Cronulla Sharks Redevelopment

Stormwater and Services Report - Concept Application

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1 INTRODUCTION

AT&L (ATL) has been engaged by Bluestone Capital Ventures No 1 Pty Limited (BCV) to address the servicing and stormwater management strategy for the proposed redevelopment of the existing Cronulla Sharks club, surrounding fields and carpark areas.

This report has been prepared in response to the Director General Requirements MP 10_0229 and sets out to address the following clauses of those DGR's;

Clause 11. Flooding, Drainage and Stormwater

- *The EA shall address drainage, groundwater and flooding issues associated with the proposed development including pipe stormwater, overland flows, drainage infrastructure and incorporation or Water Sensitive Urban Design measures.*
- *The EA shall address measures proposed to be undertaken to ensure that the disposal of stormwater to Woolooware Bay maintains/enhances the existing hydrology and water quality at the land/wetland interface.*

Clause 12. Sea Level Rise

- *Provide and assessment of sea rise (separate from flood impacts) on site in consideration of any relevant provisions of the State Governments Sea Level Rise policy and planning guidelines and address measures to reduce impacts of sea rise on the development.*

Clause 17. Utilities

- *In consultation with relevant agencies, the EA shall address the existing capacity and requirements of the development for the provision of Utilities, including staging of infrastructure.*

The Cronulla Sutherland Leagues Club site is legally described as Lot 11 DP 526492 and Lot 20 DP 529644 and is known as 461 Captain Cook Drive, Woolooware. Three lots owned by Sutherland Shire Council (being Lot 21 DP 529644, Lot 1 DP 711486 and Lot 1 DP 501920) are also included within the proposed scheme.

The site is located on the northern side of Captain Cook Drive approximately 1.5 kilometres from Caringbah (to the south west) and 2 kilometres from Cronulla (to the south east). The site is bounded by the Solander playing fields to the west, Woolooware Bay to the north, and a service station and gymnasium to the east. The Woolooware Golf Club and the Captain Cook Oval are located to the south of the site across Captain Cook Drive.

The overall site is irregular in shape with an area of approximately 10 hectares, of which approximately 6ha is occupied by Toyota Stadium, Leagues Club building and the eastern carpark and 4ha is occupied by the western training fields and car park.

Toyota Stadium (also known as Endeavour Field and Shark Park) and the Cronulla Sutherland Leagues Club building occupy the central portion of the site, and represent a major community and entertainment hub within the region. The western playing fields within the site are private open space used as training fields for the Cronulla Sharks and for local games by the Cronulla Caringbah Junior Rugby League Football Club, whilst the remainder of the site is occupied by car parking.

The Taren Point Employment Area is located approximately 200 metres to the northwest of the site and occupies land located generally between the waterfront, Taren Point Road and the Captain Cook Bridge. Woolooware Railway Station is located 1 kilometre to the south west of the site, and Caringbah Town Centre is approximately 3 kilometres by road to the south west.

This report outlines the stormwater management principles that would be adopted in formation of a sustainable stormwater management strategy for the proposed development. The stormwater management strategy has been developed with respect to water sensitive urban design, runoff quantity and quality control and potable water use reduction.

Advice is provided on the aforementioned issues where they relate to the specific constraints and opportunities associated with the site. This report places particular emphasis on the implementation of a water sensitive urban design (WSUD) approach in order to contribute to the long term sustainability of the site and its surrounding environment and ultimately the Sutherland Shire community.

Details regarding the existing servicing infrastructure in the vicinity have been investigated in order to ascertain whether capacity exists to sustain the proposed development. Where capacity is not available, advice is provided regarding necessary augmentation.

2 SUMMARY

2.1 STORMWATER MANAGEMENT STRATEGY

The proposed Stormwater Management Strategy has been designed to meet the following objectives by implementing the principles of Water Sensitive Urban Design (WSUD) and Ecologically Sustainable Development (ESD):

- Minimise Potable Water Demand
- Minimise Impacts on Water Quantity
- Minimise Impacts on Water Quality

2.1.1 Minimising Potable Water Demand

It is expected that reduction in potable water demand can be achieved through implementation of some or all of the following measures:

- Rainwater re-use tanks;
- Flow restrictors in the kitchen and toilet facilities;
- Dual flush toilets; and
- AAA rated shower heads and dishwashers.

2.1.2 Minimising Impacts on Water Quantity

Flooding

The proposed development will alter the existing surface levels across the site which will impact on the overland flows and flood storage. Mitigation of these impacts will potentially be achieved through the following measures:

- Provision of the an overland flow path adjacent the top of bank extents of the existing tidal channel discharging to Woolooware Bay;
- Enlargement of the culvert underneath Captain Cook Drive.

Implementation of the above measures would ensure that the development does not adversely affect the current flooding conditions.

For further details refer to Appendix A – Concept Flooding and Stormwater Quality Assessment.

Detention

The purpose of On Site Detention (OSD) systems is to detain storms and reduce peak discharge rates, however volumetric runoff remains unchanged. OSD is usually beneficial in the upper and middle parts of a catchment. However, OSD is ineffective in the downstream parts of the catchment and can even increase the peak discharge because of the coincidence of peaks of the catchment hydrograph and the outlet hydrograph from the OSD. Therefore, OSD is not recommended for this development on the basis that there is no significant benefit and increased risk of the peak discharge value coinciding.

Volumetric Runoff Coefficient

Stormwater management practices proposed to reduce the increase in runoff volume include:

- Installation of rainwater re-use tanks;
- Installation of lined bio-retention swales; and
- Maximisation of pervious area within the development.

Implementation of the abovementioned retention measures would reduce the volume of runoff from the site.

2.1.3 Minimising Impacts on Water Quality

Runoff water quality is to be managed through a combination of treatment measures, with special emphasis on source control. The proposed stormwater treatment measures include rainwater tanks, lined bio-retention swales and gross pollutant traps.

The implementation of the various treatment measures would satisfy the water quality objectives set for the site thereby making a substantial contribution to the long-term improvement of receiving water quality.

The water quality management strategy will also aim to minimise infiltration into the landfill areas of the site, thus reducing the likelihood of leachate export.

There is opportunity to capture gross pollutants currently generated by the golf course prior to discharging under Captain Cook Drive via the existing culvert system. Implementation of a trash rack upstream of the culvert will capture gross pollutants prior to discharging into the tidal channel.

For further details refer to Appendix A – Concept Flooding and Stormwater Quality Assessment.

2.2 STORMWATER DRAINAGE CONCEPT PLAN

A major/minor drainage philosophy has been adopted for managing runoff on the site. The majority of flows generated as runoff are proposed to be directed to either rainwater tanks or lined bio- retention swales and then discharged via GPTs to the tidal channel. These will maximise pollutant removal and minimise the runoff volumes.

All piped drainage infrastructure would be designed to convey the 10yr ARI flows generated on site. Flows in excess of the 10yr ARI (up to the 100yr ARI) event would be conveyed within the internal roadways and swales.

2.3 SERVICING STRATEGY

Initial discussion with various service authorities have determined that the development can be serviced through provision of adequate planning and future negotiations.

3 EXISTING SITE CONDITIONS

The site is located between Woolooware Bay and the Woolooware Golf Course. The site was reclaimed some 30 years ago by landfill of building and domestic refuse.

The site can be divided into four main hydrological parts:

- The Toyota Stadium, playing field which drains to the tidal channel;
- The club's building which drains towards Captain Cook Drive's drainage system, which eventually discharges to the tidal channel;
- The carpark adjacent to the club's building. Approximately one third of the bitumen covered carpark area drains towards Captain Cook Drive, one third discharges to Woolooware Bay as a diffuse outflow through grassed buffer located to the east of the site and one third drains through a 150 mm diameter pipe directly to the Bay as concentrated flow; and
- The playing fields to the west of the tidal channel, including the car park. Most of the carpark drains towards Captain Cook Drive, where the runoff is intercepted by a series of pits and pipes and disposed to the West Lane between playing fields and the Solander Playing Fields. The Lane drains to Woolooware Bay via a stormwater drainage system. Most of the playing fields drain towards Woolooware Bay, with some area draining to the tidal channel.

The total site area east of the tidal channel is approximately 5.8Ha, the site area west of the tidal channel is approximately 4.1Ha, while the catchment area upstream of the tidal channel is some 253Ha.

4 PROPOSED DEVELOPMENT

The proposed mixed use redevelopment of the Cronulla Sutherland Leagues Club site including a new neighbourhood retail centre, residential development and upgrades to the sports facilities, including the Toyota Stadium, will create a long term sustainable and viable solution for the Club as well as create a new centre and destination location that meets the needs of the surrounding community. The Concept Plan prepared for the site is seeking to develop the site in three stages, being:

Stage 1 – New Neighbourhood Retail Centre, Medical and Leisure facilities on the eastern car park site and redevelopment of the Leagues Club facilities;

Stage 2 - Residential Masterplanned Estate on the western car park and field area; and

Stage 3 - Extension and improvement of the Sharks playing field facilities including grandstand extensions.

Should the Concept Plan be approved, future project or development applications will be lodged for the assessment of the detailed design of the various components of the Concept Plan and will be released progressively over a number of stages.

It is recognised that this site represents an ideal opportunity to provide an environmental benchmark for residential and retail development within NSW. To this effect, a strong commitment has been made to develop the site in such a way which incorporates the latest principles of Ecologically Sustainable Development (ESD).

5 WATER MANAGEMENT STRATEGY

The water management strategy for the development would be at the leading edge of ESD. The three underlying principles of the water management strategy for the development would be:

1. Minimise Potable Water Demand

Minimise the potable water demand of the development by implementing water saving measures and water re-use measures (refer ***Section 6****).*

2. Minimise Impacts on Water Quantity

Minimise the volume of stormwater runoff from the developed site through minimising impervious areas and implementation of stormwater retention measures (refer ***Section 7****).*

3. Minimise Impacts on Water Quality

Ensure there is no impact on water quality (nutrients, sediment and gross pollutants) during and following construction activities, and where possible improve existing conditions (refer ***Section 8****).*

The water management strategy for the site will be developed to comply with the Council DCPs (Development Control Plans) and Director General Requirements to maintain the existing condition.

These principles generally include the following:

- Promote long-term improvement of waterways health;
- Enhance the ecological integrity of the system;
- Conserve and utilise stormwater;
- Mitigate the impact of flooding;
- Treat runoff to ensure no adverse impact on downstream flora and fauna;
- Implement collection, conservation and re-use of stormwater; and
- Integrate water management with urban design.

6 MINIMISING POTABLE WATER DEMAND

The Cronulla Sharks Redevelopment presents an excellent opportunity to minimise the potable water demand through the provision of water re-use devices and conservation practises such as:

- Water harvesting such as temporary water storage or rainwater tanks,
- Irrigating with appropriate systems to minimise water loss and evaporation;
- Using water-efficient taps, shower roses or flow restricting devices; and
- Providing water efficient dishwashers and toilets (dual flush) etc.

6.1 WATER SAVING MEASURES

The main uses of potable water in a traditional household (*refer* ***Table 1***) are garden irrigation (*27%*), shower (*25%*), toilet (*16%*) and washing machine (*19%*).

Area/Use	***Traditional Household***		***With Water Saving Devices***	
	Usage l/house/day	**Percentage of Total Use (%)**	**Usage l/ house/day**	**Reduction (%)**
Internal				
Kitchen	47.9	5.4	47.9*	-*
Bathroom basin	23.6	2.6	23.6*	-*
Laundry basin	19.7	2.2	19.7*	-*
Shower	227.4	25.4	159.2	30%
Toilet	140.8	15.7	84.5	40%
Washing machine	169.9	19.0	169.9	-
Dishwasher	13.2	1.5	9.2	30%
Sub Total	642.5	71.8	514.0	20%
External				
Irrigation	237.3	26.5	237.3	-
car washing	14.8	1.7	14.8	-
Sub Total	252.1	28.2	252.1	-
TOTALS	**894.6**	**100**	**766.1**	**14%**

Table 1. Typical Household Water Usage

Notes:

* Water saving benefits conservatively assumed as negligible in this investigation.

The reductions in potable water use due to water saving devices (*listed in **Table 1***) have been derived from discussions with Sydney Water and the report, *Investigation of Options to Minimise Potable Water Demand and Reduce Wastewater Flows* (*URS 2003*).

Water saving devices in combination with reuse of rainwater from rainwater tanks (*described further in **Section 6.2***) for toilet flushing, washing machines, car washing and irrigation would be implemented to achieve reduction in potable water demand.

6.2 RAINWATER RE-USE

6.2.1 Strategy

The re-use of rainwater from rainwater tanks has the potential to make considerable reductions in potable water usage in concert with water savings devices. With full substitution of potable water with harvested water for toilet flushing, washing machines, car washing and irrigation the reduction in potable water usage would be approximately 70% *(with the 14% reduction due to water saving devices – see **Section 7.1***). However, full substitution could not be guaranteed due to the variability of rainfall. To analyse this and to determine the most efficient rainwater tank size, a water balance analysis would be undertaken for the entire site for three scenarios (*existing, proposed without rainwater re- use, proposed with rainwater re-use*) incorporating parameters such as rainfall, imperviousness, water usage, evaporation etc.

6.2.2 Rainwater Tanks

A rainwater re-use tank system can be installed in many different configurations including placing the tank above or below ground and using gravity or pressure systems (pumps) to deliver rainwater for toilet flushing, washing machines, car washing and irrigation. The rainwater system would also employ a mains top-up scheme to ensure reliable water supply from the tank. When tank water levels are low, during period of little rainfall, the tank is topped up with mains water via a trickle system. This trickle system reduces the peak demands on the mains water distribution network. Tanks would be fitted with a first flush device which causes the initial volume of runoff (containing the highest concentration of pollutants) to bypass the tank.

Detailed analysis can be undertaken at subsequent approval stages to refine the tank sizes to achieve the required targets and the best outcome for the overall design amenity and functionality of the site.

7 MINIMISING IMPACTS ON WATER QUANTITY

There are three issues which require consideration in regard to the water quantity management of the site:

- Flooding;
- Detention; and
- Runoff volume.

These are discussed in the following sections.

7.1 FLOODING

7.1.1 Objective

The objective of Flood assessment of flood prone land is to identify the extent of the existing flooding and mitigate the risk of future flooding.

Council have current flood mapping of the site which is proposed to be updated at the Project application stage, refer Appendix D- Council Flood Maps

For further details refer to Appendix A – Concept Flooding and Stormwater Quality Assessment.

7.1.2 Proposed Flood Mitigation Measures

The proposed development will alter the existing surface levels across the site which potential will impact on the overland flows and flood storage volumes. Mitigation of these impacts will potentially be achieved through the following measures:

- Provision of the an overland flow path adjacent the top of bank extents of the existing tidal channel discharging to Woolooware Bay (Refer 11-59 SKC03-A);
- Enlargement of the culvert underneath Captain Cook Drive;

Implementation of the above measures and any outcome of the detailed analysis (to be undertaken at the Project application stage) would ensure that the development does not adversely affect the current flooding conditions or pose risk to human safety.

Whilst detailed modelling has yet to be undertaken, we are confident based on the information available, any adverse affects to the flooding in or around the development site can be adequately engineered and catered for.

7.1.3 Analysis

Flood analysis will include but not be limited to:

- Prepare hydrologic model of the catchment draining to the site using the RAFTS modelling software. Assessment of the 1 in 20, 1 in 100 year and PMF events climate change impact considered by increasing design rainfall intensities of each storm in accordance with state government policy.
- Prepare detailed hydrologic model for the site using the TUFLOW 2D flood modelling system. This will require a detailed contour survey of the site and surrounding areas.
- Review pre- and post-development flooding inundation levels / extents.
- Produce hydraulic hazard map for the developed site.
- Assess development and community safety on flood prone land up to the PMF in accordance with the NSW FDM (2005), relevant sections of Council's DCP and other relevant guidelines.

7.1.4 Overland Flow Management

The overland flows would be contained within the road carriageways (and swales where present) and therefore measures would be implemented to limit the danger this would present to pedestrians.

It would be ensured that the product of the depth and velocity of the overland flows (standard measure used to estimate risk to pedestrians) would not exceed $0.4m^2/s$. This would be achieved through installation of larger pipes (i.e. containing a greater proportion of the runoff flow beneath the surface) and/or flow diversion.

7.2 STORMWATER DETENTION

7.2.1 Objective

The purpose of On Site Detention (OSD) systems is to detain storms and reduce peak discharge rates, however volumetric runoff remains unchanged.

7.2.2 Proposed Stormwater Detention Measures

OSD is usually beneficial in the upper and middle parts of a catchment. However, OSD is ineffective in the downstream parts of the catchment and can even increase the peak discharge because of the coincidence of peaks of the catchment hydrograph and the outlet hydrograph from the OSD.

Therefore, OSD is not recommended for this development on the basis that there is no significant benefit and increased risk of the peak discharge value coinciding.

Where possible the natural hydrological regime will be maintained.

7.2.3 Analysis

DRAINs software will be used to develop a rainfall runoff model for the site. The model will been used to quantify site flows that discharge to Woolooware Bay and Captain Cook Drive. This analysis will be undertaken in conjunction with flood modelling.

7.3 VOLUMETRIC RUNOFF CO-EFFICIENT

7.3.1 Objective

One of the major objectives of the water management strategy for the proposed development is to maximise the reduction in runoff volume from the site.

Water management practices proposed to reduce the increased runoff volume include:

- Installation of rainwater re-use tanks;
- Installation of bio-retention swales; and
- Maximisation of pervious area within the development.

It is expected that implementation of the abovementioned retention measures would significantly reduce the volumetric runoff coefficient (Cv).

This reduction in runoff volume would lead to a reduction in the pollutant loads exported from the site and a reduction in the size of the drainage facilities required. The improvement in runoff quality achieved by the retention measures is addressed in **Section 8**.

7.3.2 Proposed Stormwater Retention Measures

Rainwater Re-use Tanks

Rainwater tanks retain a portion of the stormwater falling on the roof areas of the development and therefore contribute to reducing the total volume of runoff from the site.

Bio-Retention Swales

These devices would serve a threefold function of stormwater retention, stormwater detention and reduction of stormwater pollution levels.

Bio-retention swales would be located where possible in the streetscape

The extent and type of planting proposed within the swales would be designed to discourage mistreatment and misuse. Swales would be located in visually prominent areas to promote best practice maintenance.

A typical swale would be designed to cater for the major storm event. A typical bio-retention swale cross section is shown in **Section 8**. Each swale would consist of a low flow storage area underlain by topsoil and infiltration media. To promote detention, the surface of the swales will be densely planted in accordance with the landscape architects specifications and bunds or check dams will be incorporated at regular intervals.

A proportion of the runoff captured by the swales will infiltrate through the drainage media at a rate of greater than 100mm/h to an underdrain system. Flows collected by the underdrain system will eventually discharge into the trunk drainage system. This underdrain system along with the permeable backfill and topsoil (*sandy loam*) utilised within the swale will prevent the area from being saturated or becoming “boggy” during extended periods of wet weather so as to prevent mosquito breading.

Pervious Area

Runoff from the development would be further reduced by promoting pervious areas and minimising impervious areas. Impervious areas would be minimised by adopting minimum pavement widths of roads, reducing the extent of concrete footpaths and maximising the use of vegetated swales.

Permeable pavers will be implemented in off street parking bays to reduce the volumetric runoff, hence, reduce the pollutant loads exported from the site.

8 MINIMISING IMPACT ON WATER QUALITY

8.1 WSUD

8.1.1 Objectives

In accordance with best management practice and Council guidelines this site is considered an ideal opportunity to improve/maintain the quality of the stormwater discharged to the receiving waters.

In order to achieve these objectives, a treatment train approach would be implemented into the development where the stormwater treatment flow path for runoff would generally be:

1. Runoff from roofed areas would be collected and detained in rainwater tanks with an overflow by-pass to the street drainage system;
2. Large impervious areas such as roads would be directed to bioretention swales where they would be filtered and treated biologically;
3. Excess flows from the bioretention swales would flow to the pipe drainage system designed to cater for the 10 year ARI event;
4. Stormwater exiting the pipe drainage system would pass through a GPT to remove remaining coarse sediment, litter, debris, oils and greases; and
5. Stormwater would drain from the GPT to the discharge point either in the tidal channel or Woolooware Bay. Appropriate scour protection measures will be in place at all outlets.
6. Reduce gross pollutants entering the tidal channel through external catchments via implementation of a trash rack at the upstream end of the culvert under Captain Cook Drive.

For further details refer to Appendix A – Concept Flooding and Stormwater Quality Assessment.

8.1.2 Proposed WSUD Measures

Rainwater Tanks

In addition to the water re-use benefits evident with installation of a rainwater tank, there are also water quality benefits. Rainwater tanks contribute to the retention of rainwater thus resulting in a reduction of the runoff co-efficient for the development which in turn reduces the annual pollutant loads.

Bio-retention Systems

Bio-retention systems are systems that promote the filtration of stormwater through a prescribed filter medium. The type of filter medium determines the effectiveness of the pollutant removal, with material of lower hydraulic conductivity providing the most efficient pollutant removal.

Figure 1. Swale Image

Bioretention swales would be incorporated into road reserves and/or adjacent overland flow path tidal channel where they can aesthetically enhance the visual impact of the development (refer photo). The swales would be planted with native grasses and fringe vegetation on a layer of coarse sand and soil. Below the swale would be a gravel filled trench approximately 1000mm deep and 1000mm wide wrapped in geo-textile with a perforated pipe at the base. A typical bioretention swale is shown in the figure below.

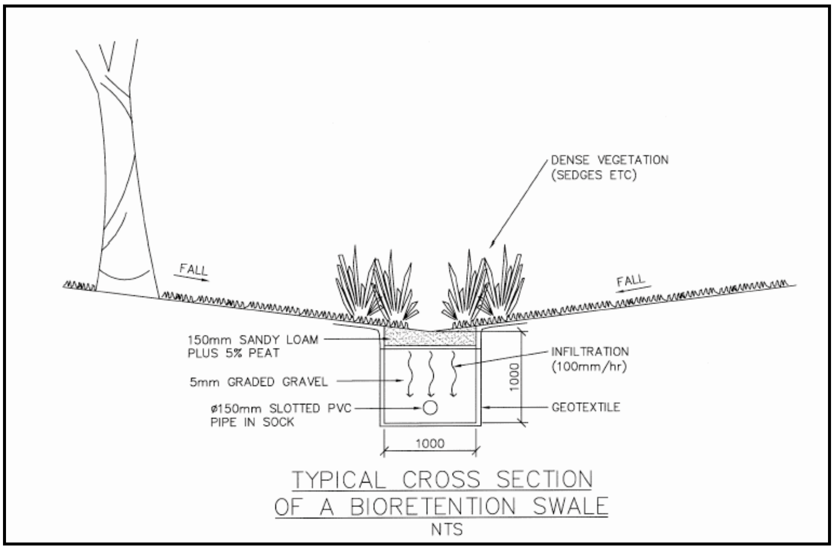


Figure 2. Typical Swale Cross-section

The purpose of a bio-retention swale is to provide a filtering effect to remove pollutants typically found in urban runoff (i.e. TN, TP and TSS). Further treatment would be achieved by filtering through the gravel trench and biological action due to growth on the gravel.

Low flows are maintained as much as possible on the surface which would be exposed to sunlight and with turbulence introducing oxygen to the flows. These swales can be located in the streetscape and/or in open space areas.

The top bank adjacent the existing tidal channel is ideal for implementation of bioretention systems as flat grades enable water to temporarily pond thus increasing the nutrient uptake capacity. This will also serve as a dual function to increase capacity of the tidal channel during peak storms.

Gross Pollutant Traps

A Gross Pollutant Trap (GPT) captures litter, coarse sediment, some nutrients, oils and greases. While the pollutant capture efficiency of various traps may vary, the paper "Removal of Suspended Solids and Associated Pollutants by a Gross Pollutant Trap" (Cooperative Research Centre for Catchment Hydrology, 1999) suggests the following efficiencies:

- gross pollutants — majority
- sediments — up to 70%
- total phosphorous — up to 30%
- total nitrogen — up to 13%

It is vital that the entire catchment is serviced by these GPT's and therefore that they are placed at the end of main stormwater lines or other critical locations and sized accordingly.

The external catchment draining via the existing culvert under Captain Cook Drive may be serviced by a trash rack to capture gross pollutants prior to discharge into the tidal channel.

8.1.3 Analysis

Model for Urban Stormwater Improvement Conceptualisation (MUSIC)

The software package developed by the CRC for Catchment Hydrology termed "MUSIC" (Model for Urban Stormwater Improvement Conceptualisation) would be used to assess the effectiveness of the proposed "treatment train" and therefore ensure compliance with the proposed objectives.

MUSIC is a continual-run conceptual water quality assessment model developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH). MUSIC can be used to estimate the long-term annual average stormwater volume generated by a catchment as well as the expected pollutant loads. MUSIC is able to conceptually simulate the performance of a group of stormwater treatment measures (treatment train) to assess whether a proposed water quality strategy is able to meet specified water quality objectives.

MUSIC would be used to ensure compliance because it has the following attributes:

- It can account for the temporal variation in storm rainfall throughout the year;
- Modelling steps can be as low as 6 minutes to allow accurate modelling of treatment devices;
- It can model a range of treatment devices;
- It can be used to estimate pollutant loads at any location within the catchment; and
- It is based on logical and accepted algorithms.

The model's algorithms are based on the known performance characteristics of common stormwater quality improvement measures. These data, derived from research undertaken by CRCCH and other organisations, represent the most reliable information currently available in the water management industry.

8.1.4 Maintenance Programme

A maintenance program for the water quality control measures installed within the development would consist of the following:

- Periodic (6 monthly) inspection and removal of any gross pollutants & coarse sediment that is deposited in the bio-retention swales and replacement of vegetation as necessary; and
- Periodic (3 monthly) and episodic (post storm greater than 1 yr ARI) inspection and removal of trapped pollutants from all GPTs.

8.1.5 Construction Phase

Sediment and erosion control plans would be designed in accordance with the NSW Department of Housing "*Managing Urban Stormwater – Soils and Construction*" (Blue Book) and to the satisfaction of Council. Staging of the development would minimise impacts during construction. These controls would ensure that there are no significant adverse impacts on receiving water quality during construction.

A sediment and erosion control plan would be prepared prior to construction, outlining the strategies proposed to prevent excessive pollutant loads being exported from the site in runoff during and immediately following construction. It is recommended that the following measures be implemented:

- At the upstream end of works, clean water would be temporarily diverted around disturbed areas;
- A sediment fence would be erected at the downstream end of any disturbed areas;
- The area of soil disturbed at any one time would be minimised where possible;
- Sediment basins would be constructed as required; and
- Disturbed areas would be rehabilitated as soon as practical.

9 SERVICING STRATEGY

We have contacted all of the following service Authorities who have provided preliminary advice that the development can be serviced through provision of adequate planning.

A DBYD investigation was undertaken and along with the detailed survey we have prepared plans indicating the location of the existing services.

9.1 SEWERAGE (SYDNEY WATER)

There is an existing 1800mm diameter trunk sewer carrier with two 225dia stubs that currently service the site. This carrier is anticipated to have adequate capacity to service the development.

Sydney Water have indicated they will provided further advice on the existing system and capacity once the concept application has been referred on.

Refer SKC04 and SKC05 for the location of the existing services.

9.2 POTABLE WATER (SYDNEY WATER)

It is anticipated that early stages of the development will utilise supply from the existing 100mm dia and 150mm dia mains in Captain Cook Drive. Ultimately, a future lead-in may be required of approximately 2km of 300-375mm diameter main. Preliminary advice is that this can be completed via an extension to Cronulla High or the Kingsway via Gannons Road or along the extended Captain Cook Drive.

Sydney Water have indicated they will provided further advice on the existing system and capacity once the concept application has been referred on.

Refer SKC04 and SKC05 for the location of the existing services.

9.3 POWER (AUSGRID)

Our assessment of power supply for this project is based on the development requiring an 11kV feeder to supply a number of on-site kiosk type substations. It is expected the residential precinct will require a single kiosk per building and the retail precinct having a single chamber type sub station.

From the network diagrams we received from Ausgrid via our DBYD enquiry and our initial discussions with Ausgrid, it appears there will be sufficient supply within the existing 11kV overhead and underground cables that front the site along Captain Cook Drive.

Refer SKC04 and SKC05 for the location of the existing services.

9.4 Telecommunications (NBN Co)

Based on the anticipate demand National Broadband Network (NBNco) Development Management Team have committed to servicing the future development.

An application has been lodged with NBNco (Application number AYCA-E8WIP)

Refer SKC04 and SKC05 for the location of the existing services.

9.5 GAS (JEMENA)

The existing Gas network in the area consists of:

- 110mm Nylon main (300kPa) near the corner of Captain Cook Drive and Woolooware Road. This main would be suitable for connection depending on the required demand.
- 300mm Secondary main (1050kPa) running along Captain Cook Drive with appears to currently service the site. This main may be suitable for connection depending on the required demand.

Based on our initial discussions with Jemmena it's expected the existing services have sufficient capacity to service the development.

Refer SKC04 and SKC05 for the location of the existing services.

10 CONCLUSIONS

WATER MANAGEMENT

This report has outlined how a successful water management strategy would be implemented to the site. The specific conclusions that can be drawn regarding the three areas of water management are outlined below:

Potable Water Use

Installation of rainwater re-use tanks to provide water for certain uses (*toilet flushing, car washing and irrigation*) in conjunction with implementation of water saving measures (*flow restrictors, water efficient appliances, responsible landscaping etc*) would significantly reduce the potable water demand.

Water Quantity

The proposed strategy would mitigate risk in flooding or stormwater flows at any upstream and/or downstream locations during peak rainfall events.

Water Quality

Incorporation of a treatment train (*rainwater tanks, bioretention swales and gross pollutant traps*) will significantly reduce the pollutant export from the site. The level of treatment that would be provided would seek to improve or maintain the existing condition.

Climate Change and Sea Level Rise

Any future modelling will incorporate Sea Level Rise of a prescribed rise of 0.41m.

SERVICING STRATEGY

Initial discussion with various service authorities have determined that the development can be adequately serviced subject to adequate planning and future negotiations.

Appendix A

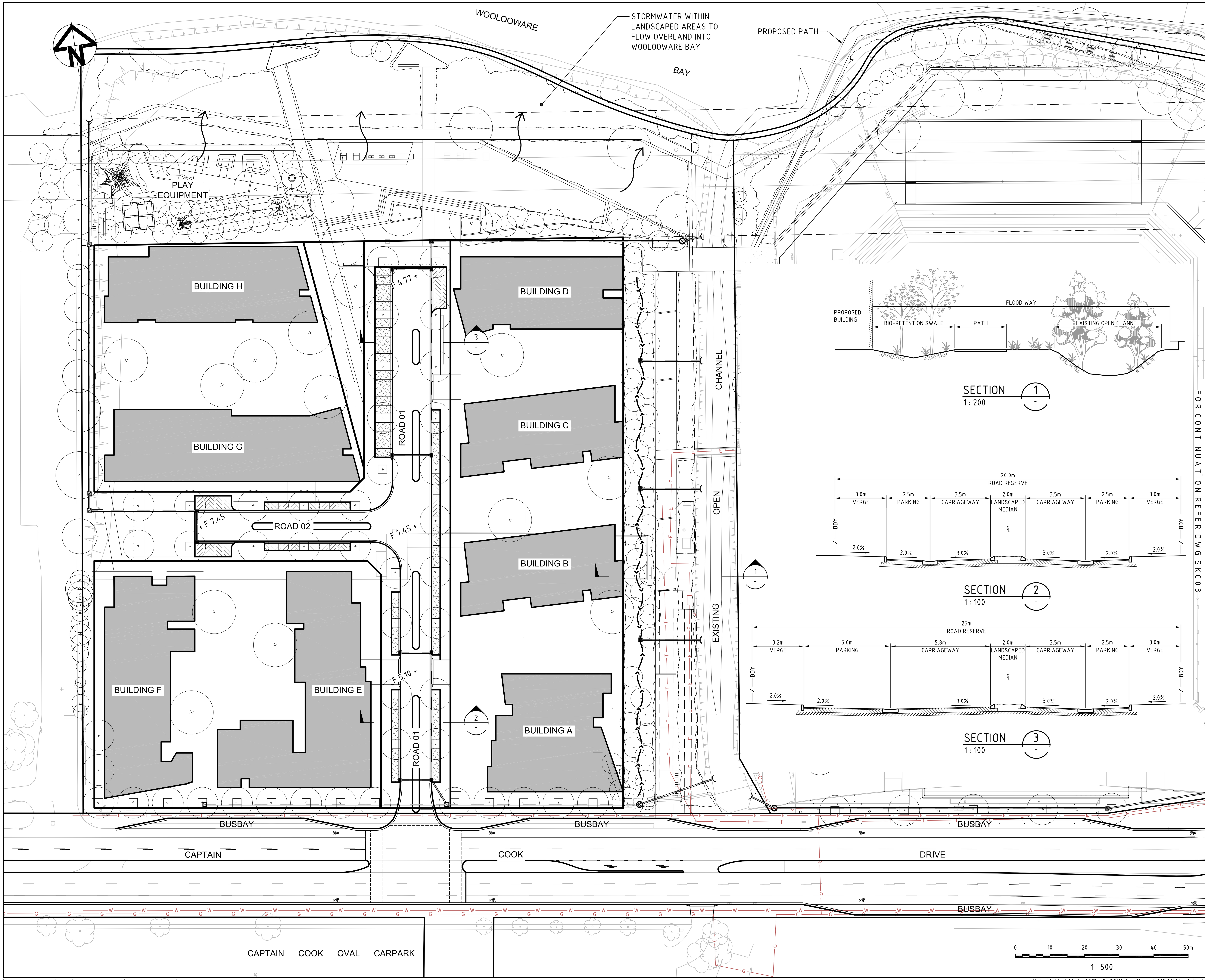
Concept Application Drawings

11-59 SKC02 – A Residential Roadworks and Stormwater plan

11-59 SKC03 – A Retail Roadworks and Stormwater plan

11-59 SKC04 – A Existing Services Sheet 1

11-59 SKC05 – A Existing Services Sheet 2



LEGEND

- STORMWATER PIT
- STORMWATER PIPE
- STORMWATER OUTLET
- GROSS POLLUTANT TRAP
- BIO-RETENTION SWALE
- + F 7.00 FINISHED SURFACE LEVEL
- 'ECO' PAVERS
- SURFACE FLOW DIRECTION ARROW
- RT RAINWATER TANK

Issue	Description	Date
A	CONCEPT APPLICATION	25-07-11
P3	ISSUED FOR INFORMATION	20-07-11
P2	ISSUED FOR INFORMATION	15-07-11
P1	ISSUED FOR INFORMATION	13-07-11

Status: PRELIMINARY — NOT TO BE USED FOR CONSTRUCTION — A1

Scales	1 : 500	Drawn	TS
		Designed	MM
Height Datum	AHD	Checked	AMc
Grid	MGA	Approved	

File: SKC02-Residential-Masterplan.dwg

Client: BLUESTONE CAPITAL VENTURES No.1 PTY LTD

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Milsons Point NSW 2061
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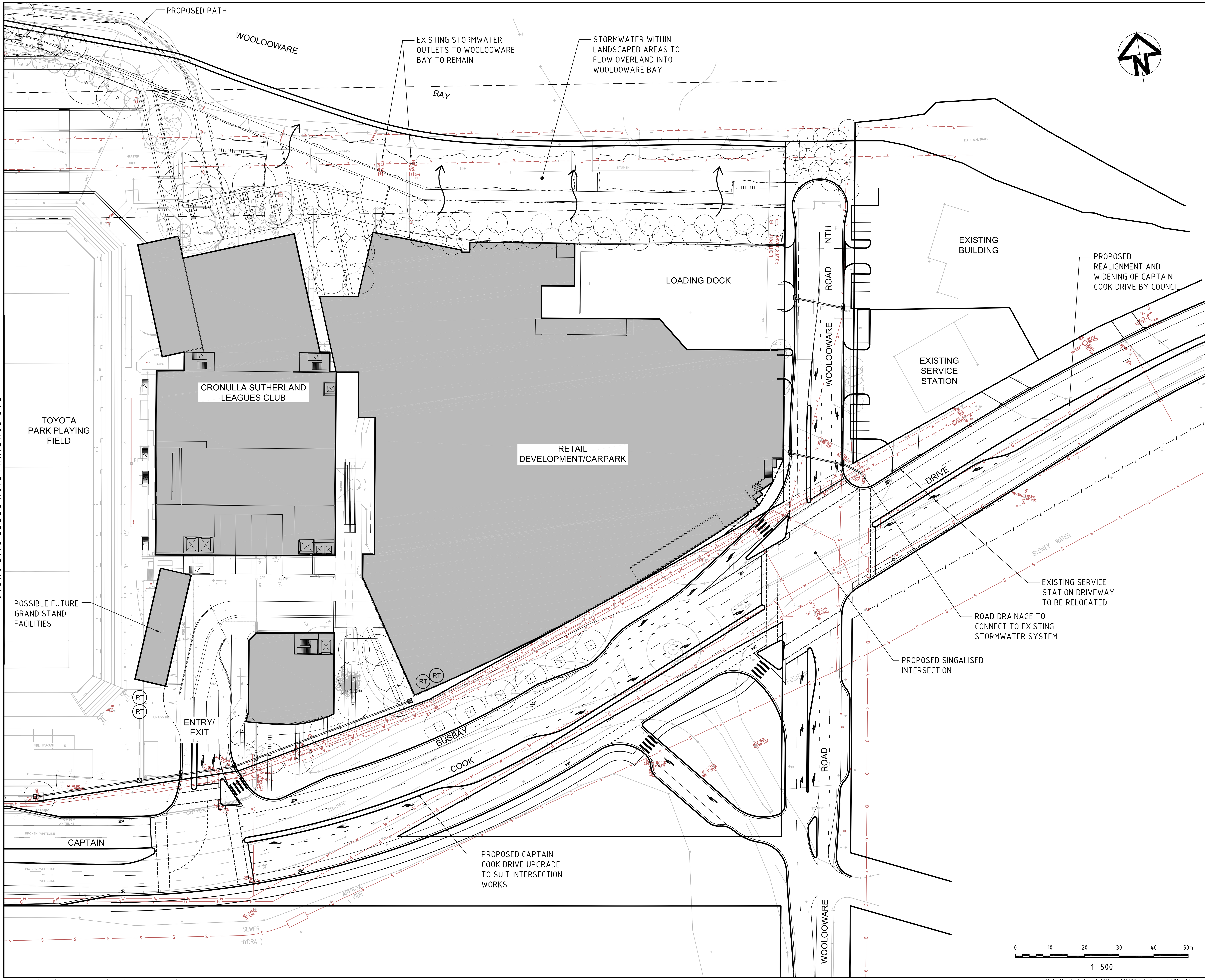
info@atl.net.au

Project: CRONULLA SHARKS REDEVELOPMENT

Title: RESIDENTIAL ROADWORKS AND STORMWATER PLAN

Drawing No.	Project No.	Issue
SKC02	11-59	A



LEGEND

▪	STORMWATER PIT
━	STORMWATER PIPE
(	STORMWATER OUTLET
⊗	GROSS POLLUTANT TRAP
	BIO-RETENTION SWALE
+ F 7.00	FINISHED SURFACE LEVEL
	'ECO' PAVERS
	SURFACE FLOW DIRECTION ARROW
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Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
A1

Scales: 1 : 500
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Height Datum: AHD
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Approved
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Client
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Project
CRONULLA SHARKS REDEVELOPMENT

Title
RETAIL ROADWORKS AND STORMWATER PLAN

Drawing No.	Project No.	Issue
SKC02	11-59	A

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Date Plotted: 25 Jul 2011 - 03:16PM File Name: F:\11-59 Shark Park\Drgs\Civil\Sketches\SKC03-Retail-Masterplan.dwg V1

FOR CONTINUATION REFER DWG SKC05

EXISTING SERVICES

- EXISTING ELECTRICAL
- EXISTING OVERHEAD ELECTRICAL
- EXISTING LOW VOLTAGE
- EXISTING GAS
- EXISTING TELSTRA
- EXISTING WATER
- EXISTING SEWER
- SEWER MAN HOLE

