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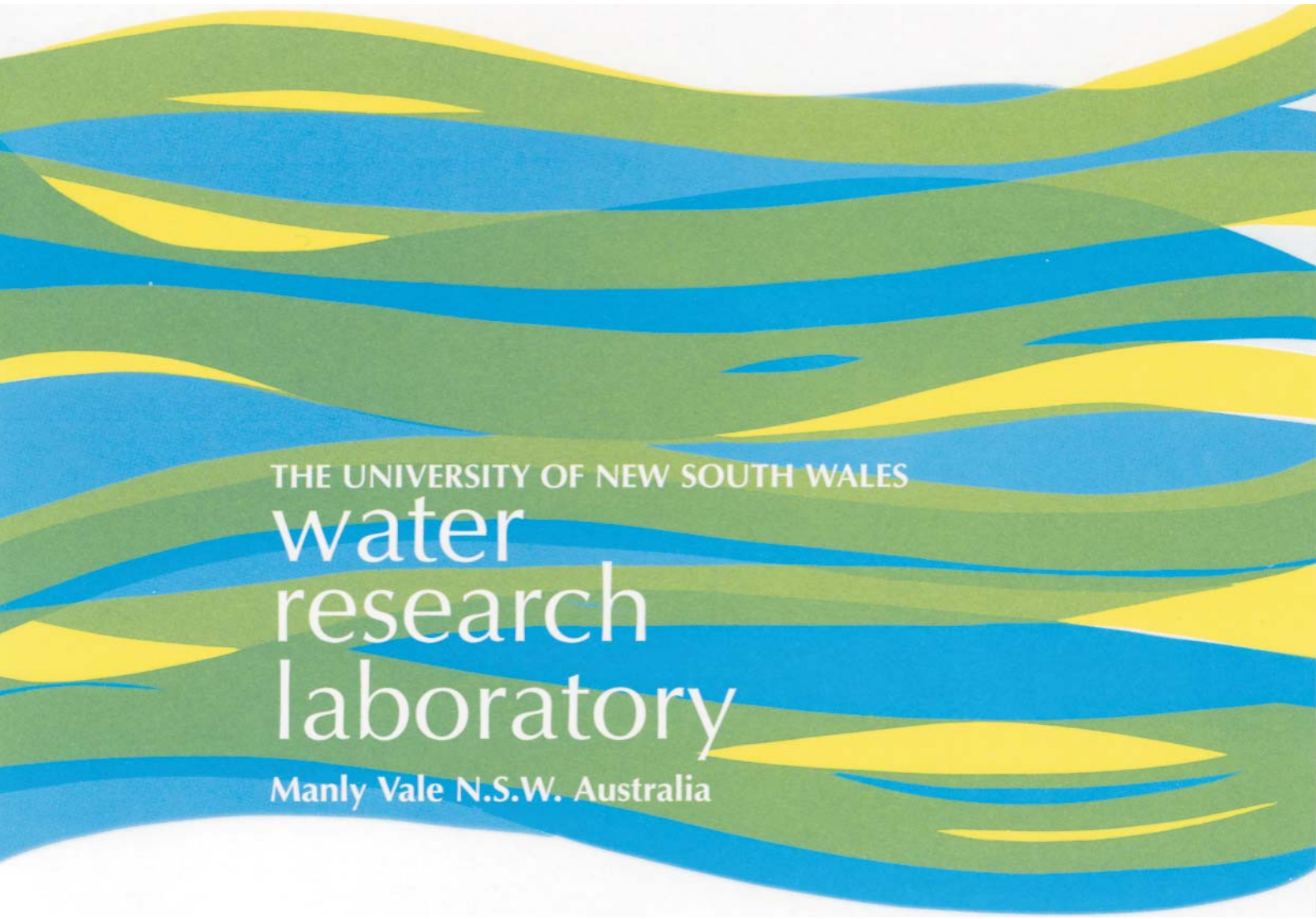

FEASIBILITY ASSESSMENT FOR MANAGED AQUIFER RECHARGE JOYNTON AVENUE RE-DEVELOPMENT SITE STAGES 1 AND 2

by

W A Timms, I L Cunningham and A M Badenhop

Technical Report 2007/25
December 2007

THE UNIVERSITY OF NEW SOUTH WALES
SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING
WATER RESEARCH LABORATORY

FEASIBILITY ASSESSMENT FOR MANAGED AQUIFER RECHARGE – JOYNTON AVENUE RE-DEVELOPMENT SITE, STAGES 1 AND 2

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The work reported herein was carried out at the Water Research Laboratory, School of Civil and Environmental Engineering, University of New South Wales, acting on behalf of the client.

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1. INTRODUCTION

The Water Research Laboratory (WRL) was commissioned by the City of Sydney (CoS) to assess the feasibility of managed aquifer recharge (MAR) at the Joynton Avenue redevelopment site. The site is located east of Joynton Avenue and north of Epsom Road in Zetland (Figure 1).

The primary objective of a possible MAR scheme was to assist in flood mitigation. There are significant stormwater management challenges on the site, with flood depths and flow velocities of concern on Joynton Avenue. Increasing infiltration of stormwater could partially reduce flooding problems, provided that subsurface conditions at the site were suitable for MAR. Water banking, or MAR, is the intentional diversion of harvested water into aquifer storages to achieve a range of benefits including flood mitigation and increased sustainable groundwater yield.

It was recognised that MAR alone could not solve flooding problems, particularly in large catchments, but may have a role to play in flood mitigation and non-potable water supply. Increased infiltration and recharge through injection bores and leaky structures (i.e. MAR) could decrease a proportion of stormwater runoff and provide underground storage for water re-use.

A suitably designed MAR system such as a buried leaky tank, could assist in reducing stormwater runoff from impermeable urban areas. However, the feasibility and cost-effectiveness of MAR, and long term hydraulic performance of MAR structures require assessment on a site by site basis. Whether or not MAR structures can significantly reduce flooding depends on:

- Stormwater factors such as catchment size, storm intensity and duration and drainage
- Size, design and hydraulic performance of the MAR structure
- Groundwater factors such as permeability of sediments and how quickly the mounding of recharge waters can dissipate and flow away from the site through the aquifer.

This report will show that while the aquifer below the Joynton site consists of thick sandy sediments that are likely to be favourable for MAR schemes, contamination of backfill material on the site would require removal or *in situ* remediation. Contamination issues should be addressed prior to further technical feasibility assessment at the site. Feedback from regulatory authorities is also required regarding licensing of groundwater extraction and MAR. However, preliminary assessment of stormwater flow volumes and possible

infiltration scenarios indicates that multiple distributed MAR schemes located upstream of the Joynton site may play an important role in flood mitigation. It is recommended to proceed with assessment of MAR systems in the Joynton catchment near Southern Cross Drive, outside of the Zone 2 groundwater management area.

1.1 Scope of Works

The scope of works was staged, with the option of ceasing the project if MAR appeared unfeasible after drilling works in Stage 2. If conditions appeared to be favourable, further work was to be undertaken to complete the feasibility assessment of the potential role of MAR in flood mitigation and groundwater supply.

- Stage 1 - Review and site inspection
- Stage 2 - Test drilling and groundwater hydraulic measurements
- Stage 3 - Groundwater hydraulic measurements
- Stage 4 - Analysis, assessment & recommendations
- Stage 5 - Water quality assessment (if required).

This report provides findings for Stages 1 and 2 of the project.

The findings of this report confirms and expands upon interim advice that was provided to CoS by email (14/6/07).

1.2 Report Outline

This report provides findings from a review and preliminary site investigations. A review of the Joynton Avenue site and surrounds is presented in Section 2. A review of MAR in the context of the Botany aquifer, and possible role in flood mitigation is presented in Section 3.

The findings of site investigations are presented in Section 4, including test drilling and preliminary calculations on the value of groundwater storage and the significance of MAR systems for flood mitigation. Section 5 provides a summary and Section 6 outlines recommendations for the CoS.

2. REVIEW - JOYNTON AVENUE SITE

2.1 Description of Site and Regional Context

The Joynton Avenue redevelopment site is located in the parish of Alexandria and County of Cumberland. General catchment and site characteristics are outlined in Table 1. The site encompasses two areas including one hardstand area facing Joynton Avenue (132-138 and 140-144 Joynton Avenue) and the council depot facing Epsom Road (94-104). It is located at approximately 20 m AHD (Figure 2) in a small gully that slopes west towards Sheas Creek, which is located approximately 700 m from the site and drains to Alexandra Canal. Site surroundings are shown in Google Earth/aerial photos from 2007 (Figure 2) and 1998 (Figure 3), showing active development sites. A stormwater drainage channel passes through the site from north to south. It is expected that the groundwater table would be a muted reflection of the local topography, and therefore groundwater would be flowing to the west-south-west.

Table 1
Catchment Characteristics

Parameter	Comment
Catchment area	~250 hectares (Green Square & West Kensington) ~120 hectares (Joynton site and upstream catchments)
Site area	-1.935 ha (Lot 2 DP 850686, encompassing 132-138 Joynton Avenue WRL2S, WRL3S and WRL3D) -0.81 ha (Lot 2 DP 24134, encompassing 140-144 Joynton Avenue WRL1S and WRL4S and WRL4D) -1.44 ha (Lot 5 DP 235181) encompassing Council Depot, 94-104 Epsom Road
Stormwater drainage	Cement culvert about 2.5 m wide and 1.5 m deep, underground between eastern edge of council depot area and Joynton Avenue.
Receiving water	Alexandra Canal and Botany Bay
Rainfall	1049 mm annual average at Sydney airport (1987-2006)

The site is situated over the northern region of the Botany Sands underlain by Hawkesbury Sandstone. The Botany Basin is a sediment filled topographic depression filled with interbedded marine sands, peaty sands, peat and mud. During the Tertiary period, a system of valleys (palaeochannels) were eroded in the Hawkesbury sandstone. These valleys were filled during the Quaternary period with a maximum of 65 m of unconsolidated Aeolian

sands, intercalated with minor clay and peat deposits. Sediment thickness is highly variable.

The Botany aquifer is the permeable sandy part of the Botany Basin that is saturated with water. Groundwater flow is generally from north to south, and south-easterly towards Alexandra Canal. Groundwater levels appear to be in dynamic equilibrium, responding to rainfall recharge events with no long term drawdown due to extraction. However, recent groundwater hydrographs within Zone 2 are not available to confirm typical regional behaviour. The closest DWE owned monitoring bore is GW51729 located to the south of Epsom Road.

A century of heavy industry in the area over a permeable sand aquifer has resulted in contamination impacts, particularly in the south of the aquifer. Due to the vulnerability of the aquifer and present contamination, the NSW Government has designated 4 management zones in which domestic groundwater use is, at the time of writing banned (further details are provided in Section 3.1). The site is located in Zone 2 of the Botany Sands Management Zones (Figure 1).

2.2 Registered Bores in the Area

Details of 7 groundwater bores licensed to the council within the local government area are shown in Table 2. Council advises that currently 5 of these bores are in use. New meters will enable volume of usage information to be obtained. Further investigation is required to determine the status of these bores and licensing issues in regard to extraction.

A search of the Department of Water and Energy (DWE, formerly the Department of Natural Resources, DNR) database of registered bores was undertaken (Figure 4). However, this database did not include 6 monitoring wells that were installed to 6 m depth on the site by HLA Envirosciences (2002). These monitoring bores are referred to in Section 2.5.1.

The DWE database review showed three registered bores in the area that were drilled to intersect the base of the sand aquifer (Figure 4). These included GW1014125 (22 m depth) located to the north-east of the Joynton Avenue site, GW072622 (16 m depth) located to the south of the site, and GW051728 (8.3 m depth) located to the south-west. This information provided a useful guide for the expected depth of test bores required at the Joynton Avenue site. Further details about these DWE registered bores can be found in Appendix A.

Groundwater quality and current usage of registered bores adjacent to the Joynton Avenue site is unknown.

Table 2
City of Sydney Groundwater Bores

Location	Lot & DP no.	Licence No.	Use	Comments
Sydney Park	NA	10BL154407	Recreation	Water quality assessed*
Epsom Road Depot	GW072622	10BL156770	Recreation/Commercial	Located on the Joynton Avenue site which is the focus of this report - water quality assessed*
Redfern Oval	NA	10BL157688	Recreation	Water quality assessed*
Erskineville Oval	Lot 2, DP135627	NA	Recreation	
Turruwul Park	Lot 492, DP7534	NA	Recreation/Commercial	Water quality assessed*
Redfern Park	NA	10LB016918	NA	
Groundwater Works	NA	10LB152224 (GW071907)	NA	

Note:
Source: CoS via email 26/3/07
* WRL Letter Report 16/4/07 - Appendix B;
NA – not available

2.3 Current and Historical Site Usage

The history of the site was discussed by HLA Envirosciences (2002) from which the following section is largely drawn. As outlined in Section 2.1, the site can be divided into two areas – one fronting Joynton Avenue, which is the former South Sydney Council administration complex and the other fronting Epsom Rd, which is the current CoS council depot.

Currently only one of the buildings fronting Joynton Avenue is used and only for administration, although a former workshop building is still present on the site. The hardstand at Joynton Avenue is used by 3 businesses for equipment and materials storage.

The Council Depot consists of six buildings:

- Two storey warehouse with rooftop parking
- Two storey building used for storage
- Vehicle maintenance and welding shop
- Two storey carpark with an underground storage tank of diesel fuel
- Maintenance depot building that was formerly a service station in the 1960's

- A garage used for administration, vehicle maintenance, and storage of paints, oils with an underground storage tank of waste oil.

There are two more underground storage tanks used for fuel located east of the maintenance depot building and a wash bay for council vehicles on the site.

The site has been used for industrial and commercial purposes over a period of 60 years, including:

- Motor vehicle assembly plant
- Printing activities
- Storage and distribution of petroleum hydrocarbons
- Vehicle maintenance
- Maintenance of electrical equipment
- A racetrack.

During construction, large amounts of fill have been used to level and raise the site. Cinder ash from brick kilns was used to construct the race track. Ash and landfill wastes may have been used as fill materials on the site. In addition, asbestos has been used for roofing on the site and damage of the roofing has lead to some contamination of soils with asbestos fibres.

2.4 Soil Contamination on the Site

HLA Envirosciences (2002) completed a soil and groundwater sampling program at the site. They found soil fill materials consisting of soils, brick, glass, concrete and bitumen pieces and ash at most locations with depths ranging from 0.1 to 4.5 m below ground, and averaging 1.3 m below ground. Beneath the fill, natural soils consisting of sands and sandy silts were located. HLA found that most of the sampled fill materials contained significant concentrations of metals (copper, lead, zinc and mercury), with some samples containing total petroleum hydrocarbons (TPH) and polyaromatic hydrocarbons (PAH) and one sample containing asbestos fibres. None of the samples of the natural soils contained significant concentrations of the contaminants analysed (HLA Envirosciences, 2002). Much of the site is now concreted, therefore changing the site use and encouraging infiltration of stormwater through these soils could have significant impacts on the groundwater. HLA Envirosciences (2002) consider that removal of the fill materials

(~55 000 m^3) would be a technically viable, yet costly means for managing the contamination on site.

2.5 Groundwater Quality at the Site

2.5.1 Monitoring Bore Quality in 2002

A total of 6 shallow monitoring wells (up to ~6 m depth) were installed and sampled at the Joynton Avenue site as part of contaminated site investigations (Figure 5). HLA Envirosciences (2002) compared groundwater sample analyses at the Joynton site with ANZECC (2000) trigger levels for marine and fresh waters. The NSW Groundwater Quality Protection Policy (DLWC, 1998) requires all groundwater systems be managed so that degradation to the system does not result in a substantial change with respect to the natural baseline quality and that the most sensitive identified beneficial use is maintained.

Groundwater metal concentrations were below Australian Drinking Water Guidelines (ADWG) (NHMRC, 2004) in all bores, apart from one sample which had lead concentrations (12 μg/L) marginally above the guideline value of 10 μg/L. TPH fractions were detected in all groundwater samples, with maximum concentrations of 626 μg/L C_{15} – C_{28} fraction. No drinking water guidelines exist for TPH. BTEX were found in one sample with concentration twice that of the ADWG of 1 μg/L. PAHs were found in 2 samples with concentration of benzo(a)pyrene in one sample of 2 μg/L, which is many times greater than the ADWG value of 0.01 μg/L. VOCs were not detected in the groundwater; however, halogenated aliphatic hydrocarbons were detected in one sample with the concentration of 1,2-dichlorethene greater than the ADWG value of 60 μg/L.

2.5.2 Production Bore Quality in 2007

Groundwater quality of a production bore at the Epsom Road site was recently assessed by WRL. The screen openings of this production bore were between 10.5 and 15 m below ground. The following section is summarised from WRL Letter Report (16/4/07), which is provided in Appendix B. Groundwater samples were tested for all parameters listed in the Draft Department of Infrastructure, Planning and Natural Resources (DIPNR, now DWE) Recommended Bore Licence Minimum Analytical Suite for the Botany Sands Aquifer, as outlined in the attached guideline (Appendix C).

The irrigation bore at the council depot is a high flow bore used to continuously fill a large water storage tank. The bore was installed more than 10 years ago. Council trucks fill their

tanks from this storage tank on a daily basis for street cleaning and irrigation of parks. Samples were taken from a high flow large diameter tap fitted to the side of the bore on 27th March 2007. Water sampled was clear and had a slight sulphur odour, indicative of reducing conditions (i.e. low dissolved oxygen).

In general, the quality of the groundwater was found to be good and within available guideline values for irrigation and secondary contact. It is important to note that no organics such as pesticides or hydrocarbons were detected in the water, in contrast to the shallow monitoring wells installed and sampled by HLA Envirosciences (2002).

Groundwater from the production bore was fresh and of near neutral acidity (pH 6.15). Observed EC was 191 µS/cm and Total Dissolved Solids (TDS – the sum of major ions) was 109 mg/L. Aluminium, barium, copper, iron, manganese and zinc were the only metals detected in the water. With the exception of iron (4.24 mg/L), all metals were present in concentrations below those recommended for long term irrigation (up to 100 years) or secondary contact. No nutrients were detected above guideline levels, and most nitrogen was in the form of ammonia (0.34 mg/L). These nitrogen levels are unlikely to be caused by recent sewage contamination as there was no corresponding measure of bacteria, with neither thermotolerant (faecal) coliforms or faecal streptococci detected.

It was noted that groundwater quality may change over time and one sample does not provide statistical confidence.

2.6 Contaminated Sites in the Area

Aerial photography of the site from 1998 (Figure 3) and from 2007 Google Earth images (Figure 2) shows that the surrounding land was predominantly commercial/industrial, but has been redeveloped in recent years with many industrial buildings being demolished with some replaced by residential buildings.

A search of the EPA Contaminated Land record of notices (http://www.environment.nsw.gov.au/clm/searchregister.aspx) found 11 sites in the CoS local government area with current or former cleanup notices, the closest of which being for a drycleaners located approximately 1 km north on Bourke Street, Waterloo. The City of Sydney local government website contains records of recent development applications. A development application for 13 Joynton Avenue (City of Sydney, 2007a) records the need for State Environmental Planning Policy (SEPP) 55 land remediation including treatment of soils and groundwater on a site formerly used for manufacturing and iron and bronze

foundry operations. Another development application for 114 Joynton Avenue, Zetland also records the need for SEPP 55 remediation (City of Sydney, 2007b).

Even if contamination on the Joynton site is remediated and/or removed, it is possible that contamination at other sites nearby may limit or preclude the development of MAR at the Joynton Avenue site. From the change in land use evidenced in the aerial photography, it is likely that other contamination sources may have been capped, remediated or removed for disposal - although some contaminant sources may remain. A regional scale groundwater contamination assessment is required, along with advice from the relevant regulatory authorities.

2.7 Site Inspection

A site inspection on 27/3/2007 was attended by Cumar Siva, John Barrett and Bruce Pickering from the CoS, and Wendy Timms and Alexandra Badenhop from WRL. Notes from the site inspection and meeting follow:

Epsom Road Depot:
Large stormwater culvert underneath the carpark next to Epsom Road. Water flowing 20-30 mm depth in the culvert to the west. Many entry points seen into the drain, but only one flowing at the time of visit. Gate entry possible down to the drain for future sampling. It was confirmed by Bruce Pickering that this site will not be redeveloped in the medium term and therefore focus should be on the Joynton Avenue site.

Joynton Avenue Site:
HLA monitoring wells were located except that in the middle of the site which was mostly likely underneath some demountable buildings in the middle of the site. The monitoring well in the north-east corner of the site was located under a non-standard gattic cover and opened. It contained an old bailer, which must have been used for the sampling.

It was discussed that the only plausible solution for using the site for MAR would be to remove the fill layer over the whole site, as the contamination appeared to be of limited depth. The need for appropriate stormwater treatment devices was also considered.

Preliminary plans for the development of the site were presented by Cumar Siva. These showed a 36 m roadway passing east-west along the northern boundary, with an electrical cable channel on the southern side of it. A 20 m wide thoroughfare would pass north-south along the eastern boundary of the site. CoS advised that the stormwater drain passing

north-south on this site is to be opened up as a feature of the site with the possibility for turning it into a swale subject to drainage performance assessment. CoS approved proceeding with Stage 2 works of drilling to determine the depth of aquifer and stratigraphy below the site, with the installation of 4 monitoring bores.

