DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL INVESTIGATION, PROGRESS REPORT JULY, 1965

PROPOSED SOUTH-EAST FREEWAY

CRAFERS-STIRLING SECTION,

STA 53 to STA 180, Hundred Noarlunga

by

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ENGINEERING AND SOILS GEOLOGY
SECTION

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ABSTRACT

The routes for a proposed Freeway and associated minor roads have been investigated to assess the nature of the materials which will be met in cuttings. In particular it has been required to delineate the portions which can be excavated by dozing or ripping, as distinct from those requiring drilling and blasting, and to assess angles for cuttings to ensure their permanent stability.

The work has included detailed geological mapping of natural outcrops and existing cuttings, diamond drilling, seismic refraction traverses, and resistivity measurements.

Precambrian rocks including shale, sandstones, quartzite, schist, and gneiss occur along the routes. They are weakened to varying degrees by structural weaknesses, principally jointing, and by chemical and mechanical weathering. The relationships between the rock mass, including these weaknesses, and its behaviour during excavation and stability in cuttings, are discussed.

Assessments of excavation methods required and suggestions for cutting angles are given in tables, which also list the factual data from which the assessments are made.

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INTRODUCTION

In a letter from the Commissioner of Highways to the Director of Mines of 10th June, 1964, it was requested that a geological investigation be carried out along the Crafers-Stirling section of the proposed South-East Freeway. This section is 11,700 feet long, located from 10 to 12 miles south-east of Adelaide (Figure 1). Details of the various roads are as follows:

1. Measdays Corner to Crafers (STA 53 to STA 105).

The carriageway constructed in 1955 will be duplicated along its northern side. The length is approximately 0.6 miles, of which 0.3 miles is inside cut of average depth 10 to 12 feet. The maximum depth is approximately 20 feet.

2. Crafers to Stirling (STA 105 to STA 135).

A divided highway with formation width of 80 feet is proposed. The length is 1.6 miles, of which 0.7 miles is in cut. The maximum depth of cut is 50 feet.

3. Summit Road Deviation (STA 64 to STA 100).

This is 0.9 miles long, and has a formation width of 46 feet. About 0.3 miles is in cut with a maximum depth of 45 feet.

4. Minor roads, including service roads and ramps with some cut up to 25 feet.

Survey stations are at 100 ft. intervals along the proposed centre line, progressively in the direction away from Adealide, as stations 53, 54, 55 etc. The chainage of points between these stations are given by adding the distance in feet from the previous stations, i.e. STA 53 + 64.

In places where the road divides, the same distances are used for stations along both roads, from the point where the divergence commences.

The purpose of the investigation was to assess the nature of the materials which will be encountered in cuttings; in particular to classify the materials for excavation purposes as follow:

...Material which can be excavated by heavy duty ripper.

...Material which will require blasting.

It was also required to assess angles at which cutting faces could be made to ensure permanent stability.

The following has been carried out:

...Detailed geological mapping of the ground surface along and near the pegged routes, and of existing road cuttings and other excavations nearby.

...Geophysical work including resistivity observations, and seven seismic refractions traverses each 300 feet long.

...Diamond drilling; three holes with a total depth of 187 feet.

This report describes the general geology of the project area, details of the various exploratory methods used, and the bases upon which the assessments of engineering properties of the various materials are made. Assessments of conditions along individual portions of the route are given in Tables 4 to 7 inclusive.

GENERAL GEOLOGY OF THE AREA

Topography

The proposed section of Freeway commences on the eastern slopes of the Mount Lofty Ranges about 1 mile to the east of the divide which is known as the Summit Ridge (Fig. 1). It passes over the divide in a saddle at the Summit Road turnoff and then follows the valley of Main Creek for $1\frac{1}{2}$ miles, ending $\frac{1}{2}$ mile north-east of Stirling township. In most parts of the route the natural slopes are relatively gentle, ranging from 5 to 15^{o}. Steeper slopes (up to 25^{o}) occur locally.

Stratigraphy and Structure

The route lies in the Mount Lofty Province of Precambrian and Archaean rocks. Table 1 shows the Rock Units and main rock types.

TABLE 1

GEOLOGICAL SUCCESSION

AGE	UNIT NAME	DESCRIPTION
Precambrian	Stonyfell Quartzite Formation	Interbedded quartzite, felspathic sandstone and shale. The rocks occur in roughly equal proportions in beds generally several hundred feet thick. Some thinly interbedded sandstones and shales with individual beds less than 1 ft. thick.
	Aldgate Sandstone	Alternating micaceous sandstone and shale beds with 20ft. thick basal conglomerate. The individual beds of sandstone and shale are mostly less than 0.1 ft. thick.
—UNCONFORMITY—		
Archaean	Crafers-Aldgate Inlier	Mainly schist with bands of gneiss up to 20 ft. wide, and some granitic gneiss.

The distribution of the rocks within the project area is shown on Fig. 1. The Stonyfell Quartzite rocks occupy 90 per cent of the area, and are bounded at the south-eastern end, between Crafers and Stirling, by a steeply dipping fault zone (the Crafers Fault), trending roughly north-east south-west. The Archaean schists and gneisses, and the Aldgate Sandstone, occur to the south of this fault.

The Precambrian rocks are gently folded and generally dip between 10 and 45° to the south-east. The Archaean schists and gneisses have prominent schistosity and foliation which dip between 40 and 75° to the south and south-east, i.e. almost parallel to the bedding of the younger rocks.

Weathering

All of the rocks where exposed in the project area are considerably affected by weathering, and in most places are overlain by shallow sedentary soils.

In general the more prominent ridges are underlain by resistant rocks, which are mainly slightly weathered near the surface. Valleys and depressed areas are commonly underlain by rocks which are less resistant to weathering.

Stability of Natural Slopes

No scars or cracks indicating recent slope instability have been found in the project area.

Soil-covered slopes with an irregular, hummocky appearance occur immediately east of Drill Hole SEF3 in the Stirling Interchange Section. Such slopes have often developed due to "creep" or slow movement downslope of the near-surface soil layers. In other cases the irregularities are the surface expression of deep-seated soil or rock-sliding. The core of hole SEF3 suggests that the surface soil mantle is too thin to develop the observed irregularities due to creep. At depth the core shows some extensively weathered rocks, but there is no evidence of any deep-seated disturbance.

Soil-covered slopes along Ramps S2 and S3 of the Stirling Interchange, in the Parson's House area and further west, are probably underlain by schist and gneiss. Mapping and the results of Drill Hole SEF4 suggest that the rocks are extensively weathered and that the schistosity dips generally downslope. There are no obvious signs of past instability in these slopes, but it is considered that sliding along schistosity planes and seams is likely in deep cuttings, unless these are made at flatter angles than the weakness planes.

Groundwater

All three of the diamond drill holes were dry after completion. This suggests that groundwater levels are probably well below the levels of the proposed cutting.

There is very little other factual information available on groundwater levels in the project area. Seepages have been observed after wet weather near the base of shallow cuttings for the Freeway near Measdays House. These appear to be from perched water travelling downslope on the soil-rock interface.

The floor of Main Creek Valley is in many places flat and alluviated, Swampy type vegetation on and near these flats suggests that groundwater occurs at shallow depths, even during the summer.

ENGINEERING PROPERTIES OF ROCKS

Structural Weaknesses

The rock mass has been weakened to varying degrees by geological structures of the types shown in Figure 7.

The major weaknesses which are faults (sheared and crushed zones), are probably present in many places, but are seldom recognised as such in shallow cuttings as they are usually obscured by highly weathered material. Jointing (usually 2 main sets), bedding, foliation and cleavage occur in patterns which vary in different parts of the area. The orientations and dips of these structures where observed, are shown on the geological plans, Figures 2 to 5. The mapping has shown that each rock type has a characteristic weakness pattern.

Quartzite is generally massive, but is intersected by steeply dipping joints spaced commonly from 1 to 6 ft. apart, which with the flat lying bedding planes divide the rock into roughly cubic and tabular blocks. Some of the quartzite and the finer-grained sandstone have closely spaced (less than 1 ft.) bedding weaknesses which are often accentuated by weathering forming seams of clay. With joints spaced mainly 0.5 to 4 ft. apart, the rock is divided into roughly tabular blocks.

Felspathic sandstone is massive with numerous steeply dipping joints, but the degree of weathering is such that the rock tends to break across the fabric rather than along geological weaknesses.

Schist and Shale in many places possess closely spaced schistosity and cleavage planes due to the parallel arrangement of micaceous minerals. These planes and joints divide the rock into platy blocks.

Gneiss commonly has bands of weakness due to schistose material along the foliation direction which, combined with 2 approximately perpendicular sets of joints spaced commonly 2 to 8 feet apart, give large cubic or tabular blocks.

Chemical Weathering Products

Chemical weathering is the process of chemical alteration of the mineral constituents of rocks by the action of groundwaters. These waters obtain access to relatively impervious rocks by travelling along open joints and faults, and to porous rocks by percolation through the rock itself.

The degrees of chemical weathering are defined according to the physical properties of the weathered products, as set out on Table 2.

TABLE 2 WEATHERING PRODUCTS OF HARD* ROCKS

	Term	Abbreviation on Drawings	Definition
Essentially "rock" properties	Fresh	Fr	The rock shows no discolouration, loss of strength, or any other effect due to weathering.
	Slightly Weathered	SW	The rock is slightly discoloured, but not noticeably lower in strength than the fresh rock.
	Moderately Weathered	MW	The rock is usually discoloured and noticeably weakened, but NMLC and NM cores cannot usually be broken up in unaided hands.
Essentially "soil" Properties	Highly Weathered	HW	The rock is usually discoloured and weakened to such an extent that NMLC or NM cores can be broken up readily by hand, across the rock fabric. Wet strength noticeably lower than dry strength.
	Completely Weathered	CW	The rock is usually discoloured and reduced to a soil, but the original fabric of the rock is mostly preserved. It is difficult to recover as diamond drill core, and usually can be recovered only by dry drilling.

*The shale and schist in the project area are not in this category but for convenience the same field test criteria as for hard rocks, have been applied to classify their weathering products.

The six main rock types present show important variations in their susceptability to chemical weathering and in the nature of their weathering products. Of these the quartzite and gneiss are generally resistant, and the felspathic sandstone, schist and shale have been considerably weathered, probably more than 50 ft. below the surface in many places. The weathering characteristics of each rock type are shown in Table 3.

Mechanical Weathering Effects

The rocks in the project area have also been affected by mechanical weathering. This is mechanical loosening of the rock mass due to opening up of joints. It occurs close to the ground surface and is effected by the roots of trees and scrub which grow into slightly open joints in the rock, opening them up further and dividing the rock into separate blocks. Joints may also be opened up due to the release of load when overlying material is removed by erosion.

In rocks where the joints are widely spaced (1 to 8 ft.) the effects of mechanical weathering are not very noticeable. The quartzite near Measdays House and the massive shale in the eastern part of the Measdays Section are examples of this, with little evidence of mechanical loosening below a depth of about 5 feet.

In laminated and schistose rocks there is evidence of mechanical weathering extending to considerable depths. In drill hole SEF2 the laminated shale within 50 feet from the ground surface contains numerous clay filled joints and bedding plane partings, some of which contain roots up to 0.02 ft. diameter.

TABLE 3 PROPERTIES OF ROCKS

Rock Type	Notes on Petrology	Probable Properties when Fresh	Conditions where exposed along Route
Quartzite	Massive to poorly bedded rock composed mainly of quartz grains up to 2 mm. with varying amounts of secondary silicification. Felspathic in part.	Very strong and dense rock when fresh or slightly weathered. Tests on similar rocks (Ref. 12) gave qu (unconfined compressive strength) from 8000 to 15000 lb/sq.in.	Generally resistant to weathering. Mainly SLIGHTLY TO MODERATELY weathered, cannot be broken by light blow with a geological pick. Where felspar grains or thin shaley beds ; are present the rock is mostly HIGHLY weathered.
Felspathic Sandstone	Massive to poorly bedded rock consisting mainly of quartz and felspar grains up to 2mm., some mica grains.	Naturally porous rock, moderately strong when fresh. Similar sandstones (Ref. 9) have qu ranging between 4000 and 8000 lbs/sq.in.	No fresh felspathic sandstone is exposed. Most exposures are uniformly HIGHLY weathered. Small pieces are easily broken by hand.
Micaceous Sandstone	Well-bedded rock composed mainly of quartz and mica flakes up to 1 mm. Few felspar grains.	Comparable strength to felspathic sandstone. Mica flakes oriented along bedding may form weaknesses in this direction	No fresh micaceous sandstone is exposed. Most exposures are MODERATELY weathered and may be broken by a light blow with a geological pick. The rock tends to break preferentially along bedding planes.
Shale	Laminated to poorly bedded rock, consisting mainly of silt sized grains, some sand grains.	Moderately strong, dense rock when fresh. Laminated types break more easily along bedding planes. Tests on shales (Ref.9) show values of qu ranging from 2500 to 5000 lbs/sq.in.	Exposures of shale vary widely, from SLIGHTLY TO COMPLETELY weathered. The less weathered rock cannot be broken by a light blow with a geological pick.
Schist	Laminated, flaky rock composed mainly of sericite, quartz, chlorite and talc.	Some schist, particularly the talc and sericite rich varieties are very weak and flaky. Tests on schists (Refs. 9 and 10) show values of qu ranging from 1200 to 5000 lbs/sq.in.	Mainly HIGHLY to COMPLETELY weathered, some SLIGHTLY to MODERATELY (not broken by light blow with a geological pick.) Chlorite and talc rich varieties are more susceptible to weathering than quartz rich types, and weather to silty and clayey soils

TABLE 3 (contd.)

Rock Type	Notes on Petrology	Probable Properties when Fresh	Conditions where Exposed along Route
Gneiss	Crystalline rock consisting mainly of quartz, felspar, mica and chlorite, approaching coarse granitic texture.	Strong dense rock when fresh or slightly weathered. Similar gneiss (Ref. 10) has qu ranging from 5500 to 13000 lbs/sq.in.	Varies from SLIGHTLY to COMPLETELY weathered. Felspar grains are partly or wholly decomposed to silty material.

RIPPABILITY

Assessment of Rippability

Assessments of rippability of materials to be met in cuttings along individual sections of the route are given in Tables 4 to 7 inclusive.

These assessments are assuming the use of a D9 or equivalent tractor and are based on the following.

.......An assumed condition of the rock mass - rock type. structural weaknesses, degree of chemical and mechanical weathering, orientation of main weaknesses.

.......Excavation methods used in the existing roads in the area, adjacent to proposed roads.

.......Seismic velocities in the materials.

.......Electrical resistivities of the materials.

Behaviour of the Rock Mass during Ripping

In assessing the rippability of the materials present in the project area it has been assumed that ripping can be accomplished in any of the following ways.

(a) By tension, shear, or crushing failure of the rock material across its fabric. It is considered that such failure across the rock fabric is likely to occur only in highly or completely weathered materials. This type of behaviour was observed in the ripping already carried out in the Crafers underpass excavation. In this excavation the material ripped was mainly highly weathered sandstone.

(b) By failure along existing joints or seams, dividing the rock into separate intact joint-blocks. This type of behaviour is to be expected in slightly or moderately weathered rocks, intersected by numerous open or weakly cemented joints, or by soft seams. The ripping would be easiest within the zone of mechanical weathering or loosening, and become much more difficult below.

(c) By a combination of the effects described in (a) and (b); in rocks which are weakened by the combined effects of structural weaknesses, and mechanical weathering.

The mapping and subsurface exploration suggest that most of the rippable materials which will be encountered in cuttings fall into categories (a) and (c) above.

Assessment from Seismic Velocities

The seismic refraction method (Refs. 4, 5, 6, 7,) has been used extensively in the assessment of the rippability of rock materials in road cuttings. It has been found by experience that seismic velocities are related to degrees of compactness of rock masses and hence to their rippability (Fig. 8).

Seven traverses, each 300 ft. long have been made during this investigation. Their positions are shown on the detailed plans. Figs. 2 to 5. The first two traverses were made for correlation purposes, in areas where subsurface conditions are known. The other five are in sections where relatively deep cuttings are proposed and subsurface conditions are uncertain. The results are given on Tables 4 to 7 inclusive.

In assessing rippability from the seismic results, the experience gained from the first two trial traverses, and from the work of several other organizations (Fig.8) has been used.

Resistivity Observations

The resistivity of a rock mass is an indication of its water content, and hence its porosity or degree of compactness.

In this investigation 13 measurements of earth resistivity were made, 3 for correlation purposes in areas of known subsurface conditions and 10 in areas of proposed cuttings.

The resistivities shown in the depth probes and the corresponding geological conditions are as follows:

Position of Depth Probe	Apparent Resistivity (ohm meters)	Geological Conditions in Excavations Nearby
Sta 103 on Freeway centreline	Up to 650	Moderately weathered quartzite and highly weathered felspathic sandstone near the surface.
Sta 128+50 on the Freeway centre-line	Up to 550	Highly weathered sandstone and shale.
Sta 89+50 on Summit Road Deviation centre-line (Quarry floor)	Up to 2500	Quarry walls show 40 ft. of mainly moderately weathered quartzite with some slightly weathered bands

The remaining probes made at Sta's 106+50, 109, 112, 114+50, 118, 121+50, 125, 136+50, 139 and 162+50 all show resistivity values of less than 1600 ohm-meters.

The inferences given in Tables 5 and 6 were made by comparing the resistivity values for these probes with those of the probes where conditions are visible.

STABILITY OF CUTTINGS

The rocks along the route are weakened to varying degrees by joints and seams, and by chemical and mechanical weathering.

Experience has shown, and it has also been shown theoretically (Refs. 8 and 13), that the stability or otherwise of a cutting in such materials is controlled by the attitude or orientation of relatively minor planar weaknesses. Most failures in steep cuttings occur by sliding along one or more thin soft seams or joints coated with soft material.

By geological mapping of rock exposures and existing cuttings, and by careful diamond drilling using NMLC coring equipment, it is possible to obtain a general indication of the nature and orientation of the main sets of seams and joints. However, it is seldom possible, with the degree of pre-construction exploration justified for road cuttings, to determine in advance the exact locations and attitudes of individual weaknesses. These usually become evident only during the excavation stage. If they are found to be oriented to favour instability, then the cutting angle or shape must be amended, or else some form of support devised.

The suggested cutting angles given in Tables 4 to 7 inclusive have been chosen in each case by consideration of an assumed, generalized, picture of the rock mass. Particular attention has been paid to the attitudes of known weaknesses, and some allowance has been made for unfavourably oriented weaknesses which may be present but have not been detected in the investigation.

The following method has proved satisfactory in the excavation of deep cuttings, especially where there is a marked improvement in rock quality with depth. A cutting angle is chosen as logically as possible from the known or assumed geological conditions. The top of the cutting is then pegged to give a cutting angle some 5^{o} (or more) flatter than this, and the excavation commenced from a pilot track at the top. If the material remains uniform then the cutting is completed at the flatter, pegged slope. If at any level at or more than halfway down to grade it becomes evident that the underlying material is more competent and should stand at a steeper angle, than a horizontal or gently sloping berm can be left, and the cutting continued at the new steeper angle. If the material below the berm fails, only the berm is affected, if the overall slope chosen is a stable one.

DETAILED GEOLOGY OF PROPOSED ROUTES

Measdays Section

(Sta 53 to Sta 105, length 5200 ft.)

The Measdays Section (Fig. 2) passes for the greater part of its length along the western slopes of a north-south ridge with moderate side slopes (10 to 20°). It cuts through the ridge crest and finishes on the saddle of the Summit Ridge.

Cuttings up to 40 feet deep in the existing freeway are to be widened to allow a formation width of 80 ft. About 1600 feet of the section is to be constructed on fill.

The section is located in variably weathered rocks of the Stonyfell Quartzite Formation. The approximate total lengths of route in each rock type are as follows:

Length of Route (ft.)	Rock Type
* 3700	Shale
800	Quartzite
700	Sandstone

* For about 1600 feet of this length the road is to be constructed on fill.

Details of the geology and an assessment of excavation conditions along individual parts of the route are given in Table 4.

TABLE 4

GEOLOGICAL CONDITIONS, MEASDAYS SECTION, STA 53 to STA 105 (FIG. 2)

CHAINAGE FROM	CHAINAGE TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATION
53+00	71+00 Junction with Uptrack to Crafers	1700	Cut up to 15 ft. deep on north side (up to 50 ft. north of existing cutting). Some fill on south side.	Cuttingsin the existing road up to 15 ft. deep expose quartzite and shale bands. MW quartzite occurs from STA 53 to STA 55 and SW to CW quartzite occurs from STA 58 to STA 63+50. (See Section at STA 61 Fig. 6). This rock is mainly slightly weathered with tight joints spaced mainly 4 ft. apart. Several patches of HW to CW rock up to 15 ft. wide occur where near vertical joints are closely spaced. The shale varies from SW to CW with a prominent cleavage dipping at 40 to 50°, and joints spaced mainly 3 ft. apart.	None	The prominent cleavage should enable the shale to be ripped. The quartzite will probably require blasting. Suggested cutting angles 1:1 (45°) or flatter in the shale.
71+00	75+50	450	Fill on both sides	Road crosses a gully. Weathered rock is present near the surface.	None	No excavation required.
75+50	93+00	1750	Cut on north side up to 15 ft. deep, will extend up to 50 ft. beyond the existing cutting face.	Some outcrop of weathered shale is present in the table drain of the existing road. There is no outcrop at natural surface level but loose shale fragments up to 0.5 ft. occur.	None	Should be rippable. Suggested cutting angle 1:1 (45°) or flatter.

TABLE 4 (contd.)

CHAINAGE FROM	TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SURFACE EXPLORATION	REMARKS AND INTERPRETATION
93+00	99+00	600	Cut on north side up to 40 ft. deep, will extend up to 40 ft. beyond the present cutting. A little cut on south side.	Shale outcrops in cuttings up to 40 ft. high on both sides of the existing road. The rock is well bedded with 2 main sets of tight steeply dipping joints. It is mainly slightly weathered. See Section at Sta 95+50, Fig.6.	A seismic refraction traverse shows material with a velocity of 10,000 ft/sec. close to the surface.	This section requires blasting. Explosives were used for the existing road cuttings. Suggested cutting angle $\frac{3}{4}$:1 (53°).
99+00	105+00 Summit Rd. Turnoff	600	Continuous cut on south side up to 35 ft.	Sandstone and quartzite are exposed in a cutting within 30 ft. of the proposed centre line. The rock is HW to CW up to 101+50 and mainly MW with some SW from 101+50 to 105+00. The quartzite is well jointed and contains thin soft bands along the bedding See Section at Sta 102 Fig. 6.	None	Mainly rippable to 30 ft. The slightly weathered quartzite may require light blasting, but the thin clayey beds should allow ripping. Suggested cutting angle 1:1 (45°).

Crafers Interchange

(Sta 105 to Sta 135, length 3000 ft.)

The Crafers Interchange section (Fig. 3), commences on the saddle of the Summit Ridge and passes down slope, south of Crafers township to the valley of Main Creek. The ground slopes are gentle (less than 10°).

Cuttings are proposed for most of the length, and will be up to 40 feet deep in places, with a formation width of 80 feet. Four ramps are proposed, each with a formation width of 14 feet. An overpass will cross the freeway at Crafers township.

The section is located in highly weathered rocks of the Stonyfell Quartzite formation. The approximate total length of route in each rock type are as follows:

Length of Route (ft.)	Rock Type
2200	Sandstone
800	Shale

Details of the geology and an assessment of excavation conditions for individual parts of the route are given in Table 5.

TABLE 5

GEOLOGICAL CONDITIONS, CRAFERS INTERCHANGE, STA 105 to STA 135 (FIG. 3)

CHAINAGE FROM	CHAINAGE TO	DISTANCE	DETAILS OF PROPOSED CONSTRUCTION	SUBSURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS & INTERPRETATIONS
105+00	121+50	1650	Continuous cut - up to 30 ft. at Sta 114.	Route is soil covered to 117+00. From 117+00 to 131+50 excavation for overpass has exposed HW felspathic sandstone. Trench shows HW sandstone to 12 ft. below surface.	A resistivity survey along the proposed centre-line shows a 400 to 700 ohm-metre formation to more than 30 ft. Seismic refraction traverses from 112+00 to 115+00 and 117+00 to 120+00 show a refractor of 3000 to 4000 ft/sec to a depth of well over 50 ft.	Soil from 2 to 6 feet deep overlying highly weathered sandstone. Resistivity and seismic results suggest that the rock is highly weathered to more than 50 ft., and hence should be rippable. Suggested cutting angle $1\frac{1}{2}$:1 (34°)
121-50	132+00 Junction of proposed freeway with existing road	1050	Continuous cut on S side up to 38 ft. deep at Sta 130+00. Continuous cut on N side up to 17 ft. deep at Sta 123+00.	Route is mainly soil covered. Nearby cuttings up to 5 ft. deep expose MW and HW sandstone and shale in alternating bands. A series of parallel near vertical quartz veins form a band 10 ft. wide, which crosses the proposed cutting between Sta 127+50 and Sta 128+50.	Resistivity work along the proposed centre-line shows a 400-700 ohm metre formation to more than 30 ft. Two power auger holes drilled by H. & L.G. Dept. show MW rock (sandstone in one, shale in other) to a depth of 20 ft. Diamond drill hole SEF2 near Sta 130 shows weathered laminated shale to a depth of 60 ft. (See Section at Sta 130. Fig. 6). The shale contains numerous joints and highly weathered bands along the bedding which dips upslope at 20 to 40°.	The jointing and weathering of the shale should enable it to be ripped, with little or no blasting. The quartz vein band may require blasting. Suggested cutting angle 1:1 (45°).

TABLE 5 (Contd.)

CHAINAGE FROM	TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATION
132+00	135+00	300	Cut on south side from Sta 132+00 to 134+00 decreasing from 20 ft. to zero. Fill on north side	No rock is exposed within 100 ft. of the route which is soil covered.	None.	Probably rippable to 20 ft. Suggested cutting angle $1\frac{1}{2}$:1 (34°)
RAMP C-1, STA 102 to STA 116 (FIG.3)						
102+00	116+00	1400	Shallow cut on western side.	The route is soil covered and the nearest exposures to the west show highly weathered sandstone.	None.	Highly weathered rock occurs under 2 to 3 ft. of soil. The small amount of cut proposed is rippable. Suggested cutting angle $1\frac{1}{2}$:1 (34°).
RAMP C-2, AND CRAFERS MAIN STREET, STA 101 to STA 125+50						
101+00	108+00	800	Cut commences as an extension of the cut for the freeway with a maximum depth of 20 ft. at 104. The level of the ramp pavement rises with respect to the freeway pavement. The route follows approximately the existing road.	Nearby exposures show highly to moderately weathered sandstone and quartzite.	None	From 2 to 4 ft. of soil overlying HW sandstone should be rippable. Suggested cutting angle $1\frac{1}{2}$:1 (34°).

TABLE 5 (Contd.)

CHAINAGE FROM	TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATION
RAMP C-2 (Contd.)						
108+00	125+00	1750	Cut on North side from Sta 110 to Sta 113, up to 15 ft. deep at Sta 112. Fill on south side. Ramp C-2 finishes at 110+50. Crafers Main Street extends from 110+50 to 125+50.	Cuttings up to 5 ft. deep in the existing road expose MW to HW sandstone. This appears to become more solid towards the base of the existing cutting.	None.	Some blasting may be necessary towards the base of the excavation near STA 112. Suggested cutting angle 1:1 (45°).
RAMP C-3 STA to STA 135 (FIG. 3)						
125+50	135+00	1000	Cut on south side up to 15 ft. at 130 ft.	Some highly to moderately weathered sandstone and quartzite occurs near the route.	None.	The small cut proposed should be rippable. Suggested cutting angle 1:1 (45°).
RAMP C-4 STA 118 to STA 130 (FIG.3)						
118+00	130+00	1200	Cut will be an extension of the freeway cut at Sta 130 rising to ground surface at Sta 125	The route is soil-covered.	Diamond drill hole SEF2 near Sta 130 (see Section at Sta 130, Fig. 6) shows weathered laminated shale with numerous joints and highly weathered bands along the bedding.	The jointing and weathering of the shale should allow it to be ripped with little or no blasting. Suggest cutting angle 1:1 (45°)
HILLCREST RD. DEVIATION			STA 60 to STA 75 (FIG. 3)			
60+00	75+00	1500	Cut on west side up to 20 ft.	Route is soil covered. Nearby excavations expose HW sandstone.	None.	Highly weathered sandstone occurs under 1 to 3 ft. of soils. should be rippable. Suggested cutting angle 1:1 (45°) or flatter.

Stirling Interchange

(Sta 135 to Sta 180, length 4500 ft.)

The Stirling Interchange section (Fig. 4), follows down the valley of Main Creek which it crosses 3 times. The section finishes ½ mile north-east of Stirling township. Moderate side slopes of 10 to 25° occur, becoming more gentle at the eastern end.

More than half the route will be constructed on fill, and several cuts up to 45 feet are proposed. The formation width is to be 80 feet. Four ramps, each with a formation width of 14 feet, are also planned.

The route passes from the Stonyfell Quartzite rocks, through Archaean schists and gneisses, and then into rocks of the Aldgate Sandstone Formation. The approximate total lengths of route in each rock type are as follows:

Length of Route (ft.)	Rock Type	
2500	Sandstone and shale (Aldgate Sandstone Formation)	
1000	Schist and gneiss	
400	Sandstone	Stonyfell Quartzite Formation
400	Shale	Stonyfell Quartzite Formation
200	Quartzite	Stonyfell Quartzite Formation

Details of the geology and an assessment of excavation conditions along individual parts of the route are given in Table 6.

TABLE 6

GEOLOGICAL CONDITIONS, STIRLING INTERCHANGE, STA 135 to STA 180 (FIG. 4).

CHAINAGE FROM	TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SURFACE EXPLORATION	REMARKS AND INTERPRETATION
135+00	145+00	1000	South side cut from Sta 137 to Sta 141, up to 25 ft. deep at Sta 139. Fill from Sta 141 to Sta 145. North side cut from Sta 130 to Sta 142, up to 45 ft. at Sta 139. Fill from Sta 142 to Sta 145.	The route is mainly soil covered. Rock is exposed within 100 ft. of the proposed centre line near 136+50, near Sta 131 and in bands in the creek bed near 141+00 The rock is well bedded and dips 40 to 55°. It consists of bands of fine laminated sandstone and shale. The shale is well cleaved and there are 2 main sets of steeply dipping tight joints. The quartzite exposed near Sta 141 occurs in a near vertical band about 12 ft. thick and is particularly hard. The soil-covered slopes above the proposed road have a slightly hummocky appearance.	A seismic refraction traverse between 138+00 and 141+00 shows a 9000 ft/sec refractor below an average depth of 65 ft. and a refractor of up to 6000 ft/sec. above this depth. Results not clear from 139+50 to 141+00 possibly due to bands of harder rock. Drill-hole SEF3 angled to penetrate the bedding at right angles (see Section at Sta 139, Fig. 6) showed MW to HW medium sandstone to 20 ft. then laminated fine sandstone and shales to 74 ft. Above 55 ft. the rock is HW to MW with prominent joints along the bedding, and several bands of CW rock. Below 55 ft. fresh rock is seperated by several bands up to 1 ft. thick, of HW rock.	3 ft. of soil covers weathered rock. Probably mostly rippable, but some blasting will be necessary near the base of the cutting on the uphill side. Hummocky slopes suggest past instability of at least the near-surface layers. Suggested cutting angles $1\frac{1}{2}$:1 (34°) near surface, and $\frac{3}{4}$:1 (53°) below.

CHAINAGE FROM	TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATIONS
145+00	149+00	400	Continuous cut in south side up to 20 ft. Fill in north side.	Schist and gneisses are exposed in a cutting on the existing highway 30 to 100 ft. south of the proposed centre-line. Similar rock is exposed in the creek bed up to 120 ft. north of the line. The weathering of these rocks is variable. Typically the rock exposures show large platy blocks of rock up to 6 ft. wide separated by up to 3 ft. of HW and CW rock along the schistosity which dips 45 to 50°. Solid rock is more continuous at the base of the cutting. Two sets of joints (as shown) are spaced from 1 to 5 ft. apart - mainly 4 ft. These joints are irregular and open up to 0.1 ft.	A seismic traverse from Sta 149 to Sta 151 shows a refractor of 7200 ft/sec. within 3 ft. of the surface. This represents an average velocity, and harder bands may occur, separated by weathered rock as seen in the existing cutting.	Blasting will probably be necessary between 145+00 and 149+00. Drill holes remaining in the rock suggest that blasting or wedging was used during construction of the existing road. Suggested cutting angle $\frac{3}{4}$:1 (53°).
149+00	154+00	500	Mainly fill.	Schists and gneisses, mainly HW and CW but with some MW material, occur in the road cutting and in a few outcrops in the creek.	A seismic traverse from Sta 148 to Sta 151 shows a refractor with an average velocity of 7200 ft/sec. close to the surface.	Only a small amount of shallow cut is proposed. This should be rippable.
154+00	180+00	1600	Mainly fill. Some cut up to 10 ft. deep from 178+00 to 180+00.	The route is covered by soil and rubble, part of which (from Sta 162 to 163) is river alluvium. Sandstone outcrops 200 ft. south of Sta 161.	None.	The small amount of cut proposed should be rippable.

TABLE 6 (contd.)

CHAINAGE FROM	TO	DISTANCE	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATIONS
RAMP S-1, STA 148 to STA 170						
148+00	158+00	1000	Ramp is on fill at a lower level than the freeway.	Soil covered.	None.	-
158+00	170+00	1200	Cut on south side up to 25 ft. below the existing road.	Existing road cuttings nearby expose MW fine sandstone dipping steeply separated by bands of HW to CW rock.	None	Parts of the excavation may require blasting near formation level. Suggested cutting angle $\frac{3}{4}$:1 (53°).
RAMP S-2, STA 145 to STA 170						
145+00	170+00	2500	Mainly fill. Cut from Sta 153 to Sta 162, up to 25 ft. deep at Sta 159.	Soil covered.	See Section at Sta 159 (Fig. 6). A seismic traverse near Sta 160 showed a refractor with a velocity of 10,000 ft/sec at 20 to 25 ft. below the surface. Drill hole SEF 4 encountered HW to CW schist from the surface to below formation level. This is very weak, flakey material Mapping and drilling results suggest that schistosity dips downslope at 30° to 50°.	The schist should be rippable down to formation level. Suggested cutting angles $1\frac{1}{2}$:1 (34°) or flatter; slides along schistosity are likely with steeper angles.

TABLE 6 (Contd.)

CHAINAGE FROM	TO	DISTANCE	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATIONS
RAMP S-3. STA 155 to STA 165. FIG. 4						
155+00	165+00	1000	Cut decreasing from 25 ft. at STA 155	The route is soil covered.	Drill hole SEF4 showed weathered schist dipping downslope at 30° to 50°.	The schist should be rippable down to formation level. Suggested cutting angles $1\frac{1}{2}$:1 (34°) or flatter.
RAMP S-4. STA 160 to STA 175. FIG. 4						
160+00	175+00	1500	Mainly fill.	Route is soil covered.	None	-

Summit Road Deviation

(Sta 63 + 25 to Sta 100, length 3675 ft.)

The Summit Road Deviation (Fig. 5), crosses the Freeway by an overpass near Crafers, and then follows along the south-eastern side of the Summit Ridge. Side slopes range from 5^{o} to 20^{o}.

Cuttings up to 45 feet deep are planned, and the proposed formation width is 46 feet.

The route passes for its whole length through partly weathered quartzite of the Stonyfell Quartzite Formation.

Details of the geology, and an assessment of excavation conditions along individual parts of the route, are given in Table 7.

TABLE 5

GEOLOGICAL CONDITIONS SUMMIT ROAD DEVIATION, STA 64 + 25 to STA 100 + 00 (FIG. 5).

CHAINAGE FROM	CHAINAGE TO	DISTANCE FEET	DETAILS OF PROPOSED CONSTRUCTION	SURFACE GEOLOGY	SUBSURFACE EXPLORATION	REMARKS AND INTERPRETATION
63+25	68+00	400	Small cut on east side	Nearby exposures are MW sandstone.	None	Rippable
68+00	75+00	700	Continuous cut on west side up to 30 ft. Cut on east side from 68+00 to 75+00 up to 35 ft. at 71.	The route is covered by soil and MW to SW quartzite fragments up to 1 ft. A small quartzite outcrop occurs at 72+50. Exposures on the present Summit Road show quartzite varying from SW to CW. Beds dip downslope at 15° to 30°.	A seismic traverse from 170+00 to 173+00 shows a 9000 ft/sec. refractor at 80 to 100 feet. Material with average velocity of less than 5000 ft/sec extends from the surface to 80 ft.	Should be mainly rippable. Localized bands of harder rock may require light blasting. Orientation of bedding planes may make ripping difficult, and create a stability problem in high cuttings. Suggested cutting angle 1:1 (45°) or flatter.
75+00	87+00	1200	Continuous cut on west side. Fill on east side.	Route is covered by soil and loose blocks up to 1 ft. across. Nearby quarry is in mainly MW quartzite. Thin beds of very soft clayey rock up to 0.1 ft. thick occur at intervals of 0.5 to 2 ft.	None	Should be mainly rippable. May be some hard bands requiring light blasting. Suggested cutting angle $\frac{3}{4}$: 1 (53°).
87+00	100+00	1300	Fill.	Soil covered.	None	-

CONCLUSIONS

1. Most of the cuttings proposed for the Freeway and associated ramps will be in extensively weathered rocks which can be excavated by dozing or ripping with a D9 class machine.

2. There are several localized areas in which surface exposures of apparently unrippable rock occur adjacent to or along the route, and it is evident that explosives will be required.

3. In several of the proposed deep cuttings subsurface exploration suggests that ripping will be feasible for the greater part, but explosives may be required near the base.

4. Along most of the route suggested cutting angles are either $1\frac{1}{2} : 1$ (34°) or 1:1 (45°) for permanent stability. For a few sections $\frac{3}{4}:1$ (53°) is suggested.

J. P. Trudinger

JPT:AWK:MG:PAL
21.7.65

J.P. TRUDINGER
GEOLOGIST
ENGINEERING AND SOILS GEOLOGY
SECTION.

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APPENDIX A - LOGS OF DIAMOND DRILL HOLES

Hole No.	Co-ordinates East	Co-ordinates North	Reduced Level (ft.)	Angle From Horizontal	Direction	Depth (ft.)
SEF 2	513,200	2,028,135	1920	63°	352°	62.7
SEF 3	514,085	2,028,085	1893	45°	307°	74
SEF 4	515,980	2,027,330	1770	45°	355°	50.5

DOCKET 87/64

DEPARTMENT OF MINES — SOUTH AUSTRALIA

GEOLOGICAL LOG OF DRILL HOLE

HOLE No. SEF 2
SHEET 1 OF 1

PROJECT S.E. FREEWAY INVESTIGATION CO-ORDINATES E 513,200; N 2,028,135 R.L. 1920 FT.
FEATURE EXCAVATION CONDITIONS HUNDRED NOARLUNGA DIRECTION 352
LOCATION CRAFERS–STIRLING SECTION SECTION 19 ANGLE FROM HORIZONTAL 63

ROCK TYPE | DESCRIPTION OF CORE | CORE LOSS / LIFT % | CORE SIZE / DEPTH / RL. FT. | LOG | FRACTURE LOG 1 4 16 64 | STRUCTURES | Water Level | Casing | DRILL WATER LOSS % | WATER PRESSURE TESTS — PERMEABILITY IN LUGEON UNITS (0, 20, 30 / 40, 80, 120)

PRECAMBRIAN – TORRENSIAN
STONYFELL QUARTZITE FORMATION
Shale and Sandstone

Weathering: High to Complete; Mainly Moderate; CW; High to Moderate; CW; Moderate to slight; CW; Moderate to Complete

Soil and HW shale fragments
NO CORE
Laminated shale with thin sandstone as shown.
Irregular quartz veins up to 5 m.m. wide.
Banded, grey-green to yellow-brown.
NO CORE
NO CORE
Mainly red-brown to yellow-brown
Felspathic sandstone, grains up to 1·2 m.m. Pale reddish-brown

NMLC

Depth: 10, 20, 30, 40, 50, 60
RL: 1910, 1900, 1890, 1880, 1870

Bedding dip 20° to 30° on Core.
= Broken by drilling
CW rock broken by drilling.
Seams of clay and CW rock 0·3 ft. wide.
CW rock and clay.
CW rock, clay and decayed root.
Broken by drilling
Rock broken along bedding planes.
Rock broken along bedding planes.

Joints mainly along bedding, smooth, limonite coated, some clay coated. Drilling causes breakages along bedding planes.
Some near perpendicular to bedding, tight, smooth, discontinuous, limonite coated.

Hole Empty (May '65)

Full water return

NOT WATER PRESSURE TESTED

END of HOLE 62·7 ft
R.L. 1864 ft.

TRIM

DRILL No. 24
TYPE A 1000
DRILLER Jensen
COMMENCED 23 Apr. '65
COMPLETED 28 Apr. '65

EXPLANATION

FRACTURE LOG
1 4 16 64 Breaks in core per foot, or diameter of fragments in feet
12 3 3/4 3/16 Inches } Equivalent
1 ·25 ·06 ·015 Feet } diameter

CW - Completely weathered.

ENGINEERING AND SOILS GEOLOGY SECTION
LOGGED BY J.P.T. (4 May '65)
DRAWN BY J.P.T.
CHECKED BY D.H.S.
DRAWING No. S4375 Ha 6+9

LOG No. 87/64

DEPARTMENT OF MINES – SOUTH AUSTRALIA

GEOLOGICAL LOG OF DRILL HOLE

HOLE No. SEF 3

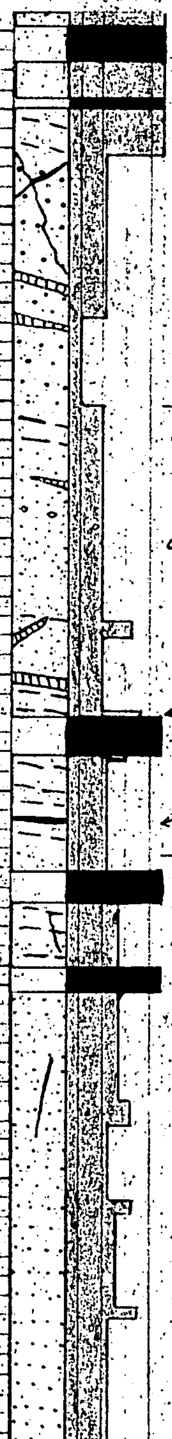
SHEET 1 OF 1

PROJECT S.E. FREEWAY INVESTIGATION CO-ORDINATES E. 514085, N. 2028085 R.L. 1893 FT.

FEATURE EXCAVATION CONDITIONS HUNDRED NOARLUNGA DIRECTION 307°

LOCATION CRAFERS-STIRLING SECTION SECTION 19 ANGLE FROM HORIZONTAL 45°

ROCK TYPE | DESCRIPTION OF CORE | CORE LOSS LIFT % 20 60 | CORE SIZE DEPTH RL. FT. | LOG | FRACTURE LOG 1 4 16 64 | STRUCTURES | Water Level | Casing | DRILL WATER LOSS % 50 | WATER PRESSURE TESTS PERMEABILITY IN LUGEON UNITS 0 20 30 / 40 80 120



PRECAMBRIAN – TORRENSIAN STONYFELL QUARTZITE FORMATION

Sandstone

Complete

Moderate to high

Soil, dark grey brown plant roots

NO CORE

NO CORE

Shale, brown.

Sandstone has quartz grains up to 1 mm., slightly porous.

Quartz vein 0.1ft wide

Coarse grained sandstone

Vuggy quartz vein 0.2ft wide

Sandstone and Shale

Mainly high

NO CORE

Sandstone is finegrained, dense with thin shaley laminations.

Shale bands as shown

NO CORE

Light brown to grey-brown

NO CORE

Mainly FRESH, with some high to moderate

Grey to dark grey. Some disseminated Pyrite mineralisation

NMLC

10

20

1880

30

1870

40

1860

50

60

1850

70

Broken rock

Bedding indistinct, dips about 20° on core.

Joints along bedding, smooth, some with up to 0.02ft of clay

Few joints at 30° to 45° and 75° to 85° on core, irregular

Joints mainly along bedding, which dips 15° to 25° on core, smooth, limonite coated, few are clay coated.

Drilling causes breakage along bedding planes and joints

Clay and CW rock

0.02ft of clay in joint

Bedding dips less than 5°, some cross-bedding.

Joints near parallel to core, smooth, limonite coated, tight

Hole Empty (May '65)

Full water return

NOT WATER PRESSURE TESTED

END OF HOLE 74 Ft.

R.L. 1842 Ft.

TRIM

DRILL No. 24

TYPE A.1000

DRILLER Jensen

COMMENCED 30 Apr. '65

COMPLETED 4 May '65

EXPLANATION

FRACTURE LOG 1 4 16 64 Breaks in core per foot, or diameter of fragments in feet

12 3 ¾ 3/16 Inches } Equivalent

1 .25 .06 .015 Feet } diameter

CW Completely weathered

ENGINEERING AND SOILS GEOLOGY SECTION

LOGGED BY J.P.T. (10 May '65)

DRAWN BY J.P.T.

