Shire of Serpentine Jarrahdale
Sustainable. Connected. Thriving!

All enquiries to Planning Services on 9526 1111
Our ref: PA17/958: CON:wj

2 May 2018

Coterra
Level 3, 25 Prowse Street
WEST PERTH WA 6005

Via email: rebecca.epworth@coterra.com.au

Dear Sir/Madam,

Proposed Three Irrigation Dams
Lot 2, 206 Firns Road, Serpentine

I refer to your application, received 19 October 2017, for approval to commence development on the aforementioned lot.

In accordance with the provisions of the Shire's Town Planning Scheme No. 2 and the authority delegated to Council under the provisions of the Metropolitan Region Scheme, your application to commence development has been refused. Attached is the Notice of Determination of Application for Development Approval stating the reason(s) for which development was refused.

Should you be aggrieved by any of the decision or any conditions imposed, you have the right under the *Planning and Development Act 2005* to have the decision reviewed by the State Administrative Tribunal. Applications for review must be submitted to the Tribunal within 28 days of the date on the decision notice. Further information can be obtained by calling the Tribunal on (08) 9219 3111 or by visiting their website at www.sat.justice.wa.gov.au

Yours faithfully

Ashwin Nair
Manager Statutory Planning and Compliance

a 6 Paterson Street, Mundijong WA 6123 t 08 9526 1111 f 08 9525 5441 e info@sjshire.wa.gov.au www.sjshire.wa.gov.au

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Planning and Development Act 2005
Shire of Serpentine Jarrahdale
Notice of Determination on Application for Development Approval

Property File:	A7900	Application No:	PA17/958
Location:	206 Firns Road, Serpentine		
Lot:	2	Plan/Diagram:	36434
Vol. No:	242	Folio No:	92A
Application Date:	11 October 2018	Received On:	19 October 2017

Description of Proposed Development: Three Irrigation Dams

Use Class: 'Rural Use'

Date of Determination: 2 May 2018

That the Manager Statutory Planning and Compliance REFUSE Development Approval under Delegated Authority 11.1.1 pursuant to Clause 68(2) of the Deemed Provisions of *Planning and Development (Local Planning Schemes) Regulations 2015* for Proposed Irrigation Dams subject to the following reasons for refusal:

Reasons:

1. The proposal does not include sufficient information in accordance with Local Planning Policy 33 – Construction of Dams by way of justification of the purpose of the dams and the land use.

2. The proposal is in consistent with the objectives of the 'Rural' zone in accordance with Clause 5.10.1 of the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 as it does not demonstrate a 'rural pursuit'.

3. Insufficient information has been provided in relation to the proposal to be able to determine the land use in accordance with Clause 67 of the *Planning and Development (Local Planning Schemes) 2015.*

4. Insufficient information has been provided to demonstrate the impacts on down-stream users and the environment, inconsistent with the objectives of Local Planning Policy 33 – Construction of Dams and orderly and proper planning.

5. The proposal is inconsistent with the Rural Strategy Review and which designates the site as 'Agricultural Protection'. No detail has been provided to demonstrate the nexus to the agricultural viability of the land.

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NOTE 1: If an applicant or owner is aggrieved by this determination there is a right of review by the State Administrative Tribunal in accordance with the *Planning and Development Act 2005* Part 14. An application must be made within 28 days of the determination.

Signed: Dated: 2 May 2018

For and on behalf of the Shire of Serpentine Jarrahdale

COTERRA
ENVIRONMENT

Application for Development Approval

Lot 2 Firns Road, Serpentin

Revision 0, October 20 7

SHIRE OF SERPENTINE-JARRAHDALE
PLANNING REFUSAL
Date: File No
Signed
(Authorised Officer)

CALIBRE | COMMITMENT | COLLABORATION

SHIRE OF SERPENTINE-JARRAHDALE
PLANNING REFUSAL
Date: 02/05/2018 File No
Signed
(Authorised Officer)

COTERRA ENVIRONMENT

Application for Development Approval

Lot 2 Firns Road, Serpentine

Revision 0, October 2017

This report was prepared by:

Coterra Pty Ltd trading as COTERRA ENVIRONMENT
ABN: 92 143 411 456

Our Ref: XYDSER01
Author(s): C. Hopkirk
Reviewer: R. Epworth
Report Version: Revision C
Date: October, 2017

This report was prepared for:

Saraband Investments Pty Ltd
Level 1, 420 Hay Street
SUBIACO WA 6008

Notice

COTERRA ENVIRONMENT

TABLE OF CONTENTS

Page

COTERRA ENVIRONMENT

TABLES (Compiled within the report)

Page

FIGURES (Compiled at the end of the report)

APPENDICES

1.0 INTRODUCTION

1.1 Site Overview

Lot 2 Firns Road, Serpentine (the site) is a 75.3 ha privately owned landholding located within the Shire of Serpentine-Jarrahdale. The site location is shown in Figure 1.

The property is partially cleared and currently contains a dwelling, ancillary buildings and a number existing farm dams of various sizes.

The property ownership details are listed in Table 1 below. The Certificate of Title is provided in Appendix A.

Table 1 Owner/Proponent Details

Details	Description
Premise Description	206 Firns Road, Serpentine Lot 2 on Diagram 36431
Certificate of Title	Volume 242, Folio 92A
Premise Owner	Saraband Investments Pty Ltd
Contact	Harry Xyda
ABN	91 078 576 735
Job Title	Director
Address	Level 1, 220 Hay Street, SUBIACO

1.2 Proposed Works

Saraband Investments Pty Ltd (the proponent) propose to construct three new farm dams within the site to facilitate the storage of runoff from the property for irrigation of proposed future orchards.

The proposed works include:

- The construction of two dams on a small gully near the site's northern boundary 'the northern gully'. The proposed dams (dams 3A and 3D) will be located downstream and upstream of the existing dams on this gully (dams 3B and 3C) respectively. The proposed and existing dams on the northern gully are shown in Figure 2.
- The construction of one dam (dam 2) on a small gully near the sites southern boundary 'the southern gully'. The location of the proposed dam 2 is shown in Figure 3.

- Agricultural techniques such as grade banks and feeder drains will be applied at the site to increase catchment size and optimise runoff to the dams from within the property.

- Near the northern gully, four existing farm dams (ND1, ND4, ED1 and ED2) may be decommissioned or have their outlets graded to direct any runoff collected towards proposed dams 3A and 3D as these dams are located within the catchment of the proposed dams.

No buildings or other infrastructure is proposed as part of this application for Development Approval.

1.3 Planning and Approvals

The land is zoned 'rural' under Shire of Serpentine Jarrahdale Town Planning Scheme No. 2. Farm dams are permitted within the rural zone.

1.3.1 State Government Approvals

Extensive liaison was undertaken with Department of Water and Environmental Regulation (DWER) regarding the hydrological modelling. Liaison was undertaken to determine the DWER licencing requirements for the proposed works. DWER have advised that a 5C Licence to Take Water under the *Rights in Water and Irrigation Act 1914* is not required for the proposed dams. DWER have determined this on the basis that:

1. The excavation of the dams facilitates access to shallow groundwater. The site is located within a non-proclaimed groundwater area therefore a groundwater licence is not required.

2. The gullies on the property originate within the property boundary. In accordance with Section 5(1)(a) of the *Rights in Water and Irrigation Act 1914* this does not constitute a watercourse until such time as it flows beyond the property boundary;

   5. Waters to which this Part does not apply
   (1) This Part does not apply to or in relation to —
   (a) the water flowing from any spring the water of which rises to the surface on land that has been granted or demised by the Crown until it has passed beyond the boundaries of the land belonging to the owner or occupier of the land on which the water so rises; or

   Therefore, a surface water licence is not required.

Correspondence from DWER identifying this is provided in Appendix B.

DWER have issued a Section 17 *Permit to Obstruct or Interfere with Bed and Banks* under the Rights in Water and Irrigation Act 1914 to undertake the dam construction works for all three dams (Appendix C).

A Native Vegetation Clearing Permit is required to facilitate construction of the dams. This is discussed further in Section 4.1.

2.0 SITE CHARACTERISTICS

2.1 Climate

The site experiences a Mediterranean climate with mild winters and hot dry summers. The average annual rainfall at the Serpentine weather station is 906.2 mm.

Table 2 Average Total Rainfall by Month.

Month	Rainfall (mm)
January	9.7
February	12.9
March	17.3
April	48.2
May	127.8
June	18[illegible].5
July	180.7
August	139.5
September	89.9
October	56.4
November	24.5
December	13.8
Total	906.2

BoM (2017). Serpentine Weather Station #9039.

2.2 Topography

The site is located on the Darling Scarp, a north-south aligned low escarpment comprised of hilly landforms. The site is centred on a small ridge which extends north-west across the property from a maximum elevation of 275 mAHD, and slopes down to the north, west and south to a minimum elevation of approximately 150 mAHD.

Two small gullies are present near the northern and southern boundaries of the site. These gullies form the northern and southern gullies.

2.3 Geology and Soils

2.3.1 Regional Geological Mapping

Regional geological mapping indicates that the site is underlain by:

- CLAYEY SANDY SILT – fine to medium-grained angular quartz/feldspar, moderate cohesion, of alluvial origin.
- GRAVEL – loose, fine (less than 19 mm) red-brown to black, pisolitic, moderately sorted, highly variable angular sand content, of colluvial origin.
- LATERITE – massive and vuggy to cemented pisolites up to 4 m thick, associated loose residual sandy pioslite gravel, of residual origin.

2.3.2 Site Specific Investigations

A geotechnical investigation was undertaken by Galt Geotechnics in April 2016. The geotechnical investigation was undertaken in order to:

- Assess the soil and groundwater conditions within the proposed dam footprints.
- Assess suitability of the site soils for use as embankment fill.
- Provide recommendations and geotechnical design parameters for the proposed dams.
- Recommend appropriate site preparation procedures including compaction criteria.

The geotechnical investigation involved the excavation of 36 test pits within the proposed dam embankment, reservoir and borrow pit locations, and testing of laboratory samples. The results of the geotechnical investigation indicate that the site soils are consistent with the regional geological mapping.

The recommended geotechnical design parameters and site preparation procedures are summarised in Section 3.0. The geotechnical investigation is provided in full in Appendix D.

2.4 Hydrology

2.4.1 Surface Water

The headwaters of two small, ephemeral gullies are located within the property boundary. These gullies are referred to as the 'northern gully' and the 'southern gully' in this document. The northern gully traverses westwards across the site via two existing dams (dams 3B and 3C) and discharges on the property's western boundary.

The southern gully also originates on the property, with headwaters located below an existing catchment dam (dam 1). The southern gully also discharges on the property's western boundary.

It is noted that as both the northern and southern gullies originate within the property, they are not considered to be watercourses under the Rights in Water and Irrigation Act 1914 until they flow beyond the property boundary (please refer to DWER correspondence in Appendix B).

Another smaller watercourse or gully 'the eastern watercourse' is mapped (DWER hydrography database) as discharging to the site from the neighbouring property to the east. This watercourse is dammed in a number of locations on the neighbouring property to the east and very little discharge enters the site. Any discharge that does enter the site is captured in dam ED2 at the property boundary and goes no further. The watercourse does not extend westwards across the site as mapped. Department of Water and Environmental Regulation undertook a site visit in January 2017 and agreed the eastern watercourse and northern gully are not connected (Appendix B).

2.4.1.1 Existing Dams

The site contains one large and eight small existing farm dams. The existing dams have historically been used for livestock watering, irrigation and bushfire protection. The dams are summarised in Table 3 below.

Table 3 Existing Dams within the Site

Dam name	Approx. volume (kL)	Historical use
ND1	270	Irrigation
Dam 3B	1050	Irrigation
Dam 3C	1200	Irrigation
ND4	820	Irrigation
ED1	14.4	Livestock watering
ED2	14.4	Livestock watering
SD5	228	Irrigation
SD7	1,000	Irrigation
Dam 1	20,000	Irrigation
Total	**24,596.8 kL**	

2.4.2 Groundwater

No extensive groundwater resources are likely to be present at the site as a result of the low permeability geology.

The site is not within a proclaimed groundwater area. Water can be taken from an underground water source in an unproclaimed area without a licence, where the original water sourced is non-artesian. Given the absence of a confined aquifer at this site due to the geology, a groundwater licence is therefore not required.

During the geotechnical investigation, groundwater seepage was encountered within five test pits, as outlined in Table 4 below.

Table 4 Groundwater Seepage

Dam name	Test Pit ID	Depth seepage encountered (m)	Location
Dam 2	TP28	2.8	Reservoir
	TP32	2.2	Reservoir
Dam 3A	-	Not encountered	-
Dam 3D	TP01	4.4	Embankment
	TP04	1.1	Embankment

It is noted that the geotechnical investigation was undertaken during April. Groundwater levels vary seasonally and are typically at their lowest between March and May. As such, groundwater may be present at the site at shallower depths during wetter periods of the year.

3.0 PROPOSED DAMS

As outlined in Section 1.2, three new farm dams are proposed at the site to facilitate the irrigation of proposed future orchard. The proposed dams are summarised in Table 5 below. The dam locations are shown in Figure 2 and 3. Surveys of the areas are provided in Appendix E.

Table 5 Proposed Dams

Dam name	Location	Capacity (kL)
3A	Northern gully	2,430
3D	Northern gully	13,100
2	Southern gully	11,370

The proposed dams will be constructed using a compacted earthfill (clay core) embankment. The clay core will be constructed using selected low permeability materials while the embankment shell that surrounds the clay core will be constructed using surficial non cohesive material or clayey materials, in line with the recommendations of the geotechnical report.

The embankment will be constructed with 1:3 batters on the downstream side of the embankment and 1:4 batters on the upstream side. The dam embankments will include a spillway comprised of twin 600 mm diameter pipes with invert levels approximately 1.2 m below the top of embankment. Scour protection will be installed on the top of the embankment at the spillway location to manage overtopping during blockage or high water levels. The dam design details are provided in Table 6 below.

The dam embankments have been designed by Pritchard Francis engineers. Dam design drawings including cross sections are provided in Appendix F.

Table 6 Dam Design

Dam name	Wall length (m)	Wall height (m)	Free board (m)	Full supply level (mAHD)	Dam crest elevation (mAHD)	Crest width (m)
3A	88	4.5	1	198.75	199.75	6
3D	107	7.5	1	210.35	211.35	6
2	151	11.6	1	212.95	213.95	6

Access to the site will be maintained at existing access/cross-over locations.

No revegetation works or introduction of fauna to the dams is proposed.

3.1.1 Method of Excavation and Fill

The proposed dams will be constructed using material sourced from borrow areas within the site. A geotechnical engineer will be present during the excavation and fill works to direct the use of materials for construction of the embankment.

The method of excavation and fill is detailed in Appendix F of the geotechnical report (Appendix D), a summary is provided below:

1. **Undertake clearing, grubbing and stripping:** clearing of vegetation and removal of roots, rootmat, stumps, logs and other objectionable material from borrow material. Strip topsoil and stockpile.

2. **Borrow area development:** working of borrow material to achieve optimum moisture content and to remove and dispose of unacceptable materials.

3. **Excavation:** excavation of borrow material using common excavation, hand excavation and rock excavation techniques. Excavated material will be stockpiled on site.

4. **Foundation treatment:** earth and rock foundation preparation will be undertaken to remove inappropriate materials, achieve optimum moisture content, and fill any holes, defects or irregularities.

5. **Earthfill**:
   - Undertake in-situ compaction tests in test trenches and laboratory compaction tests to determine the compaction required on the embankment.
   - Ensure suitable bonding between fill and foundations through sloping of fill layers against the contact and compaction.
   - Placement of fill in layers of up to 250 mm prior to compaction using a 10 tonne vibratory footpad or equivalent. Compaction should be undertaken to a dry density ratio of 98% (clay core) and 95% (embankment shell).

6. **Diversion and Dewatering**:
   - Works will be undertaken during summer (where possible) to minimise interaction with surface water.
   - Surface water may be diverted around the works.

- Dewatering may be required to facilitate construction of dam foundations. As the site is located in an unproclaimed groundwater area, a dewatering licence is not required.

3.1.2 Embankment and Stability

As outlined above, the dam embankment will be constructed using a central impervious core of selected clayey material and an outer embankment shell.

The width of the clay core at surface level will be at least equal to the height of the embankment. The central core can be tapered with height but will not be reduced to less than 3 m, in line with the recommendations of the geotechnical report.

The upstream and downstream embankments outside of the clay core will be constructed using a variety of other soils. Appropriate slopes for the dam embankment are provided in the geotechnical report.

To reduce seepage from the dams cut-off trenches will be constructed at the base of the clay core. The trenches will extend at least 0.6 m into the underlying clays at dams 3A and 3D and will be at least 3 m wide, as per the geotechnical recommendation. At dam 2 the cut-off trench will extend at least 0.3 m into the underlying rock and be in the order of 0.5 – 1.0 m wide.

The central core and embankment shell are to be compacted to a minimum dry density of 95% using the standard compactive effort. The moisture content of the embankment should be within +2% of the optimum moisture content to reduce permeability.

3.1.3 Liner

The proposed dams 2 and 3D will be lined with bentonite to minimise losses. Dam 3A will be unlined to allow for potential interception of groundwater seepage. If losses in this dam are found to be too high and groundwater inputs are low, then this dam can be lined at a later stage.

3.2 Dam Sizing

3.2.1 Existing Catchment

3.2.1.1 Northern Gully

The catchment of the northern gully has been historically modified by human activities, primarily the construction of Firns Road and dams within the catchment. The catchment boundaries were determined through topographical catchment

delineation and a ground truthing exercise during a site visit in October 2015. While a portion of the original catchment to the north of Firns Road continues to discharge to the northern gully through a road culvert, the significant majority of the catchment is located within the property boundary (Figure 2).

3.2.1.2 Southern Gully

The current catchment of the proposed southern dam has been modified by the construction of Dam 1 which is located higher in the catchment and collects localised runoff. The current catchment boundary has been determined through topographical catchment delineation.

Approximately 79% of the catchment is located within the property boundary (Figure 2).

3.2.2 Water Balance Modelling

A hydrological assessment has been undertaken to determine appropriate sizing of the dams. A rainfall-runoff approach using a runoff coefficient was used. The assessment was undertaken using a daily timestep using measured rainfall and evaporation data over the last 5 years and provides daily dam and overflow volumes. The rainfall data was adjusted to account for climate change using the GFDLCM21 Dry Scenario to 2030 (Department of Water, 2015) to simulate a future dry scenario, in order to simulate "worse case" scenario impacts. Direct dam losses such as evaporation and infiltration were also included in the model.

The initial hydrological modelling used a runoff coefficient of 0.35 based on the 100% vegetative cover of the catchment which consists of a mixture of forest and long pastoral grasses, the variable catchment slope, and the low permeability catchment geology. Advice from DWER identified that the rainfall runoff coefficient was too high (Appendix B), so the modelling was revised to use 0.15 (on advice from DWER), resulting in reduced catchment runoff and a smaller dam capacity. The results presented below are following the DWER advice and recommendation for further investigation, which has now been undertaken.

The assessment included the expansion of the current catchments using agricultural techniques to maximise runoff harvesting. A summary of results from this assessment is provided in Table 7 below.

Table 7 Hydrological Assessment – Summary of Results

Gully	Dam	Modified Catchments (ha)	Average Annual Runoff (m^3)	Total dam capacity (kL)
Northern	3A – 3D	38.1	44,155	17,780*
Southern	2	20.3	23,527	11,000

*The total capacity of dams on the northern gully, including existing dams 3B and 3C. The combined capacity of the proposed new dams (3A and 3D) on this gully is 15,530 kL.

3.2.3 Flooding Assessment

An assessment was also undertaken to determine whether any flooding from the dam would cause water to flood across property boundaries. A preliminary assessment was undertaken to determine the extent of inundation based on embankment height and surrounding topographic elevation. The extent of inundation, before overtopping of the weird would occur, is shown in Figure 4.

This approach was put forward as part of an application for a *Permit to Interfere with Beds and Banks* and deemed to be acceptable to the DWER.

It is noted that the existing dams on the northern gully are considered by DWER to intercept some shallow groundwater/sub-surface through flow. The modelling undertaken does not include discharge to the dam from groundwater seepage.

3.3 Irrigation

The proponent intends to establish up to 20 hectare (ha) of commercial orchard within the property with the irrigation water supply coming from both new and existing dams (dam 1, 3B and 3C and the proposed dams 2, 3A and 3D). The variety of crop is yet to be confirmed, but for irrigation calculation purposes, walnut trees have been assumed.

The annual orchard water requirements are expected to range from approximately 3,000 – 5,000 kL per ha. The irrigation requirement will be highest during establishment and will decrease as the crop matures. The orchard size could therefore be staged dependant on water availability and water requirements of different ages of trees.

An annual irrigation rate of 4,000 kL per ha for 7 ha of orchard (total of 28,000kL/annum) has been assumed in the water balance calculations for the new proposed dams (dams 2, 3A and 3D).

4.0 OTHER CONSIDERATIONS

4.1 Clearing

The clearing of approximately 1.02 ha of native vegetation is required to facilitate construction of the dams. The vegetation largely consists of open marri-wandoo woodland over both native and exotic understory.

A Native Vegetation Clearing Permit (NVCP) application was submitted to the Department of Water and Environmental Regulation in August 2016. DWER conducted an assessment of the application and attended a site visit in September 2016.

The preliminary assessment found that the vegetation proposed to be cleared was mostly degraded with no conservation significant flora likely to be present. The clearing was assessed to be at variance to clearing principle (a) only. This principle regards which is required for the construction of dams.

The application was advertised in The West Australian newspaper on 29 August 2016 for a 7 day submission period and no submissions were received in relation to the application.

Liaison with the DWER following their assessment and site visit indicated their in-principle support provided the relevant approvals were received from other regulatory authorities within the timeframe specified (3 months), then the NVCP would be granted (*pers. comm.*, K. Wilkes, 22/09/2016). The relevant approvals cited were;

- DWER licences required under the RIWI Act 1986 – Now obtained (Appendix C).
- Shire of Serpentine Jarrahdale: Planning approval – DA application (this document).

At the time of the initial clearing permit application, the RIWI licences and planning approval had not been substantially progressed and it was not considered that a response/approval would be received within the specified timeframe. So following further liaison with the DWER officers, advice was given to withdraw the clearing application until the Development Approval had been substantially progressed. Advice provided from DWER (*pers. comm.*, K. Wilkes, 22/09/2016) was that the assessment/site visit would not need to be redone and the outcome would remain unchanged (ie. approval granted following receipt of other relevant approvals).

The clearing application and correspondence is provided in Appendix G.

COTERRA ENVIRONMENT

FIGURES

DAM 3B
DAM 3C
DAM ND1
SCRIVENER RD
FIRNS RD
NORTHERN WATERCOURSE
EASTERN WATERCOURSE
DAM ED2
DAM ND4
DAM ED1
SOUTHERN WATERCOURSE
DAM 1
DAM SD5
DAM SD7
LOT 2
75.2 HA
PA17/958

LEGEND
- Site Boundary
- Cadastre
- Contour (mAHD)
- Watercourse
- Existing Waterbody
- Existing Online Dam
- Proposed Dam Wall Earthworks Area

N
0 25 50 100 150 200 m
Scale: 1:5,000 @ A3
GDA 1994 MGA Zone 50

Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, 2017
Topography - Landgate, 2016

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Saraband Investments Pty Ltd
APPLICATION FOR DEVELOPMENT APPROVAL
FIRNS ROAD, SERPENTINE

SITE LOCATION

Figure 1

LEGEND
- Site Boundary
- Cadastre
- Contour (mAHD)
- Watercourse
- Existing Waterbody
- Existing Online Dam
- Future Dam
- Future Catchment
- Proposed Dam Wall Earthworks Area

N

0 25 50 100 150 200 m

Scale: 1:4,100 @ A3
GDA 1994 MGA Zone 50

SCRIVENER RD
FIRNS RD
DAM 3A
DAM 3B
DAM 3C
DAM 3D
DAM 1
DAM 2
EASTERN WATERCOURSE
LOT 2
75.2 HA
3000
1913
564
2272
304
2273
3
4
2
1
240
270
265
230
260
205
200
210
195
290
295
280
250
255
235
245
275
180
175
170
190
215
220
225

PAID

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Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, 2017
Topography - Landgate, 2016
Proposed Dams - Pritchard Francis, 23.06.17

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Saraband Investments Pty Ltd
APPLICATION FOR DEVELOPMENT APPROVAL
FIRNS ROAD, SERPENTINE

NORTHERN DAMS

Figure 2

LEGEND
- Site Boundary
- Cadastre
- Contour (mAHD)
- Watercourse
- Existing Waterbody
- Existing Online Dam
- Future Dam
- Future Catchment
- Proposed Dam Wall Earthworks Area

N

0 12.5 25 50 75 100 m

Scale: 1:3,000 @ A3
GDA 1994 MGA Zone 50

564
6
2
5
4
736
813
LOT 2
75.2 HA
SOUTHERN WATERCOURSE
DAM 2
DAM 1
DAM SD7
FIRNS RD
135
140
145
150
155
160
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170
175
180
185
190
195
200
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220
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230
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240
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250
255
260
265
270
275

PA17/958

Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, 2017
Topography - Landgate, 2016
Proposed Dams - Pritchard Francis, 23.06.17

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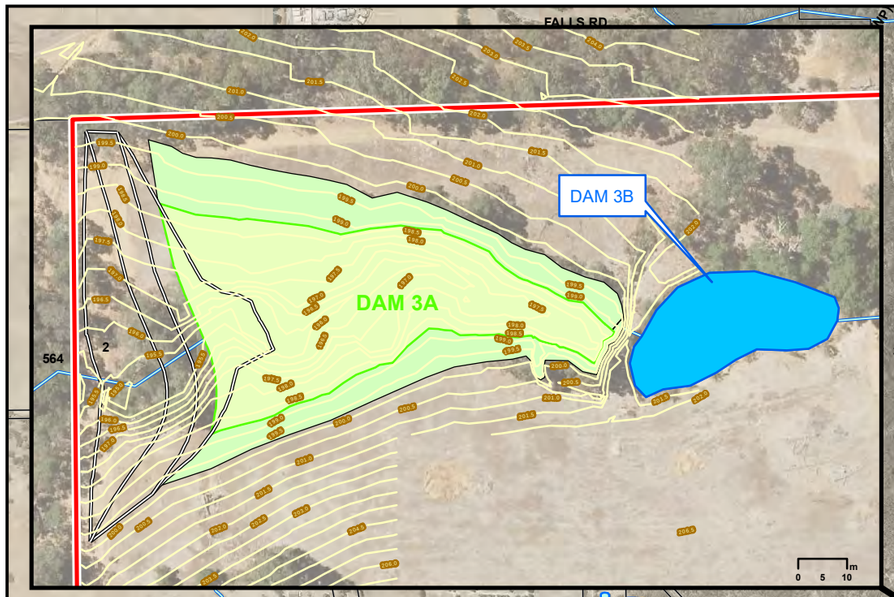
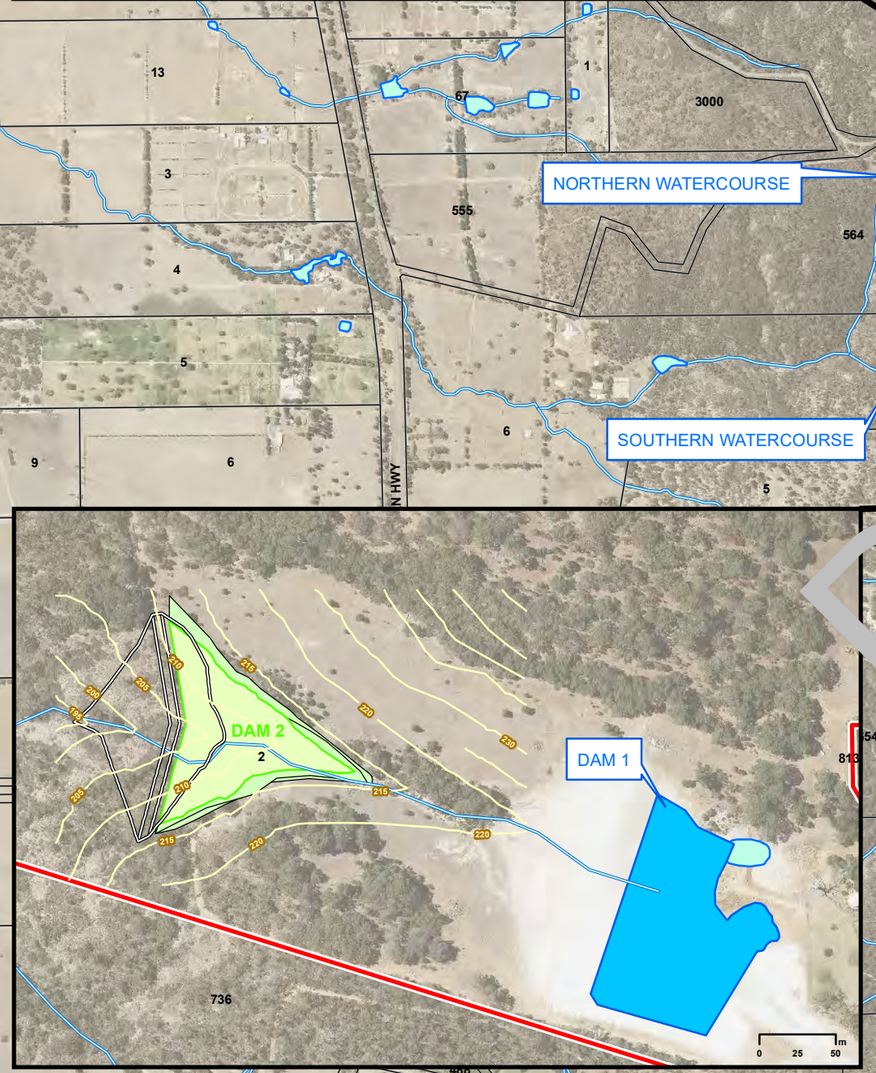
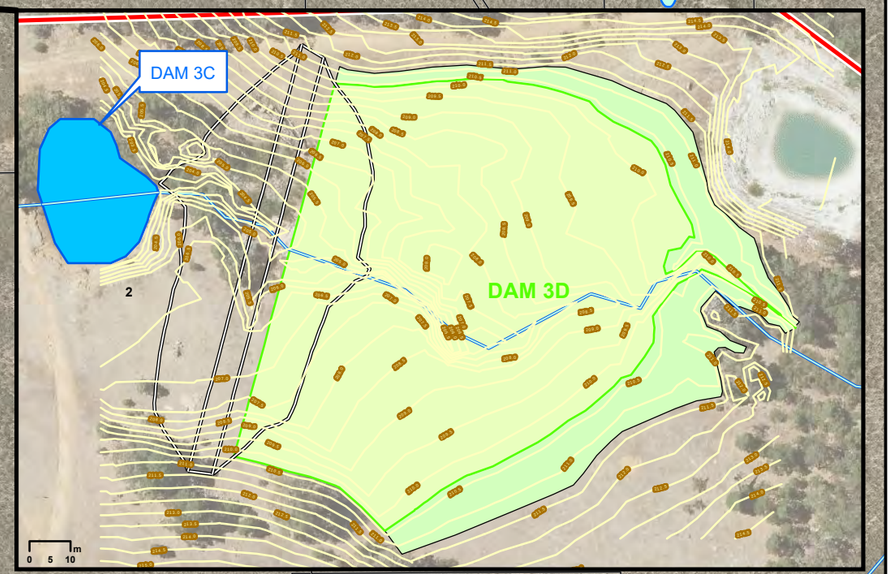
Saraband Investments Pty Ltd
APPLICATION FOR DEVELOPMENT APPROVAL
FIRNS ROAD, SERPENTINE

SOUTHERN DAM

Figure 3







LEGEND
- Site Boundary
- Cadastre
- Contour (mAHD)
- Watercourse
- Existing Waterbody
- Existing Online Dam
- Future Dam
- Area of Inundation
- Proposed Dam Wall Earthworks Area

N

0 100 200 400 600 800 m

Scale: 1:15,000 @ A3
GDA 1994 MGA Zone 50

FALLS RD
FIRNS RD
NORTHERN WATERCOURSE
SOUTHERN WATERCOURSE
EASTERN WATERCOURSE
LOT 2
75.2 HA
DAM 3B
DAM 3C
DAM 1

Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, 2017
Topography - Landgate, 2016
Proposed Dams - Pritchard Francis, 23.06.17

ENVIRONMAPS | t: 0406 590 006 | Environmental Mapping Solutions | www.environmaps.com.au

COTERRA ENVIRONMENT

Job: XYDSER01
Doc: 004
Date: 09.10.17
Ph: (08) 9381 5513
Fax: (08) 9381 5514
E: info@coterra.com.au

Saraband Investments Pty Ltd
APPLICATION FOR DEVELOPMENT APPROVAL
FIRNS ROAD, SERPENTINE

INUNDATION

Figure 4

COTERRA ENVIRONMENT

APPENDIX A – CERTIFICATE OF TITLE

214D
Perth Batch
L440239

WESTERN AUSTRALIA

REGISTER NUMBER	
2/D36434	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	8/11/2010

DUPLICATE CERTIFICATE OF TITLE

VOLUME 242 FOLIO 92A

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 2 ON DIAGRAM 36434

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

SARABAND INVESTMENTS PTY LTD OF LEVEL 1, 420 HAY ST[illegible] SUBIACO
(T L4[illegible]0239) REC[illegible]TERED 29 SEPTEMBER 2010

LIMITATIONS, INTERESTS, ENCUMBR[illegible]NCES AN[illegible]D NOTIFICATIONS:
(SECON[illegible] S[illegible]HED[illegible]LE)

Warning: A current search of the certificate of title held in elect[illegible]ic form should[illegible] obtained before dealing on this land.
Lot as described in the land description may be a lot [illegible] lo[illegible]tion.

----------END O[illegible] D[illegible]PLICAT[illegible] CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out b[illegible]ow are[illegible]ot inte[illegible]ded to be nor should they be relied on as substitutes for inspection of the land and the rel[illegible]nt docu[illegible]ents or [illegible]r local government, legal, surveying or other professional advice.

SKETCH OF LAND: [illegible]242-92A (2/D36434).
PREVIOUS TITLE: [illegible]147-768, 1147-936.
PROPERTY STREET ADDRESS: 206 FIRNS RD, SERPENTINE.
LOCAL GOVERNMENT AREA: SHIRE OF SERPENTINE-JARRAHDALE.

37.5 HA 75 HA 180 ACRES 5 HA

INDEXED BH

Transfer A184643
Volume 1147 Folio 936
1317 768

WESTERN AUSTRALIA

ORIGINAL REGISTER BOOK

VOL. 242 FOL. 92A

CT 0242 0092A F

Certificate of Title

UNDER THE "TRANSFER OF LAND ACT, 1893" AS AMENDED

Peter Bruce De Barran Cullen of 22 York Terrace, Mosman Park, Farmer and Solicitor, is now the proprietor of an estate in fee simple subject to the easements and encumbrances notified hereunder in all that piece of land delineated and coloured green on the map hereon containing one hundred and eighty-six acres and one perch or thereabouts, being Cockburn Sound Location 822 and portion of Cockburn Sound Location 636, together being Lot 2 the subject of Diagram 36434.

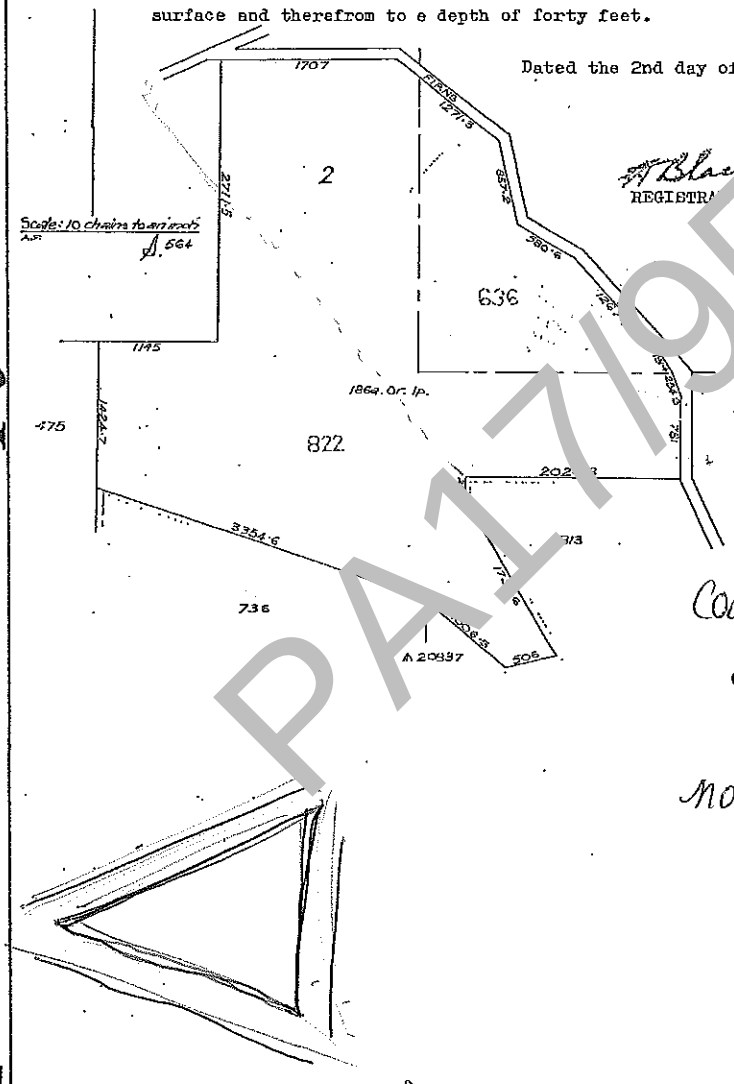
As to Cockburn Sound Location 822 only: Limited however to the natural surface and therefrom to e depth of forty feet.

Dated the 2nd day of July 1969

REGISTRAR OF TITLES

The correspondence address of the registered proprietor is Lot 2 Firns Road, Serpentine. By 941568. Dated 21st July 1992 at 9.18 hrs.

OFFICE OF TITLES Western Australia



Cockburn Sound Locanon
old locanon number.
636 / 822
now Lot 2 Diagram 36434.

PA17/958

For encumbrances and other matters affecting the land see back

APPENDIX B – DWER CORRESPONDENCE

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Your ref: ACC 7959
Our ref: RF14465
Enquiries: Carmel Sullivan

Saraband Investments Pty Ltd
PO Box 119
WEST PERTH, WA 6872
Attention: Harry Xydas

Dear Mr Xydas

Re: Application to take water / application for a perm[illegible]
Property: Lot 2 Firns Road, Serpentine.

The Department of Water refers to your appli[illegible]ns dated 31st May 2016 in which you applied for two licenses to take surface [illegible]ater [illegible]nd three permits to undertake works on the property above.

Under the *Rights in Water and Irrig[illegible]ation Act 1914* your proposed project does not require a licence under Section 5C, as th[illegible] watercourse flowing into the proposed new dam on the northern boun[illegible]y originates within the property boundary. In accordance with Section 5(1)(a) of [illegible]he *Rights in Water and Irrigation Act 1914* this does not constitute a wa[illegible] course u[illegible]il such time as it flows beyond the property boundary. The proposed dam [illegible]ill therefore not require a surface water licence to take 59,367kL per [illegible]um [illegible] irrigate 5.5 hectares of orchard.

The proposed ne[illegible] d[illegible]m on the southern boundary of the property does not require a surface water lice[illegible]ce as it meets the same requirements outlined above. A permit is still considered appropriate to facilitate the construction of both the northern and southern dams and will be assessed and issued in due course.

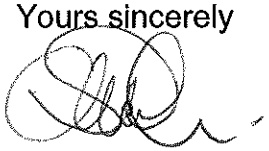
Please note that receipt of a permit does not absolve the licensee from responsibility for compliance with the requirements of all Commonwealth and State legislation, including the Local Government Authority.

Hydrological studies which have been undertaken by Coterra Environment in support of your application to take 80,375kL per annum to irrigate a total of 7.7 hectares of orchard, suggest that there is insufficient water available in the catchment for your requirements. Furthermore the methodology undertaken is not appropriate to determine daily runoff rates for a daily water balance assessment. As such the model does not reflect a realistic runoff from the catchment and the rainfall coefficient is too high. The Department of Water has provided our assessment to your consultant and advised them further investigation is recommended should the project continue in its current form.

Kwinana Peel Region
107 Breakwater Parade Mandurah Ocean Marina Mandurah Western Australia 6210
PO Box 261 Mandurah Western Australia 6210
Telephone (08) 9550 4222 Facsimile (08) 9581 4560
www.water.wa.gov.au

If you have any questions in relation to the above matter please do not hesitate to contact me on telephone 9550-4210.

Yours sincerely



Carmel Sullivan
A/ Program Manager – Water Licensing
Peel Region

February 7, 2017

CC: Rebecca Epworth, Coterra Environmental (email)

APPENDIX C – BEDS AND BANKS PERMIT

Government of **Western Australia**
Department of **Water**

looking after all our water needs

Your ref: PMB182964(1)
Our ref: RF14465
Enquiries: Carmel Sullivan
Tel: 9550-4210

Saraband Investments Pty Ltd
PO Box 119
WEST PERTH, WA 6872
Attention: Mr Harry Xydas

Dear Mr Xydas

Re: Issue of a permit under the *Rights in Water and Irrigation Act 1914*
Property*: Lot 2 Firns Rd, Serpentine*

Please find enclosed the following:

- Your permit to interfere with the bed and banks of a watercourse - PMB182964(1)
- A leaflet titled *Your permit*

Please take time to read these documents as they contain important information about your rights and responsibilities.

Please note this permit does not absolve the permit holder from responsibility for compliance with the requirements of all Commonwealth and State legislation.

You can now use online services to manage all of your licensing needs. Water Online provides the easiest, fastest and most efficient way to:

- Apply for a new licence or permit
- Apply to amend, renew or transfer an existing licence; and
- Manage your account details.

Register for Water Online at www.water.wa.gov.au by clicking on the Water Online Login icon.

The instructions for registering, checking your details and updating them where required can be found by selecting the Quick Reference Guides link on the water online home page.

Please check your details to ensure that they are correct. If they are not correct please contact the department's online business support unit on 1800 508 885 (select option 2).

Kwinana Peel Region
107 Breakwater Parade Mandurah Ocean Marina Mandurah Western Australia 6210
PO Box 332 Mandurah Western Australia 6210
Telephone (08) 9550 4222 Facsimile (08) 9581 4560
www.water.wa.gov.au

If you have any queries about this or any other water licensing matter please contact me on telephone 9550-4210.

Yours sincerely

Carmel Sullivan
A/ Program Manager – Water Licensing
Peel Region

28 March 2017

Cc: Rebecca Epworth, Coterra Environment (email)

File No: RF14465

Government of Western Australia
Department of Water

Instrument No. PMB182964(1)

PERMIT TO OBSTRUCT OR INTERFERE (S17)

Granted by the Minister under section 17 of the Rights in Water and Irrigation Act 1914

Permit Holder(s)	Saraband Investments Pty Ltd	
Description of Water Resource	Serpentine Hills Serpentine Hills	
Location of Water Source	Lot 2 On Diagram 36434 - Volume/Folio 242/92a - Lot 2 Firns Rd Serpentine	
Authorised Activities	**Activity**	**Location of Activity**
	Construct 3 dams	Lot 2 On Diagram 36434 - Volume/Folio 242/92a - Lot 2 Firns Rd Serpentine
Duration of Permit	From 28 March 2017 to 27 March 2019	

This Permit is subject to the following terms, conditions and restrictions:

1 The permit holder must undertake the works authorised by this permit with minimal disturbance to the watercourse.

2 The permit holder shall ensure that the dam does not act as an artificial barrier or levee, causing water to pond upstream.