Issue	Description	Date
A	CONCEPT APPLICATION	01/08/11

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
A1

Scales: 1 : 500
Height Datum: AHD
Grid
Drawn: TS
Designed: MM
Checked: AMc
Approved

File: SKC04-Services-Plan-Sheet-1.dwg

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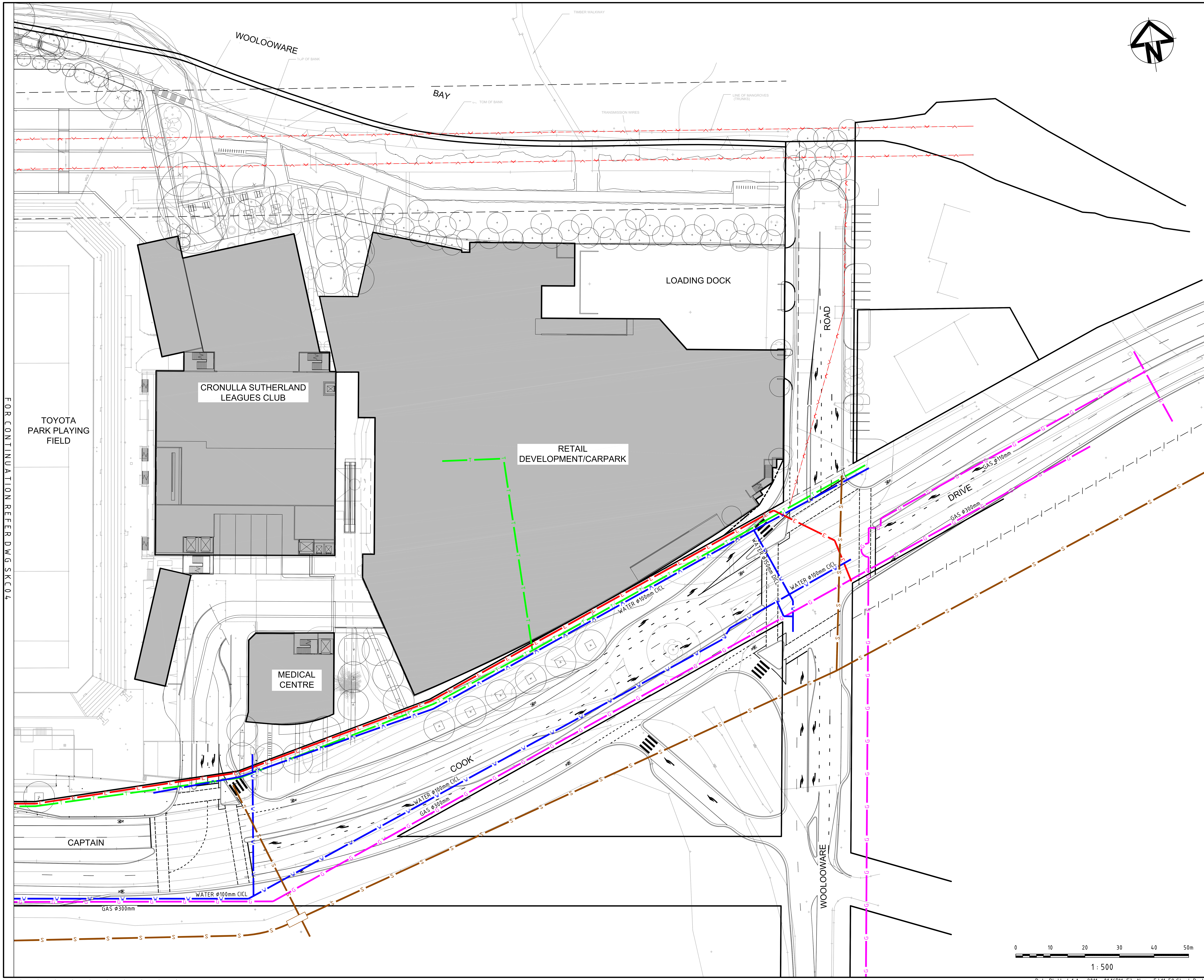
Project
CRONULLA SHARKS REDEVELOPMENT

Title
EXISTING SERVICES PLAN SHEET 1

Drawing No.	Project No.	Issue
SKC04	11-59	A



EXISTING SERVICES

- E — EXISTING ELECTRICAL
- EXISTING OVERHEAD ELECTRICAL
- LV — EXISTING LOW VOLTAGE
- G — EXISTING GAS
- T — EXISTING TELSTRA
- W — EXISTING WATER
- S — EXISTING SEWER
- SEWER MAN HOLE

Issue	Description	Date
A	CONCEPT APPLICATION	01/08/11

Status: PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
A1

Scales: 1 : 500
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Designed: MM
Height Datum: AHD
Checked: AMc
Grid:
Approved:

File: SKC05-Services-Plan-Sheet-2.dwg

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Project
CRONULLA SHARKS REDEVELOPMENT

Title
EXISTING SERVICES PLAN SHEET 2

Drawing No.	Project No.	Issue
SKC05	11-59	A

Date Plotted: 1 Aug 2011 - 01:16PM File Name: F:\11-59 Shark Park\Drgs\Civil\Sketches\SKC05-Services-Plan-Sheet-2.dwg V1

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Appendix B

Martens and Associates
Flooding and Stormwater Quality Report

Bluestone Capital Venture No. 1 Pty Limited

martens consulting engineers

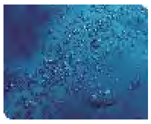
Concept Flooding and Stormwater Quality Assessment:

Proposed Cronulla Sharks Redevelopment

Captain Cook Drive, Woolooware

ENVIRONMENTAL

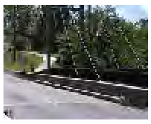
WATER



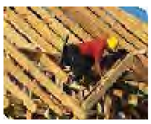
WASTEWATER

GEOTECHNICAL

CIVIL



PROJECT MANAGEMENT



P1103017JR01V01
July 2011

Limitations Statement

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to provide a concept flood and water quality assessment in accordance with the scope of services set out in the contract / quotation between Martens & Associates Pty Ltd and AT&L P/L (hereafter known as the Client). That scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources which may include for example site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

In preparing this report, Martens & Associates Pty Ltd may have relied upon and presumed accurate certain information (or absence thereof) relative to the site. Except as otherwise stated in the report, Martens & Associates Pty Ltd has not attempted to verify the accuracy of completeness of any such information (including for example survey data supplied by others).

The findings, observations and conclusions expressed by Martens & Associates Pty Ltd in this report are not, and should not be considered an opinion concerning the completeness and accuracy of information supplied by others. No warranty or guarantee, whether express or implied, is made with respect to the data reported or to the findings, observations and conclusions expressed in this report. Further, such data, findings and conclusions are based solely upon site conditions, information and drawings supplied by the Client *etc*. in existence at the time of the investigation.

This report has been prepared on behalf of and for the exclusive use of the Client, and is subject to and issued in connection with the provisions of the agreement between Martens & Associates Pty Ltd and the Client. Martens & Associates Pty Ltd accepts no liability or responsibility whatsoever for or in respect of any use of or reliance upon this report by any third party.

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1	Prelim Draft Report	Draft	12.07.2011	1E,1P,1H	-	1P	
1	Draft Report	Draft	14.07.2011	1E,1P,1H	-	1P	1P
1	Final	Final	01.08.2011	1E,1P,1H		1E	

Distribution Types: F = Fax, H = hard copy, P = PDF document, E = Other electronic format. Digits indicate number of document copies.

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

Contents

1 Overview

1.1 Background

Martens & Associates Pty Ltd has prepared this concept flooding and stormwater quality assessment for the proposed Concept Plan application for the Cronulla Sharks Redevelopment Club located at Toyota Stadium, 461 Captian Cook Drive, Woolooware NSW. The application is being lodged by t Bluestone Capital Venture No. 1 Pty Limited (BCV).

This report reviews findings from previous studies produced for a previous development application (DA) lodged for Toyota Stadium including:

- SMEC (March 2002). *Stormwater Drainage and Water Quality Strategy* (Document Number 31226.067);
- DHI (October 2002). *Stormwater Drainage and Water Quality Strategy* (Project Number 50139);
- J & K (September 2002). Geotechnical Investigation for Proposed Cronulla Leagues Club Rezoning (Ref: 17119SPrpt);
- Kozarovski and Partners (March 2007). *Flood Study* (Project Number 891);
- Kozarovski and Partners (2009). *Impact and Climate Change on Flood Levels in Captain Cook Drive* (Job Number 1404).
- Hyder Consulting (March 2009) *Site Stormwater Assessment*

1.2 Development Proposal

The proposed mixed use redevelopment of the Cronulla Sutherland Leagues Club site including a new neighbourhood retail centre, residential development and upgrades to the sports facilities, including the Toyota Stadium, will create a long term sustainable and viable solution for the Club as well as create a new centre and destination location that meets the needs of the surrounding community. The Concept Plan prepared for the site is seeking to develop the site in three stages, being:

Stage 1 – New Neighbourhood Retail Centre, Medical and Leisure facilities on the eastern car park site and redevelopment of the Leagues Club facilities;

Stage 2 - Residential Masterplanned Estate on the western car park and field area; and

Stage 3 - Extension and improvement of the Sharks playing field facilities including grandstand extensions.

1.3 Objectives and Scope

Martens and Associates were engaged by AT&L (on behalf of the BCV) to prepare a review of previously prepared site documentation and provide advice regarding development constraints relating to flooding, climate change and water quality. This advice is based entirely on review of past assessments. New modelling is expected to be undertaken for future applications.

Site flooding and climate change objectives included:

- Review previous site stormwater study conducted for the site by Hyder (2009).
- Review previous site flooding and climate change reports.
- Review relevant sections of Council's DCP and other relevant guidelines.
- Discuss known flood levels and preliminary impacts on proposed development.
- Discuss the impact of climate change on flood levels in accordance with current state government policy.

Water quality objectives included:

- Determine site water quality targets and review existing water quality data;
- Review existing reports from previous DA;
- Assess preliminary requirements for stormwater quality management.

2 Site Characterisation

2.1 Location and Site Description

The Cronulla Sutherland Leagues Club site is legally described as Lot 11 DP 526492 and Lot 20 DP 529644 and is known as 461 Captain Cook Drive, Woolooware. Three lots owned by Sutherland Shire Council (being Lot 21 DP 529644, Lot 1 DP 711486 and Lot 1 DP 501920) are also included within the proposed scheme.

The site is located on the northern side of Captain Cook Drive approximately 1.5 kilometres from Caringbah (to the south west) and 2 kilometres from Cronulla (to the south east). The site is bounded by the Solander playing fields to the west, Woolooware Bay to the north, and a service station and gymnasium to the east. The Woolooware Golf Club and the Captain Cook Oval are located to the south of the site across Captain Cook Drive.

The site is generally flat, sloping to the south towards Captain Cook Drive. The site was a former landfill which accepted putrescible and non-putrescible refuse, explaining the peculiar site aspect (i.e. drains away from Woolooware Bay).

An open channel (approximately 5 - 6m wide and 1.5m deep) is located on the shared boundary of the two allotments which flows north to the wetland and eventually Woolooware Bay. A culvert drains the upslope catchment (approximately 253 ha) under Captain Cook drive and discharges into the open channel. The channel is impacted by tidal movements.

Existing site conditions are shown on the site aerial (Figure 1 of Attachment B).

2.2 Geology and Groundwater

2.2.1 Geology & Soils

The Wollongong / Port Hacking 1:100,000 Geological Sheet 9129 (NSW Dept. Mineral Resources, 1985) describes the geology in the area of the site as man-made fill consisting of dredged estuarine materials, coal wash, industrial and household waste. Fill is underlain by quaternary marine deposits consisting of organic rich estuarine sediments and marine sands. Hawkesbury Sandstone is expected at greater depths.

J&K (2002) geotechnical report identified poorly compacted fill (consisting of silty clay and sand mixed with metal, timber, sandstone and demolition rubble) overlying soft marine deposits (consisting of organic silty clays and sandy soils). Sandstone bedrock was encountered at depths ranging from 7.7 to 13.3m below existing grades.

2.2.2 Groundwater

Reference to the J&K (2002) geotechnical report reveals groundwater is at depths ranging from 0.4 to 3.8m below grade.

3 Flooding

3.1 Policy and Guidelines

The following guidelines are considered applicable to the site flood assessment:

- o NSW Department of Environment, Climate Change and Water (DECCW), *Flood Risk Management Guide – Incorporating sea level rise benchmarks in flood risk assessments (2010);*
- o NSW Department of Infrastructure, Planning and Natural Resources (DIPNR), *Floodplain Development Manual* (2005);
- o Sutherland Shire Council (SSC), *Development Control Plan* (2006).

3.2 Document Review

3.2.1 Flood Assessment Review

The flood report prepared by Kovarovski and Partners (K& P, 2007) includes past information developed by SMEC (2002) and DHI (2002) and adds further modelling detail to those previous assessments. Findings of K & P (2007) are summarised below:

- A flood model was prepared using the MikeStorm hydraulic model.
- King tide level was assumed to be 1.8 m AHD. A more conservative design king tide level of 1.9 m AHD was applied as the model downstream boundary condition.
- The 60 minute storm duration produced the highest peak discharge values.
- Peak 1% AEP flood level along Captain Cook Drive was modelled at 2.78 m AHD.
- Existing 1% AEP flood levels downstream of Captain Cook Drive were modelled as being at or below 2.7 m AHD.
- The extreme flood event (simulated using 4 times the 1% AEP hydrograph) levels along Captain Cook Drive were modelled as being at or below 3.18 m AHD.

The flood assessment concluded that the proposed development would increase flood levels (however extent and location was not specified / discussed).

Hydraulic flood hazard was reviewed by considering the VD product (velocity x depth). Toyota Stadium was considered to have a low flood hazard, however the site development contains areas of high hazard (particularly areas adjacent to and within the main channel).

A range of detailed prescriptive controls were recommended in the K & P (2007) report for each of the proposed development stages at address site flood impacts and hydraulic hazard. It is proposed that a similar assessment of hazard and mitigation measures shall be developed for the current proposed site development. Measures likely to be required (and to be detailed at the Project Application stage) include.

- Provision of the an overland flow path adjacent the top of bank extents of the existing tidal channel discharging to Woolooware Bay;

- Enlarging the opening under Captain Cook Drive.

3.2.2 Climate Change Impact Review

The impact of climate change on flood levels in Captain Cook Drive was reviewed by Kozarovski and Partners (K & P, 2009). The following assumptions and outcomes are reported:

- A design tide level of 2.21 mAHD was specified by Council's Stormwater Engineer (Dr Guy Amos) for modelling purposes. This represents an increase in design high tide of only 0.41m.

- Modelled increase in the 1% AEP flood level in the vicinity of Captain Cook Drive was between 15 – 19mm.

- Recommended design 1% AEP flood level for basement carpark and driveway entry level was raised from 2.77 m AHD (from 2007 report) to 2.87 m AHD.

3.2.3 Site Emergency Response Plan Review

K & P (2007) recommended a Crowd Management Plan be prepared, which would be included in an overall Site Emergency Response Flood Plan. The site planning is to:

- Minimise the number of people and cars which may be in the inundated areas;

- Prevent people and cars being swept into areas of deeper water and/or with higher velocities;
- Direct people to safe refuge locations.

Flood depth indicators must be placed:

- Along the footpath of Captain Cook Drive;
- On each landscaping island of the western car park area;
- At 20 m intervals along the fence on the west side of the tidal channel ;
- At 10 m intervals along the service road between the tidal channel and the ET Stand / main oval, from Captain Cook Drive to north of the north-west entry;
- On each side of the foot bridges;
- Flood evacuation plaques should be placed at strategic locations identifying the closest flood refuge location.

3.2.4 Sutherland Shire Council DCP (2006)

Chapter 5 (Environmental Risk) of SSC DCP (2006) provides prescriptive controls for development of flood prone land in the Sutherland Shire LGA. Flood Notations on Section 149 Certificates contain the requirements for the development controls that apply to that parcel of land.

SSC DCP (2006) controls shall be applied to the appropriate categories of development at the Project Application stage of works.

3.3 Discussions and Recommendations

Kozarovski and Partners (2009) report considered a design tide level of 2.21 mAHD in light of discussions with SSC (Dr Guy Amos). This level represents an assumption of 0.41m of sea level rise. NSW DECCW (2010) guideline provides direction on projected sea level rise. The benchmark levels set for 2050 and 2100 are 0.4m and 0.9m respectively, relative to the 1990 mean sea level.

It is recommended that detailed flood modelling for the development be undertaken at the Project Application stage to assess design levels for the development and mitigation requirements. Modelling shall include a sea level rise benchmark of 0.9m giving a downstream boundary condition of 2.7 m AHD for future flood modelling.

The proposed Cronulla Sharks Redevelopment will alter the existing surface levels across the site which may impact on flood flows and flood storage. This is particularly the case on the western portion of the site, and without mitigating measures, the filling may increase flood heights across the siteand surrounding areas.

At this stage we expect any increase in this level to be minor. Mitigation works may be required to ensure impacts are acceptably small, these may include:

- Provision of the an overland flow path adjacent the top of bank extents of the existing tidal channel discharging to Woolooware Bay;

- Enlargement of the culvert underneath Captain Cook Drive.

Flood levels determined by K & P (2007 and 2009) provided in Section 3.3 provide a general guide to indicative flood levels across the site. It is intended a detailed re-assessment of levels for the current development layout as well as an updated assessment of the impact of Climate Change will be undertaken for future applications.

Detailed flood impacts and levels are to be assessed at the Project Application stage. This assessment shall consider the 1% AEP and PMF and shall consider the effects of sea level rise as outlined in NSW government planning policy.

4 Stormwater Quality

4.1 Policy and Guidelines

The following guidelines are considered applicable to the site stormwater quality assessment:

- Australian Rainfall Quality (2006);
- Department of Environment and Climate Change NSW (DECC), Management Urban Stormwater: Urban design (Consultation Draft, 2008);
- Sutherland Shire Council (2006) *Development Control Plan*;
- Sutherland Shire Council (2009) *Environmental Specification – Stormwater Management;* and

4.2 Stormwater Quality Objectives

Sutherland Shire Council's Environmental Specification – Stormwater Management (2009) provides reduction objectives for stormwater quality assessment. These are summarised in Table 1 and are proposed as the water quality objectives for the site redevelopment.

Table 1: Proposed project stormwater pollutant reduction objectives.

Pollutants	Project Objectives (SSC 2009)
Total Suspended Solids (TSS)	70%
Total Phosphorus (TP)	20%
Total Nitrogen (TN)	35%
Litter	Retention of litter greater than 50mm to the maximum extent possible for storm events up to 1 in 3 month ARI

Pollutant reduction percentages are expressed in terms of "annual post-development pollutant loads" from the development.

Existing water quality data for Woolooware Bay was unavailable at the time of writing this report.

4.3 Review of Previous Reports

4.3.1 Overview

Water quality assessment was provided in SMEC (2002) and further developed in DHI (2002). Water quality control issues were discussed and water quality control devices recommend in light of MUSIC modelling.

4.3.2 Summary of Water Quality Control Issues

Impacts on the adjacent RAMSAR wetland are likely to be incurred from the concentrated use of Toyota Stadium during game events, as well as from parking and other impervious areas.

Additionally, the site is located over a land fill which has the potential for export of leachate to the wetland. The stormwater quality strategy should aim to minimise infiltration into the landfill areas of the site, thus reducing the likelihood of leachate export.

4.3.3 Summary of Water Quality Control Devices

A summary of the water quality control recommendations provided by SMEC (2002) and DHI (2002) is documented as:

- Separate roof and surface runoff drainage systems are to be provided.
- Rainwater tanks are to harvest roof runoff for irrigation of Toyota Stadium and associated training fields.
- A piped stormwater system to be installed over the landfill area to reduce infiltration.
- Grassed swales with sub-soil drainage are to be constructed along Captain Cook Drive with invert levels above the ground water table. Swales reduce stormwater flow velocities; remove pollutants during small storm events; and expose the accumulated litter to the public (stormwater pipes hide the litter).

- Off-line GPT with oil traps to be installed at the end of the swales to protect the tidal channel from litter, coarse sediments and oil/fuel.

- Prepare and implement erosion and sediment control measures during construction to prevent sediment export to Woolooware Bay.

Water quality control structures above were modelled using MUSIC (as documented in DHI 2002) and indicate a pollutant load reduction (post compared to pre-development) by some 30%.

4.4 Proposed Water Quality Modelling Requirements

4.4.1 Modelling Overview

Stormwater quality modelling shall be undertaken at the Project Application stage to determine specific requirements for stormwater quality improvement devices (SQIDs) to protect the wetland and Woolooware Bay to achieve adopted project water quality objectives. A model such as the Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*) or similar is to be developed to evaluate pre- and post-development pollutant loads from the site and to assess required mitigation measures.

4.4.2 Modelling Parameters

Pollutant concentration parameters for proposed land-use types are to be derived from Australian Runoff Quality (Engineers Australia, 2006) and Bui *et al*. (November, 2002).

4.5 Proposed Stormwater Quality Improvement Devices

Stormwater quality improvement devices (SQIDs) likely to be implemented at the proposed development are described in Table 2.

Table 2: Summary of proposed stormwater quality improvement devices (SQIDs).

Element	Water Quality Function	Description & Preliminary Specification(s)
Gross Pollutant Traps (GPT)	Primary: litter and sediment removal mechanism. Secondary: nutrient removal.	Where possible road runoff to be directed to GPT's prior to discharge off-site by overland flow through the existing channel. Proposed location, number and size of GPT's will ultimately depend on inflow rates and detailed drainage design. GPT treatment is likely to consist of two functions: • Primary: pit basket inserts (i.e. enviropod or similar) and larger end of line structures (such as CDS units or other commercially available equivalent) for litter and coarse sediment removal. • Secondary: stormwater filtration systems (i.e. Stormfilter or other commercially available equivalent) for nutrient and fine sediment removal. Treatment efficiencies of the GPT's should be sourced directly from the manufacturer at the time of detailed assessment and modelling.
Rainwater Tanks (RWTs)	Provides primary sedimentation and beneficial re-use of stormwater.	Where possible stormwater shall be collected from roofs in appropriately designed RWTs. Rainwater shall be re-used for landscape irrigation (i.e. Toyota Stadium playing surface and garden areas across the development) as well as toilet flushing in the Leagues Club and proposed Shopping Centre development.
Grassed Swales	Provides sedimentation, infiltration and nutrient removal.	Grassed swales to be included where possible alongside internal road networks. Swales shall be lined to prevent excess infiltration over landfill areas. Grassed swale size and locations to be confirmed at the Project Application stage through detailed modelling.
Permeable Pavers	Removal of particulates and some dissolved pollutants through filtration and absorption on to filter media particles. Reduce runoff during storm event.	Permeable pavers are to be provided in off street parking bays. Surface area and depth of filter media to be confirmed at the Project Application stage through detailed modelling.

4.6 Conclusions

Stormwater quality objectives outlined in SSC DCP (2006) shall be achieved using catchment controls such as swales and litter reduction programs as well as various end of line treatment structures including pit inserts and GPTs, as well as stormwater collection and re-use within the site.

Stormwater re-use of collected roof water for non-potable re-use such as toilet flushing and landscape irrigation is proposed. Total rainwater tank capacity shall be determined based on roof areas and water demand.

5 References

Institute of Engineers Australia, 2006. *Australian Rainfall and Runoff.*

Department of Environment and Climate Change NSW (DECC), 2008. *Management Urban Stormwater: Urban design* (Consultation Draft).

Department of Environment, Climate Change and Water (DECCW), 2010. *Flood Risk Management Guide – Incorporating sea level rise benchmarks in flood risk assessments*.

DHI (October 2002). *Stormwater Drainage and Water Quality Strategy* (Project Number 50139).

J & K (September 2002). Geotechnical Investigation for Proposed Cronulla Leagues Club Rezoning (Ref: 17119SPrpt).

Kozarovski and Partners (March 2007). *Flood Study* (Project Number 891).

Kozarovski and Partners (2009). *Impact and Climate Change on Flood Levels in Captain Cook Drive* (Job Number 1404).

SMEC (March 2002). *Stormwater Drainage and Water Quality Strategy* (Document Number 31226.067).

Sutherland Shire Council, 2006. *Sutherland Shire Development Control Plan.*

Sutherland Shire Council, 2009. *Environmental Specification: Stormwater Management.*

Hyder Consulting, (March 2009*) Site Stormwater Assessment*

6 Attachment A – Site Development Plans

7 Attachment B - Figures

Martens & Associates Pty Ltd ABN 85 070 240 890		Environment | Water | Wastewater | Geotechnical | Civil | Management	
Drawn:	JSF	**SITE AERIAL (2011)** **Approximate site boundaries.**	**FIGURE 1**
Approved:	ASN		
Date:	12/7/11		
Scale:	N/A		Job No: P1103017

8 Attachment C – Previous Reports

REFER AT&L Stormwater and Services Report – Concept Application for the following reports

DHI (October 2002). *Stormwater Drainage and Water Quality Strategy* (Project Number 50139).

J & K (September 2002). Geotechnical Investigation for Proposed Cronulla Leagues Club Rezoning (Ref: 17119SPrpt).

Kozarovski and Partners (March 2007). *Flood Study* (Project Number 891).

Kozarovski and Partners (2009). *Impact and Climate Change on Flood Levels in Captain Cook Drive* (Job Number 1404).

SMEC (March 2002). *Stormwater Drainage and Water Quality Strategy* (Document Number 31226.067).

Hyder Consulting (March 2009) Site Stormwater Assessment

Appendix C – Reference Documents

- SMEC (March 2002). *Stormwater Drainage and Water Quality Strategy* (Document Number 31226.067);
- DHI (October 2002). *Stormwater Drainage and Water Quality Strategy* (Project Number 50139);
- J & K (September 2002). Geotechnical Investigation for Proposed Cronulla Leagues Club Rezoning (Ref: 17119SPrpt);
- Kozarovski and Partners (March 2007). *Flood Study* (Project Number 891);
- Kozarovski and Partners (2009). *Impact and Climate Change on Flood Levels in Captain Cook Drive* (Job Number 1404).
- Hyder Consulting (March 2009) Site Stormwater Assessment

SHARKS

EASTERN SITE RE-ZONING

STORMWATER DRAINAGE AND WATER QUALITY STRATEGY

Job No 31226.067

SMEC

Snowy Mountains Engineering Corporation

March 2002

DOCUMENT RELEASE INFORMATION

Client	BDO Property
Project Name	Sharks Eastern side re-zoning, stormwater drainage and water quality strategy
Document Number	31226.067
Document Title	Report on Stormwater Drainage and Water Quality Strategy
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1 Introduction

The Cronulla Sharks have for some time been negotiating with Sutherland Shire Council in regard to future land use and development potential of their landholdings. A previous proposal sought the rezoning and use of their entire site for a range of new activities. However, more recently, Council has indicated general support to the rezoning of the eastern portion of the site.

BDO Property, consultants to the Sharks, have commissioned a group of consultants to facilitate and review all aspects of the proposed rezoning and development of the site.

SMEC Australia was commissioned to develop a stormwater drainage and water quality strategy for the proposed rezoning and development of the site. The previous strategy sought to prepare an overall drainage strategy for the entire Sharks site, however this has now been altered to deal with the eastern portion of the site only.

The overall purpose of this study is to:

- To improve the current relationship between the site and Woolooware Bay in terms of drainage and water quality;
- Assess the current flooding and develop strategy to overcome flooding problems if any.
- Assess the ground water regime, and ground water quality.
- Develop a stormwater drainage and water quality strategy in accordance with the Council's Stormwater Management Policy and Guidelines and Stormwater Drainage Manual.
- Address the requirements in Southerland Shire draft DCP for Wetlands

The initial proposal covered the entire site owned by Sharks International, however, this report refers to the eastern side only, covering the area east of the tidal channel.

2 Background

Subsequent to the lodgement of the original rezoning proposal Council reviewed the initial SMEC report on stormwater and drainage for the proposed rezoning. That review identified a range of issues on which Council officers required further detail. These were confirmed in correspondence from Council, dated 24 December, 2001, and are noted below as follows:

A revised stormwater quality and quantity report that addresses the following deficiencies:

- *The submission has not defined the flood behaviour accurately or determined the design levels along the channel. Hydraulic modelling of the Golf Course, the tidal channel and all overland flow paths will be required.*

- *No detailed survey plan has been submitted. The site is generally flat so a survey plan (min. contours of at least 0.25 metres) would be required to assess whether or not there is adequate grade for pipes, channels and grass swales to be constructed in accordance with the requirements of Council's Stormwater Management Policy and guidelines. As* *the area is tidal influenced, preliminary indications are that the site may have been filled in areas in order to achieve adequate grade. Flooding of basement car parks is relevant.*

- *It should be noted that adjoining the site is a nationally Significant Wetland (RAMSAR listed wetland). No indication of flow rates within the existing channel on the site and the potential impacts of the stormwater outflow on the adjoining wetland have been provided.*

- *No structural or hydrological information in regard to the proposed humeceptor, gross pollution traps, grassed swales, rainwater tanks or the water re-use systems has been provided.*

- *No information has been submitted in regard to the biota required within the drainage channel and grassed swales in order to effectively 'polish' the stormwater. Further hydraulic information would be required in order to determine the flow rates required for efficient 'polishing' of the stormwater.*

- *No information has been submitted in regard to maintenance of the proposed riparian corridor, or in regard to the desilting of the drainage channel.*

- *No comments have been submitted in regard to the potential breeding of mosquito's within the drainage channel, grassed swales, or the rainwater tanks. As the site adjoins a wetland, mosquito breeding may be an important issue.*

- *A preliminary review of the proposal indicates that there may be impacts on Council's stormwater system and future road works on Captain Cook Drive may impact on the stormwater drainage proposal. Any further information submitted should be referred to Stormwater Management Unit (Engineering Division) for comment.*

A prior meeting was arranged with the various Council officers responsible for reviewing the original specialist reports to discuss and define the required additional works. This meeting was held at Council on 20 December, 2001 and included the responsible officer for the stormwater and drainage issues.

At that meeting, the officer was advised that the proposal put forward by the Sharks was not a Development Application and at this stage was a land use concept and that the initial report had therefore sought to identify a strategy for dealing with and improving the relationship of the site with Woolooware Bay.

The officer agreed that the strategy put forward for the site would be suitable but that certain additional information would be required to determine its suitable application. Many of the items noted in Council's correspondence could therefore be dealt with at the Development Application stage. Furthermore it was confirmed that the revised rezoning proposal only sought development on the eastern portion of the site and not the western playing fields. It was therefore agreed and minuted that the following additional items should be provided to Council in a revised report that dealt with the rezoning proposal for the eastern site:

- A review of the site survey to demonstrate that the grades are suitable for the strategy;
- Preliminary sizing of pipes and tanks to suit the proposal;

- Some demonstration of the fact that flows from the site will be decreased as outlined by the strategy; and
- A revision of the drainage strategy to conform with the latest land use and development proposal for the eastern site.

However, it was generally concluded by the Council officer that the strategy was a good drainage solution that would be suitable to the site.

3 Site description

The subject site is located between Woolooware Bay and the Woolooware Golf Course, extending east from the existing tidal channel (Figure 1, 2 and 3). The site has been created some 30 years ago by a landfill of building and domestic refuse. The site is relatively flat, sloping away from Woolooware Bay towards Captain Cook Drive, with ground elevations between 3.2 and 4 m AHD. A recently undertaken survey confirmed these elevations. The playing field has a layer of topsoil with grassed cover. The car park is with bitumen cover.

4 Main Issues

4.1 Proximity to a Wetland

The site is adjacent to a Woolooware Bay wetland and the Councils draft DCP for wetlands applies to this development. The hydrological and water quality objectives of the DCP are repeated below for clarity:

> **Objective 1**: To improve, maintain or restore the physical, chemical and biological processes of the wetland by minimising negative impacts created by changes to wetland hydrology from adjoining land uses in the catchment.
>
> **Objective 2:** To protect and enhance the natural values and ecological functions of wetland habitat from potential impacts of adjoining or upstream/downstream land uses. This includes elevated nutrient and sediment loads, stormwater runoff, removal of vegetation and changes to landform.

These objectives have been incorporated into the proposed stormwater management scheme, and particular aspects are discussed in the following sections. In general the above objectives would be achieved if the impacts of the current land use are minimised and/or eliminated. The obvious current land use impacts on the adjacent wetland are:

- The subject site has an area of some 5.93ha and discharges into a tidal channel. The upstream catchment connected to the tidal channel has an area of some 246 ha. The subject site represents only 2.4% of the total catchment. The hydrological, hydro-geological and the water quality regimes of the wetland are thus governed by the land use in the upstream catchment, with the subject site having a minimal impact. However, the best management practice principles have been incorporated into the proposed stormwater management strategy aiming at maximising the benefits and minimising the negative impacts.

- The existing land use is associated with a significant concentration of people during game events, resulting in large quantities of litter being deposited on the surface. A significant amount of this litter is transported into the tidal channel and then into the wetland. The proposed development would have to minimise and even eliminate litter export to the wetland.

- The site is located over a land fill, which has a potential for leachate generation and leachate export to the wetland. The exothermic processes inside the landfill consume the internally available moisture, however, leachate is created when external water such as rainfall infiltration exceeds the exothermic water consumption. The stormwater management strategy for the site is thus based on minimising the rainfall infiltration aiming at leachate reduction.

- The existing carpark is covered with bitumen, resulting in most of the site being impervious. The rainfall runoff from the existing roofs and the carpark enters the tidal channel, resulting in higher velocities during short, but intensive storms. The pollutants deposited on the roofs and the carpark as a result of atmospheric fallout and leakage from cars are exported into the tidal channel and then into the wetland. The stormwater management strategy would have to reduce the peak discharge values and runoff volumes and minimise the pollutants' export.

4.2 Flooding

There is an open, tidal channel to the west of Toyota Park. The channel is 5 to 6 m wide and approximately 1.5 m deep. It drains a significant catchment area of approximately 246 ha. The catchment boundaries were defined using the 1:4000 ortho-photo maps. 153 ha are estimated as the pervious fraction of the catchment with the remaining 93 ha as impervious. The runoff from the catchment is discharged into the Golf Course area, which acts as a temporary flood storage.

The design peak discharge values were obtained using RAFTS-XP hydrological model. The catchment was subdivided into 13 sub-catchments taking into account the topographical features and the flow paths into account. The catchment subdivision is shown on Figure 1 and the main sub-catchment parameter values are given in Table 2.1

Table 2.1 Catchment parameter values

Link	Area (ha)		Slope (%)	Pern		B		Initial loss (mm)		Cont. loss (mm/hr)	
	Perv	Imp.		Perv.	Imp.	Perv.	Imp.	Perv.	Imp.	Perv.	Imp.
11	0.22	0.22	5	0.035	0.025	0.0081	0.0007	15	2	15	0.5
10	26.55	26.55	4	0.035	0.025	0.1088	0.0098	15	2	15	0.5
9	12.3	12.3	6	0.035	0.025	0.0596	0.0054	15	2	15	0.5
8	12.7	12.7	8	0.035	0.025	0.0525	0.0047	15	2	15	0.5
7	18	1.6	2	0.035	0.025	0.1257	0.0032	15	2	15	0.5
13	15.7	15.7	4	0.035	0.025	0.0828	0.0075	15	2	15	0.5
12	7.5	0	1.7	0.035	0	0.0864	0	15	2	15	0.5

6	23.4	15.4	4	0.035	0.025	0.1019	0.0074	15	2	15	0.5
5	12.9	4	4.5	0.035	0.025	0.0705	0.0035	15	2	15	0.5
2	8.6	0	0.1	0.035	0	0.3816	0	15	2	15	0.5
1	5	5	0.5	0.035	0.025	0.1289	0.0117	15	2	15	0.5
4	10.2	0	1	0.035	0	0.1322	0	15	2	15	0.5
3	0.2	0	1	0.035	0	0.0171	0	15	2	15	0.5
Out	0.001	0	1	0.025	0	0.0008	0	15	2	15	0.5

No streamflow gauging data were available to calibrate the hydrologic model, so typical parameter values expected for this catchment were adopted. The model was run for the 100 year ARI case to determine the critical rainfall duration. The 90 minutes storm produced the highest peak discharge value, so it was adopted as the critical storm duration (it does not reflect the time of concentration, but rather the design rainfall temporal pattern). The 90 minutes design rainfall for various return periods were used to obtain the corresponding peak discharge values, which are given in Table 2.2

Table 2. 90 minutes design peak discharge (m3/s)

ARI (year)	5	10	20	50	100
Q golf course	44.0	52.0	63.9	74.2	86.5
Q site (including the training fields)	2.0	2.3	2.8	3.2	3.6

Note: The peak runoff value from the site east of the channel is 2 m3/s or only 2% of the total peak value, of which 1.0 m3/s is directed to the rainwater tank and 1.0 m3/s is directed to the tidal channel. The runoff from the proposed development would be less than the peak discharge value for existing conditions due to the effect of the rainwater tank. It can be concluded that there is no impact from the site's runoff on total flow entering the wetland.

The existing channel will not be able to convey all the runoff, during larger storms, so it is expected that approximately 50% of water would overflow the Captain Cook Drive during the 100-year event and flow along the paved driveway opposite to the Captain Cook Ovals into Woolooware Bay. The proposed development is not adjacent to the channel (Toyota Park is located between the development and the channel) and is not expected to be affected by the flooding from the channel, as the 100 year flood levels are expected not to exceed elevations of 2 m AHD.

4.3 Leachate from the landfill and Acid Sulfate Soils

The existing site was created by a landfill some 30 years ago. Initial consultation with geotechnical consultants, involved in the previous investigations of the site, indicated that:

- The deposited material is mainly building refuse and a domestic waste.
- The land fill was most likely created by depositing the refuse over mangroves area at R.L 0.0 m AHD without any excavation, so there are no active acid sulfate soils expected to have been created by the land fill operation.

In accordance with the opinion of SMEC's landfill expert Mr. Daniel Cramer, an intensive leachate is generated from a domestic refuse land fill in the initial 20 years of deposition with gradual decrease within the following 30 years. Some leachate is thus still expected to be generated from the land fill area. The deposited organic mater is decomposed as a result of the anaerobic processes. The fermentation is an exothermic process, which can create temperatures as high as 50 ° C consuming most of the available moisture releasing gases such as methane. When the decomposed organic mater gets in contact with external water a nutrient reach solution is created, which, if it finds its way out of the land fill area, is referred to as a leachate. In this particular case, the source of water is either the ground water flow and/or the rainfall infiltration.

A groundwater flow can exist in this location because of the significant catchment area upstream. However, the open tidal channel in the Golf Course area intercepts the ground water flow, so the resulting water table at the site is expected to oscillate around the mean sea level. The remaining source of water is thus the rainfall infiltration. In order to minimise the possibility for leachate creation and its export to Woolooware Bay, it would be desirable to minimise the rainfall infiltration on site. It is thus proposed not to increase rainfall infiltration and if possible, to reduce it by intercepting the surface runoff into piped stormwater drainage system and conveying it to a suitable discharge point.

No active acid sulfate soils are expected on site, however it is almost a certainty that potential acid sulfate soils are present bellow the pre land fill natural ground levels. If these soils are exposed to oxygen they will oxidize into active sulfate soils, which if not treated, will result in a sulfuric acid discharge to Woolooware Bay. Any plans for future development on this site must minimise the amount of excavation below the pre landfill natural ground levels, and if it is unavoidable, an appropriate treatment must be specified.

4.4 Discharge into Woolooware Bay

It is an imperative not to discharge stormwater runoff directly into Woolooware Bay in order to prevent erosion by concentrated flows. The stormwater drainage system of the future development would have to intercept the surface runoff from the site and convey it away from Woolooware Bay. The most suitable point of discharge would be the tidal channel, which would attenuate the higher velocities prior to entering the wetland area.

