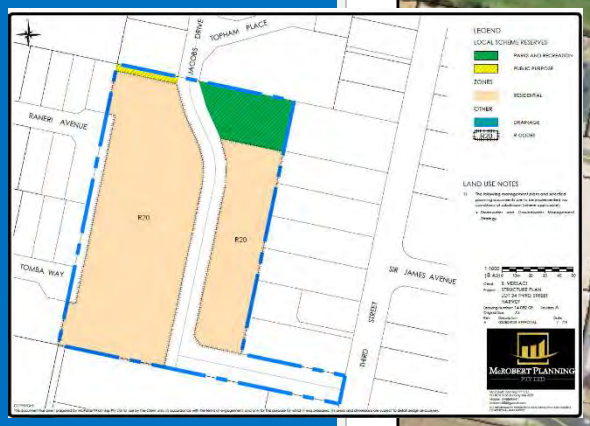

Local Structure Plan
Lot 34 Third Street, Harvey

(August 2019)
Ref: 17-05-VER

Prepared For

Mr B. Versaci

&

The Shire of Harvey

Prepared By

McROBERT PLANNING
PTY LTD

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Endorsement Page

This Structure Plan is prepared under the provisions of The Shire of Harvey District Planning Scheme No. 1

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON

10 August 2020
_____ Date

Signed for and on behalf of the Western Australian Planning Commission:

an officer of the Commission duly authorised by the Commission pursuant to section 16 of the *Planning and Development Act 2005* for that purpose, in the presence of:


_____ Witness

10 August 2020
_____ Date

10 August 2030
_____ Date of Expiry

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Amendment No.	Summary of the Amendment	Amendment Type (major or minor)	Date Approved by WAPC

Executive Summary

The land the subject of this structure plan is described as Lot 34 Third Street, Harvey and is situated approximately 1km (by road) north-west of the Harvey town centre (refer to **Figure 1** – Location Map).

According to Landgate information, Lot 34 has an area of 2.6776 hectares. The Structure Plan area is bounded by relatively recent residential subdivisions to the west and north. To the east, Lot 34 abuts existing residential lots ranging in area from 938m^2 to 2,655m^2 each of which have been developed with single dwellings. To the south, land has generally been fragmented into narrow and long semi-rural lots ranging in area between approximately 2,900m^2 and 6,800m^2.

Figure 1
Location Map

Source: Landgate SLIP Locate V5 Website - https://maps.slip.wa.gov.au/landgate/locate

The subject land is owned by Mr Biaggio Versaci.

The Local Structure Plan has been prepared by *McRobert Planning Pty Ltd* on behalf of the landowner and has been formulated using the *Structure Plan Framework* as released by the Western Australian Planning Commission (WAPC) in August 2015.

The Structure Plan incorporates 0.1242 hectares of Public Open Space with a 5.17% cash-in-lieu equivalent in recognition of the very close proximity of the subject land to the Harvey Recreation and Cultural Centre.

The Local Structure Plan is intended to facilitate residential development at a density of R20 with lots sizes anticipated to range from approximately 350m^2 to 660m^2. Once developed, the Local Structure Plan is estimated to be capable of supporting approximately 31 lots catering for 31 dwellings and an overall estimated population of approximately 96 people.

The land is currently zoned 'Urban' under the terms of the Greater Bunbury Region Scheme (GBRS) and 'Residential' under the Shire of Harvey District Planning Scheme No 1. The land is currently included within a multi-coded R15/30/50 residential density area and is also identified within the Scheme as an 'Outline Planning Area'.

The Structure Plan embraces the principles of the WAPC's Liveable Neighbourhoods and seeks to:

- provide a walkable and permeable layout by including an 8m wide P.A.W. containing a Dual Use Path connecting Tomba Way to the internal subdivision road;
- foster a strong sense of community and identity;
- provide an inter-connected network of streets to provide for safe and efficient walking, cycling and driving experiences;
- ensure active street/land use interfaces maximising surveillance opportunities;
- provide a variety of lot sizes and housing types to cater for a range in housing choice and lifestyle opportunities;
- provide an integrated approach to the design of open space and urban water management;
- promote opportunities for affordable housing; and,
- ensure the efficient use of the developable portions of the structure plan area.

The structure plan is supported by a 'Stormwater and Groundwater Management Strategy' (SGMS) prepared by Pippin Civil Engineering in conjunction with the Shire of Harvey (**Technical Appendix 1**).

Table 1 below provides a summary of the key structure plan statistics and planning outcomes.

Table 1
Summary of Key Statistics & Planning Outcomes

Item	Data	Structure Plan Ref (section no.)
Total area covered by the Structure Plan	2.6776ha	Part 1 Section 1.0 & Part 2 Section 1.2.2
Area of each land use proposed:	Hectares Lot Yield	
Residential R20 Public Open Space Drainage – Basin 1 (POS) Drainage Reserve	 1.6573 ha 31 0.1242 ha 0.0841 ha 0.0218 ha	Table 1 & Table 2 (Executive Summary & Part 1 Section 4.3)
Total Estimated Lot Yield	31	Table 1 & Table 2
Estimated Number of Dwellings	31	Table 1 & Table 2
Estimated Residential Site Density	11.58 dwellings per hectare	Table 1 & Table 2
Estimated Population	96 persons	Table 1 & Table 2
Number of High Schools	0	
Number of Primary Schools	0	
Estimated commercial floor space	0 m^2 nett lettable area	
Estimated area and percentage of public open space given over to: **Local Parks**	0.1242 ha (4.83%) 1 park 5.17% proposed as cash-in-lieu of POS	Table 1 & Table 2
Estimated number and area of natural area and biodiversity assets	0	

Notes: 1. Estimated population based on 3.1 persons/dwelling.
2. Estimated lot yields and numbers of dwellings subject to detailed design and survey.

Part One

IMPLEMENTATION

1.0 Structure Plan Area

The boundaries of the structure plan area include that portion of the Local Government district of the Shire of Harvey as shown on **Figure 2** – Lot 34 Third Street Local Structure Plan Area. The subject land is owned by Mr Biaggio Versaci.

The Structure Plan area is adjacent to relatively recent residential subdivisions to the west and north. To the east, the land abuts large existing residential lots and to the south, land has generally been fragmented into narrow and long semi-rural lots.

Figure 2
Lot 34 Third Street Local Structure Plan Area

Source: Landgate Locate V5 website - https://maps.slip.wa.gov.au/landgate/locate

The Structure Plan area is highlighted by a blue line in **Figure 3** and **Attachment 1**.

Figure 3
Lot 34 Third Street Local Structure Plan

2.0 Operation

In accordance with the Planning and Development (Local Planning Schemes) Regulations 2015, this structure plan shall come into operation on the date it is approved by the Western Australian Planning Commission.

3.0 Staging

The proposed development is considered likely to be constructed in one stage (yet to be determined). It is anticipated that the landowners will commence with an application for subdivision approval (and implementation thereof) as soon as possible following endorsement of this Structure Plan.

4.0 Subdivision and Development Requirements

The Lot 34 Third Street Local Structure Plan Map (refer to Figure 3 and Attachment 1) outlines the proposed 'Residential' portions of the land and the associated R20 density coding to be applied to those areas. In addition, the structure plan identifies the areas proposed to be reserved (eg recreation and drainage) and outlines the relevant land use notes applicable to the structure plan area.

4.1 Land Use Permissibility

The Structure Plan will be used by the Shire of Harvey and the Western Australian Planning Commission respectively, as a guide for the assessment of applications for planning approval under the Shire of Harvey District Planning Scheme No 1 and applications for approval to subdivide land under the provisions of Part 10 of the Planning and Development Act 2005.

The subdivision of land within the structure plan area shall require further assessment and any approvals shall be conditioned with respect to the development control of issues of local and regional importance, additional infrastructure requirements to support the scale and nature of proposed development, and more detailed local planning considerations.

The deemed provisions of the Regulations will override any operational scheme provisions that seek to give a structure plan the force and effect of a scheme.

The Shire of Harvey District Planning Scheme No 1 includes the subject land within the 'Residential' zone while also including the land within an 'Outline Planning Area'. Accordingly, the land is subject to the various provisions of the Scheme relating to the 'Residential' zone, Clause 5.5 'Outline Planning Areas Development Requirements' of the Scheme together with the relevant provisions of the WAPC's State Planning Policy 3.1 'Residential Design Codes'.

4.2 Residential Density Target

The Structure Plan establishes a residential site density target of 11.58 dwellings per hectare and an estimated 31 dwellings within the structure plan area. This compares with the density target of 15 dwellings per gross hectare established by the Department of Planning, Lands and Heritage within the Greater Bunbury Strategy.

The comparatively low residential density target associated with the Lot 34 Third Street, Harvey Local Structure Plan largely reflects the urban fabric of the Harvey townsite, which is of lower density as a result of its rural setting.

4.3 Public Open Space

The provision of public open space (POS) is to be achieved in accordance with the WAPC's Liveable Neighbourhoods. Public Open Space is to be provided generally in accordance with **Table 2** and Figure 3.

Table 2
Calculation of Gross Subdivisible Area & Public Open Space Provision
(refer to Figure 3)

Item	Data
Total area covered by the Structure Plan	2.6776ha
Area of each land use proposed:	
R20	1.6573 ha
POS unrestricted	0.1242 ha
Drainage Area in POS **Drainage Reserve**	0.0841 ha 0.0218 ha
Estimated Lot Yield	31
Estimated No of Dwellings	31
Estimated Residential site density	11.58 dwellings/ha
Estimated population	96 people
Estimated % of Public Open Space:	4.83% with 5.17% cash-in-lieu of POS
Estimated area and number of parks	
Neighbourhood parks	0.1242ha 1 park

Part Two

EXPLANATORY SECTION

1.0 Planning Background

1.1 Introduction & Purpose

The purpose of the Structure Plan is to provide for the orderly and proper planning of the Harvey townsite urban area in accordance with the State Planning Framework and the Shire of Harvey Local Planning Policy Framework.

The intent of this Structure Plan is to guide the subdivision, development and infrastructure servicing of the Lot 34 Third Street, Harvey Local Structure Plan Area.

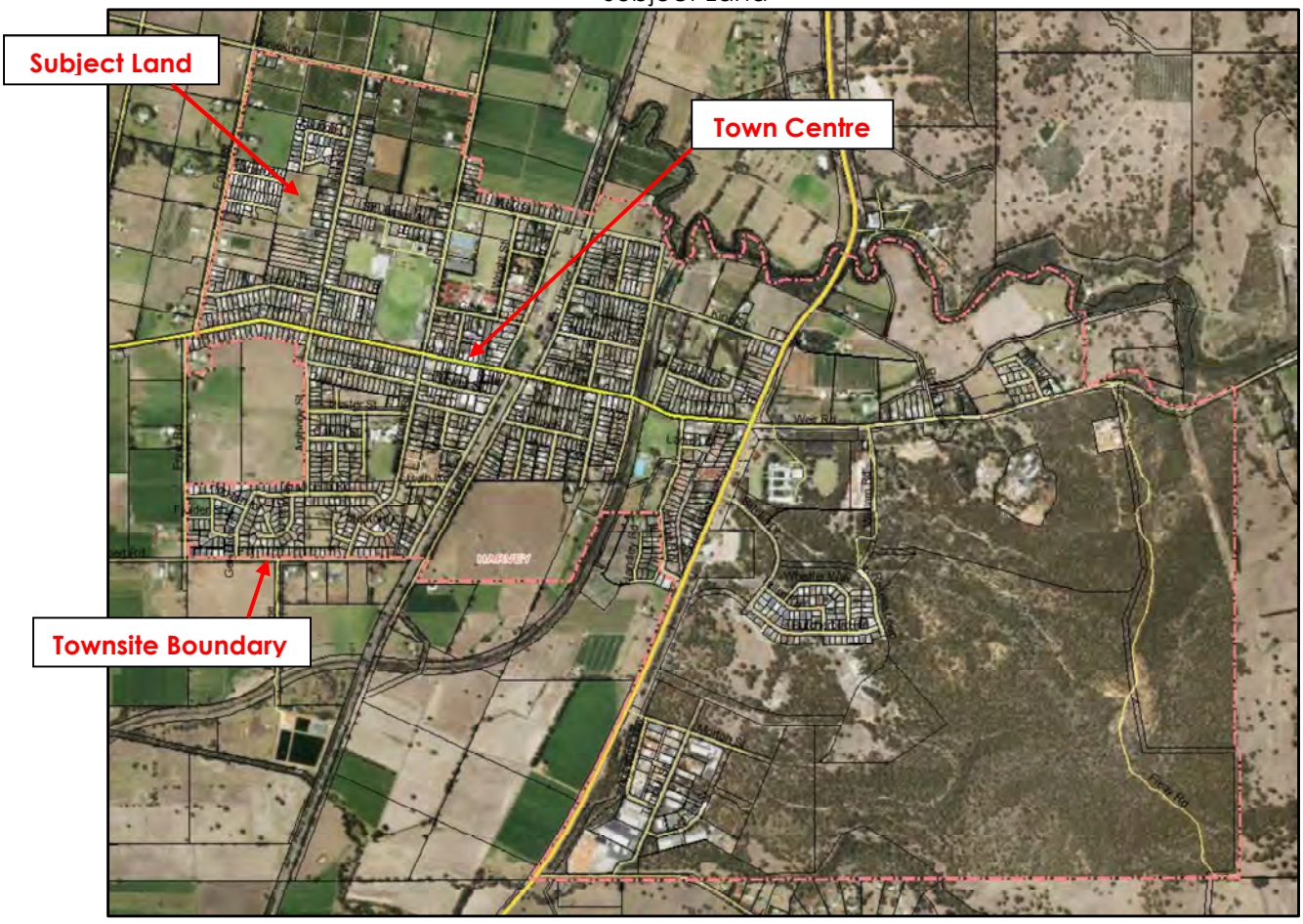
1.2 Land Description

1.2.1 Location

The land the subject of this structure plan is described as Lot 34 Third Street, Harvey. Lot 34 adjoins previously developed subdivisions to the north and west, existing residential lots to the east and existing larger lots to the south.

Lot 34 is situated approximately 1km (by road) north-west of the Harvey town centre (refer to **Figure 4**). The land is located approximately 200 metres (by foot) from the Harvey Recreation and Cultural Centre.

Figure 4
Subject Land



1.2.2 Area & Land Use

The structure plan area comprises a total of 2.6776 hectares and has historically supported rural land use activities (primarily grazing).

Much of the subject land, due to its previous rural use, is generally cleared with some intermittent trees. **Figure 5** depicts the predominantly cleared nature of the land. It should be noted that the shed that appears on the land within Figure 5 has been removed.

The Structure Plan area is bounded by relatively recent residential subdivisions to the west and north. To the east, Lot 34 abuts existing residential lots ranging in area from 938m^2 to 2,655m^2 each of which have been developed with single dwellings. To the south, land has generally been fragmented into narrow and long semi-rural lots ranging in area between approximately 2,900m^2 and 6,800m^2.

Figure 5
Aerial Photograph

Source: Landgate Locate V5 website - https://maps.slip.wa.gov.au/landgate/locate

1.2.3 Legal Description & Ownership

The legal description and ownership details of the subject land are summarised in **Table 3** and a copy of the Certificate of Title is provided in **Attachment 2**.

Table 3
Land Ownership & Lot Details

Lot Number	Ownership	Certificate of Title	Lot Area
34	Mr Biaggio Versaci	1711/499	2.6776ha
		Total	**2.6776ha**

Source: landgate.wa.gov.au

1.3 Planning Framework

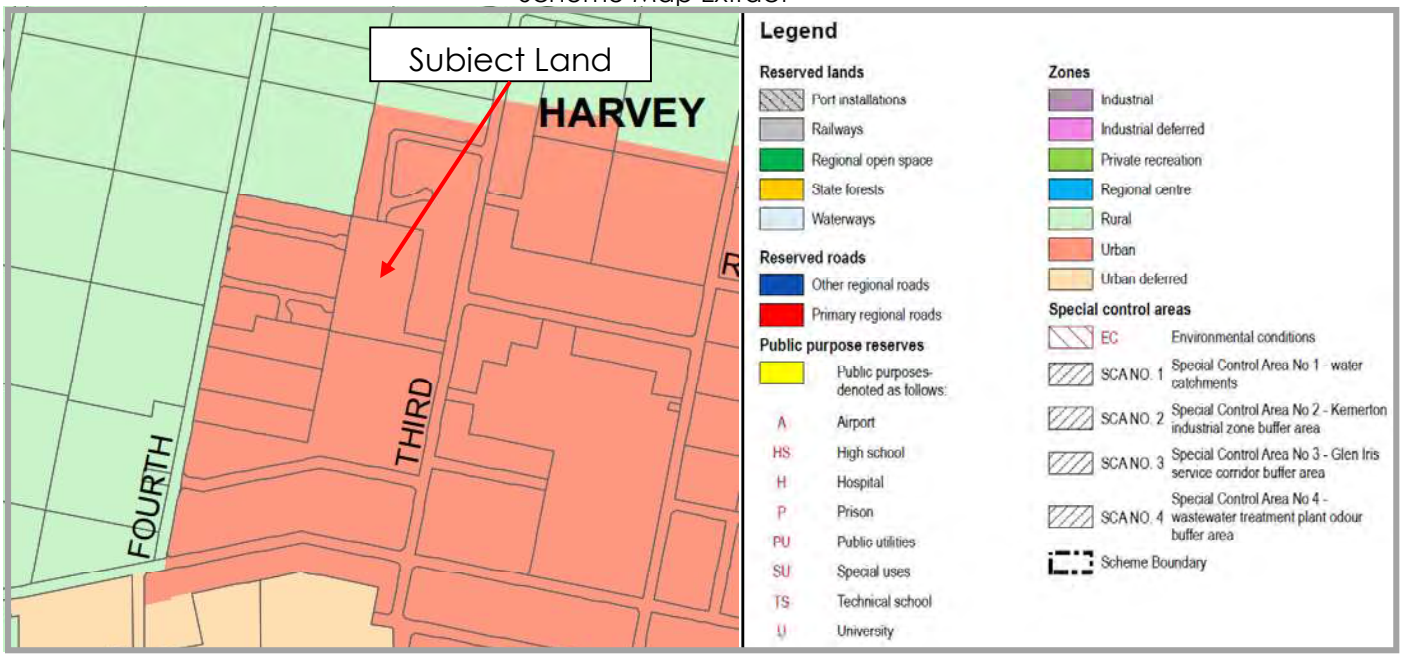
1.3.1 Zoning

1.3.1.1 Greater Bunbury Region Scheme (GBRS)

The Greater Bunbury Region Scheme (GBRS) has been in operation since November 2007 and provides the planning context for growth and development within the Greater Bunbury Region.

The subject land is currently zoned 'Urban' within the GBRS. Surrounding land is generally also zoned 'Urban' with the exception of that land adjoining to the north-west which is currently zoned 'Rural' and further to the north and west of which is also zoned 'Rural' (refer to **Figure 6**).

Figure 6
Greater Bunbury Region Scheme
Scheme Map Extract



Source: Department of Planning, Lands & Heritage website - www.dplh.wa.gov.au

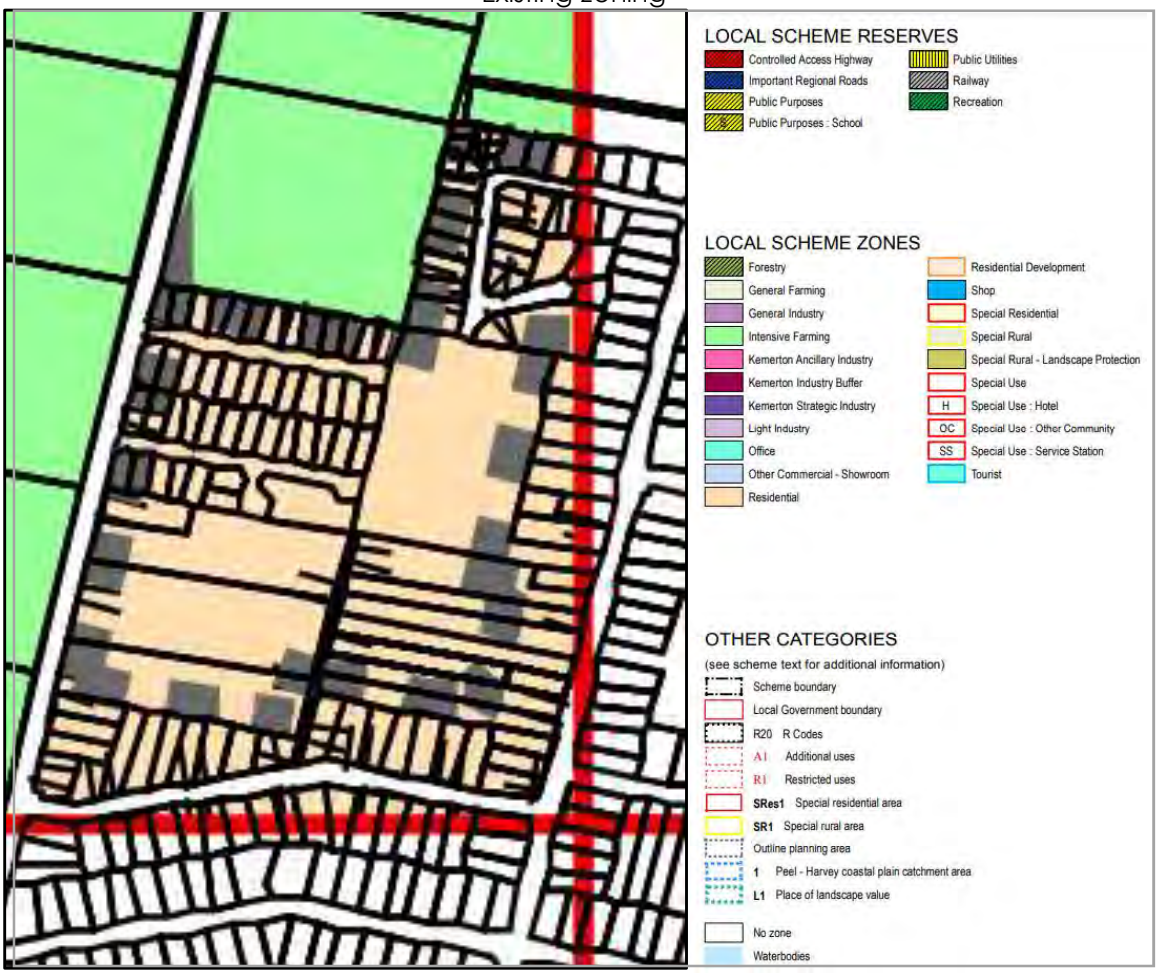
The proposed Local Structure Plan is consistent with the existing 'Urban' zoning of the subject land under the GBRS.

The subject land is not identified as being within an area known to have 'Regionally Significant Basic Raw Materials'. The Structure Plan is included within the Greater Bunbury Region Scheme Priority Agricultural Land Policy 2017 (buffer area).

1.3.1.2 Shire of Harvey District Planning Scheme No. 1

The Lot 34 Third Street, Harvey Local Structure Plan area is zoned 'Residential' under the terms of the Shire of Harvey District Planning Scheme No 1. The land is situated within an area having a split residential density coding of R15/30/50 (refer to **Figure 7**).

Figure 7
Shire of Harvey District Planning Scheme No 1 Scheme Map Extract
Existing Zoning



Source: Department of Planning, Lands & Heritage website - www.dplh.wa.gov.au

The subject land is identified within Scheme No 1 as part of an 'Outline Planning Area'.

Clause 5.5.1 of Scheme No 1 states the following in relation to 'Outline Planning Areas Development Requirements':

"The subdivision or development of land within an O.P.A. is not permitted unless:

a) a structure plan has been prepared and approved by the Local Government and the Western Australian Planning Commission in accordance with the requirements of Part 4 of the Deemed Provisions.

nor otherwise than in accordance with the requirements and provisions of the overall plan or the development Scheme as the case may be. An amendment report will be necessary if the land requires rezoning."
The Policy Statement relating to 'Residential' Development as stated in Table 2 'Zoning and Development Standards' of District Planning Scheme No. 1 states as follows:

"*Primarily single storey dwelling houses on separate lots. Uses reasonably associated with residential areas will be permitted by Local government only after consideration of the likely nuisance that such uses could create. The Residential Planning codes referred to in Clause 4.5 shall apply to residential development within this zone.*"

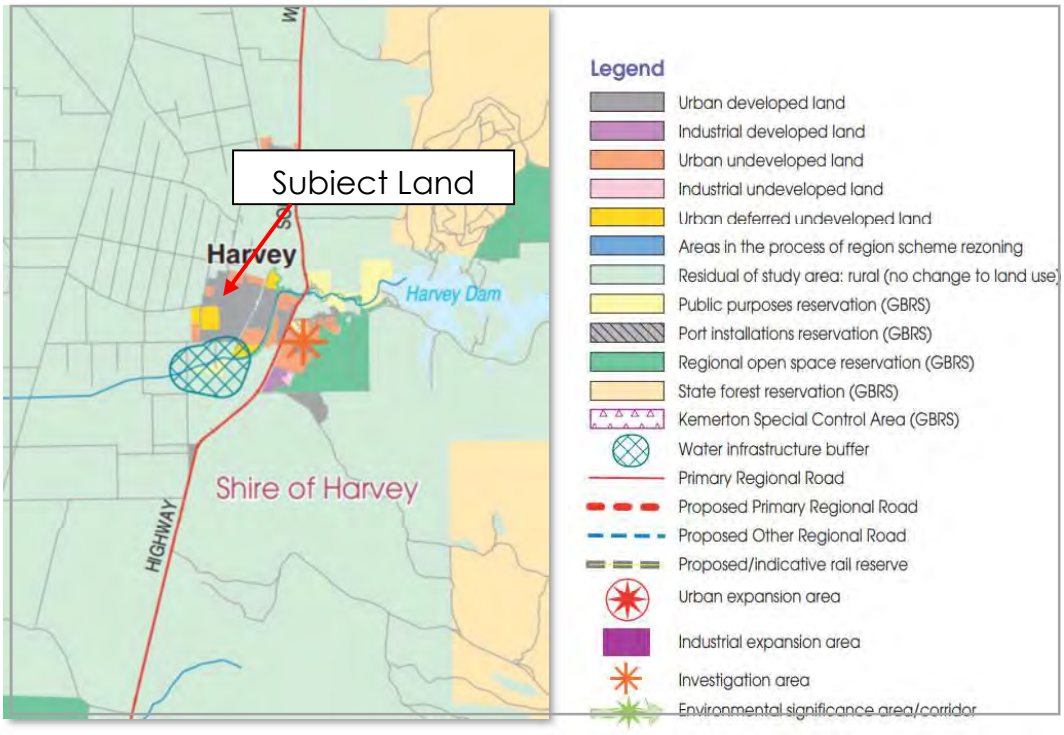
The 34 Third Street Harvey Local Structure Plan the subject of this report fulfils the above requirements of Scheme No 1.

1.3.2 Planning Strategies

1.3.2.1 Greater Bunbury Strategy 2013 & the Greater Bunbury Structure Plan 2011-2031+

The Greater Bunbury Strategy 2013 and the Greater Bunbury Structure Plan 2011-2031+ (refer **Figure 8**) were prepared by the then Department of Planning (now the Department of Planning, Lands and Heritage) to guide urban and regional planning in the Greater Bunbury sub-region.

Figure 8
Extract from Greater Bunbury Structure Plan 2011-2031+



The Greater Bunbury Strategy incorporates the Greater Bunbury Structure Plan which is based on ensuring a 25 year supply of undeveloped land. The main purpose of the Structure Plan is to identify land ahead of the rezoning process and to stage the rezoning of that land in response to future growth trends.

The Strategy advocates that land that is already zoned, such as the Lot 34 Third Street Harvey Local Structure Plan area, should be encouraged and prioritised for development given the considerable supply of land that has already been deemed suitable, or potentially suitable, for new urban development and that has already been zoned accordingly under the Greater Bunbury Region Scheme.

1.3.3 Planning Policies & Framework

1.3.3.1 Liveable Neighbourhoods

Liveable Neighbourhoods (2007) operates as a neighbourhood design code, intended to facilitate the development of sustainable communities. The policy has many aspects but fundamentally the principle idea is to promote walkable mixed-use neighbourhoods.

The Lot 34 Third Street Harvey Local Structure Plan has been formulated to comply with the objectives and intentions of Liveable Neighbourhoods.

1.3.3.2 Structure Plan Framework

The Western Australian Planning Commission's 'Structure Plan Framework' "*Constitutes the manner and form in which a structure plan and activity centre plan is to be prepared, pursuant to Section 2, Part 4, clause 16 and Section 2, Part 5, clause 32 of the Planning and Development (Local Planning Schemes) Regulations 2015*." (WAPC)

The Lot 34 Third Street Harvey Local Structure Plan has been formulated to comply with the Structure Plan Framework.

1.4 Pre-lodgement Consultation

Table 4

Pre-Lodgement Consultation

Agency	Date of Consultation	Method of Consultation	Summary of Outcome
Local Government	Numerous, May 2016 - present	Meetings, telephone discussions & EMail	On-going consultation and meeting regarding stormwater management.
Dept. of Planning, Lands & Heritage	May 2016 to present	Meetings, telephone discussions & EMail	Initial consultation. Dept awaiting formal submission of LSP.
Harvey Water	September, 2016	Telephone discussion.	Confirmed outlet for stormwater not their asset.
Dept. of Water	September 2016 to present	Meetings, telephone discussions, Email & site meeting.	Stormwater and Groundwater Management.
Water Corporation	September 2016 to present	Email & telephone discussions.	Awaiting response on drainage.

2.0 Site Conditions and Constraints

2.1 Landform and Soils

2.1.1 Soil Type

The Harvey Lake Preston 1:50,000 Urban Geology sheet indicates that shallow sub surface conditions beneath the site consist of Guildford Formation, described as alluvial sandy clays (Douglas Partners, October 2016).

A geotechnical survey, undertaken by Douglas Partners in September 2016 states that the observed ground conditions beneath the site generally comprise topsoil, organic clayey silt, sandy silty clay and slightly clayey silty sand.

2.1.2 Topography

The structure plan area is best described as flat with levels generally of approximately 34m AHD across the site.

2.1.3 Acid Sulfate Soils (ASS)

The Department of Environment Regulations Acid Sulfate Soils Risk Assessment maps show two risk categories:

Class 1 - (red/pink) high to moderate risk of ASS occurring within 3m of natural soil surface.
Class 2 - (orange) moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface.

Acid Sulfate Soil mapping indicates that the subject land is located within (refer to **Figure 9**) an area of moderate to low risk of ASS occurring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface. This low to moderate risk is considered unlikely to impact development of the site.

Figure 9
Acid Sulfate Soil Map

Source: Landgate Locate V5 website - https://maps.slip.wa.gov.au/landgate/locate

Subsequent to a preliminary field investigation, Douglas Partners considers that management of acid sulphate soils is not warranted subject to the excavations being less than 2.5m in depth and with no dewatering.

2.2 Existing Building Infrastructure

All previous buildings erected on the subject land have been removed.

2.3 Illegal Dumping and Contamination

Visual inspection of the site does not indicate any areas of potential illegal dumping or areas potentially contaminated with unwanted waste, materials etc. Research of the contaminated site database on data.wa.gov.au, does not indicate any form of registered contamination on the site or that the site has been remediated in the past.

2.4 Ground Water and Surface Water

The geotechnical survey encountered shallow perched groundwater over the majority of the site. Section 2.8.2 details the proposed water management measures.

2.5 Bushfire Hazard

The development has not been identified in the mapping prepared by the Department of Fire and Emergency Services as 'Bushfire Prone Areas'.

Notwithstanding, the road layout enables safe vehicular and pedestrian access/egress in the event of a fire or other emergency. Reticulated water is also proposed to service the development which enables a source of water for fire-fighting purposes. Hydrant locations will be detailed at detailed engineering design stage.

