'79-#657-# 8078

REPORT ON

SEISMIC REFRACTION SURVEY

MCDAME LAKE, B.C.

NOVEMBER 1979

KENTING
EXPLORATION SERVICES LIMITED

REPORT ON A
SEISMIC REFRACTION SURVEY
MCDAME LAKE, B.C.
NOVEMBER 1979

for

ERICKSON GOLD MINING CORPORATION

by

KENTING EXPLORATION SERVICES LIMITED

J.B. Henry, M.Sc., P.Geoph., P.Eng.,
Supervisor - Engineering Geophysics.

P.D. Phillips, B.Sc.,
Junior Geophysicist

W.M. Morrow, B.Sc.,
Junior Geophysicist

KENTING
EXPLORATION SERVICES LIMITED

TABLE OF CONTENTS

		PAGE
SECTION I	- INTRODUCTION	1
SECTION II	- THEORY OF SEISMIC REFRACTION	2 3
SECTION III	- EQUIPMENT AND METHODS	
	3.1 Equipment	5
	3.2 Field Methods	8
	3.3 Survey Production Summary	8 13
SECTION IV	- DATA REDUCTION AND INTERPRETATION	
	4.1 Data Reduction and Interpretation	14
	4.2 Interpretation Methods	14
	4.3 Results of Interpretation	
	4.3.1 SL-21J2-1	15 16
	4.3.2 SL-2152-2	16
	4.3.3 SL-2152-3	17
	4.3.4 SL-2152-4 and SL-2152-5	17 18
SECTION V	- CONCLUSIONS AND RECOMMENDATIONS	
	5.1 Conclusions	19
	5.2 Recommendations	19
LIST OF FIGURES		
LIST OF TABLES		
REFERENCES		

LIST OF FIGURES

		PAGE
Figure 2.2	Limitation of Refraction Method	4
Figure 3.1	Block Diagram of Recording System	6
Figure 3.2	Location of Seismic Lines	9
Figure 3.3	Production Rate Variation	11
Figure 3.4	Survey Procedure	12
Figure 4	Time-Distance Plots; Profiles and Velocity Histograms	Map Pocket
Figure 5.1	Alternative Survey Procedure	20

LIST OF TABLES

		PAGE
Table 3.1	List of Survey Equipment	7
Table 3.2	Summary of Manpower Allotment	10

SECTION I - INTRODUCTION

A seismic refraction survey was performed by Kenting Exploration Services Limited for Erickson Gold Mining Corporation from November 8 to November 16, 1979. The primary purpose of the survey was to determine depth to bedrock over a number of claims held by Erickson Gold Mining Corporation in the McDame Lake area of northern British Columbia. Also, the structure of the overburden was to be found, if possible.

The Kenting field party consisting of a party chief, operator and shooter equipped with a portable seismograph carried out the survey. The results of the survey were generally fair to excellent. Depths to bedrock were determined over most of the area surveyed.

Lateral variations in the overburden caused some distortion in the data, but this could be corrected for in most cases. The depths to overburden were substantially greater than anticipated, a fact which altered the survey parameters and reduced the production rate.

SECTION II - THEORY OF SEISMIC REFRACTION

When an explosion takes place in the ground, energy propagates through the ground with a velocity which depends primarily on the density of the material. When this energy passes from material of one density to a material of different density, its direction of travel is changed, or refracted. For a seismic wave travelling at an angle i_1 to the interface between two mediums of velocity V_1 and V_2, the emergent angle i_2 is given be Snell's law.

$$\frac{\sin i_1}{\sin i_2} = \frac{V_1}{V_2}$$

If $V_1 < V_2$ then at some angle i_{1C}, the critical angle sin i_2 will equal unity and so i_2 will be 90^0. In other words, the energy will propagate along the interface. Figure 2.1 shows the path the energy follows at the critical angle. As the seismic wave travels along the interface it generates waves which travel back to the surface at an angle of i_C. These waves can be detected by geophones on the surface. The time taken for the energy to reach the geophones from the location of the explosion is then recorded. These times are plotted against the distance of the geophones from the source, giving a time-distance graph. Analyzing these plots can give the depths to the refracting layer and some indication of the sub-surface structure.

Certain ground features can obscure the interpretation. One common situation is that of a velocity inversion. This occurs when a layer has a velocity lower than that of the layers above it and can cause large errors in computing the depths to various layers. A high speed layer can cause depth underestimation, and a low speed layer can cause depth over estimation. Another problem occurs when the various interfaces are not straight lines but curves. The small scale features of the interface may be below the limits of resolution of the survey and important features could be missed.

Also lateral inhomogeneities in a layer can distort the data received from deeper layers. A change in the surface velocity will show up as a break in the refractor time-distance plot which may be interpreted as a shift in the refraction depth. This problem can be usually corrected for if sufficient information is obtained.

Finally, if the survey is to be done in a narrow valley, the refractor may be too deep to be picked up with a spread laid out across the valley. These problems are illustrated in Figure 2.2.

