

Ardent Leisure Pty Ltd



Geotechnical, Acid Sulfate Soil and Stage 2 Contamination Assessment: The Spit Marina, Mosman, NSW

ENVIRONMENTAL



WATER



WASTEWATER



GEOTECHNICAL



CIVIL



PROJECT
MANAGEMENT



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All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Overview

This report has been prepared by Martens & Associates for the purpose of a Geotechnical, Acid Sulfate Soil (ASS) and Stage 2 Contamination Assessment for the proposed redevelopment of The Spit Marina at Mosman (the "Site"). SEPP 55 is to be addressed due to past and present site uses, including underground storage tanks and use as a marina with boat maintenance facilities. This report provides a geotechnical assessment of the site, assesses site contamination and provides recommendations for the proposed development.

Method

Field investigations were carried out on the 12th and 13th of December 2007, and involved the excavation of ten (10) boreholes, 3 dynamic cone penetrometer (DCP) tests and the collection of fifty seven (57) soil samples for contamination and ASS purposes. Five (5) samples were sent for laboratory testing by the SPOCUS method for ASS assessment.

For the Stage 2 assessment, fourteen (14) soil samples and two (2) water samples were initially analysed for heavy metals and hydrocarbons (BTEX, TRH & PAHs), with four (4) of these samples also being tested for pesticides (OCP/OPP) and PCB's. Three (3) samples that were over Inert Waste specific contamination concentration (SCC1) threshold values and located in the proposed UST area were analysed using the toxicity characteristics leaching procedure (TCLP) test. Additional testing of one (1) sample for tributyl tin (TBT) was conducted on sediment samples collected in or near the marina lease area in Middle Harbour. Contamination analysis, assessment and recommendations have been conducted with reference to Guidelines for the NSW Site Auditor Scheme (NSW EPA, 2nd Ed 2006).

Results

The site is underlain by sandy clay (weathered sandstone) fill to depths of around 1.5 m, overlying natural horizons of quaternary marine sands. Depth to underlying bedrock is unknown; however it exceeds the investigation depth of 10.5 m bgl. Groundwater is located at between 0.1 – 0.2 mAHD, and is expected to fluctuate with tidal influences. Results of SPOCUS testing reveals site soils are neither actual nor potential ASS.

Results of laboratory analysis reveal one sample from borehole 5 exceeds SILs for benzo(a)pyrene, as provided by NSW EPA (2006) for commercial sites. Following SCC1 and TCLP testing, fill has been classed as an 'Inert Waste' in accordance with NSW EPA (1999). The underlying natural soils on the land are free from contamination and are classified as VENM. Groundwater was found to have elevated contaminated levels of arsenic, copper, lead, zinc, toluene and total xylenes above adopted guideline (EPA 1994 and ANZECC/ARMCANZ 2000) trigger values.

Recommendations

Stage 2 contamination assessment recommendations include the preparation of RAP for removal of UST's and an environmental management plan if dewatering is required for site works, due to various contaminants having levels above guideline trigger values for marine and fresh water.

All excavation below the water table shall require shoring support, implementation of a site dewatering plan (not yet prepared) and a detailed dilapidation survey of surrounding infrastructure. Other geotechnical recommendations include additional sub-surface investigations to allow for final design of footings (according to structural engineering requirements) as well as design of dewatering and construction management plans prior to site works. For excavation conducted near the boundary of the site, below the water table or any other areas where batter slopes cannot be utilised, temporary sheet piling or geocast walls with soil anchors are recommended to support excavation.

Conclusions

Various heavy metal, toluene and xylene contaminants were found in groundwater well 2. These are likely to have leaked from the existing UST's. A RAP is to be prepared to manage the removal of the UST's. From the preliminary geotechnical assessment, it appears the site is fit for the proposed purpose provided the recommendations of this report are implemented. The ASS investigation has revealed that the site contains neither actual nor potential ASS and subsequently a management plan is not required.

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1 Overview

1.1 Background

The purpose of this report is to provide an Acid Sulfate Soil Assessment, Stage 2 Contamination Assessment and a preliminary Geotechnical Assessment to identify potential development constraints at The Spit Marina, Mosman, NSW. A Stage 1 report was previously prepared by Martens and Associates (P0701675JR01_V2) which reviewed historic aerial photos and Mosman Municipal Council's DA records. The Stage 1 and 2 assessments are required to support a Part 3(a) development application (DA) for the site.

1.2 Proposed Development

The following summarises our understanding of works associated with the proposed development:

- A number of alterations and extensions to the existing arms of the marina facility. Overall, 35 new berths will be created.
- Replacement of the existing slipway, located on the northern side of the building, with a new hardstand area. Car parking will also be provided on the hardstand area.
- Relocation of the fuel berth and sewerage pump out, and decommissioning of the existing underground storage tanks (UST's). New UST's will be located below the existing on-grade car parking area.
- Demolition of the existing marina complex and construction of a new building to enable the use of 2 floors. It is proposed to also replace the piling beneath the building for support.

1.3 Project Scope

Geotechnical investigations outlined in this report assess sub-surface conditions over the area of the proposed development with particular emphasis on:

- Detail of underlying sub-surface soil strength.
- Sub-surface moisture conditions and subsequent groundwater level.

- Details of any underlying layers of low strength materials (if encountered).
- Preliminary construction recommendations with regards to design of shoring, site dewatering and site instability.
- Details of actual or potential acid sulfate soil (ASS) risk based on a geomorphological assessment and laboratory testing of soil samples.

The main objectives of the Stage 2 contamination assessment are as follows:

- Provide an assessment of site soil contamination in accordance with NSW EPA guidelines and the findings of the Stage 1 report.
- Assess the suitability of the site for the proposed commercial land use.
- Provide a waste classification for the underlying soil should threshold levels of potential contaminants exceed those provided by relevant NSW EPA guidelines.

2 Site Description

2.1 Field Investigations

Site inspections were undertaken on the 13th and 14th of December, 2007. Works conducted during the field investigations included:

- A walk over inspection of the site and surrounding property to review drainage and topography.
- Excavation of ten (10) geotechnical bore holes to depths ranging between 4.5 and 10.5m b.g.l. using a 4WD mounted auger.
- Three (3) Dynamic Cone Penetrometer (DCP) tests to determine the strength and depth of subsurface materials at representative locations.
- Collection of water samples from the two (2) existing wells and collection of numerous soil samples for contamination and acid sulfate soil assessment.

DCP, bore hole and well locations can be found on the site plan in Attachment A. Borehole logs are provided in Attachment B.

2.2 Location and Existing Land-use

The site is located on the Spit Rd, Mosman and is within the Mosman Municipal Council (MMC) LGA. The site is located on the western side of Spit Rd, and to the north of the Spit Reserve and comprises maritime leases 101 – 104 DP 1011363. The marina's jetty and floating pontoons are located on Middle Harbour to the east. Attachment A provides the site plan with pertinent site features.

The site is currently utilised as a Marina, and has been generally operating in its current capacity since the 1960's. Located on the site is an existing marina complex (which includes restaurant, offices and toilets), maintenance / storage sheds, slipway, timber jetty and multiple floating pontoons. There is no vegetation on the land portion of the site; however sea grasses have been identified within the lease area and are addressed by others.

Figure 1 shows a site aerial photo and approximate site boundaries.



Figure 1: Aerial photo of The Spit, showing site location (land and lease area), (source: Google Maps, 2007).

2.3 Topography and Drainage

Due to the construction of a sea wall along Middle Harbour and the development of the entire Marina site, the site's original grade is unknown. The existing sea wall along the tidal boundary of the site generates a relatively flat site, which drains to the west to Middle Harbour. The landward component of the site is entirely covered by hardstand features and buildings.

2.4 Local Geology

A review of the 1:100 000 Sydney geology series sheet 9130 (1983) indicates that the site is underlain by Quaternary (Holocene) age sediments and potentially some man made fill (dredged estuarine / marine sediments). Field investigations confirm the site is underlain by fill, over deep Holocene sand horizons.

Underlying bedrock was not encountered during field investigations; however it is likely that bedrock at the site is greater than 20 m depth.

2.5 Groundwater

2.5.1 Field Groundwater Observations

Groundwater was encountered at the site at approximately 0.1 – 0.2 m AHD. Two groundwater monitoring wells previously installed on the site were utilised for water sampling purposes and water level assessment. Groundwater wells were purged during the first hour of fieldwork, and allowed to recover before taking water measurements and samples later in the day.

Groundwater level measurements indicate that groundwater fluctuates around the 0.1 – 0.2 m AHD mark. These levels are expected, considering the proximity of the site to Middle Harbour and the permeability of the underlying sandy soil.

Table 1: Approximate groundwater levels at monitoring locations +/- 0.1m.

