Annex 7.4

South Humber Channel Marine Studies: Ground Engineering Interpretive Report

(Buro Happold)

027559 South Humber Channel Marine Studies

Ground Engineering Interpretative Report

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Contents

1 Introduction

1.1 Overview

This Ground Engineering Interpretative Report summarises the geotechnical conditions relating to the planning and design of the marine elements of the proposed commercial development of an area of the South Humber estuary at Killingholme. It has been prepared on behalf of Yorkshire Forward by Buro Happold.

The nature of any commercial development of the site is, as yet, undefined and it is intended that the data and knowledge gathered from the geotechnical (and other) studies will inform decisions regarding the feasibility/viability of specific commercial development proposals for the site. It has emerged during the course of the investigations that the most plausible and economically beneficial development for the region would be the development of a multi-user marine terminal, with associated dredging, to be used for the production, assembly and installation of wind turbines or tidal turbines by one or more manufacturer. For the purposes of this report (and in line with the brief from Yorkshire Forward), it has been assumed that this is the most likely development. However, a possible alternative use could be to develop a tidal power generating farm using a run of tide turbines.

It is anticipated that the data and information gained through the this study is largely generic and would be equally applicable to the planning of various types of marine development, although it is recognised that additional studies would be needed that are specific to whatever commercial development ultimately proves to provide the greatest economic benefit to the region.

1.2 Study Aims and Objectives

The aim of this study was to develop strategies for the design of jetty foundations, the construction of earth retaining structures and earthworks.

This was achieved though the following objectives:

- To determine the ground conditions (ground profile, ground water levels);
- To determine the geochemical composition of the soils and groundwater for foundation purposes, and as a guide to likely waste disposal routes;
- To provide recommendations on the concrete class for buried structures;
- To determine parameters for the detailed design of foundations; and
- To assess the design parameters for construction of any earth retaining structures.

2 The Site

2.1 Location and Description

The ground investigation study site is located within the intertidal and subtidal zone adjacent to the south bank of the Humber estuary at Killingholme Marshes, approximately 3.5km to the north west of Grimsby town centre at Ordnance Survey grid reference 517359, 419018.

The marine site comprises a gently shelving foreshore, with a narrow, near-shore margin hosting grasses and small trees/shrubs which passes in to mudflats. The bathymetric data for this area shows the sea bed slopes away from the shoreline in a south-west north-east direction with the lowest bed level lying at approximately -10m OD. The gradient of the submarine slope varies, but at it steepest lies at 1 in 22. The landward edge of the site is marked by a flood defence bund, comprising a concrete pavement and wall. The pavement level lies at approximately +5.8m OD, some 1.8m above the general site levels.

The adjacent land, defended by the flood defence bund, is flat, with a general ground level lying at approximately +3m OD. The land use is mixed, with both industrial and arable farmland as well as small areas of unused space comprising predominantly of standing water. The industrial land is concentrated mainly to the north of the site and consists mainly of hardstanding used for vehicle storage.

2.2 Previous Ground Investigation

A number of previous ground investigations have been undertaken across the adjacent land. The earliest was by George Wimpey & Co Ltd in 1965. This investigation was followed by a further two investigations carried out in 1970 by Soil Mechanics Ltd and Dredging Investigations Ltd. The factual data from these reports is not presently available but the field data was précised and summarised by Allot Atkins Mouchel (Ref. 1). Details of these earlier findings are summarised in Table 2-1 below.

2.3 Geology & Hydrogeology

2.3.1 Published Geology

The British Geological Survey sheet 81, 1:50,000 series, shows that the superficial deposits on the site comprise two distinct groups of soils. The spatial distribution of the various soils are shown on a extract from the geological plan presented in Figure 1.The near shore materials comprise estuarine deposits composed of silts, clays, thin peat layers and undifferentiated beds. Inland from the shoreline, the soils grade in to glacial deposits which are predominantly Tills, however there are outcrops of sands and gravels which lie just to the south of the site. The Tills are reported to be between 10m to 21m thick in the area and contain a coarser gravel size fraction comprising sandstone, mudstone and chalk. Shell fragments are also reported to be present within the Till.

In addition to the natural superficial soils the geological plan also identifies areas of filled ground which are concentrated to the north area of site. No detail is given regarding the nature or vertical extent of this material.

The solid geology underlying the superficial deposits comprises the Upper Cretaceous Chalk which is reported to be in excess of 250m thick in this region. The Chalk strata dip at a very shallow angle, of the order of 2° to the north east and east, and have an undulating top surface. The undulations are described as shallow depressions which run in a north west to south east direction. The upper surface is also characterised by a highly fractured zone extending apparently to a depth of 10m to 20m, and is reported to be a function of glacial and periglacial processes.

The Upper Cretaceous Chalk beneath site has been divided in to two formations, the Flamborough Chalk and Burnham Chalk.

The younger Flamborough Chalk has identifiable bedding surfaces, distinct marl bands and is reported to be “without” flints. The underlying Burnham Chalk, which subcrops along the eastern side of the site, is described as thinly bedded and laminated and contains continuous flint bands, which vary in thickness from 10mm to 300mm.

The subsoil profile on the site derived from the available information is summarised in Table 2-1 and incorporates the data from the previous desk study (Ref. 1)

Table 2—1:-Existing Information on Ground Profile derived during previous evaluation of the adjacent land area (outside study area)

Strata	Top level of Strata (m OD)	Thickness min to max (m)	Material
Made Ground	+2.3 to +5.5	0.8 to 5.8	Fill comprising ash, clay, concrete, slag, sand, gravel. Occasional wood, domestic refuse, glass & pottery
Alluvium	+2.5 to -0.9	2.10 to 8.9	Very soft – soft very silty clay, fibrous peat. Firm laminated clay. Stiff grey – blue clay traces of roots
Glacial Till	+1.2 to -7.2	10.0 to 13.7	Firm and stiff clay – laminated – thin sand bands – layers of sandy silt, with some gravel of siltstone, sandstone & chalk
Chalk	-10 to -20.6	Thickness proved 1.7 to 45	Gravel sized chalk fragments in a stiff silty clayey matrix with occasional flints

2.3.2 Hydrology/ Hydrogeology

The available data from the Environment Agency shows that the Chalk bedrock is designated as a Principal Aquifer. The superficial deposits in the foreshore area beyond the flood defence bund are designated as Secondary (undifferentiated) aquifer whilst the remainder of the superficial deposits on the site are unclassified. In terms of source protection zones the site lies outside any zones; however, an inner zone lies just to the south of the site boundary.

3 Ground Investigation

3.1 General

A ground investigation was undertaken by Soil Engineering Ltd (part of the Technology Division of VINCI Construction UK Limited) between 15 June and 15 July 2010. The scope of works was defined by Buro Happold within the budgetary constraints set by Yorkshire Forward. The work was concentrated on the offshore section of the site and comprised the following work:

- 30 No vibrocores
- Bathymetric Survey
- Magnetometer Survey
- Unexploded Ordnance Desk Study

The results of the investigation are reported in the factual ground investigation report by Soil Engineering (Ref. 2)

3.2 Soil Sampling and Laboratory Testing

Soil samples for geotechnical and contamination testing were selected from the soils recovered at all vibrocore locations. The site investigation was followed by laboratory testing of the soil samples retrieved from the vibrocores including:

- soil classification tests (moisture content, plasticity, particle size distribution);
- unconsolidated-undrained (UU) triaxial tests;
- one-dimensional consolidation tests including measurement of swelling and swelling pressure;
- Sulphate and pH tests (BRE SD1 2005 Suite); and
- Metals (Cd,Cr,Cu,Pb,Hg,Ni & Zn), Total Petroleum Hydrocarbons (Carbon Working Group includes: Benzene, Toluene, Ethyl benzene & Xylene), speciated/total Polycyclic Aromatic Hydrocarbons (16), speciated/total Poly Chlorinated Biphenyls ((WHO(12) & ICES(7)) and Organo-tins..

3.3 Exploratory Holes

A total of 30 vibrocores where sunk as part of the investigation. The depth penetrated by the vibrocores in to the sea bed varied form 1.8m at VC 14 to 6m at VC 02. The vibrocore locations are shown on the exploratory hole location plan presented in Figure 2.

3.4 Geophysics and Bathymetric Survey

Magnetometer

As part of the investigation a magnetometer survey was undertaken to determine the presence of any magnetic anomalies. The survey was undertaken using a 10m line spacing using G882/G881 magnetometers. The investigation located seven significant anomalies and two smaller anomalies. One of the significant anomalies was a known wreck which is plotted on the admiralty charts. The remainder are unknown ferrous objects which may be debris or possible UXO. The detailed findings of the survey are presented in the Soil Engineering report (Ref. 2) and a sketch plan showing the evaluation area and identified anomalies is presented in Figure 3.

Single Beam Echo Sounding

The bathymetric survey was undertaken using Knudsen 320M single beam echo sounder. The results of the survey show that the deepest bed level occurs at the northern edge of the study area (within the HST berth pocket) with an overall variation in bed level ranging from -1m OD to -17m OD, albeit with minimum level of -10m OD within the footprint of the potential multi – use terminal. The detailed results from the survey are presented in Soil Engineering's report (Ref. 2) and a sketch plan showing the bathymetric levels in m below Ordnance Datum is presented on Figure 4.

Boomer Survey

A boomer survey was undertaken using an Applied Acoustic Boomer and a 20 element single-channel hydrophone array. The purpose of the survey was to determine the depth from seabed to "rockhead". An isopachyte plan contouring the distance from seabed to rockhead, and a plan showing the contour levels of the interpreted rockhead are presented in the Soil Engineering report (Ref. 2).

An extract from the contour plot is presented in Figure 5. The plot shows the contoured surface in relation to Chart Datum. Chart Datum is 3.9m below Ordnance Datum. The inferred rockhead levels based on the Boomer survey suggest that rockhead level dip away from the foreshore area from a level around -6m OD to approximately -22m OD furthest from the shore.

As with all geophysical methods the boomer survey, which is a seismic reflection technique, relies on there being sufficient contrast in the physical properties between geological layers to generate a reflection of the seismic wave. A seismic reflection is generated when there is a contrast in the acoustic impedance which is a product of the density of the rock (ρ) and the wave travel velocity (v). If there is not sufficient contrast in these properties then no reflection is detectable. The published geological data indicates that the chalk rockhead is highly fractured and a weathered zone also exists which may be vertically fairly extensive. There is a possibility that the difference in acoustic impedance between the glacial till and chalk at rockhead is not sufficient to generate a reflection. It is therefore important that any future investigations include deep boreholes to correlate with the seismic information.

Table 3—1:-Standard Tide Levels for Immingham (reference port) to Ordnance and Chart Datum

Tidal Range for Immingham	**Tide**	**CD**	**OD**
Highest Astronomical Tide	HAT	+7.97	+4.1
Mean High Water Springs	MHWS	+7.19	+3.3
Mean High Water Neaps	MHWN	+5.74	+1.8
Mean Sea Level	MSL	+4.20	+0.30
Mean Low Water Neaps	MLWN	+2.58	-1.3
Mean Low Water Springs	MLWS	+1.0	-2.9
Lowest Astronomical Tide	LAT	+0.11	-3.8
Notes: Relationship between CD and OD	OD = 3.90m above CD		

Levels are generally presented as Ordnance Datum.

4 Ground Conditions

4.1 General

The vibrocore investigation shows that the general subsoil sequence in the area of the investigation comprises the following:

- o Very soft – soft alluvial clays/clayey silts – occasional thin peat layers;
- o Silty and gravelly sands; and/or
- o Soft to firm becoming stiff glacial till with beds of glacial sands and gravels.

A series of sketch sections have been produced across the site, these show the variation of the subsoil sequence. The location of the sections is presented on Figure 2 and the sections, A to F, are presented on Figures 6 to 11. On the cross sections no attempt has been made to differentiate between the alluvial sands and the glacial sands and gravels. In some locations the distinction is clear, as there are bands of peat present which is a clear indication that the material is alluvial in origin. Where peat is not present however it is not possible to clearly differentiate the materials. There is a compositional difference in places, refer to Figure 16, where there is a set of data which shows the material to be predominantly a silty fine sand, there is a chance that that this material could be alluvial sands, simply due to the lack of gravel. However glacial sands can also exhibit a similarly narrow compositional variation. At this stage it is not too critical to be able to differentiate between the two. Differentiating between sand with peat and sand without is probably sufficient. In Figure 2 the location of the peat layers has been delimited. Knowing the relative density of the sand/gravel material would be useful and this can be done in later phases of the investigations using techniques such a static cone testing.

Indicative engineering design parameters for the various soil units are discussed in the following sections, and summarised in Table 4-1, below.

4.2 Alluvial Clays/Silts

4.2.1 General Characteristics of the Alluvial Clays/Silts

With the exception of vibrocores 11, 14, 18, 23 and 28, alluvial clays and silts were encountered to depths varying between 0.3m (VC 8) and 3.90m (VC12). The Atterberg limits tests undertaken on this material (Figure 12) show the material to range between a low to high plasticity clay with bands of low and high plasticity silt. The grading curves show the particle size distribution to vary, and compositionally the material ranges from a gravelly clay to a silty clay with the clay fraction ranging from 11% to 35%. The undrained shear strength of the alluvium is very low (Figure 14). The maximum shear strength recorded was 20kN/m^2; however, there is a significant proportion of the data which is less than 5kN/m^2. Consolidation test data on a single sample of alluvium (Figure 15) shows it to be highly compressible with a coefficient of volume change (m_v) value of $1.3m^2/MN$.

Peat layers were encountered within the alluvial clays at 6 vibrocore locations (VC 05, 07, 09, 12, 13 &15). The peat is generally described as occurring in thin lenses, which range in thickness from <10mm to <30mm. At one location however, VC13, two thicker, persistent bands of peat are recorded, each less than 100mm thick.

4.2.2 Engineering Properties of the Alluvial Clays and Silts

The undrained strength of the alluvial clays is very low. As a consequence the material will be highly compressible and this is borne out by the oedometer test data which indicates the material has a constrained modulus, E_{oed} of $550kN/m^2$. The shear strength shows similarly low values, however there is a larger data set so the variability of the layer stiffness can be estimated in more detail. The Young's modulus for normally consolidated clays can be derived from the relationship E=250 x Cu. Using this relationship, the variation in stiffness of the alluvium, ranges from $500kN/m^2$ to $5000kN/m^2$. The long-term strength parameters (effective stress) can be determined from the plasticity index data (Ref. 3). The general range of the plasticity index varies from 35% to 70% (Figure 12). Based on this data the drained angle of shearing resistance ϕ' is expected to vary between 22° and 26°. No drained cohesion should be considered. The permeability of the alluvial clays is estimated from the oedometer test data. This shows the permeability of clay material lies in the range $1x10^{-9}$ to $9x10^{-11}m/s$. However, the test results will not reflect the influence of mass fabric such as silt or sand laminations which could result in significantly higher mass permeability characteristics.

4.3 Silty and Gravelly Sands

4.3.1 General Characteristics of the Silty and Gravelly Sands

As discussed above, it is difficult to clearly differentiate whether the sands/gravels are of alluvial or glacial origin. In some cases, the presence of peat for instance in VC 05, 06, 08 and 09, defines the material as alluvium (refer to Figure 2 for the plan positions where peat was encountered). In other cases, sand/gravel underlies the glacial clays, and must be glacial in origin. Elsewhere the distinction is not clear; therefore, no distinction is made in this report.

In general terms the grading test results (Figure 16) show the granular soils to vary between a silty sand and gravel, a gravelly sand to a silty fine sand. The layer thickness of these granular soils varied generally between 0.3m and 4.25m.

4.3.2 Engineering Properties of the Silty and Gravelly Sands

The grading curves, Figure 16, show that this material can be divided into two groups based on the particle size distribution. The finer group, which is a silty fine sand, has a uniformity coefficient of 2, whilst the coarser material, comprising a silty very gravelly sand, has a uniformity coefficient of around 20. In the absence of field strength test data it is not possible to determine the stiffness of this material; however, in terms of the effective angle of shearing resistance ϕ' the guidelines given in BS8002 (Ref. 3) can be used in conjunction with the grading curves and the soil descriptions on the logs. This method is not rigorous, but provides a guide to the likely values. On this basis it is estimated that the finer material will have a ϕ' value of approximately 32° whilst the coarser material will have a ϕ' value in the range 34° to 36°.

