

Sand Suitability Investigation – Semaphore and Largs Bay

Findings report



Aim

The aim of this sand grain size investigation was to determine the suitability of sand on northern Adelaide's metropolitan beaches as a potential source of sand for beach replenishment projects further south along the metropolitan coast.

The field sampling and analysis was undertaken in May 2019.

Background

Sand characteristics vary along and across the beach as a consequence of wave sorting and seasonal conditions. The suitability of material for the purposes of replenishment and placement on the beach is based what is called the overfill ratio (US Army Corps of Engineers, *Shore Protection Manual*, 1984).

The overfill ratio is calculated by comparing the size distribution characteristics of the sand at the beach to be replenished with the characteristics of the sand at the source beach. It includes an adjustment for the percentage of fine grain size sediment in the source area.

The overfill factor (R_A) is used to "...predict the volume of borrow material needed to produce a unit volume of stable fill material with the same general grain size as the native beach" (Stauble 2005, <http://www.fsbpa.com/publications/2005-tech.html>).

Method

To test the suitability of sand in Largs Bay for replenishing areas further south, samples from northern metropolitan beaches were compared with samples from the beach at the Semaphore South breakwater (Point Malcolm), which is supplied with sand via littoral drift from beaches to the south. The samples were also compared with a historic control sample of sand taken from Brighton beach in 1982. The Brighton 1982 sample is used as it is representative of Adelaide beach sand prior to the start of intensive beach management activities that included large scale sand recycling and addition of sand from external sand sources such as quarries or offshore deposits at Port Stanvac.

In May 2019, a total of 48 beach sand samples, to a depth of 1.0m, were collected by the University of Adelaide. The twelve sample sites correspond with the Coast Protection Board beach profiles between Semaphore Park and North Haven. On each of these profile lines, samples were collected from four heights along the beach profile:

- Low Water Mark: -1.45m Australian Height Datum (AHD)
- Mean Sea Level: 0.0m AHD
- High Water Mark: 0.9m AHD
- Toe of foredune: height varies

The Environmental Analysis Laboratory of Southern Cross University in New South Wales performed sand grain analyses to determine grain size and composition. These analyses allowed calculation of overfill ratios.

Results

The results from the sand grain analysis show that sand grain sizes at the Semaphore South breakwater (Figure 1) are very similar to sand grain sizes located between Semaphore and Largs Bay (Figures 2-4).

The analyses also demonstrated that the distribution of sand grain size changes significantly for the samples collected on beach profiles further north toward North Haven. This shows that there is a higher proportion of fine grain sediment found within the samples in the northern part of Largs Bay (e.g. 31 per cent and 40 per cent retained of 0.125 mm particle sizes at Taperoo and Osborne, respectively).

The sand sample analyses showed that between Semaphore and Largs Bay, sand comprises predominantly silica while the northern-most samples contain more carbonate material. Carbonate sediment is less dense and therefore lighter than silica sediment. Grains of carbonate sand are more prone to movement as a result.

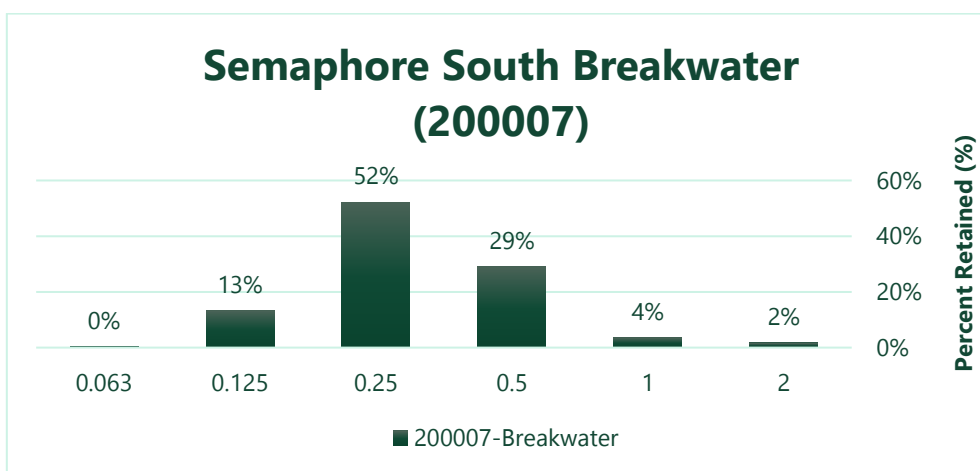


Figure 1: Average sand grain size across the three intertidal samples (excluding toe of dune) at Profile 200007, Semaphore South breakwater.