LIMITATIONS OF REFRACTION METHOD

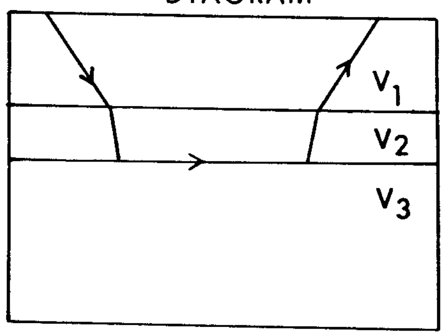
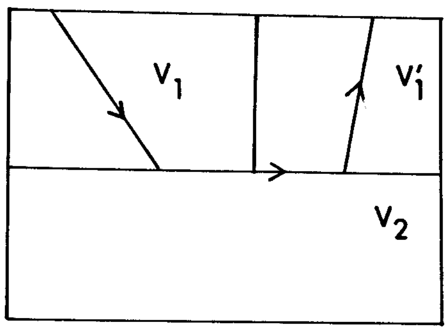
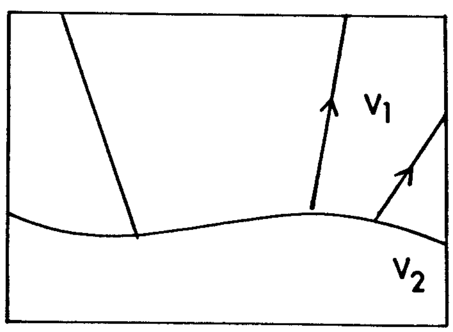
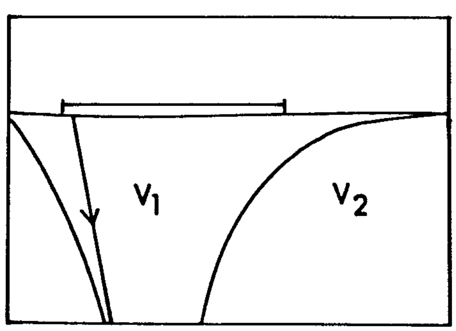
PHENOMENOM	DIAGRAM		RESULT
VELOCITY INVERSION, HIDDEN LAYER		$V_2 < V_1$ $V_1 < V_3 > V_2$	DEPTH TO V_3 PICKED TOO GREAT OR TOO SHALLOW FOR V_2 LOWER THAN V_1, OR HIGHER THAN V_3, RESPECTIVELY
LATERAL VELOCITY CHANGE		$V_1' \neq V_1$	DEPTHS INACCURATE USING SOME METHODS, REFRACTOR PROFILE DISTORTED
CURVING REFRACTOR			DIFFICULT TO PROFILE ACCURATELY WITHOUT VERY DETAILED DATA
REFRACTOR TOO DEEP			SPREAD CANNOT BE MADE LONG ENOUGH

