BAY WEST PRELIMINARY GEOTECHNICAL INVESTIGATIONS (DRAFT)

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ABSTRACT

Infrastructure Victoria requested Guy Holdgate & Associates to conduct a preliminary assessment of the marine geotechnical conditions for the proposed port site at Bay West which covers the area between Point Cook and Point Lillias on the north-western shore of Port Phillip Bay. The exact location of the port and channels within this area have not yet been determined.

It is expected that development of the port will involve dredging of access channels, swinging basins and berths as well as a significant area of reclamation for quays and container terminals. These activities may form a significant proportion of the overall project CAPEX, and the opportunity exists to site the port in a location that minimised the cost of dredging and reclamation.

This study aims to provide preliminary information on the nature of seabed and sub-seabed material so that the possible location of the port can be refined and sensible assumptions can be made re the cost of dredging and the use of dredged material in reclamations.

Specifically, we are interested in:

- The likely extent, depth and thickness of basalt or other hard rock ***shallower than 20m below Chart Datum*** across the study area;
- The nature of seabed sediments overlying basalt, proportion of sand, silt and clay.

The scope of the investigation was to:

Undertake a desktop investigation. Site investigations may be carried out in future.

- To source and review existing relevant data in the study area, including aerial magnetic surveys, geophysics, boreholes, and LiDAR surveys (Infrastructure Victoria supplied some borehole data along the Geelong channel)
- Map all data and, if possible, identify the probable extent of rock. Map to be provided in JPG format suitable for inclusion in documents.
- Brief report addressing extent of rock and nature of sediments. This report will be made public on the IV website.

Study Extents Point Cook to Pt Lillias, from the shoreline to existing Geelong channel or -20m contour, as per Fig. 1 below

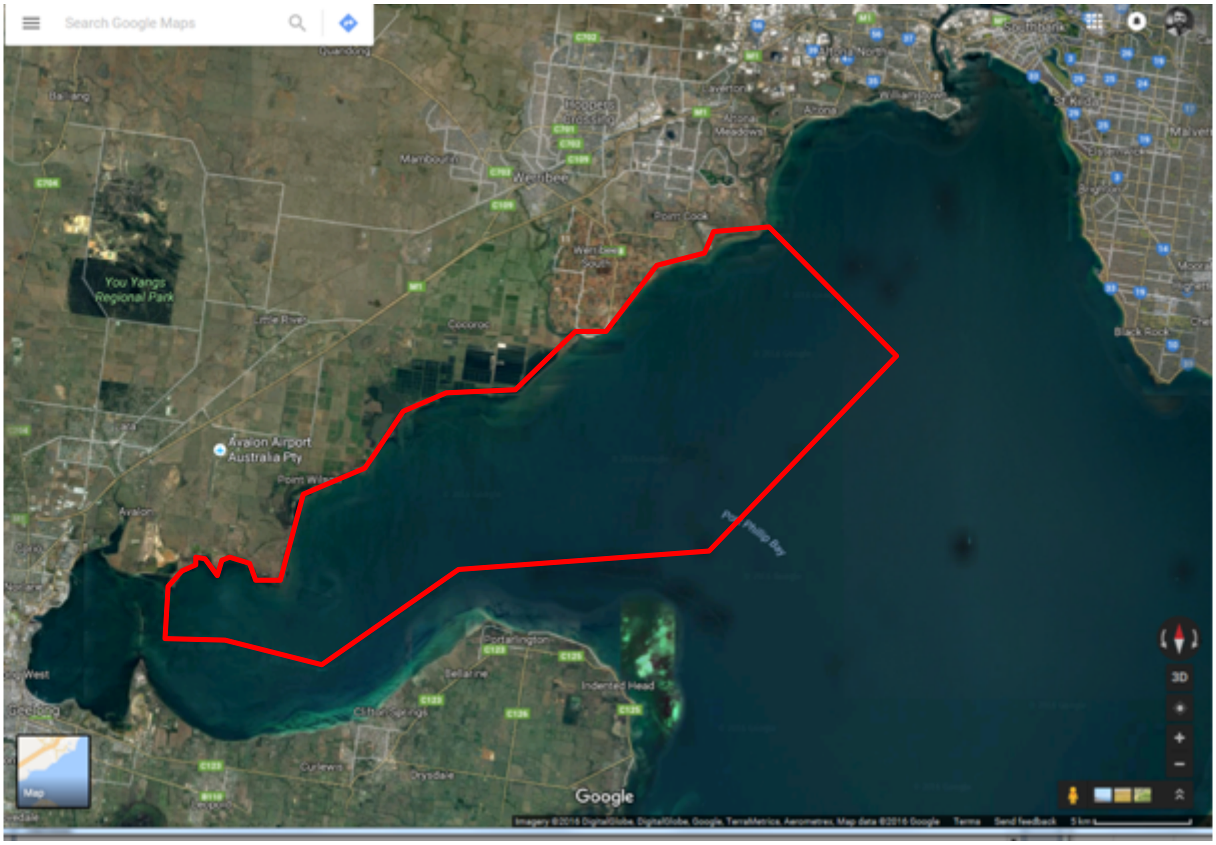


Figure 1 – Approximate extent of Study Area

(A) LIDAR SURVEYS

Spectacular imagery of the shallow parts of Port Phillip bay floor is available using the LiDAR technique: LiDAR is an airborne light detection and ranging mapping survey technique that is very effective on land and can provide topographic details down to under 1.0 m differences. It also has the possibility of discriminating man-made cultural features from natural features (eg. buildings) if appropriate programmes are used. In the offshore a variation to the airborne surveys means the LiDAR technique can be very effective in mapping sea bed features out to an approximate water depth of 10.0 m dependent on water clarity.

LiDAR surveys were primarily carried out in in recent years over Port Phillip Bay by the Department of Sustainability and Environment (DSE). Their main purpose was to map the coastal strip onshore and offshore with a view to determining likely areas that could flood if

sea-levels were to rise in future. The onshore and offshore LiDAR is available publicly from DSE at cost. The following image (Fig. 2) illustrates the LiDAR coverage over Port Phillip offshore. As can be seen good detail is provided from the shoreline out to about 10.0 m water depths. The best results occur in the southern Port Phillip Bay area where water clarity is much better. In northern Port Phillip the water tends to be cloudy due to mud discharge from the Yarra River and penetration is less. Note that Figure 2 mostly covers the offshore because the splice between onshore and offshore LiDAR results had not been satisfactorily achieved at the time this image was produced several years ago. Presumably this has now been achieved and could be purchased from DSE.