CHECKED BY D.H.S

DRAWING No. S4376 Hd 649

DOCKET 87/64

SERIAL No.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

GEOLOGICAL LOG OF DRILL HOLE

HOLE No. SEF 4

SHEET 1 OF 1

PROJECT S.E. FREEWAY INVESTIGATION CO-ORDINATES E515980, N.2027330. R.L.1770 FT.

FEATURE EXCAVATION CONDITIONS HUNDRED NOARLUNGA DIRECTION 355°

LOCATION CRAFERS - STIRLING SECTION SECTION 2798 ANGLE FROM HORIZONTAL 45°

ROCK TYPE	DESCRIPTION OF CORE	CORE LOSS LIFT %	CORE SIZE DEPTH RL FT.	LOG	FRACTURE LOG 1 4 16 64	STRUCTURES	Water Level	Casing	DRILL WATER LOSS %	WATER PRESSURE TESTS PERMEABILITY IN LUGEON UNITS
Soil	Soil, dark grey-brown NO CORE Clay, yellow-brown. NO CORE		NXCC		NA NA					
CW					NA	Schistocity dips 0° to 20° on core.				NOT WATER PRESSURE TESTED
ARCHAEAN SCHIST Moderate to Complete FRESH to High	Sericitic, talcose, chloritic, micaceous schist, closely foliated, few thin gneissic bands. Soft, talc-rich bands up to 0.4ft. wide, parallel to schistocity NO CORE Dark grey to blue-grey, bands of grey-white		10 NMLC 1760 20 1750 30 40 1740			← Joints with 0.02ft of clay. ← Seams of clay and crushed rock. Zones of weak, flaky schist, can be moulded by hand to silt. Clay (silt) seams up to 0.1ft., mainly 0.03ft., spaced up to 0.5ft. apart partly formed by drilling operations Rock tends to be broken along schistocity by drilling. ← Clay seam 0.07ft thick at end of lift, formed by drilling operation Joints mainly parallel to schistocity, smooth faces, slickensided, some limonite stained. A few dip 60° to 85° on core, rough surfaces, clay coatings.	Hole Empty (May '65)		Full water return	

END OF HOLE 50.5 ft.
R.L. 1734.5 ft.

TRIM

DRILL No. 24

TYPE A1000

DRILLER Jensen

COMMENCED 6 May 65

COMPLETED 10 May 65

EXPLANATION

CASING IN HOLE DURING DRILLING

WATER LEVEL IN DRILL HOLE (DATE)

FRACTURE LOG 1 4 16 64 Breaks in core per foot, or diameter of fragments in feet

12 3 3/4 3/16 Inches Equivalent

1 .25 .06 .015 Feet diameter

N.A. Not applicable

C.W. Completely weathered

ENGINEERING AND SOILS GEOLOGY SECTION

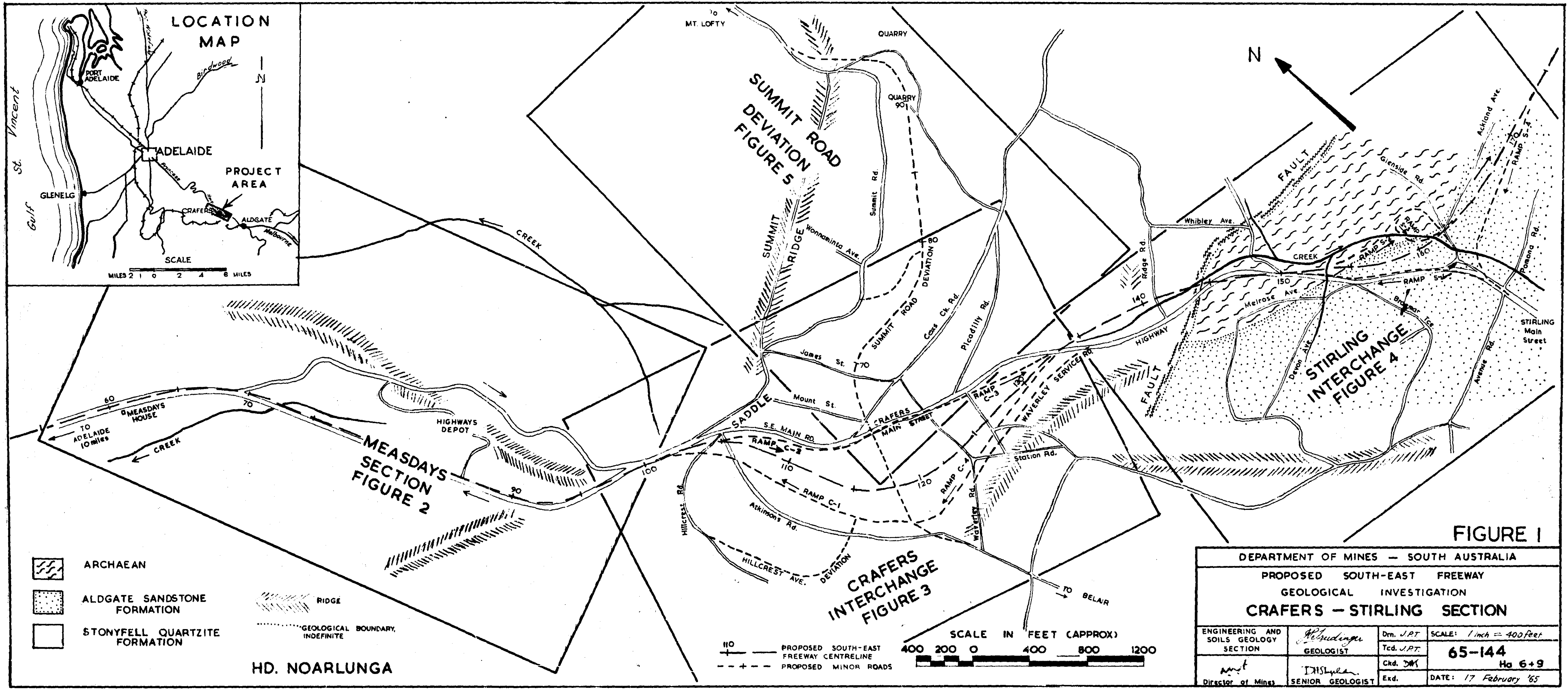
LOGGED BY J.P.T. & J.A.C.P. (11 May)

DRAWN BY T.P.S.

CHECKED BY D.H.S.

DRAWING No. S4377/H0619

200 - 8/64 - B16

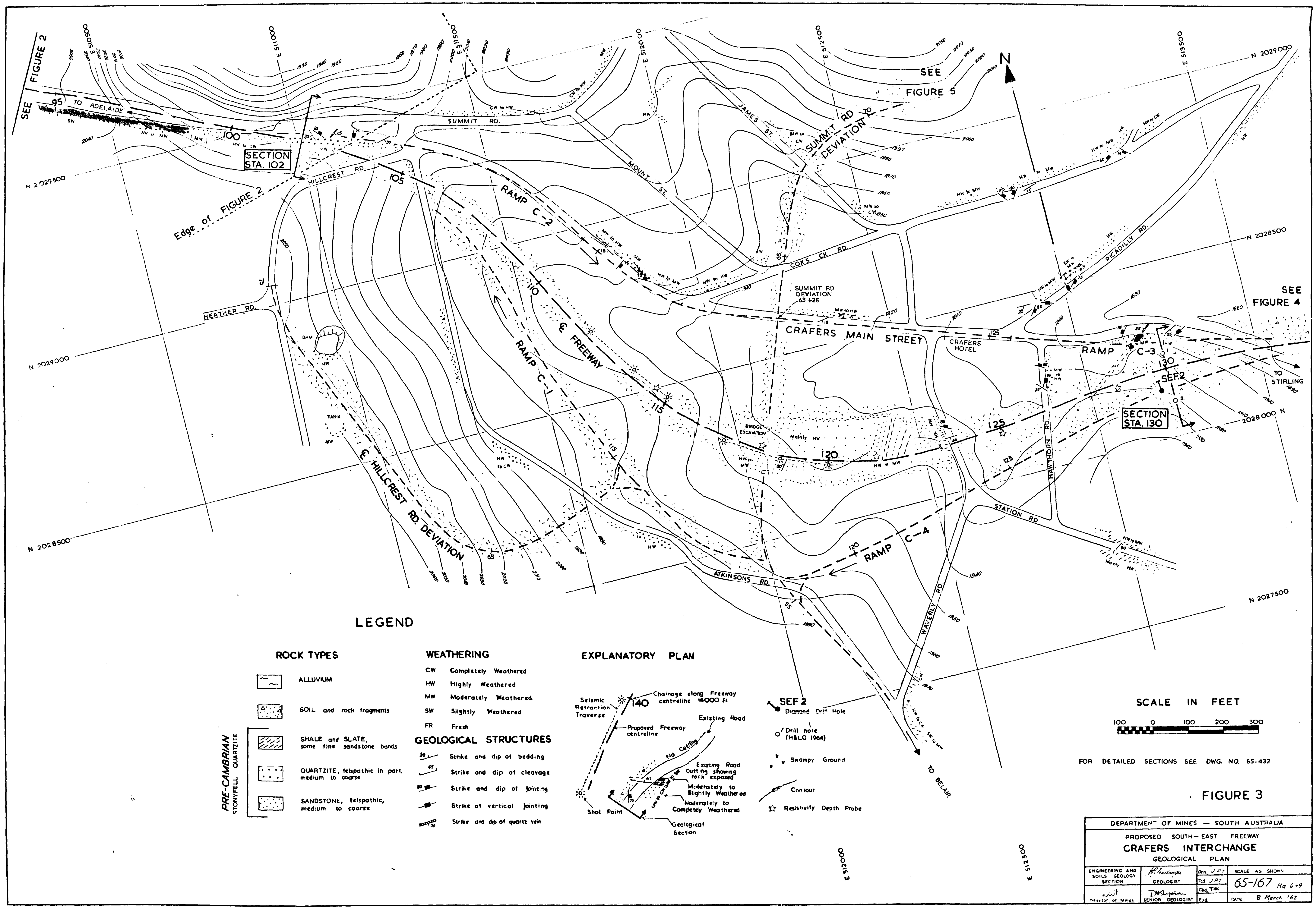

LOCATION MAP
PORT ADELAIDE
ADELAIDE
GLENELG
Gulf St. Vincent
Birdwood
PROJECT AREA
CRAFERS
ALDGATE
Melbourne
SCALE
MILES 2 1 0 2 4 6 MILES
N
TO MT. LOFTY
QUARRY
SUMMIT ROAD DEVIATION FIGURE 5
SUMMIT RIDGE
Summit Rd.
Wonnaminta Ave.
SUMMIT ROAD DEVIATION
Coxs Ck. Rd.
Picadilly Rd.
James St.
Mount St.
SADDLE
S.E. MAIN RD.
CRAFERS MAIN STREET
RAMP C-2
RAMP C-1
RAMP C-3
RAMP C-4
WAVERLEY SERVICE RD.
Station Rd.
Waverley Rd.
Atkinsons Rd.
Hillcrest Rd.
HILLCREST AVE. DEVIATION
CRAFERS INTERCHANGE FIGURE 3
TO BELAIR
CREEK
MEASDAYS HOUSE
TO ADELAIDE 10 miles
HIGHWAYS DEPOT
MEASDAYS SECTION FIGURE 2
HIGHWAY
FAULT
Ridge Rd.
Whibley Ave.
Glenside Rd.
Ackland Ave.
RAMP S-1
RAMP S-2
RAMP S-3
RAMP S-4
Melrose Ave.
Braemar Tce.
Devon Ave.
Avenue Rd.
Pomona Rd.
STIRLING Main Street
STIRLING INTERCHANGE FIGURE 4
60
70
90
100
110
120
130
140
150
160
170
80
ARCHAEAN
ALDGATE SANDSTONE FORMATION
STONYFELL QUARTZITE FORMATION
RIDGE
GEOLOGICAL BOUNDARY, INDEFINITE
PROPOSED SOUTH-EAST FREEWAY CENTRELINE
PROPOSED MINOR ROADS
SCALE IN FEET (APPROX)
400 200 0 400 800 1200
HD. NOARLUNGA
FIGURE 1
DEPARTMENT OF MINES — SOUTH AUSTRALIA
PROPOSED SOUTH-EAST FREEWAY
GEOLOGICAL INVESTIGATION
CRAFERS — STIRLING SECTION
ENGINEERING AND SOILS GEOLOGY SECTION
GEOLOGIST
Director of Mines
SENIOR GEOLOGIST
Drn. J.P.T.
Tcd. J.P.T.
Ckd.
Exd.
SCALE: 1 inch = 400 feet
65-144
Ha 6+9
DATE: 17 February '65

TOP OF DAM R.L. 553 FT.
THRUST BLOCK
SPILLWAY CREST R.L. 546 FT.
DOWNSTREAM SECTION
UPSTREAM SECTION
ORIGINAL GROUND SURFACE
EXCAVATION SURFACE
TOP OF DAM
CLAY seam, 0.2 ft thick, some crushed rock, roots up to 0.04 ft, 0.4 ft SW to MW rock adjacent.
JOINT, slightly irregular, 0.02 to 0.1 ft clay
MW along siltstone and conglomerate beds
JOINTS, slightly curved, 0.01 to 0.1 ft clay
Partly SHEARED zone, 1 ft wide, mainly MW.
CRUSHED seams, recemented in HW to CW zone 0.8 ft wide
CRUSHED seams, 0.01 to 0.03 ft thick, mainly hard and recemented.
CRUSHED seams, 0.02 to 0.06 ft thick, recemented in part.
CRUSHED zone, 7 to 8 ft wide, mainly siliceous and very hard, 0.1 to 0.6 ft softer crushed rock adjacent.
CRUSHED seams, 0.02 to 0.2 ft thick
CRUSHED seam, 0.02 to 0.06 ft thick, up to 0.1 ft HW sheared rock adjacent.
Partly SHEARED zone. Joints spaced 0.1 to 0.4 ft, mainly SW, appears discontinuous.
CRUSHED seam, irregular, discontinuous, 0.02 ft thick
CRUSHED seam, 0.02 to 0.04 ft thick, roots up to 0.01 ft.
ZONE of CLAY SEAMS. Seams contain from 0.02 to 0.3 ft red clay and crushed rock, mainly CW, up to 0.5 ft MW and SW rock adjacent, few slight seepages.
JOINTS, mainly regular, open in parts up to 0.02 ft, contain clay and in parts crushed rock up to 0.04 ft, roots up to 0.01 ft.
CLAY seam 0.1 ft thick, some crushed rock, up to 0.3 ft SW to MW rock adjacent.
JOINT, slightly irregular, 0.02 to 0.1 ft clay.
CRUSHED seam, 0.2 ft thick.
CRUSHED seams, 0.02 to 0.1 ft thick, re-cemented in part.
JOINTS, irregular, 0.01 to 0.06 ft clay.
CRUSHED zone 7 to 8 ft wide mainly siliceous and very hard, 0.1 to 0.6 ft softer crushed rock adjacent.
CRUSHED seam, up to 0.6 ft thick
CRUSHED seam, 0.02 ft thick hard and recemented with calcite.
CRUSHED seams, 0.02 to 0.06 ft thick up to 0.1 ft HW sheared rock and 0.3 ft SW rock adjacent.
CRUSHED seams, 0.02 to 0.04 ft thick, roots up to 0.01 ft.
SHEARED zone up to 0.5 ft thick
LEGEND
ROCK TYPES
SLATY TILLITE
Trace of Cleavage
SLATY SILTSTONE with CONGLOMERATE bed
SANDSTONE
QUARTZ (a) MASSIVE, VUGGY (b) VEINS
CLAY SOIL, DECOMPOSED ROCK AND ROCK FRAGMENTS
GEOLOGICAL BOUNDARY
WEATHERING
FR FRESH
FR.ST FRESH, WITH LIMONITE STAINED JOINTS
SW SLIGHTLY WEATHERED
MW MODERATELY WEATHERED
HW HIGHLY WEATHERED
CW COMPLETELY WEATHERED
GEOLOGICAL STRUCTURES
TRACE OF CLEAVAGE
TRACE OF JOINT
TRACE OF SHEARED OR CRUSHED SEAM
ROCK BOLT - PROJECTED G = grouted in place
DIAMOND DRILL HOLE - PROJECTED
TELL-TALE MORTAR PAD
RAY No 3A
NOTE: SECTIONS ARE DEVELOPED ... AND UPSTREAM FACES ...
TO BE READ IN CONJUNCT... RAY SECTIONS DRAWING ...
FOR PLAN AND RAY SECTIO...

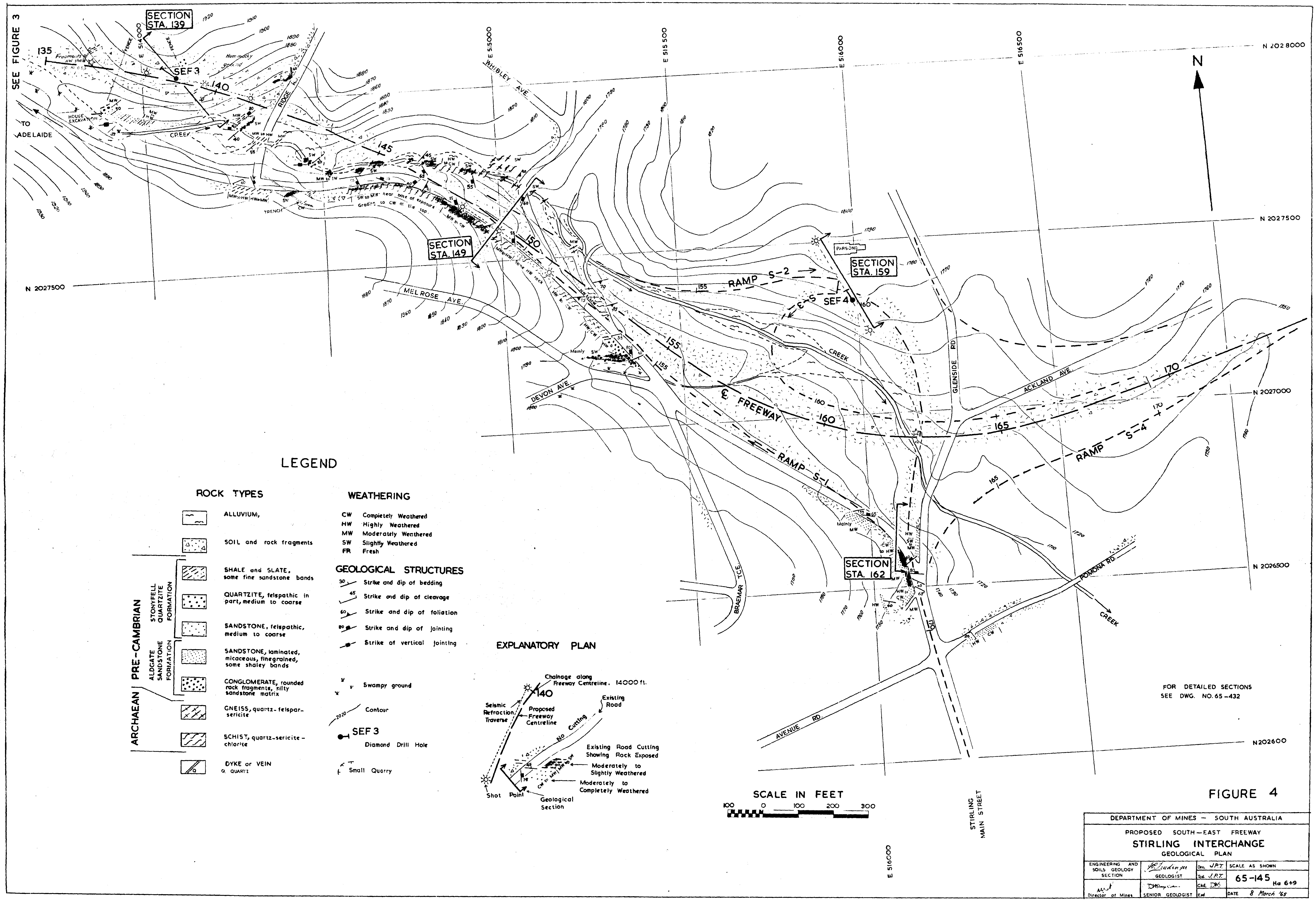
F 2

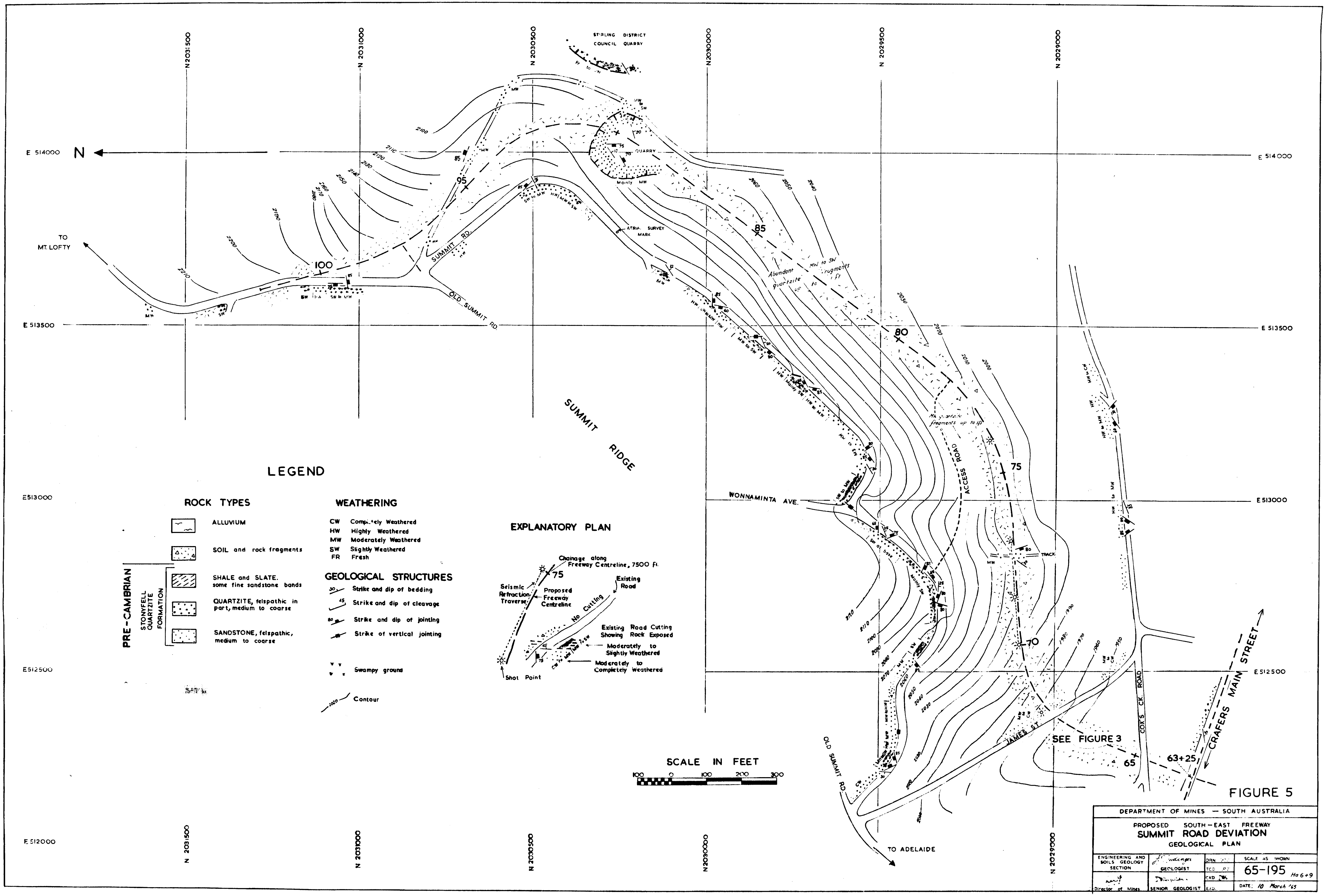
FIGURE 2

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
PROPOSED SOUTH-EAST FREEWAY MEASDAYS SECTION GEOLOGICAL PLAN			
ENGINEERING AND SOILS GEOLOGY SECTION	J.P. Trudinger GEOLOGIST	Drn. J.P.T. Tcd. J.P.T.	SCALE AS SHOWN L65-50
Director of Mines	SENIOR GEOLOGIST	Ckd. Exd	



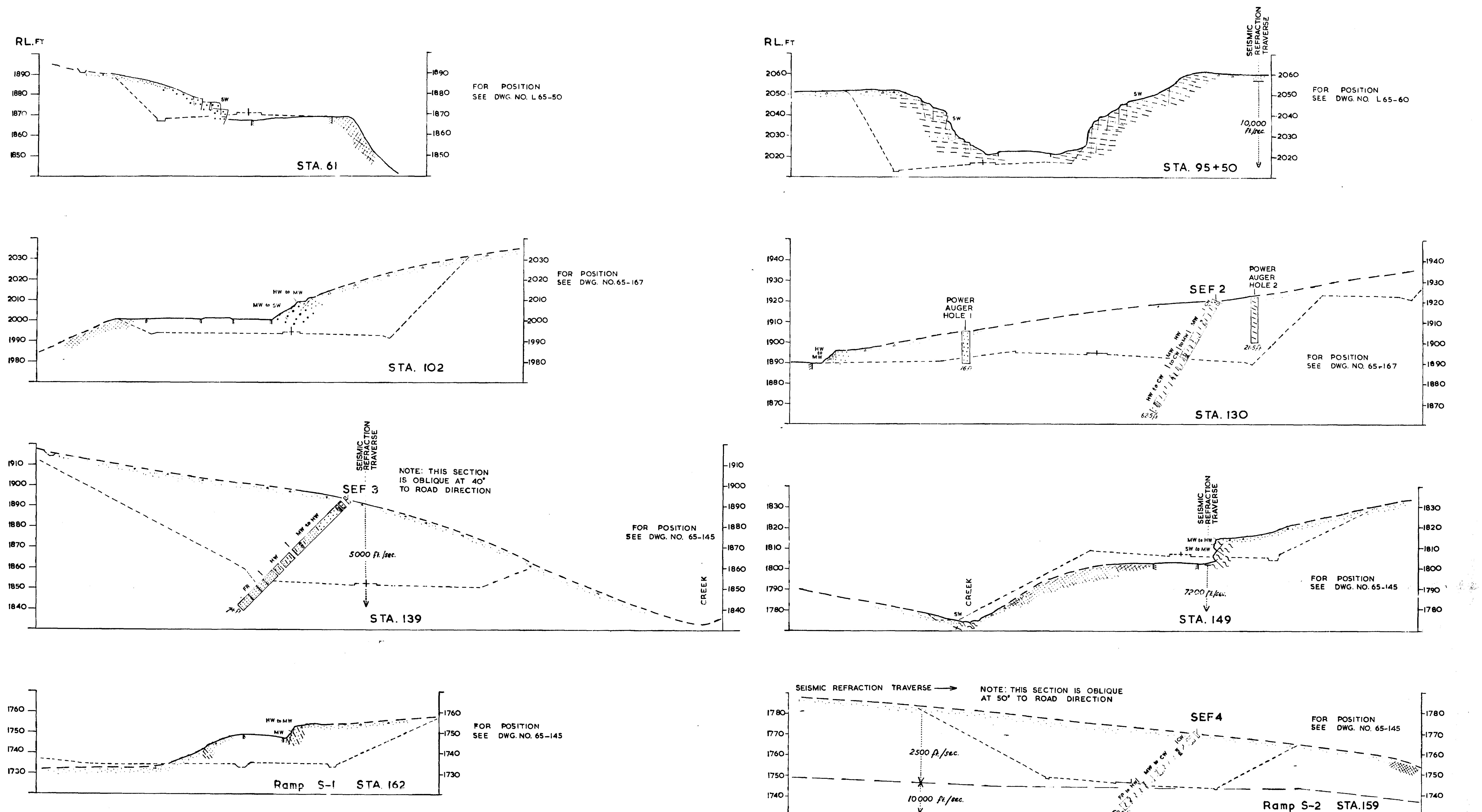
SEE FIGURE 2
TO ADELAIDE
SECTION STA. 102
Edge of FIGURE 2
SUMMIT RD.
HILLCREST RD.
HEATHER RD.
RAMP C-2
RAMP C-1
℄ FREEWAY
℄ HILLCREST RD. DEVIATION
MOUNT ST.
JAMES ST.
SUMMIT RD DEVIATION
SEE FIGURE 5
COX'S CK. RD.
SUMMIT RD. DEVIATION 63 +25
CRAFERS MAIN STREET
CRAFERS HOTEL
PICADILLY RD.
SEE FIGURE 4
RAMP C-3
SEF 2
TO STIRLING
SECTION STA. 130
HAWTHORN RD.
STATION RD.
RAMP C-4
ATKINSONS RD.
WAVERLY RD.
TO BELAIR
BRIDGE EXCAVATION
Mainly HW
DAM
TANK
N 2029000
N 2028500
N 2028000
N 2027500
E 510500
E 511000
E 511500
E 512000
E 512500
E 513000
E 513500
LEGEND
ROCK TYPES
ALLUVIUM
SOIL and rock fragments
PRE-CAMBRIAN
STONYFELL QUARTZITE
SHALE and SLATE, some fine sandstone bands
QUARTZITE, felspathic in part, medium to coarse
SANDSTONE, felspathic, medium to coarse
WEATHERING
CW Completely Weathered
HW Highly Weathered
MW Moderately Weathered
SW Slightly Weathered
FR Fresh
GEOLOGICAL STRUCTURES
Strike and dip of bedding
Strike and dip of cleavage
Strike and dip of jointing
Strike of vertical jointing
Strike and dip of quartz vein
EXPLANATORY PLAN
Seismic Refraction Traverse
Chainage along Freeway centreline 14000 ft
Existing Road
Proposed Freeway centreline
No Cutting
Existing Road Cutting showing rock exposed
Moderately to Slightly Weathered
Moderately to Completely Weathered
Shot Point
Geological Section
SEF 2 Diamond Drill Hole
Drill hole (H&LG 1964)
Swampy Ground
Contour
Resistivity Depth Probe
SCALE IN FEET
100 0 100 200 300
FOR DETAILED SECTIONS SEE DWG. NO. 65-432
FIGURE 3
DEPARTMENT OF MINES — SOUTH AUSTRALIA
PROPOSED SOUTH-EAST FREEWAY
CRAFERS INTERCHANGE
GEOLOGICAL PLAN
ENGINEERING AND SOILS GEOLOGY SECTION
GEOLOGIST
SENIOR GEOLOGIST
Director of Mines
Drn. J.P.T.
Tcd. J.P.T.
SCALE AS SHOWN
65-167 Ha 6+9
DATE: 8 March '65


SEE FIGURE 3
SECTION STA. 139
SEF 3
TO ADELAIDE
CREEK
RIDGE RD.
WHIBLEY AVE.
SECTION STA. 149
MELROSE AVE.
DEVON AVE.
SECTION STA. 159
PARSONS
SEF 4
RAMP S-2
RAMP S-3
℄ FREEWAY
RAMP S-1
RAMP S-4
GLENSIDE RD
ACKLAND AVE.
SECTION STA. 162
POMONA RD.
BRAEMAR TCE
AVENUE RD.
STIRLING MAIN STREET
N 2028000
N 2027500
N 2027000
N 2026500
N 202600
E 515000
E 515500
E 516000
E 516500
E 514000
N
LEGEND
ROCK TYPES
ALLUVIUM,
SOIL and rock fragments
SHALE and SLATE, some fine sandstone bands
QUARTZITE, felspathic in part, medium to coarse
SANDSTONE, felspathic, medium to coarse
SANDSTONE, laminated, micaceous, finegrained, some shaley bands
CONGLOMERATE, rounded rock fragments, silty sandstone matrix
GNEISS, quartz-felspar-sericite
SCHIST, quartz-sericite-chlorite
DYKE or VEIN
Q. QUARTZ
STONYFELL QUARTZITE FORMATION
ALDGATE SANDSTONE FORMATION
PRE-CAMBRIAN
ARCHAEAN
WEATHERING
CW Completely Weathered
HW Highly Weathered
MW Moderately Weathered
SW Slightly Weathered
FR Fresh
GEOLOGICAL STRUCTURES
Strike and dip of bedding
Strike and dip of cleavage
Strike and dip of foliation
Strike and dip of jointing
Strike of vertical jointing
Swampy ground
Contour
SEF 3 Diamond Drill Hole
Small Quarry
EXPLANATORY PLAN
Chainage along Freeway Centreline. 14000 ft.
Seismic Refraction Traverse
Proposed Freeway Centreline
Existing Road
No Cutting
Existing Road Cutting Showing Rock Exposed
Moderately to Slightly Weathered
Moderately to Completely Weathered
Shot Point
Geological Section
SCALE IN FEET
100 0 100 200 300
FOR DETAILED SECTIONS SEE DWG. NO. 65-432
FIGURE 4
DEPARTMENT OF MINES - SOUTH AUSTRALIA
PROPOSED SOUTH-EAST FREEWAY
STIRLING INTERCHANGE
GEOLOGICAL PLAN
ENGINEERING AND SOILS GEOLOGY SECTION
GEOLOGIST
SENIOR GEOLOGIST
Director of Mines
SCALE AS SHOWN
65-145
Ha 6+9
DATE 8 March '65



STIRLING DISTRICT COUNCIL QUARRY
QUARRY
N
E 514000
E 513500
E 513000
E 512500
E 512000
N 2031500
N 2031000
N 2030500
N 2030000
N 2029500
N 2029000
TO MT. LOFTY
SUMMIT RD
OLD SUMMIT RD
AERIAL SURVEY MARK
SUMMIT RIDGE
WONNAMINTA AVE.
ACCESS ROAD
TRACK
JAMES ST
COX'S CK. ROAD
CRAFERS MAIN STREET
OLD SUMMIT RD
TO ADELAIDE
SEE FIGURE 3
100
95
85
80
75
70
65
63+25
Abundant quartzite fragments
LEGEND
ROCK TYPES
ALLUVIUM
SOIL and rock fragments
PRE-CAMBRIAN
STONYFELL QUARTZITE FORMATION
SHALE and SLATE, some fine sandstone bands
QUARTZITE, felspathic in part, medium to coarse
SANDSTONE, felspathic, medium to coarse
WEATHERING
CW Completely Weathered
HW Highly Weathered
MW Moderately Weathered
SW Slightly Weathered
FR Fresh
GEOLOGICAL STRUCTURES
Strike and dip of bedding
Strike and dip of cleavage
Strike and dip of jointing
Strike of vertical jointing
Swampy ground
Contour
EXPLANATORY PLAN
Chainage along Freeway Centreline, 7500 ft.
Seismic Refraction Traverse
Proposed Freeway Centreline
Existing Road
No Cutting
Existing Road Cutting Showing Rock Exposed
Moderately to Slightly Weathered
Moderately to Completely Weathered
Shot Point
SCALE IN FEET
100 0 100 200 300
DEPARTMENT OF MINES — SOUTH AUSTRALIA
PROPOSED SOUTH-EAST FREEWAY
SUMMIT ROAD DEVIATION
GEOLOGICAL PLAN
ENGINEERING AND SOILS GEOLOGY SECTION
GEOLOGIST
SENIOR GEOLOGIST
Director of Mines
SCALE AS SHOWN
65-195
DATE: 10 March '65

FIGURE 5



LEGEND

ROCK TYPES

ARCHAEAN

- GNEISS, quartz-felspar-sericite
- SCHIST, quartz-sericite-chlorite-talc

PRE-CAMBRIAN

ALDGATE SANDSTONE FORMATION

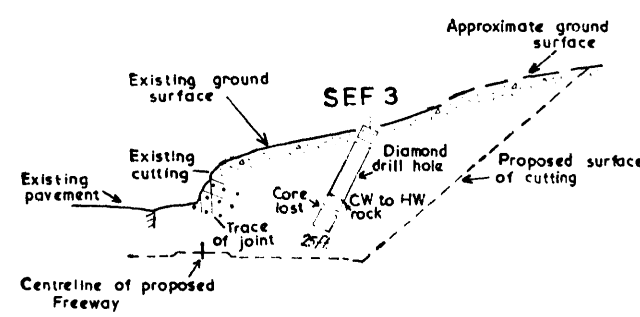
- SANDSTONE, laminated, micaceous, shale bands
- CONGLOMERATE, rounded rock fragments in sandstone matrix

STONYFELL QUARTZITE FORMATION

- SHALE, some fine sandstone bands
- QUARTZITE, felspathic in part, medium to coarse
- SANDSTONE, felspathic, medium to coarse or fine

- FILL; soil and rubble
- SOIL and rock fragments

EXPLANATORY SECTION



WEATHERING

CW	Completely Weathered
HW	Highly Weathered
MW	Moderately Weathered
SW	Slightly Weathered
FR	Fresh

SCALE IN FEET (NATURAL)
20 0 20 40 60

FIGURE 6

DEPARTMENT OF MINES — SOUTH AUSTRALIA

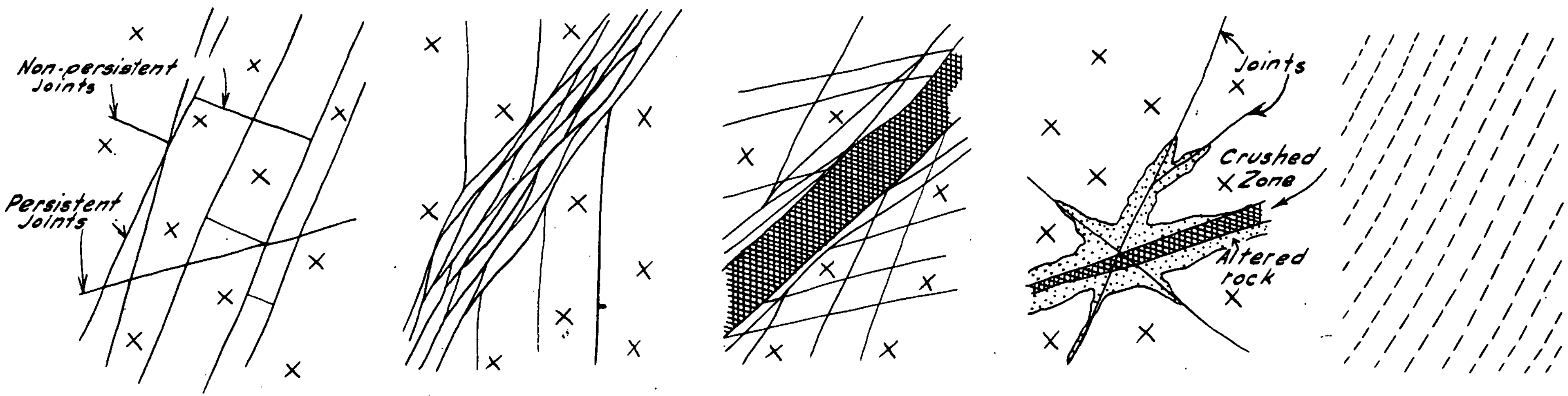
PROPOSED SOUTH-EAST FREEWAY

CRAFERS — STIRLING SECTION

GEOLOGICAL SECTIONS

ENGINEERING AND SOILS GEOLOGY SECTION	GEOLOGIST	Drn. J.P.T. / Tcd. J.P.T.	SCALE: AS SHOWN
Director of Mines	SENIOR GEOLOGIST	Ckd. D.H.S. / Exd.	65-432 Ha 6+9 / DATE: 17 May 65

COMMON WEAKNESSES IN UNWEATHERED HARD ROCK



JOINTS

Planar fractures or cracks, persistent or non-persistent, formed due to tension or shearing. The joint surfaces may be rough, smooth or slickensided. Joints may be open, or tightly closed, coated or uncoated and strongly or weakly cemented. Common cements include calcite and quartz, and coatings include chlorite, limonite, clay and pyrites.

SHEARED ZONE

Planar zone of closely spaced, nearly parallel joints, usually slightly curved and intersecting to give thin, platy or wedge-shaped joint blocks. The joint surfaces are slickensided and in most cases, chlorite or clay coated. Rock behaviour depends mainly upon the types of joint coatings, degree of separation of joints, and water content & pressure.

CRUSHED ZONE

Planar zone of soft, unconsolidated material, consisting usually of small rock fragments in a clayey matrix. The rock has been mechanically disintegrated, but not necessarily chemically decomposed.

ALTERED OR DECOMPOSED ZONE

Irregular zones, in which the rock is softened due to chemical alteration. Biotite commonly alters to chlorite, and felspars to clay minerals. The alteration is usually caused by the circulation of mineralized water through joints, sheared zones, or crushed zones.

BEDDING, CLEAVAGE, SCHISTOSITY OR FOLIATION

Planes of relative weakness along which rock may break in preference. This type of planar anisotropy results in a wide range of shear strengths and elastic moduli for a particular rock, depending upon the direction of applied stress.

FIGURE 7

S.A. DEPARTMENT OF MINES

COMMON WEAKNESSES IN UNWEATHERED HARD ROCK

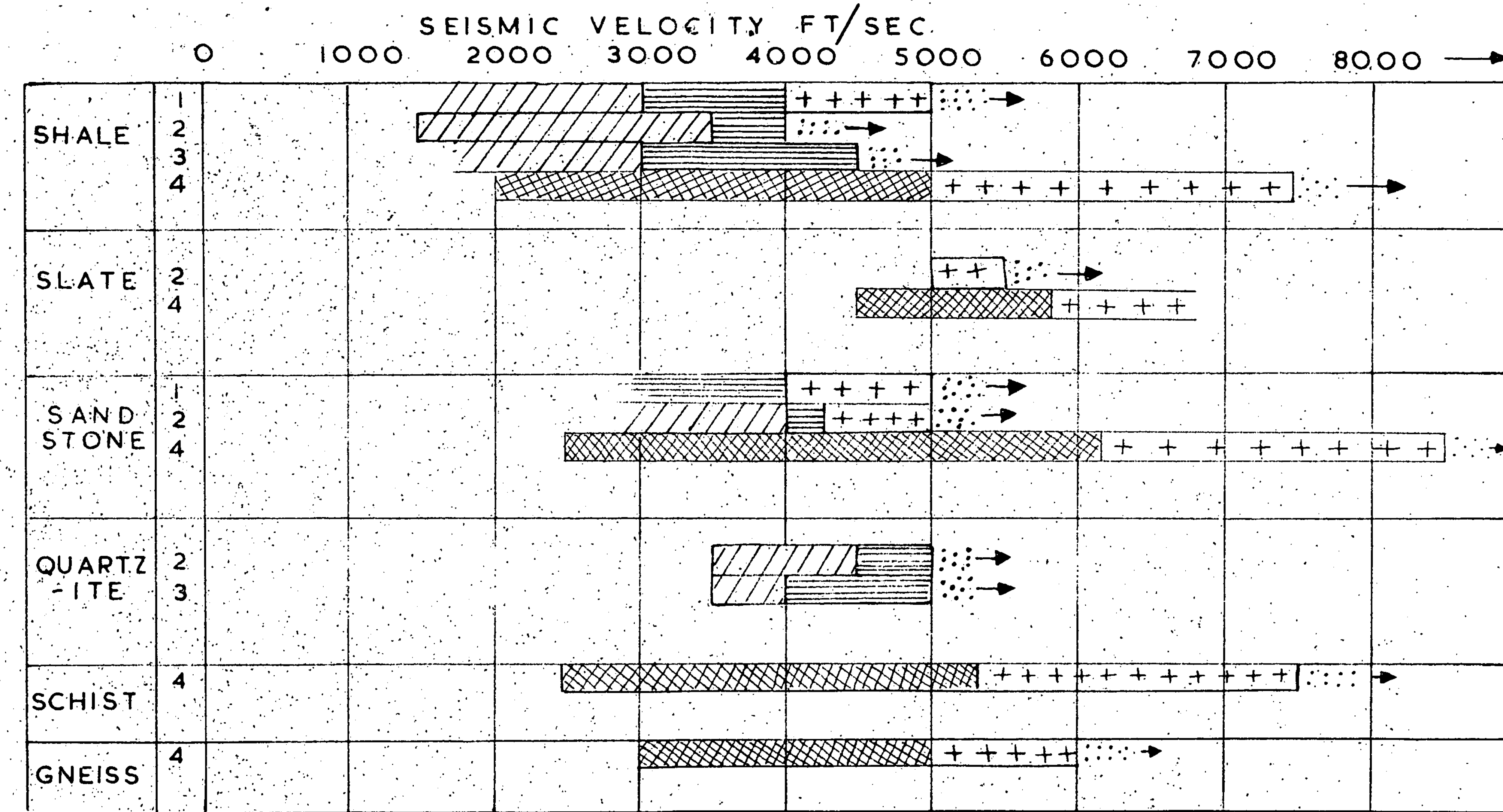
Approved | Director | Passed | Drn. | Tcd. A.W. | Ckd. | Exd. | D.M. | Req. | Scale | S3622 | MG | Date 24-3-64

200-2-61 3805

DEPARTMENT OF MINES — SOUTH AUSTRALIA

ENGINEERING SERVICES SECTION

SEISMIC VELOCITIES AND EXCAVATION EXPERIENCE



1. California Division of Highways.
2. Snowy Mountains Authority.
3. Country Roads Board, Victoria.
4. Caterpillar Tractor Company

CAN BE DOZED

RIPPABLE (D8)

RIPPABLE (D9)

DOUBTFUL

REQUIRES BLASTING

FIG. 8

Drn. NRL	SCALE: Not to Scale
Tcd.	S4406 MG
Ckd.	DATE: 22 June 1965
Exd.	