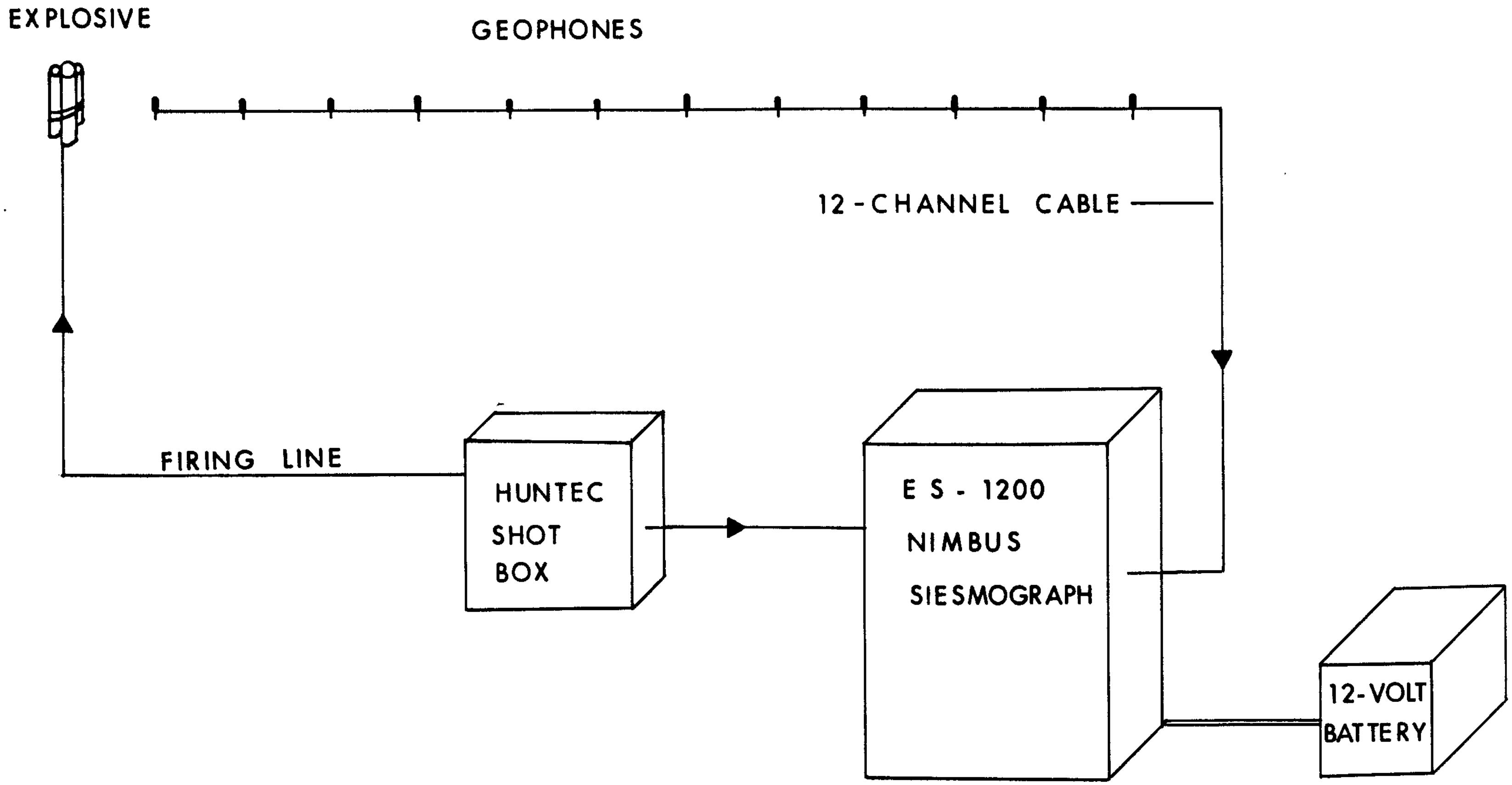
FIGURE 2.2

KENTING
EXPLORATION SERVICES LIMITED

SECTION III - EQUIPMENT AND METHODS

3.1 Equipment

A Geometrics Nimbus ES-1200 12 channel portable recording seismograph was used to record the data in the field. Firing and recording were initiated by a Huntec shot box. Closing the shot box's firing switch detonates the charge and at the same time starts the recording operation of the Nimbus seismograph. As signals are received from the geophones they are filtered and amplified and then stored in the Nimbus' digital memory. Later, they can be output in the form of wiggle traces on a paper record. A number of shots can be stacked coherently in memory to allow enhancement of the data with respect to noise. Figure 3.1 shows a block diagram of the system and Table 3.1 lists the equipment used.



BLOCK DIAGRAM OF RECORDING SYSTEM

FIGURE 3.1

KENTING
EXPLORATION SERVICES LIMITED

SURVEY EQUIPMENT

Seismograph	-	Geometrics 12 channel digital signal enhancement recording seismograph - Model ES-1200.
Geophones	-	Single, 40 hertz phones; 10 m and 15 m geophone interval
Source	-	Type - Forcite 70% 1/3 lb. (150 g) sticks.
		Size - 1/3 - 5 lb. charges.
		Depth - 0 - 1.5m.
		Detonator - Huntec shot box.
Drill	-	Stihl Model 4309 c/w 1.5m stem.
Other Equipment	-	Radios, 16lb. (7kg) hammer and base plate shot wire, Huntec shot box, 12 channel 15m takeout seismic cable.