End of terms, conditions and restrictions

This Permit is granted subject to the Rights in Water and Irrigation Regulations 2000

APPENDIX D – GEOTECHNICAL REPORT

Report on

GEOTECHNICAL STUDY
PROPOSED NEW DAMS
LOT 822 (206) FIRNS ROAD
SERPENTINE

Submitted to:
Pritchard Francis
PO Box 2150
SUBIACO WA 6904

www.galtgeo.com.au
4/15 Walters Drive,
OSBORNE PARK WA 6017
T: +61 (8) 6272-0200

J1701059 001 R Rev3

18 July 2017

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1. INTRODUCTION

This report presents Galt Geotechnics Pty Ltd (Galt's) results of a geotechnical study for the proposed new dams located on Lot 822 (206) Firns Road, Serpentine ("the site"). The location of Lot 822 relative to the surrounding area is shown on Figure 1, Site and Location Plan. The study was requested by of Pritchard Francis and authorised in an email from Demetra Xydas of Doric Group dated 9 March 2017.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the lot covers an area of approximately 75 ha. Three new dams are proposed, with two new dams, designated Dam 3A and Dam 3D, to be located adjacent the northern boundary and one dam, designated Dam 2 to be located adjacent to the southern boundary, downstream of an existing dam commonly referred to as the South Dam. Details of the dam sites are as follow:

Proposed Dam 2

A gully aligned in a general south east to north west direction runs through this dam site. The majority of the site is covered with medium dense spreads of mature trees. Rock outcrop is located downstream of the proposed dam site.

The proposed work is to comprise construction of a new dam with a crest level of RL 213.95 m AHD and a stored volume of 11,370 kL.

Proposed Dams 3A and 3D

A gully aligned in a general east to west direction runs through these dam sites. Trees line the banks of the gully however beyond the trees the ground surface is open and covered with surface grass. An existing turkey nest dam is present adjacent to and north east of the proposed upstream dam reservoir (Dam site 3D) and two ponds are present along the western part of the gully.

We understand that the two dams and two ponds are proposed across the gully adjacent to and along the north boundary of Lot 622. The proposed work is to comprise:

- Construction of a new dam in the north-west corner of Lot 622 (Dam 3A) with a crest level of RL 199.95 m AHD and a stored volume of 2,430 kL.
- Storage ponds immediately upstream of the new dam's reservoir with storage volumes of 415 kL and 350 kL and water surface areas of 921 m^2 and 816 m^2.
- Construction of a new dam immediately upstream of the proposed ponds (Dam 3D) with a crest level of RL 211.35 m AHD and a stored volume of 13,100 kL.

There is also a requirement to provide a drain to discharge water stored in the upstream dam (3D) into the downstream ponds.

General

The location of the proposed dams including the existing South Dam are shown on Figure 1, Site and Location Plan.

It is intended that borrow material will be obtained from within the area of the reservoirs.

The location of each of the dams is shown on Figure 2, Overall Site Plan. The extent of the proposed dam embankments are shown on Figure 3, Site Plan – Dam 2, Figure 4, Site Plan –Dams 3A and Figure 5, Site Plan - Dam 3D.

3. PROJECT OBJECTIVES

The objectives of the study were to:

- assess subsurface soil and groundwater conditions across the areas of the proposed new dam footprints;
- assess the suitability of the soils contained in the proposed reservoirs and ponds for use as embankment fill;
- provide recommendations and geotechnical design parameters for the proposed dams;
- recommend appropriate site preparation procedures including compaction criteria;
- a review of the current preliminary design; (not included in this draft report); and
- ultimate sign off on the design (not included in this draft report).

4. FIELDWORK

Fieldwork was conducted over the period of 4 to 6 April 2017 and comprised:

- a walkover survey of each of the dam sites and borrow areas;
- excavation of test pits at the following locations:

  Dam 2
  - TP21 to TP25, across the proposed location of the dam embankment, extending to depths ranging from 0.3 m to 3.0 m;
  - TP26 to TP36, across the area of the proposed reservoir including the potential borrow area, extending to depths ranging from 1.0 m and 3.0 m.

  Dam 3A
  - TP11 to TP14, across the proposed location of the dam embankment, extending to depths ranging from 1.8 m to 3.2 m;
  - TP15 to TP20, across the area of the proposed reservoir including the potential borrow area, extending to depths ranging from 0.8 m and 3.0 m;

  Dam 3D
  - TP01 to TP05 and TP10, across the proposed location of the dam embankment, extending to depths ranging from 3.0 m to 4.5 m;
  - TP06 to TP09, across the area of the proposed reservoir including the potential borrow area, extending to depths ranging from 1.2 m and 3.5 m;
- collection of representative soil samples.

Test locations were surveyed using a hand held GPS accurate to around 5 m in the horizontal plane. The approximate test locations are shown on Figure 2. Site photographs are presented in Appendix A, Site Photographs. A summary of ground conditions is presented in Table 1 (Dam 2), Table 2 (Dam 3A) and Table 3 (Dam 3D).

Table 1: Summary of Ground Conditions – Dam 2

Test Name	Test Area	Test Depth (m)/ Reason for Termination[1]	Groundwater Depth (m)[2,3]	Superficial Soil (Unsuitable for Embankment Fill)		Depth to Foundation/Suitable Embankment Fill (m)
				Type[3]	Thickness (m)	
TP21	Embankment	0.3 R	NE	Gravelly Silty SAND	0.3	0.3
TP22	Embankment	0.4 R	NE	Silty Gravelly SAND	0.4	0.4
TP23	Embankment	3.5 SE	NE	Silty SAND	0.6	1.5
TP24	Borrow	1.6 R	NE	Silty SAND	0.2	0.2
TP25	Embankment	3.0 SE	NE	Silty SAND	0.2	0.8
TP26	Borrow	1.5 SE	NE	Silty SAND	0.2	0.2
TP27	Borrow	1.5 SE	NE	Silty SAND/Gravelly Silty SAND	0.3	0.3
TP28	Borrow	3.0 T	2.8	None	0.0	0.2
TP29	Borrow	2.5 T	NE	Silty SAND	0.2	0.0
TP30	Borrow	1.0 R	NE	Silty SAND	0.1	1.0
TB31	Borrow	1.4 R	NE	Silty SAND	0.2	0.2
TP32	Borrow	3.0 T	2.2	Silty SAND	0.4	0.4
TP33	Borrow	1.2 R	NE	Silty SAND	0.1	0.1
TP34	Borrow	3.0 T	NE	Silty Gravelly SAND	0.5	0.5
TP35	Borrow	2.5 T	NE	Silty SAND	0.4	0.4
TP36	Borrow	2.8 T	NE	Silty SAND	0.4	0.4

NOTES: 1. T – Target Depth, R – Refusal, SE – Slow Excavation

2. Depth to groundwater is where groundwater was observed during test pit excavation (as inflow into the pit). True groundwater is expected to be near the top of the clayey soil contact and is likely to be higher than the depths indicated as the test pits could not be left open long enough to fill up and establish the true groundwater level.

3. NE – not encountered

Table 2: Summary of Ground Conditions – Dam 3A

Test Name	Test Area	Test Depth(m)/ Reason for Termination[1]	Groundwater Depth (m)[2,3]	Superficial Soil (Unsuitable for Embankment Fill)		Depth to Foundation/Suitable Embankment Fill (m)
				Type[3]	Thickness (m)	
TP11	Embankment	2.0 SE	NE	Silty SAND	0.2	0.2
TP12	Embankment	2.0 SE	NE	Silty SAND/SAND	0.8	0.8
TP13	Embankment	1.8 SE	NE	Silty/Gravelly SAND	0.6	0.6
TP14	Borrow	3.2 T	NE	Silty SAND	0.1	0.1
TP15	Borrow	2.2 SE	NE	Silty SAND	0.2	0.2
TP16	Borrow	2.5 T	NE	Silty SAND	0.1	0.1
TP17	Borrow	3.0 T	NE	Silty SAND	0.1	0.1
TP18	Borrow	3.0 T	NE	Silty SAND	0.1	0.1
TP19	Borrow	0.8 R	NE	Silty/Gravelly SAND/GRAVEL	0.8	0.8
TP20	Borrow	1.6 R	NE	Silty SAND	0.1	0.1

NOTES: 1 to 4. As per Table 1.

Table 3: Summary of Ground Conditions – Dam 3D

Test Name	Test Area	Test Depth (m)/ Reason for Termination[1]	Groundwater Depth (m)[2,3]	Superficial Soil (Unsuitable for Embankment Fill)		Depth to Foundation/ Suitable Embankment Fill (m)
				Type[3]	Thickness (m)	
TP01	Embankment	4.5 T	4.4	Silty SAND	0.2	0.2
TP02	Embankment	4.5 T	NE	Silty/Gravelly SAND	1.5	1.5
TP03	Embankment	4.5 T	3.8	Silty/Gravelly SAND	1.4	1.4
TP04	Embankment	4.5 T	1.1	Silty SAND	0.1	1.9
TP05	Embankment	4.5 T	NE	Silty SAND	0.1	1.0
TP06	Borrow	3.5 T	NE	Silty SAND	0.2	0.2
TP07	Borrow	1.2 R	NE	Silty SAND/SAND	1.2	None
TP08	Borrow	3.0 T	NE	Silty SAND	0.1	0.1
TP09	Borrow	3.0 T	NE	Silty SAND/SAND	0.6	0.6
TP10	Borrow	3.0 T	NE	Silty/Gravelly SAND	0.1	0.1

NOTES: 1 to 4. As per Table 1.

Test pits were excavated using a John Deere 8 tonne backhoe equipped with a 600 mm toothed bucket. Test pit reports for Dam 2 along with a list of notes, abbreviations and the method of soil description used on the reports are presented in Appendix B, Test Pit Reports – Dam 2. Test pit reports for Dams 3A and 3 D are presented in Appendix C, Test Pit Reports – Dam 3A and Appendix D, Test Pit Reports – Dam 3D. The same list of notes, abbreviations and the method of soil description used on the test reports for Dam 2 were used on the reports for Dams 3A and 3D. Included at the end of each test pit report is a photograph of the open pit and the spoil removed from the pit.

A senior geotechnical engineer and design geotechnical engineer from Galt conducted the site walkover survey of the proposed dams, including the areas of the proposed reservoirs and borrow areas.

A design geotechnical engineer from Galt positioned the test locations, observed the test pitting, logged the materials encountered in the test pits and collected samples for inspection and possible laboratory testing.

5. LABORATORY TESTING

Laboratory testing on soil samples was conducted by Liquid Labs WA and E-Precision Laboratory in their NATA accredited laboratories. The testing comprised determination of:

- particle size distribution on 10 samples;
- Atterberg limits and linear shrinkage on 10 samples;
- moisture content on 10 samples;
- dry density – moisture content relationship using standard compactive effort on 7 samples;
- Emerson class number on 10 samples; and
- Multistage saturated undrained shear strength with pore water pressure measurements on 1 sample remoulded to 95% SMDD at OMC.

Laboratory test results along with the test methods followed are presented in Appendix C, Laboratory Test Results and are summarised in Table 4: Summary of Laboratory Test Results and Table 5: Results of Triaxial Test.

Table 4: Summary of Laboratory Test Results

Dam	Test Pit	Sample Depth (m)	USC	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PI (%)	LS (%)	MC (%)	SMDD (t/m³)	OMC (%)	Emerson Class Number
3D	TP04	4.0-4.4	CH	0	11	89	89	63	19.0	62.8	-	-	2
3D	TP06	0.6-1.0	GC	67	17	16	44	21	7.0	15.5	1.75	20.0	5
3D	TP08	1.4-1.8	GC	50	24	26	53	25	6.0	17.7	1.79	16.0	5
3A	TP14	1.0-1.4	GC	41	26	33	61	29	11.0	18.5	1.74	19.9	6
3A	TP18	0.4-0.6	GP/GC	75	16	9	39	18	6.5	12.1	2.07	12.8	5
3A	TP20	0.6-0.8	CH/SC	6	44	50	58	42	10.0	16.0	-	-	5
2	TP25	2.0-2.5	CH	4	22	74	87	59	18.0	42.8	-	-	5
2	TP28	0.8-1.0	SC	2	66	32	27	12	5.0	14.8	1.84	13.3	5
2	TP32	1.4-1.8	SC	0	53	47	37	20	7.0	16.6	1.81	14.5	5
2	TP36	2.0-2.4	CH	1	37	62	61	28	10.5	[illegible]5	1.51	23.5	6

Notes: USC Unified soils classification LL: Liquid Limit [illegible] Plastic Index
LS: Linear Shrinkage MC Moistur[illegible] Content
SMDD: Standard maximum dry density OMC: Opti[illegible]m m[illegible]re c[illegible]ent

Table 5: Results o[illegible]rial Test

Dam	Test Pit	Sample Depth (m)	USC	Remoulded Conditions		Cont[illegible]ing [illegible]ssur[illegible] (kPa)			Coefficient of Consolidation (m²/year)	Effective Strength Parameters	
				DD (t/m³)	MC (%)	Sta[illegible]e 1	[illegible]tage 2	Stage 3		C' (kPa)	Ø' (Degrees)
2	TP32	1.4 – 1.8	SC	1.72	[illegible]6	75	150	300	98	11	24

Note: Failure Criteria – Peak Principal Stress Ratio Strain Rate 0.0055 mm/min DD Dry density
c'' effective cohesion ø effective angle of shear resistance

6. SITE CONDITIONS

6.1 Geology

The Serpentine sheet of the [illegible]0,000 scale Environmental Geology series map indicates that the area is underlain by either:

- CLAYEY SANDY SILT – *fine to medium-grained angular quartz / feldspar sand, moderate cohesion, of alluvial origin*; and/or
- GRAVEL – *loose, fine (less than 19 mm) red-brown to black, pisolitic, moderately sorted, highly variable angular sand content, of colluvial origin;* and / or
- LATERITE – *massive and vuggy to cemented pisolites up to 4 m thick, associated loose residual sandy pisolite gravel, of residual origin.*

The findings of the site investigation are consistent with the geological mapping.

6.2 Subsurface Conditions

6.2.1 Dam 2

Dam 2 Embankment – TP21 to TP25

The typical subsurface conditions encountered at Dam 2 may be summarised as:

Northern Abutment (TP21 & TP22):

- Gravelly/Silty SAND (SP/SM), fine to medium grained, brown, with some clayey fines, fragments of slightly to moderately weathered rock, present to the depth of refusal of 0.3 m to 0.4 m.

Southern Abutment (TP23):

- TOPSOIL: Silty SAND (SM), fine to medium grained, brown, trace grave, extending from the surface to a depth of 0.1 m; overlying
- Silty SAND/Clayey SAND (SM/SC), fine to medium grained, brown, trace gravel, low to medium plasticity fines, extending to a depth of 0.6 m; overlying
- Sandy CLAY/Clayey SAND (SC/CI), medium to high plasticity, dark brown, trace gravel, extending to a depth of 1.1 m; overlying
- Sandy GRAVEL/Clayey GRAVEL (GP/GC), fine to medium grained, low to medium plasticity fines, pale grey/brown/orange, with fragments of slightly to moderately weathered roc, extending to a depth of 1.5 m.

There are variations to the above, the most significant of which is the high plasticity CLAY below the Sandy CLAY in the centre of the valley of the dam (TP25). The material was recovered as dark grey CLAY with rock fragments.

Reservoir and Borrow Area – TP26 to TP36

The subsurface conditions encountered across the reservoir including the borrow area are relatively consistent. The typical soil profile in this area may be summarised as:

- TOPSOIL: Silty SAND (SM), fine to medium grained, brown, trace gravel, extending from the ground surface to depths ranging from 0.1 m to 0.2 m; overlying
- Silty SAND/Clayey SAND (SM/SC), fine to medium grained, brown, trace gravel, low to medium plasticity fines, extending to depths ranging from 0.2 m to 1.2 m; overlying
- Sandy CLAY (CI/CH) and CLAY/Sandy CLAY/Clayey SAND (CI/CH/SC), medium to high plasticity, brown/grey/orange, completely to highly weathered rock, extending to the maximum depth investigated of 3.0 m.

6.2.2 Dam 3A

Dam 3A Embankment – TP11 to TP14

The typical subsurface conditions encountered at Dam 3A may be summarised as:

- TOPSOIL: Silty SAND (SM), fine to medium grained, brown, trace gravel, extending from the ground surface to depths ranging from 0.1 m to 0.2 m; overlying
- Clayey SAND (SC), Clayey GRAVEL (GC), Clayey SAND/Gravelly SAND (SC/SP), fine to medium grained, low to medium plasticity fines, brown, extending to depths ranging from 1.4 m to 2.2 m; overlying
- CLAY/Sandy CLAY (CI/CH), medium to high plasticity, fine to medium grained sand, with some gravel, grey/brown/dark red, with clasts of Sandy CLAY, extending to the maximum depth investigated of 3.2 m.

Reservoir and Borrow Area – TP15 to TP20

The subsurface conditions encountered across the reservoir including the borrow area are relatively consistent. The typical soil profile in this area may be summarised as:

- TOPSOIL: Silty SAND (SM), fine to medium grained, brown, trace gravel, extending from the ground surface to depths ranging from 0.1 m to 0.2 m; overlying
- Clayey GRAVEL/Clayey SAND (GC/SC), fine to medium grained, brown, low to medium plasticity fine, extending to depths ranging from 0.5 m to 1.2 m; overlying
- Clayey SAND (SC), fine to medium grained, low to medium plasticity fines, with some gravel, brown/pale brown/pale grey, extending to depths ranging from 0.7 m to 2.0 m; overlying
- Sandy CLAY/CLAY (CI/CH), medium to high plasticity, brown/grey/dark red, trace gravel, completely weathered rock, extending to the maximum depth investigated of 3.0 m.

6.2.3 Dam 3D

Dam 3D Embankment – TP01 to TP05 and TP10

The typical subsurface conditions encountered at Dam 3D may be summarised as:

- TOPSOIL: Silty SAND (SM), fine to medium grained, brown, trace gravel, extending from the ground surface to depths ranging from 0.1 m to 0.2 m; overlying
- Gravelly SAND (SP), fine to coarse grained, brown, with some clayey fines, extending to depths ranging from 0.6 m to 1.5 m; overlying
- Clayey SAND/Sandy CLAY (SC/CI/CH), fine to medium grained, medium to high plasticity, pale grey/brown, extending to depths ranging from 2.6 m to 4.0 m; overlying
- CLAY/Sandy CLAY/Clayey SAND (SC/CI/CH/SC), medium to high plasticity, fine to medium grained, with some gravel, pale grey/brown/pale brown with pieces of rock fragments, completely to moderately weathered rock, extending to the maximum depth investigated of 4.5 m.

Reservoir and Borrow Area – TP06 to TP

The subsurface conditions encountered across the reservoir including the borrow area are relatively consistent. The typical soil profile in this area may be summarised as:

- TOPSOIL: Silty SAND (SM), fine to medium grained, brown, trace gravel, extending from the ground surface to depths ranging from 0.1 m to 0.2 m; overlying
- Clayey SAND/SAND (SC/SP), fine to medium grained, brown, with some gravel, low to medium plasticity fines, extending to depths ranging from 0.6 m to 1.2 m; overlying
- Clayey SAND/Clayey GRAVEL/Sandy CLAY (SC/GC/CI), fine to medium grained, low to medium plasticity fines, brown/pale grey, extending to depths ranging from 2.2 m to 2.5 m; overlying
- Sandy CLAY/CLAY (CI/CH), medium to high plasticity, pale grey mottled brown, completely to highly weathered, extending to the maximum depth investigated of 3.5 m.

6.3 Groundwater

Groundwater was encountered as seepage in the following test pits:

- Dam 2 – TP28 at 2.8 m and TP32 at 2.2 m.
- Dam 3A – Groundwater not encountered to the maximum depth investigated of 3.2 m.
- Dam 3D – TP01 at 4.4 m, TP03 at 3.8 m and TP04 at 1.1 m.

The groundwater encountered at Dam 2 was encountered in the reservoir and upstream area adjacent to the gully whereas groundwater encountered at Dam 3D was encountered below the proposed footprint of the embankment.

7. GEOTECHNICAL ASSESSMENT

7.1 Embankment Foundations

7.1.1 Dam 2

The foundation of the proposed dam should be readily supported by the rock which is exposed or very close to the surface over the area of the northern (right) abutment and at shallow depth over the southern (left) abutment. Notwithstanding the presence of shallow rock below the abutments, it was not encountered to the investigated depth of 3 m within the base of the valley. Foundation preparation within the base of the valley will need to address the presence of the soil rather than rock within the base of the valley. It will also be necessary to excavate a cut-off trench extending to the rock on the abutments and into the stiff clayey soils in the base of the valley.

Geotechnical sections along the valley of the gully and along the centreline of the proposed embankment are presented on Figure 5, Geotechnical Sections Dam 2 -2 - A and 2 – B.

The interpreted depth to a competent foundation encountered in the test pits is presented in Table 1.

7.1.1 Dams 3A and 3D

The foundation of both of these proposed dams should readily support the earthfill embankments without undue distress. However, consideration needs to be given to limiting seepage through the foundation soils. It is essential that sandy and gravelly lateritic soils overlying the completely weathered rock be removed from below the central low permeability core. To this end it is essential that a cut off trench be extended into the *in situ* clayey soils below the level of the central low permeability core. The depth of this trench will be dependent on the condition of the completely weathered *in situ* material which has numerous remnant joints and other imperfections. The final base level of the cut off trench is best determined once the trench is excavated.

Geotechnical sections along the valley of the gully and along the centreline of the proposed embankment are presented on:

- Dam 3A:
  - Figure 6, Geotechnical Sections Dam 3A - 3A – A and 3A – B.
- Dam 3D:
  - Figure 7, Geotechnical Sections Dam 3D - 3D – A and 3D - B

The interpreted depths to a competent clayey foundation encountered in the test pits are presented in Table 2 (Dam 3A) and Table 3 (Dam 3D).

7.2 Borrow Materials

7.2.1 Dam 2

Figure 3 shows the approximate extent of the borrow areas upstream of the dam footprint that was investigated and found to contain soils which we consider are suitable for use in the dam embankment (embankment earth fill and embankment shell fill). In summary, the thickness of suitable material that can be readily won for use varies considerably within the upstream area of the dam as shown in Table 1. In general, the thickness of the material

reduces as you proceed upslope of the gully. It should be noted that the borrow areas are likely to extend beyond the area of the reservoir.

The surficial non cohesive sandy and gravelly soils are not suitable for the central low permeability core but are likely to be suitable for use in the upstream and downstream shells of the embankment.

The soils considered suitable for use in the central embankment earthfill (low permeability core) comprise clayey sand, sandy clay, clay and clayey gravel. These materials are also suitable for the upstream and downstream earthfill shells of the embankment.

It should be noted that the clayey soils suitable for use in the embankment earthfill are often interbedded with or above layers of sandy soils. There are also locations within the borrow area that contain granular soils through much of the soil profile. In light of this, due care must be exercised in winning materials for use in the central core.

Geotechnical sections through the borrow areas are presented in Figure 7: Geotechnical Sections Dam 2 - 2 – C and 2 – D.

7.2.1 Dams 3A and 3D

Suitable soils for use in the low permeability core zone and for the upstream and downstream shells of the embankments are present in the upstream area of the proposed reservoirs. The approximate area of suitable borrow materials is shown on Figure 3. Given the similarity of the surficial subsurface conditions encountered across the sites, including below the proposed footprints of the dam embankment, suitable material for use in the embankment is likely to be present over most of the reservoir areas and upstream of the reservoirs. The depths of suitable material are shown in Table 2 (Dam 3A) and Table 3 (Dam 3D).

The surficial non cohesive sandy and gravelly soils are not suitable for the embankment earthfill but are likely to be suitable for use in the upstream and downstream shells of the embankment.

The clayey gravels and underlying completely weathered granitic material (recovered as clayey sand, sandy clay and clay) are considered suitable for use in the central low permeability core. These materials are also suitable for the upstream and downstream shells of the embankment.

The interpreted depths of soil considered suitable for use as embankment fill encountered in the test pits are presented in Table 2 (Dam 3A) and Table 3 (Dams 3A and 3D).

Any shortfall in embankment material should be able to be won from upslope of the reservoir or further upstream.

Geotechnical sections through the borrow areas of dams 3A and 3D are presented in Figure 9: Geotechnical Sections Dam 3A - 3A – C and 3A – D and Figure 11: Geotechnical Sections Dam 3D - 3D – C and 3D – D.

7.3 Embankments and Stability

The dams are to be built across gullys and these types of dams are commonly referred to as gully (embankment) dams. Given the variation in plasticity of the soils present in the proposed borrow areas the most appropriate dam embankments would be zoned embankments with a central impervious core of selected clayey material. The upstream and downstream shells of the embankments can therefore be constructed using a variety of materials including both non-cohesive and cohesive soils. This will ensure that almost all the soils excavated from below the embankments and in the reservoirs and borrow areas are able to be re-used.

The central cores of the dams will need to be keyed into the foundation to form a cut-off to reduce seepage. Cut-offs should extend to a depth of at least 0.6 m into the underlying clays (Dams 3A and 3D) and at least 0.3 m into the rock

(Dam 2) or as directed by the Engineer. The base of the cut-off trenches for Dams 3A and 3D should be at least 3.0 m wide. The width of the cut-off below Dam 2 will only need to be in the order of 0.5 m to 1.0 m wide.

The width of the central core at ground surface level (not including depth of cut-off) should be at least equal to the height of the embankment above natural ground surface. The width of the central core can be tapered with height in the dam embankment however it should not be reduced to less than 3 m.

For preliminary design, we recommend the slopes presented in Table 5: Preliminary Slopes for Dams:

Table 5: Preliminary Slopes for Dams

Height of Dam (m)	Shell	Slope (horizontal to vertical)
Up to 3	Upstream	2.5:1
	Downstream	2:1
3 to 6	Upstream	2.5:1
	Downstream	2.5:1
6 to 10	Upstream	3:1
	Downstream	3:1

The stability of the proposed embankment sections of the dams will need to be checked using both total and effective stress methods for the following conditions:

- Rapid drawdown – effective stress analysis.
- Steady seepage – effective stress analysis.
- End of construction – effective stress and total stress analysis.

7.4 Construction Procedures

Constructions procedures have been prepared for the project and are presented in Appendix F, Construction Procedures. Seven sections have been prepared, namely:

- Clearing, Grubbing and Stripping.
- Borrow Area Development.
- Excavation Requirements.
- Foundation Treatment.
- Earthfill.
- Erosion, Sediment & Pollution Control.
- Diversion and Dewatering.

The main things to note that have been incorporated in these sections are:

- The embankment earthfill (central low permeability core) and earthfill shells of the embankments are to be compacted to a minimum dry density ratio of 95% using Standard compactive effort.
- The range of moisture contents at which the embankment earthfill is required to be placed is relatively narrow from close to optimum moisture content (OMC) to +2% OMC. This is intended to reduce permeability.

8. CLOSURE

We would like to draw your attention to Appendix G of this report, "Understanding your Geotechnical Engineering Report". The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

Yours Faithfully,

GALT GEOTECHNICS PTY LTD

Fred Davenport CPEng

Geotechnical Engineer

Blake Lu[illegible]

Geotechn[illegible]l Engi[illegible]eer

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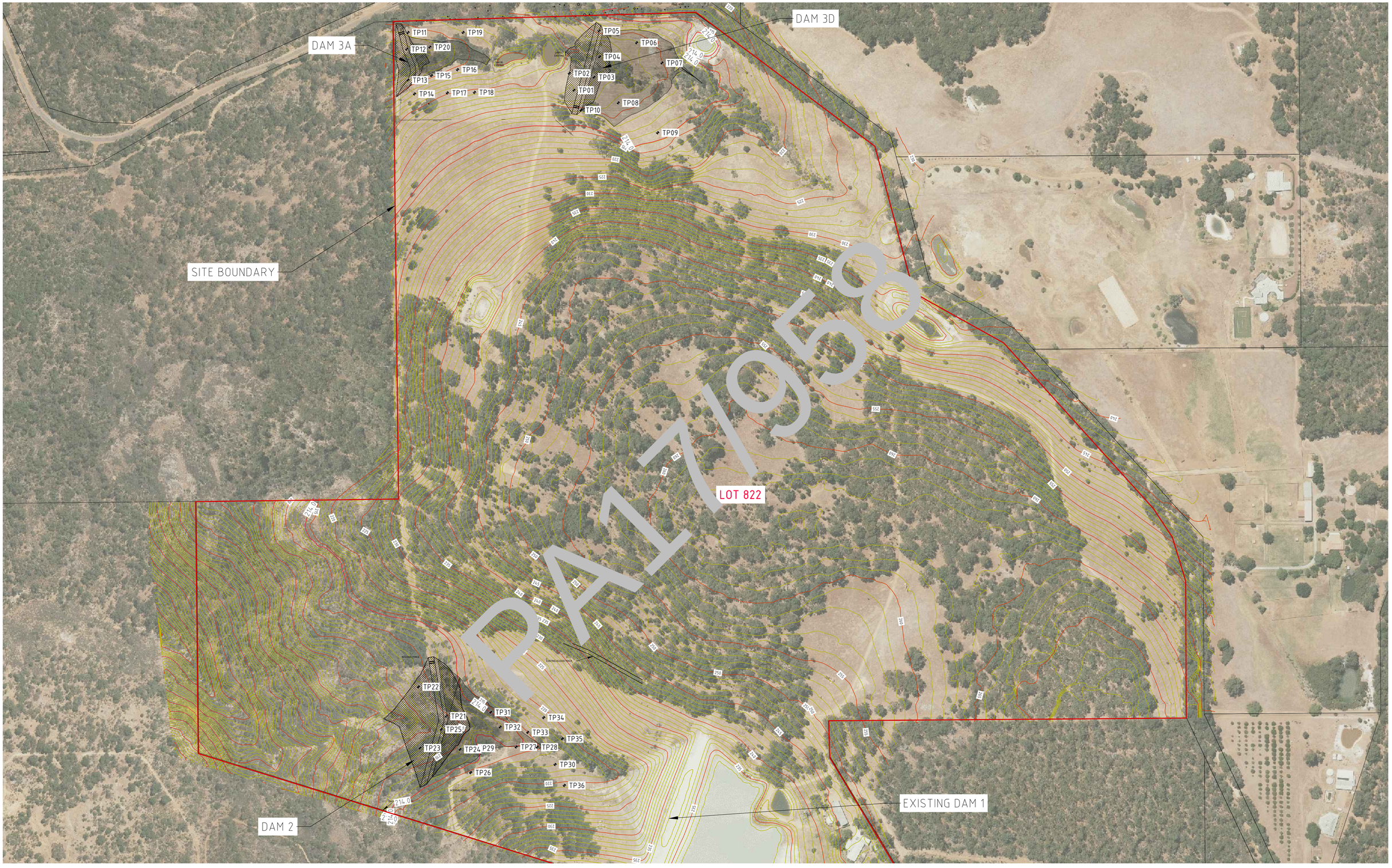

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CLIENT	PRITCHARD FRANCIS
PROJECT	PROPOSED NEW DAMS
LOCATION	LOT 822 FIRNS ROAD SERPENTINE
TITLE	OVERALL SITE PLAN
JOB NO.	J1701059
FIGURE	FIGURE 002

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CLIENT: PRITCHARD FRANCIS
PROJECT: PROPOSED NEW DAMS
LOCATION: LOT 822 FIRNS ROAD SERPENTINE
TITLE: SITE PLAN - DAM 2
JOB NO.: J1701059
FIGURE: FIGURE 3

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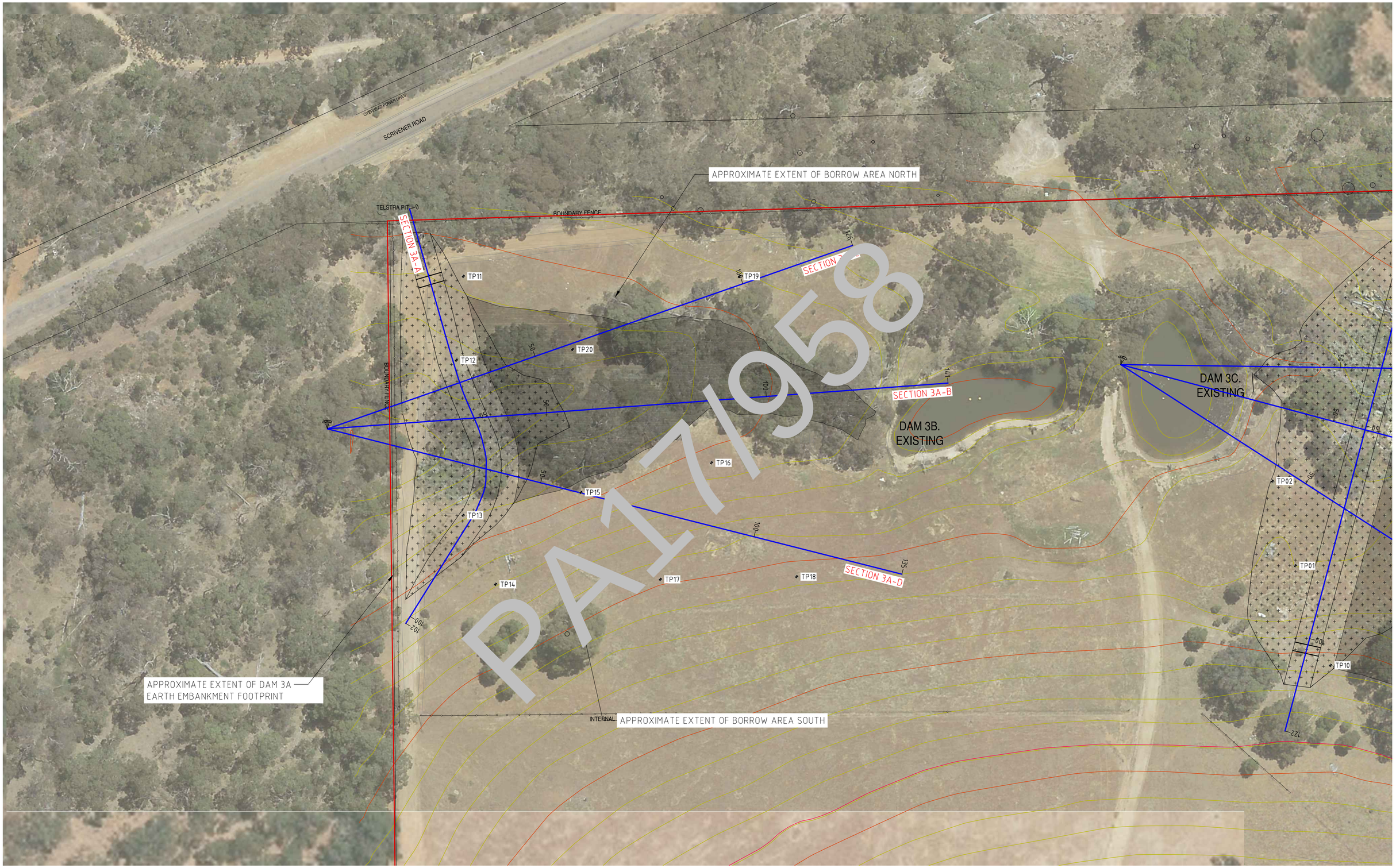

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CLIENT	PRITCHARD FRANCIS
PROJECT	PROPOSED NEW DAMS
LOCATION	LOT 822 FIRNS ROAD SERPENTINE
TITLE	SITE PLAN - DAM 3A
JOB NO.	J1701059
FIGURE	FIGURE 4

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CLIENT: PRITCHARD FRANCIS
PROJECT: PROPOSED NEW DAMS
LOCATION: LOT 822 FIRNS ROAD SERPENTINE
TITLE: SITE PLAN - DAM 3D
JOB NO.: J1701059
FIGURE: FIGURE 5

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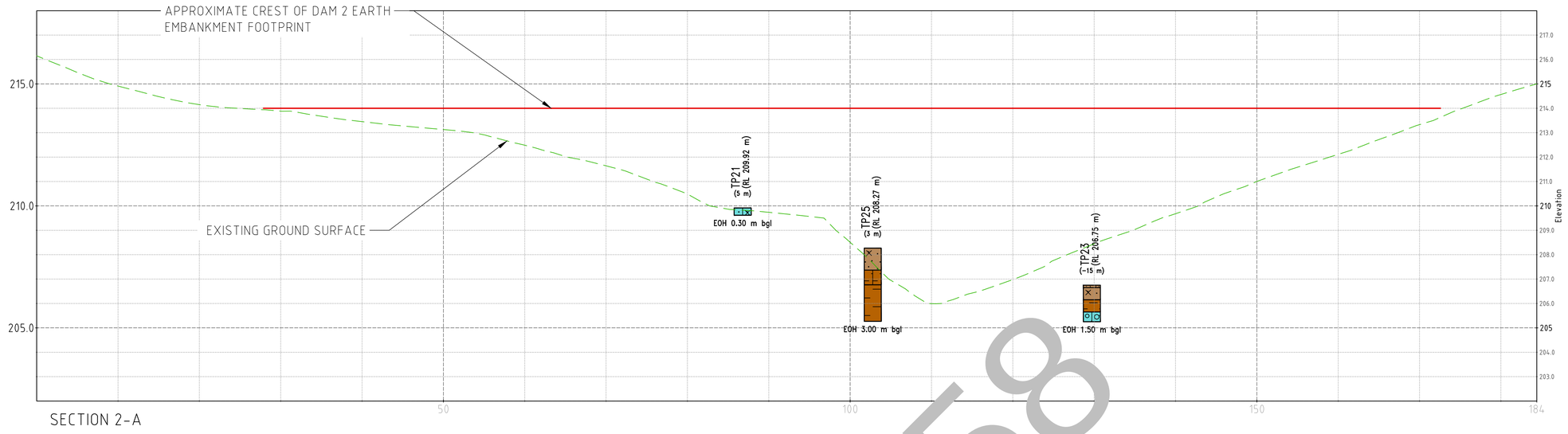
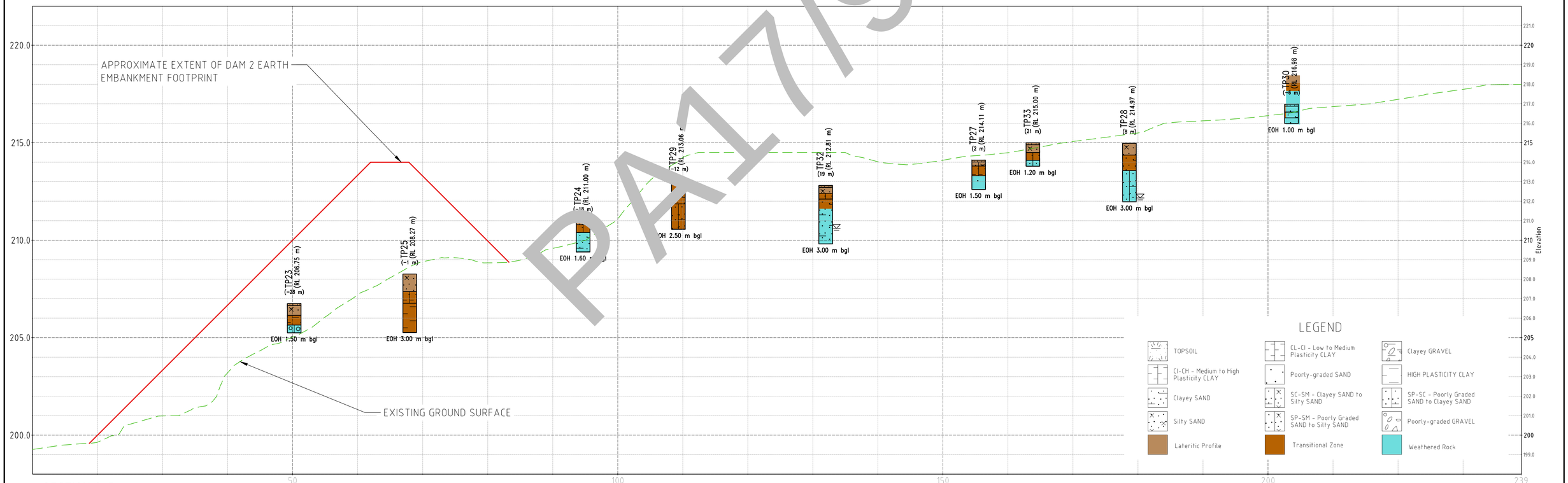


SECTION 2-A



SECTION 2-B

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CLIENT PRITCHARD FRANCIS
PROJECT PROPOSED NEW DAMS
LOCATION LOT 822 FIRNS ROAD SERPENTINE
TITLE DAM 2 GEOTECHNICAL SECTIONS 2-A & 2-B
JOB NO. J1701059
FIGURE FIGURE 6

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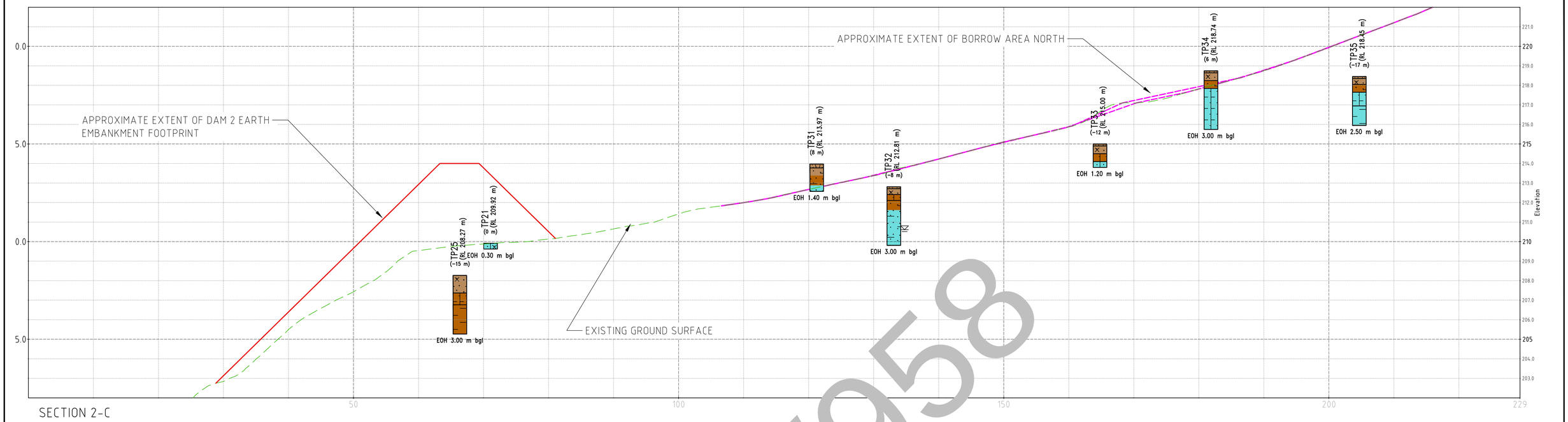