2.8 Flooding Issues

A flood study is currently being prepared for Green Square - West Kensington (GSWK) catchment by Webb McKeown & Associates to define flood behaviour and to establish suitable hydrologic/hydraulic model(s) for a subsequent Floodplain Risk Management Study. A revised draft of the Flood Study was recently released (July, 2007).

The Green Square and West Kensington catchment area of approximately 250 hectares drains westward towards Sheas Creek and Alexandria Canal. The area is predominately zoned for residential usage, with recent redevelopment of medium to high density housing and commercial premises. The area includes the Australian Golf Course and Moore Park Supacentre and lies within both the CoS and Randwick local government areas.

The Joynton Avenue site, including the CoS depot is located within the eastern sub-catchment described by Webb McKeown (2007). Three sub-catchments drain mainly to the trapped depression between Joynton Avenue and Botany Road where the "Big Waterloo Dam" was once located.

Urbanisation of the catchment has caused flooding in a number of ways:

- Increased proportion of paved area, decreased infiltration and increased peak stormwater flows and volumes
- Removal of storages for stormwater including swamps and dams
- Development within trapped depressions such as the former "Big Waterloo Dam".

The largest known historical flood occurred on 8-9 November 1984. Rainfall intensities recorded in nearby catchments were found to correspond to a 100 year ARI event (based on storm durations between 2 and 4 hours). Flooding occurred to a depth of 1.0 m in the old South Sydney Hospital site located opposite the Joynton Avenue site that is the focus of this report.

2.9 Previous Stormwater Modelling

Low flow events (< 3 month ARI) are of most relevance for MAR schemes with the primary objective of harvesting stormwater. These low flow events provide the bulk of the stormwater yield and the greater proportion of urban pollutant loads (DEC, 2006). It is estimated that 90-97% of mean annual run-off from Australian urban catchments occur at flow lower than the 3 month ARI peak flow (Wong *et al.* 2000).

In contrast, high flow events are the focus of MAR schemes where the primary objective is flood mitigation associated with the reduction of peak flows and/or runoff volumes. Flood studies undertaken as part of the NSW Government flood program typically focus on larger, less frequent flow events including the Probable Maximum Flood. The GSWK Flood Study defines design flood behaviour for a number of design flood events ranging from the 50% AEP (~1 in 2 year ARI event) through to the 1% AEP (1 in 100 year ARI) event and the PMF.

Modelling of surface water in the Joynton Avenue area has been undertaken using fully dynamic hydrologic and hydraulic models. The runoff routing methodology was based on the ILSAX/DRAINS style approach. The sub-surface drainage system model comprised over 870 pits and pipes.

Flow modelling in the Joynton Avenue area was undertaken using an integrated one-dimensional/two-dimensional (1D/2D) hydraulic model. 1D elements were used to represent the sub-surface drainage system and formal stormwater channels. These were dynamically linked to a 2D overland flow model to better define the more complex flow paths in this area. The 2D model topography was defined based on a regular grid of 2 m x 2 m square cells.

Peak modelled flows at Joynton Avenue East ranged from 8.2 m^3/s for a 1 in 2 year ARI to 19.0 m^3/s for a 1 in 100 year ARI storm event. For the 1 in 2 year ARI, all flow occurred via pipes, whereas for the larger storm, overland flow accounted for 53% of total flow. An embedded design storm approach was used comprising a 1 hour peak burst within a six hour duration storm.

Flood hazard is a product of both peak flow velocity and peak depth. Figure 7 shows modelled flood depth and the main pipe flows for a 1 in 100 year ARI event across the Joynton Avenue site. Modelled flow depths were depicted for various scenarios by Webb McKeown (2005), but will not be discussed further here. Sensitivity testing of the flood modelling suggested that assumed initial losses and antecedent moisture conditions could

significantly impact on peak flow. The modelled flows appeared less sensitive to soil type and Mannings ‘n’ for overland flow.

3. REVIEW- MANAGED AQUIFER RECHARGE AND FLOODING

3.1 The Botany Aquifer Strategy

The Botany Aquifer Management Strategy was initiated in 2005 by NSW Government agencies, including the then Department of Environment and Conservation, the Department of Health and local government. The objectives of the strategy were to set rules for granting licenses, identify the sustainable water yield and protect the environmental and economic values of the groundwater system. The Groundwater Status report for the Botany aquifer (Bish, 2000) is yet to updated with recent groundwater hydrograph and scientific information.

A summary of aquifer management orders is as follows:

- August 2003 – Groundwater Embargo Area. Incorporates parts of the western half of the Botany Sand Beds northern zone. North of Gardeners Road, groundwater on the western side of Southern Cross Drive was embargoed, while groundwater on the eastern side was not. The embargo precluded any new bore licenses for the extraction of groundwater from being issued with the exception of temporary dewatering, monitoring and remediation bores.
- August 2006 - All domestic groundwater use banned in Zones 2, 3 and 4. An extraction exclusion zone (Zone 1) was already in place (Figure 1). The NSW government offered free water quality testing of domestic and recreational licensed bores. All licensed industrial bore water users in Zones 1-4 were required to test water quality on an annual basis with results provided to the NSW government.
- 10 July 2007 – The Botany aquifer embargo was extended to encompass the entire Botany sand aquifer. This new embargo (excluding the existing Zones 1-4) precludes new groundwater bores, except for private domestic purposes, urban water supply purposes, dewatering, monitoring, test and remediation bores. There are a number of exceptions to the order including an application for a license for a bore to replace some other licensed bore that the applicant has ceased to use.

The CoS should seek advice from the NSW government as to the implications of these recent groundwater management orders for groundwater recharge and extraction in the Joynton Avenue site. The site itself is located within Zone 2 where existing production bores require annual water quality testing. Part of the stormwater catchment lies outside Zone 2 where it appears that new private groundwater bores and urban water supply bores

may be permitted. It is unclear as to the regulatory status of recreational irrigation bores, or the possibility of MAR systems in either area.

National guidelines on MAR are currently being prepared to assist agencies such as the DWE in implementing appropriate regulatory approvals for MAR (Dillon and English, 2007). These draft guidelines are due for release in November 2007 to assist in appropriate planning mechanisms for MAR schemes.

3.2 MAR in the Botany Aquifer

The potential for MAR in the north-eastern part of the Botany aquifer is described by Timms *et al.* (2006). The types of MAR that may be practiced in the north-eastern Botany aquifer are shown schematically in Figure 8. Stormwater is diverted to groundwater through soakage pits, and inadvertently leaks to groundwater through ponds and channels (Figure 8A and 8B). Aquifer storage recovery using injection bores (Figure 8C) is restricted to sites where the watertable is at least 5 m depth below ground level. Rainwater harvesting using large structures (Figure 8D) is now practiced at the UNSW campus. Infiltration tanks were installed in mid-2006 that capture runoff from the campus. Increased recharge has enabled increased extraction for beneficial uses including irrigation, toilet flushing and cooling water.

A schematic of an MAR system for diversion of stormwater is shown in Figure 9. A weir within an existing stormwater pipe or culvert is used to divert stormwater flow into the MAR system. The weir height would be designed taking into account hydraulic head losses in the stormwater system, design stormwater flows and the capacity of the MAR system including pre-treatment devices. Pre-treatment would be required to remove gross pollutants and coarse sediment (including heavy metals). Additional treatment to remove nutrients and fine sediment may also be required, depending on the capacity of the recharge process to improve water quality prior to mixing with native aquifer water.

A stormwater quality and recharge treatment assessment would be required to ensure appropriate design of pre-treatment and that water quality in the aquifer down-gradient of the MAR system, or that the beneficial use of the aquifer is not compromised. Figure 9 shows a off-line recharge structure that could be a leaky concrete tank, porous plastic cells or a system of porous pipes. A flow diversion weir would require careful design for target flow rates to ensure that hydraulic performance of the pipe/culvert is not compromised. It is important to note that stormwater that recharges the aquifer will eventually discharge to a receiving water, such as Alexandra Canal or Botany Bay. A groundwater extraction bore,

located down-gradient of the MAR structure may also be included so that stored water can be re-used. Groundwater extraction is not however an essential part of an MAR system designed for flood mitigation and in fact may be precluded by regulatory issues in Zone 2 of the Botany aquifer.

3.3 MAR Projects for Flood Mitigation

A review of existing MAR schemes in Australia indicated that they have generally been focused at on-site stormwater management on sites up to several hectares (Appendix G). Whilst the technology for infiltration is of interest, the volumes of stormwater generated on site were much smaller than for the catchment that drains through the Joynton Avenue site.

Three examples of those relevant to flood mitigation on a catchment scale are shown below in Table 3 (details of the site locations are not yet available to the public). Examples 1 and 2 were designed to assist in flood mitigation for up to 1 in 100 year ARI storms in sandy aquifers. However, both cases were for catchments smaller than for Joynton Avenue site, and also included detention basins or wetlands as part of the MAR scheme. The third example of MAR assists with flood mitigation objectives up to a 1 in 10 year ARI storm for a large (1600 ha) urban catchment. In that case, stormwater is treated in a wetland prior to injection into a deep limestone aquifer.

Table 3
Examples of MAR Schemes used on a Catchment Scale to Reduce Flood Impacts

Site	Catchment area	MAR area (m^2)	MAR type	Comments
1	19.4 ha	1000 Plus 19,300m^2 detention basin (15,000m^3)	Infiltration gallery	Designed for up to 1:100 ARI storms with associated detention basin. Recharge into sandy aquifer with watertable about 8 m depth. Assumed 25 yr design life. Discharge reduced from 1.28m^3/s to 0.85m^3/s and the initial discharge delayed by some 20 minutes. Reduced severity of short to medium duration flooding
2	68 ha (8.4 ha site)	550 × 0.5 m wide recharge conduits, 11 m long. Plus ~2 ha wetland basin (70,000 m^3).	Gravity-fed recharge conduits (up to 791 m^3/hr)	Designed for 1:100 ARI storm event (48 hr duration or 76,000 m^3). Catchment 70% impervious. Recharge conduits feed into sand aquifer below clay & coffee rock.
3	1600 ha (12 ha site)	2 ha cleansing wetland, plus 2 × 47 ML holding storages and 2 ASR bores.	Injection bores	Designed for up to 1:10 yr ARI events. Detention time of 10 days in wetland prior to injection into limestone aquifer at ~160 m depth. Max yield of 3,000 ML/year, with injection rate of 40 L/s per bore. Project cost $4.1 million.
Joynton Avenue site	~120 ha (2.06 ha site)	Possibility of ~3 × 10 m wide x 100 m long MAR structures (up to 15% of site area)	Leaky concrete tanks, infiltration galleries/plastic cells, or porous pipes/culverts	Subject to further technical investigations, remediation/removal of contaminated fill and regulatory approvals.

Source: Regel *et al.* 2006; Graham and Mulvey, 2007 and unpublished data.

4. INVESTIGATIONS - JOYNTON AVENUE SITE

4.1 Test Drilling

4.1.1 Drilling and Installation Details

Installation of groundwater monitoring bores was completed in the period 4th to the 6th June, 2007 by WRL and Nealings Drilling and Mechanical Services. Nealings used a hollow flight auger type drill rig, allowing the drilled hole to be held up by the steel auger casing preventing hole collapse. The auger has an outside diameter of 200 mm and an inside diameter of 85 mm through which the monitoring bores are installed. Photos of the drilling can be seen in Figures 10 and 11.

DWE licenses for test bores are provided in Appendix D.

The bores were installed as follows:

- Where required, a concrete corer was attached to the drill rig and used to drill through the concrete slabs to reach ground surface.
- The hollow flight augers were attached and the hole was drilled, with cuttings separated into two piles of fill material and natural sediments to prevent spread of any potentially contaminated soil.
- At all sites, holes were drilled until 'refusal' at the bottom of the unconfined aquifer. Soil samples and stratigraphic information were taken when an observable change in stratigraphy occurred.
- If necessary, the hole was backfilled with natural material to the required depth. The depth being dependant on the information the monitoring bore intended to capture.
- The monitoring bore casing consisted of a 50 mm outside diameter PVC casing with a screen covered by a filter sock. This was installed to the required depth and the augers were removed around the piezometer.
- As the augers were removed the holes naturally collapsed to a depth approximate to the water table, backfill was added and a bentonite seal was installed on top of the collapse to allow for slug testing at a later date. The hole was filled in to the surface with fill/cuttings placed back to the approximate depth they were removed from. There was no obvious evidence of contamination in fill material, with an absence of odour and staining in fill material.

- The hole was ‘finished’ by cutting the piezometer slightly below ground level and installing a steel gattic cover that was cemented in.
- Approximately 30 L of water was removed from each hole using a bailer.
- The bores were allowed to recover and water levels were recorded with a dip meter.

A summary of the bores installed is listed in Table 4 below and existing bores detailed in Table 5.

Table 4
Groundwater Monitoring Bore Installation Details

ID	Description	Date Completed	Bore License Number	Easting[1]	Northing[1]	Depth of Refusal[2,3] (m)	Piezometer Depth[2] (m)	Lip of PVC[2] (mm)	Screen Interval[2] (m)	Lithology at screen depth	SWL[2]
WRL 1S	Site near substation	4/6/07	10BL601773	334124	6246295	10.2	7.86	70	1.86-7.86	Sand	3.15
WRL 2S	Site leased by Energy Australia	4/6/07	10BL601773	334315	6246329	14	8.57	80	7.07-8.57	Sand	1.68
WRL 3S	Site leased by various businesses	5/6/07	10BL601773	334199	6246285	13	7.48	80	1.48-7.48	Sand	3.08
WRL 3D	“	5/6/07	10BL601773	334191	6246344	13	12.5	80	11-12.5	Sand	3.2
WRL 4S	City of Sydney workshop area	6/6/07	10BL601773	334265	6246237	12.7	8.14	90	6.64-8.14	Sand	2.32
WRL 4D	“	6/6/07	10BL601773	334260	6246239	12.7	12.52	90	11.02-12.52	Sand	2.43

Table 5
Existing Monitoring Bores Adjacent to those Installed in June 2007

ID	Date Completed	Bore License Number	Easting[1]	Northing[1]	Piezometer Depth[2] (m)	Lip of PVC[2] (mm)	Screen Interval[2,5] (m)	Lithology at screen depth	SWL[2]
MW2	4/6/2002	?	~334315	~6246329	3.36//6.1[4]	25	0.5-3.5	Sand/fill	2.1
MW4	5/6/2002	?	334265	6246295	3.07//4[4]	60	1-4	Sand/fill	2.32

Note.
1. UTM/UPS WGS 84, zone 55 co-ordinates
2. Represents depth below ground level
3. The drilling generally became more difficult starting at the depths noted indicating the start of clay material though drilling continued in most cases for approximately another metre into the clay material
4. These piezometer depths were taken from the HLA (2002) report though were not consistent with the depths measured on-site which are also listed
5. Screen intervals are taken from the HLA (2002) report.

4.1.2 Stratigraphy

Detailed stratigraphy can be seen in the bore logs shown in Appendix E. In each of the holes drilled sandy fill material was encountered in the upper layer. The fill sediment was of medium grain size and poorly sorted. There was no obvious evidence of hydrocarbon contamination in the fill material, in that no odour or obvious staining could be detected. The fill material extended from a depth of 0.6 to as deep as 3.5 m below ground level.

Below the fill material the natural sediments of the shallow aquifer consisted of sandy medium grained, well sorted sediments. The sandy sediments changed colour with depth as shown in the photographic record of the drill cuttings in Figure 11. At sites 1, 2 and 3 approximately 1-2 m before refusal, the driller encountered thin lens of harder material in the sand layers. Due to the nature of the drilling it was not possible to retrieve a sample or determine the exact nature of the sediments.

For the deeper holes drilling continued until refusal. The driller found the material harder for the last metre of drilling to the point where refusal was met at a depth ranges of 10 to 14 m. In relation to the bore logs, this is indicated by the start of the clay section. The clay material was a mottled grey and orange colour likely to be weathered sandstone. The aquifer is therefore deeper than the 10 m thickness expected in this area (HLA Envirosciences, 2002). The point of refusal indicated the base of the unconfined aquifer (Table 6).

Table 6
Depth of Shallow Aquifer for New Monitoring Bores

Bore	Depth of Shallow Aquifer[1] (m)
WRL1S	10.2-11.3
WRL2S	14-15.1
WRL3S/3D	13-13.9
WRL4S/4D	12.7-13.6

4.2 Preliminary Estimates of Stormwater Diversion to MAR

The shallow water table precludes the use of injection bores for groundwater recharge and means that infiltration/recharge structures would need to be carefully designed to prevent excessive watertable mounding. A number of underground MAR structures may be feasible including leaky concrete tanks, infiltration galleries using plastic cells and porous

[1] Indicates base of shallow aquifer below ground level, where concrete slab was encountered indicates depth from top of slab

pipes and/or culverts. Water quality treatment including removal of gross pollutants and sediment would be required prior to recharge to prevent physical clogging and protect aquifer water quality. A site specific detailed concept design would need to be developed for the Joynton Avenue site, for each of the MAR system parts shown in Figure 9.

Modelled stormwater hydrographs by Webb McKeown (draft 2007) were used as a basis for preliminary calculations on potential effectiveness of MAR for reducing flood volumes. This preliminary assessment by WRL suggested that suitable MAR schemes could be a useful flood mitigation strategy, while also providing underground storage of water for subsequent re-use. First-pass estimates of the reduction of peak flood flows and total flows is shown in Figure 12, assuming constant infiltration rates. Stormwater hydrographs generated by numerical models (Webb McKeown, draft 2007) for 2 different stormwater pipes and a 1 in 100 year ARI storm event, as described in Section 2.9 were used as the basis for these calculations.

Figure 12A shows the stormwater hydrograph and possible MAR scenarios for a pipe exiting the Joynton Avenue site with peak discharge of ~10 m^3/s. Figure 12B shows the stormwater hydrograph and possible MAR scenarios for a pipe further upstream in the catchment (draining from Southern Cross Drive) with a lower peak discharge of ~4 m^3/s.

Two MAR scenarios were considered to reduce stormwater flows in each of the two pipes.

- Scenario 1 assuming an infiltration rate of 300 mm/hour over an area of 1000 m^2 (possible conservative design scenario)
- Scenario 2 assuming an infiltration rate of 900 mm/hour over an area of 3000 m^2 (possible best-case design scenario).

Infiltration rates are taken from the Australian Runoff Quality (ARQ) (2006) and are values expected in sandy sediments. The possibility of installing MAR structures with an area of 1000-3000 m^2, is considered realistic compared to other MAR projects (Table 3). However, the larger infiltration area would account for up to 15% of the site area, and would need to be considered in the context of other structures planned for the site and potential overlap with the existing 6 m wide drainage easement through the site.

It should be noted that infiltration rates described above are indicative of the hydraulic conductivity of the saturated sub-surface soil profile. They are not equivalent to the infiltration rates adopted for surface water modelling of design floods. For the latter case, the infiltration capacity reflects the limiting rate at which a soil surface can absorb rainfall

and may be subject to a range of factors including (but not limited to) antecedent moisture content, soil surface conditions, etc.

These preliminary estimates indicate that pipe/culvert stormwater volumes prior exiting to Joynton Avenue could be reduced by 1-10% for a 1 in 100 year ARI storm event. However, if MAR structures were located further upstream in the catchment, stormwater volumes could be reduced by ~3-30% for a 1 in 100 year ARI storm event. Total infiltration volumes were about 1,000 m^3 (conservative case) and 10,000 m^3 (best case) during the 1 in 100 year ARI event. These infiltration volumes are less than the estimated viable groundwater storage of 12,400 m^3 (Table 7), but do not take into account the dynamic nature of the groundwater system, including watertable mounding and regional flow.

Further work is recommended to improve these estimates based on consideration of a range of different size floods, long-term performance (e.g. continuous simulation approaches rather than event based floods) and alternative MAR scenarios. Continuous numerical stormwater models linked with groundwater flow models should be adopted, along with improved infiltration functions over time. Uncertainty related to realistic infiltration rates, particularly over longer time periods should be verified by site specific assessment. Site specific hydraulic parameters will enable better estimates to be made for MAR impact on flooding. More complex numerical modelling would be required to determine the reduction in flood peak flows and flooding depth during and after a storm event in specific parts of the catchment.

It is evident that MAR would be most effective during low flow events, particularly if located upstream of critical flood points, but cannot of itself solve flooding problems and should be considered together with other flood mitigation strategies.

4.3 Remediation and Regulatory Issues to be Addressed

There are several impediments to development of MAR schemes at the Joynton Avenue site. The primary issue is that contaminated fill would require either removal or on-site remediation. It is recommended that CoS consider as a matter of priority, contaminant removal or remediation as part of urban development. MAR and additional groundwater use at the site would probably not be feasible if the contaminated material was capped rather than removed or remediated. Table 7 provides a useful comparison of the volume of contaminated sediment with the water storage volume of the aquifer, and that may be

available for MAR systems and groundwater use. The cost of contamination cleanup should be considered in the context of the value of the groundwater resource.

A second possible impediment is the increased groundwater flow rates that would result from large MAR schemes that would require a sub-regional assessment (i.e. Zone 2 of GWMA018). Both groundwater quality and quantity would require consideration, including groundwater flow modelling. Even if contamination on the Joynton site is remediated and/or removed, it is possible that contamination at other sites nearby may limit or preclude the development of MAR in the Zone 2 area. A comprehensive assessment of groundwater and contamination throughout Zone 2 is required, along with advice from the relevant regulatory authorities as to the conditions under which MAR schemes may or may not be considered.

