APPENDIX 8
LOCAL WATER MANAGEMENT STRATEGY

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DETERMINE • DESIGN • DELIVER



MUNDIJONG PRECINCT E2

Local Water Management Strategy

Peet Limited

Rev B – February 2013

engineering project management environment

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Project Brief

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1 INTRODUCTION

1.1 Background

Peet Limited has engaged Wave International to prepare a local water management strategy (LWMS) for a 55ha landholding within the Mundijong/Whitby District Structure Plan area. The site is approximately 40km south-east of the Perth CBD, and 2km south/west of the Mundijong Town Centre.

The Mundijong/Whitby District Structure Plan (DSP) was adopted by the Shire of Serpentine Jarrahdale (SJ Shire) in August 2011 to control the development of over 1400ha of mostly rural land within the SJ Shire for urban development.

This LWMS will address water management issues over the proposed local structure plan (LSP) area, which forms sub-precinct E2 of the Mundijong/Whitby DSP area. The LSP area (the site) covers Lot 50 Cockram St and Lot 119 Sparkman Road, and is expected to yield approximately 500 residential lots and a primary school when fully developed. The site is located on Mundijong Road, and is bounded by Mundijong Road, Adams Road, Sparkman Road and the future Tonkin Highway reserve. The location of the site in relation to surrounding areas is shown in Figure 1.1, while the proposed LSP layout is included as Figure 1.2.

The site has historically been used for stock grazing and is almost entirely cleared, with natural surface levels falling from east to west across the site at a grade of approximately 0.8%. Existing ground levels range from 30mAHD along the eastern boundary to 26mAHD in the west, and soil conditions generally comprise sand of varying depths overlying the clays of the Guildford formation.

Lot 50 Cockram Street falls within the area covered by the Mundijong Whitby DSP District Water Management Strategy (DWMS), which was prepared by GHD in 2010.The DWMS addresses broad-scale stormwater management measures over an 1800ha area which extends from the future Tonkin Highway reserve to South Western Highway.

The DWMS identified two drainage flow paths which cross the site from east to west, although both are very shallow and not well-defined. These drainage paths convey flow from a small catchment to the east of Precinct E2 across the site towards a drainage reserve immediately west of the future Tonkin Highway reserve. Section 2.5 details the pre-development surface water conditions across the LSP area.

1.2 Proposed development

The Mundijong/Whitby DSP was produced to guide urban development over previously rural land across Mundijong & Whitby, which was broken down into seven precincts (Precincts A-G). An amendment to the DSP in April 2012 further delineated two of the precincts (E & G) into sub-precincts (E1, E2 and G1, G2). An LSP has been prepared to address the proposed development of Sub-precinct E2, and this LWMS is a key supporting document of the LSP.

The development of the LSP area is expected to yield approximately 500 residential lots, with a primary school and associated sporting oval on the eastern side of the site.

1.3 Design principles and objectives

The DWMS set out several design principles and objectives for water conservation, stormwater management and groundwater management within the Mundijong/Whitby DSP area. These design objectives and criteria are summarised in the table below:

Table 1.1 - DWMS design objectives

Category	Design objectives	Strategies	Design criteria
Protection of environmental assets	• Minimise changes to hydrology to prevent impacts on watercourses & wetlands • Manage & restore watercourses & wetlands • Assess & manage impacts on native flora & fauna • Assess & manage impacts on sites of indigenous significance		
Urban water use	• Ensure the efficient use of all water resources in the newly-developing urban form & aim to achieve highest value use for fit-for-purpose water. • Maintain opportunities for future generations by using water more	Potable water: • Adopt drinking water targets. • Use only water efficient fixtures & fittings. • Ensure that landscaping & irrigation use water	• Consumption target of 100 kL/person/year (40-60 kL/person/year of scheme water). • Meet 5-star Plus provisions for all new dwellings. • Promote the use of native plants. All parts of POS except turfed areas are to contain only native plants. Alternative non-local plants may be considered where passive solar exposure is required. • The use on on-site rainwater tanks is to be promoted to achieve water

Category	Design objectives	Strategies	Design criteria
	efficiently. This is best achieved by combining several approaches such as raising community awareness, regulation, market mechanisms to facilitate recognition of the true value of water and financial incentives/ assistance to facilitate change.	efficiently. Fit-for-purpose water: • Ensure that non-potable water supply systems deliver a net benefit to the community. • Ensure that non-potable water supply systems are designed as part of an integrated water supply.	consumption targets whilst also having the ability to fully or partially meet on-site retention requirements.
Stormwater management	• Protection of wetlands & waterways from the impacts of urban runoff. • Protection of infrastructure and assets from flooding and inundation.	• Minimise changes in hydrology to prevent impacts on receiving environments: • 1yr1hr ARI post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions at subcatchment outlets. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles	• Retain 1yr 1hr ARI event at-source via soakage or storage devices. • Post-development critical 1yr peak flow and volume & 100yr ARI peak flow to be consistent with pre-development flows at the discharge point from all subdivisions, at discharge points from each structure plan & at discharge points from each subcatchment. • Flows from developed areas to be attenuated via flood detention storage areas incorporated into POS and located outside defined floodways. • Post-development flows for all ARI events to be discharged at flow rates which are consistent with pre-development flow rates for those same events. • Floodways shown in DWMS Figure A11 are not to be developed or obstructed in any way.

Category	Design objectives	Strategies	Design criteria
		as approved by the DoW. • Implement BMPs that promote on-site retention of events up to 1yr 1hr ARI. • Manage surface water flows from major events to protect infrastructure an assets. • Uphold environmental values of downstream waterways within and surrounding the study area.	• Development outside the floodway should ensure finished flood levels are a minimum of 0.5m above the 100yr ARI flood level in streamlines and basins, and 0.3m above the 100yr ARI flood level for other drainage paths (eg road reserves). • Existing cross-sectional areas of waterways to be maintained. • POS and retention basins should operate as dry basins with minimum 0.3m separation between invert and CGL. • Defined major arterial roads to remain passable in the 100yr ARI storm event. • Minor roads to remain passable in the 5yr ARI event • Emergency evacuation areas to be at least 2m above 100yr ARI flood level. • Water quality treatment systems and WSUD structures to be designed in accordance with the Stormwater Management Manual and Australian Runoff Quality.
Surface water quality	• Uphold environmental values of downstream waterways within and surrounding the study area.		• Non-structural measures to reduce applied nutrient loads. • On-site retention of 1yr 1hr ARI event. • Use of bioretention structures. • The following water quality targets are to be achieved as compared to a development that does not actively manage water quality: • 80% reduction in TSS

Category	Design objectives	Strategies	Design criteria
			• 60% reduction in TP • 45% reduction in TN • 70% reduction in gross pollutants. • If no water quality modelling is done, the following are to be achieved: • Retain 1yr 1hr ARI event from connected impervious areas at-source. • Maintain critical pre-development 1yr ARI peak flows and volumes. • Size bioretention systems to be 2% of connected impervious area. • Soil amendment should include a 300mm deep layer of material to reduce nutrient export (PRI>10) across at least 10% of the site including all landscaped POS and drainage structures. • Swales and bioretention/infiltration systems to have sufficient clearance from groundwater to ensure that they do not remain permanently wet.
Groundwater management	• Protect infrastructure & assets from flooding by high seasonal groundwater levels, perching and/or soil moisture. Protection of groundwater dependent ecosystems from the impacts of urban runoff.	• Manage groundwater levels to protect infrastructure & assets. • Maintain groundwater regimes for the protection of groundwater dependent ecosystems.	• Where a perched water table exists or the predicted maximum groundwater level is within 1.2m of natural surface, clean fill and/or subsoil drainage is required to ensure adequate separation to finished levels. Subsoil drains to be installed at or above approved CGL. • Bioretention system & drainage inverts to be at or above approved CGL, although existing inverts below this level may remain.

Category	Design objectives	Strategies	Design criteria

	• Managing & minimising changes in groundwater level & groundwater quality following development/redevelopment.	• Manage the shallow aquifer to protect the value of groundwater resources.	• Subsoil drains to be at or above CGL.
			• Subsoil drains to have free-draining outlets.
			• Finished lot levels to be at least 0.8m above the phreatic line (ie the mounding between parallel subsoil drains).
			• Clean fill imported on the site for WSUD elements is to incorporate a band of material that will reduce phosphorous export via soil leaching, whilst also meeting soil permeability & soil compaction criteria specified by the local government authority.
			• Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted (as compared to a site that does not actively manage water quality):
			  • 60% reduction in TP
			  • 45% reduction in TN.
			• Where development is associated with an ecosystem that is dependent of a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of the DEC.

2 PRE-DEVELOPMENT ENVIRONMENT

The subject area is 55ha in area and is well located, at the intersection of Mundijong Road and the future Tonkin Highway extension. The following sections include information on existing (pre-development) site conditions and summaries of the various studies and site investigations that have been completed to support this LWMS and LSP.

The site is almost entirely cleared, except for a few scattered trees and an area of vegetation in the north-western corner of the site. A house and farm buildings are located on Lot 119, in the north-eastern corner of the precinct. Figure 2.1 shows a recent aerial photo of the LSP site and surrounding area.

2.1 Topography

The site is relatively flat, sloping at a grade of approximately 0.5% from east to west. Levels fall from 30mAHD along the eastern end of the site to 26mAHD along the site's western boundary. Existing surface contours are shown in Figure 2.1.

2.2 Geotechnical conditions and acid sulfate soils

A geotechnical site investigation was carried out by Galt Geotechnics in 2011, which found that soil conditions across the site generally comprised Clayey Sand (SC), Sand (SP) and Ferricrete Gravel (GC). The site stratigraphy is quite variable both laterally and vertically. The average depth of the sand layer is 0.9m at the north-western region of the study area, increasing to 1.8m in the southern boundary of the study area. Figure 2.2 shows the test pit locations and contours of the underlying clay levels, while Figure 2.3 shows the depth from natural surface to the underlying clays. A copy of the bore logs from the geotechnical investigation is included as Appendix A.

A review of the Department of Environment & Conservation's (DEC) risk mapping for acid sulfate soils (ASS) showed that the entire site is classified as "Class 2 – Moderate to low risk of ASS occurring within 3m of natural surface". According to the Galt Geotechnics report, there is low likelihood of actual ASS or potential ASS at the site, based on the field testing that was carried out during the geotechnical investigation.

2.3 Wetlands and Bush Forever sites

The majority of the site is classified as a Multiple Use Wetland (MUW) under the Department of Environment & Conservation's Geomorphic Wetland mapping dataset (UFI 15785 – Palusplain Multiple Use). The Mundijong Road reserve along the southern boundary is classified as a Conservation Category Wetland (CCW) (UFI 14817 – Palusplain Conservation) and a Bush Forever site (Bush Forever site 360). Wetland mapping for the LSP area is included in Figure 2.4.

2.4 Groundwater

Groundwater flows from east to west across the region, generally following the topography. The Perth Groundwater Atlas (DoW, online) shows a snapshot of groundwater levels as measured in May 2003 (which are an indication of low groundwater levels); showing groundwater levels at the site ranging from 27mAHD in the east to 23mAHD in the west.

2.4.1 Pre-development groundwater levels

Site-specific groundwater monitoring was carried out by Brown Geotechnical & Environmental and Emerson Stewart between September 2008 and August 2011 to gain an understanding of pre-development groundwater levels and water quality across the LSP area. The monitoring showed that groundwater levels were at their highest in September 2009, when depth to groundwater ranged from at-surface to 700mm below natural surface.

Groundwater across this area tends to perch on the underlying clayey soils, causing large fluctuations of up to 2.5m between high and low groundwater levels. In areas of the site where the depth to the underlying clay materials is low, typical peak groundwater levels are very shallow (within 100mm of existing surface). Parts of the site with a greater depth of sand over the underlying clays have a slightly larger natural separation between existing surface and peak groundwater levels (up to 800mm).

A comparison of the pre-development monitoring data to nearby long-term DoW monitoring bores showed that the maximum groundwater levels measured in September 2009 were close to the long-term (25-year) average maximum levels. Using the long-term DoW data, the site groundwater levels have been calibrated to estimate a typical winter perched water level (refer Appendix B). Figure 2.5 shows the groundwater monitoring bore locations and the pre-development perched water level contours, and Figure 2.6 shows the depth from natural surface to typical winter water levels.

A combination of fill and subsoil drainage will be required in the areas where groundwater is close to the natural surface – Section 4 contains details of how groundwater will be managed across the proposed development.

DWMS groundwater modelling

The Mundjiong Whitby DWMS (GHD, 2010) included details of groundwater modelling completed over the entire district structure plan area. Figure A.8 of the DWMS shows that GHD's estimated groundwater levels fall from 32-33mAHD at the eastern edge of Precinct E2 to 27mAHD at the western edge of Precinct E2. These modelled levels are several metres above existing surface level, and are not considered to be an accurate representation of actual groundwater behaviour at this site.

The groundwater design criteria outlined in this LWMS has been determined for Precinct E2 based on the site-specific groundwater monitoring data described above.

2.4.2 Pre-development groundwater quality

Groundwater quality monitoring at the site was assessed on a quarterly basis by Brown Geotechnical & Environmental and Emerson Stewart between September 2008 and August 2011 using 6 bores distributed across the study site. Bore locations are shown in Figure 2.5. Samples were analysed for physical parameters and nutrients. A summary of average groundwater quality results is shown in Table 2.1 below.

Table 2.1 - Average pre-development water quality

	pH (Field)	EC (field)	Dissolved Oxygen	Phosphorus	Total Nitrogen	Ammonium	Iron
		uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Guideline values	6.5 - 8	1200 - 3000		0.07	1.2	0.08	
MB01	5.7	741	0.9	0.69	3.71	0.14	20.8
MB02	5.9	642	0.6	0.29	1.56	0.12	7.1
MB03	6.1	1697	0.8	0.34	2.10	0.43	45.1
MB04	6.3	8657	0.8	0.03	9.84	0.62	8.3
MB05	6.5	876	1.0	0.03	11.91	0.28	6.4
MB06	6.4	4245	1.6	0.18	21.64	0.09	24.2
Mean	6.2	2810	0.95	0.26	8.46	0.28	18.65
Count	6	6	6	6	6	6	6
Std Dev	0.31	3169	0.35	0.25	7.72	0.21	15.0

The range of the Phosphorous concentration values across the northern half of study site is between 0.03 mg/L at MB04 & MB05 and a high of 0.69 mg/L at MB01. Phosphorous concentrations across the site are generally low and within guideline values.

The Nitrogen (Total) (TN) has a mean value of 8.46 mg/L and a min/max range of 20 mg/L which indicates significant difference in values across the study site. The highest concentrations were observed around the south-east bore locations of MB06. The samples taken on 17 September 2009 and 14 December 2009 showed particularly high concentrations of Total Nitrogen, but the samples taken in all other monitoring events was similar to the other bores across the site.

Average pH values are around 6, which indicates that overall the site does not represent significant risk to down-gradient ecosystems.

Results of the groundwater quality monitoring are contained in Appendix B

2.5 Surface water

Surface runoff from the site is via overland flow from east to west, following the natural topography. There are some very shallow farm drains (approx 0.2 - 0.5m deep) across the site, which direct stormwater runoff towards the western side of the site. The main flow path through the site becomes more pronounced near the site's western border, and this existing waterway discharges to a Water Corporation main drain at Kargotich Road, approximately 1.5km west of the site.

Another Water Corporation main drain is present along the southern side of Mundijong Road. This drain also flows towards the west, but runoff from Precinct E2 doesn't fall within the catchment of this drain, with the exception of a small area to the east of the site, which flows across the south-eastern corner of Lot 50.

The Mundijong-Whitby DWMS (GHD, 2010) identified two flow paths which take runoff from upstream catchments east of Adams St through the site. The DWMS estimated the combined flow through the Precinct E2 site from upstream catchments to be approximately $12m^3/s$ under pre-development conditions (for the critical 100yr ARI event). 2-dimensional pre-development surface water model of the surrounding catchment was developed to confirm the estimated flow rates and flow paths outlined in the DWMS. The results of this modelling are outlined in Section 2.5.1 below.

2.5.1 Pre-development surface water modelling

Surface runoff from a 390ha catchment discharges through Lot 50 Cockram Street and Lot 7 Adams Street. Due to the relatively flat nature of the site and very shallow existing drains, there is significant interaction between flow paths throughout the catchment which makes the calculation of pre-development flow rates particularly complex.

A 2-dimensional surface water model was developed using XP Storm's 2D module, which has the ability to model floodplains and areas with poorly-defined flow paths with greater accuracy than a traditional 1-dimensional model. The model was developed to clarify pre-development flow rates from the overall catchment and to better delineate the flow paths through the catchment, as the existing drains are very shallow and not well defined. The extent of the upstream catchment was determined using LiDAR topographical data obtained from the Department of Water, and was generally consistent with the catchments shown in the Mundijong/Whitby DWMS.

The 2D modelling showed that pre-development flows entering Precincts E1 & E2 are concentrated into four main flow paths:

- Lot 9003 Adam St, between Kiernan St and Tonkin St
- Lot 7 Adams St, north of Livesey St
- Lot 119 Sparkman Rd, near Richardson St
- Lot 50 Cockram St, between Mundijong Road and Cockram St.

