Appendix A

Trenchless Construction Techniques Analysis

Water Corporation

Trenchless Construction Techniques Analysis
Balannup Pressure Main

September 2013

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Executive Summary

In order to continue to service the rapidly growing Balannup (Southern) corridor between Armadale Rd and Ranford Rd the Water Corporation needs to construct 4.5km of sewerage pipeline to connect Collared Rd Pump Station (PS) in Harrisdale to Water Works Rd PS in Haynes.

Of the 4.5km of sewerage pipeline needed, 1.5km traverses a ‘Bush Forever’ area. Alternative paths for the pipeline which avoid the ‘Bush Forever’ area are not feasible due to the vicinity of major transport routes and severe congestion of existing underground services.

In order to minimise the environmental impact of constructing the pipeline through the ‘Bush Forever’ area the Water Corporation is seeking to utilise a ‘Trenchless’ construction technique. This report represents the outcome of an investigation into the most suitable technique.

A wide range of ‘Trenchless’ techniques have been evaluated. All but one technique have been eliminated due to either a requirement for some excavation within the ‘Bush Forever’ area or due to the resultant pipeline being unsuitable for operation by the Water Corporation.

Use of ‘Ploughing’ technology is recommended as the least invasive and most suitable of existing ‘Trenchless’ techniques. A ‘Plough’ can install a DN-450 pipe through the ‘Bush Forever’ area along an existing cleared track without the requirement for any clearing or dewatering. The pipe can be installed at a constant grade and at a suitable depth with no ongoing operational or environmental risks.

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1. Introduction

1.1 Background

Water Corporation is planning a Mechanical and Electrical upgrade of the Collared Street Wastewater Sewerage Pump Station (WWPS) and to construct a new pressure main along Keane Road to the Waterworks Road WWPS in Haynes. See Water Corporation's sketch of pipeline route at Appendix A.

GHD has been commissioned to carry out the Engineering and Detailed Design for the project.

The chosen alignment of the proposed pressure main along Keane Road passes through a 'Bush Forever' conservation area. The local government authority, City of Armadale, has a road reserve located across the 'Bush Forever' land. A recent proposal by City of Armadale to construct a sealed road within the road reserve has been deferred by the regulatory authorities.

Alternative alignments along Skeet Road and Armadale or Ranford Road have been ruled out by the Water Corporation because of severe congestion of existing underground services and high volume traffic corridors.

There is understandably strong pressure from community groups and environmental regulators for preservation of the 'Bush Forever' area. As such conventional open trenching will not be acceptable and the Water Corporation has subsequently identified trenchless techniques as the way forward.

This report is intended to provide Water Corporation with an overview of available 'Trenchless' construction techniques and discuss the feasibility, risks and opportunities that each offers.

1.2 Scope

This report provides background information as a basis for understanding options, limitations, risks and opportunities associated with trenchless techniques specific to the application of construction of a sewerage pressure main underneath the 'Bush Forever' area at Harrisdale.

The majority of the pressure main is to be DN375 PVC pipe as advised by the Water Corporation, but with HDPE used under the 1.5km 'Bush Forever area'. Trenchless techniques generally require a wall thickness based on the tensile strength required for pulling the pipe into position and this will require an HDPE pipe of 450mm outer diameter.

2. Pipeline design considerations

2.1 General

The design as requested is for a pipeline on a grade with scour valves and air valves at regular intervals. No air valves or scour valves will be permissible within the ‘Bush Forever’ area. It is therefore a requirement that the final profile of the pipeline has the following characteristics in order to provide a workable pressure main.

- Continuous decent from an air release point (valve) to a low point followed by
- Continuous ascent to another air valve
- No inverted U configurations where air may become trapped (preventing pumping)

2.2 Sedimentation

It is inevitable that some sedimentation in the pipeline will occur. Appropriate flow velocities can minimise sedimentation build up but some means of sediment removal must be considered. Under normal circumstances a scour valve will provide means of sediment removal but a scour valve is not permissible within the ‘Bush Forever’ area. Therefore two possibilities exist:

- The low point of the section running under the ‘Bush Forever’ area must occur at one end, just outside the conservation zone
- The section under the ‘Bush Forever’ area must rely on pigging to remove sediment

Any technique used to construct the pressure main must provide a profile that can be managed for sediment removal.

2.3 Geotechnical and groundwater

In summary the geotechnical and groundwater conditions expected are generally iron or silica cemented silty sand or peaty sand with groundwater at a shallow depth. As such geotechnical issues are not expected to provide any impediments to the use of trenchless techniques. A separate geotechnical report has been prepared to accompany the Engineering Summary Report and this provides a more detailed investigation. Some brief information is provided at Appendix E.

3. Trenchless technology techniques

Trenchless technology has been in development for pipe installation since the 1970s, arising from the oil and gas industry in the United States. Around the world many contractors offer services employing variations of the technology for the purposes of replacing existing services or installation of new services.

Trenchless techniques to be evaluated as alternatives for the purposes of construction of the DN-450 sewerage pipeline are:

1. Pipe Jacking and Guided Boring
2. Horizontal Directional Drilling
3. Ploughing

Tunnel boring as used for the Channel Tunnel between England and France and extensively across Scandinavia is not considered in this family of pipe laying techniques and is beyond the scope of this report.

3.1 Pipe jacking and guided boring

Pipe Jacking uses hydraulic equipment to push lengths of pipe through the ground. Guided Boring uses hydraulics to power a drilling head with spoil taken away by an auger. Alignment is maintained by laser.

Both of these techniques begin with the construction of a shaft that accesses the initial starting elevation (depth) of the pipe to be installed. Equipment to drill or thrust is lowered into the pit and the installation is made in a straight line penetration through the ground. Pit size is dependent on the specific technique and equipment but for this project a minimum pit plan size of 5m x 5m can be expected. Each pit would require clearing, dewatering and ASS management. Excavation would very probably extend below the water table making it more difficult and expensive.

The limit to these construction techniques varies with geotechnical conditions and specific technique involved but in general no installation has been made extending more than approximately 150 meters from a pit. Where greater distances need to be installed then a second pit is required to receive the incoming pipe and the process is repeated to extend again in any direction from this second pit.

Therefore, this method would require a significant level of construction activity within the ‘Bush Forever’ area with approximately ten 5m x 5m pits required.

3.2 Horizontal directional drilling (HDD)

HDD is a trenchless method of installing underground conduits, pipes and cables from the surface. In this group of techniques the drill process begins at ground level from a prepared launch site. The drill is directed into the ground at a relatively steep angle in order to get the drilling head underground and away from the surface as quickly as possible.

The drilling is performed with the assistance of drilling fluids or “mud”. Drilling mud primarily consists of Bentonite and water although in some cases synthetic muds and plasticizers are also used. The mud is pumped under high pressure through the drill string; it powers the drill motor and mixes with the drill cuttings (drill spoil) and the mixture then returns to the drill site. The mud is then processed to remove the cuttings and reused. Another function of the mud is to support the hole from collapse in weak ground.

The installation process begins with construction of entry and exit pits. Estimates of the required area needed for the entry pit construction area for the Balannup project is estimated at approximately 30m x 90m. These pits collect the drilling mud and allow it to be reused. See diagram at Appendix B for full depiction of the drilling pits and construction profile.

Within HDD techniques there are three alternatives, Single Stage HDD, Multi Stage HDD and Intersect Drilling.

3.2.1 Single Stage HDD

The maximum length of a single construction stage varies with ground conditions and with available equipment capacity. Generally however, the maximum length of a single stage is in the range of 600m to 1000m.

Additional risks with this methodology include the drilling fluid (bentonite) bursting through to the surface, particularly in the early stages of the bore. Also, HDD has been known to result in low accuracy in both horizontal and vertical planes of +/- 1 to 2m.

Single Stage HDD can be ruled out as a feasible option due to the reasons stated above.

3.2.2 Multi Stage HDD

A pipeline may be installed in multiple stages in a ‘Daisy Chain’ profile. In the case of this project, the length of the installation required means that one or two intermediate construction pits are to be located within the ‘Bush Forever’ area. In addition to the limitations highlighted within Single Stage HDD this would result in significant impact on the ‘Bush Forever’ area and can be ruled out also.

3.2.3 Intersect Drilling

Intersect drilling almost doubles the potential installation length compared to a single drive. HDD techniques with single stages in the order of 1km are possible depending on geotechnical conditions. The reach may be effectively doubled by drilling from two starting points to meet in the middle. To date the longest pipeline successfully installed in Australia using this method is approximately 2.2 km.

Any option involving intersect drilling would have to begin some distance from the ‘Bush Forever’ area. This increases the length and therefore the cost of this option. Additionally, there are also implications for the accuracy of the construction meaning risk of impact to the ‘Bush Forever’ area and costs to the Water Corporation should the method prove unsuccessful during construction.

The depth of installation also presents a significant risk to the Water Corporation and the environment. For any application of HDD there is a requirement to drill steeply through the surface material and maintain that steep profile up or down to a low point in order to avoid trapping air and making pumping impossible. This low point has been estimated conservatively at approximately 25m below natural surface level. A depiction is provided in Appendix B.

In the unlikely event of a requirement to access this pipeline for maintenance or repair it would involve significant excavation in the ‘Bush Forever’ area and present enormous costs and risk to the Water Corporation.

3.3 Ploughing

Ploughing is a construction technique whereby a machine installs a narrow trench in the ground where neither soil removal nor dewatering is required. Either simultaneously or later a pipe is inserted at a controlled depth. Ploughing is considered in the industry as a trenchless technique.

There are several contractors offering this service in Australia. Most offer some variation of the basic process. To date GHD has been in contact with Underground Services Australia (USA) who conducts operations in several states including WA. Their variant of the process, the Eco-Plough' is described below.

An 'Eco Plough' drags a vertical plough through the ground creating a narrow trench for the pipe to be inserted within (see Appendix C for a diagram). The 'Eco Plough' then returns to the start of the pipe route where the pipe is lifted over the 'Eco Plough' and installed in equipment mounted behind it. The 'Eco Plough' then drives over the previously created trench and as it does so the pipe is ploughed into the 'trench'. The plough vibrates at high frequency as it inserts the pipe to encourage smaller particulate matter to accumulate around the pipe to form bedding material. All the preceding work is completed within the width of the 'Eco Ploughs' tracks which is less than 4m.

The proposal is to utilise the existing track through which the 'Eco Plough' could install the pipeline without any clearing or dewatering. See proposed pipe route in Appendix D. In some places the track is marginally narrower than the 'Eco Plough'. It is proposed to minimise potential impact by pruning back any affected vegetation prior to the plough going through.

The maximum size of pipe that can be inserted is currently 415 mm in outer diameter but, USA have indicated that modification of the equipment to accommodate 450 mm can be performed in order to meet the requirements of the this project without the need for any modification of the 'Eco Plough' machine overall dimensions.

A concern with the use of the Ploughing technique is its ability to install a pipe at a constant grade appropriate for a sewer main. The plough is able to vary the depth of cover over the pipe as it travels. The maximum depth of insertion is approximately 1.5m. This range is not sufficient to provide a grade of 1:500 of the 1.5 km route, however there is a natural ground level difference over the 1.5 km length of the alignment of approximately 2.5m which together with the adjustable cover gives a suitable grade on the pipe of 1:490 (approximate).

Another issue with the ploughing technique is material compaction around the pipe in order to provide the support it needs in service now and in the future. Over specification of the pipe thickness will be sufficient to provide adequate strength in service. This will be specifically addressed at detailed design stage.

The pipe will be installed in the existing cleared track resulting in the alignment not being straight or following any cadastral boundary. This is not standard for the Water Corporation as it places assets at risk of damage by other work amongst other issues.

In order to mitigate this risk it is proposed that a trace wire is installed to facilitate accurate location in future. There are a number of other factors which negate this issue including:

- There are no air or scour valves within the 'Bush Forever' area meaning that the pipeline does not need to be accessed during normal operation.
- The 'Bush Forever' area provides significant protection to the pipeline given the extreme level of difficulty to gain approval to construct in the area.
- In the future should City of Armadale gain approvals and construct Keane Road the Water Corporation could relay the pipeline (with a duplication if needed) on a consistent alignment within the road reserve.

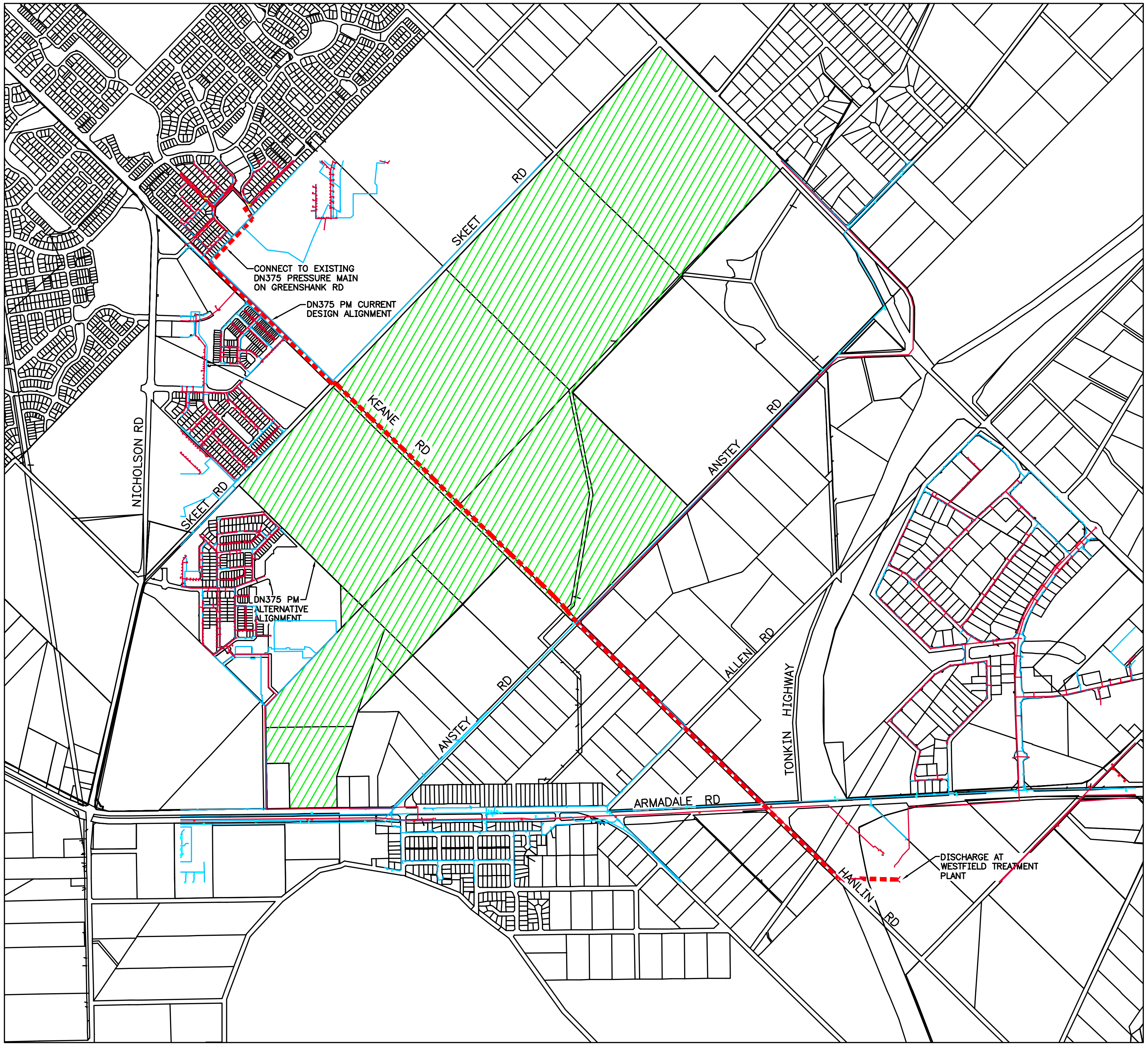
4. Conclusions and recommendations

It is GHD's recommendation that ploughing is taken forward as the preferred option for installation of the pressure main through the Balannup 'Bush Forever' area for the following reason:

- It can be installed without any clearing, open trenching or dewatering.
- It can be installed at a suitable grade over the 1.5km 'Bush Forever' Site with no scour or air valve pits in the 'Bush Forever' site.
- It is cost effective.

Appendices

Appendix A – Route diagram



LEGEND

DN375 PM ALIGNMENT OPTION 1

BUSH FOREVER

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PRELIMINARY ONLY
NOT TO BE USED FOR CONSTRUCTION

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DESIGN SURVEY NONE

ASCON SURVEY NONE

VERTICAL DATUM NONE

COORDINATE SYS NONE

DES REF

DES CALC

DES CHD

DRN

Q.C. CHD

NORTH POINT

INFRASTRUCTURE DESIGN BRANCH

RECOMMENDED

CONSULTANT PROJECT MANAGER

APPROVED

CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER
BALLANUP PUMPING STATION NO. 175-01
DN375 PRESSURE MAIN
ROUTE ALIGNMENT

FILE

PROJECT C-S01249

PLAN

SKETCH 1

CAD

ISSUE B

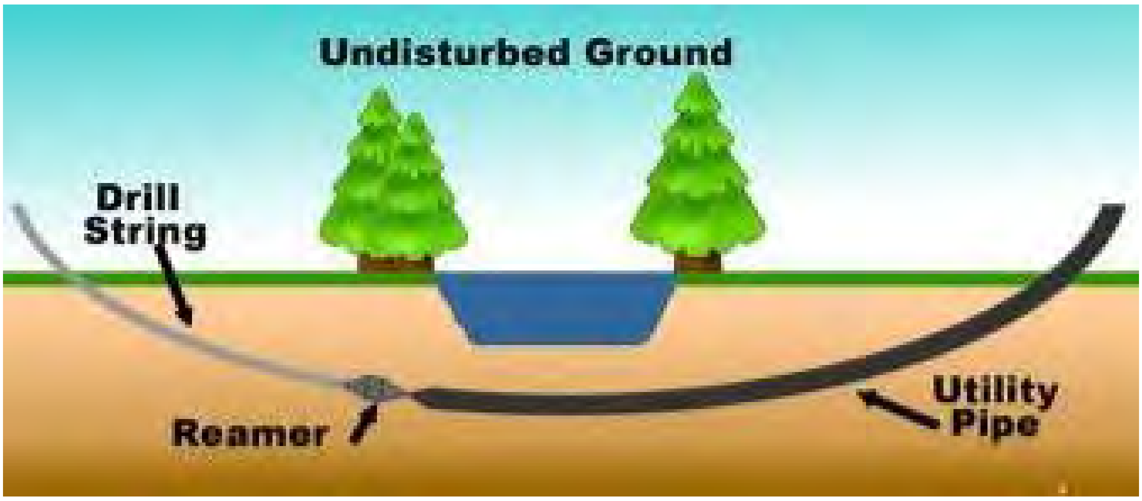
MF

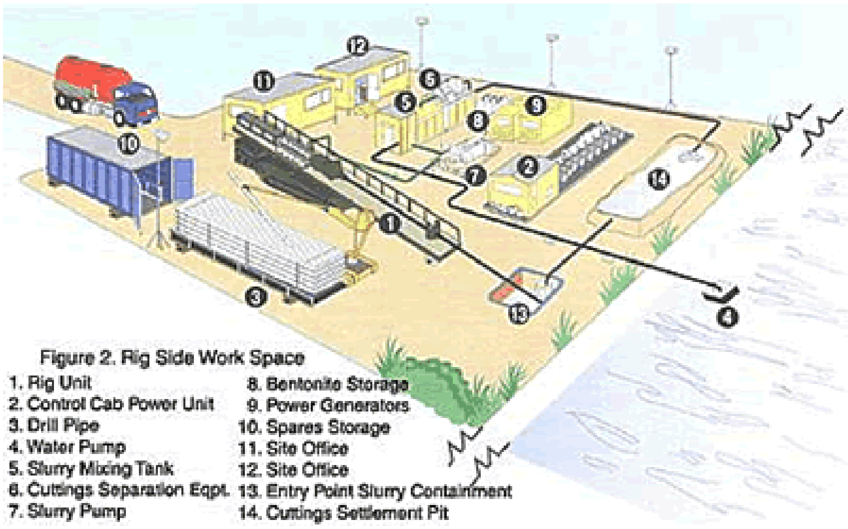
ORIGINAL SHEET SIZE A1

566 810

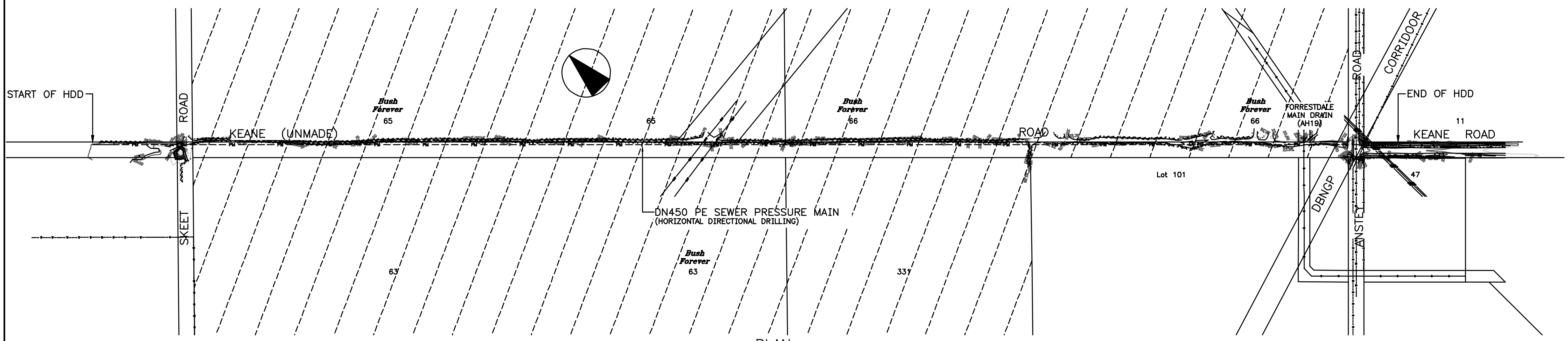
CAD MANAGEMENT_NOT READ ONLY\WWCS\PERTHR\BALANNUP PS\CAD\ROUTE ALIGNMENT\SKETCH 1 02/05/2013

Appendix B – HDD layouts and profiles





Drawing reproduced with kind permission of HDD Solutions



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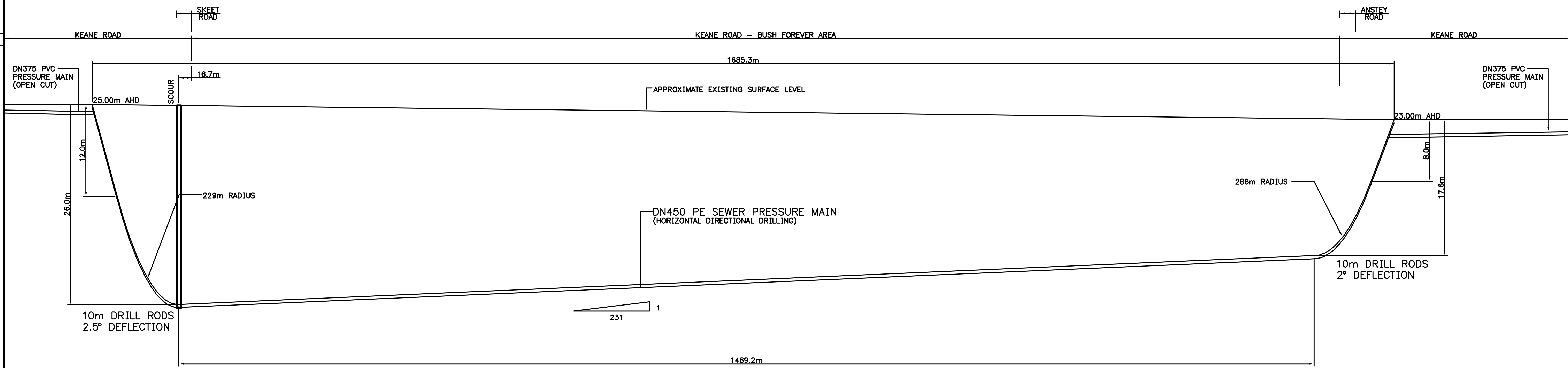

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DATE : 28-May-2013

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VERTICAL DATUM AHD
COORDINATE SYS MGA94-50
DES CALC N.MAKIN
DES CHD
ASCON SURVEY NONE
DES REF GHD 61-29471
DRN K.BOSMAN
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CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND SECTION – HDD PROFILE OPTION 1

FILE
PROJECT C-S01249
PLAN HDD OPTION 1
CAD
ISSUE 1
ORIGINAL SHEET SIZE A1
MF

566
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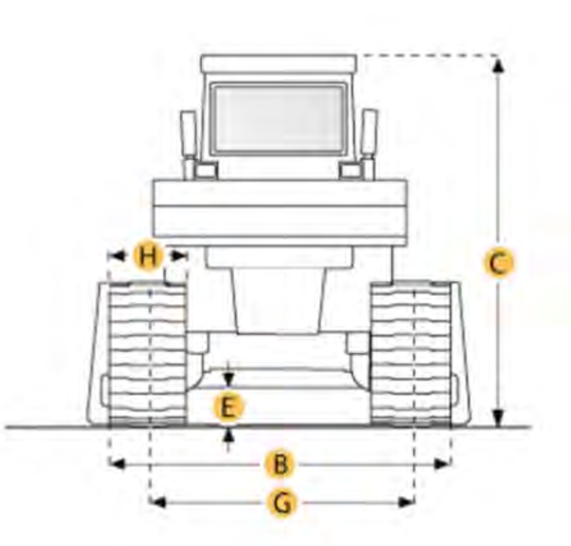
Appendix C – Eco Plough dimensions

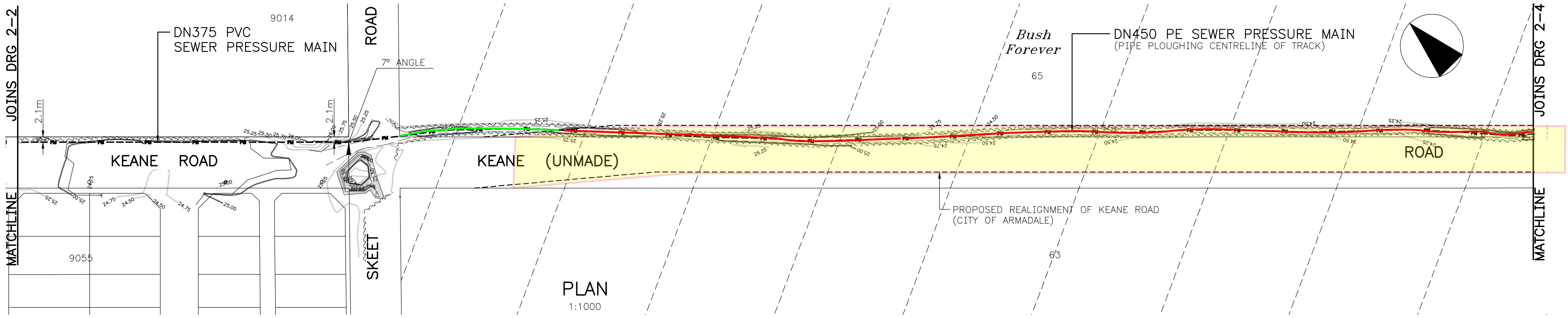


Selected Dimensions		
Dimensions		
A. LENGTH W/ BLADE	34.9 ft in	10637.5 mm
B. WIDTH OVER TRACKS	11.8 ft in	3606 mm
C. HEIGHT TO TOP OF CAB	13.4 ft in	4078 mm
D. LENGTH OF TRACK ON GROUND	12.7 ft in	3855 mm
E. GROUND CLEARANCE	2.2 ft in	674.5 mm
F. LENGTH W/O BLADE	19.8 ft in	6027 mm
Undercarriage		
G. TRACK GAUGE	9.5 ft in	2896 mm
H. STANDARD SHOE SIZE	28 in	710 mm

Screenshot from USA Website

Appendix D – Proposed 'Eco Plough' alignment

JOINS DRG 2-2



JOINS DRG 2-4

MATCHLINE

PLAN
1:1000

PERTH ONE CALL SYSTEM
DIAL 1100
DIAL BEFORE YOU DIG

NOTE:
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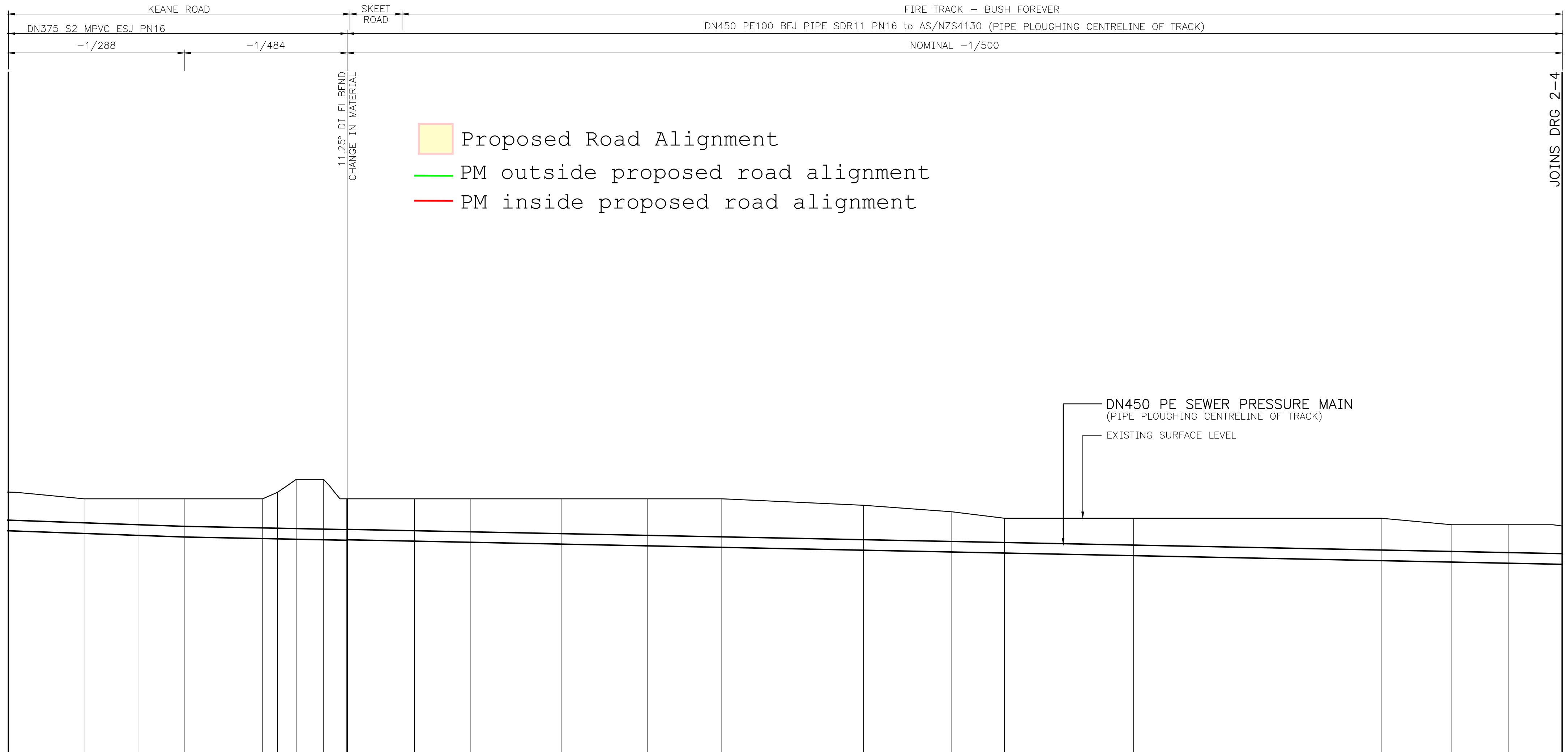
LEGEND

PROPOSED SEWER PRESSURE MAIN
EXISTING WATER MAINS
EXISTING TELECOMMUNICATION CABLES
EXISTING OPTIC FIBRE
EXISTING UNDERGROUND POWER
EXISTING OVERHEAD POWER
EXISTING GAS MAINS
EXISTING SEWER MAINS
EXISTING SEWER PRESSURE MAINS
EXISTING DRAINAGE
EXISTING FENCE
EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-2



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1048.2	25.00		
1053.9	25.25		
1061.2	25.75		
1071.7	25.75		
1080.8	25.00	1.60 / 1.57	23.40 / 23.43
1106.8	25.00		
1128.4	25.00		
1156.9			
1163.5	25.00		
1196.7	25.00		
1225.5	25.00		
1280.3	24.75		
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1334.7	24.25		
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1480.2	24.25		
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1529.2	24.00		
1550			

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
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DATE : 27-Aug-2013

(1:1000) (1:100)

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COORDINATE SYS MGA94-50
ASCON SURVEY NONE
DES REF GHD 61-29471
DES CALC J.POTTS
DES CHD
DRN K.BOSMAN
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APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 3 OF 8

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PROJECT C-S01249
PLAN HW91-85-2-3
CAD
ISSUE 1
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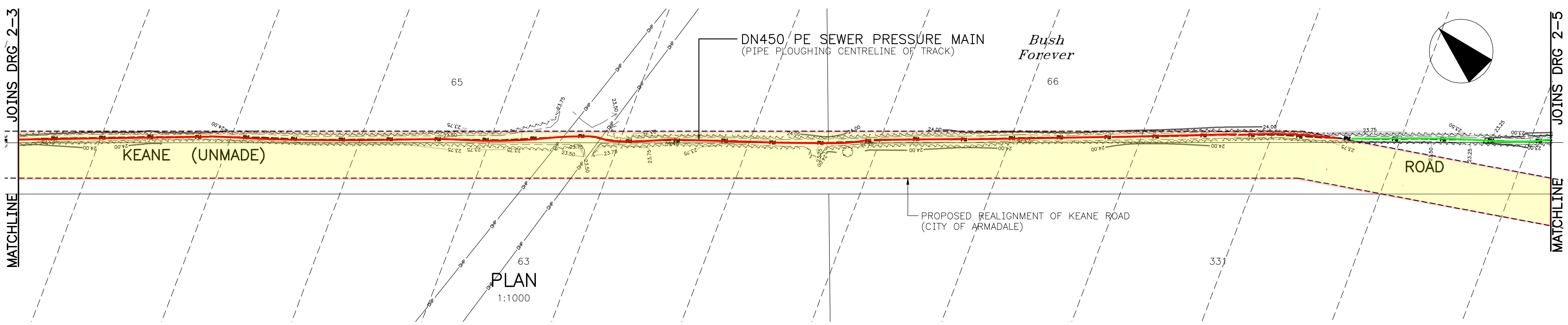

JOINS DRG 2–5

MATCHLINE

PLAN
1:1000

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PERTH ONE CALL SYSTEM
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LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85–1–2

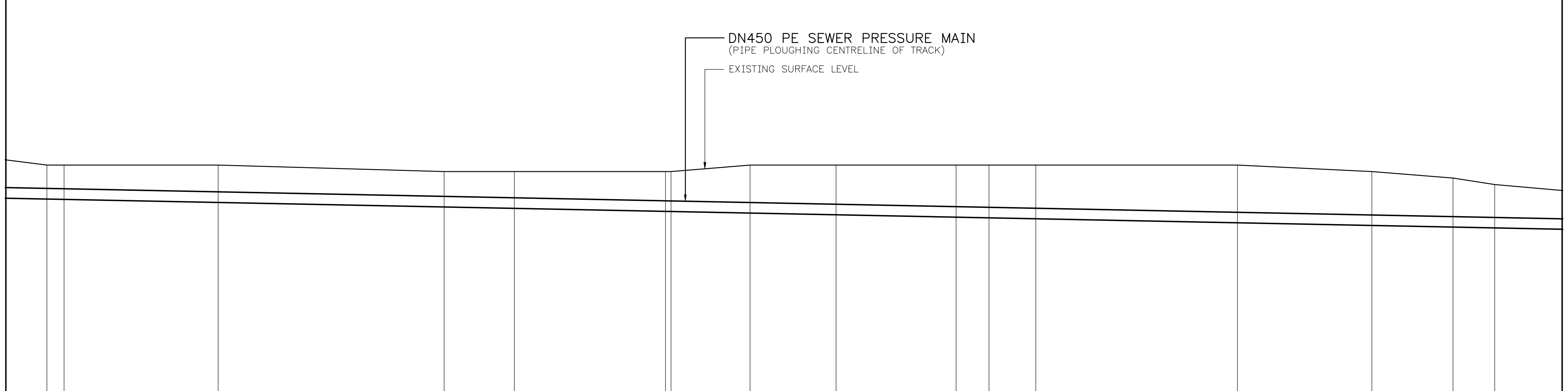
FIRE TRACK – BUSH FOREVER

DN450 PE100 BFJ PIPE SDR11 PN16 to AS/NZS4130 (PIPE PLOUGHING CENTRELINE OF TRACK)

NOMINAL –1/500

JOINS DRG 2–3

JOINS DRG 2–5



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INVERT LEVEL																		
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ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
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DATE : 27-Aug-2013

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		Q.C. CHD

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METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION – SHEET 4 OF 8

FILE

PROJECT C–S01249

PLAN

CAD

HW91–85–2–4

ISSUE 1

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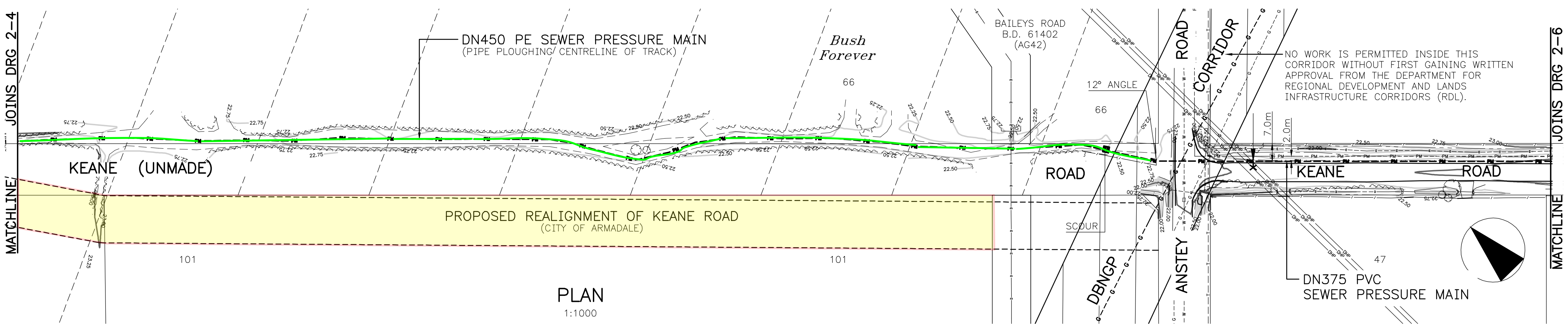

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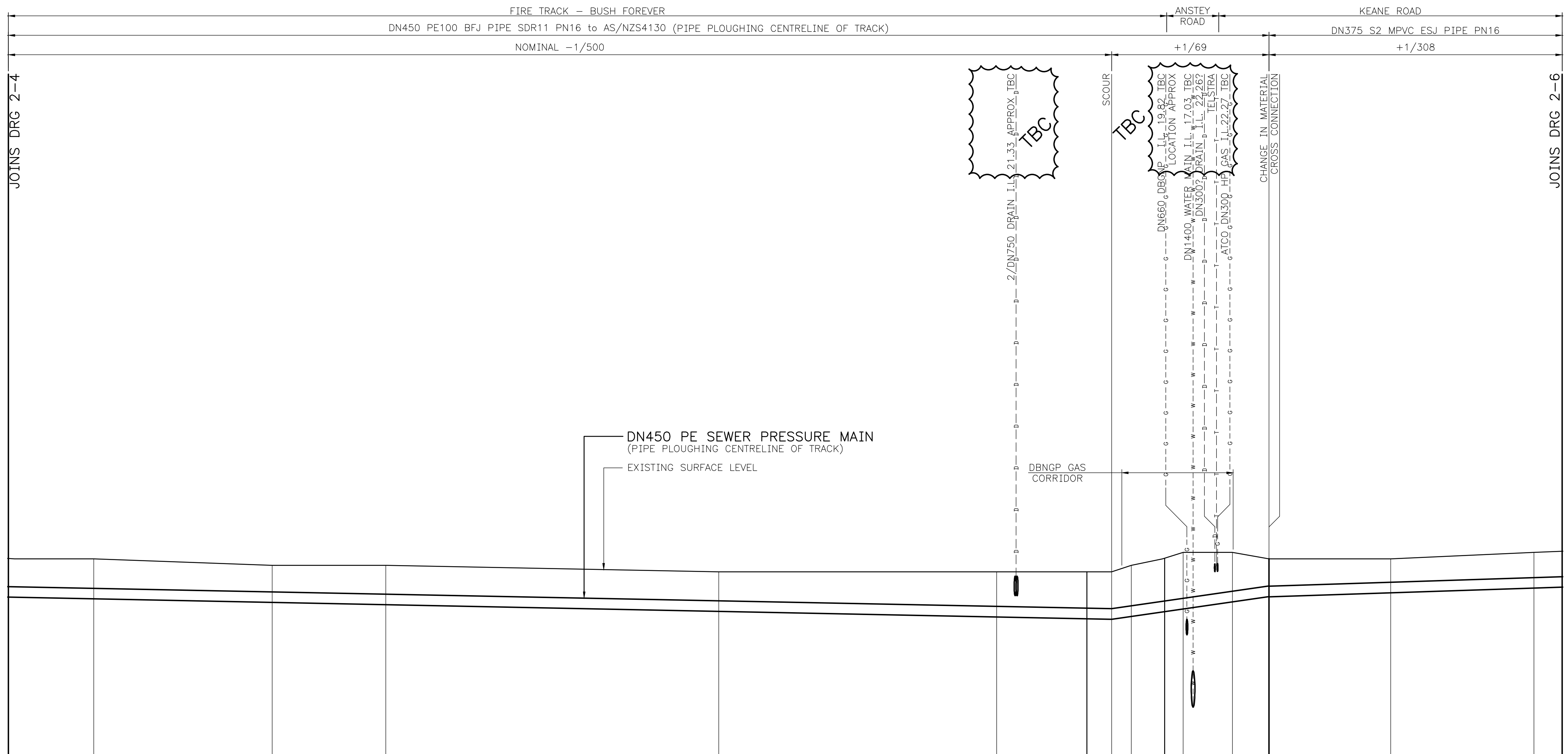
LEGEND

- PROPOSED SEWER PRESSURE MAIN — PM
- EXISTING WATER MAINS — W
- EXISTING TELECOMMUNICATION CABLES — T
- EXISTING OPTIC FIBRE — OF
- EXISTING UNDERGROUND POWER — UGP
- EXISTING OVERHEAD POWER — OHP
- EXISTING GAS MAINS — G
- EXISTING SEWER MAINS — S
- EXISTING SEWER PRESSURE MAINS — PM
- EXISTING DRAINAGE — D
- EXISTING FENCE
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-2



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DEPTH TO INVERT									1.82					1.45 1.46			
INVERT LEVEL									20.42					21.30 21.29			
HORIZONTAL DISTANCE	2150	2183.0	2251.9	2295.7	2424.3	2531.6	2542.1	2566.5	2576.0	2583.6	2596.5	2603.6	2622.7	2636.8	2683.8	2739.1	2750

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

(1:1000) (1:100)

DATE : 27-Aug-2013

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
1	05/13		ISSUED FOR INFORMATION	KB	GD	PGS

DESIGN SURVEY: GHD 2661551 V01
VERTICAL DATUM: AHD
COORDINATE SYS: MGA94-50
DES CALC: K.BOSMAN
DES CHD
ASCON SURVEY: NONE
DES REF: GHD 61-29471
DRN: K.BOSMAN
Q.C. CHD
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RECOMMENDED
CONSULTANT JOB MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 5 OF 8

FILE
PROJECT C-S01249
PLAN
CAD
HW91-85-2-5
ISSUE 1
ORIGINAL SHEET SIZE A1
MF

566
810

61\29471\CADD\HW91\HW91-85-2-005.DWG 12 June 2013 - 1:5PM 0000

Appendix E – Geotechnical investigation

Published data on ground conditions

Ground conditions are shown on published 1:50,000 scale maps as predominantly "thin Bassendean Sand overlying Guildford Formation". Bassendean Sand is aeolian quartz sand, with a typical relative density of medium dense. A thin covering of Bassendean Sand, in the local context, implies a thickness between approximately 5 m and less than 1 m.

The Guildford Formation is an alluvial deposit, comprising a mixture of a wide variety of soil types. Local experience suggests that it is likely to principally comprise Clayey Sand or Silty Sand. Iron- or silica- cemented soils are known in the area, particularly where the Guildford Formation is overlain by Bassendean Sands with shallow groundwater. Often an iron-cemented Silty Sand (colloquially called "Coffee Rock") forms at the interface between the two units, where seasonal fluctuation of the groundwater table results in precipitation of dissolved iron in the groundwater.

Discrete zones of "peaty sand" are mapped for the 'Bush Forever' locality. Along the proposed pressure main route, two such locations are shown. One is approximately central to the 'Bush Forever' component of the alignment, the other near the southern boundary. Local experience suggests peaty sand is likely to comprise Silty Sand with significant diatomite content. These can be acid sulphate soil risks.

A number of exploratory boreholes have been drilled in the area by various government agencies. A graphic lithology log of these boreholes, shown with the published ground conditions map, indicates these comprise sand only to between 25 and 30 m depth overlying the Osborne Formation. The borehole locations appear to be confined to localities where Peaty Sand is mapped and may not be representative of the broader ground conditions.

The Osborne Formation in this area comprises the Kardinya Shale member. Published information suggests the interface between the Osborne Formation and superficial units to be approximately -10 m AHD. The Kardinya Shale consists of moderately to tightly consolidated interbedded siltstones and shales. These are often puggy, glauconitic and contain thin interbeds of fine grained sandstone. It is also a confining bed for the underlying Leederville aquifer. Kardinya Shale is likely to persist to approximately -40 m AHD.

Groundwater Conditions

Published data (Davidson, 1995) shows that groundwater is shallow, with actual depth fluctuating seasonally. Groundwater is likely to be brackish and high in dissolved iron.

To the west of 'Bush Forever' land is the Jandakot mound, which is one of the more important groundwater supply and recharge areas for the Perth metro area. The 'Bush Forever' site occupies a col between the Jandakot mound (~25 m AHD) and the Armadale area recharge (water table also ~25 m AHD). Therefore superficial groundwater should be expected at slightly less than 25 m AHD.

The Leederville aquifer is a confined aquifer that, in the vicinity of the site, is contained by the Kardinya Shale member of the Osborne Formation. Interaction with the Leederville aquifer should be avoided or minimised, as the risk of undesirable environmental impacts is relatively high.

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G:\61\29471\WP\HDD Report\20131004\Trenchless option report Rev 4.docx

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	G Dunlop	P Spencer	Peter Spencer	P Spencer	Peter Spencer	4/7/2013
1	G Dunlop	P Spencer	Peter Spencer	P Spencer	Peter Spencer	11/9/2013
2	G Dunlop	P Spencer	Peter Spencer	P Spencer	Peter Spencer	17/9/2013
3	G Dunlop	P Spencer	Peter Spencer	P Spencer	Peter Spencer	24/9/2013
4	G Dunlop	J Foley		J Foley		4/10/2013

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Appendix B

EcoPlough

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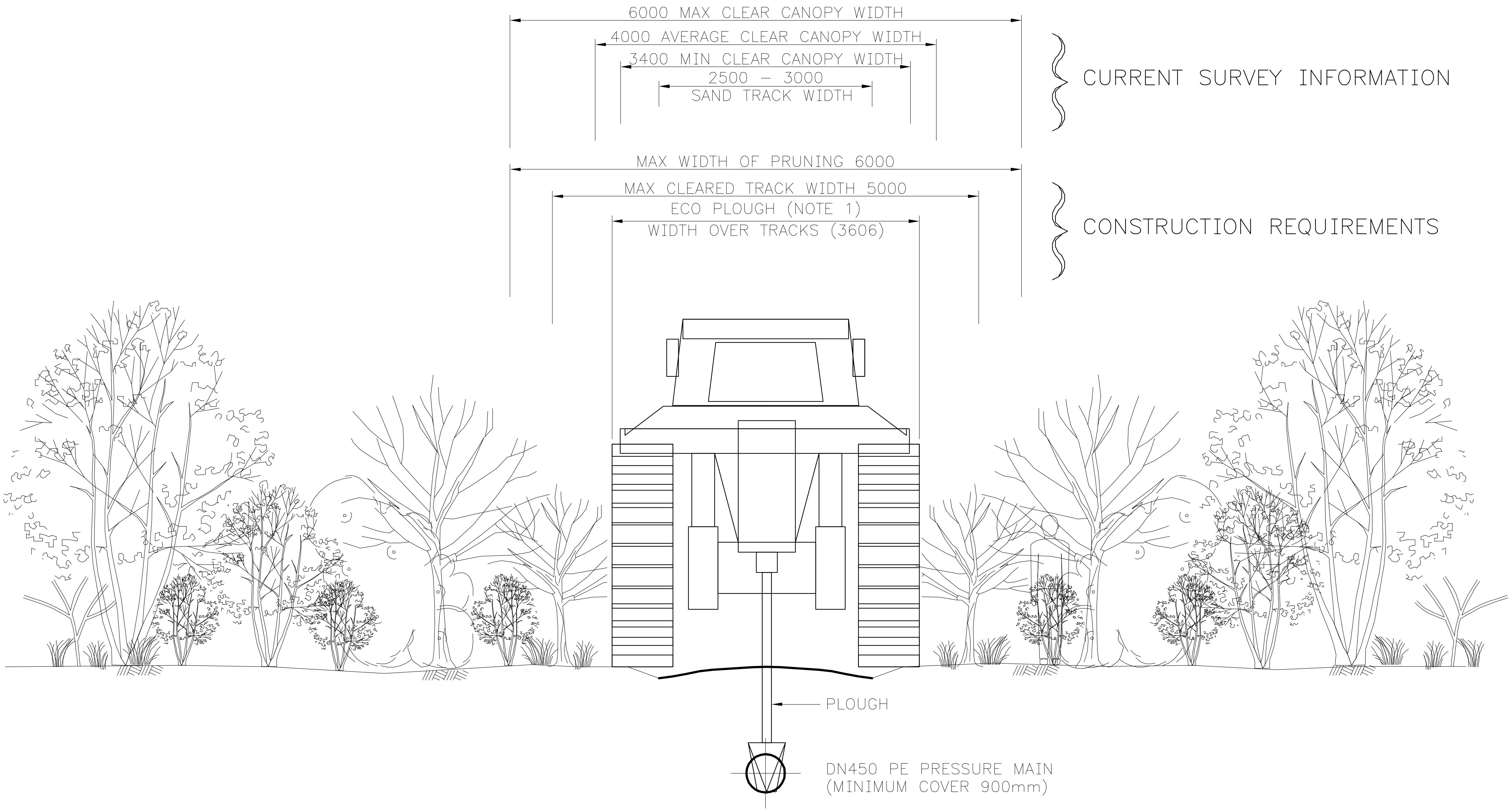

NOTE
1. DIMENSIONS BASED ON CATERPILLAR D11

1000 500 0 1000 2000 3000 mm (1:50)

FOR GENERAL NOTES REFER DRG HW91–2–13–1

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DES CALC E. BISHOP	RECOMMENDED 06/02/2014 P.G. SPENCER (SIGNED) for CONSULTANT JOB MANAGER	METROPOLITAN WASTEWATER WAPC 127155 BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM DN450 PE PRESSURE MAIN – BUSH FOREVER AREA TYPICAL SECTION OF ECO PLOUGH THROUGH BUSH FOREVER AREA	ORIGINAL SHEET SIZE A3
DES CHD G. DUNLOP			
DRN K.BOSMAN	APPROVED 06/02/2014 P.G. SPENCER (SIGNED)	FILE JT1 201202141 V01	PLAN CAD ISSUE A
Q.C. CHD R. SPILLANE	CONSULTANT PROJECT DIRECTOR	PROJECT C–S01249	HW91–2–13–2 MF

WATER CORPORATION

283

394

61\29471\CADD\HW91\HW91-002-013-02A 06/02/2014

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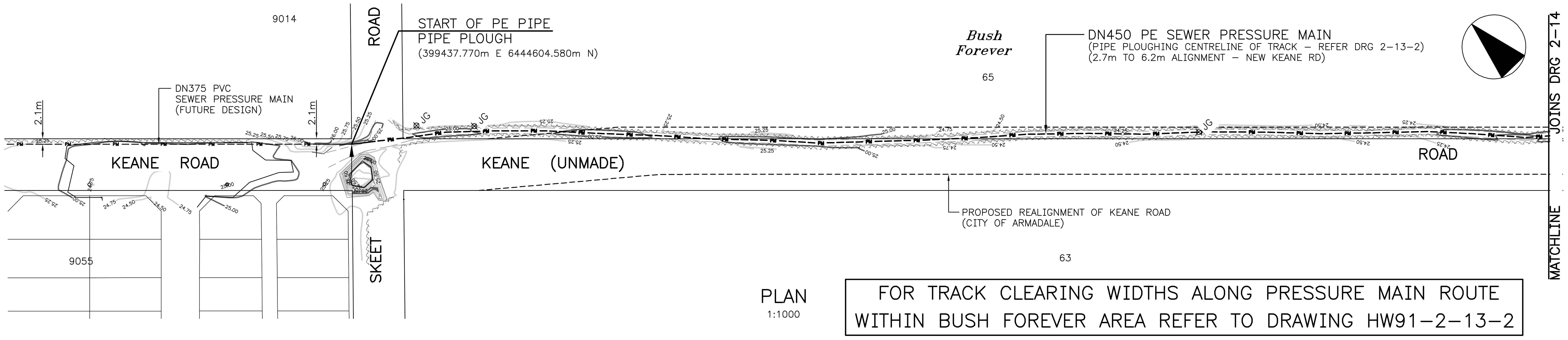
LEGEND

PROPOSED SEWER PRESSURE MAIN
EXISTING WATER MAINS
EXISTING TELECOMMUNICATION CABLES
EXISTING OPTIC FIBRE
EXISTING UNDERGROUND POWER
EXISTING OVERHEAD POWER
EXISTING GAS MAINS
EXISTING SEWER MAINS
EXISTING SEWER PRESSURE MAINS
EXISTING DRAINAGE
EXISTING FENCE
EXISTING TREE
EXISTING BUSHLINE
JACKSONIA GRACILLIMA LOCATION

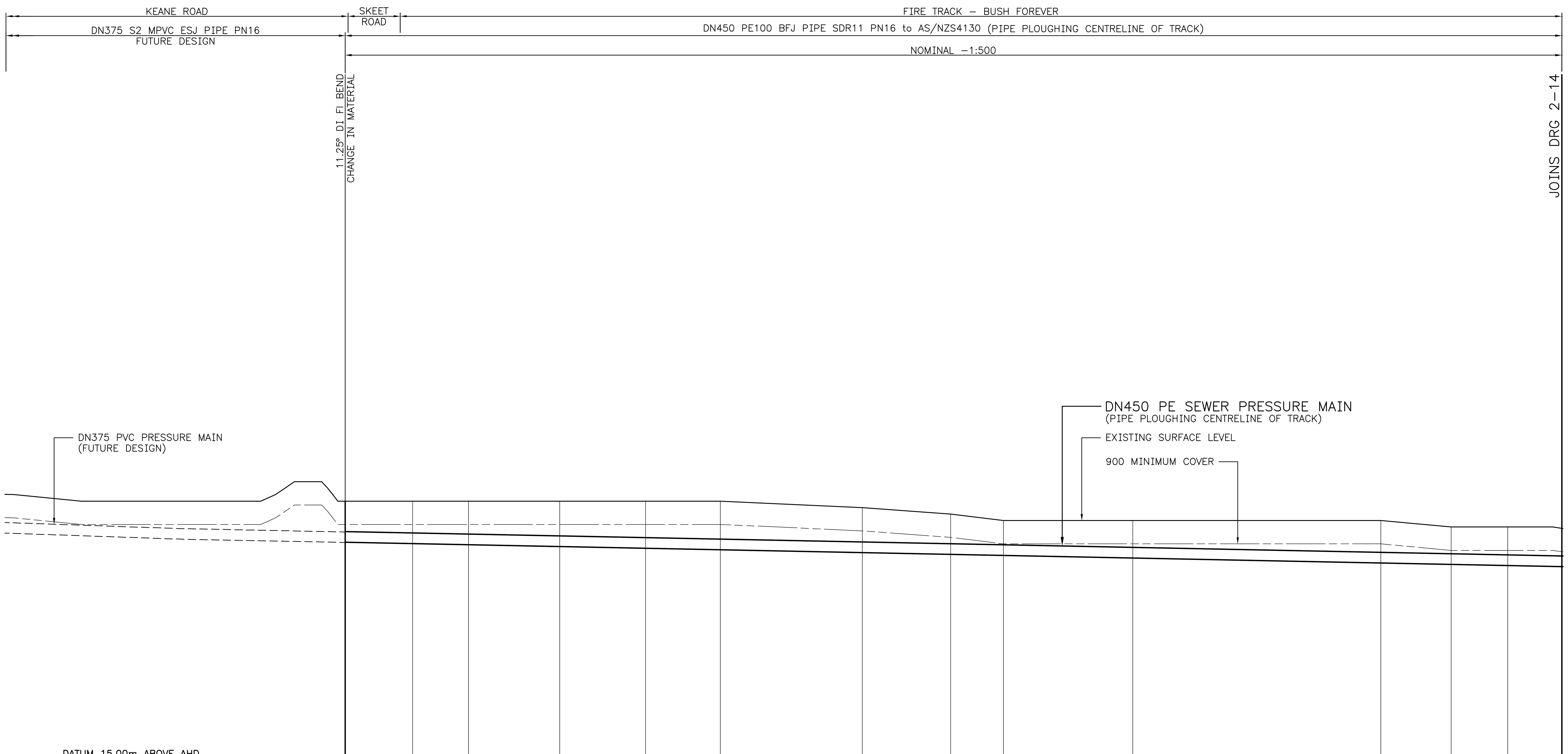


PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2

GENERAL NOTES

1. PRESSURE MAIN SHALL BE SET OUT AS SHOWN ON THE DRAWINGS WITH REAL TIME RECORDING OF ALIGNMENT GPS CO-ORDINATES, INCLUDING DEPTH, USING IN-VEHICLE ELECTRONIC EQUIPMENT.
2. NO DEVIATION FROM THE ALIGNMENT SHOWN IS ACCEPTABLE UNLESS APPROVED IN WRITING BY THE SUPERINTENDENT.
3. PRESSURE MAIN SHALL HAVE A MINIMUM DEPTH OF COVER OF 900mm.
4. PRESSURE MAIN SHALL BE LAID TO UNIFORM GRADE BETWEEN INVERT LEVELS SHOWN.
5. PRIOR TO CONSTRUCTION OF THE PRESSURE MAIN THE EXISTING DRAIN AS SHOWN ON DRAWING HW91-2-15 SHALL BE REMOVED TO 3 METRES EITHER SIDE OF THE TRACK CENTRELINE. THE DRAIN SHALL BE REINSTALLED AT ITS ORIGINAL LEVELS ON COMPLETION OF INSTALLATION OF THE PRESSURE MAIN.
6. PE PRESSURE MAIN TO BE AS/NZS4130, SERIES 1. PRESSURE MAIN PIPES TO BE COLOURED BLACK.
7. DEFLECTION AT BENDS SHALL BE ACHIEVED BY BENDING THE PIPE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
8. PE PIPES SHALL BE BUTT FUSION WELDED.
9. NO CONSTRUCTION OR LAYDOWN AREAS TO BE CREATED WITHIN THE 'BUSH FOREVER' AREA OTHER THAN WITHIN THE APPROVED CLEARED TRACK ALIGNMENT.
10. NO CLEARING OR DAMAGE TO BUSHLAND SHALL OCCUR OUTSIDE THE APPROVED CLEARED TRACK ALIGNMENT WITHIN THE 'BUSH FOREVER' AREA.
11. JACKSON GRACILLIMA, AS LOCATED ON THE PLANS, ARE NOT TO BE REMOVED OR DAMAGED DURING CONSTRUCTION.
12. ANY CONSTRAINTS TO CONSTRUCTION OR DAMAGE TO EXISTING FLORA TO BE REPORTED IMMEDIATELY TO THE SUPERINTENDENT.
13. NO DEWATERING OR OPEN TRENCHING (OTHER THAN DRAIN CROSSING INDICATED ON DRG 2-15) TO BE CARRIED OUT WITHIN THE BUSH FOREVER AREA.



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DEPTH TO INVERT	1.57								1.35					1.48
INVERT LEVEL	23.43								22.90					22.47
HORIZONTAL DISTANCE	0.0	26.0	47.6	82.7	115.9	144.7	199.5	233.5	253.9	303.7	399.4	426.6	448.4	469.2

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC E. BISHOP	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD G. DUNLOP	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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RECOMMENDED 06/02/2014
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for CONSULTANT JOB MANAGER
APPROVED 06/02/2014
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
DN450 PE PRESSURE MAIN – BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION – SHEET 1 OF 3

FILE JT1 201202141 V01
PROJECT C-S01249
PLAN CAD HW91-2-13-1
ISSUE A
ORIGINAL SHEET SIZE A1
MF

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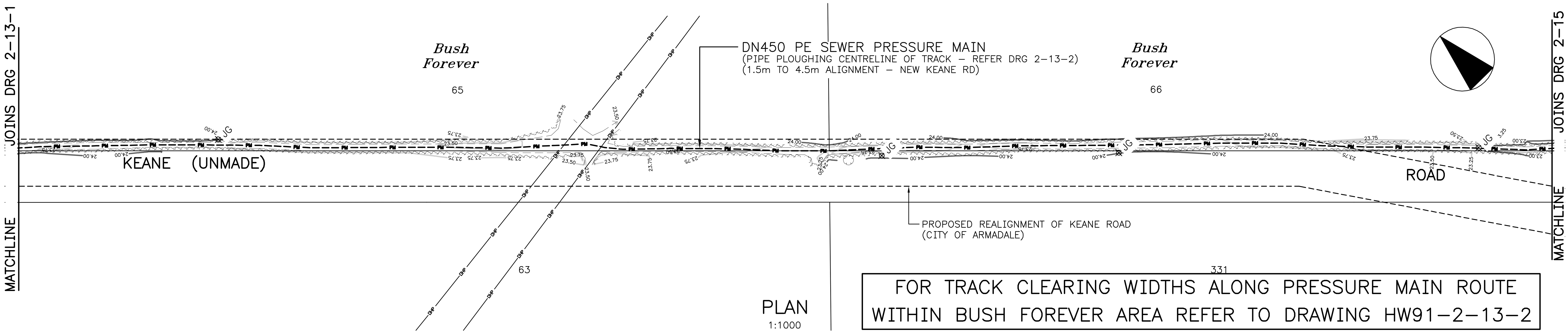

PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2

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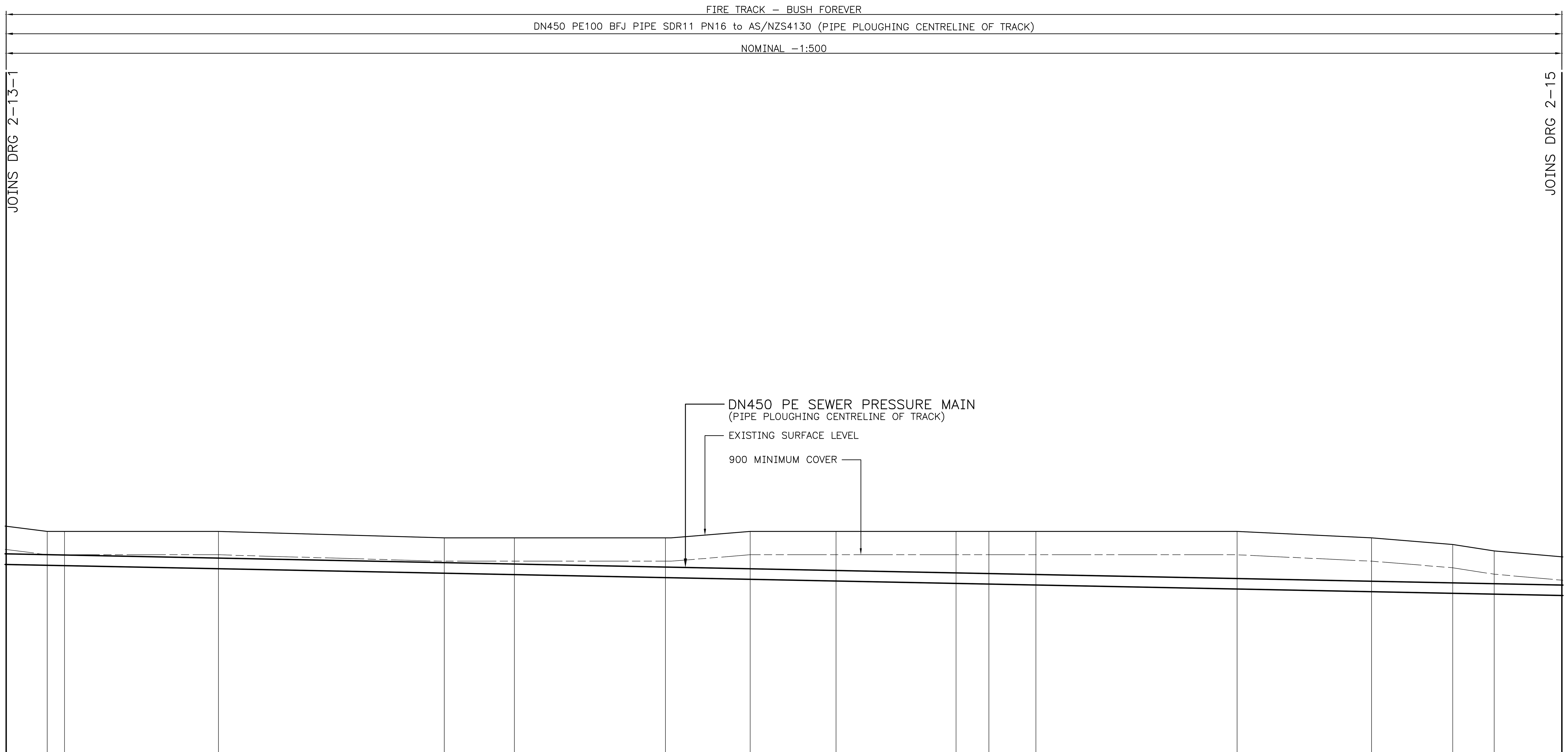
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	
EXISTING BUSHLINE	
JACKSONIA GRACILLIMA LOCATION	JG

FOR GENERAL NOTES REFER DRG HW91-2-13-1



DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL		23.75	23.75	23.75	23.50	23.50	23.50	23.75	23.75	23.75	23.75	23.75	23.75	23.50	23.25	23.00	22.77
DEPTH TO INVERT	1.48	1.31															1.50
INVERT LEVEL	22.47	22.44															21.27
HORIZONTAL DISTANCE	469.2	485.0	491.6	551.0	638.9	665.2	723.5	756.1	789.3	835.5	848.3	866.3	944.0	995.8	1027.1	1043.2	1069.2

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01
ASCON SURVEY NONE
VERTICAL DATUM AHD
COORDINATE SYS MGA94-50
DES REF GHD 61-29471
DES CALC E. BISHOP
DES CHD G. DUNLOP
DRN K.BOSMAN
Q.C. CHD R.SPILLANE
NORTH POINT

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APPROVED 06/02/2014
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
DN450 PE PRESSURE MAIN – BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION – SHEET 2 OF 3

FILE JT1 201202141 V01
PROJECT C-S01249
PLAN
HW91-2-14
CAD
ISSUE A
ORIGINAL SHEET SIZE A1
MF

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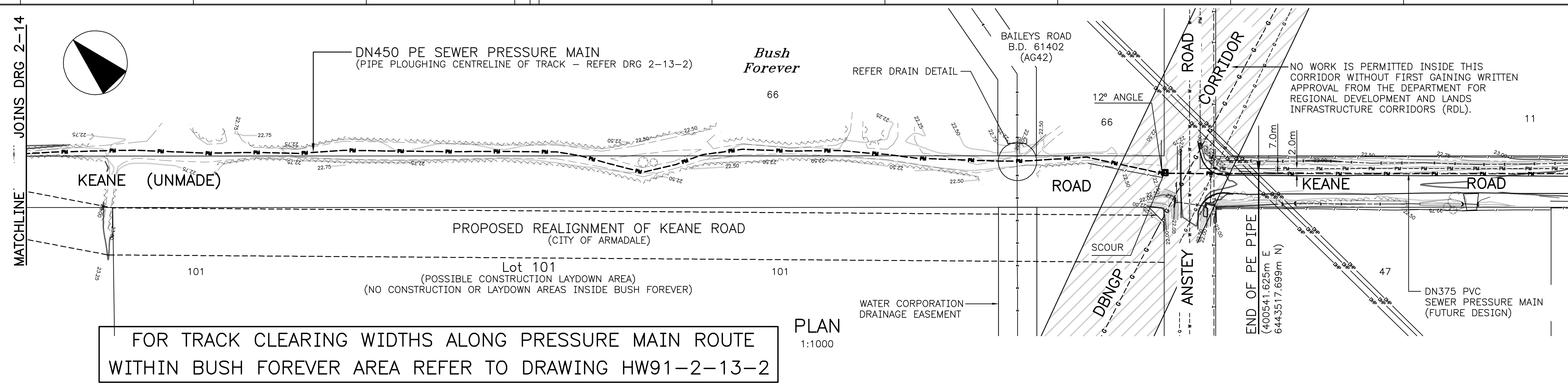
LEGEND

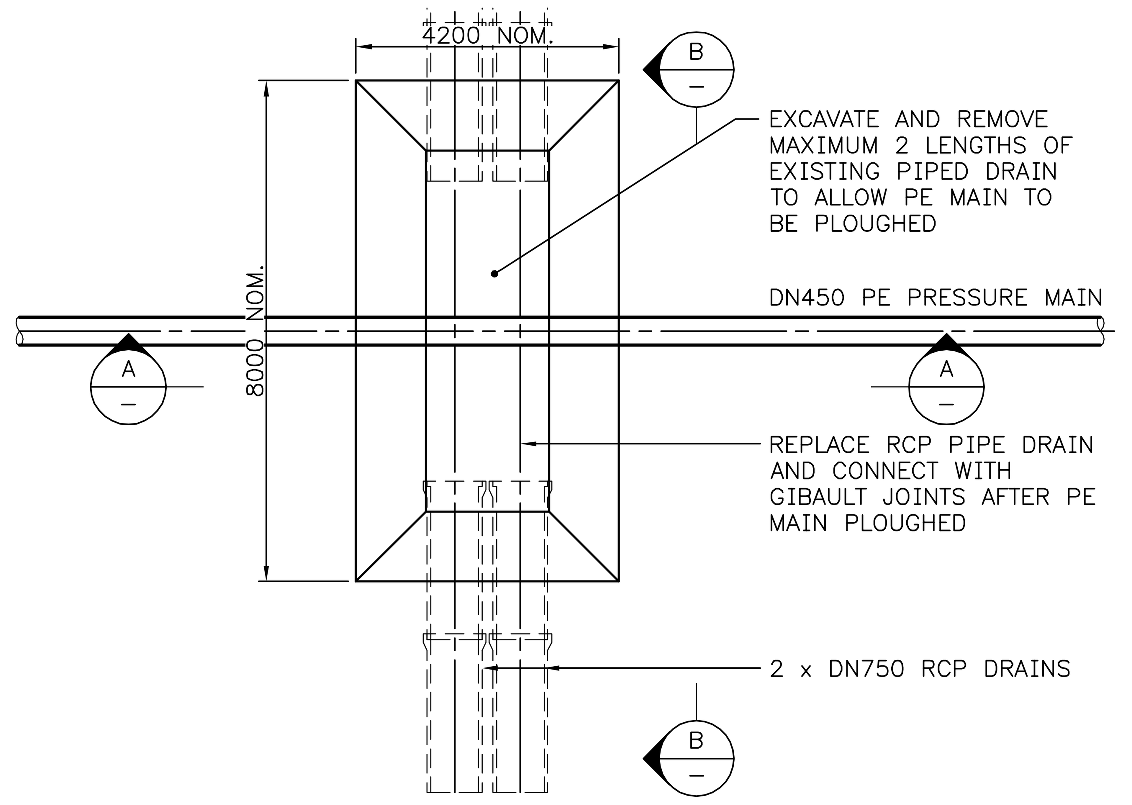
- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE
- EXISTING BUSHLINE
- JACKSONIA GRACILLIMA LOCATION

FOR GENERAL NOTES REFER DRG HW91-2-13-1

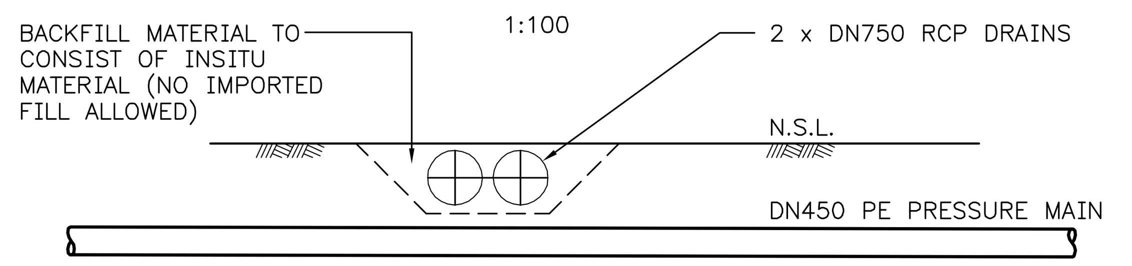


FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2

PLAN
1:1000



DRAIN CROSSING DETAIL - PLAN
1:100



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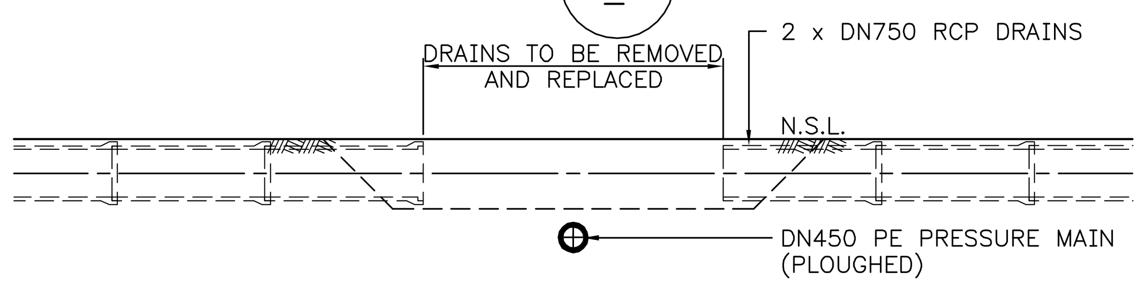
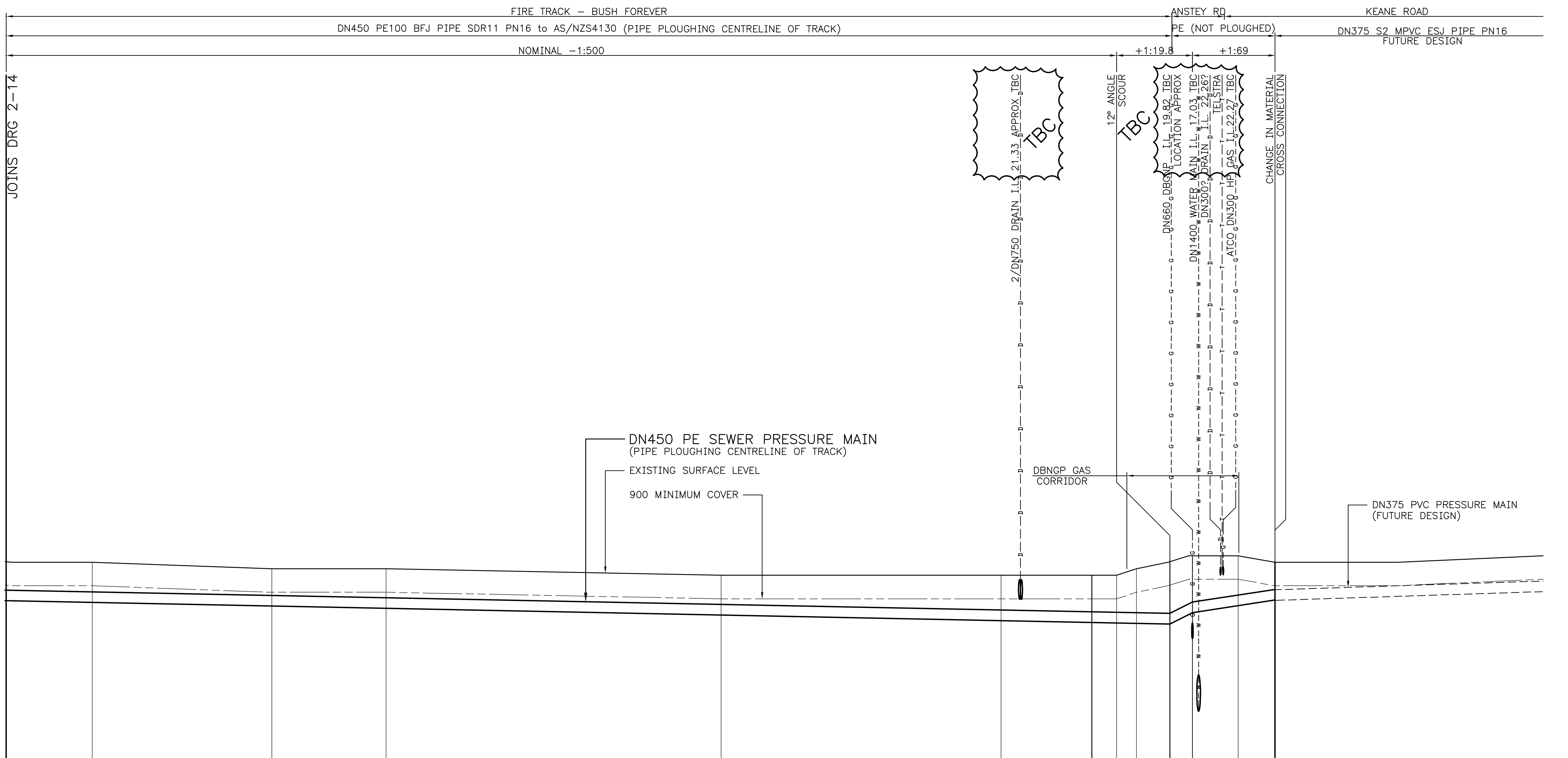


SECTION B



DATUM 15.00m ABOVE AHD

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DEPTH TO INVERT	1.50		1.43							2.39	2.18		1.45
INVERT LEVEL	21.27		21.07							20.38	20.82		21.30
HORIZONTAL DISTANCE	1069.2	1102.2	1171.1	1214.9	1343.5	1450.8	1485.7	1495.2	1502.8	1515.7	1522.8	1541.9	1556.0

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY: GHD 2661551 V01	VERTICAL DATUM: AHD	DES CALC: E. BISHOP	NORTH POINT
	COORDINATE SYS: MGA94-50	DES CHD: G. DUNLOP	
ASCON SURVEY: NONE	DES REF: GHD 61-29471	DRN: K.BOSMAN	
		Q.C. CHD: R.SPILLANE	

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BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
DN450 PE PRESSURE MAIN - BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION - SHEET 3 OF 3

FILE JT1 201202141 V01
PROJECT C-S01249
PLAN
CAD
HW91-2-15
ISSUE A
ORIGINAL SHEET SIZE A1
MF

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EcoPlough

Construction Methodology

Balannup A Wastewater Sewerage Pump Station and Pressure Main – OD 450mm PN16 HDPE Pipeline Installation

Water Corporation

ECOPLOUGH

Contents

1 Purpose

The purpose of this Construction Methodology is to define the site-specific tasks relating to the construction of the Balannup A Wastewater Pump Station (WWPS) Pressure Main. It details the general requirements, quality requirements, protection to foreign services, safety and environmental issues.

2 Scope

This Construction Methodology applies to all employees and sub-contractors in the performance of their duties for Underground Services Australia ("USA") on the construction of the Balannup A WWPS Pressure Main.

3 Definitions

Ploughing A trenchless service installation method using a heavy blade to create a furrow in which the service package is immediately placed behind the blade before the spoil settles back into the void Excess spoil is spread within defined parameters and rolled using appropriate machinery.

4 References

- GHD Pty Ltd Engineering Summary Report, Balannup Pump Station A (Collared St) M&E Upgrade & New Pressure Main (Keane Rd), Water Corporation Project Number: C-S01249, Revision C
- GHD Pty Ltd Report on the Geotechnical, Acid Sulphate Soils and Contaminated Sites Investigation, Balannup A WWPS and Keane Road Pressure Main, November 2013
- Water Corporation ASSDMP
- Occupational Safety and Health Act 1984
- Occupational Safety and Health Regulations 1996
- Excavation Code of Practice 2005
- Traffic management-Works on Roads Code of Practice 2008
- Restoration and Reinstatement Code of Practise 2002
- Utility providers Code of Practise 2010
- Australian Standard - AS 2885.1 -1997 Part 1. Section 6
- Australian Standard - AS 1270 Acoustics - Hearing protectors
- Australian Standard - AS 1336 Recommended practices for occupational eye protection
- Australian Standard - AS 1337 Eye protectors for industrial applications
- Australian Standard - AS 1800 Occupational protective helmets - Selection, care and use
- Australian Standard - AS 1801 Occupational protective helmets
- Australian Standard - AS 1885.1 Workplace injury and disease recording
- Australian Standard - AS 2161 Occupational protective gloves
- Australian Standard - AS 2210 Occupational protective footwear
- Australian Standard - AS 4360 Risk Management
- Australian Standard - AS 1742.3 Manual of uniform traffic control
- Underground Services' Work Practice Manual – including but not limited to;
    - USA-OPS-WP-04-01 Manual Handling Safety
    - USA-OPS-WP-05-01 Excavation and Trenching
    - USA-OPS-WP-05-03 Locating Services
    - USA-OPS-WP-05-04 Safe Use of Prodders
    - USA-OPS-WP-05-05 Excavation Soil Management
    - USA-OPS-WP-05-06 Barricading
    - USA-OPS-WP-08-02 Butt Fusion Welding
    - USA-OPS-WP-10-01 Ploughing
    - USA-OPS-WP-12-02 Dewatering & Pumping Waste Water
    - USA-OPS-WP-12-04 Site Protection and Restoration of Vegetation
    - USA-OPS-WP-12-09 Fuel and Chemical Spill Control and Clean-Up
    - USA-OPS-WP-12-10 Management of Flora & Fauna
    - USA-OPS-WP-12-11 Erosion & Sediment Control
    - USA-OPS-WP-12-14 Heritage and Archaeology

- Underground Services Environment Management Plan USA-ENV-EMP-001
- Underground Services' Policies and Procedures – including but not limited to;
    - USA-OSH-PRO-013 OSH&E Responsibility & Accountability Procedure
    - USA-OSH-PRO-019 Job Safety Analysis ("JSA") Procedure
    - USA-POL-004 OHS Policy
    - USA-POL-005 Environmental Policy
- Emergency Response Plan
- Traffic Management Plan ("TMP")
- Current Dial Before You Dig ("DBYD") Plans
- Water Corporation Clearance to Work Permit

5 Responsibilities

The Project Organisation chart outlines the management structure of the project.

It is the responsibility of the Project Manager/Project Supervisor to ensure the requirements of this Methodology are understood by all employees and that they have the capacity to comply with this procedure. Project Specific inductions will cover the existence and importance of the task specific work practices. The Project Manager will ensure that Safe Work Practices for specific tasks are covered in regular toolbox meetings. All Work Practice requirements will be monitored and compliance audited by the Health, Safety, Environment and Quality ("HSEQ") Manager. Any non-compliance/issues will be reported to the Project Manager as well as the Water Corporation Site Representative.

The Project Supervisor will delegate day to day duties to the project team.

The roles and responsibilities to carry out the OSH&E functions of this Methodology are defined in the Responsibility and Accountability Procedure.

6 Construction Methodology

6.1 Summary

The ploughing will allow the pipe line and associated pipework to be installed without undue stresses, free from defects at the time of installation and in accordance with the Water Corporation's Technical Specification or Direction, Alignment Sheets and other relevant standards, drawings and data tables. The installation will provide an environment that will prevent any such defects occurring during its testing and subsequent operating life.

Environmental concerns and landowner issues will be considered and will be addressed prior to the commencement of any works. Similarly, care and protection of existing foreign services will be exercised and conditions of each service provider will be adhered to.

Safety risks (i.e. depth of excavation, ground condition, underground foreign services, proximity to public and other infrastructure, access, etc.) will be assessed and considered prior to works as a part of the JSA process.

6.2 Preliminaries

The HSEQ Manager or his nominee will confirm to the supervisor that all personnel involved in the works have attended the Project Induction.

The supervisor will ensure that all safety precautions and recommendations have been implemented, JSA's have been reviewed, discussed and signed on to, and that all personnel involved have the required safety equipment and Personal Protective Equipment ("PPE"). This must include all safety risks (i.e. depth of excavation, ground condition, underground foreign services, proximity to public and other infrastructure, access, etc.) that are highly likely while undertaking the ploughing work.

The specific environmental management actions will be determined and implemented in accordance with the Water Corporation's Construction Environmental Management Framework (CEMF), which will be prepared prior to construction, and all relevant approvals and permits. The CEMF will include site specific requirements regarding dewatering management, lime dosing for ASS management, hygiene (including weed management and dieback) , clearing limitations and all other constraints.

6.3 Site Investigation

Investigations ahead of the ploughing will be undertaken to locate and uncover all buried services, underground structures and all other obstructions intersecting or immediately adjacent to the planned pipe location. All such crossings will be clearly marked and exposed (potholed) sufficiently in advance of the works to allow sufficient time to clear the obstruction. Refer to Locating Services Safe Work Practice.

6.4 Protection of Existing Services and Structures

This section must be read in conjunction with the Locating Services Safe Work Practice.

USA will obtain contact details for the various authorities responsible for overhead and underground services affected by the work. Prior to commencing work near any such services, USA will notify the relevant authorities of the anticipated schedule of works. Any permit to work that may be issued by the asset owner must be checked prior to excavation and conditions therein must be adhered to.

In the event of damage to a foreign service, the service owner and the Water Corporation's Site Representative will be informed immediately. The service excavation will remain open until the owner has approved the repair, wherever possible without affecting public or employee safety.

6.5 Clearing Minimisation

All works will be conducted within the cleared fire access track where practicable, or within a 4 m demarcated construction corridor. Some areas require the plough to track over sections of native vegetation. This work will be carried out without removing original vegetation to enable faster regeneration of the flora once the works have been completed.

All sign boards, post and features will be delicately removed to enable reinstatement without any damage.

6.6 Ground Penetration

Before beginning any plough works the Project Supervisor will ensure that all underground services and cabling are located as per the Dial Before You Dig plans and positively identified as appropriate (i.e. gas pipeline, optic fibre, pipeline cathodic protection, earth matting etc.). These services will be protected and marked (pegged or paint) and Clearance to Work requirements implemented prior to plough operations.

All identified services in the vicinity of the works must be isolated or, where isolation is not possible, physically marked and protected against accidental damage.

Minor excavations (1000mm wide by 1500mm deep and 5000mm long) are required in addition to the plough works to allow for entry and exit of the plough blade. Where practicable, the entry and exit points for the plough blade will be excavated outside of the Bush Forever area and will remain within the demarcated construction footprint.

Any mechanical excavation work must be carried out with a dedicated spotter (Safety Observer) in place. All minimum clearances for mechanical excavations set out in USA-OPS-WP-05-01 Excavation and Trenching should be maintained unless otherwise specified by the service owner.

Where the possibility of underground services exists in an area that is to be excavated and there is no information about the existence of these services, then controlled mechanical and manual digging with a permanent spotter (Safety Observer) is to be used or a service location crew is to be brought in to remove any doubt as to the existence of services before normal excavation commences.

6.7 Access/Egress

All accessible areas of an excavation of more than 150 mm below grade level whether temporary or permanent must be adequately signposted and/or protected to identify the potential hazard and prevent unauthorised access.

No person will enter any excavation created outside the Bush Forever area until the Project Supervisor has granted permission to enter and has checked and ensured that the excavation or furrow is safe.

Due to the EcoPlough methodology only a shallow furrow will be present. As a result shoring, battering and/or benching will not be required, however for all excavations outside of the Bush Forever site that exceed 1.5m, the applicable legislation will be followed. Safe access and egress will be provided in the form of ladder(s), ramp(s) or stairs; and other personnel will be present at all times that any person is in an excavation.

6.8 Warning signs

Where an excavation created outside the Bush Forever area may not be immediately visible to personnel approaching the Site, hazard warning signs will be displayed. This applies to excavations that may be obscured by buildings or equipment.

6.9 Barricading

All barricading on site will be erected in accordance with the work practice; USA-OPS-WP-05-06 Barricading.

Materials to be used for barricading will be made available prior to commencing any excavation and erected progressively. Excavated materials may be used to establish a windrow as a barricade. The start and end points of excavations will be barricaded where appropriate. Barricading will be, where practicable, at least 1.5m back from the lip of an excavation.

Barricading must be constructed to a height of not less than 1m and, with the exception of windrow or individual risk assessment in built up areas, barricades positioned no less than 1m from the edge of an excavated area.

6.10 Inspection and Testing

The ploughing works will be performed in accordance with the Inspection and Test Plan (ITP) for ploughing. The ITP details the acceptance criteria for each process. It lists the relevant specifications, inspection procedures, test frequency, inspection characteristics and the subsequent verifying records.

ITP details the agreed Hold & Witness Points during the implementation of the works and will be submitted for approval with Water Corporation's Site Representative for approval prior to works commencing on site. The ITP's in Section 12 are samples which, given client approval, will be used for any ploughing works.

6.11 Danger Tape & Tracer Wire

Separation distances between danger tape and tracer wire and pipes will be set as per the Water Corporation technical specification.

6.12 Quality Control

Inspection holes will be potholed at regular intervals within the first 50m of plough runs. This is to ensure; correct depth of package, correct separation of danger tape and tracer wire and to audit and calibrate the GPS systems

7 Ploughing

Ploughing is an efficient, environmentally friendly trenchless underground service installation method. Higher productivity than conventional excavate and lay techniques is possible in suitable ground conditions. Furthermore, the environmental impact of excavations is reduced because there is far less ground disturbance with ploughing and reinstatement occurrs soon after service installation.

The EcoPlough is fitted with a GPS Tracking and Data Collection system which collates the GPS Position (Easting & Northing) and depth of the package being installed. The EcoPlough is also fitted with several video cameras as an additional quality assurance measure. The information captured by these cameras is to be reviewed at the completion of the plough run and checked against GPS information. This information is also utilised by the Business Improvement Department to address any issues and to identify areas for improvement.

The requirements of each section are:

7.1 GPS Tracking and Data Collection

- The plough supervisor and operator are to be competent in the utilisation / set up of the tracking tool.
- The proposed installation route is to be surveyed by the plough operator and/or surveyor.
    - The existing ground levels are to be stored in the plough's GPS recorder unit alongside the positioning data.
    - File to be saved as a unique specified run.
    - On completion of ploughing the 2 files are overlapped and the depth of the package is collated.
    - All data collated over the life of the project is saved to a Universal Serial Bus ("USB") drive and backed up to the project file as soon as practicable. A copy of the raw data is given to the Client.
    - A diagram can also be produced for the purpose of as-constructed drawings (a surveyor may be required to help complete this task).

