APPENDIX C | LOCAL WATER MANAGEMENT STRATEGY

LOCAL WATER MANAGEMENT STRATEGY

Lot 124 & 125 South Coast Hwy

Marbelup, WA 6330

01/05/2024

DOCUMENT CONTROL

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1 Introduction

1.1 Background

Lot 124 and 125 South Coast Highway, Marbelup Local Water Management Strategy (LWMS), has been prepared by Bio Diverse Solutions on behalf of Dora Porter and Brian Fuller (the land owners) in support of a Scheme Amendment (SA)/rezoning and subsequent future subdivision prepared for the site.

The LWMS provides the framework for the application of total water cycle management to the proposed SA. This is consistent with the Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD), described in the Stormwater Management Manual (DoW, 2007).

1.2 Key Design Principles and Objectives

The LWMS employs the following key documents to define its content, key principles and objectives:

- Stormwater Management Manual for Western Australia (DoW, 2007).
- Better Urban Water Management (WAPC, 2008).

A summary of the key design principles and objectives from these documents is summarised below and provided in Table 1.

1.2.1 Stormwater Management Manual (DoW, 2007)

The Department of Water (DoW), now Department of Water and Environmental Regulation (DWER), released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998. The manual defines and practically describes Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aims to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by the DoW (now DWER), but also by other State and Local Government Authorities and sectors of the urban development industry.

DoW completed a major review of the manual in consultation with a working team comprising industry and government representatives. The revised manual was officially launched in August 2007.

DWER's current position on urban stormwater management in Western Australia, is outlined in Chapter 2: *Understanding the Context of the Stormwater Management Manual for Western Australia* (DoW, 2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long-term.
- Public Health: To minimise public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and water logging.

- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high-quality developed areas, in accordance with sustainability and precautionary principles.

1.2.2 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (BUWM; WAPC, 2008), focuses on the process of integration between land use and water planning. The document specifies the level of investigation and documentation required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This LWMS complies with the BUWM process.

Table 1: Summary of design principles and objectives

Key Guiding Principles		
• Facilitate implementation of sustainable best practice urban water management. • Provide integration with planning processes and clarity for agencies involved with implementation. • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation. • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development.		
Category	**Key Design Principles & Objectives**	**LWMS Criteria**
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the principles of WSUD. • Adopt nutrient load reduction design objectives for stormwater runoff. • Floodplain management and urban drainage. • Adopt treatment train approach.	• Post-development critical peak flows will be consistent with pre-development peak flow at the discharge point of each catchment within the Subject Site up to the 1% AEP. • First 15 mm of rainfall from storm events will be treated at source where possible. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation.
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets. • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems. • Protect the value of groundwater resources. • Adopt nutrient load reduction design objectives for discharges to groundwater.	• Managing and minimising changes in groundwater levels and groundwater quality following development.
Monitoring and Implementation	• Adopt an adaptive management approach. • Maintain drainage and treatment structures.	• Design based on methodology in Stormwater Management Manual of adopting a treatment train including: • structural treatment measures (infiltration storages, plus bio-retention treatment structures). • Non-structural measures to reduce applied nutrient loads. • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
Water Conservation	• Adopt drinking water consumption target. • 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.	• Aim to achieve the State Water Plan target for water use and reduce water use where possible. • Consider alternative fit for purpose water sources where appropriate and cost-effective.

1.3 Suitable Qualified Hydrologist

This LWMS has been prepared by Chiquita Cramer, who has 15 years of experience working as a hydrologist and hydrogeologist.

Chiquita Cramer currently has the following tertiary qualifications:

- Bachelor of Science in Natural Resource Management (University of Western Australia); and
- Graduate Certificate in Hydrogeology (University of Western Australia).

Chiquita completed a Bachelor of Science in Natural Resource Management in 2008 at the University of Western Australia. Chiquita worked as a hydrologist and senior hydrologist at JDA Consultant Hydrologists in Perth for 8 years. Chiquita's experience includes preparation of multiple local and urban water management strategies, hydrological and hydraulic investigations, surface water and groundwater monitoring reports and hydrogeological reports. Chiquita completed a Graduate Certificate in Hydrogeology and in 2017 joined Bio Diverse Solutions (BDS) to provide expertise in hydrology and hydrogeology to the company.

1.4 Location

The Subject Site is defined as Lots 124 and 125 South Coast Highway, Marbelup WA within the City of Albany. The site comprises of ~109 ha and is bound by South Coast Highway to the north, rural residential properties to the south and west and a City of Albany reserve to the east. The Subject Site is shown in Figure 1.

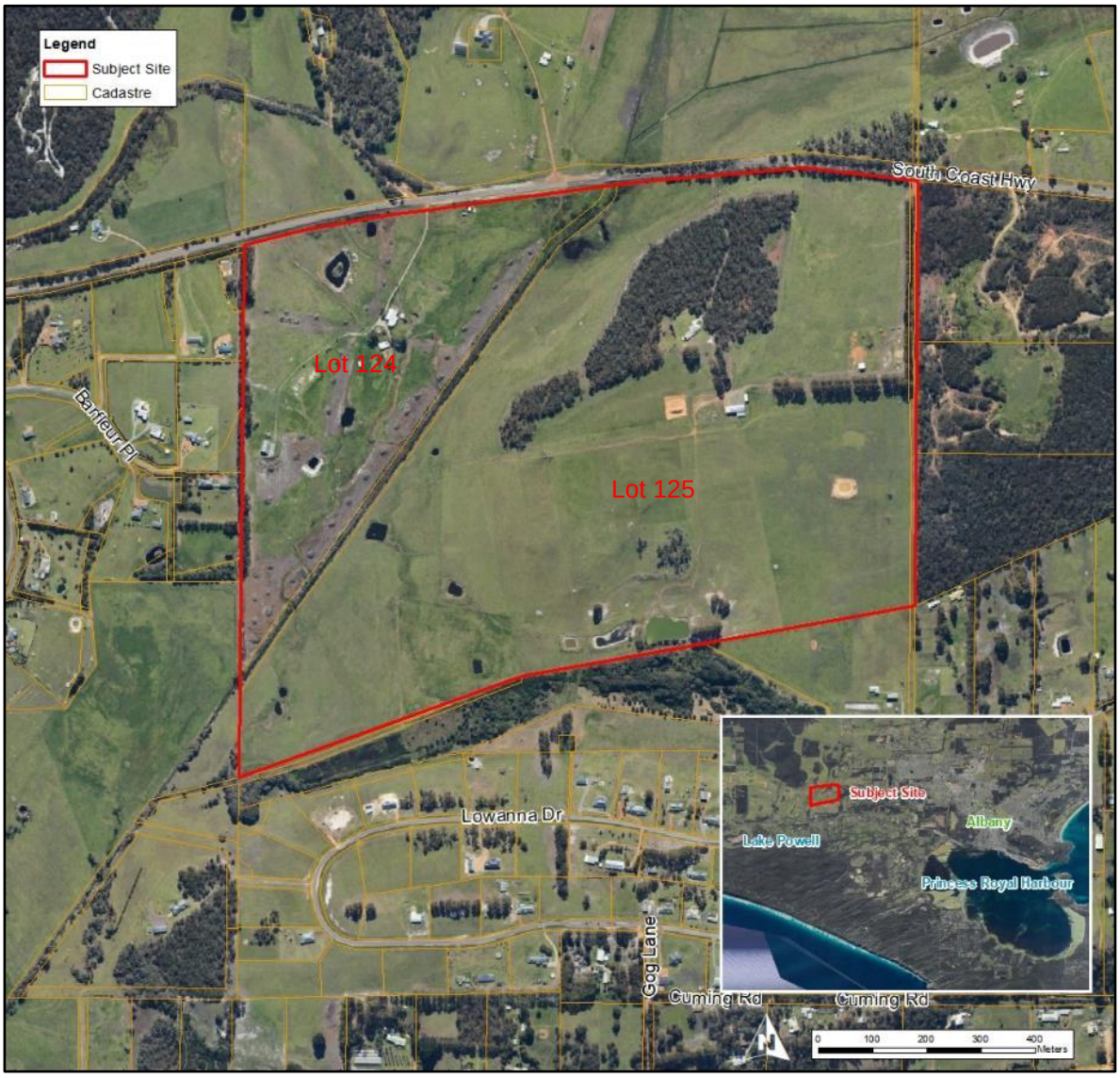


Figure 1: Location Plan

2 Proposed Development

The Subject Site is zoned as *'General Agriculture'* under the City of Albany's Local Planning Scheme No. 1 (DPLH, 2014). It is proposed the Subject Site be rezoned to '*Rural Residential'* and '*Rural smallholdings*', and forms part of a larger plan area that includes Lot 9001 Lower Denmark Road to the southwest of the Subject Site. The Scheme Amendment plan for the site is shown in Figure 2.

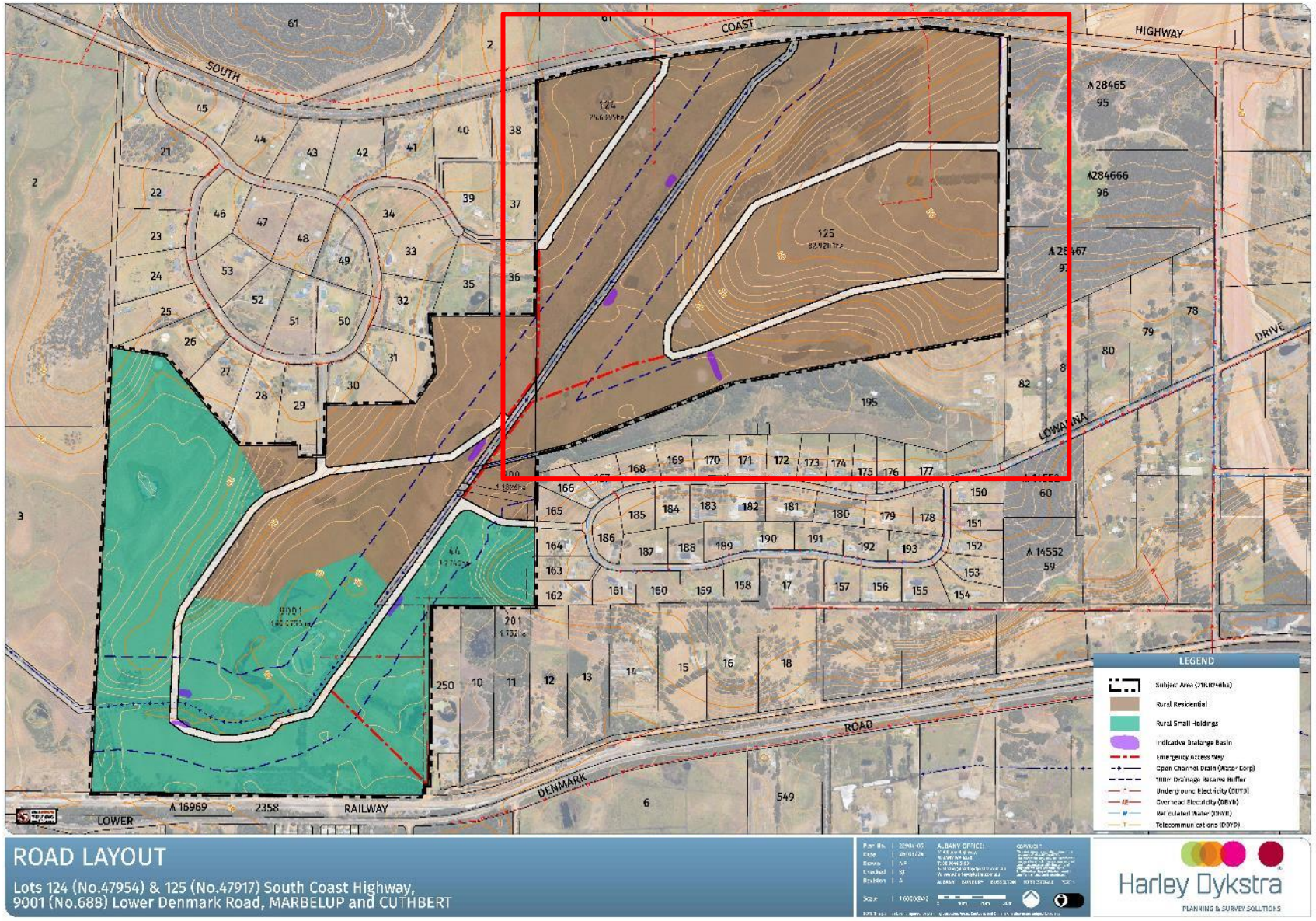


Figure 2: Scheme Amendment Plan. Subject Site is defined by red square.

3 Pre-development Environment

3.1 Existing Land Use

The site currently consists of agricultural land used for mixed cropping and livestock (Photo 1 and 2). There are two residential dwellings on the Subject Site, one to the west of Five Mile Creek, on Lot 124 (Photo 3 and 4) and one to the east on Lot 125. The land immediately south and west of the Subject Site is currently utilised for rural residential living.

Photo 1: East elevation of agricultural land within the Subject Site.

Photo 2: View to the east of cattle within the Subject Site.

Photo 3: View to the east northeast of dwelling within the Subject Site in the northwest.

Photo 4: View to the north northwest of rural residential area to the west of the Subject Site.

3.2 Topography

The Subject Site is elevated in the eastern and central portions of the site with a slight elevation in the northwest. Elevation ranges from a high point of 54 mAHD in the east of the Subject Site, to a lowest point of 12 mAHD in the southwest. Topographic contours (2 metre) are shown in Figure 3.

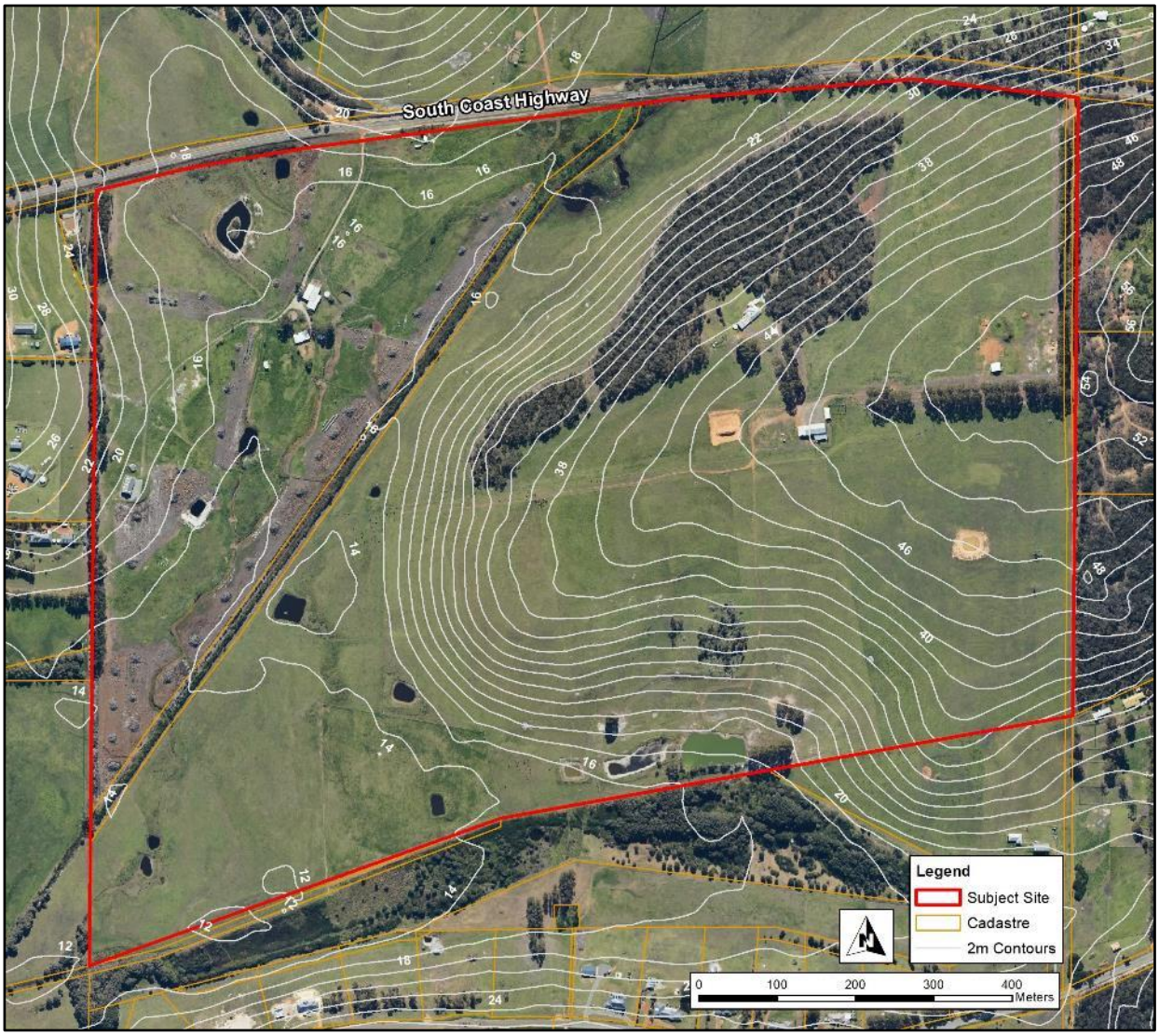


Figure 3: Topography

3.3 Climate

The Albany area is characterised by a Mediterranean climate with warm dry summers and cool wet winters. Rainfall data is from the nearby Bureau of Meteorology (BoM, 2022), Albany Station (Site No. 9500).

The closest open Bureau of Meteorology (BoM) station to the Subject Site, is the Albany Station (009500). The average annual temperature at Albany Station ranges from 8.3-22.9°C. The average summer temperature ranges between 14.1-22.9°C, whilst average winter temperatures range between 8.3-16.7°C. The annual mean rainfall for Albany station is 920.8 mm (BoM, 2023). On average the months of May - September are the months with the highest rainfall (Figure 4). There was a higher than average rainfall recorded in the months of April and June 2022, and October and November 2023.

The average annual pan evaporation for the Albany area is approximately 1397 mm (Luke et al 1988).

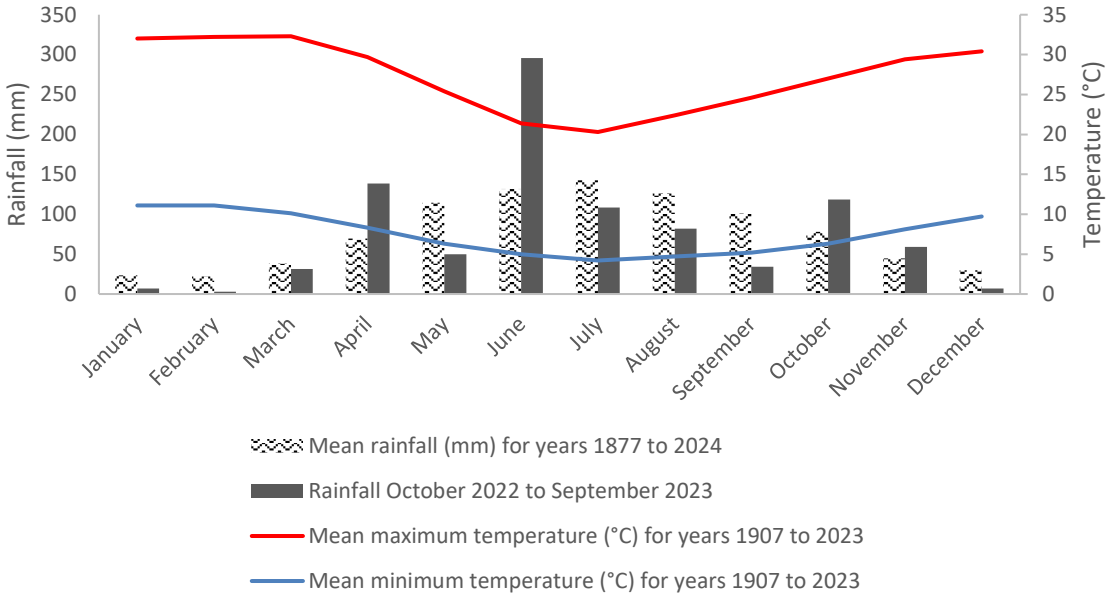


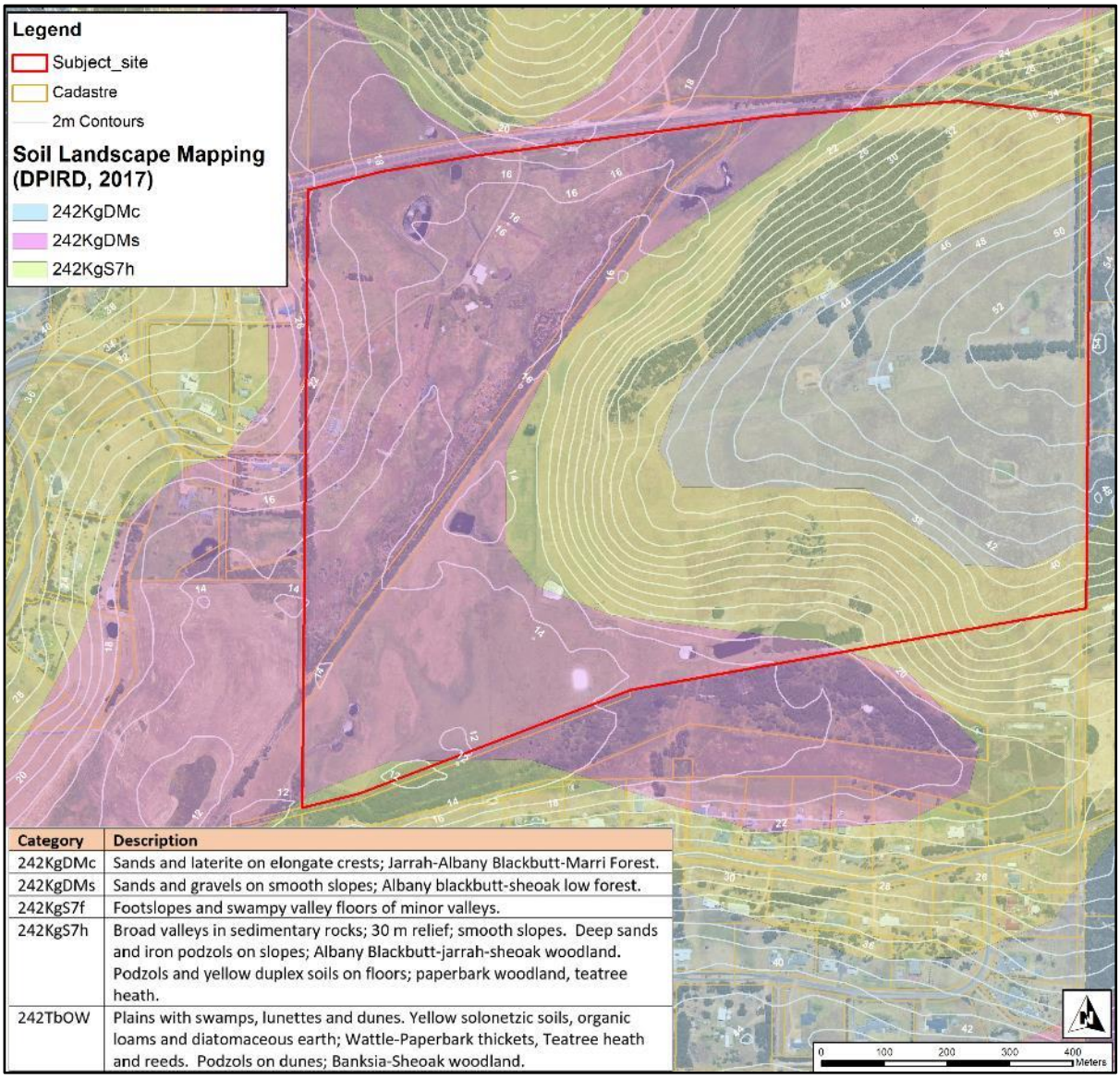
Figure 4: Climate Data for Albany BoM Weather Station No. 009500

3.4 Geology and Soils

Soil mapping – Zones (DPIRD, 2017a) shows the Subject Site lies within one soil zone being; the Albany Sandplain Zone (242). The Albany Sandplain Zone is described as '*Gently undulating plain dissected by a number of short rivers flowing south. Eocene marine sediments overlying Proterozoic granitic and metamorphic rocks. Soils are sandy duplex soils, often alkaline and sodic, with some sands and gravels.'*.

Soil mapping – Systems (DPIRD, 2018) shows the Subject Site lies within one soil systems being; the King System (242Kg). The King System is described as *'Dissected siltstone and sandstone terrain, on the southern edge of the Albany Sandplain Zone, with shallow gravel, sandy gravel, grey sandy duplex and pale deep sand. Jarrah-marri-sheoak woodland and mallee-heath.'*.

The Subject Site is also located within several sub-systems of the King system as defined by DPIRD (2017b). The sub-systems are shown and described in Figure 5.



Category	Description
242KgDMc	Sands and laterite on elongate crests; Jarrah-Albany Blackbutt-Marri Forest.
242KgDMs	Sands and gravels on smooth slopes; Albany blackbutt-sheoak low forest.
242KgS7f	Footslopes and swampy valley floors of minor valleys.
242KgS7h	Broad valleys in sedimentary rocks; 30 m relief; smooth slopes. Deep sands and iron podzols on slopes; Albany Blackbutt-jarrah-sheoak woodland. Podzols and yellow duplex soils on floors; paperbark woodland, teatree heath.
242TbOW	Plains with swamps, lunettes and dunes. Yellow solonetzic soils, organic loams and diatomaceous earth; Wattle-Paperbark thickets, Teatree heath and reeds. Podzols on dunes; Banksia-Sheoak woodland.

Figure 5: Soil Mapping (DPIRD, 2017b)

Site soil testing was conducted on the 19th of October 2021, by Great Southern Geotechnics, under late winter conditions. Testing involved site soil analysis, photographic recording, logging of soil types, measuring of water table and laboratory analysis. In total, 22 test holes were constructed up to a depth of 2 m and left open for a minimum of 1 hour to identify any water table present. The soil investigation for the site is shown in Appendix A, test hole locations are shown in Figure 6.

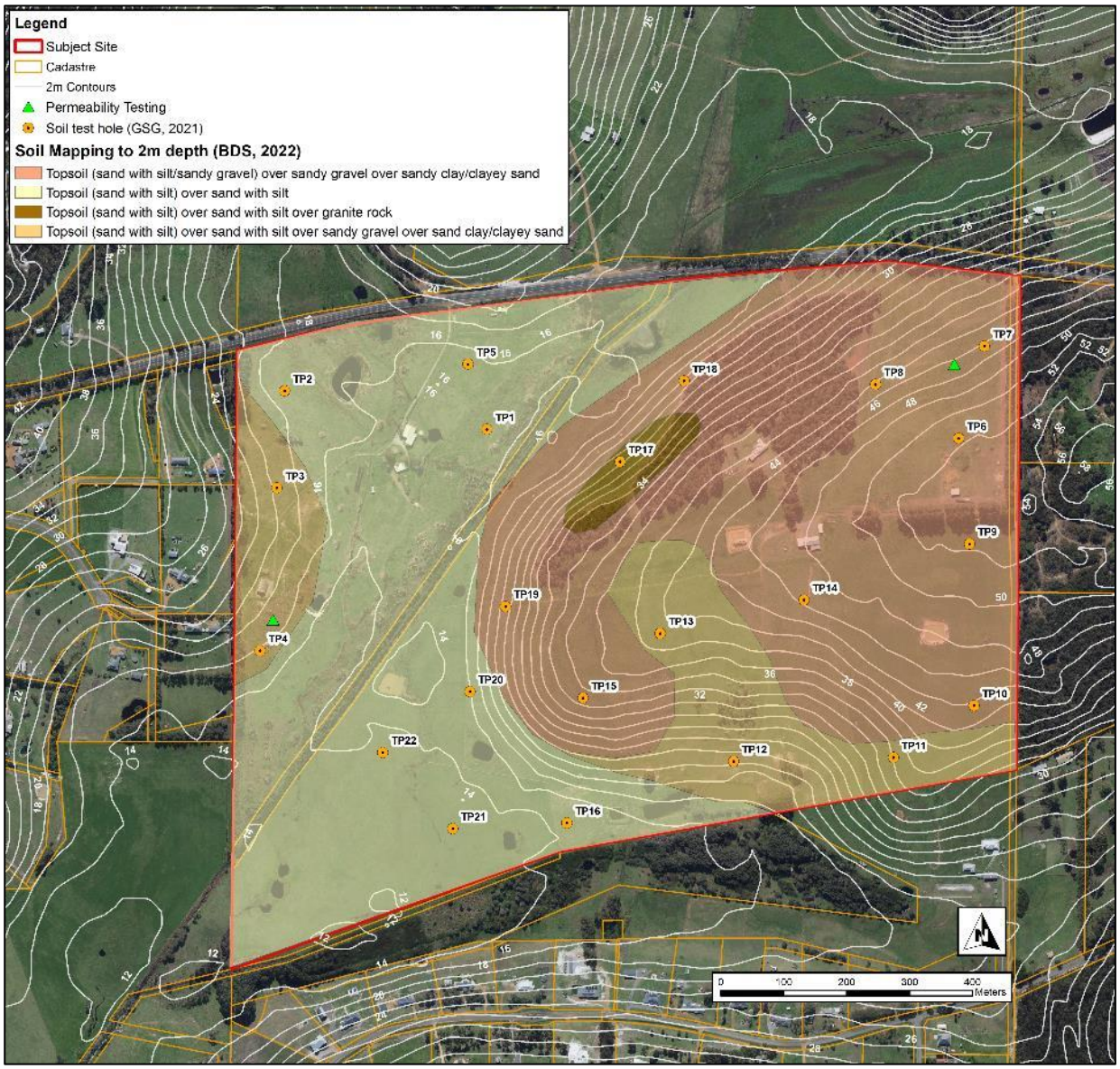


Figure 6: Soil Testing Locations and Soil Mapping

The 22 test pits (TP) revealed that soils across the Subject Site generally comprised of four soil profiles to 2 m depth, being;

- Topsoil (sand with silt), over sand with silt to the depth of the hole;
- Topsoil (sand with silt) over sand with silt (to a depth of between 460 and 1050 mm), over sandy gravel, over sandy clay/clayey sand;
- Topsoil (sand with silt or sandy gravel) over sandy gravel/gravelly sand (to a depth of between 300 and 920 mm), over sandy clay/clayey sand; and
- Topsoil (sand with silt), over sand with silt, over bedrock.

The four soil profiles identified at the Subject Site via the test pits, are mapped in Figure 6. Comprehensive soil logs for each soil testing hole are shown in Appendix A. TP17 was the only test hole to encounter refusal of drilling, which was encountered at 1300 mm depth, refusal was likely a result of hitting bedrock.

3.4.1 Phosphorous Retention Index

Phosphorous Retention Index (PRI) is a measure of the soils ability to absorb and treat nutrients within the soil (i.e., Soil microbe disinfecting ability). Soils with a PRI less than 1 have a very poor ability to treat effluent waters, whilst soils with a PRI of >5 having a high ability to treat effluent waters. PRI testing was conducted at TP4, TP7 and TP12. The PRI results are presented in Table 2.

Table 2: Phosphorus retention index results (CSBP, 2021)

Test Pit	Depth (mm)	Soil Type	Phosphorus Retention Index
TP4	160-1050	Sand with silt	327.4
TP7	180-400	Gravelly sand	810.8
TP12	200-800	Sand with silt	4.9
TP12	800-1000	Gravelly sand	844.0

PRI within the subsurface layers, varied consistent with soil type, as shown in Table 2. The PRI of the gravelly sand layers were found to be extremely high, whereas the PRI of the sand with silt layer varied from moderate to very high, likely dependant on the percentage of silt content.

3.4.2 Permeability

Silts and clay soils generally record poor permeability results whereas coarse sands and loose gravels generally record high permeability, as shown in Figure 7.

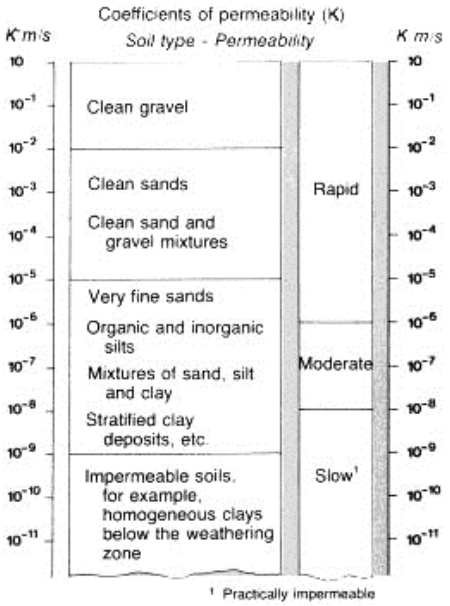


Figure 7: Hydraulic Conductivity of Soil Types (Artiola et al, *2004)*

In-field permeability testing was conducted during the site soil investigation by BDS, adjacent to TP4, within the sand with silt layer (at 500 mm depth BGL) and adjacent to TP7, within the clayey sand with gravel layer (Figure 6). Permeability testing was conducted using the Talsma-Hallam method. The Talsma-Hallam permeameter is suitable for use in soils with permeability in the range 0.009 to 2.9 metres/day ($1x10^{-7}$ to $3x10^{-5}$m/s). Hydraulic conductivity was found to be 1.50 x 10^{-5} m/sec (1.3 m/day) adjacent to TP4, which is considered a moderate to rapid permeability and 3.4 x 10^{-6} m/sec (0.29 m/day) adjacent to TP7, which is considered a moderate permeability.

3.5 Acid Sulphate Soils

Acid sulphate soils (ASS) are naturally occurring soils and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). When undisturbed below the water table, these soils are benign and not acidic (potential acid sulphate soils). However, if the soils are drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid. ASS Risk Mapping indicates the Subject Site lies within an area with moderate to low risk of ASS occurring within 3 metres of natural soil surface (DWER, 2017). ASS Risk Mapping (DWER, 2017) is shown in Figure 8.

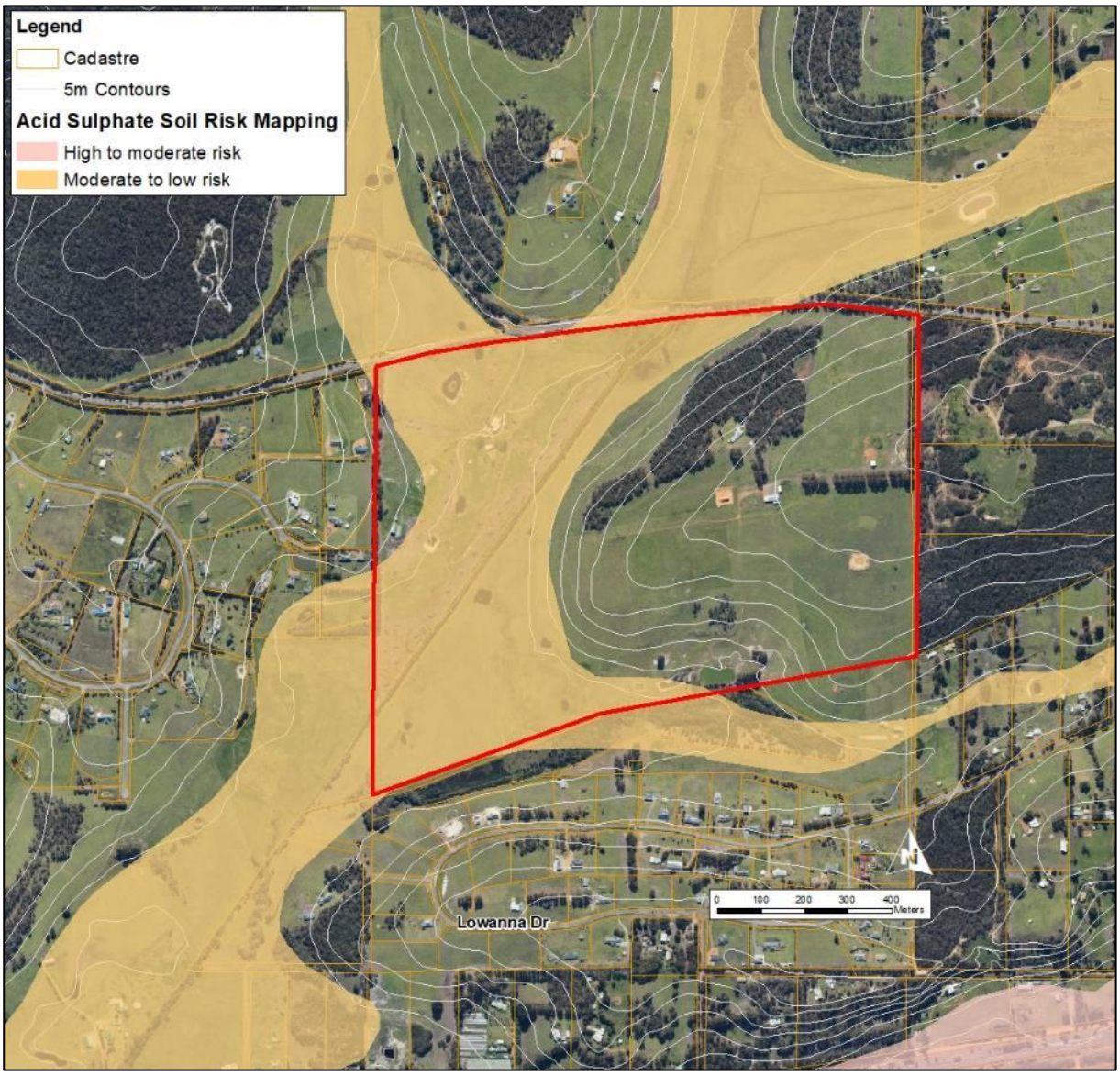


Figure 8: ASS Risk Mapping

An ASS Preliminary Investigation was conducted on the property directly southwest of the Subject Site (Lot 9001 Lower Denmark Road, Cuthbert), on the 15th January 2008, as part of a Land Capability Assessment (Opus, 2007) for the site. Lot 9001 Lower Denmark Road has similar geological and hydrological features as the Subject Site. In summary, the investigation found the peat layers investigated at Lot 9001 Lower Denmark Road, Cuthbert had acidity levels which exceeded DWER Guidelines. However, the acidity was found not to be caused by sulfur and likely to be caused from the mobilisation of hydrolysed ions, likely attributed to iron or aluminium leaching through the soil profile (Opus, 2007).

Soil analysis showed the surface soils had high Electrical Conductivity (EC) and corresponding acidity, which Opus (2007) found is likely attributed to bicarbonate salts and not sulfur salts. Sulfur acidity (ASS) was detected in the soil layers from approximately 1000 mm BGL (Opus, 2007).

Opus (2007) recommended that the site not be excavated deeper than 500 mm to avoid mobilisation and oxidation of ASS. The top 500 mm of soil will still require treatment with lime upon disturbance and ASS shall be managed in accordance with ASS guidelines (Opus, 2007).

3.6 Surface Water Hydrology

The whole of the Subject Site drains towards Five Mile Creek. Five Mile Creek runs through the Subject Site from the central north to the south west of the site. Five Mile Creek connects to Seven Mile Creek to the southwest of the Subject Site and Seven Mile Creek discharges to Lake Powell and ultimately the Torbay Inlet further west. The surface hydrology of the Subject Site is shown in Figure 9.

There are no other major waterways or waterbodies within the Subject Site other than Five Mile Creek. There are several farm dams that are likely to be decommissioned as part of development works. There is also a tributary of Five Mile Creek that runs adjacent to the southern boundary of the Subject Site.

The Subject Site is located within one hydrographic catchment being Torbay Inlet and one hydrographic sub-catchment being Seven Mile Creek (DWER, 2018a).

According to flow modelling conducted for Five Mile Creek by DWER (Pers Comms N.Sykora, 2023), the maximum daily flow rate recorded in Five Mile Creek at the downstream end of the LSP area (DWER station No. 6031115), between 1997 and 2022 is 199,000 m^3. This equates to 2.3 m^3/sec. According to data results for site No. 603115, the highest recorded water level in Five Mile Creek at the downstream end of the LSP area is 10.3 m AHD, which was recorded on the 30th August 2001.

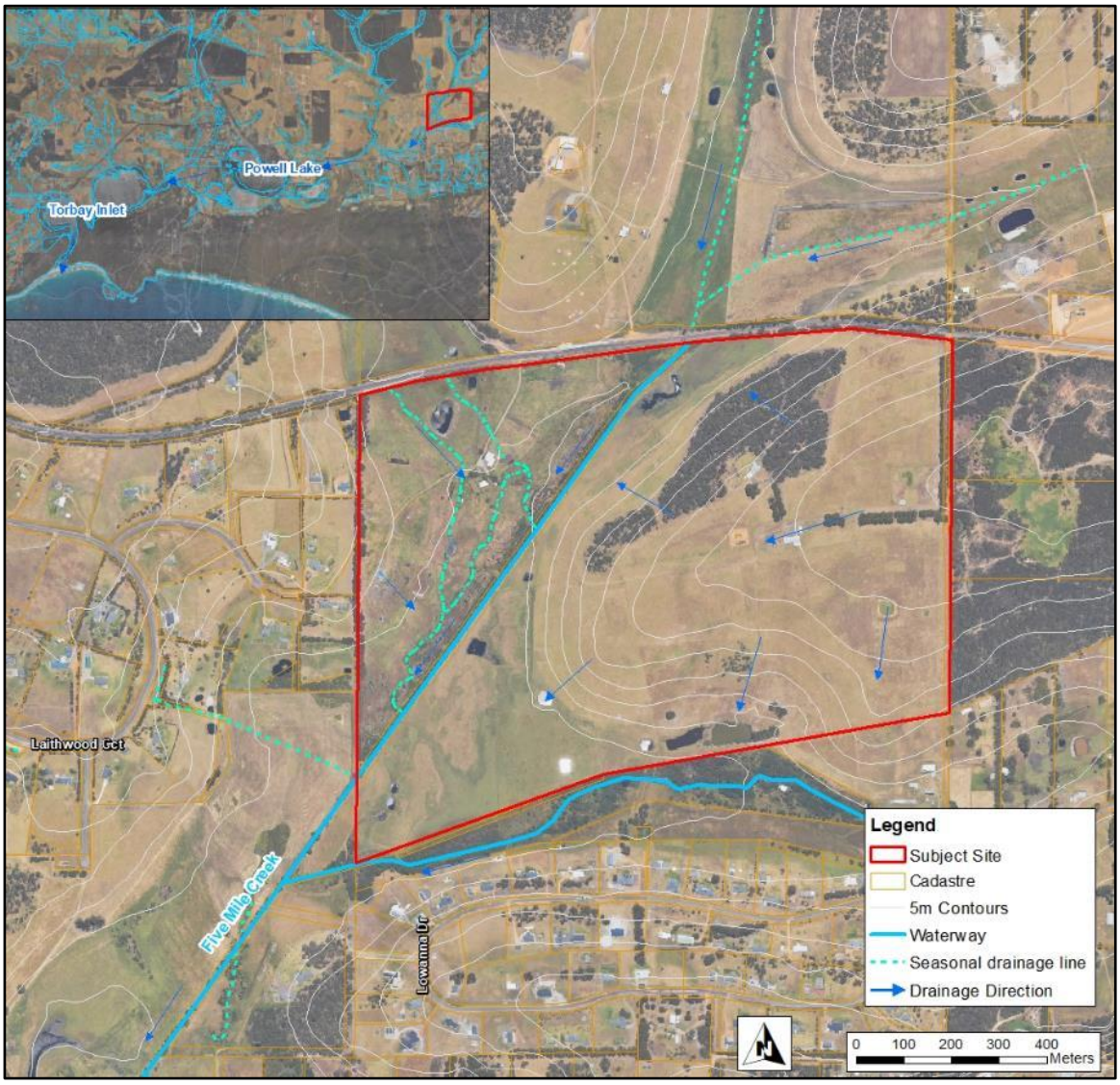


Figure 9: Surface Water Hydrology

3.6.1 Hydrological site assessment

A site investigation of the hydrological features of the site was conducted on the 19th of October 2021 to confirm the surface water hydrology and to assist the development of the stormwater management plan. Rainfall in the Albany area (BoM Station No. 009500) prior to the site investigation, was significantly higher than for the same time in an average year. The increased rainfall resulted in increased surface water expressions in the area compared to an average late winter period providing an adequate depiction of the 'worst case scenario' in terms of seasonal inundation. Photographs 5 to 8 show the hydrological features of the site during the site investigation.

