DEVELOPMENT SERVICES ATTACHMENTS
ORDINARY MEETING OF COUNCIL
WEDNESDAY 21 JUNE 2023

Draft (23 March 2023)

SHIRE OF CHITTERING

EXTRACTIVE INDUSTRIES LOCAL LAW 2023

LOCAL GOVERNMENT ACT 1995

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EXTRACTIVE INDUSTRIES LOCAL LAW 2023

Under the powers conferred by the *Local Government Act 1995* and by all other powers, the local government of the Shire of Chittering resolved on ???? to make the following local law.

PART 1 — PRELIMINARY

1.1 Citation

This local law may be cited as the *Shire of Chittering Extractive Industries Local Law 2023*.

1.2 Commencement

This local law comes into operation 14 days after the date of its publication in the *Government Gazette*.

1.3 Definitions

In this local law, unless the context otherwise requires-

Act means the *Local Government Act 1995*;
AS means an Australian Standard published by Standards Australia, as amended from time to time, and available for viewing free of charge at the Shire of Chittering Administration office;
carry on an extractive industry means quarrying and excavating for stone, gravel, sand, and other material;
CEO means the Chief Executive Officer of the local government;
district means the district of the local government;
excavation includes quarry;
land unless the context otherwise requires, means the land on which the applicant proposes carrying on the extractive industry to which the licence application relates;
licence means a licence issued under this local law;
licensee means the person named in the licence as the licensee;
local government means the Shire of Chittering;
occupier has the meaning given to it in the Act;
owner has the meaning given to it in the Act;
person does not include the local government;

planning approval means an approval for a development and/or a land use that is issued under a local planning scheme administered by the local government;
secured sum means the sum required to be paid or the amount of a bond, guarantee or other security under clause 5.1;
Schedule means a schedule to this local law; and
site means the land specified by the local government in a licence.

1.4 Application

(1) The provisions of this local law-
(a) subject to paragraphs (b), (c), (d) and (e)-
(i) apply and have force and effect throughout the whole of the district; and
(ii) apply to every excavation whether commenced prior to or following the coming into operation of this local law;
(b) do not apply to the extraction of minerals under the *Mining Act 1978*;
(c) do not apply to the carrying on of an extractive industry on Crown land;
(d) do not apply to the carrying on of an extractive industry on land by the owner or occupier of that land for use on that land; and
(e) do not affect the validity of any licence issued under the local law repealed by clause 1.5 of this local law if that licence is currently in force at the date of gazettal of this local law.

(2) In subclause (1)(d), land includes adjoining lots or locations in the same occupation or ownership of the owner or occupier referred to in subclause (1)(d).

1.5 Transitional provisions

(1) Within 90 days of commencement of this local law or within 90 days of the date of the annual licence fee of a previous licence becoming due and payable (under clause 3.2), the local government may in respect of the licence—
(a) vary or delete a condition; or
(b) impose one or more other conditions, as specified in clause 3.1(5).

(2) A condition that is varied, deleted or imposed under subclause (1) does not become effective until 90 days (or longer period that is specified by the local government) after written notice of the condition is given by the local government to the licensee.

1.6 Repeal

This local law repeals the *Shire of Chittering Extractive Industries Local Law 2014* as published in the *Government Gazette* on 24 October 2014.

PART 2 — LICENSING REQUIREMENTS FOR AN EXTRACTIVE INDUSTRY

2.1 Extractive industries prohibited without licence

A person must not carry on an extractive industry—

(a) unless the person is the holder of a valid and current licence; and
(b) otherwise than in accordance with any terms and conditions set out in, or applying in respect of, the licence.

2.2 Applicant to advertise proposal

(1) Unless the local government first approves otherwise, a person seeking the issue of a licence shall, before applying to the local government for a licence—

(a) forward by registered mail a notice in the form determined by the local government from time to time to—
(i) the owners and occupiers of all land adjoining the land upon which it is proposed to excavate, or within an area determined by the local government as likely to be affected by the granting of a licence, advising of the application and specifying that they may, within 21 days from the date of service of the letter, object to or make representations in writing in respect of the issue of a licence by the local government;
(ii) every authority or person having control or jurisdiction over any of the things referred to in clause 2.3(1)(a)(vii) and (viii) within 500 metres from the boundaries of the land, or within an area determined by the local government as likely to be affected by the granting of a licence; and

(b) as soon as practicable after complying with the requirements of paragraph (a)—
(i) forward a copy of the notice to the CEO; and
(ii) publish the notice in a newspaper circulating in the area in which the proposed excavation is located.

(2) The local government may, within 14 days after receiving a copy of a notice referred to in subclause (1), cause to be displayed, or require the proposed applicant to display, in a prominent position on the land one or more notices—

(a) in the form determined by the local government from time to time;
(b) the content, size and construction of which have been approved by the CEO;
(c) specifying particulars of the proposed excavation; and
(d) inviting objections or comments within 21 days from the placement of the notice.

2.3 Application for licence

(1) Subject to subclause (3), a person seeking the issue of a licence in respect of any land shall apply in the form determined by the local government from time to time and must forward the application duly completed and signed by each of the applicants, the owner of the land and any occupier of the land to the CEO together with—

(a) one (1) copy of a plan of the excavation site to a scale of between 1:500 and 1:2000 showing—
   (i) the existing and proposed land contours based on the Australian Height Datum and plotted at 1 metre contour intervals;
   (ii) the land on which the excavation site is to be located;
   (iii) the external surface dimensions of the land;
   (iv) the location and depth of the existing and proposed excavation of the land;
   (v) the location of existing and proposed thoroughfares or other means of vehicle access to and egress from the land and to public thoroughfares in the vicinity of the land;
   (vi) the location of buildings, treatment plant, tanks and other improvements and developments existing on, approved for or proposed in respect of the land;
   (vii) the location of existing power lines, telephone cables and any associated poles or pylons, sewers, pipelines, reserves, bridges, railway lines and registered grants of easement or other encumbrances over, on, under or adjacent to or in the vicinity of the land;
   (viii) the location of all existing dams, watercourses, drains or sumps on or adjacent to the land;
   (ix) the location and description of existing and proposed fences, gates and warning signs around the land; and

(x) the location of the areas proposed to be used for stockpiling excavated material, treated material, overburden and soil storage on the land and elsewhere;

(b) one (1) copy of a works and excavation programme containing—

(i) the nature and estimated duration of the proposed excavation for which the licence is applied;

(ii) the stages and the timing of the stages in which it is proposed to carry out the excavation;

(iii) details of the methods to be employed in the proposed excavation and a description of any on-site processing works;

(iv) details of the depth and extent of the existing and proposed excavation of the site;

(v) an estimate of the depth of and description of the nature and quantity of the overburden to be removed;

(vi) a description of the methods by which existing vegetation is to be cleared and topsoil and overburden removed or stockpiled;

(vii) a description of the means of access to the excavation site and the types of thoroughfares to be constructed;

(viii) details of the proposed number and size of trucks entering and leaving the site each day and the route or routes to be taken by those vehicles;

(ix) a description of any proposed buildings, water supply, treatment plant, tanks and other improvements;

(x) details of drainage conditions applicable to the land and methods by which the excavation site is to be kept drained;

(xi) a description of the measures to be taken to minimise sand drift, dust nuisance, erosion, watercourse siltation and dangers to the general public;

(xii) a description of the measures to be taken to comply with the *Environmental Protection (Noise) Regulations 1997*;

(xiii) a description of the existing site environment and a report on the anticipated effect that the proposed excavation will have on the environment in the vicinity of the land;

(xiv) details of the nature of existing vegetation, shrubs and trees and a description of measures to be taken to minimise the destruction of existing vegetation; and

(xv) a description of the measures to be taken in screening the excavation site, or otherwise minimising adverse visual impacts, from nearby thoroughfares or other areas;

(c) one (1) copy of a rehabilitation and decommissioning programme indicating—

- (i) the objectives of the programme, having due regard to the nature of the surrounding area and the proposed end-use of the excavation site;
- (ii) whether restoration and reinstatement of the excavation site is to be undertaken progressively;
- (iii) how any face is to be made safe and batters sloped;
- (iv) the method by which topsoil is to be replaced and revegetated;
- (v) the numbers and types of trees and shrubs to be planted and other landscaping features to be developed;
- (vi) how rehabilitated areas are to be maintained; and
- (vii) the programme for the removal of buildings, plant, waste, completion of the restoration and reinstatement of the excavation site and final site clean-up;

(d) evidence that a datum peg has been established on the land related to a point approved by the local government on the surface of a constructed public thoroughfare or such other land in the vicinity;

(e) certificate from a licensed surveyor certifying the correctness of—
- (i) the plan referred to in paragraph (a); and
- (ii) the datum peg and related point referred to in paragraph (d);

(f) where the applicant is required to display a notice, evidence that the requirements of clause 2.2 (2) have been carried out;

(g) copies of all land use planning approvals required under any planning legislation;

(h) copies of any environmental approval required under any environmental legislation;

(i) copies of any geotechnical information relating to the excavation site;

(j) the consent in writing to the application from the owner of the excavation site;

(k) the licence application fee specified by the local government from time to time; and

(l) any other information that the local government may reasonably require.

(2) All survey data supplied by an applicant for the purpose of subclause (1) shall comply with Australian Height Datum and Australian Map Grid standards.

(3) Where in relation to a proposed excavation—

(a) the surface area is not to exceed 5000 square metres; and

(b) the extracted material is not to exceed 5000 cubic metres;

the local government may exempt a person making application for a licence under subclause (1) from supplying any of the data specified in paragraphs (b), (d), (e) and (i) of subclause (1).

PART 3 — DETERMINATION OF APPLICATION

3.1 Determination of application

(1) The local government may refuse to consider an application for a licence that does not comply with the requirements of clause 2.3, and in any event shall refuse an application for a licence where planning approval for an extractive industry use of the land has not first been obtained.

(2) The local government may, in respect of an application for a licence—

(a) refuse the application; or

(b) approve the application—

(i) over the whole or part of the land in respect of which the application is made; and

(ii) such terms and conditions, if any, as it sees fit.

(3) Where the local government approves an application for a licence, it shall—

(a) determine the licence period, not exceeding 5 years from the date of issue; and

(b) approve the issue of a licence in the form determined by the local government from time to time.

(4) Where the local government approves the issue of a licence, the CEO upon receipt by the local government of—

(a) payment of the annual licence fee, or the relevant proportion of the annual licence fee to 30 June, determined by the local government under and in accordance with sections 6.16 to 6.19 of the *Local Government Act 1995*;

(b) payment of the secured sum if any, imposed under clause 5.1;

(c) the documents, if any, executed to the satisfaction of the CEO, under clause 5.1; and

(d) a copy of the public liability insurance policy required under clause 7.1(1) shall issue the licence to the applicant.

(5) Without limiting subclause (2), the local government may impose conditions in respect of the following matters—

(a) the orientation of the excavation to reduce visibility from other land;

(b) the appropriate siting of access thoroughfares, buildings and plant;

(c) the stockpiling of material;

(d) the hours during which any excavation work may be carried out;

(e) the hours during which any processing plant associated with, or located on, the site may be operated;
(f) requiring all crushing and treatment plant to be enclosed within suitable buildings to minimise the emission of noise, dust, vapour and general nuisance to the satisfaction of the local government;
(g) the depths below which a person shall not excavate;
(h) distances from adjoining land or thoroughfares within which a person must not excavate;
(i) the safety of persons employed at or visiting the excavation site;
(j) the control of dust and wind-blown material;
(k) the planting, care and maintenance of trees, shrubs and other landscaping features during the time in which the extractive industry is carried out in order to effectively screen the area to be excavated and to provide for progressive rehabilitation;
(l) the prevention of the spread of dieback or other disease;
(m) the drainage of the excavation site and the disposal of water;
(n) the restoration and reinstatement of the excavation site, the staging of such works, and the minimising of the destruction of vegetation;
(o) the provision of retaining walls to prevent subsidence of any portion of the excavation or of land abutting the excavation;
(p) requiring the licensee to furnish to the local government a surveyor's certificate each year, prior to the renewal fee being payable, to certify the quantity of material extracted and that material has not been excavated below the final contour levels outlined within the approved excavation programme;
(q) requiring the licensee to enter into an agreement with the local government by which it agrees to pay any extraordinary expenses incurred by the local government in repairing damage caused to thoroughfares in the district by heavy or extraordinary traffic conducted by or on behalf of the licensee under the licence;
(r) requiring the licensee to enter into an agreement with the local government in respect of any condition or conditions imposed under this local law; and
(s) any other matter for properly regulating the carrying on of an extractive industry.

3.2 Payment of annual licence fee

On or before 30 June in each year, a licensee shall pay to the local government the annual licence fee determined by the local government under and in accordance with sections 6.16 to 6.19 of the Act.

PART 4 — TRANSFER, CANCELLATION AND RENEWAL OF LICENCE

4.1 Transfer of licence

(1) An application for the transfer of a licence shall—
(a) be made in writing;
(b) be signed by the licensee and the proposed transferee of the licence;
(c) be accompanied by the current licence;
(d) be accompanied by the consent in writing to the transfer from the owner of the excavation site;
(e) include any information that the local government may reasonably require; and
(f) be forwarded to the CEO together with the fee determined by the local government from time to time.

(2) Upon receipt of any application for the transfer of a licence, the local government may—
(a) refuse the application; or
(b) approve the application on such terms and conditions, if any, as it sees fit.

(3) Where the local government approves an application for the transfer of a licence, the local government shall transfer the licence by an endorsement on the licence in the form determined by the local government from time to time, signed by the CEO.

(4) Where the local government approves the transfer of a licence it shall not be required to refund any part of the fees paid by the former licensee in respect of the transferred licence.

4.2 Cancellation of licence

(1) The local government may cancel a licence where the licensee has—
(a) been convicted of an offence against—
(i) this local law; or
(ii) any other law relating to carrying on an extractive industry;
(b) transferred or assigned or attempted to transfer or assign the licence without the consent of the local government;
(c) permitted another person to carry on an extractive industry otherwise than in accordance with the terms and conditions of the licence and of the provisions of this local law;
(d) failed to pay the annual licence fee under clause 3.2; or

(e) failed to have a current public liability insurance policy under clause 7.1 (1) or failed to provide a copy of the policy or evidence of its renewal as the case may be, under clause 7.1 (2).

(2) Where the local government cancels a licence under this clause—
(a) the local government shall advise the licensee in writing of the cancellation;
(b) the cancellation takes effect on and from the day on which the licensee is served with the cancellation advice; and
(c) the local government shall not be required to refund any part of the fees paid by the licensee in respect of the cancelled licence.

4.3 Renewal of licence

(1) A licensee who wishes to renew a licence must apply in writing to the local government at least 45 days before the date of expiry of the licence and shall submit with the application for renewal—
(a) the fee determined by the local government from time to time;
(b) a copy of the current licence;
(c) a plan showing the contours of the excavation carried out to the date of that application;
(d) details of the works, excavation and rehabilitation stages reached and of any changes or proposed changes with respect to any of the things referred to in clauses 2.3 (1) (b) and (c); and
(e) any other things referred to in clauses 2.3 and 3.1.

(2) The local government may waive any of the requirements specified in clause 4.3 (1) (d) or (e).

(3) If—
(a) an application to renew a licence is in relation to land in respect of which the current licence was issued less than 12 months prior to the date from which the new licence if granted would apply; and

(b) the methods to be employed in the proposed land excavation are identical to those being employed at the date of the application,
then the applicant shall not be obliged, unless otherwise required by the local government to submit details of any of the things referred to in clauses 2.3 and 3.1.

(4) Upon receipt of an application for the renewal of a licence, the local government may—

(a) refuse the application; or
(b) approve the application on such terms and conditions, if any, as it sees fit.

4.4 Notice of outcome

The local government will provide written notice to an applicant whenever it makes a decision regarding the issue, renewal, transfer or cancellation of a licence.

PART 5 — SECURED SUM AND APPLICATION THEREOF

5.1 Security for restoration and reinstatement

(1) For the purpose of ensuring that an excavation site is properly restored or reinstated, the local government may require that—
(a) as a condition of a licence; or
(b) before the issue of a licence, the licensee shall give to the local government a bond, bank guarantee or other security, of a kind and in a form acceptable to the local government, in or for a sum determined by the local government from time to time.

(2) A bond required under subclause (1) is to be paid into a fund established by the local government for the purposes of this clause.

(3) Subject to clause 5.2, any interest accrued in respect of the bond paid into the fund under subclause (2) is to be returned to the licensee at the completion of the restoration and reinstatement works required by the licence conditions or otherwise under this local law.

5.2 Use by the local government of secured sum

(1) If a licensee fails to carry out or complete the restoration and reinstatement works required by the licence conditions either—
(a) within the time specified in those conditions; or
(b) where no such time has been specified, within 60 days of the completion of the excavation or portion of the excavation specified in the licence conditions,

then, subject to the local government giving the licensee 14 days notice of its intention to do so—
(c) the local government may carry out or cause to be carried out the required restoration and reinstatement work or so much of that work as remains undone; and

(d) the licensee shall pay to the local government on demand all costs incurred by the local government or which the local government may be required to pay under this clause.

(2) The local government may apply the proceeds of any bond, bank guarantee or other security provided by the licensee under clause 5.1 towards its costs under this clause.

(3) The liability of a licensee to pay the local government's costs under this clause is not limited to the amount, if any, secured under clause 5.1.

PART 6 — LIMITATIONS, OBLIGATIONS OF THE LICENSEE AND PROHIBITIONS

6.1 Limits on excavations near boundary

Subject to any licence conditions imposed by the local government, a person shall not, without the written approval of the local government, excavate within—

(a) 20 metres of the boundary of any land on which the excavation site is located;
(b) 20 metres of any land affected by a registered grant of easement;
(c) 40 metres of any thoroughfare; or
(d) 40 metres of any watercourse.

6.2 Obligations of the licensee

A licensee shall-

(a) where the local government so requires, securely fence the excavation to a standard determined by the local government and keep the gateways locked when not actually in use in order to prevent unauthorised entry;
(b) erect and maintain warning signs along each of the boundaries of the area excavated under the licence so that each sign—
   (i) is not more than 200 metres apart;
   (ii) is not less than 1.8 metres high and not less than 1 metre wide; and
   (iii) bears the words 'DANGER EXCAVATIONS KEEP OUT';
(c) except where the local government approves otherwise, drain and keep drained to the local government's satisfaction any excavation to which the licence applies so as to prevent the accumulation of water;

(d) restore and reinstate the excavation site in accordance with the terms and conditions of the licence, the site plans and the works and excavation programme approved by the local government;
(e) take all reasonable steps to prevent the emission of dust, noise, vibration and other forms of nuisance from the excavation site; and
(f) otherwise comply with the conditions imposed by the local government in accordance with clause 3.1.

6.3 Prohibitions

A licensee shall not—

(a) remove any trees or shrubs within 40 metres (or such lesser distance as may be allowed, in writing, by the local government) of the boundary of any thoroughfare on land in respect of which a licence has been granted, except for the purpose of constructing access thoroughfares, erecting buildings or installing plant for use in connection with the excavation and then only with the express approval of the local government and subject to any conditions which the local government may impose in accordance with clause 3.1;
(b) store, or permit to be stored, any explosives or explosive devices on the site to which the licence applies other than with the approval of the local government and the Department of Mines, Industry Regulation and Safety; or
(c) fill or excavate, other than in accordance with the terms and conditions of the licence, the site plans and the works and excavation programme approved by the local government.

6.4 Blasting

(1) A person shall not carry out or permit to be carried out any blasting in the course of excavating unless—
  (a) the local government has otherwise given approval in respect of blasting generally or in the case of each blast;
  (b) subject to subclause (2), the blasting takes place only between the hours of 8.00am and 5.00pm, or as determined by the local government, on Mondays to Fridays inclusive;
  (c) the blasting is carried out in strict accordance with the AS2187 SAA Explosives Code as amended from time to time, the *Mines Safety and Inspection Act 1994*, the *Environmental Protection Act 1986*, and all relevant local laws of the local government; and
  (d) in compliance with any other conditions imposed by the local government concerning—
    (i) the time and duration of blasting;

(ii) the purposes for which the blasting may be used; and

(iii) such other matters as the local government may reasonably require in the interests of the safety and protection of members of the public and of property within the district.

(2) A person shall not carry out or permit to be carried out any blasting on a Saturday, Sunday or public holiday except with the prior approval of the local government.

PART 7 — MISCELLANEOUS PROVISIONS

7.1 Public liability

(1) A licensee shall have at all times a current public liability insurance policy taken out in the joint names of the licensee and the local government indemnifying the licensee and the local government for a sum of not less than $20,000,000 in respect of any one claim relating to any of the excavation operations.

(2) The licensee shall provide to the local government a copy of the policy taken out under subclause (1), within 14 days after the issue of that policy and shall provide to the local government evidence of renewal within 14 days of each renewal date.

7.2 Mines Safety and Inspection Act and Environmental Protection Act

(1) In any case where the *Mines Safety and Inspection Act 1994* or the *Environmental Protection Act 1986* applies to any excavation carried on or proposed to be carried on at a site, the licensee in respect of that site shall provide to the local government within 14 days full particulars of any inspection or report made under that Act or those Acts.

(2) In this clause, the *Mines Safety and Inspection Act 1994* and the *Environmental Protection Act 1986* include all subsidiary legislation made under those Acts.

7.3 Notice of cessation of operations

(1) Where a licensee intends to cease carrying on an extractive industry—
(a) temporarily for a period in excess of 12 months; or
(b) permanently,
the licensee shall, as well as complying with clause 7.4, give the local government written notice of the cessation not later than 1 week after those operations have ceased.

(2) Where a licensee has given written notice to the local government of the intention to permanently cease carrying on an extractive industry on the site to which the licence applies the licence is deemed to have expired on the date such cessation is so notified.

(3) The temporary or permanent cessation of the carrying on of an extractive industry on a site or the deemed expiration or cancellation of a licence does not entitle the licensee to any refund of any licence fee.

7.4 Works to be carried out on cessation of operations

Where the carrying on of an extractive industry on the site permanently ceases or on the expiration or cancellation of the licence applicable to the site, whichever first occurs, the licensee shall, as well as complying with the provisions of clause 7.3—

(a) restore and reinstate the excavated site in accordance with the proposals approved by the local government or in such other manner as the local government may subsequently agree in writing with the licensee;

(b) ensure that any face permitted to remain upon the excavation site is left safe with all loose materials removed and where the excavation site is—
   (i) sand, the sides are sloped to a batter of not more than 1:3 (vertical:horizontal); and
   (ii) limestone or material other than sand, the sides are sloped to a batter which, in the opinion of the local government, would enable the site to be left in a stable condition;

(c) ensure that the agreed floor level of the excavation is graded to an even surface or is otherwise in accordance with the rehabilitation and decommissioning programme approved by the local government;

(d) ensure that all stockpiles or dumps of stone, sand or other materials are left so that no portion of that material can escape onto land not owned or occupied by the licensee nor into any stream, watercourse or drain that is not wholly situated within the land owned or occupied by the licensee;

(e) erect retaining walls where necessary to prevent subsidence of land in the vicinity of any excavation;
(f) remove from the site all buildings, plant and equipment erected, installed or used for or in relation to the carrying on of an extractive industry on the site and fill all holes remaining after such removal to the level of the surrounding ground and compact such filled holes sufficiently to prevent settling; and
(g) break up, scarify, cover with topsoil and plant with grass, trees and shrubs all parts of the site where buildings, plant and equipment were erected or installed and all areas which were used for stockpiling unless otherwise specified under this local law.

PART 8 — OBJECTIONS AND REVIEW

8.1 Objection and review rights

(1) The provisions of Division 1 of Part 9 of the Act and regulation 33 of the *Local Government (Functions and General) Regulations 1996* shall apply when the local government makes a decision as to whether it will—
(a) grant a person a licence under this local law; or
(b) renew, vary, transfer, or cancel a licence that a person has under this local law.

(2) The provisions of this clause are subject to section 3.25 and item 12 of Division 1 of Schedule 3.1 of the *Local Government Act 1995* and any power of entry exercised by the local government under this local law is subject to Part 3, Division 3 of the *Local Government Act 1995.*

PART 9 — OFFENCES, PENALTIES AND FORMS

9.1 Offences

A person who fails to do anything required or directed to be done under this local law, or who does anything which under this local law that person is prohibited from doing, commits an offence.

9.2 General penalty

A person who commits an offence under this local law is liable, on conviction, to a penalty not exceeding $5,000 and if the offence is of a continuing nature to an additional penalty no exceeding $500 for each day or part of the day during which the offence has occurred.

9.3 Modified penalty

(1) An offence against a clause specified in Schedule 1 is a prescribed offence for the purposes of section 9.16 (1) of the Act.

(2) The amount of the modified penalty for a prescribed offence is that specified adjacent to the clause in Schedule 1.

9.4 Forms

For the purposes of this local law—

(a) the form of the infringement notice given under section 9.16 of the Act is that of Form 2 in Schedule 1 of the *Local Government (Functions and General) Regulations 1996*; and

(b) the form of the notice sent under section 9.20 of the Act withdrawing an infringement notice is that of Form 3 in Schedule 1 of the *Local Government (Functions and General) Regulations 1996*.

SCHEDULE 1

PRESCRIBED OFFENCES

(clause 9.3)

Item	Clause	Description	Modified Penalty $
1	2.1	Carry on extractive industry without licence or in breach of terms and conditions	500
2	6.1	Excavate near boundary	500
3	6.2(a)	Gateways not kept locked where required	500
4	6.2(b)	Warning signs not erected or maintained as required	500
5	6.2(c)	Excavation not drained as required	500
6	6.2(e)	Failure to prevent the emission of dust, noise or other forms of nuisance	500
7	6.3(a)	Remove trees or shrubs near boundary without approval	500
8	6.3(b)	Store without required approval explosives or explosive devices	500
9	6.3(c)	Fill or excavate in breach of licence	500
10	6.4(1)(a)	Blasting without approval of the local government	500
11	6.4(1)(b)	Blasting outside times authorised	500
12	6.4(1)(d)	Blasting in breach of conditions imposed by the local government	500
13	6.4(2)	Blasting without approval on Saturday, Sunday or public holiday	500

Dated: ??????

The Common Seal of the Shire of Chittering was affixed by authority of a resolution of the Council in the presence of—

Aaron King
Shire President

Melinda Prinsloo
Chief Executive Officer

Local Planning Scheme No. 6 Amendment Request

Lots 202-203 Wandena Road, and Lots 204-205 Great Northern Highway, Muchea, Shire of Chittering

Prepared on behalf of Swan Industrial Development Pty Ltd and David Weightman Smith

May 2023 | 19-545

element.
the art and science of place

We acknowledge the custodians of this land, the Whadjuk Nyoongar and their Elders past, present and emerging. We wish to acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

Document ID: /Volumes/Graphics/2019/19-545 Muchea, Lots 202-205 Wandena Road/Draft Report/19-545 Muchea, Lots 202-205 Wandena Road Folder/19-545 Muchea, Lots 202-205 Wandena Road Scheme Amendment F4 230522.indd

Issue	Date	Status	Prepared by	Approved by
1	18/05/21	Draft	Leigh Caddy	Matt Raymond
2	24.05.21	Final	Leigh Caddy	Matt Raymond
3	26.11.21	Final - Amended	Leigh Caddy	Matt Raymond
4	23.02.23	Final - Amended 2	Leigh Caddy	Matt Raymond
5	28.02.23	Final - Amended 3	Leigh Caddy	Matt Raymond
6	22.05.23	Final - Amended 4	Leigh Caddy	Matt Raymond

List of Appendices

Key Application Details

Applicant Details	
Landowner	Swan Industrial Developments Pty Ltd; and David Weightman Smith
Property Location	Lot 202 on P46016 Wandena Road, Muchea Lot 203 on P46016 109 Wandena Road, Muchea Lot 204 on P55930 3362 Great Northern Highway. Muchea Lot 205 on P55930 Great Northern Highway, Muchea
Subject Area	Total Land Area: 83.0436ha
Local Government	Shire of Chittering
Shire of Chittering Local Planning Scheme No. 6	**Existing Zoning:** Agricultural Resource **Proposed Zoning:** General Industry and Light Industrial Refer to Appendix A – Proposed Local Planning Scheme Amendment Mapping
Existing Land Use	**Lots 202 and 203** - a disused clay quarry, which is being progressively rehabilitated with inert construction and demolition waste material being processed on the site. **Lots 204 and 205** - rural grazing land incorporating a thoroughbred horse agistment stud.

Consultant Team

This rezoning application has been prepared on behalf of Swan Industrial Developments Pty Ltd and David Weightman Smith (landowners). The following consultants form part of the project team:

Consultant	Discipline
element	Planning
Porter Consulting Engineers	Traffic impact assessment Civil engineering and servicing
Bayley Environmental Services	Environmental Assessment and Management Strategy Local Water Management Strategy Landscape design
Douglas Partners	Geotechnical investigations

Executive Summary

This proposal seeks to initiate a local planning scheme amendment to the *Shire of Chittering Local Planning Scheme No. 6* (LPS6), to facilitate the future redevelopment of land situated within Precincts 2 and 4 of the *Muchea Employment Node Structure Plan* area for industrial purposes. Specifically, this local scheme amendment request seeks to modify the scheme map to reclassify the land from its existing 'Agricultural Resource' zone to 'General Industry and Light Industrial', and introduce text provisions to Schedule 11 (Muchea Employment Node Special Control Area Zone) of LPS6 to guide future subdivision and development.

The Muchea Employment Node comprises some 1,100 hectares of land earmarked for future industrial purposes.

The proposed amendment is consistent with the objectives of the regional and local strategic planning framework for the area, including in particular the Western Australian Planning Commission's *Muchea Employment Node Structure Plan*, which sets out the framework for the redevelopment of the broader area as an industrial park.

It is requested that the local scheme amendment assessment process be run in parallel with a proposed local structure plan; which is expected to be lodged shortly for assessment following the commencement of the amendment process.

The detail provided within this proposed local scheme amendment and associated structure plan shall assist the referral agencies and decision makers undertake an informed assessment of the subject site as a whole. The concurrent assessment of the applications should also assist agencies utilise their time more effectively by having all levels of information made available to them at once, rather than staggered over time.

Contents

1. Introduction

This proposal seeks to initiate a local planning scheme amendment to the *Shire of Chittering Local Planning Scheme No. 6* (LPS6). The proposal will facilitate the future redevelopment of land situated within Precinct 2 (P2) and Precinct 4 (P4) of the *Muchea Employment Node Structure Plan* area for industrial purposes.

The amendment proposes to reclassify Lots 202-203 Wandena Road, and Lots 204-205 Great Northern Highway, Muchea, (hereon referred to as the subject site) from the existing 'Agricultural Resource' zone to the 'General Industry and Light Industrial' zoning proposed consistent with that envisaged under the strategic framework for the area, facilitating the future land use and development of the subject land consistent with the agreed vision for the area.

LPS6 identifies the following objectives for each of the zones:

Light Industrial Zone:

- *To provide for a range of industrial uses and service industries generally compatible with urban areas, that cannot be located in commercial zones.*
- *To ensure that where any development adjoins zoned or developed residential properties, the development is suitably set back, screened or otherwise treated so as to not detract from the residential amenity.*

General Industry:

- *Accommodate a range of service based and related industrial land uses such as livestock, fabrication, warehousing, wholesaling and general commercial uses which will not by the nature of their operations, detrimentally impact upon residential and other sensitive land uses outside of the General Industry zone.*
- *To apply environmental standards and practices that protect and maintain the amenity and water and air quality of adjoining areas and support the retention and enhancement of the environmental values of the site and its surrounds.*
- *Maintain the visual amenity of the area as seen from major public roads.*
- *Minimise the visual impact of development to achieve a built form that is harmonious with the surrounding area.*
- *Ensure orderly and comprehensive planning and coordinated subdivision and development.*

The following report provides a description of the subject site, details of the proposal and planning rationale for the amendment.

Scope and Nature of Amendment

This local scheme amendment request seeks to amend the scheme map and text to reclassify the subject site from its existing 'Agricultural Resource' zone to 'General Industry and Light Industrial', and introduce text provisions to Schedule 11 (Muchea Employment Node Special Control Area Zone) of LPS6 to guide future subdivision and development.

Refer to Figure 1 – Proposed Scheme Amendment Map; Table 1 – Schedule 11 Provisions; and Appendix A – Proposed Scheme Amendment

The amendment is deemed to be a 'Standard' amendment under the provisions of the *Planning and Development (Local Planning Schemes) Regulations 2015* for the following reasons:

- It is an amendment that is generally consistent with the objectives of the relevant zone;
- It is generally consistent with the sub-regional and local planning framework;
- It will have minimal impact on land in the Scheme not subject to this amendment; and
- It does not result in any significant environmental, social, economic or governance impacts on land in the Scheme area.

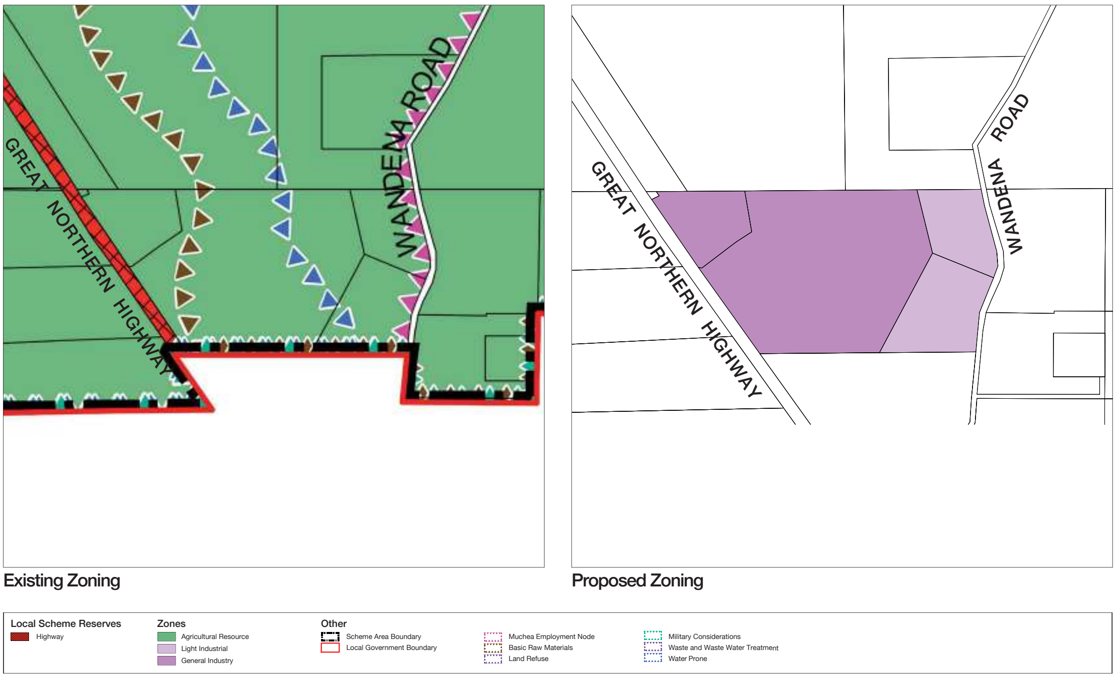


Figure 1. Proposed Scheme Amendment Map

Table 1 – Schedule 11 Provisions

No.	Description of Land	Conditions
3	Portions of Precinct 2 (P2) and Precinct 4 (P4) of the Muchea Industrial Park – Lots 202 & 203 on Plan 46016; and Lots 204 & 205 on Plan 55930	**1. Hierarchy of Plans** Structure planning, subdivision and development shall be undertaken in accordance with the Scheme. **2. Structure Plan** a. Structure Plan Preparation A Structure Plan shall be prepared in accordance with the provisions of the deemed provisions over the subject land. b. Environmental Management Plans The following Environmental Management Plans shall be prepared as part of the Structure Plan process and approved as required by the relevant agency: i. Local Water Management Strategy ii. Environmental Assessment and Management Strategy Environmental Management Plans shall be implemented to the satisfaction of the local authority. c. Additional Studies / Reports The following additional studies shall be prepared as part of the Structure Plan process and approved as required by the relevant agency: i. Traffic Impact Assessment ii. Bushfire Management Plan **3. Subdivision** a. Road Reservation and Construction i. The Distributor 'Loop' Road to accommodate RAV10 vehicles, shall be constructed in accordance with Austroads and MRWA standards. ii. When a lot is subdivided, the totality of land required for road reserves within that lot shall be ceded to the Crown. The construction of those roads will be the responsibility of the landowner(s). The Shire of Chittering is not responsible for the construction of roads within any ceded road reserves on the land. iii. The full length of roads within the subdivision area is to be constructed on the creation of all lots. A staging plan and triggers for road construction, to ensure construction of roads within the subdivided area is to be outlined in the Structure Plan. iv. Subdivision applications shall demonstrate that a suitable temporary turning circle for the Distributor 'Loop' Road can be provided within the boundaries of the subdivision area until the entire road is constructed to allow RAV10 vehicles access and egress onto Great Northern Highway. At that time, the temporary turning circle shall be removed and the land suitably remediated. b. Drainage i. An Urban Water Management Plan shall be prepared, consistent with the Local Water Management Strategy required under 2(b)(i), for approval by the relevant agency, to satisfy a condition of subdivision approval. c. Water Supply i. A reticulated water supply provided by a licensed operator shall be provided at the first stage of subdivision. **4. Development** a. Development of land shall be generally in accordance with the Scheme and approved Structure Plan. b. Land use permissibility shall be in accordance with the General Industry Zone and Light Industrial Zone of the Scheme (as amended), subject to the following: i. No development shall be approved by the relevant authority until such time that there is an endorsed Structure Plan over the land. ii. The determining authority shall not approve a development application over land containing the Distributor 'Loop' Road unless the road has been constructed and ceded in accordance with an approved Structure Plan.

2. Background

2.1 Location and Context

The subject site comprises around 83 hectares of land situated at the southern extent of the Muchea Employment Node, within the Shire of Chittering. The land is bound by private rural land to the north and south, Wandena Road to the east, and Great Northern Highway to the west.

The subject site is situated approximately 42 kilometres north-east of the Perth Central Business District and 32 kilometres north of the Midland City Centre. In relatively close proximity are the Muchea and Bullsbrook townsites (approximately 3 kilometres west and 7 kilometres south respectively), whilst Bindoon is situated approximately 24 kilometres to the north-east.

Refer to Figure 2 – Location Plan.

The subject site is positioned in close proximity to the regional movement corridors of Tonkin Highway, Brand Highway and Great Northern Highway. Land immediately surrounding the site is generally characterised by agricultural activities on large broad-acre landholdings. Several landholdings on Wandena Road further to the north have been subject to extraction activities over time, however it is understood that the operations have since ceased. The Western Australian Meat Industry Authority Sale Yards is situated approximately 3 kilometres to the north of the subject site, whilst rural residential subdivisions exist approximately 2 kilometres to the north-west and 3 kilometres to the north-east of the subject site.

A scheme amendment is currently being progressed in relation to land to the west (situated within Precinct 3 of the Muchea Industrial Park) which will provide for the future redevelopment of the land for industrial purposes.

Refer to Figure 3 – Context Plan.

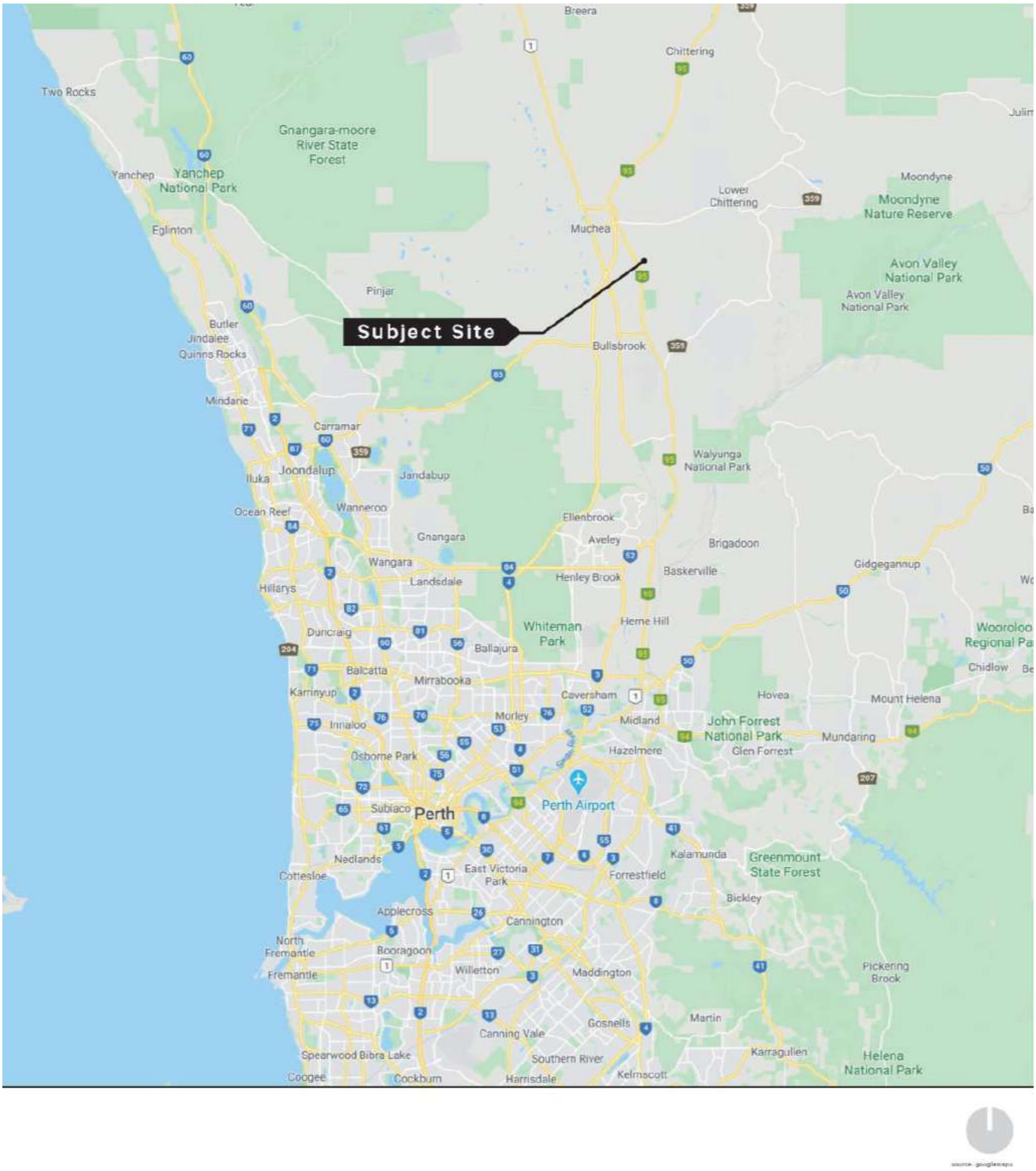


Figure 2. Location Plan

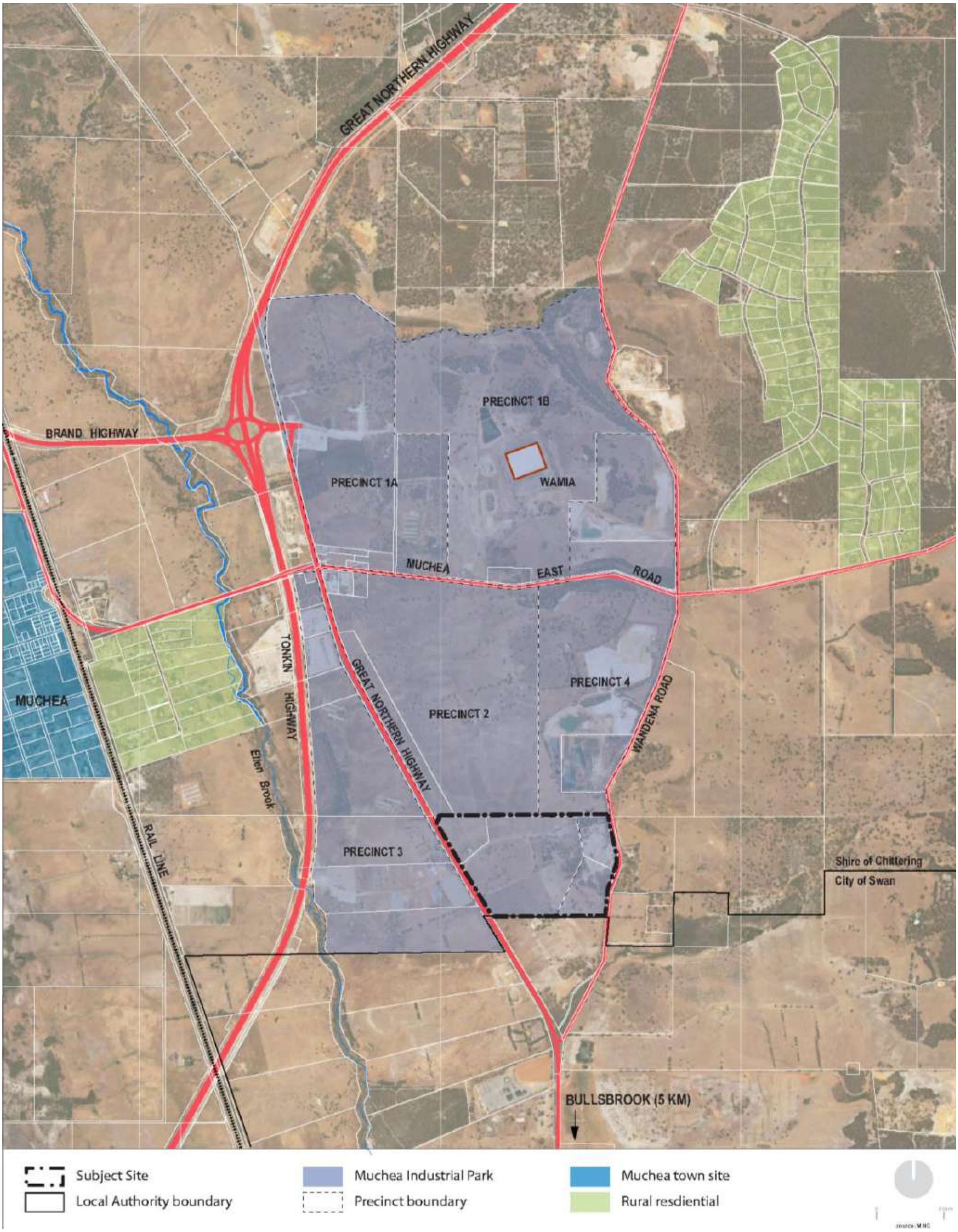


Figure 3. Context Plan

2.2 Legal Description and Ownership

The following table summarises the property details of the land subject of this scheme amendment proposal.

Table 2: Property and Landowner Details

Lot	Volume / Folio	Plan / Diagram	Area (Ha)	Landowner
202	2627 / 151	P46016	8.8169	Swan Industrial Developments Pty Ltd
203	2627 / 152	P46016	12.6676	
204	2908 / 599	P55930	8.8951	David Weightman Smith
205	2908 / 600	P55930	52.6640	

2.2.1 Encumbrances on Title

Several encumbrances exist on the titles, which include the following:

- Easement burden for right to enter on Lot 202;
- Restrictive covenant burden to Lots 202 and 203; and
- Notifications under section 165 of the *Planning and Development Act 2005* to Lots 204 and 205.

The encumbrances do not limit the future redevelopment of the land as proposed under this Amendment. Copies of the Certificates of Title are included at Appendix B – Certificates of Title.

2.3 Existing Land Use

A disused clay quarry is situated on Lots 202 and 203. The quarry is partially backfilled and is being progressively rehabilitated with inert construction and demolition waste material transported in and processed on the site. Areas of scattered shrubs and trees exist on the land, primarily surrounding the northern and southern extents of the former clay quarry.

A thoroughbred horse agistment stud is situated on Lots 204 and 205 with the land generally comprising of grassy paddocks and scattered mature trees.

Refer to Figure 4 – Aerial Photo.

Figure 4. Aerial Photo

3. Planning Framework

3.1 Planning Strategies

3.1.1 Wheatbelt Regional Planning and Infrastructure Framework (2015)

The Wheatbelt Regional Planning and Infrastructure Framework is a strategic planning document that provides an overview of the planning issues and priorities for the wheatbelt region (which includes the Shire of Chittering).

A key objective of the document is to provide a diversified and adaptive economy through the establishment and growth of new and innovative industries.

The document recognises the Muchea Employment Node as a "strategic industrial estate" that will provide serviced industrial land for new industries in, and relocation of existing industries, to the Wheatbelt. Planning elements are to be implemented through local government strategies and schemes. This local scheme amendment request reflects this objective.

3.1.2 Muchea Employment Node Structure Plan (MENSP) (2011)

The *Muchea Employment Node Structure Plan* (MENSP) provides the land use planning framework for the development of around 1100 hectares of land for service-based industrial and general commercial purposes.

The subject land is situated within Precinct 2 (P2) and Precinct 4 (P4) of the MENSP and identified for 'Proposed Industrial Development'. The MENSP identifies the following matters affecting the subject land:

- 500m landuse buffer associated with the existing horse agistment stud;
- 500m rural residence buffer associated with land to the east of Wandena Road;
- Proposed local distributor road which runs north-south centrally through the structure plan area, connecting with Great Northern Highway at the south-western extent of the subject land; and
- Areas requiring special protection (relating to the areas of existing vegetation over Lots 202, 203 and the eastern extent of Lot 205).

The document envisages implementation of the framework will be undertaken through a scheme amendment to that would establish a future industry zone over the node, together with relevant provisions requiring the preparation and adoption of more specific local structure plans for a precinct or portion of a precinct.

This local scheme amendment request is largely consistent with this approach, as well as the broader vision set out under the framework.

Refer to Figure 5 – Muchea Employment Node Structure Plan.

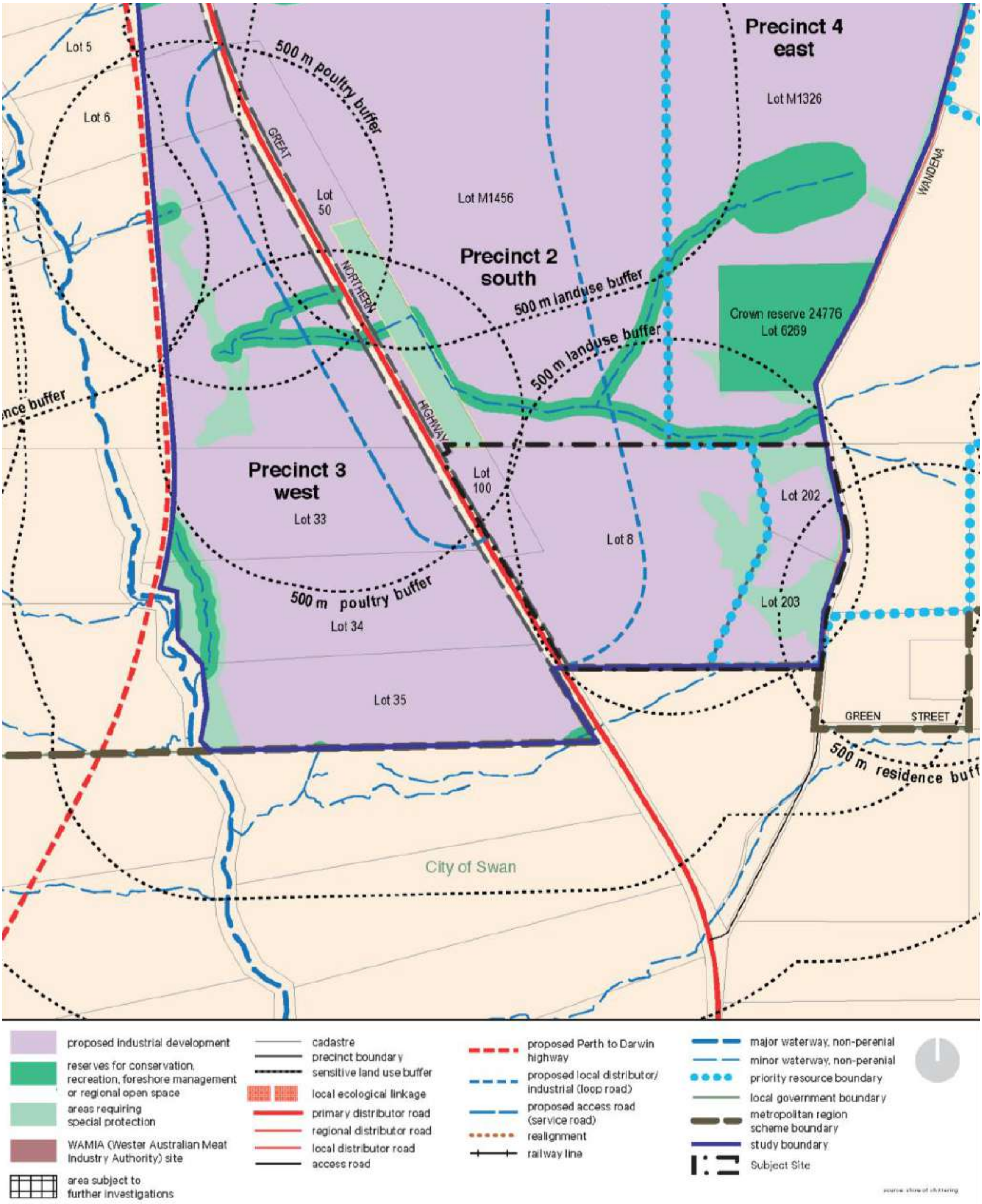


Figure 5. Muchea Employment Node Structure Plan

3.1.3 Muchea Industrial Park Structure Plan (2022)

The *Muchea Industrial Park Structure Plan* reviews and updates the MENSP to respond to recent changes in planning frameworks at the State, sub-regional and local level, and economic drivers which have brought forward planning and development activity. This includes the recently completed Tonkin Highway extension, which provides direct interchange access into the industrial park, as well as the relocation of the triple road train assembly facilities to Muchea, thereby positioning Muchea as potentially the closest industrial land to Perth with triple road train (RAV10) access to the Wheatbelt, Mid-West and North-West regions.

The MIPSP focuses general industry in the central portion of the industrial park and locates light industry and service commercial around the periphery, to limit the impacts of industrial development to within the industrial park.

The document state that land in the industrial park will predominantly be zoned 'Industrial Development' under LPS6, with local structure planning to occur prior to determining the ultimate zoning of the land for either light or general industry.

Relevant updates identified under the MIPSP affecting the subject land include:

- Clarifying Precinct 2 as the 'General Industry core' with Precinct 4 identified as a 'Light Industry focus' (generally along the boundary);
- Minor realignment of the indicative local distributor road (RAV10 route) to provide for a four-way intersection with Great Northern Highway and the local distributor road (RAV10 route) servicing Precinct 3; and
- Identification of an indicative RAV10 access point to service the subject land.

The document envisages implementation of the framework at the precinct level will be addressed through the rezoning of land to the 'Industrial Development' zone under LPS6, together with the preparation of local structure plans.

This local scheme amendment request is consistent with the zoning and general principles proposed under the document.

Refer to Figure 6 – Muchea Industrial Park Structure Plan.

3.1.4 Shire of Chittering Local Planning Strategy 2019

The Shire of Chittering's Local Planning Strategy 2019 (Strategy) establishes the direction for future population growth and sets out broad strategies and actions for housing, industrial and business uses.

In relation to industrial land use, a key objective as outlined under clause 3.4.2 of the Strategy is to provide for and protect industrial land uses at strategic locations, with a key strategy to make the Muchea Industrial Park a focus for industrial development.

The Strategy reinforces the vision and objectives set out under the MENSP.

Refer to Figure 7 – Shire of Chittering Local Planning Strategy.

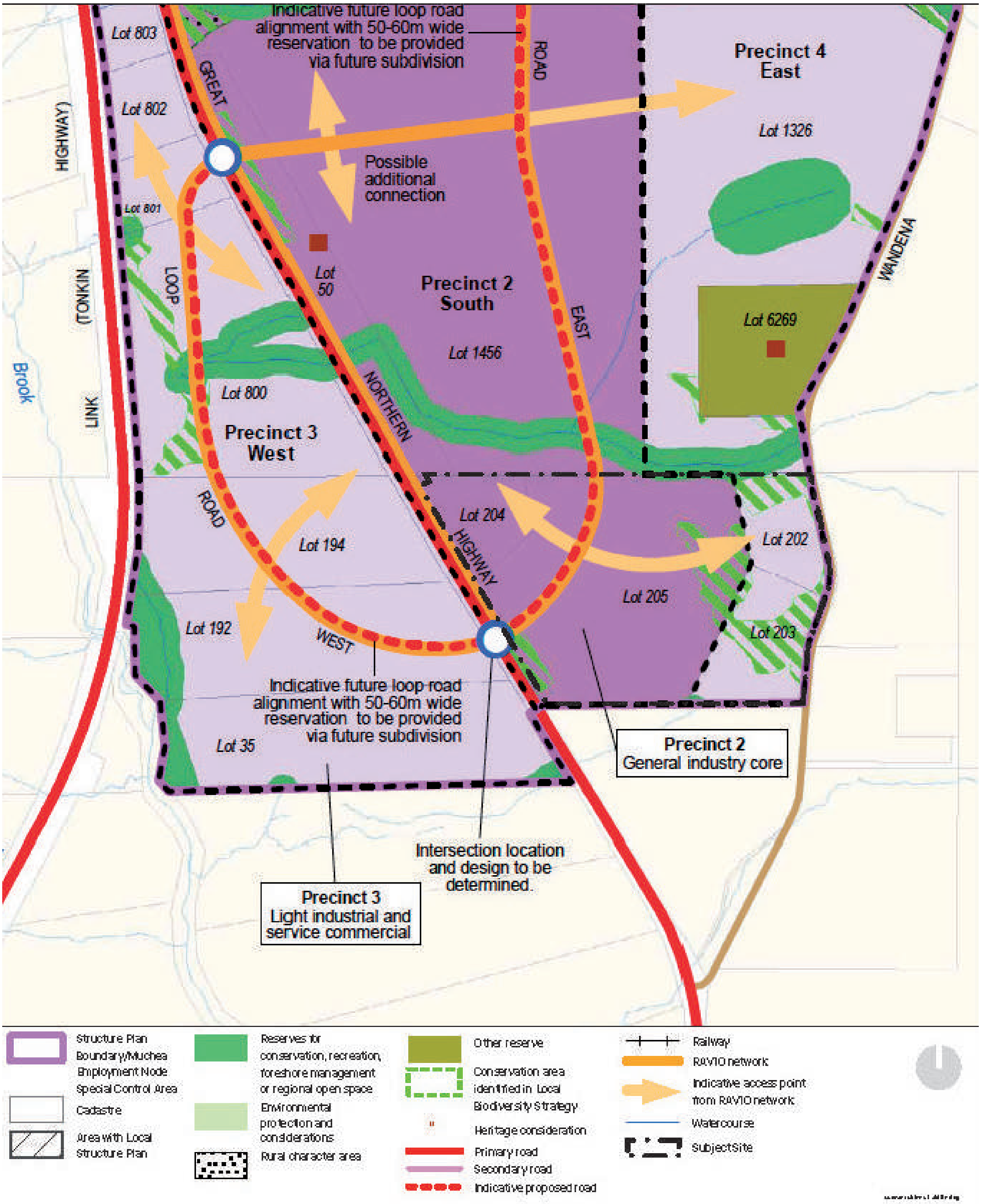


Figure 6. Muchea Industrial Park Structure Plan

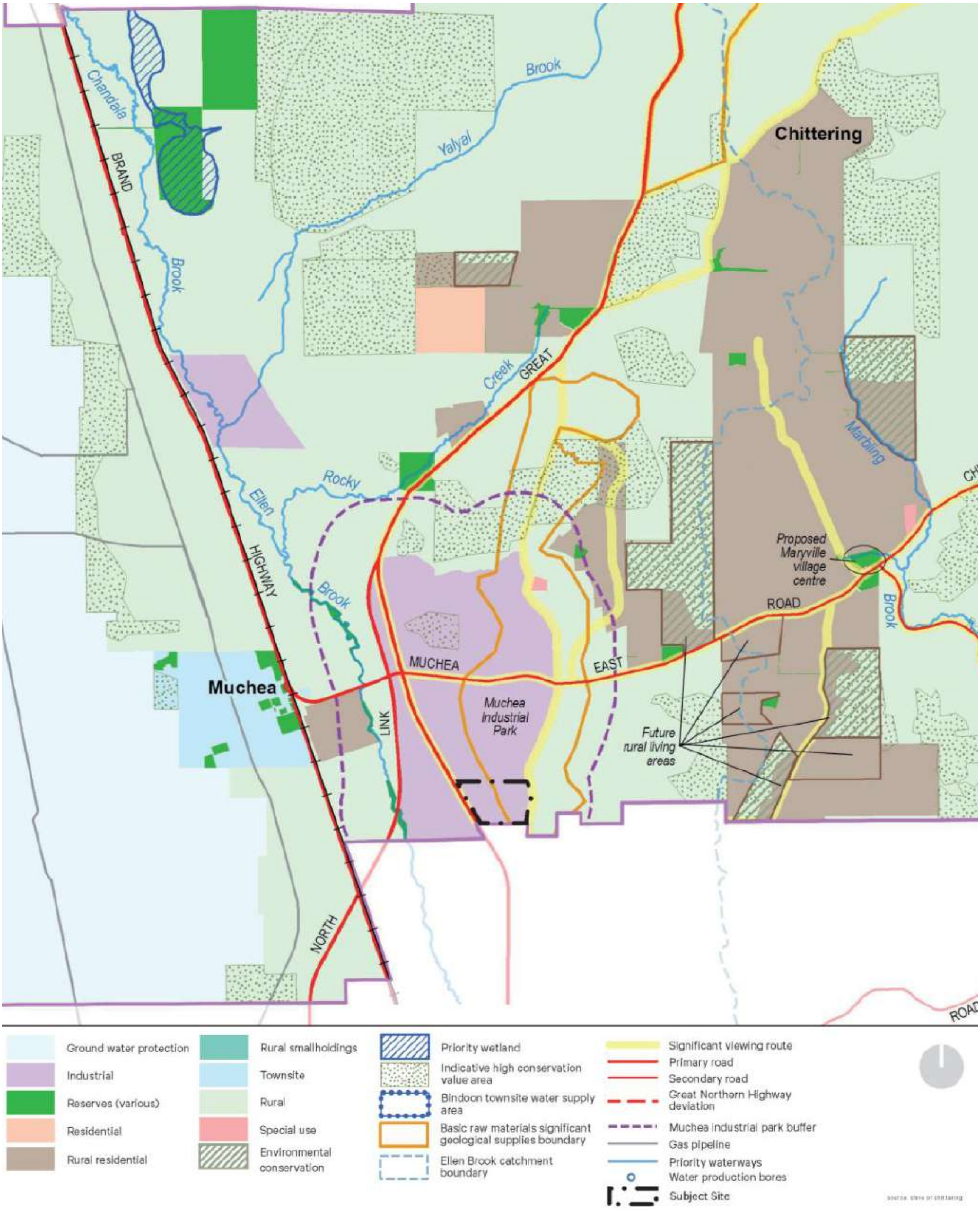


Figure 7. Shire of Chittering Local Planning Strategy

3.2 Shire of Chittering Local Planning Scheme No.6

Under the Shire Chittering's *Local Planning Scheme No.6* (LPS6), the subject land is zoned 'Agricultural Resource'. Great Northern Highway is reserved 'Highway'.

Part 5 of LPS6 establishes a number of special control area (SCA)'s relating to the Muchea Employment Node, Basic Raw Material, Military Considerations and Water Prone areas. The Muchea Employment Node SCA affects the whole site and is discussed further below. The remaining SCA's affect portions of the subject site and impose certain requirements required to be addressed as part of a development application.

3.2.1 Muchea Employment Node SCA

As indicated above, the subject land is located within the Muchea Employment Node SCA. The purpose of this SCA is to provide a basis for the zoning and development of the Muchea Employment Node as an industrial estate in accordance with the MENSP.

Clause 5.7.2.2 states that proposals to rezone land to 'General Industry' and 'Light Industry are to address the objectives and requirements of the MENSP, including matters relating to stormwater management; wastewater disposal; environmental impacts; land capability; Aboriginal heritage; and other relevant considerations (such as access and egress, and basic raw materials).

This local scheme amendment request includes supporting technical reports addressing these mattes and which are discussed further under the following sections of this report.

Clause 5.7.2.5 requires the subdivision or development of land within the Muchea Employment Node to be in accordance with the provisions and requirements of Schedule 11 as applicable. This local scheme amendment request proposes to introduce appropriate provisions to guide future planning of the subject site.

Refer to Figure 8 – Shire of Chittering Local Planning Scheme No. 6.

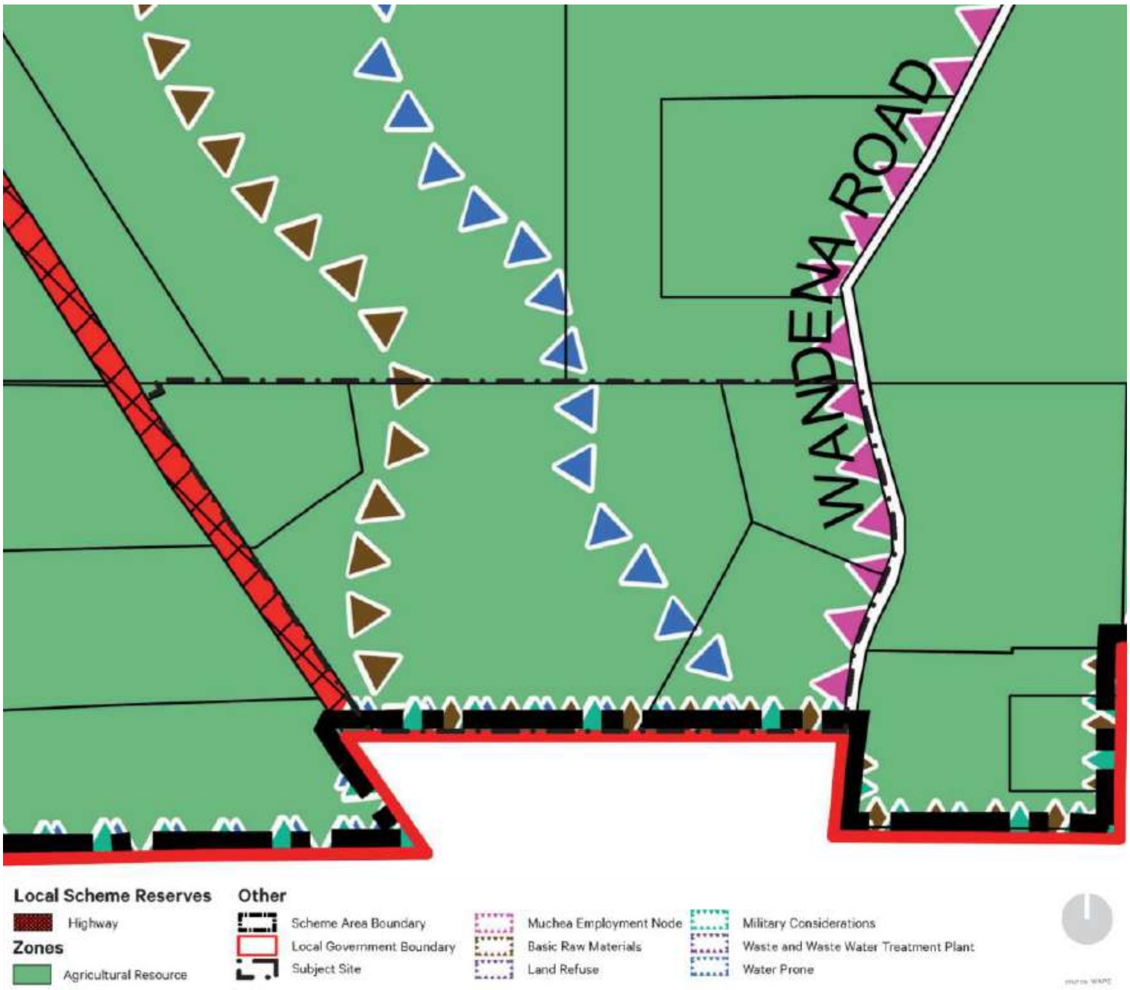


Figure 8. Shire of Chittering Local Planning Scheme No. 6

3.3 Planning Policies

3.3.1 State Planning Policy No.2.4 – Basic Raw Materials

This policy sets out the matters which are to be taken into account and given effect to by the Commission and local governments in considering zoning, subdivision and development applications for extractive industries (for the extraction of basic raw materials) and zoning, subdivision and development applications in the vicinity of identified basic raw material resource areas.

The policy identifies Lots 202 and 203 within a 'Priority Resource Location'.

Lots 202 and 203 previously formed part of Midland Brick's Clay extraction operations. Extraction activities has been ceased for a significant number of years, as the clay material has been exhausted.

Following acquisition of the land from Midland Brick, the current landowner (Swan Industrial Development Pty Ltd) submitted a development application with the Shire seeking approval for the landfill and rehabilitation of the land, to enable the property to be used for other purposes.

The rehabilitation and subsequent reuse of the property for alternative purposes was deemed consistent with the strategic direction for this site under the planning framework and the intention to be rezoned for industrial purposes at some time in the future. The application was conditionally approved by the Shire of Chittering Council at its Ordinary meeting of 16 March 2016.

3.3.2 State Planning Policy No.3.7 – Planning in Bush Fire Prone Areas

The subject site is within a designated bushfire prone area as per the *Western Australia State Map of Bush Fire Prone Areas* (DFES 2019), which triggers bushfire planning requirements under *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; Western Australian Planning Commission (WAPC) 2015) and reporting to accompany submission of the development application in accordance with the associated *Guidelines for Planning in Bushfire Prone Areas v 1.3* (the Guidelines; WAPC 2017).

Eco Logical Australia have prepared a Bushfire Management Plan (BMP) report in support of the proposed Amendment.

The BMP has determined that the amendment can satisfy the requirements of SPP 3.7 and the Guidelines. This is discussed further under section 5.7 of this report.

3.3.3 State Planning Policy No.3.6 – Development Contributions

This policy set out the principles and considerations that apply to development contributions for urban infrastructure and the form, content and process to identify and equitably apportion and collect cost contributions under a local planning scheme.

The strategic framework for the MIPSP envisages alternative funding arrangements outside of a formal contribution system as being more appropriate, due to issues and uncertainties around timing and staging.

It is understood that individual private landowner agreements (in line with the principles of the policy) are envisaged as the preferred approach to addressing cost sharing arrangements for new infrastructure.

3.3.4 Draft State Planning Policy No 4.1 – Industrial Interface

This policy guides planning decisions with the aim of protecting the long-term future operation of industry and infrastructure facilities, by avoiding encroachment from sensitive land uses and potential land use conflicts.

Relevant to this amendment, the policy identifies the following measures with respect to managing land use conflict and preventing adverse impacts:

> *5.2.1(c) Strategic and General Industry zones should not have a direct interface with sensitive zones in local planning schemes. An interface of compatible land use zones and/or reserves should be identified in local planning schemes (such as Light Industry and Commercial zones and Public Open Space reserves) to ensure a compatible interface is achieved.*

> *5.2.1(f) To ensure a compatible interface is retained, there should be a presumption against zoning proposals that would allow the development of new sensitive land uses on Rural zoned land adjacent to General Industry zones.*

Consideration against the policy measures is discussed further in this report under the Planning Merit.

3.3.5 EPA Guidance for the Assessment of Environmental Factors No.3

This document provides guidelines for separation distances between industrial and sensitive land uses. The subject site is located some distance away from the Muchea town site and existing rural-residential development in the area. Isolated residences on rural land existing in proximity to the subject site including a residence to the west of Great Northern Highway (within Precinct 3) and a residence approximately 350m to the east of Wandena Road.

Proponents of future industrial activities will need to give consideration to separation distances between the proposed land use and any affected residential or other sensitive uses in accordance with the Guidance Statement at the development application stage.

4. Design Considerations – Concept Plan

An indicative concept plan has been prepared to provide a basis for informing the scheme amendment and the preparation of a future structure plan for the subject site.

Refer to Figure 9 – Indicative Concept Plan.

The concept plan design has been informed by the higher order strategic planning framework that applies to the site, in particular the key structural elements identified under the draft Muchea Industrial Park Structure Plan.

Key principles of the concept plan include:

- Provision of industrial lots ranging in area from 1 hectare to 2.5 hectares capable of accommodating the range of land uses that can be contemplated within both the 'General Industry' and 'Light Industrial' zones under LPS6.
- A design layout that responds to the existing topography, site constraints and land ownership, whilst retaining a level of design flexibility and robustness to facilitate the creation of an industrial lot product that can meet future market demand;
- Provision of the indicative local distributor road (RAV10 route) as identified under the draft Muchea Industrial Park Structure Plan, however with the intersection with Great Northern Highway realigned to be further south (as a 'T' intersection, rather than as a four-way roundabout).
- The utilisation of the existing site access to Lot 203 to provide direct vehicular access to Wandena Road, and the provision of a local road network that provides opportunities to integrate with future development on adjoining land.

A structure plan is currently being finalised, which will address the detailed design for the subject land, including the proposed road layout, distribution of land uses, location and size of drainage areas, landscape design / buffer requirements, and associated infrastructure.

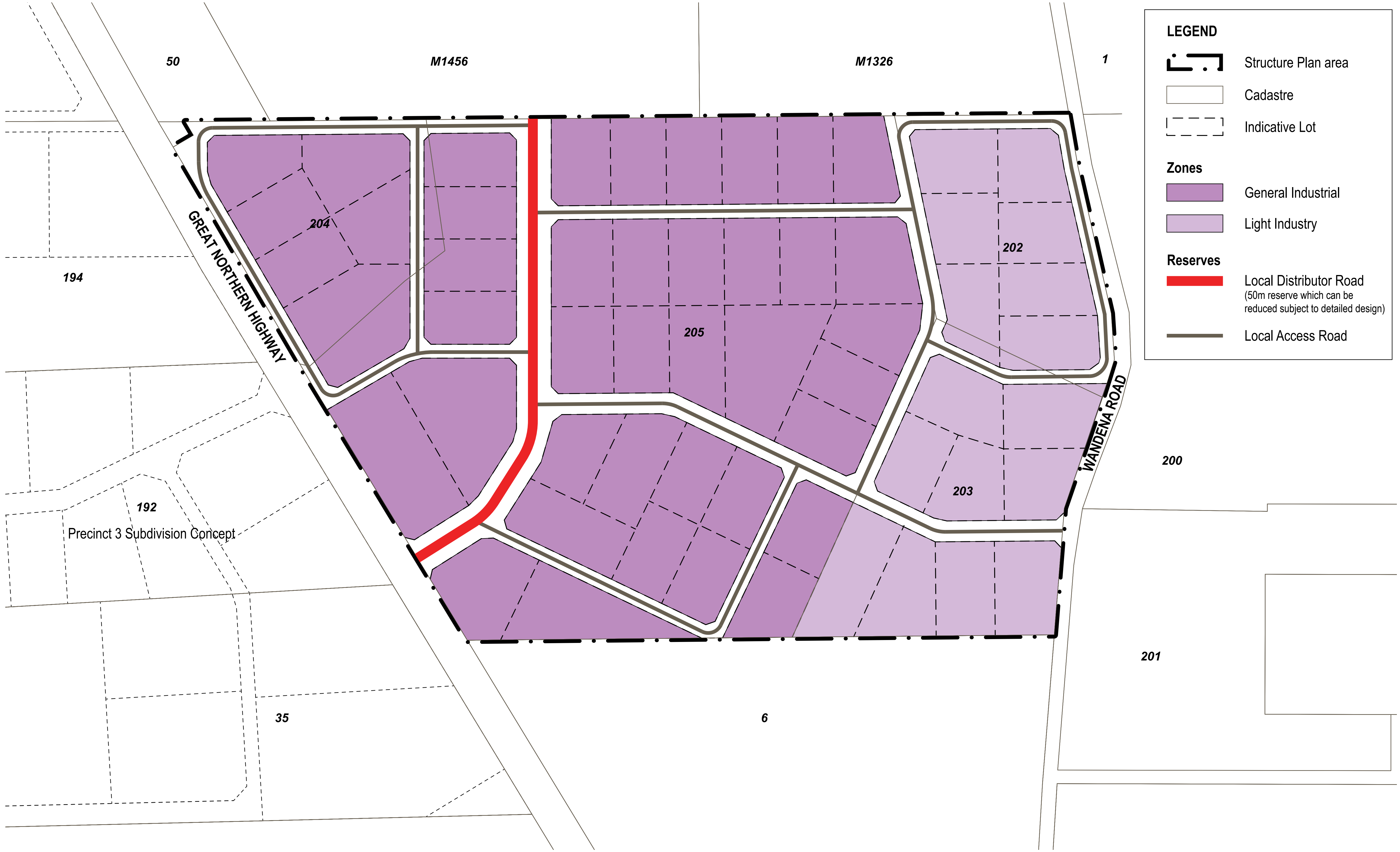


Figure 9. Indicative Concept Plan

5. Planning Merit

The following provides the rationale for the proposed amendment:

- The Amendment is aligned with the general principles and the broader vision set out under the State and local Shire of Chittering strategic planning framework for the area.
- Specifically, the Amendment is consistent with the zoning contemplated under the WAPC endorsed Muchea Industrial Park Structure Plan (2022), whereby Lots 202 and 203 are proposed to be zoned as Light Industry, and Lots 204 and 205 are proposed to be zoned as General Industry.
- The Amendment is consistent with the Shire of Chittering Local Planning Strategy (2019), specifically clause 3.4.2 of the Strategy which seeks to provide for and protect industrial land uses at strategic locations, with a key strategy to make the Muchea Industrial Park a focus for industrial development.
- The Amendment is supported by relevant technical inputs which demonstrate the land can be developed for industrial purposes consistent with the strategic vision for the area, subject to further detailed investigations.
- The provisions proposed to be inserted into Schedule 11 of the Scheme will ensure that key site considerations will be addressed through the preparation of a local structure plan. The Amendment also includes appropriate mechanisms to coordinate the provision of key infrastructure to service future industrial development.
- The Amendment is deemed to be a 'Standard' amendment under the provisions of the *Planning and Development (Local Planning Schemes) Regulations 2015* as it is consistent with the sub-regional and local planning framework, and will not result in any environmental, social, economic or governance impacts on land elsewhere in the locality.

6. Environmental Considerations

6.1 Landform and Soils

Douglas Partners have prepared a Preliminary Geotechnical Investigation report in support of the proposed Amendment, which is contained within the Environmental Assessment and Management Strategy (attached as Appendix C to this report). The following summarises the key findings of their report.

Site surface levels generally grade from approximately RL 100 metres AHD at the eastern part of the site to RL 58 metres AHD in the south-western corner. A terrain slope analysis indicates that generally the surface levels in the western half of the site grade between 1° and 3° and the eastern part of the site has slope angles generally between 3° and 6° with isolated areas of up to 15°. Note that the slopes associated with the quarry pit have been ignored in the slope analysis.

Ground conditions across the site were observed to generally comprise gravelly soils to a depth of between 0.5 metre and 1 metre underlain by cemented soil comprising mixture of clay, sand and gravel. Siltstone was encountered at a depth of approximately 2 m (generally below uncontrolled fill) at a few locations within the eastern part of the site.

Based on the encountered soils, no significant geotechnical constraints or challenges for the intended industrial development were identified during this investigation across most of the site, other than possibly its eastern end where various thicknesses of fill were identified within and around the existing quarry. The shallow cemented clayey soils across the site are generally hard and the siltstone in the eastern part of the site was low to medium strength. Therefore, it is anticipated that the one geotechnical constraint could be ground excavatability, depending on proposed excavation depths. Uncontrolled fill was encountered within and near the exiting quarry in the eastern part of the site and will require suitable site preparation to be re-used as foundation material.

The clayey soils, generally encountered from depths of between 0.5 metre and 1.0 metre are slightly reactive and therefore, it is considered that the areas of the site with natural soils have a site classification of Class S, in accordance with AS 2870-2011.

In accordance with AS 2870-2011, locations that have fill (e.g. generally the north-eastern part of the site) should be considered Class P in the absence of any certification from those controlling the placement of the fill (understood to be an ongoing process at the time of this reporting). If no certification for the fill can be provided, the filled class P areas could be reclassified following further geotechnical investigation.

Achieving Class A, if targeted, would require at a thickness of least 1.8 metre of non-reactive soils over any reactive clayey material, which at this site would generally require the placement of over 1 metre of non-reactive, granular fill.

6.2 Groundwater

Groundwater occurs at shallow depth across the lower-lying western parts of the site (Lots 204 and 205) in winter. The depth to groundwater varies from over 18 metres in the east of the site to less than two metres in winter in the west. The DWER maps minimum groundwater levels at 48-53m AHD (13-48m below ground), flowing south-west towards Ellen Brook.

In wet winters, rainfall infiltration may be impeded by the low-permeability soils, creating temporary surface saturation in the lower parts of the site. There is no evidence in the water measurements or soil profiles of the occurrence of a seasonally perched water table.

Groundwater measurements in 14 bores in and around the site in August 2020, shows that the groundwater levels were about 0.4m below the AAMGL. The winter of 2020 was drier than average, and the levels measured are considered to approximate the peak for the year. Simultaneous measurements of DWER bores located 680m south (Swan GWA 2-98) and 800m north (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated.

Combining the groundwater levels with topographic levels digitised from LIDAR data enabled depths to groundwater to be calculated. The results show that the AAMGL is within one metre of the ground surface in the far north and south of the site, and that the MGL will intersect the ground surface in the north of the site, resulting in surface saturation in this area.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally low to moderate.

The groundwater shows mostly low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are mostly low except for aluminium and zinc, which are slightly elevated across much of the site.

6.3 Surface Water

There are no natural defined drainage channels within the site, although several artificial drains have been cut in and around the quarry on Lots 202 and 203. The relatively low permeability soils of the soils would result in sheet flow across the ground surface during high rainfall events.

Water enters the project area from one 36ha external catchment to the east via a culvert beneath Wandena Road. This water flows via a constructed drain into a sump within Lot 202, which overflows to a farm dam on the adjoining lot and then into a drain that flows west to Great Northern Highway and ultimately into Ellen Brook. The land to the east is expected to remain as farmland for the foreseeable future, so this water inflow is not expected to change significantly in rate, volume or quality. There is no other flow from external catchments into the site.

All drainage from the site flows eventually into Ellen Brook, the major drainage feature of the region.

6.4 Vegetation and Flora

The following provides an overview of vegetation and flora considerations relevant to the subject site and which is discussed in further detail in the Environmental Assessment and Management Strategy contained in Appendix C.

6.4.1 Vegetation Type and Condition

The subject site is largely cleared of native vegetation, consisting mostly of farm paddocks and current and former quarries. All of Lot 204, most of Lot 205 and the southern part of Lot 203 are cleared paddocks with some scattered mature trees, either native or planted. Native vegetation is present in the central east of Lot 205, the northern end of Lot 202 and the north of Lot 203 consisting of Marri and Wandoo open woodland.

The native vegetation ranges in condition from Completely Degraded to Excellent. The highest quality vegetation is located in the north of Lot 203, the east of Lot 205 and the north of Lot 202, in patches of 1.3ha or less.

Refer to Figure 10 - Vegetation Mapping and Figure 11 - Vegetation Condition.

6.4.2 Rare and Significant Flora

The Department of Biodiversity Conservation and Attractions (DBCA)'s Naturemap and Commonwealth databases of Threatened and Priority Flora list 42 plant taxa with the potential to occur within the site.

No Threatened Flora pursuant to the *Biodiversity Conservation Act 2016* or the *EPBC Act 1999* were recorded during the vegetation surveys.

One species (*Haemodorum loratum* (P3)) listed as Priority Flora by the DBCA was recorded at two locations and in adjacent areas of the Wandoo open woodland in the south eastern part of the site and in the Marri woodland. One species of *Cyathochaeta* was recorded, due to the timing of the survey, it could not be determined whether it was the Priority 3 species *C. teretifolia*.

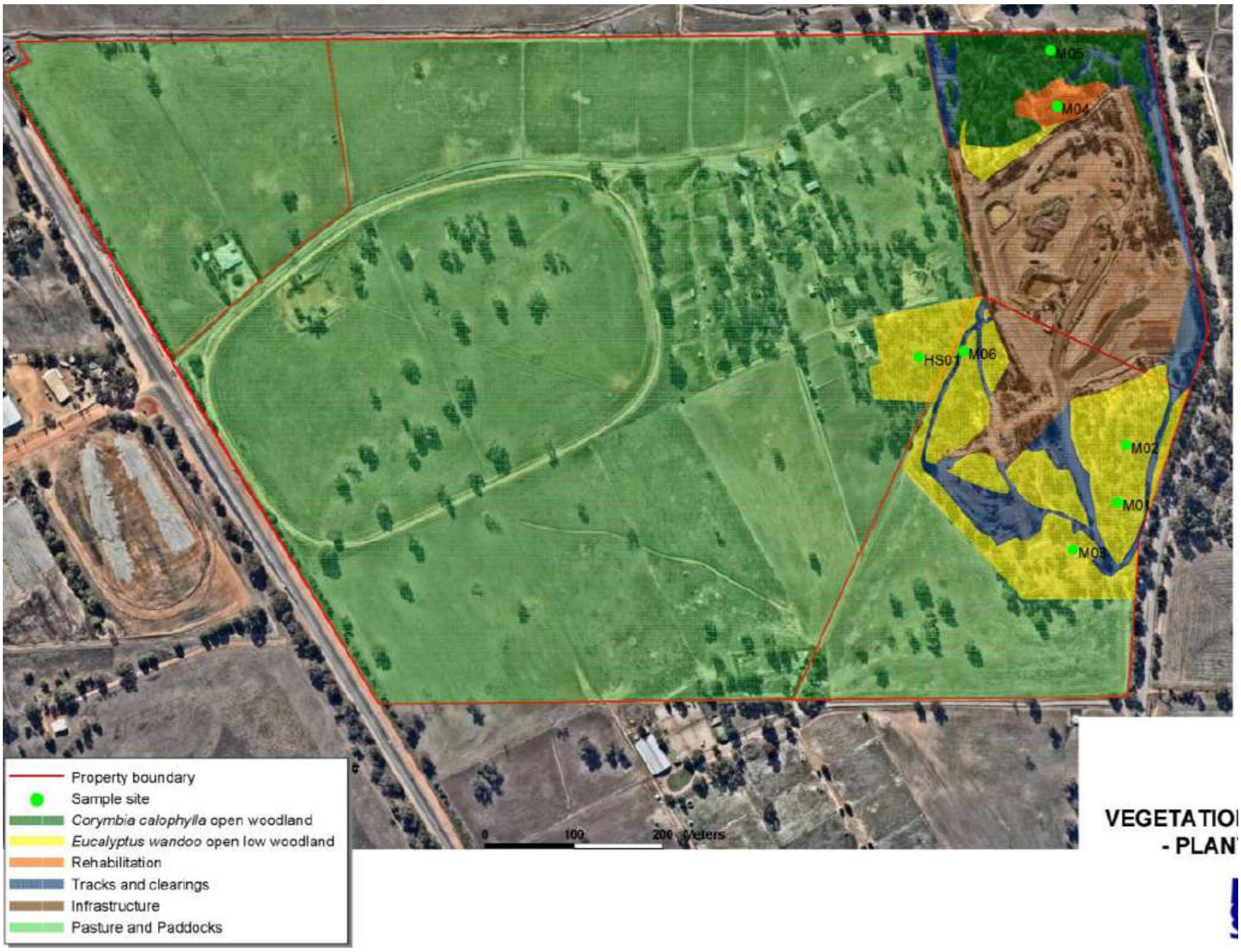


Figure 10. Vegetation Mapping (source: Bayley Environmental)

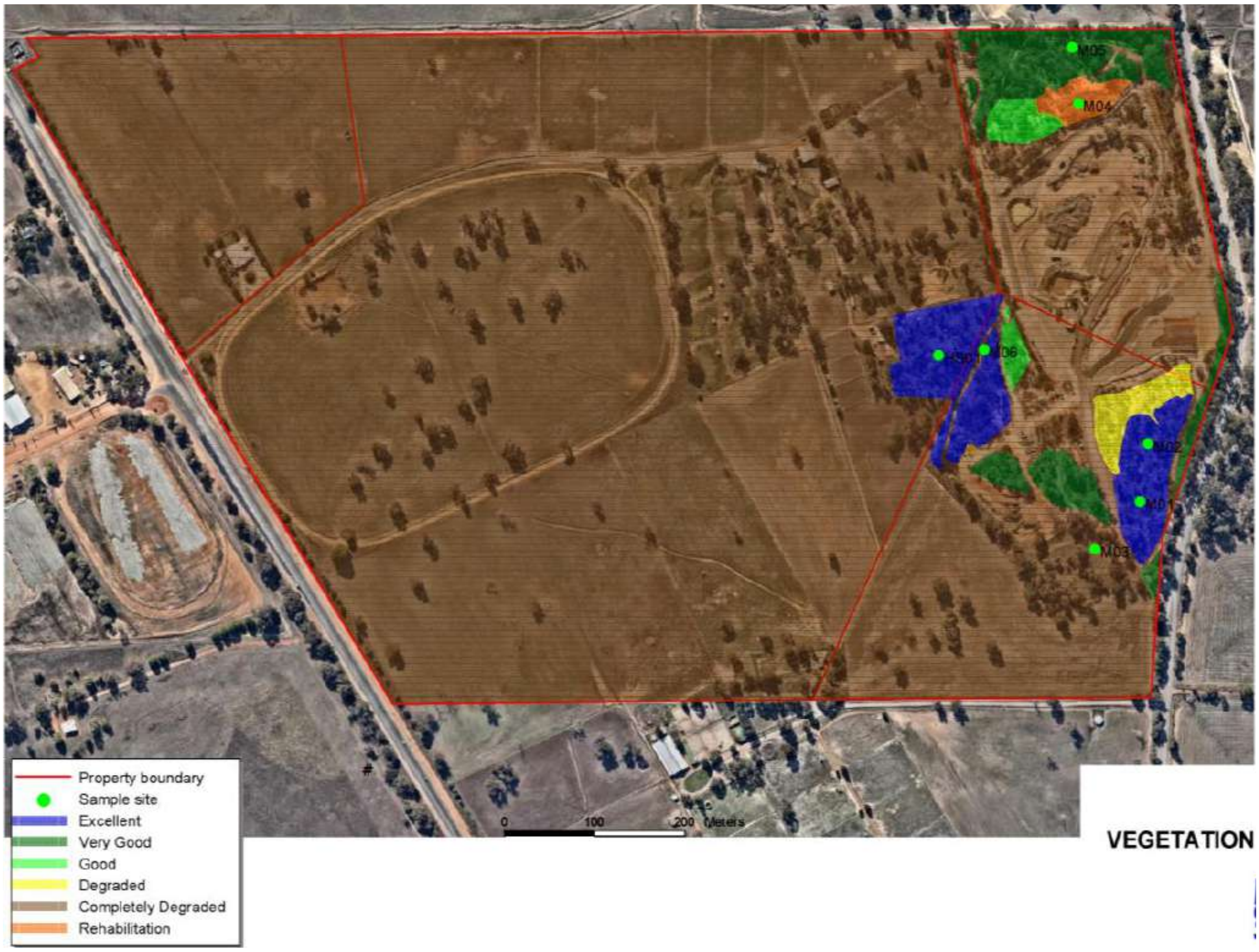


Figure 11. Vegetation Conditions (source: Bayley Environmental)

6.4.3 Threatened and Priority Ecological Communities

The DBCA and EPBC Threatened and Priority Ecological Community databases list several Threatened Ecological Communities (TECs) and Potential Ecological Communities (PECs) within 5km of the project area, however none were found to exist within the subject site.

6.5 Fauna

The following provides an overview of fauna considerations relevant to the subject site and which is discussed in further detail in the Environmental Assessment and Management Strategy contained in Appendix C.

6.5.1 Species and Habitats

Most of Lots 204 and 205 is cleared apart from isolated paddock trees, and offers little habitat for native fauna. The exception is an area of about 1ha in the east of Lot 205, which supports wandoo woodland in excellent condition and offers good quality habitat for fauna.

Lots 202 and 203 support areas of native vegetation ranging in condition from Completely Degraded to Excellent, as well as fully cleared areas. The vegetation in Good, Very Good and Excellent condition offers good quality habitat for fauna.

Overall, the project area contains approximately 2.4ha in Excellent condition, 2.3ha in Very Good condition and 0.5ha in Good condition.

The following fauna habitats have been identified at the site:

- Marri and Wandoo woodlands with largely undisturbed understorey;
- Eucalypt woodlands with degraded understorey; and
- Cleared paddocks with isolated mature Marri, Wandoo and Jarrah trees.

The Marri and Wandoo woodlands offer a range of feeding and nesting habitats for native fauna including mature trees with hollows, shrubs, dense understorey, groundcover and ground litter. These are expected to support a wide range of reptile, mammal and bird species.

The Eucalypt woodlands with degraded understorey have little or no ground cover or shrub layer and are expected to offer low-quality habitat for birds and some disturbance-tolerant terrestrial species.

The cleared paddocks with isolated mature trees would provide grazing habitat for kangaroos, particularly in areas close to uncleared woodland in the east of Lot 205. Stock troughs in the paddocks are focal points for ducks (particularly Maned or Wood Duck, *Chenonetta jubata* and Mountain Duck or Shelduck, *Tadorna tadornoides*), which feed in small flocks in the paddocks around the troughs. The paddocks also support a large population of the introduced Long-Billed Corella (*Cacatua tenuirostris*), which is an agricultural pest in Western Australia.

The mature trees in the paddocks are mostly larger than 0.5m diameter at breast height (dbh), and a number contain hollows of various sizes that offer potential nesting sites for black cockatoos and other bird species. Results of a survey of potential nesting hollows are detailed below.

6.5.2 Significant Fauna

A search relevant Commonwealth and State environmental agency databases produced an extensive list of Threatened Fauna species, Priority Fauna species and otherwise significant species in the vicinity of the subject site. Many of these were marine or aquatic species for which no habitat exists in the subject site.

Species that might occur, together with an assessment of their likelihood of occurrence are provided below:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (S1, EN) – Feeds and breeds in eucalypt and Banksia woodland from the lower Murchison to the lower south-west. Numerous records of occurrence near the project area. The project area contains food resources including Marri trees and potential nesting sites. Signs of feeding on Marri nuts, possibly by Carnaby's Black Cockatoo (or possibly by Twenty-Eight Parrots) were observed beneath trees in the south of Lot 203 during the site inspection in March 2020.
- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* (S1, VU) - Feeds and breeds in eucalypt and Banksia woodland from Gingin to the lower south-west. May occur in and around the project area. The project area contains food resources including Marri trees and potential nesting sites. A small group (8-10 individuals) was observed in Wandoo trees on the opposite side of Wandena Road during the site inspection March 2020.

- Black-striped Snake *Neelaps calonotos* (P3) - Inhabits dense leaf litter in Banksia and eucalypt woodlands with sandy soil from Lancelin south to Mandurah. Likely to be present in or around the project area.
- Black-flanked Rock Wallaby *Petrogale lateralis* subsp. *lateralis* (T, EN) – Restricted to parts of Cape Range, Little Sandy Desert, granite rocks in the Avon Wheatbelt, Kalbarri National Park and Barrow and Salisbury Islands. Occurs on rocky habitats with a preference for complex caves and crevices. Unlikely to be present in the project area due to the absence of suitable habitat.
- Woylie Bettongia *penicillata ogilbyi* (T, EN) - Formerly widespread species now restricted to six known sites in the south-west. Inhabits open eucalypt forest, open mallee woodlands and shrublands. Unlikely to be present in the vicinity due to predation by foxes and cats.
- Douglas' Broad-headed Bee *Hesperocolletes douglasi* (T, CR) – Recently rediscovered in Banksia woodland at Pinjar in 2019 after being presumed extinct. Only previous sighting was on Rottnest Island in 1938. Unlikely to be present in the project area.
- Chuditch *Dasyurus geoffroii* (S3, VU) - Occurs in a wide range of habitats including woodlands, dry sclerophyll forests and riparian vegetation. The project area provides foraging habitat and the species is likely to be an occasional visitor to the project area.
- Peregrine Falcon *Falco peregrinus* (S4) - A wide-ranging species that prefers nesting in cliff faces. Likely to overfly the project area but would not be resident.
- Rainbow Bee-eater *Merops ornatus* (S3, MI) - A common and widespread migratory species that utilises a wide range of habitats, with a preference for nesting in open sandy ground. The project area has few open sandy areas and is unlikely to provide habitat for the species.
- Fork-tailed Swift *Apus pacificus* (S3, MI) - A widespread and almost entirely aerial species. Likely to overfly the project area but would not be resident or dependent upon it.
- A short-tongued bee *Leioproctus douglasiellus* (CR) - Known from only three locations within the Perth metropolitan area in association with two plant species: *Goodenia filiformis* and *Anthotia junciforme*, neither of which are present at the site.
- Brush-tailed Phascogale *Phascogale tapoatafa* (P3) - Inhabits dry sclerophyll forests and open woodlands with hollow-bearing trees and sparse ground cover between Perth and Albany. A specimen was captured in open Tuart woodland in Baldivis, 23km south-west of the project area, in 2017 (Australian Ecological Services, 2017). Unlikely to be present at the site due to its scarcity and the absence of its preferred habitat.
- Graceful Sunmoth *Synemon gratiosa* (P4) - Inhabits coastal heathland on Quindalup dunes and banksia woodland on Spearwood and Bassendean dunes, in association with two species of mat-rush, *Lomandra maritima* and *L. hermaphrodita*. Neither plant species was found in the project area so the moth is unlikely to be present.
- Inornate Trapdoor Spider *Euoplos inornatus* (northern Jarrah Forest) (P3) – Known from several locations in the northern Jarrah forest, the closest 6.5km south-east of the site. May be present in uncleared areas at the site.
- A short-tongued Bee *Leioproctus contrarius* (P3) – Occurs on the Swan Coastal Plain in association with *Scaevola repens* var. *repens* and *Lechenaultia spp*, neither of which are present at the site.
- Quenda Isoodon *obesulus fuscivénter* (P4) - Inhabits dense ground cover in forests, woodlands and heaths, preferring areas around wetlands and damplands. May be present in uncleared parts of the project area although no evidence of presence (e.g. diggings) were observed.
- Grey Wagtail *Motacilla cinerea* (MI) – Breeds in northern Europe and migrates to the southern hemisphere, mostly Africa and Asia. Two Western Australian records from near Pemberton and Northcliffe. Unlikely to be present at the site.

6.5.3 Black Cockatoo Habitat Assessment

The subject site contains several potential food resource species for Carnaby's Cockatoo, however in most cases these species are present at low density over small areas. Limited evidence of Carnaby's Cockatoo feeding (in the form of chewed nuts) was observed during site inspection.

The subject site contains no significant water sources and limited feeding habitat as defined under the EPBC Act Referral Guidelines for Black Cockatoos. It is therefore unlikely that black cockatoos will roost in the area.

Field inspections of potential hollows undertaken in October 2020 found no evidence of current or previous black cockatoo nesting.

6.6 Aboriginal and European Heritage

The Department of Planning Lands & Heritage's online database shows one registered site, (ID 3525 Ellen Brook: Upper Swan) covering the whole project area.

The DPLH mapping usually extends well beyond the actual registered site boundary in order to protect sensitive sites. The DAA has advised that the actual boundaries of the registered site do not affect the project area, and that therefore no approval under the *Aboriginal Heritage Act 1972* is required for development of the project area (refer to Appendix C - Environmental Assessment and Management Strategy).

6.7 Bushfire Hazard

The subject site is within a designated bushfire prone area as per the *Western Australia State Map of Bush Fire Prone Areas* (DFES 2019), which triggers bushfire planning requirements under *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; Western Australian Planning Commission (WAPC) 2015) and reporting to accompany submission of the development application in accordance with the associated *Guidelines for Planning in Bushfire Prone Areas v 1.3* (the Guidelines; WAPC 2017).

Eco Logical Australia have prepared a Bushfire Management Plan (BMP) report in support of the proposed Amendment. Refer to Appendix D – Bushfire Management Plan.

The proposed rezoning is required to comply with policy measures 6.2 and 6.3 of SPP 3.7 and the Guidelines. Implementation of the BMP is expected to meet objectives 5.1-5.4 of SPP 3.7.