The permeability of granular soils can also be estimated from the methods detailed CIRIA Report 113 (Ref. 4). This uses the D_{10} value from the grading curves. On this basis the permeability of the material is estimated to vary between 4.0×10^{-5} and 1.7×10^{-4}m/s. The values are presented merely as guidance as more accurate values would require a wider data set and an indication of the in situ density of the material.

4.4 Glacial Till

4.4.1 General Characteristics of the Glacial Till

The glacial till was encountered in the majority of the vibrocore locations but was not encountered in VC 07, 08, 09 12 & 15, the general spatial distribution of the material is shown on the sections presented in Figures 6 to 11. The till comprises generally soft to firm, firm, and stiff, low to intermediate plasticity clay. The undrained strength data is presented in Figure 14, and shows the strength range to lie generally between 30kN/m^2 and 110kN/m^2. The plasticity data presented on Figure 17 show the Atterberg Limits of the material lie in a tight range with the plasticity index (PI) varying between 7% and 25%.

The grading curves, Figure 18, show the material to be well graded, with a size fraction ranging from fine to medium gravel to clay. The clay content ranges between 22% and 62%. The gravel fraction generally comprises sandstone, mudstone and chalk, however at certain locations, VC 05, 10, 13, 16 and 22 there is a very high proportion of chalk present. In VC 22, the material was very similar to structureless chalk and therefore could be interpreted as chalk rockhead. The data from previous investigations and the BGS information suggests that the glacial tills in this area are of the order of 10m to 21m thick, therefore it is unlikely that the material in VC 22 represents chalk rockhead (see 2.3.1, above) However it must also be borne in mind that the chalk “surface” is described as “undulating” (see 2.3.1, above) and any future investigations should set out to establish the relationship between the till and the underlying chalk. Any variation in chalk surface level may have a significant influence on the settlement behaviour of any earthworks and the length of any piles associated with the construction of the marine facility.

4.4.2 Engineering Characteristics of the Glacial Till

The till varies in strength and the data shows that the strength increases with depth below bed level (Figure 14). The oedometer test data (Figure 15) indicates that the till is of low to medium compressibility with m_v values varying between 0.12 and 0.34m^2/MN. This equates to a constrained modulus ranging from 3MN/m^2 to

8MN/m^2. Based on the undrained strength, values of Young's Modulus suggest higher stiffness, with the undrained modulus (Eu) in the range 12MN/m^2 to 44MN/m^2 and drained modulus E' varying from 6MN/m^2 to 22MN/m^2.

In respect of permeability, this can be estimated from the oedometer test data and this suggests that the permeability of the till lies in the range 10^{-10} to 10^{-11}m/s. It should be borne in mind that this does not take account of any influence of coarser layers within the clay, which could significantly increase the mass permeability.

Table 4—1 Summary of engineering parameters

Engineering properties	Alluvial clays/silts	Silty gravelly sands	Glacial till
Bulk unit weight, γ (kN/m^3)	1.37 – 2.09	-	2.13 to 2.23
Plasticity Index, PI (%)	35 to 70	N/A	7 to 25
Undrained shear strength, c_u (kN/m^2)	5 to 20	N/A	30 to 110
Angle of shearing resistance, ϕ' (deg)	22 to 26	32 fine grading 34 to 36 coarse grading	
Estimated in situ permeability, k (m/s)	1.0×10^{-9} to 9.0×10^{-11}	1.7×10^{-4} to 4.0×10^{-5}	1.0×10^{-10} to 1.0×10^{-11}
Coefficient of volume change, m_v (m^2/MN)	1.3	N/A	0.12 to 0.34

5 Engineering Assessment

5.1 Design Considerations

The key design consideration with a development such as this is the consolidation of the founding soils under the loads imposed by the dock walls, structures and back-fill materials. Rate of settlement is also an important consideration.

The ground investigation has shown that the alluvial soils are highly compressible containing impersistent peat layers. Values of Young's moduli for the alluvial soils are in the range 0.5 to $5MN/m^2$. Based on these figures a preliminary settlement estimate, assuming a general surcharge loading imposed from the development of the order $50kN/m^2$ as a uniformly distributed load (UDL), would result in consolidation settlement in the order of 250 to 350mm.

With respect to differential settlement the ground investigation shows that the highly compressible alluvial clay layer varies in thickness across the area, ranging from 0.3m to 3.9m thick. With such a variation it is likely that differential settlements of the order of 50% or more of the total settlement could occur over specific areas of the development.

In order to mitigate the effects of overall settlement and the effects of differential settlement a number of construction options could be considered. The choice of options will be largely dependent on the construction programme. A critical element in a design of this nature is the rate of settlement of the subsoils under the imposed loads. The results of the ground investigation have shown, that both the alluvial and glacial clay soils have relatively low permeability, between 10^{-9} to 10^{-11}m/s. It should be borne in mind that the data comes from tests on relatively small samples, and the results will not reflect the mass permeability of the soil. Mass permeability of soils can be significantly higher than laboratory data suggests as it is very often governed by the macro structure of the soils, which is difficult to reproduce in the laboratory. The macro structure often comprises silt and sand laminations and layers, which have the effect of significantly reducing the drainage path which governs the rate of consolidation. In order to accurately assess the effects of this macro structure, future investigations should employ methods such as piezocone testing which can readily identify the presence of thin layers of higher permeability material.

The construction options which could be considered are as follows:

Option A – dredge alluvial soils leaving a subgrade of more uniform stiffness

Option B – install vertical drains to increase the rate of settlement

Option C – Surcharge the backfill to accelerate the settlement

Option D – Any combination of the above

5.1.1 Option A – Dredge out alluvial soils

A significant proportion of the overall settlement results from the settlement of the alluvial clays. By removing this material through dredging the overall magnitude of the total settlement and the differential settlement could be significantly reduced.

5.1.2 Option B - Install vertical drains

The effects of settlement and differential settlement can be mitigated to a greater or lesser extent by speeding up the settlement process and ensuring that a certain percentage of the overall settlement has occurred prior to construction of the settlement sensitive structures on the quay. The rate of settlement is a function of the permeability of the soils, the mass permeability determined by the presence of a soil fabric, and the drainage path. The permeability and the mass fabric are in effect a constraint but the drainage path can be altered by the provision of vertical drains. The vertical drains are proprietary products which can be installed rapidly. The technique requires on-site monitoring to ensure that the anticipated settlement occurs at the expected rate.

5.1.3 Option C – Surcharge

Surcharging of fills and subgrades is a commonly used technique and works by applying load ahead of the main construction phase, thereby reducing the level of settlement from the construction stage onwards. It requires that sufficient surplus material is available to form the surcharge and that sufficient time is available in the construction programme to allow the required settlement to occur.

5.1.4 Option D – Combined Treatment

It is often the case that more than one technique is adopted to accelerate the settlement phase and all the above could be used to a lesser or greater degree in combination. The key drivers are often cost and programme and it is necessary to optimise the design to achieve the most satisfactory result.

5.1.5 Stability

The bathymetric data indicates that the seashore slopes at a gradient of approximately 1 in 20 at its steepest point. Whilst this is a relatively slack slope, instability can be generated by the surcharging effect of placing the fill. The alluvial soils are very weak, and time will be required for these to consolidate and gain strength during the filling process. Instability can also be generated through the build up of excess pore water pressures, particularly in finer grained soils such as silt. If the rate of filling is not controlled, and monitored against the development of pore pressures, then the strength of the soils can be reduced due to a decrease in effective stress. If overall stability is an issue then these effects can be mitigated by the introduction of vertical drains or controlling the rate of filling.

5.1.6 Retaining Structures

The ground conditions on the site lend themselves well to the construction of embedded cantilever or propped/anchored retaining walls. The driving conditions appear to be favourable and sheet piles, combi-walls or driven bearing piles should be acceptable. The depth to which piles can be driven may be governed by rockhead level, and more data is required to identify accurately the depth and nature of this layer. Flint bands in the chalk may present an obstacle to piling, and further investigation is required to identify the presence or otherwise of significant flint bands.

5.1.7 Additional Investigations

The current ground investigation has given a good overall indication of the nature and variability of the shallower ground conditions. In order to complete the detailed design it is recommended that further investigations are undertaken to obtain more data. As discussed above, overall settlement, rate of settlement and stability are important aspects of the design. In order to obtain sufficient and adequate data the additional work should include cone penetration testing with pore water measurement, cable percussion and rotary boreholes to obtain quality samples of the superficial deposits and accurate determination of the depth and nature of the chalk.

6 Geoenvironmental Assessment

6.1 Design Considerations

The disposal route is a key design consideration with a development such as this where surplus alluvial soils may be generated. Options include

- dredging and disposal off-shore;
- dredging and treatment for retention on-site;
- dredging and disposal on-shore; and/or
- do nothing leave *in situ*.

The ground investigation has shown that the alluvial soils contain elevated levels of potential contaminants (measured against background levels) as well as impersistent peat layers. The results of laboratory analysis have been compared to CEFAS (Centre for Environment, Fisheries & Aquaculture Science) Action Levels (see Appendix A), and assessed using our Hazardous Waste Assessment Spreadsheet (based on the EA Waste Classification Calculations). The results indicate the following:

- Several of the determinands (metals) fall above CEFAS Action Level 1 but all fall below Level 2 and therefore the arisings are likely to be suitable for disposal at sea (pending approval and potentially further testing and liaison with CEFAS and the MMO (Marine Management Organisation)); and
- For disposal on-shore, the material tested is likely to be classified as Non-Hazardous Waste.

6.1.1 Dredge with disposal off-shore

The material may be suitable for disposal off-shore; however further testing may be required by CEFAS and/or the MMO before a license is issued.

6.1.2 Dredge and treat with retention on-site

The material may be suitable for stabilisation treatment using lime and/or cement which should allow reuse on-site as general fill, if required. The bulk of the organic component (peat layers) will have to be removed in order to make this option viable.

6.1.3 Dredge with disposal on-shore

The dredged material is likely to require pre-treatment prior to on-shore disposal to reduce moisture content to levels where the as-dredged material ceases to behave as a liquid. This can be achieved by addition of cementitious material. The material is likely to be classified as non-hazardous waste although this would have to be confirmed by the producer of the waste (dredging/earthworks contractor) in tandem with the receiving landfill.

6.1.4 Do nothing – leave in situ

The cheapest option would be to leave the material in-situ although there are geotechnical constraints that come into play due to the high moisture content etc the details of which are discussed above. There is however, a potential impact to any buildings and enclosed spaces etc that may be built on site in the future arising from the potential for ground gas (methane and carbon dioxide etc), although this may be mitigated during the reclamation process through incorporation of impermeable membranes or low permeability soil layers. Nevertheless, the risk to buildings and human health arising should be explored in more detail and suitable mitigation measures built into building design as required.

References

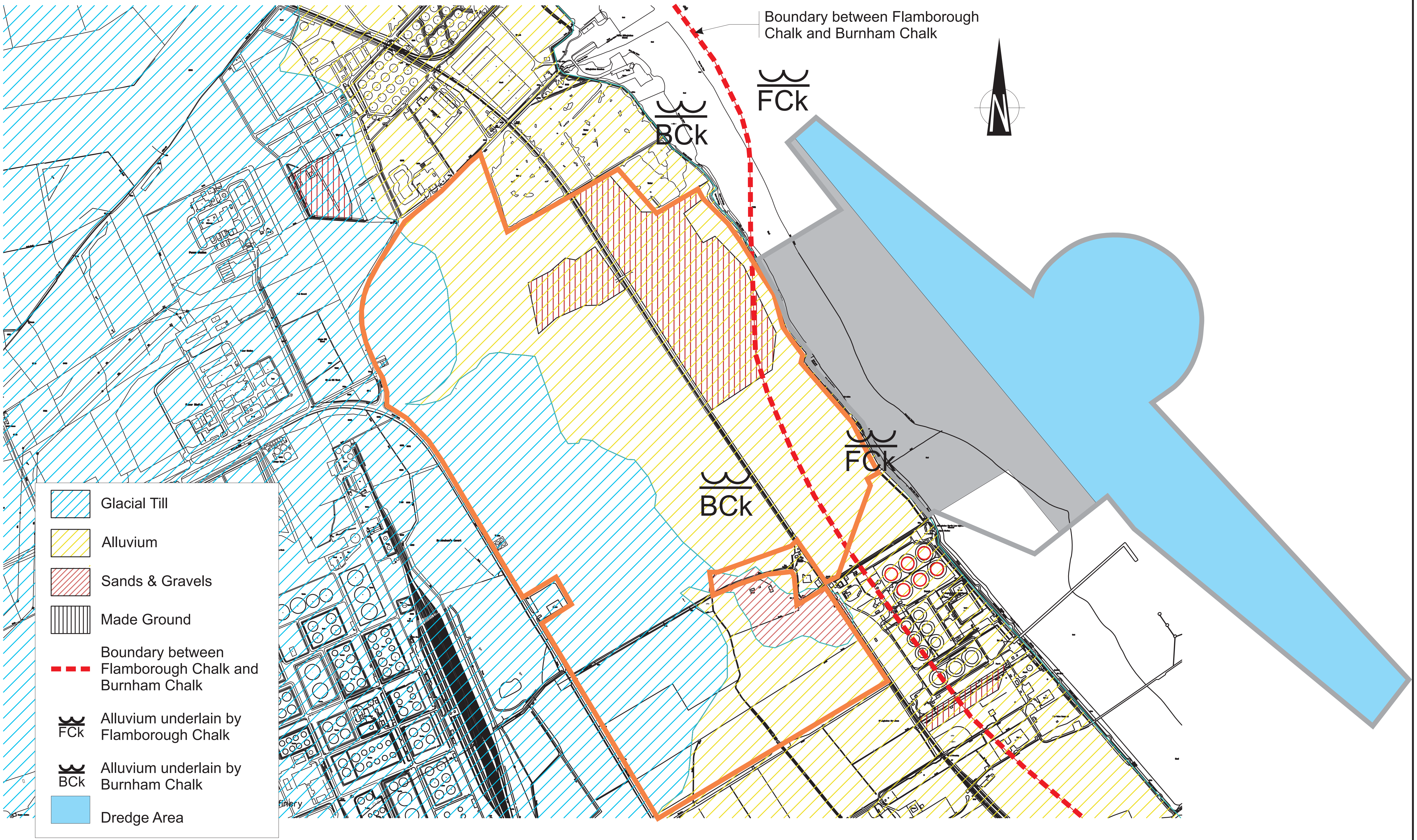
Ref. 1. Desk Study by Allott Atkins Mouchel, in connection with a proposed power station development (1987)

Ref. 2. Report on a Ground Investigation for South Humber Channel Marine Studies, Soil Engineering Ltd (part of the Technology Division of VINCI Construction UK Limited), Report No SI FR 1.05 2010