Figure 2.7 shows the extent of the upstream surface water catchment, and the main flow paths and peak pre-development flow rates from the overall catchment, while the parameters used in the 2D modelling are detailed in Appendix C. Table 2.2 below summarises the pre-development flow rates at critical locations across the catchment for the peak 5-year and 100-year ARI events.

Table 2.2 - Peak pre-development runoff rates

Flow location	5yr ARI peak flow	100yr ARI peak flow
A Lot 9003 Adams St - near Tonkin St	1.2 m^3/s	2.9 m^3/s
B Lot 7 Adams St - near Livesey St	0.8 m^3/s	1.9 m^3/s
C Lot 7 Adams St	1.8 m^3/s	4.6 m^3/s
D1 Lot 50 Cockram St - at Sparkman Rd	1.2 m^3/s	2.1 m^3/s
D2 Lot 50 Cockram St - south of Sparkman Rd	1.1 m^3/s	3.3 m^3/s
E1 Lot 119 Sparkman Rd - north-western corner	0.5 m^3/s	1.4 m^3/s
E2 Lot 119 Sparkman Rd - south-western corner	1.5 m^3/s	3.2 m^3/s
F Lot 50 Cockram St – western boundary (main drainage outlet)	3.6 m^3/s	7.2 m^3/s
G1 Lot 50 Cockram St – eastern boundary, between Mundijong Rd & Cockram St	1.0 m^3/s	2.5 m^3/s
G2 Lot 50 Cockram St – south-eastern corner, near Mundijong Rd	0.4 m^3/s	0.9 m^3/s
H Lot 50 Cockram St – south-western corner	0.5 m^3/s	1.8 m^3/s

The pre-development modelling results show the runoff that is generated within the Precinct E2 catchment, and these flow rates will be the allowable post-development flow rates from the development of the LSP area. Basins within the POS areas will be sized to attenuate post-development flows to these pre-development levels (to be determined for each subcatchment on a pro-rata area basis).

Table 2.3 - Allowable flow rates from Precinct E2

	5yr ARI peak flow	100yr ARI peak flow
Peak allowable flow rate from Precinct E2	1.0 m^3/s	2.1 m^3/s

3 WATER CONSERVATION

The DWMS identified two key objectives for water use and conservation in the Mundijong/Whitby DSP area:

- Ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use of fit-for-purpose water.
- Maintain opportunities for future generations by using water more efficiently.

This development will be designed to minimise potable water use, and to ensure fit-for-purpose water use. "Fit-for-purpose" refers to the use of water that is of a suitable quality for the intended use. The use of high-quality drinking water for garden irrigation, for example, is not a fit-for-purpose use and lower-quality water (e.g. rainwater, groundwater etc) would be more suitable for this purpose.

The DWMS identified the following design criteria that should be considered for developments within the DSP area to achieve the water use objectives.

- Achieve a water consumption target of 100kL/person/year, of which only 40-60kL/person/year should be from potable water.
- Meet the State Government's '5-Star Plus' provisions for all new dwellings.
- Promote the use of native plants throughout the development. Non-turfed areas in POS to contain only native plants.
- Promote the use of on-site rainwater tanks to achieve water consumption targets.

Future urban water management plans (UWMPs) for the precinct will outline the specific water conservation measures that will be taken to ensure that the consumption targets are achieved.

3.1 Potable water supply

Potable water will be supplied from the Water Corporation's reticulated water supply.

The total water consumption target of 100kL/person/year is generally achieved through the use of waterwise fittings and appliances inside the house, along with planting water efficient gardens with minimal lawn areas and native, low-water-use plants. Future UWMPs will include a detailed water consumption estimate to show that the development can achieve the water consumption targets.

To achieve the potable water consumption target of 40-60kL/person/year, all water use outside the house (i.e. outdoor taps and irrigation) would need to be from non-potable sources like groundwater, rainwater or recycled water.

Appendix C contains an estimate of water consumption for the LSP area, based on the current estimate densities and approximate lot yield.

3.1.1 Water efficient appliances

Potable water use will be minimised throughout the LSP area by ensuring that new dwellings install water efficient appliances and fittings that comply with the State Government's 5 Star Plus program.

The requirements of the 5 Star Plus program have been incorporated into the Building Code of Australia to ensure that all new houses install water and energy efficient hot water systems, taps and toilets, and swimming pool covers.

In addition to these regulatory requirements, the developer will encourage lot purchasers to install water efficient appliances (e.g. washing machines) to further reduce potable water use.

3.2 Non-potable water supply

An important part of water sustainability is fit-for-purpose water use, or the use of alternative water sources for applications where drinking-quality water is not necessary (e.g. toilet flushing, garden watering).

The State Water Plan (Government of Western Australia, 2007) identified a potable water consumption target of 40-60 kL/person/year. This target can only by achieved if all outdoor water use is supplied by non-potable sources, and the widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A reticulated non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The Shire of Serpentine Jarrahdale is investigating potential alternative water sources that could be used for a third-pipe scheme throughout the greater Mundijong area. The developer will continue to liaise with the Shire as the development process continues, with a view to implementing a reticulated third-pipe system should an alternative water source be available at the time of development. The road reserves within the development are wide enough to accommodate a third pipe network within the verges, should an alternative water source be available at the time of subdivision.

3.2.1 POS irrigation

Public open space is expected to be irrigated using groundwater from the superficial aquifer. The site falls within the Serpentine Groundwater Area, and the Byford 3 Groundwater Subarea. According to the Department of Water (September 2012), there is water available in the superficial aquifer, and a groundwater licence application is currently being assessed by the DoW with the licence expected to be issued in March 2013.

The groundwater licence application is for approximately 44 kL/yr, to irrigate 5.6 ha of POS and streetscapes. The primary school site has not been included in the application, and the DET will be responsible to secure a groundwater allocation for the primary school area. When the groundwater licence is approved, exploratory drilling will be undertaken to determine the possible yield in the proposed bore locations.

4 GROUNDWATER MANAGEMENT

4.1 Groundwater levels & subsoil drainage

The design of the development will need to achieve sufficient separation between finished lot levels and post-development perched groundwater levels. This will be achieved via a combination of subsoil drainage and imported sand fill.

Existing groundwater levels are shallow, with some seasonal inundation occurring in low-lying areas of the site. During winter months, groundwater perches on the underlying clays, with the maximum measured water levels (in September 2009) within 0.8m of existing ground level. Water levels in late 2009 were representative of typical winter peak levels, and a calculation of typical winter perched water levels is included in Section 2.4.1.

The DWMS proposed controlled groundwater levels (CGLs) across the entire DSP area; however the levels shown are several metres above existing ground level in Precinct E2, and as such are not considered to be applicable to this LSP area.

We propose that the following criteria should apply to setting a localised CGL for Precinct E2 – which would set the minimum level for subsoil drainage or open drainage inverts:

- In areas near groundwater dependant ecosystems (eg CCWs), CGL should be equivalent to the pre-development perched winter water levels. The design of the subsoil drainage system will need to show that no drawdown of pre-development perched water levels will occur within wetlands or their buffers.
- In all other areas, the level of the underlying clay material will dictate minimum drainage and subsoil drainage invert levels. Some localised shaping of the clay may be undertaken, to ensure ponding of perched water in localised low points is avoided. Open drains and bioretention areas should be designed to ensure that baseflow during winter months is contained within defined areas that will be planted with sedges and appropriate plant species.
- Subsoil drainage invert levels at the outfall locations should be at least 0.6m above the invert of the closest open drain, to ensure sufficient separation above baseflow levels. Subsoil drains should discharge to bioretention treatment areas.

4.1.1 Subsoil drainage network

A combination of imported sand fill and subsoil drainage will be used to ensure adequate separation between finished lot levels and perched water levels, and to alleviate the perching of infiltrated rainwater on the impermeable clay soils & ferricrete across the site. Finished lot levels are to be a minimum of 1.5m above subsoil drainage inverts, or 1.8m above the underlying clay surface – whichever is higher.

Minimum subsoil drainage levels will be dictated by several factors – the level of the clay & ferricrete material present across the site; the invert level of the open drainage swales at subsoil outfall locations; and in the upstream reaches of the subsoil drainage network the invert levels will be governed by minimum pipe grades.

The underlying clay & ferricrete material will be shaped towards the proposed open drains through POS corridors in localised areas, with the invert of the open drains to be no lower than the graded clay surface. Subsoil drains will be installed to alleviate the perching of infiltrated rainfall that occurs during winter months, with outfalls to be at least 0.6m above open drain inverts to ensure sufficient freeboard above winter baseflow levels. Subsoil drainage inverts must be above the clay surface in all locations to allow the drains to operate effectively.

The detailed design of the subsoil drainage network will need to ensure that subsoil drains at the southern end of the site, near Mundijong Road, will be at or above typical pre-development perched water levels, to ensure that water levels in the CCW along Mundijong Road are not affected by the development.

4.2 Groundwater quality

Groundwater quality will primarily be managed through the landscaping design, with the design to include plants that required low fertiliser use to reduce the amount of nutrients leaching into the groundwater. A similar approach will be taken with the landscaping packages offered to residents, which will include information on minimising fertiliser use.

The perched groundwater that is intercepted by subsoil drains during winter months will be treated in bioretention swales at the drainage outfalls, which will be located in POS areas and will be designed with appropriate soil media and plant species to retain and treat the discharge from subsoil drains.

5 SURFACE WATER MANAGEMENT

The Mundijong/Whitby DWMP identified the following key strategies for the management of stormwater in the DSP area:

- Minimise changes in hydrology to prevent impacts on receiving environments (by managing post-development runoff to pre-development flow rates, and promoting on-site retention of the 1yr 1hr ARI storm event)
- Manage surface water flows from major events to protect infrastructure and assets
- Uphold environmental values of downstream waterways within and surrounding the study area.

The surface water strategy for the site is to generally maintain the pre-development flow paths, which follow the site's natural topography. Storage basins and swales will be integrated into the public open space to attenuate post-development runoff and ensure that runoff discharging from the site is within pre-development flow rates, to protect downstream landholdings from flooding.

The open drains that convey flow from upstream catchments – and from the basins within the site – to downstream waterways have been sized with a trapezoidal shape. The drains have a 3m wide base, with 1:6 side slopes, and the 100yr flood depth in these drainage swales is between 0.5m and 1.2m. The drainage swales will be landscaped to appear as a natural, landscaped living stream.

Main detention storage areas for 5yr and 100yr ARI events should be designed with their invert level 0.6m above the invert of the adjacent open drain. This will allow room for localised subsoil drainage beneath the main basins, to encourage infiltration and avoid extended waterlogging of the basin areas during periods of high groundwater.

5.1 Stormwater modelling

5.1.1 Local drainage management

Road runoff from events up to 1yr ARI will be directed into the bioretention swales in POS areas for on-site retention. Residential lots are expected to retain runoff from roof and hardstand areas in soakwells within the lot.

Inflows from the upstream catchment to the east of Precinct E2 have been allowed for in the design of the open drainage swales through Precinct E2.

JDA Consultant Hydrologists has prepared an LWMS to address water management for Precinct E1 (immediately north of Precinct E2), which proposes to discharge flow from the Precinct E1 LSP area along the Sparkman Road reserve, without discharging into Precinct E2. This flow would be piped for up to the 5yr ARI event, and conveyed by overland flow for major storm events.

Runoff within Precinct E2 will be managed by collecting road runoff in a piped drainage network, which will discharge to flood storage basins in the POS areas. These basins will act to attenuate the runoff to pre-development levels and will discharge to the open drains which replicate, as closely as practicable, the pre-development flow paths through POS corridors.

Table 5.1 below shows the required storage areas for the 1yr 1hr ARI and critical 5yr and 100yr ARI storm events to attenuate post-development runoff to allowable (pre-development) levels. Parameters used in the stormwater modelling to size the storage areas are included in Appendix C.

Table 5.1 - Required storage volumes for critical storm events

Basin ref	1yr 1hr ARI bioretention area	5yr ARI flooded area	100yr ARI flooded area
1	370 m^2	1,000 m^2	1,300 m^2
2	540 m^2	1,000 m^2	1,300 m^2
3	1,050 m^2	1,800 m^2	2,300 m^2
4	480 m^2	1,600 m^2	1,900 m^2
5	930 m^2	2,600 m^2	3,100 m^2
6	820 m^2	3,100 m^2	3,900 m^2
7	1,710 m^2	3,400 m^2	3,900 m^2
8	550 m^2	1,000 m^2	2,100 m^2

5.1.2 Major flood management

Earthworks design through Precinct E2 will ensure that roads grade towards the POS areas, with finished floor levels required to achieve a minimum of 0.3m above 100yr flood levels in all parts of the catchment (0.5m above 100yr flood levels in basins and open drains).

The outlets from the flood storage basins, and culverts at road crossings, will be sized to ensure that post-development flows at the downstream (western) end of the site are within pre-development levels. Figure 5.1 shows the required storage areas for the critical 100yr ARI storm event to attenuate post-development runoff to allowable levels.

Figure 5.2 shows the expected 5yr & 100yr ARI flood width and depths in the open drains through the POS corridors.

5.1.3 Diversion of upstream flows

The location of the drainage connection for upstream catchments at the southern end of the LSP area does not align with the pre-development inflow location. Under pre-development conditions, runoff from the southern part of the catchment enters the site between Cockram Street and Mundijong Road (noted as Locations G1 and G2 on Figure 2.7).

The main flow path (G1) will be intercepted where it crosses Cockram Street and piped to the MUC south of the proposed primary school.

A small flow path (G2) takes overflow from the flow path at G1, crosses the south-east corner of the LSP area and discharges to the existing open drain on the southern side of Mundijong Road. This overflow path will be diverted via piped drainage along Adonis Street when the south-eastern corner of the LSP area is developed.

5.2 Surface water quality

Surface water quality will be managed via the bioretention treatment swales within each POS area. Stormwater runoff will be directed into these areas, which will be constructed with amended soil and planted with appropriate plant species to maximise nutrient uptake from the stormwater runoff.

The provision of landscaping packages to lot purchasers will ensure that appropriate native species that require minimal fertiliser use are planted, and educational material will be provided to landowners about appropriate fertiliser use, to minimise the amount of fertiliser wash-off from gardens into the stormwater drainage network.

5.3 Wetlands & waterways

There are no significant wetlands or water-dependant ecosystems within Precinct E2, but there is a CCW to the south of the site, alongside Mundijong Road. No stormwater flow from the development will discharge to this wetland area, and subsoil drainage in the vicinity of the wetland area will be designed with invert levels are at or above typical winter perched water levels to ensure that water levels in this wetland area are not impacted by the development.

6 MONITORING AND IMPLEMENTATION

6.1 Monitoring program

The proposed monitoring program for the LSP area is outlined in Table 6.1 below, and indicative monitoring locations are shown in Figure 6.1. The monitoring locations are shown in areas of POS, and are subject to change as the planning process progresses and the subdivision layout evolves.

Table 6.1 - Monitoring program

Responsible agency	Monitoring program	Requirements	Duration & frequency
Developer	Pre-development groundwater monitoring	GW levels & nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals).	Minimum period of 18 months (including 2 winters), preferably 3 years. Monthly water levels, quarterly water quality.
	Post-development groundwater monitoring	GW levels & nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals).	Period of 2 years post-development (including at least 1 year following completion of 80% of the development. Monthly water levels, quarterly water quality.
	Post-development surface water monitoring	Flows, water levels & nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals)	Period of 2 years post-development (including at least 1 year following completion of 80% of the development. Levels and water quality as appropriate during winter periods.
SJ Shire - with funding from developer contribution scheme	Post-development groundwater & surface water monitoring	Monitor local superficial groundwater levels, water quality and flows within development & wetlands, behavioural patterns with respect to non-structural measures for water quality management.	After developer-funding monitoring program is complete.
DoW	Regional groundwater & surface water monitoring	Monitor regional surface water flows & quality, confined aquifer& regional groundwater levels & quality, groundwater abstraction, efficacy of BMPs, performance of new drainage systems.	Ongoing

Responsible agency	Monitoring program	Requirements	Duration & frequency
DEC	Environmental asset monitoring	Evaluate health of significant environmental assets.	Ongoing

6.2 Trigger values and contingency actions

6.2.1 Groundwater quality targets

Groundwater quality targets for the LSP area have been determined (Table 6.2 below). Target values are set with regard to the baseline quality data and the potential to improve the groundwater quality at the site. Targets are the mean plus one standard deviation and are considered to be met if the mean of all the post development bores is within the target range.

Table 6.2 - Post-development groundwater quality targets

Analyte	Groundwater quality target
pH	> 5.9
Electrical conductivity	< 5900 µS/cm
Dissolved oxygen	< 1.3 mg/L
Phosphorous	< 0.5 mg/L
Total Nitrogen	< 15.7 mg/L
Ammonium	< 1.0 mg/L
Iron (mg/L)	< 33.7 mg/L

6.2.2 Contingency actions

If post-development monitoring finds that water quality-related objectives are not being met, the developer and Shire would undertake the following procedures:

- Ensure that the development has fully complied with development conditions relating to water quality management (i.e. installation and operation of BMPs). If such BMPs have not been designed and installed as approved, then the developer would do so or council would be entitled to take regulatory action for a breach of development conditions.

- Investigate opportunities to apply additional non-structural BMPs to the study area (e.g. educational programs, street sweeping, nutrient management plans, alteration of maintenance regimes, soil amendment, local rainwater tank rebate scheme etc). Funding for such additional measures would typically be covered by the local government authority.

These contingency actions will depend on the specific BMPs that are implemented in the development, and will be confirmed as part of future UWMPs within the LSP area.

6.3 Implementation

Table 12 of the Mundijong/Whitby DWMS includes an extensive list of actions & responsibilities for the implementation of the measures outlined in the DWMS.

6.4 Matters to be addressed in future UWMPs

Future urban water management plans for developments in the Precinct E2 area will include more detailed information on the design of the following infrastructure:

- Stormwater retention/detention basin sizes, depths & configurations, including details of bioretention areas.
- Subsoil drainage layouts & invert levels.
- Minimum earthworks levels to achieve drainage design objectives.
- Proposed cross-sections for open drains through the site.
- Confirmation that the final stormwater drainage design achieves the objectives of this LWMS – particularly that post-development flow rates remain within pre-development levels.
- Details of the specific water-conservation measures that will be applied at the site (including any proposed non-potable water supply).
- POS landscaping concept plan, and confirmation that a water source for POS irrigation has been secured.

7 REFERENCES

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ & ANZECC) (2000), *National Water Quality Management Strategy Australian Guidelines for Urban Stormwater Management*

Cardno (2011), *Whitby, Various Lots - Local Water Management Strategy*

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Engineers Australia (2001), *Australian Rainfall & Runoff, A Guide to Flood Estimation*

Galt Geotechnics (2011), *Geotechnical Study - Proposed Residential Development Lot 46 Mundijong Road, Mundijong*

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Shire of Serpentine Jarrahdale (2010), *Mundijong/Whitby District Structure Plan*

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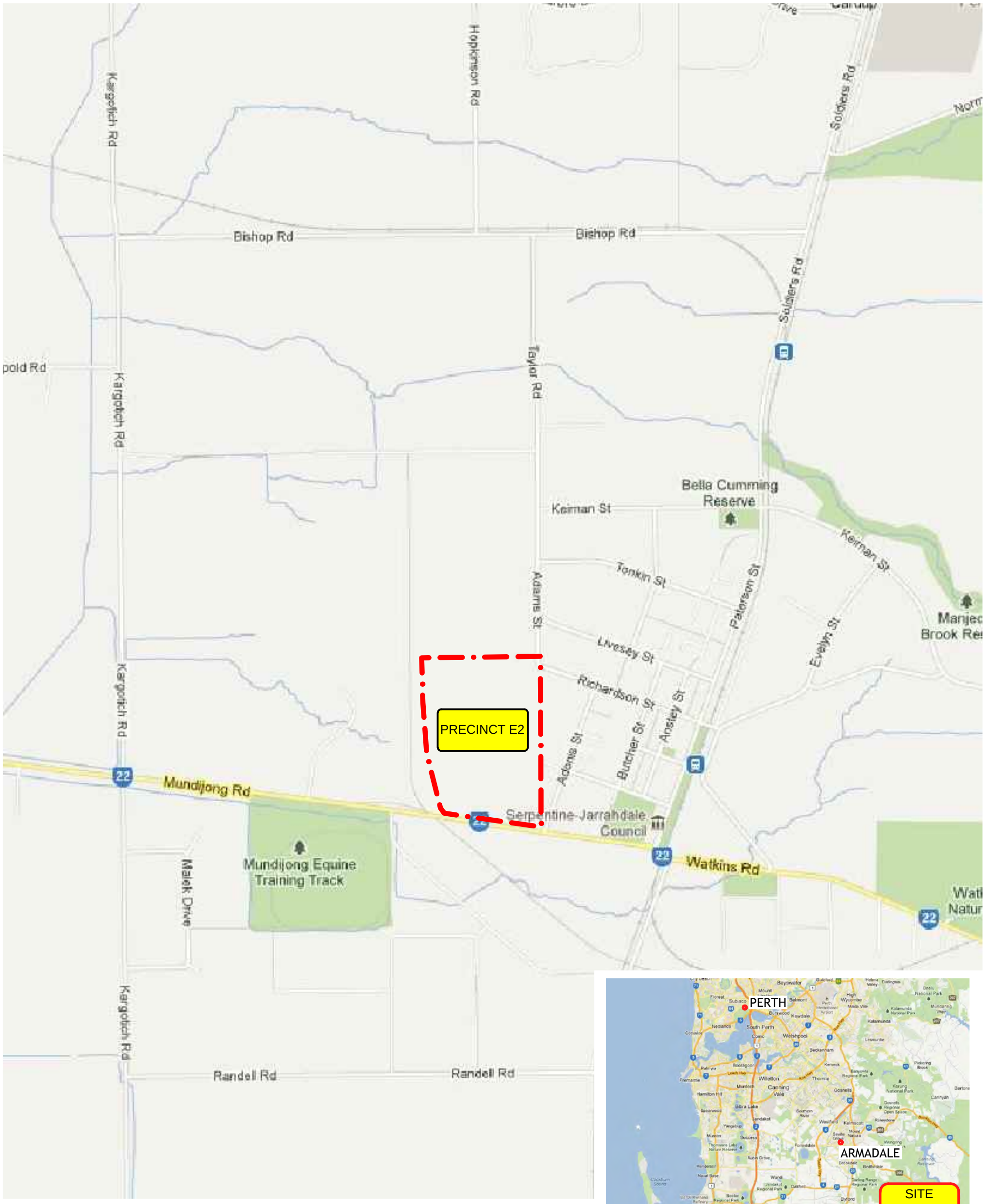

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MUNDIJONG PRECINCT E2 LWMS

SITE LOCALITY PLAN

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 1.1

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-01-01.dwg - anthony iddon - 29/10/2012 2:19:45 PM

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

SERVICE CORRIDOR

PRIMARY SCHOOL

ADAMS ST

ADONIS

COCKRAM ST

ADONIS ST

MUNDIJONG RD

80 40 0 80 160 240 Metres

SCALE 1 : 4000

LEGEND

- LSP BOUNDARY
- PUBLIC OPEN SPACE
- PRIMARY SCHOOL
- WATER CORPORATION SERVICE CORRIDOR

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MUNDIJONG PRECINCT E2 LWMS

LOCAL STRUCTURE PLAN LAYOUT

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 1.2

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-01-02.dwg - anthony iddon - 29/10/2012

LEGEND

LWMS BOUNDARY

26.5 PREDEVELOPMENT GROUND CONTOURS (0.5m INTERVAL)

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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MUNDIJONG PRECINCT E2 LWMS

EXISTING CONTOURS AND AERIAL PHOTO

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 2.1

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

ADAMS ST

ADONIS ST

COCKRAM ST

MUNDIJONG RD

TP01 TP02 TP03 TP04 TP05 TP06 TP07 TP08 TP09 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP18 TP19 TP20 TP21 TP22 TP23 TP24 TP25

26.0 27.0 28.0 25.0

LEGEND

- LWMS BOUNDARY
- EXISTING CLAY CONTOURS (0.2m INTERVAL)
- 27.0 EXISTING CLAY CONTOURS (1.0m INTERVAL)
- TP16 GEOTECH TEST LOCATION

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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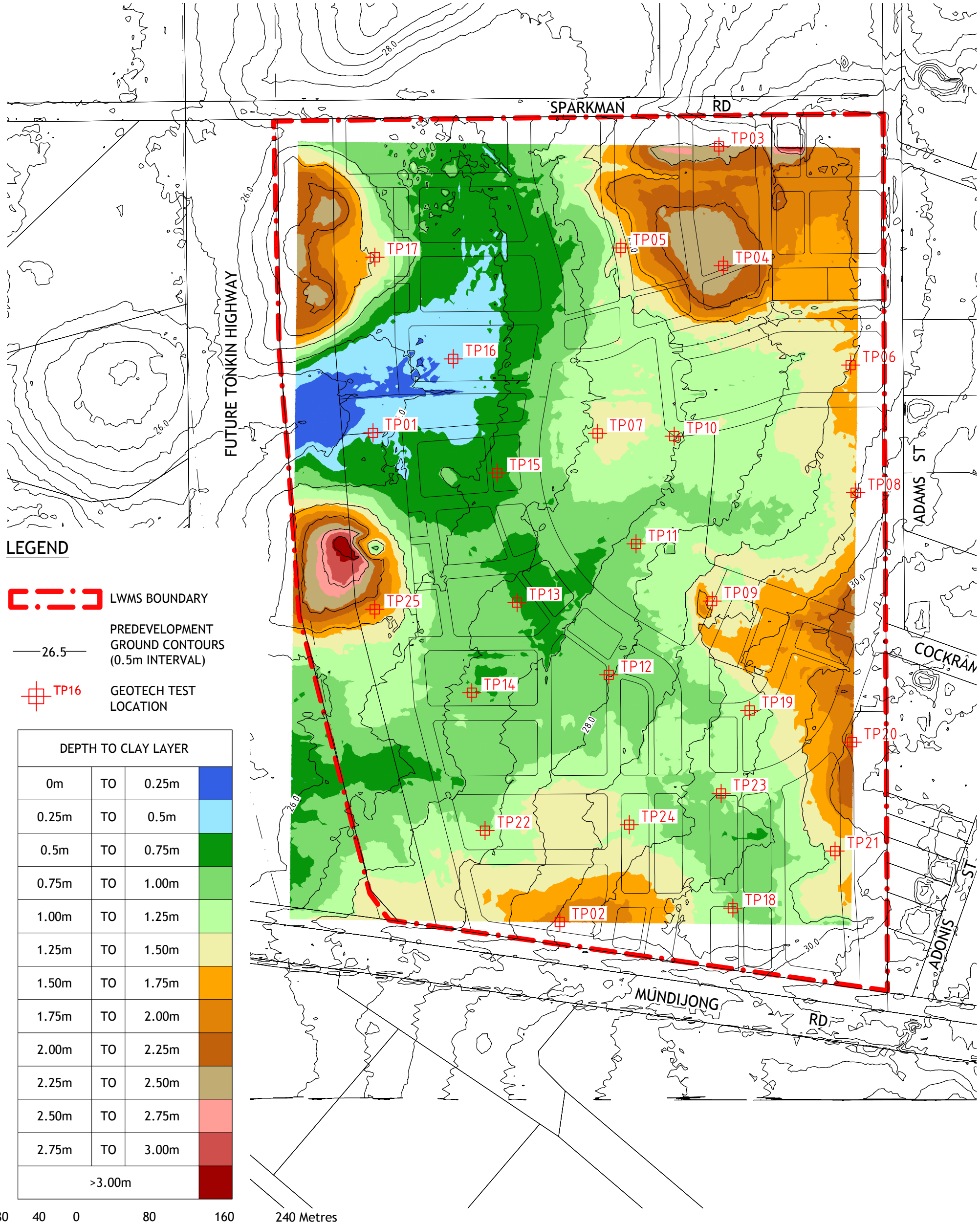
GEOTECHNICAL TEST PIT LOCATIONS & CLAY CONTOURS

Job Number 2681-22
Revision A
Date OCTOBER 2012

FIGURE 2.2

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-02.dwg - anthony iddon - 29/10/2012



LEGEND

LWMS BOUNDARY

26.5 — PREDEVELOPMENT GROUND CONTOURS (0.5m INTERVAL)

TP16 — GEOTECH TEST LOCATION

DEPTH TO CLAY LAYER		
0m	TO	0.25m
0.25m	TO	0.5m
0.5m	TO	0.75m
0.75m	TO	1.00m
1.00m	TO	1.25m
1.25m	TO	1.50m
1.50m	TO	1.75m
1.75m	TO	2.00m
2.00m	TO	2.25m
2.25m	TO	2.50m
2.50m	TO	2.75m
2.75m	TO	3.00m
>3.00m		

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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DEPTH TO CLAY LAYER

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

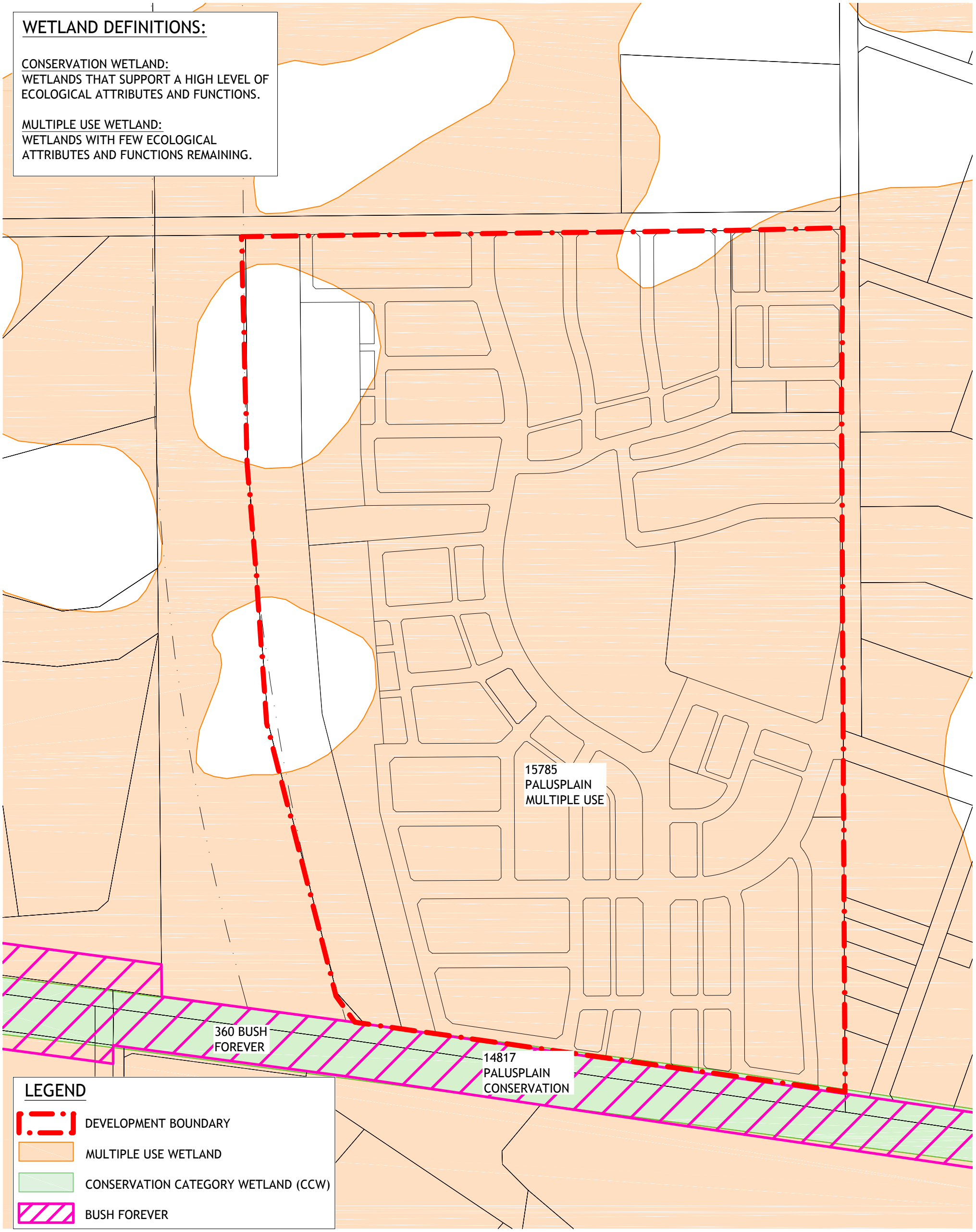
FIGURE 2.3

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-03.dwg - anthony iddon - 29/10/2012

WETLAND DEFINITIONS:

CONSERVATION WETLAND:
WETLANDS THAT SUPPORT A HIGH LEVEL OF ECOLOGICAL ATTRIBUTES AND FUNCTIONS.

MULTIPLE USE WETLAND:
WETLANDS WITH FEW ECOLOGICAL ATTRIBUTES AND FUNCTIONS REMAINING.



80 40 0 80 160 240 Metres

SCALE 1 : 4000

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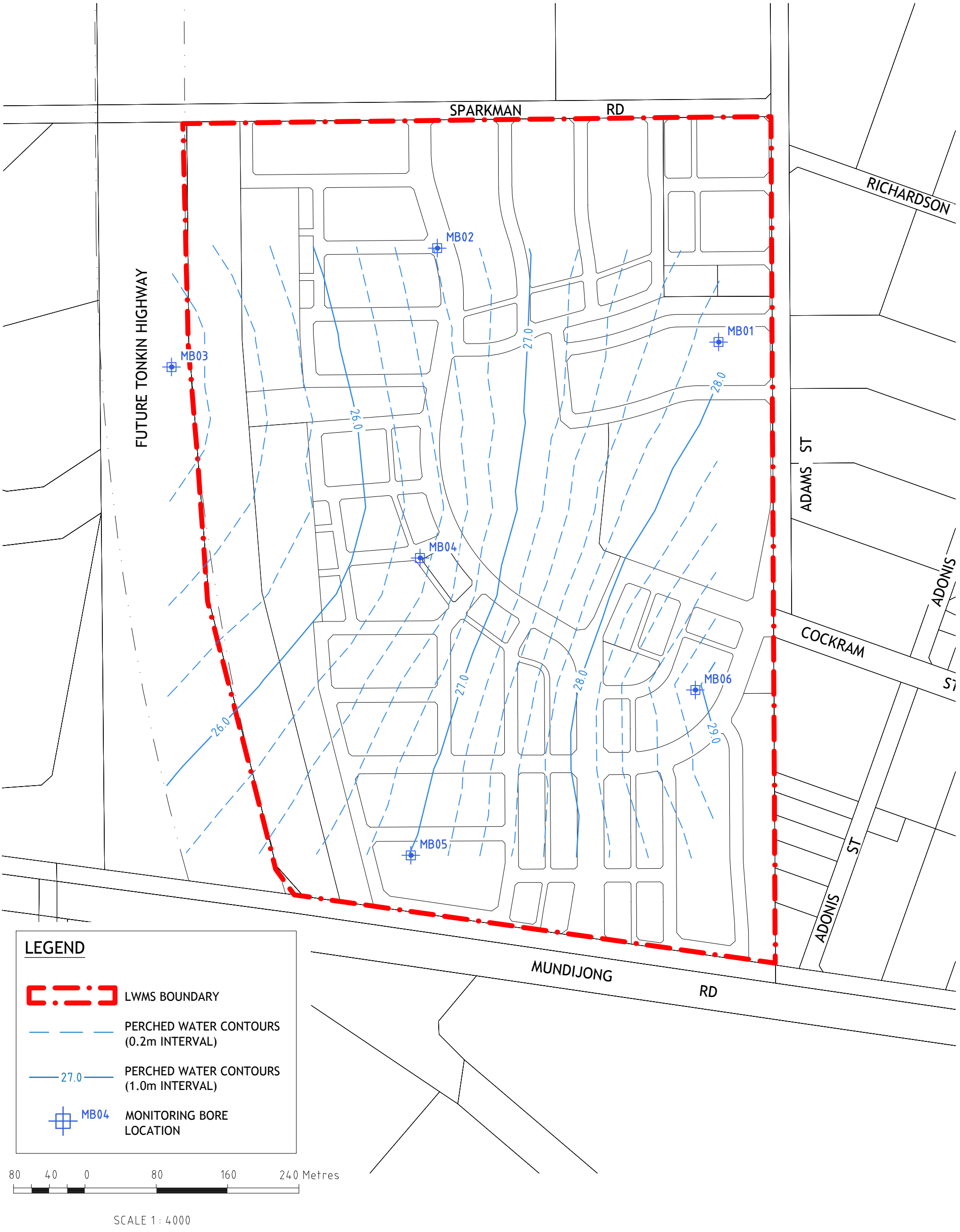
DEC WETLAND MAPPING

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 2.4



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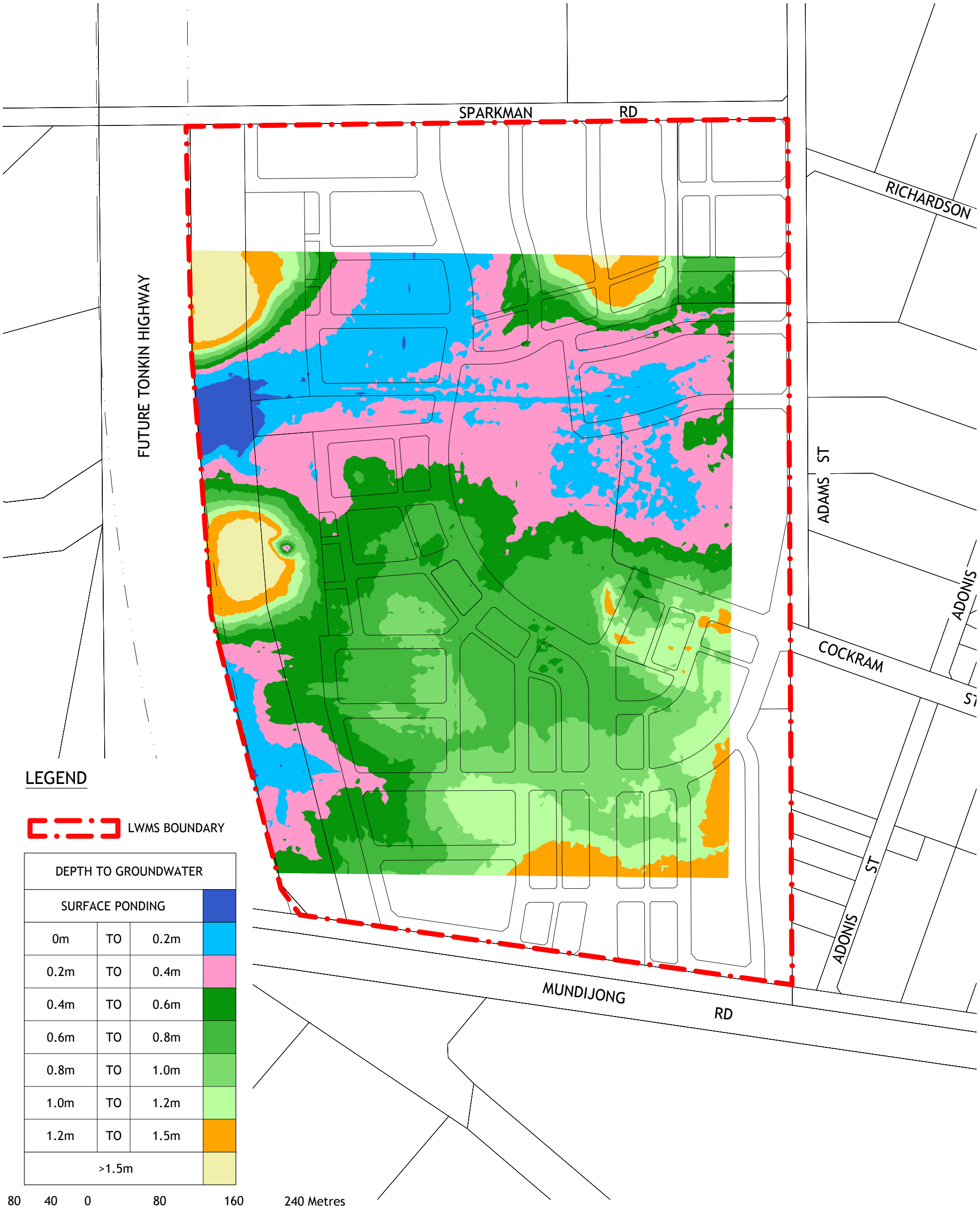
MUNDIJONG PRECINCT E2 LWMS

Job Number 2681-22
Revision A
Date OCTOBER 2012

MONITORING BORE LOCATIONS & PRE-DEVELOPMENT WINTER PERCHED WATER LEVELS

FIGURE 2.5

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-05.dwg - anthony iddon - 29/10/2012



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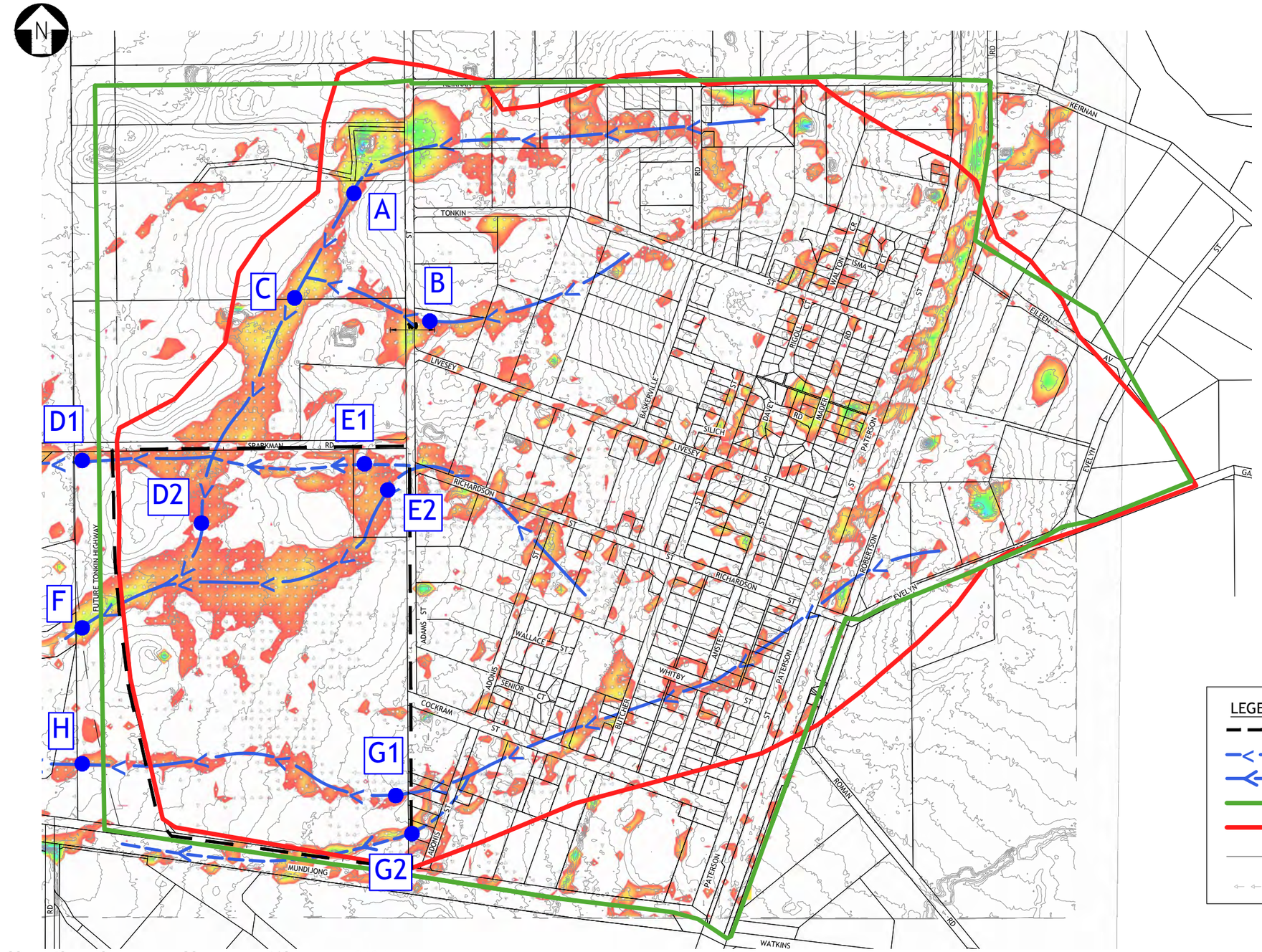
Job Number	2681-22
Revision	A
Date	OCTOBER 2012

DEPTH TO PRE-DEVELOPMENT PERCHED WINTER WATER LEVELS

FIGURE 2.6

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-06.dwg - anthony iddon - 29/10/2012



SCALE 1 : 4000

100YR ARI DEPTH OF INUNDATION

- 1.000m
- 0.900m
- 0.800m
- 0.700m
- 0.600m
- 0.500m
- 0.400m
- 0.300m
- 0.200m
- 0.100m

LOCATION	5yr Q (m^3)	100yr Q (m^3)
A	1.2	2.9
B	0.8	1.9
C	1.8	4.6
D1	1.2	2.1
D2	1.1	3.3
E1	0.5	1.4
E2	1.5	3.2
F	3.6	7.2
G1	1.0	2.5
G2	0.4	0.9
H	0.5	1.8

LEGEND

- DEVELOPMENT BOUNDARY
- PRE-DEVELOPMENT FLOW PATH
- OVERLAND FLOW PATH FOR MAJOR STORM EVENTS
- CATCHMENT BOUNDARY (GHD DWMS)
- CATCHMENT BOUNDARY (2D MODELLING)
- PREDEVELOPMENT GROUND CONTOUR (0.5m INTERVAL)
- DIRECTION OF FLOW

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PRE-DEVELOPMENT SURFACE FLOW PATHS

Job Number 2681-22
Revision A
Date OCTOBER 2012

FIGURE 2.7

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-07.dwg - anthony iddon - 29/10/2012

BASIN INFORMATION

BASIN NUMBER	BASIN OUTLET SIZE (mm)	INVERT LEVEL (mAHD)	1YR AREA (m^2)	5YR AREA (m^2)	5YR TWL (mAHD)	100YR AREA (m^2)	100YR TWL (mAHD)
1	300	26.0	370	1000	26.8	1300	26.9
2	225	25.9	540	1000	26.8	1300	26.8
3	525	26.0	1050	1800	26.8	2300	26.9
4	225	26.8	480	1600	27.7	1900	27.7
5	225	27.1	930	2600	28.0	3100	28.0
6	225	26.8	820	3100	27.7	3900	27.8
7	375	28.0	1710	3400	28.8	3900	28.8
8	225	27.3	550	1000	28.3	2100	28.3

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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POST DEVELOPMENT DRAINAGE MANAGEMENT

Job Number	2681-22
Revision	C
Date	MARCH 2013

FIGURE 5.1

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-05-01.dwg - anthony iddon - 22/03/2013

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.7	12
100 YEAR	1.2	18

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.4	9
100 YEAR	0.7	13

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.6	11
100 YEAR	0.9	15

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.5	10
100 YEAR	0.9	15

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.6	11
100 YEAR	1.1	17

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.7	12
100 YEAR	1.2	18

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.3	8
100 YEAR	0.5	10

LEGEND

DEVELOPMENT BOUNDARY

PUBLIC OPEN SPACE

OPEN DRAINAGE SWALE

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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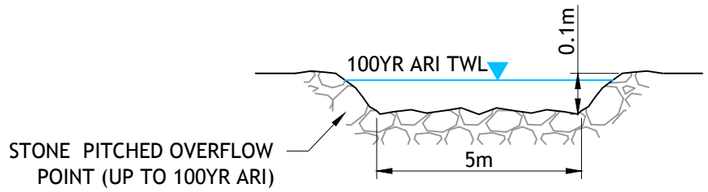
DRAINAGE SWALE
FLOOD DEPTHS AND WIDTHS

Job Number 2681-22
Revision B
Date FEBRUARY 2013

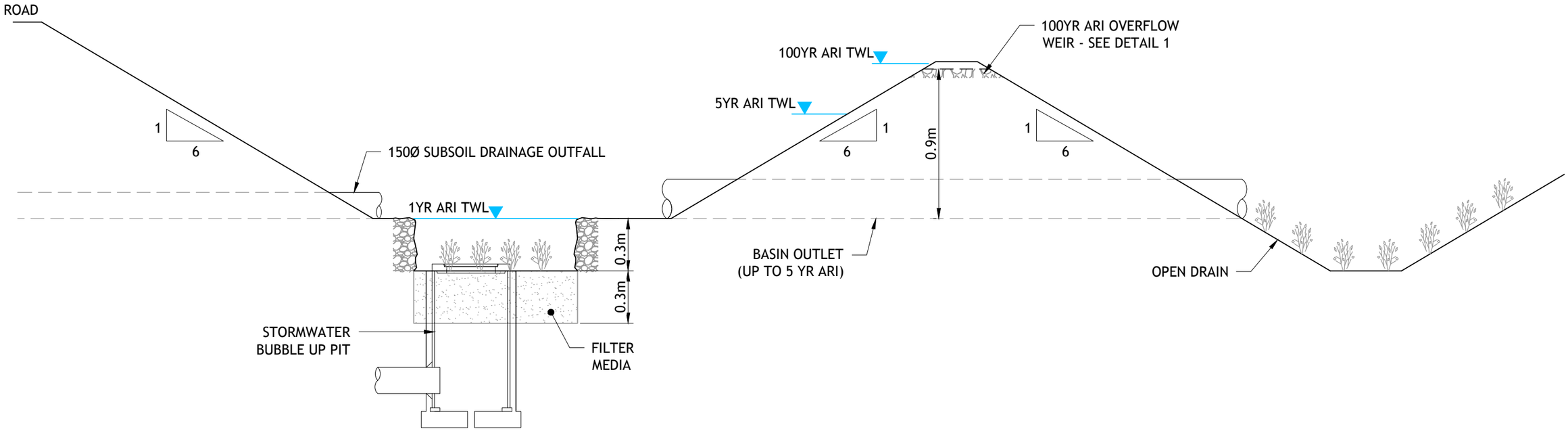
FIGURE 5.2

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-05-02.dwg - anthony iddon - 13/02/2013