The BMP identifies a number of bushfire risk management measures, in accordance with the Guideline's Acceptable Solutions to meet compliance with bushfire protection criteria, and which are outlined in the following table:

Table 3: Summary of solutions used to achieve bushfire protection criteria

Bushfire Protection Criteria	AS	PS	N/A	Comment
Element 1: Location A1.1 Development location				Post-development, the subject site will be located in an area subject to BHLs of Low and Moderate with a minor portion of Extreme hazard associated with the revegetation proposed. (Refer to Figure 5; Figure 6 of the BMP). This area will be separated from future buildings to ensure that they will be subject to BAL ratings of BAL-29 or lower. The proposed rezoning is considered to be compliant with A1.1.
Element 2: Siting and design of development A2.1 Asset Protection Zone (APZ)				As the lot layout is currently unconfirmed, APZs are unable to be prescribed at this level of planning. APZs will be defined in BMPs supporting future planning applications (subdivision) to ensure that all future lots will be subject to a BAL rating of BAL-29 or lower. Figure 6 of the BMP demonstrates that the majority of the subject site will be subject to BHLs of Moderate or Low and ELA expects that APZs will be able to be accommodated within road reserves, maintained Public Open Space areas etc. The proposed rezoning is considered to be compliant with A2.1.
Element 3: Vehicular access A3.1 Two access routes				There are currently two access routes from the subject site being north/south on Great Northern Highway and Wandena Road (Refer to Figure 6 of the BMP). BMPs supporting future planning applications (subdivision) will provide greater detail on road networks and ensure that all stages of development are provide with two forms of access at all times where relevant and possible.

Bushfire Protection Criteria	AS	PS	N/A	Comment
A3.2 Public road				All future public roads will be designed and constructed to comply with the Guidelines (Refer to Appendix C of the BMP). BMPs supporting future planning applications (subdivisions) will address this element in greater detail. The proposed development is considered to be compliant with A3.2.
A3.3 Cul-de-sac				At this stage, no cul-de-sacs are proposed to be constructed within the subject site.
A3.4 Battle-axe				At this stage, no battle-axe lots are proposed within the subject site.
A3.5 Private Driveway longer than 50 m				At this stage, no private driveways longer than 50 m are proposed to be constructed within the subject site.
A3.6 Emergency Access way				At this stage, no emergency access ways are proposed to be constructed.
A3.7 Fire-service access routes				At this stage, no fire service access routes are proposed to be constructed.
A3.8 Firebreak width				The subject site will be managed in accordance with the Shire of Chittering Firebreak & Bushfire Hazard Reduction Notice. BMPs supporting future planning applications (subdivisions) will address this element in greater detail. The proposed development is considered to be compliant with A3.8.
Element 4: Water A4.1 Reticulated areas				The subject site is not connected to a reticulated water supply. Reticulated water is not present within the area.
A4.2 Non-Reticulated areas				No reticulated water is currently available to the subject site. Future planning stages will ensure that a firefighting water supply will be provided in accordance with the Guidelines. The proposed development is considered to be compliant with A4.2.
A4.3 Individual Lots within non-reticulated areas				It is unlikely that a development proposal for the subject site will result in the construction of one additional lot.

Figure 12 details the post-development BHL assessment and a spatial represnttion of bushfire management strategies based on the entire subject site being managed to a low threat state as per the Guidelines and AS3959-2018 with the exception of a proposed 10 metre revegetated strip of classified vegetation along Wandena Road. The revegetated strip of vegetation has been classified as Class A-Forest based on the precautionary principle and may change at future planning stages due to further definition of the proposed revegetation. Updated BMPs will be prepared to support subsequent planning applications where relevant and will contain re-assessments of bushfire risk including Bushfire Attack Level assessments.

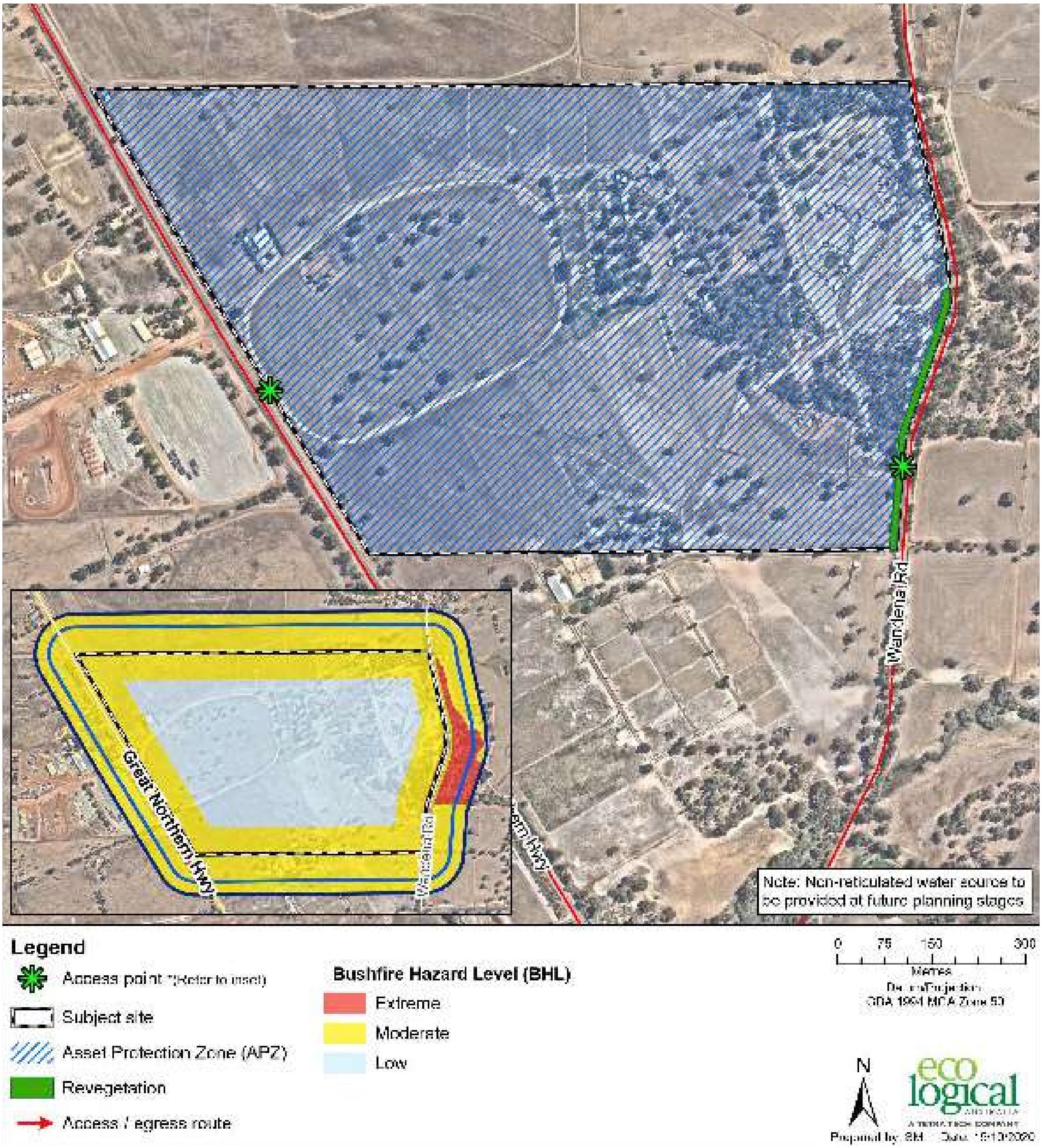


Figure 12. Spatial Representation of Bushfire Management Strategies (source: Ecological Australia)

7. Environmental Impacts & Management

The Environmental Assessment and Management Strategy contained in Appendix C outlines various environmental considerations and management measures, and which are presented below.

7.1 Noise

Active management of noise within and from future industrial development on the subject site will not generally be required. Where a proposed industrial land use has the potential to generate substantial noise that may impact residential (or other sensitive) uses, such applications will need to demonstrate that they comply with EPA requirements by way of preparation of a suitable assessment and management plan undertaken at the development application stage.

7.2 Dust

Individual lot holders within the project area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable process dust will be required to hold a DWER licence, which will specify dust limits and monitoring requirements. Similarly to noise, industrial land uses that have the potential to generate dust impacts will need to demonstrate that they comply with EPA requirements at the development application stage.

7.3 Vegetation and Flora

Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER.

Landscaping within private lots and public areas (e.g. road reserves and drainage swales/basins) will be carried out using local native species.

7.4 Fauna

Development of the site as proposed will require the clearing of about 5.2ha of Marri and Wandoo woodland in Completely Degraded to Excellent condition.

Prior to clearing, a fauna capture and relocation exercise will be undertaken by a qualified specialist consultant to relocate any sedentary animals (e.g. snakes and lizards) from the application area. During and after clearing, monitoring of debris will be carried out to locate and salvage any fauna caught within the clearing operation.

Fauna captured or salvaged during this operation will be relocated to parks or reserves in consultation with and by permission of the DBCA. Any injured fauna found after clearing will be taken to a refuge where possible. Any feral animals captured, as well as native animals that are too badly injured to recover, will be euthanased.

Fauna habitat will be created in the revegetation of drainage swales and basins. Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

7.5 Water Monitoring

Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Surface water quality in drainage lines within, upstream and downstream of the project area will be monitored to determine what (if any) impacts the development may be having on surface water quality.

The proponent of each stage of subdivision will be responsible for monitoring water quality in bores and drainage swales within that stage.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

7.6 Landscape Approach

Landscaping of the site will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot), effluent irrigation areas and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted.

The plantings in swales, basins and effluent irrigation areas will include a high proportion of species recommended in the Monash University (2014) *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia*.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation-tolerant species including sedges and low shrubs in order to stabilise the basins and maximise their ability to take up nitrogen from the water.

The total area to be planted is approximately 13.7 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 92 ML of water would be required to irrigate the new plantings for the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year. If the development took place over ten years and each stage were irrigated for two years, the annual water demand would be about 18.5 ML/yr for most of that ten-year period, decreasing in zero after eleven years. The DWER (T. Walker, 2021 pers. comm.) has confirmed that sufficient water is available from the surficial aquifer to supply the needs of the project.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (Eco Logical Australia, 2021).

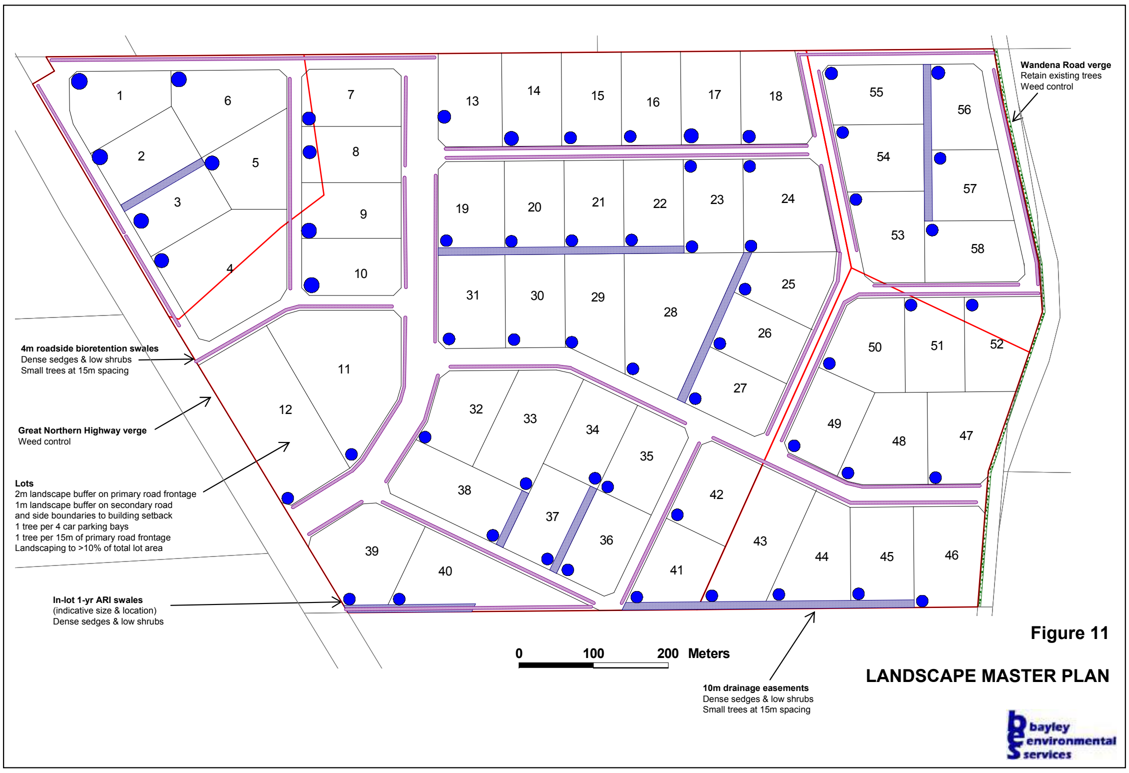


Figure 13. Landscape Master Plan Concept (source: Bayley Environmental)

8. Local Water Management

A Local Water Management Strategy (LWMS) has been prepared for the subject site and is included at Appendix D of the Environmental Assessment and Management Strategy (Appendix C of this report). The following section summarises the strategies proposed for the management of stormwater and groundwater.

8.1 Stormwater Management Strategy

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at or below their pre-development levels.

The existing drainage line entering at the north-east of Lot 202 will be realigned and consolidated in a vegetated swale within a road reserve. The swale will be sized to accommodate the flow from a 100-year ARI critical storm from both the upstream and internal catchments.

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, basins and/or landscaping areas. The in-lot drainage structures will also be sized to capture and detain the runoff from roofs, paved surfaces and hardstand areas from critical storms up to 100-year ARI.

Overflows from the basins will run into roadside bioretention swales, either directly or via drainage easements for those lots that do not have a downslope road frontage. Lots will be filled as necessary adjacent to the roads to enable lot drainage to enter the roadside swales.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The inverts of the swales will be at or above the AAMGL.

The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm.

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where it will enter the roadside drains and culverts on Great Northern Highway. The rate and volume of drainage out of the site will be controlled to be no greater than those existing before development.

The drainage from the site flows beneath Great Northern Highway via four culverts. The culverts have sufficient capacity to carry the flow from a 100-year ARI critical storm without upstream ponding.

8.1.1 Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15.
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out.

8.1.2 Groundwater Management Strategy

The drainage system for the site is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their inverts at or above the AAMGL. Subsoil drainage within lots will be limited to filled areas used for buildings or effluent disposal.

Subsoil drainage may be employed within some lots where necessary to maintain existing maximum groundwater levels beneath building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales via free-draining outlets.

Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement.

All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of the site will be minimal.

Groundwater quality will be protected by measures including:

- regular street sweeping to remove accumulated contaminants; and
- selection of native species with low water and fertiliser requirements for public open space and landscape areas.

8.1.3 Monitoring

Groundwater levels and quality will be monitored and compared against baseline levels and relevant guidelines. Water quality in surface drains will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses. Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

8.1.4 Implementation and Further Management Plans

Further planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) will be prepared as a condition of subdivision approval for each stage of subdivision. The UWMP will present the detailed design of the storm water drainage system within that stage.

The developer of each stage of subdivision will maintain the drainage system, landscaped areas and water monitoring program within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for.

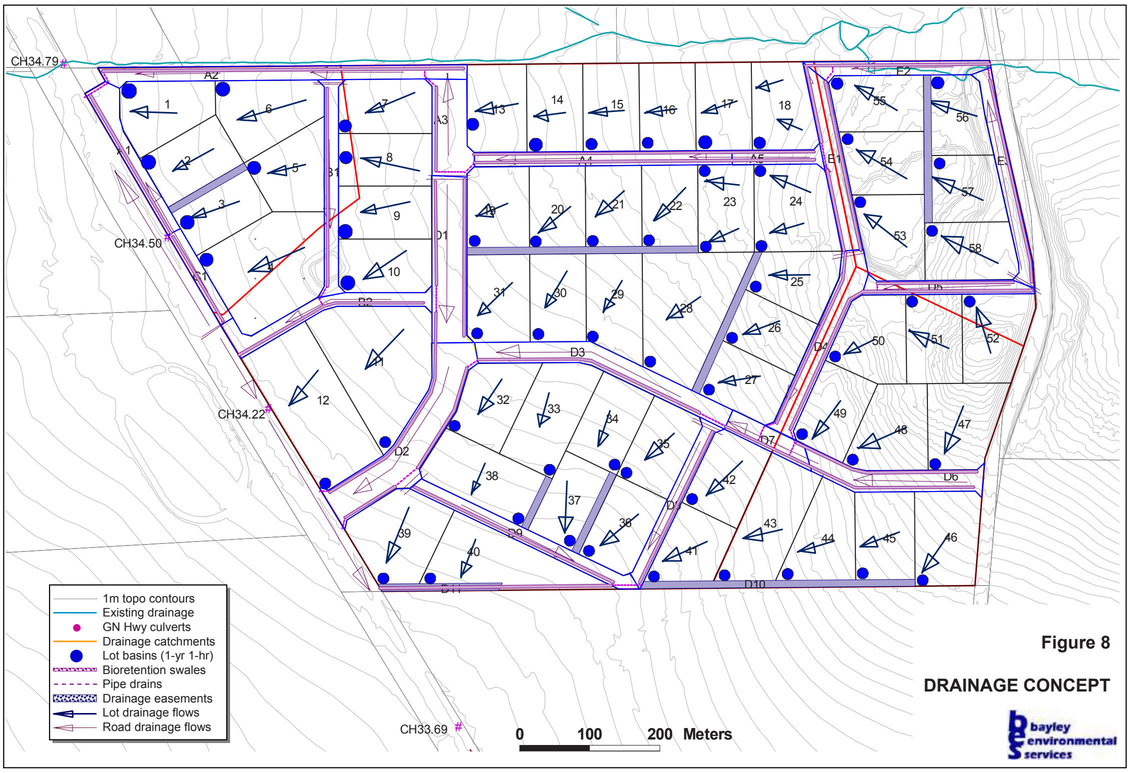


Figure 14. Drainage Concept (source: Bayley Environmental)

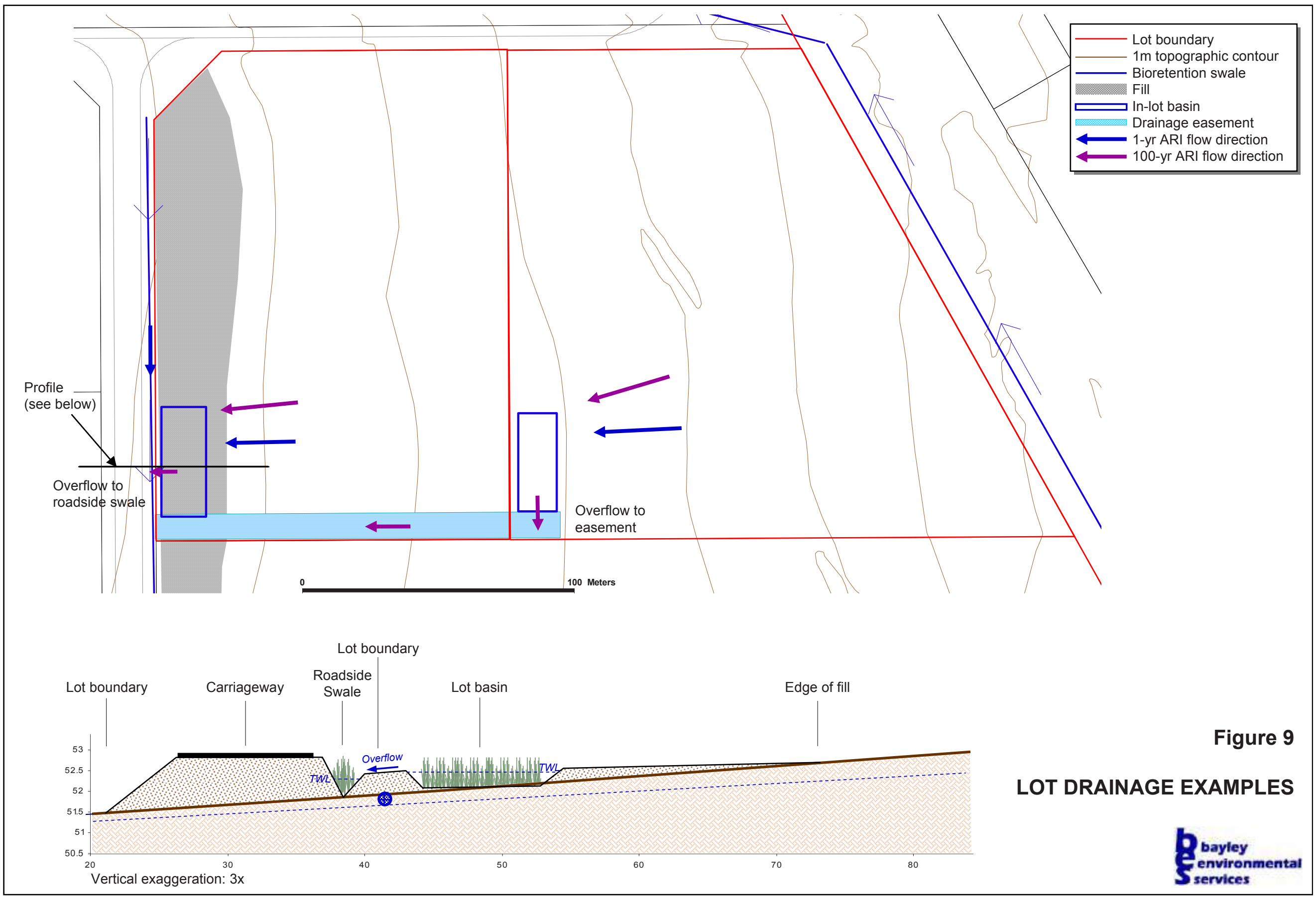


Figure 15. Lot Drainage Examples (source: Bayley Environmental)

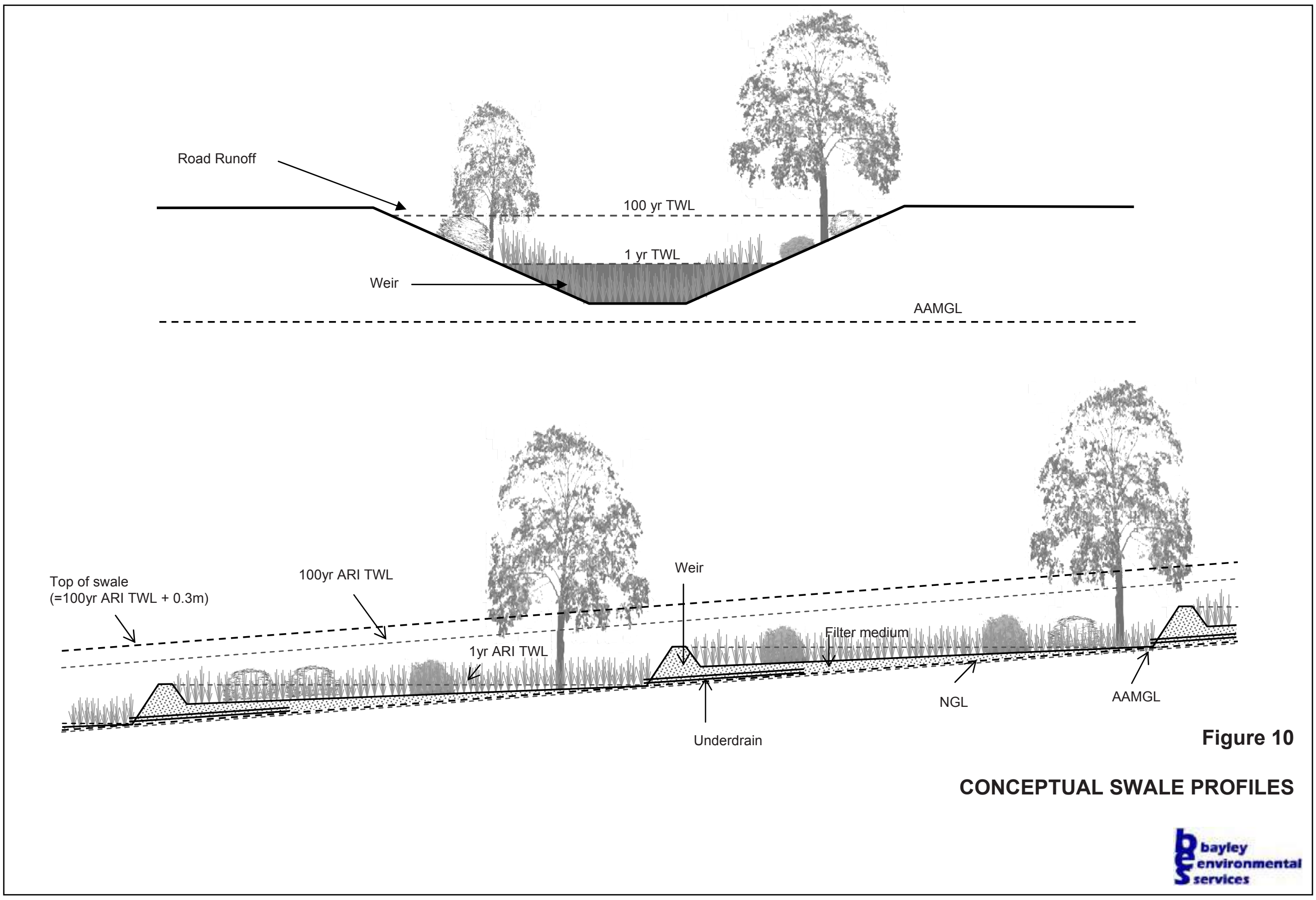


Figure 16. Conceptual Swale Profiles (source: Bayley Environmental)

9. Servicing Considerations

Porter Consulting Engineers have undertaken an assessment of engineering servicing requirements in support of the proposed Amendment. Refer to Appendix F – Engineering Servicing Report. The following summarises the key findings of their report.

9.1 Earthworks

The geotechnical investigation notes that where clayey soils are encountered at depths between 0.5m to 1m, the site will have a classification of Class S in accordance with AS2870-2001. For locations that have fill (generally the north-eastern part of the site), these should be considered Class P in the absence of any certification from those controlling the placement of fill.

To achieve a Class A site classification, the investigation notes that 1.8m of non-reactive soils (e.g. sandy soils) would be required over reactive clay, which would generally require the placement of 1m of granular non-reactive fill. Reference should be made to the geotechnical investigation and LWMS during the subdivisional detailed design phase and built-form design works to inform site preparation requirements.

In general terms, earthworks during the subdivisional works will be undertaken to satisfy the requirements of the roadworks, road drainage, and limited earthworks within lots to provide appropriate grades/access. Isolated 'pad' earthworks and leveling are expected to be undertaken as part of the built-form works for individual lots to facilitate proposed structures, hardstands, lot drainage, and the on-site wastewater management disposal systems.

Typically for industrial development, level, and near-flat levels lots or 'pads' are desired as it offers the greatest flexibility. The IPWEA subdivisional guidelines12 note that the maximum grade across industrial lots shall not exceed 6.67% (one in 15). The western half of the site has natural surface grades up to 3%, whereby the eastern portion is relatively steep with grades up to approximately 10%.

9.2 Water Reticulation

There is currently no reticulated water supply networks in the immediate area, with the Water Corporation's nearest scheme water infrastructure approximately 7.2km to the south, at the intersection of Great Northern Highway and North Avenue in Bullsbrook. The Corporation does not have current plans to expand the network. Water supply to existing properties in the area comes from groundwater and rainwater harvesting.

The Muchea Industrial Park Structure Plan notes "Groundwater resources for reticulated water supply for the Shire are either fully allocated or approaching full allocation, although, there is a limited local groundwater allowance through private companies and options for the purchase of water entitlements outside the industrial park. The surficial aquifer in the Eclipse Hill subarea, located east of Great Northern Highway and Old Gingin Road, has approximately 1.9 GL of unallocated volume per annum (as of October 2018).

Without a water allocation for public drinking water purposes the most efficient and cost effective way to deliver a reticulated water supply to the industrial park is via water trading with third party who has a suitable existing licence, or the ability to obtain a suitable allocation amount through trading. Under the current *Rights in Water and Irrigation Act 1914*, landholders who hold water allocation licences in fully allocated areas can trade or transfer all or part of their allocation, provided water policy requirements can be met. Trades and agreements can only take place within the same water resource (i.e. same groundwater sub-area and aquifer or same surface water area).

Two water service providers have begun the process of gaining approval to provide a reticulated service in the industrial park from groundwater as the supply source. As of late 2019, the most advanced is in development by Aqua Ferre, which includes construction of a water treatment facility on Lot 2 Reserve Road as part of a proposed 250 lot residential development. Aqua Ferre is applying for a Water Service Provider Licence from the Economic Regulation Authority. The project proposes drawing water from the Leederville Aquifer, with treatment to meet drinking water quality guidelines. The successful provider will be the one that can offer the best outcome for the developers and secure an allocation from DWER and a water services operating licence from the ERA".

Porter Consulting Engineers has made contact with the two water service providers (Aqua Ferra and Chittering Valley Irrigators).

During a phone discussion with Aqua Ferra, it was reported that they have secured a licence to supply potable water to the Muchea Employment Node with a recently installed portion of the network within Precinct 1 expected to become live in May 2020. The water supply network is being designed and installed in accordance with the Water Corporation's standards. Aqua Ferra indicated that the proposed development area is likely to be serviceable but will be confirmed when estimated water demands are provided to them.

In terms of planning for the subject site, two water demand estimates have been derived. One estimate is based on a similar industrial development which utilised 4.0 kL/Ha/day, yielding an estimated demand of 98,800kL per annum. Another estimate has been prepared to be consistent with the Water Corporation's design standard DS50 which is based on 14.967 kL/Ha/day, yielding a significantly higher demand of 369,400kL per annum.

As noted in the Muchea Industrial Park Structure Plan, developers will need to consider their total water needs in preparation of Local or Urban Water Management Plans.

9.3 Effluent Disposal

The majority of Muchea Industrial Park including the subject site are situated within a sewerage sensitive area due to its location within the Swan-Canning River estuary catchment.

There is currently no reticulated wastewater networks in the immediate area, with the nearest Water Corporation sewer infrastructure some 6km to the south. The Corporation does not have current plans to expand the network.

The Government Sewerage Policy outlines acceptable standards for alternative wastewater disposal, mainly through the use of Aerobic Treatment Units (ATU's) for secondary treatment systems with nutrient removal. The Policy notes that lot sizes within Sewerage sensitive area are to be a minimum one hectare in area. The concept plan for the proposed development satisfies the minimum lot area.

The arrangement of the wastewater disposal system will be guided by the Government Sewerage Policy. All on-site wastewater treatment systems require the provision of adequate nutrient removal capability, clearance to groundwater, and ongoing maintenance by lot owners, to ensure they are working correctly and providing the necessary level of treatment before discharging wastewater to the local environment. All systems should meet the requirements of the Shire and Department of Health (DoH) as part of the approvals and monitoring process.

Industrial operators are expected to manage their own trade waste by either onsite or offsite disposal. The suitability of on-site disposal will depend on hazardous materials onsite, the risks posed, and likely failure mode of the primary containment, and pathways to downstream environments.

9.4 Power

There is existing high voltage overhead powerline along the eastern verge of Great Northern Highway and an overhead line intersecting the subject site in an east-west direction. It is expected that this HV east-west line will be relocated within future road reserves as part of the subdivision works so not to constrain development of individual lots.

At the north-west corner of the site is a fenced compound that appears to be a possible HV capacitor bank or line protection kit which is contained within its own small lot separate to the development. It is expected that this compound is required to remain.

The Western Power Network Capacity Mapping Tool forecasts a 25-30 MVA capacity in 2021 and a drop to 20-25 MVA in 2036. Although there appears to be sufficient capacity in the network beyond 2021, a more detailed assessment will be undertaken by Western Power when a Feasibility Study is requested or Design Information Package during the detailed design phase.

9.5 Gas

There is no existing gas infrastructure in the area. In the vicinity of Muchea, the Dampier to Bunbury natural gas pipeline lies to the west of Brand Highway. There are no current plans to extend gas infrastructure to the Muchea Industrial Park.

9.6 Telecommunications

There are existing Telstra assets in Great Northern Highway, cabling that serves the various farm buildings and assets along the eastern extent of Wandena Road.

Based on the NBN Rollout-map, NBN Fixed Wireless technology is forecast to be available to the area from June 2020 to service the development.

10. Traffic Considerations

Porter Consulting Engineers have undertaken an assessment of traffic and transport considerations in support of the proposed Amendment. Refer to Appendix G – Traffic Impact Assessment Report. The following summarises the key findings of their report.

The layout proposes 5 internal intersections with the District Loop Road over a length of 700m. To prioritise vehicle movement function along the District Loop Road consideration would need to be given to restricting the turning vehicular movements at a number of intersections, and providing one intersection with full turning movements to service the area to the west of the District Loop Road and one intersection to service the area to the east. This will result in the spacing of the two main intersections being approximately 400m. The permeability of the proposed internal road network layout will accommodate these vehicular movement restrictions.

The draft MIPSP states that the District Loop Road is not to provide direct vehicle access to lots. For this reason the layout provides for two internal roads (Roads 6 and 8) able to be designed for RAV 10 vehicles. The remaining roads within the layout are considered to be access roads and could be designed for smaller design vehicles such as a b–double as the development and lot demand requires. This will be confirmed as part of future detailed planning.

Refer to Figure 17 – Indicative Intersection Configuration and Figure 18 – Indicative RAV Network.

The layout is expected to generate in the order of 2,200 vehicles per weekday with approximately 304 and 349 vehicles within the am and pm peak hours.

The additional traffic of 2,200 vehicles per day on the District Loop Road is lower than that ultimately expected to be carried on this category of road with the full development of the Muchea Industrial Park. The internal traffic flows within the development site are in line with those expected on local access roads.

There is sufficient spare capacity for the additional traffic that would be generated by the development on to Great Northern Highway with traffic volumes estimated to be in the order of 2,960-3,730 vehicles per day, which is still less than the historic volumes of 7,500 vehicles per day that occurred prior to the Tonkin Highway – Northlink extension.

The concept layout proposes the creation of a staggered T-junction arrangement on Great Northern Highway with the proposed District Loop Road on the subject site, and the Loop Road to Precinct 3 of the Muchea Industrial Park located on the western side of Great Northern Highway. Whilst the draft MIPSP identifies a 4 way roundabout, initial liaison with Main Roads WA has indicated that in principal there is no objection to a staggered T-junction arrangement instead of a 4 way roundabout.

The intersection of Great Northern Highway and the southern District Loop Road which is included within the subject site has been assessed. To ensure a robust assessment the analysis was based on full development of the subject site without the further extension of the District Loop Road to the north, requiring the majority of traffic from the subject site to use the Great Northern Highway intersection. Furthermore, traffic volumes along Great Northern Highway were increased generously to 5,000 vehicles per day which would allow for development within the Industrial Park. Two intersection layout options were modelled that utilised the existing overtaking lanes on Great Northern Highway in the form of acceleration lanes and/or auxiliary turning lanes. The analysis indicated that both intersections would operate satisfactorily.

Further development to the north of the subject site will likely see increases in generated traffic along the District Loop Road and further connections to Great Northern Highway resulting in the redistribution of traffic. As development progresses and the likely staging is known, further investigations to confirm the level of intersection control will be required at the intersection of Great Northern Highway and the southern District Loop Road.

As Main Roads WA is the controlling authority of Great Northern Highway, the ultimate and staged treatments and layout of all intersections with the highway will be subject to Main Roads WA approval.

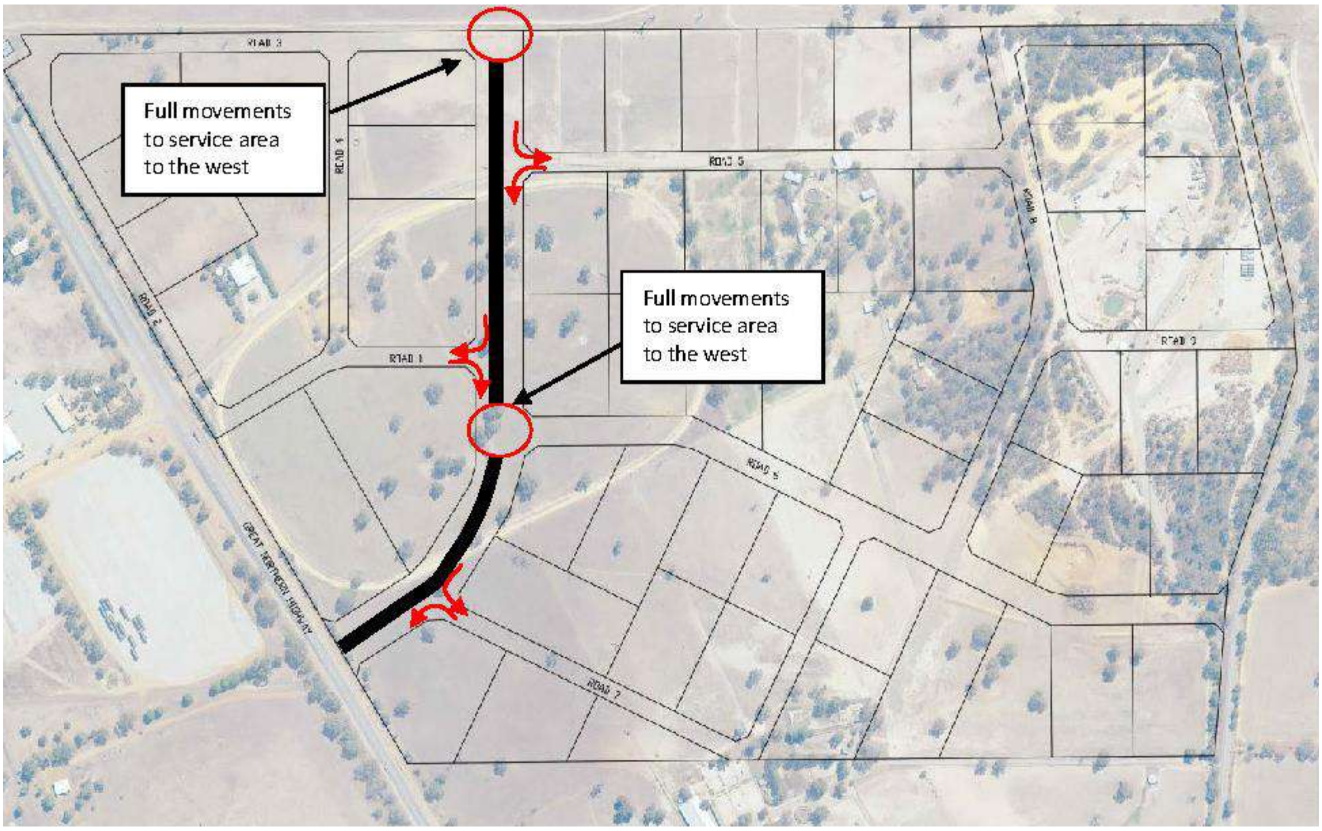


Figure 17. Indicative Intersection Configuration

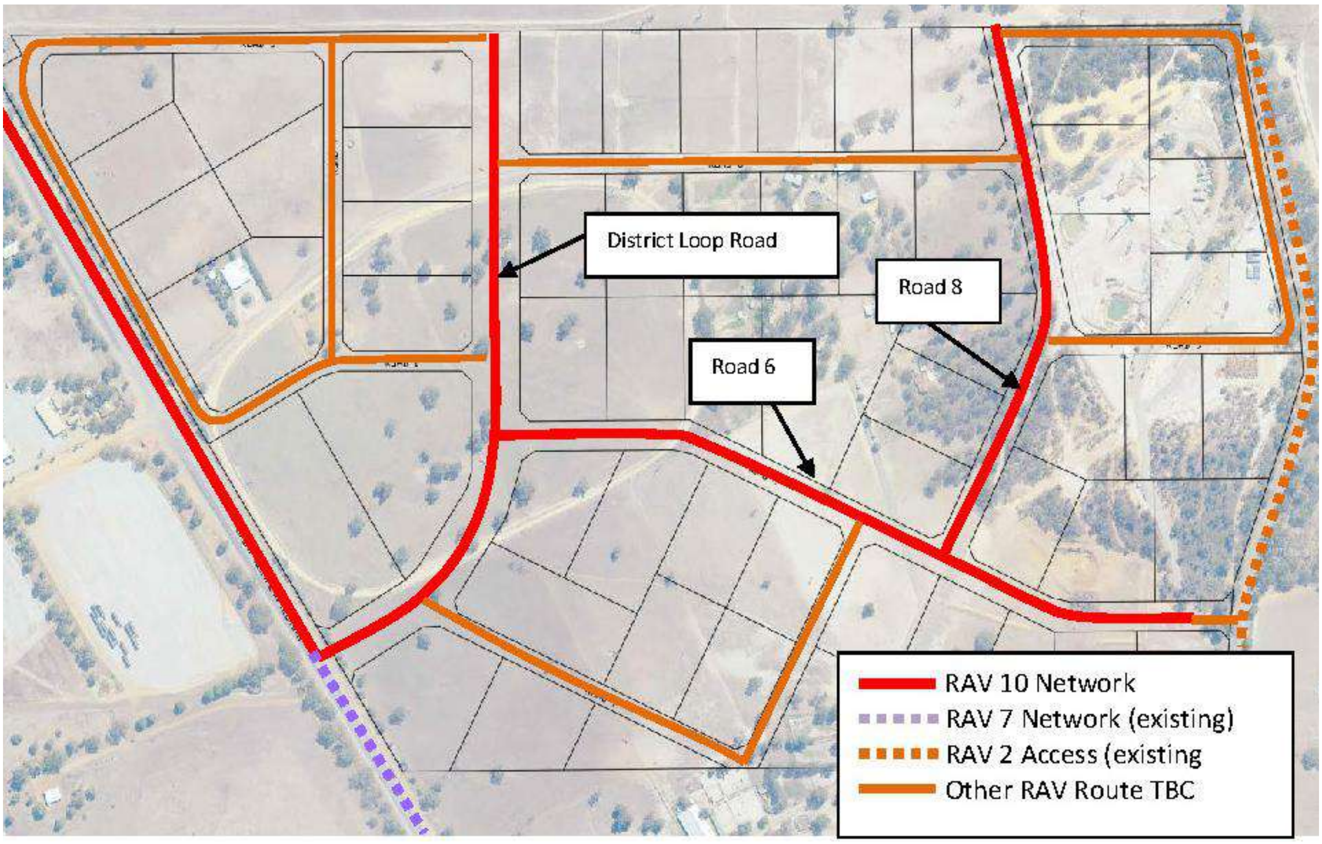


Figure 18. Indicative RAV Network

11. Conclusion

This local scheme amendment request seeks to reclassify Lots 202-203 Wandena Road, and Lots 204-205 Great Northern Highway, Muchea from the existing 'Agricultural Resource' zone to the 'General Industry' and 'Light Industrial' zones under the *Shire of Chittering Local Planning Scheme No. 6* (LPS6) and introduce text provisions to Schedule 11 (Muchea Employment Node Special Control Area Zone) of LPS6 to guide future subdivision and development.

The proposed amendment is consistent with the objectives of the regional and local strategic planning framework for the area, including the Western Australian Planning Commission's *Muchea Industrial Park Structure Plan*, which sets out the framework for the redevelopment of the broader area as an industrial park.

This report and associated technical studies demonstrate that the land is capable of being redeveloped for industrial purposes in line with the planning framework for the area.

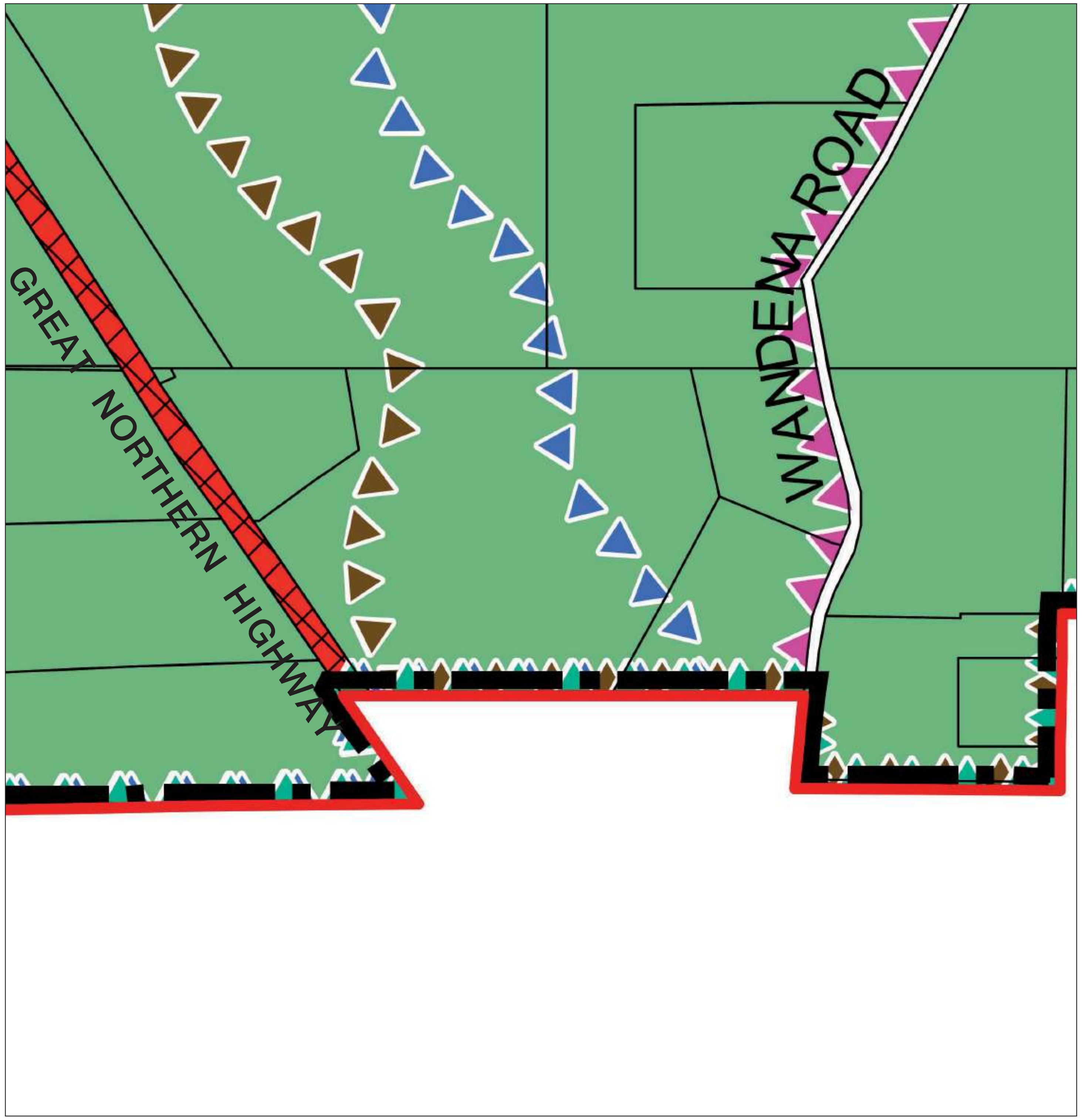
The text provisions proposed to be inserted into LPS6 as part of this amendment will facilitate detailed planning for the subject land to be undertaken through the preparation of a structure plan to guide future subdivision and development.

The amendment as proposed is deemed an appropriate mechanism to facilitate the future redevelopment of the land for industrial purposes consistent with the agreed vision for the area.

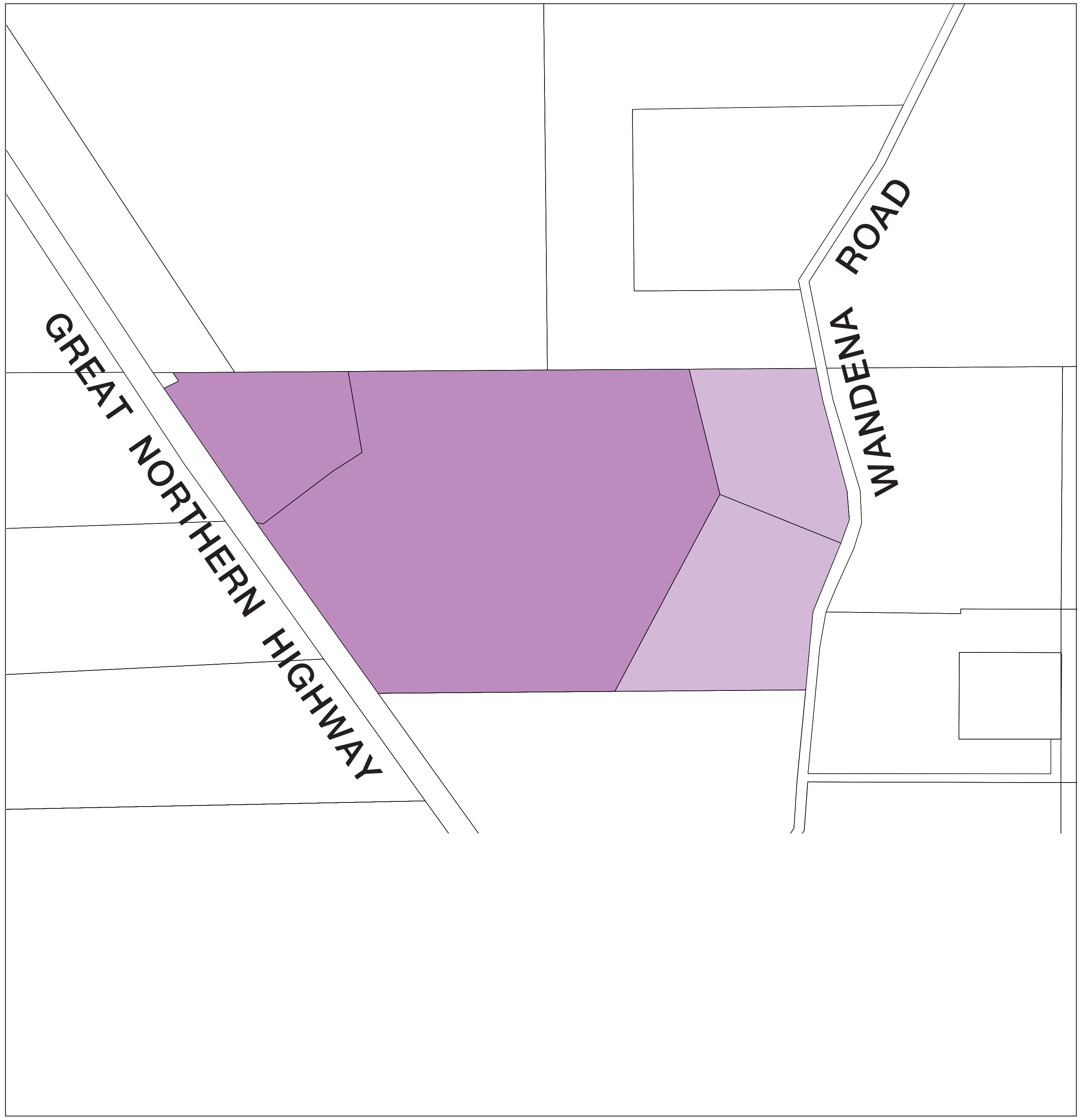
We respectfully request the Shire of Chittering initiate the amendment as proposed.

Appendix A

Proposed Local Planning Scheme Amendment



Existing Zoning



Proposed Zoning

Local Scheme Reserves
- Highway

Zones
- Agricultural Resource
- Light Industrial
- General Industry

Other
- Scheme Area Boundary
- Local Government Boundary
- Muchea Employment Node
- Basic Raw Materials
- Land Refuse
- Military Considerations
- Waste and Waste Water Treatment
- Water Prone

Scheme Amendment

Lots 202 and 203 (109) Wandena Drive and Lots 204 (3362) and 205 Great Northern Highway, Muchea

Date: 20 February 2023 Scale: NTS@ A3 File: 19-545 PL1B Amendment Staff: MR/LC Checked: MR

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | E.hello@elementwa.com.au elementwa.com.au

Appendix B

Certificates of Title

REGISTER NUMBER	
202/DP46016	
DUPLICATE EDITION **1**	DATE DUPLICATE ISSUED **22/9/2015**

WESTERN AUSTRALIA

VOLUME **2627** FOLIO **151**

RECORD OF CERTIFICATE OF TITLE

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.

BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 202 ON DEPOSITED PLAN 46016

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

SWAN INDUSTRIAL DEVELOPMENTS PTY LTD OF 61 SPENCER STREET COCKBURN CENTRAL
(T N110622) REGISTERED 2/9/2015

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

1. B096855 EXCEPT AND RESERVING ALL MINES AND MINERALS AS SET OUT IN THE SAID INSTRUMENT. REGISTERED 6/2/1976.
2. B096855 EASEMENT BURDEN FOR RIGHT TO ENTER PURPOSES. SEE INSTRUMENT B096855. REGISTERED 6/2/1976.
3. N110640 RESTRICTIVE COVENANT BURDEN. REGISTERED 17/9/2015.

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

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

STATEMENTS:

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

SKETCH OF LAND: DP46016
PREVIOUS TITLE: 1425-897
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY: SHIRE OF CHITTERING

REGISTER NUMBER	
203/DP46016	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

WESTERN AUSTRALIA

VOLUME	FOLIO
2627	**152**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

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BGRoberts

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 203 ON DEPOSITED PLAN 46016

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

SWAN INDUSTRIAL DEVELOPMENTS PTY LTD OF 61 SPENCER STREET COCKBURN CENTRAL
(T N110622) REGISTERED 2/9/2015

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

1. *EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3615/1943.
2. *N110640 RESTRICTIVE COVENANT BURDEN. REGISTERED 17/9/2015.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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--END OF CERTIFICATE OF TITLE--

STATEMENTS:

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SKETCH OF LAND:	DP46016
PREVIOUS TITLE:	1404-899
PROPERTY STREET ADDRESS:	109 WANDENA RD, MUCHEA.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

NOTE 1: DUPLICATE CERTIFICATE OF TITLE NOT ISSUED AS REQUESTED BY DEALING N110623

REGISTER NUMBER	
204/DP55930	
DUPLICATE EDITION **1**	DATE DUPLICATE ISSUED **9/8/2016**

WESTERN AUSTRALIA

VOLUME **2908** FOLIO **599**

RECORD OF CERTIFICATE OF TITLE

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.

BGRoberts
REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 204 ON DEPOSITED PLAN 55930

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DAVID WEIGHTMAN SMITH OF 1A HACKETT DRIVE, CRAWLEY

(AF N388037) REGISTERED 9/8/2016

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

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3615/1943. AS TO PORTION ONLY - SEE SKETCH ON DEPOSITED PLAN 55930.
2. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 10183/1948. AS TO PORTION ONLY - SEE SKETCH ON DEPOSITED PLAN 55930.
3. *N388038 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 9/8/2016.
4. *N388039 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 9/8/2016.

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

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

STATEMENTS:

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

SKETCH OF LAND:	DP55930
PREVIOUS TITLE:	1404-900, 2711-182
PROPERTY STREET ADDRESS:	3362 GREAT NORTHERN HWY, MUCHEA.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

REGISTER NUMBER	
205/DP55930	
DUPLICATE EDITION 1	DATE DUPLICATE ISSUED 9/8/2016

WESTERN AUSTRALIA

VOLUME 2908 FOLIO 600

RECORD OF CERTIFICATE OF TITLE

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.

BGRoberts
REGISTRAR OF TITLES

LAND DESCRIPTION:

LOT 205 ON DEPOSITED PLAN 55930

REGISTERED PROPRIETOR:

(FIRST SCHEDULE)

DAVID WEIGHTMAN SMITH OF 1A HACKETT DRIVE, CRAWLEY

(AF N388037) REGISTERED 9/8/2016

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:

(SECOND SCHEDULE)

1. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 3615/1943. AS TO PORTION ONLY - SEE SKETCH ON DEPOSITED PLAN 55930.
2. EXCEPT AND RESERVING METALS, MINERALS, GEMS AND MINERAL OIL SPECIFIED IN TRANSFER 10183/1948. AS TO PORTION ONLY - SEE SKETCH ON DEPOSITED PLAN 55930.
3. *N388038 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 9/8/2016.
4. *N388039 NOTIFICATION SECTION 165 PLANNING & DEVELOPMENT ACT 2005 LODGED 9/8/2016.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
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STATEMENTS:

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

SKETCH OF LAND:	DP55930
PREVIOUS TITLE:	1404-900, 2711-182
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AUTHORITY:	SHIRE OF CHITTERING

Appendix C

Environmental Assessment and Management Strategy

LOTS 202 & 203 WANDENA ROAD
AND
LOTS 204 & 205 GREAT NORTHERN HIGHWAY
CHITTERING

ENVIRONMENTAL ASSESSMENT
AND MANAGEMENT STRATEGY

Prepared for

Focus Demolition Pty Ltd
and
Mr David Weightman Smith

Draft Report No. J19018a
18 May 2021

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

EXECUTIVE SUMMARY

The owners of Lots 202 & 203 Wandena Road and Lots 204 & 205 Great Northern Highway, Chittering (the project area) have applied to the Shire of Chittering for the lots to be rezoned from Agricultural Resource to General Industry. The draft Muchea Industrial Park Structure Plan 2019 (MIPSP) shows Lots 204 and 205 as part of Precinct 2 (General Industry Core) and Lots 202 and 203 as part of Precinct 4 (Light Industry following completion of quarrying).

The total area of the rezoning is approximately 82 hectares. The MIPSP concept for Precincts 2 and 4 is for industries with a minimum lot size of one hectare, with effluent disposed on site using secondary treatment systems such as aerobic treatment units.

EXISTING ENVIRONMENT

Climate, Physiography and Hydrology

The climate, physiography and hydrology of the project area are described in detail in the Local Water Management Strategy (Appendix D).

Vegetation and Flora

Vegetation Types
The project area is largely cleared of native vegetation, consisting mostly of farm paddocks and current and former quarries. All of Lot 204, most of Lot 205 and the southern part of Lot 203 are cleared paddocks with some scattered mature trees, either native or planted. Native vegetation is present in the central east of Lot 205, the northern end of Lot 202 and the north of Lot 203.

The vegetation of the low-lying western part of the site is mapped by Heddle *et al.* (1980) as Coonambidgee Complex. None of this complex remains in the project area.

The more elevated eastern part of the site is mapped by Heddle *et al.* (1980) as Reagan Complex. The vegetation on the site does not agree well with the descriptions of Reagan Complex in Heddle *et al.* (1980), notably in the presence and in some parts dominance of Wandoo and the absence of *E. todtiana* and Banksia tree species.

Beard (1981) mapped most of the project area as Pinjarra 4.30000: Medium woodland, marri and wandoo. The north-east corner (about 2.3ha) was mapped as Gingin 1020.09998: Mosaic of Medium forest, jarrah-marri and Medium woodland, marri-wandoo.

360 Environmental (2015) identified seven native vegetation associations within Lots 202 and 203:

- EaCcEm (4.15ha): Woodland of *Eucalyptus accedens, Eucalyptus wandoo, Corymbia calophylla, Eucalyptus marginata* and *Allocasuarina huegeliana* over *Xanthorrhoea preissii, Bossiaea eriocarpa, Hakea undulata, Acacia pulchella, Pultenaea reticulata, Hakea stenocarpa* and *Tetraria octandra*.

- Mps (0.1ha): Sedgeland of *Mesomelaena pseudostygia, Mesomelaena tetragona, Lepidosperma leptostachyum, Tetraria octandra, Hypocalymma robustum, Daucus glochidiatus* and *Acacia pulchella*.

- CcXp (1.17ha): Woodland of *Corymbia calophylla* over *Mesomelaena pseudostygia, Xanthorrhoea preissii, Bossiaea eriocarpa, Hibbertia hypericoides, Acacia pulchella, Banksia sessilis, Allocasuarina humilis* and *Banksia nivea*.

- EwMps (0.83ha): Low Open Woodland (young regrowth) of Eucalyptus wandoo over Mesomelaena pseudostygia, Mesomelaena tetragona, Tetraria octandra, Bossiaea eriocarpa and Daucus glochidiatus.

- Ea (0.08ha): *Eucalyptus accedens* woodland.

- Ew (2.14ha): *Eucalyptus wandoo* woodland.

- Cc (0.36ha): *Corymbia calophylla* scattered trees over pasture.

Plantecology (2020) identified two native vegetation communities within the site:

- Marri (*Corymbia calophylla*) Open Woodland over shrubland of *Xanthorrhoea preissii, Hibbertia hypericoides* subsp. *septentrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia, Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams on lower ground in the north-east of the site. Other common species include *Allocasuarina humilis, Acacia pulchella* subsp. *pulchella, Desmocladus fasciculatus, Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata*.

- Wandoo (*Eucalyptus wandoo*) Open Low Woodland over shrubland of *Xanthorrhoea preissii, Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra, Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite on upper and middle slopes. Other common species include *Hakea stenocarpa, Gastrolobium acutum, Hakea lissocarpha* and *Desmocladus fasciculatus*.

Vegetation Condition

The native vegetation ranges in condition from Completely Degraded to Excellent. The highest quality vegetation is located in the north of Lot 203, the east of Lot 205 and the north of Lot 202, in patches of 1.3ha or less. Figure 9 shows the vegetation condition.

Flora
360 Environmental (2015) found 39 native flora taxa and seven introduced species in Lots 202 and 203. Plantecology (2020) found a total of 86 native and nine introduced taxa across Lots 202-205, most of which were found in Lots 202 and 203.

Rare and Significant Flora
No Threatened Flora pursuant to the *Biodiversity Conservation Act* 2016 or the *EPBC Act* 1999 were recorded during the vegetation surveys. One species listed as Priority Flora by the DBCA was recorded by Plantecology (2020): *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the Wandoo open woodland in the south eastern part of the site and in the Marri woodland.

Floristic Communities
360 Environmental (2015) tentatively assigned floristic community types (FCTs) to the vegetation associations on Lots 202 and 203 as follows:

- EaCcEm and EwMps — **S8** – *Eucalyptus wandoo* woodlands
- CcXp and Mps — **3c** – *Corymbia calophylla-Xanthorrhoea preissii* woodlands and shrublands / **S18** – *Eucalyptus marginata-Corymbia calophylla* woodlands on laterite

The vegetation of Lots 204 and 205, consisting mostly of isolated paddock trees, is too severely degraded to assign to any FCT except for the patch of Wandoo woodland in the east of Lot 404, which is tentatively assigned to FCT S8.

Threatened and Priority Ecological Communities
Floristic Community 3c is listed as Critically Endangered under the Western Australian *Biodiversity Conservation Act 2016* and as Endangered under the Commonwealth *EPBC Act 1999*.

No other Threatened or Priority Ecological Community was found within the project area.

Local and Regional Representation
The vegetation types present in the project area are moderately to well represented both locally and regionally, but their formal reservation status is generally poor.

Fauna

Fauna Habitats
Most of Lots 204 and 205 is cleared apart from isolated paddock trees, and offers little habitat for native fauna. The exception is an area of about 1ha in the east of Lot 205, which supports wandoo woodland in excellent condition and offers good quality habitat for fauna.

Lots 202 and 203 support areas of native vegetation ranging in condition from Completely Degraded to Excellent, as well as fully cleared areas. The vegetation in Good, Very Good and Excellent condition offers good quality habitat for fauna.

Overall, the project area contains approximately 2.4ha in Excellent condition, 2.3ha in Very Good condition and 0.5ha in Good condition.

Significant Fauna
A search of relevant databases produced an extensive list of Threatened Fauna species, Priority Fauna species and otherwise significant species from the search area. Of these, several may be present in or near the site:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (S1, EN)
- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* (S1, VU)
- Black-striped Snake *Neelaps calonotos* (P3)
- Chuditch *Dasyurus geoffroii* (S3, VU)
- Peregrine Falcon *Falco peregrinus* (S4)
- Fork-tailed Swift *Apus pacificus* (S3, MI)
- Inornate Trapdoor Spider *Euoplos inornatus* (northern Jarrah Forest) (P3)
- Quenda *Isoodon obesulus fusciventer* (P4)

A group of Forest Red-tailed Black Cockatoo was observed in trees on the other side of Wandena Road during the site inspections. The inspections also revealed possible evidence of Carnaby's Black Cockatoo feeding beneath marri trees in the project area.

Black Cockatoo Habitat Assessment

Feeding Habitat
The project area contains nine species recorded by Valentine & Stock (2008) as food resource species for Carnaby's Cockatoo: *Corymbia calophylla, Eucalyptus marginata, Xanthorrhoea preissii, Hakea lissocarpha, Mesomelaena pseudostygia, M. tetragona, Allocasuarina fraseriana, Banksia sessilis* and *Lambertia multiflora*. In most cases (except *C. calophylla*), these species are present at low density over small areas, so the site offers limited food resources for black cockatoos. The large Marri trees in the cleared areas would be expected to provide food for black cockatoos. Limited evidence of Carnaby's Cockatoo feeding (in the form of chewed nuts) was observed in the south of Lot 203 during the site inspection.

Roosting Habitat
The EPBC Act Referral Guidelines for Black Cockatoos (DSEWPC, 2012) define black cockatoo roosting sites as tall trees or groups of tall trees, usually close to an important water source and within an area of quality feeding habitat.

The project area contains no significant water sources and limited feeding habitat. It is therefore unlikely that black cockatoos will roost in the area.

Breeding Habitat

The DSEWPC (2012) defines black cockatoo breeding habitat as follows:

- Current breeding habitat - Trees of suitable species (including Marri, Jarrah and Wandoo) with suitably-sized hollows (generally minimum 140mm opening, 200mm internal width, 450mm depth).

- Potential breeding habitat - Trees of suitable species of size at least 500mm diameter at breast height (dbh) (or 300mm for Wandoo).

360 Environmental (2015) and BES (2020) in combination found a total of 190 trees met the DEWA size criteria for potential nesting habitat, including 56 that contained hollows or potential hollows.

BES inspected all potential hollows in October 2020 with a pole-mounted camera (Cocky Cam) supplied by Birdlife Australia. The inspection found nine hollows in use by Corellas, two by Australian Kestrels and one by Kookaburras. No evidence of current or previous black cockatoo nesting was found. A large number of hollows (approximately 15 of 56 examined) contained feral bee hives.

Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965. Quarrying has been underway on Lots 202 and 203 since before 1977.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area.

The former clay quarry on Lots 202 and 203 is currently being backfilled with inert waste such as building rubble prior to rehabilitation. The backfilling and rehabilitation are being undertaken under the terms of a DWER Licence (L9181/2018/1), which carries conditions including control of waste acceptance and prevention of pollution.

Aboriginal and European Heritage

The Department of Planning Lands & Heritage's online database shows one registered site, (ID 3525 Ellen Brook: Upper Swan) covering the whole project area.

The DPLH has advised that the actual boundaries of the registered site do not affect the project area, and that therefore no approval under the Aboriginal Heritage Act 1972 is required for development of the project area.

Landscape

The project area is visible from Great Northern Highway and Wandena Road. The view from Great Northern Highway is partly screened but not blocked by trees planted within the property. From Wandena Road the southern end of the project area is visible through a screen of roadside trees, but for the most part is obstructed by dense vegetation and the banks of a cutting through which the road passes.

The landscape in the west consists mostly of cleared horse paddocks with scattered trees and isolated buildings set well back from the highway.

ENVIRONMENTAL IMPACTS AND MANAGEMENT

Surface Water Protection

The project area drains to Ellen Brook via culverts beneath Great Northern Highway and small drainage lines within and adjacent to the site. The contaminant of major concern in Ellen Brook and the Swan-Canning River system is phosphorus.

Industrial development has the potential to affect the volume, rate and quality of water flows in the drainage lines and Ellen Brook. Water outputs from the project area will be limited to stormwater, groundwater and minor process water (such as washdown water).

Management strategies to be implemented include:

- Industries permitted in Precinct 2 will be those that dispose of domestic-quality wastewater at a rate less than 5,400 litres per hectare per day (R10 equivalent).

- Wastewater from toilets and bathrooms will be treated by nutrient-removing systems (e.g. ATU or modified leach drains).

- The single existing drainage line crossing the project area will be retained within a roadside bioretention swale (see LWMS).

- All road runoff will be captured and infiltrated (up to 1-year ARI 1-hour storm) or detained (up to critical 100-yr storm) in bioretention swales in accordance with DWER guidelines.

- Any process wastewater generated by industries will be treated on-site to a standard suitable for discharge to the ground or disposed offsite.

- All lot drainage from storms up to 1-year ARI 1-hour will be retained and infiltrated within individual lots. Runoff from critical storms up to 100-year ARI will be detained within lots and released at a rate no greater than the pre-development rate.

- Temporary drainage controls will be implemented during the construction period.

Groundwater Protection

Groundwater is an important contributor to water flow and quality in Ellen Brook. Given the silty clay soils of the project area, groundwater throughflow and discharge is relatively low.

Groundwater protection measures will include:

- Industries in Precinct 2 (Lots 204 and 205) will be restricted to those with low water use and waste water generation of less than 5,400 litres/ha/day.

- Subsoil drains, if required, will be set at or above the pre-existing Average Annual Maximum Groundwater Level.

- Subsoil and stormwater drains will discharge to vegetated swales with PRI of at least 15.

Noise

Active management of noise within and from the Structure Plan area will not generally be required. Industries with high noise emissions may be required to undertake technical analyses to determine separation requirements. These industries may be restricted to certain parts of the Structure Plan area where suitable separations are available.

Dust

Individual lot holders within the project area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable process dust will be required to hold a DWER licence, which will specify dust limits and monitoring requirements.

Construction Impacts

Construction of the project is expected to be carried out at various times, in accordance with the land owners' preferences. Construction of roads, drainage and other services will be undertaken by the owner(s) of each stage of subdivision.

Management of construction impacts will be the subject of conditions attached to subdivision approvals, works approvals and development approvals.

In general, control of construction impacts will be the responsibility of the construction contractor. The developer of each stage of subdivision will implement a Construction Management Plan for the development dealing with dust management, erosion and sediment control, containment of environmentally hazardous materials (chiefly fuel and oils) and spill response.

Vegetation and Flora

The native vegetation over most of the project area consists of mature paddock trees, rows and groups of planted trees. In the eastern part of the site, the vegetation consists of Marri and Wandoo open woodland in Completely Degraded to Excellent condition.

Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER.

Landscaping within private lots and public areas (e.g. road reserves and drainage swales/basins) will be carried out using local native species.

Fauna

Development of the site as proposed will require the clearing of about 5.2ha of Marri and Wandoo woodland in Completely Degraded to Excellent condition.

Prior to clearing, a fauna capture and relocation exercise will be undertaken by a qualified specialist consultant to relocate any sedentary animals (e.g. snakes and lizards) from the application area. During and after clearing, monitoring of debris will be carried out to locate and salvage any fauna caught within the clearing operation.

Fauna habitat will be created in the revegetation of drainage swales and basins. Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

Landscape

Development in accordance with the Structure Plan will change the landscape of the project area from predominantly rural to industrial, in keeping with the industrial landscape of the overall Muchea Industrial Park.

The objective of landscaping will be not to hide the industry from view but to provide vegetation features that “soften” and break up the industrial landscape. This will include plantings within lots along the interface of Great Northern Highway, drainage swales and basins, verge trees within the developed areas and landscape buffers within lots.

In accordance with the Shire of Chittering’s *Muchea Industrial Park Design Guidelines* (2018), landscaping within lots will include:

- a minimum 2m wide landscape buffer on the primary road frontage;

- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays; and
- one tree per 10m of road frontage.

The landscape plantings within lots will be of a mix of native trees, shrubs and ground covers. The 1-year ARI 1-hour bioretention swales within each lot will be densely planted with native sedges and low shrubs. This will form part of the 10% landscaping requirement for each lot.

Roadside bioretention swales will be densely planted with native sedges and low shrubs to stabilise the beds and banks of the swales, slow water flows and promote the uptake of sediments and nutrients from the water.

Plantings within the swales will be kept to a height that meets the definition of Shrubland in the Bushfire Hazard Assessment (Eco Logical Australia, 2020) so as not to create an unacceptable fire hazard.

MONITORING

Groundwater levels and quality will be monitored and compared against baseline levels and relevant guidelines. Surface water quality in drainage lines within, upstream and downstream of the project area will be monitored to determine what (if any) impacts the development may be having on surface water quality.

The developer of each stage of subdivision will be responsible for monitoring water quality in bores and drainage swales within that stage.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Subdivision and development in the project area will be undertaken in accordance with the Structure Plan, this EAMS and the attached LWMS.

Development may occur in accordance with a subdivision approval or, in the absence of subdivision, a Development Approval. Subdivision approvals will include a requirement for an Urban Water Management Plan (UWMP). If development occurs without a subdivision, a Local Water Management Plan (LWMP) may be required to set out drainage design for the development.

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1.0 INTRODUCTION

1.1 Background

The owners of Lots 202 & 203 Wandena Road and Lots 204 & 205 Great Northern Highway, Chittering (the site) have applied to the Shire of Chittering for the lots to be rezoned from Agricultural Resource to General Industry. The draft Muchea Industrial Park Structure Plan 2019 (MIPSP) shows Lots 204 and 205 as part of Precinct 2 (General Industry Core) and Lots 202 and 203 as part of Precinct 4 (Light Industry following completion of quarrying). Figure 1 shows the location of the site within the draft Muchea Industrial Park Structure Plan area.

The total area of the rezoning is approximately 82 hectares. Figure 2 shows the boundaries of the site. Figure 3 shows a preliminary conceptual plan of subdivision.

The MIPSP concept for Precincts 2 and 4 is for industries with a minimum lot size of one hectare, with effluent disposed on site using secondary treatment systems such as aerobic treatment units.

1.2 Scope of the EAMS

The scope of this Environmental Assessment & Management Strategy (EAMS) is to:

- document the existing environment of the site;
- briefly describe the proposed development;
- examine the potential impacts of development;
- propose management strategies to avoid or mitigate impacts; and
- outline a proposed monitoring program.

This EAMS is accompanied by a Local Water Management Strategy (LWMS), which deals specifically with water-related matters including water supply, drainage, groundwater management and wastewater disposal.

1.3 Relevant Guidelines and Policies

1.3.1 Better Urban Water Management

Better Urban Water Management (WAPC, 2008) sets out the following objectives for water sensitive urban design:

Water Conservation

- Consumption of 100kL/pp/yr including less than 40-60 kL/p/yr scheme water.

Water Quantity

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.

- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

Water Quality

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of Total Suspended Solids;
  - at least 60% reduction of Total Phosphorus;
  - at least 45% reduction of Total Nitrogen; and
  - at least 70% reduction of gross pollutants.

Mosquitoes and Midges

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

1.3.2 Shire of Chittering Local Planning Scheme No. 6

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and
iii. a suitable and unencumbered land project area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m^2 of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant;

(f) where a caretaker's dwelling is a discretionary use –

i. only one dwelling be permitted on each lot;
ii. the dwelling is to have a maximum floor area of 100m^2;
iii. the dwelling is to be incidental to the industrial land use;
iv. subdivision of the dwelling from the parent lot will not be permitted;
v. the use of notifications on title may be considered to advise prospective purchasers of potential impacts from noise, dust, odour or amenity that may arise from the location of a residential land use within the zone;
vi. the local government will not consider projects for caretakers' dwellings prior to the primary site activity being either approved or constructed;
vii. where simultaneous approval has been granted by local government for both a caretaker's dwelling and the main activity on the same lot, the main activity must be developed and operational prior to occupation of the dwelling; and
viii. caretaker's dwellings are to be carefully sited and constructed so the potential site (or estate) impacts from noise, dust, odour or amenity are minimised;

(g) in considering rezoning proposals for industrial zones, the local government may require the preparation of a structure plan, and any information relevant to the site conditions, in keeping with the matters listed in clause 67 of the deemed provisions and clause 5.7 of the scheme; and

(h) any other requirement as included in a Local Planning Policy adopted by the local government."

The Scheme shows Lot 204, most of Lot 205 and part of Lot 203 as part of a Water Prone Area (Ellen Brook Palusplain), within which the following special provisions apply:

"5.3.3 Planning Requirements

The local government will impose conditions on any Development approval relating to -

a) the construction and occupation of any dwelling or outbuilding;

b) the type of effluent disposal system used in this area shall be high performance with bacterial and nutrient stripping capabilities to the specifications of local government and the Health Department and shall be located in a position determined by local government.;

c) minimum floor levels for any building above the highest known water levels;

d) any land use that may contribute to the degradation of the surface or sub-surface water quality.

e) no development other than for conservation purposes will be permitted within 30 metres of any natural water body; AMD 21 GG 3/4/09

f) damming, draining or other developments which may alter the natural flow of surface water will not be permitted unless such works are part of an approved Catchment Management Plan."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Industrial Park:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water.

2.2.2 Environmental Assessment and Management Strategy

The developer shall submit to the Local Authority an Environmental Assessment and Management Strategy for approval as an additional detail of a Local Structure Plan pursuant to Part 4 of the deemed provisions in order to ensure the local structure plan provides a comprehensive and coordinated response to all environmental features within the Structure Plan area and in accordance with the Muchea Industrial Park Structure Plan.

The Environmental Assessment and Management Strategy is to include the following:

- Identification of significant environmental features within the local structure plan area including flora, vegetation, fauna, wetlands and waterways.
- Identification of appropriate management strategies, consistent with industry best practice, to ensure that the local structure plan responds appropriately to these environmental features. Appropriate management strategies might include identification of buffers / setbacks, potential areas of revegetation / rehabilitation, public open space and fauna relocation.
- Consideration of Acid Sulphate Soils (if present) and identification of the likely requirement for ASS management during future planning stages.
- Identification of, and the means for retention and protection of, key cockatoo habitat trees / locations.
- Identification of measures to retain the rural character of views of the Structure Plan area from roads within, adjoining, or in the vicinity of the Structure Plan area, by providing details of vegetation screen planting, as well as the details for the siting and design of structure and major earthworks within the Structure Plan area.

The Local Authority must consult with the relevant environmental agencies regarding the proposed strategy in advertising the Local Structure Plan pursuant to clause 5.19.

The Environmental Assessment and Management Strategy shall be consistent with the EPA's current Guidance Statement No. 33 Environmental Guidance for Planning and Development, or any successor Guidance Statement.

The Environmental Assessment and Management Strategy required by 2.2.2 shall be implemented to the satisfaction of the Local Authority on the advice of the applicable environmental agencies."

This Environmental Assessment and Management Strategy (EAMS) has been prepared to satisfy the requirements of Clause 2.2.2 of Schedule 11.

1.3.3 Government Sewerage Policy

The Government Sewerage Policy (2019) requires that all new subdivision and development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits. In these cases, on-site effluent disposal may be approved where the responsible authority is satisfied that:

- each lot is capable of accommodating on-site sewage disposal without endangering public health or the environment; and
- the minimum site requirements for on-site sewage disposal as set out in the Policy can be met.

The Policy designates certain areas as Sewage Sensitive Areas (SSAs), including land:

- within the coastal catchment of the Swan Estuary; and
- within 1km upgradient or 250m downgradient (or overall 1km where the groundwater gradient is unknown) of a significant wetland.

Additional restrictions and requirements apply to on-site effluent disposal in SSAs, including:

- a minimum lot size of one hectare (unless exempted on a case-by-case basis);
- minimum vertical separation of 1.5m from the discharge point of effluent disposal systems to the highest groundwater table level; and
- secondary effluent treatment systems with nutrient removal.

The Policy shows all of Lots 203 and 204, most of Lot 205 and the southern part of Lot 202 within an SSA associated with the Ellen Brook catchment. Lot 203, the southern part of Lot 205 and the northern half of Lot 202 are also shown within SSAs associated with significant wetlands. Figure 3 shows the mapped SSAs.

In the case of Lot 202 and the north-east of Lot 205, the SSA mapping is considered to be erroneous. The wetland in question (a Conservation category dampland) is located upgradient of the site, is maintained by surface flow and/or locally perched groundwater (the mapped permanent groundwater table is 45-50m below the ground surface) and is separated from the site by several watercourses, drains and deep excavations, so that there is no possibility of groundwater flow from the site to the wetland. This matter is examined further in the LWMS (Appendix D).

2.0 EXISTING ENVIRONMENT

2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 6.5km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce RAAF.

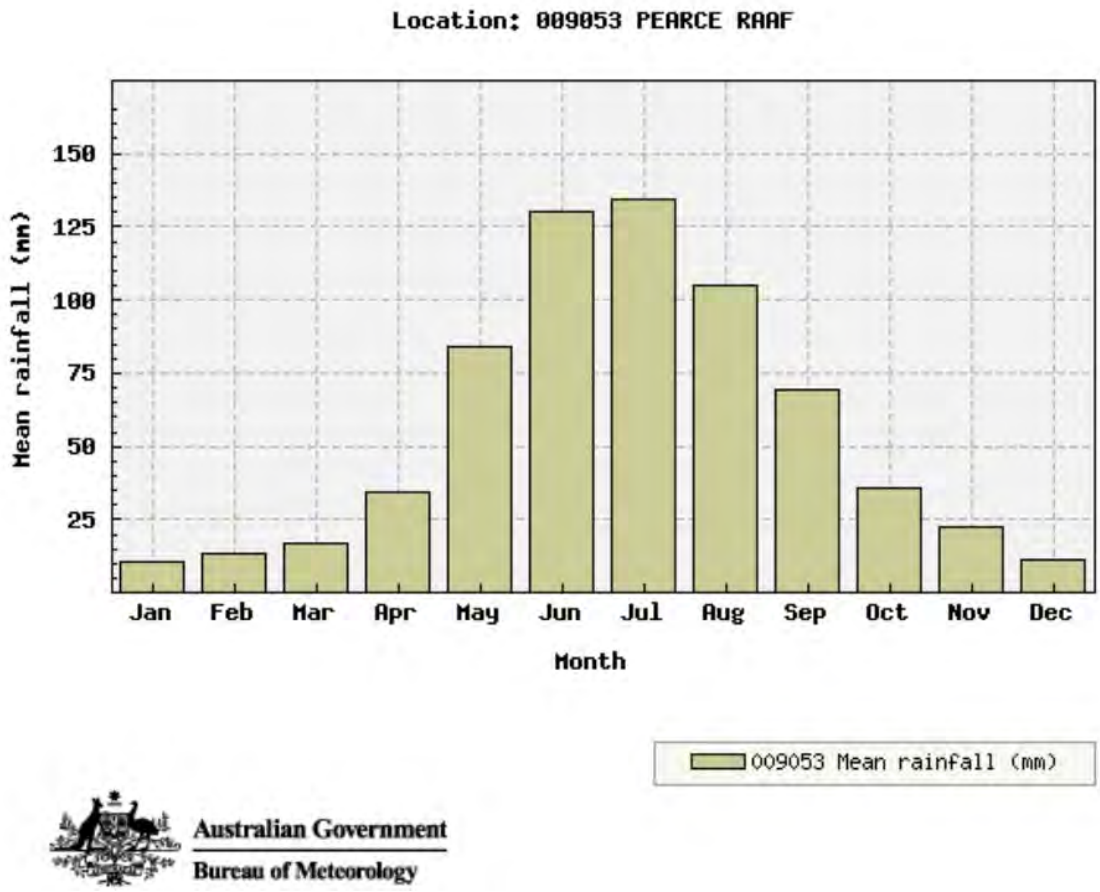

Figure 4 Pearce RAAF Mean Rainfall

2.2 Physiography

2.2.1 <u>Topography</u>

The site extends from a very gently sloping plain in the west to low hills in the east. The elevation ranges from 58m AHD in the south-west to 101m AHD on the eastern boundary.

The north-eastern quarter of the site, comprising Lot 202 and the northern half of Lot 203, is significantly higher and steeper than the rest of the site.

The slope is generally to the south-west, with gradients ranging from less than 1% in the north-west to over 40% in places on the eastern boundary. Excavation in the quarry on Lots 202 and 203 has produced some steeper gradients, but these are expected to be reduced in the filling and rehabilitation of the quarry. Figure 5 shows the topography of the site.

2.2.2 Geology, Landforms and Soils

The site is located on the eastern edge of the Pinjarra Plain and the western colluvial outwash zone of the Dandaragan Scarp. The soils in the west are pebbly silts belonging to the Guildford Formation, which originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams. In the eastern part the soils are colluvium, colluvial sands and Leederville Formation siltstone eroded from the scarp.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as "Mgs_1: Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin".

The colluvial soils are described as:

- "Msg: Strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix, containing quartzite, quartz, granite, laterite of colluvial origin";
- "S_5: Very pale brown, medium to coarse-grained, well sorted, little fines, sub-angular to rounded quartz and feldspar, of colluvial origin"; and
- "S_6: Light grey, fine to coarse, angular to sub-rounded, quartz with some feldspar, moderately sorted, loose, of colluvial origin".

The Leederville Formation siltstone in the north-east is described as "ST_1: White, thinly bedded, well laminated, fine-grained, some large ferruginous concretions and laminae, occasionally micaceous".

Drilling by BES at four sites on Lots 204 and 205 in March 2020 showed a pebbly silty sand to pebbly silty clay profile in the top 5.5m, which corresponds to the GSWA description for the Guildford Formation. Previous drilling by Bowman & Associates Pty Ltd (2016) at four sites on Lots 202 and 203 found a silty clay profile with ironstone commonly occurring at between 5m and 18m, which corresponds generally with the GSWA descriptions for Leederville Formation and colluvium.

Figure 5 shows the site geology. Soil logs from the drilling are attached in the Local Water Management Strategy (Appendix D).

2.2.3 Soil Permeability

The permeability of the site soils will vary depending on the clay content. Test pumping during sampling of one on-site bore (WB3) indicated a hydraulic conductivity in the depth range of 2.6m to 5.1m in the order of 0.14 m/day. The permeability of the top 2m of the soil profile is expected to be higher.

Douglas Partners (2020) undertook constant-head permeability testing at six sites and at depths of 0.2 – 0.8 metres. The tests returned permeabilities ranging from 0.9 – 8.6 m/day, with a mean of 3.3m/day and a median of 4.75m/day. The geotechnical report is attached in the LWMS (Appendix D).

For preliminary drainage and effluent design purposes, a conservative permeability of 1 m/day has been assumed. Further constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* will be undertaken prior to subdivision.

2.2.4 Acid Sulphate Soils

The DBCA maps the site as Low to Nil risk of Acid Sulphate Soils (ASS). The nearest mapped High ASS risk area is a palusplain about 600m to the south.

Bore sampling between July 2016 and September 2020 has found no significant indications of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary.

2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty clay soils of the Guildford Formation and other alluvial and colluvial soils generally have moderate to very high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

PRI Range	*Rating*	*Typical soils*
0 – 0.5	Very Low	Bassendean Sand
2 – 4	Low – Moderate	Karrakatta Sands
5 – 12	Moderate – High	Cottesloe Sands
12 – 20	High	Crushed Limestone, Limesand
20 – 1000+	Very High	Clay

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins and swales. The site soils are expected to meet or exceed this requirement. PRI testing of soils beneath proposed infiltration basins will be undertaken before subdivision.

2.3 Hydrology

2.3.1 Groundwater

Groundwater occurs at shallow depth across the lower-lying western parts of the site (Lots 204 and 205) in winter. The depth to groundwater in most years varies from over 18 metres in the east of the site to less than two metres in winter in the west The DWER maps minimum groundwater levels at 48-53m AHD (13-48m below ground), flowing south-west towards Ellen Brook.

In wet winters, rainfall infiltration may be impeded by the low-permeability subsoils, creating temporary surface saturation in the lower and flatter parts of the site. There is no evidence in the water measurements or soil profiles of the occurrence of a seasonally perched water table.

Groundwater measurements in 14 bores in and around the site in August 2020 (Figure 6), during a drier than average winter, gave the water depths and levels shown in Table 2.1.

Simultaneous measurements of DWER bores located 680m south (Swan GWA 2-98) and 800m north (Gnangara Monitoring GD20) enabled average annual maximum groundwater levels (AAMGL) at the site to be calculated. Figure 6 shows the calculated AAMGL and depth to AAMGL contours across the site.

Table 2.1 shows that the groundwater levels measured on 21 August 2020 were about 0.4m below the AAMGL. The winter of 2020 was drier than average, and the levels measured on 21 August are considered to approximate the peak for the year.

Table 2.1 shows that the AAMGL is within one metre of the ground surface in parts of the north-west and south-west of the site. However, the pattern of groundwater levels is not uniform: Bore WB1 on the western boundary has an indicated depth to the AAMGL of over 4.5m.

Table 2.1 also suggests that the MGL may intersect the ground surface in the north-west and south-west of the site.

Table 2.1 Groundwater Depths and Levels 21 August 2020

Bore	*Depth (mbgl)*	*Level (m AHD)*	*AAMGL (m AHD)*	*MGL (m AHD)*	*Depth to AAMGL (m)*	*Depth to MGL (m)*
MW1	>17.44	<74.76	<75.19	<75.77	>17.01	>16.43
MW2	16.14	78.26	78.69	79.27	15.63	15.05
MW3	12.55	70.67	71.10	71.68	12.12	11.54
MW4	14.45	64.33	64.76	65.34	14.02	13.44
WB1	>4.68	<56.55	<56.98	<57.56	>4.25	>3.67
WB2	>4.98	65.89	<66.32	<66.90	>4.55	>3.97
WB3	1.58	67.51	67.94	68.52	1.15	0.57
WB4	2.34	59.53	59.96	60.54	1.91	1.33
TB7	1.14	57.26	57.69	58.27	0.71	0.13
TB8	1.11	64.14	64.57	65.15	0.68	0.10
TB9	0.56	74.24	74.67	75.25	0.13	-0.45
MB5	0.77	56.02	56.45	57.03	0.34	-0.24
MB7	0.65	54.86	55.29	55.87	0.22	-0.36
GD20	0.88	60.6	59.85	61.35	1.63	0.13
2-98	2.12	56.17	56.6	57.18	1.69	1.11

2.3.2 Surface Drainage

There are no natural defined drainage channels within the site, although several artificial drains have been cut in and around the quarry on Lots 202 and 203. The relatively low permeability of the soils would result in sheet flow across the ground surface during high rainfall events.

Water enters the project area from one 36ha external catchment to the east via a culvert beneath Wandena Road. This water flows via a constructed drain into a sump within Lot 202, which overflows to a farm dam on the adjoining lot and then into a drain that flows west to Great Northern Highway and ultimately into Ellen Brook. The land to the east is expected to remain as farmland for the foreseeable future, so this water inflow is not expected to change significantly in rate, volume or quality.

All drainage from the site flows eventually into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715km^2 (WRC, 2012). The Brook rises as Chandala Brook about 22km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

2.3.3 Water Resources

The project area is within the Eclipse Hill sub-area of the Gingin Groundwater Area for the surficial and superficial aquifers, the Southern Scarp sub-area for the semi-confined (Mirrabooka) aquifer, the Cowalla sub-area for the confined Leederville-Parmelia aquifer and the Chandala sub-area for the Yarragadee aquifer. Groundwater allocations within the Gingin Groundwater Area are managed under the Gingin Groundwater Areas Allocation Plan (DoW, 2015).

Under the plan (as of 2015), the Eclipse Hill (superficial), Southern Scarp (Mirrabooka) and Cowalla (Leederville) sub-areas are over-allocated and no new allocations are available.

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows one groundwater licence for Lot 205 (GWL 152031, expiring November 2023), which is licensed to abstract up to 1,500 KL/yr from the Leederville aquifer via a bore on the adjacent Lot 206.

Water supply will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand in Precinct 2 (Lots 204 and 205) is likely to be limited to landscape irrigation, as industries within this precinct will be limited to those with low water usage.

The water requirement for the fully developed project area is unknown. Calculations by Cossill & Webley (2018) based on a study carried out by GHD for the Karratha Gap Industrial Estate suggested that approximately 4 KL/ha/day will be required for both potable and non-potable uses. Over the 82ha of the site (assuming 80% developable land), this equates to a total water demand of approximately 96ML/yr.

Potable water will be supplied to the developed site by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Lots 202-205 with potable water. Discussions with Aqua Ferre are ongoing.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the site is likely to be necessary. The landowners will negotiate with existing licence holders within and outside of the project area with a view to purchasing an existing groundwater allocation., and will submit a groundwater licence application to the DWER in due course.

2.4 Water Quality

2.4.1 Groundwater

Groundwater samples have been collected from 13 bores within and around the site on various occasions since 2016. The sampling and analysis results are summarised in Tables 2.2 , 2.3 and 2.4.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally low to moderate

The groundwater shows mostly low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are mostly low except for aluminium and zinc, which are slightly elevated across much of the site.

2.4.2 Surface Water

There was no flowing surface water anywhere on the subject land during any of the site inspections, so no surface water quality data are available.

Table 2.2 Groundwater Quality – Physico-Chemical Parameters

Bore (Figure 6)	*Date*	*pH*	*EC (ms/m)*	*Salinity (ppm)*	*Hardness (mg/l $CaCO_3$)*	*Acidity (mg/L $CaCO_3$)*	*Alkalinity (mg/L $CaCO_3$)*	*Acidity/Alkalinity Ratio*	*Cl (mg/L)*	*SO_4 (mg/L)*	*Cl/SO_4 Ratio*
MW1	12/7/16	**3.9**	4.72			96	< 20	>4.8	1700	58	29.3
	2/9/16	**4.6**	2.8						430	190	2.3
	28/9/16	**4.5**	2.8						430	200	2.2
	22/11/16	**4.3**	2.8						500	600	0.8
	12/1/18	**4.3**	2.7						720	210	3.4
	30/5/19	**4.40**	2.30						420	570	0.7
MW2	12/7/16	**4.6**	2.8			59	< 20	>2.95	430	190	2.3
	2/9/16	**3.9**	5.8						1700	57	29.8
	28/9/16	**3.8**	5.7						1400	57	24.6
	22/11/16	**4.3**	5.5						1600	170	9.4
	12/1/18	**3.9**	5.5						1900	59	32.2
	30/5/19	**3.9**	4.70						1700	190	8.9
MW3	12/7/16	**5.8**	7.6			57	25	2.28	2100	130	16.2
	2/9/16	**5.5**	14						5200	180	28.9
	28/9/16	**4.6**	17						5000	180	27.8
	22/11/16	**4**	2.1						4800	480	10.0
	12/1/18	**3.9**	12						4300	140	30.7
	30/5/19	**4**	9.6						3400	370	9.2
MW4	12/7/16	**4.7**	8.73			67	< 20	3.35	4100	120	34.2
	2/9/16	**5.9**	6.4						1700	130	13.1
	28/9/16	**5.4**	6.5						1800	120	15.0
	22/11/16	**5.5**	7.1						2100	390	5.4
	12/1/18	**5.6**	7.2						2400	130	18.5
	30/5/19	**5.2**	6.70						2200	440	5.0
TB7	17/8/17	6.6	0.49	294	59	19	50	0.38	100	17	5.9

TB8	17/8/17	7	0.55	330	63	7	38	0.18	110	40	2.8
TB9	17/8/17	7.4	0.63	378	48	7	67	0.10	130	23	5.7
MB5	22/8/18	6.6	0.25	150	52	15	27	0.29	44	12	3.7
MB7	22/8/18	**6.3**	3.5	2100	170	77	65	0.45	1100	130	8.5
WB3	2/10/20	6.1	0.23	138	32	20	18	1.11	40	9	4.44
WB4	2/10/20	6.1	7.9	4740	620	24	19	0.95	1800	540	3.33
Aquatic Ecosystems[a]		6.5-8.0	0.12-0.3	72-180	ng	40[c]	ng	1[c]	ng	ng	
Irrigation[b]		6-8.5	1.3	780	60-350	ng	ng		350	ng	
Notes	ng denotes "no guideline". a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years) c. DEC(20__) Oxidation indicator triggers for ASS-affected groundwater.										

Table 2.3 Groundwater Quality – Nutrients

Bore (Figure 6)	*Date*	*TN*	*TKN*	*NH_3*	*NOx*	*TP*	*FRP*
MW1	12/7/16	0.6	0.3	<0.01	**0.27**	**0.15**	
	2/9/16	**5.0**	0.7	0.02	**4.3**	**0.2**	
	28/9/16	**4.88**	0.6	<0.01	**4.3**	<0.25	
	22/11/16	**4.9**	0.9	0.01	**4**	**0.29**	
	12/1/18	**4.7**	0.2	0.02	**4.5**	-	
	30/5/19	**4.7**	0.3	<0.01	**4.4**	-	
MW2	12/7/16	**3.7**	<0.2	<0.01	**3.7**	**0.35**	
	2/9/16	0.5	0.3	<0.01	**0.24**	**0.1**	
	28/9/16	0.35	<0.2	<0.01	**0.35**	**0.27**	
	22/11/16	0.6	0.3	0.03	**0.33**	**0.2**	
	12/1/18	0.9	<0.2	0.04	**0.29**	-	
	30/5/19	0.28	<0.2	<0.01	**0.28**	-	
MW3	12/7/16	**1.5**	0.9	0.12	**0.56**	<0.05	
	2/9/16	0.8	0.6	0.24	**0.19**	**0.13**	
	28/9/16	**1.8**	1.6	0.35	**0.2**	**0.33**	
	22/11/16	0.5	0.4	0.13	0.09	0.05	
	12/1/18	<0.2	<0.2	0.08	<0.05	-	
	30/5/19	<0.2	<0.2	0.04	<0.05	-	
MW4	12/7/16	**1.7**	1.1	0.03	**0.63**	**0.32**	
	2/9/16	**2.2**	0.4	0.05	**1.8**	<0.05	
	28/9/16	**2.3**	0.4	0.02	**1.9**	**0.31**	
	22/11/16	1.1	0.4	0.08	**0.71**	**1.8**	
	12/1/18	0.5	<0.2	0.18	**0.45**	-	
	30/5/19	0.43	0.4	0.13	0.06	-	
TB7	17/8/17	0.6	0.4		**0.18**	0.04	<0.01

TB8	17/8/17	1.2	1		**0.25**	**0.3**	<0.01
TB9	17/8/17	**6.2**	2.4		**3.8**	**3.5**	<0.01
MB5	22/8/18	**2**	<0.2		**2**	**0.2**	<0.01
MB7	22/8/18	1.2	1		**0.21**	**0.2**	0.02
WB3	2/10/20	1.2	0.0		1	0.03	<0.01
WB4	2/10/20	1.4	0.3		0.12	0.03	<0.01
Aquatic Ecosystems[a]		1.2	ng		0.15	0.065	0.04
Irrigation[b]		5	ng		ng	0.05	ng
Notes	ng denotes "no guideline". a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years).						