The proposed stormwater system is thus based on a piped system combined with grassed swales (Figure 3). Some invert levels and the corresponding ground levels are indicated on the Figure to demonstrate that the proposed system is realistic.

The grassed swales would discharge into the tidal channel immediately downstream of the Captain Cook Drive’s culvert. The invert level of the grassed swales would have to be above the existing ground water table, to avoid oxidation of the potential acid sulfate soils.

The minimum slope of the grassed swale would have to be 0.15%, with subsoil drainage to avoid water logging and mosquito breeding. The grass swales should have flat side slopes (1 in 4) and be covered with normal grass as a part of the overall landscaping in order to simplify the maintenance. The maximum velocities should not exceed 2.0 m/s and depth of flow should be less than 0.2 m to maintain a low flood hazard even during a 1 in 100 year event.

4.5 On Site Detention

An On Site Detention (OSD) system reduces the peak discharge rates from a developed site to pre-development peak values, however, the volume of the runoff remains unchanged. The impact of OSDs is usually beneficial in the upper and middle parts of a catchment. OSDs are ineffective in the downstream parts of a catchment and can even increase the peak discharge values because of the coincidence in the peaks of the catchment hydrograph and the outlet hydrograph from the OSD. The results from hydrologic modelling described in section 3.2 indicated that the site's peak discharge occurs earlier than the upstream catchment's peak. An On Site Detention on the site would cause these peaks to coincide, resulting in an increase in the peak discharge value, so it is not recommended.

4.6 Constructed wetland as a device for water quality control

As discussed in section 3.3, an infiltration should be discouraged to minimise the leachate from the site. A constructed wetland would have to be located at the lowest point of the site, near the tidal channel with a ground elevation of approximately 1.5 m AHD. The bottom of the wetland would have to be below the mean sea level (0.0 to –1.0 m AHD), allowing for 1.0m to 1.5m head for stormwater pipes and swales and additional 1.0m to 1.5m for the wetland itself. Two major problems are expected:

- Submerged discharge to the tidal channel and salt water intrusion into the wetland;
- Generation of acid sulfate soils during the excavation for the wetland.

Taking into account the above as well as the high standard of maintenance required for the constructed wetlands to perform properly a constructed wetland is not recommended. Runoff harvesting is proposed instead.

4.7 Stormwater harvesting

Roof runoff can be used for toilet flushing and irrigation without pre-treatment. The runoff is relatively clean, and if the rainwater tanks are installed at high elevation, it can be used by gravity.

The Toyota Park and the training fields are irrigated in order to maintain the grass cover. The total roof area of the proposed development is approximately 1.4 ha, while the Toyota Park has an area of some 1.8 ha. The average annual rainfall in the area is around 1.1 m/year, while the evaporation rate is approximately 1.2 m/year. It is obvious that the annual demand for irrigation would exceed the annual roof runoff. So if sufficient storage is provided it could be expected that all roof runoff could be stored and disposed for irrigation.

Results from water balance modelling undertaken for a similar system in Kogarah area (stormwater re-use for toilet flushing and irrigation with tank volumes of 45 l/m2 of roof area) indicate that the system is capable of capturing all roof runoff generated from 1 in 3 months to 1 in 6 months rainfall events.

A 700 m3 rainwater tank could be installed under the viewing stand north of Toyota Park (Pepsi Hill). The roof runoff would be intercepted by a system of gutters, down pipes and stormwater pipes and discharged to the rainwater tank by gravity. A small buster pump would be required to pump water from the tank for irrigation. The layout of the proposed system is shown on Figure 2. The required pipe diameters range between 225 mm to 750 mm, allowing some pressurised flow during a 100 year storm event. If the rainwater tank fills up the spill would be directed to the tidal channel. A general type GPT would have to be constructed upstream of the rainwater tank to intercept leaves and sediments.

The rainwater tank / reuse system would be extremely beneficial for the protection of the water quality in Woolooware Bay, as it would capture the deposited pollutants from the atmospheric fallout and re-direct most of the polluted water to the grassed area, which would act as a filter strip for the irrigated water. This system is better than a wetland because it eliminates 100% of the pollutants during all events up to and including the 1 in 3 months rainfall events, while a well designed and maintained wetland can uptake only a portion of the pollutants during the same events.

The runoff re-use would improve the water quality, reduce the discharge quantity and flow frequency and save potable water, so it is strongly recommended.

4.8 Litter and coarse sediment control

The subject site is a high generator of litter. The majority of the litter is expected from the open carpark and the main pedestrian access routes. The surface runoff from the site would discharge into grassed swales. The grass swales would intercept some of the pollutants, however, significant quantities of litter, coarse sediments and oil and grease could still enter the tidal channel. In order to intercept these pollutants from entering Woolooware Bay, a general type Gross Pollutant Trap (GPT) is proposed at the end of the grass swale. The storage capacity of the GPTs would have to be in excess of 200m3 (10 m wide, 30 m long and 1.5 m deep) to achieve velocities in a range of 0.1 m/s during a 1 in 100 year event to separate coarse sediments and litter from the flow. The GPT would have to be off-line, to prevent export of accumulated gross pollutants into the tidal channel. The GPT would have to be covered to ensure public safety, to hide the accumulated litter and to prevent mosquito breeding.

4.9 Sediment and erosion control during construction

Sediment and erosion control measures must be designed to EPA requirements. An erosion and sediment control plan must be prepared in accordance with the NSW Department of Housing Manual “Managing Urban Stormwater, Soils and Construction” at the building application stage.

The plan should consist on the best practices within the construction site, with sediment ponds at the outlets as the final safeguards.

5 Recommended Stormwater Drainage and Water Quality Control Strategy

The proposed strategy addresses all the main issues identified in section 2 and incorporates the following:

- Separate roof and surface runoff systems.
- Rainwater tank to harvest roof runoff for irrigation of Toyota Park and the training fields.
- Discharges of stormwater runoff away from Woolooware Bay.
- A piped system over the land fill area to reduce infiltration.
- Grassed swales with subsoil drainage along Captain Cook Drive with invert levels above the ground water table to slow down the flow velocities, to remove pollutants during smaller storm events and to expose the accumulated litter to the public (stormwater pipes hide the litter).
- Off-line GPT with oil traps at the end of the swale to protect the tidal channel from litter, coarse sediments and oil/fuel.
- Prepare and implement erosion and sediment control measures during construction to prevent sediment export to Woolaware Bay.

The layouts of the proposed stormwater drainage and water quality control systems are shown on Figures 2 and 3.

SHARKS

EASTERN SITE RE-ZONING

STORMWATER DRAINAGE AND WATER QUALITY STRATEGY

Stage 2 ZAP

Distribution: BDOProperty: Mr. AD (13=number of sets)
DHI: PK - (1=number of sets)

Client BDO Property		Client's representative Mr. Andrew Dubridge			
Project Stormwater drainage and water quality strategy for proposed re-zoning of the Sharks eastern side		Project No 50139			
Authors: Pavel Kozarovski		Date: 2 October 2002 Approved by: GPS			
Revision	Description	By	Checked	Approved	Date
Key words: Stormwater, flooding, water quality, stormwater harvesting		Classification ☐ Open ☐ Internal ☒ Proprietary			

1. EXECUTIVE SUMMARY

The Sutherland Shire Council passed a resolution of support for the rezoning requesting additional research and investigation work as a part of Stage 2 of the Zoning Assessment Policy. The work undertaken by DHI Water and Environment has shown that the rezoning and the subsequent development :

- Will not be affected by the 100 year ARI flood, even though Captain Cook Drive is expected to be inundated;
- Will not cause any impact on flood levels upstream nor erosion downstream of Captain Cook Drive;
- Will not be flood affected (basement carpark) during an extreme flood event caused by a coincident king tide and storm flow equal to three times the 1 in 100 year flow;
- Will not affect the groundwater flow regime and the water table upstream or downstream of the site;
- Will improve the water quality entering the wetland area;
- Will reduce the amount of leachate export to Woolooware Bay;
- Will slightly reduce the total volume of fresh water exported to the wetland, which is perceived as a beneficial impact (because urban development increases the volume of runoff and the proposed development will reduce it);
- Will conserve water by harvesting stormwater flow for irrigation;
- Will not encourage or promote mosquito breeding;

The details of the proposed stormwater drainage and water quality management scheme are given below, together with the description of the modelling employed to quantify the impacts of the proposed development on flooding and water quality.

2. INTRODUCTION

The Cronulla Sharks have for some time been negotiating with Sutherland Shire Council in regard to future land use and development potential of their landholdings. The rezoning project is subject to Council's Zoning Assessment Policy (ZAP). At a meeting of Council on 12 August 2002 Council passed a detailed resolution of support for the rezoning requesting the Sharks to undertake additional research and investigation work as a part of Stage 2 of ZAP.

BDO Property, consultants to the Sharks, have commissioned a group of consultants to facilitate and review all aspects of the proposed rezoning and development of the site.

SMEC Australia prepared a report on stormwater drainage and water quality strategy for the proposed rezoning and development of the site during Stage 1. DHI Water and Environment Pty Ltd was commissioned by BDO Property to complement SMEC's report in accordance with the additional requirements specified by the Council. The Council's specific requirements addressed by this report are listed in Table 1.1, together with the relevant section number/heading.

Table 1.1 Cross reference of requested information with the sections in the report

Item	Council Specification	Section/heading addressing the requested specification
21	A geotechnical report shall be prepared by appropriately qualified engineer and in accordance with the following: b)An assessment of the impacts of a dual level basement and associated development on the natural subsoil hydrology. Will subsoil flow regimes become effected? Will the groundwater/leachate be redirected? Detailed assessment is required of the impacts on the adjoining wetland	Section 3.3
23	Stormwater Drainage – To adequately assess the impacts that the proposed development will have on the adjoining wetland and aquatic reserve, the following issues must be satisfactorily resolved:	
	a) The submission must conclusively address the changes and effects of stormwater flow on the wetland for both pre and post development. The existing stormwater flow from the site is a combination of un-concentrated overland sheet flow and concentrated flow, with the stormwater leaving the site at varying locations and varying volumes and velocities. A detailed assessment of the changes to the stormwater flow regime and its impact on the adjoining wetland is required.	Section 3.2
	b) The previous submission had not accurately defined the flood behaviour of the effected floodplain during varying storm events. Hydraulic modelling of the of course, tidal channel and all overland flow paths (both pre and post development) are required. A complete catchment analysis is required to accurately determine the appropriate flood management during a probable maximum flood. In relation to option 1, what effects will the probable maximum flood have on the proposed development?	Section 3.2
	c) No detailed information has been submitted in regard to stormwater water-quality and its on-site treatment (eg, sediment loading, nutrient loading, pollutants generated from trafficable areas). What effects are anticipated on the wetland due to changes in water quality as a result of the development?	Section 3.4, 3.9
	d) Provide information in regard to the ongoing maintenance of the stormwater system,	Section 5

Item	Council Specification	Section/heading addressing the requested specification
	pollution prevention devices, maintenance of the riparian corridor, and on-going maintenance in regard to de-silting the drainage channel. In relation to option 1, what are the estimated pollution loads generated as a result of the proposed development? e) No comments have been submitted in regard to the potential breeding of mosquitos within the drainage channel, grassed swales, or rainwater tanks. As the site adjoins a wetland, mosquito breeding is an important issue.	 Section 3.4
26	Will the volume of stormwater exiting the site through the tidal channel be increased post development? If so, what impact will result from concentrating the point of stormwater discharge? Will energy dissipation be required at the outlet? Will the changed hydrological scheme result in changed velocities of water entering the mangrove area from the tidal channel? What impact will this have on the mangroves, mudflat and wetland areas?	No, the volume exiting the site through the tidal channel will be reduced by some 30%. See Table 3.7, Section 3.9. The hydrological regime is not expected to change significantly. The frequent low flows are expected to reduce slightly, while the high flows are expected to increase by some 0.5%, which is negligible.

3. SITE DESCRIPTION

The subject site is located between Woolooware Bay and the Woolooware Golf Course, extending east from the existing tidal channel. The site has been created some 30 years ago by a landfill of building and domestic refuse.

The site can be divided into three main hydrological parts:

- The Toyota Park, Shark's playing field which drains to the tidal channel;
- The club's building which drains towards Captain Cook Drive's drainage system , which eventually discharges to the tidal channel and
- The carpark adjacent to the club's building. Approximately one third of the bitumen covered carpark area drains towards Captain Cook Drive, one third discharges to Woolooware Bay as a diffuse outflow through grassed buffer located to the east of the site and one third drains through a 150 mm diameter pipe directly to the Bay as concentrated flow.

The total site area east of the tidal channel is some 5.8 ha, while the catchment area upstream of the tidal channel is some 253 ha or approximately 40 times the site area.

4. MAIN ISSUES

4.1. Proximity to a Wetland

The site is adjacent to a Woolooware Bay wetland and the Councils draft DCP for wetlands applies to this development. The hydrological and water quality objectives of the DCP are repeated below for clarity:

Objective 1: To improve, maintain or restore the physical, chemical and biological processes of the wetland by minimising negative impacts created by changes to wetland hydrology from adjoining land uses in the catchment.

Objective 2: To protect and enhance the natural values and ecological functions of wetland habitat from potential impacts of adjoining or upstream/downstream land uses. This includes elevated nutrient and sediment loads, stormwater runoff, removal of vegetation and changes to landform.

These objectives have been incorporated into the proposed stormwater management scheme, and particular aspects are discussed in the following sections. In general the above objectives would be achieved if the impacts of the current land use are minimised and/or eliminated. The obvious current land use impacts on the adjacent wetland are:

- The subject site has an area of some 5.8 ha, of which approximately 3.8 ha discharge to the tidal channel and some 2.0 ha discharge directly to Woolooware Bay. The upstream catchment connected to the tidal channel has an area of some 253 ha. The subject site represents only 1.5% of the total catchment. The hydrological, hydro-geological and the water quality regimes of the wetland are thus governed by the land use in the upstream catchment, with the subject site having a minimal impact. However, the best management practice principles have been incorporated into the proposed stormwater management strategy aiming at maximising the benefits and minimising the negative impacts.
- The existing land use is associated with a significant concentration of people during game events, resulting in large quantities of litter being deposited on the surface. A significant amount of this litter is transported into the tidal channel and then into the wetland. The proposed development would have to minimise and even eliminate litter export to the wetland.
- The site is located over a land fill, which has a potential for leachate generation and leachate export to the wetland. The exothermic processes inside the landfill consume the internally available moisture, however, leachate is created when external water such as rainfall infiltration exceeds the exothermic water consumption. The stormwater management strategy for the site is thus based on minimising the rainfall infiltration aiming at leachate reduction.
- The existing carpark is covered with bitumen, resulting in most of the site being impervious. The rainfall runoff from the existing roofs and the carpark enters the tidal channel, resulting in higher velocities during short, but intensive storms. The pollutants deposited on the roofs and the carpark as a result of atmospheric fallout and leakage from cars are exported into the tidal channel and then into the wetland. The stormwater management strategy would have to reduce the peak discharge values and runoff volumes and minimise the pollutants' export.

4.2. Flooding

There is an open, tidal channel to the west of Toyota Park. The channel is 5 to 6 m wide and approximately 1.5 m deep. It drains a significant catchment area of approximately 253 ha. The catchment boundaries were defined using the 1:4000 ortho-photo maps. 156 ha are estimated as the pervious fraction of the catchment with the remaining 97 ha (38%) as impervious. The bulk of the runoff from the catchment is discharged into the Golf Course area, which acts as a temporary flood storage.

The design peak discharge values were initially estimated using RAFTS-XP hydrological model and then checked using WUFS model. WUFS is a time area model similar to the well known ILSAX model. The peak design flood discharge values estimated by WUFS (ILSAX) where some 10% less than those estimated by RAFTS-XP. There is no gauging of streamflows in the catchment, so WUFS (ILSAX) estimates were used as it has less parameters than RAFTS-XP.

The model layout is shown on Figure 3.1, and the basic model parameter values are given in Table 3.1. The 60 minute design storm duration produced the highest peak discharge values. The estimated peak discharge values for 1 in 5, 1in 10, 1in 20, 1 in 50 and 1 in 100 year ARI storm events are summarised in Table 3.2 for existing catchment conditions.

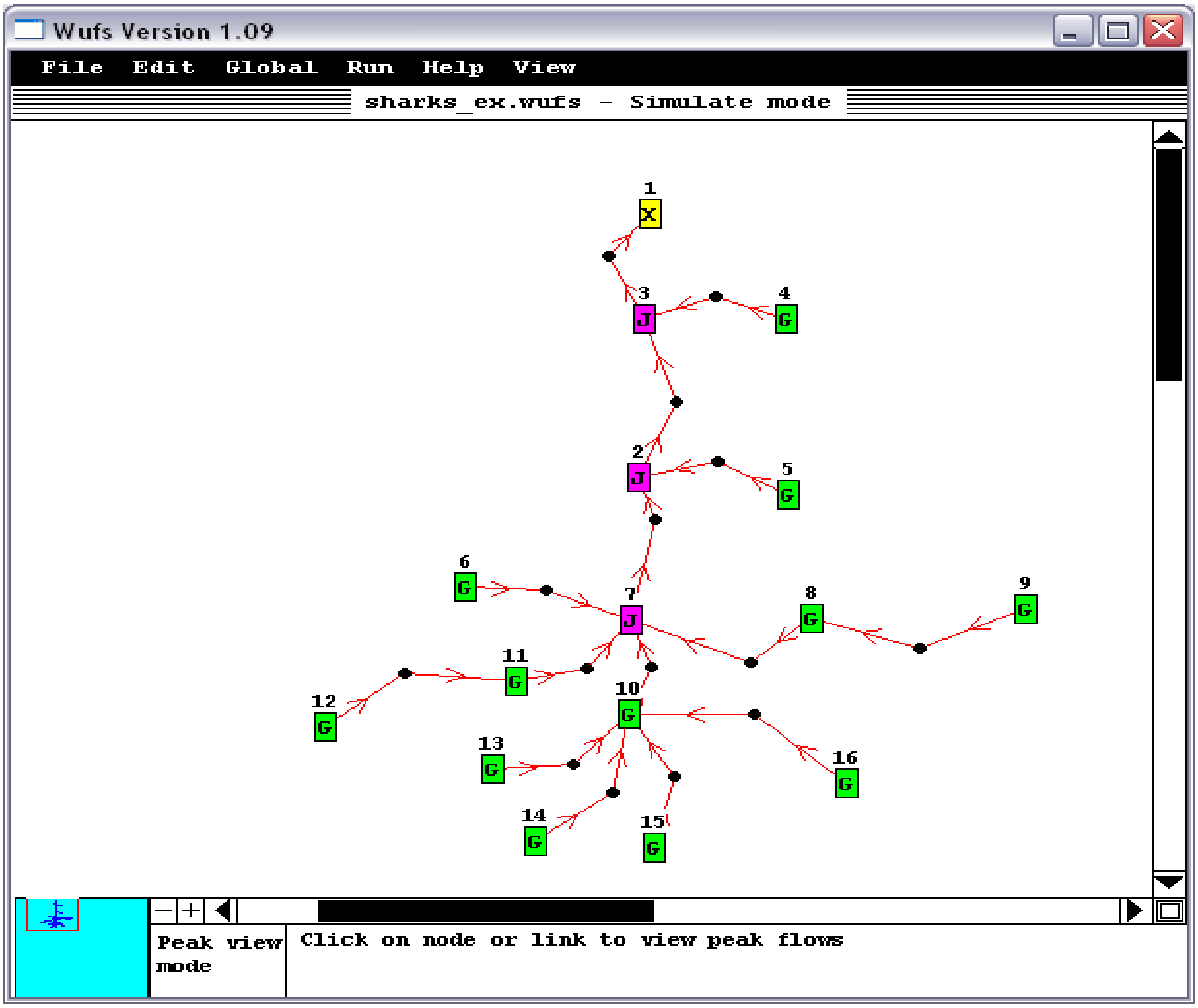

Figure 3.1 Hydrological model layout existing conditions

Table 3.1 Hydrological model parameter values (existing conditions)

Node Name	Impervious Area (ha)	Imp. A Tc (min)	Pervious	L (m)	S (%)	n
2 Captain Cook Drive						
3 d/s Endeavor Field						
4 Sharks Land	2	20	5.3	100	5	0.2
5 Lower Golf Course			8.6	200	0.5	0.2
6 Captain Cook Ovals	2.04	15	8.16	50	1	0.2
7 Middle of the Golf C						
8 Eastern Golf Course	4	15	12.9	200	5	0.2
9 East of Woolooware Rd	15.4	20	23.4	400	4	0.2
10 Southern Part_Golf_C	1.6	20	18	500	2	0.2
11 Western part_Golf_C			7.5	500	1.7	0.2
12 West of Gannons Rd	15.7	20	15.7	800	4	0.2
13 South_West_Railway	5	20	5	400	5	0.2
14 U/S John Dwyer Mem R	26.55	20	26.55	500	4	0.2
15 South of railway Lne	12.3	20	12.3	500	5	0.2
16 South East of Railw.	12.7	20	12.7	400	8	0.2

Table 3.2 Peak discharge values (m3/s) – existing conditions

		ARI (year)				
No.	Node Name	5	10	20	50	100
2	Captain Cook Drive	37.11	44.49	54.31	65.43	75.75
3	d/s Endeavor Field	38.36	45.97	56.13	67.57	78.13
4	Sharks Land	1.70	2.06	2.54	2.99	3.43
5	Lower Golf Course	0.84	1.06	1.37	1.82	2.20
6	Captain Cook Ovals	2.29	2.79	3.42	4.11	4.76
7	Middle of the Golf C	36.63	43.88	53.45	64.16	74.27
8	Eastern Golf Course	8.51	10.36	12.87	15.86	18.52
9	East of Woolooware Rd	6.13	7.30	8.87	10.59	12.25
10	Southern Part_Golf_C	20.53	24.44	29.69	35.56	41.10
11	Western part_Golf_C	5.42	6.41	7.73	9.16	10.53
12	West of Gannons Rd	5.15	6.02	7.18	8.38	9.57
13	South_West_Railway	1.81	2.13	2.57	3.04	3.49
14	U/S John Dwyer Mem R	9.17	10.79	12.93	15.20	17.41
15	South of railway Lne	4.36	5.14	6.18	7.29	8.37
16	South East of Railw.	4.76	5.64	6.81	8.08	9.31

The proposed stormwater drainage strategy would intercept the runoff from the roofs and discharge it into a rainwater tank, and all remaining surface area would be intercepted and discharged towards the tidal channel via a grassed swale. The rainwater tank would spill into the tidal channel near its outlet to Woolooware Bay. For the purpose of estimation of the flood discharge values it was assumed that the rainwater tank would be full at the start of each flood. This assumption is not the best representation of the proposed system, however it was adopted to remain on a conservative side. The layout of the adjusted model representing the proposed conditions is shown on Figure 3.2 , the model parameter values are given in Table 3.3 and the results are given in Table 3.4. The fall between the proposed development site and the tidal channel is in the range between 3 to 5 metres, which is sufficient to provide appropriate gradients.

Table 3.3 Hydrological model parameter values (proposed conditions)

No	Name	Imp. A (ha)	Tc (min)	Perv A (ha)	L (m)	S (%)
2	Captain Cook Drive					
3	d/s Toyota Park					
4	Training fields	0.64	5	5.3	100	5
5	Lower Golf Course			8.6	200	0.5
6	Captain Cook Ovals + u/s of Gannons Rd	2.04	15	8.16	50	1
7	Middle of the Golf C					
8	Eastern Golf Course	4	15	12.9	200	5
9	East of Woolooware Rd	15.4	20	23.4	400	4
10	Southern Part_Golf_C	1.6	20	18	500	2
11	Western part_Golf_C			7.5	500	1.7
12	West of Gannons Rd	15.7	20	15.7	800	4
13	South_West_Railway	5	20	5	400	5
14	U/S John Dwyer Mem R	26.55	20	26.55	500	4
15	South of railway Lne	12.3	20	12.3	500	6
16	South East of Railw.	12.7	20	12.7	400	8
17	Roofs	1	15	0	0	5
18	Eastern Side surface	2.35	15	0	0	5

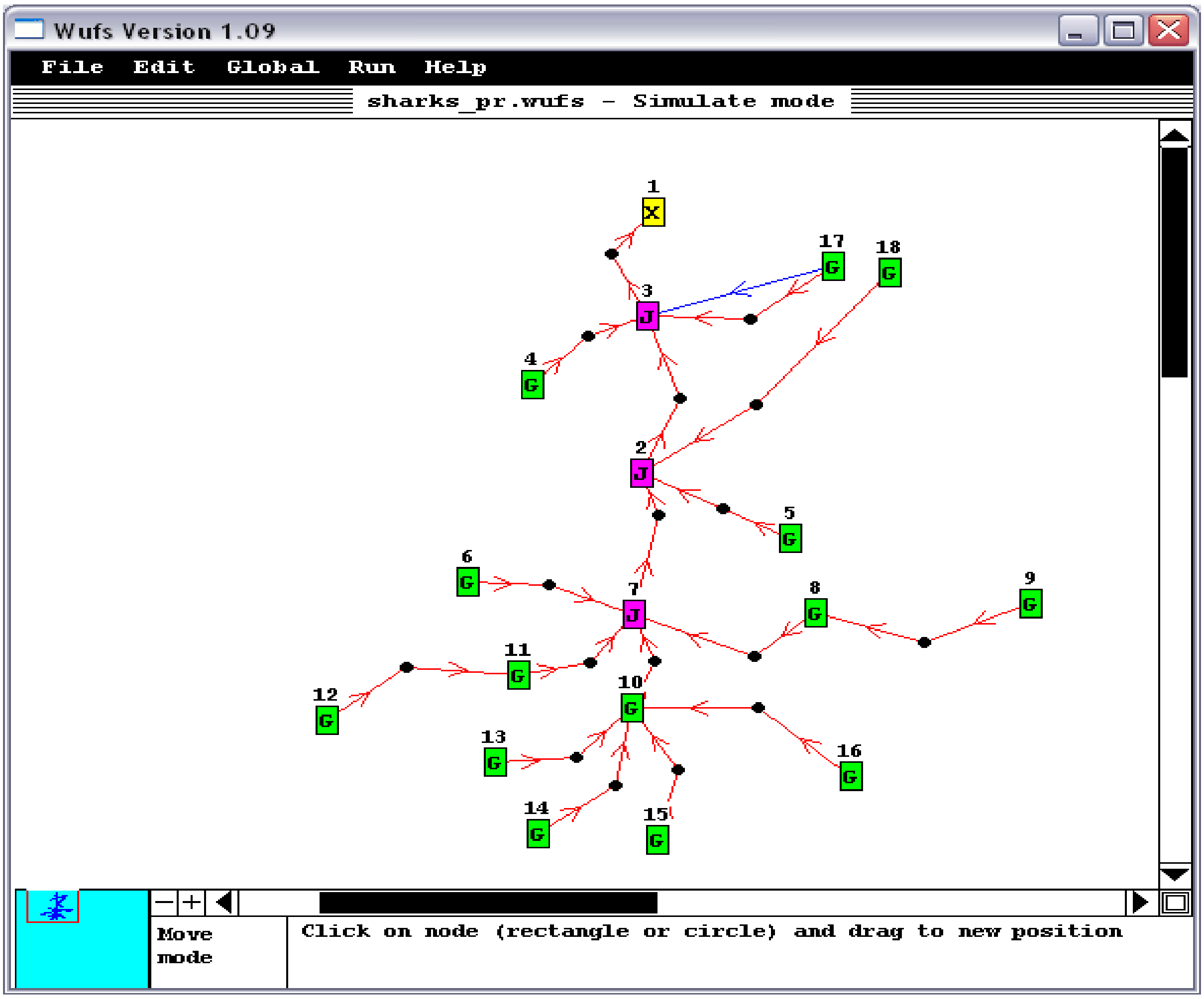

Figure 3.2 Hydrological model layout proposed conditions

Table 3.4 Peak discharge values (m3/s) – proposed conditions

		5	10	20	50	100
2	Captain Cook Drive	37.67	45.15	55.09	66.31	76.76
3	d/s Toyota Park	38.56	46.21	56.41	67.90	78.51
4	Training fields	1.31	1.59	1.98	2.46	2.87
5	Lower Golf Course	0.84	1.06	1.37	1.82	2.20
6	Captain Cook Ovals + u/s of Gannons Rd	2.29	2.79	3.42	4.11	4.76
7	Middle of the Golf C	36.63	43.88	53.45	64.16	74.27
8	Eastern Golf Course	8.51	10.36	12.87	15.86	18.52
9	East of Woolooware Rd	6.13	7.30	8.87	10.59	12.25
10	Southern Part_Golf_C	20.53	24.44	29.69	35.56	41.10
11	Western part_Golf_C	5.42	6.41	7.73	9.16	10.53
12	West of Gannons Rd	5.15	6.02	7.18	8.38	9.57
13	South_West_Railway	1.81	2.13	2.57	3.04	3.49
14	U/S John Dwyer Mem R	9.17	10.79	12.93	15.20	17.41
15	South of railway Lne	4.36	5.14	6.18	7.29	8.37
16	South East of Railw.	4.76	5.64	6.81	8.08	9.31
17	Roofs	0.31	0.36	0.42	0.46	0.52
18	Eastern Side surface	0.74	0.84	0.98	1.09	1.22

The impact of the proposed rezoning on peak flood flows entering Woolooware Bay is summarised in Table 3.5. It can be seen from the results that the impact of the proposed stormwater management scheme on flood flows in negligible and is within 0.5% of the total flows. Further more, the proposed scheme would eliminate concentrated discharge to Woolooware Bay from some 2 ha currently discharging to the Bay, and it does not take into account the beneficial impact of the rainwater tank on flood flows.

Table 3.5 Comparison of flood flows

Case	5	10	20	50	100
Q existing (m3/s)	38.36	45.97	56.13	67.57	78.13
Q proposed (m3/s)	38.56	46.21	56.407	67.897	78.513
difference (m3/s)	0.2	0.24	0.277	0.327	0.383
Difference (%)	0.52	0.52	0.49	0.48	0.49

Mike-11, an unsteady, quasi-two dimensional hydraulic model was established for the site to assess the flood behaviour of the tidal channel during large floods. 9 cross sections were surveyed by A.B. Stephens & Associates along the tidal channel. These cross sections were incorporated into Mike-11 model. The layout of the model is shown on Figure 3.4. Discharge hydrographs calculated by WUFS were entered into Mike-11 model as upstream boundary condition and the king tide was applied as a downstream condition. The joint probability of coincident peak king tide and peak runoff is very small. However the two coinciding peaks were used for definition of the flood behaviour in the tidal channel to remain on a conservative side. The king tide stage hydrograph and the 100 year discharge hydrograph are shown on Figure 3.3.

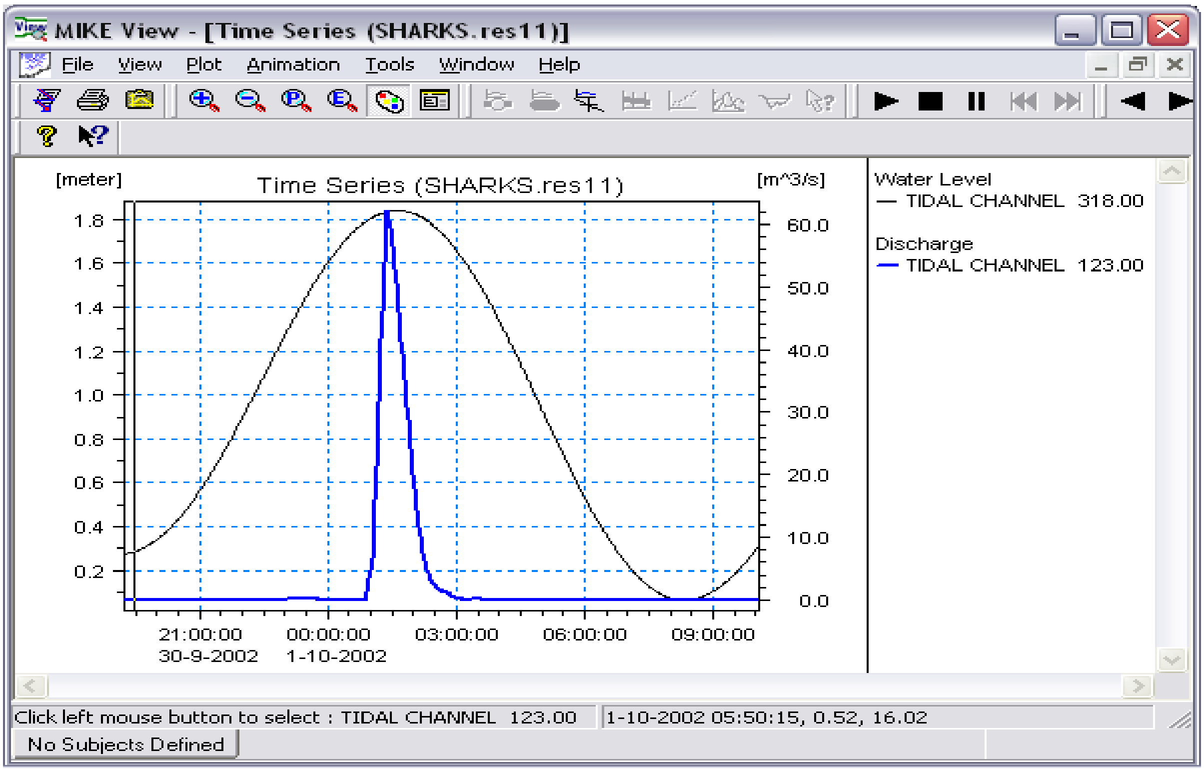

Figure 2.3 100 year discharge hydrograph and king tide

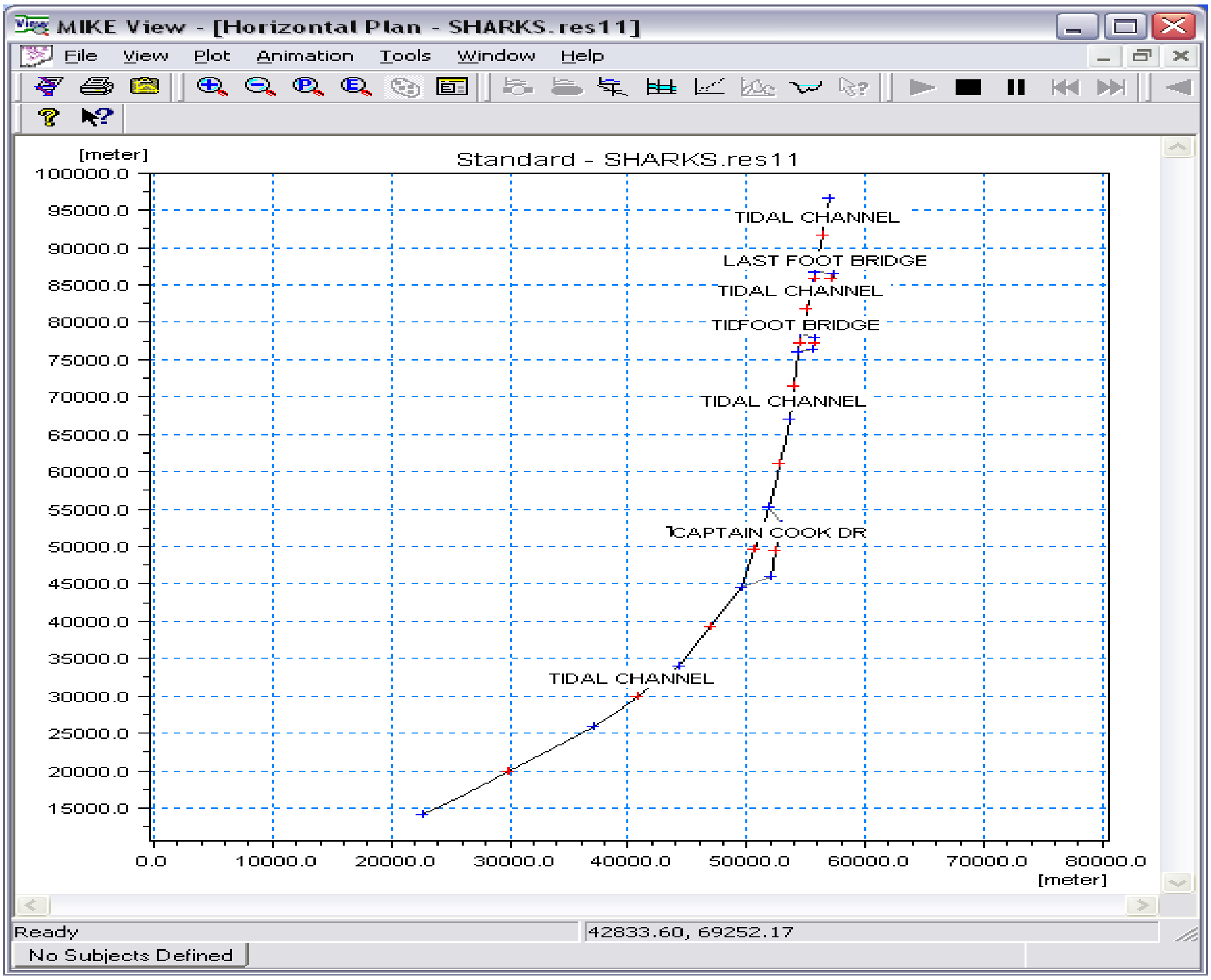

Figure 3.4 Mike-11 model layout

2 x2.4x1.2 m box culverts are located under Captain Cook Drive. It is reasonable to expect that the culverts would be blocked during a large storm event, so their capacity was halved. The 100 year ARI flood profile along the tidal channel is shown on Figure 3.5. It should be considered as a conservative estimate of the 100 year flood levels because of the coincidence between the king tide (peak at R.L. 1.85 m AHD), and concentrated flow along the Sharks land only. Namely, significant amount of overland flow is expected to enter the playing fields to the west of the site, however this flow path was not taken into account to remain on a conservative site.

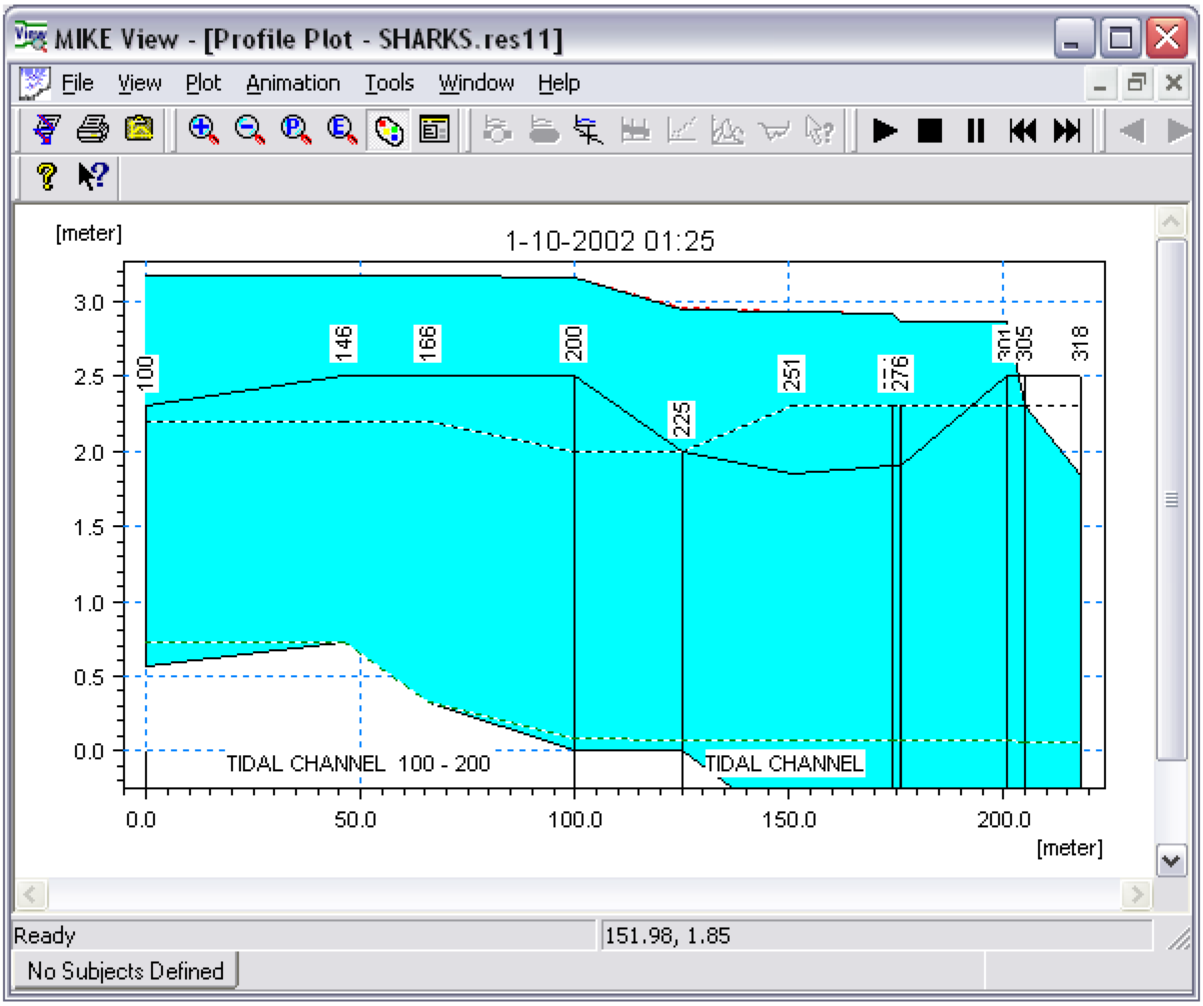

Figure 3.5 100 year flood profile along the tidal channel.
Note: Captain Cook Drive is located between cross sections 200 and 225

It can be seen from the profile that the conservative estimates of the 100 year flood levels are at or below R.L. 2.9 m AHD downstream of Captain Cook Drive, while the entrance to the level 1 basement carpark is at R.L. 3.4 m AHD, which represents 0.5 m freeboard.