Ref. 3. BS 8002 : (1994) Code of Practice for Earth Retaining Structures

Ref. 4. CIRIA Report 113 (1986) Control of Groundwater for Temporary Works

Figures



Project: South Humber Channel Marine Studies

GEOLOGICAL PLAN

Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 1	Rev: 02

Buro Happold
Consulting Engineers

SKETCH SHOWING THE VIBROCORE LOCATIONS WHERE PEAT & PLANT MATERIAL WAS ENCOUNTERED

VIBROCORE

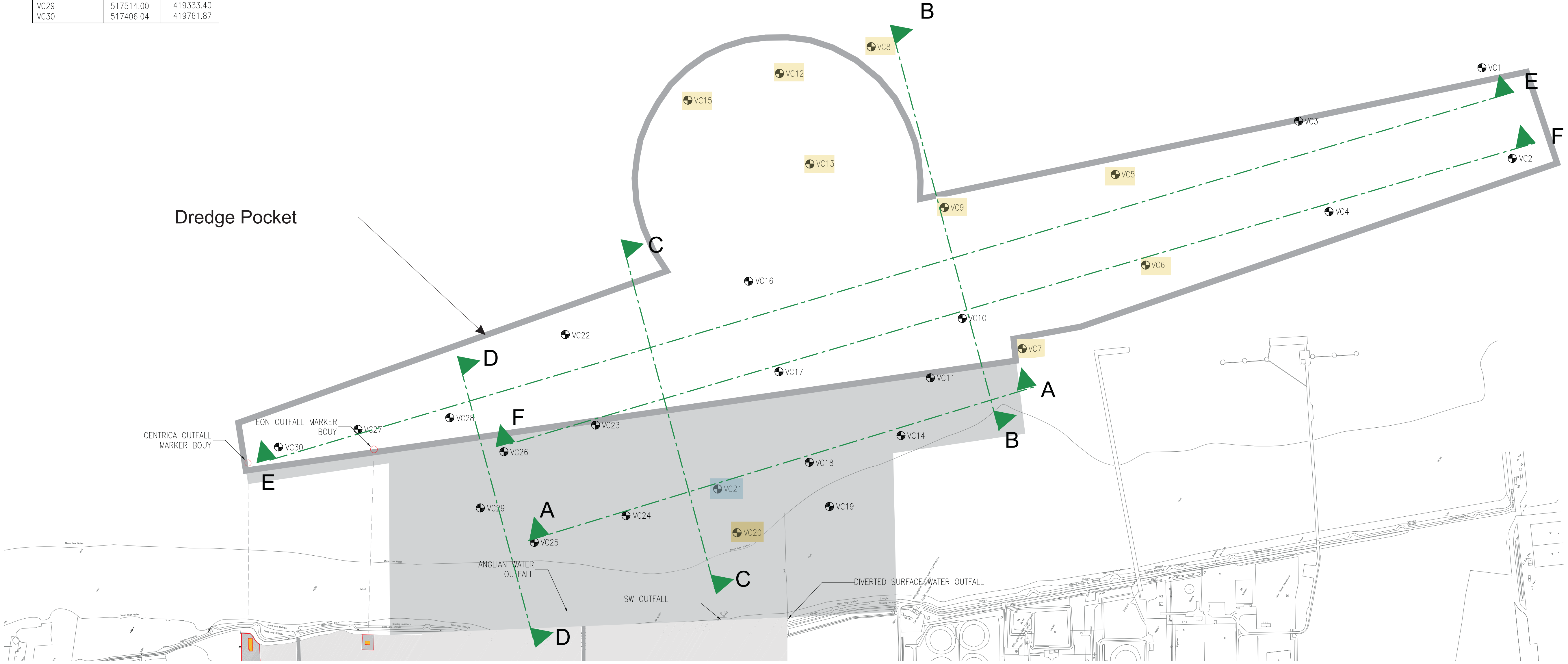
VIBROCORE REF.	EASTING	NORTHING
VC1	519385.11	418006.23
VC2	519254.99	417855.08
VC3	519090.98	418279.34
VC4	518961.84	418126.17
VC5	518797.85	418551.43
VC6	518667.72	418399.28
VC7	518384.45	418530.56
VC8	518763.96	419127.84
VC9	518554.69	418822.82
VC10	518374.58	418671.37
VC11	518233.13	418664.33
VC12	518617.89	419263.88
VC13	518487.77	419111.73
VC14	518097.39	418655.27
VC15	518470.83	419399.93
VC16	518210.57	419095.63
VC17	518080.45	418943.48
VC18	517950.32	418791.33
VC19	517893.14	418707.14
VC20	517746.10	418845.20
VC21	517804.25	418927.37
VC22	517917.44	419367.72
VC23	517787.31	419215.57
VC24	517657.18	419063.42
VC25	517510.12	419199.47
VC26	517640.24	419351.63
VC27	517523.29	419638.24
VC28	517643.13	419485.57
VC29	517514.00	419333.40
VC30	517406.04	419761.87

Vibrocores where peat was encountered

NB peat is generally described as pseudo-fibrous. It occurs either as distinct layers generally no more than 200mm thick but also as "frequent or occasional" lenses.

It generally lies at relatively shallow depths, ie less than 1.5m below bed level. There are some instances where peat occurs to greater depths eg VC05 & VC06 where it is present to 3.45 and 4.5m depth below bed level respectively

Vibrocores where plant remains where identified 1.50m to 3.10m below bed level (including seaweed) Also material had a strong organic odour NB peat was not present



Project: South Humber Channel Marine Studies						
EXPLORATORY HOLE LOCATION PLAN						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 2	Rev: 02

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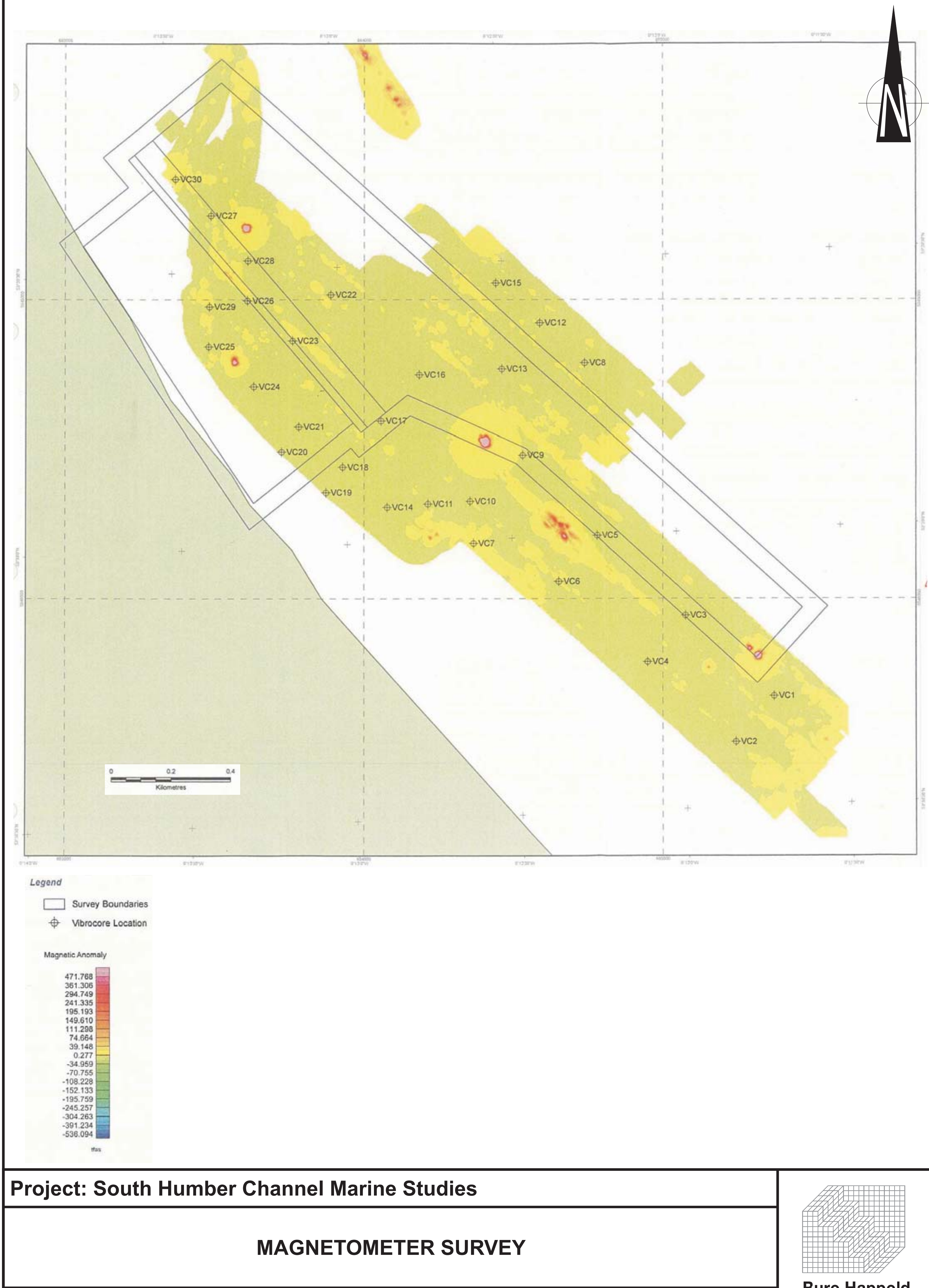

Project: South Humber Channel Marine Studies

MAGNETOMETER SURVEY

Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 3	Rev:02

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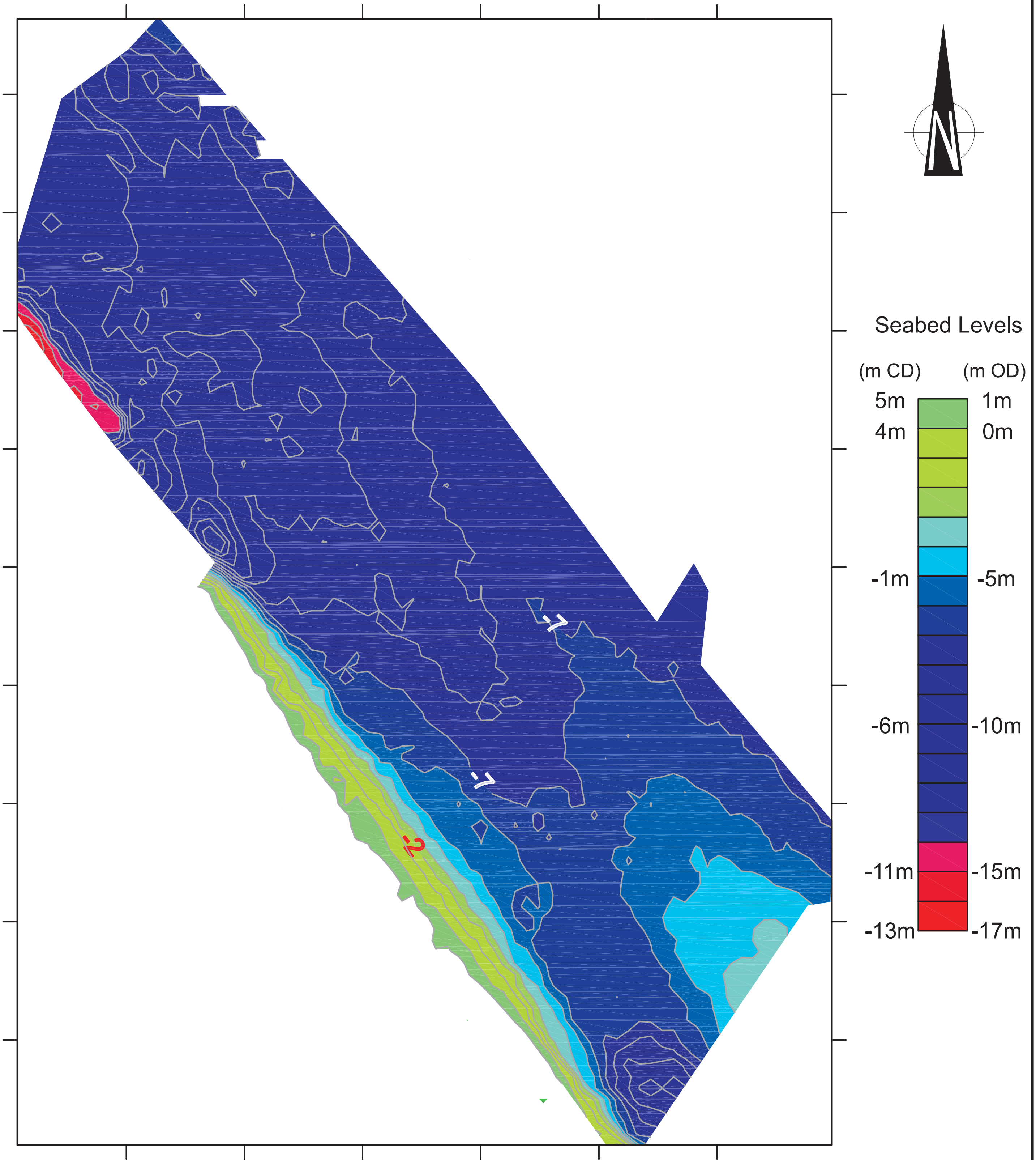
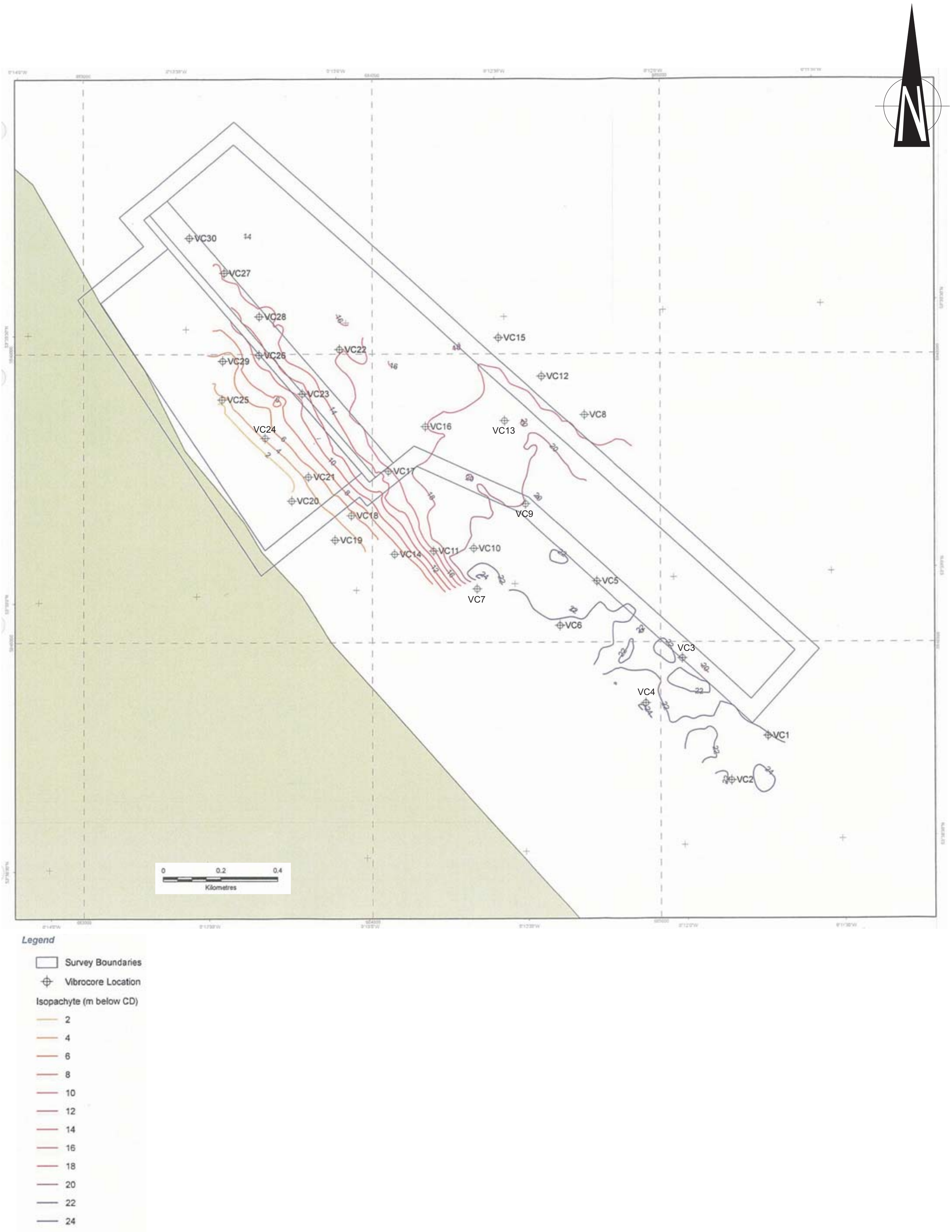


Note: Levels shown are in m OD

Project: South Humber Channel Marine Studies							Buro Happold Consulting Engineers
BATHYMETRIC LEVELS IN M BELOW ORDNANCE DATUM							
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 4	Rev:02	



Project: South Humber Channel Marine Studies

ROCKHEAD LEVELS (m BELOW CD)
(DETERMINED FROM BOOMER SURVEY)

Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 5	Rev:02

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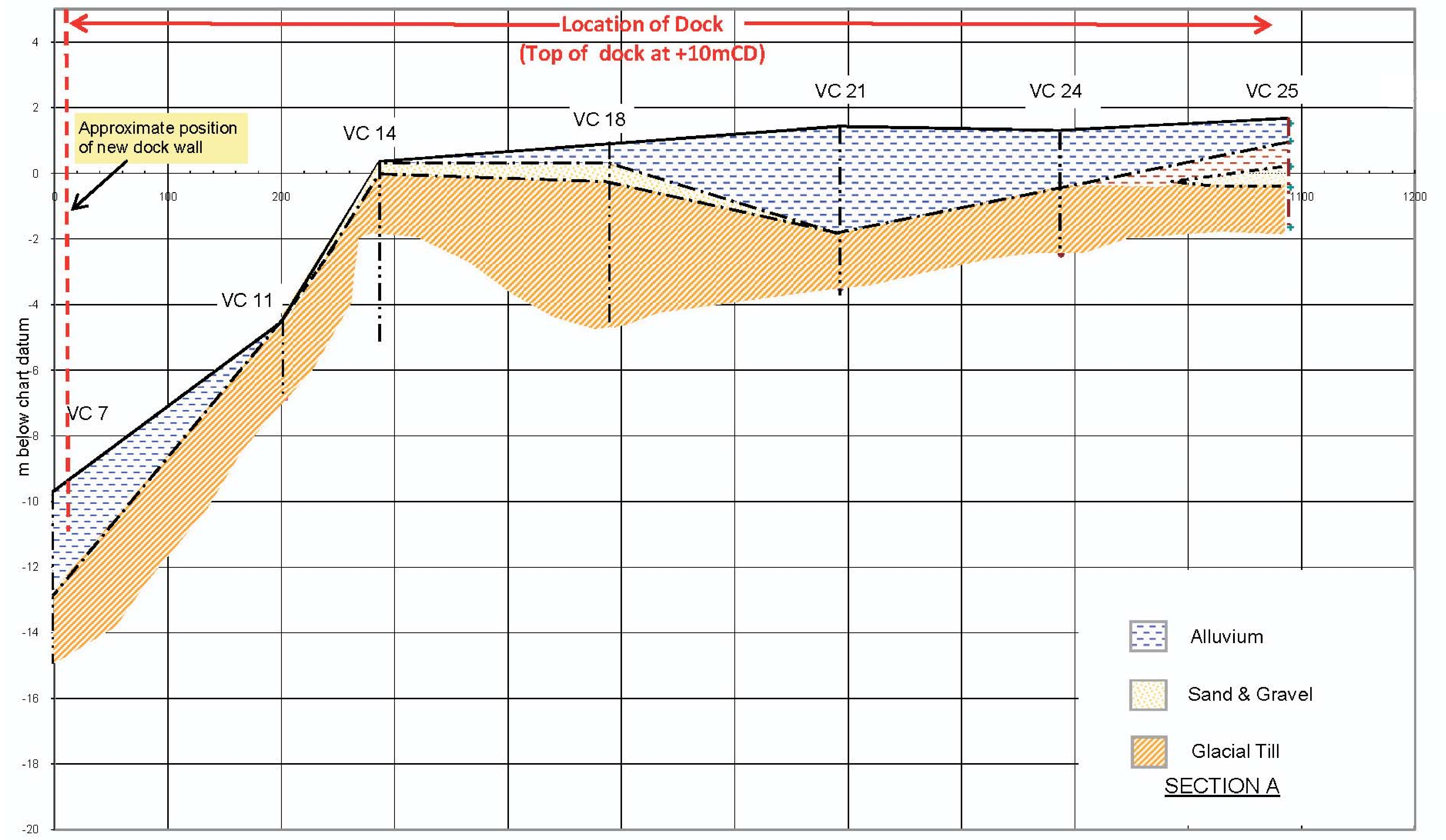

(Refer to figure 2 for section locations)

Project: South Humber Channel Marine Studies						
GEOLOGICAL SECTION A						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 6	Rev: 02

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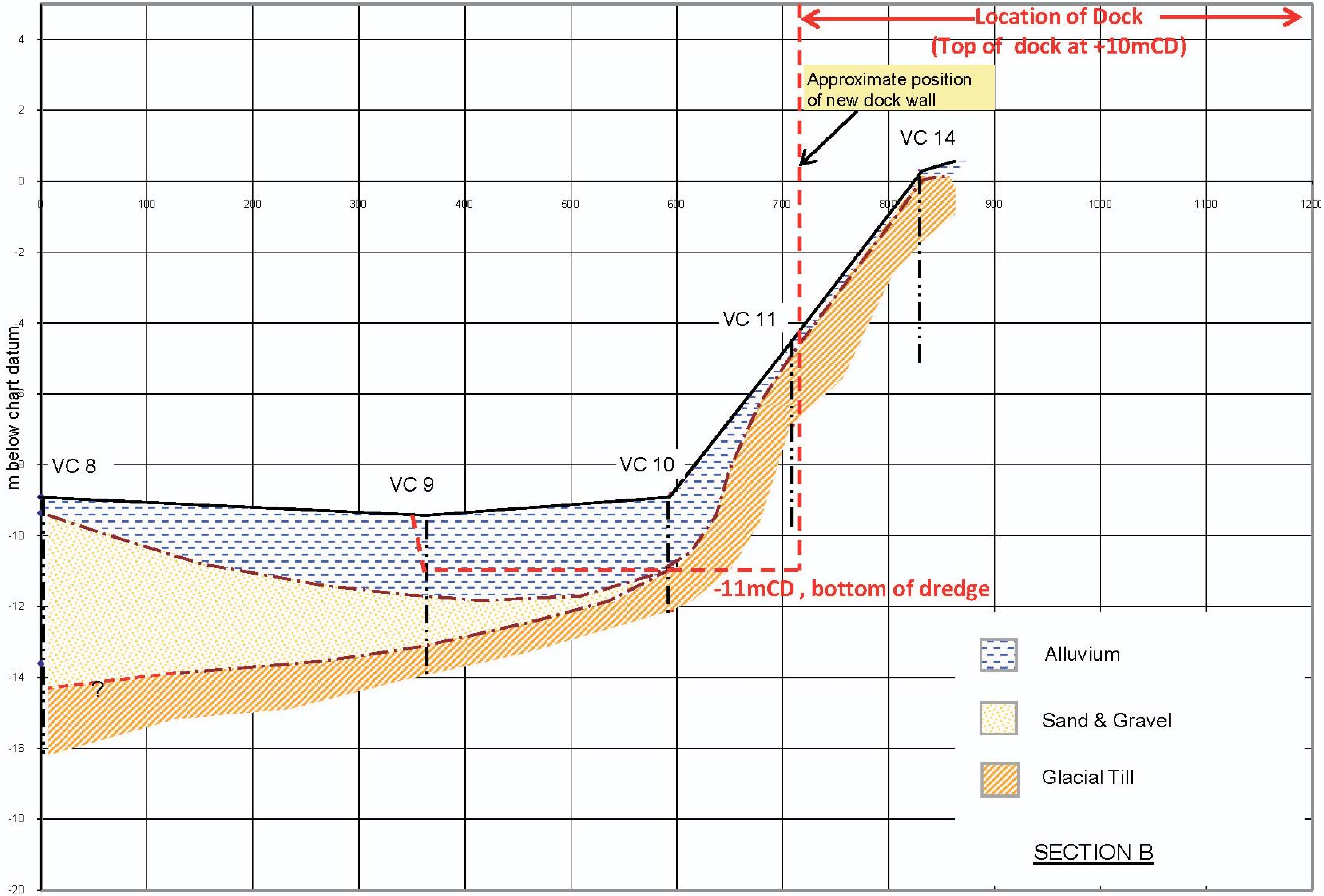

(Refer to figure 2 for section locations)

Project: South Humber Channel Marine Studies						
GEOLOGICAL SECTION B						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 7	Rev: 02

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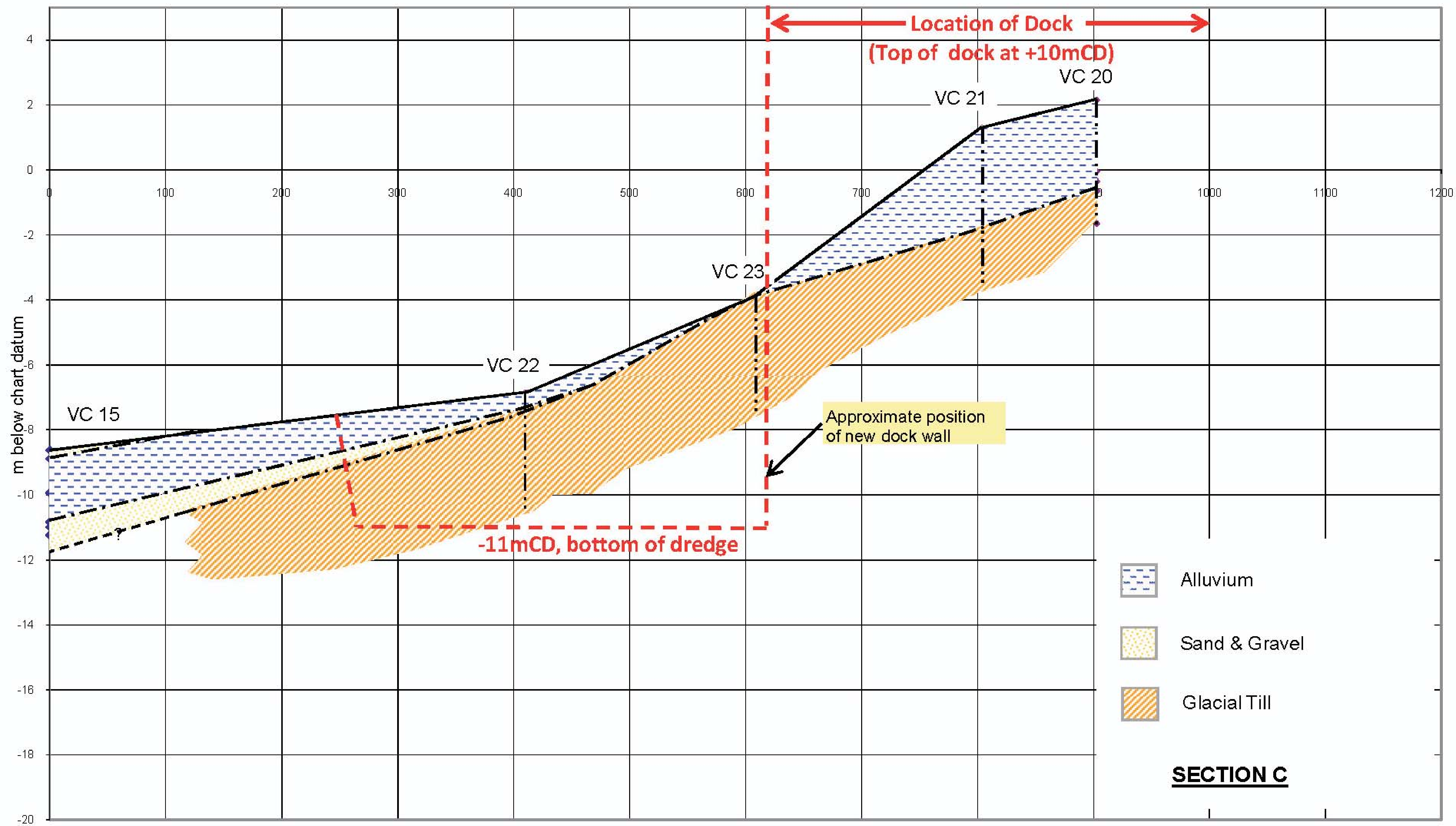

(Refer to figure 2 for section locations)

Project: South Humber Channel Marine Studies						
GEOLOGICAL SECTION C						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 8	Rev: 02

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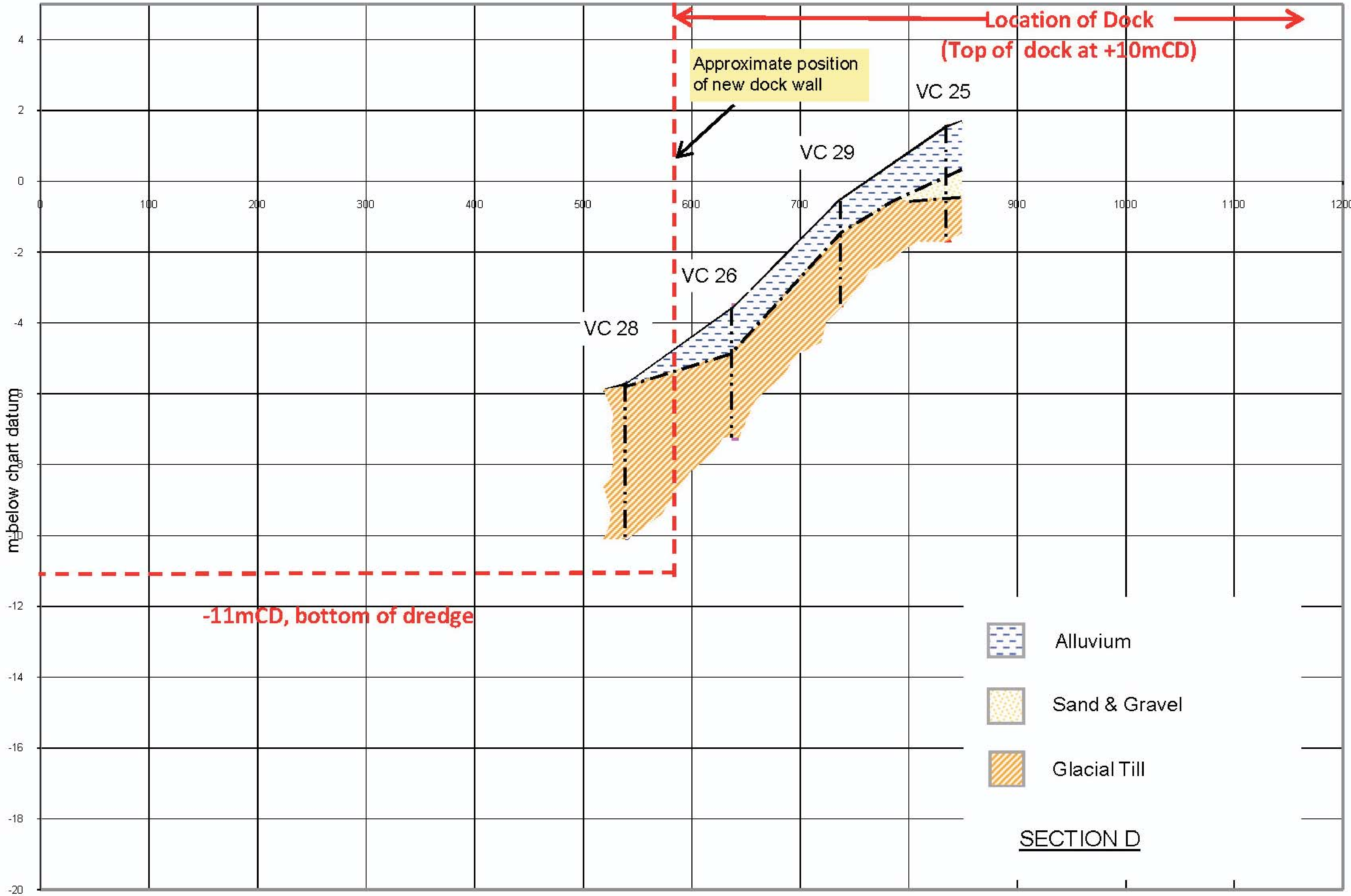

(Refer to figure 2 for section locations)

Project: South Humber Channel Marine Studies							
GEOLOGICAL SECTION D							
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 9	Rev: 02	