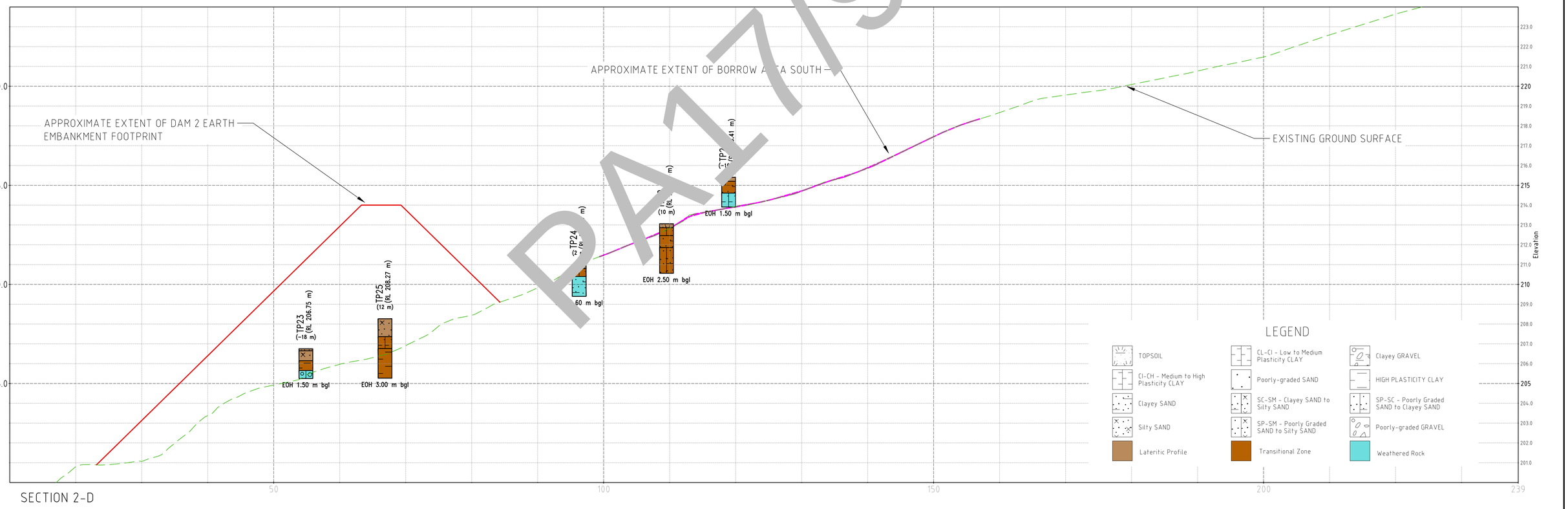

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CLIENT	PRITCHARD FRANCIS
PROJECT	PROPOSED NEW DAMS
LOCATION	LOT 822 FIRNS ROAD SERPENTINE
TITLE	DAM 2 GEOTECHNICAL SECTIONS 2-C & 2-D
JOB NO.	J1701059
FIGURE	FIGURE 7

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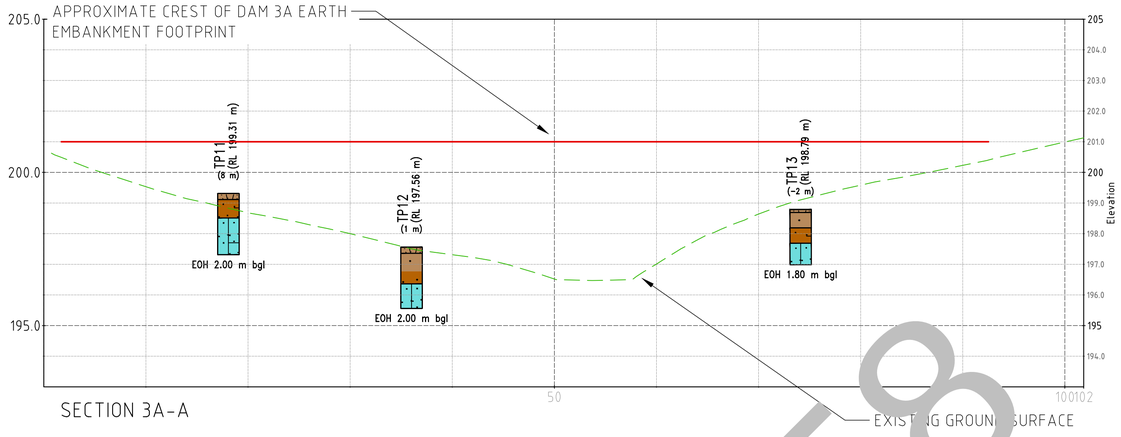
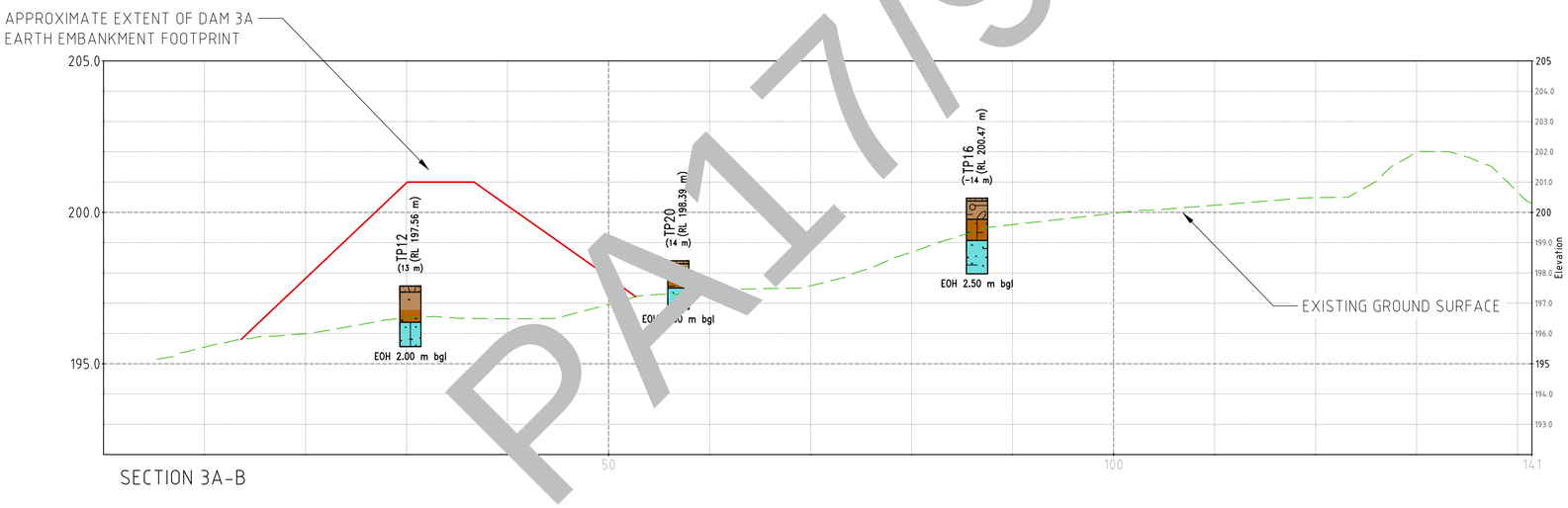


SECTION 3A-A

LEGEND

- TOPSOIL
- CI-CH - Medium to High Plasticity CLAY
- Clayey SAND
- Silty SAND
- Lateritic Profile
- CL-CI - Low to Medium Plasticity CLAY
- Poorly-graded SAND
- SC-SM - Clayey SAND to Silty SAND
- SP-SM - Poorly Graded SAND to Silty SAND
- Transitional Zone
- Clayey GRAVEL
- HIGH PLASTICITY CLAY
- SP-SC - Poorly Graded SAND to Clayey SAND
- Poorly-graded GRAVEL
- Weathered Rock



SECTION 3A-B

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CLIENT PRITCHARD FRANCIS
PROJECT PROPOSED NEW DAMS
LOCATION LOT 822 FIRNS ROAD SERPENTINE
TITLE DAM 3A
GEOTECHNICAL SECTIONS 3A-A & 3A-B
JOB NO. J1701059
FIGURE FIGURE 8

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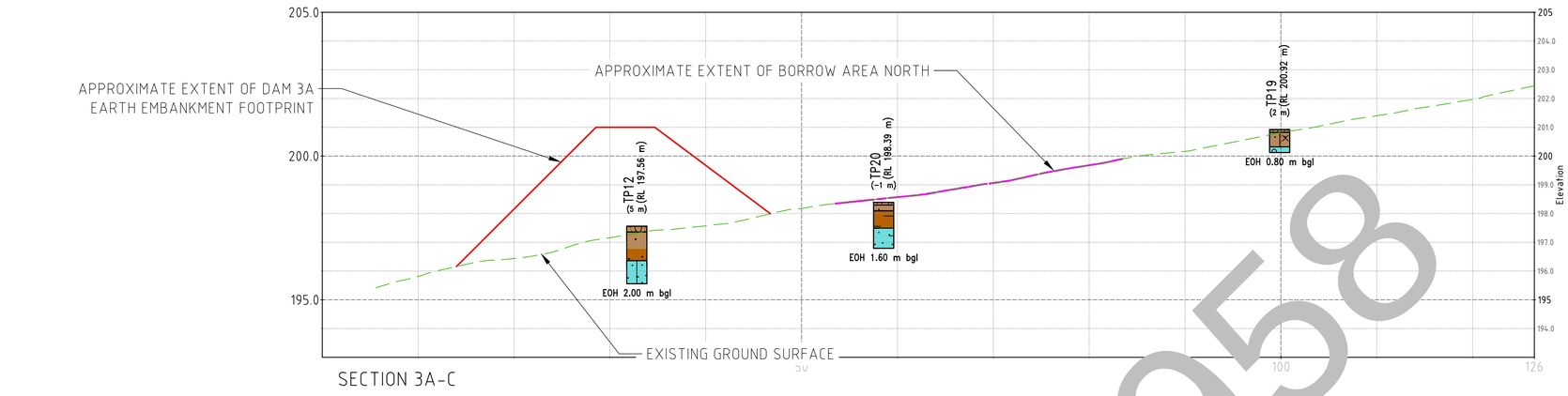
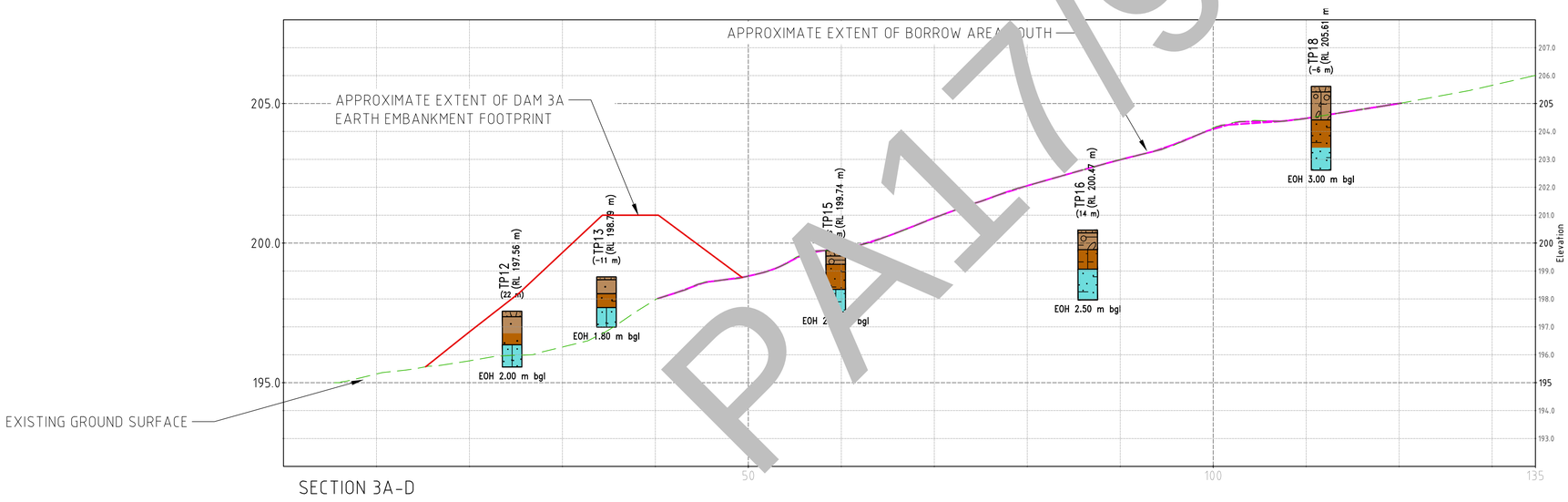


SECTION 3A-C



SECTION 3A-D

LEGEND

- TOPSOIL
- Laterite Profile
- CL-CI - Low to Medium Plasticity CLAY
- Poorly-graded SAND
- SC-SM - Clayey SAND to Silty SAND
- SP-SM - Poorly Graded SAND to Silty SAND
- Transitional Zone
- Clayey GRAVEL
- HIGH PLASTICITY CLAY
- SP-SC - Poorly Graded SAND to Clayey SAND
- Poorly-graded GRAVEL
- Weathered Rock
- CI-CH - Medium to High Plasticity CLAY
- Clayey SAND
- Silty SAND

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CLIENT PRITCHARD FRANCIS
PROJECT PROPOSED NEW DAMS
LOCATION LOT 822 FIRNS ROAD SERPENTINE
TITLE DAM 3B
GEOTECHNICAL SECTIONS 3A-C & 3A-D
JOB NO. J1701059
FIGURE FIGURE 9

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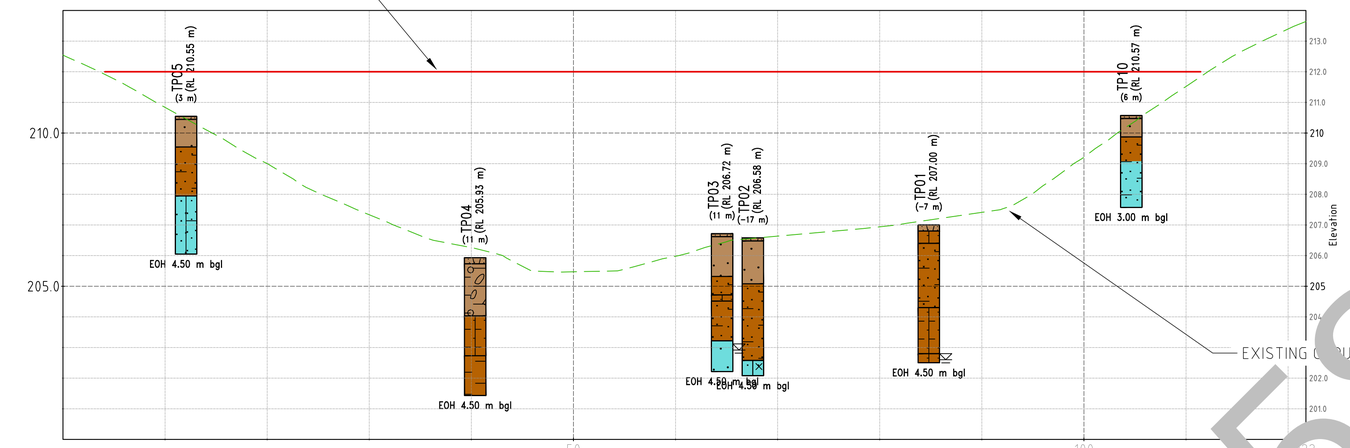
APPROXIMATE CREST OF DAM 3D EARTH EMBANKMENT FOOTPRINT

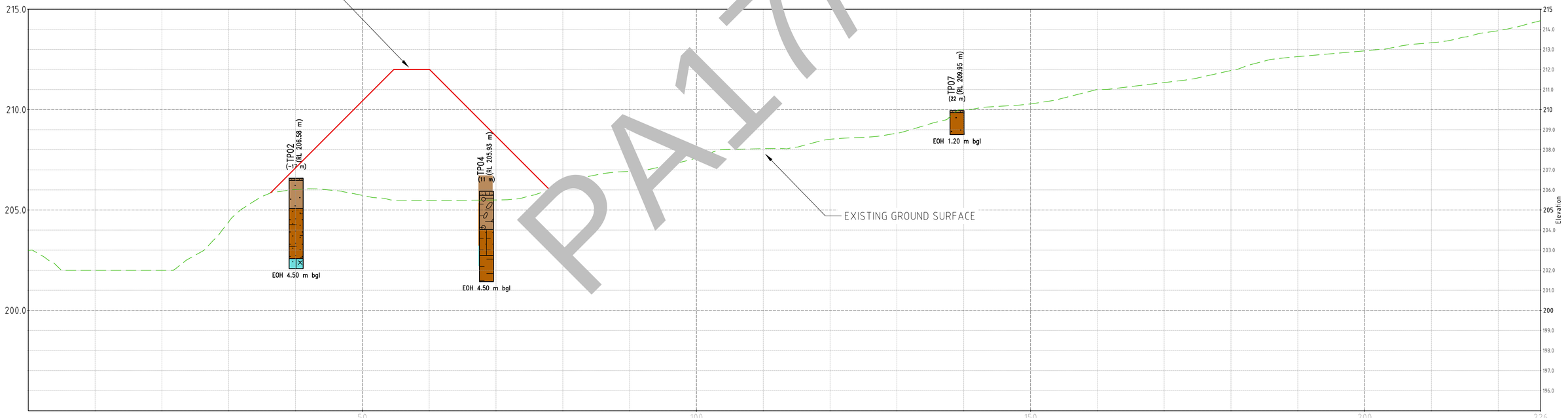


SECTION 3D-A

LEGEND

- TOPSOIL
- CL-CI - Low to Medium Plasticity CLAY
- Clayey GRAVEL
- CI-CH - Medium to High Plasticity CLAY
- Poorly-graded SAND
- HIGH PLASTICITY CLAY
- Clayey SAND
- SC-SM - Clayey SAND to Silty SAND
- SP-SC - Poorly Graded SAND to Clayey SAND
- Silty SAND
- SP-SM - Poorly Graded SAND to Silty SAND
- Poorly-graded GRAVEL
- Lateritic Profile
- Transitional Zone
- Weathered Rock

APPROXIMATE EXTENT OF DAM 3D EARTH EMBANKMENT FOOTPRINT



SECTION 3D-B

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CLIENT PRITCHARD FRANCIS
PROJECT PROPOSED NEW DAMS
LOCATION LOT 822 FIRNS ROAD SERPENTINE
TITLE DAM 3D GEOTECHNICAL SECTIONS 3D-A & 3D-B
JOB NO. J1701059
FIGURE FIGURE 10

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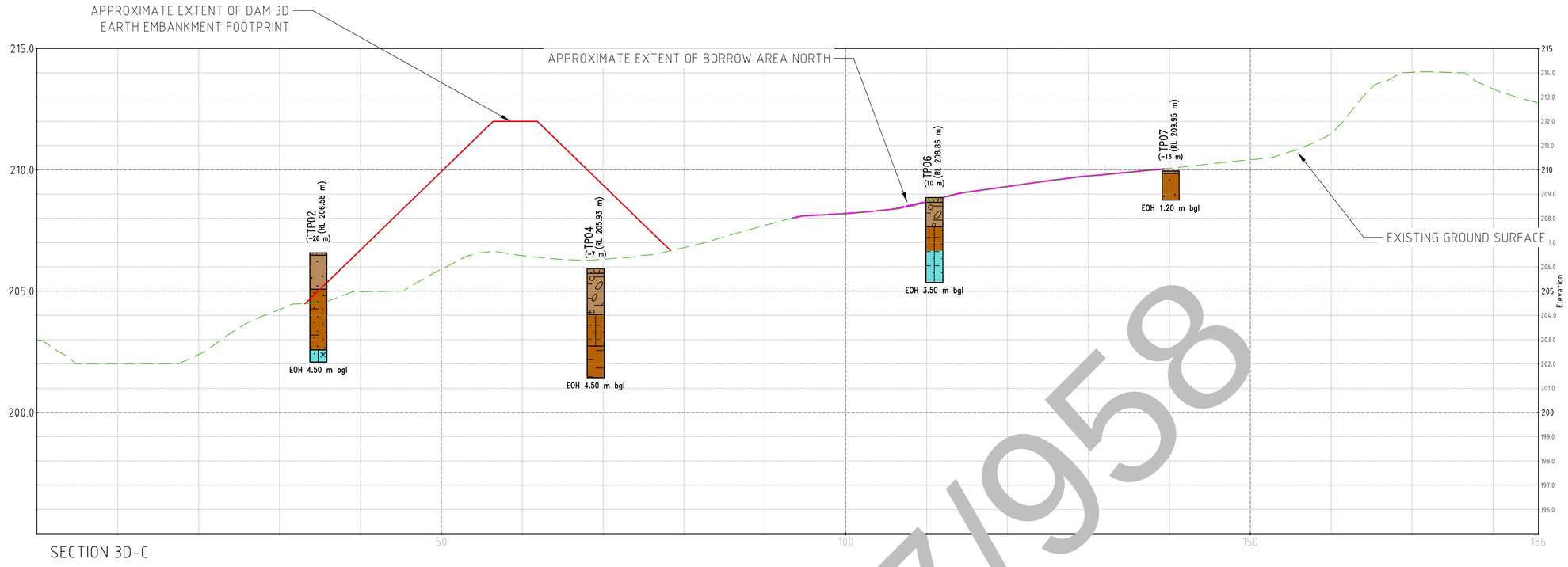
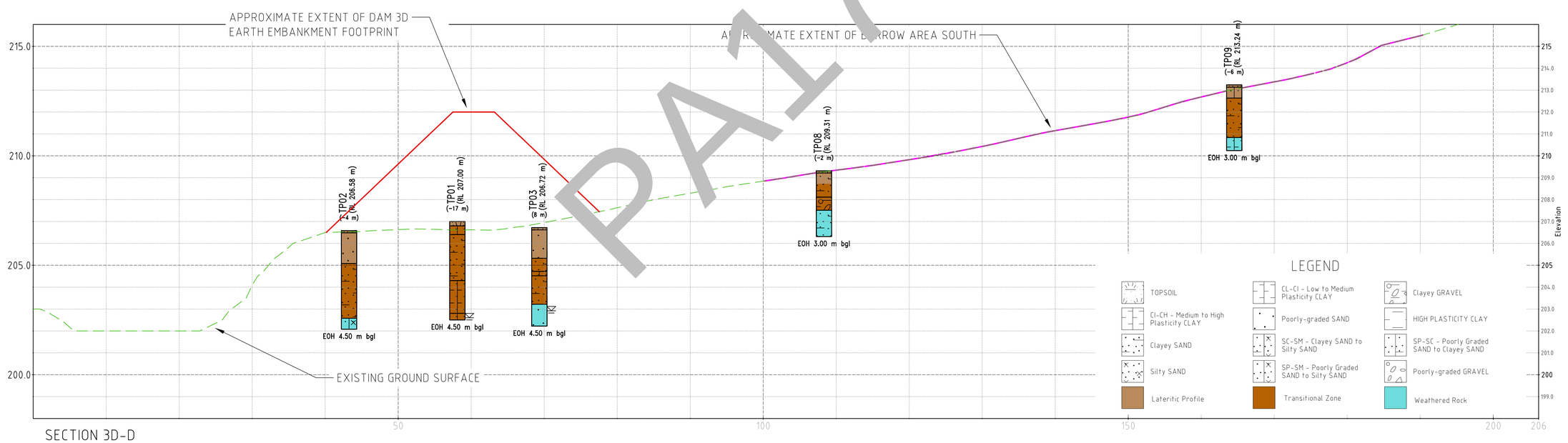


SECTION 3D-C



SECTION 3D-D

0 4 8 16 32
HORIZONTAL SCALE (m)
0 1 2 4 8
VERTICAL SCALE (m)

REV	DESCRIPTION	DATE	CHK

SCALE 1:300(H) 1:100(V) (@A1)
DRAWN DAC
DATE DRAWN 01/06/2017
CHECKED FAD
DATE CHECKED 01/06/2017

Galt Geotechnics Pty Ltd
ACN : 138 490 865
Tel : +61 (0)8 6272-0200
Address : Unit 4, 15 Walters Drive, OSBORNE PARK, WA, 6017

CLIENT PRITCHARD FRANCIS
PROJECT PROPOSED NEW DAMS
LOCATION LOT 822 FIRNS ROAD SERPENTINE
TITLE DAM 3D
GEOTECHNICAL SECTIONS 3D-C & 3D-D
JOB NO. J1701059
FIGURE FIGURE 11

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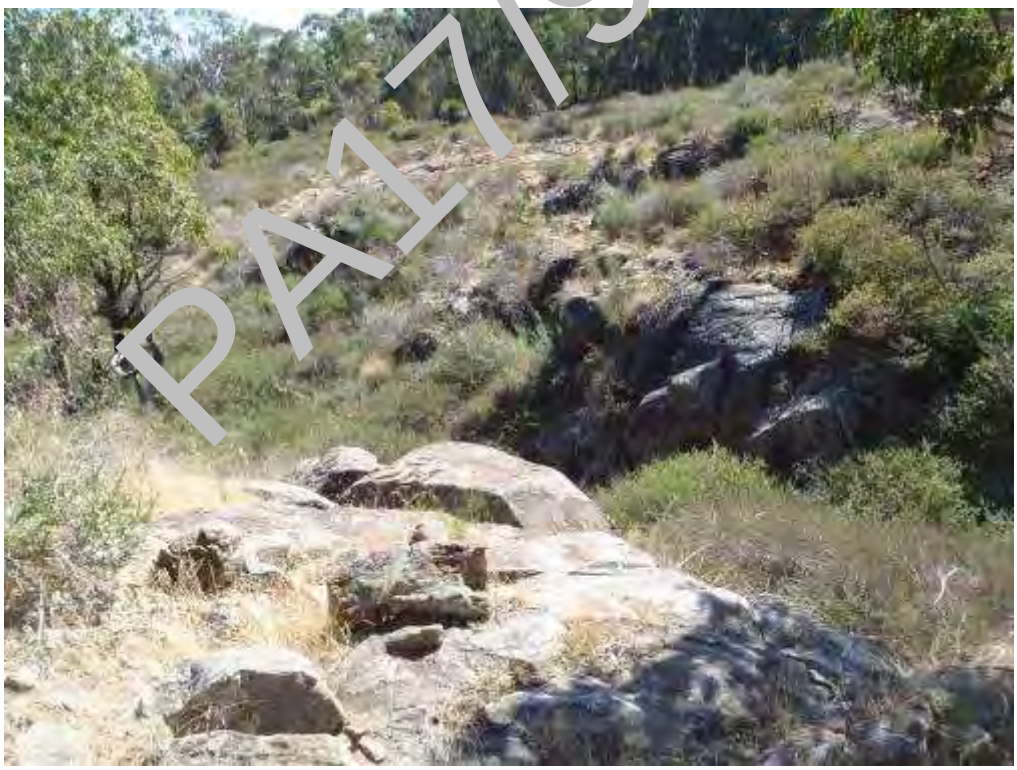
Appendix A: Site Photographs

Photograph 1: Dam 2 – View of rock exposed at surface on northern abutment

Photograph 2: Dam 2 – View of rock exposed at surface on northern abutment

Photograph 3: Dam 2 – View of dam site looking south across the existing valley



Photograph 4: Dam 2 – View of dam site looking north across the existing valley

Photograph 5: Dam 2 – View of dam site looking east across the proposed dam reservoir

Photograph 6: Dam 2 – View of dam site looking west

Photograph 7: Dam 3A – View of dam site looking south across the proposed dam alignment

Photograph 8: Dam 3A – View of dam site looking east

Photograph 9: Dam 3A – View of dam site looking west

Photograph 10: Dam 3A – View of dam site looking south across the proposed dam reservoir

Photograph 11: Dam 3D – View of dam site looking east

Photograph 12: Dam 3D – View of existing pond to the west of the proposed Dam 3D

Photograph 13: Dam 3D – View of dam site looking south

Photograph 14: Dam 3D – View of dam site looking north-east

Appendix B: Test Pit Reports – Dam 2

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

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

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

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

WATER

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

SAMPLING AND TESTING

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

ROCK CORE RECOVERY

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

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

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

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

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

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

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

RESISTANCE TO EXCAVATION

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

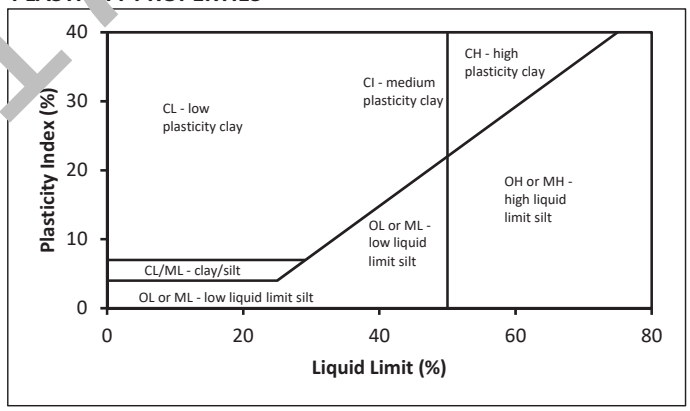
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

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

PARTICLE SIZE

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

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

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

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

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

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

Note: PSP correlations only valid to 450 mm depth

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

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3	4		+S +S ,S+ ,ST /S+ /ST 0S 0S RS RS TS				12	1Ð9Ã ! ; 56Æ=>ÃP?Ã@>AB@ÃCDE=>AÃGDH=ÃH9ÃJ?@>ÃCDEK>B 9DE>ÃD?9J	2	25 4ÃÃ19			
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9 - //! . "): 1>>Ã^MEB=E9DÃ?9 >JÃE=AÃ >9 ?AÃ>Ã1?ÃÃ>JNDM9?=Ã!>>9JÃ>?D A>9EÐJÃ>ÃEGGDE9?=JÃE=AÃEJ7Ã>ÃA>JNM9?=J

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			0S 0ST RS RST TS						#?8>Ã>D@7=E9>AÃE9ÃS+Ã?@ * EDC9ÃÃM9 ÃD?B=AHE9>DÃ=N?B=9>D> ÃÃVS2@			

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3	4		+S +S ,S+ ,ST /S+ /ST 0S 0S RS RS TS		( )* " /]-,.			12 %$ %# 1%- %$ 1"- 1%	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7E@ÃCDE7=>AFÃG?!=FÃ9EN>ÃD??9J 1E=A:Ã%&! L6Ã@>AB@Ã?A7CIÃMEJ9N9 FÃGDH=Ã@?9B>A ?DE=C>OG?!=ÃED?ÃEÃCD>: FÃ9EN>ÃD??9JÃH>IÃ?@>ÃCDEK>8 %8E>: Ã1!;5ÃOÃ1EA: Ã%& L6Ã<7Ã9Ã@>A7E@ÃCDE7=>AFÃ8HÃ9? @>AB@ÃMEJ9N9 Ã+?9ÃAED?ÃGDH=ÃMEDI8 D??9J8(>7JCD: CEDH=?DE=C>ÃED?ÃD>A?ADE>ÃCDEK>8ÃN?@M89>8 H>E9> D>A?D'NP %ÆE:>: Ã! ; 5ÃÃDEK>8Ã! ; 56Ã+?9ÃJ?@>Ã7=>JF?7=>Ã?Ã@>AB@ CDE7=>AFÃMEB>ÃCD: Ã+?9ÃAED?ÃGDH=ÃK>7JF?DE>A?9J (>N?@7=CÃÆE:>: Ã! ; 5ÃÃE=A:Ã%&! L6Ã+?9ÃÃNÆEJ9JÃ &! LÃ CD: .FÃ@>AB@Ã?A7CIÃMEJ9N9 Ã7=>JF+?9ÃJ?@ ÃCDEK> D??9JFÃMB>ÃCD: Ã+?9ÃAED?ÃCD: CEDH=ÃK>7J #?8>Ã>D@7=E9>AÃE9ÃST+Ã@ * ED89ÃÃM9 ÃD?B=AHE9>DÃ?9Ã>N?B=9>D>A	2	25 4ÃÃ19	

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3	4		+S				12	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7E@ÃCDE=>AÃGDH=ÃHD!ÃI?@> CE!K>8	5		
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3	4		DEPTH		12		25	
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				DEPTH								
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23*#5	3W%!Q! *$; 31 $!*! ,% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %'Q3 35	Ã !"# &' Ã $%	V1 % 1Ã1.2(&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $';	2$1*V 3 %'; 5 $$;	%'; 1$1*3; 53 ;1 $*L %L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S		( )* " 0R-,.			12	*' "1' $&Ã178Ã!;56Ã<7>Ã9Ã@>A7B@ÃCDE7>AÃG?H=Ã7I9IÃ?@> CDEK>ÃDE>ÃD?9J		25	
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A-#+",-.:	&?9Z// /Ã)/+ [. Ã4TÐ=JÃ ?EAPÃ1 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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3	4		+S+				12		*' "1' $ÃÃ78ÃÃ!;56Ã<7=>Ã9Ã@>A7E@ÃCDE7=>AFÃG?!=FÃ7DIÃ?@> CDEK>ÃÐDE=>Ã)?9J	5	25	
			+S+				12		1 Ã9Ã ! ; 56Ã7=>Ã9Ã@>AÐ@ÃCDE7=>AÃ79ÃJ?@>ÃCDEK>ÃÐDE=>Ã)?9JF GÐH=			
			,S+				1%		%ÆE:>:Ã ! ; 56Ã7=>Ã9Ã@>AÐ@ÃCDE7=>AÃMEÐÃGÐH=?DE=C>Ã7Ã9HÃ9 @>A7ÃÐÃMEJ97N9:		25 Ã) 4	
			,ST				%$ %#		1E=A:Ã%&! LÃ7CIÃMEJÃN9 FÃMÐÃCÐ:Ã@?9ÐÃAÃEDP D>A?DE=C>GÐH=Ã179ÃAEDÃCÐ:?MÐÃ)?9J?K>7JÃÃ?@M89>8 H>E9> D>AÐ?NP			
		#	/S+				%#		%&! LÃ7CIÃE=A:Ã%&! LÃ7CIÃMEJÃN9 FÃK>DÃ1>ÃÃ>@>=9>AÃMÐ CÐ:?GÐH=?AEDÃÐ>A?DE=C>Ã179ÃAEDÃGÐH=?MÐÃÃK>7JÐ?9J		4ÃOÃ19	
		Q#							(>N?@7=CÃMÐÃCÐ:Ã@?9Ð>AÃEDÃÐ>A179ÃAEDÃCÐ:Ã ÃÃK>7J			
			/ST						#?9>Ã>D@7=E9>AÃE9ÃST+Ã@ *EDG9ÃÃM9 Ã?B=AHE9>DÃ?9Ã>N?B=9>D>A			
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9 - //! . ") :	1>>Ã9^MÐ=E9DÃ?9 >JÃE=AÃ >9 ?AÃ>Ã1?ÃÃ5>JNDM9?=Ã!>>9JÃ>?D A>9E7ÃÃ>ÃEGGDE9Ã?=JÃE=AÃGEJ7ÃÃ>ÃA>JNM9?=J

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9 -." '+#"-': 19>K>Ã5 : JE19
5 +#$,. !: 0,+Ã1YÃ\ENP1 ?>ÃZ*
&0!'+"-': 19>K>Ã5 : JE19
; <# !": [++Ã@@Ã*??9 >A

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A-22!4: (&
9$!# !4Ã 6+"!: +/O+TO+,\
9$!# !4Ã ; B: 4! 5

78#+*+",-.					Ã+/ 01,.2		3,!14Ã5+"!' ,+1ÃÐ#" ,0",-.					
23*#5	3V%!Q! *$; 31 $!* ! ;%3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &; Á	V1%1ÁL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S +S ,S+ ,ST /S+ /ST		( )* " 0[-,.		12 12 1%- %$	*' "1' $&Ã178Ã!;56Ã<7=>Ã9Ð>A7E@ÃCDE7=>AFÃÆDÐÃCD?H=FÃ9DN> CDEK>ÐÃDDE>Ã)?9J 1Ð9Ã! ; 56Ð7=>ÃÐÃ@>AB@ÃCDE7=>AÃ79ÃJ?@>ÃCDEK>ÐÃGDH=F 9DE>Ã)?9JFÃDDE>ÃCDEK>8 %8E>: Ã1!;5ÃOÃ1EA: Ã%& L6Ã<7Ã9Ð>A7E@ÃCDE7=>AFÃ8FÃ9? @>A7Ð@ÃÆEJ9'N7ÐÃ8ÃCD?H=O DE=C>FÃDN>ÃCDEK>8		25	
	#				( )* " 0[-/.		%$ %#	1E=A:Ã%&! L6Ð@>AB@Ð9Ã7CIÃÆEJ9N9 FÃGDH=OÆB>ÃCD: FÃDE> CDEK>ÐÃ?@Æ89-8Ã>E9> D>AÃD?NP (>N?@7=CÃÆB>ÃCD: CDH=OADÐÃ>ODE=C>	2		
	Q#						%#	1E=A:Ã%&! L6Ã7CIÃÆEJ9N9 FÃÆB>ÃCD: Ã+D9ÃADÐÃCD: O DH= K>7=JFÃN@Æ89-8Ã>E9I>D>AÃD?NP			4ÃÃ19
			0S 0S RS RS TS					#?8>Ã>D@7=E9>AÃE9SZ+Ã@ *EDC9Ã>ÆJ9 ÃD?B=AHE9>DÃ?9Ã>N?B 9>D;				

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9 - //! . ") :

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A>9E9JÃ>ÁEGGDE9?=JÃE=AÃEJ7JÃ>ÁA>JNM9?=J

Appendix C: Test Pit Reports – Dam 3A

Galt GEOTECHNICS

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91,! ." :	" DÐNIEDÃDE=NJ	5 +#$,. !:	0,+Ã1YÃ\ ENP1 ?>ÃZ*	A-22!4:	(&
?' -@#":	" D?M?J>AÃ\ >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Z// /Ã)/+ [. Ã4T>JÃ ?EAPÃ1 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#5	3V%!Q! *$; 31 $!*! ;.% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &' Ã	V1 %!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S+					12	*' "1' $&Ã789Ã!;56Ã<7=>Ã9Ã@>A7E@ÃCDE7=>AFÃG?!=FÃH7DIÃ?@> D?9J	5	25	
			+S+					1%	%Æ:>:Ã! ; 5ÃF=>Ã?Ã@>AB@ÃCDE7=>AÃH7DÃJ?@>ÃCDEK>B GD?!=@AEDÃ?DE=C>FÃ9D>Ã?9JÃ9Ã=S?Ã@ÃA>M9 Ã@?A>DB>8 N>@>=9>AÃ!?=>J			
	#		,S+					1"- 1%	ÃDEK>8Ã1!;56Ã<7=>Ã9Ã@>A7E@ÃCDE7=>AFÃH79ÃN8E9JÃ<Ã%8E>: 1! ; 5FÃCD: G:DH=@AEDÃD>AÃN?@M89>8Ã?Ã7CI 8Ã!>E9> D>AÃD?NP	2	25 Ã Q19	
	Q#		,ST						(>N?@7=OÃMB>ÃCD: G:DH=@AEDÃD>A			
			/S+						#?8>Ã>D@7=E9>AÃE9S++Ã@ *>D@7=E9>AÃMB>Ã?Ã!8?HÃ?C?=C ÃD?B=AHE9>DÃ?9Ã>N?B=9>D>A			
			/ST									
			0S+									
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9 - //! . "') :

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91,! ." :	" D9NIEDÀÃDE=NJ	5 +#$,. !: 0,+Ã1YÃ ENPI ?>ÃZ*	A-22!4: (&
?' -@#":	" D?M?J>AÃ >HÃ5 E@J	&0!'+"-': 19>K>Ã5 : JE9	9 $!# !4Ã 6+"!: +/O+TO+,\
A-#+",-.:	&?9Z/ /Ã)/+ [. Ã4 D=JÃ ?EAÃ >M>=9=>	; <# !": [++Ã@@Ã*??9 >A	9 $!# !4Ã ; B: 4! 5

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23*#5	3W%!Q! *$; 31 $!*! ,% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %'Q3 35	Ã !"# &' Ã $%	V1 %1Ã1.2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2$1*V 3 %'; 5 $$;	%'; 1$1*3; 53 ;1 $*L %L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S		( )* " ,/-,.			12	[illegible]	2	25	
	#		+S					1"	[illegible]			
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9 - //! . ") :

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91,! ." :	" DØNIEDÃDE=NJ	5 +#$,. !:	0,+Ã1YÃ\ENP1 ?>Ã2*	A-22!4:	(&
?' -@#":	" D?M?J>AÃ\ >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Z// /Ã)/+ [. Ã4T>JÃ ?EAÃ1 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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3	4		+S				12	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7B@ÃCDE=>AFÃG?!H=FÃH?DIÃ?@> CBEK>8			
			+S				1"	ÃDEK>8:Ã1!;56Ã<7=>Ã9Ã@>A7B@ÃCDE=>AÃH?DIÃ?@>Ã?HÃ9Ã@>A7B@ MBEJ9N9 Ã=>JFÃGDH=FÃ@?A>DE9:8Ã!>8ÃA>@>=9>AÃ!?=>J		25	
			,S+				1%	%ÆE:>:Ã ! ; 5 6Ã=>ÃP?Ã@>AÃB@ÃCDE=>AFÃPHÃP?Ã@>AÃB@ÃMBEJ9N9 F GDH=@AEDÃGDH=@AEDÃD:A	2	4ÃÃ!9	
		#					1"- 1%	ÃDEK>8:Ã1!;5ÃOÃ%8E:Ã!;56Ã<7=>Ã9Ã@>A7B@ÃCDE=>AFÃ8HÃ9? @>AÃB@ÃMBEJ9N9 FÃCD:ÃGDH=@AEDÃD:AFÃNEJ9JÃ?>ÃNE:>:Ã ! ; 5 H9ÃAEDÃCD:Ã<?JFÃN?@M89>8Ã!>E9> D>AÃD?NP		25 Ã 19	
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9 - //! . "): 1>>Ã9^MBE=E9DÃ?9>JÃE=AÃ2 >9 ?AÃ?<Ã1?Ã5>JNDM9?=Ã!>>9JÃ<?D A>9E7ÃJÃ?<ÃEGGDE9?=JÃE=AÃEJ7JÃ?<ÃA>JNM9?=J

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5 +#$,. !: 0,+Ã1YÃ\ ENÃ1 ?>ÃZ*
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3	4		+S+ +S+ ,S+ ,ST /S+ /ST 0S+ 0ST RS+ RST TS+	( )* " ,R-,. ( )* " ,R-/. ( )* " ,R-0.			12 Ä% Ä% 1% %$ %# %$ %#	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7Ð@ÃCDE7=>AFÃG?H=FÃ7DIÃ?@> CDEK>8 %E: >: ÃÄ !Q3& 6Ã<7Ã9ÃNEDJ>ÃCDE7=>AFÃG?H=FÃ8IÃ9Ã@A7Ð@ MEJ9NÐ %E: >: ÃÄ !Q3& 6Ã<7Ã9ÃNEDJ>ÃCDE7=>AFÃ8?IÃ9Ã@A7Ð@ÃMEJ97NÐ9: GDH=@AEDÃÐDE=C> %E: >: Ã ! ; 5 6Ã7=>ÃÐÃ@>AÐ@ÃCDE7=>AÃÐ?HÃÐÃ@>AÐ@ÃMEJ9NÐ F CD: Ã@?9Ð>AÃGDH=Ã@?9Ð>AÃAEDÃÐ>AÃMEJ9JÃ7Ã<E=A:Ã% %& LO1E=A:Ã%&L6Ã@A7Ð@Ã9Ã7CJÃMEJ97N Ð>Ã@?9Ð>A DP D>AÃDÃE>ÃAEDÃCD: Ã<>7=J %& LO1E=A:Ã%&L6Ã@A7Ð@Ã9Ã7CJÃMEJ97 Ð>ÃDÃCD>: Ã 98A D>AÃAEDÃCD: Ã<>7=JÃMEJ9JÃ7<Ã 5	2	25 4ÃÃ19	
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?' -@#":	" D?M?J>AÃ, >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Ã// /Ã)/+ [. Ã4T9=JÃ ?EAPÃ¶ >DM>=9F=>	; <# !'":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#5	3V%!Q! *$; 31 $!* ! ;% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &: Ã	V1 %!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S +S ,S+ ,ST /S+ /ST 0S 0S RS RS TS		( )* " ,[-. ( )* " ,[-/. ( )* " ,[-0.		12 Ä% %$ %# 1% 1%	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7B@ÃCDE7=>AFÃG?!=FÃ9EDN>Ã?9J %4E: >: ÃÃ !Q3& 6Ã<=Ã9Ã@>A7B@ÃCDE7=>AFÃ8?Ã9Ã@>A7B@ÃÃ4EJ97N79: 7=>JFÃGDH=FÃMED9Ã@?A>DE9 8Ã?ÃK>DÃ!>8ÃN>@=9>A 1E=A:Ã%&! L6Ã@>AB@Ã?Ã7CIÃMEJ9N9 FÃGDH=FÃDE>ÃCDEK>8ÃDE>D?9J %4E:>: Ã! ; 5 Ã7=>Ã?Ã@>AB@ÃCDE7=>AFÃDE>ÃCDEK>8ÃMEB> CD: GDH=ÃED FÃD>AFÃDE>Ã?9JFÃN?@M89>8Ã!>E9> D>AÃD'NP %4E:>: Ã! ; 5 Ã7=>Ã?Ã@>AB@ÃCDE7=>AFÃ?HÃ?` =>AB@ÃMEJ9 F GDH=ÃED FÃGDH=ÃED FÃCD: GMEDI8ÃED FÃ` =FÃN?@M89>8 H>E9> D>AÃD'NP #?8>Ã>D@7=E9>AÃE9ST+Ã@ * EDG9Ã>M9 ÄD?B=AHE9>DÃ?9Ã>N?B=9>D>A	5 2	25 4ÃÃ19 25 Ã0 19