Borehole Location	Surface mAHD	Date	Time	GW level (m bgl)	GW level (mAHD)
BH1	1.47	13/12/07	7:30 am	1.28	0.19
			3:45 pm	1.33	0.14
BH2	1.40	13/12/07	7:40 am	1.24	0.16
			3:35 pm	1.30	0.10

Locations of groundwater monitoring wells are shown on the site plan (Attachment A). The resolution of surface level information at each of the bore location combined with small differences in groundwater levels mean that analysis of hydraulic gradients is not possible.

2.5.2 Groundwater Recharge Systems

Based on the site inspection and the local hydrogeological setting, we are of the view that groundwater is mostly dependant on sea level.

3 Geotechnical Assessment

3.1 Geology and Soils

3.1.1 Soil Profile and Preliminary Design Considerations

Soil properties estimated from field test boreholes and penetration testing are provided in Table 1. Approximately 1.5 – 2.0 m of ripped sandstone / sandy clay fill was found behind the retaining wall and underneath the asphalt carpark in the northern portion of the site.

Safe bearing pressures in sands are dependent on the depth and width of footing embedment, or the pile diameter. As such, it is assumed a pile of 600 mm width is utilised on the site to allow an estimate of allowable bearing pressures as detailed below.

Table 2: Typical *in-situ* ground conditions, estimates for soil strength properties.

Layer	Average Depth Range b.g.l. (m)	Description	In-Situ Unit Weight (kN/m ³)	Q _a ¹	φ ²	Shaft Friction
1	0 – 0.10	Concrete	-	-	-	-
2	0.10 – 0.4	GP – Blue metal gravel fill.	17	-	-	-
3	0.40 – 1.2	EW – ripped sandstone / sandy clay fill.	19	-	-	20
4	1.20 – 2.50	SP – Silty sand, brown, wet, med dense, med grained.	18	200	28	25
5	2.50 – 10.50	SP – Sand, light brown, wet, med dense.	19	500	30	30 to 70 (linear increase with depth)

Notes: ¹ Preliminary allowable end bearing pressure for 600 mm pile. Estimates based on limited field testing and penetration tests, with bearing pressures to be confirmed following further detailed investigation ² Effective friction angle.

Design parameters for site soils are based on preliminary field testing data, visual inspection of soil materials and penetration testing. No soft

organic peat or clay layers were encountered during drilling and DCP testing.

3.1.2 Site Instability

No signs of gross instability or mass movement were observed on the site or surrounding property at the time of inspection, however there were a number of signs of differential settlement / site instability on the allotment. Pavements to the east of the marina building showed signs of cracking and instability. Sub-surface investigations revealed many of the site rigid pavements had significant voids beneath them, signifying settlement of the underlying sub-grade.

3.2 Geotechnical Hazards

Table 3 outlines the site specific hazards associated with the proposed commercial development. Mitigation strategies are provided to reduce the probability of these hazards impacting on the future development of the site.

Table 3: Summary of geotechnical hazards and management recommendations.

Hazards	Description of Hazard	Hazard Minimisation / Recommendation
Foundation material movement / settlement	Instability of layers of soils, such as peat and clays, between sands.	1. Risk is possible for pavements, based on existing evidence. Risk negligible for deep foundations based on preliminary testing identifying no such layers at depth, and that development foundations will be founded in medium dense / dense sands. 2. It is recommended that further sub-surface investigation to facilitate pile / pier design is conducted. 3. Appropriate sub-base and sub-grade treatment to be conducted prior to pavement construction.
Coastal Recession	Sea levels rise due to climate change	1. Risk negligible due to sea wall protection along the site.
Groundwater level & fluctuation	Groundwater levels affect bearing pressures and construction techniques.	1. Excavation below water table will require appropriate shoring / retention. 2. Foundation designs should take into account full hydrostatic pressures up to 1 mAHD.

Dewatering of groundwater table (considered unlikely to be required for construction of proposed development)	Dewatering impacts on neighbouring allotments and roads via differential settlement.	1. Hydraulic conductivity (K sat) testing on existing groundwater bores to enable a groundwater dewatering management plan to be prepared. 2. A groundwater dewatering management plan may be required as well as applicable licences and approvals.
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3.3 Recommendations

3.3.1 Footings and Foundations

Discussions with the client reveal that the likely foundation solution will be suspended concrete on driven piles. Precast and prestressed driven concrete piles would be suitable on the site, provided adequate structural engineer design with consideration given to the highly aggressive environment in which the piles will reside. Driven piles are appropriate from an environmental viewpoint as they do not create large amounts of spoil which can be an issue in a sensitive marine environment and do not require site dewatering for their installation.

Pile design should take into account full hydrostatic load, be designed by a suitably qualified and experienced structural or geotechnical engineer and be designed in light of the preliminary geotechnical parameters provided in Table 2. Considering the amount of testing performed thus far, limited comments can be made on the founding depth of piles within the inter-tidal zone and further out into Middle Harbour. Due to the unknown depth of bedrock below Middle Harbour bed, piles are likely to be founded on medium dense / dense sand (> 6.0 m depth), with consideration given to the estimated shaft friction depending on final pile size and shape.

3.3.2 Excavations

Minor excavations are likely to be required to allow construction of the marina complex. The following recommendations are made in relation to excavation:

1. Unsupported excavations made above the water table in sand or fill material may be undertaken at 1V:2H.
2. All excavations required steeper than 1V:2H are to be temporarily (or permanently) shored or retained. Parameters given in Table 3 should be used as a guide for preliminary design of all support or shoring structures. Discussion of shoring / retaining options is provided below.

3. Any excavation below the water table will require shoring support of unconsolidated material and a dewatering / groundwater management plan is to be prepared. A license to dewater will be required from the Department of Natural Resources.
4. Management of any excavated material must be in accordance with relevant NSW EPA guidelines for assessment and management of contaminated lands and wastes and SEPP 55. See Section 6.4 for waste classification details.

Where required, the following possible alternatives for support of excavations on the site are provided:

3.3.2.1 Sheet Piles

The use of sheet piling and temporary soil anchors has an advantage of being a relatively quick and low cost installation. Sheet piles may adversely affect nearby structures due to the potential to cause vibration (thus necessitating the implementation of a vibration management and monitoring plan), however this is considered unlikely due to the sub-surface conditions underlying the site. Following construction, sheet piling can be removed or left in place.

3.3.2.2 Geocast walls

Geocast walls are an innovative proprietary system for the installation of reinforced concrete walls. The process utilises a modified trench excavation system, and review of the Geocast system can be viewed on their website (www.geocast.com.au). The primary disadvantage of adopting the system is the requirement of full site dewatering to allow casting of the walls. Geocast walls can be formed as a shoring and also a foundation option, and do not cause much vibration during construction.

3.3.2.3 Contiguous or Secant Pile Walls

Contiguous / secant pile systems are more expensive than sheet piles or Geocast walls (not taking into account dewatering requirements), however they can form the permanent load bearing foundations of a structure as well as the shoring support. Such a system involves the construction of 'abutting' piles (contiguous) or intersecting adjacent piles (secant). Waterproofing of the internal face of the wall is conducted by shotcreting or grout injection.

Secant / contiguous piles generally do not require significant dewatering to be constructed. Subsequently, risks associated

with potential dewatering impacts on neighbouring properties / structures are reduced. Depending on where excavation is to take place and the piles can form part of the structural integrity of building's post excavation. They also do not cause much vibration during construction.

3.3.3 Further Testing

We recommend the following works to be undertaken at the CC Stage to enable detailed design to proceed:

