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TASMANIA DEPARTMENT OF MINES

1979

GEOLOGICAL SURVEY

PAPER 3

Whitewater Creek dam sites, Kingston and the Tertiary channels of the Kingston - Margate area

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Frontispiece. *View from Leslie Road, looking south-east to Kingston, Tinderbox Hills and Margate.*

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ABSTRACT

While completing the Whitewater Creek dam site investigation, a second buried valley filled with sand, clay and gravel of Tertiary age was located in the western section of the reservoir area of the upper dam site. The valley was located and traced by geophysical methods south to Pritchards Road, the approximate water level of the proposed dam. Here it joined with the eastern tributary valley found in 1969 at the southern abutment of the proposed dam and flowed south through the saddle of Doctors Hill and Little Parks Hill.

Magnetometer and constant spaced resistivity traverses were used to locate and trace the valley and refractive seismic surveys were used to estimate its depth and drainage direction. Four drill holes confirmed the position of the valley and that its sediments would provide a major leakage path from the reservoir area through the saddle to the south.

By extending the geophysical techniques used in the dam site investigation, the valleys were traced 4 km south to North West Bay and Dru Point and through the reservoir areas to Fishers Creek, 2.5 km to the north. The valley location was confirmed by two drill holes on Howden Road, North West Bay and by exposures on the coast west of Dru Point. To the north, the valley was exposed in a new road cutting in the area where it had been located geophysically.

Drilling at North West Bay encountered the proposed sequence of Tertiary rocks in stratigraphic sequence, enabling better correlation of sediments in the reservoir area. A re-examination of the Permian sections of the area and further fossil collections gave a greater understanding of the differences between the Permian succession in the Hobart-Kingston and Cygnet areas.

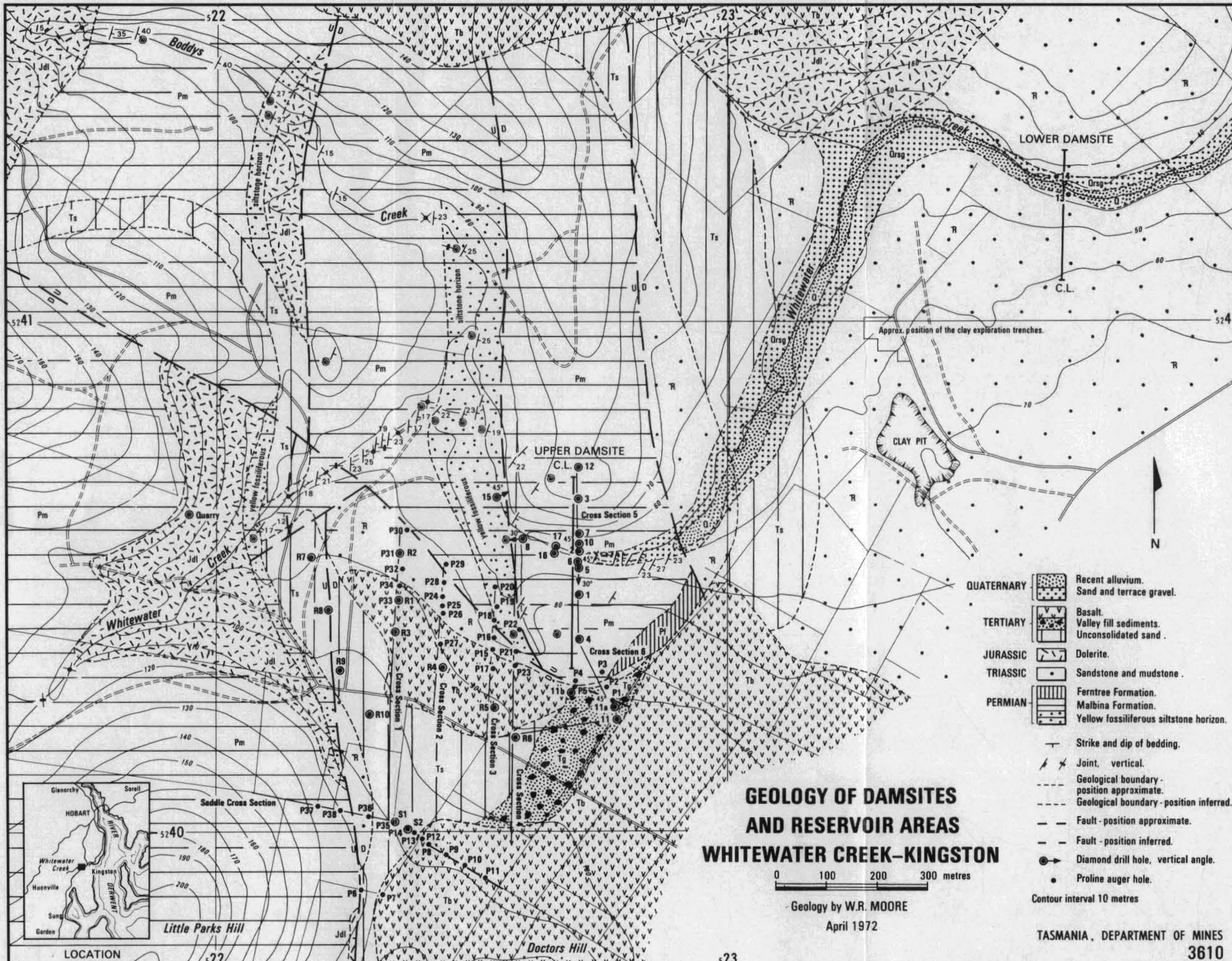
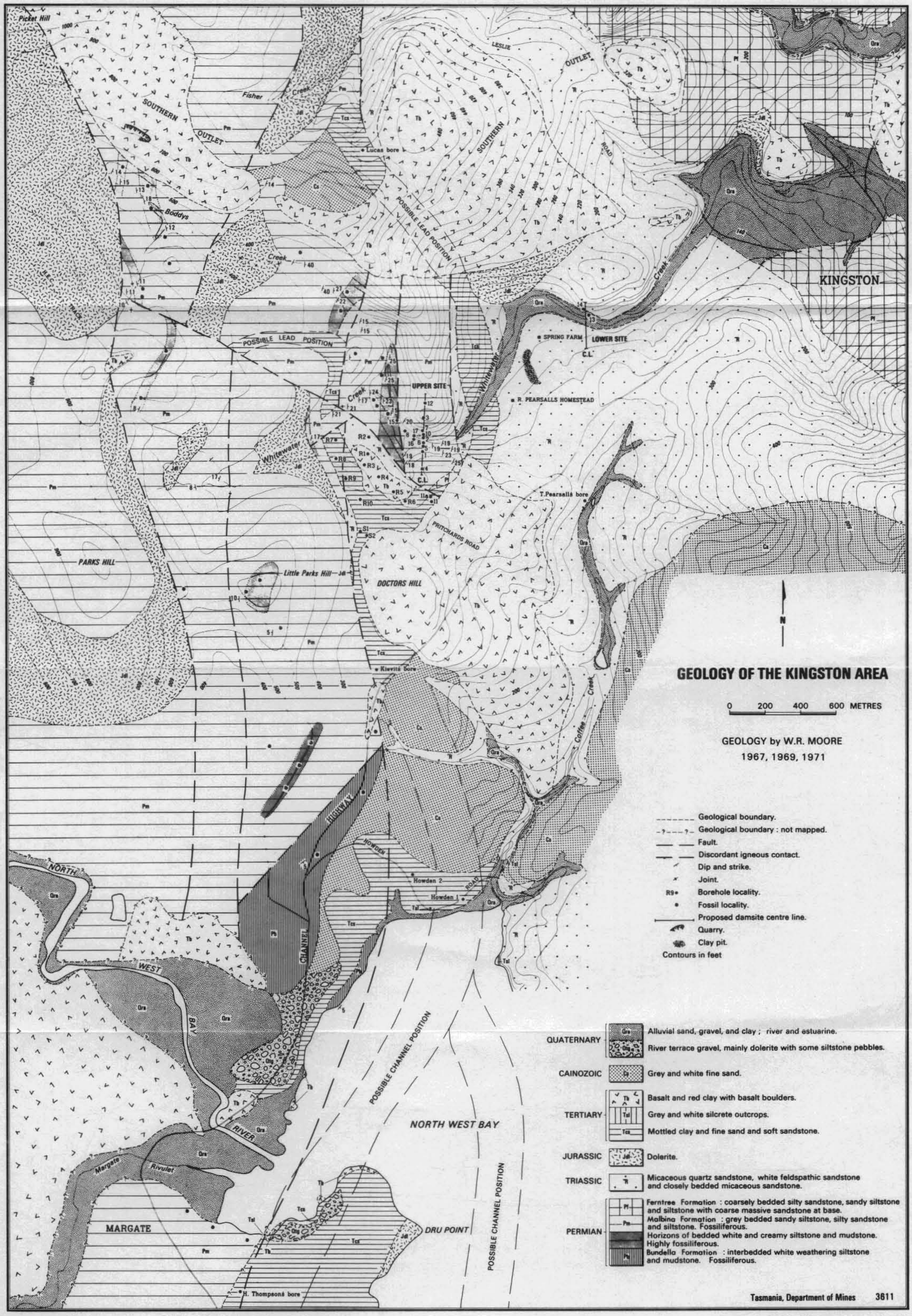

GEOLOGY OF DAMSITES
AND RESERVOIR AREAS
WHITEWATER CREEK–KINGSTON
0 100 200 300 metres
Geology by W.R. MOORE
April 1972
QUATERNARY
Recent alluvium.
Sand and terrace gravel.
TERTIARY
Basalt.
Valley fill sediments.
Unconsolidated sand.
JURASSIC
Dolerite.
TRIASSIC
Sandstone and mudstone.
PERMIAN
Ferntree Formation.
Malbina Formation.
Yellow fossiliferous siltstone horizon.
Strike and dip of bedding.
Joint, vertical.
Geological boundary - position approximate.
Geological boundary - position inferred.
Fault - position approximate.
Fault - position inferred.
Diamond drill hole, vertical angle.
Proline auger hole.
Contour interval 10 metres
TASMANIA, DEPARTMENT OF MINES
3610
LOWER DAMSITE
UPPER DAMSITE
C.L.
CLAY PIT
Approx. position of the clay exploration trenches.
Cross Section 1
Cross Section 2
Cross Section 3
Cross Section 4
Cross Section 5
Cross Section 6
Saddle Cross Section
Boddys Creek
Whitewater Creek
Quarry
siltstone horizon
yellow fossiliferous
Little Parks Hill
Doctors Hill
LOCATION
Glenorchy
Sorell
HOBART
RIVER
DERWENT
Whitewater Creek
Kingston
Huonville
Sung
Garden
N

Figure 1.



GEOLOGY OF THE KINGSTON AREA
0 200 400 600 METRES
GEOLOGY by W.R. MOORE
1967, 1969, 1971
Geological boundary.
Geological boundary : not mapped.
Fault.
Discordant igneous contact.
Dip and strike.
Joint.
Borehole locality.
Fossil locality.
Proposed damsite centre line.
Quarry.
Clay pit.
Contours in feet
QUATERNARY
Alluvial sand, gravel, and clay ; river and estuarine.
River terrace gravel, mainly dolerite with some siltstone pebbles.
CAINOZOIC
Grey and white fine sand.
TERTIARY
Basalt and red clay with basalt boulders.
Grey and white silcrete outcrops.
Mottled clay and fine sand and soft sandstone.
JURASSIC
Dolerite.
TRIASSIC
Micaceous quartz sandstone, white feldspathic sandstone and closely bedded micaceous sandstone.
PERMIAN
Ferntree Formation : coarsely bedded silty sandstone, sandy siltstone and siltstone with coarse massive sandstone at base.
Malbina Formation : grey bedded sandy siltstone, silty sandstone and siltstone. Fossiliferous.
Horizons of bedded white and creamy siltstone and mudstone. Highly fossiliferous.
Bundella Formation : interbedded white weathering siltstone and mudstone. Fossiliferous.
Tasmania, Department of Mines 3611
KINGSTON
PARKS HILL
Little Parks Hill
DOCTORS HILL
NORTH WEST BAY
MARGATE
DRU POINT
SOUTHERN OUTLET
POSSIBLE LEAD POSITION
POSSIBLE CHANNEL POSITION
UPPER SITE
LOWER SITE
SPRING FARM
R. PEARSALLS HOMESTEAD
T.Pearsalls bore
Lucas bore
Kievits bore
H. Thompsons bore
Howden 1
Howden 2
PRITCHARDS ROAD
CHANNEL HIGHWAY
Whitewater Creek
Coffee Creek
Fisher Creek
Picket Hill

Figure 2.

5 cm

INTRODUCTION

In 1970, funds became available from the Metropolitan Water Board to complete the geological site investigation of the proposed upper dam site on Whitewater Creek, Kingston, as proposed in 1969 (Moore, 1971). The immediate aim of this work was to ascertain if the second tributary of a buried Tertiary valley, found at the southern abutment of the proposed dam in the 1969 investigation, existed in the reservoir area of the upper site. This stage of the site investigation was completed in April 1970 and the presence of a second valley, indicated by geophysical methods, was confirmed by drilling (fig. 1).

From this site investigation it appeared that the two tributaries of the Tertiary valley joined immediately south of Pritchards Road and drained southwards through the saddle between Doctors Hill and Parks Hill towards North West Bay (figs 2, 3). From what had been up to this date strictly a dam site investigation widened in an attempt to trace the main Tertiary valley south to North West Bay and the two tributary valleys upstream into the two reservoir areas of the proposed dam sites on Whitewater Creek.

SUMMARY OF INVESTIGATIONS

1966-1967

Detailed geological mapping of the two dam sites at Whitewater Creek and the regional geological mapping of the catchment area of Whitewater Creek was undertaken in 1966 (Moore, 1968). Drilling for the subsurface investigation commenced late in 1966 and continued into 1967 (fig. 1). With the completion of Hole 10 on the centre line of the upper dam site, drilling was stopped because of the financial restrictions imposed by the Tasmanian Government resulting from the Hobart bush fires of 1967.

1967

A gravity survey covering the two dam sites was completed early in 1967 (Leaman, 1968). Resistivity and magnetometer surveys were undertaken over the same area by W.R. Moore and P.C. Stevenson.

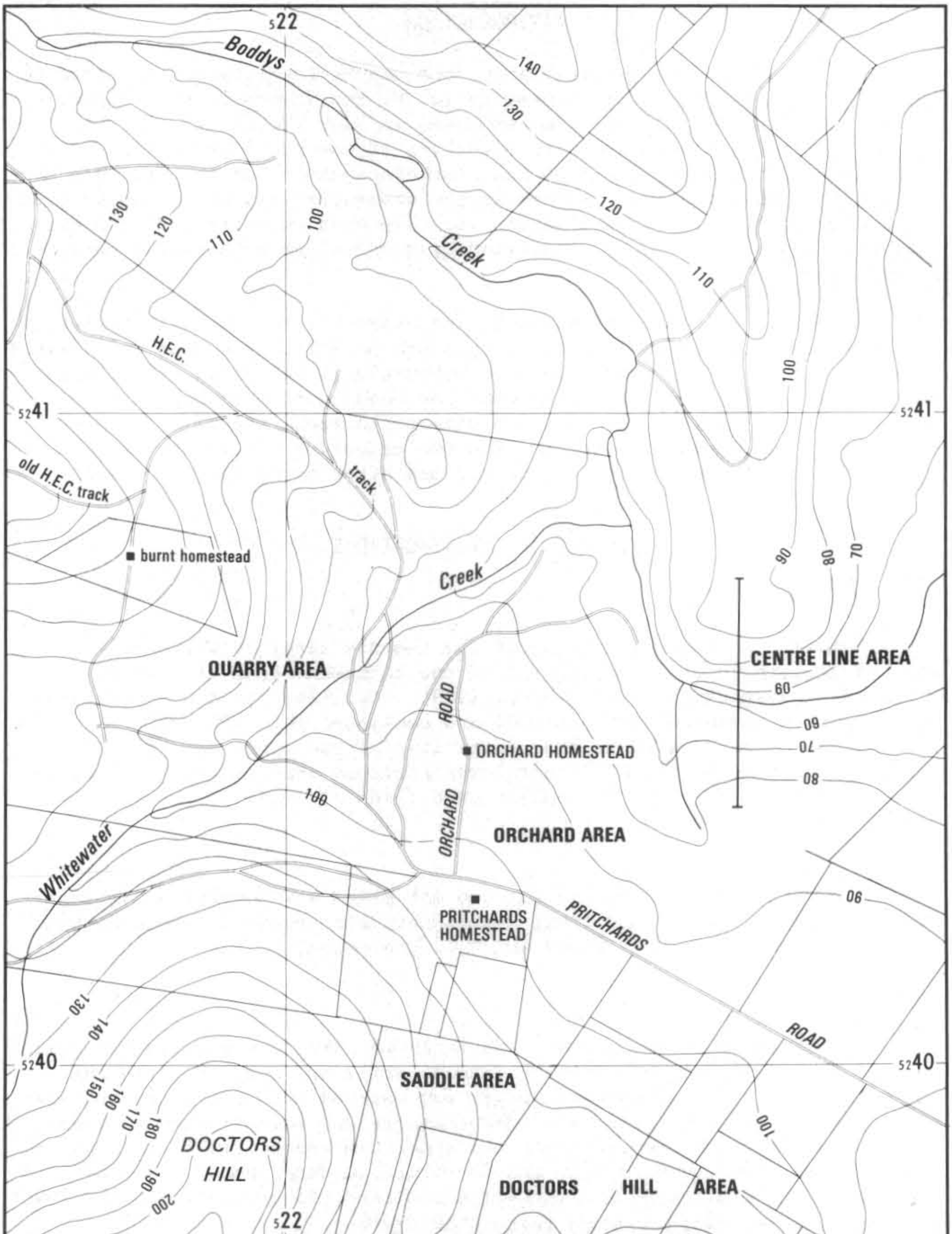
1969

With further funds becoming available in 1969, the drilling programme of 1967 was completed with further diamond drilling, augering, trenching and bulldozing. A magnetometer survey was carried out in the orchard area of the upper reservoir (fig. 3). Magnetometer and seismic surveys were carried out on the quarry site for the upper dam (Moore, 1971). It was on the basis of these surveys that the Metropolitan Water Board abandoned the lower dam site and lifted the investigation land closure covering the lower site and its reservoir area on Whitewater Creek.

1970

In 1970, further magnetometer and seismic surveys followed by drilling were carried out in the reservoir area of the upper dam site (figs 10-13). With the completion of this stage of the investigation in April, the Metropolitan Water Board abandoned the upper site and lifted the investigation land closure over the upper dam site and its reservoir area.

In the wet months of July and August, a series of east-west constant spaced resistivity traverses were undertaken from Pritchards Road south to



LOCALITY MAP WHITEWATER CREEK

0 500 METRES

GEOLOGIST : W.R. Moore
November 1971
Contour interval 10 metres

TASMANIA. DEPARTMENT OF MINES

3564

Figure 3.

5 cm

the Channel Highway and along the Howden Road from the Channel Highway to the Coffee Creek bridge (figs 14-16). In conjunction with the resistivity traverse along Pritchards Road, a gravity survey was run from the Channel Highway to a dolerite outcrop just beyond the end of Pritchards Road (fig. 17). Two seismic spreads were fired across the saddle between Little Parks Hill and Doctors Hill (figs 20, 21) in November.

A cemetery site investigation was undertaken near Coffee Creek for the Southern Metropolitan Master Planning Authority (Moore, 1973). The cemetery sites were close to where two anomalies had been found on the resistivity traverse along Howden Road and two seismic spreads were fired on these anomalies.

A further seismic spread was fired at Dru Point on the Margate reserve where dolerite crops out on the shoreline (fig. 22). It was hoped that this seismic spread would indicate if this dolerite was *in situ* or large blocks underlain by Tertiary sediments, as found elsewhere in the Derwent estuary *e.g.* at Wrest Point and Taroona (Stevenson, 1971; Leaman, 1976).

1971

No further work was undertaken at Kingston until August 1971 when the Department of Mines made a diamond drill rig available to drill the two anomalies on Howden Road to confirm the geological interpretation for the seismic spreads fired on these areas. These two drill holes (Howden 1 and 2) were critical in the understanding of the Tertiary stratigraphy of the area (fig.22), as it was the first time that the two Tertiary stratigraphic units of the 1969 subsurface investigation (fig. 1) had been found in stratigraphic sequence in the one bore hole (Howden 1). Hole 2, drilled on the western anomaly, contained only a limited amount of Tertiary sediments followed by a sequence of Triassic sediments weathered to a depth of 10 metres. The presence of this deep weathering of Tertiary age in older sediments close to a known Tertiary lead was significant in the understanding of Tertiary valleys in the Whitewater Creek dam site reservoir areas to the north.

A further seismic spread was fired on the Margate reserve in an area with no outcrops between the dolerite outcrop at Dru Point and the Tertiary valley fill sediments associated with the basalt to the west (figs 5, 22).

A fluxgate magnetometer became available in the Department in October. Because of the speed with which an area can be covered with this type of instrument compared with the Elsec proton magnetometer used in the previous investigations, it was considered worthwhile to complete the magnetometer coverage of the upper dam site reservoir north from the quarry area to the Southern Outlet (figs 11-13).

1972

Further fossil collections and a re-examination of the Permian sections exposed at Parks Hill, Whitewater Creek and Boddys Creek were made by M. Clarke and N. Farmer in January and February (fig. 4). A limited amount of geological mapping was undertaken between the Channel Highway south of Doctors Hill to the shores of North West Bay (fig. 2).

STRATIGRAPHY

The geology of the Kingston area is shown in Figure 2. The majority of mapping was undertaken prior to 1967, with only small areas in the Dru Point-Coffee Creek area subsequently mapped.

Much of Parks Hill has been cleared since 1967 and the track up to the hill regraded. In 1972, there was almost continuous exposure from the foot of Little Parks Hill to above the level of the dolerite sill on Picket Hill and Parks Hill. The failure of two farm dams in Boddys Creek gave several new exposures in critical parts of the Permian section. With these new outcrops, a better correlation between the three Permian sections at Parks Hill, Whitewater Creek and Boddys Creek (fig. 4) was now possible than when the area was mapped in 1967.

The generalised lithological sequence in the Kingston area is:

QUATERNARY	Alluvial sand, gravel and clay. River terrace gravel, mainly dolerite, with some siltstone pebbles. Grey and white fine sand.
TERTIARY	Basalt and red clay with basalt boulders. Valley fill sediment, agglomerate, clay and cemented gravel. Grey and white silcrete. Mottled clay and fine sand and soft sandstone.
JURASSIC	Dolerite
TRIASSIC	Micaceous quartz sandstone, white feldspathic sandstone and closely bedded micaceous mudstone.
PERMIAN	
FERNTREE FORMATION	Coarsely bedded silty sandstone, sandy siltstone and siltstone with sandstone at base.
MALBINA FORMATION	Grey bedded sandy siltstone, silty sandstone and siltstone. Fossiliferous horizons of bedded white-cream siltstone and mudstone.
BUNDELLA FORMATION	Interbedded white weathering siltstone and mudstone with fossils.

Permian

Permian sediments comprise the oldest rocks in the area mapped. Most of the area covered by the two dam sites has been previously mapped by MacCleod (1962) and Paxton (1964, 1968). The stratigraphic subdivisions of the Permian used in previous reports are given in Table 1.

STRATIGRAPHIC PROBLEMS

The Permian sequence of the Hobart area has been subdivided by Banks and Hale (1957) and Banks and Read (1962). The original subdivisions set up by these authors have been used by numerous workers in areas in southern Tasmania, often at a considerable distance from the original type sections. These original subdivisions have been applied as essentially time rock units in previous studies at Risdon Vale (Moore, 1965) and Whitewater Creek (Moore, 1968). This was done with some misgivings, but owing to the complex faulting in the Kingston area, generally poor exposure, lack of good marker

Table 1. STRATIGRAPHIC SUBDIVISION OF PERMIAN ROCKS, KINGSTON AREA

MacCleod (1962)	Paxton (1964, 1968)	Moore (1968)	Moore (this report)
Ferntree Group	Ferntree Mudstone Formation	Ferntree Formation	Ferntree Formation
Woodbridge Group	Malbina Formation	Malbina Formation	Malbina Formation
	Grange Formation	Grange Mudstone Formation	-
	Lower Permian	Lower Permian	Bundella Formation

horizons and the absence of key stratigraphic sections in which both the overlying and underlying units are exposed, this practice appeared justifiable. The alternative to this system would have been a host of local formations with which lithological correlation between areas would have been difficult and any attempt at stratigraphic correlation almost impossible.