2.6 Heritage

A search of the Aboriginal Heritage Inquiry System indicates that no Registered Sites or Other Heritage Sites are located in the Structure Plan Area.

2.7 Development Siteworks

2.7.1 Earthworks

Douglas Partners has recommended that a minimum of 0.8m of clean granular fill be placed above the prepared clay surface for the development to occur and that a minimum of 0.8m of clean granular fill be placed above the prepared clay surface in order to achieve an 'S' classification for the development.

The Douglas Partners geotechnical study clearly states the preparation and fill requirements for the development to achieve an 'S' classification, in addition to the construction management, compaction and material specification. It is intended that these requirements and recommendations be incorporated into any future construction contracts associated with development of the site.

The levels across the development will be relatively flat and follow the current profile of the land to ensure a general drainage pattern to the south-western corner.

Based upon a conceptual earthwork design for both the subsurface clay material and minimum finished earthworks levels (completed as part of a Stormwater and Groundwater Management Strategy), it is envisaged that some areas will require fill greater than 0.8m in order to achieve the minimum clay surface slope as prescribed in the geotechnical report, the minimum sand depth below the road pavement (to meet the minimum requirements for stormwater pipework gradient) and to achieve an adequate separation to the groundwater (pre and post development).

The preparation of the Earthworks plan at detailed design stage will involve the careful consideration of design levels in order to ensure that a balance of cut to fill can be undertaken to prepare the clayey material surface and the minimisation of imported sand fill material.

2.7.2 Retaining Walls

Given the relatively flat topography it is envisaged that very limited retaining walls will be required between each and every proposed residential lot.

An indicative stormwater and earthworks concept design has indicated that limited height retaining walls may only be required to those lots that are located adjacent the proposed public open space and drainage reserve link. A retaining wall would also be proposed to the eastern boundary of the development site, given that new development will be approximately 800mm higher than the existing rear yards of the existing residences on Third Street.

2.7.3 Landscaping

The development will include areas of biofiltration treatment for stormwater. These treatment areas will require the implementation of biofiltration vegetation that will be considered as

part of the landscape works. The vegetation will be implemented in accordance with the requirements of the Vegetation Guidelines for stormwater biofilters in the south-west of Western Australia and be limited to establishment watering only.

Additional landscaping treatments are subject to Shire requirements and relevant approvals.

2.8 Infrastructure & Servicing

2.8.1 Movement Networks

The internal road layout has been designed to achieve a high level of permeability as well as to provide safe and efficient access for vehicles, pedestrians and cyclists. Connections are provided to the existing roads abutting the site to the north and west, and a connection to the south has been provided for future development.

All roads/streets will be developed by the landowners/developers and will be standard kerb with asphalt seal. Detailed road design will be undertaken as part of the subdivision process.

Generally, streets adjoining Public Open Space (POS) will have a one-way cross fall towards the public open space and propose to have a flush kerb on the POS side to enable street runoff to enter the POS via overland flow. The verges and POS are to be stabilized and/or grassed or vegetated to prevent erosion.

Generally, the proposed movement network hierarchy will consist of three varied types to accommodate the existing, surrounding development:

- A central 16 metre residential street incorporating a dual use path, on-street parking at the POS, street lighting and occasional tree planting;
- A 20 metre residential street linking the development to Third Street, incorporating a dual use path, street lighting and occasional tree planting; and,
- A 15.0 metre residential street, providing a trafficable link between Tomba Way and Raneri Avenue.

An 8 metre wide P.A.W. containing a Dual Use Path is proposed to connect between Tomba Way and the internal subdivision road providing additional connectivity to the Harvey Town Centre and other community infrastructure.

2.8.2 Water Management

A Stormwater and Groundwater Management Strategy (SGMS) has been prepared for the Structure Plan and is attached as **Technical Appendix 1**.

<u>2.8.2.1 Stormwater Management</u>

In accordance with the Better Urban Water Management Framework, stormwater management principles for the Lot 34 Third Street, Harvey Local Structure Plan area will include:

- *Environmental stormwater management will include the retention of the first 15mm of all rainfall events within a bioretention basin located within the Public open space area and a bioretention swale/garden located in the southern verge of the road link to Third Street.*
- *Based upon the geotechnical investigation, the likely 'S' classification for all future dwellings and the requirements of the Shire of Harvey, each proposed lot will be provided with a direct connection to the stormwater pit and pipe network with limited to no infiltration permitted.*
- *Major stormwater management will include the implementation of pit and pipe network to collect, transfer and discharge the 20% AEP storm event to a detention basin located within the public open space area and a detention swale located in the southern verge of the road link to Third Street. The detention basin* and swale will include a controlled outlet releasing stormwater at a rate not greater than that which presently occurs pre-development. Those lots fronting Raneri Avenue and Tomba Way will be connected to the existing Shire stormwater drainage network and will connect to the existing detention basin located at the intersection of Fourth Street and Raneri Avenue. The existing

detention basin will be cleaned and enlarged to accommodate the additional stormwater flow.

- Extreme stormwater management will occur through the utilisation of the road network to convey the 1.0% AEP storm event to a detention basin within the POS area and a detention swale located in the southern verge of the road link to Third St. The western catchment will utilise the existing Tomba Way and Raneri Avenue road reserves to convey the 1.0% AEP storm event flow to Fourth St and then north to the Government Rd North Drain. A 1.0% AEP storm event sized surface flow path will also be defined along the northern boundary of the site, via the drainage reserve and a box culvert to convey existing and proposed 1.0% AEP storm flows to the east of the development site, in line with the pre-development flow paths.

The use of soakwells by building development will not be permitted, with all future dwellings to be provided with a direct connection to the stormwater pit and pipe network.

2.8.2.2 Groundwater Management

Groundwater management will be undertaken across the development site. Due to the existence of high groundwater and perched groundwater in some areas of the development site, a network of subsoil drainage pipework will be installed. The subsoil drainage will be designed to free outlet at the detention basins, in order to permit the treatment of collected groundwater prior to release to the existing drainage network externally of the site.

The subsoil network will be located within each road reserve and the rear of all proposed lots, to prevent any groundwater rise due to development. The subsoil network will not be located lower than current recorded groundwater levels or the perched groundwater across the site, which has generally been located at RL 33.5m AHD.

Any offsite/incidental upgrades and increases in storage volumes to existing local government drainage basins will need to be undertaken by the proponent.

2.8.2.3 Water Efficiency Measures

Consistent with the Water Corporation's "Waterwise" land development criteria, measures will be introduced to reduce scheme water consumption within the development, including:

- promotion of waterwise practices including water efficient fixtures and fittings;
- use of native plants in POS areas;
- use of existing, adjoining POS reticulation sources for the proposed POS and common areas;
- where practicable, maximising on site retention of stormwater;
- promotion of the use of rainwater tanks for non-potable water.

2.8.3 Sewer

The subject land falls within an area licensed to the Water Corporation for the provision of sewer infrastructure and services. Two connection points have been provided from the subdivision to the west. There is also an existing connection to the site in the south eastern corner to Third Street.

Any subdivision development within the Local Structure Plan area will be required to connect to reticulated sewer.

The future development of the Local Structure Plan area will necessitate the developer funding the installation of a gravity sewer network throughout, providing each proposed residence with a connection to reticulated sewer, that would connect to the Water Corporation network.

2.8.4 Water

The Water Corporation is the current ERA licensed service provider for provision of water supply to this site.

Existing mains and connection points are available from the existing subdivisions to the north and west allowing for a ring main feeder system that will distribute water along the roads within the proposed development. Standard water reticulation mains will be provided to each relevant part of the development to provide a potable drinking water supply to each lot.

2.8.5 Power

Initial inspection of the development site indicates that, based upon the extent of existing infrastructure in the area, that the Local Structure Plan area can be supplied with underground power, as will be a Western Australian Planning Commission condition of subdivisional approval. Internally of the development a network of underground cables, transformers and overhead power relocations will be required to be designed, supplied and installed by the developer.

2.8.6 Gas

The proposed Local Structure Plan area is surrounded with reticulated gas infrastructure, in all adjoining road reserves, that is controlled locally by Atco Gas Australia. Liaison and discussions with Atco Gas has indicated that a connection to reticulated gas is possible for the development however the extent of any external upgrades to their network that may be required, would be subject to detailed demand design at the time of subdivision.

2.8.7 Communications

It is anticipated that the land will have access to the existing array of communications infrastructure and technology in the surrounding area. Based upon the number of lots created at subdivision approval stage and the location of the subject land within the Harvey Townsite, the development may be eligible for connection to the NBN Co network for the provision of telecommunication services for all future lots. This connection will be subject to NBN Co approval at the time of development.

Should the developer choose, the development will be required to design, supply and install a communications pit and pipe network for NBN Co.

2.8.8 Drainage

The stormwater collection and disposal within Lot 34 Third Street, Harvey will be designed in accordance with the Stormwater and Groundwater Management Strategy (SGMS) included at Technical Appendix 1 and described at section 2.8.2.1 above.

Final details of the proposed stormwater drainage system will be included within the detailed design to be undertaken at subdivision stage.

2.9 Context and Other Land Use Constraints and Opportunities

The structure plan area is located within the town of Harvey and is approximately 1km (by road) north west of the Harvey Post Office.

A range of community facilities and employment opportunities are within close proximity to the site including:

- Harvey Town Centre;
- Harvey Hospital; and
- A number of local primary schools, high school and the WA College of Agriculture.

The Structure Plan site provides for ease of access to Uduc Road via Third and Fourth Streets. Uduc Road then provides direct access to the South Western Highway.

Within the structure plan area there are currently no existing internal roads, pedestrian or cycle networks.

There are no existing public transport facilities within the structure plan area. The Harvey Train Station is nearby providing access to the TransWa train service that provides morning and evening trains between Perth and Bunbury, stopping at Harvey.

Figure 10 provides a context and site analysis identifying the key opportunities and constraints related to the structure plan area. The figure identifies existing neighbourhood form in surrounding areas and surrounding road and community infrastructure. The structure plan area is generally devoid of topographic features. View corridors are focussed onto the POS area.

2.10 Lot 34 Third Street Harvey Structure Plan

The Structure Plan provides for a range of residential lot sizes consistent with the R20 Residential Density Code. In addition, the structure plan makes provision for:

- 1242m^2 of local public open space with a 5.17% cash-in-lieu equivalent in recognition of the subject land's close proximity (approximately 200 metres walking distance and 400 metres via car) to the Harvey Recreation and Cultural Centre.
- 2 areas for drainage (consistent with the Shire's 'Stormwater and Groundwater Management Strategy') totalling 806m^2 as follows:
    - 841m^2 being the area above the top water level of the 20%AEP storm event within that area identified on the local structure plan for parks and recreation; and,
    - 218m^2 being the drainage reserve providing connection to the north west of the local structure plan area;
- An inter-connected network of roads providing for convenient access to the north, south and east;
- The linking of the existing culs-de-sac heads at the end of each of Raneri Avenue and Tomba Way to the west; and,
- The inclusion of an 8 metre wide Pedestrian Access Way containing a Dual Use Path connecting Tomba Way to the internal subdivision road (extension of Jacobs Way) promoting walkability and connectivity with the Harvey Town Centre.

The Lot 34 Third Street, Harvey Local Structure Plan is consistent with the structure planning undertaken by the Shire of Harvey in its formulation of the 'Stormwater and Groundwater Management Strategy' (refer to Technical Appendix 1).

Figure 10
Local Context, Opportunities & Constraints

Attachments

Attachment 1

Lot 34 Third Street Local Structure Plan

Local Structure Plan –
Lot 34 Third Street, Harvey

Attachment 2

Certificate of Title

REGISTER NUMBER	
34/D1654	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	N/A

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 1711 FOLIO 499

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 34 ON DIAGRAM 1654

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

BIAGGIO VERSACI OF 321 UDUC ROAD HARVEY

(T D149029) REGISTERED 18/11/1985

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

1. THE LAND THE SUBJECT OF THIS CERTIFICATE OF TITLE EXCLUDES ALL PORTIONS OF THE LOT DESCRIBED ABOVE EXCEPT THAT PORTION SHOWN IN THE SKETCH OF THE SUPERSEDED PAPER VERSION OF THIS TITLE. VOL 1711 FOL 499.
2. *M441302 MORTGAGE TO WESTPAC BANKING CORPORATION REGISTERED 24/10/2013.
3. *N127729 MORTGAGE TO WESTPAC BANKING CORPORATION REGISTERED 21/9/2015.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND:	1711-499 (34/D1654)
PREVIOUS TITLE:	1045-568
PROPERTY STREET ADDRESS:	29 THIRD ST, HARVEY.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF HARVEY

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING M441302

LANDGATE COPY OF ORIGINAL NOT TO SCALE 21/05/2019 01:19 PM Request number: 59323681

Landgate
www.landgate.wa.gov.au

Attachment 3

Feature Survey

Local Structure Plan –
Lot 34 Third Street, Harvey

McROBERT PLANNING PTY LTD

Technical Appendices

Technical Appendix 1

Stormwater & Groundwater Management Strategy

June 2020

STORMWATER
&
GROUNDWATER
MANAGEMENT STRATEGY

LOT 34 THIRD STREET, HARVEY

PREPARED FOR: Mr. Biaggio Versaci

PIPPIN
CIVIL ENGINEERING

Submitted by
Pippin Civil Engineering Pty Ltd
PO Box 1837
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DOCUMENT CONTROL

Author (s) : **CRAIG PIPPIN**

Job No. : **1615**

Client: **B. VERSACI**

Revision

Revision	Summary	Revised by	Approved by	Date
A	Issued for Approval		CP	January 2017
B	Structure Plan updated, Revised and Issued for Approval	CP	CP	August 2019
C	Structure Plan updated by WAPC, Revised and Issued for Approval	CP	CP	June 2020

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EXECUTIVE SUMMARY

Pippin Civil Engineering has been engaged to prepare a Stormwater and Groundwater Management Strategy (SGMS) for the proposed residential development of Lot 34 Third Street, Harvey. The report has been prepared to support the Local Structure Plan (LSP) for Lot 34 Third Street, Harvey. The LSP proposal is to guide the subdivision, development and infrastructure servicing of the site for residential development. The SGMS provides the strategy for the implementation of best management practises and principles of water sensitive urban design to ensure that the management of stormwater and groundwater is achieved within the LSP and its subsequent development.

The SGMS has been completed in accordance with the Better Urban Water Management (Western Australian Planning Commission, 2008), the constraints and opportunities identified in referenced consultant reports, information from state and local government authorities.

The land the subject of this report is described as Lot 34 Third Street, Harvey. Lot 34 adjoins recently developed subdivisions to the north and west, existing residential lots to the east and existing larger lots to the south. The land is situated approximately 4km north west of the Harvey town centre. The subject area comprises a total of 2.6776 hectares and has historically supported rural land use activities (primarily grazing). Much of the subject land, due to its previous rural use, is generally cleared with some intermittent trees.

Acid Sulphate Soil mapping indicates that the site is located within an area with moderate to low risk of actual and potential acid sulphate soils occurring within 3.0m of the natural surface. In this regard, A preliminary ASS investigation was undertaken by Douglas Partners in September 2016, which undertook preliminary testing to depths of 2.5m. This investigation indicated one exceedance of the DER criteria. Douglas Partners *"considers the single exceedence of the action criterion associated with an elevated TAA result to be of low significance. Provided excavations are less than 2.5 m depth and dewatering is not required, DP considers that management of acid sulphate soils is not warranted."*

The geotechnical investigation was completed on the 21st September 2016. The investigation included the excavation of 8 test pits across the entire site, of which all but 1 pit noted groundwater seepage. The investigation and reporting, undertaken by Douglas Partners stated "*that the observed ground conditions beneath the site generally comprise topsoil, organic clayey silt, sandy silty clay and slightly clayey silty sand. From a geotechnical standpoint, the land is considered physically capable of development for the proposed residential subdivision, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration, recommendations are implemented and subject to geotechnical constraints. Douglas Partners concluded "A depth of 0.8 m of non-reactive filling is required to achieve an equivalent site classification of Class 'S', assuming the organic materials underlying the northern part of the site are removed. Characteristic surface movement with 0.8 m of non-reactive filling above the sandy silty clay in situ soil is estimated to be approximately 10 mm*."

The structure plan area is best described as relatively flat with levels only ranging from RL 34 metres AHD to RL 34.5 metres AHD. The development site does not contain any surface water storage bodies such as lakes, dams or areas of permanently standing water. It does however contain several areas of seasonal inundation. The development site itself is not definitively characterised by surface water flow paths due to its relatively flat surface profile. However, it does contain a partial swale to the southern boundary and a defined drain to its eastern property boundary.

The key components of the stormwater management strategy are;

- Residential building development on the proposed lots to connect directly to the stormwater pipework of the road network via controlled outlet pit/raingarden installed within the private property.
- Stormwater treatment by retention of the first 15mm from the impervious road reserve area of each storm event within biofiltration basins, swales or gardens.
- Collection and transfer of storm events up to the 20% AEP from the development area within a stormwater drainage pit and pipe system.
- Detention of events upto the 20% AEP major storm within end of development catchment basin or swale with a controlled outflow rate set at the lesser of the pre-development peak flow rate or the maximum flow rate permitted under the Water Corporation drainage guidelines.
- Protection of existing Third St lots adjoining the properties eastern boundary and replacement of an existing surface water drain with a pit and pipe network to the eastern boundary of the properties and connecting it to the existing Shire stormwater network in Third St. The location of this pipe could be relocated to the rear of the existing Third St properties subject to the approval of the existing landowners.
- Conveyance of events upto the 1.0% AEP storm event through the road network and surface water flows paths to existing outlet points associated with the land.

- Detention of events upto the 1.0% AEP extreme storm event for the development catchment, within end of development catchment basin or swale with a controlled outflow rate set at the lesser of the pre-development peak flow rate or the maximum flow rate permitted under the Water Corporation drainage guidelines.

A summary of the storage volumes and treatment areas required for the environmental flow are defined in table 3, below.

	TREATMENT AREA	RETENTION VOLUME
Catchment 1	119 m^2	41.8 m^3
Catchment 2	71 m^2	25 m^3
Catchment 3	Existing	Existing

Table 3
Environmental Treatment Requirements

A summary of the predevelopment flow rates, approximate controlled outlet sizes, required detention storage volumes and indicative basin areas for the 20% AEP storm event are summarised in table 5, below.

	PREDEVELOPMENT OUTFLOW RATE	REQUIRED DETENTION VOLUME	REQUIRED LAND AREA FOR TWL
Catchment 1	0.0084 m^3/s	398 m^3	841m^2
Catchment 2	0.0105 m^3/s	93.3 m^3	165 m^2
Catchment 3	0.0264 m^3/s	1201 m^3 (Only 780m^3 provided)	Existing Basin Site

Table 5
Large Storm – 20% AEP Stormwater Requirements

A summary of the predevelopment flow rates, detention storage volumes and indicative basin sizes 1.0% AEP storm event are defined in table 6, below.

	PREDEVELOPMENT OUTFLOW RATE	REQUIRED DETENTION VOLUME	REQUIRED LAND AREA FOR BASIN
Catchment 1	0.0084 m^3/s	1167 m^3	1952 m^2
Catchment 2	0.022 m^3/s	173 m^3	294 m^2

Table 6
Major Storm Event – 1.0% AEP Stormwater Requirements

The development proposes to install a network of subsoil pipe work to manage the groundwater levels and any potential groundwater rise due to development. The groundwater strategy's core principle is to maintain the existing groundwater regime.

The final earthworks levels of the development will be established in order to meet the requirements of the geotechnical report to achieve an 'S' classification for residential footing construction on the site. The minimum fill requirements will not be established to achieve development separation to groundwater levels, as each proposed lot (future home construction) will not be permitted to utilise soakwells for the disposal of stormwater.

This Stormwater and Groundwater Strategy provides the strategy to address structure planning related water management considerations, the UWMP will clarify and refine these considerations into detailed engineering design.

1.0 INTRODUCTION AND BACKGROUND

Pippin Civil Engineering has been engaged to prepare a Stormwater & Groundwater Management Strategy for the proposed residential development of Lot 34 Third Street, Harvey. The report has been prepared to support the Local Structure Plan as being prepared by McRobert Town Planning.

The Stormwater and Groundwater Management Strategy provides the approach to stormwater management required to be undertaken by development of the land in accordance with the Structure Plan , to ensure it is consistent with Better Urban Water Management (WAPC, 2008).

A geotechnical investigation was undertaken by Douglas Partners. This report is included as Attachment 2 of this report and summarised herein.

1.1 LOCATION

The land that is subject to this structure plan is described as Lot 34 Third Street, Harvey. Lot 34 adjoins previously developed residential subdivisions to the north and west, existing residential lots to the east and existing larger lots to the south. The land is situated approximately 4km north west of the Harvey town centre. The location of the site is shown in Figure 1 below.

Figure 1 – Location Plan

The latest aerial photograph of the site, courtesy of Google Maps is provided as Figure 2 below, to illustrate the site condition and proximity to prominent topographic features.

Figure 2 – Aerial Photo

1.2 PROPOSED DEVELOPMENT

The Lot 34 Third Street, Harvey Local Structure Plan area is zoned 'Residential' under the terms of the Shire of Harvey Town Planning Scheme No 1, with a mixed coding of R15/30/50.

Within the Scheme, the land is located in an 'Outline Planning Area' that requires the preparation of a Structure Plan prior to subdivision or development of the land. This Stormwater and Groundwater Management Strategy has been prepared to support the Local Structure Plan.

The proposed Structure Plan as lodged by McRobert Planning for approval was requested to be amended in May 2020 by the Western Australian Planning Commission (WAPC), this has resulted in the need to create revision 3 of this Stormwater and Groundwater Management Plan. The amended Structure Plan including the requested amendments by the WAPC is shown below, with an A3 version included as Attachment 1.

Figure 3
Amended Structure Plan

2.0 DESIGN CRITERIA

Objective	Design criteria
Stormwater Management	
Extreme Storm Events	• Ensure overland conveyance to pre-development outlet locations via the road network. • Ensure the top water level of overland conveyance mechanisms provides a minimum habitable floor level 0.3m above the 1.0% AEP flood event levels. • Provide on-site detention storage to maintain pre-development outflow rate
Major Storm Events	• Provision of stormwater, pit and pipe network designed to convey up to the 20% AEP storm event. • Interconnection with the existing Shire of Harvey stormwater network. • Ensure on-site detention storage capable of maintaining pre-developed outflow rate for storm events up to the 20% AEP.
Pollutant Treatment	• Retain the first 15mm of each storm event within on site bio-filtration treatment basins, swales or gardens.
Groundwater Management	
Maintain surface-water and ground water quality at pre-development levels	• Drainage – Ensure that all runoff contained within the drainage infrastructure network receives treatment prior to discharge to a receiving or downstream environment consistent with the *Stormwater management manual for Western Australia* (2004–07). • Vegetated swales/vegetated bio-filtration systems sized to retain and treat the first 15mm of impervious area generated stormwater.
Subsoil Drainage	• Maintain the existing groundwater profile (generally at surface) post-development through the implementation of a subsoil pipe network to the road reserve and rear of all proposed lots.
Disease vector and nuisance insect management	
To reduce the health risk from mosquitoes, retention and detention treatments should be designed to ensure that between the months of November and May, detained immobile stormwater is fully infiltrated within a time period not exceeding 96 hours.	• All stormwater detention areas will be constructed with subsoil draining outflow after post-bio-filtration treatment, to ensure no permanent water bodies.

Table 1
Design Criteria

3.0 PREDEVELOPMENT ENVIRONMENT

3.1 EXISTING LAND USE

Existing and past use of the property has consisted of rural activities, primarily grazing. Consequently, the property is largely cleared of vegetation with few remaining trees and negligible understorey.

The following aerial photograph with cadastral overlay (refer to Figure 4) depicts the predominantly cleared nature of the land.

Figure 4
Aerial Photograph with Cadastral Overlay
Source: landgate.wa.gov.au

3.2 ENVIRONMENTAL AND LANDFORM FEATURES

3.2.1 Vegetation Types

As can be noted from the aerial photograph the site is largely devoid of extensive vegetation. The use of the property for general farming and storage has resulted in the larger vegetation being removed.

The road/track entry from Third Street is lined to the north with imported palms. The eastern boundary of the site does contain several large gums that are located just inside the property boundary.

3.2.2 Acid Sulphate Soils

Acid Sulphate Soil mapping (refer Figure 4) indicates that the site is located within an area with moderate to low risk of actual and potential acid sulphate soils occurring within 3.0m of the natural surface.

In September 2016 Douglas Partners undertook a geotechnical and preliminary acid sulphate soil investigation across the development site. The report advised and concluded *"With reference to Table D-1, Appendix D, the reported results indicate the following:*

- *the results for pHF are not indicative of actual acid sulphate soils conditions at the test locations up to a depth of 2.5 m;*
- *the results for pHFOX are not indicative of potential acid sulphate soil conditions at the test locations up to a depth of 2.5 m with the exception of one sample collected from TP1 at a depth of 2.0 m. Subsequent laboratory testing suggest the low pHFOX is a false positive results and not indicative of potential acid sulphate soils; and*
- *the calculated net acidities are below the adopted action criterion of 0.03% S for all samples with the exception of one sample collected from TP7 at a depth of 2.0 m which reported a net acidityof 0.036% S.*

It should be noted that the single exceedence of the action criterion is attributed to a higher result reported for the titratable actual acidity (TAA) component of net acidity, which is a measure of the soils existing acidity. It should also be noted that the corresponding results for SPOS results was reported as less than the laboratory limit of reporting, indicating the general absence of peroxide oxidisable sulphur. Furthermore, given the absence of sulphidic material, the pH of the soil is not expected to decrease as a result of sulphide oxidation, following disturbance. Given the apparent absence of sulphidic material in the samples analysed, it is expected that the higher results for 'existing acidity' are attributed to metal complexes, and are not necessarily representative of actual acid sulphate soil conditions. This is further supported by the SkCl results which were all reported <0.03% S indicating no appreciable soluble sulphur.

In this regard, DP considers the single exceedence of the action criterion associated with an elevated TAA result to be of low significance. Provided excavations are less than 2.5 m depth and dewatering is not required, DP considers that management of acid sulphate soils is not warranted.

It should be noted, however, that the investigation was a preliminary investigation that was undertaken to provide preliminary advice on the presence or otherwise of acid sulphate soils. In this regard, should a development condition requiring 'clearance' by DoWER be imposed, we anticipate that the DoWER would require further detailed investigation to meet endorsed guidelines. "Douglas Partners, Lot 34 Third St, Harvey Report on Geotechnical Investigation, October 2016.

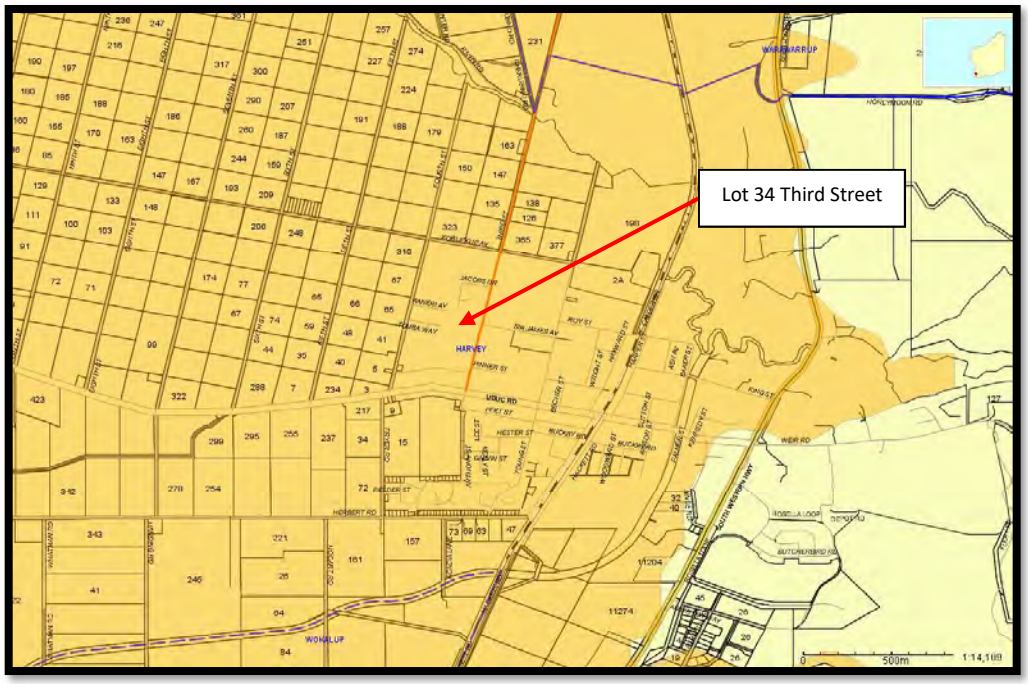

Figure 5
Acid Sulphate Soil Mapping Source: landgate.wa.gov.au (WA Atlas)

3.2.3 Soil Types

Further to the preliminary ASS investigation completed, Douglas Partners undertook a geotechnical investigation across the site on the 21st September 2016. The complete Douglas Partners geotechnical investigation is included within this strategy as Attachment 2, however extracts of their report and their summary of subsurface conditions is as follows: *"The Harvey Lake Preston 1:50,000 Urban Geology sheet indicates that shallow sub surface conditions beneath the site consist of Guildford Formation, described as alluvial sandy clays"* (*Douglas Partners, October, 2016*).

The Douglas Partners geotechnical survey, states *"that the observed ground conditions beneath the site generally comprise topsoil, organic clayey silt, sandy silty clay and slightly clayey silty sand*."

3.2.3a Field Work

"Field work was carried out on 21 September 2016 and comprised a site walk over, the excavation of eight test pits, DCP tests adjacent to each test pit, and in-situ permeability testing at two locations."

3.2.3b Ground Conditions

"The observed ground conditions beneath the site generally comprise:

- *Topsoil – dark grey brown, organic sandy silty topsoil with some silt but generally slightly silty, and with some clay in areas, encountered from the surface to depths of up to 0.3 m at all test locations at all test locations except TP6. The topsoil was filling at TP4, having been placed over sand and crushed limestone filling (see below), but was the same material as the topsoil encountered elsewhere on the site.*
- *Organic Clayey Silt – firm, brown-black, low to medium plasticity organic clayey silt, encountered underlying topsoil to depths between approximately 0.6 m and 1.0 m underlying the northern part of the site at TP1 to TP3.*
- *Sandy Silty Clay – firm becoming stiff with depth, dark orange-brown, low to medium plasticity sandy silty clay, encountered underlying the organic clayey silt to depths of between 1.1 m and the extent of the investigation at a depth of 2.0 m at TP1 to TP3, and underlying the topsoil to the extent of the investigation at depths up to 2.6 m at TP5 to TP8. The sand fraction is fine to medium grained.*
- *Slightly Clayey Silty Sand – brown, fine to medium grained slightly clayey silty sand encountered underlying the sandy silty clay to the extent of the investigation at TP1 and TP2 on the northern boundary of the site. The fines fraction was low plasticity.*

The following additional soils were observed:

- *Filling (sand and crushed limestone) – dense yellow brown, fine to medium grained sand filling, with a trace of silt and yellow-white, fine to coarse sized slightly silty sandy crushed limestone gravel, encountered underlying topsoil to a depth of 0.6 m at BH4.*
- *Filling (sandy silty clay) – soft to firm, dark orange-brown, low to medium plasticity sandy silty clay filling, with fragments of plastic piping encountered from the surface to a depth of approximately 0.4 m at TP6. The sand fraction is medium grained.*
- *Sandy Clayey Silt – dark blue-black, low to medium plasticity sandy clayey silt, encountered underlying the filling to the extent of the investigation at TP4. The sand fraction was fine to medium grained*."