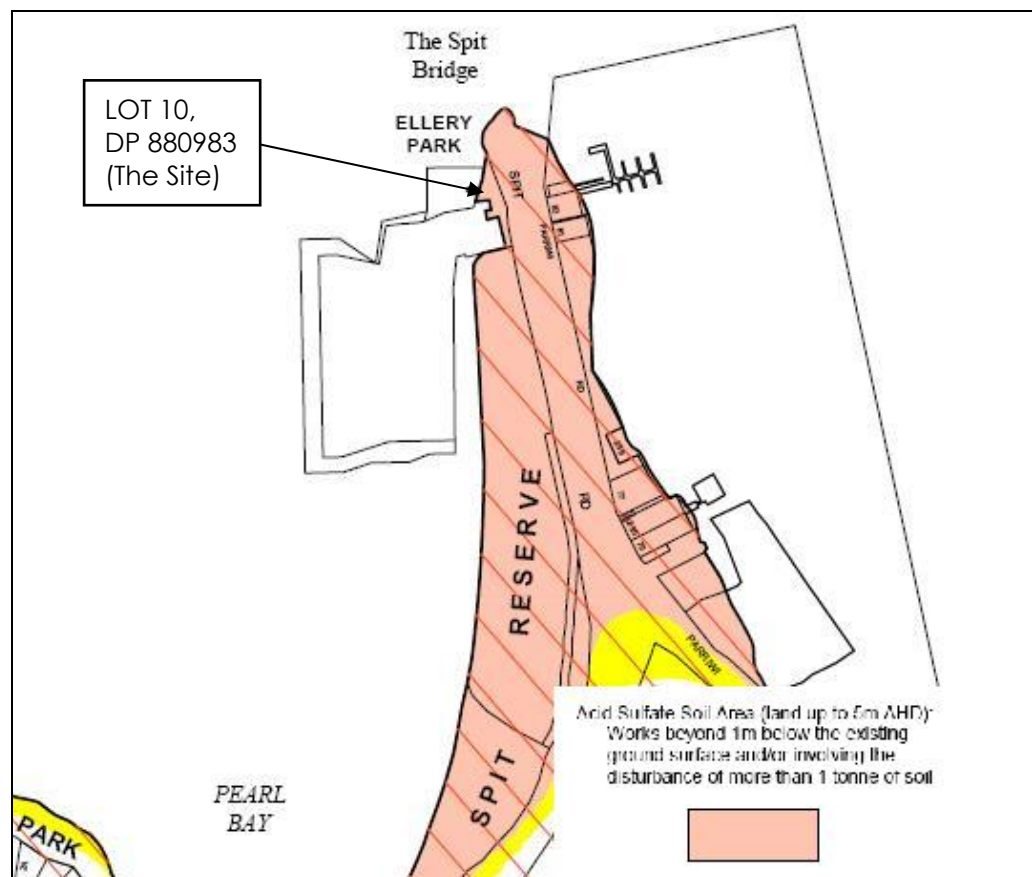
1. If a site dewatering plan is required due to selected construction techniques, pump testing of existing groundwater wells to determine aquifer properties.
2. Testing to structural engineer specification likely to include shear box testing (say 5-6 samples) combined with CPT (or continuous SPT) testing once building has been demolished, to provide further detail on soil engineering properties.
3. Preparation of a construction management plan (see Section 3.3.4).
4. A detailed dilapidation survey of the neighbouring Spit Rd (northern lane and footpath adjacent to the site and 20m to the south) and park (from site boundary to 20m south) with particular emphasis on pavement condition, sea wall and structural characteristics.

4 Acid Sulfate Soils Assessment

4.1 ASS Risk Map Classification

According to the acid sulfate soils planning map produced by Mosman Council (2005), the site is classified as having ASS risk. ASS risk refers to works that occur below 1m of existing ground level or works that disturb more than 1 tonne of soil.

Figure 2: ASS risk map (Mosman Council, 2005).



4.2 Geomorphic Setting

The likelihood of ASS occurrence at a site is a function of various geomorphic parameters (ASSMAC, 1998). Such parameters and their presence at the site are listed in Table 4.

Table 4: Geomorphic site features indicative of ASS and their presence or absence at the site.

Geomorphic Feature	Present on site?
Holocene sediments	Yes
Soil horizons less than 5 m AHD	Yes
Marine / estuarine sediments or tidal lakes	Yes
Coastal wetland; backwater swamps; waterlogged or scaled areas; interdune swales or coastal sand dunes.	Yes
Dominant vegetation is mangroves, reeds, rushes and other swamp or marine tolerant species.	No ¹
Geologies containing sulphide bearing material	Unknown
Deep older (Pleistocene) estuarine sediments	No

Note: ¹ Past vegetation most likely included these species.

Four (4) of the seven geomorphic features listed are present on site. This indicates likelihood that ASS may be present at the site.

4.3 Preliminary Sampling Strategy

Analyses of the presence of ASS material on the site has been evaluated by laboratory testing of five (5) soil samples. Soil samples were analysed from borehole's 1, 2 and 4. Soil samples were analysed with the SPOCUS method by a NATA accredited laboratory.

4.4 Soil Profile & Water Table

Refer to Section 2 for sub-surface conditions across the site.

4.5 Results

Results for the five samples are summarised in Table 5 with the complete laboratory report provided in Attachment C.

Table 5: Results of SPOCUS testing.

Sample ID	Bore Hole	Sample Depth (m)	pH _{KCL} ¹	pH _{OX} ²	TPA (mol H+/t) ³	TSA (mol H+/t) ⁴	S _{POS} (%S oxidisable) ⁵
1675/1/2.5	1	2.5	9.86	7.7	<5.0	<5.0	0.024
1675/2/2.0	2	2.0	9.76	7.6	<5.0	<5.0	0.016
1675/2/4.0	2	4.0	10.0	7.7	<5.0	<5.0	0.020
1675/2/5.0	2	5.0	9.92	7.6	<5.0	<5.0	0.078
1675/2/3.0	4	3.0	9.94	7.3	<5.0	<5.0	0.022

Note: ¹ Actual pH; ² Post peroxide oxidation pH; ³ Total Potential Acidity; ⁴ Total Sulfidic Acidity; ⁵ Percentage peroxide oxidisable sulfur.

Using pH_{KCL} and post peroxide oxidation pH_{OX} criteria (ASSMAC, 1998, p12) all soils with a pH_{KCL} of < 4.0 are considered actual ASS. Soils with pH_{KCL} > 4.0 and pH_{OX} < 3.0 are classified as potential ASS. On the basis of this classification system no site samples are classified as actual or potential ASS.

In accordance with the Action Criteria (ASSMAC, 2000, p27), a management plan is required for disturbance of sands < 1,000 tonne if peroxide oxidisable sulphur (S_{POS}) is greater than 0.03 % or total potential acidity (TPA) is greater than 18 mol H+/tonne. Testing indicates that TPA in all samples are below these values, however S_{POS} is > 0.03 % in sample 1675/2/5.0. Observed pH_{OX} (soil pH after oxidation) are all in the alkaline range (>7.0) suggesting any oxidisable acid generating material is more than buffered by natural soil buffers (such as calcium carbonate in shell). Results of the completed assessment indicate no 'actual' or 'potential' acid sulfate soils are on the site.

4.6 Conclusion

On the basis of site sub-surface investigations and results of the pH_{KCL} and pH_{OX}, the materials tested are classified as neither potential ASS nor actual ASS. On the basis of the above, further site ASS testing and a site management plan is not considered necessary.

5 Stage 2 Assessment: Site Sampling

5.1 Summary of Stage 1 Assessment

The Stage 1 assessment completed for the site (Martens report P0701675JR01_v2, May 2010) indicated that there is potential for contamination at the site from uses including fuel storage and from the importation of backfill from an unknown source.

5.2 Field Investigations

Site investigations were undertaken by Martens and Associates on 13th and 14th of December, 2007 and are described in Section 2.1. Additional underwater sediment sampling within the lease area was conducted by W.S. Rooney and Associates on the 3rd and 19th of December, 2007.

5.3 Sampling Density

NSW EPA (1995) sampling guidelines specify testing at a minimum of 5 (five) locations for UST's and a minimum of 5 (five) locations for the general site. Accordingly, sampling was undertaken at a total of 10 (ten) locations within the land based portion of the site, and 4 (four) locations in the lease area of the site.

5.4 Sampling Locations and Sampling Depths

Soil sampling locations were distributed to allow investigation around the UST's, the slipway and behind the retaining wall. Sample depths were determined to achieve sampling of both fill and underlying natural soil profiles.

Approximate sample depths are outlined in Table 6 and sampling and groundwater well locations are shown on the site plan (Attachment A).

Table 6: Approximate sample depths.

Location ID	Depth of Samples (m)							Max Sample Depth
	0.25	0.5	1.0	1.5	2.0	2.5	3.0	
BH 1	X	X	X	X	-	X	X	4.5
BH 2	X	X	X	X	X	-	X	4.3
BH 3	X	X	X	X	X	-	-	4.2
BH 4	-	X	X	-	X	-	-	2.0
BH 5	X	X	X	X	X	-	X	4.5
BH 6	X	X	X	X	X	-	X	4.2
BH 7	X	X	X	X	X	-	X	4.2
BH 8	X	X	X	X	X	-	X	4.2
BH 9	X	X	X	X	X	-	X	4.3
BH 10	X	X	X	X	X	-	X	4.3

All collected samples were stored in glass jars with Teflon lined lids, kept on ice in an esky and delivered to the nominated laboratory by courier within 48 hours of sampling.

5.5 Sample Analysis

Soil samples submitted for initial laboratory analysis are shown in Table 7 and additional testing in Table 8. The testing regime was configured to provide a broad understanding of the likely nature of contamination within the underlying site fill and around the existing petrol tanks to assess contaminant migration to underlying natural soil layers. The soil samples selected included:

- 14 soil samples (not including trip spike and trip blank samples) and 2 water samples were initially tested for hydrocarbons and heavy metals, with 4 of the samples and the 2 water samples also tested for PCB's, and organochlorine and organophosphorous pesticides.
- Additional testing using TCLP techniques of three samples located in the proposed excavation area, where reported contaminant levels exceed the specific contaminant concentration levels for inert waste (SCC1).

Laboratory analysis was conducted by the NATA accredited laboratory, 'Envirolab'.

Table 7: Soil samples submitted for initial laboratory analysis.