With the completion of regional mapping in the Oatlands (Forsyth *et al.*, 1976), Brighton (Leaman and Legge, 1975), Hobart (Leaman, 1973) and Kingborough (Farmer *in prep.*) Quadrangles, and with more fossil locations and lithological control becoming available, the distinction between lithological and palaeontological correlations will have to be emphasised.

Difficulties were experienced in the Whitewater Creek area using the Grange Mudstone as a local marker horizon (Moore, 1968, p. 62-63). At Mount Nassau, Banks and Hale (1957) placed the Grange Mudstone at the top of the Cascades Group and it there separates this group from the overlying Malbina Formation. South and east of Hobart, the Berriedale Limestone, which underlies the Grange Mudstone at Mount Nassau, lenses out and the Cascades Group is represented by the Grange Mudstone as at its accepted type locality at the Grange Quarry, Taroona.

On Parks Hill, 800 m south of Whitewater Creek, Paxton (1964, 1968) mapped a sequence of Malbina sediments overlying Grange Mudstone and lower Permian sediments. However, in Whitewater and Boddys Creeks, several fossiliferous cream-coloured siltstone and mudstone horizons lithologically similar to the Grange Mudstone appear to be present at several stratigraphic levels. Near the upper dam site, they occur high in the sequence above beds that are lithologically similar to the Malbina Formation (Moore, 1968, p. 63).

The stratigraphic position of these cream siltstones in the upper dam site area had very important practical implications on the dam site investigation. Firstly, if the stratigraphic position of the cream siltstone horizons could be established, a more accurate estimation of the throw of the faults was possible (Moore, 1968). Secondly and more important, if the cream siltstone horizon upstream from the upper dam site and penetrated by Holes 8 and 15 (fig. 1) did belong to the Grange Formation, the sediments below must belong to the Lower Permian as mapped by Paxton. The then suggested correlation with the Faulkner Group applied. The Faulkner Group south of Taroona was then thought to contain conglomerate and sandstone as well as siltstone and mudstone (Banks and Hale, 1957; Leaman and Naqvi, 1968).

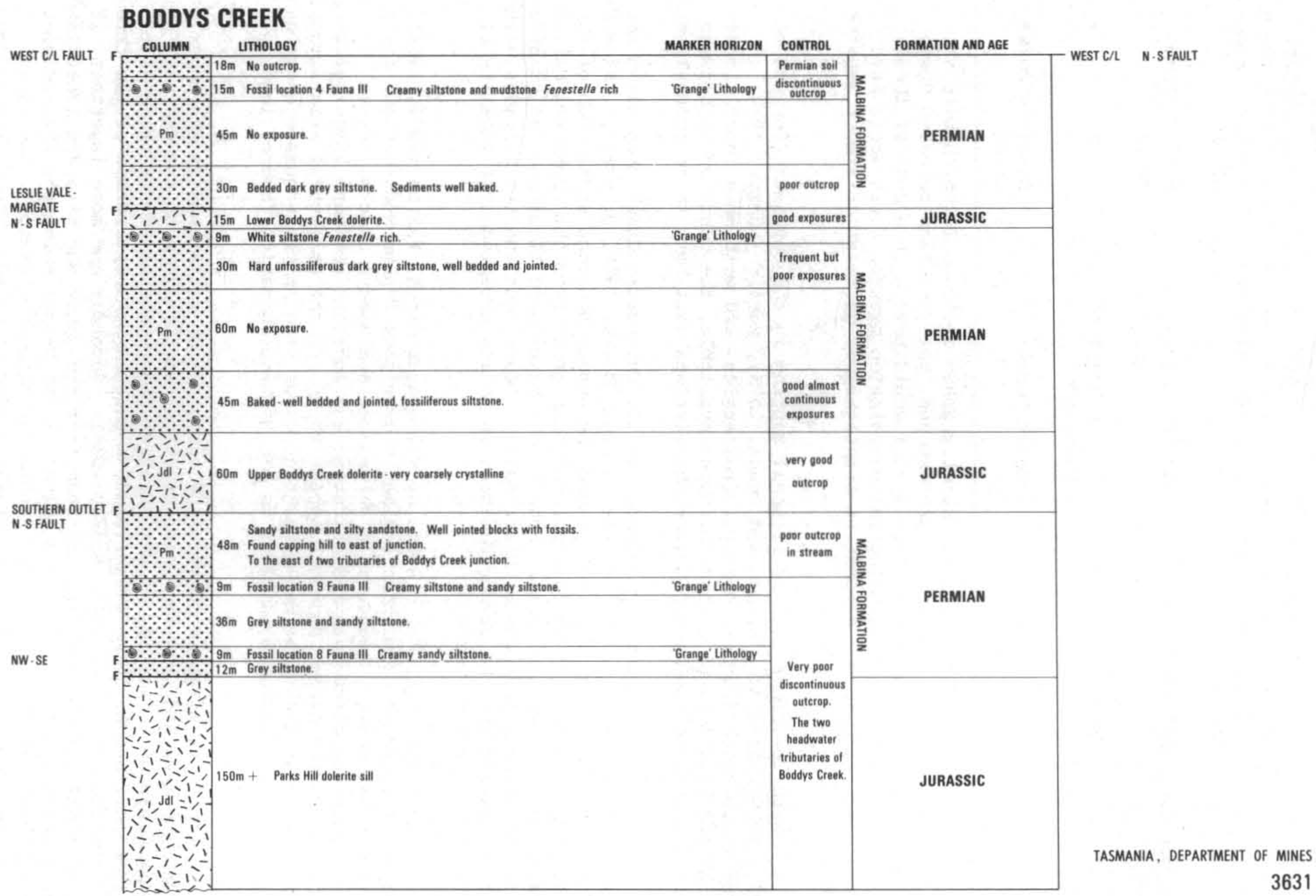


Figure 4. *Permian succession, Boddys Creek.*

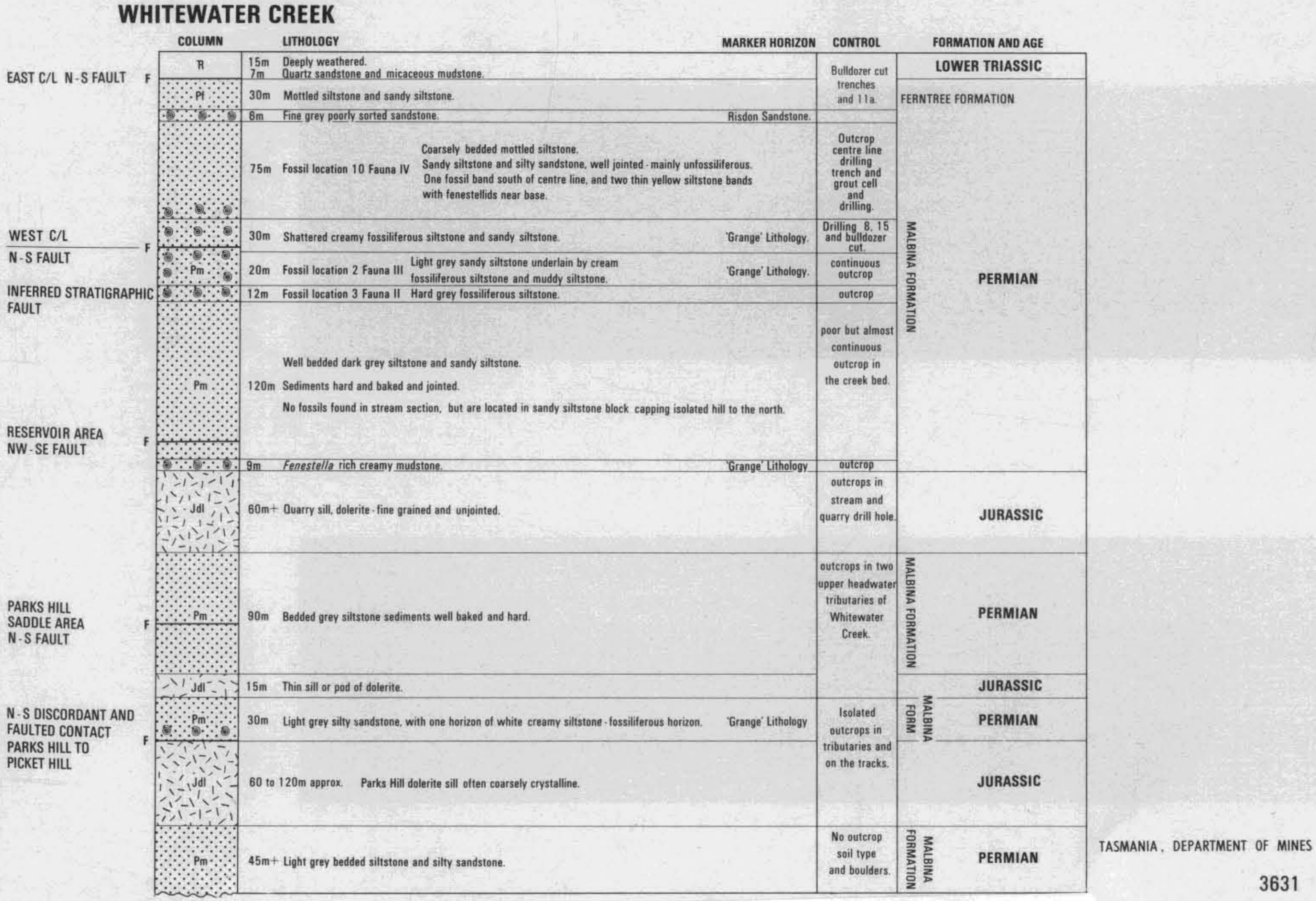
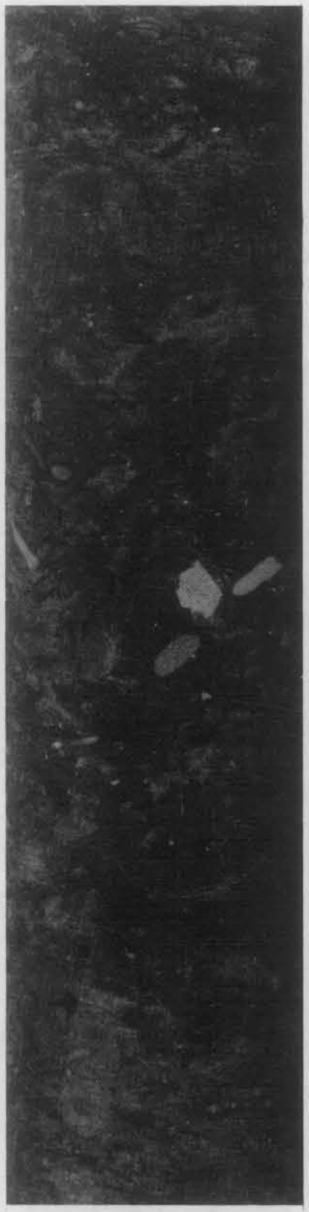
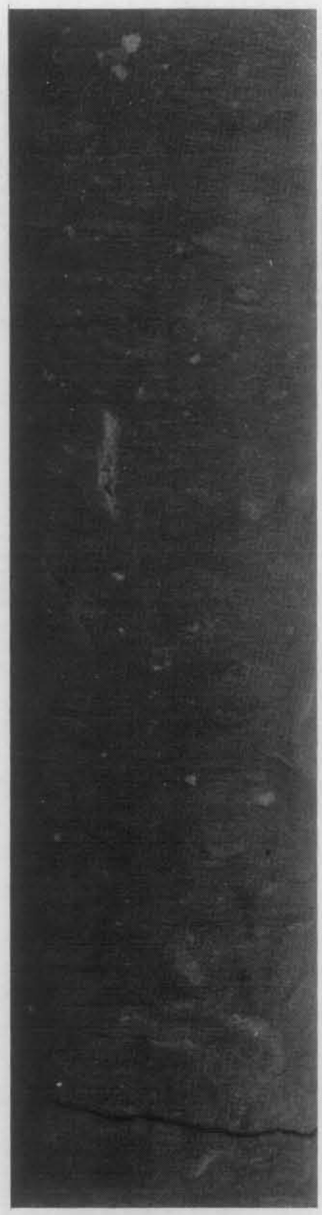


Figure 4. *Permian succession, Whitewater Creek.*



Ferntree Formation
B.H. 8

Risdon Brook dam site



Malbina Formation
B.H. 2

Whitewater Creek upper dam site

Plate 1. *Drill core of Ferntree Formation from Risdon Brook and Malbina Formation from Whitewater Creek*

5 cm

It was conceivable that in such a poorly exposed area as that of the upper dam site reservoir area, some Lower Permian sandstone beds were present but were not exposed. By fretting and weathering these sandstone beds could conceivably have formed the thick layer of superficial sand covering the orchard area in the upper reservoir. If such a sandstone bed had existed in the Permian sequence at this locality and with the same dip and strike as the siltstone and mudstone cropping out in Whitewater Creek, it would have provided an excellent potential leakage from the proposed reservoir to the south through Doctors Hill saddle. Because of this potential threat, much of the stream beds of both Whitewater Creek and Boddys Creek were trenched and bulldozed to expose Permian rock (Moore, 1968) and a detailed palaeontological study was undertaken (Clarke, 1968).

The faunas collected from the cream siltstone and mudstone of Grange-type lithology are probably of a different age in Whitewater and Boddys Creek (Clarke, 1968). Further examination of the fossils in new exposures in Boddys Creek and on Parks Hill confirm this conclusion. The majority of faunas collected in 1967 from these beds belong to Fauna III (Dickins *et al.*, 1964) and indicate a lower Malbina age. Only one fauna collected to date belongs to Fauna II or the Cascades Group proper (M.J. Clarke, pers. comm.).

Problem of distinguishing Ferntree and Malbina Formation sediments

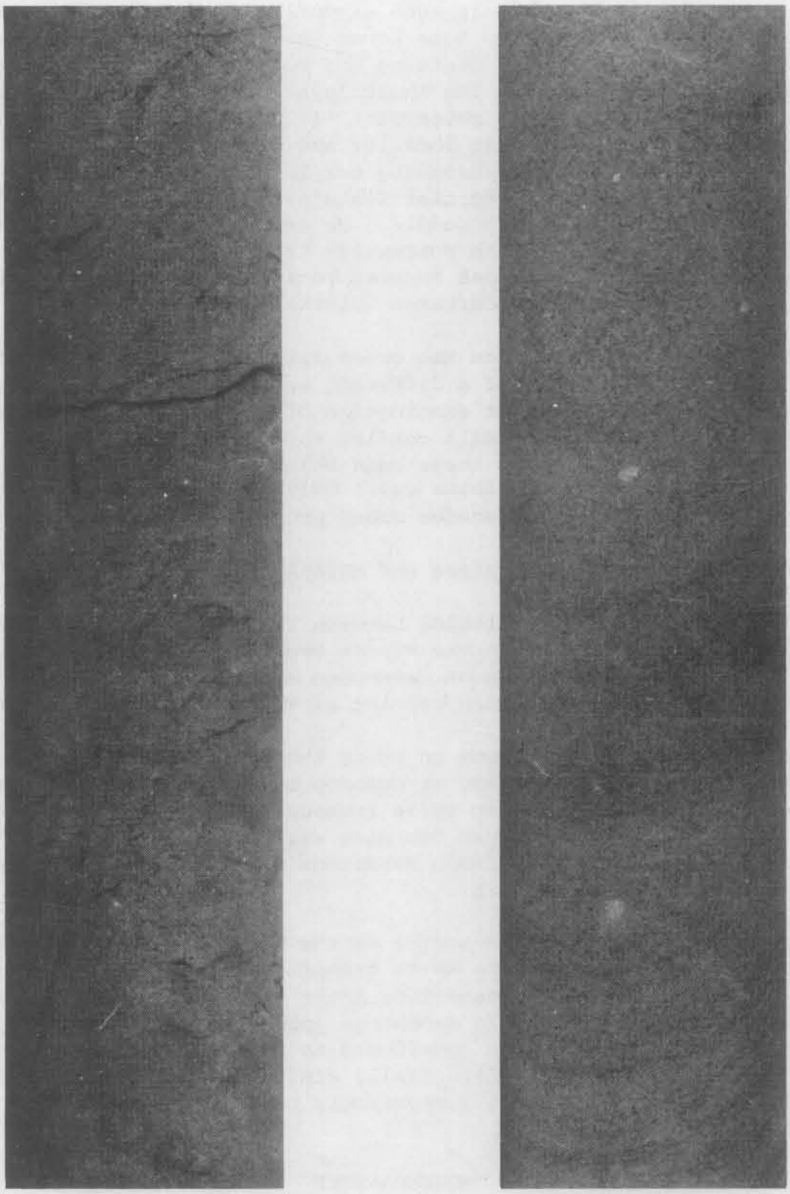
The problem of distinguishing between the Ferntree and Malbina Formations had been encountered at the Risdon Brook dam site in 1964, when mapping in areas where the Risdon Sandstone marker horizon was not exposed. The same difficulties arose when mapping at Whitewater Creek in 1967.

The rocks forming the spur on which the upper dam site was located appeared lithologically the same at outcrop and in core as those from the Risdon dam site (plate 1). For these reasons, the sediments of the fault-bounded block on which the upper dam site was situated were mapped as Ferntree Formation, although no Risdon Sandstone was exposed (the absence was explained by the upstream fault).

In 1969, on the southern sector of the upper dam site, Hole 11a drilled at an angle of 45° to cross the NW-SE trending Triassic fault bottomed in 5.5 m of grey, poorly bedded sandstone after passing through the fault and 7 m of Permian sediments. This sandstone (plate 2) was ill sorted, dirty and of fine grain size and was considered to be the Risdon Sandstone (Moore, 1971). This sandstone is lithologically similar to the Risdon Sandstone which was penetrated in Hole 8 (incorrectly referred to as Hole 5) at Risdon Brook (Moore, 1965).

NOMENCLATURE

At the time of mapping, regional mapping of the Hobart and Kingborough Quadrangles was in progress and it was deemed inappropriate to set up a sequence of local formations for the Whitewater Creek area for what was originally a dam site investigation rather than a stratigraphic study of the Permian. The subdivisions used in this report are similar to those of Moore (1968) except for the sediments which were then considered to belong to the Grange Mudstone (Banks and Hale, 1957). These are now referred to the Malbina Formation (Banks and Read, 1962; Banks, 1962). These terms are used as purely local formation names. The Permian succession appears to be more closely related to the Cygnet succession to the south rather than to the Hobart succession to the north. This conclusion is only tentative and must await completion of the regional mapping programme and further palaeontological studies.



Risdon Sandstone
B.H. 8

Risdon Brook dam site

Risdon Sandstone
B.H. 11a

Whitewater Creek upper dam site

Plate 2. *Drill core of Risdon Sandstone from Risdon Brook and Whitewater Creek*

5 cm

BUNDELLA FORMATION

Sediments of this formation are exposed only in the southern portion of the area mapped, cropping out in road cuttings south of Doctors Hill along the Channel Highway and forming the cliffs along the north-east shoreline of North West Bay.

The sediments comprise interbedded siltstone and mudstone with the thickness of the beds varying between thicker units of 0.6-1.2 m and thinner units of 150-300 mm thick. This variation in thickness occurs in a somewhat regular pattern and gives the bedding an alternating appearance, which helps to distinguish this formation from other Permian units. Fossils are also generally abundant with a diagnostic Bundella Mudstone (Allandale) fauna present in outcrops along the Channel Highway (M.J. Clarke, pers. comm.).

Nowhere in the area mapped are the Bundella sediments seen in contact with the younger Malbina sediments and a fault separating the outcrops of these two formations is inferred in the Channel Highway and Parks Hill region.

MALBINA FORMATION

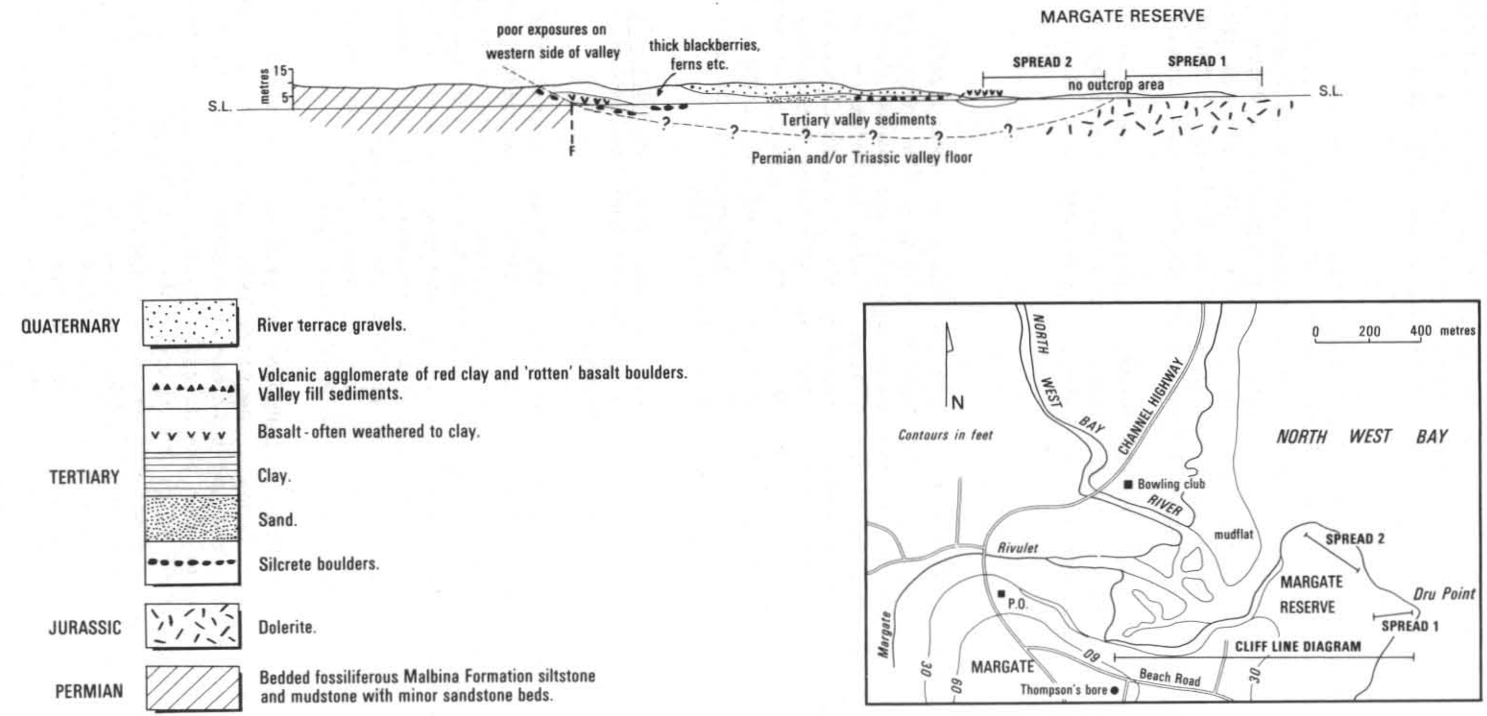
Most of the Permian rocks mapped during the dam site investigations are now referred to this formation. The Malbina Formation now incorporates those rocks previously mapped in the catchment areas of Whitewater Creek and Boddys Creek as Grange Mudstone (Moore, 1968). Also included in the Malbina Formation are all the sediments exposed on the track which climbs to Parks Hill. Previously a succession of Malbina and Grange Formations was thought to be exposed (Paxton, 1964, 1968). With the presence of the Risdon Sandstone in Hole 11*a*, all the Permian sediments mapped as Ferntree Formation (Moore, 1968) and which occur below this sandstone at the upper dam site, must belong to the Malbina Formation (Moore, 1971).

The rocks exposed in the cliff line west of Dru Point, Margate (fig. 5) and exposed on the Southern Outlet below the basalt near Leslie Vale are also considered to belong to the Malbina Formation.

No complete section of the Malbina Formation has been located in the Whitewater Creek area and the boundaries with the overlying and underlying formations have not been seen in outcrop or in drilling. All the sections exposed in the area are known to be faulted and this faulting is probably more complex than shown from the mapping. In the two best exposed sections in Boddys Creek and Whitewater Creek, correlation is possible but is more difficult upstream above the first dolerite. With the exposure of new sections on Parks Hill, it was possible to approximately correlate these two sections with the sediments exposed on Parks Hill (fig. 4).