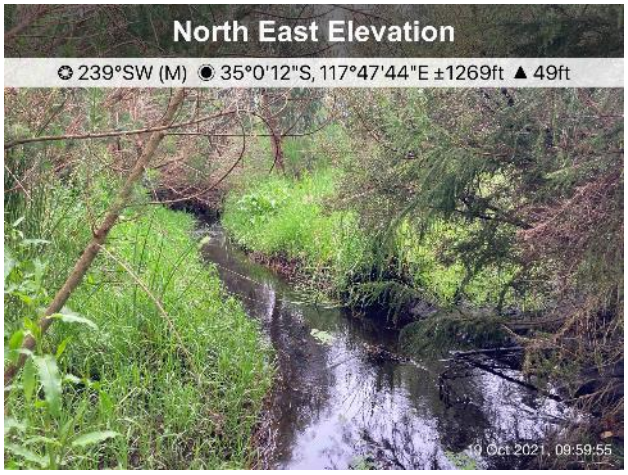


Photo 5: A northeast elevation of Five Mile Creek, centrally located within the Subject Site. This is a general view of Five Mile creek within the Subject Site.

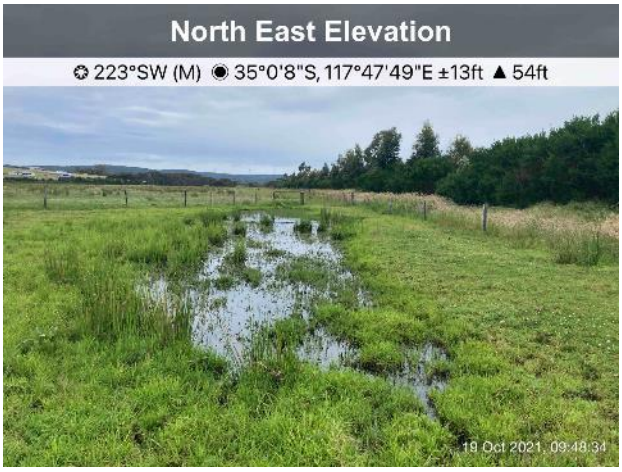


Photo 6: A northeast elevation of a seasonally inundated area adjacent to Five Mile Creek.

Photo 7: A southwest elevation of a farm dam in the northwest of the Subject Site.

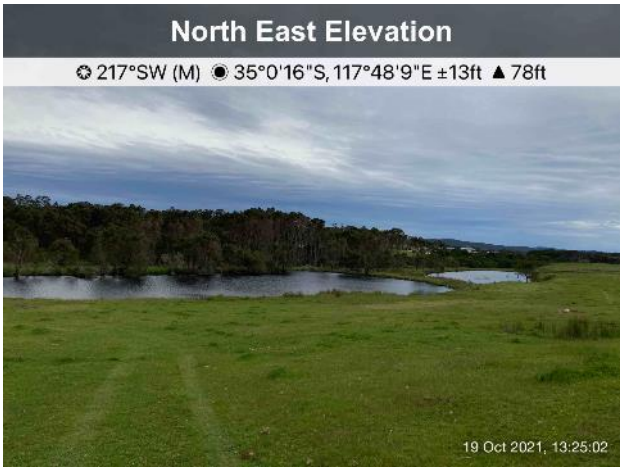


Photo 8: A northeast elevation of farm dams along the southern boundary of the Subject Site.

In-situ water quality testing was conducted at three waterway locations on site. Water quality testing results are presented in Table 3. The surface water monitoring locations are shown in Figure 9.

Table 3: Water quality of Subject Site water bodies

Creek	Temperature (º C)	pH	Electrical Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (g/L)
Dam 1 (Central west)	17.23	5.84	0.339	2.55	0.220
Dam 2 (North west)	17.10	5.81	0.344	3.70	0.225
Five Mile Creek (Central)	15.70	5.85	0.460	5.73	0.299
Five Mile Creek* (South)	11.44	5.93	1.33	5.80	0.851

Note: * Water quality sampling was conducted on a different day (12th Oct 2021)

Water quality testing results found that surface water within Five Mile Creek was slightly saline at the downstream end and reasonably fresh within the central portion of the creek within the Subject Site. The difference in salinity readings within Five Mile Creek is likely due to the different time of sampling and the varying rainfall received prior to the two sampling events. pH in Five Mile Creek and the dams was found to be slightly acidic. A slightly acidic pH is typical of waterways in low-lying areas in the south-west of Western Australia. Dissolved oxygen in Five Mile Creek was slightly lower than expected in a flowing creek and just below the ANZECC & ARMCANZ (2000) trigger value for low-lying rivers in South-west Australia. Dissolved oxygen in the farm dams was also low.

The surface water quality found in Five Mile Creek shall be maintained or improved in the post-development scenario.

3.7 Hydrogeology

Australian Geoscience Mapping and Department of Water and Environmental Regulation 250K Hydrogeological mapping (DWER, 2001) places the Subject Site within two hydrogeological zones as described in Table 4.

Table 4: 250K Hydrogeological zones within Subject Site

Geology Unit	Geology Time	Aquifer Description	Geology Description
TP	Tertiary – Cainozoic – Phanerozoic	Sedimentary aquifer with intergranular porosity - extensive aquifers, major groundwater resources.	PLANTAGENET GROUP - siltstone, spongolite; minor sandstone, peat, and conglomerate.
P_g	Proterozoic	Fractured and weathered rocks - local aquifer, minor groundwater resources.	Granitoid rock, porphyritic and even-grained, generally weathered to clayey sand.

The Subject Site is not situated within a Priority Drinking Water Catchment Area (DWER, 2018b). Desktop analysis of the site indicates that the nearest designated Public Drinking Water Source Area (PDWSA) is the "South Coast Water Reserve", as defined by the *Country Areas Water Supply Act 1947* located approximately 950 m south of the Subject Site.

3.1 Groundwater, Waterlogging and Seasonal Inundation

As determined by the Site Soil Investigation (Great Southern Geotechnics, 2021) on the 19th October 2021, the depth to the peak annual water-table varied across the Subject Site from at ground level in the lower lying areas, to not encountered to 2 m BGL in the elevated areas. The depth to the peak annual water-table at each test hole during the Site Soil Investigation is shown in Table 5, with test hole locations shown in Figure 10.

Table 5: Depth to peak annual water-table

Test Hole	Depth to peak annual water-table (mm BGL)	Test Hole	Depth to peak annual water-table (mm BGL)
TP1	0	TP12	850
TP2	50	TP13	400
TP3	1020	TP14	800
TP4	350	TP15	Not encountered
TP5	50	TP16	0
TP6	Not encountered	TP17	Not encountered
TP7	Not encountered	TP18	Not encountered
TP8	Not encountered	TP19	Not encountered
TP9	Not encountered	TP20	150
TP10	Not encountered	TP21	0
TP11	Not encountered	TP22	550

It is assumed that areas within the Subject Site that have 0.5 m or less separation to the peak annual water-table, are classified as being subject to seasonal waterlogging. The approximated areas subject to seasonal waterlogging at the Subject Site, during the site investigation, along with the peak annual water-table levels recorded at each test hole, on the 19th October, are shown in Figure 10. Figure 10 also shows the areas subject to seasonal inundation (water sitting on the surface for extended periods of time) during the site assessment.

The majority of the area subject to seasonal waterlogging was found to be in the low-lying elevations. TP13 was the only exception to this, situated mid slope, TP13 had a peak annual water-table of 400 mm BGL, this is likely a result of a perched water-table between soil layers in this area.

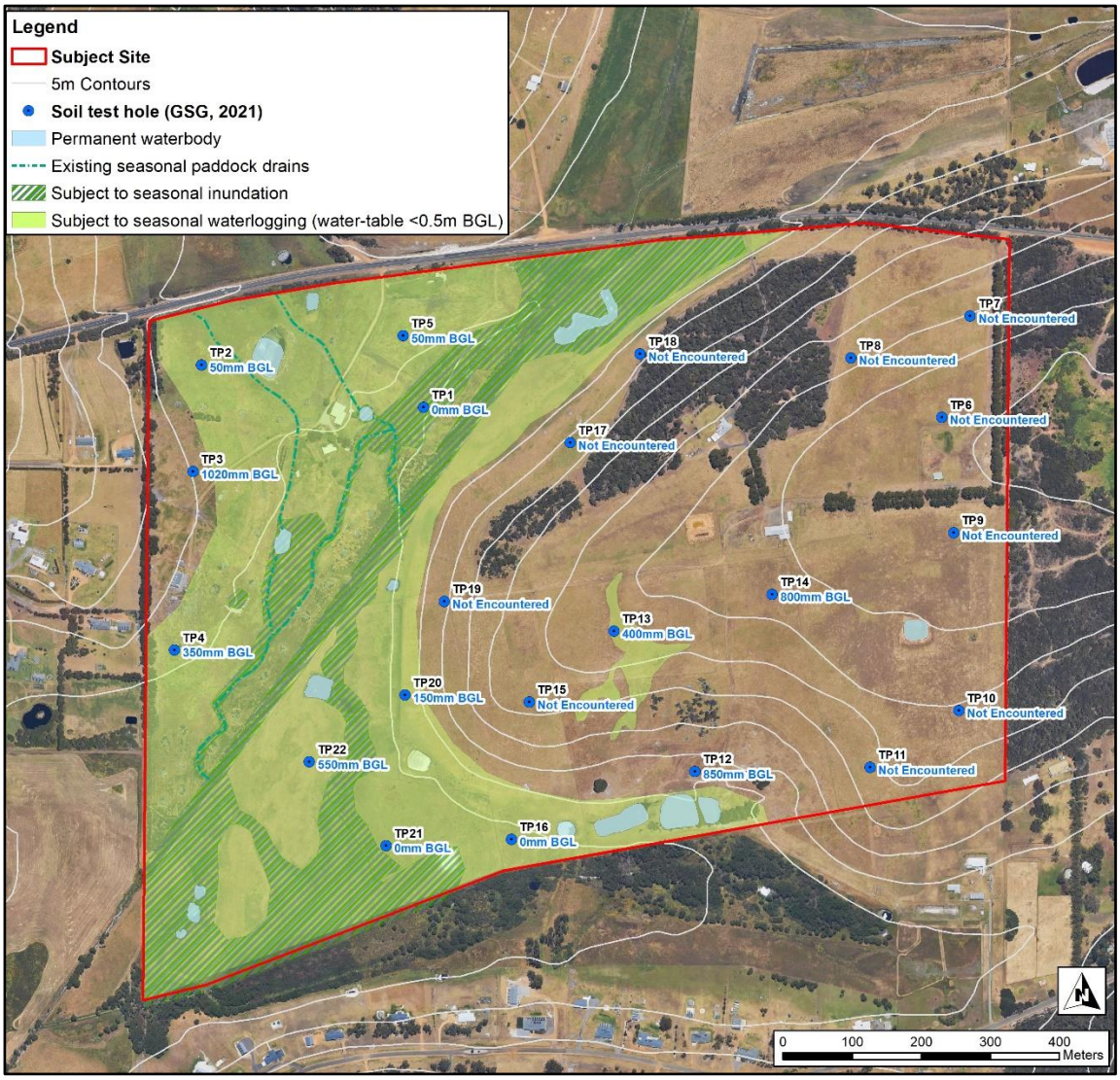


Figure 10: Groundwater levels, seasonal waterlogging and seasonal inundation

3.2 Wetlands

There are no significant wetlands within the Subject Site or within close proximity of the Subject Site. The nearest significant wetland is located approximately 1.1 km to the northwest of the Subject Site, being the Seven Mile Creek wetland. The Subject Site is located down-gradient of the Seven Mile Creek wetland (DBCA, 2017).

4 Wastewater Management

The Subject Site is situated in an area that does not have access to deep or reticulated sewerage. The health and environmental requirements for wastewater treatment and disposal for developments not serviced by deep sewerage systems are contained in the *Government Sewerage Policy* (GSP; DPLH, 2019). The GSP (DPLH, 2019) states minimum requirements apply for all on-site sewage disposal systems.

A Site Soil Evaluation (SSE; BDS, 2024) has been prepared for the Subject Site in conjunction with this LWMS. The SSE details the site soils under late winter conditions and assesses the suitability for on-site effluent disposal across the site in relation to the planning proposal.

In summary, the SSE identifies the areas within the Subject Site suitable for onsite effluent disposal as those that have free draining soil, are not located in heavily waterlogged or seasonally inundated areas and are a minimum of 100 m from Five Mile Creek and it's tributaries, and 30 m from other less significant waterways/waterbodies such as retained dams and seasonal drains (BDS, 2024). Given the shallow depth to groundwater across the western and southern portion of the site, imported fill and special design requirements and distribution techniques will be necessary to ensure that effluent disposal systems are free draining and meet the minimum separation to groundwater requirement stipulated in the GSP (DPLH, 2019).

Leach drains and irrigation systems (surface or subsurface) in conjunction with a secondary treatment system, have been identified as the most suitable land application systems for future lots, depending on localised site constraints. Areas deemed as suitable for LAAs and LAA specifications are described in more detail in the SSE (BDS, 2024).

5 Local Water Management Strategy

5.1 Water Sustainability Initiatives

5.1.1 Water Supply

Water supply to households is to be via extension of the scheme water system. The project civil engineer will negotiate the extension of the system with Water Corporation Western Australia.

5.1.2 Water Efficiency Measures

To achieve water efficiency targets, households are to be built consistent with current Building Code of Australia (BCA) water efficiency standards. Water efficiency initiatives are proposed to reduce potable water demand for irrigation of residential lots. These include encouragement of:

- Minimising turf areas;
- Selection of predominantly local native, drought tolerant plants;
- Use of waterwise gardens, restricted lawn areas and water wise lawn varieties;
- Use of rainwater tanks, and
- Community education initiatives on water conservation and reuse.

5.2 Stormwater Management

5.2.1 Design Capacity

The stormwater management system for the development has been designed in accordance with DWER guidelines, through the Better Urban Water Management framework and the requirements of the local government. The stormwater drainage system has been designed using a major/minor approach.

The stormwater drainage system is designed to manage a range of rainfall events up to 1% AEP.

The major drainage system is designed for rainfall events greater than the 20% AEP, up to the 1% AEP. The major system uses overland flow paths, which includes grading the road network to direct flow to the lowest point of the catchment for flood mitigation.

The minor drainage system has capacity for frequent rainfall events up to the 20% AEP and includes the pipe drainage system and use of bio-retention storages. The minor drainage system is designed to also provide the structural controls for water quality treatment.

5.2.2 Stormwater Modelling

The stormwater modelling has been completed utilising the Rational Method and the Boyd Equation. A critical design criterion for both these methods includes the runoff coefficients. The pre-development and post-development runoff coefficients assumed for the Subject Site, are shown in Table 6.

Table 6: Runoff coefficients

LAND USE	RUN OFF COEFFICIENT		
	First 15mm	20% AEP	1% AEP
Agricultural land	0	0.2	0.3
Road Reserve	0.8	0.8	0.9
Rural Residential	0	0.3	0.35

The general pre-development hydrological regime (Figure 9), is maintained in the post-development scenario, with the majority of the Subject Site proposed to discharge to Five Mile Creek either directly, via the internal road network or via the creek running along the southern boundary of the site.

The majority of the area proposed as Rural residential lots, will discharge unattenuated from the site towards Five Mile Creek or the creek along the southern boundary that discharges to Five Mile Creek, consistent with the existing hydrological regime. It is assumed that the majority of the lot area will remain grassed and/or vegetated with roofed areas connected to rainwater tanks, soakwells and/or rain gardens and therefore there will be little change in the runoff coefficient of these areas compared to the pre-development scenario. Where lots are upgradient of the internal road network, the road network will intercept runoff from the lots and direct it to the road's drainage system. Lot areas that discharge to the internal road network therefore form part of the site's drainage sub-catchments, as shown in Figure 11. The total area of each sub-catchment and the estimated land use area for each sub-catchment is presented in Table 7.

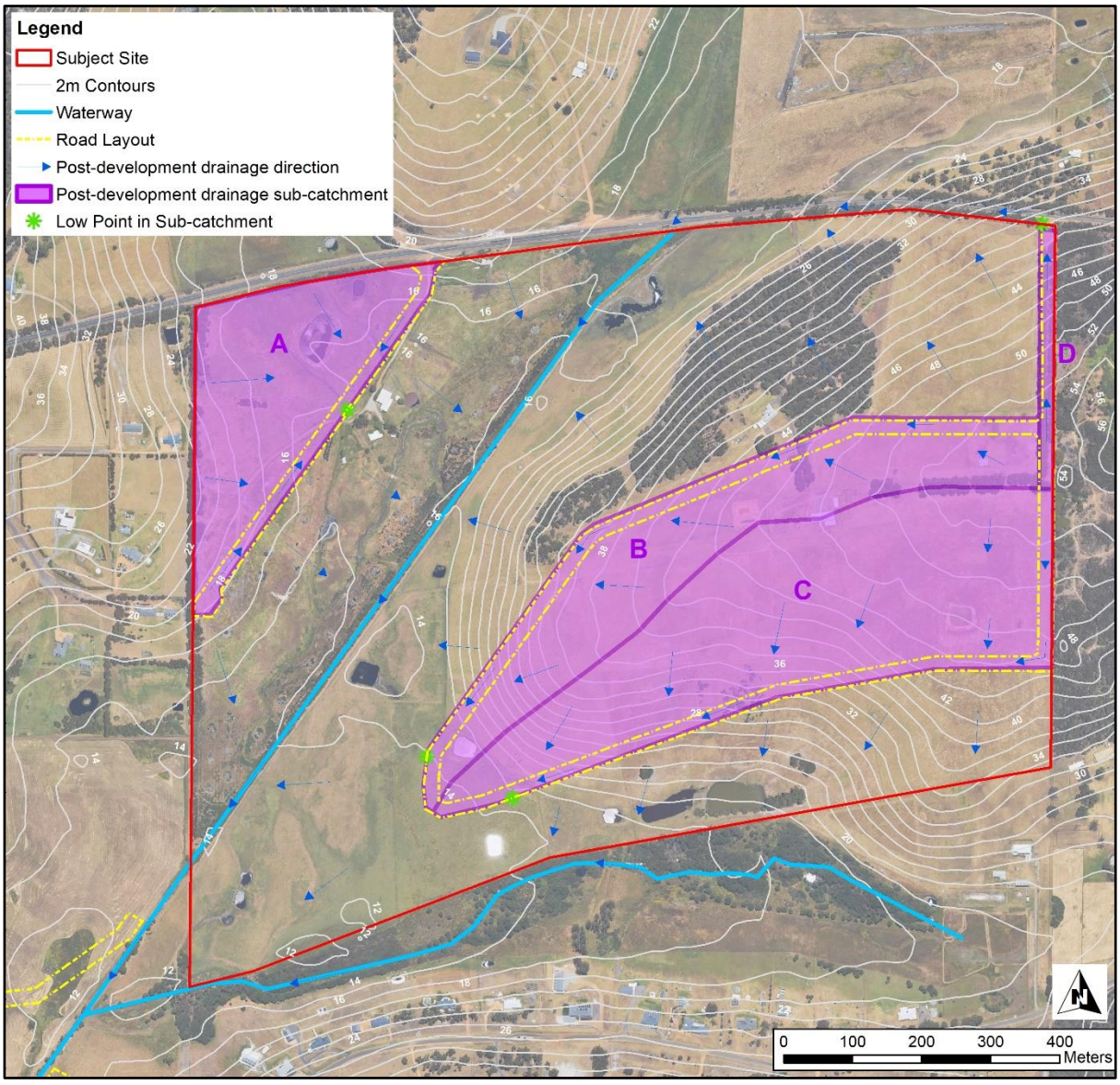


Figure 4: Post-development Drainage Catchments

Table 7: Post-development catchment areas

Land Use	Catchment			
	A	B	C	D
Road Reserve (ha)	1.3	2.2	2.3	0.8
Rural Residential (ha)	7.5	9.3	15.8	0
Total Area (ha)	**8.8**	**11.5**	**18.1**	**0.8**

Runoff from the Subject Site's internal road network will be retained on site within bio-retention storages with outflows from the bio-retention storages directed to Five Mile Creek. Outflow from the bio-retention storages will be consistent with estimated pre-development flow rates.

Multiple storm events have been modelled utilising the Rational Method, as described in Australian Rainfall and Runoff (AR & R) (Engineering Australia, 2001). Pre-development outflow rates have been calculated based upon peak flow stream discharge as determined by Section 1.4 of AR & R.

Rainfall intensities for the various storm events and storm durations are calculated and provided by the Bureau of Meteorology (BoM) computerised design Intensity Frequency Duration (IFD) Data System (www.bom.gov.au). Calculations have been undertaken utilising up to date IFD charts.

The Boyd method has been utilised to calculate the stormwater storage volume required for each sub-catchment based on the post-development runoff from the site and the allowable outflows set for the stormwater storages, which are determined by the peak pre-development outflow rate. The Boyd method is considered a conservative estimate of stormwater storage volume calculation.

5.2.3 Drainage System Requirements

Key elements of the proposed drainage system are as follows:

Lot Attenuation

- It is the landowner's responsibility to manage stormwater runoff from buildings, hard stand (impervious) areas and gardens within the property boundary consistent with the City of Albany's lot attenuation guidelines. I.e., 0.5 m^3 of storage is required per 100 m^2 of impervious area. Lot stormwater management systems should be assessed and approved by the City of Albany upon Development Application.
- Rainwater tanks are recommended on all lots and shall be plumbed into homes using a mixed demand system or a trickle feed system to provide available storage for recurrent storm events.
- Soakwells shall only be utilised where there is adequate separation to the peak annual water-table from the base of the soakwell (>300 mm) and adequate gradient for graduated pipe overflow pipes. In areas with shallow depth to groundwater, attenuation basins integrated into the garden landscaping will provide the most effective attenuation mechanism. When designing lot stormwater management systems, overland flow routes directing runoff away from buildings and adjoining properties shall be considered. Lot stormwater management systems should be assessed and approved by the City of Albany upon Development Application.

Stormwater Conveyance

- Roadside swales designed to convey storm events up to the 20% AEP and where required, pipe drains to connect sections of swale sized to convey the 20% AEP storm event. Pipe drains include lot crossovers which shall be constructed prior to subdivision to ensure the integrity of the drainage system is maintained.
- Roadside swales shall have a minimum side slope of 1:4 between the road and swale and 1:5 between the lot boundary and swale for ease of maintenance. The swales shall be designed with adequate

grade for peak runoff conveyance, the minimum longitudinal grade criterion for the swales is 1:200 (0.005). The estimated capacity and top water level of each section of swale shall be calculated using the Manning's formula or appropriate modelling software subsequent to earthwork design, once the incoming sub-catchment to each swale section is confirmed.

- Road drainage from storm events greater than the peak 20% AEP event up to the peak 1% AEP event will be directed to the lowest point in each catchment via overland flow along the road pavement. The ultimate road low point will be located adjacent to Five Mile Creek in each sub-catchment to ensure road runoff is directed off site during storm events greater than the 20% AEP. Runoff from storm events greater than the 20% AEP event will be directed off site unattenuated. Attenuation of flows for storm events greater than the peak 20% AEP event, up to the peak 1% AEP event are likely to have negligible impact on the flood regime of the downstream area.

Bio-retention and Stormwater Storage

- Drainage treatment train utilising bio-retention storages, designed to treat the first 15 mm of rainfall, by providing infiltration close to source. Bio-retention storages shall be designed to convey up to the 20% AEP storm event. Storages will be located at the low point of the sub-catchments, to direct runoff away from infrastructure in the case that the capacity of the storage is exceeded. The bio-retention storages shall be located outside of Five Mile Creek and its flood/riparian vegetation zone. A conceptual cross section of the bio-retention storage is shown in Figure 12 and sizing of the bioretention storages for each sub-catchment is shown in Table 8.
- The maximum side slopes of the bio-retention storages shall be 1:6, with at least 0.3 m of freeboard provided between the 20% AEP top water level and top of bank. A stabilised low point in the bank shall be provided at the 20% AEP top water level, located downstream in the bio-retention storage so that overflow is directed off site when/if the capacity of the storage is exceeded.
- The base of the bio-retention treatment area shall be underlain with 0.4 m depth of amended soil, 0.15m depth of a transition layer (coarse sand) and 0.15 m depth of a drainage layer with 100 mm (maximum) perforated collection pipes (subsoils), as shown in Figure 12. Bio-retention treatment areas shall be planted, the specifications for the amended soil and the planting are provided in Section 5.4.
- Outflow from the bio-retention treatment area of the storage for minor storm events (up to the 20% AEP) shall be set at the top water level of the first 15 mm runoff event, this is set at a maximum depth of 0.3 m to allow for adequate water quality treatment across a larger surface area. Outflow from the treatment area will be via an overflow pit sized to match the peak pre-development outflow for the 20% AEP storm event for each catchment (Table 8).
- Outflow from the bio-retention storages for minor storm events (up to the 20% AEP) shall be set at the top water level of the first 15 mm runoff event, this is set at a maximum depth of 0.5 m to allow for adequate water quality treatment across a larger surface area. Outflow from the storages will be via an overflow pit sized to match the peak pre-development outflow for the 20% AEP storm event for each sub-catchment (Table 8).
- Outflow from bio-retention storages in Sub-catchments A and B will discharge to Five Mile Creek. Outflow from Sub-catchment C will discharge to the Five Mile Creek tributary to the south of the Subject Site, whilst Sub-catchment D will discharge to South Coast Highway and ultimately Five Mile Creek further downstream. The Sub-catchment D bio-retention storage is proposed to be a swale within the road reserve with side slopes consistent with that specified for roadside swales and all other specifications consistent with a bio-retention storage. Measures shall be taken at the downstream end of the storage outlets to ensure scouring and movement of sediment is minimal, this may include rock pitching and stabilisation matting.
- All bio-retention/stormwater storages shall be contained within easements and have adequate access for maintenance. Bio-retention storages located adjacent to Five Mile Creek shall be located outside of the designated creek easement.

Flood Protection

- All building pad finished levels shall have a minimum of 0.3 m separation above the estimated 20% AEP top water level in the bio-retention storages and above the 1% AEP top water level in nearby waterways and waterbodies consistent with the Local Government Guidelines for Subdivisional Development (IPWEA, 2017).
- All roads shall have a minimum separation of 0.3 m above the 20 % AEP top water level in the bio-retention storages and nearby waterways and waterbodies.
- Building pads shall be set back a minimum of 100 m from Five Mile Creek for both flood protection and environmental protection of the waterway.

The First 15mm, 20% AEP and 1% AEP storage requirements are presented in Table 8. The stormwater management plan for the Subject Site is shown in Figure 12.

Table 8: Drainage system requirements (bio-retention storages)

	Catchment			
	A	**B**	**C**	**D**
First 15mm				
Runoff Volume (m^3)	156	264	276	96
Storage Volume required (m^3)	156	264	276	96
Maximum Ponding Depth (m)	0.5	0.5	0.5	0.5
20% AEP				
Critical Storm Duration (hours)	1	1	1	1
Storm Duration Runoff Volume (m^3)	671	928	1342	131
Storage Volume (m^3)	312	459	604	98
Maximum Ponding Depth (m)	0.9	0.9	0.9	0.6
Allowable Outflow from Storage (L/s)	100	130	205	9

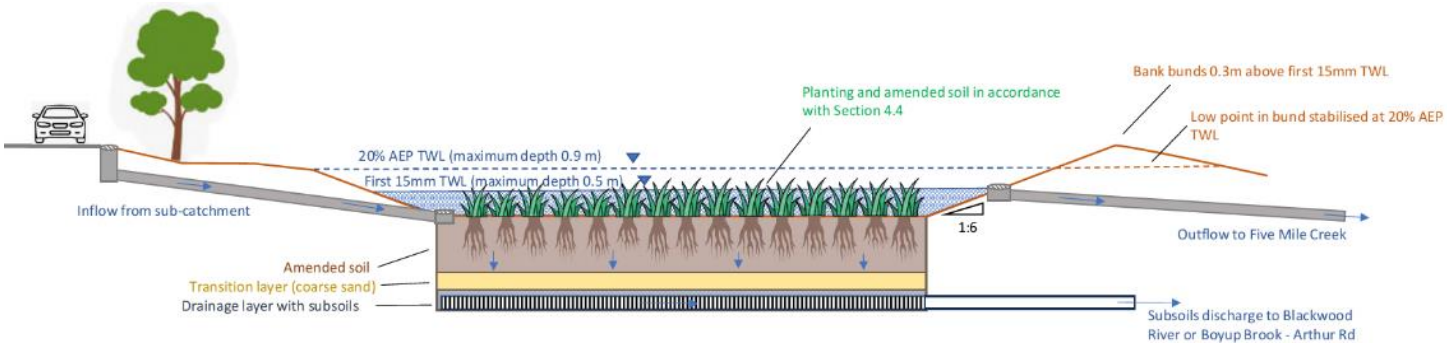
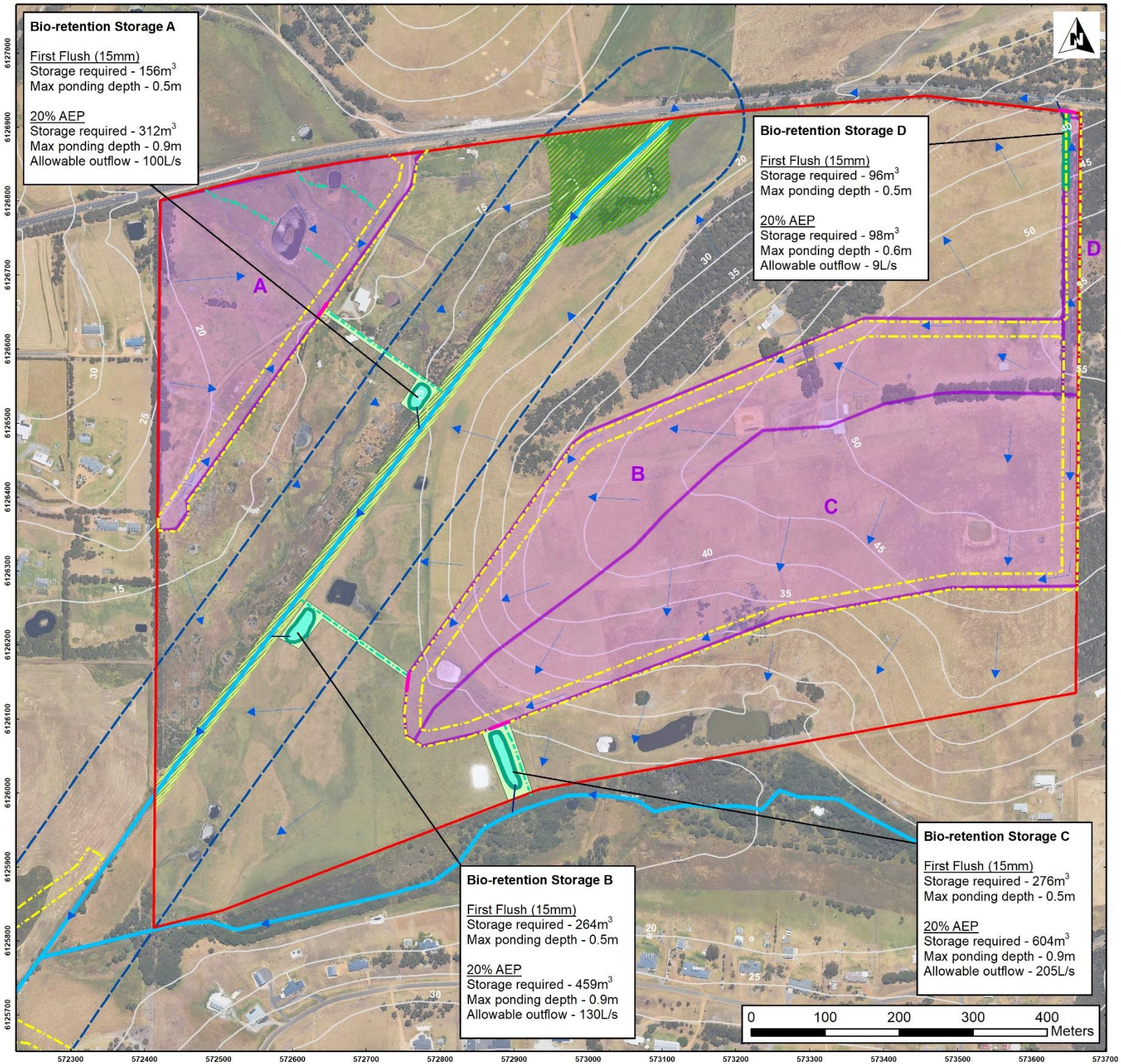


Figure 5: Conceptual cross-section of bio-retention storage/swale



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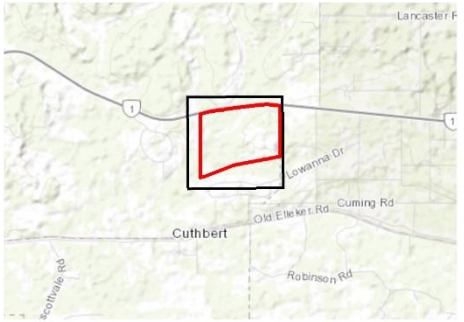
BIO DIVERSE SOLUTIONS



Overview Map Scale 1:100,000

Legend

- Subject Site
- 5m Contours
- Waterway
- Road Layout
- Revegetation Zone
- Vegetation Protection Zone
- Post-development drainage direction
- Post-development drainage sub-catchment
- Post-development drain alignment
- 100m setback to waterway
- Low point in road
- Storage outlet

Stormwater Storage

- Bio-retention storage (First 15mm TWL)
- Bio-retention storage (20% AEP TWL)

Scale
1:5,000 @ A3
GDA MGA 94 Zone 50

Data Sources
Aerial Imagery: WA Now, Landgate Subscription Imagery
Cadastre, Relief Contours and Roads: Landgate 2017
IRIS Road Network: Main Roads Western Australia 2017
Overview Map: World Topographic map service, ESRI 2012

CLIENT
Brian Fuller and Dora Porter
Lot 124 and 125 South Coast Hwy
Marbelup, WA 6330

Figure 12: Stormwater Management Plan

	QA Check	Drawn by
	AT	CC
STATUS	FILE	DATE
FINAL	HD063-001	30/04/2024

5.3 Groundwater Management

The groundwater management objectives for the Subject Site are to:

- Manage groundwater levels to protect infrastructure and assets;
- Maintain groundwater regimes for the protection of groundwater dependent ecosystems;
- Protect the value of groundwater resources; and
- Adopt nutrient load reduction design objectives for discharges to groundwater.

The following strategies will be implemented for the proposed development of the Subject Site to ensure the above objectives are met:

- To protect infrastructure from high seasonal groundwater levels. Building pads and foundations shall be set in accordance with applicable building standards based on soil type and separation to groundwater. Imported fill will be required where there is a low separation to groundwater, to ensure there is adequate separation between groundwater and building pads/foundations. A minimum separation of 1.5 m (in sands) is required between the land application of effluent disposal and peak groundwater levels (BDS, 2024). Where imported fill is required for the LAA, the same minimum fill depth shall be required for building pads.
- Subsoil drains shall be installed where the road finished level is less than 2 metres above the peak annual water-table. Subsoil drains shall have free draining outlets directed to bio-retention/stormwater storages for treatment prior to discharge.
- Bio-retention storages to have subsoils beneath the amended soil layer to prevent long standing water. Subsoil drains shall have a free draining outlet directed to Five Mile Creek.

5.4 Water Quality Management

The effective implementation of the structural and non-structural controls as part of the development will enhance water quality from this site as a result of the land use change from agricultural to rural residential.

The Subject Site uses a treatment train of structural and non-structural controls to treat up to the first 15 mm of rainfall from storm event.

Structural controls include the use of:

- Lot attenuation through the use of plumbed in rainwater tanks, soakwells and/or rain gardens to capture runoff from rooves and hardstand areas reducing runoff from the site. Infiltration of rainwater at source allows for treatment of water as it moves through the soil profile.
- Bio-retention storages which will receive runoff from the development's internal road network. Bio-retention storages are designed to treat the first flush event (first 15 mm) and retain up the 1% AEP storm event. Bio-retention storages will allow for infiltration at source, they will be underlain with amended soil and subsoils, and planted to allow for uptake of nutrients and heavy metals. The minimum specifications for all bio-retention storages are presented in Table 9.
- Revegetation of Five Mile Creek and the associated flood plain is proposed in the central north of the Subject Site where Five Mile Creek enters the Subject Site. This area receives untreated runoff from a relatively large section of South Coast Hwy and also receives inflow from the upstream catchment of Five Mile Creek, predominantly from agricultural areas. Revegetation shall be consistent with minimum requirements for the bio-retention storages (Table 9) with larger native shrubs suitable for the outer creek line. Figure 12 shows the area proposed to be revegetated. The existing fringing vegetation along Five Mile Creek within the drainage easement shall not be impacted as part of development works and as such has been categorised as a Vegetation Protection Zone (Figure 12).

- Any revegetation or bioretention planting has been accounted for in the Bushfire Management Plan (BMP), as Forest Type A or Shrubland Type C. Refer to details in the overall BMP for the rezoning.

Table 9: Minimum requirements for bio-retention storages

Item	Specification
Amended soil media	• Well graded sand. • Clay and silt content <3%. • Organic content between 3 and 5%. • Hydraulic Conductivity (sat) >150mm/hour. • Light compaction only. • Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program.
Plant selection	• In accordance with Vegetation Guidelines for Stormwater Biofilters in the South-West of WA (Monash University, 2014). • Tolerant of periodic inundation and extended dry periods. • Spreading root system. • Preferential selection of endemic and local native species. • Planting to provide 70-80% coverage at plant maturity.
Planting density and distribution	• Planting density appropriate for species selection. • Even spatial distribution of plant species.

The bio-retention systems should be sized to function correctly with a hydraulic conductivity (K) (saturated) of at least 3 m/day. Research conducted by the Facility for Advancing Water Biofiltration (FAWB, 2008) indicates that the desired K_{sat} is in the range of 2.5 to 7 m/day, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research also specifies that for vegetated systems, some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

Bio-retention systems are to be planted in a low fuel manner so as to not increase the bushfire risk of the area.

Non-structural source controls to reduce nutrient export from the Subject Site will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed;

- Promotion of the use of local native plants for landscaping to new lot owners. The use of local native plants will reduce the need for fertilisers across the site; and
- Undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system.

6 Implementation

6.1 Construction Management

Any temporary stormwater storage required during construction shall be built where the final storage area will be located. The temporary storage will be sized to contain the ultimate capacity of stormwater runoff from the connected area. Measures shall be taken to prevent the transportation of sediment during the construction phase, including infiltrating at source where possible and sand bagging/rock placement at the inlet of any pipe systems discharging outside the Subject Site. Remedial measures shall be undertaken by the developer if any disturbances to the surrounding areas are caused during construction.

6.2 Maintenance of Drainage Systems

The bio-retention swales and drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be required and undertaken by the client periodically, until successful practical completion of the development and handover to the City of Albany. Following handover, it is the City of Albany's responsibility to maintain drainage structures accordingly:

- Removal of debris to prevent blockages;
- Maintenance of vegetation in bio-retention swales; and
- Cleaning of sediment build up and litter layer on the bottom of storages.

6.3 Monitoring Program

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

6.3.1 Hydraulic Performance Monitoring

The hydraulic performance monitoring will aim to measure the movement of storm water through the stormwater storage structures to determine if stormwater conveyance is consistent with the intended design.

Where amended soil profiles have been installed in the bio-retention swales, infiltration testing shall be completed to test the hydraulic conductivity of the media. Testing should be repeated every 12 months to ensure clogging of the storages does not occur.

Water levels in the stormwater swales and the drainage basin east of the Subject Site shall be observed during significant storm events to ensure they are consistent with design and not overflowing.

6.3.2 Groundwater Monitoring

Two years of post-development groundwater level monitoring (quarterly) shall be conducted with results compared to the peak annual water-table levels recorded in the test pits constructed during the October 2021 Soil Investigation (GSG, 2021). A minimum of 8 groundwater monitoring bores shall be installed adjacent to eight test pit locations that intercepted groundwater during the Soil Investigation (GSG, 2021). If groundwater levels are found to exceed pre-development groundwater levels by more than 500 mm with no significant change in rainfall a review of the development design and operations will be required and alterations/modifications to the development will be conducted to reduce groundwater levels accordingly.

7 References

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Appendix A

Site Soil Investigation (Great Southern Geotechnics, 2021)

GREAT SOUTHERN
GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Site Investigation

Report 5175/1

Monday, 25 October 2021

Bio Diverse Solutions

Lot 124 & 125 South Cst Hwy, Marbellup WA 6330

Presented By: A.Purdie
Great Southern Geotechnics Pty Ltd
5a 209 Chester Pass Rd, Albany WA

GREAT SOUTHERN GEOTECHNICS

1.0 INTRODUCTION

As authorised by Bio Diverse Solutions an investigation for the proposed Development on Lot 124 & 125 South Cst Hwy, Marbellup WA 6330 was performed on the 19/10/2021

2.0 GENERAL

The intent of the investigation was to determine the following:

- In Situ soil types and profiles, and
- Depth of groundwater

3.0 SITE INVESTIGATION

Site conditions and test pit locations were recorded and are displayed in Appendix A - Maps.
Test pits logs/ soil profiles are noted in Appendix B - Test Pit Logs

The field investigation consisted of **22** Boreholes excavated on-site to depths of up to **2** meters using a Kubota KX41-3V mini excavator with a 300mm Auger.

Test pits were spread across the the proposed development as locations specified by the client.

All soil layers encountered were visually assessed and classified on-site.

IMPORTANT NOTE: The test pits have been spread so that they are representative of the subsurface materials across the intended reconstruction area, however, soil conditions may change dramatically over short distances and our investigations may not locate all soil variations across the site.

4.0 LABORATORY TESTING

N/A

This report and associated documentation was undertaken for the specific purpose described in the report and shall not be relied on for other purposes.

This report was prepared solely for the use by Bio Diverse Solutions any reliance assumed by other parties on this report shall be at such parties own risk.