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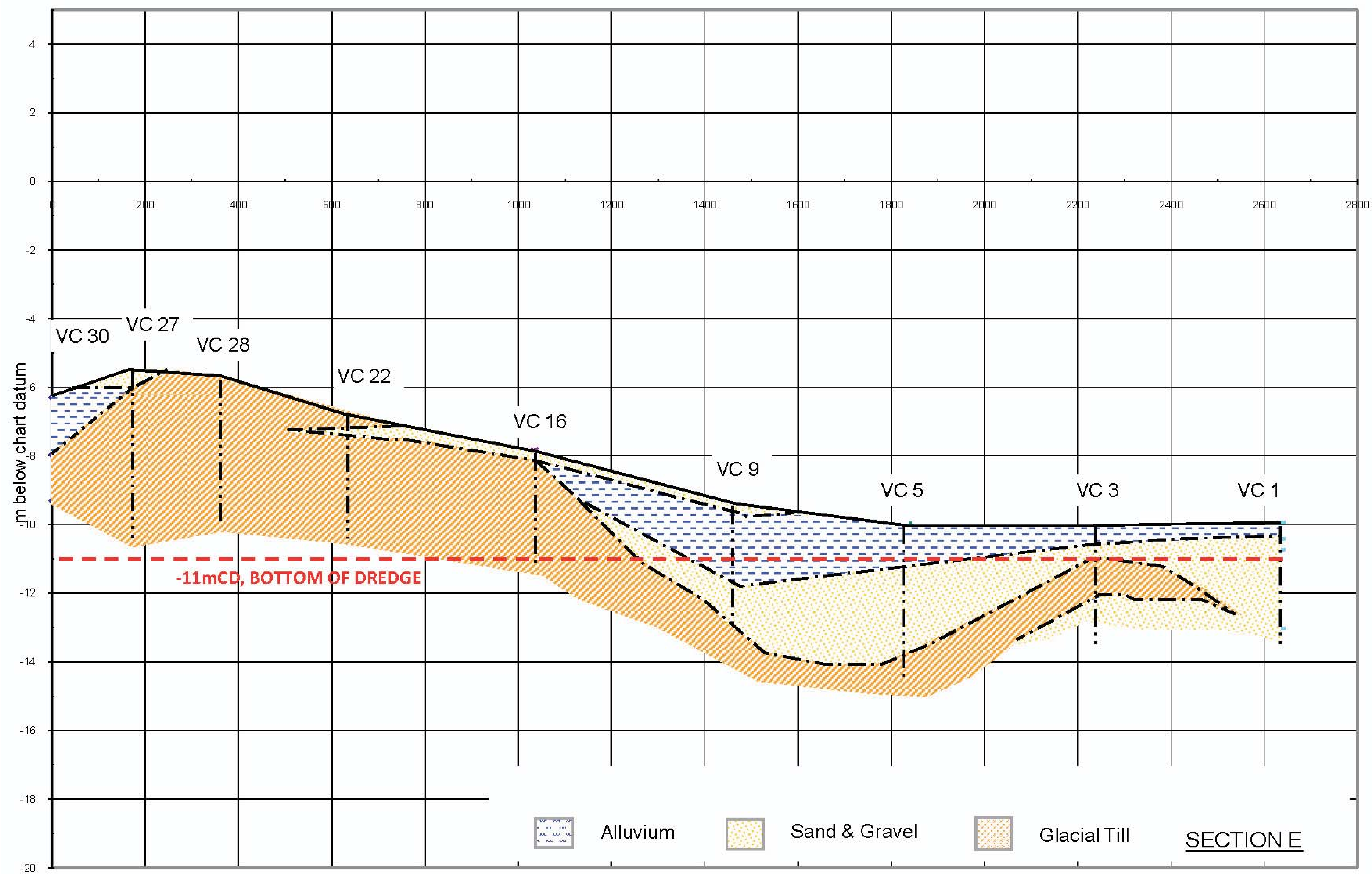

(Refer to figure 2 for section locations)

Project: South Humber Channel Marine Studies						
GEOLOGICAL SECTION E						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 10	Rev: 02

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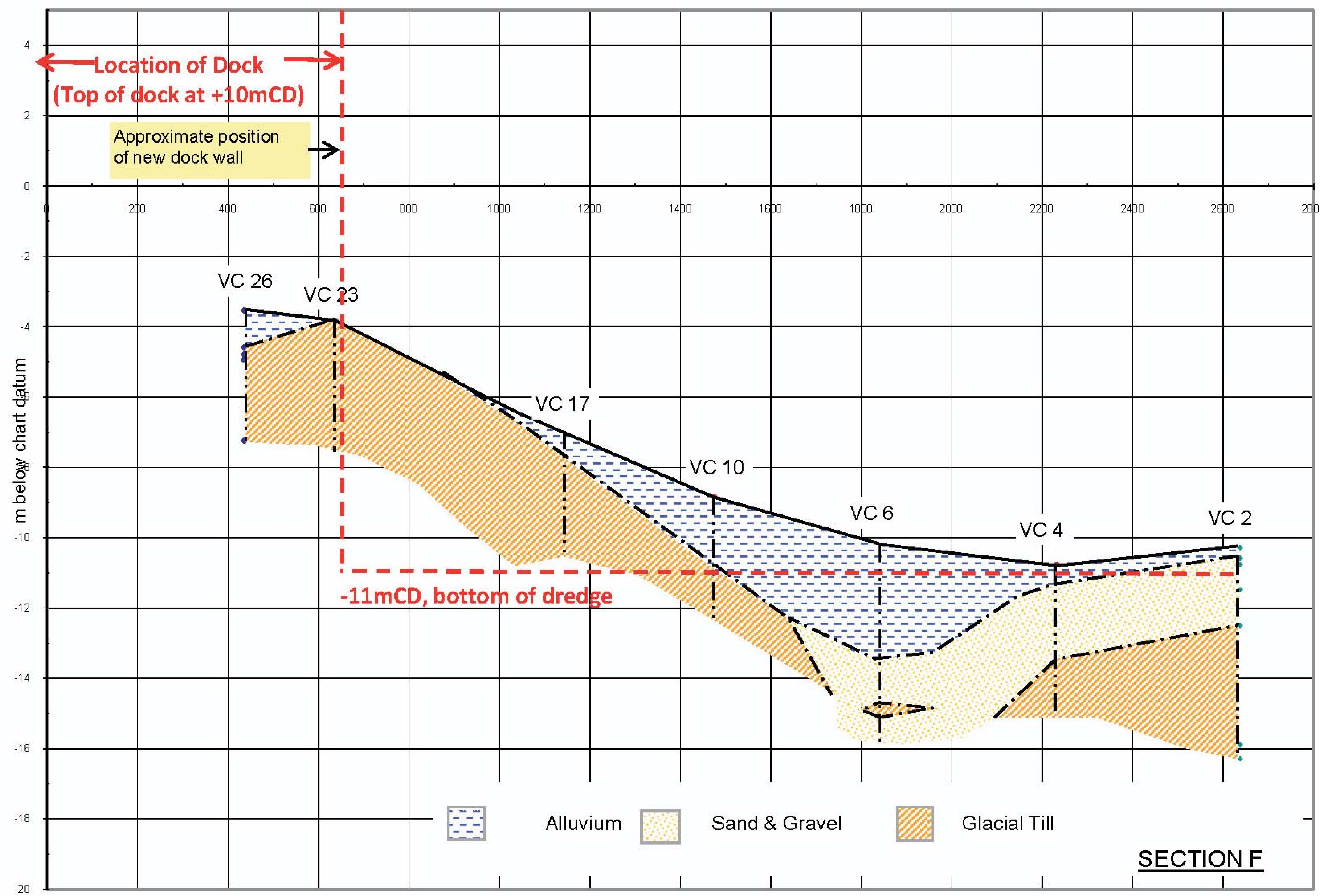

(Refer to figure 2 for section locations)

Project: South Humber Channel Marine Studies

GEOLOGICAL SECTION F

Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 11	Rev: 02

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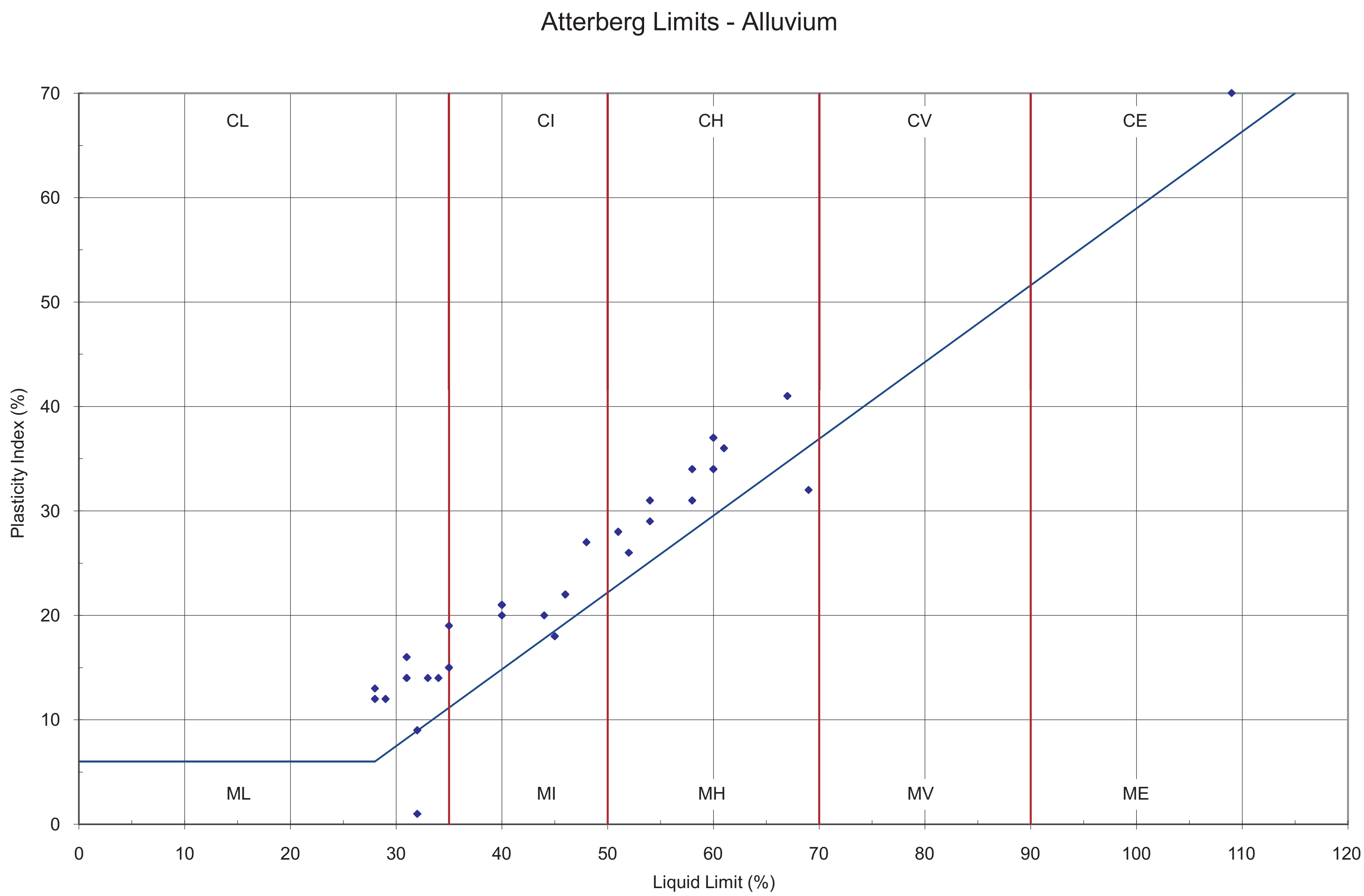

Project: South Humber Channel Marine Studies

ATTERBERG LIMITS ON ALLUVIUM

Scale: NTS	Drawn: JMB	Chk: BJ	Date: OCTOBER 2010	Job No: 027559	Figure No: 12	Rev: 01

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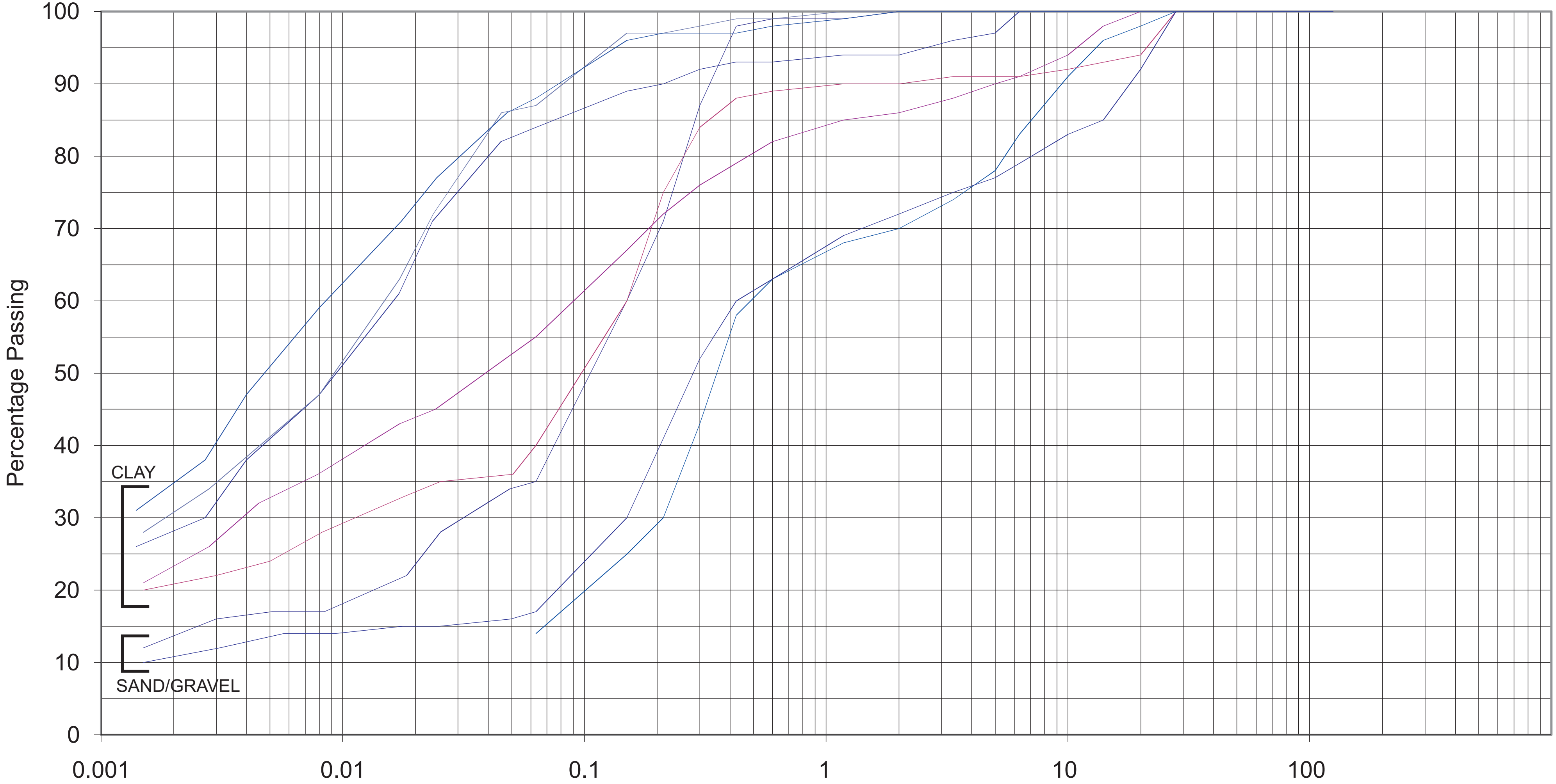
Particle Size Distribution Curves - Alluvium



Clay	SILT			SAND			GRAVEL			Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse		