Sample ID	TRH	BTEX	PAH	Heavy Metals ¹	PCB	OC/OP
1675/1/1.0	Y	Y	Y	Y	Y	Y
1675/3/0.25	Y	Y	Y	Y	Y	Y
1675/7/1.5	Y	Y	Y	Y	Y	Y
1675/10/0.25	Y	Y	Y	Y	Y	Y
1675/3/1.0	Y	Y	Y	Y		
1675/5/1.5	Y	Y	Y	Y		
1675/6/1.0	Y	Y	Y	Y		
1675/6/2.0	Y	Y	Y	Y		
1675/7/3.0	Y	Y	Y	Y		
1675/7/4.2	Y	Y	Y	Y		
1675/8/1.5	Y	Y	Y	Y		
1675/8/2.0	Y	Y	Y	Y		
1675/8/3.0	Y	Y	Y	Y		
1675/8/4.2	Y	Y	Y	Y		
1675/GW1	Y	Y	Y	Y		
1675/GW2	Y	Y	Y	Y		
Trip Blank		Y				
Trip Spike		Y				

Note: ¹ Nine heavy metals: As, Cd, Cr, Cu, Pb, Hg, Ni, Sn, Zn.

Table 8: Soil samples submitted for additional laboratory analysis following review of initial laboratory testing.

Sample ID	TCLP ¹ testing for:		
	Chromium	Nickel	Lead
1675/1/1.0	X	X	X
1675/3/0.25	X	X	X
1675/3/1.0		X	

Note: ¹ Toxicity characteristics leaching procedure.

5.6 Quality Assurance and Quality Control

5.6.1 Field QA/QC

All sampling was undertaken by an experienced environmental engineer. Soil samples were collected directly from the end of the soil auger and placed in Teflon lined glass sample jars. Sample jars were uniquely labelled and an appropriate chain of custody form used

(Attachment D). The trip blank recovered no traces of BTEX, whilst the trip spike had recovery rates ranging from 99 – 121%.

5.6.2 Laboratory QA/QC

As indicated by the Labmark laboratory report (Attachment C), the laboratory QA/QC included the analysis of reagent blanks, sample portion duplicates, matrix spike duplicates and surrogate spikes. Results indicate that acceptable recovery rates were achieved by the laboratory.

5.7 Contamination Guidelines

Soil sample laboratory analysis results were assessed with reference to the following guidelines (Table 9):

- NSW EPA (2006) *Guidelines for the NSW Site Auditor Scheme: Soil Investigation Levels* (Column 1 – residential) – for assessment of heavy metals, PAH, OC/OP and PCB concentrations.
- NSW EPA (1994) *Contaminated Sites: Guidelines for Assessing Service Station Sites* - for assessment of TRH and BTEX concentrations in the absence of other suitable guidelines.

Table 9: Contamination guideline limits adopted for assessment of The Spit Marina.

Contaminant	Guideline Limit (mg/kg)	
	NSW EPA (2006) Guidelines for the NSW Site Auditor Scheme: Soil Investigation Levels (Column 4 – Commercial)	NSW EPA (1994) Contaminated Sites: Guidelines for Assessing Service Station Sites
Arsenic	500	-
Cadmium	100	-
Chromium	500	-
Copper	5,000	-
Lead	1,500	-
Mercury	75	-
Nickel	3,000	-
Zinc	35,000	-
PAHs (total)	100	-
PCBs (total)	50	-
Aldrin and Dieldrin	50	-
DDT	1,000	-
Heptachlor	50	-
TRH C6 – C9	-	65
TRH C10 – C40	-	1,000
Benzene	-	1
Toluene	-	1.4
Ethyl benzene	-	3.1
Total Xylenes	-	14

6 Stage 2 Assessment: Results

6.1 Site Contamination Observations

Fill material up to 2.0 m in depth, atypical of natural site soil (fill comprising sandy clay / ripped sandstone), was observed behind the retaining wall and underneath the asphalt pavement in the northern portion of the site. Fill material consisting of sands and silty sands (most likely derived from excavation of in-situ material for UST placement) was observed around the UST's. Fill material at all testing locations appeared to be free of deleterious material and no olfactory or visual signs of contamination were observed. The natural site soils underlying the fill in all testing locations appeared clean and showed no visual or olfactory signs of contamination.

Groundwater appeared to be clean; however results indicate there are a number of contaminant levels above guideline trigger values (see section 6.3).

6.2 Laboratory Analysis Results – Soil

The complete laboratory test reports are provided as Attachment C. Results are summarised for heavy metals (Table 10), PAHs (Table 12) and TRH (Table 13) with complete laboratory reports provided as Attachment C. The following sections provide a summary and brief discussion of the results.

6.2.1 Heavy Metals

All heavy metal test results are detailed in Table 10. All samples tested for heavy metals are below the SIL's for commercial / industrial landuses (excepting tin, which has no guideline limit). Almost all samples tested, however, have chromium, lead, mercury and nickel values in excess of waste classification levels for inert waste. TCLP testing was conducted on selected samples and waste classification is discussed in Section 6.4.

Testing for tin was conducted on all samples, with one sediment sample (B – surface, located in front of slipway) analysed for the various tin sub-species (Monobutyl, Dibutyl and Tributyl). Tributyltin (TBT) has been compared to the National Ocean Disposal Guidelines (NODG, 2002), in the absence of other relevant guidelines. Testing revealed TBT was above the NODG limit, however this is not considered significant as dredging and dumping of harbour sediments is not proposed for the site.

Table 10: Results of heavy metal analysis of soil samples (mg/kg).

Sample ID	As	Cd	Cr	Cu	Pb	Hg	Ni	Sn	Zn
1675/1/1.0	<4	<1	10	3.5	28	<0.1	<1	<1	4
1675/3/0.25	<4	<1	10	160	140	0.31	38	14	93
1675/7/1.5	14	<1	33	570	710	8.3	27	21	230
1675/10/0.25	<4	<1	25	61	120	0.72	28	20	77
1675/3/1.0	<4	<1	10	1.7	18	<0.1	<1	<1	1.1
1675/5/1.5	25	<1	18	680	580	7.3	21	49	520
1675/6/1.0	5.8	<1	9.5	110	390	2.6	5.3	15	190
1675/6/2.0	<4	<1	5	47	120	0.67	2	2.7	100
1675/7/3.0	<4	<1	8.5	83	130	1.8	5.2	12	120
1675/7/4.2	<4	<1	7.7	30	44	0.75	5.1	2.9	71
1675/8/1.5	6.4	<1	6.9	120	280	5.7	1.8	6.1	120
1675/8/2.0	6.7	<1	9	130	320	4.1	3	14	240
1675/8/3.0	<4	<1	6.3	68	120	2.4	1.7	5.3	150
1675/8/4.2	<4	<1	4.8	16	14	0.45	<1	1.3	100
A – surface	4.2	<1	6.7	12	25	<0.1	<1	26	1.9
B – surface	10	<1	19	350	120	1.8	3.9	180	28
C – surface	<4	<1	4.7	5.7	15	0.12	<1	16	1.7
D – surface	<4	<1	6.7	10	19	<0.1	1.1	21	1.4
A – 200mm	<4	<1	5.2	10	19	<0.1	<1	19	1.4
B – 200mm	5.1	<1	19	230	83	0.76	2.2	96	10
C – 200mm	<4	<1	4.7	6.8	17	0.15	<1	17	2
D – 200mm	<4	<1	6	10	19	<0.1	1	20	1.3
Guideline Limit¹	500	100	500	5000	1500	75	3000	-	35000
General Solid Waste²	100	20	100	Na³	100	4	40	Na³	Na³
Restricted Solid Waste²	400	80	400	Na³	400	16	160	Na³	Na³

Note: ¹ SIL guideline limit based on commercial / industrial landuse from NSW EPA, (2006). ² NSW DECC (2008) Waste Classification Guidelines: Table 1, Contaminant Threshold Values (CT1 and CT2) for classifying waste by chemical assessment without the leaching (TCLP). ³ No criteria listed.

Table 11: Results of tin sub-species analysis (µg/kg).

Sample ID	Monobutyltin	Dibutyltin	Tributyltin
B - surface	19	62	240
Screening Level¹	-	-	5
Maximum Level¹	-	-	70

Note: ¹ National Ocean Disposal Guidelines for Dredged Material (2002) in the absence of other relevant guidelines.

6.2.2 Polycyclic Aromatic Hydrocarbons (PAH)

Results (Table 12) show levels of PAH in 1 sample is slightly above guideline limits for benzo(a)pyrene. No samples are above the total PAH limit.

Table 12: Results of PAH analysis of soil samples.

