UR1976_72

1976/72. Seismic survey at Leven Bridge, Ulverstone by-pass.

D.E. Leaman

This seismic survey was requested urgently by the Public Works Department following problems encountered during the initial piling of piers, which had arisen because of inadequate subsurface information.

The questions asked of the survey, the implications of its interpretation and the quality of prior and present probings in the Leven River are discussed in unusual length because no final resolution is yet possible. Recommendations are made to remedy this situation, which is one that should not have been allowed to develop and should certainly not have persisted into the construction stage.

The proposed bridge site is located upstream of the railway viaduct at Ulverstone on the Leven River [DQ288427]. The total crossing width is about 400 m of which more than half has been filled as a causeway. The remainder has been temporarily bridged to facilitate construction.

AVAILABLE CONTROL DATA

The only regional geological information available has been presented by Burns (1963) on the Devonport 1:63 360 geological map sheet. Its scale is such that it is of little value to this project but it does indicate that a wide range of materials may be present.

On the west bank a sequence of folded sandstones and mudstones may be observed. On the east bank there is some shattered quartzite and a cemented gravel-conglomerate composed of metamorphic fragments in a mixed matrix of limonite (iron oxide), coarse sand and clay. All units are overlain by sand on the river terraces and this is well exposed behind the camp on the east bank. Basalt, clay and quartzite occur nearby but are not exposed at the bridge site. The quartzite near the east abutment is not in the opinion of the writer considered to be *in situ*.

Two river probing programmes have added much detail concerning the bed materials but failed to define bedrock, its continuity or such variations that might be present.

A survey in 1971 consisted of a series of jet borings and probings across the river to a depth of about 17 m. With the exception of one bore near the eastern abutment all holes revealed a similar stratigraphic succession, comprising (from top to bottom): sand, clay, silty clay and gravel including some thin gravel and clay beds. In approximate terms sand is recorded from 0-8 m, clay from 8-16 m, silty clay from 15-17 m. The exceptional hole records 'rock' at less than 3 m.

Subsequent drilling in 1974 tends to confirm this profile. Two auger holes, one at the eastern abutment and another mid-river (at the end of the causeway); both offered results in agreement but again did not penetrate the 17 m gravel barrier. The only diamond hole (to 4 m), also on the eastern abutment, provided conflict by yielding 'white siltstone'. The inconsistency of results on the eastern abutment does not seem to have been noticed or resolved.

Springs of both cold and warm water have been encountered and some groundwater is confined (head > +3 m).

Piles at pier 5 (near east bank) have been driven to about 30 m, one

to 35 m, and no supportive base noted. As a result piling has been halted pending further drilling and this survey. One hole to more than 30 m passed through the normal succession to 17 m and further mixed materials. No definite sampling was provided and rotary/hammer drilling was stopped. At pier 5 a percussion plant encountered a yellow matrix(?) conglomerate or possibly weathered rock, fragments of metamorphic rock, and some iron oxides at 25 m. The samples derived from all drilling plants provide no clear resolution of the problems because of the use of the wrong type of equipment.

STATEMENT OF PROBLEMS

Several key pieces of information are needed to resolve the difficulties encountered during pile driving and which affect the stability of piles and of the bridge:

(1) The thickness of river deposits. This is unknown since neither the jet boring plant nor the auger, could penetrate gravel at 17 m.

(2) The thickness and character of the gravel at 17 m. These were not established but were presumed to be adequate for bridge design.

(3) The nature and position of the bedrock. No bedrock has been positively identified east of the west bank.

(4) The nature and thickness of the deposit of quartzite, gravel or conglomerate on the east bank. These were unresolved by the two deeper holes, but great emphasis was placed on the solitary very shallow diamond drill hole which could well have been in one large boulder. One boulder at the east abutment is more than 4 m across.

(5) The nature and source of the confined water.

