		-5.85	-0.45



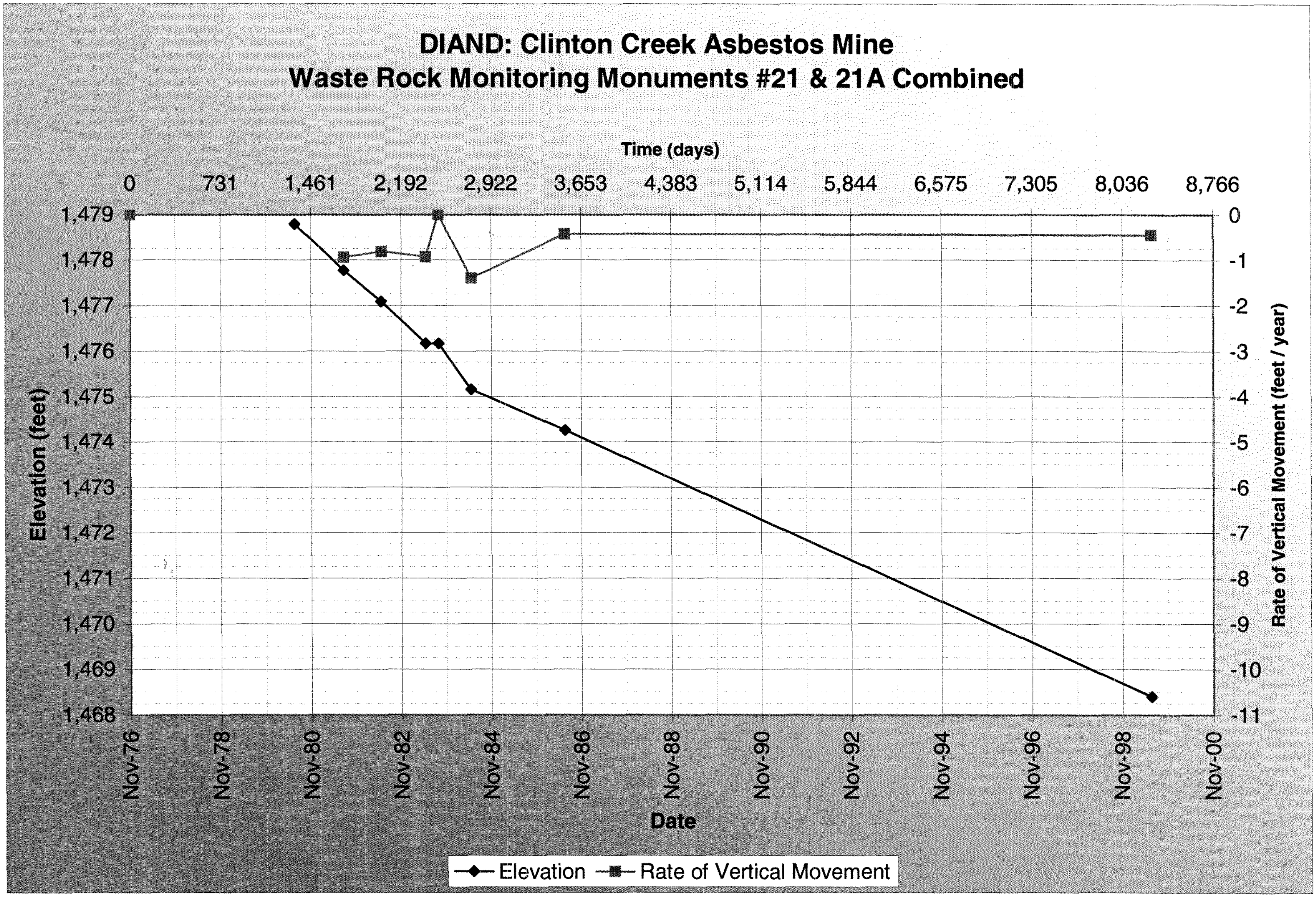
File: monitoring data #21A Tab: #21A-NE

Date: 11/10/2000



File: monitoring data #21A Tab: #21A-horiz mvmnt

Date: 11/10/2000



File: monitoring data #21A Tab: #21A-vert mvmnt

Date: 11/10/2000

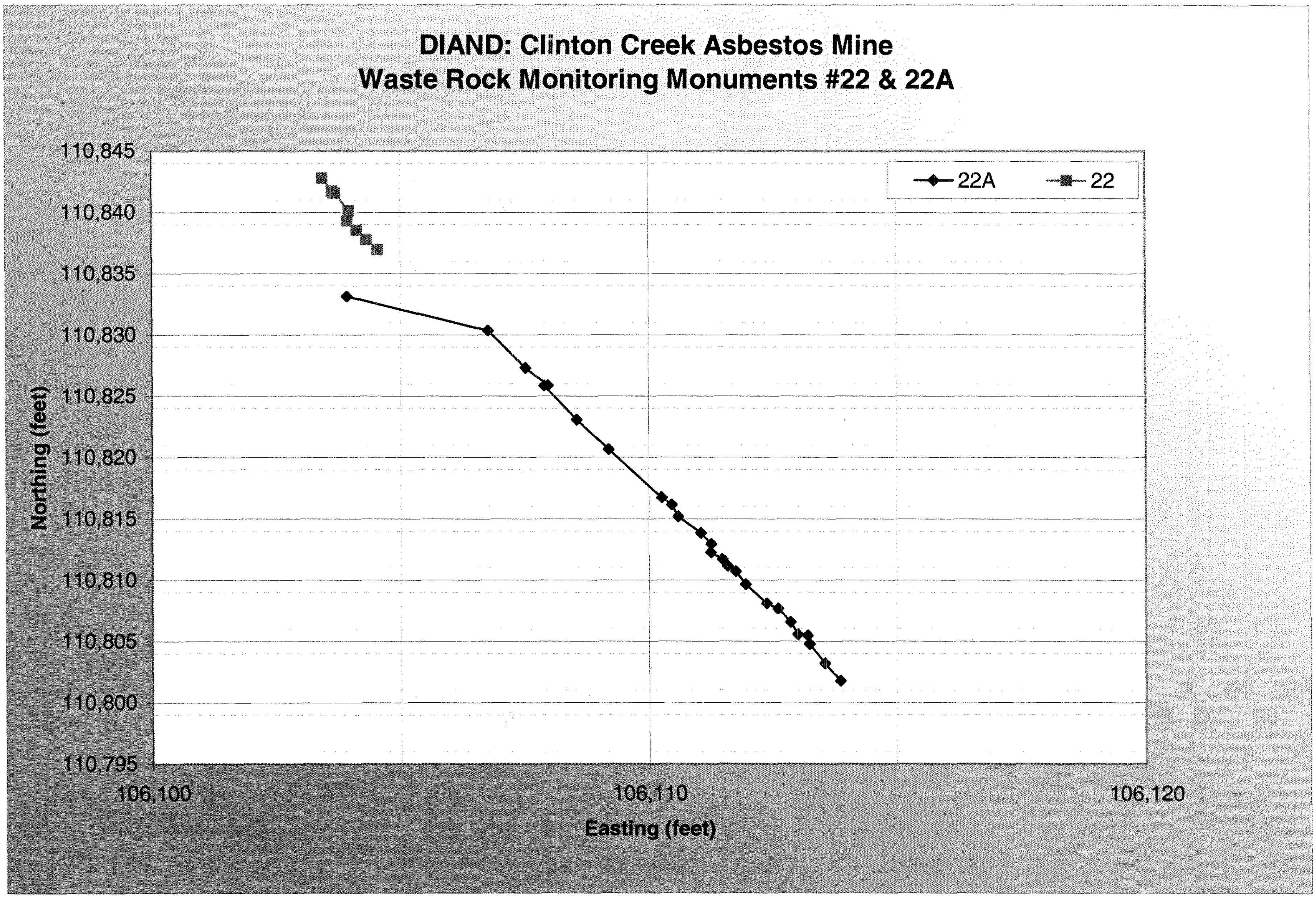
Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Points #22 & 22A

Monitoring Date	Northing (feet)	Easting (feet)	Elevation (feet)	Time: Total (days)	Time: Incremental (days)	Horizontal Movement: total (feet)	Horizontal Movement: incremental (feet)	Horizontal Movement: rate (feet/year)	Vertical Movement: total (feet)	Vertical Movement: incremental (feet)	Vertical Movement: rate (feet / year)
Monitor Point #22											
24-Nov-76	110,836.97	106,104.54		0	0	0	0	0			
29-Dec-76	110,837.76	106,104.32		35.0	35.0	0.82	0.82	8.552			
25-Jan-77	110,838.57	106,104.12		62.0	27.0	1.65	0.83	11.279	-0.88	-0.88	-11.90
24-Feb-77	110,839.33	106,103.93		92.0	30.0	2.44	0.78	9.531			
23-Mar-77	110,840.16	106,103.96		119.0	27.0	3.24	0.83	11.228			
10-May-77	110,841.60	106,103.69		167.0	48.0	4.71	1.47	11.141			
24-May-77	110,841.60	106,103.65		181.0	14.0	4.71	0.04	1.043			
3-Jun-77	110,841.77	106,103.63		191.0	10.0	4.89	0.17	6.248			
19-Jul-77	110,842.80	106,103.43		237.0	46.0	5.93	1.05	8.325			
Monitor Point #22A											
18-Nov-77	110,801.76	106,113.86		0	0	0	0	0			
20-Jan-78	110,803.21	106,113.55		63.0	63.0	1.48	1.48	8.591			
20-Apr-78	110,804.77	106,113.24		153.0	90.0	3.07	1.59	6.450			
26-May-78	110,805.48	106,113.20		189.0	36.0	3.78	0.71	7.210			
6-Jun-78	110,805.56	106,113.00		200.0	11.0	3.90	0.22	7.148			
27-Jul-78	110,806.57	106,112.85		251.0	51.0	4.91	1.02	7.308			
22-Sep-78	110,807.67	106,112.61		308.0	57.0	6.04	1.13	7.210			
19-Oct-78	110,808.10	106,112.38		335.0	27.0	6.51	0.49	6.592			
1-Feb-79	110,809.66	106,111.95		440.0	105.0	8.13	1.62	5.625			
22-Apr-79	110,810.72	106,111.75		520.0	80.0	9.21	1.08	4.922			
16-May-79	110,811.15	106,111.59		544.0	24.0	9.66	0.46	6.978			
18-Jun-79	110,811.70	106,111.48		577.0	33.0	10.22	0.56	6.204			
1-Aug-79	110,812.28	106,111.25		621.0	44.0	10.84	0.62	5.176			
7-Sep-79	110,812.95	106,111.26		658.0	37.0	11.49	0.67	6.610			
10-Nov-79	110,813.85	106,111.05		722.0	64.0	12.41	0.92	5.271			
4-Apr-80	110,815.18	106,110.59		868.0	146.0	13.81	1.41	3.518			
24-May-80	110,816.16	106,110.46		918.0	50.0	14.80	0.99	7.217			
17-Jul-80	110,816.74	106,110.26	1478.09	972.0	54.0	15.41	0.61	4.147			
15-Aug-81	110,820.65	106,109.19	1476.33	1366.0	394.0	19.46	4.05	3.76		-1.76	-1.63
15-Jun-82	110,823.07	106,108.55	1475.58	1670.0	304.0	21.96	2.50	3.01		-0.75	-0.90
9-Jun-83	110,825.85	106,107.89	1474.30	2029.0	359.0	24.82	2.86	2.91		-1.28	-1.30
23-Sep-83	110,825.87	106,107.97	1474.24	2135.0	106.0	24.82	0.08	0.28		-0.06	-0.21
14-Jun-84	110,827.32	106,107.52	1472.76	2400.0	265.0	26.33	1.52	2.09		-1.48	-2.04
15-Jul-86	110,830.34	106,106.76	1471.30	3161.0	761.0	29.45	3.11	1.49		-1.46	-0.70
16-Jul-99	110,833.15	106,103.92	1463.60	7910.0	4749.0	32.93	4.00	0.31		-7.70	-0.59