3.2.3c Site Suitability

"From a geotechnical standpoint, the land is considered physically capable of development for the proposed residential subdivision, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration, recommendations are implemented and subject to the following geotechnical constraints:

- *the northern part of the site is subject to flooding during wet periods, as observed during the field work, and therefore surface levels will need to be raised and the requirement for subsoil drainage should be considered;*
- *the site is currently classified Class 'M' in accordance with AS2870-2011, and a pad of nonreactive filling will be required to achieve a classification of Class 'S'. Due to the potential for some ongoing consolidation settlement following filling of the site, it is recommended that footings designed to Class 'A' are not used on this site.*
- *the encountered topsoil is organic, and this is underlain by organic clayey silt across the northern part of the site. Laboratory tests undertaken on samples of these materials produced results of 13.4% organic content for the topsoil and 11.4% organic content for the underlying organic clayey silt. These organic materials are considered to form unsuitable foundation materials and it is recommended that they are removed and replaced with engineering fill. Dewatering may be required if this is done in the winter period. Alternatively, it is considered that, following stripping of the topsoil, the organic clayey silt could be left in situ provided that footings be designed for a Class 'M' site, even after sand filling, to accommodate possible additional movement due to the decomposition of the organic material (and consequent settlement) during the life span of the proposed housing;*
- *shallow perched groundwater was encountered across the site. This, together with the clayey nature of the soils underlying the site, presents some limitation on the use of soakwells for stormwater disposal. Dewatering for excavations existing ground level is anticipated to be required, in particular during the wet period of the year*."

3.2.3d Site Classification

"The site classification is based on the anticipated soil movement due to the shrinking and swelling of the reactive soils following seasonal wetting and drying. For a given site, the main factors that determine this movement are:

- *the reactivity of the soils; and*
- *the depth affected by soil moisture change from the impact of the climate."*

"Following AS 2870-2011, a design suction depth (i.e. the depth to which the climate impacts soil moisture) of 1.5 m is considered appropriate for soils not influenced by trees in the Harvey area. Trees are considered to increase the design suction depth (and hence increase surface movement). It is estimated that at this particular site, trees could increase the natural surface movement by up to 10 mm and therefore, it is recommended that a specific assessment is undertaken at proposed building envelopes if it is proposed for trees to remain within 1.5 times the tree's mature height of that location.

To provide an indication of the reactive surface movements of the natural soil profile, the results of a shrink swell test and correlations with Atterberg limits, were used to estimate the site classification in general accordance with AS 2870-2011. The results indicate a site classification of Class 'M'."

"A depth of 0.8 m of non-reactive filling is required to achieve an equivalent site classification of Class 'S', assuming the organic materials underlying the northern part of the site are removed. Characteristic surface movement with 0.8 m of non-reactive filling above the sandy silty clay in situ soil is estimated to be approximately 10 mm."

Douglas Partners October 2016

3.2.4 Contamination

A review of the WA Atlas into potential contamination of land noted in January 2017 that the development site is not recorded as contaminated land. No visual evidence exists on the property of illegal dumping or potential areas of contamination, however the site has been utilised for storage (including vehicles) therefore a review of the stripped and demolished surface should be undertaken during construction activities.

3.2.5 Topography

The structure plan area is best described as relatively flat with levels ranging from RL 34 metres AHD to RL 34.5 metres AHD. A copy of the feature survey plan is included below, as Figure 6 and included in A3 size as Attachment 3.

Figure 6
Topography Source: BCE Surveyors

3.3 SURFACE WATER HYDROLOGY

A visual representation of the sites surface water hydrology is included below as a series of photographs taken of the site in August 2016, following and during a rain event.

Figure 7
Property Picture (looking east, from site towards Third Street)
Note: shallow swale to southern boundary Source: Craig Pippin, 10th Aug 2016

Figure 8
Property Picture (looking north along eastern boundary)
Note: Drain to east boundary and sitting water in drain and adjoining Lot 5
Source: Craig Pippin, 10th August 2016

Figure 9
Property Picture (looking north at the northern end of existing drain to east boundary)
Note: Defined drain and trees. Source: Craig Pippin, 16th August 2016

Figure 10
Property Picture (surface water ponding in northern portion of site)
Source: Craig Pippin, 16th August 2016

Figure 11
Property Picture (looking west along northern boundary)
Note: Existing Drainage basin to north and existing grated pits
Source: Craig Pippin, 16th August 2016

Figure 12
Property Picture (looking south east from the existing end of Raneri Ave)
Source: Craig Pippin, 16th August 2016

3.3.1 *Wetlands*

The WA Atlas contains the DEC record of Geomorphic Wetlands of the Swan Coastal Plan. A review of the database indicates that the site and entire town of Harvey is recorded as a Multiple Use Wetland (Palusplain). Multiple Use classification does not place a restriction upon development of the site.

3.3.2 *Surface Water Bodies*

The development site does not contain any surface water storage bodies such as lakes, dams or areas of permanently standing water. It does however contain several areas of seasonal inundation as can be seen from the pictures included in this section, taken in August 2016.

It is considered that these areas are perched surface water following and during rain events, which will be removed with the development and the implementation of sand fill and subsoil network.

3.3.3 *Streams, Creeks and Surface Water Flow Paths*

The development site itself is not definitively characterised by surface water flow paths due to its relatively flat surface profile. However, it does contain a partial swale to the southern boundary and a defined drain to its eastern property boundary. This swale and drain are identified on Figure 13 below, being the Predevelopment Stormwater Plan. An A3 sized copy of this Figure is included as Attachment 4.

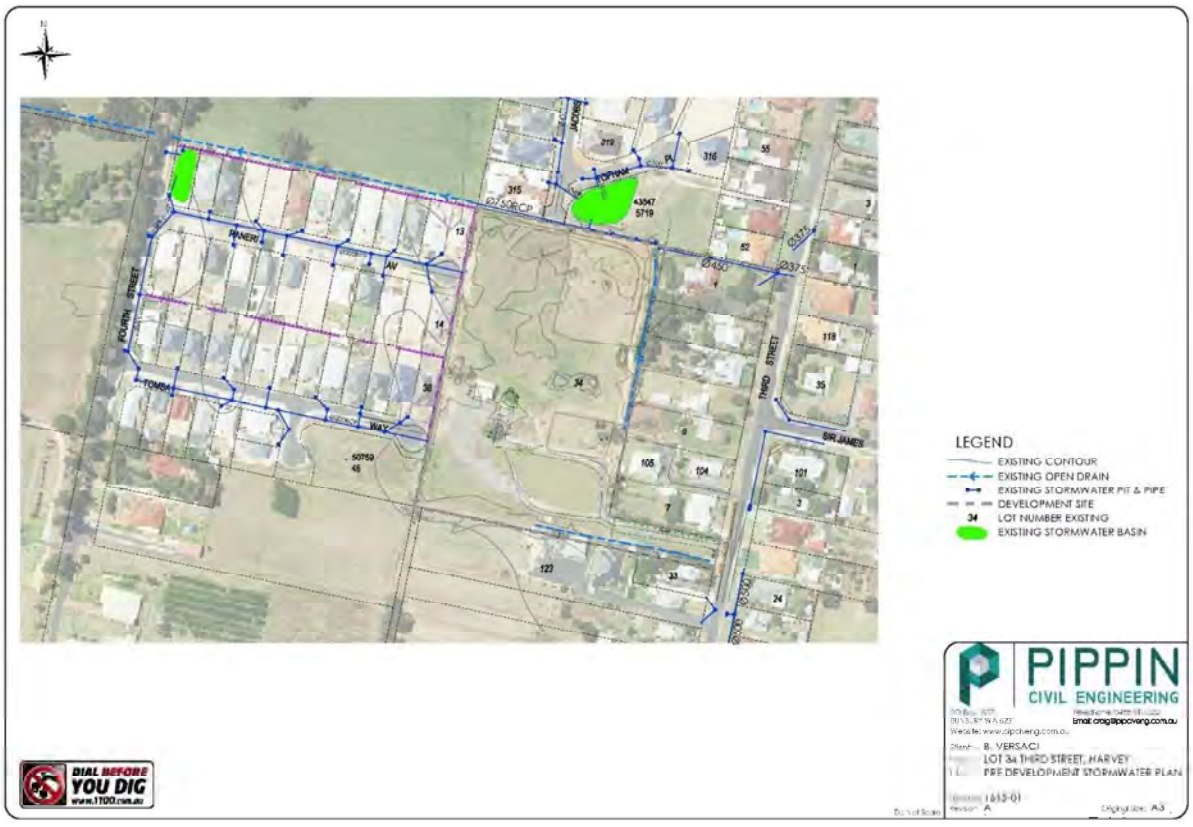

Figure 13
Predevelopment Stormwater Plan

The eastern boundary drain, based upon the feature survey and site inspection, drains in a northerly direction, discharging into the 600 diameter concrete pipe that is located across the northern boundary. The existing 600 RCP drains in westerly direction, into a 750mm diameter RCP that enters an existing open drain to the north west of the site. This drain was advised by Harvey Water to be the Government Rd North B drain and under Water Corporation management, however subsequent advice from the Water Corporation has indicated that this drain is under the control of the Shire of Harvey.

Contact was made with the Water Corporation via a Planning submission on the 9th September 2016. Initial verbal advice only from the Water Corporation was that they would not provide any planning advice as they wanted a Structure Plan created for the entire eastern portion of the Harvey townsite. Subsequent to lodgement of the

Structure Plan, the Water Corporation made comment directly to the WAPC advising "it was satisfied with calculations of inflows into its network," and "its drainage system commences at the culvert under Fourth Street and includes the open drain running to the west of this road."

The 600mm and 750mm diameter pipework to the north of Lot 34 was installed by the existing residential development to the north and provides an outlet for that developments drainage basin as well as a drainage connection to the Shire of Harvey's drainage network from Third St.

The southern boundary drain appears to drain in an easterly direction towards Third St. This is based upon visual inspection only as no outlet pit was located on the feature survey and the drain does not visually include a connection to the west.

Further feature survey was undertaken in July 2019 by BCE Surveying, to locate and identify the stormwater pit and pipe network within Third St. This additional information is shown in the above Figure 13 and identifies the pipe size and southerly direction of flow for stormwater in Third St.

Stormwater drainage pipework has also been installed to the property boundary as part of the existing residential development to the west of Lot 34. The location, size and grade of this pipework was confirmed by the Shire of Harvey providing design plans (refer Attachment 5) for the development and partial survey pick up.

3.4 GROUNDWATER HYDROLOGY

The geotechnical investigation completed by Douglas Partners undertook the excavation of multiple test holes across the site that recorded groundwater depth for geotechnical purposes.

The geotechnical investigation was completed on the 21st September 2016. The investigation included the excavation of 8 test pits across the entire site, of which all but 1 pit noted groundwater seepage. A plan of the test pits locations is included on the Predevelopment Groundwater Plan as included below as Figure 14 and within Attachment 6.

As can be noted from the Predevelopment Groundwater Plan the existing groundwater surface profile varies from 0.6m to in excess of 2.0m deep, however surface water ponding occurs in several areas across the development site and covers an extensive area along the northern boundary.

Figure 14
Predevelopment Groundwater Plan

The Douglas Partners geotechnical investigation reports notes the following in relation to groundwater;

"Perched groundwater was encountered at seven test pit locations. Table 1 below summarises the groundwater observations made on 21 September 2016. All test pits were backfilled following sampling, which precluded longer-term monitoring of groundwater levels.

Test Location	Surface Level (m AHD)	Depth to Groundwater (m)	Groundwater Level (m AHD)	Groundwater Comments
TP1	33.5	0.6	32.9	High inflow of perched groundwater.
TP2	33.5	2.5	31	High inflow of perched groundwater.
TP3	34	0.4	33.6	High inflow of perched groundwater.
TP4	34	0.6	33.4	High inflow of perched groundwater.
TP5	34	0.6	33.4	High inflow of perched groundwater.
TP7	34	0.6	33.4	High inflow of perched groundwater.
TP8	34	1	33	High inflow of perched groundwater.

Table 1: Summary of Groundwater Observations

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time."

"*In addition to trees, excess moisture can increase the natural ground surface movements and should be avoided where possible. Abnormal soil moisture conditions are defined in AS 2870, and in summary comprise:*

- *removal of buildings or structures prior to development which is likely to have affected soil moisture conditions;*
- *unusual moisture caused by drains, channels, ponds, dams or tanks;*
- *recent removal of large trees;*
- *excessive or irregular watering of gardens adjacent to the structure;*
- *lack of maintenance of site drainage; and*
- *failure to repair plumbing leaks.*

For further advice on protecting structures overlying clayey soils, reference should be made to the CSIRO note, entitled 'Foundation Maintenance and Footing Performance: A Homeowner's Guide', which is attached in Appendix E of this report."

4.0 WATER SUSTAINABILITY INITATIVES

4.1 WATER SUPPLY

A requirement for development will be the connection of the proposed lots to the Water Corporation's existing reticulated water supply scheme for the local Harvey area.

Rainwater tanks installed at building development stages, as a non-potable source is an obvious choice for minimisation of reticulated water importation and in addition can assist in the reduction of stormwater exiting the development.

Water use within each of the proposed lots will be at the discretion of the lot purchaser, however education will be provided to encourage lot purchasers in the implementation of water wise practises (e.g. water efficient taps, showers, toilets and appliances).

4.2 WATER WISE GARDENS

Lot scale water efficiency can be enhanced through the implementation of water wise gardens. The Water Corporation and Department of Water both provide information on the establishment and maintenance of water wise gardens with this information actively promoted to lot purchasers.

The following water wise principles can be implemented in areas of the development:

- Restriction of seeded turf areas.
- Test and improve the LOS soil with an Australian Standard Soil Conditioner, if required.
- Utilise subsoil irrigation where appropriate.
- Installation of locally sourced wood/bark mulch to a thickness of at least 75mm.
- Installation of native vegetation endemic to the area.

4.3 RAINGARDENS

The detention of stormwater within the lots will be a requirement of this development and the Shire of Harveys standard guidelines. It can occur through the implementation of controlled outflow pits with suitably sized on-site detention, which is generally implemented by subsurface storage or concrete pits. The use of private raingardens can also provide the on-site detention and controlled outflow in addition to providing treatment of stormwater at source.

A raingarden collects and filters stormwater run-off from impervious surfaces within the lot, including the home, driveway and paved areas. It is a vegetated area that is constructed with a detention volume and an amended soil profile to remove litter and excess nutrients from entering downstream stormwater systems and ultimately our waterways.

Private raingarden at Evermore Heights, photo courtesy of Department of Water and Environmental Regulation

4.4 WASTEWATER

Wastewater will be collected and transferred offsite by a network of developer funded, Water Corporation sewerage reticulation, transferring the sewer effluent to the Harvey wastewater treatment plant.

5.0 STORMWATER MANAGEMENT STRATEGY

The stormwater management strategy for the development of Lot 34 Third Street, Harvey is to be undertaken in accordance with the guidelines of the Department of Water and Environmental Regulation through the Better Urban Water Management framework and the requirements of the Shire of Harvey.

The key components of the stormwater management strategy are;

- Residential building development on the proposed lots to connect directly to the stormwater pipework of the road network via controlled outlet pit/raingarden installed within the private property.
- Stormwater treatment by retention of the first 15mm from the impervious road reserve area of each storm event within biofiltration basins, swales or gardens.
- Collection and transfer of storm events up to the 20% AEP from the development area within a stormwater drainage pit and pipe system.
- Detention of events upto the 20% AEP major storm within end of development catchment basin or swale with a controlled outflow rate set at the lesser of the pre-development peak flow rate or the maximum flow rate permitted under the Water Corporation drainage guidelines.
- Protection of existing Third St lots adjoining the properties eastern boundary and replacement of an existing surface water drain with a pit and pipe network to the rear of the existing properties and connecting it to the existing Shire stormwater network in Third St.
- Conveyance of events upto the 1.0% AEP storm event through the road network and surface water flows paths to existing outlet points associated with the land.
- Detention of events upto the 1.0% AEP extreme storm event for the development catchment, within end of development catchment basin or swale with a controlled outflow rate set at the lesser of the pre-development peak flow rate or the maximum flow rate permitted under the Water Corporation drainage guidelines.

5.1 MODELLING

The stormwater modelling has been completed utilising the Rational Method, based on the relatively small scale of the development area. The development site exists as an undefined catchment given the relatively flat nature of the existing site and is modelled post development as three catchments, based upon the existing and possible points of outlet via open drains and stormwater drainage infrastructure.

A critical design criterion for the rational method includes the runoff coefficients which are shown below in Table 2.

LAND USE	RUN OFF COEFFICIENT		
	Environmental	20% AEP	1.0% AEP
Residential <R30	0	0.7	0.75
Road Reserve	0.8	0.8	0.8
POS	0	0.5	0.6
Drainage Basin	0	0.9	0.9

Table 2
Runoff Coefficients

Multiple storm events have been modelled utilising the Rational Method as described in Australian Rainfall and Runoff (AR & R). Predevelopment peak outflow rates have been calculated based upon estimated 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 2016 IFD Data System (www.bom.gov.au).

Based upon the ground conditions encountered by the geotechnical investigation only a nominal soakage of 0.85m/day has been included for drainage basin areas only, as recommended by Douglas Partners.

5.2 LOT LEVEL STORMWATER MANAGEMENT

All lots proposed within the development will be R20 residential zoning.

In relation to the use of soakwells for the collection and disposal of stormwater generated by future building construction, the Douglas Partners Geotechnical Investigation states "*In-situ permeability testing undertaken using the constant head method in accordance with AS 1547:2012 within the firm to stiff sandy silty clay at TP7 and TP8 indicated permeability values of 1.1x 10-5 m/s (0.95 m/day) and 1.3 x 10-5 m/s (1.0 m/day) respectively. It is recommended that design permeability values of 1.0 x 10-5 m/s (0.85 m/day) is adopted for clayey material at the site. Stormwater disposal using infiltration via soakwells and sumps is considered to be unsuitable in the clayey materials encountered underlying the site due to low permeability and shallow groundwater*."

Therefore, the development does not propose that future building construction will include the use of soakwells for each home/building. It is proposed that each home site is provided with a stormwater pit/pipework connection to the proposed stormwater pit and pipe network within the road reserve. The Shire of Harvey already permits the use of piped connections to their stormwater assets within the road reserves for the Harvey townsite. The Shire utilise Engineering Information Sheet ES1 – Stormwater Management for Residential Properties, a copy of which is included within this document as Attachment 7. The information sheet permits the homes within the Harvey townsite to discharge their stormwater into the drainage network subject to the home construction including stormwater detention at a rate of 1m^3 per 100m^2 of impervious area. Future connection to the pit will be a requirement of the home construction.

Future residents will be encouraged to install rainwater tanks associated with their building development, enabling the lot pipe connection to be utilised only for overflow from the rainwater tank.

Residents can determine the most appropriate method of stormwater detention on their lot through the implementation of subsurface storage devices, such as concrete pits or the use of surface storage and treatment devices such as raingardens. The use of private raingardens would be encouraged as it can provide the on-site detention and controlled outflow in addition to providing treatment of stormwater at source.

A raingarden collects and filters stormwater run-off from impervious surfaces within the lot, including the home, driveway and paved areas. It is a vegetated area that is constructed with a detention volume and an amended soil profile to remove litter and excess nutrients from entering downstream stormwater systems and ultimately our waterways.

The various storm events for the proposed development and the subsequent drainage detention basin sizes, have been modelled based upon the Shire of Harvey enforcing the requirements of ES1 on new home construction. The storage to be provided by each future home is based on an estimated 350m^2 of impervious area (roof, shed, alfresco area, paving and driveway) per new lot which equates to 3.5m^3 of detention storage.

This development proposes to construct the connections from each lot to what will become the Shire's pit and pipe network within the road reserve, as part of the subdivision process. In addition, due to the removal of the existing open swale to the eastern property boundary the development proposes to install a lot connection pit in the rear of the existing lots fronting Third St. This will ensure that the drainage catchment that currently connects to this open drain remains the same in the post development strategy, as the drain will be filled in with development. An indicative plan for a shared property connection 'silt trap' pit for two lots, is shown below as Figure 15.

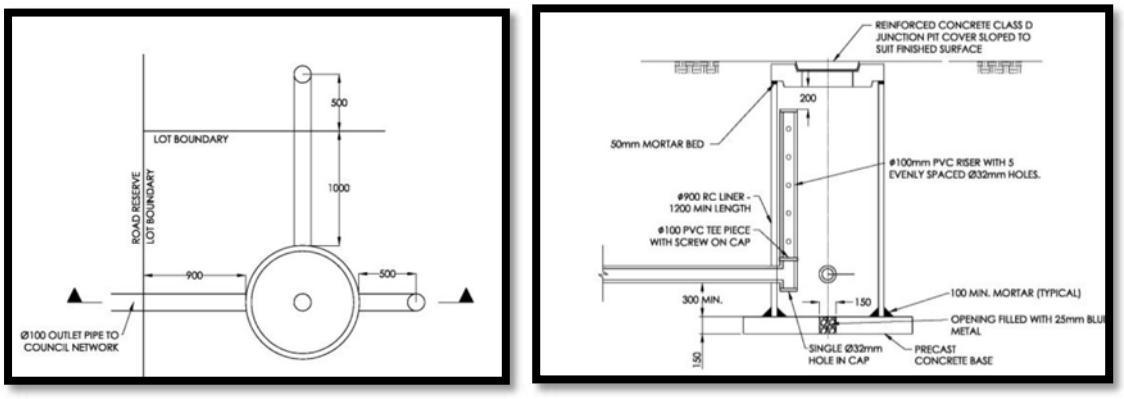

Figure 15 Lot Connection Pit – Plan and Cross Section

5.3 ENVIRONMENTAL STORM EVENT (First 15mm)

In accordance with the guidelines as provided by DoWER the development will undertake the retention of the first 15mm of each storm event within the development. The exception to this will be those lots and the road reserve for the western portion of the development connecting to the Raneri Ave and Tomba Way, which will discharge into an increased capacity, vegetated existing Fourth St/Raneri Ave basin.

The development proposes to retain the first 15mm within a bioretention basins to be located within the POS area to the north and a bioretention swale located within the southern roadside verge of the new road link to Third St. The western portion of the development will be connected to the Shire's existing stormwater pipe network that outlets to an existing vegetated basin at the corner of Fourth St and Raneri Ave.

Treatment of stormwater generated by the first 15mm of storm event will occur through the implementation of vegetated bioretention areas within the end of catchment basin/swale.

The environmental flow stormwater strategy is included in Attachment 8 and shown below as Figure 16.

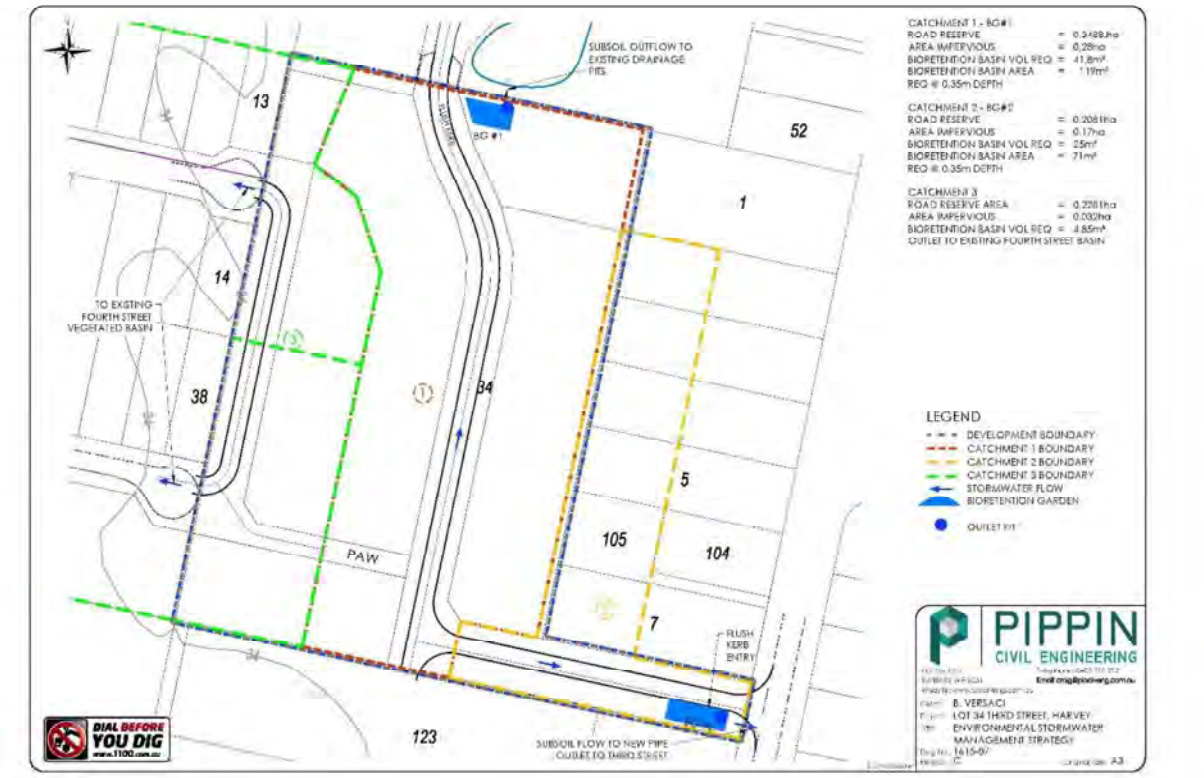

Figure 16
Environmental Stormwater Strategy

A summary of the storage volumes and treatment areas required for the environmental flow are defined in table 3, below.

	TREATMENT AREA	RETENTION VOLUME
Catchment 1	119 m^2	41.8 m^3
Catchment 2	71 m^2	25 m^3
Catchment 3	Existing	Existing

Table 3
Environmental Treatment Requirements

The two bioretention areas will be provided with a low flow subsoil outlet (to prevent extended periods of standing water), amended soil base and vegetated with suitable, locally sourced nutrient stripping vegetation in accordance with the Stormwater Biofiltration system, Adaption Guidelines by FAWB and the vegetation guidelines for biofilters in the South West of WA. The indicative cross-sectional details of the bioretention garden retention volume and subsoil outlet is shown below as Figure 17.

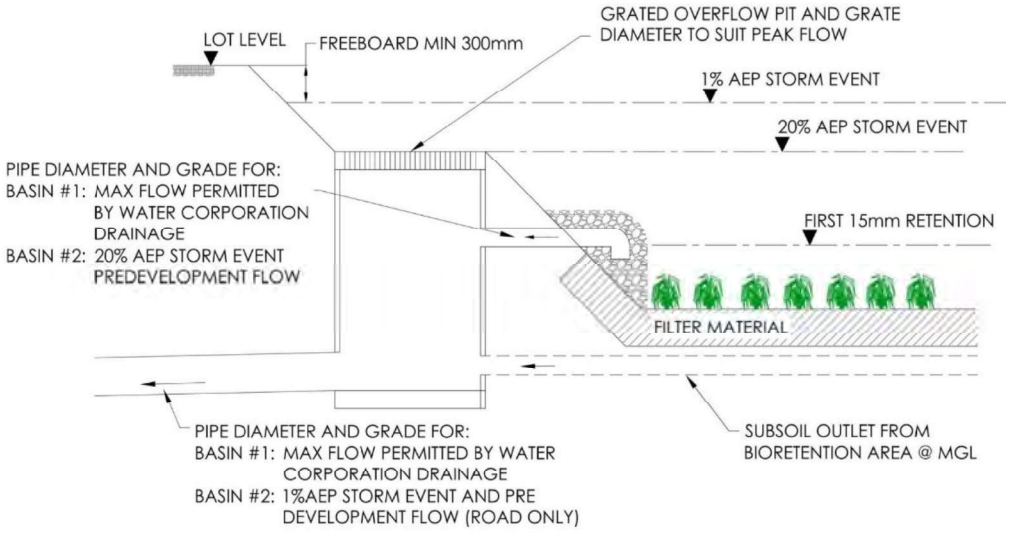

Figure 17
Indicative bioretention cross section

As noted in the detail above, each of the gardens will be provided with a raised grated pit that will permit basin overflow for the larger storm events.

The end of catchment 1 bioretention garden will form part of the larger stormwater detention basin. The indicative cross section of the end of catchment 1 basin is shown below as Figure 18.

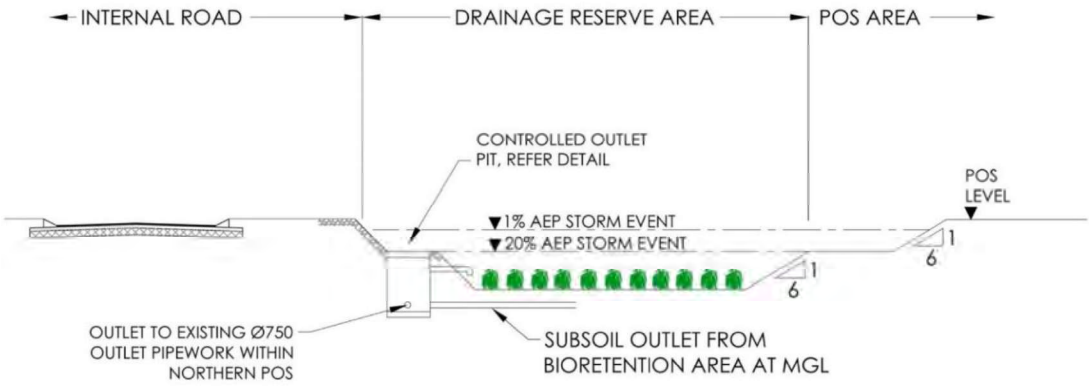

Figure 18

Detailed design at the UWMP stage will resolve the exact dimensions and locations for the basins, based upon detailed feature survey at each basin location. This will allow the basins to blend into the proposed POS, the existing POS/Drainage to the north and verge areas rather than being constructed in the indicative/standard shape shown on the strategy. The areas allocated and shown on the Figure 16, are true to scale indicating sufficient POS or verge area exists within the proposed Structure Plan. The areas shown are those for basin storage at the top water level.

The basin areas, inclusive of top water surface area and all associated batters will be contained within the POS and/or road reserves for future management by the Shire of Harvey.

Table 4 below provides a summary of the expected pollutant removal efficiencies for the proposed environmental flow WSUD options, as provided by the DoW's Stormwater Management Manual for WA.

Parameter	Design Criteria via BUWM	Structural Controls Nutrient Output Reduction	
		Vegetated Swales/Bioretention Systems	Detention/Retention Storages
Total Suspended Solids	80%	60-80%	65-99%
Total Phosphorus	60%	30-50%	40-80%
Total Nitrogen	45%	25-40%	50-70%
Gross Pollutants	70%	-	>90%

Table 4
BMP Water Quality Performance in Relation to Design Criteria (source: DoWER)

Figure 19
Indicative Verge Biofiltration Garden

5.4 LARGE STORM EVENT (20% AEP)

The development proposes a network of stormwater collection pits and pipework for the collection of stormwater generated by the proposed residential development and road network. This proposed network will manage storm events up to and including the 20% AEP for the development area, in addition to providing a stormwater connection to the rear of the existing Third St residences adjoining the eastern boundary of the property.

The detailed design of the pit and pipe network will form part of the UWMP condition of subdivision development however a conceptual design, including catchments and detention basin/swales is shown as Figure 20 below and in more detail within Attachment 9.