Regulatory approvals including licensing of groundwater extraction/recharge, would be required from relevant government agencies. Management strategies for the Botany aquifer and the approvals process for large MAR schemes are in a state of evolution. MAR provides a means to boost sustainable yield, however the implications of recent regulatory decisions on possible MAR schemes is uncertain. In particular, the recent embargo (July 2007) applies to areas of the Joynton catchment to the east of Southern Cross Drive, and existing embargoes for Zone 2 at the Joynton site. It is recommended that guidance be sought from the Department of Water and Energy (DWE) and other relevant government agencies as a priority.

Table 7
Groundwater Resources Compared with Contaminated Fill at the Joynton Avenue Site

Region/Zone	Average thickness (m below ground)	Estimated storage volume for 2.06 ha site (m^3)	Comment
Contaminated fill	1.5	~55,000[a]	Remediation/removal cost currently unknown.
Sand aquifer	~10[b]	~62,000[c] (~62 ML)	Top of aquifer impacted by localised contamination ?
Viable groundwater storage zone[d]	~2[e]	~12,400[c] (~12.4 ML)	Value of possible groundwater supply depends on usage & recharge rates. Gross estimate of ~$60,000 /year @ $1.25 per kL. Value of equivalent constructed underground water storage. Gross estimate of ~$8 million.

Note. a. Source HLA Envirosciences (2000).
b. Water table average of 2.6 m below ground (4 shallow wells), depth of aquifer average of 12.5 m below ground.
c. Assuming porosity of 30%.
d. Refers to distance between water table and drawdown depth.
e. Yet to be determined

5. SUMMARY

Findings to date indicate favourable hydrogeological conditions on the site for managed aquifer recharge (MAR), although the location and type of recharge structures will be limited by shallow watertables, particularly towards the Joynton Avenue depression. The aquifer is sandy and thick, with approximately 10 m of saturated, high permeability sands above a clayey substrate. The watertable ranges from 1.7 to 3.2 m below ground, but the watertable elevation and hydraulic gradient relative to the Joynton Avenue depression is yet to be determined.

Preliminary estimates of possible MAR scenarios for this 120 hectare urban catchment were based on design flood modelling undertaken as part of the GSWK Flood Study combined with WRL assumptions regarding infiltration rates and areas. This first-pass estimates indicate that a suitable MAR scheme for this urban catchment of about 120 hectare area could reduce pipe/culvert flow volumes prior exiting to Joynton Avenue by 1-10% for a 1 in 100 year ARI storm event. However, if MAR structures were located further upstream in the catchment, flow volumes could be reduced by ~3-30% for a 1 in 100 year ARI storm event. These estimates are probably an over-estimate of actual infiltration performance because available measurements of infiltration are based on short term testing. Further work is required to verify these first-pass estimates, particularly in regard to infiltration rates that are possible on this site. More complex numerical modelling would be required to determine the potential reduction in flood peak flows and flooding depth during and after a storm event in specific parts of the catchment.

There are at least two issues that require consideration before the CoS is in a position to decide whether or not the MAR concept for the Joynton Avenue site should proceed to further technical investigation and design:

1. Remediation and/or removal of contaminated fill
2. Regulatory approvals.

Issue 1 and/or 2 may prevent MAR schemes being implemented at the Joynton Avenue site, however there also appear to be opportunities for MAR upstream in the catchment that may not be subject to these constraints.

6. RECOMMENDATIONS

If contaminated site issues (Section 4.3) can be resolved, the technical feasibility of MAR could be further assessed in Stages 3, 4 and 5 of the project. Feedback from regulatory authorities regarding groundwater extraction and MAR licensing issues should also be sought prior to further investigations at this site.

- Stage 3 - Groundwater hydraulic measurements
- Stage 4 - Analysis, assessment & recommendations
- Stage 5 - Water quality assessment.

In addition to the scope of works for Stages 3-5 provided in WRL proposal (15/2/07), the following tasks are recommended:

- Measurement of infiltration rates through unsaturated sand. The findings to date preclude the use of injection bores at this site and have highlighted the importance of infiltration rates in determining the area required for MAR structures. Permeability measurements of the aquifer that were previously proposed remain important for determining groundwater flow rates away from possible MAR structures.
- Water quality assessment of monitoring bores (installed and sampled in 2002). The bores should be tested for the full range of contaminated site parameters with results compared to baseline results. This information would assist in updating the extent of the contamination issue on the site.
- Continuous stormwater flow modelling and coupling with groundwater flow modelling is required to improve estimates of MAR impact on flood volumes. Field measurements of infiltration rates using appropriate methods, and suitable test durations and target depths is required to improve on infiltration and loss functions within models.

Revised costs for Stages 3-5 including these additional task can be provided upon request.

It is recommended to proceed with further investigation of possible MAR sites near Southern Cross Drive to assist with flood mitigation at the Joynton Avenue site. Multiple MAR schemes distributed upstream of the Joynton site could provide better infiltration capacity and, subject to further investigation, avoid contamination issues within the Zone 2 groundwater management area.

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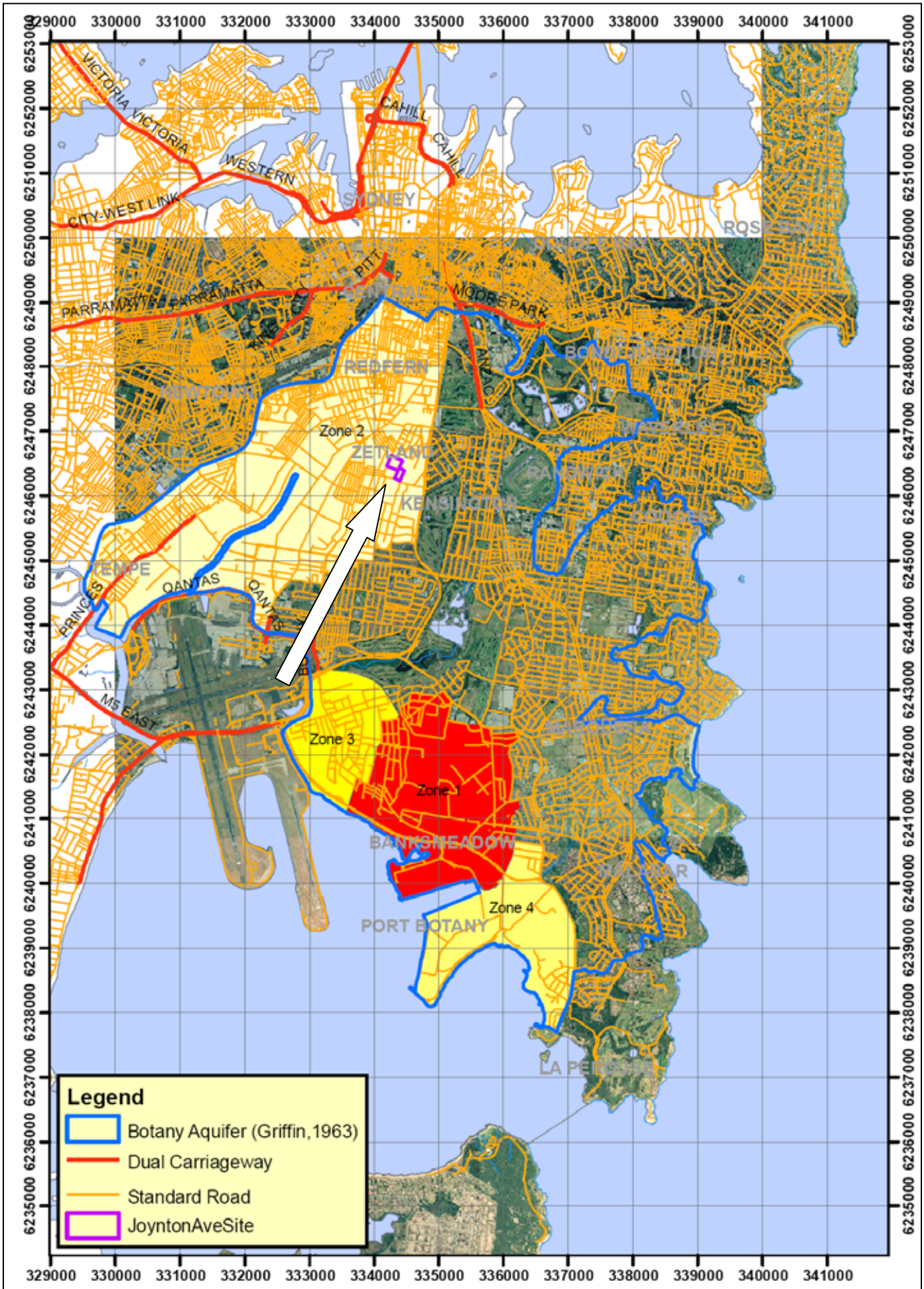
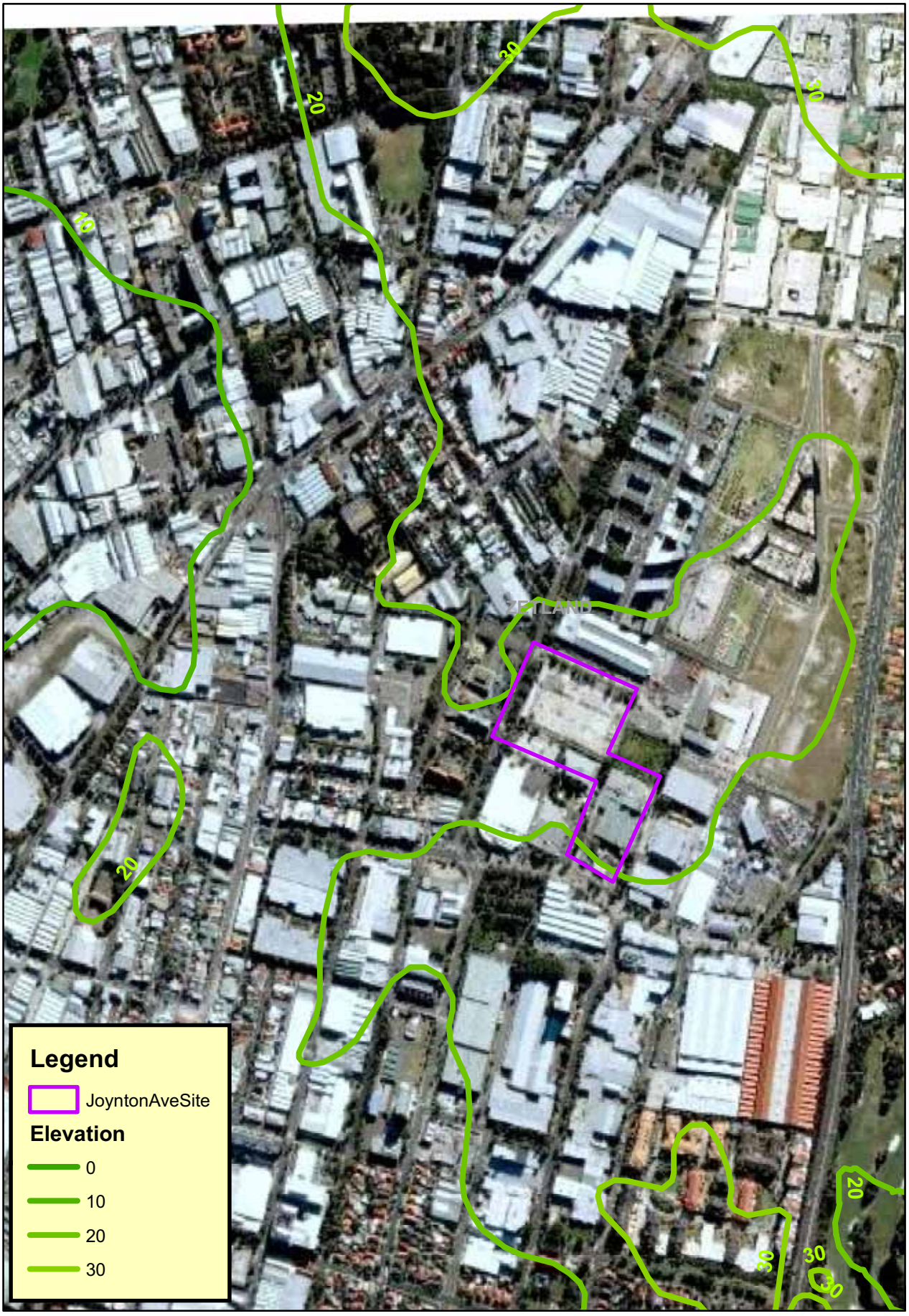
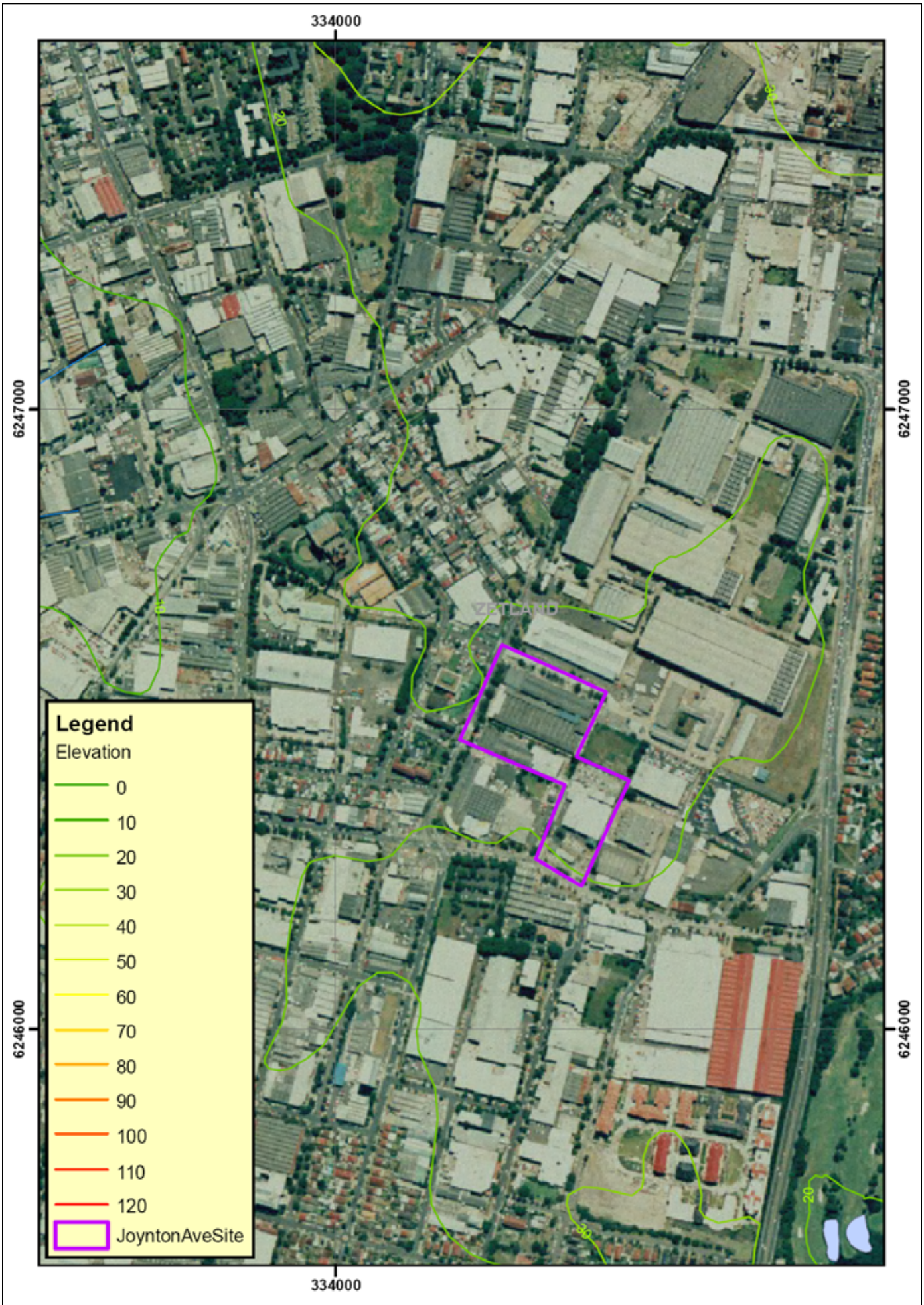


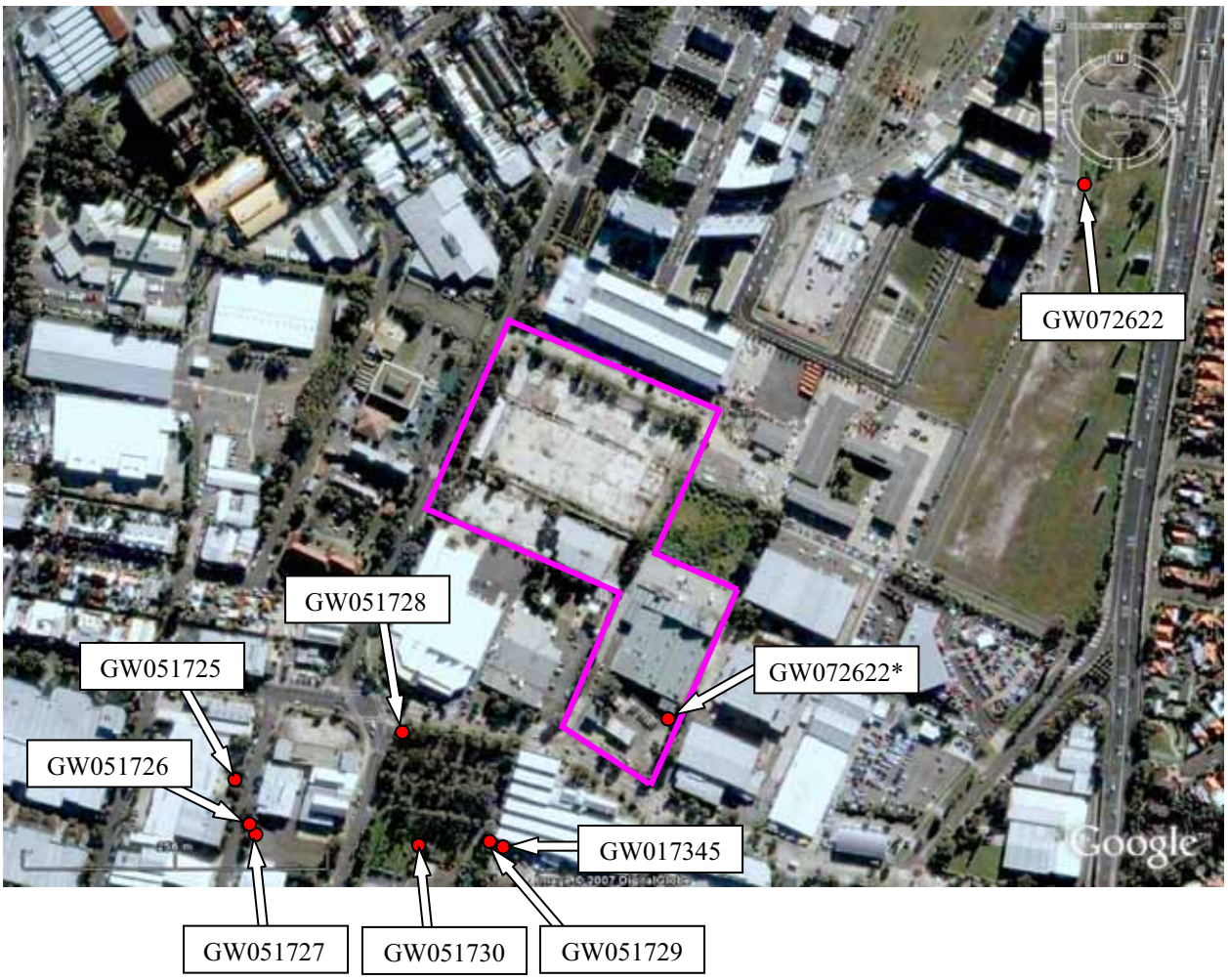
WRL Report No. 2007/25	JOYNTON AVENUE SITE RELATIVE TO BOTANY AQUIFER	Figure 1