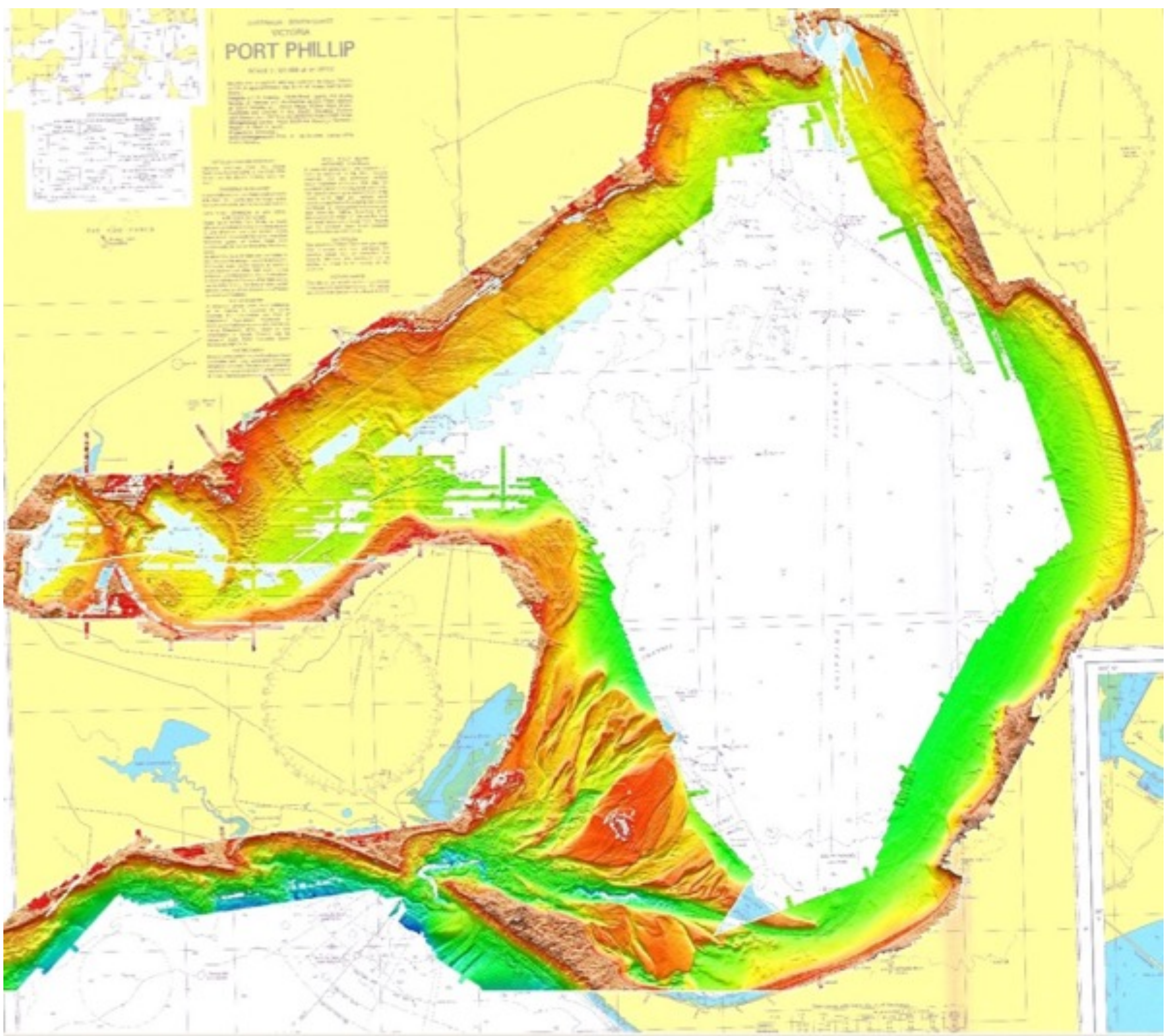


Figure 2. LiDAR coverage in Port Phillip Bay.

More detailed imaging from the offshore LiDAR in the West Port Phillip area is shown in the following image (Figure 3). Coverage is incomplete in the deeper water areas of Corio Bay and Port Phillip Bay, small busts in the data lines probably produce the northeast trending lineations.

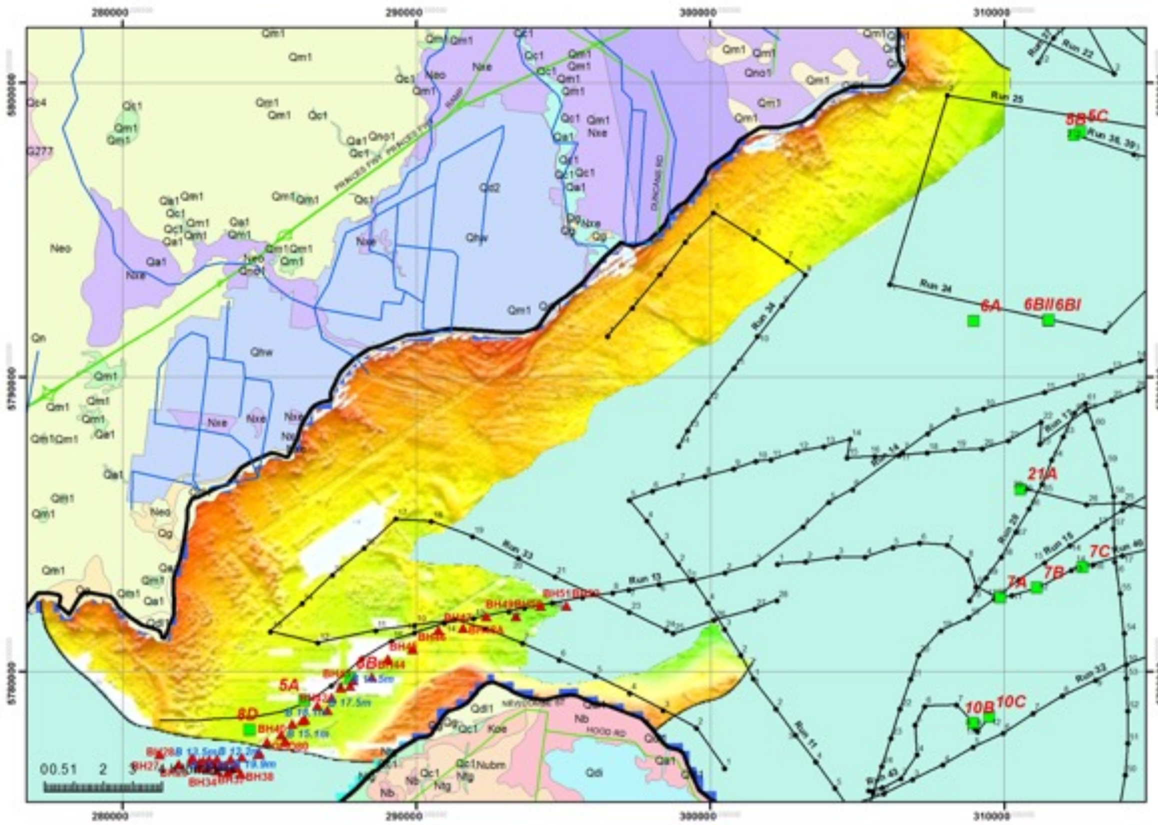


Figure 3: LiDAR imagery of West Port Phillip showing Outer Harbour, Bellarine to Point Cook area. Figure also shows onshore geology (blues & purple=Quaternary alluvium; light yellow=Newer Volcanics; On the Bellarine Peninsula pink/red=Older Volcanics; blue and light pink=Pliocen/Quaternary alluvium. Locations for offshore GSV seismic surveys (black lines) and shot point locations (small numbers). GSV cores (green squares with red numbers). Geelong Outer Harbour (URS/GHD) cores (red triangles) with depth to basalt in blue numbers. For location of coastal points see Figure 5.

Details in the bay-floor features of Figure 3 include:

1) A former lake basin originally formed in a volcanic maar constitutes the Outer Harbour basin south of Point Wilson. It has shallow basalt around the edges and a basalt floor beneath thick clay deposits. The Geelong Outer Harbour dredged

channel cuts through the sand covered basalt ridge south of Point Wilson. Sand dune ridges occur on eastely lake shorelines and represent classic lunette features typical of many Victorian western district maars (eg. Lake Corangamite). Dune lunettes tend to build up from prevailing westerly winds lifting and carrying clay/sand particles off exposed lake floor beds and deposit the sediments on the eastern shoreline. Lunette development tends to occur during drought periods. The lake features illustrate the Outer Harbour maar formed when sea-levels were lower during glacial times.

2) A second possible maar feature with an easterly basalt ridge at near-bay floor level occurs between Point Richards and Kirk Point. This delimits a deep clay-filled basin seen by seismic lines (see figure 12).

3) Ridges of exposed basalt extend offshore from Point Wilson as shown by the hummocky topography on the bay floor, and confirmed by bay floor rock samples (Figure 5) (Beasley, 1966). Similar southeast trending basalt flows also occur offshore between Point Wilson and Kirk Point area that can be seen as obvious hummocky topography in the LiDAR imagery. They illustrate Port Phillip was dry at the time basalt flows could extend into the bay (ie. during glacial times). They are corroborated from the magnetic imagery (see magnetic imagery section).

4) Offshore sand ridges, sand bars and spits develop off Point Richards and Point George in the Portarlington area of the Bellarine Peninsula. These are clearly younger features that have probably formed in the last 6000 years when bay water levels approximately equilibrated with present sea levels.

5) Offshore sand ridges and spits develop off the Wedge Point (South Werribee). In a similar fashion to the Bellarine Peninsula sand spits and sand bars, they are younger features probably formed in the last 6000 years when bay water levels

approximately equilibrated with present sea levels. The sand deposits are corroborated by Museum grab surveys (Beasley, 1966) and Port of Melbourne Authority grab surveys (Buckley & Clark, 1987). Thickness of sand deposits is unknown but they may only be 1 to 5.0 m meters thick. They probably overlie basalt (see magnetic survey section).

6) A deep channel has been cut offshore from the Werribee River mouth and represents the former course of the Werribee River during periods when Port Phillip was dry mostly at glacial periods, but also more recently when the bay dried up because the South Channel was blocked by sand (see Holdgate et al., 2011). Seismic surveys tend to suggest the channel floor may be partly infilled with soft sediments (Figures 9 to 11) and may not have basalt underneath. In the very inshore area soft sediment infill has completely smoothed over the channel.

7) Southeast trending basalt flows shown by hummocky topography extend out into the bay from the Werribee South area, and as distinct southeast trending narrow lines of basalt just south of Point Cook. The latter appear to extend many kilometres out into Port Phillip Bay where detailed multibeam imagery identifies them down to water depths greater than 14.0 m. Their very narrow but elongated dimensions makes them unusual and their mode of origin is not clear at this stage, suffice they are probably lines of basalt blocks.