Most of the Malbina Formation is composed of grey silty sandstone, sandy siltstone and siltstone. Coarser sandstone beds, often with a thin grit band at the bottom of the bed, and thin mudstone beds are present. These sediments are often baked near the dolerite sills. Fossils are present but rare. Bedding is often up to 2 m thick. The coarser grade siltstone and sandstone frequently shows a mottled weathering pattern which is the surface expression of a characteristic turbid texture. This texture has resulted from the mixing and interweaving of the sand, silt and mud of the sediments on deposition by bottom currents and marine life. The texture is noticeable in drill cores from the upper site but is also characteristic of drill cores from the Ferntree Formation (plate 1).

Within the above sequence are horizons of well bedded cream-yellow



EXPOSURES ALONG MARGATE–DRU POINT CLIFFLINE

HORIZONTAL SCALE 0 100 metres

VERTICAL SCALE 0 30 metres

GEOLOGIST: W.R. Moore

3626

TASMANIA, DEPARTMENT OF MINES

Figure 5.

5 cm

weathering, grey-green mudstone and siltstone. These beds are highly fossiliferous with fenestellids being ubiquitous. The thickness of these horizons varies from 30 mm to 18 m. White weathering thin, often gritty sandstone beds are also present within the fossiliferous sediments.

Even though the yellow fossiliferous siltstone and mudstone forms distinct outcrops, it can only be traced laterally for short distances and appears to thin rapidly. Some of the thinner exposed beds are only lenses. Lithologically, these sediments resemble the sediments in the Grange quarry at Taroona and sediments mapped as belonging to the Grange Formation of the Cascades Group of the Hobart Quadrangle (Leaman, 1973). The sediments in Whitewater Creek would appear to be of a different age and occur at varying stratigraphic levels (fig. 4).

FERNTREE FORMATION

Ferntree Formation sediments crop out in a small block south of the upper dam site. Similar sediments are extensively exposed to the east around Kingston and have been mapped by Leaman (1973) as the Ferntree Formation.

At Whitewater Creek, the rocks comprise siltstone, sandy siltstone and silty sandstone with beds 0.9-1.2 m thick separating thinner fissile sandstone beds 15-30 mm thick. The rocks are strongly jointed and the vertical joints, combined with the thick beds, give the outcrops a blocky appearance.

Triassic

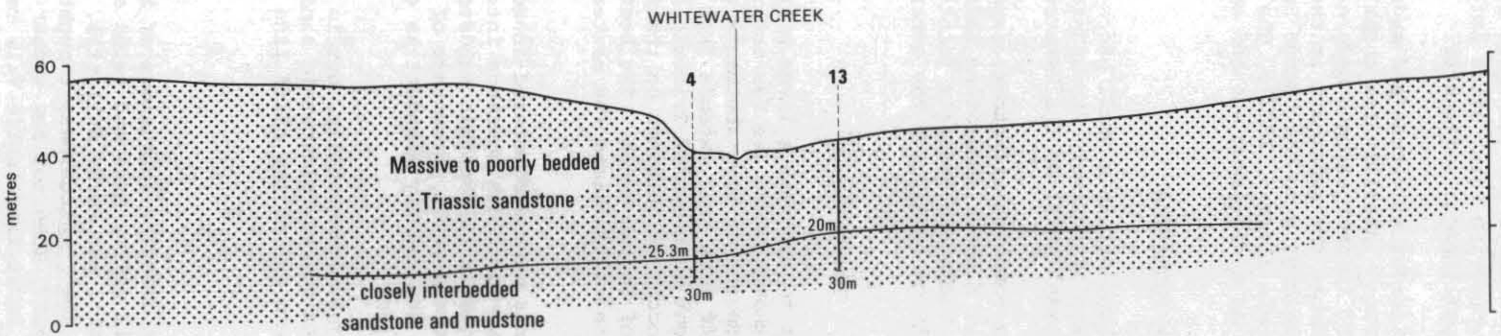
Triassic sediments are thought to underlie a large portion of the eastern half of the area mapped, although there are few outcrops. Thick beds of fine quartz sandstone are present on both abutments of the lower dam site and form part of a low cliff line that extends from this site along Whitewater Creek to Leslie Road. Poor outcrops of Triassic sediments occur along this road but good exposures occur in cuttings on the Southern Outlet. Sandstone crops out in tributaries of Coffee Creek. The best exposures of Triassic sediments in the area are in cliffs along the eastern shore of North West Bay.

Up to 30 m of Triassic sediments were encountered in Holes 13 and 14 drilled on the lower dam site. Brown micaceous mudstone interbedded with thin sandstone beds and soft white quartz feldspathic sandstone with mica and graphite partings comprised a considerable percentage of the total core length (fig. 6). Similar sediments are equally abundant as quartz sandstone in Howden Holes 1 and 2.

Micaceous mudstone crops out only occasionally, but is present at the bottom of Pearsall's clay pit. White quartz feldspathic sandstone has only been seen cropping out on the northern end of the cliff line on the eastern shore of North West Bay.

Jurassic dolerite

From geophysical evidence, the dolerite intrusions of the upper reservoir area are now thought to be small sills, pods and veins as offshoots from the feeder zone of the Picket Hill and Parks Hill sill. The close relation between faulting and these small intrusions, thought to be present from the original mapping (Moore, 1968), does not now appear to occur. The large regional north-south trending fault from Leslie Vale to North West Bay appears to mark the eastern boundary for the offshoot bodies from the Picket Hill and Parks Hill dolerite mass.



CROSS SECTION C–D

LOWER DAMSITE–WHITEWATER CREEK

0 20 40 60 80 100 metres

TASMANIA, DEPARTMENT OF MINES

Figure 6.

5 cm

The dolerite bodies occurring east of this fault, such as the small outcrop in the upper dam site reservoir and the dolerite north of Leslie Road, are thought to be associated with the large dolerite sill occurring between Taroona and the Southern Outlet. At Margate, the Dru Point dolerite is associated with a dolerite body exposed to the south.

Tertiary

The Tertiary rocks comprise a sequence of sand and clay with minor sandstone overlain by basalt and silcrete. Associated with the basalt is a sequence of valley fill sediments comprising cemented gravel, clay and agglomerate. All of the above Tertiary rocks may be overlain by Cainozoic sand, some of which is probably Tertiary in age.

Of all the rocks in the Kingston area, the Tertiary is the most difficult to map because it seldom forms any surface exposures and mapping requires the assistance of various geophysical methods followed by confirmatory drilling. Even the basalt forms few outcrops. In the orchard area of the upper reservoir, an extensive and thick layer of basalt is now known to underlie most of this area (fig. 1). From drilling, this basalt is unweathered and up to 23 m thick (Hole R4), yet the only surface evidence of this basalt was a small patch of red soil and a few scattered basalt boulders concentrated in a small area near the old house in the orchard. The remainder of the area is covered by superficial grey sand (Moore, 1968, 1971).

The subdivision of the Tertiary sediments in the Kingston area was attempted in the upper reservoir area in 1969 after extensive drilling. Here the basalt and the valley fill sediments associated with the basalt were separated from the Tertiary clay and sand in differing bore holes (fig. 1). The Tertiary sequence was thought to be basalt overlying valley fill sediments which in turn were stratigraphically above the unconsolidated sand. This sequence was established with the drilling of Howden Hole 1 in the Tertiary valley at the head of North West Bay.

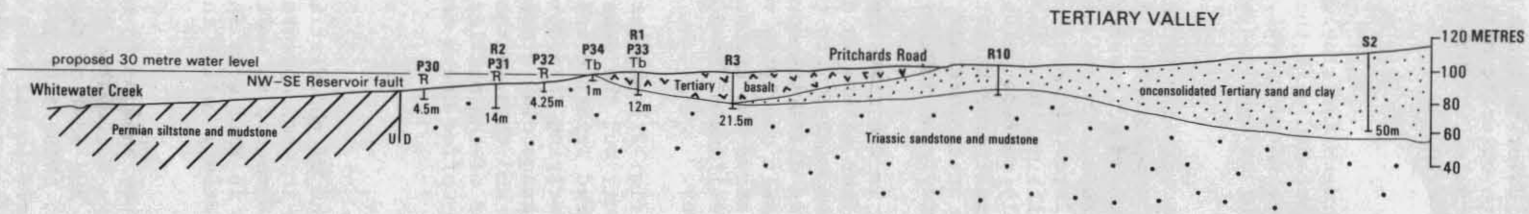
Between Howden Hole 1 and Howden Hole 2 (fig. 2), the Tertiary valley fill sediments and the overlying basalt lense out, but the underlying Tertiary sand and clay overlap on to deeply weathered Triassic sediments. The Tertiary sand is differentiated from the overlying Cainozoic sand in Howden Hole 2. In this hole, 6 m of grey and orange clay grades down into clay which retains a vesicular basalt structure and then weathered basalt. From this drill hole evidence, the poor outcrops of the mottled grey and orange clay found around the North West Bay and Coffee Creek areas are mapped as Tertiary sediments.

TERTIARY SAND AND CLAY

Sand and clay appears to be most widespread of the Tertiary sediments. Near Leslie Vale, three farm dams have been dug in what appears to be sand and clay sediments of Tertiary age. Similar sediments, as well as soft sandstone, have been reported from a water bore in this area (A.B. Gulline pers. comm.) and occur in a recently exposed Tertiary valley in a cutting on the Southern Outlet (plate 3).

Three isolated poor outcrops of what are now thought to be Tertiary sandstone were exposed in drainage ditches in the Whitewater Creek valley floor and on the eastern flanks of the ridge to the west of the stream in the reservoir area of the lower dam site (Moore, 1968; fig. 37). Tertiary sand and clay of varying thickness was encountered in all bore holes at the upper reservoir site as well as in two in the Doctors Hill saddle area (figs 1, 7 and 8). The maximum thickness of sediment encountered in drilling

SECTION 1



SECTION 2

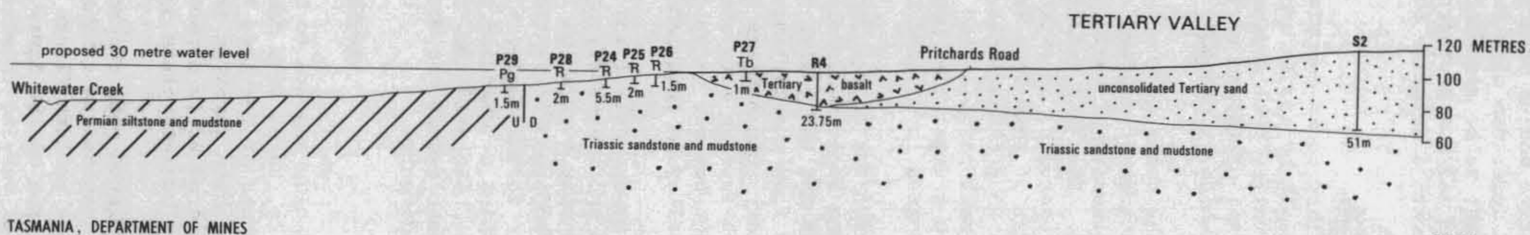


Figure 7. *Cross sections, upper dam site, Whitewater Creek.*

5 cm

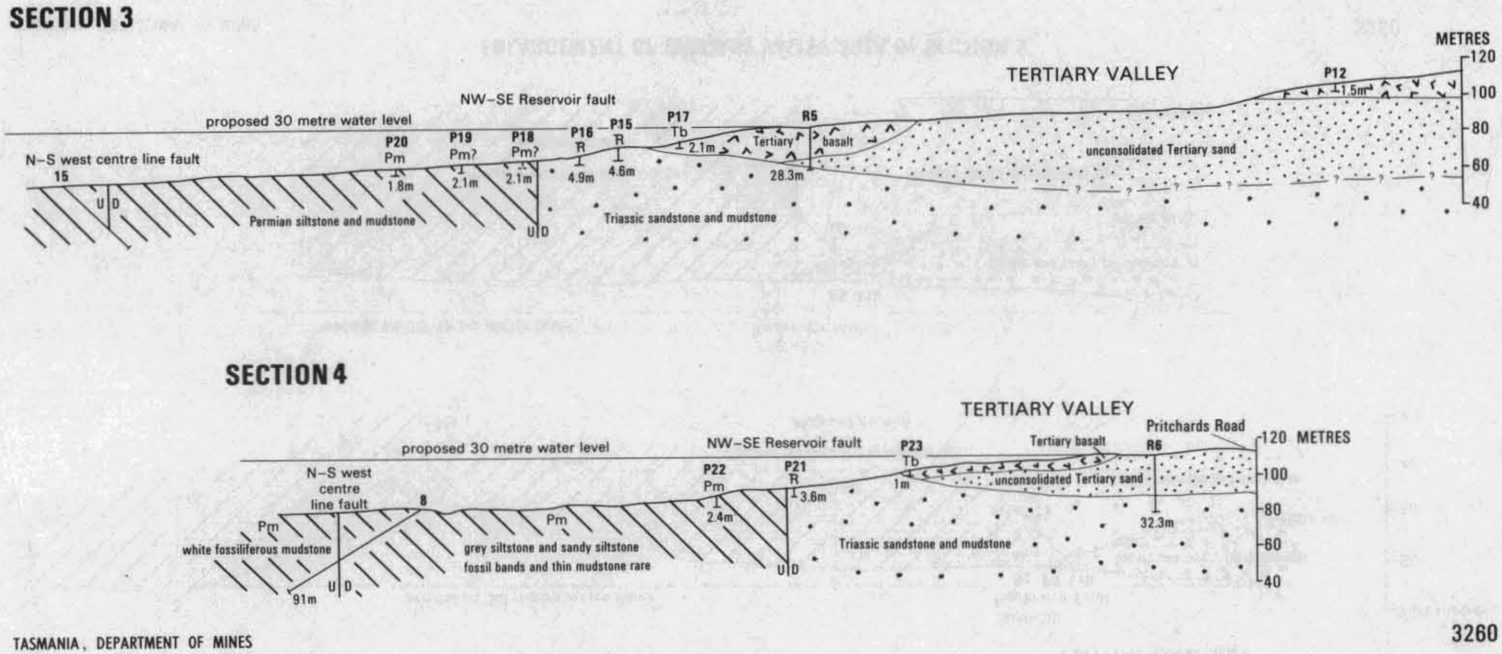


Figure 7. *Cross sections, upper dam site, Whitewater Creek.*

5 cm

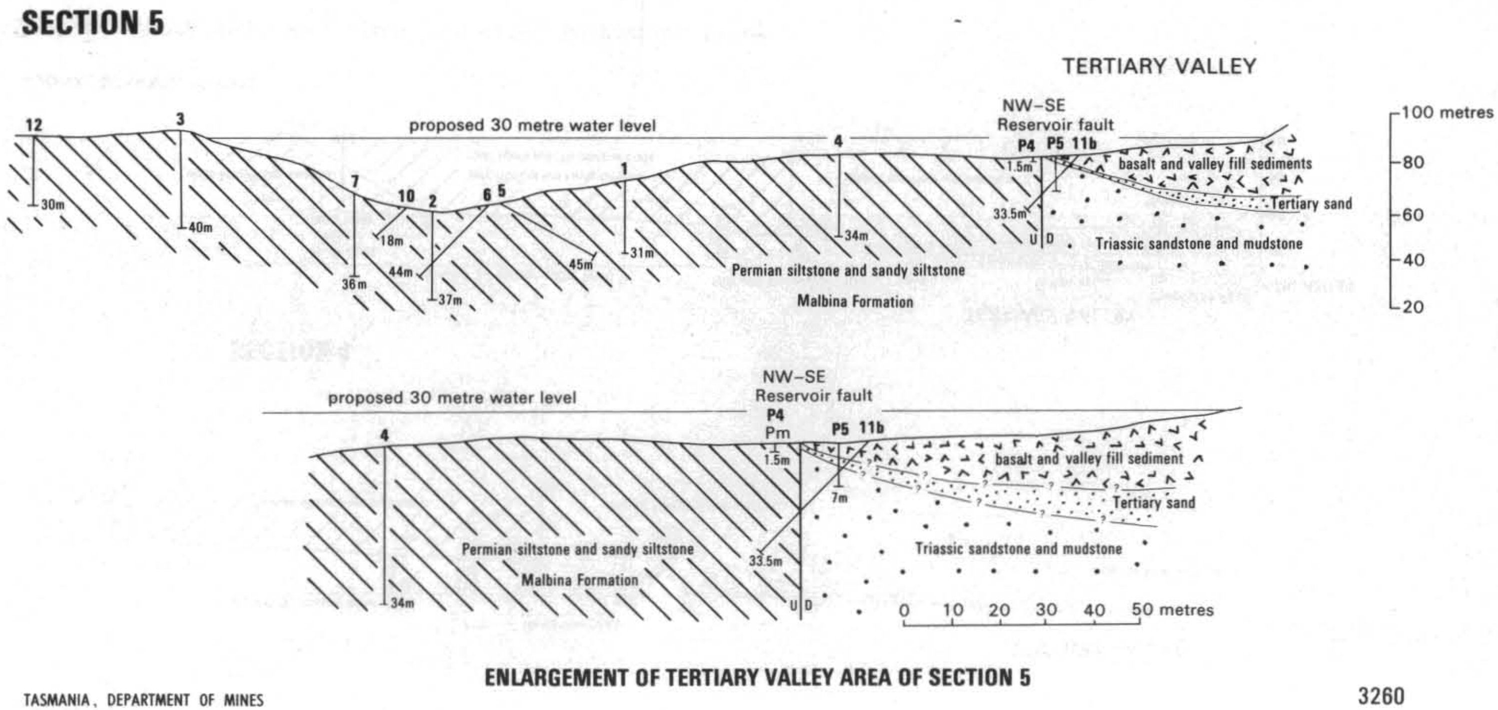
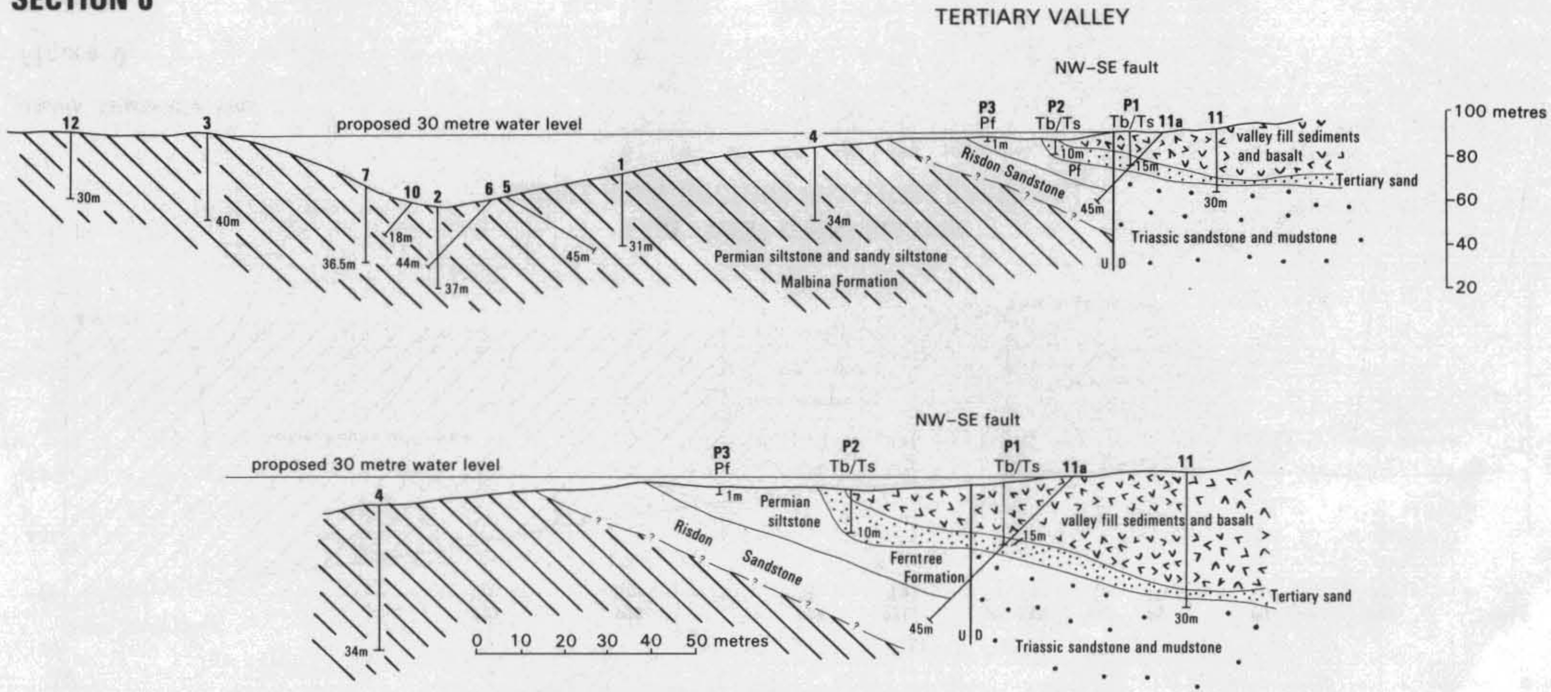


Figure 7. *Cross sections, upper dam site, Whitewater Creek.*

5 cm

SECTION 6



ENLARGEMENT OF TERTIARY VALLEY AREA OF SECTION 6

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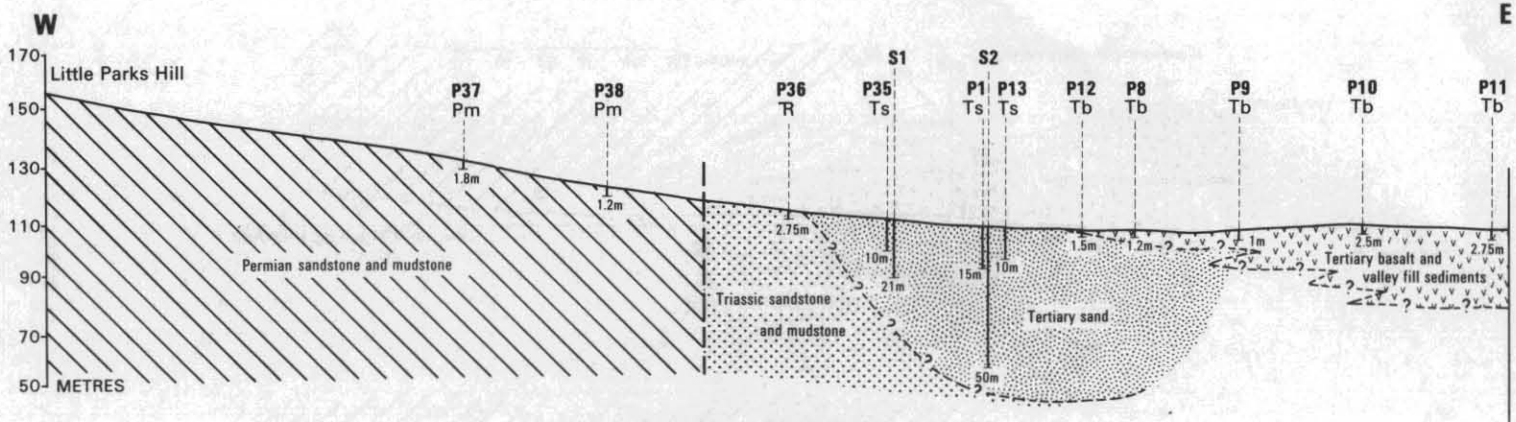
Figure 7. *Cross sections, upper dam site, Whitewater Creek.*

5 cm



EAST – WEST CROSS SECTION
SADDLE AREA–DOCTORS HILL–LITTLE PARKS HILL

0 20 40 60 80 100 120 metres

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Figure 8.

5 cm

was 49 m in Hole S2 (fig. 22 and 8). Thick superficial sand cover was a conspicuous ground feature in both areas.

The southern section of the area was mapped by correlating with the sand and clay encountered in Howden Holes 1 and 2 and it was thus possible to establish the age of the mottled orange and grey clay and white sand of this area. Poor outcrops of sand and clay, similar to those found in the upper dam site bore holes at Whitewater Creek and in the Howden bore holes, occur west of Dru Point (fig. 5) on the cliffs along the western shore of North West Bay and in cuttings on the Channel Highway between Doctors Hill and Margate.

The mottled grey-orange and grey clays occurring above the basalt in Howden Hole 1 and above basalt in Coffee Creek and west of Dru Point are included in this division of the Tertiary sediments rather than valley fill sediments. Even though they are closely related to the basalt at these localities, lithologically similar clay is known to occur west of Howden Hole 2 where no basalt is present.

This clay is also associated with the white sand clay in many of the reservoir holes.