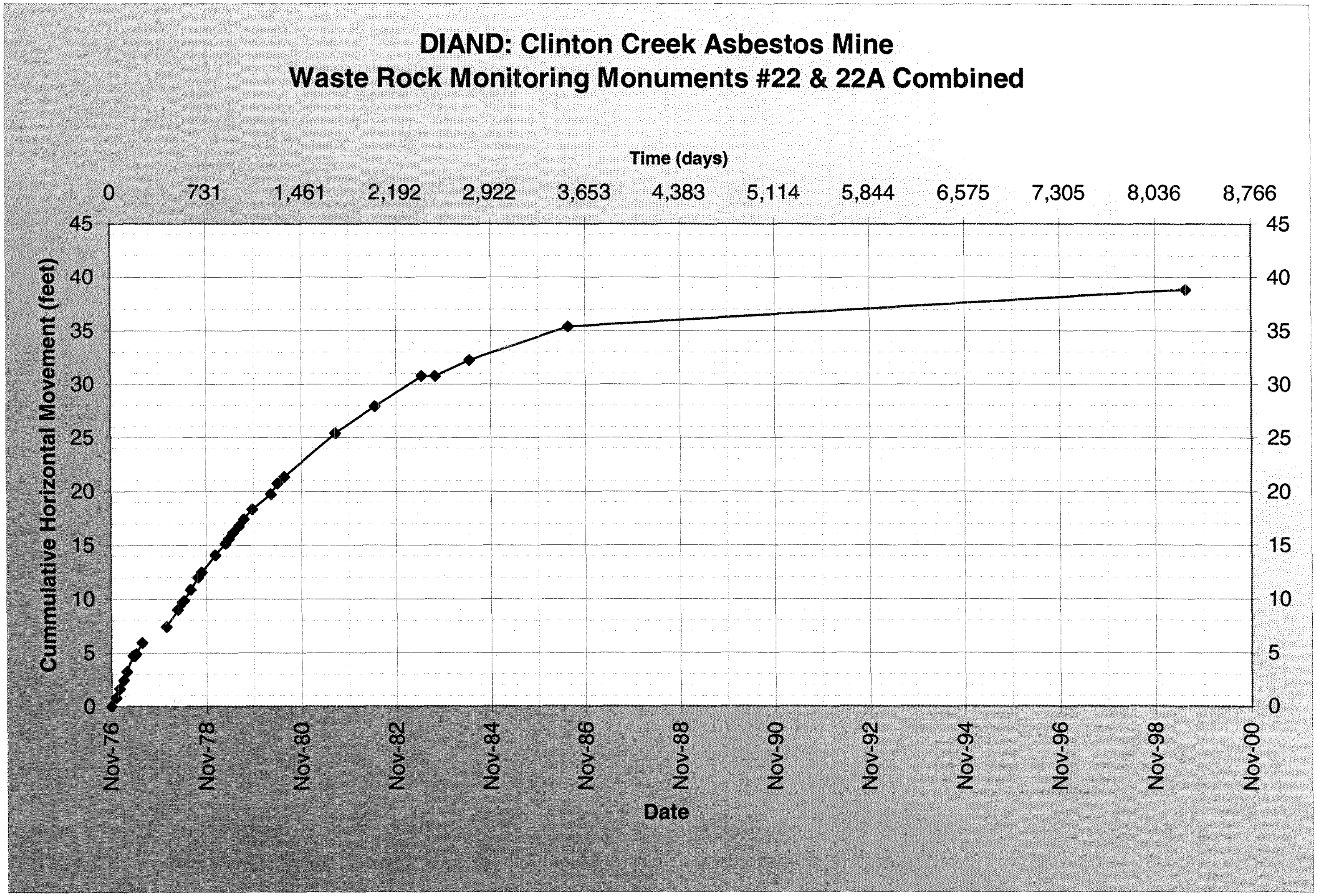
Monitor Point 22 & 22A Combined

Monitoring Date	Northing (feet)	Easting (feet)	Elevation (feet)	Time: Total (days)	Time: Incremental (days)	Horizontal Movement: total (feet)	Horizontal Movement: incremental (feet)	Horizontal Movement: rate (feet/year)	Vertical Movement: total (feet)	Vertical Movement: incremental (feet)	Vertical Movement: rate (feet / year)
24-Nov-76				0.0	0.0	0	0.00	0.00			
29-Dec-76				35.0	35.0	0.82	0.82	8.552			
25-Jan-77				62.0	27.0	1.65	0.83	11.276	-0.88	-0.88	-11.90
24-Feb-77				92.0	30.0	2.44	0.78	9.531			
23-Mar-77				119.0	27.0	3.24	0.80	10.879			
10-May-77				167.0	48.0	4.71	1.47	11.141			
24-May-77				181.0	14.0	4.71	0.01	0.193			
3-Jun-77				191.0	10.0	4.89	0.17	6.232			
19-Jul-77				237.0	46.0	5.93	1.05	8.325			
18-Nov-77				359.0							
20-Jan-78				422.0	63.0	7.42					
20-Apr-78				512.0	90.0	9.01	1.59	6.450			
26-May-78				548.0	36.0	9.71	0.70	7.147			
6-Jun-78				559.0	11.0	9.83	0.12	3.916			
27-Jul-78				610.0	51.0	10.85	1.02	7.291			
22-Sep-78				667.0	57.0	11.98	1.13	7.209			
19-Oct-78				694.0	27.0	12.45	0.47	6.350			
1-Feb-79				799.0	105.0	14.06	1.62	5.622			
22-Apr-79				879.0	80.0	15.14	1.08	4.916			
16-May-79				903.0	24.0	15.60	0.46	6.926			
18-Jun-79				936.0	33.0	16.16	0.56	6.199			
1-Aug-79				980.0	44.0	16.77	0.62	5.126			
7-Sep-79				1017.0	37.0	17.42	0.65	6.404			
10-Nov-79				1081.0	64.0	18.35	0.92	5.271			
4-Apr-80				1227.0	146.0	19.75	1.40	3.501			
24-May-80				1277.0	50.0	20.73	0.98	7.178			
17-Jul-80			1478.09	1331.0	54.0	21.34	0.61	4.127			
15-Aug-81			1476.33	1725.0	394.0	25.39	4.05	3.754		-1.76	-1.63
15-Jun-82			1475.58	2029.0	304.0	27.90	2.50	3.005		-0.75	-0.90
9-Jun-83			1474.30	2388.0	359.0	30.75	2.86	2.905		-1.28	-1.30
23-Sep-83			1474.24	2494.0	106.0	30.75	0.00	0.001		-0.06	-0.21
14-Jun-84			1472.76	2759.0	265.0	32.27	1.52	2.087		-1.48	-2.04
15-Jul-86			1471.30	3520.0	761.0	35.38	3.11	1.494		-1.46	-0.70
16-Jul-99			1463.60	8269.0	4749.0	38.86	3.48	0.267		-7.7	-0.59



File: monitoring data #22 Tab: #22-NE

Date: 11/10/2000



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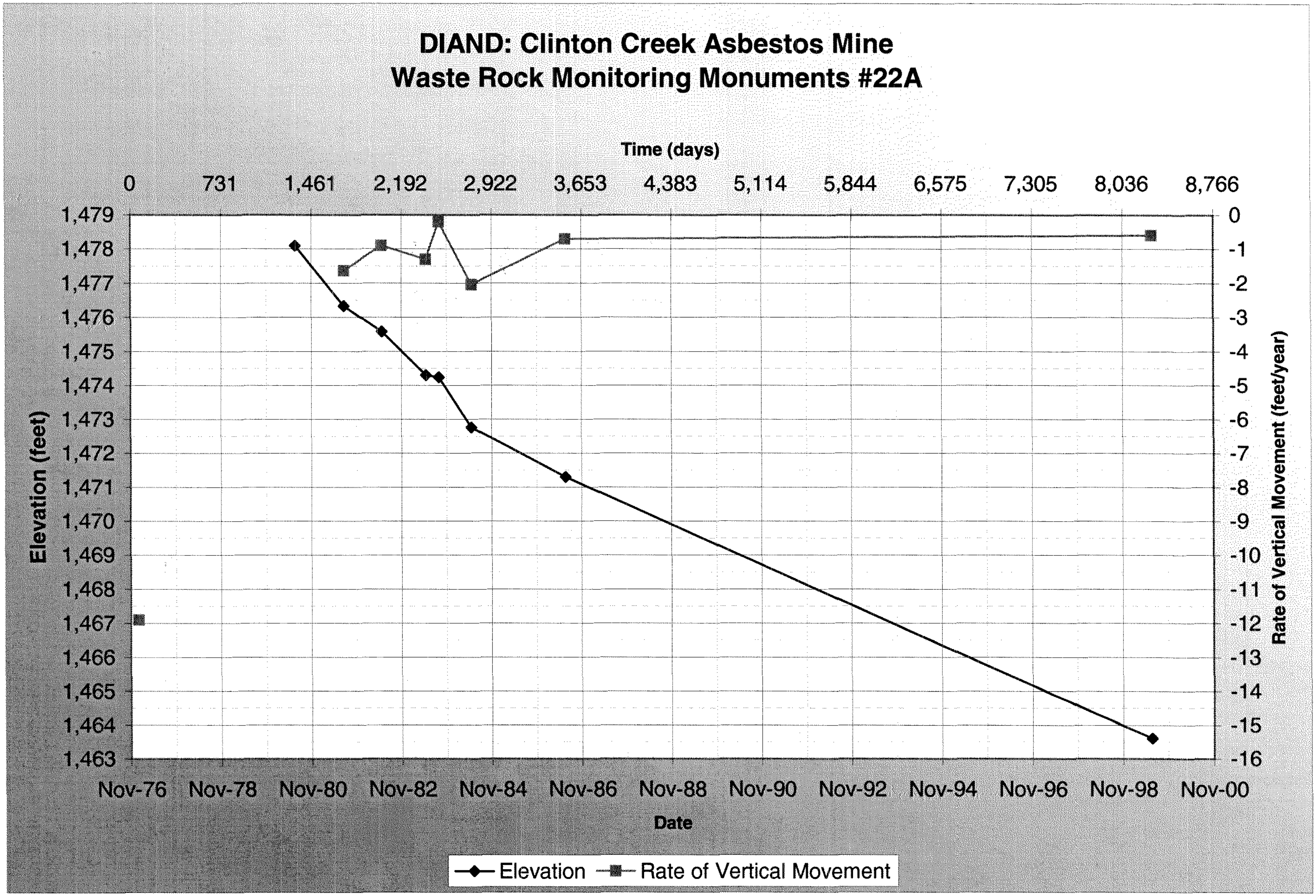
Date: 11/10/2000



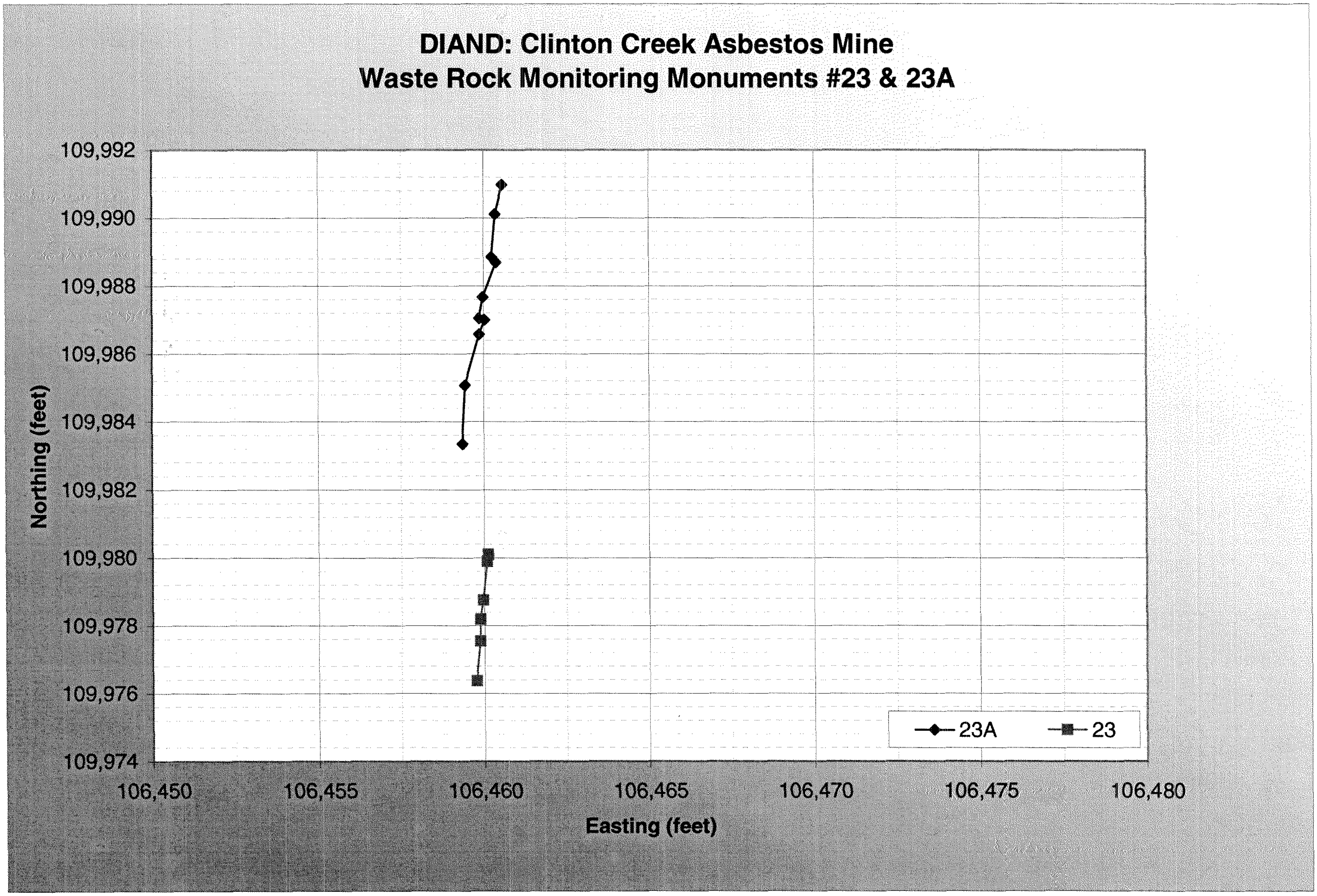
File: monitoring data #22 Tab: #22-vert mvmnt

Date: 11/10/2000

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

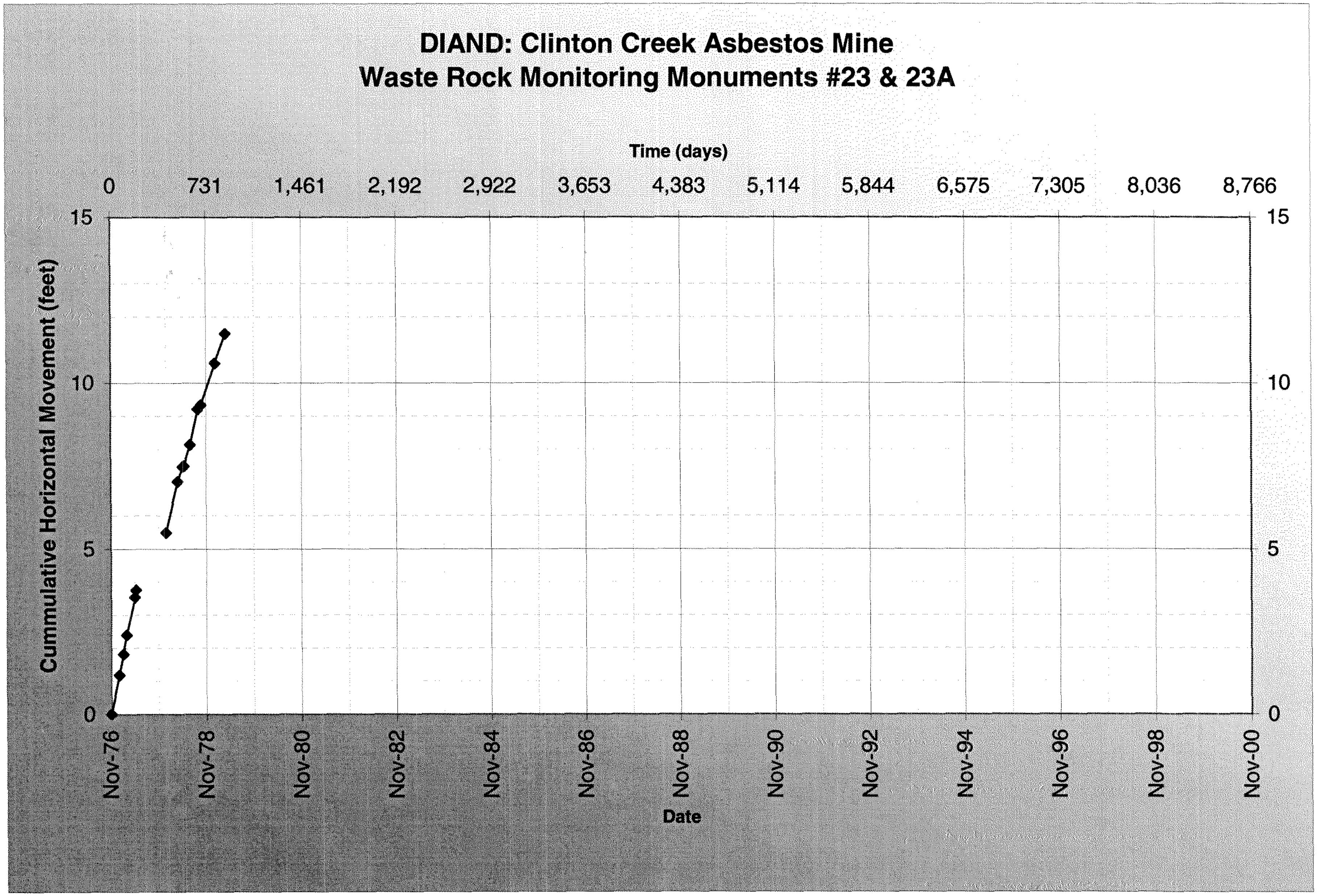
Waste Dump Stability - Monitoring Points #23 & 23A