Table 2.4 Groundwater Quality – Metals

Bore (Figure 6)	*Date*	*Al*	*As*	*Ca*	*Cd*	*Cr*	*Cu*	*Fe*	*K*	*Hg*	*Mg*	*Mn*	*Na*	*Ni*	*Pb*	*Zn*
MW1	12/7/16	**18**	0.014	8	<0.0002	**0.085**		48		<0.0001		0.038		-	**0.017**	**0.037**
	2/9/16	**0.29**	<0.001	3.4	<0.0002	<0.001		<0.05		<0.0001		0.006		0.003	<0.001	**0.032**
	28/9/16	**0.2**	<0.001	<5	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.002	<0.001	**0.019**
	21/11/16	**0.52**	<0.001	2.4	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.002	<0.001	**0.017**
	12/1/18	**6.5**	0.009	<5	<0.0002	**0.047**		20		<0.0001		0.01		0.005	0.005	**0.026**
	30/5/19	**0.21**	<0.001	2	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.002	<0.001	0.012
MW2	12/7/16	**93**	0.072	4	<0.0002	**0.43**		360		<0.0001		0.087		-	**0.05**	**0.11**
	2/9/16	**4.3**	<0.001	11	<0.0002	<0.001		<0.05		<0.0001		0.028		**0.019**	<0.001	**0.056**
	28/9/16	**3.8**	<0.001	7.2	<0.0002	<0.001		<0.05		<0.0001		0.023		0.013	<0.001	**0.031**
	21/11/16	**4.1**	<0.001	8.3	<0.0002	<0.001		0.06		<0.0001		0.029		**0.016**	<0.001	**0.049**
	12/1/18	**5.3**	0.002	8.8	0.0002	**0.018**		5		<0.0001		0.028		**0.016**	0.003	**0.031**
	30/5/19	**3.3**	<0.001	7.8	<0.0002	<0.001		<0.05		<0.0001		0.025		0.013	<0.001	<0.005
MW3	12/7/16	**29**	0.029	38	<0.0002	**0.26**		170		<0.0001		0.012		-	**0.023**	**0.038**
	2/9/16	**0.35**	<0.001	110	<0.0002	<0.001		<0.05		<0.0001		0.11		0.009	<0.001	**0.054**
	28/9/16	**1.1**	<0.001	66	<0.0002	<0.001		<0.05		<0.0001		0.27		**0.015**	<0.001	**0.07**
	21/11/16	**5**	<0.001	37	<0.0002	0.001		0.47		<0.0001		0.12		0.012	0.003	**0.023**
	12/1/18	**3.6**	<0.001	32	<0.0002	0.001		<0.05		<0.0001		<0.005		0.009	**0.01**	0.013
	30/5/19	**3.6**	<0.001	35	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.008	<0.05	0.012
MW4	12/7/16	**130**	0.05	76	<0.001	**0.71**		360		<0.0005		0.11		-	**0.098**	**0.16**
	2/9/16	<0.05	<0.001	28	<0.0002	<0.001		<0.05		<0.0001		0.005		0.002	<0.001	**0.033**
	28/9/16	<0.05	<0.001	20	<0.0002	<0.001		<0.05		<0.0001		0.005		0.003	<0.001	**0.02**
	21/11/16	**0.1**	<0.001	35	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.004	<0.001	**0.032**
	12/1/18	**0.72**	0.002	44	<0.0002	**0.011**		2.8		<0.0001		<0.005		0.002	<0.001	0.011
	30/5/19	**3.6**	<0.001	42	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.013	<0.05	<0.005
TB7	17/8/17	<0.1	<0.001	5.6	<0.002	<0.01	<0.01	0.04	0.9	<0.0002	11	-	54	<0.01	<0.01	0.01

TB8	17/8/17	<0.1	<0.001	9.1	<0.002	<0.01	<0.01	0.02	3.8	<0.0002	9.9		60	<0.01	<0.01	<0.01
TB9	17/8/17	0.3	<0.001	7.2	<0.002	<0.01	<0.01	0.16	6.6	<0.0002	7.2		80	<0.01	<0.01	<0.01
MB5	22/8/18	0.1	<0.002	17	<0.002	<0.002	<0.01	0.08	2.3	<0.0002	8.8		29	<0.01	<0.01	<0.01
MB7	22/8/18	0.2	<0.002	54	<0.002	0.003	<0.01	4.3	8	<0.0002	67		630	0.01	<0.01	**0.07**
WB3	2/10/20	0.03	<0.002	4.5	<0.0001	<0.001	<0.001	0.01	4.2	<0.0001	5		22	0.002	<0.001	<0.005
WB4	2/10/20	<0.01	<0.002	18	<0.0001	<0.001	<0.001	<0.01	4.5	<0.0001	140		1200	0.008	<0.001	0.013
Aquatic Ecosystems[a]		0.08	0.136	ng	0.0004	0.006	0.0018	ng	ng	0.0019	ng		ng	0.013	0.0056	0.015
Irrigation[b]		5	0.1	ng	0.01	0.1	0.2	10	ng	0.002	ng		230	0.2	2	2
Notes	ng denotes "no guideline". a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years).															

2.5 Vegetation and Flora

The project area is largely cleared of native vegetation, consisting mostly of farm paddocks and current and former quarries. All of Lot 204, most of Lot 205 and the southern part of Lot 203 are cleared paddocks with some scattered mature trees, either native or planted. Native vegetation is present in the central east of Lot 205, the northern end of Lot 202 and the north of Lot 203.

Plantecology (2020) surveyed the vegetation and flora of the project area in November 2019. 360 Environmental (2015) undertook a vegetation survey of Lots 202 and 203 in March 2015. The full report of the Plantecology (2020) survey is attached in Appendix A. The descriptions below are based on the findings of both surveys.

2.5.1 Vegetation Types

The vegetation of the low-lying western part of the site is mapped by Heddle *et al.* (1980) as Coonambidgee Complex, ranging from a low open-forest and low woodland of pricklybark-banksia (*E. todtiana - B. attenuata - B. menziesii – B. ilicifolia*) with local admixtures of *B. prionotes*, to an open-woodland of marri-banksia. None of this complex remains in the project area.

The more elevated eastern part of the site is mapped by Heddle *et al.* (1980) as Reagan Complex, ranging from low open-woodland of *B. attenuata – B. menziesii – E. todtiana* to closed-heath, depending on the depth of soil. The vegetation on the site does not agree well with the descriptions of Reagan Complex in Heddle *et al.* (1980), notably in the presence and in some parts dominance of Wandoo and the absence of *E. todtiana* and Banksia tree species.

Beard (1981) mapped most of the project area as Pinjarra 4.30000: Medium woodland, marri and wandoo. The north-east corner (about 2.3ha) was mapped as Gingin 1020.09998: Mosaic of Medium forest, jarrah-marri and Medium woodland, marri-wandoo.

360 Environmental (2015) identified seven native vegetation associations within Lots 202 and 203, as shown on Figure 7:

- EaCcEm (4.15ha): Woodland of *Eucalyptus accedens, Eucalyptus wandoo, Corymbia calophylla, Eucalyptus marginata* and *Allocasuarina huegeliana* over *Xanthorrhoea preissii, Bossiaea eriocarpa, Hakea undulata, Acacia pulchella, Pultenaea reticulata, Hakea stenocarpa* and *Tetraria octandra*.

- Mps (0.1ha): Sedgeland of *Mesomelaena pseudostygia, Mesomelaena tetragona, Lepidosperma leptostachyum, Tetraria octandra, Hypocalymma robustum, Daucus glochidiatus* and *Acacia pulchella*.

- CcXp (1.17ha): Woodland of *Corymbia calophylla* over *Mesomelaena pseudostygia, Xanthorrhoea preissii, Bossiaea eriocarpa, Hibbertia hypericoides, Acacia pulchella, Banksia sessilis, Allocasuarina humilis* and *Banksia nivea*.

- EwMps (0.83ha): Low Open Woodland (young regrowth) of Eucalyptus wandoo over Mesomelaena pseudostygia, Mesomelaena tetragona, Tetraria octandra, Bossiaea eriocarpa and Daucus glochidiatus.

- Ea (0.08ha): *Eucalyptus accedens* woodland.

- Ew (2.14ha): *Eucalyptus wandoo* woodland.

- Cc (0.36ha): *Corymbia calophylla* scattered trees over pasture.

Plantecology (2020) identified two native vegetation communities within the site:

- Marri (*Corymbia calophylla*) Open Woodland over shrubland of *Xanthorrhoea preissii, Hibbertia hypericoides* subsp. *septentrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia, Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams on lower ground in the north-east of the site. Other common species include *Allocasuarina humilis, Acacia pulchella* subsp. *pulchella, Desmocladus fasciculatus, Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata*.

- Wandoo (*Eucalyptus wandoo*) Open Low Woodland over shrubland of *Xanthorrhoea preissii, Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra, Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite on upper and middle slopes. Other common species include *Hakea stenocarpa, Gastrolobium acutum, Hakea lissocarpha* and *Desmocladus fasciculatus*.

Figure 8 shows the vegetation mapping by Plantecology (2020).

2.5.2 Vegetation Condition

The native vegetation ranges in condition from Completely Degraded to Excellent. The highest quality vegetation is located in the north of Lot 203, the east of Lot 205 and the north of Lot 202, in patches of 1.3ha or less. Figure 9 shows the vegetation condition.

2.5.3 Flora

360 Environmental (2015) found 39 native flora taxa and seven introduced species in Lots 202 and 203. Plantecology (2020) found a total of 86 native and nine introduced taxa across Lots 202-205, most of which were found in Lots 202 and 203. Appendix B

presents a consolidated flora species list for the site, totalling 103 native taxa and 12 introduced species.

2.5.4 Rare and Significant Flora

The DBCA's Naturemap and Commonwealth databases of Threatened and Priority Flora list 42 plant taxa with the potential to occur within the site (Table 2.5). Of these, 19 are listed as Threatened under the *Biodiversity Conservation Act 2016*. Two species are listed as Priority 1, six as Priority 2, 11 as Priority 3 and six as Priority 4. One Priority 4 species (*Centrolepis caespitosa*) is also listed as Threatened under the EPBC Act. Table 2.5 summarises the likelihood of occurrence of these species at the site.

No Threatened Flora pursuant to the *Biodiversity Conservation Act* 2016 or the *EPBC Act* 1999 were recorded during the vegetation surveys. One species listed as Priority Flora by the DBCA was recorded by Plantecology (2020): *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the Wandoo open woodland in the south eastern part of the site and in the Marri woodland. One species of *Cyathochaeta* was recorded by 360 Environmental (2015) but, due to the timing of the survey, it could not be determined whether it was the Priority 3 species *C. teretifolia.*

Table 2.5 Significant Flora Potentially Occurring Within the Site

Taxon	*DBCA Cons Code*	*EPBC Cons Code*	*Recorded Habitat(s)*	*Closest Record*	*Likelihood of Occurrence*
Acacia anomala	DRF	VU	Western slopes of the Darling Range east of Perth, on shallow grey sands over laterite.	4km	Unlikely
Acacia drummondii ssp. affinis	P3		Lateritic gravelly soils.	5km	Likely
Adenanthos cygnorum ssp. *chamaephyton*	P3		Grey sand, lateritic gravel.	2km	Likely
Andersonia gracilis	DRF	EN	Known from the Badgingarra, Dandaragan and Kenwick areas. Seasonally damp, black sandy clay flats near swamps.	111km	Unlikely
Anigozanthos viridis ssp. *terraspectans*	DRF	VU	Winter-wet depressions on grey sandy clay loam or grey sand in low heath that is regenerating after fire.	111km	Unlikely
Anthocercis gracilis		VU	Sandy or loamy soils. Granite outcrops.	31km	Unlikely
Caladenia huegelii	DRF	EN	Mixed woodland of Jarrah, Banksia, Sheoak, marri from just north of Perth to Busselton, usually within 20m of the coast. Mostly deep grey-white sand of the Bassendean dune system.	16km	Unlikely
Centrolepis caespitosa	P4	EN	Winter-wet claypans dominated by low shrubs and sedges.	8km	Unlikely
Chamaescilla gibsonii	P3		Clay to sandy clay. Winter-wet flats, shallow water-filled claypans.	4km	Unlikely
Chamelaucium sp. *Gingin* (N.G. Marchant 6)	DRF	EN	White/yellow sand in woodland with *Eucalyptus todtiana*, *Banksia attenuata* and *Hibbertia* sp.	13km	Unlikely
Conospermum densiflorum ssp. *unicephalatum*	DRF	EN	Low-lying sandy clay soils with surface gravel, over 10km between Gingin and Moora.	75km	Unlikely
Cyathochaeta teretifolia	P3		Grey sand, sandy clay in swamps and creek edges.	3km	Unlikely
Darwinia foetida	DRF	CE	Grey-white sand on swampy, seasonally wet sites.	1.6km	Unlikely
Diplolaena andrewsii	DRF	EN	Loam, clay. Granite outcrops and hillsides.	17km	Possible
Diuris micrantha	DRF	VU	Seasonally wet flats among sedges and scattered shrubs.	73km	Unlikely

Diuris purdei	DRF	EN	Under dense shrubs in seasonally-wet swamps and drainage lines.	55km	Unlikely
Drakaea elastica	DRF	EN	Bare patches of grey-white sand in low-lying areas alongside winter-wet swamps, typically in banksia woodland or spearwood thicket.	32km	Unlikely
Drosera occidentalis ssp. *occidentalis*	P4		Sandy and clayey soils. Swamps and wet depressions.	1.2km	Unlikely
Drosera sewelliae	P1		Laterite and silica sand soils.	6km	Possible
Eryngium pinnatifidum ssp. *Palustre* (G.J. Keighery 13459)	P3		Winter-wet areas, damplands and claypans.	2km	Unlikely
Eleocharis keigheryi	DRF	VU	Clay, sandy loam. Emergent in freshwater: creeks, claypans.	10km	Unlikely
Eucalyptus balanites	DRF	EN	Gently sloping heathlands on light-coloured sandy soils over laterite.	64km	Unlikely
Eucalyptus leprophloia	DRF	EN	Known over 90km range from north of Badgingarra to the Mt Adams area. Range of habitats including slopes of hills in brown loam over laterite.	154km	Unlikely
Grevillea althoferorum ssp. *fragilis*	DRF	EN	Base of the Darling Scarp on greyish-yellow colluvial sand, in banksia woodland.	2.7km	Unlikely
Grevillea christinae	DRF	EN	Clay loam, sandy clay, often moist.	76km	Possible
Grevillea corrugata	DRF	EN	Known from two locations 10km south of Bindoon, on gravelly loam in partially-cleared eucalyptus woodland on roadsides.	16km	Unlikely
Grevillea curviloba ssp. *curviloba*	DRF	EN	Winter wet, deep peaty grey sands over limestone.	4km	Unlikely
Grevillea curviloba ssp. *incurva*	DRF	EN	Open heath in winter-wet areas on sand over limestone or ironstone.	2km	Unlikely
Guichenotia tuberculata	P3		Sandy clay over laterite, sand.	69km	Possible
Haemodorum loratum	P3		Grey or yellow sand, gravel.	63km	Present
Hibbertia glomerata ssp. *ginginensis*	P1		Sand, brown clay, laterite and near roadsides.	30km	Possible
Oxymyrrhine coronata	P4		Slopes and flats with dry gravel over laterite.	4km	Possible
Persoonia rudis	P3		White, grey or yellow sand, often over laterite.	4km	Possible
Platysace ramosissima	P3		Sandy soils.	2km	Possible

Schoenus sp. Bullsbrook (J.J. Alford 915)	P2		Grey peaty sand, low-lying flats.	13km	Unlikely
Stenanthemum sublineare	P2		Littered white sand on the Swan Coastal Plain.	13km	Unlikely
Stylidium aceratum	P2		Sandy soils, swamp heathland.	3km	Unlikely
Stylidium longitubum	P3		Sandy clay, clay. Seasonal wetlands.	14km	Unlikely
Stylidium paludicola	P3		Peaty sand over clay. Winter-wet habitats. Marri and melaleuca woodlands.	14km	Unlikely
Stylidium squamellosum			Brown to red-brown clay loam. Winter-wet depressions. Open woodland, shrubland.	2km	Unlikely
Synaphea grandis	P4		Laterite.	1km	Likely
Tetraria sp. Chandala (G.J. Keighery 17055)	P2		Mound springs, wetlands and peaty sands.	14km	Unlikely
Thelymitra manginii K. Dixon & Batty ms (*Thelymitra dedmaniarum*)	DRF	EN	Open wandoo woodlands on red-brown sandy loam associated with dolerite and granite outcrops.	18km	Unlikely
Thelymitra stellata	DRF	EN	Low heath and scrub in jarrah and wandoo woodland on ridges and slopes, also on river banks and breakaways, on red, brown, yellow or grey sandy loams, clay or gravel over laterite or gravel.	5km	Possible
Trichocline sp. Treeton (B.J. Keighery & N. Gibson 564)	P2		Sand over limestone, sandy clay over ironstone. Seasonally wet flats.	8km	Unlikely
Verticordia lindleyi ssp. *lindleyi*	P4		Sand, sandy clay. Winter-wet depressions.	5km	Unlikely
Verticordia serrata var. *linearis*	P4		White sand, gravel. Open woodland.	3km	Unlikely

2.5.5 Floristic Communities

360 Environmental (2015) tentatively assigned floristic community types (FCTs) to the vegetation associations on Lots 202 and 203 as follows:

- EaCcEm and EwMps **S8** – *Eucalyptus wandoo* woodlands
- CcXp and Mps **3c** – *Corymbia calophylla-Xanthorrhoea preissii* woodlands and shrublands / **S18** – *Eucalyptus marginata-Corymbia calophylla* woodlands on laterite

The vegetation of Lots 204 and 205, consisting mostly of isolated paddock trees, is too severely degraded to assign to any FCT except for the patch of Wandoo woodland in the east of Lot 404, which is tentatively assigned to FCT S8.

2.5.6 Threatened and Priority Ecological Communities

Floristic Community 3c is listed as Critically Endangered under the Western Australian *Biodiversity Conservation Act 2016* and as Endangered under the Commonwealth *EPBC Act 1999*.

The DBCA and EPBC Threatened and Priority Ecological Community databases list several other TECs and PECs within 5km of the project area:

- Muchea Limestone – Shrublands and Woodlands on Muchea Limestone (Endangered (DBCA) Endangered (EPBC));
- SCP07 – Herb rich saline shrublands in clay pans (Vulnerable (DBCA) Critically Endangered (EPBC));
- SCP3a – *Corymbia calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain (Critically Endangered (DBCA));
- Mound Springs – Communities of Tumulus Springs (organic mound springs, Swan Coastal Plain) (Critically Endangered (DBCA) Endangered (EPBC));
- SCP23b – Northern *Banksia attenuata – B. menziesii* woodlands (Priority 3 (DBCA));
- SCP25 – Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands (Priority 3 (DBCA)); and
- SCP22 – *Banksia ilicifolia* woodlands (Priority 3 (DBCA)).

None of these floristic communities was found in the project area.

2.5.7 Local and Regional Representation

Table 2.6 summarises the status of the site vegetation types State-wide, in the Swan Coastal Plain Bioregion, the Shire of Chittering and within 15km of the site. The data in the table are sourced from the following:

- 2013 Native Vegetation extent by Vegetation complexes on the Swan Coastal Plain south of Moore River (Local Biodiversity Program, 2013).
- CAR Analysis Report 2009. WA Department of Environment & Conservation, Perth www2.landgate.wa.gov.au/slip/portal/services/files/carreserveanalysis2009.xls.
- Vegetation Extent-By-Type GIS database (Department of Agriculture, 2005).
- Swan Coastal Plain Vegetation Complexes GIS database (DPaW, 2016).
- CALM Estate GIS database (CALM, 2009).

Table 2.6 Remnant Vegetation Status

Vegetation Unit	*Pre-European Extent (km^2)*	*Current Extent (km^2)*	*% Remaining*	*% In Secure Reserves*
Remnant Vegetation				
Shire of Chittering	1,218	496	41	3
15km Radius	748	269	36	12
Reagan Complex (Heddle *et al.*, 1980)				
Swan Coastal Plain	91	31	34	6
Shire of Chittering	20	10	51	
15km Radius	39	18	46	4
Pinjarra 4 (Beard, 1981)				
Statewide	106	14	13	1.4
Shire of Chittering	45	7	16	0.6
15km Radius	97	29	30	0.4
Gingin 1020 (Beard, 1981)				
Statewide	56	19	34	1.8
Shire of Chittering	36	12	34	0.5
15km Radius	56	24	43	2

The table shows that the vegetation types present in the project area are moderately to well represented both locally and regionally, but that their formal reservation status is generally poor. Figure 10 shows the local and regional representation and reservation.

2.6 Fauna

2.6.1 Species and Habitats

Most of Lots 204 and 205 is cleared apart from isolated paddock trees, and offers little habitat for native fauna. The exception is an area of about 1ha in the east of Lot 205, which supports wandoo woodland in excellent condition and offers good quality habitat for fauna.

Lots 202 and 203 support areas of native vegetation ranging in condition from Completely Degraded to Excellent, as well as fully cleared areas. The vegetation in Good, Very Good and Excellent condition offers good quality habitat for fauna.

Overall, the project area contains approximately 2.4ha in Excellent condition, 2.3ha in Very Good condition and 0.5ha in Good condition.

The following fauna habitats have been identified at the site:

- Marri and Wandoo woodlands with largely undisturbed understorey;
- Eucalypt woodlands with degraded understorey; and
- Cleared paddocks with isolated mature Marri, Wandoo and Jarrah trees.

The Marri and Wandoo woodlands offer a range of feeding and nesting habitats for native fauna including mature trees with hollows, shrubs, dense understorey, groundcover and ground litter. These are expected to support a wide range of reptile, mammal and bird species.

The Eucalypt woodlands with degraded understorey have little or no ground cover or shrub layer and are expected to offer low-quality habitat for birds and some disturbance-tolerant terrestrial species.

The cleared paddocks with isolated mature trees would provide grazing habitat for kangaroos, particularly in areas close to uncleared woodland in the east of Lot 205. Stock troughs in the paddocks are focal points for ducks (particularly Maned or Wood Duck, *Chenonetta jubata* and Mountain Duck or Shelduck, *Tadorna tadornoides*), which feed in small flocks in the paddocks around the troughs. The paddocks also support a large population of the introduced Long-Billed Corella (*Cacatua tenuirostris*), which is an agricultural pest in Western Australia.

The mature trees in the paddocks are mostly larger than 0.5m diameter at breast height (dbh), and a number contain hollows of various sizes that offer potential nesting sites for black cockatoos and other bird species. Results of a survey of potential nesting hollows are given in Section 2.5.3 below.

2.6.2 Significant Fauna

A search was made of relevant databases for the area surrounding the project area. The databases searched included:

- DBCA Naturemap (15km radius including the project area);
- DBCA Threatened Fauna Database (15km radius including the project area);
- EPBC Protected Matters Search Tool (10km radius including the project area); and
- Birds Australia Birdata database (1 degree/60nm square including the project area).

The searches produced an extensive list of Threatened Fauna species, Priority Fauna species and otherwise significant species from the search area. Many of those were marine or aquatic species for which no habitat exists in the project area. Species that might occur in the project area or its surrounds are summarised, and their likelihood of occurrence in the project area assessed, below:

- Carnaby's Black Cockatoo *Calyptorhynchus latirostris* (S1, EN) – Feeds and breeds in eucalypt and Banksia woodland from the lower Murchison to the lower south-west. Numerous records of occurrence near the project area. The project area contains food resources including Marri trees and potential nesting sites. Signs of feeding on Marri nuts, possibly by Carnaby's Black Cockatoo (or possibly by Twenty-Eight Parrots) were observed beneath trees in the south of Lot 203 during the site inspection in March 2020.

- Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* (S1, VU) - Feeds and breeds in eucalypt and Banksia woodland from Gingin to the lower south-west. May occur in and around the project area. The project area contains food resources including Marri trees and potential nesting sites. A small group (8-10 individuals) was observed in Wandoo trees on the opposite side of Wandena Road during the site inspection March 2020.

- Black-striped Snake *Neelaps calonotos* (P3) - Inhabits dense leaf litter in Banksia and eucalypt woodlands with sandy soil from Lancelin south to Mandurah. Likely to be present in or around the project area.

- Black-flanked Rock Wallaby *Petrogale lateralis* subsp. *lateralis* (T, EN) – Restricted to parts of Cape Range, Little Sandy Desert, granite rocks in the Avon Wheatbelt, Kalbarri National Park and Barrow and Salisbury Islands. Occurs on rocky habitats with a preference for complex caves and crevices. Unlikely to be present in the project area due to the absence of suitable habitat.

- Woylie *Bettongia penicillata ogilbyi* (T, EN) - Formerly widespread species now restricted to six known sites in the south-west. Inhabits open eucalypt forest, open mallee woodlands and shrublands. Unlikely to be present in the vicinity due to predation by foxes and cats.

- Douglas' Broad-headed Bee *Hesperocolletes douglasi* (T, CR) – Recently rediscovered in Banksia woodland at Pinjar in 2019 after being presumed extinct. Only previous sighting was on Rottnest Island in 1938. Unlikely to be present in the project area.

- Chuditch *Dasyurus geoffroii* (S3, VU) - Occurs in a wide range of habitats including woodlands, dry sclerophyll forests and riparian vegetation. The project area provides foraging habitat and the species is likely to be an occasional visitor to the project area.

- Peregrine Falcon *Falco peregrinus* (S4) - A wide-ranging species that prefers nesting in cliff faces. Likely to overfly the project area but would not be resident.

- Rainbow Bee-eater *Merops ornatus* (S3, MI) - A common and widespread migratory species that utilises a wide range of habitats, with a preference for nesting in open sandy ground. The project area has few open sandy areas and is unlikely to provide habitat for the species.

- Fork-tailed Swift *Apus pacificus* (S3, MI) - A widespread and almost entirely aerial species. Likely to overfly the project area but would not be resident or dependent upon it.

- A short-tongued bee *Leioproctus douglasiellus* (CR) - Known from only three locations within the Perth metropolitan area in association with two plant species: *Goodenia filiformis* and *Anthotia junciforme*, neither of which are present at the site.

- Brush-tailed Phascogale *Phascogale tapoatafa* (P3) - Inhabits dry sclerophyll forests and open woodlands with hollow-bearing trees and sparse ground cover between Perth and Albany. A specimen was captured in open Tuart woodland in Baldivis, 23km south-west of the project area, in 2017 (Australian Ecological Services, 2017). Unlikely to be present at the site due to its scarcity and the absence of its preferred habitat.

- Graceful Sunmoth *Synemon gratiosa* (P4) - Inhabits coastal heathland on Quindalup dunes and banksia woodland on Spearwood and Bassendean dunes, in association with two species of mat-rush, *Lomandra maritima* and *L. hermaphrodita.* Neither plant species was found in the project area so the moth is unlikely to be present.

- Inornate Trapdoor Spider *Euoplos inornatus* (northern Jarrah Forest) (P3) – Known from several locations in the northern Jarrah forest, the closest 6.5km south-east of the site. May be present in uncleared areas at the site.

- A short-tongued Bee *Leioproctus contrarius* (P3) – Occurs on the Swan Coastal Plain in association with *Scaevola repens* var. *repens* and *Lechenaultia* spp, neither of which are present at the site.

- Quenda *Isoodon obesulus fusciventer* (P4) - Inhabits dense ground cover in forests, woodlands and heaths, preferring areas around wetlands and damplands. May be present in uncleared parts of the project area although no evidence of presence (e.g. diggings) were observed.

- Grey Wagtail *Motacilla cinerea* (MI) – Breeds in northern Europe and migrates to the southern hemisphere, mostly Africa and Asia. Two Western Australian records from near Pemberton and Northcliffe. Unlikely to be present at the site.

2.6.3 Black Cockatoo Habitat Assessment

Feeding Habitat

The project area contains nine species recorded by Valentine & Stock (2008) as food resource species for Carnaby's Cockatoo: *Corymbia calophylla, Eucalyptus marginata, Xanthorrhoea preissii, Hakea lissocarpha, Mesomelaena pseudostygia, M. tetragona, Allocasuarina fraseriana, Banksia sessilis* and *Lambertia multiflora*. In most cases (except *C. calophylla*), these species are present at low density over small areas, so the site offers limited food resources for black cockatoos. The large Marri trees in the cleared areas would be expected to provide food for black cockatoos. Limited evidence of Carnaby's Cockatoo feeding (in the form of chewed nuts) was observed in the south of Lot 203 during the site inspection.

Roosting Habitat

The EPBC Act Referral Guidelines for Black Cockatoos (DSEWPC, 2012) define black cockatoo roosting sites as tall trees or groups of tall trees, usually close to an important water source and within an area of quality feeding habitat.

The project area contains no significant water sources and limited feeding habitat. It is therefore unlikely that black cockatoos will roost in the area.

Breeding Habitat

The DSEWPC (2012) defines black cockatoo breeding habitat as follows:

- Current breeding habitat - Trees of suitable species (including Marri, Jarrah and Wandoo) with suitably-sized hollows (generally minimum 140mm opening, 200mm internal width, 450mm depth).

- Potential breeding habitat - Trees of suitable species of size at least 500mm diameter at breast height (dbh) (or 300mm for Wandoo).

360 Environmental (2015) found 126 Marri, Jarrah and Wandoo trees in Lots 202 and 203 that met the DSEWPC (2012) definition of future breeding habitat. None of the trees contained visible hollows potentially suitable for black cockatoo nesting. BES (2020) found 122 trees across Lots 202-205 that met the DSEWPC (2012) size criteria, including 56 that contained hollows or potential hollows, of which eight appeared to be

of a suitable size for black cockatoos. Across the two surveys, a total of 190 trees met the DEWA size criteria for potential nesting habitat.

BES inspected all potential hollows in October 2020 with a pole-mounted camera (Cocky Cam) supplied by Birdlife Australia. The inspection found nine hollows in use by Corellas, two by Australian Kestrels and one by Kookaburras. No evidence of current or previous black cockatoo nesting was found. A large number of hollows (approximately 15 of 56 examined) contained feral bee hives.

Figure 11 shows a consolidated map of all potential nesting trees identified by 360 Environmental (2015) and BES (2020).

2.7 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965. Quarrying has been underway on Lots 202 and 203 since before 1977.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 3.3km north-west of the project area. There is no potential for this contamination to directly affect the project area.

The former clay quarry on Lots 202 and 203 is currently being backfilled with inert waste such as building rubble prior to rehabilitation. The backfilling and rehabilitation are being undertaken under the terms of a DWER Licence (L9181/2018/1), which carries conditions including control of waste acceptance and prevention of pollution.

There is no visual or photographic evidence of any contaminating activities now or in the past within the project area.

2.8 Aboriginal and European Heritage

The Department of Planning Lands & Heritage's online database shows one registered site, (ID 3525 Ellen Brook: Upper Swan) covering the whole project area. Appendix C shows the search report.

The DPLH mapping usually extends well beyond the actual registered site boundary in order to protect sensitive sites. The DAA has advised that the actual boundaries of the registered site do not affect the project area, and that therefore no approval under the Aboriginal Heritage Act 1972 is required for development of the project area. The DPLH advice is attached in Appendix C.

2.9 Landscape

The project area is visible from Great Northern Highway and Wandena Road. The view from Great Northern Highway is partly screened but not blocked by trees planted within the property. From Wandena Road the southern end of the project area is visible through a screen of roadside trees, but for the most part is obstructed by dense vegetation and the banks of a cutting through which the road passes.

The landscape in the west consists mostly of cleared horse paddocks with scattered trees and isolated buildings set well back from the highway.

Figure 12 shows views of the site from Great Northern Highway and Wandena Road.

3.0 ENVIRONMENTAL IMPACTS AND MANAGEMENT

3.1 Surface Water Protection

The project area drains to Ellen Brook via culverts beneath Great Northern Highway and small drainage lines within and adjacent to the site.

Ellen Brook is a major tributary of the Swan-Canning River system and the largest contributor of nutrients, mostly from agriculture on the grey sandy soils west of the Brook. Small creeks and drainage lines are important contributors to the flow and water quality of Ellen Brook.

Industrial development has the potential to affect the volume, rate and quality of water flows in the drainage lines and Ellen Brook. Water outputs from the project area will be limited to stormwater, groundwater and minor process water (such as washdown water). In addition, the limited availability of water (groundwater or scheme) will mitigate against the establishment of industry with high water requirements.

Management
The aim of surface water protection is to maintain or improve the quality of surface water leaving the project area. Given the site's current use for agriculture, this is considered achievable.

The contaminant of major concern in Ellen Brook and the Swan-Canning River system is phosphorus. Monitoring in September 2018 (BES, 2020) showed that Ellen Brook carries very heavy phosphorus loads. Phosphorus is a major contaminant in agricultural runoff but a minor component in runoff from industrial areas.

Management strategies to be implemented include:

- In accordance with the Shire of Chittering Town Planning Scheme No. 4, industries permitted in Precinct 2 will be those that dispose of domestic-quality wastewater at a rate less than 5,400 litres per hectare per day (R10 equivalent).

- Wastewater from toilets and bathrooms will be treated by nutrient-removing systems (e.g. ATU or modified leach drains) in accordance with Health Department requirements. An analysis of the capability of the site to support on-site effluent disposal is presented in the Local Water Management Strategy (Appendix D).

- The single existing drainage line crossing the project area will be retained within a roadside bioretention swale (see LWMS).

- All road runoff will be captured and infiltrated (up to 1-year ARI 1-hour storm) or detained (up to critical 100-yr storm) in bioretention swales in accordance with

DWER guidelines. Stormwater management is detailed in the LWMS. Figure 13 shows an overview of the stormwater management system.

- Any process wastewater generated by industries will be treated on-site to a standard suitable for discharge to the ground or disposed offsite.

- All lot drainage from storms up to 1-year ARI 1-hour will be retained and infiltrated within individual lots. Runoff from critical storms up to 100-year ARI will be detained within lots and released at a rate no greater than the pre-development rate.

- A monitoring program for surface water will be implemented as detailed in the LWMS.

- Temporary drainage controls will be implemented during the construction period (see Section 3.5).

3.2 Groundwater Protection

Groundwater is an important contributor to water flow and quality in Ellen Brook. Given the silty clay soils of the project area, groundwater throughflow and discharge is relatively low.

Bore samples collected in September 2020 show that the quality of groundwater is generally good, with moderate to low concentrations of phosphorus and nitrogen.

The Structure Plan aims to maintain groundwater levels, discharge volumes and quality at their pre-development levels. With the removal of horse grazing, the quality of groundwater is expected to gradually improve.

Management
Groundwater protection measures are detailed in the LWMS and will include:

- Industries in Precinct 2 (Lots 204 and 205) will be restricted to those with low water use and waste water generation of less than 5,400 litres/ha/day (see Structure Plan report).

- Subsoil drains, if required, will be set at or above the pre-existing Average Annual Maximum Groundwater Level (AAMGL).

- Subsoil and stormwater drains will discharge to vegetated swales with PRI of at least 15 (see LWMS).

3.3 Noise

Industrial land use is inherently noisy. Noise sources include traffic, machinery, power tools, ventilators and percussive impacts.

The western side of the project area experiences intermittent high levels of noise from heavy vehicles using Great Northern Highway, although the level and frequency of this noise has diminished substantially since the opening of the new Tonkin Highway further to the west.

Noise-sensitive premises (residences) are located in Muchea 1,800 metres west of the project area. Isolated residences are also located west of Great Northern Highway (70m west of the project area) and east of Wandena Road (350m east of the project area).

Other noise sources include an active clay quarry located 600m north and air traffic (including jets) from Pearce RAAF Base located 6.5km south. The project area is in line with the main runway at Pearce.

Future noise sources will include industry to the west and north as part of the Muchea Industrial Park.

Management
Active management of noise within and from the Structure Plan area will not generally be required. Industries with high noise emissions may be required to undertake technical analyses to determine separation requirements. These industries may be restricted to certain parts of the Structure Plan area where suitable separations are available.

3.4 Dust

Industrial land uses may generate significant amounts of dust, depending on the activities carried out and the condition of the ground surface. Potentially dusty activities include processing (materials handling), unsealed roads and exposed soil surfaces.

The silty soils of the project area are susceptible to dust generation when disturbed. The main dust risk will be during construction work. Management of construction impacts including dust is detailed in Section 3.5.

Sensitive dust receptors are the same as those for noise: the town of Muchea and residences located east and west of the project area.

Management
Individual lot holders within the project area will be required to manage dust to prevent dust escape beyond their boundaries. Industries that generate appreciable process dust will be required to hold a DWER licence, which will specify dust limits and monitoring requirements.

3.5 Construction Impacts

Construction of the project is expected to be carried out at various times, in accordance with the land owners' preferences. Construction of roads, drainage and other services will be undertaken by the owner(s) of each stage of subdivision.

Construction stage impacts relate mainly to the movement of machinery and the presence of areas of exposed soil, and include noise, vibration, dust, erosion and sedimentation.

Management

Management of construction impacts will be the subject of conditions attached to subdivision approvals, works approvals and development approvals.

In general, control of construction impacts will be the responsibility of the construction contractor. The general principles of construction management will be as follows:

The developer will implement a Construction Management Plan for the development dealing with dust management, erosion and sediment control, containment of environmentally hazardous materials (chiefly fuel and oils) and spill response. The key elements of the Construction Management Plan will include the following:

Dust Minimisation

- No topsoil stripping will be undertaken in dry conditions when the wind speed is greater than 25km/h unless appropriate dust control watering is undertaken prior to and during disturbance..
- No earthworks will be undertaken in dry conditions when the wind speed is greater than 40km/h unless appropriate dust control watering is undertaken prior to and during disturbance.
- Dust will be suppressed on open ground and stockpiles by regular watering, hydromulching, wind fencing and/or covering.
- An adequate supply of water for dust suppression will be kept on site at all times.
- Soil stockpiles will be limited to a height of 2.5m to minimise dust generation and to facilitate watering.
- Other dust minimisation measures will include minimising areas of disturbance, limiting volume and speed of construction traffic and instructing site workers in dust minimisation.

Erosion and Sedimentation

- Drains and bunds will be constructed at the beginning of site disturbance as necessary to capture and direct all runoff from disturbed areas into settling ponds. Drains, bunds and ponds will be appropriately designed and sized to provide adequate settling of sediments from drained water before release.
- Vehicles and machinery will be kept to designated roads, tracks and work areas.

Water Conservation

- Water consumption during construction will be minimised by:
  - limiting dust suppression watering to prevent ponding and runoff; and
  - use of non-water dust control methods such as wind fencing and hydromulching where appropriate.

Hazardous Materials

- All environmentally hazardous materials will be stored in their original labelled containers (or labelled jerrycans or drums in the case of petroleum fuels) in a ventilated enclosure equipped with appropriate signage, fire extinguishers and a spill response kit.
- Petroleum products will be held in a bunded enclosure.
- Material Safety Data Sheets (MSDS) and a chemical register for all hazardous materials on the site will be maintained by the site supervisor in the site office.

Complaints Register

- The site supervisor will maintain a written record of any public complaints and the actions taken in response.

3.6 Vegetation and Flora

The native vegetation over most of the project area consists of mature paddock trees, rows and groups of planted trees. In the eastern part of the site, the vegetation consists of Marri and Wandoo open woodland in Completely Degraded to Excellent condition.

Development of the project area as proposed will involve the clearing of approximately 2.42ha of Marri and Wandoo woodland in Excellent condition, 2.33ha in Very Good condition, 0.48ha in Good condition and 0.86ha in Degraded condition. In addition, up to approximately 110 isolated native paddock trees (Marri, Wandoo and Jarrah) may be removed where they cannot be retained.

Remnant trees within the development area will be preserved where possible. No remnant trees may be cleared without a Development Approval from the Shire of Chittering and/or a clearing permit from the DWER.

Landscaping within private lots and public areas (e.g. road reserves and drainage swales/basins) will be carried out using local native species.

3.7 Fauna

Development of the site as proposed will require the clearing of about 6.1ha of Marri and Wandoo woodland in Degraded to Excellent condition.

Prior to clearing, a fauna capture and relocation exercise will be undertaken by a qualified specialist consultant to relocate any sedentary animals (e.g. snakes and lizards) from the application area. During and after clearing, monitoring of debris will be carried out to locate and salvage any fauna caught within the clearing operation.

Fauna captured or salvaged during this operation will be relocated to parks or reserves in consultation with and by permission of the DBCA. Any injured fauna found after clearing will be taken to a refuge where possible. Any feral animals captured, as well as native animals that are too badly injured to recover, will be euthanased.

Fauna habitat will be created in the revegetation of drainage swales and basins. Street trees planted within the project area will focus on native tree species that provide habitat for nectar-eating and seed-eating birds.

3.8 Landscape

3.8.1 Overview

Development in accordance with the Structure Plan will change the landscape of the project area from predominantly rural to industrial, in keeping with the industrial landscape of the overall Muchea Industrial Park.

The objective of landscaping will be not to hide the industry from view but to provide vegetation features that "soften" and break up the industrial landscape. This will include plantings within lots along the interface of Great Northern Highway, drainage swales and basins, verge trees within the developed areas and landscape buffers within lots.

3.8.2 Landscape Plantings

The Shire of Chittering Town Planning Scheme imposes a general requirement that all non-residential lots should provide landscaping with approved species to a minimum of 10% of the total lot area, including a minimum of one shade tree per four car parking bays.

The Shire of Chittering's *Muchea Industrial Park Design Guidelines* (2018) set out the Council's requirements and recommendations for development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. The Guidelines require:

- a minimum 2m wide landscape buffer on the primary road frontage;
- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays; and
- one tree per 10m of road frontage.

The landscape plantings within lots will be of a mix of native trees, shrubs and ground covers. The 1-year ARI 1-hour bioretention swales within each lot will be densely planted with native sedges and low shrubs. This will form part of the 10% landscaping requirement for each lot.

3.8.3 Streamline Revegetation

Roadside bioretention swales will be densely planted with native sedges and low shrubs to stabilise the beds and banks of the swales, slow water flows and promote the uptake of sediments and nutrients from the water. The areas to be planted, species and planting densities are described in more detail in the Landscape Master Plan (BES, 2020).

Plantings within the swales will be kept to a height that meets the definition of Shrubland in the Bushfire Hazard Assessment (Eco Logical Australia, 2020) so as not to create an unacceptable fire hazard.

4.0 MONITORING

Baseline water quality results for the project area are shown in Tables 2.2, 2.3 and 2.4. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Surface water quality in drainage lines within, upstream and downstream of the project area will be monitored to determine what (if any) impacts the development may be having on surface water quality.

The developer of each stage of subdivision will be responsible for monitoring water quality in bores and drainage swales within that stage.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

5.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Subdivision and development in the project area will be undertaken in accordance with the Structure Plan, this EAMS and the attached LWMS.

Development may occur in accordance with a subdivision approval or, in the absence of subdivision, a Development Approval. Subdivision approvals will include a requirement for an Urban Water Management Plan (UWMP). If development occurs without a subdivision, a Local Water Management Plan (LWMP) may be required to set out drainage design for the development.

6.0 REFERENCES

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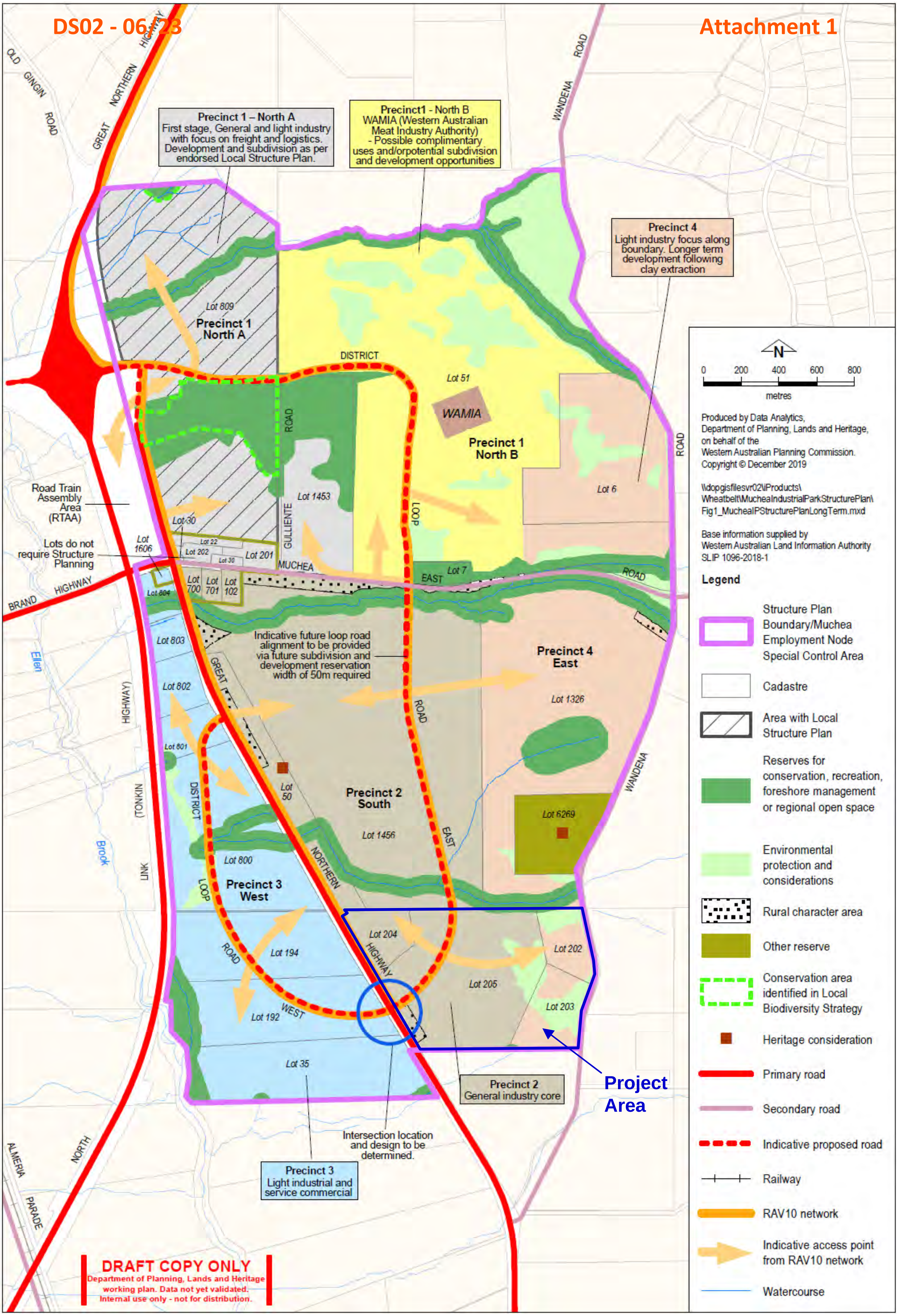
Figures



Source: WAPC, 2019

Figure 1

DRAFT MUCHEA INDUSTRIAL PARK STRUCTURE PLAN

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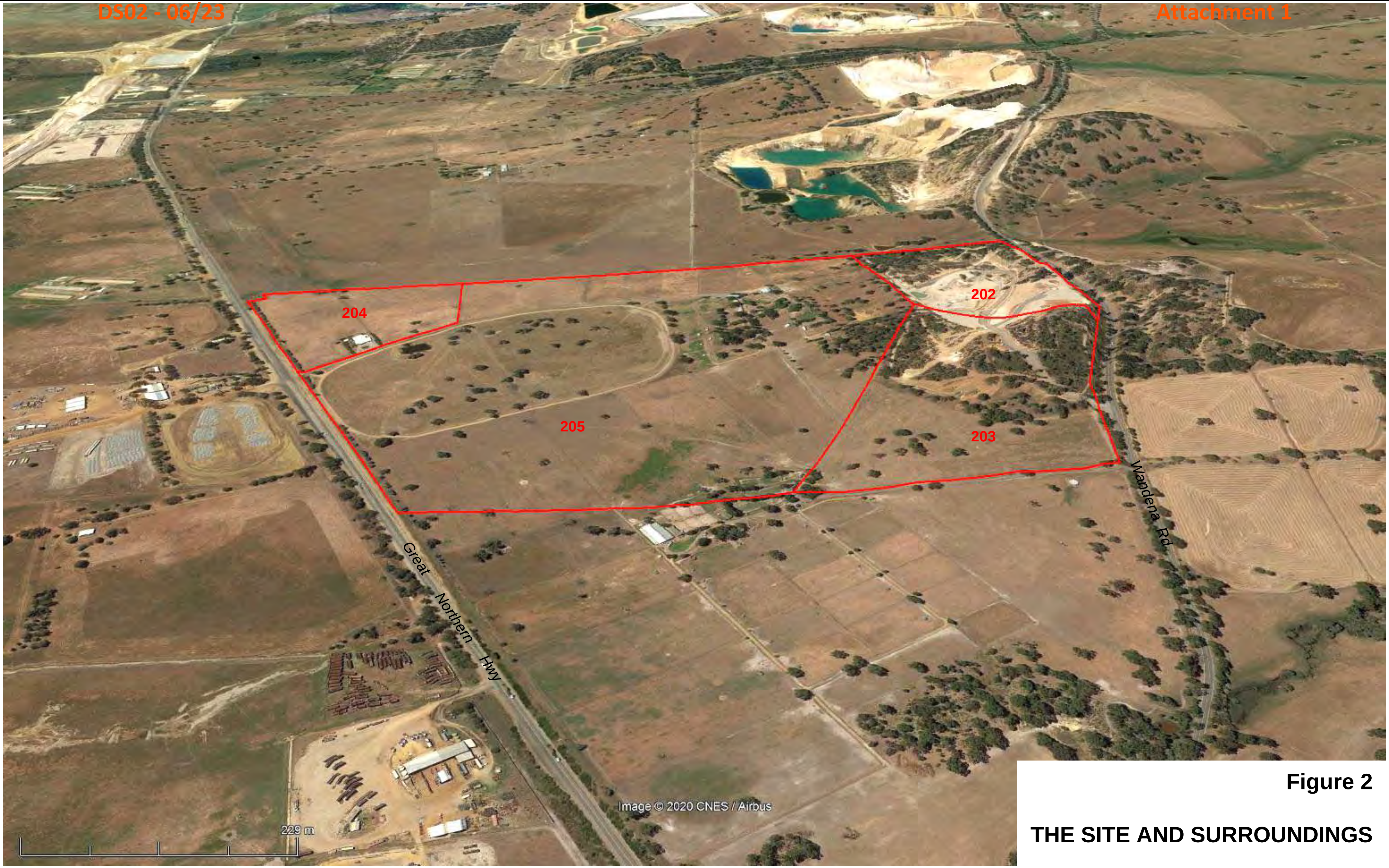

Figure 2

THE SITE AND SURROUNDINGS

Image source: Google

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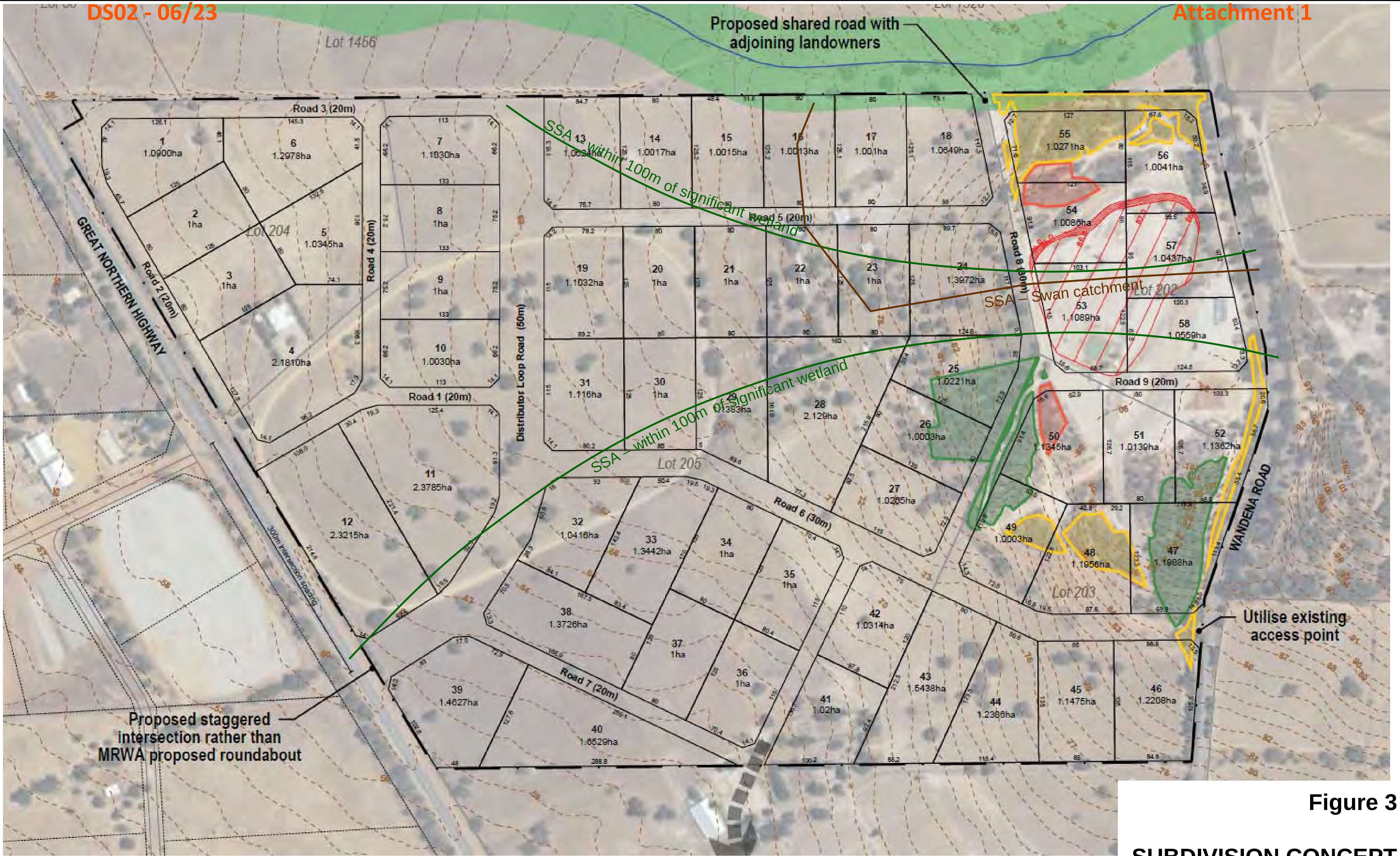

Figure 3

SUBDIVISION CONCEPT

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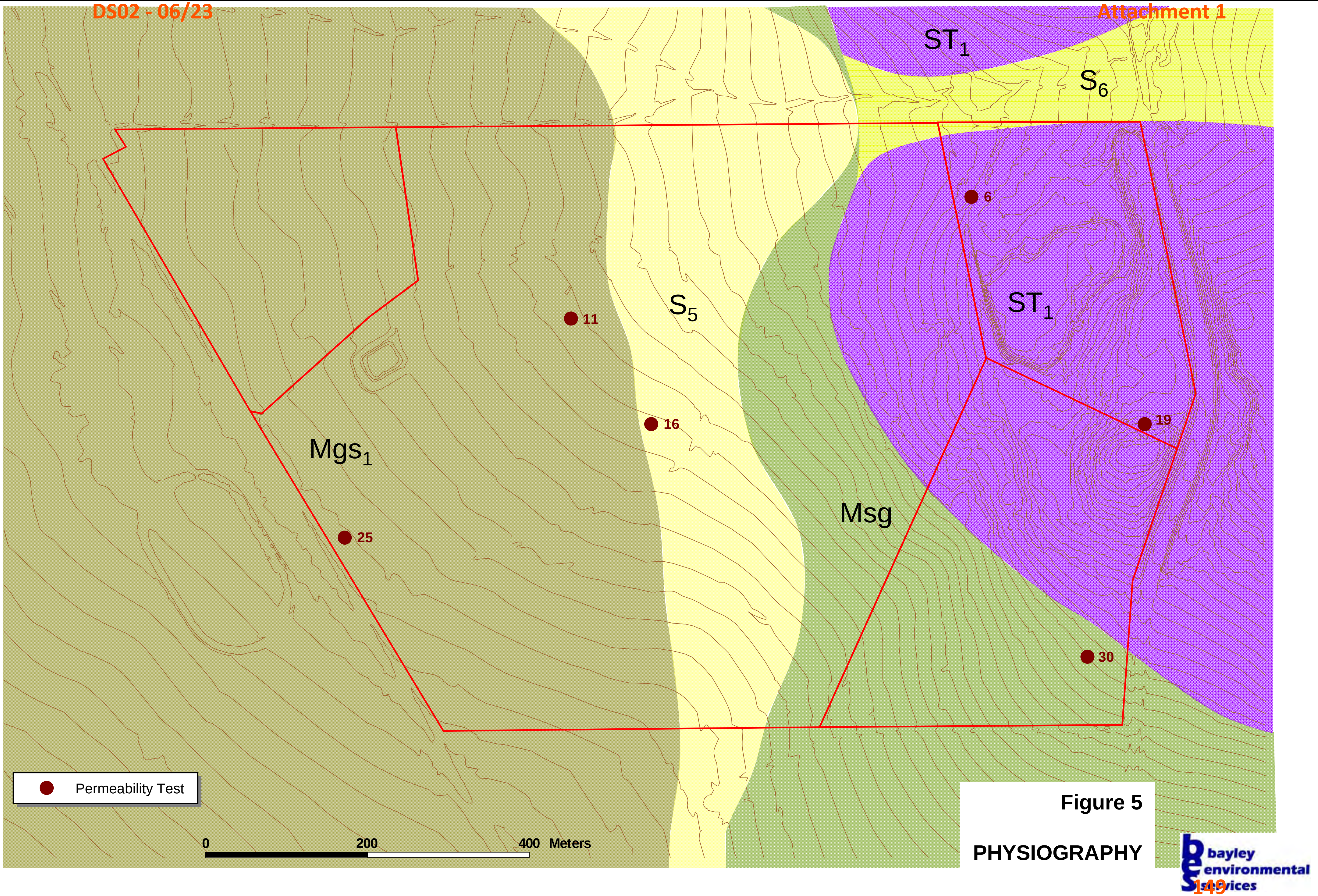

Figure 5

PHYSIOGRAPHY

DS02 - 06/23

Attachment 1

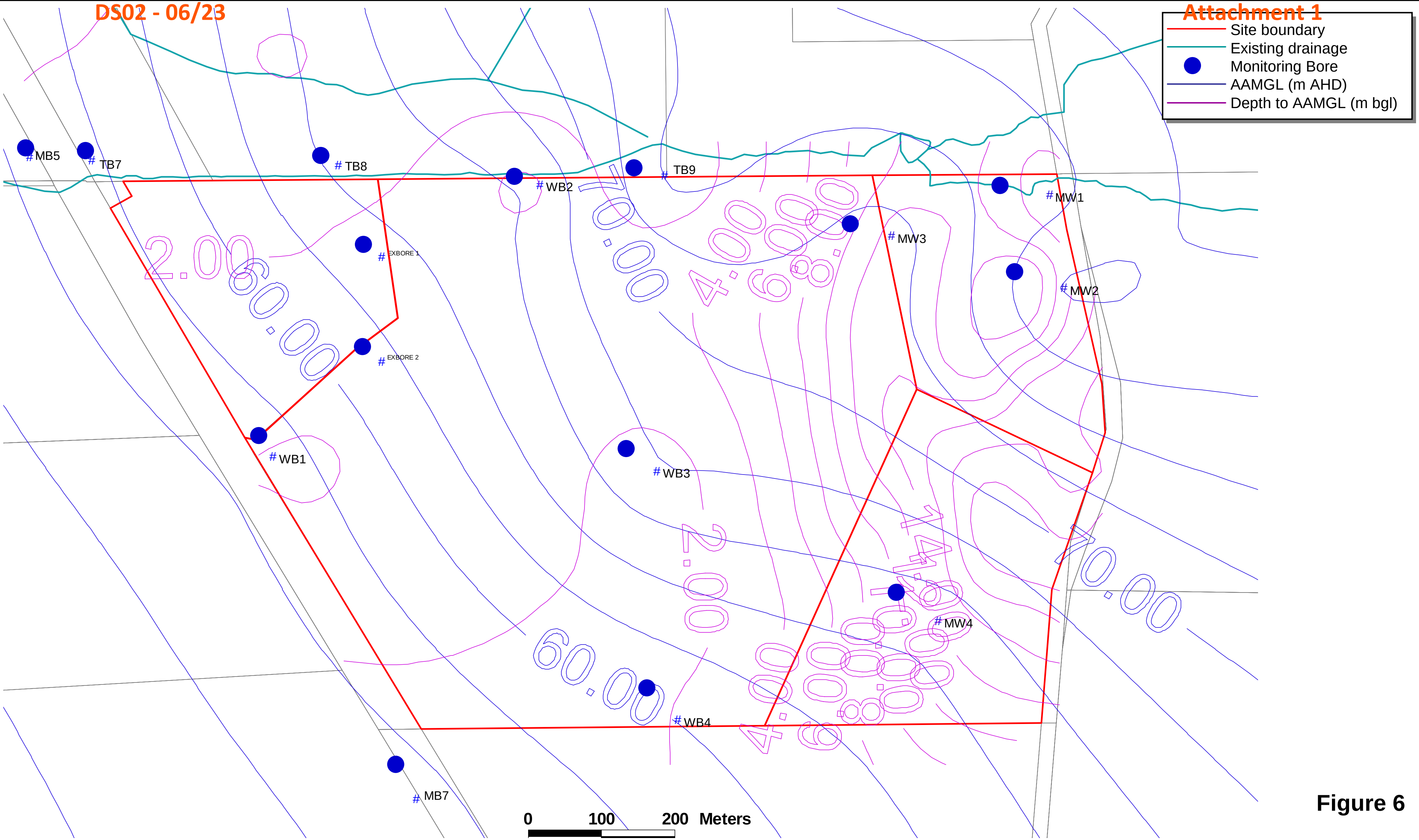

Figure 6

HYDROLOGY

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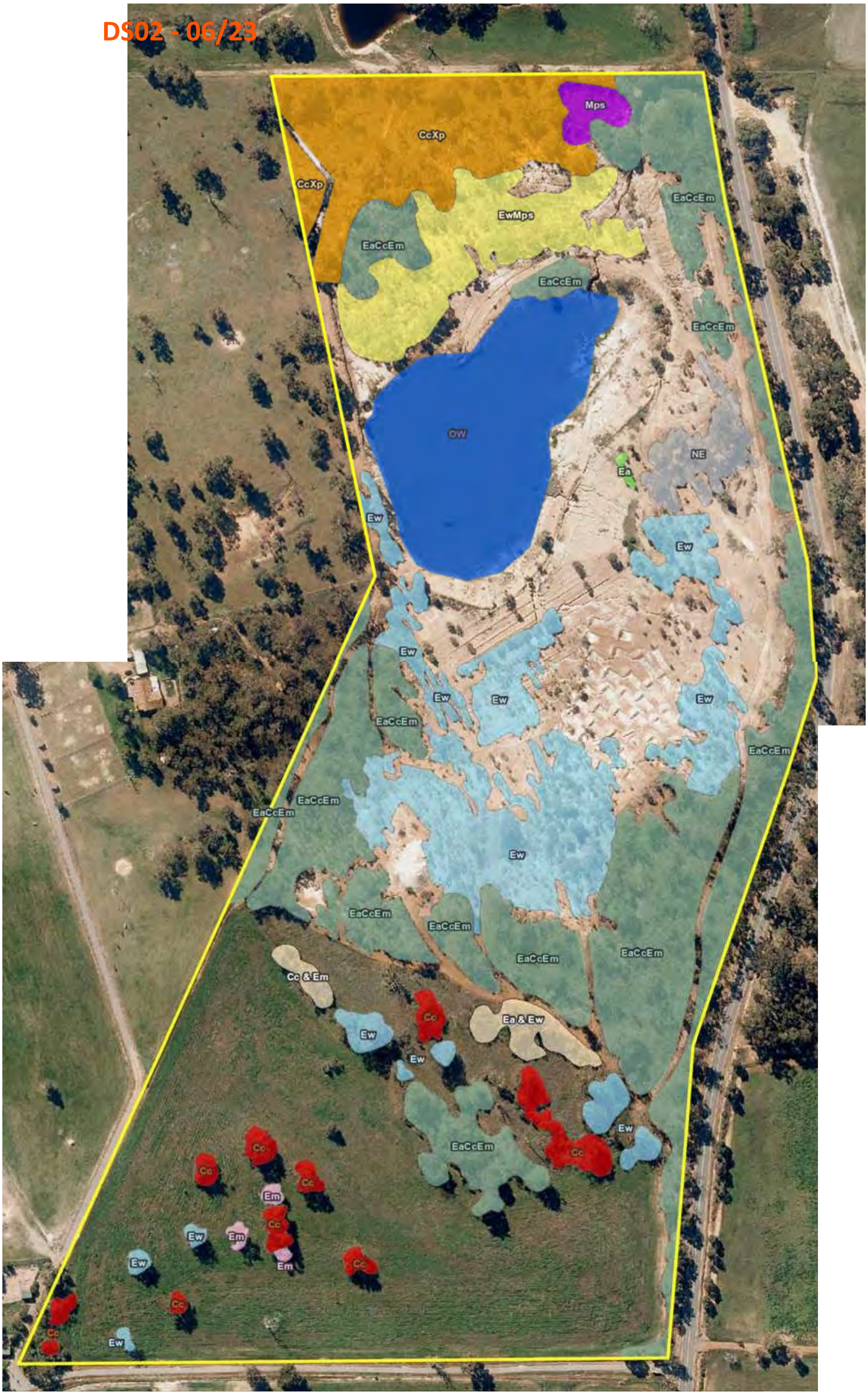
Attachment 1



	Cc (0.36 ha)	*Corymbia calophylla*
	CcXp (1.17 ha)	Woodland of *Corymbia calophylla* over *Mesomelaena pseudostygia, Xanthorrhoea preissii, Bossiaea eriocarpa, Hibbertia hypericoides, Acacia pulchella, Banksia sessilis, Allocasuarina humilis* and *Banksia nivea*
	Ea (0.08 ha)	*Eucalyptus accedens*
	EaCcEm (4.15 ha)	Woodland of *Eucalyptus accedens, Eucalyptus wandoo, Corymbia calophylla, Eucalyptus marginata* and *Allocasuarina huegeliana* over *Xanthorrhoea preissii, Bossiaea eriocarpa, Hakea undulata, Acacia pulchella, Pultenaea reticulata, Hakea stenocarpa* and *Tetraria octandra.*
	Em (0.03 ha)	*Eucalyptus marginata*
	Ew (2.14 ha)	*Eucalyptus wandoo*
	EwMps (0.83 ha)	Low Open Woodland (young regrowth) of *Eucalyptus wandoo* over *Mesomelaena pseudostygia, Mesomelaena tetragona, Tetraria octandra, Bossiaea eriocarpa* and *Daucus glochidiatus.*
	Mps (0.10 ha)	Sedgeland of *Mesomelaena pseudostygia, Mesomelaena tetragona, Lepidosperma leptostachya, Tetraria octandra, Hypocalymma robustum, Daucus glochidiatus* and *Acacia pulchella*
	NE (0.25 ha)	Non-endemic species
	OW (1.46 ha)	Open Water

Figure 7

VEGETATION MAPPING - 360 ENVIRONMENTAL

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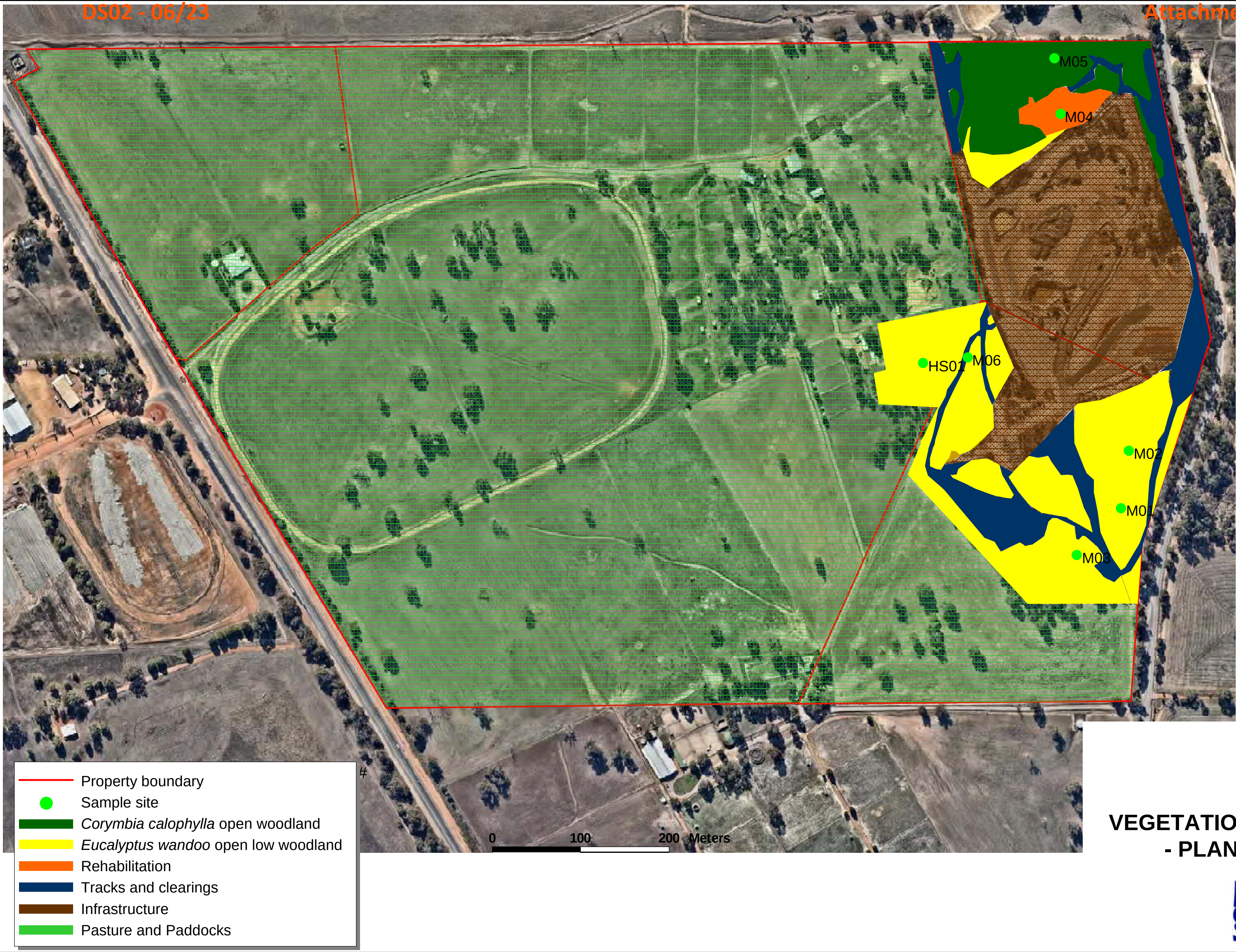

Figure 8

VEGETATION MAPPING - PLANTECOLOGY

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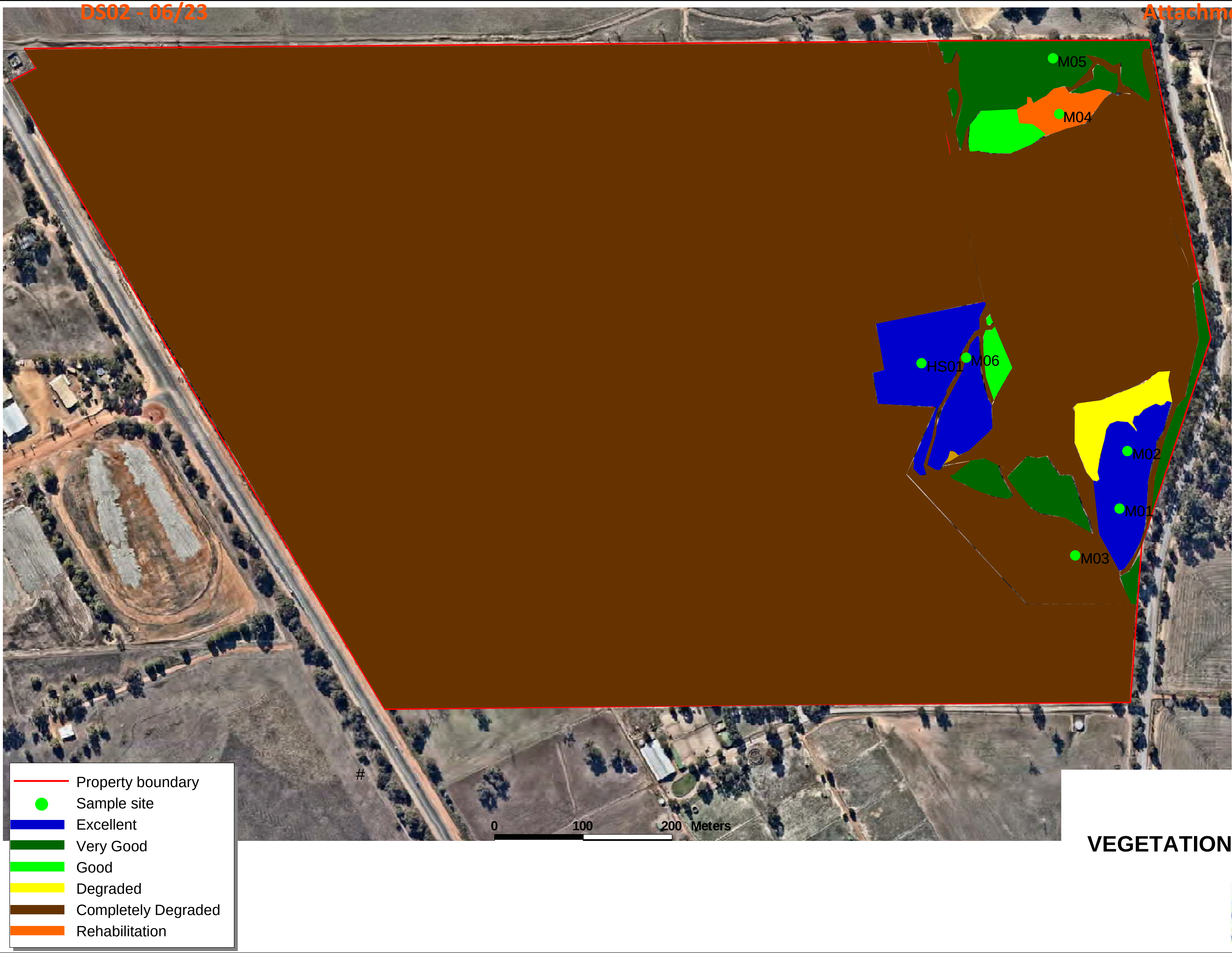

Figure 9

VEGETATION CONDITION

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Attachment 1

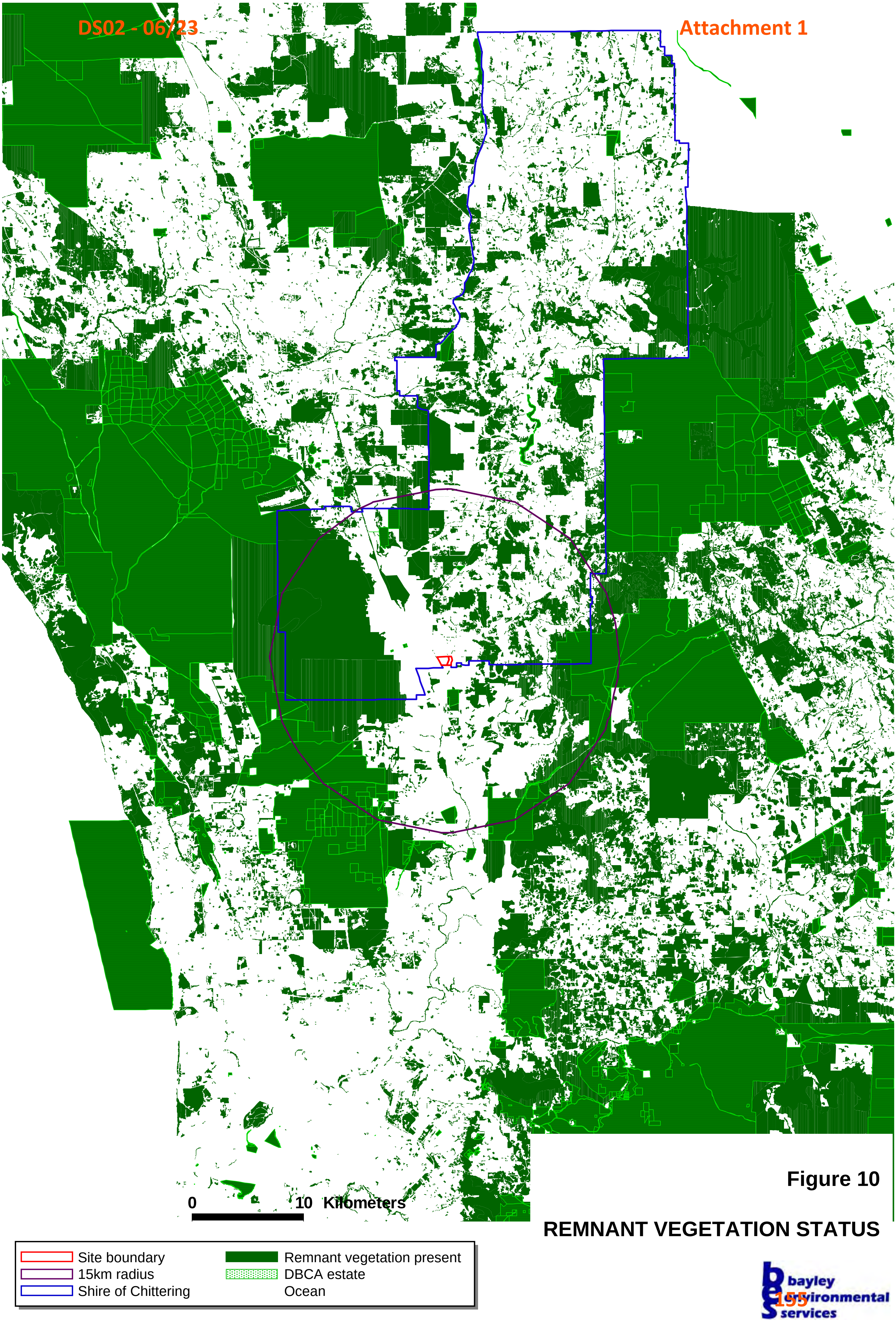

Figure 10

REMNANT VEGETATION STATUS

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Attachment 1

Site boundary
Tree >0.5m dbh
Tree >0.5m dbh with occupied hollow

Figure 11

POTENTIAL BLACK COCKATOO BREEDING HABITAT

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1 **Wandena Rd looking north-west into Lot 203**

2 **Wandena Rd looking north-west into quarry entrance**

3 **Wandena Rd looking north-west towards Lot 202**

4 **Great Northern Hwy looking north-east into Lot 205**

5 **Great Northern Hwy looking east into Lot 205 entrance**

6 **Great Northern Hwy looking south-east into Lot 204**

Images: Google (2017)

Figure 12

VIEWS FROM GREAT NORTHERN HIGHWAY AND WANDENA ROAD

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Attachment 1

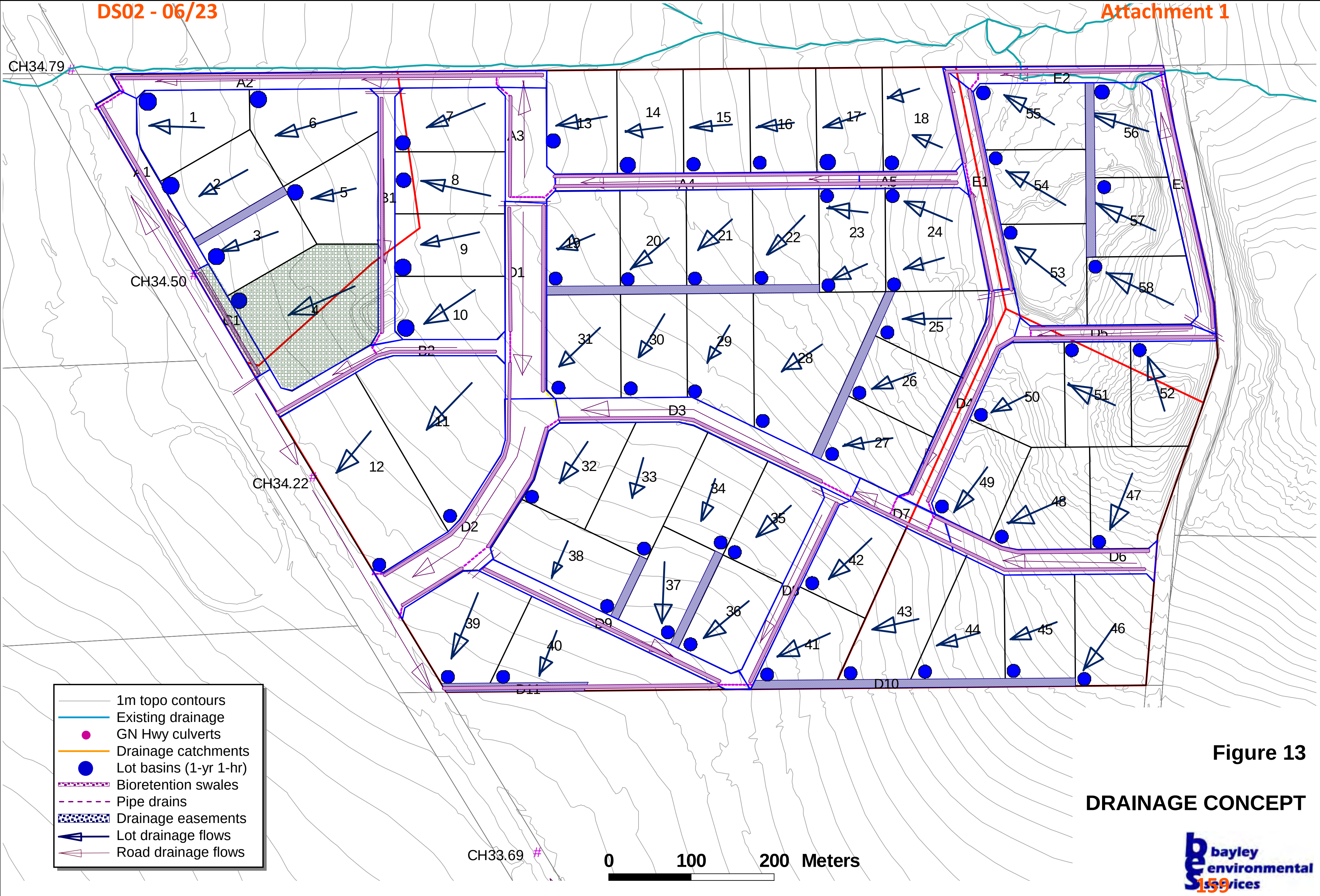

Figure 13

DRAINAGE CONCEPT

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Appendix A

Botanical Survey Report (Plantecology Ltd, 2020)

Lots 202, 203, 204 & 205 Wandena Rd Muchea Flora and Vegetation Survey

PREPARED FOR BAYLEY ENVIRONMENTAL SERVICES

Plantecology CONSULTING

FEBRUARY 2020

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Executive Summary

Plantecology Consulting was commissioned by Bayley Environmental Services to undertake a detailed flora and vegetation survey at Lots 202, 203, 204 and 205, Wandena Rd, Muchea, (the site), in the Shire of Chittering. The site covers approximately 82 ha, of which approximately 15 ha is within Lots 202 and 203. Lots 202 and 203 are currently used for extractive industry, while Lots 204 and 205 support a horse stud.

The field survey was conducted by a botanist from Plantecology Consulting on the 13th November 2019. The site was traversed on foot and search made for conservation significant flora. A detailed survey of the vegetation was undertaken at five 100 m^2 sampling plots (10m x 10m quadrats) and two recce plots, which are used to record the structure, condition and dominants in a patch. The sampling plots were selected to adequately sample the flora within a stand (Figure 2). Plots were positioned to sample a representative and homogeneous (i.e. not located in transitional areas between communities) area of each community. The location of each corner of a plot was recorded with a hand-held GPS unit and a photograph of the plot taken looking inward to the quadrat. All vascular plant species were recorded and an estimate of the Foliage Cover (FC) percentage was made for each species.

A total of 86 native and 9 non-native (exotic) taxa were recorded within the site, representing 31 families and 69 genera. The dominant families containing mostly native taxa were Fabaceae (11 native taxa, one exotic taxon), Myrtaceae (7 native taxa), Cyperaceae (7 native taxa), and Proteaceae (10 native taxa). Most exotic species were grasses (Poaceae, three exotic taxa).

No Threatened Flora pursuant to the *Biodiversity Conservation Act* (2016) nor the *EPBC Act* (1999) were recorded during the survey. One species listed as Priority Flora by the PWS was recorded during the survey. *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the *Eucalyptus wandoo* open woodland in the south eastern part of the site and the *Corymbia calophylla* woodland.

The survey identified two native plant communities within the site:

Corymbia calophylla open woodland

Woodland of *Corymbia calophylla* over shrubland of *Xanthorrhoea preissii, Hibbertia hypericoides* subsp. *septentrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia, Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams.

This unit occurs in the lower ground in the northern part of the site. Other common species include *Allocasuarina humilis, Acacia pulchella* subsp. *pulchella, Desmocladus fasciculatus, Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata.*

Eucalyptus wandoo open low woodland

Low open woodland of *Eucalyptus wandoo* subsp. *wandoo* over shrubland of *Xanthorrhoea preissii, Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra, Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite.

This unit occurs on upper and mid-slopes within the site. Other common species include *Hakea stenocarpa, Gastrolobium acutum, Hakea lissocarpha* and *Desmocladus fasciculatus.*

The vegetation condition within the site reflects past and current pastoral and quarrying activity within the site with the vegetation adjacent to the quarry area in poorer condition than that within vegetation remnants. Pastured areas, infrastructure areas for the horse stud and

extractive industries, formed tracks and stands where the understorey has been replaced by exotic species have been rated as 'Completely Degraded'. The largest stand in this category is approximately 66 ha of Lots 204 and 205, which are used for pastures with paddock trees of *Corymbia calophylla* and the supporting infrastructure of the horse stud. Also rated as 'Completely Degraded' is the area at the southern extremity of Lots 202 and 203 where an open tree layer of *Eucalyptus wandoo* and *Corymbia calophylla* remains but the understorey consists almost entirely of **Ehrharta calycina* and **Avena barbata*. Stands where the vegetation structure has been significantly altered but retain more native species are rated as 'Degraded' and occur on the southern edge of the quarry area. Adjacent to an area undergoing rehabilitation in the northern part of Lots 202 and 203 is a stand of 'Good' vegetation where the vegetation is sparser from previous disturbance but still retains its basic structure.

Nine of the taxa recorded during the survey are exotics (weeds), none of which are Declared Pests under the *Biosecurity and Agriculture Management Act* 2007. The most abundant weeds were **Ehrharta calycina* and **Avena barbata,* recorded in the more degraded areas of the site.

The search of DBCA's databases for Threatened and Priority communities showed that the Commonwealth-listed Endangered community 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' or its buffer zone is mapped as occurring within the site. To be considered a part of this community, a vegetation stand must include at least one of the diagnostic species *Banksia attenuata, Banksia menziesii, Banksia prionotes* or *Banksia ilicifolia.* None of these species were recorded within the site and neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland can be considered part of the 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' community. Neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland are listed as PECs or TECs.

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1 Introduction

Plantecology Consulting was commissioned by Bayley Environmental Services to undertake a detailed flora and vegetation survey at Lots 202, 203, 204 and 205, Wandena Rd, Muchea, (the site), in the Shire of Chittering (Figure 1). The site covers approximately 82 ha, of which approximately 15 ha is within Lots 202 and 203. Lots 202 and 203 are currently used for extractive industry, while Lots 204 and 205 support a horse stud.

1.1 Purpose

The purpose of the survey was to provide a detailed assessment of botanical values within the site, which could then inform the proposed rezoning of the site from rural to industry

The objectives of the survey were to:

- Undertake a detailed flora and vegetation survey in accordance with the Environmental Protection Authority's (EPA) Technical Guidance: Flora and Vegetation Survey for Environmental Impact Assessment (2016).
- Identify the presence of any Threatened Ecological Communities (TECs) and Priority Ecological Communities (PECs);
- Undertake a systematic search for all vascular plant taxa present; and
- Record the locations and numbers present of any Threatened Flora and Priority Flora.

1.2 Existing Environment

Much of the site currently being used for extractive industry has been developed for that purpose. Some areas have been revegetated after the end of quarrying while two areas of native vegetation remain in the northern and southern parts of the site. The vegetated remnants are dissected by tracks and firebreaks, while the northern remnant is also dissected by some drainage channels. The majority of the horse stud have been cleared to create pasture and farm infrastructure with only a small patch of remnant vegetation remaining adjacent to the extractive industry lots.

1.3 Climate

The Muchea area experiences a dry Mediterranean climate of hot dry summers and cool wet winters. Long-term climatic averages indicate the site is located in an area of moderate to high rainfall, receiving 655.1 mm on average annually (data for Pearce RAAF, station number 9053, the nearest currently reporting station; Bureau of Meteorology 2019) with the majority of rainfall received between May and August. The area experiences rainfall on an average of 107 days per year. Mean maximum temperatures range from 17.9 °C in July to 33.5 °C in January. Mean minimum temperatures range from 8.2 °C in August to 17.5 °C in February.

1.4 Soils

The Atlas of Australian Soils maps the soils for the majority of the site as Map Unit Wd9 (Natural Resource Information Centre 1991). Map Unit Wd9 comprises broad valleys and undulating interfluvial areas with some discontinuous breakaways and occasional mesas. Lateritic materials mantle the area and the chief soils are sandy acidic yellow mottled soils containing much ironstone gravel in the A horizons. The western portion of the horse stud is mapped as Sp2, which comprises gently sloping terraces of the Ridge Hill Shelf. The main soils are hard acidic yellow soils containing ironstone gravels and associated brown sands, often containing ironstone gravels at depth.

1.5 Conservation Significant Flora

Under the *Biodiversity Conservation Act 2016* ('BC Act'), the Minister for the Environment produces a gazetted list of Threatened Flora under three categories: Critically Endangered, Endangered and Vulnerable. The Parks and Wildlife Service (PWS) also produces a list of Priority Flora that have not been assigned statutory protection under the BC Act but may be under some degree of threat (PWS 2019a). The PWS recognises four Priority Flora levels. The definitions for each category of Threatened and Priority Flora are shown in Appendix E.

As well as protection under State legislation, selected flora are also afforded statutory protection at a Federal level pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides for the protection of Threatened species, pursuant to Schedule 1 of the Act, and are defined as "Critically Endangered", "Endangered", "Vulnerable" or "Conservation Dependent" under Section 179. Definitions of these categories are shown in Appendix E. Any action likely to have a significant impact on a species listed under the EPBC Act requires approval from the Commonwealth Minister for Agriculture, Water and the Environment.

A search of the DBCA and Commonwealth databases of Threatened and Priority Flora as well as NatureMap returned a list of 49 taxa with the potential to occur within the site (Table 1). Of these taxa, 11 are listed as Threatened under the BC Act. *Diuris drummondii* is an orchid of winter-wet depressions and swamps that flowers from November through to January. *Thelymitra stellata* is an orchid that occurs in gravel and lateritic loams and flowers from October to November. *Eleocharis keigheryi* is a freshwater emergent that flowers from August to November. The remaining Threatened Flora on the list are perennial shrubs and should be observable at all times of the year. The timing of the survey should, therefore, be appropriate to detect the Threatened Flora on the list.

Table 1: Threatened and Priority Flora potentially occurring within the survey area based on database searches. (VU = Vulnerable; EN = Endangered; CR = Critically Endangered; T = Threatened; 1 – 4 = Priority Flora Category)

Taxa	PWS Rating	EPBC Act Category	Flowering Period
Acacia anomala	T	VU	Aug-Sep
Acacia cummingiana	3		May – Jun, Aug
Acacia drummondii subsp. affinis	3		Jul - Aug
Acacia pulchella var. reflexa acuminate bracteole variant (R.J. Cumming 882)	3		Jul - Sep
Adenanthos cygnorum subsp. *chamaephyton*	3		Jul, Sep - Jan
Anigozanthos humilis subsp. *chrysanthus*	4		Jul – Oct
Caustis gigas	2		May
Chamaescilla gibsonii	3		Sep
Chamelaucium sp. Gingin (N.G. Marchant 6)	T	VU	
Cyathochaeta teretifolia	3		
Darwinia foetida	T	CR	
Diuris drummondii	T	VU	Nov - Jan
Drosera occidentalis	4		Oct - Jan
Drosera sewelliae	1		Oct
Eleocharis keigheryi	T	VU	Aug – Nov
Eryngium pinnatifidum subsp. *palustre*	3		
Gastrolobium crispatum	1		Sep - Oct
Gastrolobium nudum	2		Feb
Grevillea althoferorum subsp. *fragilis*	T	CR	
Grevillea candolleana	2		Aug - Sep
Grevillea corrugata	T	EN	?Aug - Sep
Grevillea curviloba subsp. *curviloba*	T	EN	Oct
Grevillea curviloba subsp. *incurva*	T	EN	Aug - Sep
Guichenotia tuberculata	3		Aug - Oct
Hydrocotyle lemnoides	4		Aug - Oct
Hydrocotyle striata	1		
Hibbertia glomerata subsp. *ginginensis*	2		Jul - Sep
Hypocalymma sylvestre	T		Aug
Hypolaena robusta	4		Sep - Oct
Isotropis cuneifolia subsp. *glabra*	3		Sep
Leucopogon squarrosus subsp. *trigynus*	2		
Millotia tenuifolia var. *laevis*	2		Sep - Oct
Ornduffia submersa	4		
Oxymyrrhine coronata	4		
Persoonia rudis	3		Sep -Jan
Platysace ramosissima	3		Oct - Nov
Schoenus capillifolius	3		Oct - Nov
Schoenus griffinianus	3		Sep – Oct
Stylidium aceratum	3		Oct – Nov
Stylidium paludicola	3		Oct – Dec

Taxa	PWS Rating	EPBC Act Category	Flowering Period
Stylidium squamellosum	2		Oct – Nov
Synaphea grandis	4		Oct - Nov
Tetraria sp. Chandala (G.J. Keighery 17055)	2		Aug - Oct
Tetratheca pilifera	3		Aug - Oct
Thelymitra stellata	T	EN	Oct – Nov
Thysanotus sp. Badgingarra (E.A. Griffin 2511)	2		Dec
Verticordia lindleyi subsp. *lindleyi*	4		May, Nov – Jan
Verticordia rutilastra	3		Sep - Nov
Verticordia serrata var. *linearis*	1		Sep - Oct

1.6 Conservation Significant Communities

The PWS defines an ecological community as "a naturally occurring assemblage that occurs in a particular type of habitat" (PWS 2019b). A Threatened Ecological Community (TEC) is one that has declined in area or was originally limited in distribution. Uncommon ecological communities that do not strictly meet TEC defined criteria, or are inadequately defined, are listed by the PWS as a Priority Ecological Community (PEC). Definitions of the categories of Threatened and Priority Ecological Communities are given in Appendix E.

As well as protection under State legislation, selected ecological communities are also afforded statutory protection at a Federal level pursuant to the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The EPBC Act provides for the protection of TECs, which are listed under section 181 of the Act, and are defined as "Critically Endangered", "Endangered" or "Vulnerable" under Section 182. Similar to flora listed under the EPBC Act, any action likely to have a significant impact on a TEC listed under the EPBC Act requires Commonwealth approval.

A search of the DBCA databases of Threatened and Priority Ecological Communities (TECs and PECs) identified five conservation-coded community types with the potential to occur within the site. These were:

- The Critically Endangered 'Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)';
- The Vulnerable 'Herb rich saline shrublands in clay pans (SCP 7)';
- The Endangered 'Shrublands and woodlands on Muchea Limestone of the Swan Coastal Plain';
- The Priority 3 'Southern *Eucalyptus gomphocephala – Agonis flexuosa* woodlands'; and
- The Priority 3 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region', listed as Endangered under Commonwealth legislation and includes the State-listed PECS:
    - Swan Coastal Plain *Banksia attenuata – Banksia menziesii* woodlands (FCT 23b); and
    - Banksia woodland of the Gingin area restricted to soils dominated by yellow to orange sands.

The 'Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)' and the Shrublands and woodlands on Muchea Limestone of the Swan Coastal Plain' are both listed by the Commonwealth as Endangered communities, while the 'Herb rich saline shrublands in clay pans (SCP 7)' is listed as Critically Endangered.

1.7 Ecological Linkages

Ecological linkages are important conservation tools that allow the movement of fauna, flora and genetic material between areas of remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improves the viability of those remnants by allowing greater access to breeding partners, food sources, refuge from disturbances such as fire and maintains the genetic diversity of plant communities and populations. Local ecological linkages seek to improve the viability of local natural areas by providing connections to other local or regionally significant natural areas and regional ecological linkages. The vegetation stands within the site is not part of either a regional or local ecological linkage (Shire of Chittering 2010).

1.8 Vegetation Complexes

Vegetation complexes are a series of plant communities forming a regularly repeating pattern associated with a particular soil unit (Government of Western Australia 2000). Two vegetation complexes have been mapped as potentially occurring within the site: Reagan Complex, which is described as varying from a low open woodland of Banksia species and/or *Eucalyptus todtiana* (Pricklybark) to a closed heath, depending on the depth of soil; and Coonambidgee Complex, which ranges from a low open forest and low woodland of *Eucalyptus todtiana* (Pricklybark) - *Banksia attenuata* - *Banksia menziesii* - *Banksia ilicifolia* with localised occurrences of *Banksia prionotes* to an open woodland of *Corymbia calophylla* - Banksia species (Webb et al. 2016). Reagan Complex has been mapped as a Swan Coastal Plain vegetation complex and has 33.8% of its original 9 180 ha pre-European extent remaining (Webb *et al.* 2016). Only 3.7% of its original extent is protected for conservation (Webb et al. 2016). Coonambidgee Complex has 45% of it original 6272 ha remaining, with 650 ha currently protected in the reserve system (Webb et al. 2016).

2 Methods

2.1 Field Survey

The field survey was conducted by a botanist from Plantecology Consulting on the 13th November 2019. The site was traversed on foot and search made for conservation significant flora. A detailed survey of the vegetation was undertaken at five 100 m^2 sampling plots (10m x 10m quadrats) and two recce plots, which are used to record the structure, condition and dominants in a patch. The sampling plots were selected to adequately sample the flora within a stand (Figure 2). Plots were positioned to sample a representative and homogeneous (i.e. not located in transitional areas between communities) area of each community. The location of each corner of a plot was recorded with a hand-held GPS unit and a photograph of the plot taken looking inward to the quadrat. All vascular plant species were recorded and an estimate of the Foliage Cover (FC) percentage was made for each species.

Environmental data recorded included topographic position, aspect, slope, soil colour and texture class, rock outcropping, litter cover as well as the degree of disturbance and an estimate of the time since the last fire event. The condition of the vegetation of the site was assessed to assist in determining the conservation values of the site. The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the metropolitan and southwest regions. The categories are listed and defined in Table 2. Data on the vegetation structure was also recorded and included the height of the three main strata and the dominant species within each stratum. The vegetation structural description follows that of the National Vegetation Information System (Thackway *et al*. 2006).

All plant specimens collected during the field survey were dried, pressed and then sorted in accordance with requirements of the Western Australian Herbarium. Identification of specimens occurred through comparison with named material and through the use of taxonomic keys. Taxonomic determinations were made using reference material at the Western Australian State Herbarium. Taxa names utilise the current terminologies from FloraBase (2019). Family names utilise the revised phylogeny of the Angiosperm Phylogeny Group - APGIII (FloraBase 2019).

2.1 Study Limitations and Survey Effort

Various factors can limit the effectiveness of a vegetation survey. Pursuant to EPA Technical Guidance: Flora and Vegetation Survey for Environmental Impact Assessment (EPA 2016), these factors have been identified and their potential impact on the effectiveness of the survey has been assessed (Table 3).

The survey was undertaken in mid-November 2019 and would likely have intercepted the flowering period of most annuals of conservation concern with the potential to occur within the site. However, the spring of 2019 was much drier than normal, which may have affected the flowering of some species.

Table 2: Vegetation Condition Scale (Keighery 1994)

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

Table 3: Potential limitations affecting the vegetation survey

Potential limitations	Constraint	Comment
Availability of contextual information	No	Sufficient regional and local information was available to place the survey site in its environmental context.
Competency and experience of the botanists undertaking the survey	No	The survey was undertaken by botanists with a comprehensive knowledge of Southwestern Western Australia vegetation, with at least 15 years' experience in vegetation surveys in Western Australia.
Seasonality	Minor	The survey was undertaken in spring 2019. The rainfall in the three months prior to the survey was well below average for the area, especially in September. Maximum and minimum temperatures were approximately 2^0 higher than the mean.
Adequate ground coverage and intensity of survey effort	No	The survey area was traversed on foot. It is considered the survey quadrats and mapping points provided adequate coverage given the degraded nature of most of the site.
Proportion of Flora identified	No	The survey recorded an estimated 77% (chao2 estimator) of the plant taxa present, although this still represents fewer species than could be expected from an undisturbed system.
Disturbance	Minor	Part of the site has and is being used for quarrying. Formed access tracks and firebreaks dissect the remnant patches and some historic tracks are still evident. Drainage channels have also been constructed in the northern part of the site. The historic disturbances may have had an impact on the species richness and structure of the vegetation and limit some of the conclusions that may be drawn from the data.
Resources	No	Adequate resources were available to conduct the survey.
Access restrictions	No	All parts of the site were accessible

3 Results

3.1 Flora

3.1.1 Floristic Summary

A total of 86 native and 9 non-native (exotic) taxa were recorded within the site, representing 31 families and 69 genera. The dominant families containing mostly native taxa were Fabaceae (11 native taxa, one exotic taxon), Myrtaceae (7 native taxa), Cyperaceae (7 native taxa), and Proteaceae (10 native taxa). Most exotic species were grasses (Poaceae, three exotic taxa). For a complete species list and the individual site data refer to Appendix A and Appendix B, respectively.