DETAIL 1

NOT TO SCALE



CROSS SECTION - BASIN ARRANGEMENT

NOT TO SCALE

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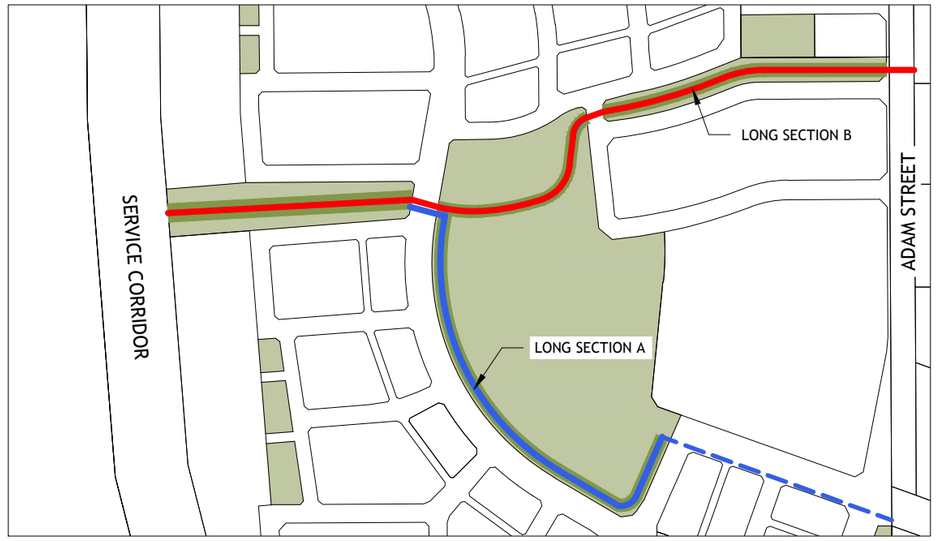
MUNDIJONG PRECINCT E2 LWMS

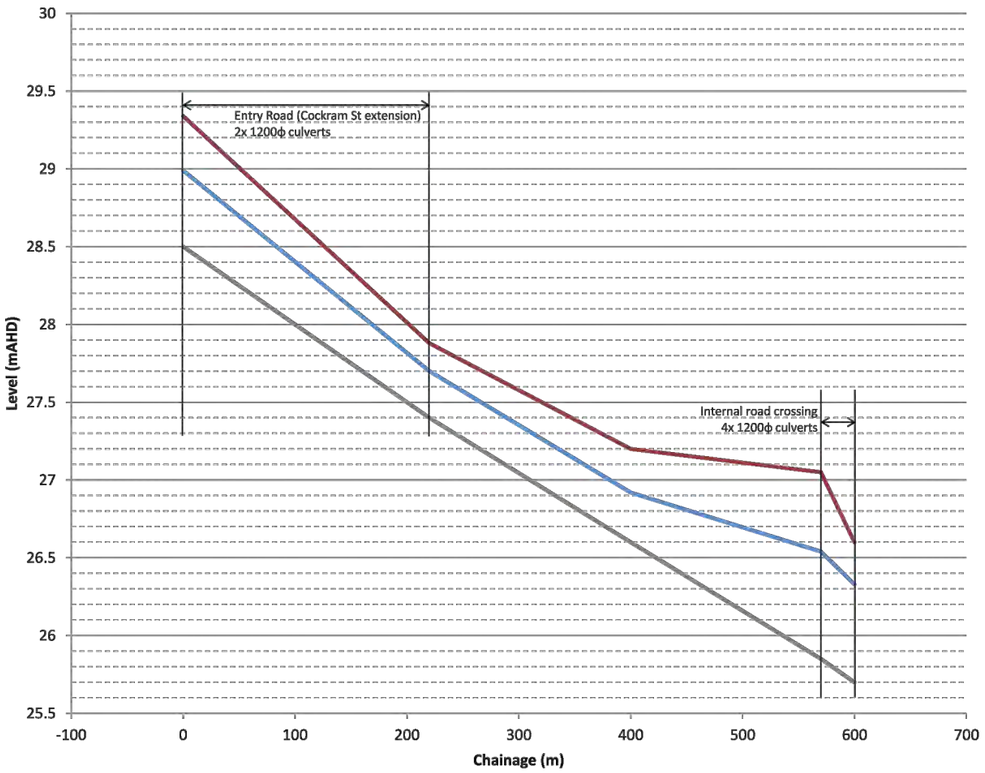
BASIN OUTLET CONFIGURATION

Job Number	2681-22
Revision	A
Date	FEBRUARY 2013

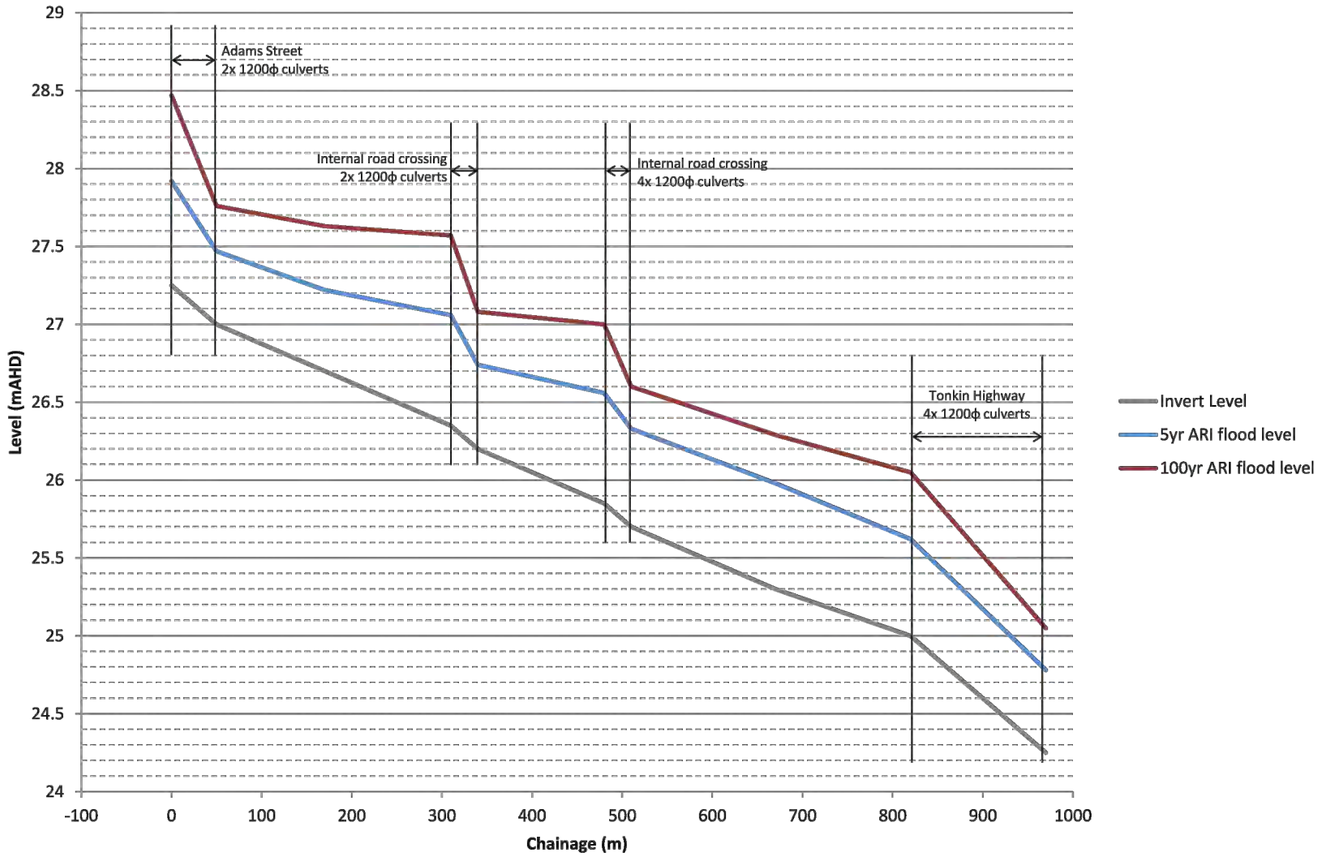
FIGURE 5.3



DRAINAGE PLAN
SCALE 1:4000



LONG SECTION A



LONG SECTION B

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INDICATIVE OPEN DRAIN LONG SECTIONS

Job Number	2681-22
Revision	A
Date	FEBRUARY 2013

FIGURE 5.4

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-05-04.dwg - anthony iddon - 13/02/2013

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

ADAMS ST

ADONIS ST

COCKRAM ST

MUNDIJONG RD

MB01

MB02

MB03

MB04

MB05

LEGEND

LWMS BOUNDARY

PUBLIC OPEN SPACE AREA

MB04 POST DEVELOPMENT MONITORING BORE LOCATION

80 40 0 80 160 240 Metres

SCALE 1 : 4000

WAVE INTERNATIONAL PTY LTD.
Mezzanine
306 Murray Street
PERTH, WA 6000
Telephone: +61 8 92040700
Email: enquiries@wavesolutions.com.au
Web: www.waveinternational.com

N

PEET LIMITED
MUNDIJONG PRECINCT E2 LWMS

INDICATIVE POST-DEVELOPMENT MONITORING BORE LOCATIONS

Job Number 2681-22
Revision A
Date FEBRUARY 2013

FIGURE 6.1

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-06-01.dwg - anthony iddon - 13/02/2013

APPENDIX A – Geotechnical bore logs

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

Galt GEOTECHNICS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

SCR = Solid Core Recovery (%) $= \frac{CCR}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Recovered Length of Core
CCR	Total Length of Cylindrical Pieces of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		BOULDERS and/or COBBLES
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	SP	SAND (poorly graded
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

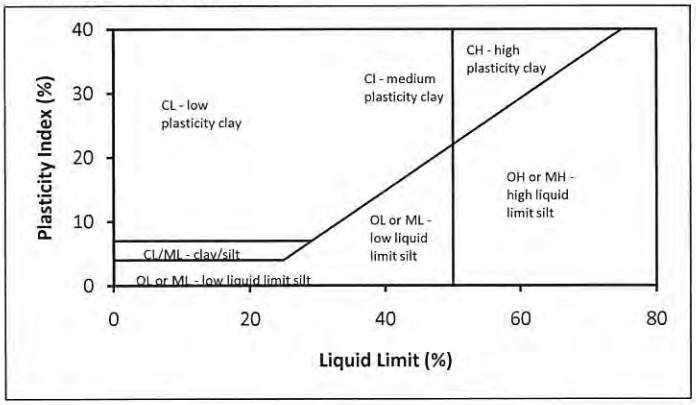
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-1993, Appendix A. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100 mm
VS	Very Soft	0 to 12	0 to 2	<1
S	Soft	12 to 25	2 to 4	<1
F	Firm	25 to 50	4 to 8	1 to 2
St	Stiff	50 to 100	8 to 15	3 to 4
VSt	Very Stiff	100 to 200	15 to 30	5 to 10
H	Hard	>200	>30	>10

Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100 mm	PSP Blows per 300 mm
VL	Very Loose	<15	0 to 4	<1	0 to 2
L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VD	Very Dense	>85	>50	>8	>15

Note: PSP correlations only valid to 450 mm depth

Consistency and density may also be inferred from excavation performance and material behaviour.

REPORT OF TEST PIT **TP01**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403139	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426624	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt, abundant rootlets	M-W	L-MD		0.0
0.2						As above, pale brown, with some low plasticity clay fines, no rootlets				0.2
0.4					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines				0.4
0.6	M				GP	GRAVEL: Fine to coarse grained ferricrete gravel, with 10% medium plasticity Sandy CLAY				0.6
0.8										0.8
1.0										1.0
1.2	E		Disturbed Sample SA01-1		CH	Sandy CLAY/Clayey SAND: High plasticity, pale grey and yellow-brown, 40-60% sand		St		1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0	M-H								Moderate to well cemented ferricrete in places from 2.0 m depth.	2.0
2.2										2.2
2.4		▶			SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, white, some low to medium plasticity clay fines	W	MD		2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow at base of pit (2.5 m).

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP02**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403347	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426097	TP Width (m): 2 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlet	M-W	L		0.0
0.2						As above, white, no fines, no rootlets		MD		0.2
0.4										0.4
0.6						As above, brown, with weakly cemented sections		L-VL		0.6
0.8						As above, yellow-brown, no cementation, trace low plasticity clay fines	W			0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6								L-MD		1.6
1.8										1.8
2.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey and yellow-brown, 10-15% low to medium plasticity clay fines				2.0
2.2										2.2
2.4									Estimated depth due to hole collapse.	2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Stopped due to hole collapse.
Water inflow at approximately 1.4 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP03**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403510	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426938	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets				0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0		▶								1.0
1.2	VE		ASS Samples taken at 0.5 m intervals		SP		M-W	L-MD	Hole collapse.	1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4					GP	GRAVEL: Fine to coarse grained ferricrete gravel, with Clayey SAND				2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow between 1.0 m and 1.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP04**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403516	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426809	TP Width (m): 0.6 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL-L		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4										0.4
0.6						As above, yellow-brown, trace low plasticity clay fines	W			0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0						As above, pale grey with some ferruginised fine to medium gravel				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth. Inferred ferricrete at base.
Water inflow at 2.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP05**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403405	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426827	TP Width (m): 2 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, trace rootlets As above, white, no fines, no rootlets	W	L		0.0
1.2			Disturbed Sample SA05-1		SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey mottled yellow-brown, 15-30% medium plasticity clay fines varying with depth	M-W		Hole collapse.	1.2
2.0						End of test pit at 2.0 m. Stopped due to hole collapse. Water inflow between 1.0 m and 1.5 m.				2.0
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT TP06

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403055	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426703	TP Width (m): 0.6 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4						Gravelly SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, 20-40% fine to coarse grained ferricrete gravel		MD	Hole collapse.	0.4
0.6										0.6
0.8										0.8
1.0	M				SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale blue mottled yellow-brown and blue-green, ~20% medium plasticity clay fines, with 20-40% fine to coarse grained ferricrete GRAVEL increasing with depth				1.0
1.2										1.2
1.4	H				GP	GRAVEL: Fine to coarse grained ferricrete, with 20% Clayey SAND, some cobbles				1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 1.5 m.
Refusal on Ferricrete.
Water inflow at approximately 0.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT TP07

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403382	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426626	TP Width (m): 2 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6					SC	Clayey SAND: Medium plasticity fines, grey-green mottled yellow-brown, medium to coarse sub-rounded to sub-angular sand, becoming sandier with depth			Estimated depth due to hole collapse.	1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8
						End of test pit at 2.0 m. Stopped due to hole collapse. Water inflow at approximately 0.5 m.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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Galt GEOTECHNICS

REPORT OF TEST PIT — TP08

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403662	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426565	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L-MD	Hole collapse.	0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4						As above, brown				0.4
0.6						As above, pale brown				0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, 15% low to medium plasticity clay fines, with some 5-15 mm ferruginised nodules		MD		1.6
1.8										1.8
2.0						End of test pit at 2.0 m. Refusal on Ferricrete. Water inflow at approximately 0.6 m.				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP09

PROJECT DETAILS

Job Number: J1101127
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lot 46 Mundijong Road Mundijong

SPATIAL DETAILS

Position: See Plan
Easting (m): 403508
Northing (m): 6426446
Datum: MGA94
Surface RL (m):

DRILLING DETAILS

Logged: HWC — Logged Date: 03/10/2011
Checked: RP — Checked Date: 27/10/2011
TP Width (m): 2 — TP Length (m):
Machine: Komatsu WB 97R — Bucket: Toothed
Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL		0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8						As above, pale brown, trace low plasticity clay fines				0.8
1.0						As above, yellow brown, some silt fines			Estimated depth due to hole collapse.	1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 1.8 m.
Stopped due to hole collapse.
Groundwater not encountered.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT — TP10

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403465	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426624	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals Sample SA10-1		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets to 0.1 m	M-W	L-MD		0.0
0.2										0.2
0.4										0.4
0.6			Sample SA10-2		SC-CI/CH	Clayey SAND/Sandy CLAY: Medium to high plasticity fines, olive grey mottled yellow-brown, medium to coarse sub-rounded to sub-angular sand, becoming sandier with depth			Slight sulphur odour while excavating	0.6
0.8										0.8
1.0										1.0
1.2					SC	Clayey SAND: Medium plasticity fines, blue-green mottled yellow-brown, medium to coarse sub-rounded to sub-angular sand, becoming sandier with depth				1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4						End of test pit at 2.4 m. Target depth. Water inflow at 0.1 m.				2.4
2.6										2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP11

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403425	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426507	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL-L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines				1.0
1.2										1.2
1.4					GC	GRAVEL: Fine to coarse grained ferricrete, in a Clayey SAND (as above) matrix (approximately 40%)				1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6						End of test pit at 2.6 m. Target depth. Water inflow at 1.2 m.				2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP12

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403397	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426365	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets to 0.1 m	M-W	VL-L		0.0
0.2										0.2
0.4										0.4
0.6										0.6
0.8									Hole collapse.	0.8
1.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines, some ferruginised nodules 5-15 mm in size		L-MD		1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow at 2.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP13

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403297	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426442	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets				0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4					SP			L		0.4
0.6		▶								0.6
0.8						Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines				0.8
1.0	VE		Disturbed Sample SA13-2				M-W			1.0
1.2										1.2
1.4			In situ sample SA13-1		SC			MD		1.4
1.6										1.6
1.8						As above, olive grey and yellow-brown predominantly, ~30% medium plasticity clay fines				1.8
2.0										2.0
2.2										2.2
2.4	H					FERRICRETE				2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow at approximately 0.7 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP14

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403249	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426344	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L-MD		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, ~15% low to medium plasticity clay fines, with increased clay content in parts, with some ferruginised nodules (5-15 mm in size)			Hole collapse.	0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4	H					FERRICRETE		MD		2.4
2.6										2.6
2.8										2.8

End of test pit at 2.7 m.
Target depth.
Water inflow at approximately 0.7 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP15

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403274	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426582	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L-MD		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4										0.4
0.6			Disturbed Sample SA15-1		SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, ~20-30% medium plasticity clay fines, with fines content increasing in parts				0.6
0.8										0.8
1.0										1.0
1.2	M				GP	Sandy GRAVEL: Fine to medium grained ferricrete, brown, with ~20% medium to coarse grained sand,	W			1.2
1.4										1.4
1.6						GRAVEL: Fine to coarse grained ferricrete gravel, pale brown and olive grey, with 20% Clayey SAND/Sandy CLAY becoming well cemented				1.6
1.8	H	▶								1.8
2.0						End of test pit at 2.0 m. Refusal on Ferricrete. Water inflow at 1.8 m.				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP16

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403225	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426705	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4			Sample SA16-1		SC	Clayey SAND: Medium to coarse grained, olive grey mottled yellow-brown, 40-50% medium to high plasticity clay fines, becoming ferruginised from 0.6 m (moderately to well cemented)				0.4
0.6	H							H		0.6
0.8			In situ sample SA16-2							0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 0.7 m.
Refusal on Ferricrete.
Groundwater not encountered.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP17

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403139	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426814	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets to 0.1 m	W	VL-L		0.0
0.2										0.2
0.4										0.4
0.6										0.6
0.8						As above, brown, with some weakly cemented nodules (5-15 mm), trace low plasticity clay fines, no rootlets				0.8
1.0										1.0
1.2						As above, yellow-brown, no cementation				1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at approximately 1.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP18

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403534	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426114	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	E	▶	ASS Samples taken at 0.5 m intervals		SP	SAND: Medium to fine grained, black to 0.1 m, becoming pale grey, with some low plasticity clay fines	W	VL	Topsoil with abundant rootlets to 0.1 m.	0.0
0.8					SC	Clayey SAND: Medium to fine grained, with 20-30% medium plasticity clay fines, with frequent ferruginised nodules (can be broken with fingers)		S-F		0.8
1.4		▶								1.4
2.0	M					As above, but generally more cemented		St		2.0
2.5						End of test pit at 2.5 m. Target depth. Water inflow at 0.4 m and 1.5 m.				2.5

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP19

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403550	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426328	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium grained, black at top 0.1 m becoming pale greyish yellow, trace fines	W	VL		0.0
0.6		▶			SC	Clayey SAND: Medium to fine grained, with ~20% medium plasticity clay fines, grey mottled orange, with weakly ferruginised nodules		F		0.6
2.6						End of test pit at 2.6 m. Refusal on moderately cemented Ferricrete nodules. Groundwater not encountered.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP20

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403661	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426295	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND: Medium grained, black at top becoming pale grey, trace fines			Topsoil to 0.1 m.	0.0
0.8			ASS Samples taken at 0.5 m intervals		SP	As above, brown becoming orange	W	VL		0.8
2.0						End of test pit at 2.0 m. Stopped due to hole collapse. Groundwater not encountered.				2.0

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP21

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403644	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426177	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium to fine grained, dark grey becoming pale yellow-grey, with ~10% low plasticity clay fines	W	VL	Black topsoil to 0.1 m.	0.0
0.2										0.2
0.4					SC-CI/CH	Clayey SAND/Sandy CLAY: Coarse, medium and fine grained, with 40-60% medium to high plasticity fines, pale grey and orange, scattered weakly ferruginised nodules				0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0		▶								2.0
2.2					GC	Clayey GRAVEL: Medium to fine grained, moderately cemented ferricrete nodules in a matrix (40%) of Clayey SAND				2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.4 m.
Near refusal.
Water inflow (slow seepage) at 2.1 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP22

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403265	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426195	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND: Medium grained, black at top 0.1 m becoming pale yellow-grey and yellow				0.0
0.2										0.2
0.4					SP					0.4
0.6		▶								0.6
0.8										0.8
1.0						Clayey SAND: Medium grained, pale grey mottled pale orange, 20% medium plasticity fines				1.0
1.2			ASS Samples taken at 0.5 m intervals				W	L		1.2
1.4										1.4
1.6										1.6
1.8					SC					1.8
2.0						As above, with occasional well cemented ferricrete nodules				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8
						End of test pit at 2.6 m. Collapse. General seepage below 0.6 m.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT TP23

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403520	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426238	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium grained, layered black, pale grey and orange yellow, trace fines	W	VL	Black topsoil to 0.1 m.	0.0
1.0					SC	Clayey SAND: Medium to fine grained, grey occasionally mottled yellow orange, 20% low to medium plasticity fines				1.0
2.0						As above, with ferricrete nodules towards base				2.0
2.6						End of test pit at 2.6 m. Collapse below 0.2 m. General seepage below 0.4 m.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT TP24

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403421	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426203	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium grained, black at top 0.1 m becoming pale grey and yellow, trace fines	W	L		0.0
0.2										0.2
0.4										0.4
0.6		▶								0.6
0.8										0.8
1.0										1.0
1.2					SC	Clayey SAND: Medium grained, grey stained orange, 20% medium to low plasticity fines				1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth. Continual collapse during excavation.
Seepage below 0.6 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT TP25

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403143	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6246433	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE		ASS Samples taken at 0.5 m intervals		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L		0.0
0.2						As above, no fines, no rootlets				0.2
0.4										0.4
0.6								MD		0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4						As above, brown, with weakly cemented nodules (5-15 mm in size)				1.4
1.6						As above, white, no nodules				1.6
1.8										1.8
2.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey mottled yellow-brown, 10-15% low to medium plasticity clay fines, becoming ferruginised with depth				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8
						End of test pit at 2.0 m. Stopped due to hole collapse. Groundwater not encountered.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

APPENDIX B – Pre-development groundwater monitoring data

	Easting	Northing	NSL (from LiDAR)	
MB01	403631	6426722	28.3	
MB02	403315	6426824	26.7	
MB03	403018	6426687	25.5	
MB04	403299	6426476	27.0	
MB05	403293	6426143	27.8	
MB06	403609	6426332	29.9	
DoW bore T270	401401	6429300	16.7	(from DoW records)

DoW avg max GWL =	17.0
DoW reading @ 14-Oct-09 =	16.7
adjustment to Oct-09 GWLs =	0.3
DoW avg min GWL =	15.7
DoW reading @ 5-May-09 =	15.3
adjustment to Apr-09 GWLs =	0.4

typical winter (high) water levels

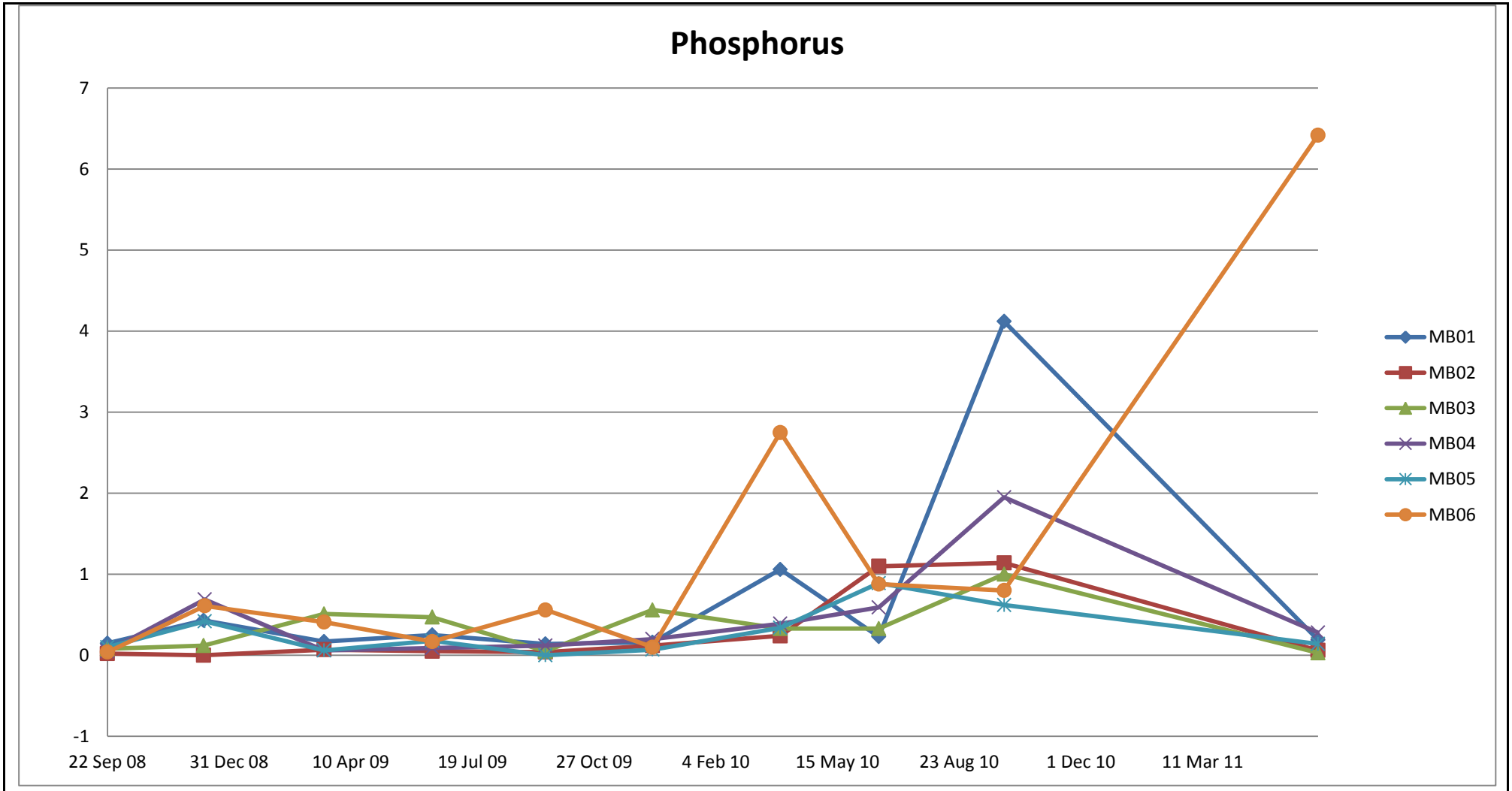
	GWL	mBGL	NSL
MB01	27.9	0.4	28.3
MB02	26.6	0.1	26.7
MB03	25.2	0.3	25.5
MB04	26.2	0.8	27
MB05	27.0	0.8	27.8
MB06	29.1	0.8	29.9
DoW bore T270	17.0	-0.3	16.7

typical summer (low) water levels

	GWL	mBGL	clay level
MB01	27.1	1.2	26.9
MB02	25.8	0.9	26.1
MB03	24.2	1.3	24.9
MB04	24.9	2.1	26.3
MB05	25.6	2.2	26.4
MB06	27.2	2.7	28.4
DoW bore T270	15.7	1.0	n/a

mAHD - corrected GWL data (= emerson stewart mAHD data MINUS casing height)

	22-Sep-08	21-Oct-08	18-Nov-08	11-Dec-08	20-Jan-09	20-Feb-09	19-Mar-09	24-Apr-09	25-May-09	16-Jun-09	15-Jul-09	14-Aug-09	17-Sep-09	09-Oct-09	18-Nov-09	14-Dec-09	19-Jan-10	23-Feb-10	29-Mar-10	18-Jun-10	26-Jul-10	24-Aug-10	29-Sep-10	14-Jun-11	18-Jul-11	15-Aug-11
MB01	27.661	27.451	27.381	27.301	27.091	26.921	26.841	26.731	26.851	26.941	27.611	27.941	27.941	27.611	27.298	27.19	27.02	26.866	26.934	27.234	27.576	27.494	27.226	27.006	27.562	27.845
MB02	26.36	26.11	26.04	25.97	25.65	25.49	25.44	25.39	25.53	25.67	26.34	26.55	26.65	26.33	26.052	25.808	25.549	25.473	25.57	25.972	26.253	26.295	25.947	25.737	26.32	26.55
MB03	24.791	24.591	24.481	24.441	24.161	24.011	23.931	23.831	23.991	24.211	24.891	25.081	25.071	24.881	24.007	24.345	24.165	24.03	24.103	24.574	24.788	24.806	24.477	24.33	24.869	25.027
MB04	25.677	25.607	25.507	25.427	25.097	24.907	24.747	24.547	24.477	24.617	26.237	26.547	26.487	25.867	26.004	25.418	25.179	24.966	24.846	25.708	26.239	26.067	25.645	25.798	26.482	26.537
MB05	26.554	26.364	26.234	26.124	25.814	25.634	25.454	25.214	25.004	25.044	26.354	27.044	27.114	26.674	26.242	26.178	26.038	25.866	25.842	25.926	26.336	26.326	26.114	25.659	26.494	26.991
MB06	28.569	28.419	28.279	29.059	27.839	27.439	27.069	26.789	26.719	26.819	28.539	29.129	29.159	28.809	28.317	28.192	27.809	27.279	27.024	27.225	28.234	28.146	27.746	26.848	28.389	29.066

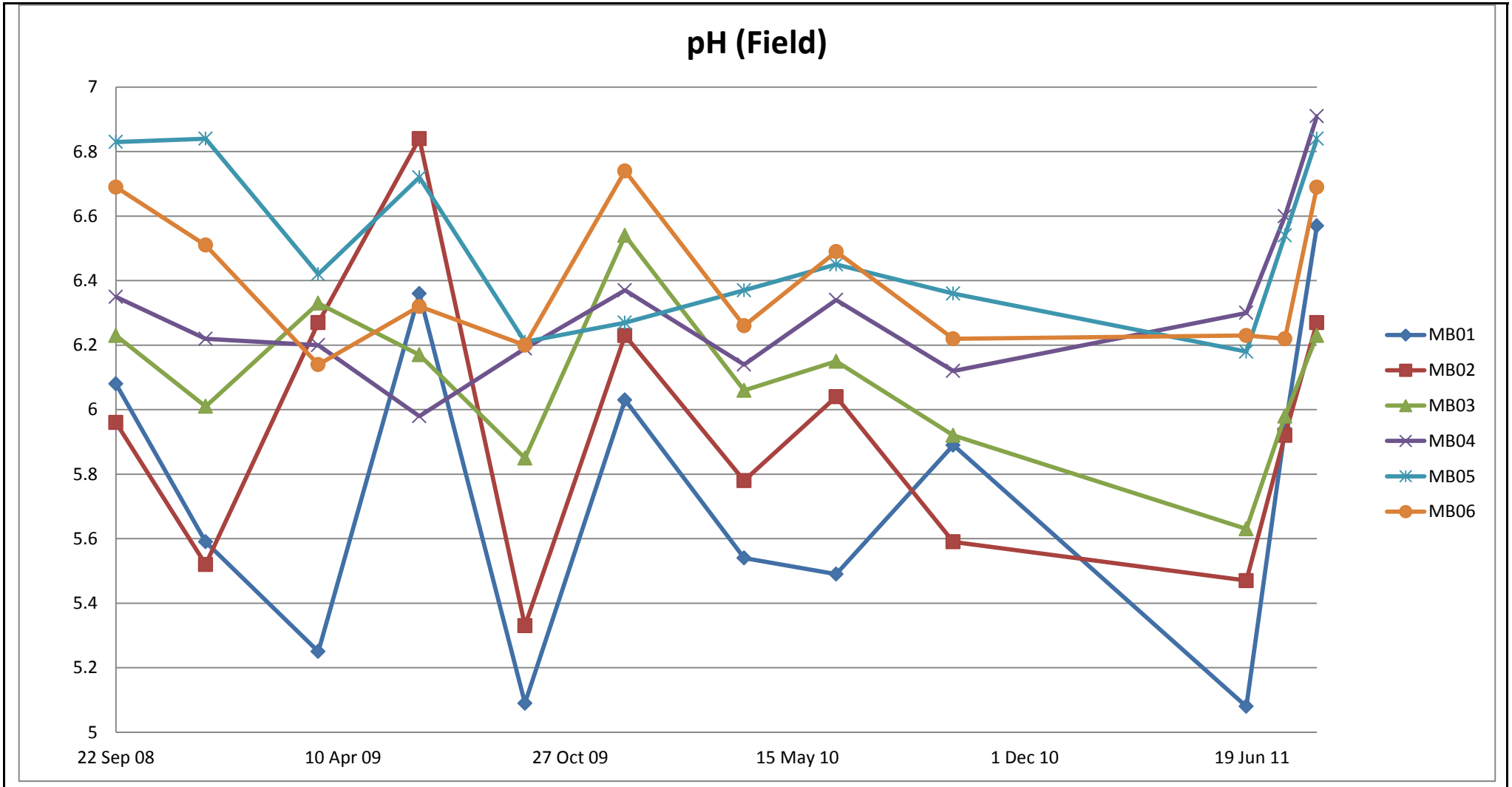


Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

ESDAT



Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

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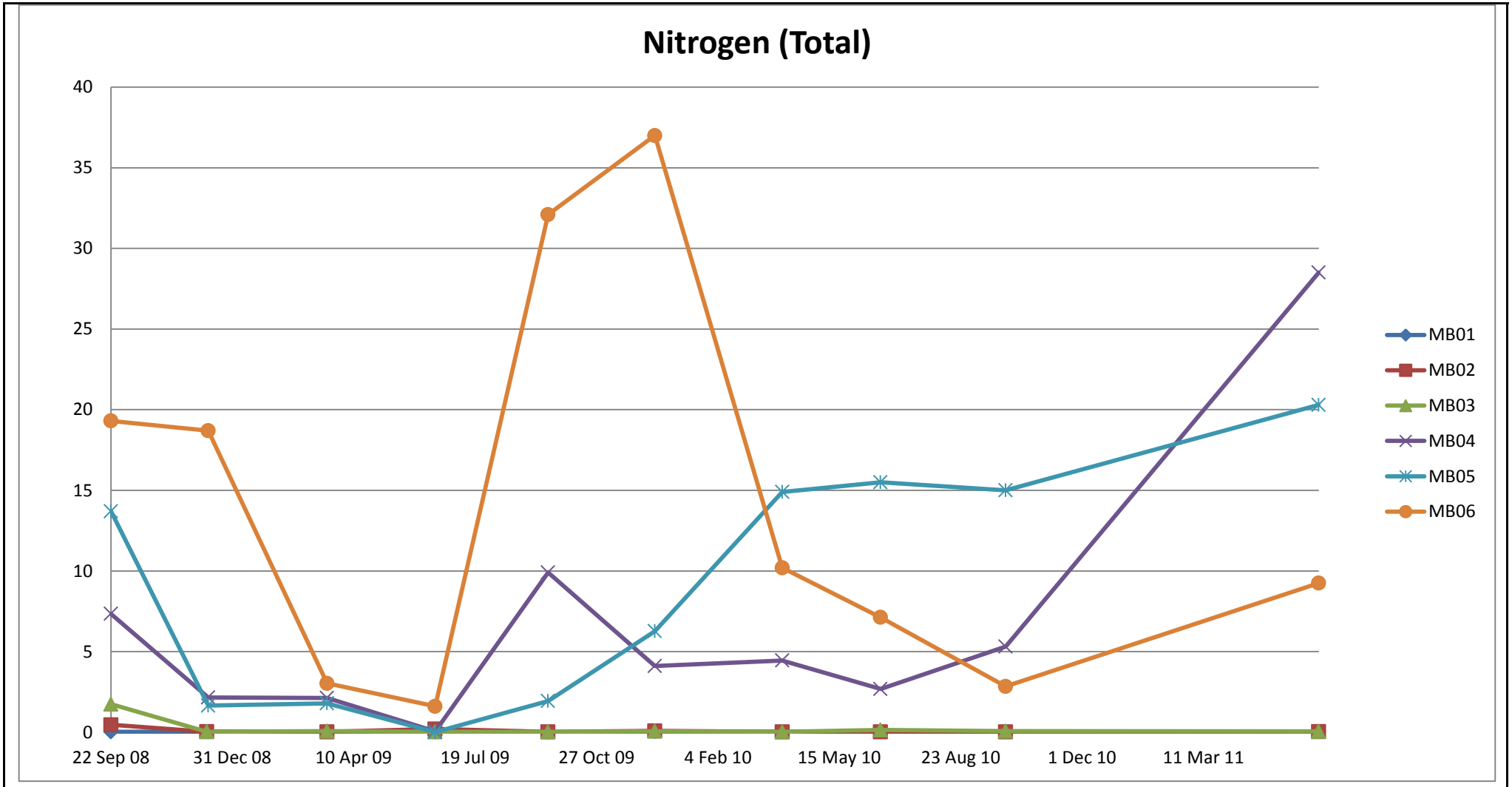
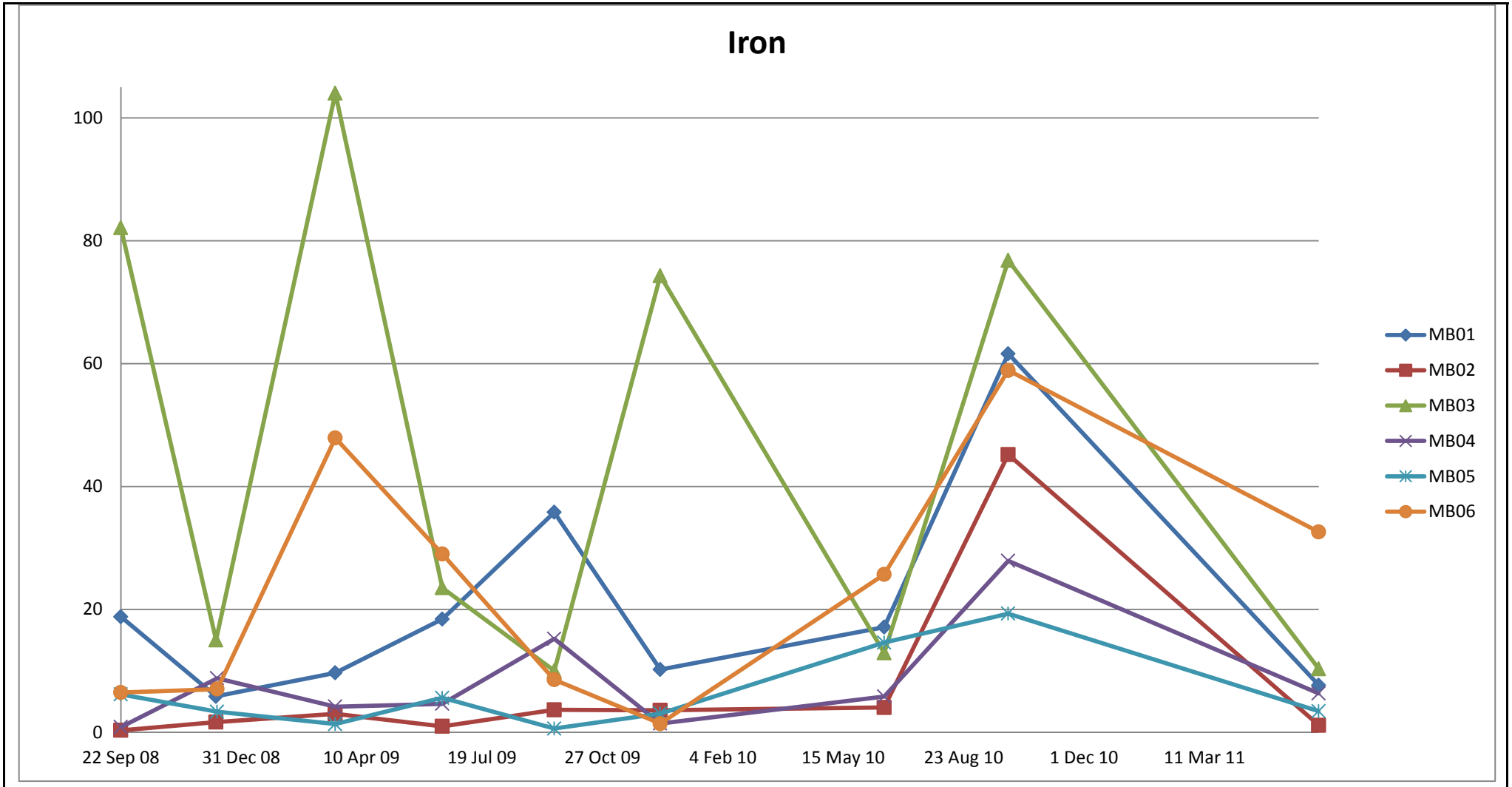


Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

ESDAT

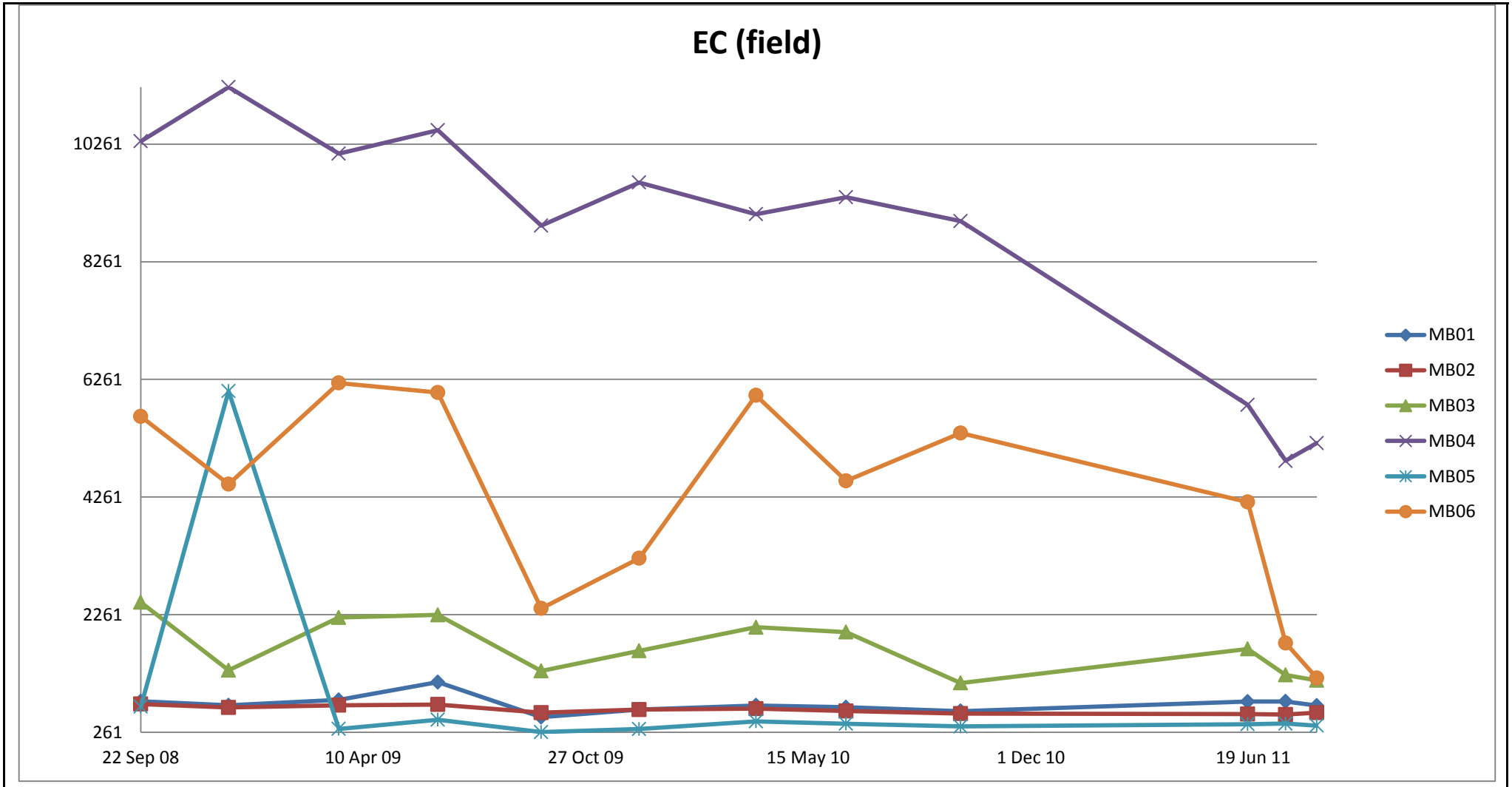


Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	**Drawn:**
Scale: nts	**Chk'd:**
Original:	**Rev:**
File Reference:	

ESDAT



Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

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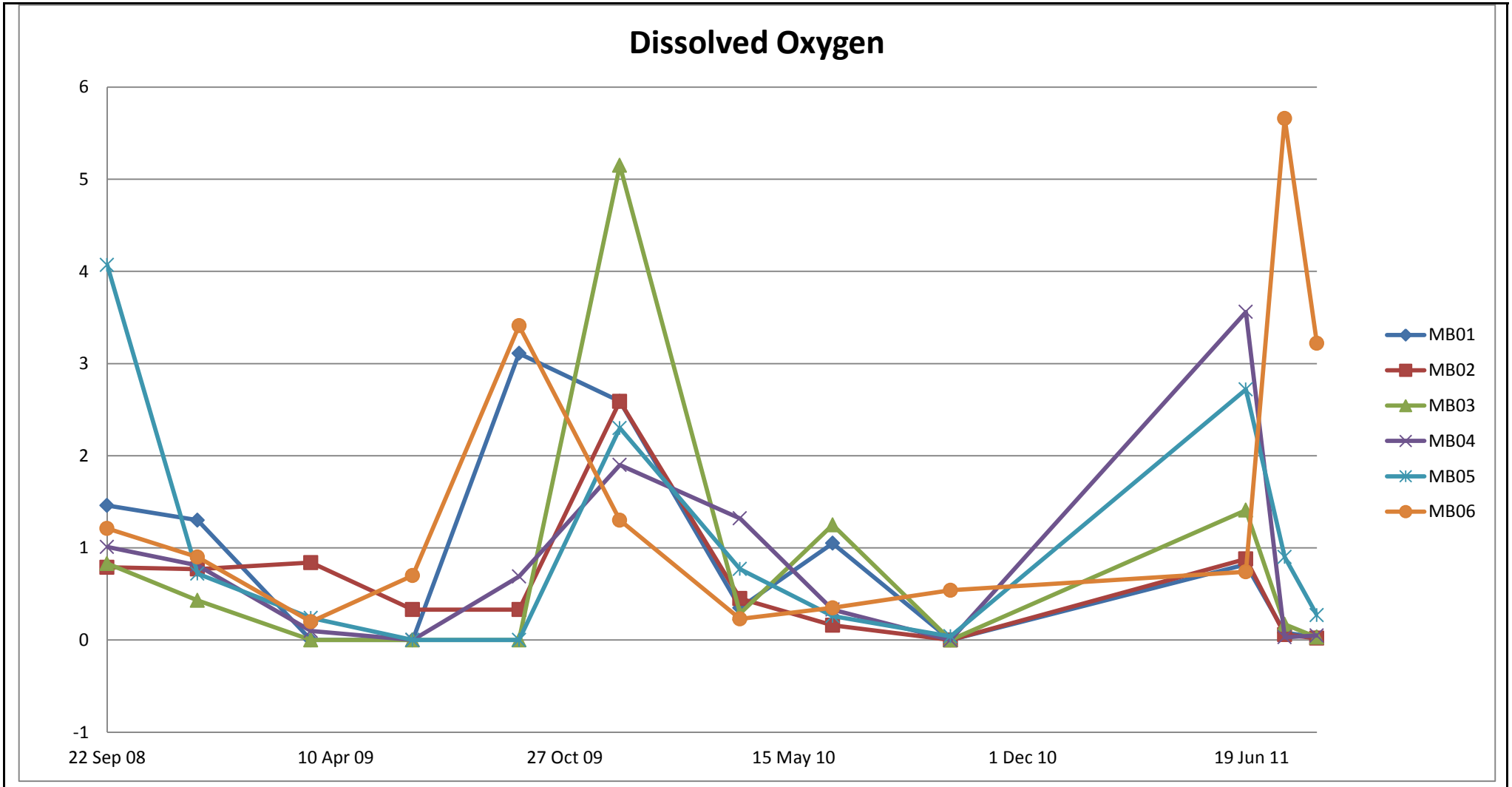

Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

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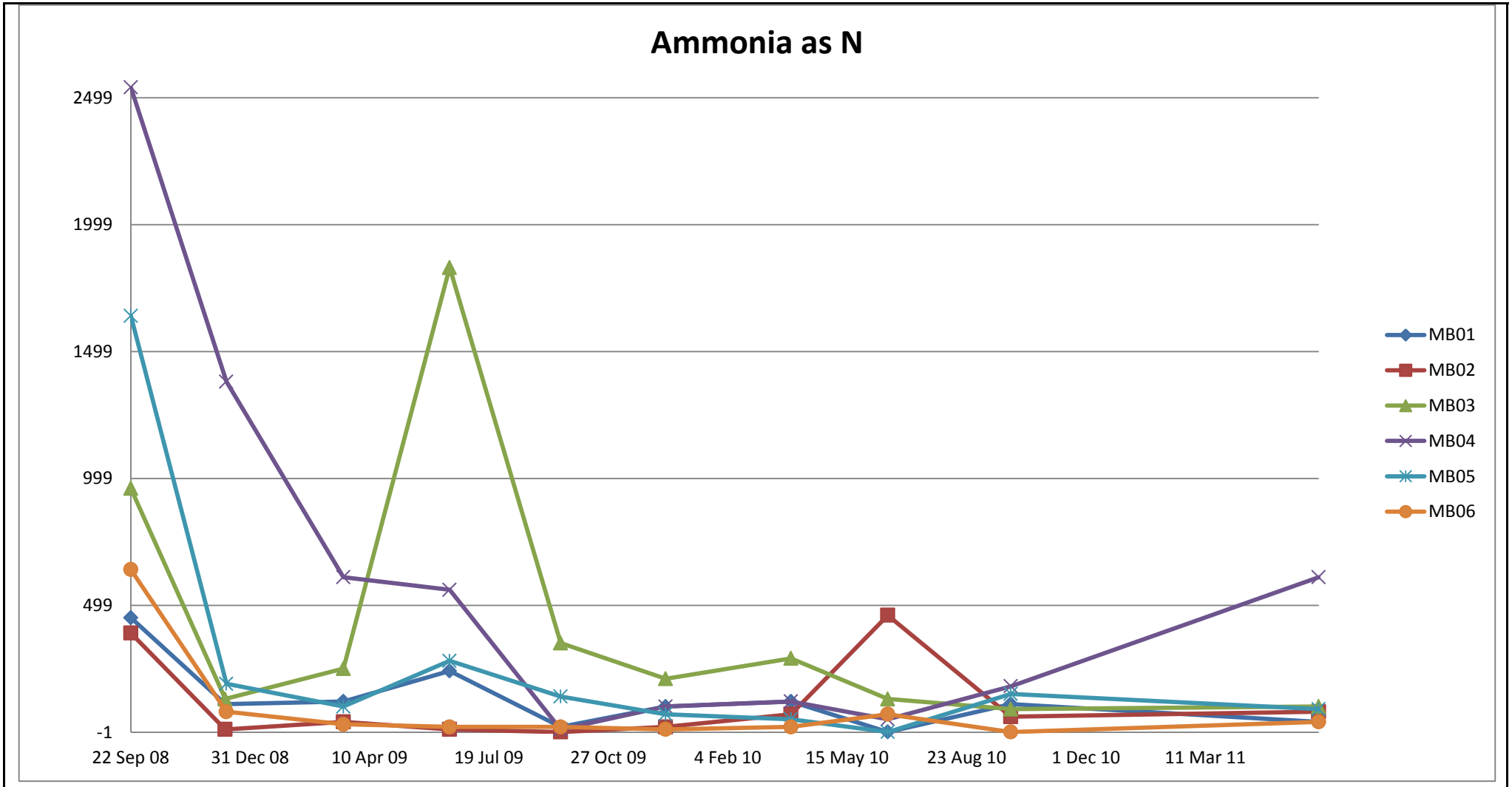


Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	**Drawn:**
Scale: nts	**Chk'd:**
Original:	**Rev:**
File Reference:	

ESDAT

APPENDIX C – Water consumption estimates

Water Use Summary

The Water Use tool is primarily aimed at residential developments but can handle mixed developments.

Developer:	Peet LTD
Development Name:	Lot 50 Mundijong Road
Date Of Entry:	7-Feb-13
Total Area of Development (m^2):	513,817

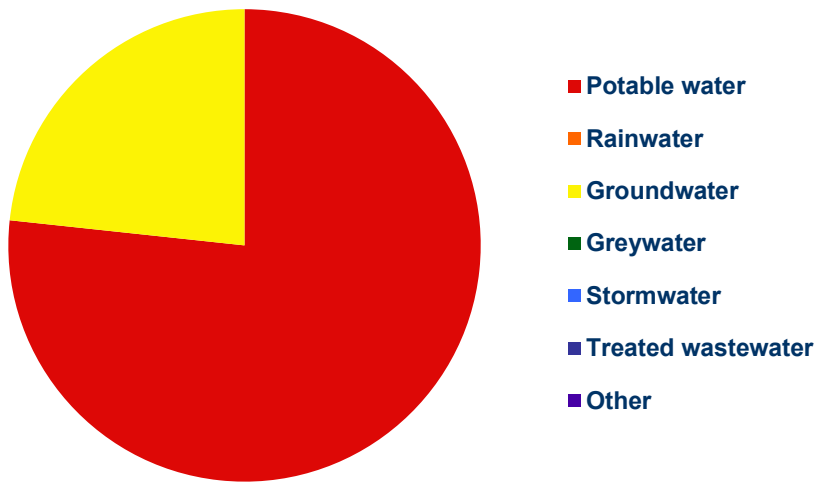
Area Totals Match

Water Demand

Help/Notes (Click)

Water demand by source type in kL/year.

Potable water[1]	151,073
Rainwater	0
Groundwater	45,897
Greywater	0
Stormwater	0
Treated wastewater	0
Other	0



Water Use

Summary in Detail (Click)

Water use for total development and by sub-section.

	Total Water[2] (kL/person/year)	Potable Water[2] (kL/person/year)	Non-Potable Water[2] (kL/person/year)	Development Consumption (kL/year)
Consumption Indicators	96	96	0	196,970

Development Summary

Click on subsection to go to page.

		Area (m^2)	Irrigation (kL/year)	Drinking[1] (kL/year)	Non-Drinking (kL/year)
1.	Residential	275,638	46,887	49,522	38,602
2.	Schools	35,022	13,448	1,568	1,045
3.	Commercial & Industrial				
4.	Public Open Spaces, Roads, Footpaths & Verges	203,157	45,897		
5.	Other				
	TOTAL	513,817	106,233	51,090	39,647

[1] All drinking water needs are met by Potable water.

[2] These consumption indicators relate to the residential segment only.

1. Residential

Please Enter Total Residential Area

Total Area (m^2): 275,638

Area Running Total (m^2): 275,638 **Area Totals Match**

Total Residential Water Use

Summary Page (Click)

Per Capita Summary		Per Year Summary	
kL/Person/Year (Total)[1]	96	kL/Year (Total)[1]	135,011
kL/Person/Year (Potable)	96	kL/Year (Irrigation)	46,887
kL/Person/Year (in-house)[2]	55	kL/Year (Drinking)	49,522
kL/Person/Year (ex-house)	41	kL/Year (Non-Drinking)	38,602
kL/Person/Year (Non-Potable)	0	kL/ha/Year (Irrigation)	1,701
kL/Person/Year (in-house)	0	kL/Year (Potable)	135,011
kL/Person/Year (ex-house)	0	kL/Year (in-house)	76,840
		kL/Year (ex-house)	58,171
		kL/Year (Non-Potable)	0
		kL/Year (in-house)	0
		kL/Year (ex-house)	0

[1]Total refers to Potable & Non-Potable Water

[2]See Parameter & Assumptions for in- & ex-house definitions

Residential Information

Summary Page (Click)

Multiple residency types are possible.

Help/Notes (Click)

Household Type	Lots	Households (per Lot)	Area (m^2/Lot)	Irrigation Area (m^2/Lot)
Lifestyle/Semi Rural	18	1	1,619	194
☐ Traditional	356	1	546	137
☐ Traditional	88	1	☑ 345	86
☐ Cottage	80	1	☑ 272	68
☐ Apartment	2		2,056	452
☐				

Water Sources

Summary Page (Click)

Select possible water sources and their contribution to Irrigation or Non-Drinking water use.

Model only uses water source when check box is ticked.

Source	Select Source(s)	Source Contribution (%) Irrigation	Non-Drinking
Potable water		100	100
Rainwater*		0	0
Groundwater			
Greywater			
Stormwater			
Treated wastewater			
Other		100	
TOTAL ALTERNATE		0	0

Apply Rainwater to:
Irrigation
Non-drinking

* Rainwater proportion calculated automatically and split between Irrigation and Non-drinking

2. Schools

Please Enter Total School Area

Total Area (m^2): 35,022

Area Running Total (m^2): 35,022 **Area Totals Match**

Total Schools Water Use

Summary Page (Click)

Per Year Summary

kL/Year (Total)[1]	16,061
kL/Year (Irrigation)	13,448
kL/Year (Drinking)	1,568
kL/Year (Non-Drinking)	1,045
kL/ha/Year (Irrigation)	3,840
kL/Year (Potable)	16,061
kL/Year (Non-Potable)	0

[1]Total refers to Potable & Non-Potable Water

School Information

Summary Page (Click)

Multiple school sizes are possible.

Help/Notes (Click)

School Type	Students	Area (m^2/School)	Irrigation Area (m^2/School)
Primary School	300	35,022	14,009

Water Sources

Summary Page (Click)

Select possible water sources and their contribution to Irrigation or Non-Drinking water use.

Model only uses water source when check box is ticked.

Source	Select Source(s)	Source Contribution (%) Irrigation	Non-Drinking
Potable water	☐	100	100
Rainwater*	☐	0	0
Groundwater	☐	100	
Greywater	☐		
Stormwater	☐		
Treated wastewater	☐		
Other	☐		
TOTAL ALTERNATE		0	0

Apply Rainwater to:
☑ Irrigation
☑ Non-drinking

* Rainwater proportion calculated automatically and split between Irrigation and Non-drinking

4. POS, Roads & Verges

Please Enter Total POS, Roads & Verges Area

Total Area (m^2): 203,157

Area Running Total (m^2): 203,157 **Area Totals Match**

Total POS, Roads & Verges Water Use

Summary Page (Click)

Per Year Summary

kL/Year (Total)	45,897
kL/Year (Irrigation)	45,897
kL/Year (Drinking)	0
kL/Year (Non-Drinking)	0
kL/ha/Year (Irrigation)	2,259
kL/Year (Potable)	0
kL/Year (Non-Potable)	45,897

[1]Total refers to Potable & Non-Potable Water

POS, Roads & Verges Information

Summary Page (Click)

Help/Notes (Click)

For Active POS, please estimate the total water use by amenities.
E.g. water fountains and shower cubicles.

Public Open Space	Area (m^2)	Amenities (kL/Year)
Active	29,000	
Passive	13,714	
Bushland/Non-Irrigated Areas	13,713	
Roads & Paths	146,730	
Verges		
Street Scaping		

Water Sources

Summary Page (Click)

Select possible water sources and their contribution to Irrigation or Non-Drinking water use.
Model only uses water source when check box is ticked.

Source	Select Source(s)	Source Contribution (%) Irrigation	Non-Drinking[1]
Potable water	☐	0	100
Rainwater[2]	☑	0	0
Groundwater	☐	100	
Greywater	☐		
Stormwater	☐		
Treated wastewater	☐		
Other	☐		
TOTAL ALTERNATE		100	0

Apply Rainwater to:
☑ Irrigation
☑ Non-drinking

[1] Non-Drinking water use for POS amenities.
[2] Rainwater proportion calculated automatically and split between Irrigation and Non-drinking

APPENDIX D – Stormwater modelling parameters & results

Pre-development surface water modelling

A surface water model of the pre-development conditions of the catchment surrounding Precinct E2 was developed using the 2D module of the XP Storm stormwater modelling software. XP Storm is an urban drainage design software package capable of hydrologic and hydraulic modelling of urban catchments. The 2D module of XP Storm models 2-dimensional flow over a grid, rather than via a series of discrete nodes and links. Topographical data, rainfall information and infiltration losses & catchment roughness parameters are input into the 2D module to determine the runoff generated by the catchment and the flow paths and extent of inundation.

The following sections outline the parameters used in the pre-development modelling.

Design rainfall

The 2D module of XP Storm uses rainfall-on-grid to model stormwater runoff from the catchment. Design storm durations varied between 1 hour & 72 hours, to determine the critical duration event for both 5yr & 100yr ARI, and to size the bioretention areas for the post-development scenario. Design rainfall Intensity Frequency Duration (IFD) data was created using the Bureau of Meteorology's online IFD-generator tool.

The data used for the Mundijong site is presented in Table D.1below.

Table D.1 - IFD design data

ARI	Duration					
	Intensity (mm/hr)					
	1 hour	6 hour	12 hour	24 hour	48 hour	72 hour
1 year	17.3	-	-	-	-	-
5 year	27.2	8.7	5.6	3.6	2.3	1.7
100 year	48.1	15.0	9.7	6.3	4.1	3.1

Catchment properties

The catchment parameters for the various landuses included in the modelling are outlined in Table D.2 below.

Table D.2 - Land use & infiltration losses

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Existing roads (impervious)	0.015	1.5 mm	0 mm/hr

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Existing urban (pervious)	0.025	10 mm	4 mm/hr
Existing rural (cleared, with sandy soils)	0.05	10 mm	4 mm/hr
Existing rural (cleared, with clay soils)	0.2	5 mm	1.5 mm/hr

Peak flow rates

Table D.3 below summarises the pre-development peak flow rates at various locations across the catchment for the critical 5yr and 100yr ARI storm event. These locations are shown on Figure 2.7.

Table D.3 - Peak pre-development flow rates

Flow location	Peak flow - 5yr 48hr ARI	Peak flow - 100yr 6hr ARI
A - Lot 9003 Adams St - near Tonkin St	1.2 m^3/s	2.9 m^3/s
B - Lot 7 Adams St - near Livesey St	0.8 m^3/s	1.9 m^3/s
C - Lot 7 Adams St	1.8 m^3/s	4.6 m^3/s
D1 - Lot 50 Cockram St - at Sparkman Rd	1.2 m^3/s	2.1 m^3/s
D2 - Lot 50 Cockram St - south of Sparkman Rd	1.1 m^3/s	3.3 m^3/s
E1 - Lot 119 Sparkman Rd - north-western corner	0.5 m^3/s	1.4 m^3/s
E2 - Lot 119 Sparkman Rd - south-western corner	1.5 m^3/s	3.2 m^3/s
F - Lot 50 Cockram St – western boundary (main drainage outlet)	3.6 m^3/s	7.2 m^3/s
G1 - Lot 50 Cockram St – eastern boundary between Mundijong Rd & Cockram St	1.0 m^3/s	2.5 m^3/s
G2 - Lot 50 Cockram St – south-eastern corner, near Mundijong Rd	0.4 m^3/s	0.9 m^3/s
H - Lot 50 Cockram St – south-western corner	0.5 m^3/s	1.8 m^3/s

Post-development surface water modelling

Post-development stormwater modelling was undertaken using the 'standard' 1D module of XP Storm.

The 1D module uses a standard node & link network to model the hydrology of the urban catchment, and the hydraulic elements such as basins and piped or open drains. The following sections outline the parameters used in the design of the post-development drainage basins and open drains.

Design rainfall

Design storm durations varied between 1 hour & 72 hours, for 1yr, 5yr & 100yr ARI design storms. Design rainfall Intensity Frequency Duration (IFD) data was created using the Bureau of Meteorology's online IFD-generator tool. The data used for the Mundijong site is presented in Table D.1 above.

Catchment properties

The catchment parameters for the various landuses included in the modelling are outlined in Table D.4 & Table D.5 below.

Table D.4 - Post-development land uses

Post-development landuse	% impervious	Catchment area
Residential lots	30 %	28.0 ha
Road reserve	80 % [1]	14.7 ha
POS	5 %	6.3 ha
Schools	10 %	3.5 ha

Note 1: An impervious fraction of 80% is sufficient to allow for the full pavement width, crossovers, footpaths on both sides of the road, and approximately 25-30% of lots to have fully paved front verges.

Table D.5 - Manning's n & infiltration losses

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Impervious surfaces	0.014	1.5 mm	0 mm/hr
Pervious surfaces	0.03	15 mm	4 mm/hr

Peak allowable flow rates

The post-development modelling has allowed for flow from upstream catchments to the east of the site to pass through the Precinct E2 (at pre-development levels). Flow which overflows into Precinct E2 from the north under pre-development conditions will be conveyed to the east along Sparkman Road, as noted in the LWMS for Precinct E1 to the north of the site.

The following peak flow rates have been allowed for in the design of the post-development drainage network:

- Location E
  - 5yr ARI - Q = 2.0 m^3/s
  - 100yr ARI - Q = 4.6 m^3/s
- Location G
  - 5yr ARI - Q = 1.3 m^3/s
  - 100yr ARI - Q = 3.4 m^3/s

The pre-development modelling for the site determined that the peak allowable runoff from Precinct E2 was **1.0 m3/s** and **2.1 m3/s** for the critical 5yr & 100yr ARI events respectively. Based on these flow rates, the storage basins through the site were designed to attenuate post-development runoff to within these allowable levels. The required areas for flood attenuation in the POS areas are shown in Table D.6 below, and also in Figure 5.1.

Table D.6 - Required bioretention & flood storage areas

Basin ref	1yr 1hr ARI bioretention area	5yr ARI flooded area	100yr ARI flooded area
1	370 m^2	1,000 m^2	1,300 m^2
2	540 m^2	1,000 m^2	1,300 m^2
3	1,050 m^2	1,800 m^2	2,300 m^2
4	480 m^2	1,600 m^2	1,900 m^2
5	930 m^2	2,600 m^2	3,100 m^2
6	820 m^2	3,100 m^2	3,900 m^2
7	1,710 m^2	3,400 m^2	3,900 m^2
8	550 m^2	1,000 m^2	2,100 m^2

Table D.7 below shows the peak flow rates from each of the basins through the subdivision. These flow rates are within the allowable (pre-development) flow rates outlined in Section 2.5.1 of this LWMS.

Table D.7 - Peak post-development flow rates from flood storage areas

Basin ref	5yr ARI peak outflow	100yr ARI peak outflow
1	0.1 m^3/s	0.1 m^3/s
2	0.1 m^3/s	0.2 m^3/s
3	0.3 m^3/s	0.5 m^3/s
4	0.1 m^3/s	0.2 m^3/s
5	0.1 m^3/s	0.3 m^3/s
6	0.1 m^3/s	0.3 m^3/s
7	0.2 m^3/s	0.4 m^3/s
8	0.1 m^3/s	0.1 m^3/s
TOTAL	**1.0 m^3/s**	**2.1 m^3/s**