Monitoring	Northing	Easting	Elevation	Time		Horizontal Movement			Vertical Movement		
Date	(feet)	(feet)	(feet)	Total (days)	Incremental (days)	total (feet)	incremental (feet)	rate (feet/year)	total (feet)	incremental (feet)	rate (feet/year)
Monitor Point #23											
24-Nov-76	109,976.37	106,459.76		0	0	0	0	0			
25-Jan-77	109,977.55	106,459.87		62.0	62.0	1.19	1.19	0.573	0.68		
24-Feb-77	109,978.19	106,459.87		92.0	30.0	1.82	0.64	0.640			
23-Mar-77	109,978.76	106,459.97		119.0	27.0	2.40	0.58	0.643			
24-May-77	109,979.90	106,460.08		181.0	62.0	3.54	1.15	0.554			
3-Jun-77	109,980.11	106,460.12		191.0	10.0	3.76	0.21	0.641			
Monitor Point #23A											
18-Nov-77	109,983.34	106,459.35		0	0	0	0	0			
20-Jan-78	109,985.07	106,459.43		63.0	63.0	1.73	1.73	0.825			
20-Apr-78	109,986.57	106,459.86		153.0	90.0	3.27	1.56	0.520			
26-May-78	109,987.00	106,460.02		189.0	36.0	3.72	0.46	0.382			
06-Jun-78	109,987.04	106,459.86		200.0	11.0	3.73	0.16	0.450			
27-Jul-78	109,987.67	106,459.98		251.0	51.0	4.38	0.64	0.377			
22-Sep-78	109,988.69	106,460.37		308.0	57.0	5.45	1.09	0.575			
19-Oct-78	109,988.85	106,460.25		335.0	27.0	5.58	0.20	0.222			
01-Feb-79	109,990.11	106,460.35		440.0	105.0	6.84	1.26	0.361			
22-Apr-79	109,990.98	106,460.57		520.0	80.0	7.74	0.90	0.337			
Monitor Points 23 & 23A Combined											
24-Nov-76				0.0	0.0	0.00	0.00	0.00			
25-Jan-77				62.0	62.0	1.19	1.19	6.98			
24-Feb-77				92.0	30.0	1.82	0.64	7.76			
23-Mar-77				119.0	27.0	2.40	0.58	7.79			
24-May-77				181.0	62.0	3.54	1.15	6.74			
3-Jun-77				191.0	10.0	3.76	0.21	7.77			
18-Nov-77				359.0	168.0						
20-Jan-78				422.0	63.0	5.49					
20-Apr-78				512.0	90.0	7.03	1.54	6.24			
26-May-78				548.0	36.0	7.48	0.45	4.57			
06-Jun-78				559.0	11.0	7.49	0.01	0.47			
27-Jul-78				610.0	51.0	8.13	0.64	4.58			
22-Sep-78				667.0	57.0	9.20	1.07	6.86			
19-Oct-78				694.0	27.0	9.34	0.14	1.85			
01-Feb-79				799.0	105.0	10.60	1.26	4.38			
22-Apr-79				879.0	80.0	11.49	0.89	4.08			



File: monitoring data #23 Tab: #23-NE

Date: 11/10/2000



File: monitoring data #23 Tab: #23-horiz mvmnt

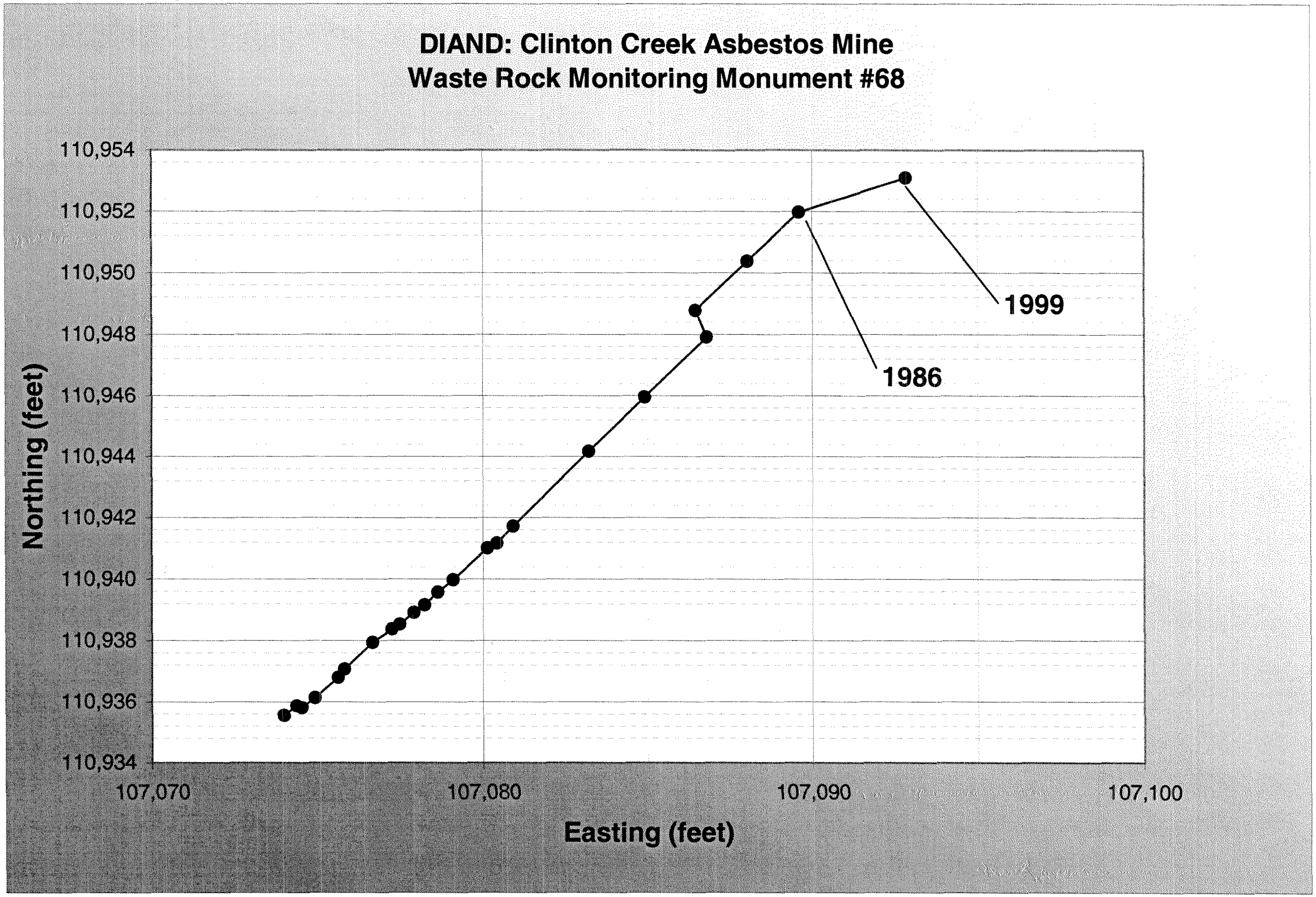
Date: 11/10/2000

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Point #68

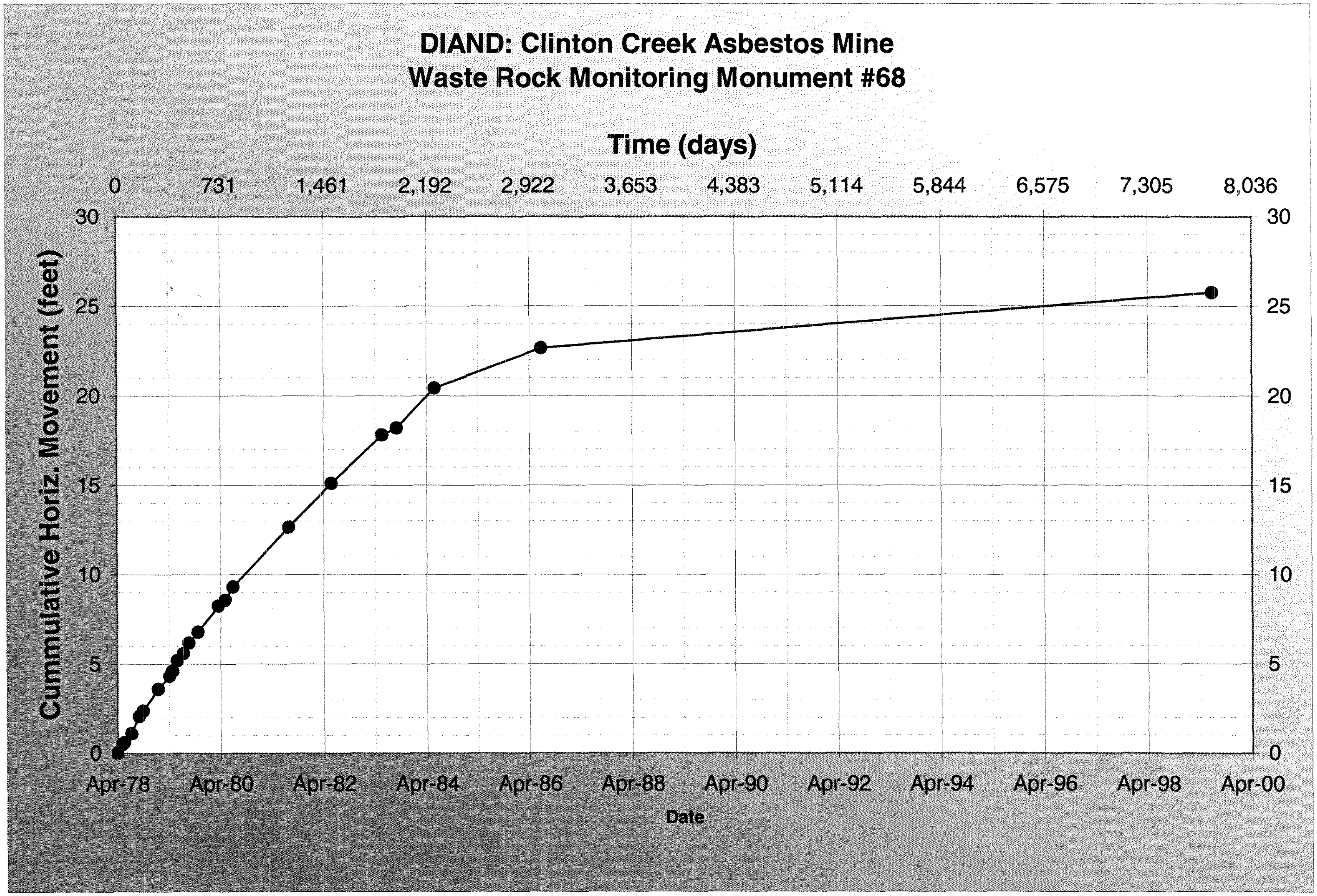
Interpolated Values

Monitoring	Northing	Easting	Elevation	Time		Horizontal Movement			Vertical Movement		
Date	(feet)	(feet)	(feet)	Total (days)	Incremental (days)	total (feet)	incremental (feet)	rate (feet/year)	total (feet)	incremental (feet)	rate (feet/year)
20-Apr-78	110,935.55	107,073.97		0	0	0	0	0			
26-May-78	110,935.87	107,074.36		36.0	36.0	0.50	0.50	5.115			
6-Jun-78	110,935.81	107,074.52		47.0	11.0	0.61	0.17	5.670			
27-Jul-78	110,936.13	107,074.91		98.0	51.0	1.10	0.50	3.610			
22-Sep-78	110,936.80	107,075.61		155.0	57.0	2.06	0.97	6.205			
19-Oct-78	110,937.07	107,075.80		182.0	27.0	2.38	0.33	4.463			
1-Feb-79	110,937.94	107,076.65		287.0	105.0	3.59	1.22	4.228			
22-Apr-79	110,938.37	107,077.24		367.0	80.0	4.32	0.73	3.331			
16-May-79	110,938.53	107,077.48		391.0	24.0	4.60	0.29	4.387			
18-Jun-79	110,938.92	107,077.91		424.0	33.0	5.18	0.58	6.421			
1-Aug-79	110,939.16	107,078.23		468.0	44.0	5.58	0.40	3.318			
7-Sep-79	110,939.58	107,078.63		505.0	37.0	6.16	0.58	5.722			
10-Nov-79	110,939.98	107,079.09		569.0	64.0	6.77	0.61	3.477			
4-Apr-80	110,941.01	107,080.14		715.0	146.0	8.24	1.47	3.677			
24-May-80	110,941.17	107,080.43		765.0	50.0	8.56	0.33	2.418			
17-Jul-80	110,941.72	107,080.92	1437.29	819.0	54.0	9.29	0.74	4.979			
15-Aug-81	110,944.17	107,083.22	1437.50	1213.0	394.0	12.64	3.36	3.113		0.2	0.19
15-Jun-82	110,945.95	107,084.91	1437.65	1517.0	304.0	15.09	2.45	2.947		0.2	0.18
9-Jun-83	110,947.91	107,086.79	1436.40	1876.0	359.0	17.81	2.72	2.761		-1.3	-1.27
23-Sep-83	110,948.78	107,086.46	1436.09	1982.0	106.0	18.19	0.93	3.204		-0.3	-1.07
14-Jun-84	110,950.38	107,088.03	1435.57	2247.0	265.0	20.44	2.24	3.088		-0.5	-0.72
15-Jul-86	110,951.97	107,089.60	1434.58	3008.0	761.0	22.67	2.23	1.072		-1.0	-0.47
17-Jul-99	110,953.09	107,092.83	1429.37	7758.0	4750.0	25.76	3.42	0.263		-5.2	-0.40