3.1.2 Threatened and Priority Flora

No Threatened Flora pursuant to the *Biodiversity Conservation Act* (2016) nor the *EPBC Act* (1999) were recorded during the survey.

One species listed as Priority Flora by the PWS was recorded during the survey. *Haemodorum loratum* (P3) was recorded at two sites, M01 and M05, and in adjacent areas of the *Eucalyptus wandoo* open woodland in the south eastern part of the site and the *Corymbia calophylla* woodland (Table 4). Approximately 50 individuals were counted in each habitat. A more accurate count was not possible as *Haemodorum discolor* was also recorded during the survey, and non-flowering individuals are difficult to discern with certainty. The described upper limit of leaf width for *Haemodorum discolor* is similar to the lower limit for *Haemodorum loratum*.

Table 4: Locations of sampling plots with *Haemodorum loratum* (P3) present (GDA94, Zone 50).

Plot	Easting	Northing
M01	406871	6503674
M05	406796	6504183

3.2 Vegetation

3.2.1 Plant Associations

The survey identified two native plant communities within the site (Figure 2):

Corymbia calophylla open woodland (Plates 2 and 3)

Woodland of *Corymbia calophylla* over shrubland of *Xanthorrhoea preissii, Hibbertia hypericoides* subsp. *septentrionalis* and *Bossiaea eriocarpa* over herbland of *Mesomelaena pseudostygia, Caustis dioica* and *Banksia dallanneyi* var. *dallanneyi* on light brown clay loams.

This unit occurs in the lower ground in the northern part of the site. Other common species include *Allocasuarina humilis, Acacia pulchella* subsp. *pulchella, Desmocladus fasciculatus, Lepidosperma asperatum* and *Conostylis aculeata* subsp. *aculeata.*

Eucalyptus wandoo open low woodland (Plate 4)

Low open woodland of *Eucalyptus wandoo* subsp. *wandoo* over shrubland of *Xanthorrhoea preissii, Bossiaea eriocarpa* and *Hibbertia hypericoides* subsp. *septentrionalis* over herbland of *Tetraria octandra, Banksia dallanneyi* var. *dallanneyi* and *Lepidosperma pubisquameum* in brown gravelly clay loams on laterite.

This unit occurs on upper and mid-slopes within the site. Other common species include *Hakea stenocarpa, Gastrolobium acutum, Hakea lissocarpha* and *Desmocladus fasciculatus.*

3.2.2 Vegetation Condition

The vegetation condition within the site reflects past and current pastoral and quarrying activity within the site with the vegetation adjacent to the quarry area in poorer condition than that within vegetation remnants (Figure 3). Pastured areas, infrastructure areas for the horse stud and extractive industries, formed tracks and stands where the understorey has been replaced by exotic species have been rated as 'Completely Degraded'. The largest stand in this category is approximately 66 ha of Lots 204 and 205, which are used for pastures with paddock trees of *Corymbia calophylla* and the supporting infrastructure of the horse stud. Also rated as 'Completely Degraded' is the area at the southern extremity of Lots 202 and 203 where an open tree layer of *Eucalyptus wandoo* and *Corymbia calophylla* remains but the understorey consists almost entirely of **Ehrharta calycina* and **Avena barbata* (Plate 3). Stands where the vegetation structure has been significantly altered but retain more native species are rated as 'Degraded' and occur on the southern edge of the quarry area. Adjacent to an area undergoing rehabilitation in the northern part of Lots 202 and 203 (Plate 4) is a stand of 'Good' vegetation where the vegetation is sparser from previous disturbance but still retains its basic structure.

The *Corymbia calophylla* woodland in the north-eastern part of the site has been rated as 'Very Good', largely due to the disturbance from drainage channels constructed through it. The shrub layer in this community is lower and sparser than could be expected in undisturbed vegetation.

Areas of 'Excellent' condition vegetation occur in the *Eucalyptus wandoo* woodland in the south-eastern part of the site. These stands have retained most of their vertical structure and native species richness (e.g. 36 native taxa at Plot M01).

3.2.3 Weeds

Nine of the taxa recorded during the survey are exotics (weeds), none of which are Declared Pests under the *Biosecurity and Agriculture Management Act* 2007. The most abundant weeds in native remnants were **Ehrharta calycina* and **Avena barbata,* recorded in the more degraded areas of the site.

4 Discussion

4.1 Flora

No species of Threatened Flora were recorded during the survey. One species of Priority Flora was recorded from two plots, one each in the *Corymbia calophylla* and the *Eucalyptus wandoo* woodlands. *Haemodorum loratum* (P3) occurs from Eneabba to Perth on the eastern side of the Swan Coastal Plain and adjacent slopes of the Dandaragan Plateau. Its usual habitat is in grey and yellow sands in low heath, and eucalypt and banksia woodlands. The soil within the *Corymbia calophylla* woodland was generally a light brown clay loam, and in the *Eucalyptus wandoo* woodland a brown loamy clay. The local population was difficult to count accurately as *Haemodorum discolor* was also recorded for the site and the upper limit of leaf width for this species is similar to the lower limit for *Haemodorum loratum.* Non-flowering individuals, therefore, could not consistently be identified to species level.

4.2 Plant Communities

The search of DBCA's databases for Threatened and Priority communities showed that the Commonwealth-listed Endangered community 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' or its buffer zone is mapped as occurring within the site. To be considered a part of this community, a vegetation stand must include at least one of the diagnostic species *Banksia attenuata, Banksia menziesii, Banksia prionotes* or *Banksia ilicifolia.* None of these species were recorded within the site and neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland can be considered part of the 'Banksia-dominated woodlands of the Swan Coastal Plain IBRA region' community. The species assemblages recorded for each community type within the site also do not match the other conservation-coded communities that are known to occur nearby.

The *Corymbia calophylla* woodland shows some similarity to the *Corymbia calophylla* – *Xanthorrhoea preissii* woodlands and shrublands TEC, but *Bossiaea eriocarpa* is present in this unit within the site and that species is a contra-indicator for this particular TEC.

Corymbia calophylla woodland is generally in 'Very Good' condition with few exotic species present. The condition of the *Eucalyptus wandoo* woodland ranged from 'Degraded' to 'Excellent'. The poorer condition areas were mostly adjacent to tracks or active work areas and been disturbed previously or were experiencing weed invasion.

Mapping of vegetation complexes for the Swan Coastal Plain places much of the site within the Reagan Complex, which is described as varying from a low open woodland of Banksia species and/or *Eucalyptus todtiana* (Pricklybark) to a closed heath, depending on the depth of soil (Webb *et al.* 2016). This description does not accurately describe the vegetation for the site and is likely due to variance from the scale of mapping as the site is situated on the lower Gingin Scarp and near the boundary between the vegetation complex mapping for the Swan Coastal Plain and that of the southwest forests.

5 Summary

One species of Priority Flora was recorded from within the site. The local population of *Haemodorum loratum* (P3) is estimated to be approximately 50 plants. Neither the *Corymbia calophylla* woodland nor the *Eucalyptus wandoo* woodland are listed as PECs or TECs. The vegetation condition of the site varies from 'Completely Degraded' in cleared areas and tracks, to 'Excellent' in intact woodland patches that support few invasive weed species.

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Figures

Figure 1

LOCATION

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- Property boundary
- Sample site
- *Corymbia calophylla* open woodland
- *Eucalyptus wandoo* open low woodland
- Rehabilitation
- Tracks and clearings
- Infrastructure
- Pasture and Paddocks

Figure 2

PLANT COMMUNITIES

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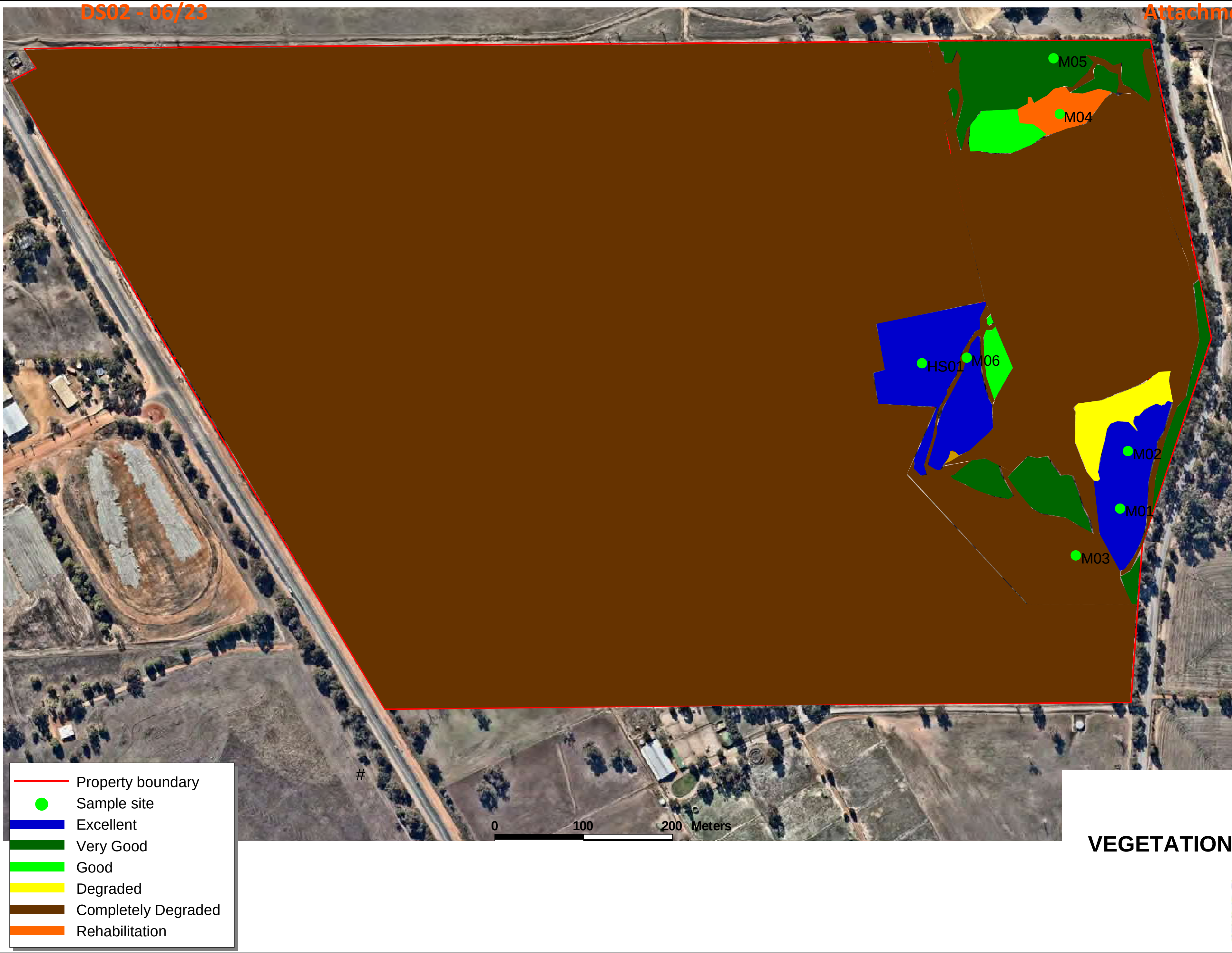

Figure 3

VEGETATION CONDITION

bayley environmental services

Plates

Plate 1: View of Eucalyptus wandoo woodland (Plot M01).

Plate 2: Another view of Eucalyptus wandoo woodland at Plot 2.

Plate 3: View of 'Completely Degraded' at Plot M03.

Plate 4: View of rehabilitation area in the northern section of the site.

Plate 5: View of *Corymbia calophylla* woodland at Plot M05.

Plate 6: View of *Eucalyptus wandoo* woodland at Plot M06.

Plate 7: View of *Eucalyptus wandoo* woodland at Plot HS01.

Appendix A

List of flora recorded within the survey area

NB: * indicates introduced flora

Family		Taxon Name
Zamiaceae		*Macrozamia riedlei*
Lauraceae		*Cassytha glabella*
Colchicaceae		*Burchardia congesta*
Iridaceae	*	*Gladiolus caryophyllaceus*
		Patersonia juncea
	*	*Romulea rosea*
Xanthorrhoeaceae		*Xanthorrhoea preissii*
Asparagaceae		*Laxmannia ramosa* subsp. *ramosa*
		Lomandra caespitosa
		Lomandra hermaphrodita
		Lomandra preissii
		Lomandra sericea
Hemerocallidaceae		*Agrostocrinum hirsutum*
		Agrostocrinum scabrum
		Tricoryne elatior
Haemodoraceae		*Anigozanthos manglesii*
		Conostylis aculeata subsp. *aculeata*
		Conostylis sp.
		Haemodorum discolor
		Haemodorum loratum (P3)
Cyperaceae		*Caustis dioica*
		Lepidosperma asperatum
		Lepidosperma pubisquameum
		Mesomelaena graciliceps
		Mesomelaena pseudostygia
		Mesomelaena tetragona
		Tetraria octandra
Restionaceae		*Desmocladus fasciculatus*
		Desmocladus flexuosus
Poaceae		*?Amphipogon debilis*
		Austrostipa ?hemipogon
		Austrostipa elegantissima
	*	*Avena barbata*
	*	*Briza maxima*
	*	*Ehrharta calycina*
		Neurachne alopecuroidea
		Rytidosperma setaceum

Family	Taxon Name
Proteaceae	*Banksia armata* var. *armata*
	Banksia bipinnatifida subsp. *multifida*
	Banksia dallanneyi var. *dallanneyi*
	Banksia sessilis
	Grevillea synapheae
	Hakea lissocarpha
	Hakea stenocarpa
	Hakea undulata
	Petrophile striata
	Stirlingia latifolia
Dilleniaceae	*Hibbertia hypericoides*
	Hibbertia sp.
	Hibbertia spicata subsp. *spicata*
	Hibertia hypericoides subsp. *septentrionalis*
Halorogaceae	*Glischrocaryon aureum*
	Gonocarpus cordiger
Fabaceae	*Acacia applanata*
	Acacia lasiocarpa subsp. *sedifolia*
	Acacia pulchella var. *pulchella*
	Bossiaea eriocarpa
	* *Chamaecytisus palmensis*
	Cristonia biloba subsp. *biloba*
	Daviesia decurrens
	Daviesia hakeoides subsp. *hakeoides*
	Daviesia preissii
	Dillwynia laxiflora
	Gastrolobium acutum
	Gompholobium marginatum
Polygalaceae	*Comesperma ciliatum*
Rhamnaceae	*Trymalium angustifolium*
Casuarinaceae	*Allocasuarina fraseriana*
	Allocasuarina humilis
Elaeocarpaceae	*Tetratheca nuda*
Phyllanthaceae	*Phyllanthus calycinus*
Proteaceae	*Isopogon asper*
Myrtaceae	*Calothamnus sanguineus*
	Corymbia calophylla
	Eucalyptus marginata
	Eucalyptus wandoo subsp. *wandoo*
	Hypocalymma angustifolium

Family		Taxon Name
Myrtaceae		*Lambertia multiflora* var. *darlingensis*
		Melaleuca clavifolia
Malvaceae		*Thomasia foliosa*
Thymeleaceae		*Pimelea imbricata* var. *piligera*
Primulaceae	*	*Lysimachia arvensis*
Rubiaceae		*Opercularia vaginata*
Stylidiaceae		*Stylidium affine*
		Stylidium piliferum
		Stylidium purpureum
Goodeniaceae		*Dampiera linearis*
		Goodenia caerulea
		Lechenaultia biloba
		Scaevola glandulifera
Asteraceae	*	*Hypochaeris glabra*
		Trichocline spathulata
	*	*Ursinia anthemoides*
Pittosporaceae		*Billardiera ?variifolia*
		Marianthus drummondianus

Appendix B

Sampling plot raw data

NB: Only taxa recorded within sampling plots included in table.

Taxon Name	Plot						
	M01	M02	M03	M04	M05	M06	HS01
?Amphipogon debilis	0.1	0.1	0	0	0	0	0
Acacia applanata	0.2	0.1	0	0	0	0.2	0
Acacia pulchella var. *pulchella*	0.4	0.5	0	0	0.3	0	0.5
Agrostocrinum hirsutum	0.3	0.2	0	0	0	0	0
Agrostocrinum scabrum	0	0	0	0	0	0	0.1
Allocasuarina fraseriana	1	0	0	0	0	0	0
Allocasuarina humilis	0.5	0	0	0	0.5	0	0
Austrostipa ?hemipogon	0	0.1	0	0	0	0	0
Austrostipa elegantissima	0	0.1	0	0	0	0	0
Avena barbata	0	0	10	0	0	0	0
Banksia armata var. *armata*	1	0	0	0	0	0.3	0
Banksia bipinnatifida subsp. *multifida*	0.2	0.3	0	0	0	0	0.5
Banksia dallanneyi var. *dallanneyi*	0.3	0.5	0	0	5	1	1
Billardiera ?variifolia	0	0	0	0	0	0	0.1
Bossiaea eriocarpa	1	1	0	0	4	2	1
Briza maxima	0.1	0	0	0	0	0.1	0.3
Burchardia congesta	0	0	0	0	0.3	0	0
Calothamnus sanguineus	0	0	0	0	0	0.5	0
Cassytha glabella	0.1	0.1	0	0	0.1	0	0.1
Caustis dioica	0	0	0	0	2	0	0
Chamaecytisus palmensis	0	0	3	0	0	0	0
Conostylis aculeata subsp. *aculeata*	0	0	0	0	0.2	0	0
Conostylis sp.	0	0	0	0	0.1	0	0
Corymbia calophylla	0	0	1	0	20	1	5
Daviesia decurrens	0	0	0	0	0.3	0	0
Daviesia hakeoides subsp. *hakeoides*	0.2	0.3	0	0	0	0	0
Desmocladus fasciculatus	0.7	0.3	0	0	0.5	0.3	0.5
Desmocladus flexuosus	0	0.2	0	0	0.5	0	0
Ehrharta calycina	0.1	0	20	0	0	0	0.5
Eucalyptus marginata	0	0	0	0	0	0.5	0
Eucalyptus wandoo subsp. *wandoo*	11	10	5	10	0	8	15
Gastrolobium acutum	2	0	0	0	0	0.3	8
Gladiolus caryophyllaceus	0.1	0	0	0	0.2	0.2	0.1
Gompholobium marginatum	0.2	0.2	0	0	0	0.2	0
Goodenia caerulea	0.1	0.1	0	0	0	0.1	0
Grevillea synapheae	0	0.2	0	0	0	0	0
Haemodorum loratum (P3)	0.2	0	0	0	0.3	0	0
Hakea lissocarpha	0.2	0.5	0	0	0.3	0.3	2
Hakea stenocarpa	0.5	0	0	0	0	0.5	0.5
Hakea undulata	0.7	1	0	0	0	0	0
Hibbertia hypericoides	0.5	1	0	0	0	0	0.3
Hibbertia sp.	0.2	0.3	0	0	0	0	0
Hibbertia spicata subsp. *spicata*	1	0	0	0	0	0	0
Hibertia hypericoides subsp. *septentrionalis*	1	1	0	0	1	1	1
Hypocalymma angustifolium	0	0	0	0	0	0.2	0
Hypochaeris glabra	0	0	0	0	0	0	0.1
Isopogon asper	0.3	0	0	0	0	0	0
Lambertia multiflora var. *darlingensis*	0	0	0	0	0.1	0	0
Laxmannia ramosa subsp. *ramosa*	0.1	0	0	0	0	0	0
Lechenaultia biloba	0	0.2	0	0	0	0.3	0.1

Taxon Name	Plot						
	M01	M02	M03	M04	M05	M06	HS01
Lepidosperma asperatum	0.1	0.2	0	0	1	0	0
Lepidosperma pubisquameum	0.3	0.5	0	0	0	1	0.5
Lomandra caespitosa	0	0	0	0	0	0	0.1
Lomandra hermaphrodita	0.2	0	0	0	0	0	0
Lomandra preissii	0	0	0	0	0	0	0.1
Lomandra sericea	0	0	0	0	0	0	0.1
Melaleuca clavifolia	0.2	0	0	0	0	0.3	0
Mesomelaena graciliceps	0	0	0	0	0.1	0	0
Mesomelaena pseudostygia	0	0	0	0	8	0	0
Mesomelaena tetragona	0.3	0	0	0	0	0	0
Neurachne alopecuroidea	0	0.1	0	0	0.1	0	0.1
Opercularia vaginata	0	0.1	0	0	0	0	0
Petrophile striata	0	0	0	0	0	0.3	0
Phyllanthus calycinus	0	0	0	0	0.2	1	0
Pimelea imbricata var. *piligera*	0	0.3	0	0	0	0	0
Stirlingia latifolia	0	0	0	0	0.3	0	0
Stylidium affine	0.1	0.1	0	0	0	0	0
Stylidium piliferum	0	0	0	0	0	0.1	0
Stylidium purpureum	0	0.1	0	0	0	0	0
Tetraria octandra	0.2	0.3	0	0	0	0.5	0.3
Tetratheca nuda	0	0	0	0	0	0	0.1
Trichocline spathulata	0.1	0.2	0	0	0	0.1	0.5
Tricoryne elatior	0	0	0	0	0	0.1	0.1
Trymalium angustifolium	0	0	0	0	0	0.1	0
Ursinia anthemoides	0	0	0	0	0	0	0.2
Xanthorrhoea preissii	4	6	2	0	4	5	2

Appendix C

Sampling Plot Environmental Data and Vegetation Structural Data

Plot	Date	Latitude	Longitude	Easting	Northing	UTM Zone	Aspect (classes)
M01	13/11/2019	-31.598258	116.0183277	406871.7153	6503674.938	50	S
M02	13/11/2019	-31.597675	116.0184214	406880.0246	6503739.64	50	SSW
M03	13/11/2019	-31.5987326	116.0177956	406821.7069	6503621.879	50	S
M04	13/11/2019	-31.5942336	116.017641	406802.5598	6504120.429	50	N/A
M05	13/11/2019	-31.5936641	116.0175812	406796.3191	6504183.503	50	N/A
M06	13/11/2019	-31.5967054	116.0165093	406697.6536	6503845.483	50	S
HS01	13/11/2019	-31.5967634	116.0159869	406648.1499	6503838.608	50	SW

Plot	Placement strategy	Plot Type	Plot Size (m^2)	Plot Width (m)	Plot Length (m)	Stand Age	Slope (%)
M01	Preferential	Quadrat	100	10	10	>3	3
M02	Preferential	Quadrat	100	10	10	>3	5
M03	Preferential	Recce	100	10	10	N/A	2
M04	Preferential	Recce	N/A	N/A	N/A	>3	0.5
M05	Preferential	Quadrat	100	10	10	>3	0
M06	Preferential	Quadrat	N/A	N/A	N/A	>3	3
HS01	Preferential	Quadrat	100	10	10	>3	3

Plot	Bare Ground (%)	Bare Rock (%)	Litter (%)	Landform	Soil Colour	Soil Texture	Rock Type
M01	2	N/A	35	Mid slope	Brown	Clay Loam	N/A
M02	5	N/A	40	Upper slope	Light brown	Loamy clay	N/A
M03	N/A	N/A	N/A	Lower slope	Brown	Gravelly loam	N/A
M04	50	N/A	25	Rehabilitation	Light brown	Loamy clay	N/A
M05	1	N/A	35	Flat	Light brown	Clay Loam	N/A
M06	5	N/A	25	Upper slope	Brown	Gravelly clay loam	N/A
HS01	1	N/A	55	Mid slope	Brown	Loam	N/A

Plot	Vegetation Condition	Cover Trees (%)	Cover Shrubs (%)	Cover Ground Layer (%)	Remarks
M01	Excellent	12	35	10	
M02	Excellent	10	30	15	
M03	Completely Degraded	N/A	N/A	N/A	
M04	Rehabilitation	N/A	N/A	N/A	
M05	Very Good	20	20	40	Some influence from drains
M06	Excellent	18	50	20	
HS01	Excellent	20	50	15	

Appendix B

Flora List

Lots 202-203 Wandena Rd and Lots 204-205 Great Northern Highway, Muchea
Consolidated Flora Species List
From 360 Environmental (2015) and Plantecology (2020)

Native Taxa
Acacia applanata
Acacia lasiocarpa subsp. sedifolia
Acacia pulchella var. pulchella
Acacia saligna
Agrostocrinum hirsutum
Agrostocrinum scabrum
Allocasuarina fraseriana
Allocasuarina huegeliana
Allocasuarina humilis
?Amphipogon debilis
Anigozanthos manglesii
Austrostipa ?hemipogon
Austrostipa elegantissima
Banksia armata var. armata
Banksia bipinnatifida subsp. multifida
Banksia dallanneyi var. dallanneyi
Banksia nivea
Banksia sessilis
Billardiera ?variifolia
Billardiera fraseri
Bossiaea eriocarpa
Burchardia congesta
Calothamnus sanguineus
Cassytha glabella
Caustis dioica
Comesperma ciliatum
Conostylis aculeata subsp. aculeata
Conostylis sp.
Corymbia calophylla
Cristonia biloba subsp. biloba
Cyathochaeta sp.
Dampiera alata
Dampiera linearis
Daucus glochidiatus
Daviesia decurrens
Daviesia hakeoides subsp. hakeoides
Daviesia preissii
Daviesia triflora
Desmocladus fasciculatus
Desmocladus flexuosus
Dillwynia laxiflora
Eucalyptus accedens
Eucalyptus marginata
Eucalyptus wandoo subsp. wandoo
Gastrolobium acutum
Gastrolobium capitatum

Glischrocaryon aureum
Gompholobium marginatum
Gonocarpus cordiger
Goodenia caerulea
Grevillea synapheae
Haemodorum discolor
Haemodorum loratum (P3)
Hakea lissocarpha
Hakea stenocarpa
Hakea undulata
Hibbertia hypericoides subsp. septentrionalis
Hibbertia sp.
Hibbertia spicata subsp. spicata
Hypocalymma angustifolium
Hypocalymma robustum
Isopogon asper
Lambertia multiflora var. darlingensis
Laxmannia ramosa subsp. ramosa
Lechenaultia biloba
Lechenaultia sp.
Lepidosperma asperatum
Lepidosperma leptostachyum
Lepidosperma pubisquameum
Lepidosperma sp.
Lomandra caespitosa
Lomandra hermaphrodita
Lomandra preissii
Lomandra sericea
Lomandra sonderi
Macrozamia riedlei
Marianthus drummondianus
Melaleuca clavifolia
Melaleuca sp.
Mesomelaena graciliceps
Mesomelaena pseudostygia
Mesomelaena tetragona
Neurachne alopecuroidea
Opercularia vaginata
Patersonia juncea
Petrophile macrostachya
Petrophile striata
Phyllanthus calycinus
Pimelea imbricata var. piligera
Pultenaea reticulata
Rytidosperma setaceum
Scaevola glandulifera
Stirlingia latifolia
Stylidium affine
Stylidium piliferum
Stylidium purpureum
Tetraria octandra
Tetratheca nuda
Thomasia foliosa
Trichocline spathulata

Tricoryne elatior
Trymalium angustifolium
Xanthorrhoea preissii

Introduced Taxa

*Avena barbata
*Briza maxima
*Chamaecytisus palmensis
*Cynodon dactylon
*Ehrharta calycina
*Eragrostis curvula
*Gladiolus caryophyllaceus
*Hypochaeris glabra
*Lupinus sp.
*Lysimachia arvensis
*Romulea rosea
*Ursinia anthemoides

Appendix C

Aboriginal Sites Search Report and DPLH Advice

Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

Search Criteria

1 Registered Aboriginal Sites in Coordinates - Area (ab site coords.csv) - 405602mE, 6504194mN (MGA50) : 406903mE, 6504201mN (MGA50) : 406974mE, 6503867mN (MGA50) : 406894mE, 6503635mN (MGA50) : 406882mE, 6503458mN (MGA50) : 406040mE, 6503450mN (MGA50)

Disclaimer

The *Aboriginal Heritage Act 1972* preserves all Aboriginal sites in Western Australia whether or not they are registered. Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist.

The information provided is made available in good faith and is predominately based on the information provided to the Department of Planning, Lands and Heritage by third parties. The information is provided solely on the basis that readers will be responsible for making their own assessment as to the accuracy of the information. If you find any errors or omissions in our records, including our maps, it would be appreciated if you email the details to the Department at AboriginalHeritage@dplh.wa.gov.au and we will make every effort to rectify it as soon as possible.

South West Settlement ILUA Disclaimer

Your heritage enquiry is on land **within or adjacent to** the following Indigenous Land Use Agreement(s): Whadjuk People Indigenous Land Use Agreement.

On 8 June 2015, six identical Indigenous Land Use Agreements (ILUAs) were executed across the South West by the Western Australian Government and, respectively, the Yued, Whadjuk People, Gnaala Karla Booja, Ballardong People, South West Boojarah #2 and Wagyl Kaip & Southern Noongar groups, and the South West Aboriginal Land and Sea Council (SWALSC).

The ILUAs bind the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Noongar Standard Heritage Agreement (NSHA) when conducting Aboriginal Heritage Surveys in the ILUA areas, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the NSHA when conducting Aboriginal Heritage Surveys in the ILUA areas. It is recommended a NSHA is entered into, and an 'Activity Notice' issued under the NSHA, if there is a risk that an activity will 'impact' (i.e. by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the NSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

Likewise, from 8 June 2015 the Department of Mines, Industry Regulation and Safety (DMIRS) in granting Mineral, Petroleum and related Access Authority tenures within the South West Settlement ILUA areas, will place a condition on these tenures requiring a heritage agreement or a NSHA before any rights can be exercised.

If you are a State Government Department, Agency or Instrumentality, or have a heritage condition placed on your mineral or petroleum title by DMIRS, you should seek advice as to the requirement to use the NSHA for your proposed activity. The full ILUA documents, maps of the ILUA areas and the NSHA template can be found at https://www.wa.gov.au/organisation/department-of-the-premier-and-cabinet/south-west-native-title-settlement.

Further advice can also be sought from the Department of Planning, Lands and Heritage at AboriginalHeritage@dplh.wa.gov.au.

Coordinate Accuracy

Coordinates (Easting/Northing metres) are based on the GDA 94 Datum. Accuracy is shown as a code in brackets following the coordinates.

Terminology (NB that some terminology has varied over the life of the legislation)

Place ID/Site ID: This a unique ID assigned by the Department of Planning, Lands and Heritage to the place.
Status:

- **Registered Site**: The place has been assessed as meeting Section 5 of the *Aboriginal Heritage Act 1972.*
- **Other Heritage Place which includes:**
  - **Stored Data / Not a Site:** The place has been assessed as not meeting Section 5 of the *Aboriginal Heritage Act 1972.*
  - **Lodged:** Information has been received in relation to the place, but an assessment has not been completed at this *stage* to determine if it meets Section 5 of the *Aboriginal Heritage Act 1972.*

Access and Restrictions:

- **File Restricted = No:** Availability of information that the Department of Planning, Lands and Heritage holds in relation to the place is not restricted in any way.
- **File Restricted = Yes:** Some of the information that the Department of Planning, Lands and Heritage holds in relation to the place is restricted if it is considered culturally sensitive. This information will only be made available if the Department of Planning, Lands and Heritage receives written approval from the informants who provided the information. To request access please contact AboriginalHeritage@dplh.wa.gov.au.
- **Boundary Restricted = No:** Place location is shown as accurately as the information lodged with the Registrar allows.
- **Boundary Restricted = Yes:** To preserve confidentiality the exact location and extent of the place is not displayed on the map. However, the shaded region (generally with an area of at least 4km²) provides a general indication of where the place is located. If you are a landowner and wish to find out more about the exact location of the place, please contact the Department of Planning, Lands and Heritage.
- **Restrictions:**
  - **No Restrictions:** *Anyone* can view the information.
  - **Male Access Only:** Only *males* can view restricted information.
  - **Female Access Only:** *Only* females can view restricted information.

Legacy ID: This is the former unique number that the former Department of Aboriginal Sites assigned to the place. This has been replaced by the Place ID / Site ID.

Basemap Copyright

Aboriginal Heritage Inquiry System

List of Registered Aboriginal Sites

ID	Name	File Restricted	Boundary Restricted	Restrictions	Status	Type	Knowledge Holders	Coordinate	Legacy ID
3525	ELLEN BROOK: UPPER SWAN	Yes	Yes	No Gender Restrictions	Registered Site	Mythological	*Registered Knowledge Holder names available from DAA	Not available when location is restricted	S02516

DS02 - 06/23

Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

Aboriginal Heritage Inquiry System

Map of Registered Aboriginal Sites

Attachment 1

For further important information on using this information please see the Department of Planning, Lands and Heritage's Disclaimer statement at https://www.dplh.wa.gov.au/about-this-website

Legend

- Registered Aboriginal Site
- Search Area
- Town
- Road
- River
- Local Government Authority

0.51 kilometres

Map Scale 1 : 15,500

MGA Zone 50 (GDA94)

Phil Bayley

From: Sammy Hamill [sammy.hamill@dplh.wa.gov.au]
Sent: Wednesday, 27 May 2020 3:36 PM
To: bayley@iinet.net.au

Subject: FW: Aboriginal Heritage Site enquiry
Attachments: Search Results Report and Map.pdf

Good afternoon Phil

Thank you for your enquiry to the Department of Planning, Lands and Heritage (DPLH) in regard to property in the Shire of Chittering comprising Lots 202-203 Wandena Rd and Lots 204-205 Great Northern Highway.

A review of the Register of Places and Objects as well as the DPLH Aboriginal Heritage Database concludes that the subject land intersects with the public boundary of Aboriginal site ID 3525 (ELLEN BROOK: UPPER SWAN) but not the boundary as administered by the DPLH. Therefore based on the information held by the DPLH and the Snipimage.jpg supplied by you, **no approvals under the *Aboriginal Heritage Act 1972* (AHA) are required.**

DPLH encourages proponents to refer to the State's Aboriginal Heritage Due Diligence Guidelines (Guidelines) which can be found on the DPLH website at the following link:

https://www.dplh.wa.gov.au/information-and-services/aboriginal-heritage/land-use-under-the-aha

The Guidelines will allow proponents to undertake their own risk assessment regarding any proposal's potential impact on Aboriginal heritage.

Regards

Sammy

Sammy Hamill | Heritage Support Officer | Aboriginal Heritage Operations
Globe Building, 497 Wellington Street, Perth WA 6000
(08) 6552 4524
www.dplh.wa.gov.au

The department is responsible for planning and managing land and heritage for all Western Australians – now and into the future

From: Aboriginal Heritage <AboriginalHeritage@dplh.wa.gov.au>
Sent: Tuesday, 19 May 2020 7:06 PM
To: Sammy Hamill <sammy.hamill@dplh.wa.gov.au>
Subject: FW: Aboriginal Heritage Site enquiry

For your action please.

Tanya Butler | Director Aboriginal Heritage Operations | Aboriginal Heritage Operations

Globe Building, 497 Wellington Street, Perth WA 6000
(08) 6551 8160 | 0427 998 365
www.dplh.wa.gov.au

The department is responsible for planning and managing land and heritage for all Western Australians – now and into the future

The department acknowledges the Aboriginal peoples of Western Australia as the traditional custodians of this land and we pay our respects to their Elders, past and present.

From: Phil Bayley <bayley@iinet.net.au>
Sent: Tuesday, 19 May 2020 3:53 PM
To: Aboriginal Heritage <AboriginalHeritage@dplh.wa.gov.au>
Subject: RE: Aboriginal Heritage Site enquiry

Sorry, forgot to attach the report.

PB

From: Phil Bayley [mailto:bayley@iinet.net.au]
Sent: Tuesday, 19 May 2020 3:53 PM
To: 'AboriginalHeritage@dplh.wa.gov.au'
Subject: Aboriginal Heritage Site enquiry

Hello,

I am working on a rezoning of a property in the Shire of Chittering comprising Lots 202-203 Wandena Rd and Lots 204-205 Great Northern Highway. The DPLH online Aboriginal Sites Database shows one registered Aboriginal site, 3525 Ellenbrook: Upper Swan, as present on the study site (see attached).

I'm aware that the online database mapping is deliberately vague and may not represent the actual boundaries of the registered site. Could you therefore advise whether the registered site actually does impinge on the study site?

Thanks and regards,

Phil Bayley
bayley environmental services
30 Thomas Street
SOUTH FREMANTLE 6162
tel: 08 9335 9160
fax: 08 9335 9160
mob: 0427 808 633
www.bayleyenvironmental.com.au

Appendix D

Local Water Management Strategy

LOTS 202 & 203 WANDENA ROAD
AND
LOTS 204 & 205 GREAT NORTHERN HIGHWAY
CHITTERING

LOCAL WATER MANAGEMENT STRATEGY

Prepared for

Focus Demolition Pty Ltd
and
Mr David Weightman Smith

Draft Report No. J19018b
18 May 2021

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

EXECUTIVE SUMMARY

The owners of Lots 202 & 203 Wandena Road and Lots 204 & 205 Great Northern Highway, Chittering (the site) have applied to the Shire of Chittering for the lots to be rezoned from Agricultural Resource to General Industry. The draft Muchea Industrial Park Structure Plan 2019 (MIPSP) shows Lots 204 and 205 as part of Precinct 2 (General Industry Core) and Lots 202 and 203 as part of Precinct 4 (Light Industry following completion of quarrying). The total area of the rezoning is approximately 82 hectares.

The MIPSP concept for Precincts 2 and 4 is for industries with a minimum lot size of one hectare, with effluent disposed on site using secondary treatment systems such as aerobic treatment units.

The Local Structure Plan for Lots 202-205 has been submitted to the Department of Planning, Lands & Heritage and the Shire of Chittering, and is currently being considered by those agencies.

EXISTING ENVIRONMENT

Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 6.5km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Physiography

The site extends from a very gently sloping plain in the west to low hills in the east. The elevation ranges from 58m AHD in the south-west to 101m AHD on the eastern boundary. The north-eastern quarter of the site, comprising Lot 202 and the northern half of Lot 203, is significantly higher and steeper than the rest of the site.

The site is located on the eastern edge of the Pinjarra Plain and the western colluvial outwash zone of the Dandaragan Scarp. The soils in the west are pebbly silts belonging to the Guildford Formation, which originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams. In the eastern part the soils are colluvial silty sands and sands, and Leederville Formation siltstone eroded from the scarp.

The permeability of the site soils will vary depending on the clay content. Test pumping during sampling of one on-site bore (WB3) indicated a hydraulic conductivity in the depth range of 2.6m to 5.1m in the order of 0.14 m/day. Constant-head testing by Douglas Partners (2020) at six sites at depths of 0.2 – 0.8 metres returned permeabilities ranging from 0.9 – 8.6 m/day, with a mean of 3.3 m/day and a median of 4.75 m/day.

For preliminary drainage and effluent design purposes, a conservative permeability of 1 m/day has been assumed.

The DBCA maps the site as Low to Nil risk of Acid Sulphate Soils (ASS). The nearest mapped High ASS risk area is a palusplain about 600m to the south.

Bore sampling between July 2016 and September 2020 found no significant indications of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary.

Hydrology

Groundwater occurs at shallow depth across the lower-lying western parts of the site (Lots 204 and 205) in winter. The depth to groundwater varies from over 18 metres in the east of the site to less than two metres in winter in the west. The DWER maps minimum groundwater levels at 48-53m AHD (13-48m below ground), flowing south-west towards Ellen Brook.

In wet winters, rainfall infiltration may be impeded by the low-permeability soils, creating temporary surface saturation in the lower parts of the site. There is no evidence in the water measurements or soil profiles of the occurrence of a seasonally perched water table.

There are no natural defined drainage channels within the site, although several artificial drains have been cut in and around the quarry on Lots 202 and 203. The relatively low permeability soils of the soils would result in sheet flow across the ground surface during high rainfall events.

Water enters the project area from one 36ha external catchment to the east via a culvert beneath Wandena Road. This water flows into a sump within Lot 202, which overflows to a farm dam on the adjoining lot and then into a drain that flows west to Great Northern Highway and ultimately into Ellen Brook.

All drainage from the site flows eventually into Ellen Brook, the major drainage feature of the region.

The project area is within the Eclipse Hill sub-area of the Gingin Groundwater Area for the surficial and superficial aquifers, the Southern Scarp sub-area for the semi-confined (Mirrabooka) aquifer, the Cowalla sub-area for the confined Leederville-Parmelia aquifer and the Chandala sub-area for the Yarragadee aquifer.

Under the plan Gingin Groundwater Areas Allocation Plan (DoW, 2015), the Eclipse Hill (superficial), Southern Scarp (Mirrabooka) and Cowalla (Leederville) sub-areas are over-allocated and no new allocations are available.

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows one groundwater licence for Lot 205 (GWL 152031, expiring November 2023), which is licensed to abstract up to 1,500 KL/yr from the Leederville aquifer via a bore on the adjacent Lot 206.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally low to moderate

The groundwater shows mostly low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are mostly low except for aluminium and zinc, which are slightly elevated across much of the site.

Vegetation

The project area is largely cleared of native vegetation, consisting mostly of farm paddocks and current and former quarries. All of Lot 204, most of Lot 205 and the southern part of Lot 203 are cleared paddocks with some scattered mature trees, either native or planted. Native vegetation is present in the central east of Lot 205, the northern end of Lot 202 and the north of Lot 203. The site does not contain any vegetation dependent on wetlands or shallow groundwater.

Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965. Quarrying has been underway on Lots 202 and 203 since before 1977.

The DWER Contaminated Sites Database shows no record of any contaminated sites in the project area.

The former clay quarry on Lots 202 and 203 is currently being backfilled with inert waste such as building rubble prior to rehabilitation. The backfilling and rehabilitation are being undertaken under the terms of a DWER Licence (L9181/2018/1), which carries conditions including control of waste acceptance and prevention of pollution.

WATER USE SUSTAINABILITY

Water will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, particularly within Precinct 4 (Lots 204-205), as industries within this precinct will be restricted to those with low water usage.

Potable water will be supplied to the project area by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the project area is likely to be necessary. The landowners will negotiate with existing licence holders within and outside of the project area with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course.

Precinct 2 (Lots 204-205) will be designed as a low-water-use precinct. Only industries with low water consumption will be permitted in this precinct. Precinct 4 (Lots 202-203) will accommodate general industry with less restrictions on water use or wastewater generation; however, industries will need to demonstrate that they can safely dispose of waste water on site. Water use will effectively be restricted by the limited availability and corresponding cost of groundwater in the area.

Potable water use within the project area will be limited to consumption for domestic use in toilets, bathrooms and kitchens. Cossill & Webley (2018) estimated total potable water demand for Lots 202-205 at 96ML per year, based on a study by GHD for the Karratha Gap Industrial Estate.

Groundwater will be used mainly for irrigation of landscape plantings and swales. These areas will be irrigated only during the establishment stage (one or two years). The Landscape Master Plan estimates total plantings of 13.7ha of sedges, shrubs and trees within the project area.

ON-SITE EFFLUENT DISPOSAL

All effluent generated within the subdivision will be treated and disposed by means of individual on-site effluent disposal systems. All lots in low-lying areas will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems (e.g. Filtrex). Lots in higher areas or with deeper groundwater may employ conventional septic systems and leach drains.

The ATU irrigation area or leach drain length on each lot will be sized to suit the expected population of the lot. The effluent disposal requirements of each lot will vary depending on the soil profile, groundwater depth, risk of saturation and expected site population. Site testing on each lot prior to development will be required to determine the location and type of effluent disposal system.

STORMWATER MANAGEMENT STRATEGY

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at or below their pre-development levels.

The existing drainage line entering at the north-east of Lot 202 will be realigned and consolidated in a vegetated swale within a road reserve. The swale will be sized to accommodate the flow from a 100-year ARI critical storm from both the upstream and internal catchments.

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, basins and/or landscaping areas. The in-lot drainage structures will also be sized to capture and detain the runoff from roofs, paved surfaces and hardstand areas from critical storms up to 100-year ARI.

Overflows from the basins will run into roadside bioretention swales, either directly or via drainage easements for those lots that do not have a downslope road frontage. Lots will be filled as necessary adjacent to the roads to enable lot drainage to enter the roadside swales.

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The inverts of the swales will be at or above the AAMGL. The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm.

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where it will enter the roadside drains and culverts on Great Northern Highway. The rate and volume of drainage out of the site will be controlled to be no greater than those existing before development.

The drainage from the site flows beneath Great Northern Highway via five culverts. The culverts have sufficient capacity to carry the flow from a 100-year ARI critical storm without upstream ponding.

Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.

- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15.

- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out.

GROUNDWATER MANAGEMENT STRATEGY

The drainage system for the site is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their inverts at or above the AAMGL. Subsoil drainage within lots will be limited to filled areas used for buildings or effluent disposal.

Subsoil drainage may be employed within some lots where necessary to maintain existing maximum groundwater levels beneath building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales via free-draining outlets.

Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement.

All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of the site will be minimal.

Groundwater quality will be protected by measures including:

- regular street sweeping to remove accumulated contaminants; and
- selection of native species with low water and fertiliser requirements for public open space and landscape areas.

LANDSCAPING STRATEGY

Landscaping of the site will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot), effluent irrigation areas and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted.

The plantings in swales, basins and effluent irrigation areas will include a high proportion of species recommended in the Monash University (2014) *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia*.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation-tolerant species including sedges and low shrubs in order to stabilise the basins and maximise their ability to take up nitrogen from the water.

MONITORING

Groundwater levels and quality will be monitored and compared against baseline levels and relevant guidelines. Water quality in surface drains will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Further planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) will be prepared as a condition of subdivision approval for each stage of subdivision. The UWMP will present the detailed design of the stormwater drainage system within that stage.

The developer of each stage of subdivision will maintain the drainage system, landscaped areas and water monitoring program within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for monitoring and management will be handed over to the Shire of Chittering.

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1.0 INTRODUCTION

1.1 Background

The owners of Lots 202 & 203 Wandena Road and Lots 204 & 205 Great Northern Highway, Chittering (the site) have applied to the Shire of Chittering for the lots to be rezoned from Agricultural Resource to General Industry. The draft Muchea Industrial Park Structure Plan 2019 (MIPSP) shows Lots 204 and 205 as part of Precinct 2 (General Industry Core) and Lots 202 and 203 as part of Precinct 4 (Light Industry following completion of quarrying). Figure 1 shows the location of the site within the draft Muchea Industrial Park Structure Plan area.

The total area of the rezoning is approximately 82 hectares. Figure 2 shows the boundaries of the site. Figure 3 shows a preliminary conceptual plan of subdivision.

The MIPSP concept for Precincts 2 and 4 is for industries with a minimum lot size of one hectare, with effluent disposed on site using secondary treatment systems such as aerobic treatment units.

The Local Structure Plan for Lots 202-205 has been submitted to the Department of Planning, Lands & Heritage and the Shire of Chittering, and is currently being considered by those agencies.

1.2 Previous Studies

1.2.1 Water Management Strategy – Muchea Employment Node

A Water Management Strategy (WMS) was prepared by Connell Wagner in 2008 in support of the District Structure Plan for the Muchea Employment Node. The WMS documented the existing environment of the MEN in broad terms, including soils and geology, topography, hydrology, vegetation and land uses. The WMS examined:

- the possible impacts of development on surface water and groundwater
- water demand and supply options;
- wastewater treatment and disposal, including leach drains, evaporation ponds and reuse.

The WMS recommended, among other things:

- Groundwater monitoring over at least two winter seasons should be undertaken to provide information on groundwater levels and quality.

- The preferred method of effluent disposal, based on desktop studies, was treatment by Aerobic Treatment Units (ATU) followed by disposal in evaporation ponds.

- Development should be set back from waterways in accordance with Water and Rivers Commission Note 23: *Determining Foreshore Reserves* (2001), with a default minimum setback of 30m.

- Stormwater runoff from lots and roads should be managed by infiltration and detention so that the runoff from a 1-year 1-hour storm is retained and infiltrated, and that peak flows from critical storms up to 100-year ARI are limited to pre-development rates.

- Water sensitive urban design measures should be implemented to meet catchment water quality targets as set out in the Swan-Canning Water Quality Improvement Plan (2009).

1.2.2 Regional Water Management Strategy – Muchea

The Muchea Regional Water Management Strategy (RWMS) was prepared by Emerge Associates for the Department of Planning, Lands & Heritage in 2019. The RWMS deals with the entire Muchea Employment Node, covering an area of 6,580 hectares.

The RWMS identifies environmental values, documents the hydrological regime and identifies requirements for wastewater management. The RWMS recommends further assessments prior to development including geotechnical, flora and fauna, wetlands, waterways, land capability and flooding.

1.3 Relevant Guidelines and Policies

1.3.1 State Planning Policy 2.9

State Planning Policy 2.9: *Water Resources* (WAPC, 2006) lists the following key principles for total water cycle management:

- Consideration of all water sources (including wastewater) in water planning, maximising the value of water resources.

- Integration of water and land use planning.

- Sustainable and equitable use of all water sources, having consideration of the needs of all water users including the community, industry and the environment.

- Integration of water use and natural water processes.

- A whole-of-catchment integration of natural resource use and management.

SPP 2.9 also lists the following general objectives for water-sensitive urban design:

- to manage a water regime;

- to maintain and, where possible, enhance water quality;
- to encourage water conservation;
- to enhance water-related environmental values; and
- to enhance water-related recreational and cultural values.

Element 5 of *Liveable Neighbourhoods* Edition 3 (WAPC, 2004) identifies specific objectives and requirements for Urban Water Management. These are based on Best Planning Practices which are defined as the best practical approach for achieving water resource management objectives within an urban framework.

1.3.2 Better Urban Water Management

Better Urban Water Management (WAPC, 2008) sets out the following objectives for water sensitive urban design:

Water Conservation

- Consumption of 100kL/p/yr including less than 40-60 kL/p/yr scheme water.

Water Quantity

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.
- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

Water Quality

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).
- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.
- As compared to a development that does not actively manage stormwater quality, achieve:
  - at least 80% reduction of Total Suspended Solids;
  - at least 60% reduction of Total Phosphorus;
  - at least 45% reduction of Total Nitrogen; and
  - at least 70% reduction of gross pollutants.

Mosquitoes and Midges

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DWER) to maximise predation of mosquito larvae by native fauna.

1.3.3 <u>Shire of Chittering Town Planning Scheme No. 6</u>

"The following development requirements shall apply to the development and subdivision of land within industrial zones and to industrial land uses –

(a) the effect on the environment by means of discharge of pollutants or contaminants into the air, ground and water be avoided, or managed within acceptable limits;

(b) where an on-site wastewater disposal system is proposed –

i. land capability assessment may be required to demonstrate the capability of the site to manage wastewater and the suitability of the proposed system;
ii. the use of fill and drains to achieve the required separation from groundwater is to be limited; and
iii. a suitable and unencumbered land application area is to be set aside to distribute treated sewage, where required;

(c) within sewerage sensitive areas secondary treatment systems with nutrient removal are to be utilised;

(d) notwithstanding any other provisions of this scheme, industrial development not connected to reticulated sewerage (for treatment on-site or off-site) is to be restricted to 'dry industry' being land uses that intend to dispose of wastewater on site to the environment of a kind and volume ordinarily discharged from a habitable building at a daily volume of less than 540 litres per 1,000m^2 of the site area [R10 equivalent];

(e) where trade waste is to be managed and/or disposed of on-site or off-site the associated risks must be identified and addressed, including the vulnerability of the receiving environment where relevant."

Schedule 11 of the Scheme contains the following provisions that apply to the Muchea Employment Node:

"2.2 Environmental Management Plans

The following Environmental Management Plans shall be prepared and used to inform the design and proposed subdivision and development within the Structure Plan area. They shall be submitted as an additional detail of a Structure Plan unless otherwise determined by the Western Australian Planning Commission.

2.2.1 Local Water Management Strategy

The developer shall submit to the Local Authority a Local Water Management Strategy (LWMS) for approval as an additional detail of a Structure Plan pursuant to clause 5.19 in order to ensure that surface and ground waters are managed with the aim of maintaining the natural water balance. The Local Authority must notify and consult with the authority responsible for water and the environment on the proposed strategy in advertising the Local Structure Plan(s) pursuant to Part 4 of the deemed provisions.

The LWMS shall be prepared in accordance with Better Urban Water Management or its successor document.

The Structure Plan design shall respond to the LWMS required by 2.2.1 and shall be implemented to the satisfaction of the Local Authority, having regard to any advice from the Department of Water."

1.3.4 Government Sewerage Policy

The Government Sewerage Policy (2019) requires that all new subdivision and development should be deep-sewered unless exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and, where appropriate, density limits. In these cases, on-site effluent disposal may be approved where the responsible authority is satisfied that:

- each lot is capable of accommodating on-site sewage disposal without endangering public health or the environment; and
- the minimum site requirements for on-site sewage disposal as set out in the Policy can be met.

The Policy designates certain areas as Sewage Sensitive Areas (SSAs), including land:

- within the coastal catchment of the Swan Estuary; and
- within 1km upgradient or 250m downgradient (or overall 1km where the groundwater gradient is unknown) of a significant wetland.

Additional restrictions and requirements apply to on-site effluent disposal in SSAs, including:

- a minimum lot size of one hectare (unless exempted on a case-by-case basis);
- minimum vertical separation of 1.5m from the discharge point of effluent disposal systems to the highest groundwater table level; and
- secondary effluent treatment systems with nutrient removal.

The Policy shows all of Lots 203 and 204, most of Lot 205 and the southern part of Lot 202 within an SSA associated with the Ellen Brook catchment. Lot 203, the southern part of Lot 205 and the northern half of Lot 202 are also shown within SSAs associated with significant wetlands. Figure 1 shows the mapped SSAs.

In the case of Lot 202 and the north-east of Lot 205, the SSA mapping is considered to be erroneous. The wetland in question (a Conservation category dampland) is located upgradient of the site, is maintained by surface flow and/or locally perched groundwater (the mapped permanent groundwater table is 45-50m below the ground surface) and is separated from the site by several watercourses, drains and deep excavations, so that there is no possibility of groundwater flow from the site to the wetland. This matter is examined further in Section 4.1.

1.3.5 DoW Operational Policy 4.3: Identifying and Establishing Waterways Foreshore Areas

DoW Operational Policy 4.3 was published in 2012 and sets out the Department of Water's policy on defining and protecting foreshore reserves. It is intended to apply to all natural waterways within development areas. The policy sets out procedures for identifying, delineating and protecting foreshore areas.

The procedure may vary depending on the size and nature of the waterway and the nature of the proposed adjacent development. The policy provides for standard or nominal foreshore widths to be employed in some cases, such as small subdivisions and/or minor tributary creeks where the waterway is adequately protected and the proposed development poses an insignificant additional risk to the waterway.

1.3.6 DoW Interim Guideline: Developing a Local Water Management Strategy

The DoW LWMS guideline was published in 2008 and sets out the DoW's preferred format and content for LWMS documents. The guideline expands on the LWMS guidance provided in *Better Urban Water Management* (2008).

This LWMS has been prepared in accordance with the principles set out in the DoW guideline. Appendix A shows a completed checklist from the DWER guideline.

1.4 Scope of the LWMS

The scope of this LWMS is to:

- Document the existing environment on the site, in relation to soils, drainage, erosion, watercourses, groundwater and water-dependent ecosystems.

- Briefly describe the proposed development in relation to water management.

- Examine the capability of the site for on-site effluent disposal.
- Address relevant regulatory requirements and design criteria for water harvesting, setbacks to watercourses, groundwater management and drainage.
- Describe the strategies to be implemented for water conservation, watercourse protection, groundwater management and stormwater drainage.
- Outline the proposed monitoring program.
- Outline what is to be addressed in future Urban Water Management Plans.

1.5 Design Objectives

Table 1.1 summarises the water-related design objectives for Lots 202-205 and the means by which they will be achieved in the LWMS and subsequent management plans.

Table 1.1 Design Objectives

Design Aspect	*Design Objective*	*How Objective is to be Achieved*
Water Conservation	Ensure efficient and sustainable use of water resources	Only low water use industries permitted in Precinct 2 (Lots 204-205). Use water efficient fixtures. Limit wastewater generation in Precinct 2 to 5.4 KL/ha/day. Use non-potable water for irrigation. Purchase groundwater licence(s) from existing holders within or outside the project area. Use water-efficient native species for landscaping. Irrigate landscape plantings only for 2 years.
Groundwater Management	Minimise impacts on groundwater level and flows Minimise impacts on groundwater quality	Subsoil drains set at or above pre-existing AAMGL, with fill used to provide additional clearance if required. Finished floor levels of habitable buildings set at least 0.5m above controlled groundwater level. Treat runoff from minor storms in bioretention swales. Minimise fertiliser and chemical use in landscaping areas. Use nutrient-removing alternative treatment systems for effluent disposal.
Surface Water Management	Minimise impacts on surface water flow rates, volumes and quality	Retain and infiltrate runoff from 1-year ARI 1-hour storms in bioretention swales. Detain runoff from larger storms and control release from lots and overall site to pre-development flow rates. Convey existing flows through the site in roadside swales at pre-development rates. Set effluent disposal facilities at least 100m back from natural waterways. Sweep streets regularly to remove accumulated contaminants.

2.0 EXISTING ENVIRONMENT

2.1 Rainfall

Muchea, like the rest of the greater Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Pearce RAAF Base (located 6.5km south of the site) is 679.7mm, of which 77% falls between the months of May and September.

Figure 4 shows a rainfall occurrence chart for Pearce RAAF. Table 2.1 shows rainfall intensity, frequency and duration for Muchea.

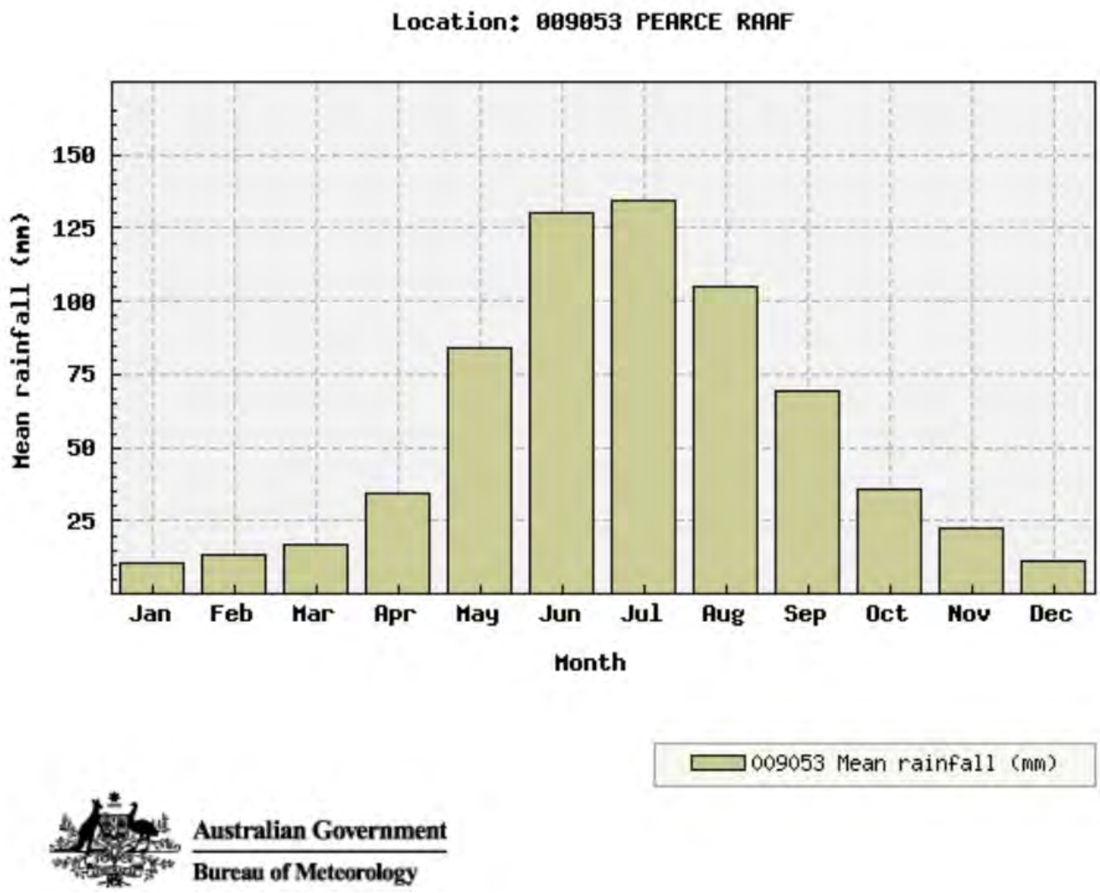

Figure 4 Pearce RAAF Mean Rainfall

IFD Design Rainfall Depth (mm)

Issued: 31 October 2018

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.51	1.68	2.26	2.69	3.14	3.77	4.29
2 min	2.61	2.89	3.82	4.49	5.18	6.18	7.00
3 min	3.52	3.90	5.17	6.11	7.07	8.47	9.62
4 min	4.28	4.75	6.34	7.50	8.72	10.5	11.9
5 min	4.92	5.48	7.34	8.71	10.1	12.2	13.9
10 min	7.23	8.07	10.9	13.0	15.2	18.2	20.8
15 min	8.75	9.76	13.2	15.7	18.3	22.0	25.1
20 min	9.90	11.0	14.9	17.7	20.6	24.8	28.2
25 min	10.8	12.1	16.2	19.3	22.5	27.0	30.7
30 min	11.6	13.0	17.4	20.7	24.0	28.8	32.8
45 min	13.6	15.1	20.1	23.9	27.7	33.3	37.9
1 hour	15.1	16.7	22.2	26.4	30.7	36.9	42.1
1.5 hour	17.4	19.3	25.6	30.4	35.4	42.8	49.1
2 hour	19.3	21.3	28.3	33.6	39.4	47.8	55.1
3 hour	22.3	24.6	32.7	39.0	45.9	56.3	65.2
4.5 hour	25.8	28.5	37.9	45.4	53.8	66.4	77.6
6 hour	28.7	31.6	42.1	50.6	60.1	74.7	87.7
9 hour	33.1	36.5	48.7	58.7	70.0	87.5	103
12 hour	36.6	40.3	53.9	65.0	77.5	96.9	114
18 hour	42.0	46.3	61.7	74.2	88.1	110	129
24 hour	46.1	50.8	67.5	80.8	95.3	118	138
30 hour	49.5	54.5	72.1	85.8	101	124	143
36 hour	52.4	57.7	75.9	89.8	105	128	147
48 hour	57.2	62.9	82.1	96.1	111	133	152
72 hour	64.9	71.2	91.5	106	120	141	158
96 hour	71.4	78.2	99.4	114	128	148	164
120 hour	77.4	84.6	107	122	136	157	173
144 hour	83.4	91.0	115	131	146	168	185
168 hour	89.4	97.3	123	140	157	181	200

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

Table 2.1 Rainfall Intensity for Muchea

2.2 Physiography

2.2.1 Topography

The site extends from a very gently sloping plain in the west to low hills in the east. The elevation ranges from 58m AHD in the south-west to 101m AHD on the eastern boundary. The north-eastern quarter of the site, comprising Lot 202 and the northern half of Lot 203, is significantly higher and steeper than the rest of the site.

The slope is generally to the south-west, with gradients ranging from less than 1% in the north-west to over 40% in places on the eastern boundary. Excavation in the quarry on Lots 202 and 203 has produced some steeper gradients, but these are expected to be reduced in the filling and rehabilitation of the quarry. Figure 5 shows the existing topography of the site.

2.2.2 Geology, Landforms and Soils

The site is located on the eastern edge of the Pinjarra Plain and the western colluvial outwash zone of the Dandaragan Scarp. The soils in the west are pebbly silts belonging to the Guildford Formation, which originated as alluvial deposits washed from the Dandaragan Plateau by rivers and streams. In the eastern part the soils are colluvial silty sands and sands, and Leederville Formation siltstone eroded from the scarp.

The Guildford Formation soils are described by the Geological Survey of Western Australia (Gozzard, 1982) as “Mgs_1: Strong brown silt with common fine to occasionally coarse grained, sub-rounded quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvial origin”.

The colluvial soils are described as:

- “Msg: Strong brown, firm, friable, dispersive in part, occasional pebbly horizons with little matrix, containing quartzite, quartz, granite, laterite of colluvial origin”;
- “S_5: Very pale brown, medium to coarse-grained, well sorted, little fines, sub-angular to rounded quartz and feldspar, of colluvial origin”; and
- “S_6: Light grey, fine to coarse, angular to sub-rounded, quartz with some feldspar, moderately sorted, loose, of colluvial origin”.

The Leederville Formation siltstone in the north-east is described as “ST_1: White, thinly bedded, well laminated, fine-grained, some large ferruginous concretions and laminae, occasionally micaceous”.

Drilling by BES at four sites on Lots 204 and 205 in March 2020 showed a pebbly silty sand to pebbly silty clay profile in the top 5.5m, which corresponds to the GSWA description for the Guildford Formation. Previous drilling by Bowman & Associates Pty Ltd (2016) at four sites on Lots 202 and 203 found a silty clay profile with ironstone commonly occurring at between 5m and 18m, which corresponds generally with the GSWA descriptions for Leederville Formation and colluvium.

Figure 5 shows the site geology. Soil logs from the drilling are attached in Appendix B.

2.2.3 Soil Permeability

The permeability of the site soils will vary depending on the clay content. Test pumping during sampling of one on-site bore (WB3) indicated a hydraulic conductivity in the depth range of 2.6m to 5.1m in the order of 0.14 m/day. The permeability of the top 2m of the soil profile is expected to be higher.

Douglas Partners (2020) undertook constant-head permeability testing at six sites at depths of 0.2 – 0.8 metres. The tests returned permeabilities ranging from 0.9 – 8.6 m/day, with a mean of 3.3 m/day and a median of 4.75 m/day. The geotechnical report is attached in Appendix C.

For preliminary drainage and effluent design purposes, a conservative permeability of 1 m/day has been assumed. Further constant-head permeability tests in accordance with the method set out in Australian Standard AS1547:2012: – *On-site Domestic Wastewater Management* will be undertaken prior to subdivision.

2.2.4 Acid Sulphate Soils

The DBCA maps the site as Low to Nil risk of Acid Sulphate Soils (ASS). The nearest mapped High ASS risk area is a palusplain about 600m to the south.

Bore sampling between July 2016 and September 2020 found no significant indications of potential or actual ASS in the groundwater. No further investigation of ASS is considered to be necessary.

2.2.5 Phosphorus Retention Index

Previous experience has shown that the gravelly and silty clay soils of the Guildford Formation and other alluvial and colluvial soils generally have moderate to very high PRI.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

PRI Range	*Rating*	*Typical soils*
0 – 0.5	Very Low	Bassendean Sand
2 – 4	Low – Moderate	Karrakatta Sands
5 – 12	Moderate – High	Cottesloe Sands
12 – 20	High	Crushed Limestone, Limesand
20 – 1000+	Very High	Clay

The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins and swales. The site soils are expected to meet or exceed this requirement. PRI testing of soils beneath proposed infiltration basins will be undertaken before subdivision.

2.3 Hydrology

2.3.1 Groundwater

Groundwater occurs at shallow depth across the lower-lying western parts of the site (Lots 204 and 205) in winter. The depth to groundwater varies from over 18 metres in the east of the site to less than two metres in winter in the west. The DWER maps minimum groundwater levels at 48-53m AHD (13-48m below ground), flowing south-west towards Ellen Brook.

In wet winters, rainfall infiltration may be impeded by the low-permeability soils, creating temporary surface saturation in the lower parts of the site. There is no evidence in the water measurements or soil profiles of the occurrence of a seasonally perched water table.

Groundwater measurements in 14 bores in and around the site in August 2020 (Figure 6), during a drier than average winter, gave the water depths and levels shown in Table 2.2. Appendix D shows all groundwater measurements collected from the site since 2004.

Simultaneous measurements of DWER bores located 680m south (Swan GWA 2-98) and 800m north (Gnangara Monitoring GD20) enabled Average Annual Maximum (AAMGL) and Maximum (MGL) groundwater levels at the site to be calculated. Figure 6 shows the calculated AAMGL and depth to AAMGL contours across the site. Figure 7 shows the hydrographs of the DWER bores.

Table 2.2 shows that the groundwater levels measured on 21 August 2020 were about 0.4m below the AAMGL. The winter of 2020 was drier than average, and the levels measured on 21 August are considered to approximate the peak for the year.

Table 2.2 shows that the AAMGL is within one metre of the ground surface in parts of the north-west and south-west of the site. However, the pattern of groundwater levels is not uniform: Bore WB1 on the western boundary has an indicated depth to the AAMGL of over 4.5m.

Table 2.2 also suggests that the MGL will intersect the ground surface in the north-west and south-west of the site.

Table 2.2 Groundwater Depths and Levels 21 August 2020

Bore	*Depth (mbgl)*	*Level (m AHD)*	*AAMGL (m AHD)*	*MGL (m AHD)*	*Depth to AAMGL (m)*	*Depth to MGL (m)*
MW1	>17.44	<74.76	<75.19	<75.77	>17.01	>16.43
MW2	16.14	78.26	78.69	79.27	15.63	15.05
MW3	12.55	70.67	71.10	71.68	12.12	11.54
MW4	14.45	64.33	64.76	65.34	14.02	13.44
WB1	>4.68	<56.55	<56.98	<57.56	>4.25	>3.67
WB2	>4.98	65.89	<66.32	<66.90	>4.55	>3.97
WB3	1.58	67.51	67.94	68.52	1.15	0.57
WB4	2.34	59.53	59.96	60.54	1.91	1.33
TB7	1.14	57.26	57.69	58.27	0.71	0.13
TB8	1.11	64.14	64.57	65.15	0.68	0.10
TB9	0.56	74.24	74.67	75.25	0.13	-0.45
MB5	0.77	56.02	56.45	57.03	0.34	-0.24
MB7	0.65	54.86	55.29	55.87	0.22	-0.36
GD20	0.88	60.6	59.85	61.35	1.63	0.13
2-98	2.12	56.17	56.6	57.18	1.69	1.11

2.3.2 Surface Drainage

There are no natural defined drainage channels within the site, although several artificial drains have been cut in and around the quarry on Lots 202 and 203. The relatively low permeability soils of the soils would result in sheet flow across the ground surface during high rainfall events.

Water enters the project area from one 36ha external catchment to the east via a culvert beneath Wandena Road. This water flows via a constructed drain into a sump within Lot 202, which overflows to a farm dam on the adjoining lot and then into a drain that flows west to Great Northern Highway and ultimately into Ellen Brook. The land to the east is expected to remain as farmland for the foreseeable future, so this water inflow is not expected to change significantly in rate, volume or quality.

All drainage from the site flows eventually into Ellen Brook, the major drainage feature of the region. The Ellen Brook catchment is the largest sub-catchment of the Swan-Canning River system, contributing 6% of the total annual flow, and is the largest single contributor of nutrients to the system (WA Govt, 2011).

Ellen Brook has a surface catchment of 715km^2 (WRC, 2012). The Brook rises as Chandala Brook about 22km north-northwest of the site. The Brook is seasonal, flowing generally between May and November with an annual flow ranging from 2.1 to 48.6 GL (SRT, 2009).

2.3.3 Water Resources

The project area is within the Eclipse Hill sub-area of the Gingin Groundwater Area for the surficial and superficial aquifers, the Southern Scarp sub-area for the semi-confined (Mirrabooka) aquifer, the Cowalla sub-area for the confined Leederville-Parmelia aquifer and the Chandala sub-area for the Yarragadee aquifer. Groundwater allocations within the Gingin Groundwater Area are managed under the Gingin Groundwater Areas Allocation Plan (DoW, 2015).

Under the plan (as of 2015), the Eclipse Hill (superficial), Southern Scarp (Mirrabooka) and Cowalla (Leederville) sub-areas are over-allocated and no new allocations are available.

The DWER Water Register (https://maps.water.wa.gov.au/#/webmap/register) shows one groundwater licence for Lot 205 (GWL 152031, expiring November 2023), which is licensed to abstract up to 1,500 KL/yr from the Leederville aquifer via a bore on the adjacent Lot 206.

2.4 Water Quality

2.4.1 Groundwater

Groundwater samples have been collected from 13 bores within and around the site on various occasions since 2016. The sampling and analysis results are summarised in Tables 2.3 , 2.4 and 2.5.

Groundwater quality within the project area is moderate, which is to be expected given the soil types and the history of agriculture. Nitrogen and phosphorus concentrations are generally low to moderate

The groundwater shows mostly low acidity and sulphate contents, indicating that there is no evidence of acid sulphate soils. Dissolved metals concentrations are mostly low except for aluminium and zinc, which are slightly elevated across much of the site.

2.4.2 Surface Water

There was no flowing surface water anywhere on the subject land during any of the site inspections, so no surface water quality data for the site are available.

Table 2.3 Groundwater Quality – Physico-Chemical Parameters

Bore (Figure 6)	*Date*	*pH*	*EC (ms/m)*	*Salinity (ppm)*	*Hardness (mg/l $CaCO_3$)*	*Acidity (mg/L $CaCO_3$)*	*Alkalinity (mg/L $CaCO_3$)*	*Acidity/Alkalinity Ratio*	*Cl (mg/L)*	*SO_4 (mg/L)*	*Cl/SO_4 Ratio*
MW1	12/7/16	**3.9**	4.72			96	< 20	>4.8	1700	58	29.3
	2/9/16	**4.6**	2.8						430	190	2.3
	28/9/16	**4.5**	2.8						430	200	2.2
	22/11/16	**4.3**	2.8						500	600	0.8
	12/1/18	**4.3**	2.7						720	210	3.4
	30/5/19	**4.40**	2.30						420	570	0.7
MW2	12/7/16	**4.6**	2.8			59	< 20	>2.95	430	190	2.3
	2/9/16	**3.9**	5.8						1700	57	29.8
	28/9/16	**3.8**	5.7						1400	57	24.6
	22/11/16	**4.3**	5.5						1600	170	9.4
	12/1/18	**3.9**	5.5						1900	59	32.2
	30/5/19	**3.9**	4.70						1700	190	8.9
MW3	12/7/16	**5.8**	7.6			57	25	2.28	2100	130	16.2
	2/9/16	**5.5**	14						5200	180	28.9
	28/9/16	**4.6**	17						5000	180	27.8
	22/11/16	**4**	2.1						4800	480	10.0
	12/1/18	**3.9**	12						4300	140	30.7
	30/5/19	**4**	9.6						3400	370	9.2
MW4	12/7/16	**4.7**	8.73			67	< 20	3.35	4100	120	34.2
	2/9/16	**5.9**	6.4						1700	130	13.1
	28/9/16	**5.4**	6.5						1800	120	15.0
	22/11/16	**5.5**	7.1						2100	390	5.4
	12/1/18	**5.6**	7.2						2400	130	18.5
	30/5/19	**5.2**	6.70						2200	440	5.0
TB7	17/8/17	6.6	0.49	294	59	19	50	0.38	100	17	5.9

TB8	17/8/17	7	0.55	330	63	7	38	0.18	110	40	2.8
TB9	17/8/17	7.4	0.63	378	48	7	67	0.10	130	23	5.7
MB5	22/8/18	6.6	0.25	150	52	15	27	0.29	44	12	3.7
MB7	22/8/18	**6.3**	3.5	2100	170	77	65	0.45	1100	130	8.5
WB3	2/10/20	6.1	0.23	138	32	20	18	1.11	40	9	4.44
WB4	2/10/20	6.1	7.9	4740	620	24	19	0.95	1800	540	3.33
Aquatic Ecosystems[a]		6.5-8.0	0.12-0.3	72-180	ng	40[c]	ng	1[c]	ng	ng	
Irrigation[b]		6-8.5	1.3	780	60-350	ng	ng		350	ng	
Notes	ng denotes "no guideline". a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years) c. DEC(20__) Oxidation indicator triggers for ASS-affected groundwater.										

Table 2.4 Groundwater Quality – Nutrients

Bore (Figure 6)	*Date*	*TN*	*TKN*	*NH_3*	*NOx*	*TP*	*FRP*
MW1	12/7/16	0.6	0.3	<0.01	**0.27**	**0.15**	
	2/9/16	**5.0**	0.7	0.02	**4.3**	**0.2**	
	28/9/16	**4.88**	0.6	<0.01	**4.3**	<0.25	
	22/11/16	**4.9**	0.9	0.01	**4**	**0.29**	
	12/1/18	**4.7**	0.2	0.02	**4.5**	-	
	30/5/19	**4.7**	0.3	<0.01	**4.4**	-	
MW2	12/7/16	**3.7**	<0.2	<0.01	**3.7**	**0.35**	
	2/9/16	0.5	0.3	<0.01	**0.24**	**0.1**	
	28/9/16	0.35	<0.2	<0.01	**0.35**	**0.27**	
	22/11/16	0.6	0.3	0.03	**0.33**	**0.2**	
	12/1/18	0.9	<0.2	0.04	**0.29**	-	
	30/5/19	0.28	<0.2	<0.01	**0.28**	-	
MW3	12/7/16	**1.5**	0.9	0.12	**0.56**	<0.05	
	2/9/16	0.8	0.6	0.24	**0.19**	**0.13**	
	28/9/16	**1.8**	1.6	0.35	**0.2**	**0.33**	
	22/11/16	0.5	0.4	0.13	0.09	0.05	
	12/1/18	<0.2	<0.2	0.08	<0.05	-	
	30/5/19	<0.2	<0.2	0.04	<0.05	-	
MW4	12/7/16	**1.7**	1.1	0.03	**0.63**	**0.32**	
	2/9/16	**2.2**	0.4	0.05	**1.8**	<0.05	
	28/9/16	**2.3**	0.4	0.02	**1.9**	**0.31**	
	22/11/16	1.1	0.4	0.08	**0.71**	**1.8**	
	12/1/18	0.5	<0.2	0.18	**0.45**	-	
	30/5/19	0.43	0.4	0.13	0.06	-	
TB7	17/8/17	0.6	0.4		**0.18**	0.04	<0.01

TB8	17/8/17	1.2	1		**0.25**	**0.3**	<0.01
TB9	17/8/17	**6.2**	2.4		**3.8**	**3.5**	<0.01
MB5	22/8/18	**2**	<0.2		**2**	**0.2**	<0.01
MB7	22/8/18	1.2	1		**0.21**	**0.2**	0.02
WB3	2/10/20	1.2	0.0		1	0.03	<0.01
WB4	2/10/20	1.4	0.3		0.12	0.03	<0.01
Aquatic Ecosystems[a]		1.2	ng		0.15	0.065	0.04
Irrigation[b]		5	ng		ng	0.05	ng
Notes	ng denotes "no guideline". a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years).						

Table 2.5 Groundwater Quality – Metals

Bore (Figure 6)	*Date*	*Al*	*As*	*Ca*	*Cd*	*Cr*	*Cu*	*Fe*	*K*	*Hg*	*Mg*	*Mn*	*Na*	*Ni*	*Pb*	*Zn*
MW1	12/7/16	**18**	0.014	8	<0.0002	**0.085**		48		<0.0001		0.038		-	**0.017**	**0.037**
	2/9/16	**0.29**	<0.001	3.4	<0.0002	<0.001		<0.05		<0.0001		0.006		0.003	<0.001	**0.032**
	28/9/16	**0.2**	<0.001	<5	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.002	<0.001	**0.019**
	21/11/16	**0.52**	<0.001	2.4	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.002	<0.001	**0.017**
	12/1/18	**6.5**	0.009	<5	<0.0002	**0.047**		20		<0.0001		0.01		0.005	0.005	**0.026**
	30/5/19	**0.21**	<0.001	2	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.002	<0.001	0.012
MW2	12/7/16	**93**	0.072	4	<0.0002	**0.43**		360		<0.0001		0.087		-	**0.05**	**0.11**
	2/9/16	**4.3**	<0.001	11	<0.0002	<0.001		<0.05		<0.0001		0.028		**0.019**	<0.001	**0.056**
	28/9/16	**3.8**	<0.001	7.2	<0.0002	<0.001		<0.05		<0.0001		0.023		0.013	<0.001	**0.031**
	21/11/16	**4.1**	<0.001	8.3	<0.0002	<0.001		0.06		<0.0001		0.029		**0.016**	<0.001	**0.049**
	12/1/18	**5.3**	0.002	8.8	0.0002	**0.018**		5		<0.0001		0.028		**0.016**	0.003	**0.031**
	30/5/19	**3.3**	<0.001	7.8	<0.0002	<0.001		<0.05		<0.0001		0.025		0.013	<0.001	<0.005
MW3	12/7/16	**29**	0.029	38	<0.0002	**0.26**		170		<0.0001		0.012		-	**0.023**	**0.038**
	2/9/16	**0.35**	<0.001	110	<0.0002	<0.001		<0.05		<0.0001		0.11		0.009	<0.001	**0.054**
	28/9/16	**1.1**	<0.001	66	<0.0002	<0.001		<0.05		<0.0001		0.27		**0.015**	<0.001	**0.07**
	21/11/16	**5**	<0.001	37	<0.0002	0.001		0.47		<0.0001		0.12		0.012	0.003	**0.023**
	12/1/18	**3.6**	<0.001	32	<0.0002	0.001		<0.05		<0.0001		<0.005		0.009	**0.01**	0.013
	30/5/19	**3.6**	<0.001	35	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.008	<0.05	0.012
MW4	12/7/16	**130**	0.05	76	<0.001	**0.71**		360		<0.0005		0.11		-	**0.098**	**0.16**
	2/9/16	<0.05	<0.001	28	<0.0002	<0.001		<0.05		<0.0001		0.005		0.002	<0.001	**0.033**
	28/9/16	<0.05	<0.001	20	<0.0002	<0.001		<0.05		<0.0001		0.005		0.003	<0.001	**0.02**
	21/11/16	**0.1**	<0.001	35	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.004	<0.001	**0.032**
	12/1/18	**0.72**	0.002	44	<0.0002	**0.011**		2.8		<0.0001		<0.005		0.002	<0.001	0.011
	30/5/19	**3.6**	<0.001	42	<0.0002	<0.001		<0.05		<0.0001		<0.005		0.013	<0.05	<0.005
TB7	17/8/17	<0.1	<0.001	5.6	<0.002	<0.01	<0.01	0.04	0.9	<0.0002	11	-	54	<0.01	<0.01	0.01

TB8	17/8/17	<0.1	<0.001	9.1	<0.002	<0.01	<0.01	0.02	3.8	<0.0002	9.9		60	<0.01	<0.01	<0.01
TB9	17/8/17	0.3	<0.001	7.2	<0.002	<0.01	<0.01	0.16	6.6	<0.0002	7.2		80	<0.01	<0.01	<0.01
MB5	22/8/18	0.1	<0.002	17	<0.002	<0.002	<0.01	0.08	2.3	<0.0002	8.8		29	<0.01	<0.01	<0.01
MB7	22/8/18	0.2	<0.002	54	<0.002	0.003	<0.01	4.3	8	<0.0002	67		630	0.01	<0.01	**0.07**
WB3	2/10/20	0.03	<0.002	4.5	<0.0001	<0.001	<0.001	0.01	4.2	<0.0001	5		22	0.002	<0.001	<0.005
WB4	2/10/20	<0.01	<0.002	18	<0.0001	<0.001	<0.001	<0.01	4.5	<0.0001	140		1200	0.008	<0.001	0.013
Aquatic Ecosystems[a]		0.08	0.136	ng	0.0004	0.006	0.0018	ng	ng	0.0019	ng		ng	0.013	0.0056	0.015
Irrigation[b]		5	0.1	ng	0.01	0.1	0.2	10	ng	0.002	ng		230	0.2	2	2
Notes	ng denotes "no guideline". a. ANZECC (2000) Aquatic Ecosystem trigger values (Nutrient, pH and Conductivity are for lowland rivers; Dissolved Metals are for freshwater ecosystems 90% species protection) b. ANZECC (2000) Irrigation trigger values (long-term irrigation up to 100 years).															

2.5 Vegetation

The project area is largely cleared of native vegetation, consisting mostly of farm paddocks and current and former quarries. All of Lot 204, most of Lot 205 and the southern part of Lot 203 are cleared paddocks with some scattered mature trees, either native or planted. Native vegetation is present in the central east of Lot 205, the northern end of Lot 202 and the north of Lot 203.

Plantecology (2020) surveyed the vegetation and flora of the project area in November 2019. 360 Environmental (2015) undertook a vegetation survey of Lots 202 and 203 in March 2015. Neither survey found any vegetation dependent on wetlands or shallow groundwater.

2.6 Land Uses and Potential Contamination

Historic Landgate aerial photography shows that the project area has been largely cleared and used for farming since at least 1965. Quarrying has been underway on Lots 202 and 203 since before 1977.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in the project area. The nearest mapped contaminated site is a service station in Muchea, 3.3km north-west of the project area. There is no potential for this contamination to directly affect the project area.

The former clay quarry on Lots 202 and 203 is currently being backfilled with inert waste such as building rubble prior to rehabilitation. The backfilling and rehabilitation are being undertaken under the terms of a DWER Licence (L9181/2018/1), which carries conditions including control of waste acceptance and prevention of pollution.

There is no visual or photographic evidence of any contaminating activities now or in the past within the project area.

3.0 WATER USE SUSTAINABILITY

3.1 Water Supply

Water will be required for both potable and non-potable purposes. The Leederville aquifer is likely to be the preferred source for potable supply due to its generally higher quality and lower risk of contamination. Non-potable groundwater demand is likely to be limited to landscape irrigation, particularly within Precinct 4 (Lots 204-205), as industries within this precinct will be restricted to those with low water usage.

Potable water will be supplied to the project area by a licensed water provider. A proposed water project for the Lower Chittering Valley is currently in development by Aqua Ferre Pty Ltd, which includes construction of a water treatment facility on Lot 2 Reserve Rd, Chittering. Aqua Ferre is in the process of applying for a Water Service Provider's Licence from the Economic Regulation Authority (ERA). Aqua Ferre has confirmed that it has the capacity within its proposed licence to supply Precinct 3 with potable water. Discussions with Aqua Ferre are ongoing. A letter from Aqua Ferre confirming this understanding is attached in Appendix E.

For non-potable uses, purchase of water entitlements from existing licensed users within or outside of the project area is likely to be necessary. The landowners will negotiate with existing licence holders within and outside of the project area with a view to purchasing an existing groundwater allocation, and will submit a groundwater licence application to the DWER in due course.

3.2 Water Efficiency Measures

Precinct 2 (Lots 204-205) will be designed as a low-water-use precinct. Only industries with low water consumption will be permitted in this precinct. This is driven largely by the hydrology of the site and its proximity to Ellen Brook, which demands that wastewater disposal be minimised. Precinct 4 (Lots 202-203) will accommodate general industry with less restrictions on water use or wastewater generation; however, industries will need to demonstrate that they can safely dispose of waste water on site. Water use will effectively be restricted by the limited availability and corresponding cost of groundwater in the area.

Potable water use within the project area will be limited to consumption for domestic use in toilets, bathrooms and kitchens. The Shire of Chittering Town Planning Scheme No. 6 limits wastewater generation in industrial zones to 5,400 litres per hectare per day. If it is assumed that all potable water used will ultimately become wastewater, it can be calculated that the maximum allowable potable water demand for the 185ha precinct will be approximately 1,000 KL per day.

Cossill & Webley (2018) estimated total potable water demand for Lots 202-205 at 96ML per year, based on a study by GHD for the Karratha Gap Industrial Estate.

Groundwater will be used mainly for irrigation of landscape plantings and swales. These areas will be irrigated only during the establishment stage (one or two years). The Landscape Master Plan estimates total plantings of 13.7ha of sedges, shrubs and trees within the project area.

The water demand for irrigation in a given year will depend on the staging of subdivision and development. If the project area were developed over ten years, the demand for irrigation water (at the DWER's default rate of 4,500 KL/ha/yr) over that ten year period would be in the order of 6.2 ML/yr, decreasing in subsequent years.

4.0 LAND CAPABILITY FOR ON-SITE EFFLUENT DISPOSAL

4.1 Published Land Capability Ratings and Constraints

King & Wells (1990) mapped the western part of the project area as Guildford Formation (Gf2): "Plain with imperfectly drained yellow duplex soils with sand to sandy loam topsoil", and the eastern part as Reagan (Re2): "Gentle slopes with deep, well drained brownish or earthy sands situated below Re1". They rated the capability of these landform types for on-site effluent disposal as follows:

Landform	*Capability*	*Limiting Factor(s)*
Gf2	Fair	Microbial purification ability, soil absorption ability
Re2	High	None

The limitations on the capability of the Gf2 landform unit relate to the imperfect drainage of the unit due to its silty soils and sometimes occurrence of clay horizons. The drilling carried out in March 2020 showed that the soils in this unit on the site possessed a sandy or pebbly silt profile to more than 2m depth, suggesting that they were well drained. Permeability testing at six locations by Douglas Partners (2020) showed permeability in the top metre of soil ranging from 0.9 to 8.6 m/day, with an average of 3.3m/day and a median of 4.75m/day. These findings suggest that the capability of the Gf2 soils on the site is higher than the average for the unit, and poses no significant constraint to effluent disposal.

The Government Sewerage Policy maps most of the project area as being within a Sewage Sensitive Area (SSA) due to its location within the catchment of the Swan-Canning Estuary and/or within 1km of significant wetlands. The Policy places additional site requirements in terms of groundwater clearance and lot density on effluent disposal within SSAs, including a lower lot size limit of 1ha. Figure 1 shows the SSA boundaries over the subject land.

The northern part of Lot 202 and the north-east of Lot 205 are mapped as SSA by the GSP under the category of land "…within one kilometre up-groundwater-gradient and 250 metres down-groundwater-gradient of a significant wetland; or where the groundwater gradient is unknown or seasonably variable within one kilometre of the significant wetland…". Closer inspection shows that the wetland in question, a Conservation Category dampland located 815m north of the project area, is upgradient of the site and maintained by surface water inflow from further upgradient. There appears to be no way that effluent disposal at the site could affect this dampland, and therefore the SSE mapping in this case is considered invalid. The GSP allows for SSE mapping to be refined through site-specific investigations as in this case.

4.2 Soil Permeability

Australian Standard AS1947:2012 - *On-site Domestic Wastewater Management* recommends a minimum hydraulic conductivity of 0.06m/day for on-site effluent disposal without special design. The testing method set out in the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974* implies a minimum conductivity of 0.11m/day without specific approval by the Director-General of Public Health. Permeabilities of this order are generally found in weakly structured or massive clays.

Douglas Partners (2020) undertook constant-head permeability testing at six sites and at depths of 0.2 – 0.8 metres. The tests returned permeabilities ranging from 0.9 – 8.6 m/day, with a mean of 3.3m/day and a median of 4.75m/day. Test pumping during sampling of one on-site bore (WB3) indicated a hydraulic conductivity in the depth range of 2.6m to 5.1m in the order of 0.14 m/day. This decline in permeability with soil depth is to be expected.

4.3 Phosphorus Retention Index

The Health Department's draft *Code of Practice for Onsite Sewage Management* (2012) recommends a PRI of at least 20 for soils beneath effluent irrigation areas.

Previous experience has shown that the gravelly and silty clay soils of the Guildford Formation and other alluvial and colluvial soils generally have moderate to very high PRI.

Fill used in effluent disposal areas will have a PRI of at least 20, in line with the Health Department's draft Code of Practice (2012).

4.4 Depth to Groundwater

The Government Sewerage Policy (GSP) (WA Govt, 2019) requires that land used for effluent disposal in sewage sensitive areas must have a minimum clearance of 1.5m from the effluent discharge point (e.g. base of leach drain or ATU drip lines) to the highest groundwater level. Under the Policy, the required clearance can be achieved by filling but not by drainage. Outside of sewage sensitive areas, the minimum groundwater clearance requirement for loams and heavy soils is 0.6m.

The groundwater measurements carried out in August 2018 indicate that the average annual maximum groundwater level (AAMGL) is more than 1.5m below the ground surface across the site (Figure 6). On-site effluent disposal in accordance with the GSP should be possible without filling. This will be confirmed by further groundwater measurements prior to subdivision.

4.5 Slope

The Government Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent.

The slope of the subject land is mostly less than 5% but does exceed 20% in some parts of Lots 202 and 203. Areas of greater than 20% will be excluded from effluent disposal or will be recontoured before construction to reduce the slope to less than 20%.

4.6 Watercourse Setbacks

The Department of Water & Environmental Regulation (DWER, 2016) recommends that effluent disposal systems should be located at least 100m from waterways and wetlands. The Government Sewerage Policy requires a 100m setback from waterways, significant wetlands and drains discharging directly into waterways or significant wetlands without treatment.

For the purposes of these requirements, "waterway" is defined as a natural watercourse as defined in the *Rights in Water and Irrigation Act 1914*. Based on site inspections and historical aerial photography as described in Section 2.3.2, there are no waterways within the project area.

The Government Sewerage Policy provides that reduced setbacks from drains may be allowed where it can be demonstrated that the reduced setbacks will not have a significant impact on the environment or public health. In this case, a reduced setback of 6m from subsoil drains is considered necessary and justified because:

- the subsoil drains will be located upslope of the effluent disposal fields (Section 4.8) and will drain only clean groundwater that has been filtered through the soil profile;
- all effluent disposal in high-groundwater areas will be by means of alternative effluent disposal systems with nutrient removal capability (Section 4.7);
- the drained water will be treated by infiltration and vegetation uptake within the roadside swales before being released to downstream watercourses (Section 5.2.2);
- a greater separation would reduce the effectiveness of the subsoil drains in limiting groundwater rise within the effluent disposal areas; and
- the clayey soils and high PRI of the site (Section 2.2.5) mean that the drained water will be of high quality.

Setbacks of less than 100m from surface drains (roadside bioretention swales) are considered acceptable and necessary because:

- all effluent disposal within 100m of drains will be by means of alternative effluent disposal systems with nutrient removal capability (Section 4.7);

- the clayey soils and high PRI of the site (Section 2.2.5) mean that leachate emanating from the effluent disposal systems will be of high quality;
- the water in the roadside swales will be treated by infiltration, vegetation uptake and soil adsorption before it reaches any downstream water body (Section 5.2.2); and
- imposing a requirement for 100m setbacks would severely constrain and in some cases prevent the siting of effluent disposal systems on lots.

The differing sized lots within the subject site will offer a range of options for siting of development elements and effluent disposal systems within each lot. At the time of subdivision and development approval, the siting of individual effluent disposal systems will be subject to review and approval by the Shire of Chittering and other agencies.

It is concluded that the proposed system of effluent disposal in the project area will pose minimal risk to the environment or public health and will meet all setback requirements set out in current government policies.

4.7 System Selection and Location

All effluent generated within the subdivision will be treated and disposed by means of individual on-site effluent disposal systems. All lots in low-lying areas will be required to employ nutrient-attenuating alternative systems such as aerobic treatment units (ATUs) with high-PRI irrigation areas or modified leach drain systems (e.g. Filtrex). Lots in higher areas or with deeper groundwater may employ conventional septic systems and leach drains.

ATU irrigation areas will be filled if necessary in order to provide 1.5m clearance from the AAMGL to the effluent drip lines as required under the Government Sewerage Policy (2019), allowing for 0.3m groundwater mounding and 0.2m soil cover over the drip lines. Fill used for this purpose will be either sourced from on site or imported. The soil will be tested to confirm a PRI of at least 20.

The ATU irrigation area or leach drain length on each lot will be sized to suit the expected population of the lot. As a rough rule of thumb, each full-time employee on site will require approximately 23m^2 of effluent irrigation area or 4.4m of leach drain. Treated ATU effluent may be disposed of via leach drains, which may reduce the area required for disposal by up to two thirds at the cost of a greater height of fill.

The effluent disposal requirements of each lot will vary depending on the soil profile, groundwater depth, risk of saturation and expected site population. Site testing on each lot prior to development will be required to determine the location and type of effluent disposal system.

4.8 Subsoil Drainage

If fill is used on any lots to created raised pads for effluent disposal, subsoil drains will be placed upslope of the filled pad to minimise groundwater rise into the fill. The drains will be placed at least 6m upslope from the drip lines or leach drains. The drains will be set with their inverts at or above the AAMGL and will discharge via free-draining outlets into the roadside swales, where the water will be further treated by infiltration and vegetation uptake within the swales. Because the water will be draining from high-PRI soil (see Section 2.2.5), it will be of high quality.

5.0 STORMWATER MANAGEMENT STRATEGY

5.1 Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the *Stormwater Management Manual for WA* (DoW, 2004) and *Better Urban Water Management* (WAPC, 2008).

Nutrient concentrations and loads in water leaving the site will be managed to comply with the targets of the draft *Swan Canning Water Quality Improvement Plan* (SRT, 2009) for the Ellen Brook catchment, as follows:

- Winter median TP concentration: 0.1 mg/L
- Winter median TN concentration: 1.0 mg/L
- Annual TP yield: 0.03 kg/ha
- Annual TN yield: 0.31 kg/ha.

5.2 Drainage Management System

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at their pre-development levels. The drainage design presented here is conceptual and will be refined in the detailed subdivision designs. Figure 8 shows an overview of the conceptual drainage design.

The priorities for managing the various sizes of storm event will be:

- 1 year ARI — Infiltrate all flows as close to the source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.

- 5 year ARI — Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.

- 100 year ARI — Maintain pre-development flow rates and volumes. Prevent flooding and damage.

5.2.1 Through Drainage

The existing drainage line entering at the north-east of Lot 202 will be realigned and consolidated in a vegetated swale within a road reserve. The swale will be sized to accommodate the flow from a 100-year ARI critical storm from both the upstream and internal catchments. The swale will be configured as described in Section 5.2.2.

5.2.2 Lot Drainage

Runoff from roofs, paved surfaces and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot in soakwells, basins and/or landscaping areas. These will be subject to detailed design on individual lots.

The in-lot drainage structures will also be sized to capture and detain the runoff from roofs, paved surfaces and hardstand areas from critical storms up to 100-year ARI. In most cases the critical storm (producing the highest peak flow rate) will be of less than twenty minutes' duration, and the volume of flow will be less than that from the 1-year 1-hour storm.

All runoff from within each lot will be directed to the bioretention/detention basin. Overflows from the basins will run into the roadside bioretention swales, either directly or via drainage easements for those lots that do not have a downslope road frontage.

On lots that front a public road on the downslope side, the part of the lot near the road will be filled if and as necessary to raise its level above the outer embankment of the roadside swale and allow overflow drainage to flow into the roadside swale. The height of filling will generally be between 0m and 0.8m. Depending on the slope of the lot, the filling will extend between about 10m and 90m from the lot boundary. This filling will be carried out by the subdivider/developer during the construction of the roads. Figure 9 shows a conceptual layout and profile of a typical lot in this situation.

On lots that adjoin another lot on the downslope side (i.e. that do not have a downslope road frontage), the in-lot basin will overflow via a drainage channel or bund along the downslope lot boundaries to the nearest roadside swale. Where the flow needs to cross another lot before reaching the road reserve, an easement nominally 10m wide will be created in favour of the Shire of Chittering. Swales and/or bunds may be created within the easements as necessary to direct the overflow. These swales and bunds will be constructed by the developer at the time of creation of the lots. Figure 7 shows the conceptual layout of the drainage easements. Figure 9 shows a conceptual layout of a typical lot of this type.

5.2.3 Internal Road Drainage

Runoff from public roads from up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The inverts of the swales will be at or above the AAMGL. Figure 8 shows the preliminary layout of the roadside swale network.

The swales will be constructed with low internal weirs set at a height that captures the 1-year 1-hour storm. The configuration of the swales and internal weirs will be subject to detailed design including:

- the height of the swale inverts at or above the AAMGL;

- the width and composition of the swale floors, designed to maximise nutrient uptake;
- planting of the swales with dense sedges and shrubs to maximise nutrient uptake; and
- the possible inclusion of underdrains within the swales to promote infiltration of 1-year ARI flows.

Figure 10 shows conceptual profiles of the roadside swales.

5.2.4 Major Storm Drainage

Road runoff from larger storms will overtop the weirs and flow along the swales to the western boundary, where it will enter the roadside drains and culverts on Great Northern Highway. The rate and volume of drainage out of the site will be controlled to be no greater than those existing before development.

Figure 8 shows the overall drainage layout and the 100-year ARI flow paths. Table 5.1 summarises the expected 100-year flows in the swales, including both runoff from road reserves and overflows from lots (conservatively assuming all lots are developed fully to hardstand). The flow calculations are detailed in Appendix F.

The drainage from the site flows beneath Great Northern Highway via five culverts, as shown on Figure 8. These were constructed in the context of a rural setting, in which culverts may be designed to allow some ponding upstream on adjacent land during major storms.

Survey of the culverts adjacent to the site, coupled with data provided by Main Roads WA from its IRIS database, enabled the flow capacities of he culverts to be calculated using Manning's Open Channel Flow Formula. The calculations show that, under current land uses, all of the culverts have sufficient capacity to carry the flow from a 100-year ARI critical storm without upstream ponding. As the post-development flows will be controlled to be no greater than the pre-development flows, these too will be within the capacity of the culverts. Table 5.2 shows the culvert flow calculations.

Table 5.1 Preliminary Swale Sizing – 100 yr ARI Critical Storm

Swale Segment (Figure 8)	*Contributing Segments*	*Contributing Lots*	*Segment Cumulative Peak Flow (L/s)*[1]	*Lots Cumulative Peak Flow (L/s)*[2]	*Total Cumulative Peak Flow (L/s)*	*Long Slope*[3]	*Height in Channel (m)*[4]	*Height Over 0.4m Weir (m)*[4]
A1	A1,C1	2,3	81.46	292.30	373.76	0.0054	0.48	0.21
A2	A2-A5	1,6,13-18,23N,24N	245.56	1413.11	1658.67	0.0202	0.70	0.33
A3	A3-A5	13-18,23N,24N	180.71	1071.36	1252.07	0.0021	0.75	0.47
A4	A4,A5	14-18,23N,24N	98.01	903.74	1001.75	0.0221	0.55	0.21
A5	A5	18,24N	41.52	257.38	298.90	0.0522	0.25	0.09
B1	B1	7-10	95.85	583.34	679.19	0.0063	0.61	0.24
B2	B1,B2	7-10	152.98	583.34	736.32	0.0204	0.49	0.18
C1	C1	4	32.62	314.51	347.13	0.0033	0.52	0.20
D1	D1	19-22,23S,31	117.72	903.62	1021.34	0.0122	0.63	0.25
D2	D1-D7	11,12,19-22,23S,24S,25-32,47-52	605.90	4094.58	4700.49	0.0223	0.80	0.50
D3	D3-D7	24S,25-30,47-52	346.64	2322.34	2668.98	0.0091	1.02	0.47
D4	D4,D5	49-52	132.34	703.90	836.24	0.0631	0.39	0.14
D5	D5	51,52	44.03	346.82	390.85	0.0321	0.32	0.13
D6	D6	47,48	82.48	379.06	461.53	0.0504	0.31	0.12
D7	D4-D7	47-52	265.38	1082.96	1348.34	0.0211	0.63	0.25
D8	D8	42	50.18	160.67	210.85	0.0294	0.24	0.09
D9	D9	33-38	39.48	957.54	997.02	0.0003	1.38	0.64
D10	D10	41, 43-46		901.21	901.21	0.0384	0.63	
D11	D8,D9,D10,D11	33-46		2378.94	2378.94	0.0093	0.57	
E1	E1	53,54	68.42	319.46	387.89	0.0205	0.36	0.13
E2	E2,E3	55-58	47.41	671.56	718.98	0.0282	0.44	0.17
E3	E3		48.44		48.44	0.0162	0.13	0.07

1. Based on runoff coefficient for the 100-year ARI storm of 0.85.
2. Based on 100% development of lots to hardstand with runoff coefficient for the 100-year storm of 0.85.
3. Based on existing topography; this may change with filling and levelling of Lots 202-203.
4. Calculated using Manning's Open Channel Flow Formula (Fang, 2000) for a trapezoidal channel with 1m base and 1:3 side slopes, and Manning's n between 0.04 and 0.4 depending on flow depth vs vegetation height (DoW, 2004).

Table 5.2 Culvert Flows

Culvert Figure 8)	*No. & Size*	*Length*	*Slope*	*Capacity (m^3/s)[1]*	*Flow (m^3/s)[1]*		
					1yr	*4.48yr*	*100yr*
CH34.79	4 x 1.2x0.75	25.7	0.0098	14.28	1.54	2.21	4.28
CH34.50	2 x 1.2x0.75	34.2	0.0118	7.93	0.06	0.11	0.21
CH34.23	2 x 0.45	33.4	0.0096	0.61	0.08	0.13	0.24
CH33.70	3 x 1.2x0.6	16	0.0108	8.38	1.26	2.16	4.15

1. Calculated by Manning's Open Channel Flow Equation as set out in Fang (2000) using pipe roughness coefficient of 0.012 (wet-cast concrete).

5.3 Surface Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales with a minimum soil PRI of 15.
- Conveying all runoff from storms between 1-year and 100-year ARI in densely vegetated bioretention swales to allow suspended particles to be filtered out.

5.4 Maintenance

The drainage system has been designed to require minimal maintenance. The following will be required to ensure that the system continues to function as designed:

- Regular (possibly annual) cleaning of side entry and junction pits, inlet pits and small culverts. More frequent cleaning may be required during the construction phase.
- Tending and maintenance of swales and other vegetated drainage features to remove litter, control weeds and encourage the growth of native species.
- Pruning, mulching or removal of vegetation in swales as necessary to maintain ground fuel loads below 8 tonnes/ha.

6.0 GROUNDWATER MANAGEMENT STRATEGY

6.1 Groundwater Levels

The drainage system for the site is designed to minimise changes to the existing groundwater regime. Roadside swales and subsoil drains will be set with their inverts at or above the AAMGL. Subsoil drainage within lots will be limited to filled areas used for buildings or effluent disposal.

6.2 Subsoil Drainage

Subsoil drainage may be employed within some lots where necessary to maintain existing maximum groundwater levels beneath building pads and effluent disposal areas. The subsoil drains will discharge into roadside swales via free-draining outlets.

Subsoil drains may also be employed within road reserves to prevent groundwater rise from damaging the road base and pavement.

All subsoil drains will be set with their invert at or above the AAMGL. Therefore, changes to the groundwater hydrology of the site will be minimal.

6.3 Groundwater Quality

The sampling undertaken to date indicates that the groundwater beneath the site contains low to moderate concentrations of nitrogen and phosphorus. This is to be expected given the nature of the soils and the land use history of the site.

The relationship between nutrient inputs and exports is complex, especially in the case of phosphorus, which travels through the soil profile as a "front" in a complex series of adsorption and desorption reactions. Nitrogen is subject to denitrification and mineralisation in the soil and groundwater. As a result, nutrient exports from the site at present will be a reflection of nutrient inputs over the last several decades, modified by soil hydrology and nutrient retention capacity.

The aim of nutrient management will be to limit nutrient inputs to the site so that nutrient outputs are minimised. As an industrial precinct, the area of fertilised gardens and lawns will be small. Landscaping areas including street trees, swales and vegetation buffers will be established with minimal fertilisers and irrigation.

Measures available to minimise nutrient inputs and exports in the development will include:

- regular street sweeping to remove accumulated contaminants; and
- selection of native species with low water and fertiliser requirements for public open space and landscape areas.

7.0 LANDSCAPING STRATEGY

Landscaping of the site will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot), effluent irrigation areas and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted.

The plantings in swales, basins and effluent irrigation areas will include a high proportion of species recommended in the Monash University (2014) *Vegetation Guidelines for Stormwater Biofilters in the South-West of Western Australia*.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation-tolerant species including sedges and low shrubs in order to stabilise the basins and maximise their ability to take up nitrogen from the water.

The total area to be planted is approximately 13.7 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 62 ML of water would be required to irrigate the new plantings for the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Hazard Assessment (Eco logical Australia, 2020).

Figure 11 shows the conceptual landscaping strategy.

8.0 MONITORING

Baseline water quality results for the site are shown in Tables 2.3, 2.4 and 2.5. Groundwater levels and quality will continue to be monitored and compared against baseline levels and relevant guidelines. Water quality in surface drains will be monitored upstream and downstream of the project area to determine what (if any) impacts the development may be having on the watercourses.

Water quality sampling will be conducted nominally once a year in late winter. Detailed water monitoring and response procedures will be developed as part of the Urban Water Management Plans to be prepared for each stage of subdivision.

9.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Further planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) will be prepared as a condition of subdivision approval for each stage of subdivision. The UWMP will present the detailed design of the stormwater drainage system within that stage.

The developer of each stage of subdivision will maintain the drainage system, landscaped areas and water monitoring program within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for monitoring and management will be handed over to the Shire of Chittering.

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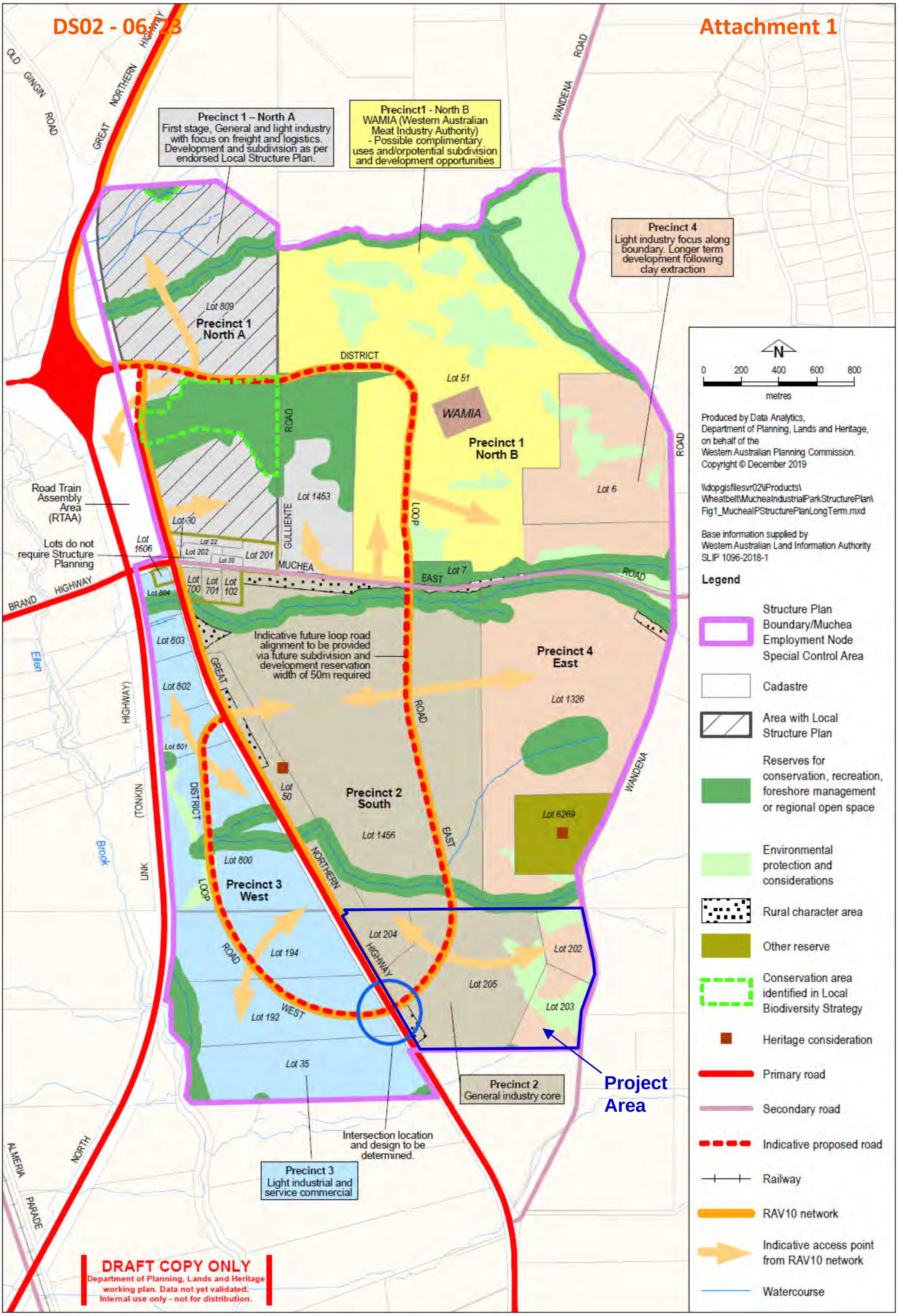
Figures



Source: WAPC, 2019

Figure 1

DRAFT MUCHEA INDUSTRIAL PARK STRUCTURE PLAN

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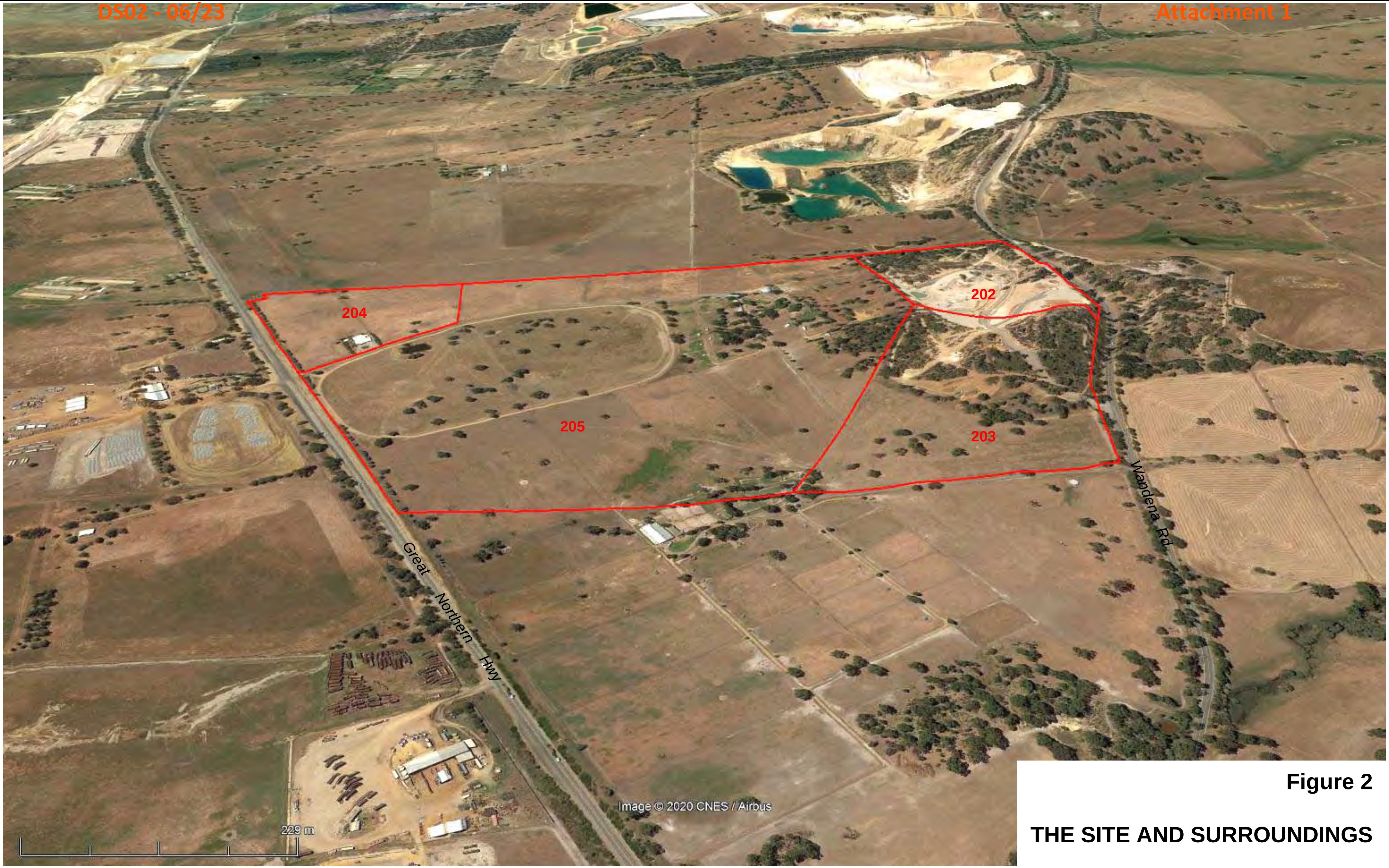

Figure 2

THE SITE AND SURROUNDINGS

Image source: Google

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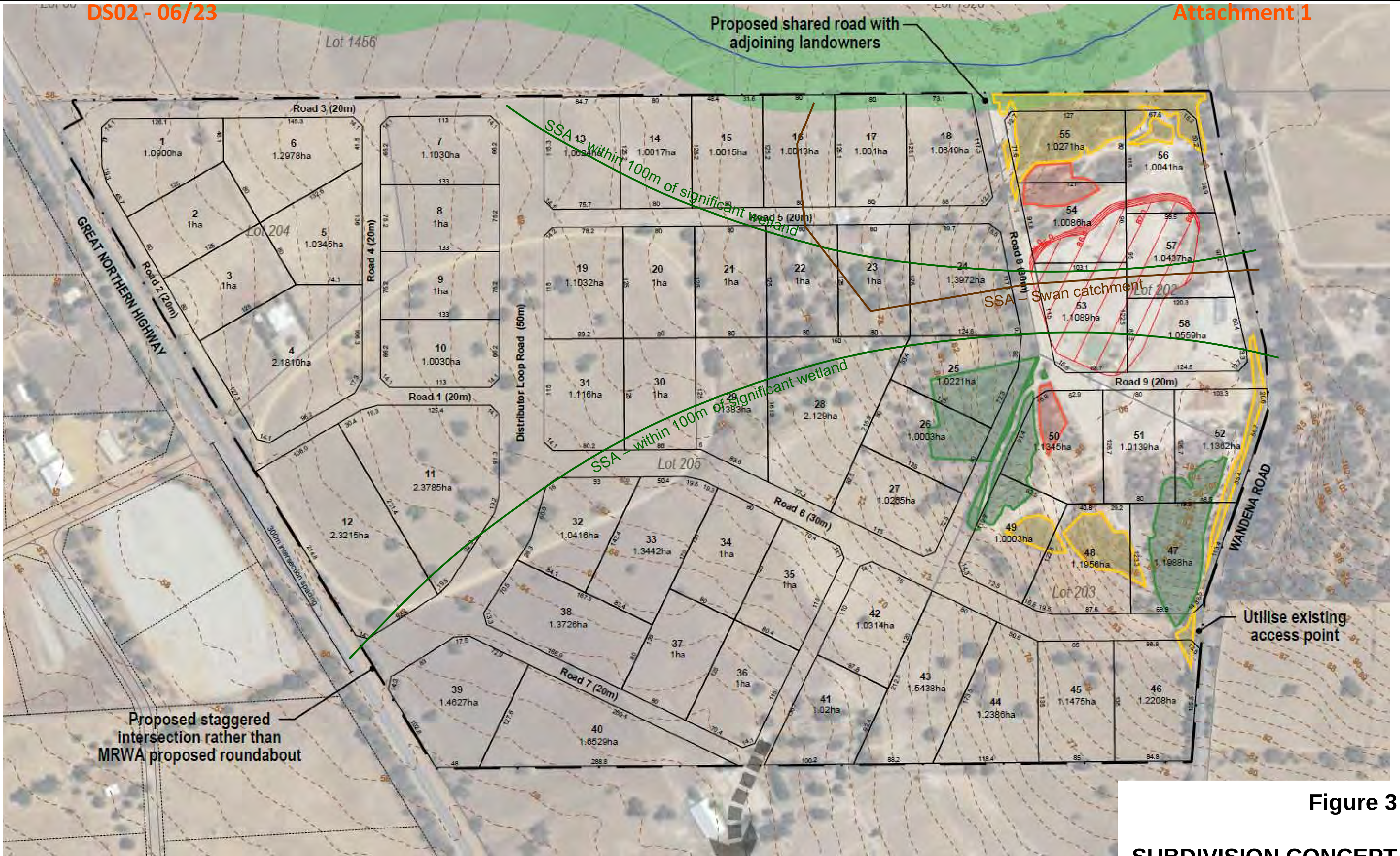

Figure 3

SUBDIVISION CONCEPT

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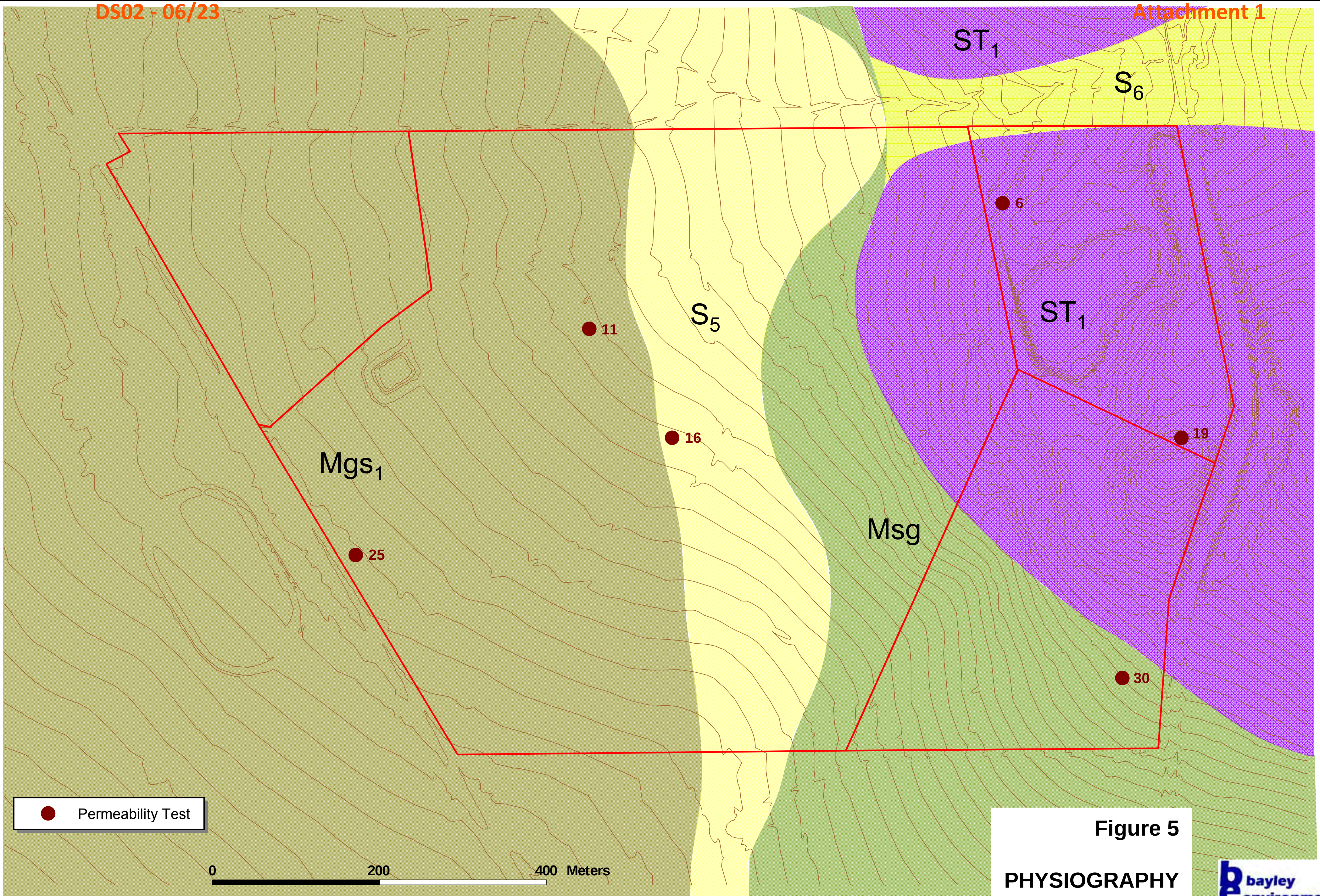

Figure 5

PHYSIOGRAPHY

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Attachment 1

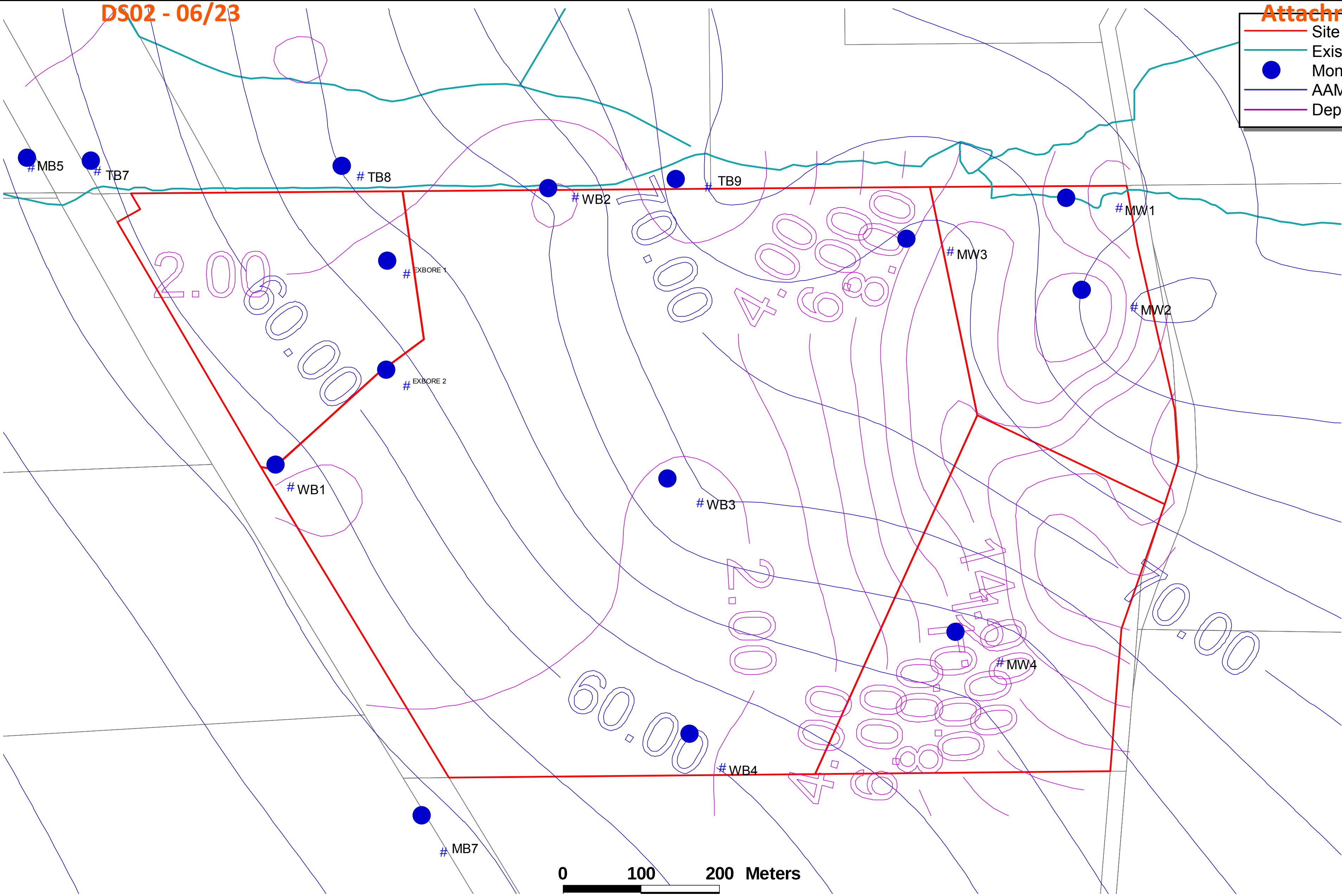

Figure 6

HYDROLOGY

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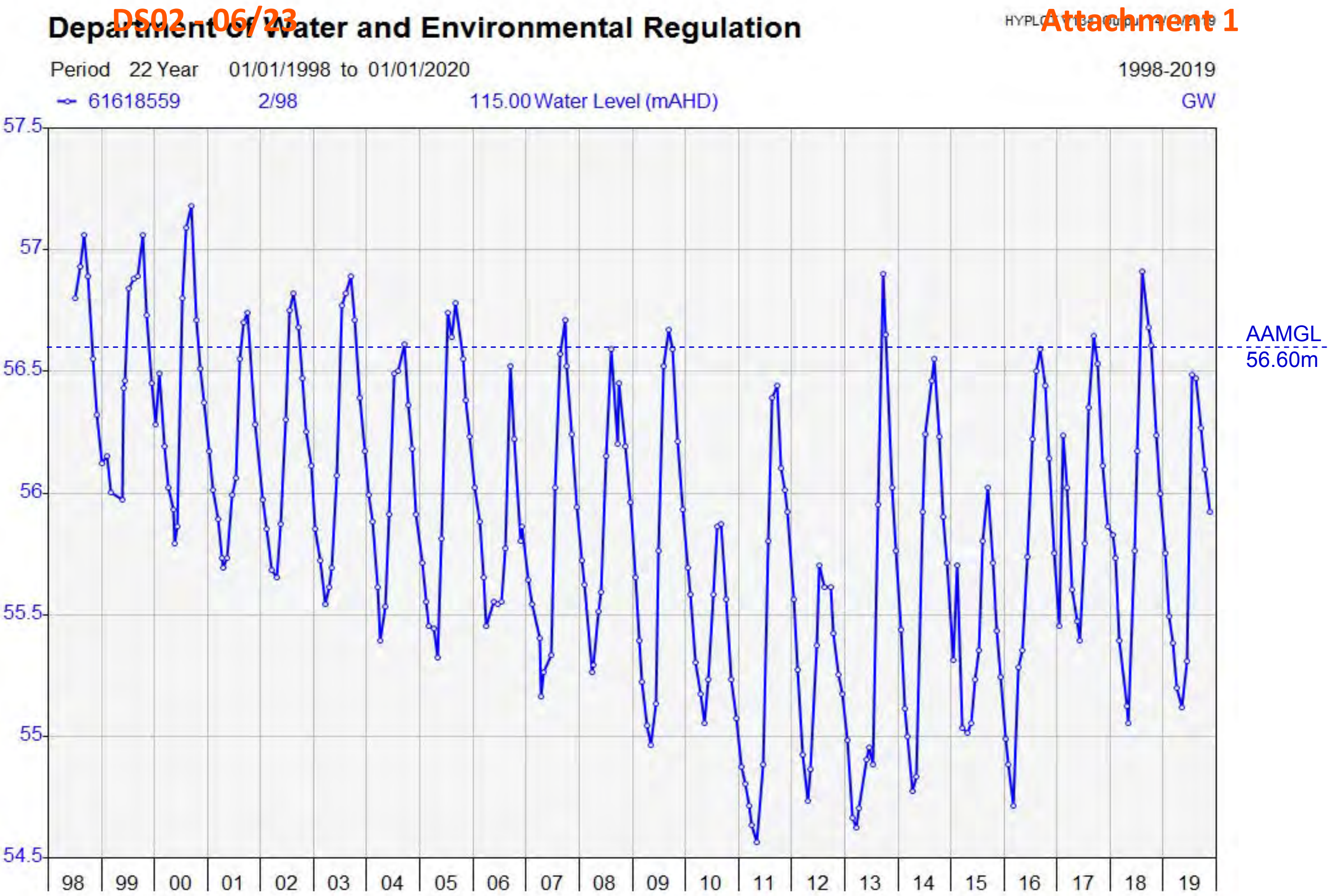
Attachment 1



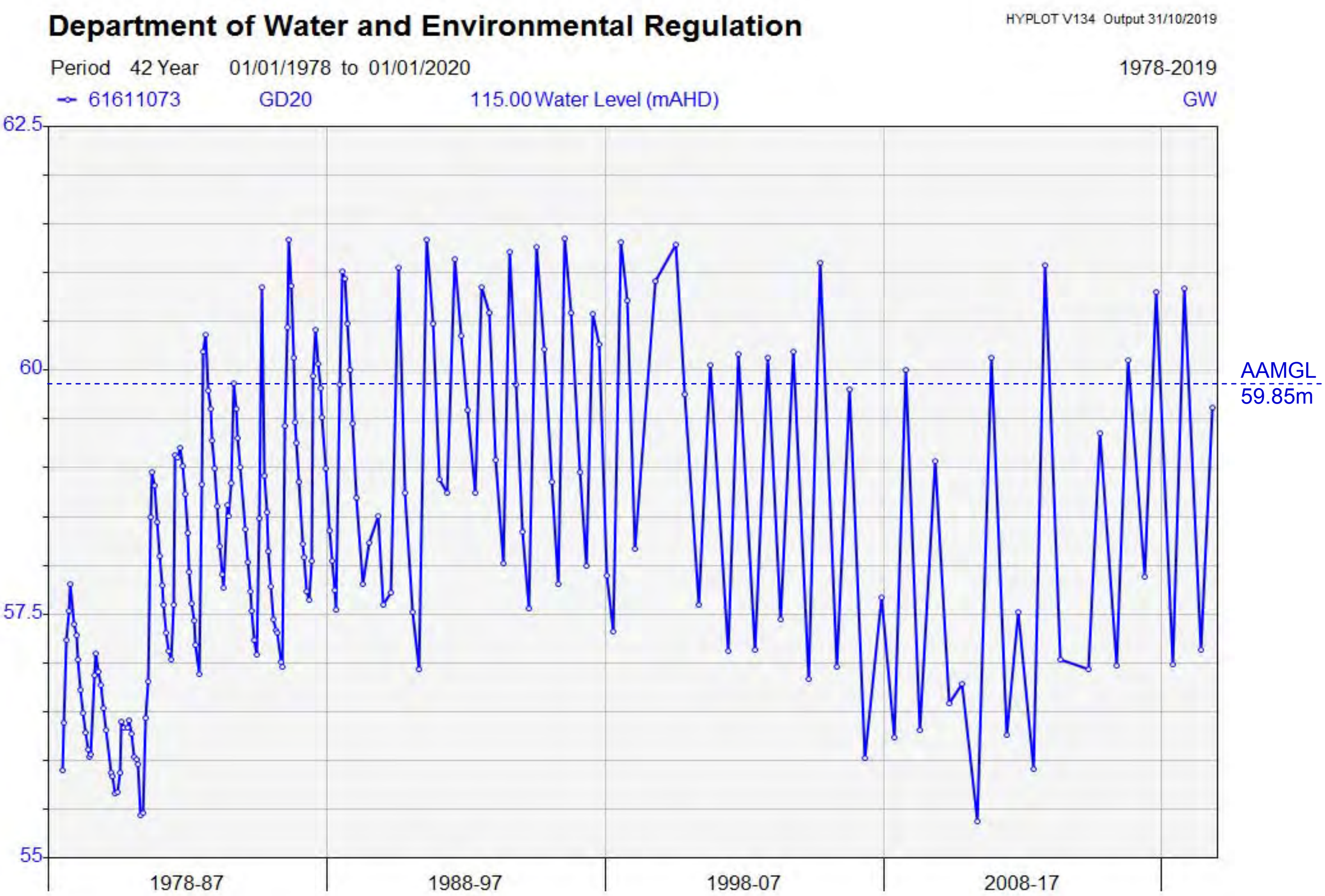


Figure 7

DWER BORE HYDROGRAPHS

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Attachment 1

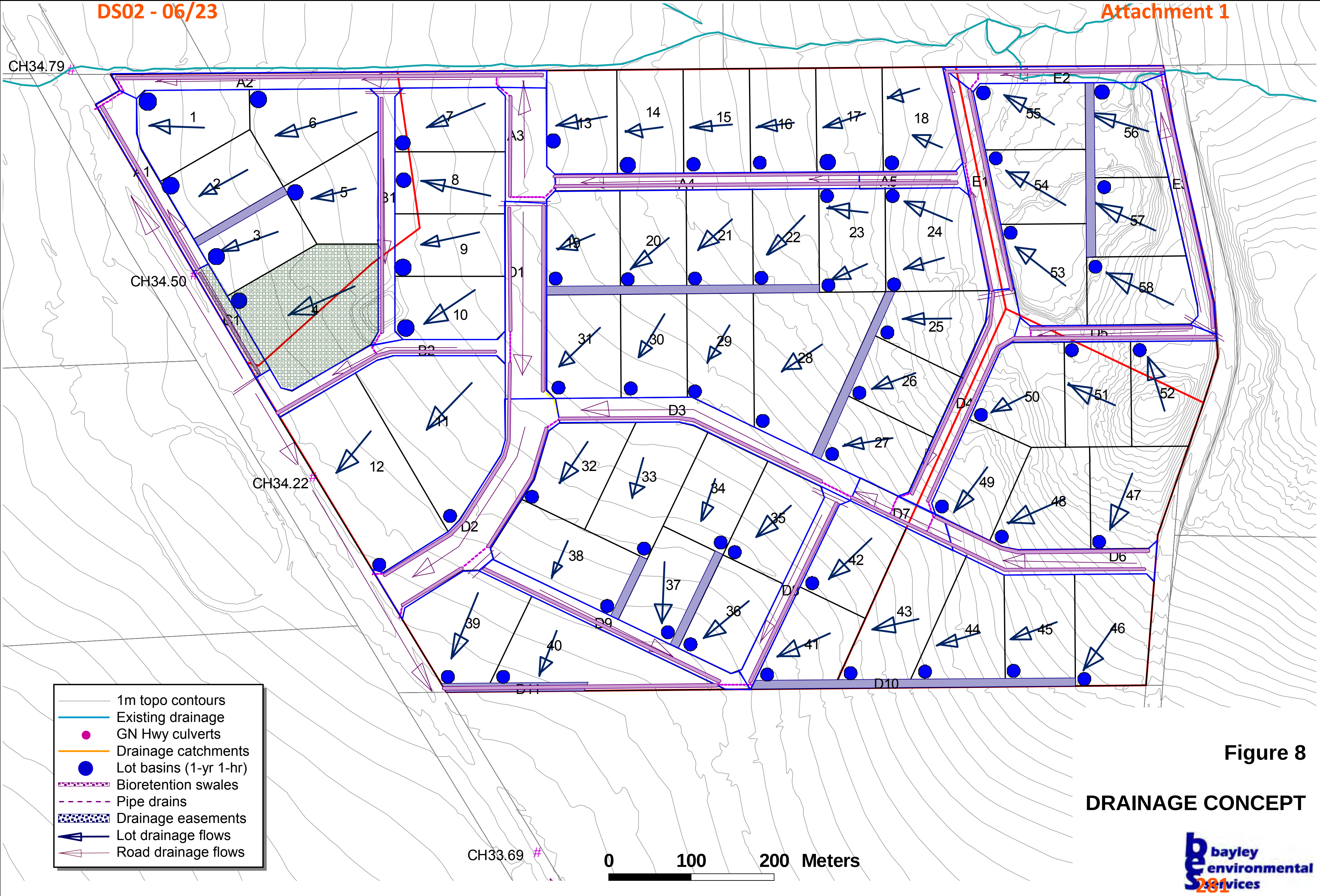

Figure 8

DRAINAGE CONCEPT

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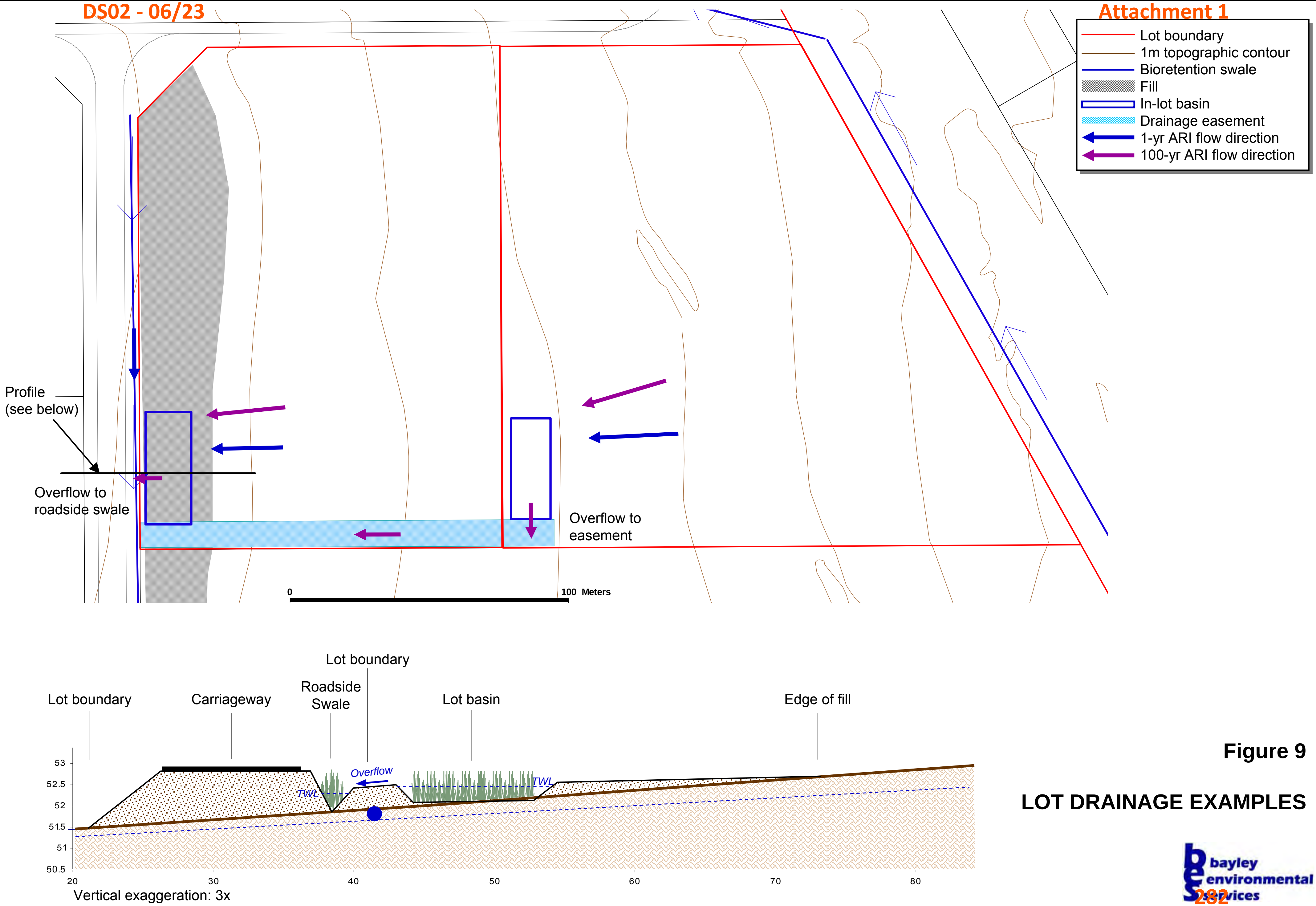

Figure 9

LOT DRAINAGE EXAMPLES

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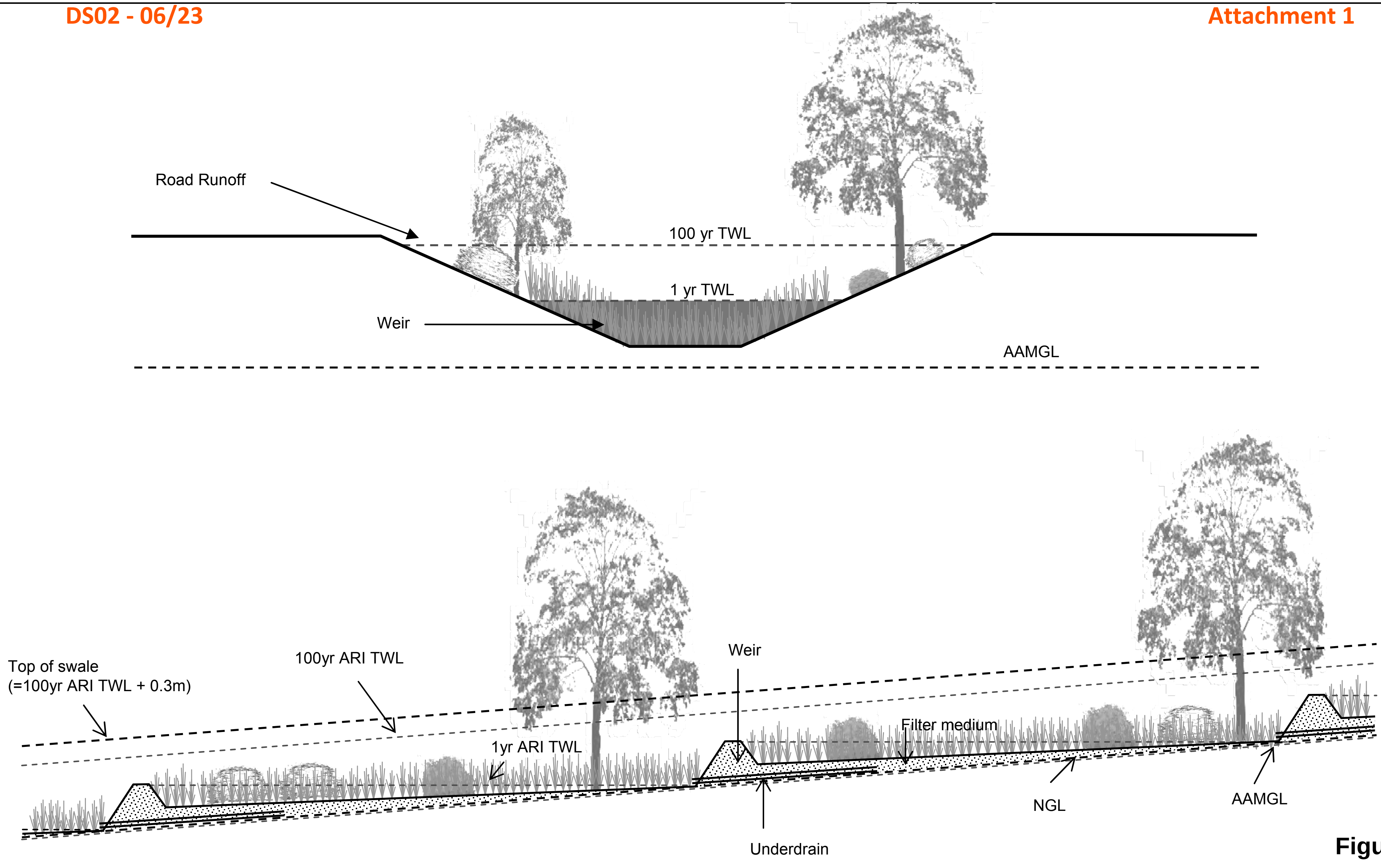

Figure 10

CONCEPTUAL SWALE PROFILES

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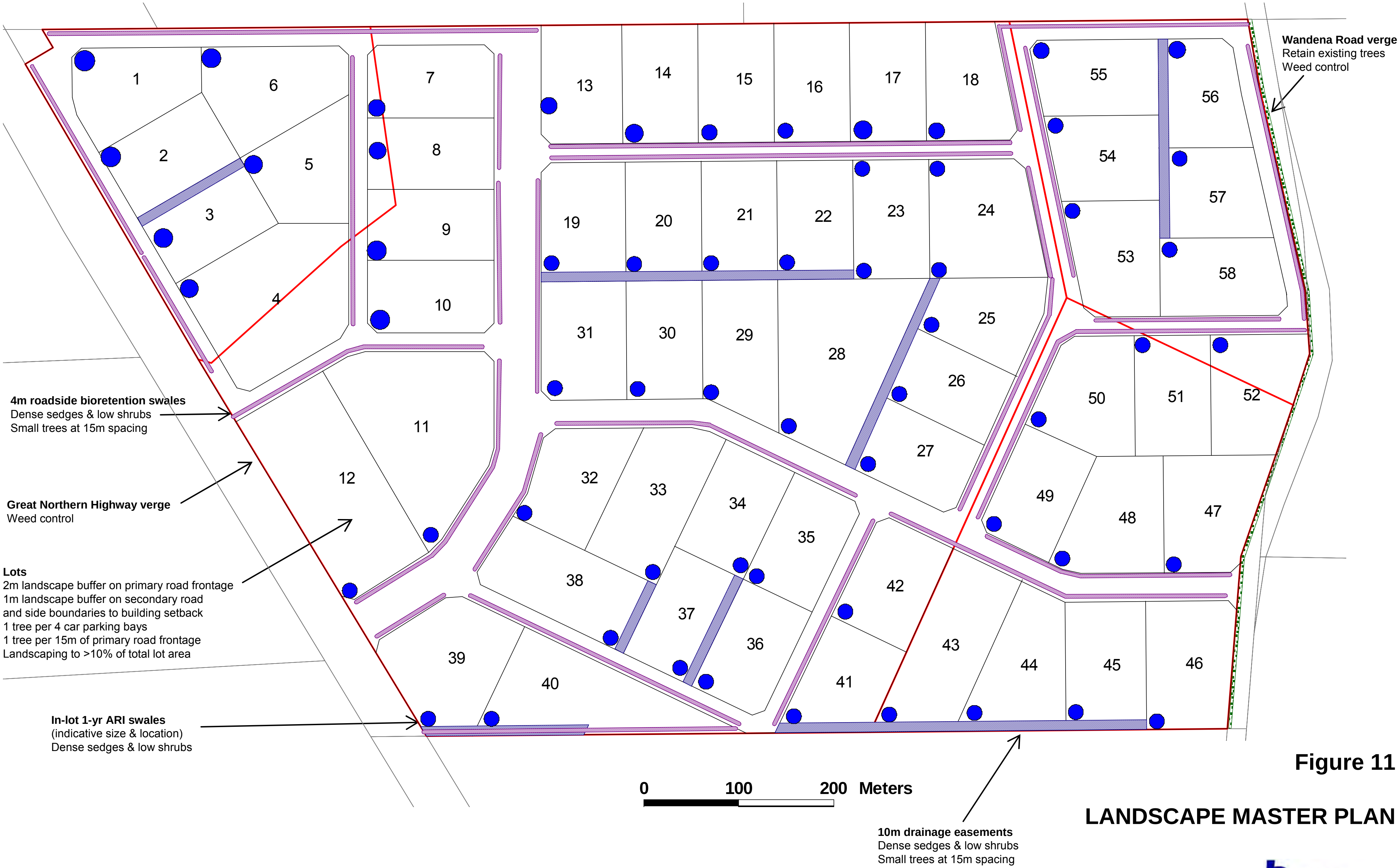

Figure 11

LANDSCAPE MASTER PLAN

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Appendix A

DWER LWMS Checklist

Appendix 2 Local water management strategy checklist

Local water management strategy item	Deliverable	☑	Notes
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for best management practices and critical control points	☑	Page 8
Introduction			
Total water-cycle management – principles and objectives Planning background Previous studies		☑	Section 1
Proposed development			
Structure plan, zoning and land use Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	Figures 1-3 Section 2
Landscape – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape plan	☑	Sections 3, 7
Design criteria			
Agreed design objectives and source of objectives		☑	Section 1.5 Table 1.1
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 2
Site conditions – existing topography/contours, aerial photo underlay, major physical features	Site condition plan	☑	Section 2
Geotechnical – topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 2
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Section 2
Surface water – topography, 100-year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface-water plan	☑	Section 2
Groundwater – topography, pre-development groundwater levels and water quality, test bore locations	Groundwater plan plus site investigations	☑	Section 2

Local water management strategy item	Deliverable	☑	Notes
Water sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☑	Section 3
Water supply (fit-for-purpose) strategy, agreed actions and implementation		☑	Section 3
Wastewater management		☑	Section 4
Stormwater management strategy			
Flood protection – peak flow rates, volumes and top water levels at control points, 100-year flowpaths and100-year detention storage areas	100-year-event plan Long section of critical points	☑ ☑	Section 5
Manage serviceability – storage and retention required for the critical 5-year ARI storm events Minor roads should be passable in the 5-year ARI event	5-year-event plan	☑	Section 5
Protect ecology – detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1-year-event plan Typical cross sections	☑ ☑	Section 5
Groundwater management strategy			
Post-development groundwater levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones	Groundwater/subsoil plan	☑	Section 6
Actions to address acid sulfate soils or contamination		☑	Sections 2.2.4 and 2.6
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design.		☑	Section 9
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 8
Implementation			
Developer commitments		☑	Section 9
Roles, responsibilities, funding for		☑	Section 9

Local water management strategy item	Deliverable	☑	Notes
implementation			
Review		☑	Section 9

Appendix B

Soil Logs

SOIL PROFILE LOG

PROJECT NUMBER:	J19018
SITE ID:	WB1
EASTING:	405843
NORTHING:	6503819
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.5
REFUSAL (Y/N):	N
DATE:	24/03/2020
DEPTH TO WATER (mbgl)	None encountered

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Pale yellow-brown sand		
0.5 - 1.5	Brown gravelly sand		
2	Orange pebbly silt		
2.5 - 3	Orange pebbly sandy silt		
3.5	Orange clayey silt		
4	Red-orange clayey silt		
4.5 - 5	Red silty clay		
5.5	Red gravelly clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J19018
SITE ID:	WB2
EASTING:	406206
NORTHING:	6504189
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.5
REFUSAL (Y/N):	N
DATE:	24/03/2020
DEPTH TO WATER (mbgl)	None encountered

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0	Pale yellow-brown pebbly silty sand		
0.5 - 2	Orange-brown gravelly sandy silt.		
2.2	Hard red/grey mottled clay		
2.5 - 3	Pale brown pebbly sandy silt		
3.5	Pink clayey silt		
4-4.5	Orange-brown pebbly clayey silt		
5-5.5	Red gravelly silty clay, hard		

SOIL PROFILE LOG

PROJECT NUMBER:	J19018
SITE ID:	WB3
EASTING:	406365
NORTHING:	6503799
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.5
REFUSAL (Y/N):	N
DATE:	24/03/2020
DEPTH TO WATER (mbgl)	None encountered

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.5	Pale yellow-brown pebbly silty sand		
1	Yellow pebbly sandy silt		
1.5	Orange-brown pebbly silt		
2 - 2.5	Orange pebbly silt		
3	Red-brown pebbly silt		
3.5	Redish pebbly silt		
4	Red-brown pebbly silty clay		
4.5 - 5	Red pebbly silty clay		
5.5	Red silty clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J19018
SITE ID:	WB4
EASTING:	406393
NORTHING:	6503460
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.5
REFUSAL (Y/N):	N
DATE:	24/03/2020
DEPTH TO WATER (mbgl)	None encountered

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0 - 0.5	Grey-brown silty sand		
1 - 2	Yellow-brown pebbly silty sand		
2.5	Yellow-brown pebbly silt		
3 - 3.5	Red-brown pebbly silt		
4	Yellow-brown pebbly silty sand		
4.5 - 5	Yellow-brown pebbly clayey silt		
5.5	Brown/grey mottled silty clay		

GEOTECH FIELD LOG

PROJECT No.:

TEST PIT/BOREHOLE No.: 1 MW 1

Client: Focus Demolition	Elevation: 103 m Eastings: 0406899 Northings: 6504175		Sheet of
Project: Wandena	Datum:		Date:
Location: Muchea	Machine:		Logged by:

Excavation Information				MATERIAL INFORMATION: Primary Component												Secondary Component					Minor Components		Strength	Moisture	IPT (%)	Sketch and Other Observations Structure, Geological Origin, Etc.	SAMPLING & TESTING: Sample No.	From	To
Depth	Method	Resist	Water	Fill	UCS	Clayey	Silty	Sandy	Gravelly	Clay	Silt	Sand	Gravel	Plasticity or Grain Size	Colour	%	Plasticity or Grain Size	Fines	Sand	Gravel	With	Trace of							
0 to 2	0-2							✓	✓	✓					Light Brown														
2 to 3									✓	✓					Light Brown														
3 to 5.5									✓		✓				Yellowish														
5.5 to 11									✓	✓					Reddish											Some cementing			
11 to 14.5										✓					Grey											Slightly Brown			
14.5 to 18						✓							✓		Red											Ironstone			
18 to 20.5						✓						✓			Brown								S			Cemented			

Method
PT = Push Tube
DPT = Dynamic push tube
AV = Auger - V bit
AR = Auger - TC rock bit
HA = Hand auger
BH = Backhoe
EX = Tracked excavator

Water
>> = Water inflow
<< = Water outflow
GWO = Water first observed
SWL = Standing water level

Samples & Tests
DS = Disturbed sample
U50 = Thin wall undistirubed sample
(diam indicated by numerals)
SPT = Standard penetration test
N = number of blows/300 mm
* = sample recovered
PP = Pocket penetrometer

Plasticity
NP = Non plastic
LP = Low plastic
MP = Med plastic
HP = High plastic
VHP = V. High plastic
EHP = E. High plastic

Grain size
F = Fine
M = Medium
C = Coarse

Moisture
<< = much less than
< = less than
c = about
> = greater than
>> = much greater than
PL = plastic limit
LL = liquid limit
D = dry
M = moist
W = wet

Strength
VS Very soft
S Soft
F Firm
St Stiff
Vst Very Stiff
H Hard
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Remarks:
End of pit: 20.5 m
Groundwater
Not encountered
Not observed
GWO at m
SWL at 16.2 m
Casing Height 0.6m, slotted pipe to 14.5m
Gravel to 6.5m - Bentonite to 3.5m

GEOTECH FIELD LOG

PROJECT No.:

TEST PIT/BOREHOLE No.: 2 MW 2

Client: Focus Demolition	Elevation: Eastings: Northings:		Sheet of
Project: Wandena	Datum:		Date:
Location: Muchea	Machine:		Logged by:

Excavation Information				MATERIAL INFORMATION: Primary Component												Secondary Component					Minor Components		Strength	Moisture	IPT (%)	Sketch and Other Observations Structure, Geological Origin, Etc.	SAMPLING & TESTING: Sample No.	From	To
Depth	Method	Resist	Water	Fill	UCS	Clayey	Silty	Sandy	Gravelly	Clay	Silt	Sand	Gravel	Plasticity or Grain Size	Colour	%	Plasticity or Grain Size	Fines	Sand	Gravel	With	Trace of							
0 to 5									✓	✓					Light Brown														
5 to 9									✓	✓					Grey											Hard Clay			
9 to 16							✓			✓					Yellow / Grey											Mottling of yellow oxidation			
16 to 18						✓							✓		Dark Red											Very well cemented iron stone			
18 to 25						✓						✓			Green / Brown											Fine/medium clayey sand			

Method
PT = Push Tube
DPT = Dynamic push tube
AV = Auger - V bit
AR = Auger - TC rock bit
HA = Hand auger

Water
>> = Water inflow
<< = Water outflow
GWO = Water first observed
SWL = Standing water level

Samples & Tests
DS = Disturbed sample
U50 = Thin wall undistirubed sample
(diam indicated by numerals)
SPT = Standard penetration test
N = number of blows/300 mm

Plasticity
NP = Non plastic
LP = Low plastic
MP = Med plastic
HP = High plastic
VHP = V. High plastic

Grain size
F = Fine
M = Medium
C = Coarse

Moisture
<< = much less than
< = less than
c = about
> = greater than
>> = much greater than

Strength
VS Very soft
S Soft
F Firm
St Stiff
Vst Very Stiff
Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense

Remarks:
End of pit: 22.4 m
Groundwater
Not encountered
Not observed

BH = Backhoe
EX = Tracked excavator

* = sample recovered
PP = Pocket penetrometer

EHP = E. High plastic

PL = plastic limit
LL = liquid limit
D = dry
M = moist
W = wet

H Hard
VD Very Dense

GWO at m
SWL at 18.4 m
Casing height 0.6m, gravel pack to 15.4 m BGL
Bentonite to 13.4 m BGL

GEOTECH FIELD LOG

PROJECT No.:

TEST PIT/BOREHOLE No.: 3 MW 3

Client: Focus Demolition	Elevation: 93 m	Eastings: 0406684	Northings: 6504119	Sheet of
Project: Wandena	Datum:			Date:
Location: Muchea	Machine:			Logged by:

MATERIAL INFORMATION / **SAMPLING & TESTING**

Excavation Information				Primary Component												Secondary Component					Minor Components		Strength	Moisture	IPT (%)	Sketch and Other Observations Structure, Geological Origin, Etc.	Sample No.	From	To
Depth	Method	Resist	Water	Fill	UCS	Clayey	Silty	Sandy	Gravelly	Clay	Silt	Sand	Gravel	Plasticity or Grain Size	Colour	%	Plasticity or Grain Size	Fines	Sand	Gravel	With	Trace of							
0 to 0.9												✔			Yellow / Brown											Fine / Medium			
0.9 to 2.1								✔					✔		Brown														
2.1 to 4									✔	✔					Orange / Brown														
4 to 5							✔			✔					White											Bleached			
5 to 7									✔	✔					Red											Ironstone			
7 to 8.5									✔	✔					Red/white											Some Bleached Zones			
8.5 to 9.7															Red											Cemented Ironstone			
9.7 to 11							✔			✔					White/grey														
11 to 16.5								✔		✔					Red/Brown											Fine			
16.5 to 19.5								✔		✔					Brown														

Method
PT = Push Tube
DPT = Dynamic push tube
AV = Auger - V bit
AR = Auger - TC rock bit
HA = Hand auger
BH = Backhoe
EX = Tracked excavator

Water
>> = Water inflow
<< = Water outflow
GWO = Water first observed
SWL = Standing water level

Samples & Tests
DS = Disturbed sample
U50 = Thin wall undistirubed sample
(diam indicated by numerals)
SPT = Standard penetration test
N = number of blows/300 mm
* = sample recovered
PP = Pocket penetrometer

Plasticity
NP = Non plastic
LP = Low plastic
MP = Med plastic
HP = High plastic
VHP = V. High plastic
EHP = E. High plastic

Grain size
F = Fine
M = Medium
C = Coarse

Moisture
<< = much less than
< = less than
c = about
> = greater than
>> = much greater than
PL = plastic limit
LL = liquid limit
D = dry
M = moist
W = wet

Strength
VS Very soft
S Soft
F Firm
St Stiff
Vst Very Stiff
H Hard

Fb Friable
VL Very Loose
L Loose
MD Medium Dense
D Dense
VD Very Dense

Remarks:
End of pit: 18.5 m BGL
Groundwater
Not encountered
Not observed
GWO at m
SWL at m

GEOTECH FIELD LOG

PROJECT No.:

TEST PIT/BOREHOLE No.: 4 MW 4

Client: Focus Demolition	Elevation:	Eastings:	Northings:	Sheet of
Project: Wandena	Datum:			Date: 6/4/16
Location: Muchea	Machine:			Logged by:

MATERIAL INFORMATION / **SAMPLING & TESTING**

Excavation Information				Primary Component												Secondary Component					Minor Components		Strength	Moisture	IPT (%)	Sketch and Other Observations Structure, Geological Origin, Etc.	Sample No.	From	To
Depth	Method	Resist	Water	Fill	UCS	Clayey	Silty	Sandy	Gravelly	Clay	Silt	Sand	Gravel	Plasticity or Grain Size	Colour	%	Plasticity or Grain Size	Fines	Sand	Gravel	With	Trace of							
0 - 1								✔					✔	Brown												Colluvial			

1 - 3.5									✓	✓				Reddish												Ferricrete (slightly cemented)			
3 - 5.7									✓	✓				Ochre												Mottled (cementing w/ gravel)			
7 - 7.2														Reddish									H			Lens of iron oxide stone			
7.2 - 8										✓				White												Bleached Clay			
8 - 8.5														Red									H			Lens of iron oxide stone			
8.5 - 11.5										✓				White												Bleached clay			
11.5 - 12.5														Reddish									H			Lens of iron oxide stone			
12.5 - 14										✓				White/Grey												Bleached clay			
14 - 15														Reddish									H			Well-cemented iron oxide			
15 - 19.7								✓						Dark Red												moist sandy clay			

Method	Water	Samples & Tests	Plasticity	Grain size	Moisture	Strength		Remarks:
PT = Push Tube	>> = Water inflow	DS = Disturbed sample	NP = Non plastic	F = Fine	<< = much less than	VS Very soft	Fb Friable	End of pit: 19.7 m
DPT = Dynamic push tube	<< = Water outflow	U50 = Thin wall undistirubed sample	LP = Low plastic	M = Medium	< = less than	S Soft	VL Very Loose	
AV = Auger - V bit	GWO = Water first observed	(diam indicated by numerals)	MP = Med plastic	C = Coarse	c = about	F Firm	L Loose	**Groundwater**
AR = Auger - TC rock bit	SWL = Standing water level	SPT = Standard penetration test	HP = High plastic		> = greater than	St Stiff	MD Medium Dense	Not encountered
HA = Hand auger		N = number of blows/300 mm	VHP = V. High plastic		>> = much greater than	Vst Very Stiff	D Dense	Not observed
BH = Backhoe		* = sample recovered	EHP = E. High plastic		PL = plastic limit	H Hard	VD Very Dense	
EX = Tracked excavator		PP = Pocket penetrometer			LL = liquid limit			GWO at m
					D = dry			SWL at 15.2 m BGL
					M = moist			
					W = wet			

Appendix C

Geotechnical Report

Douglas Partners

Geotechnics | Environment | Groundwater

Report on Preliminary Geotechnical Investigation

Proposed Industrial Development
Lots 202 & 203 Wandena Road and
204 & 205 Great Northern Highway, Muchea, WA

Prepared for
Focus Demolition & Asbestos Removal &
David Weightman Smith

Project 96712.00
October 2020

Integrated Practical Solutions

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	96712.00	Document No.	R.001.Rev0
Document title	Report on Preliminary Geotechnical Investigation Proposed Industrial Development		
Site address	Lots 202 & 203 Wandena Road and 204 & 205 Great Northern Highway, Muchea, WA		
Report prepared for	Focus Demolition & Asbestos Removal & David Weightman Smith		
File name	96712.00.R.001.Rev0.Proposed Industrial Development		

Document status and review

Status	Prepared by	Reviewed by	Date issued
Revision 0	Damian Jagoe-Banks	Fred Verheyde	12 October 2020

Distribution of copies

Status	Issued to
Revision 0	James Wortley, Tomahawk Property

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

	Signature	Date
Author		12 October 2020
Reviewer		12 October 2020

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FS 604853

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Douglas Partners
Geotechnics / Environment / Groundwater

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Report on Preliminary Geotechnical Investigation
Proposed Industrial Development
Lots 202 & 203 Wandena Road and 204 & 205 Great Northern Highway, Muchea, WA

1. Introduction

This report presents the results of a preliminary geotechnical investigation undertaken for a proposed industrial development at Lots 202 & 203 Wandena Road and 204 & 205 Great Northern Highway, Muchea, WA . The investigation was commissioned in an email dated 24 August 2020 from James Wortley of Tomahawk Property on behalf of Focus Demolition & Asbestos Removal & David Weightman Smith and was undertaken in accordance with Douglas Partners' proposal PER200244.Rev2 dated 21 July 2020.

Further to the scope of work detailed in the aforementioned proposal, a variation to assess stockpiled material within the site for its suitability for use as pavement construction material was requested by Focus Demolition & Asbestos Removal. The approval to proceed with this variation was provided via email on 16 September 2020.

It is understood that the land is currently zoned for agricultural resource and it is intended to rezone the land for future industrial use. This geotechnical report is to support the rezoning process by providing information on the typical ground conditions across the site, suitability of the soils for on-site effluent disposal and also to identify any geotechnically related opportunities or challenges with regard to future development of the land.

The purpose of the preliminary geotechnical investigation is to assess the ground conditions at the site and provide preliminary geotechnical comments on:

- The sub-surface conditions including identification of areas of problematic ground conditions, if encountered.
- The likely site classification for future development, in accordance with the requirements of AS 2870-2011.
- General site preparation requirements including comments on excavatability, material reuse and earthworks to suitably prepare the ground for the road pavement and industrial lots.
- Preliminary advice on the suitability of the soils at the site for on-site effluent disposal in accordance with AS 1547 and the Western Australian 2019 Government Sewerage Policy.
- The depth to groundwater, if encountered.
- Permeability of the encountered soils at the site.

The investigation included the excavation of 30 test pits, dynamic penetrometer testing, six in-situ infiltration tests using a constant head method and laboratory testing of selected samples. The details of the field work are presented in this report, together with comments and recommendations on the items listed above.

2. Site Description

The site is an 83 ha parcel of land, identified as Lots 202 and 203 Wandena Road and 204 and 205 Great Northern Highway in Muchea, WA. It is bound by Great Northern Highway to the West, Wandena Road to the East and rural land to the north and south.

At the time of the investigation, the eastern part of the was operating as a horse stud and the eastern part of the site was a partially backfilled quarry. The western part of the site was mostly covered in grassy paddocks with scattered mature trees. The surface across the eastern part of the site is generally gravelly and vegetation consists of scattered shrubs and trees. Figures 1 and 2 below show typical site conditions at the time of the investigation.

Figure 1: Typical site conditions in western part of the site.

Figure 2: Typical site conditions in eastern part of the site

Based on publicly available LiDAR information, site surface levels generally grade from approximately RL 100 m AHD at the eastern part of the site to RL 58m AHD in the south-western corner. A terrain slope analysis indicates that generally the surface levels in the western half of the site grade between 1° and 3° and the eastern part of the site has slope angles generally between 3° and 6° with isolated areas of up to 15°. Note that the slopes associated with the quarry pit have been ignored in the slope analysis.

The Muchea 1:50,000 scale geological mapping indicates the site is underlain by (in an east to west direction):

- ST1: Siltstone – located in the eastern part of the site, where surface levels are above RL 80 m AHD
- Msg: Colluvial Sandy Silt – located up to 150 m to the west of the siltstone
- S5: Colluvial Sand – located approximately 150 m to the west of the sandy silt; and
- Mgs1: Pebbly Silt of the Guildford Formation – located west sand, extending to the western boundary of the site.

The Perth Groundwater Atlas indicates groundwater levels were around 43 m AHD to 53 m AHD in 2003 (over 15 m below the lowest level on the site). Groundwater perched on low permeability soils or rock is anticipated during the wetter months of the year.

3. Field Work Methods

Field work was carried out between 15 and 17 September 2020 and comprised the excavation of 30 test pits, together with dynamic cone penetrometer (DCP) testing adjacent to each test pit and six in-situ infiltration tests.

The test pits (test locations 1 to 30) were excavated to depths of between 1.4 m and 2.5 m using an 8 tonne backhoe equipped with a 450 mm toothed bucket, and were logged in general accordance with AS 1726-2017 by a geotechnical engineer from Douglas Partners. Test pit termination prior to the target depth was experienced on hard soil at test locations 6, 9, 10, 17, 18, 20, 22, 24, and 29 (nine locations).

Dynamic cone penetrometer (DCP) and Perth sand penetrometer (PSP) tests were carried out adjacent to the test pits in accordance with AS 1289.6.3.2 and AS 1289.6.3.3 respectively, to assess the in-situ density and consistency of the subgrade soils.

Six in-situ infiltration tests were carried out at locations 6, 11, 16, 19, 25 and 30 using a constant head method in accordance with AS 1547-2012 Appendix 4.1F. Testing was undertaken at depths of between 0.2 m and 0.8 m to target characteristic soils across the site.

Test locations were determined using GPS coordinates and are marked on Drawing 1 in Appendix B. Surface elevations at each test location were obtained from publicly available LiDAR information, and are quoted relative to Australian Height Datum (AHD).

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions and results of the field testing are presented in Appendix B, together with notes defining descriptive terms and classification methods in Appendix A. A summary of the ground conditions encountered at the test locations is given below.

In summary, ground conditions generally comprise:

- **Unit 0A: Sandy topsoil (Silty SAND SM) –** generally 0.1 m thick, fine to medium grained, low plasticity, dark grey-brown, with gravel, with roots, at all locations except for 6 to 8 and 18 to 21.
- **Unit 0B: FILL (Gravelly, sandy soils and clayey soils) –** fill of varying consistency, density and colour, encountered from the surface to depths up to 2.1 m at test locations 6 to 8 and 18 to 21 (seven locations in the vicinity of the quarry).
- **Unit 1A: Granular soils (Sandy GRAVEL GP-GM and SAND SP-SM) –** fine to medium grained, dark grey-brown and grey-brown, sandy soils with varying gravel content encountered below the topsoil and fill to depths between 0.25 m and 0.95 m at test locations except for 7, 8, 19 and 30.
- **Unit 1B: Sandy SILT ML –** grey-brown sandy silt underlying the topsoil to a depth of 0.8 m at test location 30.
- **Unit 2: Cohesive, gravelly soils (Clayey Sandy GRAVEL GC)** – generally hard, orange-brown, clayey sandy gravel below Unit 1 to test pit termination depths up to 2.5 m at all locations except for 7 and 8 and 19 where siltstone was encountered at depths of approximately 2 m.

  Excavation was terminated at prior to 2.5 m deep due to slow digging in hard clayey, gravelly soils at locations 6, 9, 10, 17, 18, 20, 22, 24, and 29.
- **Unit 3**: **Rock (Siltstone)** – fine grained, pale red-white siltstone, moderately weathered, low to medium strength below the fill and possible fill at locations 7, 8 and 19 to test pit termination depth of 2.5 m.

4.2 Groundwater

Groundwater was observed at four test locations during the field work on 15 and 16 September 2020. The test pits were immediately backfilled following sampling, which precluded any longer-term monitoring of groundwater levels.

Table 1: Groundwater Observations on 15 and 16 September 2020

Test Location	Surface Level (m AHD)	Water Conditions	Water Depth (m)	Water Level (m AHD)
3	68.1	Water seepage	1.6	66.5
4	72.6	Water seepage	0.7	71.9
13	61.7	Large Inflow	1.1	60.6
22	69.2	Water seepage	1.9	67.3

It should be noted that groundwater levels are potentially affected by various factors such as climatic conditions and land usage and will therefore vary with time.

4.3 Results of Infiltration Testing

Six in-situ infiltration tests using the constant head method were undertaken within the site. The tests were undertaken in accordance with AS 1547 Appendix 4.1F and were undertaken at particular depths and locations to target all of the shallow soil types encountered during the investigation. The permeability results are summarised in Table 2.

Table 2: Summary of Permeability Analysis

Test Location	Depth (m)	Permeability		Material
		m/s	m/day	
6	0.3-0.5	9.0×10^{-5}	7.8	Unit 1A: Sandy GRAVEL, with silt
11	0.6-0.8	1.0×10^{-5}	0.9	Unit 2: Clayey, sandy GRAVEL
16	0.5-0.8	1.9×10^{-5}	1.6	Unit 2: Clayey, sandy GRAVEL
19	0.15-0.45	5.7×10^{-7}	0.05	Unit 0B: FILL/Sandy CLAY
25	0.2-0.4	1.0×10^{-4}	8.6	Unit 1A: Sandy GRAVEL, trace silt
30	0.3-0.5	1.2×10^{-5}	1.0	Unit 1B: Sandy SILT, trace gravel

5. Geotechnical Laboratory Testing

5.1 Soil Identification and Characteristics

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

- The particle size distributions of four samples;
- The Atterberg limits and linear shrinkage of two samples;
- The Emerson Class of four samples; and
- the pH, electrical conductivity and cation exchange capacity index on two samples.

Detailed test report sheets are given in Appendix C and the results are summarised in Tables 3 and Table 4, next page.

Table 3: Results of Laboratory Testing for Soil Identification

Test Location	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	LL (%)	PL (%)	PI (%)	LS (%)	Material
6	0.3-0.5	7	22	71	-	-	-	-	Unit 1A: Sandy GRAVEL, with silt
16	0.5-0.8	18	35	47	28	15	13	5.5	Unit 2: Clayey, sandy GRAVEL, low plasticity fines
25	0.2-0.4	4	22	74	NP	NP	NP	-	Unit 1A: Sandy GRAVEL, trace silt
30	0.3-0.5	37	53	10	-	-	-	-	Unit 1B: Sandy SILT, trace gravel

Notes: Fines are particles smaller than 75 µm.
Sand is particles larger than 75 µm and smaller than 2.36 mm.
Gravel is particles larger than 2.36 mm and smaller than 63 mm.
PL: plastic limit LL: liquid limit PI: plasticity Index LS: linear shrinkage
'-': not tested.

Table 4: Summary of Laboratory Testing Results for Effluent Disposal

Test Location	Depth (m)	pH	EC (dS/m)	CEC (meq/100g)	Emerson Class	Material
6	0.3-0.5	6.6	0.037	2	2	Unit 1B: Sandy GRAVEL, with silt
16	0.5-0.8	6.3	0.024	3	5	Unit 2: Clayey, sandy GRAVEL, low plasticity fines
25	0.2-0.4	-	-	-	5	Unit 1B: Sandy GRAVEL, trace silt
30	0.3-0.5	-	-	-	2	Unit 1A: Sandy SILT, trace gravel

Notes:
- pH and EC tests are carried out in 1:5 (soil:water) solution.
- CEC: Cation exchange capacity in meq/100g.
- EC: Electrical conductivity

6. Proposed Development

It is understood that it is proposed to rezone the land from agricultural use to industrial use. Development of the land following rezoning is anticipated to comprise road pavements and earthworks to shape the lots to finished surface levels.

7. Comments

7.1 Sub-surface Conditions and Likely Site Classification

Ground conditions across the site were observed to generally comprise gravelly soils to a depth of between 0.5 m and 1 m underlain by cemented soil comprising mixture of clay, sand and gravel. Siltstone was encountered at a depth of approximately 2 m (generally below uncontrolled fill) at a few locations within the eastern part of the site.

Based on the encountered soils, no significant geotechnical constraints or challenges for the intended industrial development were identified during this investigation across most of the site, other than possibly its eastern end where various thicknesses of fill were identified within and around the existing quarry. The shallow cemented clayey soils across the site are generally hard and the siltstone in the eastern part of the site was low to medium strength. Therefore, it is anticipated that the one geotechnical constraint could be ground excavatability, depending on proposed excavation depths. Uncontrolled fill was encountered within and near the exiting quarry in the eastern part of the site and will require suitable site preparation to be re-used as foundation material.

The clayey soils, generally encountered from depths of between 0.5 m and 1.0 m are slightly reactive and therefore, it is considered that the areas of the site with natural soils have a site classification of Class S, in accordance with AS 2870-2011.

In accordance with AS 2870-2011, locations that have fill (e.g. generally the north-eastern part of the site) should be considered Class P in the absence of any certification from those controlling the placement of the fill (understood to be an ongoing process at the time of this reporting). If no certification for the fill can be provided, the filled class P areas could be reclassified following further geotechnical investigation.

Achieving Class A, if targeted, would require at a thickness of least 1.8 m of non-reactive soils over any reactive clayey material, which at this site would generally require the placement of over 1 m of non-reactive, granular fill.

It should also be noted that the abovementioned site classification comments do not take into account the possible effect of trees increasing the seasonal surface movement. In accordance with AS 2870-2011, trees will impact the classification as follows:

- If one tree is located within a distance of approximately its mature height of a building envelope;
- If a group of trees are located within a distance of approximately twice their mature height of a building envelope; and
- If trees are removed and the development proceeds shortly after removal. Recovery from abnormal moisture conditions arising from tree removal can typically take 2 to 3 years, although this may also be affected by weather patterns. Wherever possible, sufficient time should be allowed for this recovery to take place.

The presence (either existing or proposed) or removal of trees (if the development proceeds within 2 to 3 years of removal of mature trees), may therefore impact the site. As described in Section 2, trees were present across the site during the investigation in September 2020. Thus, the possible impact of existing trees on foundation design should be considered at the site in the event that any of the above detailed conditions are met.

7.2 Site Preparation

7.2.1 Stripping

All topsoil and vegetation should be stripped from building envelopes, earth-working areas and pavement areas, and either removed from site or stockpiled for possible re-use if applicable.

Tree roots remaining from any clearing operations should be completely removed, and the excavations backfilled with material of similar geotechnical properties to the surrounding ground, and compacted to achieve a dry density ratio of not less than 92% and 95% relative to modified compaction for a cohesive and granular subgrade, respectively.

It is recommended that following stripping and prior to filling, if any, the natural subgrade be assessed by a geotechnical engineer to assess the suitability of the stripping.

7.2.2 Proof Rolling and Compaction

Once the stripped subgrade has been assessed by a geotechnical engineer, it is recommended that the exposed subgrade beneath the building and pavement envelopes be proof rolled using a heavy roller. Any areas that show signs of excessive deformation during compaction should be continually compacted until deformation ceases or, alternatively, the poor quality material should be excavated and replaced with suitable structural fill compacted to achieve a dry density ratio of not less than 92% and 95% relative to modified compaction for cohesive and granular subgrades, respectively.

It is recommended that compaction control of clayey and gravelly materials, be carried out using a nuclear surface moisture-density gauge, in accordance with AS 1289.5.8.1. Compaction control in sandy materials, for instance possible sand fill, could be carried out using a Perth sand penetrometer (PSP) test in accordance with test method AS 1289.6.3.3. It is suggested that the sand fill be compacted to achieve a minimum blow count of 8 blows per 300 mm rod penetration to a depth of not less than 1 m below foundation level. It should be noted that this compaction level has not been directly correlated to a dry density of 95% relative to modified compaction. Lower blow counts than the above level may be acceptable provided that a correlation between Perth sand penetrometer (PSP) test and dry density ratio has been established by a NATA accredited laboratory and following review by a geotechnical engineer.

7.2.3 Preparation of Uncontrolled Fill

As detailed in Section 4.1, fill was encountered to depths up to 2.1 m at seven locations near and within the quarry. The fill is considered uncontrolled and therefore, to provide a site classification other than Class P, either:

1. Certification is provided by others on the composition, density and suitability the fill for structural foundations; or

2. Provided the fill comprised soil and material suitable for foundation support (e.g. no compressible, or notable organic content) fill is compacted to a suitable depth to produce conditions suitable for foundation support.

It is possible that certification can be provided for the fill placed within the central quarry pit (e.g. test location 8), however it is anticipated that certification for fill encountered on the periphery of the pit is unlikely.

Where certification is not available, proof compaction of the existing fill should be undertaken. For fill less than 1 m deep, it is considered likely that a heavy roller (say 17 tonne) would be suitable to compact the fill. For deeper fill and up to a depth of approximately 4 m, rapid impact compaction (RIC) could be considered as a method to avoid any excavation and replacement in a controlled manner.

Rapid impact compaction is a specialised ground improvement technique that involves the repetitive dropping of a weight (5 to 10 tonnes) from limited height (1 m to 2 m), 40 to 60 times per minute, using a specialised hydraulic unit attached to an excavator. Indicatively, one possible local specialist contractor includes Rapid Impact Compaction Australia (however further research might indicate other contractors servicing Western Australia). It should be noted that RIC generates vibrations.

Alternatively to RIC, impact rolling could also be considered for fill depths of approximately 1 m to 2 m. Impact rolling is a specialised ground improvement technique that involves towing of a non-circular compaction module at a speed of about 12 km/hr. The module impact the ground, resulting in a greater depth of compaction than under a conventional circular drum roller. However, suitable expertise for such technique might be required to be sourced from interstate specialist contractors (e.g. Brooms, Landpac) who service Western Australia.

In the absence of additional information from the land owner of Lots 202 and 203, it is suggested that further investigation to provide more information on the depth and composition of the fill is undertaken to assist in the assessment of suitable site preparation methods for areas of uncontrolled fill. To optimise any further investigation for uncontrolled fill, it is also suggested that the investigation occurs once finished surface levels for future development are available.

7.3 Excavation Conditions and Groundwater

Based on the ground conditions described in Section 4.1, excavations associated with bulk earthworks, service trenches and foundations are anticipated to be undertaken through gravelly surficial soils and hard or cemented gravelly clayey soils.

Given the slow excavation rates and refusal experienced using an 8 tonne backhoe during the investigation, owing to the presence of cemented soils, the use of a powerful excavator (i.e. 20 tonne or heavier) fitted with tynes of hydraulic hammer is recommended for excavations during earthworks.

Siltstone was encountered a depths of approximately 2 m (generally below fill), however it cannot be preluded at shallower depths and therefore it is considered prudent to allow provision for hydraulic breakers or tynes during site works. Heavy ripping using D9 dozer or heavier using a single ripper tyne should be considered if large excavations in siltstone are proposed.

Slow groundwater seepage was encountered at four locations at the time of field work in September 2020 (near the typical highest groundwater levels of the year). As such, for relatively shallow excavations, say less than 2.5 m, no significant challenges with groundwater management are anticipated for shallow excavations. It is considered likely that some management of seepage water, e.g. through sump pumping to remove ponding water at the base of excavations, would be required if field work is undertaken within the wetter period of the year.

7.4 Re-use of On-Site Materials

The encountered silty sandy topsoil could be considered for re-use as fill, provided that it is blended at a suitable ratio with 'clean' imported sand, in-situ sand (SP-SM) or sandy gravel (GP-GM). Following site stripping operations, the topsoil would need to be screened (say with a 25 mm screen aperture) in order to remove the bulk of the organics (to be disposed or re-used in non-structural areas), prior to blending with the aforementioned non-organic soils. Alternatively, following stripping operation to remove the bulk of the vegetation and root mass, the remaining silty sandy topsoil could be mixed in-situ with the underlying sand or sandy gravel by raking through both materials using a dozer or grader tynes and blades. Field trials under geotechnical supervision should be considered during earthworks to assess suitable blending ratio and methodology.

The sandy and gravelly soils overlying the cemented clayey soils should generally be suitable for reuse as structural filling. However if it considered possible that some of the surficial soils may contain too much reactive components which could preclude the use of the soil for Class A lots, if such classification is targeted (rather than Class S). If earthworks to achieve Class A lots are being undertaken at the site, it is recommended that any material proposed for reuse is inspected by a geotechnical engineer.

Reuse of the cemented clayey soils is possible but should be considered with caution. If such materials are proposed to be re-used, it is recommended that excavation, placement and compaction be carried out during the dry season, in order to make handling, conditioning and compaction easier to manage. Furthermore, in order to minimise the above-mentioned difficulties, it is suggested that contractors with experience in reactive soils are engaged to undertake the site preparation works.

It is recommended that verification of the compaction works be undertaken by an experienced geotechnical engineer.

It is recommended that the in situ clayey materials and cohesive fill is placed in loose lift thicknesses with each layer compacted to achieve a dry density ratio of not less than 92% relative to modified compaction.

Compaction control of the natural clayey materials could be carried out using a nuclear surface moisture-density gauge, in accordance with AS 1289.5.8.1.

7.5 Soil Permeability

The shallow soil conditions within the site generally comprise gravelly soils (Unit 1A) overlying cemented or hard, clayey, gravelly soils (Unit 2). In situ testing indicated a permeability of approximately 8 m/day for the shallow gravelly soils and the cemented clayey gravelly soils (Unit 2) had an average permeability of approximately 1 m/day. The shallow sandy silt (Unit 1B) encountered at one location in the south-eastern corner of the site had a permeability of 1 m/day.

Unit 2 ground conditions were encountered at typical depths in which stormwater drainage systems would infiltrate water. These soils are not favourable for on-site stormwater infiltration, owing to their relatively low permeability. It is considered however, that on-site drainage systems suitably designed for the lower rate of infiltration, and possibly with overflows into a suitable outflows, could be considered for the site.

7.6 Site and Soil Effluent Disposal Preliminary Assessment

Site characteristics observed during the field work and soil properties determined during subsequent laboratory testing have been assessed in relation to the anticipated limitations that they pose to onsite disposal of domestic effluent.

For this assessment, reference has been made to AS1547-2012, the 2019 WA Government Sewerage Policy and the 2011 NSW Environment and Health Protection Guidelines. This later guideline evaluates various soil and site characteristics and assigns either a minor, moderate or major limitation depending on the restrictions to the disposal of domestic effluent. Minor limitations are regarded as not posing a constraint to the application of domestic effluent. Site and soil characteristics which are considered to be major limitations would require site or soil improvement measures to allow on-site effluent disposal at the site.

Site and soil characteristics, including, the moderate and major limitations for effluent disposal within the site, are discussed next pages.

7.6.1 Soil Permeability

Saturated hydraulic conductivity (permeability) is a measure of the ability of soil to transmit water based on soil properties such as structure, texture and porosity. The soil types noted within the test pits are predominantly gravelly, with increasing clay content with depth.

A soil permeability category Groups 1 (reference to AS 1547-2012 Tables 5.1 and E1) is considered suitable for the sandy and gravelly soils of Unit 1 (average permeability of approximately 8 m/day) and category 4 is considered suitable for the clayey soils (Unit 2) encountered below Unit 1 (average permeability of 1 m/day).

The soil category Group 1 (Unit 1) is considered to be a major limitation owing to excessive percolation that could easily transport pathogens and nutrients, and Group 4 (Unit 2) forms a minor limitation.

7.6.2 Depth to Hardpan

Material which could be considered as hardpan was encountered at locations 7, 8 and 19 at a depth of 2 m or more. Test pits refused prior to target depth at nine locations (locations 6, 9, 10, 17, 18, 20, 22, 24, and 29) which could also be considered as hardpan. The shallowest of which was 1.4 m (at location 20) which indicates that depth to hardpan may affect the selection of an appropriate effluent disposal method in some locations of the site. Based on the available information, depth to hardpan is considered to be a minor limitation.

7.6.3 Depth to Groundwater

Groundwater was encountered with four locations (locations 3, 4, 13 and 22) during the investigation in September 2020 is considered to be perched water. Based on the results of the investigation, in conjunction with desktop information, it is considered that average annual maximum groundwater levels are greater than 2.5 m below the surface levels at this site.

Therefore, the groundwater table is considered a minor limitation for on-site disposal of sewage.

7.6.4 Coarse Fragments

Coarse fragments are defined as particles greater than 2 mm in AS 1547-2012. The abundance of coarse fragments in the soils encountered underlying the site is considered to typically be between 50% and 75%, corresponding to "abundant", in accordance with Table E2, AS 1547-2012. Coarse fragment percentages over 40% can be considered as a major limitation owing to the potential for the fragments to restrict plant growth.

7.6.5 Slope

The site generally slopes downwards from the east, with typical gradients between 1° and 3° (up to approximately 5% grade). Slopes of this gradient are considered to be a minor limitation due to the limited potential of rapid runoff of the effluent from surface and subsurface irrigation and absorption systems.

7.6.6 Dispersivity

Laboratory testing of soil samples taken from the site indicate an Emerson classes of 2 (slightly dispersive) and 5 (non-dispersive). The sample representing Unit 2 soil, was non-dispersive. Although the laboratory results indicate an Emerson Class 2 for a soil sample of Unit 1B, this unit predominately granular soils (sandy gravel) that are inherently non-dispersive (the dispersivity indicated by the laboratory testing is inferred to be associated with the minor silt component of the sandy gravel forming Unit 1B). Therefore soil dispersity is not considered to be a limitation for effluent systems infiltrating into Unit 2 and Unit 1B soils.

Surface based effluent disposal systems may encounter moderate limitations due to soil dispersity, indicated by an Emerson Class 2 on Unit 1A (shallow soils).

7.6.7 pH

Laboratory testing indicates pH values of above 6. Therefore, pH is considered a minor limitation for on-site sewage disposal at the site.

7.6.8 Electrical Conductivity

Laboratory testing indicates that the electrical conductivity of soils underlying the site is less than 4 dS/m and therefore electrical conductivity is not a limitation to on-site sewage disposal.

7.6.9 Cation Exchange Capacity

The cation exchange capacity (CEC) is the total number of cations a soil can retain on its absorbent complex at a given pH, and is therefore a good measure of a soil ability to retain specific pollutants. The laboratory tests carried out on the samples collected from test locations 6 and 16, indicate CEC values of 2 and 3 meq/100g, or cmol+/kg. A cation exchange capacity of less than 5 cmol+/kg is considered as a major limitation for on-site effluent disposal, indicating some soil inability to hold pollutants and plant nutrients for the irrigation systems.

7.7 On-site Wastewater Management Options

Owing to the occurrence of soils with the major limitations, (primarily the percentage of coarse fragments and cation exchange capacity, some high permeability soils), secondary treatment of the primary effluent will need to be undertaken to produce secondary quality effluent, prior to on-site disposal over the land surface.

Several treatment options are possible and include the following:

- Aerobic Treatment Unit (ATU);
- Closed cell (amended soil) evapo-transpiration systems.

The effluent treatment system selected for use should be approved by the WA Department of Health.

Once the effluent has been treated by an approved system, the resulting effluent would be sent to the disposal area.

The disposal area required will be dependent on number of factors, including the following:

- Treatment system adopted and quality of effluent produced;
- Soil characteristics (as assessed in previous sections)
- Climate conditions; and
- Effluent loading, as determined by the number of people within the proposed buildings and the water reduction fixtures present.

The above matters are typically addressed by the designers of the adopted effluent disposal system.

The performance of an effluent disposal system is dependent on proper maintenance which should incorporate the following:

- Regular maintenance of surface vegetation to encourage water and nitrogen uptake; and
- Maintenance of surface drains to prevent the ponding of water in the vicinity of the disposal area.

7.8 Conclusions on Site Suitability for Effluent Disposal

The ground conditions at this site are generally considered suitable for on-site disposal of effluent produced by secondary treatment systems.

As there are a variety of Department of Health WA approved proprietary systems available, the choice of system is ultimately made by the purchaser of the properties within the guidelines of AS 1547:2012, local government authorities, the WA Department of Health and the site characteristics described above.

8. References

1. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
2. Australian Standard AS 1289.6.3.2-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Dynamic Cone Penetrometer Test.
3. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
4. Australian Standard AS 1726-2017, Geotechnical Site Investigation.
5. Australian Standard AS 2870-2011, Residential Slabs and Footings.
6. Australian Standard AS 1547-2012, On-site Domestic Waste Management.
7. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.
8. Government of Western Australia, Government Sewerage Policy, September 2019
9. Code of Practice for the Design, Manufacture, Installation and Operation of Aerobic Treatment Unit (ATUs) - November 2001.
10. Environment & Health Protection Guidelines: On-site Sewage Management for Single Households - January 1998.
11. Government Sewerage Policy – Consultation Draft, Department of Health, December 2011.
12. Code of Practice for Onsite Sewage Management, Consultation Draft, November 2012.

9. Limitations

Douglas Partners (DP) has prepared this report for the proposed industrial development at Lots 202 and 203 Great Northern Highway and Lots 204 and 205 Wandena Road, Muchea, in accordance with DP's proposal referenced PER200244.Rev2 dated 30 July 2020 and acceptance received from James Wortley of Tomahawk Property on behalf of Focus Demolition & Asbestos Removal & David Weightman Smith dated 24 August 2020. The work was carried out under DP's Conditions of Engagement. This report is provided for the exclusive use of Focus Demolition & Asbestos Removal & David Weightman Smith and their agents for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

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

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

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

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

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

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

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

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

Copyright

This report is the property of Douglas Partners Pty Ltd. The report may only be used for the purpose for which it was commissioned and in accordance with the Conditions of Engagement for the commission supplied at the time of proposal. Unauthorised use of this report in any form whatsoever is prohibited.

Borehole and Test Pit Logs

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

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

Groundwater

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

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

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

Reports

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

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

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

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

About this Report

Site Anomalies

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

Information for Contractual Purposes

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

Site Inspection

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

Sampling Methods

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Sampling

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

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

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

Test Pits

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

Large Diameter Augers

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

Continuous Spiral Flight Augers

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

Non-core Rotary Drilling

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

Continuous Core Drilling

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

Standard Penetration Tests

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

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

The test results are reported in the following form.

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

  4,6,7
  N=13

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

  15, 30/40 mm

Sampling Methods

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

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

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

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

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

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

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

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

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

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

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

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

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

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

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

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

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

Rock Descriptions

Rock Strength

Rock strength is defined by the Unconfined Compressive Strength and it refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects.

The Point Load Strength Index $Is_{(50)}$ is commonly used to provide an estimate of the rock strength and site specific correlations should be developed to allow UCS values to be determined. The point load strength test procedure is described by Australian Standard AS4133.4.1-2007. The terms used to describe rock strength are as follows:

Strength Term	Abbreviation	Unconfined Compressive Strength MPa	Point Load Index * $Is_{(50)}$ MPa
Very low	VL	0.6 - 2	0.03 - 0.1
Low	L	2 - 6	0.1 - 0.3
Medium	M	6 - 20	0.3 - 1.0
High	H	20 - 60	1 - 3
Very high	VH	60 - 200	3 - 10
Extremely high	EH	>200	>10

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$. It should be noted that the UCS to $Is_{(50)}$ ratio varies significantly for different rock types and specific ratios should be determined for each site.

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Residual Soil	RS	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported.
Extremely weathered	XW	Material is weathered to such an extent that it has soil properties. Mass structure and material texture and fabric of original rock are still visible
Highly weathered	HW	The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Rock strength is significantly changed by weathering. Some primary minerals have weathered to clay minerals. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Moderately weathered	MW	The whole of the rock material is discoloured , usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable, but shows little or no change of strength from fresh rock.
Slightly weathered	SW	Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.
Fresh	FR	No signs of decomposition or staining.
Note: If HW and MW cannot be differentiated use DW (see below)		
Distinctly weathered	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching or may be decreased due to deposition of weathered products in pores.