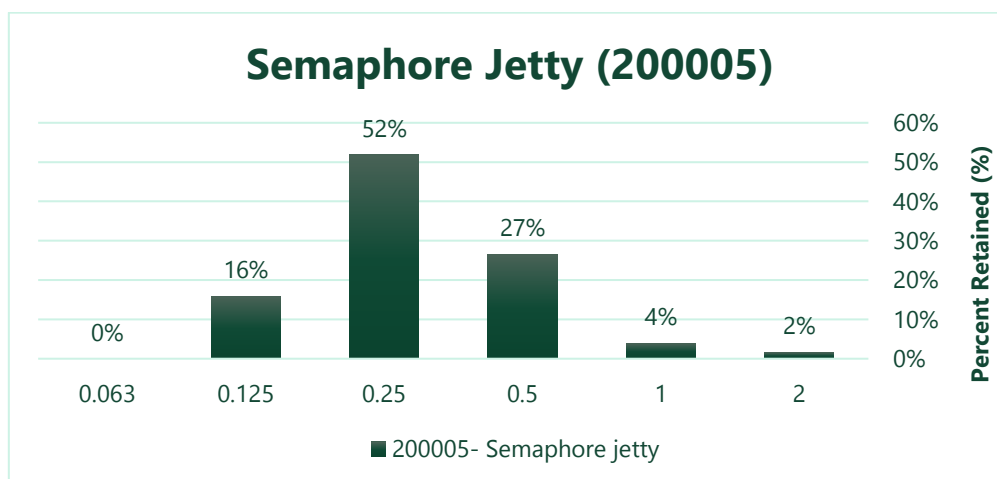


Figure 2: Average sand grain size across the three intertidal samples (excluding toe of dune) at Profile 200005, Semaphore Jetty.

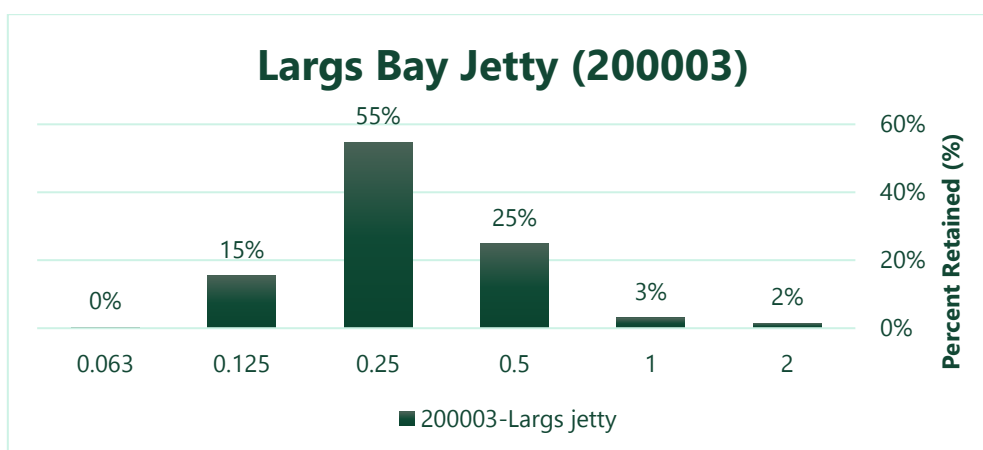


Figure 3: Average sand grain size across the three intertidal samples (excluding toe of dune) at Profile 200003, Largs Bay Jetty.