7.2 Entry and Exit Holes

- Entry and exit holes are required to lower and remove the plough blade.
- Entry and exit holes to be excavated prior to commencement of ploughing.
    - Holes to be 1000mm wide by 1500mm deep by 5000mm long to allow for approximately 1m cover of pipe.
    - Specifications are to be observed and quality control maintained.
- Entry and exit holes shall be excavated and made safe in advance of the plough. This is to eliminate the risk of damage to the package that is being installed.
- Once EcoPlough has moved past the entry/exit hole, the hole is to be made safe by immediately backfilling and compacting wherever practically possible. Safe work distances of personnel will be maintained during excavation activities.
    - All excavation works will be conducted in accordance with USA-OPS-WP-05-01 Excavation and Trenching Work Practice (or as per client specification)
- Chute to be lowered into entry hole
    - Chute to be set to ensure that minimum cover is installed over the service as per design specification. Chains attached to the chute are the guide for depth as a secondary quality check to the plough GPS systems.

7.3 Spotters

- Spotters will be used where/if required
- Operator will be using camera system as a primary control

7.4 Other plant roles

- Integrated Tool-carrier is to be utilised for the purpose of receiving materials on site and any lifting works that may be required.
- Excavators will be used for excavating entry & exit pits and anchoring the pipe.

7.5 Plough Operation

- The plough shall only be operated by a competent and qualified operator.
- Operator is to ensure spotters are aware of intended plough movements by communicating using two-way radio and blasts on the horn. Spotters (where/if required) are to maintain a safe working distance from the plough at all times while it is operating.

8 EcoPlough Trenchless Installation Methodology

The process for the installation of a 450OD PN16 HPDE pipe by the EcoPlough is as follows:

Table 2: EcoPlough Installation Methodology

Stage	Description
1	Pre-Start meeting with all project personnel prior to any works being undertaken
2	Complete the daily pre-starts for all plant and equipment
3	The Surveyor sets up the base station at the known control point
4	The base station is calibrated and then the surveyor creates the poly line created by establishing the location of the plough line every 50m on straight runs and at every change of direction or deviation from the horizontal alignment of the previous location. The poly line will represent the centre line of the horizontal alignment of the pipe, the accuracy tolerance of this position and the accuracy tolerance of depth will be +/-100mm
5	Test the compaction of the alignment using a standard Penetrometer and record the data for comparison in the final compaction report
6	Pre-rip the horizontal alignment with a D10 Dozer at the full depth of 1500mm for three passes to ensure that the alignment is clear of any objects that could damage the pipe
7	After each individual pass with the D10 they will place the appropriate level of lime in accordance with the Water Corporation ASSDMP using a Front End Wheel Loader with a Stemming Bucket, the Loader will travel up and down the horizontal alignment within the 4m corridor.
8	Unload delivery of pipe and string it out with the Front End Wheeled Loader.
9	Weld the 12m lengths of 450OD PN16 HDPE pipe using the Ritmo Delta 630 All Terrain Fast Fusion Welder along the alignment and within the access track as per USA-OPS-WP-08-02 Butt Fusion Welding.
10	Upon completion of each weld, lift the pipe to one side of the access track using the Front End Wheeled Loader, which will remain in the delineated 4m corridor during the process.
11	Excavate an entry and exit pit with the dimensions 1000x1500x5000 using a 20 tonne Excavator.
12	Attach the chute to the EcoPlough as per the Ploughing Work Practice USA-OPS-WP-10-01.
13	Place the welded pipe to the right hand side of the EcoPlough and secure the pipe into the fair lead roller arrangement.
14	Lower the chute into the entry pit.
15	Feed the welded 450OD PN16 HDPE pipe into the chute into the initial position using the 20 tonne Excavator and soft slings.
16	Secure the end of the rated pulling cone by using a 20 tonne Excavator with an approved lifting eye rated to a safe working load of 10 tonne.
17	Once the end of the pipe is secured and made safe, all personnel will make their way into the safe zone 5m behind the EcoPlough. At no time shall any personnel be allowed to be in front of the EcoPlough until it has come to a complete stop in the exit pit.
18	Commence ploughing at the depth of minimal cover of approximately 1m, the cover will be maintained throughout installation. The pipe will be installed without any undue stress and zero tension,
19	Once the EcoPlough reaches the end of the plough line, hence the chute is now exposed in the exit pit. The EcoPlough is then returned to its standby area.
20	Once the EcoPlough has been moved to the standby area all the GET attachments will be lowered and made safe.
21	The EcoPlough Operator will download all the text data file from the GPS control box inside the EcoPlough and hand it over to the Project Manager, along with video footage of the entire plough route. These will both be used as the final as-constructed drawings.
22	Use a Posi-Track Skid Steer with the Grader Blade attachment to push the furrow into one windrow on top of the plough line.
23	Compact the access track using a 15 tonne Vibe Drum Roller in accordance with client compaction requirements.

9 Health, Safety & Environmental Management

9.1 Background

Bush Forever Site 342 is recognised as an environmentally sensitive area.

9.2 Health & Safety Management

Health & Safety Management is prescribed in the USA-POL-004 OHS Policy and the associated procedures.

9.3 Environment Management

Environmental Management is prescribed in the USA-POL-005 Environmental Management Policy and associated procedures. Ploughing and excavation operations will be performed in accordance with Water Corporation's requirements, relevant management plans and approvals.

In the event of a fuel or chemical spill, the spill will be handled and cleaned up as per the Fuel and Chemical Spill Control and Clean-Up Work Practice USA-OPS-WP-12-09.

9.4 Water Table Validation & Mitigation

The water level will be determined by potholing to the maximum excavation depth prior to commencement of works.

Works should be undertaken in dry months wherever practicable to avoid any technical dewatering issues that may be encountered based upon information provided in GHD's Report on the Geotechnical, Acid Sulfate Soils and Contaminated Sites Investigation.

In the event that the water table level is above the excavation level, then the excavation does not need to be dewatered as the EcoPlough can successfully function in both wet and dry terrain.

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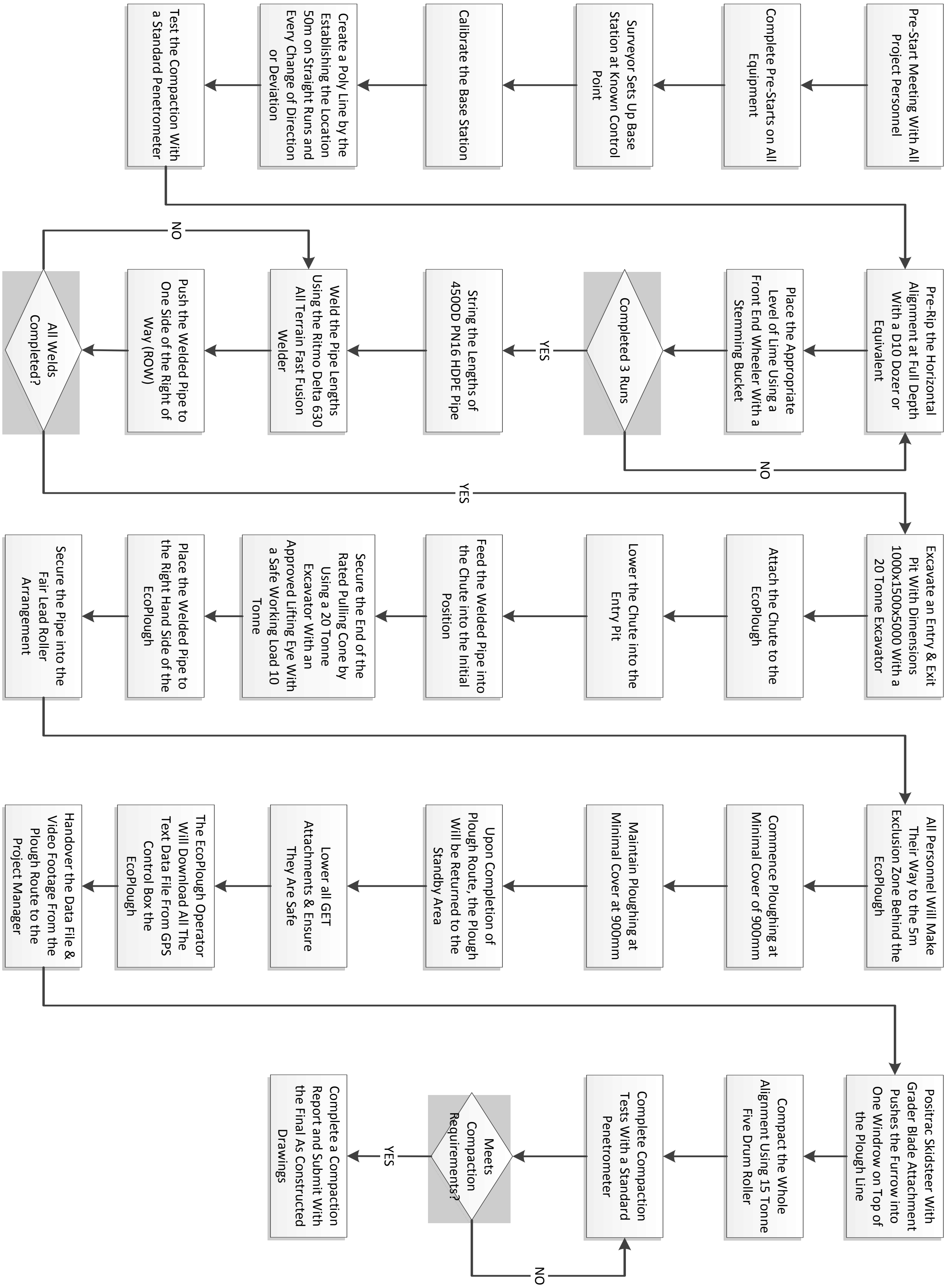
9.5 Hazard Identification, Risk Assessment and Control

Ploughing operations will be performed in accordance with Occupational Safety & Health Act 1984, the Workplace Health and Safety Regulations 1996 The Contractor Health & Safety Management Plan, Construction Environmental Management Plan.

Prior to commencing work on site all personnel are required to have satisfactorily completed a site induction held by the HSEQ Representative or appointed delegate. Personnel on site who have not attended the Site Induction will not perform any work and must complete a Visitor's Induction with the Project Supervisor prior to entering site.

10 Process Maps



11 Job Safety Analysis (JSA)

An example of a typical general works JSA for the Project is included below.

Project: USA Project No:		DATE:	☑ New o Revised
Project Manager:	Supervisor:	Analysis By:	
Location:	Department:	Reviewed By:	
Personal Protection Equipment: Mandatory: Hi-vis long sleeve and long trousers, safety boots, eye protection, hard hat, wide brims Required when appropriate: Hearing protection, double eye protection		Approved By:	

STEP No.	DESCRIPTION OF JOB/TASKS STEPS What needs to be done step by step?	POTENTIAL INCIDENTS OR HAZARDS What are the potential hazards, situations, or events that can lead to damage or harm?	Consequence, Frequency and RISK LEVEL (Before Controls)			RISK CONTROL MEASURES What controls are in place to reduce the risk level?	RESPONSIBLE PERSONS	Consequence, Frequency and RISK LEVEL (After Controls are in place)		
			F	C	R			F	C	R
1	Mobilisation of plant and equipment to drive on Site	Plant and equipment driving on Site. Traffic injury to personnel / pedestrians. Vehicle/Plant collision	D	2	H	Only project nominated drivers to drive vehicles. All signs to be strictly obeyed at all times. Use Traffic Management Plan as per procedure. All project personnel to wear high-visibility vest / shirt whilst outside a vehicle.	Project Manager Project Supervisors Crew Leader/s Ground personnel	D	3	M

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			F	C	R			F	C	R
		Insecure loads accidents caused by vehicle load shift.	D	2	H	When unloading plant, ensure adequate traffic control is organised and utilise traffic controllers when unloading on local roads. Ensure vehicles are not overloaded and that all loads are secure. Decrease speed when transporting heavy loads and increase distance from vehicles in front.	Project Manager Project Supervisors Crew Leader/s Ground personnel	D	3	M
		Oil/fuel spill Damage to Flora/Fauna	D	3	M	Pre-start checks to be conducted on all plant and vehicles daily. Report spills greater than 2 litres. Spills to be treated/recovered using spill kits. No servicing of vehicles on Site. No refuelling within 50m of any water way ESA (Environmentally Sensitive Area)	Project Manager Project Supervisors Crew Leader/s Ground personnel	D	5	L
2	General labouring on Site	Sun Exposure	A	3	E	Apply sunscreen on regular basis. Adequate sun protective clothing/headwear. Maintain adequate drinking water supplies Wear adequate PPE	All Personnel	C	2	H
		Insect Bites	A	5	H	Wear protective clothes. Use insect repellent. Have access to & know how to use tick removal first aid gear.	All Personnel	C	5	L

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			F	C	R			F	C	R
		Snake Bites	C	2	H	Be mindful that snakes may be about. Make sure that each crew has snakebite kit handy at all times. Refer Emergency Contact Sheet for contact details regarding removal of snakes.	All Personnel	C	2	H
		Slips/Trips/Falls from Uneven Surfaces	B	4	H	Be constantly aware of the work Site and the fact that uneven surfaces are around, especially when carrying loads. Create a smooth path to & from the required location to minimise the risk of injury. Job checked regularly with regard to temporary repairs prior to final reinstatement. Provide secure access to all work areas, access stairs, ladder, etc.	All Personnel	C	4	L
		Lightning	B	2	E	In event of lightning, cease work and move to area of cover within building or vehicle during period of lightning activity.	All Personnel	B	4	H
		Dust & Sand	A	5	H	Protect eyes with safety glasses (eye protection) when dust and sand is blowing.	All Personnel	A	5	H
		Hazards from working in close proximity to other contractors.	A	4	H	Good communication and consultation required with all working on the Site. Extensive planning required from all to ensure that we are not working on top of other contractors. Ensure when we are working, we have a safe amount of space to conduct our operation.	Project Supervisor Crew Leader Ground Personnel	A	4	H
3	Working in a busy environment	Motor vehicle accident, on work Site Pedestrian/cyclist accident, on the work Site	A	2	E	Ensure traffic/pedestrian management is in place Appropriate signs/barriers/barricades are available on Site or request Fencing /barricading to be appropriate for the work that is being conducted Ensure trenches are backfilled as soon as practicable	Project Supervisor Crew Leader Ground Personnel	C	2	H

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			F	C	R			F	C	R
4	Manual Handling	Injuries from incorrect manual handling.	A	4	H	Heavy Lifts – use 2 people or mechanical device. When lifting – Keep loads close to body, keep back straight & bend your knees. Remember to warm up. Avoid twisting when lifting. Be aware of uneven surfaces Follow the CERP for the Project	All Personnel	A	5	H
5	Traffic and Pedestrian Management	Vehicle & Ground Personnel Interaction	A	3	E	Traffic Management to be in place where existing utilities are being located under road pavement. Pedestrian warning signs to be in place where existing utilities are being located under pedestrian ROW's or footpaths.	All Personnel	A	2	E
6	Location of Existing Services	Damage to Services during excavation or injury to personnel	B	2	E	Ensure correct locates for all services are available and on Site in job file. Physically locate all services and complete excavation prior to commencing works as per Services Locating Procedure and Protection of Utilities & Permit to Work.	Locator Project Supervisor Crew Leader	C	2	H
		Injury to Third Party during and after locates being conducted	D	4	L	All excavations to be barricaded as per Barricading Procedure. All temporary repairs to be left in a safe state, locates to be timed to minimise impact on permanent surface treatments, temporary repairs to be monitored and maintained as required.	All Personnel on Site	D	4	L
7	Use of Mechanical Plant on Site	Failure of Mechanical Plant	C	4	M	All new plant to Site to be checked for possible hazards/defects. Plant to have a pre-start inspection daily. All defects to be noted on daily inspection sheet. Any serious defects found, plant to be stood down and workshop notified.	Plant Operators Crew Leader/s Project Supervisor	C	5	L

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			F	C	R			F	C	R
		Personnel in close proximity of Plant	A	2	E	Ground personnel to stay appropriate distance outside of swing radius of excavator. Ground Personnel to have and maintain eye contact with operator prior to entering swing radius. Spotters & Plant operators to maintain two way radio contact	Ground Personnel Machine Operators	D	3	M
		Machinery Damaging Existing Below or Above Ground Assets	C	2	H	Located utilities to be confirmed prior to start of excavation; above ground hazards to be identified and appropriate barriers erected to isolate hazard where required.	Ground Personnel Machine Operators Crew Leader	C	3	H
		Trench / Excavation Collapse	C	2	H	Shoring of excavation with sufficiently rated shield, shoring box, timber set where safe battering is impracticable. Spoil to be placed at the required distance from the edge of the excavation, as per Code of Practice, or removal by loader for storage elsewhere on Site. No personnel to enter trench deeper than waist height (1.5m) without shoring or battering to safe angle. Divert surface water using suitable open drain. Pump out groundwater ensuring it does not affect stability of trench walls.	Ground Personnel Machine Operators Crew Leader	D	4	L
		Falling / Slipping / Getting Into/Out of Machinery	D	4	L	Maintain 3 points of contact with the vehicle at all times.	Ground Personnel Machine Operators	D	4	L
8	Exposure to Hazardous materials	Asbestos Interface with Personnel (If Encountered)	C	2	H	Follow Asbestos Handling Procedure	Crew Leader Ground Personnel	C	4	M

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			F	C	R			F	C	R
		Materials used in construction	C	2	H	Make available Materials Safety Data Sheet (MSDS) for products used in construction.	Crew Leader Ground Personnel	C	4	M
9	Working in close proximity existing services in open excavations	Machinery too close to edge of trench causing trench sides to collapse	C	3	H	Equipment not to approach closer than top edge of angle of repose, unless shoring box or braced shield in place. No personnel in excavation during placement of backfill by machine.	Machine Operator	C	4	M
10	Backfill and Compaction of Excavations	Back strain or injury lifting compactor into excavation	D	2	H	Use mechanical lifting equipment to lift compactor into trench Use a two person lift if no lifting equipment available.	Machine Operator Ground Personnel	D	4	L
		Confined Space (Breathing problems etc.)	C	2	H	Ensure adequate ventilation Confined Space Risk Assessment Confined Space Accreditation-current	Ground Personnel	C	5	L
		Motor vehicle accident, on the work Site Pedestrian/cyclist accident, on the work Site	C	2	H	Ensure traffic and pedestrian management in place and adhered to. Appropriate signs/barriers/barricades will be in place on the project Site while the works are being carried out. Fencing/ barricading to be appropriate for the work that is being conducted. Ensure trenches are filled as soon as conveniently possible.	Project Manager Project Supervisor Crew Leader	C	4	M
11	Load Shifting by Machine	Injury or death to personnel by falling load	C	2	H	Ticketed operator and qualified dogman required for slinging and lifting of loads. Use of tagged lifting equipment in good condition only.	Operator Dogman Crew Leader	C	4	M
12	Barricading	Unauthorised Personnel entering Site	C	2	H	Install bunting to prevent access to work area and install information tags. Ensure safe entry/exit through/around work site where necessary. Ensure appropriate signs are used. Backfill as appropriate to minimise excavations	Crew Leader Ground Personnel	C	4	M

STEP No.	DESCRIPTION OF JOB/TASKS STEPS What needs to be done step by step?	POTENTIAL INCIDENTS OR HAZARDS What are the potential hazards, situations, or events that can lead to damage or harm?	Consequence, Frequency and RISK LEVEL (Before Controls)			RISK CONTROL MEASURES What controls are in place to reduce the risk level?	RESPONSIBLE PERSONS	Consequence, Frequency and RISK LEVEL (After Controls are in place)		
			F	C	R			F	C	R
						open at any one time. Any hole/open trench must be securely barricaded and barricading checked regularly (must be checked at end of each day) Barricading to be erected as per barricading procedure				
13	Working Under Overhead Power Lines	Electrocution	C	2	H	Ensure that machinery is not within the restricted area OH Power Lines without proper authority. If moving under Power Lines – a spotter is required to ensure the safety distance is maintained according to specifications. Catenaries to be put in place and signposted as required For further information refer to Western Power Work Practise Manual-Section 1/1.8) Any incidents must be reported to the WCWA/regulator	Machine Operators	C	4	M
		Burns	C	2	H	Keep a fire extinguisher/fire blankets handy at all times.	Crew Leader Ground Personnel	C	4	M
		Fire	C	2	H	Ensure surrounding area is free of materials and vegetation where applicable Fire extinguishers/fire blankets to be kept nearby at all times. Follow procedures outlined in CSC	Crew Leader Ground Personnel	C	4	M
14	Hot Work	Fire	C	2	H	Fire extinguishers/fire blankets to be kept nearby at all times. Use a hot work permit	Crew Leader Ground Personnel	C	4	M
15	Locating Underground services	Personal injury from hammering and handling pegs including splinters and/finger crush	C	3	H	Ensure gloves are available to survey crews for handling stakes, pegs and star pickets. Disposable splinter probes to be included in First Aid kits. Do not use broken or damaged stakes, pegs or pickets. Ensure hammer used is suitable for the application. Safety glasses to be worn at all times.	Surveyor Crew Leaders	C	4	M

STEP No.	DESCRIPTION OF JOB/TASKS STEPS What needs to be done step by step?	POTENTIAL INCIDENTS OR HAZARDS What are the potential hazards, situations, or events that can lead to damage or harm?	Consequence, Frequency and RISK LEVEL (Before Controls)			RISK CONTROL MEASURES What controls are in place to reduce the risk level?	RESPONSIBLE PERSONS	Consequence, Frequency and RISK LEVEL (After Controls are in place)		
			F	C	R			F	C	R
		Remote Locating Crew becomes stuck or lost in remote area				Personnel not to work or drive through remote areas alone. Check water depth before driving through creek crossings. Maintain communications and ensure all vehicles carry load rated towrope and adequate drinking water.				
16	Survey Works	Use of Class 1 laser equipment (Survey and general works)	C	4	M	Laser warning signs clearly posted No direct eye contact with laser beam For further information on controls refer to AS 22 11 & AS 2397 (Laser safety AS's)	All Personnel on Site	C	4	M
		Contact with sharp object Lacerations/cuts (Placing stakes and pegs as required)	C	4	M	Wear appropriate PPE in accordance with the JSA established for the task First Aid kits available on Site Qualified SNR First Aiders available on Site (USA)	All Personnel on Site	C	4	M
17	Potholing near electric fence	Contact with electric fence will cause electric shock	C	2	H	Keep clear distance between personnel and electric fence If possible turn electric fence off while working in the area Report any electric shock incidents Electric shocks must be reported to the regulator- Electric sources must be turned off	All Personnel on Site	C	4	M
18	Night Works	Workers fatigue issues	C	2	H	Refer to Safety procedure	All Personnel on Site	C	4	M
		Reduced visibility issues	C	4	M	Portable Light Towers available on Site Traffic Management	Project Supervisor Crew Leader	C	4	M

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			F	C	R			F	C	R
		Traffic and Pedestrian management	C	2	H	Signs and cones in place High visibility clothing Traffic controllers in Place as per TM Plan	Project Supervisor Crew Leader	C	4	M
19	Housekeeping	Injury to personnel due to bad housekeeping-trips and slips(rubbish/equipment/tools left lying around) Rubbish not adequately stored increasing risk of combustion	C	4	M	Designated rubbish areas/rubbish bins on Site	All Personnel	C	4	M

RISK MATRIX

	CONSEQUENCE				
FREQUENCY	**1** Major	**2** Significant	**3** Moderate	**4** Minor	**5** Insignificant
A Frequent	**Extreme**	**Extreme**	**Extreme**	**High**	**High**
B Often	**Extreme**	**Extreme**	**High**	**High**	**Medium**
C Sometimes	**Extreme**	**High**	**High**	**Medium**	**Low**
D Rarely	**High**	**High**	**Medium**	**Low**	**Low**
E Unlikely	**High**	**Medium**	**Medium**	**Low**	**Low**

RISK LEVEL	RESPONSIBILITY / ACTION REQUIRED
Extreme	Unacceptable level of risk. Interim corrective action required to reduce risk immediately, with permanent corrective action planned with high priority.
High	Undesirable level of risk. Interim corrective action required if practicable, with permanent corrective action required to reduce risk with high to medium priority.
Medium	Marginal level of risk. Planned corrective action may be required to reduce risk to lower level if so far as is practiable with medium priority. Alternatively risk may be tolerable and additional corrective action may not be required.
Low	Tolerable level of risk. Risk controlled to 'as low as reasonly practicable' and additional corrective action is not required.

12 Inspection Test Plan ("ITP")

Typical ITP for Ploughing works;

Inspection and Test Plan (ITP) – Ploughing

Project Name: Underground Services Australia - Project No: Contract No:

Client: Contractor: Underground Services Australia Project Location:

Description of Item/Service: Plough works ITP No: 3 Rev. 0

Works Location:………………………………………………………………………………………… **Construction Drawing Number:** ………………………………………

LEGEND

H – Hold Point - work shall not proceed past the Hold Point until released by the organisation imposing the Hold Point.

W – Witness Point - an inspection point that may be witnessed by the organisation imposing the Witness Point.

I – Inspection - formal inspection activity to be undertaken and recorded.

S – Surveillance - an activity that is subject to ongoing monitoring.

R – Review - review of text reports/records or other evidence of compliance.

RI – Responsible Inspectorate
Project Supervisor ("PS")
Project Engineer ("PE")
Project Manager ("PM")

REFERENCE DOCUMENTS
Construction Scope of Works
Technical Specifications for Cable Installation
Environmental Management Plan (EMP)
Safety Management Plan (SMP)
Project Execution Plan (PEP)
Daily Job Safety Analysis (JSA)

APPROVAL/REVISION

Rev	Date	Details	App'd	App'd (Client)
0	07/05/2014	Internal Review	David Lill	

LEGEND SUMMARY

H – Hold Point W – Witness Point I – Inspection S – Surveillance R – Review RI – Responsible Inspector PS - Project Supervisor PE - Project Engineer PM – Project Manager

Task No.	Task Description	RI	Acceptance Criteria	Applicable Standard (Procedure or Instruction)	Inspection Test		Verification Activity by			Verifying Documents	Verifying Signature
					Method	Frequency	Sub Con	USA	Client		
1.0	Permit to Work	PS or PE	Permit to work application form filled, approved by the client and available on site	PEP EMP, SMP	Review	Prior to Start of Work	H	H	R	Approved Permit to Work	
2.0	Application design change (if applicable)	PS or PE	Proposed change of trench submitted to client and approved	PEP EMP, SMP	Review	Each Change of Design	H	H	R	Approved Variation to Contract	
HOLD POINT							Signed:				
3.0	Check for correct Traffic Management bunting, barricading and signage	PS or PE	Correct bunting, barricading and signage	PEP EMP, SMP	Visual	Prior to Plough	S	S	S	Project File	
4.0	Check ploughing along the proposed line	PS or PE	Plough centreline as per survey layout Material as per construction specification	PEP EMP, SMP	Visual	Each Line	S	I	I	Project File	
5.0	Check Entry / Exit holes excavated in correct location	PS or PE	Correct distance for continuous pipe as per the construction specifications	PEP EMP, SMP	Visual	Each Line	S	S	S	Project File	

Task No.	Task Description	RI	Acceptance Criteria	Applicable Standard (Procedure or Instruction)	Inspection Test		Verification Activity by			Verifying Documents	Verifying Signature
					Method	Frequency	Sub Con	USA	Client		
7.0	Existing underground services	PS or PE	All 3rd party service owners have approved permit to works and been notified prior excavation commencement No services are across the line of the plough or able to be damaged by ploughing works.	PEP EMP, SMP	Visual	Prior to Ploughing	H	H	I	Project File Records	
HOLD POINT							Signed:				
8.0	Installation of pipe and marking devices (danger tape / tracer wire)	PS or PE	Pipe and marking devices installed to the correct depth and with the correct separation	PEP EMP, SMP	Visual	Each Line	H	H	I	Project File Records	
9.0	Reinstatement of plough line and exit / entry holes	PS or PE	Whatever minor ground disturbance that may have been caused is backfilled and reinstated	PEP EMP, SMP	Visual	After ploughing works	S	R	S	Project File	
10.0	Installation of above ground marker devices	PS or PE	As per construction specification	PEP EMP, SMP	Visual	Prior to De-Mobilisation	S	R	S	Project File	

Task No.	Task Description	RI	Acceptance Criteria	Applicable Standard (Procedure or Instruction)	Inspection Test		Verification Activity by			Verifying Documents	Verifying Signature
					Method	Frequency	Sub Con	USA	Client		
11.	Traffic Management and signage removed	PS, PM or PE	All additional material, signs, traffic management devices removed from site	PEP, SMP, EMP	Visual	Prior to De-Mobilisation	S	R	W	Project File Records	
HOLD POINT							Signed:				

13 Site Inspection Photographs
































Appendix C

Route Options Considered

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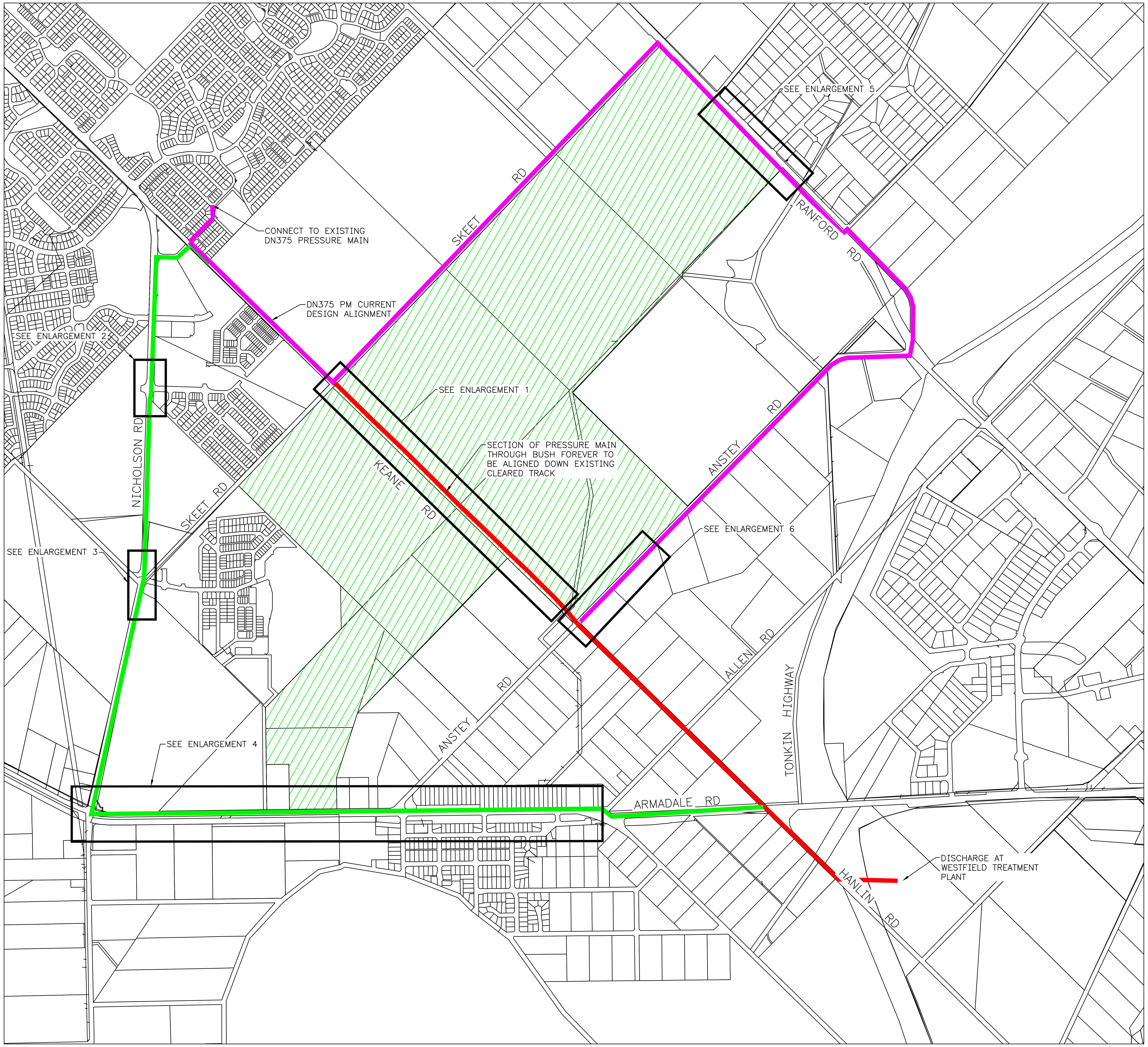
PRELIMINARY ONLY
NOT TO BE USED FOR CONSTRUCTION



LEGEND

DN375 PM ALIGNMENT OPTION 1
DN375 PM ALIGNMENT OPTION 2
DN375 PM ALIGNMENT OPTION 3
BUSH FOREVER

100 50 0 100 200 300 400 500 600 700 m (1:10000 AT A1)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY NONE	VERTICAL DATUM NONE	DES CALC
	COORDINATE SYS NONE	DES CHD
ASCON SURVEY NONE	DES REF	DRN
		Q.C. CHD

NORTH POINT

INFRASTRUCTURE DESIGN BRANCH

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER
BALLANUP PUMPING STATION NO. 175-01
DN375 PRESSURE MAIN
ROUTE ALIGNMENT

FILE | PLAN | CAD | ISSUE
PROJECT C-S01249 | HW91 | B

ORIGINAL SHEET SIZE A1
MF

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810

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PLAN
ENLARGEMENT 1

LEGEND

PROPOSED MAIN

EXISTING WATER MAIN
(ALSO HYDRANT, INSP. M/H, VALVE
CHANGE IN PIPE MATERIAL OR SIZE & AIR RELEASE SHOWN)

WASTEWATER PRESSURE MAIN
(ALSO SCOUR & AIR RELEASE SHOWN)

DRAINAGE MAIN

GAS MAIN – ?UTILITY

OVERHEAD ELECTRICAL CABLES – ?UTILITY
(ALSO POWER AND LIGHT POLES SHOWN)

UNDERGROUND ELECTRICAL CABLES – ?UTILITY

TELECOMMUNICATION CABLES – ?UTILITY

TELECOMMUNICATION OPTIC FIBRE CABLES – ?UTILITY

STREET LIGHT

POWER POLE

PRELIMINARY ONLY
NOT TO BE USED FOR CONSTRUCTION

50 40 30 20 10 0 50 100 m (1:2000 AT A1)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY NONE | VERTICAL DATUM | DES CALC
COORDINATE SYS | DES CHD
ASCON SURVEY NONE | DES REF | DRN | Q.C. CHD
NORTH POINT

INFRASTRUCTURE DESIGN BRANCH

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

OPTION 1
CONGESTED AREAS – ENLARGEMENT

FILE | PLAN | CAD | ISSUE
PROJECT | SHEET 1 | MF

ORIGINAL SHEET SIZE A1

566 810

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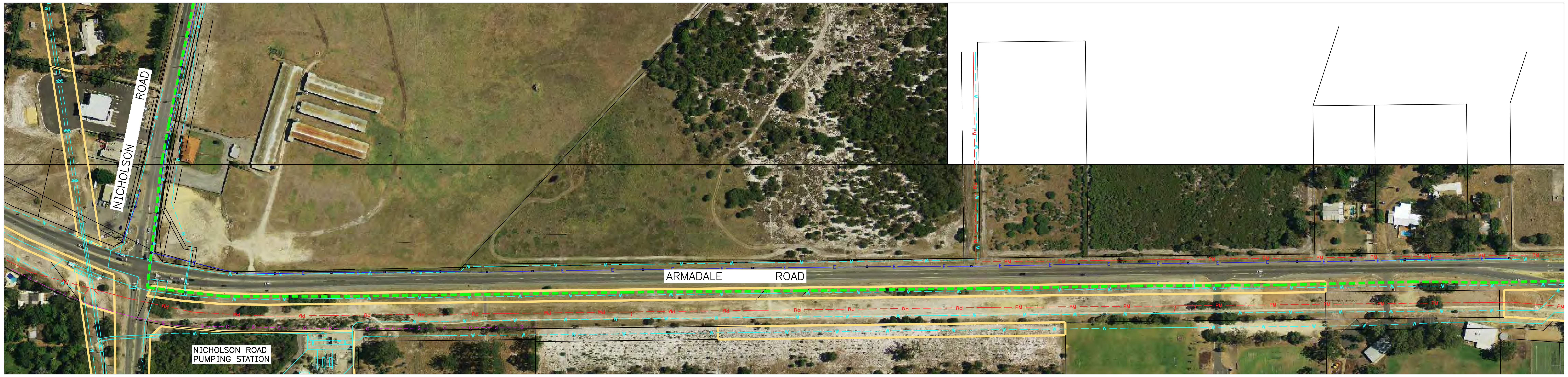

PLAN
ENGLARGEMENT 4
SCALE 1

PLAN
ENGLARGEMENT 3
SCALE 2

PLAN
ENGLARGEMENT 2
SCALE 2

PROPOSED ALIGNMENT
EXISTING WASTEWATER
EXISTING WATER
EXISTING GAS
OVERHEAD POWER LINES

1 50 40 30 20 10 0 50 100 m (1:2000 AT A1)

2 10 5 0 10 20 30 40 50 60 70 m (1:1000 AT A1)

DIAL BEFORE YOU DIG
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PRELIMINARY ONLY
NOT TO BE USED FOR CONSTRUCTION

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY	VERTICAL DATUM	DES CALC	NORTH POINT
NONE	COORDINATE SYS	DES CHD	
ASCON SURVEY	DES REF	DRN	
NONE		Q.C. CHD	

INFRASTRUCTURE DESIGN BRANCH

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

OPTION 2
CONGESTED AREAS – ENGLARGEMENT

FILE | PLAN | CAD | ISSUE
PROJECT | SHEET 2

ORIGINAL SHEET SIZE A1
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RANFORD ROAD
ENLARGEMENT 5

ANSTEY ROAD
ENLARGEMENT 6

LEGEND

- PROPOSED MAIN
- EXISTING WATER MAIN (ALSO HYDRANT, INSP. M/H, VALVE CHANGE IN PIPE MATERIAL OR SIZE & AIR RELEASE SHOWN)
- WASTEWATER PRESSURE MAIN (ALSO SCOUR & AIR RELEASE SHOWN)
- DRAINAGE MAIN
- GAS MAIN – ?UTILITY
- OVERHEAD ELECTRICAL CABLES – ?UTILITY (ALSO POWER AND LIGHT POLES SHOWN)
- UNDERGROUND ELECTRICAL CABLES – ?UTILITY
- TELECOMMUNICATION CABLES – ?UTILITY
- TELECOMMUNICATION OPTIC FIBRE CABLES – ?UTILITY
- STREET LIGHT
- POWER POLE

GENERAL NOTES:

1. THE FOLLOWING HAVE NOT BEEN INVESTIGATED;
1.1 LOCAL AUTHORITY STORMWATER MAINS
1.2 EXISITING AND FUTURE SEALED ROADS
1.3 EXISTING SURFACE FEATURES

2. SERVICES SHOWN ON THIS DRAWING;
2.1 THE LOCATIONS HAVE NOT BEEN ESTABLISHED BY SURVEY BUT RATHER BASED ON GENERAL INFORMATION (DBYD) AS AT JUNE 2013.
2.3 SERVICES TO PROPERTIES AND ASSETS MAY BE PRESENT BUT NOT SHOWN (SUCH AS: WATER, ELECTRICITY, GAS, TELECOMMUNICATION, SIGNAL CABLES)
2.3 LANDSCAPING RETICULATION MAY BE PRESENT BUT NOT SHOWN.

10 5 0 10 20 30 40 50 60 70 mm (1:1 AT A1)

PRELIMINARY ONLY
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ISSUE	DATE	GRID	REVISION	DRN	REC	APPD	DESIGN SURVEY NONE	VERTICAL DATUM	DES CALC	NORTH POINT
							ASCON SURVEY NONE	COORDINATE SYS / DES REF	DES CHD / DRN / Q.C. CHD	

INFRASTRUCTURE DESIGN BRANCH

RECOMMENDED
CONSULTANT PROJECT MANAGER
APPROVED
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

OPTION 3
CONGESTED AREAS – ENLARGEMENT

FILE | PLAN | CAD | ISSUE
PROJECT | SHEET 3 | 1 | MF

ORIGINAL SHEET SIZE A1

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Appendix D

Flora, Vegetation and Fauna Report (ENV 2013)

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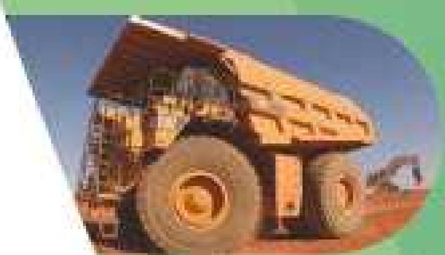
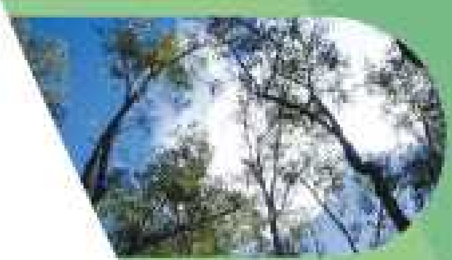
FLORA, VEGETATION AND FAUNA ASSESSMENT, KEANE ROAD



FLORA, VEGETATION AND FAUNA ASSESSMENT, KEANE ROAD

Prepared for

WATER CORPORATION

Prepared by

ENV Australia Pty Ltd
Level 1, 503 Murray Street
PERTH WA 6000
Phone: (08) 9214 6100
Fax: (08) 9226 4109
Email: env@env.net.au

Job Number: *J113163*

Report Number: *12/137*

Document Version	Author/s and Editor/s	Reviewer/s	Endorsed for Release by:	Date
Draft	*Narelle Whittington, Chris Knuckey and Damian Buller*	*Denise True, Bridget Watkins*	*Denise True*	*12/12/12*
Final	*Narelle Whittington, Chris Knuckey and Damian Buller*	*Denise True, Bridget Watkins*	*Narelle Whittington*	*19/03/13*

TABLE OF CONTENTS

TABLES

PLATES

FIGURES

APPENDICES

PERMITS

This flora survey was conducted under the following licences issued by the Department of Environment and Conservation; Licence to take flora for scientific or other prescribed purposes: SL010155 issued to Narelle Whittington and SL009905 issued to Damian Buller.

STATEMENT OF LIMITATIONS

Scope of Services

This environmental site assessment report ('the report') has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and ENV.Australia Pty Ltd (ENV) ('scope of services'). In some circumstances the scope of services may have been limited by factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, ENV has relied on data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ('the data'). Except as otherwise stated in the report, ENV has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or in part on the data, those conclusions are contingent upon the accuracy and completeness of the data. ENV will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, unavailable, misrepresented or otherwise not fully disclosed to ENV.

Environmental Conclusions

In accordance with the scope of services, ENV has relied on the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, express or implied, is made.

Report for Benefit of Client

The report has been prepared for the benefit of the Client and for no other party. ENV assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including, without limitation, matters arising from any negligent act or omission of ENV or for any loss or damage suffered by any other party relying on the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions, and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

ENV will not be liable to update or revise the report to take into account any events or circumstances occurring or facts becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report, nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

EXECUTIVE SUMMARY

ENV.Australia Pty Ltd (ENV) was commissioned by the Water Corporation in August 2012, to undertake a Level 2 Flora and Vegetation Assessment and a Level 1 Fauna Assessment for the proposed Keane Road Sewer Main, Forrestdale (the study area). The Water Corporation has two possible options for the route of the sewer main which were surveyed concurrently. ENV understands that the impact of the two proposed sewer route options, which will have an approximately 10 m wide corridor, will either be 2.11 ha or 2.32 ha depending on the selected route.

The purpose of this study is to provide information on the significance of the flora, vegetation and fauna within the study area as part of supporting documentation for environmental approvals to construct the sewer infrastructure. This study may also provide supporting documentation for an application for a Native Vegetation Clearing Permit (NVCP) under the *Environmental Protection Act 1986* (EP Act).

The field survey was conducted on the 19th of October 2012 and recorded 94 taxa from 76 genera and 30 families.

No plant species listed as Threatened under the *Environment Protection and Biodiversity Conservation Act 1999* or as Declared Rare Flora pursuant to the *Wildlife Conservation Act 1950* were recorded during the survey.

One Priority Flora, *Jacksonia gracillima* (Priority 3), was recorded in the study area. The presence of *Jacksonia gracillima* (Priority 3) does not form a statutory constraint to development of the study area. There is no written policy on responding to the presence of Priority Flora within proposed development sites. The presence of these species is dealt with by the Department of Environment and Conservation on a case by case basis.

Fifteen introduced species were identified during the survey. Two of these are listed as Declared Plants within the Swan Coastal Plain; Arum Lily (**Zantedeschia aethiopica*), and One Leaf Cape Tulip (**Moraea flaccida*).

The study area is mapped as the Southern River Complex: Vegetation consists of open woodland of *Corymbia calophylla*, *Eucalyptus marginata* and *Banksia* spp. with fringing woodland of *Eucalyptus rudis – Melaleuca rhaphiophylla* along creek beds. The pre-European vegetation in the Southern River Complex, which the study area is situated, is considered to be Vulnerable.

Four vegetation units were identified within the study area. These units are considered to represent four Floristic Community Types; SCP21c 'Low lying *Banksia attenuata* woodlands or shrublands' and SCP04 '*Melaleuca preissiana* damplands' SCP5 'Mixed Shrub damplands' and either SCP8 'Herb rich shrublands in claypans' or SCP10a 'Shrublands on dry clay flats'.

SCP21c is listed as a Priority Ecological Community by the Department of Environment and Conservation. Priority communities do not form a statutory constraint to development. There is no written policy on how to respond to the presence of Priority Ecological Communities within proposed development sites. The presence of these communities is dealt with by the Department of Environment and Conservation on a case by case basis.

SCP8 Herb rich shrublands in claypans and SCP10a Shrublands on dry clay flats both are listed as Threatened Ecological Communities by both the State and the Commonwealth. ENV advises that the presence of the Threatened Ecological Community needs to be confirmed by the Department of Environment and Conservation. If the Department of Environment and Conservation confirms the presence of the Threatened Ecological Community, they may seek a retention outcome in relation to the specific site characteristics.

The site is mapped by the Department of Environment and Conservation as supporting Conservation and Multiple Use Category wetlands. The wetlands cover the majority of the site according to the Geomorphic Wetland mapping. Conservation category wetlands are in the highest category of protection afforded by WA State legislation, and are listed as Environmentally Sensitive Areas under the *Environment Protection Act*.

The study area consists of three fauna habitat types; *Banksia* Woodland, *Melaleuca* Shrubland and Cleared Land. During the field survey a total of 26 vertebrate fauna species were recorded comprising one reptile, 23 avifauna and two mammal species.

A database search resulted in 27 conservation significant fauna species potentially occurring in the study area. Of these, one species, the Quenda which is a Priority 5 listed species by the Department of Environment and Conservation was recorded. Based on ecology, habitat present and fauna records, four species are classified as 'Likely' to occur (*Calyptorhynchus banksii naso*, *Calyptorhynchus baudinii*, *Calyptorhynchus latirostris* and *Merops ornatus*), six species are classified as 'Possible' to occur, ten species are classified as 'Unlikely' to occur and six are classified as 'Highly Unlikely' to occur.

1 INTRODUCTION

1.1 THE PROJECT

ENV.Australia Pty Ltd (ENV) was commissioned by the Water Corporation in August 2012, to undertake a Level 2 Flora and Vegetation Assessment and a Level 1 Fauna Assessment for the proposed Keane Road Sewer Main, Forrestdale (the study area). The Water Corporation has two possible options for the route of the sewer main which were surveyed concurrently. ENV understands that the impact of the two proposed sewer route options, which will have an approximately 10 m wide corridor, will either be 2.11 ha or 2.32 ha depending on the selected route (Figure 1).

The purpose of this study is to provide information on the significance of the flora, vegetation and fauna within the study area as part of supporting documentation for environmental approvals to construct the sewer infrastructure. This study will provide supporting documentation for an application for a Native Vegetation Clearing Permit (NVCP) under the *Environmental Protection Act 1986* (*EP Act).*

1.2 Objectives

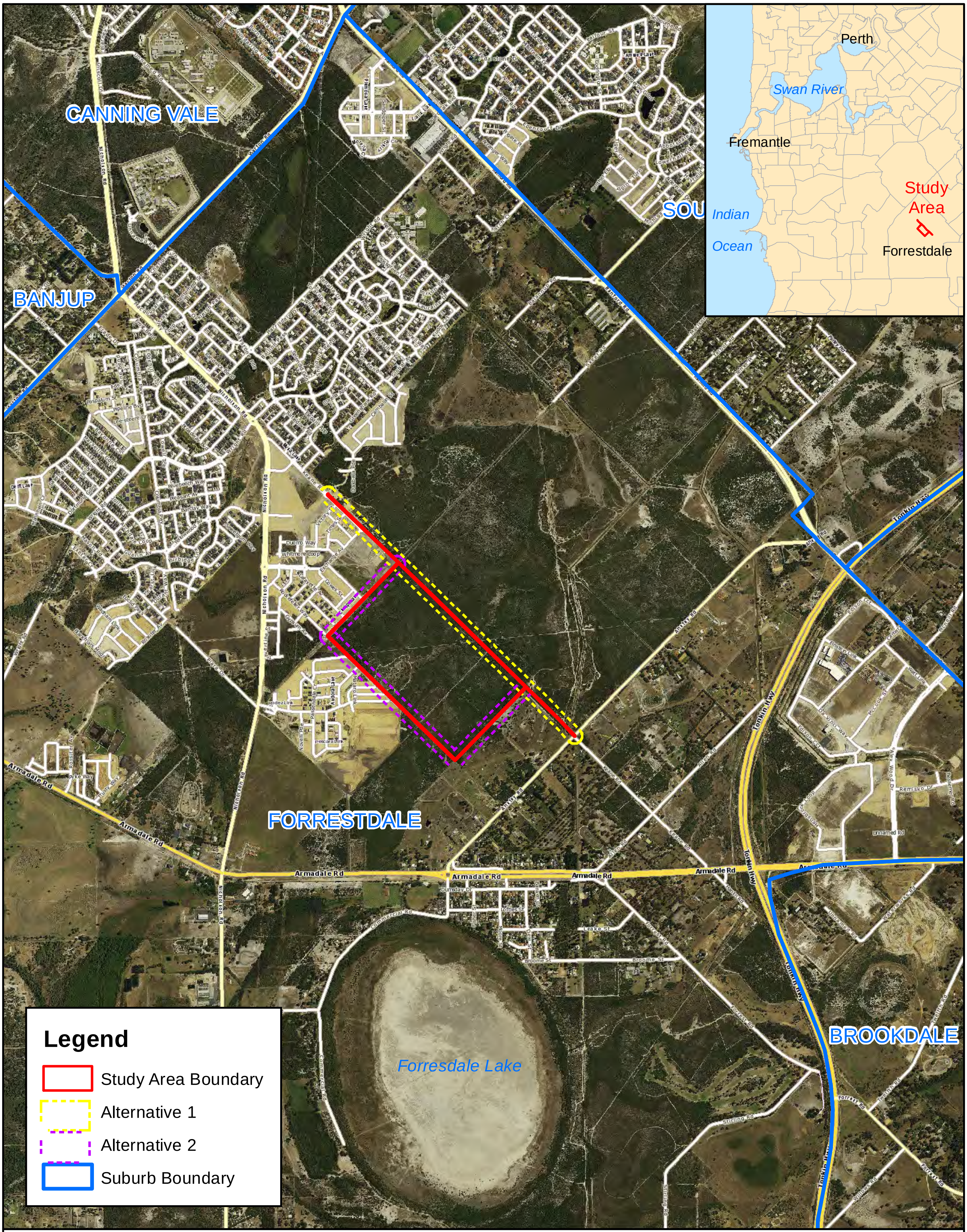
The objectives of the flora, vegetation and fauna assessment were to:

- conduct a comprehensive flora, vegetation and fauna database and literature review;
- compile an inventory of vascular plant species;
- provide an inventory of fauna species and habitats that occur or potentially occur in the study area;
- conduct targeted searches and flag the presence of field-identifiable plant species of conservation significance;
- record the occurrence of introduced plant species;
- document any potential signs of dieback disease;
- assess and map vegetation condition;
- document, describe and map the vegetation associations present;
- identify and map locations of Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs);
- provide a list of suitable plant species for use in rehabilitation;

- provide recommendations to minimise the impact of construction on native flora and fauna; and
- assess the proposed development against the ten native Vegetation Clearing Principles as detailed in Schedule 5.0 of the EP Act 1986.

1.2.1 Location

The study area is approximately 4.43 ha in size and is located 1 km north of Forrestdale in the City of Armadale (Figure 1). The closest intersection is Keane Road and Anstey Road, Forrestdale. The study area consists of remnant vegetation with cleared areas for firebreaks and informal walking paths.



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Water Corporation		J113163
AUTHOR	DRAWN	DATE
D. Buller	M. Mikkonen	05-03-13
SCALE	PROJECTION	
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env Australia

Location of Study Area

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE 1

1.3 BACKGROUND TO THE PROTECTION OF FLORA, VEGETATION AND FAUNA

Flora and fauna is protected formally and informally by various legislative and non-legislative measures, which are as follows:

Legislative Protection

- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*);
- *Wildlife Conservation Act 1950* (*WC Act*);
- *Environmental Protection Act 1986* (*EP Act*); and
- *Agriculture and Related Resources Protection Act 1976* (*ARRP Act*).

Non-Legislative Protection

- Western Australian Department of Environment and Conservation (DEC) Priority lists for flora and vegetation; and
- Recognition of locally significant populations by the DEC.

A short description of each is given below. Other definitions, including species conservation categories, are provided in Appendix A for flora and Appendix B for fauna. Conservation categories for ecological communities are provided in Appendix C.

Environment Protection and Biodiversity Conservation Act 1999

The *EPBC Act* aims to protect Matters of National Environmental Significance. Under the *EPBC Act*, the Commonwealth Department of Sustainability, Environment, Water, Populations and Communities (SEWPAC) lists threatened species and communities in categories determined by criteria set out in the Act (*www.environment.gov.au/epbc/index.html*) (Appendix A2 and Appendix B2 and Appendix C2).

Projects likely to impact on matters of national environmental significance should be referred to SEWPAC for assessment under the *EPBC Act*.

Wildlife Conservation Act 1950

The Western Australian DEC lists flora and fauna under the provisions of the *WC Act* as protected according to their need for protection (Appendix A for flora and Appendix B for fauna).

Flora is given Declared Rare status when populations are geographically restricted or are threatened by local processes. In addition, under the *WC Act*, by Notice in the

Western Australian Government Gazette of 9 October 1987, all native flora (spermatophytes, pteridophytes, bryophytes and thallophytes) is protected throughout the State.

Fauna are classified as Schedule 1 to Schedule 4 according to their need for protection (Appendix B).

Environmental Protection Act 1986

Declared Rare Flora (DRF) and TECs are given special consideration in environmental impact assessments, and have special status as Environmentally Sensitive Areas (ESAs) under the *EP Act* and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Exemptions for a clearing permit do not apply in an ESA. In addition, habitat necessary for the maintenance of indigenous fauna is a clearing principle and assessed during consideration of applications for a NVCP.

Agriculture and Related Resources Protection Act 1976

Plants may be ‘Declared’ by the Agriculture Protection Board (APB) under the *ARRP Act 1976 (WA)*. Declared Plants are gazetted under five categories (P1-P5), which define the action required. Details of the definitions of these categories are provided in Appendix D. A declaration may apply to the whole State, to districts, individual properties or even to single paddocks. If a plant is ‘Declared’, landholders are obliged to control that plant on their properties (Department of Agriculture and Food Western Australia [DAFWA] 2012).

The Environmental Weed Strategy for Western Australia (EWSWA) (Department of Conservation and Land Management [CALM] 1999) contains criteria for the assessment and ranking of weeds in terms of their environmental impacts, invasiveness and distribution (Appendix D). The Strategy defines environmental weeds as ‘plants that establish themselves in natural ecosystems and proceed to modify natural processes, usually adversely, resulting in the decline of the communities they invade.’

The DEC Invasive Plant Prioritization (IPP) Process (DEC 2012) was developed to progress the EWSWA (CALM 1999). The prioritisation process focuses on a “species-led” and “site-led” approach to set priorities for weed management on DEC managed lands for each DEC region of WA. The IPP process is also developed to assist other landholders in their management of weeds.

The Australian Government along with the State and Territory governments has endorsed 20 species as Weeds of National Significance (WONS). Four major criteria were used in determining WONS:

- The invasiveness of a weed species;

- A weed's impacts;
- The potential for spread of a weed; and
- Socio-economic and environmental values.

Each WONS has a national strategy and a national coordinator, responsible for implementing the strategy. WONS are regarded as the worst weeds in Australia because of their invasiveness, potential for spread, and economic and environmental impacts (Commonwealth of Australia 2012).

Department of Environment and Conservation Priority Lists

The DEC lists 'Priority' flora and fauna that have not been assigned statutory protection under the *WC Act*, but which are under consideration for declaration as DRF or Scheduled fauna. Flora and fauna assessed as Priority 1-3 are considered to be in urgent need of further survey. Priority 4 taxa require monitoring every 5-10 years and Priority 5 taxa are subject to a specific conservation program (Appendix A).

The DEC maintains a list of PECs which identifies ecologically valuable communities that need further investigation before possible nomination for TEC status.

Once listed, a community is a PEC, and when endorsed by the Western Australian Minister of Environment becomes a TEC, and protected as an ESA under *Environmental Protection (Clearing of Native Vegetation) Regulations* 2004 (Appendix B).

Informal Recognition of Flora

The International Union for Conservation of Nature (IUCN) publishes an international listing of species of conservation importance, known as the IUCN Red List (IUCN 2012). This list identifies those species most in need of conservation attention. The IUCN Red List is used for conservation planning, decision making and monitoring by government agencies, wildlife departments, conservation-related non-governmental organisations (NGOs), natural resource planners, educational organisations, and many others interested in preserving biodiversity.

Certain populations or communities of flora and fauna may be of local significance or interest because of their patterns of distribution and abundance. For example, a species may be locally significant because they are range extensions to the previously known distribution, or are newly discovered taxa (and have the potential to be of more than local significance). In addition, many species are in decline as a result of threatening processes (land clearing, grazing, changed fire regimes), and relict populations of such species assume local importance for the DEC. It is not uncommon for the DEC to make comment on these species of interest.

2 BIOPHYSICAL ENVIRONMENT

2.1 CLIMATE

The study area is located on the Swan Coastal Plain, this region experiences a Mediterranean climate characterised by hot, dry, summers and cool, wet, winters with an average maximum summer temperature of 30.8°C and an average minimum winter temperature of 11°C (Bureau of Meteorology [BoM] 2012) (Figure 2).

The average annual rainfall recorded at Perth Aero, the nearest BoM station, 20 km north of the study area, is 771.7 mm, with the majority of precipitation occurring in winter (BoM 2012) (Figure 2). Perth Aero recorded 694 mm of rain in the 12 months prior to survey (September 2011 – August 2012), 77.7 mm below the long term average rainfall of 771.7 mm for the same period (BoM, 2012). The three months prior to survey (June-August 2012), Perth Aero recorded 282.8 mm of rainfall, 35% below the 436.6 mm average rainfall for the same period (BoM 2012).

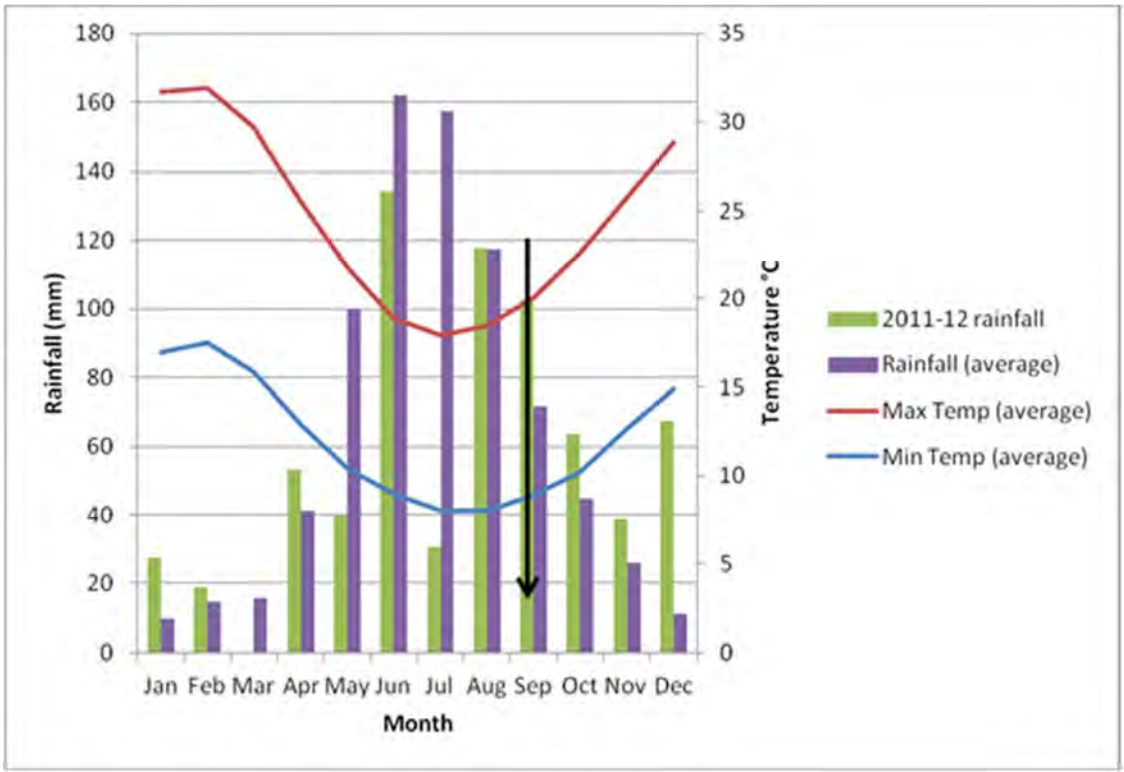

Figure 2: Average long-term (1944-2012) and 2012 Monthly Rainfall and Average Maximum and Minimum Temperatures (1944-2012) for Perth Aero (BoM, 2012). Arrow indicates survey time.

2.2 GEOLOGY AND SOILS

The study area occurs on the Swan Coastal Plain portion of the Darling System (Churchward & McArthur 1980). Soils of the Swan Coastal Plain have been described by

Churchward and McArthur (1980) as consisting of aeolian and fluviatile deposits. The study area occurs on:

- Southern River: Sandplain with low dunes and many intervening swamps; iron and humus podzols, peats and clays (Churchward & McArthur 1978)

Geological mapping of the Perth Metropolitan Region as part of the 1:50000 Geological Series, has identified the soils of study area as belonging to the following units (GSWA 1986) (Figure 3):

- (Sp_1) Peaty Sand - grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty of lacustrine origin.
- (Sp_8) Sand - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals.
- (Sp_{10}) Sand: as S_8 over sandy clay to clayey sand of the Guildford formation, of eolian origin.

2.3 BIOGEOGRAPHIC REGIONALISATION FOR AUSTRALIA

The Biogeographic Regionalisation for Australia (IBRA) divides Australia into 89 bioregions based on major biological and geographical/ geological attributes (SEWPAC 2012c). These bioregions are subdivided into 419 subregions, as part of a refinement of the IBRA framework (SEWPAC 2012c).

The study area is located in the Perth subregion (SWA02) of the Swan Coastal Plain bioregion (Thackway & Cresswell 1995). The Perth subregion is composed of colluvial and aeolian sands, alluvial river flats and coastal limestone (Mitchell et al*.* 2002). Vegetation can be characterised by heath and/or Tuart woodlands on limestone, Banksia and Jarrah-Banksia woodlands on Quaternary marine dunes of various ages and Marri on colluvial and alluvials (Mitchell et al*.* 2002).

2.4 BROAD VEGETATION TYPES

Mapping of the Swan region vegetation of Western Australia was completed on a broad scale (1:250,000) by Heddle et al. (1978). The study area is situated in South West Botanical Province and the Darling Botanical District (Beard 1990). This region typically consists of forest country with related woodlands and is divided into four subregions or botanic subdistricts. The study area is located within the Swan Coastal Plain Subregion in the Drummond Botanical Subdistrict, which consists mainly of the following vegetation communities:

- *Banksia* Low Woodland on leached sands and *Melaleuca* Swamps in poorly drained areas;
- Woodland of Tuart (*Eucalyptus gomphocephala*); and
- Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) on less leached soils (Beard 1990).

Vegetation complexes of the Darling System, in which the Swan Coastal Plain occurs, have been mapped by Heddle et al. (1978). The study area contains one Swan Coastal Plain vegetation complex which is related to the underlying soil profile (Figure 4):

- Southern River Complex – Open woodland of *Eucalyptus calophylla – E. marginata – Banksia* spp. with fringing woodlands of *E. rudis – Melaleuca rhaphiophylla* along creek beds (Heddle et al. 1978).

This vegetation complex belongs to a combination of several major geomorphic units: Bassendean Dunes/Pinjarra Plain/Spearwood Dunes (Government of Western Australia 2000b).

The Southern River Complex was estimated to have 19.8% native vegetation remaining based on the pre-European extent with 1.5% in secure tenure (EPA 2006). More recently the Perth Biodiversity Project (PBP 2010) has mapped native vegetation extent by vegetation complex on the Swan Coastal Plain. It is estimated that 19.7% of Southern River Complex remains compared to its pre-European extent (PBP 2010) (Table 1).

The EPA recognises vegetation complexes that are not well represented in reserves as being significant. Vegetation complexes which have 10-30% remaining may be considered regionally significant. Proposals that would affect a vegetation complex with 10% or less remaining are likely to be formally assessed by the EPA (EPA 2006).

Table 1: Broad Vegetation Types within the Study Area and their Regional Representation

	Pre-European area (ha)[1]	Current extent (ha)[1]	Remaining (%)[1]	Pre-European % in IUCN Class I-IV Reserves[1]	Conservation Status[2]
IBRA Bioregion Swan Coastal Plain	1,501,209.2	587,832.9	39.16	10.13	Vulnerable
Vegetation Types (Beard 1979/ Shepherd et al. 2001) Swan Coastal Plain Bioregion					
1001	57410.23	14151.90	7.19	1.14	Critically Endangered
968	136188.20	9798.61	24.65	1.12	Endangered

[1] Government of Western Australia (2011)

[2] EPA (2000)

2.5 GEOMORPHIC WETLANDS

In an effort to protect wetlands on the Swan Coastal Plain, the DEC developed a dataset, mapping the location and management category of wetlands on the Swan Coastal Plain (DEC 2012g). A management category is assigned to each wetland, which provides guidance on the nature of the management and protection of the wetland.

The DEC Geomorphic Wetlands Dataset identified several wetlands of both Conservation and Multiple Use management categories as occurring within the study area (DEC 2012g) (Figure 5).

2.6 CONSERVATION ESTATE

2.6.1 Bush Forever and Ecological Linkages

Bush Forever is a State Government Policy and program that identifies 51,200 ha of regionally significant vegetation for protection, covering 26 vegetation complexes (Government of Western Australia 2000a; 2000b). This amounts to approximately 18% of the original vegetation on the SCP portion of the Perth metropolitan area (Government of Western Australia 2000a; 2000b).

Regionally significant vegetation has been identified based on criteria relating to its conservation value. Important criteria in the identification process include the achievement, where possible, of a comprehensive representation of all the ecological communities originally occurring in the region, principally through protecting a target of at least 10% of each vegetation complex in the Bush Forever project boundary (Government of Western Australia 2000a; 2000b).

The study area is mapped as Bush Forever Site No. 342, also known as the Anstey/Keane Dampland and Adjacent Bushland, Forrestdale (Government of Western Australia 2000a). The next nearest Bush Forever sites to the study area are: Balannup Lake and Adjacent Bushland, Southern River/Forrestdale (Bush Forever site 413), abutting the northern edge of Site 342 and the Piarra Nature Reserve, Forrestdale (Bush Forever Site 262), approximately 0.6 km south-west of the study area (Government of Western Australia 2000a). Forrestdale Lake is a seasonal brackish lake situated 1.2 km south of the study area (AHC 2000). The wetland is listed as an 'Indicative Place' on the Australian Heritage Commission Register of the National Estate, Bush Forever Site no. 345 (Government of Western Australia 2000a) and as a RAMSAR wetland in the Directory of Important Wetlands in Australia (SEWPAC 2012a).

2.7 PREVIOUS BIOLOGICAL STUDIES

Previous biological surveys most relevant to the current survey include:

- Heron Park Phase Two Flora and Vegetation Assessment (ENV 2010).

The key findings of the report are provided below. It should be noted that differences in survey timing, extent and the size and locations of each study area will influence the results of each survey. For further details of specific survey methods and timing please refer to the original report.

- No plant species listed as Threatened under the EPBC Act or as DRF pursuant to the WC Act were recorded during the survey.

- One Priority Flora, *Jacksonia gracillima* (Priority 3), was recorded in the study area.

- SCP21c 'Low lying *Banksia attenuata* woodlands or shrublands' and SCP04 '*Melaleuca preissiana* damplands' were identified as occurring on site. These Floristic Community Types are not protected under Federal or State Legislation. SCP21c is listed as a Priority Ecological Community by the DEC.

- The DEC's Geomorphic Wetlands Dataset identifies five Multiple Use wetlands as occurring within the study area.

3 METHODS

3.1 FLORA ASSESSMENT

The survey was consistent with a single season Level 2 survey as per the EPA requirements for environmental surveying and reporting for flora and vegetation in Western Australia, as set out in the following documents:

- *Environmental Protection of Native Vegetation in Western Australia: Clearing of Native Vegetation with Particular Reference to Agricultural Areas. Position Statement No.2* (EPA 2000);
- *Environment Protection of Wetlands. Position Statement No. 4* (EPA 2001);
- *Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3* (EPA 2002);
- *EPA Guidance for the Assessment of Environmental Factors: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51* (EPA 2004b); and
- *EPA Guidance for the Level of Assessment for Proposals affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 region. Guidance Statement No. 10* (EPA 2006).

3.1.1 Database Review

The desktop study provided background information on the flora and vegetation of the project area. This involved a search of the following sources:

- DEC combined biological database *NatureMap* (DEC 2012b);
- DEC Threatened and Priority Flora database (DEC 2012f);
- DEC Threatened and Priority Ecological Communities information (DEC 2012d);
- IUCN Red List (IUCN 2012);
- SEWPAC Protected Matters Search Tool (SEWPAC 2012b); and
- previous flora surveys (refer to Section 2.7).

A request for a database search was submitted to the DEC September 5th 2012 within 5 kilometres of coordinates 32^{o}08’04.23”S and 115^{o}56’19.42”E to obtain a list of DRF/T or Priority flora, and TECs and PECs near the project area. These sources were used to compile a list of expected DRF or Priority species and TECs and PECs that may occur on the landforms in the project area.

3.1.2 Field Survey

The field survey was conducted on 19th October 2012, with 2 person-days invested in the field survey.

Flora and Vegetation Assessment

The survey included the assessment of one site, consisting of six quadrats and four relevés (Figure 6). Quadrats are vegetation survey plots which are accurately measured out as 5 x 20 m and marked at the NW corner using a handheld Garmin GPS unit. Relevés are ‘unmarked quadrats’, where a centre point is marked and an area equivalent to that of a quadrat is visually approximated around this point for the purpose of estimating species composition and cover.

The information recorded at each quadrat included landscape features, surface soil colour and texture, bare ground, litter cover, disturbance, fire age, aspect and vegetation condition (Government of Western Australia 2000b). Each species of plant at each quadrat was recorded, including information on height and percentage cover.

Targeted or Systematic Searches

Habitats and locations likely to support conservation significant flora were targeted for searches. Further opportunistic collections focused on the location of taxa not recorded in the quadrats and on locations of introduced species. For each population of significant flora identified the following was recorded:

- Co-ordinate locations (using handheld GPS units);
- Description of vegetation association present;
- Estimation of population size; and
- Photograph of plant *in situ*, where possible.

If a specimen was collected, a voucher will be lodged at the Western Australian Herbarium.

Targeted or Systematic Searches for Introduced Species

A targeted survey of the study area was undertaken, focussing on:

- Declared plants listed under the ARRP Act; and

- Other environmental weed species as listed by DEC on FloraBase (WAH 2012), and based on results of previous surveys in and adjacent to the study area.

3.1.3 Taxonomy and Nomenclature

Where field identification of plant taxa was not possible, specimens were collected systematically for later identification by taxonomists utilising identification keys including, Flora of Australia (1981-2011), AusGrass (Sharp & Simon 2002), EUCLID (EUCLID 2006), WATTLE (Maslin 2001), relevant taxonomic papers published in journals including Australian Systematic Botany (1988-2011) and Nuytsia (1975-2011). If required, resources of the Western Australian Herbarium (WAH) were also utilised.

The species list was checked against FloraBase (WAH 2012) to determine the species' conservation status. Threatened and Priority Flora were verified against the *EPBC Act* listing of threatened species to determine federal listing.

Introduced species were checked against the Environmental Weed Strategy for Western Australia (CALM 1999) and the DEC Invasive Plant Prioritisation Process – Swan Weed Assessment List (DEC 2012a), to determine their ranking in terms of environmental impact, and the ARRP Act was consulted to determine if any are Declared Plants.

3.1.4 Statistical Analysis

To determine the likely occurrence of TECs or PECs, a multivariate analysis was undertaken. This analysis involved transformation (presence-absence) and normalisation of the data, and computation of a similarity matrix based on Bray-Curtis similarity. The matrix allows comparison of the study area's species data similarity against Gibson et al. (1994) FCTs data and allows determination of the probability that the vegetation communities represent TECs or PECs. A dendrogram was computed, using hierarchical agglomerative cluster analysis using Primer-E version 6.1.5 (Clarke & Gorley 2006).

3.2 VEGETATION MAPPING

The vegetation associations were described based on their structure and species composition, as defined by quadrat data, results of the multivariate analysis and field observations. Vegetation was mapped in the field using handheld GPS (Garmin) units and high-resolution aerial photographs, which in the office were digitised using GIS software (OziExplorer and ArcGIS 9.3.1).

The vegetation descriptions were referenced against Gibson et al. (1994) to determine the Floristic Community Types ('FCTs') present and the potential for the study area to support TECs or PECs. FCTs were defined on the basis of Multivariate Analysis of quadrat data, species composition, soils and topography.

Vegetation condition was mapped in the field using handheld GPS (Garmin) units and high-resolution aerial photographs, which in the office were digitised using GIS software (OziExplorer and ArcGIS 10). Vegetation condition was assessed based on Bush Forever (Government of Western Australia 2000b) /Trudgen (1991) (Appendix E).

3.3 FAUNA ASSESSMENT

The survey was carried out in a manner designed to be consistent with the Environmental Protection Authority (EPA) requirements for the environmental surveying and reporting of fauna surveys in Western Australia, as set out in the following documents:

- *Terrestrial Biological Surveys as an Element of Biodiversity Protection. Position Statement No. 3* (EPA 2002);
- *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia. Guidance Statement No. 56* (EPA 2004a); and
- *Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA-DEC 2010).

3.3.1 Database Review

The purpose of the desktop review was to gather background information on the study area and the vertebrate fauna that it may support. This involved a search for records (using a 20 km buffer around the location of: 32°08'08"S, 115°56'09" from the following databases:

- Western Australian Museum (WAM) and DEC combined biological database *NatureMap* (DEC 2012b);
- DEC Threatened and Priority Fauna database (DEC 2012e);
- SEWPAC Protected Matters Search Tool (also known as an EPBC search) (SEWPAC 2012b); and
- Birdata, Birds listed by Birdlife Australia (Birdlife Australia 2012a).

Collectively, these sources were used to compile a list of species that have been recorded or that may potentially occur in the region (Appendix F). This list will invariably include some species that do not occur in the study area, as some fauna have a limited or patchy distribution, exhibit a high level of habitat specificity, are locally extirpated or were erroneously identified in previous surveys. Extinct species, clearly erroneous records and species with a high level of habitat specificity for habitats not present in the study area were excluded from this list and species which are predominantly marine in nature and do not occupy terrestrial habitats represented in the study area (i.e. Terns, Gulls, Albatross, Sandpipers).

3.3.2 Field Survey

The purpose of the field survey was to verify the accuracy of the review and to further delineate and characterise the habitat and faunal assemblages in the study area. The fauna field survey consisted of a fauna habitat assessment and opportunistic observations.

Habitat Assessment

Five habitat assessments were completed during the field survey (Appendix G; Figure 7). Each habitat was scored numerically on the basis of the presence and complexity of fauna microhabitats including vegetation cover, presence of water, tree hollows, loose bark, leaf litter etc. In addition the habitat assessment included the identification of landscape features such as soil type, rock type, vegetation type and disturbance levels. The numerical scoring system individually ranked 24 microhabitat variables as a value between 0-3 based on whether it was common (3), moderately common (2), rare (1) or not present (0). The composition and presence of ground and vegetation cover was also assessed and scores were given based on their percentage cover of the 100 x 100 m quadrat. Three was the highest possible score for each feature and corresponded to a high habitat value, while zero was the lowest value reflecting a feature that was absent and/or provided little to no fauna habitat value. For each assessment the scores were tallied to give a total numerical value out of a possible 70.

Opportunistic and Targeted Observations

Fauna were opportunistically observed and recorded during the foot traverse of site. Field staff investigated scats, tracks, burrows and other traces of animals throughout the entire study area. Where conservation significant species were located, the coordinates were recorded by GPS.

3.3.3 Taxonomic Identification

The taxonomy and naming of wildlife species is dynamic because of the ongoing description of new species, and increased understanding of the relationships of taxa through genetic, morphological and vocal studies. The taxonomy and nomenclature (common and scientific names) in this report follows authorities supplemented by the latest scientific articles which update the established names for frogs (Tyler & Doughty 2009); reptiles (Wilson & Swan 2010); mammals (van Dyck & Strahan 2008), and birds (Gill & Donsker 2012). This latter authority has replaced the taxonomic treatment of Christidis and Boles (2008) for birds.

Fauna species were identified in the field, where needed using standard field guides or scientific publications for frogs (Tyler & Doughty 2009; Tyler & Knight 2009); reptiles (Storr et al. 1999; 2002; Wilson & Swan 2010), birds (Pizzey & Knight 2007; Simpson & Day 2010) and mammals (van Dyck & Strahan 2008; Menkhorst & Knight 2011).

4 RESULTS

4.1 SURVEY LIMITATIONS AND CONSTRAINTS

It is important to note the specific constraints imposed on surveys. Constraints are often difficult to predict as is the extent to which they influence survey effort. Survey constraints of the Keane Road Sewer main flora and vegetation survey are detailed in Table 2.

Table 2: Limitations and Constraints Associated with the Keane Road Sewer Main Flora, Vegetation and Fauna Survey

Variable	Impact on Survey Outcomes
Access	No access problems were encountered.
Experience	The botanists and zoologists who executed these surveys were practitioners suitably qualified in their respective fields. • Coordinating Botanist: Narelle Whittington (Principal Botanist); • Coordinating Zoologist: Dr Ronald Firth (Principal Zoologist) • Field Staff: Damian Buller (Environmental Biologist), Narelle Whittington and Ronald Firth. • Taxonomy: Peter Jobson (Senior Botanist / Taxonomist); • Botanical Data Interpretation and Reporting: Narelle Whittington and Damien Buller. • Zoological Data Interpretation and Reporting: Ron Firth and Chris Knuckey (Environmental Biologist).
Timing, weather, season.	The survey was conducted during Spring. Therefore, the seasonal conditions for the survey were considered optimal. Flora composition changes with time particularly over the seasons and with seasonal conditions. A large proportion of arid flora is herbaceous annuals and ephemerals with specific growing periods and rainfall requirements. Fire history also affects the composition of flora. Therefore, botanical surveys completed at different times will have varying results. The timing, weather and season of the survey did not limit the survey outcomes and would not have impacted the occurrence of conservation significant fauna.
Scope: Life forms sampled	The scope of this project included the sampling of flora and the description of vegetation associations and floristic Community types. This survey scope also included searching and sampling for significant

Variable	Impact on Survey Outcomes
	flora and describing vegetation condition. A Level 1 fauna survey was carried out which included habitat assessments and opportunistic fauna records which was deemed adequate for this site.
Sources of information	The Swan Coastal Plain bioregion has been extensively surveyed; as a result, numerous published and unpublished flora surveys have been undertaken in the area. Those most relevant to the current study are listed in Section 2.7.
Completeness	The study area was accessible and the survey season was considered to be optimal and the time spent conducting the survey was considered to be adequate. It was considered that all vegetation types and fauna habitats within the study area were adequately surveyed; with quadrats, relevés and vegetation mapping notes recorded for all vegetation and fauna habitat types.

4.2 FLORA

4.2.1 Overview of Flora

A total of 94 taxa (including species, subspecies, varieties and forms) from 76 genera and 30 families were recorded from the study area. The most frequently recorded families were: Myrtaceae (14 taxa), Fabaceae (12 taxa), and Proteaceae (9 taxa). The most frequently recorded genera were *Melaleuca* (5 taxa), *Drosera* (5 taxa), *Jacksonia* (3 taxa) and *Banksia* (3 taxa). An average of 18.1 species were recorded in each quadrat, with a standard deviation of ± 5.6.

Quadrat data, including photographs, is presented in Appendix H, the flora by site matrix in Appendix I and the flora inventory in Appendix J.

4.2.2 Flora of Conservation Significance

No Threatened species pursuant to the EPBC Act and/or gazetted as DRF (Threatened) pursuant to the WC Act were recorded during the survey.

One Priority flora as recognised by the DEC, was recorded during the survey:

- *Jacksonia gracillima* (P3);

Jacksonia gracillima (Plate 1) was recorded during the current survey from eight locations, representing approximately 13 individuals in the study area. Details of locations are in Appendix K and presented in Figure 8.

Plate 1: *Jacksonia gracillma* (P3). *Source: ENV*

One further species of conservation significance was noted during the survey (*Petrophile rigida*). This species is of taxonomic interest as this record represents a significant extension from its known range.

Petrophile rigida (Plate 2) was recorded during the current survey from one location, representing four individuals in the study area.

Plate 2: *Petrophile rigida. Source: ENV*

The review of previous surveys and DEC database searches identified 26 DRF/T and Priority flora previously recorded within 5 km of the study area; six DRF /T taxa, four P1 taxa, one P2 taxa, five P3 taxa and ten P4 taxa.

The likelihood of these 26 conservation significant taxa occurring in the study area is shown in Table 3.

Table 3: Assessment of the likely occurrence of DRF and Priority Flora (as per DEC Database Searches) in the Study Area

Conservation Status	Species	Life Form	Habitat Information (WAH 2011, DEC 2012b)	Suitable Habitat Present	Number of Records[1]	Closest Record[2]	Likelihood of occurrence in the study area
T	*Caladenia huegelii*	Perennial	Grey or brown sand or clay loam, Coastal plain, near river or swamps.	Yes	10	>1 km	Likely
T	*Diuris purdiei*	Perennial	Grey-black sand, moist. Winter wet swamps.	Yes	4	>1 km	Likely
T	*Drakaea elastica*	Perennial	Brown dry rocky soils on flood plain and on rangeland.	No	1	>5 km	Likely
T	*Drakaea micrantha*	Perennial	White-grey sand	Yes	2	>5 km	Likely
T	*Lepidosperma rostratum*	Perennial	Brown. Peaty sand, clay.	Yes	5	>5 km	Likely
T	*Verticordia plumosa* var. *pleiobotrya*	Perennial	Clay, sandy loam. Seasonally inundated swamps, road verges.	Yes	1	>5 km	Likely
P1	*Acacia lasiocarpa* var. bracteolate long peduncle variant (G.J Keighery 5026)	Perennial	Grey or black sand over clay in swampy areas or winter wet lowlands.	Yes	1	>10 km	Likely
P1	*Austrostipa jacobsiana*	Perennial	Wets over limestone, sandy clay pans, seasonally damp salinized soils.	No	1	>5 km	Likely
P1	*Eremaea asterocarpa* subsp. *brachyclada*	Perennial	Deep grey sand.	Yes	1	>5 km	Likely

Conservation Status	Species	Life Form	Habitat Information (WAH 2011, DEC 2012b)	Suitable Habitat Present	Number of Records[1]	Closest Record[2]	Likelihood of occurrence in the study area
P1	*Schoenus pennisetis*	Annual	Grey or peaty sand, sandy clay. Swamps, winter-wet depressions.	Yes	2	>1 km	Likely
P2	*Acacia benthamii*	Perennial	In sand, typically on limestone breakaways.	No	1	>5 km	Likely
P3	*Byblis gigantea*	Perennial	Sandy-peat swamps. Seasonally wet areas.	Yes	3	>1 km	Likely
P3	*Eryngium pinnatifidum* subsp*. palustre*	Perennial	Clay or sandy clay of claypans and seasonally wet flats.	Yes	1	Not Known	Not Known
P3	*Jacksonia gracillima*	Perennial	Grey or brown sand or sandy loam on plains and wetlands.	Yes	7	Within study area	Within study area
P3	*Schoenus capillifolius*	Annual	Brown mud of claypans.	No	2	>5 km	Likely
P3	*Stylidium longitubum*	Annual	Sandy clay or clay of seasonal wetlands.	Yes	3	>1 km	Likely
P4	*Aponogeton hexatepalus*	Perennial	In mud of freshwater ponds, rivers or claypans.	Yes	3	>5 km	Likely
P4	*Dodonaea hackettiana*	Perennial	Sand of outcropping limestone.	No	1	>10 km	Possible
P4	*Drosera occidentalis* subsp*. occidentalis*	Perennial	Sandy and clayey soils. Swamps and wet depressions.	Yes	2	>1 km	Likely
P4	*Grevillea thelemanniana* subsp*. thelemanniana*	Perennial	Winter-wet heathland swamp.	Yes	1	>15 km	Unlikely

Conservation Status	Species	Life Form	Habitat Information (WAH 2011, DEC 2012b)	Suitable Habitat Present	Number of Records[1]	Closest Record[2]	Likelihood of occurrence in the study area
P4	*Jacksonia sericea*	Perennial	Calcareous and sandy soils.	Yes	2	>1 km	Likely
P4	*Microtis quadrata*	Annual	Coastal swamps	No	1	>10 km	Possible
P4	*Ornduffia submersa*	Annual	Clay pan soils, wetlands/seasonally inundated depressions.	Yes	6	>1 km	Likely
P4	*Thysanotus glaucus*	Perennial	White, grey or yellow sand, sandy gravel.	Yes	3	>5 km	Likely
P4	*Tripterococcus paniculatus*	Perennial	Grey, black or peaty sand. Winter-wet flats	Yes	6	>1 km	Likely
P4	*Verticordia lindleyi* subsp. *lindleyi*	Perennial	Sand, Sandy clay. Winter-wet depressions	Yes	10	>1 km	Likely

[1] Number of DEC records from database search area (DEC, 2012f)

[2] Closest DEC record to study area (DEC, 2012f)

‘Likely’ = suitable habitat present and records less than 5 km from the study area.
‘Possible’ = suitable habitat present, but records within 5 to 10 km from the study area
‘Unlikely’ = a lack of suitable habitat, and/or there are no records closer than 10 km from the study area

4.2.3 Introduced Flora

Fifteen introduced species were recorded; their locations are presented in Figure 9 and detailed in Appendix L.

None of these species are registered as WONS. Two of these species are listed as Declared Plants under the ARRP Act. All 15 species are listed as environmental weeds, as defined by the *Environmental Weed Strategy for Western Australia* (CALM 1999). The rating and criteria for these species' inclusion under this strategy, as well as their rating against the invasiveness criteria of the DEC Invasive Plant Prioritization Process (DEC 2012a), is presented in Table 4.

Table 4: Introduced Flora Recorded in the Study Area, Including Their Rating by the Environmental Weed Strategy (CALM 1999) and the DEC Invasive Plant Prioritization Process (DEC 2012a)

Taxon (Common Name)	Rating (CALM 1999)	Criteria (DEC 2012a)		
		Ecological Impact	Invasiveness	Feasibility of Control
**Arctotheca calendula (capeweed)*	Moderate	Moderate	Moderate	Low
**Briza maxima* (blowfly grass)	Moderate	Unknown	Rapid	Low
**Carpobrotus edulis* (hottentot fig)	Moderate	Unknown	Rapid	High
**Cortaderia selloana* (pampas grass)	High	High	Rapid	Moderate
**Crassula natans* var. *minus* (pond stone crop)	Moderate	Low	Rapid	Unknown
**Cynodon dactylon* (couch)	Moderate	High	Rapid	Moderate
**Ehrharta longiflora* (annual veldt grass)	Moderate	Unknown	Rapid	Moderate
**Eragrostis curvula* (african lovegrass)	High	Unknown	Rapid	Low
**Hypochaeris glabra* (flat weed)	Moderate	Moderate	Rapid	Low
**Lotus subbiflorus* (hairy birdsfeet)	unknown	Unknown	Rapid	Low
**Moraea flaccida* (one leaf cape tulip)	High	High	Moderate	Moderate
**Poa annua* (winter grass)	Mild	Unknown	Unknown	Unknown

Taxon (Common Name)	Rating (CALM 1999)	Criteria (DEC 2012a)		
		Ecological Impact	Invasiveness	Feasibility of Control
**Ursinia anthemoides*	Moderate	Unknown	Rapid	Unknown
**Vulpia myuros* (rats tail fescue)	Moderate	Unknown	Rapid	Unknown
**Zantedeschia aethiopica* (Arum lily)	High	High	Moderate	Low

The two species listed as Declared Plants on the Swan Coastal Plain identified during the survey (Figure 9) were:

- Arum Lily (**Zantedeschia aethiopica*) (Plate 3) listed as P1 for the Whole State; and
- One Leaf Cape Tulip (**Moraea flaccida*) (Plate 4) listed as P1 for the Whole State.

Plate 3: : Arum Lily (*Zantedeschia aethiopica)

Source: ENV

Plate 4: One Leaf Cape Tulip (**Moraea flaccida*) Source: WAH (2012)

4.3 VEGETATION

4.3.1 Vegetation Associations

Four vegetation associations were identified across the study area (Figure 10). The extent of each association is presented in Table 5.

Table 5: Vegetation Associations and their Extent in the Study Area

Map Reference Vegetation Code	Vegetation Association	Extent in Study Area (%)	Extent in Study Area (ha)
KRZ1 & KRZ3 MpMr	Low Open Woodland of *Melaleuca preissiana, Melaleuca rhaphiophylla*, over *Regelia ciliata, Kunzea glabrescens, Acacia pulchella* and *Hypolaena exsulca.*	9	0.41
KRZ2 & KRZ6 Kg	Tall Open Scrub of *Kunzea glabrescens* with *Regelia ciliata, Melaleuca viminea, Hypolaena exsulca, Baumea juncea* and *Acacia pulchella* with scattered *Melaleuca preissiana.*	14	0.59
KRZ4 Ba	Woodland of *Banksia attenuata* and *Banksia ilicifolia* over *Kunzea glabrescens, Hibbertia subvaginata, Melaleuca thymoides, Dasypogon bromeliifolius, Lyginia imberbis* and *Phlebocarya ciliata.*	10	0.45
KRZ5 Mv	Shrubland of *Melaleuca viminea* over *Centrolepis polygyna, Isolepis cernua* var. *setiformis, *Crassula natans* var. *minus* and **Lotus subbiflorus.*	1	0.03

4.3.2 Vegetation Condition

Vegetation condition ranged from Completely Degraded to Excellent (Figure 11). Vegetation clearing for access tracks and fire breaks, recreational vehicle access, urban development and weeds within and adjacent to the study area were the most frequently observed impacts on native vegetation.