SEISMIC SURVEY

The seismic survey was aimed directly at providing answers to (1), (3) and (4) above with possibly indirect application to (2) and (5). The survey was done in two parts; one covering the east bank and the other the water zone to be bridged. Both surveys encountered a space problem. Because of inaccessible silt areas and thick low velocity upper layers restrictions were imposed on shot positions and the shot extensions available. This has meant that options for seismic coverage penetrating more than 50 m are very limited.

East bank

A short spread fired at mean water mark revealed a very stepped time-distance plot incorporating high and low seismic velocity components (<1500 m/s, >4000 m/s). The long range average recorded was 3000 m/s. The records indicate that the east bank quartzite, gravel or conglomerate is very heterogeneous and is certainly not a massive quartzite. The larger quartzite pieces appear to be 2-4 m in size.

River section

A hydrophone spread using a 15 m interval was used for this portion of the survey. Maximum shot extensions in excess of 200 m were employed with all shots placed in contiguous related river deposits. At least four definite layers and a possible fifth may be recognised.

(1) Water; seismic velocity 1500 m/s. Maximum thickness 3 m (measured).

(2) Mud/silt; velocity 1100 m/s(?) recorded in one zone. Such a low velocity layer, if present, is rarely observed due to the overlying higher velocity medium. Its interpretation and continuity here is uncertain but ultimately critical to the survey.

(3) Water-saturated deposits; velocity 1500+ m/s. Not normally separable from (1).

(4) Weathered rock or cemented conglomerate; velocity 2300-2700 m/s.

(5) Weathered to relatively fresh rock; velocity 3300-3900 m/s. The conclusion here depends on the particular and currently unknown lithology.

All time-distance plots are discontinuous indicating quite irregular and angular relations between all units.

INTERPRETATION

Two interpretations are offered because of ambiguities due to the lack of proper drilling control, which reflects very badly on all preliminary and preceding probings. Problems are introduced by the unquestioned observation of at least one zone of 1100 m/s velocity which must be related to the upper layer of bed materials. Since the higher velocity interfaces cannot be locked absolutely into the interpretation it is not possible to invert calculations at any point in order to assess the impact of a low (1100 m/s) velocity zone or its thickness.

Figure 1 presents the interpretation if it is assumed that the 1100 m/s zone is minimal, not continuous, and simply represents a slight thickening in organic muds on the bed, *i.e.* it is very thin generally. In such a case all the river bed sands, silts, gravels and clays are assumed to have velocities in the range 1500-1600 m/s. A possible piling base may then be observed at 30-40 m deepening westward. Velocities are variable (2300-2700 m/s) indicating a heterogeneous patchy or weathered material. More reliable base material is noted at 43-52 m, again deepening westward. Layer positions toward the abutments are uncertain due to the spread location difficulties largely imposed by construction works.

A variation of interpretation is shown in Figure 1 where the impact of a localised 1100 m/s hidden layer is assessed. A 10 m reduction in depth may be noted.

Figure 2 presents the interpretation if it is assumed that the 1100 m/s zone is general and thick and comprises the organic rich bed materials observed in all probings. Layer descriptions are as for Figure 1.

CONCLUSIONS

(1) The survey suggests that a satisfactory base is no deeper than 52 m (fig. 1) or 45 m (fig. 2).

(2) An adequate pile base may be provided by the 2300-2700 m/s intermediate layer in the 25-35 m or 32-43 m ranges.