Project: South Humber Channel Marine Studies

PARTICLE SIZE DISTRIBUTION OF ALLUVIUM

Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 13	Rev: 02

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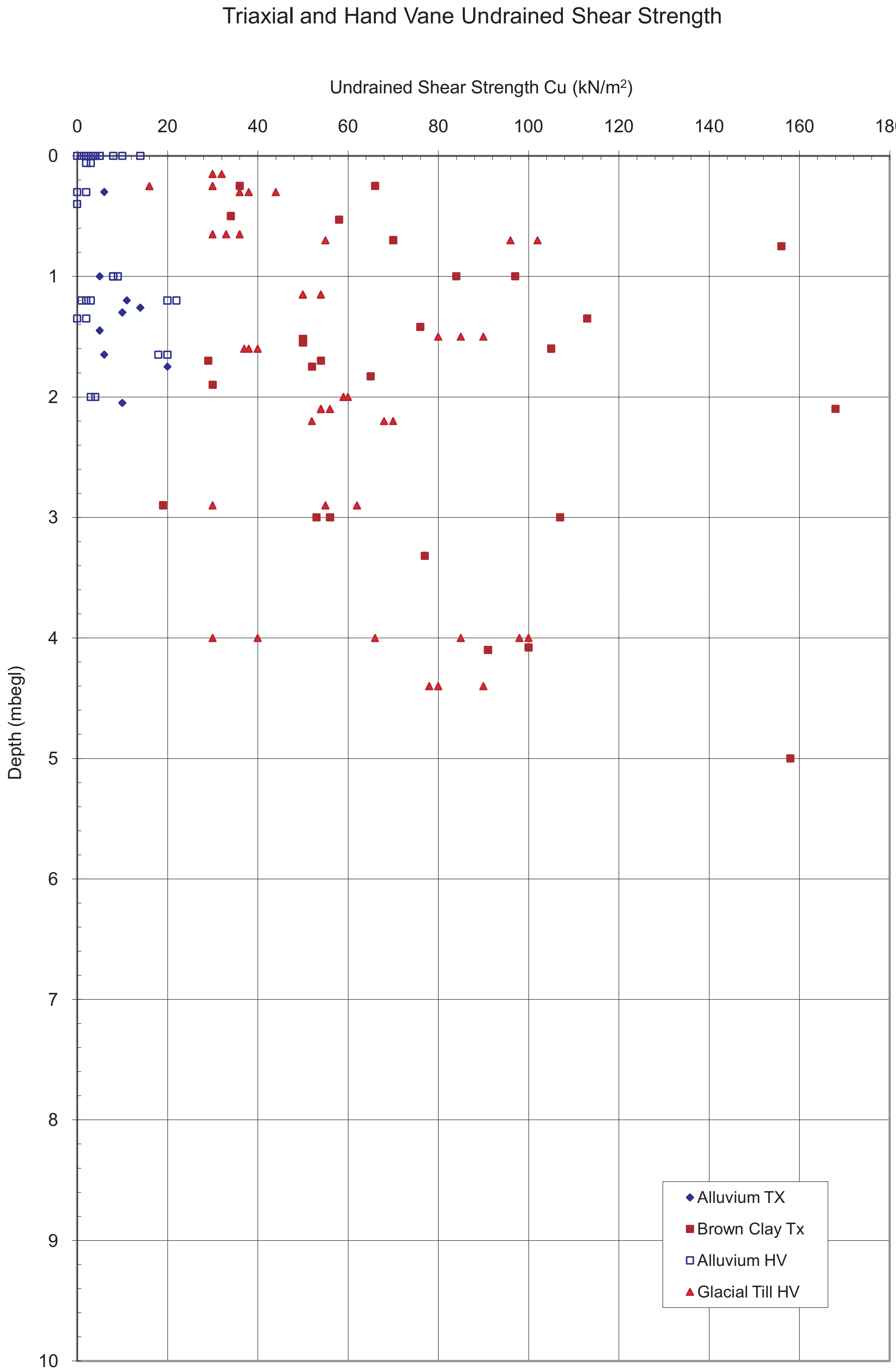

Project: South Humber Channel Marine Studies

TRIAXIAL AND HAND VANE UNDRAINED SHEAR STRENGTH TEST

Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 14	Rev:02

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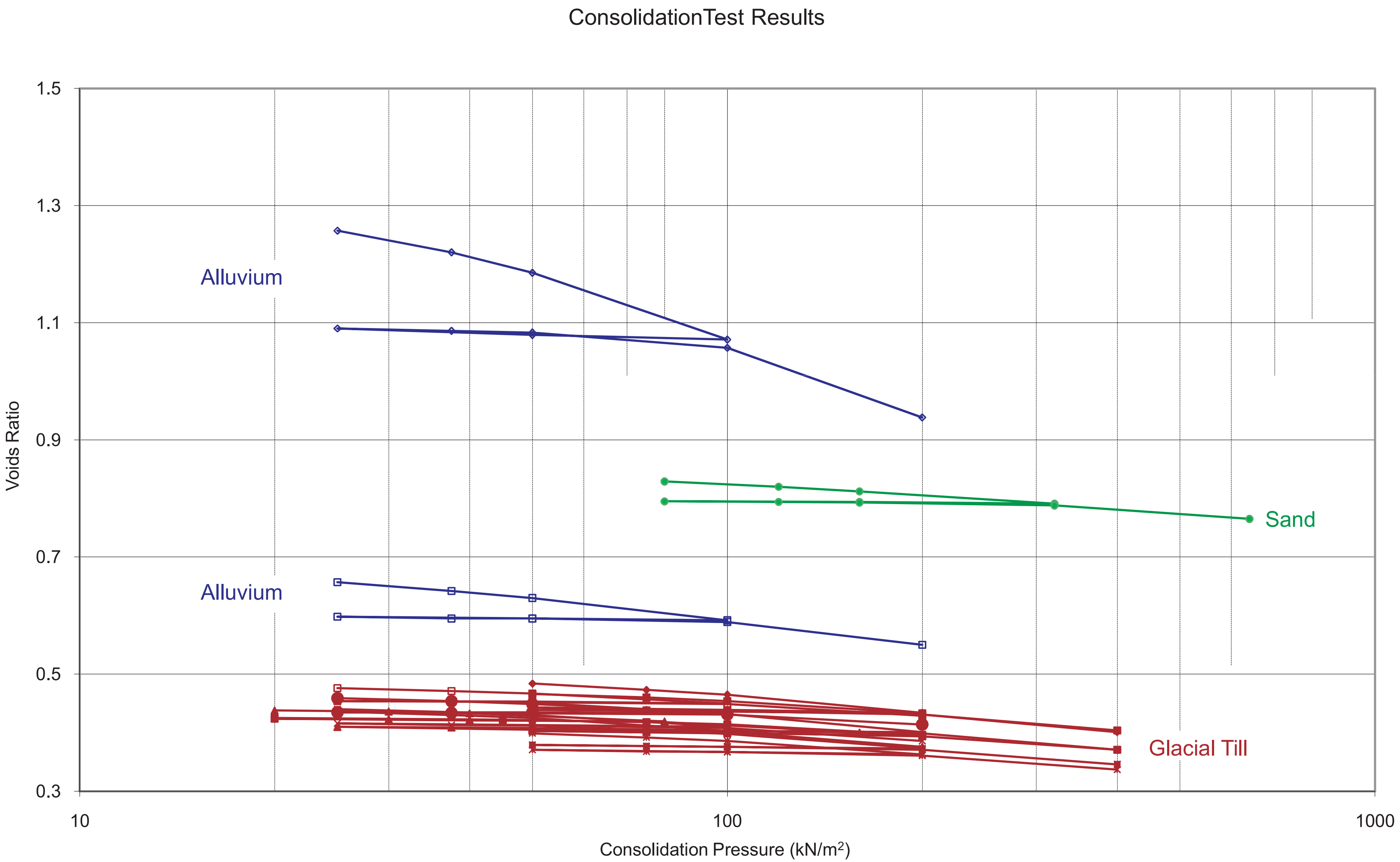

Project: South Humber Channel Marine Studies						
CONSOLIDATION TESTS						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: OCTOBER 2010	Job No: 027559	Figure No: 15	Rev: 01

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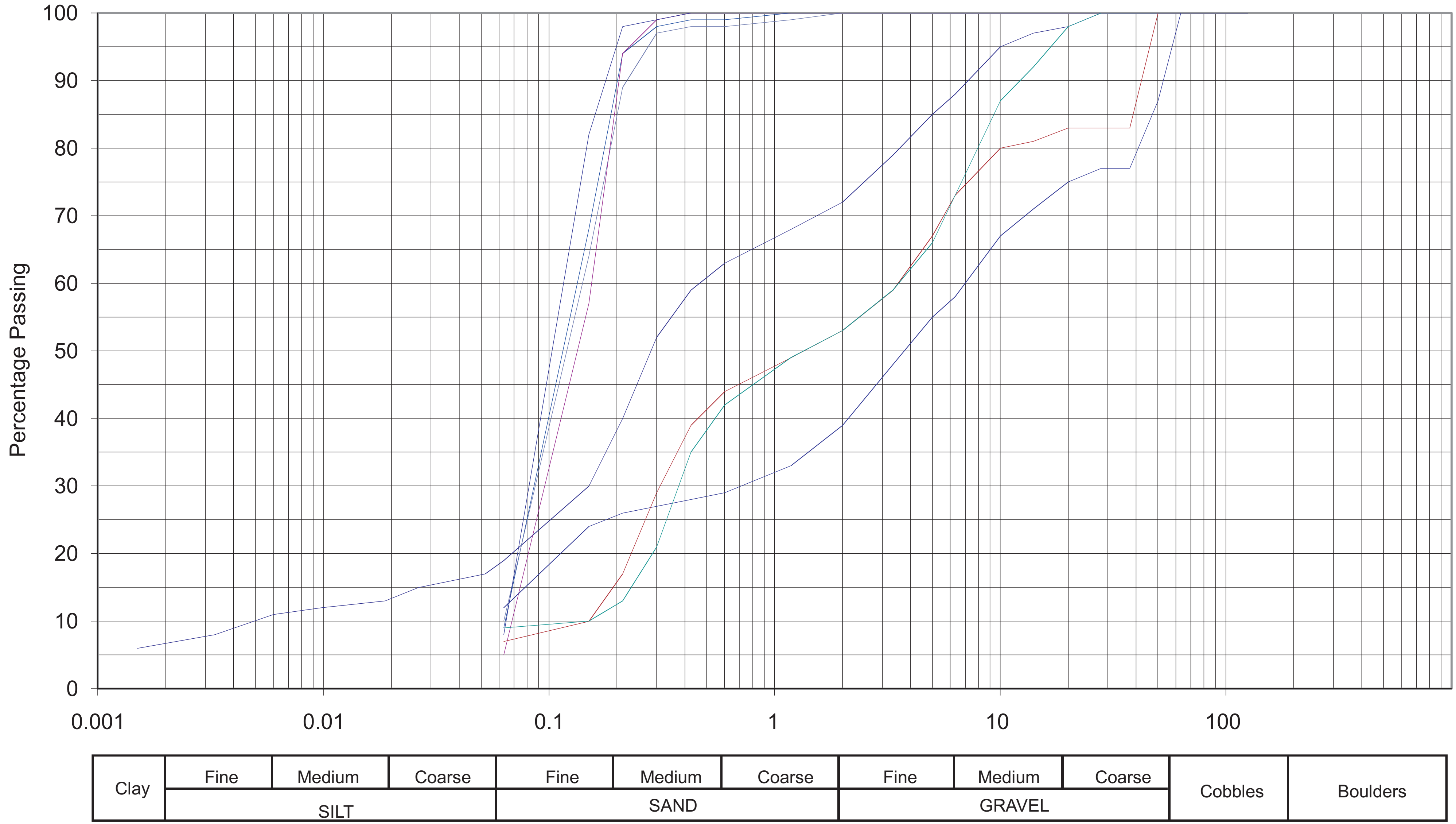
Particle Size Distribution Curves - Sands & Gravels



Project: South Humber Channel Marine Studies						
PARTICLE SIZE DISTRIBUTION OF SANDS AND GRAVELS						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: JANUARY 2011	Job No: 027559	Figure No: 16	Rev: 02

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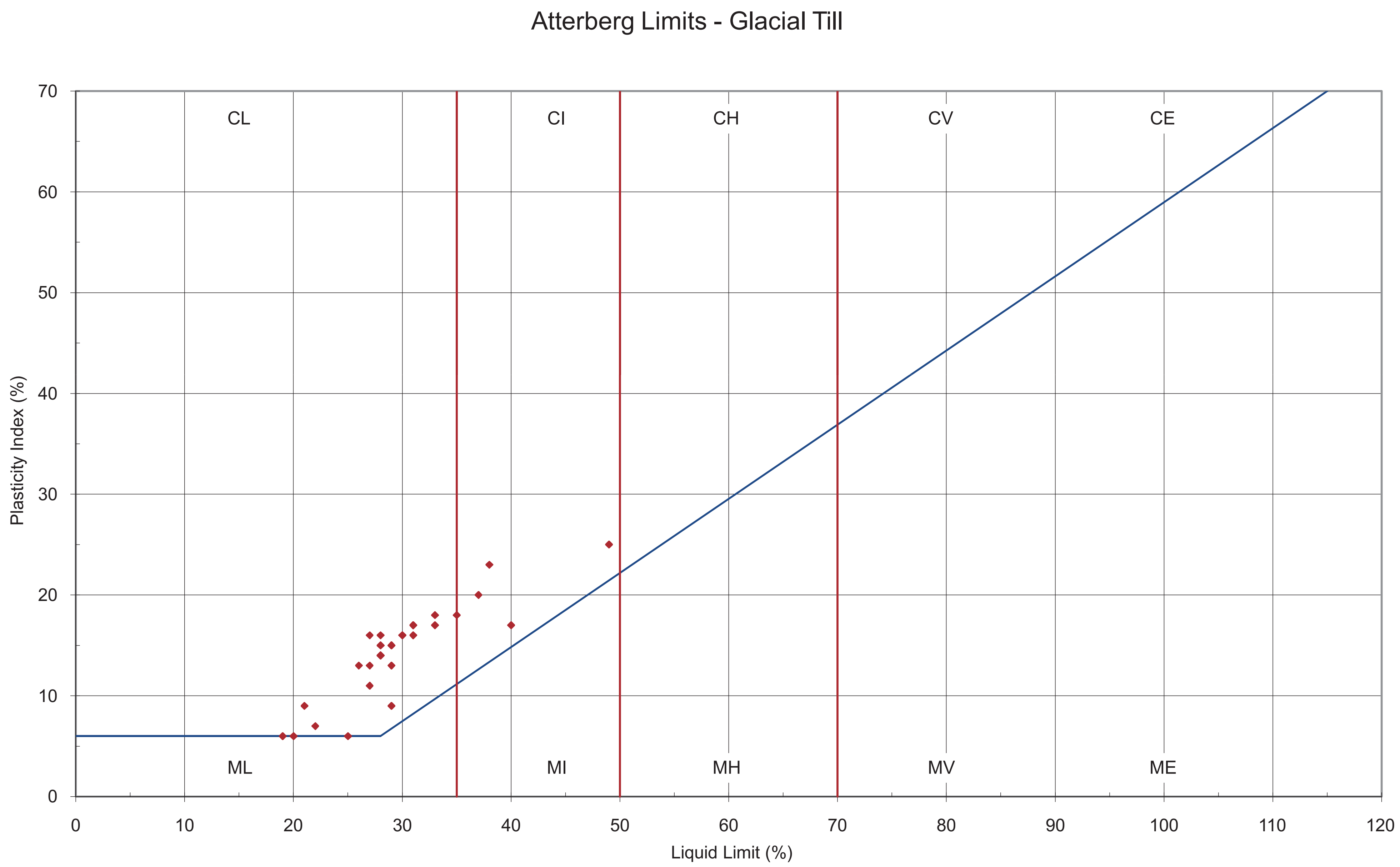

Project: South Humber Channel Marine Studies						
ATTERBERG LIMITS ON GLACIAL TILL						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: OCTOBER 2010	Job No: 027559	Figure No: 17	Rev: 01