Sample ID	Benzo(a)pyrene	Total PAHs
1675/1/1.0	0.9	7.9
1675/3/0.25	0.7	6.4
1675/7/1.5	2.7	28.1
1675/10/0.25	0.9	7.8
1675/3/1.0	<0.05	<2.0
1675/5/1.5	6.6	51.9
1675/6/1.0	1.0	8.8
1675/6/2.0	0.1	<2.0
1675/7/3.0	1.0	8.7
1675/7/4.2	0.08	<2.0
1675/8/1.5	0.3	3.4
1675/8/2.0	0.5	5.1
1675/8/3.0	0.2	<2.0
1675/8/4.2	0.05	<2.0
Guideline Limit¹	5	100
General Solid Waste²	0.8	Na³
Restricted Solid Waste²	3.2	Na³

Note: ¹ NSW EPA (2006) *Guidelines for the NSW Site Auditor Scheme*, guideline limits for commercial and industrial landuses (Column 4). ² As per Table 10. ³ No criteria listed.

6.2.3 BTEX (Benzene, Toluene, Ethyl Benzene and Xylene)

All BTEX results are below guideline limits and less than laboratory detection limits.

6.2.4 Polychlorinated Biphenyls (PCBs)

All PCB results are below guideline limits and less than laboratory detection limits.

6.2.5 OC/OP pesticides

All OC/OP results are below guideline limits and less than laboratory detection limits.

6.2.6 Total Recoverable Hydrocarbons (TRH)

There were a number of samples that recorded hydrocarbons; however all TRH results are below guideline limits.

Table 13: Results of TRH analysis of soil samples.

Sample ID	C6 –C9	C10 – C14	C15 – C28	C29 – C36	C10 – C36 TOTAL ¹
1675/1/1.0	<25	<50	<100	120	195
1675/3/0.25	<25	<50	<100	<100	-
1675/7/1.5	<25	<50	160	240	475
1675/10/0.25	<25	<50	<100	100	175
1675/3/1.0	<25	<50	<100	<100	-
1675/5/1.5	<25	<50	240	300	615
1675/6/1.0	<25	<50	<100	<100	-
1675/6/2.0	<25	<50	<100	<100	-
1675/7/3.0	<25	<50	<100	<100	-
1675/7/4.2	<25	<50	<100	<100	-
1675/8/1.5	<25	<50	<100	<100	-
1675/8/2.0	<25	<50	<100	<100	-
1675/8/3.0	<25	<50	<100	<100	-
1675/8/4.2	<25	<50	<100	<100	-
Guideline Limit ²	65		-		1000
General Solid Waste³	650		-		10,000
Restricted Solid Waste³	2600		-		40,000

Note: ¹ Includes allowance for detection limits for each parameter below PQL's. ² NSW EPA (1994) Guidelines for assessing service station sites. ³ NSW DECC (2008) Waste Classification Guidelines: Table 2 SCC values for classifying waste.

6.2.7 Summary

Contamination levels above Column 4 SILs for benzo(a)pyrene was observed in borehole 5. No other samples were found to have levels above column 4 SILs at the site.

TCLP testing was conducted on 3 samples to determine the mobility of chromium, nickel and lead contaminants in the samples located in the area proposed for the new UST's. The results of these tests are provided in Table 15, Section 6.4. Results show heavy metal contaminants are relatively immobile.

6.3 Laboratory Analysis Results – Groundwater

Groundwater analysis results provided in Table 14 indicate for groundwater well 2, concentrations of toluene, total xylene's, arsenic, copper, lead and zinc are all in excess of guideline trigger values for marine and fresh waters. Testing also revealed TRH (C6 to C9) in the groundwater well 2; however levels are not above the guideline trigger values. Groundwater well 1 had concentrations of copper and zinc above guideline trigger values.

It is concluded that the detected groundwater contamination is likely to be either:

1. The result of minor leaking from the UST's on the site or possibly from small spillages during re-fuelling of the tanks or;
2. The result of fuel spillages from boats / vehicles that use the marina access road. Pavements surrounding the groundwater wells are in a poor condition, and any spills on the surface can easily move into the underlying soil / groundwater. This said, no contamination was noted in the soil testing.

Discussions with the client reveal that there have been no significant discrepancies in the fuel inventory since the tanks were installed.

Table 14: Results of groundwater sampling.

Analyte	Units	Borehole Identity		Adopted Guideline Trigger Value
		GW1	GW2	
pH	pH units			n/a
Benzene	µg/L	<1	28	300 ¹ / 600 ²
Toluene	µg/L	2.4	530	300 ³ / 230 ⁵
Ethylbenzene	µg/L	<1	6	140 ³ / 110 ⁵
Total Xylenes	µg/L	<3	460	380 ¹ / 100 ²
TRH C ₆ – C ₉	µg/L	<10	700	10 000 ¹ total
TRH C ₁₀ – C ₁₄	µg/L	<50	<50	
TRH C ₁₅ – C ₂₈	µg/L	<100	<100	3.0 ¹
TRH C ₂₉ – C ₃₆	µg/L	<100	<100	
Total PAHs	µg/L	<2.0	<2.0	
Arsenic	µg/L	1.8	4.5	1.0 – 3.3 ⁴
Cadmium	µg/L	1	2	14.0 ²
Chromium	µg/L	1.6	<1	20.0 ⁴ Cr(VI)
Copper	µg/L	19	330	3.0 ²
Lead	µg/L	<1	22	6.6 ²
Mercury	µg/L	<0.5	0.5	0.7 ²
Nickel	µg/L	7.5	13	200.0 ²
Zinc	µg/L	170	460	23.0 ²

Note: ¹ NSW EPA (1994) *Guidelines for Assessing Service Station Sites* – Marine threshold values in Table 4. ² ANZECC / ARM CANZ (2000) Table 3.4.1 – 90th percentile protection. ³ NSW EPA (1994) *Guidelines for Assessing Service Station Sites* – Freshwater threshold – only value in Table 4. ⁴ ANZECC / ARM CANZ (2000) Table 8.3.2 marine – estuarine water. ⁵ ANZECC / ARM CANZ (2000) Section 8.3.7 marine trigger values.

6.4 Waste Classification

On the basis of completed analysis SCC and TCLP testing the contaminated fill underlying the site in the proposed UST area is classified as 'General Solid Waste' in accordance with NSW EPA (1999). The fill layer in this area ranges from 1.2 – 1.6 m below existing grade.

Table 15: Results of TCLP analysis.

Sample ID	TCLP (mg/L) – Leachable Concentration		
	Chromium	Lead	Nickel
1675/1/1.0	<0.01	<0.03	-
1675/3/0.25	<0.01	<0.03	0.06
1675/3/1.0	<0.01	<0.03	-
General Solid Waste¹	5/1900	5/1500	2/1050
Restricted Solid Waste¹	20/7600	20/6000	8/4200

¹ TCLP/SCC values from Table 2 of DECC (2008) Waste Classification Guidelines: Part 1, classifying waste.

Our testing has shown the natural soil underlying the fill is free of contamination. All soil underlying the fill material is considered virgin excavated natural material (VENM), and is to be managed accordingly.

Stage 2 Assessment - Conclusions

Site investigations (Stage 2 assessment) completed included the collection and analysis of soil samples for a range of parameters determined to assess potential contamination from past and existing uses. The investigation identified no contaminants above NSW DEC (2006) guideline levels for commercial and industrial land use. Following SCC and TCLP testing, the fill in the proposed excavation is classed as 'General Solid Waste' in accordance with EPA (1999) guidelines. The natural soil located below the fill is not contaminated and requires no specific measures for treatment or disposal. This material is considered to be VENM.

A Remediation Action Plan (RAP) is required for the site to address the removal of UST's identified as a likely source of groundwater hydrocarbon contamination. Considering the proposed development will require excavation of fill material, such material is considered 'Inert Waste' and is to be disposed of at an appropriate waste handling facility.

Stage 2 Assessment - Limitations Statement

The site contamination assessment undertaken and documented in this report has been undertaken in accordance with the current industry standard for Stage 1 and 2 contamination assessments (NSW EPA, 2006). Sampling design has been undertaken in accordance with NSW EPA (1995) sampling design guidelines.

However, it is noted that no site sampling strategy can be considered to be a complete and exhaustive characterisation of a site, nor can it be guaranteed that any assessment shall identify and characterise all areas of contamination. This is particularly the case where filling has occurred on the site. Therefore, this report should not be read as a guarantee that no contamination shall be found on the site. Should material be exposed during site works which was not encountered during the investigations undertaken, the newly discovered material should be specifically assessed by Martens & Associates to determine contamination implications.

Martens & Associates Pty Ltd has undertaken this assessment for the purpose of evaluating existing site contamination. No reliance on this report should be made for any other investigation or proposal. Martens & Associates accepts no responsibility, and provides no guarantee regarding the characteristics of areas of the site not specifically sampled in this investigation.