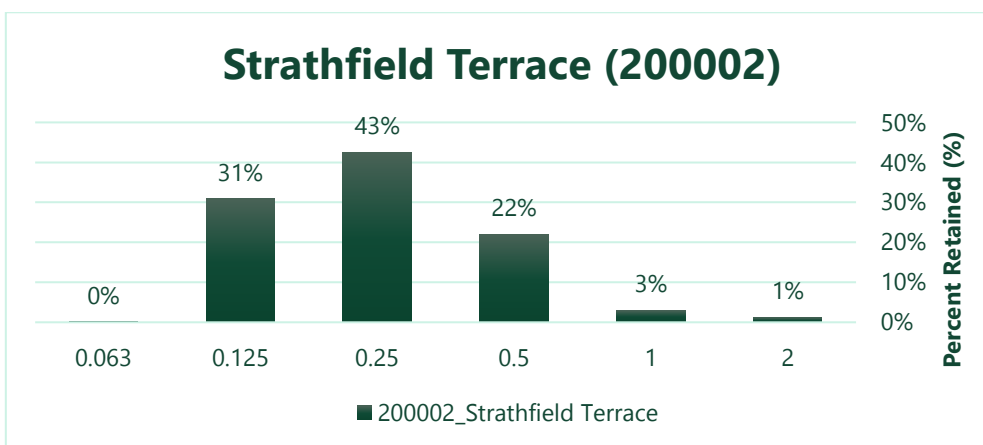


Figure 4: Average sand grain size across the three intertidal samples (excluding toe of dune) at Profile 200002, Strathfield Terrace, Taperoo.

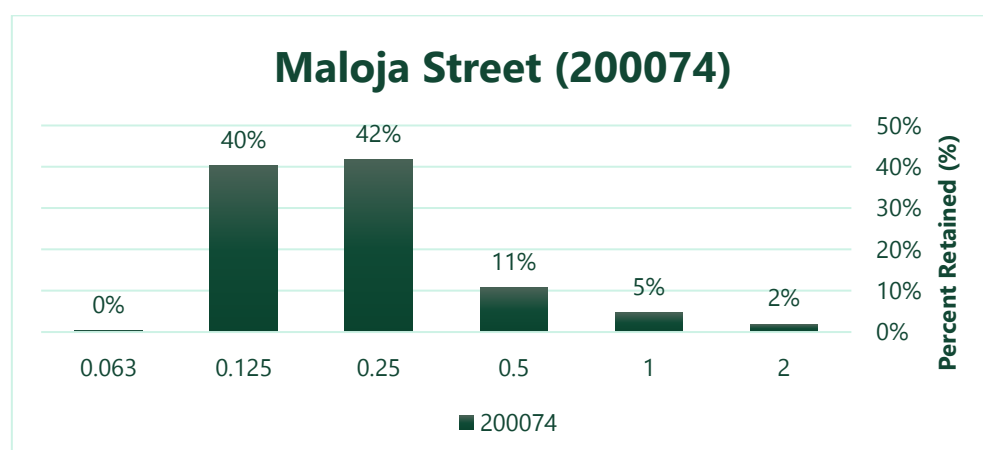


Figure 5: Average sand grain size across the three intertidal samples (excluding toe of dune) at Profile 200074, Maloja Street, Osborne.

Intertidal composite sand properties were generated using results of the three intertidal samples along each profile (i.e. excluding the toe of foredune sample). The intertidal samples were chosen for analysis as this is the zone of the beach profile that sand is collected from.

Overfill factors (or overfill ratios) were calculated when compared against sand properties at the Semaphore South breakwater (Table 1) and the Brighton 1982 sand sample (Table 2).

Since sand from source beaches will rarely be an exact match for the properties of the sand at the replenishment beach, the amount of borrow material needed to result in a net cubic metre (m^3) of beach fill material at the replenishment beach will generally be greater than one cubic metre. The excess material needed to yield one net cubic metre of material in place on the replenishment beach is the overfill ratio. For example, the overfill ratio calculations shown in Table 1 and 2 below, show that if sand were utilised from the vicinity of Profile 200124 (North Haven), 6 m^3 of sand would be required to provide the same level of protection as 1 m^3 of sand that is collected from the Semaphore breakwater area.

Profile Number	Name	D ₈₄ (mm)	φ ₈₄	D ₁₆ (mm)	φ ₁₆	σβ	m _b	(m _{φb} -m _{φn})/σ _{φ_n}	σ _{φb} /σ _{φ_n}	Overfill ratio, R _A	Carbonate (%)
200008	Recreation Parade	0.145	2.79	0.475	1.07	0.86	1.9	-0.15	1.06	Stable	1.58
200006	Hart St	0.115	3.12	0.335	1.58	0.77	2.3	0.37	0.95	1.6	1.8
200005	Semaphore Jetty	0.13	2.94	0.415	1.27	0.84	2.1	0.07	1.04	1.05	1.57
200004	Kanowna Rd	0.127	2.98	0.38	1.40	0.79	2.2	0.17	0.98	1.2	1.68
200003	Largs Jetty	0.135	2.89	0.4	1.32	0.78	2.1	0.07	0.97	1.05	1.77
200129	Afric St	0.092	3.44	0.365	1.45	0.99	2.4	0.49	1.23	1.5	1.88
200002	Strathfield Terrace	0.096	3.38	0.388	1.37	1.01	2.4	0.40	1.25	1.25	1.75
200001	Gedville Rd	0.0846	3.56	0.25	2.00	0.78	2.8	0.91	0.97	4.0	2.35
200074	Maloja Street	0.0885	3.50	0.335	1.58	0.96	2.5	0.60	1.19	1.75	2.95
200124	North Haven	0.0884	3.50	0.238	2.07	0.71	2.8	0.91	0.88	6.0	4.18
200122		0.0884	3.50	0.423	1.24	1.13	2.4	0.40	1.40	1.4	5.51
		D ₈₄	f ₈₄	D ₁₆	f ₁₆	σ	m _n				
200007	Breakwater	0.138	2.86	0.423	1.24	0.81	2.0				1.22

Table 1: Overfill ratio calculations undertaken for beach profiles between Semaphore Park and North Haven compared to Semaphore South breakwater sand. Calculations use the averages of the three intertidal samples at each profile location.

Profile Number	Name	D ₈₄ (mm)	φ ₈₄	D ₁₆ (mm)	φ ₁₆	σβ	m _b	(m _{φb} -m _{φn})/σ _{φ_n}	σ _{φb} /σ _{φ_n}	Overfill ratio, R _A	Carbonate (%)
200008	Recreation Parade	0.145	2.79	0.475	1.07	0.86	1.9	-0.19	1.19	1.05	1.58
200007	Breakwater	0.138	2.86	0.423	1.24	0.81	2.0	-0.03	1.13	1.02	1.22
200006	Hart St	0.115	3.12	0.335	1.58	0.77	2.3	0.39	1.08	1.5	1.8
200005	Semaphore Jetty	0.13	2.94	0.415	1.27	0.84	2.1	0.05	1.17	1.05	1.57
200004	Kanowna Rd	0.127	2.98	0.38	1.40	0.79	2.2	0.16	1.10	1.12	1.68
200003	Largs Jetty	0.135	2.89	0.4	1.32	0.78	2.1	0.05	1.09	1.05	1.77
200129	Afric St	0.092	3.44	0.365	1.45	0.99	2.4	0.53	1.39	1.5	1.88
200002	Strathfield Terrace	0.096	3.38	0.388	1.37	1.01	2.4	0.42	1.40	1.4	1.75
200001	Gedville Rd	0.0846	3.56	0.25	2.00	0.78	2.8	0.99	1.09	3.5	2.35
200074	Maloja Street	0.0885	3.50	0.335	1.58	0.96	2.5	0.65	1.34	1.75	2.95
200124	North Haven	0.0884	3.50	0.238	2.07	0.71	2.8	1.00	1.00	4.5	4.18
200122		0.0884	3.50	0.423	1.24	1.13	2.4	0.42	1.57	1.4	5.51
		D ₈₄	f ₈₄	D ₁₆	f ₁₆	σ	m _n				
	Brighton 1982	0.145	2.79	0.392	1.35	0.72	2.1				

Table 2: Overfill ratio calculations undertaken for beach profiles between Semaphore Park and North Haven compared to the sand sample from Brighton in 1982. Calculations use the averages of the three intertidal samples at each profile location.

Conclusions

Sediment sampling and analysis was carried out to determine the characteristics of the beach sand between the Semaphore South breakwater (Point Malcolm) and North Haven to inform the suitability for replenishment purposes. A total of 48 samples were collected and analysed at 12 beach profiles between the Point Malcolm boat ramp and the Outer Harbour breakwater. The following conclusions are derived from the test results.

Note that overfill ratios within 15 per cent of being stable ($R_A = 1$) indicate that the source sand is a relatively close match to the sand at the beach that requires replenishment.

- The sand at the Semaphore South breakwater, and between the Semaphore and Largs Bay jetties is suitable for replenishing beaches further south on the metropolitan coast. That this is the case when using the 1982 sand sample from Brighton shows how close current beach sand remains to the properties of the historical Adelaide beach sand at Brighton.
- The sand is finer at the northern end of Largs Bay, so that a much larger quantity would be required if it were to be used for replenishment of southern metropolitan beaches.
- A higher proportion of carbonate sand, which is generally less stable than silica sand because of its shape and lower density, further reduces the suitability of sand from north of Strathfield Terrace, Largs Bay for beach replenishment.