The extreme flood was simulated by using a combination of a king tide with 3 times the 100 year flood hydrograph. This is a very conservative assumption and the resulting flood profile is shown on Figure 3.6. The extreme flood levels downstream of Captain Cook Drive are below 3.0 m AHD because of the supercritical flow. In order to remain on a conservative side the flood level resulting from the hydraulic jump of R.L. 3.4 m AHD could be adopted as the extreme flood water level for the proposal, which is equal to the entrance level to basement carpark.

The 100 year and the extreme flood behaviour are the same for existing and proposed conditions, as the proposed development is located outside the flood plain area.

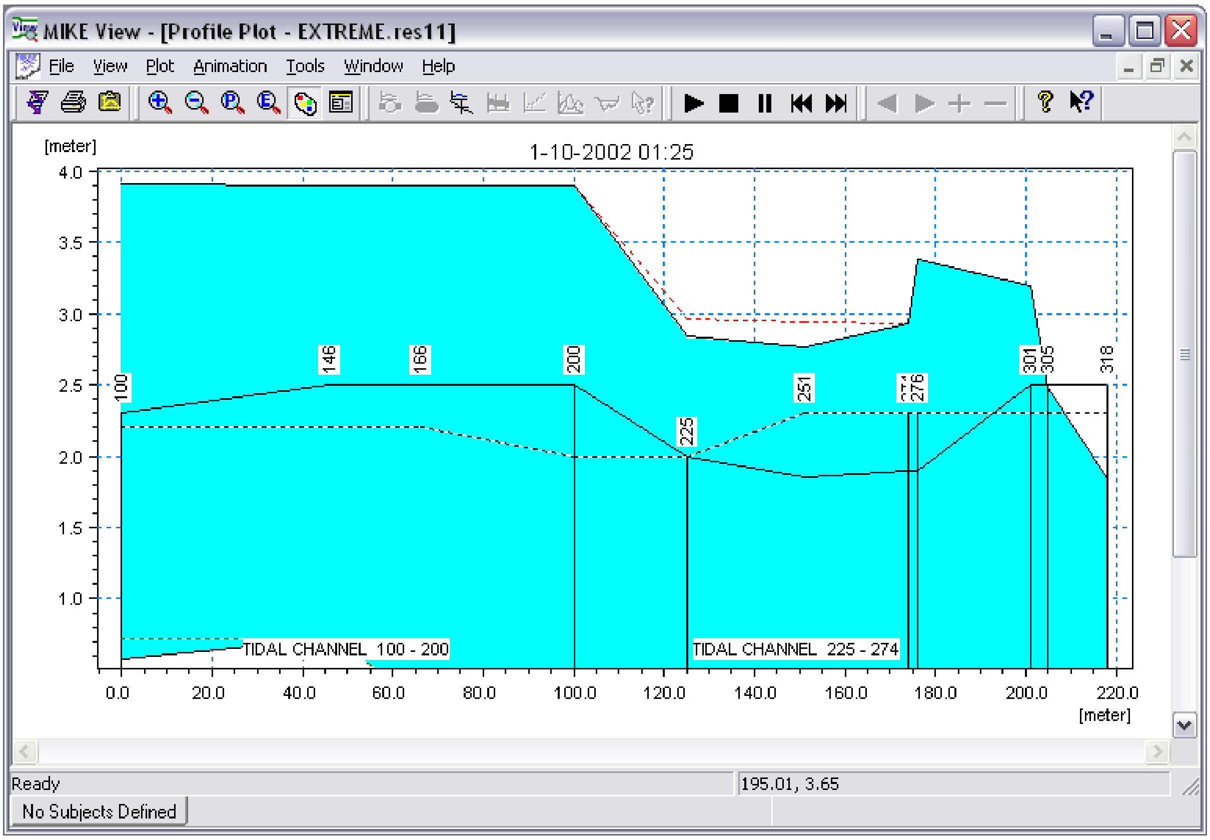

Figure 2.6 Extreme Flood Profile

4.3. Ground water, Leachate from the landfill and Acid Sulphate Soils

The existing site was created by a landfill some 30 years ago. Initial consultation with geotechnical consultants, involved in the previous investigations of the site, indicated that:

- The deposited material is mainly building refuse and a domestic waste.
- The land fill was most likely created by depositing the refuse over mangroves area at R.L 0.0 m AHD without any excavation, so there are no active acid sulfate soils expected to have been created by the land fill operation.

An intensive leachate is generated from a domestic refuse land fill in the initial 20 years of deposition with gradual decrease within the following 30 years. Some leachate is thus still expected to be generated from the land fill area. The deposited organic matter is decomposed as a result of the anaerobic processes. The fermentation is an exothermic process, which can create temperatures as high as 50° C consuming most of the available moisture releasing gases such as methane. When the decomposed organic mater gets in contact with external water a nutrient reach solution is created, which, if it finds its way out of the land fill area, is referred to as a leachate. In this particular case, the source of water is either the ground water flow and/or the rainfall infiltration.

A groundwater flow can exist in this location because of the significant catchment area upstream. However, the open tidal channel in the Golf Course area intercepts the ground water flow, so the resulting water table at the site is expected to oscillate around the mean sea level. The remaining source of water is thus the rainfall infiltration. In order to minimise the possibility for leachate creation and its export to Woolooware Bay, it would be desirable to minimise the rainfall infiltration on site. It is thus proposed not to increase rainfall infiltration and if possible, to reduce it by intercepting the surface runoff into piped stormwater drainage system and conveying it to a suitable discharge point.

No active acid sulfate soils are expected on site, however it is almost a certainty that potential acid sulfate soils are present bellow the pre land fill natural ground levels. If these soils are exposed to oxygen they will oxidize into active sulfate soils, which if not treated, will result in a sulfuric acid discharge to Woolooware Bay. Any plans for future development on this site must minimise the amount of excavation below the pre landfill natural ground levels, and if it is unavoidable, an appropriate treatment must be specified.

The latest geotechnical investigations revealed that a water mound is created in the middle of the eastern carpark at R.L. of 1.2 m AHD. The explanation for the water mound is most likely a discharge of the surface water underground through a broken pipe and/or fracture in the bitumen seal. The ground water levels reduce in all directions from the centre of the carpark stabilizing around the mean sea level near the water edge, which confirms the general direction of the ground water flow towards the tidal channel.

The construction of the basement carpark is not expected to have any impact on ground water flow because the subject site is fortunately located in a ground water flow shade area created by the specific layout of the tidal channel. Namely, the ground water levels along the tidal channel are equal to the mean sea level. The flow gradient is perpendicular to the ground water contours, which are more or less parallel to the tidal channel, resulting in the proposed basement area to be by-passed by the ground water flow. If all the area dedicated to the basement carpark is made impervious it would not have any impact on the groundwater flow regime.

The pre-land fill ground levels can be established using the information from the latest geotechnical investigation and the ground level survey. These levels vary between 0.0 m AHD in front of the club and in the middle of the eastern carpark. The pre-land fill ground levels fall towards Woolooware Bay to R.L. -1. to -1.5 m AHD along the power line easement. This information indicates that all the area dedicated to basement carpark used to be a part of Woolooware Bay prior to land fill taking place, and that if wet excavation takes place, no active sulphate soils will be left underground. The excavated natural material will have to be treated prior to disposal.

4.4. Discharge into Woolooware Bay and effects of the proposed development on the water quality discharging to the wetland

It is an imperative not to discharge stormwater runoff directly into Woolooware Bay in order to prevent erosion by concentrated flows. The stormwater drainage system of the future development would have to intercept the surface runoff from the site and convey it away from Woolooware Bay. The most suitable point of discharge would be the tidal channel, which would attenuate and defuse the concentrated flow prior to entering the wetland area.

The proposed stormwater system is based on a piped system combined with grassed swales. The grassed swale would discharge into the tidal channel immediately downstream of the Captain Cook Drive's culverts. The location of the grassed swale would be between the

Captain Cook Drive and the proposed development, located within the landscaping area. The invert level of the grassed swales would have to be above the existing ground water table, to avoid reduction in water table and consequently oxidation of the potential acid sulfate soils.

The minimum slope of the grassed swale would have to be 0.15%, with subsoil drainage to avoid water logging and mosquito breeding. The available fall of 2 m and the distance of 200 m provides a slope of 1%, so the requirement for minimum slopes can be easily achieved. The grass swales should have flat side slopes (1 in 4) and be covered with normal grass as a part of the overall landscaping in order to simplify the maintenance. The maximum velocities should not exceed 2.0 m/s and depth of flow should be less than 0.2 m to maintain a low flood hazard even during a 1 in 100 year event.

The grassed swale will be wet only during and immediately after rainfall events. No permanent water ponding is proposed along the grassed swale to avoid any possibility for mosquito breeding. The tidal channel and the wetland is saline, implying that there are no problems with mosquito breeding at the moment and that there should be no problems in the future.

The current land use of the proposed development site is club with car parking. All of the pollutants originating from the atmospheric fallout, and from the site are washed into the stormwater drainage system, and then the tidal channel and the wetland area. The proposed development consists of an underground carpark and buildings. The fact that the current carpark is going to be roofed will eliminate the pollutants from trafficable areas entering the stormwater system, which is beneficial by itself. Further more the proposed stormwater harvesting system and the grassed swales combined with GPTs will further reduce the pollutant export to the wetland. It can be stated that the proposed development will reduce the pollutants' export to the wetland and will have a beneficial impact on the wetland's health. The quantification of the pollutant loads for pre-development and for post development cases is described in section 3.9.

4.5. On Site Detention

An On Site Detention (OSD) system reduces the peak discharge rates from a developed site to pre-development peak values, however, the volume of the runoff remains unchanged. The impact of OSDs is usually beneficial in the upper and middle parts of a catchment. OSDs are ineffective in the downstream parts of a catchment and can even increase the peak discharge values because of the coincidence in the peaks of the catchment hydrograph and the outlet hydrograph from the OSD. The results from hydrologic modelling described in section 3.2 indicated that the peak 100 year discharge value entering Woolooware Bay would be 78.9 m3/s without OSD and 78.5 m3/s with a 1000 m3 OSD, representing a difference of 0.5% only.

4.6. Constructed wetland as a device for water quality control

As discussed in section 3.3, an infiltration should be discouraged to minimise the leachate from the site. A constructed wetland would have to be located at the lowest point of the site, near the tidal channel with a ground elevation of approximately 1.5 m AHD. The bottom of the wetland would have to be below the mean sea level (0.0 to –1.0 m AHD), allowing for 1.0m to 1.5m head for stormwater pipes and swales and additional 1.0m to 1.5m for the wetland itself. Two major problems are expected:

- Submerged discharge to the tidal channel and salt water intrusion into the wetland;
- Generation of acid sulfate soils during the excavation for the wetland.

Taking into account the above as well as the high standard of maintenance required for the constructed wetlands to perform properly, a constructed wetland is not recommended. Runoff harvesting is proposed instead.

4.7. Stormwater harvesting

Roof runoff can be used for toilet flushing and irrigation without pre-treatment. The runoff is relatively clean, and if the rainwater tanks are installed at high elevation, it can be used by gravity. The Toyota Park and the training fields are irrigated in order to maintain the grass cover. The total roof area of the proposed development is approximately 1.4 ha, while the Toyota Park has an area of some 1.8 ha. The average annual rainfall in the area is around 1.1 m/year, while the evaporation rate is approximately 1.2 m/year. It is obvious that the annual demand for irrigation would exceed the annual roof runoff. So if sufficient storage is provided it could be expected that all roof runoff could be stored and disposed for irrigation.

Results from water balance modelling undertaken for a similar system in Kogarah area (stormwater re-use for toilet flushing and irrigation with tank volumes of 45 l/m2 of roof area) indicated that the system is capable of capturing all roof runoff generated from 1 in 3 months to 1 in 6 months rainfall events.

A 700 m3 rainwater tank could be installed anywhere along the Northern boundary of the site. It would have to be covered with lids to ensure public safety and prevent mosquito breeding. The roof runoff would be intercepted by a system of gutters, down pipes and stormwater pipes and discharged to the rainwater tank by gravity. A small buster pump would be required to pump water from the tank for irrigation. The required pipe diameters range between 225 mm to 750 mm, allowing some pressurised flow during a 100 year storm event. If the rainwater tank fills up the spill would be directed to the tidal channel. An energy dissipater would have to be constructed at the junction with the tidal channel to eliminate any potential for soil erosion. A general type GPT would have to be constructed upstream of the rainwater tank to intercept leaves and coarse sediments.

The rainwater tank / reuse system would be extremely beneficial for the protection of the water quality in Woolooware Bay, as it would capture the deposited pollutants from the atmospheric fallout and re-direct most of the polluted water for irrigation of the grassed areas, which would act as a filter strip for the irrigated water. This system is better than a wetland because it eliminates 100% of the pollutants during all events up to and including the 1 in 3 months rainfall events, while a well designed and maintained wetland can uptake only a portion of the pollutants during the same events. Runoff re-use would improve the water quality, reduce the discharge quantity and flow frequency and save potable water, so it is strongly recommended.

The pollutant loads and the water volume balance analyses for pre-development and post development conditions incorporating the stormwater harvesting system are discussed in section 3.9.

4.8. Litter and coarse sediment control

The subject site is a high generator of litter. The majority of the litter is expected from the open carpark and the main pedestrian access routes. The surface runoff from the site would discharge into grassed swales. The grass swales would intercept some of the pollutants, however, significant quantities of litter, coarse sediments and oil and grease could still enter the tidal channel. In order to intercept these pollutants from entering Woolooware Bay, a general type Gross Pollutant Trap (GPT) is proposed at the end of the grass swale. The storage capacity of the GPTs would have to be in excess of 200m3 (10 m wide, 30 m long and 1.5 m deep) to achieve velocities in a range of 0.1 m/s during a 1 in 100 year event to separate coarse sediments and litter from the flow. The GPT would have to be off-line, to prevent export of accumulated gross pollutants into the tidal channel. The GPT would have to be covered to ensure public safety, to hide the accumulated litter and to prevent mosquito breeding.

4.9. Pollutant loads for pre and post development conditions

In order to quantify the pollutant loads for existing and proposed conditions a water quality model was established for the entire catchment upstream of the tidal channel, including the Sharks land. The conceptual layout of the water quality model is shown on Figure 3.7 for existing conditions and on Figure 3.8. The model was run using Sydney Observatory Hill daily rainfall data and the summary of the annual pollutant loads based on 80 years of simulation is given in Table 3.7.

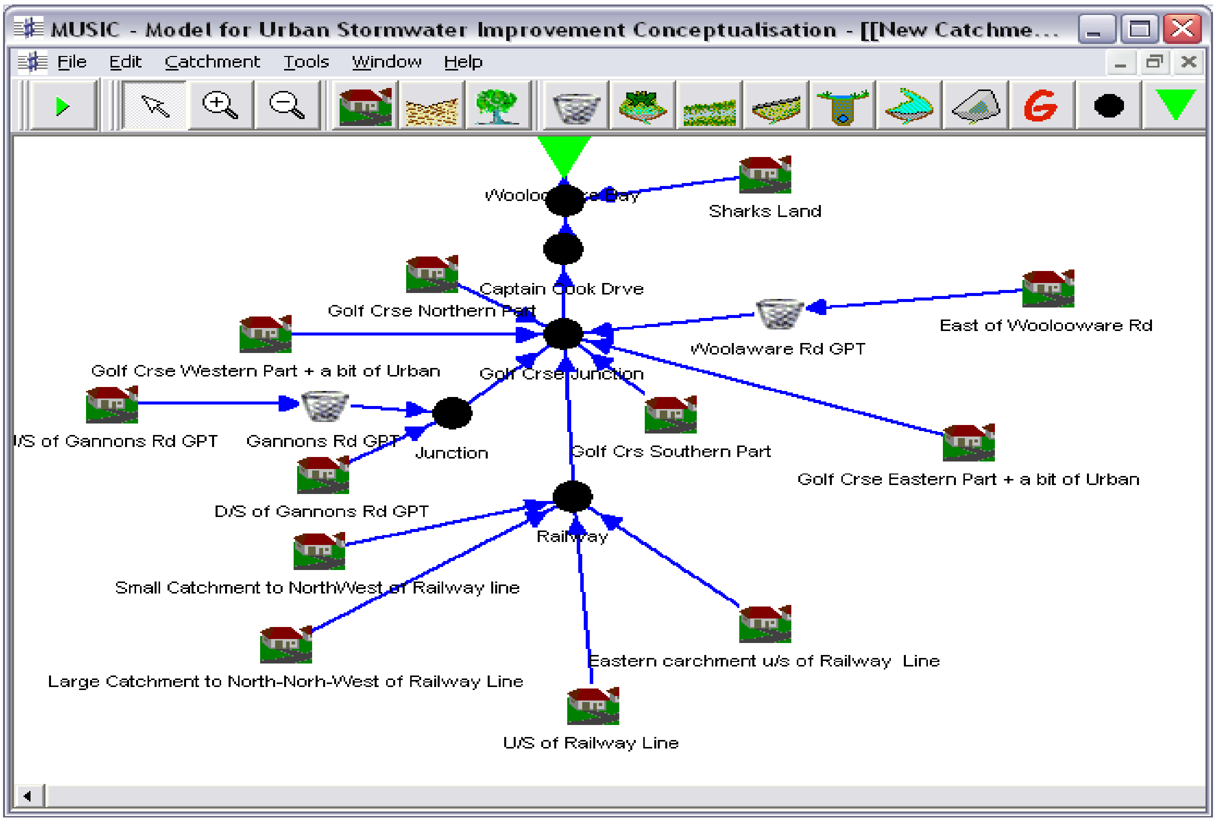

Figure 3.7 MUSIC model layout for existing catchment conditions

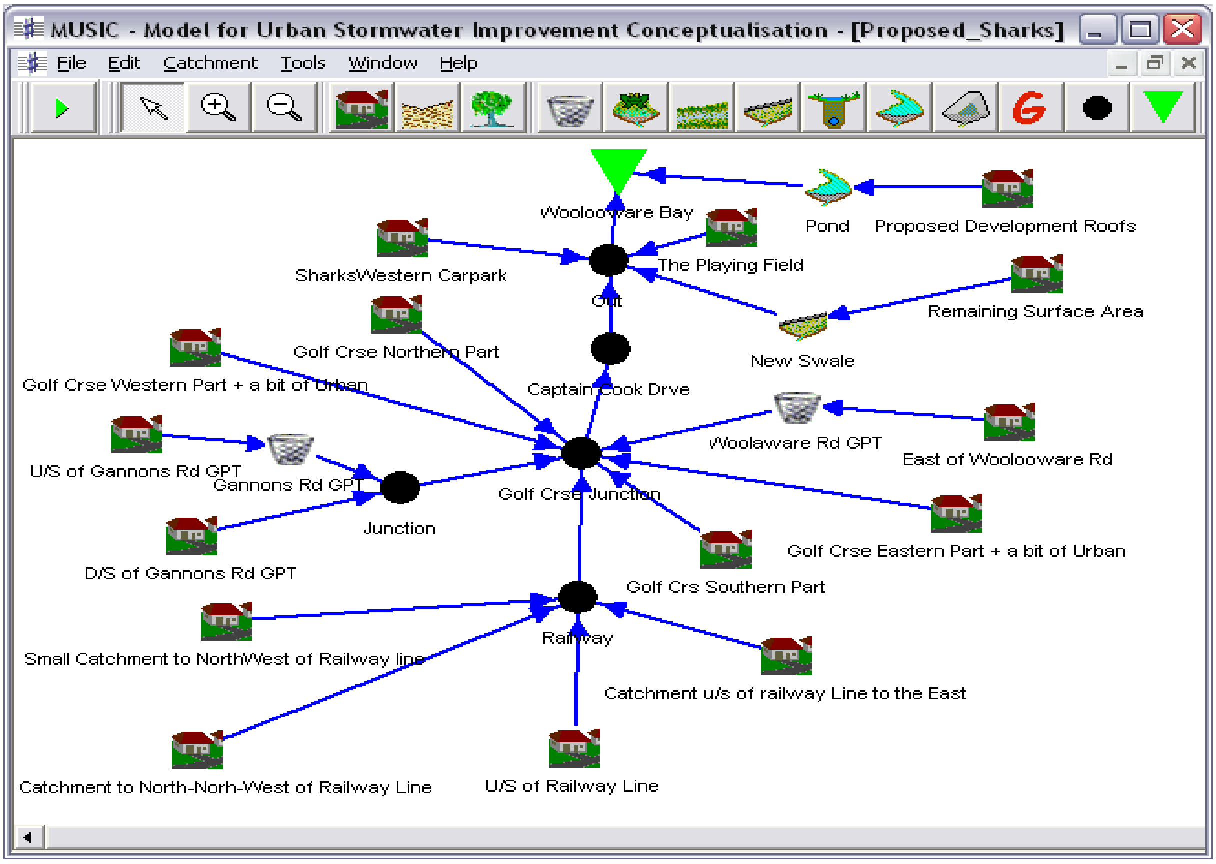

Figure 3.8 Music model layout for proposed conditions

Table 3.7 Summary of annual pollutant loads for existing and proposed conditions

Location	Q (ML/a)	TSS (kg/a)	TP (kg/a)	TN (kg/a)	GP (kg/a)
Woolooware Bay Wetland adjacent to the tidal channel	1650*	336000	683	4750	27600
	1640**	332000	676	4710	27200
Tidal Channel d/s of Captain Cook Drive	1630	332000	673	4690	27300
	1640	332000	674	4700	27200
Upstream of Captain Cook Drive	1580	32200	654	4560	26500
	1580	32200	654	4560	26500
Sharks, Western Carpark	21.5	4260	8.72	62.8	413
	21.5	4260	8.72	62.8	413
Endeavor Playing Filed + Eastern Carpark, existing conditions	25.8	5640	11.1	74	471
Eastern Carpark by-passing the tidal channel, existing conditions	21	4500	9.0	61.5	250
Rainwater harvesting system, proposed c.	4.91	520	1.37	12.6	0
Surface Stormwater, proposed conditions	20.6	4100	8.45	58.1	0
Total Sharks Land	68.3	14400	28.8	198	1134
	47.01	8880	18.5	133	413
Sharks Land change from existing conditions (%)	-31	-38	-36	-33	-64

Note: * indicates existing conditions, ** indicates proposed conditions

It can be concluded from the results that the water quality in the wetland area adjacent to the tidal channel is dominated by the pollutant loads generated from the catchments upstream of Captain Cook Drive. However, the proposed stormwater drainage and water quality management systems will reduce the pollutant loads from the entire land owned by Sharks by some 30%.

4.10. Sediment and erosion control during construction

Sediment and erosion control measures must be designed to EPA requirements. An erosion and sediment control plan must be prepared in accordance with the NSW Department of Housing Manual "Managing Urban Stormwater, Soils and Construction" at the building application stage.

The plan should consist on the best practices within the construction site, with sediment ponds at the outlets as the final safeguards.

5. RECOMMENDED STORMWATER DRAINAGE AND WATER QUALITY CONTROL STRATEGY

The proposed strategy addresses all the main issues identified in section 3 and incorporates the following:

- Separate roof and surface runoff systems.
- Rainwater tank to harvest roof runoff for irrigation of Toyota Park and the training fields.
- Discharges of stormwater runoff away from Woolooware Bay.
- A piped system over the land fill area to reduce infiltration.
- Grassed swales with subsoil drainage along Captain Cook Drive with invert levels above the ground water table to slow down the flow velocities, to remove pollutants during smaller storm events and to expose the accumulated litter to the public (stormwater pipes hide the litter).
- Off-line GPT with oil traps at the end of the swale to protect the tidal channel from litter, coarse sediments and oil/fuel.
- Prepare and implement erosion and sediment control measures during construction to prevent sediment export to Woolooware Bay.

6. MAINTENANCE REQUIREMENTS FOR THE PROPOSED SYSTEM

Regular maintenance of the proposed stormwater and water quality control systems is necessary in order to ensure the intended performance of the system. The specific maintenance requirements are discussed below for each component of the drainage system.

5.1 Stormwater harvesting system

The gutters and down pipes would have to be regularly checked as a part of building maintenance program. The proposed pipe system can be subject to lower velocities when the rainwater tank is full, so some sediment deposition can be expected. Annual checks are recommended as a part of the general building maintenance program. If sedimentation is detected then the deposited sediments would have to be removed. It is expected that the frequency of sediment removal would be in range between 1 in 2 years to 1 in 5 years on average. The general purpose GPT would have to be checked after each major storm or once in three months on average. Removal of collected gross pollutants would have to be done by a licensed by EPA contractor. The rainwater tank will develop bio-film in the first couple of month of operation. There is no need to remove this film unless the PH of the tank is changed. Once the PH gets lower than 6.5 the tank would have to be cleaned. It is expected that cleaning of the tank would be required once in 5 years on average. The energy dissipater a the inlet to the tidal channel would have to be checked regularly as a part of the building maintenance program. The frequency of checks has to be once in every six months.

5.2 Surface Stormwater System

The maintenance requirements of the surface stormwater system are similar to the requirements of the normal stormwater drainage systems, with annual inspections and regular cleaning once in two years on average. The grassed swale would have to be moved once a month, with the remaining grass height of 50 mm. Regular cleaning of deposited litter will have to be a part of the moving activity. The deposited sediments are expected to gradually reduce the depth of the swale in time. It is expected that re-grading of the swale would be required every five to 10 years on average, when the depth of the swale would be reduced to 150 mm.

The cleaning of the general purpose GPT would be necessary every 3 to six months on average. Regular inspections would be required after each major storm or every three months. The removal and disposal of the gross pollutants will have to be done by a licensed by EPA contractor.

5.3 Dredging requirements for the tidal channel

The tidal channel has reached the equilibrium, because there were no traces of sedimentation and/or erosion during the site inspections. The channel drains a significant catchment, with velocities during freshes exceeding 1.2 to 1.5 m/s, which is sufficient to pass the sediments towards Woolooware Bay. The established mangrove community along the channel ensures uniform distribution of the velocities across the channel. The only maintenance requirements would be collection of litter, especially after game events. This task would have to be done by a licensed by EPA contractor after each game event.

1132/120/09

Jeffery and Katauskas Pty Ltd

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REPORT

TO

CRONULLA SUTHERLAND LEAGUES CLUB LIMITED

ON

GEOTECHNICAL INVESTIGATION

FOR

PROPOSED CRONULLA LEAGUES CLUB REZONING

AT

CAPTAIN COOK DRIVE, WOOLOOWARE, NSW

27 September 2002 **Ref: 17119SPrpt**

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1 INTRODUCTION

This report presents the results of the review of previous geotechnical investigations at Shark Park, Woolooware, NSW. The investigation was commissioned by Mr Andrew Durbidge of BDO Property Pty Ltd on behalf of Cronulla Sutherland Leagues Club Ltd in a letter dated 4 September 2002.

We understand that it is proposed to rezone the property to the north, east and south of the existing Club. The rezoning is to allow the construction of:

- a double basement car park over the majority of the site area, requiring excavation to a level of about 0.3m AHD (a depth of about 3m to 3.5m);
- a two storey extension to the south of the existing club;
- a three storey hotel facility to the east of the proposed club extension;
- five buildings of three to five levels comprising residential units and aged care facilities to the north and north-east of the existing club;
- the placement of the existing high voltage power lines to the north of the site underground.

There could also be future extensions to the western grandstand of Shark Park, and a future vehicle drop-off zone at the southern side of Shark Park, however we understand that these are not part of the current rezoning application.

The purpose of the review was to compile the available geotechnical information on subsurface conditions, and to use this to provide comments and recommendations on earthworks, excavation, shoring, retaining wall design, construction techniques, footing design, and discussion of the effects of potential dewatering.

A review of the available environmental site screening information was completed in conjunction with this investigation by Environmental Investigation Services (EIS), a division of Jeffery & Katauskas Pty Ltd. The results of the site screening are presented in the report E17119FK dated October 2002; the report should be reviewed in conjunction with this report.

2 EXISTING INFORMATION

Jeffery and Katauskas Pty Ltd have completed eight previous investigations within the proposed redevelopment area. A summary of these investigations is provided below.

- Reference 581 dated 27 July 1978 for a proposed grandstand - the investigation comprised 2 augered boreholes drilled into the underlying sandstone.
- Reference 7391S dated 6 April 1990 for an unspecified proposed development - the investigation comprised 2 boreholes cored into the sandstone bedrock, one borehole augered to 10 metres (m) depth, and 7 Electric Friction Cone Penetration (EFCP) Tests to 5m to 11m depth.
- Reference 8309K dated 25 July 1991 for a proposed amenities block - the investigation comprised drilling three augered boreholes to depths ranging from 3.8m to 4.8m below existing ground levels.
- Reference 11630SV dated 1 February 1996 for the proposed southern stand - the investigation comprised 7 augered boreholes to depths between 1.3m and 6.0m below existing ground levels.
- Reference 12308SV dated 24 January 1997 for proposed club extensions - the investigation comprised 2 boreholes augered into the underlying sandstone and three boreholes augered to between 4.8m and 6.0m below the existing ground levels.
- Reference 12765SV dated 2 September 1997 for proposed extensions to the club - the investigation comprised the coring of 2 boreholes into the sandstone bedrock, the augering of 2 boreholes into the bedrock and augering 2 boreholes to 6.7m and 7.0m depth.

- Reference 15009JTP dated 17 April 2000 for proposed redevelopment of the Shark Park area - the investigation comprised eight EFCP tests to refusal of the equipment (depths between 5.8m and 20.6m).

Several of the reports referred to obstructions and voids within the fill, and that metal, bricks and concrete were often encountered.

Copies of the borehole logs and EFCP test results are provided in Appendix A. The approximate locations of these tests are shown on the attached Figure 1; the locations have been scaled from the plans contained in the previous reports and so the plotted locations could be in error by about 10m or so. It should also be noted that these depths were from existing ground level at the time of the fieldwork for those investigations and depths may have subsequently changed following excavations or the placement of additional fill.

In addition to the above information, 12 boreholes have been auger drilled during the recent environmental investigation to obtain samples for acid sulphate soils assessment to depths of 6.0m below existing ground levels. The borehole logs from this recent investigation are also provided in Appendix A and the information has been used in compiling this report.

3 INVESTIGATION PROCEDURE

Generally the boreholes have been completed by auger drilling with a truck mounted drilling rig with the soil strength being assessed from the recorded Standard Penetration Tests. The sandstone bedrock, when encountered, was either augered with a tungsten carbide drilling bit (in which case the rock strength was assessed from observation of the auger drilling resistance and from examination of the rock cuttings recovered from the base of the augers) or diamond cored (where the strength was assessed from examination of the recovered core and from Point Load Strength Index tests completed on the core).

The EFCP tests were completed with a purpose built truck mounted friction cone rig. The inferred strata and soil strengths shown on the EFCP traces have been assessed from correlations of the data with published charts and so the interpreted data is approximate only. The refusal depths are often assumed to be the top of bedrock and there seems to be reasonable correlation between the rock depths encountered in the boreholes and the inferred depths from the EFCP tests.

4 RESULTS OF THE INVESTIGATIONS

4.1 Site Description

The site is located to the north of Captain Cook Drive, Woolooware. The site is generally flat with a slight slope (less than 1°) down to the north. The regional topography falls gently toward the bay to the north apart from the golf course to the south of Captain Cook Drive that is generally at a lower level than the site.

A large multistorey brick building used as the leagues club is located within the central section of the site; this appeared to be in good external condition from a brief inspection of the exterior.

The main football ground was to the west of the club and there was a large multistorey grandstand at the west side of the field. At the north and south ends of the field are landscaped mounds (approximately 4m and 2m respectively above the general site level) used as spectator viewing areas. To the west of the large stand are several single storey concrete and brick buildings used as a gymnasium, amenities block and media facilities.

A drainage channel crosses the site from south to north at the west of these buildings. Mangroves line this channel and the water level was approximately 1m to 1.5m below the general site level at the time of inspection.

Two football fields are located on the far side of the main football ground with asphaltic concrete car parking on the southern side of the fields.

To the east and north of the Leagues Club is a second asphaltic concrete paved car park used by the Leagues Club. This area slopes at approximately 1° to the north with the southernmost portion gently sloping at approximately 1° to the south (toward the Captain Cook Drive boundary).

There is vacant land and mangrove swamps to the east of the site. Captain Cook Drive and then Woolooware Golf Course were located to the south. Solander Playing Fields and then industrial land lies to the west. An easement for transmission lines and then Woolooware Bay lie to the north.

4.2 Subsurface Conditions

In general terms, the testing on the site has disclosed poorly compacted fill over soft and very soft bay deposits of organic silty clays over stiff to very stiff clayey soils and medium dense to very dense sandy soils. Sandstone or inferred sandstone bedrock was encountered at depths ranging from 7.7m to 13.3m below existing ground level in the proposed works area while the sandstone to the west of the existing clubhouse extends considerably deeper (as deep as 20.6m).

Within the proposed works area, the fill had a thickness between 2.2m and 4.5m. The fill was often logged as silty sand and sandy clay with varying proportions of metal, timber, sandstone and demolition rubble. The fill was assessed as being poorly compacted.

The organic clays with some areas of clayey silty sand were encountered from the base of the fill at depths between 2.2m and 4.5m. These were generally of very soft to soft strength and had thicknesses of about 2.0m to 3.0m, though the thickness was limited to about 1.0m at some of the test locations.

Silty clays of at least stiff strength (and usually of very stiff strength) and sands generally of medium dense relative density were encountered below depths of 5 to 6m.

The sandstone bedrock (or inferred bedrock) was encountered at depths ranging from 5.6m to 20.6m below existing ground level. In the vicinity of the existing club, a sandstone capping layer was often encountered, this sandstone was generally about 0.5m to 1.0m thick and was overlying further clay bands which had thicknesses of 0.9m to 4.2m. Shallow refusal (5.8m and 5.6m) was encountered at location 803, and at a retest (numbered 803a) which was completed within 1.0m of the original test; this refusal may have been on sandstone bedrock, though this cannot be confirmed. The bedrock depths and inferred bedrock depths at the test locations are shown on the attached Figure 1.

Groundwater was encountered at depths between 0.4m and 3.8m during previous investigations. No long term groundwater monitoring has been undertaken during any of the investigations.

4.3 Site Anomalies And Construction Difficulties

There are several difficulties associated with the development at this site. These include:

- The presence of the deep, poorly compacted fill providing potentially poor trafficability, poor foundation conditions and poor pavement subgrade.

- The presence of obstructions and voids in the fill resulting in difficult piling conditions and the use of excess grout in auger grout injected piles.
- Methane has been encountered during investigations by EIS. This will require the adoption of a methane drainage blanket and extraction system below proposed structures and pavements. Other gases often found with methane are corrosive and hence copper pipes would not be recommended for underground services.
- The very soft and soft organic clay layer which will undergo additional consolidation settlements if additional load is placed above this layer. This could also give rise to negative skin friction effects on piles if the organic clay consolidates.
- The organic clays were found during the recent investigation by EIS to have an acid sulphate generation potential. As a result, if these soils are disturbed by excavation or are removed during pile construction, treatment of the soil for potential acid generation will be required. Reference should be made to the EIS report for details on acid sulphate management.
- The relatively high groundwater which will make earthworks such as replacement of fill, proof rolling and additional fill compaction difficult. This may require dewatering or the adoption of bridging layers necessary.
- The generally deep sandstone bedrock which will require long piled footings to be adopted.
- The capping layer of sandstone on which many piling systems could refuse. Very limited bearing pressures would have to be adopted if the piling cannot penetrate to the more competent sandstone bedrock at depth.

Although the above are potential problems for the construction of the proposed development at the site, the construction nevertheless appears feasible. These difficulties on the site require that good planning, design and construction techniques are used.

5 COMMENTS AND RECOMMENDATIONS

The geotechnical information available for the site is from numerous previous investigations. Further investigation for the proposed development will be useful in some areas to confirm target founding depths and allowable bearing pressures.

5.1 General Earthworks Comments

Excavation

Excavation will be required for the basement construction and the installation of underground services, including placing the existing high voltage power lines to the north of the site underground. We expect that the excavation will be limited to about 3m to 3.5m below excavation level.

The excavated material will be a combination of existing fill and natural organic soils. Reference should be made to the EIS report for details of the waste classification for these materials, and for any necessary treatment prior to disposal.

Excavations through the soils above the water table should be temporarily battered at no steeper than 1 Vertical (V) in 1.5 Horizontal (H). Where these excavations will extend below the water table, it will be necessary to dewater so that the excavation will be in "dry" soil which will require shoring of the sides of the excavation. We understand that the acid-sulphate reactivity of the soil will necessitate quite stringent controls on dewatering and so the construction of a sheet pile wall around the excavation will probably be required. Sheet pile walls may be designed using active and passive earth pressure coefficients and unit weights as provided in the table below. Appropriate surcharge loads and hydrostatic pressures (taking into account the dewatered condition) would have to be included in the design of the shoring.

Soil Description	Total Unit Weight (kN/m^3)	Active Earth Pressure Coefficient (K_a)	Passive Earth Pressure Coefficient (K_p)
Fill	19	0.35	3.0
Peat, Organic Clay, Organic Sand	10	0.50	2.0
Remaining Clayey and Sandy Soil	20	0.3	3.3

There would be two options with regard to the sheet pile walls. The first of these would be to cantilever the walls, though the lateral deflections may not be tolerable where near existing structures (such as the club building and the service station to the east). To limit the deflections, the second option would be to use embedment for toe restraint of the sheet piles in conjunction with an upper row of anchors or tie backs. The anchors could be soil anchors of either the grouted type (conventional anchors) or buried plate type (such as 'Platypus' anchors). Grouted anchors should be designed for a friction angle of 25° provided they are bonded into the fill and all anchors should be proof loaded to at least 1.3 times their working load.

Engineered Fill

A basement will extend over the majority of the site area, and so very little fill will be placed during the construction. The fill is likely to be below entry pavements (where suitable placement procedures are often detailed during the construction works as they have relatively little effect on the proposed construction) and in landscaping areas where only nominal compaction is required unless there will be additional pavements or structures in those areas.