The entire study area was dissected by an access track; this has been mapped as Completely Degraded and covered 66% of the study area (Table 6). In some areas the track did not influence the condition of the vegetation adjacent and therefore the vegetation was regarded to be in excellent condition. In other areas the track has been used by recreational vehicles and this has contributed to the disturbance and introduction of weeds into the adjacent vegetation, therefore reducing the condition.

Approximately 15.48% of the study area was in Excellent condition (Table 6). Areas mapped as Excellent show relatively low levels of disturbance, with exception of the track, with low densities of aggressive weeds.

Table 6: Vegetation Condition Recorded in the Study Area

Vegetation Condition	Area (ha)	Proportion of Study Area (%)
Excellent	0.68	15.4
Very Good	0.01	0.3
Good	0.51	11.5
Degraded	0.29	6.6
Completely Degraded (cleared)	2.94	66.2
Total	4.43	100

Fire age was variable across the site and ranged between Young (one to four years since last fire) to Old (eight to 12 years since the last fire).

4.3.3 Floristic Community Types

The FCTs represented by the vegetation within the study area were inferred by statistical analysis (Primer) and further data interpretation, as shown in Table 7 below. Due to the inconclusive results of the statistical analysis there was a need to further analyse the data to clarify what FCTs best correlate with the vegetation associations in the study area. This involves reviewing site data for other factors that are diagnostic for FCTs, including the presence of indicator species, soil types and landform position.

Table 7: Floristic Community Type Analysis

ENV Vegetation Association	Floristic Community Types[1]	Similarity %	Comments	ENV Inferred Floristic Community Type
MpMr (KRZ1 & KRZ3) Low Open Woodland of *Melaleuca preissiana*...	SCP14-Deeper Wetlands on sandy soils	25.8	SCP14 is only known to occur north of Perth and so the analysis results are considered incorrect. SCP4 is more likely to occur on site and there are similarities between SCP4 and the flora on site.	SCP4-*Melaleuca preissiana* damplands
	SCP12 – *Melaleuca teretifolia* and/or *Astartea* aff. *fascicularis* shrublands	20.7	The vegetation is not representative of SCP12 as the vegetation was a *Melaleuca* woodland and many of the typical species of SCP12 was absent.	
	SCP6 – Weed dominated wetlands on heavy soils	19.5	SCP6 is not known to occur on the landform type that is present at the site.	
Kg (KRZ2 & KRZ6) Tall Open Scrub of Kunzea glabrescens….	SCP14-Deeper Wetlands on sandy soils	25.8	SCP14 is only known to occur north of Perth and so the analysis results are considered incorrect. SCP4 is more likely to occur on site and there are similarities between SCP4 and the flora on site.	SCP5-Mixed Shrub damplands
	SCP12- *Melaleuca teretifolia* and/or *Astartea* aff. *fascicularis* shrublands	22.64	The vegetation is not represented by SCP12 as the majority of the species typical of SCP12 were not present.	
	SCP11-Wet forests and woodlands	21.69	The vegetation is not represented by SCP11 as the majority of the species typical of SCP11 were not present.	

ENV Vegetation Association	Floristic Community Types[1]	Similarity %	Comments	ENV Inferred Floristic Community Type
Ba (KRZ4) Woodland of *Banksia attenuata* and *Banksia ilicifolia*…..	SCP22-*Banksia ilicifolia* woodlands	26.5	Even though *Banksia ilicifolia* was present on site it was not dominant and the majority of the other typical species for this vegetation type were absent.	SCP21c-Low lying *Banksia attenuata* woodlands or shrublands (Priority 3)
	SCP21c-Low lying *Banksia attenuata* woodlands or shrublands	19.91	Even though *Banksia menziesii*, which is a common species found within SCP21c, was not recorded from the site, the vegetation does have the most similarity with SCP21c in terms of landscape characteristics and understory species.	
	SCP23a-Central *Banksia attenuata – Banksia menziesii* woodlands	17.82	Due to the low lying situation of the vegetation community it is unlikely that the vegetation is represented by 23a	
Mv (KRZ5) Shrubland of *Melaleuca viminea*……	SCP12- Melaleuca teretifolia and/or Astartea aff. fascicularis shrublands	14.63	The vegetation is not represented by SCP12 as the majority of the species typical of SCP12 was not present.	Due to the lack of species present within the community it is not possible to determine the FCT for the site through data

ENV Vegetation Association	Floristic Community Types[1]	Similarity %	Comments	ENV Inferred Floristic Community Type
	SCP16-Highly saline seasonal wetlands	11.76	SCP16 is not known to occur in the area therefore it is unlikely the vegetation type is present on site.	analysis, however based on the soil, location, and community structure the site is likely to be either SCP8 Herb rich shrublands in claypans (listed as 'Vulnerable' by the state and 'Critically Endangered' under the EPBC Act 1999) or SCP10aShrublands on dry clay flats (listed as 'Endangered' by the state and 'Critically Endangered' under the EPBC Act 1999)
	SCP18-Shrublands on calcareous silts	11.11	SCP18 is known to occur on lake deposits therefore would not be present on site.	

1. Gibson et al. 1994

4.3.4 Regional Representation

Vegetation associations described in the study area were not able to be correlated with the Beard (1979)/ Shepherd et al. (2001) broad vegetation types. This is due to the Beard mapping being undertaken at a scale of 1:250 000 and the site being surveyed at a much finer scale.

4.3.5 Vegetation of Conservation Significance

Of the four vegetation associations mapped on site two are considered to be of conservation significance. Ba (KRZ4) has been identified as FCT SCP21c-Low lying *Banksia attenuata* woodlands or shrublands, which is listed as a Priority 3 by the Species and Communities Branch, DEC.

The other vegetation association considered to be of conservation significance is Mv (KRZ5) which, although it is unable to be definitively identified to a single FCT, is conclusively either SCP8 Herb rich shrublands in claypans (which is listed as Vulnerable by the state and Critically Endangered under the EPBC Act) or SCP10a Shrublands on dry clay flats (which is listed as Endangered by the state and Critically Endangered under the *EPBC Act*).

4.3.6 Wetlands

The DEC Geomorphic Wetlands Dataset identified wetlands of both Conservation and Multiple Use management categories as occurring within the study area (Figure 5). The unique identification numbers (UFI) of the 13 wetlands within the study area are provided within Table 8.

Table 8: Unique Identification Number of Wetlands within the Study Area

Wetland UFI	Management Category
13347	Multiple Use
7219	
14844	
14876	
7384	Conservation Category
14167	
14891	
7482	
14893	
14165	
15183	
15427	
14170	
14875	

4.4 FAUNA

4.4.1 Habitat Assessment

The study area contains three habitat types; *Banksia* Woodland, *Melaleuca* Shrubland and Cleared Land which encompasses all land where native vegetation has been cleared e.g. tracks, roads etc (Figure 12).

Banksia Woodland

The Banksia Woodland covers approximately 0.16 ha of the study area (3.56%).The woodland is dominated by *Banksia attenuata* and *Banksia ilicifolia* over *Kunzea glabrescens*, *Hibbertia subvaginata*, *Melaleuca thymoides*, *Dasypogon bromeliifolius, Lyginia imberbis* and *Phlebocarya ciliata*. The *Banksia* Woodland is the highest ranked habitat within the study area with an average habitat value of 23. High habitat values are driven by the soft sands which provide burrowing suitability for borrowing and digging amphibians, reptiles and mammals. The *Banksia* Woodland also has a relatively high cover for all three vegetation layers (overstorey, midstorey and understorey) which provide habitat for a range of different avifauna species. Due to the low topography much of the surrounding area becomes seasonally inundated following large periods of rainfall, as such most of this habitat received high values for its close proximity to water which provides a drinking resource for mammals and breeding habitat for amphibians. The ground contained relatively high amounts of leaf litter and woody debris which provides habitat for ground dwelling fauna.

Melaleuca Shrubland

The *Melaleuca* shrubland is the most widespread and dominant habitat within the study area, it covers approximately 1.34 ha of the study area (30.07%). The habitat is dominated by *Melaleuca preissiana, Melaleuca rhaphiophylla, Melaleuca viminea* and *Kunzea glabrescens* over *Regelia ciliata*, *Centrolepis polygyna and Isolepis cernua* var*. setiformis*. The average habitat value for *Melaleuca* shrublands is 18.75 with a habitat score ranging from 18-20. High habitat values are driven by the soft sand which provides burrowing suitability for borrowing and digging amphibians, reptiles and mammals. The surrounding area was inundated with water and the habitat received high scores for its close proximity to water and the value it provides for species who prefer or are dependent on a water resource. The *Melaleuca* Shrublands have a high proportion of leaf litter cover and understorey vegetation of herbs, grasses and sedges which provides suitable habitat for ground dwelling species. The lack of overstorey vegetation is suited to larger birds such as raptors that may utilise the area when foraging.

Cleared Land

The cleared land covers approximately 2.95 ha of the study area (66.37%). The cleared land is completely degraded, it composes of sand tracks and fire breaks which run the length of the study area. These areas are sparsely vegetated and provide very little microhabitat complexity, lacking cover and food resources for vertebrate fauna. While the soft sands are well suited for digging and burrowing vertebrate species, the lack of vegetation will discourage species from utilising these areas. No habitat assessments were undertaken in these areas due to the lack of habitat it provides for vertebrate fauna.

4.4.2 Fauna Assemblage

All fauna previously recorded in the vicinity of the site are listed in Appendix F. As a Level 1 survey was conducted, a limited number of fauna were recorded during the survey, particularly ground dwelling reptiles and mammals. A total of 26 species were recorded from within the study area, 253 species have been previously recorded within the vicinity of the study area.

Amphibians

A total of twelve species of amphibians have been previously recorded in vicinity of the study area (Appendix F). The amphibians most likely to occur are the Western Banjo Frog (*Limnodynastes dorsalis*) and the Turtle Frog (*Myobatrachus gouldii*).

No amphibians were recorded during the fauna assessment.

Reptiles

Sixty-three species of reptile have been previously recorded in the vicinity of the study area (Appendix F). Reptiles likely to occur at the site include the Variegated tree Dtella (*Gehyra variegata*), the Bobtail (*Tiliqua rugosa rugosa*) and the Western Bearded Dragon (*Pogona minor minor*).

One species of reptile was recorded during the fauna assessment, a Dugite (*Pseudonaja affinis*).

Avifauna

Two hundred and twenty-four species of birds have been previously recorded in the vicinity of the study area (Appendix F). Many of these are unlikely to occur at the site, since these records are from a larger area encompassing a wide range of habitats and include rare birds that only occur on a transitory basis.

Twenty-four species of bird from seventeen families were recorded during this survey including three species belonging to the family Meliphagidae (Honeyeaters) and three species belonging to the family Columbidae (Pigeons, Doves). Other common birds of the study area included the Galah (*Eolophus roseicapilla*), Pacific Black Duck (*Anas superciliosa*) and Splendid Fairywren (*Malurus splendens*).

Mammals

Twenty-five species of mammal have previously been recorded in the vicinity of the study area (Appendix F). Many of these are unlikely to occur at the site, since these records are from larger areas encompassing a wide range of habitats, and small mammals tend to be habitat-specific.

During the fauna assessment evidence of two mammal species were recorded. This included evidence of one native mammal, the Quenda (Southern Brown Bandicoot; *Isoodon obesulus*) and one introduced mammal species, the Rabbit (*Oryctolagus cuniculus*).

4.4.3 Fauna of Conservation Significance

There are 27 conservation significant fauna species which have been previously recorded within the vicinity of the study area (Appendix M). Some of these are unlikely to occur on the site as they have a limited or patchy distribution, high level of habitat specificity, are locally extinct or were erroneously recorded in previous surveys.

Evidence of one species was recorded during the survey, the Quenda which is a Priority 5 listed species by the DEC. Four species of conservation significant species are considered 'Likely' to occur within the study area: Forest Red-tailed Cockatoo (*Calyptorhynchus banksii naso*), Baudin's Cockatoo (*Calyptorhynchus baudinii*), Carnaby's Cockatoo (*Calyptorhynchus latirostris*) and the Rainbow Bee-eater (*Merops ornatus*) (Appendix O). A further six species are considered 'Possible' to occur, ten species are considered 'Unlikely' to occur and six are classified as 'Highly Unlikely' to occur; based on their ecology, habitat present and fauna records (Appendix M).

5 DISCUSSION

5.1 CONTEXT

A total of 94 taxa (including species, subspecies, varieties and forms) from 76 genera and 30 families were recorded from the study area. An average of 18.1 species was recorded in each quadrat, with a standard deviation of ± 5.6.

The flora species richness recorded during the survey is considered to be low for the area and for the condition of the vegetation. The average flora richness per quadrat recorded during this survey, 18.1 species per quadrat, is lower than the species richness recorded by Gibson et al. (1994) within the FCTs represented on site. For example Gibson et al. (1994) recorded a mean species richness of 36.9 species within SCP04 '*Melaleuca preissiana* damplands' and 40.5 species within SCP21c 'Low lying *Banksia attenuata* woodlands or shrublands'.

Part of the difference in species richness can be attributed to survey differences, variation and environmental factors. The survey differences include that Gibson et al. (1994) conducted a larger number of quadrats (16 within both SCP04 and SCP21c) and that these quadrats were conducted within vegetation of best condition for each FCT. In contrast, the current survey is based on six quadrats and is adjacent to disturbed areas.

Environmental factors including the low rainfall experienced in the year prior to the survey being undertaken have also affected the species richness. However, it is not possible to quantify the extent that low rainfall would have impacted on the current species diversity within the study area. For example, the low rainfall may have suppressed the rejuvenation of species that usually germinate seasonally.

5.2 FLORA OF CONSERVATION SIGNIFICANCE

No threatened species pursuant to the *EPBC Act* and no plant taxa gazetted as DRF/Threatened pursuant to the WC Act were recorded in the study area. This is despite five species listed as Endangered and one listed as Vulnerable by the *EPBC Act* being identified as potentially occurring in the study area. These include four orchid species, one sedge species and one shrub species.

The four Endangered / Vulnerable orchids (*Caladenia huegelii*, *Diuris purdiei*, *Drakaea elastica* and *Drakaea micrantha*) are all perennial species persisting as tubers in the soil and only identifiable when in flower. Orchids are known to be sensitive to rainfall and in low rainfall seasons may flower late in the season or not at all. Suitable habitat for all of these species is present within the study area. These species were not recorded during the survey but potentially could be present.

The remaining Endangered species, one sedge species (*Lepidosperma rostratum*) and the one shrub species (*Verticordia plumosa* var. *pleiobotrya*), were searched for and neither were located. ENV considers that these species would have been present at the time of the survey and as they were not recorded, these species are not expected to occur within the study area.

One Priority 3 Flora was located within the study area, *Jacksonia gracillima* (P3). *Jacksonia gracillima* is known from two locations in Western Australia, Forrestdale and Busselton-Capel. Eleven records exist in the vicinity of Forrestdale, approximately 6 km south east of the study area, and ten records exist in the vicinity of Busselton-Capel, approximately 213 km south of the study area (DEC 2012f). The number of individuals present at each of these locations has not been recorded. Thus, it is not possible to determine the significance of the population recorded within the study area. However, there are two distinct populations and the individuals of *Jacksonia gracillima* recorded within the study area increases the known Forrestdale populations. The field survey included a targeted search for this species and it is considered unlikely that additional individuals occur within the study area. The presence of *Jacksonia gracillima* (Priority 3) does not form a statutory constraint to development of the study area. There is no written policy on how to respond to the presence of Priority Flora species within proposed work sites. The presence of these species is dealt with by the DEC on a case by case basis.

Of the remaining Priority Flora identified as potentially occurring within the study area, 15 are perennial species and five are annual species. Individuals of the 15 perennial species should have been identifiable and present at the time of the survey. Therefore, it is considered unlikely that these species occur within the study area. The annual species, *Schoenus capillifolius* (P3) and *Microtis quadrata* (P4), occur within habitat that is not present on site. The remaining annual priorities, *Schoenus pennisetis (P1), Stylidium longitubum* (P3) and *Ornduffia submerse* (P4) are known to favour seasonally wet flats (WAH 2012). The low winter rainfall experienced during 2010 may have affected the emergence of these species, and they may occur on site.

The survey was undertaken at the appropriate time of year (spring); however the low winter rainfall in the region may have affected the emergence of some orchid and/or annual species within the study area.

5.3 VEGETATION OF CONSERVATION SIGNIFICANCE

The vegetation association Ba is considered to be representative of SCP21c, despite SCP22 generating the highest percentage similarity with the vegetation (26.5% similarity). Both of these FCTs are listed as PECs by the DEC and based on factors, including the landform on which they occur and their position on the Swan Coastal Plain, the vegetation could represent either FCT. However, the vegetation association, Ba, is considered to represent SCP21c. This comparison is supported by the dominant and typical species identified by Gibson et al. (1994) as being characteristic of SCP21c. Importantly, the dominant overstorey species are common between the vegetation unit and SCP21c; these being *Banksia attenuata* and *Banksia menziesii*. In contrast the overstorey species of SCP22, *Banksia ilicifolia* was sparse within the vegetation on site. SCP21c is known to occur within the Harrisdale area and has been inferred as occurring within the surrounding Bush Forever sites including sites 262, 342 and 413 (Government of Western Australia 2000b).

SCP21c is listed as a Priority 3 PEC by the DEC. Priority communities listed by the DEC have no formal protection. There is no written policy on how to respond to the presence of PECs within proposed development sites. The presence of these communities is dealt with by the DEC on a case by case basis.

The analysis identified SCP12, SCP16 and SCP18 as possible FCTs for vegetation association Mv; however these were not considered to be probable based on the lack of typical species present at the site and also the location. The site is neither a saline seasonal wetland or within a lake deposit.

Given the very low diversity of vegetation association Mv, a single FCT could not be determined. Based on the soil, location, and community structure it can however be concluded that the site is likely to be either SCP8 Herb rich shrublands in claypans or SCP10a Shrublands on dry clay flats. Both these FCTs have been previously recorded within close proximity (one record is as close as 250 m away). Both of these FCTs are listed as TECs by both the State and the Commonwealth.

ENV advises that the presence of the TEC needs to be confirmed by the DEC. The DEC advises that it is not able to make decisions regarding the presence of a TEC without receiving a flora and vegetation report in conjunction with a planning application as part of the statutory approvals process.

If the DEC identifies that the vegetation within the site is not representative of the TEC then no further action will need to be taken regarding this matter. ENV considers that under this circumstance the vegetation association Mv will not pose a constraint to development.

If the DEC confirms the presence of the TEC, they may seek a retention outcome in relation to the specific site characteristics. The DEC makes decisions regarding TECs on a case by case basis. It is ENVs understanding that many factors influence the constraints and requirements imposed by the DEC in regards to the presence of a TEC. These include but are not limited to: the size and condition of the remnant within the study area; the representation and condition of the TEC in other remnants in the local area; and the representation of the TEC within protected areas. The DEC typically seeks at a minimum, the retention of vegetation in good or better condition plus a management buffer.

5.4 VEGETATION CONDITION AND INTRODUCED FLORA

Fifteen introduced species were recorded within the study area. The majority of these are considered to be common agricultural and bushland weeds in the region (Hussey et al. 2007). None of these species are registered as WONS, however, all 15 species are listed as environmental weeds, as defined by the Environmental Weed Strategy for Western Australia (CALM 1999).

Two Declared Plants were recorded within the study area: Arum Lily (**Zantedeschia aethiopica*) and One Leaf Cape Tulip (**Moraea flaccida*). These species are listed as P1 for the Whole State.

5.5 REGIONAL REPRESENTATION

The study area is mapped as Southern River Complex (Heddle et al. 1978). The Southern River Complex was estimated to have 19.8% native vegetation remaining based on the pre-European extent with 1.5% in secure tenure (EPA 2006).

More recently the Perth Biodiversity Project (PBP 2010) has mapped native vegetation extent by vegetation complex on the Swan Coastal Plain. It is estimated that 19.7% of Southern River Complex remains compared to its pre-European extent (PBP 2010).

The EPA's policy on the protection of native vegetation in Western Australia, in the context of pre-European vegetation extent remaining, is based on the following criteria:

From purely a biodiversity perspective and taking no account of any other land degradation issues, there are several key criteria now being applied where clearing is still occurring (EPA 2000):

- The threshold level below which species loss appears to accelerate exponentially at an ecosystem level is regarded as being at a level of 30% of the pre-clearing extent of the vegetation type; and
- A level of 10% of the original extent is regarded as being a level representing "endangered".

The pre-European vegetation in the Southern River Complex, which the study area is situated, is under the threshold level set by the EPA (EPA 2000). Due to the study area being below the 30% threshold level, the EPA would expect alternative mechanisms to be put forward to address the protection of biodiversity (EPA 2000).

5.6 BUSH FOREVER

The Government of Western Australia has endorsed Bush Forever as the means of seeking the appropriate protection and management of areas of regionally significant bushland on the Swan Coastal Plain Portion of the Perth Metropolitan Region and a balance between environmental, social and economic objectives.

The majority of the survey area is within a Bush Forever site that has been identified as containing regionally significant bushland with some existing protection. The vegetation varies between Good and Excellent condition in these areas.

The site meets criteria for regionally significant vegetation based on its representation of ecological communities, diversity, rarity (species and communities, Scientific or evolutionary importance, and General Criteria for the protection of wetlands.

5.7 WETLANDS

The site is mapped by the DEC as supporting Conservation and Multiple Use Category wetlands. The wetlands cover the majority of the site according to the Geomorphic Wetland mapping (DEC 2012g). Each of the vegetation associations mapped on site correlate with this information as they are either wetland communities or are likely to occur on low lying landscapes with higher soil moisture. Due to the broad scale of the DEC wetland mapping however, tracks have also been mapped as wetlands. Therefore more than half of the site (66.2%) does not actually contain wetland vegetation (Figure 5).

Conservation category wetlands are in the highest category of protection, and they are ESAs under the EP Act. Conservation Category wetlands are also identified for protection and enhancement in the Western Australian Planning Commission State Planning Policy 2.9 – Water Resources.

5.8 FAUNA HABITAT TYPES

The study area consists of three habitat types; *Banksia* Woodland dominated by *Banksia attenuata* and *Banksia ilicifolia*, *Melaleuca* Woodland dominated by *Melaleuca preissiana, Melaleuca rhaphiophylla, Melaleuca viminea* and *Kunzea glabrescens* and Cleared Land. Both the *Banksia* Woodland and *Melaleuca* Woodland habitats included in the study area border severely degraded areas which contain low fauna habitat value. Furthermore the habitat included in the study area is a very small proportion in comparison to the bushland surrounding the area. Species that occur within these habitats are likely to utalise these areas on a short term basis only (i.e. when commuting between neighbouring habitats).

Banksia Woodland

High habitat values of the *Banksia* Woodland are driven by the soft sands and high densities overstorey, midstorey and understorey vegetation layers. The soft sands provide ideal habitat for borrowing and digging amphibians such as the Banjo Frog (*Limnodynastes dorsalis*), reptiles such as Burton’s Legless Lizard (*Lialis burtonis*) and mammals such as the Quenda/Southern Brown Bandicoot (*Isoodon obesulus*). The ground contains relatively high amounts of leaf litter and woody debris providing ground dwelling fauna, particularly reptiles, places to bask and forage while keeping hidden from predators. The high cover values of overstorey, midstorey and understorey vegetation are ideal for small passerine species such as the Hooded Robin (*Melanodryas cucllata*) and Splendid Fairy Wren (*Malurus splendens*) which forage low to the ground for small insects. *Banksia* species are an important food resource for many species both common species such as honeyeaters but also for threatened species such as the three Black Cockatoo species known to occur across the region. Black Cockatoo feed on the flowers and seeds of *Banksia* species (Groom 2011) which is historically a large component of the species diet and has extensively cleared due to urban expansion (Johnstone & Kirkby 2011). The Banksia Woodland in the study area is however highly degraded and covers a small area (< 1 ha) and clearing of the study area will have minimal impact to any species that occur in this habitat.

Melaleuca Shrubland

High habitat vales of the *Melaleuca* Woodlands are due to the soft sand for burrowing species and the high proportion of leaf litter which provides suitable cover for ground dwelling species. Reptile species, in particular, forage and bask amongst the leaf litter as it provides cover from predators above e.g. small skinks such as *Hemiergis quadrilineata*, legless lizards such as *Pygopus lepidopodus* and snakes such as the Bardick (*Echiopsis curta*). The dense *Melaleuca* shrubs provide foraging habitat for small common passerines which feed on insects and small reptiles such as the Rufous Whistler (*Pachycephala rufiventris*), Western Gerygone (*Gerygone fusca*) and Grey Shike-thrush (*Colluricincla harmonica*). The *Melaleuca* and *Kunzea*, when in flower, provide a foraging resource for a suite of common nectivorous species such as the Red Wattlebird (*Anthochaera carunculata*) and the Tawny-crowned Honeyeater (*Gliciphila melanops*). This habitat coverage within the study area is minimal in comparison to the surrounding bushland, clearing of this land will have minimal effect on any species which occur in the area.

Cleared Land

The Cleared Land within the study area provides very little fauna habitat. Species most likely to occur in this area are generalist species that are common and widespread throughout the region. Birds include the Australian Magpie (*Gymnorhina tibicen*), Australian Raven (*Corvus coronoides*) and the Australian Ringneck (*Barnardius zonarius*). Ground dwelling fauna are only likely to occur when commuting to and from neighbouring habitats, as such any species which occurs within this habitat is not dependent on it and will not be affected by the planned development.

5.9 FAUNAL ASSEMBLAGE

A total of 26 species were recorded from within the study area, comprising one reptile, 23 birds and two mammals. A total of 253 species have been previously recorded within the vicinity of the study area. As this was a Level One survey to assess fauna habitat types, many of the potentially occurring species were not recorded. For example, many of the ground dwelling reptiles and mammals are mainly recorded or captured from trapping techniques employed during a Level Two survey. In addition, some potentially occurring species are nocturnal and the surveys were conducted during the day.

The expected fauna assemblage of the study area consists of species that are generally common and widespread throughout the region and are not dependent upon the habitat found within the study area.

5.10 CONSERVATION SIGNIFICANT FAUNA

No conservation significant species were recorded during the survey. Four species of conservation significant fauna are considered as ‘Likely’ to occur in the study area; Forest Red-tailed Cockatoo, Baudin’s Black Cockatoo, Carnaby’s Black Cockatoo and the Rainbow Bee-eater.

Forest Red-tailed Black Cockatoo

The Forest Red-tailed Black Cockatoo (FRBC) is distributed throughout the humid and subhumid southwest of Western Australia from Gingin through the Darling Ranges to the southwest, from approximately Bunbury to Albany (Johnstone & Storr 1998). The FRBC occurs in pairs or small flocks, or occasionally in large flocks of up to 200 birds (Johnstone & Storr 1998). The FRBC usually inhabits dense Jarrah (*Eucalyptus marginata*), Karri (*Eucalyptus diversicolor*) and Marri forests that receive more than 600 mm average annual rainfall (Chapman 2007). This species breeds in the southwest between October and November. The FRBC feeds primarily on Marri and Jarrah fruit (SEWPAC 2011). They have also been known to feed on Blackbutt (*Eucalyptus patens*), Albany Blackbutt (*Eucalyptus staeri*), Karri, Sheoak (*Allocasuarina fraseriana*) and Snottygobble (*Persoonia longifolia*) (Johnstone & Kirkby 1999). The FRBC population is estimated at approximately 15,000 birds (Johnstone & Kirkby 1999). The primary threat to the FRBC is the loss of habitat loss due to clearing and forestry (Garnett et al. 2011). The FRBC has been frequently recorded within the vicinity of the study area. While historically the species was more common in the south-west of its distribution, degradation and clearing of foraging resources in the southwest have meant a dynamic expansion of the species onto the Swan Coastal Plain, particularly within the Perth region (Johnstone & Kirkby 2011). Habitat suitable for the species within the study area is limited and degraded. the vegetation of the study area provides no known foraging, roosting or breeding species for the FRBC and there will be minimal impact to the species by the proposed development.

Baudin's Cockatoo

The Baudin's Cockatoo is distributed throughout the south western humid and sub humid zones, from the northern Darling Range and adjacent far east of the Swan Coastal Plain (south of the Swan River), south to Bunbury and across to Albany (Johnstone & Storr 1998). This species forages primarily in eucalypt forest, where it feeds on Marri seeds, flowers, nectar and buds (Johnstone & Kirkby 2008). They also feed on a wide range of seeds of *Eucalyptus, Banksia, Hakea* and exotic *Pinu*s (Pine) species, as well as fruiting apples and pears and beetle larvae from under the bark of trees (Johnstone & Kirkby 2008; Johnstone & Storr 1998). Baudin's Cockatoo is mostly a postnuptial nomad, although some populations are resident (Johnstone & Kirkby 2008). Most Baudin's Cockatoos breed in the deep south-west in spring-summer, from around October to March. Following breeding birds leave nesting areas and amalgamate to form large foraging flocks. These flocks generally migrate north to the main non-breeding wintering area in the northern Darling Range between Collie and Mundaring (Johnstone & Kirkby 2008). The total population of Baudin's Cockatoo is estimated to be about 15 000 birds, and has declined greatly in the last 50 years primarily from habitat destruction (Johnstone & Kirkby 2008). The Baudin's Black Cockatoo has been frequently recorded within the vicinity of the study area. The *Banksia attenuata* within the *Banksia* Woodland habitat is a potential food resource for the species (Chapman 2007; Johnstone & Kirkby 2008; SEWPAC 2011). This habitat within the study area is limited (0.16 ha) and widely distributed in the bushland surrounding the study area. Due to the limited habitat suitable of the species and its degraded condition, there will be minimal impact to the Baudin's Black Cockatoo.

Carnaby's Cockatoo

The Carnaby's Cockatoo is listed as Endangered under the *EPBC Act* and Schedule 1 under the WC Act. Carnaby's Cockatoo is endemic to southwest Western Australia, and is distributed from the Murchison River to Esperance and inland to Coorow, Kellerberrin and Lake Cronin (Cale 2003). The species was once common, but the population has declined significantly in the last 45 years, and is now locally extinct in some areas (Johnstone & Storr 1998; Shah 2006). In the last 45 years the species has suffered a 50% reduction in its abundance due to the extensive clearing of core breeding habitat in the wheatbelt, and the clearing of food resources upon the Swan Coastal Plain (Cale 2003). The total population of Carnaby's Cockatoo is currently estimated at 40,000 (Garnett et al. 2011). Breeding usually occurs from early July to mid-December, in the semi-arid and subhumid interior of WA's wheatbelt (Johnstone & Storr 1998). The Carnaby's Black Cockatoo (DEC 2012e) has been previously recorded throughout the vicinity of the study area. The *Banksia attenuata* and *Banksia ilicifolia* of the *Banksia* Woodland habitat within the study area provides potential foraging habitat for the species (Groom 2011; Valentine & Stock 2008; SEWPAC 2011). This habitat encompasses a small area and is highly disturbed. As such, there is likely to be minimal impact to the Carnaby's Black Cockatoo.

Rainbow Bee-eater

The Rainbow Bee-eater is listed as Migratory under the EPBC Act. This species is one of the most common and widespread birds in Australia with a distribution that covers the majority of Australia (Barrett et al. 2003). In Western Australia this bird can occur as a 'resident, breeding visitor, postnuptial nomad, passage migrant and winter visitor' (Johnstone & Storr 1998). Although the species was not recorded during this survey it has been previously recorded in the vicinity of the study area (DEC 2012e). The study area provides suitable foraging habitat and suitable nest sites in the sandy soil and can be expected in all of the habitats present. The species is not however, dependent on the habitats represented in the study area, and the common and widespread distribution of this species ensures that the proposed development will not impact upon its conservation status.

6 RECOMMENDATIONS

ENV.Australia makes the following recommendations:

6.1 FLORA

- Clearing of any TEC or PEC vegetation should be avoided;
- As a matter of principle, any clearing of native vegetation should be kept to a minimum;
- Existing tracks should be used where possible and vehicles should avoid parking, turning or reversing into vegetation;
- Clearing of known locations of all Priority flora should be avoided wherever possible; and
- Hygiene practices should be put into place to avoid the spreading of weeds.

6.2 FAUNA

The following recommendations are provided to manage and minimise impacts on fauna:

- Clear the vegetation in stages to enable the resident fauna to seek refuge outside of the study area;
- Any conservation significant ground dwelling species found during the clearing process need to be trapped and translocated by appropriately trained zoologists;
- No dead, standing or fallen timber should be removed unnecessarily;
- Where possible, current tracks and cleared sections should be used for site access to minimise the impact on the area's fauna and habitat;
- Boundaries of areas to be disturbed should be clearly demarcated to prevent any erroneous damage to habitat; and
- Clear during the non-breeding season for Black Cockatoos to avoid disturbance of breeding.

7 ASSESSMENT OF FINDINGS AGAINST THE CLEARING PRINCIPLES

Any clearing of native vegetation requires a permit under Part V Division 2 of the *EP Act*, except where an exemption applies under Schedule 6 of the *EP Act*, or where the clearing is prescribed by regulations in the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Exemptions do not apply in an ESA.

Each of the ten clearing principles, as outlined in the *EP Act* 1986, are individually assessed below, within the scope and knowledge of this flora, vegetation and fauna assessment. This project may be at variance with four of the ten clearing principles, depending upon the areas proposed for future impacts.

PRINCIPLE A - NATIVE VEGETATION SHOULD NOT BE CLEARED IF IT COMPRISES A HIGH LEVEL OF BIOLOGICAL DIVERSITY

The flora species richness recorded during the survey is considered to be low for the area and for the condition of the vegetation. The average flora richness per quadrat recorded during this survey, 18.1 species per quadrat, is lower than the species richness recorded by Gibson et al. (1994) within the FCTs represented on site. For example Gibson et al. (1994) recorded a mean species richness of 36.9 species within SCP04 '*Melaleuca preissiana* damplands' and 40.5 species within SCP21c 'Low lying Banksia attenuata woodlands or shrublands'.

A total of 26 vertebrate fauna (one reptile, 23 birds and two mammals) were recorded in the study area. The study area contains three habitat types namely *Banksia* Woodland, *Melaleuca* Shrubland and Cleared Land.

A total of 253 fauna have been previously recorded in the vicinity of the study area from the database search. These consist of 12 amphibians, 63 reptiles, 153 birds and 25 mammals. The proposed development is unlikely to disrupt the fauna assemblage of the study area as the fauna are generally common and widespread throughout the region and are not dependent upon the study area.

Therefore, clearing in the study area is unlikely to be at variance with this principle.

PRINCIPLE B - NATIVE VEGETATION SHOULD NOT BE CLEARED IF IT COMPRISES THE WHOLE OR A PART OF, OR IS NECESSARY FOR THE MAINTENANCE OF, A SIGNIFICANT HABITAT FOR FAUNA INDIGENOUS TO WESTERN AUSTRALIA

No fauna taxa of conservation significance were recorded during the current survey of the study area. Four fauna species of conservation significance are considered as 'Likely' to occur within the project area as it provides suitable habitat; the Forest Red-tailed Black Cockatoo, Baudin's Black Cockatoo, Carnaby's Black Cockatoo and the Rainbow

Bee-eater. All four species of conservation significance likely to occur within the study area are wide-ranging, mobile and not dependent on the study area.

The *Banksia* Woodland of the study area provides a potential foraging resource for the Carnaby's Cockatoo and Baudin's Cockatoo. The *Banksia* Woodland covers a small proportion of the study area and is highly disturbed. Furthermore *Banksia* Woodlands are widespread in the surrounding bushland, as such the Black Cockatoo Species will not be impacted by the clearing of this habitat within the study area.

The Rainbow Bee-eater is a common and wide-ranging species. The study area provides potential foraging and nesting habitat for the species. The species is however, not dependent on the habitats represented within the study area as such the species local or regional status will not be impacted by clearing of the habitats within the study area.

Therefore, clearing in the study area is unlikely to be at variance with this principle.

PRINCIPLE C - NATIVE VEGETATION SHOULD NOT BE CLEARED IF IT INCLUDES, OR IS NECESSARY FOR THE CONTINUED EXISTENCE OF, RARE FLORA

No Threatened species pursuant to the EPBC Act and/or gazetted as Declared Rare Flora (Threatened) pursuant to the WC Act were recorded during the survey.

Therefore, clearing in the study area is unlikely to be at variance with this principle.

PRINCIPLE D: NATIVE VEGETATION SHOULD NOT BE CLEARED IF IT COMPRISES THE WHOLE OR PART OF, OR IS NECESSARY FOR THE MAINTENANCE OF, A THREATENED ECOLOGICAL COMMUNITY

Vegetation association Mv (KRZ5) which, although it is unable to be definitively identified to a single FCT, is conclusively either SCP8 Herb rich shrublands in claypans (listed as Vulnerable by the state and Critically Endangered under the *EPBC Act*) or SCP10a Shrublands on dry clay flats (listed as Endangered by the state and Critically Endangered under the *EPBC Act*).

The disturbances associated with the project are therefore likely to be at variance with this principle.

PRINCIPLE E: NATIVE VEGETATION SHOULD NOT BE CLEARED IF IT IS SIGNIFICANT AS A REMNANT OF NATIVE VEGETATION IN AN AREA THAT HAS BEEN EXTENSIVELY CLEARED

Vegetation associations described in the study area were not able to be correlated with the Beard (1979)/ Shepherd et al. (2001) broad vegetation types. This is due to the Beard mapping being undertaken at a scale of 1:250 000 and the site being surveyed at a much finer scale.

More recently the Perth Biodiversity Project (PBP 2010) has mapped native vegetation extent by vegetation complex on the Swan Coastal Plain. It is estimated that 19.7% of Southern River Complex remains compared to its pre-European extent (PBP 2010).

The pre-European vegetation in the Southern River Complex, which the study area is situated, is considered to be Vulnerable (EPA 2000)

Disturbances associated with the project may be at variance with this principle.

PRINCIPLE F: NATIVE VEGETATION SHOULD NOT BE CLEARED IF IT IS GROWING IN, OR IN ASSOCIATION WITH, AN ENVIRONMENT ASSOCIATED WITH A WATERCOURSE OR WETLAND

The site is mapped by the DEC as supporting Conservation and Multiple Use Category wetlands. The wetlands cover the majority of the site according to the Geomorphic Wetland mapping (DEC 2010).

Conservation category wetlands are in the highest category of protection, and they are recognised as ESAs under the EP Act. Conservation Category wetlands are also identified for protection and enhancement in the Western Australian Planning Commission State Planning Policy 2.9 – Water Resources.

This project is at variance with this principle.

PRINCIPLE G: NATIVE VEGETATION SHOULD NOT BE CLEARED IF THE CLEARING OF THE VEGETATION IS LIKELY TO CAUSE APPRECIABLE LAND DEGRADATION

The gradient across the site is less than five metres (Landgate 2012). The uniformity of the landscape means it is unlikely to be effected by erosion. Due to the scale of proposed clearing it is unlikely to have effect on salinity, nutrient export, acidification or flooding.

Therefore, disturbances associated with the project are unlikely to be at variance with this principle.

PRINCIPLE H: NATIVE VEGETATION SHOULD NOT BE CLEARED IF THE CLEARING OF THE VEGETATION IS LIKELY TO HAVE AN IMPACT ON THE ENVIRONMENTAL VALUES OF ANY ADJACENT OR NEARBY CONSERVATION AREAS

The study area is mapped as Bush Forever Site No. 342, also known as the Anstey/Keane Dampland and Adjacent Bushland, Forrestdale (Government of Western Australia 2000a). The next nearest Bush Forever sites to the study area are; Balannup Lake and Adjacent Bushland, Southern River/Forrestdale (Bush Forever site 413), abutting the northern edge of Site 342 and the Piarra Nature Reserve, Forrestdale (Bush Forever Site 262), approximately 0.6 km south-west of the study area (Government of Western Australia 2000a).

Therefore, disturbances associated with the project may be at variance with this principle.

PRINCIPLE I: NATIVE VEGETATION SHOULD NOT BE CLEARED IF THE CLEARING OF THE VEGETATION IS LIKELY TO CAUSE DETERIORATION IN THE QUALITY OF SURFACE OR UNDERGROUND WATER

As the proposed disturbance area is along existing tracks and involves minimal vegetation clearing, it is unlikely to affect surface or groundwater deterioration.

Therefore, disturbances associated with the project are unlikely to be at variance with this principle.

PRINCIPLE J: NATIVE VEGETATION SHOULD NOT BE CLEARED IF THE CLEARING OF THE VEGETATION IS LIKELY TO CAUSE, OR EXACERBATE, THE INCIDENCE OR INTENSITY OF FLOODING

As the proposed disturbance area is along existing tracks and involves minimal vegetation clearing it is unlikely to cause or exacerbate the instance of flooding in the area.

Therefore, disturbances associated with the project are not likely to be at variance with this principle.

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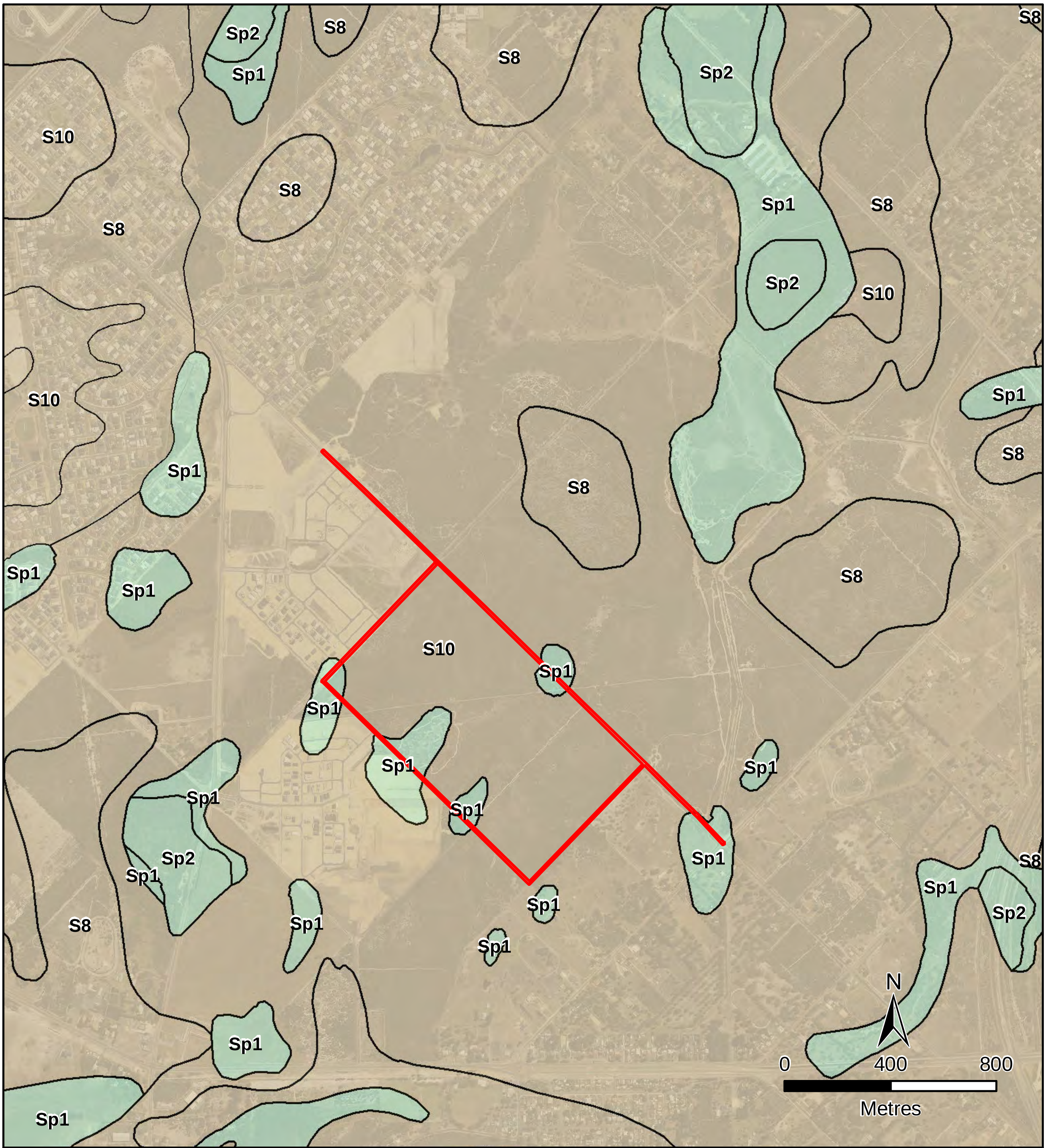
FIGURES



Legend

Sp1 PEATY SAND - grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin

S8 SAND - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals,

S10 SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin

Geological Survey of WA, 1:50K Surface Geology

env Australia

CLIENT Water Corporation		JOB NO. J113163
AUTHOR D. Buller	DRAWN T. Ellis	DATE 02-10-12
SCALE 1:20,000 @ A4	PROJECTION GDA 94 MGA 50	

Geology of the Study Area

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **3**

CLIENT
Water Corporation

JOB NO.
J113163

AUTHOR
D. Buller

DRAWN
T. Ellis

DATE
02-10-12

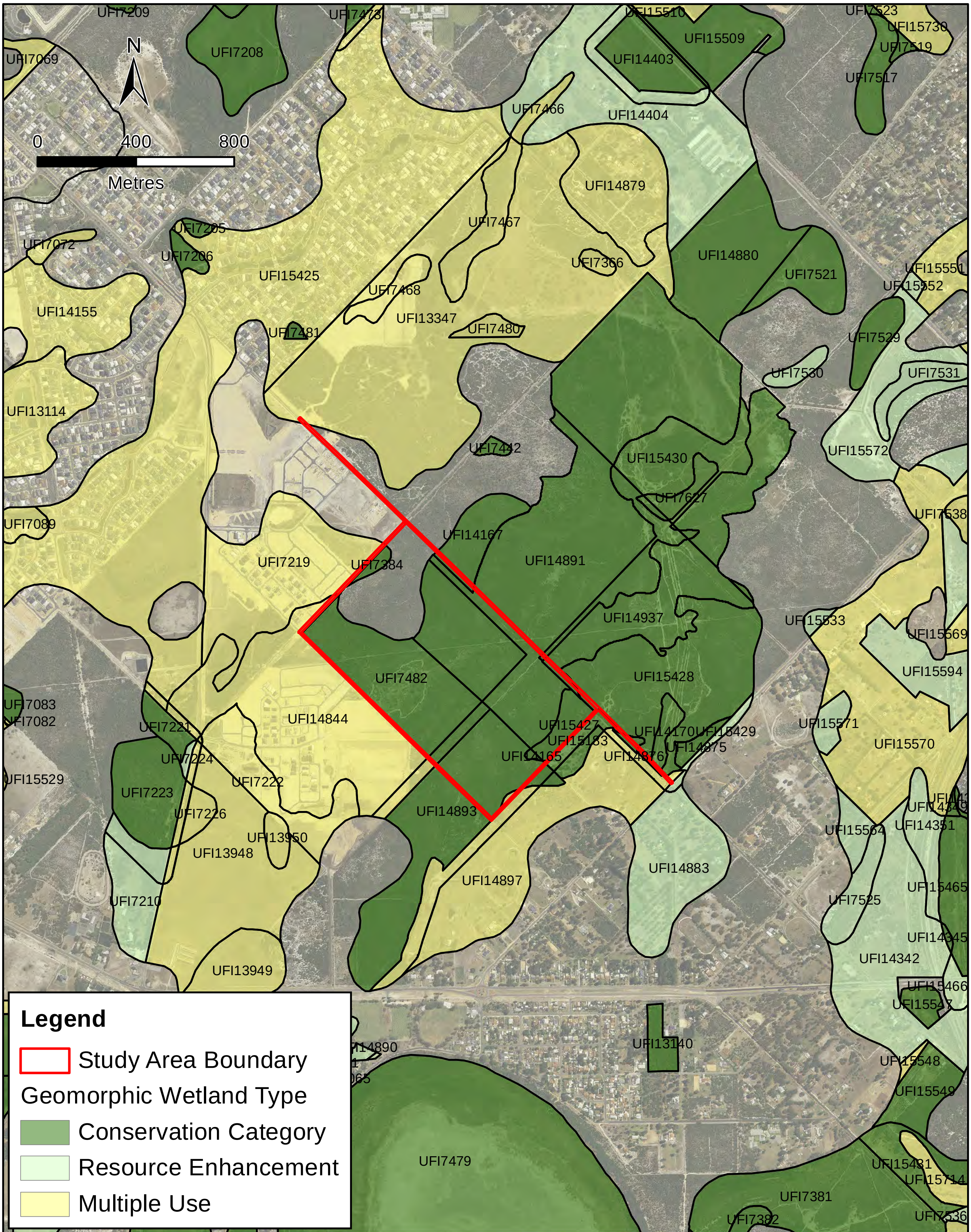
SCALE
1:50,000 @ A4

PROJECTION
GDA 94 MGA 50

System 6 Vegetation Complexes of the Study Area

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **4**



CLIENT		JOB NO.
Water Corporation		J113163
AUTHOR	DRAWN	DATE
D. Buller	T. Ellis	16-10-12
SCALE	PROJECTION	
1:20,000 @ A4	GDA 94 MGA 50	

Geomorphic Wetlands

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE 5

env Australia

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Water Corporation

JOB NO.
J113163

AUTHOR
D. Buller

DRAWN
M. Mikkonen

DATE
17-10-12

SCALE
1:9,000 @ A4

PROJECTION
GDA 94 MGA 50

Flora Quadrat Locations

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE 6

env Australia

CLIENT		JOB NO.
Water Corporation		J113163
AUTHOR	DRAWN	DATE
C. Knuckey	M. Mikkonen	15-10-12
SCALE	PROJECTION	
1:9,000 @ A4	GDA 94 MGA 50	

Fauna Habitat Assessment Locations

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

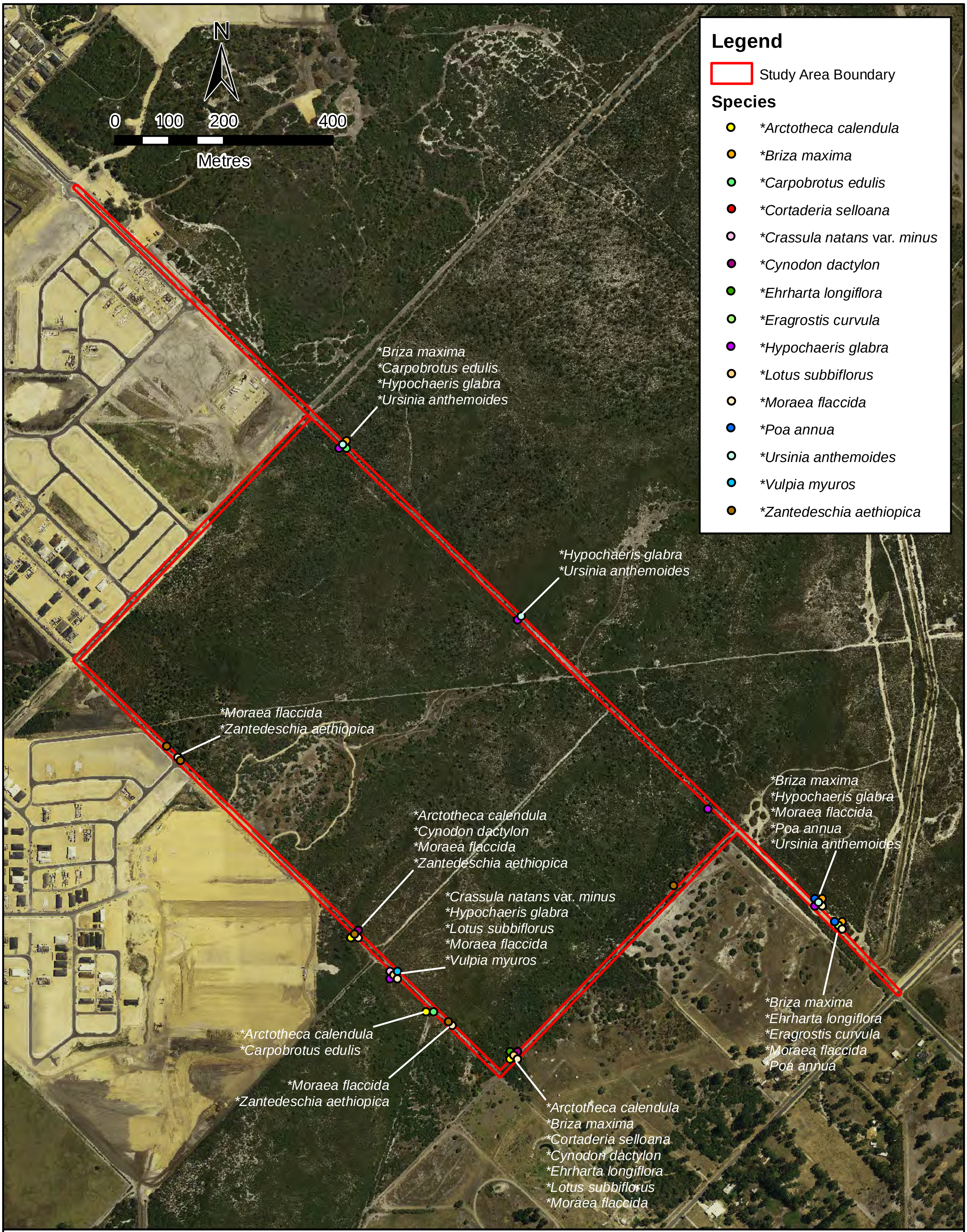
FIGURE 7

CLIENT		JOB NO.	
Water Corporation		J113163	
AUTHOR	DRAWN	DATE	
D. Buller	M. Mikkonen	17-10-12	
SCALE	PROJECTION		
1:9,000 @ A4	GDA 94 MGA 50		

Location of Conservation Significant Flora

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE 8



CLIENT	JOB NO.
Water Corporation	J113163

AUTHOR	DRAWN	DATE
D. Buller	M. Mikkonen	17-10-12

SCALE	PROJECTION
1:9,000 @ A4	GDA 94 MGA 50

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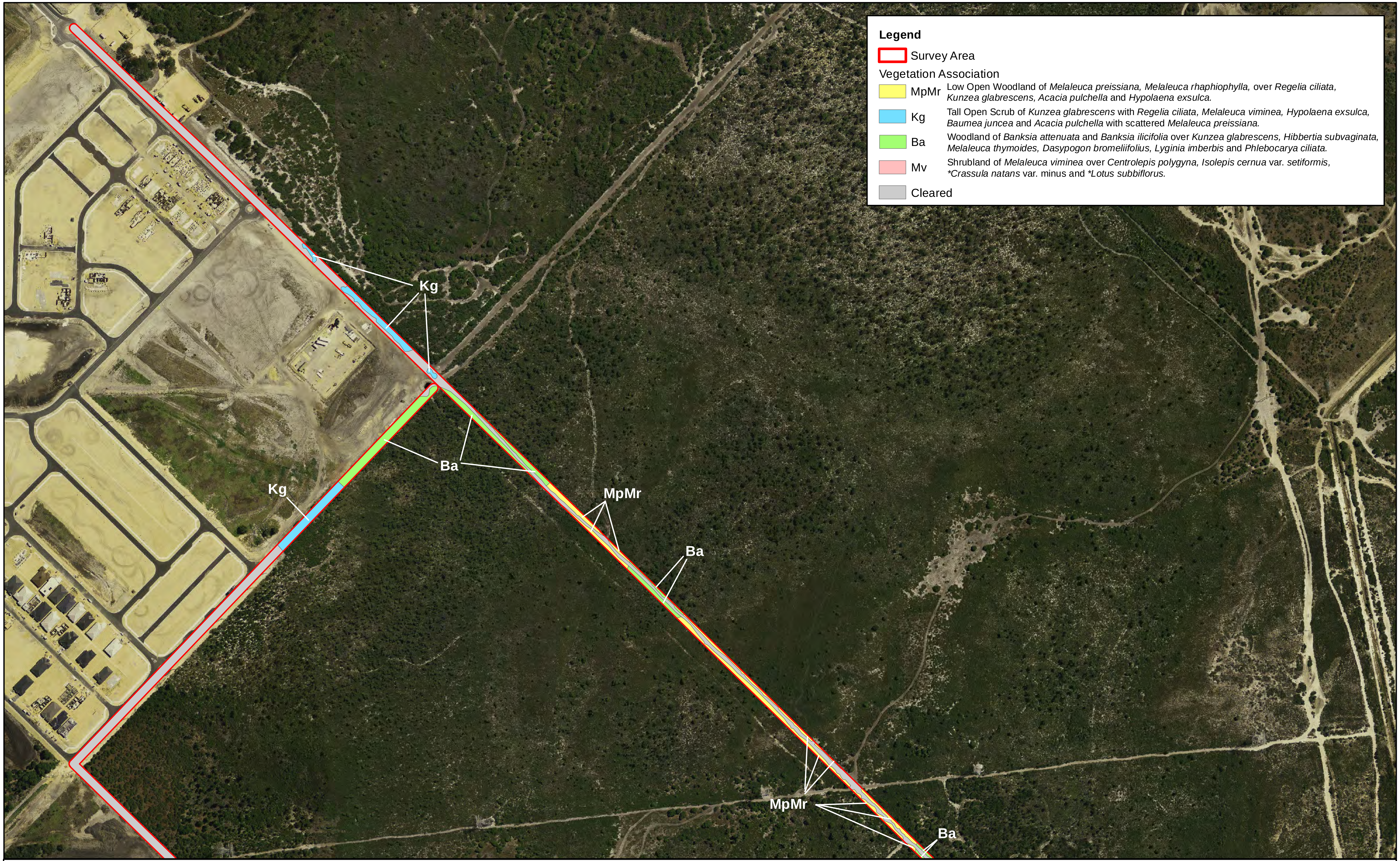
Location of Introduced Flora

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE 9



CLIENT
Water Corporation

JOB NO.
J113163

AUTHOR
N. Whittington

DRAWN
T. Ellis

DATE
28-11-12

SCALE
1:4,000 @ A3

PROJECTION
GDA 94 MGA 50

10a
10b

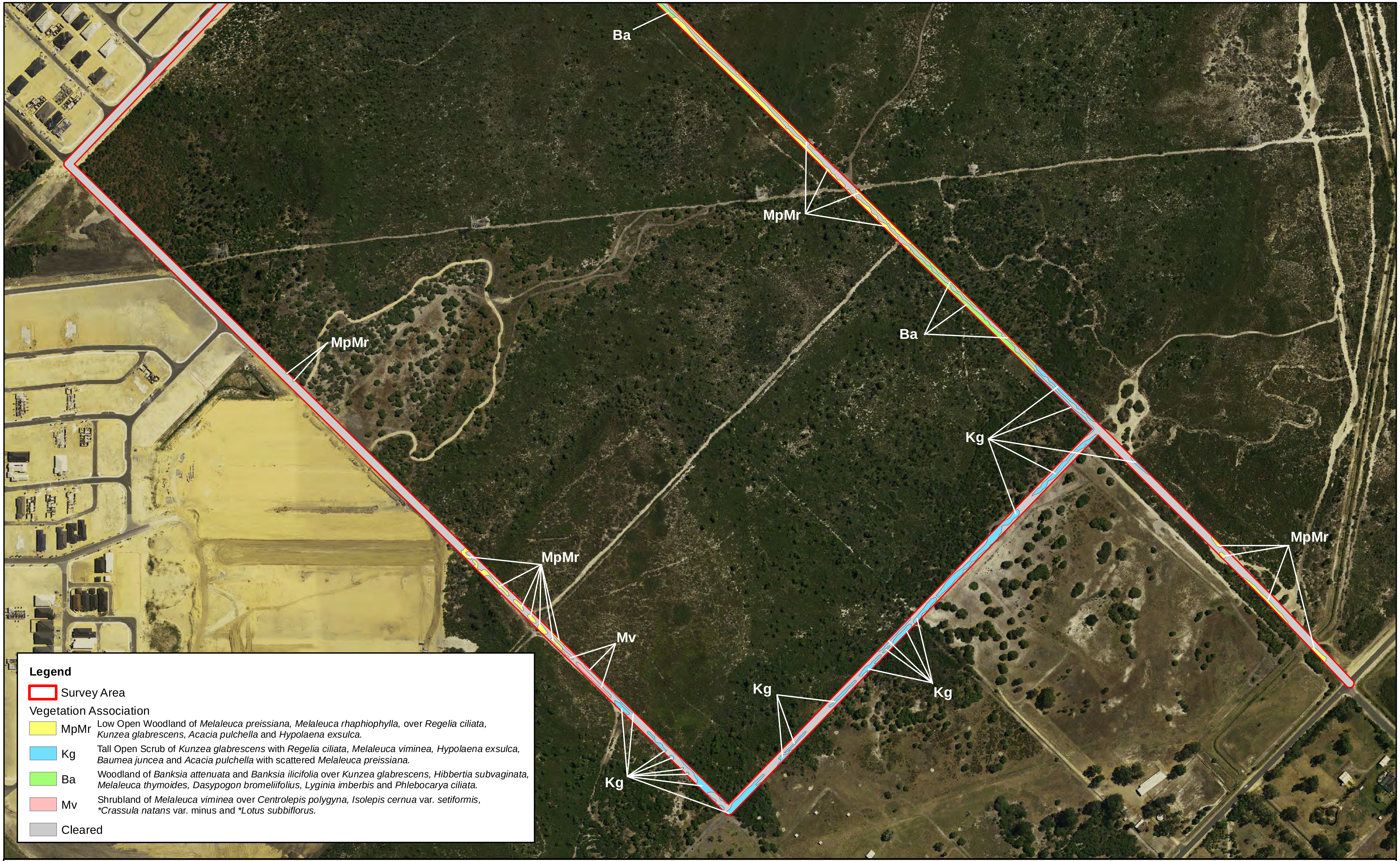
N

0 50 100 150
Metres

Vegetation Association Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

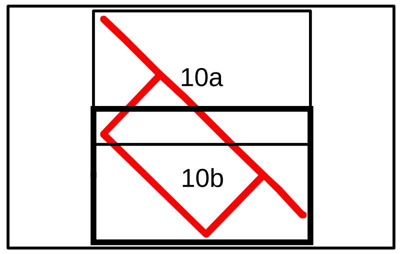
FIGURE
10a



CLIENT	JOB NO.
Water Corporation	J113163

AUTHOR	DRAWN	DATE
N. Whittington	T. Ellis	28-11-12

SCALE	PROJECTION
1:4,000 @ A3	GDA 94 MGA 50



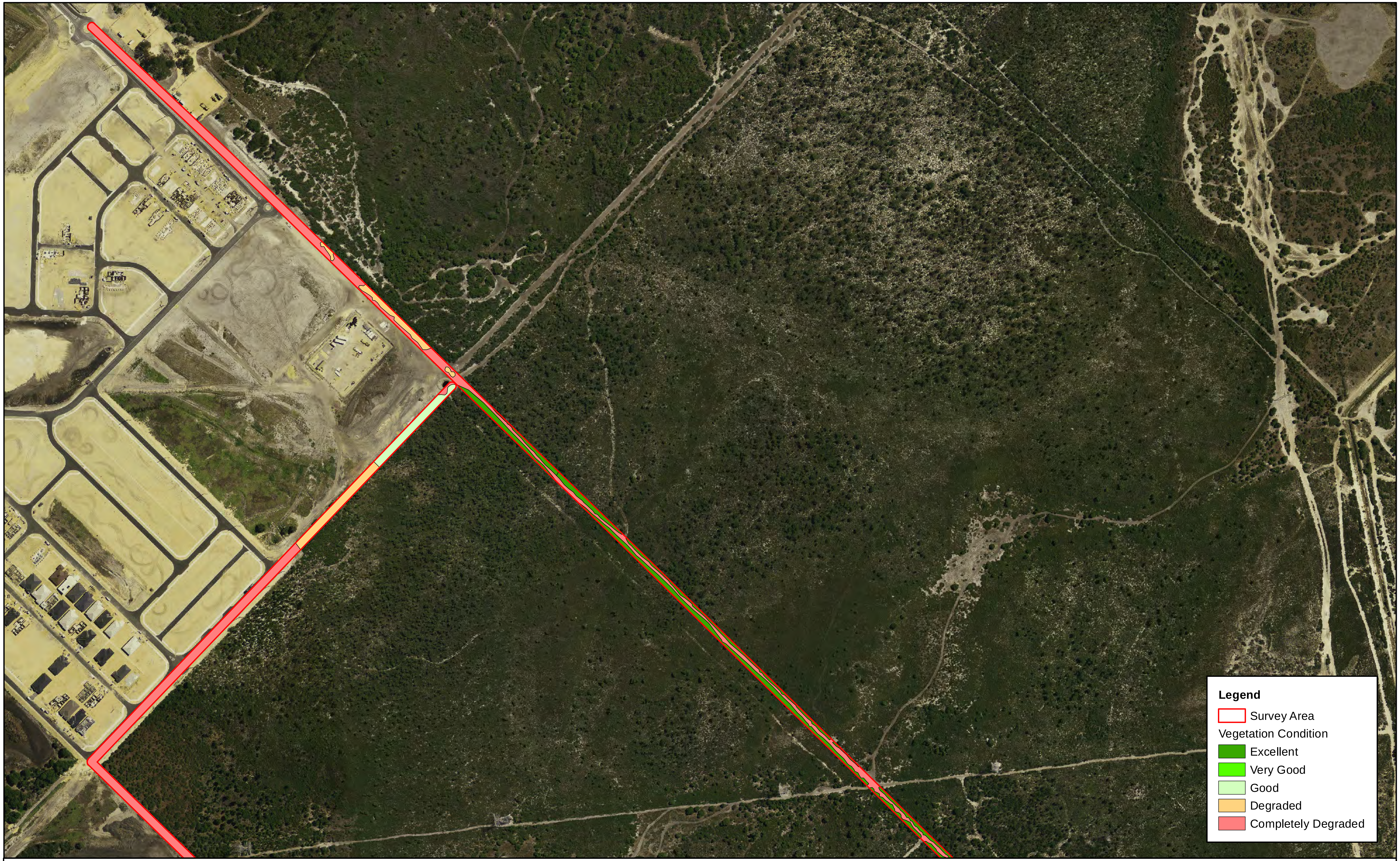
N

0 50 100 150
Metres

Vegetation Association Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **10b**



CLIENT
Water Corporation

JOB NO.
J113163

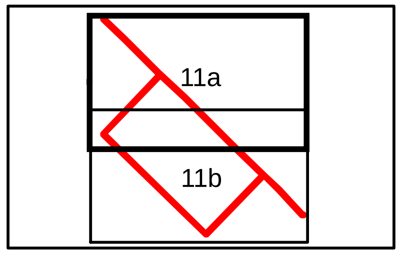
AUTHOR
N. Whittington

DRAWN
T. Ellis

DATE
01-11-12

SCALE
1:4,000 @ A3

PROJECTION
GDA 94 MGA 50



N

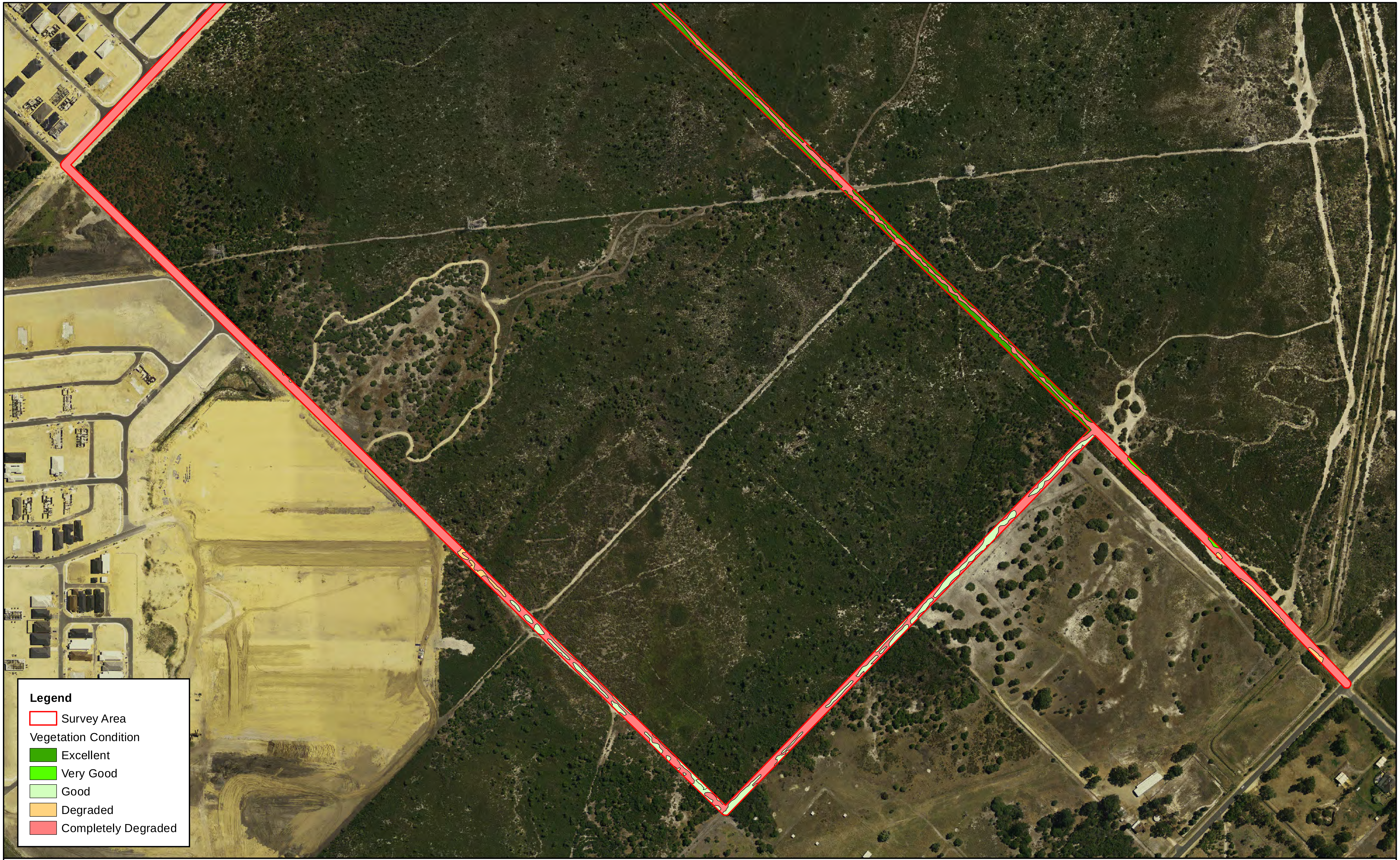
0 50 100 150

Metres

Vegetation Condition Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **11a**



CLIENT
Water Corporation

JOB NO.
J113163

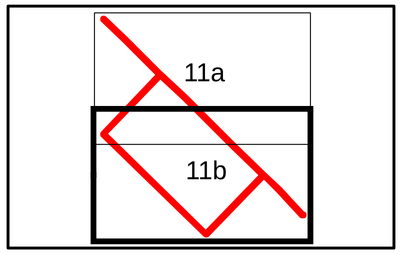
AUTHOR
N. Whittington

DRAWN
T. Ellis

DATE
01-11-12

SCALE
1:4,000 @ A3

PROJECTION
GDA 94 MGA 50

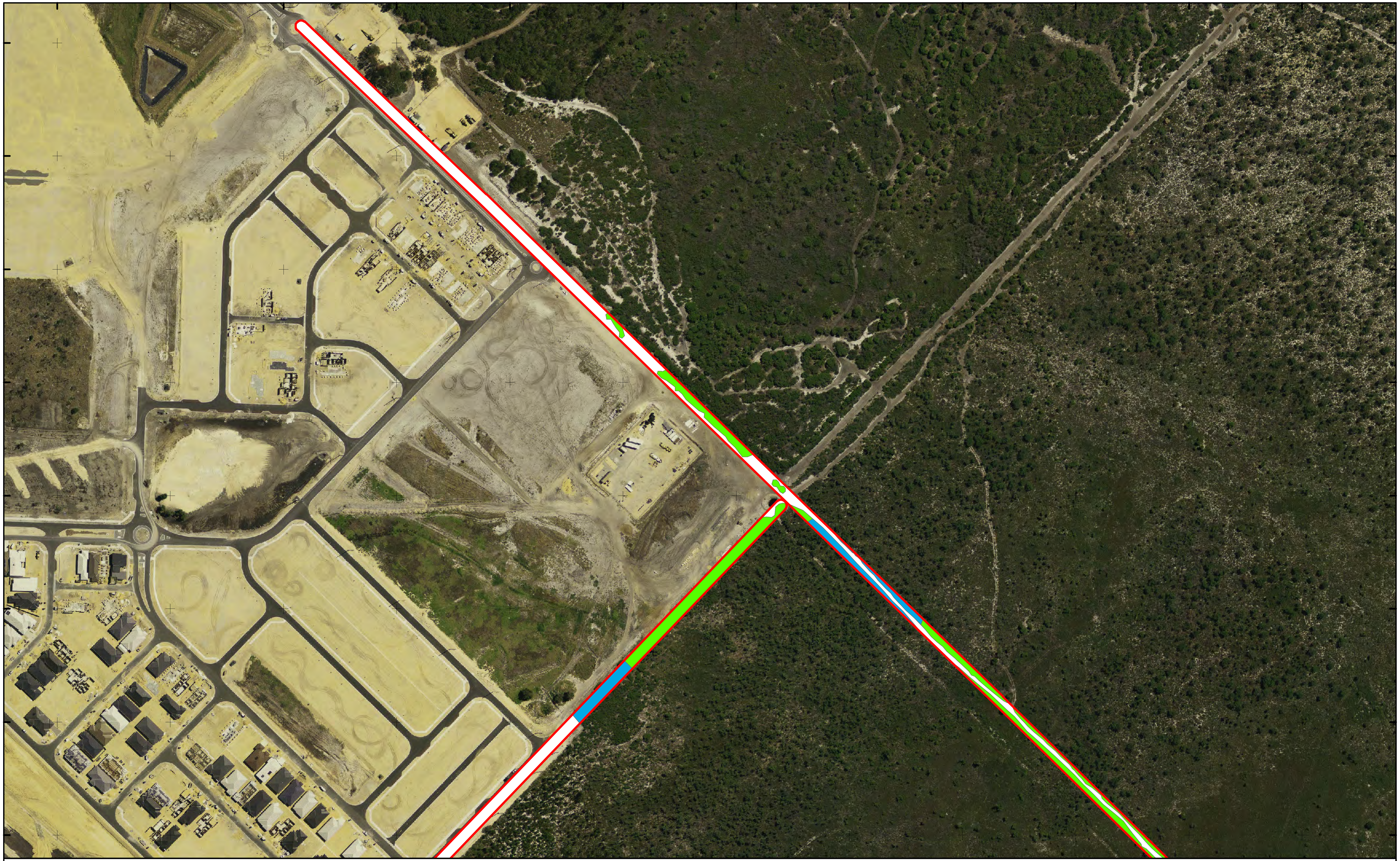


N
0 50 100 150
Metres

Vegetation Condition Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **11b**



CLIENT
Water Corporation

JOB NO.
J113163

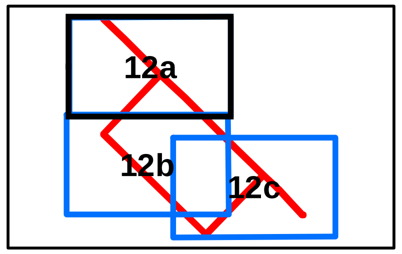
AUTHOR
R. Firth

DRAWN
M. Mikkonen

DATE
12-10-12

SCALE
1:3,000 @ A3

PROJECTION
GDA 94 MGA 50



N

0 50 100

Metres

Legend

Survey Area

Habitat

Banksia Woodland

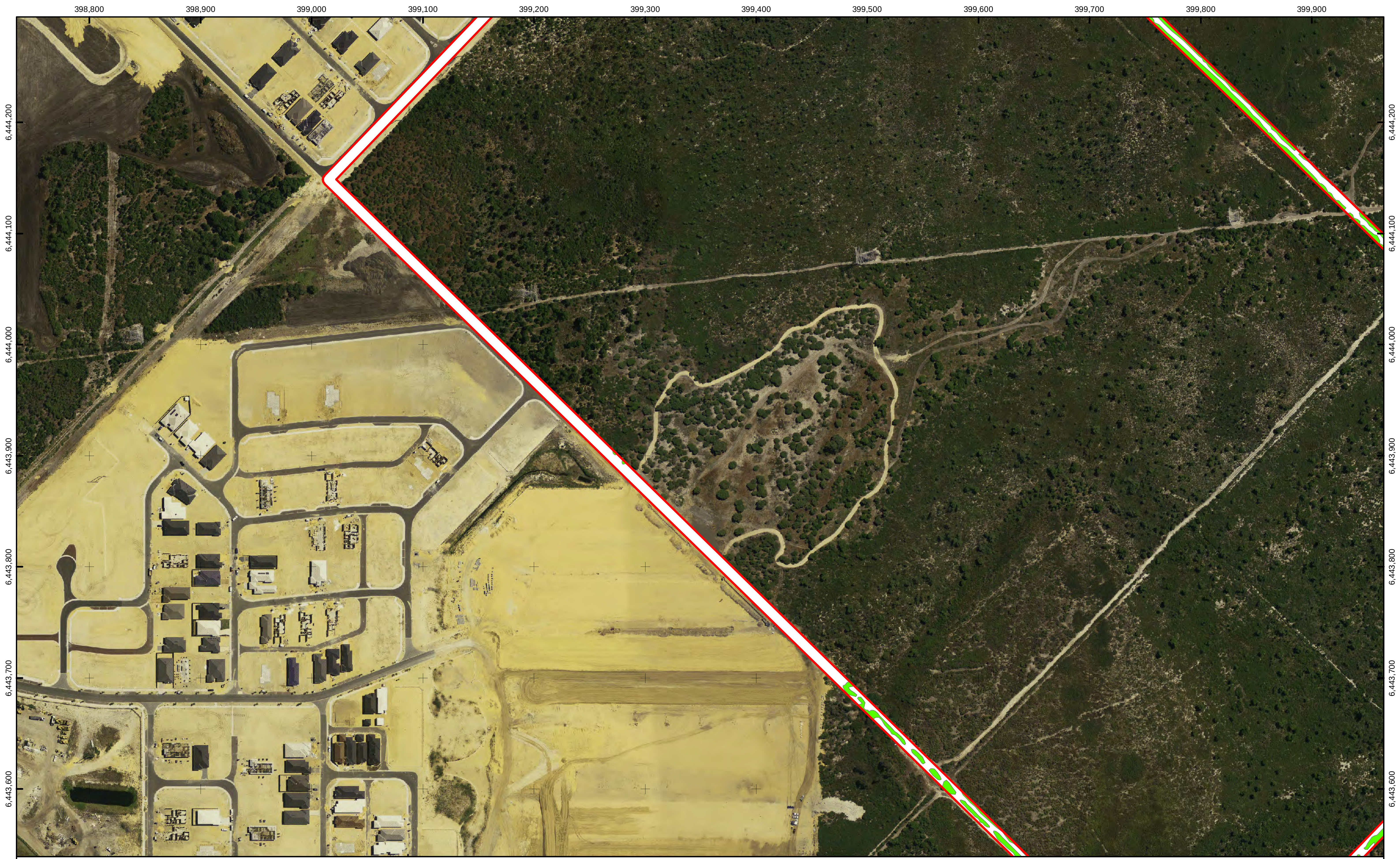
Melaleuca Shrubland

Cleared

Fauna Habitat Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE 12a



CLIENT
Water Corporation

JOB NO.
J113163

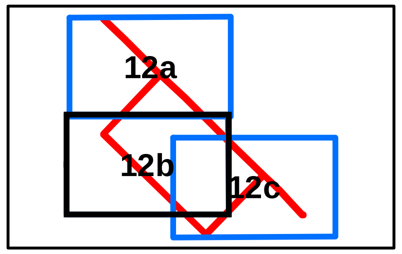
AUTHOR
R. Firth

DRAWN
M. Mikkonen

DATE
12-10-12

SCALE
1:3,000 @ A3

PROJECTION
GDA 94 MGA 50



N

0 50 100

Metres

Legend

Survey Area

Habitat

Banksia Woodland

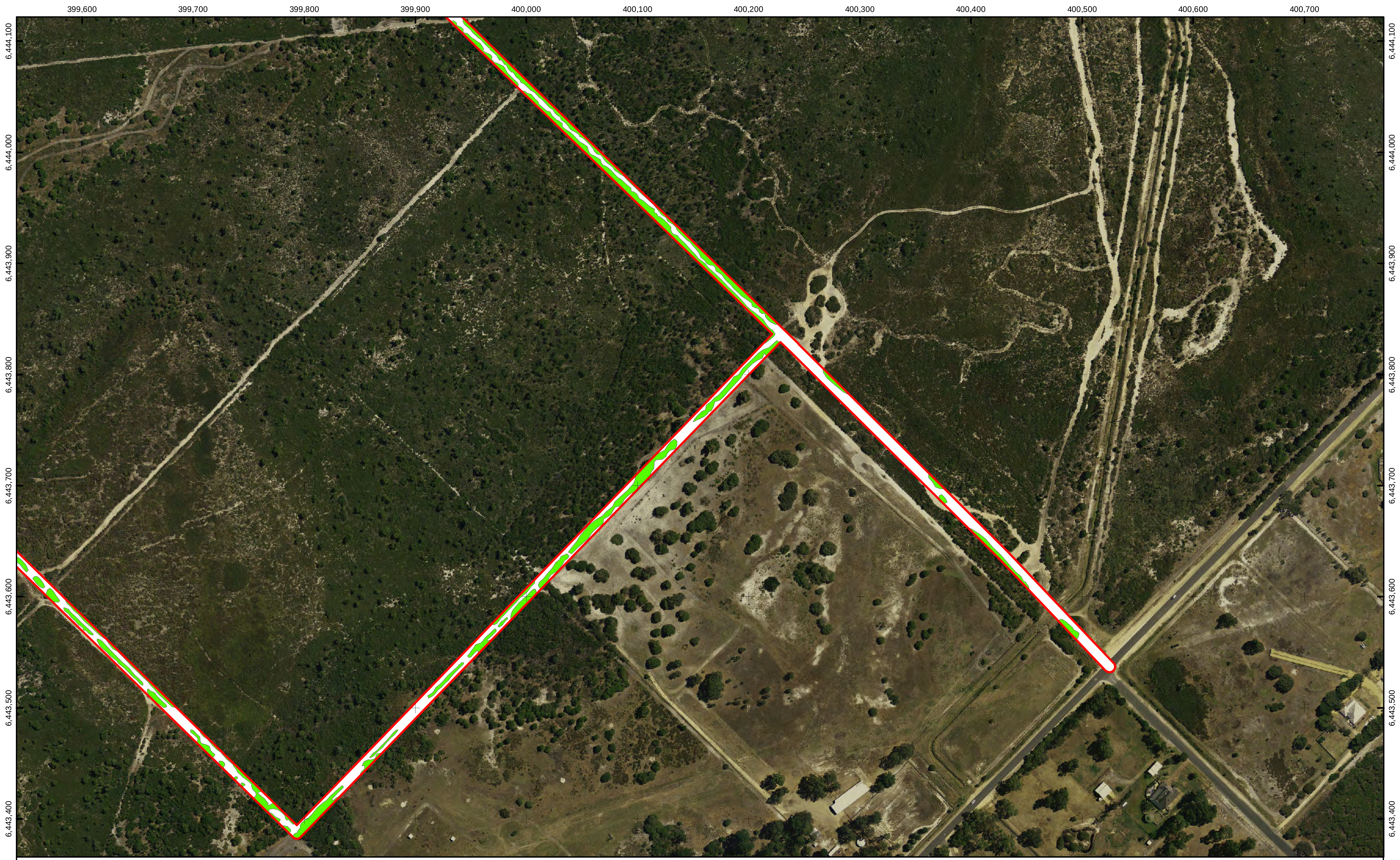
Melaleuca Shrubland

Cleared

Fauna Habitat Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **12b**



env
Australia

CLIENT
Water Corporation

JOB NO.
J113163

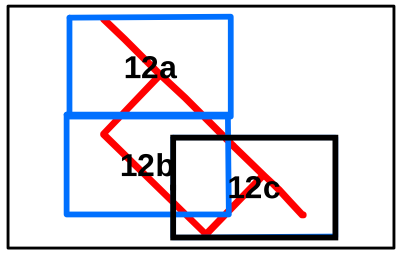
AUTHOR
R. Firth

DRAWN
M. Mikkonen

DATE
12-10-12

SCALE
1:3,000 @ A3

PROJECTION
GDA 94 MGA 50



N

0 50 100
Metres

Legend

Survey Area

Habitat

Banksia Woodland

Melaleuca Shrubland

Cleared

Fauna Habitat Map

Flora, Vegetation & Fauna Assessment
Keane Road, Forrestdale

FIGURE **12c**

APPENDIX A

DEFINITION OF DECLARED RARE / PRIORITY / THREATENED FLORA SPECIES AND SIGNIFICANT FLORA SPECIES POTENTIALLY OCCURRING IN THE STUDY AREA

APPENDIX A

DEFINITIONS OF DECLARED RARE / PRIORITY / THREATENED FLORA

A1: Categories of Declared Rare and Priority Flora

Conservation Code	Category
X	Presumed Extinct Flora (Declared Rare Flora – Extinct) "Taxa which have been adequately searched for and there is no reasonable doubt that the last individual has died, and have been gazetted as such (Schedule 2 under the *Wildlife Conservation Act 1950*)."
T	Threatened Flora (Declared Rare Flora – Extant) "Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such (Schedule 1 under the *Wildlife Conservation Act 1950*)." "Threatened Flora (Schedule 1) are further ranked by the Department according to their level of threat using IUCN Red List criteria: • CR: Critically Endangered – considered to be facing an extremely high risk of extinction in the wild; • EN: Endangered – considered to be facing a very high risk of extinction in the wild; • VU: Vulnerable – considered to be facing a high risk of extinction in the wild."
P1	Priority One: Poorly-known taxa "Taxa which are known from one or a few collections or sight records (generally less than five), all on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, Shire, Westrail and Main Roads WA road, gravel and soil reserves, and active mineral leases and under threat of habitat destruction or degradation. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes."
P2	Priority Two: Poorly-known taxa "Taxa which are known from one or a few collections or sight records, some of which are on lands not under imminent threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown Land, water reserves, etc. Taxa may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes."
P3	Priority Three: Poorly-known taxa "Taxa which are known from collections or sight records from several localities not under imminent threat, or few but widespread localities with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Taxa may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and known threatening processes exist that could affect them."

Conservation Code	Category
P4	Priority Four: Rare, Near Threatened and other taxa in need of monitoring a. Rare. "Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands." b. Near Threatened. "Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable." c. "Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy."
P5	Priority Five: Conservation Dependent taxa "Taxa that are not threatened but are subject to a specific conservation program, the cessation of which would result in the taxon becoming threatened within five years."

Source: Department of Environment and Conservation (2012). *Western Australian Flora Conservation Codes*. Department of Environment and Conservation, Perth, Western Australia. Online: http://florabase.calm.wa.gov.au.

A2: Categories of Threatened Flora Species

Category Code	Category
Ex	Extinct Taxa which at a particular time if, at the time, there is no reasonable doubt that the last member of the species has died.
ExW	Extinct in the Wild Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	Critically Endangered Taxa which at a particular time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	Endangered Taxa which is not critically endangered and it is facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
V	Vulnerable Taxa which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	Conservation Dependent Taxa which at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

Source: *Environment Protection and Biodiversity Conservation Act* 1999

APPENDIX B
DEFINITIONS OF CONSERVATION CODES FOR FAUNA OF CONSERVATION SIGNIFICANCE

APPENDIX B

DEFINITIONS OF CONSERVATION CODES FOR FAUNA OF CONSERVATION SIGNIFICANCE

B1: *Environment Protection and Biodiversity Conservation Act 1999* (*Cth*): Threatened Species and Threatened Ecological Communities Codes

The *EPBC Act* prescribes seven matters of national environmental significance:-

- World Heritage properties;
- National Heritage places;
- Wetlands of international importance;
- Threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas; and
- Nuclear actions (including uranium mining).

Species in the categories ExW, CE, E, V and M (see below), and Threatened Ecological Communities in the CE and E categories are protected as matters of national environmental significance under the *EPBC Act*.

Category	Code	Category
Extinct	Ex	Taxa for which there is no reasonable doubt that the last member of the species has died.
Extinct in the Wild	ExW	Taxa known to survive only in cultivation, in captivity or as a naturalised population well outside its past range; or not recorded in its known and/or expected habitat at appropriate seasons anywhere in its past range despite exhaustive surveys over a timeframe appropriate to its life cycle and form.
Critically Endangered	CE	Taxa facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered	E	Taxa not critically endangered and facing a very high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Vulnerable	V	Taxa not critically endangered or endangered and facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	CD	Taxa which are the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within five years.

Category	Code	Category
Migratory	Mi	Taxa that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations, that are included in an international agreement approved by the Minister for the Environment, Heritage and the Arts and that have been placed on the national List of Migratory Species under the provisions of the EPBC Act. At present there are four such agreements: • the Bonn Convention • the China-Australia Migratory Bird Agreement (CAMBA) • the Japan-Australia Migratory Bird Agreement (JAMBA) • the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
Marine	Ma	Taxa protected in a Commonwealth Marine Protected Area by virtue of section 248 of the *EPBC Act*. These taxa include certain seals, crocodiles, turtles and birds, as well as various marine fish. Commonwealth marine areas are matters of national environmental significance under the *EPBC Act*. An action will require approval if the: • action is taken in a Commonwealth marine area and the action has, will have, or is likely to have a significant impact on the environment, or • action is taken outside a Commonwealth marine area and the action has, will have, or is likely to have a significant impact on the environment in a Commonwealth marine area[1] The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory waters. The Commonwealth marine area stretches from 3 to 200 nautical miles (approximately 5-370 km) from the coast. Marine protected areas are marine areas which are recognised to have high conservation value.

B2: Western Australian Threatened Fauna Categories

Wildlife Conservation Act 1950 (WA)

Category	Code	Description
Schedule 1	S1	Rare or likely to become extinct.
Schedule 2	S2	Presumed extinct.
Schedule 3	S3	Birds subject to an agreement between the governments of Australia and Japan, the People's Republic of China & the Republic of Korea relating to the protection of migratory birds and birds in danger of extinction.
Schedule 4	S4	Other specially protected fauna.

B3: Department of Environment and Conservation Fauna Priority Codes

Category	Code	Description
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring: not currently threatened or in need of special protection, but could become so. Usually represented on conservation lands.
Priority 5	P5	Taxa in need of monitoring: not considered threatened, but the subject of a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

B4: IUCN Redlist Conservation Fauna Codes

Category	Code	Description
Extinct	EX	Taxa for which there is no reasonable doubt that the last individual has died.
Extinct in the Wild	EW	Taxa which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range and it has not been recorded in known or expected habitat despite exhaustive survey over a time frame appropriate to its life cycle and form.
Critically Endangered	CR	Taxa facing an extremely high risk of extinction in the wild.
Endangered	EN	Taxa facing a very high risk of extinction in the wild.
Vulnerable	VU	Taxa facing high risk of extinction in the wild
Near Threatened	NT	Taxa which has been evaluated but does not qualify for CR, EN, or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	LC	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	DD	Taxa for which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.

APPENDIX C
DEFINITION OF THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

APPENDIX C

DEFINITIONS OF THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

C1: Definitions of Threatened Ecological Communities

Presumed Totally Destroyed (PD)

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B);

A) Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats or

B) All occurrences recorded within the last 50 years have since been destroyed.

Critically Endangered (CR)

An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii)

- i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years)
- ii) modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

- i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years)
- ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes
- iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years)

Endangered (EN)

An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and either or both of the following apply (i or ii)

i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years)
ii) modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years)
ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes
iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).