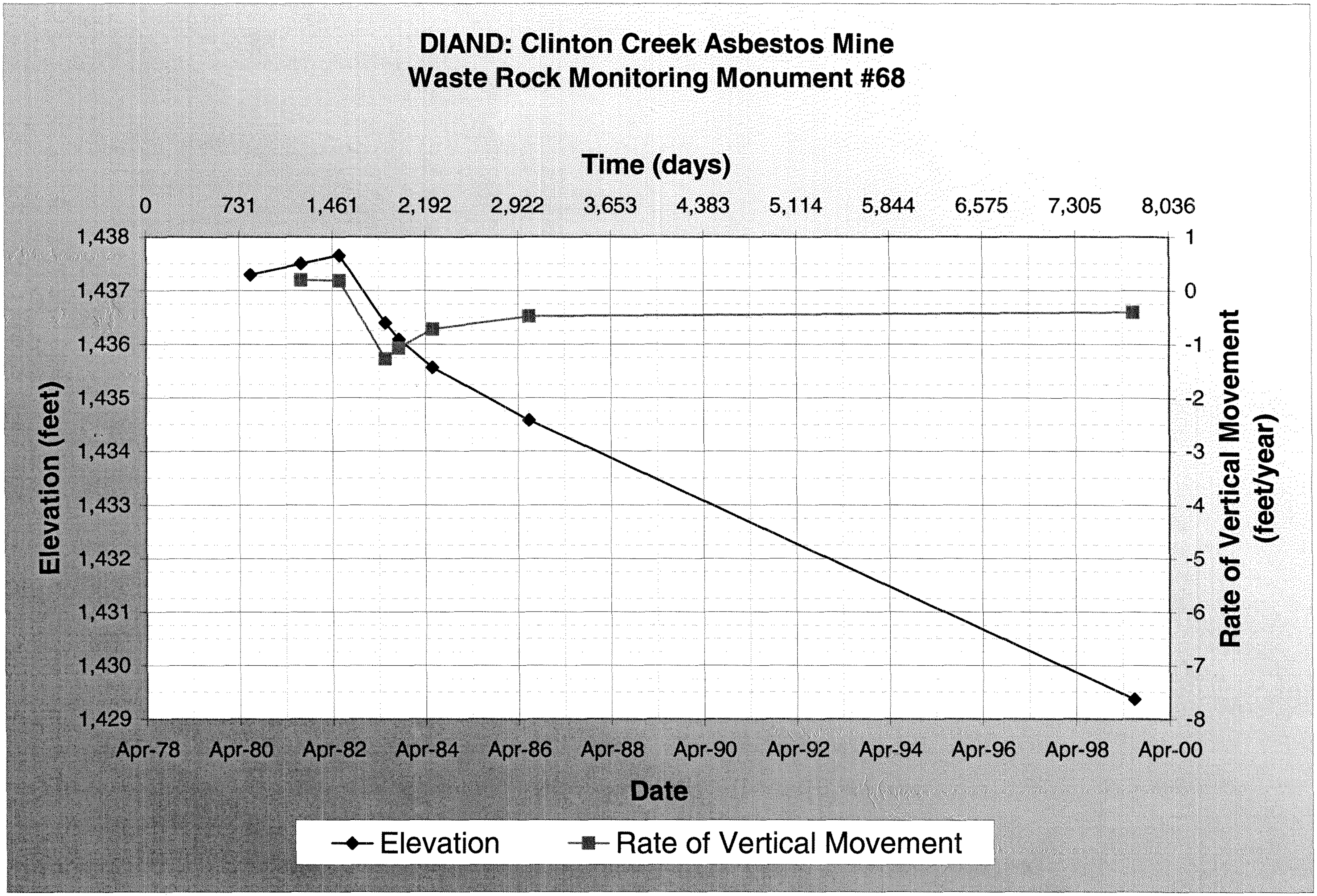
File: monitoring data #68 Tab: #68-NE

Date: 11/10/2000



File: monitoring data #68 Tab: #68-horiz mvmnt

Date: 11/10/2000



File: monitoring data #68 Tab: #68- vert mvmnt

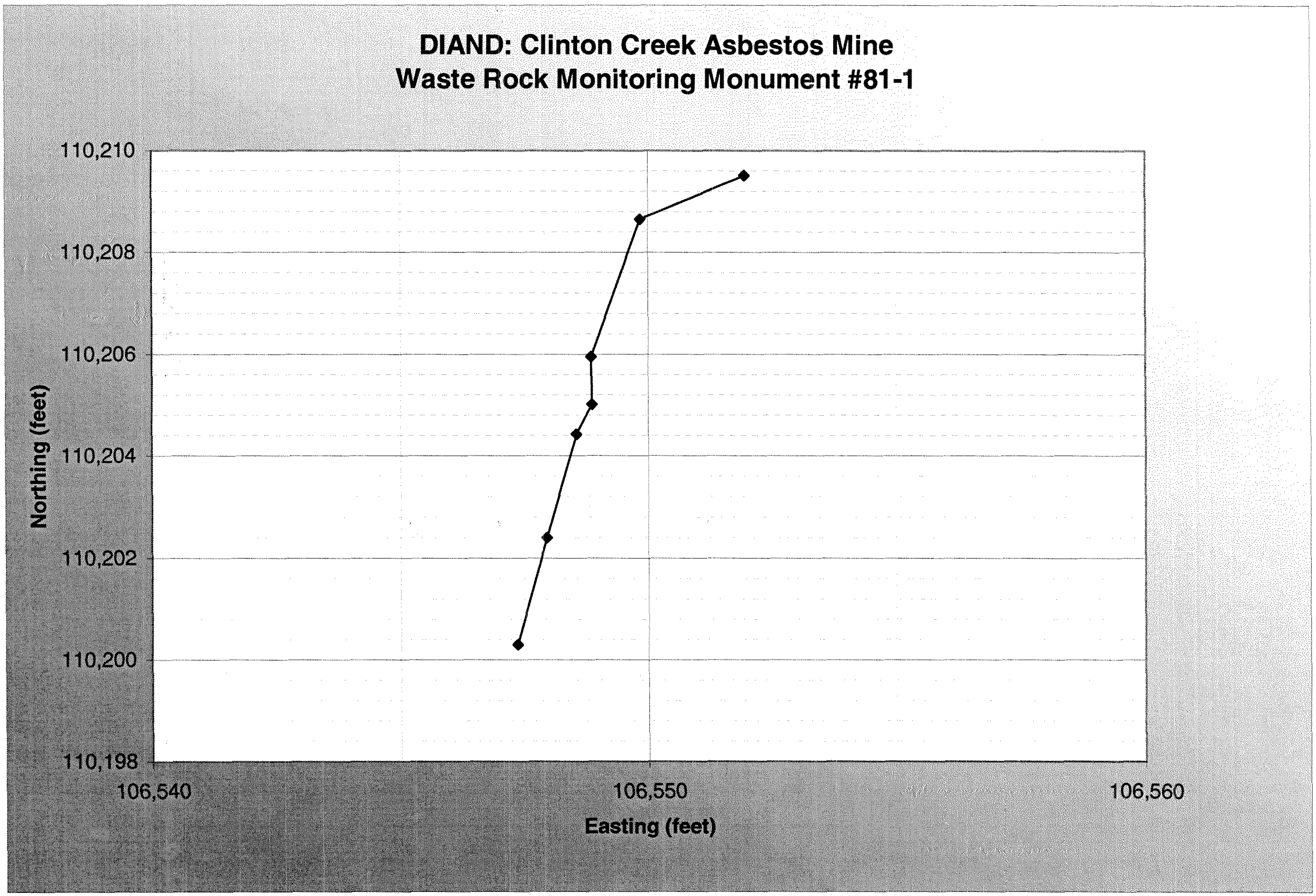
Date: 11/10/2000

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Point #81-1

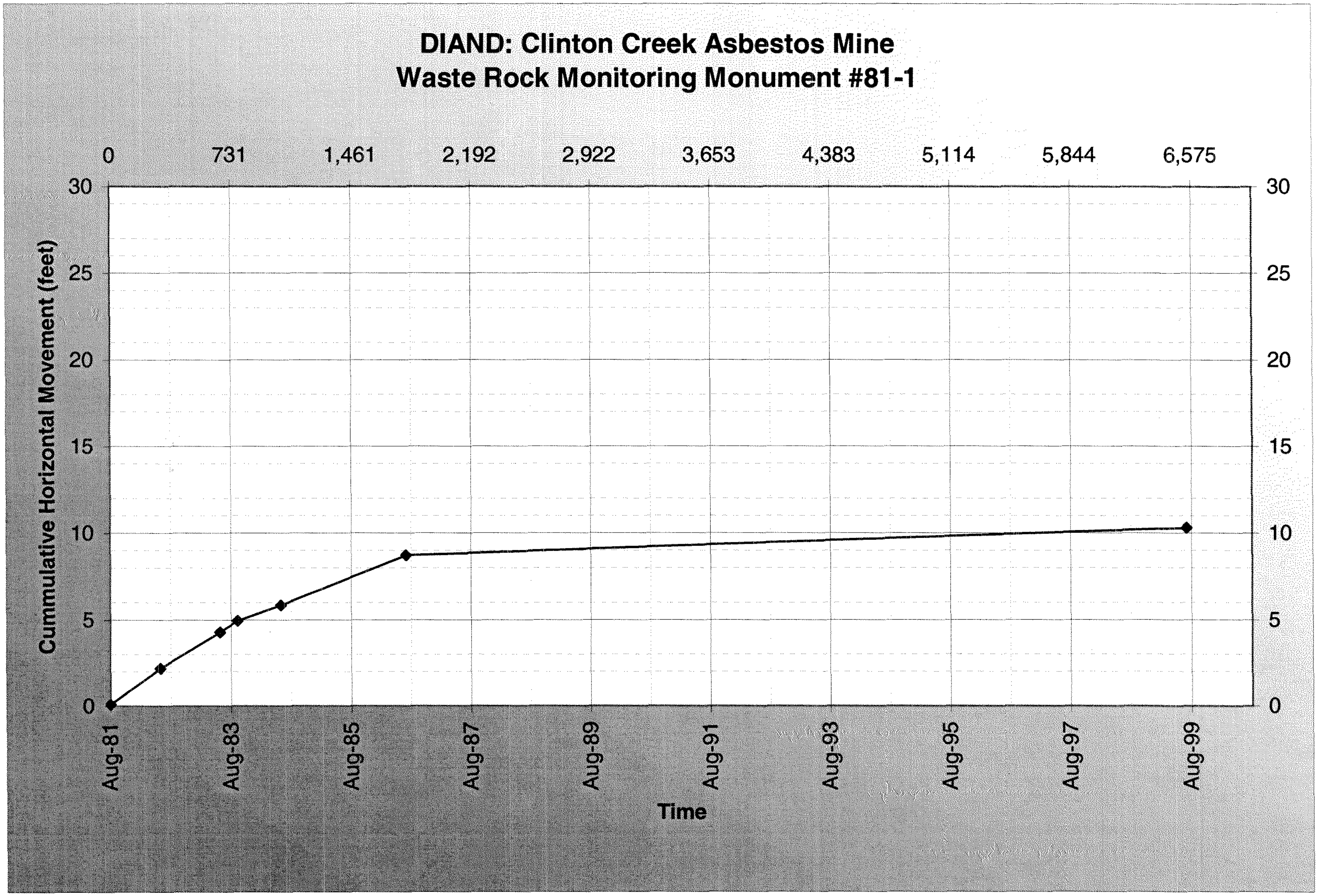
Extrapolated Values Based On Movement rates

Monitoring	Northing	Easting	Elevation	Time		Horizontal Movement			Vertical Movement		
Date	(feet)	(feet)	(feet)	Total (days)	Increment (days)	total (feet)	increment (feet)	rate (feet/year)	total (feet)	incremental (feet)	rate (feet/year)
15-Aug-81	110200.3	106547.35	1504.39	0	0	0	0	0	0	0	0
15-Jun-82	110202.4	106547.95	1503.6	304.0	304.0	2.18	2.18	2.622	-0.79	-0.79	-0.95
9-Jun-83	110,204.42	106,548.55	1502.82	663.0	359.0	4.29	2.11	2.142	-1.57	-0.78	-0.79
23-Sep-83	110,205.01	106,548.86	1502.65	769.0	106.0	4.95	0.67	2.295	-1.74	-0.17	-0.59
14-Jun-84	110,205.95	106,548.85	1501.43	1034.0	265.0	5.85	0.94	1.295	-2.96	-1.22	-1.68
15-Jul-86	110,208.65	106,549.84	1500.7	1795.0	761.0	8.71	2.88	1.379	-3.69	-0.73	-0.35
17-Jul-99	110,209.51	106,551.95	1497.28	6545.0	4750.0	10.29	2.28	0.175	-7.11	-3.42	-0.26