WRL Report No. 2007/25	SITE SURROUNDS 2007	Figure 2 SiteSurr...fig2v2.mxd



WRL Report No. 2007/25	SITE SURROUNDS 1998	Figure 3



Legend

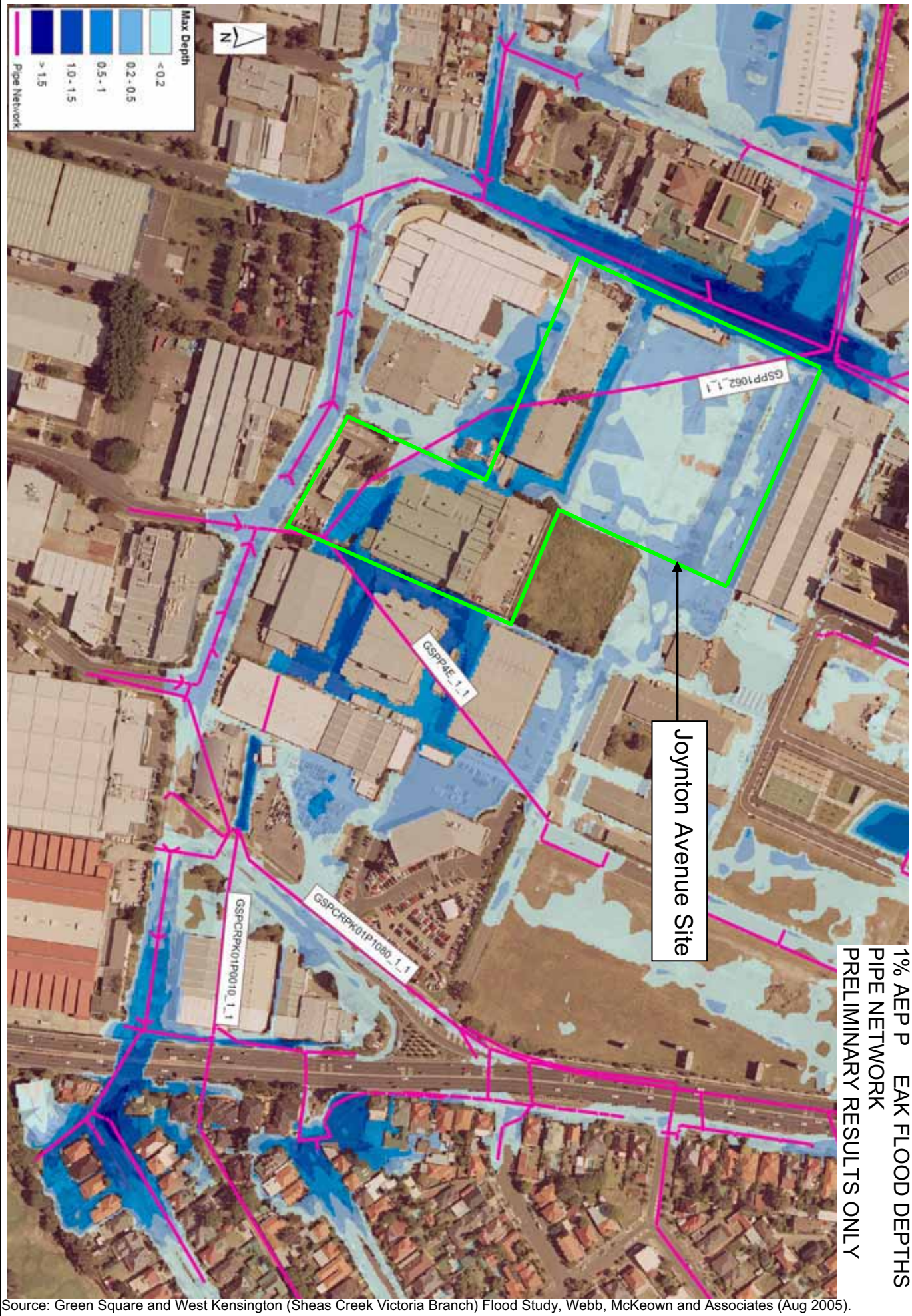
●	Groundwater bore
GW017345	Bore number
*	Denotes production bore at council site
▭	Study site boundary

Image source, Google Earth

WRL Report No. 2007/25	REGISTERED BORES IN THE AREA	Figure 4

WRL Report No. 2007/25	NEW AND EXISTING GROUNDWATER MONITORING BORES AT JOYNTON AVENUE SITE	Figure 5 Siteboresfig5v2.mxd

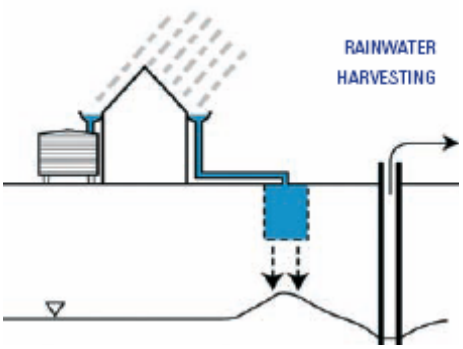
WRL Report No. 2007/25	STORMWATER DRAINAGE NETWORK	Figure 6 07014-06.cdr



Source: Green Square and West Kensington (Sheas Creek Victoria Branch) Flood Study, Webb, McKeown and Associates (Aug 2005).

WRL Report No. 2007/25	PIPE AND OVERLAND FLOW AT JOYNTON AVENUE SITE	Figure 7

A



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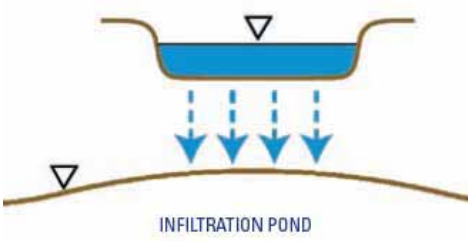

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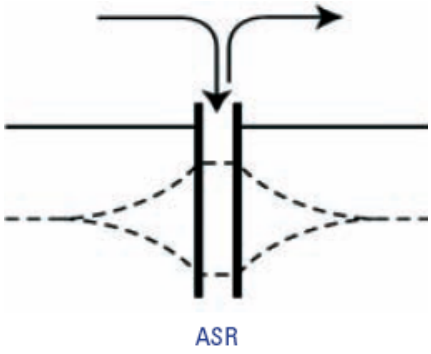

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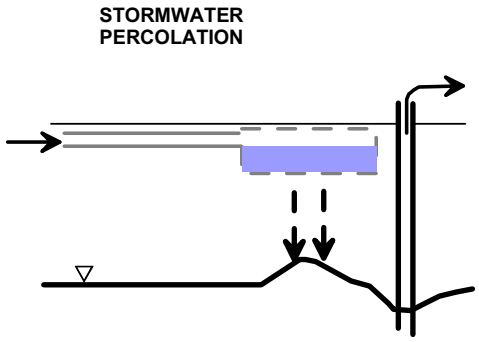
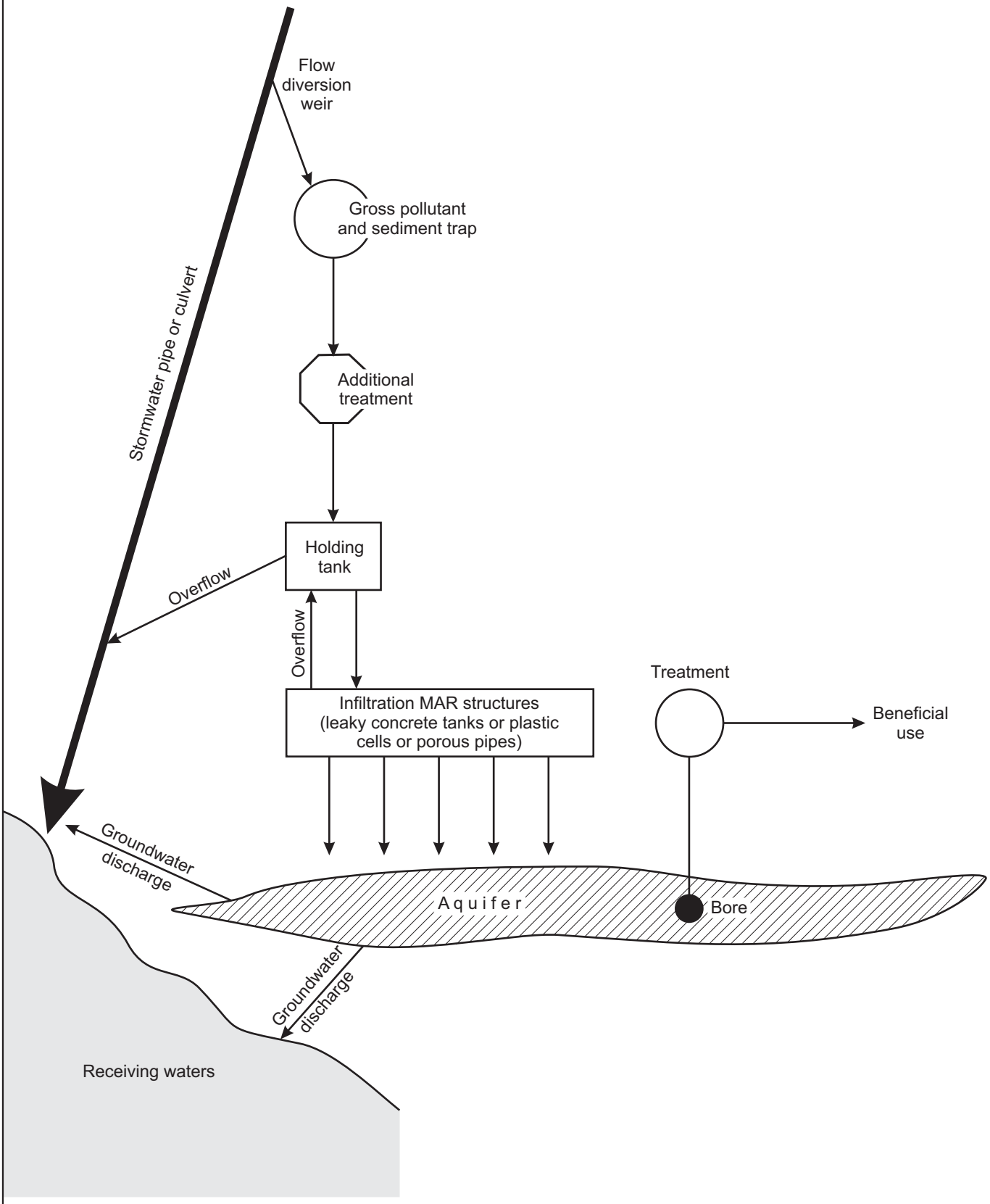


Source: Dillon (2005)

WRL Report No. 2007/25	TYPES OF MANAGED AQUIFER RECHARGE	Figure 8 03117-file



WRL Report No. 2007/25	SCHEMATIC OF STORMWATER FED MAR SYSTEM	Figure 9 07014-09.cdr

Concrete coring

Piezometer installation at site 4

Drilling at site 1

Piezometer installation at site 3

WRL Report No. 2007/25	DRILLING AND PIEZOMETER INSTALLATION	Figure 10

WRL3S and 3D

WRL4S and 4D

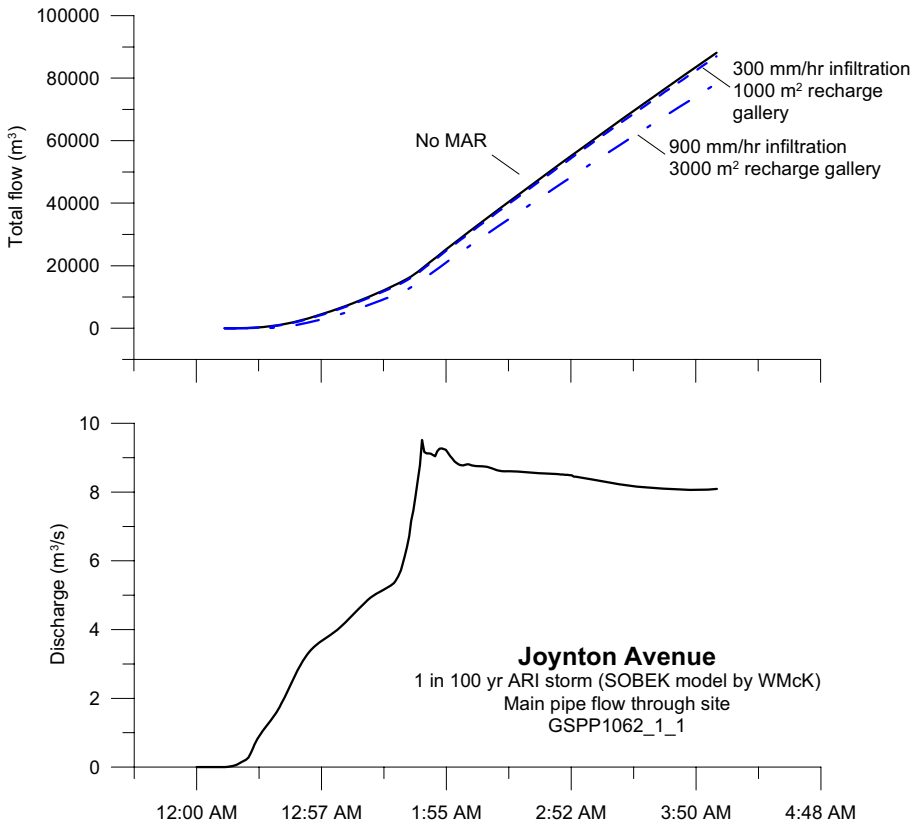
WRL1S

WRL2S

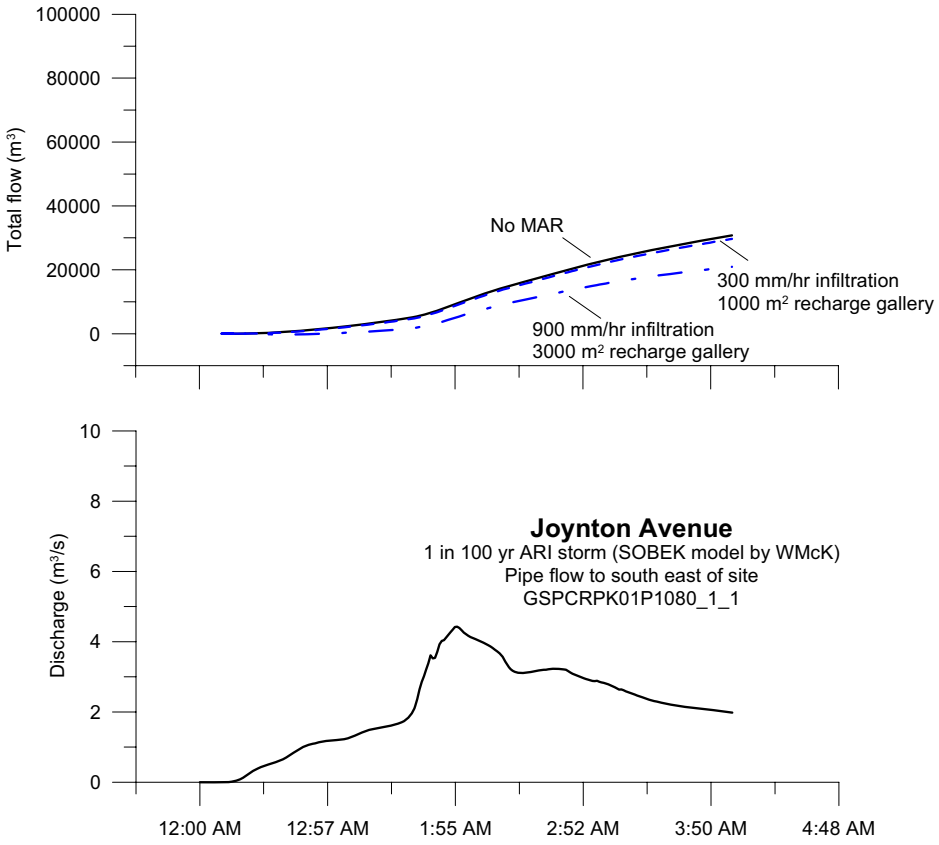
Note. Arrows indicate increasing depth

WRL Report No. 2007/25	PHOTO RECORD OF DRILL CUTTINGS	Figure 11

A



B



LEGEND

Scenario 1 - No MAR
Scenario 2 - Infiltration 300 mm/hr over 1000 m²
Scenario 3 - Infiltration 900 mm/hr over 3000 m²

WRL Report No.2007/25	STORMWATER HYDROGRAPHS WITH AND WITHOUT MAR	Figure 12

APPENDIX A
GROUNDWATER BORE SEARCHES

GW104125

Works Details

GROUNDWATER NUMBER	GW104125
LIC-NUM	10BL159859
AUTHORISED-PURPOSES	RECREATION (GROUNDWATER)
INTENDED-PURPOSES	RECREATION (GROUNDWATER)
WORK-TYPE	Bore
WORK-STATUS	Supply Obtained
CONSTRUCTION-METHOD	Rotary
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1/08/2000
FINAL-DEPTH (metres)	15.7
DRILLED-DEPTH (metres)	22
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	N/A
GWMA	- CENTRAL WEST FRACTURED ROCKS
GW-ZONE	- LACHLAN V.JEM.- WOLLO
STANDING-WATER-LEVEL	0.50
SALINITY	
YIELD	9.80

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6246511.00
EASTING	334625.00
LATITUDE	33 54' 31"
LONGITUDE	151 12' 40"
GS-MAP	
AMG-ZONE	56
COORD-SOURCE	GPS - Global Positioning System
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	LT 17 DP 1016882

Licensed

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	302 1032762

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	18.00	400			Rotary Air/Mud
1		Hole	Hole	18.00	22.00	150			Rotary Air/Mud
1	1	Casing	PVC Class 12	-0.50	6.40	200			Screwed and Glued
1	1	Casing	(Unknown)	11.40	14.30				Screwed and Glued
1	1	Opening	Screen	6.40	11.40	225			Condamine; A: .7mm
1	1	Opening	Screen	14.30	15.30	225			Condamine; A: .7mm
1	1	Opening	Screen	15.30	15.70				
1		Annulus	Waterworn/Rounded	0.00	18.00				Graded; GS: 1-2mm; Q: 4m³

Water Bearing Zones

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
2.50	6.50	4.00		2.00		9.80			
8.20	12.00	3.80		2.00		9.80			
14.20	15.20	1.00		0.50		9.80			

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.00	1.00	SAND,LT,BROWN,LOAMY		
1.00	5.30	4.30	SAND,LT,BROWN		
5.30	8.10	2.80	SAND,LT BROWN		
8.10	14.20	6.10	PEAT,BLACK		
14.20	15.20	1.00	SAND, WHITE		
15.20	18.00	2.80	PEAT,BLACK		
18.00	22.00	4.00	CLAY,GREY,SANDY		

GW072622

Works Details

GROUNDWATER NUMBER	GW072622
LIC-NUM	10BL156770
AUTHORISED-PURPOSES	IRRIGATION RECREATION (GROUNDWATER)
INTENDED-PURPOSES	IRRIGATION RECREATION (GROUNDWATER)
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	
COMMENCE-DATE	
COMPLETION-DATE	1994-11-28
FINAL-DEPTH (metres)	
DRILLED-DEPTH (metres)	16.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	SYDNEY COUNCIL
GWMA	- CENTRAL WEST FRACTURED ROCKS
GW-ZONE	- LACHLAN V.JEM.- WOLLO
STANDING-WATER-LEVEL	
SALINITY	9000.00
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	
AREA-DISTRICT	
CMA-MAP	
GRID-ZONE	
SCALE	
ELEVATION	
ELEVATION-SOURCE	
NORTHING	6246143.00
EASTING	334289.00
LATITUDE	33 54' 43"
LONGITUDE	151 12' 27"
GS-MAP	
AMG-ZONE	56
COORD-SOURCE	
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	5 235181

Licensed

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	5 235181

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	15.00	250			Cable Tool
1	1	Casing	Steel	0.00	10.50	168	160		Welded; Seated on Bottom; Cap
1	1	Opening	Screen - Wire Wound	10.50	15.00	168		1	Johnson; Stainless Steel; A: .51mm; Welded
1		Annulus	Waterworn/Rounded	8.00	15.00				Graded; GS: 1-2mm; Q: .5m³

Water Bearing Zones

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
2.95	14.70	11.75		2.95	9.50	1.60	15.00	8.00	9000.00

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.00	1.00	FILL, ROCKS & SAND		
1.00	1.50	0.50	YELLOW SAND		
1.50	2.80	1.30	PEATY SAND		
2.80	8.30	5.50	YELLOW SAND		
8.30	11.00	2.70	DARK BROWN PEATY SAND		
11.00	11.50	0.50	BLACK PEATY SAND		
11.50	14.20	2.70	BROWN PEATY SAND		
14.20	15.30	1.10	PEAT		
15.30	16.00	0.70	STIFF GREY CLAY		

GW051728

Works Details

GROUNDWATER NUMBER	GW051728
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	MONITORING BORE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Mud
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1980-12-01
FINAL-DEPTH (metres)	8.30
DRILLED-DEPTH (metres)	8.30
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6246070.00
EASTING	334090.00
LATITUDE	33 54' 45"
LONGITUDE	151 12' 19"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	0.00	100			(Unknown)
1	1	Opening	Slots	4.30	8.30	100		1	SL: 0mm; A: 0mm
1	1	Annulus	Crushed Aggregate	4.00	8.30	200			Graded; GS: 4.8mm

Water Bearing Zones

no details

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	1.00	1.00	Made Ground		
1.00	3.80	2.80	Sand Fine-medium Some Fine		
3.80	8.30	4.50	Sand Greyish Grey Fine-medium		

GW017345

Works Details

GROUNDWATER NUMBER	GW017345
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	INDUSTRIAL
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1954-10-01
FINAL-DEPTH (metres)	13.70
DRILLED-DEPTH (metres)	13.70
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6245995.00
EASTING	334174.00
LATITUDE	33 54' 48"
LONGITUDE	151 12' 23"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Welded Steel	-0.60	10.00	254			Suspended in Clamps
1	1	Opening	Screen - Gauze/Mesh	10.00	13.00	254		1	Copper Alloy; SL: 0mm; A: 0mm

Water Bearing Zones

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
7.90	13.30	5.40	Unconsolidated	5.40		10.10			Good