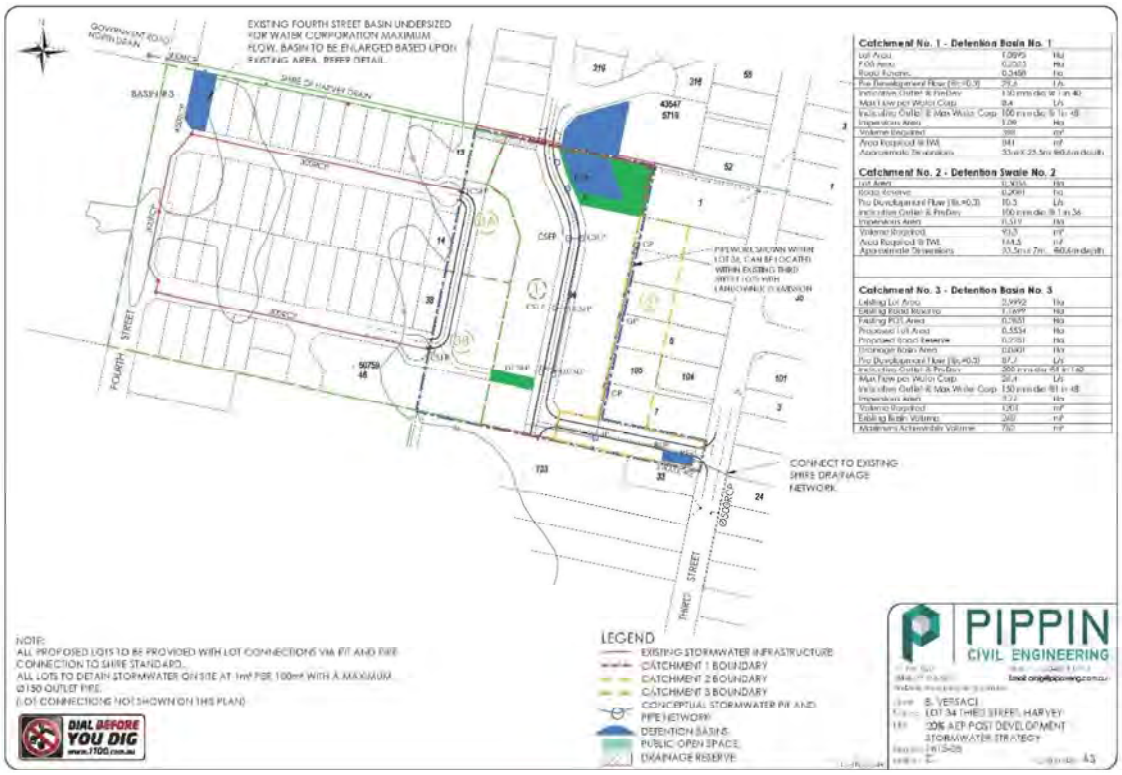

Figure 20
Large Storm – 20% AEP Stormwater Strategy

The strategy consists of three catchments and three end of catchment detention basins/swales. Catchment 1, being the central development catchment, will be serviced by an end of catchment detention basin located within the proposed northern POS area. Catchment 2 will be serviced with a verge detention swale located in the southern verge of the new road link to Third St. Catchment 3 will interconnect with the existing Shire drainage network of Raneri and Tomba Way and proposes to extend the volume of the existing Fourth St drainage basin. The detention swale and basin to be constructed will include a controlled outlet restricting outflow from the basin/swale to a pre-development rate or maximum rate permissible by Water Corporation guidelines.

Both catchment 1 and 3 discharge eventually into the Government Rd North drain (west of Fourth St), which is currently under the control of the Water Corporation and its drainage guidelines. Based upon, the Water Corporation rural drainage requirements the capacity of this drain is limited by inflow at a maximum rate of 5.0m^3/s per 1000 hectares. This significantly reduces the peak outflow from accepted pre-development flow calculations, as can be seen in the table included on Figure 20 above. For both the 20% and 1.0% AEP storm event outflows from the development, the peak outflow was determined by the lesser of the pre-development peak flow rate or the maximum flow rate permitted under the Water Corporation rural drainage guidelines.

The detention volumes and the associated surface areas for catchment 1 and 3 have been estimated for the purposes of the Structure Plan and subsequently based upon the very restricted outflow permitted under the Water Corporation drainage guidelines. The detention volume and the associated surface areas for catchment 2 has been estimated based upon the predevelopment peak flow. An indicative cross section of the detention basin was previously included as figures 17 and 18. An indicative cross section of the catchment 2 roadside swale treatment and detention swale is shown below as figure 21.

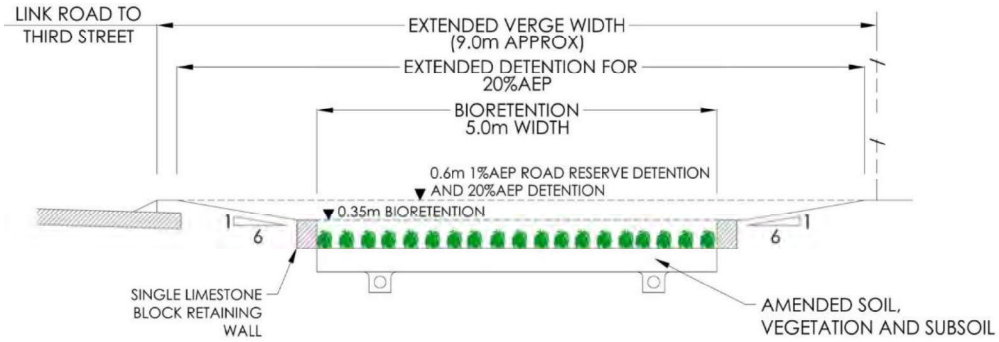

Figure 21
Cross section Catchment 2 Roadside Swale

Based upon the restricted outflow permitted under the Water Corporation drainage guidelines for catchment 3, the existing Fourth St/Raneri Ave drainage basin is undersized for the existing catchment, without adding in a small number of lots associated with the development of Lot 34. It is intended that the development of Lot 34 would undertake to enlarge the existing Fourth St/Raneri Ave drainage basin to the largest storage volume possible within the confines of the existing drainage basin site. An indicative cross section is shown below as Figure 22 showing how the basin is proposed to be expanded. Detailed design will confirm the exact dimensions of the extended storage volume and feature survey will confirm the design base and the existing storage volume, however it is anticipated that the volume of the basin can be extended from approximately 260m^3 to 780m^3. Noting that approximately 1201m^3 is required under the Water Corporation restricted outflow.

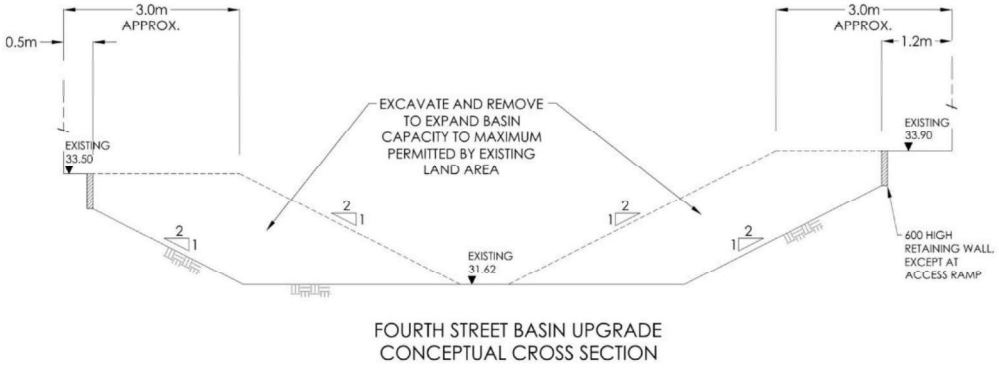

Figure 22

A summary of the predevelopment flow rates, approximate controlled outlet sizes, required detention storage volumes and indicative basin areas are summarised in table 5, below.

	PREDEVELOPMENT OUTFLOW RATE	REQUIRED DETENTION VOLUME	REQUIRED LAND AREA FOR TWL
Catchment 1	0.0084 m^3/s	398 m^3	841m^2
Catchment 2	0.0105 m^3/s	93.3 m^3	165 m^2
Catchment 3	0.0264 m^3/s	1201 m^3 (Only 780m^3 provided)	Existing Basin Site

Table 5
Large Storm – 20% AEP Stormwater Requirements

*** It is noted that the detention volume shown in Table 5 is based upon the development site only and assumes the Shire of Harvey enforce future home builders to detain stormwater at a rate of 1m^3/100m^2 of impervious home area.

Detailed design at UWMP stage will resolve with exact dimensions and locations for the basins, based upon detailed feature survey at each basin location, in order that the basins can blend into the POS area rather than being constructed to look like a standard drainage basin. The catchment 1 detention basin and catchment 2 detention swale would not be designed to remain permanently inundated with a controlled outlet providing an outflow via the outlet pipework and a network of subsoil pipes beneath the basin, ensuring the basin will drain over several days.

The basin areas, inclusive of top water surface area and all associated batters will be contained within the POS or road reserves for future management by the Shire of Harvey.

5.5 MAJOR FLOWS (1.0% AEP)

The development will include three road reserves. It is intended to utilise the road reserves, in particular the road pavement (as contained within the kerbs), to convey the major 1.0% AEP storm event as generated by the development area and catchment, to the proposed detention basin/swale. Catchment 1 and 2 will grade to the proposed POS detention area and roadside swale, respectively. Catchment 3 will utilise the existing road pavement of Raneri Ave and Tomba Way to convey the storm event westwards to Fourth St.

The detailed design of the road pavement grades will occur as part of the UWMP stage of development and will include detailed earthwork designs indicating the minimum clearance of building floor levels being 0.3m above estimated 1.0% AEP water levels (TWL) of the road network and detention basin/swale.

The detailed design of the conveyance and detention of the extreme 1.0% AEP storm event will also form part of UWMP stage of development however an indicative design, including catchments, conceptual TWL's, conceptual lot earthwork levels and detention basin sizing is shown on Figure 23 below and in more detail within Attachment 10.

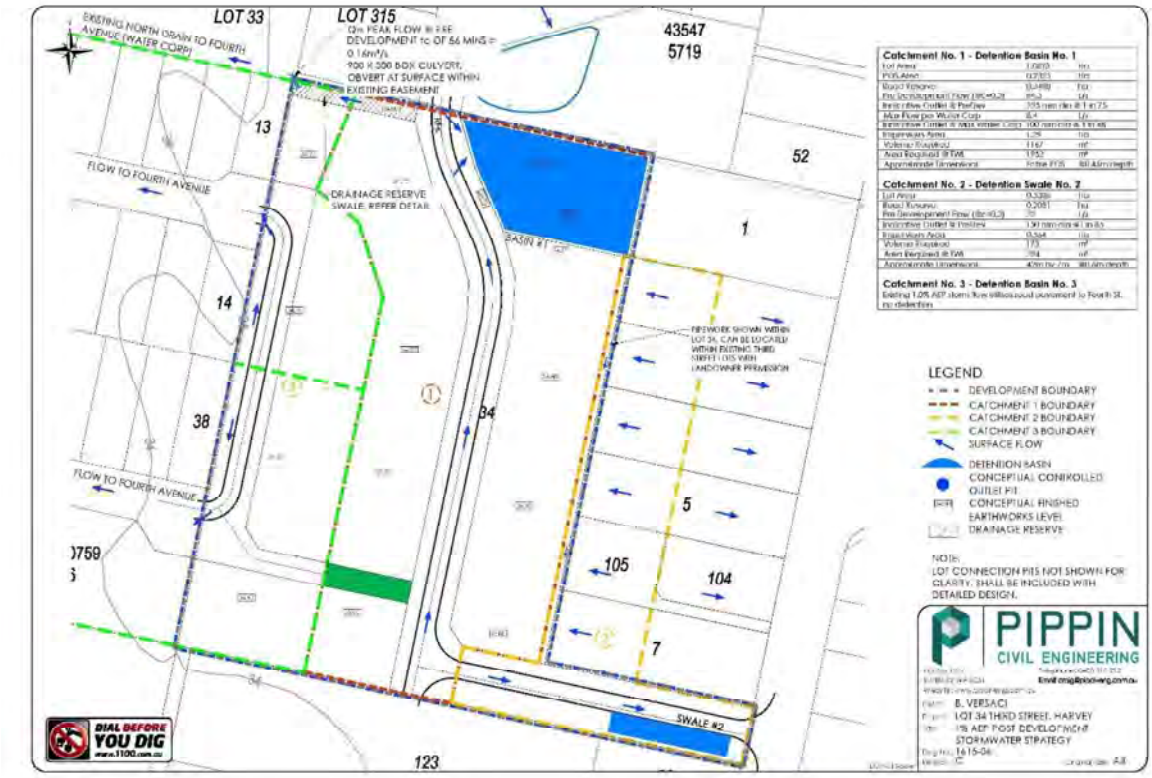

Figure 23
Major Storm – 1.0% AEP Stormwater Strategy

As noted on Figure 23 the area for catchment 1 and 3 remains consistent across the 20% and 1.0% AEP storm events, however catchment 2 is reduced in the 1.0% AEP storm event, as during an event of this scale surface stormwater would not utilise the proposed pipe link but would need to exit the properties via the Third St frontage, as surface water would not be able to flow through the existing side boundary fences.

An indicative cross section of the proposed detention basin was previously included as Figure 18 and an indicative cross section of the roadside swale was previously included as Figure 22. Entry to both the basin and roadside swale from the road pavement would be via flush kerbing.

The detention basin and roadside swale will include the construction of a controlled outlet, restricting outflow from the basin to the predevelopment rate. The detention volume and surface area of the POS detention basin (catchment 1) have been calculated based upon the maximum outflow rate permissible by Water Corporation guidelines, not the calculated pre-development peak flow rate. This is described at section 5.4 above. The detention volume and surface area of the roadside swale has been calculated based upon the predevelopment peak flow of

the road reserve area. The land area for the detention basins have been indicatively defined based upon the top water level area, plus the batter slopes of the basin freeboard. These dimensions are highlighted in Figure 21 above.

It is intended that the area required for stormwater drainage, within the POS area is defined as the 20% AEP storm event, that is likely to occur at a greater regularity than the 1.0% chance of a major storm event occurring and creating inundation of the POS.

A summary of the predevelopment flow rates, detention storage volumes and indicative basin sizes are defined in table 6, below.

	PREDEVELOPMENT OUTFLOW RATE	REQUIRED DETENTION VOLUME	REQUIRED LAND AREA FOR BASIN
Catchment 1	0.0084 m^3/s	1167 m^3	1952 m^2
Catchment 2	0.022 m^3/s	173 m^3	294 m^2

Table 6
Major Storm Event – 1.0% AEP Stormwater Requirements

*** It should be noted that the detention volume shown in Table 6 is based upon the development site only and assumes future home builders are required to detain stormwater at a rate of $1m^3/100m^2$ of impervious area.

Detailed design at the UWMP stage will resolve with exact dimensions and locations for the basins, based upon detailed feature survey at each basin location, in order that the basins can blend into the POS areas rather than being constructed to look like a standard drainage basin.

The detention basin would not be designed to remain permanently inundated with a controlled outlet providing an outflow to the existing pit network within the northern POS via the overflow outlet and a network of subsoil pipes beneath the basin, ensuring the basin will drain over several days.

The basin/swale areas, inclusive of top water surface area and all associated batters will be contained within the POS and road reserves for future management by the Shire of Harvey.

Given that the Lot 34 development proposes to drain the majority of its stormwater northwards into the POS/Drainage basin and the existing development to the north drains its catchment southwards into its POS/Drainage basin, then the POS/drainage basins are trapped with only a piped outlet. Piped outlets for 1.0% AEP storm events are generally unacceptable due to the variable nature of storm events and potential for blockage. Therefore, it is proposed to provide a surface stormwater relief path from the proposed POS through the indicated drainage reserve, beneath the existing Shire drainage easement within adjoining Lot 315 and discharging into the Government Rd North drain within Lot 33 (to the north west of the Lot 34 development). The culvert is shown on the above Figure 23 and the indicative cross section for the drainage reserve is included below as Figure 24.

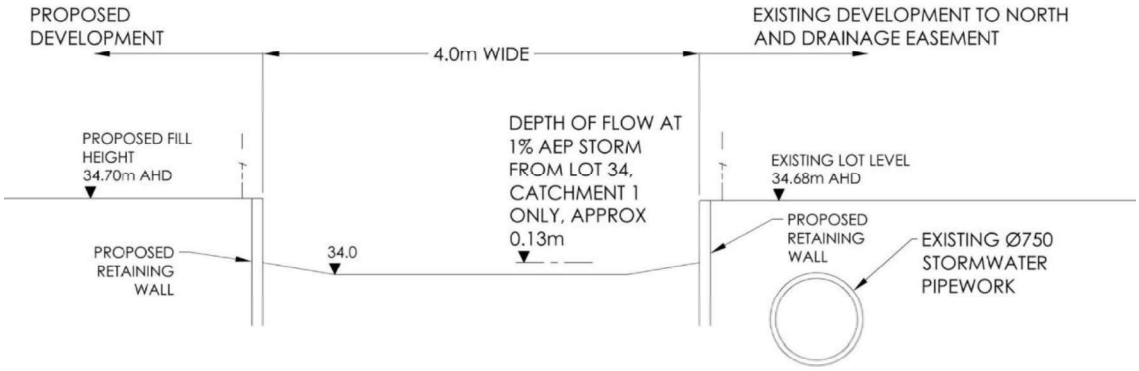

Figure 24
Drainage Reserve – Indicative Cross Section

Based upon a peak 1.0% AEP flow from Lot 34, that is estimated at $0.16m^3/s$ an indicative 900mm by 300mm box culvert is proposed to be installed at the invert of the proposed drainage reserve being approximately RL34.0AHD. This allows the top of the box culvert to be below the finished ground level proposed within the development and that existing within Lot 315.

6.0 GROUNDWATER MANAGEMENT STRATEGY

6.1 SUBSOIL DRAINAGE

The development proposes to install a network of subsoil pipe work to manage the groundwater levels and any potential groundwater rise due to development. The groundwater strategy's core principle is to maintain the existing groundwater regime.

The final earthworks levels of the development will be established in order to meet the requirements of the geotechnical report to achieve an 'S' classification for residential footing construction on the site. The minimum fill requirements will not be established to achieve development separation to groundwater levels, as each proposed lot (future home construction) will not be permitted to utilise soakwells for the disposal of stormwater. Groundwater monitoring did not get undertaken across the development site due to the existence of ponding surface water after rain events, particularly the areas evident during the joint site inspection of August 2016. The shallow groundwater levels were then confirmed during the geotechnical investigation undertaken across the site.

The subsoil network is proposed to be installed generally at the existing surface level, less the existing thickness of topsoil material except for a proposed subsoil drain along the eastern boundary that will be located at the invert of the existing drain. This will ensure that the existing groundwater levels remain consistent post development and any additional groundwater rise does not occur within the existing homesites to the east of the development site.

The proposed subsoil network will freely discharge into the proposed POS/drainage basin located to the northern end of the development to permit treatment through the proposed bioretention basin. The proposed link road to Third St will also contain a subsoil network and a shallow subsoil pipework is proposed to be installed in conjunction with the stormwater pipework to the existing Third St lots to the eastern boundary of the development. This subsoil network will interconnect with the Shire of Harveys existing pipework within Third St. Subsoil pipework is already installed along the western boundary of the development site, and connects to the Shires stormwater network in Raneri Ave and Tomba Way.

The indicative post development groundwater strategy is provided in Attachment 11 including approximate inverts of the proposed subsoil network, existing groundwater levels, existing surface levels and the proposed network. A reduced scale strategy plan is included below as Figure 25.

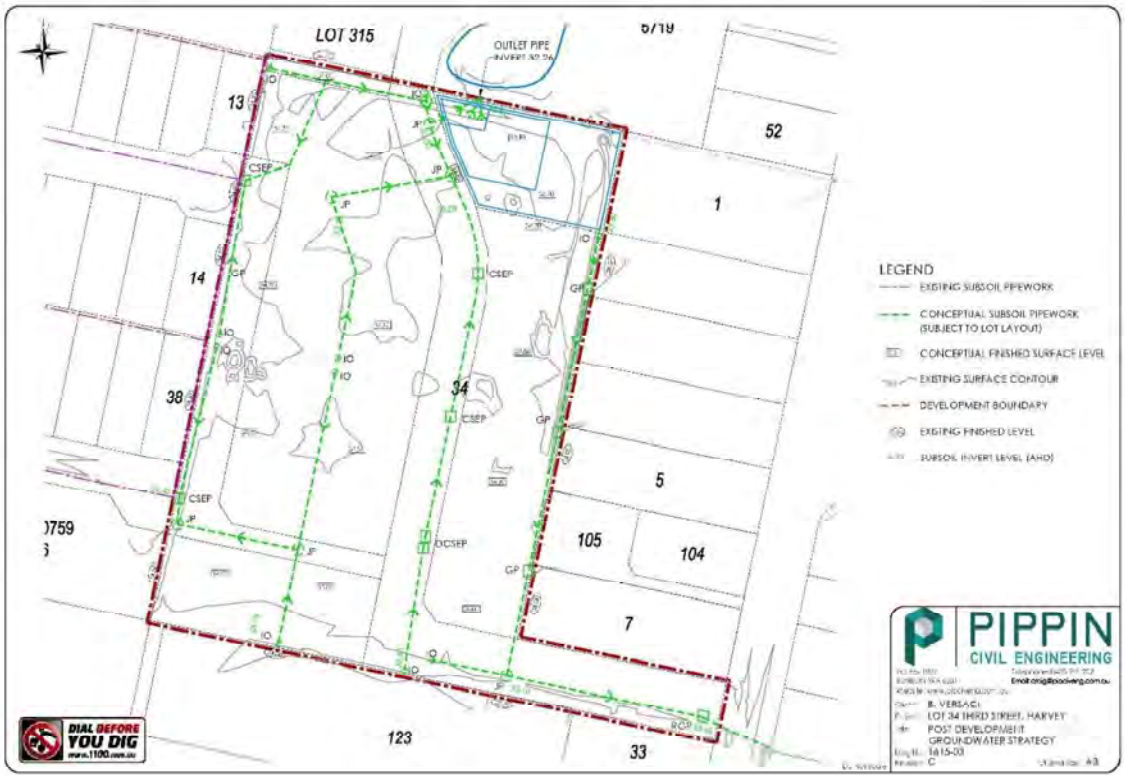

Figure 25
Post Development Groundwater Strategy

It is intended that the development site will be earthworked during the summer months, as recommended by the geotechnical report, when groundwater levels are at their lowest and ponding surface water will not be present. The site will be earthworked in accordance with the geotechnical report and shaped to provide a minimum grade on the underlying clay surface of 1.0% towards the nearest subsoil drain. The shaped, underlying clayey surface will then be covered with a minimum layer of 0.8m of imported fill sand. The fill sand utilised for the development should meet the following specification:

Imported clean sand fill, shall be approved for prior to any of the fill being carted onto the site. Imported clean sand fill shall;

- not contain contaminated, organic or deleterious material,
- not contain dangerous or toxic material, metallic objects, rubbish, plastic or any other waste material,
- be free draining, with a hydraulic conductivity greater than 4.0m per day when compacted to the specification,
- have a minimum 4 day soaked CBR value of 15% when compacted to 95.0% MDD,
- be clean, cohesionless material,
- have a linear shrinkage of 1.0% for the portion of a sample passing the 0.425mm sieve,
- be non-plastic, with a plasticity index of 0.0% for fractions finer than the 0.075mm sieve, and
- have a particle size distribution conforming to the following table.

AS Sieve (mm)	% passing (by mass)
9.5	100
4.75	80 to 100
2.36	40 to 100
1.18	20 to 100
0.425	10 to 60
0.075	0 to 4

Table 6 – Fill Sand Particle Size Distribution

6.2 ACID SULFATE SOIL MANAGEMENT

As described in Section 3.2.2 the development site is recorded as having a moderate to low risk of ASS within 3.0m of the natural surface. In addition, Douglas Partners noted within their Preliminary ASS report that "provided excavations are less than 2.5m depth and dewatering is not required, DP considers that the management of acid sulphate soils is not warranted"

Subject to detailed design, the installation of service infrastructure is unlikely to be at depths greater than 2.5m below the natural surface; however this will be reviewed at detailed design stage for the sewer and stormwater drainage works.

Douglas Partners also note within their report "*It should be noted however that the investigation that was undertaken to provide preliminary advice on the presence or otherwise of acid sulphate soils. In this regard, should a development condition require 'clearance' by the DER be imposed, we anticipate that the DER would require further detailed investigation to meet DER endorsed guidelines*."

7.0 THE NEXT STAGE – SUBDIVISION AND URBAN WATER MANAGEMENT PLAN

In accordance with the requirements of the WAPC, Better Urban Water Management (2008) and the DoWER's Urban Water Management Plans: Guidelines for preparing plans and for complying with subdivision conditions (2008) it is intended that a single UWMP would be completed for the development site as a condition WAPC approval.

This Stormwater and Groundwater Strategy provides the strategy to address structure planning related water management considerations, the UWMP will clarify and refine these considerations into detailed engineering design.

The UWMP will be required to include:

- Confirmation of compliance with the recommendations and criteria of this LWMS.
- Confirm the location of stormwater drainage pipework to the eastern boundary of Lot 34 and the potential for its location within the existing Third St lots.
- Detailed stormwater drainage design of the pit and pipe work.
- Detailed detention and bioretention basin design including; batters, inverts, dimensions, depth, access protection, inlet control and outlet control.
- Groundwater subsoil control pipe work
- Earthworks design based on the combined requirements of subsoil drainage network inverts and geotechnical fill.
- Management of development works.
- Monitoring and reporting requirements.
- Confirmation of water conservation and water quality improvement measures
- POS design, including confirmation of extent of seeded turf/grass and native planting areas.

The preparation of the proposed UWMP will be the responsibility of the developer as a condition of WAPC subdivision approval.

8.0 MONITORING

8.1 PRE DEVELOPMENT

It is not envisaged any further additional and ongoing predevelopment groundwater or surface water monitoring will be required to inform the UWMP and subdivision process.

8.2 POST DEVELOPMENT

Based upon the scale of the development it is not proposed to undertake detailed monitoring of the groundwater, stormwater or subsoil systems, post development.

A visual inspection of each catchments stormwater and groundwater infrastructure, outlet locations and outlet water quality is proposed to be undertaken at the completion of the construction phase and 12 months post construction completion.

Should the visual inspection note anything out of the ordinary, quality testing shall be undertaken and further research into the cause completed. Based on the testing outcomes, a contingency action plan would be compiled.

9.0 IMPLEMENTATION

This Stormwater and Groundwater Strategy provides the water management framework for the proposed Local Structure Plan. As such amendment of the LSP through its review and adoption by the Shire of Harvey and WAPC may occur. As such this strategy may require amendment to suit the LSP amendments. In addition, amendment of this strategy may be required subject to outcomes of the subsequent investigations and reporting associated with the preparation of the UWMP. All amendments, post approval of the strategy will require the prior agreement of the Shire of Harvey, Department of Water and Environmental Regulation and the Water Corporation.

Based upon the scale of development proposed it would be intended that all amendments to this strategy can be undertaken at UWMP stage.

The responsibilities of the strategy are summarised below in Table 5.

Implementation	Developer	Shire of Harvey	DoWER	Lot Purchaser
Detailed ASS investigation, at detailed design stage, if required.	✓			
UWMP Preparation	✓			
Approval of UWMP		✓	✓	
Implementation of Lot level detention and pipework connection to lot connection pit				✓
Construction of Stormwater Infrastructure within the Road Reserve, including lot connection pits	✓			
Construction of Subsoil Network to confirm groundwater rise.	✓			
Post 12 month defect period Maintenance of Stormwater and Groundwater Infrastructure		✓		

Table 7 – Responsibilities of this Stormwater and Groundwater Strategy

REFERENCES

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ATTACHMENT 1
LOT 34 THIRD ST, HARVEY LOCAL STRUCTURE PLAN

LEGEND

LOCAL SCHEME RESERVES

- PARKS AND RECREATION
- PUBLIC PURPOSE

ZONES

- RESIDENTIAL

OTHER

- DRAINAGE
- R20 — R CODES
- STRUCTURE PLAN AREA

LAND USE NOTES

1) The following management plans and selected planning documents are to be implemented via conditions of subdivision (where applicable):
   - Stormwater and Groundwater Management Strategy.

1:1000 (@ A3) 0 10m 20 30 40 50

Client: B. VERSACI

Project: STRUCTURE PLAN
LOT 34 THIRD STREET
HARVEY

Drawing Number: 14-052-03 Revision B

Original Size: A3

Rev	Description	Date
A	ISSUED FOR APPROVAL	/19
B	ISSUED FOR FINAL APPROVAL	05/2020

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Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Development
Lot 34 Third Street, Harvey, WA

Prepared for
B Versaci Pty Ltd

Project 88812.00
October 2016

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

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Site address	Lot 34 Third Street, Harvey, WA		
Report prepared for	B Versaci Pty Ltd		
File name	88812.00.R.001.Rev0.Report on Geotechnical Investigation		

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Revision 0	1	1	Mr B Versaci (B Versaci Pty Ltd)
Revision 0	1	-	Ms Shelley Coutts (MPM Development Consultants)

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		28 October 2016
Reviewer		28 October 2016

bsi. ISO 9001 Quality Management

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Appendix A: About This Report
Drawing
Appendix B: Results of Field Work

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Appendix C: Results of Laboratory Testing

Appendix D: Results of Acid Sulphate Soil Laboratory Testing

Appendix E: CSIRO Document, Foundation Maintenance and Footing Performance: A Homeowner's Guide

Report on Geotechnical Investigation
Proposed Residential Development
Lot 34 Third Street, Harvey, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential development at Lot 34 Third Street, Harvey, Western Australia. The investigation was commissioned in an email by Mr B Versaci on behalf of the client, B Versaci Pty Ltd on 19 September 2016 and was undertaken in accordance with Douglas Partners' proposal PER160448.P.001.Rev0 dated 9 September 2016.

It is understood that the development will comprise the subdivision of the site into residential lots with associated roadways.

The aim of the investigation was to assess the subsurface soil and groundwater conditions across the site in order to:

- provide a review the regional geology of the area;
- determine and report upon the subsurface conditions at the site, including a summary of the subsurface ground conditions and a location plan identifying differing areas of geology and / or classification;
- provide advice on the expected location and extent of any structurally unsuitable materials and the potential to use them in non-structural applications or potential for blending to create a structural material;
- provide advice on groundwater, including a summary of the depth to groundwater encountered and any measures required to control groundwater in order to meet the required site classifications
- determine the Site Classification in accordance with AS2870-2011 and provide recommendations to improve the current classification to all other possible classifications between the existing condition and Class 'A';
- provide advice on construction issues such as earthworks, excavatability and batter slopes;
- assess the permeability of the site and provide recommendations on the suitability of soakwells for stormwater disposal;
- provide a design California bearing ratio (CBR) for the pavement subgrade at the site based on testing and provide advice on any necessary subgrade improvement to obtain a subgrade CBR of greater than 12;
- provide a pavement design, based on various thicknesses of sand subgrade and base course material – a minimum of three options to be provided; and

- assess the risk of acid sulphate soils beneath the site based upon readily available desktop information and limited sampling and analysis.

The investigation included the excavation of eight test pits, dynamic cone penetrometer (DCP) tests adjacent to each test pit, in-situ permeability testing at two locations and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above.

2. Site Description

The rectangular site is approximately 200 m by 125 m in size. The site is located immediately west of some existing residential dwellings, which lie between the site and Third Street to the east. Access to the site was via a track from Third Street at the south eastern corner. The remaining three sides of the site were bound by new residential subdivisions to the west and north, and by gardens located behind houses bordering Third Street to the south.

The northern part of the site generally comprised open pasture and was generally flooded and waterlogged at the time of the investigation during September 2016. The southern part of the site is partially paved with gravel access tracks and parking areas. A large portal shed exists near the western site boundary. Historical photographs indicate that a residential dwelling used to exist to the east of the shed and was demolished at some time between 2010 and 2013. Debris including scrap metals, demolition rubble, and household items were observed in the vicinity of the demolished dwelling. The historical photographs also indicate the southern part of the site was used as a truck or trailer storage area.