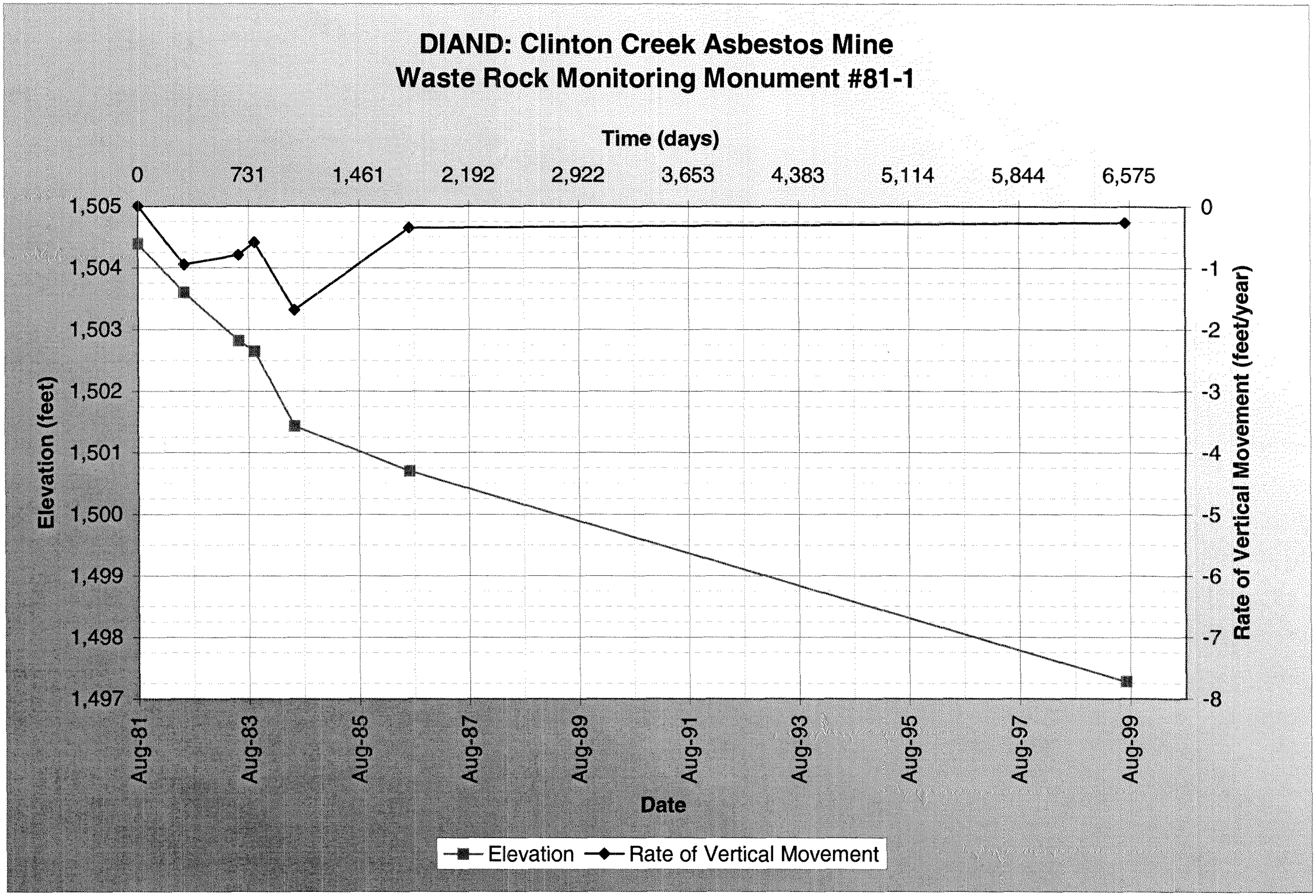
File: monitoring data #81-1 Tab: 81-1 - NE

Date: 11/10/2000



File: monitoring data #81-1 Tab: #81-1 horiz mvmnt

Date: 11/10/2000



File: monitoring data #81-1 Tab: #81-1-vert mvmnt

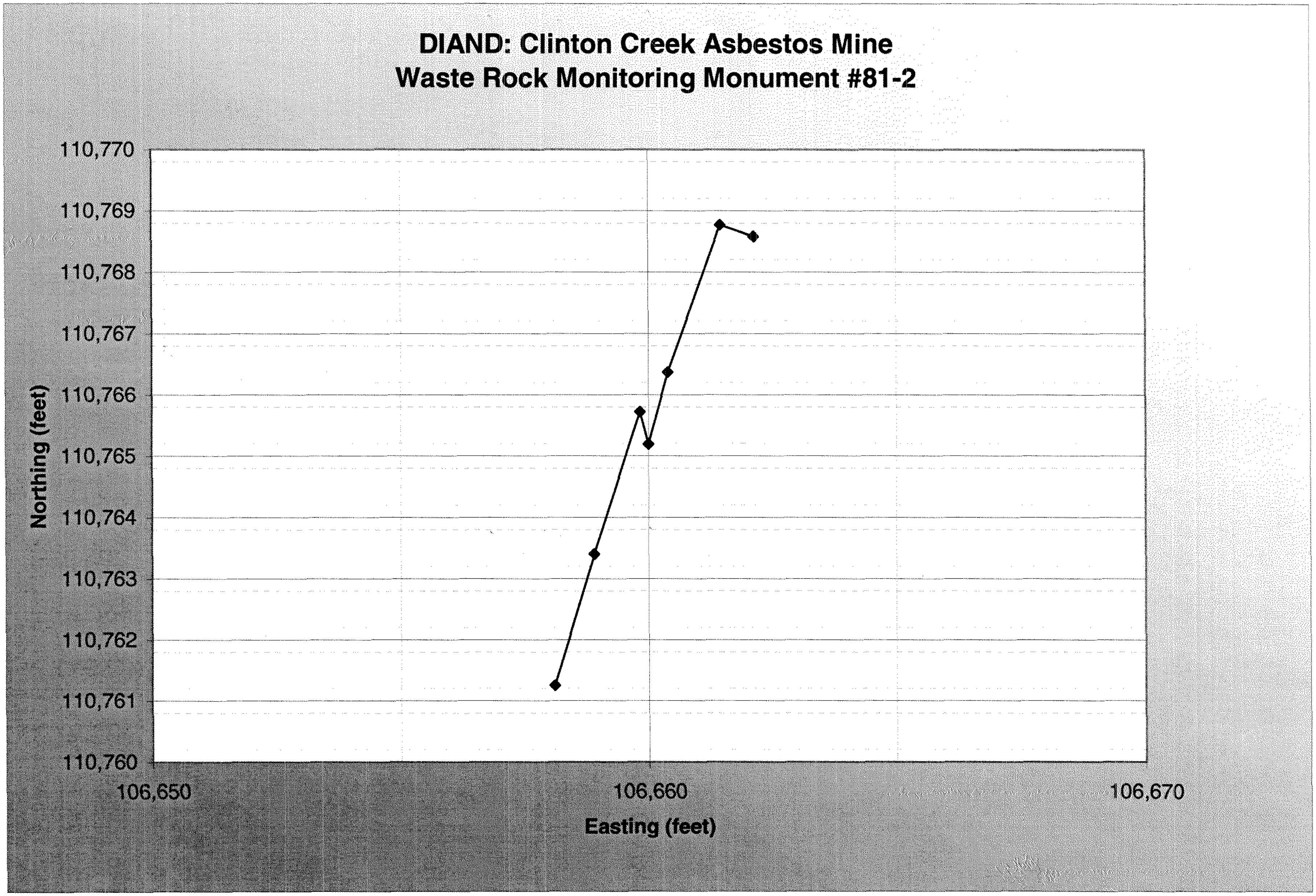
Date: 11/10/2000

Client: DIAND
Project: Clinton Creek Asbestos Mine
Job No.: 4440-038-02-02
Date: 22-Sep-00

Waste Dump Stability - Monitoring Point #81-2

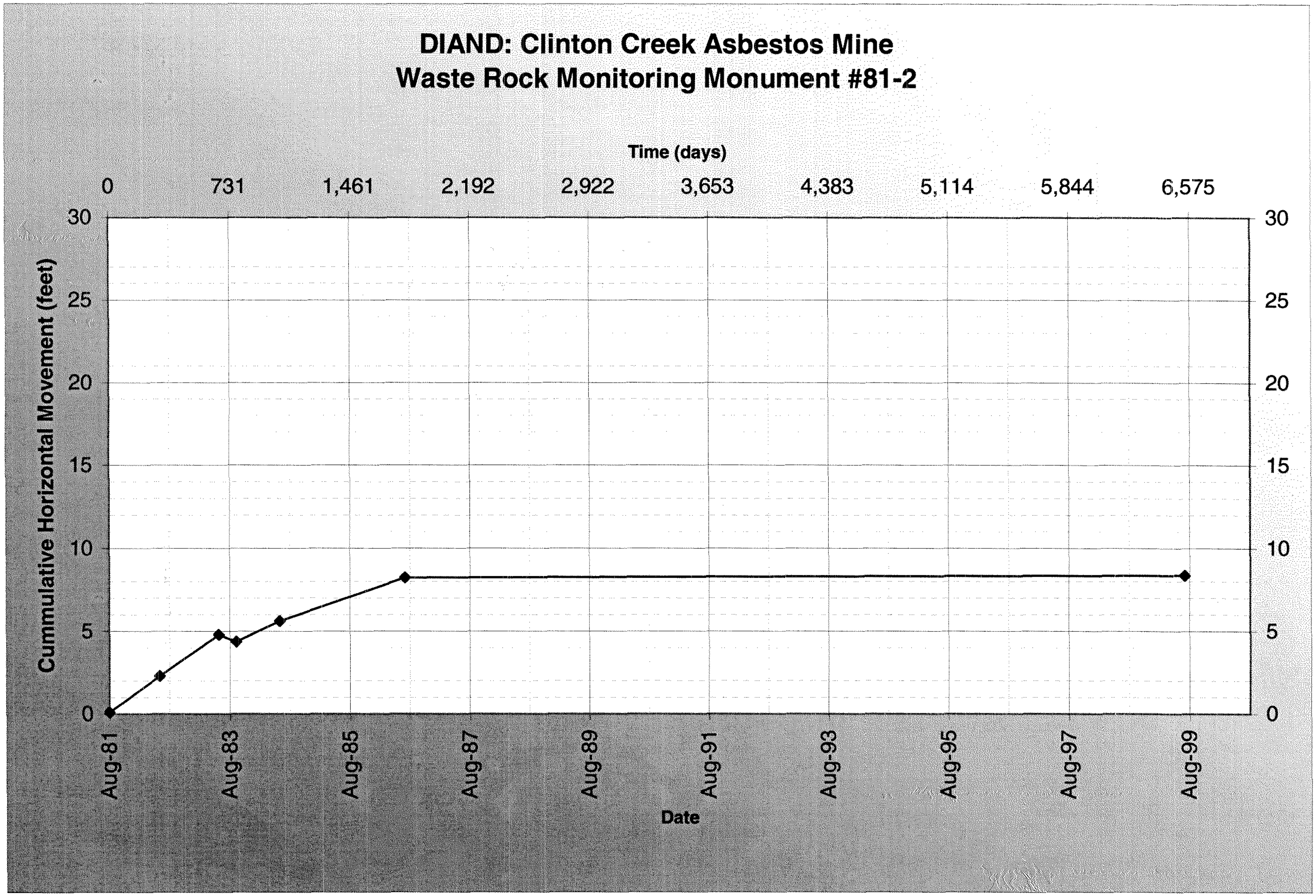
Values extrapolated

Monitoring	Northing	Easting	Elevation	Time		Horizontal Movement			Vertical Movement		
Date				Total	Increment	total	increment	rate	total	incremental	rate
	(feet)	(feet)	(feet)	(days)	(days)	(feet)	(feet)	(feet/year)	(feet)	(feet)	(feet/year)
15-Aug-81	110761.25	106658.1	1466.27	0	0	0	0	0	0	0	0
15-Jun-82	110763.4	106658.9	1465.53	304.0	304.0	2.29	2.29	2.754	-0.74	-0.74	-0.89
9-Jun-83	110,765.72	106,659.83	1465.06	663.0	359.0	4.79	2.50	2.541	-1.21	-0.47	-0.48
23-Sep-83	110,765.19	106,660.00	1463.97	769.0	106.0	4.37	0.56	1.917	-2.30	-1.09	-3.75
14-Jun-84	110,766.37	106,660.40	1463.78	1034.0	265.0	5.61	1.25	1.716	-2.49	-0.19	-0.26
15-Jul-86	110,768.77	106,661.46	1462.88	1795.0	761.0	8.24	2.62	1.258	-3.39	-0.9	-0.43
17-Jul-99	110,768.58	106,662.14	1459.45	6545.0	4750.0	8.37	0.71	0.054	-6.82	-3.43	-0.26