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23*#5	3V%!QI *$; 31 $!* ! ;%3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	Ã !"# $% &: Ã	V1%!ÃL2('&	1' $ÐO %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S +S ,S+ ,ST /S+ /ST 0S 0S RS RS TS		( )* " ,\-,.			12 Ã% 1% 1% %& %$	*' "1' $ÐÃ78Ã!;56Ã<7=>Ã9Ã@>A7B@ÃCDE7=>AFÃG?H=FÃ9DN>ÃD?9J %4E:>:ÃÃ !Q3& 6Ã<7Ã9Ã@A7B@ÃCDE7=>AFÃG?H=FÃ8IÃ9Ã@A7B@ MEJ9N9Ã7=>JFÃDE>ÃD?9J %4E:>:Ã! ; 56Ã7=>Ã?Ã@>AB@ÃCDE7=>AÃN?9ÃJ?@>ÃCDEK>ÃMEJ> GDH=Ã8?HÃ?Ã@>AB@ÃMEJ9N9 %4E:>:Ã! ; 56Ã7=>Ã?Ã@>AB@ÃCDE7=>AÃ8?HÃ?Ã@>AB@ÃMEJ9N9 F 9DE>ÃCDEK>ÃGDH=ÃMEJ>ÃCD:ÃEDÃD>A ÃDEA7=ÃÃ?Ã E=A:Ã%&! L 1E=A:Ã%&! L6Ã8IÃ9Ã@>A7B@ÃMEJ9N7ÃÃE8ÃCD: Ã@9 GDH=ÃEDÃD>AÃDE>ÃCDEK>ÃÃ?@M89>8Ã!>E9>ÃD>AÃD? #?8>Ã>D@7=E9>AÃE9ÃS+Ã? * EDÃ9ÃAM9 ÃD?B=AHE9>DÃ?9Ã>N?B=>D>A	5 2	25 4ÃÃ19	

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A-#+",-.:	&?9Z/ /Ã)/+ [. Ã4 D=JÃ ?EAÃ >DM>=9=>	; <# !":	[++Ã@@Ã*??9 >A	9 $!# !4Ã ; B:	4! 5

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23*#5	3W%!Q! "$; 31 $!* !,% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %'Q3 35	Ã !"# &' Ã $%	V1 %1Ã1.2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2$1"V 3 %'; 5$$;	%'; 1$!*3; 53 ;1 $*L %L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S / +ST / ,S+ / ,ST / /S+ / /ST		( )* " ,Z-,.			12	*' "1' $&Ã178Ã!;56Ã<7=>Ã9Ã@>A7Ã@ÃDE7=>AFÃG?H=FÃ9ED>Ã??9J	2	25	
								Ã" - Ã%	1E=A Ã !Q3& ÃOÃE>: Ã !Q3& 6Ã<7Ã9ÃN?ED>ÃDE=>AFÃDH=F 8?HÃ9Ã@>A7Ã@ÃEJ9?N7Ã7=J / (>N?@7=CÃMB>ÃGDH=		25	"7>N>JÃ?ÃH?AÃG9H>>=Ã+ÃE=Ã+S@Ã A>M9I
								1%	%8E>: Ã ! ; 56Ã7=>Ã?Ã@>AB@ÃCE7=>AÃ?HÃ?Ã@>AB@ÃMEJ9N9 <7=>JÃMB>ÃGDH=ÃH9ÃJ?@>ÃCEK>8 / ÃDE7=CÃ=9?Ã E=A:Ã%&! L		4ÃÃ19	
	#							1%- %$	%8E>: Ã1!;5ÃOÃ1EA Ã%& L6Ã<7Ã9Ã@>A7E ... =7=>AFÃ8?ÃA @>AB@ÃMEJ9N9 Ã7=>JÃEDÃGDH=@CD: ... D>AÃ?@M89> H>E9> D>AÃD?NP / (>N?@7=CÃMB>ÃCD: @GDH=@AEDÃD>A			
			0S / 0ST / RS / RST / TS						# ?8>Ã>D@7=E9>AÃE9ÃOS +Ã@ * EDG9ÃAM9 ÃD?B=AHE9>DÃ?9Ã=N?B= ... D>A			

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9 - //! . ") :

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?' -@#":	" D?M?J>AÃ\ >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+TO+,\
A-#+",-.:	&?9Z// /Ã)/+ [. Ã4TÐ=JÃ ?EAPÃ4 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#!5	3V%!QI *$; 31 $!*!.;% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &: Ã	V1%!ÃL2('&	1' $ÐO %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %:'; 5$$$:;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	#		+S				12		*' "1' $ÐÃ78ÃÑ!;56Ã<7=>Ã9Ã@>A7E@ÃCDE7=>AFÃG?!=FÃ9ÐN>ÃD??9J			
	#		+ST				1"-12		ÃDÐK>8Ã ÃÐÃ ! ; 5 6Ã?=>ÃP?Ã@>A?B@ÃCDE7=>AÃDÐE!>ÃD??9JFÃH?9 G?BÃA>DJD?NPÃDÐE@>=9JÃBMÐ?Ã++Ã@@FÃ@?A>ÐE9 8Ã!>8 N>@>=9>AFÃÐÐN>ÃD??9J	5	25 Ã 5	
			,S+				Ã"		Ã !Q3& 6Ã>DÃ!>8Ã>@>=9>AFÃMB>ÃCD>=CD: CDH=FÃE DÃ I7CI 8ÃÐÃ@?A>ÐE9 8Ã!>E9> D>AÃ?NP	2		
			,ST						#?8>Ã>D@7=E9>AÃE9A SZ+Ã@ > <BJE8 ÃD?B=AHE9>DÃ?9Ã>N?B=9>D>A			
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9 - //! . "):	1>>Ã^MÐ=E9DÃ?9 >JÃ=AÃ >9 ?AÃ<Ã1?Ã5>JNDM9?=Ã!>>9JÃ<?D A>ÐE9JÃ<ÁEGGDÐ9?=JÃ=AÃEJ7Ã<ÁA>JNM9?=J

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91,! ." :	" DÐNIEDÃDE=NJ	5 +#$,. !:	0,+Ã1YÃ\ENP1 ?>Ã2*	A-22!4:	(&
?' -@#":	" D?M?J>AÃ\ >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Ã2// /Ã)/+ [. Ã4T9>JÃ ?EAPÃ4 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#!5	3V%!Q! *$; 31 $!*! ;.% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% & ; Ã	V1 %!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$!*V 3 %'; 5$*$';	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S +S ,S+ ,ST		( )* " /+-,.			12 1% %# 1%	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã>A7E@ÃDE7=>AÃG?!=FÃ9DN>Ã?9J %ÆE:>:Ã! ; 5ÃÆ=>Ã?Ã@>AÆB@ÃDE7=>AÃGDH=Ã+H?ÃJ?@>Ã?9JF H?ÃJ?@>ÃDE K>Ã@?A>DE9>8Ã+>ÃÃ>@>=9>A 1E=A:Ã%&! LÃÃDE>ÃDE K>Ã7CIÃMEJ9N9FÃGDH=ÃÃDE>Ã?9JF 9DE>ÃDE K>8 %ÆE:>:Ã! ; 5ÃÃ E=A:Ã%&! LÃ@>AÆB@Ã?Ã7CIÃMEJ9N9F GDH=ÃMEÆDE:ÃAED?Ã>AÃMEDÆ@AED?ÃDE>=FÃH?ÃÃAED?ÃGDH= K>7JFÃÃDE>Ã?9JFÃH?ÃMF7N>JÃ?<Ã<K>DÃ+>Ã>@>=9>AÃ?NÃ? N?@M>9>8Ã+E9I>D>AÃ?NP	1% 1% 1%	5	25 4ÃOÃ19 19ÃO Q19	
			/S+ /ST 0S+ 0ST RS+ RST TS+						#?8>Ã>D@7=E9>AÆÃS[+ Ã@ > <ÆJE8 ÃD?B=AHE9>DÃ?9Ã>N?B=9>D>A			

À !"#$Ã%Ã&'$!' Ã&)!' *+",-.)

9 - //! . ") :	1>>Ã^MÆ=E9DÃ?9 >JÃÆ=AÃÆ >9 ?AÃ?<Ã1?Ã5>JNDM9?=Ã!>>9JÃ<?D A>9ÆÃ?<ÃEGGDÆ9?=JÃÆ=AÃÆEJ7Ã?<ÃA>JNM9?=J

Appendix D: Test Pit Reports – Dam 3D

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91,! ." :	" DÐNIEDÃÃDE=NJ	5 +#$,. !:	0,+Ã1YÃ\ENP1 ?>ÃZ*	A-22!4:	(&
?' -@#":	" D?M?J>AÃ, >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Z// /Ã)/+ [. Ã4T>JÃ ?EAPÃ1 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#5	3V%!Q! *$; 31 $!*! .;% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &' Ã	V1%!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S +S ,S+ ,ST /S+ /ST 0S 0ST RS RS TS				12	*' "1' $&Ã789Ã!;56Ã<7=>Ã9Ã@>A7E@ÃCDE=>AFÃG?!=FÃ?D!Ã?@>CE!K>8			25	
							%$ %#	1E=A:Ã%&! L6Ã@>AB@ÃÐÃ7CIÃME.J9N9 FÃGD!H=@A.ED?D!E=C>FÃD!E>CE!K>8				
	#				( )*" +,-.		1%- Ã%	%&E >:Ã1!; 5ÃOÃ%8EÃÃ!Q3& 6Ã<7=>Ã9Ã@>A7E@ÃCDE=>AFÃN8!EJ ?<Ã@>AB@ÃÐÃ7CIÃME.J9N9 FÃD'NFÃ9D!B!B>FÃGD!H=C:D:C:E!NFÃD'NP <D!E@>=9JFÃ?@M89>8ÃÐÃ7CI8Ã<!>E9> D>A:D'NP		25 Ã0 19	
								(>N?@?=CÃ E=A:Ã%&! LFÃ8?HÃÐÃ@>AB@ÃJ.J9N9 FÃ D:D: G!. D'NPÃ9D!B!B>				
					( )*" +,-/.		%& %$	1E=A:Ã%&! L6Ã8ÃÃ9Ã@>A7E@ÃMF <G?!=AFÃE=AÃ0Ã/?= CE!=>AFÃD!E>ÃCE!K>8ÃNEJ9Ã@>AB@ÃÃ7CIÃME.J9N9 Ã L)CD>C:D!H=.			4ÃÃ19	
	4-#				( )*" +,-0.		%$ %#	% L @A7E@Ã9Ã7CIÃME.J97NFÃD>ÃGN?@?=CÃE!D'CD>:				18?HÃJ>>MEC>
								#?8>Ã>D@?=L V <S+Ã@ *ED:9Ã>ÃM9 Ã D?B=AHE9 <=N?B=9>D>AÃE!RÃ@				

À !"#$Ã%Ã&'$!' Ã&)!' *+",-.)

9 - //! . "):	1>>Ã^ME=E9DÃ?9 >JÃE=AÃ >9 ?AÃ<Ã1?Ã5>JNDM9?=Ã\>>9JÃ<?D A>E!Ã/Ã<ÃEGGDE9Ã?=JÃE=AÃEJ7Ã/Ã<ÃA>JNM9?=J

C7ĀCĀ7DCĀCEG

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?' -@#": " D?M?J>AĀ >HĀ5 E@J	&0!'+"-': 19>K>Ā5 : JED9	9$!# !4Ā 6+"!:	+/O+TO+,\
A-#+",-.: &?9Z/ /Ā)/+ [. Ā4 D=JĀ ?EAĀ >DM>=9=>	; <# !": [++Ā@@Ā*??9 >A	9$!# !4Ā ; B:	4! 5

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23*#5	3W%!Q! *$; 31 $*! ;% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ā 4$3&5Ā*31*	3 %'Q3 35	Ā !"# &' Ā $%	V1 % 1Ā L2('&	1' $&O %UĀ2* 3 $!& Ā531% $ "* $' ;	2$1*V 3 %'; 5$$;	%'; 1$!*3; 53 ;1 $*L %L	1* V%* V 3Ā ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S					12	*' "1' $&Ā178Ā1!;56Ā<7=>Ā9Ā@>A7B@ĀCDE7=>AFĀG?H=FĀ9ED> CEK>8			
			+ST					1"	ĀDEK>8Ā1!;56Ā<7=>Ā9ĀN?ED>ĀCDE7=>AFĀG?H=FĀH7?IĀJ?@>ĀN8E>: <7=>J		25	
			,S+									
			,ST					1%- %$	%8E>: Ā1!;5ĀOĀ1EA Ā%& L6Ā<7=>Ā9Ā@>A7B@ĀCDE7=>AFĀ8?Ā9? @>AB@ĀME JN9 FĀH7?IĀJ?@>ĀCEK>8ĀGDH=ĀH7?IĀCD: OGENR?>A @?9B7CĀ9ĀN8E9JĀ?ĀE=A Ā%& L			
			/S+		( )* " +/-,.				%8E:>: Ā! ; 5 Ā7=>Ā9?Ā@>AB@ĀCDE7=>AFĀGDH=Ā@?9B>Ā D: FĀ? @>AB@ĀME JN9 FĀDE>ĀCEK>8ĀH7?IĀNE J9Ā?Ā%& L	2		
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			RST						#?8Ā9D@7=L V ;$+Ā@ *EDG9ĀĀM9 ĀD?B=AHE9 Ā9Ā=N?B=9DĀ			
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9 - //! . ") :

1>>Ā8^ ME=E9DĀ?9 >JĀE=AĀ >9 ?AĀ<Ā1?Ā5>JNDM9?=ĀI>>9JĀ<?D A>9E?JĀ?<ĀEGGDE9?=JĀE=AĀEJ7JĀ?<ĀA>JDM9?=J

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&0!'+"-': 19>K>Ã5 : JE19
; <# !": [++Ã@@Ã*??9 >A

6+"! :
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23*#5	3V%!QI *$; 31 $!* ! ;% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# &: Ã	V1 %!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$!*V 3 %'; 5$$;	%L 1$!*3; 53 ;1 $*L
3	4		+S +S ,S+ ,ST /S+ /ST 0S 0ST RS RST TS		( )*" +0-,.		12	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ð>A7E@ÃCDE=>AFÃG?!H=FÃH7DIÃ?@>CDEK>8			
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							1%- %$	%E:>:Ã! ; 5ÃÐIE=A:Ã%&! LÐH7DÃJ?@>ÃCDEK>8Ã<=ÃA9Ð>A7E@ CDE=>AFÐ>AEB@ÐÃ7CIÃMEJ9N9FÃGDH=?DE=C>		4ÃÃ19	
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							1%	%&! L3LÃ! ; 5ÐH7DÃJ?@>ÃCDEK>8ÃMEB>ÃCE ?@M89>8ÃÐ/ CI8 H>E9> D>AÐ'NP		19Ã- Q19	
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								#?8>Ã>D@=D V «S+Ã@ * EDG9ÃÃM9 ÃÐ?B=AHE9 «N?B=9>D>AÃÐÃGZÃ@			

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1>>Ã^MEB=E9DÃ?9 >JÃE=AÃ >9 ?AÃ<Ã1?ÃÃ>JNDM9?=ÃI>>9JÃ<?D
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?' -@#":	" D?M?J>AÃ\ >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Ã2// /Ã)/+ [. Ã4TÐ=JÃ ?EAPÃ4 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#5	3V%!QI *$; 31 $!*! ;%3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &; Ã	V1%!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$!*V 3 %'; 5$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S +S ,S+ ,ST /S+ /ST 0S+ 0ST RS+ RST TS+				12	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7E@ÃCDE=>AFÃG?H=FÃ9ED>CDEK>8				&?9JÃÃHE9>DÃ@ÃJÃ*>JÃ2Ã*>JÃ"79
							Ä%	%ÆE >: ÃÄ !Q3& 6Ã<7Ã9ÃNEDJ>ÃCDE=>AFÃG?H=OÆÐÃDÆE<C>FÃ8Ã? 9?Ã@>AÆB@ÃMEJ9N9 Ã7=>J (>N?@?=OÃGDH=ÐMÆ>ÃGDH=	2	25	
							%$ %#	1E=A:Ã%&! L6Ã@>AÆB@ÃÐÃ7CIÃMEJ9N9 FÃMÆ>ÃCÐ: FÃH7 AEDÃCÆ K>7=JFÃH79ÃJ?@>ÃCDEK>8 * DÆ>ÃCDEK>8	X	4	
	3				( )*" +R-,.		%#	%&! L6Ã7CIÃMEJ9N9 FÃAEL CÐ: A@ GDH= ?9Æ>AÃCÐ: (>N?@?=OÃAEDÃCÐ: ?9Æ>AÃGDH= DE=C>		1ÃÃ4	
					( )*" +R-/.							
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A-#+",-.:	&?9Ã// /Ã)/+ [. Ã4T>JÃ ?EAÐÃ >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#5	3V%!Q! *$; 31 $!* ! ;.% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &; Ã	V1%!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4 # 3		+S +ST ,S+ ,ST /S+ /ST 0S 0ST RS RST TS		( )* " +T-,. ( )* " +T-/.			12 1" 1% 1% 1"- 1%	*' "1' $&Ã789Ã!;56Ã<7=>Ã9Ã@>A7E@ÃDE=>AFÃG?H=FÃ9ED> CE!K>8 ÃDE!K>8Ã1!;56Ã<7=>Ã9Ã?ED>ÃDE=>AFÃG?H=?DE=C>FÃ?H9Ã?@> 8?HÃ9Ã@>A7@Ã\E!J97N7Ã8:7=>J %Æ:>:Ã! ; 5 6Ã7=>Ã?Ã@>AÃB@ÃDE7=>AFÃMB>ÃCD:Ã@?9B>A GD!H=D>AODE=C>Ã?H9ÃAED?ÃCD:Ã<>7JFÃME:>:ÃE=AÃN?9ÃJ?@> CE!K>8 (>N?@7=CÃAED?ÃGD!H=D>A ÃDE!K>8Ã1!;56ÃH79Ã?@>Ã7=>JFÃÃMN>JÃ=> GD!H=GD!H=FÃ?@M89>8Ã?Ã@?A #?8>Ã>D@7= * ED<9ÃÃM9 Ã D?B=AHE9 À !"#$Ã%Ã&'$!' Ã&)!' *+",-.)	5 2	25 4ÃÃ19 19Ã- Q19	&?9JÃÃHE9>DÃ@ÃJÃ>JÃ?*>JÃ"79

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A-#+",-.:	&?9Ã2// /Ã)/+ [. Ã4T>JÃ ?EAÃ1 >DM>=9F=>	; <# !'":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#5	3V%!Q! *$: 31 $!*! ;%3	X!*3	53 '"#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &: Ã	V1%!ÃL2('&	1' $ÃO %UÃ2* 3 $!& Ã531% $ '"* $' ;	2'$1*V 3 %:; 5$$$:;	%L 1$!*3: 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S+ +ST ,S+ ,ST /S+ /ST 0S+ 0ST RS+ RST TS+		( )* " +[-.. ( )* " +[-/.			12 Ä% %$ %# %$ %#	*' "1' $ÃÃ789Ã!;56Ã<7=>Ã9Ã>A7E@ÃCDE=>AFÃG?!=FÃ9ED> CDEK>8 %ÆE >: ÃÄ !Q3& 6Ã8FÃ9Ã@A7E@ÃMEJ97NÃ9:7=JFÃC?H=ÃH?DIÃÆEP D>AÃGDH=ÃCDEK>ÆE9>DØN (>N?@?=CÃGDH=CDE=C>FÃ?=ND>EJ?=CÃME:>: Ã?=>JÃN?=9>=9 1E=A:Ã%&! L6Ã@>AB@Ã?Ã7CIÃMEJ9N9FÃCD: Ã@?9B>AÃAEDÃCD: F H?9ÃJ?@>ÃCDEK>8 * DE>ÃCDEK>8 1E=A:Ã%&! L6Ã@>AB@Ã?Ã7CIÃMEJ9N9FÃDE>ÃEK>ÃMB>ÃC : F H?9ÃAEDÃCD: ÃK>?=JFÃDE>ÃD?9IÃH?9ÃM?NP ÃA?=AEDÃGDH= %ÆE >: Ã1!;5FÃN?@M9>8Ã9Ã?CI 8ÃH>E D>A	2	25 19Ã- Q19 4ÃÃ19	
									#?8>Ã>D@?=E9 ÆS ST+Ã@ * EDG9Ã>M' ÃD?B=AH DÃ?9Ã=?B=9>D>A	X		

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Galt GEOTECHNICS

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A-#+",-.:	&?9Ã2// /Ã)/+ [. Ã4TÐ=JÃ ?EAÐÃ >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#!5	3V%!Q! *$; 31 $!*! ;%3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# $% &: Ã	V1%!ÃL2('&	1' $ÃO %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$1*V 3 %'; 5$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4		+S					12	*' "1' ÃÃ78Ã!;56Ã<7=>Ã9Ã@>A7ÃÃCDE=>AÃÃG?H=			
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Galt GEOTECHNICS

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			,S+ / ,ST		( )* " +]-/.			1%	%E:>: Ā! ; 56Ā7=>Ā9Ā@>AB@ĀCDE7=>AFMEB>ĀGDH=Ā@?99>AĀMEB> CD: ĀED?D>AFDE>ĀCEK>FĀ9?HĀ9Ā@>AB@ĀMEJ9N9 Ā7=>J	2	4ĀĀ9	
			/S+		( )* " +]-0.			1%- %$	%8E>: Ā1!;5ĀOĀ1EA Ā%& L6Ā<7Ā9Ā@>A7B@ĀCDE7=>AF HĀ9? @>AB@ĀMEJ9N9 FĀMEB>ĀCD: Ā@?99>AĀGDH=ĀED?D>A			
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Galt GEOTECHNICS

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?' -@#":	" D?M?J>AÃ\ >HÃ5E@J	&0!'+"-':	19>K>Ã5 : JE19	9$!# !4Ã 6+"!:	+/O+T0+,\
A-#+",-.:	&?9Z// /Ã)/+ [. Ã4T>JÃ ?EAPÃ1 >DM>=9F=>	; <# !":	[++Ã@@Ã*??9 >A	9$!# !4Ã ; B:	4! 5

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23*#!5	3V%!Q! *$; 31 $!*! ;.% 3	X!*3	53 "*#)@>9D>J.	DEPTH &	1!2 "& 3Ã 4$3&5Ã*31*	3 %!Q3 35	À !"# &: Ã $%	V1%!ÃL2('&	1' $&O %UÃ2* 3 $!& Ã531% $ "* $' ;	2'$!*V 3 %'; 5$$$;	%L 1$!*3; 53 ;1 $*L	1* V%* V 3Ã ! ;5 !55$ * $;!& '(13 Q!* $;1
3	4 # 3		+S +S ,S+ ,ST /S+ /ST 0S 0ST RS RST TS				12 1" 1% 1% 1%	*' "1' $&Ã78Ã!;56Ã<7=>Ã9Ã@>A7B@ÃCDE7=>AFÃG?H=FÃH7DIÃ?@>CDEK>ÃH7DÃJ?@>Ã?9J ÀDEK>8Ã1!;56Ã<7=>Ã9Ã@>A7B@ÃCDE7=>AFÃG?H=FÃH7DIÃ?@>Ã<7=>JF 9DE>Ã?9J %ÃE:>:Ã! ; 5ÃÃ7=>ÃP?Ã@>AB@ÃCDE7=>AFÃH7DÃJ?@>ÃCDEK>ÃGDH=F 8?HÃ9?Ã@>A7B@ÃMEJ9?N7Ã&7=>J (>N?@7=CÃMB>ÃGDH= (>N?@7=CÃMB>ÃCD: 0MB>ÃGDH= %ÃE:>:Ã! ; 5ÃÃ7=>ÃP?Ã@>AB@ÃCDE7=>AFÃP?HÃP?Ã@>AB@ÃMBJ9?N9 F MB>ÃCD: Ã@?9B>AÃGDH=FÃN?@?89>8Ã!>E9> D>AÃD?NP (>N?@7=CÃGDH=ÃÃAEDÃD>AÃCD:	2	25 4ÃÃ19	
									# ?8>A>D@7=E9>AÃE9ÃS+Ã@ * EDC9ÃA%9 ÄD?B=AHE9>DÃ?9Ã>N?B=>D>A				

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Appendix E: Laboratory Test Results

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UNIT 4, 96 BROOG ST, WELSHPOOL, WA 6106 LIQUIDLABSWA.COM.AU

Moisture Content Test Report		Test Method: AS 1289.2.1.1	
Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dam	**Report No:**	LLS17/717-726_1
Project Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/717-726
Sample Identification:	See below	**Issue Date:**	19/04/2017
Sampling Procedure:	Tested as received		

Sample Number	Sample ID	Date Tested	Moisture Content (%)
LLS17/717	TP04 4.0-4.4m	13/04/2017	**62.8**
LLS17/718	TP06 0.6-1.0m	13/04/2017	**15.5**
LLS17/719	TP08 1.4-1.8m	13/04/2017	**17.7**
LLS17/720	TP14 1.0-1.4m	13/04/2017	**18.5**
LLS17/721	TP18 0.4-0.6m	13/04/2017	**12.1**
LLS17/722	TP20 0.6-0.8m	12/04/2017	**16.0**
LLS17/723	TP25 2.0-2.5m	12/04/2017	**42.8**
LLS17/724	TP28 0.8-1.0m	12/04/2017	**14.8**
LLS17/725	TP32 1.4-1.8m	12/04/2017	**16.6**
LLS17/726	TP34 2.0-2.4m	12/04/2017	**23.5**

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

Comments:

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Approved Signature:
Name: Matt van Herk
Function: Laboratory Manager
Date: 19-April-2017

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Emerson Class Number Test Report		Test Method: AS 1289.3.8.1	
Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dam	**Report No:**	LLS17/717-726_1
Project Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/717-726
Sample Identification:	See below	**Issue Date:**	19/04/2017
Sampling Procedure:	Tested as received		

Sample Number	Sample ID	Date Tested	Emerson Class Number
LLS17/717	TP04 4.0-4.4m	18/04/2017	**2**
LLS17/718	TP06 0.6-1.0m	18/04/2017	**5**
LLS17/719	TP08 1.4-1.8m	18/04/2017	**5**
LLS17/720	TP14 1.0-1.4m	18/04/2017	**6**
LLS17/721	TP18 0.4-0.6m	18/04/2017	**5**
LLS17/722	TP20 0.6-0.8m	18/04/2017	**5**
LLS17/723	TP25 2.0-2.5m	18/04/2017	**5**
LLS17/724	TP28 0.8-1.0m	18/04/2017	**5**
LLS17/725	TP32 1.4-1.8m	18/04/2017	**5**
LLS17/726	TP34 2.0-2.4m	18/04/2017	**6**

Client Address: 4/15 Walters Dr, Osborne Park, WA 6017

Comments:

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Function: Laboratory Manager
Date: 19-April-2017

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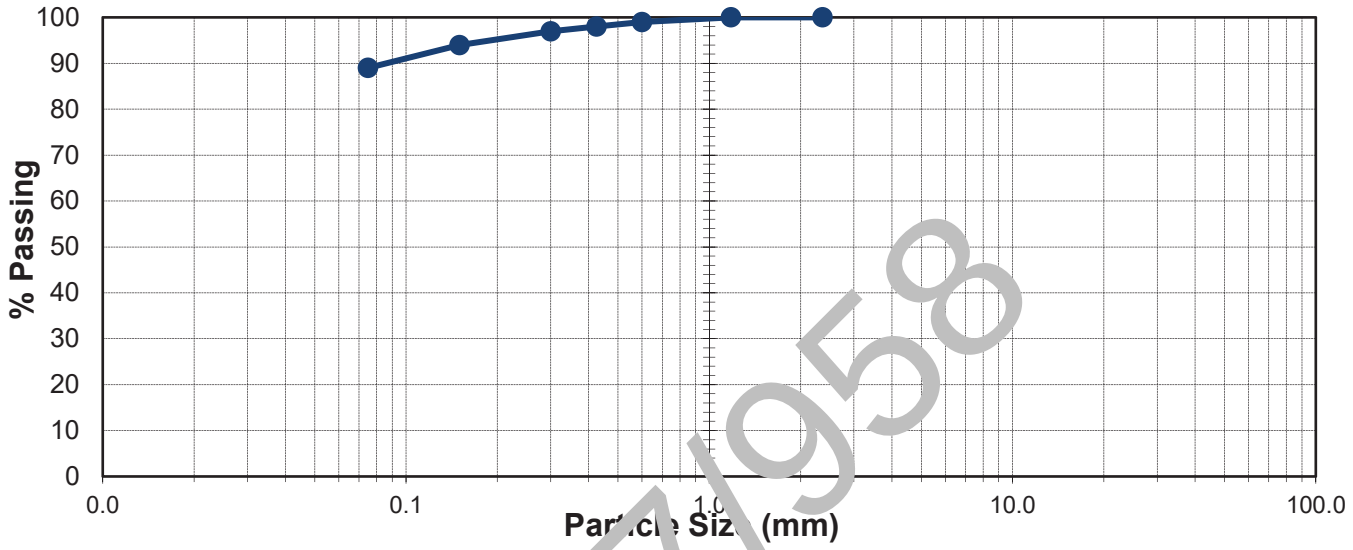
UNIT 4, 96 BRIGG ST, WELSHPOOL, WA 6106 LIQUIDLABSWA.COM.AU

Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/717_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/717
Sample ID:	TP04 4.0-4.4m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	**AS 1289.3.6.1**
Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	99
0.425	98
0.300	97
0.150	94
0.075	89

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	**89**	%
Plastic Limit 3.2.1	**26**	%
Plasticity Index 3.3.1	**63**	%
Linear Shrinkage 3.4.1	**19.0**	%
Cracked	☑	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

Comments:

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Function Laboratory Manager
Date: 19-April-2017

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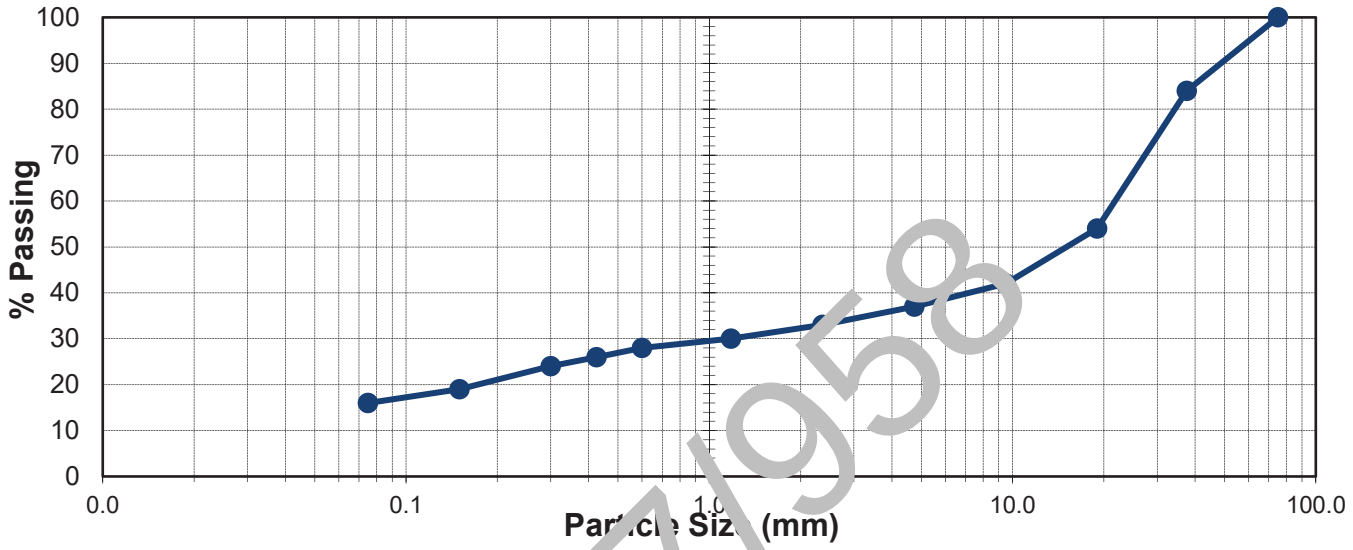
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/718_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/718
Sample ID:	TP06 0.6-1.0m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	100
37.5	84
19.0	54
9.5	[illegible]
4.75	3[illegible]
2.36	33
1.18	30
0.600	28
0.425	26
0.300	24
0.150	19
0.075	16

Atterberg Limits Tests AS 1289

Liquid Limit 3.1.1	44	%
Plastic Limit 3.2.1	23	%
Plasticity Index 3.3.1	21	%
Linear Shrinkage 3.4.1	7.0	%
Cracked	☐	
Curled	☐	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

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Name: Matt van Herk
Function Laboratory Manager
Date: 19-April-2017

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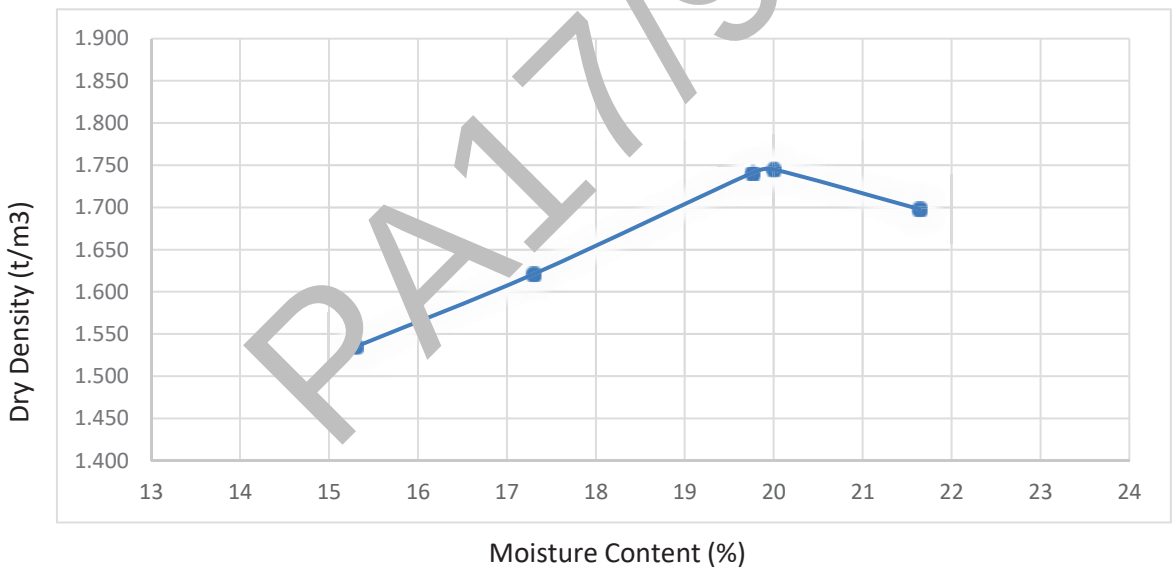
Standard Maximum Dry Density Report — Test Method: AS 1289.5.1.1

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/718_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/718
Sample ID:	TP06 0.6-1.0m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	1.745	t/m^3
Optimum Moisture Content	20.0	%
Curing Period	48	hrs

Moisture	15.3	17.3	19.8	20.0	21.6
Dry Density	1.535	1.621	1.741	1.745	1.698



Client Address: 4/15 Walters Dr, Osborne Park, WA 6017

Comments:

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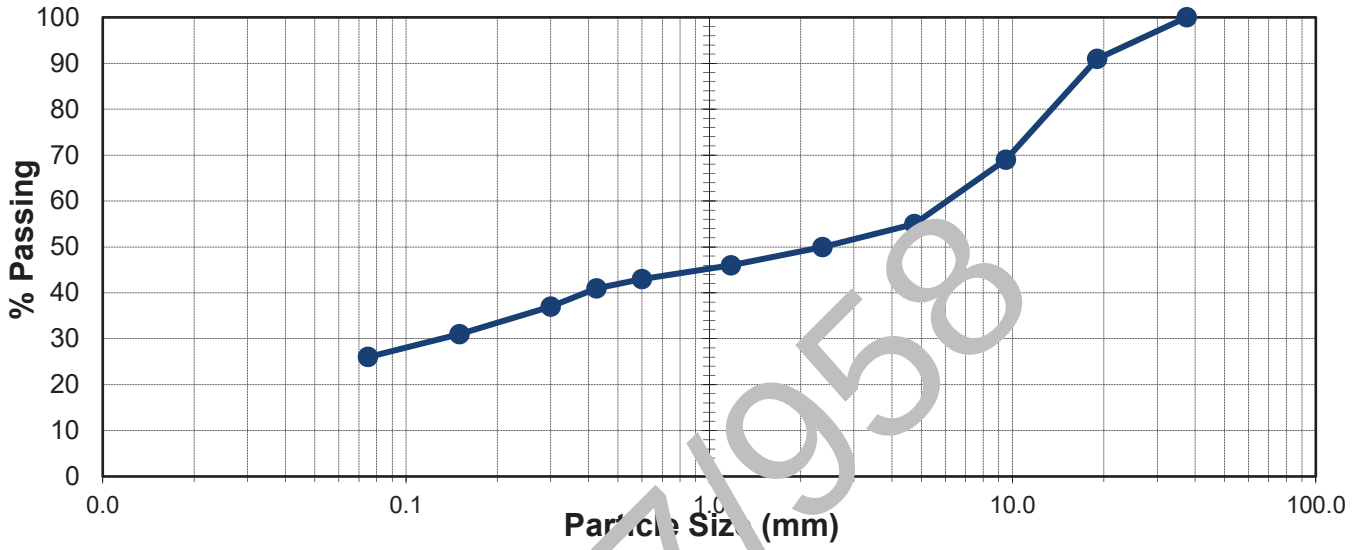
Name: Matt van Herk
Function: Laboratory Manager
Date: 26-April-2017

LIQUIDLABSWA
CONSTRUCTION MATERIALS TESTING LABORATORY
UNIT 4, 96 BRIGG ST, WELSHPOOL, WA 6106 LIQUIDLABSWA.COM.AU

Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/719_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/719
Sample ID:	TP08 1.4-1.8m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	91
9.5	[illegible]
4.75	[illegible]
2.36	50
1.18	[illegible]
0.600	43
0.425	41
0.300	37
0.150	31
0.075	26

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	53	%
Plastic Limit 3.2.1	28	%
Plasticity Index 3.3.1	25	%
Linear Shrinkage 3.4.1	6.0	%
Cracked	☐	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

Comments:

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Testing Accreditation No. 19872

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Approved Signature:
Name: Matt van Herk
Function Laboratory Manager
Date: 19-April-2017

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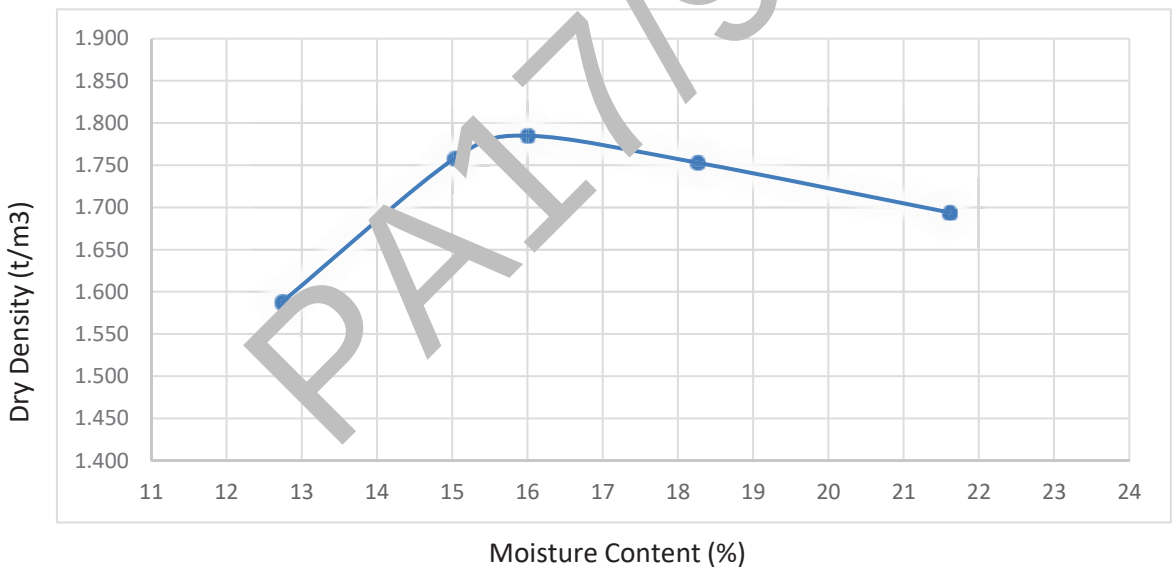
Standard Maximum Dry Density Report		Test Method: AS 1289.5.1.1	
Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/719_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/719
Sample ID:	TP08 1.4-1.8m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	1.785	t/m^3
Optimum Moisture Content	16.0	%
Curing Period	48	hrs

Moisture	12.7	15.0	16.0	18.3	21.6
Dry Density	1.588	1.758	1.785	1.753	1.694



Client Address: 4/15 Walters Dr, Osborne Park, WA 6017

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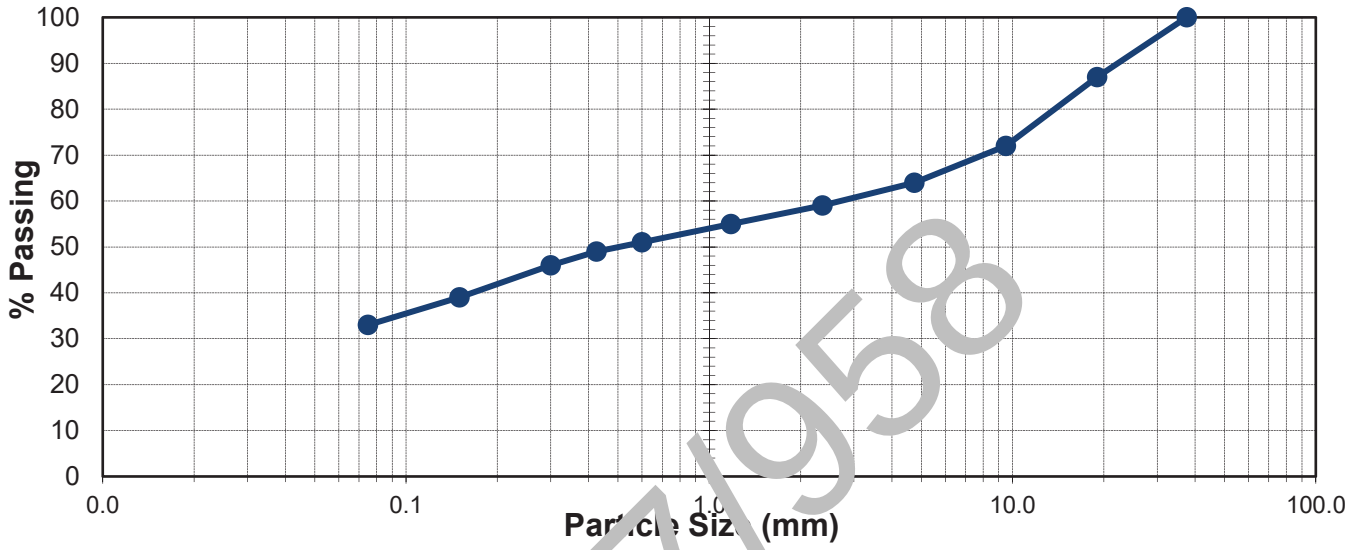
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/720_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/720
Sample ID:	TP14 1.0-1.4m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	100
19.0	87
9.5	[illegible]
4.75	6[illegible]
2.36	59
1.18	55
0.600	51
0.425	49
0.300	46
0.150	39
0.075	33