Any new structural fill placed, such as below proposed pavements, should be placed as engineered fill. Such fill should preferably be a well graded, select granular fill containing no organics or other deleterious substances. The fill should be placed in layers not exceeding 200mm loose thickness and compacted to at least 98% of Standard Maximum Dry Density (SMDD). Clayey fill is not ideal for use, though it may be used following approval of the material by the geotechnical engineers, and it should be compacted strictly to between 98% and 102% of SMDD and within 2% of the Standard Optimum Moisture Content (SOMC).

Where fill is being placed in landscaped areas, or below areas which will be supported on piles, it should be compacted to at least 95% of SMDD.

5.2 Footing Design

The existing fill and organic clays on the site are not suitable for use as a bearing stratum for the proposed structures. We recommend that the proposed buildings be supported on piles founded on the sandstone bedrock. From the limited information available at present, we consider that piles founded within the bedrock of at least medium strength may be designed for an allowable end bearing pressure of 3500kPa. In many areas of the site, further investigations would be likely to prove bearing pressures to 6000kPa as being feasible. It should be noted however that in some areas, particularly around the existing club building, a capping layer of sandstone was found to overlie further clay bands; the piles would need to penetrate through these to the sandstone bedrock below to adopt the higher pressures. Allowable bearing pressures of about 600kPa appear to be feasible on the sandstone capping layer. Further specific investigation will be required at each of the building locations to provide further information on the variability so that the above allowable bearing pressures can be confirmed.

Provided the above pressures are adopted, we expect settlements would be less than 1% of the pile diameter (ie settlements probably less than 10mm).

Where piles would only need to support relatively light loads, it may be possible to support them within the stiff to very stiff clayey soils. Such piles may be designed for an allowable end bearing pressure of 300 kPa. Any socket into the stiff to very stiff clay greater than 0.5m in length may be designed for an allowable shaft adhesion of 17kPa.

There are several piling techniques that may be adopted at this site and these are discussed in more detail below.

It would be possible to use driven steel or concrete piles on the site. In this case, there would be no spoil which would require treatment for potential acid sulphate problems. Driven piles also have the benefit that their load capacity can be calculated using published pile driving formulae. We expect that vibrations from the pile driving would not be of concern in the majority of the proposed development area, however this should be confirmed by reputable pile driving companies prior to the adoption of this piling system. One potential drawback of this system is that the piles may refuse on the capping layer of sandstone and so the pile capacity may be relatively low. Pre-drilling could be considered to overcome this but would add substantially to the cost.

An alternative to the driven piles would be the 'G pile' system. This technique involves jacking the piles into the ground from a very large ballasted rig. The load capacity of these piles can also be calculated from the piling records. These piles have the advantage over driven piles that there is very little vibration from the pile installation and so can be used close to existing structures. These piles also have the potential problem that premature refusal may occur on a capping layer of sandstone resulting in limited pile capacity, again, pre-drilling is an option.

Auger grout injected piles would also be a possibility on this site. These would be particularly useful around the club where the depths to the rock are generally less than say 15m. More difficulty could be encountered however to the west of Shark Park where the rock was in excess of 20m. These piles have the benefit that they can be drilled to depth and therefore should have the capacity to drill through capping layers of sandstone, though drilling in sandstone is usually very slow and large volumes of excavated spoil are likely to be produced. We understand that this piling system has previously been used on the site and large volumes of grout were required, presumably to fill voids within the poorly compacted fill.

It may also be possible to drill piles using bentonite mud to support the hole during drilling and concreting. A variation to this would be to adopt barettes excavated through a bentonite slurry using a 'clamshell' mechanism (similar to that used for diaphragm wall construction). These drilling techniques are usually very expensive and are only likely to be economical if the column loads are very high.

Conventional bored piles are not considered suitable at this site due to the high groundwater level and the potential for collapse of the poor quality near surface soils.

Our recommended piling techniques would be to adopt either auger grout injected piles or piles drilled through bentonite slurry everywhere on the site, or a combination of driven piles when at a distance from existing structures (and where investigation shows there is no capping layer of sandstone) and auger grout injected piles elsewhere.

We note that obstructions within the fill have been previously noted and all of the above techniques could have difficulties with these. We therefore recommend that a low productivity and increased bit wear be allowed for in the tendering of piling.

Also, a provisional sum could be allowed for the possibility of having to excavate obstructions from the fill where premature refusal of the piling occurs.

5.3 Temporary And Permanent Groundwater Considerations

Some of the soils around the site have the potential to produce acidic leachate if they become unsaturated and oxygen is allowed to react with the soil. As a result, the level of groundwater will need to be carefully monitored and controlled during the construction period.

Dewatering of the basement excavation will be required with the currently proposed level of the basement. To reduce the effects of dewatering on the groundwater conditions outside the excavation, it will be necessary to have a 'cut-off' wall, such as a sheet pile wall, around the basement. This cut-off should be socketed below the base of the excavation such that the depth of embedment below the proposed excavation level is twice the distance between the basement level and the outside water level.

As the soils are generally likely to be of low permeability within the dewatering zone, conventional well or spearpoint dewatering systems are probably not generally suitable, though may be necessary in some areas. We suggest that the dewatering be trialed using a sump and pump technique. The sump could be formed by having large diameter drums or 'formatube' with many small holes in them installed into holes excavated below the base of the excavation. The void between the 'sump' and the excavated hole could then be filled with clean fine gravel and/or coarse sand as a filter. An automated pump system could then be installed in the sump. Reference should be made to the EIS report with regard to testing, treatment and disposal of the collected water.

It will then be necessary to have monitoring wells around the perimeter of the excavation to assess the effect of dewatering outside the cut-off wall; we would expect this effect to be very minor. If there is any drawdown of the groundwater outside the cut off, an injection system could be used to overcome the drawdown effect. The injected fluid could be:

- Water pumped from the sumps, treated as necessary;
- Water from the Bay;
- Water pumped from a deep well, at such depth that the water level near the surface will not be affected;
- Town water.

Appropriate injection of water would prevent drawdown of the water level in the short term. Any other environmental effects of using these waters, in relation to the injection of salt or chlorine is beyond our area of expertise but will need to be addressed by others.

Following the completion of the basement construction, the sheet piles should be removed to reduce their effect on the long-term groundwater flows. Following the sheet pile removal, the basement will extend only slightly below the water table. The majority of the soil between the water table and the bedrock will be left in place. There are also large areas along the foreshore where there will be no development intersecting the groundwater table. As a result, we would not expect there to be any significant effect on the long-term groundwater regime.

Further reduction of risk associated with changes to the groundwater regime could be achieved using a drainage and reinjection system. Such a system could comprise a subsoil drain directly above the existing groundwater level on the road side of the proposed basement, and by connecting this via a pipe and gravity drainage to a rubble soak away system above the current groundwater level on the Bay side of the proposed basement. We do not expect that such a system would be required.

5.4 Methane Drainage

We understand from EIS that there is a methane generation problem at the site and that a methane drainage system will be required. Such a system could comprise a drainage blanket of the entire development area, though we expect that this would be very expensive. Another alternative could be to complete the basement excavation and footing installation (piling), and excavate drainage slots, wrapped in filter geotextile and filled with clean, free draining, durable gravel and slotted PVC pipe. Following backfilling of these trench drains, a layer of 'bentofix' or 'claymax' should be placed over the entire site area and wrapped up the outside of retaining walls constructed inside the shored basement. This will provide a 'seal' to prevent the methane from entering the structures. For further details of the methane collection and disposal, reference should be made to the abovementioned EIS report.

5.5 Basement Design

The proposed two level car parking basement will extend slightly below the groundwater table. It will therefore be necessary to waterproof the basement to at least the highest foreseeable groundwater level. If more detailed information cannot be found, we recommend that allowance for hydrostatic pressures be made. A detailed study of local factors will be required to arrive at a realistic maximum level. The seal for the methane drainage will assist with the waterproofing of the basement, though we note that these products are of low permeability, not impermeable. We therefore recommend that the basement floor be designed to supply the waterproofing.

We note that the construction of the basement below the water table will either require dewatering, or hold down anchors, possibly of steel screw pile type, until there is sufficient load from the structures to withstand the potential uplift forces.

As the subgrade below the basement floor will be organic and wet, it will not be possible to prepare the subgrade to construct slab on grade. We therefore recommend that the basement floor be designed as suspended from the piles. This may not require any thicker floor as the basement floor will have to be designed for hydrostatic uplift pressures anyway.

6 FURTHER INVESTIGATIONS

As mentioned above, the current investigations have provided information on inferred rock depth or rock depth and quality at relatively large centres. Further investigation will therefore be required to provide specific comments and recommendations for developments of specific areas.

7 GENERAL COMMENTS

Occasionally, the subsurface soil conditions between the completed boreholes and EFCP test locations may be found to be different (or may be interpreted to be different) from those inferred/expected. Variation can also occur with groundwater conditions, especially after climatic changes. If such differences appear to exist, we recommend that you immediately contact this office.

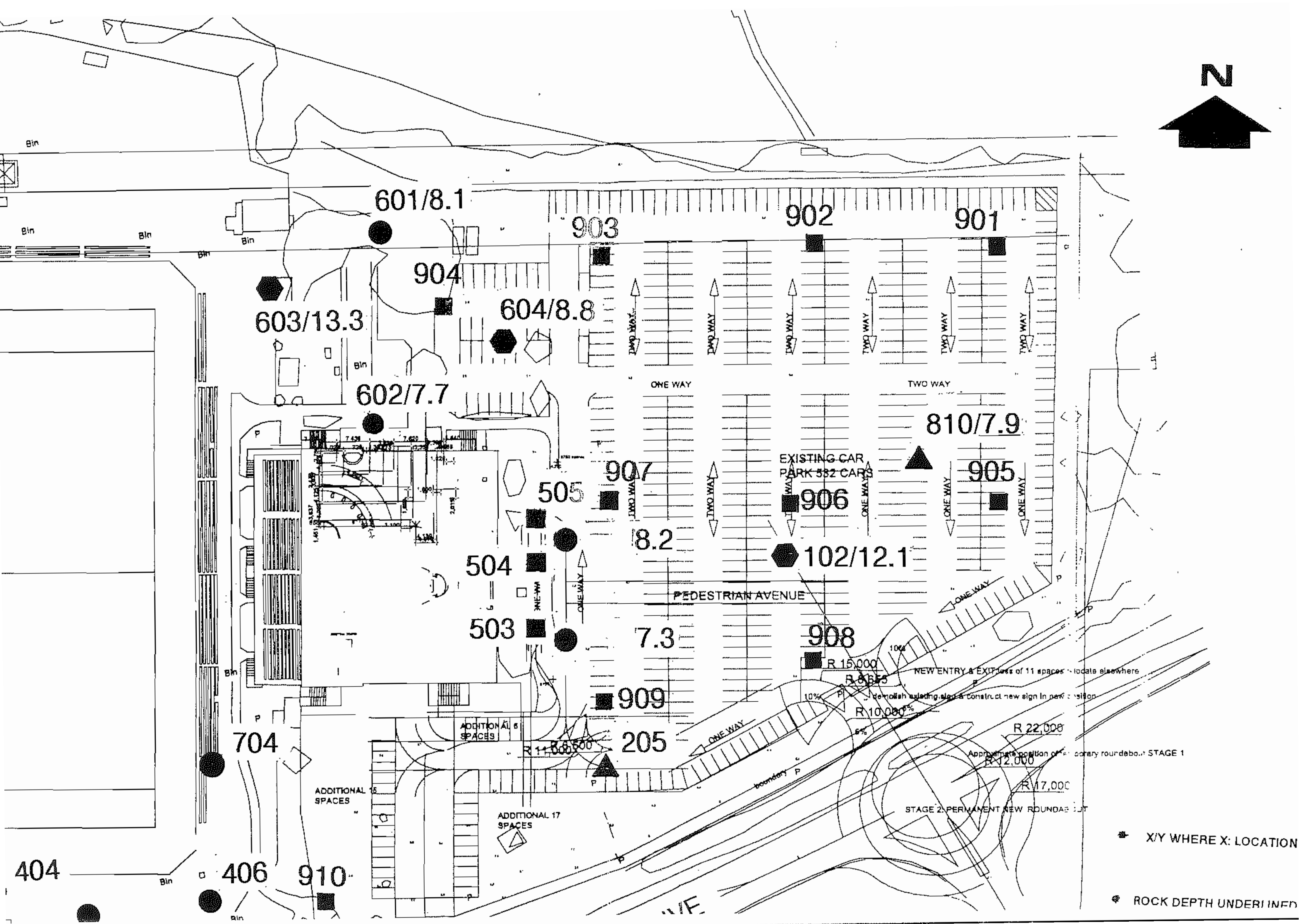
This report provides advice on geotechnical aspects of proposed civil and structural design. As part of the documentation stage of this project, Contract Documents and Specifications may be prepared based on our report. However, there may be design features we are not aware of or have not commented on for a variety of reasons. The designers should satisfy themselves that all the necessary advice has been obtained. If required, we could be commissioned to review the geotechnical aspects of contract documents to confirm the intent of our recommendations has been correctly implemented.

The offsite disposal of soil may require classification in accordance with the EPA guidelines as inert, solid, industrial or hazardous waste. We can complete the necessary classification and testing if you wish to commission us. As testing requires about seven days to complete, allowance should be made for such testing in the construction program unless testing is completed prior to construction. If contamination is found to be present then substantial further testing and delays should be expected.

Should you have any queries regarding this report, please do not hesitate to contact the undersigned.

for P Wright
Associate

P Stubbs
Director
For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD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205
704
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NEW ENTRY & EXIT loss of 11 spaces relocate elsewhere
demolish existing sign & construct new sign in new position
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R 22,000
R 12,000
R 17,000
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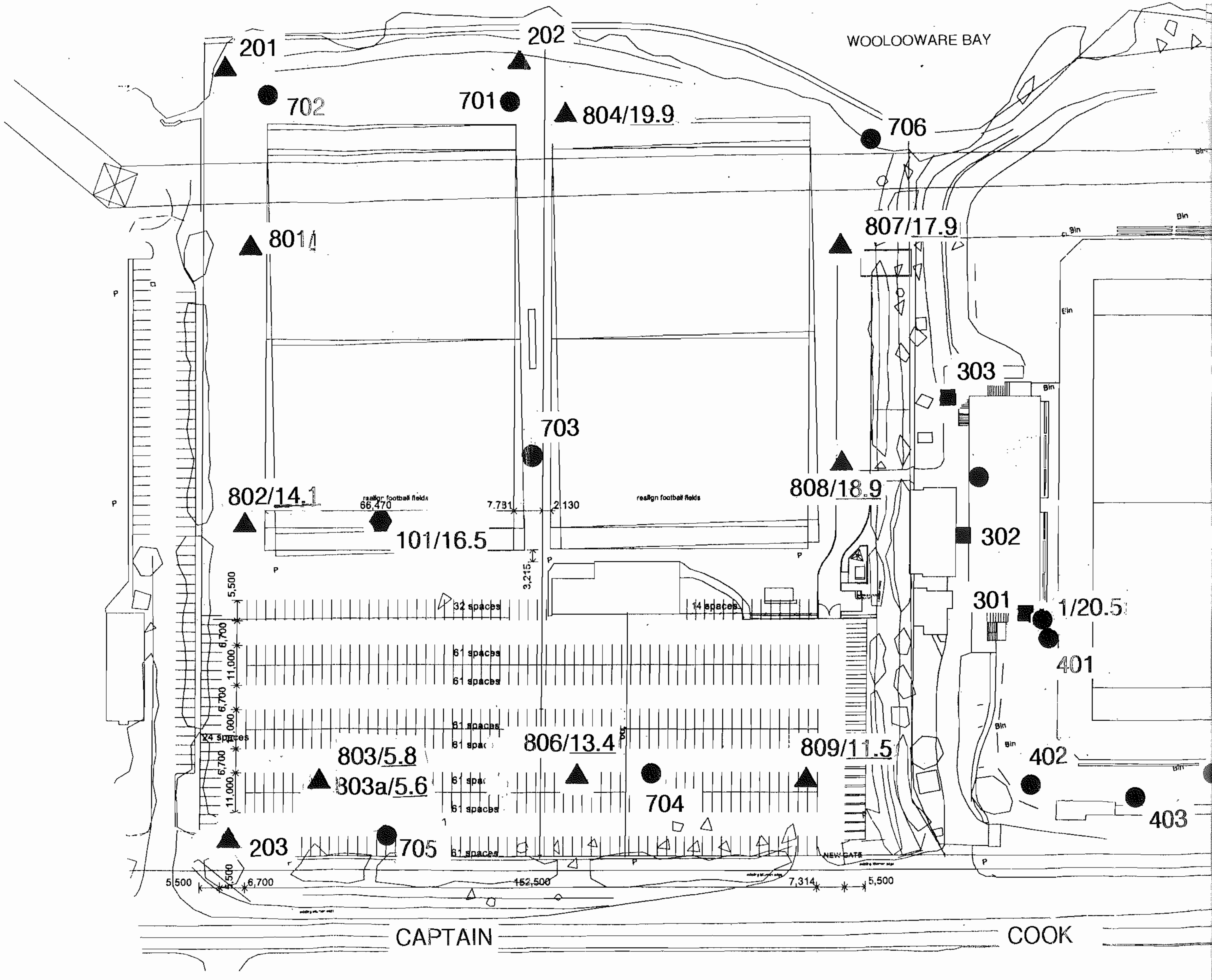

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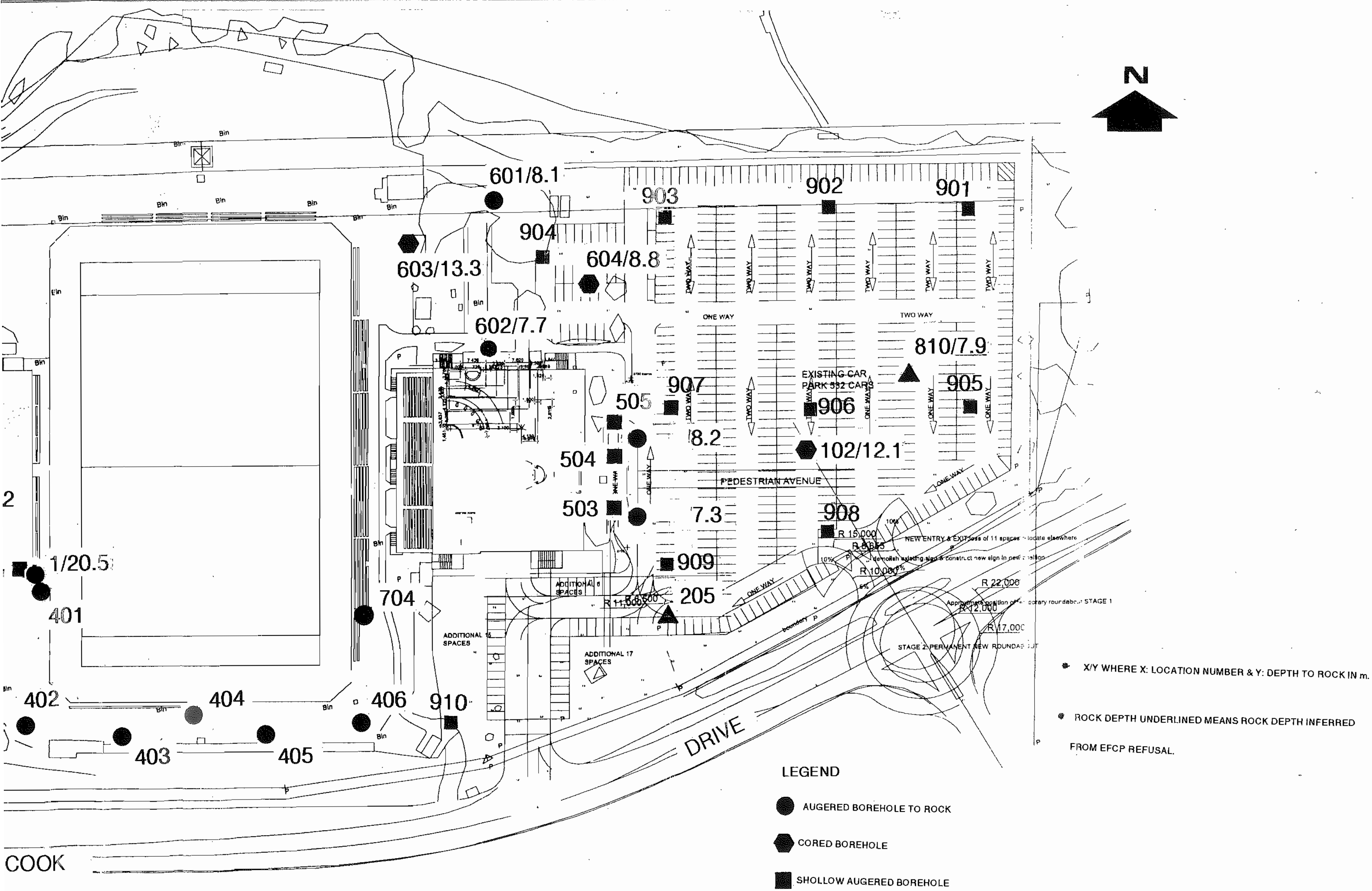


* X/Y WHERE X: LOCATION NUMBER & Y: DEPTH TO ROCK IN m.

* ROCK DEPTH UNDERLINED MEANS ROCK DEPTH INFERRED FROM EFCP REFUSAL.

NVESTIGATION LOCATION PLAN

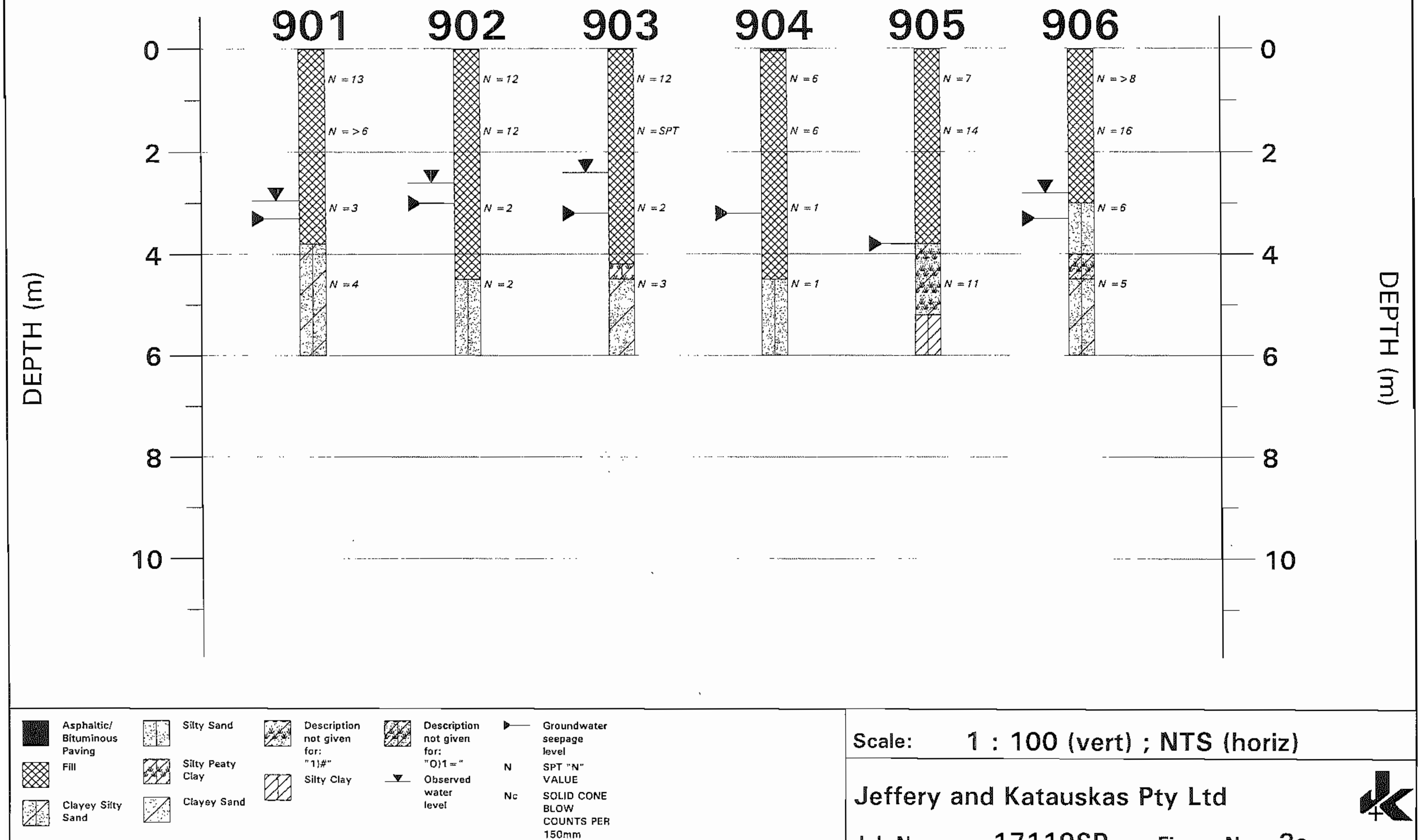
LEGEND

- AUGERED BOREHOLE TO ROCK
- CORED BOREHOLE
- SHOLLOW AUGERED BOREHOLE
- ELECTRICAL FRICTION CONE PENETRATION (EFCP) TEST

Jeffery and Katauskas Pty Ltd

Report No. 15009JTP Figure No. 1

GRAPHICAL BOREHOLE SUMMARY



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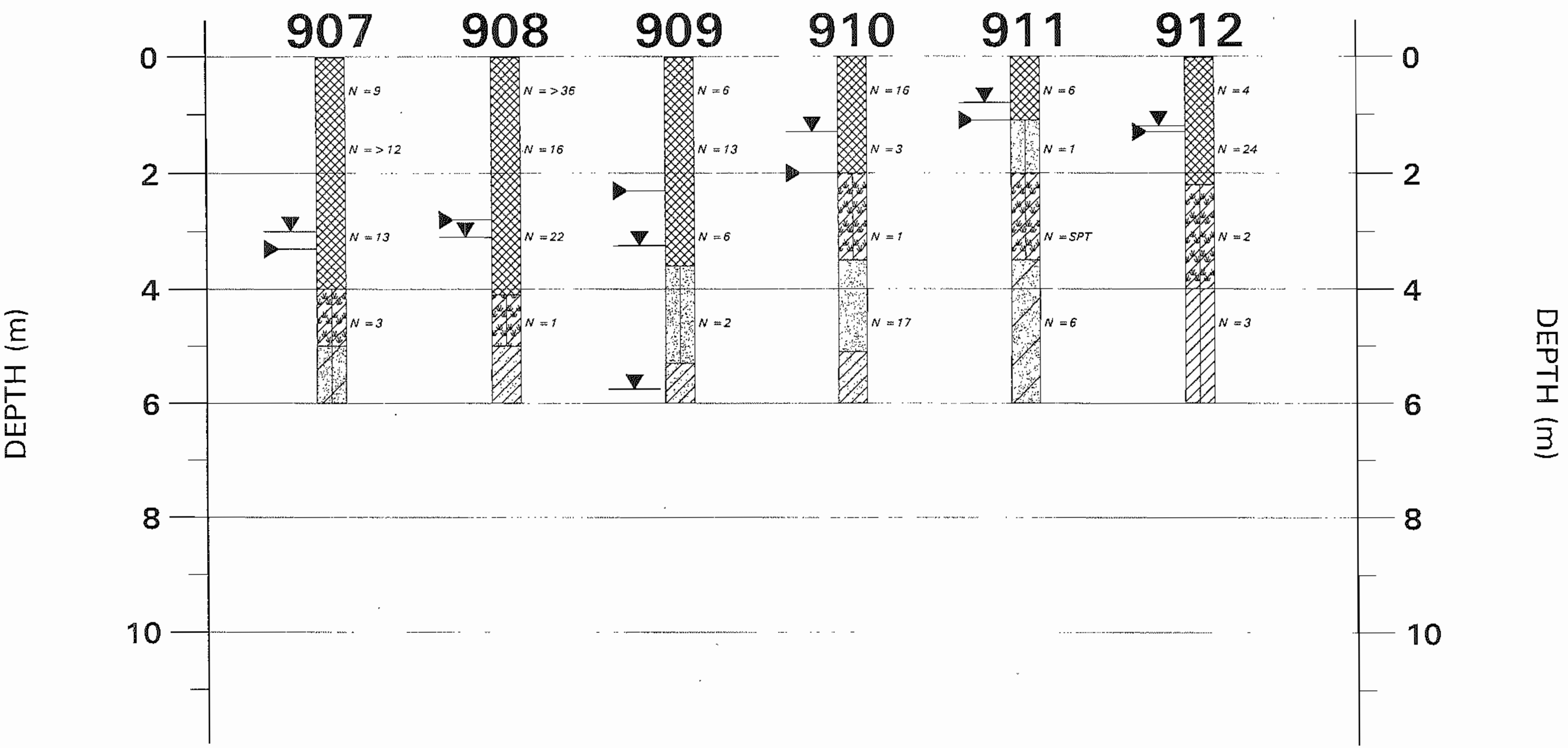
Jeffery and Katauskas Pty Ltd

Job No.: 17119SP Figure No.: 2a

GRAPHICAL BOREHOLE SUMMARY



Asphaltic/ Bituminous Paving

Fill

Silty Peaty Clay

Clayey Silty Sand

Sandy Clay

Silty Sand

Sand

Clayey Sand

Silty Clay

Observed water level

Groundwater seepage level

N SPT "N" VALUE

Nc SOLID CONE BLOW COUNTS PER 150mm

Scale: 1 : 100 (vert) ; NTS (horiz)

Jeffery and Katauskas Pty Ltd

Job No.: 17119SP Figure No.: 2b

APPENDIX A

JEFFERY AND KATAUSKAS

FIELD LOG

Location No. BH1

1/2

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location. CAPTAIN COOK DRIVE, WOOLOOWARE.

Job No: 15009-JTP
Date: 24 & 25 . 7 . 78
Method: AUGER & WASHBORE
R.L. Surface: NT
Datum: N.T

Water Level	Samples and Field Tests	Depth (m.)	Graphic Log	Unified Classif.	Soil Description	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer x100KPa 1 2 3 4	Structure & Geology
▼ (approx. 1.6 m)	N=11 (3,9,7)	0–2.5			FILL silt, sand with metal, construction rubble, wood, sandstone dark grey		loose		
	N<1	2.5–5.6		OL	SILT AND CLAY, organic some shell pieces, pungent odour dark grey	MC>PL	V.Soft		
		5.6–5.8		CL	SANDY CLAY brown	MC>PL	V.Soft		
	NC=20	5.8–7.1		SM	SAND light grey fine to medium grained		M.Dense		
	NC=14	7.1–8.3		CL	SILTY CLAY, some sand layers grey.		Stiff		
	N=13 (10,9,4)	8.3–9.8		SC	CLAYEY SAND some clay layers & shell pieces grey		loose		
NX CASING To 10.5m	N=8 (2,4,4)	9.8–15		CH	CLAY high plasticity greenish grey then mottled grey and brown then mottled red and grey	MC>PL	Stiff	x	
	N=25 (5,9,16)							x	

JEFFERY AND KATAUSKAS

FIELD LOG

Location No. BH1

2/2

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE.

Job No: 15009-JTP
Date: 24&25.7.78
Method: AUGER & WASHBORE
R.L. Surface: NT
Datum: N.T

Water Level	Samples and Field Tests	Depth (m.)	Graphic Log	Unified Classif.	Soil Description	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer 1 2 3 4	Structure & Geology
		15 – 17		CH	as above				
		18 – 20		CL	Sandy clay mottled brown and grey, some dark grey with depth				
		21			SANDSTONE				
					END BOREHOLE 21.0m.				

JEFFERY AND KATAUSKAS

FIELD LOG

Location No: BH2

1/2

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE.

Job No: 15009-JTP
Date: 24 & 25.7.78
Method: AUGER & WASHBORE
R.L. Surface: NT
Datum: N.T

Water Level	Samples and Field Tests	Depth (m.)	Graphic Log	Unified Classif.	Soil Description	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer x100 KPa 1 2 3 4	Structure & Geology
▽ (approx. 1.6 m)	N<1 N<1	0–2			FILL silt, sand, bands of ripped sandstone, with metal, wood and rubble, dark grey		V.Loose		
	N=1	2–5		OL	SILT AND CLAY, organic, fibrous bands, pungent odour dark grey	M>>PL	V.Soft		Natural Moisture Content 160% 100% 31%
	N<1 N<1	5–5.7		CL	SANDY CLAY, brown then bluish grey	M>>PL	V.Soft		
	NC=20	5.7–7.5		SM	SAND, silty, some shell fragments grey		M.Dense		
	N=1	7.5–10		CL-CH	SILTY CLAY and CLAY medium to high plasticity some shell fragments slightly organic, dark grey	M>PL	V.Soft		
	N>26 (4, 16, 10 for 0.07)	10–11.7		SC	CLAYEY SAND some clay bands, some shell pieces and charcoal fragments		M.Dense		
NX CASING TO 12m.	N=9 (2, 4, 5)	11.7–15		CH	CLAY high plasticity light grey then grey with red mottling.	M>PL	Stiff		

JEFFERY AND KATAUSKAS

FIELD LOG

Location No BH2

2/2

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE.

Job No: 15009JTP
Date: 24&25.7.78

Method: AUGER & WASHBORE

R.L. Surface: NT
Datum: N.T

Water Level	Samples and Field Tests	Depth (m.)	Graphic Log	Unified Classif.	Soil Description	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer 1 2 3 4	Structure & Geology
	N=16 (4,6,10)	15		CH	CLAY as above	M>PL	Stiff		
		16							
		17		CL	SANDY CLAY medium plasticity mottled grey and brown	M>PL	Stiff		
	N=7 (3,3,4)	18							
		19							
		20			SANDSTONE				
					END BOREHOLE 20.4m				

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Borehole No. 101 1/4

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP Method: SPIRAL AUGER
Date: 26-2-90 EDSON 3000

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
						FILL: Silty sand, fine gravel, dark brown.		VL		APPEARS POORLY COMPACTED
						FILL: Silt, sand, brick, concrete rubble, plastic & glass.				POOR SAMPLE RETURN ON AUGERS DUE TO VOIDS IN FILL
			1							
	DS									
	DS	N=5 1, 1, 4								
			2							
	DS				OL	ORGANIC SILTY CLAY: low plasticity, dark green brown with many shells & decayed roots.	MC>PL	VS		STRONG ORGANIC ODOUR
	DS	SUNK UNDER HAMMER WEIGHT N<1	3						30 45 50 50	
			4							
			5		CL	SANDY CLAY: low plasticity, mid brown, sand fine grained, occasional gravelly bands.	MC>PL	S to F		
	DS									
		N=18 3, 8, 10	6		SP	SAND: fine grained, grey & dark grey with occasional thin clayey bands.	W	MD		

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Borehole No. 101

2/4

BOREHOLE LOG

Client: CRONULLA SHARKS

Project: SHARK PARK REDEVELOPMENT

Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP

Method: SPIRAL AUGER EDSON 3000

Date: 26-2-90

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			7			SAND: as above grading to				1½ m. CAVE-IN CASED TO 7.5 m.
FULL RETURN					CH	SANDY CLAY: high plasticity, light grey, occasional orange brown veins, with occasional bands of clayey sand.	MC>PL	V. St.-H		
	DS	N=17 3, 7, 10							270 430 390	COMMENCED MUD DRILLING
			8							
			9							
			10		CL-CH	SANDY CLAY: medium to high plasticity, light grey, occasional pockets of red brown very sandy clay.				
	DS	N=12 3, 5, 7							250 200 350 410 280	
			11							
			12							
¼ RETURN			13			as above, but with occasional ironstone bands.	MC>PL	St. - V. St.		FLUSH LOSS IN IRONSTONE BANDS
FULL RETURN	DS	N=14 4, 6, 8							170 120 140 260 240	

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Borehole No. 101

3/4

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP
Method: SPIRAL AUGER EDSON 3000
Date: 26-2-90

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			14			SANDY CLAY: as above	MC>PL	St.		
	DS	N=9 3, 5, 4	15						140 200 130 140	
			16							
			17			REFER TO CORED B.H. LOG				ATTEMPTED SPT 15 BLOWS/0mm.

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Borehole No. 101 4/4

CORED BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE.

Job No: 15009JTP
Date Drilled: 26&27-2-90
Drill Type: EDSON 3000
Core Size: N.M.L.C.
Inclination: –
Bearing: –

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD INDEX STRENGTH $I_S(50)$ EW VW W MS S VS ES	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
		16		START CORING AT 16·49m.					
FULL RETURN		17		SANDSTONE: fine grained, light grey & red brown, occasional orange brown bands.	MW	W			BEDDING PARTING 0°, ORANGE BROWN STAINING
TOTAL LOSS						W-MS			CLAY SEAM, 10mm. JOINTS 30° PLANAR, SMOOTH
		18							CLAY SEAM 50mm.
					HW	EW			N.B. ALL DEFECTS NOT LABELLED ARE BEDDING PLANES, PLANAR, SMOOTH, & OCCASIONAL DRILLING BREAKS
		19		as above, but with occasional shale layers.	MW	MS			
				END OF BOREHOLE AT 19·58m.					
		20							

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BOREHOLE LOG

Borehole No. 102 1/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP
Method: SPIRAL AUGER EDSON 3000
Date: 26-2-90

Groundwater record	Samples	Field Tests	Depth (m.)	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			0		BITUMINOUS PAVEMENT				
					FILL: Clayey sand, fine grained, orange & dark brown with some sandstone gravel.	D			APPEARS MODERATELY WELL COMPACTED
	DS		1		FILL: Silty clay, medium to high plasticity, dark brown, with some shale & brick gravel.				
	DS	N=10 6, 4, 6			FILL. Sand, fine to medium grained, orange brown with occasional sandstone gravel. Rubber fragments at 1.4m.				COMPACTION VARIES
	DS		2		FILL: Clayey sand, fine grained, dark grey with domestic refuse including rubber fragments, plastic, brick, cloth.				
▶			3		— — — becomes gravelly.				
	DS	N=12 2, 1, 11							
	DS		4	OL	ORGANIC SILTY CLAY: low plasticity, dark green grey, with many decayed roots & some shells.	MC>PL	VS		STRONG ORGANIC ODOUR
			5		— — — becoming sandy.				
	DS	N=3 1, 2, 1	6	SP	SAND: fine grained, dark brown, with shells.	W	VL		

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BOREHOLE LOG

Borehole No. 102 2/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP
Date: 26-2-90
Method: SPIRAL AUGER EDSON 3000

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			7		SP	SAND: as above				
	DS	N>10 14, 10/50mm.			CH	SANDY CLAY: medium plasticity light grey & orange brown with ironstone bands.	MC>PL	V. St.	410 500,250	
	DS		8			— — — becoming mid brown.				
	DS	N>10 10/50mm.				— — — becoming light grey with some partially cemented sand layers.				COMMENCED WASH BORING
			9		CH	SILTY CLAY: medium to high plasticity, light grey with occasional orange brown mottling.				
							MC≑PL	H		
	DS	N>10 12, 10/50mm.	10						450 450,500	
			11							
			12			SANDSTONE: fine grained, light grey, moderately weathered, weak, occasionally medium strong with occasional clay bands.				
			13							
						— — — becomes fresh & medium strong.				ATTEMPTED SPT AT 14.0m. 5 BLOWS/10mm.

REFER TO CORED B.H. LOG

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Borehole No. 102 3/3

CORED BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE.