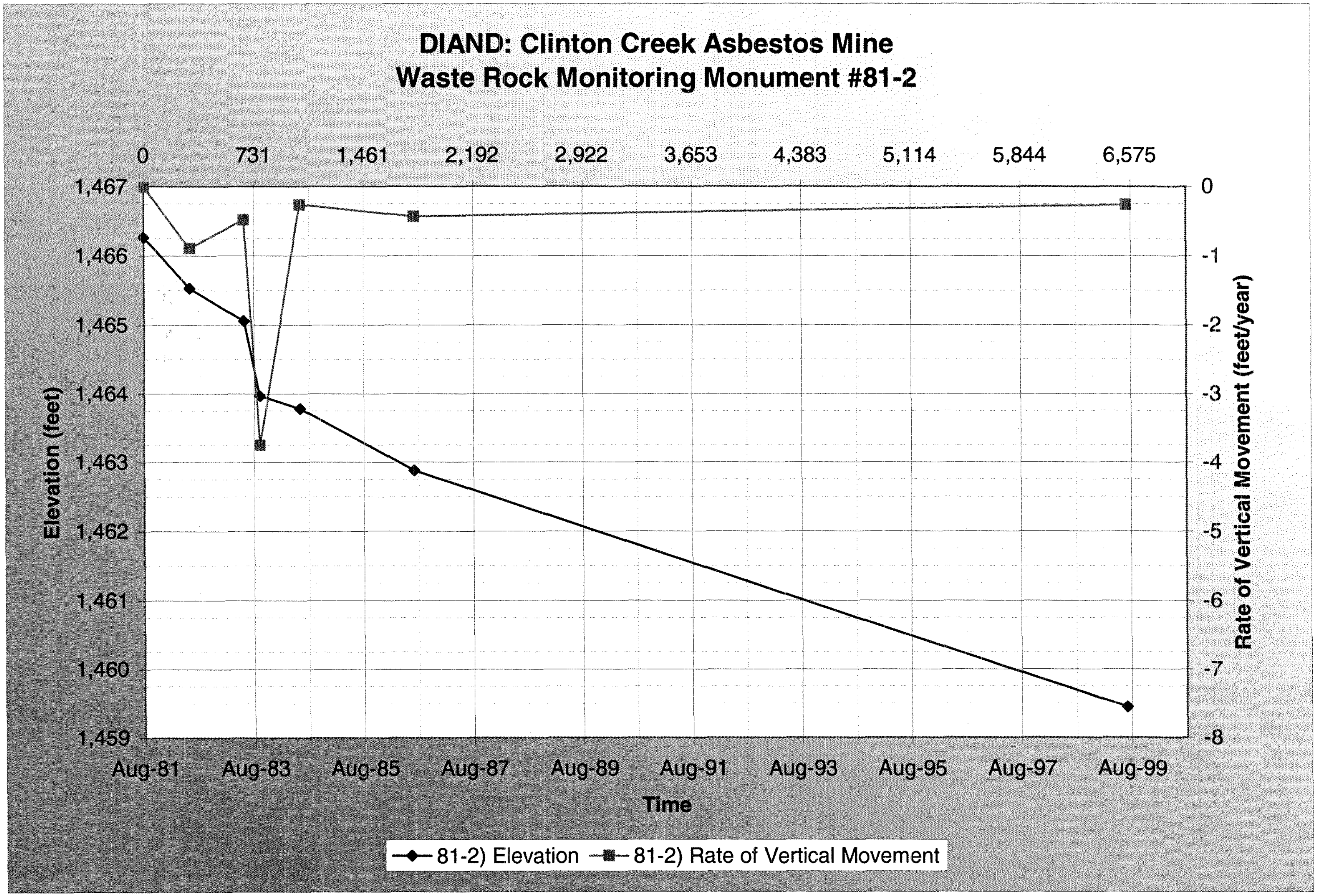
File: monitoring data #81-2 Tab: 81-2 - NE

Date: 11/10/2000



File: monitoring data #81-2 Tab: #81-2-horiz mvmnt

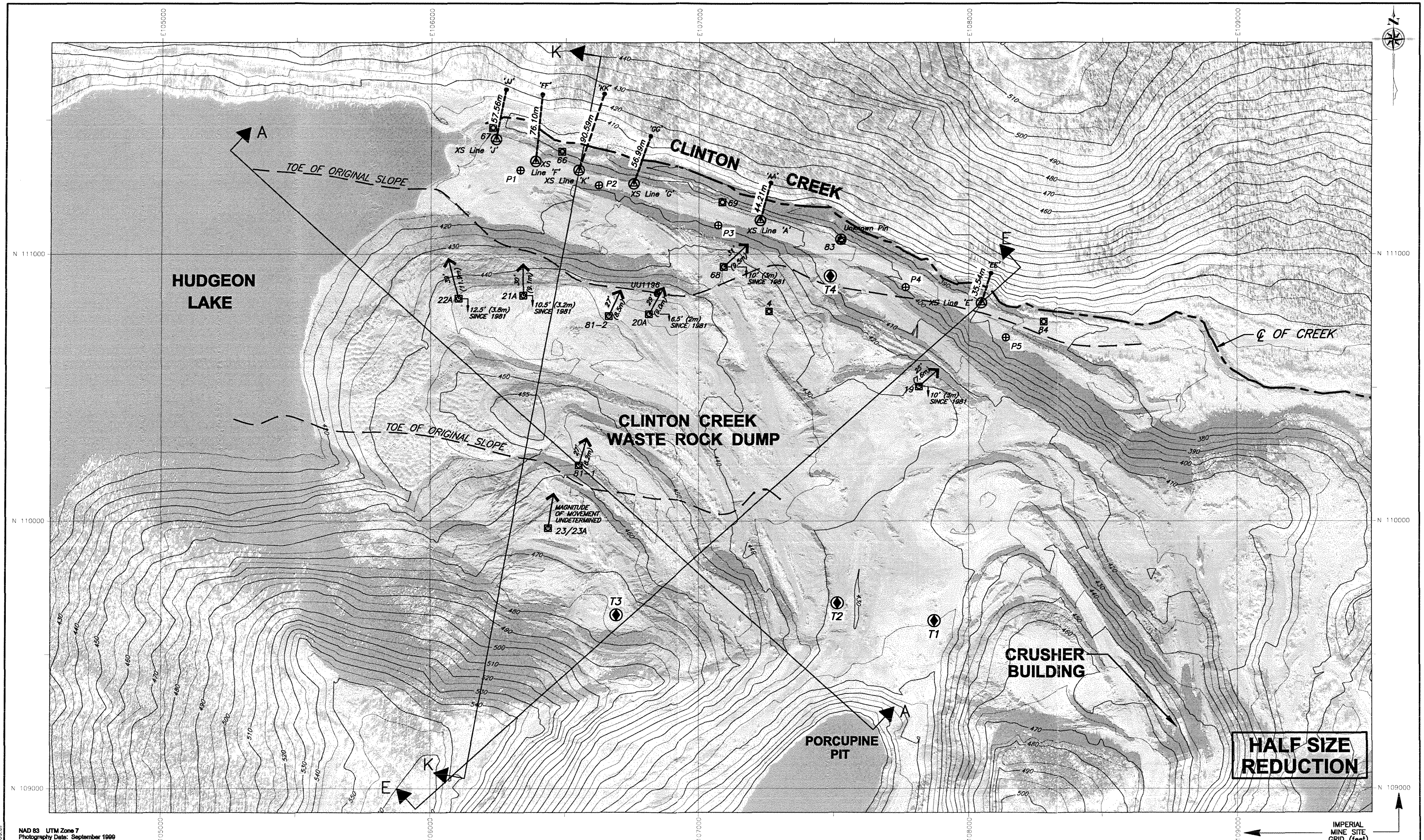
Date: 11/10/2000



File: monitoring data #81-2 Tab: #81-2-vert mvmnt

Date: 11/10/2000

DRAWINGS



NOV 16/01 Plot Scale: 1=1 ps image:MINEmos.tif
CC-01.dwg

LEGEND

- HORIZONTAL DISTANCE (1999) 57.56m — PRISM; CROSS-CHANNEL REFERENCE LINE; IRON BAR
- P1 ⊕ STANDPIPE PIEZOMETER
- ◘ PREVIOUS MOVEMENT MONITORING POINT
- T1 ◈ THERMISTOR
- 30' (9.1m) — DIRECTION & MAGNITUDE OF HORIZONTAL MOVEMENT SINCE 1976 scale 1:500
- 10' (3m) SINCE 1981 — MAGNITUDE OF VERTICAL MOVEMENT SINCE 1981

REV.	DESCRIPTION	DWN.	APP.	DATE

SEAL

SEAL

UMA — UMA Engineering Ltd. Engineers and Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

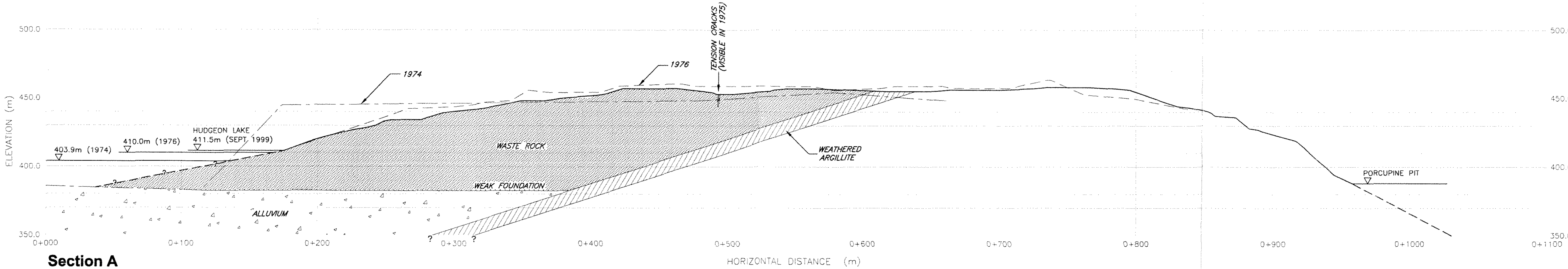
APPROVED BY	MARCH, 2001 DATE
DRAWN BY: LJV	DESIGNED BY: –
CHECKED BY: KS	CHECKED BY: –
SCALE: 1:2000	JOB No. 4440-038-02-02

INDIAN AND NORTHERN AFFAIRS CANADA

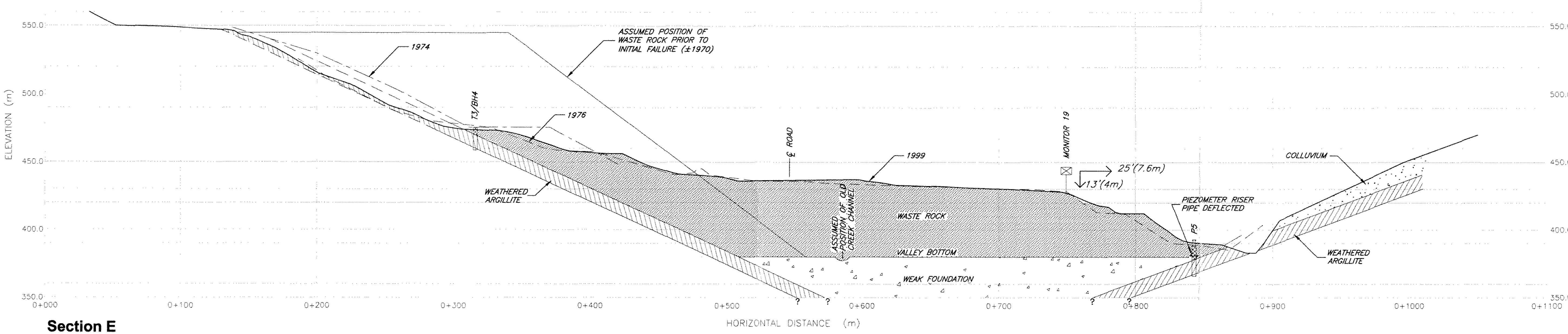
ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

WASTE ROCK DUMP INSTRUMENTATION

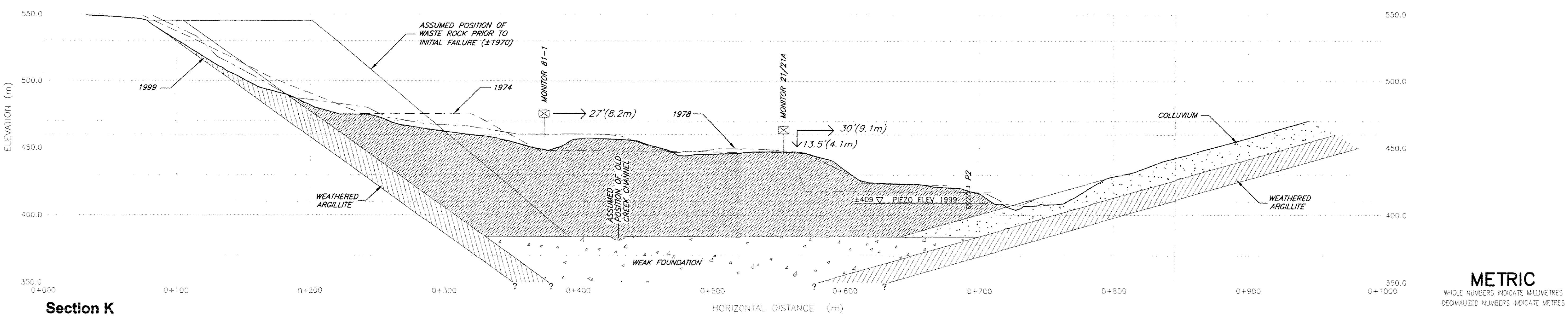
DWG. No. 01 REV. –



Section A



Section E



Section K

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

LEGEND

⊠ MOVEMENT MONITORING POINT

25' / 13' HORIZONTAL & VERTICAL MOVEMENT SINCE 1976

HALF SIZE REDUCTION

REV.	DESCRIPTION	DWN.	APP.	DATE

SEAL

SEAL

UMA Engineering Ltd.
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

APPROVED BY:	DATE: MARCH, 2001
DRAWN BY: LJV	DESIGNED BY: –
CHECKED BY: KS	CHECKED BY: –
SCALE: 1:1500	JOB No. 4440-038-02-02