At the time of the investigation on 21 September 2016, much of the northern part of the site was flooded, as can be seen in Figure 1 (next page). This controlled the layout of the testing in this area. Historical photographs indicate that a stream once ran across this northern part of the site, entering from the new area of public open space in the development immediately to the north of the site and crossing to the middle of the western boundary via a meandering route. The historical photographs indicate that this area has not been used since at least prior to 2002.

Surface level information obtained from the client indicates that the levels range from 33.5 m relative to Australian height datum (AHD) to approximately 34 m AHD.

The Harvey Lake Preston 1:50,000 Urban Geology sheet indicates that shallow sub surface conditions beneath the site consist of Guildford Formation, described as alluvial sandy clays.

Published acid sulphate risk mapping indicates that the site is mapped as “moderate to low risk of acid sulphate soils occurring within 3 m of natural soil surface”.

Figure 1: View of the Site During Field Work Looking Southwards from the North East Corner

3. Field Work Methods

Field work was carried out on 21 September 2016 and comprised a site walk over, the excavation of eight test pits, DCP tests adjacent to each test pit, and in-situ permeability testing at two locations.

Test pits were excavated using a 4.5 tonne excavator equipped with a 450 mm wide toothed bucket. Ground conditions were logged in general accordance with AS1726-1993 by a suitably experienced geotechnical engineer from Douglas Partners.

Soil samples were recovered for the assessment of acid sulphate soils from test pits TP1, TP5, TP7 and TP8 at 0.5 m intervals for subsequent laboratory testing. The samples were quickly placed in air tight plastic sample bags and chilled in insulated coolers prior to transport to the laboratory.

Dynamic cone penetration (DCP) tests were carried out adjacent to the test locations in accordance with AS 1289.6.3.2 and AS 1289.6.3.3 respectively, to assess the in-situ consistency or density of the shallow soils. Pocket penetrometer testing was also undertaken within cohesive materials where suitable.

The locations of all tests were recorded by Douglas Partners by using a hand-held GPS, and are shown on Drawing 1, Appendix A. The surface elevation at each test location was interpolated from a survey plan provided by the client.

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are given in Appendix B, together with notes defining descriptive terms and classification methods.

The observed ground conditions beneath the site generally comprise:

- **Topsoil** – dark grey brown, organic sandy silty topsoil with some silt but generally slightly silty, and with some clay in areas, encountered from the surface to depths of up to 0.3 m at all test locations at all test locations except TP6. The topsoil was filling at TP4, having been placed over sand and crushed limestone filling (see below), but was the same material as the topsoil encountered elsewhere on the site.
- **Organic Clayey Silt** – firm, brown-black, low to medium plasticity organic clayey silt, encountered underlying the topsoil to depths of between approximately 0.6 m and 1.0 m underlying the northern part of the site at TP1 to TP3.
- **Sandy Silty Clay** – firm becoming stiff with depth, dark orange-brown, low to medium plasticity sandy silty clay, encountered underlying the organic clayey silt to depths of between 1.1 m and the extent of the investigation at a depth of 2.0 m at TP1 to TP3, and underlying the topsoil to the extent of the investigation at depths up to 2.6 m at TP5 to TP8. The sand fraction is fine to medium grained.
- **Slightly Clayey Silty Sand** – brown, fine to medium grained slightly clayey silty sand encountered underlying the sandy silty clay to the extent of the investigation at TP1 and TP2 on the northern boundary of the site. The fines fraction was low plasticity.

The following additional soils were observed:

- **Filling (sand and crushed limestone)** – dense yellow brown, fine to medium grained sand filling, with a trace of silt and yellow-white, fine to coarse sized slightly silty sandy crushed limestone gravel, encountered underlying topsoil to a depth of 0.6 m at BH4.
- **Filling (sandy silty clay)** – soft to firm, dark orange-brown, low to medium plasticity sandy silty clay filling, with fragments of plastic piping encountered from the surface to a depth of approximately 0.4 m at TP6. The sand fraction is medium grained.
- **Sandy Clayey Silt** – dark blue-black, low to medium plasticity sandy clayey silt, encountered underlying the filling to the extent of the investigation at TP4. The sand fraction was fine to medium grained.

4.2 Groundwater

Perched groundwater was encountered at seven test pit locations. Table 1 below summarises the groundwater observations made on 21 September 2016. All test pits were backfilled following sampling, which precluded longer-term monitoring of groundwater levels.

Table 1: Summary of Groundwater Observations

Test Location	Surface Level (m AHD)	Depth to Groundwater (m)	Groundwater Level (m AHD)	Groundwater Comments
TP1	33.5	0.6	32.9	High inflow of perched groundwater.
TP2	33.5	2.5	31.0	High inflow of perched groundwater.
TP3	34.0	0.4	33.6	High inflow of perched groundwater.
TP4	34.0	0.6	33.4	High inflow of perched groundwater.
TP5	34.0	0.6	33.4	High inflow of perched groundwater.
TP7	34.0	0.6	33.4	High inflow of perched groundwater.
TP8	34.0	1.0	33.0	轉gh inflow of perched groundwater.

It should be noted that groundwater levels are affected by climatic conditions and soil permeability, and will therefore vary with time.

4.3 Permeability

In-situ permeability tests were carried out adjacent to two selected test pit locations using the constant head method. The method detailed in AS 1547-2000 Appendix 4.1F was used to estimate a permeability value for the shallow soils.

Table 2: Summary of Permeability Analysis

Test Location	Depth (m)	Measured Permeability[1]		In-Situ Condition of the Tested Material
		(m/s)	(m/day)	
TP7	0.42	1.1×10^{-5}	0.95	Firm to Stiff Sandy Silty Clay
TP8	0.45	1.3×10^{-5}	1.0	Firm to Stiff Sandy Silty Clay

5. Laboratory Testing

5.1 Geotechnical Laboratory Testing

A geotechnical laboratory testing programme was carried out by a NATA registered laboratory on selected samples and comprised the determination of the:

- particle size distribution on three samples;
- organic content of two samples;
- Atterberg limits and linear shrinkage on two samples;
- shrink/swell index of one sample;
- Modified Maximum Dry Density (MMDD) of one sample; and
- soaked California bearing ratio (CBR) of one sample.

The detailed test report sheets are given in Appendix C with the results summarised in Table 3 and Table 4.

Table 3: Results of Laboratory Testing for Soil Identification and Site Classification

Test	Depth (m)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	LS (%)	I_{ss} (%)	Organic Content (%)	Material
TP1	0.4	-	-	-	-	-	-	-	-	11.4	Organic Clayey Silt
TP1	1.5	-	63	37	-	-	-	-	-	-	Silty sand
TP4	1.5	3	46	51	35	20	15	6.5	-	-	Sandy silt with some clay
TP7	0.1	-	-	-	-	-	-	-	-	13.4	Clayey Silty Sandy Topsoil
TP7	0.5	5	21	74	60	24	36	13.5	-	-	Sandy silty clay with a trace of gravel
TP8	1.5-1.7	-	-	-	-	-	-	-	2.8	-	Sandy silty clay with a trace of gravel

Where:
- The % fines is the amount of particles smaller than 75 µm.
- The % gravel is the amount of particles larger than 2.36 mm.
- LL: liquid limit.
- PL: plastic limit
- PI: plasticity Index
- LS: linear shrinkage
- I_{ss}: shrink/swell index
- '-' means 'Not Tested'

The CBR test was undertaken at a target compaction level of 95% of modified maximum dry density. The samples were tested after soaking for four days with a confining surcharge of 4.5 kg, and the results are presented in Table 4.

Table 4: Results of Laboratory Testing for Pavement Parameters

Test Location	Depth (m)	MMDD (t/m^3)	CBR (%)	OMC (%)	Swell (%)	Material
TP7	0.5	1.62	5	22.9	3.0	Sandy Silty Clay

Notes: - MMDD: modified maximum dry density.
- CBR: California bearing ratio.
- OMC: optimum moisture content.

5.2 Acid Sulphate Soil Laboratory Testing

Acid sulphate soil screening tests were undertaken on select soil samples retrieved from test pits TP1, TP5, TP7 and TP8.

Initial acid sulphate soil screening tests were undertaken on 19 soil samples by the MPL Group in accordance with the method as described in Ahern CR, McElnea AE, Sullivan LA (2004), *Acid Sulphate Soils Laboratory Methods Guidelines*. The screening tests comprised measurement of pH of the soil in water (pH_F) and the pH of the soil after oxidation with a 30% solution of hydrogen peroxide (pH_{FOX}). The results of these tests provide an indication as to presence of actual and potential acid sulphate soils and should be considered as qualitative only.

Following the screening tests, as required by the DER, four soil samples were submitted to MPL Laboratories to undergo Suspension Peroxide Oxidation Combined Acidity and Sulphate (SPOCAS) suite of testing. Soil samples were selected for laboratory analysis with due consideration of the following:

- screening results, with particular focus on the lowest reported pH_{FOX} within soil strata at each test location;
- reported reaction strength; and
- visual identification of the soils encountered.

The screening results and laboratory testing (SPOCAS) including the adopted assessment criteria are presented in Table F-1 in Appendix F together with the detailed laboratory reports and associated chain of custody reports.

6. Proposed Development

It is understood that the development will comprise the subdivision of the site into residential lots with associated roadways and public open space. Specific subdivision plans were not provided to Douglas Partners at the time of preparing this report.

7. Comments

7.1 Site Suitability

The investigation indicates that the northern part of the site is underlain by organic topsoil and organic clayey silt, overlying sandy silty clay, whilst the southern part of the site is directly underlain by sandy silty clay. Uncontrolled filling was also encountered. The organic materials were encountered to depths of between 0.6 m and 1.0 m at accessible locations over the northern part of site. Much of that area was flooded at the time of the investigation on 21 September 2016, and therefore inaccessible to investigation plant. This controlled the layout of the investigation in that area. Deeper organic material may be present in the inundated lower lying areas of the northern part of the site. Historical photographs indicate that a stream ran through the northern part of the site, from the new public open space area in the adjacent northern end of the site across to the middle of the western boundary via a meandering course.

Groundwater was encountered at shallow depth across the site and the northern part of the site was extensively inundated during the field work on 21 September 2016.

From a geotechnical standpoint, the land is considered physically capable of development for the proposed residential subdivision, provided that the provisions outlined in the subsequent subsections of the report are taken into consideration, recommendations are implemented and subject to the following geotechnical constraints:

- the northern part of the site is subject to flooding during wet periods, as observed during the field work, and therefore surface levels will need to be raised and the requirement for subsoil drainage should be considered;
- the site is currently classified as Class ‘M’ in accordance with AS2870-2011, and a pad of non-reactive filling will be required to achieve an equivalent classification of Class ‘S’. Due to the potential for some ongoing consolidation settlement following filling of the site, it is recommended that footings designed to Class ‘A’ are not used on this site.
- the encountered topsoil is organic, and this is underlain by organic clayey silt across the northern part of the site. Laboratory tests undertaken on samples of these materials produced results of 13.4% organic content for the topsoil and 11.4% organic content for the underlying organic clayey silt. These organic materials are considered to form unsuitable foundation materials and it is recommended that they are removed and replaced with engineering fill. Dewatering may be required if this is done in the winter period. Alternatively, it is considered that, following stripping of the topsoil, the organic clayey silt could be left in situ provided that footings be designed for a Class ‘M’ site, even after sand filling, to accommodate possible additional movement due to the decomposition of the organic material (and consequent settlement) during the life span of the proposed housing;
- shallow perched groundwater was encountered across the site. This, together with the clayey nature of the soils underlying the site, presents some limitation on the use of soakwells for stormwater disposal. Dewatering for excavations existing ground level is anticipated to be required, in particular during the wet period of the year.

7.2 Site Classification

The site classification is based on the anticipated soil movement due to the shrinking and swelling of the reactive soils following seasonal wetting and drying. For a given site, the main factors that determine this movement are:

- the reactivity of the soils; and
- the depth affected by soil moisture change from the impact of the climate.

Following AS 2870-2011, a design suction depth (i.e. the depth to which the climate impacts soil moisture) of 1.5 m is considered appropriate for soils not influenced by trees in the Harvey area. Trees are considered to increase the design suction depth (and hence increase surface movement). It is estimated that at this particular site, trees could increase the natural surface movement by up to 10 mm and therefore, it is recommended that a specific assessment is undertaken at proposed building envelopes if it is proposed for trees to remain within 1.5 times the tree's mature height of that location.

To provide an indication of the reactive surface movements of the natural soil profile, the results of a shrink swell test and correlations with Atterberg limits, were used to estimate the site classification in general accordance with AS 2870-2011. The results indicate a site classification of Class 'M'. The characteristic surface movement, $y_{s,}$ was estimated to be approximately 30 mm. The ground conditions at the site were variable and as such, a single site classification is considered appropriate for the entire site, assuming that the organic clayey silt and topsoil will be removed.

A depth of 0.8 m of non-reactive filling is required to achieve an equivalent site classification of Class 'S', assuming the organic materials underlying the northern part of the site are removed. Characteristic surface movement with 0.8 m of non-reactive filling above the sandy silty clay in situ soil is estimated to be approximately 10 mm. A depth of 1.5 m of non-reactive filling is required in strict accordance with AS2870-2011 to achieve an equivalent site classification of Class 'A', in which case the characteristic surface movement will be approximately zero. However, some consolidation of the underlying clayey deposits due to the surcharge of the filling may continue for a prolonged period following filling and use of footings designed to Class 'S' rather than Class 'A' is recommended for this site.

Consideration was given to leaving the organic materials in place following stripping of the vegetation and topsoil, assuming at least 800 mm of clean sand filling is placed above them (see Section 7.3.2). If that approach is adopted, it is recommended that footings are design for equivalent site classification Class 'M' to accommodate potential long term settlement due to both consolidation and decomposition of the organic materials during the life span of the proposed development.

In addition to trees, excess moisture can increase the natural ground surface movements and should be avoided where possible. Abnormal soil moisture conditions are defined in AS 2870, and in summary comprise:

- removal of buildings or structures prior to development which is likely to have affected soil moisture conditions;
- unusual moisture caused by drains, channels, ponds, dams or tanks;

- recent removal of large trees;
- excessive or irregular watering of gardens adjacent to the structure;
- lack of maintenance of site drainage; and
- failure to repair plumbing leaks.

For further advice on protecting structures overlying clayey soils, reference should be made to the CSIRO note, entitled 'Foundation Maintenance and Footing Performance: A Homeowner's Guide', which is attached in Appendix E of this report.

7.3 Site Preparation

It is recommended that earthworks are undertaken during the dry period of the year due to the flooding observed during the investigation undertaken at the end of the winter period.

7.3.1 Site Stripping

All deleterious material, including as a minimum rubble and debris (such as uncontrolled filling and material remaining following demolition works of the previous and existing structures), vegetation, top 100 mm of top soil and roots larger than 10 mm in diameter should be stripped and either removed from site or stockpiled for possible re-use as landscaping filling only.

It is recommended that the full depth of topsoil and the organic clayey silt encountered over the northern part of the site should also be stripped. This material was encountered to depths of between 0.6 m and 1.0 m below the existing ground surface. It is possible that the organic material is present to a greater depth in the centre of the northern part of the site, which was inaccessible to the investigation plant during the field works on 21 September 2016 due to flooding. Dewatering may be required when removing this material, in particular if undertaken during the winter months. As discussed in Sections 7.1 and 7.2, these materials may be left in place if the footings are designed to an equivalent Class 'M' provided there is at least 800 mm of clean sand filling above them.

The exposed subgrade following stripping should be inspected by an experienced geotechnical engineer. Douglas Partners would be pleased to undertake such inspections on request.

7.3.2 Proof Rolling

Following removal of unsuitable material and prior to any filling, it is recommended that the exposed subgrade beneath the building envelopes and pavement areas be compacted using a medium to heavy (minimum of 12 tonne) roller in static mode. Any areas that show signs of excessive deformation during compaction should be further compacted until deformation ceases. Alternatively, the poor quality material should be excavated and replaced with suitable structural filling, compacted to achieve a dry density ratio of not less than 95% relative to modified maximum dry density for a

granular subgrade and 92% relative to modified maximum dry density for a cohesive subgrade. Care should be taken not to operate heavy plant immediately adjacent to existing buildings and services.

7.3.3 Re-use of Material Encountered on Site

Based on the nature of the material encountered during the investigation, it is anticipated that in situ materials are not suitable for reuse as structural filling and excavated materials should be reused for landscaping only. The high organic content of the topsoil and underlying organic clayey silt material to be stripped from the northern part of the site, and the high fines content of the sandy silty clayey preclude the possibility of blending these materials to create a suitable structural filling.

Sand and crushed limestone filling was encountered at TP4 but its volume is considered to be relatively low. Granular pavement materials remaining from the access track and parking area may be suitable for reuse provided that they are not contaminated by the underlying clayey material during excavation and that they meet the specification for imported filling in Section 7.3.4.

7.3.4 Imported Filling

If required, imported filling should comprise free draining, cohesionless, well graded sand that:

- contains less than 5% by weight of particles less than 75 microns in size;
- contains no particles greater than 150 mm in size; and
- is free of organic and other deleterious materials.

It is recommended that test certificates are reviewed and approved by the geotechnical engineer prior to importing material to site.

7.3.5 Fill Placement

Any fill should be placed in layers not exceeding 150 mm loose thickness and compacted near optimum moisture content with a roller say 8 to 12 tonne deadweight in static mode. Care should be taken not to run heavy plant immediately adjacent to existing structures and services. It is recommended that earthworks be carried out with regular inspections by a geotechnical engineer.

7.3.6 Compaction Testing

Compaction control of the sand filling could be carried out using a Perth sand penetrometer (PSP) test in accordance with test method AS 1289.6.3.3 after the relationship between PSP penetration blow counts and the dry density of the proposed sand filling is established.

During construction, some loosening of the surface materials in foundation excavations is expected. Therefore, the top 300 mm in the base of any excavation should be re-compacted using a vibratory

plate compactor prior to construction of any footings. Confirmation of adequate compaction should be carried out as outlined above.

7.4 Excavation Conditions

The investigation indicates that the ground conditions comprise predominantly loose to medium dense or firm to stiff soils. Therefore, conventional earthmoving equipment should be generally suitable for excavations undertaken within the site to the extent of the investigation.

7.5 Groundwater

Shallow groundwater was encountered across the site, with high rates of inflow of perched groundwater being encountered generally at depths of between 0.4 m and 0.6 m below existing ground level at the time of the investigation. Therefore, groundwater should be considered in the design and construction if any development at this site. Excavation of the organic material encountered underlying the northern part of the site may require dewatering if undertaken during the winter months of the year. It is recommended that earthworks, particularly the removal of the organic material at the northern part of the site, is undertaken during the summer months, when groundwater levels may be lower.

The requirement for sub soil drainage, and the possible impact of groundwater on the adjacent lands following raising levels at this site, should be considered

7.6 Foundation Design

Shallow foundation systems comprising pad and strip footings should be suitable to support the proposed structures. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for the suitable site classification discussed in Section 7.2, provided that site preparation is carried out as detailed in Section 7.3.

It is emphasised that AS 2870-2011 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. It also applies to light industrial and commercial buildings if they are similar in size, loading and superstructure flexibility to those designs included in AS 2870-2011.

If any structures fall outside those defined as Class 1 and 10a, footing systems should be designed using engineering principles. A preliminary allowable bearing pressure of 100 kPa is considered suitable for foundation design of pad footings 0.5 m to 1.0 m wide and for strip footings 0.5 m to 0.75 m wide, founded at depths of at least 0.5 m in firm to stiff clayey material or medium dense or denser sandy filling material.

Estimated total settlements are 5 mm to 10 mm and differential settlements approximately half that value under the above-mentioned bearing pressure. These values do not include seasonal ground movement from the swelling and shrinking of reactive foundation material.

7.7 Pavement Design

Specific subdivision plans were not provided to Douglas Partners at the time of preparation of this report, and thus the alignment of any proposed access road likely to form part of the proposed development, is not known at this stage.

The subgrade for any proposed pavement is anticipated to comprise:

- within the southern half of the site – sand and crushed limestone filling and sandy silty clay provided removal of the topsoil and uncontrolled filling is undertaken as described in Section 7.3.1, or sand filling if site surface levels are raised above the maximum flood level and/or to improve the site classification; and
- within the northern half of the site – sand filling provided removal of the organic clay silt is undertaken as described in Section 7.3.1.

Groundwater was encountered at shallow depth across the site (generally between 0.4 m and 1.0 m below existing site levels), and the northern part of the site was extensively inundated during the field work on 21 September 2016.

The laboratory testing results detailed in Section 5 indicate a CBR value of 5% for a soaked sample of the sandy silty clay subgrade. Based on observations made in the field, the available laboratory testing result and Douglas Partners experience, a subgrade CBR design value of 2% is recommended for the design of pavement on the sandy silty clay subgrade, provided that the subgrade is compacted achieve a dry density ratio of not less than 92% relative to modified compaction and suitably drained.

If the subgrade comprises imported sand filling, the pavement should be designed using an appropriate CBR of the material. A presumptive design CBR value of 12% is suggested for clean sand filling, provided there is at least 1.0 m of the material below any proposed pavement subgrade level, and compacted to achieve a dry density ratio of not less than 95% relative to modified maximum dry density. However, this value should be confirmed prior to pavement construction once the sand filling material is known and its CBR has been assessed.

Based on the above, it is recommended that any proposed pavement should comprise the pavement profiles included in Table 5 (next page).

Table 5: Summary of Design Pavement Thicknesses (mm)

Pavement Layer	Thickness (mm)
Asphalt	30
Basecourse	400 mm[1] for subgrade with a design CBR of 2%
	150 mm[2][3] for subgrade with a design CBR of 12%

Notes: [1] For a sandy silty clay subgrade or imported sand filling less than 1.0 m thick.
[2] If the subgrade comprises imported sand filling with a thickness of at least 1.0 m below the above design pavement thickness.
[3] A single basecourse layer is recommended, due to the anticipated difficulties in constructing a subbase layer.

A suitable pavement basecourse could consist of crushed rock base (CRB), emulsion stabilised limestone (ESL) of lateritic gravel meeting the general criteria for basecourse included in Table 501.B2 and Clause 2.4 of Annex 501.B of MRWA Specification 501 Pavements. The basecourse should be compacted to achieve a dry density ratio of not less than 98% relative to modified compaction for ESL or lateritic gravel, or 99% relative to modified compaction for CRB. It is recommended that the basecourse be dried back to a moisture content of less than 70% of OMC prior to application of the asphalt surfacing.

Compaction control should be carried out using a nuclear surface moisture-density gauge, in accordance with AS1289.5.8.1, as per the requirements of the relevant project specification.

The long term performance of any proposed pavement requires that suitable surface and sub-soil drainage be implemented to direct water away from the pavement layers, as required. Saturation of the pavement would result in a decrease in the basecourse strength and could result in pavement failure. As mentioned above, the northern part of the site was extensively inundated during the field work on 21 September 2016. Thus, a minimum distance of 0.5 m between the base of the above proposed basecourse pavement layer and the maximum flood level at the site is recommended, to minimise the risk of pavement distress due to saturation of the basecourse layer.

7.8 Soil Permeability and Stormwater Disposal

In-situ permeability testing undertaken using the constant head method in accordance with AS 1547:2012 within the firm to stiff sandy silty clay at TP7 and TP8 indicated permeability values of 1.1×10^{-5} m/s (0.95 m/day) and 1.3×10^{-5} m/s (1.0 m/day) respectively. It is recommended that design permeability values of 1.0×10^{-5} m/s (0.85 m/day) is adopted for clayey material at the site.

Stormwater disposal using infiltration via soakwells and sumps is considered to be unsuitable in the clayey materials encountered underlying the site due to low permeability and shallow groundwater.

7.9 Acid Sulphate Soil Evaluation

The Western Australian Planning Commission (WAPC) in conjunction with the Department of Environment Regulation (DER) have prepared a series of acid sulphate soil risk maps targeting areas of high development across Western Australia. These risk maps have been prepared on the basis of geological origin, depth to groundwater and partial ground truthing.

Published acid sulphate soil risk mapping indicates that the site is mapped as “moderate to low risk of acid sulphate soils occurring within 3 m of natural soil surface”. The Harvey Lake Preston 1:50,000 Urban Geology sheet indicates that shallow sub surface conditions beneath the site consist of Guildford Formation, described as alluvial sandy clays which correspond to the areas mapped as moderate to low risk. Based upon the results of the geotechnical investigation, the encountered ground conditions are generally in agreement with the published mapping.

With reference to Table D-1, Appendix D, the reported results indicate the following:

- the results for pH_F are not indicative of actual acid sulphate soils conditions at the test locations up to a depth of 2.5 m;
- the results for pH_{FOX} are not indicative of potential acid sulphate soil conditions at the test locations up to a depth of 2.5 m with the exception of one sample collected from TP1 at a depth of 2.0 m. Subsequent laboratory testing suggest the low pH_{FOX} is a false positive results and not indicative of potential acid sulphate soils; and
- the calculated net acidities are below the adopted action criterion of 0.03% S for all samples with the exception of one sample collected from TP7 at a depth of 2.0 m which reported a net acidity of 0.036% S..

It should be noted that the single exceedence of the action criterion is attributed to a higher result reported for the titratable actual acidity (TAA) component of net acidity, which is a measure of the soils existing acidity. It should also be noted that the corresponding results for S_{POS} results was reported as less than the laboratory limit of reporting, indicating the general absence of peroxide oxidisable sulphur. Furthermore, given the absence of sulphidic material, the pH of the soil is not expected to decrease as a result of sulphide oxidation, following disturbance. Given the apparent absence of sulphidic material in the samples analysed, it is expected that the higher results for ‘existing acidity’ are attributed to metal complexes, and are not necessarily representative of actual acid sulphate soil conditions. This is further supported by the S_{kCl} results which were all reported <0.03% S indicating no appreciable soluble sulphur.

In this regard, DP considers the single exceedence of the action criterion associated with an elevated TAA result to be of low significance. Provided excavations are less than 2.5 m depth and dewatering is not required, DP considers that management of acid sulphate soils is not warranted.

It should be noted, however, that the investigation was a preliminary investigation that was undertaken to provide preliminary advice on the presence or otherwise of acid sulphate soils. In this regard, should a development condition requiring ‘clearance’ by DER be imposed, we anticipate that the DER would require further detailed investigation to meet DER endorsed guidelines.

8. References

1. Geological Survey of Western Australia (1991), Yallingup 1:50 000 Sheet.
2. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
3. Australian Standard AS 1289.6.3.2-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test.
4. Australian Standard AS 1726-1993, Geotechnical Site Investigation.
5. Australian Standard AS 2870-2011, Residential Slabs and Footings.

9. Limitations

Douglas Partners (DP) has prepared this report (or services) for this project at Lot 34 Third Street, Harvey in accordance with DP's proposal dated 9 September 2016 and acceptance received from B Versaci Pty Ltd dated 19 September 2016. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of B Versaci Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The scope for work for this investigation/report did not include the assessment of surface or sub-surface materials or groundwater for contaminants, within or adjacent to the site. Should evidence of filling of unknown origin be noted in the report, and in particular the presence of building demolition materials, it should be recognised that there may be some risk that such filling may contain contaminants and hazardous building materials.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the (geotechnical / environmental / groundwater) components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report
Drawing

About this Report

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

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Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete

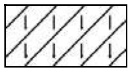

Filling

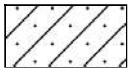
Soils


Topsoil

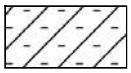

Peat


Clay

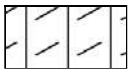

Silty clay

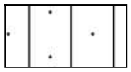

Sandy clay

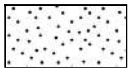

Gravelly clay

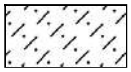

Shaly clay

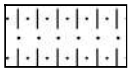

Silt


Clayey silt


Sandy silt

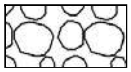

Sand


Clayey sand


Silty sand


Gravel


Sandy gravel


Cobbles, boulders

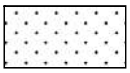

Talus

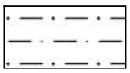
Sedimentary Rocks

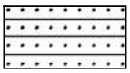

Boulder conglomerate

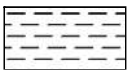

Conglomerate


Conglomeratic sandstone

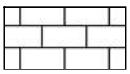

Sandstone


Siltstone

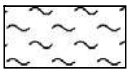

Laminite

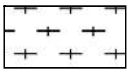

Mudstone, claystone, shale

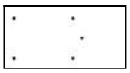

Coal


Limestone

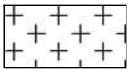
Metamorphic Rocks

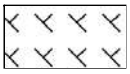

Slate, phyllite, schist

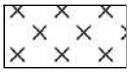

Gneiss

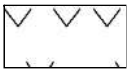

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

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Test Location Plan		PROJECT: 88812.00
Proposed Residential Development		Drawing No: 1
Lot 34 Third Street, Harvey, WA		REV: 0
CLIENT:	Mr B Versaci	DATE: 03-10-16

Appendix B

Results of Field Work

TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 33.5 m AHD*
EASTING:
NORTHING:

PIT No: TP1
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
33	0.2	TOPSOIL - dark brown-black, fine to medum grained organic sandy silty topsoil, moist to wet.							
		ORGANIC CLAYEY SILT - firm, brown-black, low to medium plasticity organic clayey silt, wet.		D	0.4				
	0.6			E	0.5	1		▽	
		SANDY SILTY CLAY - firm, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.							
	1	- becoming stiff below 0.75 m depth.		D E	1.0	2			1
	1.1	Slightly CLAYEY SILTY SAND - brown, low plasticity, fine to medium grained slightly clayey silty sand, wet.							
32				D E	1.5	3			
	2			E	2.0	4			2
31				E	2.5	5			
	2.6	Pit discontinued at 2.6m (due to collapsing conditions caused by high inflow of perched groundwater)							
	3								3

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 0.6 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 33.5 m AHD*
EASTING:
NORTHING:

PIT No: TP2
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
33	0.3	TOPSOIL - dark brown-black, fine to medum grained organic sandy silty topsoil, moist to wet.							
	0.7	ORGANIC CLAYEY SILT - loose to medium dense, brown-black, low to medium plasticity organic clayey silt, wet.							
32	1.7	SANDY SILTY CLAY - stiff, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.		D	1.5				
31	2.6	Slightly CLAYEY SILTY SAND - brown mottled blue-grey, low plasticity, fine to medium grained slightly clayey silty sand, wet.		D	2.0			▽	
		Pit discontinued at 2.6m (due to collapsing conditions caused by high inflow of perched groundwater)							

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20; 1 2 3

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 2.5 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U,	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 34.0 m AHD*
EASTING:
NORTHING:

PIT No: TP3
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
34	0.2	TOPSOIL - dark brown-black, fine to medum grained organic sandy silty topsoil, moist to wet.							
		ORGANIC CLAYEY SILT - firm, brown-black, low to medium plasticity organic clayey silt, wet.						▽	
33	1 1.0	SANDY SILTY CLAY - firm becoming stiff, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.			1.1		pp = 100		1
					1.8		pp = 180		
32	2 2.0	Pit discontinued at 2.0m (due to collapsing conditions caused by high inflow of perched groundwater)							2
31	3								3

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 0.4 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 34.0 m AHD*
EASTING:
NORTHING:

PIT No: TP4
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
34	0.0	FILLING (TOPSOIL) - dark brown-black, fine to medium grained organic clayey silty topsoil filling, moist to wet.		D	0.2				
	0.3	FILLING (SAND and CRUSHED LIMESTONE) - dense, yellow-brown, fine to medium grained sand filling with a trace of silt, and yellow-white, fine to coarse sized, slightly silty sandy crushed limestone gravel.		D	0.5				
	0.6	SANDY CLAYEY SILT - dark blue-black, low to medium plasticity, fine to medium grained, sandy clayey silt, moist to wet.						▽	
33	1			D	1.5				1
32	2								2
	2.5	Pit discontinued at 2.5m (due to collapsing conditions caused by high inflow of perched groundwater)							
31	3								3

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 0.6 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▽	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 34.0 m AHD*
EASTING:
NORTHING:

PIT No: TP5
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
34	0.0	TOPSOIL - dark brown-black, slightly organic sandy silty topsoil, moist.							
	0.3	SANDY SILTY CLAY - stiff, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.		E	0.5	15		▽	
33	1			E	1.0	16	pp = 180		1
				E	1.5	17			
32	2			E	2.0	18	pp = 280		2
				E	2.5	19			
	2.6	Pit discontinued at 2.6m (due to collapsing conditions caused by high inflow of perched groundwater)							
31	3								3

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 0.6 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 34.0 m AHD*
EASTING:
NORTHING:

PIT No: TP6
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
34		FILLING (SANDY SILTY CLAY) - soft to firm, dark orange-brown, low to medium plasticity sandy silty clay filling with plastic piping fragments, moist. Sand is fine to medium grained.							
	0.4	SANDY SILTY CLAY - firm becoming stiff, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.							
33	1								1
32	2								2
	2.5	Pit discontinued at 2.5m (due to collapsing conditions caused by high inflow of perched groundwater)							
31	3								3

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: No free groundwater observed.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 34.0 m AHD*
EASTING:
NORTHING:

PIT No: TP7
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
34		TOPSOIL - dark brown-black, slightly organic sandy silty topsoil, moist.		D	0.1				
	0.25	SANDY SILTY CLAY - firm, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.		B	0.5	11		▽	
				E					
		- becoming stiff below 0.6 m depth.							
33	1			E	1.0	12			1
				E	1.5	13	pp = 160		
32	2			E	2.0	14	pp = 300		2
	2.1	Pit discontinued at 2.1m (due to collapsing conditions caused by high inflow of perched groundwater)							
31	3								3

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 0.6 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

TEST PIT LOG

CLIENT: Mr. B Versaci
PROJECT: Proposed Residential Development
LOCATION: Lot 34 Third Street, Harvey, WA

SURFACE LEVEL: 34.0 m AHD*
EASTING:
NORTHING:

PIT No: TP8
PROJECT No: 88812.00
DATE: 21/9/2016
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
34		TOPSOIL - dark brown-black, slightly organic sandy silty topsoil, moist.							
	0.2	SANDY SILTY CLAY - firm, dark orange-brown, low to medium plasticity sandy silty clay, moist. Sand is fine to medium grained.							
		- becoming stiff below 0.45 m depth.		E	0.5	6			
33	1			D E	1.0	7		▽	1
				E	1.5	8	pp = 200		
				D	1.7				
32	2			E	2.0	9			2
				E	2.5	10			
	2.6	Pit discontinued at 2.6m (due to collapsing conditions caused by high inflow of perched groundwater)							
31	3								3

RIG: 4.5 tonne excavator equipped with 450 mm toothed bucket.
LOGGED: S Jayaseelan
SURVEY DATUM: MGA94

WATER OBSERVATIONS: High inflow of perched groundwater observed at 1.0 m depth.