TABLE 3.1

3.2 Field Methods

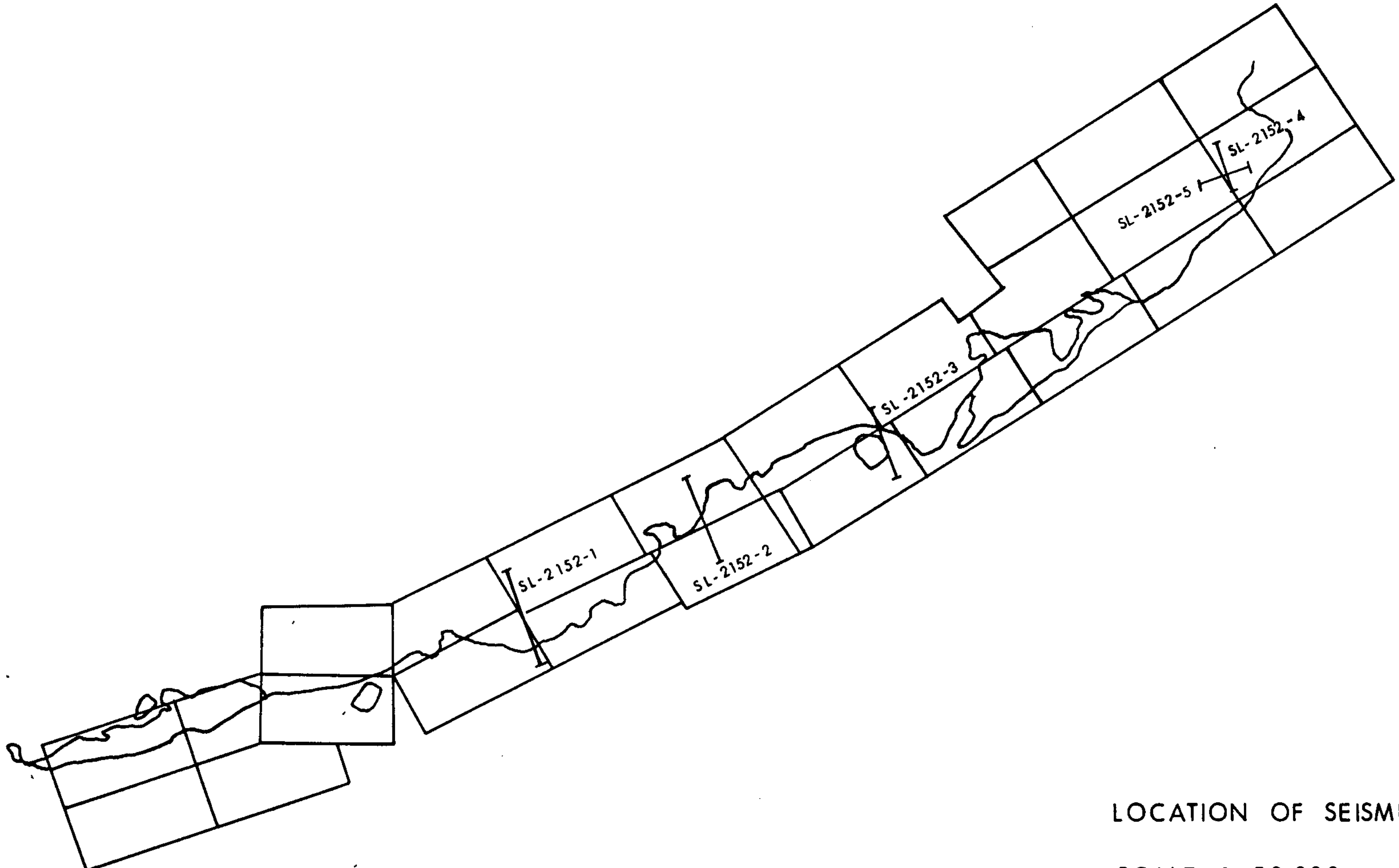
The lines to be surveyed were determined by the client represenative A. Beaton and the Kenting party chief P. Phillips on site. Figure 3.2 shows the location of these lines. Each line was then cut and chained prior to being surveyed. The survey crew consisted of a shooter, responsible for drilling and loading shot holes; an operator, who ran the instruments and the party chief who supervised the survey and lent assistance where needed. In addition a line cutter was supplied by the client. Table 3.2 lists the amount of time spent on each of these tasks, while Figure 3.3 shows the production rate.

Initially a 12 channel spread of 110m length was to be used, but this proved to be too short for the depth penetration needed, and a 165m spread was then used. This problem is discussed in more detail in Section 3.3.

Originally the spreads of geophones were to be moved down the lines in jumps, with spaces the same length as the spread in between consecutive spreads. This method provides data points at the end of each spread. Spreads in the skipped sections would only provide more information about the overburden, and was not considered to be necessary. Figure 3.4 shows this procedure. However the complexity of the overburden along with the greater depths necessitated continuous coverage of the lines.

3.3 Survey Production Summary

Considerably more time was spent on Line 1 because the specific problems on the area presented were unknown. Lateral changes in the overburden were found to be a problem over most of the line. Also the depth to bedrock was much greater than anticipated. A spread was laid out over two successive 165m segments to give



LOCATION OF SEISMIC LINE

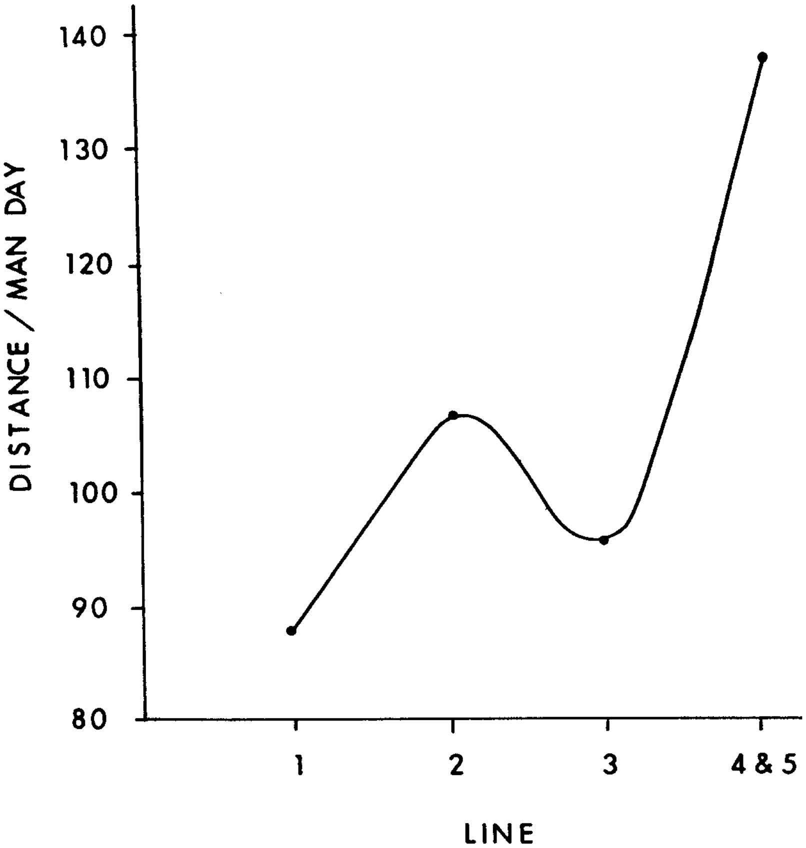
SCALE. 1:50,000

FIGURE 3.2

KENTING
EXPLORATION SERVICES LIMITED

LINE NUMBER	CUTTING & CHAINING (MAN DAYS)	SURVEYING (MAN DAYS)	TOTAL (MAN DAYS)	USEABLE SHOTS	DISTANCE COVERED	DISTANCE PER (MAN DAY)
1	1½	8½	10½	25	880m	88
2	1½	6	7½	16	800m	107
3	½	1½	2	3	193m	96
4 & 5	2	3	5	12	690m	138
TOTAL	5½	19	24½	56	2563m	105

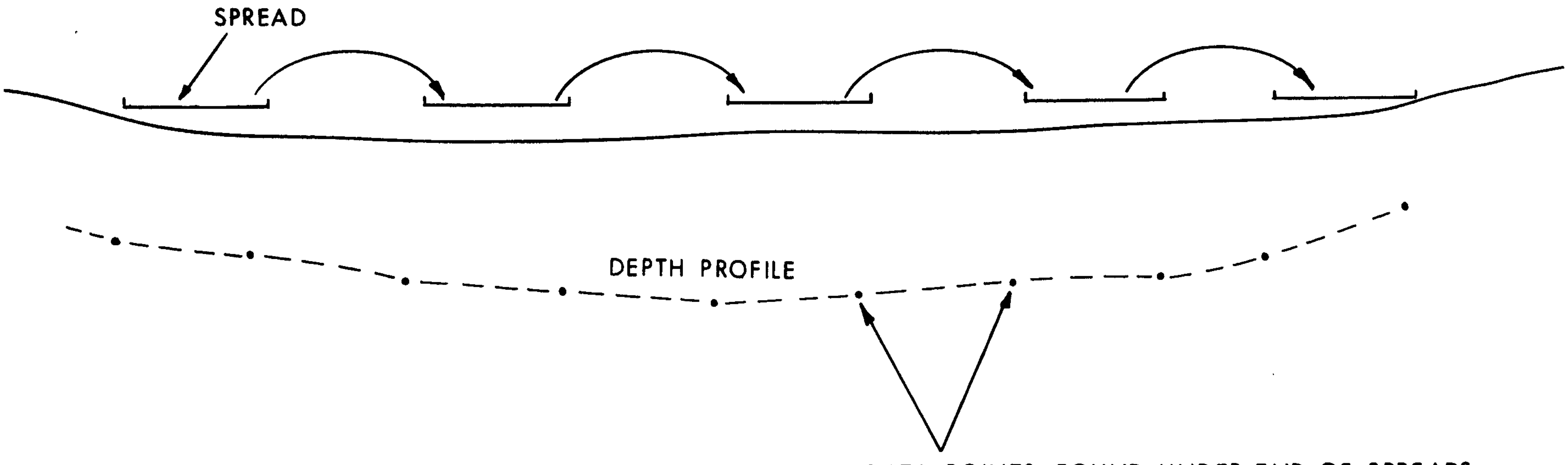
Table 3.2 Summary of Manpower Allotment



PRODUCTION RATE VARIATION

FIGURE 3.3

KENTING
EXPLORATION SERVICES LIMITED



SURVEY PROCEDURE

FIGURE 3.4

KENTING
EXPLORATION SERVICES LIMITED

3.3 Survey Production Summary (Cont'd)

coverage of 330m. The usual procedure is to use a spread length of six times the depth to the refractor. Depths on the order of 30m were expected and the spread length of 165m would have been adequate. Depths of 120m were found on Line 1, which neccessitated continuous coverage of the line. This slowed down the survey.

Line 2 proceeded with few problems since it was similar to Line 1 and the problems with Line 1 had been solved.

Line 3 was terminated unfinished so that Line 4 could be completed in the time available. It was felt that Line 4 would contribute more useful data than Line 3. Line 4 was finished with about two hours of daylight left and so Line 5 was surveyed, since no line cutting was necessary where Line 5 was located. Line 3 could not have been completed in the time available.

SECTION IV - DATA REDUCTION AND INTERPRETATION

4.1 Data Reduction and Interpretation

The results of the survey are presented in the form of time-distance plots with the sub-surface profiles interpreted from these plots. The original field records were returned to the client. The records are generally of good quality with easily discernable arrival times. In a few cases, excessive attenuation of the signal reduced the accuracy in arrival time. The main problems with the data resulted from environmental condition distorting the records, such as the lateral changes in the overburden.

4.2 Interpretation Methods

Three methods were used to interpret the data. Each method has advantages in specific cases. Hagedoorn's plus-minus method [1] was used where the overburden was relatively homogeneous. This technique gives detailed information about the depths to bedrock. However, it is only practical where the layer velocities are well known.

In situations where the plus-minus method could not be applied, Mota's time-intercept method [1] was used. This method supplies only depths below the shot points whereas the plus-minus method gives depths below each geophone stations where refractor overlaps. However, the Mota method is less sensitive to horizontal variations in each layer.

Where neither of these methods produced acceptable results, a model was constructed and then manipulated until it fit the data.

1 - See list on reference page

4.3 Results of Interpretation

4.3.1 SL-2152-1

Figure 4 shows the time-distance diagram and the subsurface plot derived from it for Line 1. The depths indicated in Figure 4 are believed reliable to within 10%. The bedrock is shallow at the ends of the line and deepens near the center. Maximum depth is interpreted to the 80m in the central region.

No detailed interpretation of the overburden was made other than to indicate the lateral velocity change as shown in Figure 4. Velocities range from .3 to 2.0 m/msec. Higher velocities are related to higher water content in the overburden. Overburden on the ends of the line tends to be more complex, particularly on the south end from stations 168 to 188.

No firm determination of the composition can be made based on the velocity alone. The profile shows an area with intermediate velocity of 2.6m m/sec which may be a lateral moraine appearing on the mountain to the south. This feature obscures the bedrock below and the depth to bedrock is unknown although it probably becomes shallower as indicated. The high velocities plotted at the extreme south end (15m/msec and 25m/msec) may be due to the dipping bedrock surface.

4.3.1 SL-2152-1 (Cont'd)

Figure 4 also shows the distribution of velocities for the entire survey. The highs from 0 to 1.0m/msec and 1.5 to 2.0m/msec correspond to dry and wet material respectively in the overburden. The velocities for saturated material, of 1.5 to 2.0m/msec, are indicative of the water in the material and prevent any distinctions being made concerning the nature of the overburden, other than degree of saturation. The distributions from 3.5 to 4.0m/msec and from 5.0 to 6.0m/msec correspond with the bedrock velocity.

4.3.2 SL-2152-2

The results from this line are similar to those of Line 1. Overburden velocities vary less and range from 1.5 to 2.0m/msec.

The bedrock profile for station 99 to 111 was derived by producing a model to fit the observed time-distance curve, assuming a bedrock velocity of 5.5m/msec. This assumption was necessary since no estimate of velocity could be made from the the data. The remainder of the line was interpreted using the conventional Mota time-intercept method. Maximum depth was found at station 122 with a value of 125m. The profile shallows out on both ends, as on Line 1.

4.3.3 SL-2152-3

Figure 4 shows the profiles obtained using Mota's method for Line 3. The change from unsaturated to saturated material corresponds to the decrease in elevation from station 108 to 114. The surface was mostly swamp south of station 114, and gravel and sand north of 114, on top of the hill. The bedrock profile shown is the minimum depth possible which was found assuming the refractor signal comes in immediately after the data ends. The depth near the middle of the spread is a minimum of 70m.

4.3.4 SL-2152-4 and SL-2152-5

Lines 4 and 5 cross at right angles, with Line 4 oriented across the valley and Line 5 down the valley. Figure 4 shows the results. The overburden is mainly unsaturated material with some saturation occurring under a swamp at the southerly end of Line 4. Pockets of saturation may occur where the velocity increases such as from station 105 to station 111 on Line 5.

The depth to bedrock is much less on these lines. No definite maximum occurs. The bedrock profile at the central part of Line 4 is flat at a depth of 30m with the rock dipping upwards at the ends. Outcrop was seen beginning at station 99 and continuing north off the line. Hagedoorn's plus-minus method was used over much of these lines, giving data points at each geophone station. The depths found where the two lines cross agree within 8%. This is well within the error in the determination of the various velocities, particularly the overburden velocity.

4.3.4 SL-2152-4 and SL-2152-5 (Cont'd)

The bedrock velocity decreased over these two lines from a mean of about 5.5 m/msec to 3.8 m/msec. The histograms in Figure 4 show two separate bedrock velocities; 5.0 m/msec for Line 1 and 2, and 3.8 m/msec for Lines 4 and 5. Although the information is inadequate to make a firm interpretation, this may represent two diffierent bedrock types.