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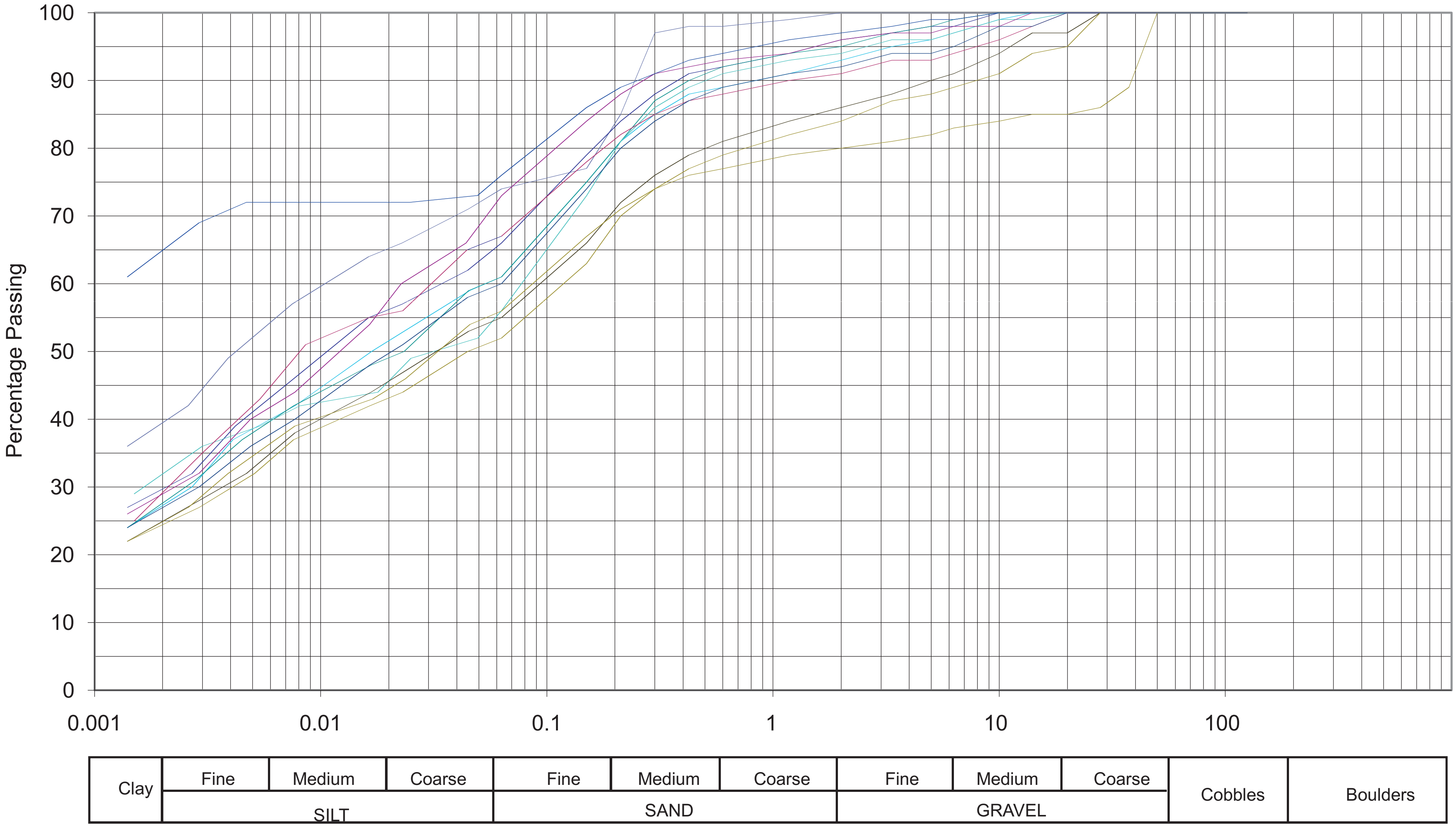
Particle Size Distribution Curves - Glacial Till



Project: South Humber Channel Marine Studies						
PARTICLE SIZE DISTRIBUTION OF GLACIAL TILL						
Scale: NTS	Drawn: JMB	Chk: BJ	Date: OCTOBER 2010	Job No: 027559	Figure No: 18	Rev: 01

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Appendix A – Hazardous Waste Assessment

Cefas Action Levels in Dredged Material Assessments

General

Action Levels are used as a part of a 'weight of evidence approach' to assessing dredged material and its suitability for disposal at sea. These values are used in conjunction with a range of other assessment methods e.g. historical data, characteristics of the dredging site, the materials physical characteristics, the disposal site characteristics and other data to make management decisions regarding the fate of the dredged material.

In general, contaminant levels in dredged material below Action Level 1 (yellow) are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above Action Level 2 (orange) are generally considered unsuitable for sea disposal. The latter situation usually exists for localised parts of a dredging area so this material can potentially be segregated and disposed of *via* other routes e.g. landfill. Dredged material with contaminant levels between Action Levels 1 and 2 require further consideration and testing before a licensing decision can be made.

		Cefas Action Levels	
Contaminant / Compound		Cefas Action Level 1	Cefas Action Level 2
Arsenic	mg/kg	20	100
Cadmium	mg/kg	0.4	5
Chromium	mg/kg	40	400
Copper	mg/kg	40	400
Lead	mg/kg	50	500
Mercury	mg/kg	0.3	3
Nickel	mg/kg	20	200
Zinc	mg/kg	130	800
PCBs, Total ICES 7	µg/kg	100	none
Tributyl tin	mg/kg	0.1	1
Triphenyl tin	mg/kg	0.1	1
Dibutyl tin	mg/kg	0.1	1
Tetrabutyl tin	mg/kg	0.1	1

Contaminated Land Generic Quantitative Risk Assessment, Humber

Table 1- Soil results		Sample Location																						Soil Screening Values	
Sample Identity		10 SUB	11 SUB	12 SUB	17 SUB	18 SUB	19 SUB	3L	4M	5L	6U	7L	8M	VC1	VC11	VC12	VC13	VC15	VC16	VC17	VC18	VC19	VC2	Cefas Action Level 1	Cefas Action Level 2
Depth (mbgl)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.10	2.20	4.30	3.80	2.60	3.40	4.00	5.20	3.30 - 3.60	6.00		
Sample Type		SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID		
Sampled Date		04/05/2010	04/05/2010	04/05/2010	04/05/2010	04/05/2010	04/05/2010							15/07/2010	14/07/2010	15/07/2010	15/07/2010	15/07/2010	14/07/2010	14/07/2010	14/07/2010	14/07/2010	15/07/2010		
Sample Number (s)		1598241	1598224	1597971	1597960	1597940	1597919	1560223	1560242	1560247	1560257	1560263	1560273	1843974	1843969	1844029	1844051	1843904	1843910	1843957	1843924	1844015	1843983		
Sample Description																									
Colour	-	Light Brown	Light Brown	Dark Brown	Light Brown	Light Brown	Light Brown	Light Brown	Light Brown	Light Brown	Dark Brown	Light Brown	Light Brown	Light Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Grey		
Grain Size	-	0.1 - 2 mm	0.063 - 0.1 mm	0.1 - 2 mm	0.1 - 2 mm	0.1 - 2 mm	0.1 - 2 mm	<<0.063 mm	<<0.063 mm	<<0.063 mm	<<0.063 mm	<<0.063 mm	<<0.063 mm	0.1 - 2 mm	<<0.063 mm	0.1 - 2 mm	0.1 - 2 mm	0.1 - 2 mm	<<0.063 mm	0.063 - 0.1 mm	<<0.063 mm	0.1 - 2 mm	0.1 - 2 mm		
Description	-	Sandy Silt Loam	Silt Loam	Sandy Silt Loam	Sandy Silt Loam	Sandy Silt Loam	Sand	Clay	Clay	Clay	Clay	Clay	Clay	Sand	Clay	Sand	Sand	Sand	Clay	Clay Loam	Clay	ndy Clay Lo	Sandy Clay		
Inclusions	-	N/A	N/A	N/A	N/A	N/A	Stones	None	None	None	None	None	None	Stones	Stones	None	N/A	Stones	N/A	Stones	Stones	Stones	Stones		
Metals																									
Arsenic	mg/kg	15.3	14.3	29.1	21.4	21	29.6	15.5	13.8	15.9	18.9	17.9	14.6	3.38	9.07	13.9	20.2	30.9	5.27	9.25	7.59	12.3	13.8	20	100
Cadmium	mg/kg	0.288	0.44	0.338	0.323	0.267	0.185	0.533	0.296	0.386	0.325	0.39	0.312	0.141	0.273	0.231	0.285	0.469	0.277	0.309	0.295	0.361	0.157	0.4	5
Chromium	mg/kg	25.4	25.7	35.4	25.2	21.4	10.7	45.7	32.7	35.6	43	41.2	31.6	4	17.3	13.2	18.4	25.5	11.8	18.5	20.7	20.7	10.3	40	400
Copper	mg/kg	16.6	15.3	22.8	16.2	49.9	7	31.4	23.5	24	27.4	27.1	24.5	3.16	12.1	8.61	11	18.2	10.3	23.3	13.5	15.4	4.61	40	400
Lead	mg/kg	40.4	26.7	52.3	37.5	57.7	30.6	47.5	35.4	42.8	54.6	49.1	38.6	2.34	9.9	29.4	27.8	42.1	6.84	11.4	9.6	12.1	5.11	50	500
Mercury	mg/kg	<0.14	0.177	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	0.3	3
Nickel	mg/kg	17.1	19	18.6	17.2	15	10.2	32.4	23.5	23.9	29.3	27	22.1	4.13	19.5	8.43	10.5	14.6	14.1	20.6	22.4	22.5	8.35	20	200
Selenium	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-
Zinc	mg/kg	90.2	110	115	102	91.2	66.7	128	108	121	145	139	112	13.1	43.5	63.9	80.7	107	35.9	46	46.2	57.4	22.2	130	800
Mineral Oil / Oils & Greases																									
TPH/Oils and Greases	mg/kg	78.8	136	145	40.2	67.8	56.9	121	24.8	73	69.1	86	<10	-	-	-	-	-	-	-	-	-	-		
Gasoline Range Organics (GRO)																									
Benzene	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10		
Toluene	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<2	<2	<2	<2	<2	<4	<2	<2	<2	<2		
Ethylbenzene	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<6	<3	<3	<3	<3		
m,p-Xylene	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<6	<6	<6	<6	<6	<12	<6	<6	<6	<6		
o-Xylene	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<6	<3	<3	<3	<3		
m,p,o-Xylene	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10		
BTEX, Total	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<10	<10	<10	<10	<10	<20	<10	<10	<10	<10		
Methyl tertiary butyl ether (MTBE)	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<10	<5	<5	<5	<5		
GRO >C5-C12	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<44	<44	<44	154	<44	<88	81.7	<44	62	<44		
Polyaromatic Hydrocarbons (PAHs)																									
Naphthalene-d8 % recovery**	%	111	110	108	109	109	109	90.1	91.9	88.3	101	92.5	97.1	97.8	103	105	97.6	110	102	93.5	102	92	88.6		
Acenaphthene-d10 % recovery**	%	111	111	109	107	110	110	90.2	92.5	88.4	103	93.4	98.3	95.4	98.5	102	95.7	107	98.4	91.5	97.6	88.3	84.6		
Phenanthrene-d10 % recovery**	%	109	110	109	102	110	110	90.1	92.4	87.4	102	93.1	98.4	92.1	98.8	102	91.9	109	98.8	89.8	97.9	84.9	79		
Chrysene-d12 % recovery**	%	105	107	106	97.2	108	108	86.7	89	83.8	99.2	89.3	95.3	86.6	84.2	88.5	86.4	97.7	84.7	87.1	83.8	81.9	73.7		
Perylene-d12 % recovery**	%	111	114	113	104	117	116	83.7	87.2	82.1	98.1	88.6	94.8	87	88.2	95.8	86.8	107	90.1	82.1	87.6	77.2	76		
Naphthalene	µg/kg	106	143	177	106	68.3	52.6	182	168	150	189	202	237	<9	<9	22.3	<9	111	33.4	11.4	<9	<9	<9		
Acenaphthylene	µg/kg	23.8	22	27.5	14.6	12.2	<12	21.6	26.4	19.9	22.4	27.8	28.3	<12	<12	<12	<12	26.9	<12	<12	<12	<12	<12		
Acenaphthene	µg/kg	30.7	27.9	41.4	22.6	22.9	18.5	37.5	45.6	29.8	38.1	45	50.9	<8	<8	<8	<8	52.6	<8	<8	<8	<8	<8		
Fluorene	µg/kg	42.4	49	72.4	33.4	39.1	25.4	55.7	58.8	46.7	59.5	65.9	72.4	<10	<10	<10	<10	60	<10	<10	<10	<10	<10		
Phenanthrene	µg/kg	250	242	264	168	161	127	293	329	251	309	343	406	<15	34.7	37.3	<15	280	48.2	32.1	<15	34.4	<15		
Anthracene	µg/kg	68.6	66.7	95.2	49.3	38.5	39.6	78	86.6	62	82.6	104	111	<16	<16	22.6	<16	107	<16	<16	<16	<16	<16		
Fluoranthene	µg/kg	361	299	377	196	165	182	355	402	304	384	438	507	<17	<17	69.6	<17	410	<17	<17	<17	65.6	<17		
Pyrene	µg/kg	329	291	347	187	162	171	343	372	291	375	410	464	<15	<15	66.7	<15	375	<15	22.1	<15	61	<15		
Benz(a)anthracene	µg/kg	268	201	236	115	118	90	194	217	169	225	257	282	<14	<14	37.3	<14	197	<14	18.8	<14	46.1	<14		
Chrysene	µg/kg	189	155	151	86.6	83.1	79.4	172	193	152	187	215	243	<10	<10	34.9	<10	162	<10	14.5	<10	35.6	<10		
Benzo(b)fluoranthene	µg/kg	296	262	292	164	148	136	300	319	251	325	363	377	<15	<15	45.2	<15	251	<15	20.5	<15	48.8	<15		
Benzo(k)fluoranthene	µg/kg	119	106	114	61.3	59.9	52	113	101	95.5	119	129	139	<14	<14	20.2	<14	99.4	<14	<14	<14	16.7	<14		
Benzo(a)pyrene	µg/kg	278	222	265	144	120	118	193	201	167	217	258	256	<15	<15	39.8	<15	217	<15	<15	<15	31.7	<15		
Indeno(1,2,3-cd)pyrene	µg/kg	145	124	148	77.8	63.5	59.5	129	125	109	141	154	146	<18	<18	28.4	<18	122	<18	<18	<18	<18	<18		
Dibenzo(a,h)anthracene	µg/kg	43.3	38.7	42.1	<23	<23	<23	<23	41.6	<23	42.4	46	48.6	<23	<23	<23	<23	35.2	<23	<23	<23	<23	<23		
Benzo(g,h,i)perylene	µg/kg	181	175	205	105	87	77.5	199	191	166	220	229	220	<24	<24	37.5	<24	169	<24	<24	<24	<24	<24		
Polyaromatic hydrocarbons, Total USEPA 16	µg/kg	2730	2430	2860	1530	1350	1230	2670	2880	2260	2940	3290	3590	<118	<118	462	<118	2670	<118	120	<118	340	<118		
Polychlorinated Biphenyls (PCBs)																									
PCB congener 28	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-		
PCB congener 52	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-		
PCB congener 101	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-		
PCB congener 118	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 138	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-		
PCB congener 153	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-		
PCB congener 180	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-		
PCBs, Total ICES 7	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	-	-	-	-	-	-	-	-	-	-	100	
PCB congener 81	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 77	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 123	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 114	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 105	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 126	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 167	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 156	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 157	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 169	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 189	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCBs, Total WHO 12	µg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
Organotins																									
Tributyl tin*	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	1
Triphenyl tin*	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	1
Dibutyl tin*	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	1
Tetrabutyl tin*	mg/kg	-	-	-	-	-	-	-	-	-	-	-	-	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	1