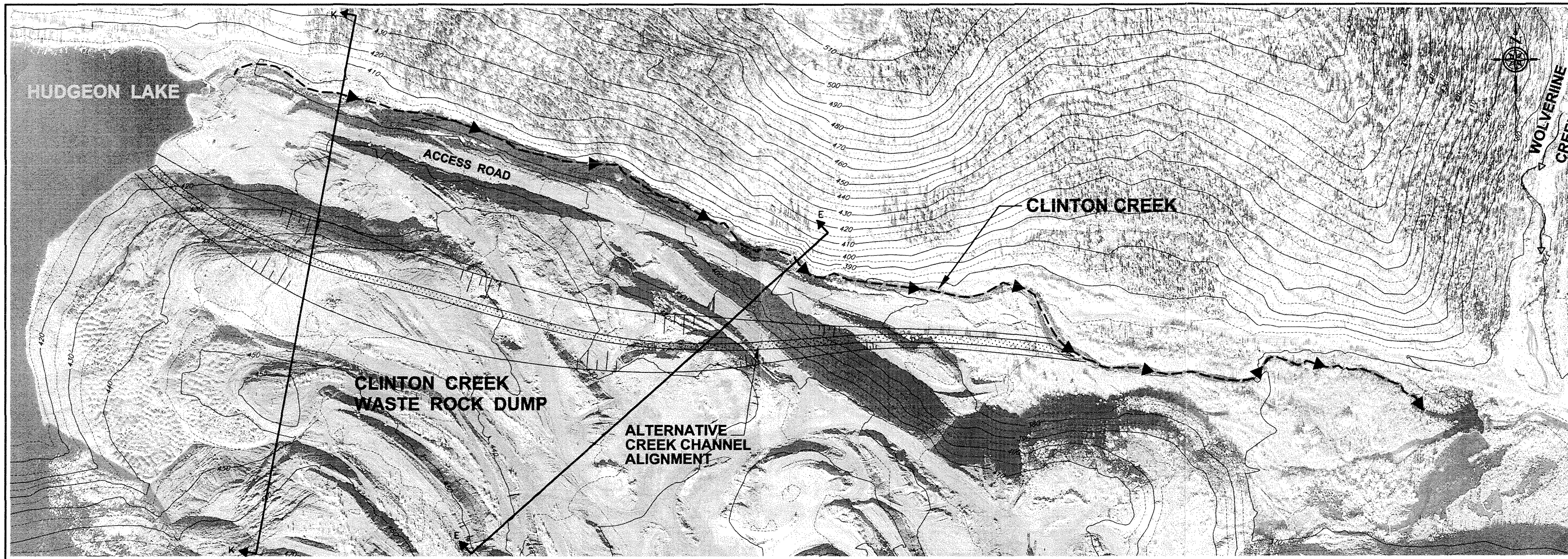
INDIAN AND NORTHERN AFFAIRS CANADA

ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

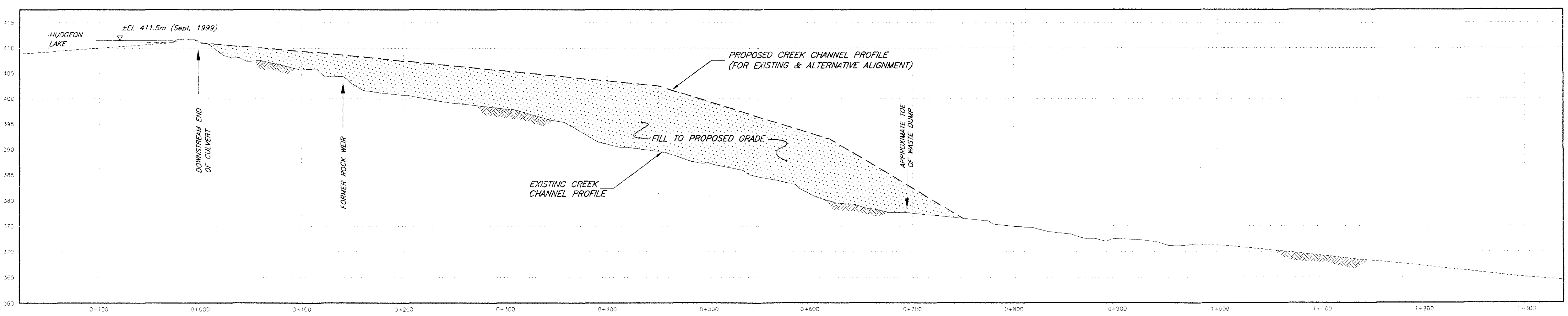
WASTE ROCK DUMP CROSS SECTIONS

DWG. No. 02 REV. –

MAR 29/01
Plot Scale: 1=1 ps
CC-02.dwg



EXISTING & ALTERNATIVE CREEK CHANNEL
SCALE 1:2000



EXISTING & ALTERNATIVE CREEK CHANNEL PROFILE
VER. SCALE 1:400
HOR. SCALE 1:2000

HALF SIZE REDUCTION

NAD 83 UTM Zone 7
Photography Date: September 1999

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

REV.	DESCRIPTION	DWN.	APP.	DATE

SEAL

SEAL

UMA Engineering Ltd.
Engineers and Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7
MARCH, 2001

APPROVED BY	DATE
DRAWN BY: LJV	DESIGNED BY: KMS
CHECKED BY:	CHECKED BY:
SCALE: AS SHOWN	JOB No. 4440-038-02-1.2

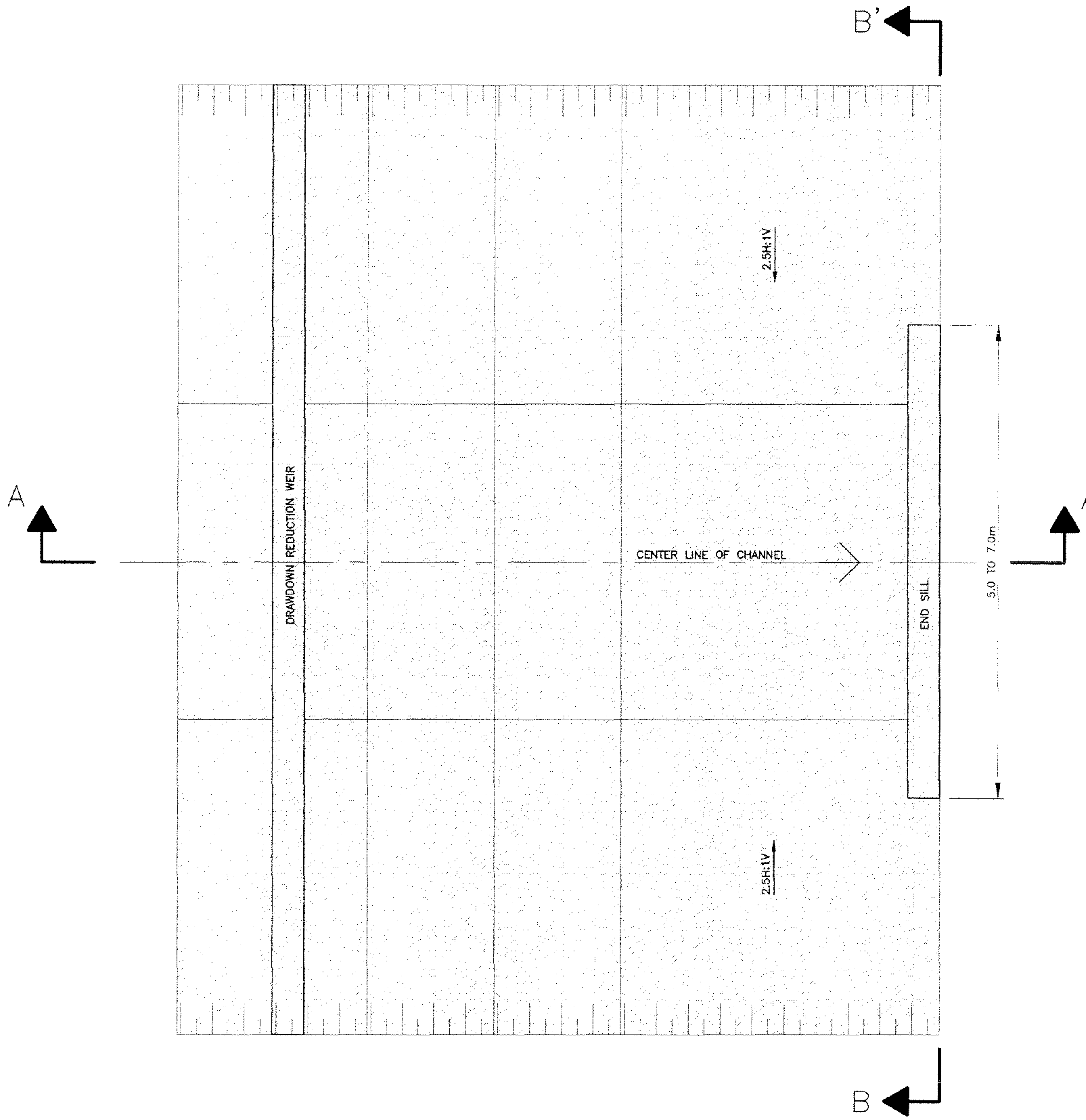
INDIAN AND NORTHERN AFFAIRS CANADA

ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

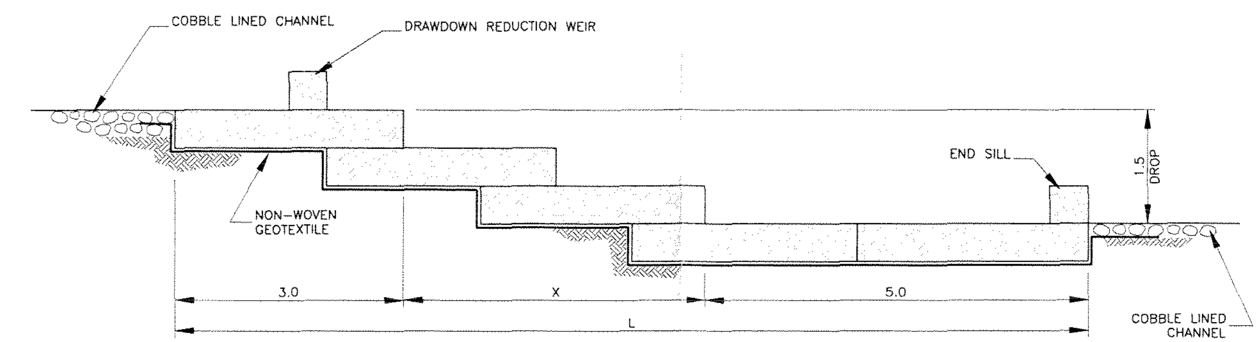
PROPOSED CREEK CHANNEL PROFILE

DWG. No. 03 REV. –

MAR 29/01
Plot Scale: 1=1 ps
CC-03.dwg



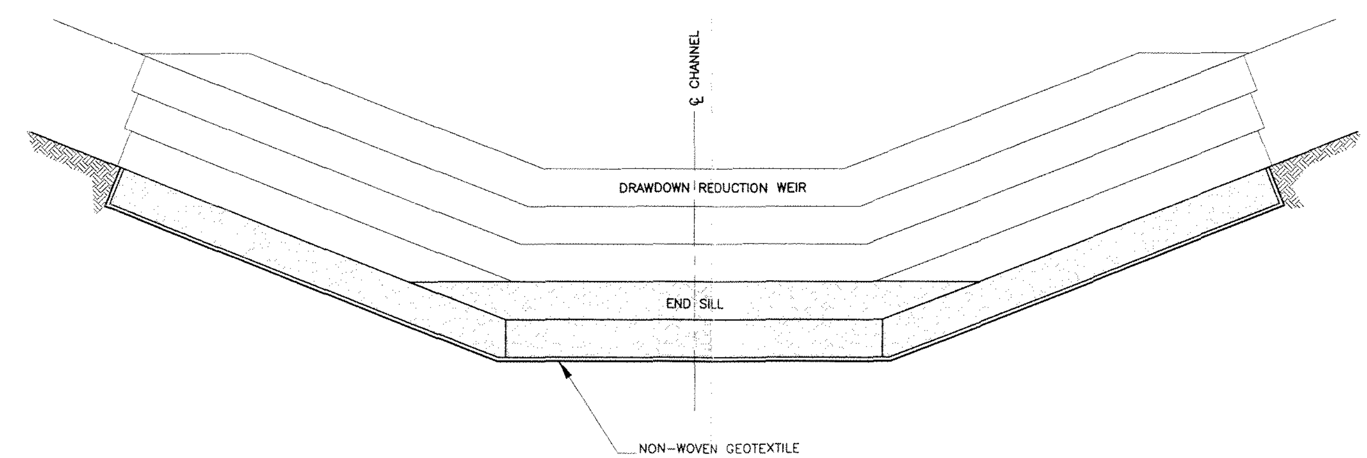
PLAN



NOTE: X = (NUMBER OF 0.5m STEPS − 1) x 2m
ie. FOR 3 STEPS (1.5m DROP) X = (3 −1) x 2 = 4m
FOR 8 STEPS (4m DROP) X = (8 − 1) x 2 = 14m

L = 12m FOR 1.5m DROP
L = 22m FOR 4.0m DROP

CENTERLINE PROFILE A–A'



SECTION B–B'

HALF SIZE REDUCTION

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

REV.	DESCRIPTION	DWN.	APP.	DATE

SEAL

SEAL

UMA Engineering Ltd.
Engineers & Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

APPROVED BY | DATE: MARCH, 2001
DRAWN BY: LJV | DESIGNED BY: KS
CHECKED BY: | CHECKED BY:
SCALE: 1:50 | JOB No. 4440-038-02-02

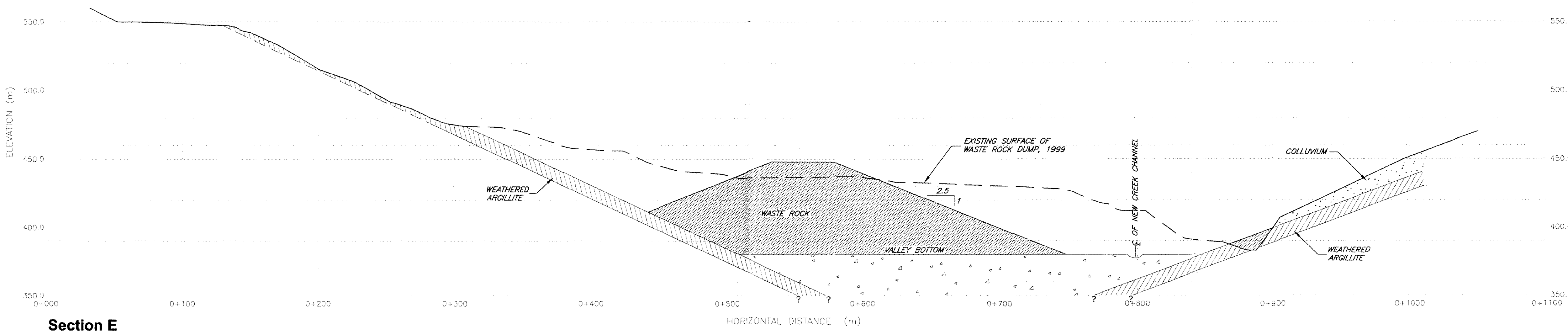
INDIAN AND NORTHERN AFFAIRS CANADA

ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

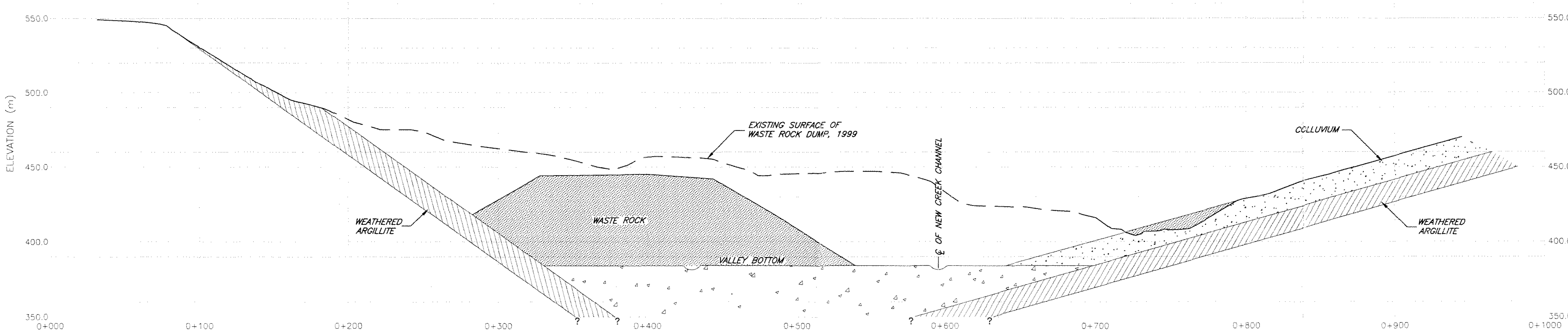
PROPOSED GABION DROP STRUCTURE

DWG. No. 04 | REV. –

MAR 29/01
Plot Scale: 1=1 ps
CC-04.dwg



Section E



Section K

MAR 29/01
Plot Scale: 1=1 ps
CC-05.dwg

HALF SIZE REDUCTION

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

REV.	DESCRIPTION	DWN.	APP.	DATE

SEAL

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1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