Vulnerable (VU)

An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated.
B) The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

Source: Department of Environment and Conservation (2010). *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*. Department of Environment and Conservation, Perth, Western Australia. Online: www.naturebase.net/

C2: Definitions of Priority Ecological Communities

Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community Lists under Priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological Communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly known ecological communities Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly known ecological communities. Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation.

Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities. Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Source: Department of Environment and Conservation (2010). *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*. Department of Environment and Conservation, Perth, Western Australia. Online: www.naturebase.net/

APPENDIX D
ENVIRONMENTAL WEEDS AND DECLARED PLANT CATEGORIES

APPENDIX D

ENVIRONMENTAL WEEDS AND DECLARED PLANT CATEGORIES

D1: Criteria used for Ranking Environmental Weeds

The Environmental Weed Strategy for Western Australia (CALM 1999) contains criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity. These criteria are as follows:

- Invasiveness – ability to invade bushland in good to excellent condition or ability to invade waterways. (Score as yes or no).
- Distribution – wide current or potential distribution including consideration of known history of wide spread distribution elsewhere in the world. (Score as yes or no).
- Environmental Impacts – ability to change the structure, composition and function of ecosystems. In particular an ability to form a monoculture in a vegetation community. (Score as yes or no).

The rating of each weed is determined by the following scoring system:

- High - a weed species would have to score yes for all three criteria. Rating a weed species as high would indicate prioritising this weed for control and/or research i.e. prioritising funding to it.
- Moderate -a weed species would have to score yes for two of the above criteria. Rating a weed species as moderate would indicate that control or research effort should be directed to it if funds are available, however it should be monitored (possibly a reasonably high level of monitoring).
- Mild – a weed species scoring one of the criteria. A mild rating would indicate monitoring of the weed and control where appropriate.
- Low – a weed species would score none of the criteria. A low ranking would mean that this species would require a low level of monitoring.

Source: Department of Conservation and Land Management (1999). *Environmental Weed Strategy for Western Australia*. Department of Conservation and Land Management, Perth, Western Australia.

D2: Standard Meanings of Declared Plant Categories

P1

Prohibits movement.

The movement of plants or their seeds is prohibited within the State.

This prohibits the movement of contaminated machinery and produce including livestock and fodder.

P2

Aim is to eradicate infestation.

Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.

P3

Aims to control infestation by reducing area and/or density of infestation.

The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.

Treat to destroy and prevent seed set all plants:

* Within 50m inside of the boundaries of the infestation;
* within 50m of roads and high water mark on waterways;
* within 50m of sheds, stock yards and houses.

Treatment must be done prior to seed set each year.

Properties with less than 20ha of infestation must treat the entire infestation.

Additional areas may be ordered to be treated.

P4

Aims to prevent infestation spreading beyond existing boundaries of infestation

The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.

Treat to destroy and prevent seed set all plants:

* within 50m inside of the boundaries of the infested property for one-leaf and 20m for two-leaf;
* within 50m of roads and high water mark on waterways;
* within 50m of sheds, stock yards and houses.

Treatment must be done prior to seed set each year. Properties with less than 20ha of infestation must treat the entire infestation.

Additional areas may be ordered to be treated.

Special considerations.

In the case of P4 infestations where they continue across property boundaries there is no requirement to treat the relevant part of the property boundaries as long as the boundaries of the infestation as a whole are treated. There must be agreement between neighbours in relation to the treatment of these areas.

P5

Aims to control infestations on public lands.

Source: Department of Agriculture and Food (2008). *List of Declared Plants*. Department of Agriculture and Food, Western Australia. Online: http://www.agric.wa.gov.au/.

APPENDIX E
BUSH FOREVER VEGETATION CONDITION SCALE

APPENDIX E

BUSH FOREVER VEGETATION CONDITION SCALE

Condition Scale Code	Condition Scale
P	Pristine (1) Pristine or nearly so, no obvious signs of disturbance
E	Excellent (2) Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
VG	Very Good (3) Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
G	Good (4) Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D	Degraded (5) Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD	Completely Degraded (6) The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Bush Forever Vegetation Condition Scale as developed by Keighery (1994) and summarized in Bush Forever (Government of Western Australia (2000b)

APPENDIX F
FAUNA SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

APPENDIX F

F1: AMPHIBIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

AMPHIBIANS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
ANURA									
Hylidae									
Litoria moorei	Motorbike Frog				x				
Litoria adelaidensis	Slender Tree Frog				x				
Limnodynastidae									
Heleioporus barycragus	Hooting Frog				x				
Heleioporus eyrei	Moaning Frog				x				
Heleioporus psammophilus	Sand Frog				x				
Limnodynastes dorsalis	Western Banjo Frog				x				
Neobatrachus pelobatoides	Humming Frog				x				
Myobatrachidae									
Crinia pseudinsignifera	Bleating Froglet				x				
Crinia glauerti	Clicking Frog				x				
Crinia insignifera	Squelching Froglet				x				
Geocrinia leai	Ticking Frog				x				
Myobatrachus gouldii	Turtle Frog				x				

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX F

F2: REPTILIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

REPTILES		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
SQUAMATA									
Diplodactylidae									
Crenadactylus ocellatus subsp. *ocellatus*	Clawless Gecko				x				
Diplodactylus granariensis	Western Stone Gecko				x				
Diplodactylus polyophthalmus	Speckled Stone Gecko				x				
Diplodactylus pulcher					x				
Nephurus milli	Barking Gecko				x				
Strophurus spinigerus	Soft Spiny-tailed Gecko				x				
Gekkonidae									
Christinus marmoratus	Marbled Gecko				x				
Gehyra variegata	Variegated Tree Dtella				x				
Pygopodidae	Legless Lizards								
Aprasia pulchella	Granite Worm-lizard				x				
Aprasia repens	Sand-plain Worm-lizard				x				
Delma fraseri					x				
Delma grayii					x				
Lialis burtonis	Burton's Legless Lizard				x				
Pletholax gracilis	Keeled Legless Lizard				x				
Pygopus lepidopodus	Common Scaly-foot				x				
Scincidae	Skinks								
Actitis hypoleucos	Western Three-lined Skink				x				
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink				x				
Cryptoblepharus plagiocephalus					x				
Ctenotus australis					x				
Ctenotus delli	Darling Range Heath Ctenotus			P4	x		x		
Ctenotus fallens					x				
Ctenotus gemmula	Jewelled South-west Ctenotus			P3	x				
Ctenotus impar	South-western Odd-stripped Ctenotus				x				
Ctenotus labillardieri					x				
Egernia kingii	King's Skink				x				
Egernia napoleonis					x				
Hemiergis initialis					x				
Hemiergis quadrilineata					x				
Lerista christinae					x				

REPTILES		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Lerista distinguenda					x				
Lerista elegans					x				
Lerista lineata	Perth Slider			P3	x		x		
Lerista lineopunctulata					x				
Lerista praepedita					x				
Menetia greyii	Common Dwarf Skink				x				
Morethia lineoocellata					x				
Morethia obscura					x				
Tiliqua occipitalis	Western Bluetongue				x				
Tiliqua rugosa subsp. *rugosa*	Bobtail				x				
Agamidae	Dragons								
Ctenophorus adelaidensis	Southern Heath Dragon				x				
Ctenophorus ornatus	Ornate Crevice Dragon				x				
Pogona minor	Bearded Dragon				x				
Varanidae	Goannas								
Varanus gouldii	Sand Monitor				x				
Varanus rosenbergi	Heath Monitor				x				
Varanus tristis	Racehorse Monitor				x				
Typhlopidae	Blind Snakes								
Ramphotyphlops australis	Southern Blind Snake				x				
Ramphotyphlops pinguis	Fat Blind Snake				x				
Ramphotyphlops waitii					x				
Boidae	Pythons								
Antaresia stimsoni	Stimpsons Python				x				
Morelia spilota subsp. *imbricata*	Carpet Python			P4	x		x		
Elapidae	Elapids								
Acanthophis antarcticus	Southern Death Adder			P3	x		x		
Brachyurophis semifasciata	Southern Shovel-nosed Snake				x				
Demansia psammophis	Yellow-faced Whipsnake				x				
Echiopsis curta	Bardick				x				
Elapognathus coronatus	western Crowned Snake				x				
Neelaps bimaculatus	Black-naped Snake				x				
Neelaps calontos	Black-striped Snake			P3	x		x		
Notechis scutatus	Tiger Snake				x				
Parasuta gouldii	Gould's Hooded Snake				x				
Parasuta nigriceps	Mitchell's Short-tailed Snake				x				
Pseudonaja affinis	Dugite				x				x
Pseudonaja modesta	Ringed Brown Snake				x				
Simoselaps bertholdi	Jan's Banded Snake				x				

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX F

F3: AVIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
CASUARIIFORMES									
Dromaiidae	Emu								
Dromaius novaehollandiae	Emu				x	x			
GALLIFORMES									
Megapodiidae	Megapodes								
Leipoa ocellata	Malleefowl	VU	S1		x		x	x	
Phasianidae	Pheasants, Fowl & Allies								
Coturnix pectoralis	Stubble Quail				x	x			
Coturnix ypsilophora	Brown Quail				x	x			
ANSERIFORMES									
Anatidae	Ducks, Geese & Swans								
Anas castanea	Chestnut Teal				x	x			
Anas gracilis	Grey Teal				x	x			
Anas platyrhynchos	Northern Mallard				x	x			
Anas rhynchotis	Australasian Shoveler				x	x			
Anas superciliosa	Pacific Black Duck				x	x			x
Aythya australis	Hardhead				x	x			
Biziura lobata	Musk Duck				x	x			
Chenonetta jubata	Maned Duck				x	x			
Cygnus atratus	Black Swan				x	x			
Malacorhynchus membranaceus	Pink-eared Duck				x	x			
Oxyura australis	Blue-billed Duck				x	x			
Stictonetta naevosa	Freckled Duck				x	x			
Tadorna tadornoides	Australian Shelduck				x	x			
PODICIPEDIFORMES									
Podicipedidae	Grebes								
Podiceps cristatus	Great Crested Grebe				x	x			
Poliocephalus poliocephalus	Hoary-headed Grebe				x	x			
Tachybaptus novaehollandiae	Australasian Grebe				x	x			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
ACCIPITRIFORMES									
Accipitridae	Kites, Hawks & Eagles								
Accipiter cirrocephalus	Collared Sparrowhawk				x	x			
Accipiter fasciatus	Brown Goshawk				x	x			
Aquila audax	Wedge-tailed Eagle				x	x			
Circus approximans	Swamp Harrier				x	x			
Circus assimilis	Spotted Harrier				x	x			
Elanoides axillaris	Black-shouldered Kite				x	x			x
Haliastur sphenurus	Whistling Kite				x	x			x
Hieraaetus morphnoides	Little Eagle				x	x			
Lophoictinia isura	Square-tailed Kite				x	x			
Milvus migrans	Black Kite				x				
FALCONIFORMES									
Falconidae	Caracaras, Falcons								
Falco berigora	Brown Falcon				x	x			
Falco cenchroides	Nankeen Kestrel				x	x			x
Falco longipennis	Australian Hobby				x	x			
Falco peregrinus	Peregrine Falcon		S4		x	x	x		
OTIDIFORMES									
Otididae	Bustards								
Ardeotis australis	Australian Bustard			P4	x		x		
Rallidae	Rails, Crakes & Coots								
Fulica atra	Eurasian Coot				x	x			
Gallinula tenebrosa	Dusky Moorhen				x				
Gallirallus philippensis	Buff-banded Rail				x	x			
Porphyrio porphyrio	Purple Swamphen				x	x			
Porzana fluminea	Australian Crake				x	x			
Porzana pusilla	Baillon's Crake				x	x			
Porzana tabuensis	Spotless Crake				x	x			
Tribonyx ventralis	Black-tailed Native-hen				x	x			
CHARADRIIFORMES									
Turnicidae	Buttonquail								
Turnix varius	Painted Buttonquail				x	x			
Turnix velox	Little Buttonquail				x				
Burhinidae	Stone-curlews								
Burhinus grallarius	Bush Stone-curlew			P4	x	x	x		
COLUMBIFORMES									
Columbidae	Pigeons, Doves								
Columba livia	Rock Dove				x	x			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Ocyphaps lophotes	Crested Pigeon				x	x			x
Phaps chalcoptera	Common Bronzewing				x	x			x
Phaps elegans	Brush Bronzewing				x	x			
Spilopelia senegalensis	Laughing Dove				x	x			x
Streptopelia chinensis	Spotted Dove				x	x			
PSITTACIFORMES									
Cacatuidae	Cockatoos								
Cacatua galerita	Sulphur-crested Cockatoo				x	x			
Cacatua pastinator	Western Corella				x	x			
Cacatua sanguinea	Little Corella				x	x			
Cacatua tenuirostris	Long-billed Corella					x			
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	VU	S1		x	x	x	x	
Calyptorhynchus baudinii	Baudin's Black Cockatoo	VU	S1		x	x	x	x	
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	EN	S1		x	x	x	x	
Eolophus roseicapilla	Galah				x	x			x
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4		x		x		
Nymphicus hollandicus	Cockatiel				x	x			
Psittacidae	Parrots								
Barnardius zonarius	Australian Ringneck				x	x			
Glossopsitta porphyrocephala	Purple-crowned Lorikeet				x	x			
Melopsittacus undulatus	Budgerigar				x				
Neophema elegans	Elegant Parrot				x	x			
Neophema petrophila	Rock Parrot					x			
Platycercus icterotis	Western Rosella				x	x			
Polytelis anthopeplus	Regent Parrot				x	x			
Purpureicephalus spurius	Red-capped Parrot				x	x			
Trichoglossus moluccanus	Rainbow Lorikeet				x	x			x
CUCULIFORMES									
Cuculidae	Cuckoos								
Cacomantis flabelliformis	Fan-tailed Cuckoo				x	x			
Cacomantis pallidus	Pallid Cuckoo				x	x			
Chrysococcyx basalis	Horsfield's Bronze Cuckoo				x	x			
Chrysococcyx lucidus	Shining Bronze Cuckoo				x	x			
STRIGIFORMES									
Tytonidae	Barn Owls								
Tyto delicatula	Eastern Barn Owl				x	x			
Tyto novaehollandiae	Australian Masked Owl			P3	x	x	x		
Strigidae	Owls								
Ninox boobook	Southern Boobook				x	x			
Ninox connivens	Barking Owl			P2	x	x			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
CAPRIMULGIFORMES									
Podargidae	Frogmouths								
Podargus strigoides	Tawny Frogmouth				x	x			x
Caprimulgidae	Nightjars								
Eurostopodus argus	Spotted Nightjar				x	x			
APODIFORMES									
Aegothelidae	Owlet-nightjars								
Aegotheles cristatus	Australian Owlet-nightjar				x	x			
Apodidae	Swifts								
Apus pacificus	Pacific Swift	Mi	S3		x	x	x	x	
CORACIIFORMES									
Alcedinidae	Kingfishers								
Dacelo novaeguineae	Laughing Kookaburra				x	x			
Todiramphus sanctus	Sacred Kingfisher				x	x			
Meropidae	Bee-eaters								
Merops ornatus	Rainbow Bee-eater	Mi	S3		x	x	x	x	
PASSERIFORMES									
Climacteridae	Australasian Treecreepers								
Climacteris rufus	Rufous Treecreeper				x	x			
Maluridae	Australasian Wrens								
Malurus elegans	Red-winged Fairywren				x	x			
Malurus lamberti	Variegated Fairywren				x	x			
Malurus leucopterus	White-winged Fairywren				x				
Malurus splendens	Splendid Fairywren				x	x			x
Stipiturus malachurus	Southern Emu-wren				x	x			
Meliphagidae	Honeyeaters								
Acanthorhynchus superciliosus	Western Spinebill				x	x			
Anthochaera carunculata	Red Wattlebird				x	x			
Anthochaera lunulata	Western Wattlebird				x	x			
Epthianura albifrons	White-fronted Chat				x	x			
Gliciphila melanops	Tawny-crowned Honeyeater				x	x			
Lichenostomus ornatus	Yellow-plumed Honeyeater				x	x			
Lichenostomus virescens	Singing Honeyeater				x	x			
Lichmera indistincta	Brown Honeyeater				x	x			x
Manorina flavigula	Yellow-throated Miner				x	x			
Melithreptus brevirostris	Brown-headed Honeyeater				x	x			
Melithreptus lunatus	White-naped Honeyeater				x				
Phylidonyris niger	White-cheeked Honeyeater				x	x			x
Phylidonyris novaehollandiae	New Holland Honeyeater				x	x			x
Purnella albifrons	White-fronted Honeyeater					x			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Sugomel nigrum	Black Honeyeater					X			
Pardalotidae	Pardalotes								
Pardalotus punctatus	Spotted Pardalote				X	X			
Pardalotus striatus	Striated Pardalote				X	X			
Acanthizidae	Australasian Warblers								
Acanthiza apicalis	Inland Thornbill				X	X			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				X	X			
Acanthiza inornata	Western Thornbill				X	X			
Gerygone fusca	Western Gerygone				X	X			X
Sericornis frontalis	White-browed Scrubwren				X	X			
Smicrornis brevirostris	Weebill				X	X			
Pomatostomidae	Australasian Babblers								
Pomatostomus superciliosus	White-browed Babbler				X				
Cracticidae	Butcherbirds and Allies								
Cracticus nigrogularis	Pied Butcherbird				X	X			
Cracticus torquatus	Grey Butcherbird				X	X			
Gymnorhina tibicen	Australian Magpie				X	X			
Strepera versicolor	Grey Currawong				X	X			
Artamidae	Woodswallows								
Artamus cinereus	Black-faced Woodswallow				X	X			
Artamus cyanopterus	Dusky Woodswallow				X	X			
Campephagidae	Cuckooshrikes								
Coracina novaehollandiae	Black-faced Cuckooshrike				X	X			
Lalage tricolor	White-winged Triller				X	X			X
Neosittidae	Sittellas								
Daphoenositta chrysoptera	Varied Sittella				X	X			
Pachycephalidae	Whistlers and Allies								
Colluricincla harmonica	Grey Shrikethrush				X	X			X
Pachycephala pectoralis	Australian Golden Whistler				X	X			
Pachycephala rufiventris	Rufous Whistler				X	X			X
Rhipiduridae	Fantails								
Rhipidura albiscapa	Grey Fantail				X	X			X
Rhipidura leucophrys	Willie Wagtail				X	X			X
Monarchidae	Monarchs								
Grallina cyanoleuca	Magpie-lark				X	X			X
Myiagra inquieta	Restless Flycatcher				X				
Corvidae	Crows, Jays								
Corvus bennetti	Little Crow				X	X			
Corvus coronoides	Australian Raven				X	X			X
Petroicidae	Australasian Robins								

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Eopsaltria georgiana	White-breasted Robin				x	x			x
Eopsaltria griseogularis	Western Yellow Robin				x	x			
Melanodryas cucullata	Hooded Robin				x	x			
Microeca fascinans	Jacky Winter				x	x			
Petroica boodang	Scarlet Robin					x			
Petroica goodenovii	Red-capped Robin				x	x			
Hirundinidae	Swallows, Martins								
Cheramoeca leucosterna	White-backed Swallow				x	x			
Hirundo neoxena	Welcome Swallow				x	x			
Petrochelidon ariel	Fairy Martin				x	x			
Petrochelidon nigricans	Tree Martin				x	x			
Acrocephalidae	Reed Warblers and Allies								
Acrocephalus australis	Australian Reed Warbler				x	x			
Locustellidae	Grassbirds and allies								
Cincloramphus cruralis	Brown Songlark				x	x			
Cincloramphus mathewsi	Rufous Songlark				x	x			
Megalurus gramineus	Little Grassbird				x	x			
Zosteropidae	White-eyes								
Zosterops lateralis	Silvereye				x	x			
Dicaeidae	Flowerpeckers								
Dicaeum hirundinaceum	Mistletoebird				x	x			
Estrildidae	Waxbills, Munias & Allies								
Lonchura castaneothorax	Chestnut-breasted Mannikin				x	x			
Stagonopleura oculata	Red-eared Firetail				x	x			
Motacillidae	Wagtails, Pipits								
Anthus australis	Australian Pipit				x	x			

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX F

F4: MAMMALIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

MAMMALS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
MONOTREMATA									
Tachyglossidae									
Tachyglossus aculeatus	Echidna				x				
DASYUROMORPHIA									
Dasyuridae									
Antechinus flavipes	Mardo				x				
Dasyurus geoffroii	Chuditch, Western Quoll	VU	S1		x		x	x	
Phascogale tapoatafa	Wambenger, Southern Brush-tailed Phascolgale		S1		x		x		
Sminthopsis gilberti	Gilbert's Dunnart				x				
Myrmecobiidae									
Myrmecobius fasciatus	Walpurti, Numbat	VU	S1		x		x		
PERAMELEMORPHIA									
Peramelidae									
Isoodon obesulus	Quenda, Southern Brown Bandicoot			P5	x		x		x
DIPROTODONTIA									
Potoroidae									
Bettongia penicillata	Woylie, Brush-tailed Bettong	EN	S1		x			x	
Macropodidae									
Macropus eugenii	Tammar Wallaby			P5	x		x		
Macropus fuliginosus	Western Grey Kangaroo				x				
Macropus irma	Western Brush Wallaby			P4	x		x		
Setonix brachyurus	Quokka	VU	S1		x		x	x	
Phalangeridae									
Trichosurus vulpecula	Common Brushtail Possum				x				
Tarsipedidae									
Tarsipes rostratus	Honey Possum				x				
Burramyidae									
Cercartetus concinnus	Western Pygmy-possum				x				

MAMMALS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
CHIROPTERA									
Vespertilionidae									
Chalinolobus gouldii	Gould's Wattled Bat				x				
Chalinolobus morio	Chocolate Wattled Bat				x				
Falsistrellus mackenziei	Western False Pipistrelle			P4	x		x		
Nyctophilus geoffroyi	Lesser Long-eared Bat				x				
Nyctophilus gouldi	Gould's Long-eared Bat				x				
Vespadelus regulus	Southern Forest Bat				x				
Molossidae									
Mormopterus planiceps	Southern Freetai-bat				x				
Tadarida australis	White-striped Freetail-bat				x				
RODENTIA									
Muridae									
Hydromys chrysogaster	Water-rat			P4	x		x		
**Mus musculus*	House Mouse				x				
Rattus fuscipes	Western Bush Rat				x				
**Rattus norvegicus*	Brown Rat				x				
**Rattus rattus*	Black Rat				x				
LAGOMORPHA									
Leporidae									
**Oryctolagus cuniculus*	Rabbit				x			x	x
CARNIVORA									
Canidae									
**Vulpes vulpes*	Red Fox				x			x	
Felidae									
**Felis catus*	Cat				x			x	
ARTIODACTYLA									
Suidae									
**Sus scrofa*	Pig				x			x	
Bovidae									
**Capra hircus*	Goat							x	

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX G
FAUNA HABITAT ASSESSMENT DATA SHEETS

APPENDIX G
FAUNA HABITAT ASSESSMENT DATA SHEETS

Habitat Assessment – HA1

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	400402 E	Proportion of Project Area:	30.07%
	6443658 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	Limestone
Aspect:	N/A	Landform:	Inland Dune

Condition Scale:	1 (degraded)	Last Fire:	2 (4-5 year)	Disturbance (other):	0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	2.5	2 (20-60%)
Midstorey:	-		0 (<5% cover)
Ground Cover:	Sedges (mixed), Grasses (mixed)	1	2 (20-60%)

Groundcover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Pebbles/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	1 (<20% cover)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	2 (20-60%)	Rock Crevices	0 (none)	Water Presence	1 (rare)
Grasses	0 (none)	No. of Caves	0	Distance to Water	2 (0.5-2 km)
Woody debris	2 (moderate)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 20/70

Habitat Assessment – HA2

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	400145 E	Proportion of Project Area:	30.07%
	6443751 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	Limestone
Aspect:	N/A	Landform:	Inland Dune

Condition Scale: 0 (completely degraded) | Last Fire: 2 (4-5 year) | Disturbance (other): 0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	5	2 (20-60%)
Midstorey:	-		1 (<20% cover)
Ground Cover:	Pig Face and other herbs		2 (20-60%)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	1 (0-30%)	No. of Caves	0	Distance to Water	2 (0.5-2 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 18/70

Habitat Assessment – HA3

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	399754 E	Proportion of Project Area:	30.07%
	6443427 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	Limestone
Aspect:	N/A	Landform:	Inland Dune

Condition Scale:	1 (degraded)	Last Fire:	2 (4-5 year)	Disturbance (other):	0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	5	2 (20-60%)
Midstorey:	-		0 (<5% cover)
Ground Cover:	Pig Face, mixed herbs, grasses, sedges	0.3	1 (<20% cover)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	1 (0-30%)	No. of Caves	0	Distance to Water	3 (<0.5 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 18/70

Habitat Assessment – HA4

Fauna Habitat:	Banksia Woodland	Total Area of Habitat:	0.16 ha
UTM Co-ordinates:	399511 E 6444544 N	Proportion of Project Area:	3.56%
		Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	N/A
Aspect:	N/A	Landform:	Inland Dune

Condition Scale: 3 (very good) Last Fire: 1 (1-3 year) Disturbance (other): 0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Banksia attenuate, Banksia ilicifolila*	8	2 (20-60%)
Midstorey:			2 (20-60%)
Ground Cover:			2 (20-60%)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	2 (<20% cover)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	0 (none)	No. of Caves	0	Distance to Water	3 (<0.5 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	1 (open)

Total = 23/70

Habitat Assessment – HA5

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	399926 E 6444134 N	Proportion of Project Area:	30.07%
		Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	N/A
Aspect:	N/A	Landform:	Inland Dune

Condition Scale:	1 (degraded)	Last Fire:	1 (1-3 year)	Disturbance (other):	0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	3	1 (<20% cover)
Midstorey:	*Acacia pulcher*	1.5	2 (20-60%)
Ground Cover:	Mixed herbs/grasses/pig face	0.3	2 (20-60%)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	1 (0-30%)	No. of Caves	0	Distance to Water	3 (<0.5 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 19/70

APPENDIX H
FLORA QUADRAT AND RELEVÉ DATA SHEETS

APPENDIX H

FLORA QUADRAT AND RELEVÉ DATA SHEETS

Keane Road Pipeline Survey Site KRZ01

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Rd

MGA Zone 50 400379 mE 6443702 mN

Habitat Lower slope

Soil White/grey sand

Rock Type N/A

Vegetation Shrubland of *Melaleuca rhaphiophylla* and *Melaleuca viminea* over *Regelia ciliata* and sedges

Veg Condition Very good

Fire Age Old

Notes Adjacent to track
Bare ground: 10%

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	15	1.1 m	NC	
Astartea affinis	2	1.2 m	KRZ16	
Briza maxima	+	0.05 m	NC	
Caladenia flava			OPP	
Callitris pyramidalis			KRZ17	
Cassytha racemosa	2	cr	KRZ15	
Caustis dioica	15	0.5 m	KRZ05	
Crassula colorata var. *acuminata*	+	3 m	KRZ08	
Cytogonidium leptocarpoides	3	0.25 m	KRZ13	
Dampiera trigona	+	0.2 m	KRZ07	
Desmocladus fasciculatus	4	0.15 m	NC	
Drosera erythrorhiza			OPP	
Drosera nitidula	+	1 m	KRZ14	
Eutaxia virgata	2	0.7 m	KRZ04	
Hakea sulcata	2	1.2 m	KRZ11	
Hypochaeris glabra	2	1 m	NC	
Hypolaena exsulca	15	0.4 m	NC	
Lepidosperma longitudinale	30	0.45 m	NC	
Melaleuca rhaphiophylla	10	2.3 m	NC	
Melaleuca viminea	15	1.4 m	KRZ01	
Moraea flaccida	4	0.3 m	NC	
Pericalymma ellipticum			KRZ18	
Poa annua	3	0.15 m	NC	
Pyrorchis nigricans			KRZ19	
Regelia ciliata	35	1 m	KRZ03	
Stirlingia latifolia			OPP	
Thysanotus sparteus	+	0.5 m	KRZ09	
Tribonanthes brachypetala	1	0.3 m	KRZ06	
Ursinia anthemoides			OPP	
Verticordia densiflora	4	0.35 m	KRZ10	

Keane Road Pipeline Survey   Site KRZ02

Described by N. WHITTINGTON AND D. BULLER   Date 18/09/2012   Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 400183 mE 6443880 mN

Habitat Dampland

Soil Grey sand

Rock Type N/A

Vegetation Closed shrubland of *Kunzea glabrescens* over *Regelia ciliata* and sedges

Veg Condition Excellent

Fire Age Old

Notes Adjacent to track
Bare ground: 15%
Litter cover: -% logs, 10% twigs, 5% leaves
Gradient unsuitable for rainfall to run-off

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella			OPP	
Bossiaea eriocarpa			OPP	
Caladenia flava	+	0.1 m	NC	
Conostylis juncea			OPP	
Crassula colorata var. *acuminata*	+	0.03 m	KRZ08	
Cytogonidium leptocarpoides	3	0.25 m	KRZ29	
Dasypogon bromeliifolius	+	0.45 m	NC	
Desmocladus fasciculatus			OPP	
Drosera erythrorhiza	3	1 m	NC	
Gompholobium tomentosum	+	0.4 m	NC	
Hibbertia subvaginata			OPP	
Hypochaeris glabra	+	1 m	NC	
Hypolaena exsulca	6	0.3 m	NC	
Jacksonia gracillima	+	0.4 m	KRZ34	
Jacksonia sternbergiana			OPP	
Kennedia prostrata			OPP	
Kunzea glabrescens	85	4 m	KRZ27	
Lomandra sericea	+	0.4 m	KRZ31	
Neurachne alopecuroidea			OPP	
Philotheca spicata			OPP	
Phlebocarya ciliata			OPP	
Pterostylis vittata	+	0.01 m	KRZ32	
Regelia ciliata	50	1 m	KRZ03	
Sowerbaea laxiflora			OPP	
Thysanotus manglesianus	+	cr	KRZ28	
Trachymene pilosa	+	0.02 m	NC	
Xanthorrhoea preissii	1.5	1.1 m	NC	

Keane Road Pipeline Survey   Site KRZ03

Described by N. WHITTINGTON AND D. BULLER   Date 18/09/2012   Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 399833 mE 6444227mN

Habitat Dampland

Soil Grey sand

Rock Type N/A

Vegetation Open woodland of *Melaleuca preissiana* over *Regelia ciliata*

Veg Condition Excellent

Fire Age Old

Notes Bare ground: 10%
Litter cover: -% logs, 3% twigs, 2% leaves

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	6	1.3 m	NC	
Banksia attenuata			OPP	
Caladenia flava			OPP	
Dampiera alata			OPP	
Dasypogon bromeliifolius	3	0.4 m	NC	
Euchilopsis linearis	3	0.3 m	KRZ37	
Hypocalymma angustifolium	7	0.55 m	NC	
Hypochaeris glabra	4	0.01 m	NC	
Hypolaena exsulca	5	0.35 m	NC	
Jacksonia gracillima	+	0.35 m	KRZ34	
Kunzea glabrescens	4	2 m	KRZ27	
Lepidosperma longitudinale	+	0.55 m	KRZ36	
Melaleuca preissiana	10	4 m	NC	
Philotheca spicata	+	1 m	NC	
Phlebocarya ciliata			OPP	
Pimelea angustifolia	1.5	1.1 m	KRZ38	
Pterostylis vittata	+	0.15 m	KRZ30	
Regelia ciliata	80	1.5 m	KRZ03	
Ursinia anthemoides	+	0.25 m	NC	
Xanthorrhoea preissii	3	1.2 m	NC	

Keane Road Pipeline Survey   Site KRZ04

Described by N. WHITTINGTON AND D. BULLER   Date 18/09/2012   Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 399506 mE 6444542mN

Habitat Lower slope

Soil Grey sand

Rock Type N/A

Vegetation *Banksia attenuata* and *B. illicifolia* woodland over *Kunzea glabrescens* and *Dasypogon bromeliifolius*

Veg Condition Excellent

Fire Age Young

Notes Bare ground: 10%
Litter cover: 2% logs, 8% twigs, 5% leaves

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	5	1.5 m	NC	
Adenanthos cygnorum	1	1.5 m	NC	
Aotus procumbens	+	0.6 m	KRZ41	
Banksia attenuata	25	12 m	NC	
Banksia ilicifolia	5	10 m	NC	
Briza maxima			OPP	
Carpobrotus edulis			OPP	
Conostylis juncea	+	0.15 m	NC	
Dampiera alata			OPP	
Dasypogon bromeliifolius	15	0.3 m	NC	
Gompholobium tomentosum	2	0.5 m	NC	
Hemiandra pungens			OPP	
Hibbertia subvaginata	20	0.4 m	NC	
Hypochaeris glabra	+	0.4 m	NC	
Hypolaena exsulca	+	0.3 m	KRZ40	
Kunzea glabrescens	40	2.5 m	KRZ27	
Lechenaultia biloba			OPP	
Lomandra nigricans	+	0.2 m	NC	
Lyginia imberbis	3	0.3 m	NC	
Melaleuca thymoides	2	1.4 m	KRZ39	
Nuytsia floribunda			OPP	
Patersonia occidentalis	+	0.4 m	NC	
Petrophile linearis	+	0.5 m	NC	
Philotheca spicata	+	0.4 m	NC	
Phlebocarya ciliata	2	0.3 m	NC	
Pimelea angustifolia	+	0.2 m	KRZ38	
Scholtzia involucrata	1.5	0.4 m	NC	
Trachymene pilosa	+	0.1 m	NC	
Ursinia anthemoides	+	0.2 m	NC	
Xanthorrhoea preissii	1	1 m	NC	

Keane Road Pipeline Survey — Site KRZ05

Described by N. WHITTINGTON AND D. BULLER — Date 18/09/2012 — Type Quadrat 10 x 10 m

Location Keane Road

MGA Zone 50 399600 mE 6443568 mN

Habitat Dampland

Soil Dark grey surface clay with sand at depth

Rock Type N/A

Vegetation Low shrubland of *Melaleuca viminea* over herbs

Veg Condition Excellent

Fire Age

Notes Quadrat was positioned outside of survey area but the vegetation inside is still of the same community type however it is in good condition and sandwiched between two tracks

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Cassytha racemosa	6	+	KRZ15	
Centrolepis polygyna	4	0.02 m	KRZ44	
Crassula natans var. *minus*	3	0.03 m	KRZ45	
Hypochaeris glabra	+	0.01 m	NC	
Isolepis cernua var. *setiformis*	+	0.03 m	KRZ48	
Lotus subbiflorus	2	0.03 m	KRZ46	
Melaleuca viminea	30	1.2 m	KRZ43	
Moraea flaccida	+	0.4 m	NC	
Vulpia myuros	+	0.05 m	KRZ47	

Keane Road Pipeline Survey Site KRZ06

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 399820 mE 6443421mN

Habitat Dampland

Soil Dark grey sand - bleached on surface

Rock Type N/A

Vegetation *Melaleuca preissiana* over *Kunzea glabrescens* over *Regelia ciliata* and *Melaleuca viminea* over *Moraea flaccida* and *Baumea juncea*

Veg Condition Excellent

Fire Age Moderate

Notes Bare ground: 5%
Litter cover: 1% logs, 4% twigs, 1% leaves
Disturbances: weeds

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	2	0.4 m	NC	
Arctotheca calendula	+	0.1 m	NC	
Baumea juncea	6	0.6 m	KRZ49	
Briza maxima	+	0.1 m	NC	
Cassytha racemosa	3	cr	KRZ15	
Cortaderia selloana	2	1.5 m	NC	
Cynodon dactylon	15	0.1 m	NC	
Dasypogon bromeliifolius			OPP	
Ehrharta longiflora	2	1 m	NC	
Hakea varia	1	0.5 m	NC	
Hypolaena exsulca	1.5	0.5 m	NC	
Jacksonia sternbergiana	+	1.5 m	NC	
Juncus pallidus	3	1.1 m	NC	
Kennedia prostrata	+	0.1 m	NC	
Kunzea glabrescens	8	2.1 m	KRZ27	
Lepidosperma longitudinale	4	1 m	NC	
Lotus subbiflorus	3	0.05 m	KRZ46	
Melaleuca preissiana	6	7 m	NC	
Melaleuca viminea	20	1.2 m	KRZ43	
Moraea flaccida	10	0.35 m	NC	
Patersonia occidentalis	+	0.4 m	NC	
Phlebocarya ciliata			OPP	
Regelia ciliata	5	1.3 m	KRZ03	
Sowerbaea laxiflora			OPP	

Keane Road Pipeline Survey Site KRZ A

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400416 mE 6443659 mN
Soil White sand
Vegetation Melaleuca viminea over weed infested understorey

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Briza maxima	1		NC	
Drosera glanduligera	+		KRZ02	
Ehrharta longiflora	2		NC	
Eragrostis curvula	3		NC	
Hypolaena exsulca	+		NC	
Lepidosperma longitudinale	15		NC	
Melaleuca viminea	50		KRZ01	
Moraea flaccida	+		NC	
Poa annua	3		NC	

Keane Road Pipeline Survey Site KRZ B

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400374 mE 6443687 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Gahnia trifida	20		NC	
Melaleuca rhaphiophylla	60		NC	

Keane Road Pipeline Survey Site KRZ C

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399528 mE 6443643 mN
Notes Tracks are flooded. Rubbish dumped all around site.

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Arctotheca calendula	2		NC	
Cynodon dactylon	5		NC	
Lepidosperma longitudinale	30		NC	
Melaleuca viminea	40		KRZ01	
Moraea flaccida	+		NC	
Zantedeschia aethiopica	+		NC	

Keane Road Pipeline Survey — Site KRZ D

Described by N. WHITTINGTON AND D. BULLER — Date 18/09/2012 — Type Opportunistic
Location Keane Road
MGA Zone 50 399666 mE 6443507 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia saligna	5		NC	
Arctotheca calendula	2		NC	
Carpobrotus edulis	5		NC	
Hakea varia	3		NC	
Jacksonia sternbergiana	2		NC	
Kunzea glabrescens	20		NC	
Melaleuca rhaphiophylla	40		NC	
Pimelea angustifolia	+		KRZ38	
Regelia ciliata	20		KRZ03	

Keane Road Pipeline Survey — Site KRZ OPP 1

Described by N. WHITTINGTON AND D. BULLER — Date 18/09/2012 — Type Opportunistic
Location Keane Road
MGA Zone 50 400311 mE 6443748 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Banksia sphaerocarpa var. *sphaerocarpa*	3		KRZ21	PH 698
Drosera marchantii subsp. *marchantii*	+		KRZ23	
Drosera menziesii subsp. *menziesii*	+		KRZ24	
Kunzea micrantha	30		KRZ22	PH 697
Petrophile rigida	4		KRZ20	PH 696

Keane Road Pipeline Survey — Site KRZ OPP 10

Described by N. WHITTINGTON AND D. BULLER — Date 18/09/2012 — Type Opportunistic
Location Keane Road
MGA Zone 50 399477 mE 6444576 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	+		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 11

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399461 mE 6444592 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	+		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 12

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399182 mE 6443988 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Zantedeschia aethiopica	4 ind		NC	

Keane Road Pipeline Survey Site KRZ OPP 13

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399196 mE 6443975 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Moraea flaccida	+		NC	

Keane Road Pipeline Survey Site KRZ OPP 14

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399208 mE 6443962 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Zantedeschia aethiopica	4 ind		NC	

Keane Road Pipeline Survey — Site KRZ OPP 15

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399566 mE 6443609 mN
Notes Located in the middle of a flooded track

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Eleocharis acuta	15		KRZ42	Ph 729-730

Keane Road Pipeline Survey — Site KRZ OPP 16

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399700 mE 6443482 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Moraea flaccida	100+ ind		NC	
Zantedeschia aethiopica	1 ind		NC	

Keane Road Pipeline Survey — Site KRZ OPP 17

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400113 mE 6443732 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Zantedeschia aethiopica	5 ind		NC	

Keane Road Pipeline Survey — Site KRZ OPP 18

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400181 mE 6443793 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	3 ind		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 19

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400113 mE 6443732 mN
Soil Grey sand

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Corymbia calophylla	1 ind	8 m	KRZ50	

Keane Road Pipeline Survey Site KRZ OPP 2

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400311 mE 6443766 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Drosera glanduligera	+		KRZ02	
Drosera menziesii subsp. *menziesii*	+		KRZ25	

Keane Road Pipeline Survey Site KRZ OPP 3

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400278 mE 6443792 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Stylidium repens	2 ind		KRZ26	

Keane Road Pipeline Survey Site KRZ OPP 4

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400260 mE 6443801 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Melaleuca cuticularis	3 ind		KRZ27	

Keane Road Pipeline Survey Site KRZ OPP 5

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400081 mE 6443977 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	2 ind		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 6

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400014 mE 6444041 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	2 ind		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 7

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399928 mE 6444127 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia furcellata	5 ind		KRZ35	

Keane Road Pipeline Survey Site KRZ OPP 8

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399900 mE 6444163 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia furcellata	1 ind		KRZ35	

Keane Road Pipeline Survey Site KRZ OPP 9

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399678 mE 6444376 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	2 ind		KRZ34	

APPENDIX I
FLORA BY SITE MATRIX

Species	KRZ A	KRZ B	KRZ C	KRZ D	KRZ01	KRZ02	KRZ03	KRZ04	KRZ05	KRZ06	KRZ OPP 1	KRZ OPP 10	KRZ OPP 11	KRZ OPP 12	KRZ OPP 13	KRZ OPP 14	KRZ OPP 15	KRZ OPP 16	KRZ OPP 17	KRZ OPP 18	KRZ OPP 19	KRZ OPP 2	KRZ OPP 3	KRZ OPP 4	KRZ OPP 5	KRZ OPP 6	KRZ OPP 7	KRZ OPP 8	KRZ OPP 9
Acacia pulchella					15		6	5		2																			
Acacia saligna				5																									
Adenanthos cygnorum								1																					
Aotus procumbens								+																					
Arctotheca calendula			2	2						+																			
Astartea affinis					2																								
Banksia attenuata								25																					
Banksia ilicifolia								5																					
Banksia sphaerocarpa var. *sphaerocarpa*											3																		
Baumea juncea										6																			
Bossiaea eriocarpa																													
Briza maxima	1				+					+																			
Caladenia flava						+																							
Callitris pyramidalis																													
Carpobrotus edulis				5																									
Cassytha racemosa					2				6	3																			
Caustis dioica					15																								
Centrolepis polygyna									4																				
Conostylis juncea								+																					
Cortaderia selloana										2																			
Corymbia calophylla																					1 ind								
Crassula colorata var. *acuminata*					+	+																							
Crassula natans var. *minus*									3																				
Cynodon dactylon			5							15																			
Cytogonidium leptocarpoides					3	3																							
Dampiera alata																													
Dampiera trigona					+																								
Dasypogon bromeliifolius						+	3	15																					
Desmocladus fasciculatus					4																								
Drosera erythrorhiza						3																							
Drosera glanduligera	+																					+							
Drosera marchantii subsp. *marchantii*											+																		
Drosera menziesii subsp. *menziesii*											+											+							
Drosera nitidula					+																								
Ehrharta longiflora	2									2																			
Eleocharis acuta																	15												
Eragrostis curvula	3																												
Euchilopsis linearis							3																						
Eutaxia virgata					2																								
Gahnia trifida		20																											
Gompholobium tomentosum						+		2																					
Hakea sulcata					2																								
Hakea varia				3						1																			
Hemiandra pungens																													
Hibbertia subvaginata								20																					
Hypocalymma angustifolium							7																						
Hypochaeris glabra					2	+	4	+	+																				
Hypolaena exsulca	+				15	6	5	+		1.5																			
Isolepis cernua var. *setiformis*									+																				
Jacksonia furcellata																											5 ind	1 ind	
Jacksonia gracillima						+	+					+	+							3 ind					2 ind	2 ind			2 ind
Jacksonia sternbergiana				2						+																			
Juncus pallidus										3																			
Kennedia prostrata										+																			
Kunzea glabrescens				20		85	4	40		8																			
Kunzea micrantha											30																		
Lechenaultia biloba																													
Lepidosperma longitudinale	15		30		30		+			4																			
Lomandra nigricans								+																					
Lomandra sericea						+																							
Lotus subbiflorus									2	3																			
Lyginia imberbis								3																					
Melaleuca cuticularis																								3 ind					
Melaleuca preissiana							10			6																			
Melaleuca rhaphiophylla		60		40	10																								
Melaleuca thymoides								2																					
Melaleuca viminea	50		40		15				30	20																			
Moraea flaccida	+		+		4				+	10					+			100+ ind											
Neurachne alopecuroidea																													
Nuytsia floribunda																													
Patersonia occidentalis								+		+																			
Pericalymma ellipticum																													
Petrophile linearis								+																					
Petrophile rigida											4																		
Philotheca spicata							+	+																					
Phlebocarya ciliata								2																					
Pimelea angustifolia				+			1.5	+																					
Poa annua	3				3																								
Pterostylis vittata						+	+																						
Pyrorchis nigricans																													
Regelia ciliata				20	35	50	80			5																			
Scholtzia involucrata								1.5																					
Sowerbaea laxiflora																													
Stirlingia latifolia																													
Stylidium repens																							2 ind						
Thysanotus manglesianus						+																							
Thysanotus sparteus					+																								
Trachymene pilosa						+		+																					
Tribonanthes brachypetala					1																								
Ursinia anthemoides							+	+																					
Verticordia densiflora					4																								
Vulpia myuros									+																				
Xanthorrhoea preissii						1.5	3	1																					
Zantedeschia aethiopica			+											4 ind		4 ind		1 ind	5 ind										

APPENDIX J
FLORA INVENTORY

APPENDIX J

FLORA INVENTORY

Family	Species
Aizoaceae	**Carpobrotus edulis*
Anarthriaceae	*Lyginia imberbis*
Araceae	**Zantedeschia aethiopica*
Araliaceae	*Trachymene pilosa*
Asparagaceae	*Lomandra nigricans*
	Lomandra sericea
	Sowerbaea laxiflora
	Thysanotus manglesianus
	Thysanotus sparteus
Asteraceae	**Arctotheca calendula*
	**Hypochaeris glabra*
	**Ursinia anthemoides*
Centrolepidaceae	*Centrolepis polygyna*
Crassulaceae	*Crassula colorata* var. *acuminata*
	**Crassula natans* var. *minus*
Cupressaceae	*Callitris pyramidalis*
Cyperaceae	*Baumea juncea*
	Caustis dioica
	Eleocharis acuta
	Gahnia trifida
	Isolepis cernua var. *setiformis*
	Lepidosperma longitudinale
Dasypogonaceae	*Dasypogon bromeliifolius*
Dilleniaceae	*Hibbertia subvaginata*
Droseraceae	*Drosera erythrorhiza*
	Drosera glanduligera
	Drosera marchantii subsp. *marchantii*
	Drosera menziesii subsp. *menziesii*
	Drosera nitidula
Fabaceae	*Acacia pulchella*
	Acacia saligna
	Aotus procumbens
	Bossiaea eriocarpa
	Euchilopsis linearis
	Eutaxia virgata
	Gompholobium tomentosum
	Jacksonia furcellata
	Jacksonia gracillima

Family	Species
	Jacksonia sternbergiana
	Kennedia prostrata
	**Lotus subbiflorus*
Goodeniaceae	*Dampiera alata*
	Dampiera trigona
	Lechenaultia biloba
Haemodoraceae	*Conostylis juncea*
	Phlebocarya ciliata
	Tribonanthes brachypetala
Iridaceae	**Moraea flaccida*
	Patersonia occidentalis
Juncaceae	*Juncus pallidus*
Lamiaceae	*Hemiandra pungens*
Lauraceae	*Cassytha racemosa*
Loranthaceae	*Nuytsia floribunda*
Myrtaceae	*Astartea affinis*
	Corymbia calophylla
	Hypocalymma angustifolium
	Kunzea glabrescens
	Kunzea micrantha
	Melaleuca cuticularis
	Melaleuca preissiana
	Melaleuca rhaphiophylla
	Melaleuca thymoides
	Melaleuca viminea
	Pericalymma ellipticum
	Regelia ciliata
	Scholtzia involucrata
	Verticordia densiflora
Orchidaceae	*Caladenia flava*
	Pterostylis vittata
	Pyrorchis nigricans
Poaceae	**Briza maxima*
	**Cortaderia selloana*
	**Cynodon dactylon*
	**Ehrharta longiflora*
	**Eragrostis curvula*
	Neurachne alopecuroidea
	**Poa annua*
	**Vulpia myuros*
Proteaceae	*Adenanthos cygnorum*
	Banksia attenuata

Family	Species
	Banksia ilicifolia
	Banksia sphaerocarpa var. *sphaerocarpa*
	Hakea sulcata
	Hakea varia
	Petrophile linearis
	Petrophile rigida
	Stirlingia latifolia
Restionaceae	*Cytogonidium leptocarpoides*
	Desmocladus fasciculatus
	Hypolaena exsulca
Rutaceae	*Philotheca spicata*
Stylidiaceae	*Stylidium repens*
Thymelaeaceae	*Pimelea angustifolia*
Xanthorrhoeaceae	*Xanthorrhoea preissii*

APPENDIX K
LOCATIONS OF PRIORITY FLORA

APPENDIX K

LOCATIONS OF PRIORITY FLORA

Taxa	Conservation Code	Site Number	Number of individuals/ cover	# Easting	# Northing
Jacksonia gracillima	P3	KRZ02	1	400183	6443880
		KRZ03	1	399833	6444227
		OPP	1	399477	6444576
		OPP	1	399461	6444592
		OPP	3	400181	6443793
		OPP	2	400081	6443977
		OPP	2	400014	6444041
		OPP	2	399678	6444376

Australian Geocentric 1994 (GDA94), Zone 50K

APPENDIX L
LOCATIONS OF INTRODUCED FLORA

APPENDIX L

LOCATIONS OF INTRODUCED FLORA

Taxa	Site Number	Number of Individuals/Cover %	Easting	Northing
**Arctotheca calendula*	KRZ06	<1%	399820	6443421
	Opp Coll	2%	399528	6443643
	Opp Coll	2%	399666	6443507
**Briza maxima*	KRZ01	<1%	400379	6443702
	KRZ04	<1%	399506	6444542
	KRZ06	<1%	399820	6443421
	Opp Coll	1%	400416	6443659
**Carpobrotus edulis*	KRZ04	<1%	399506	6444542
	Opp Coll	5%	399666	6443507
**Cortaderia selloana*	KRZ06	2%	399820	6443421
**Crassula natans* var. *minus*	KRZ05	3%	399600	6443568
**Cynodon dactylon*	KRZ06	15%	399820	6443421
	Opp Coll	5%	399528	6443643
**Ehrharta longiflora*	KRZ06	2%	399820	6443421
	Opp Coll	2%	400416	6443659
**Eragrostis curvula*	Opp Coll	3%	400416	6443659
**Hypochaeris glabra*	KRZ01	2%	400379	6443702
	KRZ02	<1%	400183	6443880
	KRZ03	4%	399833	6444227
	KRZ04	<1%	399506	6444542
	KRZ05	<1%	399600	6443568
**Lotus subbiflorus*	KRZ05	2%	399600	6443568
	KRZ06	3%	399820	6443421
**Moraea flaccida*	KRZ01	4%	400379	6443702
	KRZ05	<1%	399600	6443568
	KRZ06	10%	399820	6443421
	Opp Coll	<1%	400416	6443659
	Opp Coll	<1%	399528	6443643
	Opp Coll	<1%	399196	6443975
	Opp Coll	100 individuals	399700	6443482
**Poa annua*	KRZ01	3%	400379	6443702
	Opp Coll	3%	400416	6443659
**Ursinia anthemoides*	KRZ01	<1%	400379	6443702
	KRZ03	<1%	399833	6444227

Taxa	Site Number	Number of Individuals/Cover %	Easting	Northing
	KRZ04	<1%	399506	6444542
**Vulpia myuros*	KRZ05	<1%	399600	6443568
**Zantedeschia aethiopica*	Opp Coll	<1%	399528	6443643
	Opp Coll	4 individuals	399182	6443988
	Opp Coll	4 individuals	399208	6443962
	Opp Coll	1 individual	399700	6443482
	Opp Coll	5 individuals	400113	6443732

Australian Geocentric 1994 (GDA94), Zone 50K

APPENDIX M
POTENTIALLY OCCURRING CONSERVATION SIGNIFICANT FAUNA

APPENDIX M

POTENTIALLY OCCURRING CONSERVATION SIGNIFICANT FAUNA

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
REPTILES				
Darling Range Heath Ctenotus (*Ctenotus delli*)	P4	This species occurs in the Darling Range from Mundaring and Darlington south to Collie (Bush et al., 2007). It is patchily distributed in its geographic range and inhabits jarrah and marri woodlands over a shrubby understorey on lateritic, sandy and clay soils and occasionally granite and lateritic outcrops (Wilson & Swan, 2010).	There are two records of the Darling Range Heath Ctenotus within the vicinity of the study area, one from Thornlie in November 1986 and one from Byford in August 1969 (DEC, 2012e). These records are relatively old and the skinks distribution is likely to have contracted in this time. In addition the preferred habitat of the species (eucalypt woodland over heavy soils) does not occur in the study area.	Unlikely
Jewelled South-west Ctenotus (swan coastal plain population) (*Ctenotus gemmula*)	P3	The Swan Coastal Plain population of Jewelled Ctenotus occurs in pale sandplains supporting heaths in association with banksia or mallee woodlands. This species has a patchy distribution along the coastal plains and adjacent interior of the southwest (Wilson & Swan, 2010).	There are eight records located within the vicinity of the study area; the records range from 1971 to 1979 (DEC, 2012e). There are no records of the skink from the metro area within the past 20 years (DEC, 2012e), as such it is likely the Swan Coastal Plain population is extremely rare and perhaps locally extinct. The banksia woodlands within the study area are too heavily disturbed to support this species.	Unlikely
Perth Slider (*Lerista lineata*)	P3	The Perth Slider occurs in sandy coastal heath and shrubland areas in isolated populations in the south-west and midwest coast of Western Australia (Wilson & Swan, 2010). This burrowing species is found in loose soil or sand beneath logs and termite mounds, where it feeds on termites and other small insects (Cogger, 2000).	There are 256 records of the Perth Slider within the vicinity of the study area. Records are dated from 1972 to 2010 with the most recent record coming from Bibra Lake (DEC, 2012e). The sandy soils within the banksia woodland are suited to this species but are however heavily disturbed and border cleared tracks which may deter the species.	Possible

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Southwest Carpet Python (*Morelia spilota imbricata)*	P4	The southwest Carpet Python has a wide distribution but is generally uncommon. It inhabits semi-arid coastal and inland habitats such as banksia and eucalypt woodlands, and grasslands (Wilson & Swan, 2010). The species shelters in tree hollows, disused burrows, caves, rock crevices and beneath boulders (Pearson, 1993). This sub-species is thought to be declining markedly as urban areas expand causing loss of its habitat (Wilson & Swan, 2010).	There are seven records of the Southwest Carpet Python within the vicinity of the study area (DEC, 2012e). The records are dated from 1966 to 2003 and. There are few recent records of the species within the Perth region and it appears that all records are all situated to the east of the study area on the Darling Scarp (DEC, 2012e).	Unlikely
Southern Death Adder (*Acanthophis antarcticus*)	P3	The Southern Death Adder is distributed in the Darling Range between Mundaring to Jarrahdale but also distributed within the vicinity of Esperance across the Nullarbor and up most of eastern Australia (Cogger, 2000). Habitats are highly variable ranging from rainforest to shrublands and heaths. Adults feed largely on small mammals and birds and juveniles feed on reptiles (Cogger, 2000). Declines are mainly due to habitat destruction and altered fire regimes (Wilson & Swan 2010).	There are thirty-five records of the Southern Death Adder within the vicinity of the study area (DEC, 2012e). The records are dated from 1953 to 1982 and are all situated to the east of the study area on the Darling Scarp (DEC, 2012e). There are no recent records of the species within the Perth region. In the metro area, the Southern Death Adder prefers forests like those situated to the east of the study area which contain high amounts of woody debris and leaf litter and are not found in the study area.	Unlikely
Black-striped Snake (*Neelaps calontos*)	P3	The Black-striped Snake is exclusively distributed on the Swan Coastal Plain from Lancelin to Mandurah. It occupies sandplain habitat and is often associated with *Banksia* (Storr et al., 2002). The species was formerly listed as threatened fauna but has since been removed due to its abundance in banksia woodlands of the Swan Coastal Plain (Storr et al., 2002). The primary threat of the species is the ongoing clearing of habitat (Storr et al., 2002).	There are sixteen records of the Black-striped Snake within the vicinity of the study area. The banksia woodland of the study area contains soft sand, well-represented understorey vegetation and high leaf litter content suited for the species (Wilson & Swan, 2010). The species has however, not been recorded in the vicinity of the study area since 1979 (DEC, 2012e).	Possible
BIRDS				

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Malleefowl (*Leipoa ocellata*)	Vu; S1	Malleefowl occur in scattered locations across much of southern Australia (Barrett et al., 2003). In southwest WA the Malleefowl inhabits remnant vegetation of agricultural zones (Johnstone & Storr, 1998). The Malleefowl requires sandy substrate and abundant leaf litter to create large mounds which are used for breeding (Johnstone & Storr, 1998). Declines of the Mallefowl are strongly linked to alteration of habitat by the clearing and fragmentation of habitat, predation by foxes and cats and inappropriate fire regimes. (Parsons et al., 2008).	There is one record of the Malleefowl which is situated approximately 12 km to the south-east of the study area (DEC, 2012e). The record was taken in 2004 from Mundlinup State Forest in Jarrahdale on the Darling Scarp (DEC, 2012e). The record represents the western extend of the species distribution for the approximate latitude. The study area contains no suitable habitat and sits outside the species distribution (Garnett et al., 2011).	Highly Unlikely
Peregrine Falcon (*Falco peregrinus*)	S4	The Peregrine Falcon is an uncommon but wide-ranging Australian species. They mainly occur along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes (Johnstone & Storr, 1998; Olsen et al., 2004). The Peregrine Falcon nests primarily on cliffs, granite outcrops, quarries and old Raven and Whistling Kite nests and feeds primarily on birds (Johnstone & Storr, 1998).	There are 82 records of the Peregrine Falcon within the vicinity of the study area (DEC, 2012e). Records are dated from 1998 to 2009, a third coming from the nearby Forrestdale Lake situated 1 km to the south of the study area. The study area provides no nesting habitat for the species. The Peregrine Falcon has a home-range of approximately 20-30 km^2 (Birdlife Australia, 2012b). Consequently it is possible that the species will pass over the study area as part of its greater home-range.	Possible
Australian Bustard (*Ardeotis australis*)	P4	The Australian Bustard is typically widespread and nomadic, but locally scarce. This species is distributed across most of Western Australia, although it's most prevalent in grasslands, especially tussock grasses, arid scrub and dry open woodlands (Ziembicki, 2010). The abundance of this species varies according to habitat and season, and birds often track resources that are in abundance, such as grasshoppers (Ziembicki, 2010).	There are two records of the Australian Bustard from within the vicinity of the study area (DEC, 2012e). The records come from Harry Waring Marsupial Reserve (1979) and Lockyer Park (DEC, 2012e). The study area does not provide suitable habitat for the Australian Bustard. The study area is situated at the southern extend of the species range and is rarely recorded within this region (Johnstone & Storr, 1998).	Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Bush Stone-curlew (*Burhinus grallarius*)	P4	The Bush Stone-curlew inhabits dry open woodlands with a groundcover of small sparse shrubs and grass avoiding dense forest and closed-canopy habitats (Johnstone & Storr, 1998). The species generally occurs near watercourses and swamps (Geering et al., 2007). Bush Stone-curlews are locally rare because of predation by foxes, which is the main concern for their regional decline (Johnstone & Storr, 1998).	There are three records of the Bush Stone-Curlew from the vicinity of the study area. The records are extremely old, dated at 1917, 1936 and 1962. While the study area provides suitable habitat for the species, there are almost no recent records of the species from within the metropolitan area implying that species is significantly rare within the region or locally extinct.	Unlikely
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vu; S1	The Forest Red-tailed Black Cockatoo is endemic to the southwest of WA, distributed from Gingin through the Darling Ranges to Albany (Johnstone & Storr, 1998). The species lives in forests of the southwest, feeding primarily on seeds of Marri nuts and nesting in large tree hollows, of Marri, Jarrah and Karri. Nest hollow shortage is considered the principal threat to the species with over 36% of the species former habitat cleared for agriculture (Garnett et al., 2011; Johnstone & Kirkby, 1999). Expected population declines >30% have been postulated over the next three generations (Chapman, 2007).	There are 58 records of the Forest Red-tailed Black Cockatoo from within the vicinity of the study area. Records are dated from 1891 to 2010 (DEC, 2012e). The species has a wide-distribution within the southwest and occupies a large home range extending on the Swan Coastal Plain mainly for foraging. The study area provides no potential breeding or roosting habitat although the banksia woodlands within the study area provides ideal foraging habitat for the species.	Likely
Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)	Vu; S1	Baudin's Cockatoo is distributed from the northern Darling Range, south to Bunbury and across to Albany (Johnstone & Storr, 1998). This species forages primarily in Eucalypt forest, feeding on Marri nuts, flowers, nectar and buds as well as a wide range of seeds of *Eucalyptus*, *Banksia* and *Hakea*, (Johnstone & Kirkby, 2008; Johnstone & Storr, 1998). Baudin's Cockatoo nests in tree hollows in the deep south-west of Western Australia. Primary nesting trees are Karri, Marri, and Wandoo (Johnstone & Kirkby, 2008). Nest hollow shortage is considered the principal threat, as such the species no longer occupies over 25% of former habitat due to clearing (Chapman, 2007)	There are 163 records of Baudin's Cockatoo from within the vicinity of the study area. The records are dated from 1977 to 2009 (DEC, 2012e). The species has a wide-distribution within the southwest occupying a large home range and considered to be relatively nomadic in its movements (Johnstone & Kirkby, 2011). The study area provides no potential breeding or roosting habitat although the banksia woodlands within the study area provide ideal foraging habitat for the species.	Likely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)	En; S1	Carnaby's Cockatoo is endemic to southwest WA, distributed from the Murchison River to Esperance (Cale, 2003). Breeding occurs in the Wheatbelt from early July to mid-December (Johnstone & Storr, 1998). They feed on seeds, nuts and flowers of a variety of native and exotic plants particularly Eucalypts such as Marri (*Corymbia calophylla*) and Jarrah (*Eucalyptus marginata*), *Banksia* and other Proteaceous species (Shah, 2006). Trees used as nest sites by Carnaby's Cockatoo are mature, hollow-bearing trees, usually with a crown containing dead limbs and a sparse canopy (Cale, 2003; Johnstone & Storr, 1998). Primary threats to the species are reductions of foraging and breeding habitat.	There are 432 records of Carnaby's Cockatoo from within the vicinity of the study area (DEC, 2012e). The records are dated from 1967 to 2012 (DEC, 2012e). The species has a wide-distribution within the southwest occupying a large home range and considered to be nomadic in its movements outside of breeding season (Johnstone & Kirkby, 2011). The study area provides no potential breeding or roosting habitat although the banksia woodlands within the study area provide ideal foraging habitat for the species.	Likely
Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)	S4	Major Mitchell's Cockatoo has a widespread but disjunct distribution in arid and semi-arid zones of WA (Johnstone & Storr, 1998). They prefer open woodlands with access to water and require eucalypts with hollows for nesting, particularly River-gum and Salmon Gum (Rowley & Chapman, 1991). Major Mitchell feeds primarily on seed, fruit and flowers of a wide range of species including those from the *Grevillea* and *Acacia* genera (Rowley & Chapman, 1991).	There is one record of the species from within the vicinity of the study area (DEC, 2012e). The record is a specimen from the Western Australian Museum and taken from South Perth (DEC, 2012e). There are four records of this species in the metropolitan area. However the species distribution no longer extends this far west from the wheatbelt. Furthermore the study area provides no habitat for the species.	Highly Unlikely
Australian Masked Owl (*Tyto novaehollandiae novaehollandiae*)	P3	The Masked Owl is represented by two disjunct populations. In the south-west of WA, the species is distributed from Yanchep to Albany (Johnstone & Storr, 1998). It breeds in the forested deep south-west, with some autumn-winter movement northwards and north-westwards (Johnstone & Storr, 1998). The major threat to this species is the decline in nesting site availability because of clearing and the decline in the number of small mammals due to fox and cat predation (Johnstone & Storr, 1998).	There are four records of the Masked Owl within the vicinity of the study area (DEC, 2012e). The records are dated from 1919 to 2005 and occur in Burswood, Henderson and Beeliar (DEC, 2012e). The Masked Owl requires wooded forest tall trees that contain hollows for nesting (Johnstone & Storr, 1998); this habitat is not found within the study area. Habitats represented within the study area are highly disturbed and are not suitable to support this species.	Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Barking Owl (*Ninox connivens connivens*)	P2	This subspecies is distributed through southwest WA, north to Perth, east to Northam and south to Bremer Bay (Johnstone & Storr, 1998). This subspecies is disjunct from populations in the Pilbara and Kimberley. It inhabits dense vegetation particularly forests and thickets where it feeds on large insects and small mammals (Johnstone & Storr, 1998). This species breeds in hollow tree trunks and threatened primarily by clearing (Garnett & Crowley, 2000)	There are five records of the Barking Owl from within the vicinity of the study area. The records are dated from 2000 to 2010 and taken from the Beeliar Wetlands and Walliston on the Darling Scarp. The study area provides no suitable habitat for the species. The area contains a high proportion of disturbed habitat and contains no tall and hollow bearing trees which are needed for hunting and nesting.	Unlikely
Pacific Swift (*Apus pacificus*)	Mi; S3	The Pacific Swift is a non-breeding summer migrant (October-April) to Australia (Johnstone & Storr, 1998). The Pacific Swift is almost exclusively an aerial species, which forages high above the tree canopy (from 1-300 m above ground) for insects such as bees, wasps and moths (Higgins, 1999). They are believed to roost aerially but are occasionally observed to land (Higgins, 1999). They can occur over most habitat in Australia particularly inland plains, cliffs, beaches and islands (Higgins, 1999).	The Pacific Swift forages high in the airspace, is a highly mobile species and occurs across a range of habitat within Australia. The study area may provide some habitat for this species although the nearest two records are located 35-40 km east of the study area (DEC, 2012b). The species may overfly the study area occasionally but is not dependent on the habitat presented.	Possible
Rainbow Bee-eater (*Merops ornatus*)	Mi; S3	The Rainbow Bee-eater is a common breeding migrant that occurs widely across much of Australia and in Western Australia, from the Kimberley and Pilbara through to the southwest (Johnstone & Storr, 1998). It generally breeds in summer in the greater southwest and occurs as a passage migrant or visitor in the northern part of its range throughout the rest of the year (Johnstone & Storr, 1998; Barrett et al., 2003). It occurs in lightly wooded, often sandy country, preferring areas near water. The Rainbow Bee-eater feeds on airborne insects, and nests in burrows excavated in sandy ground or in banks of creeks and rivers (Johnstone & Storr, 1998).	There are 659 records of the Rainbow Bee-eater from within the vicinity of the study area (DEC, 2012e). The records are dated from 1902 to 2012 (DEC, 2012e). All the habitat types in the survey area provide habitat for the Rainbow Bee-eater, in particular the soft substrates which provide potential nesting sites. The Rainbow Bee-eater is likely to occur in the study area.	Likely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
MAMMALS				
Chuditch/Western Quoll (*Dasyurus geoffroii*)	Vu; S1	The Chuditch once occupied over 70% of Australia, but is now restricted to the southwest of Western Australia (van Dyck & Strahan, 2008). Being a relatively large predator, it occurs at low densities. Adult females inhabit a core area of 55-200 ha and males 400 ha (van Dyck & Strahan, 2008). The Chuditch is now only found in sclerophyll forest, woodland and mallee shrubland (Menkhorst & Knight, 2004; van Dyck & Strahan, 2008).	Thirty-four records of the Western Quoll are known from the vicinity of the study area (DEC 2012e). The most recent record 2011 comes from Martin, approximately 15 km northeast on the Darling Scarp. All recent records are situated to the east of the study area. The study area lacks suitable woodland habitat and as such no hollows (no potential den sites) means this species is unlikely to occur within the survey area.	Unlikely
Wambenger/Southern Brush-tailed Phascogale (*Phascogale tapoatafa* ssp. (WAM M434)	S1	The Wambenger is an undescribed subspecies of the Brush-tailed Phascogale that occurs in south-west Western Australia (van Dyck & Strahan, 2008; Peter Mawson *pers. com*. [DEC]). It is restricted to the extreme southwest, and its characteristic low population densities make it vulnerable to localised extinction (van Dyck & Strahan, 2008). This subspecies occupies dry sclerophyll forests and open woodlands containing hollow-bearing trees with a sparse ground cover. Habitat destruction, in particular, the loss of hollow-bearing trees and predation by feral animals, are thought to be the major threats to surviving populations (DEC, 2006).	There are 17 records of the Southern Brush-tailed Phascogale from within the vicinity of the study area (DEC 2012e). Records span from 1960 to 2007 and situated to the east of the study area, on the Darling Scarp where there is a greater amount of tall trees with hollows (DEC 2012e). The study area does not contain any hollow bearing trees and is not deemed suitable habitat for the Southern Brush-tailed Phascogale.	Highly Unlikely
Numbat (*Myrmecobius fasciatus*)	Vu; S1	The Numbat is a small, diurnal marsupial, endemic to WA. This species once ranged widely but due to predation by foxes and cats, loss of habitat and changes in fire regimes, have contracted substantially (van Dyck & Strahan, 2008). Its current distribution is limited to east of Manjimup in upland Jarrah forests, open eucalypt woodlands, *Banksia* woodlands and tall closed shrublands, where it shelters in hollow logs and branches and feeds almost exclusively on termites (van Dyck & Strahan, 2008).	There are 17 records of the Numbat situated within the vicinity of the study area (DEC 2012e). Records are likely to be old given that the species has significantly declined and the current distribution of this species is far outside of the study area (van Dyck & Strahan, 2008). Furthermore the study area contains no habitat suitable for Numbat i.e. hollow logs etc.	Highly Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Quenda, Southern Brown Bandicoot (*Isoodon obesulus*)	P5	The Quenda occurs in forest, heath and coastal scrubs along the coast of south-western WA from Moore River to Israelite Bay (Menkhorst & Knight, 2001). They typically seek daytime refuge from predators in very thick ground-storey vegetation, often associated with swamps or damplands (Long, 2009). They forage by night in open areas, leaving distinctive conical feeding holes in the ground (Long, 2009). The Quenda is threatened by clearing and fragmentation of its preferred habitat (van Dyck & Strahan, 2008).	There are 743 records of the Quenda from within the vicinity of the study area, most of which are recent (DEC 2012e). The study area and surrounding bushland provides ideal habitat for the species. There is sandy substrate and a good amount of understorey vegetation. The distinctive conical feeding holes and prints were recorded during the survey.	Recorded (from secondary evidence)
Woylie, Brush-tailed Bettong (*Bettongia penicillata*)	En; S1	The Woylie occupies sclerophyll forests and mallee eucalypt woodlands with a dense low understorey of tussock grasses (van Dyck & Strahan, 2008). Once distributed across much of mainland Australia, the species is now confined to three populations in southwest WA, Dryandra Woodland, Tutanning Nature Reserve and Perup Forest (Yeatman & Groom, 2012). Their diet consists largely of underground fungi, tubers, bulbs and grain/seeds (van Dyck & Strahan, 2008)	There are three records of the Woylie located within the vicinity of the study area (DEC, 2012e). The most recent comes from Norma Road Bushland in Whitby. The Woylie has experienced severe declines since European settlement and the species is now confined to a small number of conservation reserves within the southwest. The habitats present within the study area are not suitable to support the species.	Highly Unlikely
Tammar Wallaby (*Macropus eugenii*)	P5	In south-western Western Australia numbers of the Tammar Wallaby have been reduced primarily as a result of land clearing (van Dyck & Strahan, 2008). The Tammar requires dense low vegetation for daytime shelter and open grassy areas for foraging (van Dyck & Strahan, 2008). This species inhabits coastal scrub, heath, dry sclerophyll forest and thickets in mallee woodland (van Dyck & Strahan, 2008).	There is one record of the Tammar Wallaby from the Harry Waring Marsupial Reserve, the record is from 1971 (DEC, 2012e). The Tammar Wallaby has undergone declines since European settlement as a result of extensive land clearing and is now restricted to areas east of the Darling Scarp as well as small offshore islands (Abbott, 2008). The habitats present in the study area are not considered suitable for the species.	Highly Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Western Brush Wallaby (*Macropus Irma*)	P4	The Western Brush Wallaby occurs in open forest or woodland, particularly in areas where grassy understorey and scrubby thickets are present (van Dyck & Strahan, 2008). It is found only in south-western Western Australia where it appears to be in decline as a result of an increase in the numbers of foxes which results in greater rates of predation (van Dyck & Strahan, 2008).	There are 33 records of the Western Brush Wallaby from within the vicinity of the study area (DEC, 2012e). Over half the records come from the native bushland surrounding Jandakot Airport (2011). The melaleuca shrublands and banksia woodland of the study area both provide suitable habitat for the species, although the species is not widespread and uncommon within the Perth metropolitan area.	Possible
Quokka (*Setonix brachyurus*)	VU; S1	The Quokka is found in the south-west regions of Western Australia, from south of Perth in Jarrah, Marri and Karri Forest to Two People's Bay (Menkhorst & Knight, 2001). It mostly occurs in densely vegetated swamps, tea tree thickets on sandy soils along creek lines and dense heath on slopes (van Dyck & Strahan, 2008). Quokka numbers have declined because of predation by foxes and the clearing and burning of swamp habitats (van Dyck & Strahan, 2008).	There are 24 records of the Quokka from the vicinity of the study area (DEC, 2012e). Records are dated from 1958 with most coming from Byford and Roleystone, just south of the study area in 2010/11. The species tends to prefer habitats with a dense understorey. The study does not provide ideal habitat for the species but furthermore the study area is situated within a fragmented landscape that restricts movements of individuals and is likely to be exposed to predators such as foxes and cats which are a major cause of population decline for this species.	Unlikely
Western False Pipistrelle (*Falsistrellus mackenziei*)	P4	The Western False Pipistrelle prefers Karri forest, wetter stands of Jarrah and Tuart, and Corymbia woodlands. The Western False Pipistrelle roosts in tree hollows and forages mainly at canopy level (van Dyck & Strahan, 2008). The major threat to this species is the loss of feeding grounds and suitable habitat to forestry and clearing for agriculture.	There is one record of the Western False Pipistrelle from within the vicinity of the study area. The record is of a capture from the Harry Waring Marsupial Reserve in Jandakot, 1993 (DEC, 2012e). The study area provides no roosting habitat for the species i.e. no tree hollows. However the species is highly mobile and may possibly occur across the study area when foraging.	Possible

Key:	
En	Listed as Endangered under the *EBPC Act 1999*.
Vu	Listed as Vulnerable under the *EBPC Act 1999*.
Mi	Listed as Migratory under the *EBPC Act 1999*.
S	Scheduled under the *WC Act 1950*. Schedule 1 and 2 fauna are also protected by the *EBPC Act 1999*.
P	Listed as Priority by the DEC.
Recorded	Recorded during the field survey or site reconnaissance.
Likely	Suitable habitat is present in the study area and the study area is in the species' known distribution.
Possible	Limited or no suitable habitat is present in study area but is nearby. The species has good dispersal abilities and is known from the general area.
Unlikely	No suitable habitat is present in study area but is nearby, the species has poor dispersal abilities, but is known from the general area; or suitable habitat is present, however the study area is outside of the species' known distribution.
Highly Unlikely	The species has poor dispersal abilities, no suitable habitat is present, and the species is uncommon; or the species is thought to be locally extinct.

Appendix E

Draft Acid Sulfate Soil and Dewatering Management Plan

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Water Corporation

Keane Road Pressure Main, Balannup
Draft Acid Sulfate Soil and Dewatering Management Plan

April 2014

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Appendices

1. Introduction

1.1 Project Background

The Water Corporation (WC) is proposing an M&E upgrade of the Balannup Wastewater Sewerage Pump Station (WWPS) and to construct a new rising pressure main along Keane Road to the Waterworks Road WWPS in Haynes, 22km south of Perth in Western Australia. The site locality is depicted on Figure 1. The construction upgrade will be undertaken in a phased approach and Stage 1 (the remit of this ASSDMP) will comprise the following tasks:

1. **Section 1**: Construction of approximately 1km (Chainage (Ch) 0 to 1080) of pressure main at an assumed invert between 2m and 2.5m depth (Ch 0 to Ch 522) and 1m to 1.5m depth (Ch 522 to Ch 1080). The pressure main will commence at the existing DN375 pressure main located on Welcome Meander in Harrisdale to the start of Bush Forever area at the intersection of Skeet Road and Keane Road. The pressure main is anticipated to be installed utilising open excavation techniques.
2. **Section 2**: Installation of approximately 1.5km (Ch 1080 to 2600) DN450 PE pressure main at an invert level of 1.5m to 2m depth utilising trenchless methods (Eco-Ploughing) through the Bush Forever area to the Anstey Road and Keane Road intersection in Forrestdale.
3. **Section 3**: Construction of approximately 2km (Ch 2600 to Ch 4557) DN375 pressure main at an invert between 1m and 2m depth from the Anstey Road and Keane Road intersection to the Waterworks Road WWPS utilising open excavation techniques.
4. Three (3) road crossings have been identified during the installation; two (2) of these crossings will be undertaken utilising trenchless techniques, one (Anstey Road) will be open excavated. A DN450 PE100 pipe is anticipated to be installed for all road crossings outlined below at an invert between 3m and 3.5m depth.
   a. Armadale Road (trenchless);
   b. Tonkin Highway (trenchless); and
   c. Anstey Road/ Damper to Bunbury Natural Gas Pipeline (open excavation).

The general arrangement of the infrastructure outlined above is indicated in the GHD plan and longitudinal section drawings (i.e. Drawing No: HW91-085-01A1 to HW91-085-002-15A, Appendix B).

GHD was commissioned by Water Corporation to prepare an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) based upon the recommendations of the geotechnical and acid sulfate soil (ASS) investigations performed as part of the geotechnical consulting services for the project.

The dewatering requirements have not yet been fully identified, and this document is therefore not considered to be the final ASS Dewatering Management Plan (ASSDMP). At the time of writing the detailed design has not been completed and the construction contractor procurement process has not yet commenced.

This document has been prepared using information available at the time of preparation (engineering design drawings). This document should be updated as additional information becomes available on construction elements requiring dewatering and dewatering designs are developed.

1.2 Purpose of this Document

This document and content has been prepared on a draft basis and requires to be finalised prior to the commencement of construction. The construction methodology and management strategies are based upon assumed construction methods and these methods are required to be finalised before the management strategies are valid and suitable for the works.

When finalised, the aim of this document is to summarise the results of the ASS and groundwater investigations and document the findings of those investigations (where relevant) to assist in the preparation of the ASSDMP. This document is considered to address the ASS management and dewatering requirements for the pressure main alignment.

This document addresses the key construction issues that may impact on groundwater, environmental receptors and groundwater users within the vicinity of the site and includes:

- A framework for the treatment and management of excavated/disturbed material defined as ASS during construction of the pressure main.
- A framework for management of dewatering effluent and groundwater, specifically with regards to managing the groundwater quality and levels, during development works.
- The likely depth to groundwater within the vicinity of the pressure main alignment and highlight areas, which may require dewatering; and
- An indication of further detailed groundwater investigation work required.

This document contains an ASSDMP that will be used to inform the Contractor constructing the proposed infrastructure and provide appropriate management and action criteria during the treatment and dewatering operations to minimise potential impacts to the local groundwater, surface water systems, ecology and other groundwater users.

This document should be read in conjunction with the following geotechnical, ASS and contaminated sites investigation report for the site. The document is referenced below:

- GHD, 2013*. Report on the Geotechnical, Acid Sulfate Soils and Contaminated Sites Investigation, Balannup A WWPS and Keane Road Pressure Main* (Document number 134551, Rev 0). November, 2013.

1.3 Scope and Limitations

This report has been prepared by GHD for Water Corporation and may only be used and relied on by Water Corporation for the purpose agreed between GHD and the Water Corporation as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Water Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that and any recommendations in this report are based on conditions encountered and the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report where and as they are required. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Water Corporation and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Background information

2.1 Acid Sulfate Soil

The classification of ASS includes both actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS). AASS are soils that are generating acidity and may still have residual potential acidity, whereas PASS are soils that have the potential to generate acidity.

ASS are soils containing naturally-occurring, fine-grained metal sulfides typically pyrite (FeS_2), formed under saturated, anoxic/reducing conditions. They generally occur in Quaternary (1.8 Ma – Present) marine or estuarine sediments, predominantly confined to coastal lowlands (elevations generally below 5 m Australian Height Datum (AHD)). Within these sediments, the majority of soils that present an environmental risk are generally confined to Holocene aged material (<10 000 years). Where these materials have oxidised, they commonly have a mottled appearance (orange and yellow discolouration) due to the presence of oxidised iron minerals.

Although soils described above represent typical conditions where ASS occurs, the presence of ASS materials is not limited to these soil types. In Western Australia, ASS materials have been identified in other soil types such as leached sands and silts. Accordingly, for areas where no data is available, the extent of ASS materials should be established through field investigations.

2.2 Potential Risks of AASS and PASS

When PASS are disturbed, either by excavation or lowering of the water table below natural seasonal levels, sulfides present are exposed to air, allowing oxidisation and consequently, the formation of sulfuric acid (H_2SO_4). AASS are capable of generating acidity *in situ* in their natural state; disturbance is not required for acidic discharges to develop.

As a result of the presence of AASS, or the oxidation of PASS, surrounding land (soil) and nearby waterways may become acidic (pH<6.5). Under acidic conditions, metals such as aluminium (generally at pH<4.5) and iron, as well as trace heavy metals (including arsenic), become more mobile in the environment and can be taken up by infiltrating waters.

Disturbance of ASS impacted areas may release hydrogen sulfide gas which typically settles within confined spaces and excavations such as trenches and/or depressions. Hydrogen sulfide gas has the potential to reach toxic levels and appropriate occupational health and safety measures may require to be implemented within areas of depressions and/ or during excavation of confined spaces.

2.3 Potential Effects of Dewatering Groundwater

2.3.1 Water Quality

Dissolved metals including iron and aluminium may cause environmental issues, if the dewatering effluent is discharged prior to retention. Discharge without retention may cause iron hydroxides to precipitate out where effluent is discharged into water bodies (particularly surface water). These chemical reactions may release large quantities of acid and consume oxygen causing de-oxygenation of the water column in nearby ecosystems or the local groundwater system and decreasing local buffering capacity (alkalinity), where available. In cases where alkalinity can no longer buffer acidity, then acidification of the groundwater may occur.

Acidic conditions generated by ASS can also corrode concrete and steel (pipes, bridge abutments, underground services, and other infrastructure) and can result in the rapid deterioration of asphalt surfaces where they overlie AASS or PASS. Acidic groundwater plumes can impact on vegetation health of deep rooted vegetation, and affect the water quality of any downstream groundwater receptors including surface water bodies and domestic and industrial water supply bores.

2.4 Management

2.4.1 Management of ASS

Avoiding or minimising disturbance of ASS is the primary methods of management. Where avoiding disturbance is not possible, management techniques available for ASS can include:

- Chemical neutralisation (use of pure fine agricultural lime (AgLime) or a similar neutralising agent).
- Anoxic storage or placement of PASS below the water table and beneath clean non-ASS fill; and
- Hydraulic separation of pyrite from the soil (high maintenance process suitable for coarse grained sediment).

The addition of agricultural lime is the most common amelioration technique applied to acidic soils, where mechanical mixing is completed by plough or excavator to provide adequate homogeneity of the soil/sediment-lime mix.

2.4.2 Management of Dewatering Effluent

The groundwater conditions at the site are indicative of an area which may be vulnerable to acidification and therefore the risk of the water quality impacts outlined within Section 2.3.1 occurring is high. Dewatering operations should be undertaken with appropriate management measures, monitoring trigger actions and contingency strategies to prevent the degradation of groundwater during construction.

The management strategies implemented within this document are in accordance with the appropriate legislative requirements and guidelines outlined within Section 2.5.

2.5 Legislative Requirements in Western Australia

The following legislative requirements may apply to works involving dewatering activities:

2.5.1 Western Australian Planning Commission Bulletin 64/2009

The recently amended *Planning Bulletin 64/2009 (PB 64/09)* aims to provide advice and guidance on matters that should be taken into account in the rezoning, subdivision and development of land containing acid sulfate soils. PB 64/09 requires the identification, assessment and management of soils where:

- The surface elevation is ≤ 5m AHD, and it is proposed to excavate ≥ 100m^3 of soil;
- Where the surface elevation is ≥ 5m AHD, and it is proposed to excavate ≥ 100m^3, and the excavation depth is ≥ 2m; or
- Where any dewatering works are to be undertaken.

2.5.2 Environmental Protection Act 1986

The *Environmental Protection Act 1986* (EP Act 1986) provides for an Environmental Protection Authority, for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing.

To prevent environmental harm, the EP Act 1986 established under Section 50A, states that:

A person who –

a. causes serious environmental harm; or

b. allows serious environmental harm to be caused - commits an offence.

Accordingly, all parties to a development must show that the environmental risk associated with the development has been assessed and minimised where possible.

2.5.3 Rights in Water and Irrigation Act (1914)

In accordance with the '*Water Corporation Acid Sulfate Soil and Dewatering Management Strategy'* (Water Corporation, July 2007) the Water Corporation is not required to obtain either a Section 5C or Section 26D license under the Rights in Water and Irrigation Act (1914) in regards to dewatering. The power given to the Water Corporation by Section 83(2)(b) of the Water Agencies (Powers) Act 1984 overrides the generic requirements of Sections 5C and 26D of the Rights in Water and irrigation Act and therefore the Water Corporation is exempt from the requirement to obtain a dewatering license.

3. Site Characterisation

The information presented below has been abstracted from the geotechnical and acid sulfate soil and contaminated sites investigation report (GHD, 2013) and has been utilised to assist with the preparation of this ASSDMP.

3.1 Site Description and Topography

3.1.1 Section 1: Ch 0 to C 1080

Section 1 extends from the north west corner of the project area in Harrisdale to Skeet Road. The pressure main will connect to an existing pressure main within a recently developed subdivision (Heron Park).

This portion of the alignment gently declines in elevation from the initial starting point at Turtledove Road to the Bush Forever Area located at the intersection of Skeet Road and Keane Road. Elevation typical ranges between 26.5m AHD to 25.6m AHD.

3.1.2 Section 2: Ch 1080 to Ch 2600

Section 2 extends the length of the Bush Forever designated land (Figure 1). Section 2 is characterised by a loose sandy track approximately following the Keane Road reserve alignment. The track is boarded on either side by scrub which becomes less dense towards the east. At the far east of the Bush Forever area the scrub gives way to grass/weeds along a Water Corporation easement.

The Bush Forever area typically gently slopes north west to south east with elevations ranging from 25m AHD to 22.2m AHD. The south eastern end of the road reserve track was characterised by standing water covering most of the track during the investigation undertaken in June and July 2013. Freestanding water to approximately 0.5 m was observed from approximately Ch. 2170 to Ch. 2600 during this period.

3.1.3 Section 3: Ch 2600 to Ch 4557

Section 3 between Ch. 2600 and Ch. 4557 extends along the south east continuation of Keane Road and into Hanlin Road beyond the Armadale Road intersection before crossing Tonkin Highway and terminating within the Water Corporation depot at the WWPS.

The proposed pressure main terminates inside the Water Corporation depot at the waterworks site. The Water Corporation grounds between Tonkin Highway and the waterworks generally consist of sandy tracks, defined by derelict wire fences and low lying grasses and shrubs. The waterworks and surrounding infrastructure are located within a paved area bordered by trees.

Elevation from the Bush Forever area typically inclines from Anstey Road to the Tonkin Highway with a few gently undulations. Elevation ranges from 22.2m AHD to 25.2m AHD, with the undulations to a minimum of 23.5m AHD. Elevation at the WWPS is typically 27.3 mAHD.

3.2 Climate

The Gosnells area (closest weather station with long-term recording information within the proximity to Armadale) has a Mediterranean climate of cool, wet winters and hot, dry summers. Climatic information collected from the Gosnells meteorological monitoring station is presented in Table 1.

Table 1 Climatic information

Station	Mean Annual Minimum Temperature Range (ºC)	Mean Annual Maximum Temperature Range (ºC)	Annual Rainfall (mm)
Gosnells City (09106)	17.3 (July) – 30.5 (Jan.)	20.1 (July) – 36.3 (Feb.)	640.0[1]

Source: Bureau of Meteorology Climatic Averages of Australian Sites, 2014.

3.3 Regional Geology

3.3.1 Published Information

The 1:50,000 Environmental Geology Series "*Armadale*" Part Sheets 2033 1 and 2133 IV indicate that the site is predominantly underlain by the Bassendean Sand unit (as indicated in Figure 2). Bassendean Sand is described as a *'white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin'*. A thin layer of friable variably cemented iron and/or organic rich sands colloquially known as 'coffee rock' is commonly encountered within the vicinity of the water table.

Coffee rock forms by the precipitation of humates and iron from groundwater, mainly in the zone of water table fluctuations, and may vary between bright orange, orange brown and dark brown to black. Coffee rock horizons contain stored potential acidity in a number of forms including inorganic sulfides such as di-sulfides (pyrites) and poorly crystalline and easily hydrolysable iron and manganese oxides.

The Bassendean Sand is underlain at variable depth by alluvial clayey, silty and sandy soils of the Guildford Formation. The Guildford Formation consists of clay, sand and gravel and is variably laterised and podsolised.

Small pockets of peaty clay associated with swamps (subject to seasonal flooding) are likely to be encountered at or near surface to the south east of Skeet Road. The peaty clay found in this region is formed from swamp deposits and is described as '*grey to black, fine to medium grained, moderately sorted quartz sand, slightly peaty of lacustrine origin'*.

3.3.2 Site Specific Ground Conditions

The soils intersected during execution of the geotechnical site investigation are generally consistent with the 1:50,000 Environmental Geology map for the region. The local ground conditions along the pressure main alignment where ASS and/or dewatering management is required is described in Table 2.

[1] Annual rainfall for 2012, rainfall data for 2013 not available.

Table 2 Summary of Site Specific Ground Conditions

Section	Chainage	Subsurface Conditions	Depth (m bgl)
Section 1	0 to 1080	Topsoil: black/brown medium grained sand.	0.1 – 0.2 m
		Fill: pale yellow/brown sand with fine to medium grained limestone gravel.	0.9 – 3.5 m
		Bassendean Sand: grey/brown poorly graded sand.	Max. 3.3 m
		Guildford Formation: black medium grained silty sand/sand with gravel and weakly iron cemented clasts.	>3.5 m
Section 2	1080 to 1400	Bassendean Sand: grey to brown, fine to medium grained, poorly graded sand with trace organics.	1.5 – 2.5 m
		Guildford Formation: dark brown/black, low plasticity silty sand/sandy silts.	1.5 – 3.0 m
	1400 to 2600	Bassendean Sand: grey to brown, medium grained, poorly graded sand with trace organics.	0.5 – 2.0 m
		Guildford Formation: grey/brown clayey sand, medium grained.	>2.0 m
Section 3	2600 to 4557	Fill: pale yellow/brown sand with fine to medium grained gravel.	0 - 0.5 m
		Bassendean Sand: grey/white fine to medium grained poorly graded sand, trace organics and silt.	0 – 3.4 m
		Guildford Formation: grey to brown with medium grained sand.	>0.7 m

3.4 Regional Groundwater

The Hydrogeological Atlas of Western Australia indicates two aquifers in the area, Perth Superficial Swan and Leederville Aquifer. The Bassendean Sand geological units make up the superficial aquifer within the study area. The Leederville Aquifer is deep relative to the proposed construction and is not relevant to this ASSDMP.