Table 2- Soil results		Sample Location											Soil Screening Values	
Sample Identity		VC20	VC22	VC24	VC27	VC28	VC29	VC3	VC30	VC6	VC7	VC8	Cefas Action Level 1	Cefas Action Level 2
Depth (mbgl)		3.38	3.60	3.60	4.90	4.30	2.90	0.00	3.00	5.30	0.00	4.70		
Sample Type		SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID	SOLID		
Sampled Date		14/07/2010	14/07/2010	14/07/2010	15/07/2010	14/07/2010	14/07/2010	15/07/2010	15/07/2010	15/07/2010	14/07/2010	15/07/2010		
Sample Number (s)		1843933	1843913	1844091	1843989	1844088	1844129	1844044	1844121	1844061	1843995	1843971		
Sample Description														
Colour	-	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown	Dark Brown		
Grain Size	-	0.063 - 0.1 mm	0.063 - 0.1 mm	0.063 - 0.1 mm	0.063 - 0.1 mm	<<0.063 mm	<<0.063 mm	<<0.063 mm	<<0.063 mm	0.1 - 2 mm	0.063 - 0.1 mm	0.1 - 2 mm		
Description	-	Clay Loam	Clay Loam	Silty Clay Loam	Clay Loam	Clay	Clay	Clay	Silty Clay	Sand	Silt Loam	Sand		
Inclusions	-	N/A	N/A	N/A	N/A	Stones	Stones	N/A	Stones	N/A	None	N/A		
Metals														
Arsenic	mg/kg	12.5	3.96	18.4	6.43	6	8.99	6.65	7.42	24.9	18.9	13.6	20	100
Cadmium	mg/kg	0.4	0.29	0.441	0.294	0.25	0.297	0.296	0.266	0.453	0.469	0.27	0.4	5
Chromium	mg/kg	29.5	12.3	34.7	16.2	16.4	19.6	20.6	21.7	31.6	42.5	16.8	40	400
Copper	mg/kg	19.4	10.5	24.2	10.3	11.3	14.4	13.2	13.8	24.2	26.6	13.9	40	400
Lead	mg/kg	22	7.62	33.2	7.68	8.23	11.2	11.2	13.6	44.7	48.8	35.2	50	500
Mercury	mg/kg	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	<0.14	0.3	3
Nickel	mg/kg	28.4	15	25.5	16.4	17.7	22	20.8	20.8	17.4	24.8	11	20	200
Selenium	mg/kg	<1	<1	1.04	<1	<1	<1	<1	<1	<1	1.1	<1	-	-
Zinc	mg/kg	84.7	39.1	106	39.5	42.7	51.3	48.5	51.1	121	131	77.5	130	800
Mineral Oil / Oils & Greases														
TPH/Oils and Greases	mg/kg	-	-	-	-	-	-	-	-	-	-	-		
Gasoline Range Organics (GRO)														
Benzene	µg/kg	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10		
Toluene	µg/kg	<2	<2	<2	<2	<2	13.8	<2	<2	<2	<2	<2		
Ethylbenzene	µg/kg	<3	<3	<3	<3	<3	35.7	<3	<3	<3	<3	<3		
m,p-Xylene	µg/kg	<6	<6	<6	<6	<6	33.4	<6	<6	<6	<6	<6		
o-Xylene	µg/kg	<3	<3	<3	<3	<3	20.7	<3	<3	<3	<3	<3		
m,p,o-Xylene	µg/kg	<10	<10	<10	<10	<10	54.1	<10	<10	<10	<10	<10		
BTEX, Total	µg/kg	<10	<10	<10	<10	<10	104	<10	<10	<10	<10	<10		
Methyl tertiary butyl ether (MTBE)	µg/kg	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5		
GRO >C5-C12	µg/kg	130	<44	162	108	128	848	<44	92.8	291	<44	97.5		
Polyaromatic Hydrocarbons (PAHs)														
Naphthalene-d8 % recovery**	%	105	103	105	100	94.3	94.3	101	98.7	101	107	103		
Acenaphthene-d10 % recovery**	%	104	103	104	98.9	91.5	90.5	97.3	96.6	99.1	105	102		
Phenanthrene-d10 % recovery**	%	102	104	103	102	88.2	86.7	97.9	92.8	96.5	106	101		
Chrysene-d12 % recovery**	%	101	92.9	103	86.1	82.6	81.3	84.8	89.4	93.6	93.8	100		
Perylene-d12 % recovery**	%	97.3	105	101	94.4	83.1	82	92.6	93.5	96	103	96.1		
Naphthalene	µg/kg	112	<9	156	41.8	16.7	12.8	24.9	162	133	162	62.6		
Acenaphthylene	µg/kg	21.3	<12	43.6	<12	<12	<12	<12	26.5	32.9	33.6	23.9		
Acenaphthene	µg/kg	28.3	<8	42	<8	<8	<8	<8	35.9	54.8	42.6	36.9		
Fluorene	µg/kg	45.1	<10	61.3	<10	<10	<10	<10	62.3	75	66.9	41.9		
Phenanthrene	µg/kg	203	<15	256	68.8	27.1	22.9	52.9	279	270	287	202		
Anthracene	µg/kg	62.3	<16	106	<16	<16	<16	<16	86.9	127	94.6	82.3		
Fluoranthene	µg/kg	263	<17	396	21.8	<17	<17	36.4	383	433	340	334		
Pyrene	µg/kg	252	<15	359	26.8	<15	<15	40.8	337	372	302	363		
Benz(a)anthracene	µg/kg	157	<14	237	<14	<14	<14	<14	224	215	195	164		
Chrysene	µg/kg	123	<10	170	<10	<10	<10	20.5	180	186	169	117		
Benzo(b)fluoranthene	µg/kg	232	<15	353	18	<15	<15	33.8	345	341	283	247		
Benzo(k)fluoranthene	µg/kg	80.6	<14	108	<14	<14	<14	<14	113	104	104	98.5		
Benzo(a)pyrene	µg/kg	158	<15	249	<15	<15	<15	21.9	248	250	218	190		
Indeno(1,2,3-cd)pyrene	µg/kg	97.9	<18	142	<18	<18	<18	<18	143	142	131	102		
Dibenzo(a,h)anthracene	µg/kg	33.1	<23	43.1	<23	<23	<23	<23	45.7	44.1	40.2	<23		
Benzo(g,h,i)perylene	µg/kg	163	<24	210	29.2	<24	<24	35.5	213	204	191	145		
Polyaromatic hydrocarbons, Total USEPA 16	µg/kg	2030	<118	2930	206	<118	<118	267	2880	2980	2660	2210		
Polychlorinated Biphenyls (PCBs)														
PCB congener 28	µg/kg	-	-	-	-	-	-	-	-	-	-	-		
PCB congener 52	µg/kg	-	-	-	-	-	-	-	-	-	-	-		
PCB congener 101	µg/kg	-	-	-	-	-	-	-	-	-	-	-		
PCB congener 118	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 138	µg/kg	-	-	-	-	-	-	-	-	-	-	-		
PCB congener 153	µg/kg	-	-	-	-	-	-	-	-	-	-	-		
PCB congener 180	µg/kg	-	-	-	-	-	-	-	-	-	-	-		
PCBs, Total ICES 7	µg/kg	-	-	-	-	-	-	-	-	-	-	-	100	
PCB congener 81	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 77	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 123	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 114	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 105	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 126	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 167	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 156	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 157	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 169	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCB congener 189	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
PCBs, Total WHO 12	µg/kg	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3		
Organotins														
Tributyl tin*	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	1
Triphenyl tin*	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	1
Dibutyl tin*	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	1
Tetrabutyl tin*	mg/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	1

Table 3: Waste classification based on soil values

Worst case substances			Xylene Dimercury Dichloride Calcium Sulphide Copper Sulphate	Benzene Phenol Naphthalene Cadmium Oxide	Arsenic Trioxide Calcium Cyanide	Nickel-carbonate	PRO (C6-C10)	DRO (C10-C25 or >C10 in absence of specific information)	Threshold value for carcinogenic PAH in whole oil	Sum of carcinogenic PAHs (percentage of whole oil)	Arsenic Trioxide	Calcium Chromate	Sum of PAH	Aromatic hydrocarbons (BTEX)	Cadmium Oxide	pH	Phenol Zinc Chloride Arsenic Trioxide	Max PAH (excl. Naphthalene)	Lead sulphate	Max PAH (excl. Naphthalene)	Lead sulphate	Max PAH (excl. Naphthalene)	Phenol	Calcium Cyanide	PCBs "To maintain consistency with international and UK legislation and guidance, the agencies consider that the level of 50mg/kg (0.005%) should be the defining threshold concentration for wastes containing PCBs and PCTs; above that concentration such waste should be considered as hazardous waste."	TPH (full range - C5-C40 etc.)	**Max of R50-53's** (Zinc Sulphate Cadmium Oxide Diarsenic Trioxide Selenium Calcium Chromate Lead sulphate Dimercury Dichloride Nickel Carbonate Calcium Cyanide Copper Sulphate PAHs, PCBs)	Zinc Sulphate Cadmium Oxide Diarsenic Trioxide Selenium Calcium Chromate Lead sulphate Dimercury Dichloride Nickel Carbonate Calcium Cyanide Copper Sulphate PAHs, PCBs
	Hazard		H4 - 'Irritant'	H6(H5) - 'Toxic'		H7 - 'Carcinogenic'										H8(H4) - 'Corrosive'		H10 - 'Toxic for reproduction'				H11 - 'Mutagenic'		H12 - Substances & preparations which release toxic gases in cont. with water air and acid		H14 - 'Ecotoxic'		
	Risk Phrase		R38	R23-25, R48	R26-28	R40		R45							R49		R34	R60	R61			R63	R46	R68	R32		R52/53	R50-53	R50-53/0.25 + R51-53/2.5 + R52-53/25
	Threshold value in %		20	3	0.1	1	0.1	0.1							0.1	<2 >11.5	5	0.5	0.5		5	0.1	1.0	0.2	0.005	2.5	0.25	1
	Maximum value		0.013	0.01	0.004	0.01	0.1	0.0			0.00	0.01	0.35900	0.009	0.0001	0.0	0.03	0.0507	0.009	0.0507	0.0	0.0507	0.0000	0.0000	0.0000	0.0145	0.0507	0.0
Sample identity	Sample depth (m)	Hazardous Waste																										
0	0.0																											
0	0.0																											
10 SUB	0.0	Yes	0.00417	0.01114	0.002	0.003		0.008		0.1338	0.002	0.008	0.273000		0.00004		0.021	0.0361	0.006	0.0361	0.006	0.0361				0.01	0.04	
11 SUB	0.0	Yes	0.00384	0.01106	0.002	0.004		0.014		0.1109	0.002	0.008	0.243000		0.00006		0.025	0.0299	0.004	0.0299	0.004	0.0299				0.01	0.03	
12 SUB	0.0	Yes	0.00573	0.01084	0.004	0.004		0.015		0.1248	0.004	0.011	0.286000		0.00004		0.028	0.0377	0.008	0.0377	0.008	0.0377				0.01	0.04	
17 SUB	0.0	Yes	0.00407	0.01094	0.003	0.003		0.004		0.0672	0.003	0.008	0.153000		0.00004		0.024	0.0196	0.006	0.0196	0.006	0.0196				0.00	0.03	
18 SUB	0.0	Yes	0.01253	0.01093	0.003	0.003		0.007		0.0616	0.003	0.006	0.135000		0.00003		0.022	0.0165	0.009	0.0165	0.009	0.0165				0.01	0.02	
19 SUB	0.0	Yes	0.00176	0.01092	0.004	0.002		0.006		0.0558	0.004	0.003	0.123000		0.00002		0.018	0.0182	0.005	0.0182	0.005	0.0182				0.01	0.02	
3L	0.0	Yes	0.00789	0.00908	0.002	0.006		0.012		0.1124	0.002	0.014	0.267000		0.00007		0.029	0.0355	0.007	0.0355	0.007	0.0355				0.01	0.04	
4M	0.0	Yes	0.00590	0.00923	0.002	0.005		0.002		0.1198	0.002	0.010	0.288000		0.00004		0.024	0.0402	0.005	0.0402	0.005	0.0402				0.00	0.04	
5L	0.0	Yes	0.00603	0.00888	0.002	0.005		0.007		0.0967	0.002	0.011	0.226000		0.00005		0.027	0.0304	0.006	0.0304	0.006	0.0304				0.01	0.03	
6U	0.0	Yes	0.00688	0.01014	0.002	0.006		0.007		0.1256	0.002	0.013	0.294000		0.00004		0.033	0.0384	0.008	0.0384	0.008	0.0384				0.01	0.04	
7L	0.0	Yes	0.00681	0.00930	0.002	0.005		0.009		0.1422	0.002	0.012	0.329000		0.00005		0.031	0.0438	0.007	0.0438	0.007	0.0438				0.01	0.04	
8M	0.0	Yes	0.00615	0.00975	0.002	0.004		0.001		0.1492	0.002	0.009	0.359000		0.00004		0.025	0.0507	0.006	0.0507	0.006	0.0507				0.00	0.05	
VC1	3.1		0.00139	0.01080	0.000	0.001	0.004			0.0109	0.000	0.001	0.011800	0.002100	0.00002		0.003	0.0024	0.000	0.0024	0.000	0.0024					0.01	
VC11	2.2		0.00364	0.01134	0.001	0.004	0.004			0.0109	0.001	0.005	0.011800	0.002100	0.00004		0.010	0.0035	0.001	0.0035	0.001	0.0035					0.01	
VC12	4.3		0.00276	0.01153	0.002	0.002	0.004			0.0229	0.002	0.004	0.046200	0.002100	0.00003		0.015	0.0070	0.004	0.0070	0.004	0.0070					0.02	
VC13	3.8		0.00336	0.01080	0.003	0.002	0.015			0.0109	0.003	0.006	0.011800	0.002100	0.00004		0.019	0.0024	0.004	0.0024	0.004	0.0024					0.02	
VC15	2.6	Yes	0.00517	0.01206	0.004	0.003	0.004			0.1084	0.004	0.008	0.267000	0.002100	0.00006		0.026	0.0410	0.006	0.0410	0.006	0.0410					0.04	
VC16	3.4		0.00379	0.01124	0.001	0.003	0.009			0.0109	0.001	0.004	0.011800	0.002700	0.00004		0.008	0.0048	0.001	0.0048	0.001	0.0048					0.01	
VC17	4.0		0.00645	0.01039	0.001	0.004	0.008			0.0124	0.001	0.006	0.012000	0.002100	0.00004		0.011	0.0032	0.002	0.0032	0.002	0.0032					0.01	
VC18	5.2		0.00399	0.01124	0.001	0.004	0.004			0.0109	0.001	0.006	0.011800	0.002100	0.00004		0.011	0.0024	0.001	0.0024	0.001	0.0024					0.01	
VC19	3.30-3.60		0.00447	0.01025	0.002	0.005	0.006			0.0220	0.002	0.006	0.034000	0.002100	0.00005		0.014	0.0066	0.002	0.0066	0.002	0.0066					0.01	
VC2	6.0		0.00176	0.00988	0.002	0.002	0.004			0.0109	0.002	0.003	0.011800	0.002100	0.00002		0.006	0.0024	0.001	0.0024	0.001	0.0024					0.01	
VC20	3.4	Yes	0.00547	0.01155	0.002	0.006	0.013			0.0882	0.002	0.009	0.203000	0.002100	0.00005		0.019	0.0263	0.003	0.0263	0.003	0.0263					0.03	
VC22	3.6		0.00324	0.01134	0.001	0.003	0.004			0.0109	0.001	0.004	0.011800	0.002100	0.00004		0.009	0.0024	0.001	0.0024	0.001	0.0024					0.01	
VC24	3.6	Yes	0.00668	0.01156	0.002	0.005	0.016			0.1302	0.002	0.010	0.293000	0.002100	0.00006		0.025	0.0396	0.005	0.0396	0.005	0.0396					0.04	
VC27	4.9		0.00319	0.01104	0.001	0.003	0.011			0.0112	0.001	0.005	0.020600	0.002100	0.00004		0.009	0.0069	0.001	0.0069	0.001	0.0069					0.01	
VC28	4.3		0.00344	0.01046	0.001	0.004	0.013			0.0109	0.001	0.005	0.011800	0.002100	0.00003		0.010	0.0027	0.001	0.0027	0.001	0.0027					0.01	
VC29	2.9		0.00696	0.01047	0.001	0.004	0.085			0.0109	0.001	0.006	0.011800	0.009290	0.00004		0.012	0.0024	0.002	0.0024	0.002	0.0024					0.01	
VC3	0.0		0.00392	0.01114	0.001	0.004	0.004			0.0145	0.001	0.006	0.026700	0.002100	0.00004		0.011	0.0053	0.002	0.0053	0.002	0.0053					0.01	
VC30	3.0	Yes	0.00407	0.01090	0.001	0.004	0.009			0.1299	0.001	0.007	0.288000	0.002100	0.00003		0.012	0.0383	0.002	0.0383	0.002	0.0383					0.04	
VC6	5.3	Yes	0.00668	0.01116	0.003	0.003	0.029			0.1282	0.003	0.009	0.298000	0.002100	0.00006		0.029	0.0433	0.007	0.0433	0.007	0.0433					0.04	
VC7	0.0	Yes	0.00728	0.01176	0.002	0.005	0.004			0.1140	0.002	0.013	0.266000	0.002100	0.00006		0.030	0.0340	0.007	0.0340	0.007	0.0340					0.03	
VC8	4.7	Yes	0.00409	0.01134	0.002	0.002	0.010			0.0942	0.002	0.005	0.221000	0.002100	0.00004		0.018	0.0363	0.005	0.0363	0.005	0.0363					0.04	

Disclaimer: This spreadsheet does not take risk phrases into account that are applicable where an individual substance or the sum of substances exceed 25% (250g/kg or 250000mg/kg) of the total sample material.

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