QUINTETTE OPERATING CORPORATION

1996 ASSESSMENT REPORT FOR COAL LEASE #6 AND LICENCES

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QUINTETTE OPERATING CORPORATION
APRIL 2, 1997

1.0 Introduction

Quintette Operating Corporation performed work on Coal Lease #6 in 1996. This work entailed geotechnical investigations of the foundations of the proposed waste rock dumps for the Babcock mining development. No work was done on the coal licences in 1996.

2.0 Work Performed

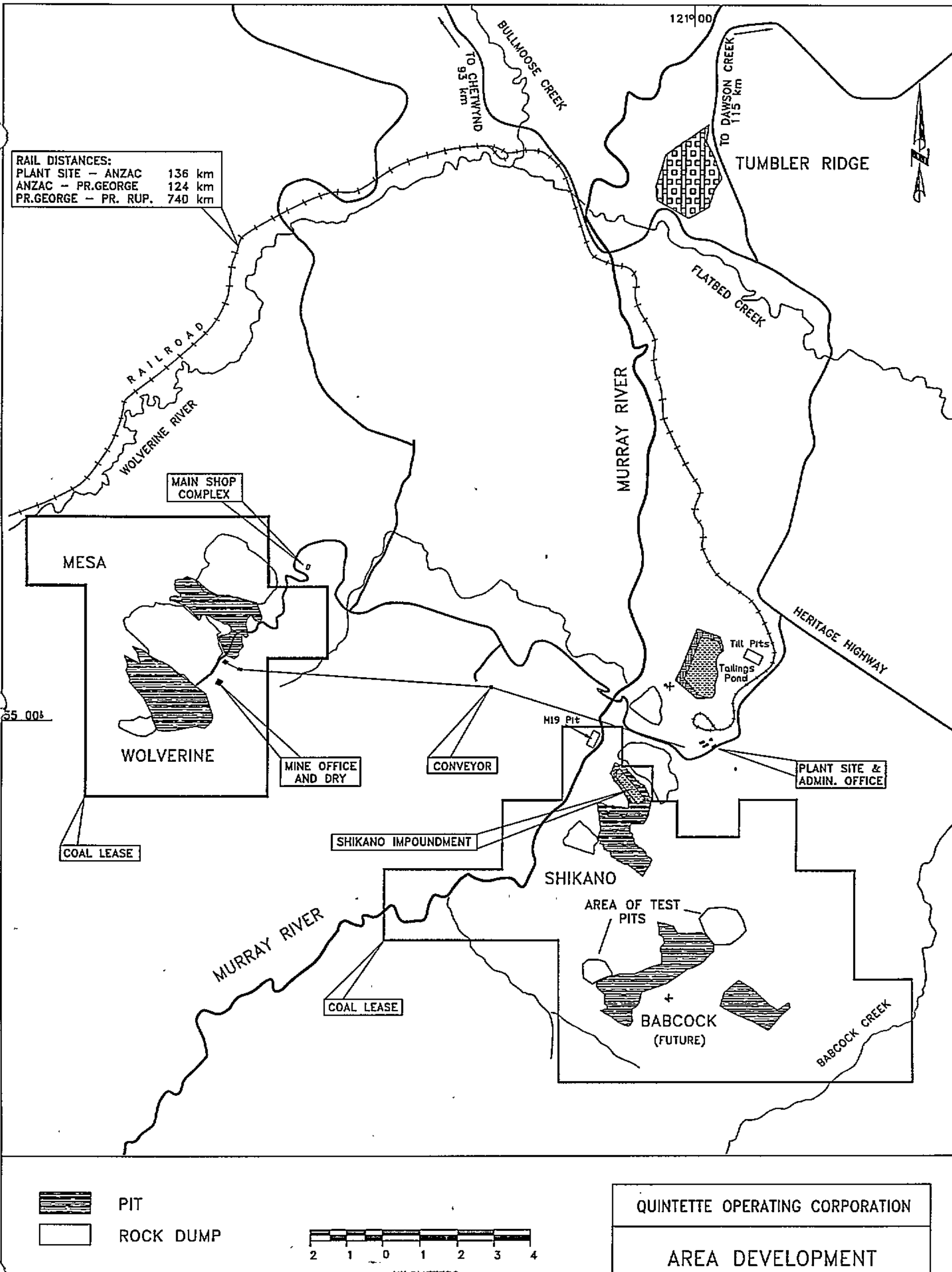
Work done on Coal Lease #6 in 1996 was in the Babcock area. This comprised 9.6 kilometers of access trail construction and excavation of 22 test pits. Figure 1 is a general location map of the Quintette site, showing the location of the 1996 work.

The test pits were dug to examine the surficial materials in the foundation area of the proposed Babcock waste dumps. Appendix A contains a 1:10,000 scale map showing the access trails and test pit locations. Appendix B contains a report by Golder Associates Ltd., entitled Geotechnical Assessment for the Proposed Waste Rock Dumps at the Windy Ridge Open Pits on Babcock Mountain, Tumbler Ridge, British Columbia (January 1997). This report documents the results of the test pits.

Salvage of merchantable timber on the access trail right-of-ways was done as directed by the Ministry of Forests. This added significantly to the cost of the program, even after sale of the recovered timber.

No seeding of 1996 disturbance was done, since the access trails and test pit areas were either to be used in upcoming seasons or were within the footprint of the proposed waste dumps. The test pits were filled in, and the trails were ditched and had waterbars constructed to control erosion.

Seeding was done on disturbance from previous exploration in the Mesa Extension area of Coal Lease #6. This was not completed during the year of disturbance due to adverse weather conditions at the end of the field program.



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AREA DEVELOPMENT

Figure 1

APPENDIX A

GOLDER ASSOCIATES REPORT

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GEOTECHNICAL ASSESSMENT FOR THE PROPOSED WASTE ROCK DUMPS AT THE WINDY RIDGE OPEN PITS ON BABCOCK MOUNTAIN TUMBLER RIDGE, BRITISH COLUMBIA

Submitted to:
Quintette Operating Corporation
Tumbler Ridge, B.C.

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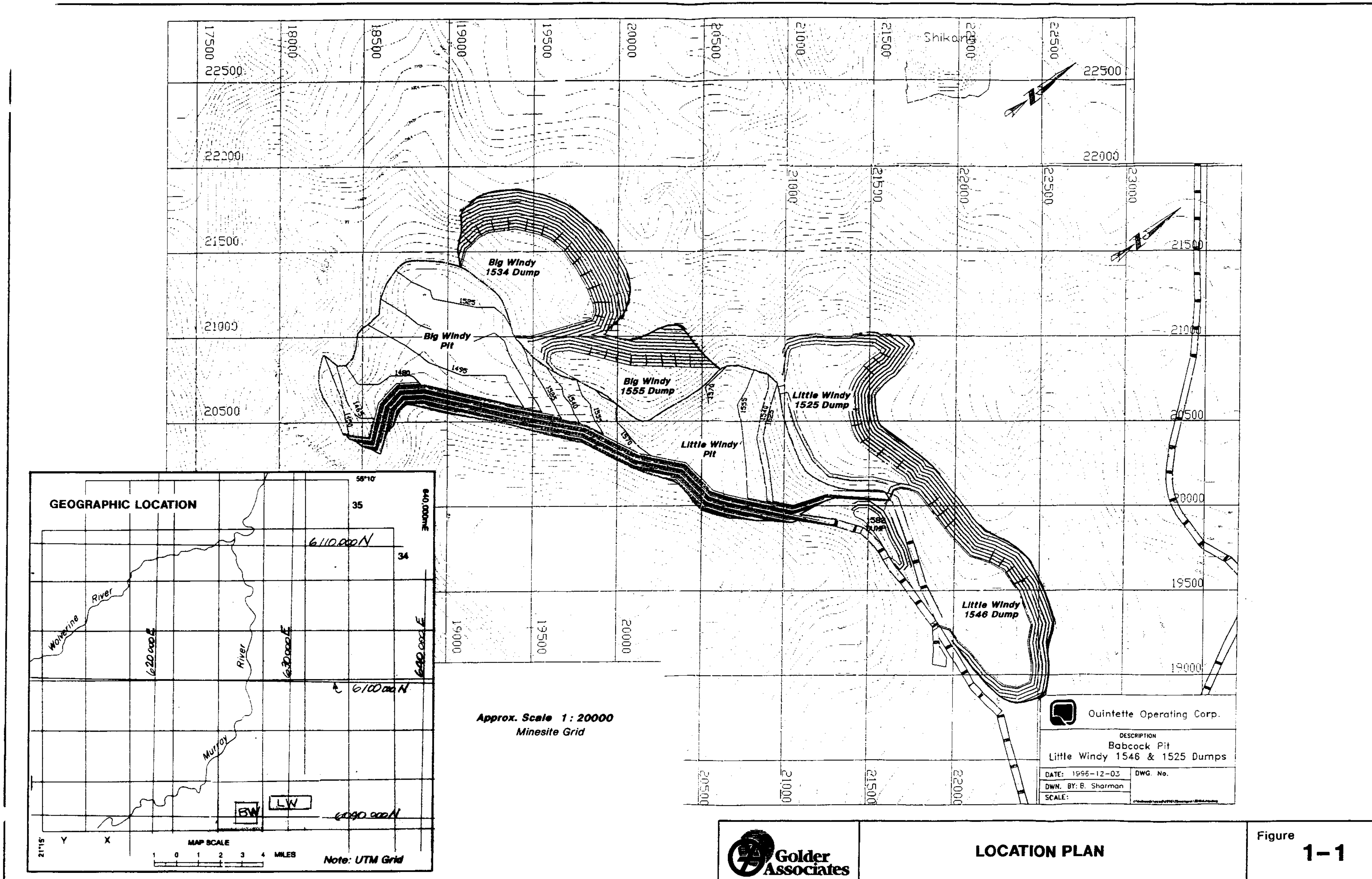
1.0 INTRODUCTION

Quintette Operating Corporation (QOC) propose to proceed with development of an open pit coal mining operation in an area known as Windy Ridge, which is located on the north-west face of Babcock Mountain. The proposed Windy Ridge development is located approximately 3 km south of the Shikano pit, at an elevation about 550 metres higher than the natural topography in the region of the eastern limit of the Shikano Pit. The geographic location of the proposed development is indicated on Figure 1-1.[1]

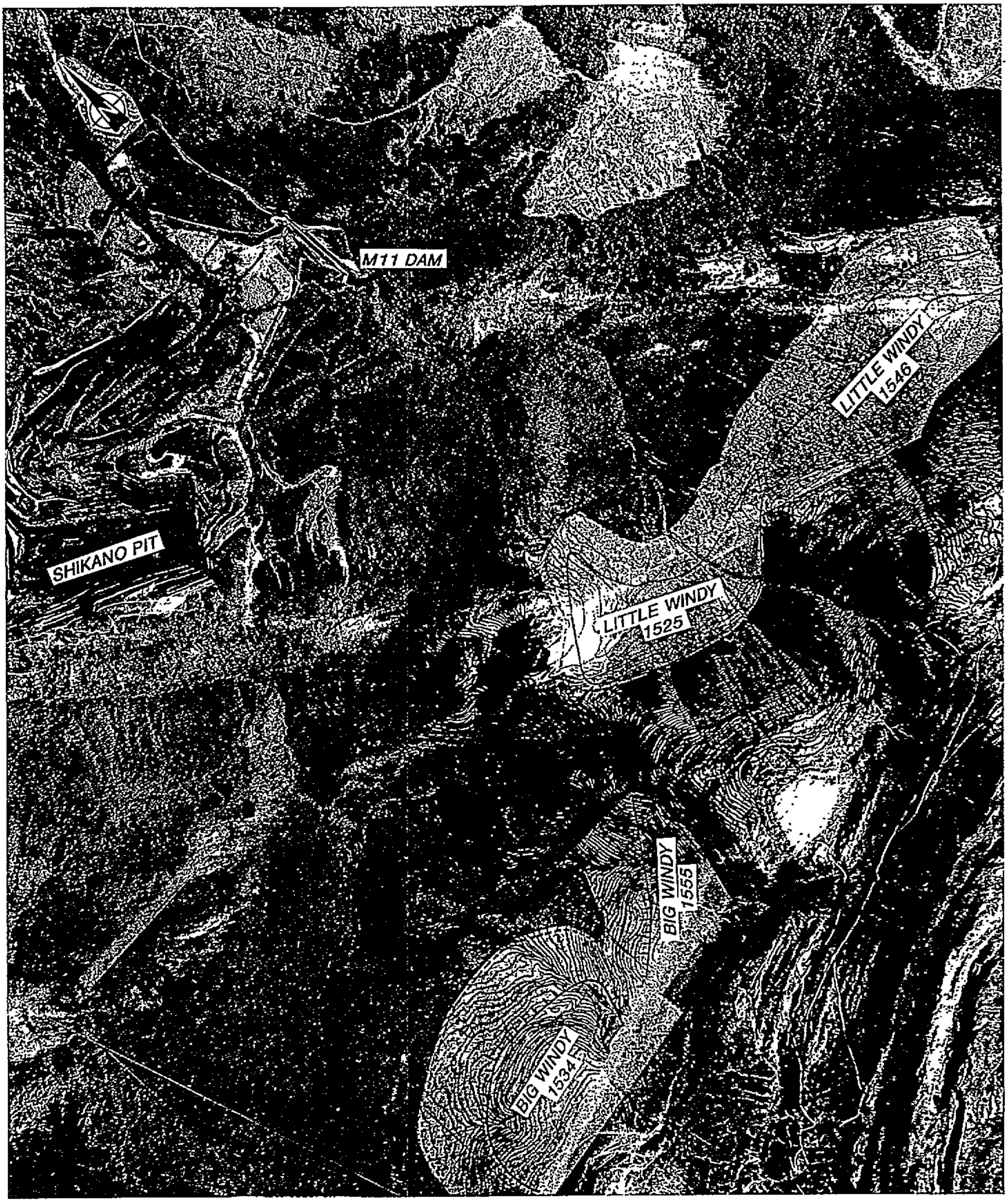
The proposed Windy Ridge development will consist of two contiguous open pit areas and their associated waste rock dumps. The relative positions of these pits and dumps, designated Big Windy and Little Windy, are shown on Figure 1-1 and on the marked air photo Figure 1-2. Little Windy will be developed first, followed by Big Windy. Golder Associates have been requested to investigate and to provide design advice relative to the development of the proposed waste rock dumps associated with the Big Windy and Little Windy open pits. The plan layout of the proposed Big Windy dump is shown on Figure 1-3, and the plan of the proposed Little Windy dump is shown on Figure 1-4

[1] In this report, figures have been assigned a numerical prefix which corresponds to the section of the report to which they pertain. For example, figures discussed in Section 1 bear the prefix '1', and these figures appear at the end of Section 1.