Review of the Department of Water's Perth Groundwater Atlas provides information in regards to the groundwater level (May, 2003) and the historical maximum groundwater levels for the pressure main alignment. Table 3 below summarises this information.

Table 3 Summary of Groundwater

Section	Chainage	May (2003) (m AHD)	Historical maximum (m AHD)
Section 1	0 to 1080	23.5 to 22.5	25.5 to 24.5
Section 2	1080 to 2600	23.0 to 21.0	25.0 to 23.0
Section 3	2600 to 4557	21.0 to 22.0	23.0 to 25.0

The Perth Groundwater Atlas historical maximum contours are presented on Figure 3, along with the groundwater monitoring data obtained during the monitoring program in August, 2013.

3.4.1 Site Specific Groundwater

Groundwater was encountered along the pressure main alignment during the June/July 2013 site investigation and the groundwater monitoring program in August 2013. Groundwater levels were estimated during the geotechnical investigation using groundwater depth data and estimates of surface elevations obtained from contour data are presented below.

The information below presented the maximum and minimum groundwater levels observed for each alignment section.

- Section 1 - 23.5 m AHD to 25.2 m AHD;
- Section 2 - 19.5 m AHD to 24 m AHD; and,
- Section 3 - 20 m AHD to 23.2 m AHD.

3.5 ASS Risk Mapping

Review of the Department of Environment Regulation (DER), formerly Department of Environment and Conservation (DEC) ASS risk mapping available through the Landgate Shared Land Information Portal (SLIP) indicates that the majority of the alignment overlies an area of *'Moderate to low risk of ASS occurring within 3 m of natural soil surface but high to moderate risk of ASS beyond 3 m of natural soil surface*'. Additionally there are three small areas of '*High to moderate risk of ASS occurring within 3 m of natural surface soil'*. These areas correspond to the following chainages:

- Section 2: Chainage 1640 – 1780;
- Section 2: Chainage 2445 – 2653; and
- Section 2: Chainage 2305 – 3612.

These areas are associated with peaty clay (Cps) sediments as depicted on the published geological information and were also targeted during the geotechnical site investigation.

The ASS risk and the environmental constraints for the pressure main alignment are presented on Figure 4.

4. Summary ASS Investigation

4.1 Background Investigation Information

In consideration of the moderate risk of ASS, a site walkover, visual assessment and site investigation was undertaken in conjunction with the geotechnical investigation. The site works were undertaken in accordance with the Water Corporation *Acid Sulfate Soil and Dewatering Management Strategy*, prepared by Parsons Brinkerhoff (Rev. C, July 2007).

The site investigation was undertaken in conjunction with the geotechnical and contamination investigation in June and July 2013 to establish the ASS risk within the footprint of the proposed works and the risk associated with potential dewatering operations associated with construction.

Additionally, a review of photographs obtained from the geotechnical investigation (where available) and logs were undertaken to identify any additional ASS indicators.

4.2 Summary of Results

The ASS investigation is reported within the geotechnical and ASS investigation report (GHD, 2013) and the below information provides a summary of the results obtained. The site investigation results are provided with Table 1, Appendix C for information purposes and to assist with the preparation of this ASSDMP. The investigation locations are provided on Figure 5.

ASS was identified in samples collected from fifteen (15) of the twenty eight (28) push probing locations drilled during the site investigation. PASS material is associated with the black silty sands, grey silty/clayey sands, black/brown sandy silt and coffee rock horizons, generally at or below the water table.

The maximum inferred RL of PASS encountered during the investigation was 23.5 m AHD within the brown silty sand horizon at BH15, located within the Bush Forever section.

Based on the proposed pipeline invert levels, it is likely that ASS material will be disturbed as part of the construction works. An Acid Sulfate Soil Management Plan (ASSMP) will be required prior to commencing earthworks to guide the treatment and management of ASS material during construction.

5. Summary of Groundwater Investigation

The groundwater investigation was undertaken as part of the geotechnical, ASS and contaminated sites investigation in August 2013 and is reported within the geotechnical and ASS investigation report (GHD, 2013), however to assist with the preparation of this ASSDMP, the groundwater investigation has been outlined below.

5.1 Groundwater Monitoring Locations

The groundwater monitoring well locations are presented in Figure 6 and summarised in Table 4.

Table 4 Borehole Summary Information

BH ID	Chainage	Co-ordinates		Elevation (m AHD)	Depth achieved (m)	Groundwater August 2013 (mAHD)
		Easting	Northing			
BH01	47	398909	6445341	26.80	3.45	25.20
BH03	570	399047	6444936	27.00	3.45	25.20
BH06 North	2,667	400565	6443495	22.00	6.00	21.20
BH06 South	2,674	400563	6443483	22.50	6.45	21.90
BH08	3,161	400922	6443153	24.25	2.80	22.60
BH10	3,665	401281	6442799	23.40	4.50	23.20
BH11	3,853	401414	6442667	23.50	4.50	22.10
BH12	4,199	401666	6442408	23.75	4.50	22.80
BH13	4,395	401821	6442405	24.75	4.50	22.50
BH16	1,396	399664	6444386	24.40	6.00	No access
BH19	1,685	399869	6444183	23.90	6.00	No access
BH22	2,000	400097	6443966	23.80	6.00	No access
BH25	2,293	400303	6443757	22.75	6.00	No access
BH28	3,553	401204	6442881	23.25	3.00	22.10

It should be noted that due to the ongoing dewatering being carried out to facilitate construction works at the Exchange Road end of the Harrisdale subdivisional site works the groundwater levels observed in BH04 may not give a true representation of natural groundwater levels.

5.2 Groundwater Laboratory Program

Laboratory testing of groundwater samples was carried out by Australian Laboratory Services (ALS), a National Association of Testing Authorities (NATA) accredited environmental laboratory based in Malaga, Perth.

Samples were submitted for the following analytes:

- Acidity, pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS);
- Major anions (Cl, SO_4, alkalinity);
- Major cations (Ca, Mg, Na, K);
- Dissolved metals (Al, As, Cd, Cr, Fe, Mn, Ni, Se, Zn);
- Total metals (Al, Fe);
- Nutrients (nitrogen and phosphorus); and
- Sulfide.

5.3 Groundwater Assessment Criteria

The following assessment criteria have been adopted for a preliminary assessment of pre-existing contamination (if present) and ASS groundwater indicators at the Site and are referred to in the DER Assessment Levels for Soil Sediment and Water (DEC, 2010, Version 4.1).

- Fresh Water
- Short Term Irrigation (STI)
- DER ASS indicator criteria

5.3.1 Freshwater Guidelines

Guidelines for the protection of ecological receptors are provided in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000), and adopted by DER in Assessment Levels for Soil, Sediment and Water (DEC, 2010, Version 4.1).

The site is located within the vicinity of natural wetland receptors and the freshwater guidelines are considered appropriate criteria to determine whether dewatered effluent may have a detrimental effect on the wetland water quality. The freshwater guidelines present various assessment criteria depending upon the surrounding environs. It is considered for this site that where more than one assessment criterion has been made available, the Wetland values will be selected.

5.3.2 Short Term Irrigation Water Guidelines

In consideration of the potential for infiltration to be used as a method for dewatering effluent disposal, groundwater quality was compared to the STI guidelines specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000).

5.3.3 DER ASS Indicator Criteria

The DER ASS Guideline Series (DEC, 2013) outline chemical indicators that may indicate the groundwater is being affected by, or has already been affected by, the oxidation of sulfides. These indicators are outlined below.

- An alkalinity: sulfate ratio of less than 5 (Swedish EPA, 2002);
- A pH of less than 5 and/or
- A soluble aluminium concentration greater than 1 mg/L.

It should be noted that the above criteria are indicators only and do not necessarily denote that the oxidation of ASS materials has occurred. Any exceedence of the criteria should be identified and compared to other analytes prior to drawing conclusions on ASS.

Additional groundwater assessment criteria (adopted by the DER from the Swedish EPA), relate alkalinity with pH and infer the potential buffering capacity of groundwater. The assessment guide for the buffering capacity of groundwater is provided in Table 5.

Table 5 Assessment Guide for Buffering Capacity of Groundwater

Class	Designation	Alkalinity (mg/L)	pH	Description
1	Very high alkalinity	>80	>6.5	Adequate to maintain acceptable pH level in the future.
2	High alkalinity	60-80	>6.0	Adequate to maintain acceptable pH level in the future.
3	Moderate alkalinity	30-60	5.5-7.5	Inadequate to maintain stable, acceptable pH level on areas vulnerable to acidification.
4	Low alkalinity	10-30	5.0-6.0	Inadequate to maintain stable, acceptable pH level.
5	Very low alkalinity	<10	<6.0	Unacceptable pH level under all circumstances.

Table 5 Adapted from Swedish EPA, 2002.

5.4 Groundwater Quality Results (August 2013)

5.4.1 Water Quality Field Parameters

Groundwater sampled from the monitoring well was generally brown, turbid and with a slight organic odour.

The following general water quality parameters were noted:

- pH values presented ranged from 5.69 to 7.68 and is indicative of acidic to near neutral conditions.
- EC values presented ranged from 0.169 mS/cm to 21.0mS/cm and are indicative of fresh water to brackish conditions.
- Temperature values presented ranged from 17.14º C to 21.72 ºC.
- Dissolved oxygen values presented ranged from 0.59mg/L to 6.12mg/L.

5.4.2 Laboratory Results

The laboratory results and the NATA endorsed final laboratory reports are available in the geotechnical and ASS investigation report (GHD, 2013). The groundwater results are provided in Table 2, Appendix C.

Laboratory results indicate that groundwater chemistry varies along the alignment:

- pH ranges from 5.83 (BH08, Ch 3161) to 7.84 (BH11, Ch 3853);
- EC ranges from 173 µS/cm (BH08, Ch 3161) to 20,800 µS/cm (BH28, Ch 3553);
- Acidity ranges from 20 mg/L $CaCO_3$ (BH11, Ch 3853) to 113 mg/L $CaCO_3$ (BH03, Ch 570);

- Alkalinity (present as bicarbonate) ranges from 11 mg/L $CaCO_3$ (BH08, Ch 3161) to 415 mg/L $CaCO_3$ (BH06 North, Ch 2667); and
- Sulfate concentrations range from 23 mg/L (BH08, Ch 3161) to 727 mg/L (BH28, Ch 3553).

DER ASS Indicator Criteria

The following groundwater indicators were noted:

- Seven of the samples recorded alkalinity:sulfate ratios < 5. These include: BH01, BH03, BH06 North, BH08, BH10, BH11, BH12, BH13 and BH28. The remaining samples collected from BH10 and BH11 contain alkalinity:sulfate ratios > 5.
- None of the groundwater samples present pH value < 5
- None of the groundwater samples present soluble aluminium concentrations > 1 mg/L.
- Acidity ranges from 20 mg/L CaCO3 (BH11, Ch 3853) to 113 mg/L CaCO3 (BH03, Ch 570);

It should be noted that the above criteria are indicators only and do not necessarily denote that the oxidation of ASS materials has occurred. Any exceedance of the criteria should be identified and compared to other analytes prior to drawing conclusions on ASS.

ANZECC and ARMCANZ (2000) Fresh Water Ecosystem Protection Guideline

The following heavy metal concentrations exceeding the adopted assessment criteria were noted:

- Total aluminium concentrations exceeded the criteria (0.027 mg/L) in all nine (9) wells with exceedances ranging from 0.51 mg/L (BH01) up to 540 mg/L (BH13);
- Dissolved aluminium concentrations exceeded the criteria (0.027 mg/L) in seven (7) wells - BH01 (0.08 mg/L), BH03 (0.35 mg/L), BH06 North (0.11 mg/L), BH08 (0.2 mg/L), BH10 (0.85 mg/L), BH12 (0.81 mg/L) and BH13 (0.04 mg/L);
- Dissolved chromium concentrations exceeded the criteria (0.00001 mg/L) in five (5) wells – BH06 North (0.005 mg/L), BH08 (0.002 mg/L), BH10 (0.001 mg/L), BH12 (0.004 mg/L) and BH28 (0.006 mg/L);
- Dissolved copper concentrations exceeded the criteria (0.001 mg/L) in seven (7) wells – BH01 (0.002 mg/L), BH08 (0.002 mg/L), BH10 (0.005 mg/L), BH11 (0.003 mg/L), BH12 (0.006 mg/L), BH13 (0.002 mg/L) and BH28 (0.006 mg/L);
- Dissolved lead concentrations exceeded the criteria (0.001 mg/L) in two (2) wells – BH01 (0.002 mg/L) and BH12 (0.004 mg/L);
- Dissolved manganese concentrations exceeded the criteria (1.2 mg/L) in one (1) well – BH28 (1.5 mg/L);
- Dissolved nickel concentrations exceeded the criteria (0.008 mg/L) in one (1) well – BH28 (0.021 mg/L); and
- Dissolved zinc concentrations exceeded the criteria (0.0024 mg/L) in five (5) wells – BH03 (0.007 mg/L), BH08 (0.025 mg/L), BH10 (0.008 mg/L), BH12 (0.008 mg/L) and BH28 (0.024 mg/L).

No exceedances were recorded for dissolved arsenic, cadmium, cobalt or selenium concentrations in the nine (9) groundwater wells monitored.

Short Term Irrigation Water Guidelines

The following total metal concentrations exceeding the adopted assessment criteria were noted:

- Total aluminium concentrations exceeded the STI criteria (20 mg/L) in four (4) wells – BH06 North (68.7 mg/L), BH10 (184 mg/L), BH12 (26.1 mg/L) and BH13 (540 mg/L); and
- Total iron concentrations exceeded the STI criteria (10 mg/L) in four (4) wells – BH06 North (32.1 mg/L), BH10 (52.6 mg/L), BH11 (18.5 mg/L) and BH12 (76 mg/L).

6. Acid Sulfate Soil Management Plan

The management strategies outlined below and within the Flow Chart 1 will be required to ensure that there are no adverse impacts to sensitive environmental receptors within the vicinity of the site. The management practices below will be implemented to ensure that soils identified as ASS are managed accordingly.

As the tender for earthworks has not yet been awarded, the following text includes generic terms for the parties that will be involved, as defined below.

- *Contractor:* Contractor to be appointed by the Water Corporation.
- *Principal's Environmental Consultant:* Environmental consultant appointed by the Water Corporation.
- *Superintendent:* Supervising engineer appointed by the Water Corporation.

The Contractor will be responsible for ensuring that all management measures outlined in this section (or as agreed otherwise) are adhered to for the duration of their contract.

6.1 ASS Management Areas

The following ASS management areas are based on the ASS laboratory results obtained by GHD (2013) and the ASS management strategies are in accordance with the DER ASS Guideline Series (DEC, 2011) and the *Water Corporation Acid Sulfate Soil and Dewatering Management Strategy'* (Water Corporation, July 2007).

6.1.1 Topsoil

<u>No ASS treatment or management of topsoils (0 - 0.3 m bgl) is necessary during construction.</u>

For the purpose of this project, topsoil is defined as material up to the first 300 mm of the soil profile generally containing organic and vegetative matter. It is routine practice to remove the topsoil before excavation and stockpile until it is needed for top-dressing.

6.1.2 Defined ASS Areas

Table 6 below defines the areas within the pressure main alignment which are deemed to be ASS. Any soil material excavated from the areas outlined Table 6 must be managed in accordance with this section.

The treatment method for ASS has yet to be defined and therefore ASS management may be undertaken via off-site or on-site treatment operations. However due to space constraints, it is assumed that off-site disposal is the preferred management option. The sections below outline the requirements for off-site management.

6.1.3 Estimated ASS Volumes Requiring Treatment

The total volume of material excavated from the pressure main alignment will be dependent on the finalised method of construction. Table 6 below identifies the anticipated volume and type of material to be excavated.

Table 6 Defined ASS Areas and Estimated Volumes Requiring Treatment

Section	Chainage	Location Description	ASS	Lithological Description	Estimated Volume of ASS Material[2]
Section 1	819 to 1080	Exchange Ave to Skeet Rd	All material below 24m AHD or approximately 1.0m to 1.5m bgl	Guildford Formation: Black medium grained sand with traces of silt and clay (including weakly cemented clasts)	650m^3 Assumes 0.5m of material requiring treatment within trench excavations[3]
Section 2	1080 to 2600	Bush Forever Area	All material regardless of depth	Bassendean Sand: Grey to brown, fine to medium grained, poorly graded sand with trace organics underlain by Guildford Formation	Material disturbed however not excavated.
Section 3	4060 to 4400	South of Armadale Road to east side of Tonkin Highway	All material below 21.75m AHD or approximately 2.0m to 3.0m bgl	Guilford Formation: Pale brown/grey, medium grained clayey sand grading to dark grey/red brown sility sand	1750m^3. Assuming 1.0m of material requiring treatment within trench and from launch/receival pit[4] excavations

[2] Bulk density assumed at 1.6 t/m^3
[3] Trench is assumed to be 3m wide and of varying depth, typically 1m to 1.5m bgl.
[4] Launch/receival pits are assumed to be 5m (length) x 3m (wide) and approximately 1m greater depth than the invert level of the pressure main.

6.2 Treatment Option 1: Off-site Management (Transport to Licensed Facility)

6.2.1 Excavation, storage and transport offsite

Excavated ASS intended for off-site treatment will be dispatched to a licensed ASS treatment facility after excavation at the end of each excavation day.

Excavated soils not able to be dispatched at the end of each day must be stored on a limestone pad constructed to the requirements of Section 6.2.5 and should comply with the temporary storage requirements outlined in Section 6.2.4.

As a minimum, the ASS treatment facility must be provided with details of the materials they are being requested to accept (i.e. volume of material, predominant texture, the maximum net acidity value for the ASS material) which is contained in Table 7. Different facilities have varying information requirements before accepting material, and it is critical to ensure that acceptance of the material is approved prior to commencing excavation.

Table 7 Off-site Disposal Information

ASS Information (Treatment Facility)	
Material Type	**Section 1**: Black medium grained sand with traces of silt and clay (including weakly cemented clasts) **Section 3**: Pale brown/grey, medium grained clayey sand grading to dark grey/red brown sility sand
Maximum Net Acidity	**Section 1:** 220 mol H+/t **Section 3:** 36 mol H+/t
Indicative Liming Rate	**Section 1:** 35kg/m^3 (including Section 6.2.3) **Section 3: 6**kg/m3 (including Section 6.2.3)

Daily records must be kept of excavation and transport volumes, as well as records of receipt at the licensed facility.

6.2.2 Offsite Treatment: Summary of Reporting Requirements

The Contractor will prepare and maintain a daily log of all ASS material disposed off-site to the nominated licensed facility. Table 8 provides a summary of the reporting requirements.

Table 8 Summary of Reporting Requirements

	Action Item	Report to	Timeframe
Contractor	Letter of approval from the operators of the treatment facility indicating that they are aware of the nature of the soil they are receiving (i.e. ASS).	Superintendent & WC Environmental Officer	Prior to commencement of construction
Contractor	Daily log of all ASS excavated and transported offsite. Log to contain information of the location	Superintendent & WC Environmental Officer	Fortnightly during construction

	Action Item	Report to	Timeframe
	and volume of ASS removed, as well as transport destination(s).		
WC Environmental Officer	Inclusion of the letter of approval and ASS delivery receipts in the Initial Closure Report.	WC Project Manager (& DER if elected by WC Project Manager)	To be prepared within 4-6 weeks of completion of all earthworks and dewatering operations.

6.2.3 Neutralisation Rate for Excavated ASS

The Contractor should provide the following information to the licensed facility operator(s) prior to excavation.

The following uncorrected liming rate calculation assumes the following variables and is adopted from the DER ASS Guideline Series (DEC, 2013):

- Maximum Net Acidity (See relevant section along alignment) ;
- Safety Factor of 2.0;
- Conservative bulk density[5] of 1.6 t/m^3; and
- Effective Neutralising Value (ENV) of neutralising material is assumed to be 100%

Table 9 provides a summary of the neutralisation rate for the site.

Table 9 Calculated Neutralisation Rates

ASS Unit	Maximum Net Acidity Result	Assumed Bulk Density (tonne/m^3)	Uncorrected Liming Rate (kg/m^3)[6]
Section 1: Ch 819 to Ch 1080	0.35%S (220 mol H+/tonne)	1.6	35
Section 3: Ch 4060 to Ch 4400	0.06%S (36 mol H+/tonne)	1.6	6

6.2.4 Temporary Storage Time Restriction

Temporary storage of ASS onsite pending treatment off-site disposal may be for a maximum of fourteen (14) days.

Excavated ASS soils may be temporarily stockpiled pending off-site disposal on the bunded treatment pad. Based on the texture of the identified ASS material (worse case consists of sands with less than 5% clay content), temporary storage of ASS pending treatment may be for a maximum of fourteen (14) days.

6.2.5 ASS Storage and Treatment Area (Limestone Pad)

Excavated soils deemed to be ASS must be stockpiled on a bunded limestone treatment pad after excavation if transport to an off-site facility cannot be achieved at the end of each excavation day.

[5] Bulk density derived from GHD (2013)
[6] Uncorrected liming rate assumes Aglime has 100% ENV, liming rate to be corrected prior to construction.

The treatment/ holding pad will consist of the following components:

- Constructed of compacted crushed limestone of not less than 300mm in thickness. The pad shall be graded to ensure good drainage towards the back of the pad to ensure runoff and any leachate is collected within a lined stormwater collection basin.
- Three (3) sides will be bunded with limestone or similar alkaline material to a minimum height of approximately 150mm above the surface of the pad to prevent lateral run-off. A leachate collection and treatment system will also be required to manage run-off during winter periods or rainfall events.
- The stormwater collection basin should be lined with a low permeability liner (clay or synthetic). The leachate collection basin should be of sufficient size to retain the first 10mm of runoff from the bunded area, and should overflow to a separate unlined infiltration area or basin after treatment (if monitoring indicates treatment is required).
- Stockpiles should not exceed 2.5m in height.

The Contractor is to provide a description of their proposed methodology including the location of the proposed storage area, if required prior to the commencement of works. The method and location is to be approved by the WC Environmental Officer prior to the commencement of excavation and may require adjustment during works.

6.3 Treatment Option 2: Ch 1080 to Ch 2600 (Bush Forever Area)

The area within the Bush Forever area has been defined as containing ASS material within varying depth throughout the proposed pressure main alignment however is predominately located from between 1m and 1.5m bgl. ASS was detected within the termination depth of sample locations to a maximum depth of 6.45m bgl.

The Water Corporation has indicated that Eco-Ploughing through this area is considered their preferred option after consultation with the Department of Parks and Wildlife (DPaW) and Department of Environmental Regulation (DER) to preserve the Bush Forever area.

The below management strategy can only be applied to an Eco-Ploughing method and should not be applied to any other area of the pressure main to be constructed. The following assumptions and construction limitations apply to this management strategy option:

Eco-Ploughing will consist of a two stage process:

- **Stage 1**: Soils will firstly be ‘ripped’ from the natural ground surface with a bull dozer tyne. This method is considered to loosen (by vibration) and displace soil and rocks (if present).
- **Stage 2:** The second pass will insert the pipe (DN450 PE) at the required depth typically between 1.5 and 2m depth.
- No material will be removed from the site during the installation of the pipe.
- No dewatering will be undertaken during the installation of the pipeline.

6.3.1 Stage 1: Initial Ripping of Natural Soil Surface

Prior to ‘ripping’ the ground surface, a layer of AgLime should be applied to the surface at a rate of 11kg per linear meter of ripped trench (uncorrected liming rate).

AgLime should be placed directly over the area to be ripped, to a maximum of 1m wide.

The rate of AgLime application is based upon the maximum net acidity encountered along this section of the pressure main alignment during the investigations undertaken in June/ July 2013. The liming rate is considered the equivalent of neutralising material required, if material was excavated and stockpiled for neutralisation.

Once AgLime has been applied to the area to be ripped, the bull dozer tyne should then rip the proposed alignment (through the neutralising material) and therefore blend the neutralising material whilst ripping the ground surface. The vibration from the tyne is also considered to assist the blending of the neutralising material to the deeper invert depths.

Photographs of the application of the neutralising material to verify the application volume and successful ripping process should be taken every 250m along the pressure main alignment.

Neutralisation Rate for Bush Forever

The Contractor should inform the WC Environmental Officer prior to commencement of construction and provide the Product Information Sheet (PIS) provided by the AgLime supplier to ensure the liming rate can be corrected prior to application.

The following uncorrected liming rate calculation assumes the following variables and is adopted from the DER ASS Guideline Series (DEC, 2013):

- Maximum Net Acidity - 0.35%S (equivalent 220 mol H+/tonne);
- Safety Factor of 2.0;
- Conservative bulk density[7] of 1.6 t/m^3; and
- Effective Neutralising Value (ENV) of AgLime of 100%

Table 10 provides a summary of the neutralisation rate for the Eco-Plough area.

Table 10 Calculated Neutralisation Rates

ASS Unit	Maximum Net Acidity Result	Assumed Bulk Density [8](tonne/m^3)	Uncorrected Liming Rate (kg/m^2)
Section 2: Ch 1080 to Ch 2600	0.35%S (220 mol H+/tonne)	1.6	11

Note: Uncorrected liming rate has been converted from m^3 into kg per linear meter. The rate will require to be corrected once the ENV value of the imported material is provided

6.3.2 Stage 2: Insertion of Pipe Alignment

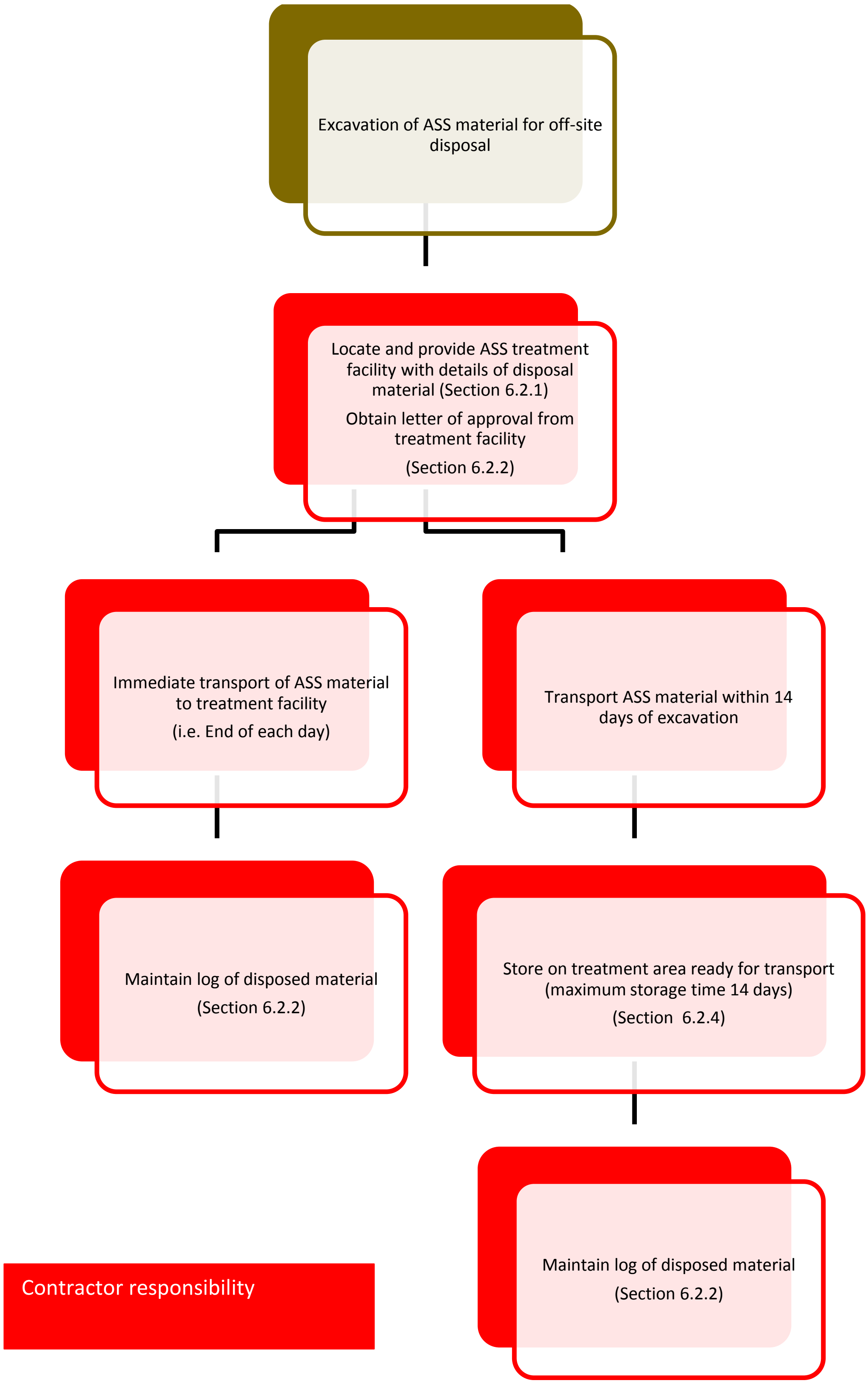
The insertion of the pipeline and backfill of natural material (including neutralising material) within one pass.

No material will be removed from the site during installation.

Photographs will be obtained of the finished alignment at 250m intervals.

[8] Bulk density derived from GHD (2013)

Flow Chart 1 Summary of ASS Off-Site Disposal Procedure



7. Dewatering Management Plan

Baseline groundwater investigations undertaken during August 2013 indicate that groundwater is classified as "Class 1: *Very high alkalinity - Adequate to maintain acceptable pH level in the future"* at most locations along the alignment (BH01, BH03, BH06 North, BH28, BH10, BH11 and BH12). Two (2) locations, BH08 and BH13 were designated as: "*Class 4: Low alkalinity - Inadequate to maintain stable, acceptable pH level"* as per the DER ASS Guideline Series (DEC, 2011).

However it should be noted that this assessment criteria does not take into account the acidity within the groundwater and the geochemistry changes that may take place during potential dewatering within identified PASS zones.

Dewatering operations should aim to maintain the current groundwater quality rather than allowing groundwater to degrade during abstraction operations. On this basis, trigger criteria and actions to manage the groundwater quality should be implemented and monitored on a daily basis during dewatering operations.

7.1 Infrastructure Requiring Dewatering

The geotechnical investigation outlined areas which have been identified as potentially requiring dewatering, determined from the maximum levels observed during the June to July investigations and August 2013 monitoring program. Dewatering is expected to be required where the observed groundwater level is either above the invert or less than 0.25 m below the invert level.

The following locations (Table 11) have been identified as potentially requiring dewatering, determined from the maximum levels observed during the June to July and August observations.

Table 11 Areas of Dewatering (August, 2013)

Section	Chainage	Comments
Section 1	Ch 0 to Ch 200 Ch 450 to 700 Ch 950 to Ch 1080	-
Section 2	-	Eco-Plough area, dewatering not required during installation. Eco-Ploughing to be undertaken when dewatering not required.
Section 3	Ch 2600 to Ch 3300 Ch 3500 to Ch 4316	High total metal concentrations exceeding short term irrigation criteria (filtration required).

Due to the seasonal fluctuation of groundwater, during construction additional areas may be identified where dewatering is required. Scheduling work for drier periods of the year will reduce the requirement for dewatering.

7.2 Dewatering Methods

The dewatering methodology would depend on the finalised construction method employed by the Contractor. However, it is likely that the following dewatering methods, or a combination thereof, could be utilised during construction.

- Dewatering spears - likely to be used for localised areas and/or trenches.
- Sump pumps - for localised dewatering inside pits and/or caissons.

7.3 Dewatering Modelling Calculations and Assumptions

GHD has estimated, using empirical modelling methods, the required abstraction rates and the potential extent of drawdown from dewatering of the excavated trenches for the pressure main. The following groundwater modelling has been based open-cut trench excavation methods with no hydraulic containment based upon the typically shallow depths of dewatering.

7.3.1 Methodology

Estimations of groundwater abstraction and the likely cones of depression have been calculated in accordance with the DER ASS Series Guideline (DEC, 2013).

The radius of influence can be estimated utilising Sichardt's equation:

$$R_o = 3000 \times s \times \sqrt{K}$$

Where: R_o = radius of influence of an equivalent pumping bore (m)
s = maximum groundwater draw down (m)
K = hydraulic conductivity of aquifer matrix (units of m/s)

Groundwater elevation resulting from dewatering activities is related to the pumping rate, hydraulic conductivity of the aquifer matrix and the radius of influence of pumping by the following equation:

$$H^2 - h^2 = \frac{nq}{\pi k}\left(\ln R_o - \ln r_e\right)$$

Where: H = saturated thickness of the aquifer undisturbed by pumping (m)
h = saturated thickness of the aquifer at maximum drawdown (m)
k = hydraulic conductivity of aquifer matrix (units of m/s)
R_o = radius of influence of an equivalent pumping bore (m)
r_e = effective radius of an equivalent pumping bore (m)
q = pumping rate of individual dewatering well points (m^3/s)
n = number of well points used to dewater the excavation

The pumping time required for the cone of depression to reach the full extent of water table drawdown is calculated utilising the Cooper-Jacob empirical relationship:

$$R_o = ((2.25\ k\ h\ t)/S)^{0.5}$$

Where: t = pumping time (seconds)
S = specific yield of aquifer sediments
Other parameters as previously defined

As a minimum, a preliminary assessment of the radial extent of the cone of depression for dewatering operations in ASS areas should be estimated.

7.3.2 Assumptions and Limitations

The scale of dewatering is subject to many assumptions such as trench dimensions (i.e. length, width, depths of excavation) and local hydrogeological conditions (i.e. connectivity to surficial aquifer, proximity of surface water bodies, precipitation).

For the purposes of these estimates, open trenching scenario within a groundwater drawdown of 1m below the groundwater table (August, 2013).

7.3.3 Calculation Assumptions

- Trench width = 3 m

- Trench length = 25 m
- Saturated thickness of the aquifer (H): 31 m
- Saturated thicknesses at maximum drawdown (h): 30 m
- Maximum groundwater drawdown: 1.0 m
- Dewatering depth: +0.5 m below trench invert
- Default hydraulic conductivities of the aquifer matrix (k): 1.91x10-4 to 9.49x10-5 m/sec (16.5 to 8.2 m/day) (Davidson, 1995)
- Specific yield of superficial aquifer (S): 0.1 (Davidson, 1995)

The above modelling assumptions have been utilised to provide the results outlined in Table 12.

Table 12 Estimated Abstraction Rate and Radius of Drawdown Estimation

Predominant Lithology	Hydraulic conductivity (m/s)*	Drawdown (m)	Cone of Depression (R_0) (m)	Estimated Abstraction Rate (L/s)	Time taken to establish required drawdown (hours)
Medium grain SAND	1.91 x10-4	1.5	41	17	4
Fine to medium grain SAND	9.49 x10-^{5}	1.5	29	10	4

Initial abstraction rates may be high to cause mass groundwater drawdown and reduce the necessary pumping time to achieve the desired dewatering invert level however GHD expect maintenance abstraction rates to be in the vicinity of 12 L/s for the project.

These abstraction rate and volume estimates are approximations only and will vary according to (but are not limited) the following:

- groundwater levels (subject to seasonal variations from rainfall events, abstraction by local residents, mounding caused by onsite re-infiltration);
- changes in ground conditions which affect the hydraulic conductivity of the soil profile;
- any construction schedule changes; and
- any sewer invert level changes.

7.4 Groundwater Acidification Risk Matrix

GHD classified the potential groundwater acidification risk at the well locations using groundwater laboratory data. Parameters assessed include acidity, alkalinity, pH, ORP, sulfate, total aluminium and iron concentrations. The likelihood of dewatering being required within 50 m was also taken into consideration.

A summary of this matrix is presented in Table 13 to characterise the risk of groundwater acidification and determine the likelihood of the groundwater (dewatering effluent once abstracted) requiring lime dosing to adjust the pH of the effluent.

Table 13 Groundwater Acidification Risk Matrix

Well ID	Chainage	Groundwater Acidification Risk	Likelihood groundwater treatment
BH01	47	Low	Possible
BH03	570	High	Highly Likely
BH05 North	Unable to be sampled		
BH05 South	Unable to be sampled		
BH06 North	2,667	Moderate	Likely
BH06 South	2,674	Moderate	Likely
BH08	3,161	High	Highly Likely
BH10	3,665	Moderate	Likely
BH11	3,853	Low	Possible
BH12	4,199	Moderate	Likely
BH13	4,395	High	High Likely
BH16	Unable to be sampled		
BH19	Unable to be sampled		
BH22	Unable to be sampled		
BH25	Unable to be sampled		
BH28	3,553	Moderate	Likely

7.5 Management of Dewatering Effluent

Monitoring of the dewatering effluent and groundwater will be undertaken in accordance with Table 17 and the trigger levels provided within this table are based upon the DER ASS Guideline Series (DEC, 2011) and the baseline water quality parameters obtained during August 2013.

7.5.1 Dewatering Effluent Management

Dewatering effluent should be directed to a retention basin or holding tank immediately after abstraction. The retention basin will be constructed as per the following requirements to enable monitoring of the effluent and flocculation of metals prior to discharge.

- Dewatering effluent will be initially directed to an impermeable retention basin or holding tank (similar to a sea container), to allow sufficient time for the mixing (if applicable) and aeration process to flocculate and settle solids, subject to space constraints.

The retention area will be of sufficient size to contain the dewatering effluent and allow the filtration of metals and Total Suspended Solids (TSS) prior to discharge.

Table 14 outlines the recommended dimensions of the retention area and is based on an abstraction rate (and ultimately the construction method) proposed by the Contractor.

It is important to note that prior to the basin size being set by the Contractor the assumptions behind the dewatering volume calculated in this report will require validating (i.e. dewatering section dimensions, groundwater depth, dewatering rate, etc.).

The Contractor is responsible for the construction and modification (if required) of the retention area.

A schematic of the dewatering effluent management system considered suitable for the site is presented in Appendix D. Variations of the effluent management system must be discussed with the WC Environmental Officer prior to commencement.

Table 14 Recommended Retention Basin Sizes (based on depth of 0.5m)

Discharge Rate (L/S)*	Approx. Area (m^2)	Approx. Length (m)	Approx. Width (m)
1.60	12.25	4.95	2.48
3.00	24.51	7.00	3.50
6.00	49.01	9.90	4.95
12.00	98.03	14.00	7.00
18.00	147.04	17.15	8.57

Table 14, adapted from Table 3.1 of DoE, 2004)

* Assuming one hour of effluent storage capacity.

7.5.2 Dewatering Effluent Disposal Options

The dewatering disposal options will depend on the dewatering rate, infiltration rates and the abstracted groundwater quality.

The currently identified disposal options and in order of preference, are:

- Re-infiltration within close proximity to the dewatering operations (i.e completed service trenches) identified on Figure 6;
- Discharge into sewer network (permit required); and
- Discharge into stormwater system (permit required).

Re-infiltration

Re-infiltration is the preferred method of disposing of effluent subject to water quality and the trigger criteria outlined in Table 17.

Re-infiltration on-site may be a feasible dewatering discharge disposal option, if a suitable area is available during construction. Re-infiltration (post retention) may be viable over completed service trenches, however the re-infiltration rate would depend on the dewatering rates/volume and the infiltration capacity and depth to groundwater level at the time of construction.

Abstraction in some areas may exceed infiltration rate and the infiltration of effluent over completed services may not be a sole viable option. In this instance excess dewatering effluent can either be stored in holding tanks for infiltration over a period of time during the construction period or the construction of infiltration basin located to the east of Ch 0 to 1080 (subject to permission from the land owner). The construction of basins or disturbance of any Bush Forever area is not permitted.

Discharge to Sewer

Disposal to the sewer may be a feasible option, however, the following should be considered:

- Approval would be required from the Water Corporation by lodging a “one-off discharge of industrial waste”.
- The disposal volume is normally restricted by the sewer capacity, which would need to be discussed with the Water Corporation and would depend on the expected discharge rates and volumes.

This disposal option would require limited on-site treatment (pH adjustment and Total Suspended Solids (TSS) given the groundwater quality information obtained in August 2013.

Discharge to sewer may also be considered as a contingency measure as a backup to other selected disposal option(s) such as re-infiltration.

7.5.3 Treatment of Dewatering Effluent

Baseline groundwater data obtained during August 2013 provides an indication of the quality of the effluent likely to be abstracted during dewatering, however water quality can change during the dewatering process (as groundwater is drawn down in from within the cone of depression, subjected to increased aeration/oxygen).

Neutralisation via a Lime Dosing Unit (LDU) prior to discharge is likely to be required during construction and dewatering. As such a LDU should be sort and all effluent should pass through the LDU and neutralised on an ‘as required’ basis.’

7.5.4 Filtration of Dewatering Effluent

Baseline groundwater quality indicates the dewatering effluent is likely to have a dissolved metal concentration (particularly iron and aluminium) below the STI and DER ASS Criteria (10mg/L (STI) and 1mg/L DER ASS Criteria respectively) indicating that filtration of dewatered effluent is not required during the dewatering operations.

Groundwater quality information indicates exceedances when compared to Freshwater Guidelines, these are considered conservative criteria, however effluent should not be discharged directly to surface water bodies without retention and/or consultation with the WC Environmental Officer.

A schematic of the recommended dewatering effluent treatment system is presented as Appendix D.

7.6 Dewatering Effluent Monitoring

7.6.1 Dewatering Effluent Monitoring Locations

Dewatering effluent will be monitored at the following locations throughout the dewatering program and analysed for the parameters outline in Table 15.

- **Monitor Point 1**: Monitoring effluent prior to entering the retention basin (before LDU if this is required).
- **Monitor Point 2**: Monitoring effluent prior to entering the infiltration area.

7.6.2 Dewatering Effluent Monitoring Suite

Dewatering effluent should be tested for the parameters and analytes outlined in Table 15.

Table 15 Dewatering Effluent Monitoring Suite

Dewatering Effluent Monitoring (DEC 2013)	
Total acidity	Manganese (total)
Total alkalinity	Nickel (total)
pH	Zinc (total)
Sulfate	Selenium (total)
Chloride	Ammoniacal nitrogen
Aluminium (dissolved)	Hydrogen sulfide
Aluminium (total)	EC
Arsenic (total)	Total suspended solids (TSS)
Chromium (total)	TDS
Cadmium (total)	Total nitrogen
Iron (total)	Total phosphorus
Iron (dissolved)	Filterable reactive phosphorus (FRP)

7.6.3 Groundwater Monitoring during Dewatering Operations

Groundwater will be monitored every second day by the Contractor during dewatering from the monitoring bores outlined in Table 13 and identified on Figure 6 when the bores are located within 200m of the dewatering operations for the field parameters:

- pH, EC, total acidity and static water level.

Groundwater results to be provided on a weekly basis to the WC Environmental Officer or within 24 hours, if groundwater quality degrades to the trigger criteria outlined in Table 16.

Table 16 Groundwater Trigger Criteria

Analyte	Trigger Criteria	Determined From	Action
pH	- 10% from baseline pH value	Second day field results	Notify WC Environmental Officer within 24hrs
Total Acidity	>25% increase from the baseline value	Second day field results	
Static Groundwater Level	- 10cm from baseline values at maximum 100m radius of dewatering operations.	Second day field results	

Table 17 Dewatering Effluent Monitoring Matrix: Monitoring Frequency, Analytes, Trigger Levels and Actions

	Trigger	Action	Monitoring
1a.	**Total titratable acidity <40mg/L** pH >6	Continue daily field measurements of pH and total titratable acidity	**Daily** – field measurement: pH, electrical conductivity (EC) & Total Titratable Acidity (TTA). **Fortnightly** - laboratory analysis: total acidity, total alkalinity, pH
2a.	**Total titratable acidity <40mg/L** pH in range of 4 to 6.	Undertake neutralisation treatment (liming)	**Daily** – field measurement: pH, EC & TTA, total alkalinity **Fortnightly** - laboratory analysis: total acidity, total alkalinity, pH
3a.	**Total titratable acidity in range 40mg/L to 100mg/L** pH>6	Undertake neutralisation treatment (liming) Effluent should be aerated to precipitate dissolved iron and directed to a series of settlement basins/trenches or other treatment system to allow removal of iron and other metals	**Daily** – field measurement: pH, EC & TTA, total alkalinity **Weekly** - laboratory analysis: total acidity, total alkalinity, pH **Fortnightly** - field measurement: dissolved oxygen (DO), redox potential (Eh)
4a.	**Total titratable acidity in range 40mg/L to 100 mg/L** pH in range of 4 to 6	Undertake neutralisation treatment (liming) Effluent should be aerated to precipitate dissolved iron and directed to a series of settlement basins/trenches or other treatment system to allow removal of iron and other metals	**Daily** – field measurement: pH, EC, TTA, total alkalinity **Weekly -** laboratory analysis: total acidity, total alkalinity, pH **Fortnightly** - laboratory analysis: total acidity, total alkalinity, pH, sulfate, chloride, total iron, dissolved iron (filtered), total aluminium, dissolved aluminium (filtered), total arsenic, total chromium, total cadmium, total manganese, total nickel, total zinc, total selenium, ammoniacal nitrogen, EC, total suspended solids (TSS), total dissolved solids (TDS), total nitrogen (TN) and total phosphorus (TP) **Fortnightly** - field measurement: DO, Eh
5a.	**Total titratable acidity >100mg/L** or pH<4 or **Total alkalinity <30mg/L**	Increase neutralisation treatment (liming) rate Effluent should be aerated to precipitate dissolved iron and directed to a series of settlement basins/trenches or other treatment system to allow removal of iron and other metals Advise Department of Environment Regulation (DER) Contaminated Sites Branch (CSB) immediately. CSB may advise appropriate action which may include ceasing dewatering	**Twice Daily –** field measurement: pH, EC, TTA, total alkalinity **Weekly** - laboratory analysis: total acidity, total alkalinity, pH, sulfate, chloride, total iron, dissolved iron (filtered), total aluminium, dissolved aluminium (filtered), total arsenic, total chromium, total cadmium, total manganese, total nickel, total zinc, total selenium, ammoniacal nitrogen, EC, TSS, TDS, TN and TP. **Fortnightly -** field measurement: DO, Eh May be required to undertake investigations to determine the size of the “acidic footprint” created and manage this impact appropriately

Additional notes:

[1] A slurry made from crushed limestone is the generally preferred neutralisation material. Other neutralising agents, such as hydrated lime or quick lime can be used, however they quickly increase the receiving waters' pH and can result in pH overshoot.

[2] Measurement of metal concentrations in dewatering effluent should be as total concentrations from an unfiltered water sample. These concentrations should then be used to determine appropriate treatment options for the effluent and to identify any emerging trends in groundwater quality. It is not the intention that these values for total metals be directly compared against environmental or health-based criteria for dissolved metals. However, when determining treatment options, it should be borne in mind that: **a)** any metals contained within suspended solids have the potential to be mobilised if pH and/or REDOX conditions change (which is obviously fairly common in ASS environments); and b) if dewatering effluent is to be discharged into a receiving environment then these suspended solids will be discharged along with the water.

Adapted from (DEC 2011).

Table 18 Roles and Responsibilities – Dewatering Effluent and Groundwater Monitoring

Responsibility	Task	Actions
Contractor	Continuously monitoring the dewatering discharge rate and volume. Daily monitoring and recording of the pH, EC, TTA and TAAlk of the dewatering effluent, subject to trigger criteria outlined in Table 17. When using retention areas, water sampled daily from the inlet and outlet point supplying the first tank. The trigger criteria specified in Table 17 will be used to determine the level of treatment required, or if more frequent field monitoring is required. Daily monitoring of dewatering effluent with respect to visual assessment, for example high sediment loading, iron precipitation, colour, odour etc. Daily assessment of the geofabric textiles (when installed) within the dewatering treatment system and cleaning/replacement, as required. Second day monitoring of the groundwater bores at the site for pH, EC, TTA during dewatering operations. Fortnightly groundwater monitoring of groundwater bores during dewatering operations as per Section 7.6.3.	Results of the water monitoring programs along with actions taken to achieve water quality targets including quality of the dewatering effluent to be provided to the WC Environmental Officer on a weekly basis. Results to be provided within 24 hours of water quality falling outside the parameters in Table 17.

7.7 Dewatering Management Roles and Responsibility

The water monitoring program including roles and responsibilities, outlined in Table 18, will be undertaken during dewatering operations.

A flow chart outlining the Actions and Responsibilities in relation to dewatering effluent and is included as Flow Chart 2. It is anticipated that this flow chart will be distributed amongst the Contractors at the start of the construction phase to compliment and disseminate the information contained within this management plan.

Example checklists for groundwater and dewatering effluent monitoring for the Contractor are included in Appendix E. The daily field sheet outlines all daily field measurements that are required to be recorded by the appointed Contractor and submitted to the Water Corporation on a weekly basis.

7.8 Decommissioning of Retention Basin

At the completion of the works, the WC Environmental Officer (or Principal's Environmental Consultant on formal delegation from the WC Environmental Officer) will be responsible for collection of samples of the accumulated sediments at the base of the retention basin (if utilised instead of the holding tank). The results will be used to determine the appropriate decommissioning requirements and disposal method for the accumulated sediments.

Accumulated sediments at the base of the holding tank should be disposed of by the Contractor to an appropriate facility. Sediments should not be disposed of on-site without prior consultation with the WC Environmental Officer.

Sample analyses will include, but not be limited to:

- SPOCAS; and
- Metals (Al, As, Cr, Cu, Fe, Mn, Pb, Ni, Se and Zn).

Once laboratory analysis is completed, sediments will be classified based upon the *Landfill Waste Classification and Waste Definitions* (DoE, 1996, as amended December 2009) and disposed offsite at an appropriate waste disposal facility.

7.9 Residential Bores Affected by Dewatering Operations

A search of the Department of Water (DoW) borehole database (WIN) was carried out to identify any registered bores within close proximity of the Site in March 2014.

Two (2) registered bores are located within a 500m radius of the site, both of these bores are located >100m from any dewatering operations and are operated by the City of Kwinana. The bores are licensed to abstract water from the superficial aquifer, the aquifer intended to be dewatered during construction.

Additionally some properties within and adjoining the works may have bores for producing water for their gardens. As the functionality of these bores and the quality of water may be affected by the dewatering works required for the construction of the infrastructure property owners/occupiers will have to be notified of the works prior to commencement.

The dewatering operations are not anticipated to extend beyond 100m of the dewatering site and therefore bores on the WIN database should remain unaffected.

7.9.1 Inspections of Bore and Reticulation Systems

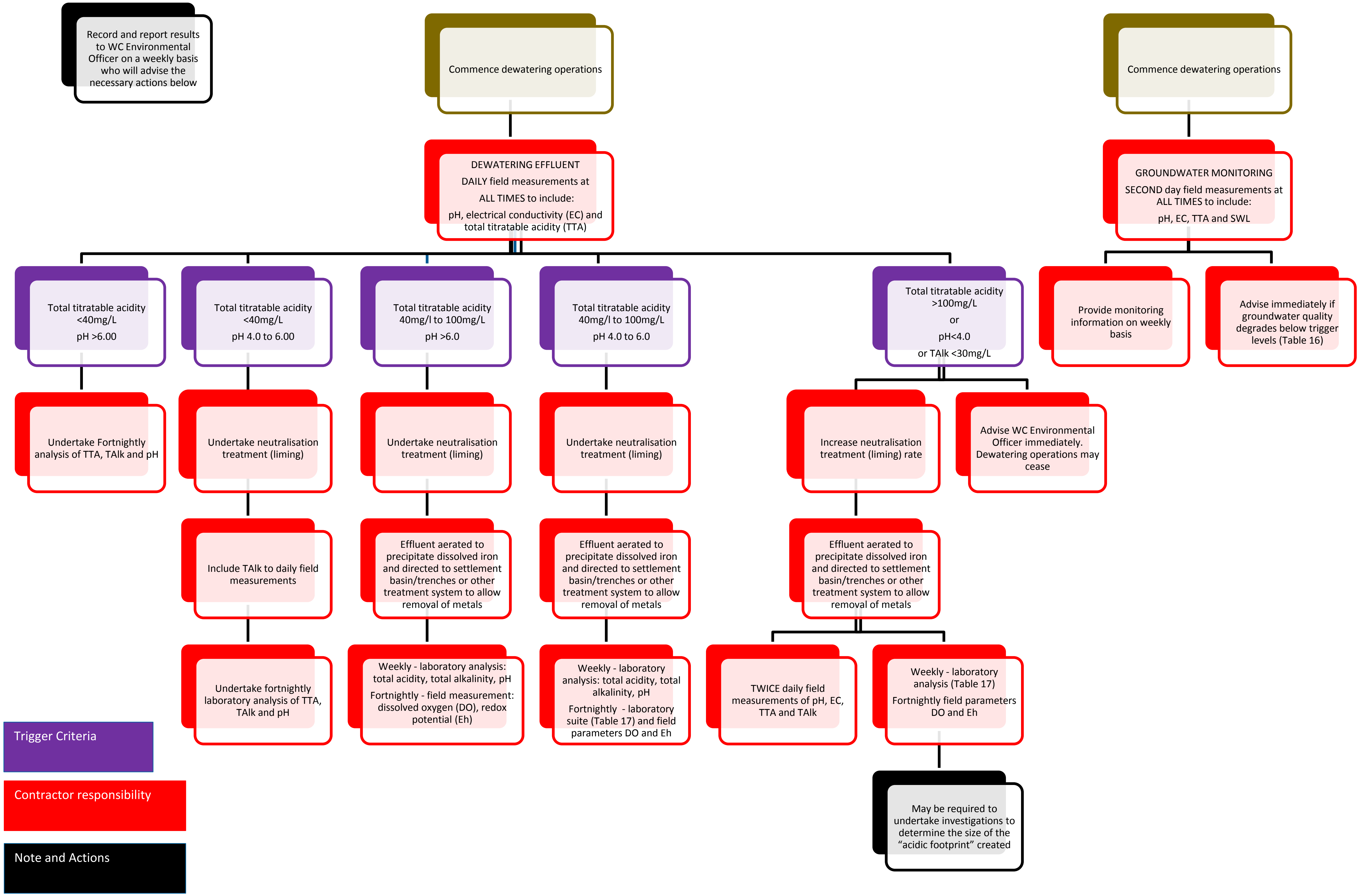
When dewatering is to commence at the pump station site, the Contractor shall:

- Request a list from the Superintendent identifying the owners and occupiers of known bores within 100m radius of the dewatering operations.
- Request an inspection of all properties within a 100m radius of the pump station to determine, if there is a bore on the property;
- Obtain the owner/occupiers permission and test the bore to confirm whether the bore is in operational or not;
- If the bore is operational then confirm which of the sprinkler or other outlets are in working order;
- Obtain the owner/occupiers signature on a 'pro forma' letter and plan of the sprinkler system to confirm they agree with results of the inspection;
- Leave the original signed letter and plan with owner/occupier, and retain a copy for the Contractor records;
- Leave a letter with the owner/occupier advising them of the start and finish date of dewatering work that will affect their property and advising them that they should not use the bore until advised by the Contractor;
- Reinspect each property with a working bore following completion of dewatering work and confirm that what equipment was working satisfactorily before, is still working satisfactorily;
- Obtain the owner/occupiers signature on the 'pro forma' letter and plan of the sprinkler system to confirm they are satisfied with results of the final inspection.

7.9.2 Records of Bore and Reticulation System Inspections

The Contractor shall maintain a file of copies of the 'bore and reticulation system' letters endorsed by the owner/occupier. A copy of the letters shall be provided to the Superintendent at the kick-off meeting.

Flow Chart 2 Summary of Monitoring and Management during Dewatering Operations



8. Groundwater Monitoring Program

8.1 General

Groundwater monitoring is an integral part of any project, where dewatering is undertaken as it allows for any changes in land and water quality to be monitored pre, during and post construction, giving an indication as to the success of the management strategies implemented.

A comprehensive monitoring program (including additional bores) will require to be finalised once the design and construction methods have been finalised. The extent of dewatering operations and type of construction method will dictate the number and location of bores required.

8.1.1 Additional Groundwater Wells

GHD recommend prior to construction commencing that wells at locations BH05 North and BH05 South be re-drilled to monitor groundwater levels and chemistry. This will provide a better network of groundwater wells to monitor pre, during and post-construction.

8.1.2 Replacement of Un-operational Groundwater Wells

It is considered that if any groundwater wells are rendered unusable as a result of construction, they will be required to be replaced as soon as possible after the well has been determined to be unusable. The WC Environmental Officer is to be informed immediately when a well has been damaged or rendered unusable.

8.2 Groundwater Monitoring Program

The groundwater monitoring program will utilise selected monitoring wells listed in Table 19 and shown in Figure 6 for the duration of the site works.

Table 19 Groundwater Monitoring Wells

BH ID	Chainage	Co-ordinates		Elevation (m AHD)	Depth (m)
		Easting	Northing		
BH01	47	398909	6445341	26.80	3.45
BH03	570	399047	6444936	27.00	3.45
BH06 North	2,667	400565	6443495	22.00	6.00
BH06 South	2,674	400563	6443483	22.50	6.45
BH08	3,161	400922	6443153	24.25	2.80
BH10	3,665	401281	6442799	23.40	4.50
BH11	3,853	401414	6442667	23.50	4.50
BH12	4,199	401666	6442408	23.75	4.50
BH13	4,395	401821	6442405	24.75	4.50
BH16	1,396	399664	6444386	24.40	6.00
BH19	1,685	399869	6444183	23.90	6.00
BH22	2,000	400097	6443966	23.80	6.00
BH25	2,293	400303	6443757	22.75	6.00
BH28	3,553	401204	6442881	23.25	3.00

Note: The proposed additional bores are likely to be required to monitor groundwater quality during dewatering operations. The location and extent of the monitoring program may be modified once the construction method is finalised.

8.2.1 Groundwater Monitoring Pre-Construction

The groundwater results presented in Section 5 are considered to be baseline groundwater geochemistry at the time of reporting. It should be noted that groundwater geochemistry within the well sampled is likely to change between the time this report is prepared and the commencement of construction.

Groundwater monitoring will be undertaken of the existing groundwater wells (Table 17) and any additional re-installed monitoring wells considered appropriate for the construction program within four (4) weeks prior to construction and this will be considered the most representative baseline groundwater quality against which results collected during and post-construction will be assessed.

8.2.2 Groundwater Monitoring During Construction

Groundwater monitoring will be undertaken on a fortnightly basis (during dewatering only) in order to assess groundwater quality trends within monitoring bores located within 200m radius of the dewatering operations. Table 20 outlines a summary of the overall monitoring program.

8.2.3 Groundwater Monitoring Post-Construction

Three (3) groundwater monitoring events undertaken bi-monthly over six months will be undertaken once construction has been finalised, if dewatering extends beyond 4 weeks and/or deterioration of groundwater quality is noted. All bores monitored during dewatering operations will be included in the post construction monitoring program.

Table 20 Overall Groundwater Monitoring Program

Parameter	Frequency	Responsibility
Pre-Construction		
Groundwater Suite as outlined in Section 5.2.	Prior to site works commencing	Principal's Environmental Consultant
During Construction (Dewatering Periods Only)		
Groundwater Suite as outlined in Section 5.2.	Fortnightly during dewatering (unless dewatering quality deteriorates – refer to Trigger criteria outlined in Table 17	Contractor
Post-Construction		
Groundwater Suite as outlined in Section 5.2.	Post-Construction once construction and dewatering have ceased	Principal's Environmental Consultant

8.3 Groundwater Action Criteria

GHD recommends the following groundwater trigger criteria (Table 21) are implemented during monitoring events and during dewatering to assess groundwater quality trends and ensure groundwater quality is not degraded.

Table 21 Groundwater Trigger Criteria

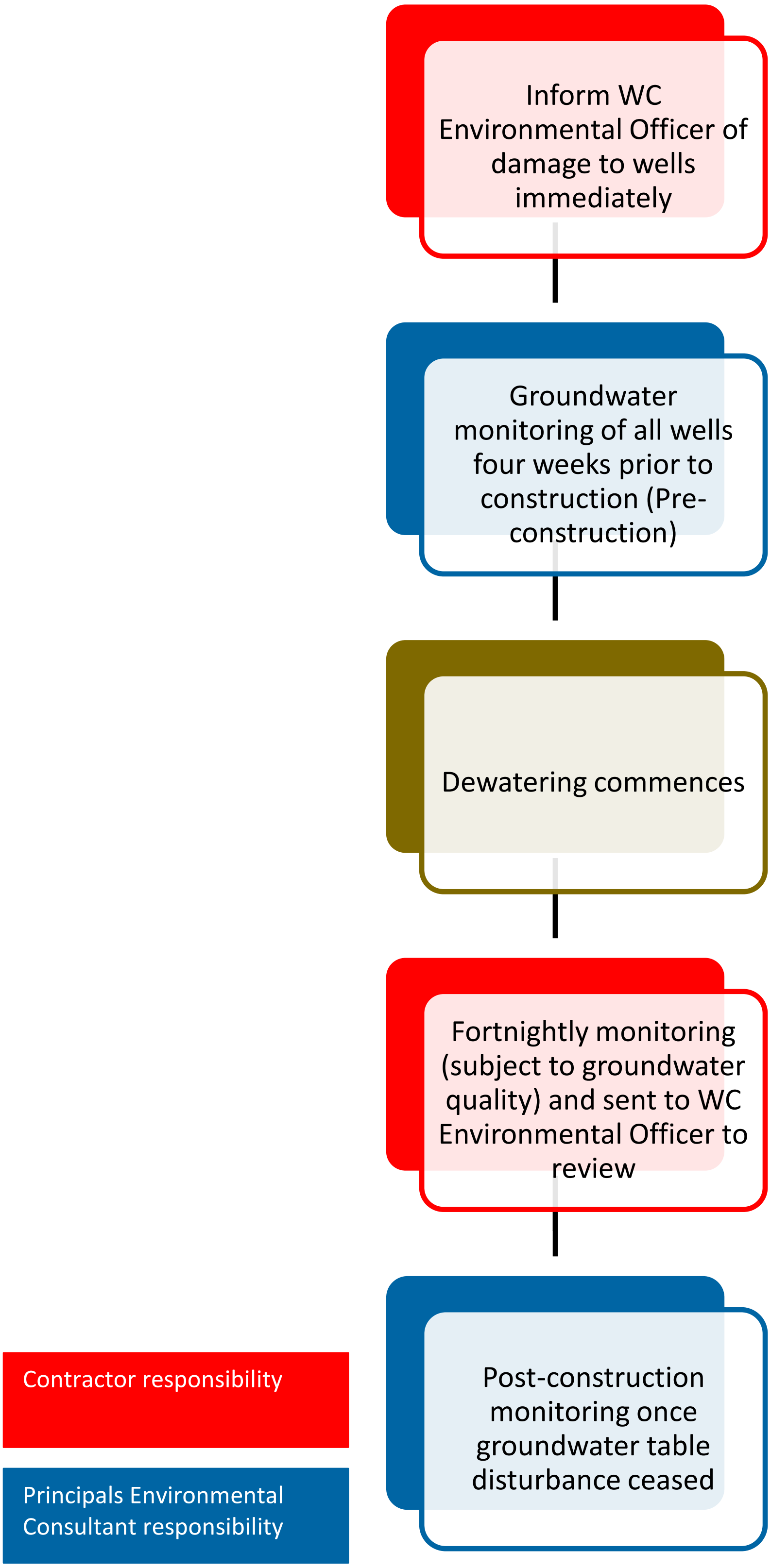
Analyte	Trigger Criteria	Responsibility	Determined From
pH	- 10% baseline value	WC Environmental Officer	Daily field results AND Fortnightly laboratory results
Total Acidity	>25% increase from the baseline value	WC Environmental Officer	Daily field results AND Fortnightly laboratory results
Soluble Aluminium	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results
Soluble Iron	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results

The pH and acidity will be compared to background results obtained from monitoring well baseline monitoring and the trigger values given in Table 21 (frequency of monitoring should be altered accordingly by the WC Environmental Officer).

The Flow Chart 3 provides a summary of the groundwater monitoring program and responsible parties for the monitoring.

Contingency measures outlined within Section 9 should be adhered to if the groundwater trigger criteria are exceeded.

Flow Chart 3 Summary of Groundwater Monitoring



9. Contingency Strategy

GHD recommends the following dewatering effluent and groundwater trigger criteria (Table 22) are implemented during monitoring of effluent:

Table 22 Dewatering Effluent Trigger Criteria

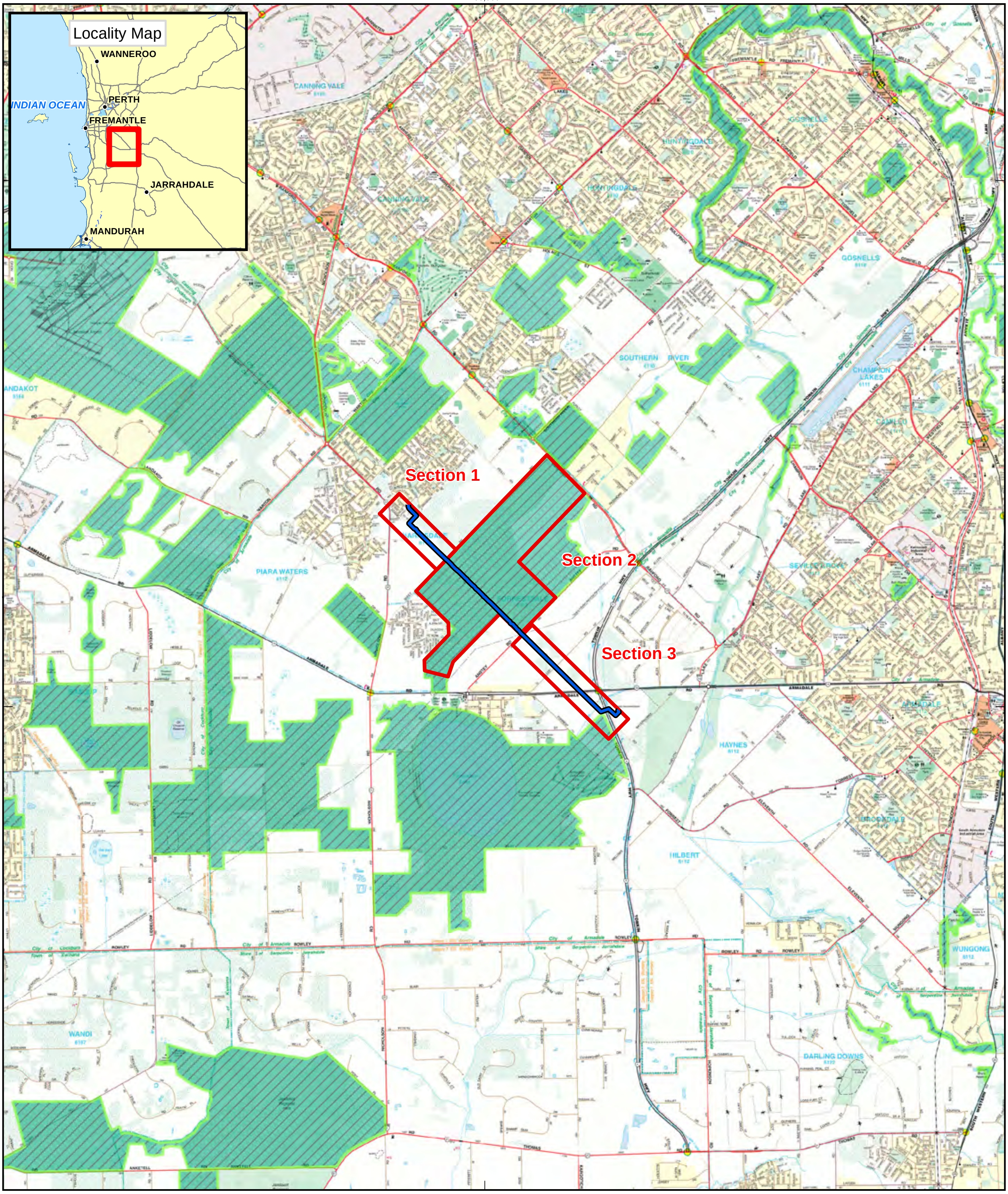
Analyte	Trigger Criteria	Responsibility	Determined From
pH	- 10% baseline value	Contractor	Daily field results AND Fortnightly laboratory results
Total Acidity	>25% increase from the baseline value	Contractor	Daily field results AND Fortnightly laboratory results
Soluble Aluminium	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results
Soluble Iron	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results

If any of the triggers in are exceeded, it is recommended that the dewatering operations are ceased (where practically possible) to avoid unnecessary environmental damage. If there is a significant delay between a trigger level being reached and the mitigation measures being implemented, this could result in unacceptable damage to groundwater quality and other sensitive receptors. The WC Environmental Officer may advise on the following contingency measures to take place:

- Commence/increase liming rates via the automated lime dosing unit;
- Employ the use of aeration/settlement tanks with geotextile fabric to remove total iron, aluminium and other metal floc;
- Implementation of longer settlement times (which may involve more settlement tanks to cater for areas requiring significant discharges);
- Implementation of increased aeration (for example, use of sprayer head);
- Modification of dewater effluent reinjection to limit drawdown in area of concern;
- Modification of the construction method (i.e. implementation of cut off walls to localise impact of dewatering and reduce the cone of depression).
- The WC Environmental Officer should be consulted if pH and total acidity trigger criteria in Table 16 are exceeded during dewatering.

Appendices

Appendix A - Figures



Legend

- Pressure Main
- Section
- Bush Forever

1: 75,000 (at A4)

0 375 750 1,500 2,250 3,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

Job Number 61-29471
Revision 0
Date 17 Apr 2014

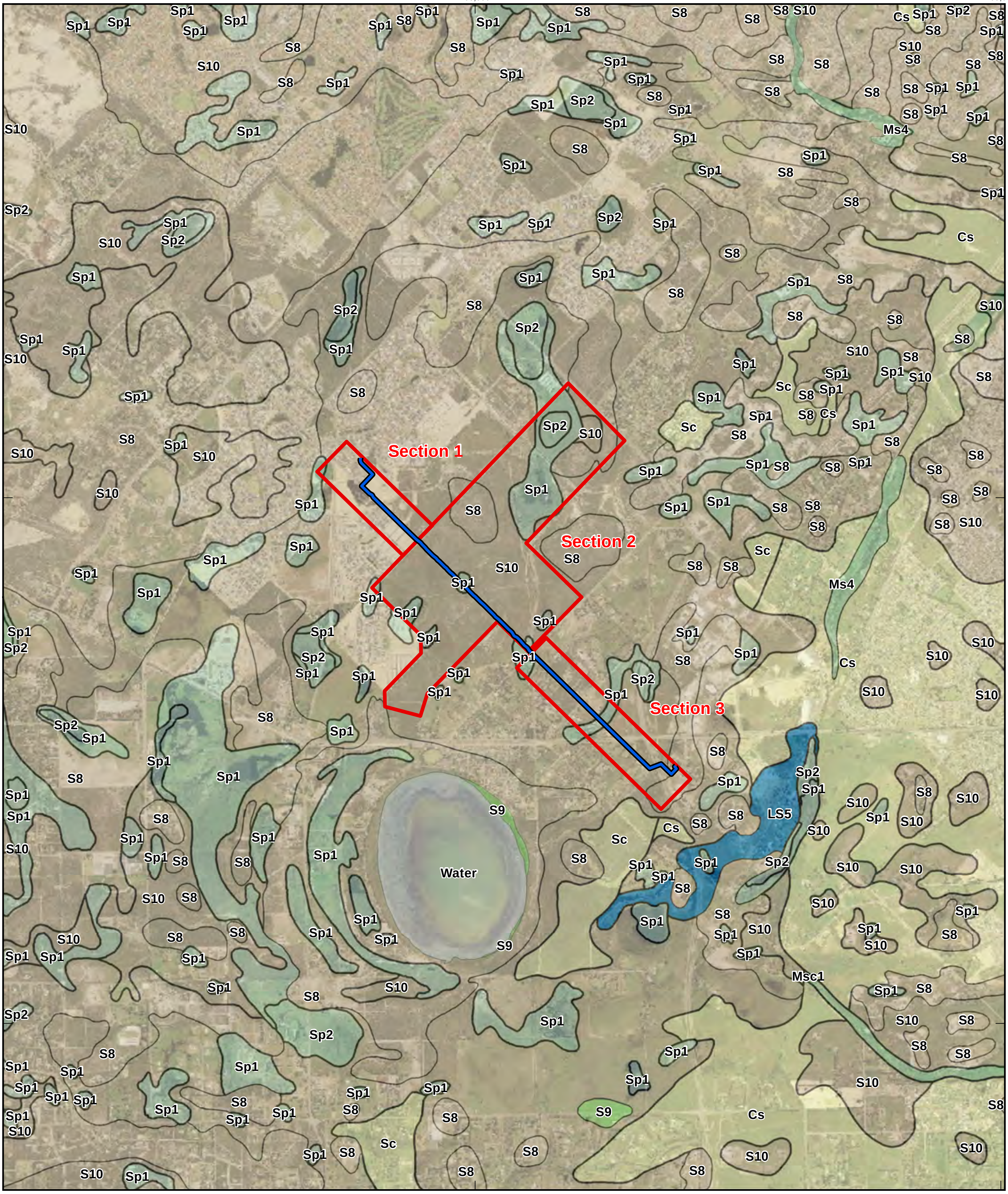
Locality Plan and Site Location

Figure 1

G:\61\29471\GIS\Maps\MXD\6129471_G001_Rev0.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: GHD: Pressure Main - 20140415, Section - 20140415; DoP: Bush Forever - 20120301; GA: Topo 250k Series 3 - 2006; WC: Streetsmart Directory - 2011. Created by: mczekaj



Legend

- Pressure Main
- Section

Geology 50k

- Sp1 - PEATY SAND - grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin
- Sp2 - PEAT-RICH SAND - fine to medium-grained quartz sand with much brown to black organic material, grades to peat, of lacustrine origin
- Ms4 - SANDY SILY - cream to pale brown alluvium, clayey in part, fine to medium-grained sand, of alluvial origin
- Msc1 - CLAYEY SANDY SILT - pale brown, angular to rounded sand, low cohesion, of alluvial origin
- S9 -
- LS5 - LIMESTONE - white to cream, fine-grained, algal lamination common
- S8 - SAND - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangul0ar to subrounded, minor heavy minerals, of eolian origin
- S10 - SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin
- Sc -
- Cs -
- Water -

1: 50,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

Job Number	61-29471
Revision	0
Date	17 Apr 2014

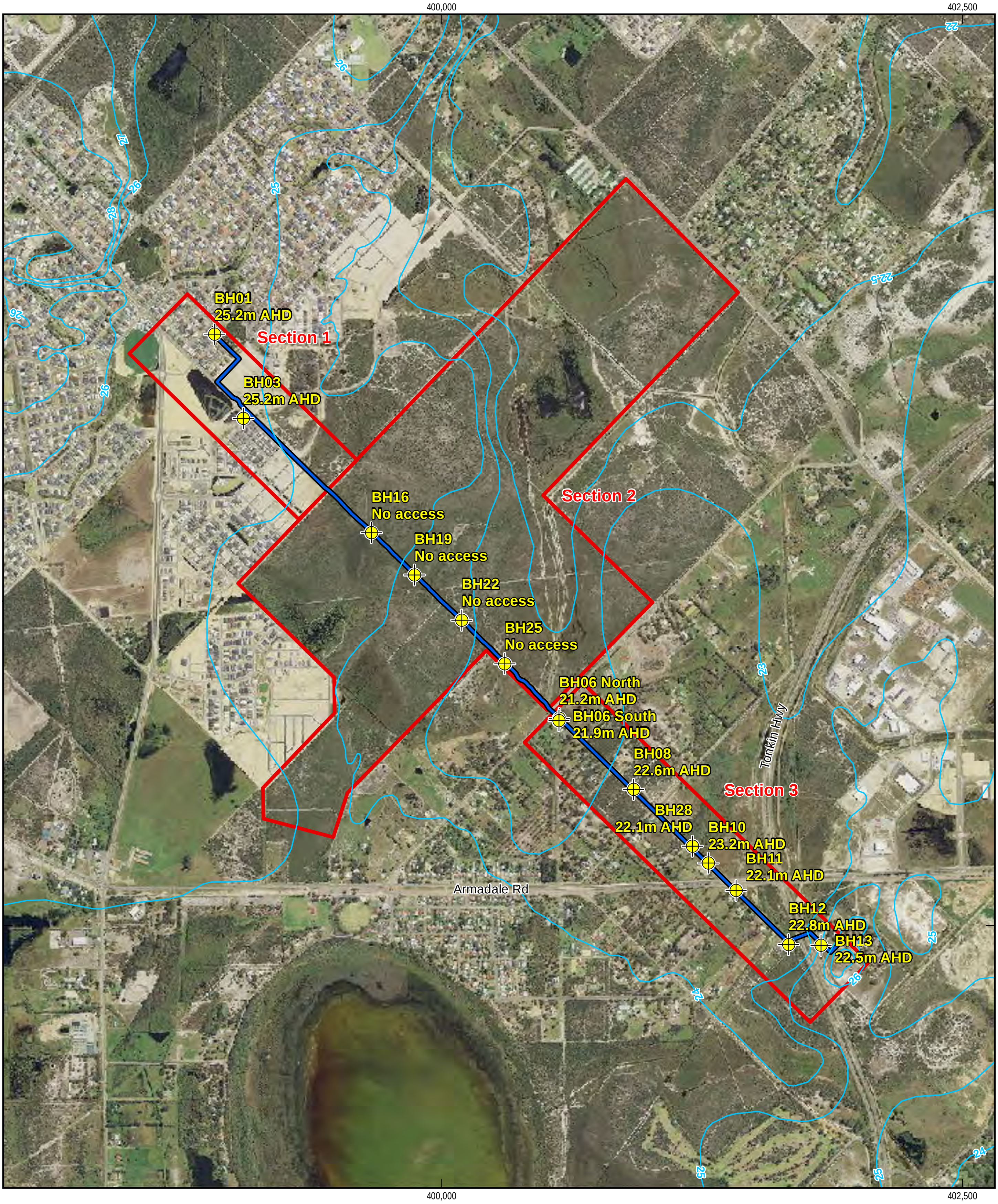
Published Geological Information

Figure 2

G:\61\29471\GIS\Maps\MXD\6129471_G002_Rev0.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: GHD: Pressure Main - 20140415, Section - 20140415; Landgate: Virtual Mosaic - 20140416; DMP: Geology 50k - 20120612. Created by: mczekaj



Legend

- Groundwater Well
- Groundwater Contours Maximum
- Pressure Main
- Section

1: 25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

Maximum Groundwater Contours (Perth Groundwater Atlas) and August 2013 Groundwater Levels

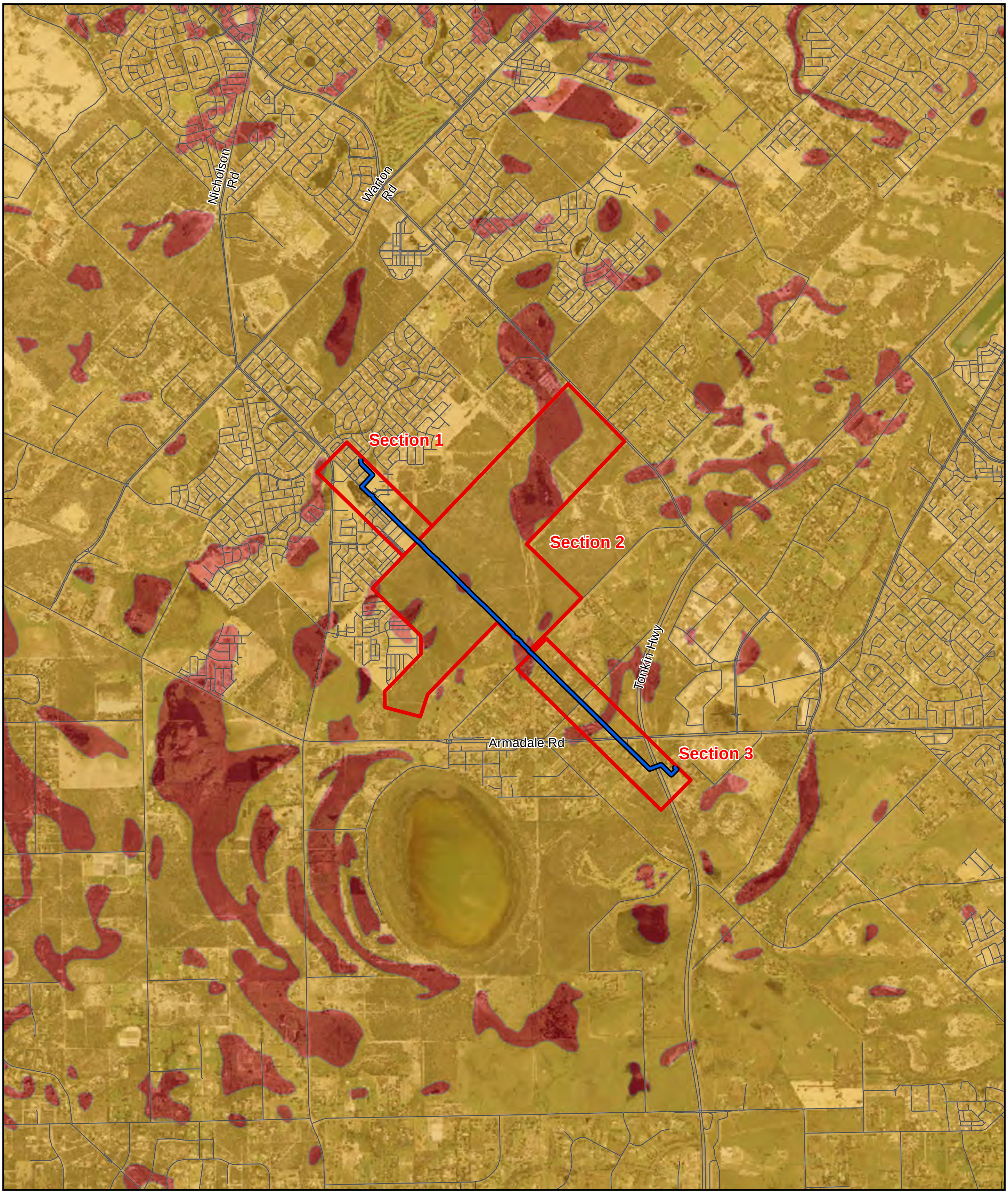
Job Number	61-29471
Revision	0
Date	17 Apr 2014

Figure 3

G:\61\29471\GIS\Maps\MXD\6129471_G003_Rev0.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: GHD: Pressure Main - 20140415, Section - 20140415, Groundwater Well - 20140416; DoW: Groundwater Contours Maximum - 20050725; Landgate: Virtual Mosaic - 20140416, Road Names - 20140416. Created by: mczekaj



Legend

Pressure Main	**Acid Sulfate Soil Risk**
Section	Class 1 - High to moderate risk of ASS occurring within 3m of natural soil surface
Road	
	Class 2 - Moderate to low risk of ASS occuring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

1: 50,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

Job Number	61-29471
Revision	0
Date	17 Apr 2014

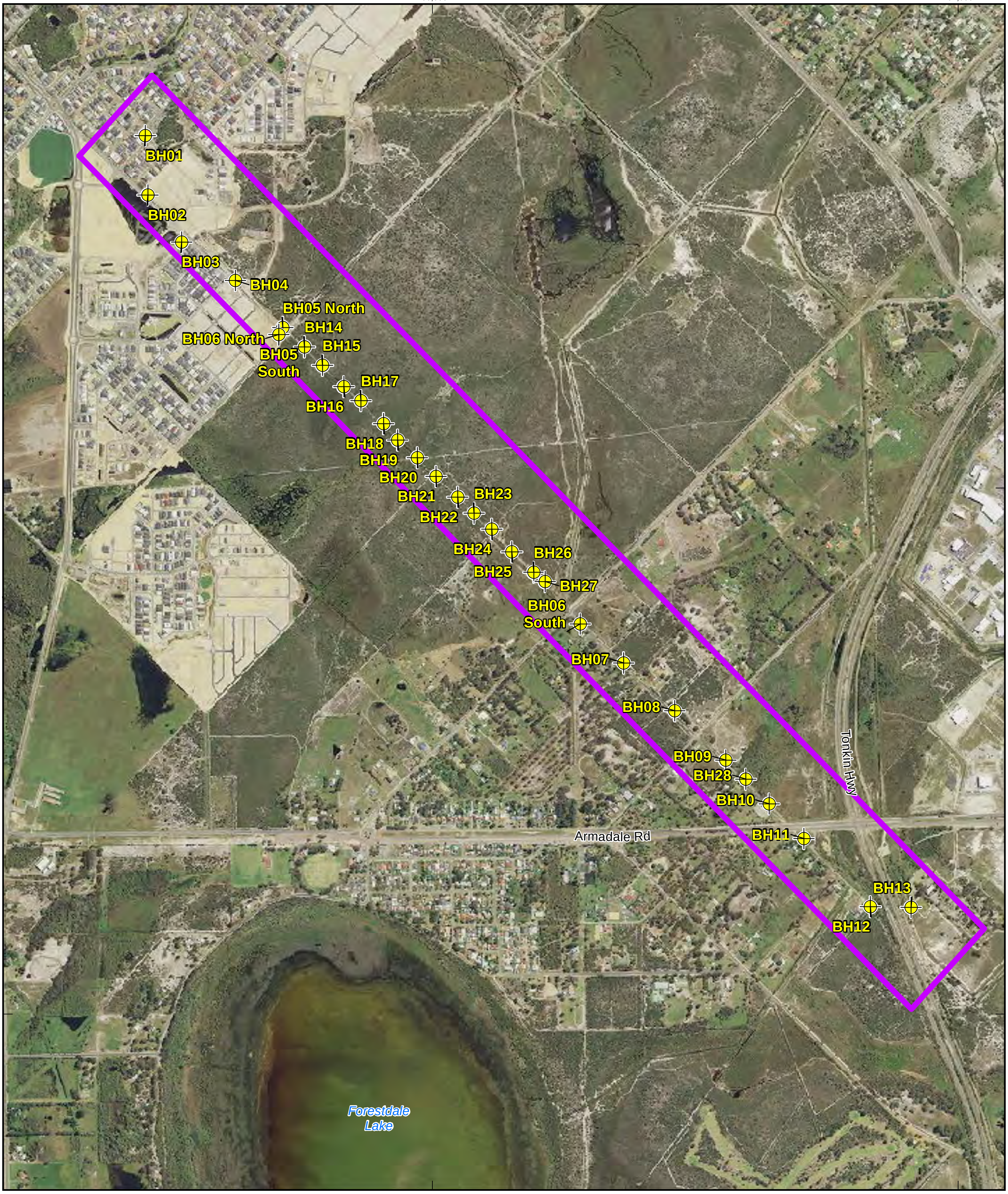
Acid Sulfate Soil Risk Mapping

Figure 4

G:\61\29471\GIS\Maps\MXD\6129471_G004_Rev0.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: GHD: Pressure Main - 20140415, Section - 20140415; DEC: Acid Sulfate Soil Risk - 20120229; Landgate: Virtual Mosaic - 20140416, Road - 20140416. Created by: mczekaj



Legend

Groundwater Well

Balannup A WWPS and Keane Road Pressure Main Works Site

1: 20,000 (at A4)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

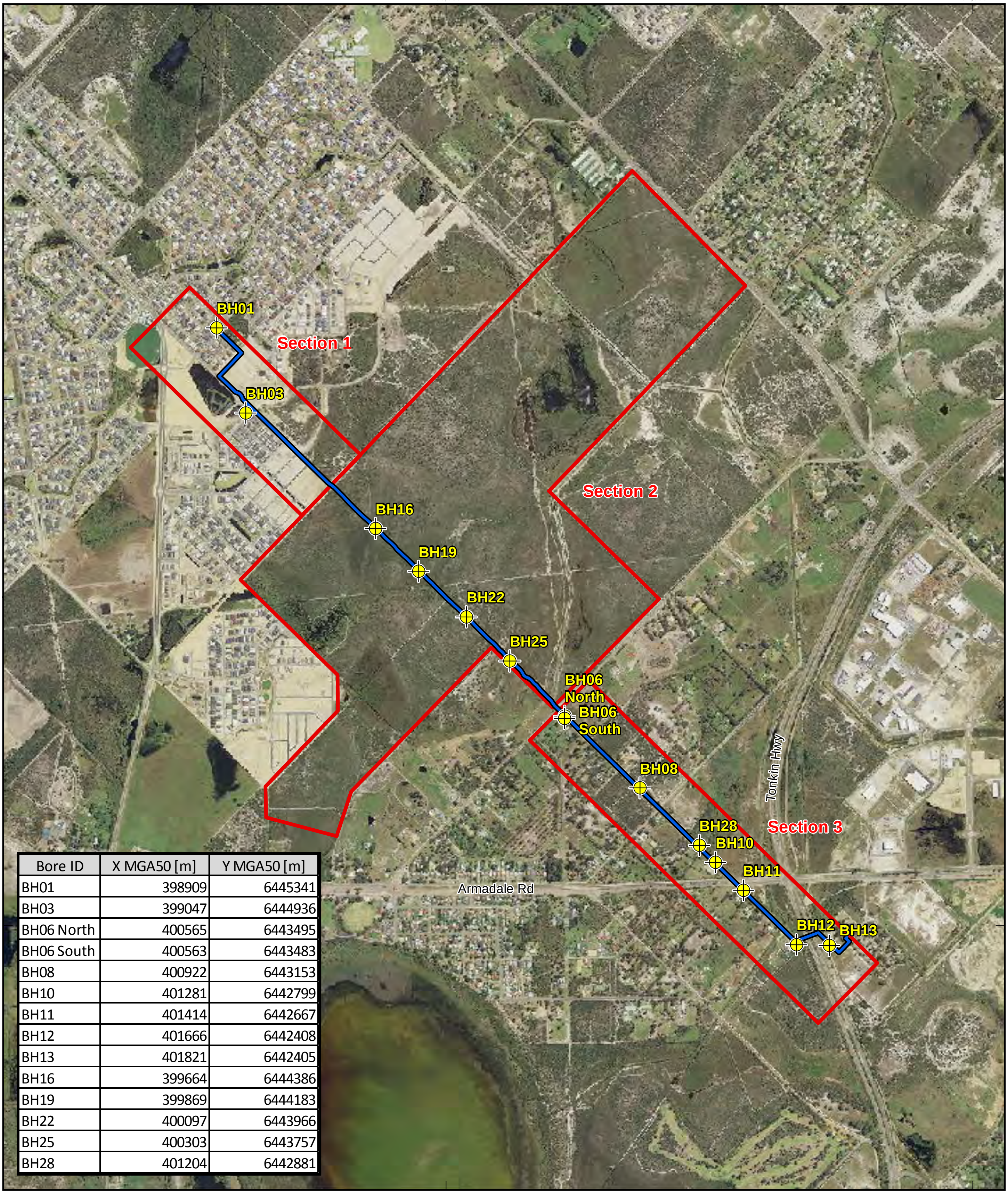
Job Number	61-29471
Revision	0
Date	17 Apr 2014

Geotechnical and ASS Investigation Locations **Figure 5**

G:\61\29471\GIS\Maps\MXD\6129471_G005_Rev0.mxd

239 Adelaide Terrace Perth WA 6004 Australia **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data source: GHD: Balannup A WWPS and Keane Road Pressure Main Works Site - 20140415, Groundwater Well - 20140417; Landgate: Road Names - 20140416, Virtual Mosaic - 20140416. Created by: mczekaj



Bore ID	X MGA50 [m]	Y MGA50 [m]
BH01	398909	6445341
BH03	399047	6444936
BH06 North	400565	6443495
BH06 South	400563	6443483
BH08	400922	6443153
BH10	401281	6442799
BH11	401414	6442667
BH12	401666	6442408
BH13	401821	6442405
BH16	399664	6444386
BH19	399869	6444183
BH22	400097	6443966
BH25	400303	6443757
BH28	401204	6442881

Legend

Selected Groundwater Well

Section

Pressure Main

1: 25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

Groundwater Well Locations

Job Number	61-29471
Revision	0
Date	17 Apr 2014

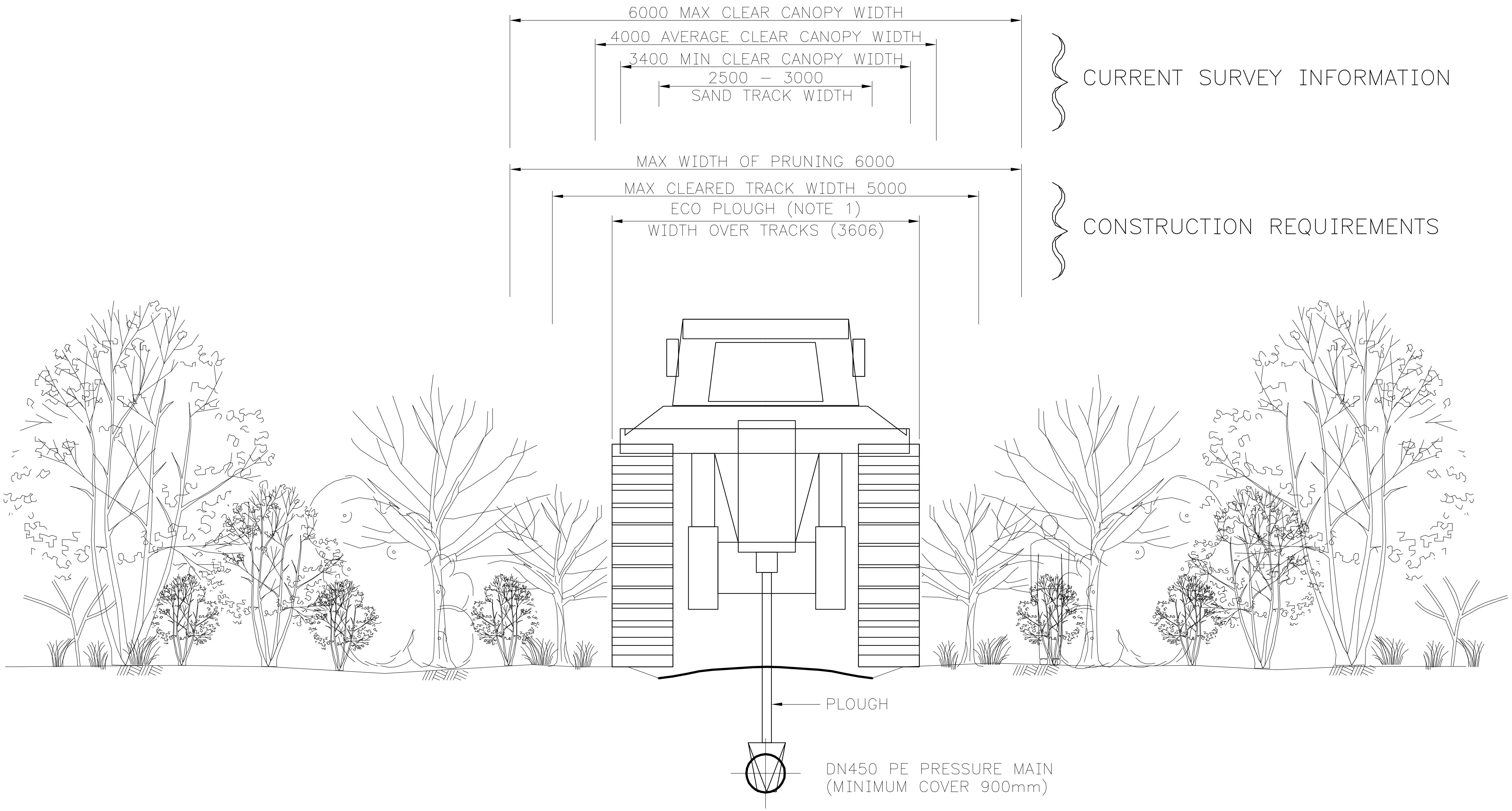
Figure 6

G:\61\29471\GIS\Maps\MXD\6129471_G006_Rev0.mxd

239 Adelaide Terrace Perth WA 6004 Australia T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data source: GHD: Pressure Main - 20140415, Section - 20140415, Selected Groundwater Well - 20140416; Landgate: Virtual Mosaic - 20140416, Road Names - 20140416. Created by: mczekaj

Appendix B – Preliminary Design Drawings



NOTE
1. DIMENSIONS BASED ON CATERPILLAR D11

1000 500 0 1000 2000 3000 mm (1:50)

FOR GENERAL NOTES REFER DRG HW91–2–13–1

GHD
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DES CALC	E. BISHOP
DES CHD	G. DUNLOP
DRN	K.BOSMAN
Q.C. CHD	R. SPILLANE

RECOMMENDED 06/02/2014
P.G. SPENCER (SIGNED)
for CONSULTANT JOB MANAGER

APPROVED 06/02/2014
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
DN450 PE PRESSURE MAIN – BUSH FOREVER AREA
TYPICAL SECTION OF ECO PLOUGH THROUGH BUSH FOREVER AREA

FILE JT1 201202141 V01
PROJECT C–S01249
PLAN HW91–2–13–2
CAD
ISSUE A
ORIGINAL SHEET SIZE A3
MF

283
394

61\29471\CADD\HW91\HW91–002–013–02A 06/02/2014

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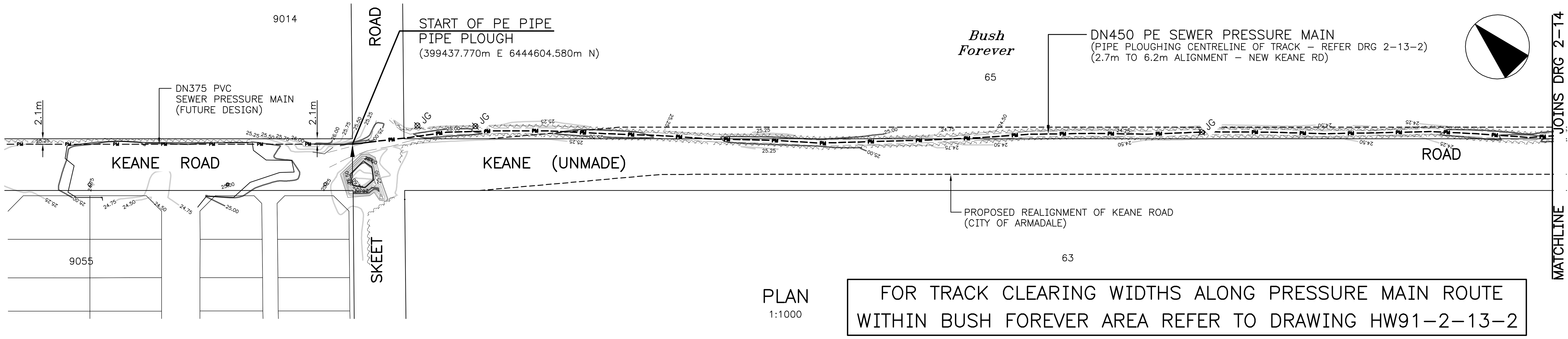
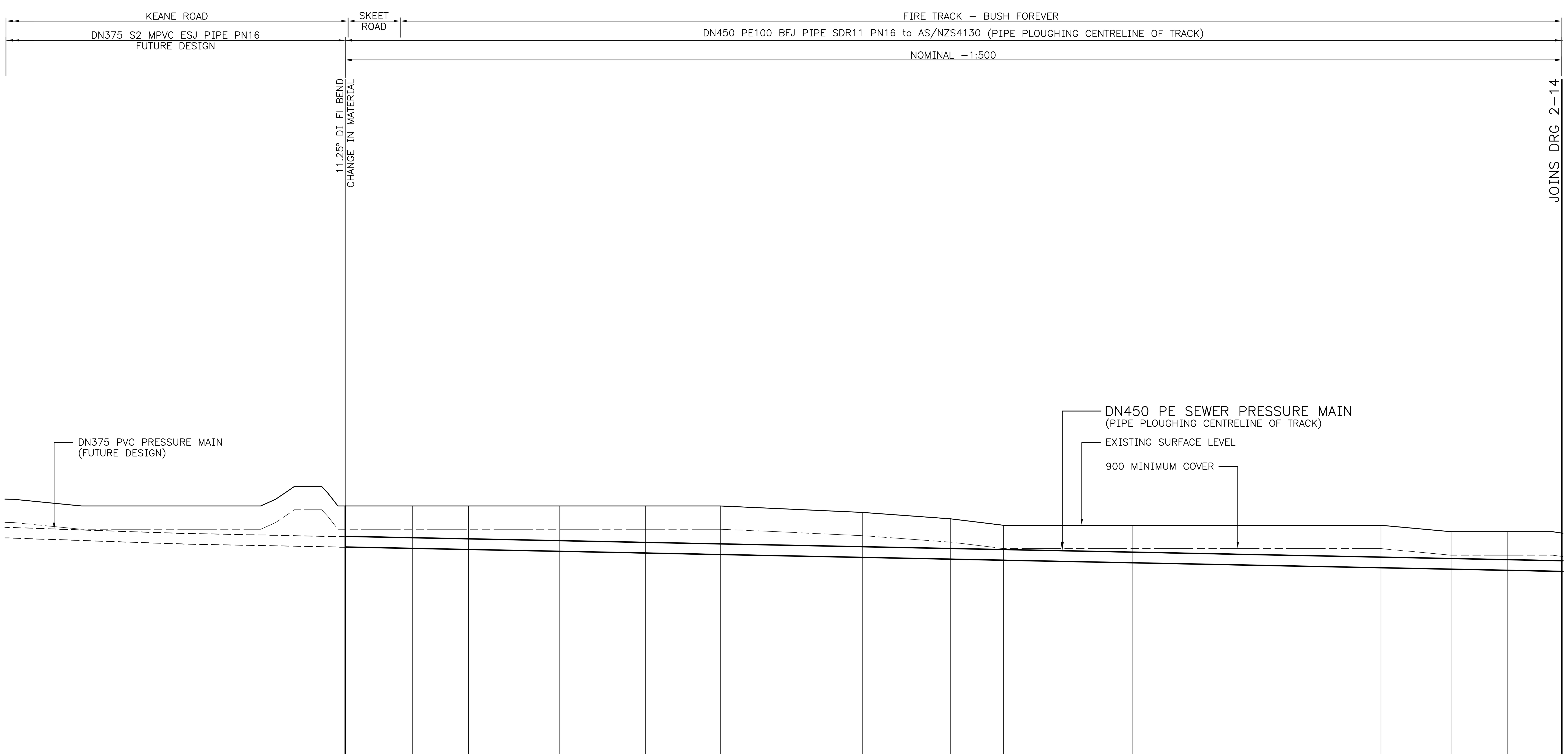
LEGEND

- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE
- EXISTING BUSHLINE
- JACKSONIA GRACILLIMA LOCATION



PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2



GENERAL NOTES

1. PRESSURE MAIN SHALL BE SET OUT AS SHOWN ON THE DRAWINGS WITH REAL TIME RECORDING OF ALIGNMENT GPS CO-ORDINATES, INCLUDING DEPTH, USING IN-VEHICLE ELECTRONIC EQUIPMENT.
2. NO DEVIATION FROM THE ALIGNMENT SHOWN IS ACCEPTABLE UNLESS APPROVED IN WRITING BY THE SUPERINTENDENT.
3. PRESSURE MAIN SHALL HAVE A MINIMUM DEPTH OF COVER OF 900mm.
4. PRESSURE MAIN SHALL BE LAID TO UNIFORM GRADE BETWEEN INVERT LEVELS SHOWN.
5. PRIOR TO CONSTRUCTION OF THE PRESSURE MAIN THE EXISTING DRAIN AS SHOWN ON DRAWING HW91-2-15 SHALL BE REMOVED TO 3 METRES EITHER SIDE OF THE TRACK CENTRELINE. THE DRAIN SHALL BE REINSTALLED AT ITS ORIGINAL LEVELS ON COMPLETION OF INSTALLATION OF THE PRESSURE MAIN.
6. PE PRESSURE MAIN TO BE AS/NZS4130, SERIES 1. PRESSURE MAIN PIPES TO BE COLOURED BLACK.
7. DEFLECTION AT BENDS SHALL BE ACHIEVED BY BENDING THE PIPE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
8. PE PIPES SHALL BE BUTT FUSION WELDED.
9. NO CONSTRUCTION OR LAYDOWN AREAS TO BE CREATED WITHIN THE 'BUSH FOREVER' AREA OTHER THAN WITHIN THE APPROVED CLEARED TRACK ALIGNMENT.
10. NO CLEARING OR DAMAGE TO BUSHLAND SHALL OCCUR OUTSIDE THE APPROVED CLEARED TRACK ALIGNMENT WITHIN THE 'BUSH FOREVER' AREA.
11. JACKSON GRACILLIMA, AS LOCATED ON THE PLANS, ARE NOT TO BE REMOVED OR DAMAGED DURING CONSTRUCTION.
12. ANY CONSTRAINTS TO CONSTRUCTION OR DAMAGE TO EXISTING FLORA TO BE REPORTED IMMEDIATELY TO THE SUPERINTENDENT.
13. NO DEWATERING OR OPEN TRENCHING (OTHER THAN DRAIN CROSSING INDICATED ON DRG 2-15) TO BE CARRIED OUT WITHIN THE BUSH FOREVER AREA.

DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL	25.00	25.00	25.00	25.00	25.00	25.00	24.75	24.50	24.25	24.25	24.25	24.00	24.00	
DEPTH TO INVERT	1.57								1.35					1.48
INVERT LEVEL	23.43								22.90					22.47
HORIZONTAL DISTANCE	0.0	26.0	47.6	82.7	115.9	144.7	199.5	233.5	253.9	303.7	399.4	426.6	448.4	469.2

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC E. BISHOP	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD G. DUNLOP	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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P.G. SPENCER (SIGNED)
for CONSULTANT JOB MANAGER
APPROVED 06/02/2014
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

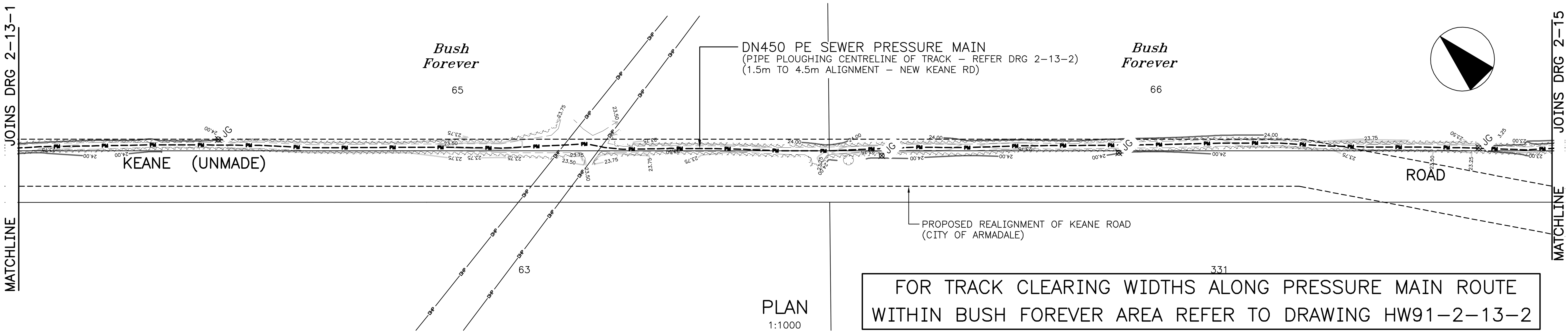
WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
DN450 PE PRESSURE MAIN - BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION - SHEET 1 OF 3

FILE JT1 201202141 V01
PROJECT C-S01249
PLAN
CAD
HW91-2-13-1
ISSUE A
ORIGINAL SHEET SIZE A1
MF

566
810
61\29471\CADD\HW91\HW91-002-013-01A 06/02/2014

1	2	3	4	5	6	7	8	9	10	11	12



PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2

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NOTE:
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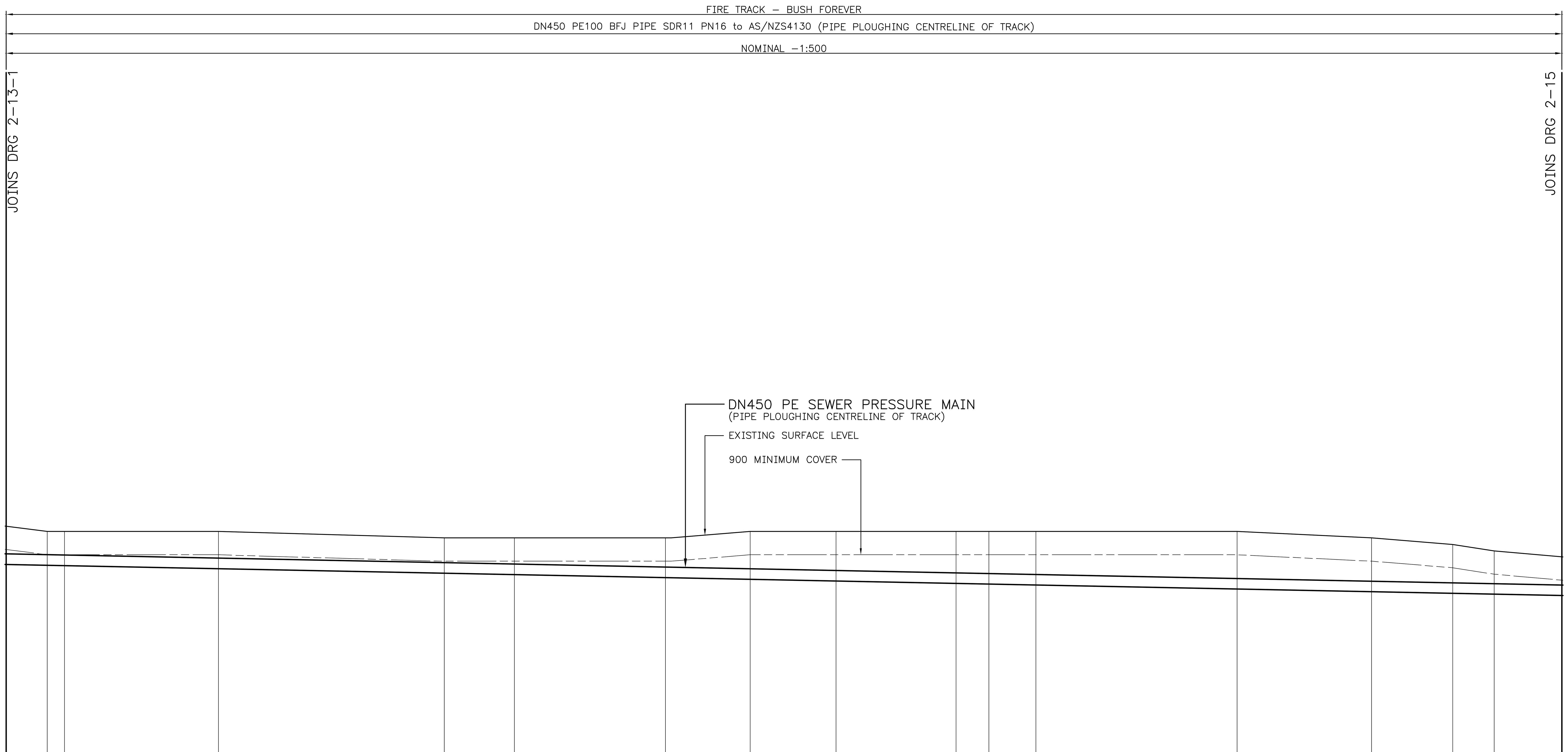
LEGEND

- PROPOSED SEWER PRESSURE MAIN — PM
- EXISTING WATER MAINS — W
- EXISTING TELECOMMUNICATION CABLES — T
- EXISTING OPTIC FIBRE — OF
- EXISTING UNDERGROUND POWER — UGP
- EXISTING OVERHEAD POWER — OHP
- EXISTING GAS MAINS — G
- EXISTING SEWER MAINS — S
- EXISTING SEWER PRESSURE MAINS — PM
- EXISTING DRAINAGE — D
- EXISTING FENCE — /
- EXISTING TREE
- EXISTING BUSHLINE
- JACKSONIA GRACILLIMA LOCATION — JG

FOR GENERAL NOTES REFER DRG HW91-2-13-1



DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL		23.75	23.75	23.75	23.50	23.50	23.50	23.75	23.75	23.75	23.75	23.75	23.75	23.50	23.25	23.00	22.77
DEPTH TO INVERT	1.48	1.31															1.50
INVERT LEVEL	22.47	22.44															21.27
HORIZONTAL DISTANCE	469.2	485.0	491.6	551.0	638.9	665.2	723.5	756.1	789.3	835.5	848.3	866.3	944.0	995.8	1027.1	1043.2	1069.2

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)

1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC E. BISHOP	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD G. DUNLOP	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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E permail@ghd.com.au W www.ghd.com.au

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for CONSULTANT JOB MANAGER
APPROVED 06/02/2014
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CONSULTANT PROJECT DIRECTOR

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METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
DN450 PE PRESSURE MAIN - BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION - SHEET 2 OF 3

FILE JT1 201202141 V01
PROJECT C-S01249
PLAN
CAD
HW91-2-14
ISSUE A
ORIGINAL SHEET SIZE A1
MF

566
810

61\29471\CADD\HW91\HW91-002-014-01A 06/02/2014

A	B	C	D	E	F	G	H

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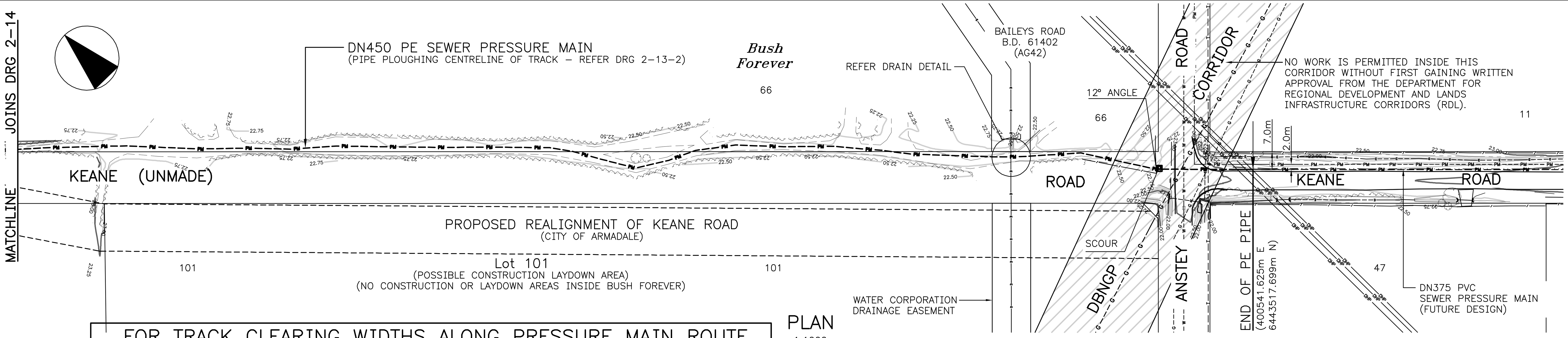
LEGEND

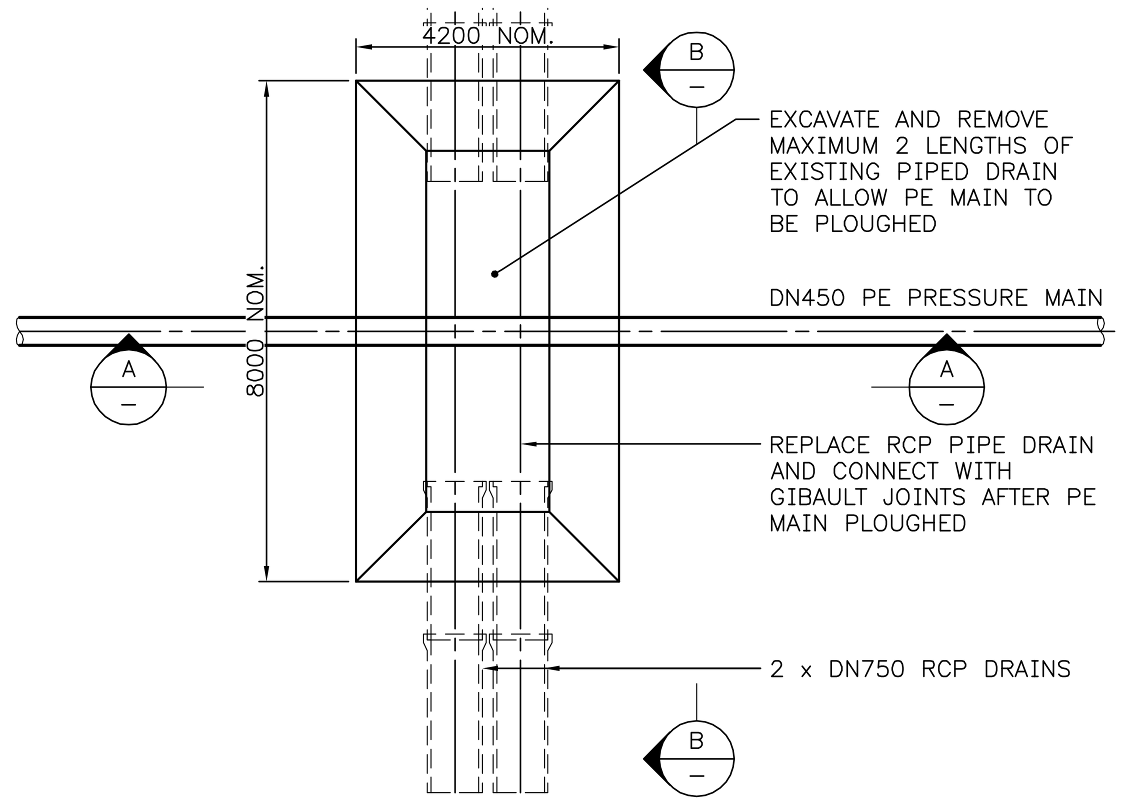
- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE
- EXISTING BUSHLINE
- JACKSONIA GRACILLIMA LOCATION

FOR GENERAL NOTES REFER DRG HW91-2-13-1

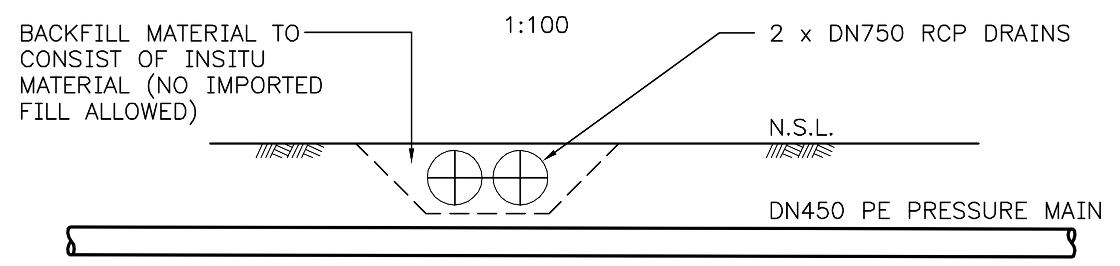


FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2

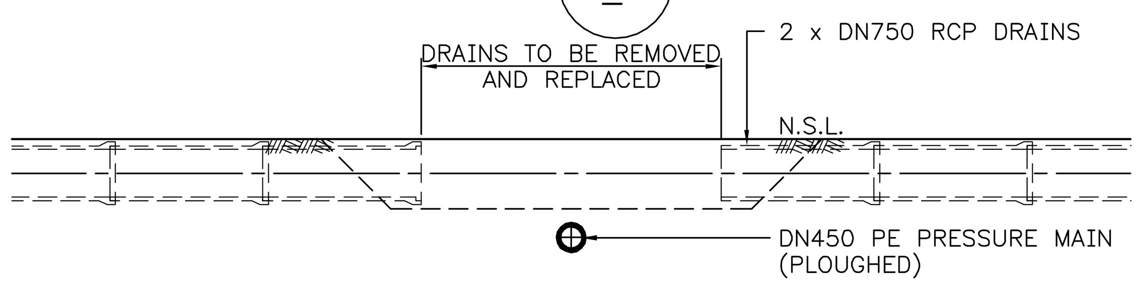
PLAN
1:1000



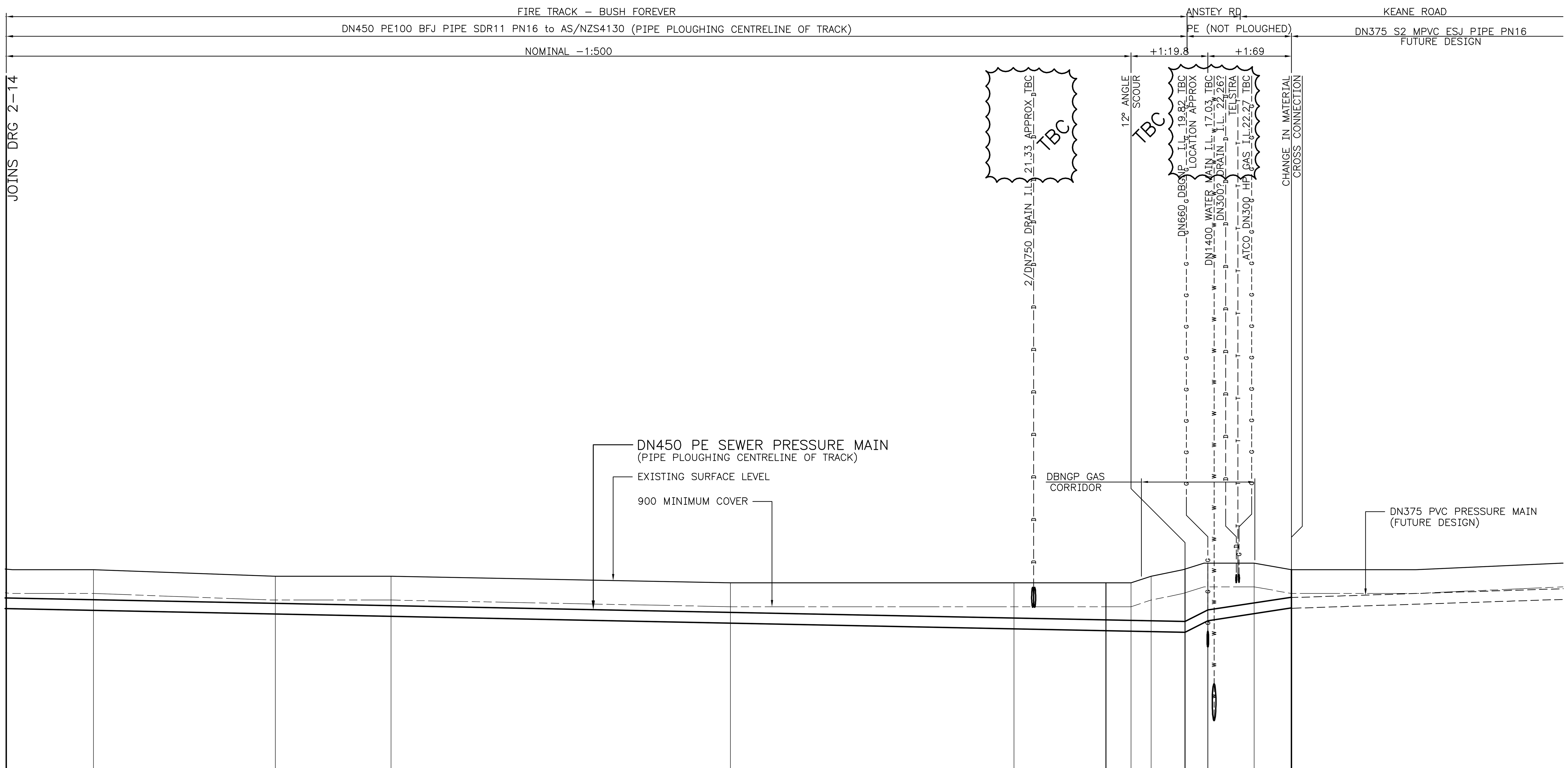
DRAIN CROSSING DETAIL – PLAN
1:100



SECTION A



SECTION B



DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL	22.77	22.75	22.50	22.50	22.25	22.25		22.25	22.50	22.77	23.00	23.00	22.75
DEPTH TO INVERT	1.50		1.43							2.39	2.18		1.45
INVERT LEVEL	21.27		21.07							20.38	20.82		21.30
HORIZONTAL DISTANCE	1069.2	1102.2	1171.1	1214.9	1343.5	1450.8	1485.7	1495.2	1502.8	1515.7	1522.8	1541.9	1556.0

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY	VERTICAL DATUM	DES CALC	NORTH POINT
GHD 2661551 V01	AHD	E. BISHOP	
	COORDINATE SYS MGA94-50	DES CHD G. DUNLOP	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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RECOMMENDED 06/02/2014
P.G. SPENCER (SIGNED)
for CONSULTANT JOB MANAGER
APPROVED 06/02/2014
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
DN450 PE PRESSURE MAIN – BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION – SHEET 3 OF 3

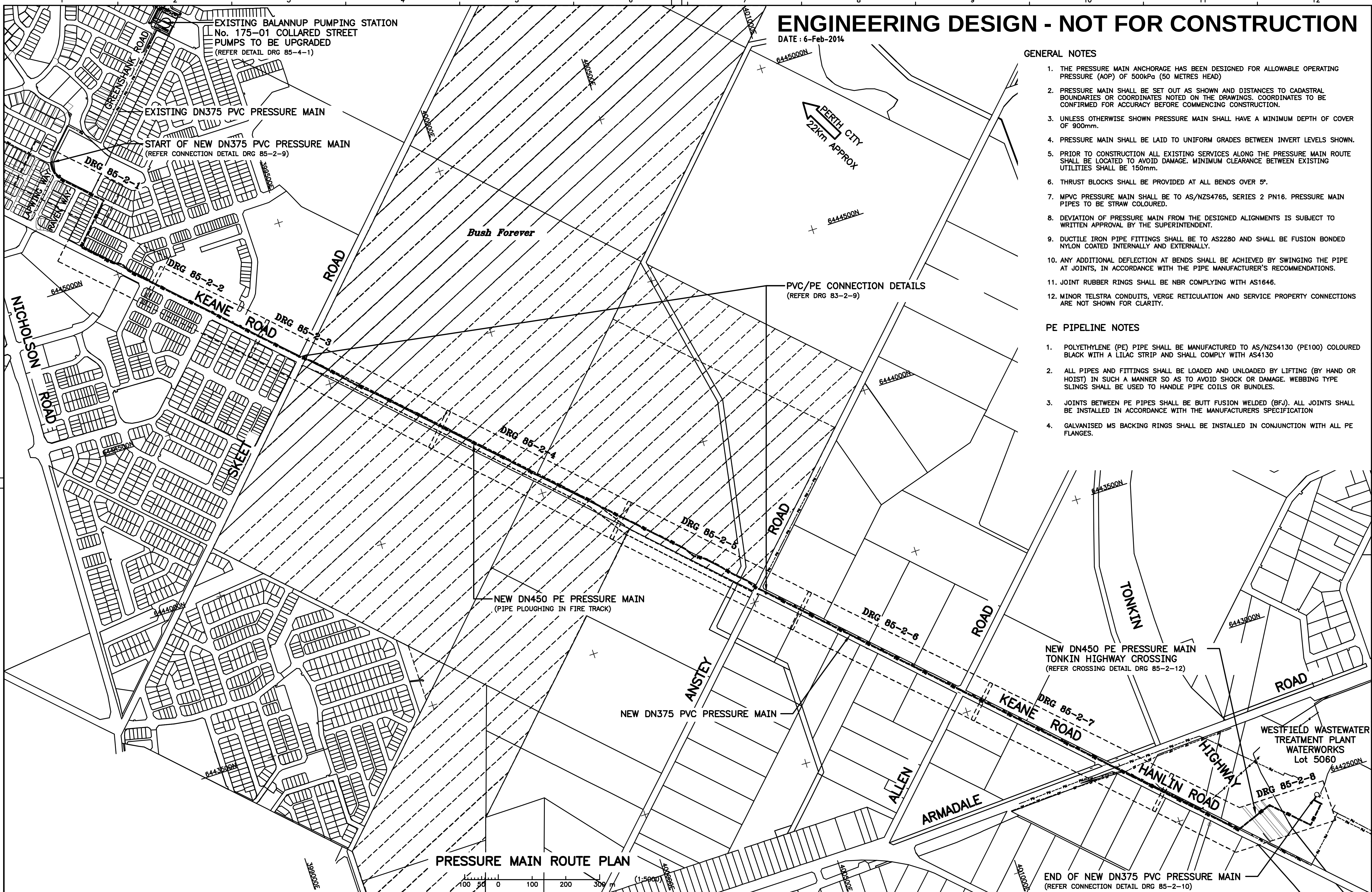
FILE JT1 201202141 V01
PROJECT C-S01249
PLAN HW91-2-15
CAD
ISSUE A
ORIGINAL SHEET SIZE A1
MF

566
810

61\29471\CADD\HW91\HW91-002-015-01A 06/02/2014

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 6-Feb-2014



GENERAL NOTES

1. THE PRESSURE MAIN ANCHORAGE HAS BEEN DESIGNED FOR ALLOWABLE OPERATING PRESSURE (AOP) OF 500kPa (50 METRES HEAD)
2. PRESSURE MAIN SHALL BE SET OUT AS SHOWN AND DISTANCES TO CADASTRAL BOUNDARIES OR COORDINATES NOTED ON THE DRAWINGS. COORDINATES TO BE CONFIRMED FOR ACCURACY BEFORE COMMENCING CONSTRUCTION.
3. UNLESS OTHERWISE SHOWN PRESSURE MAIN SHALL HAVE A MINIMUM DEPTH OF COVER OF 900mm.
4. PRESSURE MAIN SHALL BE LAID TO UNIFORM GRADES BETWEEN INVERT LEVELS SHOWN.
5. PRIOR TO CONSTRUCTION ALL EXISTING SERVICES ALONG THE PRESSURE MAIN ROUTE SHALL BE LOCATED TO AVOID DAMAGE. MINIMUM CLEARANCE BETWEEN EXISTING UTILITIES SHALL BE 150mm.
6. THRUST BLOCKS SHALL BE PROVIDED AT ALL BENDS OVER 5°.
7. MPVC PRESSURE MAIN SHALL BE TO AS/NZS4765, SERIES 2 PN16. PRESSURE MAIN PIPES TO BE STRAW COLOURED.
8. DEVIATION OF PRESSURE MAIN FROM THE DESIGNED ALIGNMENTS IS SUBJECT TO WRITTEN APPROVAL BY THE SUPERINTENDENT.
9. DUCTILE IRON PIPE FITTINGS SHALL BE TO AS2280 AND SHALL BE FUSION BONDED NYLON COATED INTERNALLY AND EXTERNALLY.
10. ANY ADDITIONAL DEFLECTION AT BENDS SHALL BE ACHIEVED BY SWINGING THE PIPE AT JOINTS, IN ACCORDANCE WITH THE PIPE MANUFACTURER'S RECOMMENDATIONS.
11. JOINT RUBBER RINGS SHALL BE NBR COMPLYING WITH AS1646.
12. MINOR TELSTRA CONDUITS, VERGE RETICULATION AND SERVICE PROPERTY CONNECTIONS ARE NOT SHOWN FOR CLARITY.

PE PIPELINE NOTES

1. POLYETHYLENE (PE) PIPE SHALL BE MANUFACTURED TO AS/NZS4130 (PE100) COLOURED BLACK WITH A LILAC STRIP AND SHALL COMPLY WITH AS4130
2. ALL PIPES AND FITTINGS SHALL BE LOADED AND UNLOADED BY LIFTING (BY HAND OR HOIST) IN SUCH A MANNER SO AS TO AVOID SHOCK OR DAMAGE. WEBBING TYPE SLINGS SHALL BE USED TO HANDLE PIPE COILS OR BUNDLES.
3. JOINTS BETWEEN PE PIPES SHALL BE BUTT FUSION WELDED (BFJ). ALL JOINTS SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURERS SPECIFICATION
4. GALVANISED MS BACKING RINGS SHALL BE INSTALLED IN CONJUNCTION WITH ALL PE FLANGES.

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		NOTE 7 PRESSURE RATING CHANGED. DRG REFERENCE CHANGED	KB	KB	PGS

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM NONE	DES CALC K.BOSMAN
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

NORTH POINT

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RECOMMENDED 09/09/2013
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CONSULTANT JOB MANAGER

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WATER CORPORATION

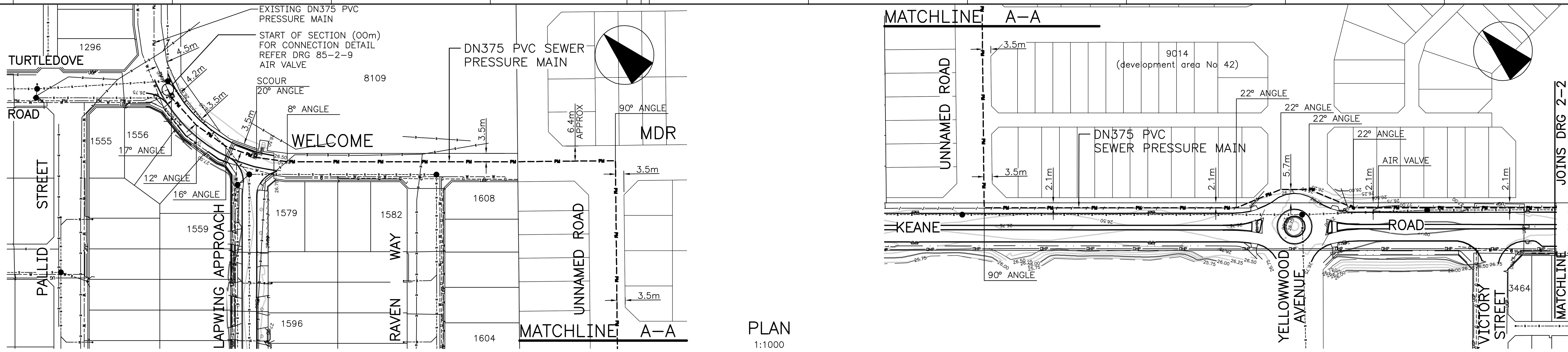
METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
ROUTE PLAN AND GENERAL NOTES

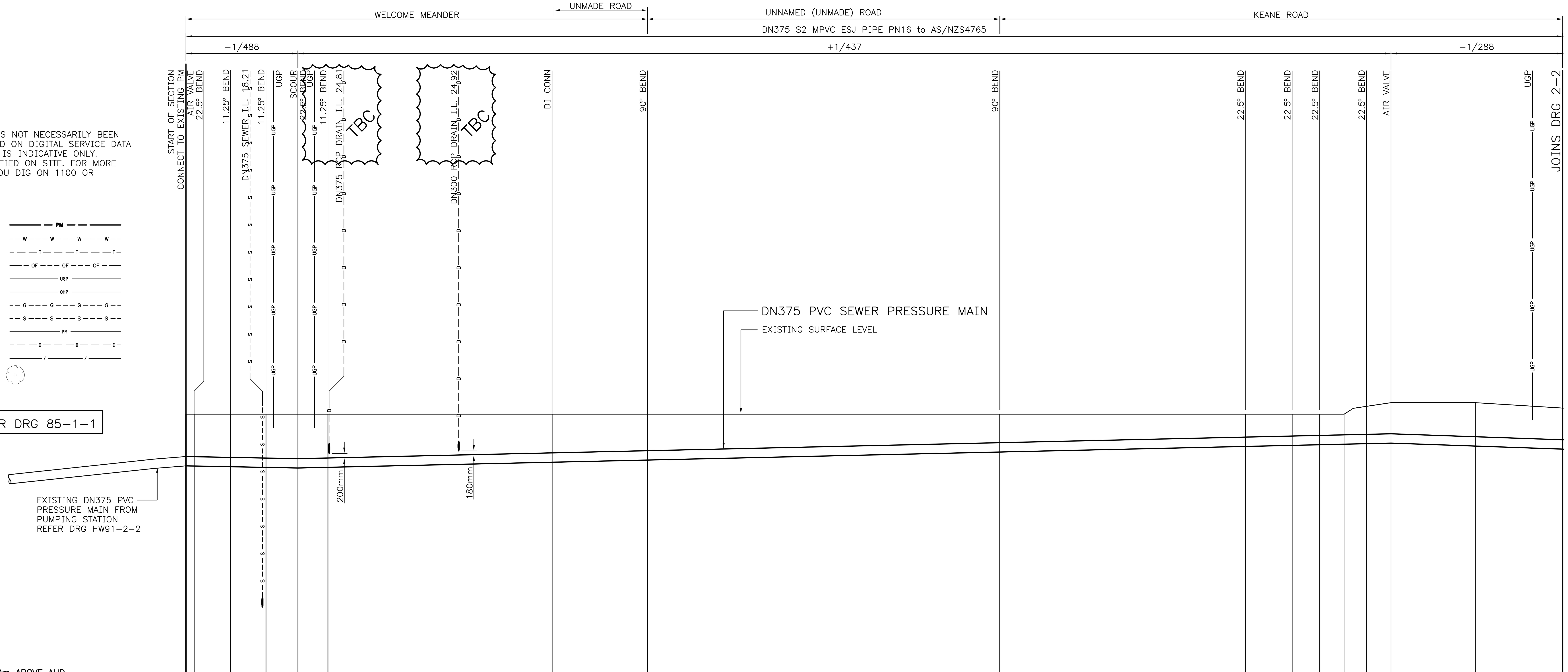
FILE	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
PROJECT C-S01249	HW91-85-1-1		B	A1

MF

566
810

61\29471\CADD\HW91\HW91-085-001-01B 06/02/2014





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LEGEND

PROPOSED SEWER PRESSURE MAIN	— PM —
EXISTING WATER MAINS	— W — W — W —
EXISTING TELECOMMUNICATION CABLES	— T — T — T —
EXISTING OPTIC FIBRE	— OF — OF — OF —
EXISTING UNDERGROUND POWER	— UGP —
EXISTING OVERHEAD POWER	— OHP —
EXISTING GAS MAINS	— G — G — G —
EXISTING SEWER MAINS	— S — S — S —
EXISTING SEWER PRESSURE MAINS	— PM —
EXISTING DRAINAGE	— D — D — D —
EXISTING FENCE	— / — / —
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85-1-1

DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	26.50				26.50								26.50		27.00	27.00	26.75
DEPTH TO INVERT	2.25				2.35										1.76		
INVERT LEVEL	24.25				24.15										25.24		
HORIZONTAL DISTANCE	0.0	3.6	19.5	34.9	48.8	61.9	159.6	201.2	354.7	461.8	482.1	494.1	504.8	514.5	525.2	562.0	600

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

(1:1000) (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC K.BOSMAN	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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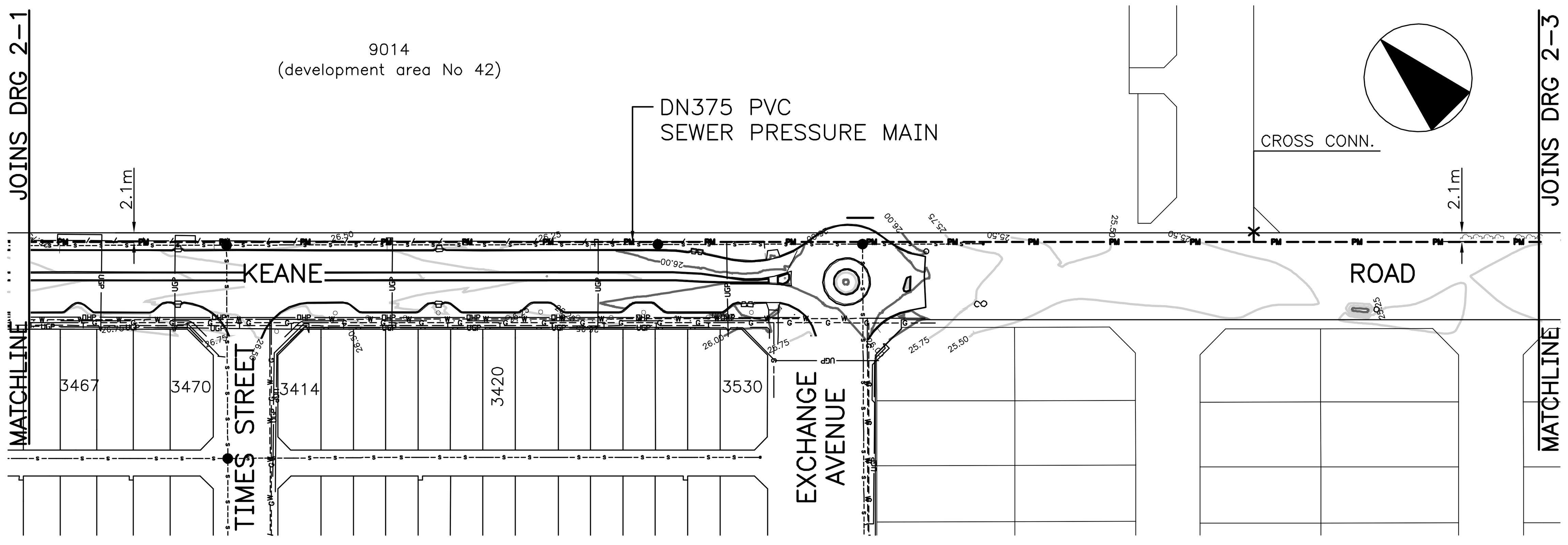
METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION – SHEET 1 OF 8

FILE | PLAN | CAD | ISSUE A
PROJECT C-S01249
HW91-85-2-1

ORIGINAL SHEET SIZE A1

MF

61\29471\CADD\HW91\HW91-085-002-01A 10/09/2013



PLAN
1:1000

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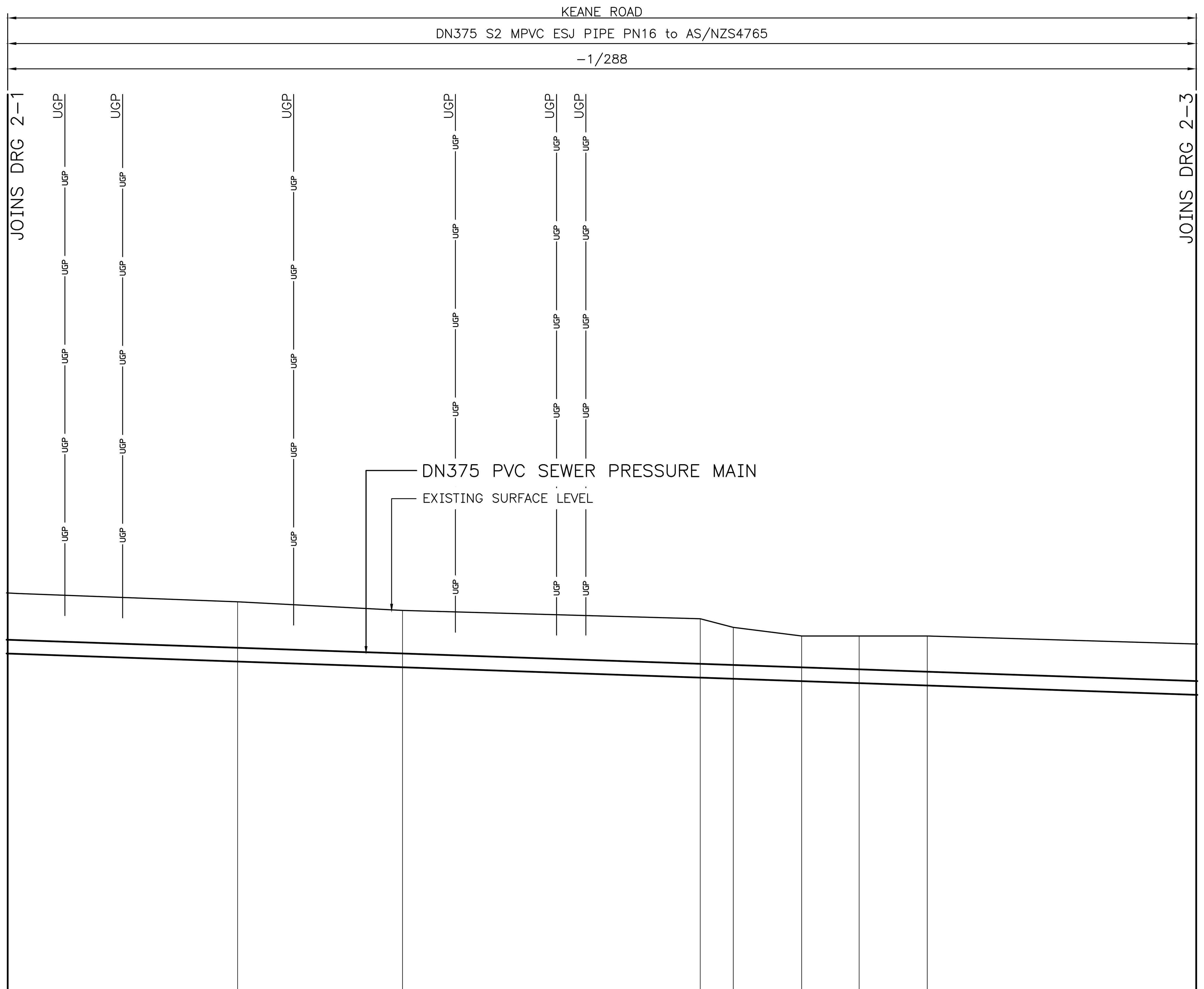
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85–1–1



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	26.75	26.50	26.25	26.00	25.75	25.50	25.50	25.50	25.25
DEPTH TO INVERT									
INVERT LEVEL									
HORIZONTAL DISTANCE	600	667.7	716.3	804.0	813.7	833.8	850.8	870.8	950

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

DATE : 10–Sep–2013

(1:1000) 10 5 0 10 20 30 40 50 60 70 m
(1:100) 1 0.5 0 1 2 3 4 5 6 7 m

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01 | VERTICAL DATUM AHD | DES CALC K.BOSMAN | NORTH POINT
ASCON SURVEY NONE | COORDINATE SYS MGA94–50 | DES CHD P.SPENCER
DES REF GHD 61–29471 | DRN K.BOSMAN | Q.C. CHD R.SPILLANE

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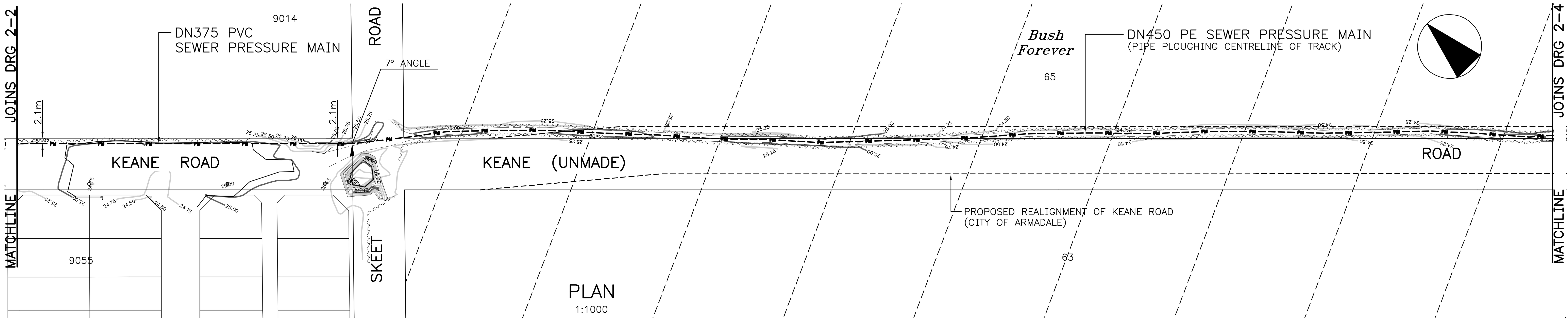
WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION – SHEET 2 OF 8

FILE | PLAN | CAD | ISSUE A
PROJECT C–S01249
HW91–85–2–2
ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91–085–002–02A 10/09/2013



PLAN
1:1000

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LEGEND

PROPOSED SEWER PRESSURE MAIN — PM
EXISTING WATER MAINS — W
EXISTING TELECOMMUNICATION CABLES — T
EXISTING OPTIC FIBRE — OF
EXISTING UNDERGROUND POWER — UGP
EXISTING OVERHEAD POWER — OHP
EXISTING GAS MAINS — G
EXISTING SEWER MAINS — S
EXISTING SEWER PRESSURE MAINS — PM
EXISTING DRAINAGE — D
EXISTING FENCE — /
EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-1

KEANE ROAD | SKEET ROAD | FIRE TRACK - BUSH FOREVER

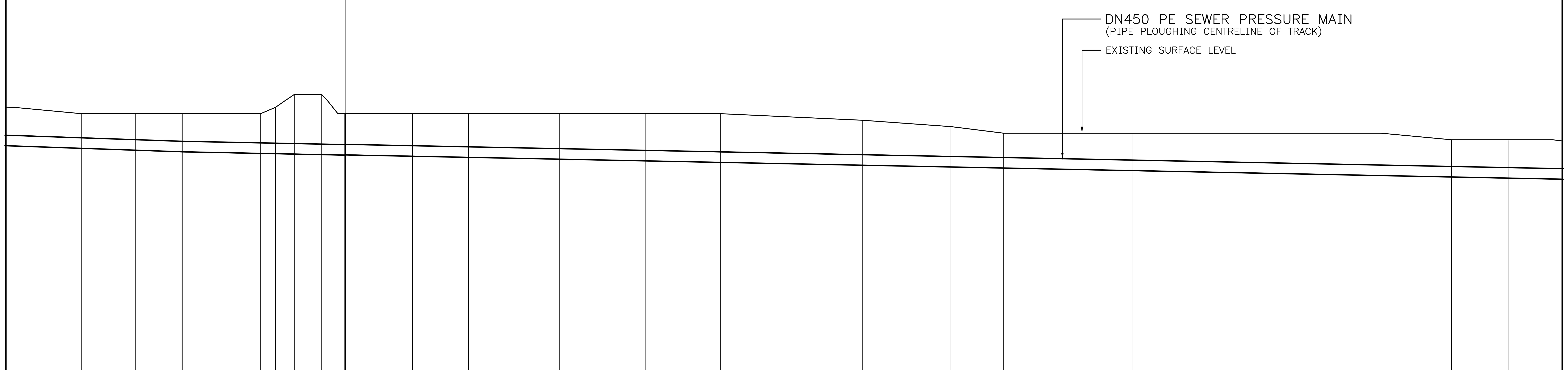
DN375 S2 MPVC ESJ PN16 | DN450 PE100 BFJ PIPE SDR11 PN16 to AS/NZS4130 (PIPE PLOUGHING CENTRELINE OF TRACK)

-1/288 | -1/484 | NOMINAL -1/500

JOINS DRG 2-2

11.25° DI FI BEND
CHANGE IN MATERIAL

JOINS DRG 2-4



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	25.25	25.00	25.00	25.00	25.00	25.25	25.75	25.75	25.00	25.00	25.00		25.00	25.00	25.00	24.75	24.50	24.25	24.25	24.25	24.00	24.00	
DEPTH TO INVERT				1.47					1.60 1.57														
INVERT LEVEL				23.53					23.40 23.43														
HORIZONTAL DISTANCE	950	979.2	1000.0	1017.9	1048.2	1053.9	1061.2	1071.7	1080.8	1106.8	1128.4	1156.9	1163.5	1196.7	1225.5	1280.3	1314.3	1334.7	1384.5	1480.2	1507.4	1529.2	1550

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC G.DUNLOP	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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WATER CORPORATION

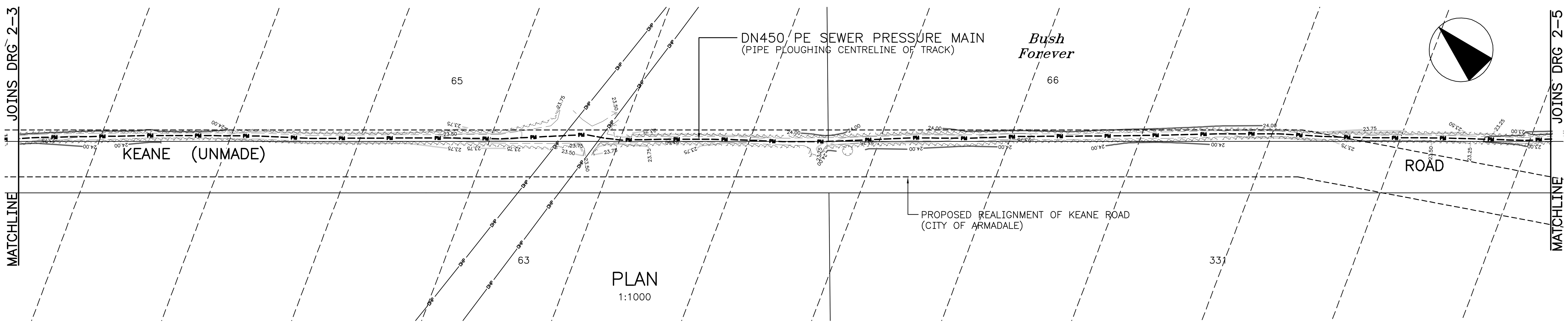
METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 3 OF 8

ORIGINAL SHEET SIZE A1

FILE | PLAN | CAD | ISSUE
PROJECT C-S01249 | HW91-85-2-3 | | A

MF

61\29471\CADD\HW91\HW91-085-002-03A 10/09/2013



PLAN
1:1000

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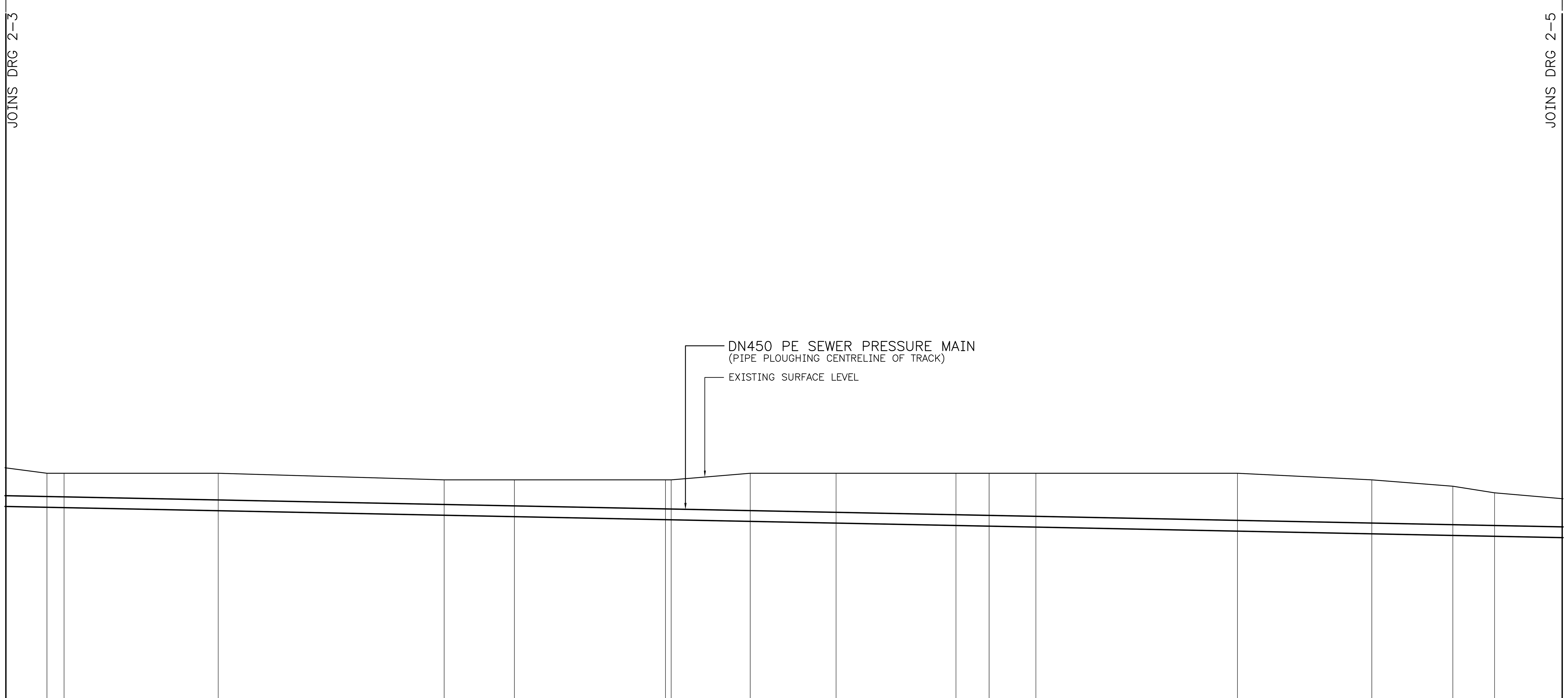
LEGEND

PROPOSED SEWER PRESSURE MAIN	— PM —
EXISTING WATER MAINS	— W —
EXISTING TELECOMMUNICATION CABLES	— T —
EXISTING OPTIC FIBRE	— OF —
EXISTING UNDERGROUND POWER	— UGP —
EXISTING OVERHEAD POWER	— OHP —
EXISTING GAS MAINS	— G —
EXISTING SEWER MAINS	— S —
EXISTING SEWER PRESSURE MAINS	— PM —
EXISTING DRAINAGE	— D —
EXISTING FENCE	— / —
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85–1–1

FIRE TRACK – BUSH FOREVER
DN450 PE100 BFJ PIPE SDR11 PN16 to AS/NZS4130 (PIPE PLOUGHING CENTRELINE OF TRACK)
NOMINAL –1/500



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL		23.75	23.75	23.75	23.50	23.50	23.50	23.50	23.75	23.75	23.75	23.75	23.75	23.75	23.50	23.25	23.00	22.75
DEPTH TO INVERT																		
INVERT LEVEL																		
HORIZONTAL DISTANCE	1550	1565.8	1572.4	1631.8	1719.7	1746.0	1804.3	1806.5	1836.9	1870.1	1916.3	1929.1	1947.1	2024.8	2076.6	2107.9	2124.0	2150

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC G.DUNLOP	NORTH POINT
	COORDINATE SYS MGA94–50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61–29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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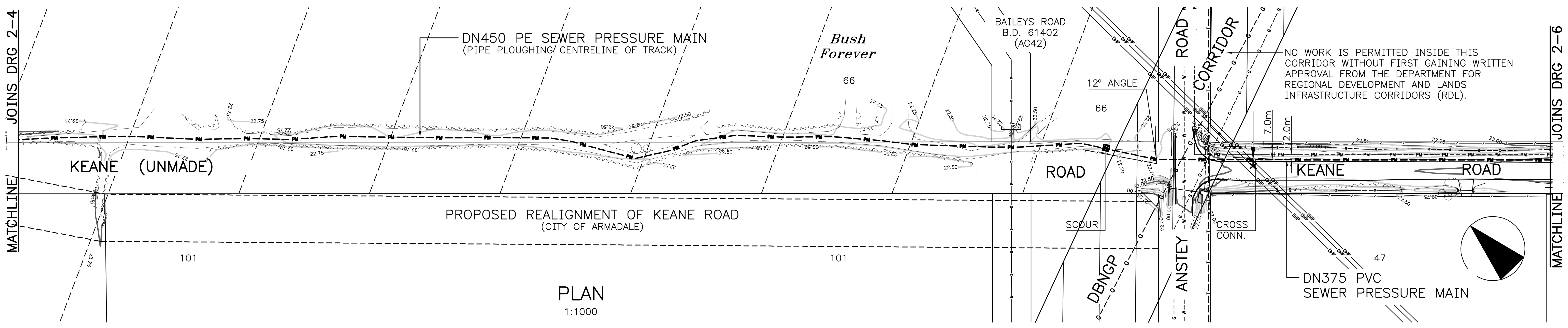
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION – SHEET 4 OF 8

FILE
PROJECT C–S01249
PLAN CAD
HW91–85–2–4
ISSUE A
ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91–085–002–04A 10/09/2013



PLAN
1:1000

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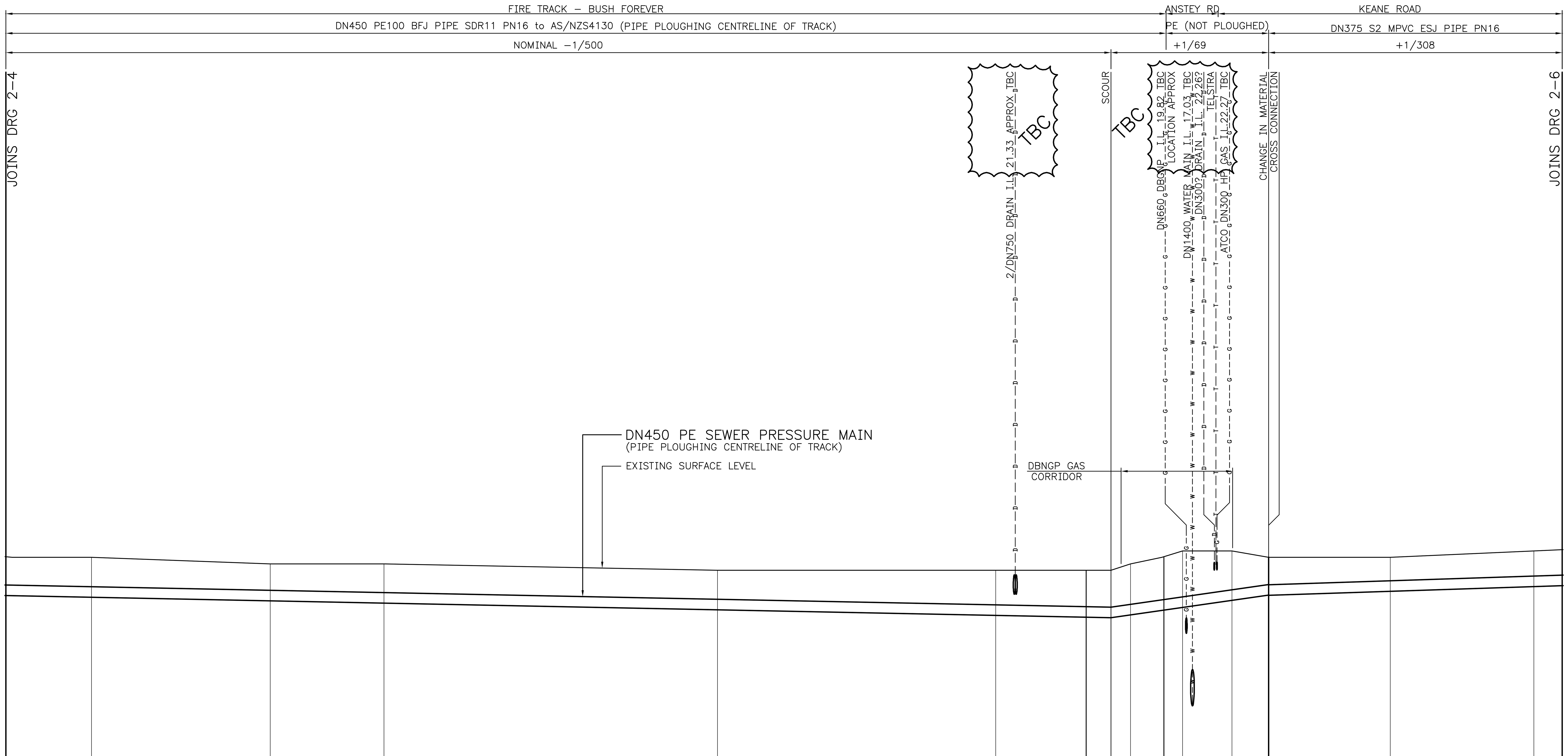
LEGEND

- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-1



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	22.75	22.75	22.50	22.50	22.25	22.25			22.25	22.50	22.75	23.00	23.00	22.75	22.75	23.00	
DEPTH TO INVERT									1.82					1.45 1.46			
INVERT LEVEL									20.42					21.30 21.29			
HORIZONTAL DISTANCE	2150	2183.0	2251.9	2295.7	2424.3	2531.6	2542.1	2566.5	2576.0	2583.6	2596.5	2603.6	2622.7	2636.8	2683.8	2739.1	2750

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

DATE : 10-Sep-2013

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY	VERTICAL DATUM	DES CALC	NORTH POINT
GHD 2661551 V01	AHD	K.BOSMAN	
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
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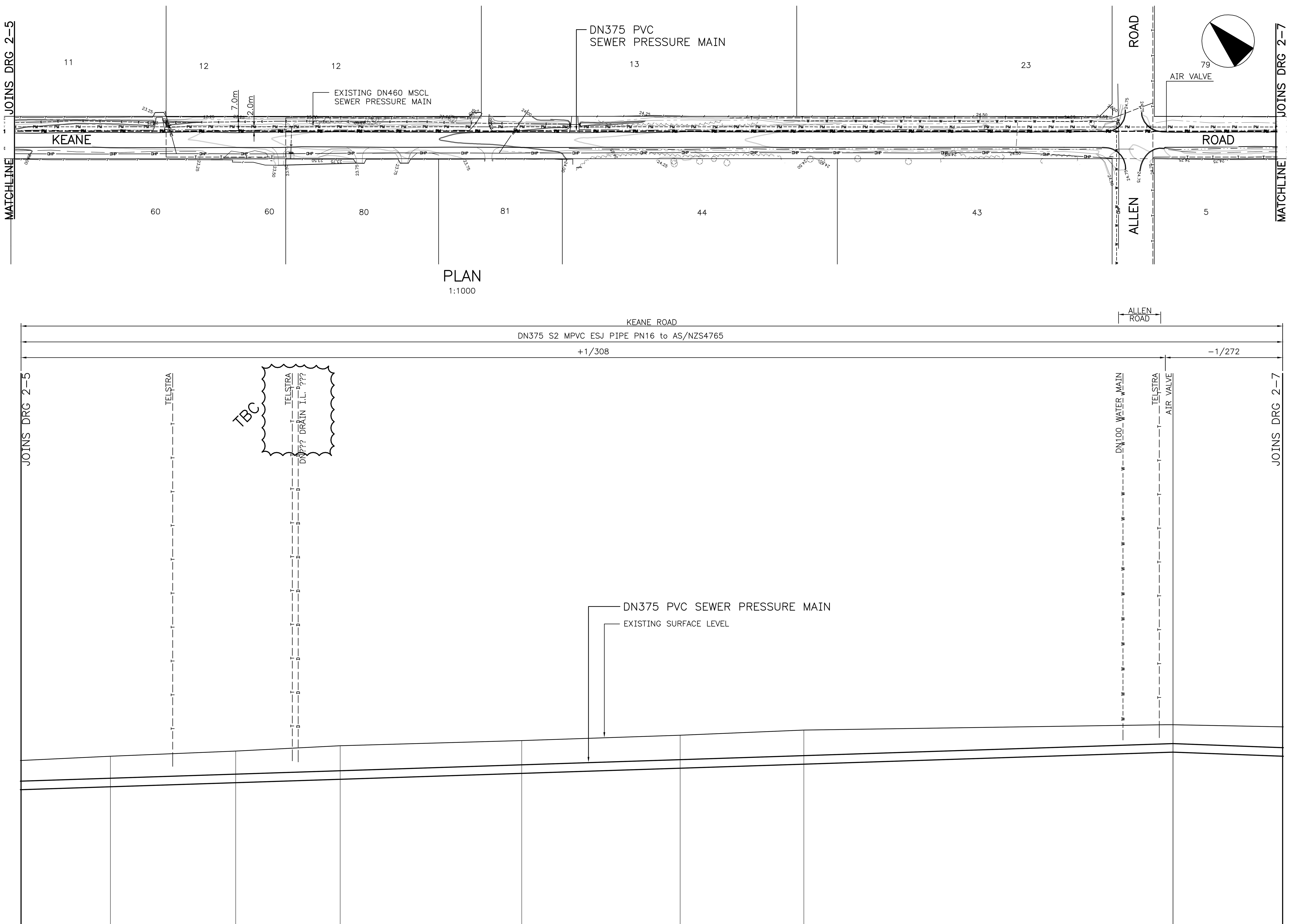
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 5 OF 8

FILE | PLAN | CAD | ISSUE
PROJECT C-S01249 | HW91-85-2-5 | A

ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91-085-002-05A 10/09/2013

566 B10



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LEGEND

- PROPOSED SEWER PRESSURE MAIN — PM
- EXISTING WATER MAINS — W
- EXISTING TELECOMMUNICATION CABLES — T
- EXISTING OPTIC FIBRE — OF
- EXISTING UNDERGROUND POWER — UGP
- EXISTING OVERHEAD POWER — OHP
- EXISTING GAS MAINS — G
- EXISTING SEWER MAINS — S
- EXISTING SEWER PRESSURE MAINS — PM
- EXISTING DRAINAGE — D
- EXISTING FENCE — /
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-1

DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL		23.25	23.50	23.75	24.00	24.25	24.50	24.75	
DEPTH TO INVERT								1.31	
INVERT LEVEL								23.44	
HORIZONTAL DISTANCE	2750	2792.5	2852.1	2901.8	2988.1	3063.5	3122.3	3297.9	3350

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

(1:1000) (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01 | VERTICAL DATUM AHD | COORDINATE SYS MGA94-50 | DES CALC K.BOSMAN | DES CHD P.SPENCER
ASCON SURVEY NONE | DES REF GHD 61-29471 | DRN K.BOSMAN | Q.C. CHD R.SPILLANE
NORTH POINT

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RECOMMENDED 09/09/2013 G. DUNLOP (SIGNED) CONSULTANT JOB MANAGER
APPROVED 09/09/2013 P.G. SPENCER (SIGNED) CONSULTANT PROJECT DIRECTOR

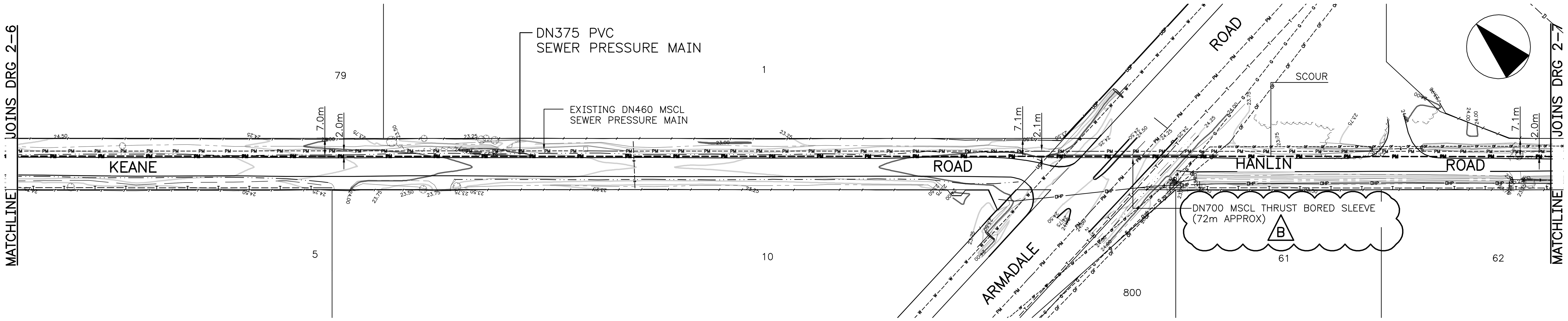
WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 6 OF 8

FILE | PLAN | CAD | ISSUE A
PROJECT C-S01249 | HW91-85-2-6
ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91-085-002-06A 10/09/2013

PLAN
1:1000



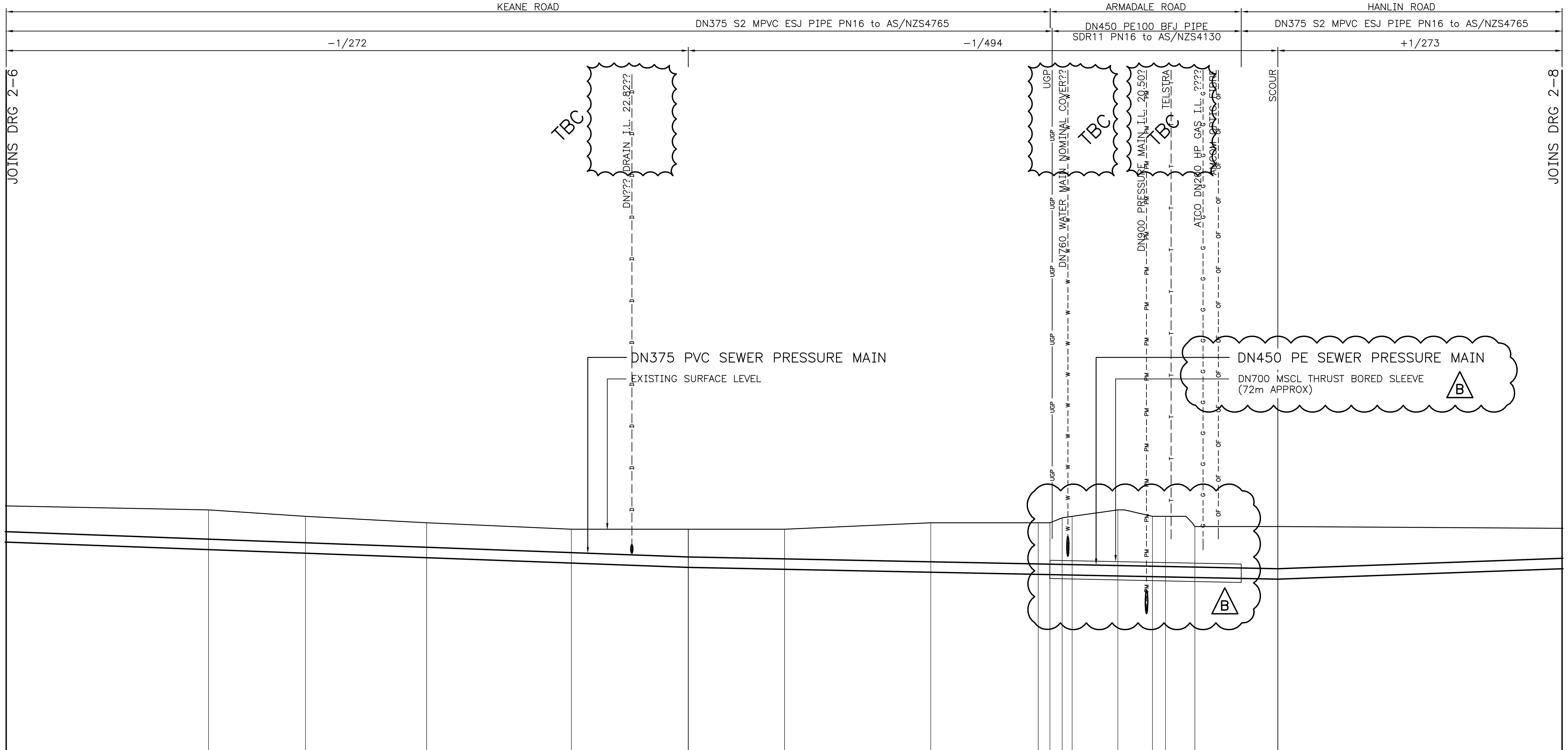
DIAL BEFORE YOU DIG
www.1100.com.au

NOTE:
THE LOCATION OF OTHER UTILITIES HAS NOT NECESSARILY BEEN ESTABLISHED BY SURVEY, BUT IS BASED ON DIGITAL SERVICE DATA PROVIDED BY THE ASSET OWNERS AND IS INDICATIVE ONLY. SERVICES MUST BE LOCATED AND VERIFIED ON SITE. FOR MORE INFORMATION CONTACT DIAL BEFORE YOU DIG ON 1100 OR WWW.1100.COM.AU

LEGEND

- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85–1–1



DATUM 15.00m ABOVE AHD

HORIZONTAL DISTANCE	NATURAL SURFACE LEVEL	DEPTH TO INVERT	INVERT LEVEL
3350			
3428.0	24.50		
3465.4	24.25		
3512.2	24.00		
3567.9	23.75		
3613.1		1.47	22.28
3650.2	23.75		
3706.5	24.00		
3748.0	24.00		
3752.5	24.00		
3757.2	24.19		
3761.1	24.25		
3778.7	24.50		
3792.0	24.25		
3797.1	24.25		
3808.4	23.85		
3840.4	23.85	2.03	21.82
3950			

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

DATE : 6-Feb-2014

(1:1000) (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		TRENCHLESS INSTALLATION SHOWN UNDER ARMADALE RD	KB	KB	PGS

DESIGN SURVEY: GHD 2661551 V01
VERTICAL DATUM: AHD
COORDINATE SYS: MGA94–50
ASCON SURVEY: NONE
DES REF: GHD 61–29471
DES CALC: K.BOSMAN
DES CHD: P.SPENCER
DRN: K.BOSMAN
Q.C. CHD: R.SPILLANE
NORTH POINT

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CONSULTANT PROJECT DIRECTOR

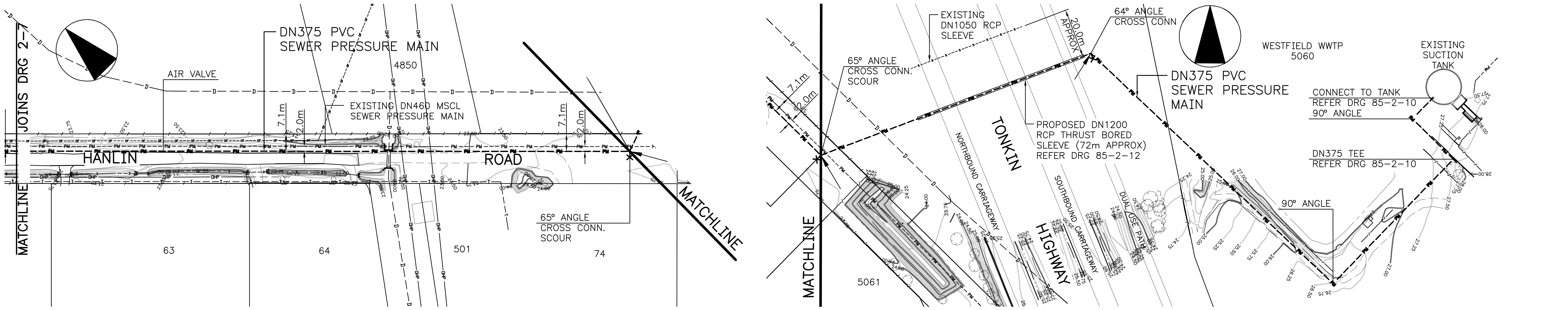
WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION – SHEET 7 OF 8

FILE
PROJECT C–S01249
PLAN CAD HW91–85–2–7
ISSUE B
ORIGINAL SHEET SIZE A1
MF

566
810

61\29471\CADD\HW91\HW91–085–002–07B 06/02/2014



PLAN
1:1000

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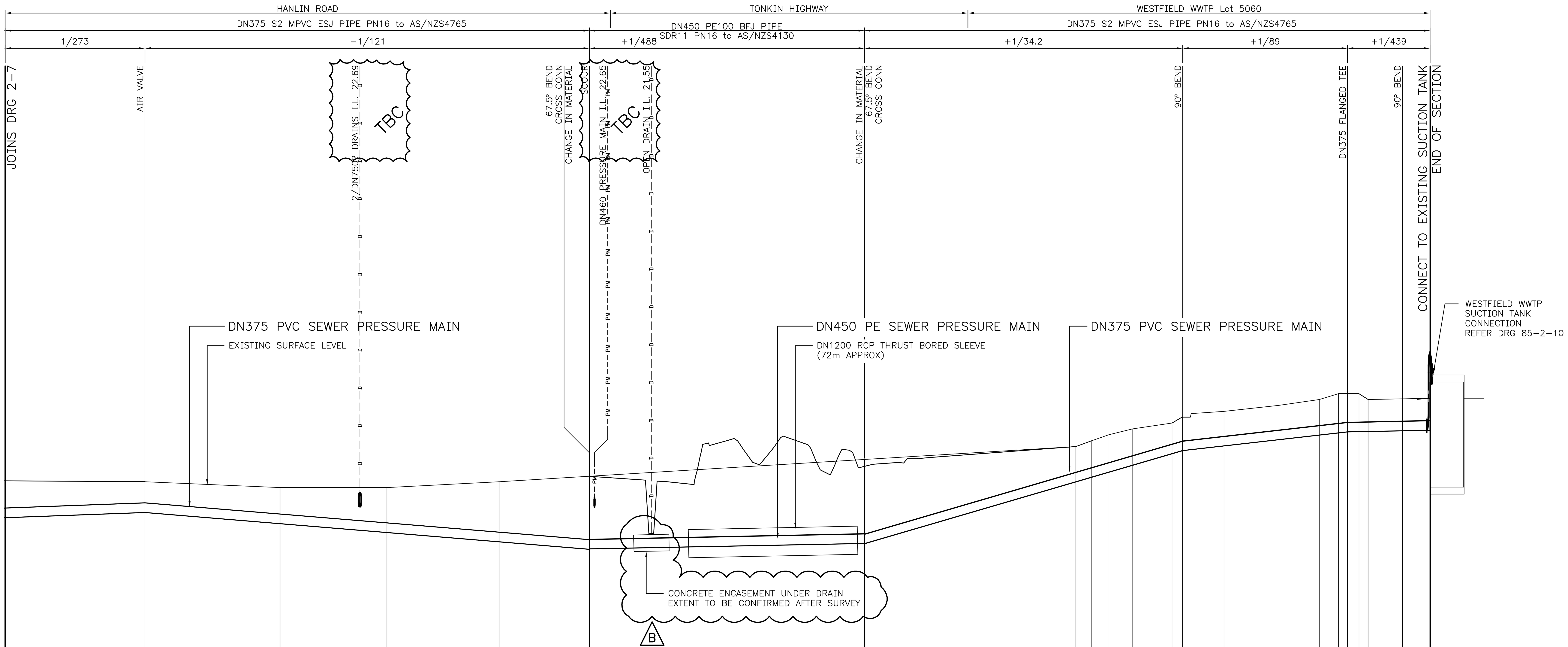
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85-1-1



DATUM 15.00m ABOVE AHD

HORIZONTAL DISTANCE	NATURAL SURFACE LEVEL	DEPTH TO INVERT	INVERT LEVEL
3950			
4009.5	23.75	1.31	22.44
4067.1	23.50		
4112.6	23.50		
4160.4	23.75		
4198.8		3.10	20.88
		3.09	20.89
4316.0		3.28	21.12
		3.29	21.11
4406.0	25.25		
4412.8	25.50		
4420.1	25.75		
4430.2	26.00		
4447.0	26.25		
4451.5	26.50	1.42	25.08
4469.1	26.75		
4492.5	27.00		
4509.7	27.25		
4517.8	27.50		
4521.7		1.63	25.87
4526.5	27.50		
4530.5	27.25		
4545.0			
4556.8	27.30	1.36	25.94

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

DATE : 6-Feb-2014

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		CONCRETE ENCASEMENT ADDED TO DRAIN CROSSING	KB	KB	PGS

DESIGN SURVEY	VERTICAL DATUM	DES CALC
GHD 2661551 V01	AHD	K.BOSMAN
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

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APPROVED 09/09/2013
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