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	61	%
Plastic Limit 3.2.1	32	%
Plasticity Index 3.3.1	29	%
Linear Shrinkage 3.4.1	11.0	%
Cracked	☐	
Curled	☐	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

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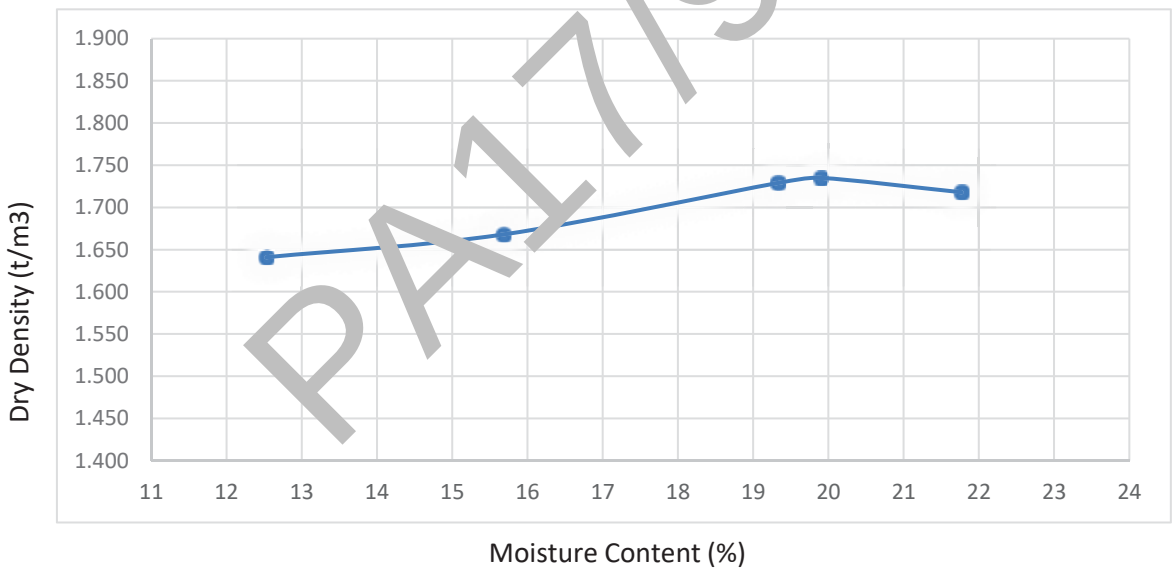
Standard Maximum Dry Density Report — Test Method: AS 1289.5.1.1

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/720_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/720
Sample ID:	TP14 1.0-1.4m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	1.735	t/m^3
Optimum Moisture Content	19.9	%
Curing Period	48	hrs

Moisture	12.5	15.7	19.3	19.9	21.8
Dry Density	1.641	1.668	1.729	1.735	1.718



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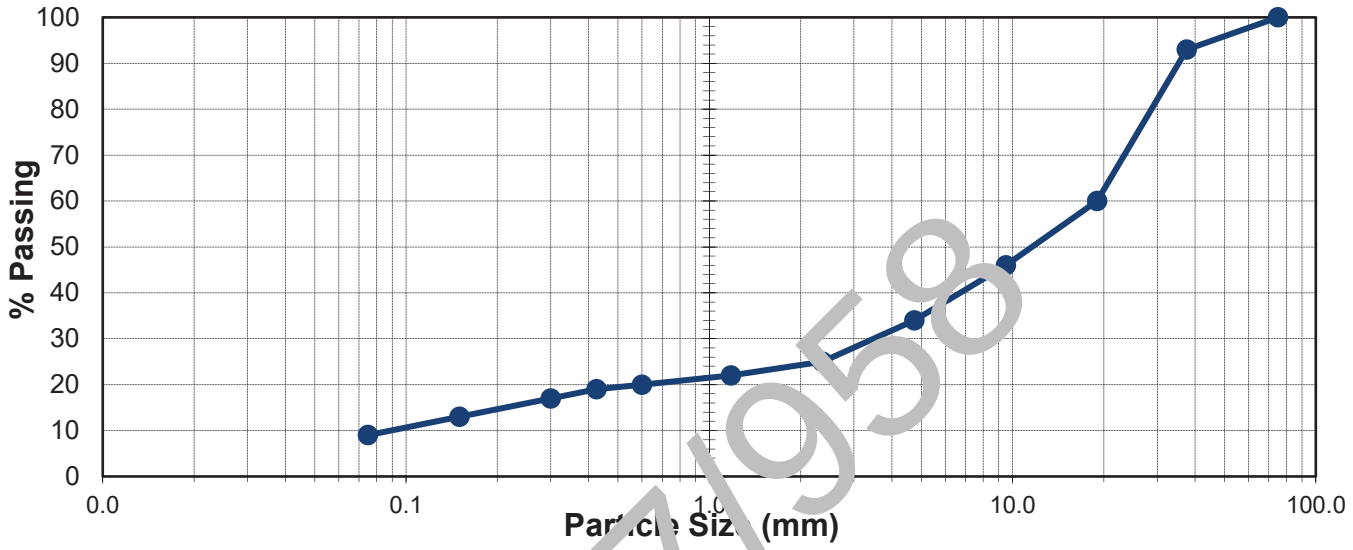
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/721_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/721
Sample ID:	TP18 0.4-0.6m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	100
37.5	93
19.0	60
9.5	[illegible]
4.75	[illegible]
2.36	25
1.18	[illegible]
0.600	20
0.425	19
0.300	17
0.150	13
0.075	9

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	39	%
Plastic Limit 3.2.1	21	%
Plasticity Index 3.3.1	18	%
Linear Shrinkage 3.4.1	6.5	%
Cracked	☑	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

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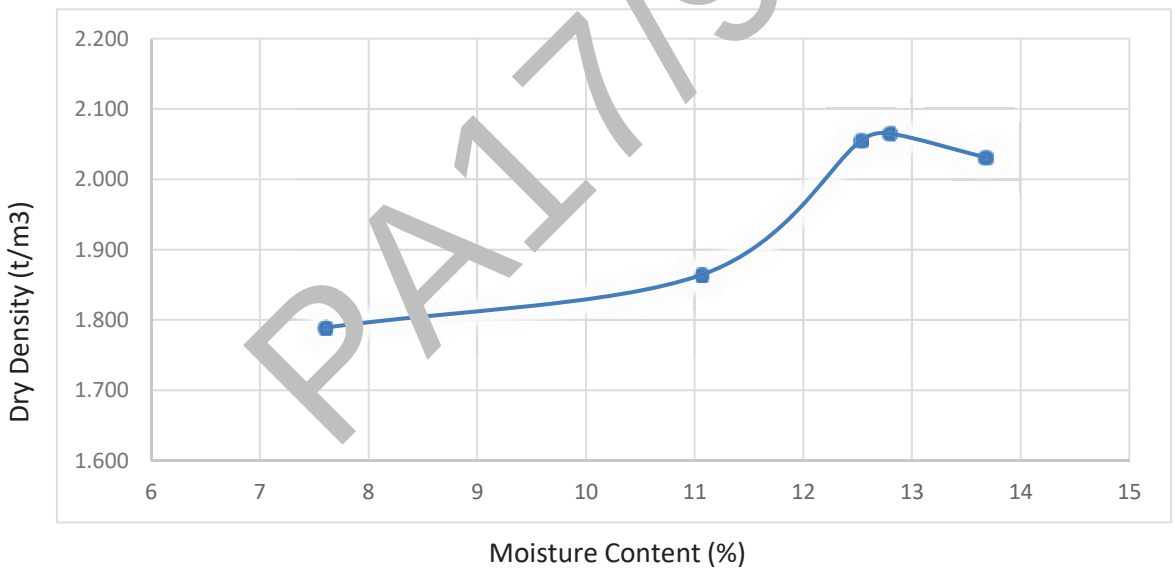
Standard Maximum Dry Density Report — Test Method: AS 1289.5.1.1

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/721_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/721
Sample ID:	TP18 0.4-0.6m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	2.065	t/m^3
Optimum Moisture Content	12.8	%
Curing Period	48	hrs

Moisture	7.6	11.1	12.5	12.8	13.7
Dry Density	1.789	1.864	2.055	2.065	2.031



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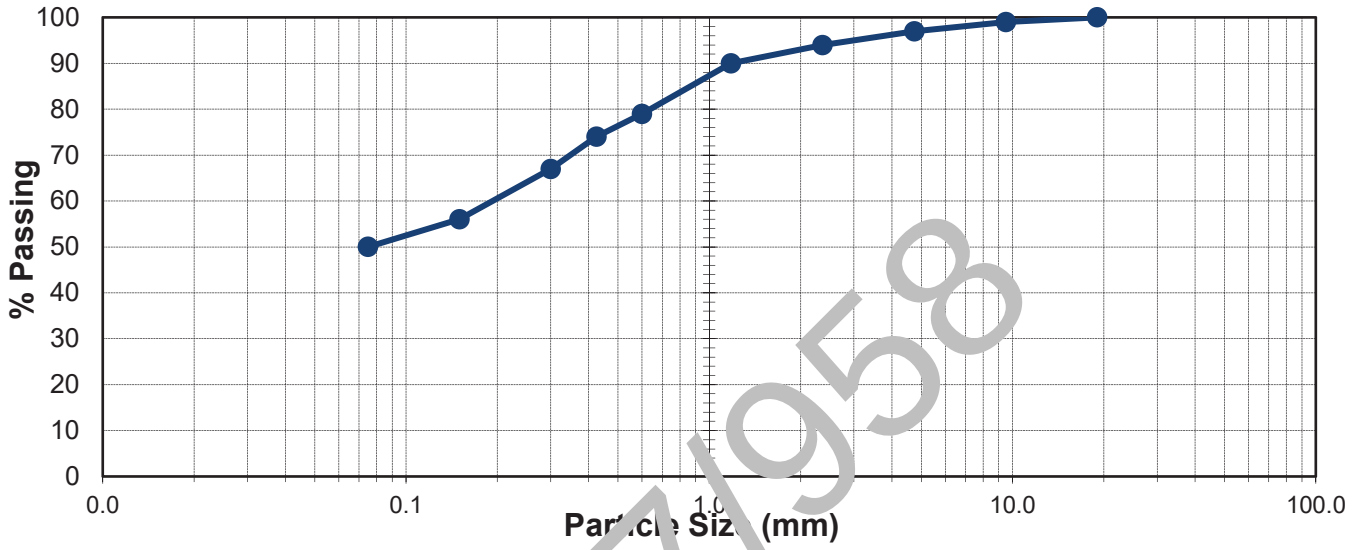
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/722_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/722
Sample ID:	TP20 0.6-0.8m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	[illegible]
4.75	9[illegible]
2.36	94
1.18	[illegible]0
0.600	79
0.425	74
0.300	67
0.150	56
0.075	50

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	58	%
Plastic Limit 3.2.1	16	%
Plasticity Index 3.3.1	42	%
Linear Shrinkage 3.4.1	10.0	%
Cracked	☑	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

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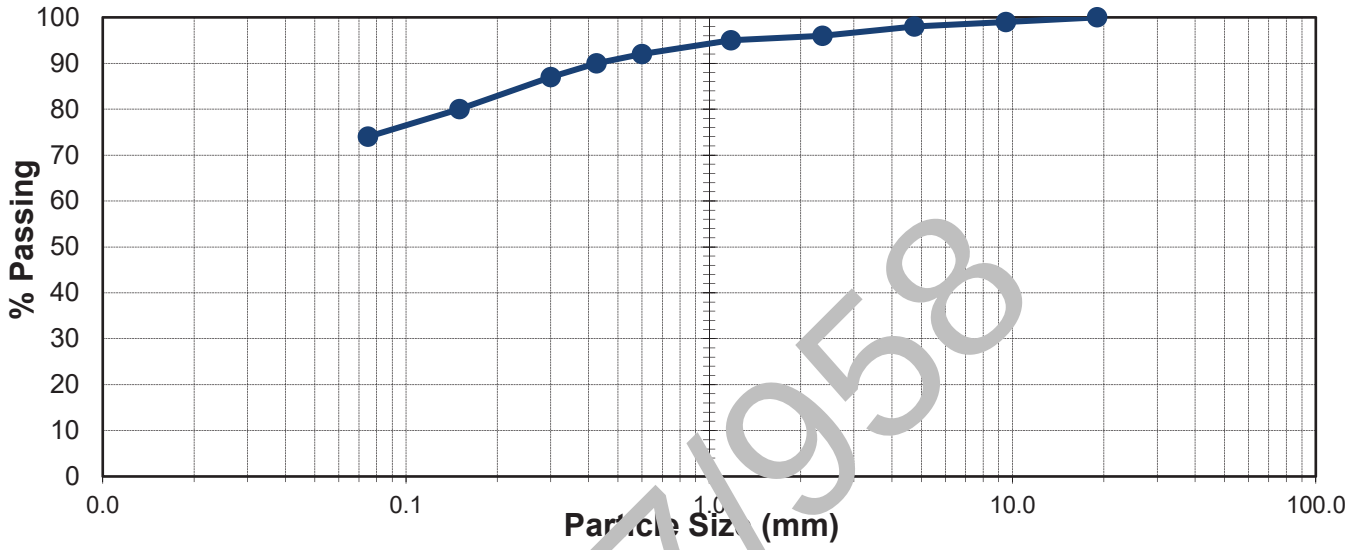
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/723_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/723
Sample ID:	TP25 2.0-2.5m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	[illegible]
4.75	[illegible]
2.36	96
1.18	[illegible]
0.600	92
0.425	90
0.300	87
0.150	80
0.075	74

Atterberg Limits Tests AS 1289

Liquid Limit 3.1.1	87	%
Plastic Limit 3.2.1	28	%
Plasticity Index 3.3.1	59	%
Linear Shrinkage 3.4.1	18.0	%
Cracked	☑	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

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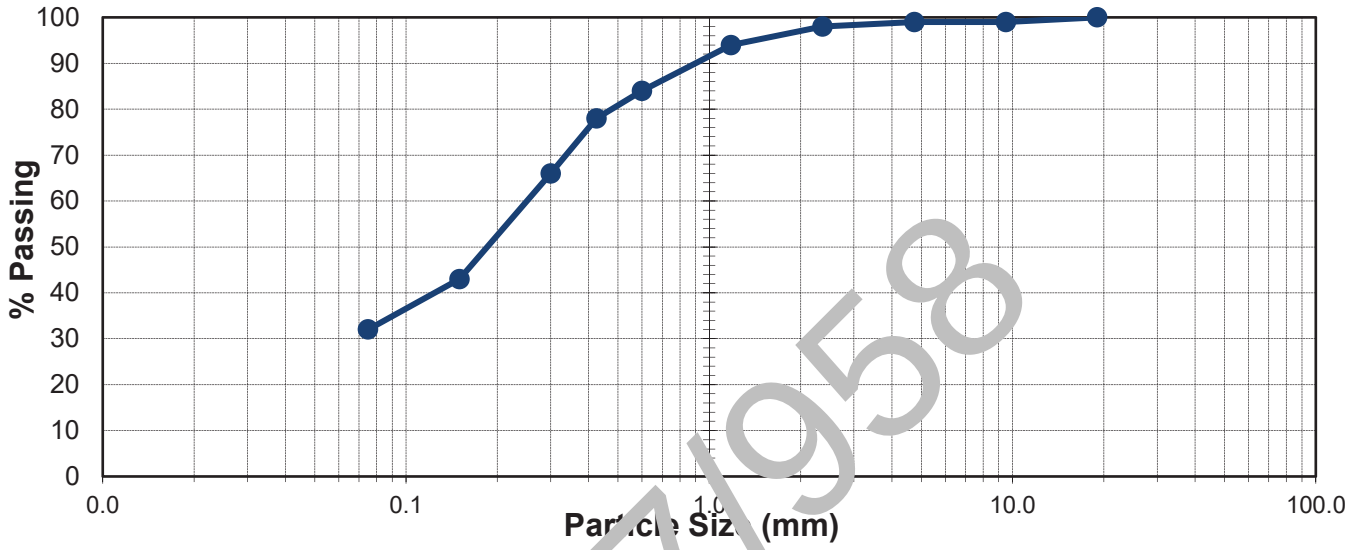
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/724_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/724
Sample ID:	TP28 0.8-1.0m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	100
9.5	[illegible]
4.75	9[illegible]
2.36	98
1.18	[illegible]4
0.600	84
0.425	78
0.300	66
0.150	43
0.075	32

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	27	%
Plastic Limit 3.2.1	15	%
Plasticity Index 3.3.1	12	%
Linear Shrinkage 3.4.1	5.0	%
Cracked	☐	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

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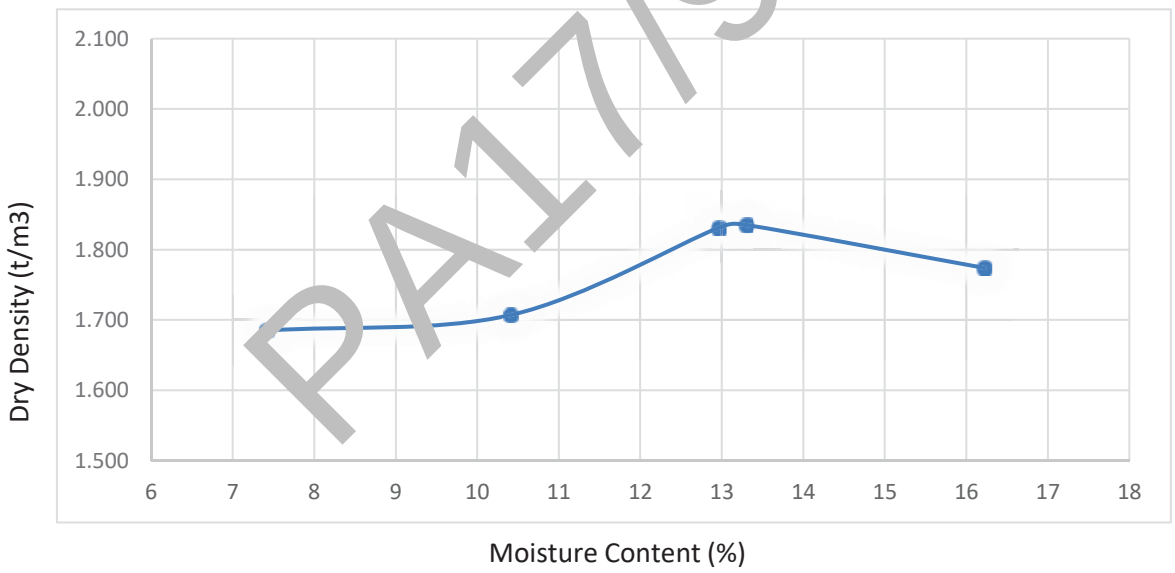
Standard Maximum Dry Density Report — Test Method: AS 1289.5.1.1

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/724_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/724
Sample ID:	TP28 0.8-1.0m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	1.835	t/m^3
Optimum Moisture Content	13.3	%
Curing Period	48	hrs

Moisture	7.4	10.4	13.0	13.3	16.2
Dry Density	1.685	1.707	1.831	1.835	1.774



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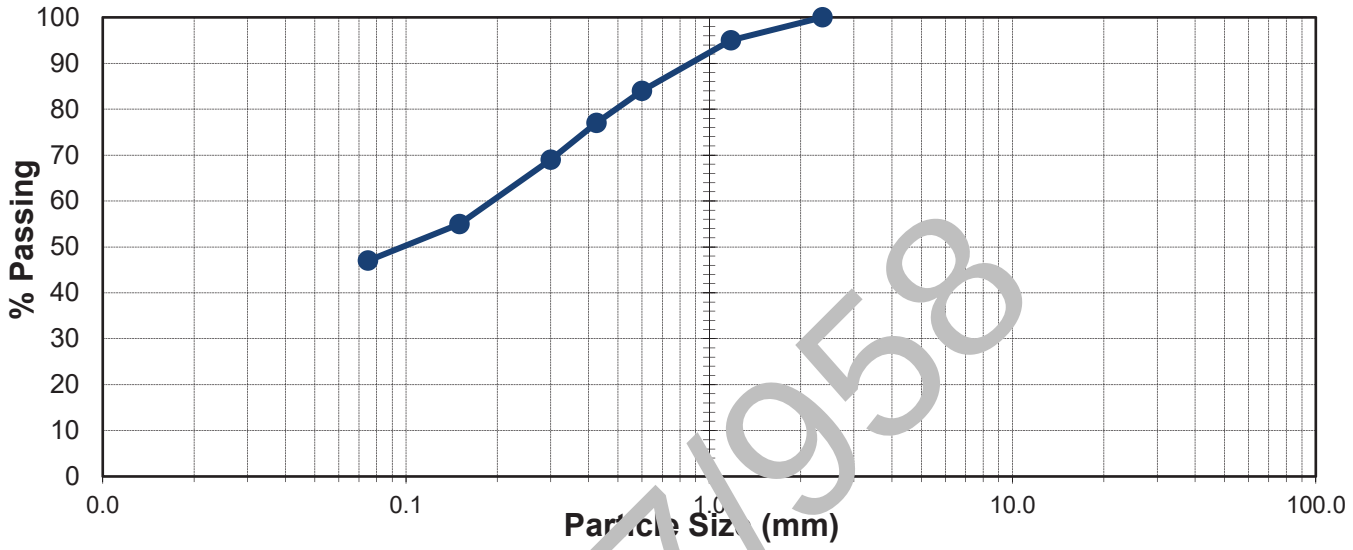
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/725_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/725
Sample ID:	TP32 1.4-1.8m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	95
0.600	84
0.425	77
0.300	69
0.150	55
0.075	47

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	37	%
Plastic Limit 3.2.1	17	%
Plasticity Index 3.3.1	20	%
Linear Shrinkage 3.4.1	7.0	%
Cracked	☐	
Curled	☐	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

Comments:

Approved Signature:

Name: Matt van Herk
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Date: 19-April-2017

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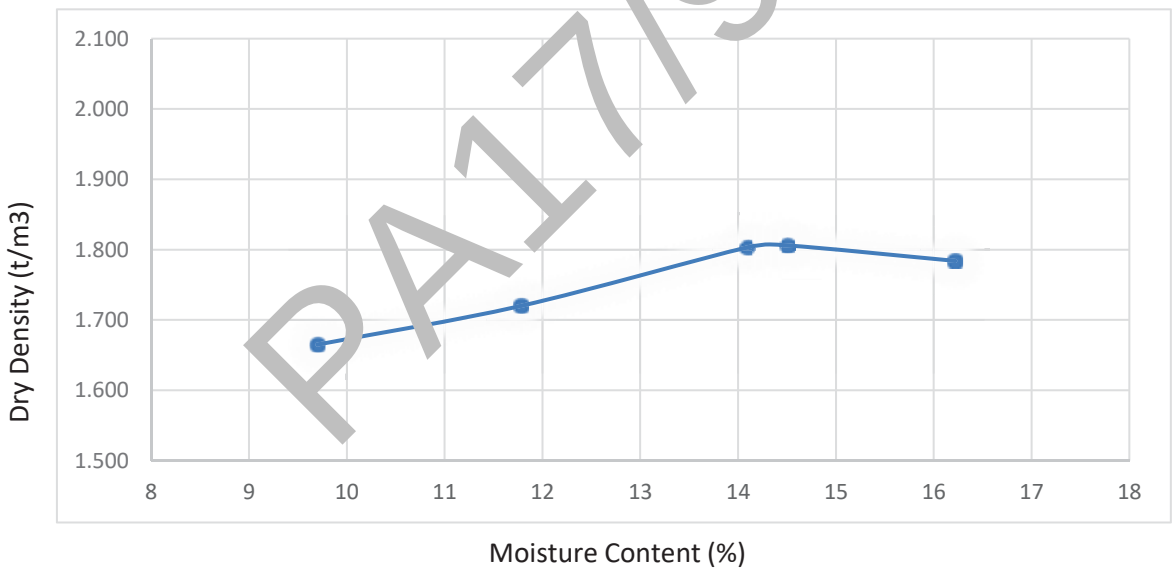
Standard Maximum Dry Density Report — Test Method: AS 1289.5.1.1

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/725_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/725
Sample ID:	TP32 1.4-1.8m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	1.806	t/m^3
Optimum Moisture Content	14.5	%
Curing Period	48	hrs

Moisture	9.7	11.8	14.1	14.5	16.2
Dry Density	1.665	1.720	1.803	1.806	1.784



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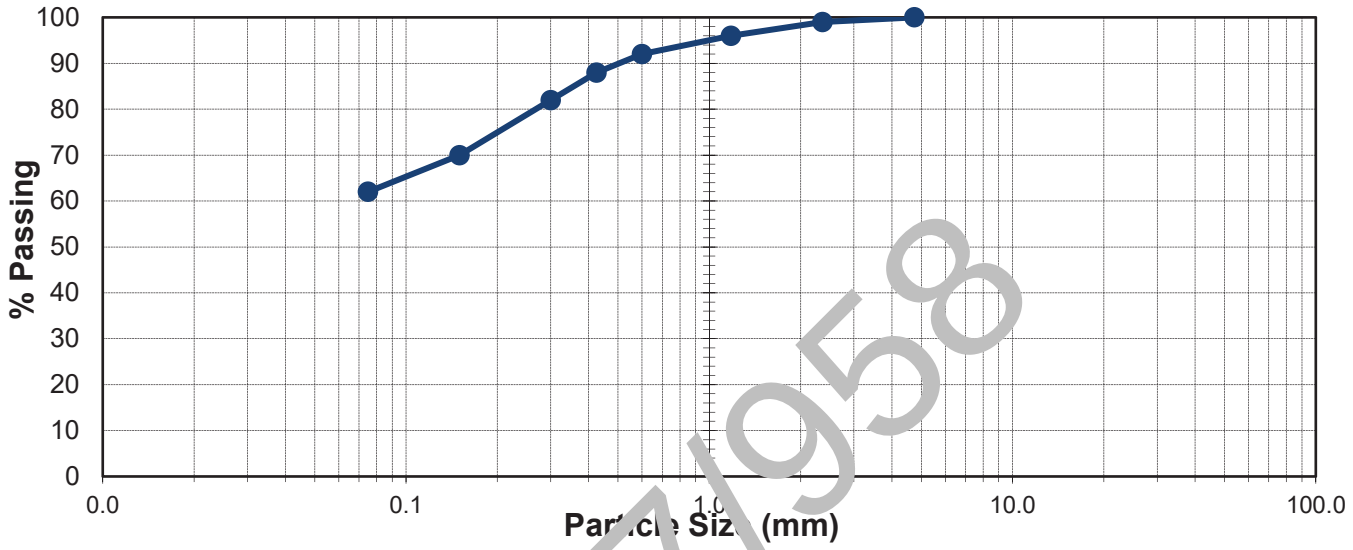
Particle Size Distribution & Atterberg Limits Test Report

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/726_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/726
Sample ID:	TP36 2.0-2.4m	**Issue Date:**	19-April-2017

Sampling Procedure: Tested as Received



SIEVE ANALYSIS	AS 1289.3.6.1
Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	100
2.36	99
1.18	96
0.600	92
0.425	88
0.300	82
0.150	70
0.075	62

Atterberg Limits Tests AS 1289		
Liquid Limit 3.1.1	61	%
Plastic Limit 3.2.1	33	%
Plasticity Index 3.3.1	28	%
Linear Shrinkage 3.4.1	10.5	%
Cracked	☑	
Curled	☑	

Client Address: 4/15 Walters Dr, Osborne Park WA 6017

Comments:

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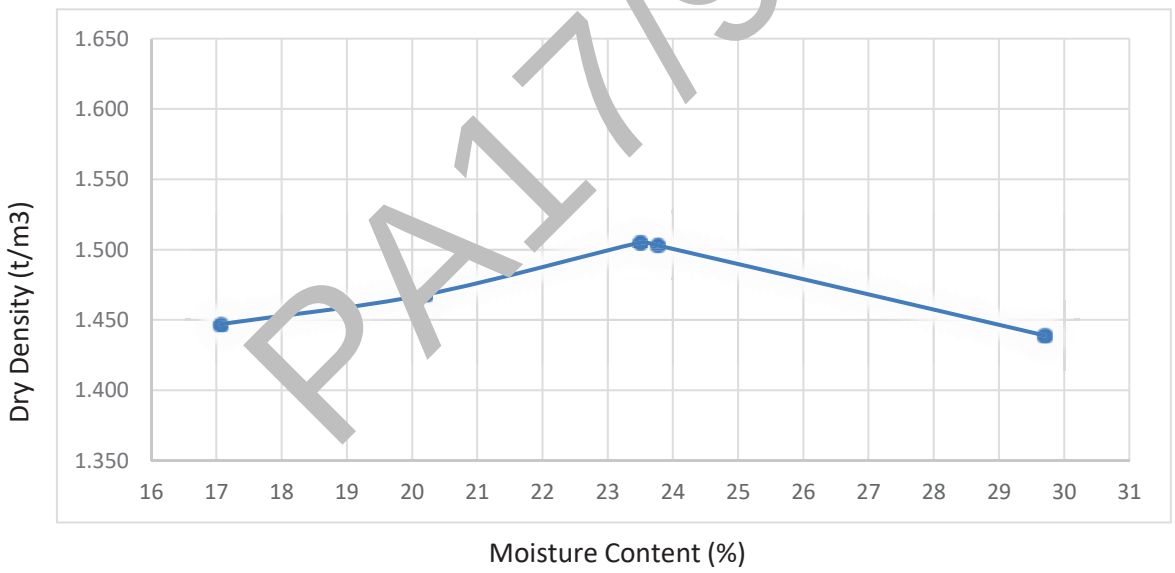
Standard Maximum Dry Density Report — Test Method: AS 1289.5.1.1

Client:	Galt Geotechnics	**Ticket No:**	S433
Project:	Proposed New Dams	**Report No:**	LLS17/726_1
Location:	Lot 822 (206) Firns Road, Serpentine	**Sample No:**	LLS17/726
Sample ID:	TP36 2.0-2.4m	**Issue Date:**	26-April-2017

Sampling Procedure: Tested as Received

Standard Maximum Dry Density	1.505	t/m^3
Optimum Moisture Content	23.5	%
Curing Period	48	hrs

Moisture	17.1	20.2	23.5	23.8	29.7
Dry Density	1.447	1.468	1.505	1.503	1.439



Client Address: 4/15 Walters Dr, Osborne Park, WA 6017

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Perth
Unit 3, 34 Sphinx Way
Bibra Lake
WA, 6163
Ph: (08) 9418 8742
E-mail: Phillip.li@eprecisionlab.com
Mob: 0422 814 231

E-Precision Laboratory

MULTI-STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST

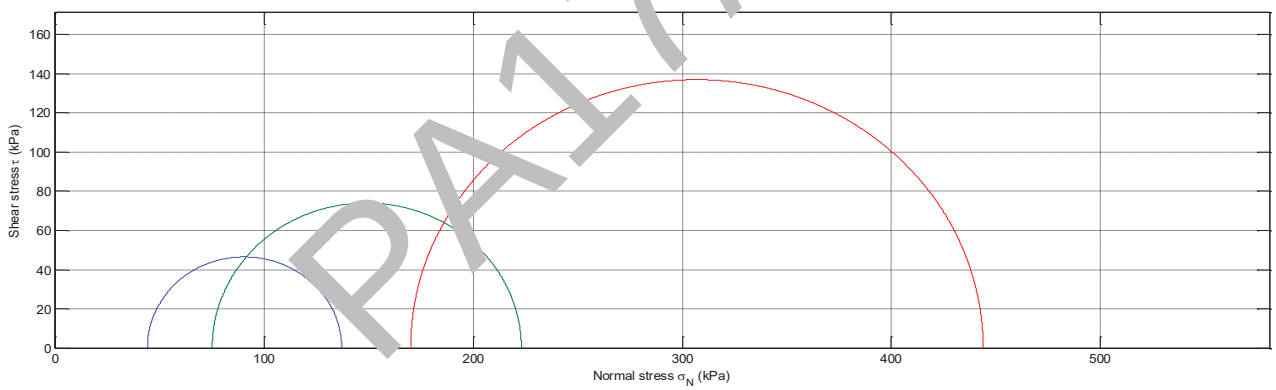
Method: AS1289.6.4.2 / In-house Method

Client:	Liquid Labs WA	Date Tested:	4/05/2017
Project:	Proposed New Dams	EP Lab Job Number:	LLABS
Sample No:	LLS17/725 TP32 (1.40-1.80)	Lab:	EPLab
Sample ID:	LLS17_725_CU3		
Depth (m):	1.40 - 1.80	Room Temperature at Test:	~ 18°c

Tested by:	PHIL	Initial Moisture (%):	14.59	Strain Rate (mm/min):	0.0055
Height (mm):	125.44	Final Moisture (%):	12.06	Skempton's (B):	0.99
Diameter (mm):	61.82	Bulk Density (t/m³):	1.97	Geology:	-
L/D Ratio:	2.03	Dry Density (t/m³):	1.72		

Failure Criteria used: Peak Principle Stress Rat...

Mohr Circle Diagram



Interpretations conducted using Matlab

Interpretation from Mohr Circle:	Stage 1 & 2	Stage 1 & 3	Stage 2 & 3
Cohesion C' (kPa):	4.48	9.54	15.91
Angle of Shear Resistance Φ' (Degrees) :	28.06	24.70	23.51

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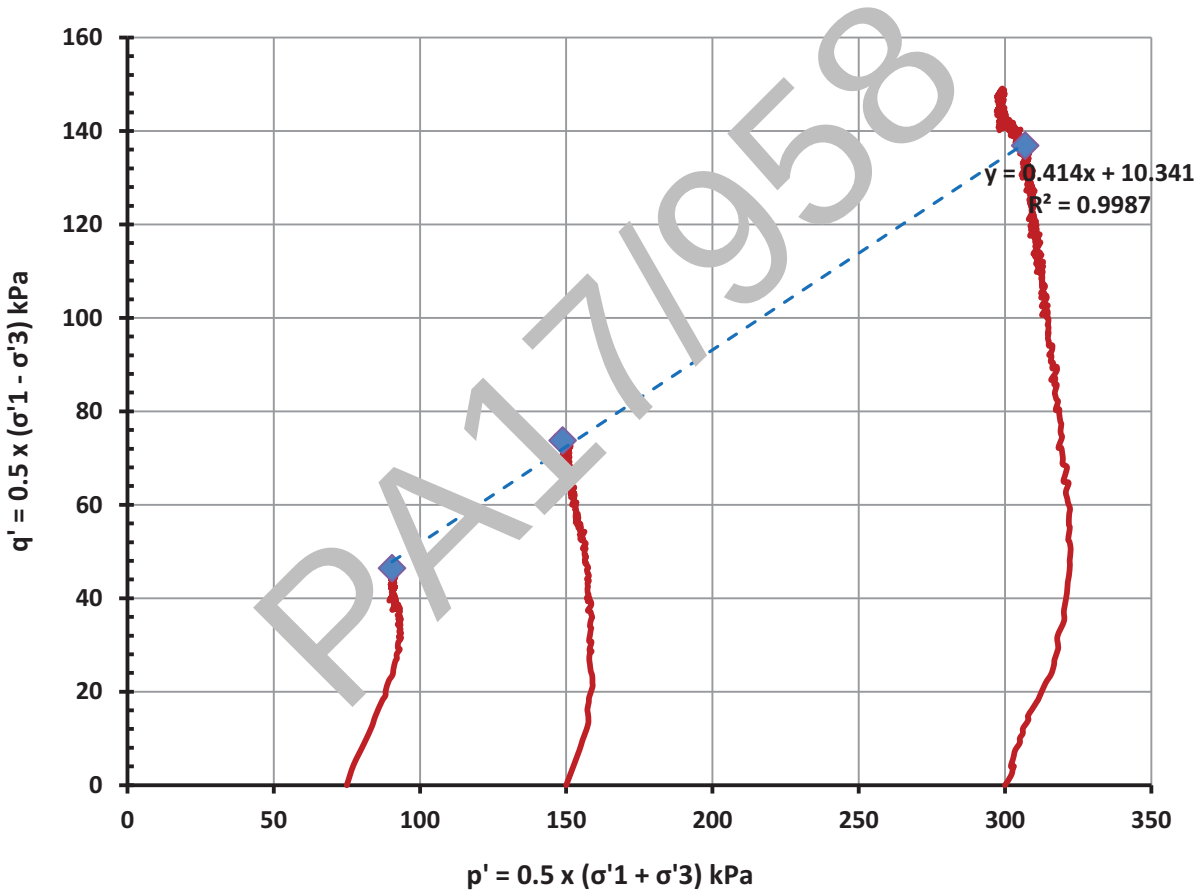
E-Precision Laboratory

MULTI-STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST

Method: AS1289.6.4.2 / In-house Method

Client:	Liquid Labs WA	Date Tested:	4/05/2017
Project:	Proposed New Dams	EP Lab Job Number:	LLABS
Sample No:	LLS17/725 TP32 (1.40-1.80)	Lab:	EPLab
Sample ID:	LLS17_725_CU3		
Depth (m):	1.40 - 1.80	Room Temperature at Test:	~ 18°C

MIT Effective Stress Path (q' vs p' diagram)



MIT Stress Path - Using Stress Path Tangency Method

Cohesion C' (kPa) :	**11.36**
Angle of Shear Resistance Φ' (Deg) :	**24.46**

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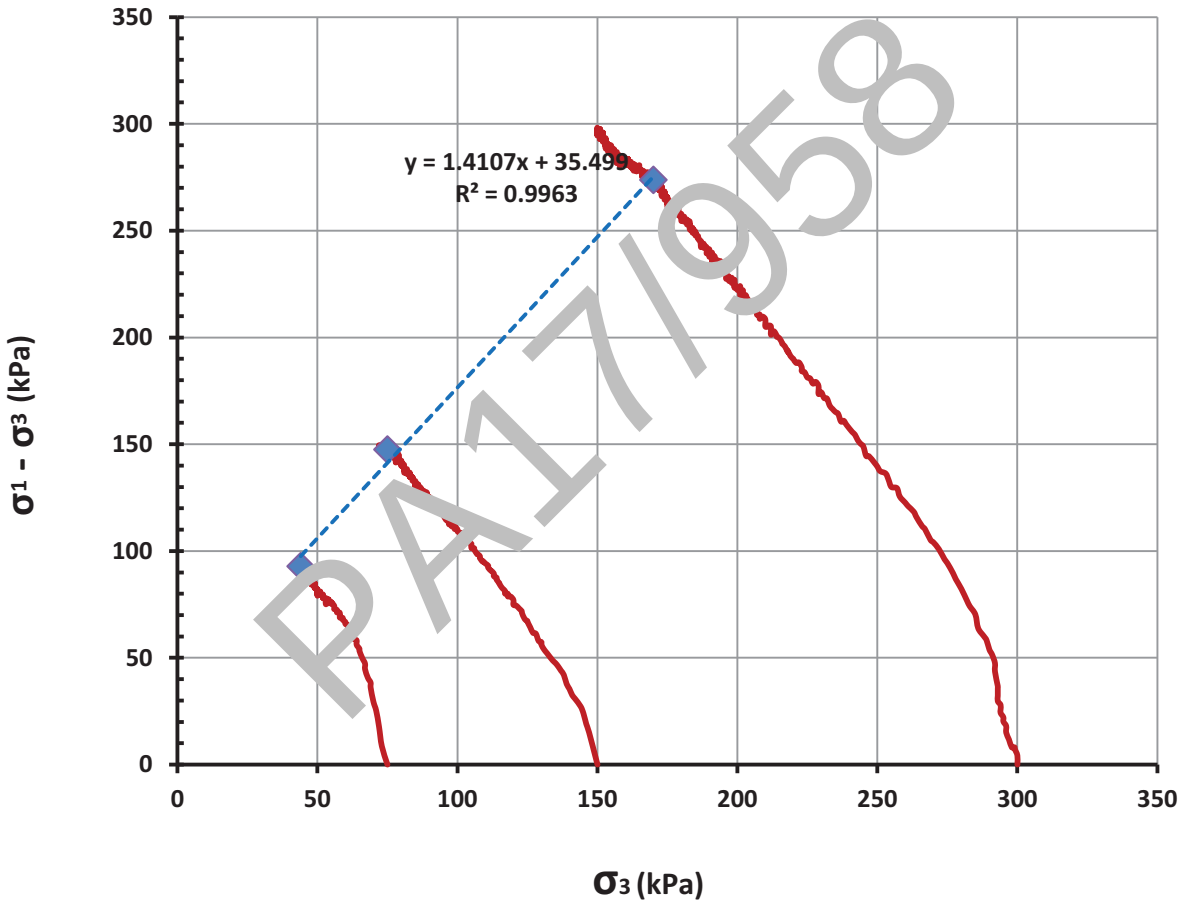
Method: AS1289.6.4.2 / In-house Method

Client:	Liquid Labs WA	Date Tested:	4/05/2017
Project:	Proposed New Dams	EP Lab Job Number:	LLABS
Sample No:	LLS17/725 TP32 (1.40-1.80)	Lab:	EPLab
Sample ID:	LLS17_725_CU3		
Depth (m):	1.40 - 1.80	Room Temperature at Test:	~ 18°C