Lithologically, the sediments vary from unconsolidated white fine-grained quartz sand through to grey iron-stained clay. Within the sand, soft grey sandstone containing lignite bands, mudstone flake pebbles as well as concretionary sandstone has been encountered in drilling.

VALLEY FILL SEDIMENTS

These sediments were encountered above and below the basalt in Holes 11, 11*a* and 11*b* at the upper dam site and below the basalt in Howden Hole 2. Small blocks of similar material occur close to the basalt contact at the upper dam site (Moore, 1968) and close to the Permian-basalt contact along the Channel Highway south of Doctors Hill (Paxton, 1964, 1968). Similar material consisting of red clay with coarse agglomerate crops out close to the basalt on the eastern section of the cliff line at Dru Point.

The red and brown clay is compact and often hard and forms the matrix for the coarse agglomerate, breccia and cemented gravel. All of these sediments have been loosely referred to as the valley fill sediments in the upper dam site investigations of 1969 to distinguish them from the more widespread unconsolidated sand and clay (Moore, 1971).

BASALT

All the areas of basalt and associated red clay with basalt boulders mapped in the Whitewater Creek area are thought to have originated from three main volcanic centres located on Picket Hill, Doctors Hill and south of the North West Bay River. The basalt flowed east from the Picket Hill centre to cover a wide area north of Whitewater Creek. Subsequent erosion has separated the original flow into four areas of red clay soil with basalt boulders and isolated outcrop. The maximum thickness of this flow is 9-12 m in the west on Picket Hill where the contact with the basalt and underlying Permian is exposed on the Southern Outlet. Only a cover of red soil remains west of the lower dam site.

A small isolated volcanic centre composed mainly of pyroclastic basaltic material occurs on the northern bank of Whitewater Creek north of Kingston. The basalt exposed on the Southern Outlet north of Kingston appears to be related to this centre rather than the Picket Hill flow.

Another isolated area of basalt and basalt scoria occurs south of Picket Hill along the Parks Hill-Picket Hill ridge. This basalt is thought to be an isolated pod which extruded up the faulted contact of the Parks Hill-Picket Hill dolerite sill.

Basalt flowed north and south from the Doctors Hill centre into the upper dam site and reservoir area and south to North West Bay. Much of these two flows are covered by superficial surface sands which become over one metre thick towards North West Bay and covers an extensive area. This southern flow from Doctors Hill is undoubtedly more extensive than shown on the geological map and both flows covers much of the Whitewater Creek buried channels. The thickness of the basalt of these flows is difficult to estimate because 19 m of basalt was encountered in Hole R3 and 14.5 m in Howden Hole 1, where no surface outcrops are present.

Only the eastern margin of the eastern flow from the third centre near North West Bay River has been mapped. The exposures along the cliff line west of Dru Point are of interest in that they show the outline of the western edge of a Tertiary valley (fig. 5).

The olivine basalt from all these centres appears to be the same at outcrop. Often the basalt is coarsely porphyritic with large phenocrysts of olivine. Pyroclastic material has been found in all flows.

Petrological examination of specimens collected from various outcrops and bore holes from the area mapped show these basalts to be the same type (Everard, 1971) which Sutherland (1976) classified as mugearite. The basalts of the Kingston area are fully discussed by Sutherland (1976, p. 50).

SILCRETE

Boulders of grey silcrete are associated with all the major basalt flows in the area mapped. A 0.9-1.2 m thick deposit occurs on the eastern shore of North West Bay where it forms a small promontory. Silcrete also crops out in Coffee Creek and along the Howden Road between Howden Holes 1 and 2.

On the western section of the Margate-Dru Point cliff, silcrete boulders occur at the base of the basalt lying between the basalt and the Permian sediments. Silcrete boulders were also found near the basalt-Permian contact in the upper dam site area.

CAINOZOIC SAND

Much of the area underlain by Triassic and Tertiary rocks is covered by superficial grey and white sand. Some of these sands are fine-grained and are windblown deposits. The remainder were considered when mapping in 1967 to have been derived from the underlying Triassic sandstone. It is now known that some of these sands are reworked deposits from the Tertiary sands, as in the orchard area of the upper reservoir (Moore, 1971).

Some of the sands in Coffee Creek have been derived *in situ* from the underlying outcrops of Triassic sandstone. However for most of the area between the tributaries of this stream, the mode of origin and the age of these conspicuous surface deposits is not known and they are grouped tentatively within the Cainozoic deposits.

Quaternary

TERRACE GRAVEL

The most conspicuous Quaternary deposits in the area are the river terrace gravel deposits along the North West Bay River and capping the cliffs at Dru Point (fig. 5). The boulders and cobbles in these deposits are well rounded, large and poorly sorted. The thickness of the gravel varies from 1-3.5 m. The gravels are dominantly composed of unweathered dolerite boulders with a few boulders of Permian siltstone, Tertiary silcrete and very rare Triassic sandstone.

ALLUVIAL DEPOSITS

Extensive deposits of clay, silt and sand with minor gravel beds occur in the valleys of most major rivers and streams (fig. 2). A large delta-like deposit occurs at the mouth of the North West Bay River.

DRILLING

Four further drill holes were drilled in the upper reservoir area in 1970. These holes confirmed the seismic indication of a western tributary of the Tertiary valley. In addition, these four holes (Holes R7, R8, R9 and R10) located more precisely the position of one of the major north-south trending faults of the region (fig. 2). Here, the fault downthrows Triassic against Permian sediments with a throw in excess of 200 m. Holes R7 and R8 bottomed in Permian rocks, while Holes R9 and R10 bottomed in Triassic sediments.

Proline drilling has enabled this fault to be traced south to the saddle area between Doctors Hill and Little Parks Hill (fig. 8). The fault passes between Permian siltstone and basalt exposed in a cutting along the Channel Highway and Triassic sandstone which crops out in the headwaters of the western tributary of Coffee Creek. To the south, the fault passes between Howden Hole 2 and the Permian mudstone cliffs along the western shore of the North-West Bay.

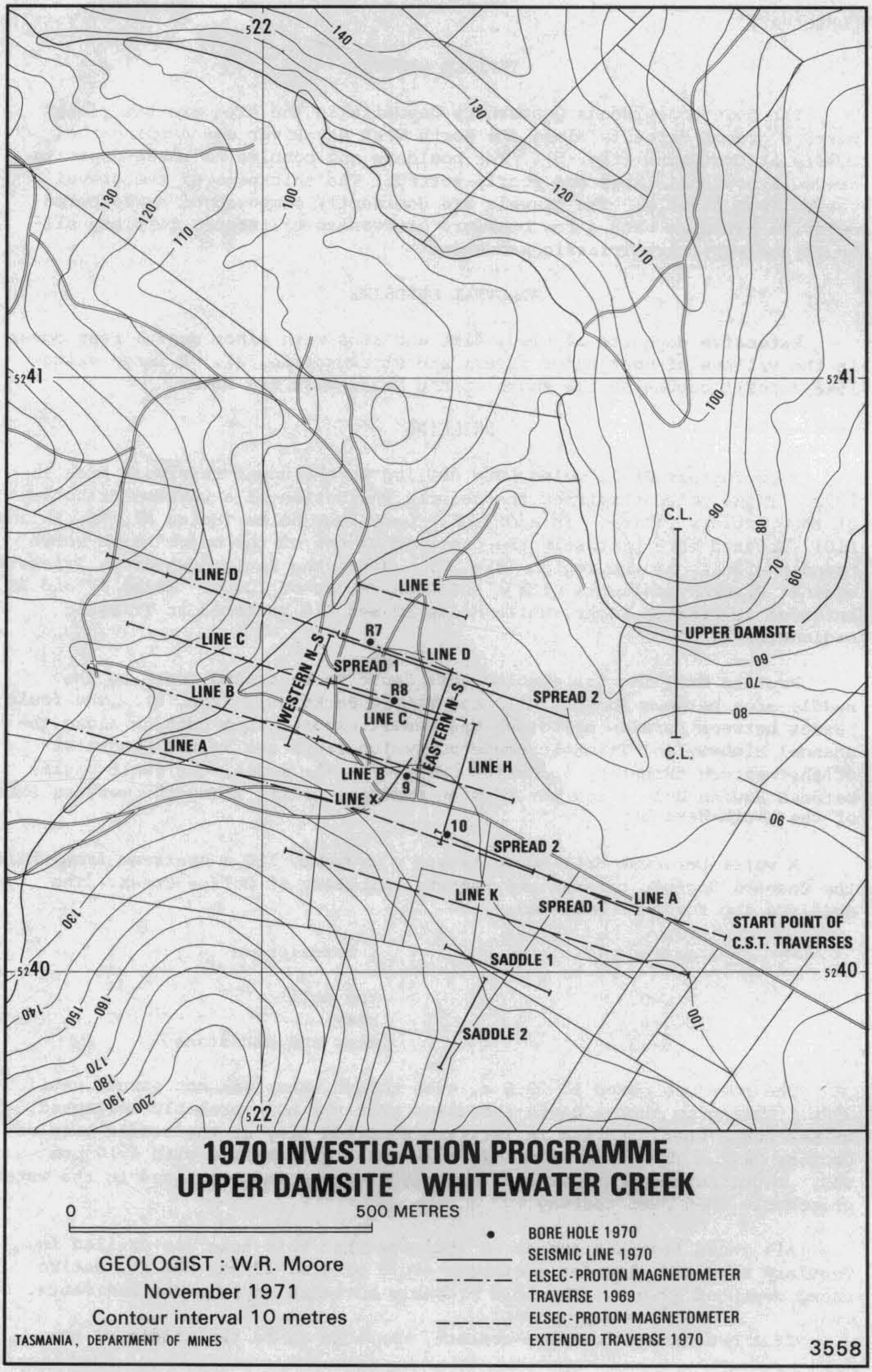
A water bore was drilled on Kievit's property 150 m upstream from where the Channel Highway crosses the western tributary of Coffee Creek. The drillers log for this hole was:-

Depth (m)	*Description*
0-0.3	top soil
0.3-6	clay
6-33.5	clay and sandstone

The hole was cased to 29.5 m, even though water was not struck until 29 m. Casing to such a depth indicates that the hole probably collapsed, as was found when drilling in Tertiary sand and clay at the saddle area of Doctors Hill. The water from this hole was highly saline with 4510 ppm TDS. Significantly, the driller notes that there was some sand in the water, presumably when pump testing.

All these features appear to indicate that this hole was drilled in Tertiary sand and clay for a minimum depth of 6 m, if not for its entire cased depth of 29.5 m. The hole probably bottomed in Triassic sediments.

If these assumptions are correct, the hole is in the middle of the



1970 INVESTIGATION PROGRAMME
UPPER DAMSITE WHITEWATER CREEK
0
500 METRES
GEOLOGIST : W.R. Moore
November 1971
Contour interval 10 metres
TASMANIA, DEPARTMENT OF MINES
BORE HOLE 1970
SEISMIC LINE 1970
ELSEC-PROTON MAGNETOMETER TRAVERSE 1969
ELSEC-PROTON MAGNETOMETER EXTENDED TRAVERSE 1970
3558
LINE A
LINE B
LINE C
LINE D
LINE E
LINE H
LINE K
LINE X
SPREAD 1
SPREAD 2
WESTERN N-S
EASTERN N-S
R7
R8
9
10
SADDLE 1
SADDLE 2
UPPER DAMSITE
C.L.
START POINT OF C.S.T. TRAVERSES

Figure 9.

5 cm

buried valley indicated by the resistivity traverse 230 m to the north and the north-south fault passes to the west of this bore hole (fig. 2).

Supporting these conclusions are some very poor outcrops of Tertiary sand, clay and gravel of the valley fill sequence along the Channel Highway between the Coffee Creek culvert and Doctors Hill. The low hill that forms the interfluve between the two western tributaries of Coffee Creek is also covered with grey sand which in one silage pit near the top of the hill is 1.5 m thick. These sands could possibly be Tertiary but are mapped as indefinite Cainozoic because of the lack of good exposures.

The only other water bore drilled in the area mapped is that drilled on T. Pearsall's property in the north-south tributary headwaters of Coffee Creek (fig. 2).

This 30 m deep hole was drilled in a reported sequence of sand, clay and mudstone. As Triassic sandstone and mudstone crop out downstream from this hole in Coffee Creek, the hole is thought to have been drilled mainly in Triassic sediments.

GEOPHYSICAL INVESTIGATIONS

MAGNETOMETER SURVEYS

Elsec proton magnetometer traverses

An Elsec proton magnetometer was used in 1969 and 1970 to locate the basalt underlying the Cainozoic grey sand in the orchard area of the upper reservoir. The western and southern boundaries of the basalt were mapped by extending east-west traverses B, C, D and E (fig. 9) from the quarry site to the north-south magnetometer traverses and reservoir drill holes of the 1969 investigation (fig. 1). The southern boundary of the basalt in the orchard area could not be located as accurately as the western boundary because of the interference from fences, power and telephone lines bordering Pritchards Road.

The profiles of the traverses south of Pritchards Road (Lines A, K; fig. 10) are flat with constant readings, indicating that basalt is not present in that area. From the previous surveys, such areas with flat profiles are known to indicate the location of Tertiary valleys filled with thick deposits of unconsolidated sand and clay (fig. 10). Thus the southern boundary of the orchard basalt follows Pritchards Road and the junction of the two Tertiary valleys may occur immediately south of the road.

In 1967, an Elsec Proton magnetometer was used in a magnetic survey of the upper dam site in conjunction with a gravity survey (Leaman, 1968). Magnetometer readings were taken at each gravity station located at approximately 15 m intervals on lines A-H (Leaman, 1968, fig. 15). This survey aimed to determine if any dolerite had been intruded up the faults known to border the Permian block on which the upper dam was to be built; both the gravity and the magnetic survey showed that intrusion had not occurred.

Another feature, the importance of which was not realized in 1967, was that the Permian siltstone gave flat readings which stepped up or down 2 to 6 nT after three to six readings. When plotted in profile and with readings taken at closer distances, a characteristic stepped magnetometer profile appears (e.g. Lines 2 and 7, fig. 11). This type of profile is characteristic of many of the later Permian traverses of 1969, 1970 and 1971, using both the Elsec proton and the McPhar fluxgate magnetometers (figs. 10, 11,

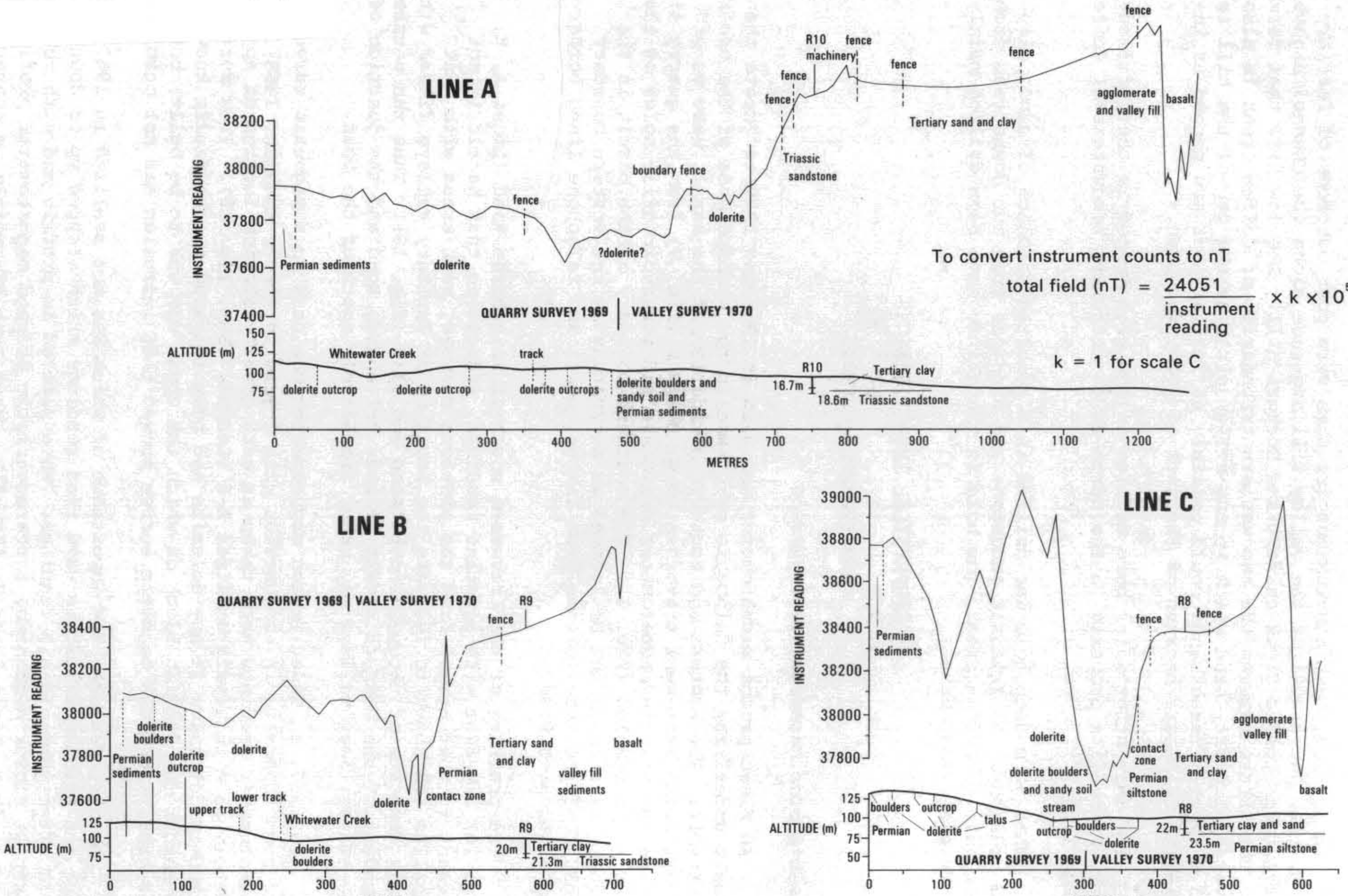


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Figure 10. *Elsec proton magnetometer traverses*