Appendix A

Maps

Figure 1

Test Pits 1 to 22

Test Pit Locations

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Job No: 5175
Client: Bio Diverse Solutions
Project: Lot 124 & 125 South Cst Hwy, Marbellup WA 6330

Appendix B

Test Pit Logs

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 1	**Sample No.** 5175G1	**Sheet** 1 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	19/10/2021	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330			**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	A.Purdie	**Excavation Method :**	300mm Auger
Location:	34°59'59.69"S 117°47'52.75"E			**Position:**	Refer to site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ ground level.		
0 - 400	400	**(Topsoil) SAND with silt:** Grey/brown, fine to medium.	W	L-M				
		Contains roots and root fibres.						
400 - 1500	1100	**SAND with silt:** Grey to light grey, fine to medium.	W	L-MD				
1500 - 2000	500	**SAND with silt:** Light brown, fine to medium.	W	L-MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.1

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 2	**Sample No.** 5175G2	**Sheet** 3 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'57.79"S 117°47'40.05"E	A.Purdie	**Position:**	Refer to site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 50mm below existing ground level.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
200 - 1350	1150	**SAND with silt**: Grey to light grey, fine to medium.	M-W	L-MD				
1350 - 2000	650	**SAND with silt:** Dark grey/black, fine to medium. (*Refer to comments)	M	MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Moderately cemented from 1550 to 2000	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.2

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	3	5175G3		5		44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'2.80"S 117°47'39.61"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 1020mm below existing ground level.		
0 - 120	120	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
120 - 500	380	**SAND with silt**: Grey to light grey, fine to medium.	M	L-MD				
500 - 1200	700	**Sandy GRAVEL:** Dark/light brown, fine to coarse, sub-rounded to sub-angular.	M	D-VD				
		Fine to medium grained sand. (*Refer to comments)						
1200 - 2000	800	**SANDY CLAY:** Low to medium plasticity, light brown/grey with red and orange mottle.	M	F-St				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Layer excavates as a Sandy GRAVEL, however consists of a conglomerate formation.	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.3

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 4	**Sample No.** 5175G4	**Sheet** 7 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'11.19"S 117°47'38.64"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 350mm below existing ground level.		
0 - 160	160	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
160 - 1050	890	**SAND with silt**: Grey to light grey, fine to medium.	M	W				
1050 - 1680	630	**Sandy GRAVEL:** Dark/light brown, fine to coarse, sub-rounded to sub-angular.	M	MD	PC			
		Fine to medium grained sand.						
1680 - 2000	320	**SAND:** Light brown/grey, fine to medium.	W	L-MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.4

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	5	5175G5	Sheet	9	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	34°59'56.34"S 117°47'51.54"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 50mm below existing ground level.		
0 - 220	220	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
220 - 2000	1780	**SAND with silt:** Grey to light grey, fine to medium.	M-W	L-MD				

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.5

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	6	5175G6	11	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'59.96"S 117°48'22.33"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 250	250	**(Topsoil) SAND with silt:** Grey, fine to medium.	M-W	L-MD				
		Contains roots and root fibres.						
250 - 325	75	**Sandy GRAVEL:** Brown/orange, fine to medium, sub-rounded to sub-angular.	M	MD				
		Fine to medium grained sand.						
325 - 780	455	**Sandy CLAY:** Low to medium plasticity, yellow.	M	F-St				
		Fine to medium grained sand. (*Refer to comments)						
780 - 2000	1220	**Sandy CLAY:** Dark brown/red with yellow and grey mottle.	M	F-St				
		fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains fine to medium, sub-rounded to sub-angular gravel to 450mm.	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.6

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 12 **of** 44

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 7	**Sample No.** 5175G7	**Sheet** 13 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'55.20"S 117°48'23.90"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 180	180	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
180 - 400	220	**Gravelly SAND:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres. (*Refer to comments)						
400 - 2000	1600	**Clayey SAND with gravel:** Low to medium plasticity, light brown, fine to medium.	M	F				
		Fine to coarse, sub-rounded to sub-angular gravel.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.7

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 8	**Sample No.** 5175G8	**Sheet** 15 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'57.21"S 117°48'17.10"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 180	180	**(Topsoil) SAND with silt and GRAVEL:** Grey, fine to medium.	M	L-MD				
		Fine to coarse, sub-rounded to sub-angular gravel.						
		Contains roots and root fibres.						
180 - 500	320	**Sandy GRAVEL:** Light brown/grey, fine to coarse, sub-rounded to sub-angular.	M	MD				
		Fine to medium grained sand. (*Refer to comments)						
500 - 1600	1100	**Clayey SAND with gravel:** Low to medium plasticity, light brown, fine to medium.	M	MD				
		Fine to coarse, sub-rounded to sub-angular gravel.						
1600 - 2000	400	**Silty SAND with clay:** Low plasticity, pale yellow with white mottle.	M	MD				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.8

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 9	**Sample No.** 5175G9	**Sheet** 17 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'5.39"S 117°48'23.06"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 140	140	**(Topsoil) Gravelly SAND:** Dark grey/brown, fine to medium.	M	L-MD				
		Fine to medium, rounded to sub-angular gravel.						
		Contains roots and root fibres.						
140 - 420	280	**Sandy CLAY with gravel:** Low to medium plasticity,	M	F				
		brown/orange with red and white mottle.						
		Fine to medium, rounded to sub-angular gravel.						
420 - 2000	1580	**Sandy CLAY:** Low to medium plasticity, red/brown with yellow and grey mottle.	M	F-St				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.9

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 10	**Sample No.** 5175G10	**Sheet** 19 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'13.73"S 117°48'23.43"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 120	120	**(Topsoil) Sandy GRAVEL:** Dark brown, fine to coarse, sub-rounded to sub angular.	M	MD				
		Fine to medium grained sand. (*Refer to comments)						
120 - 350	230	**Sandy GRAVEL:** Brown, fine to coarse, sub-rounded to sub-angular.	M	MD				
		Fine to medium grained sand.						
350 - 670	320	**Sandy CLAY:** Medium plasticity, yellow with red mottle.	M	St				
		Fine to medium grained sand.						
670 - 1200	530	**Sandy CLAY:** Low to medium plasticity, brown/red with white mottle.	M	F-St				
		Fine to medium grained sand.						
1200 - 200	800	**Silty SAND with clay:** Low plasticity, pale yellow with white mottle.	M	F-St				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.10

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	11	5175G11	Sheet 21	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'16.44"S 117°48'18.40"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 170	170	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
170 - 330	160	**SAND with silt:** Grey, fine to medium.	M	L-MD				
330 - 1150	820	**Sandy GRAVEL:** Light brown, fine to coarse, sub-rounded to sub-angular.	M	D	WC			
		Fine to medium grained sand.						
1150 - 2000	850	**Sandy CLAY:** Low to medium plasticity,brown/orange.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.11

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Reort No** 5175/1	**Test Pit No.** 12	**Sample No.** 5175G12	**Sheet** 23 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'16.70"S 117°48'8.39"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 850mm below existing ground level.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
200 - 800	600	**SAND with silt:** Grey/light grey, fine to medium.	M	L-MD				
800 - 1000	200	**Gravelly SAND:** Brown to dark brown, fine to medium.	M	MD				
		Fine to coarse, sub-rounded to sub-angular gravel.						
1000 - 2000	1000	**Clayey, Silty SAND:** Low plasticity, light brown/orange.	M-W	L-MD				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.12

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	13	5175G13	Sheet	25	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'10.14"S 117°48'3.72"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 400mm below existing ground level.		
0 - 120	120	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
120 - 460	340	**SAND with silt:** Light grey, fine to medium.	M	L-MD				
460 - 980	520	**Sandy GRAVEL:** Brown/orange, fine to coarse, sub-rounded to sub-angular.	M	D	MC			
		Fine to medium grained sand.						
980 - 1580	600	**Sandy CLAY:** Low to medium plasticity, brown/orange with red mottle.	M	F				
		Fine to medium grained sand.						
1580 - 2000	420	**Silty SAND with clay:** Low plasticity, pale yellow with white mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.13

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	14	5175G14	Sheet	27	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'8.35"S 117°48'12.72"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 800mm below existing ground level.		
0 - 300	300	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
300 - 720	420	**Sandy GRAVEL:** Brown, fine to coarse, sub-rounded to sub-angular.	M	MD-D				
		Fine to medium grained sand.						
720 - 990	270	**Sandy CLAY with gravel:** Medium plasticity, light brown/grey with red and orange mottle	W	S-F				
		Fine to medium , sub-rounded to sub-angular gravel.						
		Fine to medium grained sand.						
990 - 2000	1010	**Sandy CLAY:** Medium plasticity, red with grey and orange mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.14

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 28 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	15	5175G15	Sheet 29	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'13.50"S 117°47'58.91"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	M	L-MD				
		Contains roots and root fibres.						
200 - 810	610	**Sandy GRAVEL:** Light brown, fine to coarse, sub-rounded to sub-angular.	M	MD-D				
		Fine to medium grained sand.						
810 - 1550	740	**Sandy CLAY:** Low plasticity, brown/orange with red mottle.	M	F				
		Fine to medium grained sand.						
1550 - 2000	450	**Silty SAND with trace clay:** Low plasticity, pale yellow with white mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.15

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 30 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	16	5175G16	Sheet 31	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'19.95"S 117°47'57.96"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ ground level.		
0 - 160	160	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
160 - 750	590	**SAND with silt:** Grey, fine to medium.	M	L-MD				
750 - 1250	500	**SAND with silt:** Light grey, fine to medium.	W	L-MD				
1250 - 1700	450	**SAND with silt:** Dark grey, fine to medium.	W	L-MD				
1700 - 2000	300	**SAND with silt:** Dark grey, fine to medium.	M	MD-D	WC			

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.16

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 17	**Sample No.** 5175G17	**Sheet** 33 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'1.30"S 117°48'1.12"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 200	200	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
200 - 760	560	**SAND with silt:** Light grey, fine to medium.	M	L-MD				
760 - 1300	540	**SAND with silt:** Brown, fine to medium.	M	VD	WC			
1300	0	**REFUSAL**						

Samples Taken	Target Depth		
	Cave In		
	Refusal	✓	1300
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.17

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		
5175/1	18	5175G18	Sheet 35	of	44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	34°59'57.11"S 117°48'5.08"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 130	130	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
130 - 920	790	**Sandy GRAVEL:** Light brown, fine to coarse, sub-rounded to sub-angular.	M	D	MC			
		Fine to medium grained sand.						
920 - 2000	1080	**Silty sandy CLAY:** Low to medium plasticity, light brown with grey mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.18

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 19	**Sample No.** 5175G19	**Sheet** 37 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'8.81"S 117°47'54.01"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						No water table encountered.		
0 - 250	250	**(Topsoil) SAND with silt:** Grey, fine to medium.	M	L-MD				
250 - 740	490	**Sandy GRAVEL:** Brown, fine to coarse, sub-rounded to sub-angular.	M	MD-D				
		Fine to medium grained sand. (*Refer to comments)						
740 - 2000	1260	**Silty sandy CLAY:** Low to medium plasticity, light brown with red and white mottle.	M	F				
		Fine to medium grained sand.						

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
* Contains cobbles and boulders	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.19

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	20	5175G20		39		44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG	
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V	
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger	
Location:	35° 0'13.22"S 117°47'51.81"E	A.Purdie	**Position:**	See site plan	

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 150mm below existing ground level.		
0 - 200	200	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
200 - 1100	900	**SAND with silt:** Light grey, fine to medium.	M-W	L-MD				
1100 - 1200	100	**SAND with silt:** Dark brown, fine to medium.	M	MD	MC			
1200 - 2000	800	**SAND with silt:** Light brown, fine to medium.	W	L-MD				

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.20

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 40 **of** 44

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Report No** 5175/1	**Test Pit No.** 21	**Sample No.** 5175G21	**Sheet** 41 **of** 44

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'20.29"S 117°47'50.80"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ ground level.		
0 - 300	300	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
300 - 900	600	**SAND with silt:** Dark grey/grey, fine to medium.	W	L-MD				
900 - 1600	700	**SAND with silt:** Light grey, fine to medium.	W	L-MD				
1600 - 2000	400	**SAND with silt:** Brown, fine to medium.	W	L-MD				

Samples Taken	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.21

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 42 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

Report No	Test Pit No.	Sample No.	Sheet		of	
5175/1	22	5175G22	43		44	

Client:	Bio Diverse Solutions	**Date Commenced**	**Operator/Contractor:**	GSG
Project:	Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	19/10/2021	**Equipment type:**	Kubota KX41-3V
Project No.	QU-0578	**Logged By**	**Excavation Method :**	300mm Auger
Location:	35° 0'16.39"S 117°47'46.39"E	A.Purdie	**Position:**	See site plan

Depth Below Surface (mm)	Layer Depth (mm)	Material Description SOIL TYPE, Plasticity, Colour, Particle characteristics, Secondary and other minor components	Moist. Condition	Consistency / Strength	Cementation	Water Table	Classification Symbol	Sample/Test
						Water table encountered @ 550mm below existing ground level.		
0 - 300	300	**(Topsoil) SAND with silt:** Dark grey, fine to medium.	W	L-MD				
		Contains roots and root fibres.						
300 - 1600	1300	**SAND with silt:** Grey , fine to medium.	W	L-MD				
1600 - 2000	400	**SAND with silt:** Dark grey/ black , fine to medium.	W	L-MD	PC			

Samples Taken			
	Target Depth	✓	2000
	Cave In		
	Refusal		
Comments	Near Refusal		
	Flooding		
	Lack of Reach		

Cohesive	Non-Cohesive	Rock	Cementation	General
VS - Very Soft	VL - Very Loose	EL - Extremely Low	IN - Indurated	D - Dry M - Moist W - Wet
S - Soft	L - Loose	VL - Very Low	PC - Poorly Cemented	
F - Firm	MD - Medium Dense	L - Low		N/A - Not Applicable
St - Stiff	D - Dense	M - Medium	MC - moderately Cemented	
VSt - Very Stiff	VD - Very Dense	H - High		N/D - Not Determined
H - Hard	CO - Compact	VH - Very High	WC - Well Cemented	
		EH - Extremely High		

Test Pit No.22

Excavation

Spoil

GREAT SOUTHERN GEOTECHNICS CONSTRUCTION MATERIALS TESTING	**Job No:** 5175/1 **Client:** Bio Diverse Solutions **Project:** Lot 124 & 125 South Cst Hwy, Marbellup WA 6330	**Sheet** 44 **of** 44

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

COLOURS

BLACK - BROWN (bk)	BLUE (bl)	ORANGE (or)
BROWN (br)	BLUE - GREEN (bl/gr)	RED (rd)
GREY - BROWN (gy/br)	GREEN (gr)	RED - BROWN (rd/br)
GREY (gy)	YELLOW (yl)	PINK (pk)
BLUE - GREY (bl/gy)	YELLOW - BROWN (yl/br)	PURPLE (pr)

MOISTURE CONDITION OF SOIL

TERM	DESCRIPTION
Dry	Cohesive soils; hard and friable or powdery, well dry of plastic limit. Granular soils; cohesionless and free-running.
Moist	Soil feels cool, darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	Soil feels cool, darkened in colour. Cohesive soils usually weakened and free water forms on hands when handling. Granular soils tend to cohere and free water forms on hands when handling.

PARTICLE SHAPES

ANGULAR	SUB-ANGULAR	SUB-ROUNDED	ROUNDED

PARTICLE SIZES

BOULDERS	COBBLES	COARSE GRAVEL	MEDIUM GRAVEL	FINE GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY
>200mm	63-200mm	20-63mm	6-20mm	2.36-6mm	0.6-2.36mm	0.2-0.6mm	0.075-0.2mm	0.002-0.075mm	<0.002mm

GRAIN SIZE

SOIL TYPE (ABBREV.)	CLAY (CL)	SILT (SI)	←	SAND (SA)	→	←	GRAVEL (GR)	→	COBBLES (CO)
SIZE	< 2µm	2-75µm	Fine 0.075-0.2mm	Medium 0.2-0.6mm	Coarse 0.6-2.36mm	Fine 2.36-6mm	Medium 6-20mm	Coarse 20-63mm	63-200mm
SHAPE & TEXTURE	Shiny	Dull	← angular or sub angular or sub rounded or rounded →						
FIELD GUIDE	Not visible under 10x	Visible under 10x	Visible by eye	Visible at < 1m	Visible at < 3m	Visible at < 5m	Road gravel	Rail ballast	Beaching

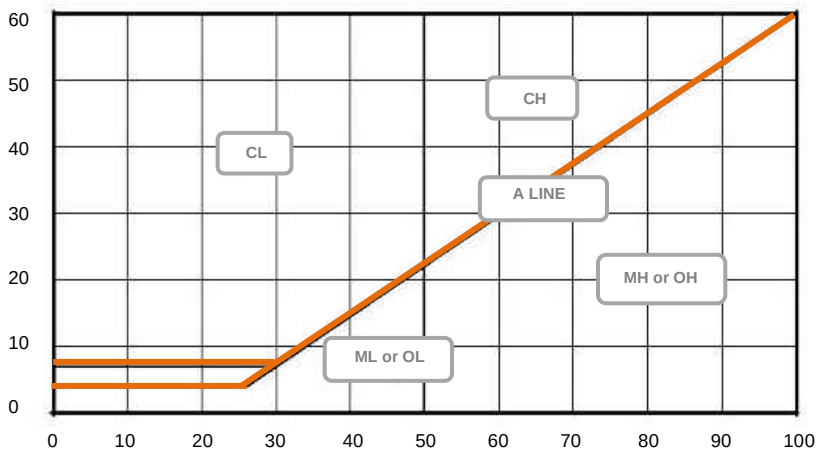
GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

CLASSIFICATION CHART

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60mm and basing fractions on estimated mass)					GROUP SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS More than 50% of material less than 63 mm is larger than 0.075 mm	GRAVELS More than 50% of coarse fraction is larger than 2.36mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength		GW	Well graded gravels, gravel-sand mixtures, little or no fines
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength		GP	Poorly Graded gravels and gravel-sand mixtures, little or no fines, uniform gravels
		GRAVELS WITH FINES (Appreciable amount of fines)	Dirty' materials with excess of non-plastic fines, zero to medium dry strength		GM	Silty gravels, gravel-sand-silt mixtures
			'Dirty' materials with excess of plastic fines, medium to high dry strength		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS More than 50% of coarse fraction is smaller than 2.36mm	CLEAN SANDS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength		SW	Well graded sands, gravelly sands, little or no fines
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength '		SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands
		SANDS WITH FINES (Appreciable amount of fines)	Dirty' materials with excess of non-plastic fines, zero to medium dry strength		SM	Silty sands, sand-silt mixtures
			'Dirty' materials with excess of plastic fines, medium to high dry strength		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm	IDENTIFICATION PROCEDURES ON FRACTIONS <0.2mm					
	SILTS AND CLAYS Liquid limit less than 50	DRY STRENGTH	DILATANCY	TOUGHNESS		
		None to low	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with low plasticity. Silts of low to medium Liquid Limit.
		Medium to high	None to very slow	Medium	CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays.
		Low to medium	Slow	Low	OL	Organic silts and organic silt-clays of low to medium plasticity.
	SILTS AND CLAYS Liquid limit greater than 50	Low to medium	Slow to none	Low to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, silts of high Liquid Limit.
		High to very high	None	High	CH	Inorganic clays of high plasticity.
		Medium to high	None to very slow	Low to medium	OH	Organic clays of high plasticity
HIGHLY ORGANIC SOILS	Readily identified by colour, odour, spongy feel and frequently by fibrous texture				Pt	Peat and other highly organic soils

PLASTICITY CHART

For laboratory classification of fine grained soils



GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

PLASTICITY

DESCRIPTIVE TERM	OF LOW PLASTICITY	OF MEDIUM PLASTICITY	OF HIGH PLASTICITY
Range Of Liquid Limit (%)	≤ 35	> 35 ≤ 50	> 50

DESCRIPTION OF ORGANIC OR ARTIFICIAL MATERIALS

PREFERRED TERMS	SECONDARY DESCRIPTION
Organic Matter	Fibrous Peat/ Charcoal/ Wood Fragments/ Roots (greater than approximately 2mm diameter)/ Root Fibres (less than approximately 2mm diameter)
Waste Fill	Domestic Refuse/ Oil/ Bitumen/ Brickbats/ Concrete Rubble/ Fibrous Plaster/ Wood Pieces/ Wood Shavings/ Sawdust/ Iron Filings/ Drums/ Steel Bars/ Steel Scrap/ Bottles/ Broken Glass/ Leather

CONSISTENCY - Cohesive soils

TERM	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD
Symbol	VS	S	F	St	VSt	H
Undrained Shear Strength (kPa)	< 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
SPT (N) Blowcount	0 - 2	2 - 4	4 - 8	8 - 15	15 - 30	> 30
Field Guide	Exudes between the fingers when squeezed	Can be moulded by light finger pressure	Can be moulded by strong finger pressure	Cannot be moulded by fingers. Can be indented by thumb nail	Can be indented by thumb nail	Can be indented with difficulty with thumb nail

CONSISTENCY - Non-cohesive soils

TERM	VERY LOOSE	LOOSE	MEDIUM DENSE	DENSE	VERY DENSE	COMPACT
Symbol	VL	L	MD	D	VD	CO
SPT (N) Blowcount	0 - 4	4 - 10	10 - 30	30 - 50	50 - 100	> 50/150 mm
Density Index (%)	< 15	15 - 35	35 - 65	65 - 85	85 - 95	> 95
Field Guide	Ravels	Shovels easily	Shovelling very difficult	Pick required	Pick difficult	Cannot be picked

MINOR COMPONENTS

TERM	TRACE	WITH
% Minor Component	Coarse grained soils: < 5% Fine grained soils: <15%	Coarse grained soils: 5 – 12% Fine grained soils: 15 – 30%
Field Guide	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary components	Presence easily detectable by feel or eye, soil properties little different to general properties of primary component

GREAT SOUTHERN GEOTECHNICS
CONSTRUCTION MATERIALS TESTING

GEOLOGICAL ORIGIN

	TYPE	DETAILS
TRANSPORTED SOILS	Aeolian Soils	Deposited by wind
	Alluvial Soils	Deposited by streams and rivers
	Colluvial Soils	Deposited on slopes
	Lacustrine Soils	Deposited by lakes
	Marine Soils	Deposited in ocean, bays, beaches and estuaries
FILL MATERIALS	Soil Fill	Describe soil type, UCS symbol and add 'FILL'
	Rock Fill	Rock type, degree of weathering, and word 'FILL'.
	Domestic Fill	Percent soil or rock, whether pretrucible or not.
	Industrial Fill	Percent soil, whether contaminated, particle size & type of waste product, ie brick, concrete, metal

STRENGTH OF ROCK MATERIAL

TERM	SYMBOL	IS(50)	(MPA)	FIELD GUIDE TO STRENGTH
Extremely Low	EL	≤0.03		Easily remoulded by hand to a material with soil properties.
Very Low	VL	>0.03	≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxle sample by hand. Pieces up to 3 cm thick can be broken by finger pressure.
Low	L	>0.1	≤0.3	Easily scored with a knife; indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150 mm long by 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	M	>0.3	≤1.0	Readily scored with a knife; a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty.
High	H	>1	≤3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	>3	≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High	EH	>10		Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported
Extremely Weathered Rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded, in water.
Distinctly Weathered Rock	DW	Rock strength usually changed by weathering. Rock may be highly discoloured, usually be iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathering products in pores.
Slightly Weathered Rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	FR	Rock shows no sign of decomposition or staining.

LOCAL WATER MANAGEMENT STRATEGY

Lot 9001 Lower Denmark Road

Cuthbert, WA 6330

01/05/2024

BUSHFIRE | ENVIRONMENTAL | WATER | GIS

DOCUMENT CONTROL

Title: Local Water Management Strategy – Lot 9001 Lower Denmark Road, Cuthbert WA

Author (s): Chiquita Cramer

Reviewer (s): Marisa Wearing and Alexandra Tucker

Job No.: HD063-002

Client: Barry Panizza

REVISION RECORD

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1 Introduction

1.1 Background

Lot 9001 Lower Denmark Road, Cuthbert WA Local Water Management Strategy (LWMS), has been prepared by Bio Diverse Solutions on behalf of Barry Panizza (the land owner), in support of a rezoning and subsequent future subdivision prepared for the site.

The LWMS provides the framework for the application of total water cycle management to the proposed rezoning. This is consistent with the Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD), described in the Stormwater Management Manual (DoW, 2007).

1.2 Key Design Principles and Objectives

The LWMS employs the following key documents to define its content, key principles and objectives:

- Stormwater Management Manual for Western Australia (DoW, 2007).
- Better Urban Water Management (WAPC, 2008).

A summary of the key design principles and objectives from these documents is summarised below and provided in Table 1.

1.2.1 Stormwater Management Manual (DoW 2007)

The Department of Water (DoW), now Department of Water and Environmental Regulation (DWER), released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998. The manual defines and practically describes Best Management Practices (BMPs) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aims to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by the DoW (now DWER), but also by other State and Local Government Authorities and sectors of the urban development industry.

DoW completed a major review of the manual in consultation with a working team, comprising of industry and government representatives. The revised manual was officially launched in August 2007.

DWER's current position on urban stormwater management in Western Australia is outlined in Chapter 2: *Understanding the Context of the Stormwater Management Manual for Western Australia* (DoW, 2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long-term.
- Public Health: To minimise public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and water logging.

- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: To ensure the delivery of best practice stormwater management through planning and development of high-quality developed areas in accordance with sustainability and precautionary principles.

1.2.2 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (BUWM; WAPC, 2008) focuses on the process of integration between land use and water planning. The document specifies the level of investigation and documentation required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This LWMS complies with the BUWM process.

Table 1: Summary of design principles and objectives

Key Guiding Principles		
• Facilitate implementation of sustainable best practice urban water management. • Provide integration with planning processes and clarity for agencies involved with implementation. • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation. • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development.		
Category	**Key Design Principles & Objectives**	**LWMS Criteria**
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the principles of WSUD. • Adopt water quality treatment design objectives for stormwater runoff. • Flood management. • Adopt treatment train approach.	• Post-development critical peak flows will be consistent with pre-development peak flows at the discharge point of each catchment within the Subject Site up to the 20% AEP. • First 15 mm of rainfall from storm events intercepting road network will be treated at source where possible. • Manage surface water flows from major storm events to protect infrastructure and assets from flooding and inundation.
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets. • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems. • Protect the value of groundwater resources.	• Managing and minimising changes in groundwater levels and groundwater quality following development.
Monitoring and Implementation	• Adopt an adaptive management approach. • Maintain drainage and treatment structures.	• Design based on methodology in Stormwater Management Manual of adopting a treatment train including: • Structural treatment measures (bio-retention treatment structures). • Non-structural measures to reduce applied nutrient loads. • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
Water Conservation	• Adopt drinking water consumption target. • 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.	• Aim to achieve the State Water Plan target for water use and reduce water use where possible. • Consider alternative fit for purpose water sources where appropriate and cost-effective.

1.3 Suitable Qualified Hydrologist

This LWMS has been prepared by Chiquita Cramer, who has 15 years of experience working as a hydrologist and hydrogeologist.

Chiquita Cramer currently has the following tertiary qualifications:

- Bachelor of Science in Natural Resource Management (University of Western Australia); and
- Graduate Certificate in Hydrogeology (University of Western Australia).

Chiquita completed a Bachelor of Science in Natural Resource Management in 2008 at the University of Western Australia. Chiquita worked as a hydrologist and senior hydrologist at JDA Consultant Hydrologists in Perth for 8 years. Chiquita's experience includes preparation of multiple local and urban water management strategies, hydrological and hydraulic investigations, surface water and groundwater monitoring reports and hydrogeological reports. Chiquita completed a Graduate Certificate in Hydrogeology and in 2017 joined Bio Diverse Solutions (BDS) to provide expertise in hydrology and hydrogeology to the company.

1.4 Location

The Subject Site is defined as Lot 9001 (No. 688) Lower Denmark Road, Cuthbert WA within the City of Albany. The site has an area of ~107 ha and is bound by Lower Denmark Road to the south, rural residential lots to the north and east, and agricultural land to the west. The location of the Subject Site is shown in Figure 1.

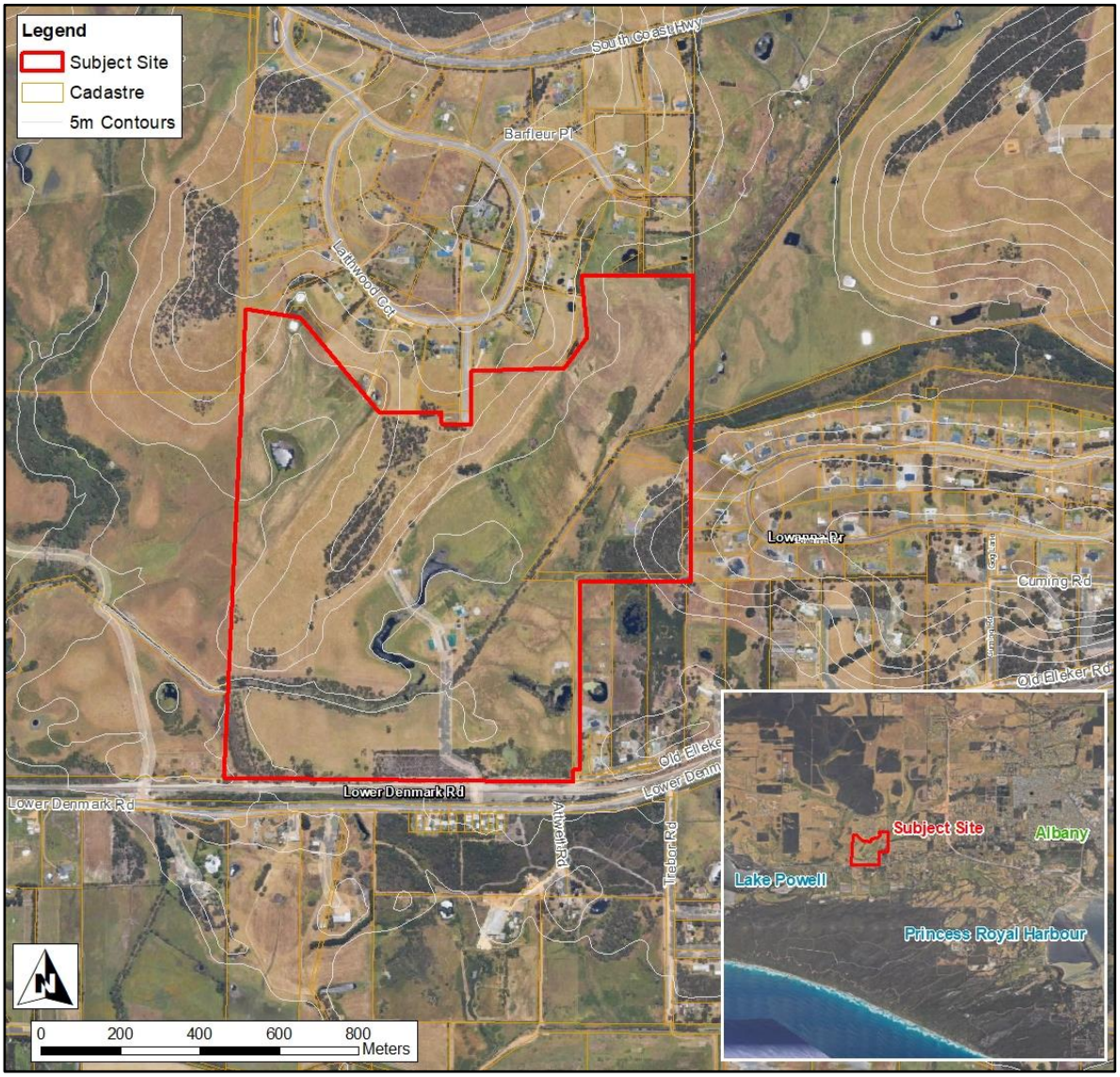


Figure 1: Location plan

2 Proposed Development

The Subject Site is zoned as *'General Agriculture'* under the City of Albany's Local Planning Scheme No. 1 (DPLH, 2019). It is proposed the Subject Site be rezoned to '*Rural residential'* and *'Rural smallholdings',* and forms part of a larger structure plan area that includes Lots 124 and 125 South Coast Highway to the northeast of the Subject Site. The proposed rezoning for the site is shown in Figure 2.

Figure 2: Zone Plan (Harley Dykstra, 2022). Note Subject Site area depicted by blue square.

3 Pre-development Environment

3.1 Existing Land Use

The site currently consists of agricultural land used for mixed cropping and livestock (Photo 1). There is one residential dwelling, centrally located on the Subject Site (Photo 2 to 4). The land immediately north and east of the Subject Site is currently utilised for rural residential living.

Photo 1: View to the west of agricultural land within the Subject Site.

Photo 2: View to the south southeast of driveway to Subject Site.

Photo 3: View to the southwest of dwelling centrally located within the Subject Site.

Photo 4: View to the east southeast of rural residential property to the east of Subject Site.

3.2 Topography

The Subject Site is generally low lying and flat, with an elevated ridgeline running from northeast to southwest in the central west of the site. The northwest corner and the central eastern edge of the Subject Site are also elevated. Elevation ranges from a high point of 32 mAHD in the northwest of the Subject Site to a low point of 10 mAHD in the central and southern portions of the site. Topographic contours are shown in Figure 3.

Figure 3: Topography

3.3 Climate

The Albany area is characterised by a Mediterranean climate with warm dry summers and cool wet winters. Rainfall data is from the nearby Bureau of Meteorology (BoM, 2023) Albany Station (Site No. 009500).

The closest open Bureau of Meteorology (BoM) station to the Subject Site, is the Albany Station (009500). The average annual temperature at Albany Station ranges from 8.3-22.9°C. The average summer temperature ranges between 14.1-22.9°C, whilst average winter temperatures range between 8.3-16.7°C. The annual mean rainfall for Albany station is 920.8 mm (BoM, 2023). On average the months of May - September are the months with the highest rainfall (Figure 4). There was a higher than average rainfall recorded in the months of April and June 2022, and October and November 2023.

The average annual pan evaporation for the Albany area is approximately 1397 mm (Luke et al., 1988).

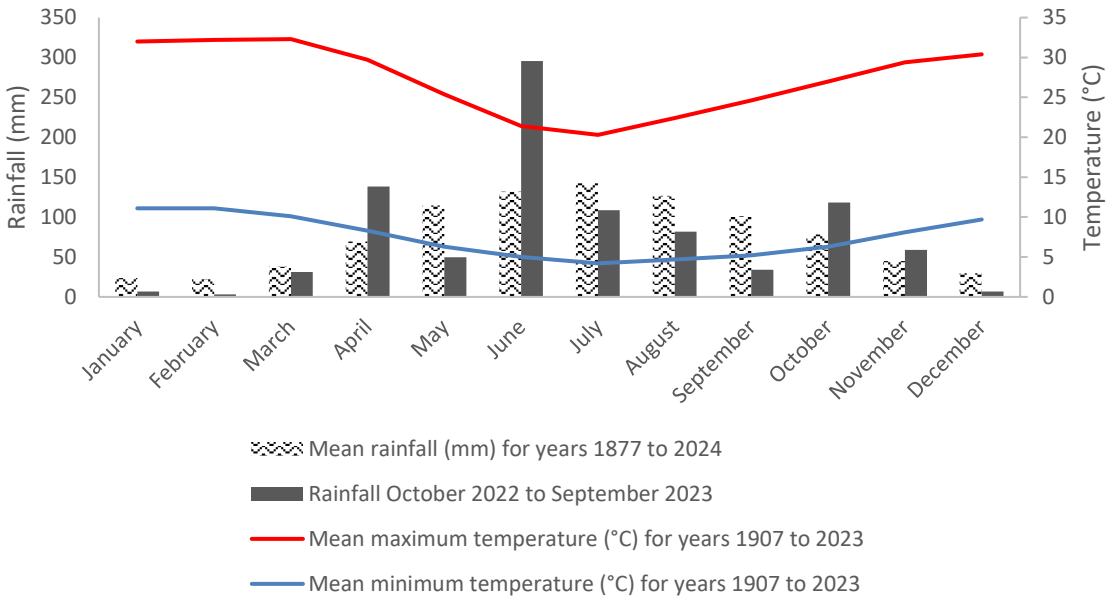


Figure 4: Climate Data for Albany BoM Weather Station No. 009500

3.4 Remnant Vegetation

The Subject Site predominantly consists of cleared agricultural land with scattered paddock trees, and patches of remnant vegetation surrounding waterways/waterbodies and the ridge in the northwest. The Subject Site lies within the JF02 – Jarrah Forrest Interim Bio-geographic Regional Area (IBRA) and characterised by Jarrah-Marri forest on laterite gravels. Eluvial and alluvial deposits support Agonis shrublands (DSEWPC, 2012).

The vegetation has also been mapped on a broad scale by J.S. Beard (Shepherd et al., 2002) in the 1970's, where a system was devised for state-wide mapping and vegetation classification based on geographic, geological, soil, climate structure, life form and vegetation characteristics. A GIS search of J.S. Beards vegetation classification places the Subject Site within two System and Vegetation Associations as shown in Table 2 (DPIRD, 2017a).

Table 2: Vegetation Associations (DPIRD, 2017a)

System Association Name	Vegetation Association Number	Vegetation Description
Albany	3	Mainly jarrah and marri *Eucalyptus marginata*, *Corymbia calophylla*.
Denmark	51	Cyperaceae, Restionaceae, Juncaceae (mainly in the South-West).

There are no Conservation Parks or Class "A" Reserves within the Subject Site or within the vicinity of the Subject Site.

3.5 Acid Sulphate Soils

Acid Sulphate Soils (ASS) are naturally occurring soils and sediments containing sulphide minerals, predominantly pyrite (an iron sulphide). When undisturbed below the water table, these soils are benign and not acidic (potential ASS). However, if the soils are drained, excavated or exposed by lowering of the water table, the sulphides will react with oxygen to form sulphuric acid. ASS Risk Mapping indicates that the low-lying areas within the Subject Site are situated within an area of moderate to low risk of ASS occurring within 3 metres of natural soil surface, as shown in Figure 5 (DWER, 2017).

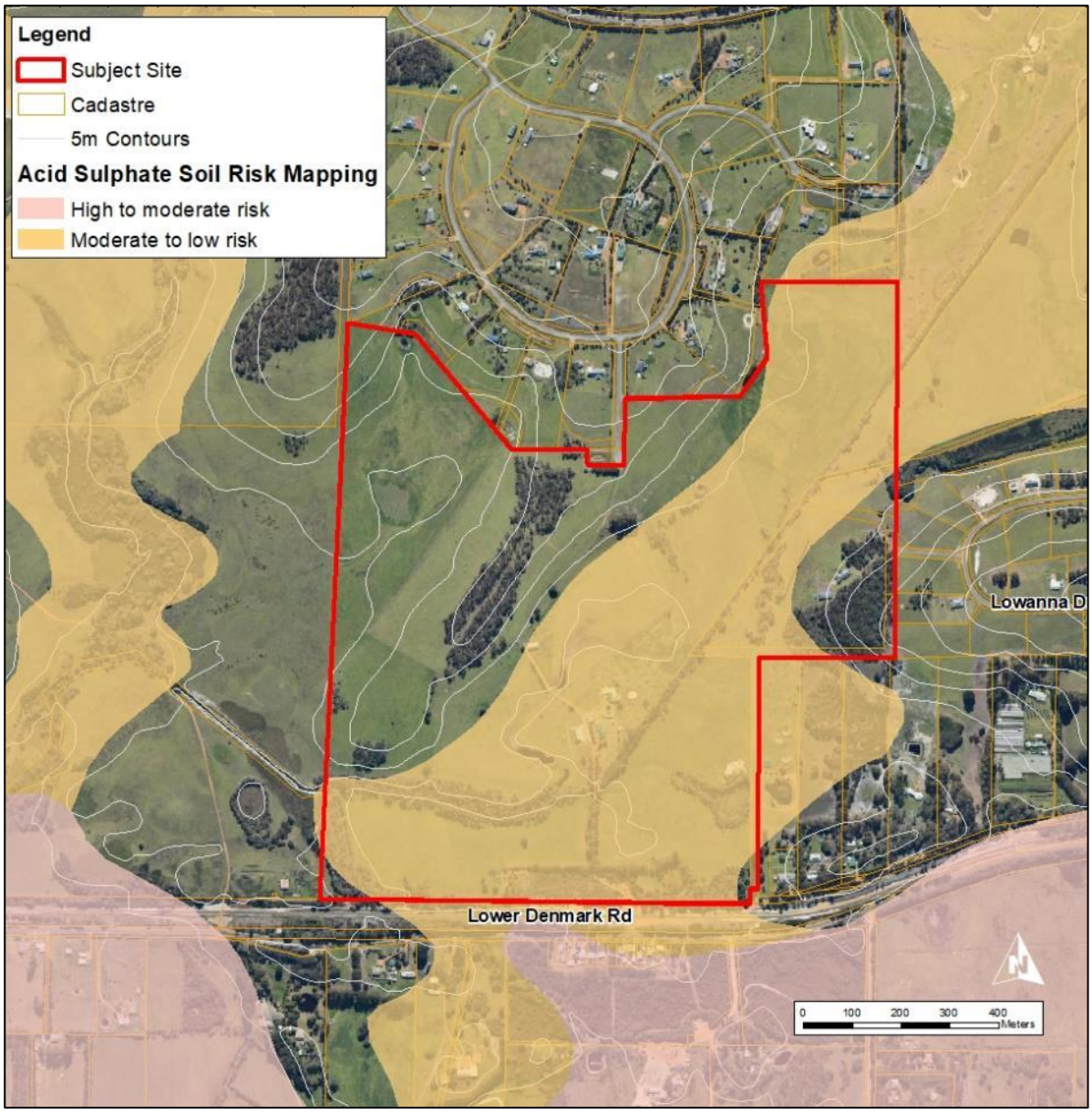


Figure 5: ASS risk mapping

An ASS Preliminary Investigation was conducted at the Subject Site by Opus on the 15th January 2008 as part of an Addendum to the Land Capability Assessment (Opus, 2007). In summary, the investigation found the peat layers at the Subject Site had acidity levels which exceeded DWER Guidelines. The acidity was found not to be caused by sulphur and likely to be caused from the mobilisation of hydrolysed ions, attributed to iron or aluminium leaching through the soil profile (Opus, 2007).

Soil analysis showed the surface soils had high Electrical Conductivity (EC) and corresponding acidity, which Opus (2007) found likely to be attributed to bicarbonate salts and not sulphur salts. Sulphur acidity (ASS) was detected in the soil layers from approximately 1000 mm BGL (Opus, 2007).

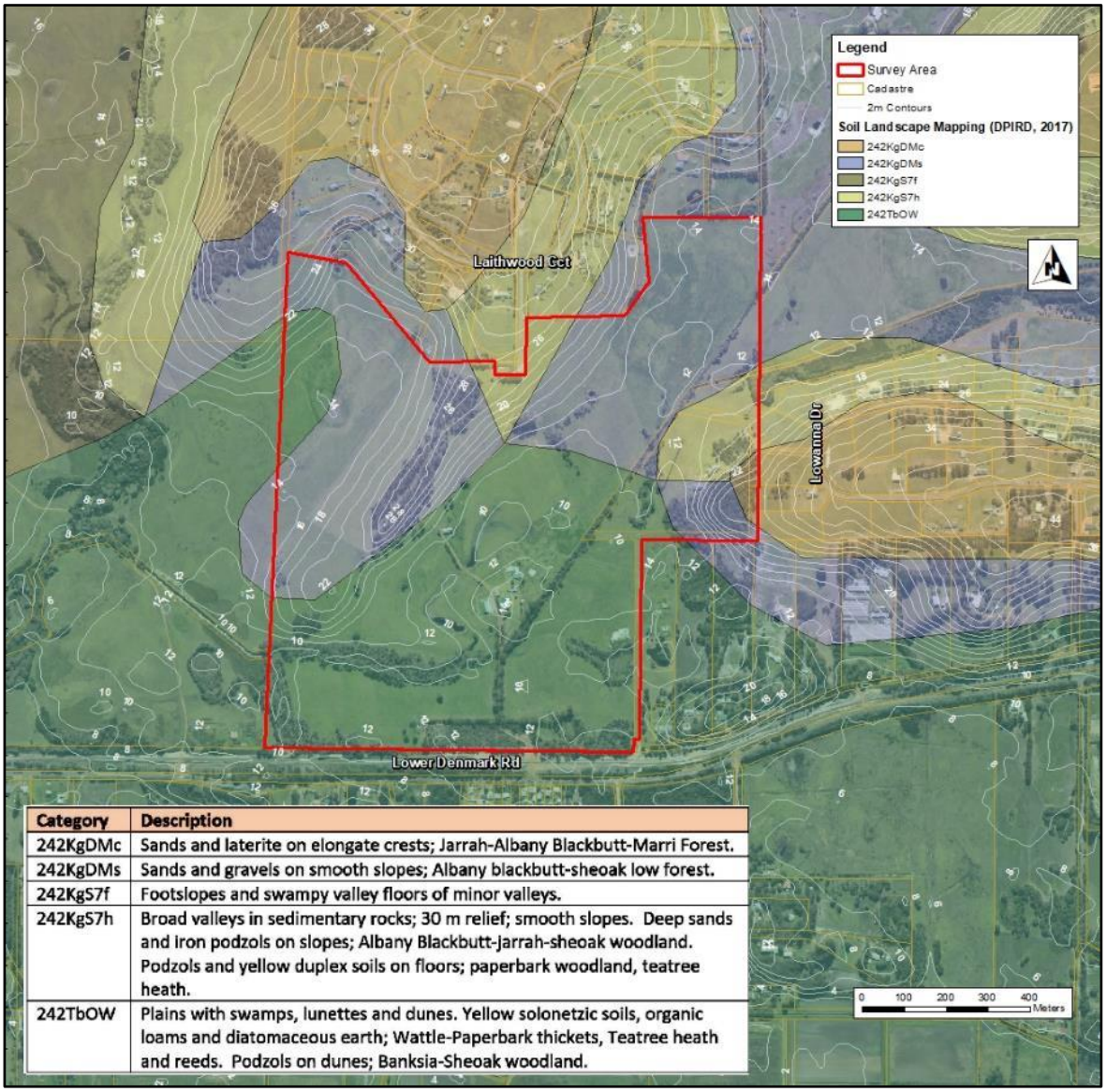
Opus (2007) recommended that the site not be excavated deeper than 500 mm to avoid mobilisation and oxidation of ASS. The top 500 mm of soil will require treatment with lime upon disturbance and ASS shall be managed in accordance with ASS guidelines (Opus, 2007).

3.6 Geology and Soils

Soil Mapping – Zones (DPIRD, 2017c) shows the Subject Site is within the Albany Sandplain Zone (242) and described as '*Gently undulating plain dissected by a number of short rivers flowing south. Eocene marine sediments overlying Proterozoic granitic and metamorphic rocks. Soils are sandy duplex soils, often alkaline and sodic, with some sands and gravels.*'

Soil mapping – Systems (DPIRD, 2018) shows the Subject Site lies within two soil systems being; the King System (242Kg) and the Torbay System (242Tb). The King System is described as *'Dissected siltstone and sandstone terrain, on the southern edge of the Albany Sandplain Zone, with shallow gravel, sandy gravel, grey sandy duplex and pale deep sand. Jarrah-marri-sheoak woodland and mallee-heath.'* and the Torbay System (242Tb) is described as '*Narrow swampy coastal plain, on the southern edge of the Albany sandplain Zone. Non-saline wet soil and pale deep sand. Sedgelands, ti-tree heath and wattie-paperbark thickets'* (DPIRD, 2018).

The Subject Site is located within four sub-systems of the King and Torbay Systems, as defined by DPIRD (2017b). The sub-systems are shown and described in Figure 6.



Category	Description
242KgDMc	Sands and laterite on elongate crests; Jarrah-Albany Blackbutt-Marri Forest.
242KgDMs	Sands and gravels on smooth slopes; Albany blackbutt-sheoak low forest.
242KgS7f	Footslopes and swampy valley floors of minor valleys.
242KgS7h	Broad valleys in sedimentary rocks; 30 m relief; smooth slopes. Deep sands and iron podzols on slopes; Albany Blackbutt-Jarrah-sheoak woodland. Podzols and yellow duplex soils on floors; paperbark woodland, teatree heath.
242TbOW	Plains with swamps, lunettes and dunes. Yellow solonetzic soils, organic loams and diatomaceous earth; Wattle-Paperbark thickets, Teatree heath and reeds. Podzols on dunes; Banksia-Sheoak woodland.