Modified Mohr Coulomb Stress Path



Modified Mohr Coulomb Path - Using Stress Path Tangency Method

Cohesion C' (kPa) :	**11.43**
Angle of Shear Resistance Φ' (Deg) :	**24.44**

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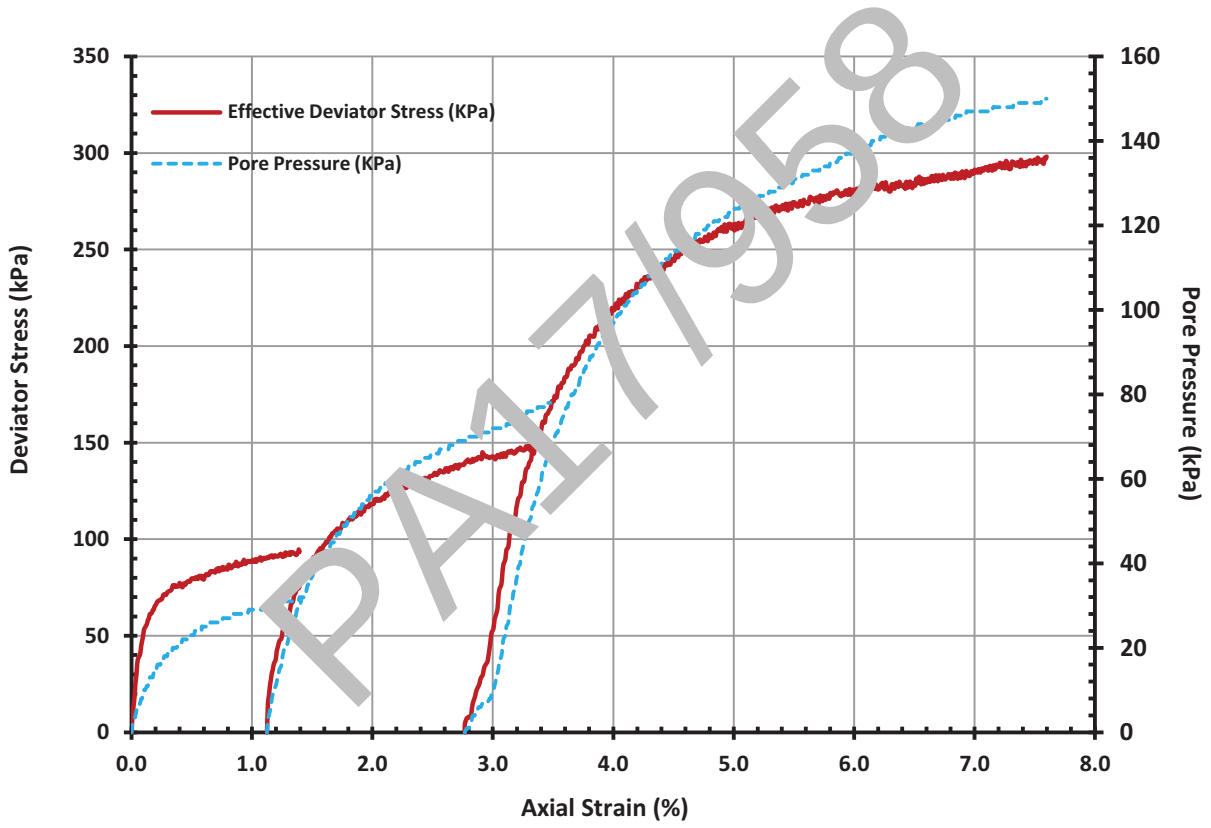
MULTI-STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST

Method: AS1289.6.4.2 / In-house Method

Client:	Liquid Labs WA	Date Tested:	4/05/2017
Project:	Proposed New Dams	EP Lab Job Number:	LLABS
Sample No:	LLS17/725 TP32 (1.40-1.80)	Lab:	EPLab
Sample ID:	LLS17_725_CU3		
Depth (m):	1.40 - 1.80	Room Temperature at Test:	~ 18°C

Deviator Stress Vs Strain Diagram



SHEAR STAGE DATA AND STRESS MEASUREMENTS (kPa)

Shear Stage	Confining Pressure	U'0	U'f	Principal Effective Stresses			σ'1 - σ'3	Strain (%)
				σ'1	σ'3	σ'1 / σ'3		
1	75	0	31	137	44	3.11	93	1.28
2	150	0	75	223	75	2.97	148	3.23
3	300	0	130	444	170	2.61	274	5.43

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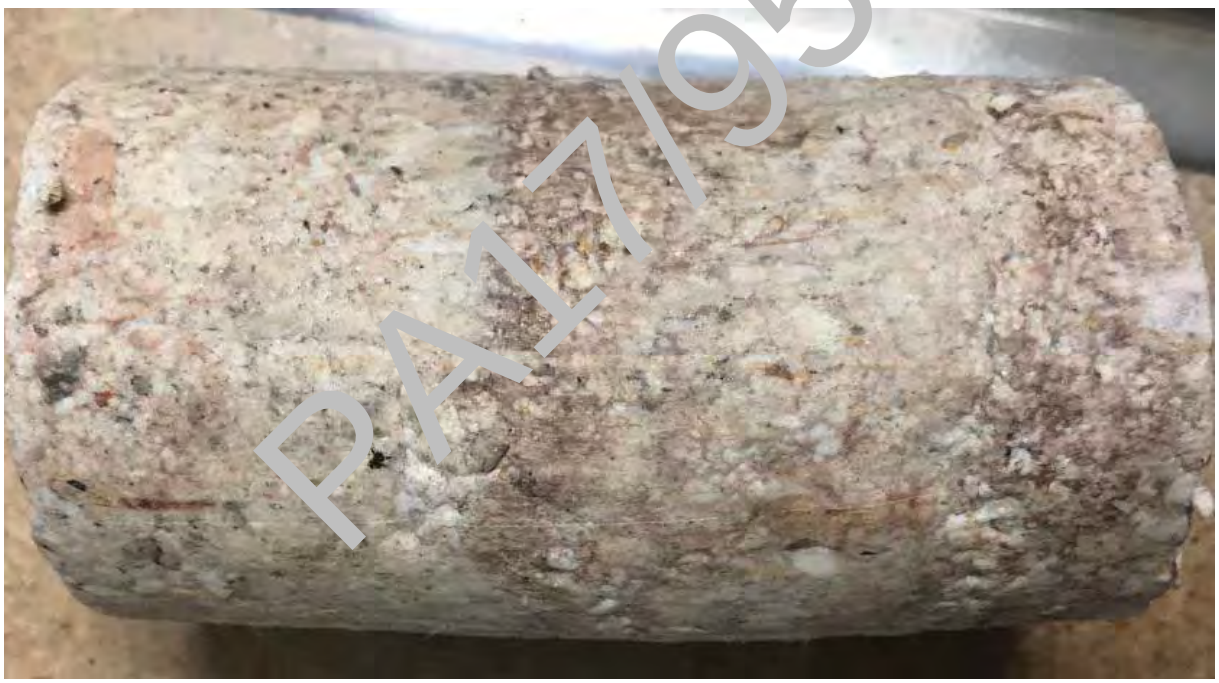
MULTI-STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST

Method: AS1289.6.4.2 / In-house Method

Client:	Liquid Labs WA	Date Tested:	4/05/2017
Project:	Proposed New Dams	EP Lab Job Number:	LLABS
Sample No:	LLS17/725 TP32 (1.40-1.80)	Lab:	EPLab
Sample ID:	LLS17_725_CU3		
Depth (m):	1.40 - 1.80	Room Temperature at Test:	~ 18°C

Photo After Test

Sample ID: LLS17/725 TP32 (1.40-1.80) **Depth (m)** 1.40 - 1.80
Lab ID: LLS17_725_CU3 **Date Tested:** 4/05/2017



Failure Mode: Bulging Failure

Notes:
Stored and Tested the Sample as received
Samples supplied by the Client

NATA: 19078

Authorised Signatory (Geotechnical Engineer):

NATA

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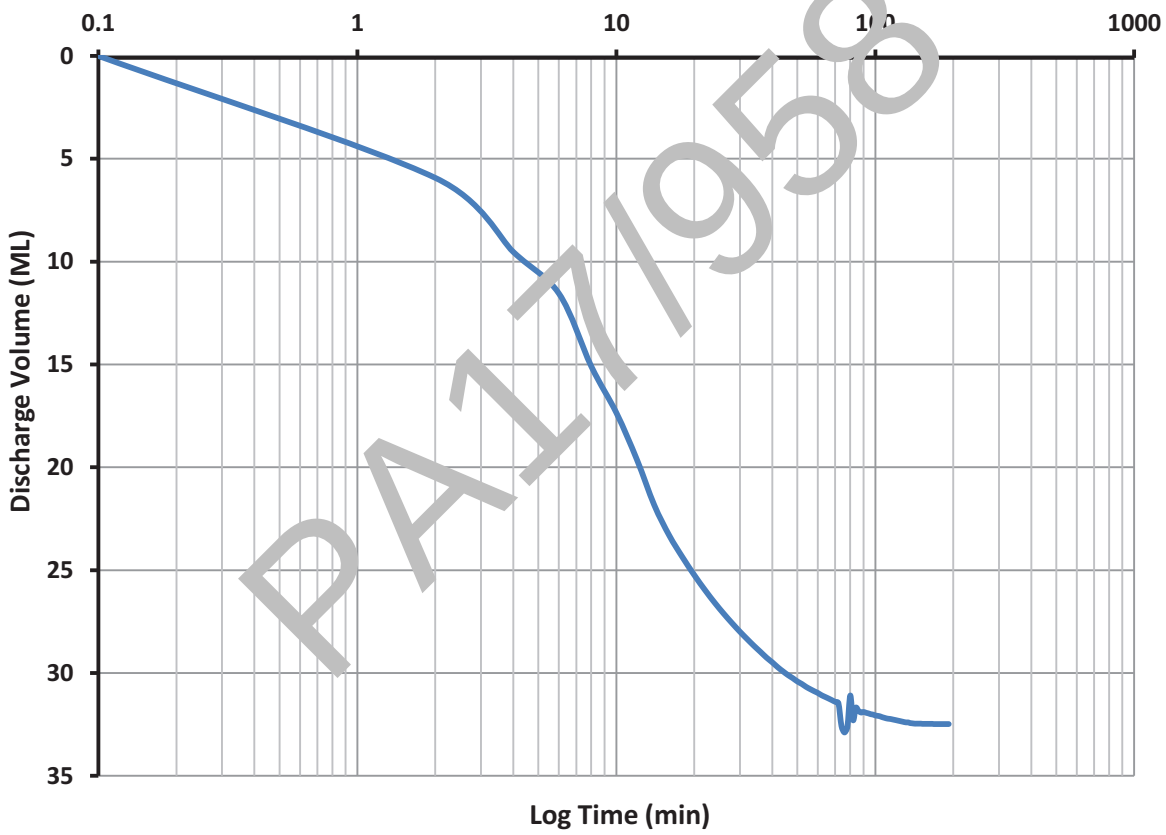
MULTI-STAGE CONSOLIDATED UNDRAINED TRIAXIAL TEST

Method: AS1289.6.4.2 / In-house Method

Client:	Liquid Labs WA	Date Tested:	4/05/2017
Project:	Proposed New Dams	EP Lab Job Number:	LLABS
Sample No:	LLS17/725 TP32 (1.40-1.80)	Lab:	EPLab
Sample ID:	LLS17_725_CU3		
Depth (m):	1.40 - 1.80	Room Temperature at Test:	~ 18°C

Discharge Volume (ML) Vs Log Time (min)



Cv (cm²/s): 0.031 based on t_{90}

Appendix F: Construction Procedures

1. CLEARING, GRUBBING AND STRIPPING

1.1 Definitions

For the purposes of this section the following definitions shall apply:

Clearing: Clearing shall consist of the cutting and felling of trees and the satisfactory disposal of trees, limbs, rubbish, and other vegetation.

Grubbing: Grubbing shall consist of the removal and disposal of roots, root mat, stumps, logs, and other objectionable matter which could affect the quality of the sub-grade or borrow material.

***Topsoil*:** Topsoil is the upper soil horizon that is characterised by a significant organic content.

1.2 Construction Requirements

1.2.1 Areas to be Cleared and Grubbed

Perform clearing and grubbing only in specified areas, with written approval in advance from the **ENGINEER**. Clear and grub all areas where excavation, embankment construction and spillway construction is to take place under this contract. Clear and grub all borrow areas to the extent necessary to provide fill materials free of objectionable matter described above. Trees and shrubs designated to be left in place, and those outside of construction limits and above the embankment crest level, shall not be damaged.

1.2.2 Disposal of Cleared and Grubbed Material

Dispose from the site, all trees, logs, rubbish, stumps, and other debris from the clearing and grubbing operations and all debris remaining from previous clearing operations in accordance with the **OWNER**'s requirements and in accordance with any applicable laws and regulations.

1.2.3 Topsoil Stripping

Topsoil will need to be stripped from excavation, embankment and spillway areas. Topsoil shall be segregated from soil material that may be suitable for use in embankment construction. Topsoil stockpiling shall be performed in areas designated by the **OWNER**. The sequencing of topsoil stripping activities shall be performed at the **CONTRACTOR's** discretion, but in such a manner that the efficient development of borrow materials and areas for placement are not impeded. Topsoil will subsequently be used to reclaim cut slopes and other disturbed areas.

2. BORROW AREA DEVELOPMENT

2.1 Construction Requirements

The **CONTRACTOR** shall provide a means of adjusting the water content of the materials to be excavated for placement in the embankment when the materials are too dry or too wet for satisfactory placement. Such means shall include but not be limited to:

- Sloping the stripped surfaces of the borrow area to drain at the maximum possible slope consistent with natural contours of the ground surface so that surface water resulting from precipitation will not be ponded, but will drain away from borrow areas and will not infiltrate into the underlying borrow material. Channel all seeps and free water from surfaces and faces in the borrow areas to drain away and not become incorporated into the material being excavated. Install and operate pumps, well points, or other dewatering methods as necessary to maintain the borrow area free of standing water.

- Take all necessary precautions to ensure that the moisture content of materials being hauled from borrow pits to placement areas do not suffer detrimental changes during transportation.

Borrow areas are located above the stream bed area and are not expected to encounter large flows of groundwater and may not require dewatering.

All borrow area discharges shall be clear and shall not cause sedimentation or erosion in river and stream channels in the area. The **CONTRACTOR** shall be required to provide sedimentation basins, silt fences, log and pole structures, and all means necessary to prevent eroded material from entering natural drainage channels as required by all applicable Laws, Regulations, and **OWNER** requirements.

Some of the clay/sandy clay/clayey sand/clayey gravel fill material from the borrow areas may be well below Optimum Moisture Content (OMC). Where necessary, water shall be added at the borrow area by spraying or other method approved by the **ENGINEER** to provide ample time for curing, and additional water shall be added at the embankment location as the lifts are being placed if necessary.

If, on the other hand, the material excavated is more than 2 percent above the OMC, the **CONTRACTOR** shall dry the material to a maximum of two (2) percent above OMC before removing it from the borrow area. This may be achieved by discing, harrowing, ploughing, scarifying or by other means acceptable to the **ENGINEER**. The material shall be at OMC and no more than 2 percent above optimum moisture at the time of actual lift placement and compaction.

By carefully planning and excavating the borrow area, it should be possible to avoid double-handling of the fill material in most cases. If the **CONTRACTOR** elects to stockpile some of the material it shall be done at a location and in a manner approved by the **ENGINEER** and at no cost to the **OWNER**.

The **CONTRACTOR** shall leave worked-out borrow areas in a safe and neat condition with slopes not steeper than 1.5 horizontal to 1.0 vertical. Borrow pits shall be excavated and finally dressed in a manner to prevent the creation of residual hazards or unsightly conditions by reason of steep or unstable side slopes.

Although the results of the test pits are representative of the subsurface conditions at the specific locations at which they were made, local variations in the subsurface materials are to be expected. Unacceptable materials within the borrow areas will be removed and dispersed of within the boundaries of the Site as directed by the **ENGINEER**.

3. EXCAVATION REQUIREMENTS

3.1 Definitions

All excavation will be designated as common excavation, hand excavation, or rock excavation in accordance with the following definitions:

Common Excavation: Common excavation shall consist of and include all earth, clay, sand, silt, gravel, loosely cemented gravel, soft or weathered rock, and similar materials that can be removed by hand, heavy ripping equipment, or combined use of wheel tractor scrapers and pusher tractors and shall also include all boulders and loose rock less than one (1) cubic metre in volume. The heavy ripping equipment, shall be defined as a tractor-mounted, heavy duty, single-tooth ripping attachment mounted on a tractor having a power rating of 200 - 300 (kW) rating (at the flywheel).

Hand Excavation: Hand excavation shall consist of excavating and cleaning out local pockets, cavities and irregularities of overburden material in the rock, if rock is encountered during excavation. This shall only include material that cannot be removed by a backhoe with a one cubic metre bucket and has to be excavated by picks, shovels, pry bars and other hand-held tools.

Rock Excavation: Rock excavation shall consist of and include all excavation which cannot be removed by the methods described for common excavation and shall also include all boulders and detached rock one (1) cubic metre or greater in volume.

3.2 Materials

3.2.1 Use of Excavated Materials

To the extent that they are needed, all suitable material removed from the specified excavations shall be used in the construction of the specified earth-filled portions of permanent works. The **ENGINEER** will determine the suitability of materials for specific purposes. The **CONTRACTOR** shall not waste or otherwise dispose of suitable excavated materials. Areas for stockpiling suitable materials will be designated by the **ENGINEER**.

3.2.2 Disposal of Waste Materials

All surplus or unsuitable excavated materials will be designated as waste and shall be disposed of at locations designated by the **OWNER** and approved by the **ENGINEER**.

3.3 Construction Requirements

3.3.1 Borrow Excavation

The quantity of suitable material obtained from specified excavations is likely to be sufficient to construct the specified embankment fill portions of the permanent works. Any additional materials will likely be sourced from designated borrow areas only. If required, the **ENGINEER** shall designate borrow areas and the limits of the depth of cut in all parts of the borrow pits. Placement of embankment fill material is described in Section 5.

3.3.2 Over Excavation

Unless otherwise authorised by the **ENGINEER**, excavation shall not extend below the exact lines of the base of the embankment dam footprint and any designated cut slopes above the crest of the dam. Excavation beyond the limits of

these specified cross sections and elevations shall be corrected by the **CONTRACTOR** by filling the resulting voids to the specified contours and elevations with approved compacted earth fill or concrete as directed by the **ENGINEER**.

3.3.3 Waste Areas

Excavated material that is designated by the **ENGINEER** to be wasted will be placed and spread in the waste stockpile areas in an orderly manner so that the resulting area is stable and free draining.

3.3.4 Ground and Surface Water Control

In the event that groundwater or surface water is encountered in excavation areas, the **CONTRACTOR** shall control the water by the use of drainage ditches, sumps, pumping, or any other method acceptable to the **ENGINEER**. Control of water shall be performed and continued so that fill material can be placed and compacted to the required density and moisture content as specified in Section 5.

4. FOUNDATION TREATMENT

4.1 Definitions

For purposes of this Section, the following definitions shall apply:

Alluvium: Alluvium means all materials between the surface of the natural ground in the valley bottom after stripping and surface of completely weathered rock (residual soil) or bedrock.

***Residual Soil*:** Residual soil means non alluvial soil resulting from complete in-place weathering of bedrock.

***Weathered Rock*:** Weathered rock means rock that has weathered sufficiently to be excavated and worked with standard earthmoving equipment without ripping or blasting. The degree of weathering will vary from highly weathered to moderately weathered. Material will contain gravel and cobble-sized rock core-stones in a matrix of residual soil.

Surface Compaction: Surface compaction means method of compacting loose soil particles into a more dense state with conventional heavy vibratory rollers.

Dental Concrete: Dental concrete shall be lean mix (14 MPa) concrete.

Publications listed below form part of this Section to the extent specified.

Australian Standards (AS):

- AS 1289.2.1.4 (2000) Determination of the moisture content of a soil –Microwave-oven drying method (subsidiary method).
- AS 1289.3.6.1 (2000) Determination of the particle-size distribution of a soil – Standard method of analysis by sieving.
- AS 1289.5.1.1 (2000) Determination of the dry density moisture content relationship of a soil using standard compactive effort.
- AS 1289.5.8.1 Determination of field density and field moisture content of a soil using a nuclear surface moisture-density gauge – Direct transmission mode.
- AS 3600-2001 Concrete Structures
- AS 4671-2001 Steel Reinforcing Materials

Foundation treatment shall be carried out to lines and grades shown on Drawings or as otherwise directed by the **ENGINEER**. The **ENGINEER** reserves the right to alter horizontal dimensions of zones or to realign dividing lines between zones requiring different degree of treatment at any time prior to or during construction where such changes are considered necessary by the **ENGINEER**.

4.2 Construction Requirements

4.2.1 Material Stripping

Strip all areas as shown on Drawings and as directed by the **ENGINEER** and in accordance with Section 1.

4.2.2 Foundation Preparation

4.2.2.1 General

Stockpile or dispose of excavated material in locations shown on Drawings and approved by the **ENGINEER**.

Schedule foundation preparation such that required fill may be placed immediately after preparation.

4.2.2.2 Earth Foundation Preparation

When material has been stripped from the dam embankment area, the surface shall be inspected by the **ENGINEER** prior to compaction. Any unsuitable material such as organic matter, topsoil, soft clay, etc. shall be removed as directed by the **ENGINEER**.

If the surface layer of soil has a moisture content greater than two (2) percent above Standard OMC the surface shall be scarified to a depth between 225 mm and 300 mm and allowed to dry out to the required moisture content.

If the moisture content is between minus one (-1) percent and plus two (+2) percent of Standard OMC, the surface shall be compacted by a minimum of six (6) passes of a ten (10) ton pad foot or sheepsfoot roller before fill placement.

The **ENGINEER** shall approve all areas of the foundation prior to placing fill material.

4.2.2.3 Rock Foundation Preparation

Where rock is exposed in the foundation, remove all loose and objectionable material using appropriate hand excavation tools and equipment. All open or filled joints shall be hand cleaned with bars, spades, high velocity air, and water jets as directed by the **ENGINEER**.

Wash clean all contact areas of all dirt, mud, debris, or other materials with broom, air and water jets, immediately before surface treatment or placement of materials.

Following cleanup, treat rock foundations to correct rock defects and irregularities with dental concrete, as directed by the **ENGINEER**.

Fill with dental concrete any pothole, cavity or any opening where contiguous embankment material cannot be placed and compacted as specified by the **ENGINEER**.

Replace materials which have been damaged or have deteriorated prior to placement of embankment fill.

The **ENGINEER** shall approve all areas of the foundation prior to placing fill material.

5. EARTHFILL

5.1 Definitions

Earth fill for the Work of this Section shall be divided into the following types:

***Embankment Earth Fill*:** Embankment earth fill means material sourced from borrow areas to construct the central core of the dam embankment.

***Shell Earth Fill*:** Shell earth fill means material sourced from borrow areas to construct the upstream and downstream shells of the dam embankment.

Publications listed below form part of this section:

- AS 1289.2.1.4 (2000) Determination of the moisture content of a soil –Microwave-oven drying method (subsidiary method).
- AS 1289.5.1.1 (2000) Determination of the dry density moisture content relationship of a soil using standard compactive effort.
- AS 1289.5.8.1 Determination of field density and field moisture content of a soil using a nuclear surface moisture-density gauge – Direct transmission mode.

5.2 Materials

All earth fill materials shall be obtained from required cut slopes and below-grade excavations and/or other designated borrow areas. The selection, blending, routing, and location of materials in the various fills shall be subject to approval by the **ENGINEER**. Earth fill materials shall contain no vegetation, roots or other organic and unsuitable materials. The types of materials used in the various earth fills shall be as listed and described in the **SPECIFICATIONS** and **DRAWINGS**.

5.2.1 Embankment Earth Fill

Embankment earth fill shall consist of materials sourced from an approved borrow area which, in the opinion of the **ENGINEER** are sufficiently impervious and suitable for construction of the embankment. Rock particles larger than 100 mm shall not be incorporated into the embankment earth fill. Embankment earth fill shall have approximately the following gradation or as otherwise approved by the **ENGINEER:**

Sieve Size	Percent Passing by Mass
75 mm	100
2.36 mm	40-100
0.075 mm	15-80

5.2.2 Embankment Shell Fill

Material to be used as embankment shell fill shall have approximately the following gradation or as otherwise approved by the **ENGINEER:**

Sieve Size	Percent Passing by Mass
200 mm	100

2.36 mm	20-100
0.075 mm	0-50

5.3 Construction Requirements

5.3.1 Test Fill and Field Compaction Tests

As soon as practicable, after excavated materials suitable for reuse (or borrow areas) becomes exploitable, the **CONTRACTOR** shall construct a test fill to ascertain compactive effort required for compaction of embankment earth fill.

Locate test sections, for performance of these tests, in the borrow areas, stockpile area, or any other area approved by the **ENGINEER**. If performed in the permanent work, materials shall remain in place at discretion of the **ENGINEER**. If tests are not performed in permanent work, materials may be excavated for use in work with approval of the **ENGINEER**.

Test fills shall comprise at least 3 layers of fill material and shall be at least 1[illegible] m[illegible]y 20 m. The **ENGINEER** reserves the right to vary lift thickness and number of lifts; to change number of test sec[illegible]ons[illegible] to [illegible]ake changes in lines and grades; and to require construction of supplemental test fills as specified.

Construction equipment shall be furnished by the **CONTRACTOR** as req[illegible]red by [illegible]xcavating, hauling, processing, placing, controlling moisture, and compacting test fills in accordance w[illegible]th spe[illegible]fied re[illegible]irements. Except as otherwise approved by the **ENGINEER**, all equipment shall be of same type as [illegible]ill [illegible]e use[illegible] i[illegible] construction of embankments.

Material for construction of test fills shall be obtain[illegible] [illegible]om ap[illegible]roved borrow areas and shall meet specified gradations. Subgrade at the test fill location shall be stripped of veg[illegible]tation, [illegible]ebris and other objectionable material. Test area shall be graded as required to provide an adequa[illegible]ely drained [illegible]rface suitable for tests.

Where surface at each test fill location has been s[illegible]ipped, graded, cleaned and approved by the **ENGINEER**, the subgrade shall be compacted by at least six ([illegible] p[illegible]sses of a 10[illegible]onne vibratory pad foot roller. The roller shall travel at speeds not to exceed eight (8) kilometres per ho[illegible]r.

Materials shall be spread in uni[illegible]rm la[illegible]ers over entire width and length of test fill under construction to such depth that, before compaction, meet[illegible] the lift thickness directed by the **ENGINEER**. Moisture content shall be adjusted to within allowable limits from [illegible]ptimum value as determined by the **ENGINEER** on basis of results of tests by addition of water where required, and by ha[illegible]rowing and aerating where excess moisture is evident. Compaction shall be performed by successive passes over test fill with specified compaction equipment in accordance with the **ENGINEER's** instructions.

In situ and laboratory compaction tests will be performed and test trenches shall be excavated across compacted test sections at locations as directed by the **ENGINEER** to determine overall efficiency of compaction methods used. Based on results of these test sections, the number of passes required shall be determined.

5.3.2 Protection

The **CONTRACTOR** is responsible for protecting the work. Any damage to the embankment earth fill and shell earthfill during construction (i.e. from inclement weather or improper trafficking) shall be removed and/or repaired as determined by the **ENGINEER**. Work shall be discontinued with rainfall as instructed by **ENGINEER**.

After occurrence of heavy rains, do not operate equipment until fill has dried sufficiently to prevent occurrence of excessive rutting. In order to minimise effect of precipitation on placed fill, surface shall be made smooth, and adequate drainage shall be provided with onset of precipitation where operations must be suspended.

All openings through embankments for construction purposes shall be subject to the **ENGINEER's** approval. Slope of openings left through embankments and end of any unfinished section shall not be steeper than 3 horizontal to 1 vertical.

Any layer or layers which, in the opinion of the **ENGINEER**, have suffered a reduction in density after compaction due to action of rain, equipment, or any other reason, shall be removed, and allowed to dry, or worked with harrow, disc, or other suitable equipment, to reduce moisture content to required amount, and it shall be recompacted by the **CONTRACTOR** before placing operations are resumed.

Desiccation and crusting of the lift surfaces shall be avoided as much as possible. The compacted surface of fill shall be protected from drying out by sprinkling, seal-rolling, covering with plastic, or by other means as may be approved by the **ENGINEER**. The **ENGINEER** will identify any areas of significant desiccation and crusting of a lift surface. The **CONTRACTOR** shall scarify the surface of such areas to a nominal depth of 50 mm or to the depth of desiccation identified by the **ENGINEER**, and then moisture-condition, disc or mix as necessary and recompact the area.

5.3.3 Bonding

To achieve best possible contact between fill and foundations, slope the fill layers up against the contact. Use pneumatic-tired units, or similar approved equipment, to compact fill directly against foundation, as required by the **ENGINEER**.

During Work, whenever, in opinion of the **ENGINEER**, surface of earth fill already in place becomes too dry or too smooth to bond properly with succeeding lifts, and whenever fill operations resume after 24 hours suspension, disc or scarify the fill surface in place to such depth as specified by the **ENGINEER**, and moisture-condition as necessary to achieve specified moisture content.

Upon resumption of operations after suspension, prepared surfaces shall be approved by the **ENGINEER** prior to being covered by permanent material. During work, whenever, in opinion of the **ENGINEER**, the surface of prepared foundation, or surface of rolled earth fill is too wet for proper compaction of layer of earth material to be placed thereon, it shall be removed, allowed to dry, or worked with harrow, disc, or other suitable equipment, to reduce moisture content to required amount, then it shall be recompacted before the succeeding layer of earth fill is placed thereon.

Mixing of wet and dry materials to achieve material with proper moisture content shall not be permitted unless sufficient curing time is allowed and the mixing operation is approved by the **ENGINEER**.

5.3.4 Placing

Embankment Earth Fill and Shell Fill: The thickness of embankment earth fill and shell earthfill layers before compaction shall not exceed 250 mm. Fill is to be compacted by a 10 tonne vibratory pad foot or sheepsfoot roller or accepted alternative. Compaction units performing work on the embankment shall travel in a direction parallel to the axis of the embankment.

Placing of earth fill shall be directed to obtaining a homogeneous fill, which is free of horizontal stratifications and of lenses or pockets of materials which do not satisfy requirements of this Section of the **SPECIFICATIONS**. If the surface of any layer becomes too hard and smooth for proper bonding with the succeeding layer, it shall be scarified parallel to the axis of the fill to a depth of not less than 50 mm before the next layer is placed.

Spread earth fill materials in horizontal layers of uniform thickness by bulldozers or other approved means. If necessary, employ discing, harrowing, or other approved means to break up the material and to blend it before compaction. The approved vibratory padfoot or sheepsfoot roller shall travel at speeds not to exceed 8 kilometres per hour. During compacting operations, effect turning of equipment carefully to ensure uniform compaction and kneading action.

Layers within a zone and at junctions with adjacent zones shall be compacted in strips, with adjacent strips overlapping not less than thirty (30) cm. Compaction in any area shall be achieved completely by a single type of compaction unit. Remove any and all materials not approved as earth fill which accumulate on the surface of any layer or prepared foundation, before further material is placed on succeeding layer.

Final acceptance of earth fill material will only be made after material has been dumped, spread and compacted in place and the fill achieves the required level of compaction. Rejection by the **ENGINEER** of earth fill material may be made in the borrow area, in transporting vehicle, or in place. The **CONTRACTOR** shall cooperate with the **ENGINEER** to ensure that only acceptable earth material will be hauled from borrow areas to the Works. Remove any materials placed outside prescribed zone limits or slope lines.

The top surfaces of the embankment shall be maintained approximately level during construction, except that a crown or cross-slope of not less than two (2) percent shall be maintained to ensure effective drainage. If the **DRAWINGS** or **SPECIFICATIONS** require, or the **ENGINEER** directs, that fill be placed at a higher level in one part of an embankment than another, the top surface of each part shall be maintained as specified above.

The embankment shall be constructed in continuous layers from end to end except where openings to facilitate construction or to allow the passage of stream flow during construction are specifically authorised in the contract. Embankments built at different levels as described above shall be constructed so that the slope of the bonding surfaces between embankment in place and embankment to be placed is not steeper than 5 horizontal to 1 vertical.

The bonding surface of the embankment in place shall be stripped of all loose material, and shall be scarified, moistened and recompacted when the new fill is placed against it as needed to ensure a good bond with the new fill and to obtain the specified moisture content and density in the junction of the in-place and new fill.

Hauling equipment shall travel in directions parallel to axis of embankment and no roads or tracks shall be formed across it, unless authorised by the **ENGINEER**. Vehicles and machines shall not follow each other in same paths but shall spread their tracks over surface of the fill.

5.3.5 Moisture Content

Maintain uniform placement water content in each layer of fill and control within following limits unless otherwise specified by the **ENGINEER**.

Placement water content in embankment fill shall be maintained between a value of two (2) percent below OMC, as defined in AS 1289.5.1.1 and two (2) percent above OMC.

During placement and compaction of fill, the moisture content of the materials being placed shall be maintained within the specified range. The application of water to the fill materials, if needed, shall be accomplished at the borrow areas insofar as practicable. Water may be applied by sprinkling the materials after placement on the fill, if necessary. Uniform moisture distribution shall be obtained by discing, blading or other approved methods prior to compaction of the layer.

Material that is too wet when deposited on the fill shall either be removed or be dried to the specified moisture content prior to compaction.

If the top surface of the preceding layer of compacted fill or a foundation surface in the zone of contact with the fill becomes too dry to permit a suitable bond with successive layers, it shall be scarified and moistened by sprinkling to an acceptable moisture content prior to placement of the next layer of fill.

5.3.6 Compaction

Embankment earth fill and embankment shell fill shall be compacted to a dry density ratios of at least 98 percent and 95 percent respectively of standard maximum dry density as determined by AS 1289.5.1.1.

The side slopes of the completed embankment shall be compacted by walking a track-type tractor or dozer up and/or down the slopes until the entire surface is traversed by at least one pass of the tractor or dozer tread.

5.3.7 Removal and Placement of Defective Fill

Fill placed at densities lower than the specified minimum density or at moisture contents outside the specified acceptable range of moisture content or otherwise not conforming to the requirements of the **SPECIFICATIONS** shall be reworked to meet the requirements or removed and replaced by acceptable fill.

The replacement fill and the foundation and fill surfaces upon which it is placed shall conform to all requirements of this **SPECIFICATION** for foundation preparation, approval, placement, moisture control, and compaction.

5.3.8 Field Quality Control

5.3.8.1 Quality Control by Engineer

Compaction tests will be performed during the construction of the embankment to determine compliance with moisture-density **SPECIFICATIONS** in accordance with the approved plan and to detect any significant changes in the material properties over the construction period.

The **ENGINEER** or his representative will conduct such tests in accordance with Australian Standard procedures at the following minimum frequencies.

- One (1) field test for every 500 cubic meters of compacted embankment earth fill, with at least one (1) test per lift.
- One (1) field test for every 2,000 cubic meters of compacted shell earth fill material, with at least one test per lift.
- One (1) field test for every 200 cubic meters of compacted backfill in trenches or around structures, with at least one test per lift.
- One (1) test any time there is suspicion of the effectiveness of compaction.
- Supplementary laboratory compaction curves for at least every 20 field density tests. Field tests will be performed at random locations in the fill.

Records of the test results, as well as the test locations, will be kept on Site during construction.

The **ENGINEER** will notify the **CONTRACTOR** of any deficiencies in materials or construction when results of the tests are known. Deficiencies shall be remedied by such measures as the **ENGINEER** may direct. Remedies shall include complete removal of portions of embankment if so directed by the **ENGINEER**. Such tests are not intended to provide the **CONTRACTOR** with the information required by him for the proper execution of the work and their performance shall not relieve the **CONTRACTOR** of the necessity to perform tests for that purpose.

5.3.8.2 Additional Measures to Increase Density

In case of earth fill which does not have specified density, additional measures which may be specified to increase density include:

- Compacting with additional passes of roller.
- Adding ballast to rollers (or increasing the frequency of vibrating rollers) up to maximum capacity specified by roller manufacturer.
- Reducing lift thickness.

5.3.8.3 Additional Measure to Lower Moisture Content

In case of earth fill which is too wet, additional measures which may be specified to lower moisture content include:

- Aerating by discing, harrowing, scarifying or employing other suitable means to facilitate drying. This applies to compacted wet fill and to uncompacted wet fill spread on compacted fill.
- Mixing wet fill with fill having lower moisture content. This applies to uncompacted fill in the borrow areas.
- Installing interceptor ditches in borrow areas to prevent rain and surface run-off from soaking into material.
- Removal of wet fill and replacement with compliant fill.

5.3.8.4 Additional Measure to Raise Moisture Content

In case of earth fill that is too dry, additional measures that may be specified to raise moisture content include:

- Removal of dry fill and replacement with compliant fill.
- Adjusting moisture content of fill prior to compacting. In general the application of additional water, where required, shall be done in borrow areas, supplemented, if necessary, by sprinkling surface of the material following spreading with required amount of water and mixing uniformly throughout the layer, or by such other means as may be approved by the **ENGINEER**.
- Water supplied on a layer of fill shall be sprinkled in a uniform manner at a controlled rate so that free water will not appear on surface during or subsequent to rolling.
- Irrigating borrow pits by approved methods.

The location of the **CONTRACTOR's** access and haul roads, storage and other construction areas, required temporarily in the performance of the Work, shall be approved by the **ENGINEER**.

All access and haul roads used during construction shall have cross drains installed in all drainage ways. Temporary stream channel crossings shall be constructed, maintained, and removed in a manner that will not result in unnecessary pollution. Road surfaces shall be kept free draining. Concentrations of water shall be directed into stabilised watercourses or piped to stable outlets. Debris shall be disposed of in spoil areas approved by the **ENGINEER**, or otherwise disposed of as approved by the **ENGINEER**.

The **CONTRACTOR** shall remove all signs of temporary construction facilities such as haul roads, work areas, structures, foundations of temporary structures, or stockpiles of excess or waste materials.

The **CONTRACTOR** shall not deface, injure, or destroy trees or shrubs, nor remove or cut them above the normal pool elevation without special authority approved by the **OWNER**. No ropes, cables, or guys shall be fastened to or attached to any existing nearby trees for anchorages unless approved by the **OWNER**.

6. EROSION, SEDIMENTATION AND POLLUTION CONTROL

6.1 Construction Requirements

6.1.1 Chemical Pollution

The **CONTRACTOR** shall provide watertight tanks or barrels or construct a sump sealed with plastic sheets to be used to dispose of chemical pollutants (such as drained lubricating or transmission oils, greases, soaps, asphalt, etc.) produced by a by-product of the project's Work. At the completion of the Work, sumps shall be voided without causing pollution as specified in Section 6.1.4 of this **SPECIFICATION.**

Sanitary facilities such as pit toilets, chemical toilets, or septic tanks shall not be placed adjacent to live streams, wells, or springs. They shall be located at a distance sufficient to prevent contamination of any water sources. At the completion of the Work, facilities shall be disposed of without causing pollution as specified in Section 6.1.4 of this **SPECIFICATION.**

6.1.2 Fire

All applicable Laws, Regulations, and **OWNER** requirements concerning the burning of brush or rubbish or disposal of other materials shall be adhered to. Fire prevention measures shall be taken to prevent the start or the spreading of fires which result from the Work.

All public access or haul roads used by the **CONTRACTOR** during construction of the project shall be sprinkled or otherwise treated to fully suppress dust.

6.1.3 Maintenance, Removal and Restoration

All erosion, sedimentation and pollution control measures and works shall be adequately maintained in a functional condition as long as needed during the Project. All temporary measures shall be removed and the Site restored to as nearly original conditions as practicable.

6.1.4 Performance

Sanitary facilities such as chemical toilets, sumps, tanks, or barrels used to temporarily store chemical pollutants such as drained lubricating oils, shall be disposed of in accordance with all applicable Laws, Regulations, and **OWNER** requirements.

The location of the **CONTRACTOR's** access and haul roads, storage and other construction areas, required temporarily in the performance of the Work, shall be approved by the **ENGINEER**.

All access and haul roads used during construction shall have cross drains installed in all drainage ways. Temporary stream channel crossings shall be constructed, maintained, and removed in a manner that will not result in unnecessary pollution. Road surfaces shall be kept free draining. Concentrations of water shall be directed into stabilised watercourses or piped to stable outlets. Debris shall be disposed of in spoil areas approved by the **ENGINEER**, or otherwise disposed of as approved by the **ENGINEER**.

The **CONTRACTOR** shall obliterate all signs of temporary construction facilities such as haul roads, work areas, structures, foundations of temporary structures, or stockpiles of excess or waste materials.

The **CONTRACTOR** shall not deface, injure, or destroy trees or shrubs, nor remove or cut them above the normal pool elevation without special authority approved by the **OWNER**. No ropes, cables, or guys shall be fastened to or attached to any existing nearby trees for anchorages unless approved by the **OWNER**.

Monuments, markers, and sites of natural, historical, or archaeological significance shall be protected before beginning operations near them.

7. DIVERSION AND DEWATERING

7.1 Definitions

For the purposes of this SPECIFICATION, the following definitions shall apply:

Diversion: Diversion means performance of all Work to divert the runoff from the valley and the associated tributaries during embankment foundation preparation, treatment, and placement of all fill materials during the construction of the embankment.

Dewatering: Dewatering system means ditches, sumps, pumps, monitoring devices, and all associated equipment for the removal of surface water and groundwater as needed to perform the required construction in accordance with the Specification.

Diversion and dewatering systems will be required during excavation of the dam foundation and core trench, placement of embankment fill materials, and other parts of the construction site.

7.2 Construction Requirements

7.2.1 Diverting Surface Water

The **CONTRACTOR** shall build, maintain, and operate all cofferdams, channels, sumps, and other temporary diversion and protective works needed to divert streamflow and other surface water through or around the construction site and away from the construction work while construction is in progress. Unless otherwise specified, this diversion must discharge in the same natural state and into the same natural drainage way in which its head works are located.

Earth Material: The earth material used in constructing the earth fill cofferdam portions shall be obtained from the channel excavation or other approved sources.

Cofferdam Foundation Preparation: The base area of the cofferdam sections shall be stripped of unsuitable material and scarified and compacted prior to placing fill.

Fill Placement: Fill material shall contain no rock particles greater than fifteen (15) cm in diameter, brush, or other objectionable material.

The earth materials used to construct the cofferdams and other temporary berms shall be placed in lifts no thicker than fifteen (15) cm and compacted by routing the hauling and spreading equipment over the fills in such a manner that the entire surface of the fills will be traversed by not less than one tread track of the loaded equipment. The completed work shall conform to the cross-section shown on the DRAWINGS.

7.2.2 Dewatering the Construction Site

Performance: Foundations, core trenches and other parts of the construction site shall be dewatered and kept free of standing water or excessively muddy conditions as needed for proper execution of the construction Work. The **CONTRACTOR** shall furnish, install, operate and maintain all drains, sumps, pumps and other equipment needed to perform the dewatering as specified. Dewatering methods that cause a loss of fines from foundation areas will not be permitted.

To effectively dewater the core trench and the dam foundation, it will be necessary to construct sumps which are strategically placed at low points so that the foundation excavations drain to the sumps.

It will be necessary to construct sedimentation ponds for the discharge from the sumps to settle out the suspended solids. These shall be designed and maintained in such a manner that only clear water is discharged to the creek. The cost of the sumps, well points, interception trenches and sedimentation ponds shall be incidental to the Work.

7.2.3 Dewatering of Borrow Areas

The **CONTRACTOR** shall maintain the borrow areas in drainable condition or otherwise provide for timely and effective removal of surface waters that accumulate, for any reason, within the borrow areas.

7.2.4 Removal of Temporary Works

After the temporary works have served their purposes, the **CONTRACTOR** shall remove them or level and grade them to the extent required to present a tidy appearance and to prevent any obstruction of the flow of water or any other interference with the operation of or access to the permanent works.

Except as otherwise specified, pipes and casings shall be removed from temporary wells and the wells shall be abandoned according to the requirements of the **OWNER**.

Appendix G: Understanding Your Geotechnical Engineering Report

UNDERSTANDING YOUR REPORT

GALT FORM PMP11 Rev2

1. EXPECTATIONS OF THE REPORT

This document has been prepared to clarify what is and is not provided in your report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with the conditions on site.

Geotechnical engineering and environmental science are less exact than other engineering and scientific disciplines. We include this information to help you understand where our responsibilities begin and end. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of projects and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following:

- the project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the project team. Furthermore, we recommend that we be able to review work produced by other members of the project team that relies on information provided in our report.

3. SOIL LOGS

Our reports often include logs of intrusive and non-intrusive investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party because of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including anthropogenic events (such as construction or contaminating activities on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use professional judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from professional judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL AND GEOTECHNICAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not addressed in geotechnical reports. Similarly, geotechnical issues are not addressed in environmental reports. The investigation techniques used for geotechnical investigations can differ from those used for environmental investigations. It is the client's responsibility to satisfy themselves that geotechnical and environmental considerations have been taken into account for the site.