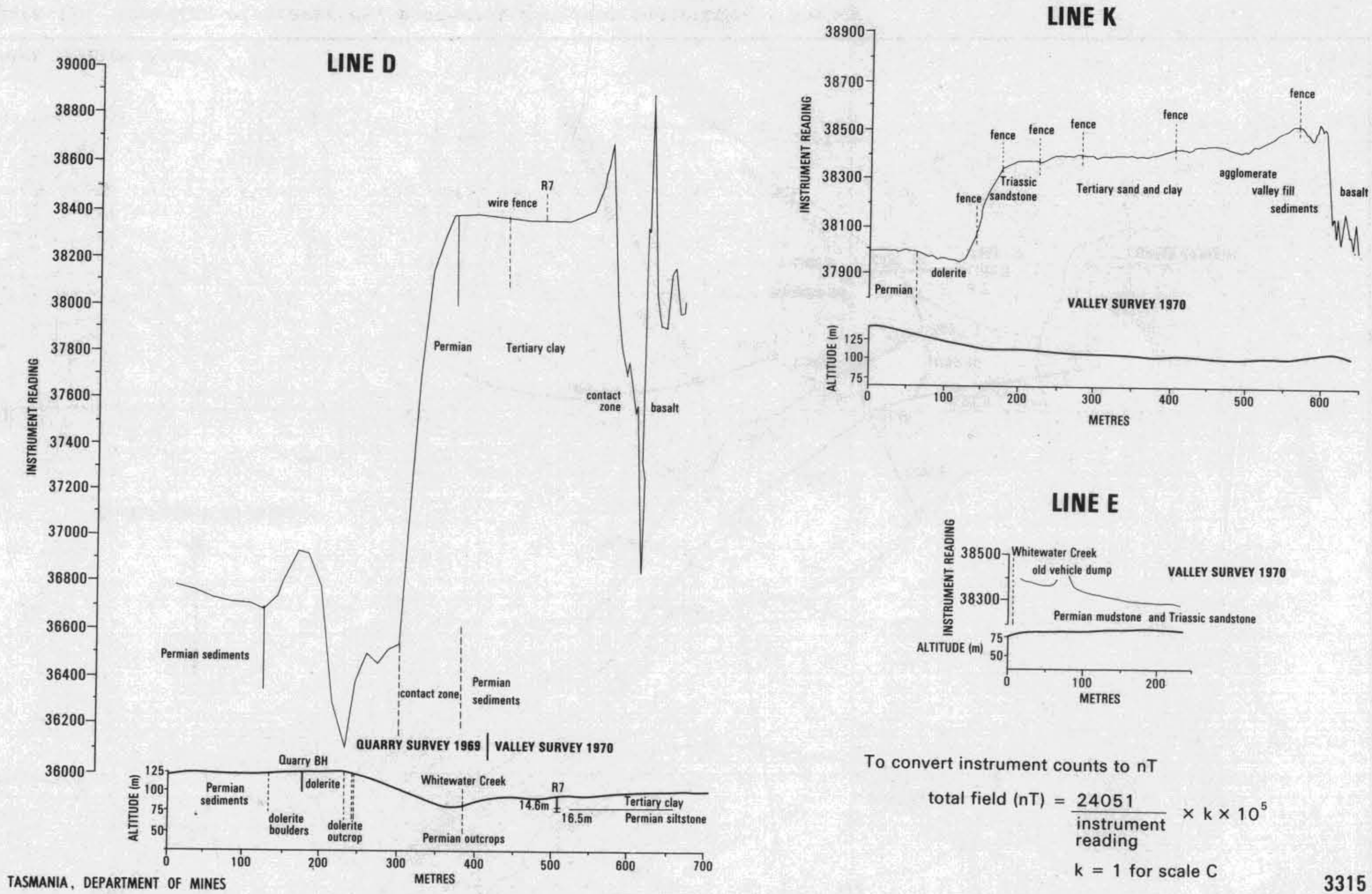


Figure 10. *Elsec proton magnetometer traverses*

5 cm

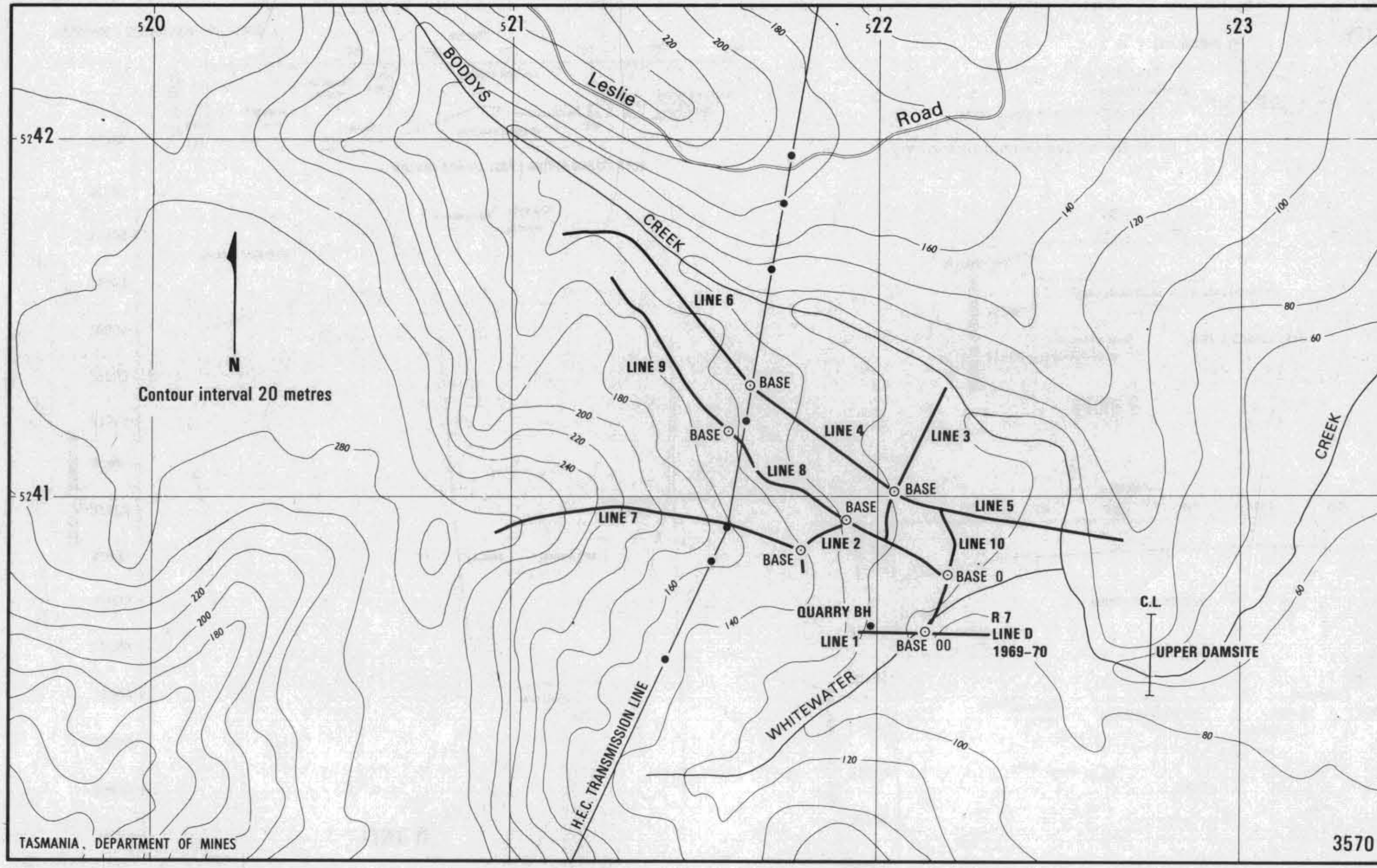


Figure 11. *Location of traverses, east-west fluxgate magnetometer survey*

5 cm

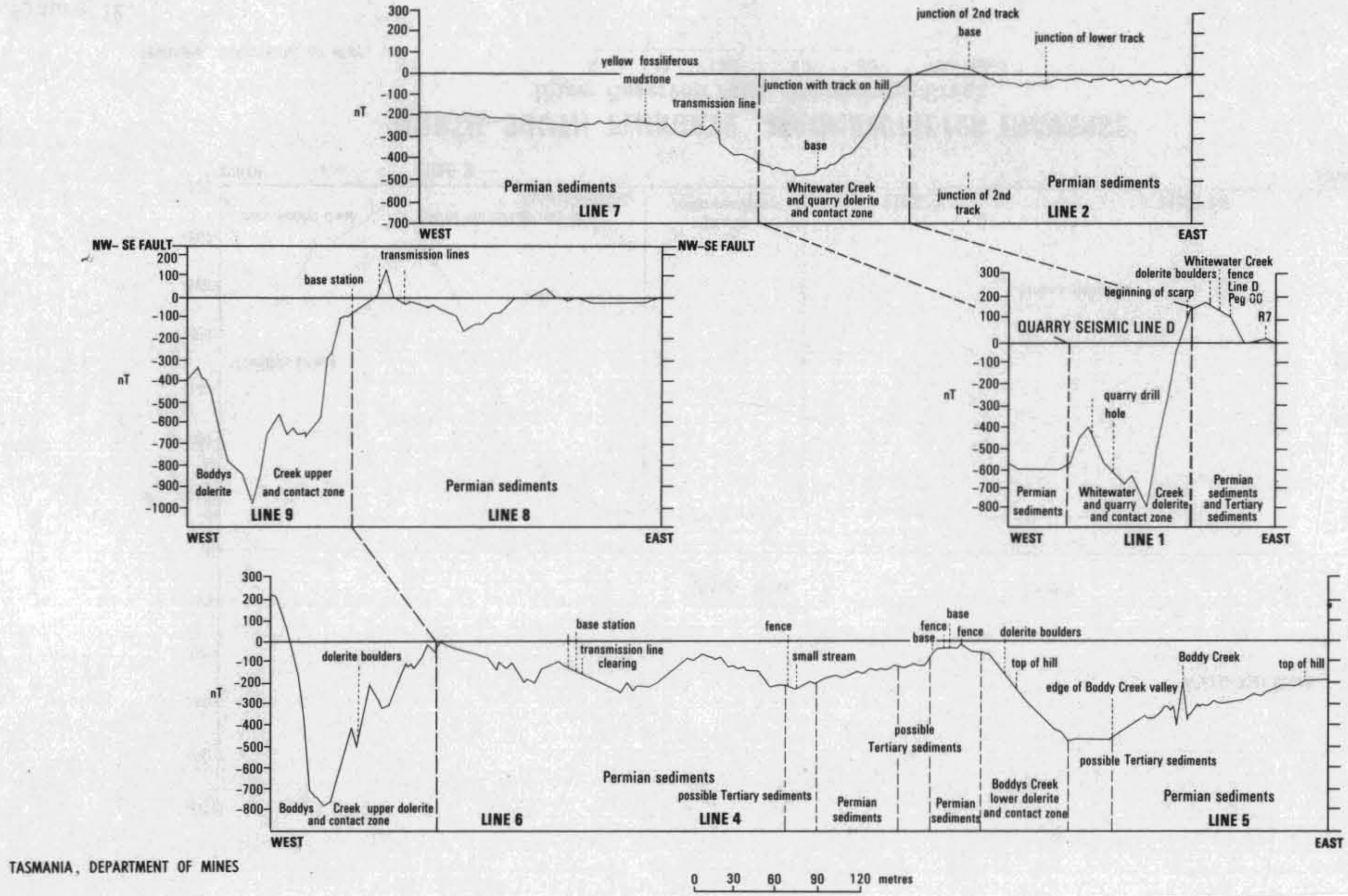
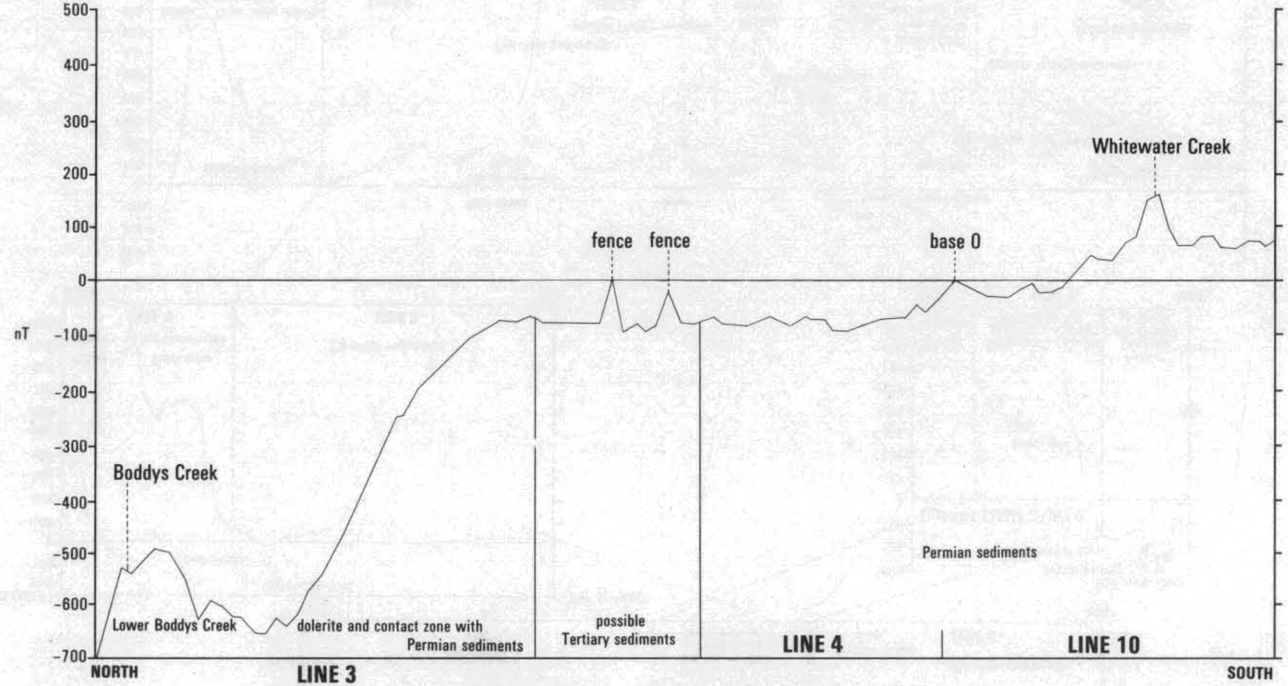


Figure 11. *East-west fluxgate magnetometer traverses*



NORTH–SOUTH FLUXGATE MAGNETOMETER TRAVERSE

Upper Reservoir Area Whitewater Creek

0 20 40 60 80 100 metres

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Figure 12.

5 cm

12, 13). By 1969, it had become possible, by use of the characteristic magnetometer profiles, to distinguish areas of Permian and Tertiary rocks as well as dolerite and basalt areas (fig. 10). Readings on line H in the 1967 survey (Leaman, 1968) were most constant and gave a very flat profile. This was then thought to be characteristic only of the Triassic areas where sand and clay are deeply weathered, as in nearby clay pits, but it is now known to be equally indicative of thick Tertiary sand in a buried valley.

McPhar fluxgate magnetometer traverses

A fluxgate magnetometer was used in 1971 to locate the position of the western Tertiary valley in the upper reservoir area of Whitewater Creek. These traverses also showed how dolerite outcrops found between Permian outcrops in Whitewater, Boddys and Fisher Creeks were interconnected.

A small number of stations giving constant readings which form narrow, flat zones on lines 4 and 5 of the east-west traverse (fig. 11) and lines 3 and 4 on the north-south traverse (fig. 12) were observed. These flat areas are thought to indicate Tertiary sediments in a buried valley.

North of Whitewater Creek, the western valley is not as distinctive as that shown in the Elsec proton magnetometer profiles south of Whitewater Creek (fig. 10). This is thought to be because the valley is shallower, narrower and possibly has subdivided into two tributaries north of Whitewater Creek, one tributary passing east of the isolated low hill that forms the interfluve between the two valleys near the junction of Boddys Creek and Whitewater Creek (fig.23). The main tributary passes west of this hill beneath the narrow flat that separates this hill from the hilly Permian country to the west. Some superficial sand was noted in the areas of these flat profiles on lines 3 and 4, but none was seen on the eastern side of the hill on line 5.

From the east-west fluxgate magnetometer traverses in the reservoir area of the upper dam site, it appears that the quarry dolerite sill is faulted out prior to reaching the tracks that climb to the power lines (fig. 11, line 1, 2, 7, 8, 9). There is no evidence on the east-west traverses for the second dolerite that crops out above the quarry sill in the two headwater tributaries of Whitewater Creek (fig. 2) extending north to the H.E.C. tracks (fig. 11). It would appear that these outcrops are from a small offshoot dolerite body from the main feeder of the Parks Hill sill.

In the upper reservoir area of Boddys Creek, two areas of dolerite outcrops occur between areas of Permian sediments. From the 1971 magnetometer traverses, the two dolerite bodies in these two tributaries do not appear to be connected as was thought from surface mapping (Moore, 1968). The smaller dolerite body, the lower dolerite cropping out further down stream in the reservoir area of Boddys Creek (fig. 11 and 12), was traced south (line 3, fig. 12) to east-west traverse line 5 (fig. 11), but does not continue southwards to Whitewater Creek. This lower dolerite would appear to be a thin sill following the contours of the Permian bedding dipping east, but is cut off by the major north-west - south-east fault. The quarry dolerite sill is also faulted out to the south and Permian sediments are upthrown against Triassic in the orchard area (figs. 1 and 2).

The upper dolerite exposed in Boddys Creek below the power lines appears to the south on east-west traverse lines 8 and 9 and 4 and 6, but does not appear on traverse line 7 to the south (fig. 11). It is also thought to be cut out by the north-west - south-east trending fault (fig. 2).

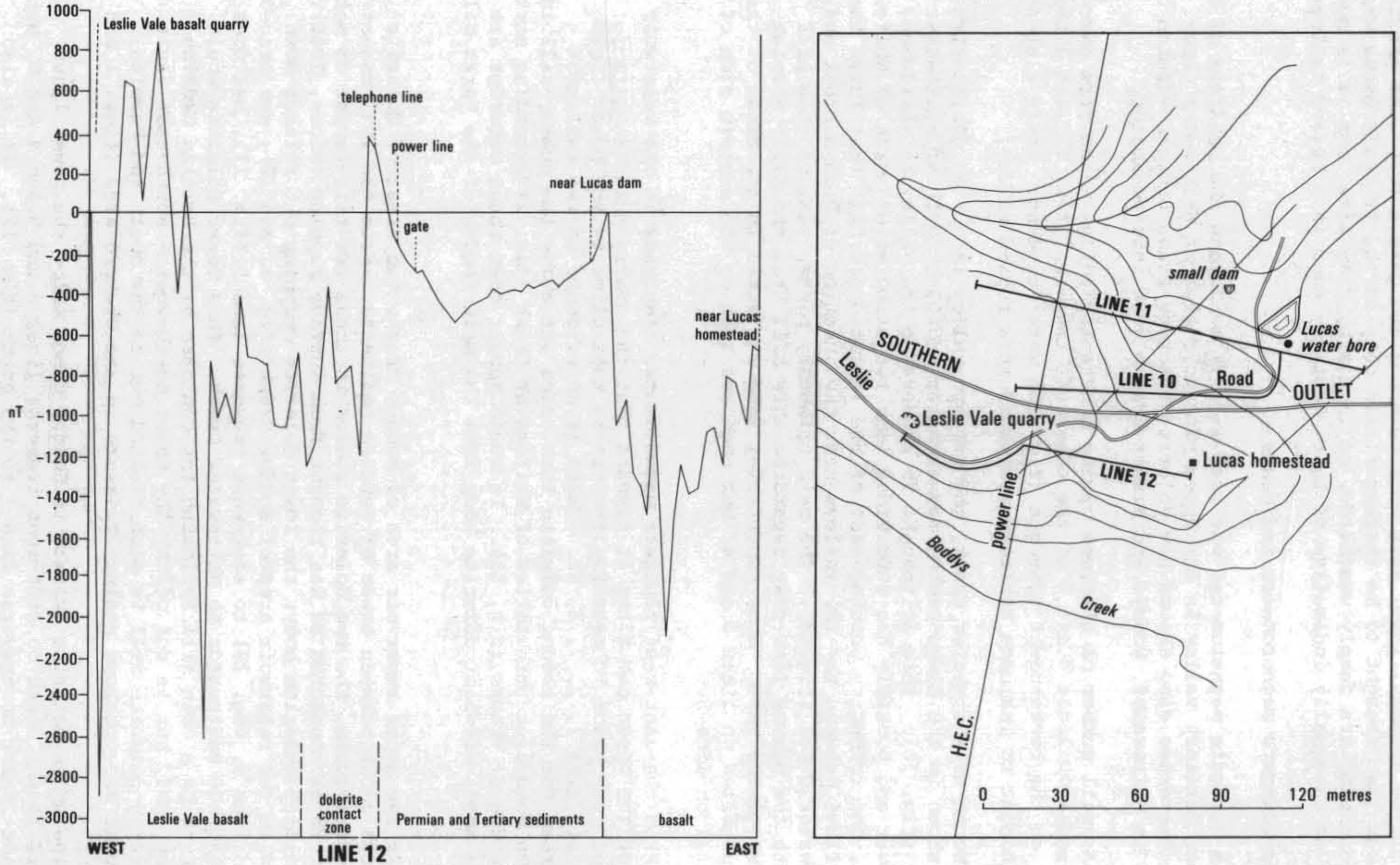

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Figure 13. *Magnetometer survey, Leslie Vale.*

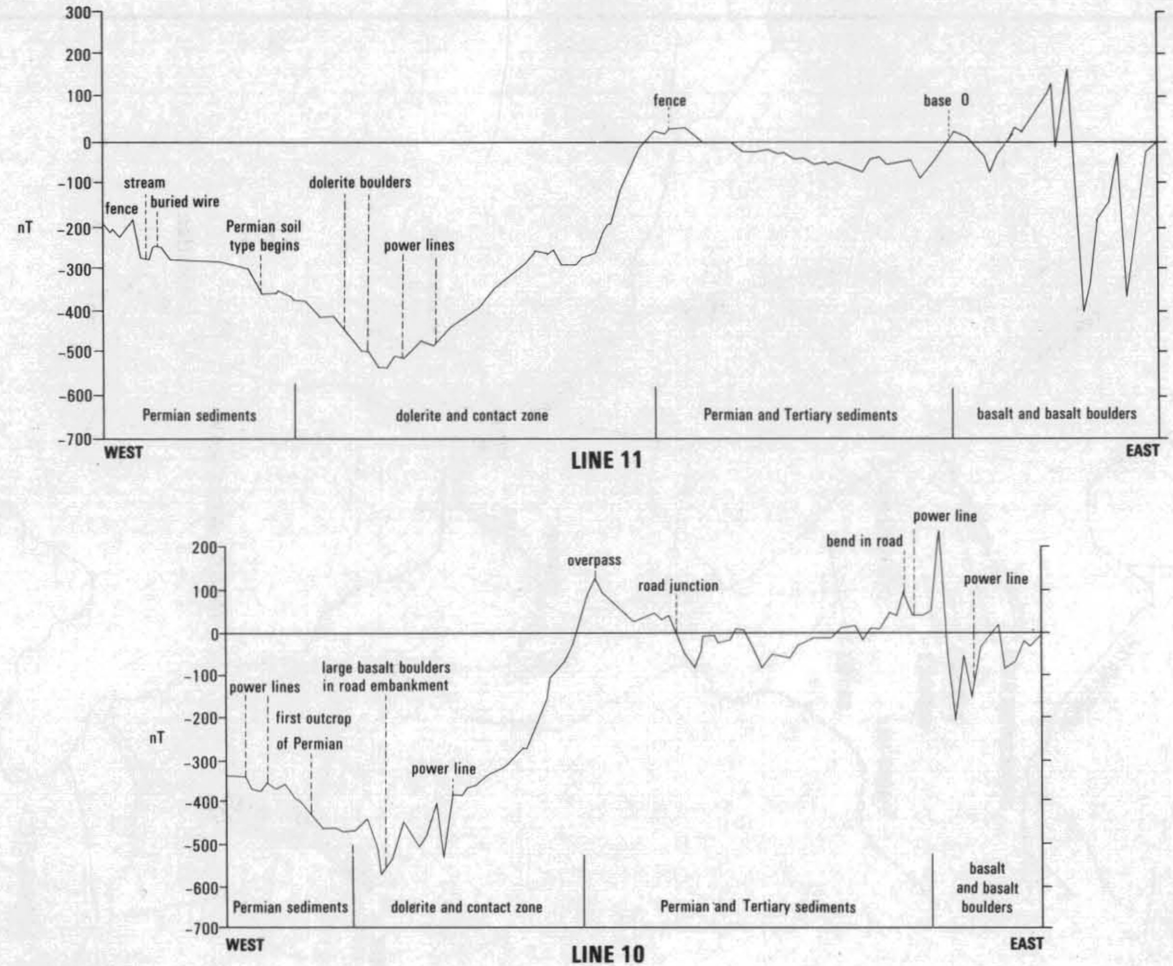

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Figure 13. *Magnetometer survey, Leslie Vale.*

5 cm

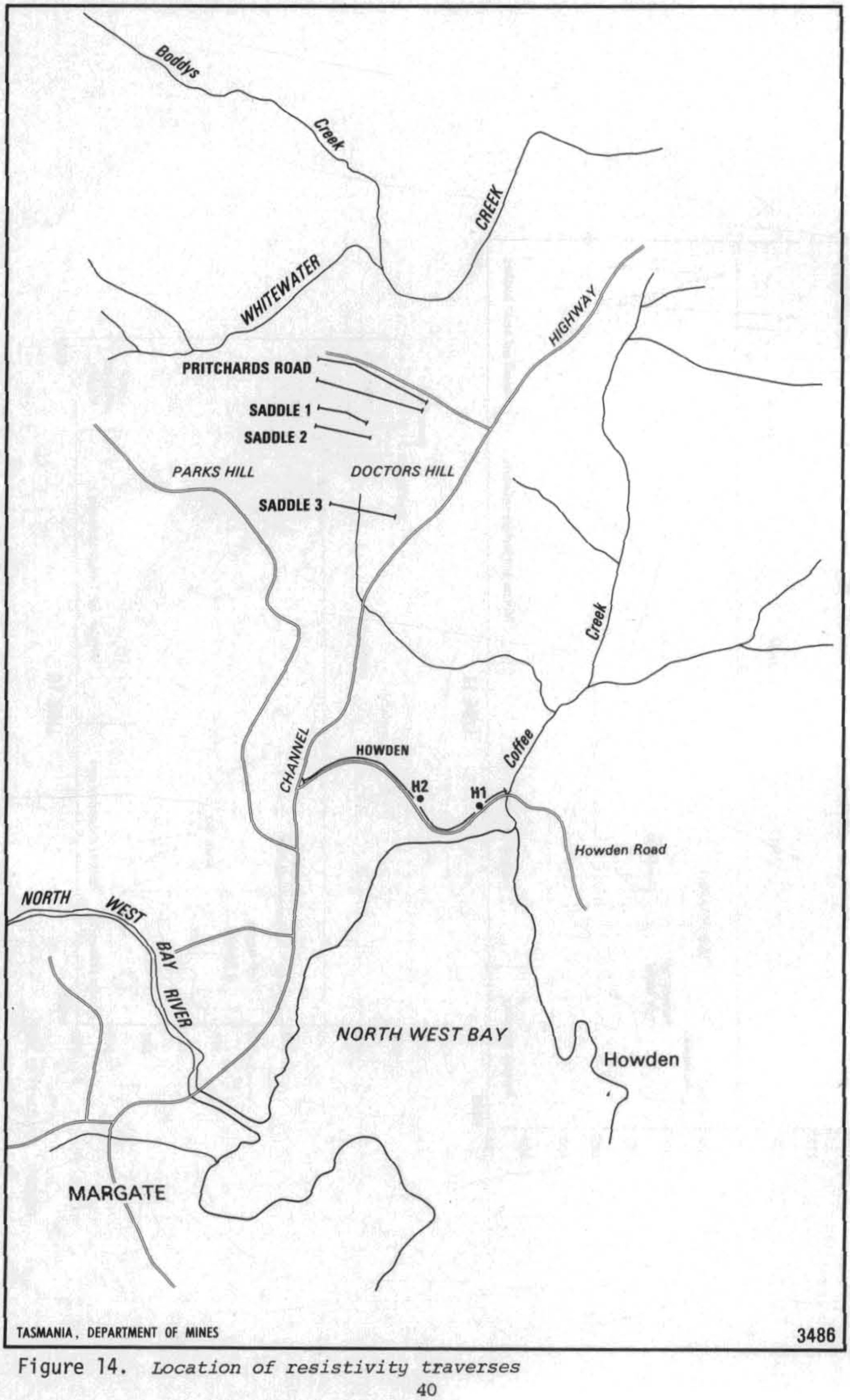


Figure 14. *Location of resistivity traverses*

In an attempt to connect the upper dolerite of Boddys Creek with the dolerite that crops out in Fisher Creek, three magnetometer lines were run across the Leslie Vale Col (fig. 13). It was hoped that these traverses would show the location of a buried valley in this locality, as three poor outcrops of suspected Tertiary sediments in three agricultural dams indicated the likelihood of a valley. On the three profiles, the typical dolerite roughness with the characteristic climb of the profile near the contact with Permian sediments is recognizable. With the exception of the traverse along the crest of the col (line 10, fig. 13), the smaller dolerite anomalies are obscured by the large anomalies or roughness of profile produced by the basalt to the east and west. Because of the nearness of the basalt and presence of basalt boulders on the surface of the col, the Permian and Tertiary areas could not be subdivided satisfactorily on the profiles (fig. 13). The upper dolerite of Boddys Creek was traceable with the magnetometer south to the NNE - SSW trending fault (fig. 11) and northwards to Fishers Creek and is probably an easterly dipping sill within the Permian sediments.

RESISTIVITY TRAVERSES

Two experimental resistivity traverses were undertaken along Pritchards Road (fig. 14). This survey used a Wenner configuration with stations spaced at approximately 15 m intervals with the probes spaced at about 7.5 and 15 m.

An anomaly was apparent on each of the traverses but was more apparent with the closer spacing of 7.5 m (fig. 15). The position of these anomalies coincided reasonably accurately with the known geology. In addition, the two sub-divisions of the Tertiary sediments of the upper site (Moore, 1971) gave contrasting profiles, with water saturated unconsolidated sand and clay giving large anomalies while the cemented sand, clay and gravel of the valley fill sediments gave no anomaly (fig. 15).

The Pritchards Road traverse and the traverse to the south showed that the valley fill sediments were more extensive in the eastern tributary than previously thought, extending some 250 m further to the west.

A parallel resistivity traverse approximately 100 m south of Pritchards Road showed the same contrast between the areas of Tertiary sand and valley fill sediments. However on this traverse, the anomaly produced by the Tertiary sand was considerably dampened. Considerable difficulty was experienced generating enough power in the ground and the dampening of the anomaly was possibly the result of a clayey subsoil known to be close to the surface in this area.