Rock Descriptions

Degree of Fracturing
The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with occasional fragments
Fractured	Core lengths of 30-100 mm with occasional shorter and longer sections
Slightly Fractured	Core lengths of 300 mm or longer with occasional sections of 100-300 mm
Unbroken	Core contains very few fractures

Rock Quality Designation
The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100\text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or stronger. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing
For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

Symbols & Abbreviations

Douglas Partners

Introduction

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

Drilling or Excavation Methods

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

Water

▷	Water seep
$\underline{\nabla}$	Water level

Sampling and Testing

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

Description of Defects in Rock

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

Defect Type

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

Orientation

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

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

Coating or Infilling Term

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

Coating Descriptor

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

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General

- Asphalt
- Road base
- Concrete
- Filling

Soils

- Topsoil
- Peat
- Clay
- Silty clay
- Sandy clay
- Gravelly clay
- Shaly clay
- Silt
- Clayey silt
- Sandy silt
- Sand
- Clayey sand
- Silty sand
- Gravel
- Sandy gravel
- Cobbles, boulders
- Talus

Sedimentary Rocks

- Boulder conglomerate
- Conglomerate
- Conglomeratic sandstone
- Sandstone
- Siltstone
- Laminite
- Mudstone, claystone, shale
- Coal
- Limestone

Metamorphic Rocks

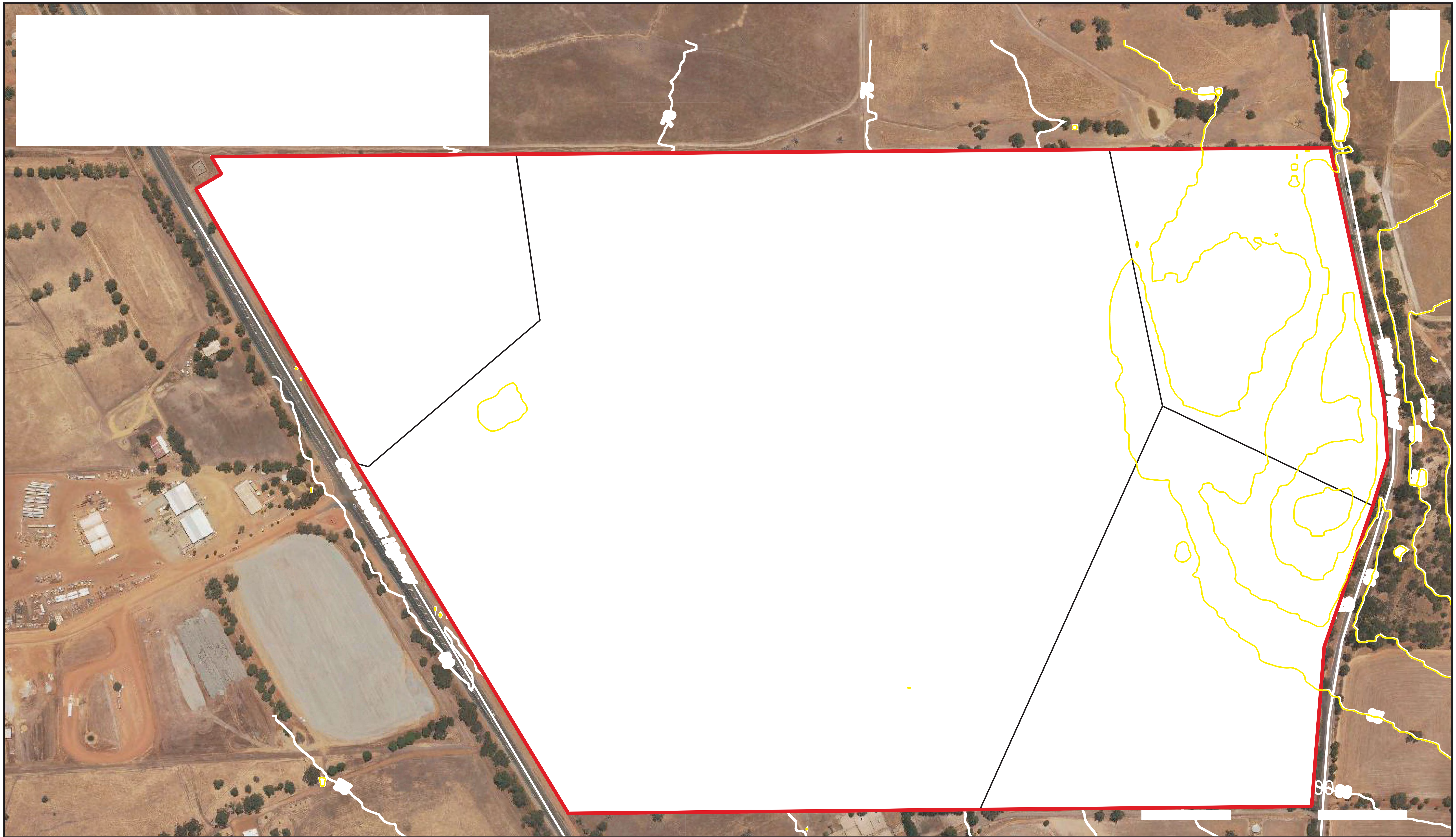
- Slate, phyllite, schist
- Gneiss
- Quartzite

Igneous Rocks

- Granite
- Dolerite, basalt, andesite
- Dacite, epidote
- Tuff, breccia
- Porphyry

Appendix B

Test Location Plan
Test Pit Logs



Douglas Partners
Geotechnics | Environment | Groundwater

Test Location Plan

Proposed Industrial Development

Lots 202 and 203 Wandena Road & Lots 204 and 205 Great Northern Highway, Muchea, WA

CLIENT:	Focus Demolition & Asbestos Removal & David Weightman Smith
PROJECT:	96712.00
Drawing No:	1
REV:	0
DATE:	8/10/2020

Appendix D

Groundwater Measurements

WANDENA RD / GT NORTHERN HWY BORES
STATIC DATA

Bore	Easting	Northing	Install Date	RLT (mAHD)	RLG (mAHD)	Total Depth (mbtoc)	Stickup (magl)	Total Depth (mbgl)
WB1	405843	6503819	24/03/2020	61.81	61.23	5.27	0.58	4.69
WB2	406206	6504189	24/03/2020	71.39	70.87	5.45	0.52	4.93
WB3	406365	6503799	24/03/2020	69.72	69.09	5.7	0.63	5.07
WB4	406393	6503460	24/03/2020	62.48	61.87	5.86	0.61	5.25
Ex Bore 1	405991	6504091	uk	66.03	65.73	uk	0.3	
Ex Bore 2	405991	6503948	uk	65.32	65.32	uk	0	
MW1	406899	6504175	6/04/2016	92.76	92.2	20.5	0.56	
MW2	406919	6504048	6/04/2016	94.96	94.32	25	0.64	
MW3	406684	6504119	6/04/2016	83.87	83.22	19.5	0.65	
MW4	406748	6503595	6/04/2016	79.43	78.78	19.7	0.65	
GD20	405300	6506021	uk	62.09	61.48	19.51	0.61	18.9
2-98	406399	6502795	uk	58.893	58.29	18.603	0.603	18

WANDENA RD / GT NORTHERN HWY BORES
DEPTHS TO WATER

	DEPTH TO WATER (mbgl)									
Bore	**12/07/2016**	**2/09/2016**	**28/09/2016**	**22/11/2016**	**17/08/2017**	**12/01/2018**	**18/10/2018**	**30/05/2019**	**21/08/2020**	**9/09/2020**	**2/10/2020**
WB1									>4.68		>4.69
WB2									>4.98		>4.93
WB3									1.58		2.64
WB4									2.34		1.73
Ex Bore 1									16.62		17.19
Ex Bore 2									9.92		9.74
MW1	18.54	15.67	15.38	15.32		15.39		15.64	>17.44		15.94
MW2	16.36	18.06	17.8	17.61		17.68		17.69	16.14		18
MW3	15.25	11.01	10.54	10.5		11.39		12.15	12.55		12.1
MW4	12.57	14.09	13.53	13.32		13.39		15.75	14.45		14.16
GD20					0.19				0.88		1.48
2-98					1.49				2.117		2.267

WANDENA RD / GT NORTHERN HWY BORES
WATER LEVELS

	WATER LEVEL (m AHD)										
Bore	**12/07/2016**	**2/09/2016**	**28/09/2016**	**22/11/2016**	**17/08/2017**	**12/01/2018**	**18/10/2018**	**30/05/2019**	**21/08/2020**	**9/09/2020**	**2/10/2020**
WB1									<56.55		<56.54
WB2									<65.89		<65.94
WB3									67.51		66.45
WB4									59.53		60.14
Ex Bore 1									49.11		48.54
Ex Bore 2									55.4		55.58
MW1	73.66	76.53	76.82	76.88		76.81		76.56	<74.76		76.26
MW2	77.96	76.26	76.52	76.71		76.64		76.63	78.26		76.32
MW3	67.97	72.21	72.68	72.72		71.83		71.07	70.67		71.12
MW4	66.21	64.69	65.25	65.46		65.39		63.03	64.33		64.62
GD20					61.29		60.91		60.6		60
2-98					56.793		56.623		56.173		56.023

WANDENA RD / GT NORTHERN HWY BORES
AAMGL and MGL
from 21/8/20 measurements

Bore	AAMGL (mAHD)	MGL (mAHD)	DTAAMGL (m)	DTMGL (m)
WB1				
WB2				
WB3	67.937	68.517	1.153	0.573
WB4	59.957	60.537	1.913	1.333
Ex Bore 1	49.537	50.117	16.193	15.613
Ex Bore 2	55.827	56.407	9.493	8.913
MW1				
MW2	78.687	79.267	15.633	15.053
MW3	71.097	71.677	12.123	11.543
MW4	64.757	65.337	14.023	13.443
GD20	59.85	61.35	1.63	0.13
2-98	56.6	57.18	1.69	1.11

Appendix E

Letter from Aqua Ferre Pty Ltd

AQUA FERRE PTY LTD

ACN 121 146 772
PO Box 1982 West Perth WA 6872
Level 1, 5 Ord Street West Perth WA 6005
Tel: 08 9282 5400
Fax: 08 9282 5484

29 January 2018

Tom Carmody
Director and Licensee
Tomahawk Property on behalf of the Muchea Employment Node Precinct 3 Landowner Group
8/355 Stirling Highway
Claremont WA 6010

Dear Mr Carmody

Muchea Employment Node Precinct 3 Landowner Group

I refer to your enquiries to Aqua Ferre Pty Ltd (Aqua Ferre) regarding the availability of water and the potential future supply of water, within the Muchea region.

You have advised that you represent a number of landowners with properties on Great Northern Highway and Brand Highway in Muchea (collectively described as the Muchea Employment Node Precinct 3 Landowner Group or more generally the landowner group).

On behalf of the landowner group you have requested information from Aqua Ferre in support of two planning documents:

- Shire of Chittering Town Planning Scheme No 6 Amendment No.67 - Rezoning Lots M1601, 800-804, 192, 194 and 35 Great Northern Highway, Muchea from 'Agricultural Resource' zone to 'Industrial Development' zone, and amending the Scheme Maps accordingly; and
- Precinct 3 Muchea Industrial Park Structure Plan.

In particular you have sought information regarding Aqua Ferre's water entitlements, the prospect that some of Aqua Ferre's water entitlement may be allocated to the landowner group properties, and whether the water can be practically supplied from Aqua Ferre's operations to the landowner group properties.

1 MEN & Precinct 3

The Muchea Employment Node Structure Plan (MENSP) was adopted by the WAPC in August 2011, and provides a 20-year planning framework for industrial development within the Shire of Chittering. We understand that the MENSP is currently under review and a revised document is expected to be released during 2019.

You have advised that the subject land is located within Precinct 3, which forms the eastern portion of the MENSP, to the west of Great Northern Highway (GNH).

Precinct 3 of the Muchea Employment Node (more recently referred to as the Muchea Industrial Park (MIP)) ('the Structure Plan area') is approximately 185ha in area and located to the south east of the townsite of Muchea. Precinct 3 is triangular in shape and extends in a lineal pattern from Brand Highway in the north, along Great Northern Highway (GNH) in the east, to the southern boundary of the Shire of Chittering, and along the Perth-Darwin Highway (PDNH) to the west, which is currently under construction.

Figure 1 below shows the proposed Precinct 3 development boundaries (Urbis 2019, LPS Amendment, Muchea Employment Node, DWG-11).

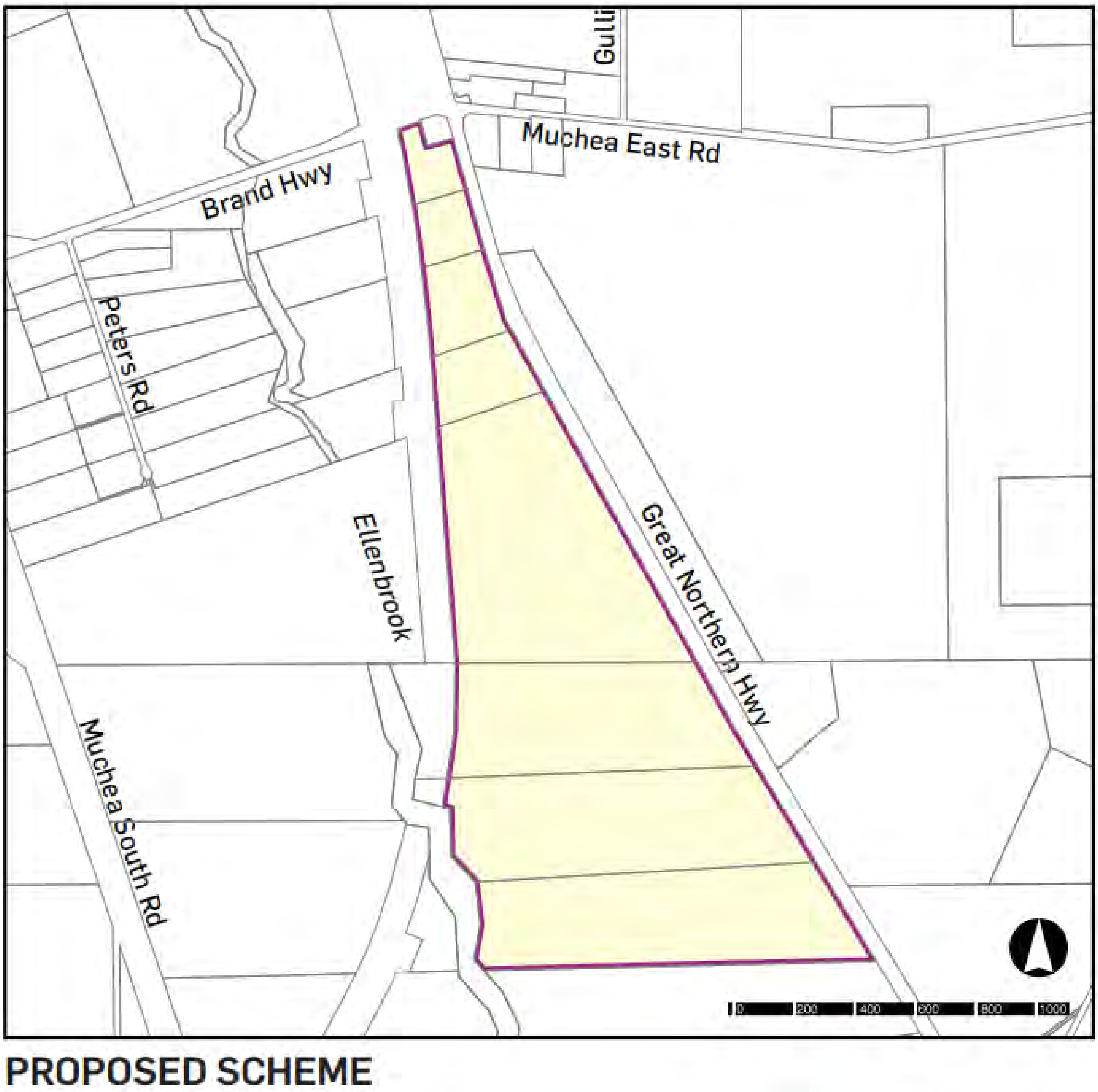


Figure 1 Proposed Precinct 3 development

Urbis[1] have indicated that the land has largely been historically cleared for agricultural purposes and contains stands of large, mature trees with degraded understorey, and a number of rural drainage lines.

[1] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

You have advised that the Structure Plan[2] will provide approximately 51 lots of approximately 1.3ha to 7.6ha providing flexibility for a range of industrial uses, expected to be primarily transport logistics related.

We understand that the Structure Plan is being progressed concurrently with Amendment No.67 to LPS6 which proposes to rezone the land from 'Agricultural Resource Zone' to the 'Industrial Development' zone, to introduce land use permissibility for Precinct 3; clarify requirements for the preparation of Management Plans, and introduce provisions relating to provision of reticulated water and construction of the loop road.

2 Aqua Ferre

Aqua Ferre was established to be an independent water service provider following approaches by property development groups seeking water services in the Chittering/Muchea region. Aqua Ferre is proposing to build and operate a potable water supply system at Reserve Road, Chittering (as shown in Figure 2).

The proposed water treatment plant (WTP) would be operated as a constant flow rate to promote a stable process with the intention of producing reliable potable water that meets the Australian Drinking Water Guidelines.

Figure 2 below broadly shows the Precinct 3 development (outlined in red) to the south of Harvis' proposed MEN (Phase 1) development (outlined in yellow) and Aqua Ferre's proposed water facility to the north.

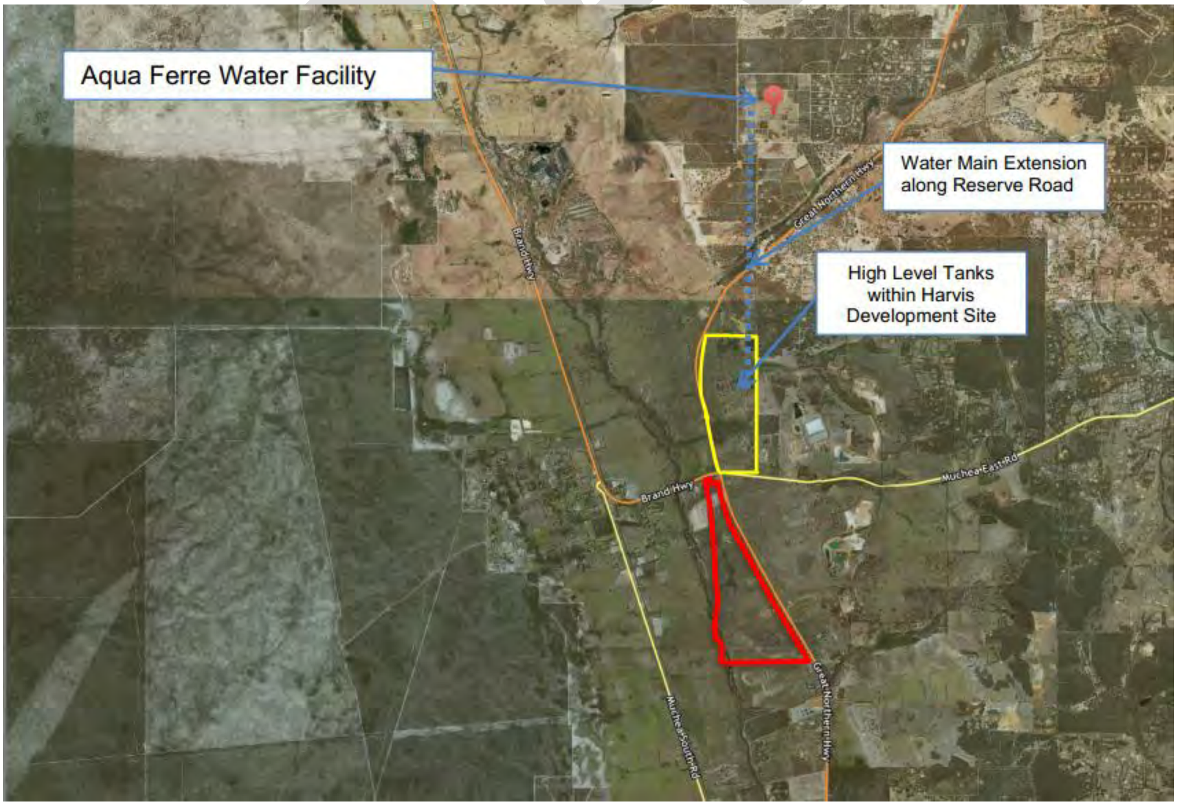


Figure 2 Development boundaries

[2] Urbis Pty Ltd 2019, Precinct 3, Muchea Industrial Park, Structure Plan, Draft January 2019

2.1 Water Entitlement

The Reserve Road (Chittering) property currently has a total water entitlement or allocation (licence to abstract water from an artesian aquifer) of 288,800 kL per annum. The developer of the Reserve Road residential development, Riverside, has transferred the Water Licence GWL 59907(3) to the Water Corporation to enable the licence to be changed from an agricultural extraction to public water supply. It is intended that this water entitlement will be transferred to Aqua Ferre when a water service licence has been granted.

Aqua Ferre has similar entitlement rights to a further 362,900 kL per annum licence, originally GWL 102502(4) which is now part of GWL 65011.

In total, it is intended that Aqua Ferre will have access to 651,700 kL of water per annum.

There is an existing production bore located within the proposed Reserve Road development that was previously used for wildflower irrigation, where the proposed potable WTP would be located.

2.2 Existing water supply commitments

Aqua Ferre intends supplying approximately 153 ML of treated potable water to the residential development at Reserve Road, Chittering, and to a commercial/industrial development at the adjacent MEN (northern Precinct 1 only). It is intended that a further 75 ML will be set aside for future demand across these two developments.

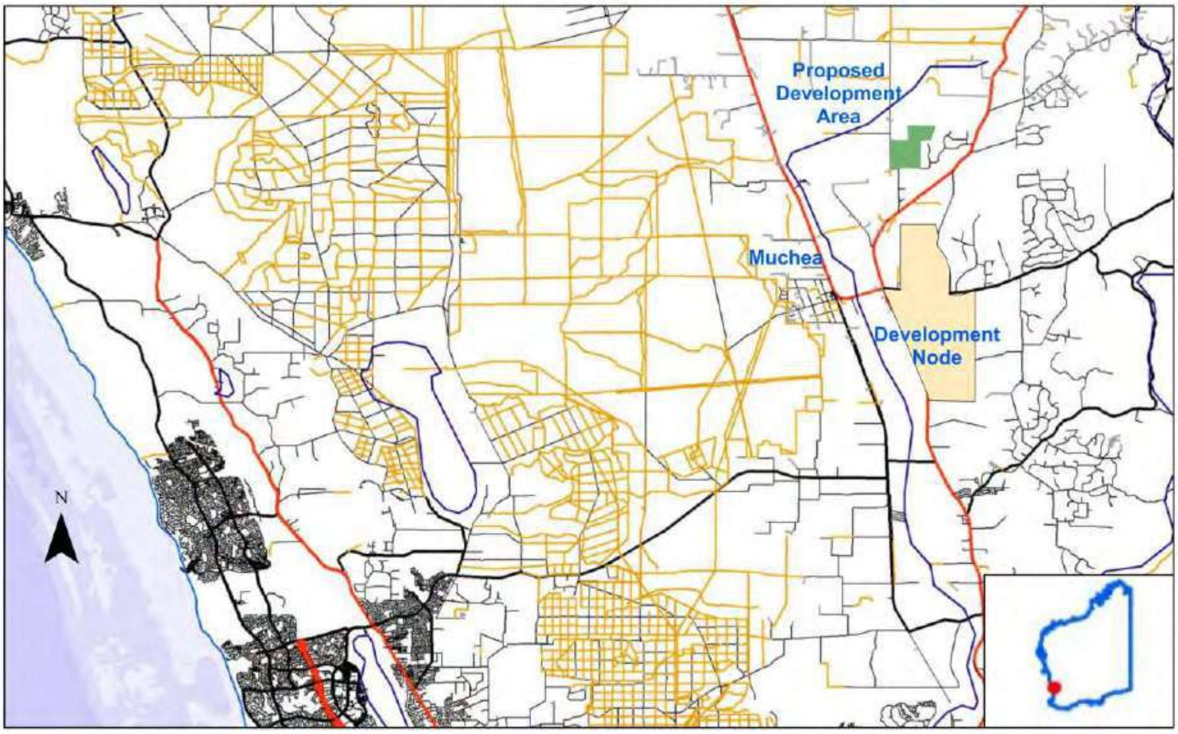


Figure 3 Location of Reserve Road residential development and MEN

The new Reserve Road rural living allotment development is located 8km north east of the Muchea town site and 80km north of the Perth central business district. It is also in close proximity (4km) to the proposed MEN on the eastern side of Great Northern Highway. The development is in accordance with the Shire of Chittering's planning scheme (2004). The Reserve Road development covers an area of approximately 160 hectares and involves the creation of approximately 245 rural residential allotments in progressive stages. It is a requirement of the development approval that potable reticulated water is available.

Figure 4 Contour map (5m contour lines) of the Harvis MEN development showing ephemeral swale

Phase 1 of the MEN development is being undertaken by development group Harvis Capital Pty Ltd (Harvis). The Harvis development is located on the northern end of the proposed MEN. The site is slightly undulating with an ephemeral swale running through the development (Figure 4). The development is well placed and has been planned around the proposed Perth Darwin Highway.

It is the intention of the MEN development that these lots also have a reticulated water resource. Currently, the area does not have a public water supply scheme. Aqua Ferre is finalising documentation to allow the Economic Regulation Authority Western Australia to consider an application for a water services licence.

It is proposed that the water supply for the Harvis MEN development will have a standalone delivery and network system, to ensure that the demand of both systems can meet peak demand and firefighting requirements.

After treatment, it is intended that the water required for the Harvis MEN site will be delivered to a 500kL holding tank with aeration. Water would be reticulated to customers using a standard, continually pressurised water reticulation network. The piping would follow the general topography and alignment of the development streets and will have 600mm coverage.

3 Precinct 3 water requirement

You have advised that the intention is that the land the subject of the Structure Plan would be serviced with reticulated water provided by a licensed water provider.

The total area of supply is for an industrial development totalling approximately 185 hectares. No indication of staging of development has been provided at this point.

Estimated annual water usage has been provided (based on preliminary modelling by Cossill & Webley) as 203ML per annum on a net area of 139 hectares (after allowing for a 25% reduction in land area calculation to accommodate roads/drainage). The proposed system has been modelled at 4kL/day per hectare based on advice from Cossill & Webley of studies of similar industry types and uses. It is noted that this compares to the Water Corporation design standard for industrial land of approximately 17 kL/ha/day.

Based on your advice of estimated water usage, Aqua Ferre would have capacity under its entitlements to meet the demand of the subject land. This is not an undertaking to commit an allocation of water, or to supply water, to the Muchea Employment Node Precinct 3 Landowner Group. Any such arrangements would be the subject to future commercial negotiation, agreement on terms including pricing and remaining water availability under Aqua Ferre's entitlements.

4 Supply assessment

Aqua Ferre has conducted a preliminary desktop assessment of the potential supply route from its planned water treatment plant at Reserve Road to the proposed Precinct 3 development via Harvis' phase 1 MEN development. This represents a distance of approximately 3.5 kilometres.

The assessment did not highlight any major engineering impediments to the provision of water to the proposed development. (This is not to say, however, that any impediments would not become apparent on more detailed analysis.)

Any proposal for supply would be inclusive of the requirements of:

- Water Corporation Design Standard DS 63 – Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems or Water Reticulation Systems up to DN250
- DFES requirements for firefighting services
- Hydraulic modelling using EPANET 2 for system hydraulics.

Hydraulic modelling would require topographical mapping at 0.5m.

Additionally, there would be a requirement for a water reserve for tanks, pumps, sumps, generator and chlorination which would need to be met by the subject landowners' group.

5 Disclaimer

This report is dated 29 January 2019 and incorporates information available to Aqua Ferre up to that date only. It excludes consideration of any information arising, or event occurring, after that date which may impact opinions expressed or statements made by Aqua Ferre in this report.

Aqua Ferre has prepared this report on the instructions, and for the sole benefit, of Tomahawk Property (Instructing Party), for inclusion within a rezoning application and Structure Plan as described in paragraph 3 of this letter (Purpose) and not for any other purpose or use. To the extent permitted by applicable law, Aqua Ferre expressly disclaims all liability, whether direct or indirect:

- to the Instructing Party, which may arise in connection with any reliance or purported reliance on this report for any purpose other than the Purpose, and
- to any other person, which may arise in connection with any reliance or purported reliance on this report for any purpose whatsoever (including the Purpose).

All statements and opinions contained in or associated with this report are made on the basis of information supplied to Aqua Ferre as at the date of this report, and upon which Aqua Ferre has relied. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with any errors or omissions in this report arising from information provided to Aqua Ferre by the Instructing Party or by any other person.

Achievement of any proposed or intended events or circumstances described in this report will depend, among other things, on the actions of others, over which Aqua Ferre has no control. To the extent permitted by applicable law, Aqua Ferre expressly disclaims any liability, whether direct or indirect, which may arise in connection with the delay in, or failure to occur of, any proposed or intended events or circumstances described in this report.

Yours sincerely

Peter Fogarty
Director

Appendix F

Flow Calculations

LOTS - 1 YEAR ARI 1 HOUR

Rainfall Intensity i (mm/h)	15.1	(1yr, 1hr Storm)
Runoff Coefficient Lots	0.8	
Permeability k (m/hr)	0.0417	

Segment	Lot(s)	Lot Area (m2)	Ai (m2)	Q (L/s)	Vinflow (m3)
A1					
	1	10900	8720	37	132
	2	10000	8000	34	121
	3	10000	8000	34	121
	5	11453	9162	38	138
A2					
	6	13372	10698	45	162
A3					
	13	10624	8499	36	128
A4					
	14	10017	8014	34	121
	15	10015	8012	34	121
	16	10013	8010	34	121
	17	10010	8008	34	121
	23N	4625	3700	16	56
A5					
	18	10649	8519	36	129
	24N	6205	4964	21	75
B1					
	7	10212	8170	34	123
	8	10000	8000	34	121
	9	10000	8000	34	121
	10	10000	8000	34	121
B2					
C1					
	4	24227	19382	81	293
D1					
	19	11032	8826	37	133
	20	10000	8000	34	121
	21	10000	8000	34	121
	22	10000	8000	34	121
	23S	5354	4283	18	65
	31	11160	8928	37	135
D2					
	11	20441	16353	69	
	12	22155	17724	74	
	32	10416	8333	35	126
D3					
	24S	7763	6210	26	94
	25	10221	8177	34	124
	26	10003	8002	34	121
	27	10265	8212	34	124
	28	21290	17032	71	257
	29	11383	9106	38	138
	30	10000	8000	34	121
D4					
	49	10003	8002	34	121
	50	11345	9076	38	137
D5			0		
	51	10139	8111	34	123
	52	11362	9090	38	137
D6					
	47	11988	9590	40	145
	48	11956	9565	40	145
D7					
D8					
	42	10314	8251	35	125
D9					
	33	13442	10754	45	163
	34	10000	8000	34	121

	35	10000	8000	34	121
	36	10000	8000	34	121
	37	10000	8000	34	121
	38	13726	10981	46	166
D10					
	41	10200	8160	34	123
	43	15438	12350	52	187
	44	12386	9909	42	150
	45	11475	9180	39	139
	46	12208	9766	41	148
D11					
	39	14627	11702	49	177
	40	16529	13223	56	200
E1					0
	53	11089	8871	37	134
	54	10086	8069	34	122
E2					
	55	10271	8217	34	124
	56	10041	8033	34	121
	57	10437	8350	35	126
	58	10559	8447	35	128
E3					

Swale Sizing		**Depth**	**Slope 1:x**	**Base Width**	**Base Length**	**Top Width (m)**	**Top Length (m)**	**Volume**	**Effective Volume**	**Surface Area (m2)**	**Volume check**
A1											
	1	0.5	4	12	16	16	20	127	137	320	ok
	2	0.5	4	11	16	15	20	118	127	300	ok
	3	0.5	4	11	16	15	20	118	127	300	ok
	5	0.5	4	13	16	17	20	136	147	340	ok
A2											
	6	0.5	4	15	16	19	20	154	166	380	ok
A3											
	13	0.5	4	12	16	16	20	127	137	320	ok
A4											
	14	0.5	4	11	16	15	20	118	127	300	ok
	15	0.5	4	11	16	15	20	118	127	300	ok
	16	0.5	4	11	16	15	20	118	127	300	ok
	17	0.5	4	11	16	15	20	118	127	300	ok
	23N	0.5	4	7	10	11	14	55	59	154	ok
A5											
	18	0.5	4	12	16	16	20	127	137	320	ok
	24N	0.5	4	8	12	12	16	71	77	192	ok
B1											
	7	0.5	4	11	16	15	20	118	127	300	ok
	8	0.5	4	11	16	15	20	118	127	300	ok
	9	0.5	4	11	16	15	20	118	127	300	ok
	10	0.5	4	11	16	15	20	118	127	300	ok
B2											
C1											
	4	0.5	4	19	24	23	28	274	296	644	ok
D1											
	19	0.5	4	12	16	16	20	127	137	320	ok
	20	0.5	4	11	16	15	20	118	127	300	ok
	21	0.5	4	11	16	15	20	118	127	300	ok
	22	0.5	4	13	22	17	26	181	196	442	ok
	23S	0.5	4	7	12	11	16	64	69	176	ok
	31	0.5	4	12	16	16	20	127	137	320	ok
D2											
	11	0.5	4	11	16	15	20	118	127	300	ok
	12	0.5	4	14	21	18	25	185	200	450	ok
	32	0.5	4	11	16	15	20	118	127	300	ok
D3											
	24S	0.5	4	9	14	13	18	89	96	234	ok
	25	0.5	4	11	16	15	20	118	127	300	ok
	26	0.5	4	11	16	15	20	118	127	300	ok

	27	0.5	4	11	16	15	20	118	127	300	ok
	28	0.5	4	17	24	21	28	248	268	588	ok
	29	0.5	4	13	16	17	20	136	147	340	ok
	30	0.5	4	12	16	16	20	127	137	320	ok
D4											
	49	0.5	4	11	16	15	20	118	127	300	ok
	50	0.5	4	12	16	16	20	127	137	320	ok
D5											
	51	0.5	4	11	16	15	20	118	127	300	ok
	52	0.5	4	13	16	17	20	136	147	340	ok
D6											
	47	0.5	4	13	16	17	20	136	147	340	ok
	48	0.5	4	13	16	17	20	136	147	340	ok
D7											
D8											
	42	0.5	4	11	16	15	20	118	127	300	ok
D9											
	33	0.5	4	13	18	17	22	151	163	374	ok
	34	0.5	4	11	16	15	20	118	127	300	ok
	35	0.5	4	11	16	15	20	118	127	300	ok
	36	0.5	4	11	16	15	20	118	127	300	ok
	37	0.5	4	11	16	15	20	118	127	300	ok
	38	0.5	4	14	18	18	22	161	174	396	ok
D10											
	41	0.5	4	11	16	15	20	118	127	300	ok
	43	0.5	4	14	20	18	24	177	191	432	ok
	44	0.5	4	13	17	17	21	143	155	357	ok
	45	0.5	4	13	16	17	20	136	147	340	ok
	46	0.5	4	14	16	18	20	145	157	360	ok
D11											
	39	0.5	4	14	19	18	23	169	183	414	ok
	40	0.5	4	15	20	19	24	188	203	456	ok
E1											
	53	0.5	4	12	16	16	20	127	137	320	ok
	54	0.5	4	11	16	15	20	118	127	300	ok
E2											
	55	0.5	4	11	16	15	20	118	127	300	ok
	56	0.5	4	11	16	15	20	118	127	300	ok
	57	0.5	4	11	16	15	20	118	127	300	ok
	58	0.5	4	12	16	16	20	127	137	320	ok
E3											

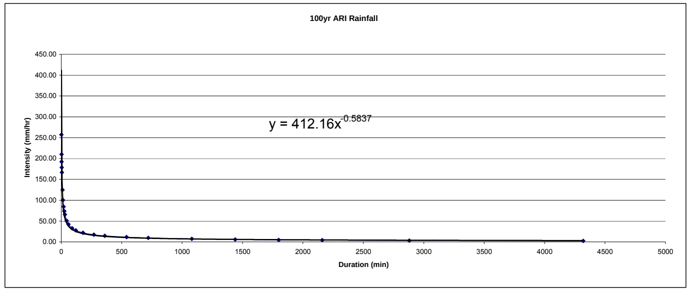
100 YEAR ARI DRAINAGE PROPERTIES - LOTS

Segment	Lot(s)	AREAS (m2)			TIME OF CONCENTRATION PRE-DEVELOPMENT					TIME OF CONCENTRATION POST-DEVELOPMENT					CRITICAL STORM INTENSITY (mm/h)		
		Area (m2)	Effective Area (m2) Pre	Effective Area (m2) Post	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (min)	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (min)	Pre-Dev	Post-Dev	Time to Overflow (min)
A1																	
	1	10900	3815	9265	126	62.7	60.2	19.84	7.0	126	62.7	60.2	19.84	6.4	132.2	139.2	5.89
	2	10000	3500	8500	134	62.9	60.7	16.42	7.8	134	62.9	60.7	16.42	7.2	124.1	130.7	6.35
	3	10000	3500	8500	122	63.4	60.8	21.31	6.8	122	63.4	60.8	21.31	6.2	135.1	142.3	5.83
	5	11453	4009	9735	124	65.5	63	20.16	6.8	124	65.5	63	20.16	6.3	134.1	141.2	5.92
A2																	
	6	13372	4680	11366	148	65.5	63	16.89	8.3	148	65.5	63	16.89	7.6	119.5	125.9	6.44
A3																	
	13	10624	3718	9030	116	72	69.6	20.69	6.4	116	72	69.6	20.69	5.9	139.2	146.6	5.74
A4																	
	14	10017	3506	8514	134	73.6	71.7	14.18	8.0	134	73.6	71.7	14.18	7.4	122.0	128.5	6.45
	15	10015	3505	8513	134	75.5	73.5	14.93	8.0	134	75.5	73.5	14.93	7.3	122.7	129.3	6.41
	16	10013	3505	8511	132	77.6	75.5	15.91	7.7	132	77.6	75.5	15.91	7.1	124.7	131.4	6.31
	17	10010	3504	8509	132	79.6	77.3	17.42	7.6	132	79.6	77.3	17.42	7.0	126.1	132.8	6.25
	23N	4625	1619	3931	84	79.5	77	29.76	4.7	84	79.5	77	29.76	4.3	167.0	175.9	4.74
A5																	
	18	10649	3727	9052	132	81.5	79.5	15.15	7.8	132	81.5	79.5	15.15	7.1	124.5	131.1	6.40
	24N	6205	2172	5274	115	86.7	80	58.26	5.5	115	86.7	80	58.26	5.0	153.0	161.1	4.99
B1																	
	7	10212	3574	8680	136	69	65.8	23.53	7.4	136	69	65.8	23.53	6.7	128.5	135.3	6.01
	8	10000	3500	8500	127	68.3	65.6	21.26	7.0	127	68.3	65.6	21.26	6.4	132.0	139.0	5.97
	9	10000	3500	8500	140	68.7	65.4	23.57	7.6	140	68.7	65.4	23.57	7.0	126.2	132.9	6.25
	10	10000	3500	8500	136	68	64.8	23.53	7.4	136	68	64.8	23.53	6.8	128.3	135.1	6.14
B2																	
C1																	
	4	24227	8479	20593	173	64.8	61.1	21.39	8.8	173	64.8	61.1	21.39	8.0	116.1	122.3	6.52
D1																	
	19	11032	3861	9377	131	71.5	69	19.08	7.3	131	71.5	69	19.08	6.7	128.7	135.6	5.98
	20	10000	3500	8500	129	73.2	70.5	20.93	7.2	129	73.2	70.5	20.93	6.6	130.5	137.5	6.04
	21	10000	3500	8500	129	75	72	23.26	7.0	129	75	72	23.26	6.4	132.2	139.2	5.97
	22	10000	3500	8500	129	76.9	73.7	24.81	6.9	129	76.9	73.7	24.81	6.3	133.2	140.2	9.09
	23S	5354	1874	4551	91	79.7	75.7	43.96	4.6	91	79.7	75.7	43.96	4.2	168.3	177.2	4.73
	31	11160	3906	9486	136	79.7	67	93.38	5.5	136	79.7	67	93.38	5.1	151.7	159.7	5.01
D2																	
	11	20441	7154	17375	152	79.7		524.34	4.1	152	79.7		524.34	3.8	180.1	189.7	2.14
	12	22155	7754	18832	153	63	60	19.61	8.0	153	63	60	19.61	7.3	122.8	129.4	4.55
	32	10416	3646	8854	154	67.4	64.2	20.78	8.5	154	67.4	64.2	20.78	7.8	117.9	124.2	6.42
D3																	
	24S	7763	2717	6599	116	86.5	79.5	60.34	5.3	116	86.5	79.5	60.34	4.9	154.9	163.1	4.94
	25	10221	3577	8688	132	87.0	78.0	68.18	5.8	132	87.0	78.0	68.18	5.3	148.0	155.9	5.21
	26	10003	3501	8503	123	83.0	74.1	72.36	5.3	123	83.0	74.1	72.36	4.9	155.1	163.4	5.08
	27	10265	3593	8725	122	77.5	70.8	54.92	5.6	122	77.5	70.8	54.92	5.1	151.2	159.2	5.08
	28	21290	7452	18097	216	78.7	69.5	42.59	9.7	216	78.7	69.5	42.59	8.8	109.7	115.5	7.11
	29	11383	3984	9676	139	73.0	68.9	29.50	7.1	139	73.0	68.9	29.50	6.5	131.1	138.0	6.09
	30	10000	3500	8500	133	71.4	68.2	24.06	7.2	133	71.4	68.2	24.06	6.6	130.3	137.3	6.51
D4																	
	49	10003	3501	8503	129	84.2	74.0	79.07	5.5	129	84.2	74.0	79.07	5.0	152.5	160.6	5.17
	50	11345	3971	9643	133	87.8	81.5	47.37	6.2	133	87.8	81.5	47.37	5.7	142.1	149.7	5.27
D5																	
	51	10139	3549	8618	137	100.0	87.8	89.05	5.7	137	100.0	87.8	89.05	5.2	149.4	157.3	5.21
	52	11362	3977	9658	129	98.0	94.5	27.13	6.7	129	98.0	94.5	27.13	6.1	135.6	142.8	5.90
D6																	
	47	11988	4196	10190	157	97.0	85.0	76.43	6.6	157	97.0	85.0	76.43	6.1	136.8	144.1	5.54
	48	11956	4185	10163	151	91.0	77.6	88.74	6.2	151	91.0	77.6	88.74	5.7	142.4	150.0	5.34
D7																	
D8																	
	42	10314	3610	8767	133	71.0	66.0	37.59	6.6	133	71.0	66.0	37.59	6.0	137.6	144.9	5.56
D9																	
	33	13442	4705	11426	160	68.0	63.8	26.25	8.3	160	68.0	63.8	26.25	7.5	120.3	126.7	6.25
	34	10000	3500	8500	133	68.4	64.8	27.07	7.0	133	68.4	64.8	27.07	6.4	132.1	139.2	5.97
	35	10000	3500	8500	131	69.4	64.6	36.64	6.5	131	69.4	64.6	36.64	6.0	138.1	145.5	5.71
	36	10000	3500	8500	133	65.0	61.2	28.57	6.9	133	65.0	61.2	28.57	6.4	133.0	140.0	5.93
	37	10000	3500	8500	126	64.7	61.3	26.98	6.7	126	64.7	61.3	26.98	6.1	136.3	143.6	5.78
	38	13726	4804	11667	166	64.0	61.8	13.25	9.8	166	64.0	61.8	13.25	9.0	108.8	114.6	7.21
D10																	
	41	10200	3570	8670	135	67.4	62.7	34.81	6.8	135	67.4	62.7	34.81	6.2	135.1	142.2	5.72
	43	15438	5403	13122	199	74.0	66.5	37.69	9.4	199	74.0	66.5	37.69	8.6	111.3	117.3	6.89
	44	12386	4335	10528	151	76.5	69.8	44.37	7.1	151	76.5	69.8	44.37	6.5	131.6	138.6	5.89
	45	11475	4016	9754	138	81.0	73.8	52.17	6.3	138	81.0	73.8	52.17	5.8	140.7	148.2	5.63
	46	12208	4273	10377	147	84.7	77.5	48.98	6.8	147	84.7	77.5	48.98	6.2	135.1	142.3	5.88
D11																	
	39	14627	5119	12433	140	61.2	58.2	21.43	7.5	140	61.2	58.2	21.43	6.8	127.6	134.4	6.06
	40	16529	5785	14050	277	61.3	58.7	9.39	17.2	277	61.3	58.7	9.39	15.7	78.4	82.5	9.71
E1																	
	53	11089	3881	9426	144	86.0	81.0	34.72	7.2	144	86.0	81.0	34.72	6.5	130.7	137.6	5.86
	54	10086	3530	8573	134	90.0	85.0	37.31	6.6	134	90.0	85.0	37.31	6.1	136.7	143.9	5.72
E2																	
	55	10271	3595	8730	140	85.0	82.6	17.14	8.1	140	85.0	82.6	17.14	7.4	121.8	128.2	6.30
	56	10041	3514	8535	130	94.0	87.0	53.85	6.0	130	94.0	87.0	53.85	5.5	145.1	152.9	5.41
	57	10437	3653	8871	129	95.0	81.5	104.65	5.2	129	95.0	81.5	104.65	4.7	157.9	166.3	4.78
	58	10559	3696	8975	138	95.0	84.0	79.71	5.8	138	95.0	84.0	79.71	5.3	147.2	155.0	5.46
E3																	

Runoff Coefficients

Cleared Upland	0.35
Hardstand	0.85

Event	Duration (mins)	Intensity (mm/hr)
1 min	1	257.40
2 min	2	210.00
3 min	3	192.40
4 min	4	178.50
5 min	5	166.80
10 min	10	124.80
15 min	15	100.40
20 min	20	84.60
25 min	25	73.68
30 min	30	65.60
45 min	45	50.53
1 hr	60	42.10
1.5 hr	90	32.73
2 hr	120	27.55
3 hr	180	21.73
4.5 hr	270	17.24
6 hr	360	14.62
9 hr	540	11.44
12 hr	720	9.50
18 hr	1080	7.17
24 hr	1440	5.75
30 hr	1800	4.77
36 hr	2160	4.08
48 hr	2880	3.17
72 hr	4320	2.19



100 YEAR ARI FLOWS - LOTS

Storm Duration (mins)									A1												A2			A3
	1				2				3				5				6				13			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	140.08	662.45	522.37	-11.21	120.66	607.75	487.09	-12.28	131.39	607.75	476.36	-9.62	149.27	696.06	546.78	-11.29	155.37	812.68	657.31	-18.10	143.77	645.67	501.90	-9.29
2	140.08	540.46	400.38	8.07	120.66	495.83	375.18	5.84	131.39	495.83	364.44	7.91	149.27	567.88	418.60	8.85	155.37	663.03	507.66	6.45	143.77	526.77	383.00	9.10
3	140.08	495.16	355.09	25.22	120.66	454.28	333.62	22.02	131.39	454.28	322.89	23.48	149.27	520.28	371.01	26.75	155.37	607.46	452.09	28.43	143.77	482.62	338.86	25.40
4	140.08	459.39	319.31	39.12	120.66	421.46	300.80	35.23	131.39	421.46	290.07	36.08	149.27	482.70	333.42	41.24	155.37	563.57	408.20	46.44	143.77	447.76	303.99	38.54
5	140.08	429.28	289.20	50.40	120.66	393.83	273.18	46.03	131.39	393.83	262.44	46.26	149.27	451.06	301.78	52.98	155.37	526.63	371.26	61.23	143.77	418.41	274.64	49.11
10	140.08	321.19	181.11	78.24	120.66	294.67	174.01	73.82	131.39	294.67	163.28	70.96	149.27	337.48	188.21	81.62	155.37	394.03	238.66	100.11	143.77	313.05	169.28	74.16
15	140.08	258.39	118.31	81.77	120.66	237.06	116.40	79.33	131.39	237.06	105.67	73.38	149.27	271.50	122.23	84.73	155.37	316.99	161.62	109.19	143.77	251.85	108.08	75.51
20	140.08	217.73	77.65	73.93	120.66	199.75	79.09	74.41	131.39	199.75	68.36	65.35	149.27	228.77	79.50	75.89	155.37	267.11	111.74	104.32	143.77	212.21	68.45	65.78
25	140.08	189.62	49.55	60.22	120.66	173.97	53.31	64.10	131.39	173.97	42.58	51.94	149.27	199.24	49.97	60.88	155.37	232.63	77.26	92.26	143.77	184.82	41.05	50.32
30	140.08	168.83	28.75	42.56	120.66	154.89	34.23	50.17	131.39	154.89	23.50	34.91	149.27	177.39	28.12	41.72	155.37	207.12	51.75	75.37	143.77	164.55	20.78	31.01
45	140.08	130.05	-10.02	-22.91	120.66	119.31	-1.34	-3.04	131.39	119.31	-12.07	-27.67	149.27	136.65	-12.62	-28.90	155.37	159.55	4.18	9.42	143.77	126.76	-17.01	-39.12
60	140.08	108.35	-31.73	-98.42	120.66	99.40	-21.25	-65.44	131.39	99.40	-31.99	-99.47	149.27	113.85	-35.43	-110.07	155.37	132.92	-22.45	-68.80	143.77	105.61	-38.16	-119.07
90	140.08	84.24	-55.83	-265.74	120.66	77.29	-43.37	-205.13	131.39	77.29	-54.10	-258.04	149.27	88.52	-60.76	-289.56	155.37	103.35	-52.02	-245.11	143.77	82.11	-61.66	-294.89
120	140.08	70.90	-69.17	-445.41	120.66	65.05	-55.61	-356.11	131.39	65.05	-66.34	-427.95	149.27	74.50	-74.77	-482.03	155.37	86.98	-68.39	-436.45	143.77	69.11	-74.66	-482.79
180	140.08	55.93	-84.14	-827.58	120.66	51.31	-69.34	-678.91	131.39	51.31	-80.07	-788.76	149.27	58.77	-90.50	-890.98	155.37	68.62	-86.75	-846.98	143.77	54.52	-89.25	-880.92
270	140.08	44.38	-95.70	-1433.93	120.66	40.72	-79.94	-1193.36	131.39	40.72	-90.67	-1360.38	149.27	46.63	-102.64	-1539.23	155.37	54.45	-100.92	-1503.10	143.77	43.26	-100.51	-1510.50
360	140.08	37.62	-102.46	-2066.15	120.66	34.51	-86.14	-1731.46	131.39	34.51	-96.88	-1955.76	149.27	39.53	-109.75	-2214.68	155.37	46.15	-109.22	-2190.80	143.77	36.67	-107.10	-2165.35
540	140.08	29.45	-110.62	-3381.53	120.66	27.02	-93.63	-2854.32	131.39	27.02	-104.37	-3193.28	149.27	30.95	-118.33	-3619.13	155.37	36.13	-119.24	-3628.50	143.77	28.71	-115.06	-3524.79
720	140.08	24.45	-115.63	-4739.92	120.66	22.43	-98.23	-4016.58	131.39	22.43	-108.96	-4470.28	149.27	25.69	-123.58	-5068.78	155.37	29.99	-125.38	-5118.85	143.77	23.83	-119.94	-4926.19
1080	140.08	18.44	-121.63	-7525.96	120.66	16.92	-103.74	-6404.56	131.39	16.92	-114.47	-7087.85	149.27	19.38	-129.89	-8040.86	155.37	22.63	-132.74	-8184.36	143.77	17.98	-125.79	-7796.57
1440	140.08	14.80	-125.28	-10367.27	120.66	13.58	-107.08	-8843.26	131.39	13.58	-117.81	-9756.13	149.27	15.55	-133.72	-11071.03	155.37	18.15	-137.22	-11317.69	143.77	14.42	-129.35	-10720.81
1800	140.08	12.27	-127.81	-13241.24	120.66	11.25	-109.40	-11311.99	131.39	11.25	-120.13	-12454.34	149.27	12.89	-136.38	-14135.49	155.37	15.05	-140.32	-14491.25	143.77	11.96	-131.81	-13676.82
2160	140.08	10.51	-129.57	-16126.74	120.66	9.64	-111.02	-13791.26	131.39	9.64	-121.75	-15163.14	149.27	11.04	-138.23	-17212.07	155.37	12.89	-142.48	-17678.86	143.77	10.24	-133.53	-16644.10
2880	140.08	8.15	-131.93	-21923.54	120.66	7.48	-113.18	-18773.52	131.39	7.48	-123.91	-20604.40	149.27	8.56	-140.71	-23392.34	155.37	10.00	-145.37	-24085.81	143.77	7.94	-135.83	-22603.78
4320	140.08	5.65	-134.43	-33559.71	120.66	5.18	-115.48	-28776.98	131.39	5.18	-126.21	-31526.01	149.27	5.93	-143.34	-35797.63	155.37	6.93	-148.44	-36951.75	143.77	5.50	-138.26	-34564.72
Volume check				ok				ok				ok				ok				ok				ok

Storm Duration (mins)									A4																A5			
	14				15				16				17				23N				18				24N			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	118.82	608.78	489.96	-12.86	119.51	608.66	489.15	-12.66	121.44	608.54	487.10	-12.13	122.70	608.36	485.66	-11.78	75.10	281.08	205.98	-1.84	128.88	647.19	518.31	-12.97	92.29	377.11	284.82	-3.82
2	118.82	496.68	377.85	5.40	119.51	496.58	377.07	5.55	121.44	496.48	375.04	5.98	122.70	496.33	373.63	6.25	75.10	229.32	154.22	5.47	128.88	528.01	399.13	6.30	92.29	307.66	215.37	6.47
3	118.82	455.05	336.23	21.72	119.51	454.96	335.45	21.84	121.44	454.87	333.43	22.15	122.70	454.73	332.03	22.34	75.10	210.10	135.00	11.85	128.88	483.76	354.88	23.51	92.29	281.88	189.59	15.51
4	118.82	422.17	303.35	35.07	119.51	422.09	302.58	35.14	121.44	422.01	300.57	35.34	122.70	421.88	299.18	35.45	75.10	194.92	119.82	16.84	128.88	448.81	319.93	37.56	92.29	261.51	169.22	22.70
5	118.82	394.50	275.68	46.01	119.51	394.42	274.91	46.04	121.44	394.35	272.90	46.12	122.70	394.23	271.53	46.15	75.10	182.15	107.04	20.72	128.88	419.39	290.51	49.04	92.29	244.37	152.08	28.40
10	118.82	295.17	176.35	74.44	119.51	295.11	175.60	74.25	121.44	295.05	173.61	73.77	122.70	294.96	172.26	73.42	75.10	136.28	61.18	28.01	128.88	313.79	184.91	78.52	92.29	182.84	90.55	40.62
15	118.82	237.46	118.64	80.54	119.51	237.41	117.90	80.15	121.44	237.36	115.92	79.10	122.70	237.29	114.59	78.38	75.10	109.64	34.53	24.98	128.88	252.44	123.56	84.27	92.29	147.09	54.80	39.01
20	118.82	200.09	81.27	76.19	119.51	200.05	80.54	75.60	121.44	200.01	78.57	73.99	122.70	199.95	77.25	72.90	75.10	92.38	17.28	17.11	128.88	212.71	83.83	78.91	92.29	123.94	31.65	30.91
25	118.82	174.26	55.44	66.45	119.51	174.23	54.72	65.66	121.44	174.19	52.75	63.48	122.70	174.14	51.44	62.02	75.10	80.46	5.36	6.74	128.88	185.26	56.37	67.82	92.29	107.95	15.65	19.47
30	118.82	155.15	36.33	53.10	119.51	155.12	35.61	52.10	121.44	155.09	33.65	49.36	122.70	155.04	32.35	47.53	75.10	71.64	-3.47	-5.30	128.88	164.94	36.06	52.87	92.29	96.11	3.82	5.77
45	118.82	119.52	0.70	1.57	119.51	119.49	-0.02	-0.04	121.44	119.47	-1.97	-4.47	122.70	119.43	-3.26	-7.41	75.10	55.18	-19.92	-46.79	128.88	127.06	-1.82	-4.14	92.29	74.03	-18.26	-42.47
60	118.82	99.57	-19.25	-59.15	119.51	99.55	-19.96	-61.37	121.44	99.53	-21.91	-67.50	122.70	99.50	-23.20	-71.56	75.10	45.97	-29.13	-92.59	128.88	105.85	-23.03	-70.93	92.29	61.68	-30.61	-96.47
90	118.82	77.42	-41.40	-195.50	119.51	77.40	-42.11	-198.94	121.44	77.39	-44.05	-208.48	122.70	77.36	-45.33	-214.77	75.10	35.75	-39.36	-191.20	128.88	82.30	-46.58	-220.39	92.29	47.96	-44.34	-213.83
120	118.82	65.16	-53.66	-343.13	119.51	65.15	-54.36	-347.80	121.44	65.13	-56.31	-360.75	122.70	65.11	-57.58	-369.28	75.10	30.08	-45.02	-295.14	128.88	69.27	-59.61	-381.86	92.29	40.36	-51.93	-338.29
180	118.82	51.40	-67.42	-659.27	119.51	51.39	-68.12	-666.40	121.44	51.38	-70.06	-686.19	122.70	51.37	-71.33	-699.20	75.10	23.73	-51.37	-512.86	128.88	54.65	-74.24	-727.01	92.29	31.84	-60.45	-600.34
270	118.82	40.79	-78.04	-1163.73	119.51	40.78	-78.73	-1174.55	121.44	40.77	-80.67	-1204.65	122.70	40.76	-81.94	-1224.39	75.10	18.83	-56.27	-853.71	128.88	43.36	-85.52	-1276.96	92.29	25.26	-67.03	-1012.43
360	118.82	34.57	-84.25	-1691.88	119.51	34.56	-84.95	-1706.39	121.44	34.56	-86.88	-1746.80	122.70	34.55	-88.15	-1773.29	75.10	15.96	-59.14	-1205.67	128.88	36.75	-92.13	-1852.10	92.29	21.41	-70.88	-1439.37
540	118.82	27.07	-91.76	-2794.86	119.51	27.06	-92.45	-2816.76	121.44	27.06	-94.38	-2877.81	122.70	27.05	-95.65	-2917.78	75.10	12.50	-62.61	-1931.37	128.88	28.78	-100.11	-3052.05	92.29	16.77	-75.53	-2322.38
720	118.82	22.47	-96.35	-3937.31	119.51	22.46	-97.05	-3966.58	121.44	22.46	-98.98	-4048.29	122.70	22.45	-100.25	-4101.74	75.10	10.37	-64.73	-2675.41	128.88	23.89	-105.00	-4293.98	92.29	13.92	-78.38	-3229.94
1080	118.82	16.95	-101.87	-6285.75	119.51	16.95	-102.56	-6329.78	121.44	16.94	-104.50	-6452.79	122.70	16.94	-105.76	-6533.19	75.10	7.83	-67.28	-4193.02	128.88	18.02	-110.86	-6845.41	92.29	10.50	-81.79	-5084.61
1440	118.82	13.60	-105.22	-8684.99	119.51	13.60	-105.91	-8743.77	121.44	13.59	-107.85	-8908.07	122.70	13.59	-109.11	-9015.41	75.10	6.28	-68.82	-5734.06	128.88	14.46	-114.43	-9450.85	92.29	8.42	-83.87	-6970.73
1800	118.82	11.27	-107.55	-11114.34	119.51	11.27	-108.24	-11187.86	121.44	11.27	-110.17	-11393.42	122.70	11.27	-111.43	-11527.68	75.10	5.21	-69.90	-7288.84	128.88	11.99	-116.90	-12088.26	92.29	6.98	-85.31	-8875.34
2160	118.82	9.66	-109.16	-13554.24	119.51	9.66	-109.86	-13642.49	121.44	9.65	-111.79	-13889.33	122.70	9.65	-113.05	-14050.50	75.10	4.46	-70.64	-8848.57	128.88	10.27	-118.62	-14736.90	92.29	5.98	-86.31	-10786.56
2880	118.82	7.49	-111.33	-18457.78	119.51	7.49	-112.02	-18575.50	121.44	7.49	-113.95	-18904.87	122.70	7.48	-115.21	-19119.88	75.10	3.46	-71.65	-11978.92	128.88	7.96	-120.92	-20059.43	92.29	4.64	-87.65	-14623.65
4320	118.82	5.19	-113.63	-28303.88	119.51	5.19	-114.32	-28480.53	121.44	5.19	-116.25	-28974.98	122.70	5.19	-117.51	-29297.65	75.10	2.40	-72.71	-18257.85	128.88	5.52	-123.37	-30745.99	92.29	3.22	-89.08	-22322.20
Volume check				ok				ok				ok				ok				ok				ok				ok

Storm Duration (mins)									B1								C1			
	7				8				9				10				4			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	127.55	620.63	493.08	-11.41	128.31	607.75	479.44	-10.34	122.68	607.75	485.07	-11.74	124.75	607.75	483.00	-11.21	273.48	1472.40	1198.91	-35.20
2	127.55	506.35	378.79	6.86	128.31	495.83	367.53	7.36	122.68	495.83	373.15	6.26	124.75	495.83	371.08	6.68	273.48	1201.26	927.77	9.72
3	127.55	463.91	336.36	23.13	128.31	454.28	325.97	23.11	122.68	454.28	331.60	22.33	124.75	454.28	329.53	22.63	273.48	1100.58	827.09	50.00
4	127.55	430.39	302.84	36.38	128.31	421.46	293.15	35.88	122.68	421.46	298.78	35.43	124.75	421.46	296.71	35.61	273.48	1021.07	747.58	83.09
5	127.55	402.18	274.63	47.16	128.31	393.83	265.53	46.24	122.68	393.83	271.15	46.11	124.75	393.83	269.08	46.17	273.48	954.14	680.66	110.34
10	127.55	300.91	173.36	74.29	128.31	294.67	166.36	71.83	122.68	294.67	171.98	73.32	124.75	294.67	169.92	72.79	273.48	713.89	440.41	183.08
15	127.55	242.08	114.53	78.67	128.31	237.06	108.75	75.13	122.68	237.06	114.37	78.24	124.75	237.06	112.31	77.12	273.48	574.31	300.83	201.83
20	127.55	203.98	76.43	72.39	128.31	199.75	71.44	68.00	122.68	199.75	77.07	72.74	124.75	199.75	75.00	71.01	273.48	483.93	210.45	195.32
25	127.55	177.65	50.10	60.60	128.31	173.97	45.66	55.48	122.68	173.97	51.28	61.84	124.75	173.97	49.22	59.52	273.48	421.47	147.99	175.78
30	127.55	158.17	30.62	45.13	128.31	154.89	26.58	39.34	122.68	154.89	32.21	47.33	124.75	154.89	30.14	44.41	273.48	375.25	101.77	147.50
45	127.55	121.84	-5.71	-12.99	128.31	119.31	-8.99	-20.55	122.68	119.31	-3.37	-7.65	124.75	119.31	-5.44	-12.37	273.48	289.06	15.58	34.97

60	127.55	101.51	-26.04	-80.51	128.31	99.40	-28.91	-89.65	122.68	99.40	-23.28	-71.82	124.75	99.40	-25.35	-78.36	273.48	240.82	-32.66	-99.74
90	127.55	78.93	-48.63	-230.79	128.31	77.29	-51.02	-242.79	122.68	77.29	-45.40	-215.08	124.75	77.29	-47.46	-225.24	273.48	187.24	-86.24	-405.10
120	127.55	66.43	-61.12	-392.61	128.31	65.05	-63.26	-407.27	122.68	65.05	-57.63	-369.62	124.75	65.05	-59.70	-383.44	273.48	157.59	-115.89	-737.66
180	127.55	52.40	-75.15	-737.61	128.31	51.31	-76.99	-757.16	122.68	51.31	-71.37	-699.60	124.75	51.31	-73.44	-720.73	273.48	124.32	-149.16	-1453.11
270	127.55	41.58	-85.97	-1286.06	128.31	40.72	-87.59	-1312.36	122.68	40.72	-81.97	-1224.83	124.75	40.72	-84.03	-1256.98	273.48	98.64	-174.84	-2599.22
360	127.55	35.24	-92.31	-1858.70	128.31	34.51	-93.80	-1891.30	122.68	34.51	-88.17	-1773.75	124.75	34.51	-90.24	-1816.92	273.48	83.61	-189.87	-3802.47
540	127.55	27.59	-99.96	-3051.69	128.31	27.02	-101.29	-3095.90	122.68	27.02	-95.66	-2918.24	124.75	27.02	-97.73	-2983.51	273.48	65.47	-208.02	-6321.74
720	127.55	22.91	-104.64	-4284.94	128.31	22.43	-105.88	-4339.96	122.68	22.43	-100.25	-4102.16	124.75	22.43	-102.32	-4189.52	273.48	54.34	-219.14	-8936.34
1080	127.55	17.28	-110.27	-6816.29	128.31	16.92	-111.39	-6891.60	122.68	16.92	-105.76	-6533.47	124.75	16.92	-107.83	-6665.05	273.48	41.00	-232.49	-14319.12
1440	127.55	13.86	-113.69	-9399.43	128.31	13.58	-114.73	-9493.96	122.68	13.58	-109.11	-9015.50	124.75	13.58	-111.17	-9191.30	273.48	32.89	-240.59	-19824.79
1800	127.55	11.49	-116.06	-12013.20	128.31	11.25	-117.05	-12126.29	122.68	11.25	-111.43	-11527.54	124.75	11.25	-113.50	-11747.54	273.48	27.27	-246.22	-25403.40
2160	127.55	9.85	-117.71	-14637.76	128.31	9.64	-118.67	-14769.18	122.68	9.64	-113.04	-14050.13	124.75	9.64	-115.11	-14314.34	273.48	23.36	-250.13	-31007.44
2880	127.55	7.64	-119.92	-19911.06	128.31	7.48	-120.83	-20078.66	122.68	7.48	-115.21	-19119.01	124.75	7.48	-117.27	-19471.63	273.48	18.11	-255.37	-42273.06
4320	127.55	5.29	-122.26	-30497.50	128.31	5.18	-123.13	-30736.65	122.68	5.18	-117.50	-29295.77	124.75	5.18	-119.57	-29825.23	273.48	12.55	-260.93	-64898.46
Volume check				ok				ok				ok				ok				ok

D1

Storm Duration (mins)	19				20				21				22				23S				31			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	138.06	670.47	532.41	-12.26	126.91	607.75	480.84	-10.67	128.48	607.75	479.27	-10.29	129.45	607.75	478.30	-10.06	87.58	325.39	237.81	-2.04	164.58	678.25	513.67	-7.11
2	138.06	547.00	408.94	7.46	126.91	495.83	368.92	7.10	128.48	495.83	367.35	7.40	51.04	495.83	444.79	35.95	87.58	265.47	177.89	6.39	164.58	553.35	388.77	11.46
3	138.06	501.16	363.10	25.03	126.91	454.28	327.37	22.93	128.48	454.28	325.80	23.13	51.04	454.28	403.24	55.35	87.58	243.22	155.64	13.73	164.58	506.97	342.40	27.80
4	138.06	464.95	326.89	39.32	126.91	421.46	294.55	35.78	128.48	421.46	292.98	35.89	51.04	421.46	370.42	71.83	87.58	225.65	138.07	19.48	164.58	470.35	305.77	40.82
5	138.06	434.48	296.42	50.95	126.91	393.83	266.92	46.22	128.48	393.83	265.35	46.24	51.04	393.83	342.79	85.94	87.58	210.86	123.28	23.94	164.58	439.52	274.94	51.15
10	138.06	325.08	187.02	80.19	126.91	294.67	167.75	72.21	128.48	294.67	166.18	71.78	51.04	294.67	243.63	130.12	87.58	157.76	70.18	32.18	164.58	328.85	164.27	73.54
15	138.06	261.52	123.46	84.84	126.91	237.06	110.14	75.92	128.48	237.06	108.57	75.04	51.04	237.06	186.01	152.18	87.58	126.92	39.34	28.49	164.58	264.55	99.98	71.05
20	138.06	220.36	82.31	77.98	126.91	199.75	72.84	69.19	128.48	199.75	71.27	67.85	51.04	199.75	148.71	163.99	87.58	106.95	19.36	19.20	164.58	222.92	58.34	56.90
25	138.06	191.92	53.86	65.17	126.91	173.97	47.05	57.07	128.48	173.97	45.48	55.28	51.04	173.97	122.93	170.67	87.58	93.14	5.56	7.01	164.58	194.15	29.57	36.72
30	138.06	170.87	32.81	48.38	126.91	154.89	27.98	41.34	128.48	154.89	26.41	39.09	51.04	154.89	103.85	173.91	87.58	82.93	-4.66	-7.13	164.58	172.86	8.28	12.50
45	138.06	131.63	-6.43	-14.64	126.91	119.31	-7.60	-17.33	128.48	119.31	-9.17	-20.95	51.04	119.31	68.27	173.23	87.58	63.88	-23.70	-55.72	164.58	133.16	-31.42	-73.02
60	138.06	109.66	-28.40	-87.82	126.91	99.40	-27.51	-85.21	128.48	99.40	-29.08	-90.20	51.04	99.40	48.36	164.65	87.58	53.22	-34.36	-109.30	164.58	110.93	-53.65	-168.90
90	138.06	85.26	-52.80	-250.63	126.91	77.29	-49.62	-235.90	128.48	77.29	-51.20	-243.65	51.04	77.29	26.25	135.13	87.58	41.38	-46.20	-224.58	164.58	86.25	-78.33	-377.48
120	138.06	71.76	-66.30	-425.91	126.91	65.05	-61.86	-397.91	128.48	65.05	-63.43	-408.43	51.04	65.05	14.01	96.67	87.58	34.83	-52.76	-346.04	164.58	72.59	-91.98	-598.82
180	138.06	56.61	-81.45	-799.55	126.91	51.31	-75.60	-742.85	128.48	51.31	-77.17	-758.94	51.04	51.31	0.27	2.85	87.58	27.47	-60.11	-600.35	164.58	57.27	-107.31	-1065.11
270	138.06	44.92	-93.14	-1393.46	126.91	40.72	-86.20	-1290.62	128.48	40.72	-87.77	-1315.07	51.04	40.72	-10.32	-162.34	87.58	21.80	-65.78	-998.35	164.58	45.44	-119.14	-1798.74
360	138.06	38.07	-99.99	-2013.51	126.91	34.51	-92.40	-1862.10	128.48	34.51	-93.97	-1894.94	51.04	34.51	-16.53	-347.73	87.58	18.48	-69.11	-1409.22	164.58	38.51	-126.06	-2559.04
540	138.06	29.81	-108.25	-3305.12	126.91	27.02	-99.89	-3051.77	128.48	27.02	-101.46	-3101.40	51.04	27.02	-24.02	-760.96	87.58	14.47	-73.12	-2256.17	164.58	30.16	-134.42	-4132.03
720	138.06	24.75	-113.31	-4640.24	126.91	22.43	-104.48	-4280.90	128.48	22.43	-106.05	-4347.31	51.04	22.43	-28.61	-1211.20	87.58	12.01	-75.57	-3124.35	164.58	25.03	-139.55	-5749.18
1080	138.06	18.67	-119.39	-7380.54	126.91	16.92	-109.99	-6802.67	128.48	16.92	-111.56	-6902.69	51.04	16.92	-34.12	-2171.79	87.58	9.06	-78.52	-4894.90	164.58	18.88	-145.69	-9054.58
1440	138.06	14.98	-123.08	-10176.78	126.91	13.58	-113.34	-9375.15	128.48	13.58	-114.91	-9508.77	51.04	13.58	-37.46	-3183.35	87.58	7.27	-80.31	-6692.58	164.58	15.15	-149.43	-12416.56
1800	138.06	12.42	-125.64	-13006.12	126.91	11.25	-115.66	-11977.61	128.48	11.25	-117.23	-12144.81	51.04	11.25	-39.79	-4228.27	87.58	6.03	-81.56	-8506.15	164.58	12.56	-152.02	-15811.80
2160	138.06	10.64	-127.42	-15847.10	126.91	9.64	-117.27	-14590.64	128.48	9.64	-118.84	-14791.43	51.04	9.64	-41.40	-5282.02	87.58	5.16	-82.42	-10325.46	164.58	10.76	-153.82	-19218.93
2880	138.06	8.25	-129.81	-21555.20	126.91	7.48	-119.43	-19840.37	128.48	7.48	-121.01	-20108.34	51.04	7.48	-43.56	-7414.72	87.58	4.00	-83.58	-13976.69	164.58	8.34	-156.23	-26059.53
4320	138.06	5.72	-132.34	-33014.43	126.91	5.18	-121.73	-30378.88	128.48	5.18	-123.30	-30781.23	51.04	5.18	-45.86	-11714.93	87.58	2.77	-84.81	-21300.25	164.58	5.78	-158.80	-39784.54
Volume check				ok				ok				ok				ok				ok				ok

D2

Storm Duration (mins)	11				12				32			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	357.96	1242.30	884.34	-4.71	264.59	1346.47	1081.88	-27.95	119.39	633.03	513.64	-14.58
2	357.96	1013.53	655.57	26.17	264.59	1098.52	833.93	12.33	119.39	516.46	397.07	4.63
3	357.96	928.59	570.63	52.84	264.59	1006.45	741.86	48.34	119.39	473.18	353.79	21.85
4	357.96	861.50	503.54	73.41	264.59	933.74	669.15	77.77	119.39	438.99	319.60	35.97
5	357.96	805.03	447.07	89.05	264.59	872.54	607.95	101.85	119.39	410.22	290.83	47.58
10	357.96	602.33	244.37	113.69	264.59	652.83	388.24	164.21	119.39	306.92	187.54	78.33
15	357.96	484.57	126.60	92.74	264.59	525.20	260.60	177.19	119.39	246.92	127.53	85.88
20	357.96	408.31	50.35	50.41	264.59	442.55	177.95	167.07	119.39	208.06	88.67	82.56
25	357.96	355.61	-2.36	-3.00	264.59	385.42	120.83	145.01	119.39	181.20	61.81	73.63
30	357.96	316.61	-41.35	-63.84	264.59	343.16	78.56	114.96	119.39	161.33	41.94	60.95
45	357.96	243.89	-114.07	-270.03	264.59	264.34	-0.25	-0.57	119.39	124.28	4.89	11.00
60	357.96	203.19	-154.77	-495.36	264.59	220.23	-44.37	-136.43	119.39	103.54	-15.85	-48.50
90	357.96	157.98	-199.98	-977.16	264.59	171.23	-93.36	-441.14	119.39	80.50	-38.89	-182.96
120	357.96	132.97	-225.00	-1482.64	264.59	144.12	-120.48	-770.81	119.39	67.75	-51.63	-329.13
180	357.96	104.89	-253.07	-2537.34	264.59	113.69	-150.90	-1476.35	119.39	53.45	-65.94	-643.12
270	357.96	83.23	-274.73	-4182.79	264.59	90.21	-174.39	-2601.61	119.39	42.41	-76.98	-1145.50
360	357.96	70.55	-287.42	-5877.55	264.59	76.46	-188.13	-3779.26	119.39	35.95	-83.44	-1672.46
540	357.96	55.23	-302.73	-9363.56	264.59	59.87	-204.73	-6237.87	119.39	28.15	-91.24	-2774.89
720	357.96	45.85	-312.11	-12930.77	264.59	49.69	-214.90	-8783.76	119.39	23.36	-96.03	-3918.32
1080	357.96	34.59	-323.37	-20195.84	264.59	37.49	-227.10	-14016.11	119.39	17.63	-101.76	-6271.23
1440	357.96	27.75	-330.21	-27564.52	264.59	30.08	-234.51	-19360.84	119.39	14.14	-105.25	-8676.97
1800	357.96	23.01	-334.96	-34993.67	264.59	24.93	-239.66	-24772.12	119.39	11.72	-107.67	-11114.05
2160	357.96	19.71	-338.25	-42444.83	264.59	21.36	-243.23	-30206.74	119.39	10.04	-109.35	-13562.07
2880	357.96	15.28	-342.68	-57395.20	264.59	16.56	-248.03	-41128.52	119.39	7.79	-111.60	-18482.85
4320	357.96	10.59	-347.37	-87376.74	264.59	11.48	-253.11	-63058.37	119.39	5.40	-113.99	-28364.90
Volume check				ok				ok				ok

D3

Storm Duration (mins)	24S				25				26				27				28				29				30			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	116.88	471.80	354.92	-4.53	147.09	621.18	474.09	-7.18	150.87	607.93	457.06	-5.79	150.86	623.86	473.00	-6.64	227.08	1293.90	1066.82	-35.25	145.05	691.80	546.75	-12.01	126.71	607.75	481.04	-10.72
2	116.88	384.92	268.04	8.26	147.09	506.79	359.70	10.03	150.87	495.98	345.11	10.67	150.86	508.97	358.11	10.48	227.08	1055.63	828.55	4.93	145.05	564.41	419.36	8.19	126.71	495.83	369.12	7.06
3	116.88	352.66	235.78	19.49	147.09	464.32	317.22	25.21	150.87	454.41	303.54	25.13	150.86	466.32	315.46	25.54	227.08	967.16	740.07	41.09	145.05	517.10	372.06	26.17	126.71	454.28	327.56	22.90
4	116.88	327.18	210.30	28.41	147.09	430.77	283.68	37.34	150.87	421.58	270.71	36.60	150.86	432.63	281.77	37.54	227.08	897.28	670.20	70.93	145.05	479.75	334.70	40.77	126.71	421.46	294.74	35.76
5	116.88	305.73	188.86	35.45	147.09	402.54	255.44	47.01	150.87	393.95	243.08	45.66	150.86	404.27	253.41	47.07	227.08	838.47	611.39	95.63	145.05	448.30	303.25	52.62	126.71	393.83	267.12	46.22
10	116.88	228.75	111.87	50.33	147.09	301.18	154.08	68.57	150.87	294.76	143.89	64.76	150.86	302.48	151.62	67.82	227.08	627.35	400.26	163.35	145.05	335.42	190.37	82.04	126.71	294.67	167.95	72.27
15	116.88	184.03	67.15	47.91	147.09	242.29	95.20	67.34	150.87	237.13	86.26	61.56	150.86	243.34	92.48	65.68	227.08	504.69	277.61	183.63	145.05	269.84	124.79	86.09	126.71	237.06	110.34	76.03
20	116.88	155.07	38.19	37.37	147.09	204.16	57.07	55.44	150.87	199.81	48.94	47.91	150.86	205.04	54.18	52.82	227.08	425.27	198.18	181.72	145.05	227.38	82.33	78.26	126.71	199.75	73.04	69.36
25	116.88	135.05	18.17	22.64	147.09	177.81	30.72	38.01	150.87	174.02	23.15	28.85	150.86	178.58	27.72	34.41	227.08	370.38	143.29	168.36	145.05	198.03	52.98	64.30	126.71	173.97	47.25	57.29
30	116.88	120.24	3.36	5.10	147.09	158.31	11.22	16.88	150.87	154.94	4.07	6.16	150.86	158.99	8.13	12.28	227.08	329.76	102.68	147.33	145.05	176.31	31.26	46.22	126.71	154.89	28.17	41.62
45	116.88	92.62	-24.25	-56.49	147.09	121.95	-25.14	-58.26	150.87	119.35	-31.52	-73.43	150.86	122.48	-28.38	-65.93	227.08	254.02	26.94	59.97	145.05	135.82	-9.23	-21.07	126.71	119.31	-7.40	-16.88
60	116.88	77.17	-39.71	-125.29	147.09	101.60	-45.50	-142.88	150.87	99.43	-51.44	-162.32	150.86	102.04	-48.82	-153.66	227.08	211.63	-15.45	-46.84	145.05	113.15	-31.90	-98.85	126.71	99.40	-27.31	-84.58
90	116.88	60.00	-56.88	-274.59	147.09	79.00	-68.10	-327.50	150.87	77.31	-73.56	-355.18	150.86	79.34	-71.52	-344.60	227.08	164.54	-62.54	-291.95	145.05	87.98	-57.07	-271.40	126.71	77.29	-49.43	-234.93
120	116.88	50.50	-66.38	-432.80	147.09	66.49	-80.61	-523.79	150.87	65.07	-85.80	-559.51	150.86	66.77	-84.09	-547.27	227.08	138.49	-88.59	-560.86	145.05	74.04	-71.00	-456.85	126.71	65.05	-61.67	-396.59
180	116.88	39.84	-77.04	-765.64	147.09	52.45	-94.65	-937.94	150.87	51.33	-99.54	-989.35	150.86	52.67	-98.19	-974.31	227.08	109.25	-117.83	-1142.76	145.05	58.41	-86.64	-851.57	126.71	51.31	-75.40	-740.83
270	116.88	31.61	-85.27	-1288.72	147.09	41.62	-105.48	-1590.44	150.87	40.73	-110.14	-1664.81	150.86	41.80	-109.06	-1646.33	227.08	86.68	-140.40	-2079.47	145.05	46.35	-98.70	-1478.19	126.71	40.72	-86.00	-1287.55
360	116.88	26.79	-90.08	-1830.39	147.09	35.27	-111.82	-2267.34	150.87	34.52	-116.35	-2364.21	150.86	35.43	-115.43	-2342.88	227.08	73.48	-153.61	-3066.24	145.05	39.28	-105.76	-2131.82	126.71	34.51	-92.20	-1857.97
540	116.88	20.98	-95.90	-2950.17	147.09	27.62	-119.48	-3669.09	150.87	27.03	-123.84	-3810.00	150.86	27.74	-123.12	-3784.16	227.08	57.53	-169.55	-5138.73	145.05	30.76	-114.29	-3492.27	126.71	27.02	-99.69	-3045.54
720	116.88	17.41	-99.46	-4100.69	147.09	22.93	-124.17	-5111.26	150.87	22.44	-128.43	-5295.39	150.86	23.02	-127.83	-5266.05	227.08	47.75	-179.33	-7294.90	145.05	25.53	-119.51	-4897.62	126.71	22.43	-104.28	-4272.56
1080	116.88	13.14	-103.74	-6451.21	147.09	17.30	-129.80	-8060.67	150.87	16.93	-133.94	-8329.92	150.86	17.37	-133.49	-8295.23	227.08	36.03	-191.06	-11742.06	145.05	19.26	-125.79	-7780.64	126.71	16.92	-109.79	-6790.11
1440	116.88	10.54	-106.34	-8841.08	147.09	13.88	-133.22	-11061.91	150.87	13.58	-137.29	-11415.16	150.86	13.94	-136.92	-11376.45	227.08	28.90	-198.18	-16297.22	145.05	15.45	-129.59	-10721.38	126.71	13.58	-113.14	-9358.38
1800	116.88	8.74	-108.14	-11254.06	147.09	11.50	-135.59	-14093.64	150.87	11.26	-139.61	-14530.18	150.86	11.55	-139.31	-14488.26	227.08	23.96	-203.12	-20916.61	145.05	12.81	-132.24	-13696.24	126.71	11.25	-115.46	-11956.62
2160	116.88	7.48	-109.39	-13675.32	147.09	9.85	-137.24	-17136.24	150.87	9.64	-141.23	-17655.87	150.86	9.90	-140.96	-17611.01	227.08	20.53	-206.56	-25558.28	145.05	10.97	-134.07	-16683.13	126.71	9.64	-117.07	-14565.43
2880	116.88	5.80	-111.07	-18536.17	147.09	7.64	-139.45	-23245.59	150.87	7.48	-143.39	-23930.86	150.86	7.67	-143.18	-23880.74	227.08	15.92	-211.16	-34892.24	145.05	8.51	-136.54	-22683.86	126.71	7.48	-119.24	-19806.73
4320	116.88	4.02	-112.85	-28288.37	147.09	5.30	-141.80	-35504.37	150.87	5.18	-145.69	-36520.15	150.86	5.32	-145.54	-36460.49	227.08	11.03	-216.05	-53642.75	145.05	5.90	-139.15	-34729.77	126.71	5.18	-121.53	-30328.37
Volume check				ok				ok				ok				ok				ok				ok				ok

D4 D5 D6 D8

Storm Duration (mins)	49				50				51				52				47				48				42			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	148.26	607.93	459.67	-6.24	156.74	689.49	532.75	-9.25	147.23	616.20	468.96	-6.88	149.74	690.53	540.78	-10.82	159.48	728.57	569.09	-11.09	165.55	726.63	561.07	-9.67	137.93	626.83	488.90	-9.38
2	148.26	495.98	347.72	10.36	156.74	562.52	405.79	10.21	147.23	502.73	355.49	10.13	149.74	563.37	413.62	9.07	159.48	594.41	434.92	9.82	165.55	592.82	427.27	10.82	137.93	511.40	373.47	8.57
3	148.26	454.41	306.15	24.97	156.74	515.38	358.64	27.43	147.23	460.59	313.36	25.10	149.74	516.15	366.41	26.73	159.48	544.59	385.10	28.37	165.55	543.13	377.58	28.95	137.93	468.54	330.61	24.49
4	148.26	421.58	273.32	36.60	156.74	478.14	321.41	41.28	147.23	427.32	280.08	37.06	149.74	478.86	329.12	41.01	159.48	505.24	345.76	43.36	165.55	503.90	338.34	43.52	137.93	434.69	296.76	37.34
5	148.26	393.95	245.69	45.81	156.74	446.80	290.07	52.39	147.23	399.31	252.07	46.58	149.74	447.47	297.73	52.56	159.48	472.13	312.64	55.45	165.55	470.87	305.31	55.20	137.93	406.20	268.27	47.70
10	148.26	294.76	146.49	65.66	156.74	334.30	177.56	78.20	147.23	298.76	151.53	67.58	149.74	334.80	185.06	80.49	159.48	353.25	193.76	84.50	165.55	352.30	186.75	82.30	137.93	303.92	165.99	72.48
15	148.26	237.13	88.87	63.21	156.74	268.94	112.20	78.73	147.23	240.35	93.12	65.98	149.74	269.34	119.60	83.11	159.48	284.18	124.70	86.82	165.55	283.42	117.87	82.74	137.93	244.50	106.57	74.28
20	148.26	199.81	51.55	50.32	156.74	226.62	69.88	67.41	147.23	202.53	55.29	53.79	149.74	226.96	77.21	73.86	159.48	239.46	79.98	76.63	165.55	238.82	73.27	70.70	137.93	206.02	68.09	65.30
25	148.26	174.02	25.76	32.02	156.74	197.37	40.63	49.96	147.23	176.38	29.15	36.12	149.74	197.66	47.92	58.48	159.48	208.55	49.07	59.98	165.55	207.99	42.44	52.21	137.93	179.43	41.50	50.77
30	148.26	154.94	6.67	10.09	156.74	175.72	18.98	28.41	147.23	157.04	9.81	14.78	149.74	175.98	26.24	38.99	159.48	185.68	26.20	38.98	165.55	185.19	19.63	29.39	137.93	159.75	21.82	32.50
45	148.26	119.35	-28.91	-67.22	156.74	135.36	-21.38	-49.29	147.23	120.97	-26.26	-60.92	149.74	135.57	-14.18	-32.50	159.48	143.03	-16.45	-37.75	165.55	142.65	-22.90	-52.82	137.93	123.06	-14.87	-34.15
60	148.26	99.43	-48.83	-153.81	156.74	112.77	-43.97	-137.48	147.23	100.78	-46.45	-146.01	149.74	112.94	-36.80	-114.49	159.48	119.16	-40.32	-125.56	165.55	118.85	-46.71	-146.09	137.93	102.52	-35.41	-110.33
90	148.26	77.31	-70.95	-342.08	156.74	87.68	-69.06	-330.89	147.23	78.36	-68.87	-331.47	149.74	87.81	-61.93	-295.46	159.48	92.65	-66.83	-319.12	165.55	92.40	-73.15	-350.57	137.93	79.71	-58.22	-278.13
120	148.26	65.07	-83.19	-541.79	156.74	73.80	-82.94	-537.22	147.23	65.95	-81.28	-528.52	149.74	73.91	-75.84	-489.33	159.48	77.98	-81.50	-526.30	165.55	77.77	-87.78	-568.67	137.93	67.09	-70.84	-457.64
180	148.26	51.33	-96.93	-962.38	156.74	58.22	-98.52	-973.75	147.23	52.03	-95.21	-944.03	149.74	58.30	-91.44	-900.91	159.48	61.52	-97.97	-965.83	165.55	61.35	-104.20	-1030.04	137.93	52.93	-85.01	-838.34
270	148.26	40.73	-107.53	-1623.92	156.74	46.19	-110.55	-1663.17	147.23	41.28	-105.95	-1598.34	149.74	46.26	-103.48	-1552.83	159.48	48.81	-110.67	-1661.61	165.55	48.68	-116.87	-1758.58	137.93	41.99	-95.94	-1440.79
360	148.26	34.52	-113.74	-2309.37	156.74	39.15	-117.58	-2379.62	147.23	34.99	-112.24	-2276.86	149.74	39.21	-110.53	-2231.76	159.48	41.37	-118.11	-2385.89	165.55	41.26	-124.29	-2515.61	137.93	35.60	-102.34	-2067.76
540	148.26	27.03	-121.23	-3727.25	156.74	30.66	-126.08	-3865.66	147.23	27.40	-119.84	-3681.47	149.74	30.70	-119.04	-3642.75	159.48	32.39	-127.09	-3890.54	165.55	32.31	-133.25	-4085.67	137.93	27.87	-110.06	-3369.98
720	148.26	22.44	-125.82	-5184.71	156.74	25.45	-131.29	-5396.52	147.23	22.74	-124.49	-5126.19	149.74	25.49	-124.26	-5098.60	159.48	26.89	-132.59	-5442.53	165.55	26.82	-138.73	-5702.98	137.93	23.13	-114.80	-4712.93
1080	148.26	16.93	-131.33	-8163.37	156.74	19.20	-137.54	-8530.44	147.23	17.16	-130.08	-8080.19	149.74	19.23	-130.52	-8082.51	159.48	20.29	-139.20	-8622.71	165.55	20.23	-145.32	-9013.67	137.93	17.45	-120.48	-7464.40
1440	148.26	13.58	-134.68	-11192.74	156.74	15.40	-141.34	-11721.88	147.23	13.77	-133.47	-11085.60	149.74	15.43	-134.32	-11124.05	159.48	16.28	-143.21	-11863.69	165.55	16.23	-149.32	-12384.99	137.93	14.00	-123.93	-10268.17
1800	148.26	11.26	-137.00	-14251.91	156.74	12.77	-143.97	-14947.21	147.23	11.41	-135.82	-14121.24	149.74	12.79	-136.96	-14199.59	159.48	13.49	-145.99	-15140.53	165.55	13.46	-152.10	-15792.02	137.93	11.61	-126.32	-13102.80
2160	148.26	9.64	-138.62	-17321.74	156.74	10.94	-145.80	-18184.59	147.23	9.78	-137.46	-17167.68	149.74	10.95	-138.79	-17287.17	159.48	11.56	-147.93	-18430.08	165.55	11.53	-154.03	-19211.74	137.93	9.94	-127.99	-15948.35
2880	148.26	7.48	-140.78	-23485.02	156.74	8.48	-148.26	-24686.17	147.23	7.58	-139.65	-23284.49	149.74	8.50	-141.25	-23489.21	159.48	8.96	-150.52	-25037.53	165.55	8.94	-156.61	-26079.46	137.93	7.71	-130.22	-21663.86
4320	148.26	5.18	-143.08	-35850.86	156.74	5.88	-150.86	-37733.76	147.23	5.25	-141.98	-35557.91	149.74	5.89	-143.86	-35937.70	159.48	6.21	-153.27	-38299.32	165.55	6.19	-159.36	-39861.72	137.93	5.34	-132.59	-33135.23
Volume check				ok				ok				ok				ok				ok				ok				ok

D9

Storm Duration (mins)	33				34				35				36				37				38			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	157.16	816.94	659.77	-57.50	128.47	607.75	479.28	-39.05	134.27	607.75	473.48	-37.38	129.28	607.75	478.47	-38.81	132.54	607.75	475.21	-9.36	145.20	834.20	688.99	-23.14
2	157.16	666.50	509.34	-23.85	128.47	495.83	367.36	-14.65	134.27	495.83	361.56	-13.30	129.28	495.83	366.55	-14.45	132.54	495.83	363.29	8.11	145.20	680.58	535.38	2.83
3	157.16	610.64	453.48	1.55	128.47	454.28	325.81	3.58	134.27	454.28	320.00	4.60	129.28	454.28	325.00	3.73	132.54	454.28	321.74	23.61	145.20	623.54	478.34	26.21
4	157.16	566.52	409.36	22.24	128.47	421.46	292.99	18.31	134.27	421.46	287.18	19.00	129.28	421.46	292.18	18.41	132.54	421.46	288.92	36.14	145.20	578.49	433.29	45.51
5	157.16	529.39	372.23	39.28	128.47	393.83	265.36	30.32	134.27	393.83	259.56	30.67	129.28	393.83	264.55	30.38	132.54	393.83	261.29	46.26	145.20	540.58	395.37	61.51
10	157.16	396.09	238.93	28.73	128.47	294.67	166.20	21.93	134.27	294.67	160.39	22.00	129.28	294.67	165.38	21.95	132.54	294.67	162.13	70.63	145.20	404.46	259.25	105.51
15	157.16	318.65	161.49	60.81	128.47	237.06	108.59	42.47	134.27	237.06	102.78	40.86	129.28	237.06	107.77	42.25	132.54	237.06	104.52	72.71	145.20	325.38	180.18	118.93
20	157.16	268.50	111.34	70.68	128.47	199.75	71.28	46.48	134.27	199.75	65.48	43.20	129.28	199.75	70.47	46.03	132.54	199.75	67.21	64.36	145.20	274.18	128.97	118.04
25	157.16	233.85	76.68	68.67	128.47	173.97	45.50	41.65	134.27	173.97	39.69	36.68	129.28	173.97	44.68	40.96	132.54	173.97	41.43	50.61	145.20	238.79	93.58	109.78
30	157.16	208.20	51.04	59.10	128.47	154.89	26.42	31.18	134.27	154.89	20.61	24.54	129.28	154.89	25.61	30.26	132.54	154.89	22.35	33.24	145.20	212.60	67.40	96.56
45	157.16	160.38	3.22	4.37	128.47	119.31	-9.15	-12.68	134.27	119.31	-14.96	-20.91	129.28	119.31	-9.97	-13.82	132.54	119.31	-13.23	-30.34	145.20	163.77	18.57	41.28
60	157.16	133.62	-23.55	-51.03	128.47	99.40	-29.07	-64.00	134.27	99.40	-34.87	-77.32	129.28	99.40	-29.88	-65.86	132.54	99.40	-33.14	-103.15	145.20	136.44	-8.76	-26.54
90	157.16	103.89	-53.27	-155.28	128.47	77.29	-51.18	-151.46	134.27	77.29	-56.99	-169.77	129.28	77.29	-52.00	-154.02	132.54	77.29	-55.25	-263.74	145.20	106.08	-39.12	-182.46

120	157.16	87.44	-69.73	-319.75	128.47	65.05	-63.42	-294.19	134.27	65.05	-69.23	-322.75	129.28	65.05	-64.23	-298.18	132.54	65.05	-67.49	-435.69	145.20	89.29	-55.92	-353.72
180	157.16	68.98	-88.19	-543.92	128.47	51.31	-77.15	-481.05	134.27	51.31	-82.96	-519.73	129.28	51.31	-77.97	-486.46	132.54	51.31	-81.23	-800.57	145.20	70.43	-74.77	-724.63
270	157.16	54.73	-102.43	-973.03	128.47	40.72	-87.75	-841.00	134.27	40.72	-93.56	-900.17	129.28	40.72	-88.57	-849.28	132.54	40.72	-91.82	-1378.32	145.20	55.89	-89.32	-1322.17
360	157.16	46.39	-110.77	-1624.53	128.47	34.51	-93.96	-1387.29	134.27	34.51	-99.76	-1477.44	129.28	34.51	-94.77	-1399.91	132.54	34.51	-98.03	-1979.85	145.20	47.37	-97.83	-1951.97
540	157.16	36.32	-120.84	-2373.32	128.47	27.02	-101.45	-2005.34	134.27	27.02	-107.25	-2126.19	129.28	27.02	-102.26	-2022.26	132.54	27.02	-105.52	-3229.67	145.20	37.09	-108.11	-3275.33
720	157.16	30.15	-127.01	-3815.31	128.47	22.43	-106.04	-3201.53	134.27	22.43	-111.84	-3384.47	129.28	22.43	-106.85	-3227.15	132.54	22.43	-110.11	-4518.98	145.20	30.79	-114.42	-4652.64
1080	157.16	22.75	-134.42	-5386.14	128.47	16.92	-111.55	-4492.40	134.27	16.92	-117.35	-4736.85	129.28	16.92	-112.36	-4526.64	132.54	16.92	-115.62	-7161.17	145.20	23.23	-121.98	-7494.17
1440	157.16	18.25	-138.91	-8459.73	128.47	13.58	-114.89	-7025.94	134.27	13.58	-120.70	-7394.61	129.28	13.58	-115.71	-7077.58	132.54	13.58	-118.96	-9854.07	145.20	18.63	-126.57	-10405.32
1800	157.16	15.13	-142.04	-11603.44	128.47	11.25	-117.21	-9611.55	134.27	11.25	-123.02	-10104.38	129.28	11.25	-118.03	-9680.58	132.54	11.25	-121.29	-12576.89	145.20	15.45	-129.76	-13357.91
2160	157.16	12.96	-144.20	-14781.86	128.47	9.64	-118.83	-12223.03	134.27	9.64	-124.63	-12840.05	129.28	9.64	-119.64	-12309.46	132.54	9.64	-122.90	-15310.31	145.20	13.23	-131.97	-16324.84
2880	157.16	10.05	-147.11	-18023.80	128.47	7.48	-120.99	-14879.19	134.27	7.48	-126.80	-15619.16	129.28	7.48	-121.81	-14982.85	132.54	7.48	-125.06	-20800.81	145.20	10.26	-134.94	-22291.36
4320	157.16	6.96	-150.20	-24419.07	128.47	5.18	-123.29	-20125.73	134.27	5.18	-129.09	-21111.68	129.28	5.18	-124.10	-20263.85	132.54	5.18	-127.36	-31820.90	145.20	7.11	-138.09	-34277.62
Volume check				ok				ok				ok				ok				ok				ok

D10

Storm Duration (mins)	41				43				44				45				46			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	133.93	619.91	485.98	-9.83	167.12	938.24	771.12	-24.73	158.50	752.76	594.26	-12.90	157.02	697.39	540.37	-9.67	160.40	741.94	581.54	-11.74
2	133.93	505.75	371.82	8.06	167.12	765.47	598.35	4.28	158.50	614.14	455.64	9.04	157.02	568.97	411.95	10.10	160.40	605.31	444.92	9.66
3	133.93	463.36	329.43	23.94	167.12	701.31	534.19	30.36	158.50	562.67	404.17	28.57	157.02	521.28	364.26	27.61	160.40	554.58	394.19	28.67
4	133.93	429.89	295.96	36.79	167.12	650.65	483.53	51.85	158.50	522.02	363.52	44.41	157.02	483.62	326.60	41.70	160.40	514.52	354.12	44.04
5	133.93	401.71	267.78	47.18	167.12	608.00	440.88	69.63	158.50	487.80	329.30	57.27	157.02	451.92	294.90	53.02	160.40	480.79	320.39	56.47
10	133.93	300.56	166.63	72.41	167.12	454.91	287.79	118.02	158.50	364.97	206.47	89.09	157.02	338.13	181.11	79.57	160.40	359.73	199.33	86.63
15	133.93	241.80	107.87	74.89	167.12	365.97	198.85	132.03	158.50	293.62	135.12	93.30	157.02	272.02	115.00	80.53	160.40	289.40	129.00	89.58
20	133.93	203.75	69.82	66.74	167.12	308.37	141.25	129.94	158.50	247.41	88.91	84.59	157.02	229.21	72.19	69.52	160.40	243.85	83.46	79.79
25	133.93	177.45	43.52	53.08	167.12	268.57	101.45	119.54	158.50	215.48	56.97	69.20	157.02	199.63	42.61	52.32	160.40	212.38	51.98	63.41
30	133.93	157.99	24.06	35.73	167.12	239.12	72.00	103.58	158.50	191.85	33.34	49.33	157.02	177.74	20.72	30.96	160.40	189.09	28.69	42.62
45	133.93	121.70	-12.23	-28.02	167.12	184.20	17.08	38.10	158.50	147.78	-10.72	-24.48	157.02	136.91	-20.11	-46.31	160.40	145.66	-14.74	-33.77
60	133.93	101.39	-32.54	-101.18	167.12	153.46	-13.66	-41.50	158.50	123.12	-35.38	-109.70	157.02	114.06	-42.96	-134.18	160.40	121.35	-39.05	-121.42
90	133.93	78.83	-55.10	-262.77	167.12	119.32	-47.81	-223.54	158.50	95.73	-62.77	-298.65	157.02	88.69	-68.33	-327.14	160.40	94.35	-66.05	-315.00
120	133.93	66.35	-67.58	-435.92	167.12	100.42	-66.70	-422.86	158.50	80.57	-77.93	-501.62	157.02	74.64	-82.38	-533.16	160.40	79.41	-80.99	-522.42
180	133.93	52.34	-81.59	-803.64	167.12	79.22	-87.90	-853.48	158.50	63.56	-94.94	-933.51	157.02	58.88	-98.14	-969.33	160.40	62.65	-97.75	-962.89
270	133.93	41.53	-92.40	-1386.23	167.12	62.86	-104.26	-1545.78	158.50	50.43	-108.07	-1618.94	157.02	46.72	-110.30	-1658.58	160.40	49.71	-110.69	-1660.70
360	133.93	35.20	-98.73	-1993.05	167.12	53.28	-113.84	-2274.41	158.50	42.75	-115.76	-2333.76	157.02	39.60	-117.42	-2375.15	160.40	42.13	-118.27	-2387.53
540	133.93	27.56	-106.37	-3254.39	167.12	41.72	-125.40	-3803.44	158.50	33.47	-125.03	-3821.28	157.02	31.01	-126.01	-3862.03	160.40	32.99	-127.41	-3898.27
720	133.93	22.88	-111.05	-4556.00	167.12	34.63	-132.49	-5393.17	158.50	27.78	-130.72	-5357.68	157.02	25.74	-131.28	-5394.24	160.40	27.38	-133.01	-5457.21
1080	133.93	17.26	-116.67	-7224.06	167.12	26.12	-141.00	-8670.42	158.50	20.96	-137.54	-8509.14	157.02	19.42	-137.60	-8531.66	160.40	20.66	-139.74	-8652.67
1440	133.93	13.85	-120.08	-9943.83	167.12	20.96	-146.16	-12025.98	158.50	16.82	-141.69	-11723.43	157.02	15.58	-141.44	-11727.27	160.40	16.57	-143.82	-11910.05
1800	133.93	11.48	-122.45	-12694.15	167.12	17.37	-149.75	-15428.09	158.50	13.94	-144.56	-14974.83	157.02	12.91	-144.11	-14957.17	160.40	13.74	-146.66	-15203.96
2160	133.93	9.83	-124.10	-15455.26	167.12	14.88	-152.24	-18846.37	158.50	11.94	-146.56	-18239.32	157.02	11.06	-145.96	-18199.25	160.40	11.77	-148.63	-18510.81
2880	133.93	7.63	-126.30	-21001.62	167.12	11.54	-155.58	-25719.62	158.50	9.26	-149.24	-24797.63	157.02	8.58	-148.44	-24710.54	160.40	9.13	-151.27	-25153.38
4320	133.93	5.28	-128.64	-32134.21	167.12	8.00	-159.12	-39526.04	158.50	6.42	-152.08	-37962.62	157.02	5.95	-151.07	-37778.04	160.40	6.33	-154.07	-38486.25
Volume check				ok				ok				ok				ok				ok