LOCATION PLAN

Figure **1–1**



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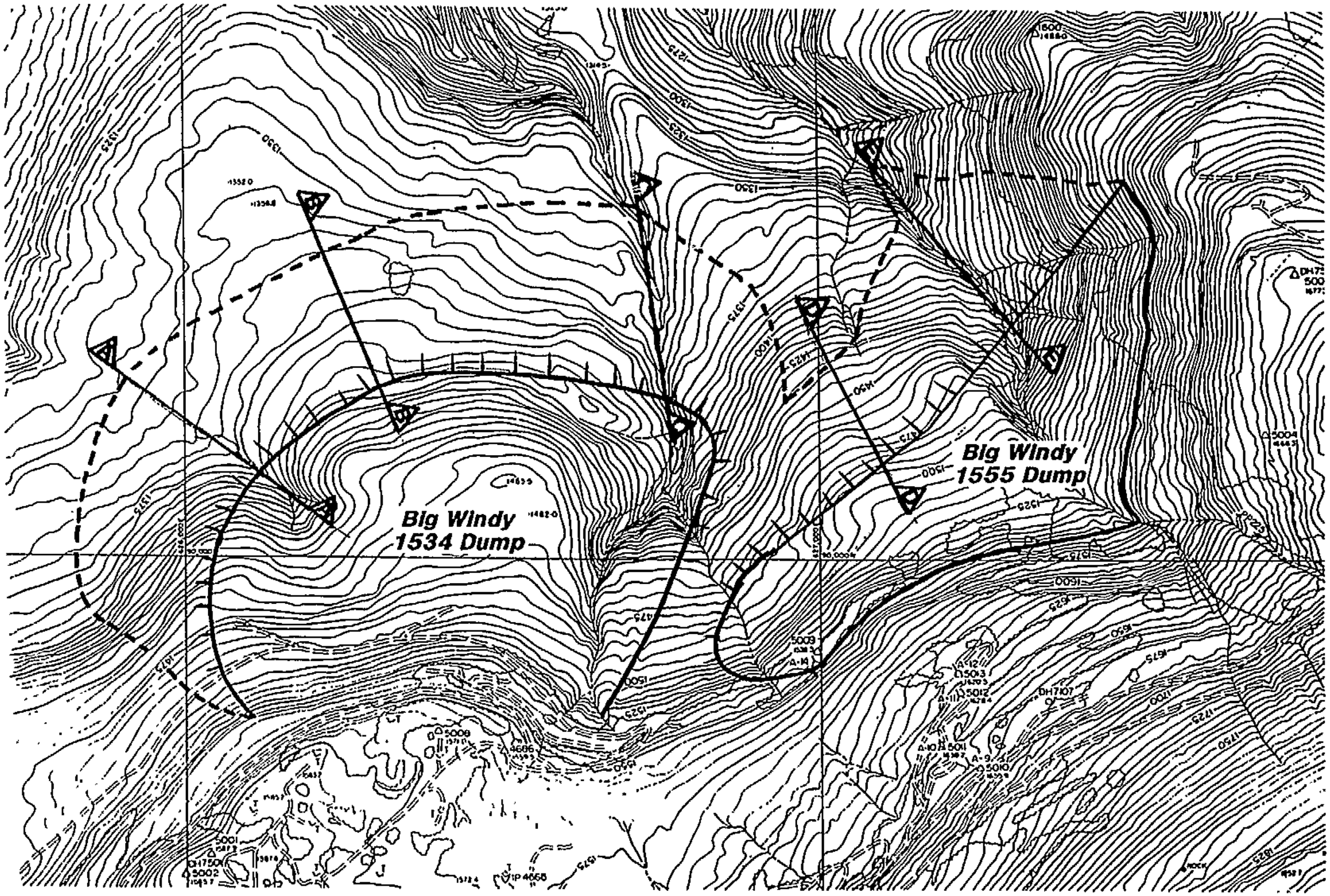
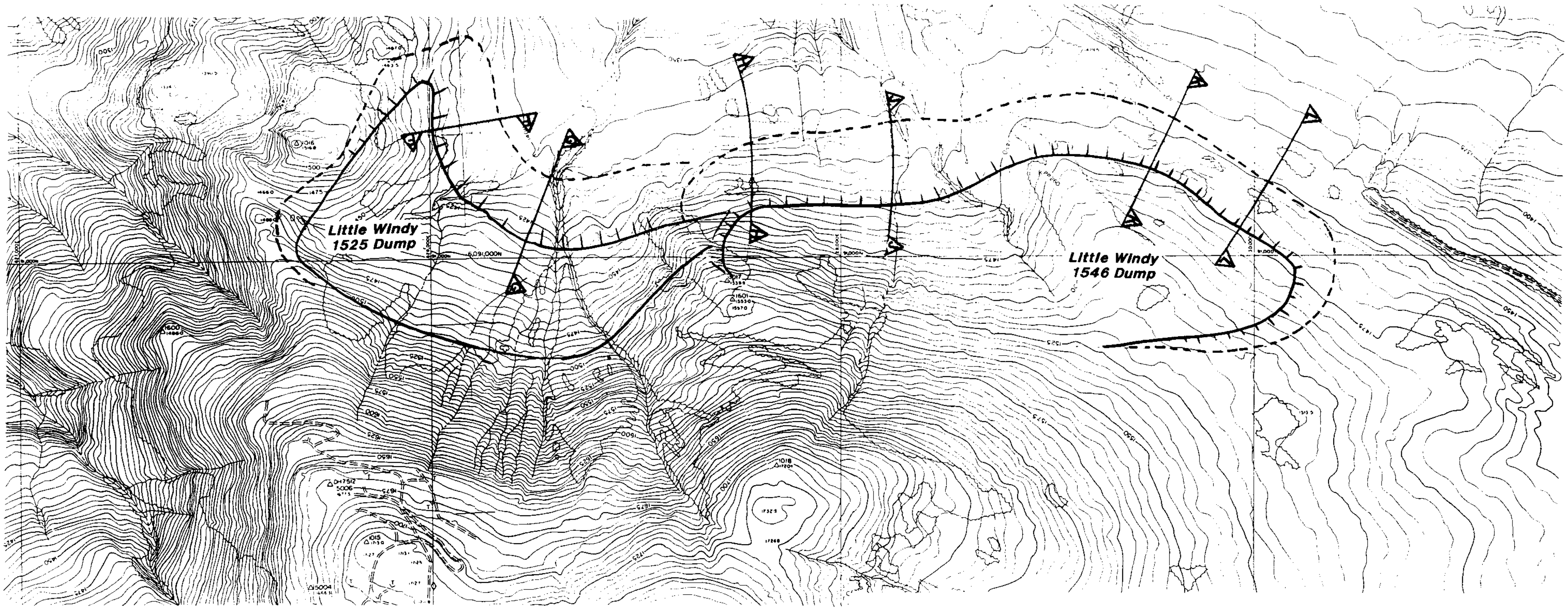
MARKED AIR PHOTO

Figure **1-2**



Approx. Scale 1 : 10000

Project No. 962-1474 Drawn BAD Reviewed DBC Date Jan.'96	Golder Associates	**PLAN SHOWING BIG WINDY DUMPS**	Figure **1-3**



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PLAN SHOWING LITTLE WINDY DUMPS

Figure 1–4

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2.0 SOURCES OF INFORMATION

Data available in the area of the proposed Big Windy and Little Windy dumps include the following:

- Air photos flown in the summer of 1996;
- Digital topography based on the 1995 fly-over;
- scale photogrammetric topography, contour interval = 5 metres, based on air photos flown September 1975; and
- Geologic surface mapping showing the classifications of the sedimentary units that outcrop in the area.

In the summer of 1996, roads were extended into the area of the proposed waste rock dumps to provide access for machinery that was used to excavate test pits in the surficial soils that mantle the upper surface of in situ rock. These access roadways were traversed on foot, and the soils exposed in the backslopes of the road cuts were examined and photographed.

In October 1996, the overburden soils were investigated by excavation of test pits. The tests pits in the area of the Big Windy dump were logged by an experienced technician from Peace Country Testing of Dawson Creek, British Columbia. In the area of the Little Windy dump, the test pits were logged by an experienced technician from the Burnaby office of Golder Associates Ltd. The logs of the test pits are presented in Appendix A.

3.0 GEOLOGIC SETTING

On the Quintette property, the coal occurs within sedimentary strata that consist of shales, siltstones, mudstones, and sandstones, along with numerous coal seams. These sedimentary units have been subjected to tectonic compression in the northeast - south-west direction. In response to these tectonic compression strains, the strata have been deformed into a series of northwest-southeast trending anticlines, synclines, chevron folds, and compression shears. At some locations, segments of the sedimentary units have been rotated to the vertical.

The attitude of the sedimentary strata at the top of Babcock Mountain is in stark contrast to the attitude of the strata elsewhere on the QOC property. The sedimentary units that form the top of Babcock Mountain are essentially flat-lying and they have not been folded, sheared, and deformed by orogenic compression, as is common for the remainder of the sedimentary units on the QOC property. The rocks at the top of Babcock appear to be part of a block of sedimentary strata that has been thrust over the folded units. The contrast between the flat-lying strata at the top of Babcock Mountain and the underlying steeply-dipping units is particularly evident on the right (north) valley wall of Waterfall Creek that borders the south-west side of Babcock Mountain.

The coal measures at the proposed Windy Ridge development occur with the flat-lying sedimentary units[1]. The bulk of the Big Windy waste rock dumps will be underlain by the flat-lying units. The northern limits of the proposed Little Windy dumps extend onto areas that are underlain by folded and steeply dipping sedimentary units. However, whether the sedimentary rock units comprising the dump foundations are flat-lying or folded does not adversely affect the stability of the proposed Big Windy or Little Windy waste rock dumps.

4.0 SURFICIAL SOILS

The surficial soils in the area consist predominantly of glacial tills, overlain by a thin veneer of sandy silt that appears to be weathered glacial till. These glacial till soils are a heterogeneous mixture of clay, silt, sand, and gravel, with scattered cobbles and boulders. The area proposed for development of the waste rock dump is a north-aspect slope. The forest cover consists predominantly of spruce, balsam fir, and scattered lodgepole pine. The predominance of spruce and balsam fir, and the paucity of lodgepole pine is an indication that in general, the surficial soils on this north-aspect slope are poorly drained.

Where the edges of the more weathering-resistant strata (such as sandstones and conglomerates) of the flat-lying sedimentary units outcrop on the slope, they form local steps and steep segments of topography. On the faces of many of these steeply sloping segments, the in situ rock is exposed at surface and the surficial soils are either absent, or

[1]Compared with the intensely folded sedimentary units at the Wolverine, Mesa, and Shikano Pits, the strata that form the top of Babcock Mountain are flat-lying. However, it should be noted that strata at the proposed Little Windy and Big Windy pits dip at a shallow angle toward the south, that is, into the hillside.

are of negligible thickness. At other areas on the flatter segments of topography, the glacial till soils are in excess of five metres thick. For the most part, the dumps have been positioned so that they will be supported on the flatter segments of topography and the steeper segments of topography have been avoided.

5.0 STABILITY ANALYSES

5.1 Shear Strength of Surficial Soils and the Waste Rock

A series of consolidated undrained triaxial shear strength tests with pore pressure measurements was performed on representative samples of the glacial till soils from the Babcock area. These shear strength test results are summarized in graphical form on Figure 5-1. The lower boundary of the envelope that encompasses the points representing the results of the shear strength tests can be defined as an angle of shearing resistance (ϕ) of 33°, with zero cohesion. The upper bound of the shear strength envelope is represented by an angle of shrearing resistance, $\phi = 37.3°$, and a cohesion value of about 50 kPa. For purposes of the stability evaluations, the shear strength for the surficial foundation soils has been assumed to be in the range of $\phi = 32^0$ to 38^0, and cohesion has been neglected.

For the waste rock, the shear strength parameters have been taken as:

$\phi = 38°$

c= 0 kPa

Unit weight = 20 kN/m^3

5.2 Potential Failure Mode

It is the double wedge potential failure mechanism that controls stability of waste rock dumps at the open pit coal mining operations in British Columbia. The double wedge mechanism is ubiquitous. The internal strains associated with the double wedge produce surface manifestations that are evident on the faces of virtually all of the waste rock dumps in both the Southeast and the Northeast Coal Blocks.

5.3 The Double Wedge

Field observations show that large strains (displacements) develop at the crests of waste rock dumps, including at those dumps that remain stable. In most instances, the shear displacements are so large that it is clearly evident that the shear strength of the waste rock in the region of the dump crest remains fully mobilized. In the so-called 'conventional' methods of stability analyses, the factor of safety is defined as "*That factor by which the shear strength parameters must be reduced (along the boundaries of the potential failure mass) to bring the potential failure mass into a state of limiting equilibrium*". This definition implies that, at any particular time 't', the factor of safety is the same value along all segments of the potential failure mass. The large displacements in the region of the dump crest clearly show that the factor of safety in that region is 1.0. Nevertheless, the dump remains stable. These observations are a clear indication that neither the conventional definition of factor of safety, nor the so-called conventional methods of stability analyses are applicable in assessment of the stability of waste rock dumps at the open pit coal mines in British Columbia.

5.4 Factor of Safety for the Double Wedge

The double wedge is illustrated on Figure 5-2. The shear displacements within the Active Wedge are sufficiently large that the shear strength parameters for the waste rock within the Active Wedge, including at the wedge boundaries, are fully mobilized. The factor of safety of the Active Wedge is, and remains at 1.0.

The stability of the Active Wedge is dependent on the support provided by the Toe Wedge. Provided the shearing resistance along the base of the Toe Wedge is sufficiently large, the Toe Wedge remains stable and continues to provide support for the Active Wedge. As a result, the whole of the dump face remains stable. In short, the stability of the dump face is dependent on the stability of the Toe Wedge, and in particular, on the available shearing resistance within the foundation soils at shallow depth beneath the base of the waste rock comprising the Toe Wedge.

The available shearing resistance within the foundation soils along the base of the Toe Wedge can be expressed as:

$$s = (p_n - u) \tan \phi \qquad \text{(Equation 1)}$$

Where:
- s is the maximum available shearing stress
- p_n is the total stress normal to the failure surface
- u is the pore water pressure on the failure surface
- ϕ is the angle of shearing resistance for the foundation soils at shallow depth below the base of the Toe Wedge

Equation 1 shows that for a given applied stress, the maximum available shearing resistance along the base of the toe wedge is dependent on the angle of shearing resistance, ϕ , for the near-surface foundation soils and on the pore water pressure 'u'. The angle of shearing resistance ϕ may be considered to be a property of the particular foundation soils over which the dump is developed. For a given soil type at a given density, the value of ϕ is essentially constant. The pore water pressure 'u' on the other hand, is a variable that is dependent on several factors, some of which are not subject to manipulative control, as explained in the following section.

5.5 Strain-Generated Pore Water Pressure

The foundation soils within the footprint of the proposed waste rock dumps on Windy Ridge consist predominantly of glacial till. Having been heavily pre-loaded by glacial ice, these soils are very dense. When subjected to shearing strains, glacial tills are normally dilatant. That is, shearing strains are accompanied by a tendency for the soil particles to move into a less densely packed arrangement, accompanied by a **reduction** in pore water pressure, and an **increase** in shearing resistance.

Although the bulk of the glacial till foundation soils within the footprint of the Windy Ridge dumps are likely to be dilatant, the near-surface soils, extending to a depth of a metre or so below ground surface, have been loosened by frost action and by disturbance due to root penetration. As a result of this post-glacial disturbance, the near-surface soils have 'forgotten' their preloading history, and now exhibit the properties of normally loaded soils. That is, when subjected to shearing strains under constant normal applied stress, these soils tend to be contractive. The near-surface soils are saturated and of low permeability, so that when they are subjected to shearing strains, the constituent soil particles tend to move into a more closely packed arrangement. Since the void spaces between the constituent soil particles are water-filled, contraction of the soil skeleton cannot occur instantaneously. As a result, the shearing strains can produce an **increase** in pore water pressure, accompanied by a **reduction** in the available shearing resistance. Reduction in the available shearing resistance in response to unidirectional shearing strain is illustrated on Figure 5-3. If shearing continues, the void ratio of the soil will tend toward the steady state void ratio, as illustrated on Figure 5-4. For a given soil, the steady state void ratio is not a unique soil property, but is a function of the applied normal stress.

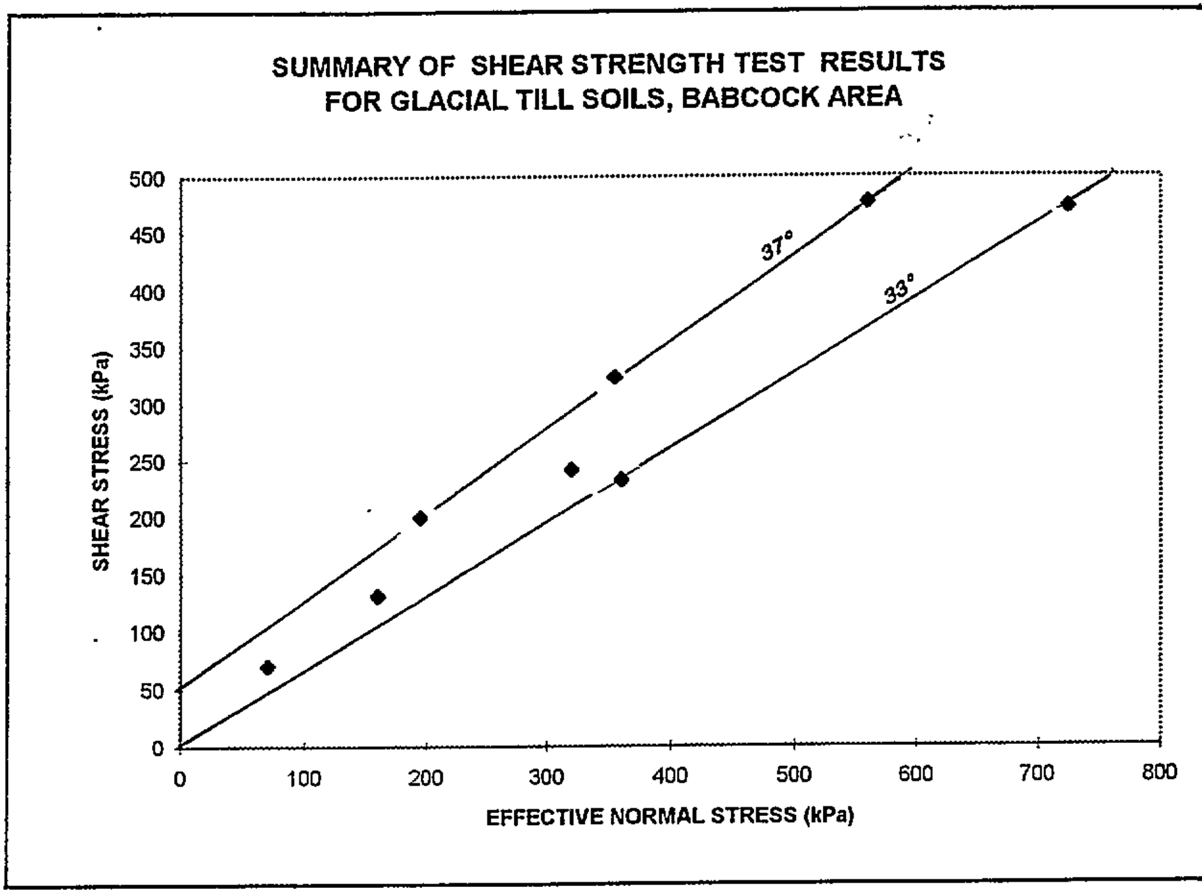
5.6 Strain-Generated Pore Water Pressure and Stability of Toe Wedge

The proposed Big Windy and Little Windy dumps will be developed on a north-aspect slope. The near-surface foundation soils in this area are likely to be saturated, or nearly so, at the time of dump development. Even if the foundation soils were (are) not saturated at the time that they are covered by the advancing face of the dumps, saturation of the foundation soils will occur as a result of downward percolation of precipitation through the waste rock to the base of the dump. Once saturated, the foundation soils that have been covered by a dump never again have an opportunity to dry out. Thus, it may be concluded that the foundation soils beneath the Toe Wedge are saturated and that they remain so.

If the applied shearing stresses along the base of the Toe Wedge initiate shearing strains, these strains would be accompanied by an increase in the pore water pressures within the foundation soils at shallow depth below the base of the Toe Wedge. These excess pore water pressures will tend to dissipate as a result of drainage toward the base of the waste rock fill. Rate of pore pressure dissipation is a function of:

- the permeability of the foundation soils; and
- the maximum length of the drainage path to the drainage boundary.