Job No: 15009JTP.
Date Drilled: 26&27-2-90
Drill Type: EDSON 3000

Core Size: N. M. L. C.
Inclination: –
Bearing: –

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD INDEX STRENGTH $I_S(50)$ EW VW W MS S VS ES	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific / General
				START CORING AT 14.0m.					
TOTAL LOSS		14		SANDSTONE: fine grained, light grey, with some very thin dark grey laminae to 14.7m.	F	MS			
				as above, but light grey with dark grey bands.					
		15							
		16				S			
									— JOINT, 20° PLANAR, SMOOTH
									— CLAY SEAM, 5mm.
		17		END OF BOREHOLE AT 16.95m.					
		18							
		19							

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Borehole No. 103

BOREHOLE LOG

Client: CRONULLA SHARKS

Project: SHARK PARK REDEVELOPMENT

Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP

Method: SPIRAL AUGER EDSON 3000

Date: 26-2-90

Groundwater record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			0–2.3			FILL: Domestic refuse, including clothes, concrete & brick gravel, plastic. Some sandy clay & clayey sand.				POORLY COMPACTED, VOIDED
			1							
	DS	N=12 3, 7, 5								
			2							
						END OF BOREHOLE AT 2.3m.				OBSTRUCTION IN FILL CAUSED AUGER TO MOVE OUT OF LINE
			3							
			4							
			5							
			6							

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BOREHOLE LOG

Borehole No. 103A 1/2

1m. WEST OF B.H.3

Client: CRONULLA SHARKS

Project: SHARK PARK REDEVELOPMENT

Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP Method: SPIRAL AUGER

Date: 26-2-90 EDSON 3000

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			0			FILL: silty clay, low plasticity, with some domestic refuse including bricks, cloth, plastic.	MC>PL	L		POORLY COMPACTED, VOIDED
			1							
			2							
	DS	N=4 1, 2, 2	3							
	DS		4		OL	ORGANIC SANDY SILTY CLAY: low plasticity, dark green grey with abundant decayed organic matter & some shells.	MC>PL	V.S.		STRONG ORGANIC ODOUR
	DS	SUNK UNDER HAMMER WEIGHT N<1	5							
	DS				CL	SANDY SILTY CLAY: medium plasticity, light grey.		VSt		
	DS	N=11 3, 4, 7	6						290 220 280 280	

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Borehole No. 103A 2/2

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP Method: SPIRAL AUGER
Date: 26-2-90 EDSON 3000

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			7			AS above — — becoming mid brown mottled, with sandstone layers.	MC>PL	V. St.		
	DS	N = 22 4, 8, 4							260 320 280 300	
			8							
			9							
	DS									
			10			END OF BOREHOLE AT 10.0m.				
			11							
			12							
			13							

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EFC PT No. 201
Sheet 1 of 2

ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F5.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE, WOOLOOWARE

Operator BRYAN CLANCY
Time & Date 6-3-90
Last Calibration 9:30 a.m.
Comment on Cone Condition GOOD

Cone Type MACSIL
Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder

Comments Log

FILL - CLAY

FILL - CLAYEY SAND

ORGANIC SILTY CLAY: Soft to very soft.

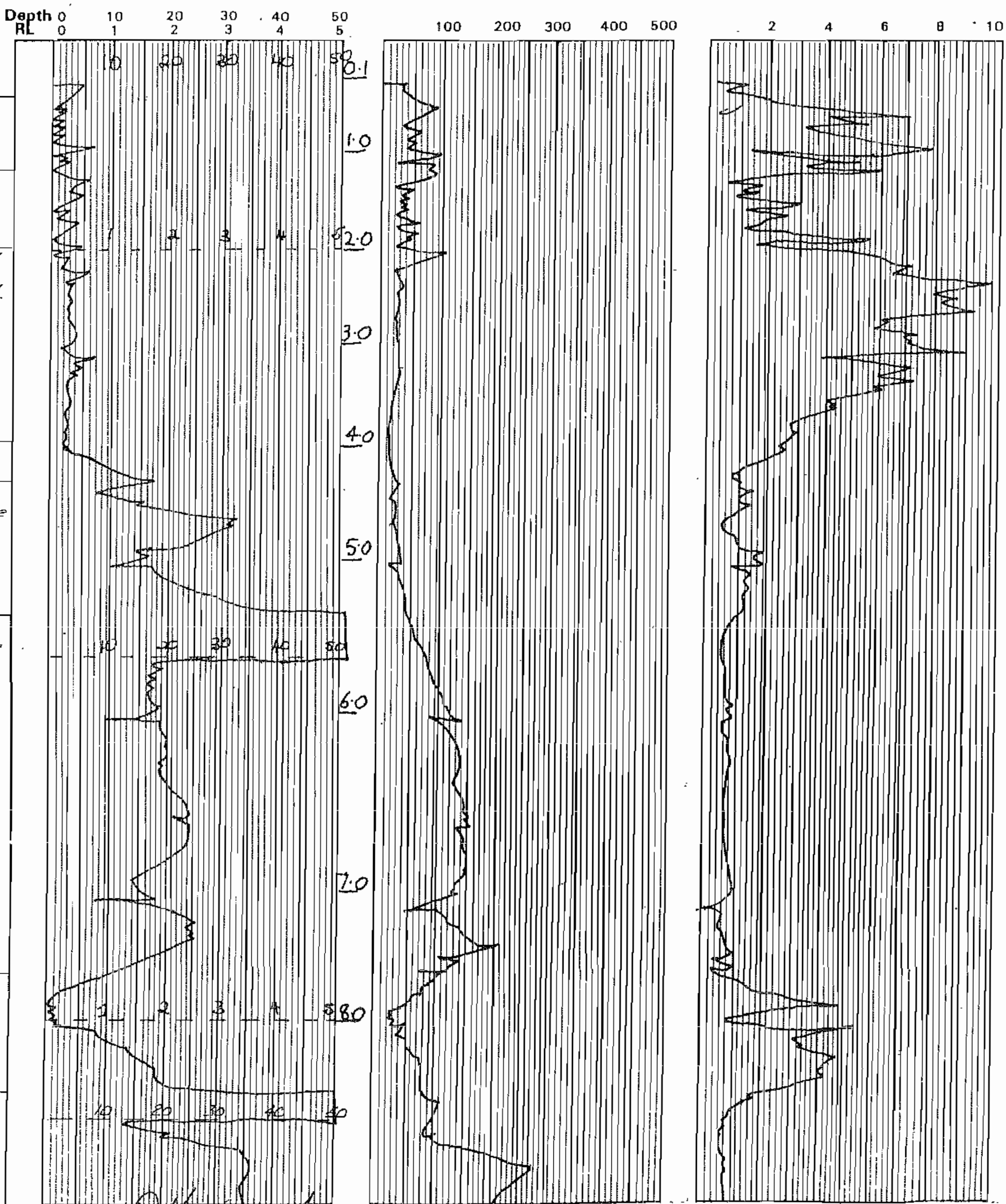
SANDY CLAY

SAND: very loose to loose

SAND: Dense to very dense

SANDY CLAY

SAND: very dense



Authorised Signatory

Date 8/3/90

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EFC PT No. 201
Sheet 2 of 2

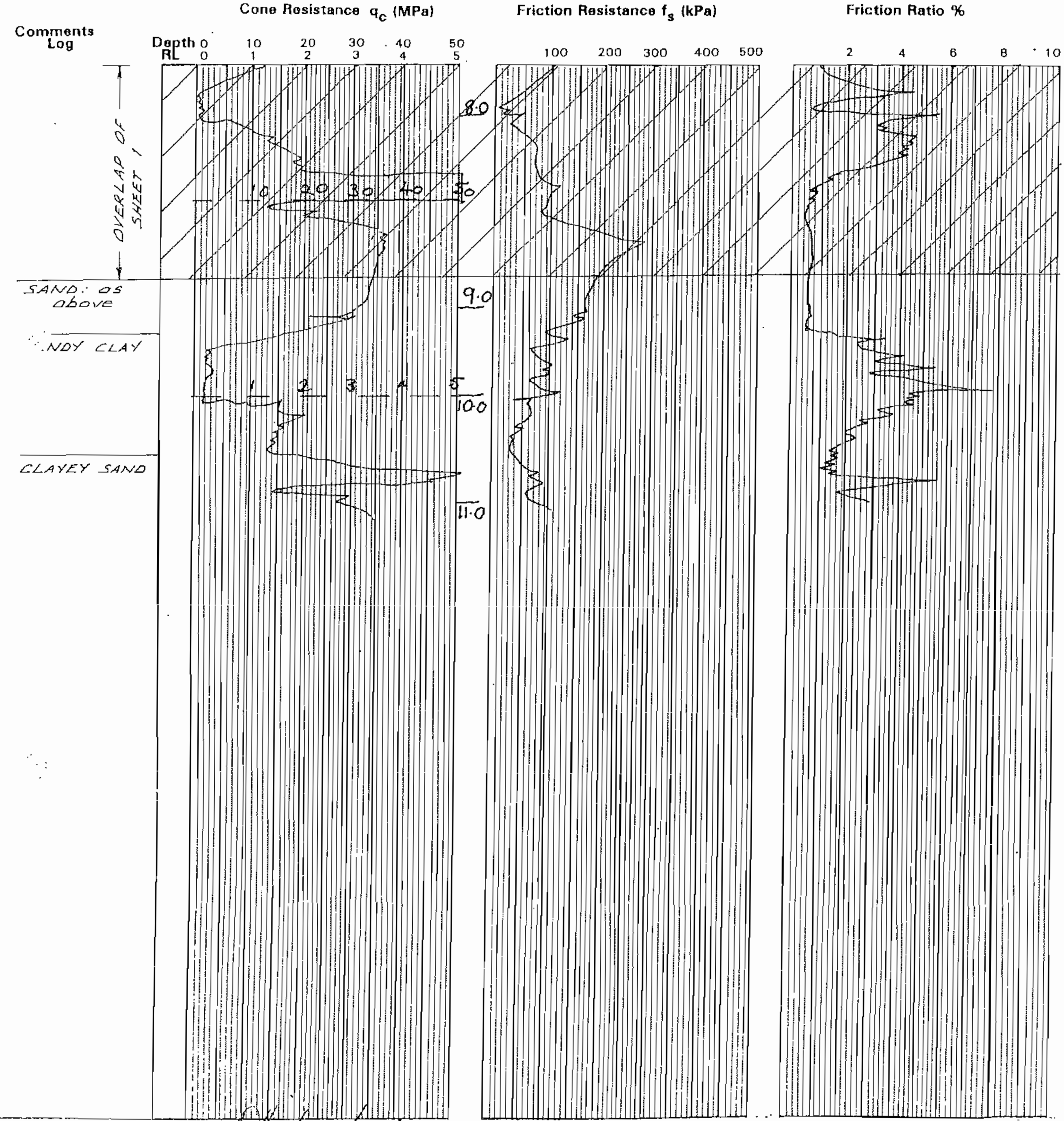
ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F6.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE WOOLOOWARE

Operator BRYAN CLANCY
Time & Date 6.3.90
Last Calibration 9:30 a.m.
Comment on Cone Condition GOOD

Cone Type MACSIL
Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder



Authorised Signatory

Date 8/8/90

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EFC PT No. 202
Sheet of

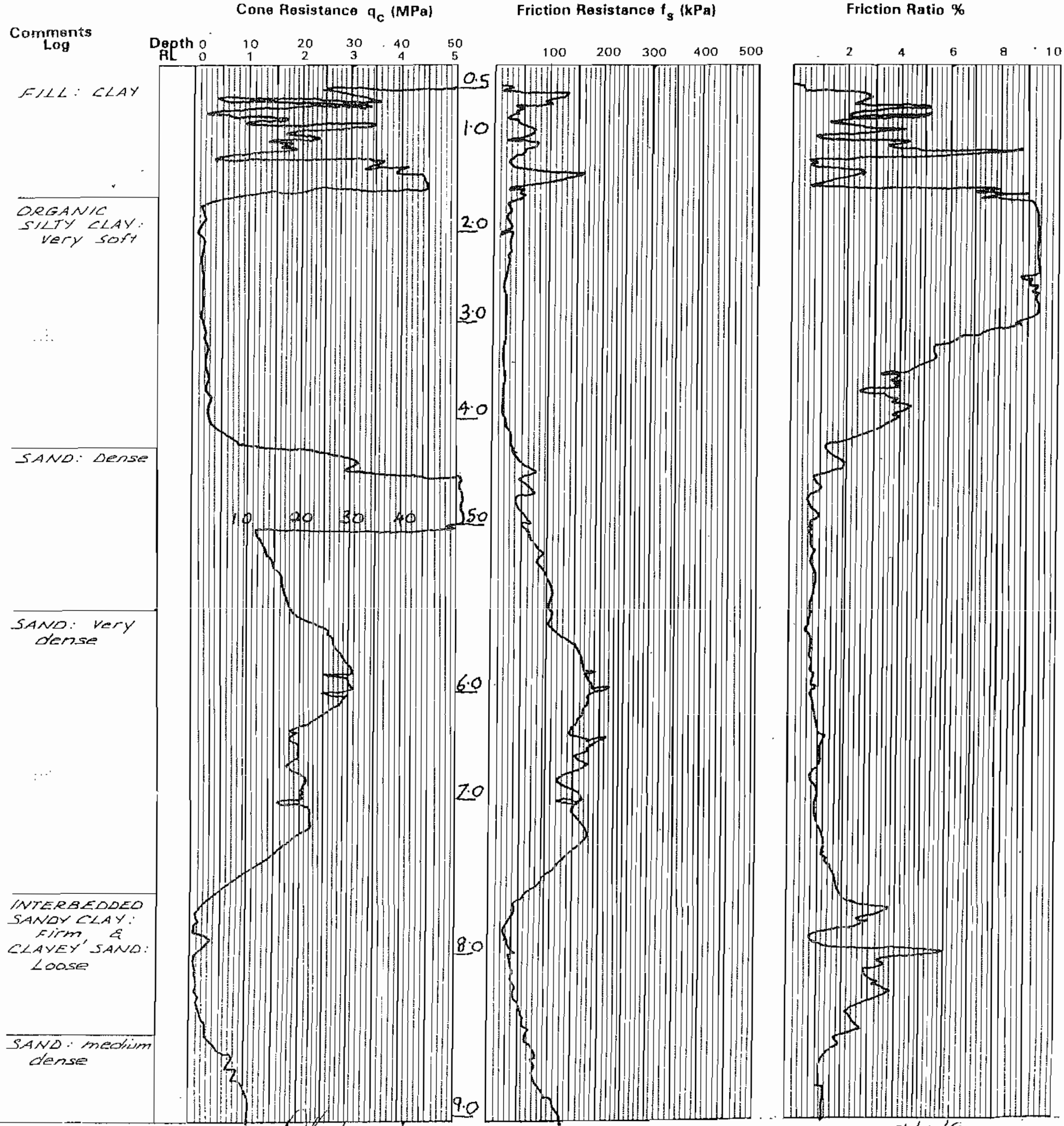
ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F6.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE, WOOLOOWARE

Operator BRYAN CLANCY
Time & Date 6-3-90
Last Calibration 9:30 a.m.
Comment on Cone Condition GOOD

Cone Type MACSIL
Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder



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EFC PT No. 203
Sheet of

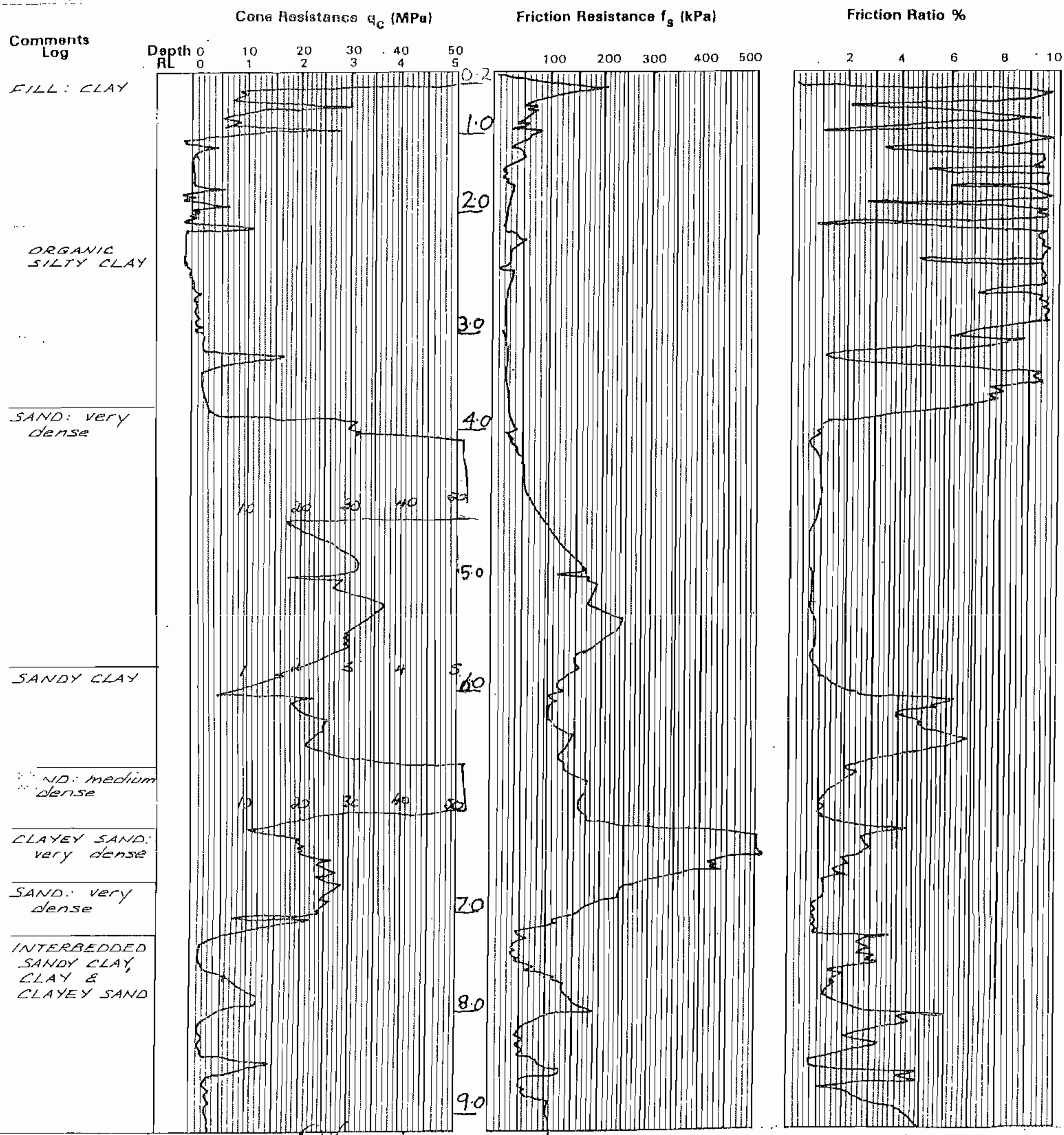
ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F6.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE, WOOLOOWARE

Operator BRYAN CLANCY
Time & Date 6-3-90
Last Calibration 9:30 a.m.
Comment on Cone Condition GOOD

Cone Type MAGSIL
Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder



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EFC PT No. 204
Sheet of

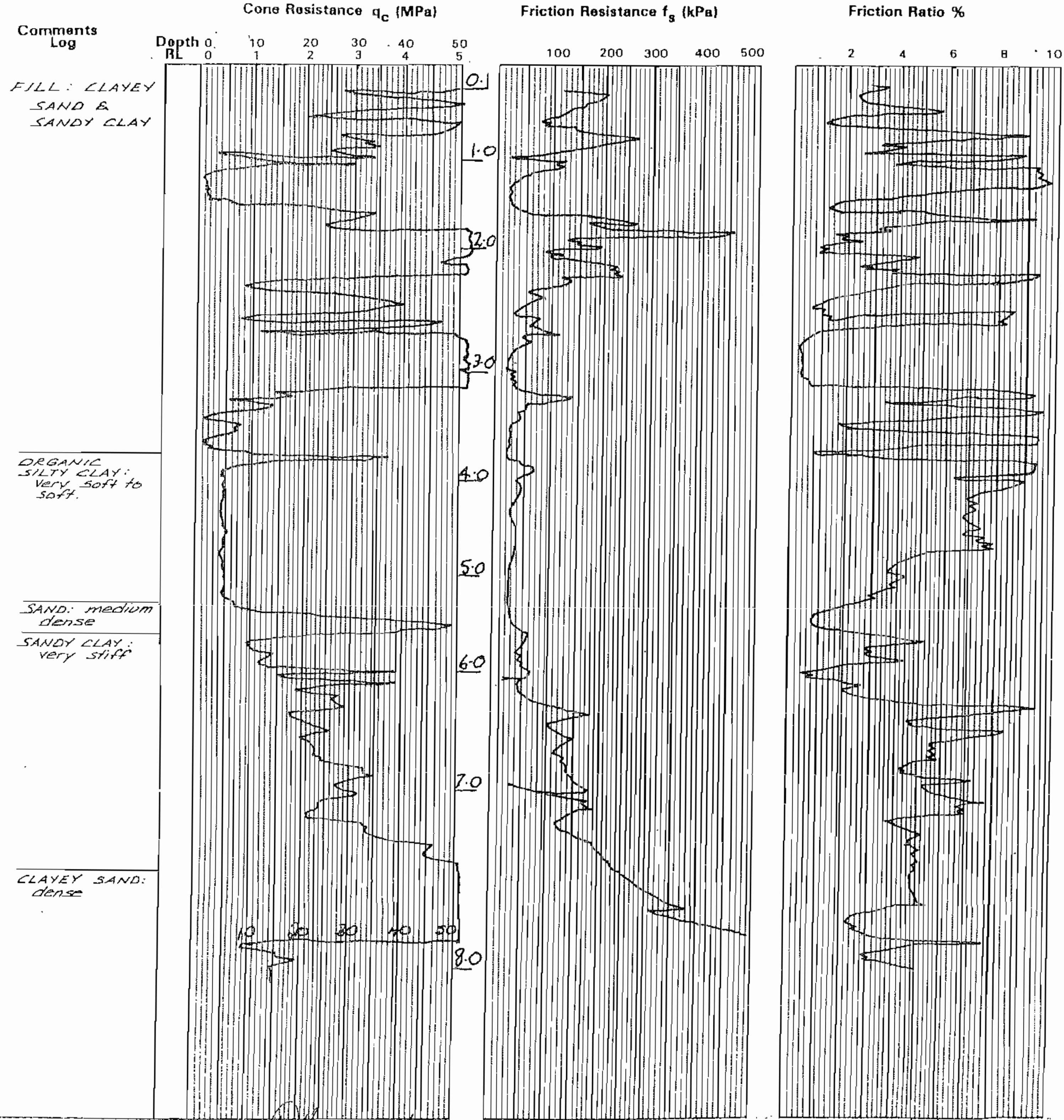
ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F5.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE WOOLOOWARE

Operator BRYAN CLANCY
Time & Date 6-3-90
Last Calibration 9:30 a.m.
Comment on Cone Condition GOOD

Cone Type MACSIL
Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder



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Date 8/3/90

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EFC PT No. 205
Sheet 1 of 1

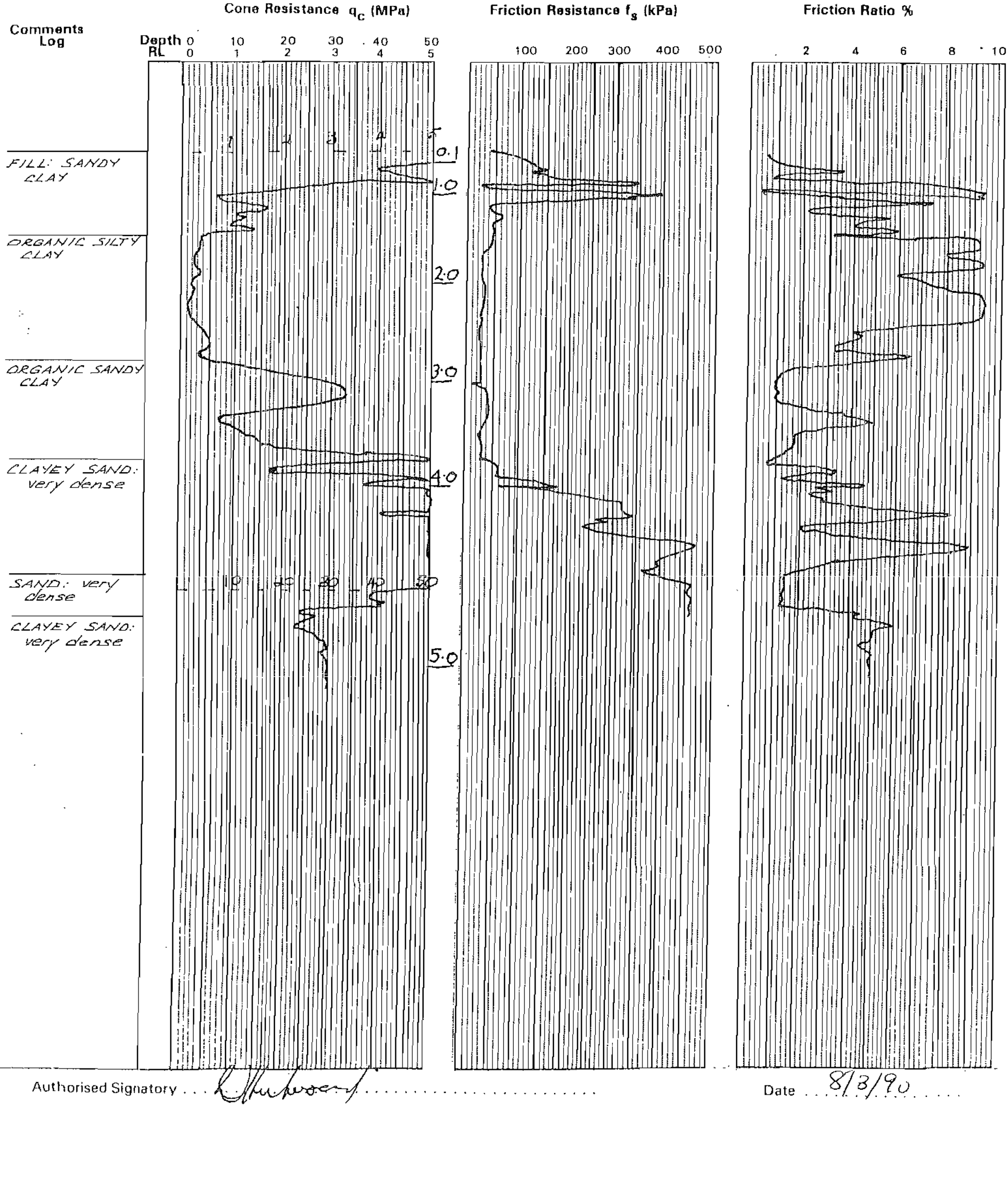
ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F6.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE WOOLOOWARE

Operator BRYAN CLANCY
Time & Date 6-3-90
Last Calibration 9:30 a.m.
Comment on Cone Condition GOOD

Cone Type MACSIL
Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder



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Date 8/3/90

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EFC PT No. 206
Sheet 1 of 1

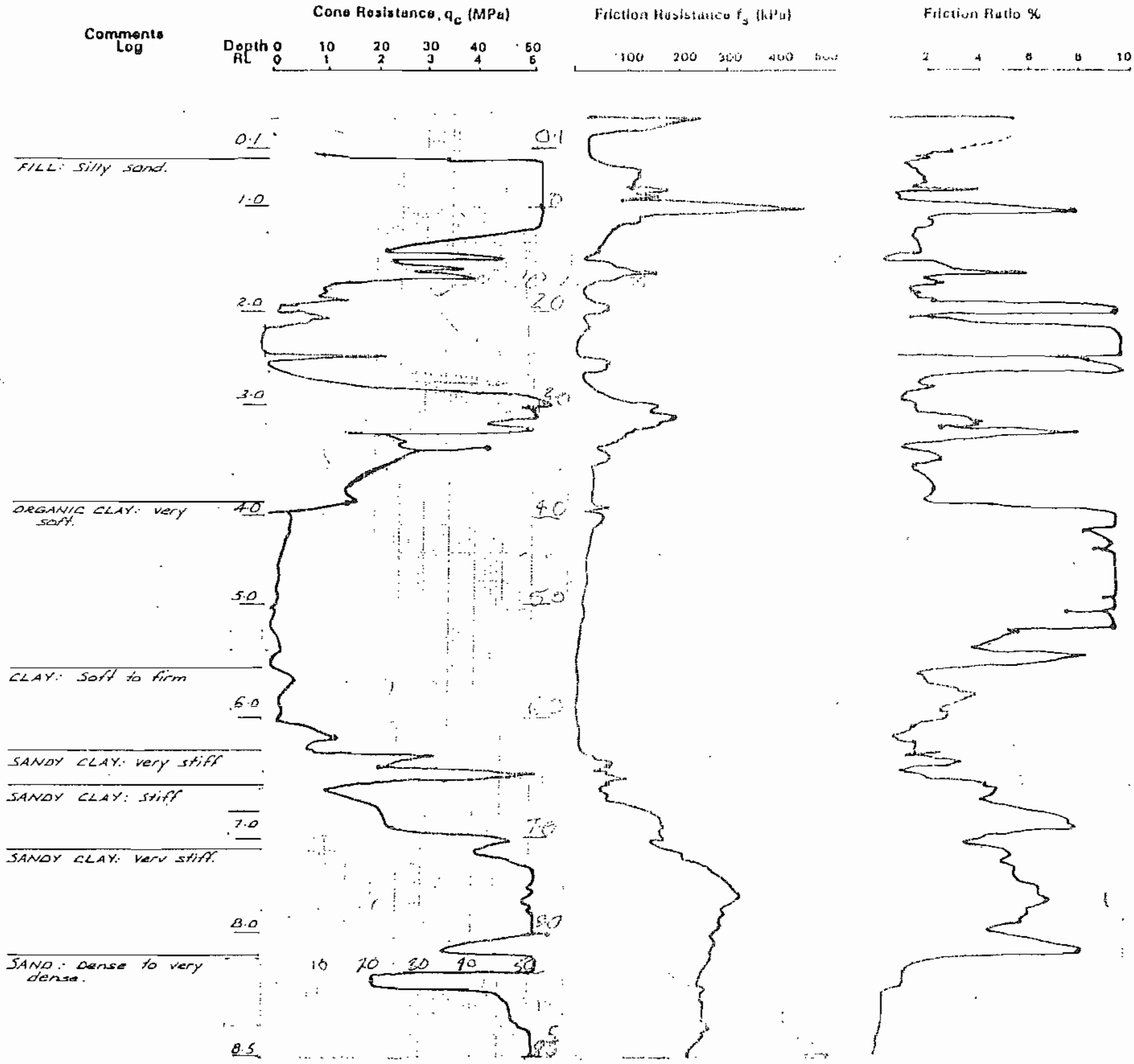
ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F6.1 - 1977)

Job No. 15009JTP
Client CRONULLA SHARKS
Project SHARK PARK REDEVELOPMENT
Location CAPTAIN COOK DRIVE, WOOLOOWARE

Operators BRYAN, G, STEVE
Time & Date 13-3-90
Last Calibration 9:30 p.m.
Comment on Cone Condition Good

Cone Type MAC51L
Note: Test performed with 37mm dia. Res. No Friction Reducer used.
15 tonne thrust Penetrometer used.
Results recorded on 3 Track Chart Recorder



Jeffery and Katauskas Pty. Ltd.

CONSULTING GEOTECHNICAL ENGINEERS

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EFC PT No. 207

Sheet 1 of 1

ELECTRONIC FRICTION CONE PENETROMETER TEST

(TO AS. 1289 F6.1 - 1977)

Job No. . 15009JTP

Client . CRONULLA SHARKS

Project . SHARK PARK REDEVELOPMENT

Location CAPTAIN COOK DRIVE WOOLOOWARE

Operators . BRYAN

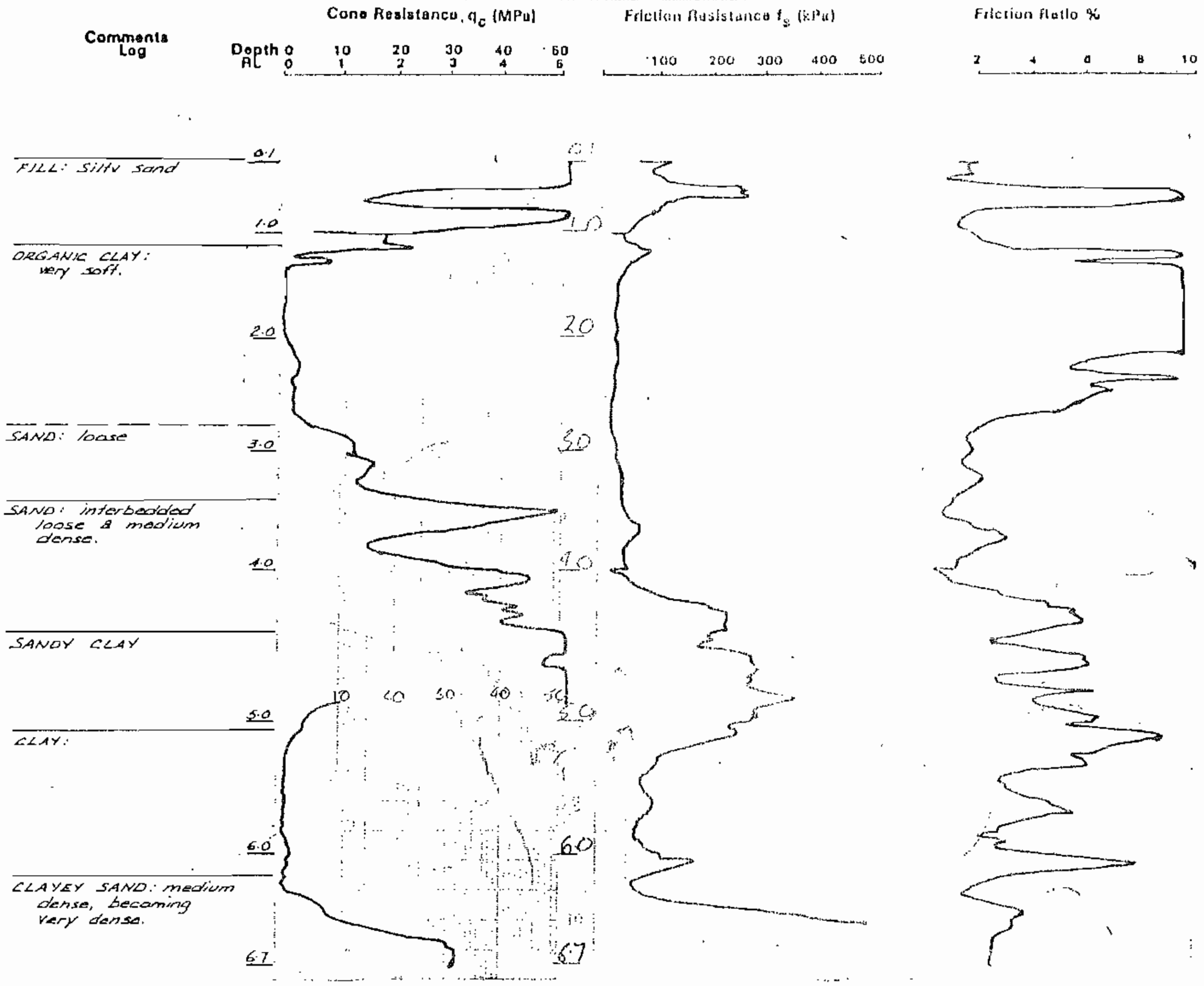
Time & Date . [illegible]

Last Calibration . [illegible]

Comment on Cone Condition . [illegible]

Cone Type . [illegible]

Note: Test performed with 37mm dia. Rods. No Friction Reducer used. 15 tonne thrust Penetrometer used. Results recorded on 3 Track Chart Recorder



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Borehole No. 301 & 301A

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP
Date: 16 - 7 - 91
Method: SPIRAL AUGER G.C.H. RIG.
R.L. Surface: 2·4m.
Datum: A.H.D.

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			0			FILL: Clayey Sand with some gravel, glass, cobbles, broken tile, metal pieces, grey.				1A MEET REFUSAL AT 1M ON COBBLY FILL. POORLY COMPACTED.
	DS	N = 4 4, 2, 2	1							
▼ (approx. 2.0 m)			2							
		SUNK UNDER WEIGHT OF RODS								
	DS	N >12 1, 6, 11/50mm								
		BOUNCING	3							
					OH	ORGANIC CLAY: high plasticity, grey.	MC>PL	S		PUNGENT ODOUR.
		N < 1 2/700mm	4							
			5			END OF BOREHOLE AT 4·7m				
			6							
			7							

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Borehole No.
302

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP Method: SPIRAL AUGER R.L. Surface: 1·7m.
Date: 16 - 7 - 91 G.C.H. RIG. Datum: A.H.D.

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
						ASPHALTIC CONCRETE: over base.				PAVEMENT.
						FILL: Clayey Sand with gravel, rubble and abundant timber fragments, dark grey.				POORLY COMPACTED.
▼	DS	N = 6 2, 3, 3	1							
						becoming more silty sand.				
			2							
		N<1 1/700mm			OH.	ORGANIC CLAY: high plasticity, with shell fragments.	MC>PL	S		
			3							
		SUNK UNDER HAMMER WEIGHT.	4							
			5			END OF BOREHOLE AT 4.8m				
			6							
			7							

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Borehole No. 303

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE WOOLOOWARE.

Job No. 15009JTP | Method: SPIRAL AUGER G.C.H. RIG. | R.L. Surface: 1·7m.
Date: 16 - 7 - 91 | | Datum: A.H.D.