APPROVED BY	DATE: MARCH, 2001
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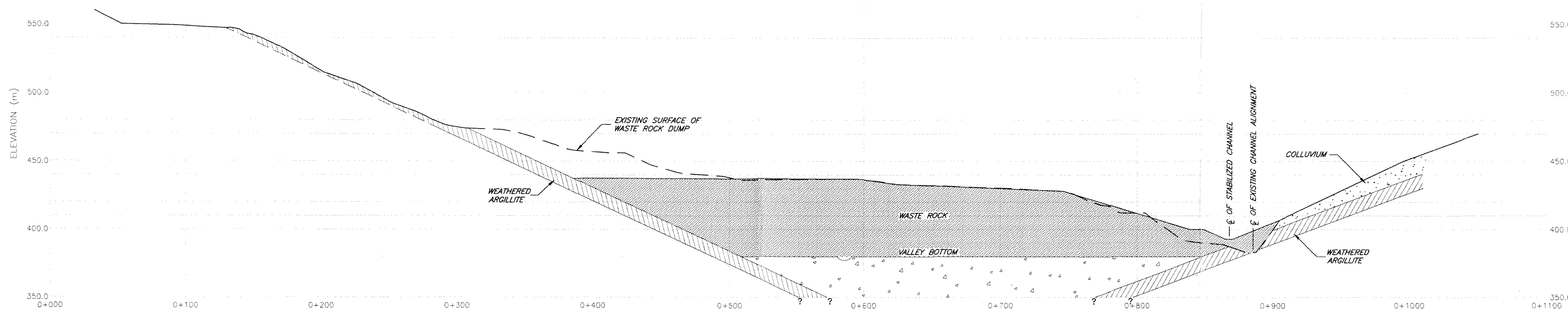
SCALE: 1:1500	JOB No. 4440-038-02-02

INDIAN AND NORTHERN AFFAIRS CANADA

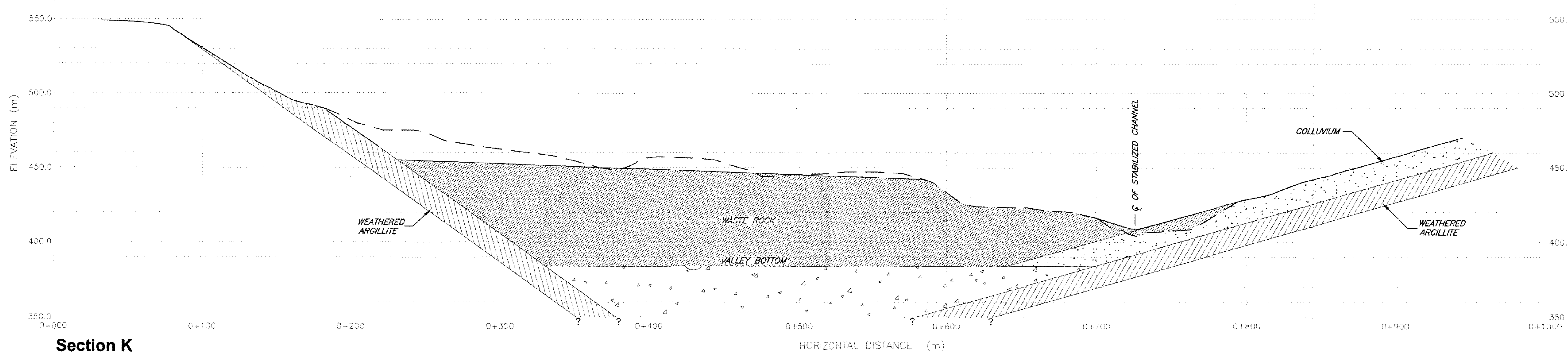
ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

PROPOSED WASTE ROCK DUMP GEOMETRY FOR VALLEY RESTORATION

DWG. No. 05
REV. –



Section E



Section K

HALF SIZE REDUCTION

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

REV.	DESCRIPTION	DWN.	APP.	DATE

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SCALE: 1:1500	JOB No. 4440-038-02-02

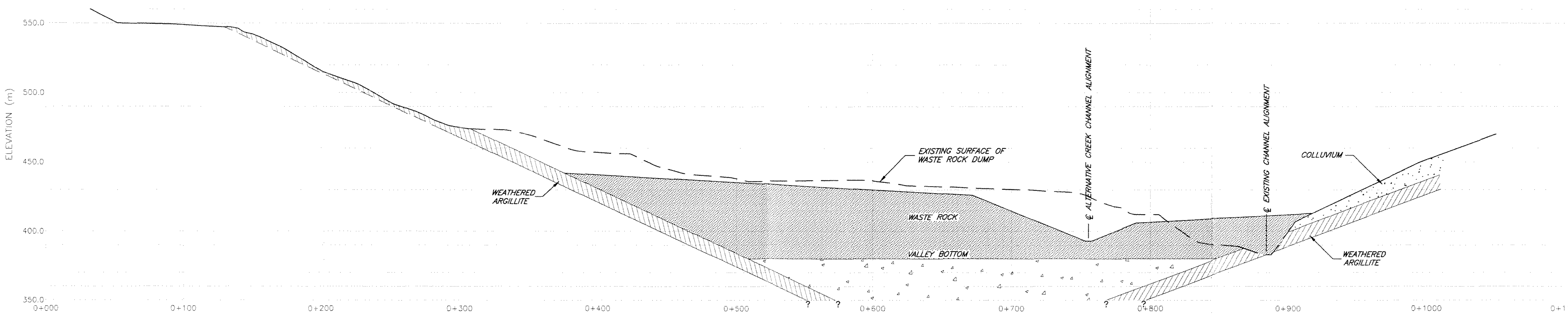
INDIAN AND NORTHERN AFFAIRS CANADA

ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

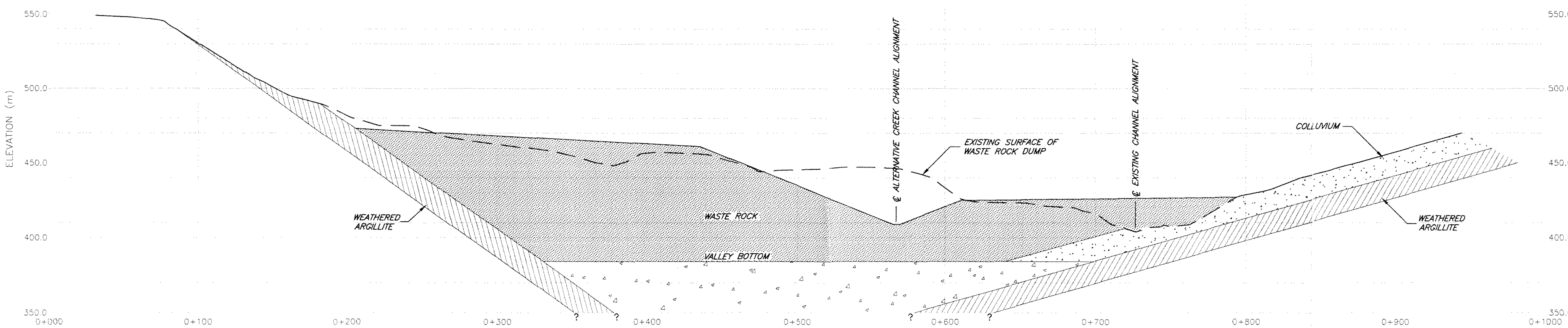
PROPOSED WASTE ROCK DUMP GEOMETRY FOR EXISTING CREEK CHANNEL ALIGNMENT

DWG. No. 06 REV. –

MAR 29/01
Plot Scale: 1=1 ps
CC-06.dwg



Section E



Section K

HALF SIZE REDUCTION

METRIC
WHOLE NUMBERS INDICATE MILLIMETRES
DECIMALIZED NUMBERS INDICATE METRES

REV.	DESCRIPTION	DWN.	APP.	DATE

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SCALE: 1:1500 | JOB No. 4440-038-02-02

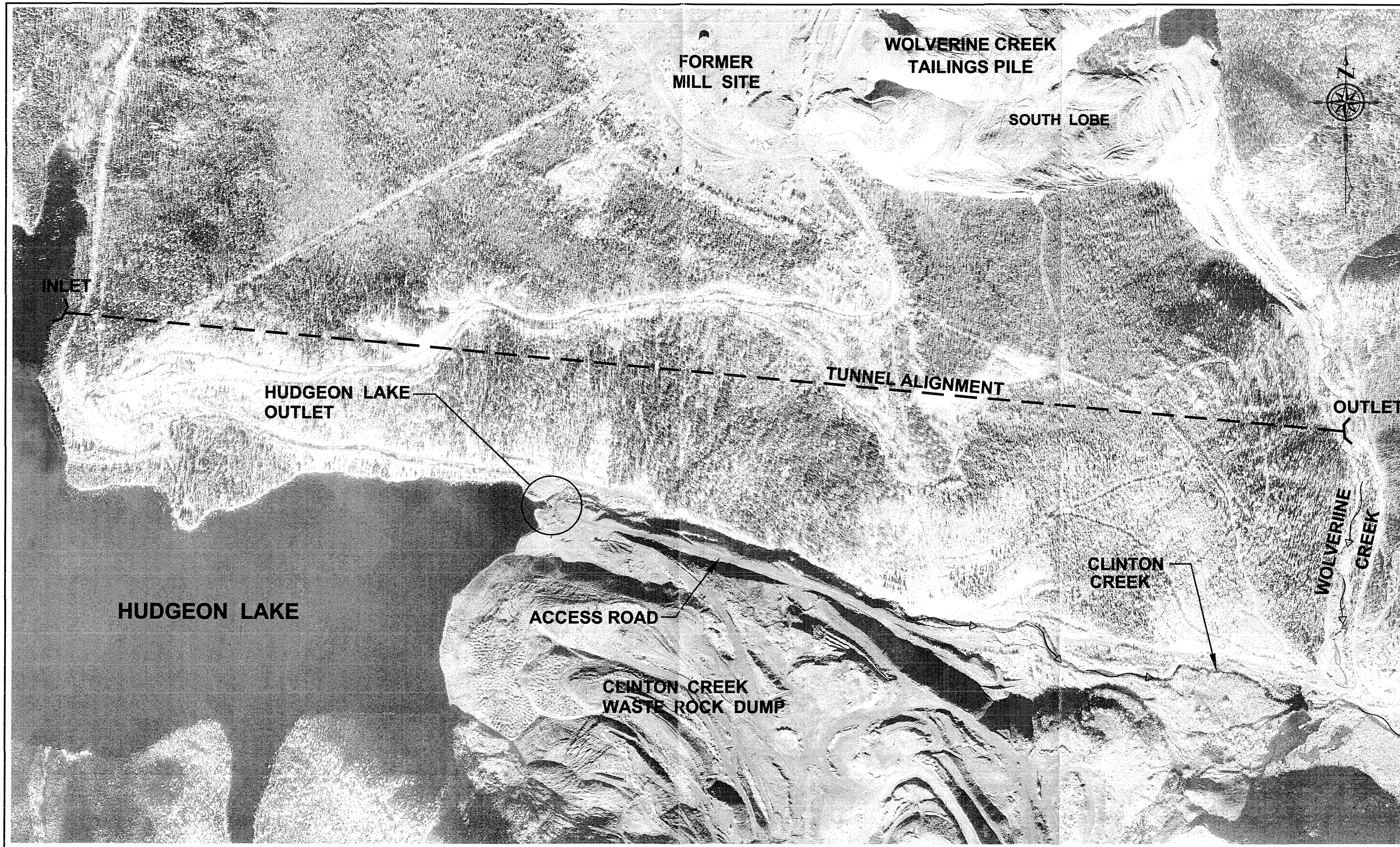
INDIAN AND NORTHERN AFFAIRS CANADA

ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

PROPOSED WASTE ROCK DUMP GEOMETRY FOR ALTERNATIVE CREEK CHANNEL ALIGNMENT

DWG. No. 07 | REV. -

MAR 29/01
Plot Scale: 1=1 ps
CC-07.dwg



HALF SIZE REDUCTION

METRIC
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DECIMALIZED NUMBERS INDICATE METRES

REV.	DESCRIPTION	DWN.	APP.	DATE

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APPROVED BY	DATE MARCH, 2001
DRAWN BY: LJV	DESIGNED BY:
CHECKED BY: KS	CHECKED BY:
SCALE: 1:3000	JOB No. 4440-038-02-02

INDIAN AND NORTHERN AFFAIRS CANADA

ABANDONED CLINTON CREEK ASBESTOS MINE
CONCEPTUAL STABILIZATION MEASURES

PROPOSED TUNNEL

DWG. No. 08
REV. –

MAR 29/01
Plot Scale: 1=1 ps
CC-08.dwg