Drillers Log

FROM	TO	THICKNESS	DESC		GEO-MATERIAL		COMMENT
0.00	0.60	0.60	Made Ground				
0.60	2.43	1.83	Sand Grey				
2.43	2.74	0.31	Wood				
2.74	4.26	1.52	Sand Wood				
4.26	6.70	2.44	Sand White Hard				
6.70	7.92	1.22	Sand White Hard				
6.70	7.92	1.22	Clay				
7.92	13.41	5.49	Sand Water Supply				
13.41	13.71	0.30	Clay				

GW051729

GROUNDWATER NUMBER	GW051729
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	MONITORING BORE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Mud
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1980-12-01
FINAL-DEPTH (metres)	8.50
DRILLED-DEPTH (metres)	8.50
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6245990.00
EASTING	334160.00
LATITUDE	33 54' 48"
LONGITUDE	151 12' 22"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD,,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1		Hole	Hole	0.00	8.50	100			
1	1	Casing	P.V.C.	0.00	0.00	100			(Unknown)
1	1	Opening	Slots	4.50	8.50	100		1	SL: 0mm; A: 0mm
1	1	Annulus	Crushed Aggregate		0.00	200			Graded; GS: 4.8mm

Water Bearing Zones

no details

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.80	0.80	Made Ground		
0.80	1.80	1.00	Sand Light Brown Fine-medium Some Fine		
1.80	5.70	3.90	Sand Dark Brown Fine-medium		
5.70	8.50	2.80	Sand Light Brown Fine-medium		

GW051730

Works Details

GROUNDWATER NUMBER	GW051730
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	MONITORING BORE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Mud
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1980-12-01
FINAL-DEPTH (metres)	0.00
DRILLED-DEPTH (metres)	8.30
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6245950.00
EASTING	334120.00
LATITUDE	33 54' 49"
LONGITUDE	151 12' 20"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	0.00	100			(Unknown)
1	1	Opening	Slots	3.30	8.30	100		1	SL: 0mm; A: 0mm
1	1	Annulus	Crushed Aggregate	3.00	8.30	200			Graded; GS: 4.8mm

Water Bearing Zones

no details

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	3.30	3.30	Sand Reddish Fine-medium Some Fine		
3.30	8.30	5.00	Sand Greyish Light Brown Fine-medium		

GW026142

Works Details

GROUNDWATER NUMBER	GW026142
LIC-NUM	10BL019576
AUTHORISED-PURPOSES	DOMESTIC
INTENDED-PURPOSES	GENERAL USE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Cable Tool
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1967-02-01
FINAL-DEPTH (metres)	12.40
DRILLED-DEPTH (metres)	12.50
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	ROSEBERY PROPERTIES
GWMA	018 - BOTANY BAY SAND BEDS
GW-ZONE	- LACHLAN V.JEM.- WOLLO
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6245885.00
EASTING	334275.00
LATITUDE	33 54' 52"
LONGITUDE	151 12' 26"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,PR. MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	99999

Licensed

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	2 229802

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	Corrugated Galvenised Iron	0.00	9.40	101			Suspended in Clamps
1	1	Opening	Screen - Gauze/Mesh	9.40	12.40	101		1	Copper Alloy; SL: 0mm; A: 0mm

Water Bearing Zones

FROM-DEPTH (metres)	TO-DEPTH (metres)	THICKNESS (metres)	ROCK-CAT-DESC	S-W-L	D-D-L	YIELD	TEST-HOLE-DEPTH (metres)	DURATION	SALINITY
9.40	12.40	3.00	Unconsolidated	5.30		0.72			(Unknown)

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	5.18	5.18	Sand		
0.00	5.18	5.18	Rubble		
5.18	12.49	7.31	Sand White Wet Clean Water Supply		
12.49	12.51	0.02	Peat Sandy		
12.49	12.51	0.02	Clay		

GW051725

Works Details

GROUNDWATER NUMBER	GW051725
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	MONITORING BORE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Mud
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1980-02-01
FINAL-DEPTH (metres)	8.00
DRILLED-DEPTH (metres)	8.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6246055.00
EASTING	333960.00
LATITUDE	33 54' 46"
LONGITUDE	151 12' 14"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	0.00	100			(Unknown)
1	1	Opening	Slots	2.50	8.00	100		1	SL: 0mm; A: 0mm
1	1	Annulus	Crushed Aggregate	2.00	8.00	200			Graded; GS: 4.8mm

Water Bearing Zones

no details

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.70	0.70	Made Ground		
0.70	3.50	2.80	Sand Dark Brown Fine-medium		
3.50	8.00	4.50	Sand Greyish Light Brown Fine-medium		

GW051726

Works Details

GROUNDWATER NUMBER	GW051726
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	MONITORING BORE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Mud
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1980-02-01
FINAL-DEPTH (metres)	8.00
DRILLED-DEPTH (metres)	8.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6246015.00
EASTING	333980.00
LATITUDE	33 54' 47"
LONGITUDE	151 12' 15"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	PIPE-NO	COMPONENT-CODE	COMPONENT-TYPE	DEPTH-FROM (metres)	DEPTH-TO (metres)	OD (mm)	ID (mm)	INTERVAL	DETAIL
1	1	Casing	P.V.C.	0.00	0.00	100			(Unknown)
1	1	Opening	Slots	2.00	8.00	100		1	SL: 0mm; A: 0mm
1	1	Annulus	Crushed Aggregate		0.00	200			Graded; GS: 4.8mm

Water Bearing Zones

no details

Drillers Log

FROM	TO	THICKNESS	DESC	GEO-MATERIAL	COMMENT
0.00	0.80	0.80	Made Ground		
0.80	3.20	2.40	Sand Grey Yellow Yellowish Fine-medium Interlayere		
3.20	8.00	4.80	Sand Light Brown Grey Fine-medium		

GW051727

Works Details

GROUNDWATER NUMBER	GW051727
LIC-NUM	
AUTHORISED-PURPOSES	
INTENDED-PURPOSES	MONITORING BORE
WORK-TYPE	Bore
WORK-STATUS	(Unknown)
CONSTRUCTION-METHOD	Rotary Mud
OWNER-TYPE	Private
COMMENCE-DATE	
COMPLETION-DATE	1980-12-01
FINAL-DEPTH (metres)	8.00
DRILLED-DEPTH (metres)	8.00
CONTRACTOR-NAME	
DRILLER-NAME	
PROPERTY	
GWMA	
GW-ZONE	
STANDING-WATER-LEVEL	
SALINITY	
YIELD	

Site Details

REGION	10 - SYDNEY SOUTH COAST
RIVER-BASIN	213 - SYDNEY COAST - GEORGES RIVER
AREA-DISTRICT	
CMA-MAP	9130-3S
GRID-ZONE	56/1
SCALE	1:25,000
ELEVATION	
ELEVATION-SOURCE	(Unknown)
NORTHING	6245990.00
EASTING	333975.00
LATITUDE	33 54' 48"
LONGITUDE	151 12' 15"
GS-MAP	0055A4
AMG-ZONE	56
COORD-SOURCE	GD.,ACC.MAP
REMARK	

Form-A

COUNTY	CUMBERLAND
PARISH	ALEXANDRIA
PORTION-LOT-DP	411

Licensed

no details

Construction

Negative depths indicate Above Ground Level;H-Hole;P-Pipe;OD-Outside Diameter;
ID-Inside Diameter;C-Cemented;SL-Slot Length;A-Aperture;GS-Grain Size;Q-Quantity

HOLE-NO	**PIPE-NO**	**COMPONENT-CODE**	**COMPONENT-TYPE**	**DEPTH-FROM (metres)**	**DEPTH-TO (metres)**	**OD (mm)**	**ID (mm)**	**INTERVAL**	**DETAIL**
1	1	Casing	P.V.C.	0.00	0.00	100			(Unknown)
1	1	Opening	Slots	2.50	8.00	100		1	SL: 0mm; A: 0mm
1	1	Annulus	Crushed Aggregate	2.00	8.00	200			Graded; GS: 4.8mm

Water Bearing Zones

no details

Drillers Log

FROM	**TO**	**THICKNESS**	**DESC**	**GEO-MATERIAL**	**COMMENT**
0.00	0.60	0.60	Made Ground		
0.60	4.60	4.00	Sand Yellow Dark Brown Fine-medium		
4.60	8.00	3.40	Sand Light Brown Fine-medium		

APPENDIX B
WRL LETTER REPORT 16/4/07

24th April, 2007

Our Ref: WRL 07027 AMB:BMM 070424

Mr Nick Criniti
City of Sydney
PO Box 1591
SYDNEY NSW 2001

Dear Nick,

BORE WATER QUALITY TESTING, CITY OF SYDNEY BORES

The Water Research Laboratory (WRL) is pleased to provide this assessment of groundwater quality from the bores at the Epsom St Depot, Redfern Oval and Sydney Park. The purpose of the water quality testing was to assess the suitability of the water for irrigation of parks and secondary contact by humans.

Each of the bores tested are located in Management Zone 2 of the Botany Sands Aquifer. Industrial groundwater users (including the Council) in this zone are now required to test their bore water at least annually and provide the results to the NSW Departments of Natural Resources and Environment and Conservation.

SAMPLING AND ANALYSIS

Groundwater samples were tested for all parameters listed in the Draft Department of Infrastructure, Planning and Natural Resources (DIPNR, now DNR) Recommended Bore Licence Minimum Analytical Suite for the Botany Sands Aquifer, as outlined in the attached guideline (Appendix A). These parameters are broadly representative of the known contamination in the Botany Sands Aquifer, including contamination from sewers, road runoff, petrol stations and groundwater contamination from Orica, Botany. The results of these tests have been compared to the ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality and NHMRC (2006) Guidelines for Managing Risks in Recreational Water. The guidelines were used to determine if any threat to plant health is likely from irrigating with the groundwater or threat to human health is likely from coming into contact with the groundwater.

Water quality parameters were analysed either on-site with calibrated water quality meters and electrodes, or by the Australian Laboratory Services which is NATA registered for these tests.

Water quality parameters tested included:

- Electrical conductivity, EC, an estimate of salinity (on-site).
- Acidity, known as pH (on-site).
- Water temperature (on-site).
- Dissolved oxygen (on-site)
- Alkalinity – a measure of water hardness.
- Major ions – calcium, sodium, potassium, magnesium, chloride and sulphate.
- Inorganics and total metals (unfiltered) – antimony, arsenic, barium, boron, cadmium, copper, chromium, iron, lead, lithium, manganese, mercury, nickel, selenium, silver and zinc
- Nutrients – ammonia, nitrate, total nitrogen and total phosphorous (nutrients from fertilizer and sewage effluent).
- Thermotolerant coliforms and Faecal streptococci – indicators of bacterial contamination.
- Organic compounds - benzene, toluene, ethylbenzene, xylene (BTEX) (5), chlorinated hydrocarbons (10), halogenated aromatic hydrocarbons (9), halogenated aliphatic hydrocarbons (28), fumigants (5), pesticides (42), phenols (12), polychlorinated biphenyls (PCBs) (total), polynuclear aromatics (16), trihalomethanes (4), and total petroleum hydrocarbons (TPH) (4).

Copies of the complete ALS test results are found in Appendix B. A summary of these results is found in Table 1. The details of sampling and results for each bore are found in the following sections.

EPSOM RD DEPOT

Sampling

The irrigation bore at Epsom Rd Depot is a high flow bore which continuously fills a large water storage tank. The bore was installed more than 10 years ago. Council trucks fill their tanks from this storage tank on a daily basis for street cleaning and irrigation of parks. Samples were taken from a high flow large diameter tap fitted to the side of the bore on 27th March, 2007. Water sampled was clear and had a slight sulphur odour, which was also attested to by several workers on site who commented on the persistent smell of the water.

Results

In general, the quality of the groundwater was found to be good and within available guideline values for irrigation and secondary contact.

EC was measured to be 191 µS/cm and Total Dissolved Solids (TDS – the sum of major ions) were 109 mg/L, indicating that the groundwater was fresh. At 6.15, the pH was slightly acid but within the range listed by ANZECC (2000) as having limited corrosion potential and is within the range of acceptable levels for secondary contact by humans. The water hardness is, however, very low at 19 mg/L $CaCO_3$, which increases the corrosion potential (< 60 mg/L). Aluminium, barium, copper, iron, manganese and zinc were the only metals detected

in the water. Other than iron, all metals were present in concentrations below those recommended for long term irrigation (up to 100 years) or secondary contact. The concentration of iron in the water (4.24 mg/L) is below the guideline value for short term irrigation of up to 20 years (10 mg/L). The presence of iron and manganese in the water is not surprising given the reducing water conditions indicated by the smell of sulphur during sampling.

No nutrients were present in concentrations above guideline levels, however the concentration of ammonia was significant. These nitrogen levels are unlikely to be caused by recent sewage contamination as there was no corresponding measure of bacteria, with neither thermotolerant (faecal) coliforms nor faecal streptococci being detected.

No organics, such as pesticides or hydrocarbons were detected in the water.

SYDNEY PARK

Sampling

The irrigation bore at Sydney Park was not in operation at the time of sampling. The bore is used to fill one of the landscaped lakes in the park, which at the time of sampling was under redevelopment. Water from this lake is then transferred between other lakes in the park. As the bore had not been used for some time, the bore was purged for 15 minutes at a flow rate of approximately 1 L/s and field parameters were allowed to stabilise prior to sampling. Sampling was completed on 27th March, 2007. Water sampled was clear and had no apparent odour.

Results

In general, the quality of the groundwater was found to be fair and may be suitable for irrigation and secondary contact after appropriate holding times within the lake.

EC was measured to be 2027 µS/cm and Total Dissolved Solids (TDS – the sum of major ions) was 1581 mg/L, indicating that the groundwater was fresh to brackish. Sodium and chloride concentrations exceed the guideline values for sensitive plant species, however plants that are moderately tolerant to salts, such as most grasses, should not be affected. Spray irrigation should be avoided to prevent foliar injury to plants.

The pH was slightly acid at 6.39, but within the range listed by ANZECC (2000) as having limited corrosion potential and is within the range of acceptable levels for secondary contact by humans. The water hardness (425 mg/L) indicates an increased fouling potential of the water, thus the bore, pumps and pipework may be affected by clogging, encrustation and scaling over time.

Aluminium, arsenic, barium, boron, copper, iron, manganese, nickel, silver and zinc were all detected in the water. Other than boron, iron and manganese, all metals were present in concentrations beneath those recommended for long term irrigation (up to 100 years) or

secondary contact. While iron concentrations (47.4 mg/L) are very high and manganese concentrations (0.491 mg/L) are also significant, the process of storing the water in the lake prior to further use will greatly reduce the risk of any plant or human health issues from use of the water for irrigation. If the receiving lake does not become stratified in summer and the vertical profile remains oxygenated, both manganese and iron will precipitate out of the water and settle on the bottom of the lake as iron and manganese oxides. Boron is an essential trace element for humans and will not cause any health risk at the concentrations measured. However, boron concentrations measured exceed the ANZECC (2000) guideline value for long term irrigation (up to 100 years) of plants. This value has been set to protect plant species most sensitive to boron toxicity. Of the plants listed in the guidelines, it is assumed that the sensitivity of lawns would be most similar to clover which is moderately tolerant to boron and can tolerate short term irrigation concentrations up to 2.0 - 4.0 mg/L. Based on this examination, the concentrations of metals in groundwater sampled from Sydney Park are not likely to be problematic for either irrigation or secondary contact by humans.

Of the nutrients analysed, both ammonia (31.2 mg/L) and Total Kjeldahl Nitrogen[1] (39.7 mg/L) were detected in very high concentrations. The concentration of ammonia greatly exceeds the drinking water guideline value (NHMRC, 2004) of 0.5 mg/L based on potential for corrosion and also exceeds long term irrigation guideline values. The nitrogen levels are unlikely to be caused by recent sewage contamination as there was no corresponding measure of bacteria, with neither thermotolerant (faecal) coliforms nor faecal streptococci being detected. As with iron and manganese, it is expected that ammonia will at least partially oxidise during the holding time in the receiving lake. As ammonia oxidises to nitrate, this may lead to very high concentrations of nitrate in the lake which may subsequently cause excessive growth of plants and algae. Use of this water for irrigation should be scheduled carefully to balance the nutrient needs of the plants being irrigated, and application of additional nitrogen fertilisers should be limited accordingly.

Of the organics analysed, only petroleum hydrocarbons (C_{10}-C_{36}) were detected. No guideline values exist for either irrigation or secondary contact of TPH. The detection of TPH indicates some general contamination of the water with petroleum hydrocarbons, however the effects of this contamination may be highly variable as the hydrocarbons may vary in composition. Irwin (1997) states that the main hazards and carcinogenicity of TPH are related to the concentrations of PAH's. Vapours from alkanes can also be hazardous, although it should be noted that no hydrocarbon odours were noticed by the sampler. In addition, Irwin (1997) argues for the use of BTEX as a more appropriate criteria for use with assessing the effectiveness of spill cleanups due to its high mobility. While the presence of TPH is the groundwater is certainly concerning, the absence of both BTEX and PAH's in the water may reduce the apparent risk associated with this contamination.

Due to the high concentrations of reduced products in the water, it is recommended that the practice of storing the water in the lake prior to further use be continued. In this way, some of the contamination may attenuate. It is also recommended that lake water quality be regularly tested to ensure that the use of these waters for irrigation is appropriate. We also recommend conducting monitoring of algal buildup and stratification in the lake.

[1] Note that the analytical method for the determination of TKN includes both ammonia and organic nitrogen

REDFERN PARK

Sampling

From discussion with Council prior to submitting the proposal of 26th March, 2007, it was understood that the bores to be sampled at Redfern Park were irrigation bores and that "the purpose of water quality testing is to ensure that the water is suitable for park irrigation and secondary contact by people using the water." However, upon meeting with Garth Shayler, Project Manager of the Redfern Park redevelopment, at Redfern Park on 27th March, WRL found that the bores to be sampled were shallow monitoring bores, not irrigation bores.

At this time Garth Shayler informed WRL that an irrigation bore had existed on the site, but this was not going to be used for future irrigation and could not be located with any certainty. For future irrigation a new bore would be drilled. As the monitoring bores were very shallow (4 m for Redfern 1 and 2.9 m for Redfern 2), it is certainly not appropriate to assess this water for irrigation, as any irrigation bore would be drilled deeper into the sands and therefore water quality could be quite different. The purpose of testing at this site therefore seemed to be uncertain. The key issue for Garth Shayler in the redevelopment of the park was dewatering during the construction of the underground carpark and any health issues associated with contact with this water.

The monitoring bores to be sampled were protected with gattic covers, for which tools were required for access. This was contrary to the assumption stated in the proposal that "groundwater may be sampled by a tap or pump installed on the property". WRL was not informed of the tools required to access the bores and therefore only Redfern 1, located on the western side of the park, could be accessed on 27th March, 2007. The flow in this bore was so low that it could not be sampled with a pump, but only with a Teflon bailer. This bore was completely emptied using the bailer on 27th March. WRL returned early on 28th March to take the samples from the bore and to access Redfern 2, located on the eastern side of the park. It was found that the depth of water in Redfern 2 was so shallow and the flow so low that it was not feasible to sample from the bore. Only field parameters were measured from this bore. Water from both bores was very turbid and black in colour.

Results

In general, the quality of the groundwater was found to be fair, however secondary contact of the water is not advised due to the presence of heavy metals. As the assessment of this water with reference to irrigation guidelines would be inappropriate, discussion of the testing results is limited to health based guidelines. Note that guidelines for chemical concentrations in waters for recreational contact (NHMRC, 2006) are based on the assumption of some consumption of water and therefore may be more conservative than necessary for the purposes of assessing the risk of contact during dewatering processes. While it is beyond the scope of this assessment to discuss the disposal of water from dewatering works in detail, it is likely that this water will require treatment prior to disposal into any waterways.

EC was measured to be 307 µS/cm and Total Dissolved Solids (TDS – the sum of major ions) were 248 mg/L, indicating that the groundwater was fresh. At 6.56, pH was slightly acid but

within the range listed by ANZECC (2000) as having limited corrosion potential and is within the range of acceptable levels for secondary contact by humans. The water hardness (101 mg/L) is neither beneath the concentration likely to increase corrosion potential, nor greater than the concentration likely to cause fouling.

All metals tested for were detected in the water. Other than aluminium, iron, and lead, all metals were present in concentrations beneath those recommended for long term irrigation (up to 100 years) or secondary contact. While aluminium and iron concentrations are very high, there are no health based guidelines for either aluminium or iron. Lead concentrations (0.235 mg/L) are double the recreational contact value of 0.1 mg/L. Metal concentrations may be in part related to the very high turbidity of the water and may possibly be reduced by some settling of the waters. Bacterial indicators were detected in the groundwaters at concentrations below the NHMRC (2006) guidelines for recreational contact.

Of the organics analysed, only petroleum hydrocarbons (C_{15}-C_{36}) were detected. As discussed regarding Sydney Park, no guideline values exist for either irrigation or secondary contact of TPH. The detection of TPH indicates some general contamination of the water with petroleum hydrocarbons, however the effects of this contamination may be highly variable as the hydrocarbons may vary in composition. While the presence of TPH is the groundwater is certainly concerning, the absence of both BTEX and PAH's in the water indicates that the risk associated with this contamination may not be high.