D11 E1

Storm Duration (mins)	39				40				53				54			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	181.45	888.96	707.51	-16.66	125.92	1004.55	878.63	-51.21	140.86	673.93	533.07	-11.80	134.00	612.98	478.97	-9.37
2	181.45	725.26	543.81	9.57	125.92	819.56	693.64	-17.33	140.86	549.83	408.97	7.90	134.00	500.10	366.10	8.23
3	181.45	664.47	483.03	32.96	125.92	750.88	624.95	13.60	140.86	503.75	362.89	25.44	134.00	458.18	324.18	23.85
4	181.45	616.47	435.02	52.00	125.92	696.63	570.71	39.63	140.86	467.36	326.49	39.69	134.00	425.08	291.08	36.47
5	181.45	576.06	394.61	67.51	125.92	650.97	525.04	61.68	140.86	436.72	295.86	51.26	134.00	397.22	263.22	46.65
10	181.45	431.01	249.56	106.74	125.92	487.05	361.13	128.58	140.86	326.76	185.89	80.04	134.00	297.20	163.20	71.14
15	181.45	346.74	165.30	113.36	125.92	391.83	265.91	158.68	140.86	262.87	122.01	84.11	134.00	239.09	105.09	73.15
20	181.45	292.17	110.73	104.73	125.92	330.17	204.24	171.59	140.86	221.50	80.64	76.62	134.00	201.47	67.47	64.63
25	181.45	254.46	73.02	88.21	125.92	287.55	161.63	175.65	140.86	192.91	52.05	63.14	134.00	175.46	41.46	50.67
30	181.45	226.56	45.11	66.41	125.92	256.02	130.09	173.79	140.86	171.76	30.89	45.65	134.00	156.22	22.22	33.06
45	181.45	174.52	-6.92	-15.75	125.92	197.22	71.29	149.54	140.86	132.31	-8.55	-19.52	134.00	120.34	-13.66	-31.35
60	181.45	145.40	-36.05	-111.36	125.92	164.30	38.38	110.41	140.86	110.23	-30.63	-94.90	134.00	100.26	-33.74	-105.07
90	181.45	113.05	-68.40	-324.41	125.92	127.75	1.82	8.16	140.86	85.70	-55.16	-262.23	134.00	77.95	-56.05	-267.61
120	181.45	95.15	-86.30	-553.99	125.92	107.52	-18.40	-112.17	140.86	72.13	-68.73	-442.10	134.00	65.61	-68.39	-441.60
180	181.45	75.06	-106.39	-1043.72	125.92	84.82	-41.10	-386.35	140.86	56.90	-83.96	-825.07	134.00	51.76	-82.25	-810.76
270	181.45	59.56	-121.89	-1822.62	125.92	67.30	-58.62	-846.19	140.86	45.15	-95.71	-1433.18	134.00	41.07	-92.94	-1395.20
360	181.45	50.48	-130.97	-2636.18	125.92	57.04	-68.88	-1344.31	140.86	38.27	-102.59	-2067.58	134.00	34.81	-99.19	-2003.61
540	181.45	39.52	-141.92	-4331.57	125.92	44.66	-81.26	-2416.61	140.86	29.96	-110.90	-3388.20	134.00	27.25	-106.75	-3267.62
720	181.45	32.81	-148.64	-6084.64	125.92	37.08	-88.85	-3553.46	140.86	24.87	-115.99	-4752.55	134.00	22.62	-111.38	-4571.46
1080	181.45	24.75	-156.69	-9683.64	125.92	27.97	-97.95	-5931.26	140.86	18.76	-122.10	-7551.71	134.00	17.07	-116.93	-7243.26
1440	181.45	19.86	-161.59	-13356.83	125.92	22.44	-103.48	-8392.95	140.86	15.05	-125.81	-10407.10	134.00	13.69	-120.31	-9966.21
1800	181.45	16.46	-164.98	-17073.90	125.92	18.60	-107.32	-10905.08	140.86	12.48	-128.38	-13295.74	134.00	11.35	-122.65	-12719.33
2160	181.45	14.10	-167.34	-20806.41	125.92	15.94	-109.99	-13434.22	140.86	10.69	-130.17	-16196.08	134.00	9.72	-124.28	-15483.14
2880	181.45	10.94	-170.51	-28306.08	125.92	12.36	-113.56	-18532.05	140.86	8.29	-132.57	-22023.04	134.00	7.54	-126.46	-21034.62
4320	181.45	7.58	-173.87	-43362.48	125.92	8.56	-117.36	-28791.11	140.86	5.75	-135.12	-33720.26	134.00	5.23	-128.78	-32177.02
Volume check				ok				ok				ok				ok

E2

Storage Duration (mins)	55				56				57				58			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	121.60	624.22	502.62	-13.26	141.69	610.24	468.55	-7.59	160.24	634.31	474.07	-5.57	151.08	641.72	490.64	-7.58
2	121.60	509.27	387.67	5.48	141.69	497.87	356.18	9.47	160.24	517.50	357.27	11.45	151.08	523.55	372.47	10.25
3	121.60	466.59	344.99	22.23	141.69	456.14	314.45	24.54	160.24	474.13	313.89	26.37	151.08	479.67	328.59	25.98
4	121.60	432.88	311.28	35.94	141.69	423.19	281.50	36.62	160.24	439.88	279.64	38.18	151.08	445.02	293.94	38.56
5	121.60	404.51	282.91	47.16	141.69	395.45	253.76	46.29	160.24	411.04	250.81	47.47	151.08	415.85	264.77	48.60
10	121.60	302.65	181.05	76.38	141.69	295.87	154.19	68.28	160.24	307.54	147.31	66.58	151.08	311.14	160.06	71.13
15	121.60	243.48	121.88	82.70	141.69	238.03	96.34	67.88	160.24	247.41	87.18	62.42	151.08	250.31	99.23	70.11
20	121.60	205.16	83.56	78.32	141.69	200.57	58.88	57.00	160.24	208.48	48.24	47.36	151.08	210.92	59.84	58.07
25	121.60	178.68	57.08	68.40	141.69	174.68	32.99	40.70	160.24	181.57	21.33	26.65	151.08	183.69	32.61	40.32
30	121.60	159.09	37.49	54.77	141.69	155.52	13.84	20.77	160.24	161.66	1.42	2.16	151.08	163.55	12.47	18.75
45	121.60	122.55	0.95	2.15	141.69	119.80	-21.88	-50.59	160.24	124.53	-35.71	-83.36	151.08	125.98	-25.09	-58.11
60	121.60	102.10	-19.50	-59.91	141.69	99.81	-41.88	-131.25	160.24	103.75	-56.49	-178.58	151.08	104.96	-46.12	-144.75
90	121.60	79.38	-42.22	-199.30	141.69	77.60	-64.08	-307.65	160.24	80.66	-79.57	-384.78	151.08	81.61	-69.47	-333.92
120	121.60	66.81	-54.79	-350.25	141.69	65.32	-76.37	-495.50	160.24	67.89	-92.34	-602.97	151.08	68.68	-82.39	-535.15
180	121.60	52.71	-68.89	-673.57	141.69	51.53	-90.16	-892.38	160.24	53.56	-106.68	-1061.46	151.08	54.18	-96.90	-959.87
270	121.60	41.82	-79.78	-1189.57	141.69	40.88	-100.80	-1518.37	160.24	42.50	-117.74	-1781.28	151.08	42.99	-108.09	-1629.26
360	121.60	35.45	-86.15	-1729.84	141.69	34.65	-107.03	-2168.31	160.24	36.02	-124.22	-2526.10	151.08	36.44	-114.64	-2323.84
540	121.60	27.75	-93.84	-2858.26	141.69	27.13	-114.56	-3515.25	160.24	28.20	-132.03	-4064.78	151.08	28.53	-122.55	-3762.52
720	121.60	23.04	-98.56	-4027.14	141.69	22.52	-119.17	-4901.88	160.24	23.41	-136.82	-5644.81	151.08	23.68	-127.39	-5242.96
1080	121.60	17.38	-104.22	-6430.06	141.69	16.99	-124.70	-7739.07	160.24	17.66	-142.57	-8871.40	151.08	17.87	-133.21	-8271.07
1440	121.60	13.94	-107.65	-8885.08	141.69	13.63	-128.06	-10627.16	160.24	14.17	-146.07	-12150.89	151.08	14.34	-136.74	-11352.71
1800	121.60	11.56	-110.04	-11370.96	141.69	11.30	-130.39	-13545.23	160.24	11.75	-148.49	-15461.44	151.08	11.88	-139.19	-14465.85
2160	121.60	9.90	-111.70	-13867.66	141.69	9.68	-132.01	-16473.97	160.24	10.06	-150.17	-18783.14	151.08	10.18	-140.90	-17590.22
2880	121.60	7.68	-113.92	-18885.41	141.69	7.51	-134.18	-22355.18	160.24	7.80	-152.43	-25451.15	151.08	7.89	-143.18	-23863.92
4320	121.60	5.32	-116.28	-28960.91	141.69	5.20	-136.49	-34156.95	160.24	5.41	-154.83	-38828.21	151.08	5.47	-145.61	-36452.71
Volume check				ok				ok				ok				ok

1 YEAR ARI 1 HOUR FLOWS - ROADS

Rainfall Intensity i (mm/h)	15.1	(1yr, 1hr Storm)
Runoff Coefficient Road Reserves	0.8	
Runoff Coefficient Swale	1	
Runoff Coefficient Lots	0	
Runoff Coefficient OS	0	
Permeability k (m/hr)	**0.0417**	
Swale Depth (m)	0.50	
Weir Height (m)	0.40	
Driveway Width (m)	10.0	
Swale Side Slope (1/x)	3.00	
Trapezoidal Swale Base Width (m)	1.00	
Swale top width (m)	4.00	

Segment	Road Reserve (m2)	Swale Length (m)	Swale Area (m2)	Lots (m2)	POS (m2)	Ai	Segment Peak Flow (L/s)	Segment 1 hr Flow (m3)
A1	5630					4504	19	68.1
A2	10573					8458	36	127.8
A3	7253					5802	24	87.7
A4	7494					5995	25	90.6
A5	2715					2172	9	32.8
B1	6454					5163	22	78.0
B2	6669					5335	22	80.6
C1	2968					2374	10	35.9
D1	11939					9551	40	144.3
D2	16225					12980	54	196.2
D3	11446					9157	38	138.4
D4	9025					7220	30	109.1
D5	4678					3742	16	56.6
D6	7843					6274	26	94.8
D7	3738					2990	13	45.2
D8	5120					4096	17	61.9
D9	6854					5483	23	82.9
E1	7788					6230	26	94.2
E2	5015					4012	17	60.6
E3	6372					5098	21	77.0

Trapezoidal Swales

Swale Segment	No. Driveways	No. Weirs	Length	Weir Spacing (m)	Long Slope	Max U/S Reach (m)	Upstream Ht (m)	1 hr Inflow per Weir (m3)	Storage per Weir (m3)	Total Storage (m3)	Effective Storage per Weir (m3)	Effective Total Storage (m3)	Volume Check
A1	0	4	227	57	0.0054	56.8	0.1	17.02	25.06	100.22	30.22	120.88	ok
A2	0	23	513	22	0.0202	19.8	0.0	5.56	5.81	133.60	7.10	163.36	ok
A3	1	7	118	17	0.0021	15.3	0.4	12.53	12.65	88.53	14.46	101.22	ok
A4	9	17	734	43	0.0221	18.1	0.0	5.33	5.31	90.26	6.49	110.36	ok
A5	2	14	233	17	0.0522	7.7	0.0	2.34	2.25	31.47	2.75	38.48	ok
B1	1	5	281	56	0.0063	54.2	0.1	15.61	21.59	107.94	26.03	130.17	ok
B2	0	14	281	20	0.0204	19.6	0.0	5.76	5.75	80.52	7.03	98.46	ok
C1	0	1	139	139	0.0033	121.2	0.0	35.88	35.56	35.56	43.48	43.48	ok
D1	0	14	452	32	0.0122	32.3	0.0	10.31	10.33	144.68	12.49	174.89	ok
D2	2	33	518	16	0.0223	15.1	0.1	5.94	6.10	201.43	7.37	243.11	ok
D3	4	10	335	34	0.0091	29.5	0.1	13.84	14.41	144.09	17.21	172.06	ok
D4	1	56	490	9	0.0631	6.3	0.0	1.95	1.86	104.13	2.27	127.33	ok
D5	2	15	659	44	0.0321	12.5	0.0	3.77	3.66	54.83	4.47	67.04	ok
D6	3	39	492	13	0.0504	7.9	0.0	2.43	2.33	90.79	2.85	111.02	ok
D7	2	8	143	18	0.0211	15.4	0.1	5.65	6.45	51.59	7.80	62.42	ok
D8	1	15	238	16	0.0294	13.6	0.0	4.13	3.99	59.86	4.88	73.20	ok
D9	2	1	314	314	0.0003	294.0	0.3	82.86	216.79	216.79	249.97	249.97	ok
E1	3	16	471	29	0.0205	19.5	0.0	5.88	5.72	91.58	7.00	111.98	ok
E2	0	14	260	19	0.0282	14.2	0.0	4.33	4.16	58.25	5.09	71.23	ok
E3	0	11	294	27	0.0162	24.7	0.0	7.00	7.24	79.67	8.86	97.42	ok

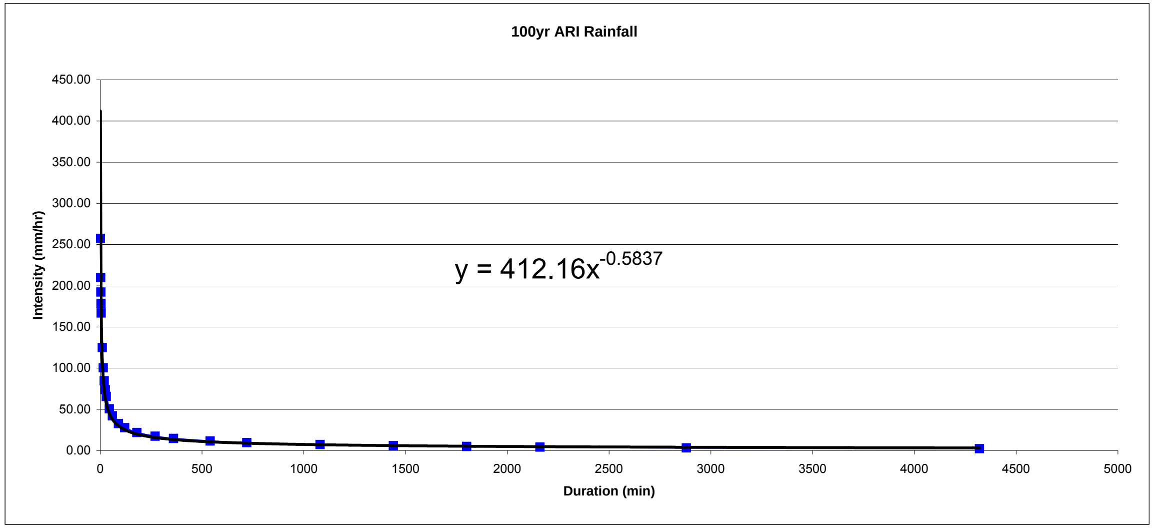
100 YEAR ARI DRAINAGE PROPERTIES - ROADS

CATCHMENT	AREAS (m2)					EFFECTIVE AREAS (m2)		TIME OF CONCENTRATION PRE DEVELOPMENT					TIME OF CONCENTRATION POST-DEVELOPMENT					CRITICAL STORM INTENSITY (mm/h)	
	Road Reserve (m2)	Swale	Lots (m2)	POS (m2)	Total	Pre	Post	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (mIn)	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope	TC (mIn)	Pre-Dev	Post-Dev
A1	5630		0	0	5630	1971	4786	225	60.5	59	6.67	16.6	225	60.5	59	6.67	15.2	79.8	84.1
A2	10573		0	0	10573	3701	8987	522	70.2	59.4	20.69	28.9	522	70.2	59.4	20.69	26.5	57.8	60.9
A3	7253		0	0	7253	2539	6165	144	69.8	69	5.56	10.8	144	69.8	69	5.56	9.9	102.9	108.4
A4	7494		0	0	7494	2623	6370	367	78	70	21.80	20.8	367	78	70	21.80	19.1	70.1	73.8
A5	2715		0	0	2715	950	2308	129	85	78	54.26	6.8	129	85	78	54.26	6.2	135.2	142.4
B1	6454		0	0	6454	2259	5486	303	66	65	3.30	25.5	303	66	65	3.30	23.3	62.3	65.6
B2	6669		0	0	6669	2334	5669	294	67	60.8	21.09	17.0	294	67	60.8	21.09	15.5	78.9	83.1
C1	2968		0	0	2968	1039	2523	148	61.3	60.2	7.43	11.4	148	61.3	60.2	7.43	10.5	99.5	104.7
D1	11939		0	0	11939	4179	10148	236	69.8	66	16.10	13.6	236	69.8	66	16.10	12.4	89.9	94.7
D2	16225		0	0	16225	5679	13791	319	66.8	59.3	23.51	16.5	319	66.8	59.3	23.51	15.1	80.2	84.5
D3	11446		0	1	11447	4006	9729	382	71.5	66.4	13.35	22.9	382	71.5	66.4	13.35	21.0	66.2	69.8
D4	9025		0	2	9027	3159	7671	286	86	73	45.45	13.8	286	86	73	45.45	12.6	89.3	94.0
D5	4678		0	0	4678	1637	3976	243	93	88	20.58	14.6	243	93	88	20.58	13.4	86.1	90.7
D6	7843		0	0	7843	2745	6667	263	87	72	57.03	12.3	263	87	72	57.03	11.2	95.5	100.5
D7	3738		0	0	3738	1308	3177	133	73	70.3	20.30	8.2	133	73	70.3	20.30	7.5	120.6	127.1
D8	5120		0	0	5120	1792	4352	251	70	62	31.87	13.7	251	70	62	31.87	12.5	89.4	94.2
D9	6854		0	0	6854	2399	5826	316	61.7	61.3	1.27	32.0	316	61.7	61.3	1.27	29.2	54.6	57.5
E1	7788		0	0	7788	2726	6620	273	86	81.5	16.48	16.3	273	86	81.5	16.48	14.9	80.8	85.1
E2	5015		0	0	5015	1755	4263	260	89	81.5	28.85	14.5	260	89	81.5	28.85	13.3	86.5	91.1
E3	6372		0	0	6372	2230	5416	319	93	89	12.54	20.5	319	93	89	12.54	18.8	70.6	74.4

Runoff Coefficients	Pre-Dev	Post-Dev
Roads	0.35	0.85
Swales/Basins	0.35	0
Lots	0.35	0
OS	0.35	0

Rainfall IFD

Event	Duration (mins)	Intensity (mm/hr)
1 min	1	257.40
2 min	2	210.00
3 min	3	192.40
4 min	4	178.50
5 min	5	166.80
10 min	10	124.80
15 min	15	100.40
20 min	20	84.60
25 min	25	73.68
30 min	30	65.60
45 min	45	50.53
1 hr	60	42.10
1.5 hr	90	32.73
2 hr	120	27.55
3 hr	180	21.73
4.5 hr	270	17.24
6 hr	360	14.62
9 hr	540	11.44
12 hr	720	9.50
18 hr	1080	7.17
24 hr	1440	5.75
30 hr	1800	4.77
36 hr	2160	4.08
48 hr	2880	3.17
72 hr	4320	2.19



100 YEAR ARI FLOWS - ROADS

Storm Duration (mins)	A1 Pre-Dev Flow (l/s)	A1 Post-Dev Flow (l/s)	A1 Excess Flow (l/s)	A1 Storage (m3)	A2 Pre-Dev Flow (l/s)	A2 Post-Dev Flow (l/s)	A2 Excess Flow (l/s)	A2 Storage (m3)
1	43.69	342.16	298.47	-16.93	59.45	642.57	583.12	-50.67
2	43.69	279.15	235.46	-5.43	59.45	524.24	464.79	-27.91
3	43.69	255.76	212.06	5.05	59.45	480.31	420.85	-6.95
4	43.69	237.28	193.59	13.88	59.45	445.61	386.15	10.88
5	43.69	221.73	178.03	21.34	59.45	416.40	356.95	26.17
10	43.69	165.90	122.20	43.90	59.45	311.55	252.10	74.88
15	43.69	133.46	89.77	53.93	59.45	250.64	191.19	100.07
20	43.69	112.46	68.76	58.10	59.45	211.20	151.74	114.28
25	43.69	97.94	54.25	59.25	59.45	183.93	124.48	122.84
30	43.69	87.20	43.51	58.39	59.45	163.76	104.31	127.64
45	43.69	67.17	23.48	49.44	59.45	126.15	66.70	130.18
60	43.69	55.96	12.27	35.41	59.45	105.10	45.65	123.33
90	43.69	43.51	-0.18	-0.81	59.45	81.72	22.26	94.50
120	43.69	36.62	-7.07	-43.21	59.45	68.78	9.32	54.33
180	43.69	28.89	-14.80	-139.42	59.45	54.26	-5.20	-47.09
270	43.69	22.92	-20.77	-300.30	59.45	43.05	-16.40	-229.78
360	43.69	19.43	-24.26	-474.23	59.45	36.49	-22.96	-436.62
540	43.69	15.21	-28.48	-848.02	59.45	28.57	-30.88	-898.58
720	43.69	12.63	-31.07	-1243.80	59.45	23.72	-35.74	-1401.61
1080	43.69	9.53	-34.17	-2070.82	59.45	17.89	-41.56	-2473.95
1440	43.69	7.64	-36.05	-2926.41	59.45	14.35	-45.10	-3599.97
1800	43.69	6.34	-37.36	-3799.18	59.45	11.90	-47.55	-4758.57
2160	43.69	5.43	-38.27	-4677.75	59.45	10.19	-49.26	-5927.89
2880	43.69	4.21	-39.48	-6448.35	59.45	7.91	-51.55	-8291.97
4320	43.69	2.92	-40.78	-10011.15	59.45	5.48	-53.97	-13060.29
Volume check				ok				ok

Storm Duration (mins)	A3 Pre-Dev Flow (l/s)	A3 Post-Dev Flow (l/s)	A3 Excess Flow (l/s)	A3 Storage (m3)	A4 Pre-Dev Flow (l/s)	A4 Post-Dev Flow (l/s)	A4 Excess Flow (l/s)	A4 Storage (m3)
1	72.57	440.80	368.23	-13.77	51.04	455.45	404.41	-27.55
2	72.57	359.63	287.06	0.18	51.04	371.58	320.54	-11.87
3	72.57	329.49	256.92	12.77	51.04	340.44	289.39	2.49
4	72.57	305.68	233.12	23.21	51.04	315.84	264.80	14.63
5	72.57	285.65	213.08	31.90	51.04	295.14	244.10	24.97
10	72.57	213.72	141.15	56.34	51.04	220.82	169.78	57.00
15	72.57	171.94	99.37	64.62	51.04	177.65	126.61	72.36
20	72.57	144.88	72.31	65.35	51.04	149.69	98.65	79.93
25	72.57	126.18	53.61	62.18	51.04	130.37	79.33	83.49
30	72.57	112.34	39.77	56.39	51.04	116.07	65.03	84.37
45	72.57	86.54	13.97	30.79	51.04	89.41	38.37	78.57
60	72.57	72.10	-0.47	-1.42	51.04	74.49	23.45	66.05
90	72.57	56.06	-16.51	-76.52	51.04	57.92	6.88	30.21
120	72.57	47.18	-25.39	-159.69	51.04	48.75	-2.29	-13.77
180	72.57	37.22	-35.35	-341.00	51.04	38.46	-12.59	-116.83
270	72.57	29.53	-43.04	-634.63	51.04	30.51	-20.53	-293.30
360	72.57	25.03	-47.54	-945.27	51.04	25.86	-25.18	-487.04
540	72.57	19.60	-52.97	-1600.18	51.04	20.25	-30.79	-908.90
720	72.57	16.27	-56.30	-2283.57	51.04	16.81	-34.23	-1359.97
1080	72.57	12.27	-60.29	-3696.21	51.04	12.68	-38.36	-2309.21
1440	72.57	9.85	-62.72	-5145.66	51.04	10.17	-40.87	-3296.50
1800	72.57	8.16	-64.41	-6617.04	51.04	8.43	-42.61	-4306.74
2160	72.57	6.99	-65.58	-8095.98	51.04	7.23	-43.82	-5324.65
2880	72.57	5.42	-67.15	-11071.13	51.04	5.60	-45.44	-7378.44
4320	72.57	3.76	-68.81	-17049.51	51.04	3.88	-47.16	-11514.65
Volume check				ok				ok

Storm Duration (mins)	A5 Pre-Dev Flow (l/s)	A5 Post-Dev Flow (l/s)	A5 Excess Flow (l/s)	A5 Storage (m3)
1	35.69	165.00	129.32	-2.61
2	35.69	134.62	98.93	2.15
3	35.69	123.34	87.65	6.38
4	35.69	114.43	78.74	9.80
5	35.69	106.93	71.24	12.56
10	35.69	80.00	44.31	19.26
15	35.69	64.36	28.67	19.91
20	35.69	54.23	18.54	17.73
25	35.69	47.23	11.54	14.08
30	35.69	42.05	6.36	9.45
45	35.69	32.39	-3.29	-7.55
60	35.69	26.99	-8.70	-27.06
90	35.69	20.98	-14.70	-70.13
120	35.69	17.66	-18.03	-116.29
180	35.69	13.93	-21.76	-214.31
270	35.69	11.05	-24.63	-369.59
360	35.69	9.37	-26.32	-531.31
540	35.69	7.34	-28.35	-867.47
720	35.69	6.09	-29.60	-1214.34
1080	35.69	4.59	-31.09	-1925.35
1440	35.69	3.69	-32.00	-2650.12
1800	35.69	3.06	-32.63	-3383.02
2160	35.69	2.62	-33.07	-4118.79
2880	35.69	2.03	-33.66	-5596.76
4320	35.69	1.41	-34.28	-8563.32
Volume check				ok

Storm Duration (mins)	B1 Pre-Dev Flow (l/s)	B1 Post-Dev Flow (l/s)	B1 Excess Flow (l/s)	B1 Storage (m3)	B2 Pre-Dev Flow (l/s)	B2 Post-Dev Flow (l/s)	B2 Excess Flow (l/s)	B2 Storage (m3)	C1 Pre-Dev Flow (l/s)	C1 Post-Dev Flow (l/s)	C1 Excess Flow (l/s)	C1 Storage (m3)
1	85.90	392.24	306.35	-75.38	51.15	405.31	354.16	-20.44	28.70	180.38	151.68	-6.04
2	39.09	320.01	280.92	-14.25	51.15	330.67	279.52	-6.79	28.70	147.16	118.47	-0.27
3	39.09	293.19	254.10	-1.62	51.15	302.96	251.81	5.67	28.70	134.83	106.13	4.93
4	39.09	272.01	232.91	9.11	51.15	281.07	229.92	16.15	28.70	125.09	96.39	9.26
5	39.09	254.18	215.09	18.29	51.15	262.65	211.50	25.03	28.70	116.89	88.19	12.88
10	39.09	190.18	151.08	47.24	51.15	196.51	145.36	51.93	28.70	87.46	58.76	23.16
15	39.09	153.00	113.90	61.83	51.15	158.09	106.94	63.97	28.70	70.36	41.66	26.84
20	39.09	128.92	89.82	69.72	51.15	133.21	82.06	69.08	28.70	59.29	30.59	27.42
25	39.09	112.28	73.18	74.16	51.15	116.02	64.87	70.63	28.70	51.63	22.94	26.41
30	39.09	99.97	60.87	76.30	51.15	103.30	52.14	69.78	28.70	45.97	17.27	24.33
45	39.09	77.01	37.91	75.46	51.15	79.57	28.42	59.69	28.70	35.41	6.71	14.72
60	39.09	64.15	25.06	68.87	51.15	66.29	15.14	43.61	28.70	29.50	0.80	2.41
90	39.09	49.88	10.79	46.43	51.15	51.54	0.39	1.75	28.70	22.94	-5.76	-26.58
120	39.09	41.98	2.89	17.04	51.15	43.38	-7.77	-47.40	28.70	19.31	-9.39	-58.86
180	39.09	33.12	-5.98	-54.68	51.15	34.22	-16.93	-159.23	28.70	15.23	-13.47	-129.53
270	39.09	26.28	-12.82	-180.97	51.15	27.15	-24.00	-346.59	28.70	12.08	-16.61	-244.39
360	39.09	22.27	-16.82	-322.06	51.15	23.02	-28.13	-549.39	28.70	10.24	-18.45	-366.20
540	39.09	17.44	-21.65	-633.76	51.15	18.02	-33.13	-985.70	28.70	8.02	-20.68	-623.56
720	39.09	14.48	-24.62	-970.57	51.15	14.96	-36.19	-1448.05	28.70	6.66	-22.04	-892.56
1080	39.09	10.92	-28.17	-1684.67	51.15	11.28	-39.87	-2414.76	28.70	5.02	-23.68	-1449.33
1440	39.09	8.76	-30.33	-2431.55	51.15	9.05	-42.10	-3415.31	28.70	4.03	-24.67	-2021.16
1800	39.09	7.26	-31.83	-3198.26	51.15	7.51	-43.64	-4436.22	28.70	3.34	-25.36	-2601.98
2160	39.09	6.22	-32.87	-3971.54	51.15	6.43	-44.72	-5463.99	28.70	2.86	-25.84	-3185.88

2880	39.09	4.83	-34.27	-5533.61	51.15	4.99	-46.16	-7535.48	28.70	2.22	-26.48	-4360.77
4320	39.09	3.34	-35.75	-8682.33	51.15	3.46	-47.70	-11704.05	28.70	1.54	-27.16	-6722.00
Volume check				ok				ok				ok

Storm Duration (mins)	D1				D2				D3			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	104.36	725.59	621.23	-29.34	126.57	986.07	859.50	-48.39	73.73	695.63	621.90	-45.61
2	104.36	591.98	487.61	-5.58	126.57	804.49	677.92	-15.29	73.73	567.53	493.80	-21.45
3	104.36	542.36	438.00	16.00	126.57	737.07	610.49	14.90	73.73	519.97	446.24	0.72
4	104.36	503.18	398.82	34.05	126.57	683.82	557.24	40.28	73.73	482.40	408.67	19.50
5	104.36	470.20	365.83	49.21	126.57	638.99	512.42	61.76	73.73	450.78	377.05	35.53
10	104.36	351.80	247.44	93.74	126.57	478.10	351.52	126.59	73.73	337.28	263.55	85.65
15	104.36	283.02	178.66	111.67	126.57	384.62	258.05	155.30	73.73	271.33	197.61	110.29
20	104.36	238.48	134.12	117.18	126.57	324.09	197.52	167.13	73.73	228.63	154.91	123.04
25	104.36	207.70	103.34	116.29	126.57	282.26	155.69	170.28	73.73	199.12	125.40	129.68
30	104.36	184.92	80.56	111.11	126.57	251.31	124.73	167.60	73.73	177.29	103.56	132.22
45	104.36	142.45	38.09	82.03	126.57	193.59	67.02	141.24	73.73	136.57	62.84	126.99
60	104.36	118.68	14.31	42.14	126.57	161.28	34.71	100.27	73.73	113.78	40.05	111.53
90	104.36	92.27	-12.09	-55.09	126.57	125.40	-1.17	-5.27	73.73	88.46	14.74	64.12
120	104.36	77.66	-26.70	-165.50	126.57	105.54	-21.03	-128.57	73.73	74.45	0.73	4.33
180	104.36	61.26	-43.10	-410.73	126.57	83.26	-43.31	-408.13	73.73	58.73	-14.99	-138.23
270	104.36	48.61	-55.75	-813.95	126.57	66.06	-60.51	-875.22	73.73	46.60	-27.12	-385.41
360	104.36	41.20	-63.16	-1244.98	126.57	56.00	-70.58	-1379.92	73.73	39.50	-34.22	-658.89
540	104.36	32.26	-72.10	-2162.21	126.57	43.84	-82.73	-2464.04	73.73	30.93	-42.80	-1258.29
720	104.36	26.78	-77.58	-3126.19	126.57	36.39	-90.18	-3611.55	73.73	25.67	-48.05	-1902.26
1080	104.36	20.20	-84.16	-5129.49	126.57	27.45	-99.12	-6008.78	73.73	19.37	-54.36	-3262.09
1440	104.36	16.21	-88.15	-7193.37	126.57	22.03	-104.54	-8488.36	73.73	15.54	-58.19	-4680.03
1800	104.36	13.44	-90.93	-9293.53	126.57	18.26	-108.31	-11017.43	73.73	12.88	-60.84	-6133.09
2160	104.36	11.51	-92.85	-11406.05	126.57	15.64	-110.93	-13563.20	73.73	11.04	-62.69	-7597.83
2880	104.36	8.93	-95.44	-15659.59	126.57	12.13	-114.44	-18693.55	73.73	8.56	-65.17	-10554.78
4320	104.36	6.19	-98.18	-24212.67	126.57	8.41	-118.17	-29016.53	73.73	5.93	-67.80	-16512.35
Volume check				ok				ok				ok

Storm Duration (mins)	D4				D5				D6			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	78.33	548.49	470.16	-22.48	39.17	284.31	245.14	-12.40	72.79	476.66	403.87	-17.27
2	78.33	447.49	369.16	-4.49	39.17	231.95	192.78	-3.00	72.79	388.88	316.09	-1.88
3	78.33	409.99	331.65	11.86	39.17	212.51	173.34	5.56	72.79	356.29	283.50	12.06
4	78.33	380.37	302.03	25.53	39.17	197.16	157.99	12.72	72.79	330.55	257.76	23.67
5	78.33	355.43	277.10	37.02	39.17	184.24	145.07	18.76	72.79	308.88	236.09	33.39
10	78.33	265.94	187.60	70.84	39.17	137.85	98.68	36.70	72.79	231.11	158.32	61.44
15	78.33	213.94	135.61	84.56	39.17	110.89	71.73	44.22	72.79	185.92	113.13	72.02
20	78.33	180.27	101.94	88.89	39.17	93.44	54.28	46.87	72.79	156.66	83.87	74.43
25	78.33	157.00	78.67	88.38	39.17	81.38	42.22	47.01	72.79	136.44	63.65	72.63
30	78.33	139.79	61.46	84.62	39.17	72.46	33.29	45.48	72.79	121.48	48.69	68.01
45	78.33	107.68	29.35	63.12	39.17	55.82	16.65	35.57	72.79	93.58	20.79	45.25
60	78.33	89.71	11.38	33.46	39.17	46.50	7.33	21.45	72.79	77.96	5.17	15.37
90	78.33	69.75	-8.58	-39.06	39.17	36.15	-3.01	-13.64	72.79	60.62	-12.17	-55.90
120	78.33	58.71	-19.63	-121.53	39.17	30.43	-8.74	-53.88	72.79	51.02	-21.77	-135.86
180	78.33	46.31	-32.02	-304.93	39.17	24.01	-15.16	-143.88	72.79	40.25	-32.54	-311.87
270	78.33	36.75	-41.59	-606.76	39.17	19.05	-20.12	-292.72	72.79	31.93	-40.86	-599.21
360	78.33	31.15	-47.19	-929.61	39.17	16.14	-23.02	-452.44	72.79	27.07	-45.72	-904.88
540	78.33	24.39	-53.94	-1617.00	39.17	12.64	-26.53	-793.45	72.79	21.19	-51.60	-1552.50
720	78.33	20.24	-58.09	-2339.72	39.17	10.49	-28.67	-1152.77	72.79	17.59	-55.20	-2230.87
1080	78.33	15.27	-63.06	-3842.11	39.17	7.92	-31.25	-1900.91	72.79	13.27	-59.52	-3637.16
1440	78.33	12.25	-66.08	-5390.30	39.17	6.35	-32.82	-2672.78	72.79	10.65	-62.14	-5083.24
1800	78.33	10.16	-68.17	-6965.92	39.17	5.26	-33.90	-3458.89	72.79	8.83	-63.96	-6553.11
2160	78.33	8.70	-69.63	-8550.88	39.17	4.51	-34.66	-4249.84	72.79	7.56	-65.23	-8031.12
2880	78.33	6.75	-71.58	-11742.35	39.17	3.50	-35.67	-5842.90	72.79	5.86	-66.93	-11005.84
4320	78.33	4.68	-73.66	-18160.05	39.17	2.42	-36.74	-9047.03	72.79	4.06	-68.73	-16985.56
Volume check				ok				ok				ok

D1

Storm Duration (mins)	D7				D8				D9			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	43.84	227.18	0.00	-4.94	44.50	311.17	266.67	-12.71	36.35	416.55	380.20	-35.41
2	43.84	185.34	0.00	1.90	44.50	253.87	209.36	-2.51	36.35	339.84	303.49	-20.55
3	43.84	169.81	0.00	8.02	44.50	232.59	188.09	6.76	36.35	311.36	275.01	-6.84
4	43.84	157.54	0.00	13.03	44.50	215.79	171.28	14.51	36.35	288.87	252.52	4.84
5	43.84	147.21	0.00	17.14	44.50	201.64	157.14	21.03	36.35	269.93	233.58	14.87
10	43.84	110.15	0.00	27.89	44.50	150.87	106.37	40.20	36.35	201.96	165.61	47.06
15	43.84	88.61	0.00	30.31	44.50	121.37	76.87	47.96	36.35	162.48	126.13	63.99
20	43.84	74.67	0.00	28.83	44.50	102.27	57.77	50.40	36.35	136.91	100.56	73.81
25	43.84	65.03	0.00	25.34	44.50	89.07	44.57	50.09	36.35	119.24	82.89	79.98
30	43.84	57.90	0.00	20.50	44.50	79.30	34.80	47.94	36.35	106.16	69.81	83.71
45	43.84	44.60	0.00	1.71	44.50	61.09	16.59	35.69	36.35	81.78	45.43	87.22
60	43.84	37.16	0.00	-20.52	44.50	50.89	6.39	18.80	36.35	68.13	31.78	84.65
90	43.84	28.89	0.00	-70.53	44.50	39.57	-4.93	-22.46	36.35	52.97	16.62	69.74
120	43.84	24.32	0.00	-124.74	44.50	33.30	-11.20	-69.36	36.35	44.58	8.23	47.50
180	43.84	19.18	0.00	-240.95	44.50	26.27	-18.23	-173.63	36.35	35.17	-1.18	-10.60
270	43.84	15.22	0.00	-426.56	44.50	20.85	-23.66	-345.21	36.35	27.91	-8.44	-117.49
360	43.84	12.90	0.00	-620.99	44.50	17.67	-26.83	-528.71	36.35	23.65	-12.70	-240.01
540	43.84	10.10	0.00	-1027.28	44.50	13.84	-30.67	-919.36	36.35	18.52	-17.83	-516.29
720	43.84	8.38	0.00	-1448.30	44.50	11.48	-33.02	-1330.06	36.35	15.37	-20.98	-819.17
1080	43.84	6.33	0.00	-2314.03	44.50	8.66	-35.84	-2183.77	36.35	11.60	-24.75	-1467.86

Storm Duration (mins)	E1				E2				E3			
	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)	Pre-Dev Flow (l/s)	Post-Dev Flow (l/s)	Excess Flow (l/s)	Storage (m3)
1	61.16	473.32	412.16	-22.98	42.16	304.79	262.63	-13.20	43.74	387.26	343.52	-23.16
2	61.16	386.16	325.00	-7.11	42.16	248.66	206.50	-3.13	43.74	315.95	272.21	-9.85
3	61.16	353.79	292.63	7.36	42.16	227.82	185.66	6.03	43.74	289.47	245.73	2.34
4	61.16	328.23	267.07	19.52	42.16	211.36	169.20	13.70	43.74	268.55	224.81	12.65
5	61.16	306.72	245.56	29.80	42.16	197.51	155.35	20.17	43.74	250.95	207.21	21.42
10	61.16	229.49	168.33	60.81	42.16	147.78	105.62	39.35	43.74	187.76	144.02	48.57
15	61.16	184.62	123.46	74.48	42.16	118.88	76.73	47.36	43.74	151.05	107.31	61.53
20	61.16	155.57	94.41	80.04	42.16	100.17	58.02	50.16	43.74	127.28	83.54	67.86
25	61.16	135.49	74.33	81.44	42.16	87.24	45.09	50.26	43.74	110.85	67.11	70.80
30	61.16	120.63	59.47	80.04	42.16	77.68	35.52	48.57	43.74	98.70	54.96	71.45
45	61.16	92.92	31.77	67.04	42.16	59.84	17.68	37.80	43.74	76.03	32.29	66.22
60	61.16	77.41	16.26	47.02	42.16	49.85	7.69	22.51	43.74	63.34	19.60	55.29
90	61.16	60.19	-0.97	-4.34	42.16	38.76	-3.40	-15.40	43.74	49.25	5.51	24.23
120	61.16	50.66	-10.50	-64.23	42.16	32.62	-9.54	-58.83	43.74	41.45	-2.29	-13.76
180	61.16	39.96	-21.19	-199.83	42.16	25.73	-16.42	-155.92	43.74	32.70	-11.04	-102.58
270	61.16	31.71	-29.45	-426.16	42.16	20.42	-21.74	-316.38	43.74	25.94	-17.79	-254.43
360	61.16	26.88	-34.28	-670.55	42.16	17.31	-24.85	-488.50	43.74	21.99	-21.75	-420.96
540	61.16	21.04	-40.11	-1195.21	42.16	13.55	-28.61	-855.89	43.74	17.22	-26.52	-783.27
720	61.16	17.47	-43.69	-1750.29	42.16	11.25	-30.91	-1242.90	43.74	14.29	-29.45	-1170.41
1080	61.16	13.18	-47.98	-2909.53	42.16	8.49	-33.67	-2048.54	43.74	10.78	-32.96	-1984.77

1440	43.84	5.07	0.00	-3198.72	44.50	6.95	-37.55	-3063.45	36.35	9.31	-27.05	-2151.35	61.16	10.57	-50.58	-4108.30	42.16	6.81	-35.35	-2879.64	43.74	8.65	-35.09	-2831.46
1800	43.84	4.21	0.00	-4094.66	44.50	5.76	-38.74	-3958.70	36.35	7.71	-28.64	-2855.99	61.16	8.77	-52.39	-5330.81	42.16	5.64	-36.51	-3726.00	43.74	7.17	-36.57	-3697.68
2160	43.84	3.60	0.00	-4994.52	44.50	4.94	-39.57	-4859.25	36.35	6.61	-29.74	-3567.56	61.16	7.51	-53.65	-6561.34	42.16	4.84	-37.32	-4577.53	43.74	6.14	-37.60	-4570.41
2880	43.84	2.79	0.00	-6803.12	44.50	3.83	-40.67	-6672.56	36.35	5.12	-31.23	-5007.22	61.16	5.82	-55.33	-9041.04	42.16	3.75	-38.41	-6292.59	43.74	4.76	-38.97	-6331.15
4320	43.84	1.94	0.00	-10434.86	44.50	2.65	-41.85	-10318.92	36.35	3.55	-32.80	-7912.52	61.16	4.04	-57.12	-14030.33	42.16	2.60	-39.56	-9742.00	43.74	3.30	-40.44	-9876.99
Volume check				ok				ok				ok				ok				ok				ok

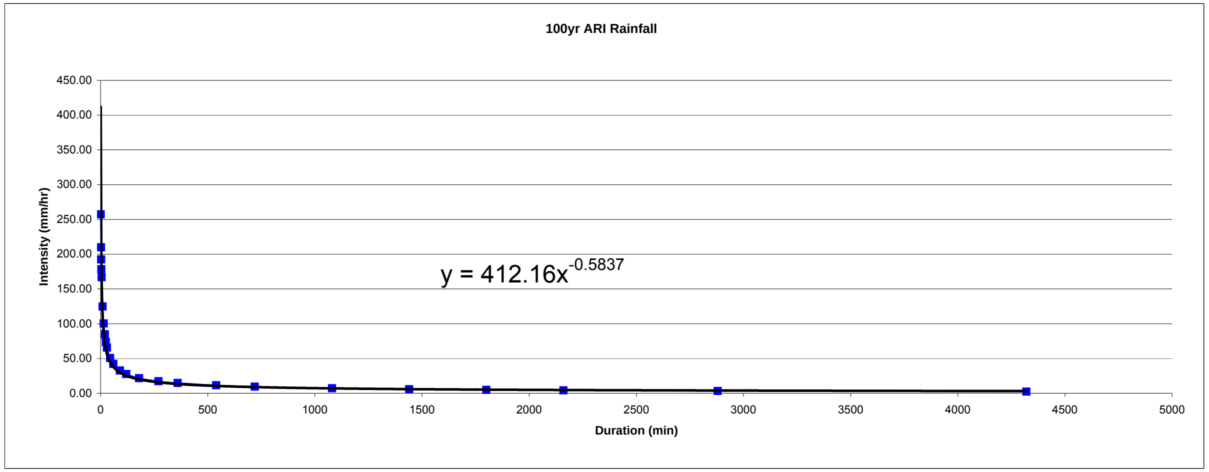
COMBINED 100 YEAR ARI DRAINAGE PROPERTIES

CATCHMENT			CUMULATIVE EFFECTIVE AREAS (m2)		TIME OF CONCENTRATION POST-DEVELOPMENT					CRITICAL STORM INTENSITY (mm/h)
	Contibuting Segments	Contributing Lots	Road	Lots	Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope	TC (mIn)	Post-Dev
A1	A1,C1	2,3	7308	17000	378	61.3	59	6.08	25.0	63.0
A2	A2-A5	1,6,13-18,23N,24N	23830	69894	1162	85	59.4	22.03	52.8	40.7
A3	A3-A5	13-18,23N,24N	14843	61334	640	85	69	25.00	29.7	56.9
A4	A4,A5	14-18,23N,24N	8678	52304	496	85	70	30.24	23.4	65.5
A5	A5	18,24N	2308	14326	129	85	78	54.26	6.2	142.4
B1	B1	7-10	5486	34180	303	66	65	3.30	23.3	65.6
B2	B1,B2	7-10	11155	34180	458	66	60.8	11.35	25.6	62.1
C1	C1	4	2523	20593	148	61.3	60.2	7.43	10.5	104.7
D1	D1	19-22,23S,31	10148	18863	236	69.8	66	16.10	12.4	94.7
D2	D1-D7	11,12,19-22,23S,24S,25-32,47-52	55160	48914	1282	93	59.3	26.29	51.7	41.2
D3	D3-D7	24S,25-30,47-52	31221	125560	974	93	66.4	27.31	41.2	47.0
D4	D4,D5	49-52	11648	36422	483	93	73	41.41	20.8	70.2
D5	D5	51,52	3976	18276	243	93	88	20.58	13.4	90.7
D6	D6	47,48	6667	20352	263	87	72	57.03	11.2	100.5
D7	D4-D7	47,48	21491	20352	587	93	70.3	38.67	24.1	64.4
D8	D8	42	4352	8767	251	70	62	31.87	12.5	94.2
D9	D9	33-38	5826	57093	316	61.7	61.3	1.27	29.2	57.5
D10	D10	41,43-46	0	52451						
D11	D8,D9,D10,D11	33-46	0	109544						
E1	E1	53,54	6620	17999	273	86	81.5	16.48	14.9	85.1
E2	E2,E3	55-58	9679	35112	260	89	81.5	28.85	12.2	95.5
E3	E3		5416	0	319	93	89	12.54	18.8	74.4

Runoff Coefficients	Pre-Dev	Post-Dev
Roads	0.35	0.85
Swales/Basins	0.35	0
Lots	0.35	0
OS	0.35	0

Rainfall IFD

Event	Duration (mins)	Intensity (mm/hr)
1 min	1	257.40
2 min	2	210.00
3 min	3	192.40
4 min	4	178.50
5 min	5	166.80
10 min	10	124.80
15 min	15	100.40
20 min	20	84.60
25 min	25	73.68
30 min	30	65.60
45 min	45	50.53
1 hr	60	42.10
1.5 hr	90	32.73
2 hr	120	27.55
3 hr	180	21.73
4.5 hr	270	17.24
6 hr	360	14.62
9 hr	540	11.44
12 hr	720	9.50
18 hr	1080	7.17
24 hr	1440	5.75
30 hr	1800	4.77
36 hr	2160	4.08
48 hr	2880	3.17
72 hr	4320	2.19



COMBINED 100 YEAR ARI FLOWS

Segment	Contributing Segments	Contributing Lots	Segment Cum Peak Flow (L/s)	Lots Cum Peak Flow (L/s)	Total Cum Peak Flow (L/s)	Long Slope	Height in Channel (m) (Fang)	Height Over Weir (m)
A1	A1,C1	2,3	72.39	252.05	324.44	0.0054	0.48	0.21
A2	A2-A5	1,6,13-18,23N,24N	218.75	1217.97	1436.72	0.0202	0.70	0.33
A3	A3-A5	13-18,23N,24N	159.30	922.52	1081.82	0.0021	0.75	0.47
A4	A4,A5	14-18,23N,24N	86.73	778.75	865.48	0.0221	0.55	0.21
A5	A5	18,24N	35.69	221.18	256.86	0.0522	0.25	0.09
B1	B1	7-10	85.90	503.29	589.19	0.0063	0.61	0.24
B2	B1,B2	7-10	137.05	503.29	640.34	0.0204	0.49	0.18
C1	C1	4	28.70	273.48	302.18	0.0033	0.52	0.20
D1	D1	19-22,23S,31	104.36	775.07	879.43	0.0122	0.63	0.25
D2	D1-D7	11,12,19-22,23S,24S,25-32,47-52	538.79	3508.57	4047.36	0.0223	0.80	0.50
D3	D3-D7	24S,25-30,47-52	307.86	1991.56	2299.42	0.0091	1.02	0.47
D4	D4,D5	49-52	117.50	601.98	719.47	0.0631	0.39	0.14
D5	D5	51,52	39.17	296.98	336.14	0.0321	0.32	0.13
D6	D6	47,48	72.79	325.04	397.83	0.0504	0.31	0.12
D7	D4-D7	47-52	234.13	927.01	1161.14	0.0211	0.63	0.25
D8	D8	42	44.50	137.93	182.43	0.0294	0.24	0.09
D9	D9	33-38	36.35	826.93	863.28	0.0003	1.38	0.64
D10	D10	41, 43-46		776.97	776.97	0.0384	0.63	
D11	D8,D9,D10,D11	33-46		2049.20	2049.20	0.0093	0.57	
E1	E1	53,54	61.16	274.86	336.02	0.0205	0.36	0.13
E2	E2,E3	55-58	42.16	574.60	616.76	0.0282	0.44	0.17
E3	E3		43.74		43.74	0.0162	0.13	0.07

Appendix D

Bushfire Management Plan

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Lot 202, 203, 204 and 205 Wandena Road		
Suburb: Muchea	**State**: WA	**P/code**: 6030
Local government area: Shire of Chittering		
Description of the planning proposal: Rezoning application		
BMP Plan / Reference Number: 14138	**Version**: v1	**Date of Issue**: 20/10/20
Client / Business Name: **Bayley Environmental Services**		

Reason for referral to DFES	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?	☐	☑
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the BPC elements)?	☐	☑
Is the proposal any of the following special development types (see SPP 3.7 for definitions)?		
Unavoidable development (in BAL-40 or BAL-FZ)	☐	☑
Strategic planning proposal (including rezoning applications)	☐	☑
Minor development (in BAL-40 or BAL-FZ)	☐	☑
High risk land-use	☐	☑
Vulnerable land-use	☐	☑

If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	**Accreditation Level**	**Accreditation No.**	**Accreditation Expiry**
Alex Aitken	Level 2	37739	November 2021
Company		**Contact No.**	
Eco Logical Australia		08 6218 2200	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

Signature of Practitioner		**Date**	20-Oct-20

Bushfire Management Plan: Rezoning Application: Lots 202-205 Wandena Road, Muchea

Bayley Environmental Services

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BPAD Bushfire Planning & Design Accredited Practitioner Level 3
1300 646 131
www.ecoaus.com.au

DOCUMENT TRACKING

Project Name	Bushfire Management Plan: Rezoning Application: Lots 202-205 Wandena Road, Muchea
Project Number	19PER-14138
Project Manager	James Leonard
Prepared by	Alex Aitken (BPAD Level 2 – 37739)
Reviewed by	James Leonard**;** Daniel Panickar (BPAD Level 3 – 37802)
Approved by	Daniel Panickar (BPAD Level 3 – 37802)
Status	Final
Version Number	v1
Last saved on	20 October 2020

This report should be cited as 'Eco Logical Australia 2020. *Bushfire Management Plan: Rezoning Application: Lots 202-205 Wandena Road, Muchea* . Prepared for Bayley Environmental Services.

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Bayley Environmental Services (the client).

Template 2.8.1

Contents

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1. Introduction

1.1 Proposal details

Eco Logical Australia (ELA) was commissioned by Bayley Environmental Services to prepare a Bushfire Management Plan (BMP) to support a rezoning application for Lots 202 and 203 Wandena Road and Lots 8 and 100 Great Northern Highway, Muchea (hereafter referred to as the subject site, Figure 1). The subject site is currently zoned as 'Agricultural Resource' under the local planning scheme and is proposed to be zoned as 'Industrial Development'.

The subject site is within a designated bushfire prone area as per the *Western Australia State Map of Bush Fire Prone Areas* (DFES 2019; Figure 2), which triggers bushfire planning requirements *under State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7; Western Australian Planning Commission (WAPC) 2015) and reporting to accompany submission of the development application in accordance with the associated *Guidelines for Planning in Bushfire Prone Areas v 1.3* (the Guidelines; WAPC 2017).

The subject site is part of Precinct 2 within the Muchea Industrial Park being developed by the Shire of Chittering, with assistance from State and Federal Governments.

This assessment has been prepared by ELA Senior Bushfire Consultant Alex Aitken (FPAA BPAD Level 2 Certified Practitioner No. BPAD37739) with quality assurance undertaken by Principal Bushfire Consultant Daniel Panickar (FPAA BPAD Level 3 Certified Practitioner No. BPAD37802).

1.2 Purpose and application of the plan

The primary purpose of this BMP is to act as a technical supporting document to inform planning assessment. This BMP is also designed to provide guidance on how to plan for and manage the bushfire risk to the subject site through implementation of a range of bushfire management measures in accordance with the Guidelines.

1.3 Environmental considerations

SPP 3.7 policy objective 5.4 recognises the need to consider bushfire risk management measures alongside environmental, biodiversity and conservation values.

The subject site has been subject to extensive historical clearing for agricultural operations with the majority of the subject site being utilised as a horse stud.

Any clearing (including re-clearing) of native vegetation and/or non-native vegetation providing habitat for Matters of National Environmental Significance onsite may require consultation with State and Commonwealth Government environmental agencies and subsequent approvals prior to development commencing.

At this stage of planning, there is a proposal to revegetate a 10 m wide strip of vegetation adjacent to Wandena Road (Figure 6). If changes to this proposed revegetation and/or additional revegetation or landscaping is to occur as part of development, these elements will be addressed in future BMPs.

Figure 1: Site Overview

DS02 - 06/23

Attachment 1

Legend

- Subject site
- 100m site assessment
- 150m site assessment
- Cadastre

0 125 250 500
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

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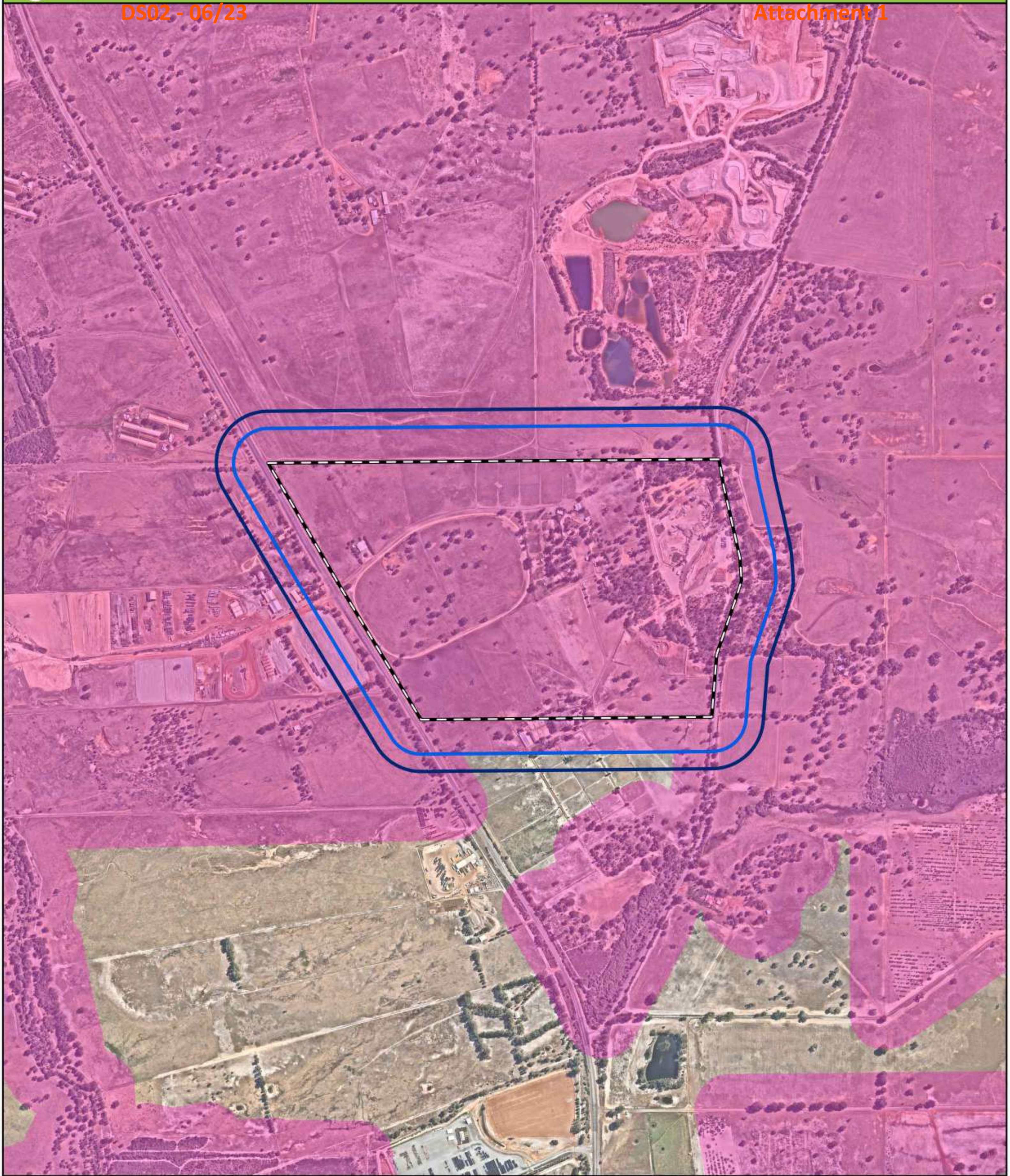
Prepared by: SM Date: 15/10/2020

Figure 2: Bushfire Prone Areas



Legend

- Subject site
- 100m site assessment
- 150m site assessment
- Bushfire Prone Mapping (DFES 2019)

0 125 250 500
Metres
Datum/Projection:
GDA 1994 MGA Zone 50

N

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2. Bushfire assessment results

2.1 Bushfire assessment inputs

The following section is a consideration of spatial bushfire risk and has been used to inform the bushfire assessment in this report.

2.1.1 Fire Danger Index

A blanket rating of FDI 80 is adopted for Western Australia, as outlined in Australian Standard (AS) 3959–2018 and endorsed by Australasian Fire and Emergency Service Authorities Council (AFAC).

2.1.2 Vegetation classification

Vegetation within the subject site and surrounding 150 m (the assessment area) was assessed in accordance with the Guidelines and *AS 3959-2018 Construction of Buildings in Bushfire Prone Areas* (SA 2018) with regard given to the *Visual guide for bushfire risk assessment in Western Australia* (DoP 2016). Site assessment was undertaken on 29 October 2019.

The classified vegetation for the site from each of the identified vegetation plots are identified below, Table 1 and Figure 3.

Table 1: Classified vegetation as per AS 3959-2018

Plot	Vegetation Classification	Effective Slope
1	Class G Grassland	All upslopes and flat land (0 degrees)
2	Class A Forest	All upslopes and flat land (0 degrees)
3	Class A Forest	Downslope >0 to 5 degrees
4	Class G Grassland	Downslope >0 to 5 degrees
5	Excluded AS 3959-2018 2.2.3.2 (e & f)	-
6	Class B Woodland	All upslopes and flat land (0 degrees)
7	Class G Grassland	Downslope >0 to 5 degrees

Photographs relating to each area and vegetation type are included in Appendix A.

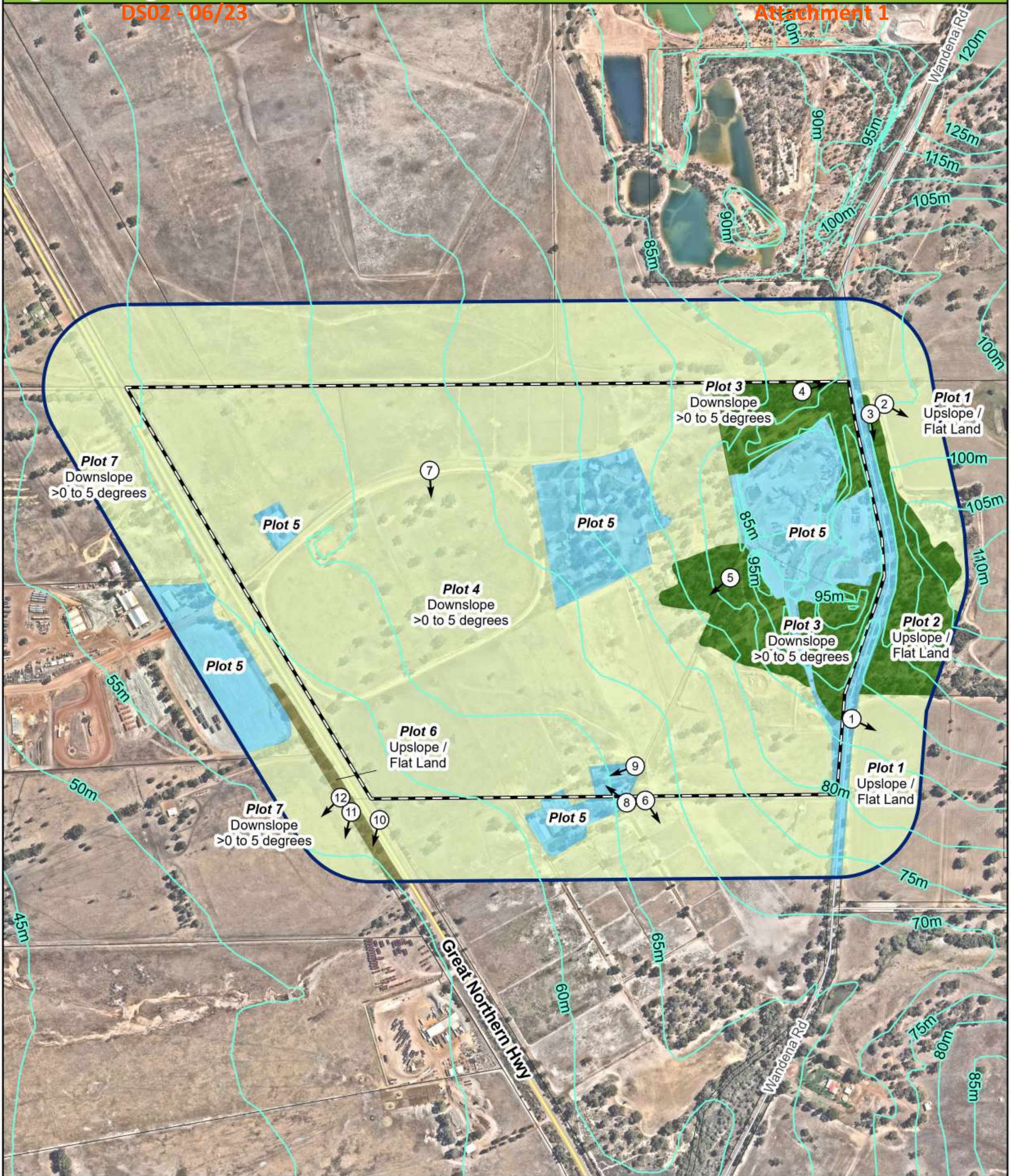
2.1.3 Topography and slope under vegetation

Effective slope under vegetation was assessed for a distance of 150 m from the subject site in accordance with the Guidelines and AS 3959-2018 and is depicted in Figure 3. Slope under classified vegetation was assessed and is shown in Table 1.

Figure 3: Vegetation Classification

DS02 - 06/23

Attachment 1



Legend

- Subject site
- 150m site assessment
- Contour (5m)
- Cadastre
- Photo location

Vegetation classification

- Class A forest
- Class B woodland
- Class G grassland
- Excluded as per clause 2.2.3.2 (e) and (f)

0 75 150 300

Metres

Datum/Projection: GDA 1994 MGA Zone 50

N

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Prepared by: SM Date: 16/10/2020

2.2 Bushfire assessment outputs

A bushfire hazard level (BHL) assessment has been undertake in accordance with SPP 3.7, the guidelines, AS 3959-2018 and the bushfire assessment inputs in Section 2.1.

2.2.1 Bushfire hazard level (BHL) assessment

All land located within 150 m of the site has been classified as per AS3959-2018 as shown in Figure 3. These vegetation classifications have been combined with slope under the classified vegetation to define the BHL as per the methodology indicated within the Guidelines. In addition, all land within 100 m of Extreme and Moderate BHLs has also been mapped as a Moderate hazard as per the Guidelines.

The BHL provides an indication of potential bushfire impact on the subject site by providing a likely intensity based on the classified vegetation.

Table 2 and Figure 4 display the BHL assessment that has been completed for the proposed rezoning in accordance with the Guidelines and AS 3959-2018 methodology.

Clearing will be undertaken within the subject site for development purposes, and consequently the pre-development BHLs are subject to change. A post-development BHL assessment is provided in Table 2 and Figure 5 which takes into account the assumption that the entire subject site will be managed in a low threat state as per the Guidelines and AS3959-2018 with the exception of a proposed 10 m revegetated strip of classified vegetation along Wandena Road. The revegetated strip of vegetation has been classified as Class A-Forest based on the precautionary principle and may change at future planning stages due to further definition of the proposed revegetation.

Table 2: BHL assessment

Plot and vegetation classification	Effective slope	BHL rating Pre-Development	BHL rating Post-Development
Plot 1- Class G Grassland	All upslopes and flat land (0 degrees)	Moderate	Moderate
Plot 2- Class A Forest	All upslopes and flat land (0 degrees)	Extreme	Extreme
Plot 3 - Class A Forest	Downslope >0 to 5 degrees	Extreme	Low
Plot 4- Class G Grassland	Downslope >0 to 5 degrees	Moderate	Low
Plot 5- Excluded AS 3959-2018 2.2.3.2 (e)	-	Low	Low
Plot 6- Class B Woodland	All upslopes and flat land (0 degrees)	Extreme	Extreme
Plot 7- Class G Grassland	Downslope >0 to 5 degrees	Moderate	Moderate

2.3 Identification of issues arising from the BHL assessment

Should there be any changes in development design or vegetation/hazard extent that requires a modified bushfire management response, then the above BHL ratings will need to be reassessed for the affected areas and documented in a brief addendum to this BMP.

The on-site vegetation extent is proposed to be cleared to enable development of an industrial zone amongst areas of landscaped/managed Public Open Space (POS) and various easements. Therefore, for the purposes of strategic level planning, ELA does not consider the current on-site vegetation extent to be a bushfire hazard issue post-development, since these hazards can be managed through a staged clearing process, adequate separation of future built assets from classified vegetation (both external and internal [e.g. retained vegetation] to the subject site), and ongoing fuel management that can be undertaken in and around individual development stages.

On the basis of the above information, ELA considers that the bushfire hazards within and adjacent to the subject site and the associated bushfire risk is readily manageable through standard management responses and compliance with acceptable solutions outlined in the Guidelines. These management measures will need to be factored into the development design as early as possible to ensure a suitable, compliant and effective bushfire management outcome is achieved to ensure protection of future life and property assets.

Demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS3959-2018 at future planning stages will also depend on the developer's ability to coordinate the timing and staging of clearing and development works within the subject site with the aim of avoiding bushfire impacts from temporary, retained vegetation.

Figure 4: Pre-Development Bushfire Hazard Level (BHL) Assessment

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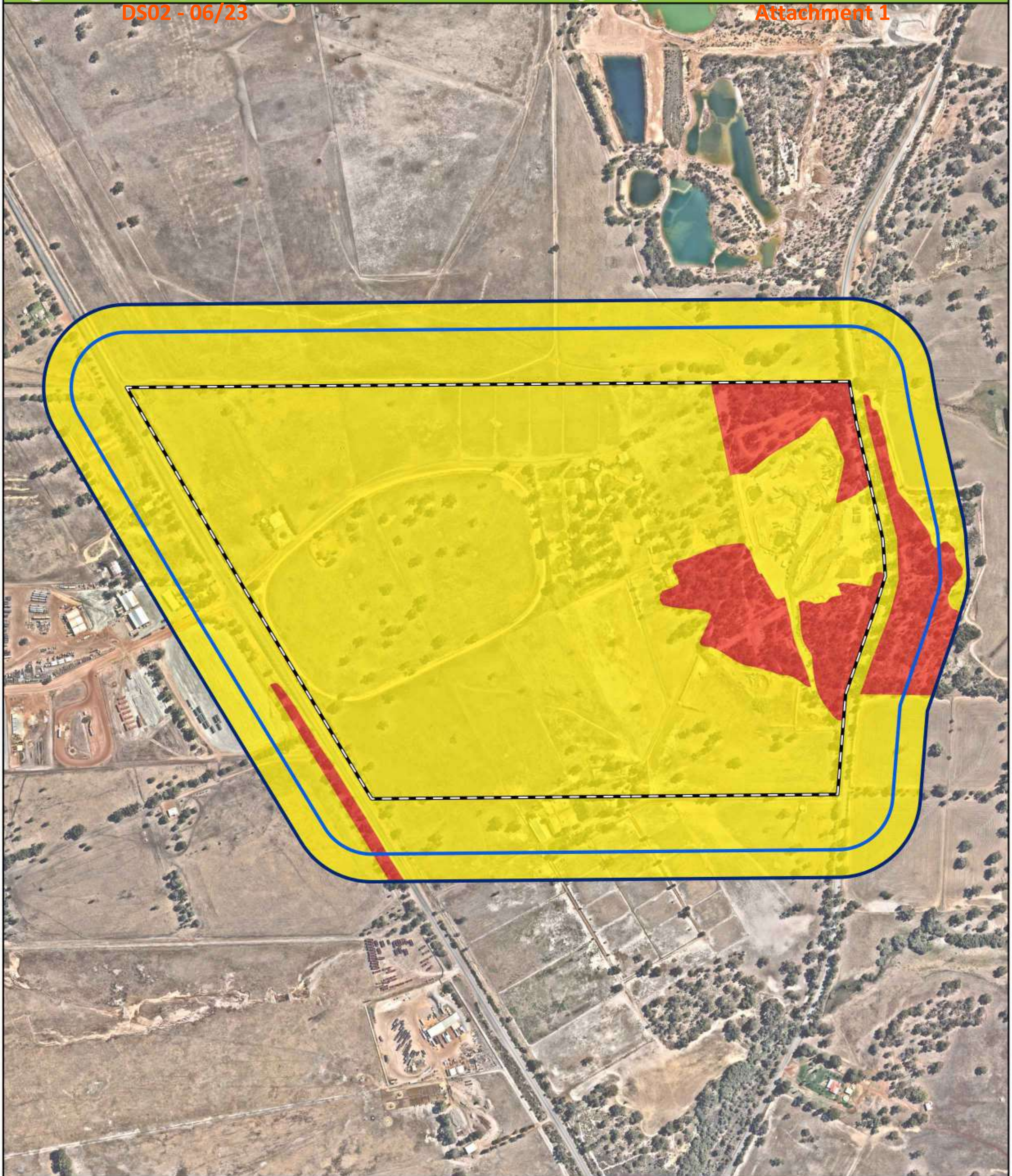
Attachment 1



Legend

Subject site

100m site assessment

150m site assessment

Bushfire Hazard Level (BHL)

Extreme

Moderate

Low

0 75 150 300

Metres

Datum/Projection:
GDA 1994 MGA Zone 50

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

Prepared by: SM Date: 15/10/2020

Figure 5: Post-Development Bushfire Hazard Level (BHL) Assessment

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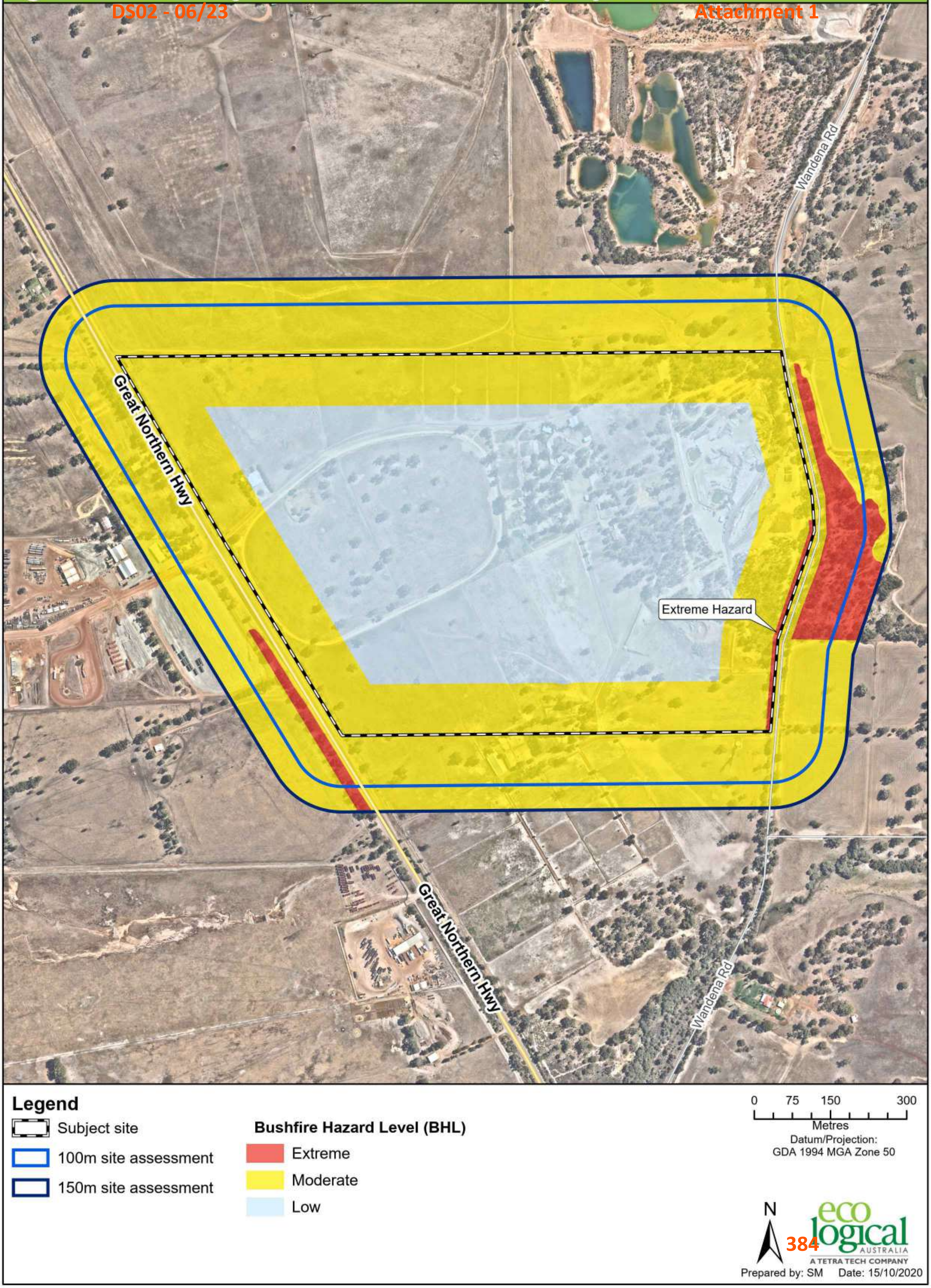
Attachment 1



Prepared by: SM Date: 15/10/2020

3. Assessment against the Bushfire Protection Criteria

3.1 Compliance

The proposed rezoning is required to comply with policy measures 6.2 and 6.3 of SPP 3.7 and the Guidelines. Implementation of this BMP is expected to meet objectives 5.1-5.4 of SPP 3.7.

In response to the above requirements of SPP 3.7 and the Guidelines, bushfire risk management measures, as outlined, have been devised for the proposed rezoning in accordance with the Guideline acceptable solutions to meet compliance with bushfire protection criteria.

Table 3 outlines the Acceptable Solutions (AS) that are relevant to the proposal and summaries how the intent of each Bushfire Protection Criteria has been achieved. No Performance Solutions (PS) have been proposed for this proposal. These management measures are depicted in Figure 6 where relevant.

Table 3: Summary of solutions used to achieve bushfire protection criteria

Bushfire Protection Criteria	AS	PS	N/A	Comment
Element 1: Location A1.1 Development location	☒	☐	☐	Post-development, the subject site will be located in an area subject to BHLs of Low and Moderate with a minor portion of Extreme hazard associated with the revegetation proposed. (Figure 5; Figure 6). This area will be separated from future buildings to ensure that they will be subject to BAL ratings of BAL-29 or lower. The proposed rezoning is considered to be compliant with A1.1.
Element 2: Siting and design of development A2.1 Asset Protection Zone (APZ)	☒	☐	☐	As the lot layout is currently unconfirmed, APZs are unable to be prescribed at this level of planning. APZs will be defined in BMPs supporting future planning applications (subdivision) to ensure that all future lots will be subject to a BAL rating of BAL-29 or lower. Figure 6 demonstrates that the majority of the subject site will be subject to BHLs of Moderate or Low and ELA expects that APZs will be able to be accommodated within road reserves, maintained Public Open Space areas etc. The proposed rezoning is considered to be compliant with A2.1.
Element 3: Vehicular access				
A3.1 Two access routes	☒	☐	☐	There are currently two access routes from the subject site being north/south on Great Northern Highway and Wandena Road (Figure 6). BMPs supporting future planning applications (subdivision) will provide greater detail on road networks and ensure that all stages of development are provide with two forms of access at all times where relevant and possible.

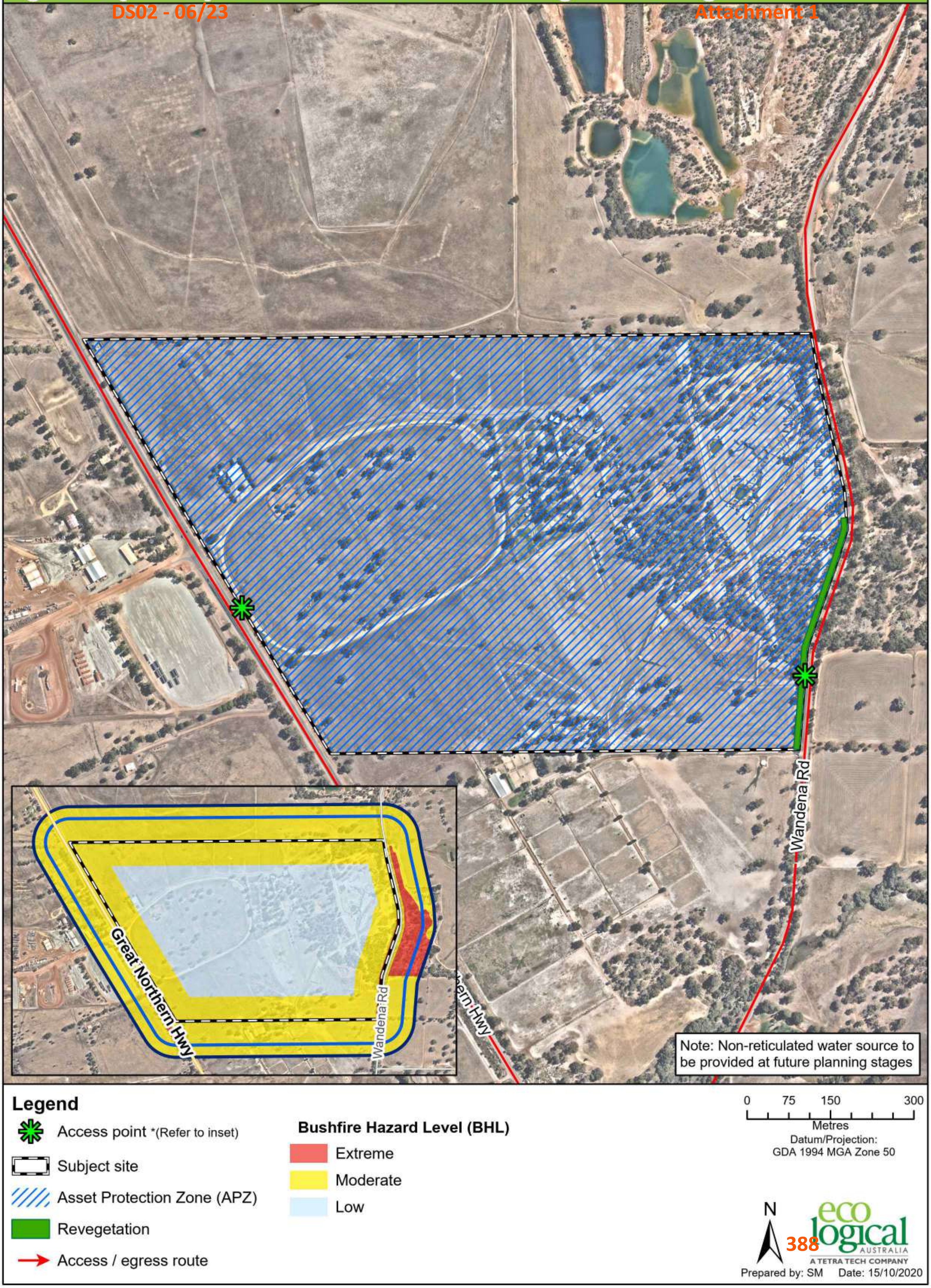
Bushfire Protection Criteria	AS	PS	N/A	Comment
				The proposed development is considered to be compliant with A3.1.
A3.2 Public road	☒	☐	☐	All future public roads will be designed and constructed to comply with the Guidelines (Appendix C). BMPs supporting future planning applications (subdivisions) will address this element in greater detail. The proposed development is considered to be compliant with A3.2.
A3.3 Cul-de-sac	☐	☐	☒	At this stage, no cul-de-sacs are proposed to be constructed within the subject site.
A3.4 Battle-axe	☐	☐	☒	At this stage, no battle-axe lots are proposed within the subject site.
A3.5 Private Driveway longer than 50 m	☐	☐	☒	At this stage, no private driveways longer than 50 m are proposed to be constructed within the subject site.
A3.6 Emergency Access way	☐	☐	☒	At this stage, no emergency access ways are proposed to be constructed.
A3.7 Fire-service access routes	☐	☐	☒	At this stage, no fire service access routes are proposed to be constructed.
A3.8 Firebreak width	☒	☐	☐	The subject site will be managed in accordance with the Shire of Chittering Firebreak & Bushfire Hazard Reduction Notice. BMPs supporting future planning applications (subdivisions) will address this element in greater detail. The proposed development is considered to be compliant with A3.8.
Element 4: Water A4.1 Reticulated areas	☐	☐	☒	The subject site is not connected to a reticulated water supply. Reticulated water is not present within the area.
A4.2 Non-Reticulated areas	☒	☐	☐	No reticulated water is currently available to the subject site. Future planning stages will ensure that a firefighting water supply will be provided in accordance with the Guidelines. The proposed development is considered to be compliant with A4.2.
A4.3 Individual Lots within non-reticulated areas	☐	☐	☒	It is unlikely that a development proposal for the subject site will result in the construction of one additional lot.

NOTE – AS- ACCEPTABLE SOLUTION, PS- PERFORMANCE SOLUTION, N/A- NOT APPLICABLE

3.2 Additional Bushfire Requirements

Future demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS3959-2018 will depend on the developer's ability to coordinate the timing of development works within the subject site. Updated BMPs will be prepared to support subsequent planning applications where relevant and will contain re-assessments of bushfire risk including Bushfire Attack Level assessments etc.

Figure 6: Spatial representation of the bushfire management strategies



4. Implementation and enforcement

Implementation of the BMP applies to the developer, the Shire of Chittering, and future landowners to ensure bushfire management measures are adopted and implemented on an ongoing basis. This BMP has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. In this respect, management measures documented in Section 3, where applicable, will be incorporated into development design as early as possible and confirmed through Structure Plan and subdivision design. Therefore, aside from the revision of this BMP or preparation of a BMP addendum to accompany future subdivision applications, there are no further items to implement, enforce or review at this stage of the planning process.

The revised BMPs or addendums to this BMP are required to meet the relevant commitments outlined in this strategic level BMP, address the relevant requirements of SPP 3.7 (i.e. Policy Measure 6.4) and demonstrate in detail how the proposed development will incorporate the relevant acceptable solutions to meet the performance requirements of the Guidelines.

5. Conclusion

In the author's professional opinion, the bushfire protection requirements listed in this assessment provide an adequate standard of bushfire protection for the proposed rezoning. As such, the proposed rezoning is consistent with the aim and objectives of SPP 3.7 and associated guidelines and is recommended for approval.

6. References

Department of Fire and Emergency Services, 2019, *Map of Bush Fire Prone Areas, [Online]*, Government of Western Australia, available from: http://www.dfes.wa.gov.au/regulationandcompliance/bushfireproneareas/Pages/default.aspx

Department of Planning (DoP), 2016, *Visual guide for bushfire risk assessment in Western Australia*. DoP, Perth.

Shire of Chittering. 2020. *Shire of Chittering Firebreak & Bushfire Hazard Reduction Notice*.

Standards Australia, 2018, *Construction of buildings in bushfire-prone areas, AS 3959-2018*. SAI Global, Sydney.

Western Australian Planning Commission, 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*. WAPC, Perth.

Western Australian Planning Commission,2017, *Guidelines for Planning in Bushfire Prone Areas Version 1.3 (including appendices),* WAPC, Perth.

Western Australian Planning Commission, 2019, *A guide to developing a Bushfire Emergency Evacuation Plan, October 2019*.

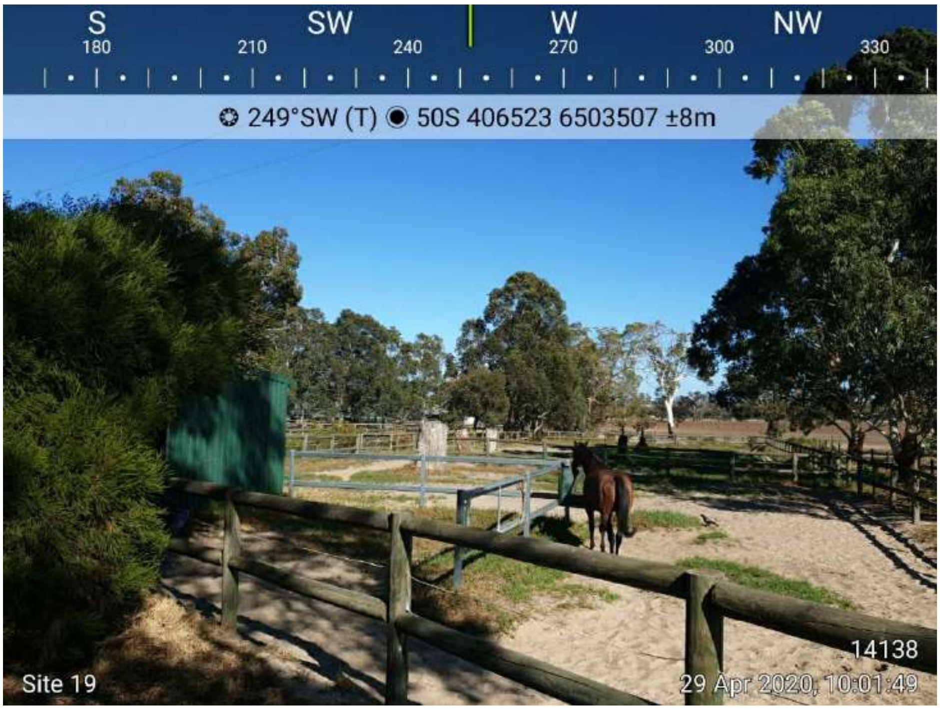
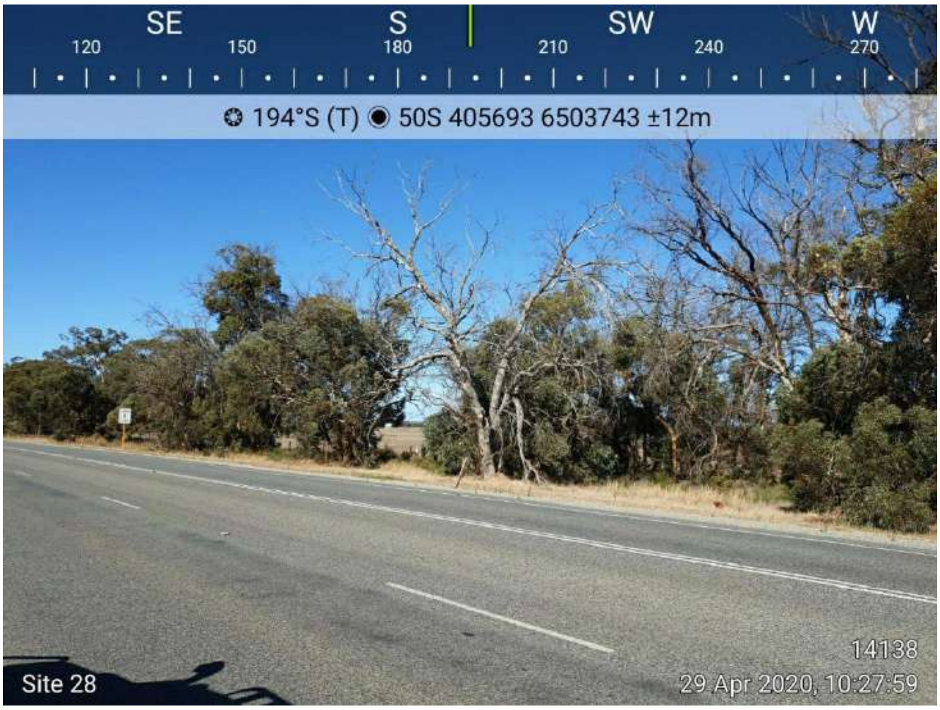
Appendix A – Classified Vegetation Photos

Plot	Photo ID	Photo and vegetation classification
1	1	 Class G Grassland
1	2	 Class G Grassland

Plot	Photo ID	Photo and vegetation classification
2	3	 Class A Forest Photo represents the northern end of vegetation area where understorey vegetation is thinner.
3	4	 Class A Forest

Plot	Photo ID	Photo and vegetation classification
3	5	 Class A Forest
4	6	 Class G Grassland

Plot	Photo ID	Photo and vegetation classification
4	7	 Class G Grassland
5	8	 Excluded AS 3959-2018 2.2.3.2 (e)

Plot	Photo ID	Photo and vegetation classification
5	9	 Excluded AS 3959-2018 2.2.3.2 (e)
6	10	 Class B Woodland

Plot	Photo ID	Photo and vegetation classification
6	11	 Class B Woodland
7	12	 Class G Grassland

Appendix B – Standards for Asset Protection Zones

The following standards have been extracted from the *Guidelines for Planning in Bushfire Prone Areas v 1.3* (WAPC 2017).

Every habitable building is to be surrounded by, and every proposed lot can achieve, an APZ depicted on submitted plans, which meets the following requirements:

a. Width: Measured from any external wall or supporting post or column of the proposed building, and of sufficient size to ensure the potential radiant heat impact of a fire does not exceed 29kW/m² (BAL-29) in all circumstances.

b. Location: the APZ should be contained solely within the boundaries of the lot on which a building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity (see explanatory notes).

c. Management: the APZ is managed in accordance with the requirements of '*Standards for Asset Protection Zones*' (below):

- Fences: within the APZ are constructed from non-combustible materials (e.g. iron, brick, limestone, metal post and wire). It is recommended that solid or slatted non-combustible perimeter fences are used
- Objects: within 10 metres of a building, combustible objects must not be located close to the vulnerable parts of the building i.e. windows and doors
- Fine Fuel load: combustible dead vegetation matter less than 6 millimetres in thickness reduced to and maintained at an average of two tonnes per hectare
- Trees (> 5 metres in height): trunks at maturity should be a minimum distance of 6 metres from all elevations of the building, branches at maturity should not touch or overhang the building, lower branches should be removed to a height of 2 metres above the ground and or surface vegetation, canopy cover should be less than 15% with tree canopies at maturity well spread to at least 5 metres apart as to not form a continuous canopy (**Figure 7**).

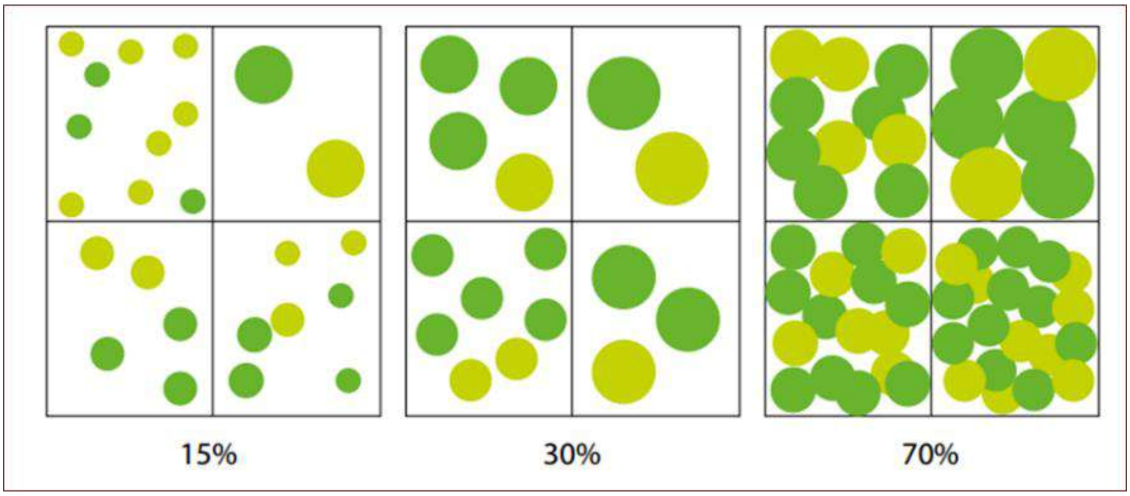


Figure 7: Illustrated tree canopy cover projection (WAPC 2017)

- **Shrubs (0.5 metres to 5 metres in height):** should not be located under trees or within 3 metres of buildings, should not be planted in clumps greater than 5m^2 in area, clumps of shrubs should be separated from each other and any exposed window or door by at least 10 metres. Shrubs greater than 5 metres in height are to be treated as trees
- **Ground covers (<0.5 metres in height):** can be planted under trees but must be properly maintained to remove dead plant material and any parts within 2 metres of a structure, but 3 metres from windows or doors if greater than 100 millimetres in height. Ground covers greater than 0.5 metres in height are to be treated as shrubs
- **Grass:** should be managed to maintain a height of 100 millimetres or less.

Additional notes

The Asset Protection Zone (APZ) is an area surrounding a building that is managed to reduce the bushfire hazard to an acceptable level. Hazard separation in the form of using subdivision design elements or excluded and low threat vegetation adjacent to the lot may be used to reduce the dimensions of the APZ within the lot.

The APZ should be contained solely within the boundaries of the lot on which the building is situated, except in instances where the neighbouring lot or lots will be managed in a low-fuel state on an ongoing basis, in perpetuity. The APZ may include public roads, waterways, footpaths, buildings, rocky outcrops, golf courses, maintained parkland as well as cultivated gardens in an urban context, but does not include grassland or vegetation on a neighbouring rural lot, farmland, wetland reserves and unmanaged public reserves.

Appendix C - Vehicular access technical requirements (WAPC 2017)

Technical requirements	Public road	Cul-de-sac	Private driveway	Emergency access way	Fire service access route
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal distance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 m	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius	8.5	8.5	8.5	8.5	8.5

* Refer to E3.2 Public roads: Trafficable surface

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Appendix E

Landscape Masterplan

LOTS 202 & 203 WANDENA ROAD
AND
LOTS 204 & 205 GREAT NORTHERN HIGHWAY
CHITTERING

LANDSCAPE MASTER PLAN

Prepared for

Focus Demolition Pty Ltd
and
Mr David Weightman Smith

Draft Report No. J19018d
18 May 2021

BAYLEY ENVIRONMENTAL SERVICES
30 Thomas Street
SOUTH FREMANTLE WA 6162

Sundowner Nominees Pty Ltd as trustee for the Bayley Cook Family Trust ABN 20 822 598 897
trading as Bayley Environmental Services

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LIST OF FIGURES

1.0 INTRODUCTION

The owners of Lots 202 & 203 Wandena Road and Lots 204 & 205 Great Northern Highway, Chittering (the project area) have applied to the Shire of Chittering for the lots to be rezoned from Agricultural Resource to General Industry. The draft Muchea Industrial Park Structure Plan 2019 (MIPSP) shows Lots 204 and 205 as part of Precinct 2 (General Industry Core) and Lots 202 and 203 as part of Precinct 4 (Light Industry following completion of quarrying). Figure 1 shows the location of the project area within the draft Muchea Industrial Park Structure Plan area.

The owners have submitted a Local Structure Plan (LSP) for the project area. The total area of the rezoning and LSP is approximately 82 hectares. Figure 2 shows an aerial view of the project area and surroundings. Figure 3 shows a preliminary conceptual plan of subdivision for the project area.

The Muchea Industrial Park will form the southern gateway to the Shire of Chittering. A priority of the Shire Council is that the MIP should present an attractive visual landscape for observers travelling on the main approaches into Chittering. This includes preserving native vegetation (mostly roadside trees and some paddock trees) where possible, landscape plantings, building design and layout of development within lots.

The Shire of Chittering has set out its priorities in its *Muchea Industrial Park Design Guidelines* (2018). The Guidelines deal with development layout within lots, streetscaping, landscaping, bushfire management, fencing, signage and building design. The Shire of Chittering Town Planning Scheme No. 6 also contains provisions relating to landscape within industrial zones. This Landscape Master Plan recognises and reflects the recommendations of the Design Guidelines and the Scheme provisions.

2.0 EXISTING LANDSCAPE

The project area is visible from Great Northern Highway and Wandena Road. The view from Great Northern Highway is mostly open, with some screening by trees planted within the Project Area. The view from Wandena Road is obscured by heavy vegetation and terrain except for about the southernmost 140m of the site and about 100m to the south. Figure 4 shows views from Great Northern Highway and Wandena Road.

The landscape of Lots 202 and 203 is a mix of uncleared Wandoo woodland and a former clay quarry, which is currently being backfilled prior to rehabilitation. The landscape of Lots 204 and 205 consists of cleared paddocks with scattered trees and buildings associated with the Scenic Lodge horse stud.

3.0 LANDSCAPING STRATEGY

Landscaping of the project area will focus on the use of species with low water demand. Plantings will include bioretention swales and basins, landscape buffers (to a minimum of 10% of the area of each lot) and street trees. The plantings will not be irrigated after the establishment phase. No turf grass will be planted in public areas, although individual lot owners may choose to plant grass. Lawn areas will not count towards the landscaping requirement on each lot.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised.

The bioretention basins and swales will be densely planted with inundation and drought tolerant native species including sedges and low shrubs in order to stabilise the swales and maximise their ability to immobilise nutrients and sediments from the water.

The total area to be planted is approximately 13.7 hectares. If all of this area were planted simultaneously during the establishment phase, approximately 62 ML of water would be required to irrigate the new plantings in the first year. As the project area is likely to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a small part of the total demand being required in any one year.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (Eco Logical Australia, 2021).

Figure 5 shows an overview of the Landscape Master Plan.

4.0 LANDSCAPING ZONES

4.1 Great Northern Highway

The Great Northern Highway road reserve includes a cleared verge 10m wide adjacent to Lots 204 and 205.

The road reserve is mostly classed as "Grassland" under the Bushfire Management Plan, with a moderate fire hazard rating. An exception is the western side of the road reserve opposite the south-west corner of the site, which due to its greater tree density is classes as "Woodland" with an extreme fire hazard rating.

No landscape planting is proposed in the Great Northern Highway road reserve, in line with Main Roads WA advice (A. Rao, MRWA 2021 pers. comm.).

4.2 Wandena Road

The Wandena Road reserve includes a 3m to 8m partly-vegetated verge adjacent to Lots 202 and 203. The verge supports remnant native trees including Wandoo and Marri. The understorey is sparse and includes some low native shrubs and large areas of open ground.

The Wandena Road reserve is currently classed as "Excluded" under the Bushfire Management Plan, with a moderate fire hazard rating. This classification is due to the spacing of the existing trees, the separation of canopies and the absence of a mid-storey. The fire hazard would be increased by any substantial increase in the overstorey canopy density or by an increased understorey.