REMARKS: *Approximate Surface level interpolated from Google Earth.

☐ Sand Penetrometer AS1289.6.3.3
☒ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U$_x$	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▽	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Photo 1: TP1

Photo 2: TP2

Douglas Partners Geotechnics / Environment / Groundwater	**Proposed Residential**		PROJECT:	88812
	Lot 34 Third Street		Plate	1
	Harvey, WA		REV:	A
	Client	Mr B. Versaci	DATE:	21-Sep-16

Photo 3: TP3

Photo 4: TP4

Douglas Partners Geotechnics / Environment / Groundwater	**Proposed Residential**		PROJECT:	88812
	Lot 34 Third Street		Plate	2
	Harvey, WA		REV:	A
	Client	Mr B. Versaci	DATE:	21-Sep-16

Photo 5: TP5

Photo 6: TP6

Douglas Partners Geotechnics / Environment / Groundwater	**Proposed Residential**		PROJECT:	88812
	Lot 34 Third Street		Plate	3
	Harvey, WA		REV:	A
	Client	Mr B. Versaci	DATE:	21-Sep-16

Photo 7: TP7

Photo 8: TP8

Douglas Partners Geotechnics / Environment / Groundwater	**Proposed Residential**		PROJECT:	88812
	Lot 34 Third Street		Plate	4
	Harvey, WA		REV:	A
	Client	Mr B. Versaci	DATE:	21-Sep-16

Appendix C

Results of Laboratory Testing

Particle Size Distribution

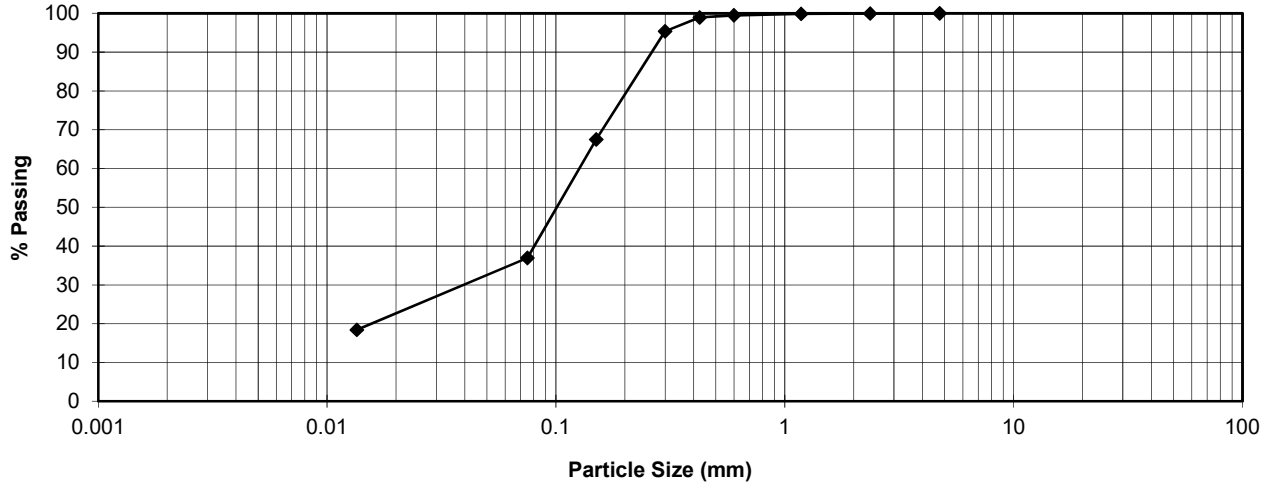
Mining & Civil
Geotest Pty Ltd

9 Lerista Court, Bibra Lake WA 6164
Ph: (08) 9418 1873 Mob: 0412 427 245
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/2927**
Sample No:	**P16/2927**
Issue Date:	**06-Oct-16**

Client:	Mr B Versaci
Project:	Proposed Residential Development
Location:	Lot 34 Third Street, Harvey WA

Sample Details	TP1
Sample Depth (m)	1.5



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	100
1.18	100
0.600	99
0.425	99
0.300	95
0.150	68
0.075	37
0.0135	18

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017

Sampling Procedure: Tested as received

Notes:

NATA
WORLD RECOGNISED ACCREDITATION

Approved signature

Craig Hugo

Particle Size Distribution & Plasticity Index tests

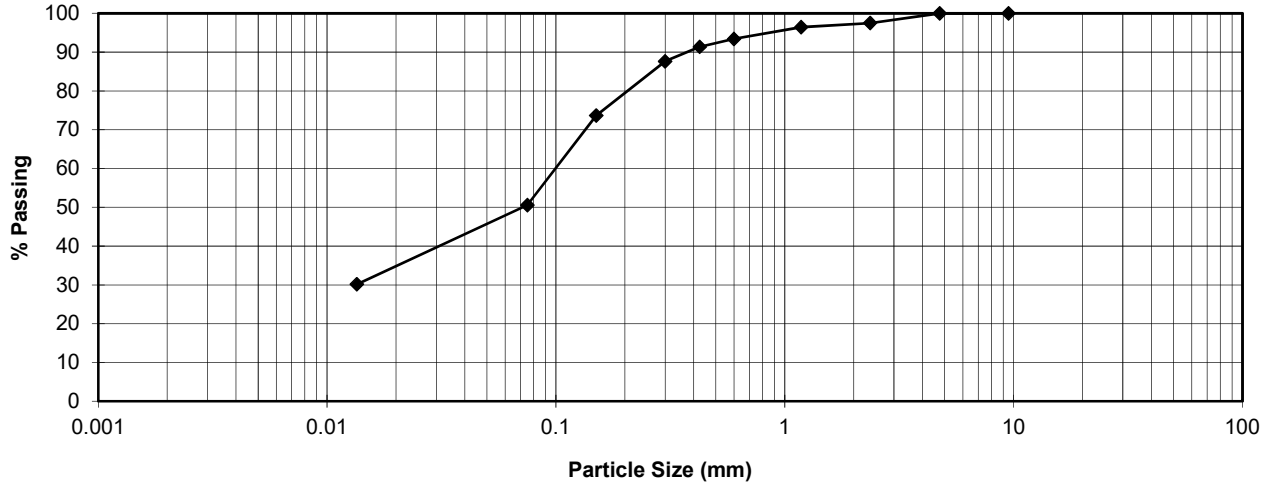
Mining & Civil
Geotest Pty Ltd

9 Lerista Court, Bibra Lake WA 6164
Ph: (08) 9418 1873 Mob: 0412 427 245
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/2929**
Sample No:	**P16/2929**
Issue Date:	**06-Oct-16**

Client: Mr B Versaci
Project: Proposed Residential Development
Location: Lot 34 Third Street, Harvey WA

Sample Details TP4
Sample Depth (m) 1.5



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	100
4.75	100
2.36	97
1.18	96
0.600	93
0.425	91
0.300	88
0.150	74
0.075	51
0.0135	30

Plasticity index tests
AS 1289

Liquid Limit 3.9.2	35	%
Plastic Limit 3.2.1	20	%
Plasticity Index 3.3.1	15	%
Linear Shrinkage 3.4.1	6.5	%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Notes:

Sampling Procedure: Tested as received

Approved signature

Craig Hugo

Particle Size Distribution & Plasticity Index tests

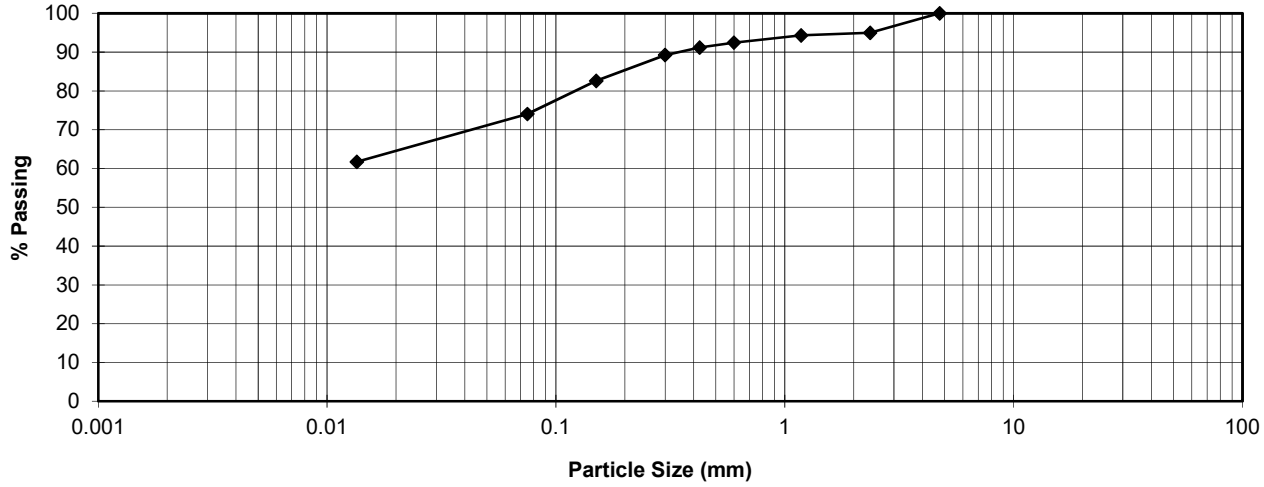
Mining & Civil
Geotest Pty Ltd

9 Lerista Court, Bibra Lake WA 6164
Ph: (08) 9418 1873 Mob: 0412 427 245
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/2930**
Sample No:	**P16/2930**
Issue Date:	**06-Oct-16**

Client: Mr B Versaci
Project: Proposed Residential Development
Location: Lot 34 Third Street, Harvey WA

Sample Details TP7
Sample Depth (m) 0.5



SIEVE ANALYSIS WA 115.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	95
1.18	94
0.600	92
0.425	91
0.300	89
0.150	83
0.075	74
0.0135	62

Plasticity index tests
AS 1289

Liquid Limit 3.9.2	60	%
Plastic Limit 3.2.1	24	%
Plasticity Index 3.3.1	36	%
Linear Shrinkage 3.4.1	13.5	%

Cracked ☐

Curled ☐

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017
Notes:

Sampling Procedure: Tested as received

NATA
WORLD RECOGNISED ACCREDITATION

Approved signature

Craig Hugo

Maximum Dry Density (AS 1289.5.2.1) &
California Bearing Ratio (AS 1289.6.1.1)
Test Report

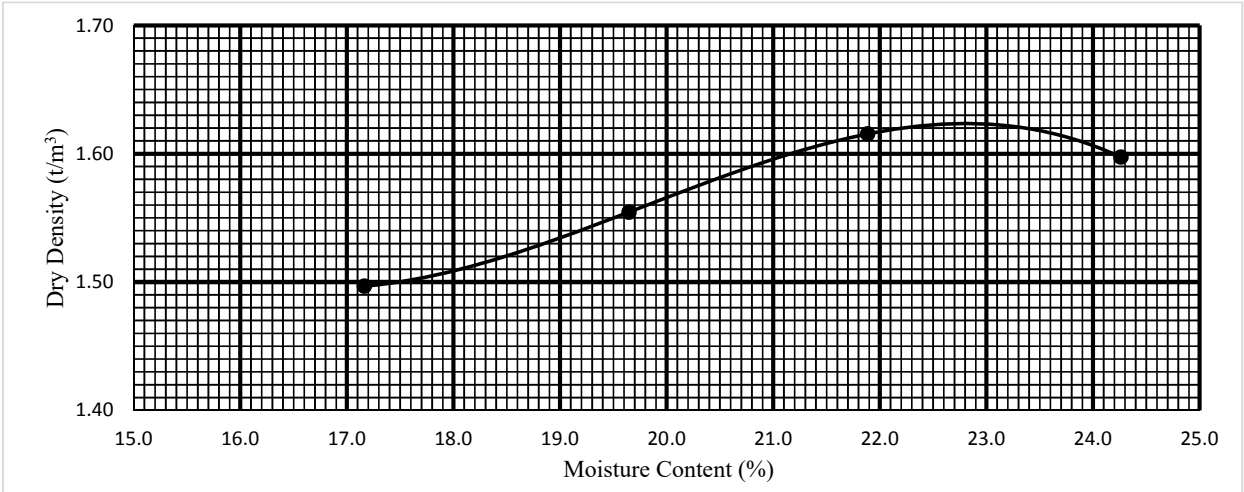
Mining & Civil
Geotest Pty Ltd

9 Lerista Court, Bibra Lake WA 6164
Ph: (08) 9418 1873 Mob: 0412 427 245
Email: craig@mcgeotest.com.au

Client:	Douglas 126416/88812.00	**Job No:**	60017
Project:	Mr B Versaci - Proposed resdiental Development	**Sample No:**	P16/2930
Location:	lot 34 Third Street, Harvey, WA	**Issued Date:**	10-Oct-16
Sample ID:	Sample 1	**Report No:**	60017-P16/2930

Maximum Dry Density t/m3	1.62	**Conditions at Test**	
Optimum Moisture Content %:	22.9	Soaking Period (Days)	4
Desired Conditions: MDD/OMC	95/100	Surcharge (kg)	4.5
Retained on 19.0mm %	7	Entire Moisture Content %	29.1
Compactive Effort		Entire Moisture Ratio %	127.0
Mass of hammer kg	4.9	Top 30mm Moisture Content %	31.7
Number of layers	5	Top 30mm Moisture Ratio %	138.5
Number of blows/layer	15	Swell %	3.0
Conditions after Compaction		C.B.R. at 5.0 mm Penetration %	5
Dry Density t/m3	1.55	**Conditions after Soaking**	
Moisture Content %	22.4	Dry Density t/m3	1.50
Density Ratio %	95.5	Moisture Content %	24.5
Moisture Ratio %	97.5	Dry Density Ratio %	92.5
Soaked / Unsoaked	Soaked	Moisture Ratio %	107.0

Comments:



Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017

Approved Signature

Craig Hugo

Organic Content of Soils
ASTM: D 2974-07a Test Method C

Mining & Civil
Geotest Pty Ltd

9 Lerista Court, Bibra Lake WA 6164
Ph: (08) 9418 1873 Mob: 0412 427 245
Email:craig@mcgeotest.com.au

Job No:	60017
Report No:	60017-P16/2926
Sample No:	P16/2926-2928
Issue Date:	06-Oct-16

Client:	Mr B Versaci	**Date Tested:**	05-Oct-16
Project:	Proposed Residential Development	**Tested By:**	P.Culverston
Location:	Lot 34 Third Street, Harvey WA	**Checked:**	C. Hugo

Sample Number	Sample Description	Ash Content (%)	Organic Content (%)
P16/2926	TP1 0.4m	88.6	11.4
P16/2928	TP7 0.1m	87.0	13.0

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017

Sampling Procedure: Tested as received

Notes: Samples oven dried prior to test

Furnace temperature 440^{o}

Approved signature

Craig Hugo

Determination of the Shrinkage Index of a Soil
Shrink Swell Index (AS 1289.7.1.1)

Mining & Civil
Geotest Pty Ltd

9 Lerista Court, Bibra Lake WA 6164
Ph: (08) 9418 1873 Mob: 0412 427 245
Email:craig@mcgeotest.com.au

Job No:	**60017**
Report No:	**60017-P16/2677**
Sample No:	**P16/2677**
Issue Date:	**3/10/2016**

Client:	Mr B Versaci	**Sample Details**	TP8
Project:	Proposed Residential Development	**Sample Depth**	1.5 - 1.7
Location:	Lot 32 Third Street, Harvey WA		

Sample Details

Sample Description	Dark yellow sandy clay/clayey sand
Sample Type	Tube - U60

Swell Specimen

Dry Density - Initial ($t/m^{3)}$	1.55
Moisture Content - Initial (%)	24.4
Moisture Content - Final (%)	24.9
Overburden Pressure (kPa)	25.0
Inert Inclusions (%)	1.0%

Shrinkage Specimen

Moisture Content Initial (%)	24.1
Length/Diameter Ratio	2.5
Extent of Crumbling	Nil
Extent of Cracking	Cracking

Shrink Swell Index

I_{ss} = 2.8 % Vertical strain per pF change in Total suction

Client Address: 36 O'Malley Street, Osborne Park Western Australia 6017

Sampling Procedure: Tested as received

Notes:

Approved signature

Craig Hugo

Appendix D

Results of Acid Sulphate Soil Laboratory Testing

Table F-1: Summary of Soil Laboratory Results

Test Location	Sample ID	Depth (m)	Soil Description	Screening Tests[1]				SPOCAS Suite of Testing							
				pH_F	pH_{FOX}	Reaction[2] Strength	Δ pH[3]	pH_{KCl}	pH_{OX}	TAA[4] (%S)	TPA[5] (%S)	S_{POS}[6] (%S)	N_{RASS}[7] (%S)	ANC[8] (%S)	Net[9] Acidity (%S)
Assessment Criteria				**<4**	**<3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**>0.03**
TP1	1	0.5	ORGANIC CLAYEY SILT - brown black	7.0	4.2	low	2.8	-	-	-	-	-	-	-	-
TP1	2	1	SANDY SILTY CLAY - dark orange brown	6.9	4.0	low	2.9	-	-	-	-	-	-	-	-
TP1	3	1.5	SLIGHTLY CLAYEY SILTY SAND - brown	7.1	6.6	low	0.5	-	-	-	-	-	-	-	-
TP1	4	2	SLIGHTLY CLAYEY SILTY SAND - brown	6.5	**2.6**	low	3.9	5.8	5.5	0.012	0.016	0.014	NT	NT	0.026
TP1	5	2.5	SLIGHTLY CLAYEY SILTY SAND - brown	6.4	4.2	low	2.2	-	-	-	-	-	-	-	-
TP8	6	0.5	SANDY SILTY CLAY - dark orange brown	7.0	5.7	Medium	1.3	-	-	-	-	-	-	-	-
TP8	7	1	SANDY SILTY CLAY - dark orange brown	6.9	5.1	low	1.8	-	-	-	-	-	-	-	-
TP8	8	1.5	SANDY SILTY CLAY - dark orange brown	6.9	5.0	low	1.9	-	-	-	-	-	-	-	-
TP8	9	2	SANDY SILTY CLAY - dark orange brown	6.4	4.6	low	1.8	-	-	-	-	-	-	-	-
TP8	10	2.5	SANDY SILTY CLAY - dark orange brown	6.6	4.5	low	2.1	5.6	6.2	0.014	0.025	<0.005	NT	NT	0.016
TP7	11	0.5	SANDY SILTY CLAY - dark orange brown	6.5	5.0	low	1.5	-	-	-	-	-	-	-	-
TP7	12	1	SANDY SILTY CLAY - dark orange brown	6.5	4.8	low	1.7	-	-	-	-	-	-	-	-
TP7	13	1.5	SANDY SILTY CLAY - dark orange brown	6.5	4.6	low	1.9	-	-	-	-	-	-	-	-
TP7	14	2	SANDY SILTY CLAY - dark orange brown	5.4	3.7	low	1.7	5.2	5.6	0.033	0.051	<0.005	NT	NT	**0.036**
TP5	15	0.5	SANDY SILTY CLAY - dark orange brown	7.1	6.9	low	0.2	-	-	-	-	-	-	-	-
TP5	16	1	SANDY SILTY CLAY - dark orange brown	7.1	6.4	low	0.7	5.9	6	0.012	<0.01	<0.005	NT	NT	0.014
TP5	17	1.5	SANDY SILTY CLAY - dark orange brown	6.9	5.4	Medium	1.5	-	-	-	-	-	-	-	-
TP5	18	2	SANDY SILTY CLAY - dark orange brown	6.7	5.2	Medium	1.5	-	-	-	-	-	-	-	-
TP5	19	2.5	SANDY SILTY CLAY - dark orange brown	6.5	4.9	low	1.6	-	-	-	-	-	-	-	-

Note:

1. Screening Tests undertaken by MPL Laboratories
2. Low – indicates no or low effervescence in hydrogen peroxide;
   Moderate – indicates moderate effervescence in hydrogen peroxide;
   High – indicates vigorous effervescence in hydrogen peroxide.
3. Δ pH – pHF - pHFOX
4. TAA – titratable actual acidity
5. TPA – titratable peroxide acidity;
6. Spos – peroxide oxidisable sulphur
7. N_{RASS} – retained acidity (reported for pHkCl < 4.5)
8. ANC – acid neutralising capacity (reported for pHkCl > 6.5).
9. Net Acidity = TAA + Spos + NASS. (It should be noted that ANC is excluded as per WA Guidelines)

NT Not Tested

0.04 Exceedance of criteria.

Appendix E

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip, mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

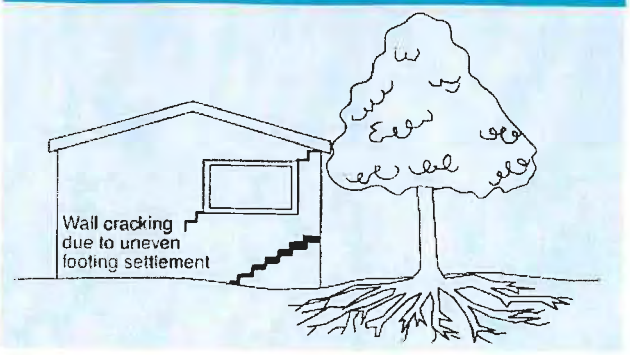
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

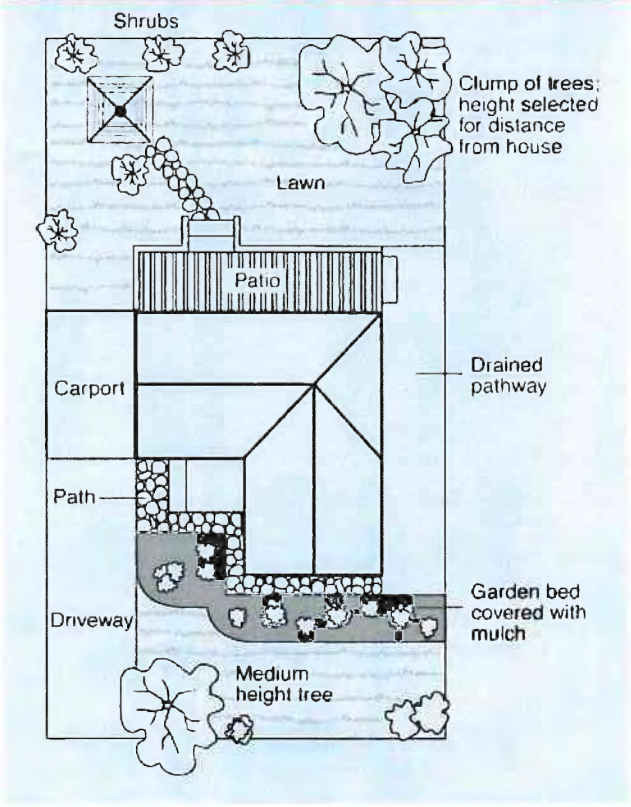
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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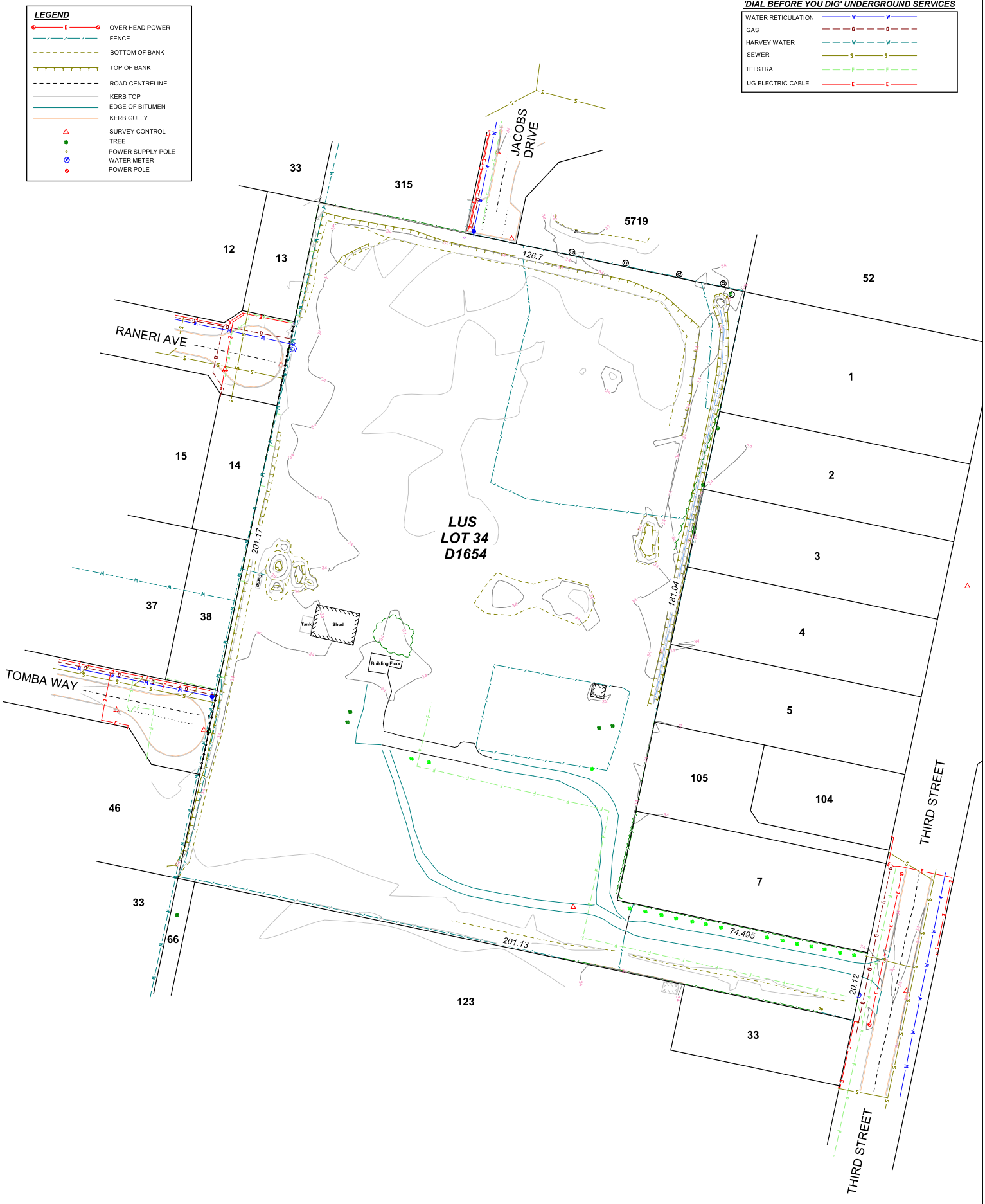
ATTACHMENT 2

GEOTECHNICAL AND PRELIMINARY ASS INVESTIGATION, DOUGLAS PARTNERS

ATTACHMENT 3

BCE SURVEYING, FEATURE SURVEY PLAN



CLIENT: B. VERSACI PTY LTD

SCALE: 0 10 20 30 40 50 60 70 80 90 100

REV	REV DATE	SURVEY DATE	DESCRIPTION	DRAWN	SURVEYOR	APPROVED
A	23/05/2016	12/05/2016	INITIAL ISSUE	D. QINGREN	D. QINGREN	T. LLOYD

COORDINATES
HORIZONTAL : PCG94
VERTICAL : AHD
CONTOUR INTERVAL : 0.5m
CAD FILE : E4714-03

NORTH POINT

DISCLAIMER
This plan has been prepared for building design only. The plan shows visible services & underground services based on DBYD information. Underground services should be located by the appropriate service authorities prior to any works.
Cadastral boundaries were NOT established during survey
Cadastral boundaries data come from Landgate
All dimensions shown are subject to final survey calculations and boundary re-establishment.