O:\Administration\Standard Forms and Documents\PMP11-Rev2 Understanding your Report.docx

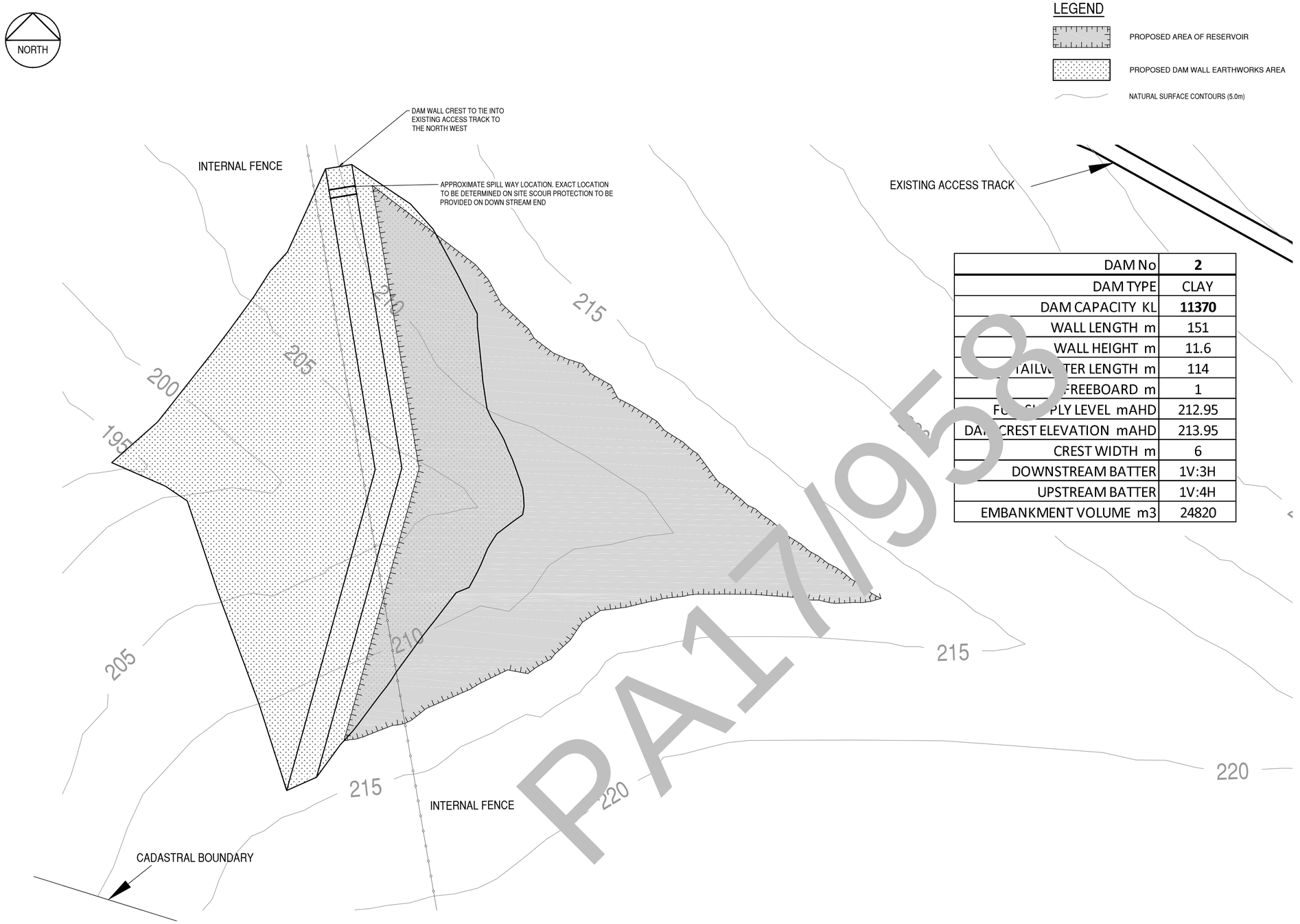
APPENDIX E – SURVEYS

H & D XYDAS FIRNS ROAD SERPENTINE JARRAHDALE SHIRE

CONTOURS AT 0.5m INTERVAL SHOW SURFACE OF DECEMBER 2015. BURIED SERVICES NOT SHOWN.

PROJECTION MGA ZONE50. DATUM AHD (GPS)

APPENDIX F – ENGINEERING DRAWINGS



LEGEND

- PROPOSED AREA OF RESERVOIR
- PROPOSED DAM WALL EARTHWORKS AREA
- NATURAL SURFACE CONTOURS (5.0m)

DAM No	**2**
DAM TYPE	CLAY
DAM CAPACITY KL	**11370**
WALL LENGTH m	151
WALL HEIGHT m	11.6
TAILWATER LENGTH m	114
FREEBOARD m	1
FULL SUPPLY LEVEL mAHD	212.95
DAM CREST ELEVATION mAHD	213.95
CREST WIDTH m	6
DOWNSTREAM BATTER	1V:3H
UPSTREAM BATTER	1V:4H
EMBANKMENT VOLUME m3	24820

NOTES

GENERAL:

1. THE PRINCIPAL'S SURVEYOR WILL MARK THE BOUNDARIES OF THE SITE.
2. NO CLEARING TO BE OUTSIDE THE SCOPE OF WORKS INDICATED ON THE DRAWING, CLEARING TO BE IN ACCORDANCE WITH APPROVAL.
3. ALL SURVEY BENCH MARKS ARE TO BE PROTECTED AND PRESERVED.
4. SITE FACILITIES WILL BE MADE AVAILABLE TO THE CONTRACTOR.
5. ALL CONSTRUCTION AND DESIGN IS TO BE IN ACCORDANCE WITH THE INSTITUTE FOR PUBLIC WORKS ENGINEERS AUSTRALIA - SUBDIVISION GUIDELINES 2009 AND THE DEPARTMENT OF WATER'S WATER QUALITY PROTECTION NOTE 53 FOR DAM CONSTRUCTION AND OPERATION IN RURAL AREAS.
6. THE CONTRACTOR IS RESPONSIBLE FOR THE PROTECTION OF WORKS DURING CONSTRUCTION. THIS INCLUDES ANY DEWATERING AND DISPOSAL OF WATER RUNOFF SHOULD IT BE ENCOUNTERED IN EXCAVATIONS. THIS ALSO INCLUDES ANY TEMPORARY EMBANKMENTS SHOULD THEY BE WARRANTED.
7. THE CONTRACTOR TO ALLOW THE WORKS NECESSARY TO DIRECT RUNOFF WATER FROM THE PROPERTY LOT 822 (206 FIRNS RD) TO THE PROPOSED DAMS, AS PER COTERRA INSTRUCTIONS (TO BE CONFIRMED ON SITE).
8. CONTRACTOR IS TO CARRY OUT ALL WORKS IN ACCORDANCE WITH GALT GEOTECHNICAL STUDY J1701059 001 R Rev 2.

EARTHWORKS:

1. ALL WORKS TO MAKE SMOOTH CONNECTION TO EXISTING LEVELS.
2. ALL EXCESS MATERIAL TO BE STOCKPILED NEATLY ON SITE - INCLUDING TOPSOIL STRIPPED FROM FOUNDATION AREAS.
3. IT IS ANTICIPATED ALL MATERIAL FOR THE DAM EMBANKMENT CONSTRUCTION WILL BE AVAILABLE FROM BORROW PITS ONSITE. THE CONTRACTOR IS TO ALLOW FOR ALL CARTING ONSITE.
4. FINAL EARTHWORK BATTERS MUST BE NO STEEPER THAN THOSE DOCUMENTED ON THE DRAWINGS.

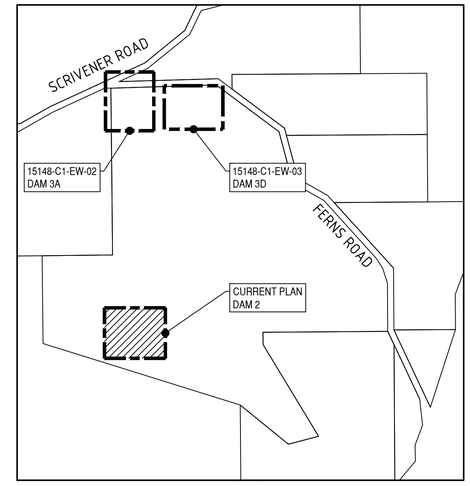
MATERIAL & PLACEMENT:

1. WHEN MATERIAL HAS BEEN STRIPPED FROM THE DAM EMBANKMENT AREA THE SURFACE SHALL BE INSPECTED BY THE ENGINEER PRIOR TO COMPACTION. WHERE THE FOUNDATION OF SOIL IS CLAYEY:
   a. IF THE SURFACE HAS MOISTURE CONTENT GREATER THAN 2% ABOVE OPTIMUM MOISTURE CONTENT IT SHALL BE SCARIFIED TO 300 MM AND ALLOWED TO DRY.
   b. IF THE SURFACE MOISTURE CONTENT IS BETWEEN -1% AND 2% OF THE STANDARD OPTIMUM MOISTURE CONTENT THE SURFACE SHALL BE COMPACTED BY A MINIMUM OF (6) PASSES OF A TEN TONNE PAD FOOT OR SHEEPSFOOT ROLLER BEFORE FILL PLACEMENT.

   WHERE THE FOUNDATION IS GRANULAR:
   c. IF THE SURFACE IS GRANULAR THEY SHOULD BE COMPACTED BY 4 PASSES OF A TEN TONNE SMOOTH DRUM ROLLER WITH A MINIMUM STATIC MASS OF TEN TONNE.
2. MATERIAL EXCAVATED IN BORROW AREAS SHALL BE WITHIN 2% OF OPTIMUM MOISTURE CONTENT. WHERE MATERIAL IS WELL BELOW WATER SHALL BE ADDED, WHERE MATERIAL IS MORE THAN 2% ABOVE OPTIMUM THE CONTRACTOR SHALL DRY THE MATERIAL BY RIPPING BEFORE FINAL PLACEMENT. MATERIAL FOR BOTH EMBANKMENT EARTH FILL AND EMBANKMENT SHELL FILL IS TO MEET THE GRADING REQUIREMENTS AS DETAILED IN THE GEOTECHNICAL REPORT.
3. EMBANKMENT EARTH FILL (CLAY CORE) SHALL CONSIST OF MATERIAL FOUND IN BORROW AREAS THAT IS SUFFICIENTLY IMPERVIOUS AS APPROVED BY THE GEOTECHNICAL ENGINEER.
4. AS SOON AS PRACTICABLE, THE CONTRACTOR SHALL CONSTRUCT A TEST FILL TO ASCERTAIN COMPACTIVE EFFORT REQUIRED TO MEET DENSITY REQUIREMENTS AS SPECIFIED. THIS IS TO BE REVIEWED ONSITE BY THE GEOTECHNICAL ENGINEER.

COMPACTION & TESTING:

1. EMBANKMENT EARTH FILL (CLAY CORE) SHALL BE COMPACTED TO A MINIMUM DRY DENSITY RATIO OF 98% AS DETERMINED BY AS 1289.5.1.1.
2. EMBANKMENT SHELL FILL SHALL BE COMPACTED TO A MINIMUM DRY DENSITY RATIO OF 95% AS DETERMINED BY AS 1289.5.1.1.
3. IF FILL IS PLACED AT LOWER THAN THE SPECIFIED MINIMUM DENSITY OR OUTSIDE THE SPECIFIED MOISTURE CONTENT IT SHALL BE REWORKED TO MEET THE REQUIREMENTS OR REMOVED AND REPLACED.
4. COMPACTION TESTING IS TO BE COMPLETED BY A NATA REGISTERED TESTING AGENCY AT THE FOLLOWING MINIMUM FREQUENCIES, VARIOUS TEST METHODS TO BE FOLLOWED IE AS1289.5.8.1:
   a. ONE (1) FIELD TEST FOR EVERY 1,000 CUBIC METERS OF COMPACTED EMBANKMENT EARTH FILL, WITH AT LEAST ONE TEST PER LIFT.
   b. ONE (1) FIELD TEST FOR EVERY 2,000 CUBIC METERS OF COMPACTED EMBANKMENT SHELL FILL, WITH AT LEAST ONE TEST PER LIFT.
   c. ONE (1) FIELD TEST FOR EVERY 200 CUBIC METERS OF COMPACTED BACKFILL IN TRENCHES OR AROUND STRUCTURES, WITH AT LEAST ONE TEST PER LIFT.
   d. ONE (1) TEST ANY TIME THERE IS SUSPICION OF THE EFFECTIVENESS OF COMPACTION.
   e. SUPPLEMENTARY LABORATORY COMPACTION CURVES FOR AT LEAST EVERY 20 FIELD DENSITY TESTS. FIELD TEST WILL BE PERFORMED AT RANDOM LOCATIONS IN THE FILL.

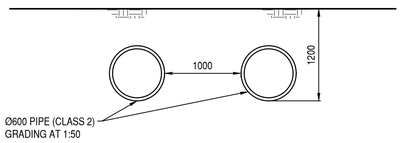


LOCALITY PLAN

NOT TO SCALE

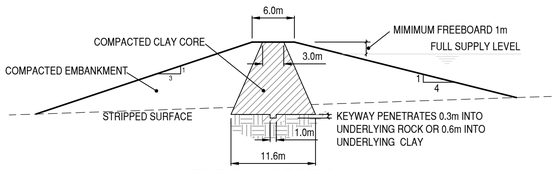
SCALE 1:500 0m 10m 20m

DIAL BEFORE YOU DIG www.1100.com.au
The Essential First Step.



TYPICAL SPILL WAY ABOVE PIPES

NOT TO SCALE



TYPICAL SECTION

NOT TO SCALE

REV	DATE	DESCRIPTION	BY	CHKR
C	23/06/17	CLIENT & GEOTECH COMMENTS ADDED	JS	AW
B	20/06/17	COUNCIL SUBMISSION	JS	AW
A	08/06/17	INITIAL ISSUE	JS	AW

pritchard francis
civil and structural engineering consultants

Level 1, 430 Roberts Road
Subiaco WA 6008
PO Box 2150
Subiaco WA 6904

Telephone: (08) 9382 5111
admin@pfeng.com.au

DRAWING STATUS: NOT FOR CONSTRUCTION

DATE: JUNE 2017 | GRID: LOCAL | DATUM: LOCAL

DESIGNED: AW | DRAWN: JS | CHECKED: MRi | APPROVED: MRi ..../ ....

W.A.P.C.

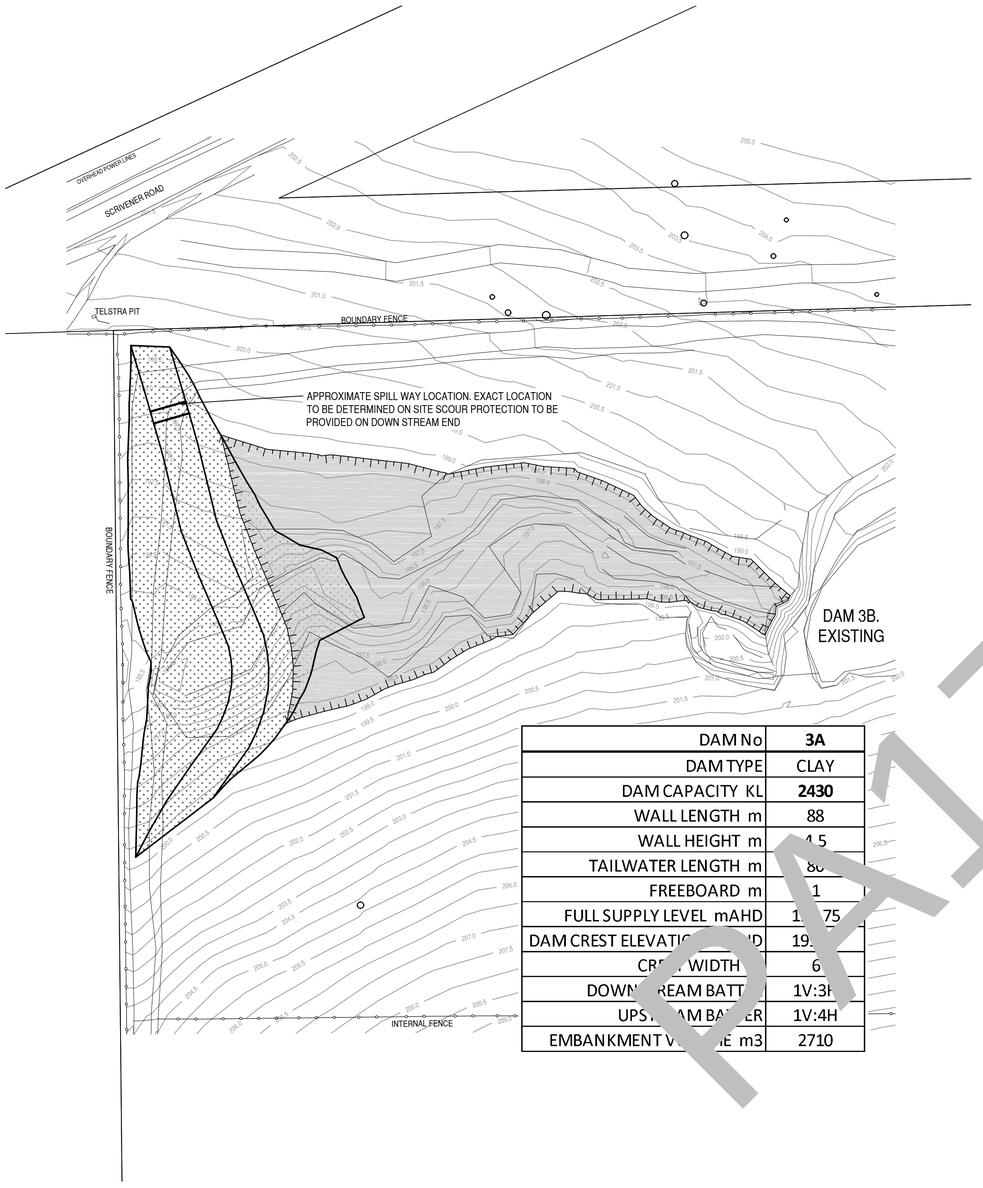
SCALE U.N.O.: AS SHOWN @ A1

CLIENT & JOB: SARABAND INVESTMENTS
LOT 206 FIRNS ROAD, SERPENTINE

TITLE: PROPOSED DAM
DAM 2

SHEET SIZE: A1 | DRG No.: 15148-C1-EW-01 | REVISION: C

NORTH



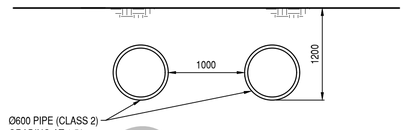
DAM No	**3A**
DAM TYPE	CLAY
DAM CAPACITY KL	**2430**
WALL LENGTH m	88
WALL HEIGHT m	4.5
TAILWATER LENGTH m	80
FREEBOARD m	1
FULL SUPPLY LEVEL mAHD	1[illegible]75
DAM CREST ELEVATION mAHD	19[illegible]
CREST WIDTH	6
DOWNSTREAM BATTER	1V:3H
UPSTREAM BATTER	1V:4H
EMBANKMENT VOLUME m3	2710

SCALE 1:500 0m 10m 20m

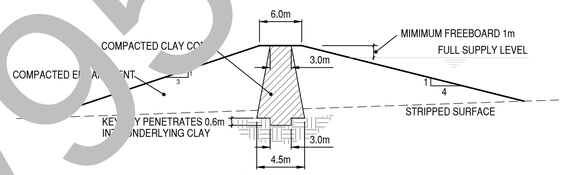
DIAL BEFORE YOU DIG www.1100.com.au
The Essential First Step.

LEGEND

- PROPOSED AREA OF RESERVOIR
- PROPOSED DAM WALL EARTHWORKS AREA
- NATURAL SURFACE CONTOURS (5.0m)



TYPICAL SPILLWAY ABOVE PIPES
NOT TO SCALE



TYPICAL SECTION
NOT TO SCALE

NOTES

GENERAL:

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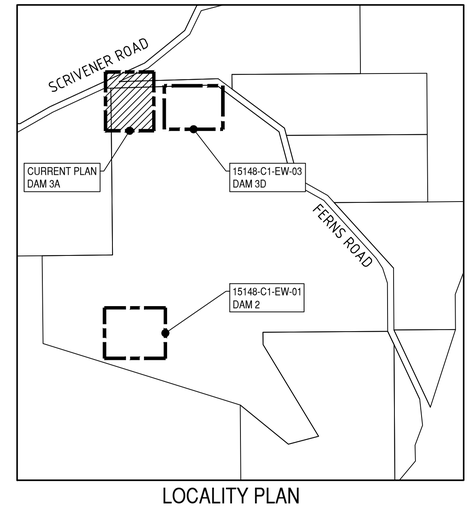

LOCALITY PLAN
NOT TO SCALE

REV	DATE	DESCRIPTION	BY	CHKR
C	23/06/17	CLIENT & GEOTECH COMMENTS ADDED	JS	AW
B	20/06/17	COUNCIL SUBMISSION	JS	AW
A	08/06/17	INITIAL ISSUE	JS	AW

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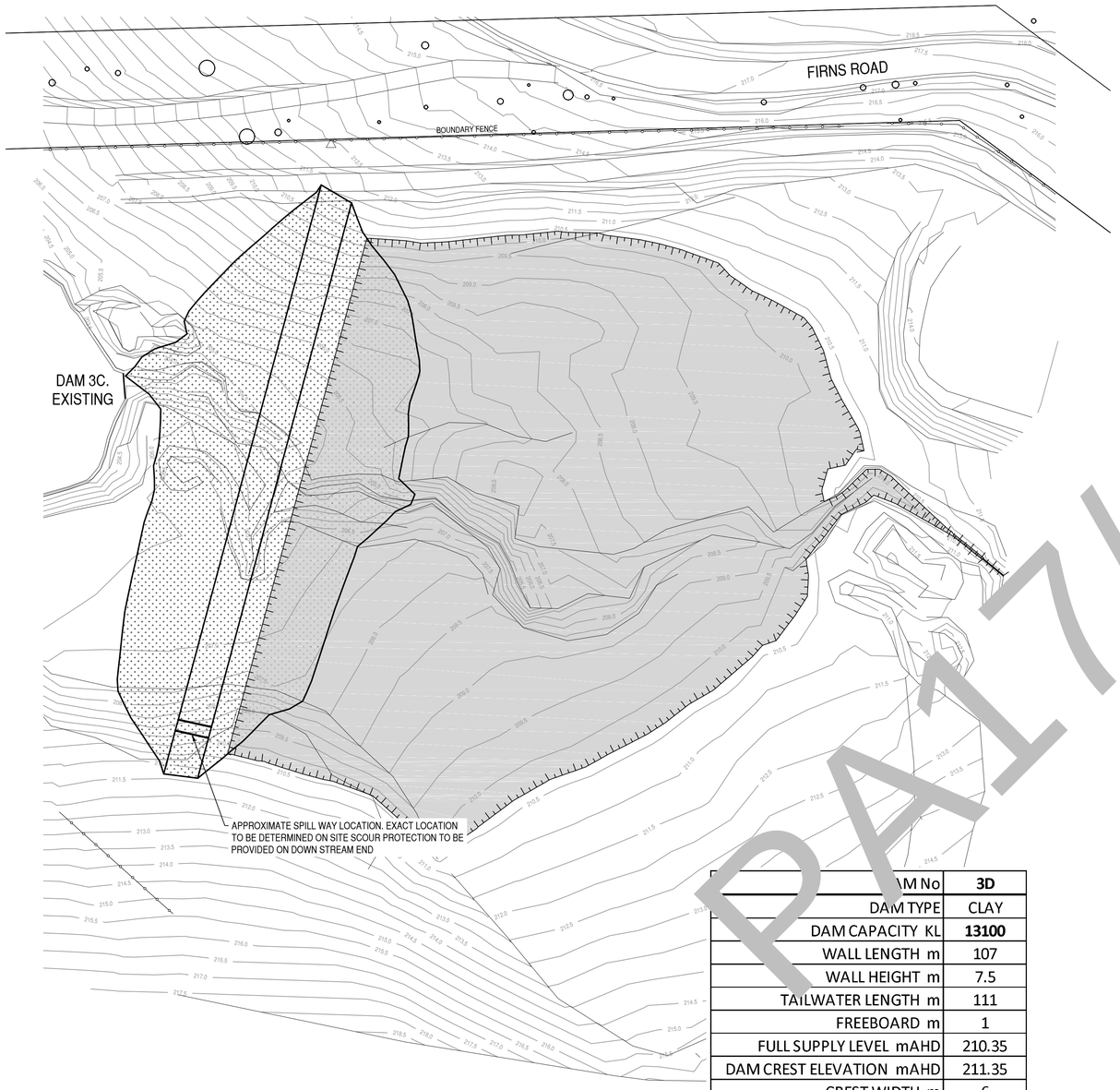
civil and structural engineering consultants
Level 1, 430 Roberts Road
Subiaco WA 6008
PO Box 2150
Subiaco WA 6904
Telephone: (08) 9382 5111
admin@pfeng.com.au

DRAWING STATUS: NOT FOR CONSTRUCTION
DATE: JUNE 2017 | GRID: LOCAL | DATUM: LOCAL
DESIGNED: AW | DRAWN: JS | CHECKED: MRi | APPROVED: MRi ..../ ....
W.A.P.C.
SCALE U.N.O.: AS SHOWN @ A1

CLIENT & JOB: SARABAND INVESTMENTS
LOT 206 FIRNS ROAD, SERPENTINE
TITLE: PROPOSED DAM
DAM 3A
SHEET SIZE: A1
ORG No.: 15148-C1-EW-02
REVISION: C

NORTH



DAM No	**3D**
DAM TYPE	CLAY
DAM CAPACITY KL	**13100**
WALL LENGTH m	107
WALL HEIGHT m	7.5
TAILWATER LENGTH m	111
FREEBOARD m	1
FULL SUPPLY LEVEL mAHD	210.35
DAM CREST ELEVATION mAHD	211.35
CREST WIDTH m	6
DOWNSTREAM BATTER	1V:3H
UPSTREAM BATTER	1V:4H
EMBANKMENT VOLUME m3	9980

SCALE 1:500 0m 10m 20m

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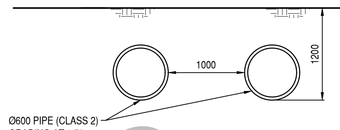
LEGEND

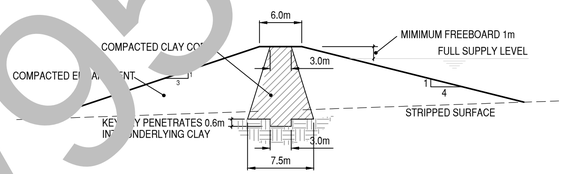
PROPOSED AREA OF RESERVOIR

PROPOSED DAM WALL EARTHWORKS AREA

NATURAL SURFACE CONTOURS (5.0m)



TYPICAL SPILLWAY ABOVE PIPES
NOT TO SCALE



TYPICAL SECTION
NOT TO SCALE

NOTES

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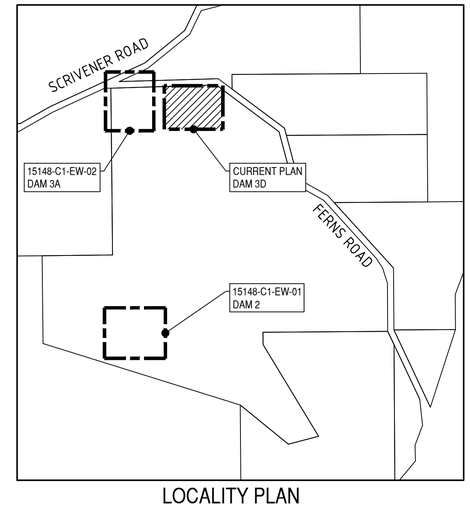

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W.A.P.C.
SCALE U.N.O.: AS SHOWN @ A1
SHEET SIZE: A1
DRG No.: 15148-C1-EW-03
REVISION: C

APPENDIX G – APPLICATION FOR CLEARING PERMIT AND CORRESPONDENCE

Our Ref: XYDSER02

4 August 2016

COTERRA ENVIRONMENT
2/460 Roberts Road
SUBIACO WA 6008

T (08) 9381 5513
F (08) 9381 5514

www.coterra.com.au
info@coterra.com.au

Department of Environment Regulation
Native Vegetation Conservation Branch
Locked Bag 33, CLOISTERS SQUARE
PERTH WA 6850

via email: nvp@der.wa.gov.au

To whom it may concern

CLEARING PERMIT APPLICATION – LOT 2 FIRNS ROAD, SERPENTINE

On behalf of the proponent, Saraband Investments Pty Ltd, please find enclosed an application for a clearing permit (area permit) for clearing within Lot 2 Firns Road, Serpentine. The property has both cleared and vegetated expanses, and limited clearing is required to enable the construction of three online dams necessary for the irrigation of ~7 ha of fruit orchards.

The enclosed application for an area clearing permit is for the clearing of approximately 1.02 ha of vegetation located within the property, which has a total area of ~75 ha. The areas proposed to be cleared are:

Future north-western dam (Dam 3A): 0.27 ha (0.22 ha vegetation cover)

Future north-eastern dam (Dam 3D): 0.27 ha (0.25 ha vegetation cover)

Future southern dam (Dam 2): 0.68 ha (0.55 ha vegetation cover)

The following documents are enclosed in support of this application:

- Supplementary information
- Form C1 Application for (Area) Clearing Permit (Attachment 1)
- Certificate of Title for Lot 2 on Diagram 36434 (Attachment 2)
- Form C3 Payment by Credit Card (Attachment 3)

Thank you for your assistance with this application. Should you require a site visit, please contact me to arrange access to the site. If you have any other questions or require any further information please do not hesitate to contact me.

Yours Sincerely

E. Bryce

Emma Bryce
Lead Scientist

COTERRA ENVIRONMENT

SUPPLEMENTARY INFORMATION

1. Project Status

Lot 2 Firns Road, Serpentine (the site) is located within the Shire of Serpentine-Jarrahdale, situated approximately 50 km south of Perth and approximately 30 km north-east of Mandurah (site location shown in Figure 1). The three dams proposed to be constructed will be used to irrigate ~7 ha of orchards proposed to be planted within the site (Figure 2).

Development approval will be sought for the creation of the three new dams, supported by surface water licenses and permits to interfere with beds and banks, issued by the Department of Water.

2. Native Vegetation Clearing Permit Application

The enclosed application for an area clearing permit is for the clearing of approximately 1.02 ha of native vegetation within a clearing footprint of approximately 1.92 ha on Lot 2 Firns Road, Serpentine, consisting largely of open marri-wandoo woodland over both native and exotic understorey.

It is understood that clearing of native vegetation cannot be initiated across the site without a clearing permit. For this reason Coterra Environment, on behalf of the landowner are seeking a native vegetation clearing permit to undertake clearing within the site.

3. Site Characteristics

The site occurs on the Darling Scarp and the local geology consists of varying levels of laterite, ranging from boulders in the higher sections and loamy / clay gravels in the lower lying sections and in the vicinity of the streams. It is highly undulating, with approximate elevations of ~250 to 260 mAHD across the lot (Figure 2).

The headwaters of two small ephemeral watercourses are located within the property boundary (northern and southern watercourses shown in Figure 2). The watercourses originate onsite, traverse the property via three existing online dams and discharge downstream onto a neighbouring property.

The site is partly vegetated, with the areas proposed for clearing parkland cleared in some parts, with some understorey along drainage lines. The site lies between Karnet Nature Reserve and Serpentine National Park, with other rural properties nearby (largely to the west) supporting livestock grazing, orchards and other rural pursuits.

Vegetation

Regional vegetation mapping undertaken by Heddle et al. (1980) indicates three vegetation complexes occurring across the site (Figure 3). These complexes are described as:

- Darling Scarp: Vegetation ranges from low open woodland to lichens according to the depth of soils. Woodland components chiefly *Eucalyptus wandoo*, with

E. laeliae in the north, *E. haematoxylon* in the south, and *Corymbia calophylla* throughout the region.

- Yarragil (Yg1): Open forest of *Eucalyptus marginata subsp. marginata – Corymbia calophylla* on slopes with mixtures of *Eucalyptus patens* and *Eucalyptus megacarpa* on the valley floors in humid and sub-humid zones.
- Dwellingup (D1): Open forest of *Eucalyptus marginata subsp. marginata – Corymbia calophylla* on lateritic uplands in mainly humid and sub-humid zones.

The areas proposed for clearing exist largely in the Darling Scarp complex (Dam 3A) and the Yarragil 1 complex (Dam 3D and Dam 2). The current reservation of both complexes is provided in Table 1.

Table 1: Historical and current extent and reservation of regional vegetation complexes on the Darling Plateau (DP)

Veg. Complex	Total Pre-European Extent (ha) on DP	% remaining on DP (area)	% remaining in secure tenure on DP (area)	Total Pre-European Extent (ha) in SoSJ	% remaining in SoSJ (area)	% remaining in secure tenure in SoSJ area)
Darling Scarp	35,512	41.94%	13.62%	11,179	56.39%	12.18%
Yarragil 1	80,202	82.05%	10.18%	4,735	89.42%	12.18%

Source: Local Biodiversity Program (2013)

The vegetation across the site was described by Eric Skipworth and Associates (2010) as similar to surrounding areas on the Darling Scarp, with the main tree species being *Eucalyptus marginata* and *Corymbia calophylla*, with assorted shrubs within and adjacent to drainage lines.

A vegetation survey was undertaken in November 2011 by Lundstrom Environmental, focusing on the Dam 3D area as well as two prospective dam sites in the southern part of the site which are no longer being treated as options. The vegetation in the northern portion of the site (Dam 3D vicinity) was described as parkland cleared marri-wandoo woodland, with section along the drainage line consisting of understorey species such as; *Taxandria linearifolia*, *Acacia pulchella*, *Xanthorrhoea preissii*, *Drosera sp.*, *Lepidosperma sp.*, *Mesomelaena sp.* and *Kennedia prostrate*. A mid storey of tall *Taxandria linearifolia* and *Melaleuca rhaphiophylla* also occurred in some sections. Lundstrom Environmental (2011) described the vegetation in the vicinity of Dam 2 (southern portion of the site) as parkland cleared open marri-powderbark woodland with an upper storey of marri with the occasional presence of tall powderbark (*Eucalyptus accedens*). The lower storey and ground cover comprised the following species: *Taxandria linearifolia*, *Acacia pulchella*, *Xanthorrhoea preissii*, *Mesomelaena sp.*, and *Jacksonia sternbergiana*.

Coterra Environment undertook a site visit in July 2016 and found that whilst the majority of the vegetation within the site consisted of *Eucalyptus marginata* and *Corymbia calophylla* parkland cleared woodland, there were other tree species present, including *E. wandoo* and *E. accedens*. There was some riparian undergrowth along the watercourses, however much of the area proposed for clearing was overtaken by weedy grasses and other species such as *Gomphocarpus fruticosus* (narrow-leaved cottonbush, a Declared plant). The areas proposed to be cleared for

the future dam locations have been located in the areas shown so as to utilise existing drainage lines and to minimise the amount of clearing required (Figure 2 and 3).

Vegetation within the three proposed dams is described generally as follows:

- Dams 3A and 3D – Wandoo (*E. wandoo*) and marri (*C. calophylla*) over sedges (such as *Lepidosperma sp*. and *Mesomelaena sp*.), *Taxandria linearifolia*, *Acacia pulchella*, introduced grasses and narrow-leaf cottonbush (*Gomphocarpus fruticosus*) understorey. Large sections are entirely cleared or parkland cleared. (Plates 1 - 6)

- Dam 2 – Young marri (*C. calophylla*) and powderbark (*E. accedens*) over low scrub dominated by *Darwinia citriodora*, *Taxandria linearifolia, Hibbertia hypericoides, Acacia pulchella*, sedges (such as *Lepidosperma sp*. and *Mesomelaena sp*.), with invasion of introduced grasses and narrow-leaf cottonbush (*G. fruticosus*) (Plates 7 and 8).

Given the extent of introduced species and altered vegetation structure (likely as a result of grazing in the adjacent parkland cleared areas), the majority of vegetation within the proposed clearing areas is considered degraded. Lundstrom Environmental (2011) also described surveyed areas as Degraded according to the Keighery (1994) scale, with the main altering factor being prolonged and recent grazing. The effects of grazing can be seen in areas where the understorey is largely removed.

Weed species recorded by Lundstrom Environmental (2011) include:

- *Ehrharta longiflora* - annual veldt grass
- *Arcotheca calendula* - capeweed
- *Gladiolus undulata* - wild gladiolus
- *Briza maxima* - blowfly grass
- *Hypochaeris sp*. - cats ear
- *Moraea flaccida* - one leaf cape tulip
- *Gomphocarpus fruticosus* - narrow-leaf cotton bush
- *Lavendula stoechas* - Italian lavender
- *Lotus sp*. - lotus
- *Pennisetum clandestinum* - kikyu grass
- *Bromus sp*.
- *Avena sp*.
- *Agapanthus praecox* - agapanthus
- *Carduus sp*. - thistle
- *Rumex sp*. - dock

Plate 1: **Dam 3A vegetation**

Plate 2: **Dam 3A vegetation**

Plate 3: **Dam 3A vegetatio**

Plate 4: **Dam 3D vegetation**

Plate 5: **Dam 3D vegetation**

Plate 6: **Dam 3D vegetation**

Plate 7: **Dam 2 vegetation**

Plate 8: **Dam 2 vegetation**

Threatened or Priority Ecological Communities

A search of the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters database found no records of threatened or priority ecological communities potentially occurring within the site.

Conservation Significant Flora

There were twelve occurrences of Declared Rare Flora or priority flora identified as potentially occurring within the vicinity of the site, following a search of the WA Museum and Department of Parks and Wildlife NatureMap flora and fauna database, and the EPBC Act Protected Matters database (Table 2).

Table 2: Conservation significant flora species

Species	WA Status	EPBC Status
Acacia horridula	Priority 3	-
Acacia oncinophylla	Priority 3	-
Anthocercis gracilis	Threatened	Vulnerable
Caladenia huegelii	Threatened	Endangered
Diuris micrantha	Threatened	Vulnerable
Diuris purdiei	Threatened	Endangered
Drakaea elastica	Threatened	Endangered
Eucalyptus balanites	Threatened	Endangered
Lasiopetalum glutinosum glutinosum	Priority 3	-
Lasiopetalum pterocarpum	Threatened	Endangered
Synaphea sp. Fairbridge Farm	Threatened	Critically Endangered
Thelymitra stellata	Threatened	Endangered

Given the mostly degraded nature of the vegetation within the areas proposed for clearing, it is not likely that any plant species of conservation significance occur within these areas.

Fauna Habitat

Conservation Significant Fauna

A search of the WA Museum and Department of Parks and Wildlife NatureMap flora and fauna database, and the federal EPBC Act Protected Matters database found that the site may provide habitat to the conservation significant fauna species listed in Table 3.

Table 3: Conservation significant fauna species

Species	WA Status	EPBC Status
Birds		
Forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*)	Threatened (Vulnerable)	Vulnerable
Baudin's black cockatoo (*Calyptorhynchus baudinii*)	Threatened (Vulnerable)	Vulnerable
Carnaby's black cockatoo (*Calyptorhynchus latirostris*)	Threatened (Endangered)	Endangered
Malleefowl (*Leipoa ocellata*)		Vulnerable
Australian Painted Snipe (*Rostratula australis*)		Endangered
Mammals		
Chuditch (*Dasyurus geoffroii*)	Threatened (Vulnerable)	Vulnerable
Quenda (*Isoodon obesulus fusciventer*)	Priority 5	-
Western Ringtail Possum (*Pseudocheirus occidentalis*)	Threatened (Vulnerable)	Vulnerable
Quokka (*Setonix brachyurus*)	Threatened (Vulnerable)	Vulnerable

Habitat Availability

The vegetation within the proposed clearing areas is described in the previous section, and consists mostly of open marri-wandoo and marri-powderbark woodlands, of which much is parkland cleared.

Given the general paucity of understory species across the majority of the area proposed for clearing, it is highly unlikely that small / medium mammals such as chuditch, quenda or quokka would inhabit this vegetation.

However, it is noted that three conservation significant species of black cockatoo (Table 3) are known to occur in this area, and during the site visit, 22 marri and wandoo trees of sufficient size to form cockatoo nesting hollows (500 mm Diameter at Breast Height (DBH) for marri and 300 mm DBH for wandoo) were recorded within the proposed clearing areas (Figure 4). Areas directly adjacent to the proposed clearing areas were also surveyed to account for any change in clearing boundary or indirect impacts to surrounding vegetation resulting from the dam construction. A total of 42 potential habitat trees were recorded, however almost half of these occurred outside of the dam footprint boundaries.

Whilst no hollows capable of supporting breeding were identified within these trees (ie. where hollows were present, they were not considered sufficiently large), evidence of foraging undertaken by both Baudin's black cockatoo and forest red-tailed black cockatoo on marri fruits was observed and noted across the three proposed clearing areas. As such, there is considered to be habitat value for the three black cockatoo species listed in Table 4 within these impact areas.

Carnaby's black cockatoo mapping prepared by the Department of Planning (2011) indicates that the subject is likely to contain potential foraging habitat, and three known breeding sites and three known roosting sites have been mapped as occurring between 1 and 3 km east of the site. This information originated from the Storr-Johnstone Bird Data Bank, current to 2010. A potential Carnaby's black cockatoo roost site has previously been recorded by Birdlife Australia, approximately 300 m east of the site. This site was documented in 2011 as a potential roost site but has not been verified by any Great Cocky Count undertaken since (Tegan Douglas, pers.comm. July 2016).

5. Assessment against Clearing Principles

Table 4 provides assessment of the proposed clearing against the EPA's ten clearing principles, as provided in Schedule 5 of the *Environmental Protection Act 1986*.

Table 4: Assessment Against Clearing Principles

Native Vegetation Clearing Principles	Assessment of Proposed Clearing
1. Native vegetation should not be cleared if it comprises a high level of biological diversity	The vegetation within the areas proposed for clearing is considered to be relatively degraded, and unlikely to comprise a high level of biological diversity. Given the partial, parkland cleared nature of the proposed clearing areas, there are surrounding expanses of vegetation (eg. in Serpentine National Park and Karnet Nature Reserve) that comprise a greater level of species diversity.
2. 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	It has been observed that the proposed clearing areas provide some foraging habitat for black cockatoos, though the general lack of logs and degraded understorey growth potentially limits the presence of conservation significant ground-dwelling fauna. The proposed clearing area has been identified as containing foraging habitat suitable for black cockatoos (Carnaby's, forest red-tailed and Baudin's black cockatoos), which are protected under State and Federal legislation. Large marri and wandoo trees onsite may provide future breeding opportunities for black cockatoos, however there was no evidence of current breeding or the presence of sufficiently large hollows to enable breeding onsite.

Native Vegetation Clearing Principles	Assessment of Proposed Clearing
	The specific site data will be reviewed in terms of the likely impacts to black cockatoos, in consultation with the Department of the Environment, to determine whether the proposed clearing triggers the requirement for referral under the EPBC Act.
3. Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora	It is unlikely that any conservation significant flora is present within the proposed clearing areas, due to the degraded nature of these areas. Much of the area proposed for clearing is parkland cleared, and where there is understorey present, it has had its natural structure altered in most locations. There is significant weed invasion along the drainage lines.
4. Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community	A search of the federal EPBC Act Protected Matters database found no records of threatened or priority ecological communities potentially occurring within the site. As the majority of the vegetation present is considered degraded, it is unlikely to represent a threatened or priority ecological community (TECs and PECs must have a minimum of Good rating using the Keighery (1994) scale)
5. Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared	The majority of the proposed clearing area lies within the mapped extent of the Darling Scarp and Yarragil vegetation complexes (Table 2). Both of these complexes are well-represented within the Darling Plateau region, with 41.94% and 82.05% remaining respectively. As such, the clearing of a significant remnant vegetation complex will not occur as a result of the proposed clearing.
6. Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or a wetland	No wetlands with any significant protection status are mapped as occurring within the proposed clearing area (Local Biodiversity Program, 2016). The clearing is proposed to occur within and adjacent to two watercourses that intersect the site, as the purpose of the clearing is to construct online dams in these areas. A Permit to Interfere with Beds and Banks has been submitted to the Department of Water and all disturbance to the watercourses (including the removal of vegetation) will be assessed through this mechanism.