If the rate of pore pressure reduction due to consolidation drainage is slower than the rate of pore pressure generation due to strain, then there will be a net increase in pore water pressure within the foundation soils along the base of the Toe Wedge. Pore pressure increase leads to increased rate of strain, which in turn produces a further increase in pore water pressures. This sequence is referred to as the 'Vicious Circle'. It is illustrated on



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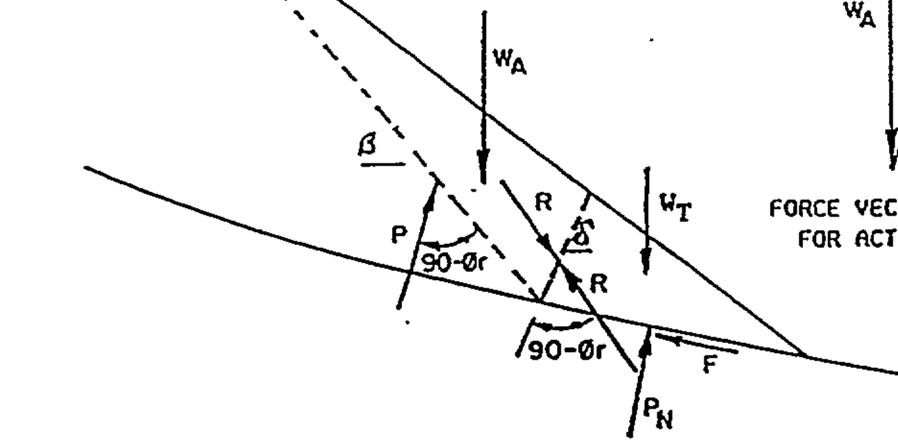
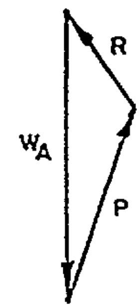
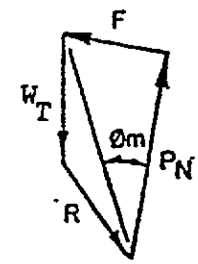
SUMMARY OF SHEAR STRENGTH TEST RESULTS

Figure 5-1





FORCE VECTOR DIAGRAM
FOR ACTIVE WEDGE



FORCE VECTOR DIAGRAM
FOR TOE WEDGE

W_A	=	Effective weight of active wedge.
β, δ	=	Inclination of Active wedge boundaries.
P, R	=	Resultant forces on boundaries of active wedge assuming friction angle for waste rock fully mobilized.
W_T	=	Effective weight of toe wedge.
P_N	=	Effective force acting normal to base of toe wedge.
F	=	Mobilized base friction for limiting equilibrium of toe wedge.
Φ_r	=	Angle of internal friction for waste rock.
Φ_m	=	Mobilized friction angle on base of toe wedge.

An illustration of the double wedge method for assessing the stability of the face of a dump and the forces that act on the active wedge and on the toe wedge. Along the inclined boundaries of the active wedge, the shear strength parameters for the waste rock are assumed to be fully mobilized. Limiting equilibrium is assumed, and the force "R" that acts across the mutual boundary between the active and the toe wedges is calculated. The force "R" is then applied to the toe wedge, and the mobilized friction angle on the base of the toe wedge corresponding to limiting equilibrium is calculated. An indication of the factor of safety for the toe wedge is provided by the ratio of the tangent of the base friction angle to the tangent of the mobilized base friction angle.

In performing the analyses for a selected section through a waste rock pile, a trial location is selected for the point at which the boundaries of the active wedge intersect the waste rock/foundation surface of contact. The angle β and δ are then varied to find that combination of inclinations for the active wedge boundaries that result in the lowest factor of safety, or alternatively in the highest mobilized friction angle on the base of the toe wedge.

The analyses are repeated for different trial positions for the lower apex of the active wedge, until the lowest factor of safety has been found.

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DOUBLE WEDGE FAILURE MECHANISM AND METHOD OF ANALYSES

Figure **5-2**

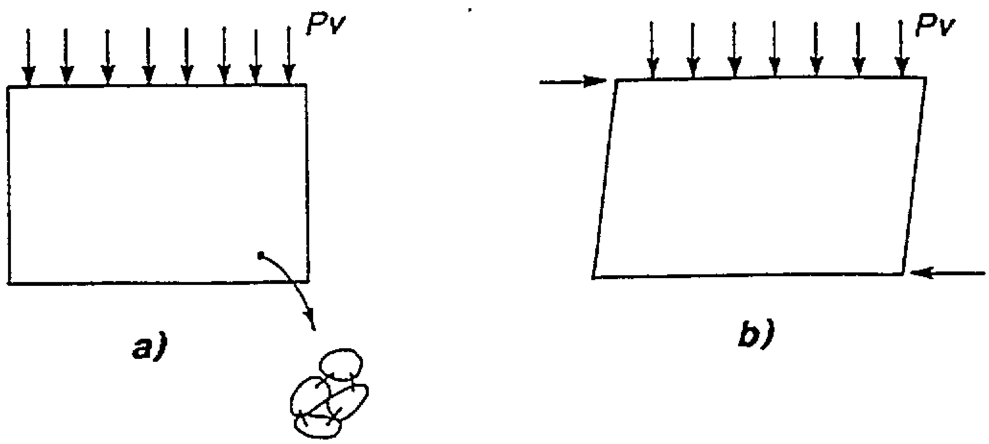

Figure (a)

Illustrating an element of normally loaded saturated soil which is subjected to a vertical stress 'p' which has acted for sufficient time that pressure within the void spaces is virtually zero, and the applied stress is supported by particle-to particle contact forces between adjacent soil particles.

Figure (b)

The element illustrated in (a) is subjected to shearing strain, while the vertical stress remains unchanged. The soil particles tend to move into a more closely packed arrangement, i.e. the volume of the element tends to decrease. Since the void spaces are filled with water, reduction in volume cannot occur immediately and part of the applied vertical stress is transferred to the pore water, reducing the intergranular (effective) stress. The increase in pore pressure and the attendant reduction in effective stress reduces available shearing resistance.

$$s = (p-u) \tan\phi$$

where:

s = Shearing Resistance
p = Total Applied Normal Stress
u = Pore Water Pressure
ϕ = The Angle of Internal Friction

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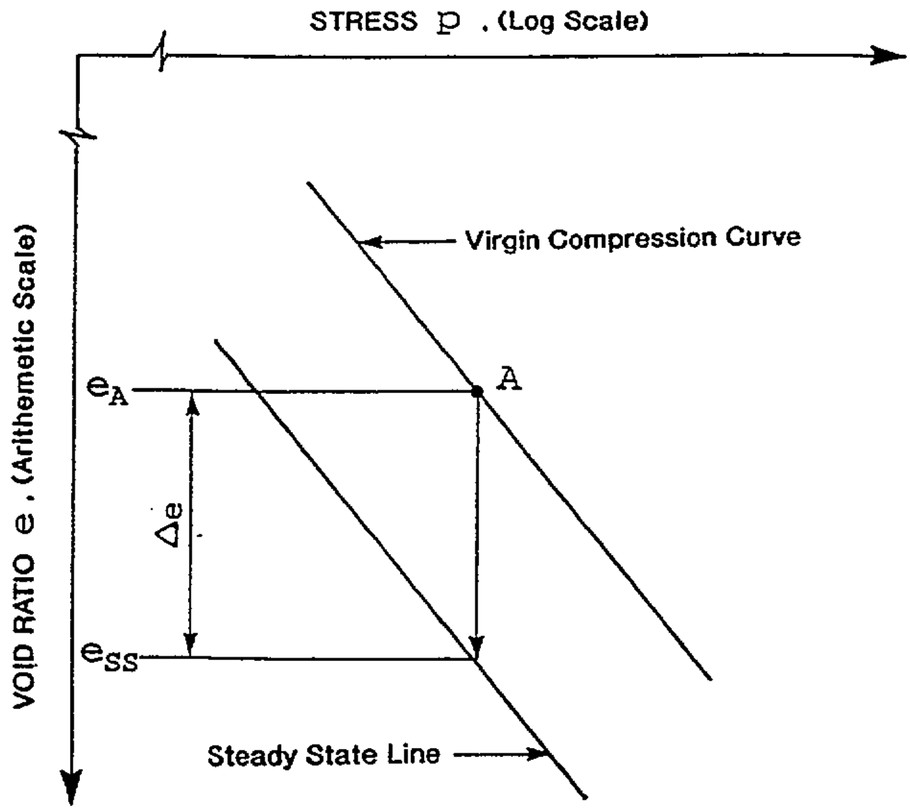
REDUCTION IN 'e' DUE TO STRAIN

Figure **5–3**



Point A represents the effective stress p, and the void ratio e_A of a soil, after the soil has fully consolidated under the applied vertical stress p. Provided the vertical stress remains constant at p, and the soil is not subjected to shearing strains, the void ratio remains at e_A.

If the soil in the state represented by Point A is then subjected to shearing strains while the vertical stress remains at p, the void ratio will tend to decrease from e_A to e_{SS}. If the soil is saturated and of low permeability, the change in void ratio from e_A to e_{SS} is accompanied by transfer of stress from the soil skeleton to the pore fluid, with an attendant reduction in effective stress, and a reduction in the available shearing resistance of the soil.

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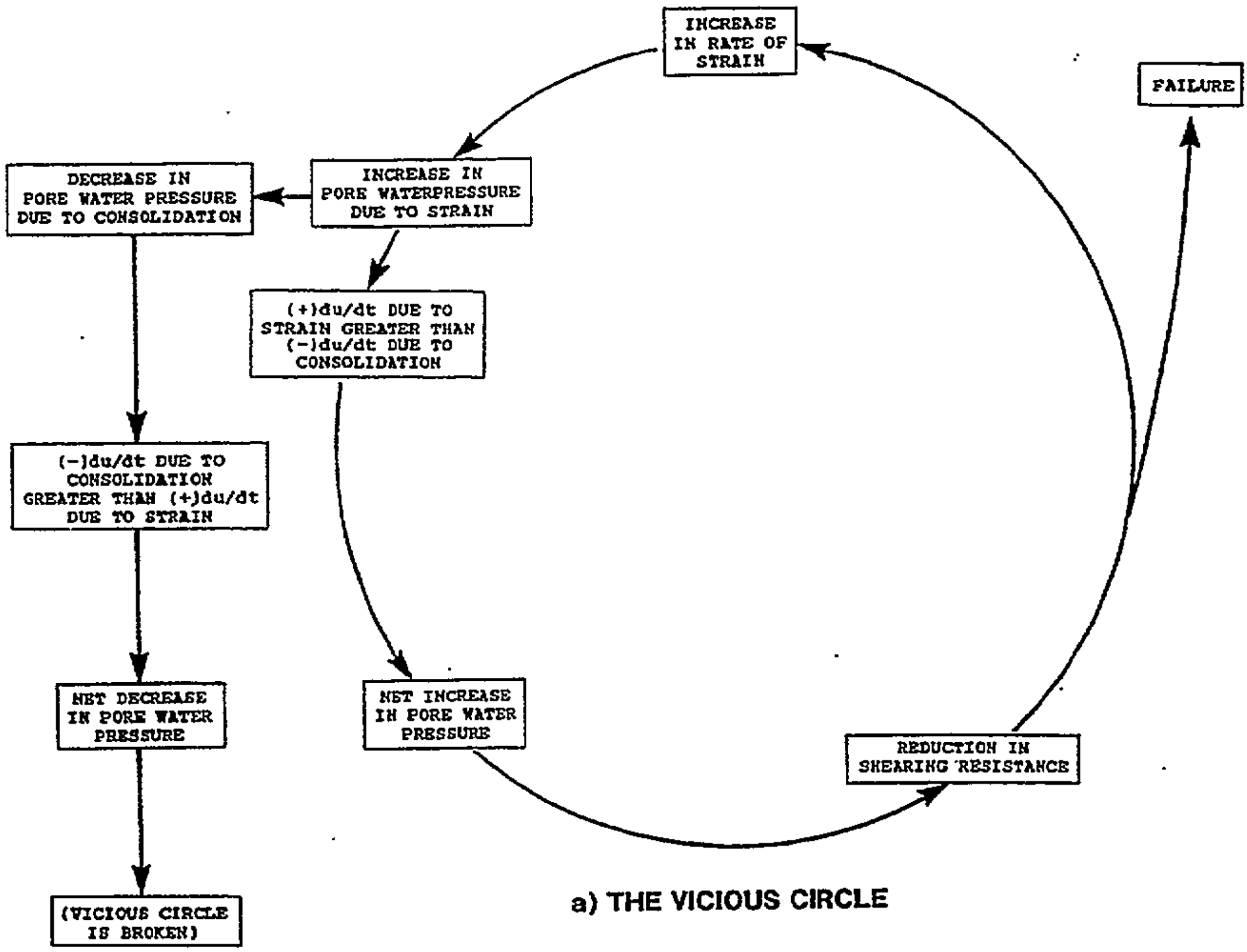
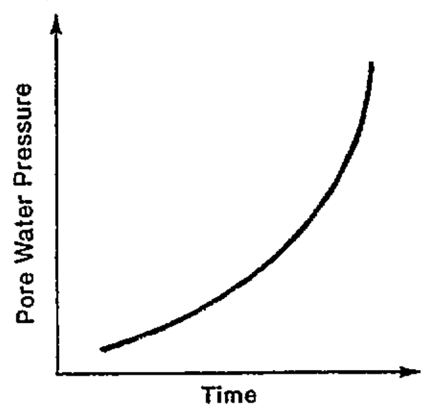
COMPRESSION CURVE AND STEADY STATE LINE

Figure **5-4**



a) THE VICIOUS CIRCLE

NOTE: du/dt denotes rate of change of pore water pressure with respect to time



b) RATE OF INCREASE IN PORE PRESSURE (PROBABLE)

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VICIOUS CIRCLE

Figure 5-5

Figure 5-5. The vicious circle mechanism can occasionally lead to failure, even at dumps that have remained dormant for several months.

6.0 STABILITY ASSESSMENT FOR BIG WINDY DUMP

6.1 Numerical Analyses

The stability of the proposed Big Windy dump has been assessed using the double wedge method of analysis. This method is illustrated on Figure 5-2. In the double wedge analysis, factors of safety refer to the ability of the Toe Wedge to resist lateral down-slope displacement due to shearing along its base.

The factors of safety of the toe wedge, as indicated by the numerical analyses for five representative sections, are summarized on Figure 6-1(b). The indicated factors of safety summarized on 6-1(b) are based on the following conditions:

- angles of shearing resistance for the foundation soils in the range of 32 to 38 degrees; and
- pore water pressures within the foundation soils are negligible.

In the stability analyses, cohesion has been neglected. Neglecting cohesion results in conservative values for the indicated factors of safety. The stability analyses indicate factors of safety in the range of about 1.7 to greater than 2 for sections A-A, B-B, and

C-C. For sections E-E and D-D, the indicated factors of safety are in the range of 1.3 to about 1.6, corresponding to ϕ-values in the range 32 to 38 degrees.

Analyses were also carried out to determine the level of pore water pressure, within the foundation soils at shallow depth below the base of the Toe Wedge, that would result in limiting equilibrium of the Toe Wedge. In this part of the stability analyses, pore water pressures were expressed in terms of r_u[2]. Again, the range of base friction angles was taken as 32 to 38 degrees. The values of r_u corresponding to limiting equilibrium of the Toe Wedges at the sections for the Big Windy dump are summarized in graphical form by the lower group of curves on Figure 6-1(b).

[2] r_u is defined as the ratio of pore water pressure to total normal stress on the potential failure surface.

6.2 Stability as Indicated by Empirical Data

Rate of strain within the foundation soils along the base of the Toe Wedge is one of the factors that governs pore water pressure and the value of the pore pressure ratio r_u. Since this rate of strain cannot be predicted, it follows that numerical analyses can provide only an indication of the likely stability of a waste rock dump. As a further assessment of the likely stability of the proposed Big Windy dump, the sections presented on Figure 6-1 have been compared with dump height and foundation slopes for major dump failures that have occurred at B.C. coal mines over the past 28 years. This comparison is summarized in graphical form on Figure 6-1(c). The diamond-shaped symbols on Figure 6-1(c) represent foundation slopes and dump heights for recorded waste dump failures at B.C. coal mines. The grouping of the data points on the plot shows that major dump failures have not developed where the slope of the foundation beneath the Toe Wedge was flatter than about 15 degrees. The data also indicate that as the foundation slope increases, failures can occur at progressively lower dump heights.

The circular symbols on Figure 6-1(c) represent the data points for the sections presented on Figure 6-1. The data points for all of the sections through the proposed Big Windy dump fall well outside the region of the plot that contains the data points representing precedent dump failures. Figure 6-1(c) provides an indication that failures are unlikely to occur at the proposed Big Windy dump.

Both the numerical analyses and the empirical data indicate that the Big Windy dump can be expected to remain stable.

6.3 Reducing the Probability of Dump Failure

The following factors are known to influence dump stability.

1. Rate of loading
2. The inclination of the dump face
3. The inclination of the foundation slope beneath the face of the dump

If dump development takes place in a direction parallel to contour, the inclination of the surface of the waste rock fill, in the plane of a fall-line section, is considerably flatter than the angle of repose for the waste rock. Thus, by advancing parallel to contour, the effective inclination of the dump face is reduced, at least during the early stages of waste rock development within a fall-line section. In accordance with item (2) above, stability is improved.

At Section C-C on Figure 6-1, if the direction of advance of the dump is approximately parallel to foundation contours, placement of approximately 14 million bulk m^3 of waste rock would be required between the time that the advancing toe of the waste rock arrives at the plane of the section and the time that the section has been fully developed. Thus, by advancing the dump parallel to foundation contour, the rate of loading is as low as practicable and in accordance with item (1) above, the probability of failure is reduced. To minimize the probability of failure at the Big Windy dump, we recommend that so far as practicable, the azimuth of the active dumping face should remain perpendicular to contour and that the direction of advance of the dump face should be parallel to contour on the foundation.

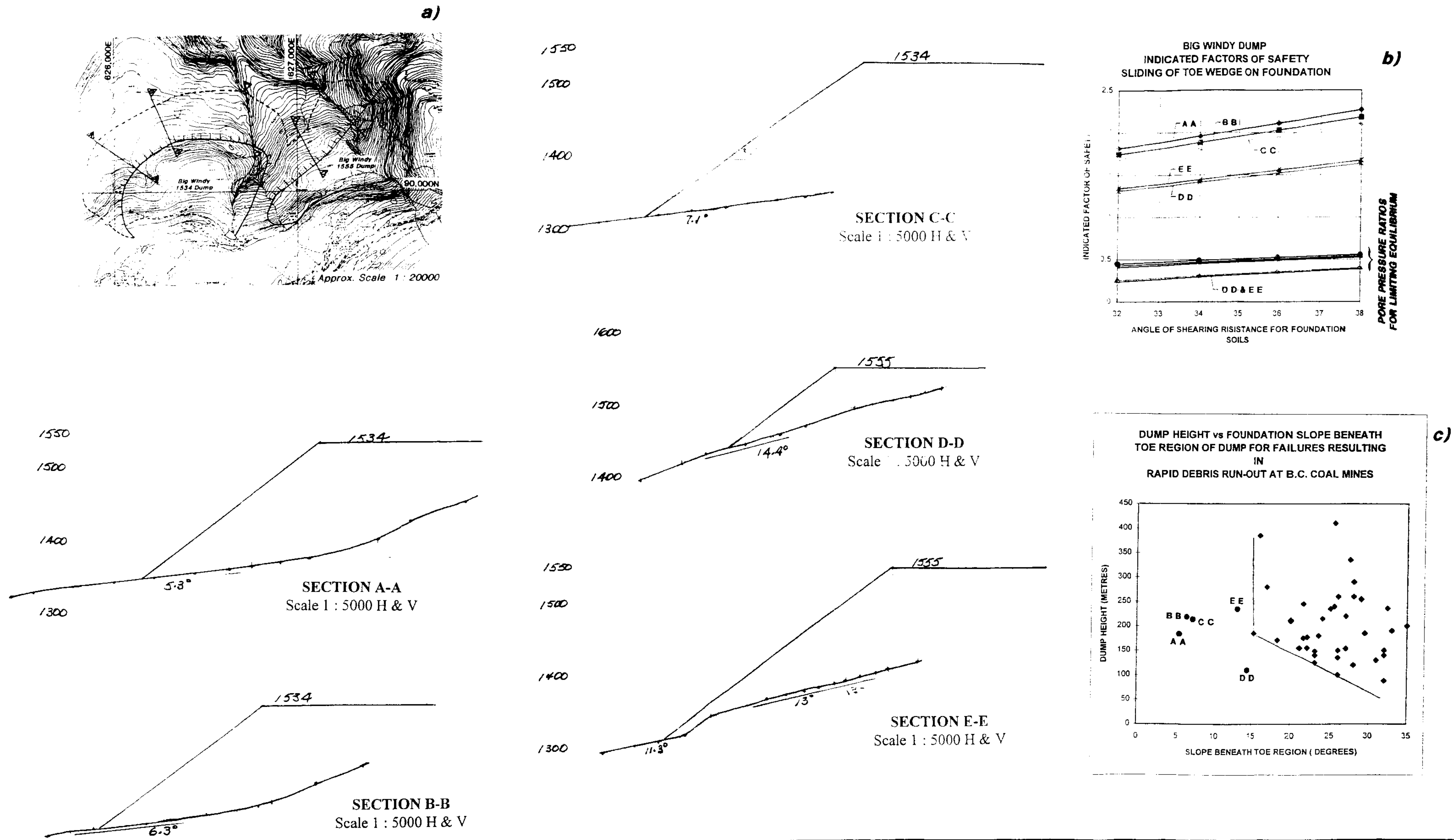
6.4 Potential Debris Run-Out

Although the numerical analyses, as well as the empirical data, indicate that the Big Windy dumps will remain stable, debris run-out analyses have nevertheless been carried out to provide an indication of the distance that debris might be expected to travel, in the unlikely event that a failure on the dump face were to develop.

In the debris run-out analyses, reliance was placed on the empirical data presented in the debris run-out study noted at the bottom of this page[3]. The dynamic angles governing debris run-out within confined draws, as determined by back-analyses of recorded events at B.C. Coal mines, were assumed to be part of a larger normally-distributed set of data. The resulting dynamic angle (ϕ_d) frequency distribution curve is presented on Figure 6-2.

Any potential debris run as a result of a failure at the Big Windy dump would follow drainage courses that extend north-northwest from the proposed dump. There are

[3] Run-out Characteristics of Debris from Dump Failures in Mountainous Terrain Stage 2: Analysis, Modeling and Prediction. February 1995. A study carried out by Golder Associates and Dr. O. Hungr for CANMET, Canada Department of Supply and Services.

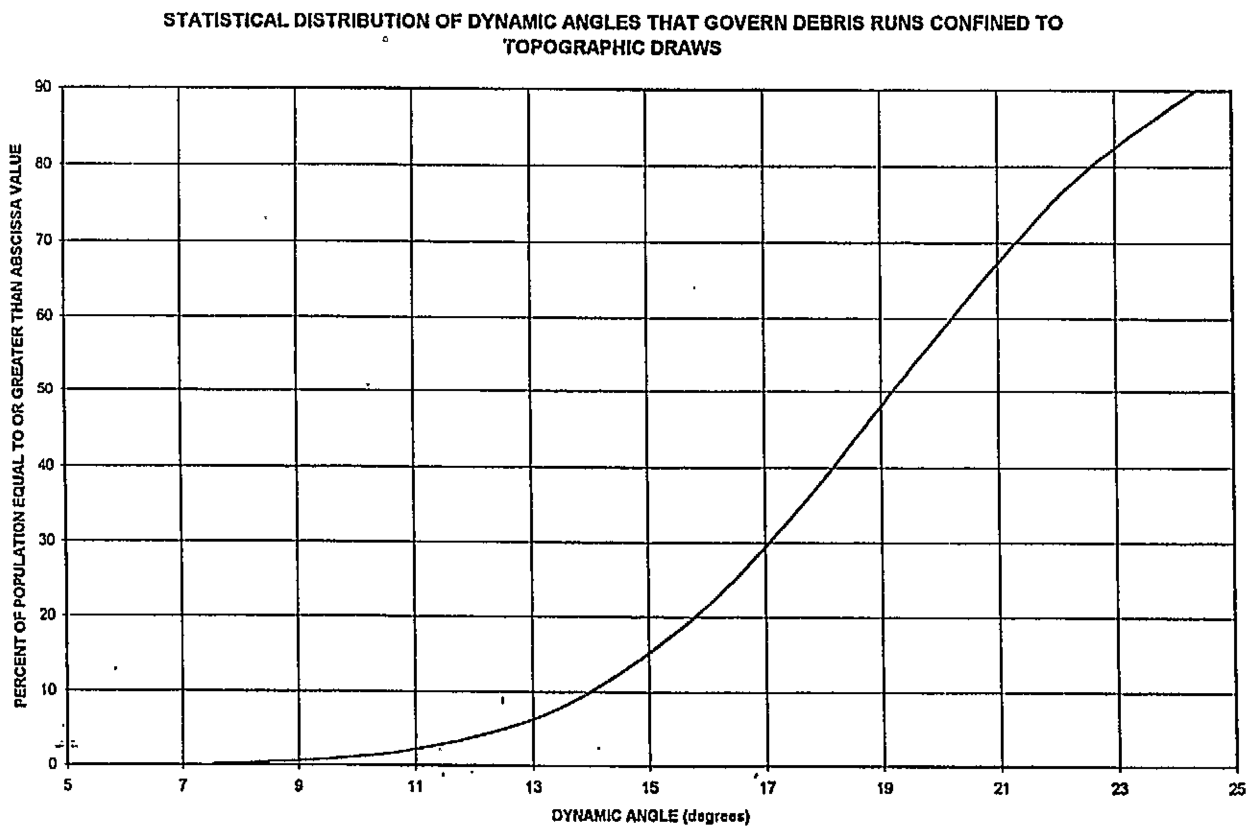


Golder Associates

STABILITY ASSESSMENTS FOR BIG WINDY DUMPS

Figure 6–1

Project No. 962-1474 Drawn BAD Reviewed DBC Date Jan.'9.



Project No. 962-1474 Drawn BAD Reviewed DBC Date Jan. '97	Golder Associates	**DYNAMIC RUN-OUT ANGLES FOR FAILURE DEBRIS CONFINED TO DRAWS**	Figure **6-2**

currently no infrastructure installations along potential debris runs, with the exception of the access road and the gas pipeline along the east side of the Murray River.

The debris run analyses indicate that providing the dynamic angle governing a debris run were equal to or greater than 11.5°, debris would come to rest well short of the road/pipeline along the east edge of the river. According to the stasticical analyses, there is only a 3.5 % probability that the dynamic angle governing a debris run would be less than 11.5°. Judging from the position of the data points representing the sections through the Big Windy dump, the probability of a failure is estimated at less than 2 per cent. The probability that failure debris might reach the road and pipeline along the east edge of the Murray River may be considered as the product of the probabilities of these two events. Thus the probability that debris might reach the base of the slope is about 0.07 per cent, or about 1 in 1400. It is our opinion that a probability this low represents an acceptable risk.

6.5 Safety of Proposed Talisman Well Site

Talisman Energy propose to drill a gas well at 90550N, 626000E (reference UTM grid). This location is approximately 1.1 km north of the angle-of-repose toe of the Big Windy dump. In the unlikely event of a failure of the Big Windy dump, the failure debris would not reach the location of the proposed wellsite. Consequently, the Big Windy dump does not represent a hazard to the proposed well-site, nor to the proposed access roadway to the wellsite.

7.0 STABILITY ASSESSMENT FOR LITTLE WINDY DUMP

7.1 Numerical Analyses

As for the Big Windy dumps, the double wedge method was used in the stability assessments for the proposed Little Windy dumps. The sections analyzed are presented on Figure 7-1 and the results of stability calculations are presented in graphical form on Figure 7-1(b). For base friction angles in the range of 32 to 38 degrees and negligible pore water pressures along the base of the toe wedge, the stability calculations indicate factors of safety in the range of about 1.3 to 1.6 at section J-J. At Section F-F, the corresponding range of calculated factor of safety is 1.6 to greater than 2. Based on these relatively large calculated factors of safety, development of a failure at the Little Windy dump is considered to be unlikely.

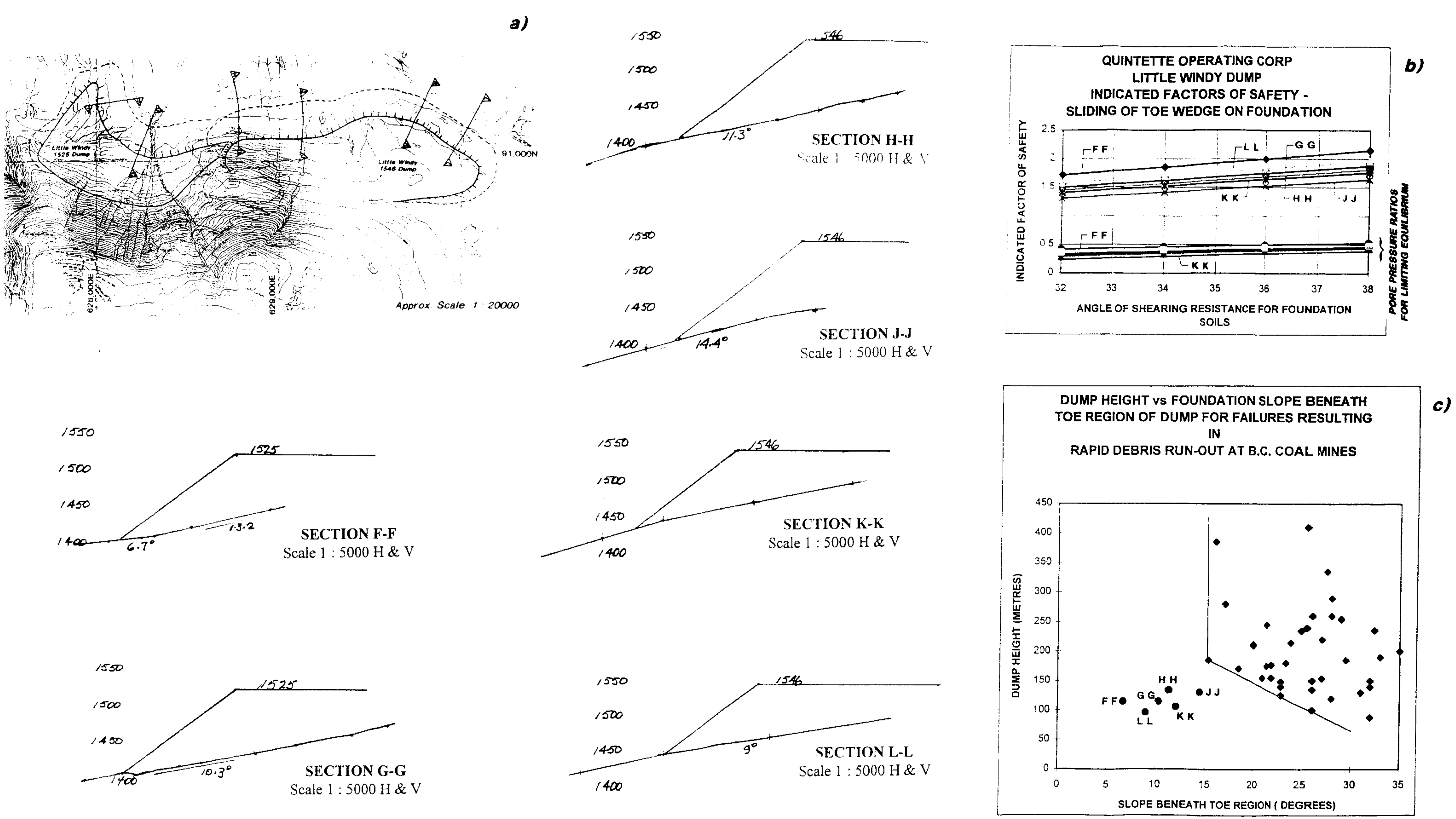
7.2 Stability as Indicated by Empirical Data

The combinations of dump height and foundation slope for the sections at the Little Windy dumps were compared with the combinations of dump height and foundation slope for precedent dump failures at B.C. coal mines. This comparison is shown in graphical form on Figure 7-1(c). All of the data points representing the sections at Little Windy are located well outside the region of the plot that contains the data points for precedent dump failures at B.C. coal mines. The data plotted on Figure 7-1(c) provide a further indication that the Little Windy dumps can be expected to remain stable.

7.3 Potential Debris Run-Out

Although the numerical, as well as the empirical assessments, indicate that the Little Windy dumps can be expected to remain stable, analyses were carried out to provide an indication of the distance that debris might travel, in the unlikely event that a failure were to develop at the Little Windy dumps.

The Little Windy dumps are located within the catchment of M11 Creek. The M11 Diversion Dam is located on M11 Creek, above the Shikano Pit. The location of the M11 dam and the small pond above the dam is indicated on the marked air photo, Figure 1-2. The elevation of the dam crest is approximately 1070 metres. The primary question is: if



Golder Associates

STABILITY ASSESSMENTS FOR LITTLE WINDY DUMPS

Figure **7–1**

Project No. 9... 474 Drawn ..AD Reviewed DC Date Dec.

a failure were to occur at the Little Windy dumps, could the debris be expected to travel as far as the M11 dam?

The debris run analyses indicate that provided the dynamic angle governing a potential debris run were 12.5° or greater, the failure debris would not reach the pond at the M11 dam. According to the statistical analyses, there is only a 5 per cent probability that the dynamic angle governing a debris run would be equal to or less than 12.5 degrees. Thus, in the unlikely event of a dump failure, the probability is only about 5% that the debris would reach the M11 pond.

Considering the position of the points representing dump height and foundation slope, relative to the segment of the plot that contains data points representing precedent dump failures (see Figure 7-1(c)) , we are of the opinion that the probability of a dump failure at Little Windy is less than 2 per cent. The probability of debris reaching the M11 pond is the product of the two probabilities:

- the occurrence of a dump failure, and
- a dynamic run-out angle lower than 12.5°.

The probability that failure debris might reach the M11 Pond is therefore approximately 1:1000. It is our opinion that this probability is acceptably low. However, if the associated risk is considered to be unacceptable, one of the following mitigating measures might be considered.

- Construct a rock fill barrier upstream of the M11 Pond.
- Fill the M11 pond with waste rock, so that water is no longer stored in the pond.
- Extend the Shikano rock dump onto the downstream face of the M11 dam.

GOLDER ASSOCIATES LTD.

D.B. Campbell, P.Eng.
Principal

DBC/ggg
962-1474
J:\RPT-97\JAN\DBC-1474.DOC

APPENDIX A

LOGS OF TEST PITS IN REGION OF PROPOSED WINDY RIDGE WASTE ROCK DUMPS

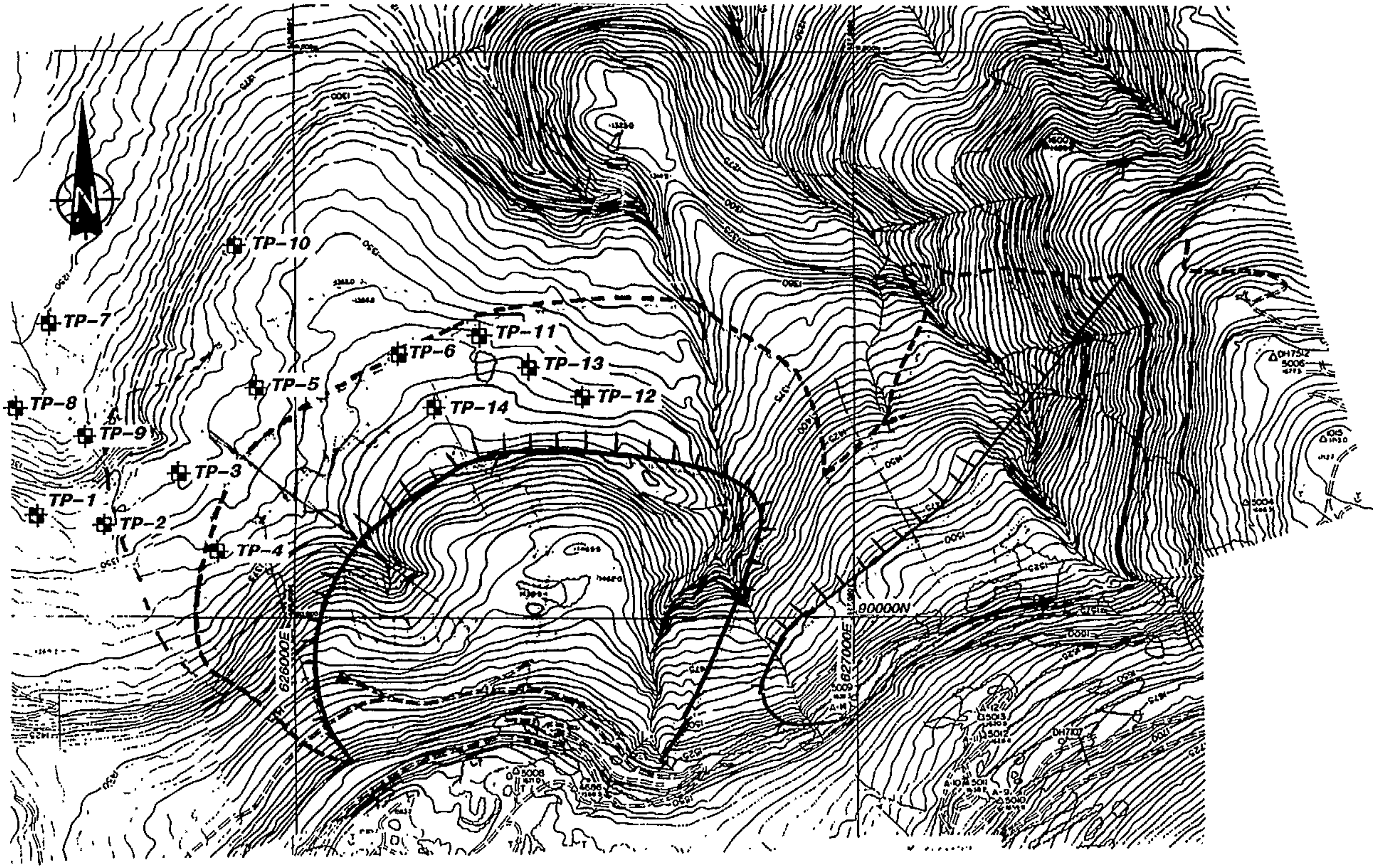
FOUNDATION INVESTIGATIONS FOR WINDY RIDGE WASTE ROCK DUMPS

The surficial foundation soils at the Little Windy and Big Windy waste rock dumps were investigated by test pits that were excavated into the surficial soils. Following excavation and logging of the test pits. the waste rock dumps were re-configures so that dump heights were reduced, and the toe regions of the dumps were located on flatter topography. This reconfiguration of the dumps resulted in improved stability, and in reduced debris run-out in the unlikely event that failure of a might develop.

As a result of the dump reconfiguration, some of the test pits that were excavated within the foundation area of the dumps as originally proposed are located outside the footprint of the dumps as presently proposed. The foundation soils in the area consist of glacial tills that have been weathered near surface. It is our view that although some of the test pits are located outside of the footprint of the dumps, the data that were collected in the course of the foundation investigaitons are applicable to the dumps as presently proposed

DBC

7 January, 1997.

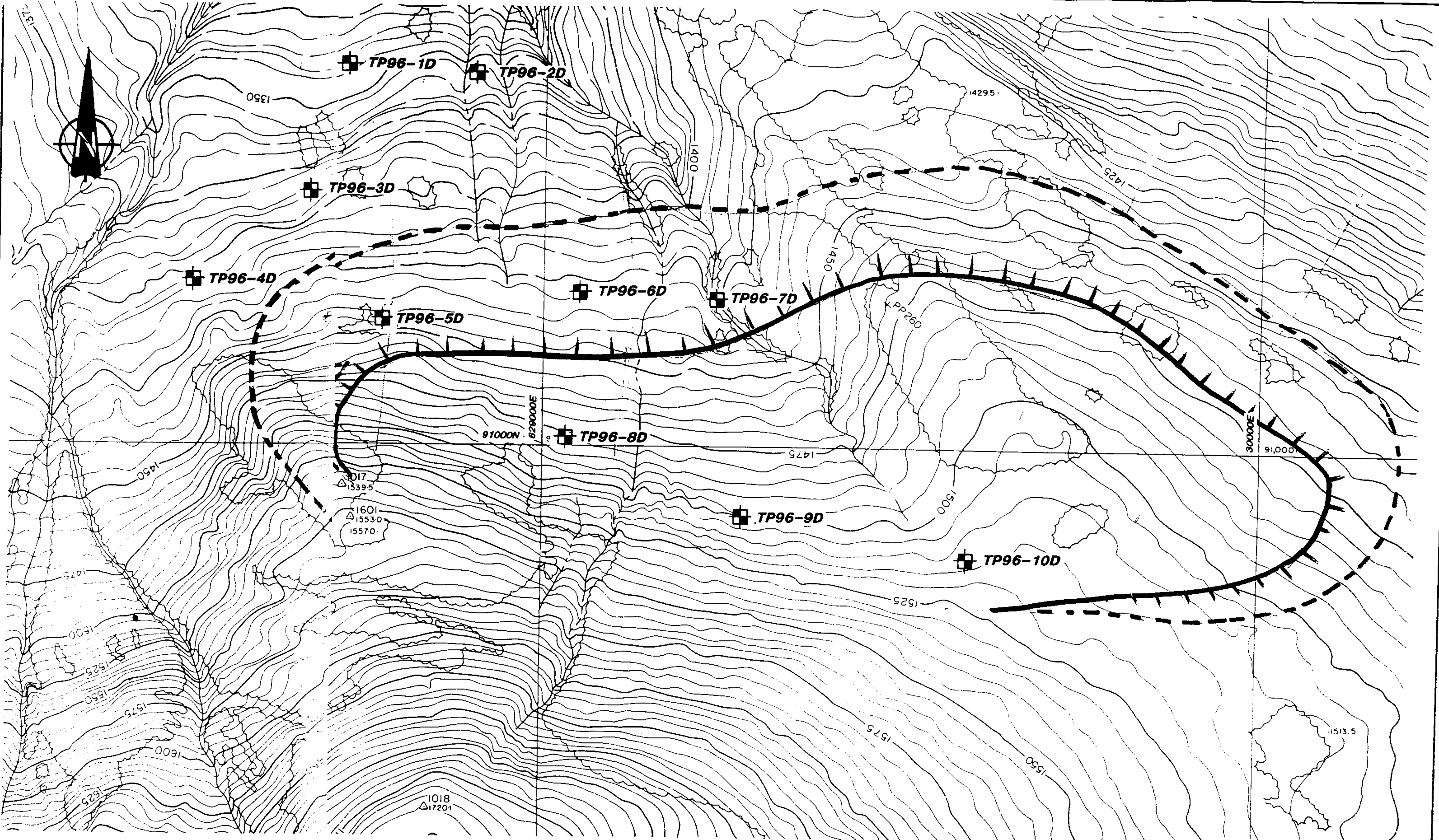


Legend:

Approx. location of Test Pit.

Approx. Scale 1 : 10000

Project No. 962-1474 Drawn BAD Reviewed DBC Date Jan.'97	Golder Associates	**BIG WINDY** **TEST PIT LOCATIONS**	Figure **A-1**



Legend:

Approx. location of Test Pit

Approx. Scale 1 : 5000

Golder Associates

LITTLE WINDY
TEST PIT LOCATIONS

Figure A-2

ct No. 96...174 Drawn ...DD Reviewed ...DDC Date Jan...

PEACE COUNTRY MATERIALS TESTING LTD. — *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 01	CHECKED BY: [signature]
DRILLER: GREG WILSON TRACKER CONTRACTORS	DRILL TYPE: JD 690 ELC EXCAVATOR

WATER CONTENT (Wp - ■ W - ● WL- ▲ PERCENT % 10 20 30 40 50 60 70)	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION — LOCATION: AS PER SITE PLAN.	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			MOSS, PEAT, ORGANIC, ROOTS, BROWN, WET.			
			SILT, LITTLE FINE SAND, NON PLASTIC, GREY TURNING BROWN, ROOT FIBRES, MOIST.			
	0.5		BEDROCK, SANDSTONE, FINE GRADED, WEATHERED, BROWN, WATER SEEPAGE FROM WITHIN FRACTURES.			
	1.0		- BECOMES MORE COARSE, STILL ABLE TO EXCAVATE.			
			END OF HOLE 1.2 M, NO FREE WATER.			

540-IBH.FRM

PEACE COUNTRY MATERIALS TESTING LTD.

BOREHOLE LOG

CLIENT: QUINTETTE OPERATING CORPORATION

PROJECT NO: CAN 0540

PROJECT: PROPOSED BIG WINDY DUMP

LGD': ES DWN': BT

DATE OF INVESTIGATION: 09/17/96

HOLE NUMBER: 02

CHECKED BY:

DRILLER: GREG WILSON TRACKER CONTRACTORS

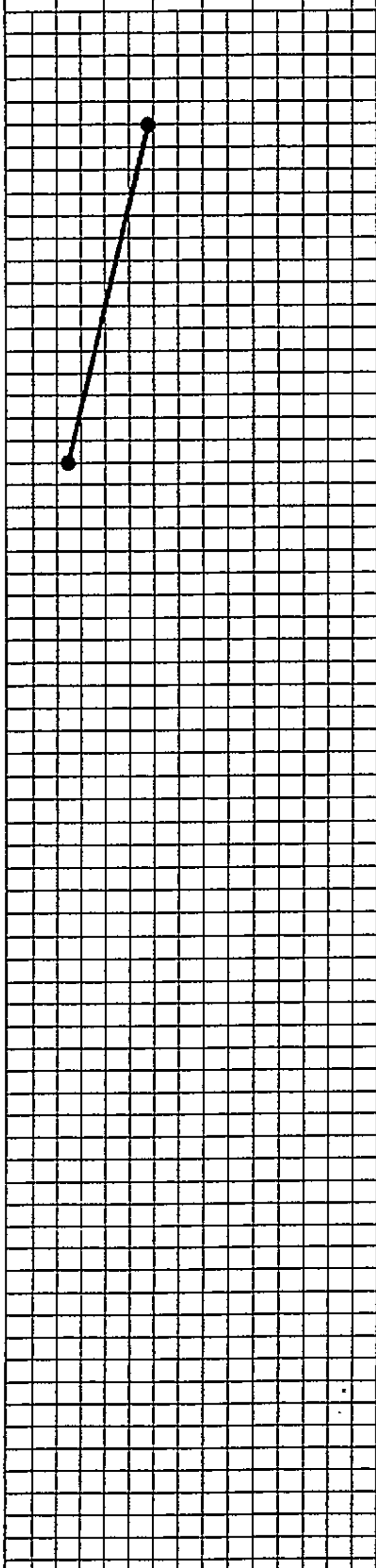
DRILL TYPE: JD 690 ELC EXCAVATOR

WATER CONTENT

WP - ■ W - ● WL - ▲

PERCENT %

10 20 30 40 50 60 70



DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
	LOCATION: AS PER SITE PLAN.			
	MOSS, PEAT, ORGANIC, ROOTS, BLACK, WET.			
	SILT, LITTLE FINE SAND, NON PLASTIC, BROWN, SENSITIVE, MOIST TO WET.			
0.5				
	SILT, SOME SAND, SOME GRAVEL, TRACE OF CLAY, HARD, LOW PLASTIC, BROWN, MAXIMUM SIZE 80 MM, ANGULAR, INFREQUENT COBBLES TO 200 MM, FISSURED, MOIST, TILL.			
1.0				
1.5				
2.0				
2.5				
	- BEDROCK, COULD NOT PENETRATE.			
	END OF HOLE 2.8 M, NO FREE WATER.			

540-2BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. **BOREHOLE LOG**

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT.
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 03	CHECKED BY: [signature]
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT: WP - ■ W - ● WL - ▲ PERCENT % 10 20 30 40 50 60 70

LOCATION: AS PER SITE PLAN.

DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
	MOSS, PEAT, ORGANIC, ROOTS, BROWN, WET.			
	SILT, LITTLE SAND, ORGANIC, NON PLASTIC, BLACK, ROOTS AND ROOT FIBRES, SENSITIVE, SATURATED.			
0.5	SILT, LITTLE FINE SAND, STIFF, NON PLASTIC, GOLDEN BROWN, SENSITIVE, MOIST TO WET.			
1.0 – 1.5	SILT, SOME SAND, SOME GRAVEL, HARD, NON PLASTIC, GREY, MAXIMUM SIZE 80 MM, ANGULAR, OCCASIONAL COBBLES TO 150 MM, MOIST TO WET, TILL.			
2.0	BEDROCK, SANDSTONE, FRACTURED, WEATHERED, BROWN.			
	END OF HOLE 2.3 M. WATER FLOW AT INTERFACE OF TILL AND SANDSTONE.			

540-3BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. | **BOREHOLE LOG**

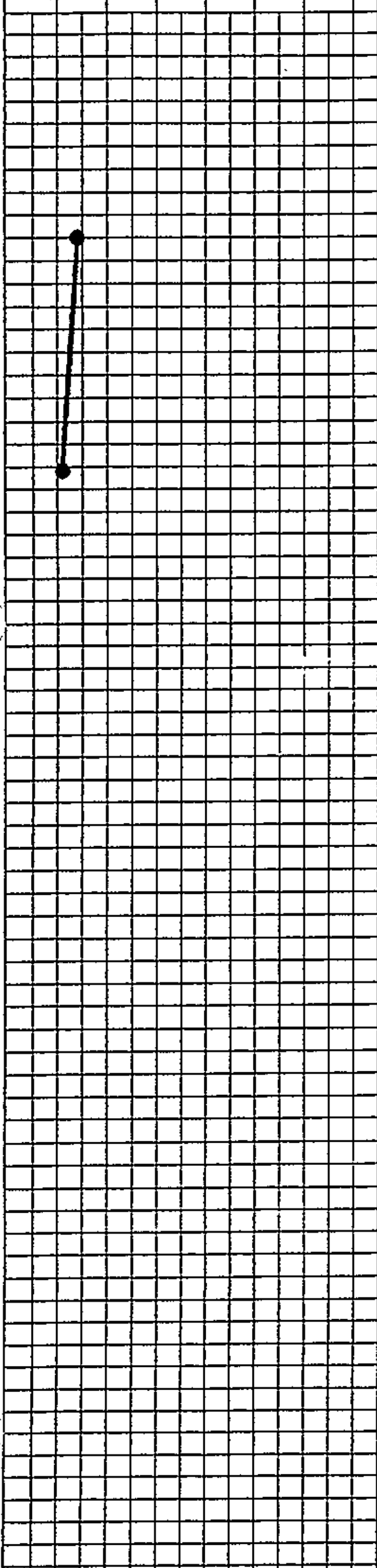
CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 04	CHECKED BY: [illegible]
DRILLER: GREG WILSON TRACKER CONTRACTORS	DRILL TYPE: JD 690 ELC EXCAVATOR

WATER CONTENT

WP - ■ W - ● WL- ▲

PERCENT %

10 20 30 40 50 60 70



DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
		LOCATION: AS PER SITE PLAN.			
		MOSS, PEAT, ORGANIC, ROOTS, BLACK, WET.			
0.5		SILT, LITTLE FINE SAND, ORGANIC, BLACK, SENSITIVE, WET.			
1.0		GRAVEL, SOME SAND, SOME FINES, MEDIUM DENSE, NON PLASTIC, BROWN, MAXIMUM SIZE 80 MM, ANGULAR, MOIST TO WET, TILL.			SIEVE
1.5					
2.0					
2.5		CLAY, VERY SILTY, LITTLE SAND, LITTLE FINE GRAVEL, HARD, LOW PLASTIC, GREY, MOIST TO WET, TILL.			
3.0		BEDROCK, SILTSTONE, SANDSTONE, GREY TO BROWN, WEATHERED, FRACTURED, FINE GRADED.			
		END OF HOLE 3.3 M. WATER FLOW AT INTERFACE OF TILL AND BEDROCK.			

540-48H.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION — PROJECT NO: CAN 0540

PROJECT: PROPOSED BIG WINDY DUMP — LGD': ES DWN': BT

DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 05 — CHECKED BY: [signature]

DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR

WATER CONTENT: WP - ■ W - ● WL - ▲ PERCENT % 10 20 30 40 50 60 70

LOCATION: AS PER SITE PLAN.

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
		MOSS COVER UNDERLAIN BY ORGANIC SILT, BLACK, SENSITIVE, WET.			
		SILT, LITTLE SAND, STIFF, NON PLASTIC, BROWN, SENSITIVE, ROOT FIBRES, WET.			
0.5		SILT, SOME SAND, SOME GRAVEL, VERY STIFF, NON PLASTIC, BROWN, MAXIMUM SIZE 80 MM, ANGULAR, WET, TILL.			
1.0					
1.5		SILT, LITTLE SAND, LITTLE GRAVEL, TRACE OF CLAY, HARD, LOW PLASTIC, GREY, OXIDIZED, MOIST, TILL.			
2.0		END OF HOLE 2.0 M. LARGE ROCK IN THE FRONT OF HOLE AND COULD NOT EXCAVATE OUT. NO FREE WATER.			

540-5BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 06	CHECKED BY: BT
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT (Wp - ■ W - ● WL - ▲; PERCENT % 10 20 30 40 50 60 70)	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION — LOCATION: AS PER SITE PLAN.	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			MOSS, PEAT, ORGANIC, ROOTS, BROWN, WET.			
			SILT, LITTLE SAND, VERY STIFF, NON PLASTIC, BROWN, SENSITIVE, MOIST TO WET.			
	0.5		SILT, SOME SAND, SOME GRAVEL, NON PLASTIC, GREY, MOIST, TILL.			
	1.0		COAL, FINE GRADED, BLACK, MOIST.			
	1.5		BEDROCK, MUDSTONE, BROWN TO GREY, FRACTURED.			
	2.0		END OF HOLE 2.0 M. WATER SEEPAGE FROM FRACTURES IN BEDROCK.			

540-06H.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — ***BOREHOLE LOG***

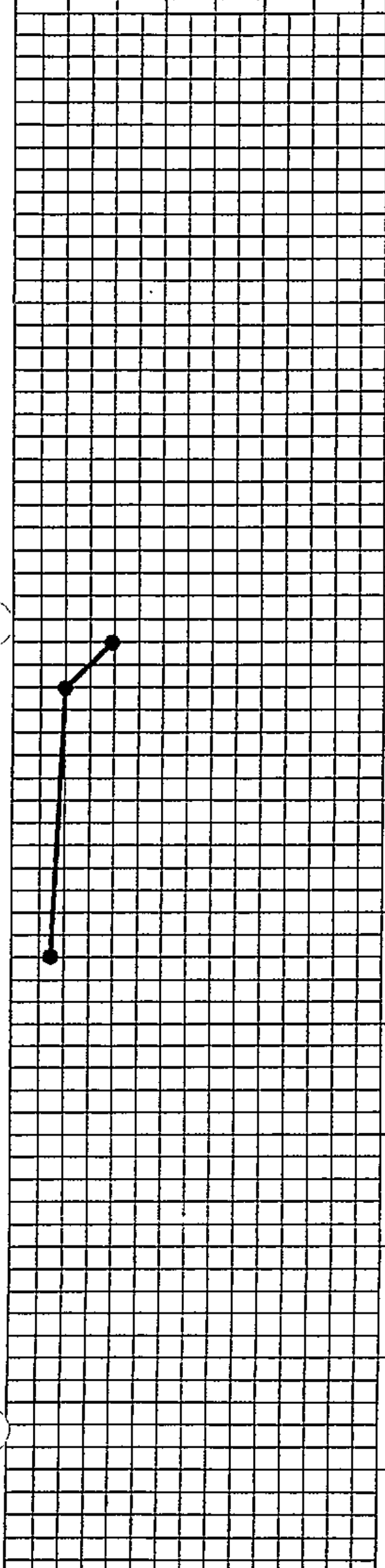
CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 07	CHECKED BY: [signature]
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT

WP - ■ W - ● WL- ▲

PERCENT %

10 20 30 40 50 60 70



LOCATION: AS PER SITE PLAN.

DEPTH (M)	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
	FILL, SILT, SOME GRAVEL, SOME SAND, NON PLASTIC, BROWN, SATURATED.			
0.5	MOSS COVER UNDERLAIN BY ORGANIC SILT, ROOTS, BROWN, MOIST TO WET.			
1.0	SILT, LITTLE SAND, VERY STIFF, NON PLASTIC, GREY, MOIST TO WET.			
1.5	SILT, SOME SAND, SOME GRAVEL, VERY STIFF, NON PLASTIC, BROWN, OCCASIONAL COBBLES TO 200 MM, FISSURED, WET, TILL.			
2.0	- BECOMES GREY.			
2.5	- INTERBEDDED WET SILTY SAND LENSES TO 50 MM THICK, POCKETS TO 0.5 M THICK FOR 1.0 M.			
				SIEVE
3.0				SIEVE
3.5				
4.0				
	END OF HOLE 4.2 M. SLIGHT WATER SEEPAGE FROM SILTY SAND LENSES.			

540-7BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 08	CHECKED BY: BT
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT: WP - ■ W - ● WL - ▲ PERCENT % 10 20 30 40 50 60 70

DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION — LOCATION: AS PER SITE PLAN.	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
		MOSS, PEAT, ORGANIC, ROOTS, BLACK, UNDERLAIN BY 100 MM OF WET, SENSITIVE, ORGANIC SILT.			
		SILT, LITTLE SAND, STIFF, NON PLASTIC, DARK BROWN, MOIST.			
0.5		SILT, LITTLE SAND, TRACE OF FINE GRAVEL, VERY STIFF, NON PLASTIC, GOLDEN BROWN, ROOT FIBRES, MOIST.			
1.0 – 3.0		CLAY, VERY SILTY, SOME SAND, SOME GRAVEL, VERY STIFF, LOW PLASTIC, GREY, MOIST TO WET, TILL.			
3.0		BEDROCK, CLAYSTONE, FINE GRADED, NUGGET STRUCTURE, GREY, MOIST TO WET.			
3.5		END OF HOLE 3.5 M, NO FREE WATER.			

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

540-BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. | *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 09	CHECKED BY: BT
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT (WP - ■ W - ● WL- ▲; PERCENT % 10 20 30 40 50 60 70)	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE: TYPE	SOIL SAMPLE: PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			LOCATION: AS PER SITE PLAN. LOCATED NEXT TO A SIDE CUT, "0" DEPTH IS TOP OF CUT.			
			MOSS COVER UNDERLAIN BY 200 MM OF GOLDEN BROWN, SANDY SILT, SENSITIVE, ROOT FIBRES, MOIST.			
	0.5		SILT, SOME SAND, LITTLE GRAVEL, HARD, NON PLASTIC, BROWN, SENSITIVE, MOIST TO WET, TILL.			
	1.0					
	1.5					
	2.0					
	2.5					
	3.0					
	3.5					
	4.0		- BEDROCK, COULD NOT PENETRATE.			
			END OF HOLE 4.0 M, NO FREE WATER. CUTSLOPE IS STANDING AT 0.5 HORIZONTAL TO 1.0 VERTICAL. SEAMS OF COAL ARE ALSO PRESENT IN THE CUTSLOPE.			

540-9BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION — PROJECT NO: CAN 0540

PROJECT: PROPOSED BIG WINDY DUMP — LGD': ES — DWN': BT

DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 10 — CHECKED BY: BT

DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR

WATER CONTENT (WP - ■ W - ● WL- ▲; PERCENT % 10 20 30 40 50 60 70)	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION (LOCATION: AS PER SITE PLAN.)	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			MOSS, PEAT, ORGANICS, ROOTS, BROWN, WET.			
			SILT, LITTLE FINE SAND, NON PLASTIC, BROWN TO GREY, ROOT FIBRES, SENSITIVE, MOIST TO WET.			
	0.5		SILT, SOME SAND, SOME GRAVEL, VERY STIFF, NON PLASTIC, BROWN, MAXIMUM SIZE 80 MM, ANGULAR, OCCASIONAL COBBLES TO 150 MM, MOIST, TILL.			
	1.0					
	1.5					
	2.0		BEDROCK, MUDSTONE, WEATHERED, BROWN.			
			END OF HOLE 2.3 M, NO FREE WATER.			

540-10BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — *BOREHOLE LOG*

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 11	CHECKED BY: BT
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT (Wp - ■, W - ●, WL - ▲; PERCENT % 10 20 30 40 50 60 70)	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			LOCATION: AS PER SITE PLAN.			
			SILT, LITTLE FINE SAND, STIFF, NON PLASTIC, BROWN, ROOT FIBRES, WET.			
	0.5		SILT, LITTLE SAND, LITTLE GRAVEL, VERY STIFF, NON PLASTIC, BROWN, SENSITIVE, MOIST TO WET, TILL.			
	1.0					
	1.5		- 300 MM THICK LAYER OF SHALE, SLIGHT WATER SEEPAGE.			
	2.0					
	2.5					
			BEDROCK, MUDSTONE, BROWN, WEATHERED, FINE GRADED, FRACTURED.			
			END OF HOLE 2.9 M. SLIGHT WATER SEEPAGE FROM SHALE LAYER AND FROM WITHIN BEDROCK FRACTURES.			

540-11SH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. — ***BOREHOLE LOG***

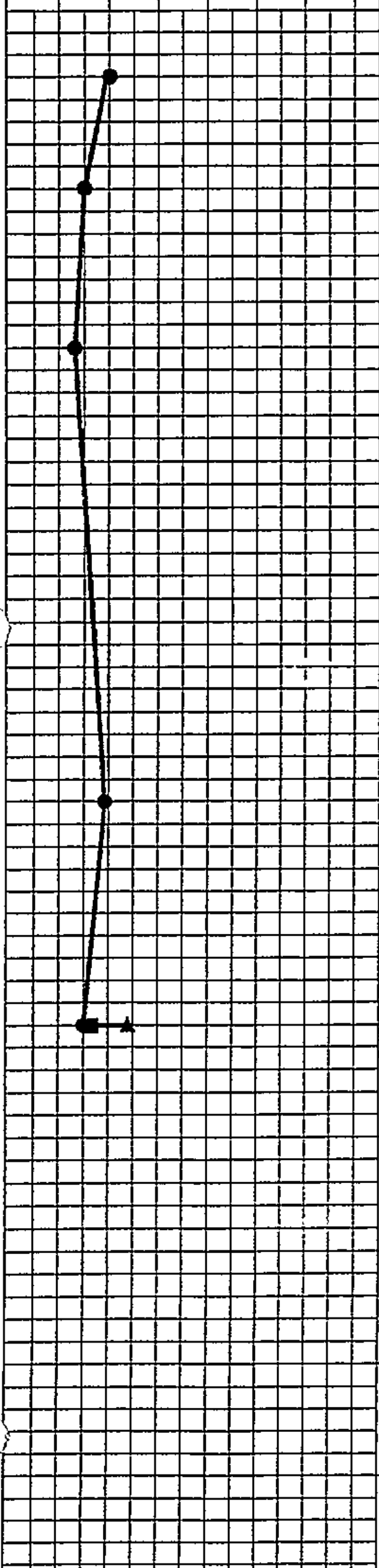
CLIENT: QUINTETTE OPERATING CORPORATION		PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP		LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96	HOLE NUMBER: 12	CHECKED BY:
DRILLER: GREG WILSON TRACKER CONTRACTORS	DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT

WP - ■ W - ● WL- ▲

PERCENT %

10 20 30 40 50 60 70



DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION	SOIL SAMPLE TYPE	SOIL SAMPLE PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
		LOCATION: AS PER SITE PLAN.			
		SILT, ORGANIC, ROOTS, BLACK, WET.			
0.5		SILT, LITTLE SAND, TRACE OF GRAVEL, STIFF, NON PLASTIC, RUST BROWN, ROOTS AND ROOT FIBRES, OXIDIZED, SENSITIVE, MOIST.			
1.0 – 3.0		GRAVEL, SOME SAND, LITTLE FINES, POORLY GRADED, MEDIUM DENSE, BROWN, MAXIMUM SIZE 80 MM, ANGULAR, OXIDIZED, MOIST TO WET. (TILL).			SIEVE
3.5 – 4.0		SAND, SOME FINES, SOME FINE GRAVEL, POORLY GRADED, MAXIMUM SIZE 25 MM, ANGULAR, GREY, SATURATED.			SIEVE
4.5	CL	CLAY, VERY SILTY, SOME SAND, LITTLE GRAVEL, VERY STIFF, LOW PLASTIC, GREY, MAXIMUM SIZE 50 MM, ANGULAR, WET, TILL.			SIEVE
5.0		END OF HOLE 5.0 M. HOLE CAVES AND FILLS AT 3.1 M. WATER PRESENT AT 3.1 M.			

540-12BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. **BOREHOLE LOG**

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 — HOLE NUMBER: 13	CHECKED BY: [illegible]
DRILLER: GREG WILSON TRACKER CONTRACTORS — DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT (WP - ■ W - ● WL - ▲) PERCENT % 10 20 30 40 50 60 70	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION — LOCATION: AS PER SITE PLAN.	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			SILT, SOME SAND, SOME GRAVEL, VERY STIFF, NON PLASTIC, BROWN, NUMEROUS COBBLES TO 200 MM, MOIST, TILL.			
	0.5					
	1.0					
	1.5					
			BEDROCK, SANDSTONE, FRACTURED, GREYISH BROWN.			
	2.0		END OF HOLE 2.0 M, COULD NOT EXCAVATE FURTHER. NO FREE WATER.			

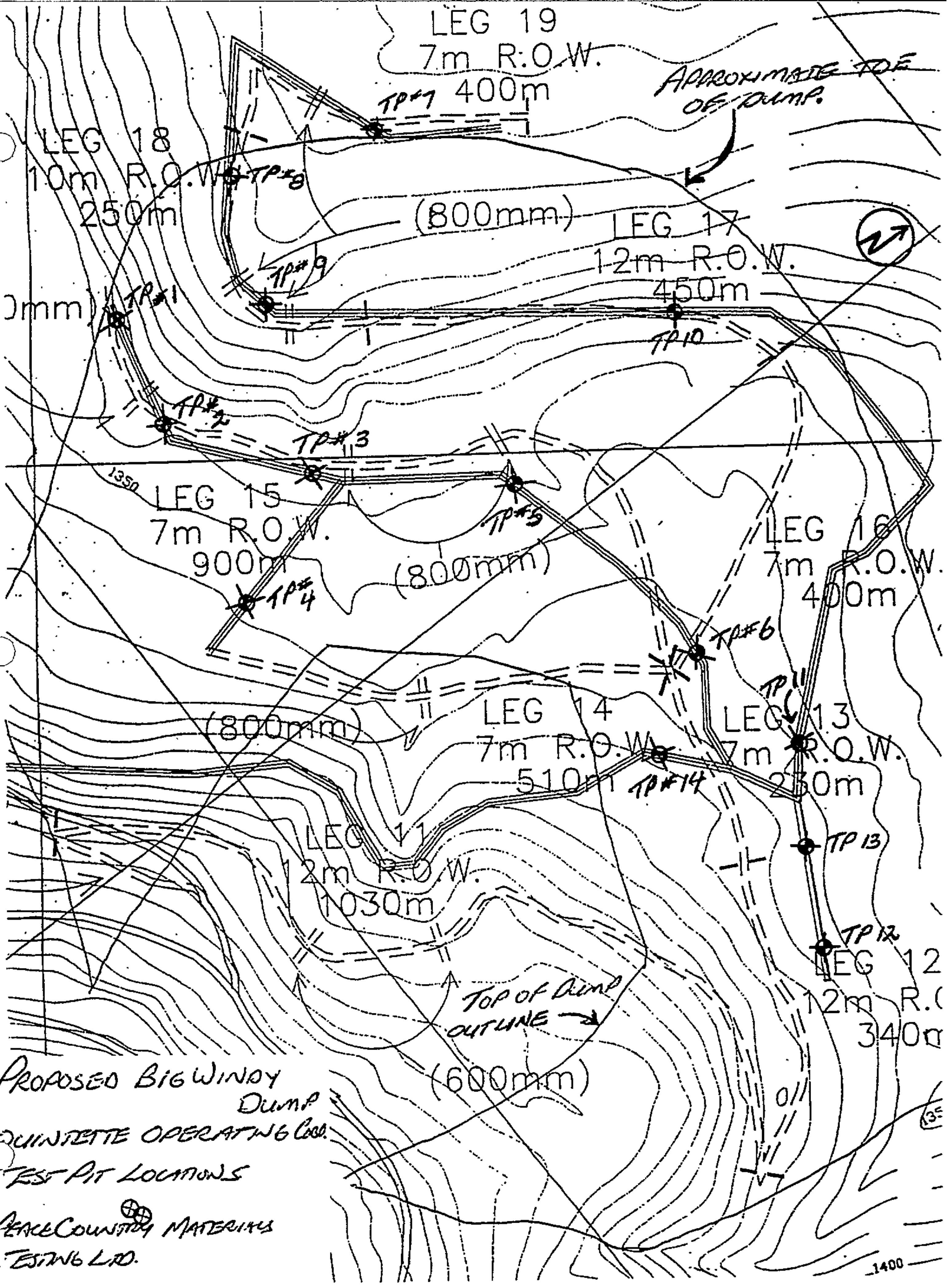
540-13BH.FRM

PEACE COUNTRY MATERIALS TESTING LTD. **BOREHOLE LOG**

CLIENT: QUINTETTE OPERATING CORPORATION	PROJECT NO: CAN 0540
PROJECT: PROPOSED BIG WINDY DUMP	LGD': ES DWN': BT
DATE OF INVESTIGATION: 09/17/96 HOLE NUMBER: 14	CHECKED BY: [initials]
DRILLER: GREG WILSON TRACKER CONTRACTORS DRILL TYPE: JD 690 ELC EXCAVATOR	

WATER CONTENT (WP - ■ W - ● WL- ▲; PERCENT % 10 20 30 40 50 60 70)	DEPTH (M)	SOIL SYMBOL	SOIL DESCRIPTION — LOCATION: AS PER SITE PLAN.	SOIL SAMPLE TYPE	PENETRATION RESISTANCE	OTHER TESTS (PP = KG/CM2)
			MOSS COVER UNDERLAIN BY ORGANIC SILT, ROOTS AND ROOT FIBRES, BROWN, MOIST TO WET.			
			SILT, LITTLE SAND, STIFF, NON PLASTIC, GOLDEN BROWN, ROOT FIBRES, SENSITIVE, MOIST.			
	0.5		SILT, SOME SAND, SOME GRAVEL, VERY STIFF, NON PLASTIC, BROWN, MAXIMUM SIZE 80 MM, ANGULAR, MOIST, TILL.			
	1.0					
	1.5					
	2.0		BEDROCK, MUDSTONE, SILTSTONE, HARDER WITH DEPTH.			
			END OF HOLE 2.3 M, NO FREE WATER.			

540-14BH.FRM



PROPOSED BIG WINDY DUMP
QUINTETTE OPERATING CORP.
TEST PIT LOCATIONS

PEACE COUNTRY MATERIALS TESTING LTD.

PEACE COUNTRY MATERIALS TESTING LTD.
DAWSON CREEK, BC

SIEVE ANALYSIS REPORT
10 20 40 60 SERIES

Mr. Dave Campbell, P. Eng.

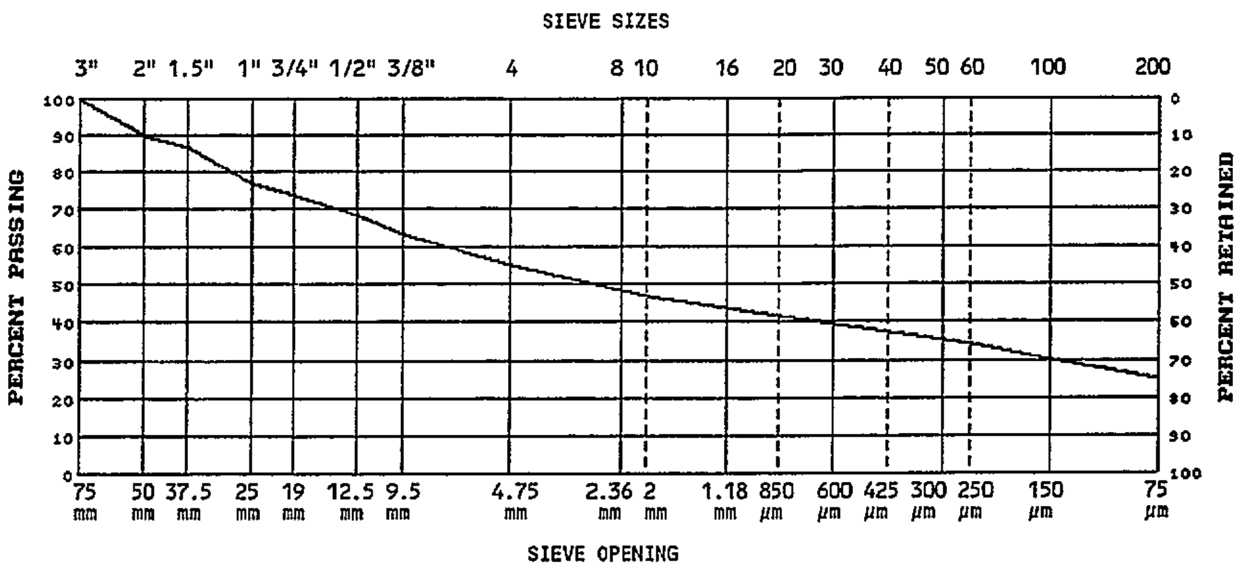
Golder Associates
224 West 8th Avenue
Vancouver, BC
V5Y 1N5

PROJECT NO: CAN00540
DATE: 96.Sep.19
CLIENT P.O.: 97721 OS 01
Quintette Operating Corporation
CC: Golder Associates

PROJECT:
Proposed Big Windy Dump

TEST NUMBER: DATE SAMPLED: 96.Sep.17
SPECIFICATION:
SAMPLE SOURCE: TP #4 @ 1.0 m
SAMPLE TYPE: Silt Till

SAMPLED BY: E. Spicer
DATE TESTED: 96.Sep.19
TEST METHOD: WASHED



GRAVEL SIZES		PERCENT PASSING	GRADATION LIMITS
3"	75 mm	100.0	
2"	50 mm	89.7	
1 1/2"	37.5 mm	86.7	
1"	25 mm	77.2	
3/4"	19 mm	74.0	
1/2"	12.5 mm	68.5	
3/8"	9.5 mm	63.5	

SAND SIZES AND FINES		PERCENT PASSING	GRADATION LIMITS
No. 4	4.75 mm	55.1	
No. 10	2.00 mm	46.9	
No. 20	850 µm	41.5	
No. 40	425 µm	37.8	
No. 60	250 µm	34.6	
No. 100	150 µm	30.4	
No. 200	75 µm	25.0	

COMMENTS: GRAVEL, some sand, some fines, poorly graded, angular, brown, TILL.

PEACE COUNTRY MATERIALS TESTING LTD. - PER: BT

for E. Spicer

Reporting of these test results constitutes a testing service only.
Engineering interpretation or evaluation of the test results is provided only on written request.

PEACE COUNTRY MATERIALS TESTING LTD.
DAWSON CREEK, BC

SIEVE ANALYSIS REPORT
10 20 40 60 SERIES

Mr. Dave Campbell, P. Eng.

Golder Associates
224 West 8th Avenue
Vancouver, BC
V5Y 1N5

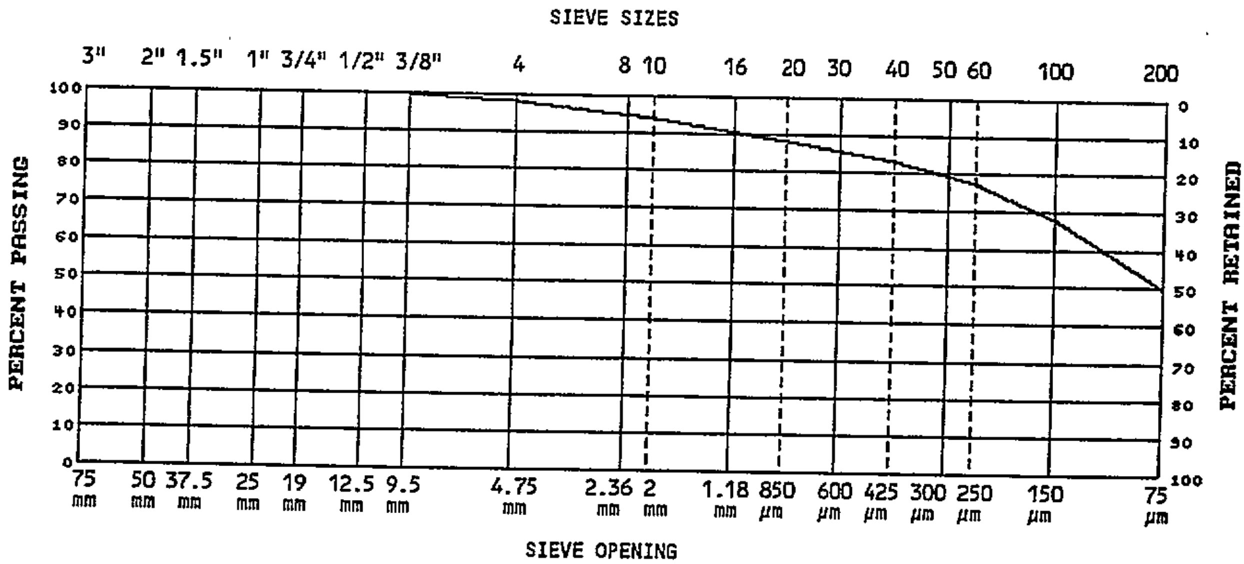
PROJECT NO: CAN00540
DATE: 96.Sep.19
CLIENT P.O.: 97721 OS 01
Quintette Operating Corporation
CC: Golder Associates

PROJECT:
Proposed Big Windy Dump

TEST NUMBER:
SPECIFICATION:
SAMPLE SOURCE: TP #7 @ 2.8 m
SAMPLE TYPE: Sand

DATE SAMPLED: 96.Sep.17

SAMPLED BY: E. Spicer
DATE TESTED: 96.Sep.19
TEST METHOD: WASHED



GRAVEL SIZES		PERCENT PASSING	GRADATION LIMITS
3"	75 mm		
2"	50 mm		
1 1/2"	37.5 mm		
1"	25 mm		
3/4"	19 mm		
1/2"	12.5 mm		
3/8"	9.5 mm	100.0	

SAND SIZES AND FINES		PERCENT PASSING	GRADATION LIMITS
No. 4	4.75 mm	98.0	
No. 10	2.00 mm	94.3	
No. 20	850 µm	88.3	
No. 40	425 µm	83.0	
No. 60	250 µm	77.4	
No. 100	150 µm	68.3	
No. 200	75 µm	49.5	

COMMENTS: SAND and SILT, fine to coarse grained, grey, carbonates.

PEACE COUNTRY MATERIALS TESTING LTD. - PER: RBT

for E. Spicer

PEACE COUNTRY MATERIALS TESTING LTD.
DAWSON CREEK, BC

SIEVE ANALYSIS REPORT
10 20 40 60 SERIES

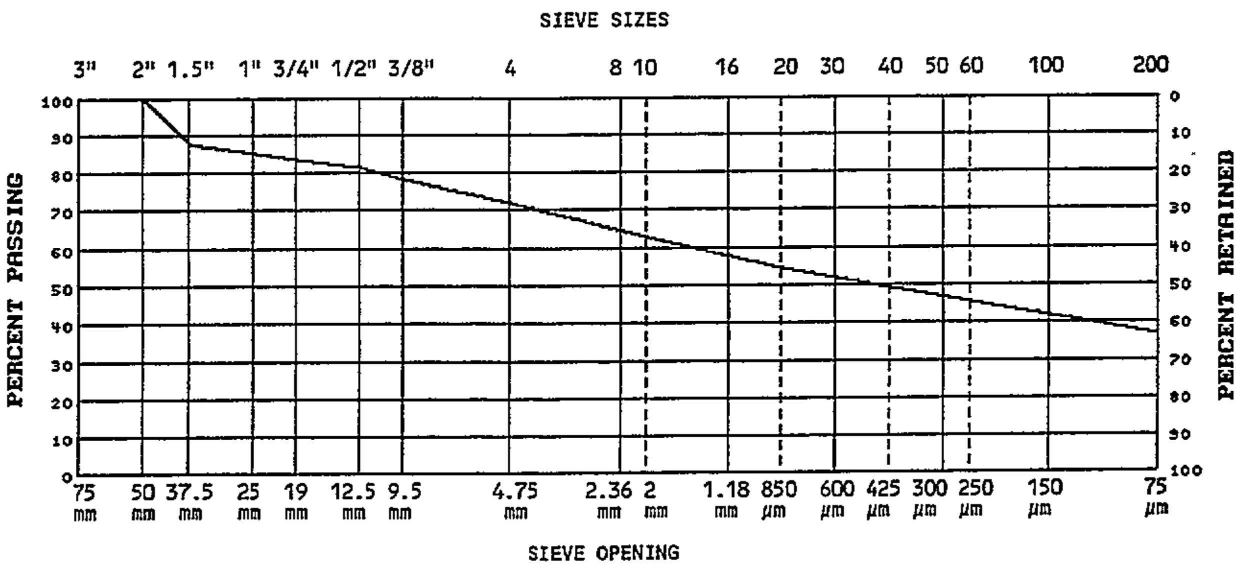
Mr. Dave Campbell, P. Eng.

Golder Associates
224 West 8th Avenue
Vancouver, BC
V5Y 1N5

PROJECT NO: CAN00540
DATE: 96.Sep.19
CLIENT P.O.: 97721 OS 01
Quintette Operating Corporation
CC: Golder Associates

PROJECT:
Proposed Big Windy Dump

TEST NUMBER:
DATE SAMPLED: 96.Sep.17
SAMPLED BY: E. Spicer
SPECIFICATION:
DATE TESTED: 96.Sep.19
SAMPLE SOURCE: TP #7 @ 3.0 m
TEST METHOD: WASHED
SAMPLE TYPE: Silt Till



GRAVEL SIZES			PERCENT PASSING	GRADATION LIMITS
3"	75	mm		
2"	50	mm	100.0	
1 1/2"	37.5	mm	87.9	
1"	25	mm		
3/4"	19	mm	83.8	
1/2"	12.5	mm	81.6	
3/8"	9.5	mm	78.3	

SAND SIZES AND FINES			PERCENT PASSING	GRADATION LIMITS
No.	4	4.75 mm	72.4	
No.	10	2.00 mm	62.9	
No.	20	850 µm	54.9	
No.	40	425 µm	49.6	
No.	60	250 µm	45.9	
No.	100	150 µm	42.1	
No.	200	75 µm	37.2	

COMMENTS: SILT, some sand, some gravel, trace of clay, low plastic, grey, angular.

PEACE COUNTRY MATERIALS TESTING LTD. - PER: BT

FOR E. Spicer

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PEACE COUNTRY MATERIALS TESTING LTD.
DAWSON CREEK, BC

SIEVE ANALYSIS REPORT
10 20 40 60 SERIES

Mr. Dave Campbell, P. Eng.

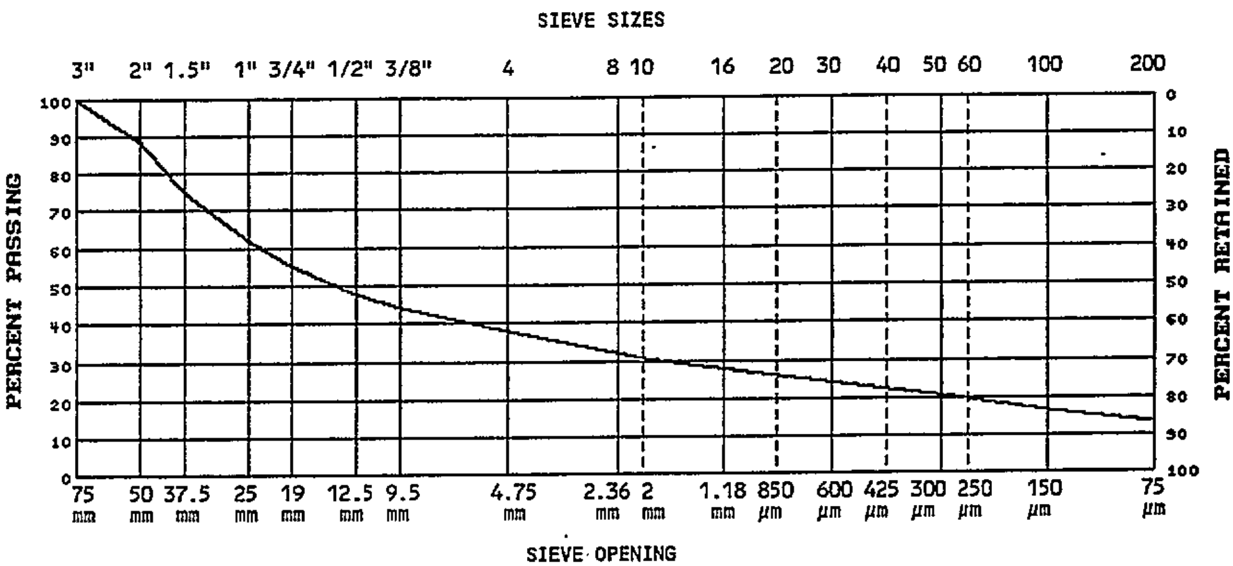
Golder Associates
224 West 8th Avenue
Vancouver, BC
V5Y 1N5

PROJECT NO: CAN00540
DATE: 96.Sep.19
CLIENT P.O.: 97721 OS 01
Quintette Operating Corporation
CC: Golder Associates

PROJECT:
Proposed Big Windy Dump

TEST NUMBER:
DATE SAMPLED: 96.Sep.17
SPECIFICATION:
SAMPLE SOURCE: TP #12 @ 1.5 m
SAMPLE TYPE: Gravel

SAMPLED BY: E. Spicer
DATE TESTED: 96.Sep.19
TEST METHOD: WASHED



GRAVEL SIZES	PERCENT PASSING	GRADATION LIMITS
3" 75 mm	100.0	
2" 50 mm	88.5	
1 1/2" 37.5 mm	75.0	
1" 25 mm	62.0	
3/4" 19 mm	55.4	
1/2" 12.5 mm	47.9	
3/8" 9.5 mm	44.3	

SAND SIZES AND FINES	PERCENT PASSING	GRADATION LIMITS
No. 4 4.75 mm	38.1	
No. 10 2.00 mm	31.0	
No. 20 850 µm	25.9	
No. 40 425 µm	22.6	
No. 60 250 µm	19.7	
No. 100 150 µm	16.7	
No. 200 75 µm	13.5	

COMMENTS: GRAVEL, some sand, little fines, poorly graded, angular, maximum size 80 mm, brown, oxidized.

PEACE COUNTRY MATERIALS TESTING LTD. - PER: BT

for E. Spicer

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PEACE COUNTRY MATERIALS TESTING LTD.
DAWSON CREEK, BC

SIEVE ANALYSIS REPORT
10 20 40 60 SERIES

Mr. Dave Campbell, P. Eng.

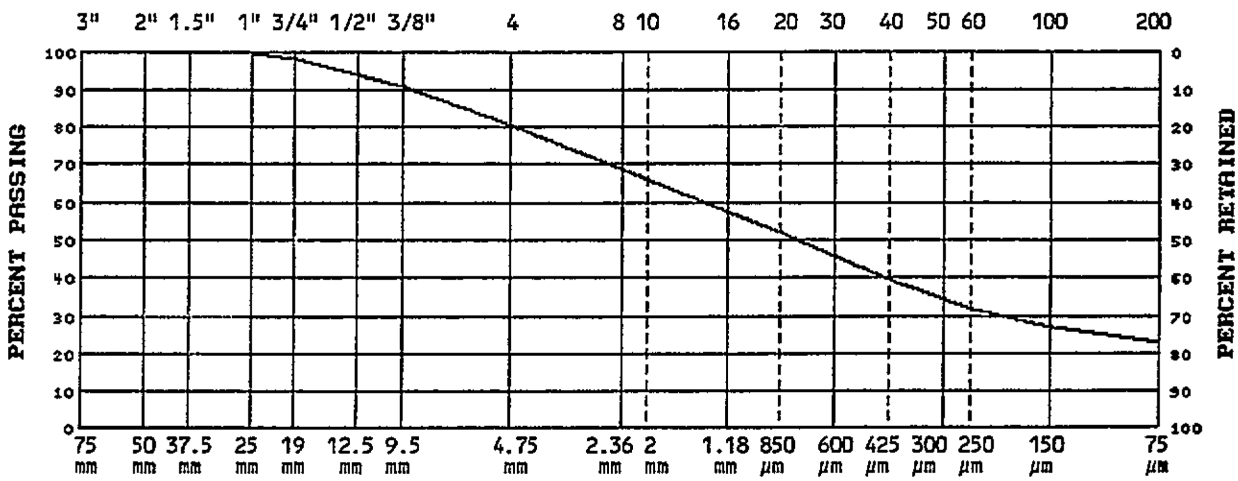
Golder Associates
224 West 8th Avenue
Vancouver, BC
V5Y 1N5

PROJECT NO: CAN00540
DATE: 96.Sep.19
CLIENT P.O.: 97721 OS 01
Quintette Operating Corporation
CC: Golder Associates

PROJECT:
Proposed Big Windy Dump

TEST NUMBER: DATE SAMPLED: 96.Sep.17
SPECIFICATION:
SAMPLE SOURCE: TP #12 @ 3.5 m
SAMPLE TYPE: Sand

SAMPLED BY: E. Spicer
DATE TESTED: 96.Sep.19
TEST METHOD: WASHED



GRAVEL SIZES	PERCENT PASSING	GRADATION LIMITS
3" 75 mm		
2" 50 mm		
1 1/2" 37.5 mm		
1" 25 mm	100.0	
3/4" 19 mm	98.2	
1/2" 12.5 mm	93.9	
3/8" 9.5 mm	91.1	

SAND SIZES AND FINES	PERCENT PASSING	GRADATION LIMITS
No. 4 4.75 mm	80.5	
No. 10 2.00 mm	66.3	
No. 20 850 µm	52.0	
No. 40 425 µm	39.8	
No. 60 250 µm	32.1	
No. 100 150 µm	27.1	
No. 200 75 µm	23.0	

COMMENTS: SAND, some fines, some fine gravel, poorly graded, angular, grey.

PEACE COUNTRY MATERIALS TESTING LTD. - PER: BT

for E. Spicer

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PEACE COUNTRY MATERIALS TESTING LTD.
DAWSON CREEK, BC

SIEVE ANALYSIS REPORT
10 20 40 60 SERIES

Mr. Dave Campbell, P. Eng.

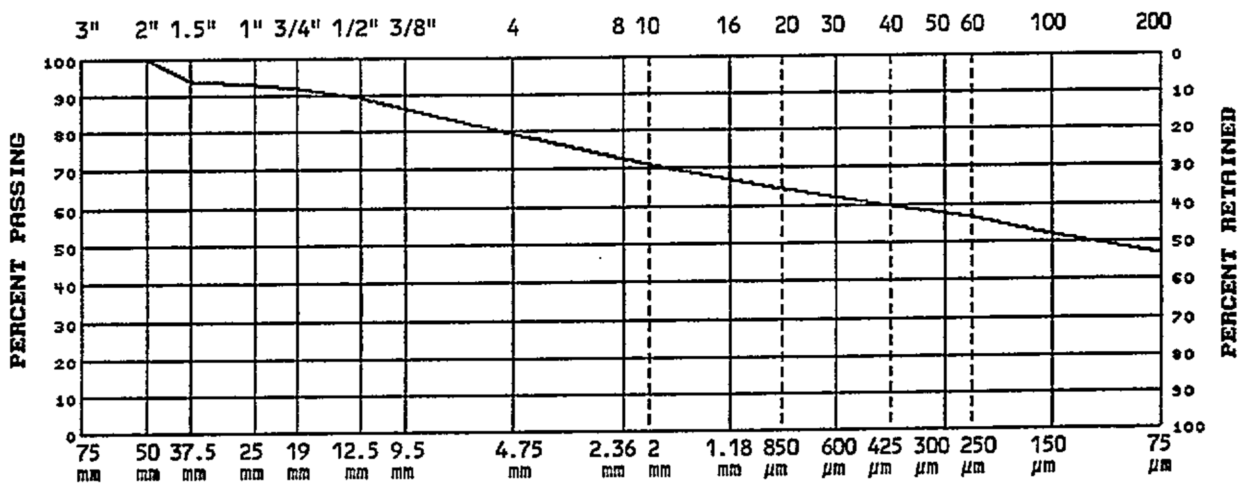
Golder Associates
224 West 8th Avenue
Vancouver, BC
V5Y 1N5

PROJECT NO: CAN00540
DATE: 96.Sep.19
CLIENT P.O.: 97721 OS 01
Quintette Operating Corporation
CC: Golder Associates

PROJECT:
Proposed Big Windy Dump

TEST NUMBER: DATE SAMPLED: 96.Sep.17
SPECIFICATION:
SAMPLE SOURCE: TP #12 @ 4.5 m
SAMPLE TYPE: Silt Till

SAMPLED BY: E. Spicer
DATE TESTED: 96.Sep.19
TEST METHOD: WASHED



GRAVEL SIZES			PERCENT PASSING	GRADATION LIMITS
3"	75	mm		
2"	50	mm	100.0	
1 1/2"	37.5	mm	94.3	
1"	25	mm	92.8	
3/4"	19	mm	91.9	
1/2"	12.5	mm	89.5	
3/8"	9.5	mm	86.2	

SAND SIZES AND FINES			PERCENT PASSING	GRADATION LIMITS
No.	4	4.75 mm	79.8	
No.	10	2.00 mm	71.1	
No.	20	850 µm	64.5	
No.	40	425 µm	60.0	
No.	60	250 µm	56.5	
No.	100	150 µm	52.3	
No.	200	75 µm	46.7	

COMMENTS: SILT, some sand, little gravel, trace of clay, low plastic, grey, angular, maximum size 50 mm.

PEACE COUNTRY MATERIALS TESTING LTD. - PER: BT

for E. Spicer

Reporting of these test results constitutes a testing service only.
Engineering interpretation or evaluation of the test results is provided only on written request.

LOGS OF TEST PITS - LITTLE WINDY DUMP AREA

PIT NO 96-1D

0 to 0.15	Topsoil
0.15 - 0.6	SILT - Soft, Brown, clayey, with cobbles and gravel-sized particles, some sand.
0.6 - 0.8	SILT Firm, brown, sandy, some gravel, moist
0.8 - 2	Bedrock. fractured, weathered siltstone and sandstone Minor seepage over the depth range 0.2 to 0.6 metres

PIT No. 96-2D

0 - 0.14	Topsoil
0.15 - 0.5	SILT, Clayey, with sand, gravel and cobbles. Soft
0.5 - 2.0	SILT Clayey, with sand gravel and cobbles, firm, moist
2.0 - 3.6	Bedrock, Siltstone and Sadstone, weathered & fractrured, weak

PIT No. 96-3D

0 - 0.15	Topsoil
0.15 - 0.4	Silt - Soft, Brown, with some gravel-sized particles. Moist
0.4 - 1.0	Silt- Sandy, some gravel. Firm to stiff
1.0 - 4.61	Silt, clayey, with sand and gravel. Brown to grey, stiff to very stiff (glacial till). Minor seepage 0.4 to 1.0 metres

PIT No. 96-4D

0 0.15	Topsoil
0.15 - 0.9	Silt, Soft to firm. Brown, sandy, some angular gravel.
0.9 - 1.5 Moist	Silt, Stiff to very stiff, brown, sandy, some gravel and cobbles.
1.5 - 4.0	Silt, brown, sandy, with gravel and cobbles, trace of clay (glacial till) Minor seepage 0.5 to 0.9 metres

TEST PIT 96-5D

0.15 - 0.5	SILT, Soft, brown, sandy, with some gravel
0.5 - 1.2	Silt, Firm, sandy, with some gravel, cobbles and small boulders
1.2 - 2.5	Silt, brown, sandy, some gravel. Stiff to very stiff (glacial till)
2.5 - 3.6	Bedrock, Siltstone, weathered, fractured.
	Minor Seepage over the interval 0.6 to 1.0 metre depth.

PIT No. 96-6D

0 - 0.15	Topsoil
0.15 - 1.0	Silt, sandy, with gravel and cobbles, Soft to firm
1.0 - 3.5	Silt, sandy, some gravel and cobbles, Stiff to very stiff,
	Moderate seepage over depth interval 1.8 to 2..2 metres

PIT No 7D

0 - 0.15	Topsoil
0.15 - 1.0	SILT, sandy, some gravel. Brown, soft to firm
1.0 - 3.0	Silt, sand, gravel, and scattered cobbles. Stiff to very stiff (glacial till)

PIT No. 8D

0 - 0.15 Topsoil

0.15 - 1.3 Silt, sandy, some gravel. Moist, soft to firm

1.3 to 4.0 Silt, clayey, sandy, with gravel and some cobbles. Stiff to very stiff

Minor seepage at 2 metres below surface.

PIT No 96-9D

0 - 0.15 SILT, sandy, with gravel and cobbles. Soft, brown

0.15 - 1.5 SILT, sandy, with gravel and cobbles, Firm to stiff, Brown

1.5 - 4.0 SILT, sandy and clayey, with gravel and cobbles. Stiff to very stiff

Minor seepage over the depth interval 0.6 to 1 metres

PIT No, 96-10D

0 - 0.15 Topsoil

0.15 - 0.5 SILT, sandy with some gravel. Brown, soft to firm. Moist

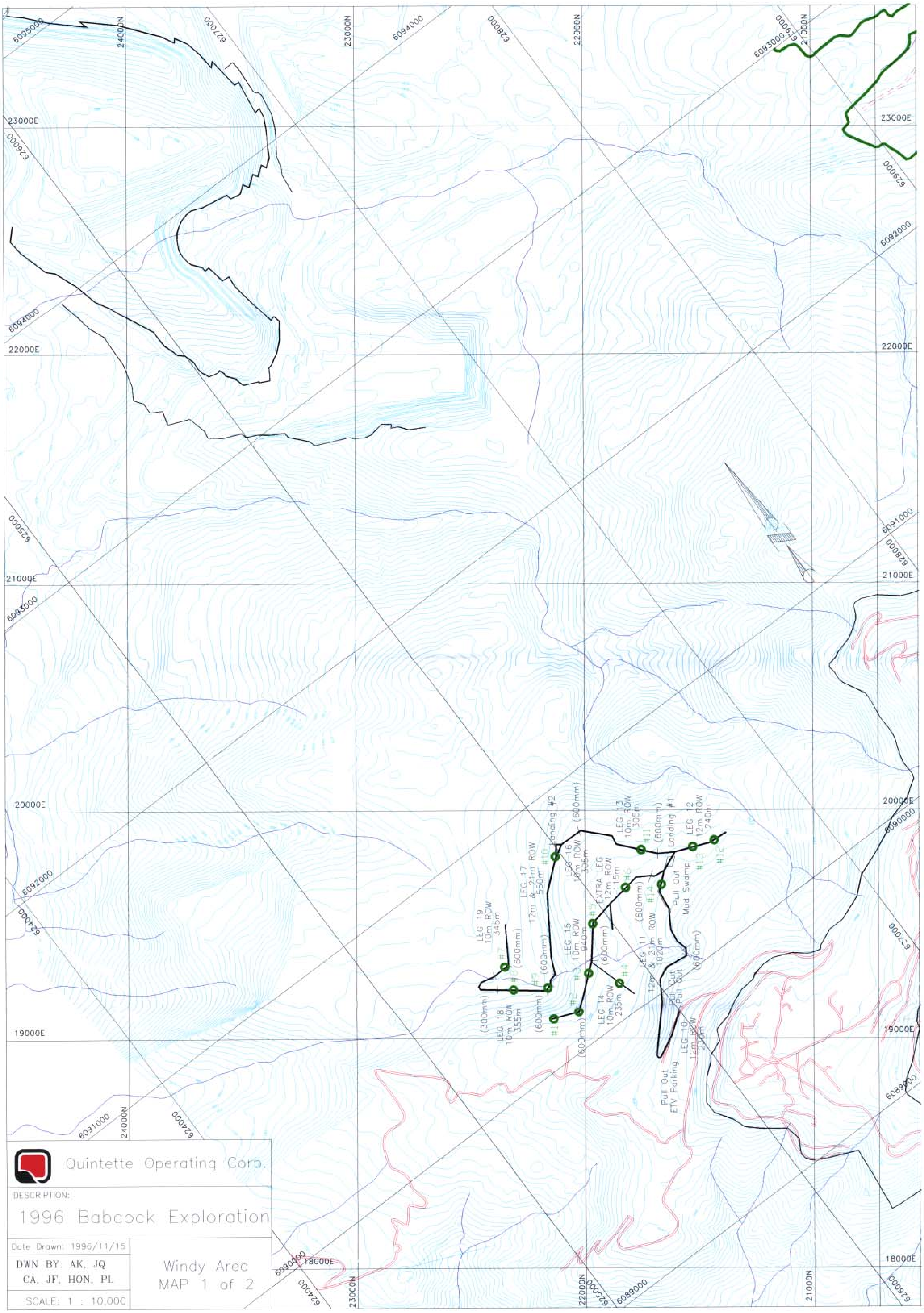
0.5 - 1.0 SILT, sandy, with gravel and scattered cobbles and boulders. Firm
to Stiff, Brownish-grey

1.0 to 1.8 SILT, sandy, with gravel and some cobbles. Stiff to very stiff.

1.8 to 3.0 BEDROCK - Siltstone and Sandstone. Weathered and fractured.

APPENDIX B

1:10000 PLAN MAP


Quintette Operating Corp.
DESCRIPTION:
1996 Babcock Exploration
Date Drawn: 1996/11/15
DWN BY: AK, JQ
CA, JF, HON, PL
SCALE: 1 : 10,000
Windy Area
MAP 1 of 2
LEG 19
10m ROW
345m
LEG 18
10m ROW
355m
LEG 17
12m & 21m ROW
550m
LEG 16
10m ROW
305m
LEG 15
10m ROW
940m
LEG 14
10m ROW
235m
LEG 13
10m ROW
305m
LEG 12
12m ROW
240m
LEG 11
12m & 21m ROW
1020m
LEG 10
12m ROW
EXTRA LEG
12m ROW
115m
Landing #1
Landing #2
Pull Out
Mud Swamp
Pull Out
ETV Parking
(600mm)
(300mm)
24000N
23000N
22000N
21000N
23000E
22000E
21000E
20000E
19000E
18000E
6095000
6094000
6093000
6092000
6091000
6090000
6089000
627000
628000
629000
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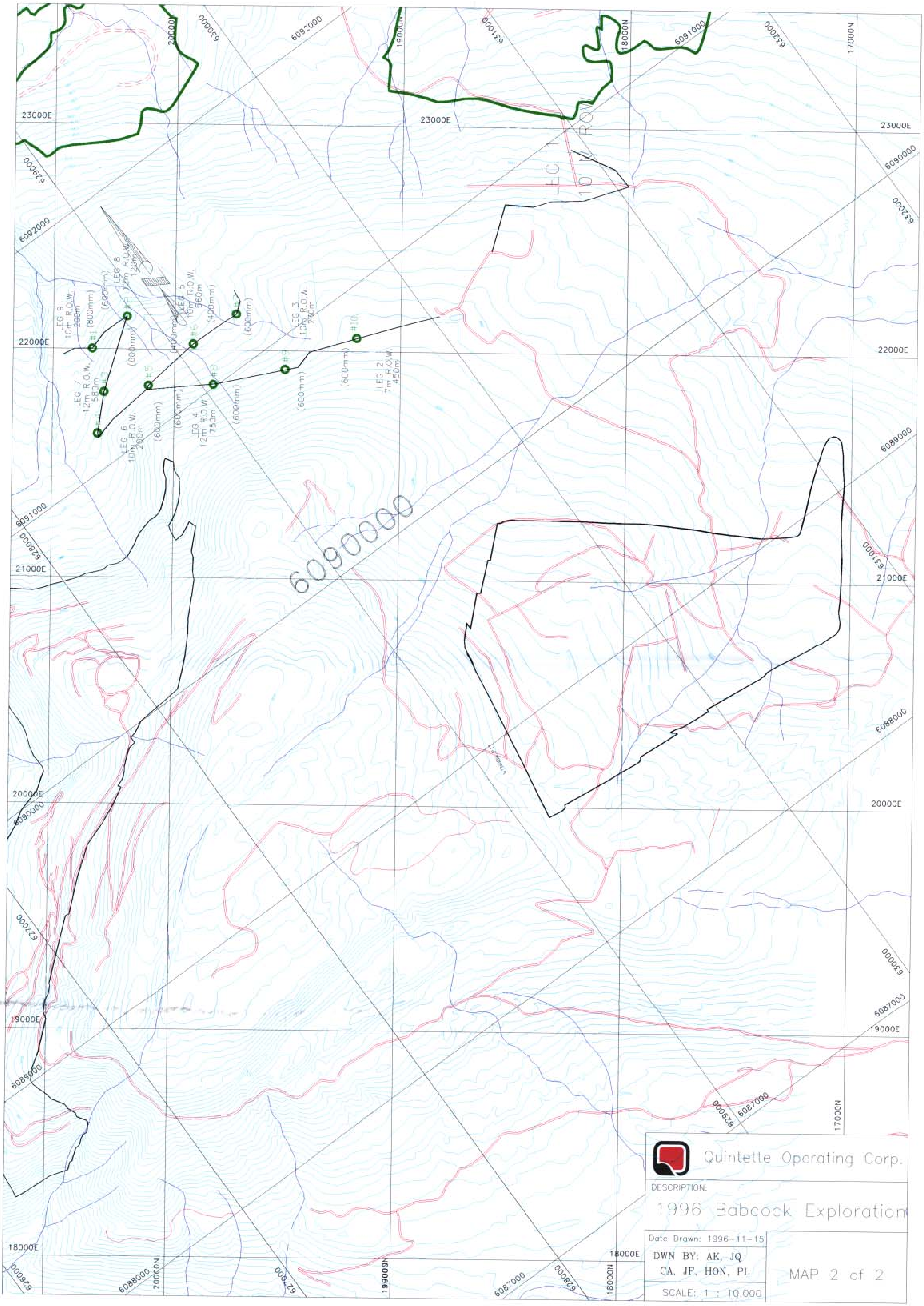
624000



Quintette Operating Corp.
DESCRIPTION:
1996 Babcock Exploration
Date Drawn: 1996-11-15
DWN BY: AK, JQ
CA, JF, HON, PL
SCALE: 1 : 10,000
MAP 2 of 2
6090000
LEG 1
10 M ROW
LEG 2
7m R.O.W.
450m
LEG 3
10m R.O.W.
230m
LEG 4
12m R.O.W.
750m
LEG 5
10m R.O.W.
560m
LEG 6
10m R.O.W.
200m
LEG 7
12m R.O.W.
580m
LEG 8
12m R.O.W.
120m
LEG 9
10m R.O.W.
200m
(600mm)
(800mm)
(400mm)
23000E
22000E
21000E
20000E
19000E
18000E
19000N
18000N
17000N
20000N
6092000
6091000
6090000
6089000
6088000
6087000
632000
631000
630000
629000
628000
627000
626000