In (1) and (2) above no depth range can be stated absolutely due to the total lack of any reliable control beyond 17 m. The percussion plant,

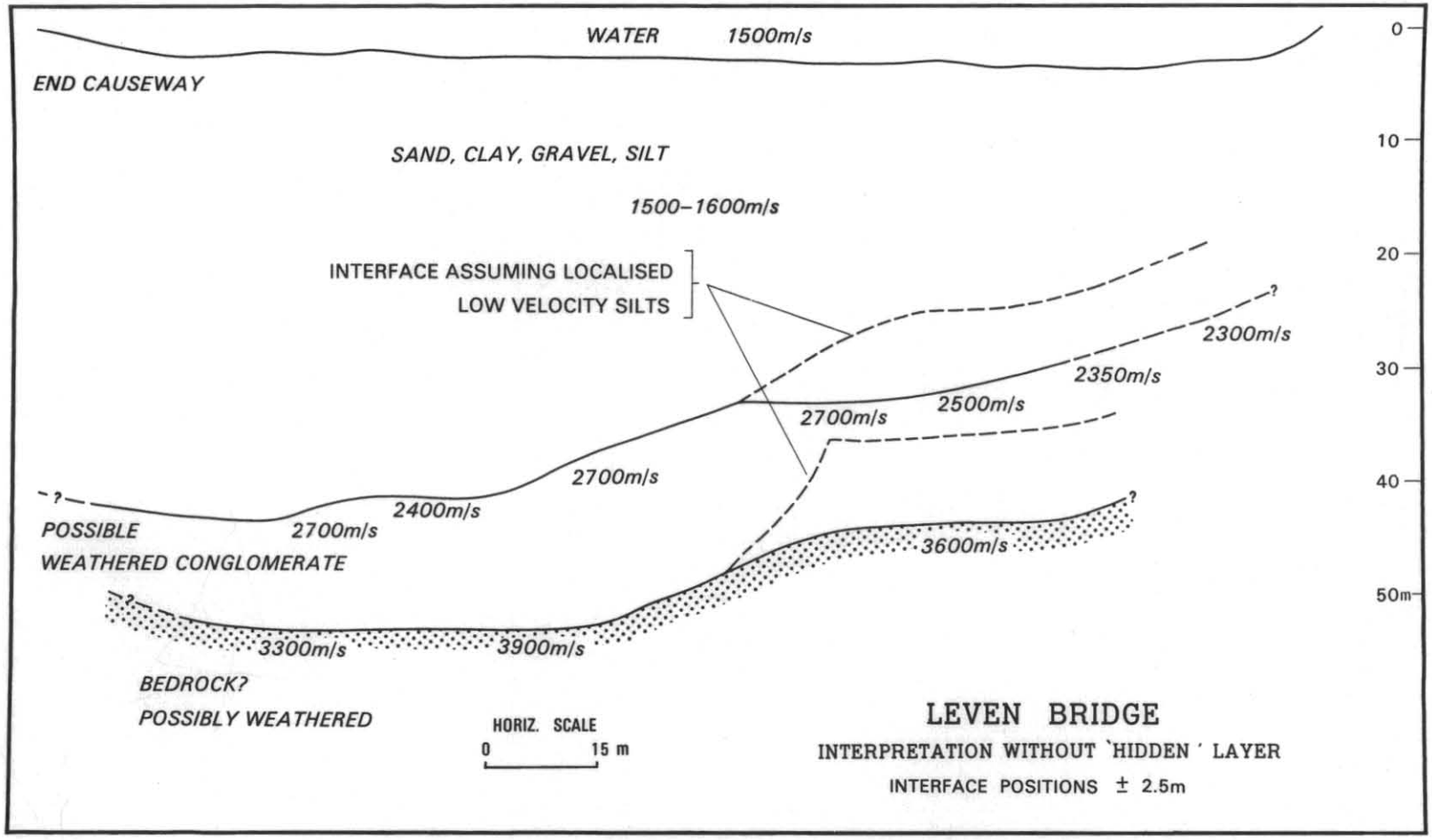
WATER 1500m/s
END CAUSEWAY
SAND, CLAY, GRAVEL, SILT
1500–1600m/s
INTERFACE ASSUMING LOCALISED
LOW VELOCITY SILTS
2300m/s
2350m/s
2500m/s
2700m/s
2700m/s
2400m/s
2700m/s
POSSIBLE
WEATHERED CONGLOMERATE
3600m/s
3300m/s
3900m/s
BEDROCK?
POSSIBLY WEATHERED
HORIZ. SCALE
0 15 m
LEVEN BRIDGE
INTERFACE POSITIONS ± 2.5m
0
10
20
30
40
50m

Figure 1.