Further traverses were conducted to the south in the Doctors Hill - Little Parks Hill saddle area (fig. 14). Distinct anomalies also occurred in this area, coinciding with the known geology. On saddle traverse 1 (fig. 6), the best recorded of the three saddle traverses, the peak of the anomaly occurs to the east of Hole S2 which penetrated 48 m of Tertiary sand and clay without reaching the valley floor (fig. 8).

Saddle traverse 2 followed the magnetometer and proline drill line 1 of the 1969 investigation. From the anomaly produced by the Tertiary sand on this traverse (fig. 16), the Tertiary valley appears wider than thought in 1969, extending almost to the Permian outcrops on the slope of Little Parks Hill.

Saddle traverse 3 started close to the dolerite dyke at the base of Little Parks Hill and continued across the valley, finishing in basalt boulders and outcrop on the flanks of Doctors Hill. The anomaly and flat area of

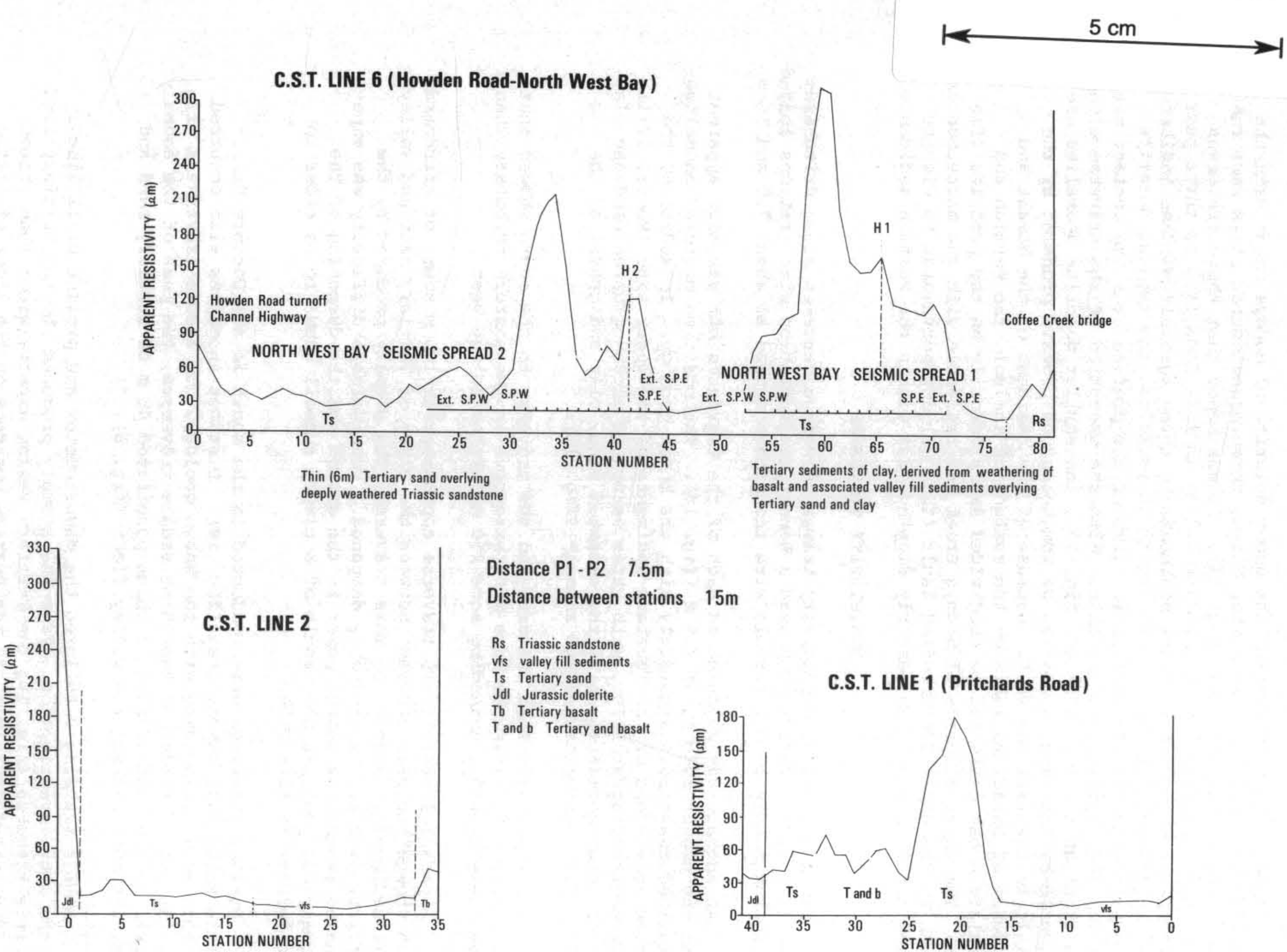


Figure 15. *Resistivity traverses, Pritchards Road and Howden.*

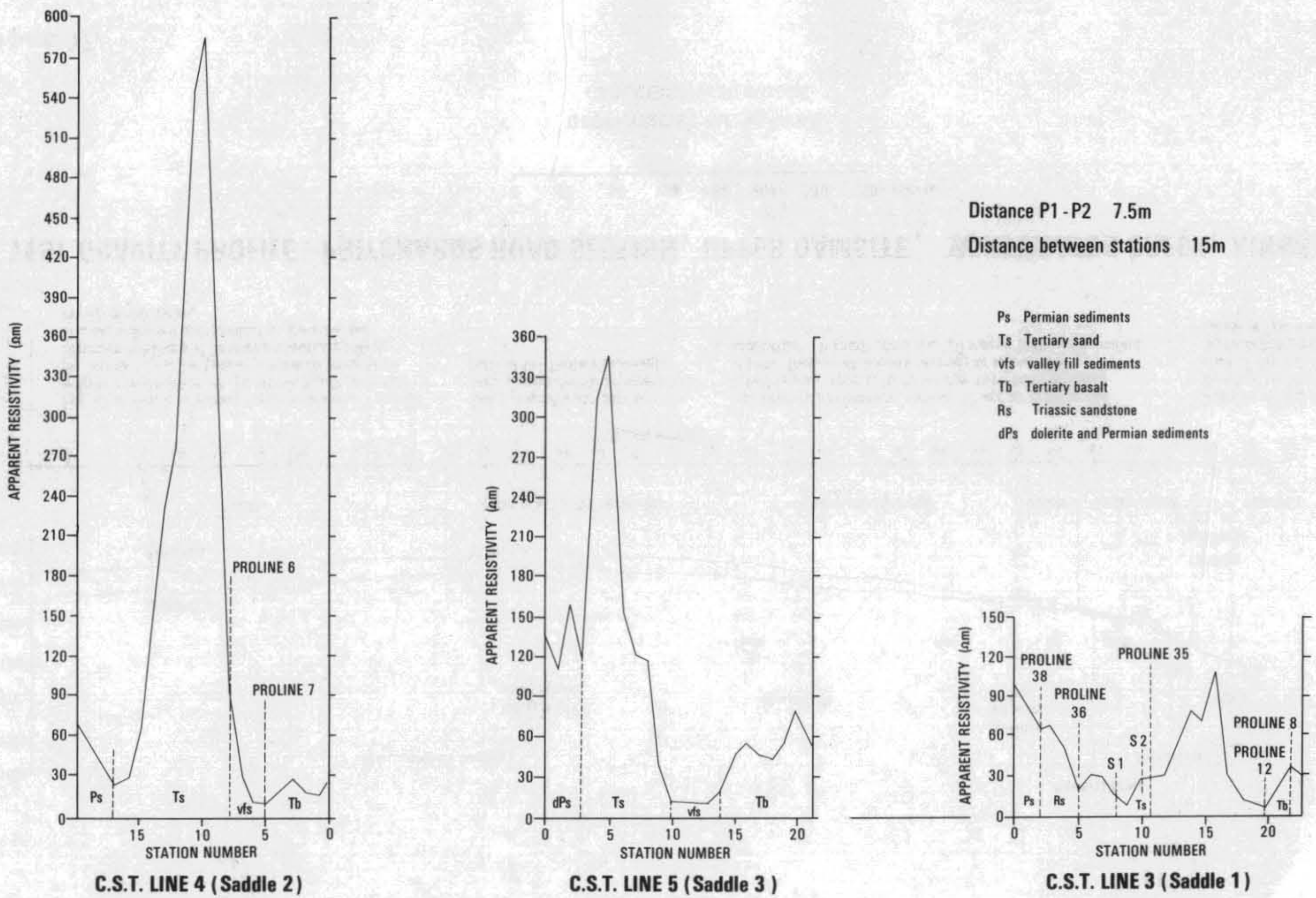
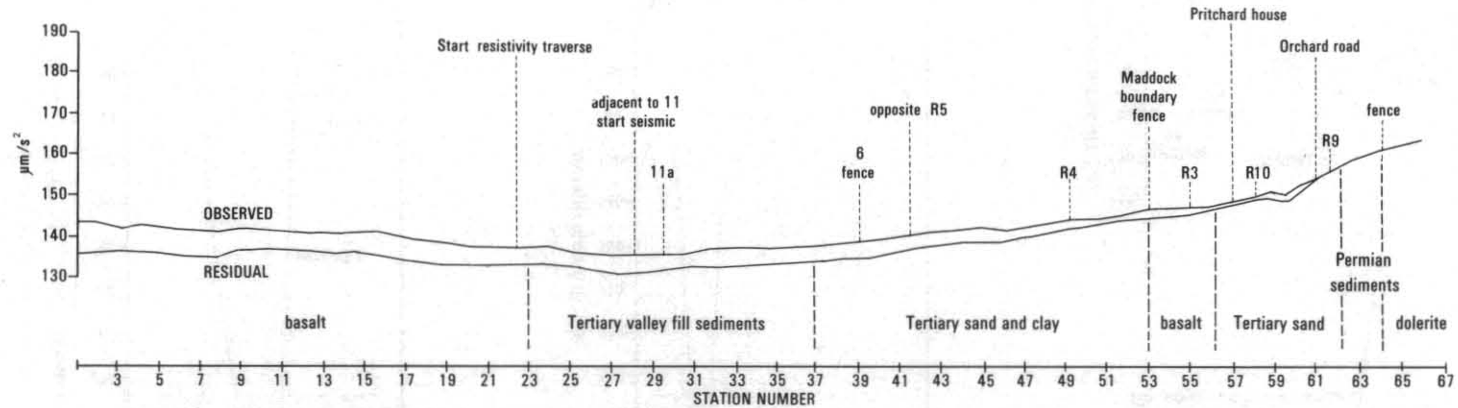


Figure 16. *Resistivity traverses, saddle area*

5 cm



The 50 µm/s² rise in anomaly between stations 1 and 20 reflects a thickness of 10 - 20 metres basalt on or near the section line. The thickness estimate presumes a consistent thickness of Tertiary sediments overlying Triassic rocks and is dependent on the state and density of the basalt.

There is insufficient data over this area to establish the thickness and form of the Tertiary sediments.

The anomaly rise between stations 37 and 59 could be due to two factors: dolerite to the west or thick flows of basalt or both. There is inadequate coverage to resolve the possibilities. If basalt, more than 20 metres thickness is implied.

Anomaly related to dolerite body. Coverage too short to establish scale of the body. Gradient implies thickness in excess of 100 metres

TEST GRAVITY PROFILE : PRITCHARDS ROAD SECTION, UPPER DAMSITE, WHITEWATER CREEK, KINGSTON

0 40 80 120 160 200 240 280 metres

GEOPHYSICIST: D.E. LEAMAN
GEOLOGIST: W.R. MOORE

5 cm

Figure 17.

the profile on this traverse (fig. 16) indicates the presence of Tertiary sand and valley fill sediments beneath this valley. No drilling has been undertaken on this traverse but a water bore 230 m south near the Channel Highway penetrated a minimum thickness of 6 m of sand and clay, presumably Tertiary sediments. Their thickness combined with Tertiary or Triassic sand could be as great as 30 m.

A resistivity traverse was carried out along Howden Road from the Channel Highway to Coffee Creek (fig. 14). The profile of this traverse (fig. 15) showed two peaks separated by a low narrow flat area. The profiles were interpreted as one valley, filled with Tertiary sand separated by a tongue of basalt with associated cemented gravel and clay of the valley fill sequence, giving the low flat area separating the two high anomalies. An alternative hypothesis was that the valley had split into two tributaries filled with Tertiary sand near the shore of North West Bay, giving two separate anomalies.

Seismic spreads were fired across the two anomalies for a cemetery site investigation (Moore, 1973) but the velocities were ambiguous making geological interpretation difficult. After drilling the anomalies on the seismic spreads, it was realized that the resistivity anomalies were probably formed by a single valley filled with Tertiary basalt, associated silcrete and valley fill sediments overlying Tertiary sand and clay sediments. These latter sediments overstep onto the margins of the valley where deep Tertiary weathering occurs on the Triassic sediments forming the valley sides.

GRAVITY SURVEY

While experimenting with the resistivity method along Pritchards Road, a gravity profile was run by D.E. Leaman using the resistivity stations (fig. 17). This located the Tertiary valley and its sediments but was not as definitive as the resistivity method. Consequently, no further gravity profiles were undertaken on the Whitewater Creek leads.

In retrospect, this method was not used to its full effectiveness during this dam site investigation. In 1967 (Leaman, 1968), the gravity method was applied to a particular geological problem instead of being used for a regional coverage of dam site and reservoir areas for general and background information. This information would possibly have indicated where particular problems may have arisen in such an area where there was poor outcrop.

Following information gained by regional mapping (Leaman, 1972), the results gained in the gravity survey have been reinterpreted (Appendix 1).

REFRACTION SEISMIC SURVEYS

Reinterpretation of 1969 quarry survey

In 1969, an area of low velocities (750-1100 m/sec) was found in spreads fired near the foot of the hill near the quarry site. This area of low velocity caused considerable concern and was thought to be the result of dolerite talus at the bottom of the slope and fault crush along the fault known to be present between the Triassic and Permian rocks near the foot of the hill (Moore, 1971).

No spreads were fired along the flat area at the base of the hill in the original survey so an extra spread was fired late in 1969. This spread was fired on the southern end of the quarry grid and gave asymmetrical