BCE SURVEYING

DETAIL SURVEY FOR LOT 34 ON D1654
THIRD STREET
HARVEY

JOB No. E4714
PLAN No. E4714-01
SCALE @A1: 1:500
SHEET: 1 of 1

B C E SURVEYING
LICENSED & ENGINEERING SURVEYING CONSULTANTS
BUNBURY
24 MOLLOY STREET
BUNBURY WA 6230
Ph:(08) 9791 7411
Fax:(08) 9791 9315
admin@bcesurveying.com.au
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SUITE 10, 7 KINTAIL ROAD
APPLECROSS WA 6153
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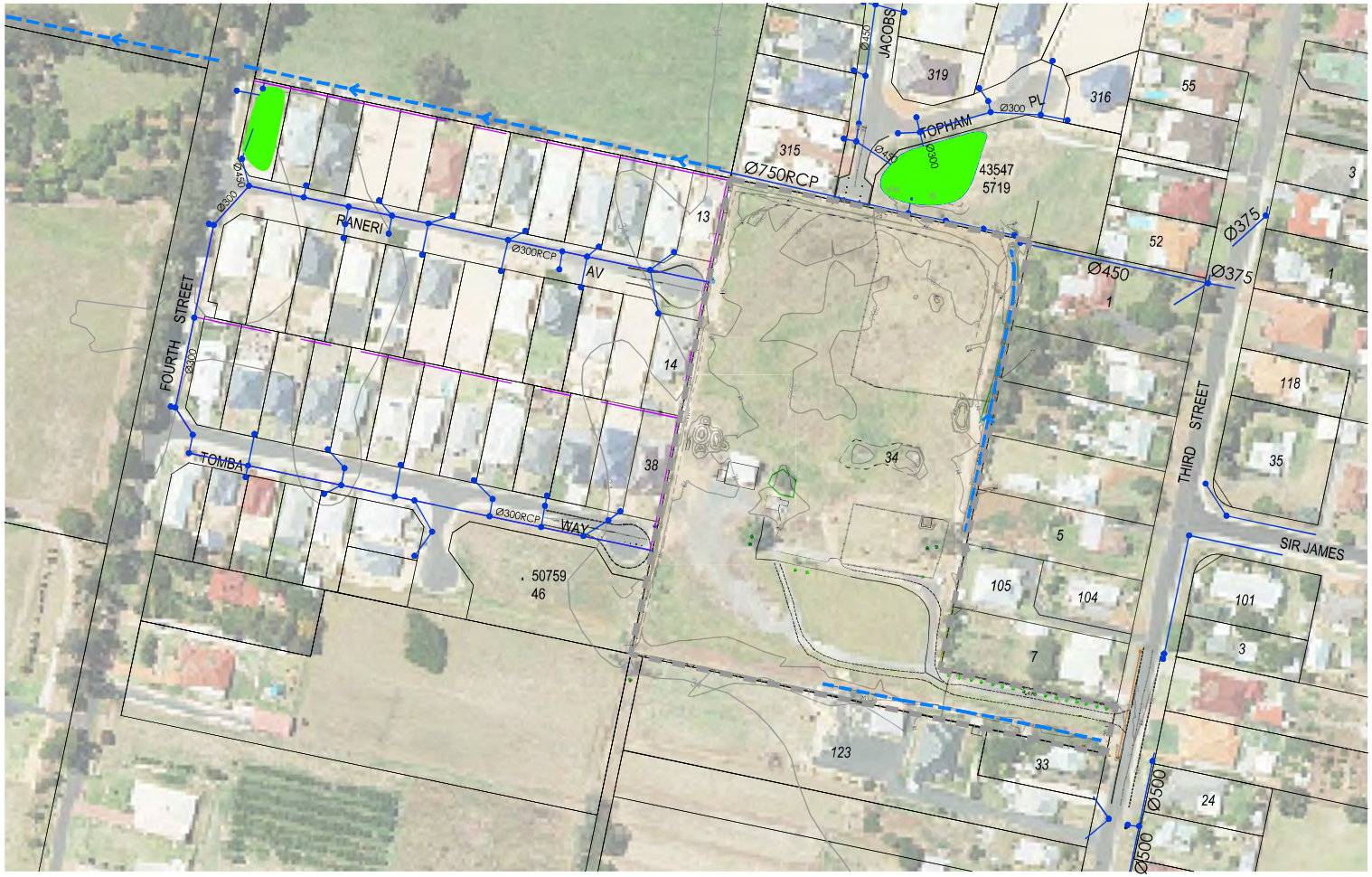
Fax:(08) 9364 6284
admin@bcesurveying.com.au



LEGEND

- EXISTING CONTOUR
- EXISTING OPEN DRAIN
- EXISTING STORMWATER PIT & PIPE
- DEVELOPMENT SITE
- 34 LOT NUMBER EXISTING
- EXISTING STORMWATER BASIN

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Do Not Scale

PIPPIN CIVIL ENGINEERING
PO Box 1837
BUNBURY WA 6231
Website: www.pipciveng.com.au
Telephone: 0488 910 222
Email: craig@pipciveng.com.au

Client: B. VERSACI
Project: LOT 34 THIRD STREET, HARVEY
Title: PRE DEVELOPMENT STORMWATER PLAN

Dwg No.: 1615-01
Revision A
Original Size: A3

ATTACHMENT 4
PRE DEVELOPMENT STORMWATER MANAGEMENT PLAN

ATTACHMENT 5

EXISTING STORMWATER INFRASTRUCTURE – SHIRE OF HARVEY

Shire of HARVEY

34 Third Street - Drainage

Wednesday, 10 August 2018

1:2751

N

NOTE

1. GENERAL

1.1. LEVELS ARE REDUCED FROM A.H.D

1.2. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH ALL DRAWINGS IN THIS SET AND THE SPECIFICATION.

1.3. THE CONTRACTOR SHALL LIMIT THE MOVEMENT OF EQUIPMENT AND MANPOWER TO THE MINIMUM AREA NECESSARY AND PROTECT ALL VEGETATION ON SITE.

2. STORMWATER DRAINAGE

2.1. DRAINAGE PIPES SHALL BE CLASS 2 UNLESS NOTED OTHERWISE.

2.2. PIPE ALIGNMENT SHALL BE 3.0m FROM THE ROAD RESERVE BOUNDARY UNLESS OTHERWISE AS SHOWN IN TABLE 2.

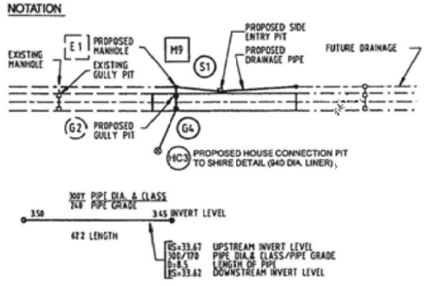
2.3. MANHOLE AND GULLY PITS SHALL BE LOCATED AT THE POSITIONS SHOWN IRRESPECTIVE OF THE PIPE LENGTHS SHOWN.

2.4. FOR CONSTRUCTION PURPOSES THE TENDERER SHALL MAKE HIS OWN ASSESSMENT OF GROUND WATER AND ITS LIKELY AFFECT ON THE WORKS AND MAKE ALL DUE ALLOWANCE IN THE LUMP SUM TENDER.

3. EXISTING SERVICES.

3.1 CONTRACTOR TO CHECK AND LOCATE THE HORIZONTAL POSITION & INVERT LEVEL OF ALL EXISTING SERVICES PRIOR TO CONSTRUCTION COMMENCING

NOTATION

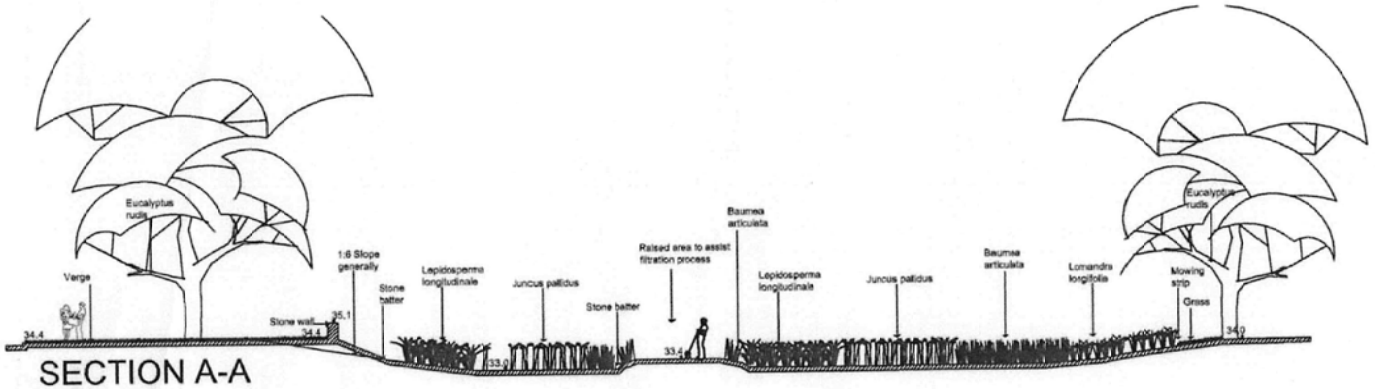


LEGEND

— 33.0 —	DESIGN CONTOURS
⇨	DIRECTION OF FLOW
30.72	DESIGN SPOT LEVEL
	EXISTING TREES TO BE PROTECTED & RETAINED
OPP	EXISTING POWER POLES
—O—D— —	EXISTING DRAINAGE AND ASSOCIATED PITS
—Φ—W—X—	EXISTING WATER MAIN & ASSOCIATED PITS
—O—T—	EXISTING TELSTRA & ASSOCIATED PITS (INCLUDING OPTIC FIBRES)
—G—	EXISTING GAS & ASSOCIATED PITS
—□—P—	EXISTING POWER & ASSOCIATED PITS
—I—	EXISTING COMMUNICATION (SWIFTEL, AAPT, VISIONSTREAM & AMCOM)
—S—	PROPOSED WATER CORPORATION SEWER
— — S — —	EXISTING WATER CORPORATION SEWER

30/12/07

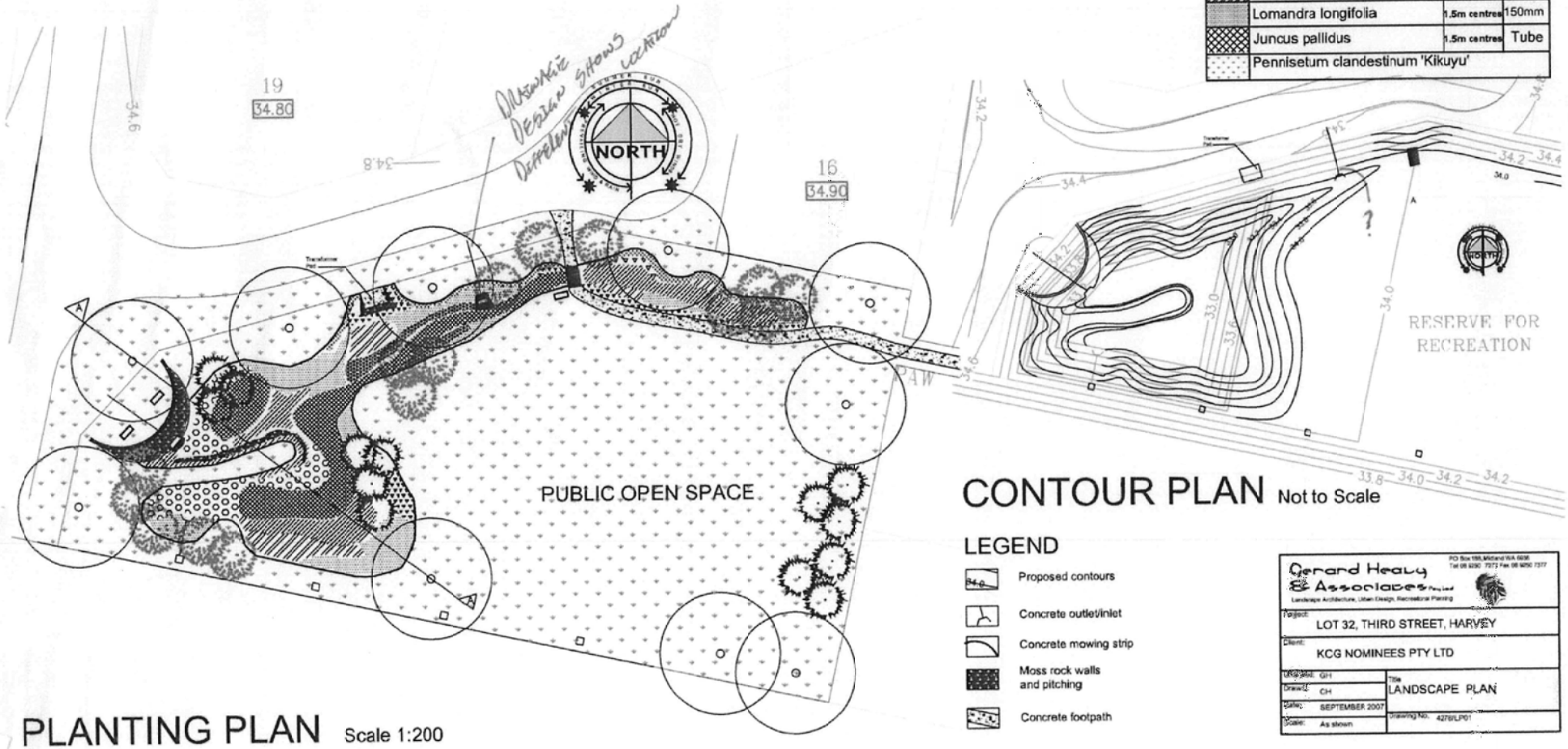
LOT 32 THIRD STREET HARVEY	MJB PAYNE CONSULTANTS CIVIL & STRUCTURAL ENGINEERING PROJECT MANAGEMENT	CLIENT KCG NOMINEESPTY. LTD. WAPC: 132781	DRAWING THIRD STREET, HARVEY DRAINAGE PLAN	06K7-35 D A1



SECTION A-A
Scale 1:100

PLANTING SCHEDULE

SYM	BOTANICAL NAME	C/S	SIZE
	Trees		
	Casuarina obesa (Swamp paperbark)	As Shown	15Lt
	Eucalyptus rudis (River Gum)	As Shown	45Lt
	Melaleuca raphiophylla (Swamp paperbark)	As Shown	15Lt
	Shrubs		
	Baumea articulata	1m centres	Tube
	Dianella 'Breeze'	8m centres	150mm
	Dianella 'cassia blue'	4m centres	150mm
	Lepidosperma longitudinale	1.2m centres	Tube
	Lomandra cassica	1.2m centres	150mm
	Lomandra longifolia	1.5m centres	150mm
	Juncus pallidus	1.5m centres	Tube
	Pennisetum clandestinum 'Kikuyu'		



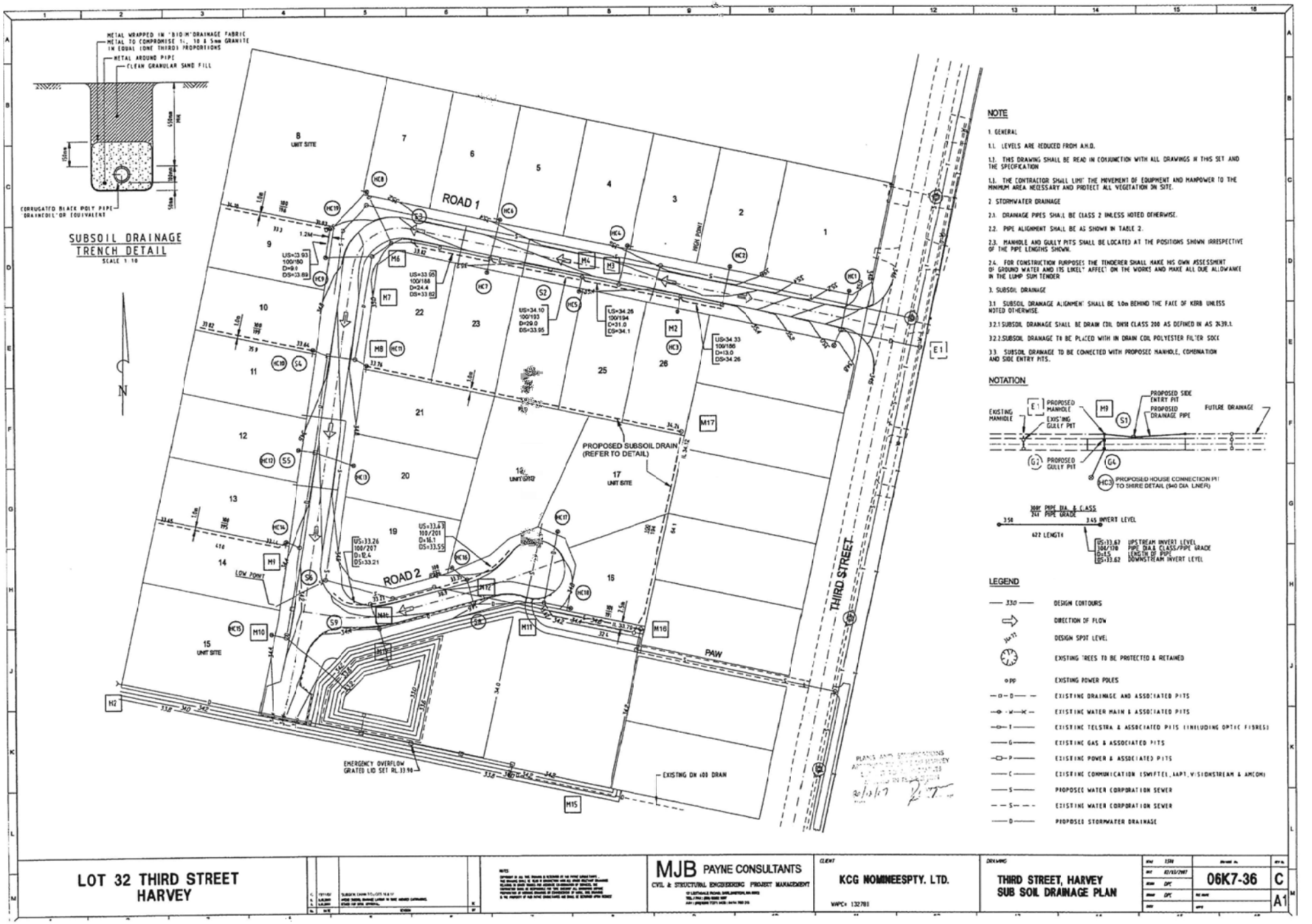
PLANTING PLAN
Scale 1:200

CONTOUR PLAN
Not to Scale

LEGEND
- Proposed contours
- Concrete outlet/inlet
- Concrete mowing strip
- Moss rock walls and pitching
- Concrete footpath

Gerard Healy & Associates Pty Ltd
PO Box 155, Midland WA 6936
Tel 08 9250 7373 Fax 08 9250 7377
Landscape Architecture, Urban Design, Recreational Planning

Project: LOT 32, THIRD STREET, HARVEY
Client: KCG NOMINEES PTY LTD
Designed: GH
Drawn: CH
Date: SEPTEMBER 2007
Scale: As shown
Title: LANDSCAPE PLAN
Drawing No. 4276/LP01



NOTE

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2. STORMWATER DRAINAGE

2.1. DRAINAGE PIPES SHALL BE CLASS 2 UNLESS NOTED OTHERWISE.

2.2. PIPE ALIGNMENT SHALL BE AS SHOWN IN TABLE 2.

2.3. MANHOLE AND GULLY PITS SHALL BE LOCATED AT THE POSITIONS SHOWN IRRESPECTIVE OF THE PIPE LENGTHS SHOWN.

2.4. FOR CONSTRUCTION PURPOSES THE TENDERER SHALL MAKE HIS OWN ASSESSMENT OF GROUND WATER AND ITS LIKELY AFFECT ON THE WORKS AND MAKE ALL DUE ALLOWANCE IN THE LUMP SUM TENDER

3. SUBSOIL DRAINAGE

3.1. SUBSOIL DRAINAGE ALIGNMENT SHALL BE 1.0m BEHIND THE FACE OF KERB UNLESS NOTED OTHERWISE.

3.2.1 SUBSOIL DRAINAGE SHALL BE DRAIN COIL DN 90 CLASS 200 AS DEFINED IN AS 2439.1.

3.2.2 SUBSOIL DRAINAGE TO BE PLACED WITH IN DRAIN COIL POLYESTER FILTER SOCK

3.3. SUBSOIL DRAINAGE TO BE CONNECTED WITH PROPOSED MANHOLE, COMBINATION AND SIDE ENTRY PITS.

NOTATION

LEGEND

- 330 — DESIGN CONTOURS
- DIRECTION OF FLOW
- 34.77 DESIGN SPOT LEVEL
- EXISTING TREES TO BE PROTECTED & RETAINED
- PP EXISTING POWER POLES
- EXISTING DRAINAGE AND ASSOCIATED PITS
- EXISTING WATER MAIN & ASSOCIATED PITS
- EXISTING TELSTRA & ASSOCIATED PITS (INCLUDING OPTIC FIBRES)
- EXISTING GAS & ASSOCIATED PITS
- EXISTING POWER & ASSOCIATED PITS
- EXISTING COMMUNICATION (SWIFTEL, AAPT, VISIONSTREAM & AMCOM)
- PROPOSED WATER CORPORATION SEWER
- EXISTING WATER CORPORATION SEWER
- PROPOSED STORMWATER DRAINAGE

PLANS AND SPECIFICATIONS APPROVED BY SHIRE OF HARVEY SUBJECT TO ... 20/12/07

LOT 32 THIRD STREET HARVEY

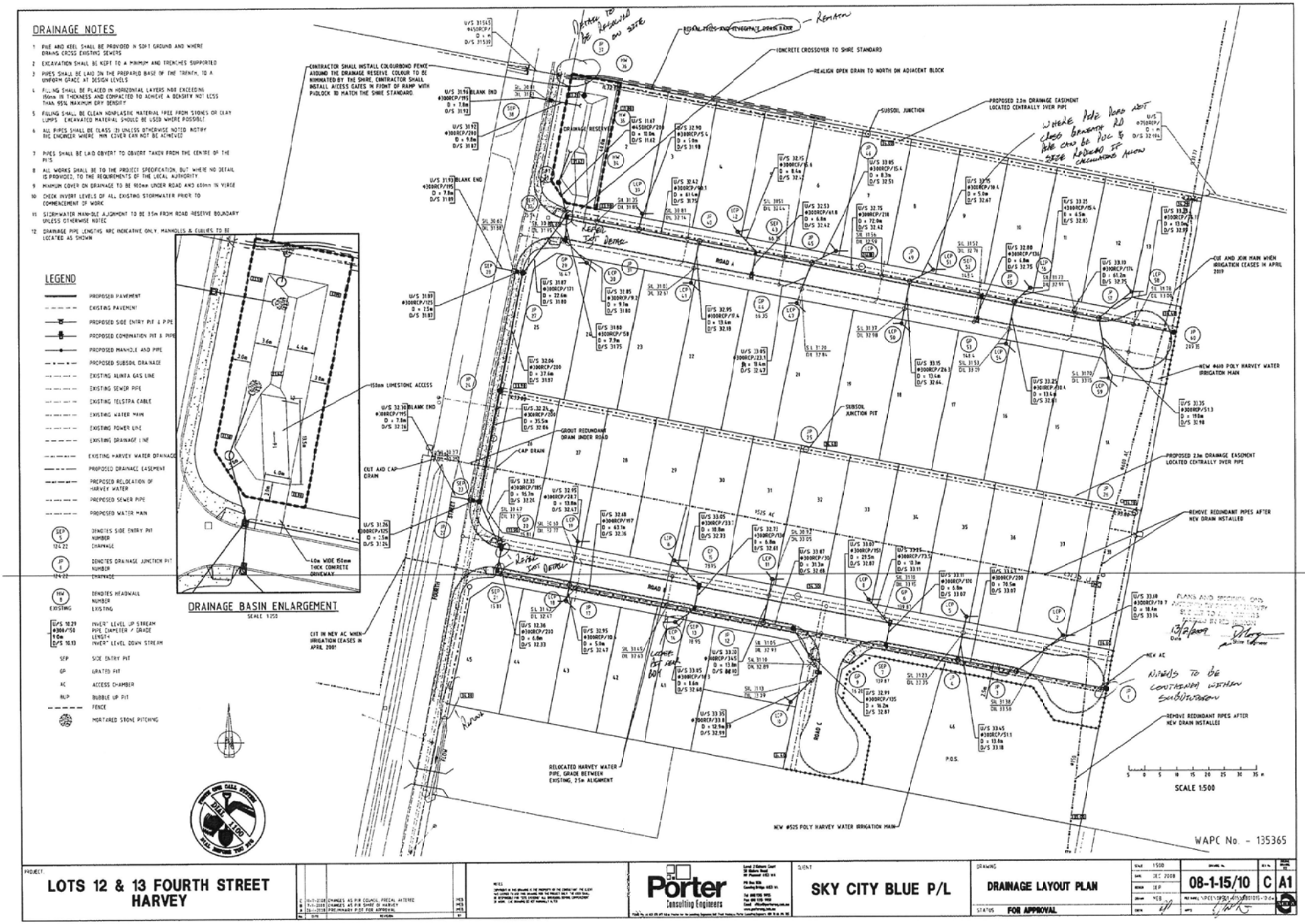
MJB PAYNE CONSULTANTS
CIVIL & STRUCTURAL ENGINEERING PROJECT MANAGEMENT

CLIENT: KCG NOMINEESPTY. LTD.
WAPC# 132781

DRAWING: THIRD STREET, HARVEY SUB SOIL DRAINAGE PLAN

DRAWN: ESH 02/12/2007
DESIGN: DPC
CHECK: DPC
DATE:

DRAWING No. 06K7-36
REV No. C
A1


DRAINAGE NOTES
1 PAE AND KEEL SHALL BE PROVIDED IN SOFT GROUND AND WHERE DRAINS CROSS EXISTING SEWERS
2 EXCAVATION SHALL BE KEPT TO A MINIMUM AND TRENCHES SUPPORTED
3 PIPES SHALL BE LAID ON THE PREPARED BASE OF THE TRENCH, TO A UNIFORM GRADE AT DESIGN LEVELS
4 FILLING SHALL BE PLACED IN HORIZONTAL LAYERS NOT EXCEEDING 150mm IN THICKNESS AND COMPACTED TO ACHIEVE A DENSITY NOT LESS THAN 95% MAXIMUM DRY DENSITY
5 FILLING SHALL BE CLEAN NONPLASTIC MATERIAL FREE FROM STONES OR CLAY LUMPS EXCAVATED MATERIAL SHOULD BE USED WHERE POSSIBLE
6 ALL PIPES SHALL BE CLASS 2D UNLESS OTHERWISE NOTED NOTIFY THE ENGINEER WHERE MIN COVER CAN NOT BE ACHIEVED
7 PIPES SHALL BE LAID OBVERT TO OBVERT TAKEN FROM THE CENTRE OF THE PITS
8 ALL WORKS SHALL BE TO THE PROJECT SPECIFICATION, BUT WHERE NO DETAIL IS PROVIDED, TO THE REQUIREMENTS OF THE LOCAL AUTHORITY
9 MINIMUM COVER ON DRAINAGE TO BE 900mm UNDER ROAD AND 600mm IN VERGE
10 CHECK INVERT LEVELS OF ALL EXISTING STORMWATER PRIOR TO COMMENCEMENT OF WORK
11 STORMWATER MANHOLE ALIGNMENT TO BE 3.5m FROM ROAD RESERVE BOUNDARY UNLESS OTHERWISE NOTED
12 DRAINAGE PIPE LENGTHS ARE INDICATIVE ONLY. MANHOLES & CUBLES TO BE LOCATED AS SHOWN
LEGEND
PROPOSED PAVEMENT
EXISTING PAVEMENT
PROPOSED SIDE ENTRY PIT & PIPE
PROPOSED COMBINATION PIT & PIPE
PROPOSED MANHOLE AND PIPE
PROPOSED SUBSOIL DRAINAGE
EXISTING ALINTA GAS LINE
EXISTING SEWER PIPE
EXISTING TELSTRA CABLE
EXISTING WATER MAIN
EXISTING POWER LINE
EXISTING DRAINAGE LINE
EXISTING HARVEY WATER DRAINAGE
PROPOSED DRAINAGE EASEMENT
PROPOSED RELOCATION OF HARVEY WATER
PROPOSED SEWER PIPE
PROPOSED WATER MAIN
DENOTES SIDE ENTRY PIT NUMBER
DENOTES DRAINAGE JUNCTION PIT NUMBER
DENOTES HEADWALL NUMBER EXISTING
INVERT LEVEL UP STREAM PIPE DIAMETER / GRADE LENGTH INVERT LEVEL DOWN STREAM
SEP SIDE ENTRY PIT
GP GRATED PIT
AC ACCESS CHAMBER
MLP BUBBLE UP PIT
FENCE
MORTARED STONE PITCHING
DRAINAGE BASIN ENLARGEMENT
SCALE 1:250
CONTRACTOR SHALL INSTALL COLOURBOND FENCE AROUND THE DRAINAGE RESERVE COLOUR TO BE NOMINATED BY THE SHIRE, CONTRACTOR SHALL INSTALL ACCESS GATES IN FRONT OF RAMP WITH PADLOCK TO MATCH THE SHIRE STANDARD.
DRAINAGE RESERVE
CONCRETE CROSSOVER TO SHIRE STANDARD
REALIGN OPEN DRAIN TO NORTH ON ADJACENT BLOCK
PROPOSED 2.0m DRAINAGE EASEMENT LOCATED CENTRALLY OVER PIPE
SUBSOIL JUNCTION
ROAD A
ROAD B
ROAD C
FOURTH STREET
150mm LIMESTONE ACCESS
GROUT REDUNDANT DRAIN UNDER ROAD
CAP DRAIN
CUT AND CAP DRAIN
SUBSOIL JUNCTION PIT
CUT IN NEW AC WHEN IRRIGATION CEASES IN APRIL 2009
CUT AND JOIN MAIN WHEN IRRIGATION CEASES IN APRIL 2019
NEW Ø610 POLY HARVEY WATER IRRIGATION MAIN
REMOVE REDUNDANT PIPES AFTER NEW DRAIN INSTALLED
NEEDS TO BE CONSTRUCTED WITHIN SUBDIVISION
RELOCATED HARVEY WATER PIPE, GRADE BETWEEN EXISTING, 25m ALIGNMENT
NEW Ø525 POLY HARVEY WATER IRRIGATION MAIN
P.O.S.
SCALE 1:500
WAPC No. - 135365
PROJECT
LOTS 12 & 13 FOURTH STREET HARVEY
C 10-11-2008 CHANGES AS PER COUNCIL PRECAL ATTEND
B 7-11-2008 CHANGES AS PER SHIRE OF HARVEY
A 28-10-2008 PRELIMINARY PLOT FOR APPROVAL
Porter Consulting Engineers
CLIENT
SKY CITY BLUE P/L
DRAWING
DRAINAGE LAYOUT PLAN
STATUS FOR APPROVAL
SCALE 1500
DATE DEC 2008
DESIGN DEP
DRAWN MEB
CHECK
08-1-15/10
C
A1

LEGEND

- EXISTING CONTOUR
- EXISTING OPEN DRAIN
- SURFACE WATER (10/8/16)
- DEVELOPMENT SITE
- EXISTING STORMWATER BASIN
- 34 EXISTING LOT NUMBER
- EXISTING SUBSOIL PIT & PIPE
- 33.4 GROUNDWATER LEVEL AT 21/9/16
- TP5 ■ GEOTECHNICAL TEST PIT, REFER DOUGLAS PARTNERS REPORT

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Client: B. VERSACI
Project: LOT 34 THIRD STREET, HARVEY
Title: PRE DEVELOPMENT GROUNDWATER PLAN
Dwg No.: 1615-02
Revision A
Original Size: A3

ATTACHMENT 6
PRE DEVELOPMENT GROUNDWATER PLAN

ATTACHMENT 7

ENGINEERING INFORMATION SHEET ES1 – SHIRE OF HARVEY

Engineering Information Sheet
(ES1)

Stormwater Management for Residential Properties

As outlined in the Local Government Act it is the landowner's responsibility to confine all stormwater runoff from buildings or hard stand (impervious) areas within your property boundary.

When designing the stormwater management for your property you also need to consider the natural flow of stormwater across your land to ensure these flows will not impact on building structures.

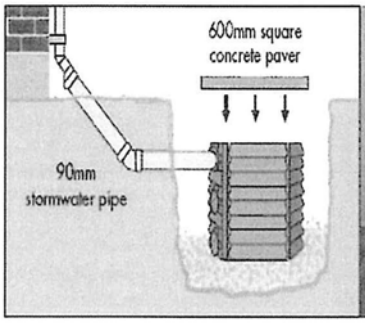
For properties that are located on sandy free draining soils (e.g. Australind / Binningup / Myalup) and/or properties greater than 1000m2

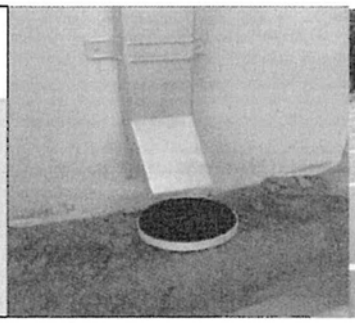
You are required to contain all stormwater on site. The required amount of storage to be provided is 1m3 per 65m2 of impervious area (e.g. roof and paved areas). This storage can be achieved by many different methods including; soakwells, rainwater tanks that have stormwater storage availability, rain gardens and rainwater detention systems that are plumbed into the house (e.g. laundry / toilet)

As a guide soakwells are to be located a minimum of 1.5m away from buildings and from rear or side boundaries (owner's responsibility to located appropriately).