SUMMARY

In general, the quality of the groundwater was found to be good at the Epsom Rd Depot, fair at Sydney Park and fair at Redfern Park. The presence of TPH and metals in groundwater from Redfern Oval should be further investigated with respect to disposal of dewatering effluent during construction of underground facilities. The quality of irrigation water at this park will need to be assessed when a new deeper bore has been drilled. Water extracted from the bore at Sydney Park should continue to be held in the receiving lake to provide oxidation prior to any further use of the water in the park. The lake, and waters extracted from the lake, should be monitored to ensure that the lake is providing the expected attenuation of contaminants.

Note that groundwater quality may change over time and one sample may not represent the water quality in previous or future periods. A larger number of samples are required for statistical confidence.

Thank you for the opportunity to undertake this assessment. Please do not hesitate to contact Alexandra Badenhop on ph. 9949 4488 ext. 274, or myself should you wish to discuss or clarify any matters.

Yours sincerely,

Brett Miller
Manager.

REFERENCES

ANZECC (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. National Water Quality Management Strategy.

Irwin, R.J. (1997). Environmental Contaminants Encyclopedia - Total Petroleum Hydrocarbons (TPH) Entry. US National Park Service, Water Resources Divisions, Water Operations Branch.

NHMRC (2004) *Australian Drinking Water Guidelines.* National Water Quality Management Strategy, Australian Government.

NHMRC (2006). *Guidelines for Managing Risks in Recreational Water.* Australian Government

Table 1:
Water quality results for groundwater compared with guidelines and limit of analysis.

Parameter	Units	Limit of Detection	Results of Test Epsom Rd Depot 27/03/07	Results of Test Sydney Park 27/03/07	Results of Test Redfern 1 28/03/07	Irrigation Water Guideline level*
EC @ 25°C	µS/cm		191	2027	307	< 950 for sensitive crops
pH			6.15	6.39	6.56	-
Temperature	°C		25.1	21.4	23.5	-
Dissolved Oxygen	mg/L		5.83[2]	2.8	1.72	-
Redox Potential (Eh_{NHE})	mV		162	132	166	
Thermotolerant (Faecal) coliforms	CFU/100 mL	1	<2	<2	430	<10000/100mL
Faecal streptococci[3]	orgs/100 mL	1	<2	<2	~40	≤40 enterococci/100 mL 95th percentile value#
Calcium - Filtered	mg/L	1	1	68	34	-
Magnesium - Filtered	mg/L	1	4	62	4	-
Sodium - Filtered	mg/L	1	25	266	24	<115 for sensitive crops
Potassium - Filtered	mg/L	1	4	34	11	-
Bicarbonate	mg/L		19	432	88	
Alkalinity as CaCO3	mg/L	1	19	432	88	-
Sulphate - Filtered	mg/L	1	10	276	31	-
Chloride	mg/L	1	41.5	348	37	<175 for sensitive crops
TDS	mg/L		109	1581	248	<2000#
Water Hardness as $CaCO_3$	mg/L		19	425	101	<500
Aluminium - Total	mg/L	0.01	0.08	0.08	18.1	5

[2] Given the reducing conditions and metals present in solution, the dissolved oxygen is likely to be much lower than that measured and may be an artefact of the high flow rate.
[3] Due to the means of enumerating streptococci, "in practice the terms faecal streptococci, enterococci, intestinal enterococci and *Enterococcus* group may refer to the same bacteria" (NHMRC, 2006). Intestinal enterococci are actually a subgroup of faecal streptococci.

Parameter	Units	Limit of Detection	Results of Test Epsom Rd Depot 27/03/07	Results of Test Sydney Park 27/03/07	Results of Test Redfern 1 28/03/07	Irrigation Water Guideline level*
Antimony - Total	mg/L	0.001	<0.001	<0.001	0.002	0.03
Arsenic - Total	mg/L	0.001	<0.001	0.008	0.005	0.07#
Barium - Total	mg/L	0.001	0.019	0.23	0.104	7#
Boron - Total	mg/L	0.01	<0.05	0.88	0.08	0.5
Cadmium - Total	mg/L	0.0001	<0.0001	<0.0001	0.0002	0.02#
Chromium - Total	mg/L	0.001	<0.001	<0.001	0.024	0.05#
Copper - Total	mg/L	0.001	0.027	0.005	0.052	0.2
Iron - Total	mg/L	0.1	4.24	47.4	20.8	0.2
Lead - Total	mg/L	0.001	<0.001	<0.001	0.235	0.1#
Lithium – Total	mg/L	0.001	<0.001	<0.001	0.004	0.075 for citrus
Manganese - Total	mg/L	0.001	0.02	0.491	0.086	0.2
Mercury - Total	mg/L	0.0001	<0.0001	<0.0001	0.0003	0.01#
Nickel - Total	mg/L	0.001	<0.001	0.006	0.104	0.2#
Selenium – Total	mg/L	0.01	<0.010	<0.010	<0.010	0.1#
Silver – Total	mg/L	0.001	<0.001	0.002	<0.001	0.05#
Zinc - Total	mg/L	0.005	0.128	0.27	0.27	2
Ammonia as N	mg/L	0.01	0.343	31.2	0.441	5 mg/L N
Nitrite as N	mg/L	0.01	0.013	0.011	0.157	-
Nitrate as N	mg/L	0.01	0.137	<0.010	1.36	
Nitrite and Nitrate as N	mg/L	0.01	0.15	0.019	1.52	5 mg/L N
Total Kjeldahl Nitrogen as N	mg/L	0.1	0.3	39.7	1.1	5 mg/L N
Total Nitrogen as N	mg/L	0.1	0.5	39.7	2.6	5 mg/L N
Total Phosphorus as P	mg/L	0.01	<0.01	<0.01	0.21	0.05

Parameter	Units	Limit of Detection	Results of Test Epsom Rd Depot 27/03/07	Results of Test Sydney Park 27/03/07	Results of Test Redfern 1 28/03/07	Irrigation Water Guideline level*
Total Polychlorinated biphenyls	ug/L	1	<1	<1	<1	
TOTAL PETROLEUM HYDROCARBONS (TPH)						-
C6 - C9 Fraction	µg/L	20	<20	<20	<20	
C10 - C14 Fraction	µg/L	50	<50	100	<50	
C15 - C28 Fraction	µg/L	100	<100	1000	1600	
C29 - C36 Fraction	µg/L	50	<50	440	70	

* Value given is the lower of the water quality required for the long term irrigation of crops on a site, and a health based guideline for recreational contact. Level only given where parameter was detected or where guideline exists. Health based guidelines for recreational contact indicated with #.

Human health guideline value for primary and secondary contact (NHMRC, 2006). These are 10 x the drinking water guideline values based on the assumption that 10% of daily water needs may be ingested during recreational contact. These guidelines replace the corresponding section in ANZECC (2000).

** In-situ value of dissolved oxygen likely to be lower. Aeration likely to have occurred during measurement process

When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insufficient sample amount for analysis. Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference.

The following compounds were not detected in any of the samples:

- Organochlorine Pesticides
- Organophosphorus Pesticides
- Triazine Pesticides
- Pyrethroid & Other Pesticides
- Phenoxyacetic Acid Herbicides
- BTEX
- Fumigants
- Halogenated Aliphatic Hydrocarbons(Vol)
- Halogenated Aromatic Hydrocarbons (Vol)
- Trihalomethanes (Volatiles)
- Phenols
- Polynuclear Aromatic Hydrocarbons
- Chlorinated Hydrocarbons

APPENDIX A:
DIPNR BORE ANALYSIS REQUIREMENTS

Department of
Infrastructure, Planning and Natural Resources

Recommended Bore Licence Minimum Analytical Suite

PARAMETERS	ANALYTES
Physical	alkalinity electrical conductivity (EC) pH redox potential (Eh) total dissolved solids (TDS) total hardness
Major anions and cations	sulphate chloride bicarbonate calcium magnesium sodium potassium
Inorganics and heavy metals	aluminium antimony arsenic barium boron cadmium chromium copper iron lead lithium manganese mercury nickel selenium silver zinc
Nutrients	ammonia nitrate total nitrogen total phosphorus
Microbiological	faecal coliforms faecal streptococci
Organic compounds	benzene, toluene, ethylbenzene, xylene (BTEX) semi-volatile chlorinated hydrocarbons volatile chlorinated hydrocarbons chlorinated aliphatics pesticides phenols polychlorinated biphenyls (PCBs) polycyclic aromatic hydrocarbons (PAHs) total petroleum hydrocarbons (TPH)

NOTE: All samples should be collected and transported in accordance with Australian Standards **AS/NZS 5667.1:1998 :** Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples and **AS/NZS 5667.11:1998 :** Water quality - Sampling - Guidance on sampling of groundwaters. Sample analysis should be undertaken by a National Association of Testing Authorities (NATA) accredited laboratory under appropriate Quality Assurance and Quality Control (QA/QC) protocols.

DISCLAIMER: The above list is broadly representative of known contamination within the Botany Sand Beds aquifer. Given the generalised nature of the list of analytical requirements, it may be necessary to expand the range of target species to reflect contaminant concerns in your area. It may be necessary to undertake more detailed analysis if any of the above screening tests indicate the presence of particular compounds. Advice on the addition of contaminants specific to your area should be sought from a suitably qualified and experienced environmental professional. All sampling procedures and results are to be clearly documented and reported.

File: Botany_Sand_Beds_Recommended_Analytical_Suite_2004-07.doc Issue date: 14 July 2004 Author: G.N. Russell

APPENDIX B:
ALS ANALYTICAL RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Client	: UNIVERSITY OF NSW	Laboratory	: Environmental Division Sydney	Page	: 1 of 11
Contact	: MS ALEXANDRA BADENHOP	Contact	: Victor Kedicioglu	Work Order	: ES0703970
Address	: WATER RESEARCH LABORATORY KING STREET MANLY VALE NSW AUSTRALIA 2093	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164		
E-mail	: alexandra@wrl.unsw.edu.au	E-mail	: Victor.Kedicioglu@alsenviro.com		
Telephone	: - Not provided -	Telephone	: 61-2-8784 8555		
Facsimile	: - Not provided -	Facsimile	: 61-2-8784 8500		
Project	: 07027	Quote number	: SY/124/06	Date received	: 28 Mar 2007
Order number	: - Not provided -			Date issued	: 5 Apr 2007
C-O-C number	: - Not provided -			No. of samples	- Received : 3
Site	: - Not provided -				Analysed : 3

ALSE - Excellence in Analytical Testing

NATA Accredited Laboratory 825

This document is issued in accordance with NATA's accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

This document has been electronically signed by those names that appear on this report and are the authorised signatories. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatory	Position	Department
Ankit Joshi		Inorganics - NATA 825 (10911 - Sydney)
Celine Conceicao	Spectroscopist	Inorganics - NATA 825 (10911 - Sydney)
Corey Williams		Inorganics - NATA 825 (10911 - Sydney)
Corey Williams		Organics - NATA 825 (10911 - Sydney)
Duyen Nguyen	Senior Microbiologist	Microbiology - NATA 825 (14913 - Sydney)
PHALAK INTHAKESONE	Organics Co-ordinator	Organics - NATA 825 (10911 - Sydney)
Sarah Millington	Senior Inorganic Chemist	Inorganics - NATA 825 (10911 - Sydney)

ALS Environmental

Comments

This report for the ALSE reference ES0703970 supersedes any previous reports with this reference. Results apply to the samples as submitted. All pages of this report have been checked and approved for release.

This report contains the following information:

- **Analytical Results for Samples Submitted**
- **Surrogate Recovery Data**

The analytical procedures used by ALS Environmental have been developed from established internationally-recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported herein. Reference methods from which ALSE methods are based are provided in parenthesis.

When moisture determination has been performed, results are reported on a dry weight basis. When a reported 'less than' result is higher than the LOR, this may be due to primary sample extracts/digestion dilution and/or insuffient sample amount for analysis. Surrogate Recovery Limits are static and based on USEPA SW846 or ALS-QWI/EN38 (in the absence of specified USEPA limits). Where LOR of reported result differ from standard LOR, this may be due to high moisture, reduced sample amount or matrix interference. When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for process purposes. Abbreviations: CAS number = Chemical Abstract Services number, LOR = Limit of Reporting. * Indicates failed Surrogate Recoveries.

Specific comments for Work Order **ES0703970**

It has been noted that Ammonia is greater than TKN (sample ID EPSOM RD), however this difference is within the limits of experimental variation.
Positive Hg confirmed by re-analysis
Microbiological analysis commenced on 28/03/2007.

ALS Environmental

Analytical Results

Analyte	CAS number	LOR	Units	Client Sample ID: EPSOM RD Sample Matrix Type / Description: WATER Sample Date / Time: 27 Mar 2007 15:00 Laboratory Sample ID: ES0703970-001	Client Sample ID: SYDNEY PARK Sample Matrix Type / Description: WATER Sample Date / Time: 27 Mar 2007 15:00 Laboratory Sample ID: ES0703970-002	Client Sample ID: REDFERN 1 Sample Matrix Type / Description: WATER Sample Date / Time: 28 Mar 2007 15:00 Laboratory Sample ID: ES0703970-003		
EA005: pH								
pH Value		0.01	pH Unit	6.06	6.31	6.41		
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1		
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1		
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	19	432	88		
Total Alkalinity as CaCO3		1	mg/L	19	432	88		
ED040F: Dissolved Major Anions								
Sulphate as SO4 2-	14808-79-8	1	mg/L	10	276	31		
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1.0	mg/L	41.5	348	37.0		
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	1	68	34		
Magnesium	7439-95-4	1	mg/L	4	62	4		
Sodium	7440-23-5	1	mg/L	25	266	24		
Potassium	7440-09-7	1	mg/L	4	34	11		
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.08	0.08	18.1		
Antimony	7440-36-0	0.001	mg/L	<0.001	<0.001	0.002		
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.008	0.005		
Barium	7440-39-3	0.001	mg/L	0.019	0.230	0.104		
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0002		
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.024		
Copper	7440-50-8	0.001	mg/L	0.027	0.005	0.052		
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.235		
Lithium	7439-93-2	0.001	mg/L	<0.001	<0.001	0.004		
Manganese	7439-96-5	0.001	mg/L	0.020	0.491	0.086		
Nickel	7440-02-0	0.001	mg/L	<0.001	0.006	0.104		
Selenium	7782-49-2	0.010	mg/L	<0.010	<0.010	<0.010		
Silver	7440-22-4	0.001	mg/L	<0.001	0.002	<0.001		
Zinc	7440-66-6	0.005	mg/L	0.128	0.270	0.270		
Boron	7440-42-8	0.05	mg/L	<0.05	0.88	0.08		
Iron	7439-89-6	0.05	mg/L	4.24	47.4	20.8		
EG035T: Total Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0003		
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.010	mg/L	0.343	31.2	0.441		

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EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N		0.010	mg/L	0.013	0.011	0.157		
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.010	mg/L	0.137	<0.010	1.36		
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N		0.010	mg/L	0.150	0.019	1.52		
EK061: Total Kjeldahl Nitrogen (TKN)								
Total Kjeldahl Nitrogen as N		0.1	mg/L	0.3	39.7	1.1		
EK062: Total Nitrogen as N								
Total Nitrogen as N		0.1	mg/L	0.5	39.7	2.6		
EK067G: Total Phosphorous-As P by Discrete Analyser								
Total Phosphorus as P		0.01	mg/L	<0.01	<0.01	0.21		
EN055: Ionic Balance								
Total Anions		0.01	meq/L	1.76	24.2	3.44		
Total Cations		0.01	meq/L	1.57	23.2	3.30		
Ionic Balance		0.01	%	----	2.19	1.99		
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls		1	µg/L	<1	<1	<1		
EP068A: Organochlorine Pesticides (OC)								
alpha-BHC	319-84-6	0.5	µg/L	<0.5	<0.5	<0.5		
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.5	<0.5	<0.5		
beta-BHC	319-85-7	0.5	µg/L	<0.5	<0.5	<0.5		
gamma-BHC	58-89-9	0.5	µg/L	<0.5	<0.5	<0.5		
delta-BHC	319-86-8	0.5	µg/L	<0.5	<0.5	<0.5		
Heptachlor	76-44-8	0.5	µg/L	<0.5	<0.5	<0.5		
Aldrin	309-00-2	0.5	µg/L	<0.5	<0.5	<0.5		
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.5	<0.5	<0.5		
trans-Chlordane	5103-74-2	0.5	µg/L	<0.5	<0.5	<0.5		
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.5	<0.5	<0.5		
cis-Chlordane	5103-71-9	0.5	µg/L	<0.5	<0.5	<0.5		
Dieldrin	60-57-1	0.5	µg/L	<0.5	<0.5	<0.5		
4.4'-DDE	72-55-9	0.5	µg/L	<0.5	<0.5	<0.5		
Endrin	72-20-8	0.5	µg/L	<0.5	<0.5	<0.5		
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.5	<0.5	<0.5		
4.4'-DDD	72-54-8	0.5	µg/L	<0.5	<0.5	<0.5		
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.5	<0.5	<0.5		
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.5	<0.5	<0.5		
4.4'-DDT	50-29-3	2	µg/L	<2	<2	<2		

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Analyte	CAS number	LOR	Units	Client Sample ID : EPSOM RD Sample Matrix Type / Description : WATER Sample Date / Time : 27 Mar 2007 15:00 Laboratory Sample ID : ES0703970-001	Client Sample ID : SYDNEY PARK Sample Matrix Type / Description : WATER Sample Date / Time : 27 Mar 2007 15:00 Laboratory Sample ID : ES0703970-002	Client Sample ID : REDFERN 1 Sample Matrix Type / Description : WATER Sample Date / Time : 28 Mar 2007 15:00 Laboratory Sample ID : ES0703970-003		
EP068A: Organochlorine Pesticides (OC)								
Endrin ketone	53494-70-5	0.5	µg/L	<0.5	<0.5	<0.5		
Methoxychlor	72-43-5	2	µg/L	<2	<2	<2		
Endosulfan (sum)	115-29-7	0.5	µg/L	<0.5	<0.5	<0.5		
Total Chlordane (sum)		0.5	µg/L	<0.5	<0.5	<0.5		
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	<0.5	<0.5	<0.5		
Demeton-S-methyl	919-86-8	0.5	µg/L	<0.5	<0.5	<0.5		
Monocrotophos	6923-22-4	2	µg/L	<2	<2	<2		
Dimethoate	60-51-5	0.5	µg/L	<0.5	<0.5	<0.5		
Diazinon	333-41-5	0.5	µg/L	<0.5	<0.5	<0.5		
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	<0.5	<0.5	<0.5		
Parathion-methyl	298-00-0	2	µg/L	<2	<2	<2		
Malathion	121-75-5	0.5	µg/L	<0.5	<0.5	<0.5		
Fenthion	55-38-9	0.5	µg/L	<0.5	<0.5	<0.5		
Chlorpyrifos	2921-88-2	0.5	µg/L	<0.5	<0.5	<0.5		
Parathion	56-38-2	2	µg/L	<2	<2	<2		
Pirimphos-ethyl	23505-41-1	0.5	µg/L	<0.5	<0.5	<0.5		
Chlorfenvinphos	470-90-6	0.5	µg/L	<0.5	<0.5	<0.5		
Bromophos-ethyl	4824-78-6	0.5	µg/L	<0.5	<0.5	<0.5		
Fenamiphos	22224-92-6	0.5	µg/L	<0.5	<0.5	<0.5		
Prothiofos	34643-46-4	0.5	µg/L	<0.5	<0.5	<0.5		
Ethion	563-12-2	0.5	µg/L	<0.5	<0.5	<0.5		
Carbophenothion	786-19-6	0.5	µg/L	<0.5	<0.5	<0.5		
Azinphos Methyl	86-50-0	0.5	µg/L	<0.5	<0.5	<0.5		
EP068C: Triazines								
Atrazine	1912-24-9	0.5	µg/L	<0.5	<0.5	<0.5		
Simazine	122-34-9	0.5	µg/L	<0.5	<0.5	<0.5		
EP068D: Pyrethroid Pesticides								
Cypermethrins(total)	52315-07-8	2	µg/L	<2	<2	<2		
EP068E: Other Pesticides								
Methoprene	40596-69-8	0.5	µg/L	<0.5	<0.5	<0.5		
Toxaphene	8001-35-2	0.5	µg/L	<0.5	<0.5	<0.5		
EP074D: Fumigants								
2.2-Dichloropropane	594-20-7	5	µg/L	<5	<5	<5		
1.2-Dichloropropane	78-87-5	5	µg/L	<5	<5	<5		
cis-1.3-Dichloropropylene	10061-01-5	5	µg/L	<5	<5	<5		
trans-1.3-Dichloropropylene	10061-02-6	5	µg/L	<5	<5	<5		