- Australian Geomechanics Society, Sub-Committee on Landslide Risk Management (2007) *Australian Geomechanics* 42 (1), p 13 – 113
- Australian Standard 1289.6.3.2 (1997) *Determination of the Penetration Resistance of a Soil using the 9 kg Dynamic Cone Penetrometer*.
- Australian Standard 1726 (1993) *Geotechnical Site Investigations*.
- Australian Standard 2870 (1996) *Residential Slabs and Footings*.
- Environment Australia (2002) *National Ocean Disposal Guidelines for Dredged Material*.
- Geological Survey of NSW (1983), *Geological Series - Sydney 1:100,000 Sheet 9130*.
- NSW Acid Sulfate Soil Management Advisory Committee (1998) *Acid Sulfate Soil Manual*.
- NSW EPA (1994) *Contaminated Sites: Guidelines for Assessing Service Station Sites*.
- NSW EPA (1995) *Contaminated Sites: Sampling Design Guidelines*.
- NSW EPA (1998) *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites*.
- NSW EPA (2006) 2nd Ed. *Contaminated Sites: Guidelines for the NSW Site Auditor Scheme*.
- NSW DECC (2008) *Waste Classification Guidelines; Part 1: Classifying Waste*.

10 Attachment A – Site Plan

11 **Attachment B – Soil Borehole Logs**

CLIENT		D'ALBORA MARINAS				COMMENCED		13/12/07		COMPLETED		13/12/07		REF		BH1	
PROJECT		STAGE 2 & GEOTECH ASSESSMENT				LOGGED		JF		CHECKED		AN		Sheet 1 of 1			
SITE		THE SPIT MARINA				GEOLOGY		SAND		VEGETATION		NONE		PROJECT NO. P0701675			
EQUIPMENT				4WD Mounted Auger				EASTING		NA		RL SURFACE		1.5 m AHD			
EXCAVATION DIMENSIONS				95mm x 4500mm				NORTHING		NA		ASPECT		W		SLOPE <1°	
EXCAVATION DATA						MATERIAL DATA						SAMPLING & TESTING					
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.		CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS			
A	Nil	N		0.1			-	ASPHALT									
A	Nil	N	D	0.4			GP	BLUE METAL GRAVEL FILL			D	A	0.25	1675/1/0.25			
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES		F		A	1.0	1675/1/1.0			
				1.6								B	0.5	1675/1/0.5			
												A	0.5	1675/1/0.5			
A	Nil	Y	W	2.0			SM	SILTY SAND- BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED			MD						
				2.5								A	2.5	1675/1/2.5			
												B	2.5	1675/1/2.5			
A	Nil	Y	W	3.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED			MD						
				4.0								B	4.0	1675/1/4.0			
								BH TERMINATED @ 4.5m				A	4.5	1675/1/4.5			
EQUIPMENT / METHOD		SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING						CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION			
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	Y USCS N Agricultural	
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test		
BH	Backhoe bucket	RB	Rock Bolts	W	Water level	W	Wet	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear		
E	Excavator	Nil	No support	Wp	Plastic limit	St	Stiff	D	Dense	D	Dense	D	Disturbed sample	DCP	Dynamic cone		
HA	Hand auger			WI	Liquid limit	VS	Very Stiff	H	Hard	VD	Very Dense	M	Moisture content	penetrometer			
S	Hand spade					H	Hard					FD	Field density				
PT	Push tube					F	Friable	Ux	Tube sample (x mm)			WS	Water sample				
A	Auger																
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																	
 MARTENS & ASSOCIATES PTY LTD 6/37 Leighton Place Hornsby, NSW 2077 Australia Phone: (02) 9476 8777 Fax: (02) 9476 8767 mail@martens.com.au WEB: http://www.martens.com.au Engineering Log - Borehole																	

CLIENT	D'ALBORA MARINAS				COMMENCED	13/12/07		COMPLETED	13/12/07		REF BH2																								
PROJECT	STAGE 2 & GEOTECH ASSESSMENT				LOGGED	JF		CHECKED	AN		Sheet 1 of 2																								
SITE	THE SPIT MARINA				GEOLOGY	SAND		VEGETATION	NONE		PROJECT NO. P0701675																								
EQUIPMENT		4WD Mounted Auger			EASTING	NA		RL SURFACE	1.5 m AHD																										
EXCAVATION DIMENSIONS		95mm x 9000mm			NORTHING	NA		ASPECT	W		SLOPE	<1°																							
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING																									
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS																						
A	Nil	N	M	0.1			-	ASPHALT																											
A	Nil	N	D	0.4			GP	BLUE METAL GRAVEL FILL		D	A	0.25	1675/2/0.25																						
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES	F		A	0.5	1675/2/0.5																						
				1.6							A	1.0	1675/2/1.0																						
											B	1.5	1675/2/1.5																						
A	Nil	Y	W	2.0			SM	SILTY SAND- BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED		MD	A	2.0	1675/2/2.0																						
				2.5							B	2.5	1675/2/2.5																						
A	Nil	Y	W	3.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED		MD	A	3.0	1675/2/3.0																						
				4.0							B	4.0	1675/2/4.0																						
				4.4							A	4.2	1675/2/4.2																						
EQUIPMENT / METHOD N Natural exposure X Existing excavation BH Backhoe bucket E Excavator HA Hand auger S Hand spade PT Push tube A Auger														SUPPORT SH Shoring SC Shotcrete RB Rock Bolts Nil No support		WATER N None observed X Not measured Water level Water outflow Water inflow		MOISTURE D Dry M Moist W Wet Wp Plastic limit WL Liquid limit		PENETRATION L Low M Moderate H High R Refusal		CONSISTENCY VS Very Soft S Soft F Firm St Stiff VSt Very Stiff H Hard F Friable		DENSITY VL Very Loose L Loose MD Medium Dense D Dense VD Very Dense		SAMPLING & TESTING A Auger sample B Bulk sample U Undisturbed sample D Disturbed sample M Moisture content Ux Tube sample (x mm)		pp Pocket penetrometer S Standard penetration test VS Vane shear DCP Dynamic cone penetrometer FD Field density WS Water sample		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Y USCS N Agricultural					
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																																			
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CLIENT	D'ALBORA MARINAS		COMMENCED	13/12/07	COMPLETED	13/12/07	REF BH2																								
PROJECT	STAGE 2 & GEOTECH ASSESSMENT		LOGGED	JF	CHECKED	AN	Sheet 2 of 2																								
SITE	THE SPIT MARINA		GEOLOGY	SAND	VEGETATION	NONE	PROJECT NO. P0701675																								
EQUIPMENT		4WD Mounted Auger		EASTING	NA	RL SURFACE	1.5 m AHD																								
EXCAVATION DIMENSIONS		95mm x 9000mm		NORTHING	NA	ASPECT	W	SLOPE <1°																							
EXCAVATION DATA				MATERIAL DATA				SAMPLING & TESTING																							
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS																		
A	NIL	Y	W				SP	SAND - LIGHT GREY, MEDIUM DENSE WET, MEDIUM TO COARSE GRAINED	MD																						
				5.0							B	5.0	1675/2/5.0																		
				6.0																											
				7.0							A	6.5	1675/2/5.0																		
				8.0							B	7.5	1675/2/7.5																		
				9.0																											
BH TERMINATED @ 9.0m ON SAND																															
EQUIPMENT / METHOD N Natural exposure X Existing excavation BH Backhoe bucket E Excavator HA Hand auger S Hand spade PT Push tube A Auger														SUPPORT SH Shoring SC Shotcrete RB Rock Bolts Nil No support		WATER N None observed X Not measured Water level Water outflow Water inflow		MOISTURE D Dry M Moist W Wet Wp Plastic limit WL Liquid limit		PENETRATION L Low M Moderate H High R Refusal		CONSISTENCY VS Very Soft S Soft F Firm St Stiff VSt Very Stiff H Hard F Friable		DENSITY VL Very Loose L Loose MD Medium Dense D Dense VD Very Dense		SAMPLING & TESTING A Auger sample B Bulk sample U Undisturbed sample D Disturbed sample M Moisture content Ux Tube sample (x mm)		pp Pocket penetrometer S Standard penetration test VS Vane shear DCP Dynamic cone penetrometer FD Field density WS Water sample		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Y USCS N Agricultural	
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																															
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CLIENT	D'ALBORA MARINAS				COMMENCED	13/12/07		COMPLETED	13/12/07		REF BH3																								
PROJECT	STAGE 2 & GEOTECH ASSESSMENT				LOGGED	JF		CHECKED	AN		Sheet 1 of 1																								
SITE	THE SPIT MARINA				GEOLOGY	SAND		VEGETATION	NONE		PROJECT NO. P0701675																								
EQUIPMENT		4WD Mounted Auger				EASTING	NA		RL SURFACE	1.5 m AHD																									
EXCAVATION DIMENSIONS		95mm x 4400mm				NORTHING	NA		ASPECT	W		SLOPE <1°																							
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING																									
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS																						
A	Nil	N	M	0.1			-	CONCRETE																											
A	Nil	N	D				GP	BLUE METAL GRAVEL FILL & SAND		D	A	0.25	1675/3/0.25																						
				0.6							A	0.5	1675/3/0.5																						
A	Nil	N	M				EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES	F		A	1.0	1675/3/1.0																						
				1.6							A	1.5	1675/3/1.5																						
A	Nil	Y	W				SM	SILTY SAND- BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED		MD	A	2.0	1675/3/2.0																						
				2.8																															
				3.0							A	3.0	1675/3/3.0																						
											B	3.0	1675/3/3.0																						
A	Nil	Y	W				SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED		MD																									
				4.0																															
				4.4							A	4.2	1675/3/4.2																						
								BH TERMINATED @ 4.4m ON SAND																											
EQUIPMENT / METHOD N Natural exposure X Existing excavation BH Backhoe bucket E Excavator HA Hand auger S Hand spade PT Push tube A Auger														SUPPORT SH Shoring SC Shotcrete RB Rock Bolts Nil No support		WATER N None observed X Not measured Water level Water outflow Water inflow		MOISTURE D Dry M Moist W Wet Wp Plastic limit WI Liquid limit		PENETRATION L Low M Moderate H High R Refusal		CONSISTENCY VS Very Soft S Soft F Firm St Stiff VSt Very Stiff H Hard F Friable		DENSITY VL Very Loose L Loose MD Medium Dense D Dense VD Very Dense		SAMPLING & TESTING A Auger sample B Bulk sample U Undisturbed sample D Disturbed sample M Moisture content Ux Tube sample (x mm)		pp Pocket penetrometer S Standard penetration test VS Vane shear DCP Dynamic cone penetrometer FD Field density WS Water sample		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Y USCS N Agricultural					
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																																			
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CLIENT		D'ALBORA MARINAS				COMMENCED		13/12/07		COMPLETED		13/12/07		REF		BH4			
PROJECT		STAGE 2 & GEOTECH ASSESSMENT				LOGGED		JF		CHECKED		AN		Sheet 1 of 1					
SITE		THE SPIT MARINA				GEOLOGY		SAND		VEGETATION		NONE		PROJECT NO. P0701675					
EQUIPMENT				4WD Mounted Auger				EASTING		NA		RL SURFACE		1.5 m AHD					
EXCAVATION DIMENSIONS				95mm x 4500mm				NORTHING		NA		ASPECT		W		SLOPE		<1°	
EXCAVATION DATA						MATERIAL DATA						SAMPLING & TESTING							
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.				CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS			
A	Nil	N	M	0.1			-	ASPHALT											
A	Nil	N	D	0.4			GP	BLUE METAL GRAVEL FILL											
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES				F		A B	0.5 0.5	1675/4/0.5 1675/4/0.5			
				1.6															
A	Nil	Y	W	2.0			SM	SILTY SAND - BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED					MD	A	2.0	1675/4/2.0			
				2.5															
A	Nil	Y	W	3.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED					MD	B	3.0	1675/4/3.0			
				4.0															
				4.5				BH TERMINATED @ 4.5m ON SAND											
EQUIPMENT / METHOD		SUPPORT	WATER	MOISTURE	PENETRATION	CONSISTENCY	DENSITY	SAMPLING & TESTING				CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION							
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	L	Low	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer	Y	USCS
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	M	Moderate	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test	N	Agricultural
BH	Backhoe bucket	RB	Rock Bolts		Water level	W	Wet	H	High	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear		
E	Excavator	Nil	No support		Water outflow	Wp	Plastic limit	R	Refusal	St	Stiff	D	Dense	D	Disturbed sample	DCP	Dynamic cone penetrometer		
HA	Hand auger				Water inflow	WI	Liquid limit			VSt	Very Stiff	VD	Very Dense	M	Moisture content	FD	Field density		
S	Hand spade									H	Hard			Ux	Tube sample (x mm)	WS	Water sample		
PT	Push tube									F	Friable								
A	Auger																		
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																			
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CLIENT	D'ALBORA MARINAS				COMMENCED	13/12/07		COMPLETED	13/12/07		REF BH5																																																																																																																																
PROJECT	STAGE 2 & GEOTECH ASSESSMENT				LOGGED	JF		CHECKED	AN		Sheet 1 of 1																																																																																																																																
SITE	THE SPIT MARINA				GEOLOGY	SAND		VEGETATION	NONE		PROJECT NO. P0701675																																																																																																																																
EQUIPMENT		4WD Mounted Auger			EASTING	NA		RL SURFACE	1.5 m AHD																																																																																																																																		
EXCAVATION DIMENSIONS		95mm x 4500mm			NORTHING	NA		ASPECT	W		SLOPE	<1°																																																																																																																															
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING																																																																																																																																	
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS																																																																																																																														
A	Nil	N	M	0.15				CONCRETE SLAB																																																																																																																																			
A	Nil	N	D	0.4			GP	BLUE METAL GRAVEL & SAND FILL		D	A	0.25	1675/5/0.25																																																																																																																														
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES	F		A	0.5	1675/5/0.5																																																																																																																														
				1.5							A	1.0	1675/5/1.0																																																																																																																														
				1.5							A	1.5	1675/5/1.5																																																																																																																														
A	Nil	Y	W	2.0			SM	SAND- BROWN WET, MEDIUM GRAIN, MEDIUM DENSE		MD	A	2.0	1675/5/2.0																																																																																																																														
				2.4																																																																																																																																							
				3.0							A	3.0	1675/5/3.0																																																																																																																														
				3.0							B	3.0	1675/5/3.0																																																																																																																														
A	Nil	Y	W	4.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED		MD																																																																																																																																	
				4.0							B	4.0	1675/5/4.0																																																																																																																														
				4.5																																																																																																																																							
				4.5				BH TERMINATED @ 4.5m ON SAND			A	4.5	1675/5/4.5																																																																																																																														
EQUIPMENT / METHOD N Natural exposure X Existing excavation BH Backhoe bucket E Excavator HA Hand auger S Hand spade PT Push tube A Auger														SUPPORT SH Shoring SC Shotcrete RB Rock Bolts Nil No support														WATER N None observed X Not measured Water level Water outflow Water inflow														MOISTURE D Dry M Moist W Wet Wp Plastic limit WL Liquid limit														PENETRATION L Low M Moderate H High R Refusal														CONSISTENCY VS Very Soft S Soft F Firm St Stiff VSt Very Stiff H Hard F Friable														DENSITY VL Very Loose L Loose MD Medium Dense D Dense VD Very Dense														SAMPLING & TESTING A Auger sample B Bulk sample U Undisturbed sample D Disturbed sample M Moisture content Ux Tube sample (x mm)														pp Pocket penetrometer S Standard penetration test VS Vane shear DCP Dynamic cone penetrometer FD Field density WS Water sample														CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Y USCS N Agricultural													
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																																																																																																																																											
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CLIENT	D'ALBORA MARINAS				COMMENCED	13/12/07		COMPLETED	13/12/07		REF BH6																								
PROJECT	STAGE 2 & GEOTECH ASSESSMENT				LOGGED	JF		CHECKED	AN		Sheet 1 of 1																								
SITE	THE SPIT MARINA				GEOLOGY	SAND		VEGETATION	NONE		PROJECT NO. P0701675																								
EQUIPMENT		4WD Mounted Auger			EASTING	NA		RL SURFACE	1.5 m AHD																										
EXCAVATION DIMENSIONS		95mm x 4300mm			NORTHING	NA		ASPECT	W		SLOPE	<1°																							
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING																									
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS																						
A	Nil	N	M	0.1			-	CONCRETE																											
A	Nil	N	D	0.4			GP	BLUE METAL GRAVEL & SAND FILL		D	A	0.25	1675/6/0.25																						
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES	F		A	0.5	1675/6/0.5																						
				1.3																															
A	Nil	Y	W	2.0			SM	SILTY SAND - BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED		MD	A	1.5	1675/6/1.0																						
				2.4																															
A	Nil	Y	W	3.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED		MD	A	3.0	1675/6/1.0																						
				4.0																															
				4.3							A	4.2	1675/6/4.2																						
								BH TERMINATED @ 4.3m ON SAND																											
EQUIPMENT / METHOD N Natural exposure X Existing excavation BH Backhoe bucket E Excavator HA Hand auger S Hand spade PT Push tube A Auger														SUPPORT SH Shoring SC Shotcrete RB Rock Bolts Nil No support		WATER N None observed X Not measured Water level Water outflow Water inflow		MOISTURE D Dry M Moist W Wet Wp Plastic limit WL Liquid limit		PENETRATION L Low M Moderate H High R Refusal		CONSISTENCY VS Very Soft S Soft F Firm St Stiff VSt Very Stiff H Hard F Friable		DENSITY VL Very Loose L Loose MD Medium Dense D Dense VD Very Dense		SAMPLING & TESTING A Auger sample B Bulk sample U Undisturbed sample D Disturbed sample M Moisture content Ux Tube sample (x mm)		pp Pocket penetrometer S Standard penetration test VS Vane shear DCP Dynamic cone penetrometer FD Field density WS Water sample		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Y USCS N Agricultural					
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																																			
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CLIENT	D'ALBORA MARINAS				COMMENCED	13/12/07		COMPLETED	13/12/07		REF BH7																				
PROJECT	STAGE 2 & GEOTECH ASSESSMENT				LOGGED	JF		CHECKED	AN		Sheet 1 of 1																				
SITE	THE SPIT MARINA				GEOLOGY	SAND		VEGETATION	NONE		PROJECT NO. P0701675																				
EQUIPMENT		4WD Mounted Auger			EASTING	NA		RL SURFACE	1.5 m AHD																						
EXCAVATION DIMENSIONS		95mm x 4400mm			NORTHING	NA		ASPECT	W		SLOPE	<1°																			
EXCAVATION DATA					MATERIAL DATA					SAMPLING & TESTING																					
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS																		
A	Nil	N	M	0.1			-	CONCRETE																							
A	Nil	N	D	0.4			GP	BLUE METAL GRAVEL & SAND FILL		D	A	0.25	1675/7/0.25																		
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES	F		A	0.5	1675/7/0.5																		
				1.2							A	1.0	1675/7/1.0																		
A	Nil	Y	W	2.0			SM	SILTY SAND - BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED		MD	A	1.5	1675/7/1.5																		
				2.2							A	2.0	1675/7/2.0																		
A	Nil	Y	W	3.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED		MD	A	3.0	1675/7/3.0																		
				4.0							B	3.5	1675/7/3.5																		
				4.2							A	4.2	1675/7/4.2																		
BH TERMINATED @ 4.4m ON SAND																															
EQUIPMENT / METHOD N Natural exposure X Existing excavation BH Backhoe bucket E Excavator HA Hand auger S Hand spade PT Push tube A Auger														SUPPORT SH Shoring SC Shotcrete RB Rock Bolts Nil No support		WATER N None observed X Not measured Water level Water outflow Water inflow		MOISTURE D Dry M Moist W Wet Wp Plastic limit Wi Liquid limit		PENETRATION L Low M Moderate H High R Refusal		CONSISTENCY VS Very Soft S Soft F Firm St Stiff VSt Very Stiff H Hard F Friable		DENSITY VL Very Loose L Loose MD Medium Dense D Dense VD Very Dense		SAMPLING & TESTING A Auger sample B Bulk sample U Undisturbed sample D Disturbed sample M Moisture content Ux Tube sample (x mm)		pp Pocket penetrometer S Standard penetration test VS Vane shear DCP Dynamic cone penetrometer FD Field density WS Water sample		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION Y USCS N Agricultural	
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																															
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CLIENT		D'ALBORA MARINAS				COMMENCED		13/12/07		COMPLETED		13/12/07		REF		BH8			
PROJECT		STAGE 2 & GEOTECH ASSESSMENT				LOGGED		JF		CHECKED		AN		Sheet 1 of 1					
SITE		THE SPIT MARINA				GEOLOGY		SAND		VEGETATION		NONE		PROJECT NO. P0701675					
EQUIPMENT				4WD Mounted Auger				EASTING		NA		RL SURFACE		1.5 m AHD					
EXCAVATION DIMENSIONS				95mm x 4300mm				NORTHING		NA		ASPECT		W		SLOPE		<1°	
EXCAVATION DATA						MATERIAL DATA						SAMPLING & TESTING							
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.		CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS					
A	Nil	N	M				-	CONCRETE											
A	Nil	N	D				GP	BLUE METAL GRAVEL & SAND FILL			D	A	0.25	1675/8/0.25					
A	Nil	N	M				EW	RIPPED SANDSTONE (SANDY CLAY) FILL - GREY & ORANGE MOTTLES		F		A	0.5	1675/8/0.5					
				1.0								A	1.0	1675/8/1.0					
A	Nil	Y	W				SM	SILTY SAND - BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED			MD	A	1.5	1675/8/1.5					
				2.0								A	2.0	1675/8/2.0					
A	Nil	Y	W				SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED			MD	A	3.0	1675/8/3.0 PID READING - 25 PPM					
				4.0								B	3.5	1675/8/3.5					
				4.3				BH TERMINATED @ 4.3m ON SAND				A	4.2	1675/8/4.2					
EQUIPMENT / METHOD		SUPPORT		WATER		MOISTURE		PENETRATION		CONSISTENCY		DENSITY		SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION			
N	Natural exposure	SH	Shoring	N	None observed	D	Dry	L	Low	VS	Very Soft	VL	Very Loose	A	Auger sample	pp	Pocket penetrometer		
X	Existing excavation	SC	Shotcrete	X	Not measured	M	Moist	M	Moderate	S	Soft	L	Loose	B	Bulk sample	S	Standard penetration test		
BH	Backhoe bucket	RB	Rock Bolts	▽	Water level	W	Wet	H	High	F	Firm	MD	Medium Dense	U	Undisturbed sample	VS	Vane shear		
E	Excavator	Nil	No support	△	Water outflow	Wp	Plastic limit	R	Refusal	St	Stiff	D	Dense	D	Disturbed sample	DCP	Dynamic cone		
HA	Hand auger			▽	Water inflow	WI	Liquid limit			VSt	Very Stiff	VD	Very Dense	M	Moisture content		penetrometer		
S	Hand spade									H	Hard			Ux	Tube sample (x mm)	FD	Field density		
PT	Push tube									F	Friable					WS	Water sample		
A	Auger																		
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																			
 Quality Sheet No. 4 MARTENS & ASSOCIATES PTY LTD 6/37 Leighton Place Hornsby, NSW 2077 Australia Phone: (02) 9476 8777 Fax: (02) 9476 8767 mail@martens.com.au WEB: http://www.martens.com.au Engineering Log - Borehole																			

CLIENT	D'ALBORA MARINAS			COMMENCED	13/12/07	COMPLETED	13/12/07	REF BH9											
PROJECT	STAGE 2 & GEOTECH ASSESSMENT			LOGGED	JF	CHECKED	AN	Sheet 1 of 3											
SITE	THE SPIT MARINA			GEOLOGY	SAND	VEGETATION	NONE	PROJECT NO. P0701675											
EQUIPMENT		4WD Mounted Auger			EASTING	NA	RL SURFACE	1.5 m AHD											
EXCAVATION DIMENSIONS		95mm x 10500mm			NORTHING	NA	ASPECT	W	SLOPE <1°										
EXCAVATION DATA				MATERIAL DATA				SAMPLING & TESTING											
METHOD	SUPPORT	WATER	MOISTURE	DEPTH (M)	PENETRATION RESISTANCE	GRAPHIC LOG	CLASSIFICATION	DESCRIPTION OF STRATA Soil type, texture, structure, mottling, colour, plasticity, rocks, oxidation, particle characteristics, organics, secondary and minor components, fill, contamination, odour.	CONSISTENCY	DENSITY INDEX	TYPE	DEPTH (M)	RESULTS AND ADDITIONAL OBSERVATIONS						
A	Nil	N	M				-	CONCRETE											
A	Nil	N	D				GP	BLUE METAL GRAVEL FILL & SAND		D	A	0.25	1675/9/0.25						
A	Nil	N	M	1.0			EW	RIPPED SANDSTONE (SAND CLAY) FILL - ORANGE WITH GREY MOTTLES	F		A	1.0	1675/9/1.0						
A	Nil	Y	W	2.0			SM	SILTY SAND- BROWN, WET, MEDIUM DENSE, MEDIUM GRAINED		MD	A	2.0	1675/9/2.0						
A	Nil	Y	W	3.0			SP	SAND - LIGHT BROWN, WET, MEDIUM DENSE, MEDIUM-COARSE GRAINED		MD	A	3.0	1675/9/3.0						
A	Nil	Y	W	4.0							A	4.3	1675/9/4.3						
EQUIPMENT / METHOD				SUPPORT		WATER		MOISTURE		PENETRATION		CONSISTENCY		DENSITY		SAMPLING & TESTING		CLASSIFICATION SYMBOLS AND SOIL DESCRIPTION	
N Natural exposure				SH Shoring		N None observed		D Dry		L Low		VS Very Soft		VL Very Loose		A Auger sample		pp Pocket penetrometer	
X Existing excavation				SC Shotcrete		X Not measured		M Moist		M Moderate		S Soft		L Loose		B Bulk sample		S Standard penetration test	
BH Backhoe bucket				RB Rock Bolts		Water level		W Wet		H High		F Firm		MD Medium Dense		U Undisturbed sample		VS Vane shear	
E Excavator				Nil No support		Water outflow		Wp Plastic limit		R Refusal		St Stiff		D Dense		D Disturbed sample		DCP Dynamic cone penetrometer	
HA Hand auger						Water inflow		Wi Liquid limit				VSt Very Stiff		VD Very Dense		M Moisture content		FD Field density	
S Hand spade												H Hard				Ux Tube sample (x mm)		WS Water sample	
PT Push tube												F Friable							
A Auger																			
EXCAVATION LOG TO BE READ IN CONJUNCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS																			
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