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1977/14. Site investigations at the Bridgewater Sewerage Treatment Plant

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The Brighton Council intends to extend the existing facilities at the Bridgewater Sewerage Treatment Plant from its present capacity of 3500 persons to 8000 persons. The Council requested that the Department of Mines investigate the geology and site conditions at the plant, so that the information can be made available to potential tenderers. In particular, the Council required detailed foundation conditions at four proposed excavation sites at the plant.

The treatment plant [EN195676] occupies about 4 ha of land on the north-eastern side of the Derwent River about one kilometre downstream from the Bridgewater Causeway. The property slopes generally south-west, and is bisected by a small, unnamed and culverted creek.

The site was visited on a number of occasions during March and early April 1977. Investigations comprised geological mapping, a seismic survey, and back-hoed trial pits.

GEOLOGY

General

Aspects of the geology of the Brighton-Bridgewater area have been described or mapped by McDougall (1956), Leaman (1975) and Sutherland (1976). In the Bridgewater area, the principal rock types are interbedded Tertiary sediments, basalts and associated pyroclastic rocks. McDougall (1956) described the morphology of the basalts, and Sutherland (1976) published some chemical, morphological and petrographic data for volcanic rocks near Herdsmans Cove. Despite such previous work, the detailed lithology of the Tertiary sequence remains uncertain: stratigraphic correlation between exposures in the Bridgewater area is hindered by the large degree of lateral and vertical variations in the morphology and gross textural features of the volcanic rocks, and associated sediments.

Geology of the treatment site

The treatment site is underlain entirely by Tertiary rocks, the oldest of which appears to be a massive to highly-fractured, relatively unweathered basalt. The rock is not exposed at the surface (being obscured by 0.5-1 m of dark brown clayey soil), but it apparently underlies the northern and north-eastern parts of the property. The basalt was encountered in a back-hoed trial pit, and its presence beneath the remainder of the site is inferred from seismic results.

The basalt is overlain by, and probably grades into, a weathered scoriaceous and brecciated pillow lava or entrail basalt which is exposed in excavations immediately south of the existing primary sedimentation tank. The pillow lava in turn grades laterally to the north-east to volcanic agglomerate (exposed in the cutting between the sedimentation tank and digesters). Parts of the agglomerate have been reworked to a conglomerate or breccia, especially at the extreme north-eastern end of the cutting, where the original wholly volcanic matrix has been replaced by one composed largely of rounded to angular sand, quartz grit and chert fragments. The same cutting has exposed a few metres of Tertiary sand and clay, which overlie agglomerate and conglomerate near the proposed sedimentation tanks, terminate abruptly against basalt to the north-east, and thin gently to the south-west. Seismic data and information from trial pits (fig. 1) indicate that the sediments are at least 2.5-3 m thick (but probably not much more) and that they form an asymmetric valley or channel deposit cut in the underlying volcanic material.

A metre or so of white-brown Tertiary(?) clay underlies basaltic soil near the perimeter fence at the extreme north-eastern corner of the property. Small basalt cobbles, ranging from massive to highly vesicular, litter much of the site and the neighbouring foreshore, and apart from areas of recent fill and creek deposits, *in situ* material is absent.

SEISMIC SURVEY

Eleven short seismic refraction spreads were conducted on the property*. The survey was designed to establish the depth to bedrock at selected excavation sites, and to indicate the depth and extent of rippable material beneath each.

Site 1 (Spreads 1, 2, 3 and 10) is the flat, grassed area north-east of the existing sedimentation tank. Three metres of material are to be excavated.

Site 2 (Spreads 4, 5 and 6) is the grassed area near the existing secondary digester, where proposed aeration tanks will require a minimum excavation of 3 m, and a maximum of 7 m.

Site 3 (Spread 8) is at the extreme southern part of the property. Three metres of material will be excavated for chlorine contact tanks.

Site 4 (Spreads 9 and 11) on the north-eastern side of the property, is largely underlain by recent fill, which will be excavated to a depth of 3.5 m for proposed secondary clarifier tanks.

Two control spreads were also fired near the Bridgewater High School construction site to enable closer correlation between seismic velocities and expected rippabilities at the sewerage treatment plant.

RESULTS OF SEISMIC SURVEY

General comments

The speed of propagation of seismic waves in rock media is a direct function of rock elasticity and density. Both properties increase with increasing degree of compaction, and in general, older, harder rocks display higher seismic velocities than does younger, unconsolidated material. Velocities are rarely diagnostic of a particular rock type, and this is especially true in the Bridgewater area where the basalt, agglomerate, sediments, and the weathered varieties of each all exhibit overlapping velocity ranges. The basalt in particular shows extreme variation in degree of weathering and fracturing, often over short distances, which makes interpretation of the profiles difficult, and which indicates the uncertainties involved in extrapolating between neighbouring spreads without adequate control.

Seismic velocities at the treatment site

Seismic velocities fall into four broad and overlapping ranges, which

*Detailed positions of the spreads are not included here. End points of all spreads (except Spread 10, aligned along the centreline of the proposed primary sedimentation tanks) were pegged at the plant, and locations transferred to site plans held by the Council and their consulting engineers. Positions of most spreads are also indicated in Figure 1.

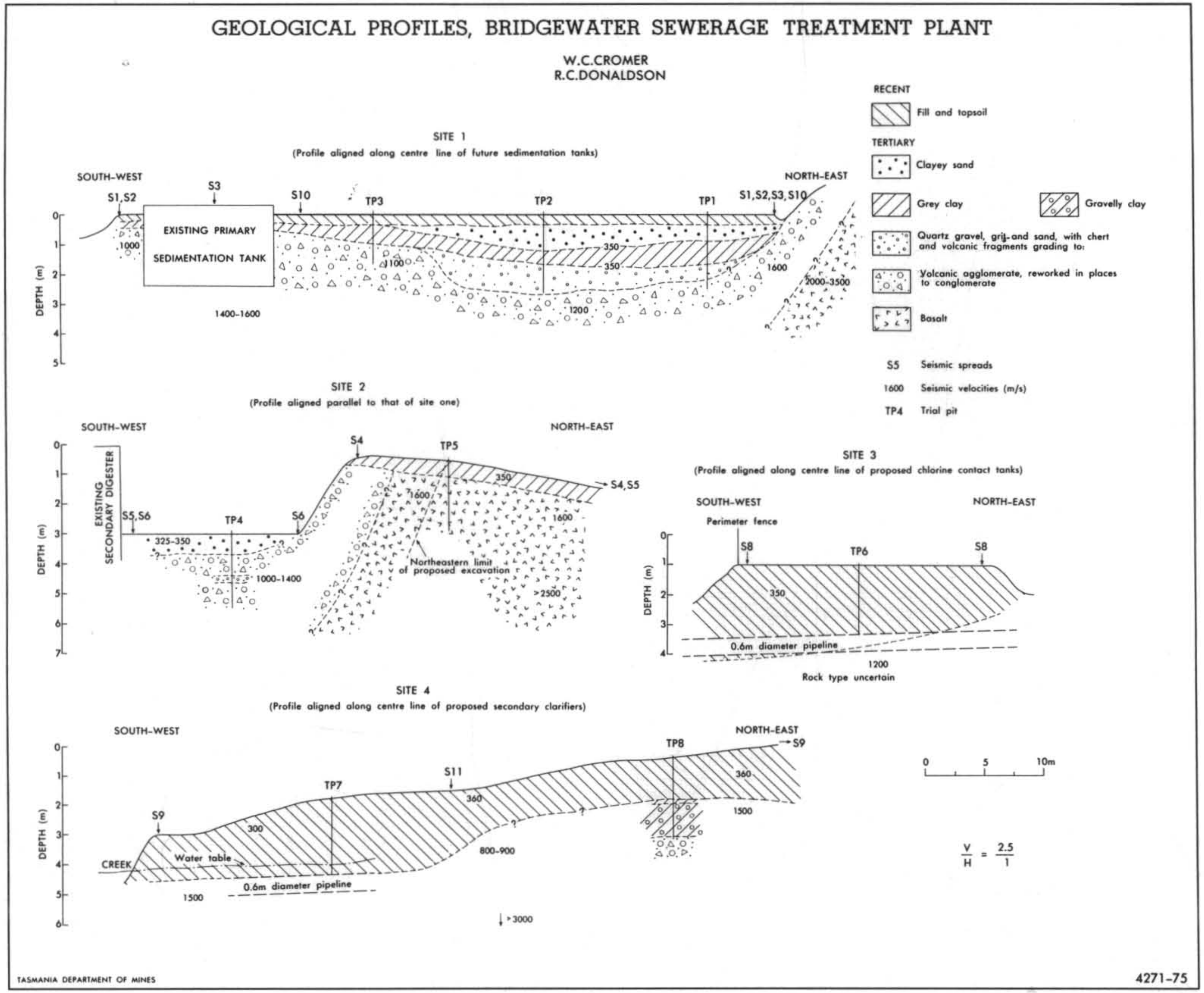

Figure 1.

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on the basis of surface exposures and trial pit logs (table 1), are interpreted as follows:

Velocity range	*Inferred rock types*
300- 500 m/s	Upper, low-velocity layer common to all spreads. Attributed to dry top soil, recent fill and dry, porous Tertiary sediments. Values at the lower end of the range (approximating the velocity of sound in air = 330 m/s) were most commonly encountered, and they indicate the dry friable nature of the material.
700-1500 m/s	Lower values in this range are ascribed to porous Tertiary sediments (slightly more consolidated than in the 300-500 m/s range). Higher values are typical of saturated sediments, but could also be ascribed to Tertiary agglomerate and associated conglomerate or strongly fractured and/or deeply weathered basalt.
1400-1900 m/s	At the treatment plant, velocities in this range are interpreted as agglomerate, conglomerate, or weathered and/or strongly fractured basalt.
2500-4500 m/s	Velocities in this range correspond to Tertiary basalt in varying stages of weathering and fracturing. Higher values in the range indicate fresh, blue, relatively massive rock.

Correlation between seismic velocity and rippability

The ease of ripping of rock materials is related directly, if complexly, to seismic velocity, which itself is a composite measure of rock weathering and fracturing. But rippability is in practice not only dependant or relative degrees of fracturing in hard rock, but also on the orientation of fractures relative to the face of the excavation. Field experience has shown that the limit of rippability of hard basalt for a D9 bulldozer using a No. 9 ripper corresponds to a seismic velocity of about 2000-2200 m/s. In favourable situations, this range can be extended to about 2500 m/s.

At the Bridgewater High School construction site, highly fractured, blocky and relatively unweathered basalt exposed in recent excavations was (according to site personnel) easily rippable with a HIMAC traxcavator using a single ripper tooth. A control seismic spread conducted 30 m from the excavations indicated a seismic velocity of 1800 m/s. Such a figure is relatively low for fractured basalt, but it agrees well with the above relative scale of rippabilities.

TRIAL PITS

Eight trial pits were excavated by conventional back-hoe on the property. Each was located over, or adjacent to, seismic spreads to aid interpretation. Their positions relative to the seismic spreads are shown in Figure 1. Only two localities presented problems to the back-hoe. Hole 3 bottomed at 1.7 m in compact agglomerate, and Hole 5 was stopped in blocky but fresh basalt at 2.3 m. Neither of these sites would present difficulties for large plant.

Logs of all holes are presented in Table 1.

GEOLOGICAL PROFILES

A synthesis of the seismic data and logs of trial pits (table 1) is presented in Figure 1, which shows interpreted geological profiles at each of the four proposed excavation sites. Each profile is a composite section based on at least 2 seismic spreads and 2 trial pits (except for Site 3).

Sites 1 and 2

The major feature of both sites is the presence of a shallow Tertiary channel cut in volcanic material and filled with unconsolidated Tertiary sediments. All Site 1, the proposed excavations straddle the channel; accordingly most of the construction work will involved these soft easily rippable sediments, and no problems are envisaged.

The north-eastern margin of the channel (a boundary between basalt and sediments) has not been located with certainty, but its inferred position and attitude marked in Figure 1 is probably accurate to within a few metres. Its position is not critical at Site 1, but it is of some importance at Site 2 since the excavation will probably transgress the boundary into harder less rippable basalt. Trial pit 5 was dug in blocky, fractured but otherwise fresh basalt on the north-eastern margin of the proposed excavation: the rock was easily rippable to 2 m with a conventional back-hoe, and the use of larger plant will extend this depth. Spreads 4 and 5 indicated higher velocity material at depth, which may need to be blasted.

Sites 3 and 4

Excavations at both sites to a depth of about 3-4 m will present no problems. Recent fill is present over the total length of each, and to a depth generally exceeding that required for construction. Trial pits 6 and 7 intersected a 0.6 m diameter pipeline at about 2.5 m, indicating a minimum depth of subsequent fill, The fill appears to be thinnest (1.5 m) near Spread 11 at Site 4: the underlying material as interpreted from seismic velocities and the log of Trial pit 8 as being volcanic agglomerate or clayey grit and sand: in either case the material is easily rippable.

CONCLUSIONS

The major rock types at the treatment plant consist of Tertiary clay, sand, quartz grit, agglomerate (and associated conglomerate) and basalt. The sediments present no difficulties for excavation. The basalt is variously and often deeply fractured and weathered, and for these reasons is expected to be generally rippable with a HIMAC traxcavator or equivalent plant. However at the north-eastern end of Site 2 where 7 m of material is to be removed, the fractured (and rippable) surface basalt is expected to become increasingly massive with depth, and blasting may be required. At all other sites, costing of the excavations should be made on the basis of soft rather than hard rock.

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Table 1. LOGS OF TRIAL PITS, BRIDGEWATER SEWERAGE TREATMENT PLANT.

Hole No.	*Depth (m)*	*Description*
1	0 - 0.1	Dark grey loam.
	0.1 - 0.3	Grey clayey fill.
	0.3 - 0.9	Friable pale grey slightly clayey fine to medium-grained sand.
	0-9 - 1.7	Stiff grey clay. Thickness variable in pit ±0.2 m.
	1.7 - 2.2	Yellow-brown friable quartz grit.
	2.2 - 2.5	Compact yellow-brown agglomerate with relatively fresh-weathered vesicular and massive basalt cobbles in a volcanic matrix.
2	0 - 0.1	Dark grey loam.
	0.1 - 0.3	Grey clay and gravelly quartzite fill.
	0.3 - 1.2	Soft, brown-yellow clayey, poorly sorted quartz sand; gritty in places.
	1.2 - 1.7	Stiff pale grey clay.
	1.7 - 2.7	Soft, friable yellow-brown clayey and gritty poorly sorted sand.
3	0 - 0.1	Dark grey loam.
	0.1 - 0.3	Grey friable sandy clay fill.
	0.3 - 1.0	Stiff grey clay.
	1.0 - 1.7	Compact green-grey agglomerate with fresh-weathered, massive-vesicular basalt cobbles in volcanic matrix.
4	0 - 0.1	Dark grey loam.
	0.1 - 0.7	Friable yellow-brown medium-grained sand and minor gravel.
	0.7 - 1.4	Conglomerate, with rounded cobbles and boulders of massive-vesicular basalt in a clay/sand matrix. Probably reworked agglomerate.
	1.4 - 1.65	Ferruginous gravel, containing well rounded quartz grains and cherty fragments.
	1.65- 2.5	Conglomerate, as above.
5	0 - 0.3	Black clay.
	0.3 - 0.6	Brown clay.
	0.6 - 0.7	White clay.
	0.7 - 2.3	Fresh, blue-grey, extensively fractured blocky basalt.
6	0 - 2.3	Recent fill. 0.6 m diameter pipe at 2-3 m.
7	0 - 2.4	Recent fill. 0.6 m diameter pipe at 2-5 m. (Water table at 2.0 m).
8	0 - 1.5	Recent fill.
	1.5 - 1.6	Dark grey clayey basaltic "top soil"
	1.6 - 2.8	Brown gravelly clay.
	2.8	Moist weathered agglomerate.

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