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Analytical Results

				Client Sample ID :	EPSOM RD	SYDNEY PARK	REDFERN 1		
				Sample Matrix Type / Description :	WATER	WATER	WATER		
				Sample Date / Time :	27 Mar 2007 15:00	27 Mar 2007 15:00	28 Mar 2007 15:00		
				Laboratory Sample ID :					
Analyte	*CAS number*	*LOR*	*Units*		ES0703970-001	ES0703970-002	ES0703970-003		
EP074D: Fumigants									
1.2-Dibromoethane (EDB)	106-93-4	5	µg/L		<5	<5	<5		
EP074E: Halogenated Aliphatic Compounds									
Dichlorodifluoromethane	75-71-8	50	µg/L		<50	<50	<50		
Chloromethane	74-87-3	50	µg/L		<50	<50	<50		
Vinyl chloride	75-01-4	50	µg/L		<50	<50	<50		
Bromomethane	74-83-9	50	µg/L		<50	<50	<50		
Chloroethane	75-00-3	50	µg/L		<50	<50	<50		
Trichlorofluoromethane	75-69-4	50	µg/L		<50	<50	<50		
1.1-Dichloroethene	75-35-4	5	µg/L		<5	<5	<5		
Iodomethane	74-88-4	5	µg/L		<5	<5	<5		
trans-1.2-Dichloroethene	156-60-5	5	µg/L		<5	<5	<5		
1.1-Dichloroethane	75-34-3	5	µg/L		<5	<5	<5		
cis-1.2-Dichloroethene	156-59-2	5	µg/L		<5	<5	<5		
1.1.1-Trichloroethane	71-55-6	5	µg/L		<5	<5	<5		
1.1-Dichloropropylene	563-58-6	5	µg/L		<5	<5	<5		
Carbon Tetrachloride	56-23-5	5	µg/L		<5	<5	<5		
1.2-Dichloroethane	107-06-2	5	µg/L		<5	<5	<5		
Trichloroethene	79-01-6	5	µg/L		<5	<5	<5		
Dibromomethane	74-95-3	5	µg/L		<5	<5	<5		
1.1.2-Trichloroethane	79-00-5	5	µg/L		<5	<5	<5		
1.3-Dichloropropane	142-28-9	5	µg/L		<5	<5	<5		
Tetrachloroethene	127-18-4	5	µg/L		<5	<5	<5		
1.1.1.2-Tetrachloroethane	630-20-6	5	µg/L		<5	<5	<5		
trans-1.4-Dichloro-2-butene	110-57-6	5	µg/L		<5	<5	<5		
cis-1.4-Dichloro-2-butene	1476-11-5	5	µg/L		<5	<5	<5		
1.1.2.2-Tetrachloroethane	79-34-5	5	µg/L		<5	<5	<5		
1.2.3-Trichloropropane	96-18-4	5	µg/L		<5	<5	<5		
Pentachloroethane	76-01-7	5	µg/L		<5	<5	<5		
1.2-Dibromo-3-chloropropane	96-12-8	5	µg/L		<5	<5	<5		
Hexachlorobutadiene	87-68-3	5	µg/L		<5	<5	<5		
EP074F: Halogenated Aromatic Compounds									
Chlorobenzene	108-90-7	5	µg/L		<5	<5	<5		
Bromobenzene	108-86-1	5	µg/L		<5	<5	<5		
2-Chlorotoluene	95-49-8	5	µg/L		<5	<5	<5		
4-Chlorotoluene	106-43-4	5	µg/L		<5	<5	<5		
1.3-Dichlorobenzene	541-73-1	5	µg/L		<5	<5	<5		
1.4-Dichlorobenzene	106-46-7	5	µg/L		<5	<5	<5		

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Analytical Results

	Client Sample ID :	EPSOM RD	SYDNEY PARK	REDFERN 1		
	Sample Matrix Type / Description :	WATER	WATER	WATER		
	Sample Date / Time :	27 Mar 2007 15:00	27 Mar 2007 15:00	28 Mar 2007 15:00		
	Laboratory Sample ID :	ES0703970-001	ES0703970-002	ES0703970-003		
Analyte	CAS number	LOR	Units			
EP074F: Halogenated Aromatic Compounds						
1.2-Dichlorobenzene	95-50-1	5	µg/L	<5	<5	<5
1.2.4-Trichlorobenzene	120-82-1	5	µg/L	<5	<5	<5
1.2.3-Trichlorobenzene	87-61-6	5	µg/L	<5	<5	<5
EP074G: Trihalomethanes						
Chloroform	67-66-3	5	µg/L	<5	<5	<5
Bromodichloromethane	75-27-4	5	µg/L	<5	<5	<5
Dibromochloromethane	124-48-1	5	µg/L	<5	<5	<5
Bromoform	75-25-2	5	µg/L	<5	<5	<5
EP075(SIM)A: Phenolic Compounds						
Phenol	108-95-2	1.0	µg/L	<1.0	<1.0	<1.0
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	<1.0	<1.0
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	<1.0	<1.0
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	<2.0	<2.0
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	<1.0	<1.0
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	<1.0	<1.0
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	<1.0	<1.0
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	<1.0	<1.0
4-Chloro-3-Methylphenol	59-50-7	1.0	µg/L	<1.0	<1.0	<1.0
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	<1.0	<1.0
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	<1.0	<1.0
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	<2.0	<2.0
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons						
Naphthalene	91-20-3	1.0	µg/L	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L	<1.0	<1.0	<1.0
Benzo(b)fluoranthene	205-99-2	1.0	µg/L	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	<1.0	<1.0

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EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	<1.0	<1.0		
EP075G: Chlorinated Hydrocarbons								
1.4-Dichlorobenzene	106-46-7	2	µg/L	<2	<2	<2		
1.3-Dichlorobenzene	541-73-1	2	µg/L	<2	<2	<2		
1.2-Dichlorobenzene	95-50-1	2	µg/L	<2	<2	<2		
Hexachloroethane	67-72-1	2	µg/L	<2	<2	<2		
1.2.4-Trichlorobenzene	120-82-1	2	µg/L	<2	<2	<2		
Hexachloropropylene	1888-71-7	2	µg/L	<2	<2	<2		
Hexachlorobutadiene	87-68-3	2	µg/L	<2	<2	<2		
Hexachlorocyclopentadiene	77-47-4	10	µg/L	<10	<10	<10		
Pentachlorobenzene	608-93-5	2	µg/L	<2	<2	<2		
Hexachlorobenzene (HCB)	118-74-1	4	µg/L	<4	<4	<4		
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction		20	µg/L	<20	<20	<20		
C10 - C14 Fraction		50	µg/L	<50	100	<50		
C15 - C28 Fraction		100	µg/L	<100	1000	1600		
C29 - C36 Fraction		50	µg/L	<50	440	70		
EP080: BTEX								
Benzene	71-43-2	1	µg/L	<1	<1	<1		
Toluene	108-88-3	2	µg/L	<2	<2	<2		
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2		
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2		
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2		
EP202A: Phenoxyacetic Acid Herbicides by LCMS								
4-Chlorophenoxy acetic acid	122-88-3	10	µg/L	<10	<10	<10		
2.4-DB	94-82-6	10	µg/L	<10	<10	<10		
Dicamba	1918-00-9	10	µg/L	<10	<10	<10		
Mecoprop	93-65-2	10	µg/L	<10	<10	<10		
MCPA	94-74-6	10	µg/L	<10	<10	<10		
2.4-DP	120-36-5	10	µg/L	<10	<10	<10		
2.4-D	94-75-7	10	µg/L	<10	<10	<10		
Triclopyr	55335-06-3	10	µg/L	<10	<10	<10		
2.4.5-TP (Silvex)	93-72-1	10	µg/L	<10	<10	<10		
2.4.5-T	93-76-5	10	µg/L	<10	<10	<10		
MCPB	94-81-5	10	µg/L	<10	<10	<10		
Picloram	1918-02-1	10	µg/L	<10	<10	<10		

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Analyte	CAS number	LOR	Units	Client Sample ID: EPSOM RD Sample Matrix Type / Description: WATER Sample Date / Time: 27 Mar 2007 15:00 Laboratory Sample ID: ES0703970-001	Client Sample ID: SYDNEY PARK Sample Matrix Type / Description: WATER Sample Date / Time: 27 Mar 2007 15:00 Laboratory Sample ID: ES0703970-002	Client Sample ID: REDFERN 1 Sample Matrix Type / Description: WATER Sample Date / Time: 28 Mar 2007 15:00 Laboratory Sample ID: ES0703970-003		
EP202A: Phenoxyacetic Acid Herbicides by LCMS								
Clopyralid	1702-17-6	10	µg/L	<10	<10	<10		
Fluroxypyr	69377-81-7	10	µg/L	<10	<10	<10		
2.6-D	575-90-6	10	µg/L	<10	<10	<10		
2.4.6-T	575-89-3	10	µg/L	<10	<10	<10		
MW006: Faecal Coliforms & E.coli by MF								
Faecal Coliforms		1	CFU/100mL	<2	<2	430		
MW013: Faecal Streptococci by MF								
Faecal Streptococci		1	orgs/100mL	<2	<2	~40		
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	100	126	93.5		
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	117	93.7	104		
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	115	98.5	104		
EP074S: VOC Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	112	118	109		
Toluene-D8	2037-26-5	0.1	%	96.5	97.4	92.4		
4-Bromofluorobenzene	460-00-4	0.1	%	91.2	91.4	86.0		
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	54.9	43.9	33.8		
2-Chlorophenol-D4	93951-73-6	0.1	%	122	105	101		
2.4.6-Tribromophenol	118-79-6	0.1	%	106	105	93.6		
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	99.0	111	111		
Anthracene-d10	1719-06-8	0.1	%	131	104	127		
4-Terphenyl-d14	1718-51-0	0.1	%	135	120	129		
EP075S: Acid Extractable Surrogates								
2-Fluorophenol	367-12-4	0.1	%	84.2	67.4	67.9		
Phenol-d6	13127-88-3	0.1	%	60.2	Not Determined	42.0		
2-Chlorophenol-D4	93951-73-6	0.1	%	111	108	102		
2.4.6-Tribromophenol	118-79-6	0.1	%	103	101	123		
EP075T: Base/Neutral Extractable Surrogates								
Nitrobenzene-D5	4165-60-0	0.1	%	113	112	102		
1.2-Dichlorobenzene-D4	2199-69-1	0.1	%	101	97.3	89.2		
2-Fluorobiphenyl	321-60-8	0.1	%	115	113	105		
Anthracene-d10	1719-06-8	0.1	%	114	89.3	98.2		

ALS Environmental

Analytical Results

				Client Sample ID :	EPSOM RD	SYDNEY PARK	REDFERN 1		
				Sample Matrix Type / Description :	WATER	WATER	WATER		
				Sample Date / Time :	27 Mar 2007 15:00	27 Mar 2007 15:00	28 Mar 2007 15:00		
				Laboratory Sample ID :					
Analyte	*CAS number*	*LOR*	*Units*		ES0703970-001	ES0703970-002	ES0703970-003		
EP075T: Base/Neutral Extractable Surrogates									
4-Terphenyl-d14	1718-51-0	0.1	%		113	116	98.6		
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		112	118	109		
Toluene-D8	2037-26-5	0.1	%		96.5	97.4	92.4		
4-Bromofluorobenzene	460-00-4	0.1	%		91.2	91.4	86.0		
EP202S: Phenoxyacetic Acid Herbicide Surrogate									
2.4-Dichlorophenyl Acetic Acid	19719-28-9	0.1	%		103	82.0	110		

ALS Environmental

Surrogate Control Limits

Matrix Type: WATER - Surrogate Control Limits ***Surrogate Control Limits***

Method name	*Analyte name*	*Lower Limit*	*Upper Limit*
EP066: Polychlorinated Biphenyls (PCB)			
EP066S: PCB Surrogate	Decachlorobiphenyl	10	164
EP068: Pesticides			
EP068S: Organochlorine Pesticide Surrogate	Dibromo-DDE	10	136
EP068T: Organophosphorus Pesticide Surrogate	DEF	10	136
EP074: Volatile Organic Compounds			
EP074S: VOC Surrogates	1,2-Dichloroethane-D4	80	120
	Toluene-D8	88	110
	4-Bromofluorobenzene	86	115
EP075: Semivolatile Organic Compounds			
EP075S: Acid Extractable Surrogates	2-Fluorophenol	21	100
	Phenol-d6	10	94
	2-Chlorophenol-D4	23	134
	2,4,6-Tribromophenol	10	123
EP075T: Base/Neutral Extractable Surrogates	Nitrobenzene-D5	35	114
	1,2-Dichlorobenzene-D4	32	129
	2-Fluorobiphenyl	43	116
	Anthracene-d10	27	133
	4-Terphenyl-d14	33	141
EP075(SIM): PAH/Phenols (GC/MS - SIM)			
EP075(SIM)S: Phenolic Compound Surrogates	Phenol-d6	10	94
	2-Chlorophenol-D4	23	134
	2,4,6-Tribromophenol	10	123
EP075(SIM)T: PAH Surrogates	2-Fluorobiphenyl	43	116
	Anthracene-d10	27	133
	4-Terphenyl-d14	33	141
EP080: TPH Volatiles/BTEX			
EP080S: TPH(V)/BTEX Surrogates	1,2-Dichloroethane-D4	80	120
	Toluene-D8	88	110
	4-Bromofluorobenzene	86	115
EP202-SL: Phenoxyacetic Acid Herbicides (LCMS - Standard DL)			
EP202S: Phenoxyacetic Acid Herbicide Surrogate	2.4-Dichlorophenyl Acetic Acid	50.5	155

APPENDIX C
DIPNR RECOMMENDED BORE LICENCE MINIMUM ANALYTICAL SUITE FOR THE BOTANY SAND AQUIFER

Department of
Infrastructure, Planning and Natural Resources

Recommended Bore Licence Minimum Analytical Suite

PARAMETERS	ANALYTES
Physical	alkalinity electrical conductivity (EC) pH redox potential (Eh) total dissolved solids (TDS) total hardness
Major anions and cations	sulphate chloride bicarbonate calcium magnesium sodium potassium
Inorganics and heavy metals	aluminium antimony arsenic barium boron cadmium chromium copper iron lead lithium manganese mercury nickel selenium silver zinc
Nutrients	ammonia nitrate total nitrogen total phosphorus
Microbiological	faecal coliforms faecal streptococci
Organic compounds	benzene, toluene, ethylbenzene, xylene (BTEX) semi-volatile chlorinated hydrocarbons volatile chlorinated hydrocarbons chlorinated aliphatics pesticides phenols polychlorinated biphenyls (PCBs) polycyclic aromatic hydrocarbons (PAHs) total petroleum hydrocarbons (TPH)

NOTE: All samples should be collected and transported in accordance with Australian Standards **AS/NZS 5667.1:1998 :** Water quality - Sampling - Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples and **AS/NZS 5667.11:1998 :** Water quality - Sampling - Guidance on sampling of groundwaters. Sample analysis should be undertaken by a National Association of Testing Authorities (NATA) accredited laboratory under appropriate Quality Assurance and Quality Control (QA/QC) protocols.

DISCLAIMER: The above list is broadly representative of known contamination within the Botany Sand Beds aquifer. Given the generalised nature of the list of analytical requirements, it may be necessary to expand the range of target species to reflect contaminant concerns in your area. It may be necessary to undertake more detailed analysis if any of the above screening tests indicate the presence of particular compounds. Advice on the addition of contaminants specific to your area should be sought from a suitably qualified and experienced environmental professional. All sampling procedures and results are to be clearly documented and reported.

APPENDIX D
DWE MONITORING BORE LICENSES FOR NEW INSTALLATIONS

Department of Water and Energy

Sydney South Coast Region
P O Box 3720
) Valentine Ave
Parramatta NSW 2124
Phone: (02) 98957814

BORE LICENSE CERTIFICATE
UNDER SECTION 115 OF THE WATER ACT, 1912

10BL601773

New South Wales Government

City Of Sydney Council
C/- Water Research Laboratory
Uni Of N S W, King Street
Manly Vale NSW 2043

LICENSE NUMBER
10BL601773
DATE LICENSE VALID FROM
17-May-2007
DATE LICENSE VALID TO
PERPETUITY
FEE
$0.00

ABN 27380445450 GST NIL

LOCATION OF WORKS

Portion(s) or Lot/Section/DP	PARISH	COUNTY
2//850686	Alexandria	Cumberland

TYPE OF WORKS	PURPOSE(S) FOR WHICH WATER MAY BE USED
Bore	Monitoring Bore

CONDITIONS APPLYING TO THIS LICENSE ARE

As shown on the attached Condition Statement

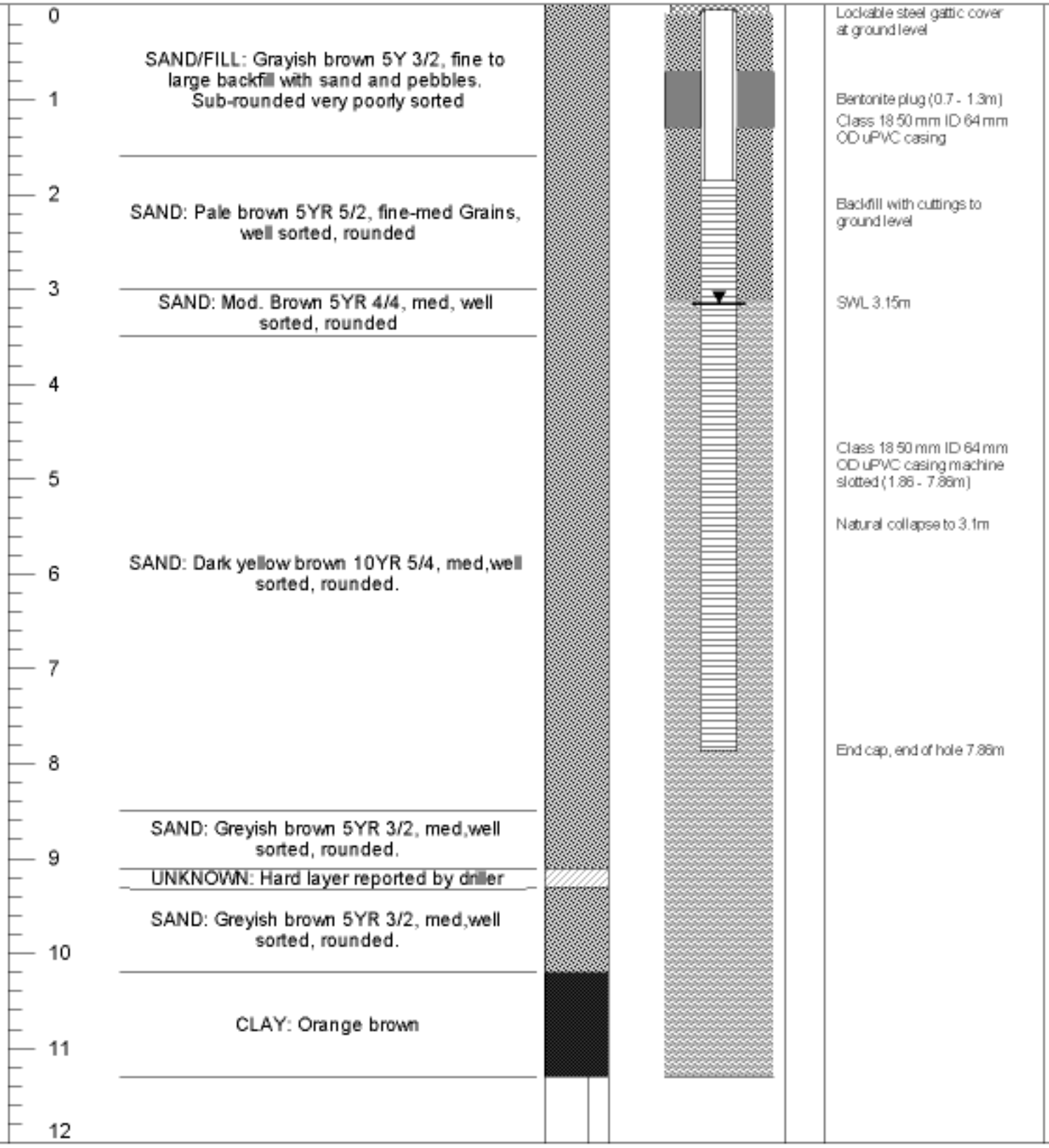
ORIGINAL

APPENDIX E
MONITORING BORE LOGS

University of New South Wales
School of Civil & Environmental Engineering
Water Research Laboratory

Project: 07014 Joynton Ave
Hole No. MW1S
Driller: Nealings Drililng
Method of Drilling: Hollow Auger