5 cm

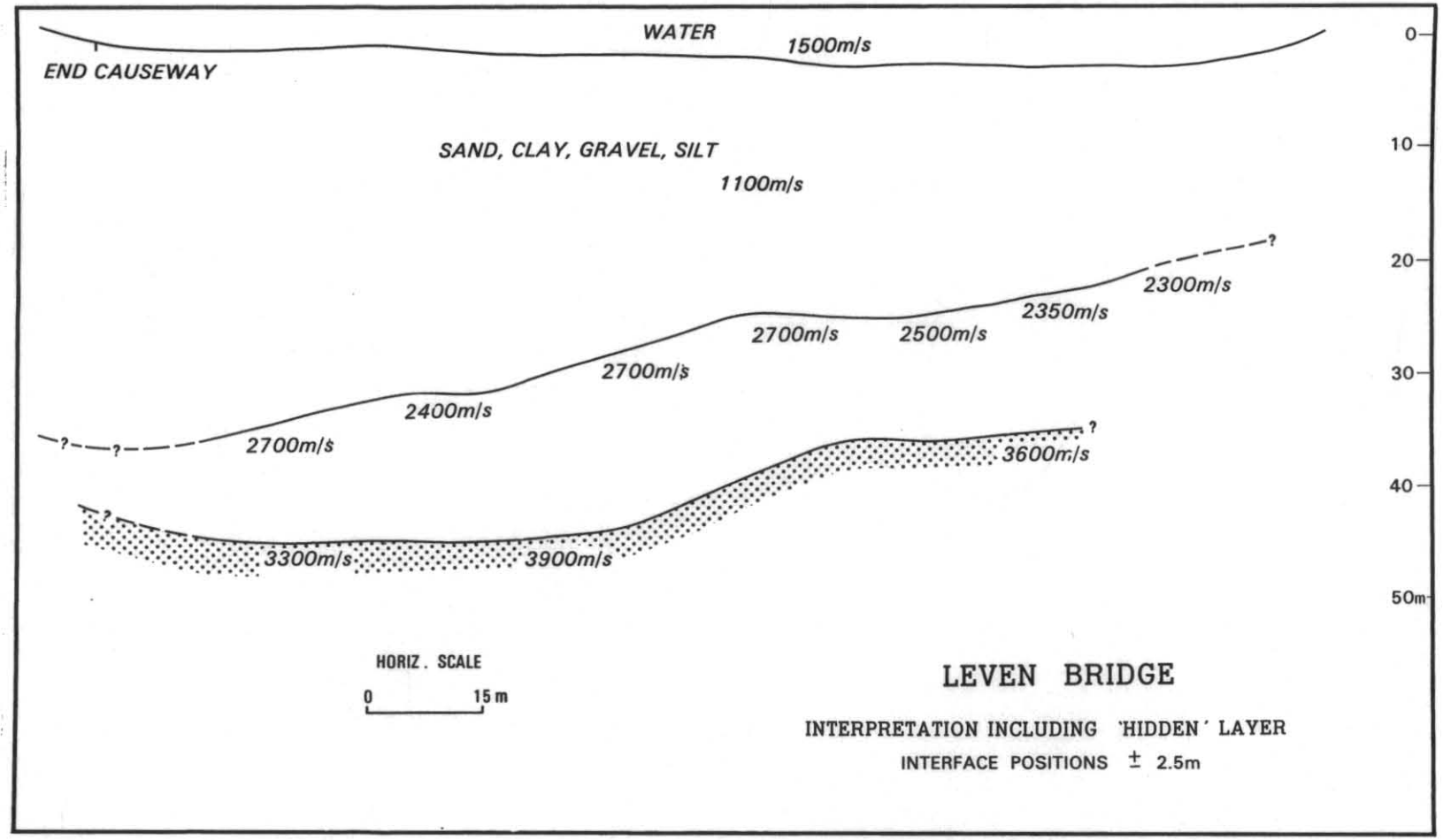
WATER
1500m/s
END CAUSEWAY
SAND, CLAY, GRAVEL, SILT
1100m/s
2700m/s
2400m/s
2700m/s
2700m/s
2500m/s
2350m/s
2300m/s
3600m/s
3300m/s
3900m/s
0
10
20
30
40
50m
HORIZ. SCALE
0 15 m
LEVEN BRIDGE
INTERPRETATION INCLUDING 'HIDDEN' LAYER
INTERFACE POSITIONS ± 2.5m

Figure 2.

5 cm

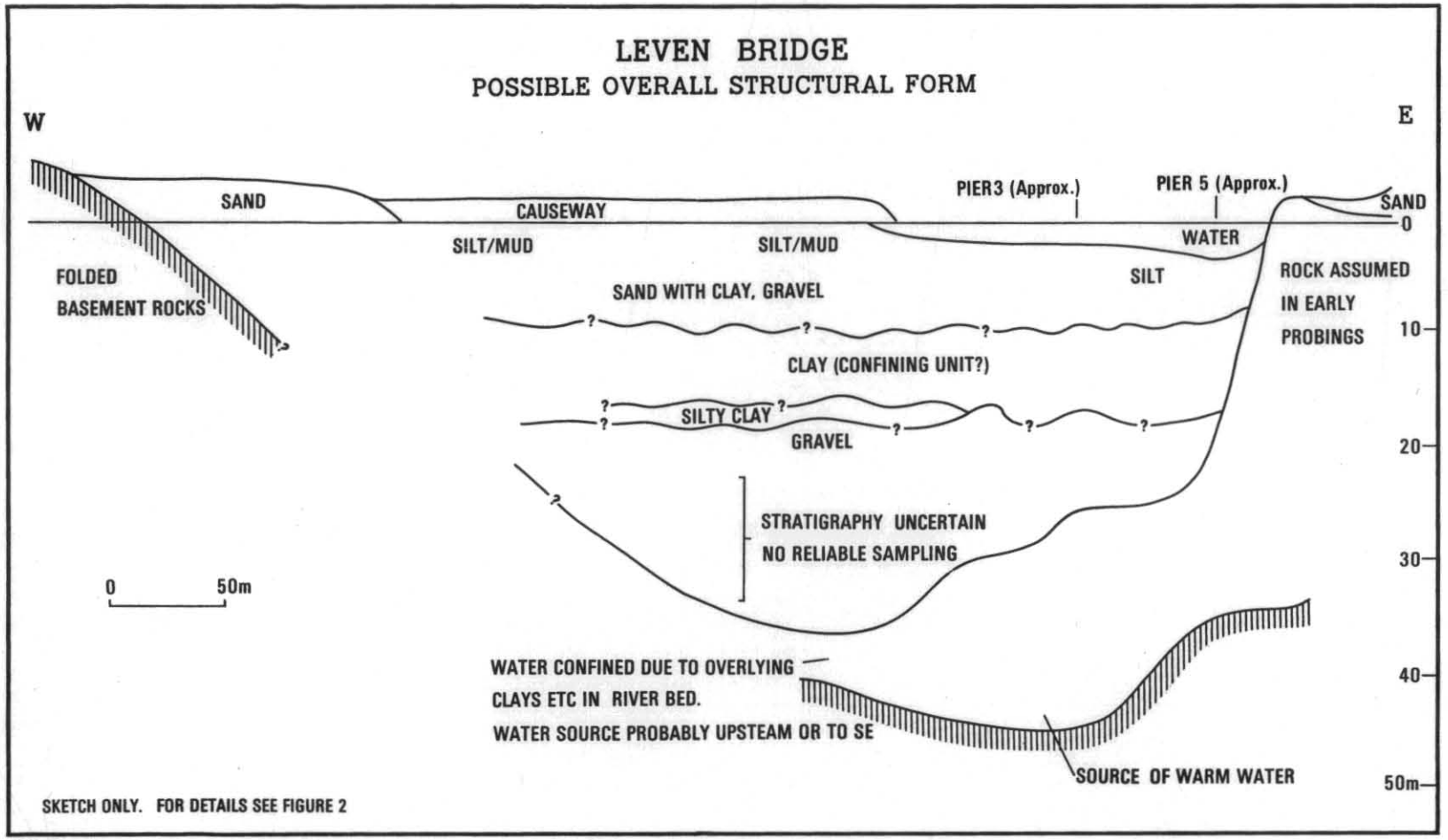
LEVEN BRIDGE
POSSIBLE OVERALL STRUCTURAL FORM
W
E
SAND
CAUSEWAY
PIER3 (Approx.)
PIER 5 (Approx.)
SAND
0
WATER
SILT/MUD
SILT/MUD
SILT
FOLDED
BASEMENT ROCKS
SAND WITH CLAY, GRAVEL
ROCK ASSUMED
IN EARLY
PROBINGS
10
CLAY (CONFINING UNIT?)
SILTY CLAY
GRAVEL
20
STRATIGRAPHY UNCERTAIN
NO RELIABLE SAMPLING
30
0
50m
WATER CONFINED DUE TO OVERLYING
CLAYS ETC IN RIVER BED.
WATER SOURCE PROBABLY UPSTEAM OR TO SE
40
SOURCE OF WARM WATER
50m
SKETCH ONLY. FOR DETAILS SEE FIGURE 2

Figure 3.

5 cm

operating at the time of the survey, passed into heterogeneous non river-bed materials at about 25 m. This piece of information suggests that the interpretation in Figure 2 is the correct one, but more definite drilling information is needed to confirm this.

(3) The east bank deposit is heterogeneous and if fragmental could easily provide the colour and fragmentation observed in the percussion bore. In addition the velocities noted are not dissimilar and the material may well be more weathered in the river channel which has probably been eroded into it (fig. 3).

(4) The confined and warmer groundwater cannot be simply confined in river deposits since this could neither account for the head nor the temperature. The water is probably confined in the heterogeneous intermediate layer with an on-shore source. This may well mean, depending on the exact nature of the material, that piles must be driven through this zone.

A simplified river section is suggested in Figure 3 which integrates all information available.

Recommendations

One or two diamond holes are required somewhere on the alignment. Each must be drilled to 50 m or at least until several metres of unquestioned bedrock is encountered and cored. The plant hired should be kept drilling and maintained until full and adequate results are obtained. Good recovery is essential and the process should not be rushed. Only in this way can the character of the deeper units be resolved. Cheap, auger or jet methods are totally inadequate for such work. Any 'floating' hole, or one stopped on the first boulders of a thick or thin gravel, is useful only to the extent that materials passed through are known.

Samples of the warmer groundwater should be analysed for sulphate content, bearing in mind the possible effects of such water on concrete.

With proper control and identified units Figures 1 and 2 can be comparatively appraised to reduce the profile for the other pier positions. This presumes that only one, or at best two, will be drilled to the standard necessary to establish the surmises included in the conclusions. Percussion drilling is not adequate for this purpose since the results are suggestive and not definitive.

The survey, and the interpretational doubts, shows that all data derived from the 1971, 1974 and current efforts are of minimal value and offer little contribution to resolution of the primary questions. It is such that the interpretation is forced to stand alone and without control. That control must be obtained immediately if this survey is to be of any value.

REFERENCE

BURNS, K.L. 1963. Geological atlas 1 mile series. Zone 7 sheet 29 (8115N). Devonport. *Department of Mines, Tasmania*.

[13 December 1976]