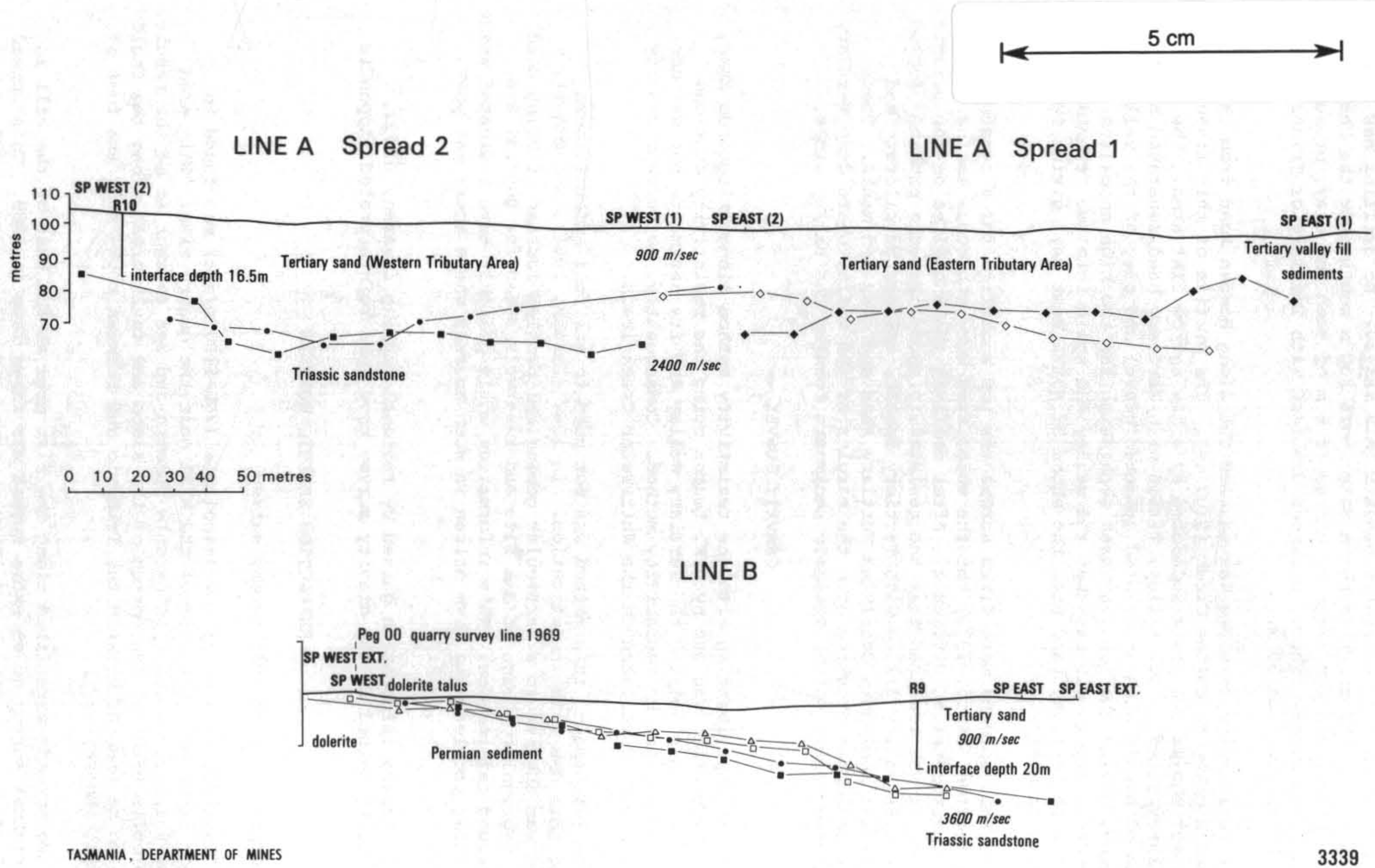


Figure 18. *East-west seismic survey*

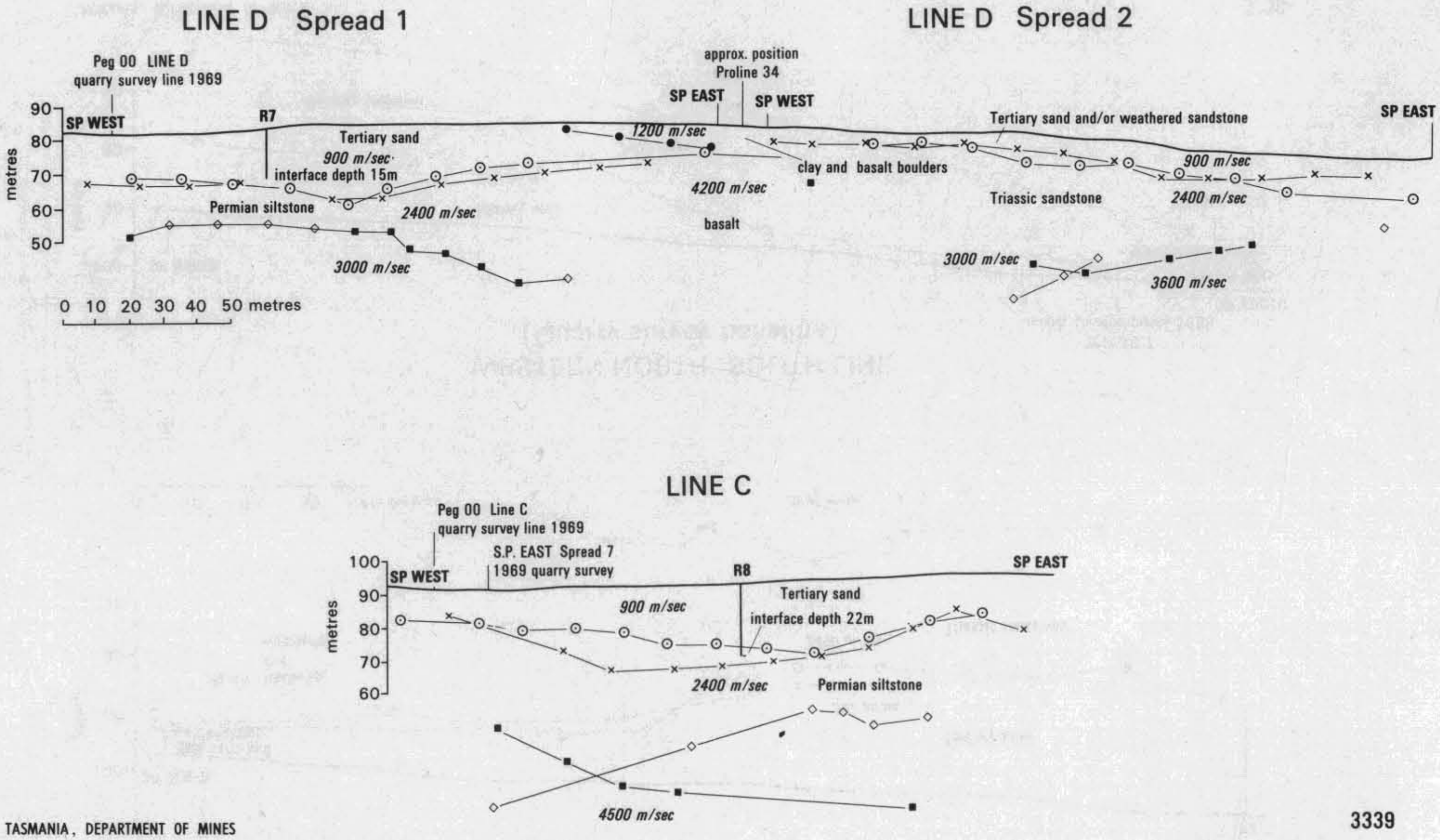


Figure 18. *East-west seismic survey*

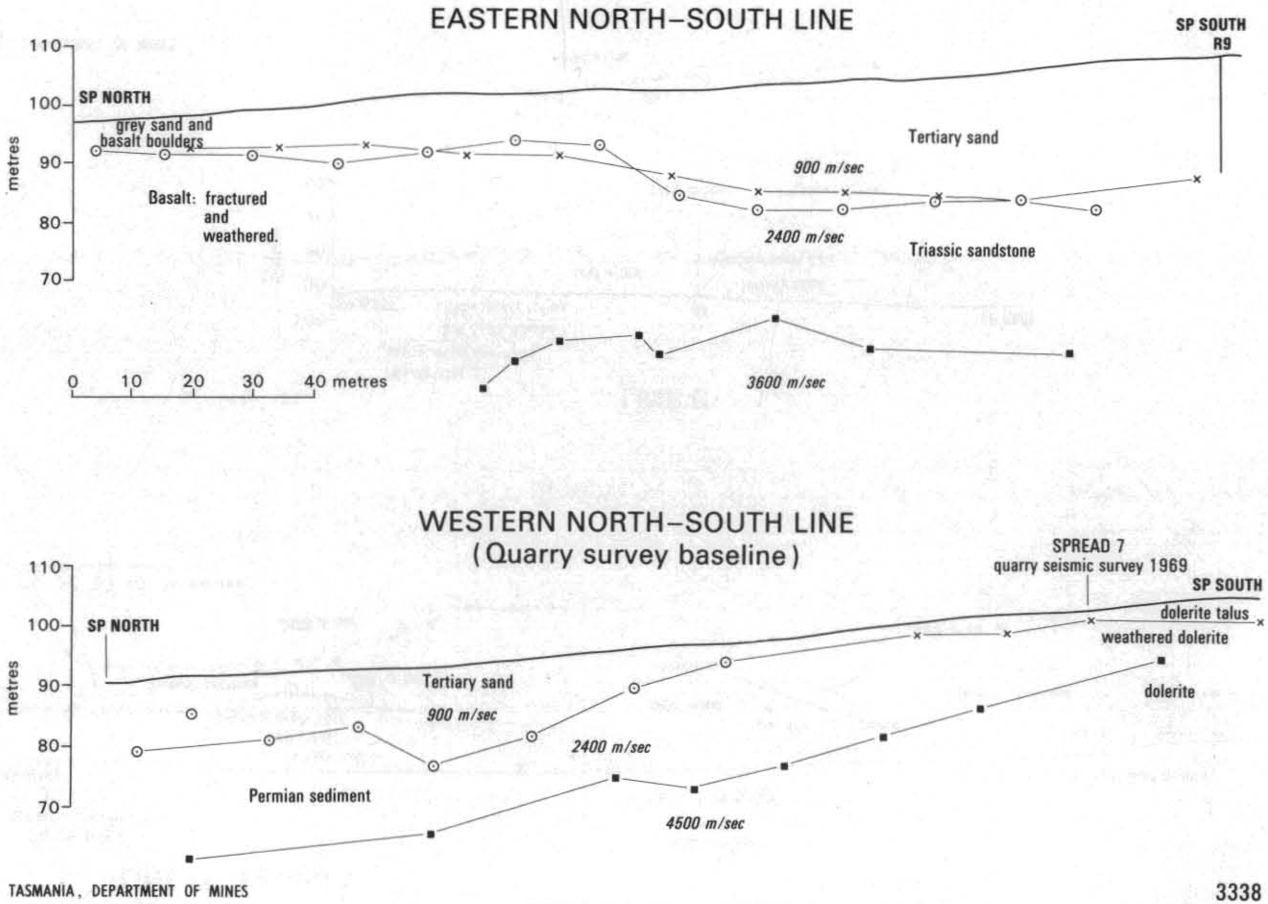


Figure 19. *North-south seismic survey*

5 cm

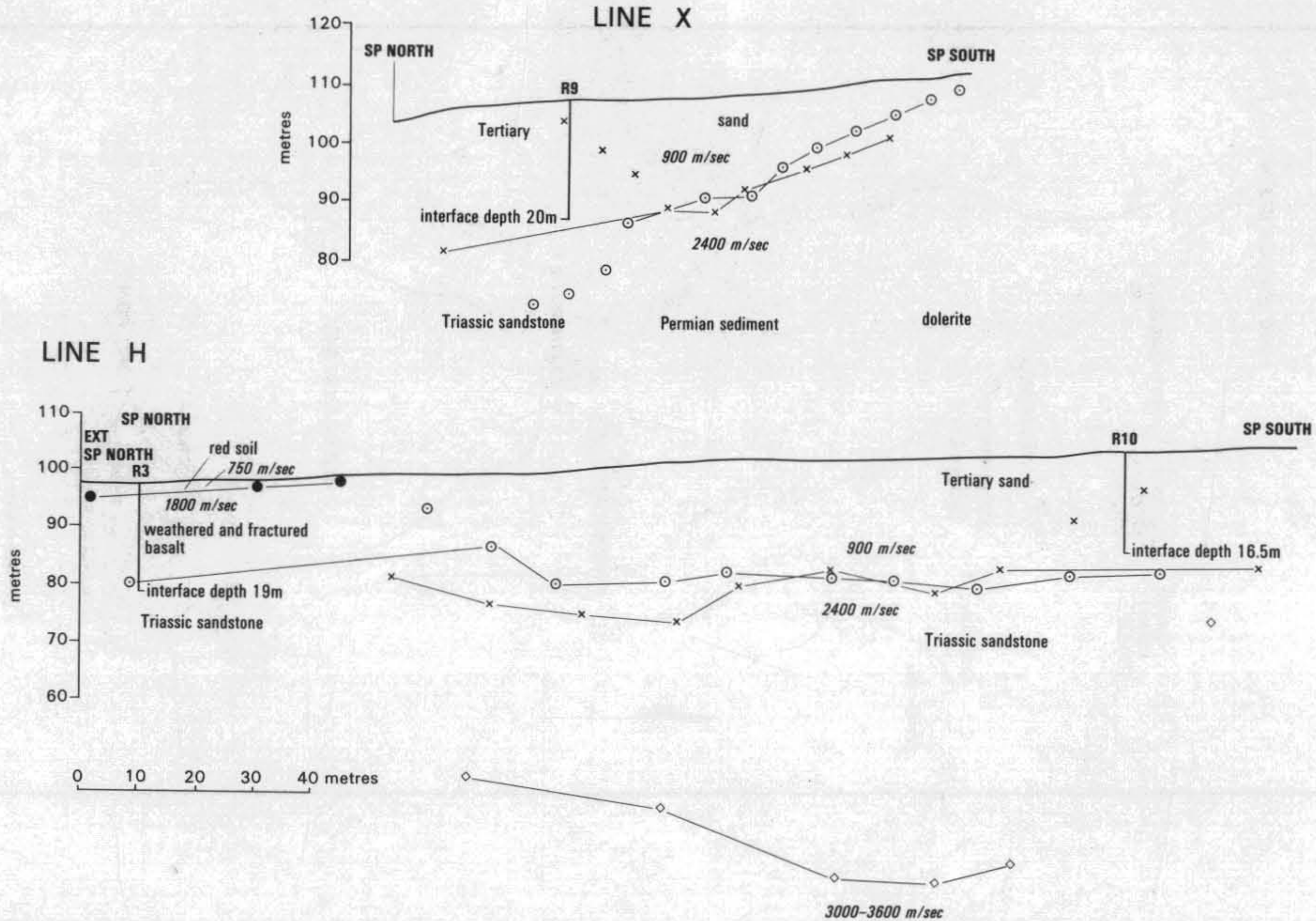


Figure 19. *North-south seismic survey*

5 cm

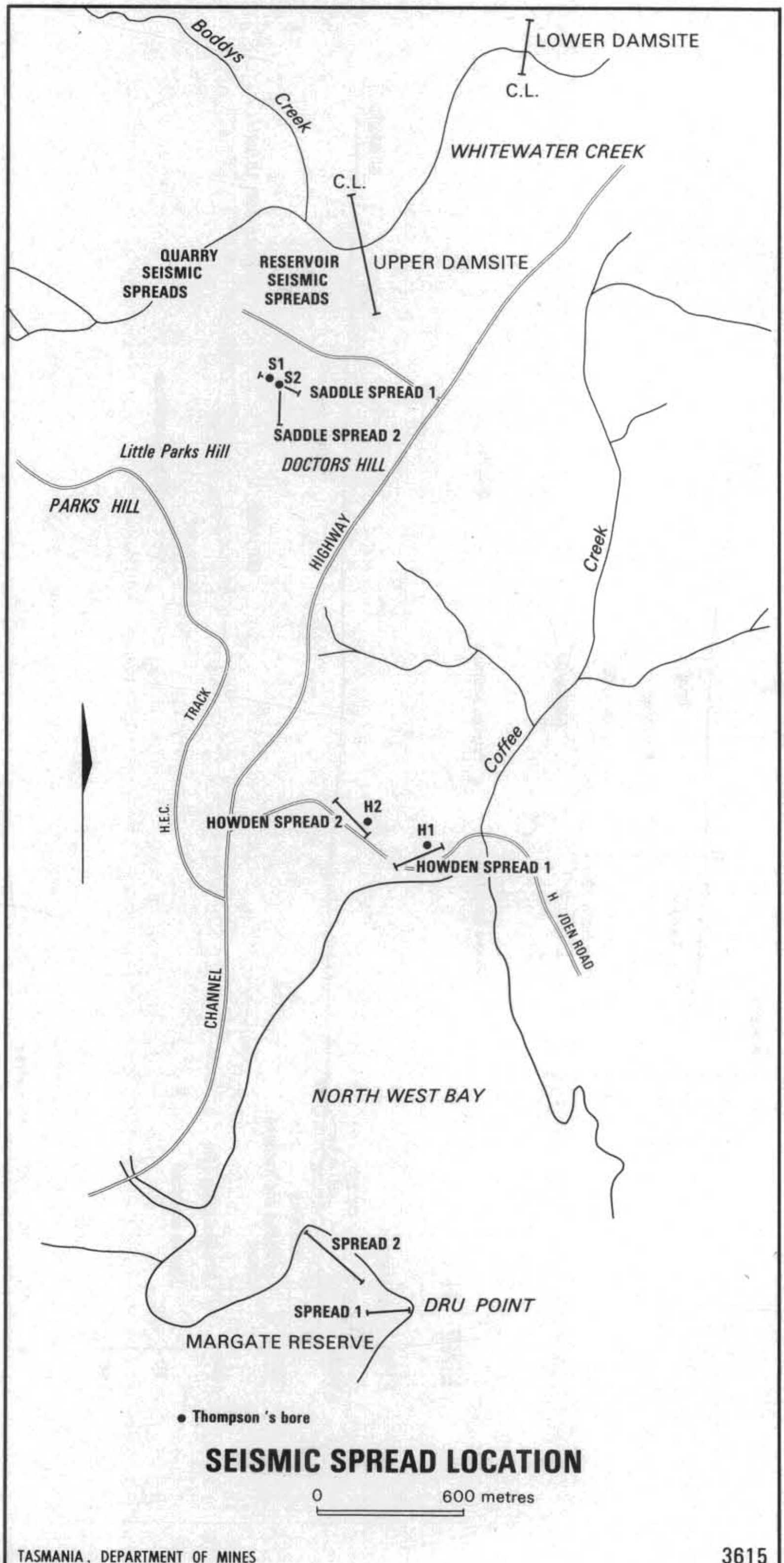


Figure 20.

5 cm

velocity curves and is now known to have crossed from dolerite onto Permian sediments and then Tertiary sand and clay of the valley sediments (line B, fig. 18). If the northern end of the original quarry grid had been selected in 1969, the entire spread would have been fired in Tertiary sand and clay (line D, fig. 18).

Even though the geological interpretation of 1969 for this area of low velocities was incorrect, it was from this survey that it became possible to warn of the possibility of a western tributary to the Tertiary buried valley and its probable position (Moore, 1971).

Upper dam site reservoir survey, 1970

This survey was an eastern extension of the quarry seismic investigation of 1969 into the orchard area of the upper reservoir (fig. 9). The original north-south quarry survey base line B was used as a base line for the seismic grid of 1970. Three east-west spreads and two north-south spreads covered the area in which the western tributary of the Tertiary valley was thought most likely to pass between the orchard basalt and quarry seismic investigation of 1969. Because difficulties were experienced in drilling some shot holes on the eastern section of the grid, some shot points ended in the basalt.

On firing this grid, a thick surface layer with a constant low velocity of 1000 m/sec was apparent; this was thought to be Tertiary sand and clay of a western tributary of the Tertiary valley. Further north-south spreads were fired on Line X and Line H in order to trace the valley south to Pritchards Road (fig. 19). Line A, with two east-west spreads, was fired south of Pritchards Road to see if the western valley joined the eastern valley south of the southern abutment of the upper dam site (figs 1, 18, 19).

An east-west spread was fired on Line D from the basalt into the Triassic towards the dam site centre line in an attempt to see if any other Tertiary valley was present below the basalt breaching the Triassic rock barrier between Hole R1 and Hole R5 in the orchard area (Moore, 1971).

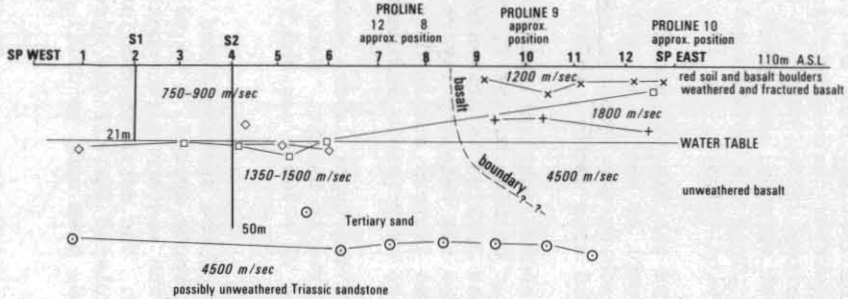
With the exception of Line B, all spreads showed constant velocities of V_0 = 1000 m/sec and V_1 = 2400 m/sec (fig. 18). On Line B, the V_1 velocity was 3600 m/sec. The west shot point of Line B was drilled in near-surface unweathered dolerite and the interface between the two velocity layers had a strong upward slope towards the west. These two factors combined to make the V_1 velocity artificially high for Permian or Triassic sediments.

The only other differing velocities for the two upper layers were in the reservoir spreads where the shots had been fired in basalt. Here velocities of V_0 = 1200 m/sec and V_1 = 4300 m/sec and V_0 = 760 m/sec and V_1 = 1800 m/sec were recorded on Line D and Line H.

A third velocity layer was apparent in six of the spreads fired in the reservoir area. On Line D and the eastern north-south spread, a V_2 velocity of 3000-3600 m/sec was recorded. On Line C and the western north-south spread, a V_2 velocity of 4500 m/sec was recorded. The depth of the interface between the second and third layer was calculated for all the spreads where a third velocity appears, but no attempt has been made to drill or interpret this third layer.

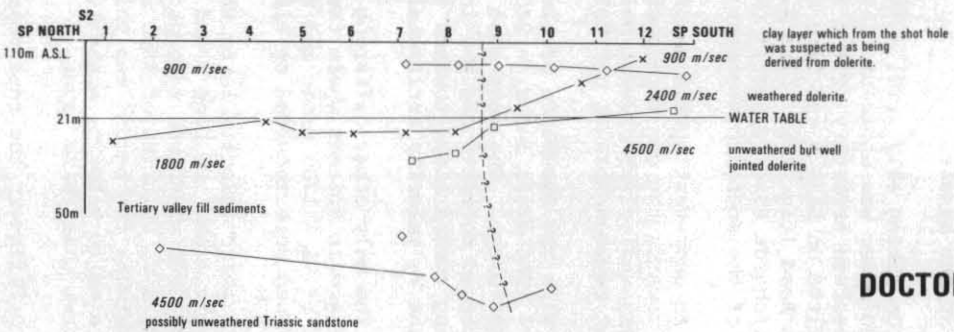
Drilling in the reservoir area showed that the V_0 layer was Tertiary sand and clay and the V_1 layer was Permian or Triassic sediments. The average depth error was 1.5 m between the calculated and actual interface depth for the four holes drilled.

SADDLE SPREAD 1



1 2 3 Geophone position and number.
SP Shot point position.
\+ Calculated shot point depth.
⊙——⊙ Depth of velocity layer calculated by time–delay method.
×——× Depth of velocity layer calculated by time–depth method.

SADDLE SPREAD 2



SADDLE AREA
DOCTORS HILL AND LITTLE PARKS HILL

0 30 metres

Figure 21.

5 cm

Doctors Hill-Little Parks Hill saddle area survey

Drilling in 1969 in the Doctors Hill-Little Parks Hill saddle did not reach the valley floor after drilling to depths of 21 m and 49 m in Tertiary sand and clay (Moore, 1971, p. 125-127). An east-west and a north-south seismic spread were fired in this locality (fig. 20) in an attempt to find the depth of this valley using the drill holes as control (fig. 8). However it was not possible to reach the valley floor refractor whilst keeping the spread confined to the limits of the sediments of the Tertiary valley.

In the east-west spread, some of the geophones were on basalt and the east shot point was in a heavy red clay soil containing basalt boulders. The west shot point was in Tertiary sand but was close to the valley wall. Similarly, in the north-south cross spread, the southern shot point was located close to a dolerite dyke in order to obtain the necessary distance. These physical limitations made the interpretation controls not as tight as would ideally be required.

In the eastern section of the east-west spread (fig. 21), a surface layer with a velocity of V_0 = 760-1000 m/sec overlay an intermediate layer with V_1 = 1400-1500 m/sec. The calculated V_0/V_1 interface was between 21 and 27 m, a depth which closely approximates the water table level found in the two saddle drill holes. A third layer with velocity V_2 = 4500 m/sec was recorded. The V_1/V_2 interface was calculated at 53-58 m. This interface is thought to be the valley floor separating the Tertiary sand from the underlying sediments, presumably Triassic sandstone. The velocity of 4500 m/sec is high for Triassic or Permian sediments and is more akin to the velocities of unweathered basalt and dolerite. However from the 1969 magnetometer traverse across the saddle, there is no evidence for the presence of either basalt or dolerite in this area.

On the western end of the east-west spread (fig. 21), an upper layer with a velocity V_0 = 760-1000 m/sec overlying a second layer with V_1 = 1800 m/sec overlying a third layer with V_2 = 4500 m/sec was recorded. The upper two layers lens out to the west approximately 60 m from the shot point and their interface depth is at approximately 3 m. This surface layer is thought to be a subsoil horizon of red clay with basalt boulders overlying deeply weathered and fractured basalt. The depth to the second interface is 15-18 m and this is thought to be unweathered basalt as exposed on Doctors Hill.

At the northern end of the north-south cross spread, the three layers were present and had similar velocities to the eastern section of the east-west spread at this locality (fig. 21). The depth of the two interfaces in this section of the north-south spread approximates those of the east-west spread except that the lower interface, thought to be the valley floor, slopes from 64 to 76 m towards the south.

The geological interpretation of the three velocity layers is as given for the east-west spread in the saddle area, with the exception of the southern end of the north-south spread. Here, a middle layer with a velocity of V_1 = 2400 m/sec was recorded. The surface layer (V_0 = 1000 m/sec) is thinner with the V_0/V_1 interface averaging 9 m depth compared with 27 m for the remainder of the spread. The V_1/V_2 interface lies between 21 m and 24 m whereas at the northern end of the spread, the V_1/V_2 interface is at 64-76 m.

It is difficult to believe that the unconsolidated sand and clay of the saddle bore holes form this intermediate layer with V_1 = 2400 m/sec in the southern end of the north-south spread. It is more likely that this is weathered dolerite overlying fractured well jointed dolerite giving a

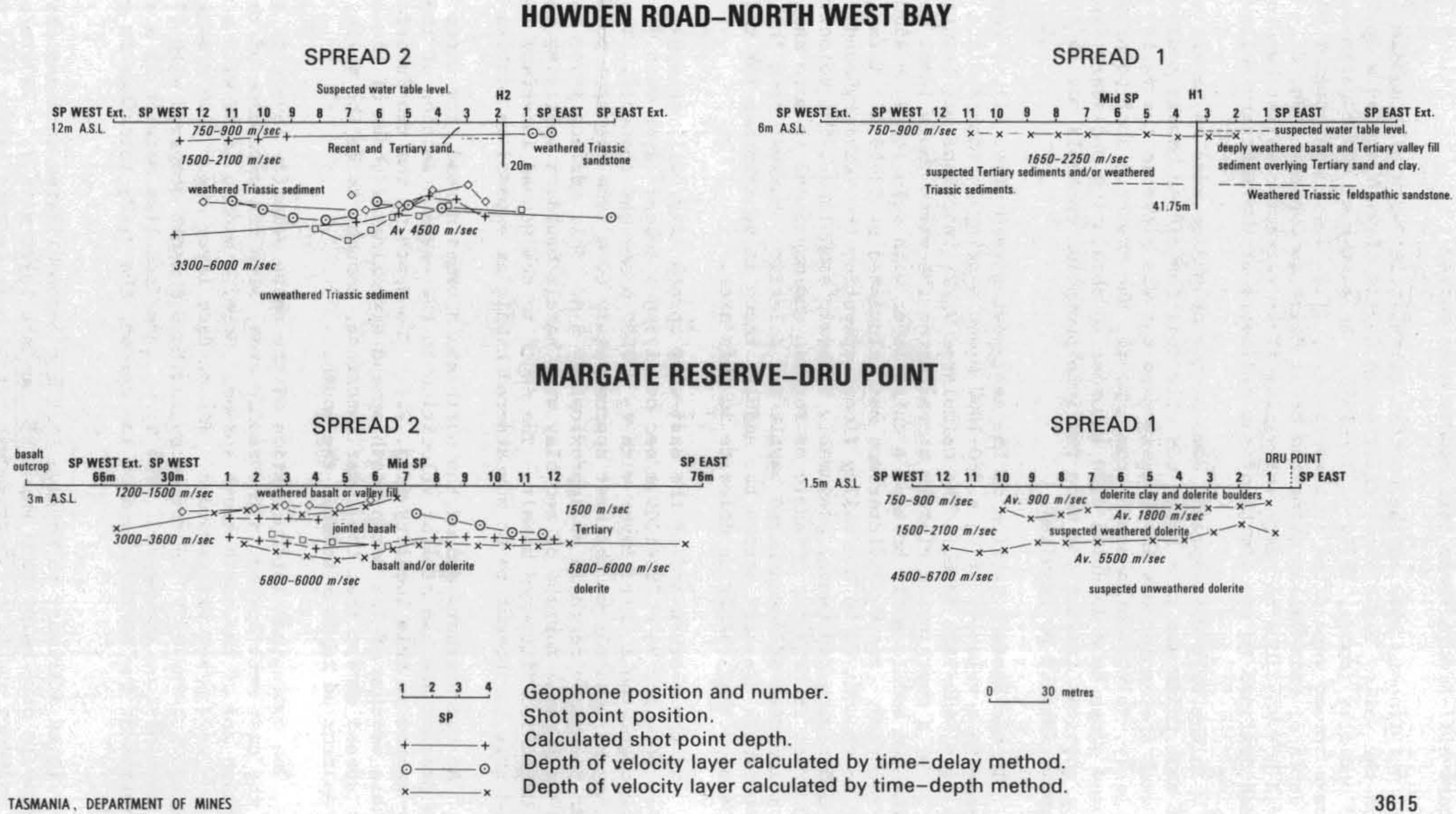


Figure 22. *Seismic surveys, Howden Road-North West Bay and Margate Reserve-Dru Point*

velocity of up to 4500 m/sec. The surface layer with a velocity of 1000 m/sec is probably dolerite derived clay containing a few dolerite boulders, as was observed in the southern shot holes. This interpretation questions the suggestion from the surface mapping that this dolerite is only a dyke (Moore, 1971).

Howden Road spreads

Two seismic spreads were fired on the resistivity anomalies along Howden Road (fig. 20). Velocities in these spreads were similar to those found in the saddle area (figs 21, 22).

The velocities recorded were:

Howden Spread 1

V_0 = 760-1000 m/sec
V_1 = 1600-2300 m/sec

V_0/V_1 = 6 m

Howden Spread 2

V_0 = 760-1000 m/sec
V_1 = 1500-2100 m/sec
V_2 = 3350-6000 m/sec

V_0/V_1 = 5.5-8.5 m
V_1/V_2 = 40-50 m calculated on an average velocity of 4500 m/sec.

In Howden Spread 2, the V_1/V_2 interface sloped to the east.

The geological interpretation of these spreads was thought to be a surface layer of 6 m of Recent and Tertiary sand, overlying an intermediate layer of weathered Triassic sandstone which overlies a third layer of unweathered Triassic sandstone at a depth of 40-50 m in Spread 2. With this interpretation, it was difficult to understand such a deep zone of weathering (over 30 m) in the Triassic sediments in Spread 2, with even deeper weathering in Spread 1, where the V_1/V_2 interface was not reached.

The alternative hypothesis was that the surface layer of V_0 = 760-1000 m/sec was Tertiary sand above the water table, with the second layer of V_1 = 1600-2300 m/sec being Tertiary sand and clay below the water table level in a valley with Triassic sandstone forming the valley floor. The difficulty with this interpretation was that velocities of 2100-2300 m/sec are high for Tertiary valley sediments and at the time of the cemetery investigation (Moore, 1973) the water table appeared at ground level.

Because of the ambiguity of the interpretation, the two seismic spreads were drilled in 1971 (fig. 22). This drilling confirmed the position of the Tertiary valley and also gave important Tertiary stratigraphic information. In Howden Hole 1, the three units of the Tertiary of the Whitewater Creek dam sites (Moore, 1971) were found together in the one bore hole and in stratigraphic order for the first time.

The sequence in Howden Hole 1 was Quaternary sand overlying deeply weathered basalt followed by associated valley fill sediments of cemented gravel, breccia, baked clay and agglomerate which in turn overly unconsolidated Tertiary sand. The Tertiary valley had been eroded in Triassic sandstone which was weathered to a depth of 3 m.

The establishment of this Tertiary sequence makes the geological interpretation of the southern abutment area of the upper dam site on Whitewater Creek simpler, especially between Holes 11*a* and 11*b* and between Hole 11 and the Proline Hole 2 (Moore, 1971, p. 124-125*). There is no need for a second fault and Proline Hole 2 is now considered to mark the boundary of the Tertiary valley in this region (figs 1, 7). In Howden Hole 2, 300 m to the west, the sequence encountered had changed and thinned, with 3 m of grey sand and sandstone of Cainozoic age overlying 3 m of white unconsolidated quartz sand and soft sandstone. This sand and sandstone is lithologically similar and correlated with the Tertiary unconsolidated sand and sandstone sequence found in the bores on Doctors Hill saddle and in the southern abutment of the upper dam site on Whitewater Creek. The Tertiary sand rests on deeply weathered Triassic sediments, comprising clay, mudstone and sandstone to a depth of 11 m which is followed by weathered feldspathic sandstone and micaceous mudstone to a depth of 16 m.