Date: 04/06/07
Logged By: I. Cunningham
Drill Hole Diameter: 200 mm

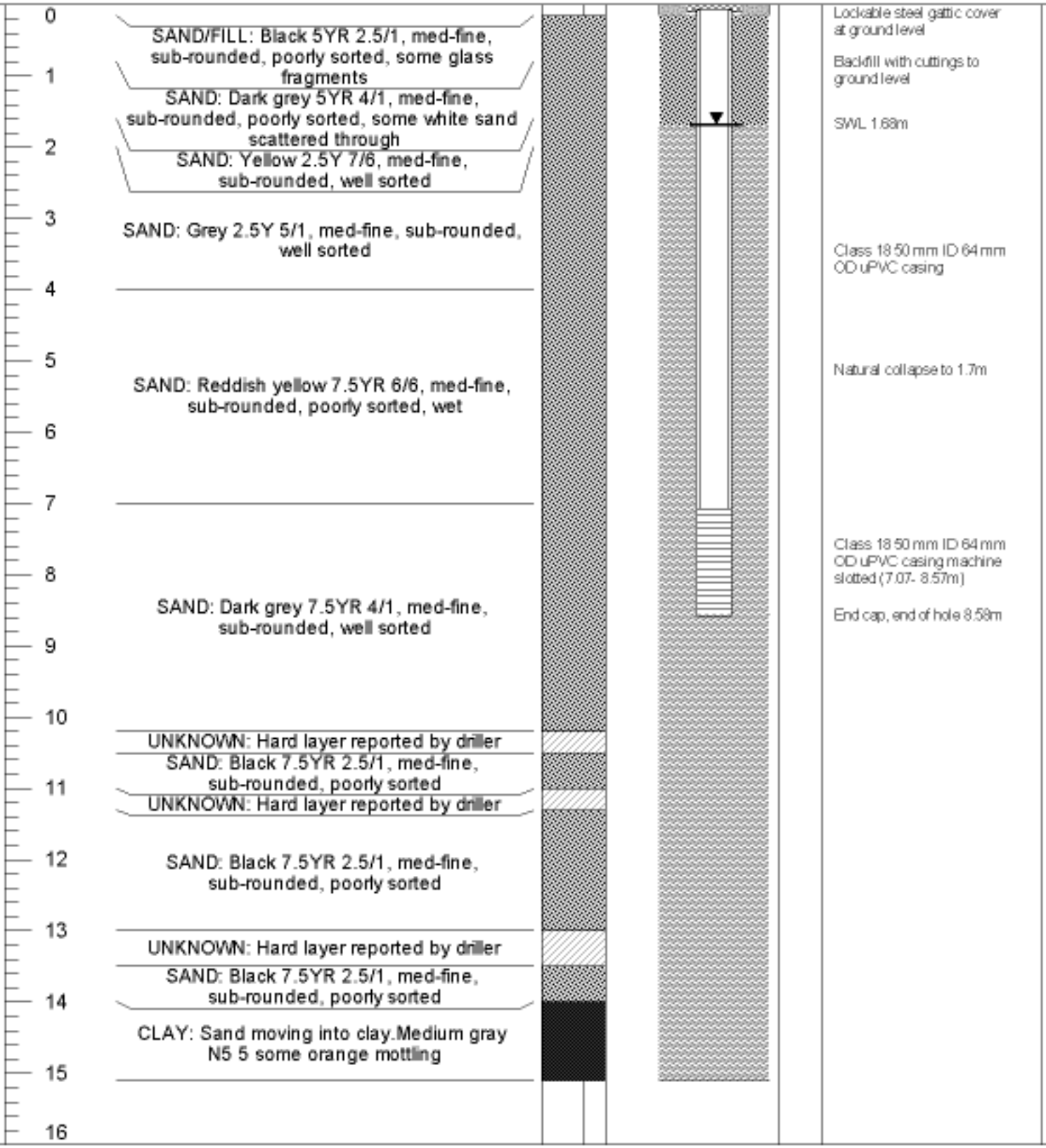


University of New South Wales
School of Civil & Environmental Engineering

Water Research Laboratory

Project: 07014 Joynton Ave
Hole No. MW2S
Driller: Nealings Drililng
Method of Drilling: Hollow Auger

Date: 04/06/07
Logged By: I. Cunningham
Drill Hole Diameter: 200 mm

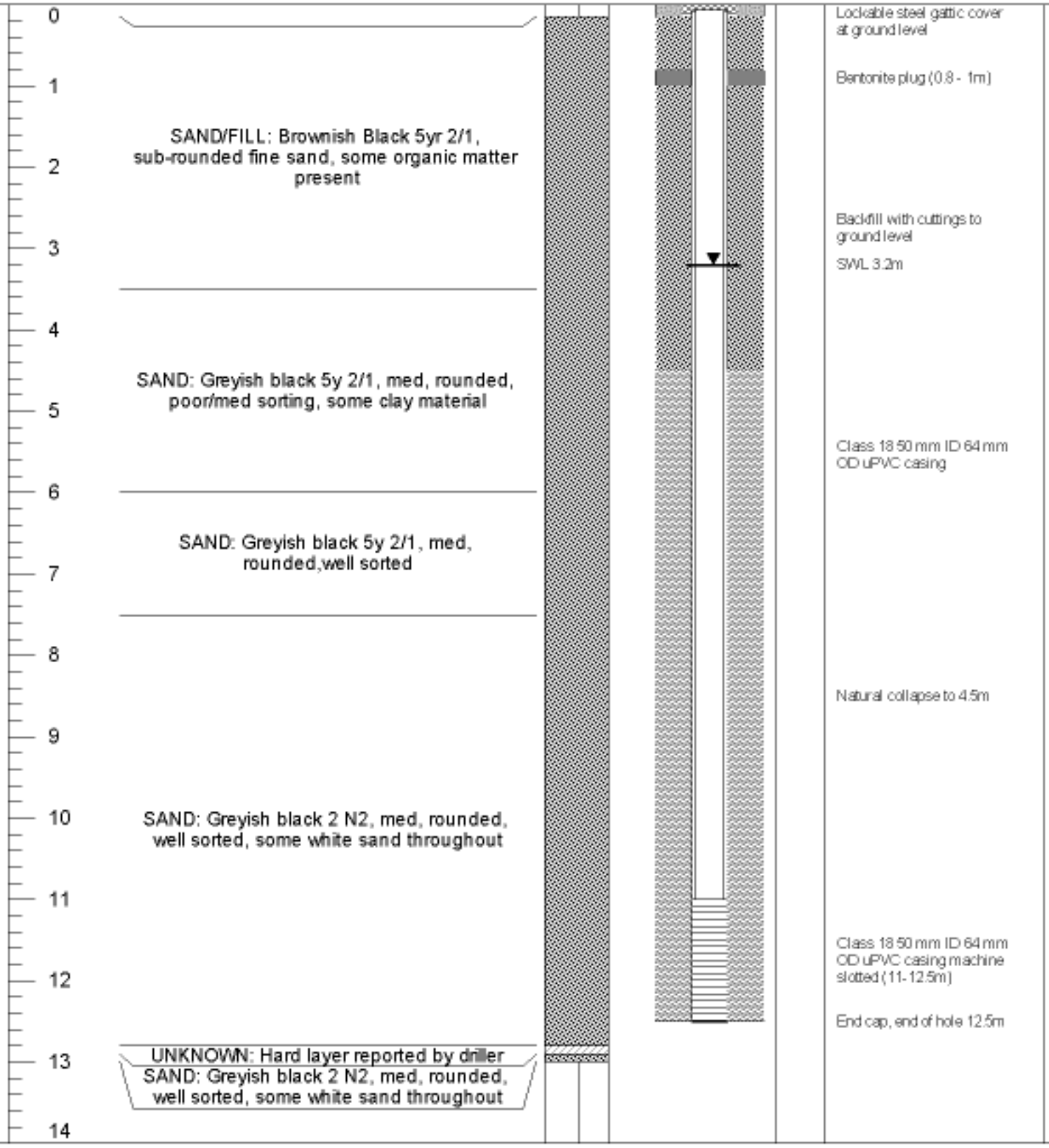


University of New South Wales
School of Civil & Environmental Engineering

Water Research Laboratory

Project: 07014 Joynton Ave
Hole No. MW3D
Driller: Nealings Drililng
Method of Drilling: Hollow Auger

Date: 05/06/07
Logged By: I. Cunningham
Drill Hole Diameter: 200 mm

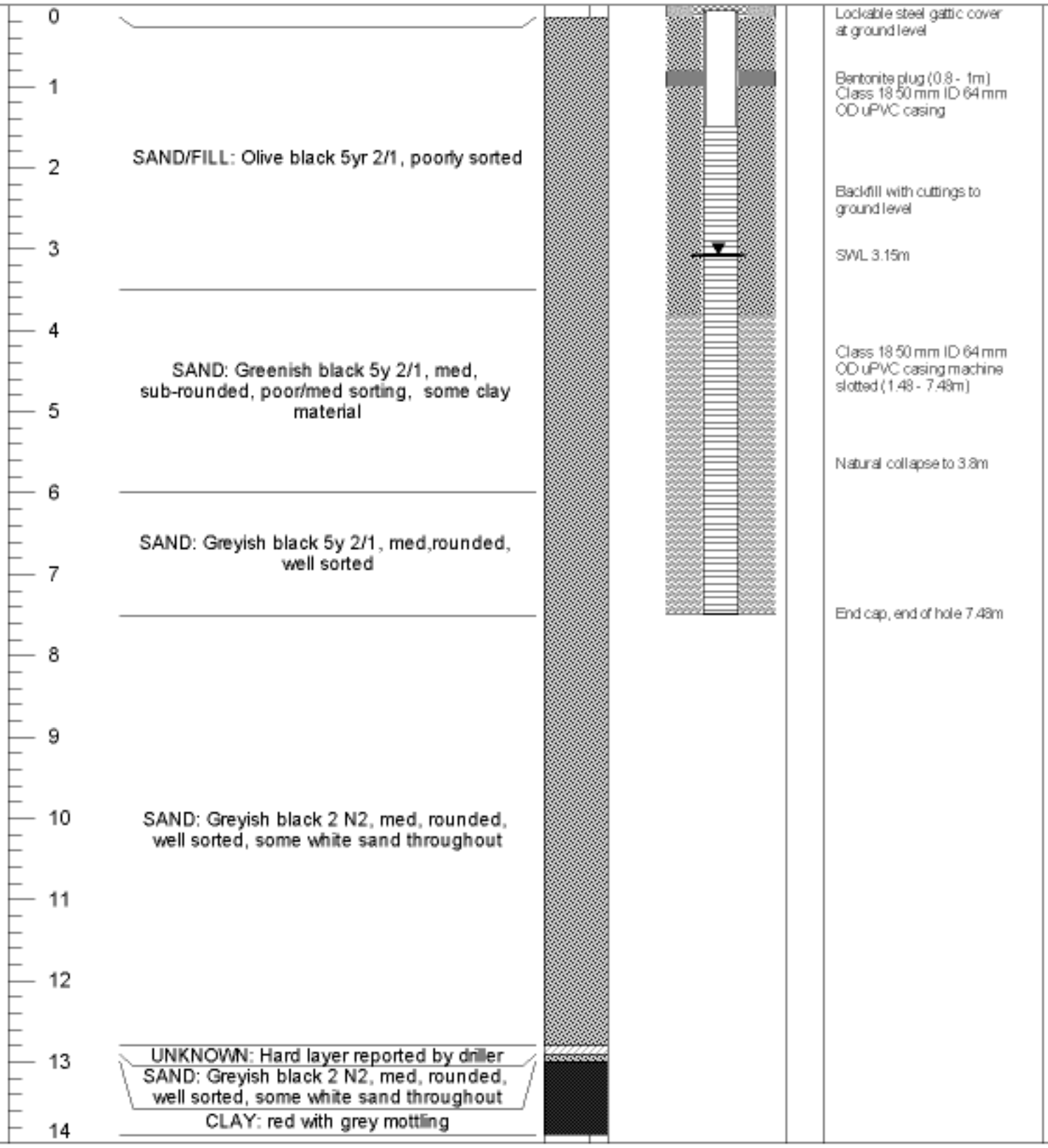


University of New South Wales
School of Civil & Environmental Engineering

Water Research Laboratory

Project: 07014 Joynton Ave
Hole No. MW3S
Driller: Nealings Drililng
Method of Drilling: Hollow Auger

Date: 05/06/07
Logged By: I. Cunningham
Drill Hole Diameter: 200 mm

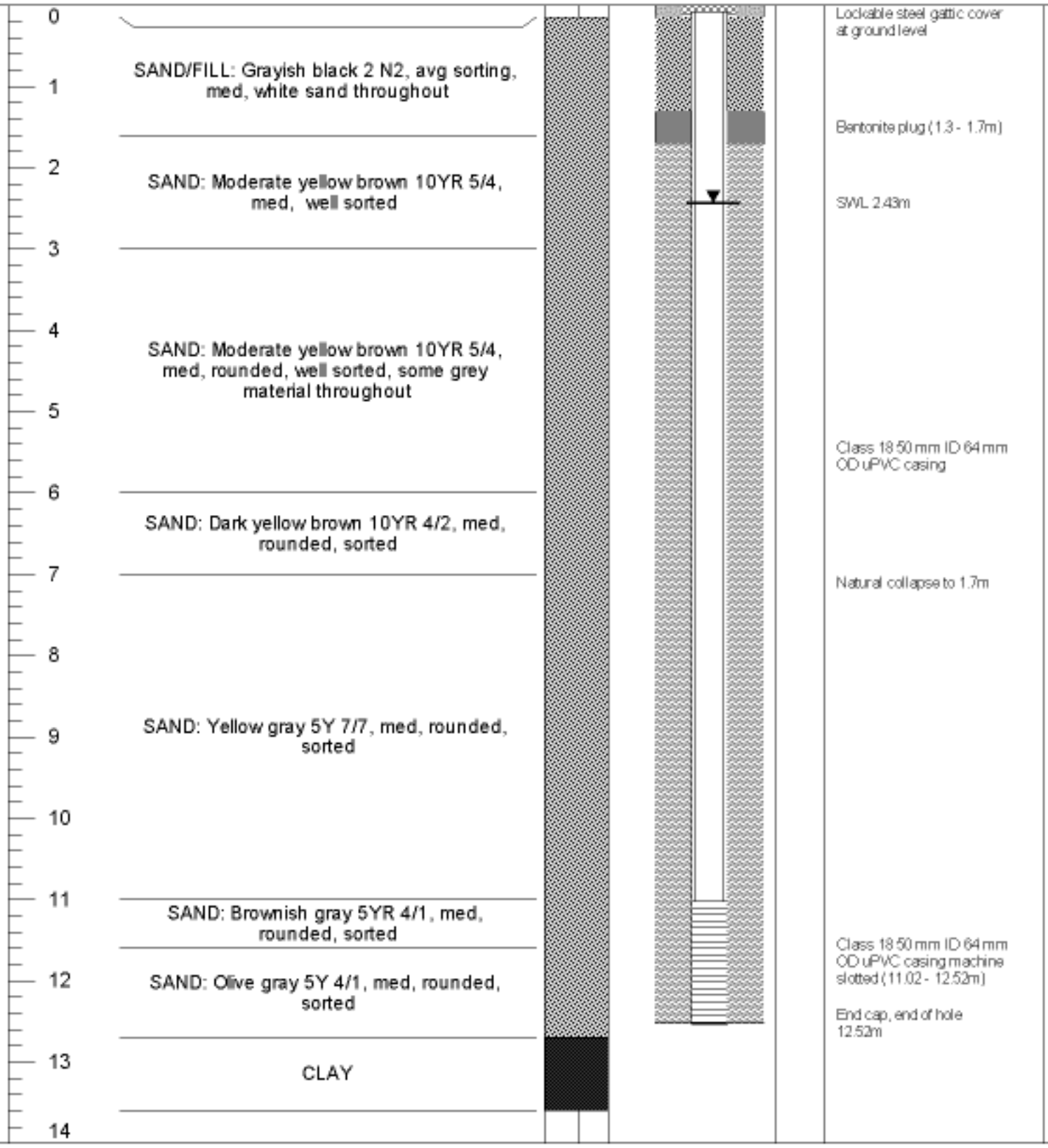


University of New South Wales
School of Civil & Environmental Engineering

Water Research Laboratory

Project: 07014 Joynton Ave
Hole No. MW4D
Driller: Nealings Drililng
Method of Drilling: Hollow Auger

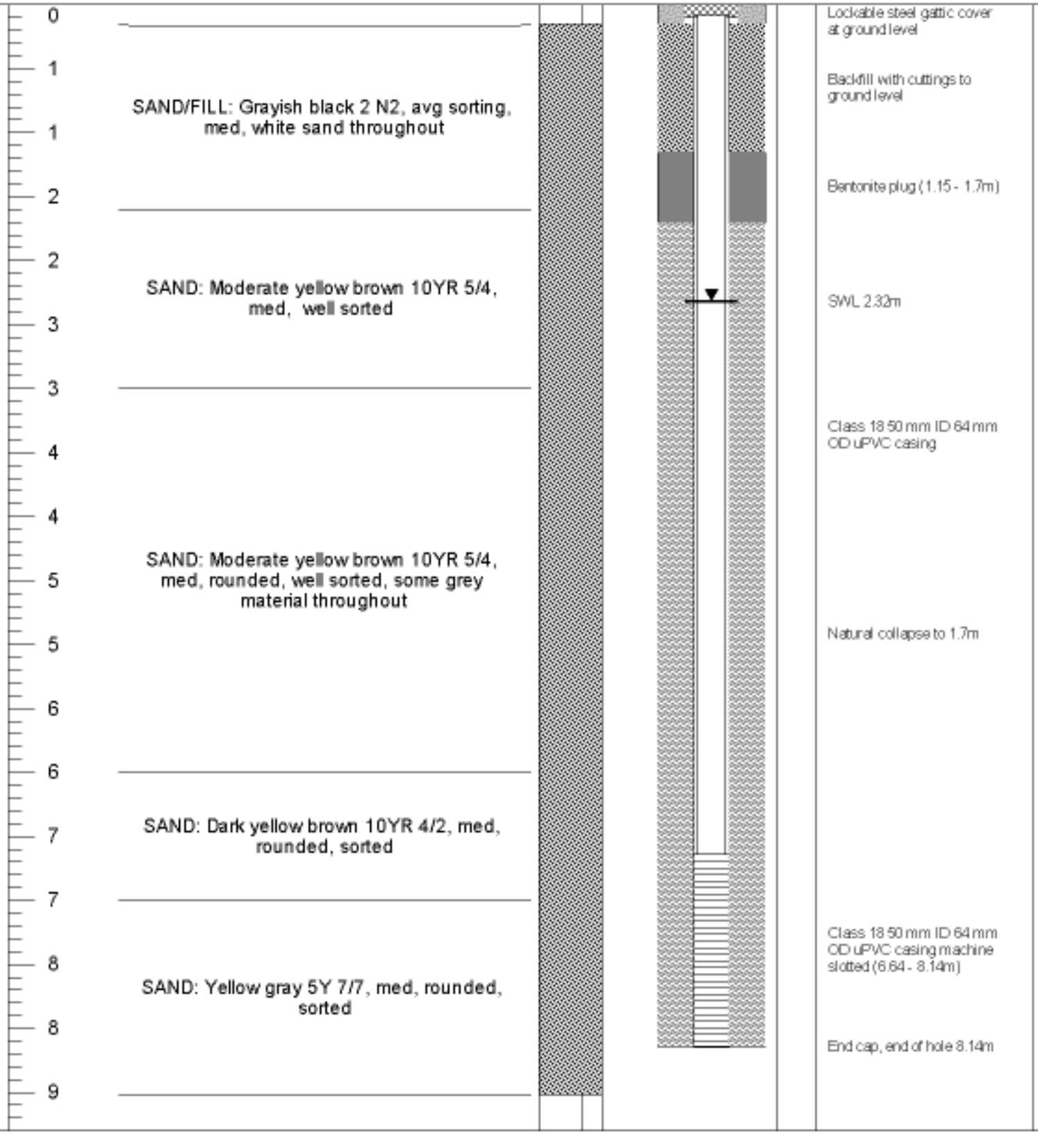
Date: 06/06/07
Logged By: I. Cunningham
Drill Hole Diameter: 200 mm



University of New South Wales
School of Civil & Environmental Engineering
Water Research Laboratory

Project: 07014 Joynton Ave
Hole No. MW4S
Driller: Nealings Drililng
Method of Drilling: Hollow Auger

Date: 06/06/07
Logged By: I. Cunningham
Drill Hole Diameter: 200 mm



APPENDIX F
RECORD OF BORE DEVELOPMENT

APPENDIX F - Record of Bore Development

The Joynton Avenue bores were developed on Wednesday 11/7/07 with a 130 CFM air compressor. MW3S and MW3D were not able to be accessed as the key supplied did not fit the padlocks on the gates. It is recommended that either an air compressor is hired again or the Bennet pump be used when next on site to develop this site prior to sampling.

Outline of development is below:

ID	Description	Duration	Observations
MW1S	Site near substation	1 hour	Water was initially a very dirty yellow sandy colour. This cleaned up slightly though remained very discoloured. Water removed from this bore was slightly less than others. When the compressor was turned off for a minute then reblown the water started off very dirty but would become cleaner with time. This cycle was repeated number of times. Approximately 300L was removed.
MW2S	Site leased by Energy Austraila	45 mins	Water was discoloured and dirty brown. When the compressor was turned off for a minute then reblown the water started off very dirty but would become cleaner with time. This cycle was repeated. Approximately 400L was removed.
MW3S	Site leased by various businesses	-	Unable to access
MW3D	"	-	Unable to access
MW4S	City of Sydney workshop area	1 hour	Water was initially a very dirty yellow sandy colour. This cleaned up slightly though remained very discoloured. When the compressor was turned off for a minute then reblown the water started off very dirty but would become cleaner with time. This cycle was repeated number of times. Approximately 400L was removed.
MW4D	"	1 hour	Water was initially a very dirty brown colour. This cleaned up slightly though remained very discoloured. When the compressor was turned off for a minute then reblown the water started off very dirty but would become cleaner with time. This cycle was repeated number of times. Approximately 400L was removed.
Existing Bore	"	45 minutes	Very sandy though ~100L water was recovered after initially blowing 5-10L of sand out.

It appears the water in the aquifer is very discoloured. There was no obvious coarse particles in the water. It is recommended that a coarser filter is used initially for any measurement of field filtered metals to speed up the sampling process.