(B) MAGNETIC IMAGERY

Airborne magnetic surveying was carried out across Victoria in the 1990's. It was undertaken for Geological Survey (GSV) mapping purposes using light aircraft with magnetic detection equipment. The aircraft flew a fixed grid of lines across the

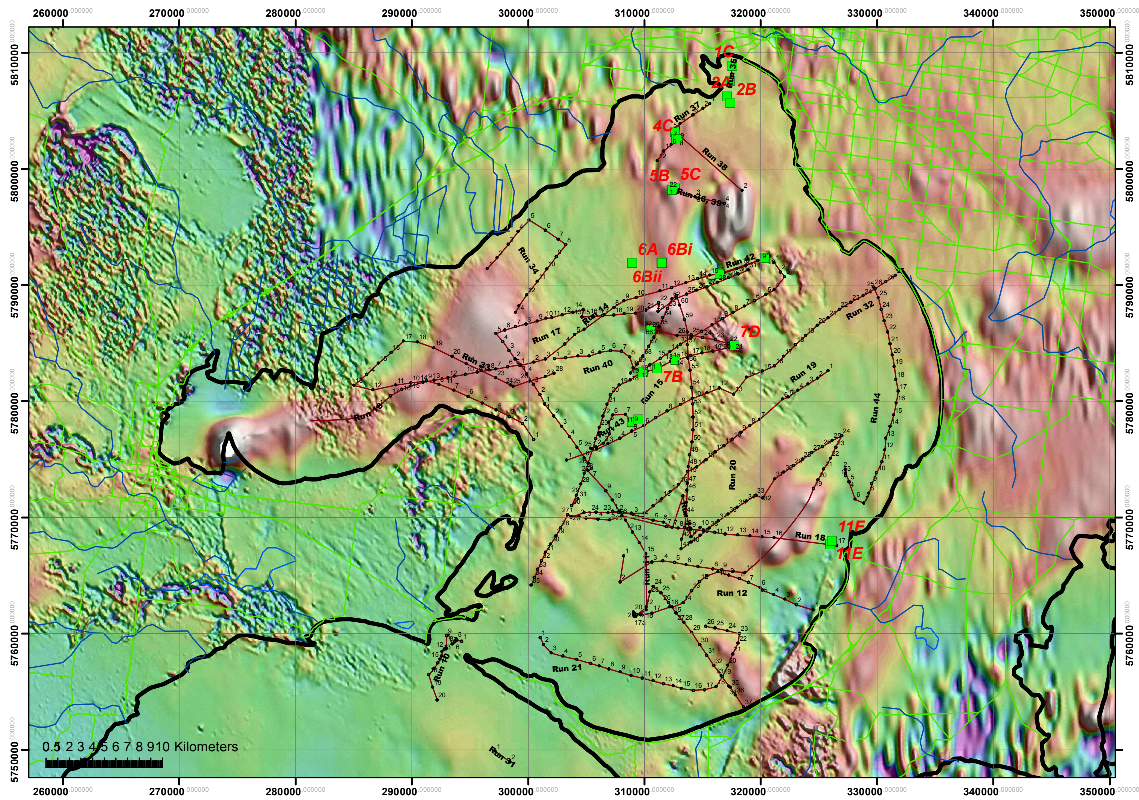
country at fixed altitudes. The results are publicly available as downloadable digital data from the GSV website. Also included with this survey was digital topographic surveys and radiometric surveys that provide various windows to detect radiometric mineral concentrations and differing basement terrains.

The magnetic surveys can give images of magnetic rocks in colour or black and white. Basaltic rocks at shallow depth are particularly well defined by this method and, depending on magnetic polarity, can be useful to detect basalt flows of different ages. Other rock types that give a strong magnetic image are those containing iron, and these may show magnetic iron mineral concentrations along old river-courses. Also, deeper-seated basement rock, is distinguished by differing magnetic signatures. These rocks tend to be more diffuse in magnetic appearance than near-surface features such as displayed by near-surface basalt flows.

In Port Phillip Bay only the southern, western and middle parts of the bay were flown by airborne magnetic surveys due to restrictions of low level flying over built up areas. Unfortunately, this meant the northern parts of the study area were not covered. Land based magnetic readings were substituted in this area but give much lower definition.

Figure 4 shows magnetic imagery over the whole Port Phillip bay area, but detail is absent or less well defined in the north and east. It also shows locations of GSV seismic lines and cores (as green squares with red numbers).

Figure 4. Magnetic image of Port Phillip Bay. Note the image deterioration with less detail in the northeastern part where airomagnetic surveys were not able to be performed. The 1979/80 GSV seismic lines and their position points are shown as black lines and position numbers. GSV core sites show as green squares with red core numbers. Core details provided on Tables 2 & 3.



Around Corio Bay, Bellarine Peninsula and Point Wilson to Wedge Point there is good data so that basalt flows can be represented by the mottled colour patterns coming south from the Bacchus Marsh area extend out into Port Phillip Bay for up to 4 km. They represent both onshore and offshore shallowly-located basalt flows. The large elliptical brown patterns such as north of the Bellarine Peninsula are probably some deep seated magnetic body such as a granite that maybe are several kilometers below the seabed. Similar features in the central part of the bay could be volcanic features. They appear to have magnetic river-like features flowing south from them and in this sense may be shallower. Similar large brown features on the Mornington Peninsula generally correspond to large granite outcrops. The intense magnetic feature over Point Henry is produced from the Alcoa aluminium smelter.

(C) COMBINED LIDAR IMAGERY AND MAGNETIC RESULTS.

South of the Werribee River combining the LiDAR imagery with magnetic results indicates where shallow basalt can be mapped with reasonable confidence as shown on Figure 5.

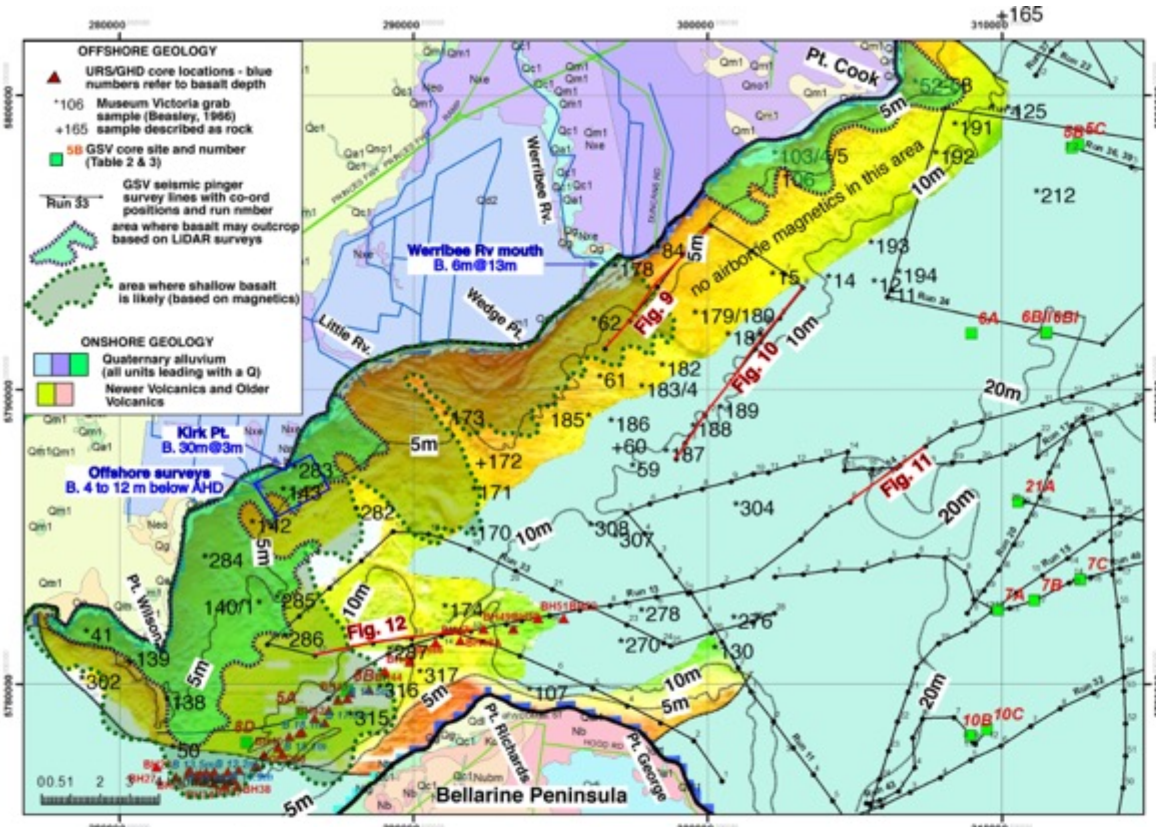


Figure 5. Combined LiDAR imagery and magnetic results showing offshore extent of basalt shown in the red area. Note definition of offshore basalt is indeterminate north of Werribee River due to lack of digital airborne magnetic coverage. Figure also shows onshore geology (for key see Figure 3 caption), locations for offshore GSV seismic surveys (black lines) and shot point locations (small numbers). Locations and number for Museum of Victoria (1966) offshore grab and pushcore samples (*182), samples described as rock (+172); GSV cores (green squares); and URS/GHD cores along Geelong Outer Harbour (red triangles). Depth to basalt (B) in all cases is indicated by blue numbers.

Areas underlain by basalt occur across the Werribee Plains (see geology map in Figures 3 and 5). Along the coast in the study area out to at least 5.0 m water depth basalt is common, almost if not outcropping, on the seabed. Beyond 10.0 m water depth some basalt especially in the Geelong Outer Harbour area may still be present but the magnetic intensity

is less, possibly indicating an increasing layer of soft sediment above. Based on the limited seismic lines, it is likely that basalt does not extend beyond about 15.0 m water depth.

(D) BASALT THICKNESS FROM ONSHORE BORES & POWER STATION GEOTECHNICAL DATA

From onshore water and minerals exploration bores drilled across the Werribee Plains the Newer Volcanics basalts appear to generally thin towards the southwest from a maximum of ~100.0 m thickness in the central Werribee Plains to less than 15.0 m at the coast (Ripper, 1975).

A State Electricity Commission of Victoria (SECV) study begun in 1968 proposed two new power station sites along the western Port Phillip Bay area - one at Werribee River mouth and one at Kirk Point (Gallimberti, 1972, 1973).

A test bore (Cocoroc-1) at the proposed Werribee River mouth site (Figure 6) indicated the basalt thickness here totaled about 6.0 m below ~13.0 m of soft sands, clays and gravels. It is considered likely that within the Werribee River valley confines there may be less basalt thickness due to erosion by the river. A similar result was interpreted from GSV seismic lines further offshore (see seismic section). Additional onshore drilling was conducted at the river mouth site (Bores A and B), but logs for these cannot be located at this stage. The offshore bathymetry to the Werribee site was also depth sounded in detail providing a seabed map at contour intervals of 1 foot (ie. ~0.3 m) (Figure 6). This seabed contour map extends offshore to ~10.3 m water depth, covering an area north and south of the river along the coast for ~5.0 km in each direction, and offshore for ~7.3 km. The contours clearly indicate the southeasterly course of the river offshore confined within a valley up to 900 m wide. Contours of the seabed south of the valley suggest a more complex seabed topography then to the north of the valley. This may indicate hard basalt occurs at shallow depths south of the Werribee channel compared to a smoother sediment

bay floor to the north side. Unfortunately, the method of contouring is not indicated on the bathymetry map, and its possible the north side was not contoured in the same detail as the south. On the other hand this offshore contouring survey was done over a similar period to surveys at Kirk Point, and likely similar methods were used in both areas; at Kirk Point the survey lines and methods are indicated and included EDO Western Profiler and Huntec Hydrosonde Profiler surveyers.

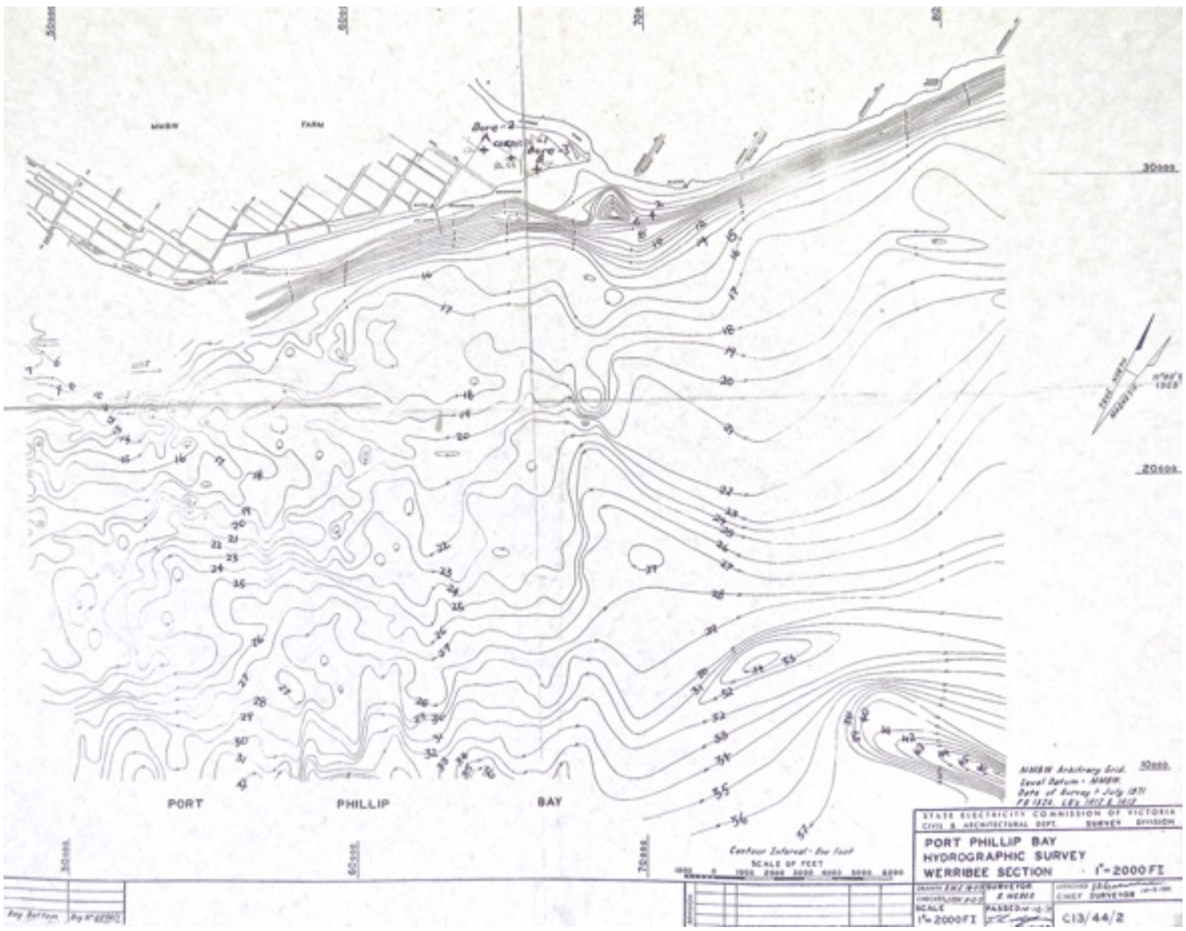


Figure 6. SECV sea bed mapping off Werribee River mouth. Note contours are in feet. For location of survey area see Figure 5.

A proposed SECV power station site on the coast at Kirk Point was investigated between 1968 and 1973 (Figure 7). At least one geotechnical bore (Murtcaim-2) ~500 m north of the point was drilled. Here 30.0 m of basalt was recorded below ~3.0 m of sandy,

silty loam. Other later bores are indicated on the maps but the logs for these cannot be located at this stage. In the offshore four bores are noted on the maps but the logs for these also cannot be located at this stage.

A detailed offshore survey by the EDO Western Profiler and Huntec Hydrosonde Profiler provided a map of depth to top of basalt relative to the sea surface, covering an area up to 1300 m offshore from Kirk Point and for along-the-coast distance of 2500 m (Figure 7). The nature and complexity of contours suggests basalt occurs at very shallow depths to possibly outcropping throughout the survey area, out to water depths of 9.0 to 10.0 m.

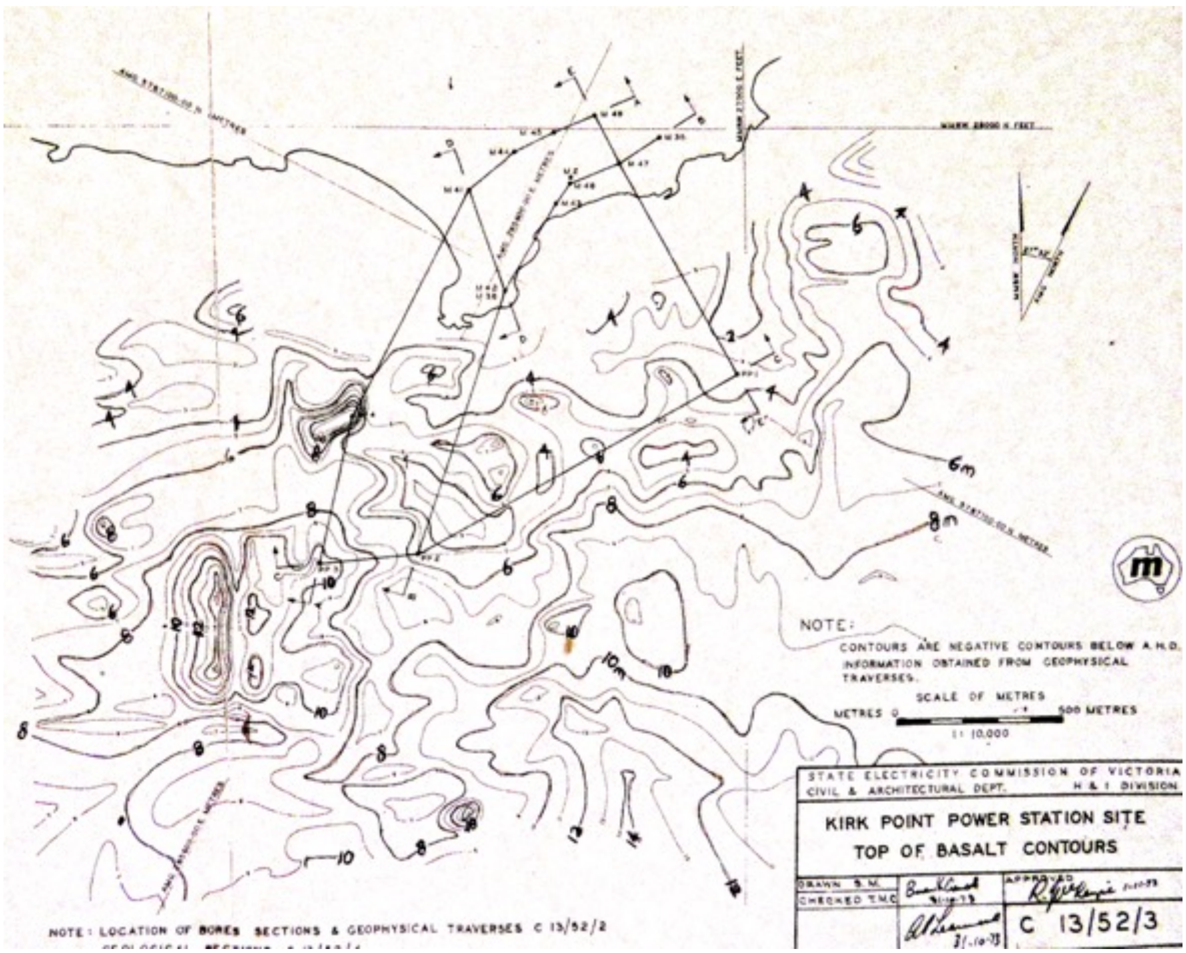


Figure 7. SECV sea bed top-of-basalt mapping off Kirk Point as determined by EDO Western Profiler and Huntec Hydrosonde Profilers. Note contours are in meters. For location of survey area see Figure 5.

(E) SEA-BED GRAB, PUSH CORE & VIBROCORE SAMPLING.

Bottom sediment distributions in Port Phillip have been published from grab samples, push cores and vibrocores (Beasley 1966, 1969 & 1971; Link, 1967; Buckley & Clark, 1987; Greilach *et al.*, 1996; Holdgate *et al.* 1981; 2001).

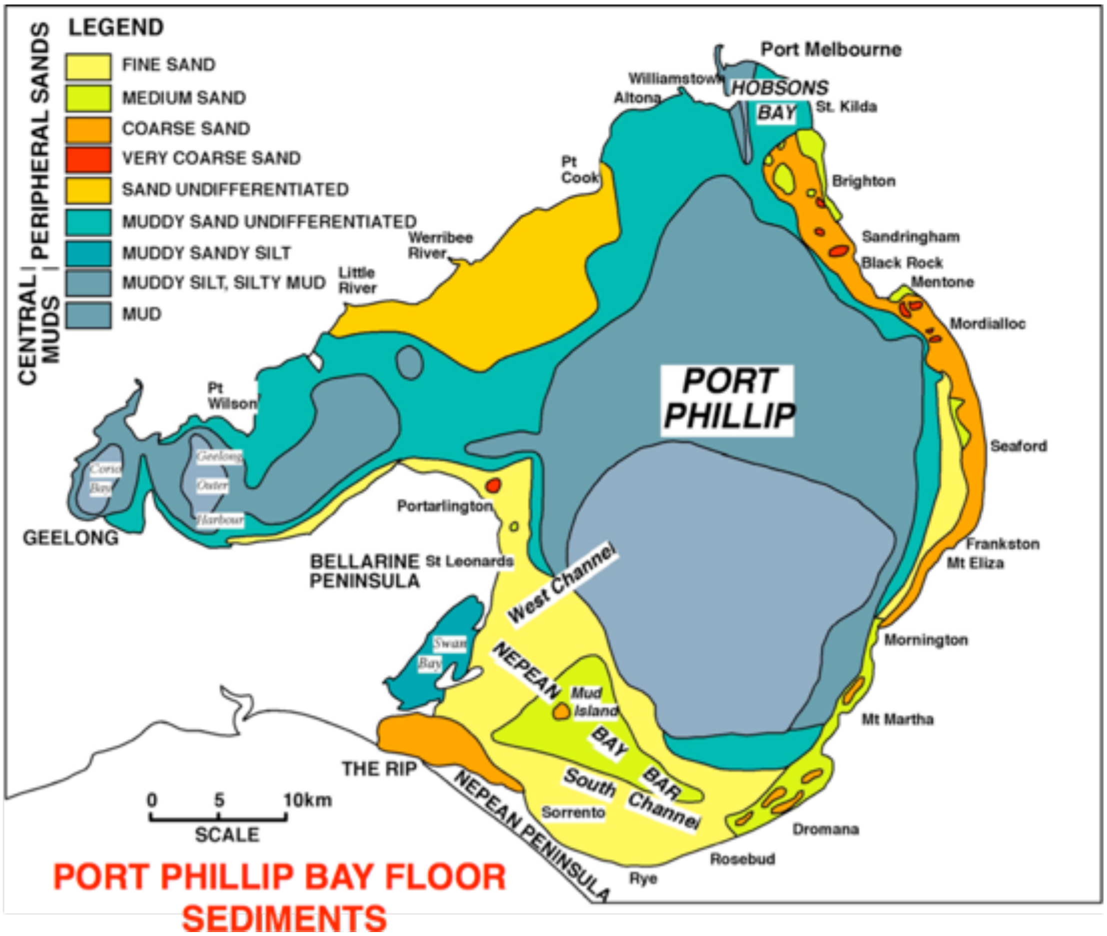


Figure 8: Summary diagram showing distribution of Port Phillip Bay floor sediments (modified from Holdgate et al. 2001).

The distribution of bay floor sediments is shown on Figure 8 adapted from Buckley & Clark (1987). The sediment characteristics of pushcores including permeability, consolidation, viscosity, settling velocity, grain size and bulk density are described by Greilach *et al.* (1996). National Museum Victoria sea bed samples in the study area are shown on Figure 5 (from Beasley, 1966). Their sediment characteristics are described in Table 1. Mostly only the top most layers were sampled so none were identified as basalt,

but those described as rock maybe basalt but could include sandstone. These include station numbers 139 (off Point Wilson - rock); 165 & 166 (north of Point Cook – rock); 172 (off Little River – rock). All other samples were variously described as sand, silt, mud, or various combinations (see Table 1).

The 1977-1982 Geological Survey studies carried out vibrocoring on the subsurface geology. In Port Phillip some twenty-nine vibrocores were drilled to depths varying between 0.5 and 5.0m. Details of this work are by Holdgate *et al.* 1981; 2001. Figure 5 shows the location of GSV vibrocores in the study area as green squares, and their details are given in Table 2 and Table 3.

(F) SEISMIC LINES SHOWING BASALT

The GSV surveys of 1977-1982 used a sub-bottom profiler from Ocean Research Equipment Inc. Position fixing used a Decca Trisponder Navigation System that had the fixes converted into Australian Map Grid (AMG) co-ordinates. Some early runs used dead reckoning between known features such as bouys, lighthouses etc. Further details are given in Holdgate et al. 2001. Thirty-six seismic runs totalling 656 kilometres were made in 1977 and 1978. Seismic penetration to 50 milliseconds 2-way-time (TWT) (about 37.0 metres) below the seabed was obtained in favourable sub-bottom conditions such as the soft mud that exists in the central basin. Resolution of single beds down to 1 millisecond (0.7 metres) is possible in muddy sediments. Around the shallower edges of the bay penetration was significantly less especially where sandy sediments prevail and basalt was completely opaque to the seismic frequencies used. Conversion of seismic two-way-time (TWT) to depth appeared to approximate the signal velocity in water of 1.5 km/sec. This assumed depth was found to agree with the depths found in the cores. The following 4 images show

inshore features in the study area mostly indicative of shallow basalt and/or mud overlying basalt in old river channels and lake basins.

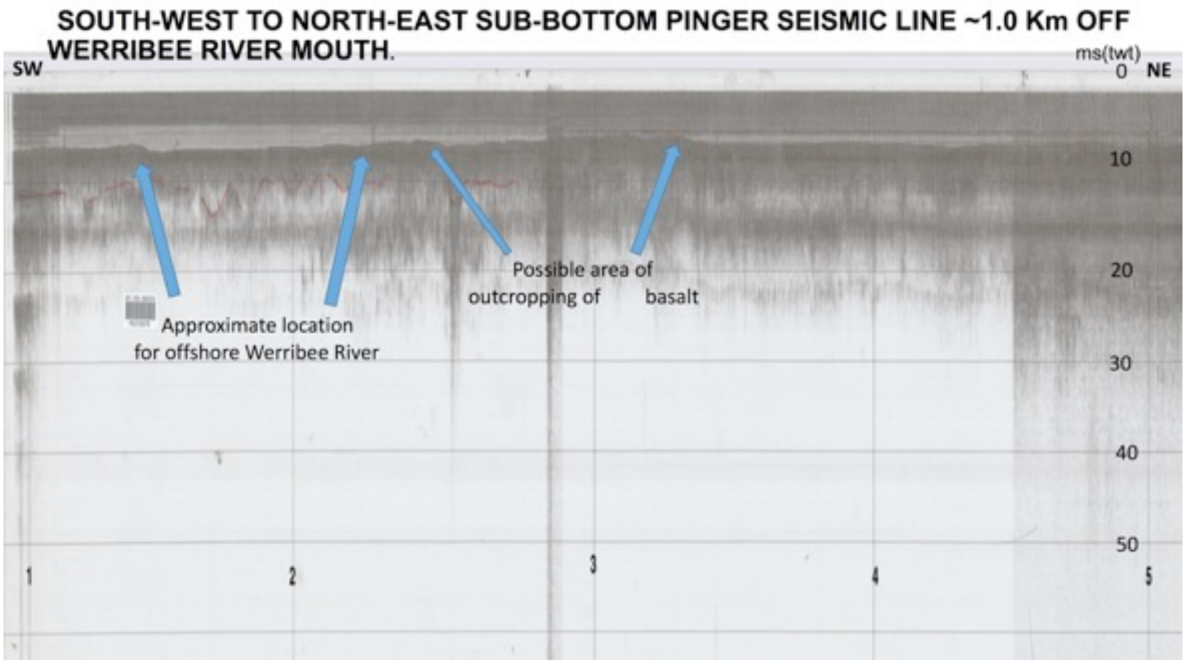


Figure 9. Part of Run 34 nearest Werribee River showing basalt outcrops. For location see Figure 5.

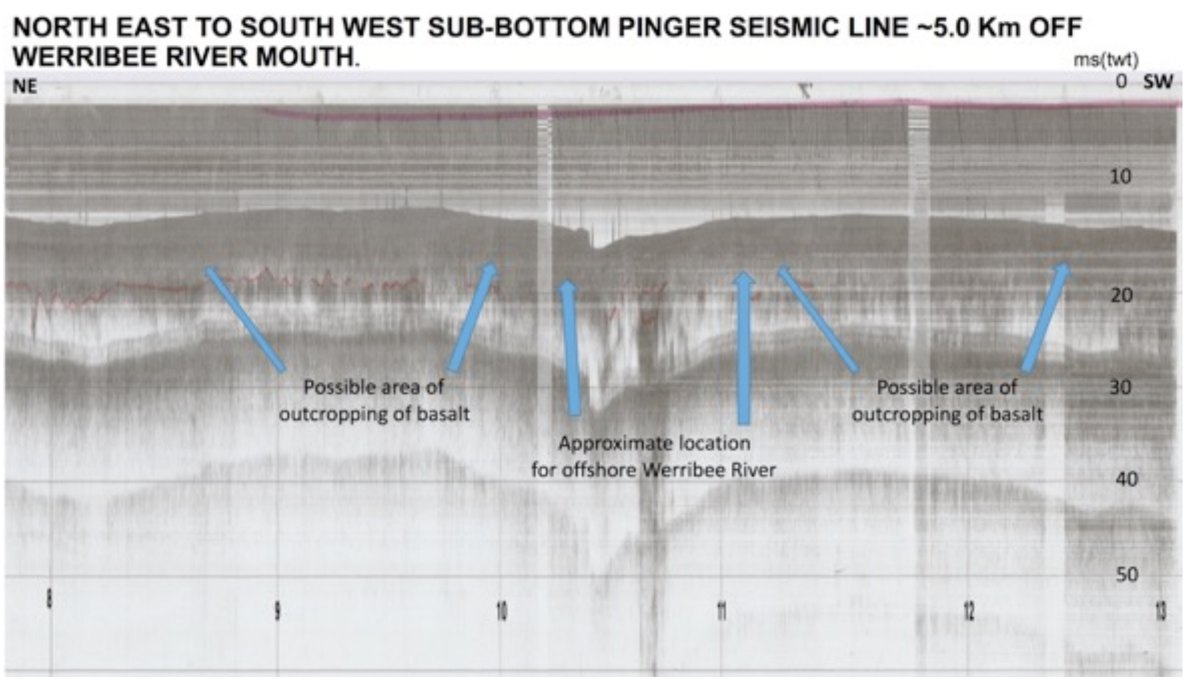


Figure 10. Part Run 34 furthest from Werribee River showing basalt outcrops. For location see Figure 5.

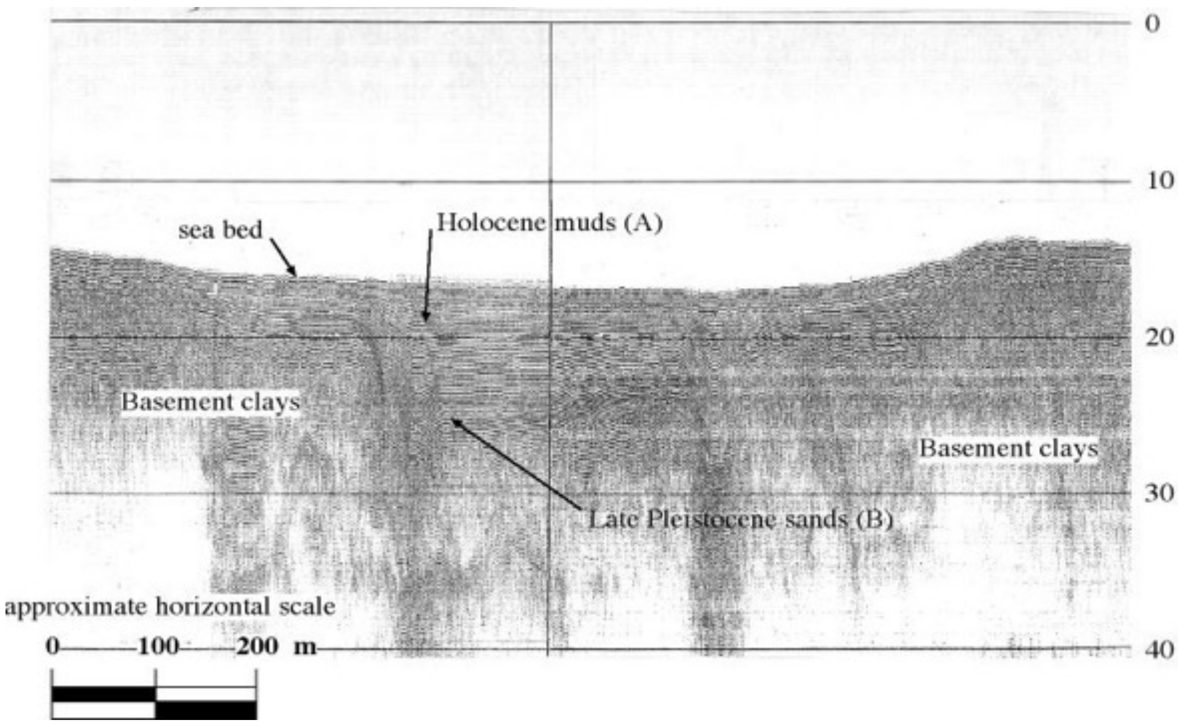


Figure 11. Part of Run 14 showing Werribee River about 9 km offshore from present river mouth showing no obvious signs of basalt in the record. For location see Figure 5.

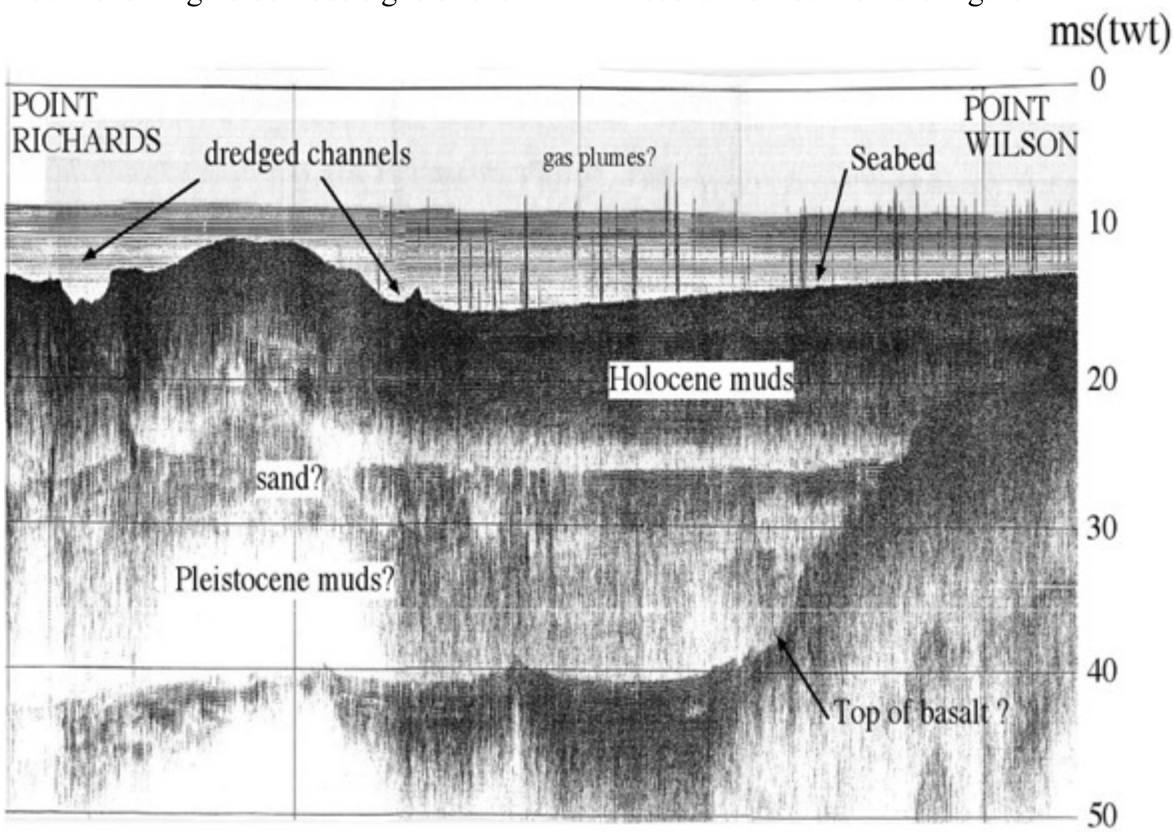


Figure 12. Part of Run 23 between Point Wilson and Point Richards showing basalts buried under thick muds and sand between Bellarine Peninsula and Little River. For location see Figure 5.

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TABLE 1. Museum Victoria seafloor samples in study area. Sample number locations are shown on Figure 6. Water depths given in fathoms and meters. Method of sampling was by diver push core (dive) or grab sampling (dredge). Textural class describes results of grain size analysis. Sa=sand; Si=silt; Cl=clay, nd=no data. For additional size analysis etc. see Beazley (1966).

1	Sample No.	Water depth in fathoms	Dive/Dredge	Textural class	Water depth in metres	Sample No.	Water depth in fathoms	Dive/Dredge	Textural class	Water depth in metres
2	11	8.50	dive	Sa	15.56	172	3.00	dive	SaSi	5.49
3	12	8.00	dive	Sa	14.64	173	2.00	dive	nd	3.66
4	14	7.00	dive	Sa	12.81	174	6.25	dive	SaSi	11.44
5	15	4.00	dive	Sa	7.32	178	1.50	dive	Sa	2.75
6	41	1.50	dive	Sa	2.75	179	3.50	dive	Sa	6.41
7	45	3.50	dive	SiSa	6.41	180	3.00	dredge	nd	5.49
8	48	3.00	dive	SiCl	5.49	181	3.50	dredge	nd	6.41
9	49	6.00	dive	SiCl	10.98	182	4.00	dredge	nd	7.32
10	50	5.00	dive	nd	9.15	183	3.50	dredge	nd	6.41
11	52	3.00	dive	nd	5.49	184	4.50	dive	Sa	8.24
12	53	3.00	dive	Sa	5.49	185	4.00	dredge	nd	7.32
13	54	2.50	dive	nd	4.58	186	4.25	dredge	Sa	7.78
14	55	3.00	dive	Sa	5.49	187	6.50	dive	Sa	11.90
15	56	3.00	dive	Sa	5.49	188	7.00	dredge	nd	12.81
16	57	2.00	dive	nd	3.66	189	7.00	dredge	nd	12.81
17	58	2.00	dive	Sa	3.66	190	6.00	dredge	nd	10.98
18	59	6.00	dive	Sa	10.98	191	6.00	dive	Sa	10.98
19	60	4.50	dive	Sa	8.24	192	5.00	dredge	nd	9.15
20	61	3.50	dive	Sa	6.41	193	6.00	dredge	SiSa	10.98
21	62	2.50	dive	Sa	4.58	194	8.00	dredge	nd	14.64
22	84	0.00	dive	nd	0.00	212	8.00	dredge	SaSi	14.64
23	102	5.00	dredge	nd	9.15	270	5.00	dredge	nd	9.15
24	103	2.25	dive	ClSi	4.12	276	8.00	dive	SaSi	14.64
25	104	2.50	dive	nd	4.58	278	8.00	dredge	SiSa	14.64
26	105	2.50	dive	nd	4.58	282	5.00	dive	SiCl	9.15
27	106	2.50	dive	nd	4.58	283	2.25	dive	SaClSi	4.12
28	107	2.50	dive	Sa	4.58	284	1.50	dive	SiSa	2.75
29	125	8.00	dive	ClSa	14.64	285	3.00	dredge	SiSa	5.49
30	126	3.50	dive	SiCl	6.41	286	5.00	dredge	SiCl	9.15
31	127	5.00	dive	SiCl	9.15	287	5.50	dredge	SaSiCl	10.07
32	130	6.00	dive	SaCl	10.98	302	4.00	dredge	Cl	7.32
33	138	2.50	dive	SiSa	4.58	304	7.00	dredge	nd	12.81
34	139	1.50	dive	SiSa	2.75	307	6.00	dredge	SiCl	10.98
35	140	3.00	dive	nd	5.49	308	6.00	dredge	nd	10.98
36	141	3.50	dive	nd	6.41	311	4.00	dredge	Cl	7.32
37	142	3.00	dive	nd	5.49	312	4.00	dredge	nd	7.32
38	143	3.50	dive	nd	6.41	314	4.50	dive	Cl	8.24
39	165	5.00	dive	SiSa	9.15	315	5.00	dredge	SiCl	9.15
40	166	7.00	dive	SiSa	12.81	316	6.00	dredge	nd	10.98
41	170	5.50	dive	SiSa	10.07	317	4.50	dredge	nd	8.24
42	171	4.50	dive	SaSi	8.24					
43	172	3.00	dive	SaSi	5.49				nd=no data	

TABLE 2: GEOLOGICAL SURVEY VIBRO-CORE SITE LOCATIONS, NANNOFOSSIL SAMPLES & STRATIGRAPHY, PORT PHILLIP.

Core Site No.	Co-ords. AMG East	Co-ords. AMG north	Water depth	Core recov-ery	Nanno-fossil sample depth	Nanno-fossil age (tr=trace nd=no age)	Coode Island Silt	Fisher-mans Bend Silt (nr=not reached)
1A	317356	807589	13.7m	1.31m	1.31m	tr, nd.	0-1.31	nr
1B	?	?	13.0m	0.53m	-	-	0-0.53	nr
1C	317589	808879	21.2m	1.00m	0.96m	nd	0-1.00	nr
2A	317106	806229	16.4m	0.94m	-	-	0-0.50	0.50-0.94
2B	317415	805673	17.1m	2.40m	-	-	0-2.40	nr
4A	312645	803125	18.5m	0.62m	0.60m	barren	0-0.37	0.37-0.62
4B	312757	802572	22.6	0.76m	0.75m	tr, nd	0-0.76	nr
4C	312901	802523	24.6m	3.07m	3.06m	barren	0-3.07	nr
5B	312372	798221	26.0m	0.77m	0.74m	tr, nd	0-0.47	0.47-0.77
5C	312599	798324	32.9	3.75m	-	-	0-3.75	nr
6A	308957	791889	30.1m	0.66m	-	-	0-0.40	0.40-0.66
6Bi	311500	791917	32.9m	0.75m	0.74m	tr, nd	0-0.56	0.56-0.75
6Bii	311511	791936	35.2m	2.80m	2.79m	Holocene	0-2.80	nr
7A	309862	782497	37.7m	2.00m	2.00m	barren	0-0.89	0.89-2.00
7B	311107	782821	39.4	0.75m	0.74m	tr, nd	0-0.20	0.20-0.75
7C	312660	783535	39.7	1.42m	1.41m	tr, nd	0-1.42	nr
7D	317743	784786	36.3m	3.80m	-	-	0-3.80	nr
8B	Corio	Bay	?	2.06m	-	-	0-1.55	1.55-2.06
8D	Corio	Bay	17.4m	1.14m	1.13m	barren	0-0.93	0.93-1.14
9A	316474	790963	31.0m	3.17	3.16	barren	0-3.17	nr
9B	320342	792322	27.1m	3.08m	-	-	0-2.93	2.93-3.08
10B	308936	778224	41.1m	1.33	1.32	barren	0-1.19	1.19-1.33
10C	309485	778431	41.0m	4.04m	4.00m	tr, nd	0-4.04	nr

11E	325991	767651	30.1m	0.61m	-	-	0-0.41	0.41-0.61
11F	326146	767999	30.4	0.71m	-	-	0-0.55	0.55-0.71
21A	310564	786177	37.7m	0.57m	0.56m	tr, nd	0-0.48	0.48-0.57
CB1	Corio Bay	Buoy No.11	10.3m	4.20m	-	-	0-4.20	nr
CB2	Corio Bay	200mNbouy 3	?	1.11m	-	-	0-1.11	nr?

TABLE 3: GEOLOGICAL SURVEY PORT PHILLIP CORE DESCRIPTIONS
(for locations etc. see Table 2)

Vibrocore 1A: 0-0.59m: dark blue-grey to black sticky silty mud. 0.59-0.99m: grey brown shelly silty and sandy mud. 0.99-1.31m: grey silty mud, slightly shelly, sticky.

Vibrocore 1B: 0-0.12m: grey brown sandy mud, slightly shelly. 0.12-0.26m: grey muddy sand with abundant shells. 0.26-0.34m: light brown very shelly muddy sand. 0.34-0.53m: grey brown very shelly sticky clay.

Vibrocore 1C: 0-0.95: dark grey silty and sandy mud with scattered shells. 0.95-1.00m: light grey-brown medium clean sand.

Vibrocore 2A: 0-0.25m: grey brown sandy mud, slightly shelly. 0.25-0.50m: dark grey very shelly quartz sand with Anadara shells at base. 0.50-0.95m: mottled brown and grey sticky clay, traces of shelly fossils (contaminants?).

Vibrocore 2B: 0-1.56m: grey slightly silty mud, sticky, traces of shells. 1.56-2.06m: grey sandy mud with some shells. 2.06-2.40m: grey mud, sticky, traces of shells.

Vibrocore 4A: 0-0.37m: brown muddy sand with shells, grading down to shelly quartz clean sand. 0.37 0.41m: hard cemented band of iron-stained carbonate nodules. 0.41-0.62m: mottled grey and light brown stiff clay.

Vibrocore 4B: 0-0.27m: grey brown medium to fine quartz sand with shells. 0.27-0.65m: coarse quartz and very shelly sand. 0.65-0.74m: dark brown peaty coal, some coarse quartz sand on top. 0.74-0.77m: coarse brown sand, slightly muddy, no shells.

Vibrocore 4C: 0-1.57m: grey muddy sand and sandy mud with some shells, grading down to: 1.57-3.07m: grey sticky silty mud with minor shells.

Vibrocore 5B: 0-0.65m: brown sandy mud with disseminated shells, particularly near the base. 0.65-0.77m: blue-grey stiff clay, brown mottling, traces of shells (contaminants?).

Vibrocore 5C: 0-0.32m: brown-grey sandy mud with shells. 0.32-3.75m: medium dark grey silty mud and mud with minor shells.

Vibrocore 6A: 0-0.40: brown muddy shelly sand, quartz sand,, very shelly at the base, oysters. 0.40-0.66m: blue-grey and brown mottled stiff clay containing brown stained quartz pebbles, traces of shells (contaminants?).

Vibrocore 6B: 0-0.56m: brown muddy shelly quartz sand. 0.56-0.64m: blue-grey mottled sandy clay. 0.64-0.75m: blue-grey and brown mottled stiff clay.

Vibrocore 6Bii: 0-2.80m: sticky brown-grey (top) grading to dark-grey silty mud, disseminated shells.

Vibrocore 7A: 0-0.89m: grey-brown sandy mud, abundant shells including oysters. 0.89-2.00m: grey-brown mottled stiff silty clay and clay, bands of iron-stained stiff clays and sands every 0.7m.

Vibrocore 7B: 0-0.20m: grey-brown silty mud. 0.20-0.40m: dark-blue grey and brown stiff clay with an oxidised clay band at the top.

Vibrocore 7C: 0-0.72m: blue-grey-brown silty mud with rare shells. 0.72-1.16m: brown sandy mud with shells at the base. 1.16-1.42m: stiff dark grey clayey mud.

<u>Vibrocore 7D:</u> 0-3.07m: medium greeny-grey-brown mud with traces of shells. 3.07-3.58m: grey sandy mud grading down to muddy quartz sand with shells at the base. 3.58-3.80m: sticky firm silty mud, dark grey, with traces of shells, becoming brown mottled at the base.

<u>Vibrocore 8B:</u> 0-0.47m: brown shelly sand. 0.47-0.96m: dark grey shelly mud with weathered zone at base. 0.96-1.55m: blue-grey sticky mud. 1.55-2.06m: mottled blue-grey and brown stiff clay, nodules of carbonate cemented sands.

<u>Vibrocore 8D:</u> 0-0.38m: brown shelly mud. 0.38-0.93m: blue-grey mud, rare shells more abundant towards the base. 0.93-1.14m: mottled blue-grey and brown stiff clay, weathered zone at top.

<u>Vibrocore 9A:</u> 0-3.17m: brown-grey slightly shelly mud, blue-grey at depth.

<u>Vibrocore 9B:</u> 0-2.93m: brown and blue-grey mud, scattered and layered shelly horizons. 2.93-3.08m: mottled grey and brown stiff clay, weathered at the top.

<u>Vibrocore 10B:</u> 0-1.19m: grey and blue-grey shelly mud, very shelly at the base with oysters. 1.19-1.33m: red-brown mottled stiff clay and sandy clay, weathered zone at top.

<u>Vibrocore 10C:</u> 0-0.30m: brown shelly mud. 0.30-3.26: blue-grey mud, some shells, firmer towards base with less shells.

<u>Vibrocore 11E:</u> 0-0.41m: brown shelly muddy sand, abundant shells at the base. 0.41-0.61m: greeny-blue-grey and purple-grey mottled stiff clay and clayey silt, weathered zone at the top.

<u>Vibrocore 11F</u>: 0-0.55m: brown shelly muddy sand, abundant shells at the base. 0.55-0.71m: blue-grey and brown mottled stiff clay.

<u>Vibrocore 11G:</u> 0-1.04m: brown shelly fine sand and muddy sand, shelly and greyer at the base. 1.04-1.32m: mottled dark grey and brown stiff sandy clay, clayey sand over the top 7cm, ligneous coal band at 1.10m.

<u>Vibrocore 21:</u> 0-0.48m: brown shelly silty mud. 0.48-0.57: grey-brown and blue-grey mottled stiff clay.

<u>Vibrocore Corio Bay Core 1 buoy 11 (Hopetown Channel):</u> 0-3.60m: brown and blue-grey sandy mud, shelly and sandy towards the base. 3.60-3.94m: light grey-white sticky mud, mottled bands of brown mud. 3.94-4.20m: dark blue-grey sticky mud.

<u>Vibrocore Corio Bay Core 2, 200m north of buoys 3 and 4:</u> 0-0.74m: brown-grey silty mud, abundant shells at the base. 0.74-1.00m: blue-grey sticky clay with shells, some brown mottling. 1.00-1.11m: brown sandy clay, disseminated coarse quartz sands.