Between Howden Hole 1 and Howden Hole 2, the Tertiary basalt and the valley fill sedimentary sequence have lensed out and the unconsolidated sand has overlapped onto the deeply weathered Triassic sandstone. Presumably this deep weathering of the Triassic sediments is of Tertiary age. Deep weathering also occurs in the Triassic sandstone and mudstone in the brick pits in the reservoir area of the lower dam site on Whitewater Creek and in an exploration pit dug into the Permian siltstone in the 1969 investigation in the upper reservoir (Moore, 1971, figs 36, 37). Both of these localities are close to where the Tertiary valleys are now thought to be present.

Margate reserve - Dru Point spreads

Two east-west spreads were fired on the Margate reserve at Dru Point (fig. 20). The area covered by the two spreads has no outcrop and lies between the basalt exposed on the western shore platform of the reserve and the dolerite cropping out on the eastern shore at Dru Point (fig. 5).

The velocities recorded on Spread 1 (fig. 22) were:

Velocity (m/sec)	*Depth of interface (calculated on average velocities)*
V_0 = 7600-1100	V_0/V_1 9-15 m
V_1 = 1500-2100	V_1/V_2 23-33.5 m
V_2 = 4500 (west end)	
6700 (east end)	

The different velocities at each end of this spread indicate a strong slope to the west from Dru Point where dolerite crops out. Both interfaces in this spread also slope west.

The surface layer of this spread is thought to comprise clay, derived from the weathering of dolerite with some dolerite boulders, overlying river terrace gravel. Such gravel is exposed along the northern shore of Dru Point and caps the low cliffs to the west around the North West Bay River (fig. 5), where the maximum exposed thickness is 3-3.6 m. The intermediate layer is interpreted as deeply weathered and jointed dolerite and the third layer as unweathered dolerite.

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*The sentence on line 8, p. 124 should read 'Bore hole 11*b* passes through a simple uncomplicated fault pattern.'

Spread 2 showed differing velocities at either end of the spread, with three velocity layers recorded on the western section while only two were recorded in the eastern section.

The velocities recorded were:

WESTERN SECTION

Velocities (m/sec)	*Depth of interface*
V_0 = 1200-1500	
V_1 = 3000-3600	V_0/V_1 = 10-15 m
V_2 = 5800-6100	V_1/V_2 = 21-24 m

EASTERN SECTION

V_0 = 1500	
V_1 = 5800-6100	V_0/V_1 = 27-30 m

From the information obtained from firing in the middle of the spread, the intermediate layer of 3000-3600 m/sec velocity of the western end of the spread wedges out to the east.

The geological interpretation for this spread is that in the western end, the upper layer is deeply weathered basalt. Such a basalt, which has weathered to a grey clay with residual flow patterns and vesicles with associated red clay containing deeply weathered and decayed basalt boulders, crops out on the cliff line immediately south-west of this spread (fig. 5). The intermediate layer in the western end of the spread is unweathered but well jointed basalt.

The third layer with very high velocities of 5800-6100 m/sec is unlikely to be Permian sediment and is possibly either unjointed dolerite or basalt.

At the eastern end of the spread, the thick surface layer with a velocity of 1500 m/sec is thought to be Tertiary sand, clay and soft sandstone, all of which crop out along the cliff line west of Dru Point (fig. 5). These sediments are thought to be Tertiary valley sediments and are calculated to be 27-30 m thick. The valley appears to be cut into or bounded by rock giving velocities of 5800-6100 m/sec. This is interpreted as dolerite.

It is possible that the surface layer of 1500 m/sec at the eastern end of Spread 2 does not lense out as shown on Figure 22, but continues below the higher velocity intermediate layer or even the third layer at the western end of the spread; this could not be traced seismically because of the velocity inversion. This velocity inversion would most likely occur if the third layer at the western end of Spread 2 was basalt. The presence of a Tertiary valley would not be detected by using refraction seismic methods.

In 1964, a water bore was drilled by the Department of Mines approximately 750 m south-west of the seismic lines. This penetrated 13.7 m of clay followed by clay and ironstone gravel from 13.7-16.7 m with mudstone from 16.7-29.8 m. Casing was used to 14 m in this hole, indicating that the top 17 m were unconsolidated Tertiary sediments.

Permian mudstone and siltstone crops out on the western end of the cliff line of the North West Bay River and is thought to form the western edge of a Tertiary valley. It is difficult to visualise the Permian sediments exposed on this cliff line having a seismic velocity of 5800-6100 m/sec and thus forming the valley floor, or even the 3000-3600 m/sec velocity of the intermediate layer found at the western end of Spread 2 at the Margate reserve.

Plate 3. *Edge of infilled Tertiary valley cut into Triassic sediment, Southern Outlet.*

Therefore it appears unlikely that the valley floor was reached at the western end of this spread. The position of the valley on its eastern side is probably controlled by the dolerite at Dru Point, as occurred in the Doctors Hill saddle area and in the orchard area of the upper dam site of the Whitewater Creek buried valley system (fig. 23).

It appears likely that the valley at Dru Point is connected with the valley at Howden Road, but this requires confirmation by a seismic spread across North West Bay.

Southern Outlet - Leslie Vale

A series of spreads were fired for the Public Works Department along the proposed route of the Southern Outlet between Kingston and Longley (Stevenson, 1973). Only one of these seismic lines, that along the saddle between Fisher and Boddys Creek (Leslie Vale col) showed any thickness of possible Tertiary sediments. Of the three spreads fired along this saddle, only the eastern spread is not now exposed in road cuttings. This spread was fired below the H.E.C. high voltage transmission lines and showed a 4.5-9 m thick surface layer with a velocity of 1000 m/sec. This layer is thought to be Tertiary sediments overlying a second layer with velocities from 2300-2600 m/sec, which is interpreted as Permian mudstone and siltstone as exposed in the road cutting to the west.

Poor exposures of Tertiary clay occur in an underpass near the Mount Pleasant homestead, 230 m east of the seismic spread and appear to be present in a small dam west of the homestead (fig. 2). Tertiary sand is exposed in a small dam situated below Leslie Vale Road. This sand is lithologically similar to the Tertiary sand found in bore holes in the reservoir area of the upper dam site and at Doctors Hill saddle.

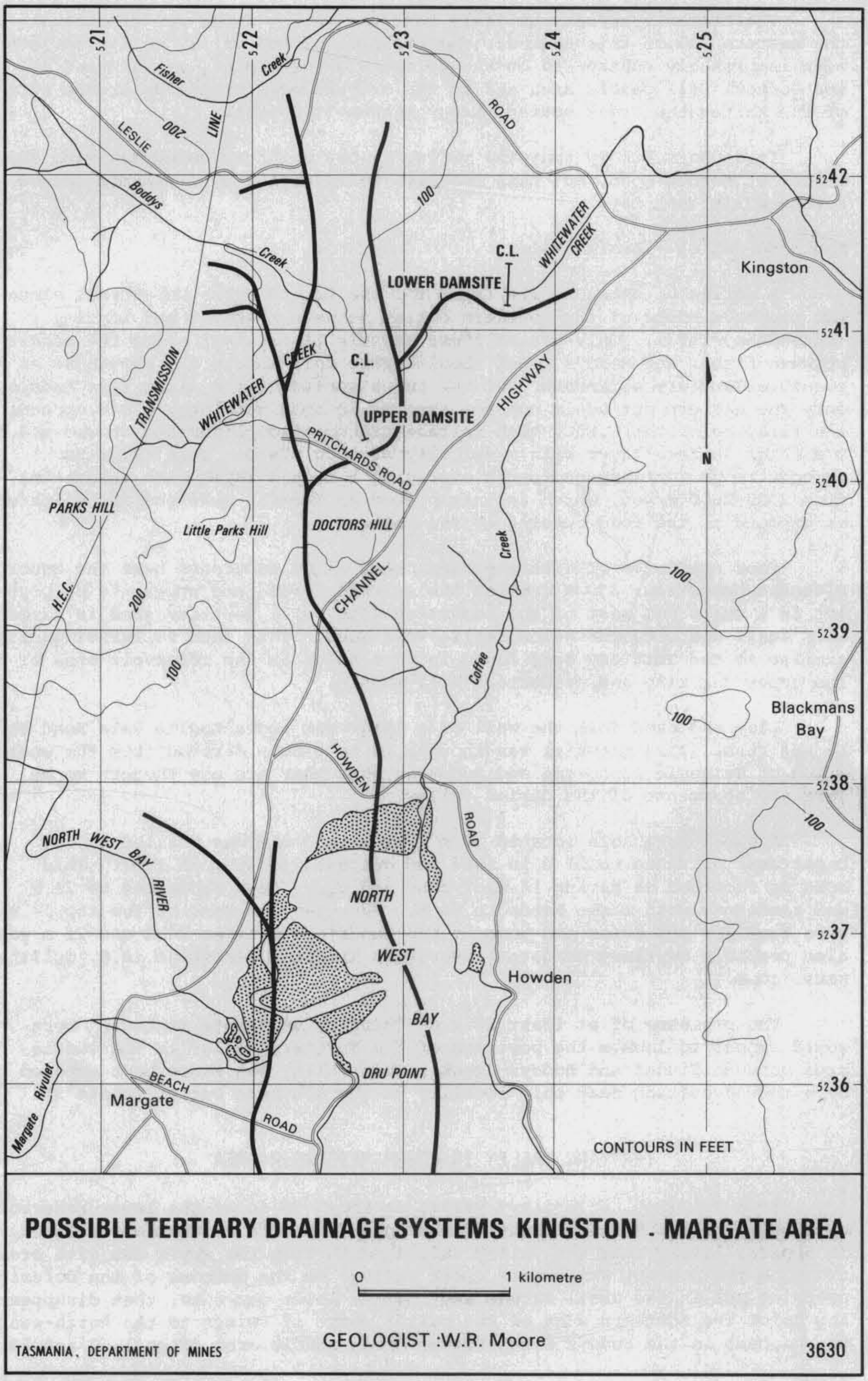
Clay and sand form the wall of a large dam above Leslie Vale Road on Lucas' farm. This material was thought to have been derived from the weathering of Triassic sandstone and mudstone, but they are now thought to be Tertiary sediments of the buried valley.

A water bore hole located 30 m from Lucas' dam was drilled by the Department of Mines to 21 m in 1962 and deepened to 46 m in 1967. This bore is recorded as having 14 m of sand and clay, then sandstone to 21 m and sandstone with shale bands to 46 m. The clay and sand of the top 14 m were Tertiary sediments and some of the sandstone between 14 m and 21 m was also probably Tertiary sandstone overlying Triassic sandstone (A.B. Gulline, pers. comm.).

The presence of at least 14 m of Tertiary sediments in Lucas' bore would appear to locate the position of the Tertiary valley in the saddle area between Fisher and Boddys Creek. This valley has since been exposed by a recent cutting near this locality on the Southern Outlet (plate 3).

TERTIARY VALLEY IN LOWER RESERVOIR AREA

From drilling, a Tertiary valley is known to enter the lower reservoir area near the southern abutment of the upper dam site on Whitewater Creek. It appears likely that the valley swings north from the upper dam site area, crossing the present Whitewater Creek valley, to the margins of the dolerite cropping out in the small stream west of the lower dam site, then disappearing below the southern edge of the basalt where it swings to the north-west to reappear in the Boddys Creek-Fisher Creek saddle area (figs 1, 2 and 23).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Creek
LESLIE
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LINE
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Boddys
Creek
100
WHITEWATER CREEK
C.L.
LOWER DAMSITE
Kingston
TRANSMISSION
WHITEWATER
CREEK
C.L.
UPPER DAMSITE
HIGHWAY
PRITCHARDS ROAD
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PARKS HILL
Little Parks Hill
DOCTORS HILL
Creek
H.E.C.
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Coffee
Blackmans Bay
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HOWDEN
ROAD
100
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RIVER
NORTH
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CONTOURS IN FEET
POSSIBLE TERTIARY DRAINAGE SYSTEMS KINGSTON - MARGATE AREA
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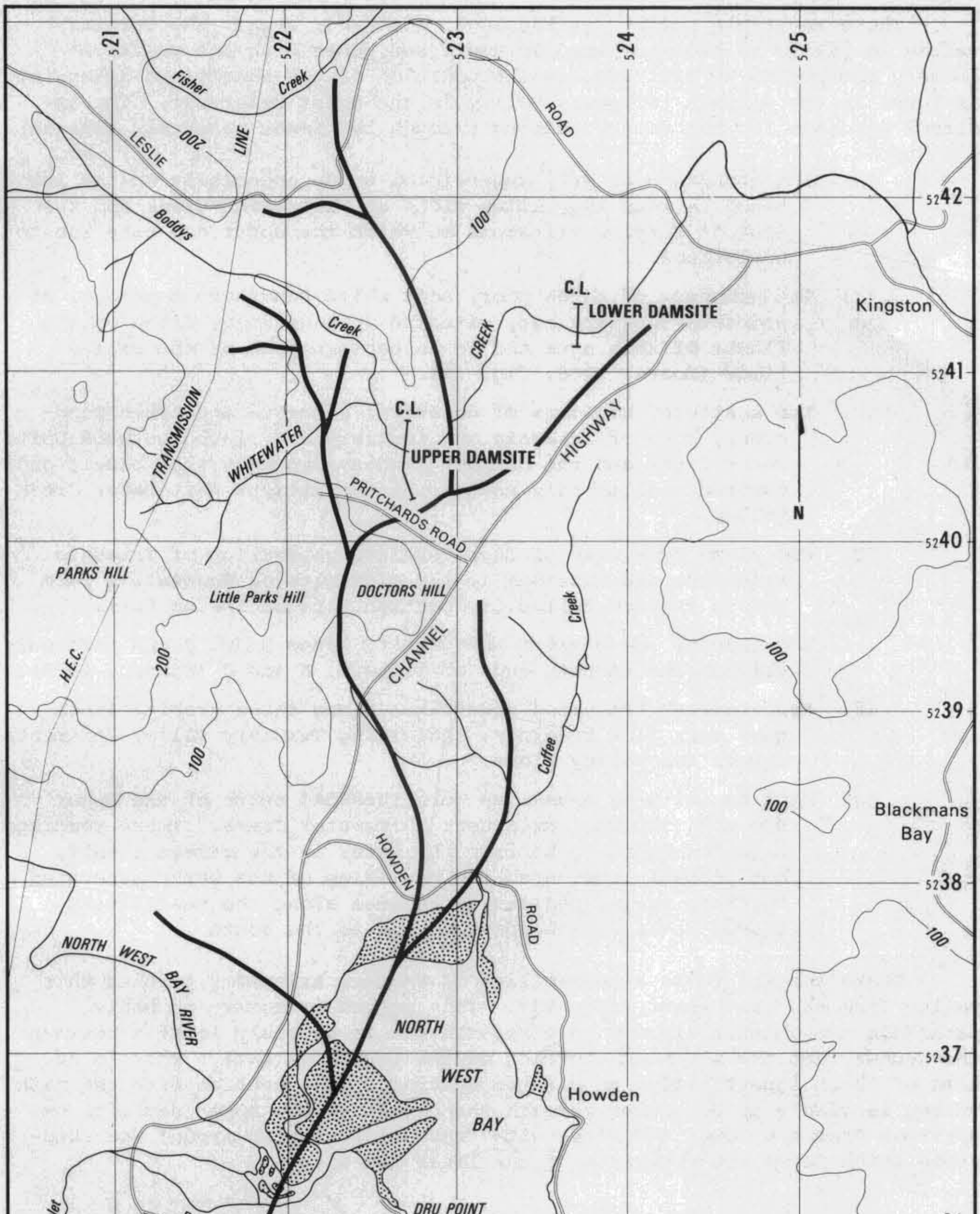
1 kilometre
GEOLOGIST :W.R. Moore
TASMANIA. DEPARTMENT OF MINES
3630

Figure 23.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Margate
CONTOURS IN FEET
POSSIBLE TERTIARY DRAINAGE SYSTEMS KINGSTON MARGATE AREA
0
1 kilometre
TASMANIA. DEPARTMENT OF MINES
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Figure 23.

There is little outcrop in the lower reservoir area. The Tertiary valley is likely to have cut into Triassic sediments with its position loosely controlled by faulting and the position of the basalt and dolerite, as found in the western tributary valley in the upper reservoir. The indirect evidence for the valley passing through the lower reservoir site is:

(*a*) The abundance of grey superficial sand, especially on the low bench between the valley floor of Whitewater Creek and the spur of Permian siltstone on which the upper dam site was to be located.

(*b*) The presence of three poor, soft white sandstone outcrops, of probable Tertiary age, situated in a drainage ditch on the flanks of this spur and in an eastern bank of the valley floor (Moore, 1968, fig. 37).

(*c*) The scattered boulders of dolerite, silcrete and baked sandstone, both of Triassic and Tertiary age, found between Whitewater Creek and the Channel Highway suggests that basalt once covered most of this section of the present Whitewater Creek valley.

(*d*) The close proximity of deep Tertiary weathering of Triassic sandstone and mudstone in the clay pits on Pearsall's farm and in the now filled exploration pits on Spring Farm.

(*e*) The gravity low between the gravity lines N and Q and particularly on the eastern ends of lines F, H and J (Leaman, 1972).

(*f*) Magnetometer traverses undertaken along these gravity lines gave very flat readings, indicating Tertiary valley sediments across the valley floor.

(*g*) High resistivity anomalies were recorded north of the upper dam site abutment area near Whitewater Creek. These readings were concluded to be from the water in the stream itself, but probably indicated the beginning of the water saturated Tertiary valley sediments, as seen along the resistivity traverses at Pritchards Road and to the south.

There appears to be a possibility of another tributary joining this valley from the north-east (fig. 23). This second tributary probably parallels the Channel Highway in direction and is probably located between the highway and the southern abutment of the lower dam site. This is an area of thick superficial sand with no outcrop. Its junction with the main valley is likely to be either beneath the basalt at the upper dam site or upstream from the lower dam site, with the valley passing around the sandstone which forms the abutments of the lower dam site.

GEOLOGICAL STRUCTURE AND HISTORY

The structure of the area is basically as outlined by Moore (1968). Briefly this showed a series of stepped, tilted fault blocks with uplifts having occurred along a series of north-south and NNE-SSW faults towards the west. Some of this faulting and associated uplift occurred with the intrusion of the dolerite during the Jurassic.

Faulting and uplift re-occurred in the Tertiary with NNE-SSW faulting offsetting some of the dolerite bodies in the Whitewater Creek area. This NNE-SSW faulting offset the block of Permian siltstone and sandstone of Boddys Creek and Whitewater Creek within the surrounding Triassic blocks to the east. Associated with this faulting was the extrusion of basalt from three main centres.

One large flow in the north originated from Picket Hill and flowed east towards the Kingston area as well as south-east towards the dam site areas. Another large flow from a centre at Doctors Hill flowed north into the reservoir area of the upper dam site. A further flow travelled south towards North West Bay.

The flows from Picket Hill and Doctors Hill probably coalesced somewhere in the vicinity of the two dam sites, covering the eastern tributary of the Tertiary valley. The basalt from the orchard area probably extended west to cover the western branch of this valley. Basalt from Doctors Hill extended west to cover the Tertiary valley in the Doctors Hill saddle area, with a large flow to the south covering the remaining section of the Tertiary valley to North West Bay.

Even though alternative drainage patterns are possible for the Whitewater Creek area, there can be little doubt that the direction of this drainage was southwards towards North West Bay and opposite to the present Whitewater Creek drainage direction (fig. 23). Whether the valley encountered in Howden Hole 1 is the same valley as that exposed on the Margate-Dru Point cliff line, or that the main Tertiary valley is present between Dru Point and the eastern shore of North West Bay with the valley at Dru Point only a tributary, must await further exploratory drilling.

The total area occupied by the older Tertiary sand and clay sediments is much larger than that occupied by the river gravel of the Tertiary valley fill sediments. The sand and clay, as well as having wider areal distribution, forms thicker deposits than the gravel, agglomerate and clay of the valley fill sediments.

The position of the initial Tertiary valleys filled with sand and clay appears to have been influenced rather than controlled by the position of the dolerite and faulting. For most of their known length, these initial valleys appear to have been eroded in the softer Triassic sediments rather than the harder dolerite and Permian siltstone.

The Tertiary fine quartz sand deposits appear to have been derived mainly from the Triassic sandstone, while the Tertiary clay appears to have been derived from the weathering of dolerite, Triassic mudstone and Permian mudstone.

These aggradational deposits which filled the deep initial valleys masked a considerable topographic relief in some sections of the valley profile. One example of this topography is seen in the western tributary of the buried channel in the upper reservoir where downstepping must be present in the valley floor from the Permian section exposed in the stream bed of Whitewater Creek to Triassic sandstone overlain by 14 m of Tertiary clay with sand in Hole R1. Another example of the steep topography of this initial buried valley is the Triassic sandstone cliffs which must exist on the western side of the valley in the saddle area between Doctors Hill and Little Parks Hill (fig. 8).

Incised within this broad aggradational sand and clay filled valley was a shallower narrow valley filled with river gravel, clay, boulders and volcanic debris which baked and hardened when buried by the basalt, forming the valley fill sequence.

Prior to the extrusion of the basalt and the filling of the valley, the weathering had been dominantly chemical rather than mechanical. Evidence for this is seen in the deep weathering of the Permian and Triassic sediments along the valley margins and on the valley floor.

Very little is known of the shape and cross sections of the valleys because normally only one side of a valley is 'exposed' by geophysical methods, *i.e.* where the basalt has been removed by erosion. The expense of drilling unweathered basalt of any great thickness precludes a series of drill holes across the valley. The only area where any number of drill holes penetrate through the basalt is in the upper reservoir and these are approximately parallel with the valley rather than across it.

After the extrusion of the basalt, the total thickness of which is unknown, the geological history of Whitewater Creek area becomes one of almost complete conjecture. With the capping of the basalt,the old valley system was fossilised presumably until the Pleistocene by when much of the basalt had been removed.

It is suspected that further Tertiary sand and clay was contained within the basalt and overlay the presently exposed basalt. These sediments cannot be distinguished from recent deposits so are included in the Cainozoic deposits.

The present drainage system was superimposed at a higher topographic level. When Whitewater Creek eroded through the basalt into the softer underlying sediments, its drainage course towards Kingston became fixed. This down-cutting through the basalt 'cover' presumably occurred where the basalt was thinnest near coalescing flows or on the edge of a flow, presumably where an initial trough was present.

Whitewater Creek and Boddys Creek are notably underfit streams and most of their erosion and down-cutting probably took place in a period of higher rainfall, presumably during the Pleistocene.

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APPENDIX 1

Further interpretation of gravity survey, Whitewater Creek dam site, Kingston.

D.E. Leaman

Shortly after initial mapping of two proposed dam sites on Whitewater Creek, a gravity survey was undertaken with the objective of examining the structural nature of the dolerite present and its relationship to faulting (Leaman, 1968). At that time the geology appeared straightforward. Subsequent drilling and additional geophysics (Moore, 1971; this volume) has shown the area to be far more complicated than anticipated. A Tertiary lead system as well as additional cross faulting has been located.

Although there is now little prospect of a dam being built at either site in the valley, in view of leakage considerations, it was felt that a more complete interpretation of this survey could, and should now be given. As a survey case-history, it also shows that potential methods should not be applied in too restricted a manner.

INTERPRETATION

The original interpretation (Leaman, 1968) stated that the faults were not related to selective dolerite intrusions, nor were intruded by them. Further, that if a sheet was present, it was common to all fault blocks covered.

Subsequent regional survey (Leaman, 1972) has verified a north-east-south-west trending regional strike, which means that the anomaly range across the area (Leaman, 1968; fig. 15), is less than 2 nT. The regional interpretation would also imply that the blocks west of the Permian/Triassic fault at the upper dam site are intruded by a major sheet and that this is absent to the east. However as the regional station spacing is some twenty-five times that of the detailed survey, no valid discrepancy can be stated since there is not sufficient overlap of the two surveys. The gradient interpreted in Leaman (1972) as due to the sheet edge is shown in detail to be not at the fault implied but slightly to the west and probably near the end of line H (Leaman, 1968).

Part of the Tertiary lead system is also reflected in the eastern end of lines A and B (Leaman, 1968) which were near top water level and just lapped onto the basalt cap to the hill which conceals the lead.

CONCLUSIONS

In view of problems raised in this area, this survey was a classic example of insufficient investigation. At the time, problems were seen on the centre line of the dams and the adjacent faults. No survey was made above TWL, or into the storage which was later shown to contain an effective leakage path.

Extension of the traverse lines to the west by less than 200 m would have done much to solve the problems of additional faulting through the storage as well as confirm the dolerite edge since postulated. As dolerite was critical to quarries further west, coverage should have been wider.

In addition, one or two more traverses south of line A, 60 m apart, would have detected the lead system. Such a single traverse has been done and is included by Moore (this volume).