Please note that during large rain events this storage capacity may be exceeded, thus when designing your stormwater management system you need to consider having safe overland flood routes away from buildings and adjoining properties.

The Shire also recommends that your gutter and downpipes have an overflow relief in the event of a blockage in the stormwater system. This can be achieved by not having the downpipe directly connected to the below ground stormwater pipes. (Refer picture)





Typical Soakwell **Overflow Relief** **Rain Garden**

For properties in clay or unsuitable ground conditions (i.e. Harvey or Brunswick)

You are permitted to discharge your stormwater into the Shire of Harvey drainage network (if available) subject to you providing stormwater detention of 1m3 of storage per 100m2 of impervious area.

The detention facilities are required so that temporary storage of runoff is allowed for in your property, and so that your stormwater is discharged into the Shire drainage network at a rate that can be accommodated by the system.

The last storage pit that your stormwater passes through before it enters the Shire of Harvey's drainage network is to have a minimum 150mm deep silt trap (refer typical detail).

Overflow relief should be provided in the event of a blockage in the stormwater system. This can be achieved by not having the downpipe directly connected to the below ground stormwater pipes (Refer picture).

In most newly developed subdivisions where the Shire will permit discharge into our stormwater system, typically a house drainage connection point will have been provided within your property boundary. The owner/builder can complete all requirements including connection as outlined above and the Shire will inspect at the building completion inspection.

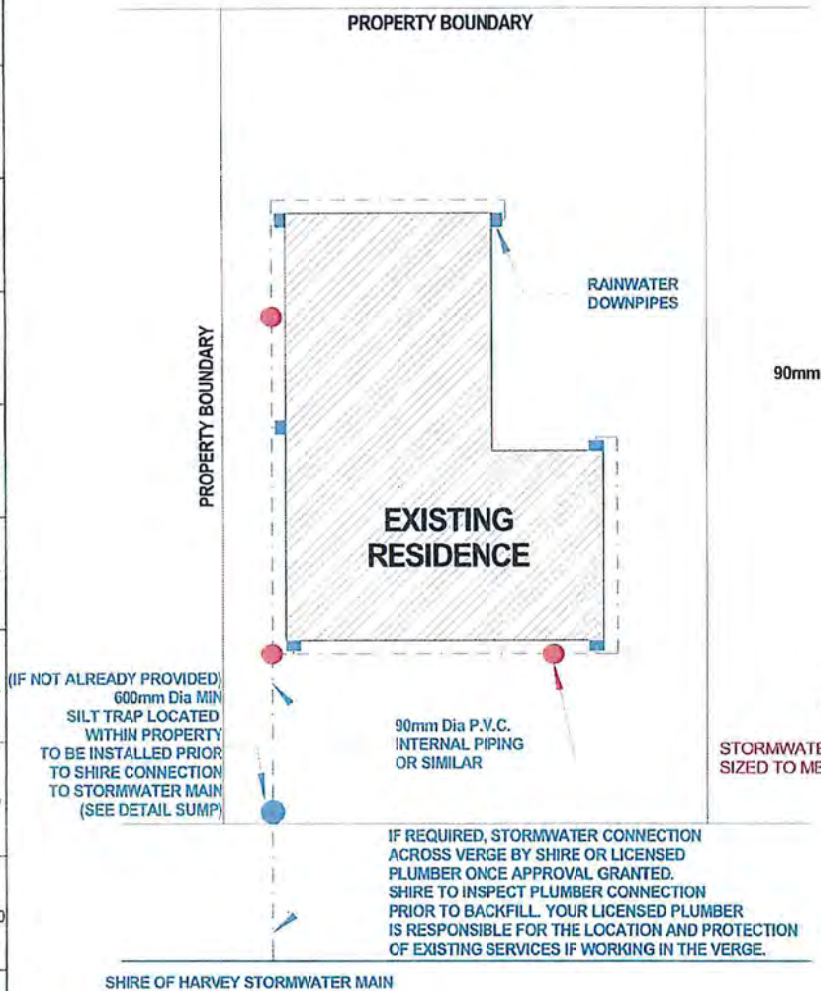
If no connection point has been provided connection can be made to the Shire of Harvey's drainage network (if available) by paying the Shire to make the connection or by engaging a licensed plumber to do the works. Prior to these works commencing the attached application form needs to be completed and the required fee amount paid to the Shire. Once approval has been received from the Shire your works can proceed as per the requirements on the application form and standard detail sheet.

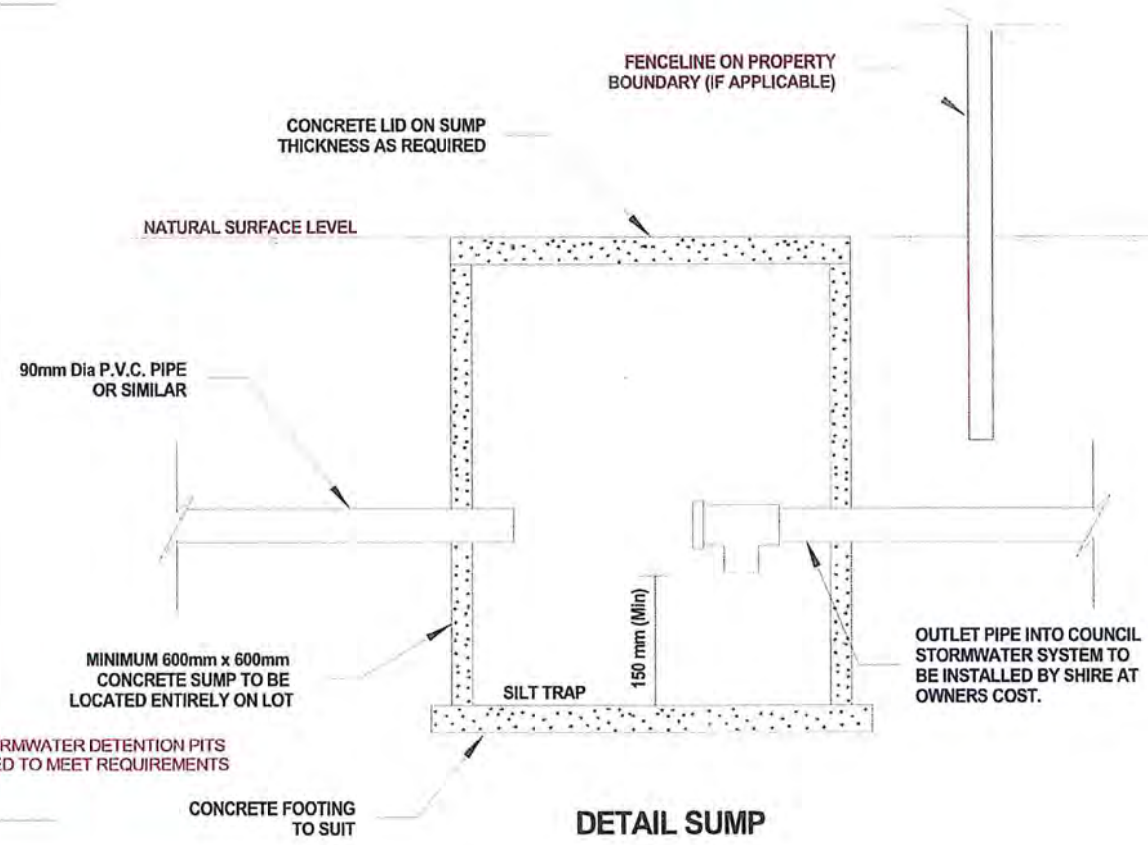
If an alternate stormwater management system is proposed, the owner will be required to submit detail plans for written approval from the Shire prior to construction commencing.

For any further Information please contact the Shire on 9729 0360 or via email shire@harvey.wa.gov.au

NOTE:

DRAINAGE CONNECTION
MAY BE AT SIDE OR REAR
BOUNDARY IN SOME AREAS





DETAIL SUMP

Shire of HARVEY
A Breath of Fresh Air

SHIRE OF HARVEY
P.O.BOX 500
HARVEY, 6220
TELEPHONE (08) 9729 0300
FACSIMILE (08) 9729 2053

STANDARD DETAIL FOR THE CONNECTION OF STORMWATER INTO SHIRE DRAINAGE NETWORK

DESIGNED:	DATUM: ASSUMED	DRAWING No: 00-124	HOR. SCALE : N/A
DRN: L.R.F	DATE : 8/9/2000	REVISION No: N/A	VERT. SCALE N/A
REVISED: D.M	DATE : 12/5/2011	GEOCOMP JOB No:	

Shire of HARVEY

A Breath of Fresh Air

APPLICATION FOR VERGE STORMWATER CONNECTION

Name of Applicant: _____

Address: _____

Phone Number: _____

LOCATION: Lot Number: _____ Street Number: _____

Street: _____ District/Locality: _____

Owner's Name: _____

Please tick which is applicable

☐ Shire of Harvey to make connection from owner/builder installed silt trap in approved location to Shire drainage network. Fee to be paid $440.

☐ Licensed plumber to make connection as per Shire requirements. Fee to be paid $44

Please provide sketch showing proposed verge connection location in relation to property boundaries, house and driveway locations.

I hereby apply to connect to the Shire of Harvey stormwater system and agree to comply with the conditions of this approval and the requirements as outlined on the Engineering Information Sheet (ES1).

SIGNATURE OF APPLICANT: _____ DATE: _____

OFFICE USE ONLY:

DATE APPROVED: _____

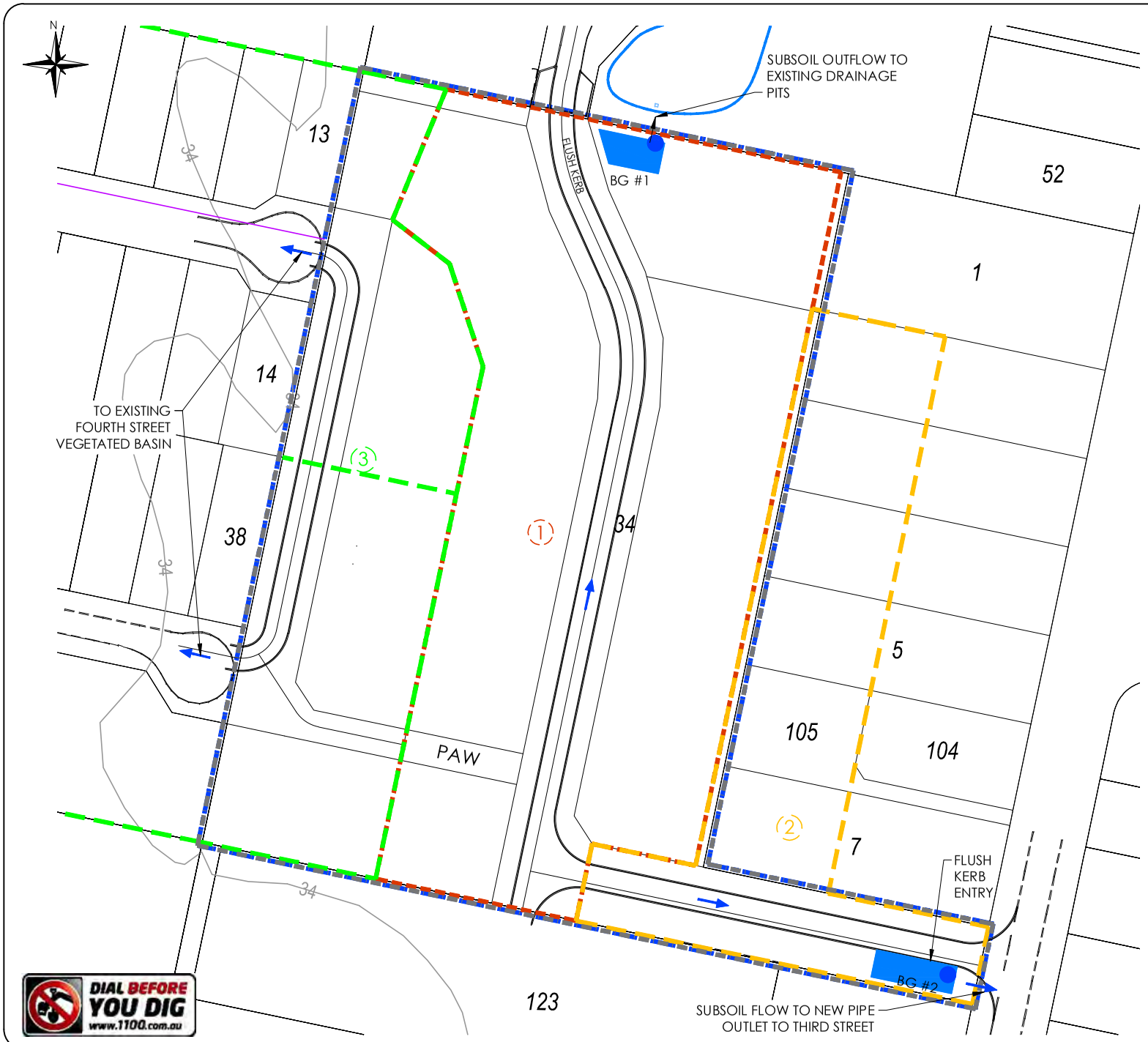
DATE INVOICE RAISED: _____

DATE PAID: _____ REC. NO: _____

SIGNATURE: _____

ASSESS NO: _____ COMPUTER UPDATED: _____

ATTACHMENT 8
ENVIRONMENTAL (1 YEAR) STORM EVENT STRATEGY



CATCHMENT 1 - BG#1

ROAD RESERVE	=	0.3488.ha
AREA IMPERVIOUS	=	0.28ha
BIORETENTION BASIN VOL REQ	=	41.8m³
BIORETENTION BASIN AREA REQ @ 0.35m DEPTH	=	119m²

CATCHMENT 2 - BG#2

ROAD RESERVE	=	0.2081ha
AREA IMPERVIOUS	=	0.17ha
BIORETENTION BASIN VOL REQ	=	25m³
BIORETENTION BASIN AREA REQ @ 0.35m DEPTH	=	71m²

CATCHMENT 3

ROAD RESERVE AREA	=	0.2281ha
AREA IMPERVIOUS	=	0.032ha
BIORETENTION BASIN VOL REQ	=	4.85m³

OUTLET TO EXISTING FOURTH STREET BASIN

LEGEND

- DEVELOPMENT BOUNDARY
- CATCHMENT 1 BOUNDARY
- CATCHMENT 2 BOUNDARY
- CATCHMENT 3 BOUNDARY
- STORMWATER FLOW
- BIORETENTION GARDEN
- OUTLET PIT

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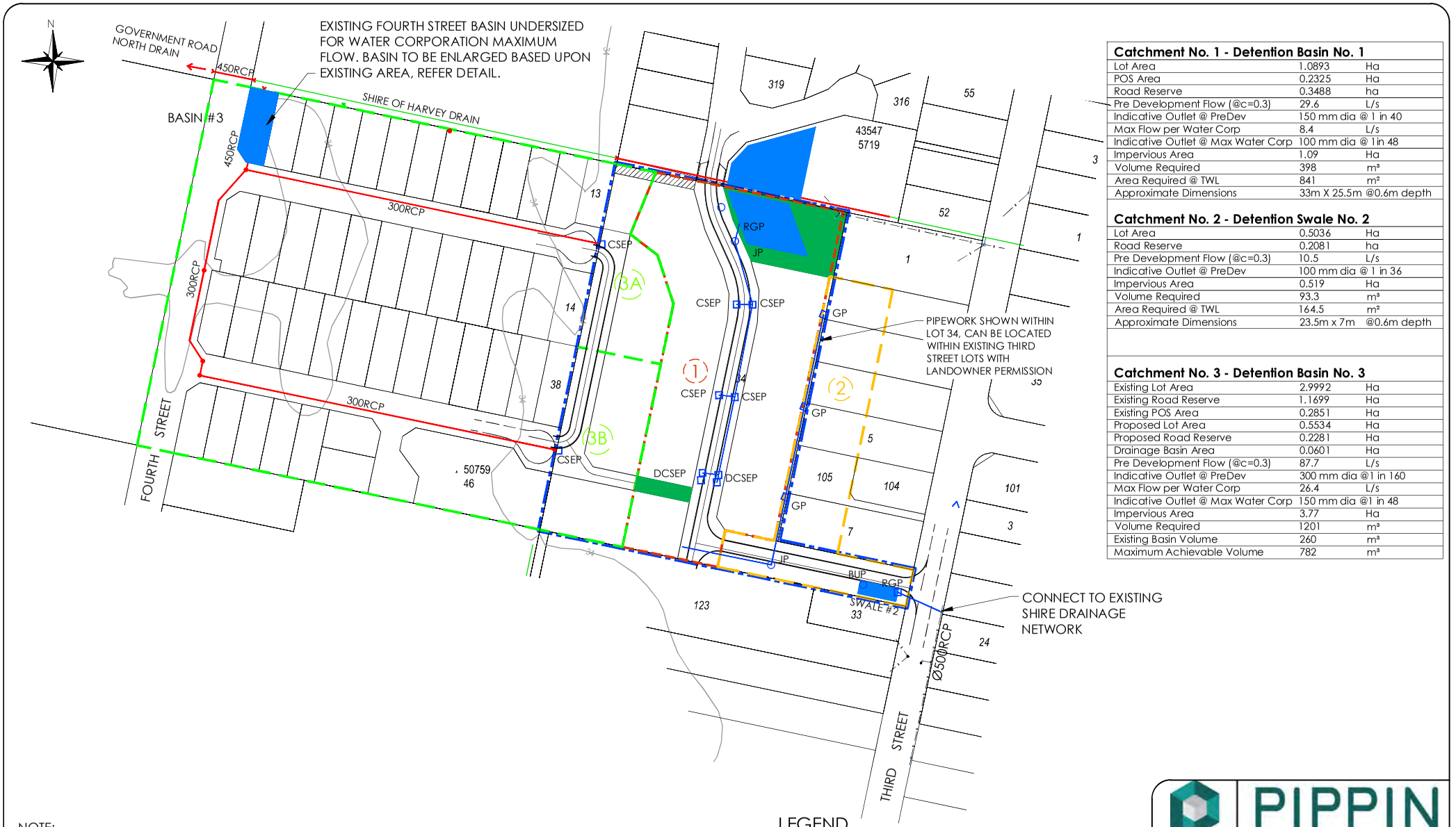
Telephone: 0488 910 222
Email: craig@pipciveng.com.au
Website: www.pipciveng.com.au

Client: B. VERSACI
Project: LOT 34 THIRD STREET, HARVEY
Title: ENVIRONMENTAL STORMWATER MANAGEMENT STRATEGY
Dwg No.: 1615-07
Revision C
Original Size: A3

ATTACHMENT 9
LARGE (20% AEP) STORM EVENT STRATEGY



Catchment No. 1 - Detention Basin No. 1		
Lot Area	1.0893	Ha
POS Area	0.2325	Ha
Road Reserve	0.3488	ha
Pre Development Flow (@c=0.3)	29.6	L/s
Indicative Outlet @ PreDev	150 mm dia @ 1 in 40	
Max Flow per Water Corp	8.4	L/s
Indicative Outlet @ Max Water Corp	100 mm dia @ 1in 48	
Impervious Area	1.09	Ha
Volume Required	398	m³
Area Required @ TWL	841	m²
Approximate Dimensions	33m X 25.5m	@0.6m depth

Catchment No. 2 - Detention Swale No. 2		
Lot Area	0.5036	Ha
Road Reserve	0.2081	ha
Pre Development Flow (@c=0.3)	10.5	L/s
Indicative Outlet @ PreDev	100 mm dia @ 1 in 36	
Impervious Area	0.519	Ha
Volume Required	93.3	m³
Area Required @ TWL	164.5	m²
Approximate Dimensions	23.5m x 7m	@0.6m depth

Catchment No. 3 - Detention Basin No. 3		
Existing Lot Area	2.9992	Ha
Existing Road Reserve	1.1699	Ha
Existing POS Area	0.2851	Ha
Proposed Lot Area	0.5534	Ha
Proposed Road Reserve	0.2281	Ha
Drainage Basin Area	0.0601	Ha
Pre Development Flow (@c=0.3)	87.7	L/s
Indicative Outlet @ PreDev	300 mm dia @1 in 160	
Max Flow per Water Corp	26.4	L/s
Indicative Outlet @ Max Water Corp	150 mm dia @1 in 48	
Impervious Area	3.77	Ha
Volume Required	1201	m³
Existing Basin Volume	260	m³
Maximum Achievable Volume	782	m³

NOTE:
ALL PROPOSED LOTS TO BE PROVIDED WITH LOT CONNECTIONS VIA PIT AND PIPE CONNECTION TO SHIRE STANDARD.
ALL LOTS TO DETAIN STORMWATER ON SITE AT 1m³ PER 100m² WITH A MAXIMUM Ø150 OUTLET PIPE.
(LOT CONNECTIONS NOT SHOWN ON THIS PLAN)

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LEGEND
- EXISTING STORMWATER INFRASTRUCTURE
- CATCHMENT 1 BOUNDARY
- CATCHMENT 2 BOUNDARY
- CATCHMENT 3 BOUNDARY
- CONCEPTUAL STORMWATER PIT AND PIPE NETWORK
- DETENTION BASINS
- PUBLIC OPEN SPACE
- DRAINAGE RESERVE

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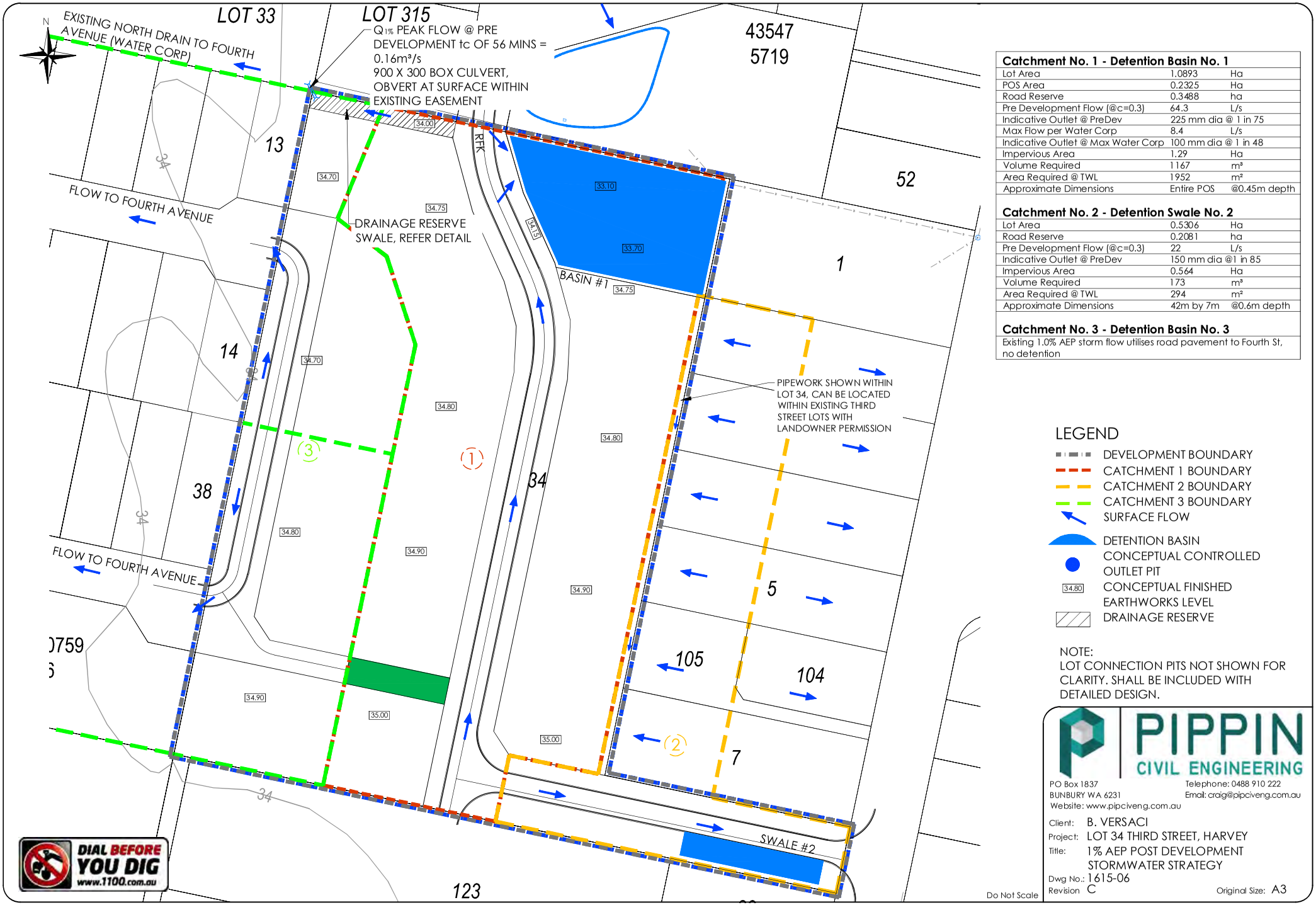
Client: B. VERSACI
Project: LOT 34 THIRD STREET, HARVEY
Title: 20% AEP POST DEVELOPMENT STORMWATER STRATEGY
Dwg No.: 1615-05
Revision C
Original Size: A3

ATTACHMENT 10
EXTREME (1.0% AEP) STORM EVENT STRATEGY



Catchment No. 1 - Detention Basin No. 1		
Lot Area	1.0893	Ha
POS Area	0.2325	Ha
Road Reserve	0.3488	ha
Pre Development Flow (@c=0.3)	64.3	L/s
Indicative Outlet @ PreDev	225 mm dia @ 1 in 75	
Max Flow per Water Corp	8.4	L/s
Indicative Outlet @ Max Water Corp	100 mm dia @ 1 in 48	
Impervious Area	1.29	Ha
Volume Required	1167	m³
Area Required @ TWL	1952	m²
Approximate Dimensions	Entire POS	@0.45m depth

Catchment No. 2 - Detention Swale No. 2		
Lot Area	0.5306	Ha
Road Reserve	0.2081	ha
Pre Development Flow (@c=0.3)	22	L/s
Indicative Outlet @ PreDev	150 mm dia @1 in 85	
Impervious Area	0.564	Ha
Volume Required	173	m³
Area Required @ TWL	294	m²
Approximate Dimensions	42m by 7m	@0.6m depth

Catchment No. 3 - Detention Basin No. 3

Existing 1.0% AEP storm flow utilises road pavement to Fourth St, no detention

LEGEND

- DEVELOPMENT BOUNDARY
- CATCHMENT 1 BOUNDARY
- CATCHMENT 2 BOUNDARY
- CATCHMENT 3 BOUNDARY
- SURFACE FLOW
- DETENTION BASIN
- CONCEPTUAL CONTROLLED OUTLET PIT
- 34.80 CONCEPTUAL FINISHED EARTHWORKS LEVEL
- DRAINAGE RESERVE

NOTE:
LOT CONNECTION PITS NOT SHOWN FOR CLARITY. SHALL BE INCLUDED WITH DETAILED DESIGN.

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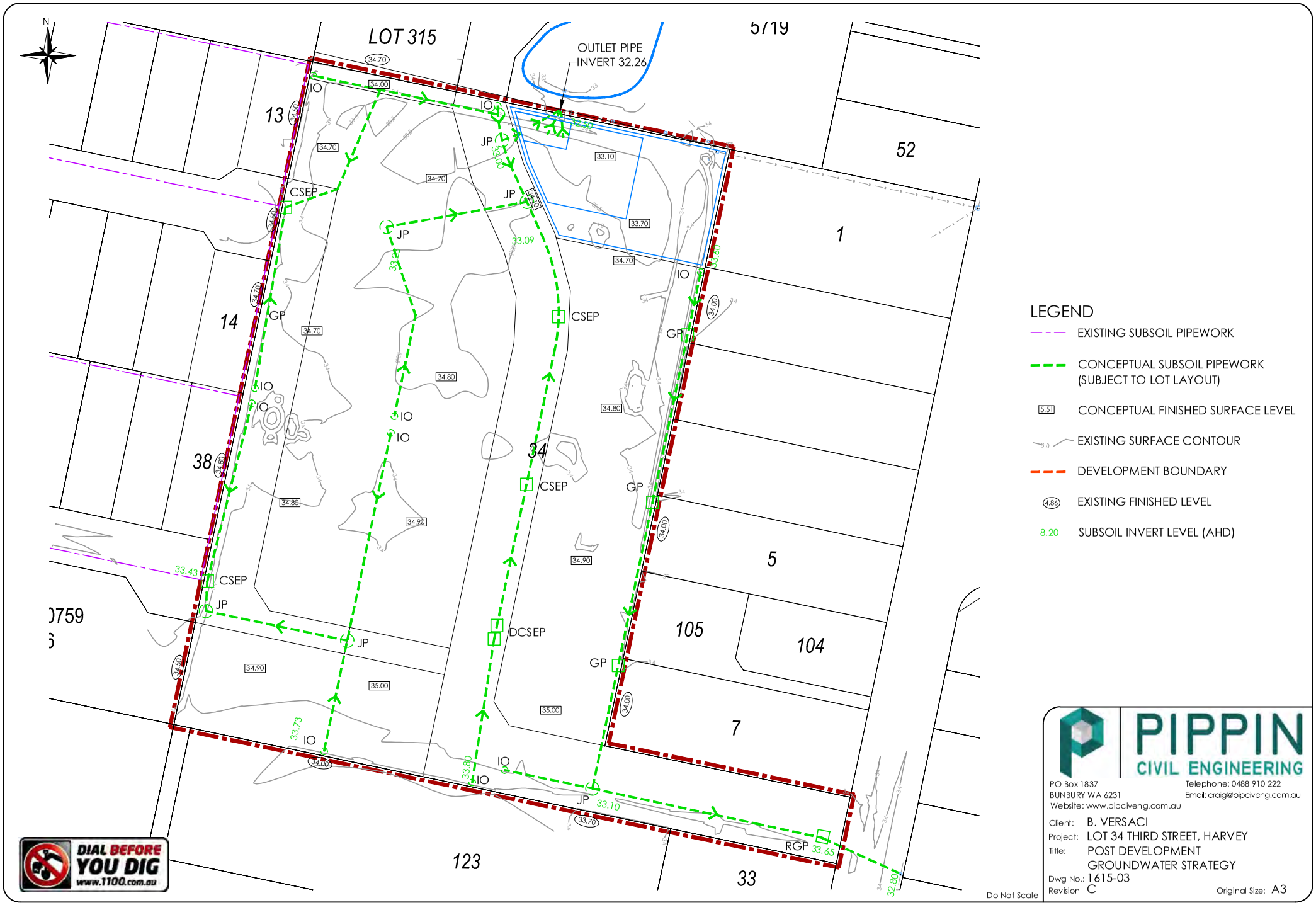
Client: B. VERSACI
Project: LOT 34 THIRD STREET, HARVEY
Title: 1% AEP POST DEVELOPMENT STORMWATER STRATEGY
Dwg No.: 1615-06
Revision C
Original Size: A3

ATTACHMENT 11
POST DEVELOPMENT GROUNDWATER STRATEGY



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Client: B. VERSACI
Project: LOT 34 THIRD STREET, HARVEY
Title: POST DEVELOPMENT GROUNDWATER STRATEGY
Dwg No.: 1615-03
Revision C
Original Size: A3