Native Vegetation Clearing Principles	Assessment of Proposed Clearing
7. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause appreciable land degradation	It is unlikely that the proposed clearing of the native vegetation will result in extensive land degradation, as the construction of irrigation dams will be undertaken and appropriate engineering design and relevant stabilisation techniques employed. The necessary planning and design approvals are required from the Shire of Serpentine-Jarrahdale prior to earthworks commencing.
8. 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 site is currently used for rural pursuits, with grazing occurring and extensive parkland cleared areas. It is not likely that the construction of additional dams will have adverse impacts on the Serpentine National Park (north of the site) or Karnet Nature Reserve (south of the site).
9. Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of the surface or underground water	The catchments of the two watercourses that intersect the site (proposed to be dammed) have been historically modified by human activities, primarily the construction of Firns Road and various offline dams within these catchments. The clearing is proposed to occur within and adjacent to two watercourses, as the purpose of the clearing is to construct offline dams in these areas. Water balance modelling has been undertaken to estimate the volume of water discharging to downstream users under the existing conditions and future scenarios (Coterra Environment, 2012). A Permit to Interfere with Beds and Banks as well as a license application to take surface water have been submitted to the Department of Water. As such, the Department of Water will assess the impacts to water resources that may occur as a result of the proposed clearing and dam construction.
10. Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding	As discussed above, water balance modelling has been undertaken to estimate the volume of water discharging to downstream users under the existing conditions and future scenarios (Coterra Environment, 2012). The beds and banks permit application requires identification of whether the proposed dams will cause water to flood across property boundaries and/or whether water will leave the property other than in the

Native Vegetation Clearing Principles	Assessment of Proposed Clearing
	watercourse. An initial preliminary assessment was undertaken by Coterra Environment to determine the extent of inundation based on the proposed weir heights in mAHD and subsequent delineation to the surrounds based on the topography. This approach was deemed acceptable to DoW. It was found that constructing the proposed dams would not result in flooding of neighbouring properties.

6. Conclusion

The development of the site to create three additional irrigation dams and the associated clearing proposed is not considered to be at variance with any of the native vegetation clearing principles (or alternatively addressed through other (local, state and federal) environmental assessment, permitting and approval mechanisms), as discussed in Section 5.

7. References

Coterra Environment (2012). Dam and Water Balance Assessment – Lot 822 (206) Firns Road, Serpentine. Rev 0, July 2012. Prepared for Harry and Demetra Xydas.

Department of Planning (DoP) and Western Australian Planning Commission (WAPC) (2011). Metropolitan Region Scheme (MRS) South East - potential habitat for the Carnaby's Black Cockatoo which may require further assessment. Produced by Mapping & GeoSpatial Data Branch, Department of Planning on behalf of WAPC.

Eric Skipworth and Associates Farm Management Consultants (2010). Land Capability Report – Lot 206 Scrivener Road, Serpentine.

Heddle, E.M. Loneragan, O.W, Havel, J.J (1980). Vegetation Complexes of the Darling System Western Australia, In. *Atlas of Natural Resources, Darling System, Western Australia.* Department of Conservation and Environment, Perth.

Keighery, B.J. (1994). Bushland Plant Survey. a Guide to Plant Community Surveys for the Community. Wildflower Society of Western Australia (Inc.) Nedlands, Western Australia.

Local Biodiversity Program (2013). Native Vegetation Extent by Vegetation complexes on the Darling Plateau. http://pbp.walga.asn.au/Portals/1/Templates/docs/SCP%202013%20remnant%20veg.pdf

Local Biodiversity Program (2013). Environmental Planning Tool. Western Australian Local Government Association (WALGA), Perth, WA.

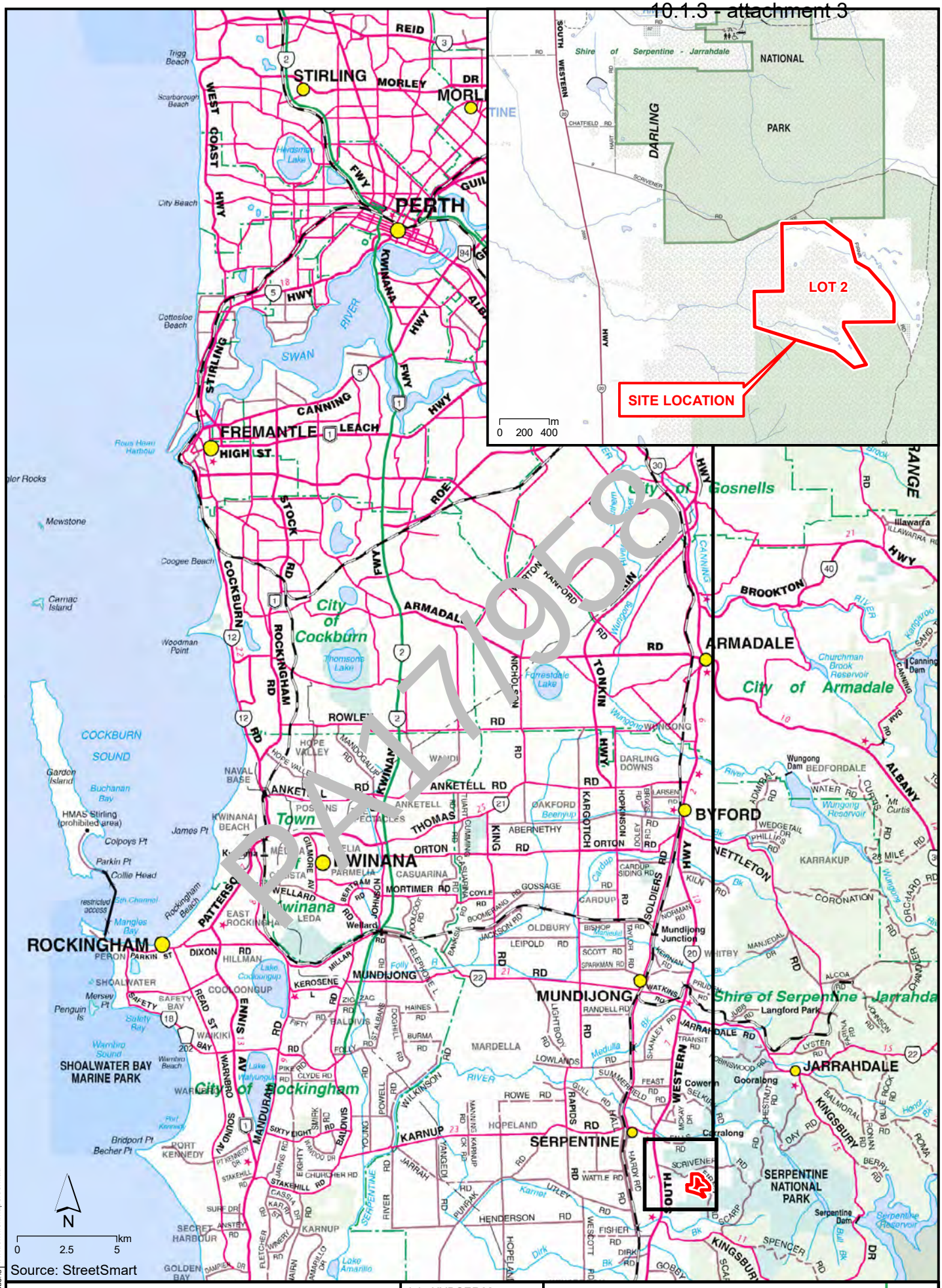
Lundstrom Environmental (2011). Reconnaissance Study of Vegetation and Hydrology for Impact Assessment of Dam Construction - Lot 822 Firns Road, Serpentine. Prepared for Saraband Investments Pty Ltd.

Figures

Attachments

COTERRA ENVIRONMENT

FIGURES



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Environmental Mapping Solutions

COTERRA ENVIRONMENT

Job: XYDSER02
Doc: 001
Date: 22.07.16
Ph: (08) 9381 5513
Fax: (08) 9381 5514
E: info@coterra.com.au

Harry and Demetra Xydas
SERPENTINE DAMS CLEARING PERMIT APPLICATION
FIRNS ROAD, SERPENTINE

SITE LOCATION

Figure 1

LEGEND

- Site Boundary
- Cadastre
- Contour (mAHD)
- Watercourse
- Existing Waterbody
- Existing Online Dam
- Future Dam
- Area Proposed to be Irrigated by Proposed North Dams
- Area Proposed to be Irrigated by Proposed South Dam
- Area Proposed to be Irrigated by Existing Dam 1

N

0 37.5 75 150 225 300 m

Scale: 1:7,500 @ A3
GDA 1994 MGA Zone 50

DAM 3A
DAM 3D
DAM 2
NORTHERN WATERCOURSE
SOUTHERN WATERCOURSE
EASTERN WATERCOURSE
SCRIVENER RD
FIRNS RD
LOT

Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, Sept. 2015
Topography - Landgate, 2016

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Harry and Demetra Xydas
SERPENTINE DAMS CLEARING PERMIT APPLICATION
FIRNS ROAD, SERPENTINE

EXISTING AND PROPOSED DAM LOCATIONS

Figure 2

LEGEND
- Site Boundary
- Cadastre
- Future Dam
- Heddle Vegetation Complex Boundary

N

0 37.5 75 150 225 300 m

Scale: 1:7,500 @ A3
GDA 1994 MGA Zone 50

SCRIVENER RD
FIRNS RD
LOT 1

3000
463
1913
3000
3000
3
4
1
562
303
304
813
736
504
502
304
654
555
564
6
5
4
2888
2272
2273
1913

Yarragil Complex (Minimum Develo-\Pment Swamps) In Medium To High Rainfall
Darling Scarp Complex
Dwellingup Complex In Medium\To High Rainfall

Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, Sept. 2015
Heddle Vegetation - DEC, 2002

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SERPENTINE DAMS CLEARING PERMIT APPLICATION
FIRNS ROAD, SERPENTINE

REGIONAL VEGETATION COMPLEXES

Figure 3

LEGEND
- Site Boundary
- Cadastre
- Future Dam

Fauna Habitat Tree Species
- Marri
- Wandoo

N

0 25 50 100 150 200 m

Scale: 1:5,000 @ A3
GDA 1994 MGA Zone 50

SCRIVENER RD
FIRNS RD
LOT 2
3000
555
564
6
5
4
3
1913
2272
1
562
2273
304
303
813
736

PAT 71958

Source: Cadastre - Landgate, 2016
Orthophoto - Landgate, Sept. 2015

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Harry and Demetra Xydas
SERPENTINE DAMS CLEARING PERMIT APPLICATION
FIRNS ROAD, SERPENTINE

FAUNA HABITAT TREE MAPPING

Figure 4

COTERRA ENVIRONMENT

ATTACHMENT 1 – FORM C1 FOR APPLICATION FOR (AREA) CLEARING PERMIT

GOVERNMENT OF WESTERN AUSTRALIA

Department of Environment Regulation – Department of Mines and Petroleum

Application for a clearing permit (area permit)

Environmental Protection Act 1986 s 51E

FORM C1

Clearing of native vegetation is prohibited in Western Australia except where a clearing permit has been granted or an exemption applies. A person who causes or allows unauthorised clearing commits an offence.

CPS No.
Date stamp

Part 1 Assessment bilateral agreement

The native vegetation clearing processes under Part V of the *Environmental Protection Act 1986* (EP Act) have been accredited by the Commonwealth of Australia under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and can be assessed under an assessment bilateral agreement.

To be assessed under the assessment bilateral agreement, the proposed clearing action must be referred to the Commonwealth under the EPBC Act prior to submitting this application form and Annex C7 must also be completed.

For further information see Annex C7 and *A guide to native vegetation clearing processes under the assessment bilateral agreement* available at www.der.wa.gov.au/our-work/clearing-permits.

Do you want your proposed clearing action assessed in accordance with, or under, an EPBC Act Accredited Process such as the assessment bilateral agreement?

☐ Yes ☒ No Proceed to Part 2

Has the proposed clearing action been referred to the Commonwealth of Australia under the EPBC Act?

☐ Yes EPBC Number

☐ No It cannot be assessed under an Accredited Process such as the assessment bilateral agreement until it has been referred to the Commonwealth. Proceed to Part 2.

Has a decision been made under the EPBC Act as to whether the proposed clearing action is a controlled action?

☐ Yes ☐ No Proceed to Part 2.

Is the proposed clearing action a controlled action under the EPBC Act?

☐ No It cannot be assessed under an Accredited Process, proceed to Part 2.

☐ Yes Complete and attach the requirements of Annex C7 to this completed form.

List the controlling provisions identified in the notification of the controlled action decision

☐ Annex C7 is complete and the required supporting information is attached.

Part 2 Land details

The location of the land where clearing is proposed must be accurately described

Land description: volume and folio number, lot or location number(s), Crown lease or reserve number, pastoral lease number or mining tenement number of all properties.

Lot 2 on Diagram 36434

FILE REFERENCE

Street address	Lot 2 Firns Road, Serpentine, Western Australia
Local government area	Shire of Serpentine-Jarrahdale
Land zoning, e.g. rural, residential, industrial	Rural

Part 3 Proposal

An aerial photograph or map with a north arrow must be attached, clearly marking the area proposed to be cleared

Total **area** of clearing proposed (hectares)	1.02 ha
and/or	

or if you have the facilities, a digital map on CDROM of the area to clear as an ESRI shapefile with the following properties: Geometry type: Polygon shape Coordinate system: GDA 1994 (Geographic latitude/longitude) Datum: GDA 1994 (Geocentric Datum of Australia 1994).	number of individual **trees** to be removed
	Proposed method of clearing Mechanical clear felling
	Period within which clearing is proposed to be undertaken, e.g. May 2014 – June 2014 from October 2016 to May 2017
	Purpose of clearing To construct online irrigation dams
	Has this clearing application or any related matter been referred to the Environmental Protection Authority (EPA)? ☐ Yes ☒ No
	Is this clearing application related to an application for another approval described in Part V, Division 3 of the EP Act (ie. Works approvals or licence)? ☐ Yes ☒ No Approval number

Part 4 Applicant

To apply for a permit you must either be: • the landowner • acting on the landowner's behalf or • likely to become the landowner. Note: If you are acting on behalf of the landowner, you must attach a letter of authority from the landowner explicitly stating that you, the applicant, have authority to clear on the said land.	Are you applying as an individual, a company or an incorporated body? Enter details for one only (please print). An individual applicant — Title: ☐ Mr ☐ Mrs ☐ Ms ☐ Other Given names Family name *or* A body corporate or other entity formed at law: Saraband Investments Pty Ltd
Ownership of land A landowner can be: • a person who holds the Certificate of Title • a person who is the lessee of Crown land *or* • a public authority that is responsible for care of the land. If granted, the permit will be granted in the name of the landowner.	Form of ownership: ☒ Certificate of Title (please attach a copy of the certificate and all associated encumbrances with the application - available from Landgate). ☐ Pastoral lease (please attach a copy of the lease and all associated encumbrances with the application). ☐ Mining lease. ☐ Public authority that has care, control or management of the land. ☐ Other form of lease, land tenure or specific arrangement. Please state:
Relationship to landowner Please indicate your relationship to the landowner.	I am (tick applicable box) ☒ the owner of the land.

If you are likely to become the landowner, please attach evidence of the pending transfer of ownership, contract of sale ('offer and acceptance') or letter from current landowner.	☐	acting on behalf of the owner and have attached an agent's authority, expressly authorising me to act on behalf of the landowner.
	☐	likely to become the owner of the land (please provide copy of 'offer and acceptance').

Proposed permit holder details		
*If applying as a company or incorporated body, please also supply the registered business office address.	Title	☒ Mr ☐ Mrs ☐ Ms ☐ Other
	Given names	Harry
	Family name	Xydas
	Position title/Company	Director
	Postal/Business address* (for future correspondence)	Level 1, 420 Hay Street, Subiaco WA 6008
	Fixed telephone number	08 938 265
	Mobile telephone number	
	Fax number	
	Email address	xyd doricgroup.com.au

Contact details		
	☐	Contact details are the same as above **OR:**
Person with whom Department of Environment Regulation or Department of Mines and Petroleum should liaise concerning the clearing application.	Title	☐ Mr ☐ Mrs ☒ Ms ☐ Other
	Given names	Emma
	Family name	Bryce
*If applying as a company or incorporated body, please also supply the registered business office address.	Position title/Company	Lead Scientist
	Postal/Business address*	Level 3, 25 Prowse Street, West Perth WA 6005
	Fixed telephone number	08 9381 5513
	Mobile telephone number	
	Fax number	
	Email address	emma.bryce@coterra.com.au

Part 5 Declaration and signature

For your application to be accepted, it must be signed either on behalf of the company or as an individual. By signing this form you are declaring that the statements on this form are true and correct. The Department in accepting this form accepts you are an expressly authorised representative and are able to	Please indicate if you are signing as an individual or a company:	
	☐	**An individual.** If an individual landowner is applying, **all landowners** must sign this form.
	☒	**A company**. A person expressly authorised or authorised to execute on behalf of a body corporate must sign this form. A company must be a legal entity and provide an Australian Company Number (ACN). Please note Australian Business Number (ABN) is not sufficient.
	☐	**Other entity formed at law**. Provide details.

Department of Environment Regulation – Department of Mines and Petroleum

act on behalf of the body corporate in applying for and in holding a permit. Knowingly providing false or misleading information is an offence under section 112 of the *Environmental Protection Act 1986* and may incur a penalty of up to $50,000.	Signature(s)	1	Date 3/8/16
		2	Date
	Print name(s)	1	Mr Harry Xydas
		2	
	Position (e.g. director, CEO etc...)	1	Director
		2	
	Company name/ACN or other entity (incorporation etc.)		Saraband Investments Pty Ltd
	Common seal (if used)		

Part 6 Prescribed fee

Make cheques or money orders payable to:

Department of Environment Regulation for **all clearing purposes other than mining and petroleum activities**

or

Department of Mines and Petroleum for **mineral and petroleum clearing activities under the Mining Act, various Petroleum Acts or State Agreement Acts.**

To make payment with a credit card, please complete Form C3 and attach to this form.

Do not send cash in the mail.

Please indicate the clearing permit application fee that you are paying:

☐	$50 for an area of less than one hectare
☒	$100 for an area between one hectare and 10 hectares
☐	$200 for an area of more than 10 hectares

Payment method (tick applicable box):

☐	Cheque
☐	Money order
☒	Credit card (please complete Form C3 and attach)

OFFICE USE ONLY

Part 7 Application checklist

Additional information to assist in the assessment of your proposal may be attached to this application – e.g. reports on salinity, fauna or flora studies or other environmental reports conducted for the site could be included in electronic format and submitted on CDROM.

Please ensure you have included the following as part of your application:

REQUIRED	☒	A completed application form that is signed and dated by all landowners, or the applicant acting on behalf of or likely to become the landowner
	☒	Payment
	☒	An aerial photograph or map with a north arrow clearly identifying the areas of vegetation proposed to be cleared or ESRI shapefile. *An ERSI shapefile must be provided if the application requires an assessment under an EPBC Act Accredited process
	☒	I have read and understand the 'Confidential or commercially sensitive information' section at the bottom of this form
REQUIRED IF APPLICABLE	☒	Copy of the Certificate of Title or pastoral lease
	☐	Copy of written authority to act on behalf of the landowner

		☐	Evidence of the pending transfer of land ownership, such as the offer and acceptance, or written notice from the current landowner
		☒	Form C3 if fee is to be paid by credit card
		☐	Annex C7 if the clearing is also to be assessed under an EPBC Act Accredited Process
	Please provide a summary of all attached documentation	Cover letter and summary report Completed application form Relevant figures Certificate of Title Form C3 for credit card payment	

Part 8 Lodgement

Send by email or post original applications for **all clearing purposes (other than mining and petroleum activities)** to: **Department of Environment Regulation** Locked Bag 33 CLOISTERS SQUARE PERTH WA 6850 Email: nvp@der.wa.gov.au Telephone: 9333 7469 For more information: www.der.wa.gov.au/our-work/clearing-permits	Send **original applications related to mining and petroleum clearing activities (under delegation)** to: **Department of Mines and Petroleum** Environment Division Mineral House 100 Plain St EAST PERTH WA 6004 Telephone: 9222 3333 For more information: www.dmp.wa.gov.au

Please retain a copy of this form for your records.

Incomplete applications will be declined in accordance with section 51E (3) of the *Environmental Protection Act 1986*.

CONFIDENTIAL OR COMMERCIALLY SENSITIVE INFORMATION

Information submitted as part of this application may be made publicly available. If you wish to submit information that you believe to be commercially sensitive or otherwise confidential, then you should submit that information in an appendix to this application, with a written statement of reasons why you request that each item of information be kept confidential. The department will take reasonable steps to protect confidential or commercially sensitive information. Please note in particular that all submitted information may be the subject of an application for release under the *Freedom of Information Act 1992*. If you have any enquiries regarding the provision of relevant information as part of this application contact either the Department of Environment Regulation or the Department of Mines and Petroleum.

If there is insufficient space on any part of this form,
please continue on a separate sheet of paper and attach to this form.

COTERRA ENVIRONMENT

ATTACHMENT 2 – CERTIFICATE OF TITLE FOR LOT 2 ON DIAGRAM 36434

214D
Perth Batch
L440239

WESTERN AUSTRALIA

REGISTER NUMBER	
2/D36434	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	8/11/2010

DUPLICATE CERTIFICATE OF TITLE

VOLUME 242 FOLIO 92A

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 2 ON DIAGRAM 36434

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

SARABAND INVESTMENTS PTY LTD OF LEVEL 1, 420 HAY ST[illegible] SUBIACO
(T L4[illegible]0239) REC[illegible]TERED 29 SEPTEMBER 2010

LIMITATIONS, INTERESTS, ENCUMBR[illegible]NCES AN[illegible]D NOTIFICATIONS:
(SECON[illegible] S[illegible]HED[illegible]LE)

Warning: A current search of the certificate of title held in elect[illegible]ic form should[illegible] obtained before dealing on this land.
Lot as described in the land description may be a lot [illegible] lo[illegible]tion.

----------END O[illegible] D[illegible]PLICAT[illegible] CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out b[illegible]ow are[illegible]ot inte[illegible]ded to be nor should they be relied on as substitutes for inspection of the land and the rel[illegible]nt docu[illegible]ents or [illegible]r local government, legal, surveying or other professional advice.

SKETCH OF LAND: [illegible]242-92A (2/D36434).
PREVIOUS TITLE: [illegible]147-768, 1147-936.
PROPERTY STREET ADDRESS: 206 FIRNS RD, SERPENTINE.
LOCAL GOVERNMENT AREA: SHIRE OF SERPENTINE-JARRAHDALE.

37.5 HA 75 HA 180 ACRES 5 HA

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Transfer A184643
Volume 1147 Folio 936
1317 768

WESTERN AUSTRALIA

ORIGINAL REGISTER BOOK

VOL. 242 FOL. 92A

Certificate of Title

UNDER THE "TRANSFER OF LAND ACT, 1893" AS AMENDED

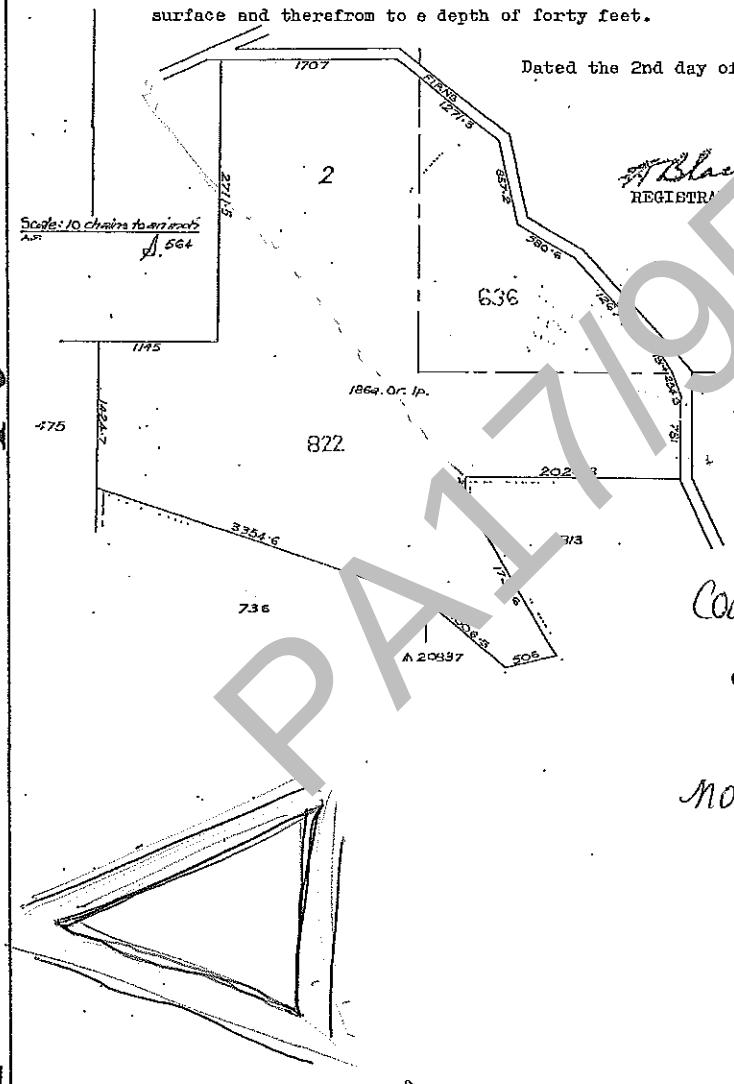
CT 0242 0092A F

Peter Bruce De Barran Cullen of 22 York Terrace, Mosman Park, Farmer and Solicitor, is now the proprietor of an estate in fee simple subject to the easements and encumbrances notified hereunder in all that piece of land delineated and coloured green on the map hereon containing one hundred and eighty-six acres and one perch or thereabouts, being Cockburn Sound Location 822 and portion of Cockburn Sound Location 636, together being Lot 2 the subject of Diagram 36434.

As to Cockburn Sound Location 822 only: Limited however to the natural surface and therefrom to e depth of forty feet.

Dated the 2nd day of July 1969

REGISTRAR OF TITLES



The correspondence address of the registered proprietor is Lot 2 Firns Road, Serpentine. By 941568. Dated 21st July 1992 at 9.18 hrs.

OFFICE OF TITLES Western Australia

Cockburn Sound Locanon
old locanon number.
636 / 822
now Lot 2 Diagram 36434.

For encumbrances and other matters affecting the land see back

COTERRA ENVIRONMENT

ATTACHMENT 3 – FORM C3 PAYMENT BY CREDIT CARD

Government of **Western Australia**
Department of **Environment Regulation**

Your ref:	XYDSER02
Our ref:	CPS 7208/1
Enquiries:	Kerri Wilkes
Phone:	9333 7528
Email:	nvp@der.wa.gov.au

Ms Emma Bryce
Lead Scientist
Coterra Pty Ltd TA Coterra Environment
Level 3
25 Prowse Street
WEST PERTH WA 6005

Dear Ms Bryce

APPLICATION TO CLEAR NATIVE VEGETATION UNDER THE *ENVIRONMENTAL PROTECTION ACT 1986*

I refer to Saraband Investments Pty Ltd's application to clear 1.02 hectares of native vegetation within Lot 2 on Diagram 36434, Serpentine, for the purpose of constructing three online irrigation dams. This application was received on 4 August 2016.

I advise that a preliminary assessment of the vegetation against the clearing principles contained in Schedule 5 of the *Environmental Protection Act 1986* (EP Act) has been conducted, taking into account information you have provided and information the Department of Environment Regulation (DER) has obtained through consultation. Attached is a Preliminary Assessment Report, which provides detail on the assessment of Saraband Investments Pty Ltd's clearing application.

While the assessment of your application has been undertaken, under s51O(4) of the EP Act, I am also required to have regard to any planning instrument or other matter considered relevant. I understand that at this stage that planning approval from the Shire of Serpentine-Jarrahdale and licences required under the *Rights in Water and Irrigation Act 1986* (RIWI) from the Department of Water have not been obtained.

Please ensure these approvals are provided within three months from the date of this letter. I advise that the Delegated Officer intends to make a decision on the application based on the information available in three months from the date of this letter. In the absence of receiving a copy of the planning approval and RIWI licences, it is likely that your application for a clearing permit will be refused, in accordance with section 51E(5)(b) of the EP Act.

If you have any queries regarding the progress of this application, please contact Clearing Regulation Officer Ms Kerri Wilkes on 9333 7528.

Yours sincerely

JAMES WIDENBAR
MANAGER
CLEARING REGULATION

Officer delegated under Section 20
of the Environmental Protection Act 1986

20 October 2016

Attached: CPS 7208/1 Preliminary Assessment Report

Government of Western Australia
Department of Environment Regulation

Preliminary Assessment Report

1. Application details

1.1. Permit application details

Permit application No.: 7208/1
Permit type: Area Permit

1.2. Applicant details

Applicant's name: Saraband Investments Pty Ltd

1.3. Property details

Property: LOT 2 ON DIAGRAM 36434, SERPENTINE
Local Government Authority: SERPENTINE-JARRAHDALE, SHIRE OF
DER Region: Greater Swan
DPaW District: PERTH HILLS
LCDC: Serpentine-Jarrahdale LCD
Localities: SERPENTINE

1.4. Application

Clearing Area (ha)	No. Trees	Method of Clearing	For the purpose of:
1.02		Mechanical Removal	Dam construction or maintenance

2. Site Information

2.1. Existing environment and information

2.1.1. Description of the native vegetation under application

Vegetation Description	Clearing Description	Vegetation Condition	Comment
The vegetation under application is mapped as: Beard vegetation association 4 is described as medium woodland; marri & wandoo (Shepherd et al., 2001). Yarragil vegetation complex (Minimum Development Swamps) in medium to high rainfall is comprised of open forest of *Eucalyptus marginata* (Jarrah) - *Corymbia calophylla* (Marri) on upper slopes with admixture of *Eucalyptus patens* (Swan River Blackbutt) and *Eucalyptus megacarpa* (Bullich) on the valley floors. Dominant vegetation types C. D. W; less consistently Q. T. U. (Heddle et al., 1980). Heddle vegetation Darling Scarp complex is comprised of vegetation that ranges from low open woodland to lichens according to depth of soils. Woodland components chiefly *Eucalyptus wandoo* (Wandoo) with *Eucalyptus laeliae* (Darling Range Ghost Gum) in the north, *Corymbia haematoxylon* (Mountain Marri) in the south, and *Corymbia calophylla* (Marri) throughout the region. Dominant vegetation types R. G. (Heddle et al., 1980). Mattiske vegetation Yg1 complex consists of open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* on slopes with mixtures of *Eucalyptus patens* and *Eucalyptus megacarpa* on the valley floors in humid and subhumid zones (Mattiske and Havel., 1998). Mattiske vegetation DS complex consists of low woodland of *Eucalyptus marginata* subsp.	The application is to clear 1.02 hectares of native vegetation within Lot 2 on Diagram 36434, Serpentine, for the purpose of constructing three online irrigation dams.	Degraded; Structure severely disturbed; regeneration to good condition requires intensive management (Keighery, 1994) To Good; Structure significantly altered by multiple disturbance; retains basic structure/ability to regenerate (Keighery, 1994).	The condition and description of the application area was determined via a site inspection conducted by Department of Environment Regulation (DER) officers on 22 September 2016 and via a reconnaissance vegetation survey conducted by Lundstrom Environmental (2011).

marginata-Corymbia calophylla-Eucalyptus staeri on small hills of siltstone plateau in the perhumid zone (Mattiske and Havel., 1998).

Mattiske vegetation D1 complex consists of open forest of *Eucalyptus marginata* subsp. *marginata-Corymbia calophylla* on lateritic uplands in mainly humid and subhumid zones (Mattiske and Havel., 1998).

3. Assessment of application against clearing principles

Comments

The application is to clear up to 1.02 hectares of native vegetation within Lot 2 on Diagram 36434, Serpentine, for the purpose of constructing three online dams for the irrigation of appropriately seven hectares of orchards proposed to be planted on the subject property.

The vegetation within the application area is considered to range from degraded to good (Keighery, 1994) condition, with the majority of vegetation in a degraded (Keighery, 1994) condition. The understorey lacks biodiversity due to the area being heavily grazed and the dominance of invasive species, resulting in vegetation that is largely in a degraded (Keighery, 1994) condition (DER, 2016). In some sections along the drainage lines, there were native shrubs and sedges scattered throughout the understorey.

The application area consisted of two vegetation types. The vegetation proposed for clearing occurs along two drainage lines, and largely comprises of *Corymbia calophylla* and *Eucalyptus wandoo* woodland in the north western (Area 1) and north eastern (Area 2) areas, and *Corymbia calophylla* and *Eucaltypus accendens* woodland in the southern portion (Area 3) of the application area. *Taxandria linearifolia* was dominant through the mid-storey within Area 2. There is some small pockets of vegetation in a degraded to good (Keighery, 1994) condition in Area 3.

A total of twenty two priority flora species and nine rare flora species have been recorded within the local area (10 kilometre radius). The closest priority flora is priority flora species *Acacia horridula*' mapped 311 metres north east of the application area. This species prefers rocky hillslopes on gravelly soils over granite or sand (Western Australian Herbarium, 1998-). Noting the habitat requirements for this species, suitable habitat may occur within the application area. However, given the degraded (Kieghery, 1994) condition of the understorey and high level of weed infestation, this species is not expected to be present.

Given the habitat requirements, history of grazing and the largely degraded (Keighery, 1994) condition of the majority of the vegetation under application, it is unlikely any other rare or priority flora occur within the area under application. Therefore, the clearing proposed is unlikely to have an impact on conservation significant species.

The Department of Parks and Wildlife (Parks and Wildlife, 2016) advised that suitable habitat for five of the nine rare flora species recorded within the local area may occur within the application area. However, these species (with the exception of one) have not been recorded within the conservation reserves adjacent to the application area and are mainly found further west, at a lower elevation, on aeolian-derived (coastal plain) soils (Parks and Wildlife, 2016). Furthermore, degradation due to historic clearing and grazing by livestock is likely to have reduced or eliminated previous occurences of any conservation significant taxa occuring within the application area (Parks and Wildlife, 2016).

Nineteen fauna species of conservation significance have been recorded within the local area (10 kilometre radius) (Department of Parks and Wildlife, 2007-). Of these, the forest red-tailed black cockatoo (*Calyptorhynchus banksii subsp. naso*), Carnaby's cockatoo (*Calyptorhynchus latirostris*) and Baudin's cockatoo (*Calyptorhynchus baudinii*) may utilise habitat within the application area. Noting the degraded (Keighery, 1994) condition of the understorey present, it is considered that the application area is unlikely to provide significant habitat for ground dwelling fauna.

Black cockatoos nest in large hollows of eucalyptus trees and forage on the seeds, nuts and flowers of a large variety of plants including proteaceous species (*banksia, hakea, grevillea*), as well as *allocasuarina* and *eucalyptus* species, *Corymbia calophylla* and a range of introduced species, especially seeds from cones of *pinus* species (Shah, 2006; Valentine and Stock, 2008).

The vegetation type recorded within the application area consists of *Eucalyptus* species and is suitable foraging habitat for the three types of black cockatoos outlined above. A flock of Carnaby's cockatoos were also observed flying over the application area during a site inspection undertaken by DER (DER, 2016). Although the application area contains suitable foraging habitat for black cockatoo species the application area is not likely to be critical for the survival of this species due to its size and as the local area (10 kilometre radius) contains approximately 55 per cent vegetation which includes a number of large remnants in conservation estate, including Serpentine National Park, Karnet Nature Reserve and thirteen Bush Forever Sites. These conservation areas are likely to contain suitable habitat for black cockatoos in equal or better condition than the application area.

A site inspection of the application area conducted by DER officers did not identify any trees of a suitable size (diameter at breast height of 50 centimetres or greater) to contain breeding hollows for black cockatoos (DER, 2016).

According to available databases, the closest mapped threatened ecological community (TEC) is the '*Eucalyptus calophylla – Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain' located approximately 1.4 kilometres north west of the application area. Given the type and condition of the vegetation proposed to be cleared, it is not representative of this community.

The local area (10 kilometre radius) retains approximately 55 per cent native vegetation. The vegetation under application is mapped as Beard vegetation association 4 of which there is approximately 28 per cent of its pre-European extent remaining within the Jarrah Forest bioregion (Government of Western Australia, 2015). The application area is also mapped as comprising Heddle vegetation Darling Scarp and Yarragil complexes, and Mattiske vegetation complexes Dwellingup, Dempster and Yarragil 1 of which approximately 36, 85, 87, 65 and 81 per cent of their pre-European vegetation remains, respectively (Department of Parks and Wildlife, 2015). The application area is located within the Shire of Serpentine-Jarrahdale, within which there is approximately 53 per cent of pre-European vegetation extent remaining (Government of Western Australia, 2015).

The national objectives and targets for biodiversity conservation in Australia has a target to prevent clearance of ecological communities with an extent below 30 per cent of that present pre-1750, below which species loss appears to accelerate exponentially at an ecosystem level (Commonwealth of Australia, 2001). All vegetation associations are above the 30 per cent threshold with the exception of Beard vegetation association 4. The majority of the vegetation within the application area is in a degraded (Keighery, 1994) condition and is no longer representative of this vegetation type. Given this, and the presence of vegetation in a similar or better condition within the adjacent A class Serpentine National Park, it is not likely to be significant as a remnant.

The application area intersects two minor perennial watercourses, one intersecting Areas 1 and 2, and the other intersecting Area 3. The watercourses originate on the property and traverse the site flowing east to west via three existing dams (DER, 2016). Given this, the application area contains vegetation that is growing in association with these watercourses.

The application area is situated on sloping land and consists of a mix of loamy/gravelly/clay soils (DER, 2016). The proposed clearing has the potential to result in soil erosion and associated turbidity given the topography of the land, soil type present, and clearing occurring over two minor watercourses. However, impacts are likely to be short term and minimal given the degraded (Keighery, 1994) condition of the vegetation proposed for clearing, and the lack of understorey present.

Given the relatively small size of the application area, the proposed clearing is not likely to lead to appreciable land degradation via water or wind erosion or result in flooding.

The nearest conservation reserve is an A class reserve known as 'Serpentine National Park' managed by the Conservation Commission of Western Australia located approximately 23 metres north of Areas 1 and 2, and the Karnet Nature Reserve located 4 metres south of Area 3. Given the distance of these reserves from the application area, it is unlikely the proposed clearing will directly impact on the environmental values of this conservation area. However it is considered that the proposed clearing may increase the risk of weeds and dieback spreading into adjacent remnant vegetation. Weed and dieback management practices will assist in mitigating this risk.

Given the above, the proposed clearing is at variance to principle (f), and is not likely to be at variance to the remaining principles.

Methodology

References:
Commonwealth of Australia (2001)
Department of Parks and Wildlife (2007-)
Department of Parks and Wildlife (2015)
Department of Parks and Wildlife (2016)
DER (2016)
Government of Western Australia (2015)
Keighery (1994)
Shah (2006)
Valentine and Stock (2008)
Western Australian Herbarium (1998-)

GIS Databases:
SAC Bio Datasets (Accessed October 2016)
NLWRA, Current Extent of Native vegetation
Hydrography, Linear
Hydrography, Hierarchy
Parks and Wildlife Tenure

Planning instruments and other relevant matters.

Comments

The application area falls within the proclaimed Serpentine River System Surface Water Area. The Department of Water (DoW) advised that the applicant has applied for two Surface Water Licences and three permits to interfere with bed and banks under the *Rights in Water and Irrigation Act 1914* (DoW, 2016). DoW has advised that these applications are still pending.

The Shire of Serpentine-Jarrahdale (2016) (the Shire) advised that they have not received an application for planning approval for the purpose of constructing three dams. The Shire has advised that they do not approve of the proposed clearing given the applicant already has a number of dams on the property that were approved in 2013 for the purpose of irrigating orchards which to date have not been constructed and no irrigation is occurring.

There are no Aboriginal Sites of Significance recorded in the application area.

The application area is zoned 'Rural' under the Town Planning Scheme.

The application was advertised in *The West Australian* newspaper on 29 August 2016 for a 7 day submission period. No submissions have been received in the relation to this application.

Methodology

References:
DoW (2016)
Shire of Serpentine-Jarrahdale (2016)

GIS Databases:
Aboriginal Sites of Significance
Town Planning Schemes

4. References

Commonwealth of Australia (2001) National Objectives and Targets for Biodiversity Conservation 2001-2005, Canberra.

Department of Parks and Wildlife (Parks and Wildlife) (2007-) NatureMap: Mapping Western Australia's Biodiversity. Department of Environment and Conservation. URL: http://naturemap.dec.wa.gov.au/. Accessed 14/10/2016

Department of Parks and Wildlife (2015) 2015 South West Forest and Swan Coastal Plain Vegetation Complex Statistics: a report prepared for the Department of Environment Regulation. Current as of March 2015. Department of Parks and Wildlife, Perth, Western Australia.

Department of Parks and Wildlife (2016) Regional advice received in relation to clearing permit application CPS 7208/1, received 12 October 2016. Department of Parks and Wildlife, Western Australia (DER Ref: A1179119).

Department of Environment Regulation (2016) Site Inspection Report for Clearing Permit Application CPS 7208/1. Site inspection undertaken on 22 September 2016. Department of Environment Regulation, Western Australia (DER Ref: A1179115).

Department of Water (2016) Direct interest response relating to requirements under the *Rights in Water and Irrigation Act 1914*. Department of Water, Western Australia (DER Ref: A1179980).

Government of Western Australia (2015). 2015 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of June 2015. WA Department of Parks and Wildlife, Perth.

Heddle, E. M., Loneragan, O. W., and Havel, J. J. (1980) Vegetation Complexes of the Darling System, Western Australia. In Department of Conservation and Environment, Atlas of Natural Resources, Darling System, Western Australia.

Keighery, B.J. (1994) Bushland Plant Survey: A Guide to Plant Community Survey for the Community. Wildflower Society of WA (Inc). Nedlands, Western Australia.

Lundstrom Environmental (2011) Reconnaissance Study of Vegetation and Hydrology for Impact Assessment of Dam Construction – Lot 822 Firns Road, Serpentine. Perth, Western Australia (DER Ref: A1180131).

Mattiske, E.M. and Havel, J.J. (1998) Vegetation Complexes of the South-west Forest Region of Western Australia. Maps and report prepared as part of the Regional Forest Agreement, Western Australia for the Department of Conservation and Land Management and Environment Australia.

Shah, B. (2006) Conservation of Carnaby's Black-Cockatoo on the Swan Coastal Plain, Western Australia. December 2006. Carnaby's Black-Cockatoo Recovery Project. Birds Australia, Western Australia.

Shepherd, D.P., Beeston, G.R. and Hopkins, A.J.M. (2001) Native Vegetation in Western Australia, Extent, Type and Status. Resource Management Technical Report 249. Department of Agriculture, Western Australia.

Shire of Serpentine-Jarrahdale (2016) Advice for Clearing Permit Application CPS 7208/1 received on 30 September 2016.

Valentine, L.E. and Stock, W. (2008) Food Resources of Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) in the Gnangara Sustainability Strategy Study Area. Edith Cowan University and Department of Environment and Conservation. December 2008.

Western Australian Herbarium (1998-) FloraBase - The Western Australian Flora. Department of Parks and Wildlife. http://florabase.dpaw.wa.gov.au/ (Accessed 14/10/2016).

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