Figure 6: Soil mapping

3.6.1 Soil Classification (BDS, 2013)

Site soil testing was conducted on the 1st August 2013 by Bio Diverse Solutions under late winter conditions. Testing involved site soil analysis, photographic recording, logging of soil types and measuring of water table. In total, eight test/bore holes were constructed to a minimum depth of 2 metres and left open for a minimum of 1 hour to identify any water table present. The soil test hole (bore hole) locations are shown in Figure 7.

Figure 7: BDS (2013) soil testing and bore locations

The eight test holes revealed that soils across the Subject Site were relatively consistent and found to be peaty sand/sandy peat over sand/silty sand with pebbles and coffee rock encountered at TP6 (1.2-2.0 mm BGL) and TP8 (1.7-2.0 mm BGL) only. Details of the site soils as classified by BDS (2013) are summarised in Table 3.

Table 3: Soil testing results (BDS, 2013)

Test Pit	Depth (mm)	Soil Type and Description
TP1	0-25 25-350 350-750 750-1070 1070-2000 2000-2500	Dark brown peaty sand, organic matter. Dark grey, sandy peat, organic matter. Dark brown sand, moist. Light brown sand, wet. Brown silty sand. Brown silty sand.
TP2	0-25 25-300 300-900 900-2000 2000-2500	Dark brown peaty sand. Dark grey sand. Grey sand. Light brown silty sand. Brown silty sand, wet.
TP3	0-30 30-300 300-600 600-900 900-1800 1800-3000	Dark brown peaty sand, organic matter, wet. Dark brown peaty sand, organic matter, moist. Dark grey silty sand. Light brown silty sand. Light grey silty sand. Light brown silty sand.
TP4	0-40 40-300 300-750 750-1300 1300-2000	Dark brown peaty sand, organic matter. Dark grey sandy silt, organic matter. Grey sandy silt. Light grey sand silt. Brown silty sand, wet.
TP5	0-240 240-400 400-700 700-1000 1000-1500 1500-1800 1800-2000	Dark brown peaty sand, organic matter. Dark grey sandy peat, organic matter. Dark grey sandy silt. Light grey silty sand. Light brown silty sand. Brown silty sand. Brown silty sand.
TP6	0-200 200-750 750-1200 1200-1800 1800-2500	Brown peaty sand. Dark brown silty sand. Light brown silty sand. Dark brown silty sand with pebbles (5-10mm). Dark brown silty sand, coffee rock, cemented.
TP7	0-250 250-600 600-1800 1800-2000 2000-	Dark brown sandy silt. Dark grey silty sand. Grey silty sand. Light brown silty sand, wet. Rock refusal.
TP8	0-100 100-450 450-750 750-1700 1700-2000	Dark brown silty sand, organic matter. Dark grey silty sand. Grey silty sand. Light grey silty sand. Dark brown silty sand, coffee rock.

3.6.2 Soil Classification (Opus, 2007)

A Land Capability Assessment (LCA; Opus, 2007) was conducted at the Subject Site to ascertain the ability of the land to sustain the Rural Residential development proposal. The LCA (Opus, 2007) has been included as Appendix A.

Testing as part of the LCA involved site soil analysis, photographic recording, logging of soil types, measuring of water table, permeability testing and laboratory PRI testing. A total of 25 test holes were constructed to a depth of 2 m with a mechanical auger and left open for a minimum of 1 hour to identify any water table present. Test hole locations are shown in Figure 8.

Four soil types were identified across the Subject Site from the soil testing results. Soil types identified by Opus (2007) include; sand with silt, sand with silt over gravel, sand over gravel over rock and sand with silt and peat, as shown in Figure 8. The majority of the Subject Site is mapped as sand with silt. More detailed descriptions of soil types found at the Subject Site are presented in Appendix A.

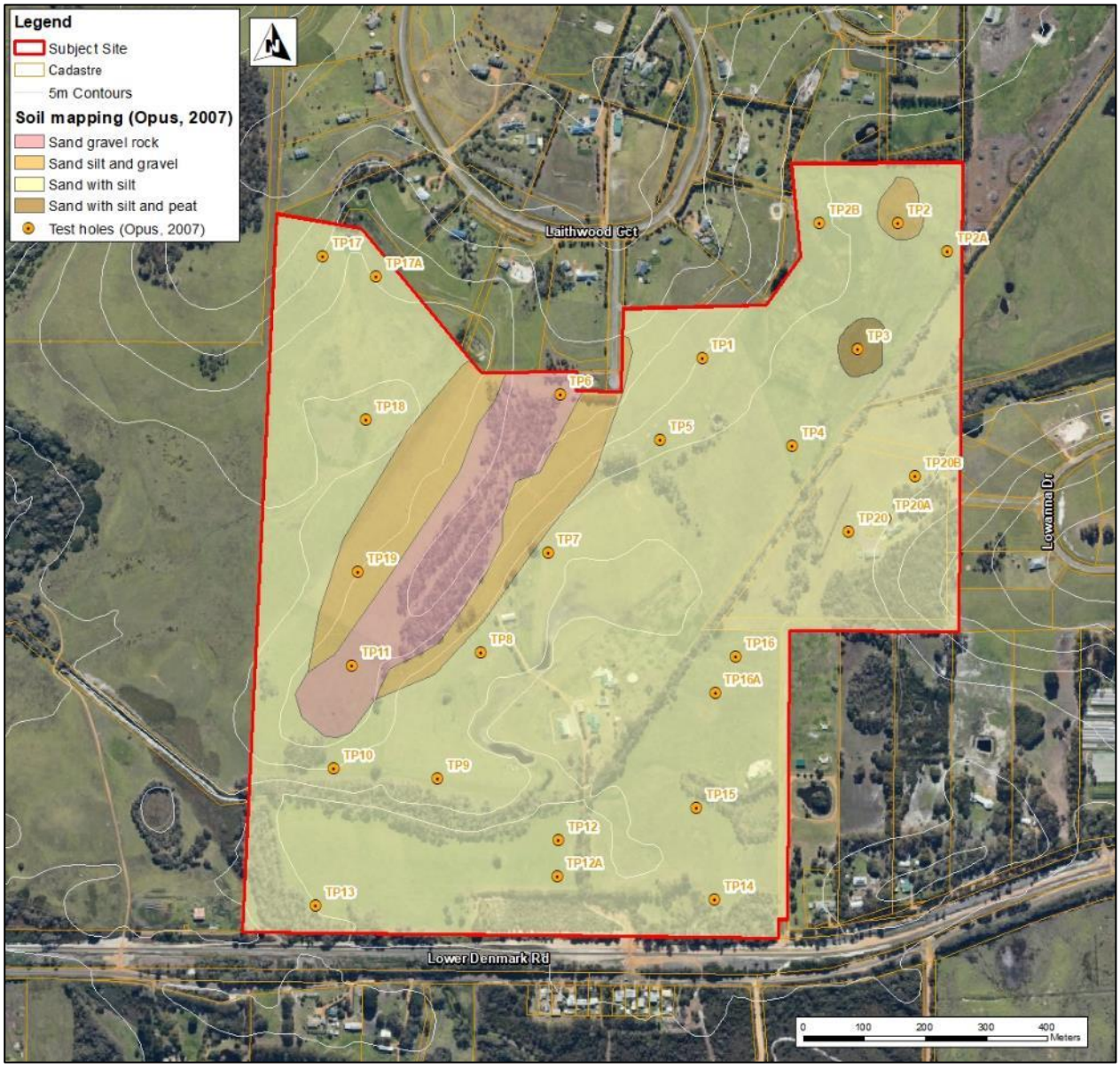


Figure 8: Soil mapping and test hole locations (Opus, 2007)

3.6.1 Soil Phosphorus Retention Index

Phosphorus Retention Index (PRI) testing was conducted by Opus (2007) on the sandy silt at Test Pits 4 and 7 (150-2000 mm depth) and the sandy gravel at Test Pit 19 (100-700 mm depth). The PRI results showed that the sandy silt had a low PRI (<1.0) and the sandy gravel had a very high PRI (324) typical of soil type (Opus, 2007).

3.6.1 Soil Permeability

Silts and clay soils generally record poor permeability results whereas coarse sands and loose gravels generally record high permeability, as shown in Figure 9.

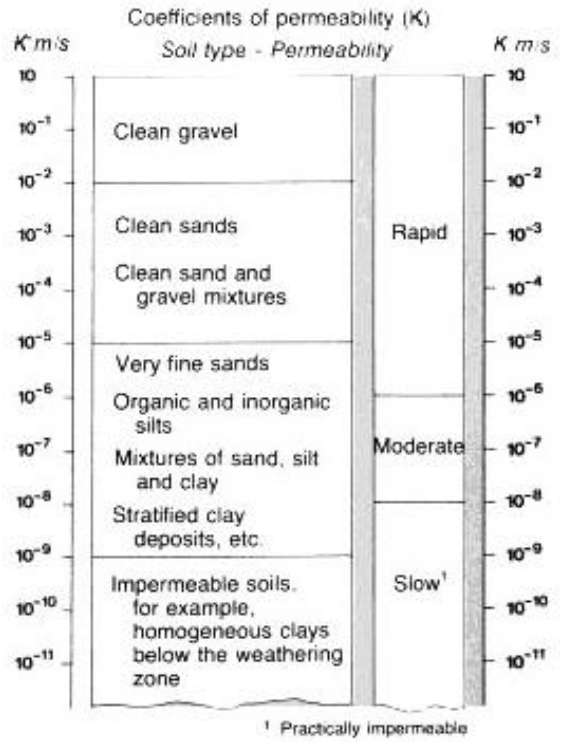


Figure 9: Hydraulic conductivity of soil types (Artiola et al., 2004)

In-field permeability testing was conducted during a site investigation by BDS on the 12th October 2021. Permeability testing was conducted adjacent to groundwater monitoring bore BH1 (Figure 7) within the silty sand layer (at 500 mm BGL). Permeability testing was conducted using the Talsma-Hallam method. Hydraulic conductivity adjacent to BH1 was found to be 4.20 x 10^{-5} m/sec (3.63 m/day) which is considered a rapid to moderate permeability, as shown in Figure 9. Permeability was also found to be consistent with Soil Category 2 - Sandy loams (weakly structured) as shown in Table L1 of AS/NZS 1547:2012.

Laboratory permeability testing was also conducted by Opus (2007) on sandy silt samples from TP4 and TP7 (150 - 2000 mm depth) and sandy gravel samples from TP19 (100 – 700 mm). Results showed that the soils were free draining typical of the sandy soil types (Appendix A; Opus, 2007).

3.7 Surface Water Hydrology

Stormwater runoff from the southern and eastern portions of the site is directed directly to Five Mile Creek. Five Mile Creek runs through the Subject Site from the northeast corner of the site to the southwest corner. The northwest corner of the Subject Site discharges to the southeast and ultimately Five Mile Creek further downstream. Five Mile Creek connects to Seven Mile Creek to the southwest of the Subject Site and Seven Mile Creek discharges to Lake Powell and ultimately the Torbay Inlet further west. The surface hydrology of the Subject Site is shown in Figure 10.

There are several less significant water bodies within the Subject Site, including a series of relatively small wetlands in the south, constructed farm dams in the central portion of the site and seasonally inundated pockets in the lower lying areas. There is also a constructed drain in the southwest corner of the site which discharges to Five Mile Creek, as shown in Figure 10.

The Subject Site is located within one hydrographic catchment, being the Torbay Inlet and one hydrographic sub-catchment, being Seven Mile Creek (DWER, 2018a).

According to flow modelling conducted for Five Mile Creek by DWER (Pers Comms N.Sykora, 2023), the maximum daily flow rate recorded at the downstream end of Five Mile Creek within the Subject Site (DWER station No. 6031115), between 1997 and 2022 is 199,000 m^3. This equates to 2.3 m^3/sec. According to data results for site No. 603115, the highest recorded level at the downstream end of Five Mile Creek within the Subject Site is 10.3 m AHD, which was recorded on the 30th August 2001.

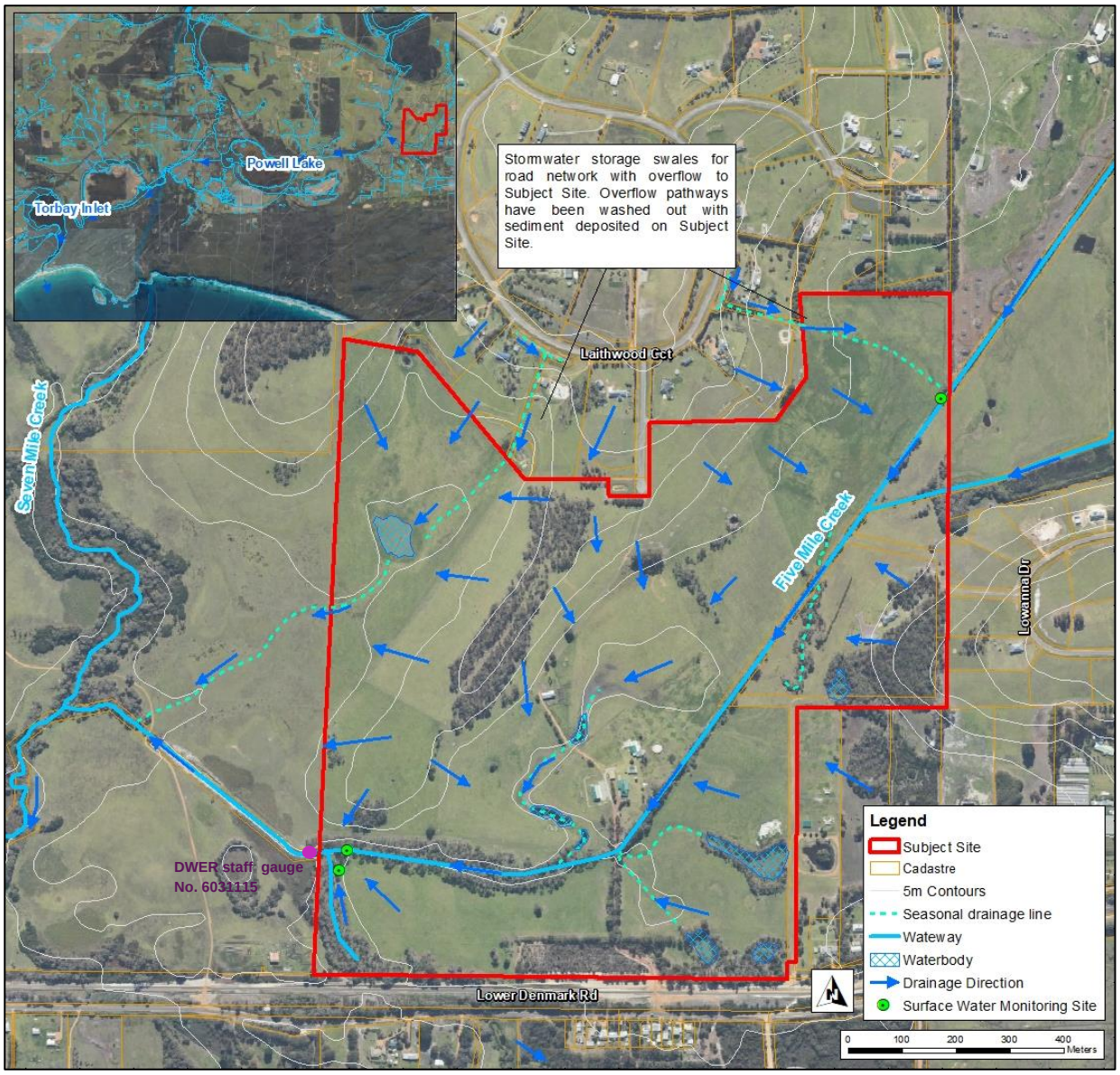


Figure 10: Surface water hydrology

3.7.1 Hydrological Site Assessment

A site investigation of the hydrological features was conducted on the 12th of October 2021 to confirm the surface water hydrology and to assist the development of the stormwater management plan. Rainfall in the Albany area (BoM Station No. 9500), prior to the site investigation was significantly higher than for the same time in an average year. The increased rainfall resulted in increased surface water expressions in the area compared to an average late winter period, providing an adequate depiction of the 'worst case scenario' in terms of seasonal inundation. Photographs 5 to 12 show the hydrological features of the site during the site investigation.

Photo 5: A general view to the east northeast of Five Mile Creek in the south of the Subject Site.

Photo 6: View to the west of Five Mile Creek at the western boundary of the Subject Site.

Photo 7: View to the south of constructed drain discharging to Five Mile Creek in the southwest of the Subject Site.

Photo 8: View to the north northeast of seasonally inundated area in the low-lying central portion of the Subject Site.

Photo 9: View to the east northeast of seasonally inundated area (wetland) in the south of the Subject Site.

Photo 10: View to the southeast of seasonally inundated area in the northwest of Subject Site.

Photo 11: View to the west northwest of eroded drainage easement to the west of eastern corner of Subject Site. Easement discharging runoff and sediment into the Subject Site.

Photo 12: View to the north of eroded drainage easement to the north of Subject Site. Easement discharging runoff and sediment into the Subject Site.

During the hydrological investigation, two drainage easements discharging into the Subject Site in the north were identified as having significant erosion and deposition of sediment in to the Subject Site. Photos of the two eroded drainage easements upstream of the Subject Site are shown in Photos 11 and 12. The location of the drainage easements discharging into the Subject Site are shown in Figure 10 (Seasonal Drainage lines).

It is recommended the drainage easements be redesigned and stabilised to prevent future erosion of the easements and sedimentation into the Subject Site and Five Mile Creek. It shall be the responsibility of the City of Albany to redesign and stabilise the easements, as these easements are not within the management of the property owner. Upon development of the Subject Site, the drainage lines extending from the drainage easements through the Subject Site shall be continued and stabilised up until the drainage pathways have reached an existing waterway/waterbody. Stabilisation methods may include rock pitching, vegetating the drain, stabilisation matting and meandering of the swale to reduce velocity. In-situ water quality testing was conducted at three waterway locations on site. The location of the water quality testing sites is shown in Figure 8. Water quality testing results are presented in Table 4.

Table 4: Water quality of Subject Site waterways

Creek	Temperature (ºC)	pH	Electrical Conductivity (dS/cm)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (g/L)
Five Mile Creek Upstream	13.99	6.04	0.366	6.35	0.234
Five Mile Creek Downstream	11.44	5.93	1.33	5.80	0.851
Constructed Drain Downstream (In the southwest of Subject Site)	12.41	6.36	1.28	9.32	0.819

Water quality testing results found that surface water within Five Mile Creek was slightly saline to brackish at the downstream end, and fresh to slightly saline at the upstream end. The constructed drain that discharges to Five Mile Creek at the downstream end was also found to be slightly saline to brackish. pH in Five Mile Creek and the drain was found to be slightly acidic. A slightly acidic pH is typical of waterways in low-lying areas in the south-west of Western Australia. Dissolved oxygen in Five Mile Creek was slightly lower than expected in a flowing creek and just below the ANZECC (2000) trigger value for low-lying rivers in South-west Australia. Quarterly Surface water monitoring (water quality) was conducted from August 2013 to May 2015 by BDS at two locations along the 5 mile creek at monitoring locations within the Subject Site. The Water Quality results are presented in Table 5.The surface water quality found in Five Mile Creek shall be maintained or improved in the post-development scenario.

Table 5: Water Quality Results -Surface Water (BDS, 2013-2015)

SAMPLED PARAMETER	SAMPLING DATE EVENT								
	Sampling Creek (CK001) 0571244 6125136	**8/08/2013**	**12/11/2013**	**11/02/2014**	**8/05/2014**	**8/08/2014**	**12/11/2014**	**12/02/2015**	**11/05/2015**
	Groundwater temperature (°C)	14.5	20.94	19.8	16.99	17.98	18.84	22.32	16.06
	pH	5.64	6.18	6.22	6.66	7.07	6.48	5.99	6.85
	Electrical conductivity (mg/cm)	0.616	1.01	0.532	0.744	0.52	0.529	0.51	0.738
	Dissolved Oxygen (mg/L)	7.58	8.85	3.67	5.24	5.62	6.48	5.14	5.54
	TDS	0.394	0.648	0	0.476	0.333	0.339	0.326	0.472
	Total N (Mg/L)	0.333	0.795	0.34	0.311	0.183	0.162	0.392	0.265
	Total P (Mg/L)	0.406	0.084	0.161	2.14	0.111	0.117	0.131	0.366
	Comments	Med flow	Low Flow	Low Flows	Low Flows		Low Flows	very low flows	Low flows

Table 5: Continued

SAMPLED PARAMETER	SAMPLING DATE EVENT							
	Sampling Creek (CK002) 0572398 6125982	**8/08/2013**	**12/11/2013**	**11/02/2014**	**8/05/2014**	**8/08/2014**	**12/11/2014**	**12/02/2015**	**11/05/2015**
	Groundwater temperature (°C)	16.22	20.49	20.08	16.91	17.06	18.8	23.96	15.9
	pH	6.03	5.91	6.02	6.22	6.09	6.09	5.93	6.46
	Electrical conductivity (mg/cm)	0.658	7.92	0.524	0.652	0.511	0.497	0.519	0.709
	Dissolved Oxygen (mg/L)	6.53	2.87	3.1	3.54	5.31	8.02	8.51	4.96
	TDS	0.421	0.507	0.335	0.417	0.327	0.323	0.332	0.454
	Total N (Mg/L)	0.113	0.481	<0.01	0.146	0.133	0.123	0.456	0.074
	Total P (Mg/L)	0.342	<0.001	0.0691	0.113	0.111	0.767	0.085	0.19
	Comments	Med flow	Low Flow	Low Flows cattle evident	Low flows		Low Flows	very low flows	Low flows

3.8 Hydrogeology and Groundwater

3.8.1 Hydrogeology

Australian Geoscience Mapping and Department of Water and Environmental Regulation 250K Hydrogeological mapping (DWER, 2001), places the Subject Site within one hydrogeological zone described as:

Geology Type: TP.
Geology Time: Tertiary – Cainozoic – Phanerozoic.
Aquifer Description: Sedimentary aquifer with intergranular porosity - extensive aquifers, major groundwater resources.
Geology Description: PLANTAGENET GROUP - siltstone, spongolite, minor sandstone, peat, and conglomerate.

The Subject Site is not situated within a Priority Drinking Water Catchment Area (DWER, 2018b). Desktop analysis of the site indicates that the nearest designated Public Drinking Water Source Area (PDWSA) is the South Coast Water Reserve as defined by the *Country Areas Water Supply Act 1947,* located approximately 80 m south of the Subject Site.

3.8.2 Groundwater

The original soil testing by Opus was conducted in June 2007, Opus consultants returned to the Subject Site to conduct late winter water-table monitoring in August 2007. Test pits were excavated to a depth of 2 m and the water table was encountered in 13 out of the 20 test pits. Five additional test pits (TP2a, TP2b, TP17a, TP20a and TP20b) were constructed alongside existing test pits to confirm soils and the high water-table level. Water-table measurements from these additional test pits were found to be the same or similar to the originally constructed test pits. The August 2007 water-table levels for each test pit are shown in Table 5.

Table 6: Water-table observations (Aug 2007)

Test Pit	Water-table observations – August 2007
1	Groundwater not encountered
2	0 mm BGL (waterlogged)
2a	500 mmm BGL (additional test pit)
2b	450 mm BGL (additional test pit)
3	0 mm BGL (waterlogged)
4	760 mm BGL
5	Groundwater not encountered
6	Groundwater not encountered
7	150 mm BGL
8	150 mm BGL
9	1400 mm BGL
10	Groundwater not encountered
11	Groundwater not encountered
12	100 mm BGL
13	980 mm BGL
14	550 mm BGL
15	800 mm BGL
16	220 mm BGL
16a	600 mm BGL

Table 6: continued.

Test Pit	Water-table observations – August 2007
17	Groundwater not encountered
17a	Groundwater not encountered (additional test pit)
18	150 mm BGL
19	Groundwater not encountered
20a	1300 mm BGL (additional test pit)
20b	1300 mm BGL (additional test pit)

Quarterly groundwater monitoring (levels and water quality) was conducted from August 2013 to May 2015 by BDS at 8 groundwater monitoring locations within the Subject Site. The location of the groundwater monitoring bores is shown in Figure 7. The depth to groundwater for each monitoring bore is presented in Table 6 and the groundwater quality results are shown in Tables 7 and 8.

Table 7: Groundwater monitoring levels

Bore	Sampling event							
	Aug 2013 (mm BGL)	Nov 2013 (mm BGL)	Feb 2014 (mm BGL)	May 2014 (mm BGL)	Aug 2014 (mm BGL)	Nov 2014 (mm BGL)	Feb 2015 (mm BGL)	May 2015 (mm BGL)
BH1	1011	640	1330	-	890	1040	1550	-
BH2	1236	1100	-	-	1145	1310	dry	-
BH3	0	0	870	1175	360	640	1017	310
BH4	150	670	1220	1105	635	1000	1400	1115
BH5	0	0	720	450	40	410	940	590
BH6	0	0	-	1006	165	1070	1600	840
BH7	790	1330	-	-	1470	1810	dry	-
BH8	530	1020	1830	-	1175	1510	dry	-

Groundwater level monitoring shows depth to groundwater varied across the site and throughout the year. Generally, the site has a shallow depth to groundwater. Groundwater was found to be at or near surface at BH3, BH4, BH5 and BH6 during the late winter period, noting that the depth to groundwater at BH4 was significantly greater in August 2014 (635 mm BGL) compared to August 2013 (150 mm BGL). Groundwater depths at BH1, BH2, BH7 and BH8 were still relatively shallow during the late winter period ranging between 530 -1236 mm BGL in August 2013 and 890-1470 mm BGL in August 2014.

Table 8: Average groundwater quality testing results

Parameter	*ANZECC Guideline Trigger Value*	Bore Number							
		BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8
Temperature (°C)	-	19.0	18.3	18.7	17.9	18.2	17.8	17.7	17.0
pH	6.5 – 8.0	5.10	4.70	5.17	5.25	5.26	5.08	5.29	5.14
EC (mS/cm)	0.12 - 0.3	0.58	0.77	0.37	0.43	0.32	0.36	0.57	0.59
Dissolved Oxygen (%)	80 – 120	49.4	29.0	40.4	29.0	43.7	44.6	46.4	22.7
Total N (mg/L)	1.20	1.53	2.81	1.29	0.55	0.80	1.42	0.66	1.68
Total P (mg/L)	0.065	2.39	1.77	2.05	0.54	0.37	0.54	1.07	1.21

Note: Orange shading indicates recorded value has exceeded ANZECC and ARMCANZ (2000) guideline trigger value for lowland rivers in South-west Australia.

Groundwater monitoring of the physical parameters and nutrients shows groundwater quality is typical of that in agricultural areas of South-west Australia. pH was found to be below the ANZECC and ARMCANZ (2000) trigger value range for lowland rivers in the South-west of Australia, and Total N and Total P levels were generally found to be above trigger values. Salinity (EC) and dissolved oxygen levels were also found to be above and below (respectively) of the ANZECC and ARMCANZ (2000) trigger value range for lowland rivers in the southwest of Australia (Table 8).

Table 9: Groundwater heavy metal concentrations

Heavy Metals	*ANZECC Guideline Trigger Value*	Bore Number & Sampling Event							
		BH3		BH4		BH5		BH6	
		22/05/2015	27/05/2015	22/05/2015	27/05/2015	22/05/2015	27/05/2015	22/05/2015	27/05/2015
Chromium (mg/L)	-	<0.01	0.003	0.017	0.012	<0.01	0.004	<0.01	0.015
Cobalt (mg/L)	-	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001
Nickel (mg/L)	-	0.036	<0.001	<0.01	0.04	<0.01	0.005	<0.01	<0.001
Lead (mg/L)	<0.0034	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001	<0.01	<0.001
Cadmium (µg/L)	<0.0002	<0.002	<0.001	<0.002	<0.001	<0.002	<0.001	<0.002	<0.001
Mercury (µg/L)	0.6	<0.01	0.056	0.078	<0.01	0.022	0.056	<0.01	<0.01
Arsenic (ug/L)	<13	4.73	4.07	3.23	2.05	<0.01	0.982	6.49	16.6

Note: Orange shading indicates recorded value has exceeded ANZECC and ARMCANZ (2000) trigger value for toxicants in freshwater ecosystems at 95% level of protection.

Groundwater testing of the heavy metals indicated levels are generally below the ANZECC and ARMCANZ (2000) guideline trigger values, with the exception of Arsenic at BH6 in May 2015, which was found to be just above the trigger value (Table 9).

3.8.3 Waterlogging and Seasonal Inundation

The areas subject to seasonal waterlogging and seasonal inundation were mapped by Opus (2007) as part of the LCA. Areas subject to seasonal waterlogging (groundwater $\leq$ 0.5 m BGL) and seasonal inundation (water sitting on the surface for extended periods of time) were confirmed during the site assessment on the 12th October 2021 and using historical imagery of the site. Approximate areas found to be subject to seasonal waterlogging and seasonal inundation are shown in Figure 11.

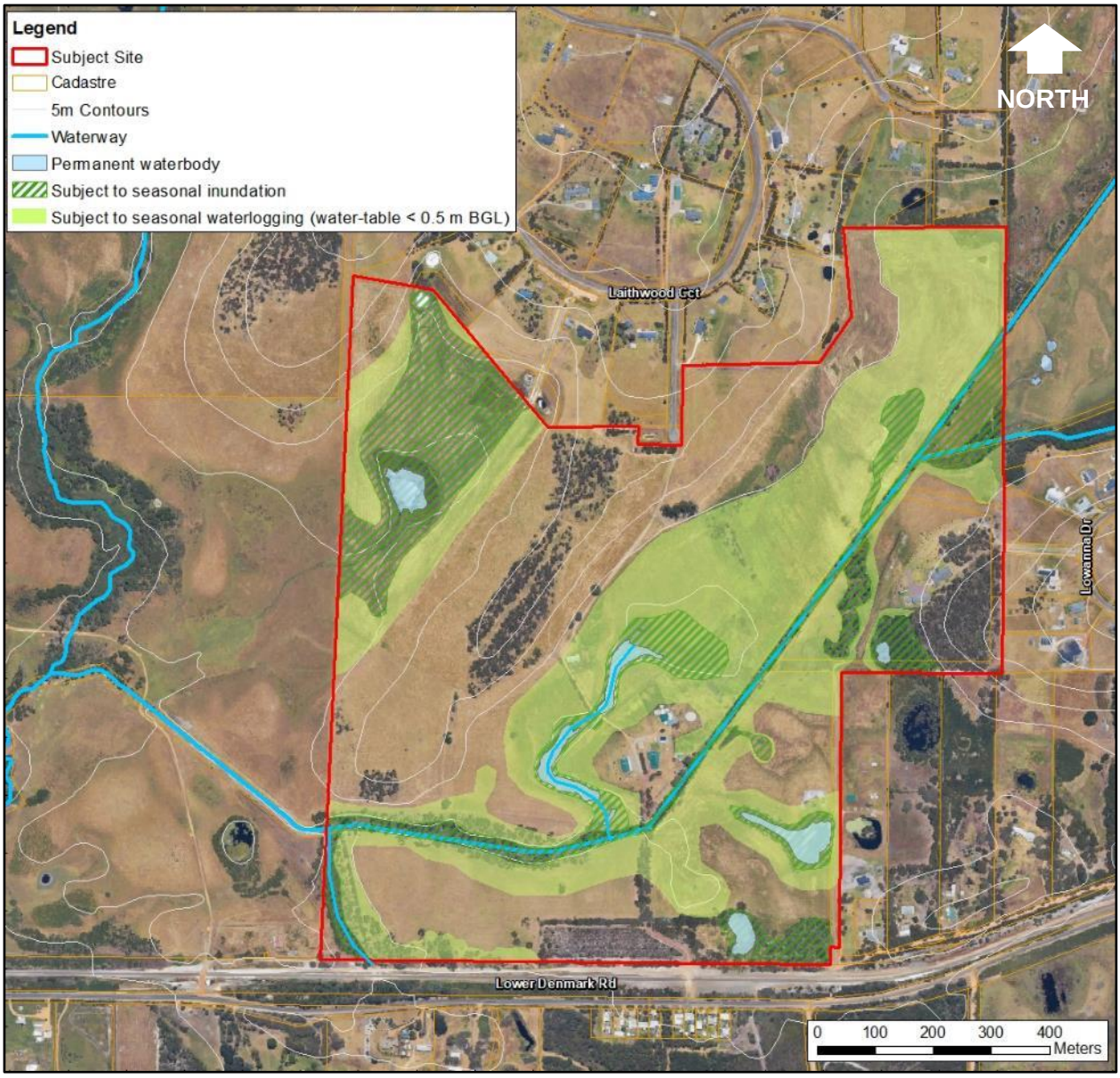


Figure 11: Waterlogged and seasonally inundated areas

3.9 Wetlands & Environmentally Sensitive Areas

There are no significant wetlands within the Subject Site or within close proximity of the Subject Site. The nearest significant wetland is located approximately 1.0 km to the north of the Subject Site, being the Seven Mile Creek wetland (DBCA, 2017). Noting that the Subject Site is down-gradient of the Seven Mile Creek wetland.

There are no Environmentally Sensitive Areas (ESA) within the Subject Site or within close proximity of the Subject Site. The nearest Environmentally Sensitive Area (ESA) is located approximately 2.5 km west of the Subject Site, being Lake Powell (DWER, 2018c). Noting that the Subject Site ultimately discharges to Lake Powell via Five Mile Creek and Seven Mile Creek.

4 Wastewater Management

The Subject Site is situated in an area that does not have access to deep or reticulated sewerage. The health and environmental requirements for wastewater treatment and disposal for developments not serviced by deep sewerage systems are contained in the *Government Sewerage Policy* (GSP; DPLH, 2019). The GSP (DPLH, 2019) states minimum requirements apply for all on-site sewage disposal systems.

A Site Soil Evaluation (SSE) (BDS, 2024) has been prepared for the Subject Site in conjunction with this LWMS. The SSE details the site soils under late winter conditions and assesses the suitability for on-site effluent disposal across the site in relation to the planning proposal.

The SSE identifies the areas within the Subject Site suitable for onsite effluent disposal as those that have free draining soil, are not located in heavily waterlogged or seasonally inundated areas and are a minimum of 100 m from Five Mile Creek and its connected tributaries/drains, and 30 m from other less significant waterway/waterbody (BDS, 2024). Effluent disposal systems shall also be a minimum of 30 m from any stormwater storage area and 12 m from any down-gradient roadside drain.

Given the shallow depth to groundwater across much of the Subject Site, imported fill and special design requirements and distribution techniques will be necessary in the low-lying areas to ensure the effluent disposal systems are free draining and meet the minimum separation to groundwater requirement, as stipulated in the GSP (DPLH, 2019).

Leach drains and irrigation systems (surface or subsurface) in conjunction with a secondary treatment system have been identified as the most suitable land application systems for future lots depending on localised site constraints. Areas deemed as suitable for LAAs and LAA specifications are described in more detail in the SSE (BDS, 2024).

5 Local Water Management Strategy

5.1 Water Sustainability Initiatives

5.1.1 Water Supply

Water supply to households is to be via extension of the scheme water system. The project civil engineer will negotiate the extension of the system with Water Corporation Western Australia.

5.1.2 Water Efficiency Measures

To achieve water efficiency targets, households are to be built consistent with current Building Code of Australia (BCA) water efficiency standards. Water efficiency initiatives are proposed to reduce potable water demand for irrigation of residential lots. These include encouragement of:

- Minimising turf areas;
- Selection of predominantly local native, drought tolerant plants;
- Use of waterwise gardens, restricted lawn areas and water wise lawn varieties;
- Use of rainwater tanks; and
- Community education initiatives on water conservation and reuse.

5.2 Stormwater Management

5.2.1 Design Capacity

The stormwater management system for the development has been designed in accordance with DWER guidelines through the Better Urban Water Management framework and the requirements of the City of Albany. The stormwater drainage system has been designed using a major/minor approach.

The stormwater drainage system is designed to manage a range of rainfall events up to the 1% AEP.

The major drainage system is designed for rainfall events greater than the 20% AEP up to the 1% AEP. The major system uses overland flow paths, which includes grading the road network to direct flow to the lowest point of the catchment for flood mitigation.

The minor drainage system has capacity for frequent rainfall events up to the 20% AEP and includes any pipe drainage system, roadside swales and use of bio-retention storages. The minor drainage system is designed to also provide the structural controls for water quality treatment.

5.2.2 Stormwater Modelling

The stormwater modelling has been completed utilising the Rational Method and the Boyd Equation. A critical design criterion for both these methods includes the runoff coefficients. The pre-development and post-development runoff coefficients assumed for the Subject Site are shown in Table 9.

Table 10: Runoff coefficients

LAND USE	RUN OFF COEFFICIENT		
	First 15mm	20% AEP	1% AEP
Agricultural land	0	0.2	0.3
Road Reserve	0.8	0.8	0.9
Rural Residential	0	0.3	0.35
Rural Smallholdings	0	0.25	0.30

The general pre-development hydrological regime (Figure 10) is maintained in the post-development scenario, with the north western portion of the Subject Site discharging to the southwest via a valley system and a seasonal creek line, and the remainder of the Subject Site discharging towards Five Mile Creek either directly or via seasonal creek lines or cut drains within the Subject Site.

The post-development drainage sub-catchments have been determined ensuring that all road runoff up to the critical 20% AEP storm event is captured and retained within the Subject Site. Post-development sub-catchments for the Subject Site are shown in Figure 12. The total area of each sub-catchment and the estimated land use area for each sub-catchment is presented in Table 10.

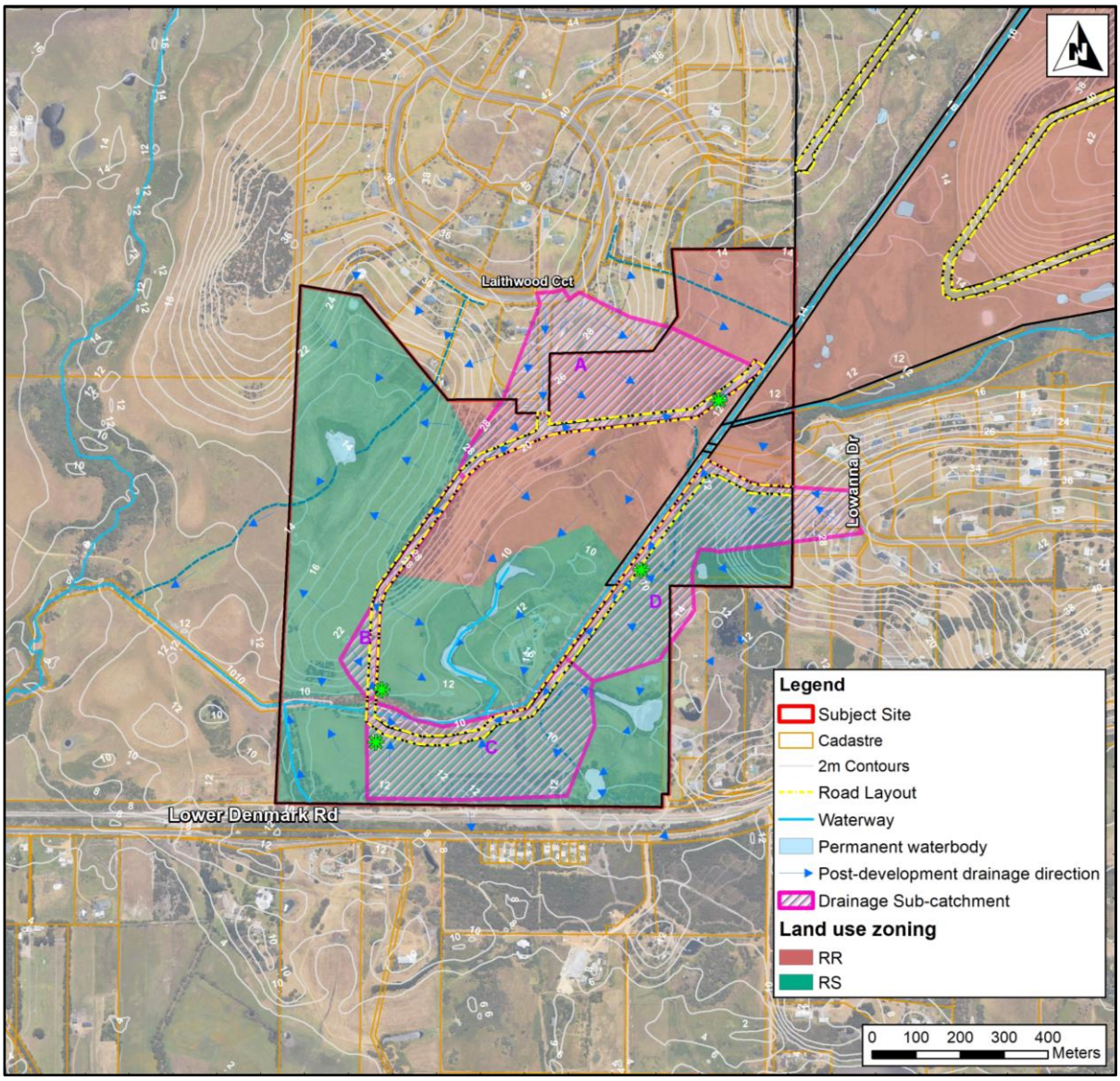


Figure 12: Post-development drainage sub-catchments

Table 11: Post-development sub-catchment areas

Land Use	Catchment			
	A	B	C	D
Road Reserve (ha)	2.4	1.2	1.3	1.8
Rural Residential Lots (ha)	10.9	0	0	0
Rural Small Holding lots (ha)	0	0.7	9.2	9.6
Total Area (ha)	**13.3**	**1.9**	**10.5**	**11.4**

The majority of the proposed lot area will discharge unattenuated from the site towards Five Mile Creek or the seasonal drainage line in the northwest of the site, consistent with the existing hydrological regime. It is assumed that the majority of the lot area will remain grassed and/or vegetated with roofed areas connected to rainwater tanks, soakwells and/or rain gardens, and therefore there will be little change in the runoff coefficient of these areas compared to the pre-development scenario. Where lots are up-gradient of the internal road network, the road network will intercept runoff from the lots and direct it to the road's drainage system. Lot areas that discharge to the internal road network therefore form part of the site's drainage sub-catchments, as shown in Figure 11.

Runoff from the Subject Site's internal road network will be retained on site within bio-retention storages with outflows from the bio-retention storages directed to Five Mile Creek. Outflow from the bio-retention storages will be consistent with estimated pre-development flow rates.

Multiple storm events have been modelled utilising the Rational Method as described in Australian Rainfall and Runoff (AR & R) (Engineering Australia, 2016). Pre-development outflow rates have been calculated based upon peak flow stream discharge as determined by Section 1.4 of AR & R.

Rainfall intensities for the various storm events and storm durations are calculated and provided by the Bureau of Meteorology (BoM) computerised design Intensity Frequency Duration (IFD) Data System (www.bom.gov.au). Calculations have been undertaken utilising up to date IFD charts.

The Boyd method has been utilised to calculate the stormwater storage volume required for each sub-catchment based on the post-development runoff from the site and the allowable outflows set for the stormwater storages, which are determined by the peak pre-development outflow rate. The Boyd method is considered a conservative estimate of stormwater storage volume calculation.

5.2.3 Drainage System Requirements

Key elements of the proposed drainage system are as follows:

Lot Attenuation

- It is the landowner's responsibility to manage stormwater runoff from buildings, hard stand (impervious) areas and gardens within the property boundary consistent with the City of Albany's lot attenuation guidelines (i.e., 0.5 m^3 of storage is required per 100 m^2 of impervious area). Lot stormwater management systems should be assessed and approved by the City of Albany upon Development Application.
- Rainwater tanks are recommended on all lots and shall be plumbed into homes using a mixed demand system or a trickle feed system to provide available storage for recurrent storm events.
- Soakwells shall only be utilised where there is adequate separation to the peak annual water-table from the base of the soakwell (>300 mm) and adequate gradient for graduated pipe overflow pipes. In areas with shallow depth to groundwater, attenuation basins integrated into the garden landscaping will provide the most effective attenuation mechanism. When designing lot stormwater management systems overland flow routes directing runoff away from buildings and adjoining properties shall be

considered. Lot stormwater management systems should be assessed and approved by the City of Albany upon Development Application.

Stormwater Conveyance

- Roadside swales designed to convey storm events up to the 20% AEP and where required, pipe drains to connect sections of swale sized to convey the 20% AEP storm event. Pipe drains include lot crossovers which shall be constructed prior to subdivision to ensure the integrity of the drainage system is maintained.
- Roadside swales shall have a minimum side slope of 1:4 between the road and swale and 1:5 between the lot boundary and swale for ease of maintenance. The swales shall be designed with adequate grade for peak runoff conveyance. The minimum longitudinal grade criterion for the swales is 0.003 (absolute) and 0.005 (preferred). The estimated capacity and top water level of each section of swale shall be calculated using the Manning's formula or appropriate modelling software subsequent to earthwork design once the incoming sub-catchment to each swale section is confirmed.
- Road drainage from storm events greater than the peak 20% AEP event up to the peak 1% AEP event will be directed to the lowest point in each catchment via overland flow along the road pavement. The ultimate road low point will be located adjacent to Five Mile Creek in each sub-catchment to ensure road runoff is directed off site during storm events greater than the 20% AEP. Runoff from storm events greater than the 20% AEP event will be directed off site unattenuated. Attenuation of flows for storm events greater than the peak 20% AEP event, up to the peak 1% AEP event are likely to have negligible impact on the flood regime of the downstream area.
- Where the two existing drainage easements discharge to the Subject Site in the north, the drains will be extended within the Subject Site discharging to Five Mile Creek in the northeast and the seasonally inundated low point in the northwest (Figure 13). The drains will be stabilised using rock pitching, vegetation and/or stabilisation matting. It is recommended the drains within the Subject Site be constructed subsequent to the re-establishment and stabilisation of the upstream sections of the drain, as discussed in Section 3.7.1, to prevent sedimentation and erosion within the newly constructed sections of drain.
- Where the internal road network crosses Five Mile Creek culverts shall be installed and sized to convey up to the critical 1% AEP storm event within Five Mile Creek and the road level shall be set 0.3 m above the 1% AEP TWL. Given the highest TWL recorded between 1997 and 2022 was 10.3 mAHD (recorded on the 30th Aug 2001) and given the land between the location of the creek cross over and the DWER staff gauge is flat (on the same contour line). A top water level within the creek of 10.3 mAHD shall be used as the 1% AEP top water level at the creek cross over. Given the maximum daily flow rate in Five Mile Creek near the proposed culvert was modelled by DWER to be 199,000 m^3, equating to 2.3 m^3/s. A 1% AEP flow rate of 4.6 m^3/sec shall be adopted for the creek cross over culverts. This flow rate is double the modelled daily flow rate, to allow for shorter more intense rainfall events and subsequent flows.

Bio-retention and Stormwater Storage

- Drainage treatment train utilising bio-retention storages, designed to treat the first 15 mm of rainfall, by providing infiltration close to source. Bio-retention storages shall be designed to convey up to the 20% AEP storm event. Storages will be located at the low point of the sub-catchments, to direct runoff away from infrastructure in the case that the capacity of the storage is exceeded. The bio-retention storages shall be located outside of Five Mile Creek and its flood/riparian vegetation zone. A conceptual cross section of the bio-retention storage is shown in Figure 13 and sizing of the bioretention storages for each sub-catchment is shown in Table 12.
- The maximum side slopes of the bio-retention storages shall be 1:6, with at least 0.3 m of freeboard provided between the 20% AEP top water level and top of bank. A stabilised low point in the bank shall be provided at the 20% AEP top water level, located downstream in the bio-retention storage so that overflow is directed off site when/if the capacity of the storage is exceeded.

- The base of the bio-retention storage shall be underlain with 0.4 m depth of amended soil, 0.15 m depth of a transition layer (coarse sand) and 0.15 m depth of a drainage layer with 100 mm (maximum) perforated collection pipes (subsoils), as shown in Figure 13. Bio-retention storages shall also be planted, the specifications for the amended soil and the planting are provided in Section 5.4.
- Outflow from the bio-retention storages for minor storm events (up to the 20% AEP) shall be set at the top water level of the first 15 mm runoff event, this is set at a maximum depth of 0.5 m to allow for adequate water quality treatment across a larger surface area. Outflow from the storages will be via an overflow pit sized to match the peak pre-development outflow for the 20% AEP storm event for each sub-catchment (Table 10).
- Outflow from bio-retention storages in all sub-catchments (A, B, C and D) will discharge to Five Mile Creek. Measures shall be taken at the downstream end of the storage outlets to ensure scouring and movement of sediment is minimal, this may include rock pitching and stabilisation matting.
- All bio-retention/stormwater storages shall be contained within easements and have adequate access for maintenance. Bio-retention storages shall be located outside of the designated Five Mile Creek easement.

Flood Protection

- All building pad finished levels shall have a minimum of 0.3 m separation above the estimated 20% AEP top water level in the bio-retention storages and above the 1% AEP top water level in nearby waterways and waterbodies consistent with the Local Government Guidelines for Subdivisional Development (IPWEA, 2017).
- All roads shall have a minimum separation of 0.3 m above the 20 % AEP top water level in the bio-retention storages and nearby waterways and waterbodies.
- Building pads shall be set back a minimum of 100 m from Five Mile Creek for both flood protection and environmental protection of the waterway. Given the highest maximum flood level at the downstream end of Five Mile Creek was recorded to be 10.3 mAHD, a 100 m setback to Five Mile Creek, ensures building envelopes are outside of the 1% AEP flood levels.

The First 15 mm and 20% AEP storage requirements are presented in Table 13. The stormwater management plan for the Subject Site is shown in Figure 14.

Table 12: Drainage system requirements (bio-retention storages)

	Catchment			
	A	**B**	**C**	**D**
First 15mm				
Runoff Volume (m^3)	288	144	156	216
Storage Volume required (m^3)	288	144	156	216
Maximum Ponding Depth (m)	0.5	0.5	0.5	0.5
20% AEP				
Critical Storm Duration (hours)	1	1	1	1
Storm Duration Runoff Volume (m^3)	1059	232	681	783
Storage Volume (m^3)	516	154	253	318
Maximum Ponding Depth (m)	0.9	0.9	0.9	0.9
Allowable Outflow from Storage (L/s)	151	21	119	129

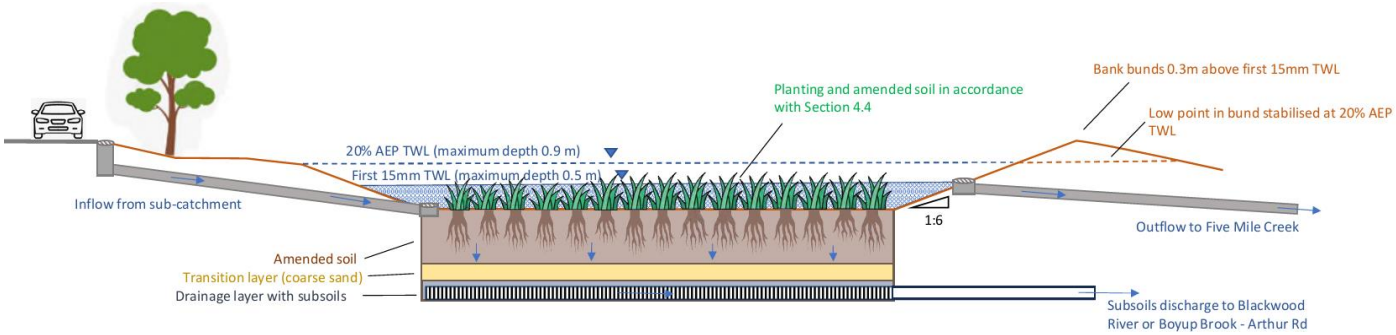


Figure 13: Conceptual cross-section of bioretention storage

Extension and stabilisation of drain required.
Subsequent to re-establishment and stabilisation of upstream section of drain.

Laithwood Cct

Bio-retention Storage B

First Flush (15mm)
Storage required - 144m^3
Max ponding depth - 0.5m

20% AEP
Storage required - 154m^3
Max ponding depth - 0.9m
Allowable outflow - 21L/s

Bio-retention Storage A

First Flush (15mm)
Storage required - 288m^3
Max ponding depth - 0.5m

20% AEP
Storage required - 516m^3
Max ponding depth - 0.9m
Allowable outflow - 151L/s

Bio-retention Storage C

First Flush (15mm)
Storage required - 156m^3
Max ponding depth - 0.5m

20% AEP
Storage required - 253m^3
Max ponding depth - 0.9m
Allowable outflow - 119L/s

Crossover surface level – 10.6 mAHD

Culvert design – Allow for 4.6m3/s

Bio-retention Storage D

First Flush (15mm)
Storage required - 216m^3
Max ponding depth - 0.5m

20% AEP
Storage required - 318m^3
Max ponding depth - 0.9m
Allowable outflow - 119L/s

A
B
C
D

Lowanna Dr

6126200 6126100 6126000 6125900 6125800 6125700 6125600 6125500 6125400 6125300 6125200 6125100 6125000

571200 571300 571400 571500 571600 571700 571800 571900 572000 572100 572200 572300 572400 572500

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BIO DIVERSE SOLUTIONS

Overview Map Scale 1:100,000

Legend

- Subject Site
- Cadastre
- 2m Contours
- Waterway
- Road Layout
- Post-development Drainage Direction
- Vegetation Protection Zone
- Drainage Sub-catchment
- Proposed culverts
- Bio-retention storage (First 15mm TWL)
- Bio-retention storage (20% AEP storage TWL)
- Revegetation area

Scale
1:4,700 @ A3
GDA MGA 94 Zone 50

Data Sources
Aerial Imagery: WA Now, Landgate Subscription Imagery
Cadastre, Relief Contours and Roads: Landgate 2017
IRIS Road Network: Main Roads Western Australia 2017
Overview Map: World Topographic map service, ESRI 2012

CLIENT
Barry Panizza
Lot 9001 Lower Denmark Road
Cuthbert, WA 6330

Figure 14: Stormwater Management Plan

	QA Check	Drawn by
	AT	CC
STATUS: FINAL	FILE: HD0063 005	DATE: 26/04/2024

5.3 Groundwater Management

The groundwater management objectives for the Subject Site are to:

- Manage groundwater levels to protect infrastructure and assets;
- Maintain groundwater regimes for the protection of groundwater dependent ecosystems;
- Protect the value of groundwater resources; and
- Adopt nutrient load reduction design objectives for discharges to groundwater.

The following strategies will be implemented for the proposed development of the Subject Site to ensure the above objectives are met:

- To protect infrastructure from high seasonal groundwater levels. Building pads and foundations shall be set in accordance with applicable building standards based on soil type and separation to groundwater. Imported fill will be required where there is a low separation to groundwater, to ensure there is adequate separation between groundwater and building pads/foundations. A minimum separation of 1.5 m (in sands) is required between the land application of effluent disposal and peak groundwater levels (BDS, 2024). Where imported fill is required for the LAA, the same minimum fill depth shall be required for building pads.
- Subsoil drains shall be installed where the road finished level is less than 2 metres above the peak annual water-table. Subsoil drains shall have free draining outlets directed to bio-retention/stormwater storages for treatment prior to discharge.
- Bio-retention storages to have subsoils beneath the amended soil layer to prevent long standing water. Subsoil drains shall have a free draining outlet directed to Five Mile Creek.

5.4 Water Quality Management

The effective implementation of the structural and non-structural controls as part of the development will enhance water quality from this site as a result of the land use change from agriculture to rural residential/rural smallholdings.

The Subject Site uses a treatment train of structural and non-structural controls to treat up to the first 15 mm of rainfall from storm event.

Structural controls include the use of:

- Lot attenuation through the use of plumbed-in rainwater tanks, soakwells and/or rain gardens to capture runoff from roofs and hardstand areas reducing runoff from the site. Infiltration of rainwater at source allows for treatment of water as it moves through the soil profile.
- Bio-retention storages which will receive runoff from the development's internal road network. Bio-retention storages are designed to treat the first flush event (first 15 mm) and retain up the 20% AEP storm event. Bio-retention storages will allow for infiltration at source, they will be underlain with amended soil and subsoils, and planted to allow for uptake of nutrients and contaminants. The minimum specifications for all bio-retention storages are presented in Table 12.
- The revegetation of Five Mile Creek's riparian zone in the northeast is proposed. Revegetation of the riparian zone shall be consistent with minimum requirements for the bio-retention storages (Table 12), with larger native shrubs suitable for the outer creek line. Figure 14 shows the area proposed to be revegetated, this area has been selected based on being the most degraded vegetation fringing the creek. The existing fringing vegetation along Five Mile Creek within the drainage easement and the proposed revegetation area shall not be impacted as part of development works and as such these areas along with other vegetated areas within the Subject Site are proposed to be categorised as a Vegetation Protection Zone (Figure 14).

- Any revegetation or bioretention planting has been accounted for in the Bushfire Management Plan (BMP), as Forest Type A or Shrubland Type C. Refer to details in the overall BMP for the rezoning.

Table 13: Minimum requirements for bio-retention storages

Item	Specification
Amended soil media	• Well graded sand. • Clay and silt content <3%. • Organic content between 3 and 5%. • Hydraulic Conductivity (sat) >150mm/hour. • Light compaction only. • Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program.
Plant selection	• In accordance with Vegetation Guidelines for Stormwater Biofilters in the South-West of WA (Monash University, 2014). • Tolerant of periodic inundation and extended dry periods. • Spreading root system. • Preferential selection of endemic and local native species. • Planting to provide 70-80% coverage at plant maturity.
Planting density and distribution	• Planting density appropriate for species selection. • Even spatial distribution of plant species.

The bio-retention systems should be sized to function correctly with a hydraulic conductivity (K) (saturated) of at least 3 m/day. Research conducted by the Facility for Advancing Water Biofiltration (FAWB, 2008) indicates that the desired K_{sat} is in the range of 2.5 to 7 m/day, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research also specifies that for vegetated systems some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

Non-structural source controls to reduce nutrient export from the Subject Site will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed;

- Promotion of the use of local native plants for landscaping to new lot owners. The use of local native plants will reduce the need for fertilisers across the site; and
- Undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system.

6 Implementation

6.1 Construction Management

Any temporary stormwater storage required during construction shall be built where the final storage area will be located. The temporary storage will be sized to contain the ultimate capacity of stormwater runoff from the connected area. Measures shall be taken to prevent the transportation of sediment during the construction phase including infiltrating at source where possible and sand bagging/rock placement at the inlet of any pipe systems discharging outside the Subject Site. Remedial measures shall be undertaken by the developer if any disturbances to the surrounding areas are caused during construction.

6.2 Maintenance of Drainage Systems

The bio-retention storages and drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be required and undertaken by the proponent periodically until successful practical completion of the development and handover to the City of Albany. Following handover, it is the City of Albany's responsibility to maintain drainage structures accordingly:

- Removal of debris to prevent blockages;
- Maintenance of vegetation in bio-retention swales; and
- Cleaning of sediment build up and litter layer on the bottom of storages.

6.3 Monitoring Program

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

6.3.1 Hydraulic Performance Monitoring

The hydraulic performance monitoring will aim to measure the movement of stormwater through the storage structures to determine if stormwater conveyance is consistent with the intended design.

Where amended soil profiles have been installed in the bio-retention storages, infiltration testing shall be completed to test the hydraulic conductivity of the media. Testing should be repeated every 12 months to ensure clogging of the storages does not occur.

Water levels in the bio-retention storages and the roadside swales shall be observed during significant storm events to ensure they are consistent with design and not overflowing.

6.3.2 Groundwater Monitoring

A series of groundwater monitoring bores (BH1 - BH8) have been established across the Subject Site to determine pre-development groundwater levels. The location of the monitoring bores is shown in Figure 7.

Groundwater levels have been measured quarterly and include one late winter period prior to development to establish baseline groundwater level data. Post-development groundwater level monitoring (quarterly) shall include two winter periods and be conducted at the same bore locations (or the nearest practical location where the same location is not possible) as the pre-development groundwater investigation, with results compared to pre-development levels. If groundwater levels are found to exceed pre-development groundwater levels by more than 500 mm with no significant change in rainfall, a review of the development design and operations will be required and alterations/modifications to the development will be conducted to reduce groundwater levels accordingly.

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Appendix A

Land Capability Assessment – Lot 800 South Coast Hwy, Cuthbert (Opus, 2007)

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land Development Pty Ltd

OPUS

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land Development Pty Ltd

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Date: August 2007
Reference: G:\Environmental Services\Environmental Projects\Whelans

Status: Final
Reference: Job No: WAENV047

LAND CAPABILITY ASSESSMENT

LOT 800 SOUTH COAST HWY, CUTHBERT, ALBANY

APPENDICES

A. Subdivision Guide Plan
B. Site Soil Test Pit Locations and Field Testing Results
C. Late Winter Water Table Testing
D. Proposed Buffer Distances
E. Approved Health Department ATU's

LIST OF TABLES IN REPORT

Executive Summary

A Land Capability Assessment was conducted on lot 800 South Coast Highway, Albany to ascertain the ability of the land to sustain Rural Residential development proposals. Grande Terra Land Development Pty Ltd engaged Opus Consultants to undertake the assessment.

Grande Terra Land Development Pty Ltd proposes to develop Lot 800 South Coast Highway, Albany into residential lots. Stage One of Albany Green is currently being developed into Rural Residential lots. Please refer to Appendix A, Copy of Subdivision proposal.

The assessment included analysis of the geology and landforms, vegetation, and historical land-uses. Site Soil Investigations were carried out in the field and in the laboratory by Opus Consultants and Albany Soil and Concrete Testing. The Land Capability Assessment was conducted as per the Department of Agriculture Land Capability Assessment Guidelines, with the proposed Rural Residential zoning being assessed against the criteria of Rural Residential with on-site effluent disposal (Land Capability Assessment for Rural Strategies 1989).

Four mapping units were identified from the soil types and landforms within the area; these were defined into mapping units A, B, C and D (refer to Mapping, page 20). The results of the Land Capability Assessment indicate there are limitations, however mainly restricted to low lying areas. The Land Capability recommends that there is some design changes to the present lot and road concept plan to follow contours and for best practise designs to be implemented for drainage.

Summary of Map Unit A

Map Unit A is predominantly sandy soils in the lower contour areas. There is remnant vegetation in this mapping unit however in poor to degraded condition from decades of stock grazing. This unit had some limitations with an overall Land Capability Rating of III – Mapping unit fairly capable of supporting the proposed Land Use (residential) with moderate physical limitations. To overcome limitations in this mapping unit it is proposed to install phosphorous retention Alternative Treatment Units (ATU's) to ensure there is little risk of water pollution, revegetate along watercourses and drains, implement Water Sensitive Urban Design principles, and if there is excavation, then an Acid Sulphate Soils Investigation will need to be initiated.

The rural component of this mapping unit was rated very low capability, with a high degree of physical limitations. The sandy soils are very poorly structured with limited nutrients (poor fertility status) and productivity, requiring regular fertiliser application and improvement. The waterlogged areas and creeklines are suffering degradation causing erosion to banks and sedimentation along watercourses.

Summary of Map Unit B

Mapping Unit B is sand over gravel and is located along the slopes of the dominant ridge which protrudes from the north to the southwest of the lot. The residential component of the Land Capability found no limitations on this soil type. Sand over gravel is very nutrient absorbing for on-site effluent disposal and traditional septic tanks could be installed. Mapping Unit B had an overall residential capability rating of II – mapping unit is highly capable of supporting the land use.

The rural component of this land use was rated III – mapping unit has a fair capability with moderate physical limitations. The soils are nutrient deficient and poorly structured with low fertility. Improvements could be made to pasture by adding fertilisers.

Summary of Map Unit C

Overall there were few limitations in mapping Unit C, which consists of shallow sand over ironstone rock. This may limit the ease of excavation if required for residential development. The Jarrah woodland present in this mapping unit is in very poor condition from decades of grazing with little to no understorey species and no regeneration of trees. Clearing of native vegetation is subject to EPA Clearing Legislation. Mapping Unit C had an overall residential capability rating of I - the mapping unit is highly capable of supporting the land use.

The rural pursuits were classified similar to Map Unit C, rated III – mapping unit has a fair capability with moderate physical limitations. Generally the soils are not favourable as there is very shallow sand over ironstone rock which gives very poorly structured soils, low moisture availability and low fertility. Improvements to soil would be required and should not be stocked at great intensities.

Summary map Unit D

This Map Unit encompasses the waterlogged soils which did not achieve greater than 500mm water table below natural ground surface. These areas have a high degree of limitation for development and it has been recommended that these areas are avoided. Native vegetation is in very poor to degraded condition with weed infestations considerable along the Five Mile Creek system. There is high risk of off-site environmental harm if these areas are developed. The land capability rating was V– Very poorly capable of supporting land use, many limitations to overcome.

The land capability for rural pursuits was also rated very poor due to the degradation that is presently occurring and contributions to offsite pollution of effluent from stock and sedimentation of eroded banks. It is recommended that these areas are fenced from stock and revegetated. This land use was rates as IV - area with low capability, high degree of physical limitations

Summary of Whole Site

Engineering design of the proposed development will control surface water runoff during and after construction, minimising concentration and erosion effects by ensuring natural landscape contours are followed where possible. Waterlogged areas should be avoided due to large limitations for development and high risk of environmental harm and off-site impacts.

The retaining of remnant vegetation into Public Open Space or drainage reserves shall enhance the native vegetation values by the proposed subdivision, as currently there is no management of these. Presently there are heavy infestations of introduced plants (weeds), which is degrading the vegetation structure and restricting natural re-establishment of native vegetation. The removal of pest weed species will encourage native vegetation recruitment.

The overall capability of the land to support rural residential development is sustainable, with low intensities of agricultural pursuits, and waterlogged areas excluded from development. It is recommended that with management and careful consideration incorporated into the planning and engineering designs the identified limitations could be overcome.

1 Introduction

Grande Terra Land Development Pty Ltd commissioned Opus Consultants to undertake a Land Capability Assessment, Environmental Assessment and give Engineering Comment on constructability of the proposed Albany Green Stage Two. The subdivision site is located on lot 800 South Coast Highway and Stage Two is the southern end of the lot bordering onto the Lower Denmark Road, near Cuthbert Village.

This report outlines the Land Capability for the proposed development of the southern half of lot 800 South Coast Highway, and is aligned to the Department of Agriculture Western Australia and State Planning Commission three step methodology for Land Capability Assessment, being:

- Land Use Requirements of the proposal,
- Land Resource Survey, and
- Land Capability Analysis

(Land Capability Assessment for Local Rural Strategies, Department of Agriculture and State Planning Commission, 1989)

This report evaluates the subject land according to Rural Residential proposed land-use (Land Capability Assessment for Local Rural Strategies, 1989). The Dept. Agriculture Land Capability Assessment Guidelines assesses Rural Residential development according to proposed lot sizes. The proposed lots are described as Rural Residential development from 1ha to 5ha. The land use requirements have been rated in view of the soil investigation, historical land use, vegetation mapping, survey and topography.

2 Locality and Site Description

The project site, lot 800 South Coast Highway is located in the village of Cuthbert west of Albany, Albany, Western Australia. Please refer to the location map* below. Albany Green Stage Two covers an area of approximately 115 hectares. The subject site is bordered by South Coast Highway to the north and Lower Denmark Road to the south. The east and west boundaries of the site are adjacent to private properties.

3 Development Proposal

Grande Terra Land Development Pty Ltd propose to subdivide the subject site, Albany Green Stage Two (lot 800 South Coast Highway) into 45 lots ranging from 1 hectare to 4.5 ha each in size. It is also proposed to develop one lot into a super lot for future Chalet resort and rural lots (proposed lot 32). Please refer to Appendix A – Subdivision Guide Plan. There is one existing residence on the subject site. The existing residence utilises septic tanks with leach drains for onsite effluent disposal.

4 Site Soil Assessment

The Geological Survey of Australia Geological Map Series 1:250, 000 mapping describes the subject site as clay silt, sand and gravel in water courses and sand, white grey or brown commonly containing iron pisoliths and overlaying alterite. The site soil testing confirmed this.

Opus Consultants and Albany Soils and Concrete Testing carried out a site inspection and conducted field testing on the 14th and 15th June 2007. The site assessment included recording of site details as per Australian Standard AS/NZS 1547:2000, soil profile logging by visual classification to a depth of 2m and observing water table depths to water table below existing surface level. Please refer to Appendix B – Soil testing results.

Please note the original site assessment was conducted in June 2007, Opus re-visited the site in late August 2007 to conduct late winter water testing.

A total of 20 bore pits were drilled by mechanical auger and water depths were recorded. Permeability and Phosphorous Retention tests were conducted on 3 samples – one sample from test pit 4 (extracted from 150 to 2000mm below surface level), one sample from test pit 7 (extracted from 150 to 2000mm below surface level) and one sample from test pit 19 (extracted from 100 to 700mm below surface level). Further test pits were excavated underlate winter conditions to verify water table levels.

Surface soils indicated that the site is primarily sand with silt over most of the site with some sand over gravel/rock in elevated areas, and small areas of sand with minor peat soils in low lying areas.

Please note that the investigation and the writing of this report does not take into account any current or future zoning of the subject land, and focuses on land use and subsequent land capability.

4.1 Site Report

The subject site, lot 800 South Coast Highway, is situated on the south side of a ridge running east west parallel to South Coast Highway and Lower Denmark Road. The site has a 2 to 10% linear planar slope, with a dominant ridge which descends in a south westerly direction. The site is predominantly cleared, there are some isolated pockets of remnant vegetation, please refer to Section 5.3.

The soil profile across the site was predominantly sand with silt and 15 test pits recorded these characteristics. Five pits recorded either sand with silt and peat (test pit 3) which is expected in lower lying areas; sand with silt over gravel (test pit 2 and 19) along mid slope areas; and sand over gravel over rock (test pit 6 and 11) on the highest contours across the site. The soil types have been representatively mapped in Appendix B from the site soil testing.

Sand with Silt

The top layer of the soil profile consisted of moist sand with silt which was light grey to dark grey in colour. The sand with silt layer extended from the surface to 2000 below the surface. The majority of the test pits across the site recorded this soil type on or below the 15m contour. Please see photographs below.

Photo One – Sand with Silt

Photo Two – View of test pit sand with silt

Sand with Silt over Gravel

Test pit 2 and 19 recorded black sand to dark grey sand with silt over brown sand with gravel. These soils were found mid slope along the ridge, with the gravel layer varying from 100mm below surface level to 900mm. Test pit 19 had some silty clayey sand below the gravel layer. The presence of gravel soils indicates that there is the capacity of the soil to absorb phosphorous and nitrogen. Test pit 2 in the north west corner was the only test pit with gravel which encountered water table (in June 2007 sampling).

Photo 4: Sand over gravel Test pit 19

Photo Four: Test pit 2 sand over gravel, water table at 1.1m in June, and water table at ground level in August.

Sand over Gravel over Rock

Test pits 6 and 11 recorded shallow layers (0-1000mm) of dark grey sand with silt over brown sandy gravel ranging from 1000mm to 6000mm below ground level, See Photo five below. The test pits were terminated due to the auger unable to penetrate past the rock layer. The locations are on the highest points of the subject site.

Photo Five: Sand over rock

Photo Six: Sand with silt and peat

Sand with Silt and Peat

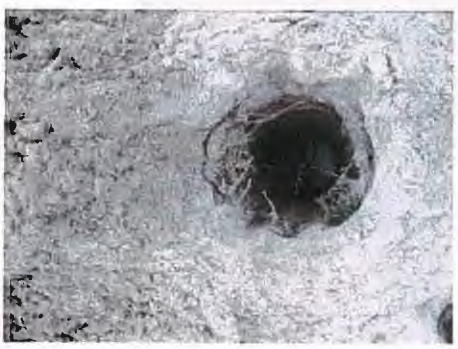
Test pit 3 was the only test pit within this sample regime which had black peaty sand with silt extending to 700mm over dark brown sand with silt. Please see photograph 6 above. This test pit reached the water table at 1.1m, sampled under late winter conditions water table was reached at ground level. Test pits 16 and 18 are low in the contour (<5m contour) and recorded high organic content in the topsoil, however were predominantly sandy silt in profile. These test pits recorded high water table under late winter conditions.

Late Winter Water Table Testing

Original testing was conducted in June, Opus Consultants returned to the site to conduct late winter water testing in August 2007. Test pits were excavated to a depth of 2m, water table was reached in 13 pits of the 20. 5 additional test pits were excavated to confirm the soil mapping and late winter water table levels across the site, please refer to Appendix C – Late Winter Water Table Testing. From this testing more definitive hydrological flow paths were noted and mapped. Please refer to mapping in Appendix C.

Gregg Harwood, City of Albany Senior Environmental Health Officer attended the late winter water table testing and the following recommendations were discussed at length on site and are formulated from these discussions.

Photo Seven, Left – Test pit 12, water table at 1000mm.
Photo Eight, Right – Test pit 9 water table at 1400mm.



Permeability Testing

The permeability tests were conducted by Albany Soil and Concrete Testing on the 150 to 2000mm of the Sandy Silt (Test pits 4 and 7) and the 100 to 700mm of the sandy gravel (Test pit 19), please refer to permeability results in Appendix B - Soil testing report. These results are typical for sandy soils and show that the soils are free draining. The concern with this site is the separation of water table as per the minimum requirement of the Health Department WA.
Testing was undertaken on three representative samples from the three main soil types, sand, sand over gravel and sand over rock.

Phosphorous Retention Index

The Phosphorous Retention Index (PRI) tests were conducted by Albany Soil and Concrete on the 150 to 2000mm of the Sandy Silt (test pits 4 and 7) and the 100-700mm of the sandy gravel (test pit 19), please refer to PRI results in Appendix B - Soil testing report.

The PRI's reveal that the sandy silt soil type has poor phosphorous retention ability with results showing at Test pits 4 and 7 being less than 1.0, whereas the PRI for the sand over gravel has very high ability and is at 323.75. The soil types with sand over gravel are very conducive to traditional on-site effluent disposal.

4.2 Policy and Legislation On-site Effluent Disposal

The *Draft Country Sewerage Policy* (Amended 2003) states the following specific requirements for on-site wastewater disposal. Large lots, where lot subdivision is to occur with divided parcels of land no smaller that 2000m^2 and development density is greater than R5, must comply with the following criteria as discussed in the appendices of the *Draft Country Sewerage Policy* (Amended 2003):

- *Irrespective of the type of on-site wastewater disposal system proposed, there should be at least 0.5 metres separation between the natural ground surface and the highest known groundwater level;*
- *The site is required to have soil characteristics capable of receiving all wastewater likely to be generated on the site without risk to public health or the environment; and*
- *The natural land slope on which wastewater disposal is to occur shall not exceed a one in five gradient.*

Wastewater System Installation Requirements:

- *The wastewater disposal site should not be subject to inundation or flooding at a probability greater than once in 10 years;*
- *No wastewater system shall be constructed so that effluent or liquid wastes will be discharged into the ground at a distance less than 30 metres from any well, stream or private supplies intended for consumption by humans;*
- *The depth to highest groundwater level from the underside of a septic tank effluent drainage receptacle shall be a minimum of 1.2metres. (For existing developed areas or infill areas a depth to highest known groundwater level may be a minimum of 1.2metres from ground level);*
- *Setbacks, groundwater clearance and installation requirements of systems other than conventional septic tank systems shall comply with any particular treatment relevant to the particular system. These are as required under the Health (Treatment of Sewerage and Disposal of Effluent and Liquid Waste) Regulations 1974, or conditions set by the Executive Director, Public Health.*

Due to environmental concerns with this particular site, it is proposed to utilise Phosphate Removing Alternative Treatment Units (ATU's). A copy of the approved Health Department WA Phosphate Removing ATU's is provided in Appendix E.
The Draft Country Sewerage Policy requires minimum setbacks and buffer distances to ensure that material does not leach into adjacent areas. The area around the Five Mile Creek and

associated creeks are classified as Environmentally Sensitive Areas according to the Draft Country Sewerage Policy. The Draft Country Sewerage Policy States the following requirements:

Table One - Environmentally Sensitive Areas

Feature	*Soil Type*	*Minimum buffer distance*	*Comments*
Environmentally sensitive areas (1) – wetlands (h) only	*All soils*	*50 metres*	*This buffer reflects the Water and Rivers Commission's and Environmental Protection Authority's policies on the minimum buffer required for any type of development near a wetland*
Environmentally sensitive areas (1) - watercourses, estuaries and marine environment only	*All soils*	*30 metres*	*Where floodplain mapping information (eg flood levels) is not available, the wastewater disposal area should be at least 30 metres from the edge of a watercourse channel. The wastewater disposal system should only be located at this distance if installation does not disturb riparian vegetation.*

Draft Country Sewerage Policy 2003.

4.3 Recommendations on site effluent disposal – Rural Residential

The site can meet on-site effluent disposal if approved phosphate removing ATU's are used and the 50m buffer distance is applied to the creeklines and drains. As the soils are relatively free draining, a separation from water table must be achieved. To achieve these minimum requirements, proposed setbacks and disposal field areas have been mapped for the site. In some areas the disposal field may be a distance from the house and pumped to the disposal area. The City of Albany Senior Environmental Health Officer (G.Harwood) attended on site and confirmed this could occur. A copy of these buffer distances is provided in Appendix D.

In reference to the above considerations which address the *Draft Country Sewerage Policy* (Amended 2003) guidelines, and in consideration that the proposed subdivision has lot sizes of greater than 1 hectares in size, Opus Consultants recommends that lot 800 South Coast Highway has a demonstrated capacity to support effluent absorption with the following conditions:

- Minimum setback distances of 50m from creeklines and drains are adhered to;
- Phosphate absorbing ATU's are utilised in depression areas. A copy of approved Health Department WA ATU's is provided in Appendix E;
- A separation of 0.5m is achieved from existing ground level and water table; and
- Disposal fields are located in designated building envelopes.

Opus Consultants concludes that the subject site is capable of supporting the proposed subdivision site effluent disposal with the above limitations to reduce negative impacts to the surrounding environment or watercourses. The limitations are included on the Land Capability rating and mapping in Section 7 of this document.

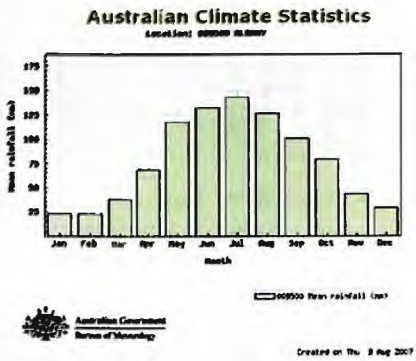
5 Environmental Assessment

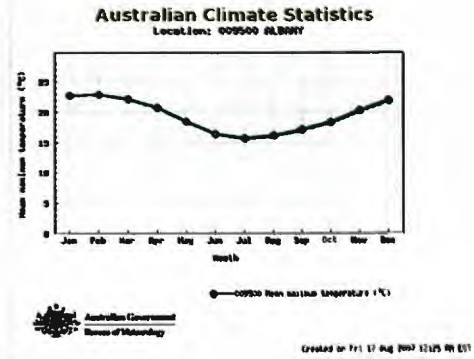
The Environmental Assessment for the subject site involved desktop analysis of climate, history fauna, and acid sulphate soils of the site; and on ground assessment of remnant vegetation and fire management. The results of these assessments are included in the land capability rating and mapping in Section 7 of this document.

5.1 Climate

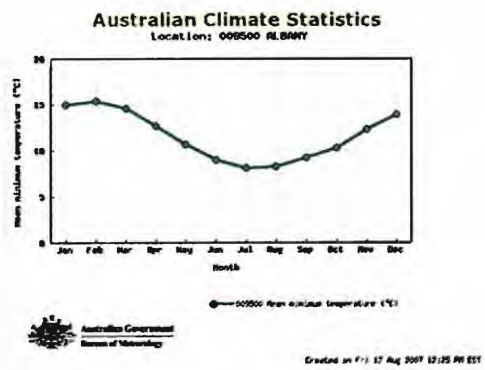
Albany sustains a Mediterranean type climate with generally warm summers and cool, wet winters. A major factor influencing Albany's climate is the Southern Ocean, giving a moderating influence via sea breezes in the warmer months and a relatively mild, moist airmass at any time through the year. During summer there is a development high pressure band (sub tropical ridges) across the south west giving north south movements. Albany's south coast aspect means winds progress with these ridges from east through north, west, south and returning to the east over periods of days and weeks bringing large variations in weather conditions. During the winter months these ridges bring moist westerly winds south of the ridge, delivering much of Albany's rainfall.

Albany's long term median rainfall is approximately 930mm (Bureau of Meteorology), with considerable variation from year to year. On average 72 per cent of Albany's rainfall occurs between May and October. Please refer to Bureau of Meteorology charts over page. Average temperatures peak in summer in January and February, with monthly maximum means of 23°C and overnight mean minimum of 15°C. Winter daily maximum temperatures average at approximately 16°C while the average daily minimum is 8°C in July. Please refer to temperature charts from the Bureau of Meteorology below.





Climate Statistical Graphs from the Bureau of Meteorology website 2007.



5.2 Current and Historical Land use

The Cuthbert area was cleared in the 1950's of native vegetation. The properties to the south of Lower Denmark Road near Cuthbert were cleared for potato growing and the areas to the north were cleared for grazing. (pers comms T.Saggers, Aug 2007) Lot 800 was cleared by the Burkin family where they grazed cattle for many years.

Lot 800 has been historically used for sheep and cattle grazing. The current tenants of the property graze cattle over the whole site and it is understood the previous owners ran a few sheep (pers comms M.J.Gibbs June 2007). The grazing across this site has been extensive with all remnant vegetation areas grazed, the drain running through the middle of the property is fenced to exclude stock, however, remnant vegetation is in very poor condition and quite degraded. (Please refer to Vegetation Assessment Section 5.3).

Stock (cattle) currently grazed on the property have access to all creek and wetland systems on the property. This is causing erosion to the creek lines and loss of vegetation to these areas. Please refer to photographs Nine and Ten below.

Photo Nine: Erosion to the banks of Five Mile Creek from cattle.

Photo Ten: Sediments and cattle effluent drain freely into five mile creek system.

The predominant soil type across Lot 800 is sandy silt. These soil types have poor structure and moisture withholding ability. Photographs Eleven and Twelve show nutrient deficient pasture in the peak growth period of August. Pasture improvement would be required for maximum nutrition for grazing, such as application of fertilisation with phosphorous & Nitrogen. This does not make the soil type suitable for pasture enhancement or tillage. Historically the Cuthbert area is known for intensive horticulture from potato growing, this site however is unsuitable for this agricultural pursuit.

Discussion with the current tenants indicates there are no sheep dip areas or potential areas for chemical contamination. A contaminated site investigation was not carried out as part of this brief, discussion to date and site visits do not indicate this would be necessary.

Photo Eleven (left): Pasture showing death and yellowing – nutrient deficiency.
Photo Twelve: ((right)) View of pasture showing nutrient deficiencies.

5.3 Vegetation Assessment

Vegetation Assessment was undertaken on site by Kathryn White Opus Consultants on 7th July 2007. Assessment was undertaken of all remnant vegetation by visual assessment. Two vegetation associations were mapped across the site, Taxandria Woodland and Jarrah Woodland. These vegetation associations have limited understorey species, consisting mostly of introduced weeds and are in degraded condition from grazing of stock.

Taxandria Woodland

Vegetation Association along the creeklines is remnant riparian vegetation consisted of dominant overstorey species such as *Taxandria juniperina, Agonis flexuosa, Callystachis lanceolata,* sparse pine trees near the existing house and sparse *Eucalyptus rudis* and *Maleleuca raphiophylla* along the Five Mile creek system. The understorey species was predominantly introduced species such as Taylorina, Blackberry, Arum lily, Inkweed, Bridal Creeper, Aloe vera, and Kikuyu, with minor native species of *Pteridium esculentum, Juncus* spp, *Hibbertia cuneformis* and *Lepidosperma* spp.

Photo Thirteen Right: View of riparian vegetation along Five Mile Creek
Photo Fourteen: View of Taxandria's

Jarrah Woodland

There are two remnant patches of Jarrah woodland, located in the north centre of the lot and along the eastern boundary. These stands have little to no understorey, and scattered A*llocasuarina frasieriana* and B*anksias grandis* (on eastern side only). The eastern remnant bushland is undergoing some unidentified dieback, this could be from a canker or from pressure from grazing.There was very limited species diversity within this association, which is a direct reflect from long term grazing pressure on the vegetation. A development buffer of 30 metres is required away from watercourses and drains. It is recommended that this buffer area is revegetated with providence species to reclaim and stabilise these areas. Vegetating along the watercourses

(especially the Five Mile Creek through the property) would also provide more sustainable fauna habitat and create micro-corridors for native animal movement. At the very minimum it is recommended that these areas are fenced off from cattle grazing.

Photo Fifteen (left): Low Jarrah forest, limited understorey. Photo Sixteen (right): View of casuarinas and jarrah on eastern side under some stress.

A comprehensive weed management plan needs to be implemented, as there are large infestations of Blackberry, Taylorina, Ink weed and Arum lily along the Five Mile Creek and adjacent watercourses. These species should be eradicated as per Department of Agriculture and Food guidelines to prevent further spread and infestations occurring.

5.4 Fauna

A complete fauna survey of the area was not completed for the purposes of this management plan. Known species to the area include western grey kangaroo, southern brown bandicoo, bush rat, honey possum, tiger snake, dugite, whistling kite, nankeen kestrel western, pacific black duck, kookaburra, rosella, grey fantail, new holland honey eater and banjo frog.

The remnant areas of vegetation have limited understorey, in reflection of this it would be assumed that there would be minimal representation of mammals and more representation from amphibians, birds and reptiles. Revegetation across the site would provide habitat for native animals and provide linking corridors to adjacent bushland areas.

5.5 Fire management

A Fire Management Plan in consultation with Fire and Emergency Services (FESA) has not been prepared as part of this assessment. Fire management aligned to the FESA guidelines states that buildings should have a minimum setback from bushfire hazards of 100 metres. Where this cannot be achieved, AS3959 building standards apply.

As this site is predominantly cleared of native vegetation, the only identified fire hazard applicable is adjacent to the eastern boundary (near proposed lot 30 and 31) where a remnant patch of vegetation occurs. A 100m setback from buildings could be applied to this area, more consultation is required with FESA and CoA Fire Managers to confirm. As it is not a continuous vegetated area, AS3959 may not apply. A minimum fuel reduction area of 20m (if under 10° slope) will need to be implemented, as per City of Albany Fire Prevention Plan. This is not mapped as a limitation.

5.6 Wetlands and water ways

The "Five Mile Creek" drains through the property from the north east corner of stage two to the south western corner. The Five Mile Creek forms part of the Torbay Catchment and drains to Lake Powell, which is a "Class A" Nature Reserve vested with the Department of Environment and Conservation. A search of the DEC database places Lake Powell as an Environmentally Sensitive Area, the subject site is not located within this area, and is located 3km from the lake edge. A

search was conducted of the Department of Water database's revealing the subject site is not in a Public Drinking Water Source Protection Area or has any wetlands of regional significance on the property.

The site is only classified as an Environmentally Sensitive Area under the Country Sewerage Policy and as discussed in Section 4.3, an on-site effluent disposal system should be setback 50 metres from adjacent creek lines and drains. A drainage easement has been placed over the Five Mile Creek and a development exclusion of 30 metres placed from the drain centreline and adjacent creek tributaries, please refer to Land Capability Mapping Section 7. It is recommended that the development exclusion area is fenced free from any stock grazing and re-vegetated with local endemic species.

It is proposed that with careful planning of site drainage and on-site effluent disposal this development would have less impact on the Five Mile Creek system than the existing rural land use is having on the area.

Evidence that this is probable is from Department of Health WA document "Movement of Nutrients from On-Site Waste Water Systems in Soils". A comparable table for phosphorous and nitrogen inputs for an onsite effluent disposal system and rural pursuits is copied from this document over the page.

Table Two Comparison of Nutrient Inputs from Agriculture and Domestic Activities

Table 1 **Overview of nutrients inputs from animals, agricultural activities and domestic septic tanks**

land use	housing density (R-)	P input	N input	P input	N input	P input	N input	P input	N input	references
		kg/ha/year		kg/ha/year		kg/ha/year		kg/year		
		unsewered		sewered						
rural residential	0.5	0	27	5	18					1
residential	5	25	125	15	25					1
residential	10	25	260	40	80					2
residential	10			30	120					3
market gardens	-					200-1200	500-900			4,5
orchard	-					100	200			4
pasture 1						20	20			4
pasture 2						20	70			4
1 septic tank								3.5	18	3
1 cat								0.25	1	1
1 dog								1.3	5	1
1 horse-a								18	70	5,6
1 horse-b								12	45	7,6
1 horse-c								10	40	5,6
1 sheep								0.4	0.7	5,6
1 pig (<20kg)								0.65	2.7	9
1 pig (20-50 kg)								2	8.4	9
1 pig (50-110 kg)								3.1	12.9	9

references
1- Gerritse, Adeney and Bates (1992).
2- Gerritse, Barber and Adeney (1996).
3 JDA Consultant Hydrologists (2001)
4 Gerritse (1990)
5- Keshill Engineers (1995).
6- van Kemenade, Deevaars and Kerkhof (1990).
7 Barker, Hudgen and Campbell (1999)
8- Primrose McConnell (1976)
9- Doeven and Nejrinks (1977)

Department of Health WA "Movement of Nutrients from on-site waste water systems in soils" 2001

Based on the above information, the following assumptions could be made;

- Impact on Lake Powell from rural residential development would be greatly reduced through less stock being run and reduced N and P loadings into the creek lines.

- The onsite effluent disposal system proposed for the subdivision is phosphorous removing systems and thus would have minimal impact on the creek lines.
- Better management and revegetation of the riparian creek lines would have a positive effect on the downstream Lake Powell.
- Nutrient stripping and retention of storm water on site will mitigate the risk of any pollution of water courses from this proposed development.

Opus Consultants have undergone preliminary consultation with the Department of Water (DoW), and there are concerns regarding drainage and effluent disposal. It is recommended that if the development proceeds, a Water Management Plan is prepared in consultation with the City of Albany and DoW.

6 Engineering Assessment

A site visit was undertaken by Scott Curran Senior Engineer Opus Consultants in light of the proposed development. The environment of the site is mainly pastured and therefore road construction and service installation should not be affected by general urban environment constructability issues such as clearing, traffic, noise and dust issues.

Cut and fill balances should be able to be managed through the design to reduce the volume of imported embankment or spoil materials. The major cut and fill design is between Lots 8 to 5 on the western side of the proposed development site. In designing this portion of road, considerations may be given to the road alignment at this location to allow the alignment to better follow the contours and reduce the gradient of the road and batter slopes. This may require consideration for adjustment to the lot boundaries.

Construction programming of the project should be carefully considered to take into account the building of roads and culverts in the lower lying areas and it is recommended to stage these works to coincide during drier months.

It is recommended that further Geotechnical investigation be undertaken on the road alignment to determine the bearing capacity of the underlying soil structure prior to pavement design. This would be particularly important where the proposed road alignment expends past Lot 22.

6.1 Ease of excavation

The site is predominantly sandy silt with some gravel through the ridge in the northwest of the lot, it is not envisaged this will pose a problem for excavation or for development of road and housing. The ease of excavation has been rated for the land capability assessment as very low limitation.

Dependant on the final design and depth of cut, it is anticipated the iron stone will be encountered along the top of the ridge between Lot 21 to Lot 16. This would not be seen as extraordinary but again should be investigated at design phase.

6.2 Foundation stability

There were no reactive clays noted across the site, a full geotechnical investigation was not carried out as part of this land capability. Given the majority of the soils are mostly sand or silty sand with no reactive clays, this would class the majority of the site as Class A soils.

The classification of soils at Loc 2, 3, 8, 12, 16 indicate that these sites could be considered as Class P and any structural elements planned for these areas will require certification of a structural engineer.

In light of the land capability assessment this was rated as High – moderately deep sandy soils with undulating plains (2-8%)

6.3 Drainage requirements

The majority of the site is relatively free draining sandy soils and is a model site for water sensitive urban design to be applied. Water management strategies should be aligned to current Best Practise and applied to this development these include:

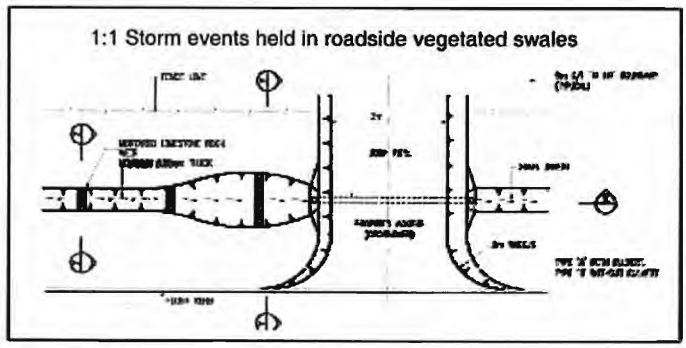
1. Maintain and where possible enhance water quality by:
    - Minimise waterborne sediment loading
    - Minimise export of pollutants to surface or ground water
    - Minimise post development flows across the site
    - Apply point source water management
    - Encourage prospective landowners not to use fertilisers on land

2. Encourage water conservation by:
    - Minimise the export and use of scheme water
    - Promote the use of rainwater
    - Promote ground water recharge
    - Reduce irrigation requirements

3. Management of the water regime by:
    - Prevent flood damage in existing and proposed development areas
    - Prevent erosion of adjacent wetlands, waterways and slopes
    - Ensure pollutants do not enter into adjacent waterways

A concept drainage design was not prepared as part of this assessment, site investigation in light of the proposal did not see any major restrictions on drainage. The proposal involves large lots sizes and drainage easements adjacent to road terminations. The use of water sensitive urban design principles should be applied where all 1:1 events are contained in road side swales. A representative drawing of this concept is provided below.

1:1 Storm events held in roadside vegetated swales



Larger 1:10 events will need to be detained prior to entering the Five Mile Creek, it is recommended that bio-retention basins, vegetated with endemic rushes and sedges are developed at all proposed drainage points from the drainage easements. This is shown as a medium limitation in the land capability to be considered in more detail in the engineering design stage.

It is recommended that roads are aligned along contours to reduce speed of runoff along drains and to implement more effective Water Sensitive Urban Design Principles. A design which replicates the roads along the contours and the lots aligned off this would allow best Practise drainage design.

6.4 Waterlogging hazard

Areas from the aerial mapping showing water logging have been mapped and were confirmed with intensive sampling regime undertaken in late winter. These areas have been mapped on are a limitation in Section 7 Land Capability. Photographs Seventeen to Eighteen below show typical waterlogged areas across the site.

Photo Seventeen: Water logged area in northwest corner.

Photo Eighteen: Close up of waterlogged soils

Development should be excluded from these waterlogged areas and revegetation of provenance and endemic species. A weed management plan should be prepared to address the major infestations along the creek lines.

Suitable land use for the water logged areas is POS or vacant land. This land is not suitable for grazing or residential use due to the water logging through most of the year and the subsequent erosion from animals in those areas. This is mapped in the Land Capability as Map Unit D. All other map units achieve a greater than 0.5m separation from natural ground level and natural water table level under late winter conditions.

Opus Consultants recommend that the residential design is redone to exclude these areas, align residential areas to higher ground and parallel to contours. Residential boundaries can extend into these areas, however development is not recommended.

6.5 Acid Sulphate Soils

The WAPC Acid Sulphate Soils Risk Mapping Classifies the lower half of lot 800 South Coast Highway as a Medium risk of Acid Sulphate Soils occurring. This investigation did not include Acid Sulphate Soil Testing, a desktop assessment was undertaken, please refer to WAPC Acid Sulphate Soil mapping in Appendix B.

Acid Sulphate Soils occur in waterlogged soils and typically sandy silts and peat soils. It was noted on site that the low lying waterlogged soils had sulphur like smells and there is a possibility that Acid Sulphate soils could occur in these areas. It is recommended that a Preliminary Acid Sulphate Soil Investigation is undertaken when the exact extent of the development is known and if there is any excavation or cut and fill proposed, the Acid Sulphate Soil Investigation targets these areas.

7 Land Capability Assessment

7.1 Description of Land Use Requirements

Areas of land for sub-division approval are assessed through Land Capability to analyse the sustainability of the particular activity and the environmental effects the proposed use may have on the land. This determines the attributes the land contains which can affect the proposed land use for the area. The Land Use proposed for this development is Rural Residential with areas for Public Open Space, and possible chalet style development.

Please refer to Appendix A for the proposed layout plan of the subdivision.

7.1.1 Rural Residential

The land use proposed for Special Residential land use is 115 ha, with 28.53 ha (lot 32) for chalet accommodation or rural (subject to land capability). The qualities required for consideration for this zoning at lot 800 South Coast Highway are defined by Agriculture Western Australia as being:

Rural Residential development with on-site effluent disposal

- *Land should be free from effects of storm surge, flooding, wave erosion or slope instability.*
- *Land should not be susceptible to a degree of erosion hazard which would prohibit its sustained use or cause off-site effects detrimental to adjacent land users or the community.*
- *Soils for effluent disposal area to be sufficiently permeable and absorptive to accept and purify effluent.*
- *Ground water or surface pollution does not occur on site or off-site.*
- *Land is sufficiently free of water logging and inundation.*
- *Land is not saline so that trees, garden or lawn establishment becomes prohibitive.*

7.1.2 Proposed Chalet Site and Rural use

The proposed Chalet site land use and rural use is proposed in lot 32. These pursuits are subject to the Land Capability Assessment, the chalet land use has been assessed, similar to "Residential" components and rural land use is assessed separately as "Rural or Hobby Farms".

It is more likely that areas in Lot 32 will become POS areas as there is a prominent amount of waterlogging through the middle of this lot.

7.2 Land Capability Assessment Method

The Land Capability Assessment compares the physical requirements for a particular land use with the qualities of the land. This analysis determines the ability of the land to sustain a particular land use without resulting in significant environmental degradation. The land use that has been considered for this study area is Rural Residential with on-site effluent disposal.

This study has included analysis of the soil and landform from soil survey, environmental assessment and engineering assessment. Late winter water levels were obtained during the soils assessment.

7.3 Land Resource Characteristics

The Land Resource Characteristics have been overlaid to determine the mapping units assessed at lot 800, South Coast Highway, as detailed on Map Two page 20. The mapping units were determined by the following information:

- Soil and Landscape characteristics, including texture, depth, soil profile, aspect, slope and water table.
- Soil testing and Laboratory analysis.
- Environmental mapping
- Historical land use.

The Four mapping units are defined in Table Three below.

Table Three– Mapping Units Lot 800

MAP UNIT	CHARACTERISTICS
Map Unit A	Sand with silt soils, well draining soils, dark grey to black and light grey sands, very little topsoil. Predominant soil type below the 15m contour. Prominently pasture, cleared land.
Map Unit B	Sand with silt over gravel, moderate to well draining soils, good nutrient and phosphorous retention ability. Along ridges above the 15m contour, predominantly pasture.
Map Unit C	Sand over gravel over rock, this soil type is prominent along the ridge, the highest point on the lot. Presently covered by degraded Jarrah woodland.
Map Unit D	Sand with silt and peat, these soils are generally in the waterlogged areas and along watercourses. Predominantly degraded riparian vegetation (Taxandria) and introduced weeds species.

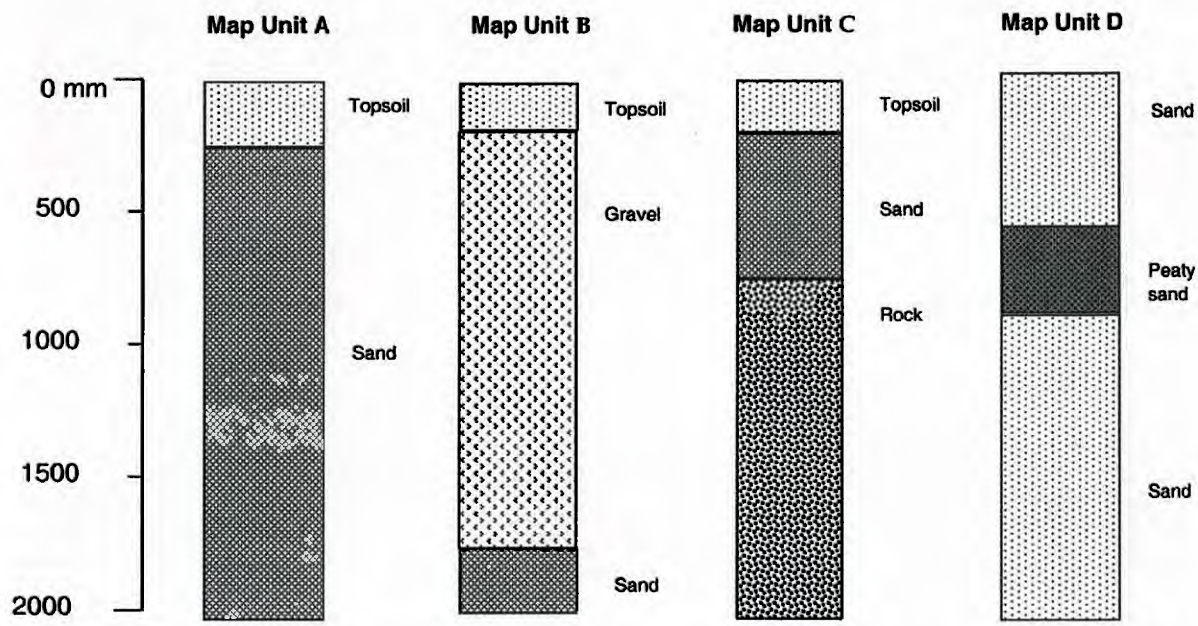
The mapping units have grouped soil characteristics that shall be referred to in the Land Capability Rating procedure and have been summarised in Table Four over the page.

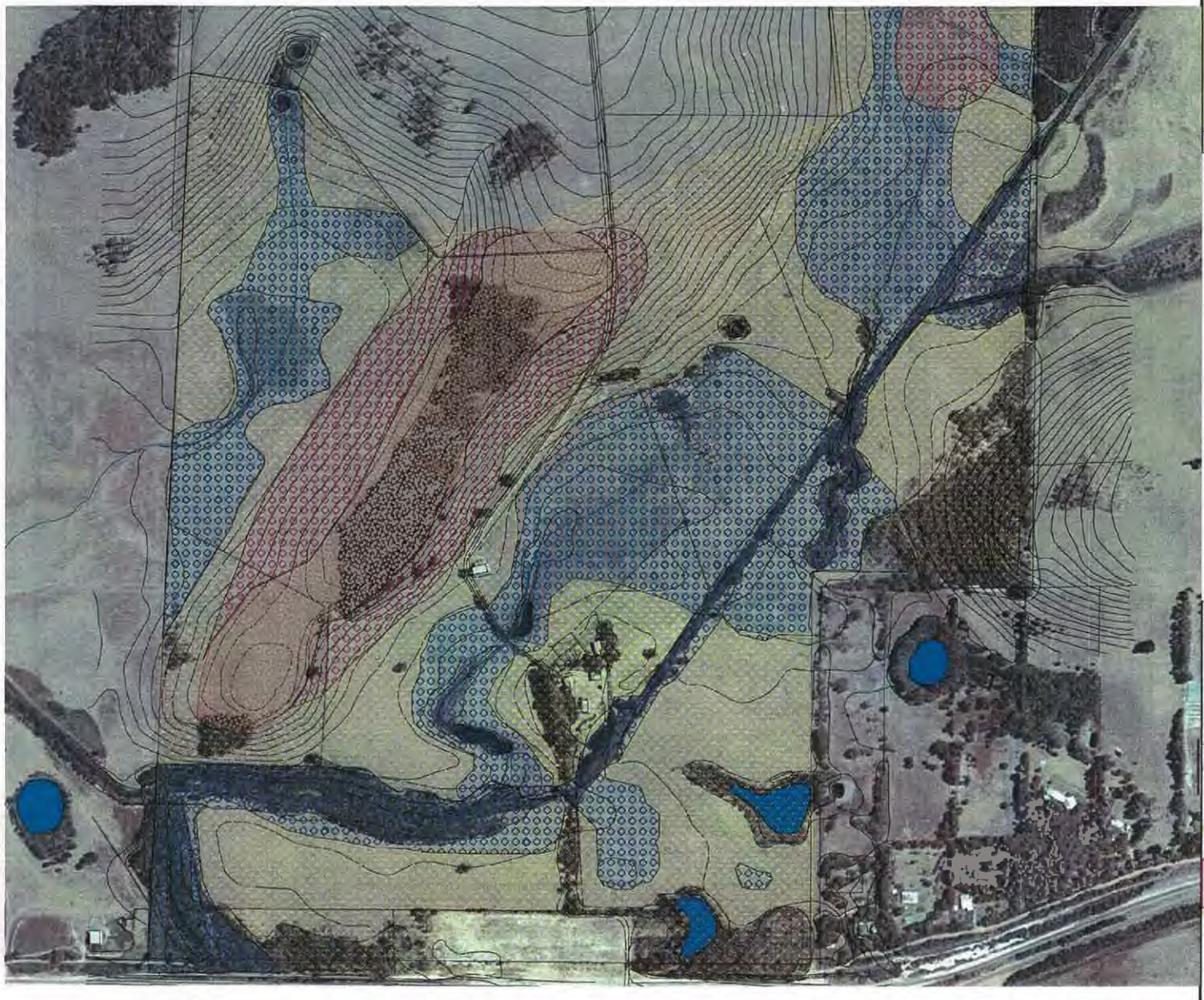
Table Four Soils Summary of Final Mapping Units

Final Mapping Units	Soil Texture	Soil Depth (max)	Slope (degrees)	Soil Permeability
A	Sand/silt	≤2000mm	<10	well drained
B	Sand/silt/gravel	≤2000mm	>10	mod – well drained
C	Sand/gravel	<600mm	>10	mod – well drained
D	Sand/silt/peat	> 2000mm	<10	well drained

The Final Mapping units soil profile descriptions are represented diagrammatically (Figure One, below). Information was compiled from the soil sampling with each test pit averaged to give representative profile descriptions of each mapping unit. The four mapping units are overlaid on lot 800 South Coast Highway, Albany, over the page.

Figure One– Soil Profile Descriptions of the Three Mapping Units





Lot 800 South Coast Highway
Albany Green Stage Two
Mapping Units
Land Capability Assessment

Legend

- Map Unit A Sand with Silt
- Map Unit B Sand Silt and Gravel
- Map Unit C Sand Gravel Rock
- Map Unit D Water logged areas

Hydro.shp

- ARTFICIAL_LAKE
- CHANNEL/DRAIN
- LAKE_NONPERENNIA
- LAKE_PERENNIAL
- SUMP
- SWAMP
- WATERCOURSE
- Creekline
- Water2.shp
- Cadastre

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OPUS

Produced by:
K.White
Opus Consultants
August 2007

400 0 400 800 Meters

8 Land Resource Survey

8.1 Qualities and limitations

The proposed land use has a set of qualities for which the Land Capability Assessment will be considered. Table Four and Five below outlines the landscape qualities and characteristics that will be assessed within the scope of this study at location 800 South Coast Highway Albany.

Table Five – Landscape Qualities and Limitations – Residential Component

Landscape qualities	Subclass	Landscape qualities	Subclass
Ease of excavation	x	Phosphorous retention ability	p
Foundation stability	b	Water pollution hazard	s
Services (reticulated water, power, telephone)	r	Soil salinity	y
Water logging hazard	i	Bushfire hazard	z
Water erosion hazard	e	Native vegetation retention	n
Wind erosion hazard	w	Potential Acid Sulphate Soils	as
Flood hazard	f		

Table Six – Landscape Qualities and Limitations – Rural Component

Landscape qualities	Subclass	Landscape qualities	Subclass
Plant growth	pl	Water availability	a
Soil trafficability	t	Shallow Soils	ss
Soil fertility status	l	Erosion	er
Soil moisture availability	m	Flood Hazard	f
Rooting conditions	l	Water pollution hazard	s

The landscape qualities are surveyed from the previously presented information in this report (Sections 1-6) and assessed for capability. The Department of Agriculture utilises a five class system of assessing land capability, these five classes rate the degree of physical limitations associated with land use and management needed for these. Please refer to Table Seven over the page.

Table Seven Land Capability Classes – Dept Agriculture Western Australia

CAPABILITY CLASS	DEGREE OF LIMITATION	GENERAL DESCRIPTION
I	Very low	Areas with a very high capability for the proposed activity or use. Very few physical limitations to the specified use are present or else they are easily overcome. Risk of land degradation under the proposed use is negligible.
II	Low	Areas with a high capability for the proposed activity or use. Some physical limitations to the use do occur affecting either its productive use or the hazard of land degradation. These limitations can however, be overcome through careful planning.
III	Moderate	Areas with a fair capability for the proposed activity or use. Moderate physical limitations to the land use do occur which will significantly affect its productive use or result in moderate risk of land degradation unless careful planning and conservation measures are undertaken.
IV	High	Areas with a low capability for the proposed activity or use. There is a high degree of physical limitations which are either not easily overcome by standard development techniques or which result in a high risk of land degradation without extensive conservation requirements.
V	Very High	Areas with a very poor capability for the proposed activity or use and the severity of physical imitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

8.2 Land Capability Rating for Land Use Rural Residential – Degree of limitation

Land qualities have been assessed in terms of the degree of limitation (Tables Eight to Eleven in following sections) to the proposed land-use. The limitation is then matched to what the land can support and rated on the limitations map (each Map unit has a limitation map proceeding). The limitations which affect the proposed land-use are given ratings and keys according to their Land Capability Sub-class (from Tables Four and Five). Limitations which record very low are not mapped as they are not deemed to be a limiting factor to the proposed land use

8.2.1 Degree of Limitation – Map Unit A

Table Eight (a) Degree of Limitation Map Unit A - Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Very low	Ease of excavation	Not deemed to have inherent risks	Residential	-
Very low	Foundation stability	Not deemed to have inherent risks	Residential	-
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	Residential	
Very low	Waterlogging hazard	Not deemed to have inherent risks	Residential	IV-i
Very low	Water erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Wind erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Flood hazard	Not deemed to have inherent risks	Residential	-
Moderate	Phosphorous retention	Installation of ATU	Residential	III-p
Moderate	Water pollution hazard	Requires setback distances to creeks	Residential	III-s
Very low	Soil salinity	Not recorded present	Residential	-
Very low	Bushfire hazard	Not deemed to have inherent risks	Residential	-
Low	Native Vegetation retention	Clearing as per EPA regulations	Residential	II-v
Moderate	Acid Sulphate Soils	Moderate risk rating WAPC mapping	Roads / residential	III-as

Limitations Include:

- Phosphorous retention ability (III-p) - Phosphate absorbing ATU's should utilised in this mapping unit. A copy of approved Health Department WA ATU's is provided in Appendix E;
- Water Pollution Hazard (III-s) – Utilise Phosphate absorbing ATU's, drainage aligned to water sensitive urban design principles, bio retention basins to nutrient and pollution strip prior to entering waterways. A 50m setback limitation is mapped for this limitation.
- Native Vegetation (II-v) – Some remnant riparian vegetation (taxandria's), vegetation should remain and be re-vegetated with endemic species. Weed management required along creeklines and drains. Vegetation in poor condition due of decades of grazing. Very minimum these areas should be fenced from stock.
- Acid Sulphate Soils (III-as) – WAPC mapping indicates there is a moderate risk, this can be overcome with management, an Acid Sulphate Soil Investigation should be undertaken to identify if present.

Overall Capability Rating for Residential- III Area with fair capability, moderate physical limitations.

Table Eight (b) Degree of Limitation Map Unit A - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	POS	III-pl
Very low	Soil trafficability	Not deemed to have inherent risks	Rural	-
High	Soil fertility status	Poor structure soils, low fertility	POS / Reveg	IV-l
Moderate	Soil moisture availability	Freely draining sands, low moisture withholding capacity	POS / Reveg	III-m
Very low	Rooting conditions	Not deemed to have inherent risks	Rural	-
Very low	Water availability	Not deemed to have inherent risks	Rural	-
Very Low	Shallow soils	Not deemed to have inherent risks	Rural	-
Very High	Erosion	Grazing causing erosion to banks and slopes	POS / Reveg	IV-er
Moderate	Flood hazard	Low lying areas	Reveg	III-f
Very High	Water Pollution Hazard	Nutrients from animals and fertilizer application	Reveg	IV-s

Limitations Include:

- Plant growth (III-pl) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application and enhancement of soils.
- Soil Moisture availability (III-m) – sandy silty soils have limited ability to withhold moisture, only waterlogged areas able to retain moisture.
- Erosion (IV-er) – Grazing from hoofed animals causing erosion to banks and slopes.
- Flood hazard (III-f) –these areas should be avoided in the planning process (same areas mapped as waterlogging hazard).
- Water Pollution Hazard (IV-s) –cattle effluent from untreated runoff from paddocks, fertiliser application required to increase fertility, causing nutrient runoff into adjacent watercourses.

Overall Capability Rating for Rural Land Use – IV Area with low capability, high degree of physical limitations.

Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit A
Limitations

Legend

- Meduim Risk ASS III-as
- 50m Setback III-p
- 30m Development Setback
- Native vegetation II-v
- Map Unit A Sand with Silt
- Guide Plan
- Proposed roads
- Drainage Easements

III-pl Plant Growth
IV- I Soil fertility status
III-m Soil Moisture Availability
IV-er Erosion
IV-s Water Pollution Hazard

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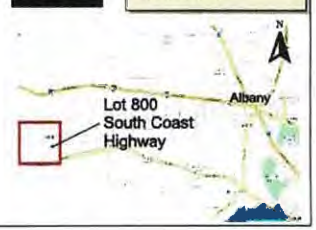


8.2.2 Degree of Limitation – Map Unit B

Table Nine(a) Degree of Limitation Map Unit B - Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Very low	Ease of excavation	Not deemed to have inherent risks	Residential	-
Very low	Foundation stability	Not deemed to have inherent risks	Residential	-
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	Residential	
Very low	Waterlogging hazard	Not deemed to have inherent risks	Residential	-
Very low	Water erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Wind erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Flood hazard	Not deemed to have inherent risks	Residential	-
Very low	Phosphorous retention ability	Not deemed to have inherent risks	Residential	-
Very low	Water pollution hazard	Not deemed to have inherent risks	Residential	-
Very low	Soil salinity	Not recorded present	Residential	-
Very low	Bushfire hazard	Not deemed to have inherent risks	Residential	-
Very low	Native Vegetation retention	Clearing as per EPA regulations, most remnant native vegetation in poor condition	POS /residential	-
Very low	Acid Sulphate Soils	Low risk rating WAPC mapping	Roads /residential	-

Limitations Include:

- This mapping unit recorded no limitations,
- Please note the area in the north west of the lot which has this soil type has included into the effluent Waterlogged Map Unit D, and assessed against the relevant criteria and not recommended for development.

Overall Capability Rating for Residential- I, very highly capable of supporting land use few physical limitations

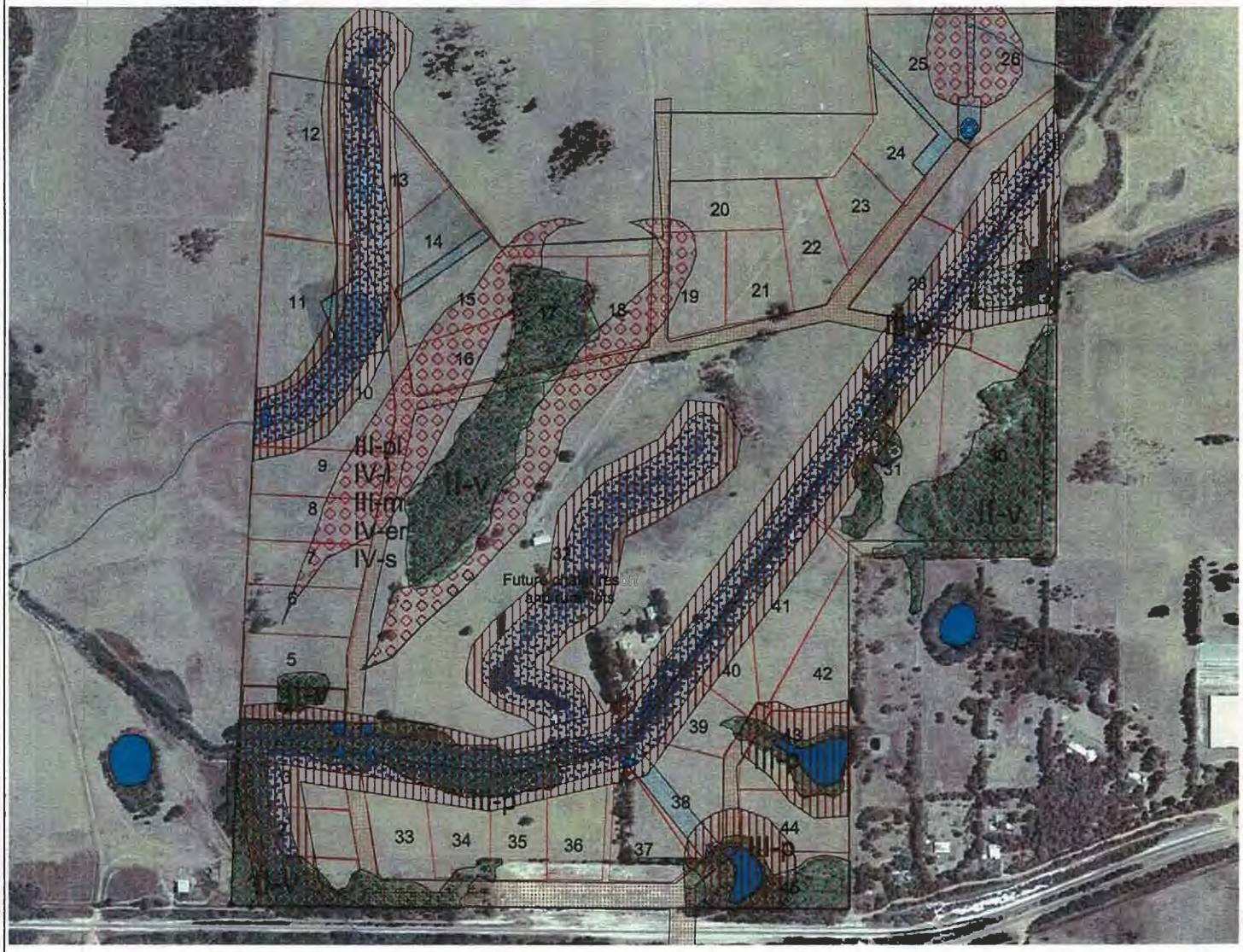
Table Nine (b) Degree of Limitation Map Unit B - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	-	III-pl
Very low	Soil trafficability	Not deemed to have inherent risks	Rural	-
High	Soil fertility status	Poor structure soils, low fertility	-	IV-l
Moderate	Soil moisture availability	Freely draining sands in topsoil, low moisture withholding capacity	-	III-m
Very low	Rooting conditions	Not deemed to have inherent risks	Rural	-
Very low	Water availability	Not deemed to have inherent risks	Rural	-
Very Low	Shallow soils	Not deemed to have inherent risks	Rural	-
Very High	Erosion	Grazing causing erosion to slopes	-	IV-er
Very low	Flood hazard	Low lying areas	Rural	-
Very High	Water Pollution Hazard	Nutrients from animals and fertilizer application	-	IV-s

Limitations Include:

- Plant growth (III-pl) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application and enhancement of soils.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil Moisture availability (III-m) – sandy silty soils in Horizon A have limited ability to withhold moisture, only waterlogged areas able to retain moisture.
- Erosion (IV-er) – Grazing from hoofed animals causing erosion to banks and slopes.
- Water Pollution Hazard (IV-s) – effluent from cattle untreated, runoff from paddocks, from fertilizer application, (required to increase fertility), and nutrient runoff into adjacent watercourses.

Overall Capability Rating for Rural Land Use - III Area with fair capability, moderate physical limitations.



Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit B
Limitations

Legend

- Bio-retetention Basins
- 50m Setback III-p
- Native vegetation II-v
- 30m Development Setback
- Map Unit B Sand Silt and Gravel
- Drainage Easements
- Guide Plan
- Proposed roads

III-pl	Plant Growth
IV- i	Soil fertility status
III-m	Soil Moisture Availability
IV-er	Erosion
IV-s	Water Pollution Hazard

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8.2.3 Degree of Limitation – Map Unit C

Table Ten (a) Degree of Limitation Map Unit C- Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Low	Ease of excavation	Some modification required on shallow rock areas	Residential/ roads	II-x
Very low	Foundation stability	Not deemed to have inherent risks	Residential	-
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	Residential	-
Very low	Waterlogging hazard	Not deemed to have inherent risks	Residential	-
Very low	Water erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Wind erosion hazard	Not deemed to have inherent risks	Residential	-
Very low	Flood hazard	Not deemed to have inherent risks	Residential	-
Very low	Phosphorous retention ability	Not deemed to have inherent risks	Residential	-
Very low	Water pollution hazard	Not deemed to have inherent risks	Residential	-
Very low	Soil salinity	Not recorded present	Residential	-
Very low	Bushfire hazard	Not deemed to have inherent risks	Residential	-
Low	Native Vegetation retention	Clearing as per EPA regulations, most remnant native vegetation in poor condition	Residential	II-v
Very low	Acid Sulphate Soils	Low risk rating WAPC mapping	Roads /residential	-

Limitations Include:

- Ease of Excavation (II-X) – Shallow sands over rock, may require some excavation or fill.
- Native Vegetation (II-v) – Some remnant Jarrah woodland along ridge, clearing permit or WAPC subdivision approval required prior to clearing. Vegetation in poor condition due to decades of grazing.

Overall Capability Rating for Residential- I, very highly capable of supporting land use few physical limitations

Table Ten (b) Degree of Limitation Map Unit C - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	-	III-pl
Moderate	Soil trafficability	Very shallow sandy soils over rock	-	III-t
High	Soil fertility status	Poor structure soils, low fertility	-	IV-l
Moderate	Soil moisture availability	Freely draining sands in topsoil, low moisture withholding capacity	-	III-m
Very low	Rooting conditions	Not deemed to have inherent risks	Rural	-
Moderate	Water availability	Sand over rock, high in landscape, low water availability	-	III-m
High	Shallow soils	Limit plant growth	-	IV-ss
Very low	Erosion	Not deemed to have inherent risks	Rural	-
Very low	Flood hazard	Low lying areas	Rural	-
Very low	Water Pollution Hazard	Not deemed to have inherent risks	-	-

Limitations Include:

- Plant growth (III-pl) - poorly structured sandy soils with limited nutrients, low productivity, would require fertilizer application.
- Soil trafficability (III-t) – shallow rock, often close to surface.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil moisture availability (III-m) – sandy silty soils have limited ability to withhold moisture, only waterlogged areas able to retain moisture.
- Water availability (III-m) –High in landscape, low water availability.
- Shallow Soils (IV-ss) –shallow sands over rock often close to surface.

Overall Capability Rating for Rural Land Use - III Area with fair capability, moderate physical limitations.

Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit C
Limitations
Legend
50m Setback III-p
30m Development Setback
Native vegetation II-v
Map Unit C Sand Gravel Rock
Bio-retetention Basins
Drainage Easements
Guide Plan
Proposed roads
III-pl Plant Growth
III-t Soil Trafficability
IV- I Soil fertility status
III-m Soil Moisture Availability
IV-ss Shallow Soils
II-x Ease of excavation
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Lot 800
South Coast
Highway
Albany
III-pl
III-t
IV-l
III-m
III-a
IV-ss
II-x
II-v
III-p
90 0 90 180 270 360 450 Meters

8.2.4 Degree of Limitation – Map Unit D

Table Eleven (a) Degree of Limitation Map Unit D- Residential

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Ease of excavation	Would require dewatering	POS / Reveg	III-x
Moderate	Foundation stability	Would require fill to bring out of water table	POS / Reveg	III-b
Very low	Services (reticulated water, power, telephone)	Not deemed to have inherent risks	-	-
Very high	Waterlogging hazard	Low lying creekline areas	POS / Reveg	IV- i
Moderate	Water erosion hazard	Low lying creekline areas	POS / Reveg	III-e
Very low	Wind erosion hazard	Not deemed to have inherent risks	-	-
Very high	Flood hazard	Low lying creekline areas	POS / Reveg	IV-f
Very high	Phosphorous retention ability	Free draining soils with shallow water table	POS / Reveg	IV-p
Very high	Water pollution hazard	Free draining soils with shallow water table	POS / Reveg	IV-s
Very low	Soil salinity	Not recorded present	-	-
Very low	Bushfire hazard	Not deemed to have inherent risks	-	-
Moderate	Native Vegetation retention	Clearing as per EPA regulations, most remnant native vegetation in poor condition	POS/ drainage reserves	II-v
Moderate	Acid Sulphate Soils	Low risk rating WAPC mapping	Roads / drainage reserves	III-as

Limitations Include:

- Ease of Excavation (II-x) – Shallow water table in sands and possibly peat, may require excavation and/or fill.
- Foundation stability (III-b) - Shallow water table in sands and possibly peat, would require drainage and excavation and/or fill.
- Waterlogging (IV-j) – These areas should be avoided in the planning process, a 30m setback limitation has been mapped.
- Water erosion (III-e) – Creeklines subject to inundation are very susceptible to water erosion, in depression areas.
- Flood hazard (III-f) –these areas should be avoided in the planning process (same areas mapped as waterlogging hazard.
- Phosphorous retention ability (III-p) - Phosphate absorbing ATU's should utilised in this mapping unit. A copy of approved Health Department WA ATU's is provided in Appendix E; most areas in this mapping unit did not meet country sewerage policy

requirements and should be avoided.

- Water Pollution Hazard (V-s) – Drainage aligned to water sensitive urban design principles, bioretention basins to nutrient and pollution strip prior to entering waterways.
- Native Vegetation (II-v) – Some remnant riparian vegetation (Taxandria's), vegetation should remain and be re-vegetated with endemic species. Weed management required along creeklines and drains. Vegetation in poor condition due to decades of grazing. Very minimum these areas should be fenced from stock.
- Acid Sulphate Soils – WAPC mapping indicates there is a moderate risk, this can be overcome with management, an Acid Sulphate Soil Investigation should be undertaken to identify if present.

Overall Capability Rating for Residential- V very poorly capable of supporting land many limitations to overcome

Table Eleven (b) Degree of Limitation Map Unit D - Rural

Degree of Limitation	Limitation	Description	Capability	Rating & Sub-class
Moderate	Plant growth	Poor structure soils, low fertility	Drainage reserve	III-pl
Moderate	Soil trafficability	Very shallow sandy soils over rock	Drainage reserve	III-t-
High	Soil fertility status	Poor structure soils, low fertility	Drainage reserve	IV-l
Very low	Soil moisture availability	Not deemed to have inherent risks	-	-
Very low	Rooting conditions	Not deemed to have inherent risks	-	-
Very low	Water availability	Not deemed to have inherent risks	-	-
Very low	Shallow soils	Not deemed to have inherent risks	-	-
Very High	Erosion	Grazing causing erosion to banks and slopes	Drainage reserve	IV-er
Moderate	Flood hazard	Low lying areas	Drainage reserve	III-f
Very High	Water Pollution Hazard	Nutrients from animals and fertilizer application	Drainage reserve	IV-s

Limitations Include:

- Plant growth (III-pl) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Soil trafficability (III-t) – shallow rock, often close to surface.
- Soil fertility status (IV-l) - poorly structured sand soils with limited nutrients, low productivity, would require fertilizer application.
- Erosion (IV-er) – Grazing from hoofed animals causing erosion to banks and slopes. These areas should be fenced from grazing animals, weeds controlled and re-vegetation of local endemic species.
- Flood hazard (III-f) –these areas should be avoided in the planning process (same areas mapped as waterlogging hazard.
- Water Pollution Hazard (IV-s)– effluent from cattle through untreated runoff from paddocks, fertiliser application required to increase fertility, causing nutrient runoff into adjacent watercourses.

Overall Capability Rating for Rural Land Use - IV Area with low capability, high degree of physical limitations.

Lot 800 South Coast Highway
Albany Green Stage Two
Map Unit D
Limitations

Legend

- 50m Setback III-p
- 30m Development Setback
- Native vegetation II-v
- Map Unit D Water logged areas
- Drainage Easements
- Guide Plan
- Meduim Risk ASS III-as
- Proposed roads

III-pl	Plant Growth
III-t	Soil Trafficability
IV- l	Soil fertility status
III-f	Flooding hazard
IV-er	Erosion hazard
IV-s	Water Pollution Hazard
II-x	Ease of excavation
III-b	Foundation stability
IV-i	Waterlogging hazard
III-e	Water erosion hazard
IV-f	Flood hazard
IV-s	Water pollution hazard

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9 Land Capability Analysis

The overall capability of the subject area to sustain the proposed developments is summarised within the mapping units in Table Twelve.

Figure Twelve – Overall land Capability Summary Table

Mapping Unit	Residential	Rural
Mapping Unit A	III	IV
Mapping Unit B	I	III
Mapping Unit C	I	IV
Mapping Unit D	V	V

I = Mapping Unit capable of supporting the Land Use.

II = Mapping Unit capable of supporting the land use and limitations can be overcome by design and management inputs.

III- Mapping Unit with a fair capability, moderate physical limitations occur which significantly affect productive use or result in moderate risk of land degradation.

IV – Areas with low capability for the proposed activity or use, high degree of physical limitations.

V – Areas with poor capability for the proposed activity or use, severity of limitations, use is prohibitive in terms of either development costs or risk of land degradation

A summary of recommendations within each Mapping Unit from the Land Capability Assessment has been provided on Page 36, Section 10 – Planning and Management Considerations.

10 Planning and Management Considerations for Rural Residential

The following recommended planning and land management considerations arise from the Land Capability Assessment:

10.1 On-site Septic Effluent Disposal

Overall the subject site has soils which are conducive to on-site effluent disposal; it is recommended that a phosphate removing ATU on site effluent system is installed in sandy areas to ensure that there is no effluent leaching into waterways. The elevated areas along the ridgeline and where sand over gravel occurs, traditional septics can be used, as there is excellent phosphorous retention ability in these soils. A list of recommended ATU's is supplied in Appendix E. The waterlogged areas (Map Unit D) where ground and water table separation is less than 500mm are not suitable for development.

It is recommended that:

- A 50m setback be applied from all creeks and drains;
- Areas which achieve a 500mm water table clearance (Map Unit A-C) are suitable for on-site effluent disposal;
- Deep sands are not suitable for traditional septic systems and phosphorous absorbing ATU's should be installed on these soil types (Map Unit A); and
- Map Unit B and C have very well nutrient absorbing capacity and traditional septic systems could be utilised on these soil types.
- Map Unit D is unsuitable for on-site effluent disposal

10.2 General Foundation and building stability

The site is predominantly sandy soils with sand over gravel or rock in elevated areas. With appropriate site preparation where required, the subject land will support building development resulting from the proposed sub-division. The dominant soil type is sand, and is suitable to be reused as fill where required. Sands should be compacted and free of loose materials and debris through screening prior to compaction. Loose sands should be protected from erosion factors.

It is recommended that:

- Consideration is give to road alignment to follow contours;
- Construction programming should occur in dry months;
- Development should not occur in waterlogged or flood prone areas (Map Unit D)
- Further geotechnical investigation is required to determine bearing capacity for pavement design; and
- Further investigation may be required at design phase to address the shallow rock in Map Unit C.

10.3 Drainage and Water Sensitive Urban Design Principles

To enable implementation of WSUD principles, planning consideration should be given to realignment of the proposed lots and roads. To more effectively manage road drainage across the site it is recommended that the development plan is re-aligned with the road designed to follow contours. This will allow for vegetated swales to be implemented to hold the 1:1 storm events and reduce the speed of run-off into adjacent areas.

It is recommended that:

- A 50 m development setback be applied around all drains and creeks;
- Bioretention basins should be strategically placed on any entering points into the creeklines or drains;

- native vegetation should be planted into drainage areas to encourage uptake of nutrients and hydrocarbons, encourage removal of sediments as a filter prior to entry of waterways.

10.4 Rural Pursuits

The land is generally very poor for pasture growth, unless fertilisers are added regularly. This is not recommended given the proximity of Lake Powell. If rural pursuits are proposed, it is recommended that this site is not suitable for intensive stocking or grazing.

It is recommended that:

- The creek areas are fenced and revegetated with native endemic plant species to reduce erosion and encourage habitat along micro corridors;
- Stock are not allowed to graze in the drainage corridors;
- Rural pursuits would need to be carefully considered in this area to ensure there is little off-site environmental harm, stocking and grazing causes erosion in sandy soils and nitrification in waterlogged soils.

10.5 Erosion (Gully erosion, wind erosion)

The Land Capability Assessment did not determine if the land was subject to wind or gully erosion and there was no evidence on site of this. It was noted there was erosion along the creeklines from stock.

It is recommended that:

- Fencing occurs to exclude animals and prevent further erosion and degradation of the creeks;
- As the site is predominantly sandy in nature it is recommended that best practise is carried out if the site is developed for residential and sediment traps are installed during development and any cleared areas are stabilised with mulched vegetation; and
- The proposed residential development would best deal with any erosion by aligning the properties and roads along the contours to ensure that storm water does not scour and encouraged to seep into road reserves.

10.6 Vegetation

There is some remnant native vegetation on site, however is in degraded to poor condition due to decades of grazing of stock.

It is recommended that:

- Native vegetation is retained across the site, and a weed management plan is implemented to reduce the competition of introduced species and encourage regrowth of ground and mid structure species;

- A revegetation program should be implemented utilising providence species. This program will need to be implemented by the developer in the first instance and then the responsibility of individual land owners;
- A weed management plan is implemented across the site to eliminate the extensive invasions of weeds, this should be aligned to WA Agriculture and Food guidelines; and
- Any native vegetation clearing is subject to EPA Clearing regulations.

10.7 Acid Sulphate Soils

A detailed Acid Sulphate Soils Investigation aligned to Department of environment and Conservation (DEC) Guidelines, was not undertaken as part of these investigations. The lower half of the subject site has a Medium Risk Rating according to WAPC mapping. Acid Sulphate Soils can be managed, DEC Best guidelines and best practise encourages avoidance, lime application or lime barriers, and protection of groundwater sources.

It is recommended that

- A Preliminary Acid Sulphate Soil Investigation is undertaken when the exact extent of the development is known and if there is any excavation or cut and fill proposed the Acid Sulphate Soil Investigation targets these areas.

11 Conclusions

Grande Terra Land Development Pty Ltd commissioned Opus Consultants to undertake Site Investigations for Land Capability Assessment for lot 800 South Coast Highway, Albany Green Stage Two. Stage One of Albany Green is currently being developed into Rural Residential lots.

The Land Capability Assessment examined the Soil Characteristics, Environmental and Engineering investigations. The investigation and the writing of this report does not take into account any current or future zoning of the subject land, and focuses on land use and subsequent land capability.

Overall the subject site has the capability to be residential development within Map Unit A, B and C. Further consideration to planning the lot layout and road alignments in light of the Land Capability Assessment findings would assist in overcoming any limitations. The waterlogged areas on the subject site are unsuitable for development and rural pursuits (Map Unit D). These areas should be revegetated or remain as vacant land possibly (POS), it is also unsuitable for rural pursuits.

Rural activities such as grazing or horticulture are not recommended; the sandy soils are highly conducive to erosion and require regular improvement as are very nutrient poor. Rural pursuits would need to be of low intensity and ensure have setbacks from the current creek and drain areas. Erosion and degradation of waterways and vegetation is inherent across the site from decades of grazing. At the very minimum, to reduce off-site environmental harm, the creeks and drains should be fenced to exclude stock.

The Chalets proposed through the central area are generally not recommended, unless these are placed out of waterlogged areas. Grouped chalets could be sustained to one central phosphorous absorbing ATU within Map Unit A, this would need appropriate design, planning and aligned to setback's as described in this report.

12 References

Land Capability Assessment for Local Rural Strategies, 1989, Department of Agriculture Western Australia.

The Beard's Vegetation Classification dataset ,1:3,000,000 digital representation of Beard's vegetation map of the state of Western Australia.

"Australian Geoscience Mapping, Map series S50-11 Part of Sheet S150-15, Mt Barker to Albany".

pers comms Thomas Saggers local historian Albany region, 20/8/07

pers comms M.J.Gibbs current occupier lot 800 South Coast Highway 14th June 2007

Department of Health WA "Movement of Nutrients from on-site waste water systems in soils" 2001

Appendices

Appendix A

Subdivision Guide Plan

Job Number: 11018

Sheet Name: 11018-SK02-Rev0.0

Scale: 1:7500 @ A3

Date: 08/TIME:3rd 10 17

Drawn By: SJF

Checked By: JEP

File: J:\2011\11018\drafting & design\design images\07_704 stg 2 sub.tif

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PROPOSED SUBDIVISION GUIDE PLAN - STAGE 2
LOT 800 SOUTH COAST HIGHWAY
ALBANY

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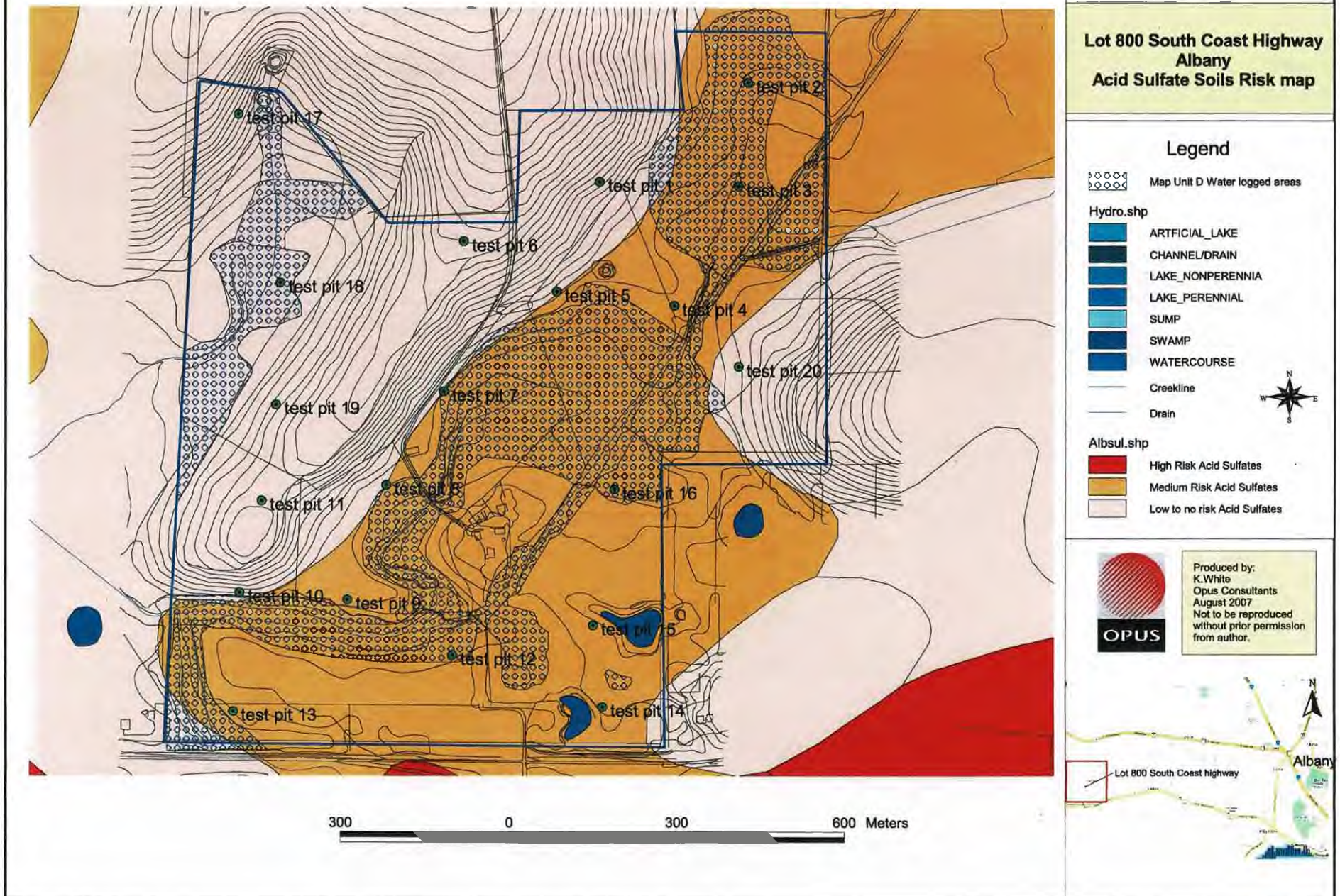
whelans

Appendix B

Test Pit Locations
Field Testing Results



Lot 800 South Coast Highway Albany Acid Sulfate Soils Risk map

Legend

Map Unit D Water logged areas

Hydro.shp

- ARTFICIAL_LAKE
- CHANNEL/DRAIN
- LAKE_NONPERENNIA
- LAKE_PERENNIAL
- SUMP
- SWAMP
- WATERCOURSE
- Creekline
- Drain

Albsul.shp

- High Risk Acid Sulfates
- Medium Risk Acid Sulfates
- Low to no risk Acid Sulfates

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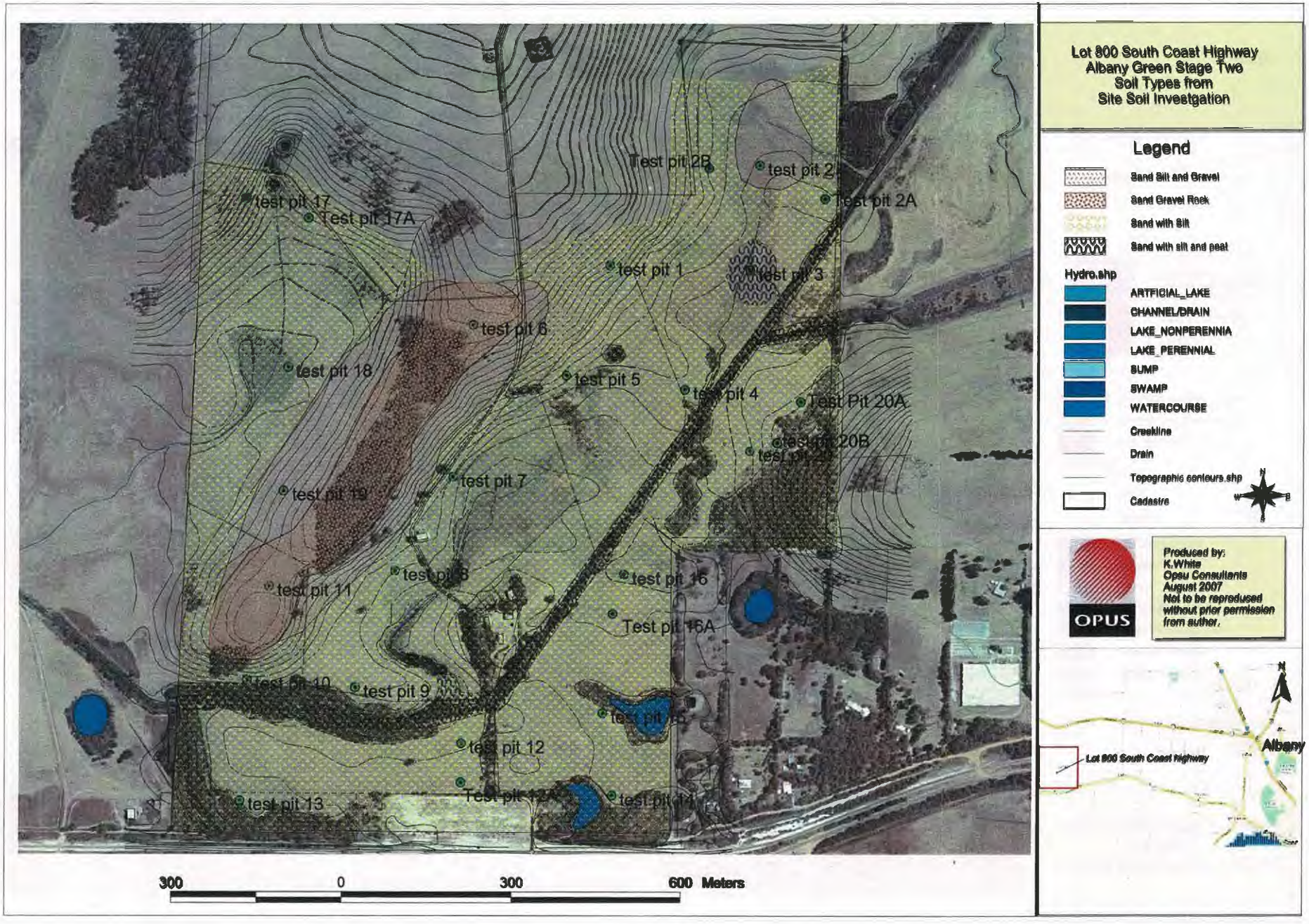
August 2007


Test pit 2B
test pit 2
Test pit 2A
test pit 17
Test pit 17A
test pit 1
test pit 3
test pit 6
test pit 18
test pit 5
test pit 4
Test Pit 20A
test pit 20B
test pit 7
test pit 19
test pit 11
test pit 8
test pit 16
Test pit 16A
Test pit 10
test pit 9
test pit 15
test pit 12
Test pit 12A
test pit 13
test pit 14
300
0
300
600 Meters
Lot 800 South Coast Highway
Albany Green Stage Two
Soil Types from
Site Soil Investgation
Legend
Sand Silt and Gravel
Sand Gravel Rock
Sand with Silt
Sand with silt and peat
Hydro.shp
ARTFICIAL_LAKE
CHANNEL/DRAIN
LAKE_NONPERENNIA
LAKE_PERENNIAL
SUMP
SWAMP
WATERCOURSE
Creekline
Drain
Topographic contours.shp
Cadastre
N
OPUS
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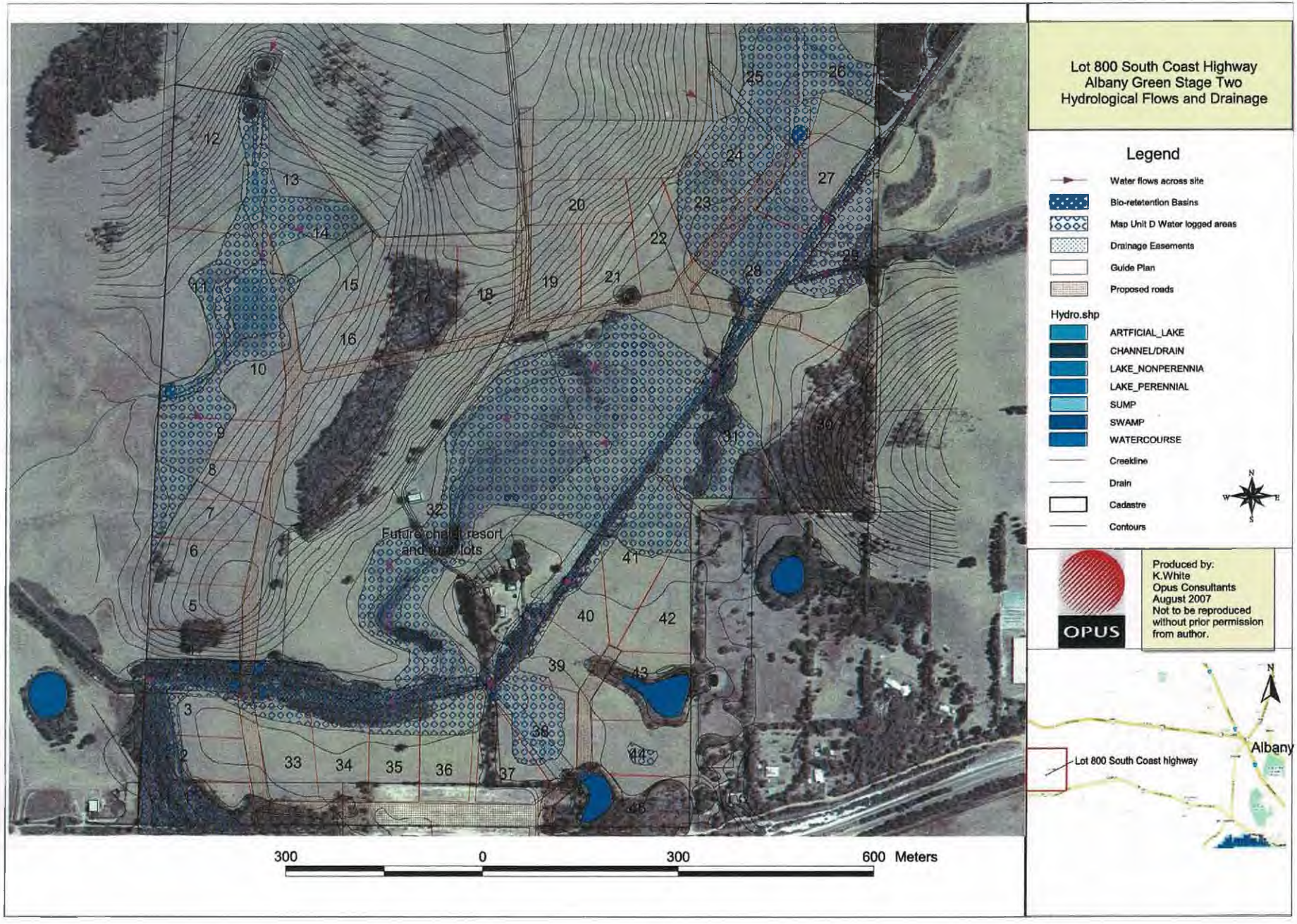
N
Albany
Lot 800 South Coast Highway

Appendix C

Late Winter Water Table Testing


Lot 800 South Coast Highway
Albany Green Stage Two
Hydrological Flows and Drainage
Legend
Water flows across site
Bio-retetention Basins
Map Unit D Water logged areas
Drainage Easements
Guide Plan
Proposed roads
Hydro.shp
ARTFICIAL_LAKE
CHANNEL/DRAIN
LAKE_NONPERENNIA
LAKE_PERENNIAL
SUMP
SWAMP
WATERCOURSE
Creekline
Drain
Cadastre
Contours
Future chalet resort and rural lots
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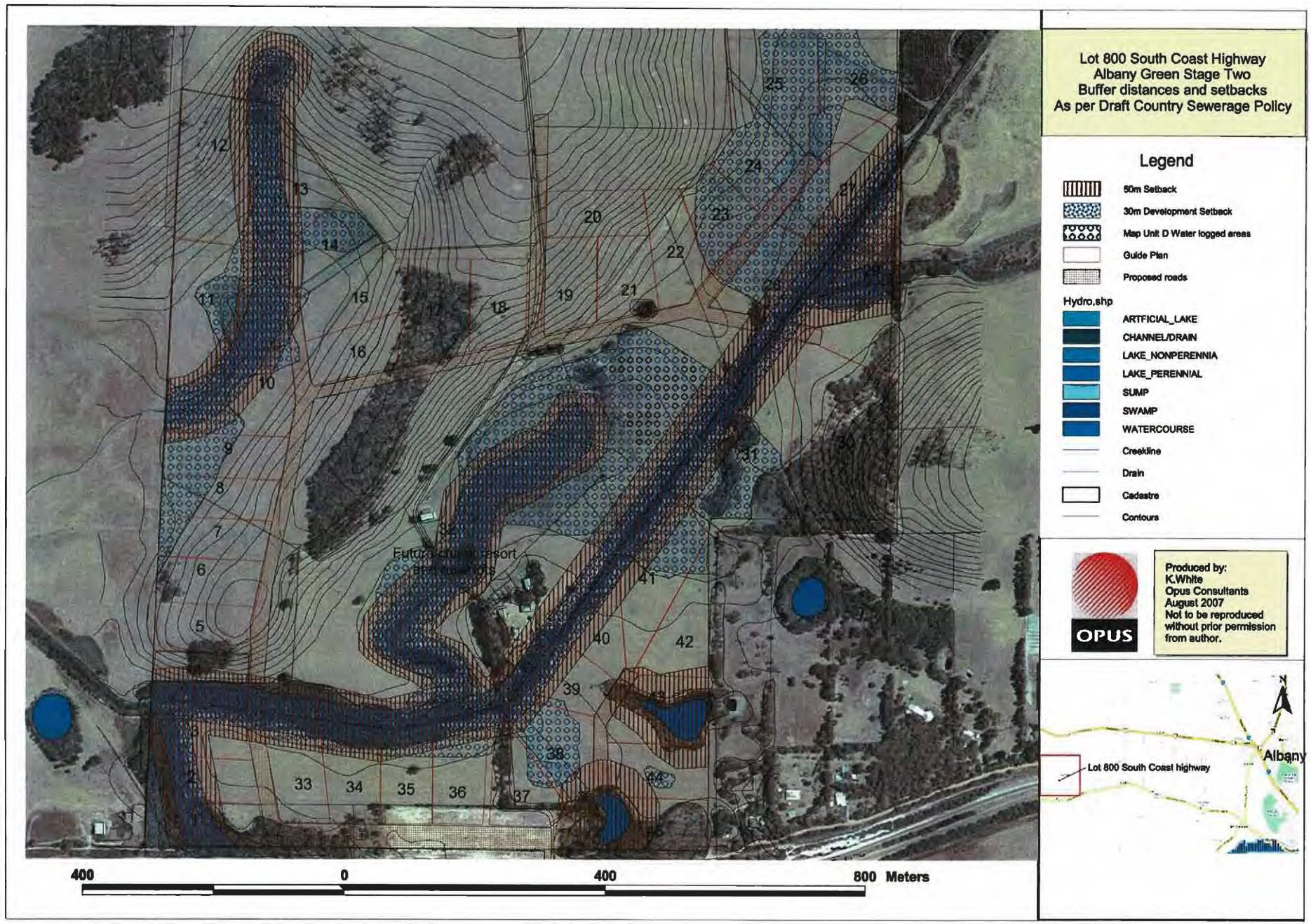
OPUS
Albany
Lot 800 South Coast highway
300
0
300
600 Meters

Test Pit	Late Winter Table	Comments
1	No water table	
2	0mm	Water logged
2a	500mm	New test pit – sand with silt
2b	450mm	New test pit – sand with silt
3	0mm	Water logged
4	760mm	
5	No water table	
6	No water table	
7	150mm	
8	150mm	
9	1400mm	
10	No water table	
11	No water table	
12	100mm	
13	980mm	
14	550mm	
15	800mm	
16	220mm	
16a	600mm	
17	No water table	
17a	No water table	New test pit – sand gravel clay
18	150mm	
19	No water table	
20a	1300mm	New test pit – sand with silt
20b	1300mm	New test pit – sand with silt

Appendix D

Proposed buffer distances


Lot 800 South Coast Highway
Albany Green Stage Two
Buffer distances and setbacks
As per Draft Country Sewerage Policy
Legend
50m Setback
30m Development Setback
Map Unit D Water logged areas
Guide Plan
Proposed roads
Hydro.shp
ARTFICIAL_LAKE
CHANNEL/DRAIN
LAKE_NONPERENNIA
LAKE_PERENNIAL
SUMP
SWAMP
WATERCOURSE
Creekline
Drain
Cadastre
Contours
Future Tourist Resort
and Residential
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N
Albany
Lot 800 South Coast highway
400
0
400
800 Meters

Appendix E

Approved Health Department WA Phosphate removing Alternative Treatment Units (ATU's)

Addendum

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land
Development Pty Ltd

Addendum

Land Capability Assessment
Albany Green Stage Two
Lot 800 South Coast Hwy
Albany

Grande Terra Land Development Pty Ltd

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Date: August 2007
Reference: G:\Environmental Services\Environmental Projects\Whelans
Status: Final
Reference: Job No: WAENV047/04za

Contents

1 Introduction

Grande Terra Land Development Pty Ltd commissioned Opus Consultants to undertake a Land Capability Assessment, Environmental Assessment and give Engineering Comment on constructability of the proposed Albany Green Stage Two. The subdivision site is located on lot 800 South Coast Highway and Stage Two is the southern end of the lot bordering onto the Lower Denmark Road, near Cuthbert Village.

The Land Capability Assessment undertaken by Opus Consultants, assessed the site to define the limitations on the site and any planning considerations related to the site for the proposed future land use. The proponent Grande Terra Land Development Pty Ltd referred the Land Capability Assessment to the City of Albany, whom forwarded this to the Department of Agriculture. As part of this referral process some specific questions were raised requiring further investigation in regards to:

- Acid Sulphate Soils Risk Assessment;
- Soil Quality Assessment;
- Hydrology of the landscape and surface water flows; and
- Drainage and constructability of the site for rural residential development

This addendum provides additional information and discussion to the Land Capability Assessment Report produced by Opus Consultants (2007) to address the above issues.

1.1 Consultation

A meeting was held with the Department of Agriculture specialists, Tim Overhue (NRM Research, Agriculture Resource Management) and Adam Lillicrap (Development Officer, Hydrology Agriculture Resource Management). To discuss the extent of Acid Sulphate Soils (ASS) across the subject site and the CSBP soil results in relation to horticultural viability of the site.

An informal meeting was held with Kevin Hopkinson (Department of Water) to discuss the hydrology of the site and the status of the Five Mile Creek.

2 Acid Sulphate Soils Preliminary Investigation

On the 15th January 2008, a further sixteen test pits across lot 800 were excavated and logged. Soil samples were collected at 250mm, 500mm, 1000mm, 1500mm and 2000mm below surface level, at each test pit location. This was conducted by Opus Consultants Kathryn White, Amanda Broome and Great Southern Drilling. For details of the methodology used for soil sampling, please refer to ASS Preliminary Investigation Report. The results of the Acid Sulphate Soil sampling is attached in this Addendum, please refer to Attachment A – Test Pit Locations, Soil Profile Descriptions and Cross Sections of the Soil Profiles.

The predominant soil present at all test pit locations excavated on 15th January 2008, was grey or brown sand, sandy silt or sandy peat. In elevated areas on lot 800, as in the June 2007 sampling, sand over gravel rock was identified.

At all test pits, dry brown topsoil with organic matter was recorded at 50mm to 100mm from the surface. At test pits 21, 24, 25, 27, 30, 33, 34 and 35 peat was recorded at 300mm to 530mm from the surface. These test pits were excavated in the low lying drainage areas on the lot. Test pit 22 and 28 recorded a layer of peat or clayey peat at depth.

Test pits 21, 31, 32, 34 and 36 recorded a layer of cemented sand with coffee rock fragments (at 10 to 15mm) and with the exception of test pit 31 excavation ceased at between 1200mm and 1500mm as the geoprobe could no longer penetrate the rock.

The water table was reached in all test pits, with the exception of test pit 32, and ranged from 300mm to 1300mm below ground level at 15th January 2008 (please refer to Attachment A- Test Pit Locations, Soil Profile Description and Cross Section of Soil Profile).

A selection of soil samples as per DEC guidelines '*Starting at the ground surface, soils samples…at intervals not exceeding 0.5m down the profile from each sampling location.*' (DoE, 2006) were couriered to NATA certified laboratory for analysis. A total of 76 samples were tested by the SPOS and Chromium Reducible method.

2.1 Laboratory Analysis

If the proposed development on lot 800 requires a soil disturbance of more than 1,000 tonnes of soil then in reference to DoE Guidelines Acid Sulphate Soils Guideline Series, *Draft Identification and Investigation of Acid Sulphate Soils – May 2006*., 27 of the 76 laboratory tested soil samples exceed the criteria for SPOS.

The 25 samples that exceed the guidelines ranged from 0.04% to 0.59%. It was also found that 56 of the 77 laboratory tested soil samples exceed the criteria for TPA. The TPA samples that exceed the guidelines range from 0.04 to 1.300%. Additionally, 33 of the soil samples exceeded the guidelines for TAA, and these ranged from 0.04 to 0.222%. For a summary of laboratory results and field data, please refer to the Summary Tables in Attachment A.

The Chromium Reducible Sulphur (SCr) was also laboratory tested for the peat layer at the surface for all test pits, with the exception of test pit 32. These results indicate that there is some acidity derived from the organic matter in the peat layer. An additional sample at test pit 2 at 1100mm was also tested. Of the 19 samples tested for SCr the sample at test pit 2 (1100mm) was the only

one to exceed the criteria for SCr. This will require consideration when calculating the liming rates for neutralisation of soil and avoidance of ASS during development of the site.

2.2 Summary of ASS Investigation

In summary the peat layer recorded acidity levels exceeding the DEC Guidelines, however this acidity is not caused from sulphur, and from further discussion with Adam Lilliecrap from Department of Agriculture, this acidity could be caused from mobilisation of hydrolysed ions, which may be attributable from iron or aluminium leaching through the soil profile.

Analysis of the soil samples revealed there is a high conductivity and corresponding acidity of the surface soils which is suspected to be attributable to bicarbonate salts, not sulphur salts. The electrical conductivity recorded in the CSBP soil tests confirms this suspicion. (Refer to Section 3 of this report). Sulphur acidity ((Acid Sulphate Soils)) was detected in the soil layers from approximately 1000mm below surface level.

It is recommended that the site is not excavated deeper than 500mm to avoid mobilisation and oxidation of the acid sulphate soils. The top 500mm of soils will still need to be treated with lime upon disturbance of these soils. Figure 1 over the page shows a generalised diagram recommended by Opus Consultants of the extent of organic acidity, ASS and maximum affordable depth of disturbance of soils.

The laboratory results clearly indicate that the some of the soil samples derived from lot 800 exceed the guideline limits set by the DEC. It is a requirement that the acidic soil conditions are managed in accordance with ASS guidelines.

2.3 Recommendations of Preliminary ASS Investigation

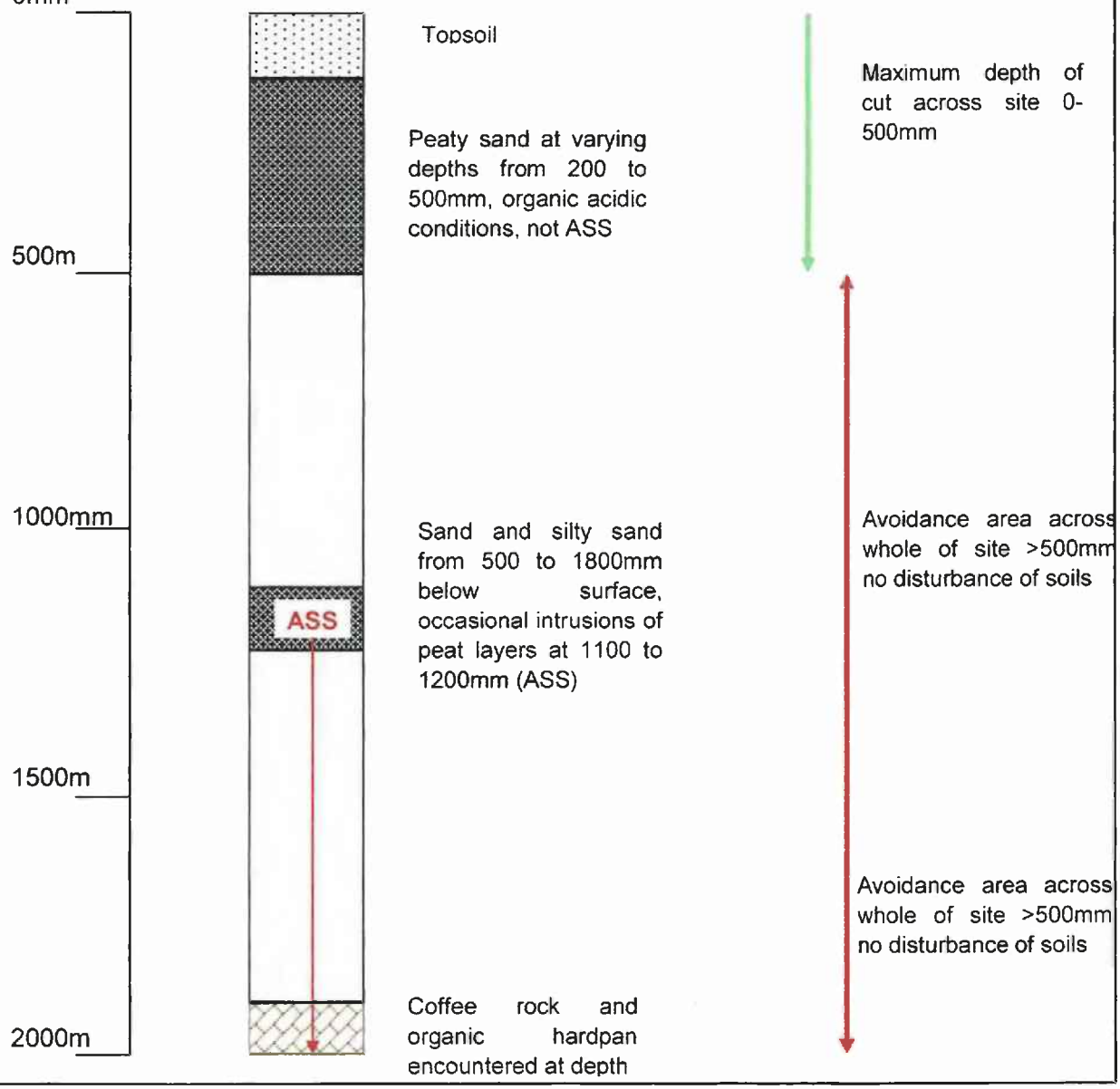
Laboratory testing confirmed that lot 800 South Coast Highway contains acid sulphate soils. The soil acidity exceeds DEC guidelines and action criteria and is required to be managed accordingly.

At the time of writing, the extent of cut and fill for future development is unknown. However if over 100 m3 will be required to be cut and used as fill or for service works Opus Consultants recommend:

1. In the areas which exceed ASS guidelines:
   - Avoidance of Acid Sulphate Soils where possible;
   - Minimise the disturbance of soil where possible;
   - Neutralisation of soil where avoidance is not possible; and
   - Ensure best practice aligned to DEC Guidelines is used.

2. If it is anticipated that to complete the future development, excavation will exceed 100m^3, DEC Guidelines state that an Acid Sulphate Soil Management Plan is to be prepared as per DEC Guidelines. Opus Consultants recommend that an Acid Sulphate Soil Management Plan is prepared and is completed and approved by the DEC prior to commencement of site works or construction.

FIGURE 1: Generalised diagram of ASS and extent of recommended disturbance



3 Soil Quality Assessment

On the 15th January 2008, a further six test pits across lot 800 were excavated, logged and soil samples were collected at depths of 0-200mm and 600mm below surface level, at each test pit location. This was conducted by Opus Consultants Kathryn White, Amanda Broome and Great Southern Drilling. These samples were sent to CSBP for testing, please refer to Attachment B for CSBP Results.

Kathryn White and Vicki Laurie (Opus Consultants) met with Adam Lillicrap and Tim Overhue (Department of Agriculture and Food) upon receipt of the soil test results to discuss the Acid Sulphate Soils and the productivity value of the land for agriculture. It was noted during discussions with the Agriculture Department representatives that less than 10% of the land on lot 800 could be used for either perennial or annual horticulture.

3.1 CSBP Testing Results

Generally the Nitrogen availability was low across the site (greater than 2 is favourable) and the organic carbon was high to medium in the topsoil, however very low in the subsoil samples. (2004, G.Moore). The response of the soils to Phosphorus (P) fertiliser application was probable (<10 probable, > 30 unlikely). Test pit 12 recorded an unlikely response to P application. Overall all the soil samples showed low potassium concentrations. Potassium is regarded as the third most important nutrient after Nitrogen and Phosphorous (2004, G.Moore). The soils were generally acidic, indicating that lime application would be necessary for optimum growth of crops.

Analysis of the soil samples revealed there is a high conductivity and corresponding acidity of the surface soils which is suspected to be attributable to bicarbonate salts, not Sulphur salts. The electrical conductivity recorded in the CSBP soil tests confirms this suspicion. Sulphur in the form of ASS was noted at depths below 1000mm surface level from the ASS Investigation and laboratory testing.

3.2 Perennial Horticulture

Perennial crops such as grape vines, olives and stone fruit crops require intensive amounts of water and often require irrigation. The soils which are suitable for the growing of these crops are located along the ridges where the sand forms over laterite. These soils are free draining and have good phosphorous retention ability. The perennial crops require unrestricted rooting depth, so any areas of rock are unfavourable (such as on top of the dominant ridge). A shallow water table and water logging restricts favourable budding conditions in September. This leaves limited area which would be suitable for these crops.

The areas suitable for perennial horticulture are along the slopes of the dominant ridge and represent less than 10% of the area. If irrigation is required for perennial horticulture, Adam Lillicrap mentioned that the Werrilup formation is the best quality aquifer for irrigation for use. Consultation with Kevin Hopkinson at the Department of Water has revealed that the geology indicates tertiary sediments of the Plantagenet Group, and at this point was not clear of this includes any Werrilup formation sediments. Please refer to the DoW generated map located in Attachment C.

3.3 Annual Horticulture

The results for the CSBP testing indicate that the soils have minerals present at adequate levels for horticultural crops, with the acidic conditions favourable to *Brassica sp* (cabbages, cauliflowers, broccoli etc). These species are best located in acidic soils (such as those present at lot 800), however the conductivity levels (salinity) at these sites are at levels which could inhibit growth and productivity.

In the water logged areas there would still be a requirement for large amounts of lime to be added to the soils so they are suitable for crops. Potatoes are grown to the south of the subject site (south of Cuthbert), however it was noted that the sandy soils located here are best suited to seed potatoes, and this represented less that 1% of the subject site, (pers comms T.Overhue).

Annual horticulture requires irrigated water. As mentioned in perennial horticulture Section 3.1, the aquifer below the subject site is questionable in origin and suitability for irrigation. Further investigation would be required.

3.4 Conclusions from Soil (CSPB Testing) Investigations

The subject site has some areas which would be suitable for intensive horticulture pursuits, although this would be a small proportion of the subject site. In general it was confirmed through discussions with the Department of Agriculture representatives that to make the site nutrient efficient and suitable for annual and perennial horticulture, the site would require a substantial modification of the soils for optimum growth conditions (ie. Liming, suitable water sources, salinity measures and fertiliser application)

It was noted by T. Overhue during the discussions that this site would form a good buffer to agriculture pursuits to the west of the subject site, with rural residential land use a favourable buffer type. There are currently no residential developments to the west of this site, however rural residential is prominent to the east, south at Cuthbert and north at Stage One Albany Green.

4 Hydrology and surface water flows

The subject site is situated on the south side of a ridge running east west parallel to South Coast Highway and Lower Denmark Road. The site has a 2 to 10% linear planar slope, with a dominant ridge (approximately 24m AHD) which descends in a south westerly direction. The valley floors of the site are approximately 10m AHD.

4.1 Surface water flows

The site has surface watershed in a south easterly and south westerly direction from the dominant ridge into the valley floors. The valley areas collect into man made drains known as the Five Mile Creek. In one site north of the Five Mile Creek there is one open water body central to the lot, adjacent to the existing dwelling. This collects surface water all year prior to entering the creek system.

There is a second large pond located in the south east of the subject site. It may be fed from a spring or external source, though this was not evident from site inspection. Further investigation of this water body may be warranted if the site is proposed to be rural residential.

The Five Mile Creek drains into Lake Powell (confirmed by K.Hopkinson DOW). This forms part of the Torbay Catchment, which is currently being targeted for research and investigation by the South Coast Natural Resource Management Group for protection and investment of nutrient reducing actions.

4.2 Ground Water

Winter periods find the valley floors with waterlogged soil profiles (refer to Land Capability Report) and during summer these areas are dry with water table varying from 300mm (adjacent to Five Mile Creek) to 1300mm below surface level.

Ground water hydrology appears from the site investigation to be flowing from the ridge, seeping into the valley floors at three major points. Please refer to Attachment D for surface water directions and ground water seepage sites.

The seepage sites are quite recognisable from the aerials and from site assessment. There is darker colouring of the pasture in these areas, which indicates increases in moisture. Analysis of the soil samples revealed there is a high acidity of the surface soils (and possibly the ground water) which is suspected to be attributable to bicarbonate salts, not sulphur salts.

4.3 Nutrient export

Currently nutrients are exported uncontrolled from the site via surface water and groundwater movement to the Five Mile Drain (constructed drain). These nutrients come from two main sources, animal effluent and fertiliser application for improvement to field pastures.

Located to the south of Cuthbert village is a variety of farms currently farming potatoes and other intensive horticulture crops. It has been recognised that these areas can export nutrients into the catchment area and can lead to nutrification of the Lake Powell and subsequently the Torbay Inlet Catchment.

5 Drainage and constructability of site for rural residential development

Opus Consultants have undertaken a field assessment and concept planning to address possible drainage requirements of the site in the event the subject site becomes a rural residential development. Based on a current version of the proposed lot layout some concepts for the drainage of site surface water and nutrient treatments were developed. Please refer to the sketches provided in Attachment E.

5.1 Road layout

i) Overall the lot and road layout favours the existing contours. Construction cuts and fills should be able to be kept to a minimum over the site with road alignments at, or close to, existing ground levels.

ii) There is an 'at grade' rail crossing proposed prior to Lower Denmark Road. Currently this is a driveway crossing; however the developer should liase with Westrail during the planning process to establish their requirements for control. Considering the potential increased traffic movements at the crossing, Westrail may require a stop signalised crossing at this point.

5.2 Pavements

Although no detailed pavement investigation has been completed on the site, review of the soil profiles and site inspections indicate that a standard pavement design of approximately 200mm pavement should be sufficient on the higher contours.

However, on lower lying areas the ground conditions appear saturated with peat or sandy peat. On the lower lying areas, the subgrade may require modification to obtain suitable bearing capacity. This may be achieved by removal of the peat and replacement with compacted sand and an increased pavement depth. Pavement condition will also be improved by installing suitable drainage, table drains and possibly sub-soil drains in the lower lying areas.

A detailed pavement design will be completed at design stage of this project.

5.3 Bridges and Culverts

i) Two bridges or culverts are proposed crossing Five Mile Creek. These will have to be designed to accommodate flood events and would be best positioned on an embankment above flood levels. Culverts of sufficient capacity to accommodate flood events would likely be too large to fit into the available space in the creek bed. Opus Consultants recommend that a single span pre-fabricated bridge deck above the flood levels should be appropriate for this location. Consideration would be needed that any embankment approaching the bridge would not divert flood flows into neighbouring properties. Further information is required from the DoW whether 1:100 flood levels are available for the Five Mile Creek.

ii) The road turning head located adjacent to Lot 2 is located in the drainage reserve and will require culvert structures beneath the turning head. It is recommended that the location of the turning head be moved westwards so that the length of culvert structures can be reduced and located on the narrower section of roadway.

iii) Culvert crossings have been marked on the sketch in Attachment E. An additional culvert/ access is required to access lot 32. Culverts will be designed to manage a 1:10 year rainfall event.

5.4 Drainage/Retention

Four locations have been identified where there are drainage issues affecting planning and construction.

i) In the vicinity of Lots 31, 32, 33, 34 and 35 very wet ground conditions were observed. From inspection it is difficult to ascertain whether this is due to surface runoff being held back due to a small ridge or if it is ground water seepage from stage 1 above or even from another source.

Detailed investigation and design is required, however construction could require the lots to be lifted approximately 200 or 300mm above existing ground level and the open drain re-graded to approximately 500mm below existing ground level at a constant grade towards Lot 43 in order for the water to flow freely from the site. The re-graded drain could assist in drying out the lots and the road subgrade. The road would have to be constructed 200 to 300mm above existing ground level to prevent failure from water ingress into the pavement. We would recommend cutting the drains a year ahead of construction of the road to attempt to dry out the subgrade if possible.

A detailed survey of the site would be required to determine the extent of drainage improvement necessary over these lots.

ii) There is a large pond located between lots 55 and 56 which is not shown on the concept pond. The pond looks larger than expected from the surrounding catchment. It may be fed from a spring or external source, though this was not evident from our inspection. It may be unfeasible to fill the pond and it should remain as a feature. An overflow drainage easement is required between lots 61 and 62 to replicate the natural overflow that exist in the area.

iii) Lots 58 and 59 are in a low lying area that appears to be susceptible to flooding from Five Mile Creek. The flood banks are low at this point and it looks as if this area could have once formed part of a natural flood plain. It is recommended that flood levels on these lots are established and either the flood bank is lifted or lots filled to accommodate a 1:100 year flood.

iv) It is recommended that a retention pond is constructed in the POS adjacent to lot 42 north of the road crossing to cater for a 1 in 100 year flood. The sizing of the culverts below the road would be suitable to maintain flows that are equal to or less than pre development flows.

5.5 Drainage from Stage 1

Drainage structures that have been constructed in Stage 1 should aid in restricting rain water runoff and flooding from Stage 1 development to the Stage 2 developments. The existing drainage structures in Stage 1 are to be assessed and included as part of the overall drainage scheme for the whole site. Net gains in terms of drainage/stormwater runoff may have already been made due to the control of water from the above sites.

5.6 Nutrient Stripping

Nutrient stripping within the site would be obtained from providing shallow retention ponds at the drainage line outlets on the site adjacent to lot 3 and lot 42 and 17 as shown on the sketch plan. The ponds would be planted with nutrient stripping native vegetation and an outlet strategically placed to control and hold a one in one year rainfall event.

Further planting would be provided in the drainage swales as defined on the concept plan. Limited nutrient control would be provided in the roadside swales, particularly in low lying areas where it is important to get the drainage clear of the pavement as quickly as possible. Vegetation would restrict the drainage paths in the road side swales. It is preferred that the nutrient stripping and soakage occurs within the POS drainage swales and retention ponds.

A plan will be required to manage drainage lines and lots that flow directly to Five Mile Creek. Some additional drainage reserve may be required where the road is crossing Five Mile Creek (Lots 62 and 63 as well as Lots 46 to 57) to construct retention swales for nutrient stripping from the lots and roads south and east of the creek.

5.7 Water main supply

From the Water Corporation asset data base, the nearest existing water main to the site is located on Lowanna Drive to the east of the site and adjacent to lot 126. No water main is available nearby on Lower Denmark Road.

Opus understands there is a proposal to develop lot 126, but is not aware as to the programme or stage of the development.

No water main exists on Lower Denmark Road in the vicinity of the development.

At this stage, Opus have not discussed water supply issues with Water Corporation, though extension of the existing water main will most probably be entirely developer funded.

The most likely option is to extend the Lowanna Drive water main through the proposed development on lot 126. This will be dependent on the proposed development of lot 126 proceeding. The alternative would be either to establish an easement through lot 126 or, although not desirable, extend the water main along Lower Denmark Road.

6 Concepts for Storm Water Treatments

The concepts proposed are aligned to DoW Best Practice and the DoW Stormwater Management Manual (2007). Water Sensitive Urban Design techniques which would be applied to the site, rely on the philosophy of treating water at point of source. This technique allows for treatment of nutrients and for natural ground water re-charge instead of directing water into water ways or sensitive receptors.

The planning for Lot 800 Albany Green storm water design is subject to detailed modelling and calculations of pre-development flows and post-development water movement and catchments. This would be the next stage of the project, and is not within the scope of this brief.

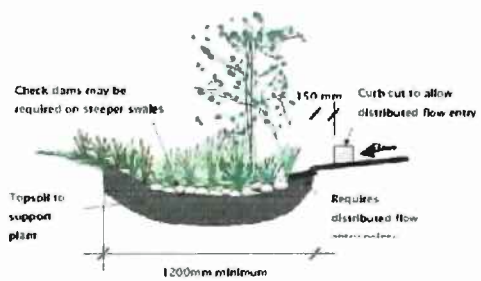
The following sections outline some recommended treatments to be applied across the site at Lot 800 Albany highway for rural residential development.

6.1 Vegetated Swales

Drainage throughout the site will be in the form of vegetated swales. Sedges and rushes will be planted in all of the swales to act as natural biofilters, and will provide cost effective, safe and attractive alternatives to pipes and drains. Endemic sedges and rushes will be used for vegetating the swales as some non endemic species are prone to multiplying rapidly in wet areas and have the potential to 'clog up' drainage lines and waterways.

The swales will follow natural drainage lines wherever possible and will have riffles (strategically placed rock beds) intermittently placed across them to slow the water down, and to create micro habitats and stabilise sediment. The vegetated swales will be located strategically along road verges and will be documented in detailed engineering design.

Figure 2: Vegetated Swales



Typical section through a swale

Swales can be used inside or outside the property boundary.

6.2 Rainwater Harvesting and Re-use

Surface water runoff will be minimised by slowing the movement of rainwater from the catchment and reducing peak flows. To reduce the amount of surface water, and for household water use, all homes will collect the rainwater from their rooftops into rainwater tanks.

6.3 Retention ponds and Living streams

To ensure that predevelopment flows are maintained across the site, it is proposed to have retention ponds with linking living streams which can filter nutrients and sediments, store water and allow for infiltration to the ground water.

Living streams feature stabilised vegetated banks and replicate a natural stream formation providing habitat for animals such as frogs, fish and waterbirds. The Living Stream concept utilises the drain infrastructure as a feature of the development with native plants, stabilised vegetated banks, rock riffles, meandering pathways and function as a conveyance system for stormwater.

The living streams proposed for Albany Green will interconnect the drainage system through the central area of the lots and feed into the retention ponds. The design of the living stream will follow Best Management Practise as per the Stormwater Management Manual DOW (2007). Examples of living streams are well documented by the DoW and shown in examples within Western Australian rural and urban developed areas.

The detailed engineering and environmental detailed design of the Living Stream and Retention ponds will consider:

- Channel Design
- Erosion prevention
- Disharge and retention capacities
- Flow velocities
- Consideration of water table and existing hydrology
- Vegetation management
- Maintenance

The retention and living streams proposed will be designed in consultation with the DoW and CoA to ensure Best practise methodology is applied.

6.4 Revegetation

Revegetation using native plants along the POS areas and in the streetscape will also allow for surface water and nutrient uptake. The swales are designed to have plants in the swale for nutrient uptake and to assist in maintaining pre-development flows. Water sensitive urban design fundamental techniques revolve around water passing over vegetation to uptake nutrients and to encourage ground water recharge.

This rural residential village is very suited to native plant revegetation and will assist in the amenity of the rural residential design. It is recommended that a Landscaping Master Plan be produced with native planting and revegetation to assist in the storm water concept design.

6.5 Water Saving Reticulation Design

To encourage water saving at individual houses, it is recommended that all reticulation across the site utilise subsurface drip lines to minimise surface water run-off and to minimise water usage.

Turfed Areas

Turfed areas will command a major portion of total water use. Considerable savings will be made by including these features in the system.

- Utilise emitters which provide coarse drops, preferably at a low trajectory. These will minimise evaporation. Gear drive sprinklers and impact sprinklers are best where large, regular areas are involved. Pop-up sprays are appropriate for smaller areas of lawn.
- Choose spray heads to closely match the outlines of the lawn. This will minimise overspray onto paths and gardens. A range of spray patterns are available.
- Purchase the highest quality emitters, and standardise on that brand - at least within each watering station. Uniform distribution is a critical consideration in water saving.
- Locate the sprinkler pop-ups at the intervals recommended by the manufacturer - usually spray head to spray head - and staggered if in rows.
- When defining the watering stations and locating the main lines, be sure that the lawn and each garden watering zone are on separate programs.

Garden areas

The important thing is to water directly onto the root zone - not onto the leaves, and not onto the areas between plants.

- Shrubs and perennials. Use drippers to individual small plants. When choosing components, work on providing 10 litres per square metre of watered soil. This corresponds to the Perth Standard Drink of 10 mm depth of precipitation.
- Larger shrubs and fruit trees. Low pressure micro-irrigation sprinklers spread water across the entire drip zone. Their low trajectory undershoots foliage, and avoids wind losses.
- Bedding plants. Large beds of densely planted flowers can also be watered by low pressure micro-irrigation sprinklers. Smaller beds may need Micro-sprays, but these must be on a pressure regulated line to avoid misting
- Pot plants and hanging baskets. Use drippers or multi-outlet emitters to each plant. Water storing granules mixed through the soil save water and improve distribution through the mix.

These water efficiency strategies could be combined into the development's policy or to new lot owners at point of sale.

6.6 Nutrient treatment of WSUD techniques

The WSUD treatments proposed manage water from the point of source. Nutrients are treated through native vegetation uptake from the vegetated swales or from the living streams. Nutrients will also be absorbed into the soil profile, as the soils are sandy allowing good infiltration and permeability. The pollutant trapping efficiency of the proposed applications on lot 800 is shown in

the Table 1 over the page.

Table 1 – Pollutant Trapping Efficiency (Source: WSUD Technical Guidelines for Western Sydney, 2004)

WSUD Element	WSUD Category	Level Control	Pollutant removal efficiencies						
			Gross Pollutants	Coarse sediment	Medium Sediment	Fine Sediment	Free Oil and grease	Nutrients	Metals
Vegetated swales	Secondary	Convey-ance Control	-	50-80%	30-50%	10-50%	10-50%	10-50%	10-50%
Retention ponds/ Living Streams	Tertiary	Discharge Control	-	80-100%	50-80%	30-50%	30-50%	30-50%	30-50%
Gravel Cells	Secondary	Source Control		50-80%	50-80%	30-50%	30-50%	30-50%	30-50%
Gross Pollutant Traps	Primary	Source Control	80-100%	80-100%	30-50%	10-50%	10-50%	10-50%	10-50%
Rainwater tanks		Source Control							

7 Conclusions

Opus Consultants carried out further investigations upon the request the Department of Agriculture and Food's queries from the Land Capability Assessment carried out by Opus in 2007. This Addendum report provides further information and investigations regarding Lot 800 and the proposed future land use of rural residential.

Acid Sulphate Soils

The site was found to have acid soils in the top 500mm of soils below ground level, this was not attributable to sulphur acidity but could be from mobilised ions of aluminium and iron and bicarbonate salts. It is recommended that if soil disturbance is proposed that the site is managed in accordance with the DEC ASS guidelines. It is further recommended by Opus Consultants that the site soils are not disturbed below the 15m contour deeper than 500mm, as sulphur soils (Acid Sulphate Soils and Potential Acid Sulphate Soils) are located from the 1000mm below surface level.

Horticulture

The subject site has some soils which are suitable for horticulture, however represent less than 10% of the subject site. The economics of having this as a sustainable pursuit in the current economic climate is questionable. It is recognised that intensive cropping of horticulture (annual and perennial crops) would require modification of the current landscape and would still contribute unrestricted nutrient flows into the Five Mile Creek and into Lake Powell, within the Torbay Catchment.

Hydrology and Surface Water

The site has predominantly surface water movement from the ridges into the valley floors, where is collects into the Five Mile Creek (a constructed drain). This drain feeds into Lake Powell and forms part of the Torbay Catchment. The valley floors of the site sustain some year round water logging and has one open water body centrally located in the site and one to the south east of the subject site. Further investigation of these water bodies may be warranted if the site is proposed to be rural residential.

Currently there is unrestricted flow of nutrients from the site into the Five Mile Drain and into Lake Powell. This site is not the only creek or tributary to Lake Powell.

Constructability/Engineering

The investigation into the constructability of the subject site for rural residential requires more defined modelling and investigations would be required prior to considering detailed engineering design. Opus Consultants have recognised there are issues of drainage, flooding and road construction which can be overcome with careful planning and design considerations, as outlined in the body of this report.

Storm water Design

Opus Consultants propose that if the subject site was to become rural residential then WSUD concepts would suit this environment. Treatment of point of source surface water flows and storm water prior to entering the Five Mile Creek would substantially reduce nutrient export from the site.

8 References

(2004) Moore, G. Soil Guide, A Handbook for understanding and Managing Agricultural Soil, Department of Agriculture and Food WA.

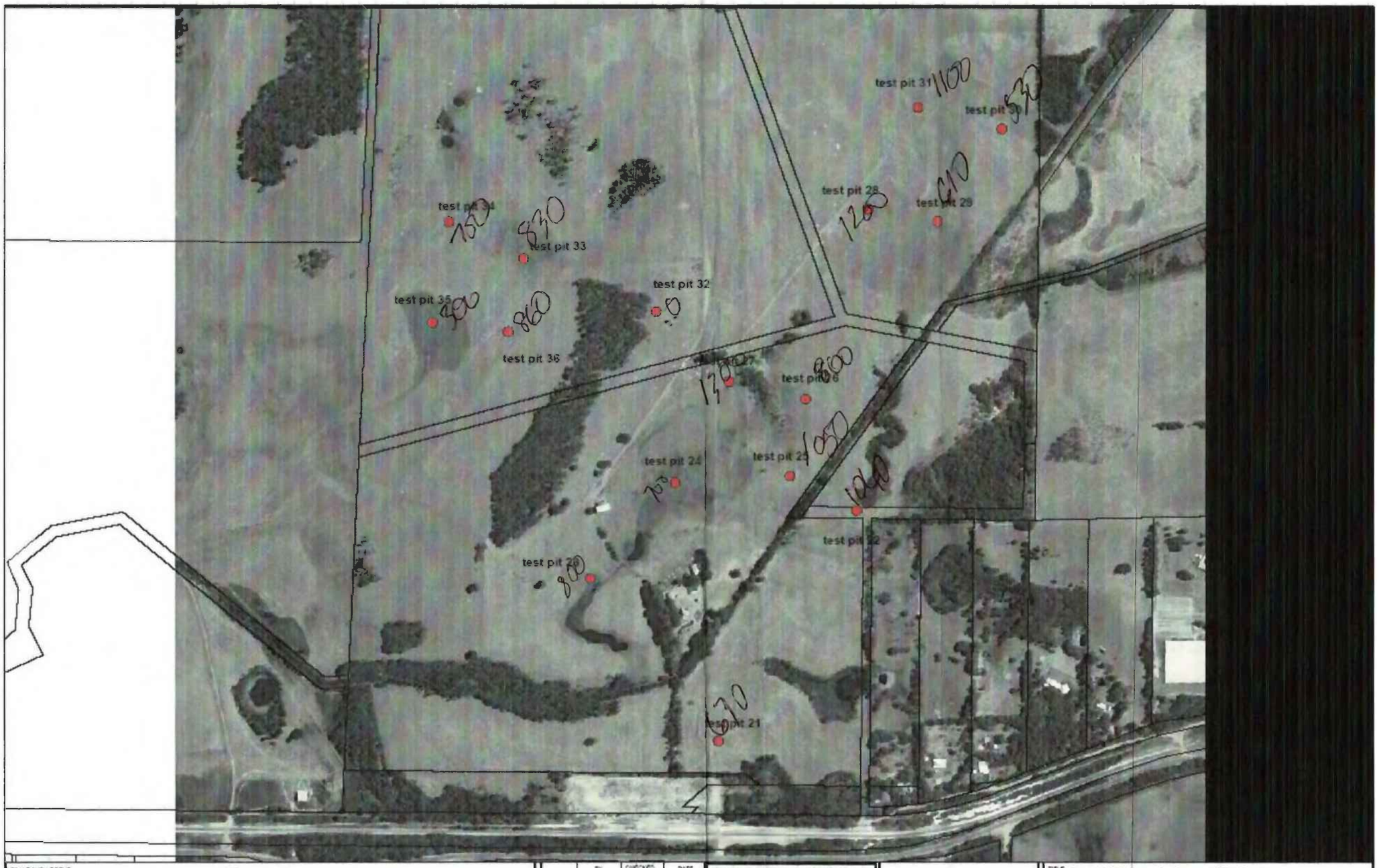
Pers comms Tim Overhue and K.White February 2008

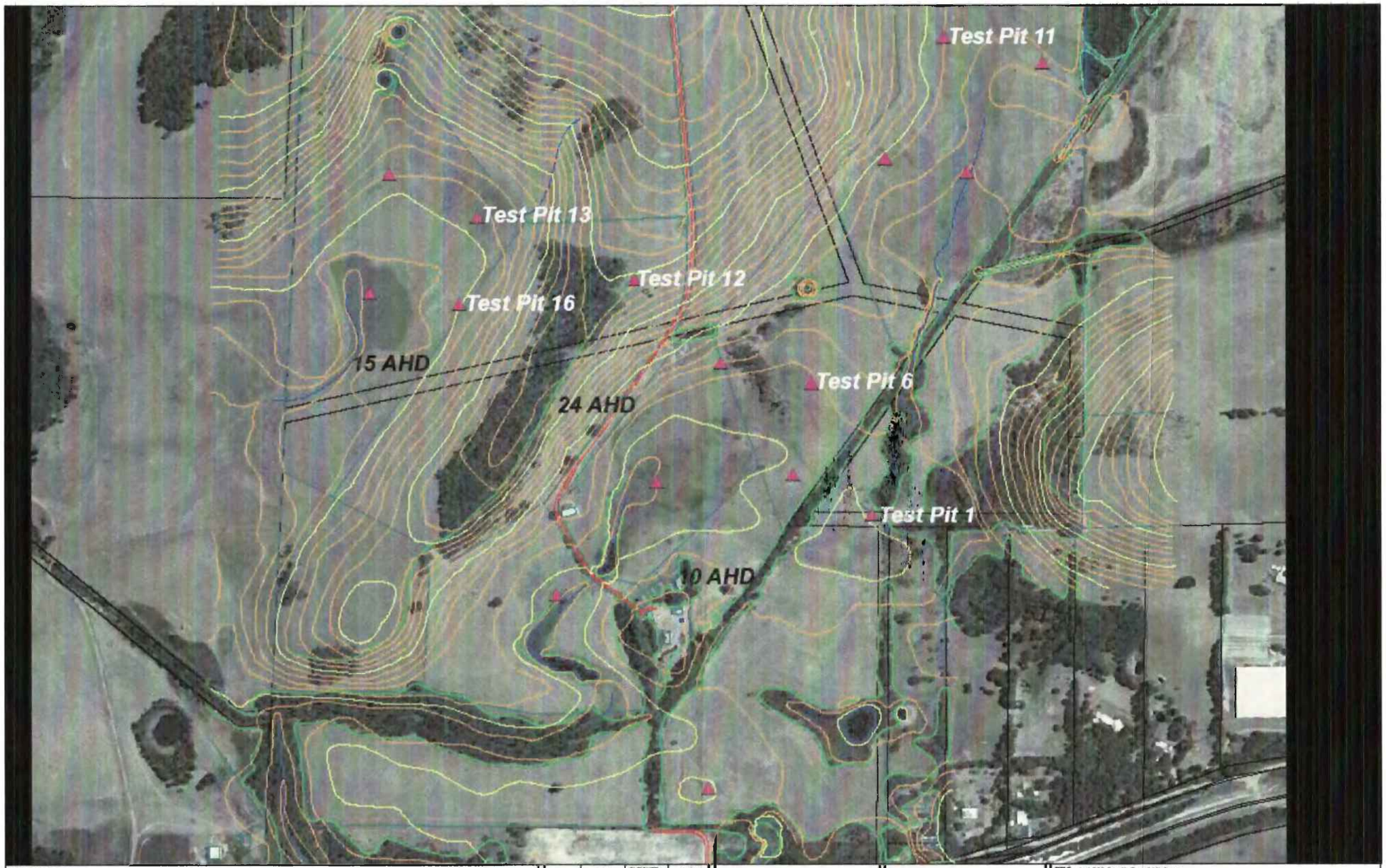
DoE Guidelines Acid Sulphate Soils Guideline Series, *Draft Identification and Investigation of Acid Sulphate Soils – May 2006.*

Whelans, Halpern Glick Maunsell, Thompson Palmer and Institute for Science and Technology Policy, Murdoch University, 1993. *Water Sensitive Urban (Residential) Design Guidelines for the Perth Region: Discussion Paper.*

Test Pit Identification

Test Pit ID January 2008 (ALS Client Sample ID)	Test Pit ID for the purposes of this report
TP 1	TP 21
TP 2	TP 22
TP 3	TP 23
TP 4	TP 24
TP 5	TP 25
TP 6	TP 26
TP 7	TP 27
TP 8	TP 28
TP 9	TP 29
TP 10	TP 30
TP 11	TP 31
TP 12	TP 32
TP 13	TP 33
TP 14	TP 34
TP 15	TP 35
TP 16	TP 36


test pit 31
1100
test pit 30
530
test pit 28
1200
test pit 29
610
test pit 34
150
test pit 33
830
test pit 32
0
test pit 35
490
test pit 36
860
test pit 27
1300
test pit 26
800
test pit 24
700
test pit 25
1050
1040
test pit 22
test pit 23
800
test pit 21
630
Test Pit Locations
ALBANY GREEN
Grande Terra Land
Development Pty Ltd
Albany Office
OPUS
Lot 800 South Coast Highway
Test Pit Locations January 2008



SCALE AND LEGEND

N W E S

0 0.03 0.06 0.12 Kilometers

Legend

Test Pits

	BY	CHECKED	DATE
DESIGN			
DRAWN			
APPROVED			

Albany Green

Albany Office
PO Box 5238
Albany, WA 6330, Australia
Tel: +61 8 9842 8125
Fax: +61 8 9842 8055

TITLE: Lot 800 South Coast Highway
Cuthbert
Albany WA

CSBP Soil Testing 15/01/08

STATUS	FILE
FINAL	WAENV1047
SCALE	PLOT DATE
1:5000	21 August 2007

Soil Profile

Location: Albany Green Stage Two
Date tested: 15th January 2008
Sampled by: Kathryn White

Location	Site description	Depth of profile (mm)	Soil Description
Test Pit 21 E 574871 N 6125036 Front east paddock	Open paddock in depression	0 – 50mm 50 – 300mm 300 – 450mm 450 – 630mm 630 – 1400mm Water table	Dry brown topsoil with organic matter Moist dark brown peaty sand Moist grey sand Moist brown sand Wet cemented dark brown sand 630mm
Test Pit 22 E 572107 N 6125428 Front east paddock	Near Taxandrias and north end of paddock near fence	0 – 50mm 50 – 300mm 300 – 1040mm 1040 – 1300mm 1300 – 2000mm Water table	Dry brown topsoil with organic matter Moist grey sand with rootlets Moist light grey sand Wet black sandy silty clayey peat Wet brown sand 1040mm
Test Pit 23 E 571653 N 6125313 In paddock west of sheds	Low lying in drainage line, cleared open paddock	0 – 100mm 100 – 300mm 300 – 1100mm 1100 – 2000mm Water table	Dry brown topsoil with organic matter Moist dark grey sand Wet dark brown sand Wet dark brown/black sandy silt (fine grained) 800mm
Test Pit 24 E 571797 N 6125475 In shed paddock, east of shed	Open paddock in drainage line	0 – 50mm 50 – 200mm 200 – 400mm 400 – 600mm 600 – 2000mm Water table	Dry brown topsoil with organic matter Dry dark brown peaty sand Slightly moist dark grey sandy silty peat Moist dark grey sandy silt Wet light brown sand 700mm

Test Pit 25 E 571994 N6125487 In windmill paddock	Open paddock	0 – 50mm 50 – 300mm 300 – 460mm 460 – 800mm 800 – 1100mm 1100 – 2000mm Water table	Dry brown topsoil with organic matter Moist grey sand with some peat (very fine) Moist dark grey silty sand (very fine) Moist grey sand (very fine) Moist grey (slightly brown) sand (very fine) Moist dark brown/black sand 1050mm
Test Pit 26 E 572020 N 6125618	Cleared paddock – Windmill paddock	0 – 50mm 50 – 200mm 200 – 500mm 500 – 800mm 800 – 1100mm 1100 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist grey sand Moist dark grey sand Moist grey sand (very fine) Moist grey (slightly brown) sand (very fine) Moist dark brown/black sand 800mm
Test Pit 27 E 571890 N 6125648 East of main race, shed paddock	Cleared open paddock	0 – 50mm 50 – 300mm 300 – 500mm 500 – 700mm 700 – 1200mm 1200 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey sandy peat Slightly moist dark grey sand Moist grey sand Moist light brown sand Wet dark brown sand 1300mm
Test Pit 28 E 572126 N 6125941	Open paddock, deep divots in ground	0 – 150mm 150 – 300mm 300 – 700mm 700 – 1350mm 1350 – 1850mm 1850 – 2000mm NB: 2000 – 2100mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey/black clayey silty sand Slightly moist black/ dark brown silty sand Moist grey sand Wet grey/brown sand Wet dark brown sand with organic matter Peat 1200mm

Test Pit 29 E 572243 N 6125920	Open paddock	0 – 50mm 50 – 250mm 250 – 600mm 600 – 850mm 850 – 1030mm 1030 – 1250mm 1250 – 1800mm 1800 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey sand Moist grey sand Wet light grey sand Wet dark brown/ black sand Wet black organic hardpan Wet light brown sand Wet dark brown sand 610mm
Test Pit 30 E 572352 N 6126077	Open paddock	0 – 100mm 100 – 260mm 260 – 530mm 530 – 1200mm 1200 – 1850mm 1850 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist grey sand Moist black peaty sand with rootlets Wet brown sand Wet light brown sand Wet light brown sand 530mm
Test Pit 31 E 572210 N 6126113		0 – 50mm 50 – 200mm 200 – 600mm 600 – 1150mm 1150 – 1350mm 1350 – 1700mm 1700 – 2000mm Water table	Dry brown topsoil with organic matter Slightly moist dark grey sand Slightly moist grey sand Moist light grey sand Wet dark brown sand with large cemented pebbles Wet grey sand Wet dark brown silty sand 1100mm
Test Pit 32 E 571766 N 6125767 East side of ridge – top of slope	Cleared paddock – top of hill	0 – 50mm 50 – 100mm 100 – 300mm 300 – 900mm 900 – 1500mm Water table	Dry brown topsoil with organic matter Dry slightly brown sand with large gravel stones (10-15mm) with roots Dry orange gravel Dry orange laterite Dry cemented orange clayey sand none reached

Test Pit 33 E 571540 N 6125857 West side of ridge	Cleared paddock	0 – 50mm 50 – 130mm 130 – 230mm 230 – 430mm 430 – 900mm 900 – 1220mm 1220 – 2000mm Water table	Dry brown topsoil with organic matter Moist dark grey sand Moist black peaty silty sand Moist dark grey sand Wet grey sand Wet brown sand Wet dark brown silty sand 830mm
Test Pit 34 E 571414 N 6125919		0 – 100mm 100 – 200mm 200 – 300mm 300 – 400mm 400 – 1000mm 1000 – 1200mm Water table	Dry brown topsoil with organic matter Moist dark grey sand with roots Slightly moist black peaty silty sand Moist dark brown sand Moist to wet light brown sand Wet dark brown sandy silt cemented in places with coffee rock 750mm
Test Pit 35 E 571385 N 6125748		0 – 100mm 100 – 200mm 250 – 600mm 600 – 1000mm 1000 – 2000mm Water table	Dry brown topsoil with organic matter Moist black peat with roots Wet dark brown sandy silt Moist dark brown clayey sandy silt with roots Wet brown sand 300mm
Test Pit 36 E 571514 N 6125732 West of ridge	Open paddock	0 – 50mm 50 – 300mm 300 – 770mm 770 – 900mm 900 – 1200mm Water table	Dry brown topsoil with organic matter Moist grey sand Moist light grey sand with roots Moist brown sand Wet cemented brown sand with coffee rock 860mm

Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite				Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF - pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 21																				
TP21/SS1	250	moist dark brown peaty sand		n/a	n/a		n/a	5.1	2.7	<0.02	0.23	0.21	0.02					<0.02	0.04	
TP21/SS2	500	moist brown sand	630	n/a	n/a		n/a	5.8	3.5	<0.02	<0.02	<0.02	<0.02						<0.02	
TP21/SS3	1000	wet cemented dark brown sand		n/a	n/a		n/a	4.1	2.2	0.19	0.61	0.42	0.11						0.32	
TP21/SS4	1400	wet cemented dark brown sand		n/a	n/a		n/a	4.7	2.7	0.07	0.18	0.11	0.04						0.11	
		Pit terminated at 1400mm due to rock																		
Test Pit 22																				
TP22/SS1	250	moist grey sand with rootlets		n/a	n/a		n/a	5.2	2.7	<0.02	0.11	0.10	<0.02					<0.02	0.03	
TP22/SS2	500	moist light grey sand		n/a	n/a		n/a	5.5	3.1	<0.02	0.05	0.04	<0.02						<0.02	
TP22/SS3	1000	moist light grey sand	1040	n/a	n/a		n/a	5.5	3.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP22/SS4	1500	wet brown sand		n/a	n/a		n/a	5.2	2.7	<0.02	0.12	0.10	0.11						0.13	
TP22/SS5	2000	wet brown sand		n/a	n/a		n/a	5.1	2.6	<0.02	0.12	0.10	0.10						0.11	
TP22/SS6	1100	wet black sandy silty clayey peat						4.4	1.8	0.13	0.90	0.77	0.59					0.33	0.73	
Test Pit 23																				
TP23/SS1	250	moist dark grey sand		4.3	4.1		M	5.0	2.5	0.03	0.20	0.18	0.06					<0.02	0.08	
TP23/SS2	500	wet dark brown sand		4.8	4.2		M	5.1	2.8	<0.02	0.18	0.16	0.03						0.05	
TP23/SS4	1000	wet dark brown sand	800	5.1	4.2		S	5.3	3.0	<0.02	0.04	0.03	0.03						0.04	
TP23/SS6	1500	wet dark brown/black sandy silt		4.8	3.9		S	5.1	2.5	0.04	0.15	0.12	0.09						0.13	
TP23/SS8	2000	wet dark brown/black sandy silt		4.5	4.0		S	5.1	2.6	0.05	0.15	0.11	0.09						0.14	
Test Pit 24																				
TP24/SS1	250	slightly moist dark grey sandy silty peat		4.7	4.1		M	4.6	2.2	0.08	0.56	0.48	0.08					<0.02	0.16	
TP24/SS2	500	moist dark grey sandy silt	700	4.8	4.3		M	4.9	2.5	<0.02	0.38	0.36	0.08					<0.02	0.10	
TP24/SS3	1000	wet light brown sand		4.9	5.3		N	5.8	4.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP24/SS4	1500	wet light brown sand		4.3	5.6		N	5.7	4.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP24/SS5	2000	wet light brown sand		4.5	6.1		N	5.8	4.6	<0.02	<0.02	<0.02	<0.02						<0.02	

Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite				Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF- pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 25																				
TP25/SS1	250	moist grey sand with some peat		4.3	3.5		M	4.2	2.3	0.13	0.81	0.68	0.02					<0.02	0.16	
TP25/SS2	500	moist grey sand		3.5	4.0		S	5.0	2.7	<0.02	0.08	0.07	<0.02						<0.02	
TP25/SS3	1000	moist grey (slightly brown) sand	1050	3.1	3.9		S	5.6	3.5	<0.02	<0.02	<0.02	<0.02						<0.02	
TP25/SS4	1500	moist dark brown/ black sand		3.5	4.1		N	4.1	2.2	0.18	0.73	0.55	0.11						0.30	
TP25/SS5	2000	moist dark brown/ black sand		4.1	4.1		N	4.6	2.3	0.08	0.34	0.27	0.07						0.14	
Test Pit 26																				
TP26/SS1	250	moist dark grey sand		3.5	3.5		n/a	4.3	2.4	0.08	0.35	0.27	<0.02					<0.02	0.09	
TP26/SS2	500	moist grey sand	800	3.2	3.5		n/a	4.7	2.5	0.05	0.11	0.06	0.03					<0.02	0.08	
TP26/SS3	1000	moist grey (slightly brown) sand		3.2	3.7		n/a	5.0	2.7	0.03	0.09	0.06	0.02					<0.02	0.05	
TP26/SS4	1500	moist dark brown/ black sand		n/a	n/a		n/a	4.5	2.3	0.10	0.36	0.26	0.05						0.15	
TP26/SS5	2000	moist dark brown/ black sand		n/a	n/a		n/a	4.6	2.3	0.08	0.29	0.21	0.04						0.12	
Test Pit 27																				
TP27/SS1	250	slightly moist dark grey sandy peat		4.4	4.9		M	4.3	2.4	0.08	0.74	0.65	0.04					<0.02	0.13	
TP27/SS2	500	moist grey sand		4.8	5.0		S-M	6.2	2.9	<0.02	0.10	0.10	<0.02						<0.02	
TP27/SS3	1000	moist light brown sand	1300	4.6	5.4		S	5.7	3.3	<0.02	<0.02	<0.02	<0.02						<0.02	
TP27/SS4	1500	wet dark brown sand		4.7	4.3		Very S	4.6	2.5	0.11	0.33	0.22	0.06						0.17	
TP27/SS5	2000	wet dark brown sand		5.0	4.2		S	4.7	2.3	0.10	0.30	0.21	0.06						0.16	
Test Pit 28																				
TP28/SS1	250	slightly moist dark grey/ black clayey silty sand		3.3	3.1		S-M	3.6	2.0	0.22	1.21	0.99	0.05					<0.02	0.28	
TP28/SS2	500	slightly moist dark grey/ black clayey silty sand		3.9	3.5		S-M	4.7	2.4	0.04	0.39	0.35	0.04					<0.02	0.07	
TP28/SS3	1000	moist grey sand	1200	4.1	4.7		N	5.5	3.1	<0.02	0.04	0.04	<0.02						<0.02	
TP28/SS4	1500	wet grey/ brown sand		4.5	5.2		N	5.6	3.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP28/SS5	2000	wet dark brown sand with organic matter		4.6	3.7		N	4.7	2.3	0.07	0.32	0.25	0.03						0.10	

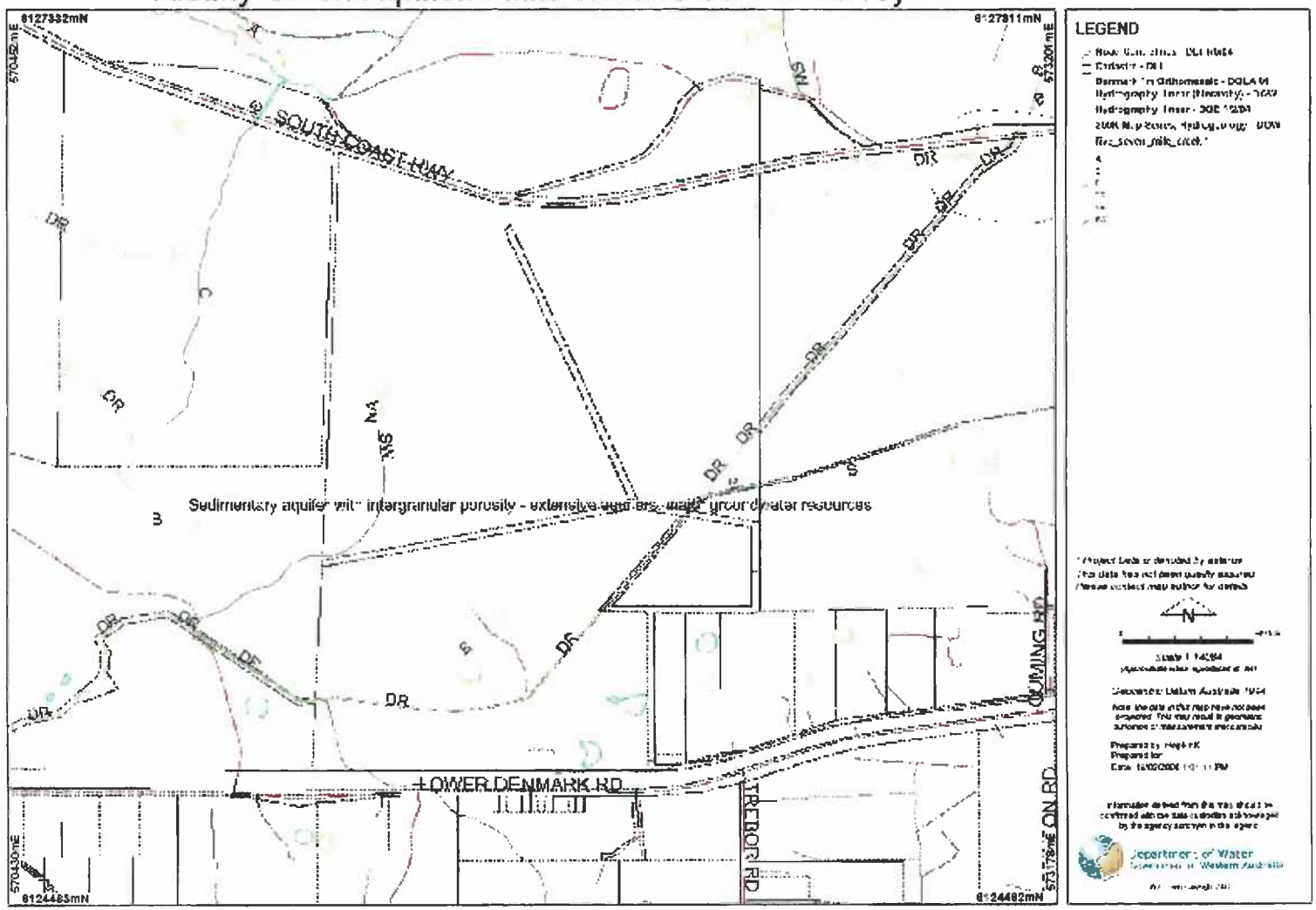
Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite			Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF- pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{POS}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 29																				
TP29/SS1	250	moist grey sand		3.9	3.7		M	4.3	2.2	0.14	1.30	1.16	0.06					<0.02	0.21	
TP29/SS2	500	moist grey sand	610	4.1	4.8		S	5.1	2.8	<0.02	0.09	0.07	<0.02						0.03	
TP29/SS3	1000	wet light grey sand		4.6	4.8		N	4.6	3.1	0.13	0.38	0.25	0.05						0.18	
TP29/SS4	1500	wet light brown sand		4.3	5.3		N	5.4	3.1	<0.02	0.05	0.03	0.03						0.05	
TP29/SS5	2000	wet dark brown sand		4.6	5.5		N	5.3	3.2	<0.02	0.05	0.04	<0.02						0.04	
Test Pit 30																				
TP30/SS1	250	slightly moist grey sand		n/a	n/a		n/a	4.4	2.5	0.07	0.40	0.33	0.03					<0.02	0.10	
TP30/SS2	500	moist black peaty sand with rootlets	530	n/a	n/a		n/a	5.0	2.6	0.02	0.19	0.17	0.03						0.05	
TP30/SS3	1000	wet brown sand		n/a	n/a		n/a	5.2	3.1	<0.02	0.02	<0.02	<0.02						<0.02	
TP30/SS4	1500	wet light brown sand		n/a	n/a		n/a	5.4	3.6	<0.02	<0.02	<0.02	<0.02						<0.02	
TP30/SS5	2000	wet light brown sand		n/a	n/a		n/a	5.5	4.1	<0.02	<0.02	<0.02	<0.02						<0.02	
Test Pit 31																				
TP31/SS1	250	slightly moist grey sand		n/a	n/a		n/a	5.5	2.6	0.03	0.46	0.43	0.02					<0.02	0.05	
TP31/SS2	500	slightly moist grey sand		n/a	n/a		n/a	5.4	2.9	<0.02	0.10	0.09	<0.02						0.02	
TP31/SS3	1000	moist light grey sand	1100	n/a	n/a		n/a	5.8	4.1	<0.02	<0.02	<0.02	<0.02						<0.02	
TP31/SS4	1500	wet grey sand		n/a	n/a		n/a	5.1	2.8	<0.02	0.05	0.03	<0.02						0.02	
TP31/SS5	2000	wet grey sand		n/a	n/a		n/a	4.3	2.5	0.16	<0.02	<0.02	0.07						<0.02	
Test Pit 32																				
TP32/SS1	250	dry orange gravel		4.2	4.9		S	6.0	5.8	<0.02	0.47	0.46	<0.02						<0.02	
TP32/SS2	500	dry orange laterite		4.7	4.9		N	5.8	5.4	<0.02	<0.02	<0.02	<0.02						<0.02	
TP32/SS3	1000	wet cemented orange clayey sand		n/a	n/a		n/a	5.8	4.8	<0.02	<0.02	<0.02	<0.02						<0.02	
TP32/SS4	1500	wet cemented orange clayey sand		n/a	n/a		n/a	5.7	5.0	<0.02	<0.02	<0.02	<0.02						<0.02	
		Pit terminated at 1500mm due to rock																		

Water table – none reached

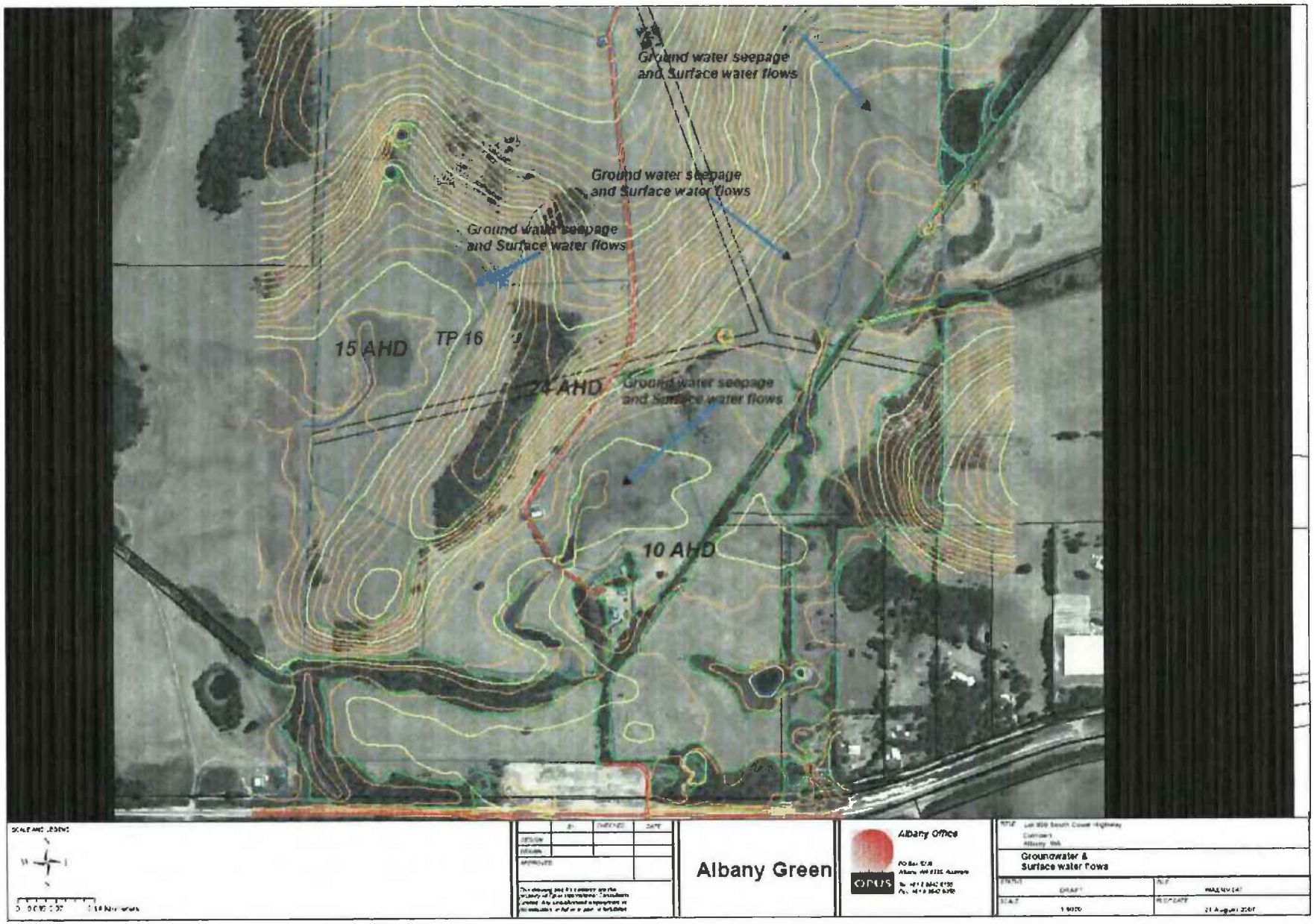
Field Observations				Field Test				Lab pH		SPOCAS						S_{CR} Suite				Action Critera	
Sample ID		Soil Description	Depth to Water	pHF	pHFOX	pHF- pHFOX	Reaction Rate	pH KCl	pH OX	TAA	TPA	TSA	S_{Pos}	ANC_E	Net Acidity	pH KCl	TAA	S_{CR}	Net Acidity (SPOCAS)	Net Acidity (S_{CR})
Location	mmBGL		mmBGL	pH units	pH units	pH units	LMHXV	pH units	pH units	%S	%S	%S	%S	%S	%S	pH	%S	%S	%S	%S
Assessment Critera			-	4	4	1	NV	4	NV	0.03	0.03		0.03	0.03	NV	NV	NV	0.03	0.03	0.03
Test Pit 33																				
TP33/SS1	250	moist dark grey sand		n/a	n/a		n/a	4.8	2.6	0.04	0.23	0.19	<0.02					<0.02	0.06	
TP33/SS2	500	wet grey sand	830	n/a	n/a		n/a	5.8	4.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP33/SS3	1000	wet brown sand		n/a	n/a		n/a	5.3	3.6	<0.02	0.03	0.03	<0.02						<0.02	
TP33/SS4	1500	wet dark brown silty sand		n/a	n/a		n/a	4.9	2.6	0.04	0.11	0.07	0.03						0.08	
TP33/SS5	2000	wet dark brown silty sand		n/a	n/a		n/a	4.8	2.6	0.05	0.17	0.11	0.04						0.09	
Test Pit 34																				
TP34/SS1	250	slightly moist black peaty silty sand		n/a	n/a		n/a	3.8	2.1	0.20	1.09	0.88	0.06						0.27	
TP34/SS2	500	moist to wet light brown sand		n/a	n/a		n/a	5.1	2.9	<0.02	0.06	0.05	<0.02						<0.02	
TP34/SS3	750	moist to wet light brown sand	750	n/a	n/a		n/a	5.4	3.3	<0.02	0.02	<0.02	<0.02						<0.02	
TP34/SS4	1000	wet dark brown sandy silt cemented in places with coffee rock		n/a	n/a		n/a	4.6	2.6	0.06	0.14	0.08	<0.02						0.06	
TP34/SS5	1200	wet dark brown sandy silt cemented in places with coffee rock		n/a	n/a		n/a	4.1	2.7	0.24	0.40	0.17	0.07						0.31	
Test Pit 35																				
TP35/SS1	250	wet dark brown sandy silt	300	n/a	n/a		n/a	4.6	2.5	0.08	0.17	0.08	0.02					<0.02	0.10	
TP35/SS2	500	wet dark brown sandy silt		n/a	n/a		n/a	4.8	2.7	0.04	0.17	0.13	0.02						0.06	
TP35/SS4	1000	wet brown sand		n/a	n/a		n/a	5.1	2.6	0.03	0.10	0.07	0.07						0.10	
TP35/SS6	1500	wet brown sand		n/a	n/a		n/a	5.7	3.3	<0.02	<0.02	<0.02	<0.02						<0.02	
TP35/SS8	2000	wet brown sand		n/a	n/a		n/a	5.5	3.0	<0.02	0.05	0.04	0.04						0.05	
Test Pit 36																				
TP36/SS1	250	moist grey sand		n/a	n/a		n/a	4.7	2.4	0.05	0.28	0.23	0.02					<0.02	0.07	
TP36/SS2	500	moist light grey sand with roots	860	n/a	n/a		n/a	5.6	3.2	<0.02	<0.02	<0.02	<0.02						<0.02	
TP36/SS3	1000	wet cemented brown sand with coffee rock		n/a	n/a		n/a	5.4	3.4	0.04	0.21	0.17	<0.02						0.05	
		Pit terminated at 1200mm due to rock																		

Attachment C – DoW Generated Map

Albany Green-Aquifer/5 Mile creek foreshore survey



Attachment D – Surface Water Flows



Attachment E Concept drainage for Rural Residential Development