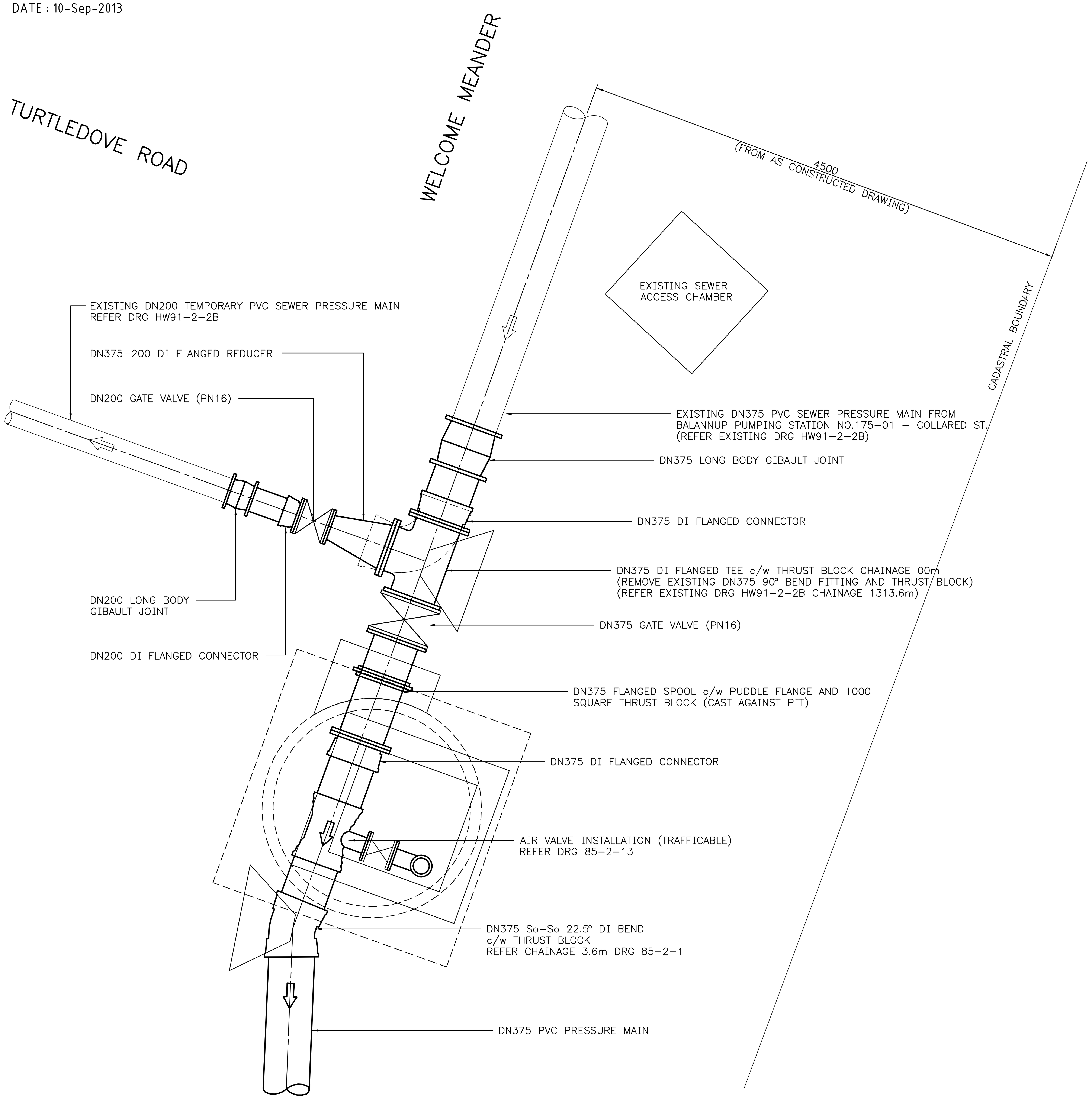
METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 8 OF 8

FILE
PROJECT C-S01249
PLAN HW91-85-2-8
CAD
ISSUE B
ORIGINAL SHEET SIZE A1
MF

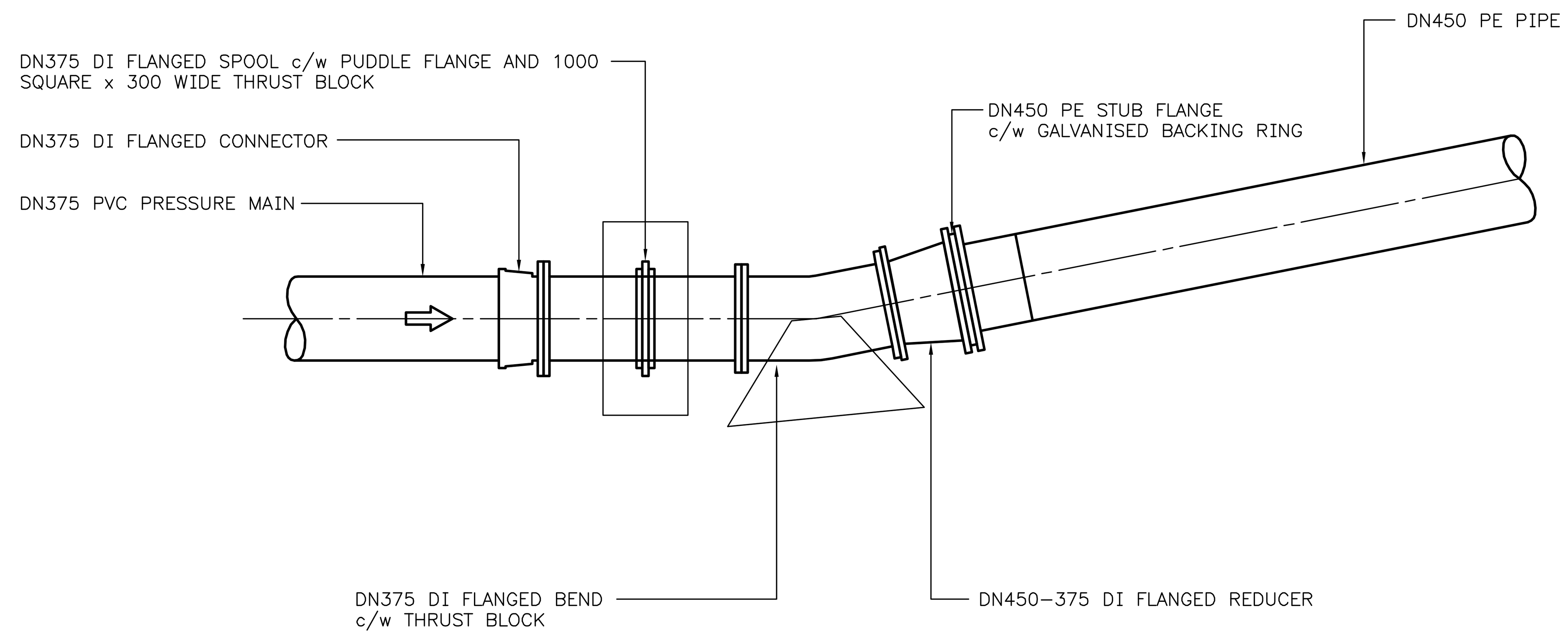
566
810

61\29471\CADD\HW91\HW91-085-002-08B 06/02/2014

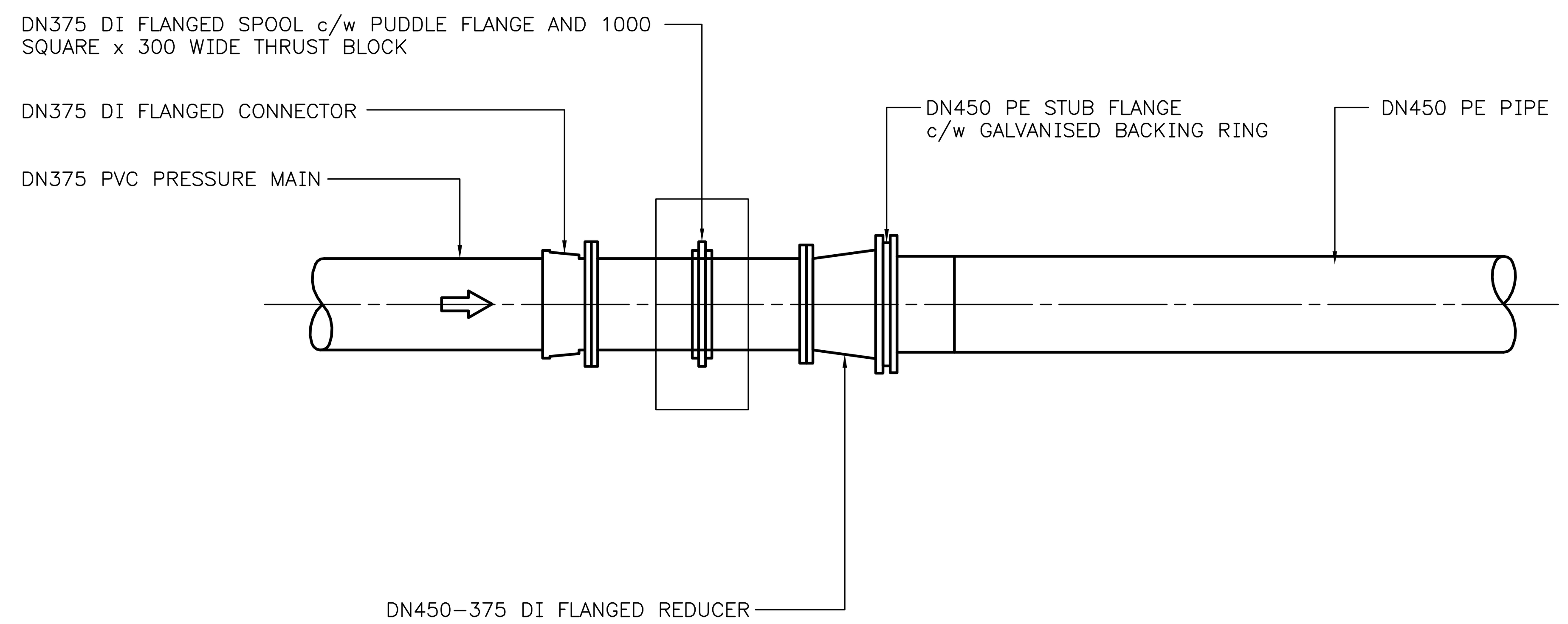
ENGINEERING DESIGN - NOT FOR CONSTRUCTION
DATE : 10-Sep-2013



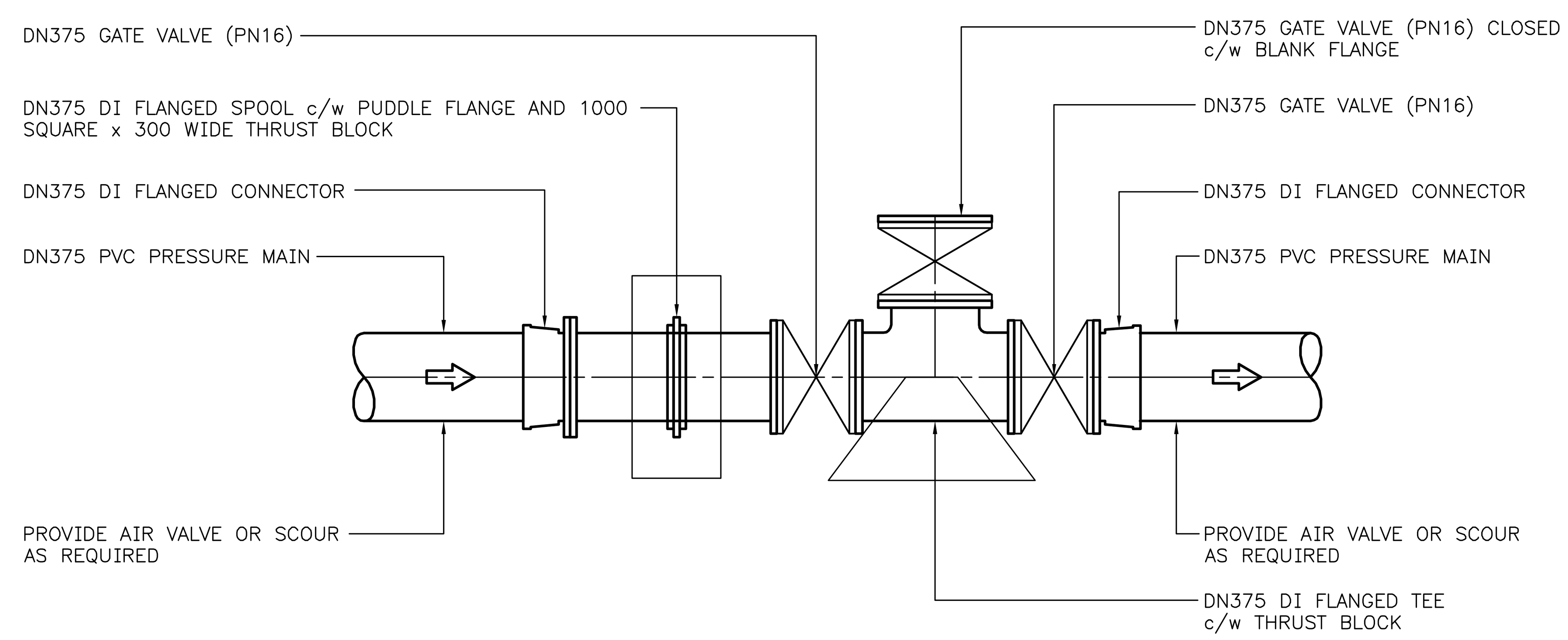
CONNECTION TO EXISTING PRESSURE MAIN
REFER DRG 85-2-1
1:25



DN375 PVC TO DN450 PE CONNECTION AT A BEND
1:25



DN375 PVC TO DN450 PE STRAIGHT CONNECTION
1:25



TYPICAL CROSS CONNECTION FOR FUTURE PRESSURE MAIN
(4 REQUIRED)
1:25

500 0 500 1000 1500 mm (1:25)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM NONE	DES CALC K.BOSMAN
	COORDINATE SYS NONE	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

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CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
CONNECTION DETAILS - SHEET 1

FILE
PROJECT C-S01249
PLAN HW91-85-2-9
CAD
ISSUE A
ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91-085-002-09A 10/09/2013

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

WESTFIELD WASTEWATER TREATMENT PLANT
CONNECTION REFER DRG 85-2-8
1:50

SECTION A –

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM NONE	DES CALC K.BOSMAN	NORTH POINT
	COORDINATE SYS NONE	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
CONNECTION DETAILS - SHEET 2

FILE | PLAN HW91-85-2-10 | CAD | ISSUE A
PROJECT C-S01249

ORIGINAL SHEET SIZE A1 | MF

61\29471\CADD\HW91\HW91-085-002-10A 10/09/2013

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC K.BOSMAN	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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CONSULTANT PROJECT DIRECTOR

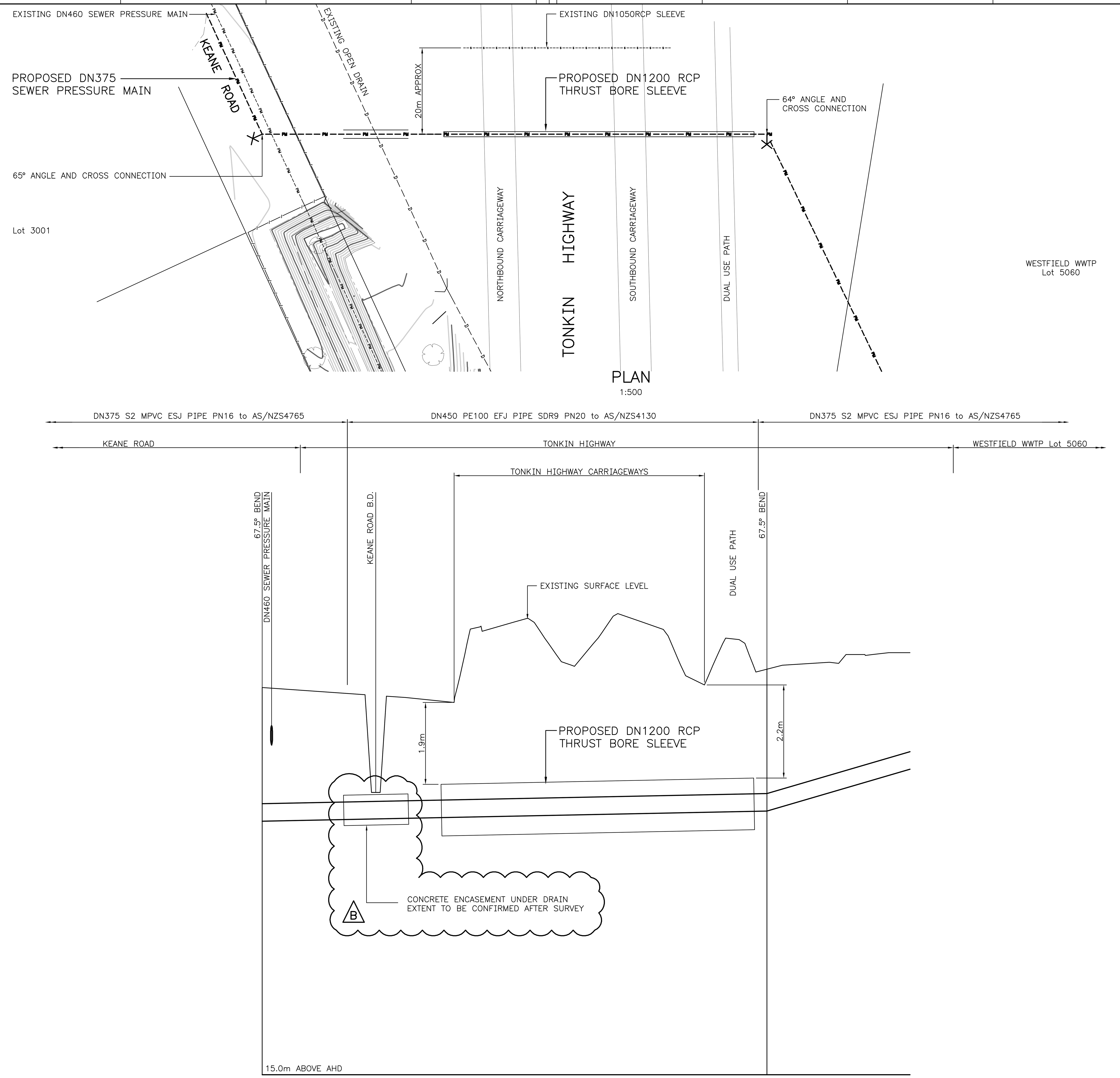
WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
DBNGP CROSSING

FILE | PLAN | CAD | ISSUE A
PROJECT C-S01249
HW91-85-2-11

ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91-085-002-11A 10/09/2013



ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 6-Feb-2014

SECTION
HORIZONTAL 1:500
VERTICAL 1:50

VERTICAL SCALE 1000 500 0 1000 2000 3000 mm (1:50)
HORIZONTAL SCALE 5 0 5 10 15 20 25 30 35 m (1:500)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		CONCRETE ENCASEMENT ADDED TO DRAIN CROSSING	KB	KB	PGS

DESIGN SURVEY: GHD 2661551 V01
VERTICAL DATUM: NONE
COORDINATE SYS: NONE
ASCON SURVEY: NONE
DES REF: GHD 61-29471
DES CALC: K.BOSMAN
DES CHD: P.SPENCER
DRN: K.BOSMAN
Q.C. CHD: R.SPILLANE
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CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
TONKIN HIGHWAY CROSSING

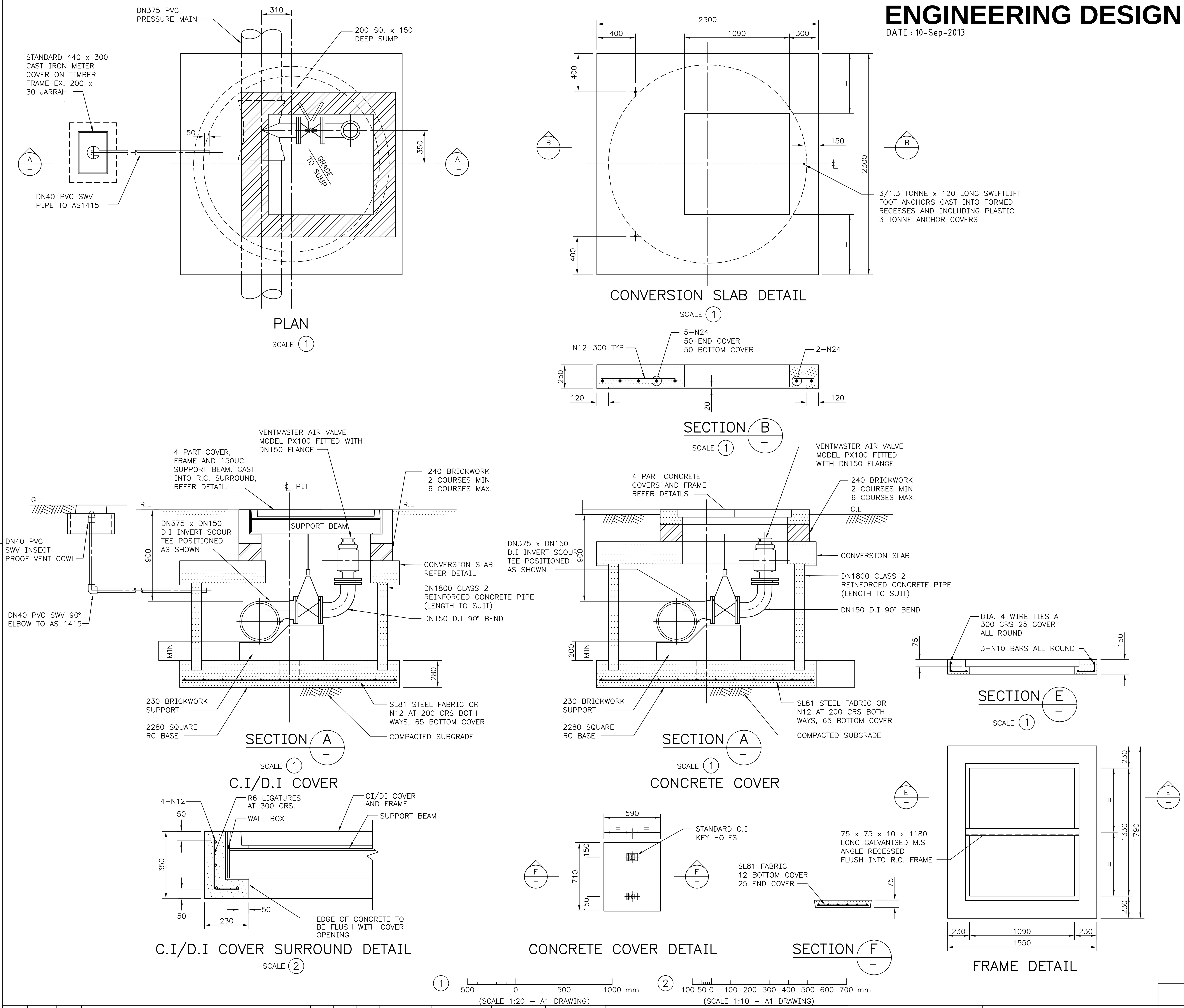
FILE
PROJECT C-S01249
PLAN HW91-85-2-12
CAD
ISSUE B
ORIGINAL SHEET SIZE A1
MF

566
810

61\29471\CADD\HW91\HW91-085-002-12B 06/02/2014

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013



GENERAL NOTES

1. ALL DIMENSION IN MILLIMETRES UNLESS SHOWN OTHERWISE.
2. ALL STEELWORK SHALL COMPLY WITH AS4100 AND SHALL BE HOT DIP GALVANISED AFTER FABRICATION TO AS/NZS4680. STEELWORK TO BE FABRICATED TO SUIT HOT-DIP GALVANISING REQUIREMENTS. INCLUDING REMOVAL OF SHARP EDGES, WELDING SLAG AND SURFACE IRREGULARITIES.
3. DAMAGE TO THE HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS4680 USING 'DIMET ZEDEN' OR ACCEPTABLE EQUIVALENT PRODUCT.
4. ALL WELDS TO BE 6mm CONTINUOUS FILLET WELDS TO AS1554 PT. 1.
5. CONCRETE SHALL BE GRADE N32 TO AS1379 PLACED IN ACCORDANCE WITH AS3600.
6. REINFORCING STEEL TO BE NORMAL DUCTILE GRADE 500N TO AS/NZS4671.
7. GATE VALVES SHALL BE TO SPS 272 AND RESILIENT SEATED. ALL FLANGES AND FLANGE DRILLING SHALL COMPLY WITH AS4087 PN16.
8. DUCTILE IRON PIPE FITTINGS SHALL BE TO AS2280 AND SHALL BE FUSION BONDED NYLON COATED INTERNALLY AND EXTERNALLY. SOCKETED (RRJ) D.I. PRESSURE MAIN FITTINGS SHALL MATCH THE AS/NZS1477 SERIES 2 PVC PIPE DIAMETER, EXCEPT WHERE OTHERWISE SHOWN.
9. ALL FASTENERS SHALL BE 12ø SS. SS TO BE TO ASTM A276 GRADE 316.
10. IF SOIL AT VALVE PIT FOUNDATION LEVEL IS NOT SAND IT SHALL BE EXCAVATED TO A MIN. DEPTH OF 300mm BELOW PIT AND THIS EXCAVATION REFILLED WITH SAND. FOUNDATION OR SAND REFILL MATERIAL SHALL BE COMPACTED AS PIPE UNDERLAY
11. AIR VALVE AVAILABLE FROM GFR INDUSTRIES, 8 ARTELLO BAY RD, MIDVALE WA 6056 PHONE (08) 9250 2944. TO SPS 201.
12. UNLESS OTHERWISE SHOWN. ALL FLANGE BOLTS, NUTS AND WASHERS TO BE HOT DIP GALVANISED STEEL. ALL DAMAGE TO HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS4680 USING 'DIMET ZEDEN' OR APPROVED SIMILAR PRODUCT.
13. UNLESS SHOWN OTHERWISE METALLIC FLANGED JOINTWORK INCLUDING NUTS AND BOLTS SHALL BE FIELD-WRAPPED BY A PROTECTION SYSTEM COMPRISING 'DENSO 600' TAPE AND 'DENSO 901' OVERWRAP TAPE OR APPROVED EQUIVALENT.

REFERENCE DRAWINGS

PLAN AND LONGITUDINAL SECTIONS 85-2-1 TO 85-2-8

THIS DRAWING IS DERIVED FROM CA01-52-3A

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY	VERTICAL DATUM NONE	DES CALC WC STD
	COORDINATE SYS NONE	DES CHD WC STD
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

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WATER CORPORATION

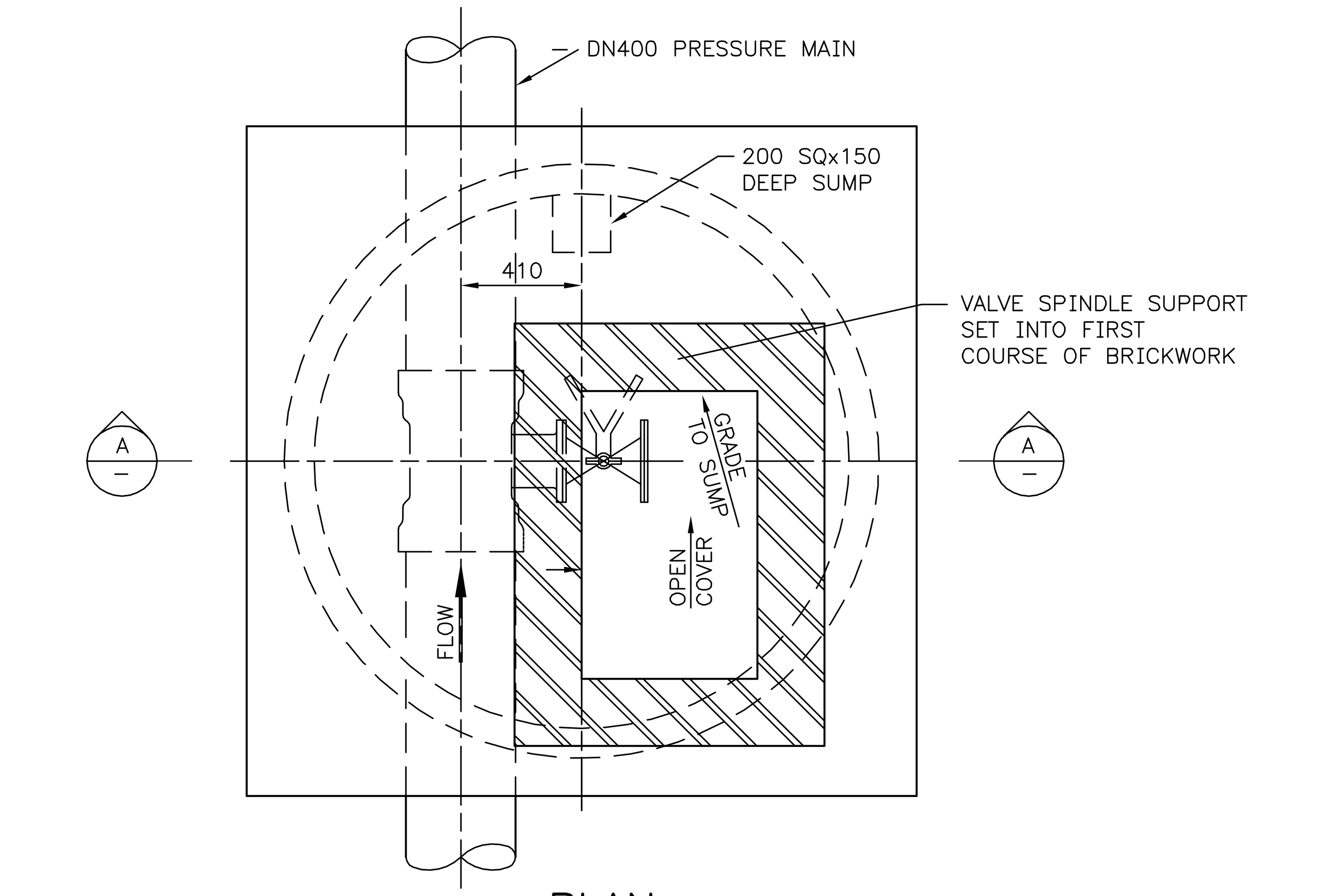
METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
AIR VALVE ARRANGEMENT AND DETAILS

FILE
PROJECT C-S01249
PLAN HW91-85-2-13 CAD
ISSUE A
ORIGINAL SHEET SIZE A1
MF

61\29471\CADD\HW91\HW91-085-002-13A 10/09/2013

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

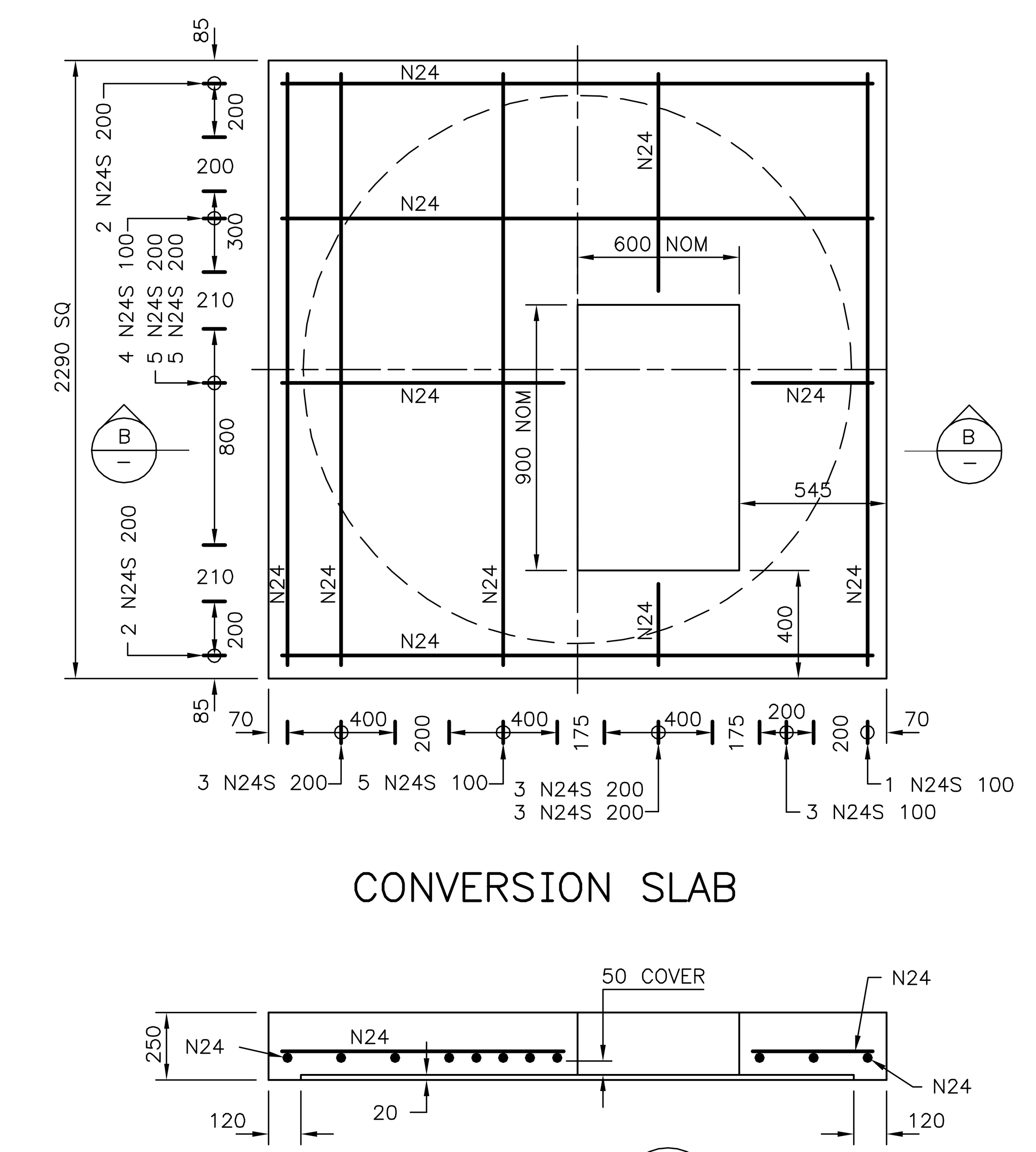
DATE : 6-Feb-2014



PLAN

SCALE 1

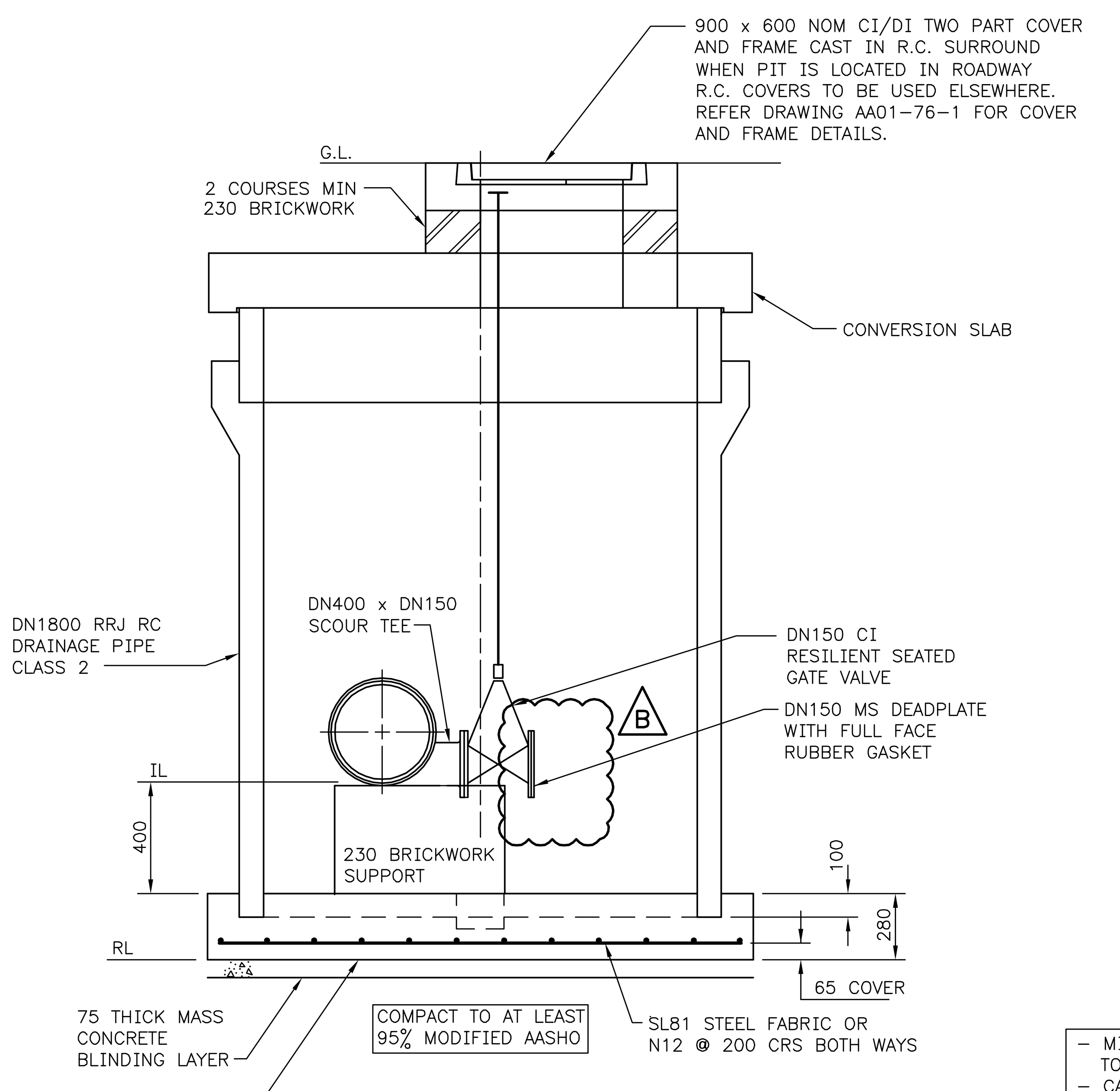
C.I./D.I. CLASS D COVERS SHALL BE USED IN ROAD PAVEMENTS.
C.I./D.I. CLASS C COVERS SHALL BE USED IN ROW'S AND CARPARKS.
REINFORCED CONCRETE COVERS SHALL BE USED ELSEWHERE.



CONVERSION SLAB

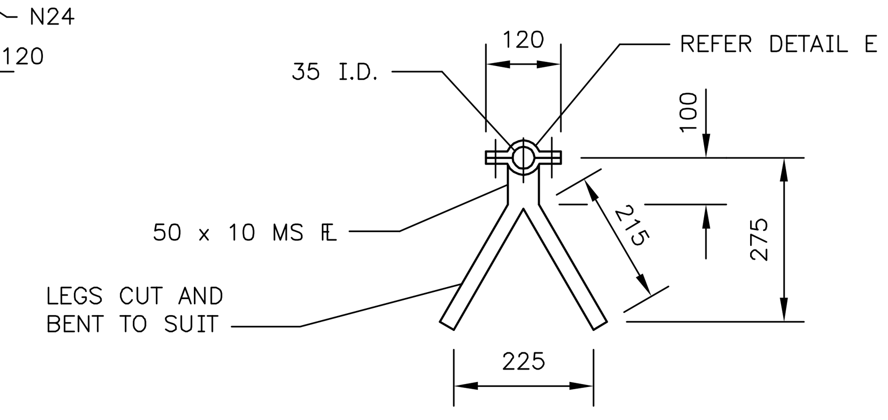
SECTION B

SCALE 1



SECTION A

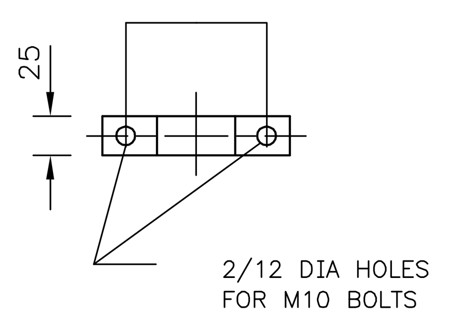
SCALE 1



VALVE SPINDLE SUPPORT BRACKET

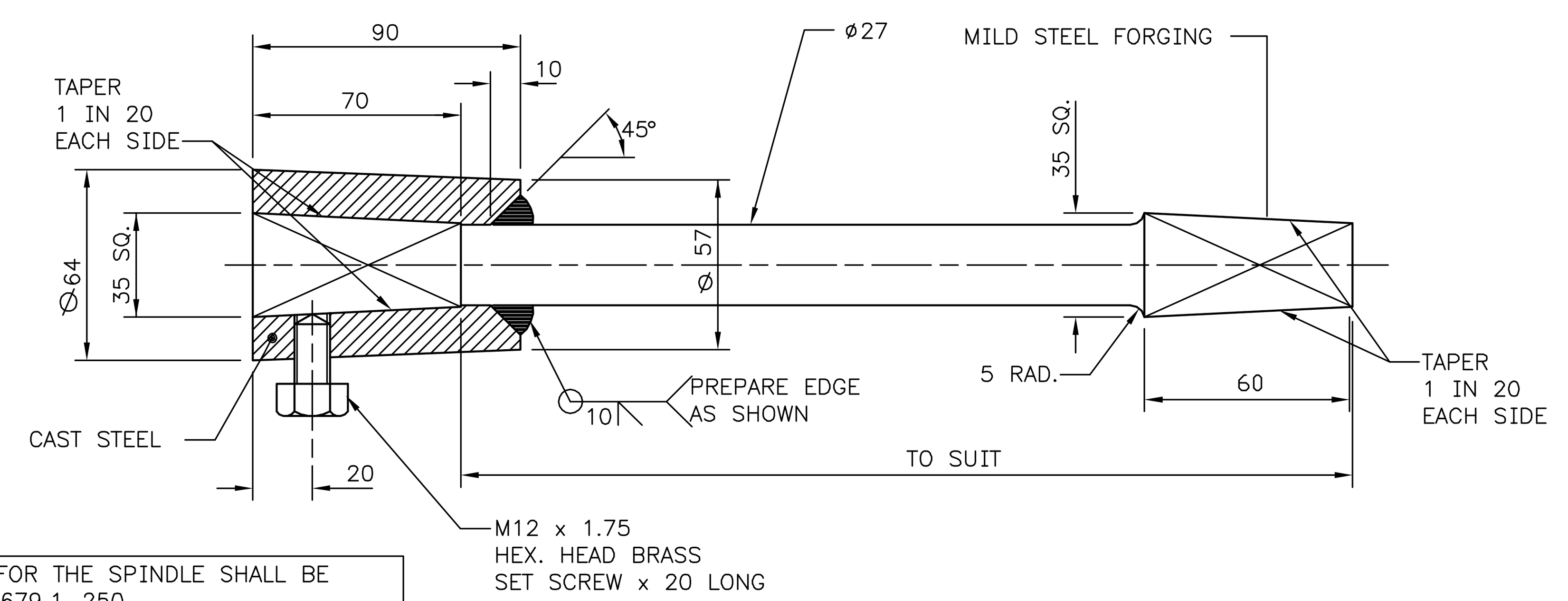
HOT DIP GALVANISED

SCALE : DIAGRAMMATIC



DETAIL E

SCALE 2



- MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1-250.
- CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
- THE SPINDLE INCLUDING TAPERED KEY END SHALL COMPLY WITH AS 2638.2
- ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1

VALVE SPINDLE EXTENSION

SCALE : DIAGRAMMATIC

GENERAL NOTES

1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES UNLESS SHOWN OTHERWISE.
2. ALL STRUCTURAL STEELWORK WELDING SHALL COMPLY WITH AS 1554 – PART 1. STEELWORK FABRICATION SHALL COMPLY WITH AS 4100.
3. MILD STEEL (MS) LADDER COMPONENTS SHALL BE HOT-DIP GALVANISED AFTER FABRICATION TO AS/NZS 4680. STEELWORK SHALL BE FABRICATED TO SUIT HOT-DIP GALVANIZING REQUIREMENTS, INCLUDING REMOVAL OF SHARP EDGES, WELDING SLAG AND SURFACE IRREGULARITIES.
4. ALL DAMAGE TO THE HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS 4680 USING 'DIMET ZEDEN' OR APPROVED EQUIVALENT PRODUCT.
5. CONCRETE SHALL BE GRADE N32 TO AS 1379 PLACED IN ACCORDANCE WITH AS 3600.
6. REINFORCING STEEL TO BE NORMAL DUCTILE IRON GRADE 500N TO AS/NZS 4671.
7. SLUICE VALVES SHALL BE RESILIENT SEATED AND TO SPS 272.
8. ALL FASTENERS SHALL BE STAINLESS STEEL TO ASTM A276 GRADE 316L.
9. IF SOIL AT VALVE PIT FOUNDATION LEVEL IS NOT SAND IT SHALL BE EXCAVATED TO A MIN. DEPTH OF 300mm BELOW PIT BLINDING LAYER AND THIS EXCAVATION REFILLED WITH SAND. FOUNDATION OR SAND REFILL MATERIAL SHALL BE COMPACTED AS PIPE UNDERLAY
10. EXTENSION SPINDLES TO CONFORM TO WATER CORPORATION STANDARD DRG AQ71-3-1 (LENGTH TO SUIT) AND FIXED WITH M12 SET SCREW TO VALVE SPINDLE. SPINDLES GREATER THAN 2m IN LENGTH SHALL REQUIRE AN ADDITIONAL MID-HEIGHT SUPPORT ATTACHED TO THE MANHOLE LINER.
11. MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1-250
12. CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
13. THE SPINDLE INCLUDING TAPERED KEY END SHALL BE HOT FORGED.
14. CAST STEEL SOCKET END AND TAPERED KEY END SHALL COMPLY WITH AS 2638.2
15. ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1
16. DEPTH TO TOP OF VALVE SPINDLE SHALL BE MEASURED OR CALCULATED FROM THE FINISHED SURFACE LEVEL

REFERENCE DRAWINGS

PLAN AND LONGITUDINAL SECTIONS 85-2-1 TO 85-2-8

1 500 0 500 1000 mm (SCALE 1:20 – A1 SHEET)

2 100 50 0 100 200 300 mm (SCALE 1:5 – A1 SHEET)

THIS DRAWING IS DERIVED FROM CA01-54-5A

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	11/2013	2G	ARROW RELOCATED TO POINT AT DEADPLATE	KB	GD	PGS

DESIGN SURVEY	VERTICAL DATUM NONE	DES CALC WC STD
	COORDINATE SYS NONE	DES CHD WC STD
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

NORTH POINT

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E permail@ghd.com.au W www.ghd.com.au

RECOMMENDED 09/09/2013 G. DUNLOP (SIGNED) CONSULTANT JOB MANAGER

APPROVED 09/09/2013 P.G. SPENCER (SIGNED) CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
GREATER THAN 2.2m TO INVERT – SCOUR ARRANGEMENT AND DETAILS

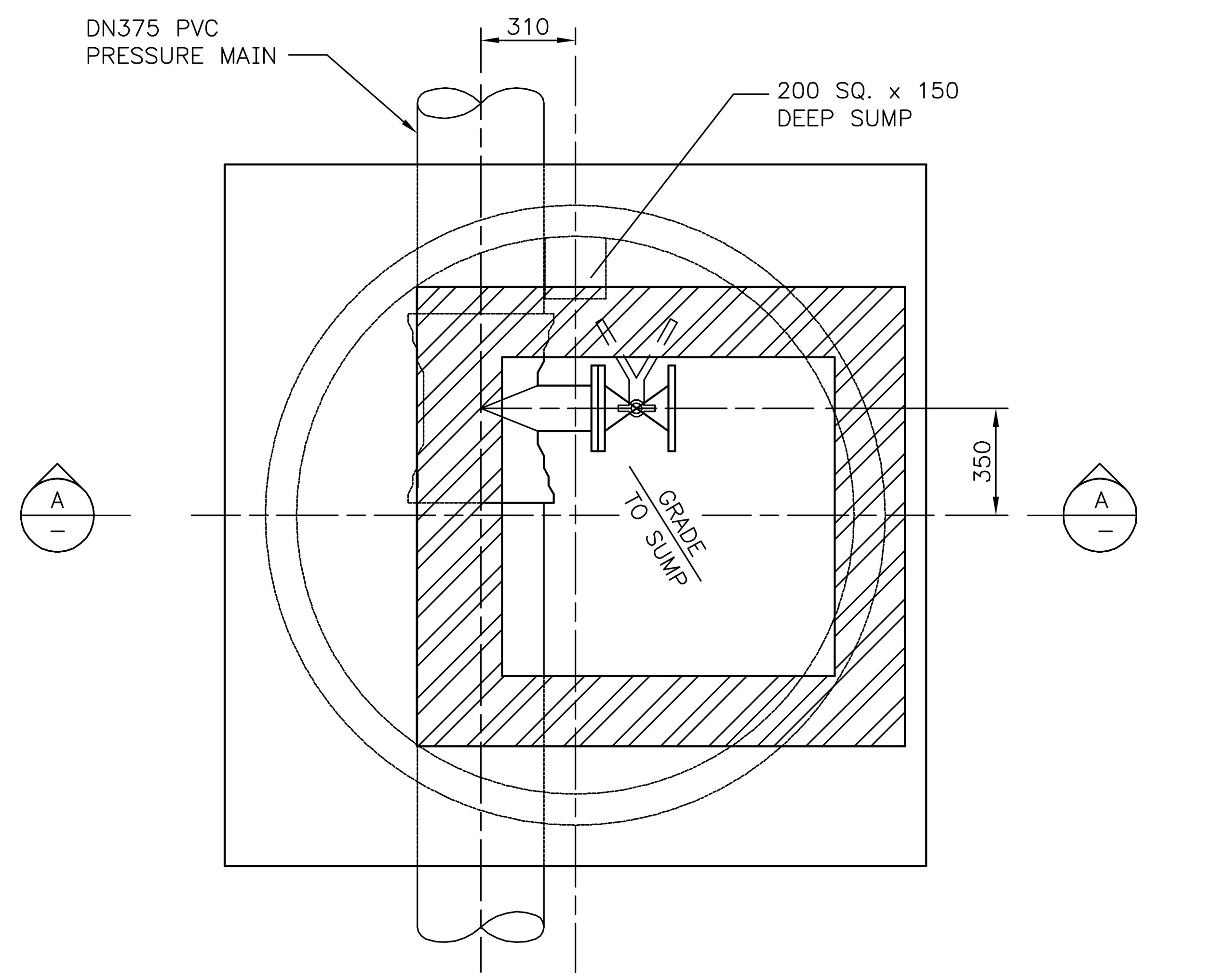
ORIGINAL SHEET SIZE A1

FILE JT1 201202141 V01 | PLAN | CAD | ISSUE

PROJECT C-S01249 | HW91-85-2-14 | B | MF

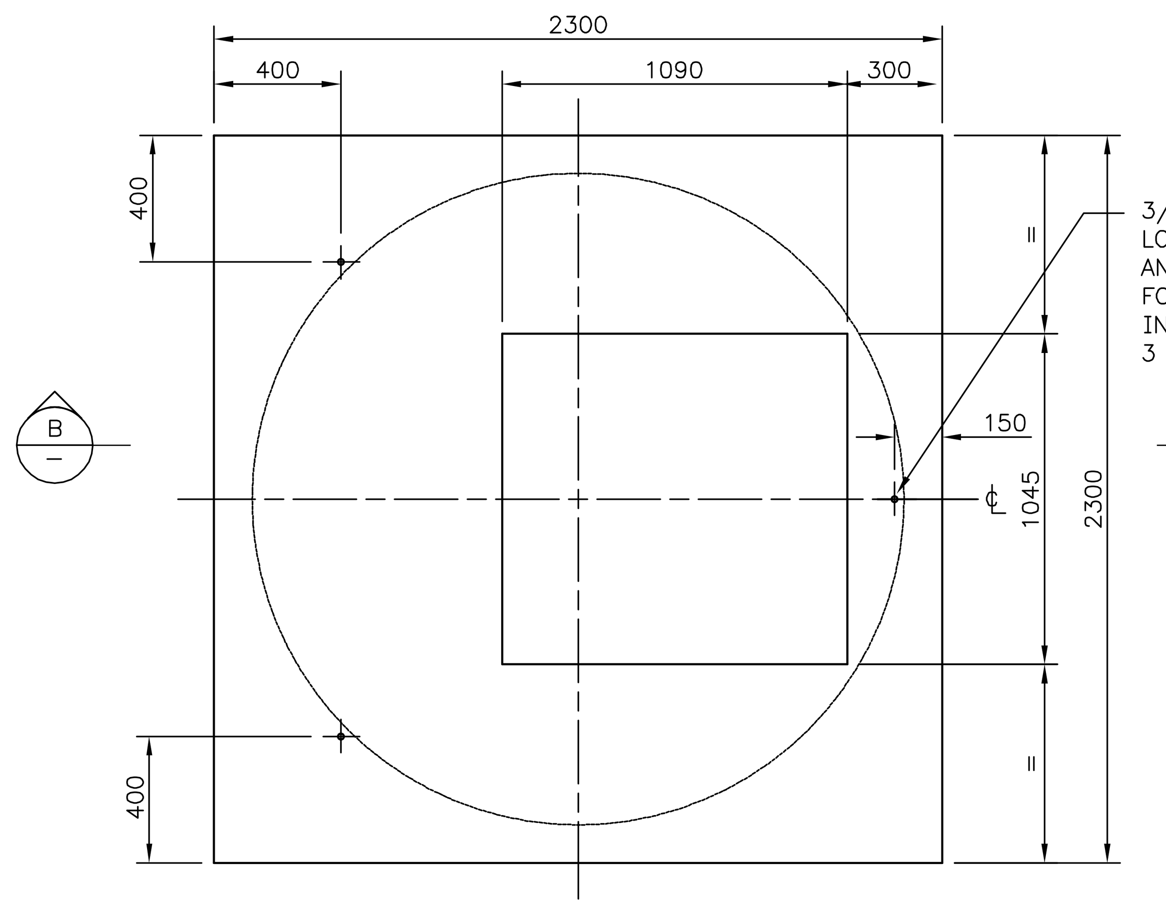
61\29471\CADD\HW91\HW91-085-002-14B 06/02/2014

566 810



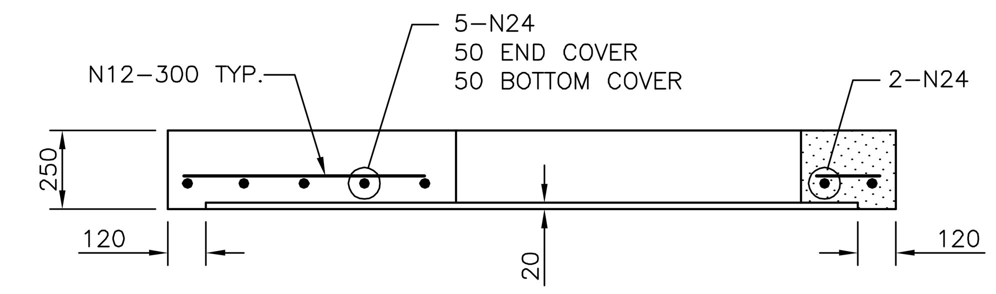
PLAN

SCALE 1



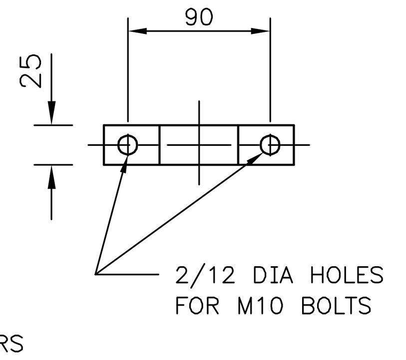
CONVERSION SLAB DETAIL

SCALE 1



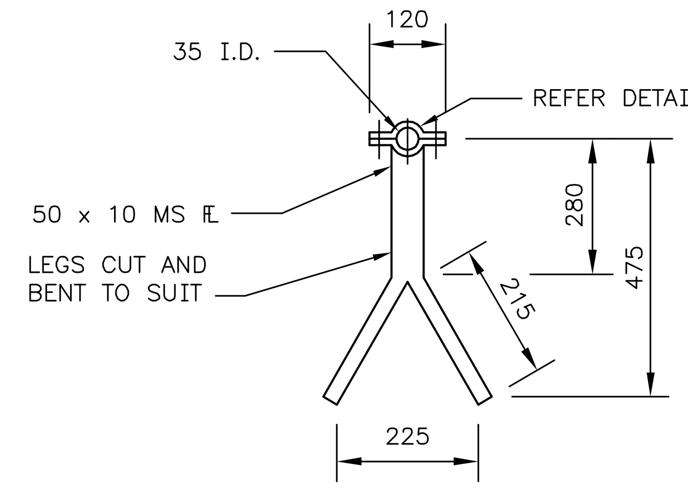
SECTION B

SCALE 1



DETAIL E

SCALE 3

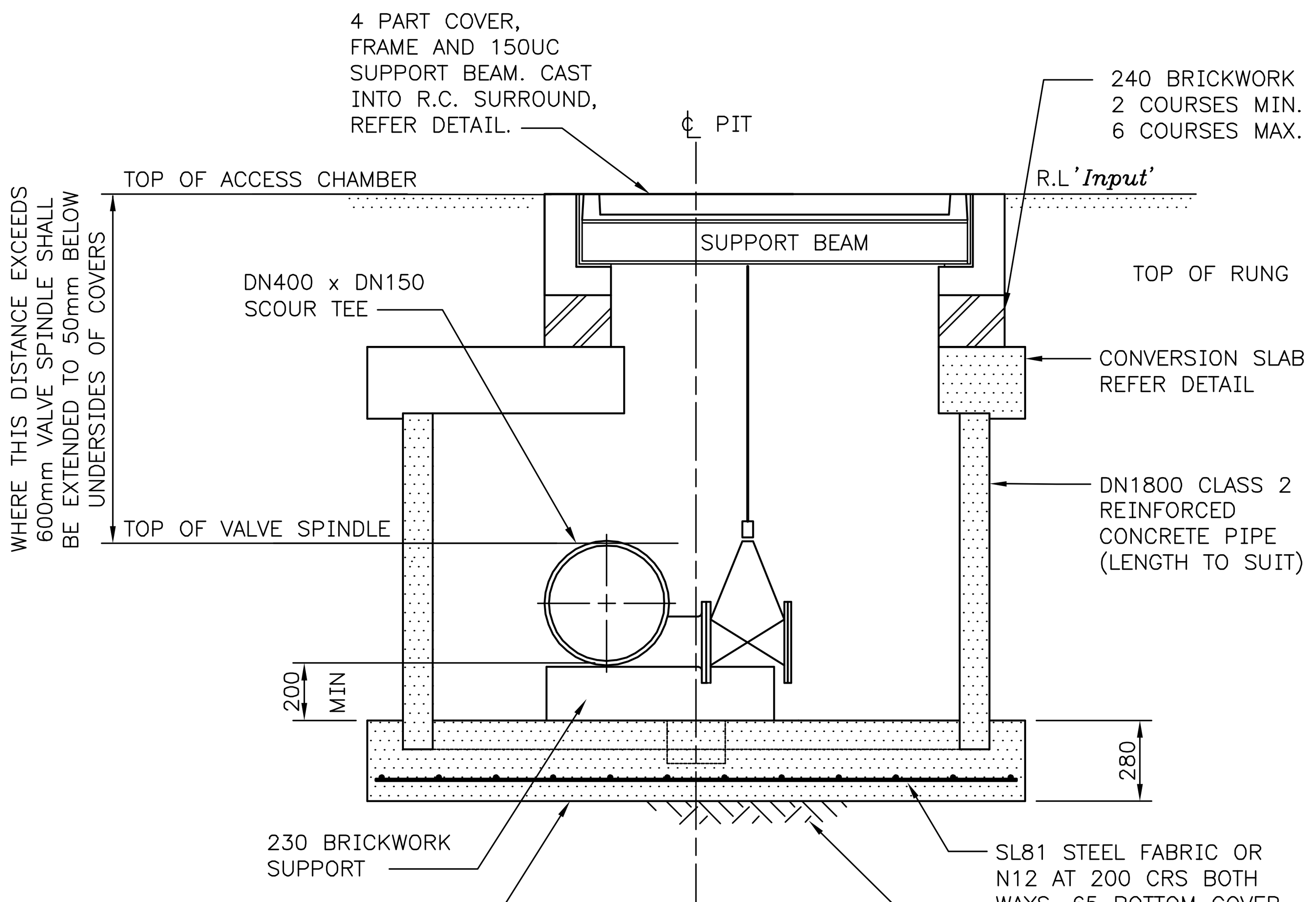


VALVE SPINDLE SUPPORT BRACKET

HOT DIP GALVANISED

SCALE : DIAGRAMMATIC

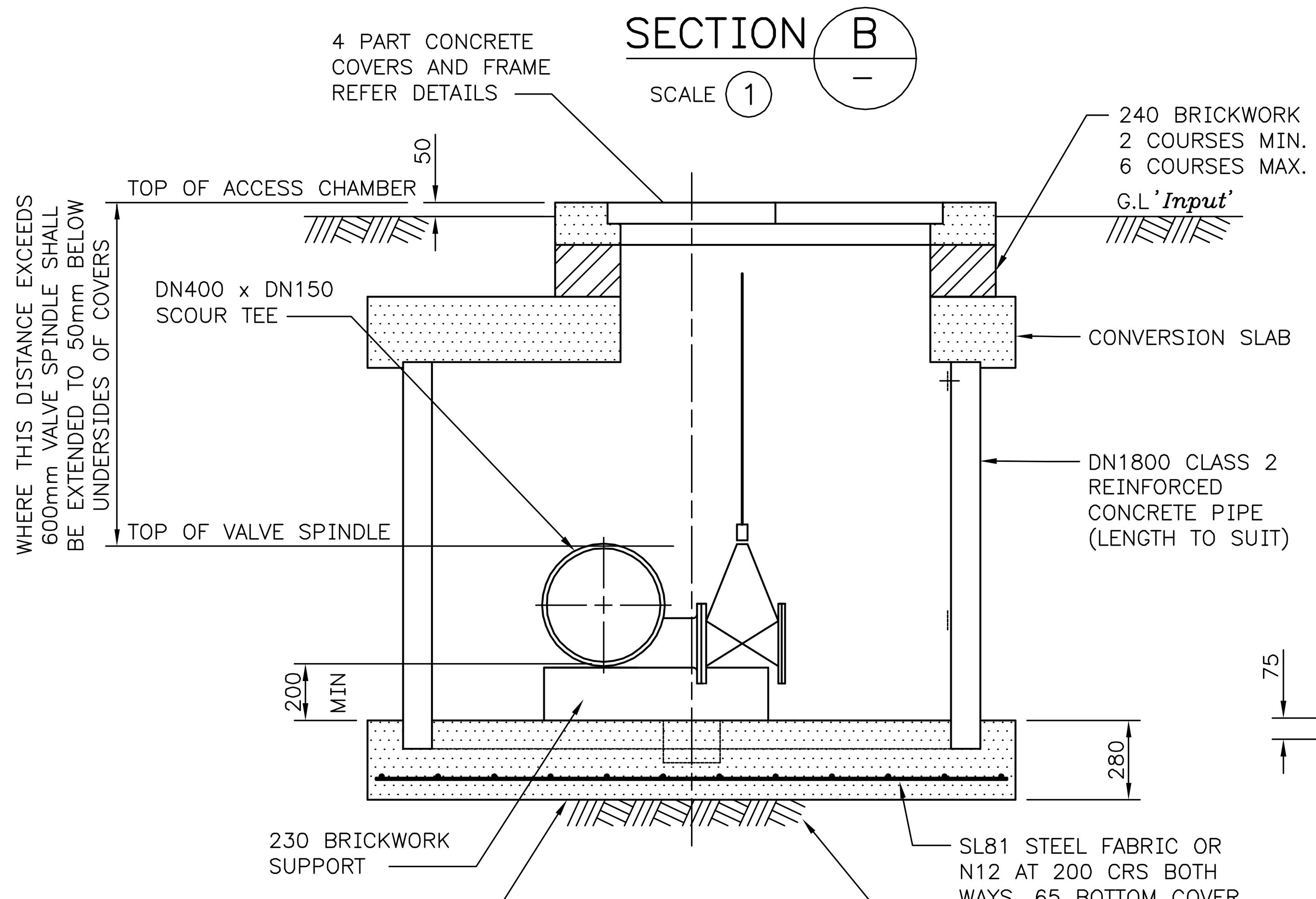
- MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1–250.
- CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
- THE SPINDLE INCLUDING TAPERED KEY END SHALL COMPLY WITH AS 2638.2
- ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1



SECTION A

SCALE 1

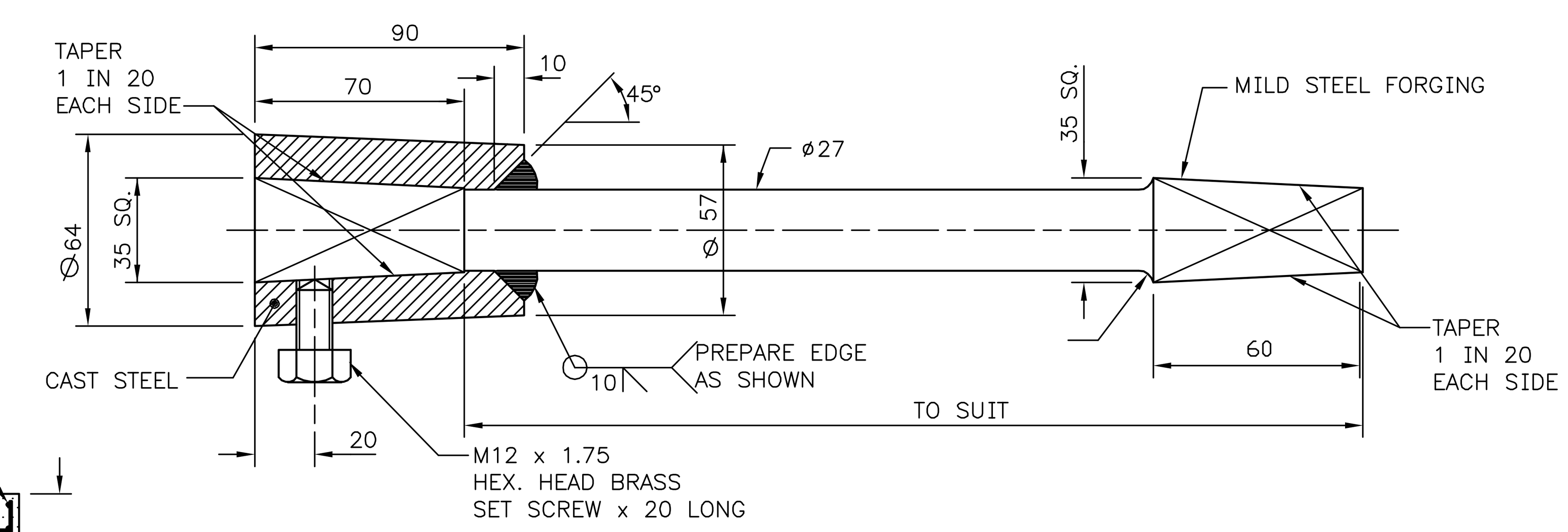
C.I/D.I COVER



SECTION A

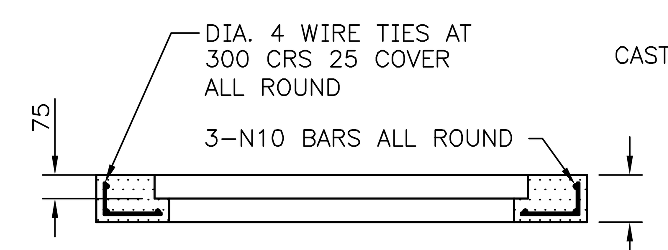
SCALE 1

CONCRETE COVER



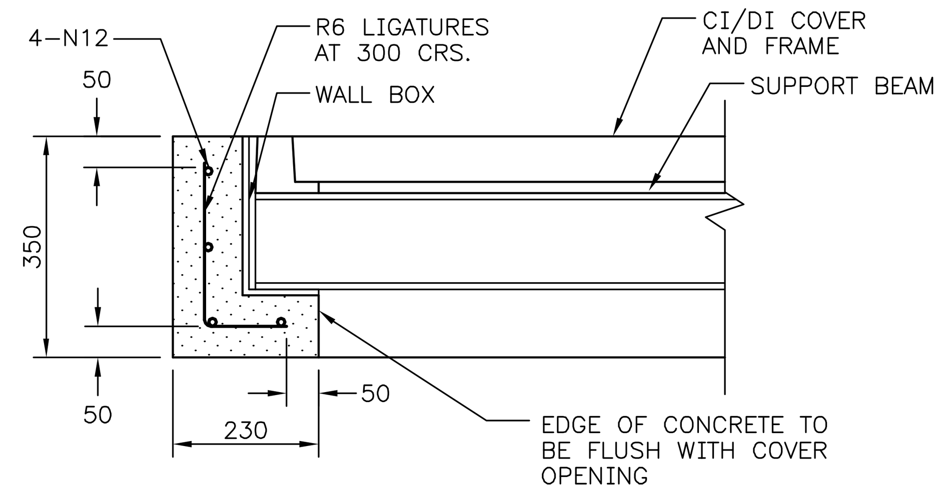
VALVE SPINDLE EXTENSION

SCALE : DIAGRAMMATIC



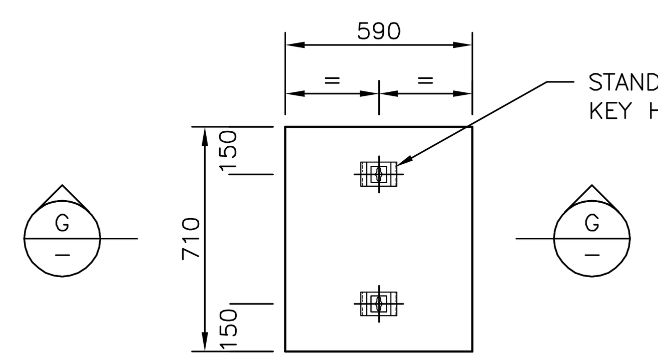
SECTION F

SCALE 1

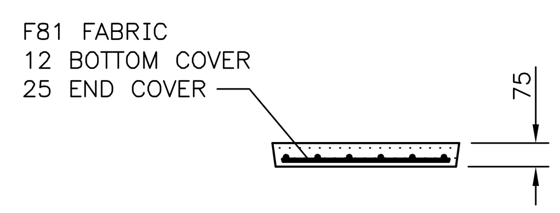


C.I/D.I COVER SURROUND DETAIL

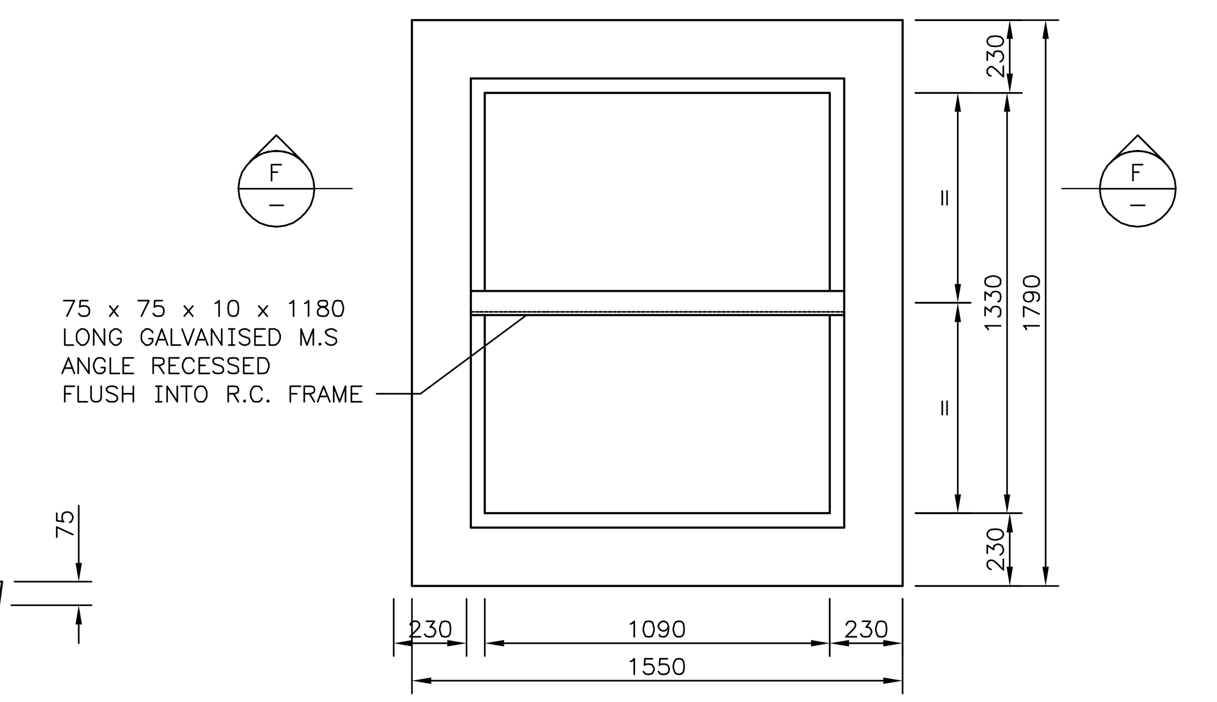
SCALE 2



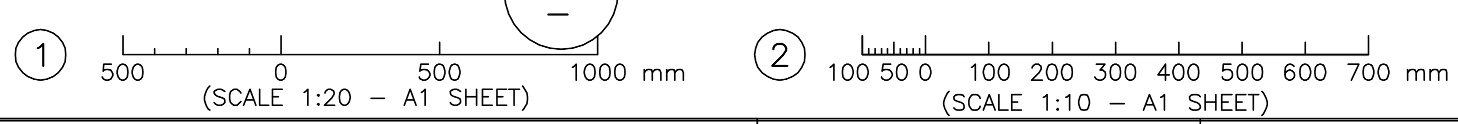
CONCRETE COVER DETAIL



SECTION G



FRAME DETAIL



GENERAL NOTES

1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES UNLESS SHOWN OTHERWISE.
2. ALL STRUCTURAL STEELWORK WELDING SHALL COMPLY WITH AS 1554 – PART 1. STEELWORK FABRICATION SHALL COMPLY WITH AS 4100.
3. MILD STEEL (MS) LADDER COMPONENTS SHALL BE HOT–DIP GALVANISED AFTER FABRICATION TO AS/NZS 4680. STEELWORK SHALL BE FABRICATED TO SUIT HOT–DIP GALVANISING REQUIREMENTS, INCLUDING REMOVAL OF SHARP EDGES, WELDING SLAG AND SURFACE IRREGULARITIES.
4. ALL DAMAGE TO THE HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS 4680 USING 'DIMET ZEDEN' OR APPROVED EQUIVALENT PRODUCT.
5. CONCRETE SHALL BE GRADE N32 TO AS 1379 PLACED IN ACCORDANCE WITH AS 3600.
6. REINFORCING STEEL TO BE NORMAL DUCTILE GRADE 500N TO AS/NZS 4671.
7. SLUICE VALVES SHALL BE RESILIENT SEATED AND TO SPS 272.
8. ALL FASTENERS SHALL BE STAINLESS STEEL TO ASTM A276 GRADE 316L.
9. IF SOIL AT VALVE PIT FOUNDATION LEVEL IS NOT SAND IT SHALL BE EXCAVATED TO A MIN. DEPTH OF 300mm BELOW PIT BLINDING LAYER AND THIS EXCAVATION REFILLED WITH SAND. FOUNDATION OR SAND REFILL MATERIAL SHALL BE COMPACTED AS PIPE UNDERLAY
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PLAN AND LONGITUDINAL SECTIONS 85–2–1 TO 85–2–8

THIS DRAWING IS DERIVED FROM CA01–54–4A

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY | VERTICAL DATUM NONE | DES CALC WC STD | NORTH POINT
COORDINATE SYS NONE | DES CHD WC STD
ASCON SURVEY NONE | DES REF GHD 61–29471 | DRN K.BOSMAN | Q.C. CHD R.SPILLANE

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E permail@ghd.com.au W www.ghd.com.au

RECOMMENDED 09/09/2013 G. DUNLOP (SIGNED) CONSULTANT JOB MANAGER
APPROVED 09/09/2013 P.G. SPENCER (SIGNED) CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
LESS THAN 2.2m TO INVERT – SCOUR ARRANGEMENT AND DETAILS