Groundwater record	Samples	Field Tests	Depth (m.)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings kPa.	Remarks
			0–2.6			FILL: Sandy Clay / Clayey Sand medium plasticity, red brown and dark grey, some gravel and cobbles, trace of timber pieces.				POORLY COMPACTED.
▼ (approx. 1.5)		2, 9, 4, 2, 3, 1, 1, 2, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1	1, 2							
			2.6–3.8		OL	ORGANIC SILTY CLAY: low to medium plasticity, dark grey, abundant reed inclusions.	MC >PL	S.		
			3, 4			END OF BOREHOLE AT 3·8m.				
			5, 6, 7							

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Borehole No.
401
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 25-1-96
Method: HAND AUGER
R.L. Surface: N/A
Datum:
Logged/Checked by: D.J./

Groundwater Record	SAMPLES U50 DB DS ES	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		REFER TO SCALA SHEET	0		–	TOPSOIL: Silty sand, fine grained, brown, with some fine roots.	M			GRASS COVER
						FILL: Clayey silty sand, fine grained, grey, with some clay nodules and fine to medium gravel.				APPEARS POORLY TO MODERATELY COMPACTED
			1			FILL: Sand, fine to medium grained, yellow brown, with some clay bands.				
						END OF BOREHOLE AT 1.3m				HAND AUGER REFUSAL
			2							
			3							
			4							
			5							
			6							
			7							

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Borehole No.
402
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP **Method:** HAND AUGER **R.L. Surface:** N/A
Date: 25-1-96 **Datum:** -
Logged/Checked by: D.J./ [illegible]

Groundwater Record	SAMPLES (U50, DB, DS, ES)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		REFER TO SCALA SHEET	0		-	TOPSOIL: Silty sand, fine to medium grained, brown, with some fine roots.	M			GRASS COVER
						FILL: Clayey silty sand, fine grained, grey, with some root bands and fine to medium gravel.				APPEARS MODERATELY COMPACTED
			1							
						as above, but with some coarse slag gravel.				
			2							
						FILL: Gravelly sandy clay, low to medium plasticity, brown, fine to coarse sandstone gravel.	MC>PL			
						END OF BOREHOLE AT 2.6m				HAND AUGER REFUSAL
			3							
			4							
			5							
			6							
			7							

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Borehole No. 403
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 25-1-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum: –
Logged/Checked by: D.J./

Groundwater Record	SAMPLES (U50, DB, DS, ES)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		–	TOPSOIL: Silty sand, fine to medium grained, brown, with some fine roots.	M			GRASS COVER
		N_c = 2, 3, 3, 3, 6, 3, 3, 4, 7, 12R	1 – 2			FILL: Clayey silty sand, fine grained, grey, with some fine to coarse gravel.				APPEARS POORLY COMPACTED
AFTER 3.5 HRS.		N_c = 1, 2, 3, 20, 6, 3, 3, 6, 4, 4, 4, 5	2 – 4			FILL: Gravelly sandy clay, low to medium plasticity, brown, fine to coarse gravel, with some cobbles.	MC>PL			
			4 – 5		OL–OH	ORGANIC CLAY: medium to high plasticity, dark grey, with numerous fine roots.	MC>PL	St		–
			5 – 6			as above, but pale yellow brown, with some fine roots.				
			6			END OF BOREHOLE AT 6.0m				
			7							

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Borehole No.
404
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 25-1-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum: –
Logged/Checked by: D.J./ [signature]

Groundwater Record	Samples (U50, DB, DS, ES)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		–	TOPSOIL: Silty sand, fine to medium grained, brown, with some fine roots.	M			GRASS COVER
	DS	N_c = 5, 8, 9, 14, 9, 5, 3, 2, 4, 9	0.1–2			FILL: Clayey silty sand, fine grained, grey, with some fine to coarse gravel and cobbles.				APPEARS POORLY TO MODERATELY COMPACTED
AFTER 2.5 HRS	DS	N_c = 2, 1, 5, 5, 3, 2, 1, 1, 1	2–3.4				W			
	DS		3.4–4.5		OL–OH	ORGANIC CLAY: medium to high plasticity, dark grey, with some fine roots.	MC>PL	F	–	–
			4.5			END OF BOREHOLE AT 4.5m				

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Borehole No.
405
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 25-1-96

Method: SPIRAL AUGER GCH RIG

R.L. Surface: N/A
Datum: –

Logged/Checked by: D.J./

Groundwater Record	Samples (U50, DB, DS, ES)	Field Tests	Depth (m)	Unified Classification	Description	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0	–	TOPSOIL: Silty sand, fine to medium grained, brown, with some fine roots.	M			GRASS COVER
	DS	N_c = 3, 6, 8, 9, 9, 11, 11, 9, 7, 6			FILL: Clayey silty sand, fine grained, grey, fine to coarse gravel, with some cobbles.				APPEARS MODERATELY COMPACTED
	DS		1						
	DS		2			W			
AFTER 1.75 HRS		N_c = 2, 3, 1, ↓, 4, 5, 5, 6, 4, 6, 8	3						APPEARS POORLY COMPACTED
	DS		4	OL-OH	ORGANIC CLAY: medium to high plasticity, yellow brown with numerous fine to medium roots.	MC>PL	St	–	–
					END OF BOREHOLE AT 4.5m				
			5						
			6						
			7						

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Borehole No. 406 1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 25-1-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum: –
Logged/Checked by: D.J./

Groundwater Record	SAMPLES (U50, DB, DS, ES)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		–	TOPSOIL: Silty san,d fine to medium grained, brown, with some fine roots.	M			GRASS COVER
	DS	N_c = 3, 3, 3, 5, 7, 5, 5, 4, 7, 7, 5	1			FILL: Clayey silty sand, fine grained, grey, with some fine to coarse gravel.				APPEARS POORLY TO MODERATELY COMPACTED
AFTER 1 HOUR	DS	N_c = 1, 1, 1, 2, 1, 4, 6, 1, 2	2			FILL: Gravelly sandy clay, medium plasticity, brown, fine to coarse gravel.	MC>PL			APPEARS POORLY COMPACTED
	DS		4		OL–OH	ORGANIC CLAY: medium to high plasticity, grey brown, with some fine roots and a trace of shells.	MC>PL	(F)	–	–
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No. 407
1/1

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP **Method:** HAND AUGER **R.L. Surface:** N/A
Date: 4-4-97 **Datum:** –
Logged/Checked by: D.J./ M

Groundwater Record	SAMPLES (U50 / DB / DS / ES)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
DRY ON COMPLETION		REFER TO SCALA SHEET	0			FILL: Silty sand, fine to medium grained, brown, with some clayey sand bands and fine to medium gravel.	M			GRASS COVER APPEARS POORLY TO MODERATELY COMPACTED
						FILL: Clayey silty sand, fine grained, grey, with some fine to coarse gravel.	MC>PL			
			1			FILL: Sandy clay, medium plasticity, various colours, with some fine to medium gravel.				
						FILL: Silty sand, fine to medium grained, brown, with same clay nodules and fine to coarse gravel.	M			
			2			END OF BOREHOLE AT 1.8m				HAND AUGER REFUSAL
			3							
			4							
			5							
			6							
			7							

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SCALA PENETRATION TEST RESULTS

Client:	CRONULLA SHARKS
Project:	SHARK PARK REDEVELOPMENT
Location:	CAPTAIN COOK DRIVE, WOOLOOWARE

Job No.	15009JTP	**Hammer Weight & Drop: 9kg/510mm**
Date:	25-1-96	**Rod Diameter: 16mm**
Tested By:	D.J.	**Point Diameter: 20mm**

Number of Blows per 100mm Penetration

Test Location / Depth (mm)	401	402	407				
0 - 100	1	1	1				
100 - 200	2	3	2				
200 - 300	3	3	1				
300 - 400	3	14	4				
400 - 500	3	19	4				
500 - 600	5	18	6				
600 - 700	4	9	7				
700 - 800	3	6	7				
800 - 900	3	4	11				
900 - 1000	6	4	7				
1000 - 1100	6	4	6				
1100 - 1200	4	5	15				
1200 - 1300	3	7	19				
1300 - 1400	3	6	9				
1400 - 1500	8	25	11				
1500 - 1600	23	12	12				
1600 - 1700	13	9	9				
1700 - 1800	9	11	9				
1800 - 1900	14	10	9				
1900 - 2000	9	10	9				
2000 - 2100	8	11	10				
2100 - 2200	9	9	10				
2200 - 2300	8	7	10				
2300 - 2400	8	15	9				
2400 - 2500	8	12	10				
2500 - 2600	8	15	11				
2600 - 2700	8	21	10				
2700 - 2800	7	21	8				
2800 - 2900	8	20	9				
2900 - 3000	END	END	END				

Remarks:

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Borehole No.
501
1/3

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
Logged/Checked by: L.S./jp
R.L. Surface: N/A
Datum:

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/Weathering	Strength/Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE PAVEMENT: 20mm over 280mm of crushed igneous gravel.				PAVEMENT
		N_c = 4, 5, 6, 5, 6, 3, 3, 4, 6				FILL: Clayey sand, fine to medium grained, brown, red brown, yellow brown, grey, some grey clay nodules, some sandstone gravel, a trace of crushed igneous gravel and sandstone cobbles.	M	–	–	APPEARS MODERATELY COMPACTED
			1			FILL: Clay, high plasticity, grey and brown, some shale gravel, some sandy clay nodules (black) with organic fibres and fine roots, a trace of timber and wire.	MC>PL			APPEARS POORLY COMPACTED
AFTER 4 HRS		N_c = 2, 4, 5, 1, 2, 1, 2, 3, 5	2			FILL: Sandy clay, low plasticity, black, fine to medium sand, some brown nodules, some timber and organic fibres, a trace of wire, concrete, sandstone gravel and clay pipe and steel reinforcing.	MC>>PL			HARD BAND APPARENT CONCRETE 0.1m THICK
			3			FILL: Gravelly clayey sand, fine to coarse grained, black, fine to coarse ash gravel, some timber, a trace of wire and metal, slight organic odour.	W			
		N < 1 1,–,–	4 / 5		OL	ORGANIC CLAY: medium plasticity, dark brown to black, some shell fragments, a trace of fibrous material.	MC>PL	(S) / VS	– / 20, <20, 20	STRONG ORGANIC ODOUR TO 6.5m. ALLUVIAL
			6		SC	CLAYEY SAND: fine to medium grained, brown, some fine rootlets.	W	(VL)		
			7		CL	SANDY CLAY: medium plasticity, pale grey and orange brown mottled.	MC>PL	St		HP 150,120 IN SAMPLE FROM AUGER. RESIDUAL SOIL

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Borehole No.
501 / 2/3

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum:
Logged/Checked by: L.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			7		CL	as above, but with some red brown mottling and fine grained sand, some silt.	MC>PL	(VSt)		25mm
		N_c = 30 R	8							
					–	SANDSTONE: fine to medium grained, pale grey, brown, dark brown and purple, some clay bands.	DW	M	–	MODERATE 'TC' BIT RESISTANCE
			9		CL	SANDY CLAY: medium plasticity, brown and pale grey.	–	–	–	–
			10							
			11		–	SANDSTONE: fine to medium grained, brown and grey.	DW	VL	–	VERY LOW RESISTANCE
			12			as above, but pale grey.		L		LOW RESISTANCE
			13					M		MODERATE RESISTANCE

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Borehole No. 501 3/3

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
Logged/Checked by: L.S./
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■		14			SANDSTONE: as above.		M		MODERATE RESISTANCE
											L		LOW RESISTANCE
						15			END OF BOREHOLE AT 15.0m				
						16							
						17							
						18							
						19							
						20							

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Borehole No. 502

1/2

BOREHOLE LOG

Client: CRONULLA SHARKS

Project: SHARK PARK REDEVELOPMENT

Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP

Method: SPIRAL AUGER GCH RIG

R.L. Surface: N/A

Date: 11-12-96

Datum:

Logged/Checked by: L.S./ [illegible]

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE: 40mm.t over crushed igneous gravel 340mm.t.				PAVEMENT
		N_c = 7, 7				FILL: Clayey sand, fine to medium grained, brown, orange brown, red brown and pale grey mottled, some sandstone gravel, and clay nodules.	M	-	-	APPEARS MODERATELY COMPACTED
		5, 7, 12, 10 R	1			FILL: Sandy clay, medium plasticity, brown, with various coloured mottling, some timber, a trace of gravel.	MC>PL			PIECE OF TIMBER
AFTER 1 HR		N_c = 3, 1, 1, 1, 2, 1, 1	2, 3			FILL: Sand, fine grained, dark brown to black, some clay, timber pieces (small) and fibrous material, slight organic odour, a trace of glass.				APPEARS POORLY COMPACTED
		1, 1, 1, 2, 3, 3, 4, 3, 4, 3	4, 5		OL	ORGANIC CLAY: medium plasticity, brown to dark brown, some fibrous material. as above, but with some shell fragments.	MC>PL	(S)		STRONG ORGANIC ODOUR ALLUVIAL
		3, 5	6		SC	CLAYEY SAND: fine to medium grained, brown, some organic clay nodules and bands.	M	(L)		
			7		CL	SANDY CLAY: medium plasticity, pale grey, with orange brown and red brown bands, some thin very low strength sandstone bands.	MC>PL	(VSt-H)		RESIDUAL SOIL

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Borehole No. 502 2/2

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum:
Logged/Checked by: L.S./[illegible]

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			7	CL	SANDY CLAY: as above.	MC>PL	(H)		
	DS			-	SANDSTONE: fine to medium grained, pale grey with brown to red brown bands.	SW	M		MODERATE 'TC' BIT RESISTANCE
			8	CL	SANDY CLAY: medium plasticity, brown.	-	(VSt)	-	-
				-	INTERBEDDED SANDSTONE AND SANDY CLAY: as above, but with thin low strength sandstone bands.	-	-	-	BANDED LOW RESISTANCE
			9, 10, 11	CL	SANDY CLAY: medium plasticity, brown, occasional very low strength sandstone bands.	-	(VSt)	-	-
	DS		12, 13	-	SANDSTONE: fine to medium grained, pale grey.	SW	M	-	MODERATE RESISTANCE
					END OF BOREHOLE AT 13.5m				

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Borehole No. **503** 1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum:
Logged/Checked by: L.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE: 40mm.t over crushed gravel in a silty sand matrix.	D			PAVEMENT
		N_c = 15, 21, 11	1			FILL: Clayey sand, fine to medium grained, brown with various coloured mottling, a trace of sandstone gravel and timber pieces, some clay nodules.	M	-	-	APPEARS WELL COMPACTED
		N_c = 5, 5, 4, 4, 8R	2			FILL: Interbedded clayey sand and sandy clay, low plasticity, fine to medium grained, dark brown with various gravel, timber and a large sandstone boulder.	M/ MC>PL			APPEARS MODERATELY COMPACTED NOTE: LOTS OF OBSTRUCTION WITHIN THE FILL MAKING DRILL PENETRATION DIFFICULT.
		N_c = 11, 11, 12, 17	3			FILL: Sandy clay, low to medium plasticity, dark brown fine grained sand, some wood pieces and gravel.	MC>PL			
AFTER 1/2 HR			4			FILL: Clayey sand, fine grained, low plasticity, dark brown, significant wood fibres and roots, strong organic odour, some metal, wire and steel pieces.				
			5		OL	ORGANIC CLAY: medium plasticity, dark brown to brown, strong organic odour, a trace of plant fibres.	MC>PL	VS-S		ALLUVIAL
						ORGANIC CLAY: as above, but with some shell fragments a trace of sand.				
			6			END OF BOREHOLE AT 6.0m				
			7							

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Borehole No. 504
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum:
Logged/Checked by: L.S./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE: over crushed igneous gravel in a silty sand matrix.				PAVEMENT
	DB	N_o = 9, 9, 6, 9, 10, 7, 8, 5, 12R	1			FILL: Clayey sand, fine to medium grained, brown with various coloured mottling, some sandstone gravel.	M	–	–	APPEARS MODERATELY TO WELL COMPACTED
	DB		2–3			FILL: Sandy clay, low plasticity, brown to dark brown with various coloured mottling, some roots and wood pieces, a trace of metal, wire and plastic.	MC>PL			APPEARS MODERATELY COMPACTED
AFTER 1 HR		N_o = 9, 10, 16, 20	4			FILL: Clayey sand, fine to medium grained, dark brown, some root, wood pieces, metal, glass and wire.				
			5		OL	ORGANIC CLAY: medium plasticity, brown, some organic fibres, strong organic adour.	MC>PL	(VS–S)	–	ALLUVIAL
						END OF BOREHOLE AT 5.2m				
			6							
			7							

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Borehole No. 505 1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-12-96
Method: SPIRAL AUGER GCH RIG
R.L. Surface: N/A
Datum:
Logged/Checked by: L.S./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE: 40mm.t., over crushed igneous gravel in a silty sand matrix.				PAVEMENT
		N_c = 11, 15, 9, 8, 12, 8	1			FILL: Clayey sand, fine to medium grained, orange brown, brown and dark brown with various coloured mottling, a trace of sandstone gravel with sandy clay bands up to 0.3m thick.	M	–	–	APPEARS WELL COMPACTED
		7, 8, 5, 3, 5, 4, 4, 3, 2, 1, 16R	2, 3, 4			FILL: Sandy clay, low plasticity, dark brown with various coloured mottling, some wood pieces, plastic, gravel, glass, metal, wire and general rubbish.	MC>PL			APPEARS MODERATELY COMPACTED APPEARS POORLY COMPACTED
ON COMPLETION					OL	ORGANIC CLAY: medium plasticity, brown, some plant fibres, strong organic odour.	MC>PL	(VS-S)	–	ALLUVIAL
			5, 6, 7			END OF BOREHOLE AT 4.8m				

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Borehole No. **601** 1/2

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-8-97
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./[illegible]

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty clay, low plasticity, brown, with fine to medium igneous gravel, ironstone gravel, sand and a trace of glass.	MC>PL			APPEARS POORLY TO MODERATELY COMPACTED
AFTER 4 HRS	DS	N = 7 2,3,4	1			FILL: Sand, fine to medium grained, grey brown, with ash, timber pieces, plastic and silt fines.	M			
	DS	N < 1 2,2/ 300mm	2			FILL: Silty clay, low plasticity, dark grey, with roots, timber pieces and sand.	MC>PL			APPEARS POORLY COMPACTED
	DS	N = 1 1,-,1	3		OL	ORGANIC CLAY: medium plasticity, dark grey brown, with fine roots and shell fragments.	MC>>PL	S	– 40 50 50	ALLUVIAL SOIL
			4		CL	SILTY CLAY: medium plasticity, grey, with fine grained sand and a trace of shell fragments and fine roots.				SLIGHT ORGANIC ODOUR BELOW 4.5m.
	DS	N = 19 4,7,12	5		SM	SILTY SAND: fine to medium grained, grey.	W	MD		
			6		SP	SAND: fine to medium grained, pale orange brown.				
			7							

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BOREHOLE LOG

Borehole No. 601 2/2

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP **Method:** SPIRAL AUGER BCD 350 **R.L. Surface:** N/A
Date: 11-8-97 **Datum:**
Logged/Checked by: S.E./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		N > 20 2,20/ 150mm BOUNCING	7		SC	CLAYEY SAND: fine to medium grained, pale brown and red brown, with bands of coffee rock.	M	MD-D		
			8		-	SANDSTONE: fine to medium grained, mottled pale grey and red brown, with a trace of sandy clay bands.	DW	L	-	LOW 'TC' BIT RESISTANCE
		N > 20 20/ 150mm BOUNCING	9		CH	SILTY CLAY: high plasticity, pale grey, with a trace of clayey sand bands.	MC<PL	H	-	-
			10		-	SANDSTONE: fine to medium grained, pale grey, with a trace of red brown mottling and clay bands	DW	L	-	LOW RESISTANCE
			11, 12					L-M		LOW TO MODERATE RESISTANCE
						SANDSTONE: fine to medium grained, pale grey.	SW	M		MODERATE RESISTANCE
			13			END OF BOREHOLE AT 13.0m				

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BOREHOLE LOG

Borehole No. **602** 1/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-8-98
Method: SPIRAL AUGER BCD 350
Logged/Checked by: S.E./
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES (ES / U50 / DB / DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			CONCRETE PAVEMENT: 130mm.t.				REINFORCEMENT 6mm.t., 100mm FROM SURFACE
						FILL: Sandy clay, low plasticity, grey, with fine to medium sandstone and ironstone gravel and a trace of timber and plastic pieces.	MC<PL			APPEARS MODERATELY COMPACTED
	DB		1							
	DS	N = 11 1,5,6								
			2			FILL: Gravelly clay, low plasticity, with fine to medium igneous, sandstone and ironstone gravel, sand and some pieces of plastic.				APPEARS POORLY COMPACTED
▶										
	DS	N = 4 2,2,2	3							
										COLLAPSED TO 3.7m AFTER 1/4 HOUR
			4		OL	ORGANIC CLAY: medium plasticity, dark grey, with fine rootlets.	MC>PL	F	–	– SPT SUNK 300mm UNDER OWN WEIGHT
	DS	N = 4 1,2,2							60 80 100	ALLUVIAL SOIL
			5							
					CL	SILTY CLAY: medium plasticity, dark grey, with a trace of fine grained sand.		S-F		SPT SUNK 200mm UNDER OWN WEIGHT
	DS	N = 2 1,1,1	6						60 30 60	
			7							

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BOREHOLE LOG

Borehole No. 602 2/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-8-98
Method: SPIRAL AUGER BCD 350
Logged/Checked by: S.E./ff
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	DS	N = 2 1,1,1	7			SILTY CLAY: medium plasticity, grey, with a trace of fine sand and sandy bands.	MC>PL	St	100 110	HOLE COLLAPSING TO 7.0m RESIDUAL SOIL
	DS		8		–	SANDSTONE: fine to medium grained, red brown mottled pale grey.	DW	M–H		MODERATE TO HIGH 'TC' BIT RESISTANCE
			9			as above, but with clay bands.				LOW TO MODERATE RESISTANCE
			10 11		CL	SANDY CLAY: low plasticity, pale brown and orange brown.	MC>PL	–	–	–
			12		–	SANDSTONE: fine to medium grained, pale grey.	DW	L	–	LOW RESISTANCE
	DS		13				SW	M–H		MODERATE TO HIGH RESISTANCE

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Borehole No. 602
3/3

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 11-8-98
Method: SPIRAL AUGER BCD 350
Logged/Checked by: S.E./
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
						14			SANDSTONE: fine to medium grained, pale grey.	SW	M-H		MODERATE TO HIGH RESISTANCE
									END OF BOREHOLE AT 14.75m				
						15							
						16							
						17							
						18							
						19							
						20							

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BOREHOLE LOG

Borehole No. 603 1/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 12-8-97
Method: SPIRAL AUGER BCD 550
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			FILL: Silty sand, fine grained, grey, with a trace of fine ash, slag and fine roots.	M			GRASS COVER APPEARS POORLY COMPACTED
	DS	N = 7 3,2,5	1							
▶	DS	N < 1 1/450mm	2							SPT SUNK 200mm UNDER OWN WEIGHT
	DS	N < 1 6,1, 1/300mm	3							
			4		OL-OH	ORGANIC CLAY: medium to high plasticity, grey brown, with a trace of fine rootlets, fine grained sand and shell fragments.	MC>PL	S	–	ALLUVIAL SOIL
	DS	N = 2 1,1,1	5							
			6							
	DS	N = 15 3,5,10	7		SM	SILTY SAND: fine to medium grained, grey.	W	MD		

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Borehole No.
603

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 12-8-97
Method: SPIRAL AUGER BCD 550
Logged/Checked by: S.E./
R.L. Surface: N/A
Datum:

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			7		SM	SILTY SAND: fine to medium grained, grey.	W	MD		
		N = 13 5,6,7	8			as above, but with sandy clay bands and a trace of extremely weathered shale bands.				RESIDUAL SOIL
		N > 20 20/50mm	9–10							
			11–12							SANDSTONE BAND, 150mm.t.
			13							0mm
					-	SANDSTONE: fine to medium grained, pale grey.	SW	M-H	-	MODERATE 'TC' BIT RESISTANCE
						REFER TO CORED BOREHOLE LOG				

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CORED BOREHOLE LOG

Borehole No. 603
3/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP | **Core Size:** NMLC | **R.L. Surface:** N/A
Date: 12-8-97 | **Inclination:** VERTICAL | **Datum:**
Drill Type: BCD 550 | **Bearing:** – | **Logged/Checked by:** S.E./

Water Loss/Level	Barrel Lift	Depth (m)	Core Description (Rock Type, grain characteristics, colour, structure, minor components)	Weathering	Strength	Defect Details – Description (Type, inclination, thickness, planarity, roughness, coating)
		13				NOTE: DEFECTS NOT INDIVIDUALLY DESCRIBED ARE BEDDING PARTINGS 0-10°, PLANAR, ROUGH
		14	START CORING AT 14.06m			
FULL RET-URN			SANDSTONE: fine to medium grained, pale grey and red brown banded, bedded at 5-10°.	DW	L	- XWS, 8mm.t.
		15	as above, but mottled pale grey and red brown.		L / M	- CS, 0°, 20mm.t. - XWS, 0°, 30mm.t. - J, 23°, P, R - Be, 17°, P, R - IRON INDURATED BAND WITH CLAY, 40mm.t. - CS, 0°, 30mm.t.
			SHALY CLAY: high plasticity, grey to dark grey, with thin sandstone bands, MC<PL, Hard.			
		16	INTERBEDDED SHALE AND SANDSTONE: dark grey shale and fine grained, pale grey sandstone.	XW	EL-VL	
			SANDSTONE: fine grained, grey.	DW	VL-L	- CS, 0°, 20mm.t.
		17	SANDSTONE: fine to medium grained, pale grey, bedded at 15°.	SW	H	
			END OF BOREHOLE AT 17.16m			
		18				
		19				
		20				

Point Load Index Strength $I_s(50)$: EL VL L M H VH EH
Defect Spacing (mm): 500 300 100 50 30 10

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BOREHOLE LOG

Borehole No. 604 1/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 14-8-97
Method: SPIRAL AUGER BCD 550
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE: 35mm.t. over Roadbase, 250mm.t.				PAVEMENT
	DS	N = 3 3,2,1				FILL: Silty sand, fine to medium grained, brown, with timber pieces and a trace of glass, brick fragments, metal pieces, wire and general rubbish.	M			APPEARS POORLY COMPACTED FILL APPEARS TO CONTAIN VOIDS
	DS	N = 7 1,2,5	1							
			2			as above, but grey and brown, with metal pieces and wire.	W			
▶ (approx. 2.4 m)			3							
			4							
					OL	ORGANIC CLAY: medium plasticity, brown, with a trace of fine rootlets and shell fragments.	MC>PL	VS	–	ALLUVIAL SOIL
	DS	N < 1 SUNK 1.0m UNDER OWN WEIGHT	5							
			6		CL	SILTY CLAY: medium plasticity, grey brown, with a trace of fine rootlets.		S	40 50 50	
			7							

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BOREHOLE LOG

Borehole No. 604

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 14-8-97
Method: SPIRAL AUGER BCD 550
R.L. Surface: N/A
Datum:
Logged/Checked by: S.E./

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			7		CL	SILTY CLAY: medium plasticity, grey brown.	MC>PL	(F)		300mm
						SILTY CLAY: medium plsticity, pale grey, with a trace of fine sond.		(VSt)		– 75 RESIDUAL SOIL
			8							SANDSTONE BAND, 200mm.t.
			9		–	SANDSTONE: fine grained, pale grey, with red brown bands and clay bands.	XW	EL	–	EXTREMELY LOW 'TC' BIT RESISTANCE
			10							0mm
			11							
			12				DW	VL		VERY LOW RESISTANCE
						SANDSTONE: fine to medium grained, pale grey.	SW	M-H		MODERATE TO HIGH RESISTANCE
					CL	SHALY CLAY: medium plasticity, grey to dark grey.	(MC<PL)	(H)	–	–
			13		–	SANDSTONE: fine to medium grained, pale grey.	SW	H	–	HIGH RESISTANCE
						REFER TO CORED BOREHOLE LOG				

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CORED BOREHOLE LOG

Borehole No. 604 3/3

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP **Core Size:** NMLC **R.L. Surface:** N/A
Date: 12-8-97 **Inclination:** VERTICAL **Datum:**
Drill Type: BCD 550 **Bearing:** – **Logged/Checked by:** S.E./

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD INDEX STRENGTH $I_s(50)$ (EL VL L M H VH EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific / General
		13		START CORING AT 13.44m					
FULL RETURN		13.44–16.59		SANDSTONE: pale grey with thin grey laminations.	SW	H	×		- Be, 15°, P, R, CLAY COATED - Be, 15°, P, S - XWS, 45mm.t. - CS, 10mm.t. - XWS, 5mm.t. - Be, 10°, P, S - XWS, 10mm.t. - XWS, 10mm.t.
		16.59		END OF BOREHOLE AT 16.59m					
		17							
		18							
		19							
		20							

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BOREHOLE LOG

Borehole No. 605 1/1

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 13-8-97
Method: SPIRAL AUGER BCD 350
Logged/Checked by: W.T./
R.L. Surface: N/A
Datum:

Groundwater Record	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
		0		FILL: Sand, fine to medium grained, dark yellow brown, with sandstone gravel and concrete, a trace of glass and nails.	M			ROOT SYSTEM EXTENDS 0.2m BELOW GROUND SURFACE
	N > 14 14/ 100mm	1		FILL: Sand, fine to medium grained, with organic material, sandstone and ironstone gravel and a trace of clay, ceramics and rubber.				APPEARS MODERATELY COMPACTED
	N = 12 1,3,9							
▼ AFTER 10 MINS	N = 15 4,10,5	2						
►				FILL: Silty sand, fine to medium grained, brown and dark grey, with a trace of wood, clay and sandstone gravel.				
	N = 5 3,3,2	3	OL	ORGANIC SILTY CLAY: medium plasticity, dark brown and black, with a trace of rootlets and fine to medium grained sand.	MC>PL	(F)	-	NO RECOVERY OF SPT SAMPLE
	N = 2 1,1,1	4				VS-S	20 40 30	
	SANK UNDER OWN WEIGHT	5						
	N_c = 1, 1, 1, 2		CL	SANDY CLAY: medium plasticity, grey.		(F)		
	5, 7, 9, 12, 12, 17, 17	6				(VSt-H)		
		7		END OF BOREHOLE AT 7.05m				

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BOREHOLE LOG

Borehole No. 606
1/1

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 13-8-97
Method: SPIRAL AUGER BCD 350
R.L. Surface: N/A
Datum:
Logged/Checked by: W.T./

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0		FILL: Sand, fine to medium grained, dark yellow and brown, with a trace of sandstone gravel.	M			ROOT SYSTEM EXTENDS APPROX. 200mm BELOW SURFACE
		N = 15 4,7,8			FILL: Gravelly sandy clay, medium plasticity, grey mottled red, with fine to coarse grained sand, sandstone gravel and glass.	MC>PL		320 280 170	APPEARS WELL COMPACTED
AFTER 5 MINS		N = 8 1,4,4	1		FILL: Silty sand, fine to coarse grained, light brown and black, with organic matter (wood) and clay fines.				APPEARS MODERATELY COMPACTED
		N = 1 1,0,1	2	OL	ORGANIC SILTY CLAY: medium plasticity, dark brown and black, with fine roots and a trace of rootlets and shell fragments.	MC>PL	VS-S		NO SAMPLE RECOVERED FROM SPT
		SOLID CONE SUNK 700mm UNDER OWN WEIGHT N_c = 1, ↓, 1, 1, 1	3–4				(S-F)		
		2, 1, 1, 2, 1, 2, 2, 2, 2, 3, 4, 8, 14, 17, 22	4.5–6.7	CL	SILTY CLAY: medium plasticity, light brown to dark grey, with fine grained sand.		(VSt-H)		
			7		END OF BOREHOLE AT 6.7m				

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BOREHOLE LOG

Borehole No.
701
1/1

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 6-10-94
Method: SPIRAL AUGER BCD 450
R.L. Surface: –
Datum: –
Logged/Checked by: FK./JS

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	DS		0			FILL: Silty clayey sand, medium grained, brown to dark brown with bricks, glass and ripped sandstone fragments and some root fibres.	D			
	DS		1			as above, but with wood, plastic and igneous rock fragments.	M			
	DS, DS		2		–	CLAYEY SILT: low plasticity, dark brown with some fine roots.	MC>PL			ORGANIC ODOUR TEMPORARY PEIZOMETER INSTALLED TO 4.5m SLOTTED FOR 3m
▼			3							
	DS		4		–	SANDY SILT: low plasticity, dark brown with some orange brown ironstaining.	MC>PL			
			5			END OF BOREHOLE AT 4.5m				
			6							
			7							

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CONSULTING GEOTECHNICAL ENGINEERS

Borehole No. 702
1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 6-10-94
Method: SPIRAL AUGER BCD 450
R.L. Surface: –
Datum: –
Logged/Checked by: FK./

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	DS		0			FILL: Silty sandy clay, low to medium plasticity, brown with brick, timber, ripped sandstone, glass, steel and material fragments.	MC<PL			
▼	DS		1			FILL: Silt, low plasticity, dark brown with some sand and some clay and wire, brick and ripped sandstone fragments.	MC>PL			
	DS		2		–	CLAYEY SILT: low plasticity, dark brown with some bands containing shell fragments, 100mm.t.	MC>PL			ORGANIC ODOUR TEMPORARY PIEZOMETER INSTALLED TO 4.5m. SLOTTED FOR 3m
	DS		4		SP	SAND: fine to medium grained, dark grey, with a trace of silt.	M			
			5, 6, 7			END OF BOREHOLE AT 4.5m				

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BOREHOLE LOG

Borehole No. 703
1/1

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 6-10-94
Method: SPIRAL AUGER BCD 450
R.L. Surface: –
Datum: –
Logged/Checked by: FK./RG

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES		0			FILL: Sandy clay, low to medium plasticity, dark brown with some igneous rock and ripped sandstone fragments.	D-M			
	ES		1			FILL: Silty sand, fine to medium grained, black with some igneous rock, glass and ripped sandstone fragments.	M			
			2							
	ES				–	CLAYEY SILT: low plasticity, dark brown.	MC>PL			MODERATE ORGANIC ODOUR TEMPORARY PIEZOMETER INSTALLED TO 4.5m. SLOTTED FOR 3m
			3							
▼	ES		4							
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

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BOREHOLE LOG

Borehole No. 704
1/1

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 6-10-94
Method: SPIRAL AUGER GCH RIG
Logged/Checked by: FK./
R.L. Surface: –
Datum: –

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES		0			FILL: Sand, fine to medium grained, brown with some silt and some igneous rock fragments.	D			
▶	ES		1			FILL: Silt, low plasticity, black, with some sand, and some wood, ceramic, igneous rock and ripped sandstone fragments.	MC>PL			
	ES		2							
	ES		3		–	CLAYEY SILT: low plasticity, dark brown.	MC>PL			
			4							
			5			END OF BOREHOLE AT 4.5m				
			6							
			7							

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CONSULTING GEOTECHNICAL ENGINEERS

Borehole No. 705 1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 6-10-94
Method: SPIRAL AUGER GCH RIG
R.L. Surface: –
Datum: –
Logged/Checked by: FK./

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES		0			FILL: Sand, medium grained, light brown with some silt and igneous rock fragments.	M			
▶ (approx. 1.0m)	ES		1			FILL: Silty sandy clay, low to medium plasticity, brown with some glass, brick, ripped sandstone and timber fragments.	MC>PL			
	ES		2			as above, but with approximately 40% ripped sandstone and timber fragments.	MC>PL			
	ES		3		–	CLAYEY SILT: low plasticity, dark brown with some bands containing shell fragments.	MC>PL			TEMPORARY PIEZOMETER INSTALLED TO 4.5m SLOTTED TO 3m
	ES		4		SP	SAND: fine to medium grained, dark grey with a trace of silt.	M			
						END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

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Borehole No. 706 1/1

BOREHOLE LOG

Client: CRONULLA SHARKS
Project: SHARK PARK REDEVELOPMENT
Location: CAPTAIN COOK DRIVE, WOOLOOWARE

Job No. 15009JTP
Date: 6-10-94
Method: SPIRAL AUGER GCH RIG
R.L. Surface: –
Datum: –
Logged/Checked by: FK./

Groundwater Record	Samples	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition	Consistency/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES		0			FILL: Silty clay, medium to high plasticity, brown with some ironstone fragments.	MC<PL			
▶ (1.0)	ES		1			FILL: Silt, low plasticity, dark brown with some sand, and some wood fragments.	MC>PL			
	ES		2		–	CLAYEY SILT: low plasticity, dark brown.	MC>PL			
	ES		3		CL	CLAY: low to medium plasticity, dark brown grey with some silt and some sand.	MC>PL			
			4			END OF BOREHOLE AT 4.5m				
			5							
			6							
			7							

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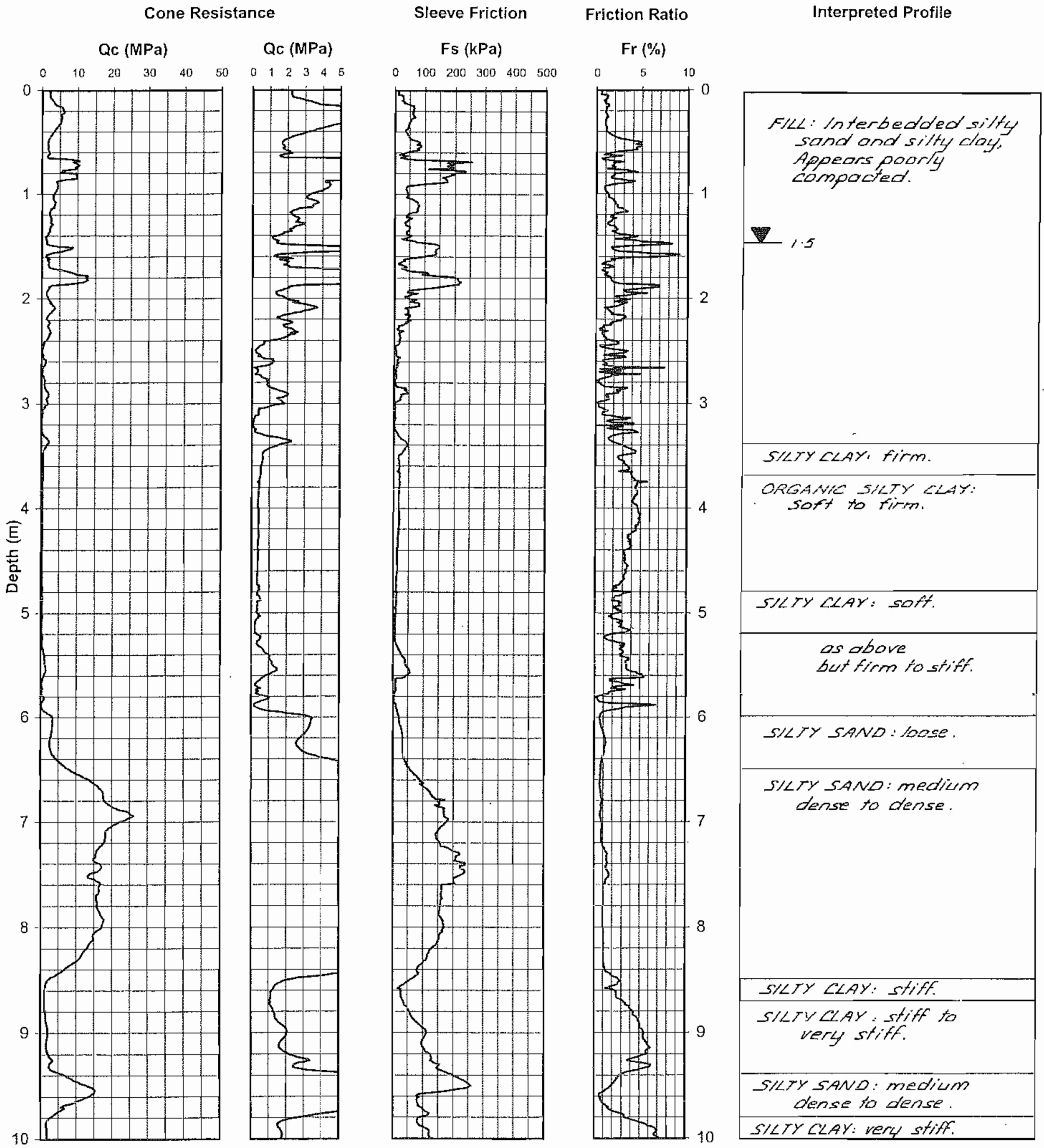
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No.
801

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks
Project:	Shark Park Redevelopment
Location:	Captain Cook Drive, Woolooware, NSW

Job Ref.:	15009JTPcpt801	**RL Surface:**	NA	**Data File:**	AP061129.H1
Test Date:	6/4/00	**Datum:**	NA	**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

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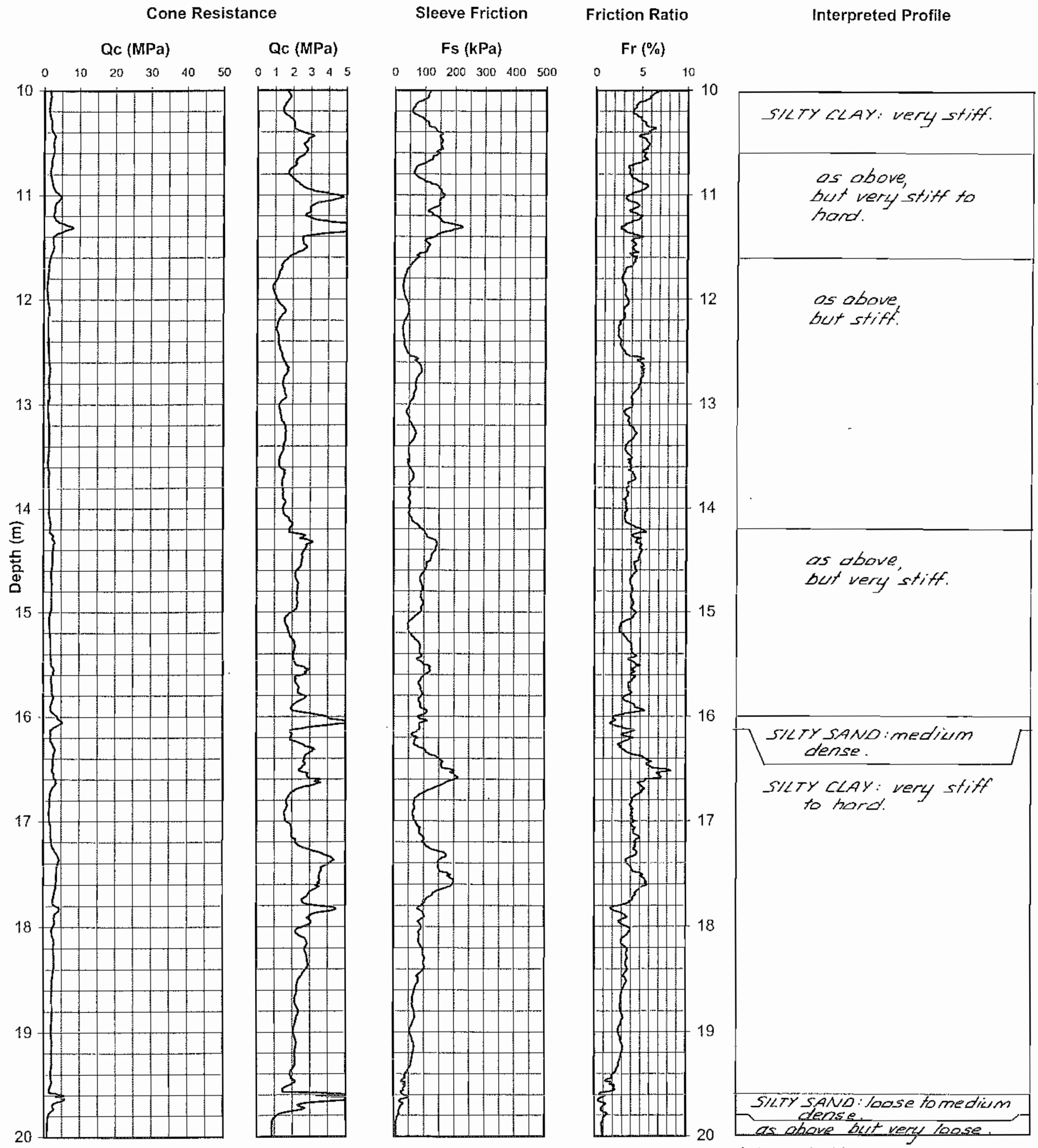
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERERS

EFCP No.
801
2/3

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client: Cronulla Sharks
Project: Shark Park Redevelopment
Location: Captain Cook Drive, Woolooware, NSW

Job Ref.:	15009JTPcpt801	**RL Surface:**	NA	**Data File:**	AP061129.H1
Test Date:	6/4/00	**Datum:**	NA	**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

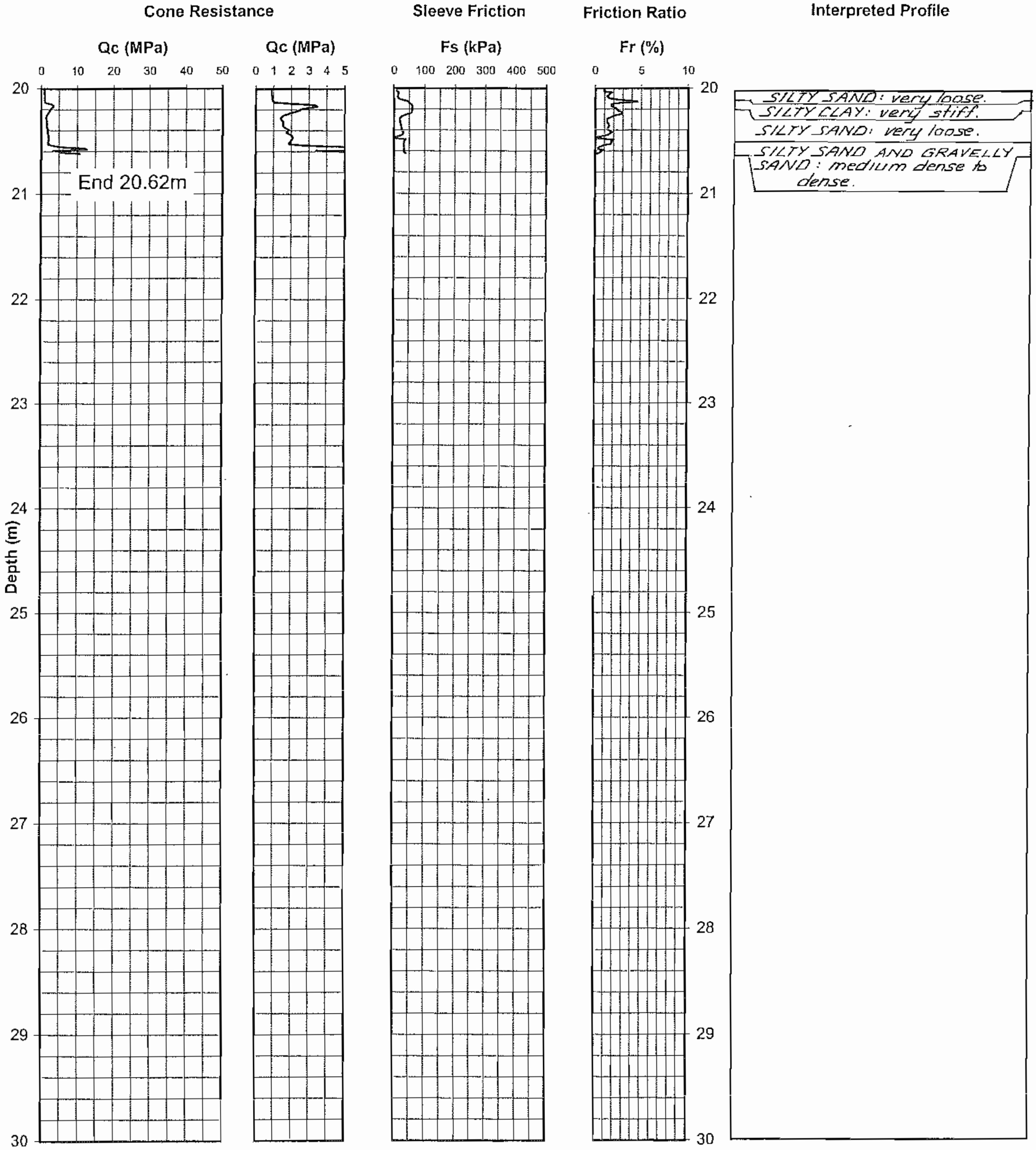
Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No.
801
3/3

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks				
Project:	Shark Park Redevelopment				
Location:	Captain Cook Drive, Woolooware, NSW				
Job Ref.:	15009JTPcpt801	**RL Surface:** NA		**Data File:**	AP061129.H1
Test Date:	6/4/00	**Datum:** NA		**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

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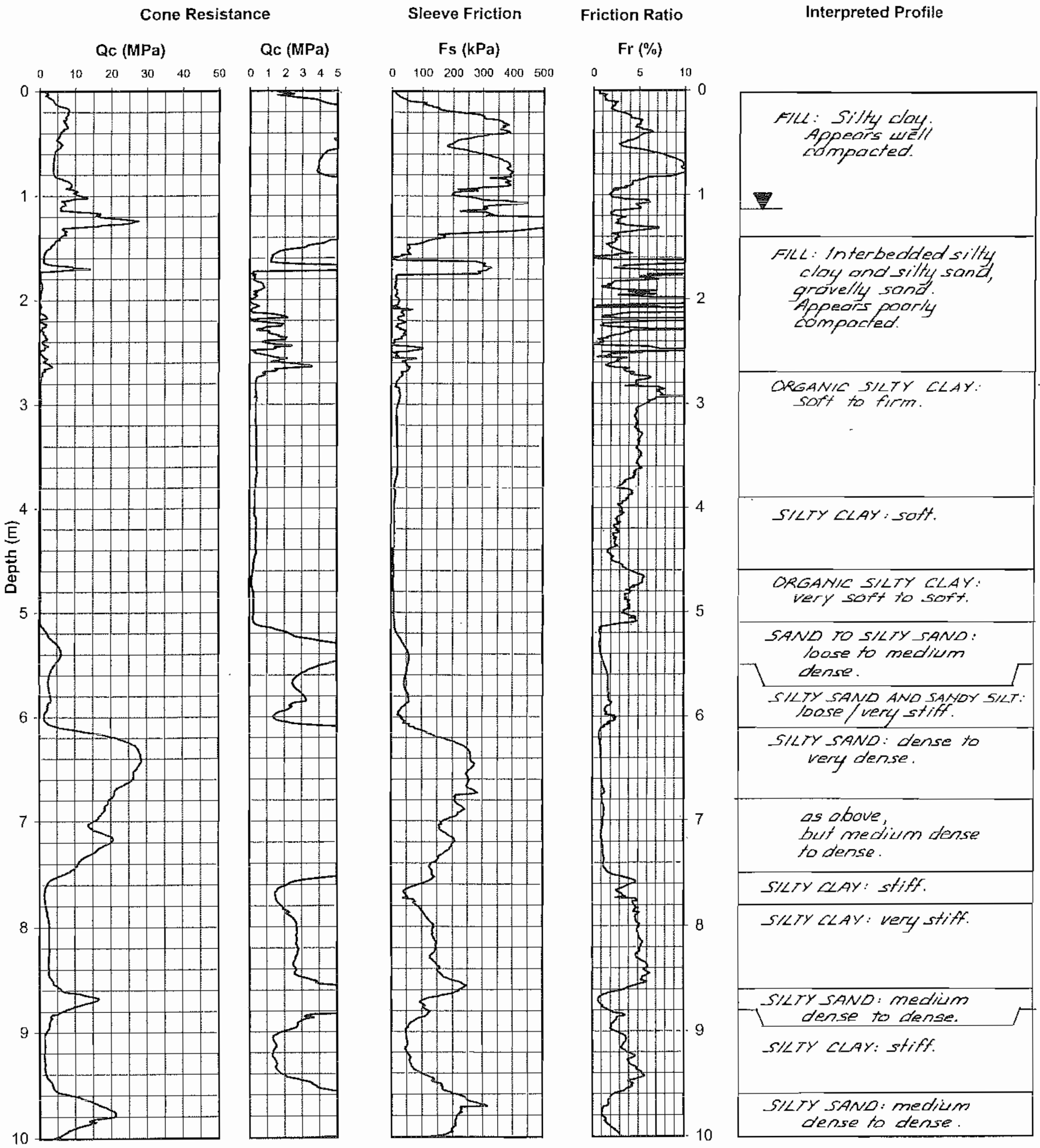
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

EFCP No.
802
1/2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks				
Project:	Shark Park Redevelopment				
Location:	Captain Cook Drive, Woolooware, NSW				
Job Ref.:	15009JTPcpt802	**RL Surface:**	NA	**Data File:**	AP061016.H1
Test Date:	6/4/00	**Datum:**	NA	**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

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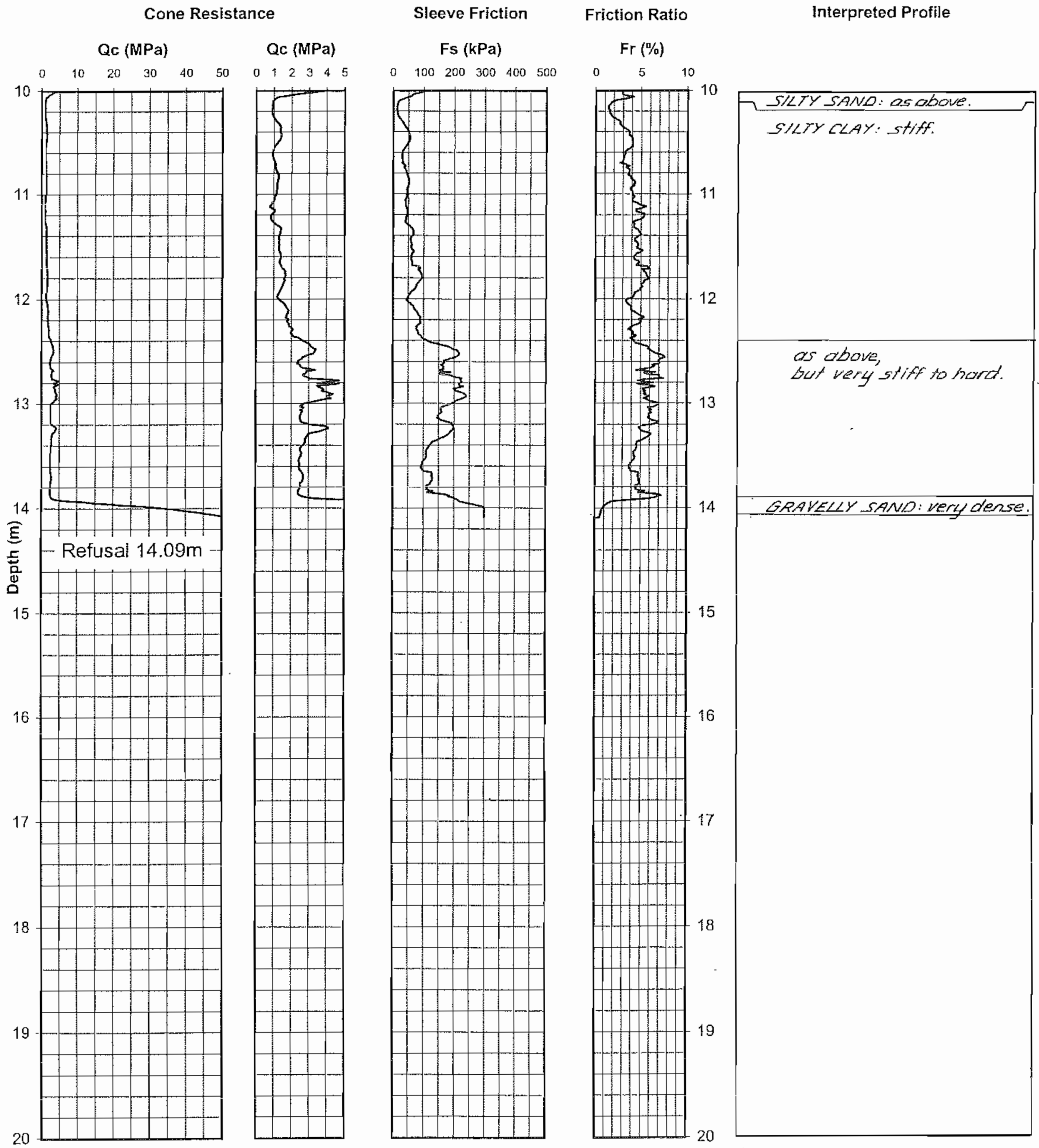
EFCP No.
802
2/2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks				
Project:	Shark Park Redevelopment				
Location:	Captain Cook Drive, Woolooware, NSW				
Job Ref.:	15009JTPcpt802	**RL Surface:**	NA	**Data File:**	AP061016.H1
Test Date:	6/4/00	**Datum:**	NA	**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

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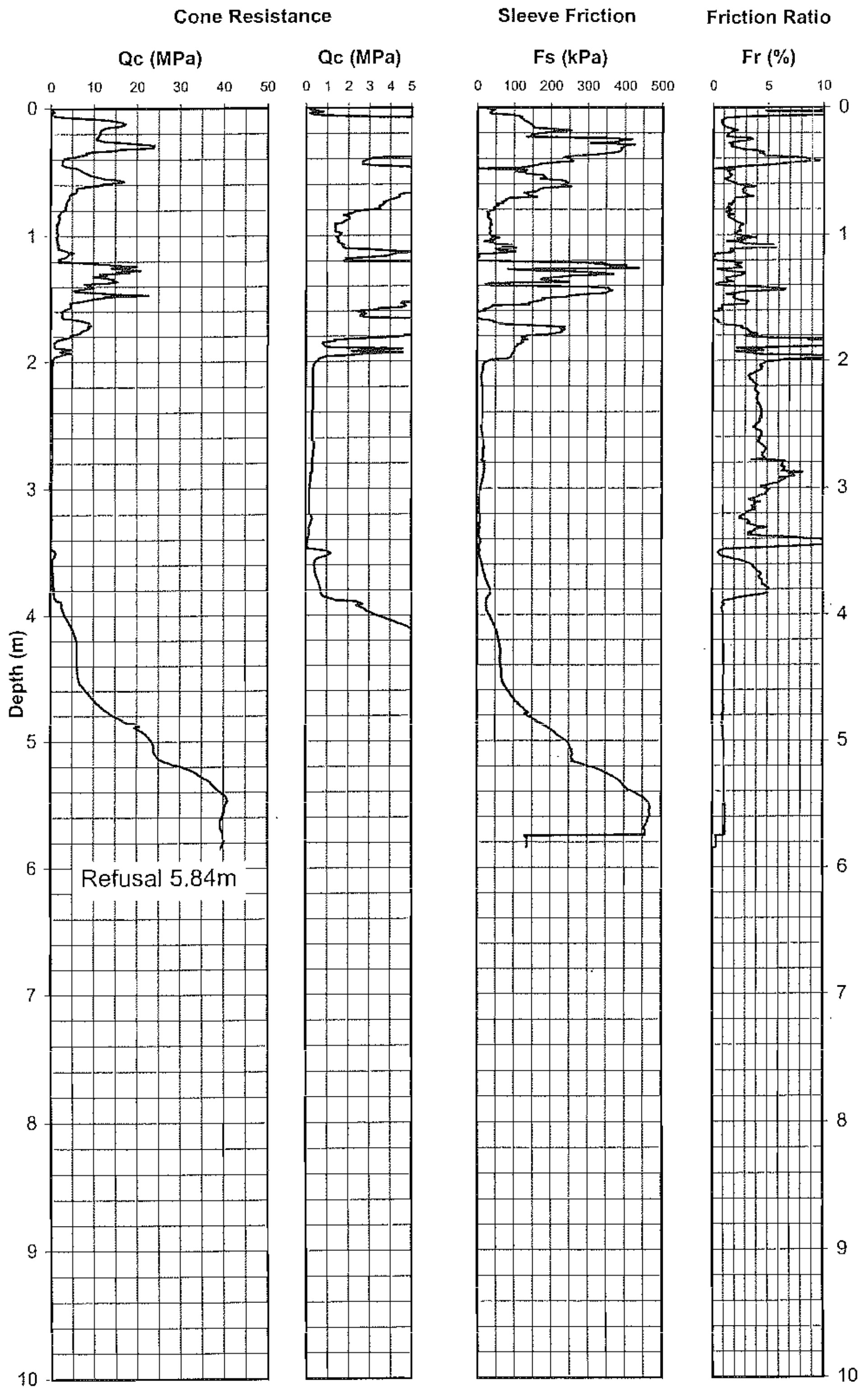
EFCP No.
803
1/1

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks
Project:	Shark Park Redevelopment
Location:	Captain Cook Drive, Woolooware, NSW

Job Ref.:	15009JTPcpt803	**RL Surface:**	NA	**Data File:**	AP051349.H1
Test Date:	5/4/00	**Datum:**	NA	**Operator:**	MK/AK



Interpreted Profile

FILL: Interbedded silty sand and silty clay. Appears well compacted.
as above, but appears poorly to moderately compacted.
as above, but appears moderately to well compacted.
ORGANIC SILTY CLAY: soft to firm.
SILTY SAND: loose to medium dense.
as above, but dense to very dense.
GRAVELLY SAND: very dense.

Interpreted by: M.K.
Checked by: PW

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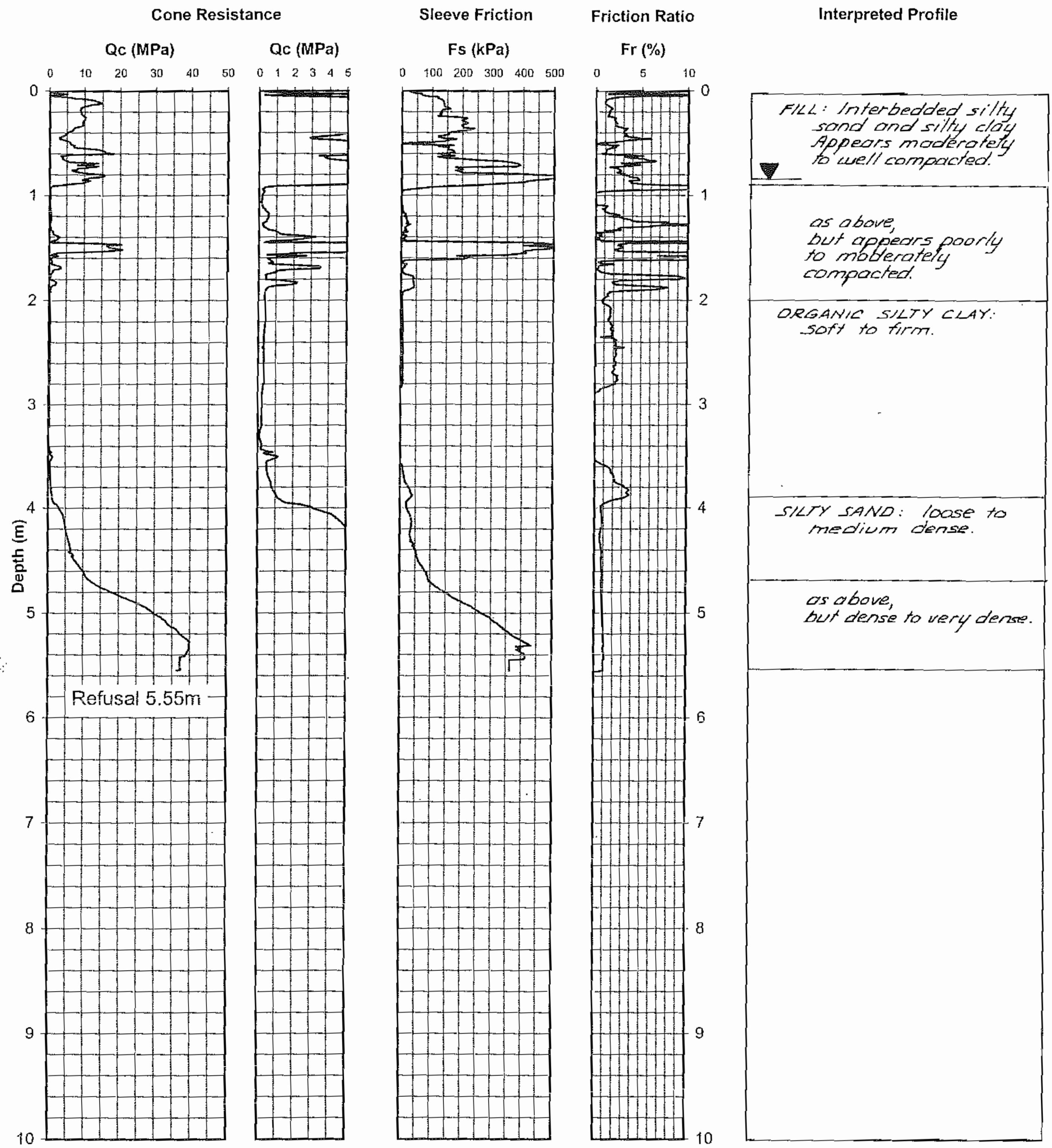
EFCP No.
803a
1/1

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks				
Project:	Shark Park Redevelopment				
Location:	Captain Cook Drive, Woolooware, NSW				
Job Ref.:	15009JTPcpt803a	**RL Surface:**	NA	**Data File:**	AP051431.H1
Test Date:	5/4/00	**Datum:**	NA	**Operator:**	MK/AK



Interpreted by: M.K.
Checked by: PW

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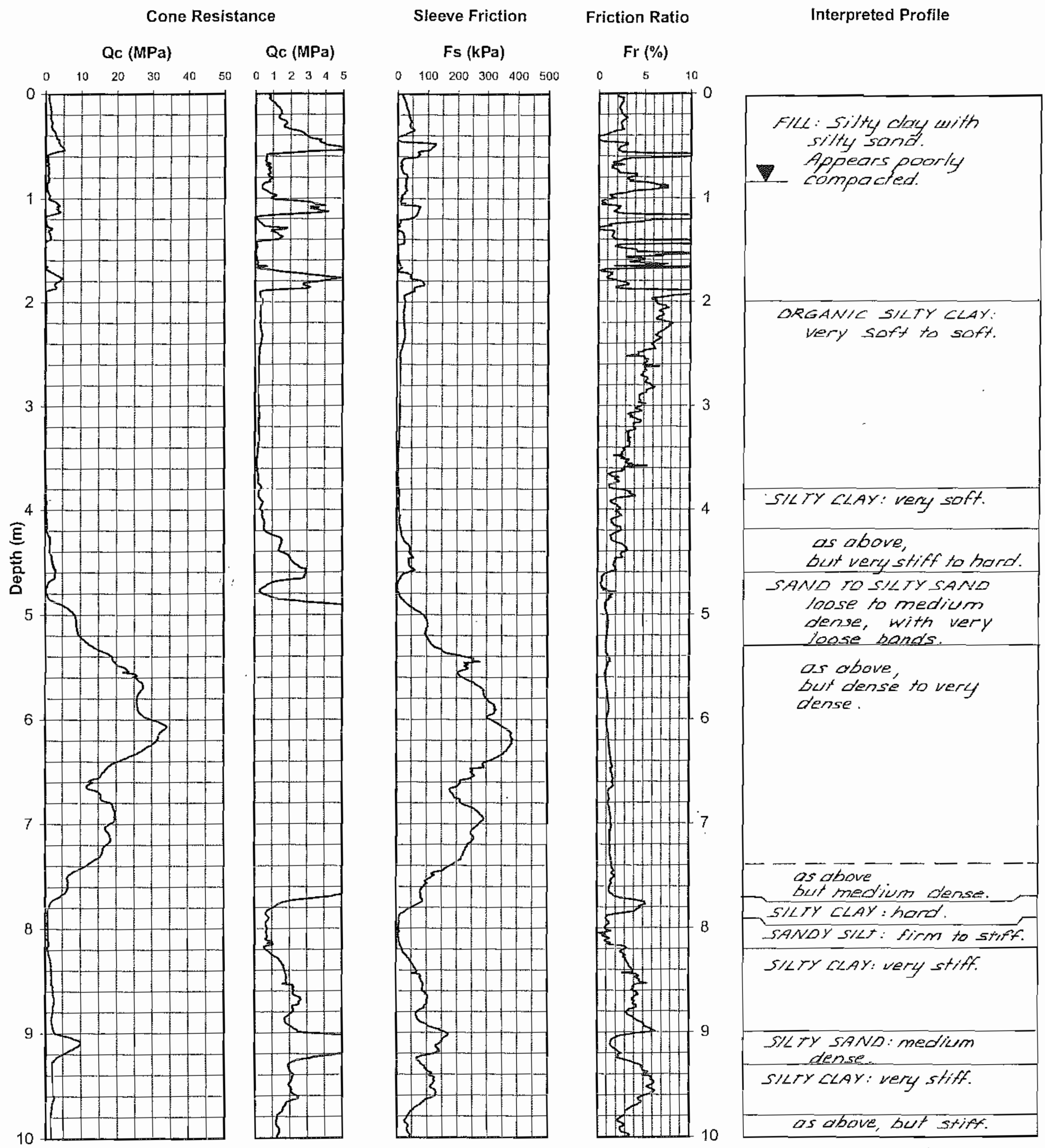
EFCP No.
804

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks
Project:	Shark Park Redevelopment
Location:	Captain Cook Drive, Woolooware, NSW.

Job Ref.:	15009JTPcpt804	**RL Surface:**	NA	**Data File:**	AP121115.H1
Test Date:	12/4/00	**Datum:**	NA	**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

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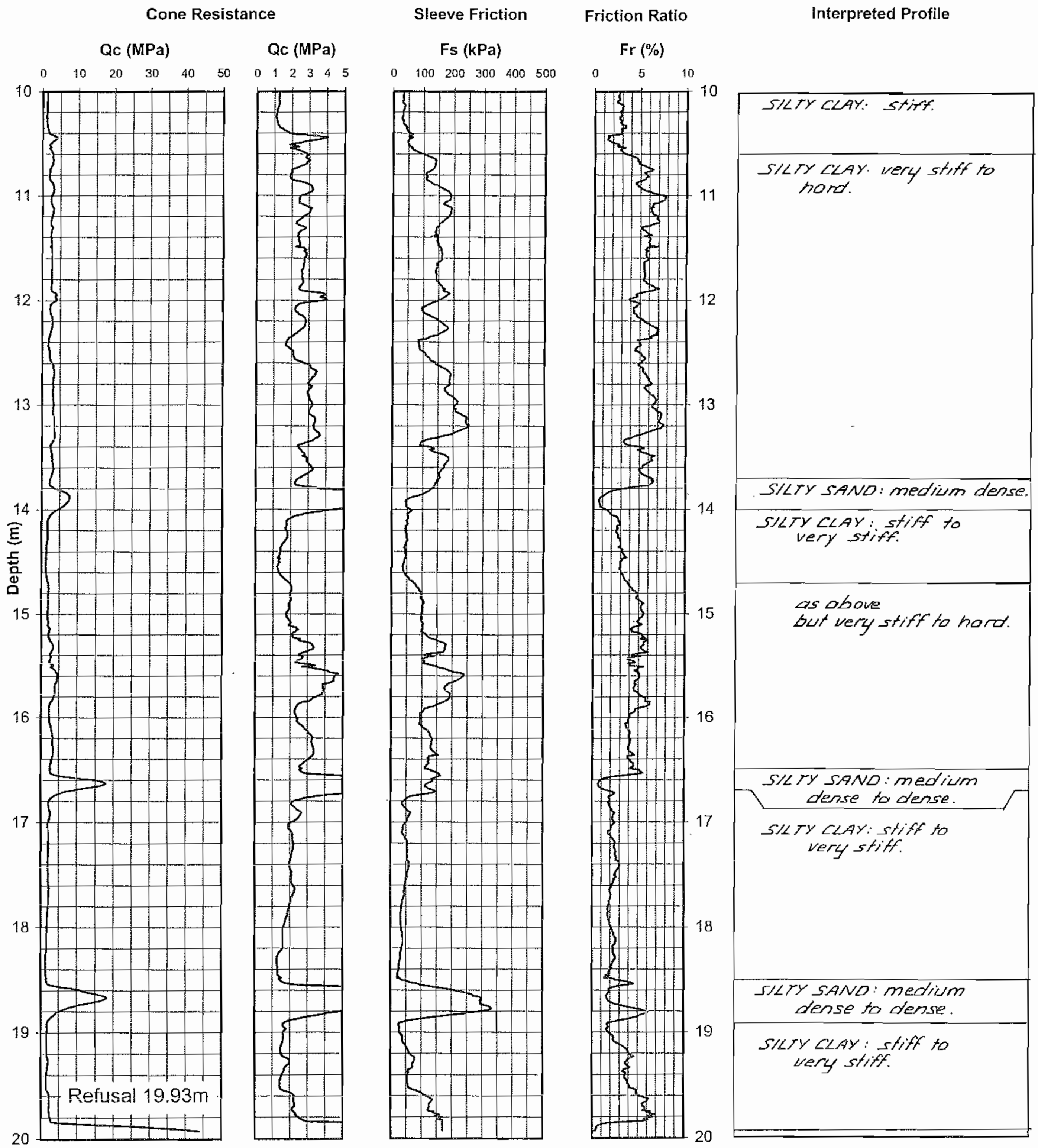
EFCP No.
804
2/2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks
Project:	Shark Park Redevelopment
Location:	Captain Cook Drive, Woolooware, NSW.

Job Ref.:	15009JTPcpt804	**RL Surface:**	NA	**Data File:**	AP121115.H1
Test Date:	12/4/00	**Datum:**	NA	**Operator:**	MK/PH



Interpreted by: M.K.
Checked by: PW

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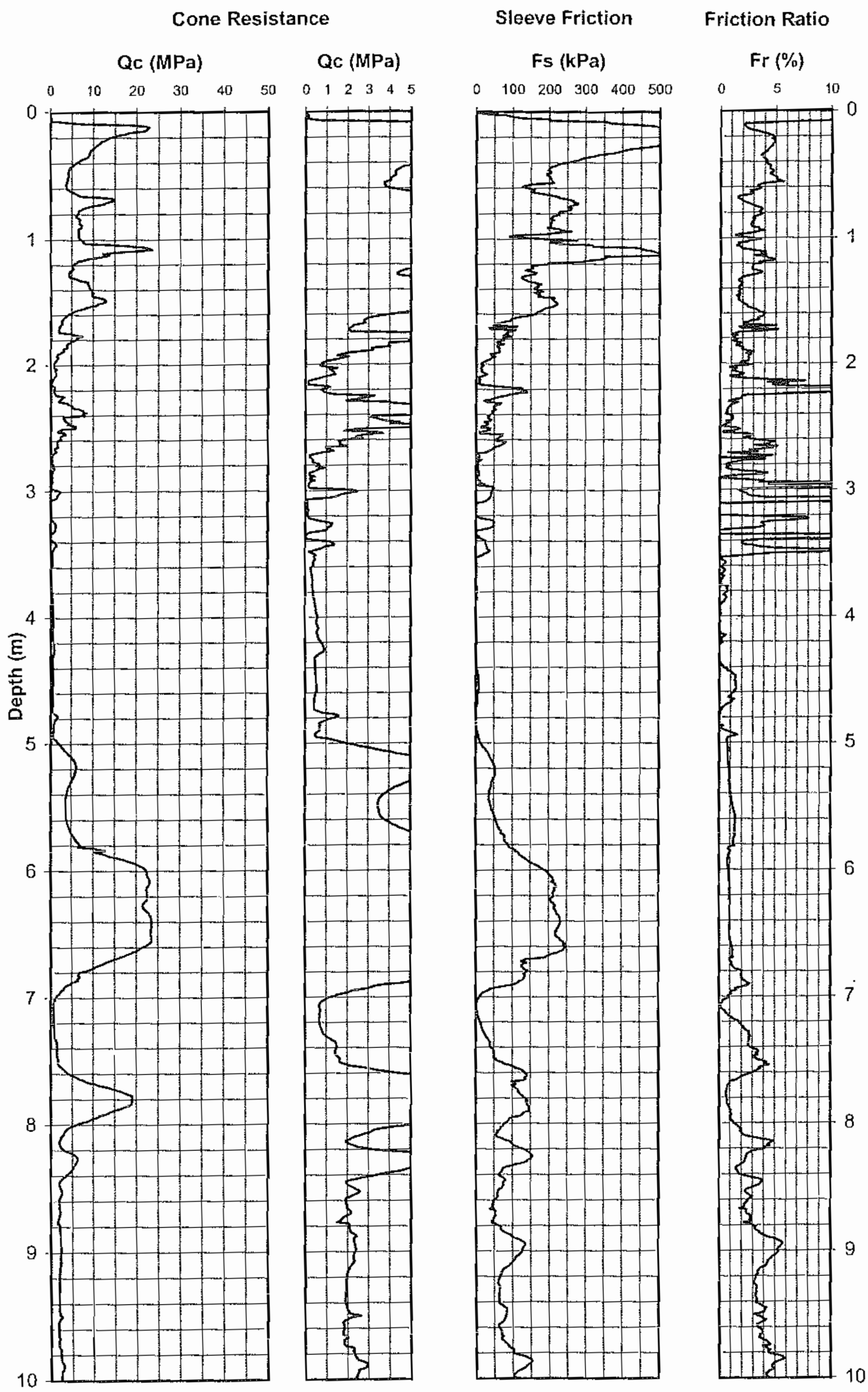
EFCP No.
806
1/2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks
Project:	Shark Park Redevelopment
Location:	Captain Cook Drive, Woolooware, NSW

Job Ref.:	15009JTPcpt806	**RL Surface:**	NA	**Data File:**	AP051158.H1
Test Date:	5/4/00	**Datum:**	NA	**Operator:**	MK/AK



Interpreted Profile

FILL: Silty clay. Appears moderately compacted.

FILL: Interbedded silty clay and silty sand. Appears poorly compacted.

ORGANIC SILTY CLAY: Soft, with sand.

SAND TO SILTY SAND: loose to medium dense.

as above, but dense to very dense.

CLAY: firm to stiff.

SILTY SAND: medium dense to dense.

SILTY CLAY: very stiff

SILTY SAND TO SANDY SILT medium dense/hard.

SILTY CLAY: very stiff.

Interpreted by: M.K.
Checked by: PW

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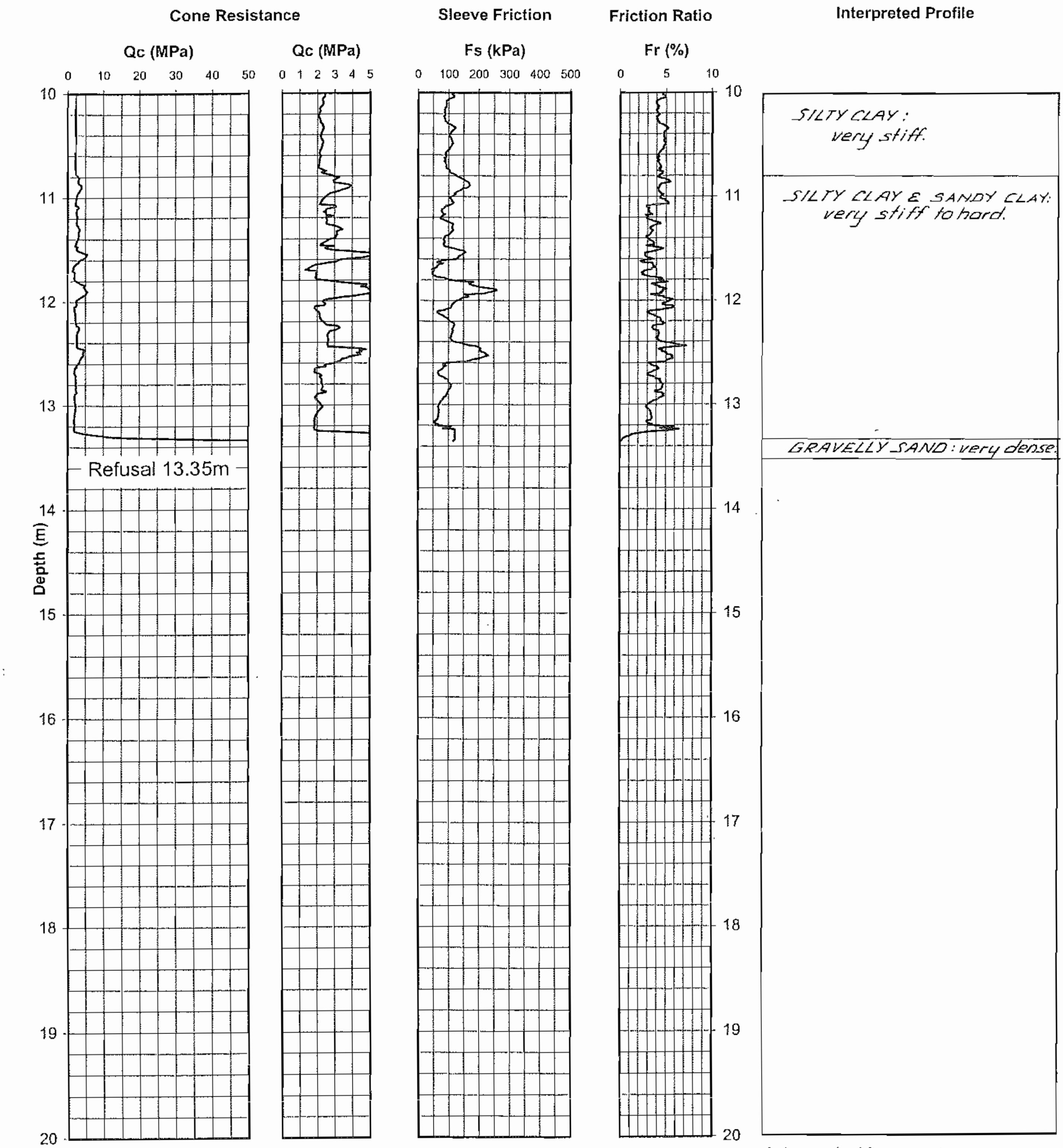
EFCP No.
806
2/2

ELECTRICAL FRICTION CONE PENETROMETER TEST RESULTS

Client:	Cronulla Sharks
Project:	Shark Park Redevelopment
Location:	Captain Cook Drive, Woolooware, NSW

Job Ref.:	15009JTPcpt806	**RL Surface:**	NA	**Data File:**	AP051158.H1
Test Date:	5/4/00	**Datum:**	NA	**Operator:**	MK/AK



Interpreted by: M.K.
Checked by: PW