SECTION V - CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

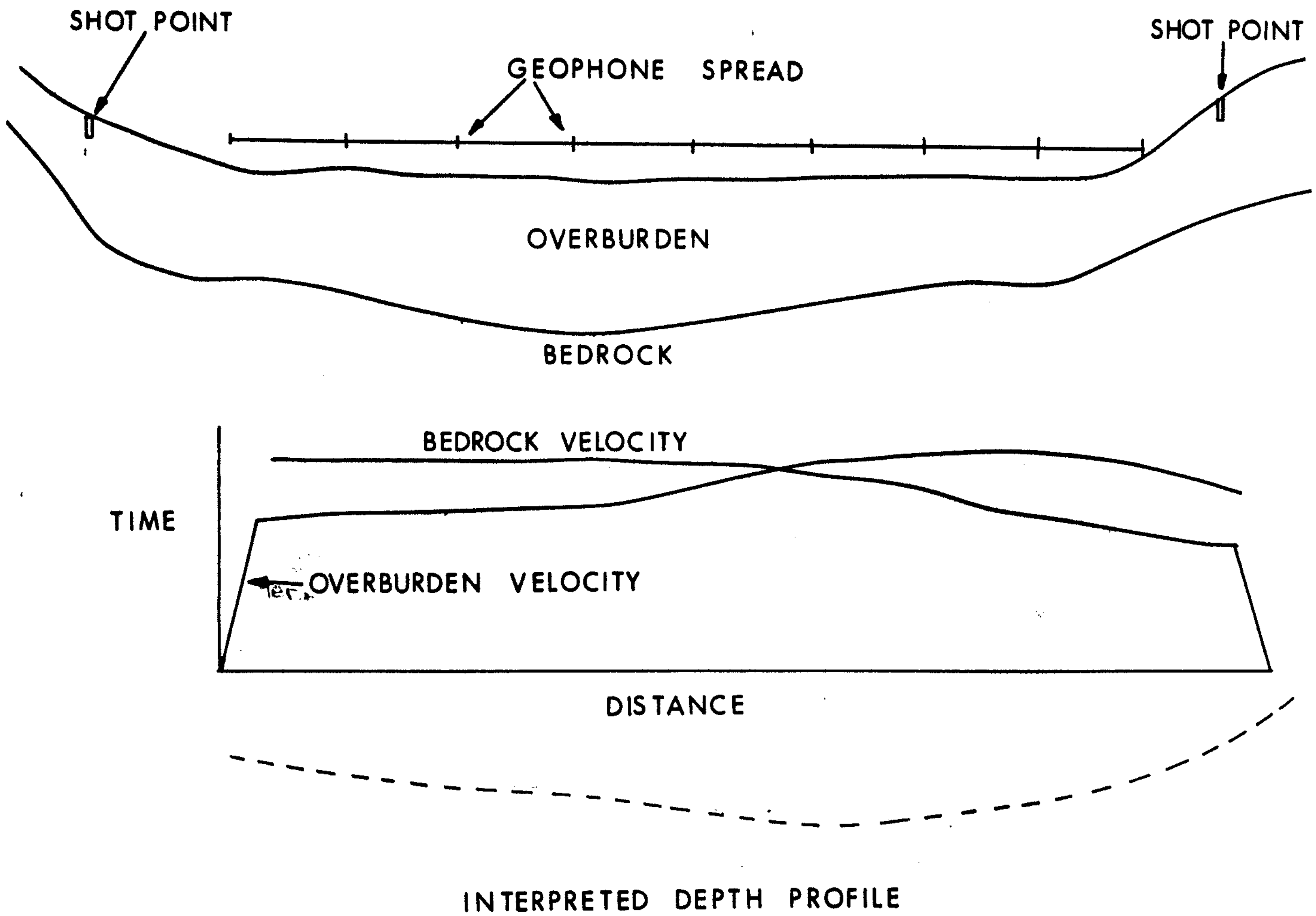
The overall quality of the data recorded in the field was high. None of the irregularities in the time-distance plots can be attributed to errors in the recording process. The complexity of the overburden is the major cause of the irregularities, but other causes, such as a convoluted non-linear bedrock surface, add to distortion.

The bedrock surface dips upward to the east from depths of 70 to 120m on Lines 1 and 2, to 30m on Lines 4 and 5. A different type of bedrock may exist in the east, but this is uncertain. Also the bedrock surface becomes flatter, with no clearly defined deepest point.

The overburden is composed of homogeneous material with varying degrees of water content.

5.2 Recommendations

More detail could be gained on the bedrock surface profile. This could be done in the following manner. A permanent shot point would be chosen at each end of the line and the spread moved down the line, giving a record of arrivals from the two shot points at each spread location. At distances greater than about one spread length, the arrivals would be from the bedrock. This would give continuous information about the bedrock over the entire line, permitting such methods as Hagedoorn's plus-minus method to be used, producing a depth to bedrock at every geophone station. Shooting would also be done close to the spread to define the overburden. Figure 5.1 shows how this could be done. However, the results of the method that was used define the bedrock depth quite well and more detail may be superfluous.