ORIGINAL SHEET SIZE A1

FILE | PLAN | CAD | ISSUE A | MF
PROJECT C–S01249 | HW91–85–2–15

61\29471\CADD\HW91\HW91–085–002–15A 10/09/2013

Appendix C – Site Investigation Results

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

LocCode	Sample Depth	Sampled Date	Sample Elevation	pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANC/FF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				ASS - Field				**ASS - pH**			**ASS - Acidity Trail**						**ASS - Sulfur Trail**				**ASS - Calcium Values**					**ASS - Magnesium Values**					**SS - Potential Acidit**		**- Net Acidity excl A**		**ASS - Excess ANC**			**ASS - Acid Base Accounting**				
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% S	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				**<4**	**<4**	**2**			**<4**	**2**	**0.03**	**0.03**	**0.03**	**18.7**	**18.7**	**18.7**	**18.7**			**0.03**											**0.03**	**18.7**	**18.7**	**0.03**								
BH01	0	25/06/2013	26.8	8.8	6.1	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	0.5	25/06/2013	26.3	8.6	6.2	**2.4**	2	9.6	**7.5**	**2.1**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	68	0.14	0.14	0.28	0.11	<5	<0.005	<0.005	0.008	0.006	-	-	<10	<0.02	178	0.89	0.28	1.5	<10	<1	<1	<0.02
BH01	1.5	25/06/2013	25.3	8.4	6.1	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	2	25/06/2013	24.8	8.6	6	**2.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	2.5	25/06/2013	24.3	8.1	5.9	**2.2**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	3	25/06/2013	23.8	8.4	6	**2.4**	1	9.1	**7**	**2.1**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.07	0.06	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	44	0.22	0.07	1.5	<10	<1	<1	<0.02
BH02	0	25/06/2013	26.5	8.3	6.4	1.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	0.5	25/06/2013	26	9.7	6.7	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	1	25/06/2013	25.5	8	5.1	**2.9**	2	7.4	**3.4**	**4**	<0.005	**0.41**	**0.41**	<2	**256**	**256**	10	<0.005	0.02	0.02	<5	<0.005	0.37	0.29	<0.005	<5	<0.005	0.02	0.02	<0.005	-	-	10	0.02	-	-	-	1.5	174	13	1	0.28
BH02	1.5	25/06/2013	25	7.8	6.1	1.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	2	25/06/2013	24.5	7.9	6.2	1.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	2.5	25/06/2013	24	7.4	6.2	1.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	3	25/06/2013	23.5	8.2	6.1	**2.1**	2	8	**6.3**	1.7	<0.005	<0.005	<0.005	<2	<2	<2	12	0.006	0.02	0.02	<5	<0.005	0.29	0.15	<0.005	<5	<0.005	0.008	0.006	<0.005	-	-	12	0.02	-	-	-	1.5	<10	<1	1	<0.02
BH03	0	25/06/2013	26.9	9.4	6.6	**2.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	0.5	25/06/2013	26.4	9.6	6.6	**3**	1	9.7	**8**	1.7	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	2670	5.36	0.22	5.58	4.28	38	0.05	0.006	0.05	0.06	-	-	<10	<0.02	3560	17.8	5.71	1.5	<10	<1	<1	<0.02
BH03	1	25/06/2013	25.9	9.1	6.6	**2.5**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	1.5	25/06/2013	25.4	9.4	6.7	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	2	25/06/2013	24.9	9	6	**3**	2	8.7	**6.8**	1.9	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.09	0.08	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	22	0.11	0.04	1.5	<10	<1	<1	<0.02
BH03	2.5	25/06/2013	24.4	6.7	5.7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	3	25/06/2013	23.9	7.2	5.6	1.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	0	25/06/2013	25.5	8.7	6.5	**2.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	0.5	25/06/2013	25	8.4	6.2	**2.2**	2	8.2	**9.3**	-1.1	<0.005	<0.005	<0.005	<2	<2	<2	**48**	0.009	0.08	**0.08**	242	0.48	0.43	0.91	0.39	8	0.009	0.01	0.02	0.01	-	-	**48**	**0.08**	379	1.9	0.61	1.5	<10	<1	4	<0.02
BH04	1.5	25/06/2013	24	8.4	6.2	**2.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	2	25/06/2013	23.5	8.3	6.2	**2.1**	2	9.2	**7.5**	1.7	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.005	0.01	<0.005	332	0.66	0.27	0.93	0.53	6	0.007	0.006	0.01	0.01	-	-	<10	<0.02	498	2.49	0.8	1.5	<10	<1	<1	<0.02
BH04	2.5	25/06/2013	23	8.2	5.9	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	3	25/06/2013	22.5	8.3	5.9	**2.4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	0	27/06/2013	25.5	8.9	6.3	**2.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	0.5	27/06/2013	25	7.8	5.9	1.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	1	27/06/2013	24.5	7.4	5.9	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	1.5	27/06/2013	24	7.2	5.9	1.3	1	7	**5.5**	1.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH05N	2	27/06/2013	23.5	7.3	5.6	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	2.5	27/06/2013	23	5	**3.5**	1.5	1	5.1	**2.6**	**2.5**	**0.1**	**0.78**	**0.68**	**63**	**485**	**422**	**62**	<0.005	0.1	**0.1**	<5	<0.005	0.08	0.08	<0.005	<5	<0.005	0.02	0.01	<0.005	<0.005	<5	**126**	**0.2**	-	-	-	1.5	126	9	9	0.2
BH05N	2.9	27/06/2013	22.6	5.2	**3.9**	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	0	25/06/2013	25.4	9.1	6.5	**2.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	0.5	25/06/2013	24.9	8.7	5.8	**2.9**	1	8.5	**6.6**	1.9	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.06	0.04	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	20	0.1	0.03	1.5	<10	<1	<1	<0.02
BH05S	1.5	25/06/2013	23.9	6.6	4.9	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	2	27/06/2013	23.4	4.4	5.5	-1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	2.5	27/06/2013	22.9	5.3	4	1.3	1	4.8	**2.8**	2	**0.22**	**1.11**	**0.89**	**137**	**695**	**558**	**83**	<0.005	0.14	**0.13**	<5	<0.005	0.01	0.007	<0.005	<5	<0.005	0.008	0.007	<0.005	0.006	<5	**220**	**0.35**	-	-	-	1.5	220	17	17	0.35
BH06N	0.5	17/07/2013	22	8.9	7.4	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	1	17/07/2013	21.5	7.7	6.4	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	1.5	17/07/2013	21	8.2	6.9	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	2	17/07/2013	20.5	8.6	7.2	1.4	1	6.7	**7**	-0.3	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.07	0.08	<0.005	-	-	<10	<0.02	28	0.14	0.04	1.5	<10	<1	<1	<0.02
BH06N	2.5	17/07/2013	20	9.6	8.7	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	3	17/07/2013	19.5	9.4	7.9	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	3.5	17/07/2013	19	8.7	7.9	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	4	17/07/2013	18.5	9.3	8	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	4.5	17/07/2013	18	8.7	8	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	5	17/07/2013	17.5	9.2	7.5	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	5.5	17/07/2013	17	8.4	5.7	**2.7**	1	6.4	**4.4**	2	<0.005	**0.04**	**0.04**	<2	**23**	**23**	**57**	0.005	0.1	**0.09**	8	0.02	0.01	0.03	0.01	7	0.008	0.03	0.04	0.01	**0.038**	**24**	**57**	**0.09**	-	-	-	1.5	57	4	4	0.09
BH06N	6	17/07/2013	16.5	8.2	5.6	**2.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	0	27/06/2013	22.5	8.6	6.2	**2.4**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	0.5	27/06/2013	22	8.8	5.8	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	1	27/06/2013	21.5	9.3	6.2	**3.1**	1	5.9	**4.8**	1.1	0.02	<0.005	<0.005	10	<2	<2	<5	0.006	0.01	0.008	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.06	0.05	<0.005	<0.005	<5	15	0.02	-	-	-	1.5	15	1	1	0.02
BH06S	1.5	27/06/2013	21	8.2	5.4	**2.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	2	27/06/2013	20.5	8.6	6	**2.6**	1	6.8	**6.8**	0	<0.005	<0.005	<0.005	<2	<2	<2	**20**	0.01	0.05	0.03	16	0.03	0.03	0.06	0.02	<5	<0.005	0.05	0.05	0.005	-	-	**21**	0.03	24	0.12	0.04	1.5	<10	<1	2	<0.02
BH06S	2.5	27/06/2013	20	9.8	6.2	**3.6**	1	7.2	**6.7**	0.5	<0.005	<0.005	<0.005	<2	<2	<2	**38**	0.008	0.07	**0.06**	25	0.05	0.02	0.08	0.04	10	0.01	0.05	0.06	0.02	0.009	6	**38**	**0.06**	23	0.12	0.04	1.5	<10	<1	3	<0.02
BH06S	3	27/06/2013	19.5	9.1	6.3	**2.8**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	3.5	27/06/2013	19	8.6	4.3	**4.3**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	4	27/06/2013	18.5	9	**2.4**	**6.6**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	4.5	27/06/2013	18	8.8	**2.2**	**6.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	5	27/06/2013	17.5	8.7	**2.1**	**6.6**	2	6.7	**4.6**	**2.1**	<0.005	0.02	0.02	<2	16	16	**36**	0.01	0.07	**0.06**	<5	<0.005	0.02	0.02	<0.005	<5	<0.005	0.05	0.05	<0.005	**0.031**	**19**	**36**	**0.06**	-	-	-	1.5	23	2	3	0.04
BH06S	5.5	27/06/2013	17	8.9	**2.9**	**6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	6	27/06/2013	16.5	9	**3.3**	**5.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	0.5	17/07/2013	23.25	6.9	6.3	0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	1	17/07/2013	22.75	5.2	4.7	0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	1.5	17/07/2013	22.25	5.4	4.8	0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	2	17/07/2013	21.75	5.4	5	0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	2.5	17/07/2013	21.25	5.3	4.6	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	3	17/07/2013	20.75	5.4	4.6	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	0.5	17/07/2013	23.75	8.1	7.2	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	1	17/07/2013	23.25	7.5	6.7	0.8	1	6.9	**5.6**	1.3	<0.005	<0.005	<0.005	<2	<2	<2	**25**	<0.005	0.04	**0.04**	17	0.03	0.02	0.06	0.03	11	0.01	0.02	0.03	0.02	-	-	**25**	**0.04**	-	-	-	1.5	<10	1	2	<0.02
BH08	1.5	17/07/2013	22.75	6.9	6.7	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	2	17/07/2013	22.25	5.8	5.6	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	2.5	17/07/2013	21.75	5.6	5.3	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	2.8	17/07/2013	21.45	5.4	4.4	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					ASS - Potential Acidity		Net Acidity excl ANC		ASS - Excess ANC			ASS - Acid Base Accounting				
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANC/FF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% S	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				**<4**	**<4**	**2**			**<4**	**2**	**0.03**	**0.03**	**0.03**	**18.7**	**18.7**	**18.7**	**18.7**			**0.03**											**0.03**	**18.7**	**18.7**	**0.03**								
LocCode	**Sample Depth**	**Sampled Date**	**Sample Elevation**																																							
BH09	0.5	17/07/2013	23.8	6.4	6.2	0.2	2	7	**4.4**	**2.6**	<0.005	<0.005	<0.005	<2	<2	<2	**31**	0.008	0.06	**0.05**	10	0.02	0.06	0.08	0.02	10	0.01	0.04	0.05	0.02	-	-	**31**	**0.05**	-	-	-	1.5	10	1	2	0.02
BH09	1	17/07/2013	23.3	6.3	6	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	1.5	17/07/2013	22.8	6.6	6.9	-0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	2	17/07/2013	22.3	5.5	5.2	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	2.5	17/07/2013	21.8	6	5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	3	17/07/2013	21.3	6	5.8	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	0.3	18/07/2013	23.1	7.2	7.1	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	1.5	18/07/2013	21.9	9.2	7.7	1.5	1	6.9	**7.1**	-0.2	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.07	0.06	<0.005	<5	<0.005	0.12	0.11	<0.005	-	-	<10	<0.02	37	0.18	0.06	1.5	<10	<1	<1	<0.02
BH10	2	18/07/2013	21.4	8.8	7.4	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	2.5	18/07/2013	20.9	8.6	7.3	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	3	18/07/2013	20.4	8	6.2	1.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	0.5	18/07/2013	23	9.5	7.9	1.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	1	18/07/2013	22.5	8.3	7.6	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	1.5	18/07/2013	22	9.6	8.2	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	2	18/07/2013	21.5	8.9	6.8	**2.1**	1	6.2	**7.7**	-1.5	<0.005	<0.005	<0.005	2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.19	0.15	<0.005	<5	<0.005	0.29	0.26	<0.005	-	-	<10	<0.02	61	0.31	0.1	1.5	<10	<1	<1	<0.02
BH11	2.5	18/07/2013	21	9.6	6.6	**3**	1	6.7	**6.7**	0	<0.005	<0.005	<0.005	<2	<2	<2	18	<0.005	0.03	0.03	9	0.02	0.04	0.06	0.01	<5	<0.005	0.06	0.06	<0.005	-	-	18	0.03	18	0.09	0.03	1.5	<10	<1	1	<0.02
BH11	3	18/07/2013	20.5	9.1	7.1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	3.5	18/07/2013	20	9.5	6.8	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	4	18/07/2013	19.5	9.3	6	**3.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	4.5	18/07/2013	19	9.2	**3.1**	**6.1**	1	6.4	**5.3**	1.1	<0.005	0.006	0.006	<2	4	4	16	<0.005	0.03	0.03	<5	<0.005	0.03	0.02	<0.005	<5	<0.005	0.04	0.03	<0.005	-	-	17	0.03	-	-	-	1.5	17	1	1	0.03
BH12	0.5	18/07/2013	23.25	8.8	6.9	1.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	1	18/07/2013	22.75	8.8	6.3	**2.5**	2	7.1	**6.2**	0.9	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH12	1.5	18/07/2013	22.25	7.3	5.9	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	2	18/07/2013	21.75	6.8	5.6	1.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	2.5	18/07/2013	21.25	4.5	**2**	**2.5**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	3	18/07/2013	20.75	5.8	**2.5**	**3.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	3.5	18/07/2013	20.25	6.2	**2.7**	**3.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	4	18/07/2013	19.75	5.6	**1.6**	**4**	2	5.8	**3.4**	**2.4**	<0.005	**0.04**	**0.04**	2	**26**	**24**	**33**	0.006	0.06	**0.05**	<5	<0.005	0.01	0.01	<0.005	<5	<0.005	0.02	0.02	<0.005	-	-	**36**	**0.06**	-	-	-	1.5	36	3	3	0.06
BH12	4.5	18/07/2013	19.25	5.6	**1.5**	**4.1**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	0.5	19/07/2013	24.25	6.1	**3.7**	**2.4**	2	6.2	**3.5**	**2.7**	<0.005	<0.005	<0.005	<2	<2	<2	8	<0.005	0.01	0.01	<5	<0.005	0.06	0.04	<0.005	<5	<0.005	0.02	0.01	<0.005	-	-	<10	0.02	-	-	-	1.5	<10	1	1	0.02
BH13	1	19/07/2013	23.75	6.2	4.4	1.8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	1.5	19/07/2013	23.25	6.3	5	1.3	1	6.3	**5.2**	1.1	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH13	2	19/07/2013	22.75	6.3	4.9	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	2.5	19/07/2013	22.25	5.7	4.8	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	2.8	19/07/2013	21.95	5.9	5	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	3.5	19/07/2013	21.25	5.7	4.8	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	3.5	25/07/2013	21.25	-	-	-	-	5.7	**5.1**	0.6	0.01	**0.04**	0.03	8	**27**	**19**	<5	<0.005	0.008	0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	12	0.02	-	-	-	1.5	12	1	1	0.02
BH14	0.5	22/07/2013	24.4	**3.7**	4	-0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	1.5	22/07/2013	23.4	**3.9**	**3.2**	0.7	1	6.7	**4.5**	**2.2**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<0.005	<5	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH14	2	22/07/2013	22.9	4.4	**3.3**	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	2.5	22/07/2013	22.4	4.2	4	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	3	22/07/2013	21.9	4.3	**3.8**	0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	3.3	22/07/2013	21.6	4.7	**3.8**	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	4.5	22/07/2013	20.4	4.6	**3.9**	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	5.5	22/07/2013	19.4	4.9	**3.8**	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	5.95	22/07/2013	18.95	5.2	4.4	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	0.5	23/07/2013	24.5	4.8	4.8	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	1	23/07/2013	24	4	4.6	-0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	1.5	23/07/2013	23.5	**3.9**	**3.6**	0.3	1	4.7	**2.4**	**2.3**	**0.2**	**0.84**	**0.64**	**123**	**521**	**398**	**51**	<0.005	0.08	**0.08**	<5	<0.005	0.005	0.005	<0.005	<5	<0.005	0.03	0.02	<0.005	-	-	**174**	**0.28**	-	-	-	1.5	174	13	13	0.28
BH15	2	23/07/2013	23	**3.6**	**3.2**	0.4	1	5.3	**4.2**	1.1	**0.09**	**0.2**	**0.11**	**55**	**125**	**70**	11	0.04	0.06	0.02	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	**66**	**0.11**	-	-	-	1.5	66	5	5	0.11
BH15	3.45	23/07/2013	21.55	4.8	4.4	0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	4.5	23/07/2013	20.5	5.2	4.2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	4.95	23/07/2013	20.05	5.6	4.7	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	5.5	23/07/2013	19.5	5.6	4.2	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	5.95	23/07/2013	19.05	5.6	4.2	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	0.5	23/07/2013	23.9	5.2	5	0.2	1	6.8	**3.3**	**3.5**	<0.005	0.01	0.01	<2	8	8	<5	<0.005	<0.005	<0.005	<5	<0.005	0.006	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH16	1	23/07/2013	23.4	4.4	4.8	-0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	1.5	23/07/2013	22.9	4.6	4.5	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	2	23/07/2013	22.4	**3.8**	**3.5**	0.3	1	5.2	**3.9**	1.3	**0.08**	**0.32**	**0.23**	**52**	**197**	**145**	**25**	<0.005	0.04	**0.04**	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	0.014	9	**77**	**0.12**	-	-	-	1.5	77	6	6	0.12
BH16	3	23/07/2013	21.4	4.7	4.4	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4	23/07/2013	20.4	5.6	4.8	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4.4	23/07/2013	20	5.5	4.5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4.5	23/07/2013	19.9	5.3	5.5	-0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4.95	23/07/2013	19.45	5.4	4	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	3	25/07/2013	21.5	6.4	5.3	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	3.5	25/07/2013	21	7	4.7	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	4	25/07/2013	20.5	7.6	4.9	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	4.5	25/07/2013	20	7.8	4.8	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	5	25/07/2013	19.5	7.3	4.4	**2.9**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	5.5	25/07/2013	19	6.9	**2.1**	**4.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	6	25/07/2013	18.5	7.1	**3.3**	**3.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					SS - Potential Acidit		- Net Acidity excl		ASS - Excess ANC			ASS - Acid Base Accounting				
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANC/FF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% S	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				<4	<4	2			<4	2	0.03	0.03	0.03	18.7	18.7	18.7	18.7			0.03											0.03	18.7	18.7	0.03								
LocCode	**Sample Depth**	**Sampled Date**	**Sample Elevation**																																							
BH18	0.5	25/07/2013	23.5	4.5	5.7	-1.2	1	6	4.1	1.9	<0.005	0.05	0.05	<2	30	29	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH18	1	25/07/2013	23	4.9	5.7	-0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	1.5	25/07/2013	22.5	5.5	3	2.5	2	6.7	3.3	3.4	<0.005	0.03	0.03	<2	17	17	<5	<0.005	0.006	0.006	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<0.005	<5	<10	<0.02	-	-	-	1.5	12	1	<1	0.02
BH18	2	25/07/2013	22	5.4	5.3	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	2.5	25/07/2013	21.5	5.4	2.1	3.3	2	5.7	3.3	2.4	0.02	0.08	0.07	11	53	42	30	0.006	0.05	0.05	<5	<0.005	0.01	<0.005	<0.005	<5	<0.005	0.04	0.03	<0.005	0.018	11	41	0.07	-	-	-	1.5	41	3	3	0.07
BH18	3	25/07/2013	21	6.3	2.3	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	3.5	25/07/2013	20.5	6.1	2.4	3.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	4	25/07/2013	20	5.8	3.1	2.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	4.5	25/07/2013	19.5	5.8	4.5	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	5	25/07/2013	19	7	2.4	4.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	5.5	25/07/2013	18.5	6.7	2	4.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	6	25/07/2013	18	6.8	2.5	4.3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	0.5	25/07/2013	23.4	5.7	5.9	-0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	1	25/07/2013	22.9	9	6.2	2.8	1	6.3	6.8	-0.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.02	<0.005	<5	<0.005	0.11	0.08	<0.005	<0.005	<5	<10	<0.02	16	0.08	0.02	1.5	<10	<1	<1	<0.02
BH19	1.5	25/07/2013	22.4	9.1	6.2	2.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	2	25/07/2013	21.9	10.3	6	4.3	1	6.6	6.4	0.2	<0.005	<0.005	<0.005	<2	<2	<2	15	<0.005	0.02	0.02	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.07	0.07	<0.005	0.008	<5	15	0.02	-	-	-	1.5	<10	<1	1	<0.02
BH19	3	25/07/2013	20.9	10.1	6.4	3.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	3.5	25/07/2013	20.4	10.2	6.2	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	4	25/07/2013	19.9	10.2	6.3	3.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	4.5	25/07/2013	19.4	9.4	3	6.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	5	25/07/2013	18.9	9.4	2.4	7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	5.5	25/07/2013	18.4	9.4	2.8	6.6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	6	25/07/2013	17.9	10	6.3	3.7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	0.5	25/07/2013	23.1	6.5	5.8	0.7	1	6.9	4.4	2.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH20	1	25/07/2013	22.6	6.2	5.8	0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	1.5	25/07/2013	22.1	6.8	5.9	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	2	25/07/2013	21.6	6.1	5.9	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	2.5	25/07/2013	21.1	8.1	6	2.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	3	25/07/2013	20.6	9.4	6.4	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	3.5	25/07/2013	20.1	9.6	6.4	3.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	4	25/07/2013	19.6	9.5	6.5	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	4.5	25/07/2013	19.1	8.9	6.4	2.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	5	25/07/2013	18.6	9.1	6.1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	5.5	25/07/2013	18.1	8.7	2.2	6.5	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	6	25/07/2013	17.6	8.7	6	2.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	0.5	25/07/2013	23.25	6.1	5.9	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	1	25/07/2013	22.75	6.3	5.4	0.9	1	5.7	3.1	2.6	0.03	0.39	0.36	20	242	223	68	<0.005	0.11	0.11	<5	0.005	0.02	0.02	<0.005	<5	<0.005	0.06	0.05	<0.005	-	-	87	0.14	-	-	-	1.5	87	7	7	0.14
BH21	1.5	25/07/2013	22.25	6.5	4.8	1.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	2	25/07/2013	21.75	7.2	4.3	2.9	3	5.7	2.8	2.9	0.02	0.26	0.25	11	164	153	78	<0.005	0.13	0.12	<5	0.008	0.02	0.03	0.006	<5	<0.005	0.06	0.06	<0.005	<0.005	<5	89	0.14	-	-	-	1.5	89	7	7	0.14
BH21	2.5	25/07/2013	21.25	4.3	2.1	2.2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	3	25/07/2013	20.75	6.8	2.9	3.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	3.5	25/07/2013	20.25	7.6	3.2	4.4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	4	25/07/2013	19.75	7.8	5.8	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	4.5	25/07/2013	19.25	7.6	5	2.6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	5	25/07/2013	18.75	7.4	3.8	3.6	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	5.5	25/07/2013	18.25	7.5	1.6	5.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	6	25/07/2013	17.75	7.3	1.8	5.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	0.5	26/07/2013	23.3	5.6	5.8	-0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	1	26/07/2013	22.8	5.1	5.7	-0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	1.5	26/07/2013	22.3	6.6	5.7	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	2	26/07/2013	21.8	4.5	3.8	0.7	1	5.2	2.5	2.7	0.08	0.47	0.39	48	293	245	46	<0.005	0.08	0.07	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	0.01	0.01	<0.005	0.006	<5	94	0.15	-	-	-	1.5	94	7	7	0.15
BH22	2.5	26/07/2013	21.3	5.7	4.4	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	3	26/07/2013	20.8	5.5	4.6	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	3.5	26/07/2013	20.3	6.6	4.6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	4	26/07/2013	19.8	6.8	4.4	2.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	4.5	26/07/2013	19.3	6.6	1.7	4.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	5	26/07/2013	18.8	6.6	3.9	2.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	5.5	26/07/2013	18.3	6.4	2.6	3.8	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	6	26/07/2013	17.8	6.7	1.7	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	0.5	26/07/2013	22.9	5.6	5.6	0	1	6.6	3.5	3.1	<0.005	0.02	0.02	<2	14	14	11	<0.005	0.02	0.02	<5	<0.005	<0.005	0.008	<0.005	<5	<0.005	0.006	0.008	<0.005	-	-	11	0.02	-	-	-	1.5	13	1	1	0.02
BH23	1	26/07/2013	22.4	6	6.5	-0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	1.5	26/07/2013	21.9	5.3	3.8	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	2	26/07/2013	21.4	5.4	5.2	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	2.5	26/07/2013	20.9	5.3	5.1	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	3	26/07/2013	20.4	5.8	2.3	3.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	3.5	26/07/2013	19.9	6	2.3	3.7	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	4	26/07/2013	19.4	7.5	4.3	3.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	4.5	26/07/2013	18.9	6.8	2.5	4.3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	5	26/07/2013	18.4	6.6	2.2	4.4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	5.5	26/07/2013	17.9	7.2	2.6	4.6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	6	26/07/2013	17.4	7.1	2.9	4.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					SS - Potential Acidit		Net Acidity excl A		ASS - Excess ANC			ASS - Acid Base Accounting				
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANC/FF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% S	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				<4	<4	2			<4	2	0.03	0.03	0.03	18.7	18.7	18.7	18.7			0.03											0.03	18.7	18.7	0.03								
LocCode	Sample Depth	Sampled Date	Sample Elevation																																							
BH24	0.5	26/07/2013	22.4	8.8	6.3	2.5	2	6.2	6.1	0.1	<0.005	<0.005	<0.005	<2	<2	<2	7	0.006	0.02	0.01	<5	<0.005	0.03	0.03	<0.005	<5	<0.005	0.14	0.15	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	1	1	<0.02
BH24	1.5	26/07/2013	21.4	8.1	5.8	2.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	2	26/07/2013	20.9	8.8	2.8	6	4	6.2	4.7	1.5	<0.005	<0.005	<0.005	<2	<2	<2	21	<0.005	0.04	0.03	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.07	0.06	<0.005	0.017	11	22	0.04	-	-	-	1.5	22	2	2	0.04
BH24	2.5	26/07/2013	20.4	7.9	4.6	3.3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	3	26/07/2013	19.9	7.8	4.3	3.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	3.5	26/07/2013	19.4	8	4.5	3.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	4	26/07/2013	18.9	8.3	3.6	4.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	4.5	26/07/2013	18.4	7.6	2.2	5.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	5	26/07/2013	17.9	8.2	2.4	5.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	5.5	26/07/2013	17.4	8.2	2.4	5.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	6	26/07/2013	16.9	7.3	3.7	3.6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	0.5	26/07/2013	22.25	8.8	6.9	1.9	3	6.7	7.4	-0.7	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.005	<0.005	<0.005	<5	<0.005	0.03	<0.005	<0.005	<5	<0.005	0.14	<0.005	<0.005	-	-	<10	<0.02	47	0.24	0.08	1.5	<10	<1	<1	<0.02
BH25	1	26/07/2013	21.75	8.4	6.1	2.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	1.5	26/07/2013	21.25	7.9	6.1	1.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	2	26/07/2013	20.75	9.3	6.8	2.5	1	7	7	0	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.007	0.007	<0.005	<5	<0.005	0.03	0.03	<0.005	41	0.05	0.11	0.16	0.07	-	-	<10	<0.02	48	0.24	0.08	1.5	<10	<1	<1	<0.02
BH25	2.5	26/07/2013	20.25	9.4	6.8	2.6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	3	26/07/2013	19.75	9.2	6.3	2.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	3.5	26/07/2013	19.25	9.2	2.9	6.3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	4	26/07/2013	18.75	8.8	3.2	5.6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	4.5	26/07/2013	18.25	8.6	4.4	4.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	5	26/07/2013	17.75	8.9	3.9	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	5.5	26/07/2013	17.25	8.1	4	4.1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	6	26/07/2013	16.75	8.6	2.6	6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	0.5	26/07/2013	21.8	9.7	6.9	2.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	1	26/07/2013	21.3	9.3	6.4	2.9	2	9.3	7.8	1.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.02	0.02	<0.005	159	0.32	0.16	0.48	0.25	36	0.04	0.06	0.1	0.06	-	-	<10	<0.02	274	1.37	0.44	1.5	<10	<1	<1	<0.02
BH26	1.5	26/07/2013	20.8	8.5	6.1	2.4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	2	26/07/2013	20.3	8.1	6	2.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	2.5	26/07/2013	19.8	7.4	5.9	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	3	26/07/2013	19.3	8.1	1.6	6.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	3.5	26/07/2013	18.8	8.2	1.7	6.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	4	26/07/2013	18.3	9.3	5.8	3.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	4.5	26/07/2013	17.8	9	6.1	2.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	5	26/07/2013	17.3	7.8	5.9	1.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	5.5	26/07/2013	16.8	9	5.9	3.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	6	26/07/2013	16.3	8	6.3	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	0.5	27/07/2013	21.8	8.7	6.3	2.4	1	7.7	7.1	0.6	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.006	0.007	<0.005	<5	<0.005	0.03	0.02	<0.005	31	0.04	0.1	0.14	0.05	-	-	<10	<0.02	64	0.32	0.1	1.5	<10	<1	<1	<0.02
BH27	1	27/07/2013	21.3	8.4	6.2	2.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	1.5	27/07/2013	20.8	8.3	6.1	2.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	2	27/07/2013	20.3	7.4	6	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	2.5	27/07/2013	19.8	9	6.3	2.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	3	27/07/2013	19.3	8.2	5.7	2.5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	3.5	27/07/2013	18.8	8.8	2	6.8	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	4	27/07/2013	18.3	9.3	2.3	7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	4.5	27/07/2013	17.8	9	5.3	3.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	5	27/07/2013	17.3	9.1	5.7	3.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	5.5	27/07/2013	16.8	8.8	6.1	2.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	0.5	18/07/2013	22.8	8.8	7.6	1.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	1	18/07/2013	22.3	9.5	8.1	1.4	1	8.4	7.5	0.9	<0.005	<0.005	<0.005	<2	<2	<2	30	0.01	0.06	0.05	21	0.04	0.07	0.12	0.03	48	0.06	0.1	0.16	0.08	-	-	30	0.05	105	0.53	0.17	1.5	<10	<1	2	<0.02
BH28	1.5	18/07/2013	21.8	9	8.3	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	2	18/07/2013	21.3	8.4	3.4	5	1	7.9	5.5	2.4	<0.005	<0.005	<0.005	<2	2	2	78	0.03	0.16	0.12	16	0.03	0.08	0.11	0.03	13	0.02	0.11	0.12	0.02	0.067	42	78	0.12	-	-	-	1.5	28	2	6	0.04
BH28	2.5	18/07/2013	20.8	9.2	7.9	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	3	18/07/2013	20.3	8.4	7.6	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Statistical Summary

Number of Results	268	268	268	268	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	16	16	52	52	19	19	19	52	52	52	52	52
Number of Detects	268	268	268	268	52	52	52	11	19	19	13	20	20	28	19	35	31	13	15	42	40	14	12	12	37	37	14	10	7	28	29	19	19	19	52	21	24	30	22
Minimum Concentration	3.6	1.5	-1.2	1	4.7	2.4	-1.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<0.005	<5	<10	<0.02	16	0.08	0.02	1.5	<10	<1	<1	<0.02
Minimum Detect	3.6	1.5	ND	1	4.7	2.4	ND	0.01	0.006	0.006	2	2	2	7	0.005	0.006	0.005	8	0.005	0.005	0.005	0.006	6	0.007	0.006	0.006	0.005	0.006	6	10	0.02	16	0.08	0.02	1.5	10	1	1	0.02
Maximum Concentration	10.3	8.7	7	4	9.7	9.3	4	0.22	1.11	0.89	137	695	558	83	0.04	0.16	0.13	2670	5.36	0.43	5.58	4.28	48	0.06	0.29	0.26	0.08	0.067	42	220	0.35	3560	17.8	5.71	1.5	220	17	17	0.35
Maximum Detect	10.3	8.7	7	4	9.7	9.3	4	0.22	1.11	0.89	137	695	558	83	0.04	0.16	0.13	2670	5.36	0.43	5.58	4.28	48	0.06	0.29	0.26	0.08	0.067	42	220	0.35	3560	17.8	5.71	1.5	220	17	17	0.35
Average Concentration	7.4	5.1	2.3	1.4	6.8	5.4	1.5	0.019	0.1	0.084	11	62	52	20	0.0055	0.036	0.031	71	0.14	0.062	0.19	0.11	6.9	0.008	0.043	0.044	0.01	0.014	9	31	0.051	287	1.4	0.46	1.5	30	2.4	2.5	0.049
Median Concentration	7.8	5.6	2.2	1	6.7	5.4	1.7	0.0025	0.0025	0.0025	1	1	1	9	0.0025	0.02	0.015	2.5	0.0025	0.02	0.02	0.0025	2.5	0.0025	0.02	0.02	0.0025	0.007	2.5	11.5	0.02	47	0.24	0.08	1.5	5	0.5	1	0.01
Standard Deviation	1.6	1.7	1.8	0.71	1.2	1.8	1.2	0.045	0.23	0.19	28	146	120	23	0.0068	0.041	0.037	372	0.75	0.095	0.78	0.6	11	0.014	0.053	0.054	0.019	0.018	11	45	0.07	804	4	1.3	0	49	3.7	3.3	0.078
Number of Guideline Exceedances	0	0	143	0	0	0	19	6	14	13	7	14	14	19	0	0	17	0	0	0	0	0	0	0	0	0	0	3	3	20	19	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	143	0	0	0	19	6	14	13	7	14	14	19	0	0	17	0	0	0	0	0	0	0	0	0	0	3	3	20	19	0	0	0	0	0	0	0	0

Reaction Rate

1 Slight
2 Moderate
3 Strong
4 Extreme

Table 2, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

Field_ID	Date	Lab Report Number	Inorganics				Nutrients						Major Ions						Acidity
			Electrical conductivity *(lab)	pH (Lab)	Sulphide	Total Dissolved Solids	Ammonia as N	Kjeldahl Nitrogen Total	Nitrogen (Total Oxidised)	Nitrogen (Total)	Phosphorus	Reactive Phosphorus as P	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulphate (Filtered)	Acidity as CaCO3
			uS/cm	pH Units	mg/L	mg/L	µg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			1	0.01	0.1	10	10	0.1	0.01	100	0.01	0.01	1	1	1	1	1	1	1
ANZECC 2000 Freshwater							**2632**												
ANZECC 2000 Short-term Irrigation										***25000***									
BH01	12/08/2013	EP1306149	531	7.43	0.2	398	50	1.2	6.52	7700	<0.05	0.01	84	30	11	6	29	55	22
BH03	12/08/2013	EP1306149	652	6.09	<0.1	570	880	4.8	12.2	17,000	0.33	0.25	58	80	14	18	51	104	113
BH06/N	12/08/2013	EP1306149	10,800	6.84	2.4	9880	140	5	<0.05	5000	0.4	<0.01	47	3470	149	12	1940	146	101
BH08	12/08/2013	EP1306149	173	5.83	<0.1	212	60	1.4	0.28	1700	0.04	<0.01	10	23	3	1	25	57	30
BH10	13/08/2013	EP1306178	852	7.31	<0.1	1520	60	10.1	0.1	10,200	0.83	<0.01	11	101	15	2	165	52	40
BH11	13/08/2013	EP1306178	1580	7.84	<0.1	2180	20	0.9	0.02	900	0.16	<0.01	16	64	22	2	353	84	20
BH12	13/08/2013	EP1306178	628	7.15	<0.1	600	50	4.2	4.31	8500	0.31	<0.01	67	38	20	2	43	97	36
BH13	13/08/2013	EP1306178	375	6.3	<0.1	760	20	9	0.13	9100	8.17	<0.01	13	65	6	6	54	54	98
BH28	13/08/2013	EP1306178	20,800	7.12	<0.1	14,300	200	2.7	<0.01	2700	0.1	<0.01	97	7940	478	17	4640	727	65
Statistical Summary																			
Number of Results			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Number of Detects			9	9	2	9	9	9	7	9	8	2	9	9	9	9	9	9	9
Minimum Concentration			173	5.83	<0.1	212	20	0.9	<0.01	900	0.04	<0.01	10	23	3	1	25	52	20
Minimum Detect			173	5.83	0.2	212	20	0.9	0.02	900	0.04	0.01	10	23	3	1	25	52	20
Maximum Concentration			20,800	7.84	2.4	14,300	880	10.1	12.2	17,000	8.17	0.25	97	7940	478	18	4640	727	113
Maximum Detect			20,800	7.84	2.4	14,300	880	10.1	12.2	17,000	8.17	0.25	97	7940	478	18	4640	727	113
Average Concentration			4043	6.9	0.33	3380	164	4.4	2.6	6978	1.2	0.033	45	1312	80	7.3	811	153	58
Median Concentration			652	7.12	0.05	760	60	4.2	0.13	7700	0.31	0.005	47	65	15	6	54	84	40
Standard Deviation			7129	0.67	0.78	5097	275	3.3	4.3	5064	2.6	0.081	34	2730	156	6.7	1563	218	37
Number of Guideline Exceedances			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Field_ID	Alkalinity				Metals														
	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Carbonate Alkalinity as CaCO3	Aluminium	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Selenium (Filtered)	Zinc (Filtered)
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL	1	1	1	1	0.01	0.01	0.001	0.0001	0.001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.01	0.005
ANZECC 2000 Freshwater					**0.027**	**0.027**		**0.00006**	**0.00001**		**0.001**			**0.001**	**1.2**	**0.008**	**0.005**	**0.0024**
ANZECC 2000 Short-term Irrigation					***20***	***20***	***2***	***0.05***	***1***	***0.1***	***5***	***10***	***10***	***10***	***10***	***2***	***0.05***	***5***
BH01	199	<1	199	<1	**0.51**	**0.08**	<0.001	<0.0001	<0.001	<0.001	**0.002**	0.6	0.08	**0.002**	0.015	<0.001	<0.01	<0.005
BH03	100	<1	100	<1	**1.42**	**0.35**	0.001	<0.0001	<0.001	0.001	<0.001	1.01	0.6	<0.001	0.086	0.001	<0.01	**0.007**
BH06/N	415	<1	415	<1	***68.7***	**0.11**	0.002	<0.0001	**0.005**	0.003	0.001	***32.1***	1.32	0.001	0.591	0.004	<0.01	<0.005
BH08	11	<1	11	<1	**0.68**	**0.2**	<0.001	<0.0001	**0.002**	<0.001	**0.002**	2.66	1.74	<0.001	0.024	0.003	<0.01	**0.025**
BH10	274	<1	274	<1	***184***	**0.85**	0.002	<0.0001	**0.001**	<0.001	**0.005**	***52.6***	0.42	0.001	0.025	0.002	<0.01	**0.008**
BH11	702	<1	702	<1	**16.7**	0.01	0.003	<0.0001	<0.001	0.001	**0.003**	***18.5***	<0.05	<0.001	0.151	0.004	<0.01	<0.005
BH12	167	<1	167	<1	***26.1***	**0.81**	0.004	<0.0001	**0.004**	0.002	**0.006**	***76***	1.07	**0.004**	0.091	0.006	<0.01	**0.008**
BH13	18	<1	18	<1	***540***	**0.04**	<0.001	<0.0001	<0.001	0.005	**0.002**	9.52	0.23	<0.001	0.097	<0.001	<0.01	<0.005
BH28	368	<1	368	<1	**3.21**	0.02	0.002	<0.0001	**0.006**	0.014	**0.006**	9.78	3.79	<0.001	**1.5**	**0.021**	<0.01	**0.024**
Statistical Summary																		
Number of Results	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Number of Detects	9	0	9	0	9	9	6	0	5	6	8	9	8	4	9	7	0	5
Minimum Concentration	11	<1	11	<1	0.51	0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	0.6	<0.05	<0.001	0.015	<0.001	<0.01	<0.005
Minimum Detect	11	ND	11	ND	0.51	0.01	0.001	ND	0.001	0.001	0.001	0.6	0.08	0.001	0.015	0.001	ND	0.007
Maximum Concentration	702	<1	702	<1	540	0.85	0.004	<0.0001	0.006	0.014	0.006	76	3.79	0.004	1.5	0.021	<0.01	0.025
Maximum Detect	702	ND	702	ND	540	0.85	0.004	ND	0.006	0.014	0.006	76	3.79	0.004	1.5	0.021	ND	0.025
Average Concentration	250	0.5	250	0.5	93	0.27	0.0017	0.00005	0.0022	0.0031	0.0031	23	1	0.0012	0.29	0.0047	0.005	0.0091
Median Concentration	199	0.5	199	0.5	16.7	0.11	0.002	0.00005	0.001	0.001	0.002	9.78	0.6	0.0005	0.091	0.003	0.005	0.007
Standard Deviation	221	0	221	0	178	0.33	0.0012	0	0.0022	0.0044	0.0021	26	1.2	0.0012	0.49	0.0064	0	0.0091
Number of Guideline Exceedances	0	0	0	0	9	7	0	9	9	0	7	4	0	2	1	1	9	9
Number of Guideline Exceedances(Detects Only)	0	0	0	0	9	7	0	0	5	0	7	4	0	2	1	1	0	5

Appendix D – Dewatering Schematic

Example of Dewatering Treatment System

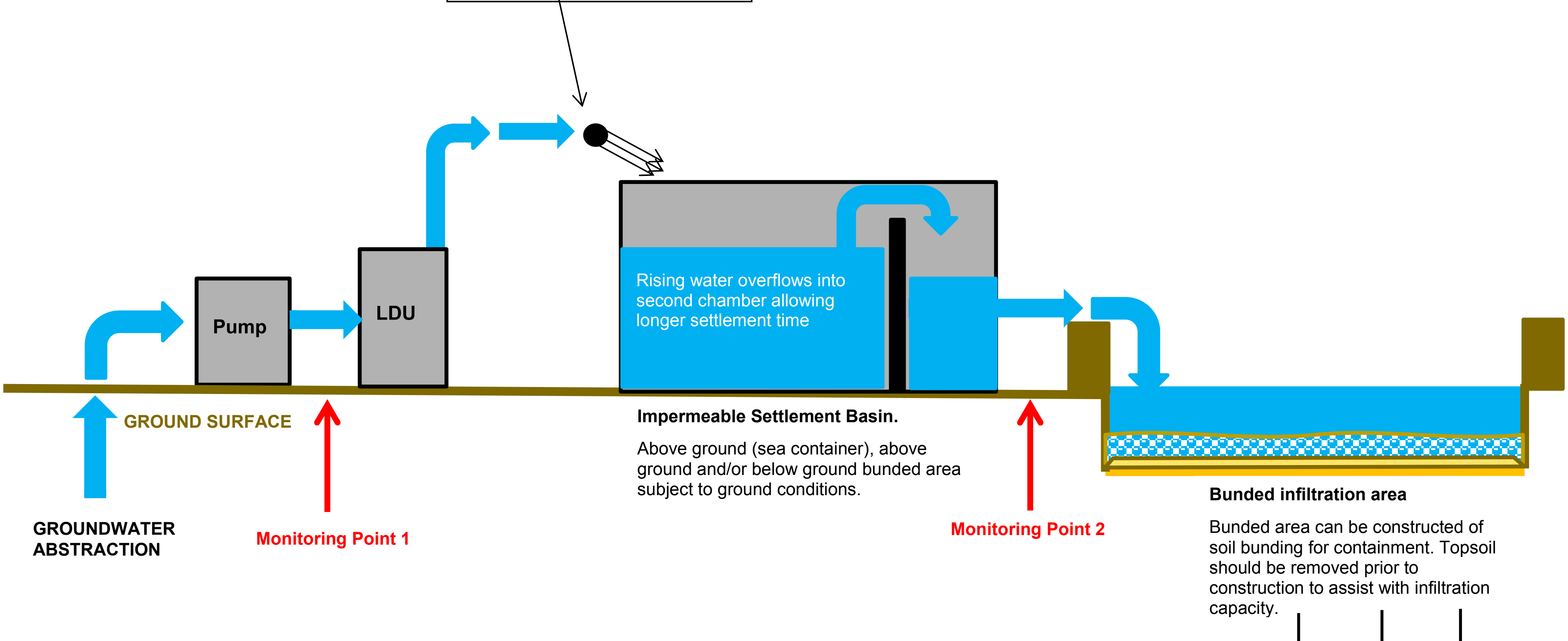
<u>Geotextile Installation Notes</u>

Geotextile only installed if effluent exceeds STI guideline post-retention (Principal's Environmental Consultant to advise when/if required.

Geotextile (pore size <0.3 mm) must be installed where either at:

1. At the base of the bunded discharge point OR

2. Within the large settlement tanks to filter for high total Al and/or Fe .metal content within the groundwater.



Notes:

It is the responsibility of the Contractor to construct and maintain adequate capacity bunded discharge area(s) during dewatering.

Lime Dosing Unit (LDU) is required if the pH is less than 6.00.

Schematic is not to scale and is a guide for treatment systems only.

Appendix E – Contractor Daily Record Sheets

DEWATERING FIELD RECORD SHEET

Date	Time	Flow rate (L/s)	Daily Total Volume of Dewatering Effluent (kL)	Water Quality Meter Calibrated?	Monitoring Point 1 (Before Treatment)				Monitorign point 2 (After Treatment)				kg of Lime used	Aeration/Settlement Tank in use? Inc geotextile fabric?	Discharge Location	Comments (filtered for acidity/alkalinity) / observations (colour, sediment load, odour)
					pH	EC (µS/cm)	TTA (mg/L)	TTAlk (mg/L)	pH	EC (µS/cm)	TTA (mg/L)	TTAlk (mg/L)				

Dewatering effluent pH is to remain >pH 6.75 and acidity is to be below 40 mg/L. If water quality falls 'outside' the aforementioned criteria, the Superintentendent's Representative (Water Corporation) and the nominated Environmental Consultant should be notified immediately.

GROUNDWATER WELL FIELD MONITORING RECORD

Date	Time	Sampler	Well ID	Total Depth of Well (m TOC)	Depth to Water Level (m TOC)	Water Column (m)	Litres to purge *	pH	EC (µS/cm)	TTA (mg/L)	TAAlk (mg/L)	Comments: Condition of headworks, requirement for filtering and observations noted (colour, sediment load, odour)

Notes:
* Litres to purge = Water column (m) x 6
m TOC denotes measurements to be taken from top of the PVC casing

Contractor:	Acid Sulfate Soil Stockpile Report

	Comments	Onsite Person Responsible
Stockpile #		
Stockpile Location		
Where has the material come from?		
When was it first excavated?		
What is the volume of the stockpile?		
How much ag-lime is needed?		
What date was it treated / mixed?		
What date was it tested?		
Where has it been used for backfill?		

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
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T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	L. Cockerton	C. Gwynne	pp D. Todd	C. Gwynne	pp D. Todd	31/03/2014
Rev 0	L. Cockerton	D. Todd	D. Todd	D. Todd	D. Todd	17/04/2014

www.ghd.com

Appendix F

WAPC Correspondence

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Western Australian Planning Commission

Your ref: JT1 2011 12136 V01
Our ref: 805/02/01/0040P
Enquiries: Alex Harrison (6551 9420)

Carl Barbato
Project Manager
Locked bag 2
Osborne Park Delivery Centre
WA 6916

Dear Carl

PROPOSED BALANNUP WASTEWATER PRESSURE MAIN

Thank you for meeting with us and your subsequent letter dated 5 August 2014 detailing the proposed Wastewater pressure main through the Anstey-Keane Dampland (Bush Forever area 342).

Bush Forever area 342 is large area of regionally significant conservation category bushland that the Western Australian Planning Commission (WAPC) continues to manage. Bush Forever area 342 has a number of exposed boundaries that render it vulnerable to entry by unauthorised off road vehicles and illegal rubbish dumping. The remaining private properties also make the co-ordinated management of the overall area difficult.

The ever-present urban development front progressively surrounding the sites, together with an increased population, bring additional pressures including trail bike use, building material dumping and a greater risk of fires.

The WAPC has been proactive in working with local governments across the metropolitan area in dealing with Off Road Vehicle (ORV) use in particular. Even where fences and signs are installed, they are simply cut and in some instances gates 'ripped' from the ground. These impact the site and create ongoing management problems.

As discussed at our recent meeting the WAPC supports the proposed location of the pipeline within Lots 65 and 66 (part of Bush Forever area 342), subject to the following conditions.

- For any proposed clearing, an offset package is prepared and approved by the Department of Environmental Regulation prior to the clearing of any native vegetation, in accordance with the Environmental Protection Authority's Position Statement No. 9: Environmental Offsets and Appendix 4 of State Planning Policy 2.8. It would be recommended that there is a net environmental gain for any clearing undertaken, preferably with offset measures provided onsite at Bush Forever area 342.

- The Water Corporation will use the least invasive method of pipeline installation possible to ensure minimal impact to the flora and fauna along the proposed path along the confines of the existing track (as per the letter dated 5 August 2014).
- Any vegetation likely to be impacted during the pipeline installation is trimmed to minimise breakage and weakening of the plants.
- No building materials, rubbish or other matter is to be deposited into Bush Forever area 342 during or after construction works.
- The Water Corporation will reinstate the path to the pre-installation ground compaction to ensure minimal impact on the hydrology of the area.
- Excess soil from the pipeline installation after normal compaction to be removed from the site to the satisfaction of the WAPC.
- The Water Corporation will provide financial support for the development of a 'Reserve' management plan to ensure ongoing safety in the area.
- That the Water Corporation will not seek an easement for the pipeline across the WAPC's land (as per the letter dated 5 August 2014).

If this office can be of more assistance please contact Alex Harrison, A/Manager Property Operations at the Department of Planning on the contact details above.

Yours sincerely

T. Hillyard

Tim Hillyard
Secretary, WAPC

15/8/2014

Appendix G

Balannup Pressure Main Groundwater Assessment (RPS ,2014)

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Our Ref: 11420001 **Email:** carl.davies@rpsgroup.com.au
Date: 13 November 2014

Bree Atkinson
Environmental Scientist
Water Corporation
629 Newcastle Street
LEEDERVILLE WA 6007

Dear Bree

BALANNUP ROAD PRESSURE MAIN- GROUNDWATER ASSESSMENT

Objective

This report has been prepared to address Environmental Protection Authority (EPA) correspondence related to the installation of the Balannup wastewater pressure main (EPA Ref CMS 14335; AC01-2014-0150, 28 October 2014). The EPA correspondence identifies that the following additional information is required to make a determination on significance and appropriate level of assessment for the proposal:

- Further information in relation to the predicted hydrological changes that may occur as a result of the installation of the pipeline are required to demonstrate that the EPA's objective for hydrological processes which is *to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*, can be met, following construction.

- Based on existing knowledge and available information regarding hydrology and stratigraphy for the Keane Road section (Bush Forever 342) the referral document needs to

  - Clearly demonstrate that the proposal would not have significant direct and indirect impacts on the subsurface flows at the site. This includes describing the current hydrological regimes and processes that operate at the site (at the local-scale) and how they may be disrupted due to the proposal. This could be set out for example, by using cross-sectional figures of the soil profile showing current hydrological processes/flows, compared with one showing the potential effects of the proposal.

  - Provide further discussion on whether there are any risks to ground water quality associated with the application of Aglime for neutralising soils as stated in the Draft Acid Sulfate Soil and Dewatering Management Plan (ASSDWMP).

The EPA correspondence is provided in Appendix 1. Essentially, the EPA has raised a concern that the 450 mm pressure main will form some sort of hydrological flow-barrier to groundwater (once installed), and that this might cause an impact on proximate wetland vegetation.

Scope

In order to address the EPA comments, the work scope includes preparation of a visual representation of the groundwater conditions before and after pressure main construction, based on outputs generated from a groundwater model. The modelling approach consists of the preparation of simple numerical "box models" to represent three scenarios that are based on natural site conditions:

1. 450 mm pressure main located within the Bassendean Sand unit (being approximately 2.5 m thickness, above clay)

2. 450 mm pressure main located within the Bassendean Sand, directly above a clayey unit.

3. 450 mm pressure main located within the clayey unit.

The box models include relevant hydrogeological parameters such as groundwater recharge (from rainfall), evapotranspiration (ET), groundwater inflow and outflow, and soil parameters such as hydraulic conductivity (K) and storage. The above scenarios capture the general geological conditions along the alignment.

Groundwater level changes have in turn been compared with generic ecological water requirements (EWRs) for wetlands of the Swan Coastal Plain. These generic EWRs relate to maximum drawdown limits and rate of change limits for wetlands and can be used to provide "risk of impact" categories for wetlands.

This approach was approved in principle by the EPA (pers. comm. Amy Sgherza, 3 November 2014), provided that suitable, up to date information was used in the model. The EPA email correspondence is provided in Appendix 2.

Geology

As described in the EPA referral supporting documentation (AECOM 2014)[1], bore sampling was conducted by GHD (2013)[2] along the entire proposed alignment. Two distinct geological areas were encountered within Bush Forever Site 342. The first section is approximately 320 m in length located from Skeet Rd to the east and typically consists of Bassendean Sand to 2.5 metres below ground level (mbgl), overlying a layer of medium dense to dense silty sand. The second section is approximately 1,200 m in length and is located directly east of the first section to Anstey Road. This second section generally consists of a thin layer of Bassendean Sand (0.5 to 2 m) overlying sandy clay/ clayey sand.

Soils along the alignment outside of the Bush Forever site were highly variable which is partly due to the disturbance of soil associated with the development. It was noted by GHD (2013) that the soils west of Skeet Road contain strongly cemented coffee rock, while east of Anstey Road the pressure main may intersect strongly cemented clayey sand, however much of this layer may be below the depth of the proposed pipeline.

---

[1] AECOM 2014. Balannup Wastewater Pressure Main. Supporting Documentation

[2] GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation

The pressure main is proposed to be installed to 1.5 m depth. It is expected to be wholly in Bassendean Sand at the western part of the alignment, which extends to 2.5 mbgl in this area. The pressure main is expected to penetrate into the sandy clay/ clayey (Guildford Formation) along the eastern part of the alignment, which is located at depths of between 0.5 and 2 mbgl.

Groundwater

Groundwater in the immediate area is generally shallow, and encountered in Bassendean Sands overlying lower permeability Guildford Formation soils. Groundwater and surface water drainage in the area is facilitated by numerous open drains which have a controlling influence on groundwater levels.

Groundwater monitoring along the proposed pressure main alignment indicates groundwater to the southeast of the alignment migrates in a west to north-westerly direction towards the Jandakot Regional Park wetland area (approximately 23 m AHD at the south-east end of the alignment to the wetland). Conversely, groundwater to the north-west of the alignment migrates in an east to south-easterly direction towards the wetland area (approximately 25 m AHD at the north-western end of the alignment to the wetland), indicating the wetland acts as a local discharge area for groundwater. Appendix 3 provides groundwater elevation information, including levels along the alignment and regional flow patterns as provided by Department of Water (DoW 2014)[3].

Groundwater Modelling

Groundwater modelling was undertaken to predict groundwater impacts associated with the pressure main installation for the three scenarios described previously, i.e. pressure main within sand (Scenario 1), pressure main located on the clayey sand surface (Scenario 2) and pressure main within the clayey sand (Scenario 3). Two separate model grids were created to take into account the variable groundwater flow direction and geology between the western and eastern parts of the alignment.

The modelling predicted minimal (< 5 cm) of groundwater level change immediately adjacent to the pressure main for all three scenarios, indicating pressure main installation has a negligible influence on groundwater flows. Details of the modelling methodology and results are provided in Appendix 4.

Wetland Ecological Water Requirements

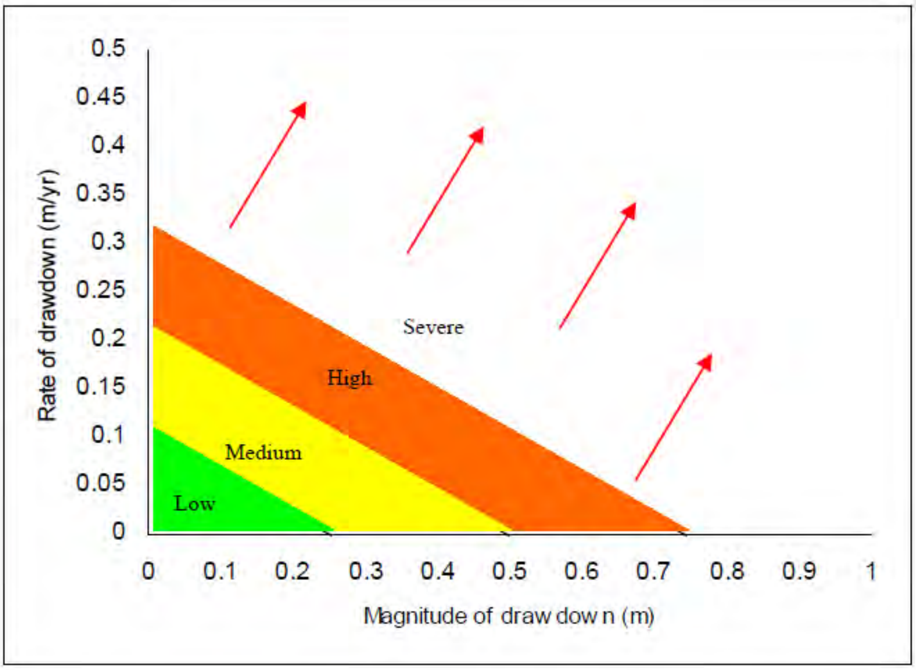
The risk of impact associated with water level changes can be provided by comparison with generic Ecological Water Requirements (EWRs) established by DoW for the Swan Coastal Plain and Blackwood region (Hyde 2006). These generic EWRs relate to maximum drawdown limits and rate of change limits for wetlands and phreatophytic vegetation. The DoW document includes "risk of impact" categories for wetlands that were developed by Froend and Loomes (2004)[4].

---

[3] DoW (2014). Perth Groundwater Atlas

[4] Froend, R. and Loomes, R. 2004. Approach to determination of ecological water requirements of groundwater dependent ecosystems in Western Australia – A report to the Department of Environment, Edith Cowan University, Perth.

As stated in Hyde (2006)[5], the categories were developed based on the results of research into the response of vegetation to groundwater decline. The cumulative rate and magnitude of the predicted groundwater drawdown is defined and the possible ecological responses to the varying degrees of drawdown are described broadly as either low, moderate, high or severe in terms of probability of noticeable impact from groundwater level change. The risk categories for wetlands are shown on Graph 1.



Froend and Loomes 2004

Graph 1: Risk of Impact for Wetland Vegetation based on Magnitude of Groundwater Level Change

On this basis, the model predicted water level change associated with pressure main installation is expected to result in a low risk of impact to wetlands.

Aglime Impact to Groundwater Quality.

The application of aglime to neutralise acid sulfate soils (ASS) is not considered to pose a significant risk to groundwater given its low solubility and weak base nature. Aglime is considered the industry standard for treating ASS and acidic dewatering effluent as described in *Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes* (DER July 2011) and is also generally not harmful to plants, livestock, humans and most aquatic species. As such it is considered suitable for use near water bodies.

Due to aglimes' low solubility, weak basic nature and its low dissociation constant, any impact on the chemistry of groundwater would be very slow and as a result the groundwater system is likely to be able to buffer any addition of bicarbonate to the system. Thus the buffering capacity of the groundwater and the low solubility of the aglime results in minimal potential for the pH to rapidly change and increase to highly basic. As such the aglime is not considered to pose a significant risk to groundwater.

[5] Hyde, N.L. (2006). A summary of investigations into ecological water requirements of groundwater-dependent ecosystems in the South West groundwater areas.

Furthermore, given the aglime is being applied to ASS, the aglime is expected to protect the groundwater from potential acidification impacts as a result of ASS oxidation during earthworks. These acidification products pose a greater risk to groundwater, should they not be managed, than the use of aglime to manage the potential acidification products. Any generated acidification products will react with the aglime and be neutralised and thus consume the aglime, reducing the concentration of aglime in the soil. As a result, the aglime concentration will decrease over time and therefore the potential for any impacts will be further decreased. It should be noted that the treatment of the ASS should result in an excess of aglime being added to the soils and as such more neutralising capacity will be added to the soils than required. However as previously stated this is considered to pose a smaller potential environmental risk than not treating the ASS.

Conclusion

Groundwater modelling has been undertaken to estimate the impact of the Balannup pressure main on nearby hydrological processes. The models utilised site specific hydrogeological information and the results indicate the pressure main will not have significant direct or indirect impacts on the subsurface flows at the site. This meets the EPA's objective which is to maintain the hydrological regime so that existing and potential uses, including ecosystem maintenance, are protected. In relation to groundwater quality, the use of aglime is the recommended option for treating ASS and its use is not expected to result in any risk to groundwater quality.

Yours sincerely
RPS

CARL DAVIES
Principal Hydrogeologist

ATTACHMENTS

Appendix 1: *EPA Referral Comments*
Appendix 2: *EPA Email Correspondence*
Appendix 3: *Groundwater Elevation Information*
Appendix 4: *Groundwater Modelling*

APPENDIX I

EPA Referral Comments

Environmental Protection Authority

GOVERNMENT OF WESTERN AUSTRALIA

Mr Rupert Duckworth
Manager EIA and Approvals
Environment and Aboriginal Affairs Branch
Water Corporation
PO Box 100
LEEDERVILLE WA 6902

Your Ref: *JT1 2011 12136v01*
Our Ref: *CMS 14335; AC01-2014-0150*
Enquiries: *Amy Sgherza, 6145 0818*
Email: *amy.sgherza@epa.wa.gov.au*

Attention: Ms Bree Atkinson

Dear Mr Duckworth

NOTICE REQUIRING FURTHER INFORMATION
s38A of the *Environmental Protection Act 1986*

PROPOSAL: **BALANNUP WASTEWATER PRESSURE MAIN**
PROPONENT: **WATER CORPORATION**

Thank you for your letter dated 3 October 2014 referring the above proposal to the Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986* (EP Act).

This means that the EPA is required to:

- determine the significance of the effect on the environment of the proposal, if implemented, and
- make a decision on whether or not to assess the proposal and, if the decision is to assess, the level of assessment.

The EPA considers that it does not have enough information about the proposal to enable it to make decisions on significance and appropriate level of assessment. Accordingly, the EPA requests that you, as the proponent, provide it with the following additional information about the proposal:

- Further information in relation to the predicted hydrological changes that may occur as a result of the installation of the pipeline are required to demonstrate that the EPA's objective for hydrological processes which is *to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*, can be met, following construction.

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Locked Bag 10, East Perth WA 6892

www.epa.wa.gov.au

- Based on existing knowledge and available information regarding hydrology and stratigraphy for the Keane Road section (Bush Forever 342) the referral document needs to:
  - clearly demonstrate that the proposal would not have significant direct and indirect impacts on the subsurface flows at the site. This includes describing the current hydrological regimes and processes that operate at the site (at the local-scale) and how they may be disrupted due to the proposal. This could be set out for example, by using cross-sectional figures of the soil profile showing current hydrological processes/flows, compared with one showing the potential effects of the proposal; and
  - provide further discussion on whether there are any risks to ground water quality associated with the application of AgLime for neutralising soils as stated in the Draft Acid Sulphate Soil and Dewatering Management Plan (ASSDWMP).

Should you have any enquiries please contact the person cited above.

Your response to this request for additional information is required by 17 November 2014. Please respond with either:

a) the information requested; or

b) advice that further information is not available and/or cannot be obtained.

Please note that the EPA has also sought additional information about the proposal from the Department of Parks and Wildlife, the Department of Water, the City of Armadale and the Department of Planning.

Your response should be sent by email to registrar@epa.wa.gov.au marked for the attention of the person cited above, or by post to the Office of the Environmental Protection Authority, Locked Bag 10, East Perth WA 6892. Please quote the above "Our ref" on any further correspondence.

It should be noted that, under the EP Act, the EPA has 28 days in which to make a decision on whether or not to assess a proposal, and if assess, the appropriate level of assessment. The 28-day period will start to run either on 17 November 2014, i.e. the expiration of the specified period, or on receipt of the requested information, whichever occurs first. However, if the information is not received within the specified period, or if it becomes apparent that such information is not available, the EPA can proceed (at the expiration of the specified period) to make its decision on whether or not to assess and if assess, the appropriate level of assessment, based on information derived from its own investigations and inquiries.

You would be notified once the EPA has made a decision.

Yours sincerely

A Sutton

Anthony Sutton
Director
Assessment and Compliance Division

For the Chairman of the Environmental Protection Authority
Under Notice of Delegation No. 33 dated 6 December 2013

28 October 2014

APPENDIX 2

EPA Email Correspondence

Doris Clarke

From: Bree Atkinson <Bree.Atkinson@watercorporation.com.au>
Sent: Monday, 3 November 2014 4:04 PM
To: Carl Davies
Cc: Carl Barbato
Subject: FW: Balannup - Proposal

FYI comments from the oEPA regarding their review of the scope of works.

Thanks
Bree

From: Amy Sgherza [mailto:Amy.Sgherza@epa.wa.gov.au]
Sent: Monday, 3 November 2014 3:50 PM
To: Bree Atkinson
Subject: RE: Balannup - Proposal

Hi Bree,

I provide the following comments in relation to the proposed scope of works (RPS).

In general, the scope of works is adequate, but please be aware that the model output is only going to be as good as the information inputted, so please ensure that the most up to date available information is utilised. Also, once the models are generated it will be necessary to then relate the results back to the EPA's objective for Hydrological Processes with a discussion on whether this objective will be met.

Thank you. Any questions please do not hesitate to contact me. I will be back in the office on Wednesday.

Kind regards

Amy Sgherza
Environmental Officer
Office of the **Environmental Protection Authority**
The Atrium, Level 8, 168 St Georges Terrace, Perth
Locked Bag 10, East Perth WA 6892
direct: 08 6145 0818| reception: 08 6145 0800 | fax: 08 6145 0895
email: amy.sgherza@epa.wa.gov.au | web: http://www.epa.wa.gov.au
@EPA_WA

Please note new postal address and phone and fax numbers.

Office of the
Environmental Protection Authority

From: Bree Atkinson [mailto:Bree.Atkinson@watercorporation.com.au]
Sent: Friday, 31 October 2014 1:59 PM
To: Amy Sgherza
Subject: Balannup - Proposal

Hi Amy

I really appreciate you agreeing to have a look at RPS's proposal (attached)

We will also address the potential impact of adding aglime to manage Acid Sulfate Soils.

Thanks for your help

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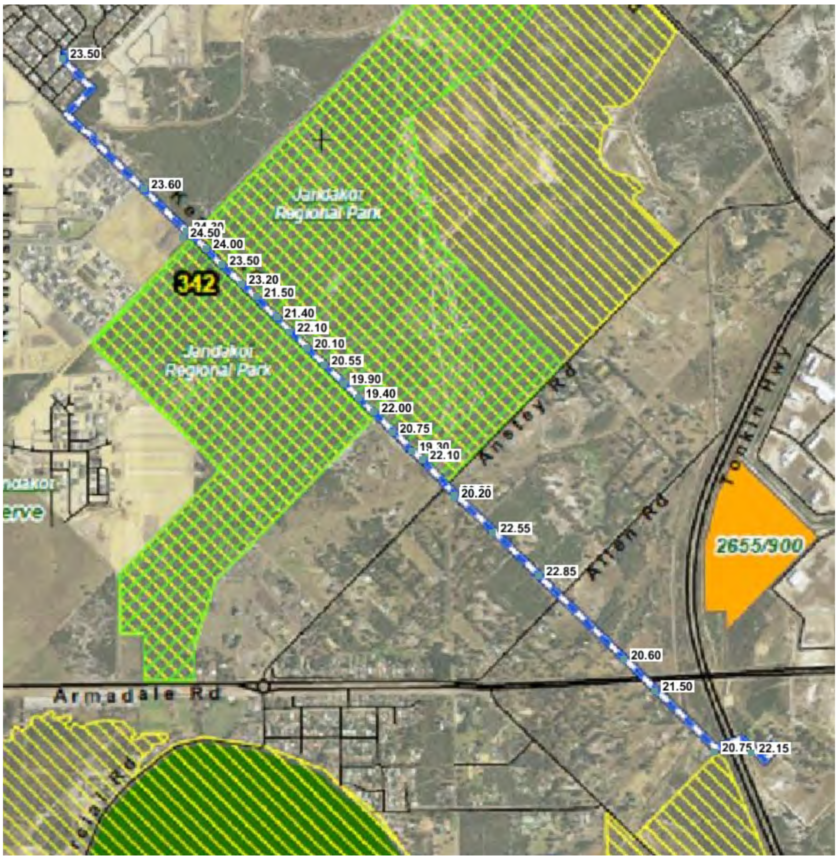
APPENDIX 3

Groundwater Elevation Information

APPENDIX 3: GROUNDWATER ELEVATION INFORMATION

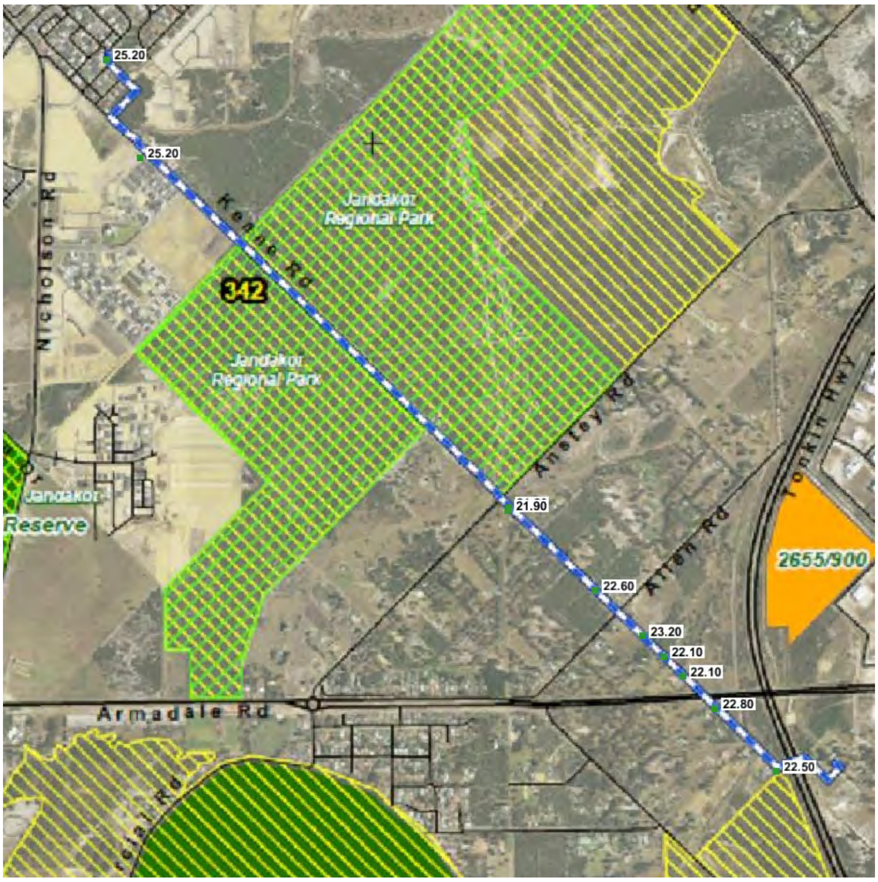
Table A3-1 Groundwater Monitoring Data (Modified from GHD 2013)

Bore	Chainage (m)	x	y	Topo Elevation (mAHD)	Depth achieved (mAHD)	Estimate GW Depth (June-July 2013)- mbgl	Bore Installed?	GWL June-July 2013_(mAHD)	GWL August 2013_(mAHD)
BH01	47	398909	6445341	26.8	3.45	3.3	Yes	23.5	25.2
BH02	353	398919	6445115	26.5	3.45	-	No		
BH03	570	399047	6444936	27	3.45	-	Yes		25.2
BH04	819	399252	6444789	25.5	3.45	1.9	No	23.6	
BH05N	1073	399432	6444610	25.5	2.86	1.2	Yes	24.3	
BH05S	1080	399417	6444584	25.4	2.5	0.9	Yes	24.5	
BH06N	2667	400565	6443495	22	6	1.8	Yes	20.2	21.2
BH06S	2674	400563	6443483	22.5	6.45	2.3	Yes	20.2	21.9
BH07	2895	400728	6443335	23.75	3.45	1.2	No	22.55	
BH08	3161	400922	6443153	24.25	2.8	1.4	Yes	22.85	22.6
BH09	3432	401117	6442965	24.3	3.45	-	No		23.2
BH10	3665	401281	6442799	23.4	4.5	2.8	Yes	20.6	22.1
BH11	3853	401414	6442667	23.5	4.5	2	Yes	21.5	22.8
BH12	4199	401666	6442408	23.75	4.5	3	Yes	20.75	22.5
BH13	4395	401821	6442405	24.75	4.5	2.6	Yes	22.15	
BH14	1183	399514	6444537	24.9	6.45	0.9	No	24	
BH15	1281	399583	6444467	25	6	1.5	No	23.5	
BH16	1396	399664	6444386	24.4	6	1.2	Yes	23.2	
BH17	1480	399729	6444332	24.5	6	3	No	21.5	
BH18	1603	399815	6444245	24	6	2.6	No	21.4	
BH19	1685	399869	6444183	23.9	6	1.8	Yes	22.1	
BH20	1784	399943	6444116	23.6	6.45	3.5	No	20.1	
BH21	1886	400014	6444044	23.75	6.45	3.2	No	20.55	
BH22	2000	400097	6443966	23.8	6	3.9	Yes	19.9	
BH23	2087	400159	6443905	23.4	6.45	4	No	19.4	
BH24	2177	400226	6443844	22.9	6.45	0.9	No	22	
BH25	2293	400303	6443757	22.75	6	2	Yes	20.75	
BH26	2409	400386	6443680	22.3	6.45	3	No	19.3	
BH27	2465	400430	6443644	22.3	6	0.2	No	22.1	
BH28	3553	401204	6442881	23.25	3	-	Yes		22.1



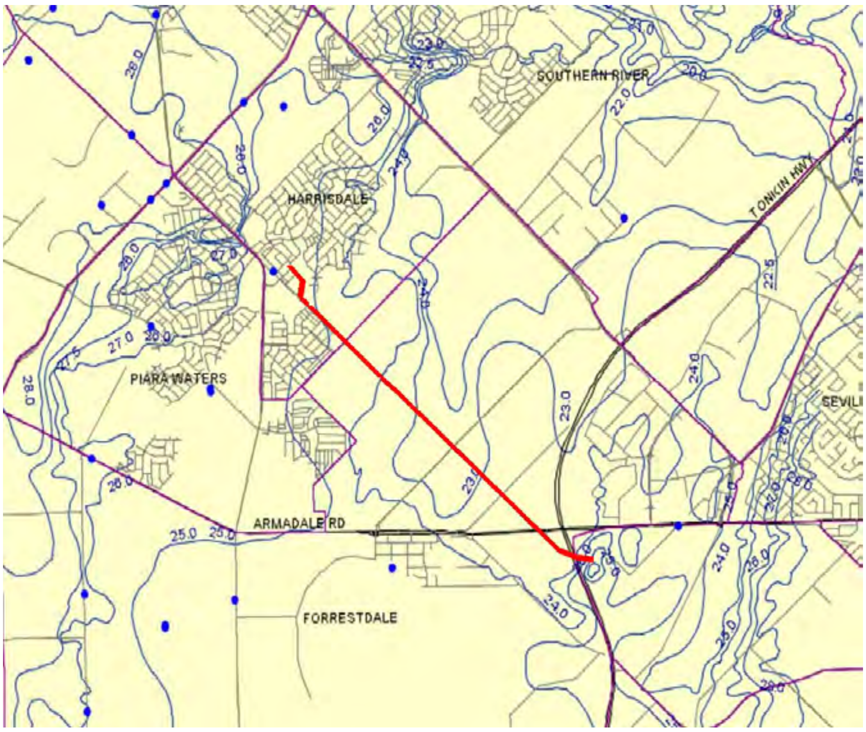
Source: GHD 2013 and AECOM 2014

Figure A3-1: Estimated Groundwater Elevation along Alignment- July 2013



Source: GHD 2013 and AECOM 2014

Figure A3-2: Estimated Groundwater Elevation along Alignment- August 2013



(DoW 2014)

Figure A3-3: Regional Groundwater Contours

APPENDIX 4

Groundwater Modelling

APPENDIX 4: GROUNDWATER MODELLING

Scenario 1: Western Model

Model Grid

Scenario 1 (pressure main located within the Bassendean Sand unit of approximately 2.5 m thickness) was simulated by constructing a model along the western side of the alignment.

A pre-installation model was initially constructed to use for comparison purposes. The model was constructed using Modflow NWT[1]. The model is approximately 1350 m × 840 m in dimension and the cell size ranges from 0.45 m along the pressure main (area of interest) and progressively increases to a maximum cell size of 20 m towards the model boundaries (Figure 1)[2]. The model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2- pressure main within sand (1.05 to 1.5 mbgl).
- Layer 3 – bottom of pressure main to top of clayey sand (1.5 to 2.5 mbgl).
- Layer 4 – clayey sand top (2.5 mbgl) to base of superficial aquifer (-7 m AHD as provided by DoW 2014[3]).

Boundaries

Specified head boundaries were used at the western (25 m AHD) and eastern (24 m AHD) ends of the model to coincide with groundwater levels as determined by measured site data (GHD 2013[4]) and DoW (2014) mapping. No flow boundaries were used along the northern and southern boundaries (Figure A4-1).

[1] Modflow NWT allows simulation of cell drying/ rewetting due to the shallow water tables in the area
[2] Small cell sizes are also shown in Figure 1 perpendicular to the drain, which is necessary as part of the model grid process.
[3] DoW (2014). Perth Groundwater Atlas
[4] GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation

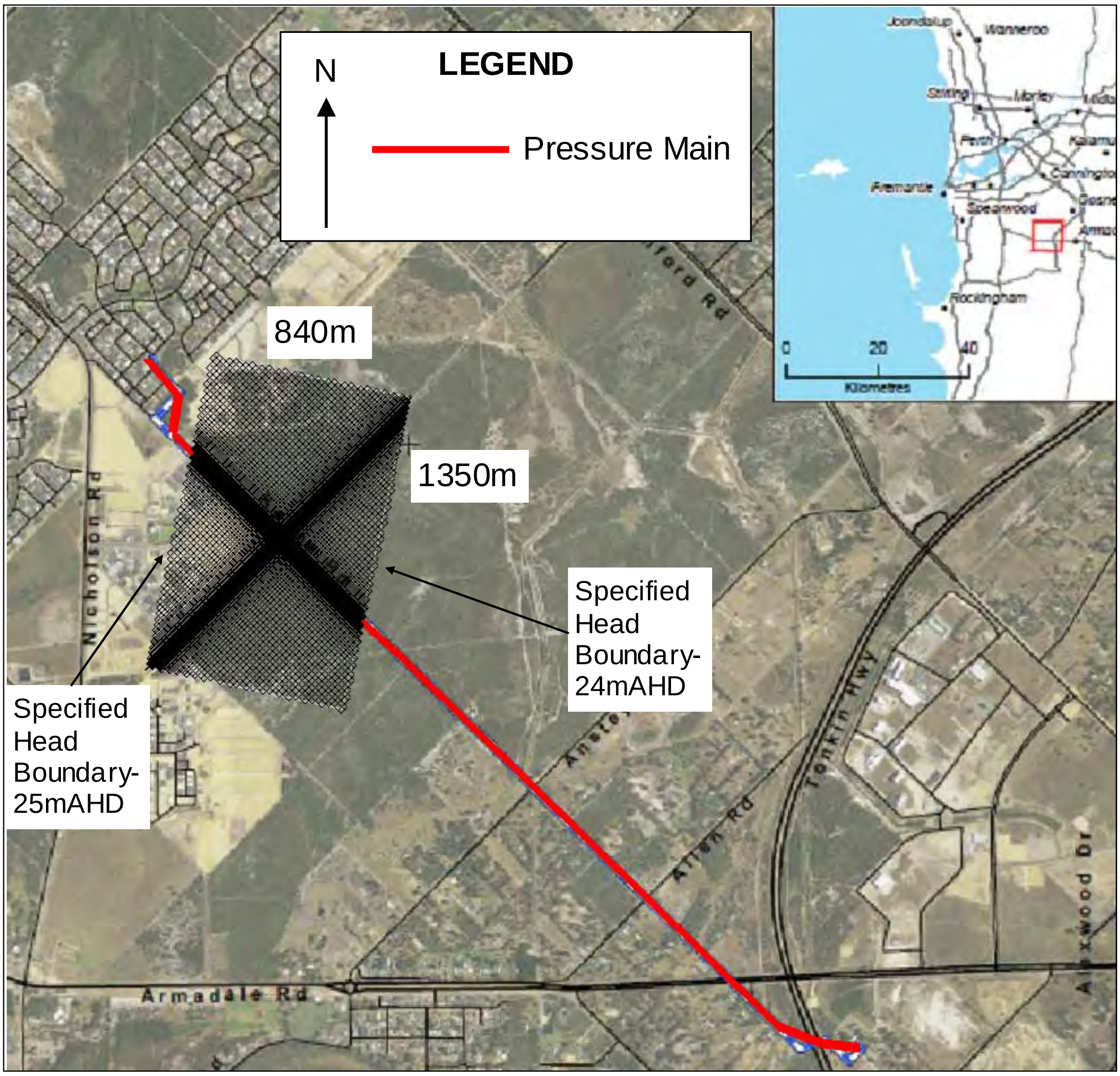


Figure A4-1: Scenario 1 Model Grid (Modified from AECOM Basemap)

Aquifer Properties

Aquifer properties were based on literature values (e.g. Davidson 1995[5]) for the geological unit, as summarised in Table A4-1.

Table A4-1: Aquifer Properties

Geological Unit	Hydraulic Conductivity (m/d)	Horizontal to Vertical K ratio	Specific Yield	Location
Bassendean Sand	15	3	0.2	Layers 1 to 3
Clayey Sand	1	10	0.07	Layer 4

[5] Davidson, W. A. 1995. Hydrogeology and Groundwater Resources of the Perth Region Western Australia. Geological Survey of Western Australia Bulletin 142.

Groundwater Recharge

The model utilises average monthly rainfall data from the Forrestdale weather station and monthly evaporation values from Medina weather station. Net recharge was simulated by applying a gross 50% rainfall recharge value with an evapotranspiration (ET) function of 0.8 pan evaporation at the ground surface that decreases linearly to zero at 1.5 mbgl.

<u>Scenario 1 Pre-Installation Groundwater Levels</u>

Pre-installation simulated groundwater contours are shown on Figure A4-2. Graph A4-1 shows a groundwater elevation time series for a point near the centre of the model domain, along the proposed main installation. The model simulated groundwater contours fluctuate approximately 1 m which is reasonable for the area (cf. Davidson 1995).

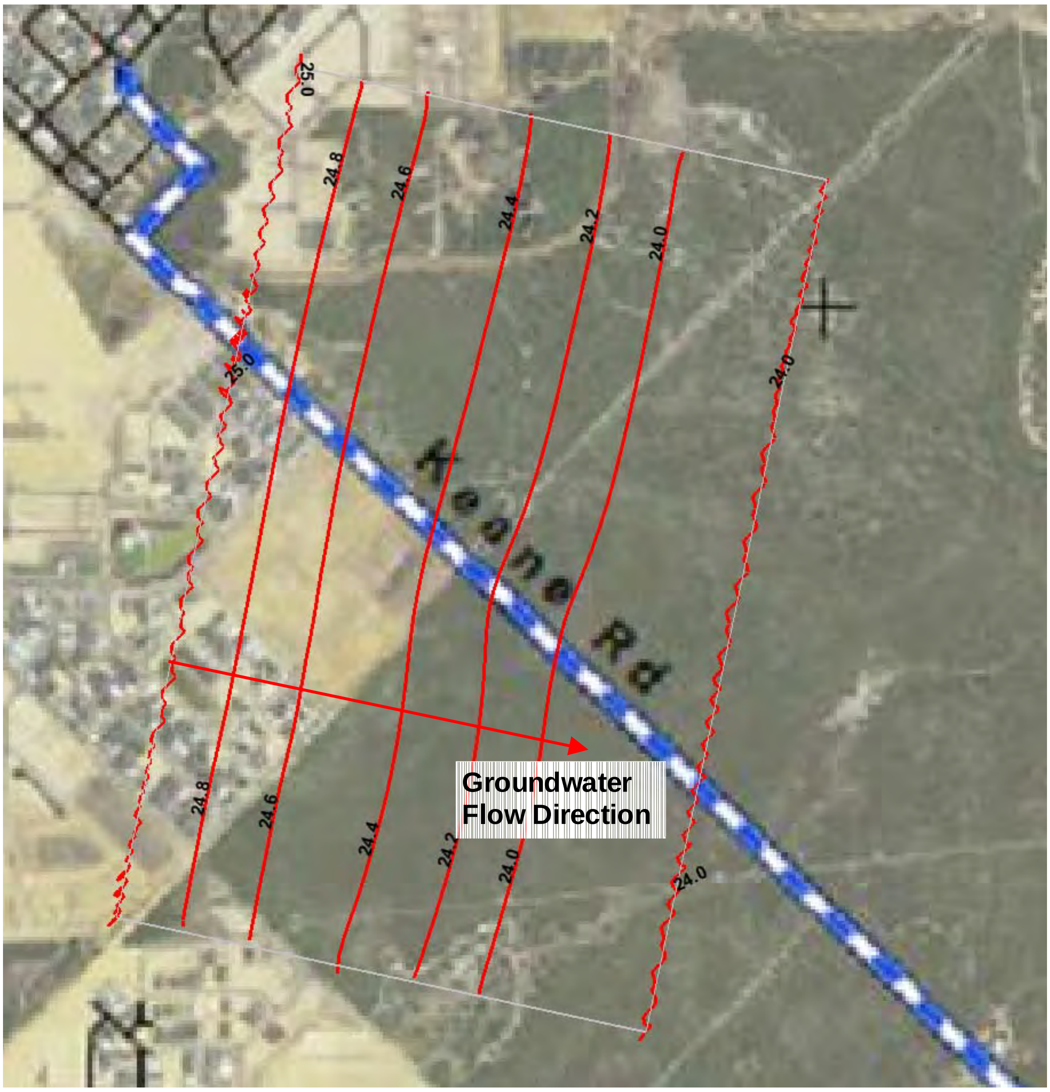
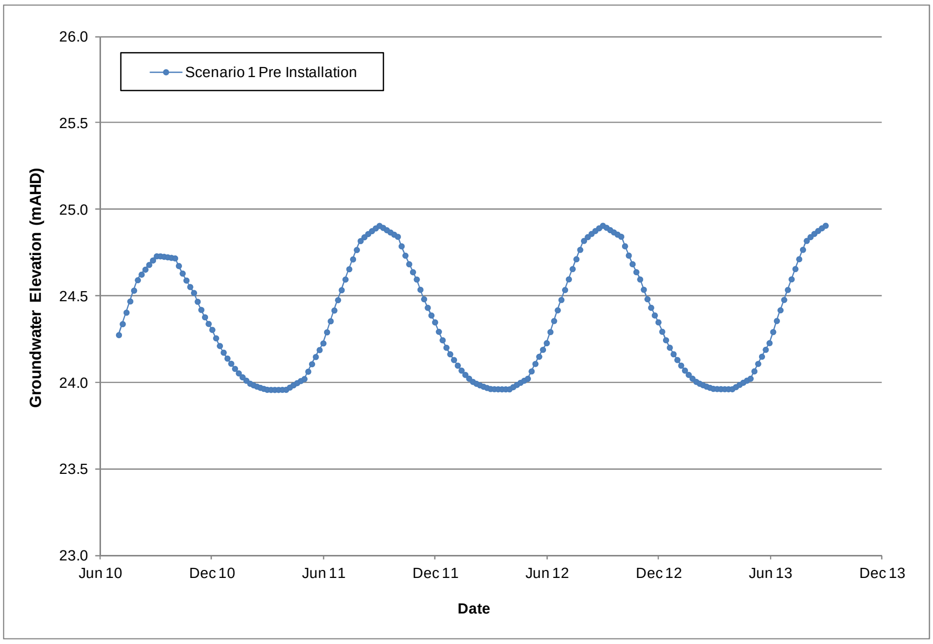


Figure A4-2: Scenario 1 Pre Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

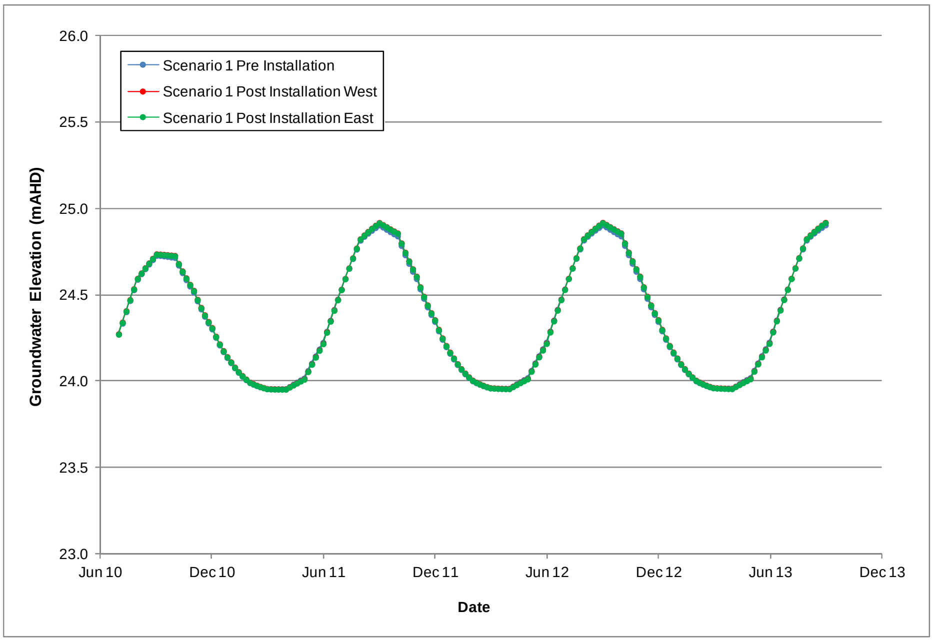


Graph A4-1: Scenario 1 Pre Installation Groundwater Elevation Time Series

<u>Scenario 1 Post-Installation Groundwater Level Change</u>

The pre installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-8} m/d along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulated minimal groundwater elevation change (<1 cm) directly adjacent[6] to the pressure main for Scenario 1 (Graph A4-2).



Graph A4-2: Scenario 1 Groundwater Elevation Time Series– Adjacent to Pipe

[6] Simulated groundwater levels taken from 0.5 m cells directly adjacent to the pressure main

Scenarios 2 and 3: Eastern Model

Model Grid

Scenarios 2 and 3 (pressure main located *on* clayey sand and *within* clayey sand respectively) were simulated by constructing a model along the eastern side of the alignment. A pre-installation model was initially constructed to use for comparison purposes for Scenarios 2 and 3. The model is approximately 1675 m × 1020 m in dimension (Figure A4-3) and the cell size ranges from 0.45 m along the pressure main and progressively increases to a maximum cell size of 20 m towards the model boundaries.

The Scenario 2 model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2- pressure main located on clayey sand (1.05 to 1.5 mbgl).
- Layers 3 and 4 – clayey sand top (1.5 mbgl) to base of superficial aquifer (-7 m AHD).

The Scenario 3 model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2 – pressure main within clayey sand (1.05 to 1.5 mbgl).
- Layers 3 and 4 – clayey sand to base of superficial aquifer (-7 m AHD).

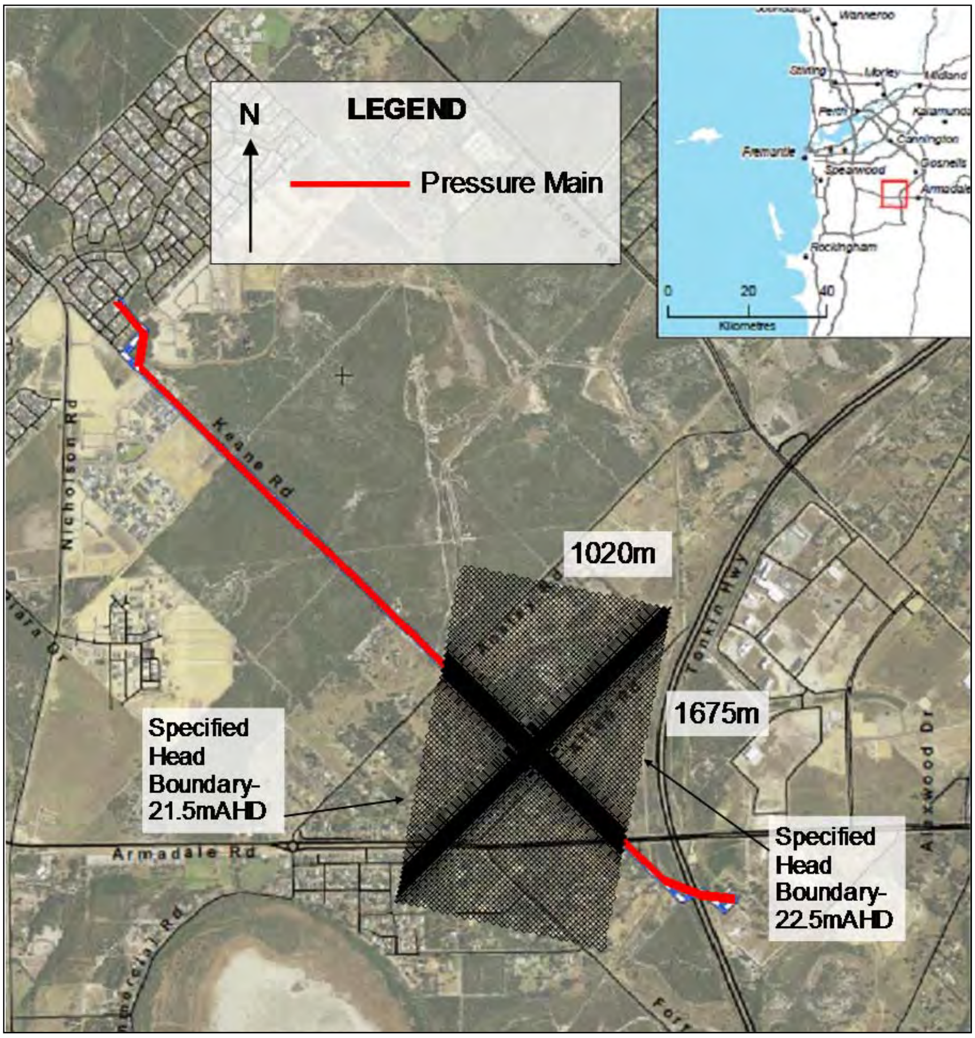


Figure A4-3: Scenarios 2 and 3 Model Grid (Modified from AECOM Basemap)

Boundaries

Specified head boundaries were used at the western (21.5 m AHD) and eastern (22.5 m AHD) ends of the model to coincide with groundwater levels as determined by measured site data (GHD 2013) and DoW (2014) mapping. No flow boundaries were used along the northern and southern boundaries.

Aquifer Properties

Aquifer properties were as per the previous model.

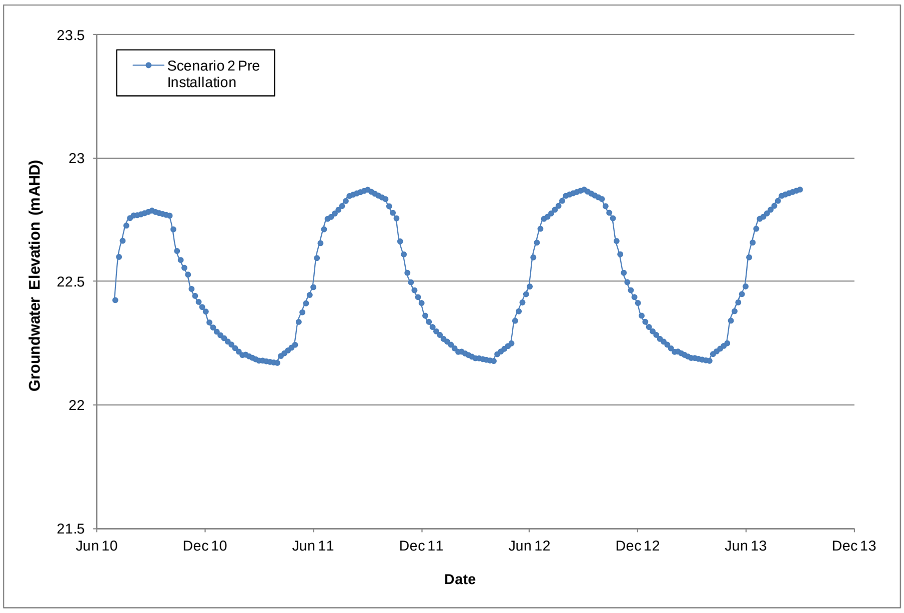
Groundwater Recharge

Net recharge was simulated by applying a gross 30% rainfall recharge value with an ET function of 0.8 pan evaporation at the ground surface that decreases linearly to zero at 2 mbgl.

Scenario 2 Pre-Installation Groundwater Levels

Pre-installation model simulated groundwater contours (Figure A4-4) correspond with the measured flat water table east of the open drain (which is in close proximity to the western boundary). Graph A4-3 shows a groundwater elevation time series for a point along the proposed main installation, near the centre of the model domain. The model simulated groundwater contours fluctuate approximately 0.8 m which is reasonable for the area.

Figure A4-4: Scenario 2 Pre-Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

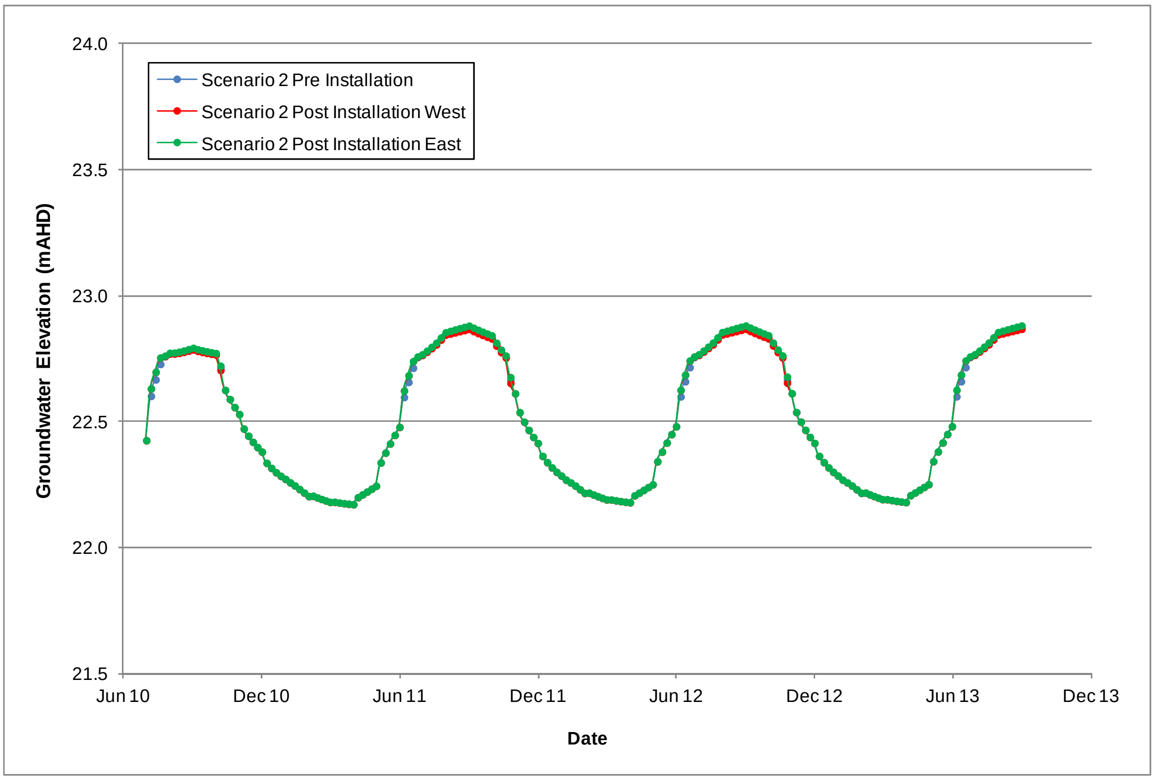


Graph A4-3: Scenario 2 Pre-Installation Groundwater Elevation Time Series

Scenario 2 Post-Installation Groundwater Level Change

The pre-installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-4} m/d[7] along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulated minimal groundwater elevation change (maximum 3 cm) directly east and west of the pressure main for Scenario 2 (Graph A4-4).



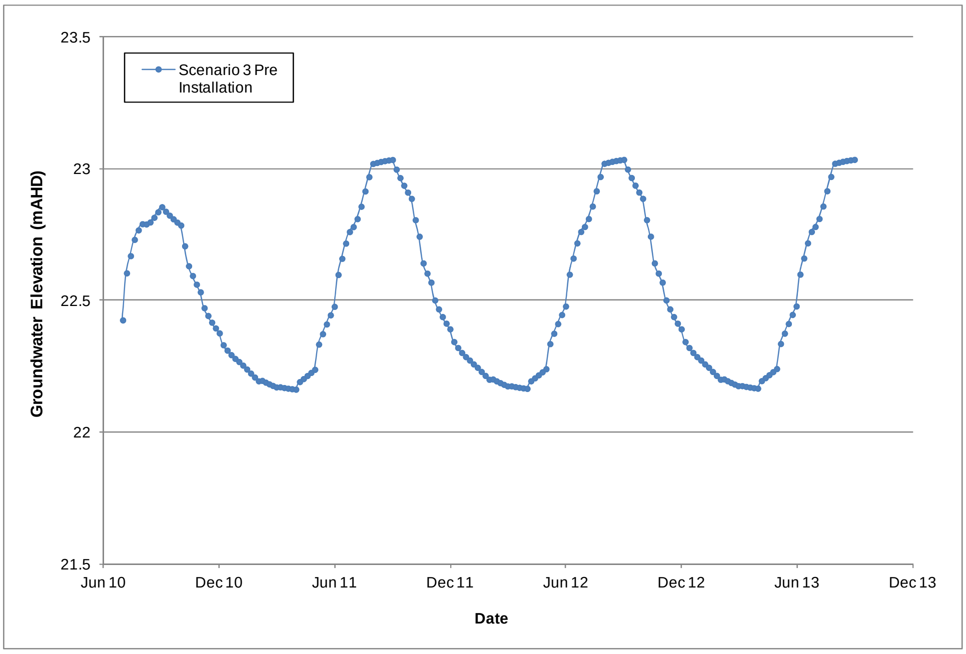
Graph A4-4: Scenario 2 Groundwater Elevation Time Series – Adjacent to Pipe

Scenario 3 Pre-Installation Groundwater Levels

Pre-installation model simulated groundwater contours (Figure A4-5) correspond with the measured flat water table east of the open drain (which is in close proximity to the western boundary). Graph A4-5 shows a groundwater elevation time series for a point along the proposed main installation, near the centre of the model domain. The model simulated groundwater contours fluctuate approximately 1 m which is reasonable for the area.

[7] A lower value was not used due to model convergence issues. This value is still 10,000 times less than the clayey sand K value and 150,000 times less than the sand K value.

Figure A4-5: Scenario 3 Pre-Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

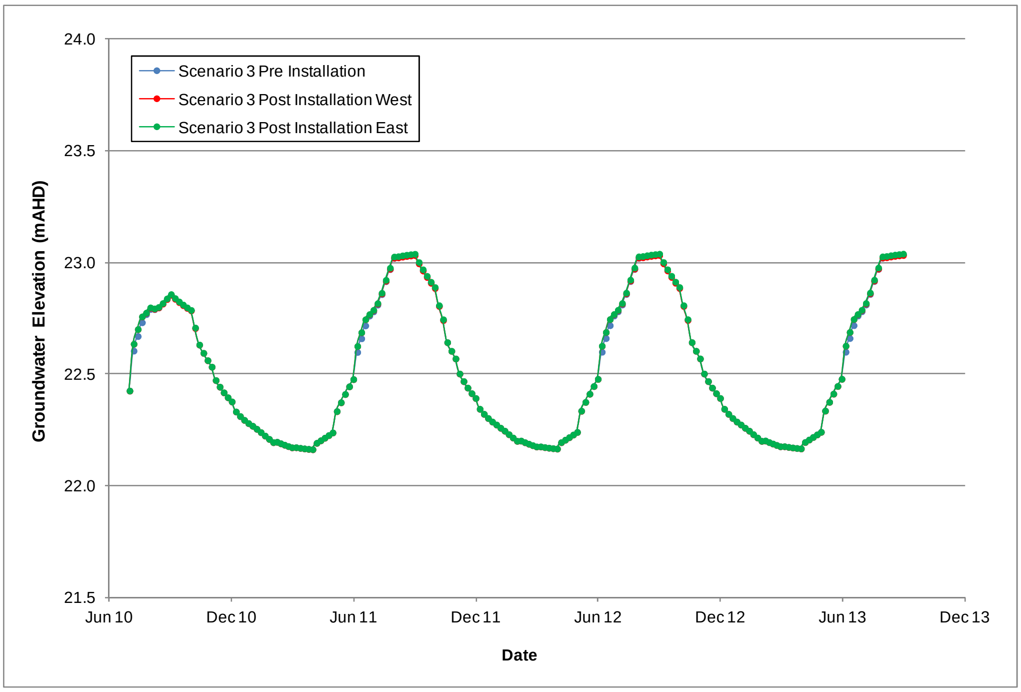


Graph A4-5: Scenario 3 Pre-Installation Groundwater Elevation Time Series

Scenario 3 Post-Installation Groundwater Level Change

The pre-installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-4} m/d along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulates minimal groundwater elevation change (maximum ~3 cm) directly east and west of the pressure main for Scenario 3 (Graph A4-6).



Graph A4-6: Scenario 3: Groundwater Level Change Time Series– Adjacent to Pipe

References

AECOM 2014. Balannup Wastewater Pressure Main. Supporting Documentation

Davidson, W. A. 1995. Hydrogeology and Groundwater Resources of the Perth Region Western Australia. Geological Survey of Western Australia Bulletin 142.

DoW (2014). Perth Groundwater Atlas

GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation