

Photo 2.13 Sediment physical attribution (naked eye view).

2.2.3 Physical Properties

Sediment particle size class results are summarised in Table 2.14 while the sediment particle size distribution at the study area is shown in Figure 2.21. Sediments at all the stations are dominated by sand particles. Noticeable amounts of fine particles (silt) were observed at stations S3f, S3g and S4b.

Table 2.14 Sediment particle size class results.

Station	Sediment Size Class (%)				
	Gravel	Sand	Silt	Silt & Clay	Clay
S1a	0	97	N.A.	3	N.A.
S1b	2	98	N.A.	0	N.A.



Station	Sediment Size Class (%)				
	Gravel	Sand	Silt	Silt & Clay	Clay
S1c	5	95	N.A.	0	N.A.
S1d	0	96	N.A.	4	N.A.
S1e	6	84	N.A.	10	N.A.
S1f	1	98	N.A.	1	N.A.
S1g	32	68	N.A.	0	N.A.
S1h	5	95	N.A.	0	N.A.
S1i	21	79	N.A.	0	N.A.
S2a	0	99	N.A.	1	N.A.
S2b	6	93	N.A.	1	N.A.
S2c	3	96	N.A.	1	N.A.
S2d	4	95	N.A.	1	N.A.
S2e	5	94	N.A.	1	N.A.
S2f	2	97	N.A.	1	N.A.
S2g	4	96	N.A.	0	N.A.
S2h	7	92	N.A.	1	N.A.
S3a	1	98	N.A.	1	N.A.
S3b	3	89	N.A.	8	N.A.
S3c	3	96	N.A.	1	N.A.
S3d	3	95	N.A.	2	N.A.
S3e	0	82	N.A.	18	N.A.
S3f	0	71	27	N.A.	2
S3g	1	71	26	N.A.	2
S3h	8	92	N.A.	0	N.A.
S4a	1	97	N.A.	2	N.A.
S4b	5	61	27	N.A.	7

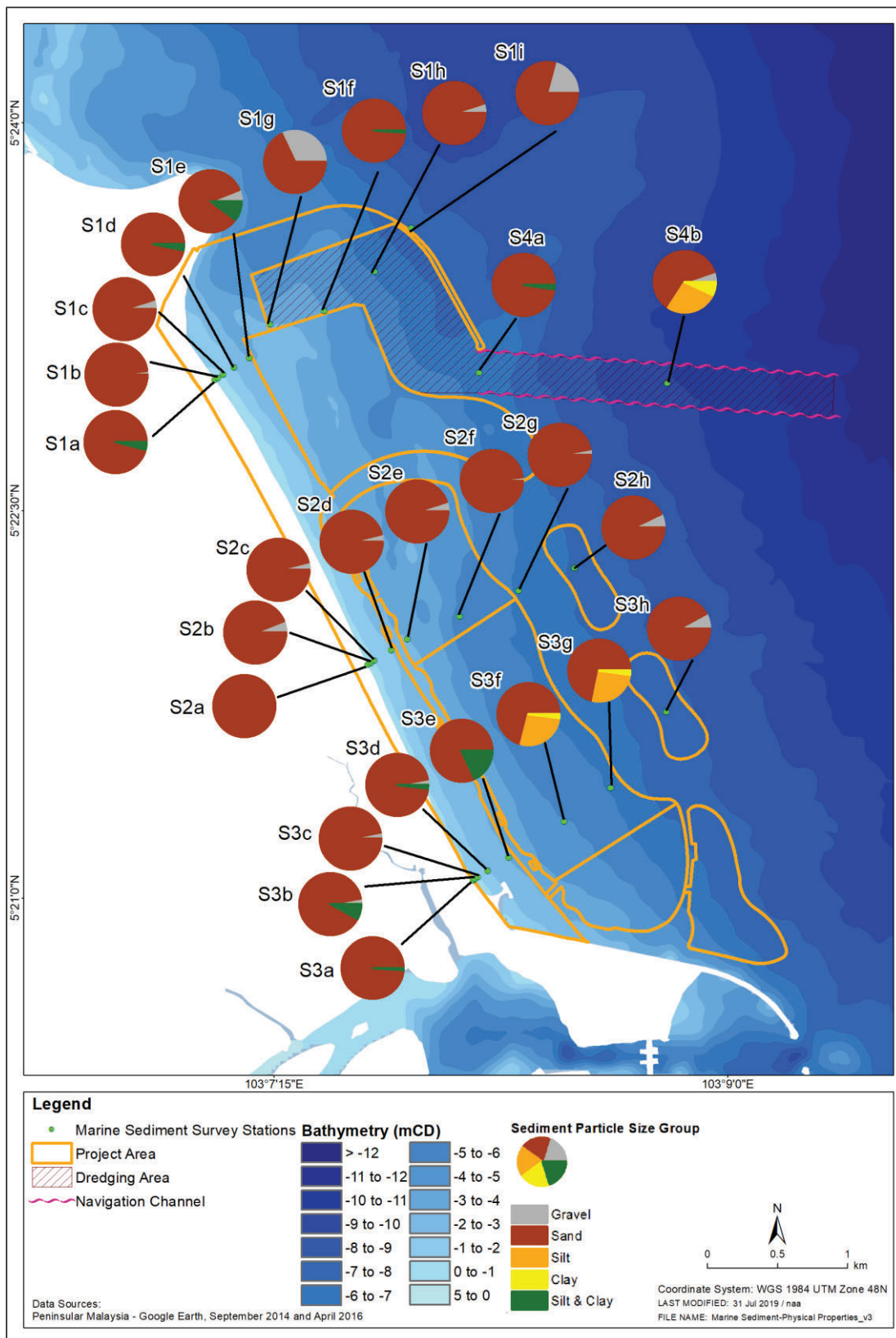


Figure 2.21 Percentage of sediment particle size group at all sampling stations.

2.2.4 Chemical Content

Chemical analysis was carried out for stations S1f, S2e, S3h, S4a and S4b only. Stations S1g, S1f, S1h, S4a and S4b lie within the proposed dredging area. As shown in Table 2.15, the sediments are clean, with concentrations of all metals listed in the Dutch Soil Remediation Circular falling well within the intervention values and petroleum hydrocarbons below the laboratory detection limit.

Heavy metals at most stations were below the laboratory detection limit, with the exception of station S4b and certain metals. The results of the heavy metals analysis are further discussed in the following subsection.

Total organic carbon (TOC) provides indication of organic carbon present in sediment, which is mainly derived from anthropogenic sources or decomposition of plants and animals /4/. As may be expected given the adjacent land uses, TOC in sediments were low and ranged between 1.0% and 1.3% within the dredging footprint, and between 0.7% and 1.6% at stations within the reclamation footprint.

Table 2.15 Chemical content in sediment against the Dutch Standards.

Parameters	Unit	Station					Dutch Standards	
		S1f	S2e	S3h	S4a	S4b	Target Value	Intervention Value
Total Organic Carbon (TOC)	%	1.1	1.6	0.74	1.3	1.0	N.A.	N.A.
Total Petroleum Hydrocarbons (TPH)	mg/kg	<1	<1	<1	<1	<1	N.A.	N.A.
TPH Fractions (C6- C9)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	N.A.	N.A.
TPH Fractions (C10- C14)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	N.A.	N.A.
TPH Fractions (C15- C26)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	N.A.	N.A.
TPH Fractions (C27- C36)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	N.A.	N.A.
Cyanide	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	N.A.	N.A.
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	0.8	12
Mercury	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	0.3	10
Arsenic	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	0.9	55
Lead	mg/kg	<0.01	<0.01	<0.01	<0.01	62	55	530
Copper	mg/kg	<0.01	<0.01	<0.01	<0.01	21	3.4	96
Nickel	mg/kg	<0.01	<0.01	<0.01	<0.01	<0.01	0.26	100
Chromium	mg/kg	<0.01	<0.01	9	7	62	<0.38	220
Iron	mg/kg	27,362	56,407	100,746	46,623	127,213	N.A.	N.A.
Manganese	mg/kg	230	590	1102	623	1,577	N.A.	N.A.

Note: N.A. means not available.

2.2.4.1 Heavy Metals

Nine heavy metals were analysed in the sediments from the sampling stations. Four out of these heavy metals were below laboratory detection limits (i.e. cadmium, arsenic, nickel: <0.01 mg/kg) and mercury (<0.02 mg/kg)) and thus below the respective Dutch Standards limits. Concentrations of other detected heavy metals are shown in Figure 2.22.

Lead and copper were detected at Station S4b only at a concentration of 62 mg/kg and 21 mg/kg respectively while chromium was detected at stations S3h, S4a and S4b only between 7 mg/kg and 62 mg/kg. Concentrations of these metals were above the target value but below the intervention value stipulated under the Dutch Standards.

Iron and manganese were detected at all the stations in which iron was recorded between 27,362 mg/kg and 127,213 mg/kg while manganese was recorded between 230 mg/kg and 1,577 mg/kg. The high amount of manganese can be attributed to it being the third most abundant transition metal in Earth's crust (0.019 mol/kg) which is low when compared to the abundance of iron (1.1 mol/kg) /5/. There is no limit for iron and manganese specified under the DSWs.

Concentrations of all the detected heavy metals were highest at Station S4b which could be associated with substantial amount of fine particles (silt and clay) present at this station (refer to Section 2.2.3). However, other factors may be affecting the metal concentration as the station with the next highest fines is S1f, followed by S4a, S2a and S3h which does not correspond with the heavy metal concentration.

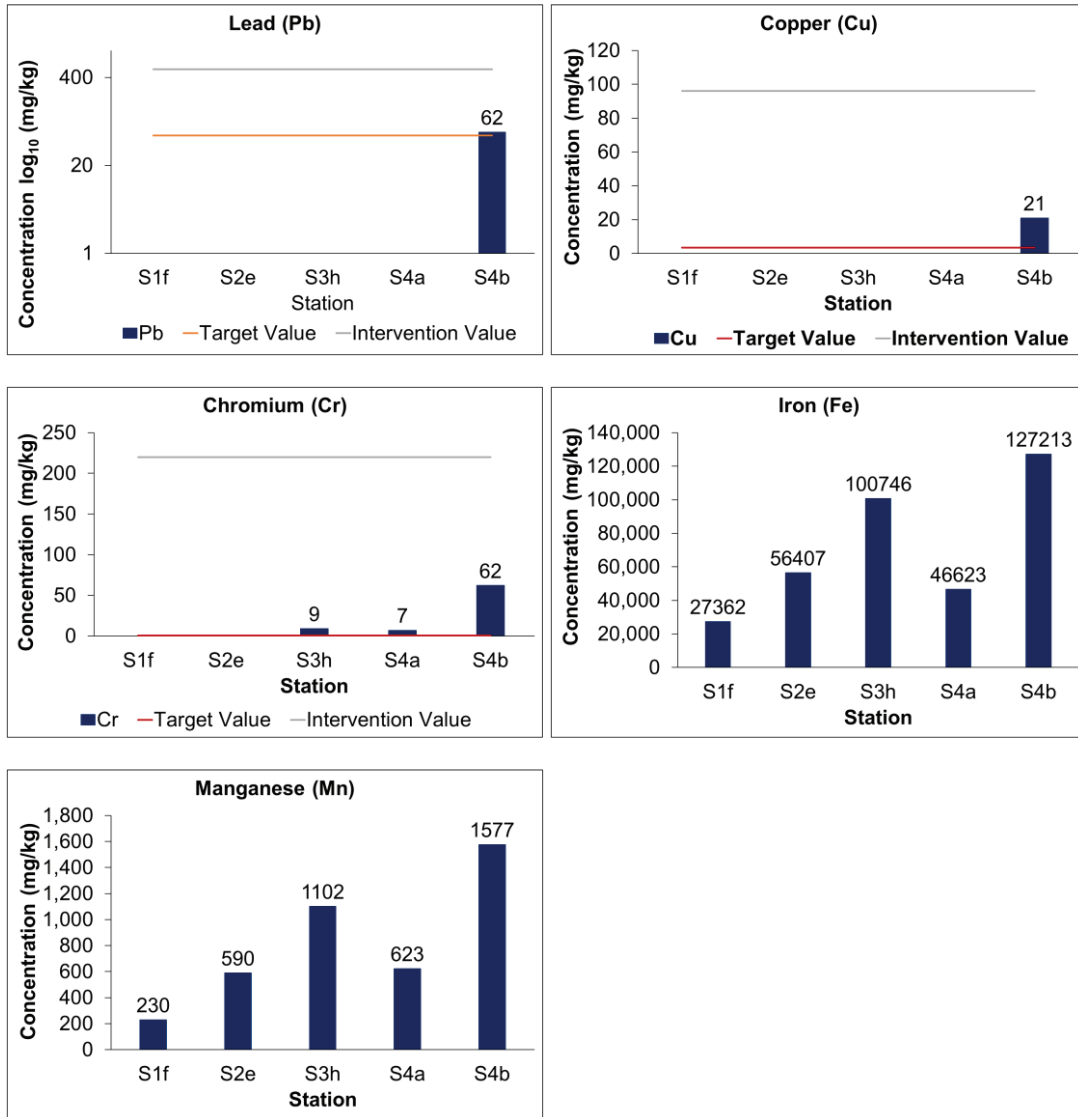


Figure 2.22 Concentration of heavy metals in sediments at the study area against Dutch Standards (if any).

2.2.5 Conclusion

In general, the Project area is dominated by sand with very little organic matter. Heavy metals in the sediment at stations S1f, S2e, S3h, S4a and S4b are below the Dutch Standards except for lead, copper, and chromium which exceeded the target values but below the intervention value. Concentration of these heavy metals (copper, lead, chromium, iron and manganese) were highest at Station S4b which has the highest fine particles (silt and clay) compared to other stations. This may reflect heavy metal adsorption to the fine sediment particles at this station.