ALTERNATE SURVEY METHOD

FIGURE 5.1

KENTING
EXPLORATION SERVICES LIMITED

REFERENCES

Dobrin, M.B. - Introduction to Geophysical Prospecting McGraw-Hill Toronto 1960.

Hagedoorn, L.G. - "The Plus-Minus Method of Interpreting Seismic Refraction - Section Geophysical Prospecting Vol 7 pg. 158 1959.

Mota, L. - "Determination of Depths and Dips of Geological Dipping Layers in Seismic Refraction" - Geophysics Vol 19 pg. 242 1954.

Telford, W.M. et al - Applied Geophysics Cambridge University Press 1976.

Engineering Geophysics for Engineers, Engineering Geophysical Services.

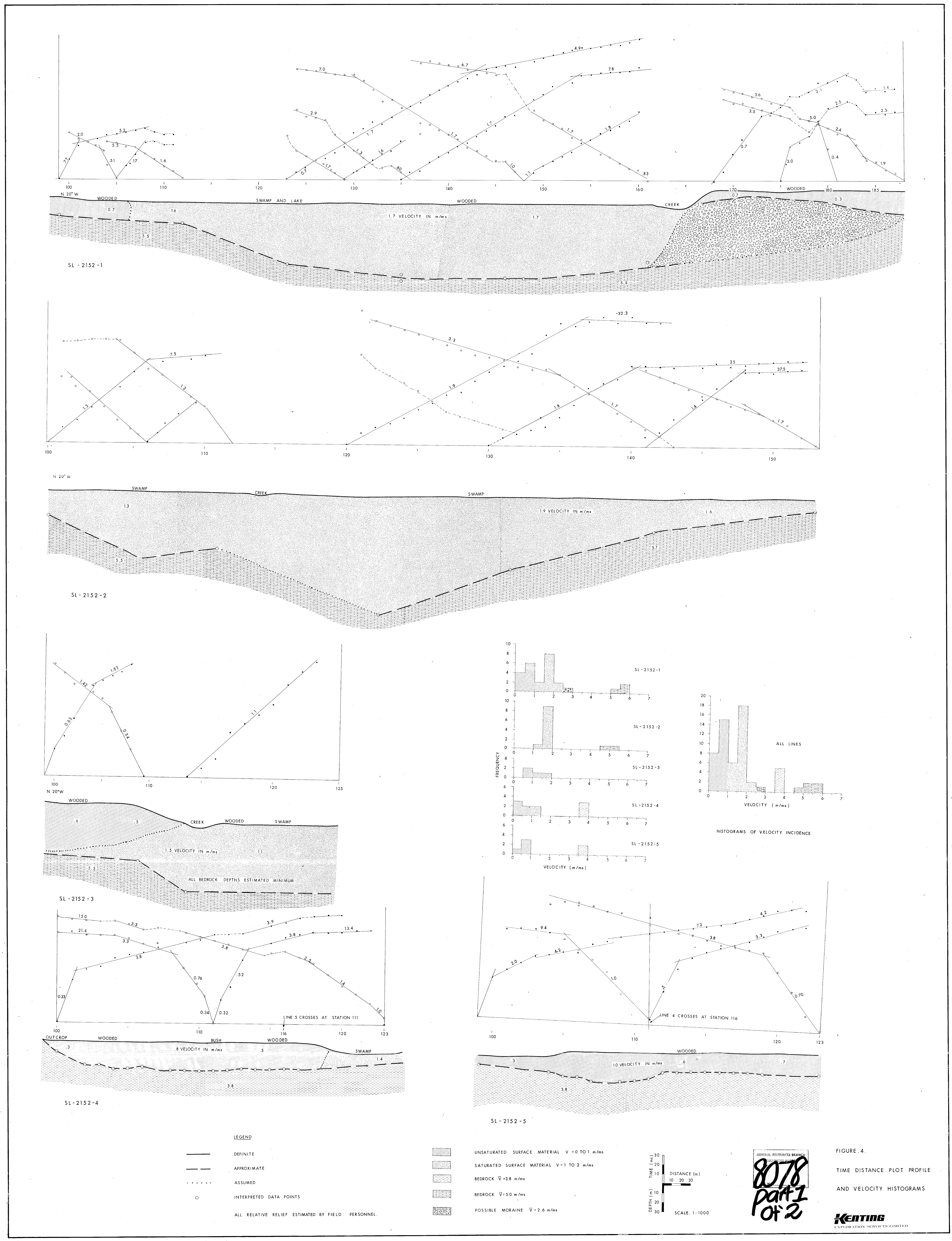


FIGURE 4.
TIME DISTANCE PLOT PROFILE AND VELOCITY HISTOGRAMS