Landscaping in the Wandena Road reserve will be limited to retention of existing trees and weed control.

4.3 Bioretention Swales

Bioretention swales 4m wide will be located on one or both sides of all roads within the project area, as well as several dedicated 10m wide drainage easements. The swales and easements will carry road runoff and excess lot runoff.

The swales and easements will be densely planted with native sedges, small (<2m) shrubs and widely-spaced small trees to stabilise the swales, slow the water flows and maximise the uptake of sediments and nutrients from the water. Figure 6 shows conceptual profiles of the roadside swales.

4.4 Lots

The Shire of Chittering's Design Guidelines set out the Shire's requirements and recommendations for landscaping within lots. Other requirements arise from provisions for drainage and effluent disposal within the lots.

The general landscaping within lots will include:

- a minimum 2m wide landscape buffer on the primary road frontage;
- a minimum 1m wide landscape buffer on secondary road interface and side boundaries extending to the building setback line;
- one shade tree per four car parking bays;
- one tree per 10m of road frontage;
- a bioretention basin to hold the 1-year ARI 1-year storm, typically measuring about 3% of the total area of the lot;
- an effluent disposal area (probably ATU irrigation area) planted with low shrubs, with size depending on the lot workforce (about 23m^2 per full-time employee); and
- other landscape plantings to a total of 10% of the area of the lot.

Plantings within lots will generally feature sedges and other ground covers, low shrubs (<2m) and widely-spaced trees in order to comply with the requirements of the Bushfire Management Plan. It is noted that the Design Guidelines' requirement for one tree every 10m of road frontage may, depending on the size of the trees, exceed the permissible canopy density for "Shrubland" under the Bushfire Management Plan. It is proposed instead to space trees 15m apart in all areas within 100m of lots.

Figure 7 shows an indicative layout of landscape plantings for a typical lot.

5.0 SPECIES SELECTION AND PLANTING DENSITY

Species to be planted in the project area will be local native species, with species for specific areas selected for their height and inundation and/or drought tolerance. Recommended species for each situation are listed below:

5.1 Swales and Basins

- Includes in-lot 1-yr ARI basins, roadside swales and drainage easements.
- Planting area approx. 6.4ha.
- Densely planted with sedges, herbs, low shrubs and scattered small trees.
- "Shrubland" classification.

Sedges & Herbs

- Planting density 10,000/ha (1m spacing)
- Recommended species:

Baumea articulata
Baumea juncea
Conostylis aculeata
Dasypogon bromeliifolius
Gahnia trifida
Hypolaena exsulca
Juncus kraussii
Juncus pallidus
Lepidosperma longitudinale
Lyginia imberbis
Patersonia occidentalis
Phlebocarya ciliata

Shrubs (<2m)

- Planting density 2,500/ha (2m spacing)
- Recommended species:

Acacia lasiocarpa
Hibbertia hypericoides
Hypocalymma angustifolium
Phyllanthus calycinus
Regelia ciliata
Xanthorrhoea preissii

Tall Shrubs (>2m) and Trees

- Planting density <50/ha (15m spacing).
- Recommended species:

Acacia saligna
Casuarina obesa
Melaleuca preissiana
Melaleuca rhaphiophylla
Viminaria juncea

5.2 Effluent Irrigation Areas

- Planting area approx. 1ha (depending on workforce on individual lots).
- Planted with dense low shrubs, sedges &herbs.
- "Shrubland" classification.

Sedges & Herbs

- Planting density 10,000/ha (1m spacing).
- Recommended species:

Hypolaena exsulca	*Lyginia imberbis*
Juncus kraussii	*Patersonia occidentalis*
Lepidosperma longitudinale	*Phlebocarya ciliata*

Low Shrubs (<2m)

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Acacia lasiocarpa	*Phyllanthus calycinus*
Hibbertia hypericoides	*Regelia ciliata*
Hypocalymma angustifolium	*Xanthorrhoea preissii*

5.3 Lot Landscaping

- Planting area approx. 6.3ha.
- Includes front & side boundary landscape buffers and other plantings to total 10% of lot area.
- Planted with sedges & herbs, low shrubs and scattered trees.
- “Shrubland” classification.

Sedges & Herbs

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Hypolaena exsulca	*Lyginia imberbis*
Juncus kraussii	*Patersonia occidentalis*
Lepidosperma longitudinale	*Phlebocarya ciliata*

Low Shrubs (<2m)

- Planting density 2,500/ha (2m spacing).
- Recommended species:

Acacia lasiocarpa	*Phyllanthus calycinus*
Hibbertia hypericoides	*Xanthorrhoea preissii*
Hypocalymma angustifolium	

Tall Shrubs (>2m) and Trees

- Planting density <50/ha (15m spacing).
- Recommended species:

Allocasuarina fraseriana	*M. teretifolia*
Casuarina obesa	*M. preissiana*
Corymbia calophylla	*M. rhaphiophylla*
Eucalyptus rudis	*Gastrolobium ebracteolatum*
E. wandoo	*Viminaria juncea*
Melaleuca incana	

Figures

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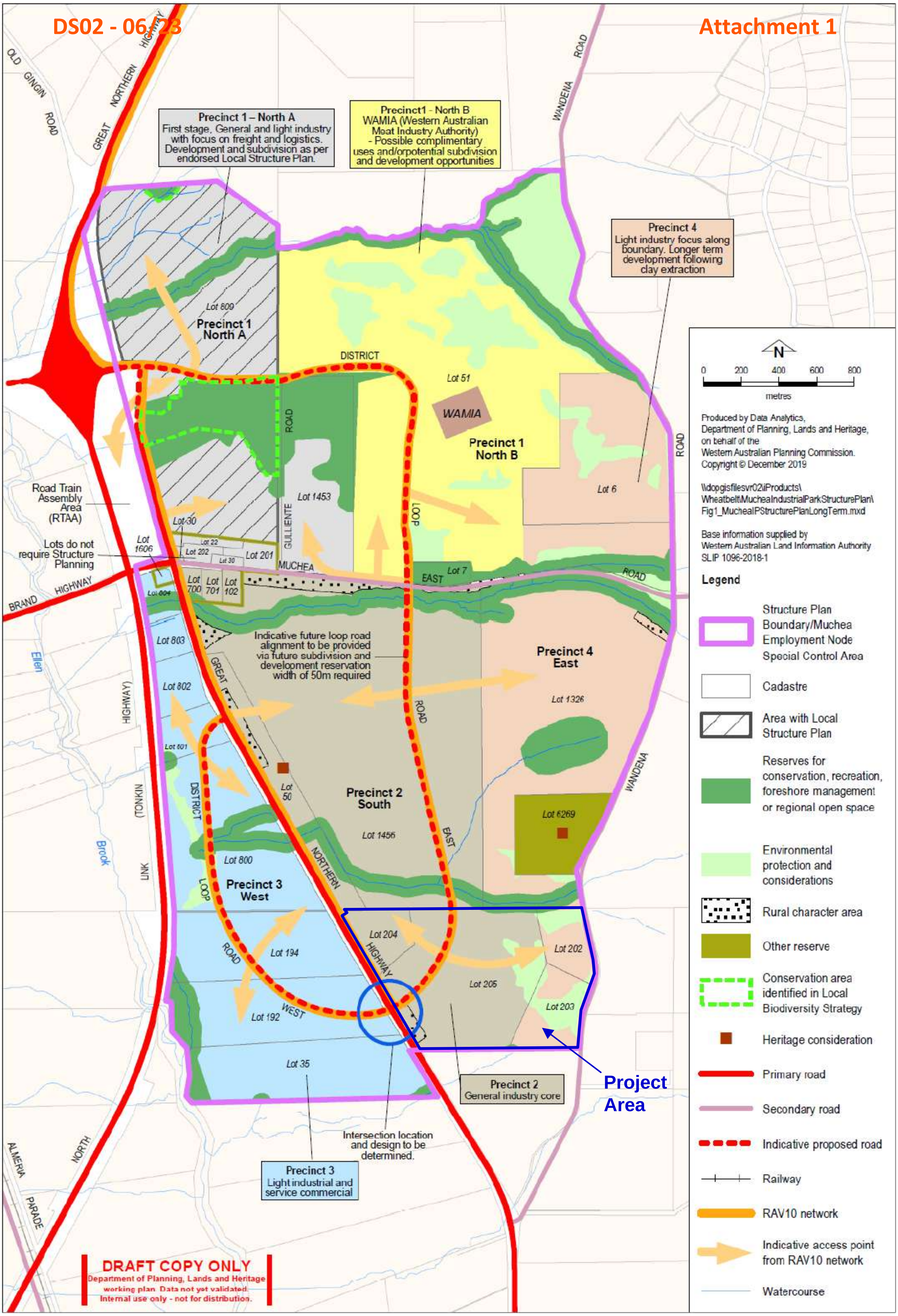
Attachment 1



Source: WAPC, 2019

Figure 1

DRAFT MUCHEA INDUSTRIAL PARK STRUCTURE PLAN

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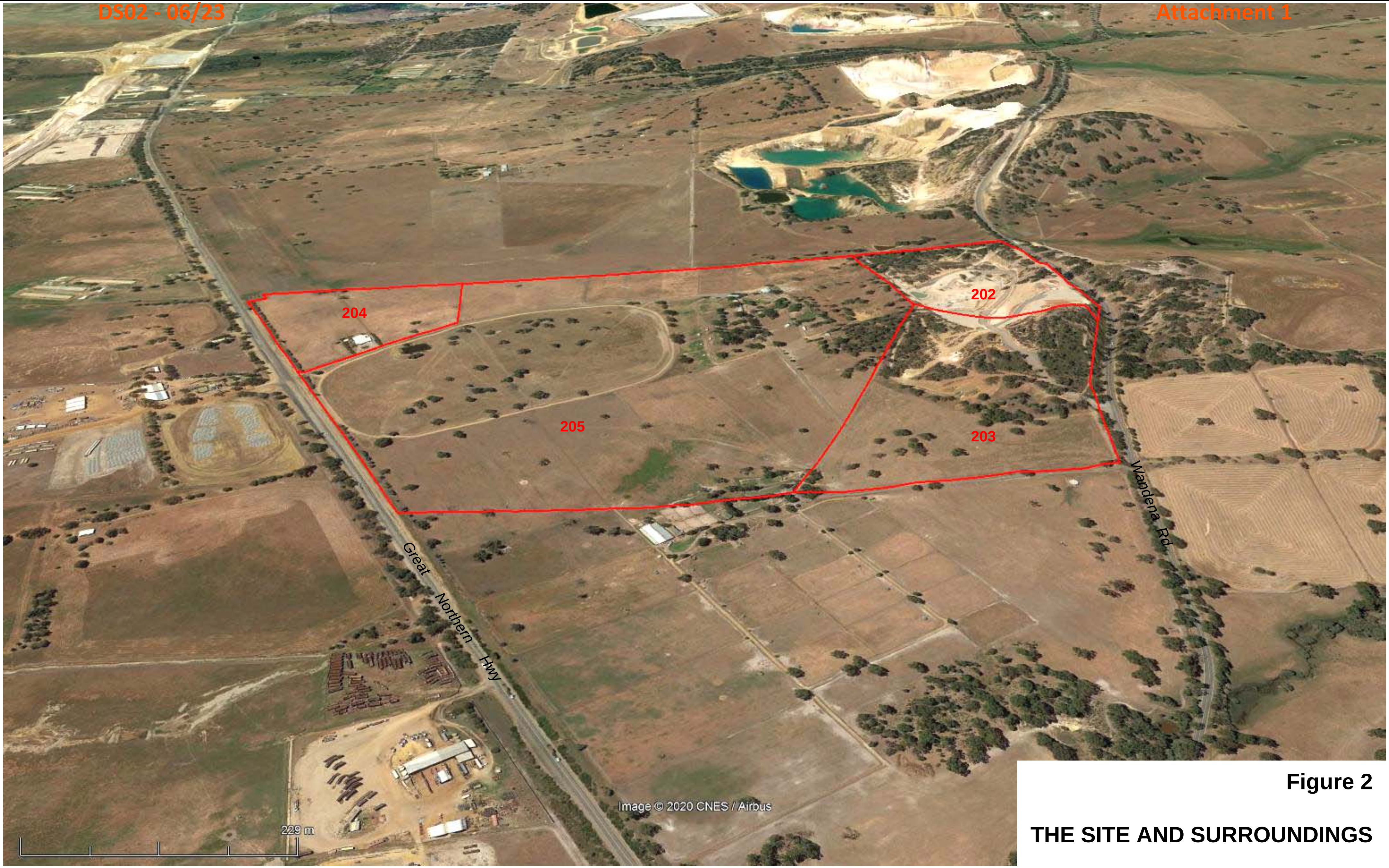

Figure 2

THE SITE AND SURROUNDINGS

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Image source: Google

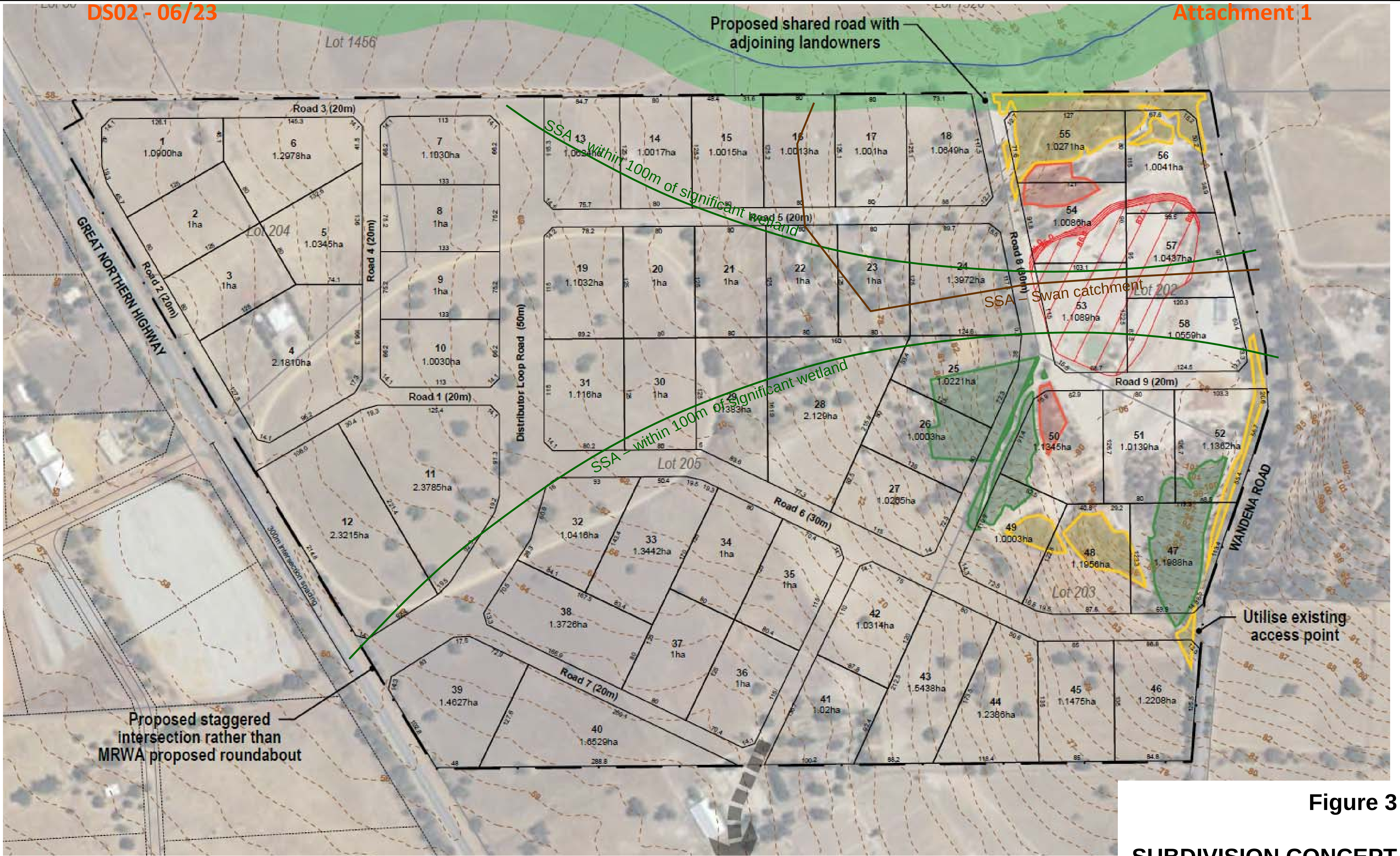

Figure 3

SUBDIVISION CONCEPT

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1 **Wandena Rd looking north-west into Lot 203**

2 **Wandena Rd looking north-west into quarry entrance**

3 **Wandena Rd looking north-west towards Lot 202**

4 **Great Northern Hwy looking north-east into Lot 205**

5 **Great Northern Hwy looking east into Lot 205 entrance**

6 **Great Northern Hwy looking south-east into Lot 204**

Images: Google (2017)

Figure 4

VIEWS FROM GREAT NORTHERN HIGHWAY AND WANDENA ROAD

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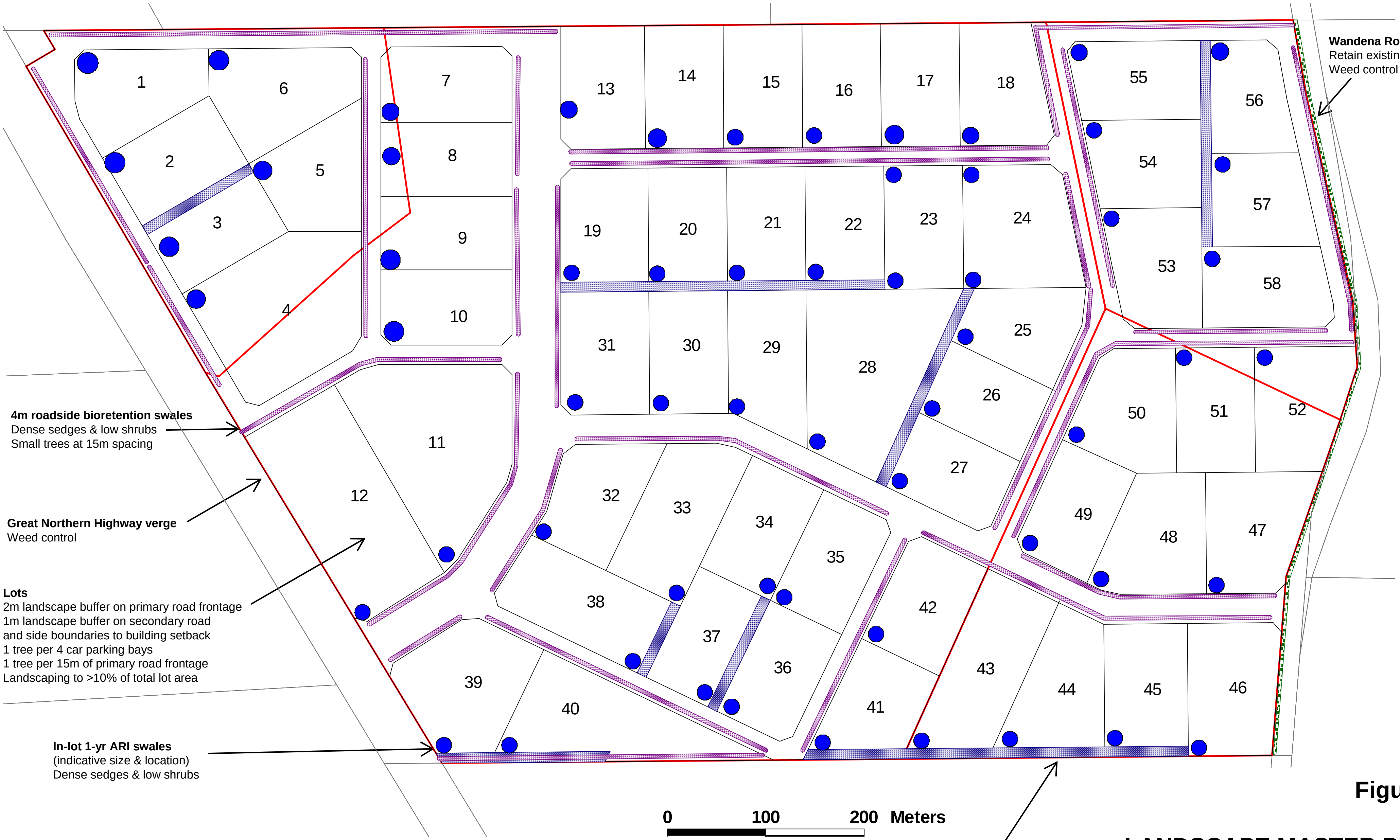

Figure 5

LANDSCAPE MASTER PLAN

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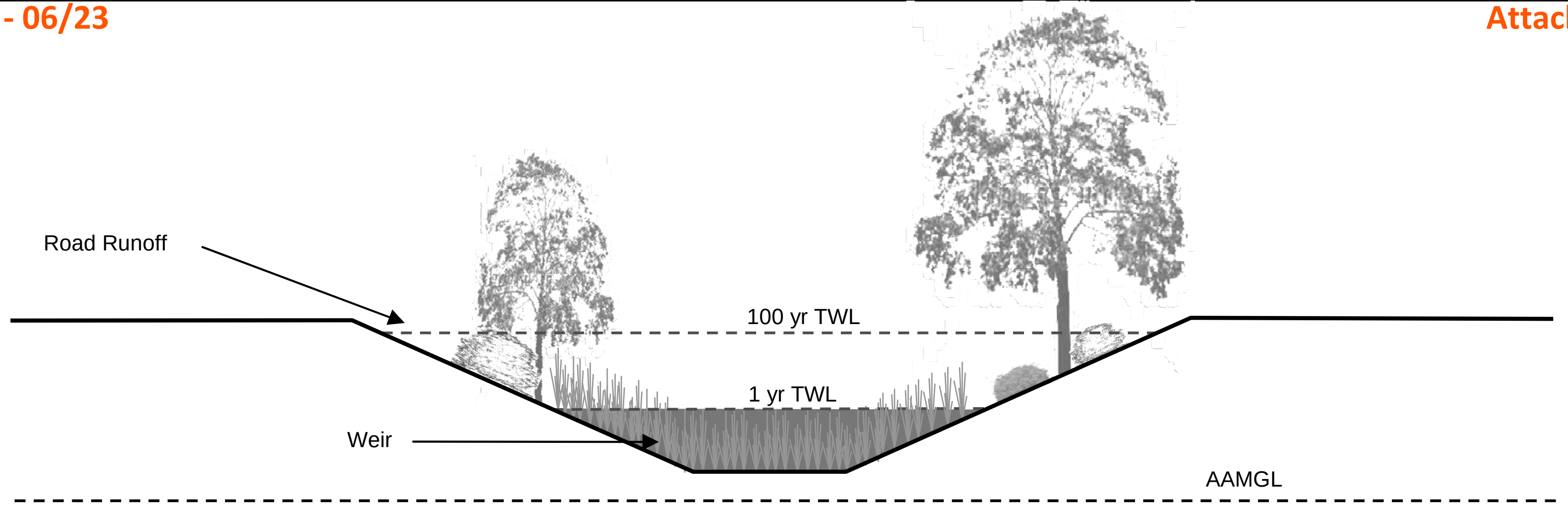

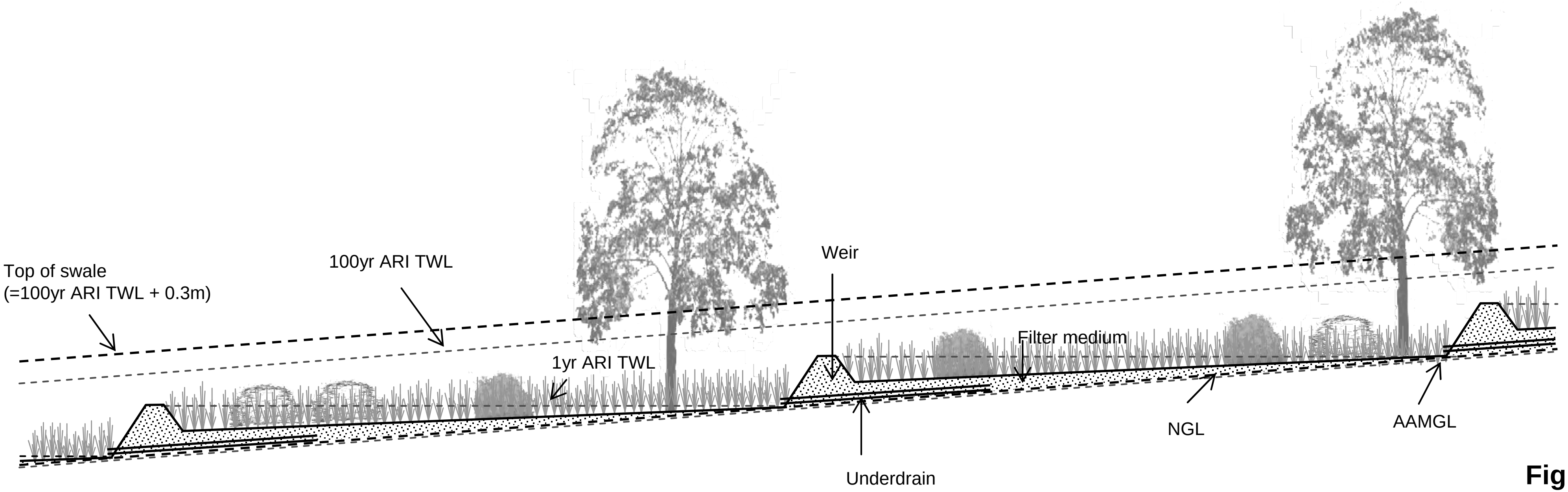

Figure 6

BIRETENTION SWALES

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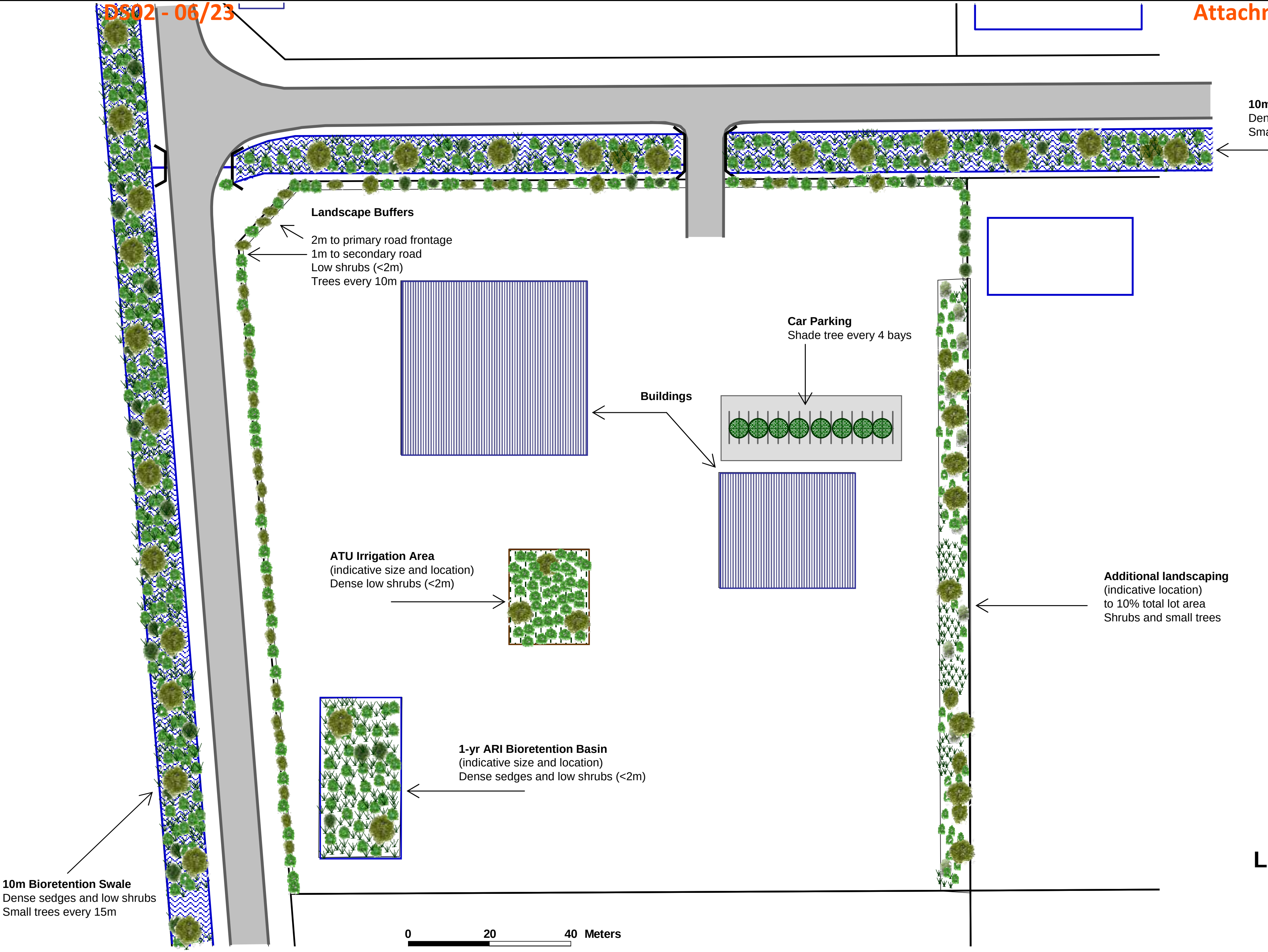

Figure 7

LOT EXAMPLE

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Appendix F

Engineering Servicing Report

Porter
Consulting Engineers

ENGINEERING SERVICING REPORT

WANDENA ROAD, MUCHEA (MUC02)

REPORT PREPARED FOR

SWAN INDUSTRIAL DEVELOPMENT PTY LTD

Prepared by	**Porter Consulting Engineers**
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Date	18 May 2021
Our reference	R30.20
Job Number	20-03-035
Checked	*BH*

HISTORY AND STATUS OF THE DOCUMENT

Revision	Date issued	Author	Issued to	Revision type
Rev A	5/05/2020	M. Cook	Client	1st issue
Rev B	22/02/2021	M. Cook	Client	2nd issue - updated layout
Rev C	18/05/2021	M. Cook	Client	3rd issue – minor updates

CONTENTS

1.0 INTRODUCTION

Porter Consulting Engineers (PCE) have been engaged by Swan Industrial Developments Pty Ltd to prepare a servicing report for a proposed industrial development in Muchea, within the Shire of Chittering. The Site is approximately 50km north of the Perth CBD and is bound by Wandena Road to the east, agricultural pastoral land to the north and south and Great Northern Highway to the west, as shown in **Figure 1.** A concept subdivisional layout is presented in **Attachment 1**.

Figure 1: Subject Site (bound in blue)

2.0 PLANNING

A draft structure plan for the Muchea Industrial Park[1] has been prepared which seeks to update the Muchea Employment Node Structure Plan[2]. The Muchea Industrial Park is at the northern terminus of NorthLink, and the intersection of Brand Highway and Great Northern Highway.

The Site is located at the southern boundary of the Muchea Industrial Park Structure Plan and straddles Precinct 2 and 4. **Attachment 2** illustrates the structure plan map for the industrial park.

2.1 Landform

The Site is approximately[3] 83.01 hectares in area. Much of the site is free of vegetation, however, the Structure Plan notes there are clusters of Reagan Complex native vegetation associated with an endangered Carnaby Cockatoo feeding area within lots 202 and 203 by Wandena Road.

[1] *Muchea Industrial Park Structure Plan, Draft,* October 2020
[2] Western Australian Planning Commission, *Muchea Employment Node Structure Plan,* Final report, August 2011
[3] Nearmap, *Nearmap,* viewed 24 April 2020, <http://maps.au.nearmap.com/>

It is understood that a formal extractive materials quarry (clay) is located within lots 202 and 203 and is being progressively filled with sorted demolition waste material under the operation of approvals (W5912/201/1) toward rehabilitating the former extraction pit.

A feature survey of the site was not available, therefore based on readily available contour information online[4], the Site rises from approximately 61m AHD by Great Northern Highway to 100m AHD at Wandena Road, with the eastern half of the site at a nominal 10% gradient.

Based on the Perth Metropolitan Region Environmental Geology Series[5] mapping for Muchea, the expected soils are noted below and illustrated in **Figure 2**:

- To the western portion of the Site:
  - M_{gs1}: Pebbly Silt-strong brown, silt with common fine to occasionally coarse grained, sub-rounded laterite, quartz, heavily weathered granite pebbles, some fine to medium-grained quartz sand, of alluvium origin. The equivalent unit being Guildford Formation (Q_{pa}).
- To the eastern portion of the Site,
  - S_5: Sand-very pale brown, medium to coarse-grained, well sorted, little fines, sub-angular to rounded quartz and feldspar, of colluvial origin.
  - M_{sg}: Sandy Silt-strong brown, firm friable, dispersive in part, occasional pebbly horizons with little matrix containing quartzite, quartz, granite, laterite, of colluvial origin.
- And within the eastern portions of the Site pockets of,
  - ST_1: Siltstone-white, thinly bedded, well laminated, fine-grained, some large ferruginous concretions and laminae, occasionally micaceous. The equivalent unit being Leederville Formation (K_{lb}).

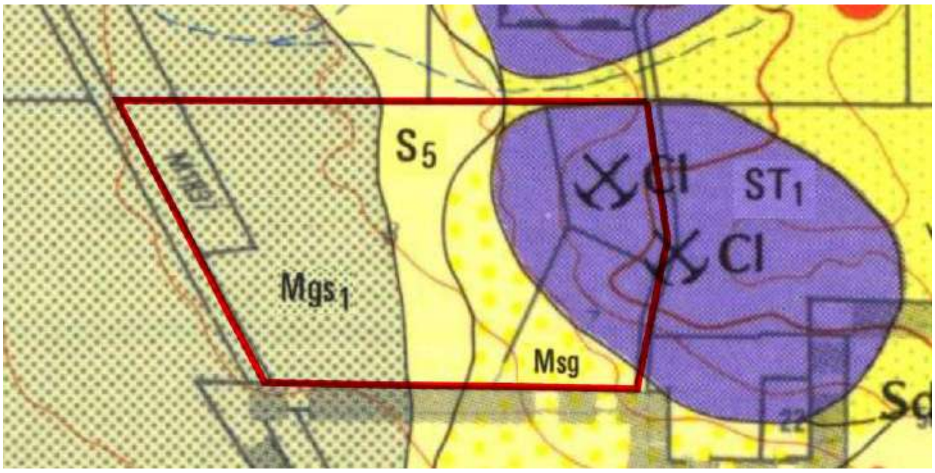


Figure 2: Geology mapping (the Site bound in red)

A geotechnical investigation[6] across the site noted ground conditions generally comprising of gravelly soils to a depth of up to 1m underlain by clay, sand, and gravelly soils, with Siltstone encountered at a depth of 2m to a few test pits within the eastern portion of the site.

[4] Water Corporation ESINET, *ESINET, viewed 24 April 2020,* <*esinet.watercorporation.com.au*>
[5] Gozzard J. R. 1982 *Muchea Sheet 2034 I and part 2124 IV*, Perth Metropolitan Region, Environmental Geology Series, Geological Survey of Western Australia.
[6] Douglas Partners, *Report on Preliminary Geotechnical Investigation Lot 202 & 203 Wandena Road and 204 & 205 Great Northern Highway, Muchea, WA* (Revision 0, 12 October 2020)

As noted in the Local Water Management Strategy[7], temporary surface saturation in the lower parts of the site may be present as infiltration may be impeded by the low-permeability soils. The geotechnical investigation noted permeability rates ranging from 0.05-8.6 m/day.

Based on the online Perth Groundwater Atlas mapping[8], the 50m groundwater contour line intersects the site, with the inferred water levels across the site being approximately 48m to 53m AHD. However, it is noted that the site is on the outer fringe of available mapping contours.

The Department of Water and Environmental Regulation[9] (DWER) has two bores within the Site (61609196, 61609197) which note that the recorded groundwater was 12m to 16m below the surface, which is generally consistent with online Atlas mapping.

Groundwater monitoring[10] has been undertaken as part of the rehabilitation of the clay extraction pit with sorted demolition rubble, which noted groundwater levels ranging from 75m to 85m AHD from three monitoring wells and 64m AHD from another monitoring well.

The LWMS noted that bore sampling results indicated no potential or actual ASS in the groundwater, and therefore no ASS management is expected to be required during the construction works.

A search of the Contaminated Sites Database[11] indicated that there are no known recorded contamination within the Site.

3.0 SERVICING

3.1 Demolition

Based on historical aerial imagery, the farms and quarry within the Site were established sometime in the late 1960's and early 1970's. Consideration should be had that there may be asbestos containing construction materials within the building. A hazardous materials assessment should be undertaken to determine if hazardous materials are present and should be removed appropriately prior to any demolition works.

3.2 Earthworks

The geotechnical investigation notes that where clayey soils are encountered at depths between 0.5m to 1m, the site will have a classification of Class S in accordance with AS 2870-2001. For locations that have fill (generally the north-eastern part of the site), thes should be considered Class P in the absence of any certification from those controlling the placement of fill.

---

[7] Bayley Environmental Services, *Lots 202 & 202 Wandena Road and Lots 204 & 205 Great Northern Highway Chittering Local Water Management Strategy* (draft, 2 February 2021)
[8] Department of Water and Environmental Regulations, *Perth Groundwater Map,* viewed 24 April 2020, < https://www.water.wa.gov.au/maps-and-data/maps/perth-groundwater-atlas>
[9] Department of Water and Environmental Regulation, *Water Information Reporting,* viewed 24 April 2020, < http://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx>
[10] Bowman & Associates Pty Ltd, *Groundwater monitoring report, lot 202 & 203, Wandena Road, Muchea,* December 2016
[11] Department of Water and Environmental Regulation, *Contaminated Sites Database,* viewed 24 April 2020, < https://www.der.wa.gov.au/your-environment/contaminated-sites>

To achieve a Class A site classification, the investigation notes that 1.8m of non-reactive soils (e.g. sandy soils) would be required over reactive clay, which would generally require the placement of 1m of granular non-reactive fill. Reference should be made to the geotechnical investigation and LWMS during the subdivisional detailed design phase and built-form design works to inform site preparation requirements.

In general terms, earthworks during the subdivisional works will be undertaken to satisfy the requirements of the roadworks, road drainage, and limited earthworks within lots to provide appropriate grades/access. Isolated 'pad' earthworks and leveling are expected to be undertaken as part of the built-form works for individual lots to facilitate proposed structures, hardstands, lot drainage, and the on-site wastewater management disposal systems.

Typically for industrial development, level, and near-flat levels lots or 'pads' are desired as it offers the greatest flexibility. The IPWEA subdivisional guidelines[12] note that the maximum grade across industrial lots shall not exceed 6.67% (one in 15). The western half of the site has natural surface grades up to 3%, whereby the eastern portion is relatively steep with grades up to approximately 10%.

3.3 Roadworks

The draft Structure Plan for the Muchea Industrial Park notes Restricted Access Vehicle category 10 (RAV10) roads being Great Northern Highway and a proposed District Loop Road intersecting the site at approximately the midpoint and continuing to Great Northern Highway as shown in **Figure 3**.

Porter Consulting Engineers has prepared a separate Traffic Impact Statement (TIS) which assesses the anticipated traffic generation and movements for the development, and review road and intersection requirements. Reference should be made to the TIS which will discuss the road requirements in greater detail.

Consideration should be made to have the intersection by lots 36 and 41 wholly contained within the site boundary, so that at the time of constructing this intersection it is not encumbered with the need to obtain approval from the neighbouring land owner to the south, to access their land. A slight adjustment to the Road 7 boundary line northwards would resolve this.

[12] Institute of Public Works Engineering Australasia, *Local Government Guidelines for Subdivisional Development*, November 2017 (Edition 2.3)

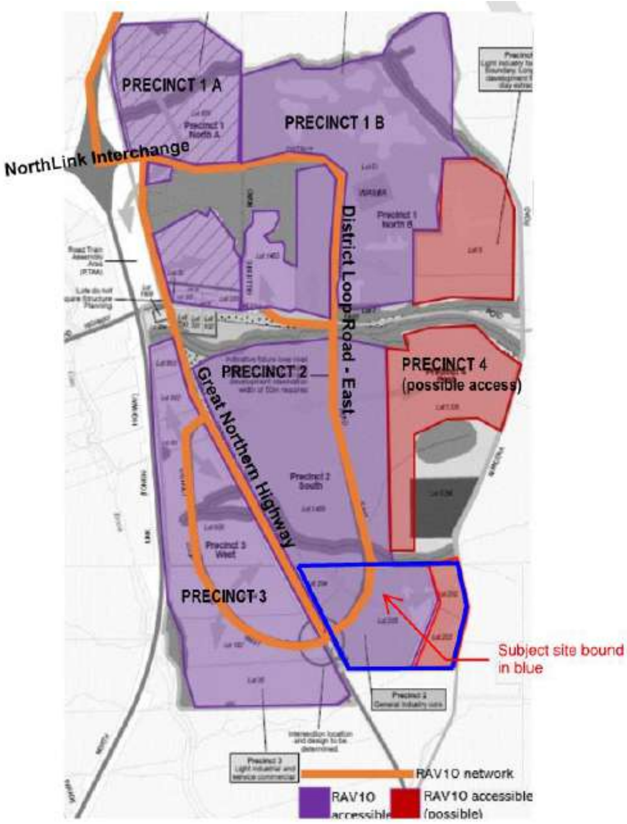


Figure 3: Proposed RAV10 network

3.4 Stormwater Drainage

<u>Lot Drainage</u>

The LWMS notes that runoff from roofs, paved surfaces, and hardstand areas within private lots from storms up to 1-year ARI 1-hour duration (about 15mm) will be retained and infiltrated within each lot by soakwells, basins or swales, and/or landscaping areas and will be subject to detailed designs for each individual lot.

The in-lot drainage structures, detention basins/ bioretention swales will be sized to capture and detain the runoff from roofs, paved surfaces, and hardstand areas from critical storms up to the 100-year ARI. Overflows from the lot basin/swales will egress into roadside swales, either directly or via drainage easements (nominally 10m wide) for those lots that do not have a downstream road frontage. Swales or bunding may be created within the easements as necessary to direct overflows, and would be constructed as part of the subdivisional works.

<u>Internal Road Drainage</u>

As noted in the LWAMS, Runoff from proposed road reserves up to the 1-year ARI 1-hour storm will be retained and infiltrated in roadside swales. The swales will be constructed with low internal weir/check dams at set heights to capture the 1-year ARI, 1-hour storm.

Road runoff from larger storms will overtop the internal weir/check dams and flow along the swales to the western boundary, where it will enter the roadside drains and culverts under Great Northern Highway, at rates and flows no greater than the pre-development. The LWMS tabulates the expected 100-year flows from the road reserves. As post-development flows will be limited to pre-development, the existing culverts by Great Northern Highway will have sufficient capacity.

Attachment 3 illustrates the drainage concept, lot drainage examples and conceptual roadside swales from the LWMS.

3.5 Electrical

There are existing high voltage overhead powerline along the eastern verge of Great Northern Highway and also an overhead line intersecting the Site in an east-west direction. It is expected that this HV east-west line will need to be relocated into proposed road reserves as part of the subdivisional works so as not to constrain development of individual lots. Consideration should also be made to arranging a Western Power Feasibility Study to investigate options for this line and also provide an estimated cost for the relocation works.

At the north-west corner of the site there is a fenced compound that appears to be a possible HV capacitor bank or line protection kit which is contained within its own small lot and separate from the development. It is expected that this compound is required to remain.

Based on the Western Power Network Capacity Mapping Tool[13], capacity is forecast at 25-30 MVA capacity in 2021 and drops to 20-25 MVA in 2036. Although there appears to be sufficient capacity in the network beyond 2021, the feasibility for the Site can only be confirmed with a more detailed assessment. This is usually undertaken by Western Power when a Feasibility Study is requested or via a Design Information Package during the detailed design phase.

3.6 Communications

There are existing Telstra assets in Great Northern Highway, with cabling that serves the various farm buildings and assets located in the eastern verge of Wandena Road.

Based on the NBN Rollout-map[14], NBN Fixed Wireless technology was forecast to be available to the area from June 2020 to service the development.

3.7 Gas

As noted in the Structure Plan, there is no existing gas infrastructure in the area. In the vicinity of Muchea, the Dampier to Bunbury natural gas pipeline lies to the west of Brand Highway. There are no current plans to extend gas infrastructure to the Structure Plan area.

Should a gas supply be required, a pressure-reducing station connection from the Dampier to Bunbury natural gas pipeline would be required with an estimated cost of $1 to $1.5 million plus the costs to bring reticulated gas to the development.

[13] Western Power, *Network Capacity Mapping Too,* viewed 24 April 2020, < https://westernpower.com.au/industry/calculators-tools/network-capacity-mapping-tool/>
[14] NBN, *Rollout-map,* viewed 24 April 2020, < https://www.nbnco.com.au/learn/rollout-map>

3.8 Wastewater

As noted in the Structure Plan, the majority of Muchea Industrial Park, including the proposed development area lies within a sewerage sensitive area due to its location within the Swan-Canning River estuary catchment.

There is currently no reticulated wastewater networks in the immediate area, with the nearest Water Corporation sewer infrastructure located some 6km to the south. The Corporation does not have current plans to expand the network.

The geotechnical investigation considered the site suitable for on-site disposal of effluent produced by secondary treatment systems. Localised filling and recontouring during the built-form works may be required to some individual lots to facilitate on-site effluent disposal systems.

The Government Sewerage Policy[15] outlines acceptable standards for alternative wastewater disposal, mainly through the use of Aerobic Treatment Units (ATU's) for secondary treatment systems with nutrient removal. The Policy notes that lot sizes within sewerage sensitive areas are to be a minimum one hectare in size. The concept plan for the proposed development satisfies this minimum lot area.

The arrangement of the wastewater disposal system will be guided by the *Government Sewerage Policy*. All on-site wastewater treatment systems require the provision of adequate nutrient removal capability, clearance to groundwater, and ongoing maintenance by lot owners, to ensure they are working correctly and providing the necessary level of treatment before discharging wastewater to the local environment. All systems should meet the requirements of the Shire and Department of Health (DoH) as part of the approvals and monitoring process.

Industrial operators are expected to manage their own trade waste by either onsite or offsite disposal. The suitability of on-site disposal will depend on hazardous materials onsite, the risks posed, and likely failure mode of the primary containment, and pathways to downstream environments.

3.9 Water

There is currently no reticulated water supply network in the immediate area, with the Water Corporation's nearest scheme water infrastructure located approximately 7.2km to the south, at the intersection of Great Northern Highway and North Avenue in Bullsbrook. The Corporation does not have current plans to expand the network. Water supply to existing properties in the area comes from groundwater and rainwater harvesting.

The Structure Plan[16] notes *"Groundwater resources for reticulated water supply for the Shire are either fully allocated or approaching full allocation, although, there is a limited local groundwater allowance through private companies and options for the purchase of water entitlements outside the industrial park. The surficial aquifer in the Eclipse Hill subarea, located east of Great Northern Highway and Old Gingin Road, has approximately 1.9 GL of unallocated volume per annum (as of October 2018).*

[15] Western Australian Planning Commission, 2019, *Government Sewerage Policy,* Western Australia Planning Commission, Perth

[16] *Muchea Industrial Park Structure Plan, Draft for Stakeholders Review*, December 2019

Without a water allocation for public drinking water purposes, the most efficient and cost-effective way to deliver a reticulated water supply to the industrial park is via water trading with a third party who has a suitable existing licence, or the ability to obtain a suitable allocation amount through trading. Under the current Rights in Water and Irrigation Act 1914, landholders who hold water allocation licences in fully allocated areas can trade or transfer all or part of their allocation, provided water policy requirements can be met. Trades and agreements can only take place within the same water resource (i.e. same groundwater sub-area and aquifer or same surface water area).

Two water service providers have begun the process of gaining approval to provide a reticulated service in the industrial park from groundwater as the supply source. As of late 2019, the most advanced is in development by Aqua Ferre, which includes construction of a water treatment facility on Lot 2 Reserve Road as part of a proposed 250 lot residential development. Aqua Ferra is applying for a Water Service Provider Licence from the Economic Regulation Authority. The project proposes drawing water from the Leederville Aquifer, with treatment to meet drinking water quality guidelines. The successful provider will be the one that can offer the best outcome for the developers and secure an allocation from DWER and a water services operating licence from the ERA".

Porter Consulting Engineers has made contact with the two water service providers identified (Aqua Ferra Pty Ltd trading as Muchea Water and Chittering Valley Irrigators Pty Ltd) with their contact details noted in **Attachment 4**.

During a telephone discussion with Aqua Ferra[17], it was reported that they have secured a licence as of February 2020 to supply potable water to the Muchea Employment Node, with a recently installed portion of the network within Precinct 1 expected to become live in May 2020. The water supply network is being designed and installed in accordance with the Water Corporation's standards. Aqua Ferra indicated that the proposed development area is likely to be serviceable however this will be confirmed when estimated water demands are provided to them. It is understood discussions with Aqua Ferra and the Developer are ongoing.

An estimate of the water demand is presented in **Table 1.** Three water demand estimates have been derived, one estimate is based on a similar industrial development which utilised 4.0 kL/Ha/day, yielding an estimated demand of 97,400kL per annum. Another estimate has been prepared to be consistent with the Water Corporation's design standard DS50 which is based on 14.967 kL/Ha/day, yielding a significantly higher demand of 364,300kL per annum. As noted in the LWMS, the Shire of Chittering Town Planning Scheme No.6 limits wastewater generation in industrial zones to 5,400 litres per hectare per day, and assuming all potable water used will ultimately become wastewater this yields a demand of 131,403 KL per annum. All three estimate values should be forwarded to the Water Provider for consideration to service the development.

Additional water demand allowances should be made for irrigation of landscape planting and swales, assuming the DWER default rate of 4,500 KL/Ha/year, typically to occur for one or two years during the plant establishment phase.

[17] Mr P. Fogharty 2002, pers. Comm, 7 April)

Table 1: Estimated Water Demand

Stage	Gross Area	Approx Net Area (after deduction of roads and drainage reserve)	Estimated Water Demand (kL/per annum)	*Comparative Water Corp Design Standard (kL/ per annum)*	*Shire of Chittering Town Planning Scheme No.6 (kl/per annum)*	Comments on Land Use
	Ha	Ha (Refer Note 1)	Per Area (Refer Note 2 & 3)	*(Refer note 4)*	*(Refer note 5)*	
Full extent of the development, 38 lots proposed, as per Element drawing 19-545 A, 9 February 2021	79.5	67	97,400	364,300	131,403	Assumed Industry - general, light, rural and service (40%); Builders storage yard (10%); community purpose(1%); garden centre/plant nursery(2%); landscape supplies(1%); motor vehicle repair (2%); roadhouse (1%); showroom (3%); storage/warehouse (10%); transport depot (30%)

Assumptions:

1. Net area represents total area of industrial lots. An area of approximately 2Ha has been assumed for drainage easements which is consistent with the extent of easements shown in the LWMS.
2. Demand based on study done by GHD for Karratha Gap Ridge Industrial Estate, which is anticipated to have similar industry types and uses.
3. Estimated demand for both sewer and water supply =4.0 kL/Ha/day
4. Note comparative Water Corporation design standard (DS50) = 14.967 kL/Ha/day
5. As noted in the LWMS, Shire of Chittering Town Planning Scheme No.6 limits wastewater generation in industrial zones to 5,400 L/Ha/ day. Calculation noted above is based on assuming all potable water used will ultimately become wastewater.
6. Additional water demand allowances should be made for irrigation of landscape planting and swales, assuming the DWER default rate of 4,500 KL/Ha/year, typically to occur for one or two years during the plant establishment phase.

4.0 CONCLUSION

Based on the information reviewed, there does not appear to be any factor that would prevent the proposed industrial development. However, this high level servicing report notes a number of issues that require further consideration and investigations these include but are not limited to:

i. Resolve the planning matters including traffic related matters raised in Porter Consulting Engineers Traffic Impact Assessment.

ii. A feature survey including surrounding roads to inform ongoing planning, design, and investigations.

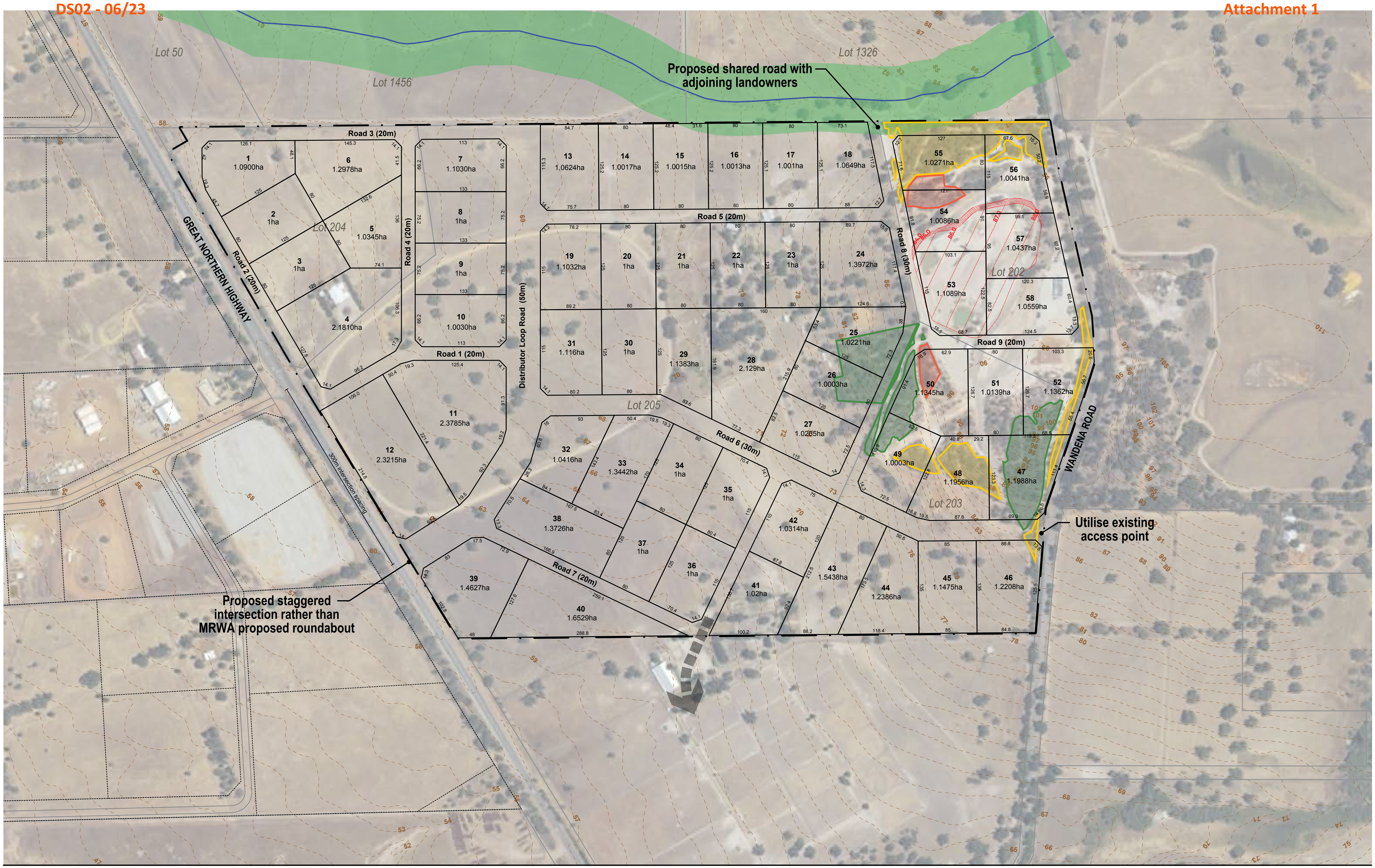
iii. A Hazardous Materials investigation for the possible presence of hazardous materials within the existing structures for demolition.

iv. Provide an estimated water demand for the development and initiate early discussions with Aqua Ferra to facilitate a secure water supply and allocation.

v. A Western Power Feasibility Study to confirm the electrical servicing to the site and also consideration for the relocation of the east-west line. Western Power typically charge $5,000 plus GST for feasibility studies.

vi. Seek to have the intersection by lot 36 and 41 wholly within the site boundary. A slight adjustment to the Road 7 boundary line northwards would resolve this.

ATTACHMENT 1 – Concept Subdivisional Layout Plan



Concept Plan

Lots 202-203 Wandena Road & Lots 204-205 Great Northern Highway, Muchea

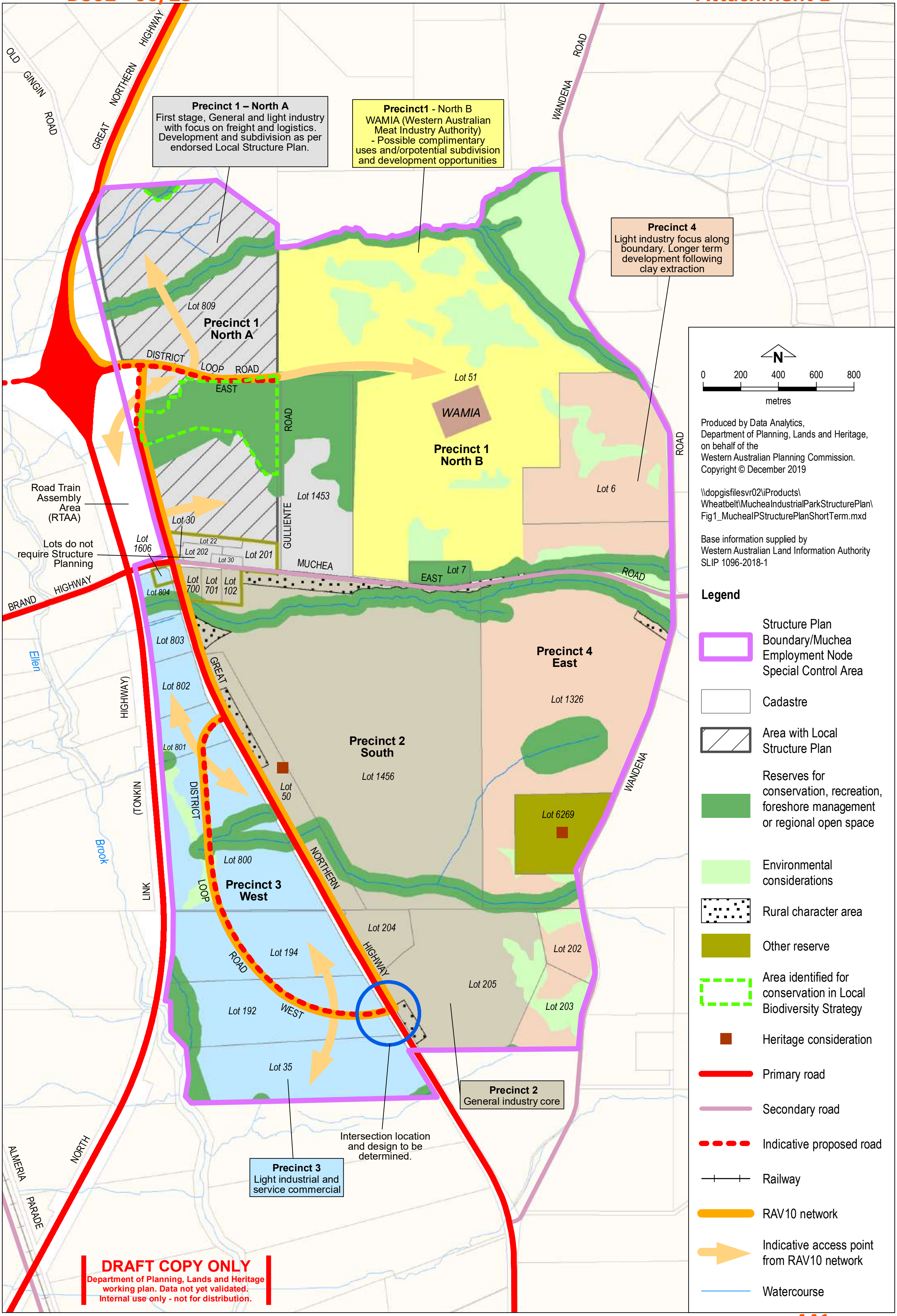
Date: 9 February 2021 | 1:5000@ A3 | 1:2500 @ A1 | 19-545 | A | Staff: MR LC | Checked: MR

0 50 100m

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 I E. hello@elementwa.com.au elementwa.com.au

ATTACHMENT 2 – Structure Plan Map



Structure plan map (short term) - indicative RAV10 network

ATTACHMENT 3 – Drainage Concept Plan and Lot Drainage Examples

- Drainage concept[18]
- Lot drainage example[19]
- Conceptual roadside swale profile[20]

[18] Extract from LWMS
[19] Extract from LWMS
[20] Extract from LWMS

DS02 - 06/23

Attachment 1

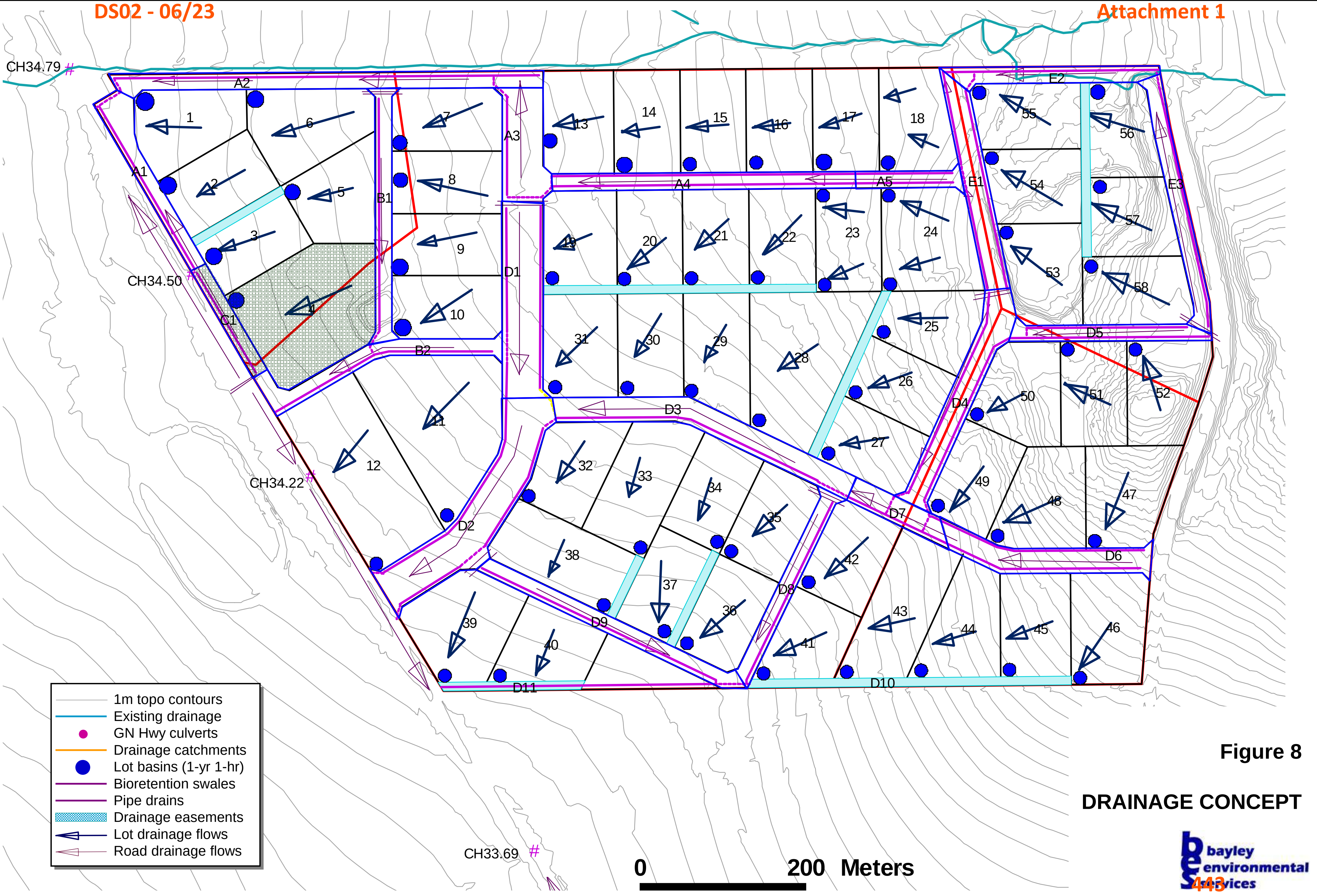


Figure 8

DRAINAGE CONCEPT

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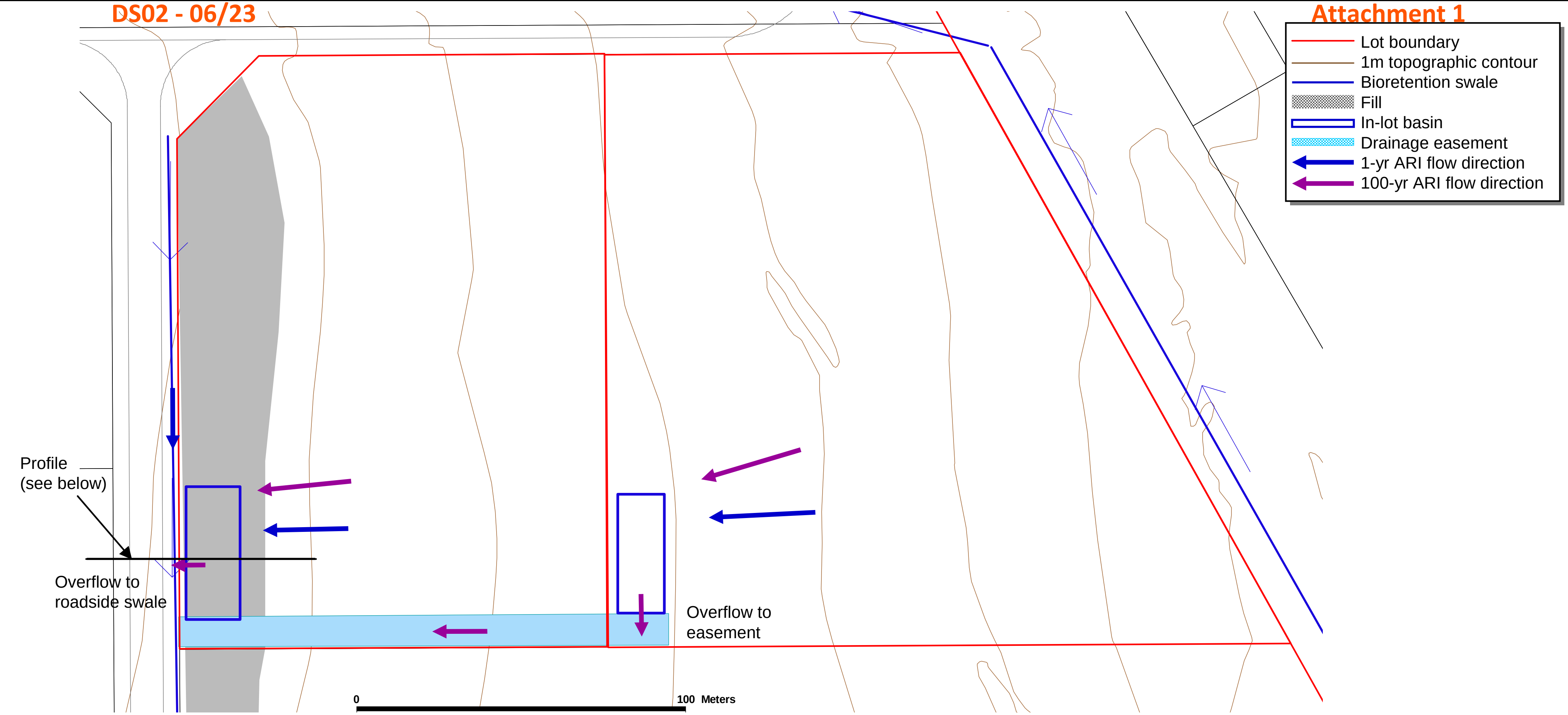
Attachment 1



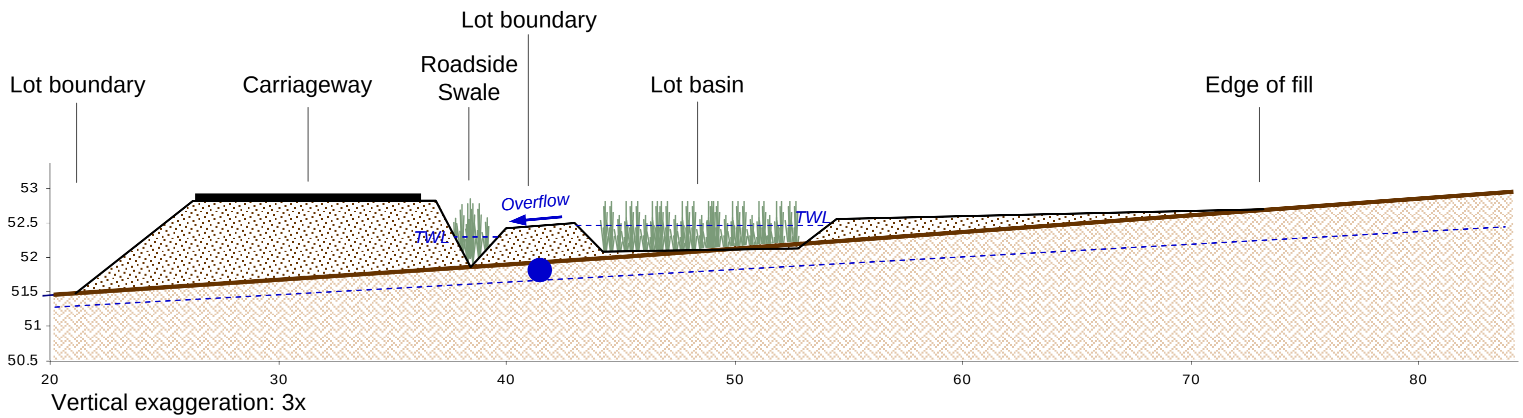


Figure 9

LOT DRAINAGE EXAMPLES

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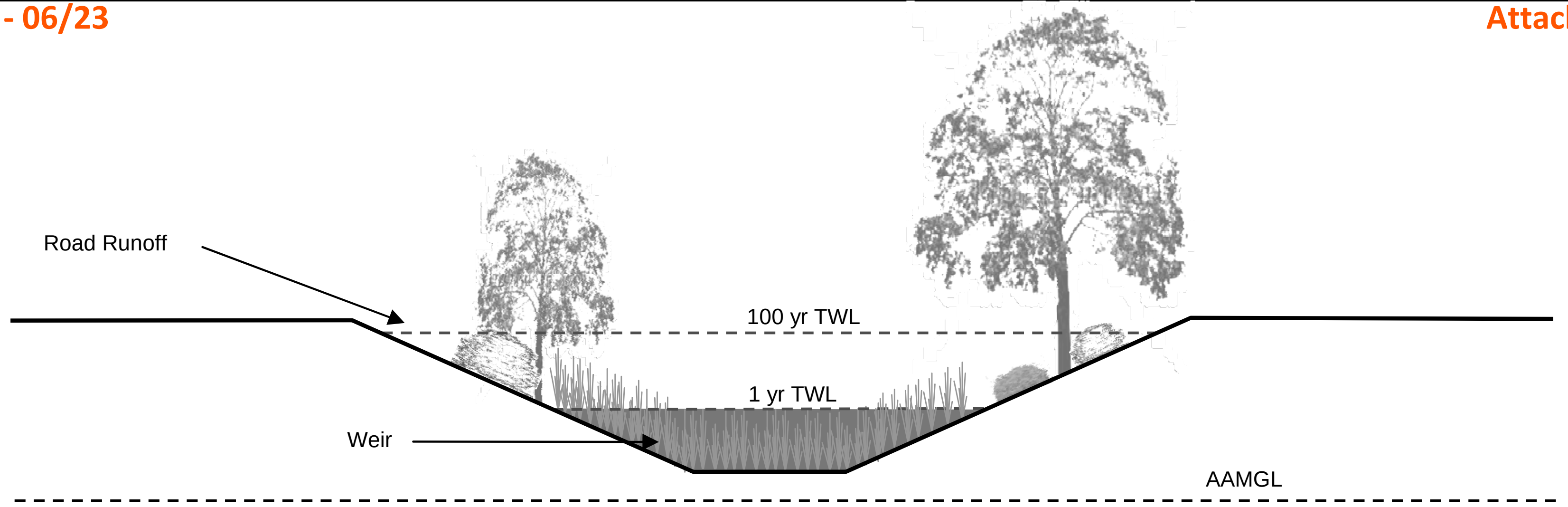

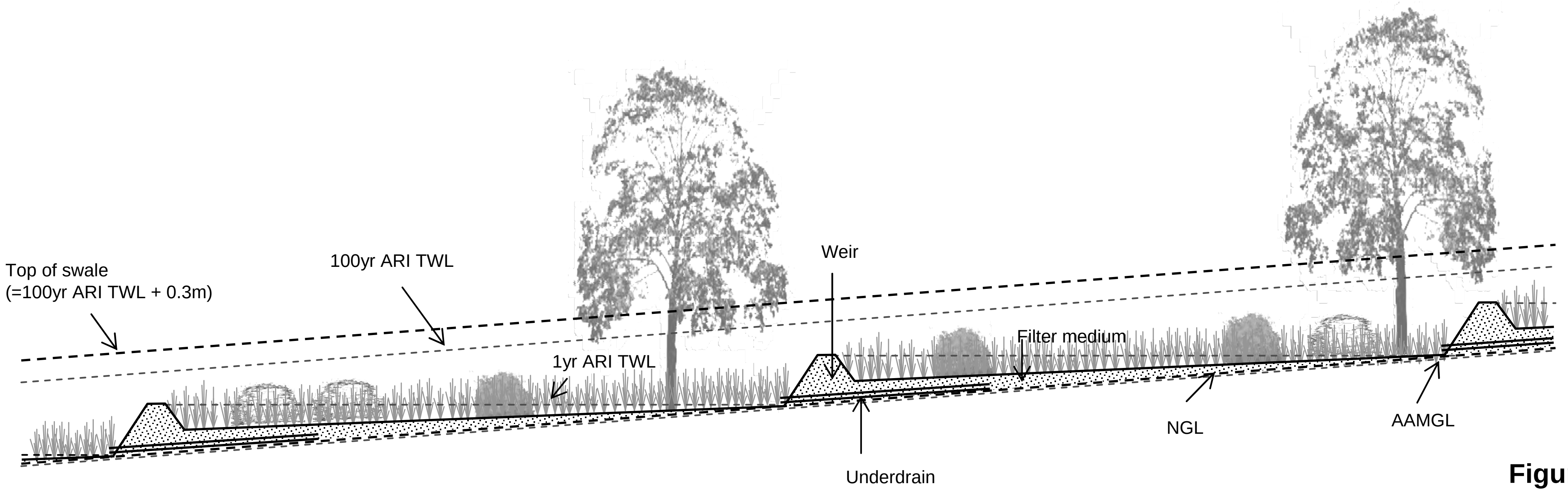

Figure 10

CONCEPTUAL SWALE PROFILES

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ATTACHMENT 4 – Water Service Provider Contact Details

Business Name:	Aqua Ferra Pty Ltd trading as Muchea Water
Contact Person:	Peter Fogharty
Email:	pf@pendulumgroup.com.au
Phone/Mobile:	0411 120 519

Business Name:	Chittering Valley Irrigators Pty Ltd
Contact Person:	Clint O’Neil
Email:	coneil@bigpond.com
Phone/Mobile:	(08) 9571 8058

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Appendix G

Traffic Impact Assessment

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TRAFFIC REPORT

LOTS 202, 203 WANDENA ROAD AND LOTS 204, 205 GREAT NORTHERN HIGHWAY LOCAL STRUCTURE PLAN

Porter

CONTENTS

1.0 INTRODUCTION

1.1 Background

Porter Consulting Engineers has been engaged to prepare a Transport Impact Statement (TIS) for the local structure plan of Lots 202-203 Wandena Road and Lots 204-205 Great Northern Highway, Muchea in the Shire of Chittering. The Site comprises of the creation of 58 industrial lots typically with a lot size of 1 hectare.

A copy of the Structure Plan layout is included in **Appendix A.**

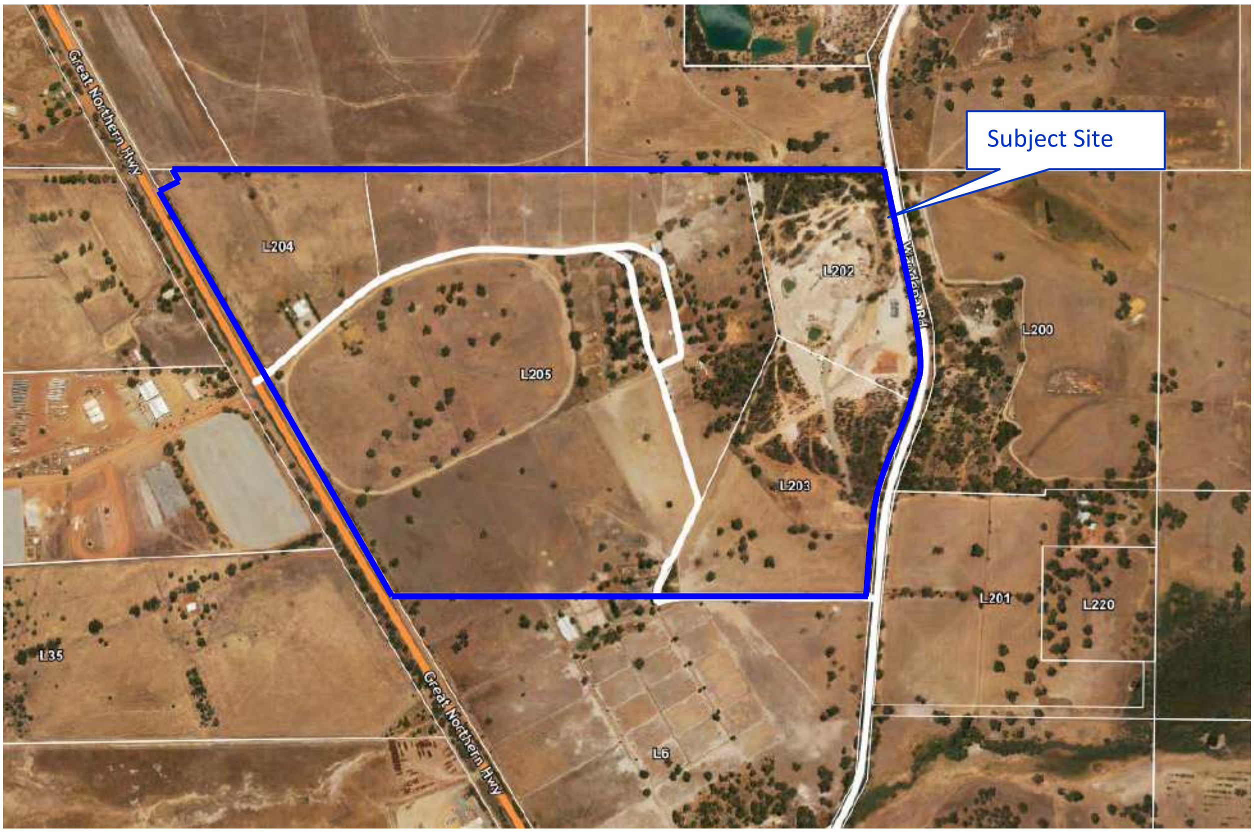


Figure 1.1: Structure Plan Lots

1.2 Scope of Assessment

The intent of this statement is to provide the approving authority with sufficient traffic information to confirm that the proponent has adequately considered the traffic aspects of the development.

2.0 STRUCTURE PLAN PROPOSAL

2.1 Structure Plan Context

The Site is bounded on the west by Great Northern Highway and on the east by Wandena Road, in Muchea within the Shire of Chittering.

The Site comprises of a number of large land holdings primarily of agricultural land uses i.e. i.e. Scenic Lodge Thoroughbred Farm, CD Tractors and industrial land uses i.e. Swan Recycling. **Figure 2.1** shows an aerial view of the Site and its immediate surrounds and its location in a local context.

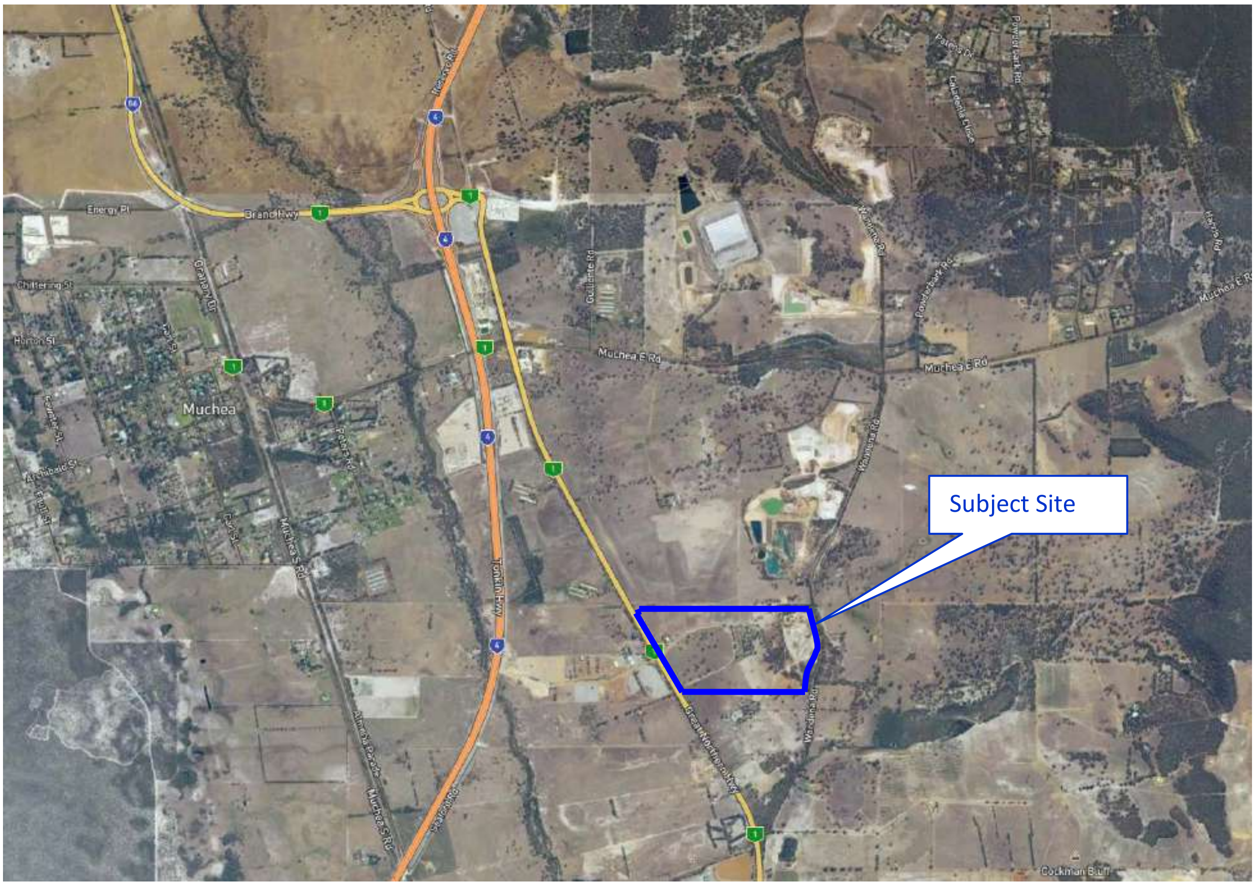


Figure 2.1: Location in a Local Context

The Site is situated approximately 5km southeast of the Muchea Townsite, 9km to the north of Bullsbrook, 35km north of Midland and 52km northeast of the Perth CBD. Major regional roads within close proximity include Great Northern Highway and the Tonkin Highway extension (Northlink). **Figure 2.2** shows the Site in a regional context.

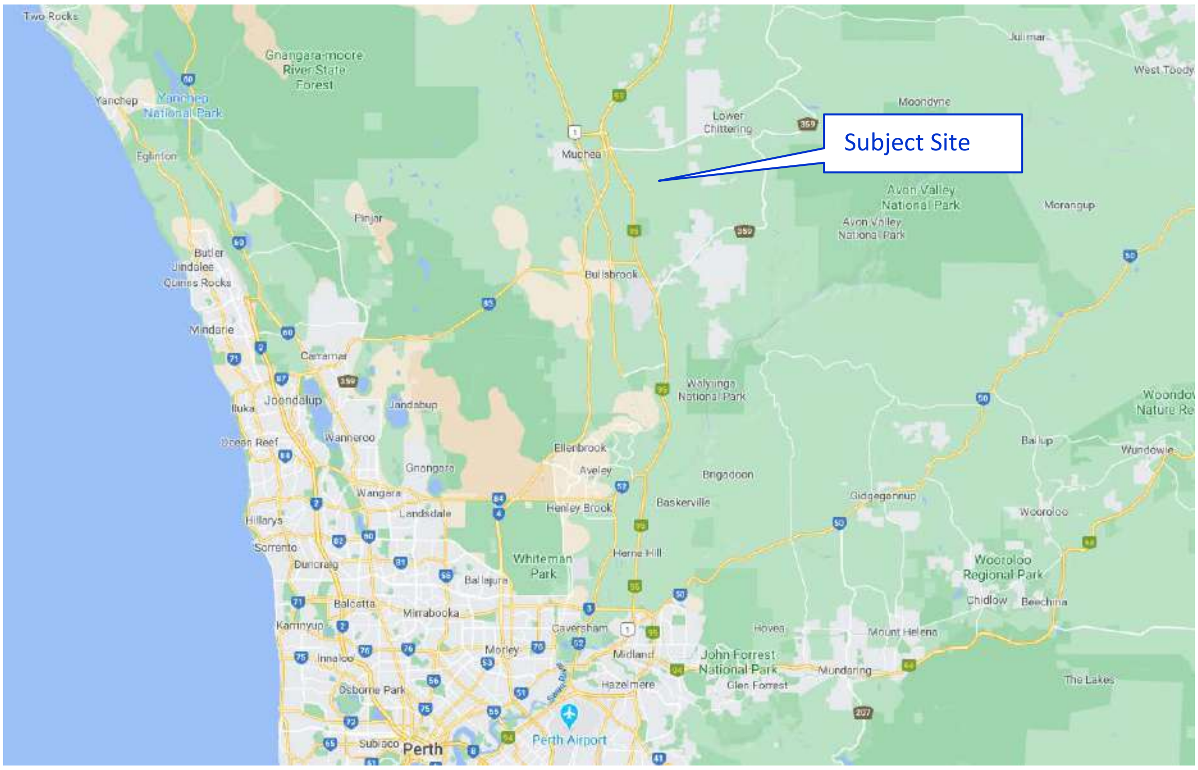


Figure 2.2: Location in a Regional Context

2.2 District Structure Plan

This local structure plan forms part of the broader area commonly referred to as the Muchea Employment Node Structure Plan. (MENSP). A district structure plan has been prepared for the MEN. The initial MENSP was prepared in August 2011. Since then the draft Muchea Industrial Park Structure Plan (MIPSP) for Stakeholder review has been prepared in December 2019.

The Muchea Industrial Park comprises of some 1,167 hectares to be developed over the next 20-30 years. The Industrial Park is intended to accommodate a range of land uses including freight and logistics, agribusiness, service based commercial, and industrial activities such as transport, livestock, fabrication, warehousing and wholesaling.

The Muchea Industrial Park has been divided into four precincts numbered 1 to 4. This Site forms part of Precinct 2 (Lots 204-205 Great Northern Highway) and Precinct 4 (Lots 202-203 Wandena Road). **Figure 2.3** outlines the Industrial Park as documented in the draft MIPSP. As demand for land within the Muchea Industrial Park is expected to be dominated by operators requiring access to a RAV10 road network, this structure plan presents a District Loop Road designed to accommodate RAV 10 vehicles.

The District Loop Road will ultimately service Precincts 1, 2 and 4 with a minimum of two connections to Great Northern Highway i.e. a northern and southern connection. Depending on staging of the various Precincts a third road connection from the District Loop Road to the Highway may also occur. The southern District Loop Road intersection with Great Northern Highway is located within the Site.

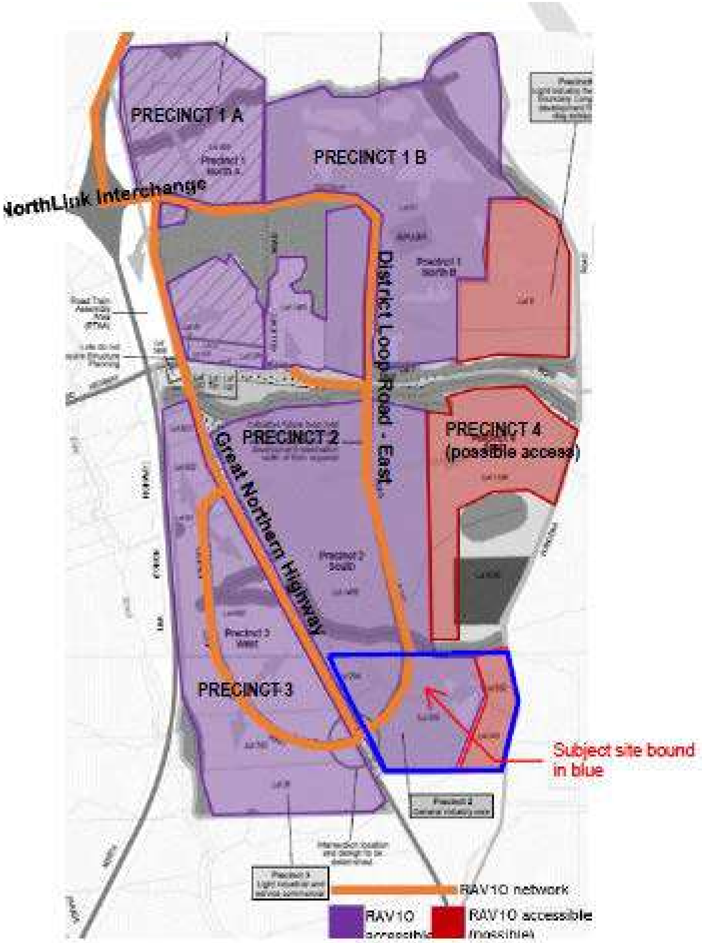


Figure 2.3: Muchea Industrial Park Structure Plan Area

2.3 Proposed Land Uses

Based on the indicative lot layout a total of 58 industrial lots are proposed typically with a lot size of 1 hectare (say 80mx 125m). The total area is approximately 68 hectares.

It is noted that the draft MIPSP informs that typically for RAV 10 access the minimum lot size is likely to be approximately 4.1hectares (i.e. 394m x 197m) or 2.5hectares (i.e. 159m x 197m) based on providing internal straight sections for unloading, decoupling and general operation. Based on the proposed lot layout and sizes within the local structure plan it is likely that adjacent lots will need to be purchased if RAV 10 access is required.

The local structure plan proposes industrial zoning which is consistent with both the MENSP and draft MIPSP.

2.4 Major Attractors and Generators of Traffic

Due to the nature of the proposed industrial structure plan it is likely to become a major employment attractor from surrounding areas.

3.0 ROAD NETWORK SITUATION

3.1 Existing Road Network

Figure 3.1 illustrates the road network within approximately 2 kilometres surrounding the Site. Due to the existing agricultural nature of the subject site the existing road network is not expansive. The Site is bordered by two existing roads, being Great Northern Highway (western boundary) and Wandena Road (eastern boundary).

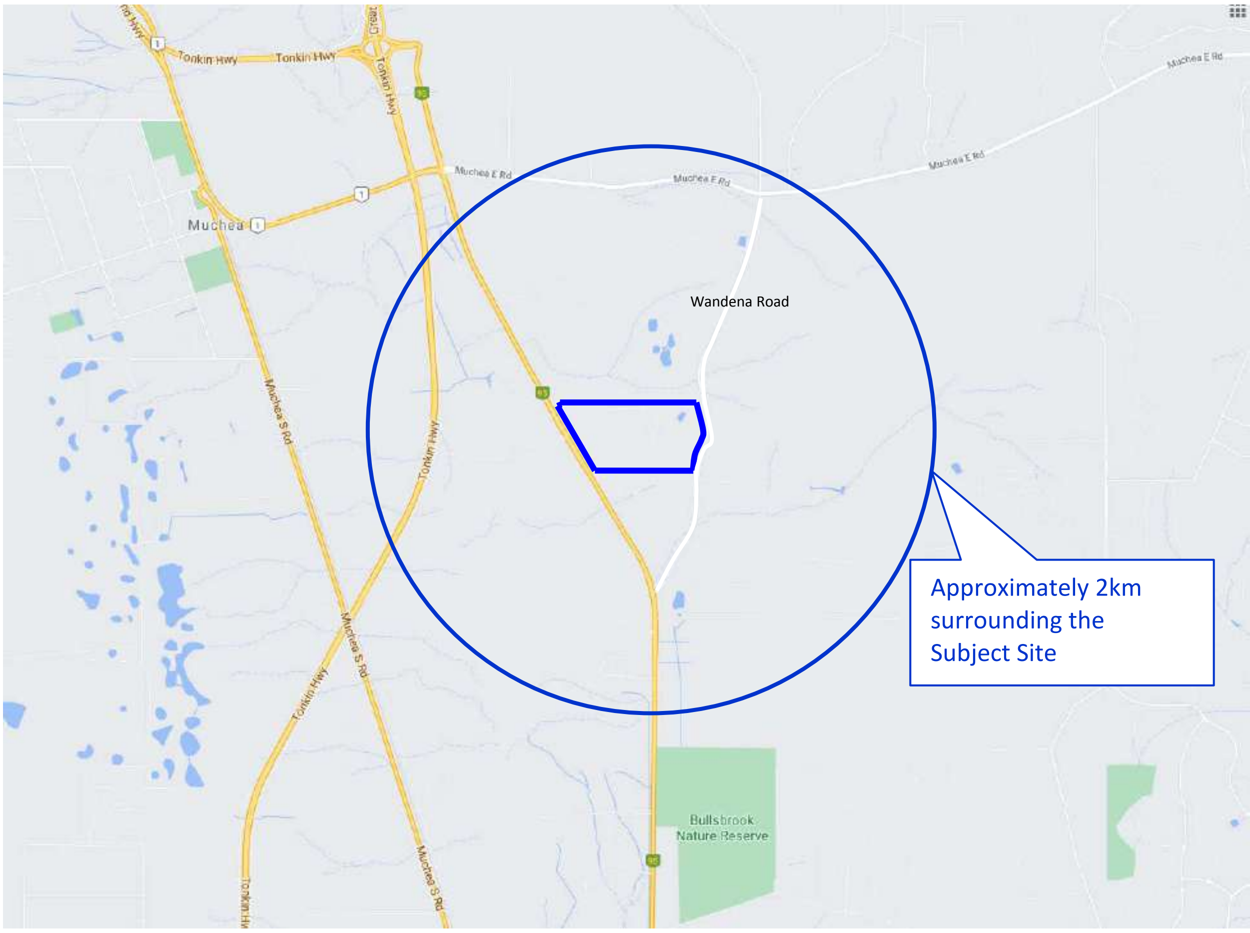


Figure 3.1: Existing Surrounding Road Network

3.2 Road Infrastructure and Road Hierarchy Classification

The road hierarchy classification of the surrounding road network as defined by Main Roads WA functional road hierarchy is shown in **Figure 3.2**.

Figure 3.2 Functional Road Hierarchy (MRWA)

Great Northern Highway

Great Northern Highway forms part of the Primary Distributor Road network and as such is controlled by Main Roads. By definition its function is to "*provide for major regional and inter-regional traffic movement and carry large volumes of generally fast moving traffic.*" This road runs in a north south direction and forms the western boundary of the Site.

The Highway at this location is constructed to a two lane undivided standard with a typical width of 7.2m plus sealed shoulders either side. The section of Highway in vicinity of the Site also includes overtaking lanes for both the southbound (1.2km in length) and northbound (800m in length) traffic. The existing sign posted speed limit along this section of Highway is 110km/hr.

Wandena Road

Wandena Road is a Local Distributor road whose function is defined as being to "*carry traffic within a cell and link to District Distributors….. should discourage through traffic so that it only carries traffic belonging to or serving the area.*" This road is controlled by the Shire of Chittering.

This road runs in a north –south direction forming the minor road of the t-junction at its intersection with Great Northern Highway at both its northern and southern ends. Wandena Road is constructed to a two lane undivided road standard with centre line marking and is approximately 8.65 km in length. The road is subject to the default 110km/h speed limit that applies outside of built up areas.

Tonkin Highway – Northlink
The extension of Tonkin Highway from Reid Highway in Malaga to Great Northern Highway in Muchea, some 37 kilometres was completed in April 2020. This new route was designed to increase efficiency of the road movement network and support the development of the Industrial Park. This is road is defined as a Primary Distributor Road to "*provide for major regional and inter-regional traffic movement and carry large volumes of generally fast moving traffic.*" The road is constructed to a four lane divided standard running in a north south direction. It has a posted speed limit of 110km/h.

Muchea Road East
Muchea Road East is a Regional Distributor Road whose function is defined as being to "*link significant destinations and are designed for the efficient movement of people and goods within and beyond regional areas.*" This road is controlled by the Shire of Chittering. This road runs in an east west direction connecting to Granary Drive and Tonkin Highway at its western end and Chittering Road some 8.7km to the east. This road is constructed to a two lane undivided road standard with centre line markings. The speed limit varies from 80km/hr near Great Northern Highway and 1.5km eastwards transitioning to 100 km/hr prior to Wandena Road and further eastwards.

3.3 Existing Traffic Volumes

Table 1.1 shows the traffic flows recorded on the road network surrounding the development Site obtained from Main Roads WA traffic map website.

3.4 Crash History

A study of the recent crash history for Great Northern Highway and Wandena Road in the vicinity of the Site has been conducted for the five year period to the end of December 2019 from the Main Roads Western Australia Integrated Road Information System (IRIS) crash database. The database records the following crashes:

- 7 intersection crashes at Great Northern Highway and Wandena Road. Five crashes involving rear end crashes between vehicles turning left from Wandena Road onto Great Northern Highway with 4 of these crashes involving property damage and one crash resulting in medical attention being required. One crash was a hit object off the carriageway crash resulting in hospitilisation. The remaining crash resulted in minor property damage only.
- 7 midblock crashes occurred along Great Northern Highway between Wandena Road and the northern boundary of the Site. Five crashes were hit object single vehicle crashes. One midblock crash was a sideswipe crash involving northbound vehicles. One crash was a rear end crash. Six of these crashes resulted in major property damage and one resulted in hospitalisation.

Table 1.1: Recorded Traffic Volumes on the Surrounding Road Network

Location	Date	AWT (veh/day)	Heavy Vehicles (%)	85% Speed (km/h)
Great Northern Highway, north of Wandena Road, SLK 34.5	Sept 2020	2,268 1,331 (N) 938(S)	30.8	
Great Northern Highway, north of Wandena Road, SLK 33.5	2018/19	7,512 3,649 (N) 3,863 (S)	30.4	107
Great Northern Highway, south of Wandena Road SLK 32.71	2015/16	9,014 4,387 (N) 4,627 (S)	27.0	112
Wandena Road, east of Great Northern Highway SLK 0.41	2015/16	2,347 1,169 (N) 1,178 (S)	18.4	100
Wandena Road, south of Muchea Road East SLK 2.6	2015/16	2,199 1,102 (N) 1,097 (S)	39.0	106
Muchea Road East, west of Wandena Road SLK 6.2	2015/16	544 254 (E) 290 (W)	52	138
Muchea Road East, east of Great Northern Hgihway SLK 8.38	2018/19	794 389 (E) 405 (W)	20.8	89.2
Brand Highway, west of Great Northern Highway SLK 0.5	2014/15	3,891 1,937 (E) 1,954 (W)	26.4	88.3
Great Northern Highway, north of Old Gingin Road SLK 38.92	2015/16	4,226 2,000 (N) 2,226 (S)	25.6	100

3.5 RAV Network

The existing surrounding road network allows for the movements of Restricted Access Vehicles (RAV) as shown in **Figure 3.3.** Great Northern Highway and Wandena Road are currently classified as RAV 7 and RAV 2 networks respectively.

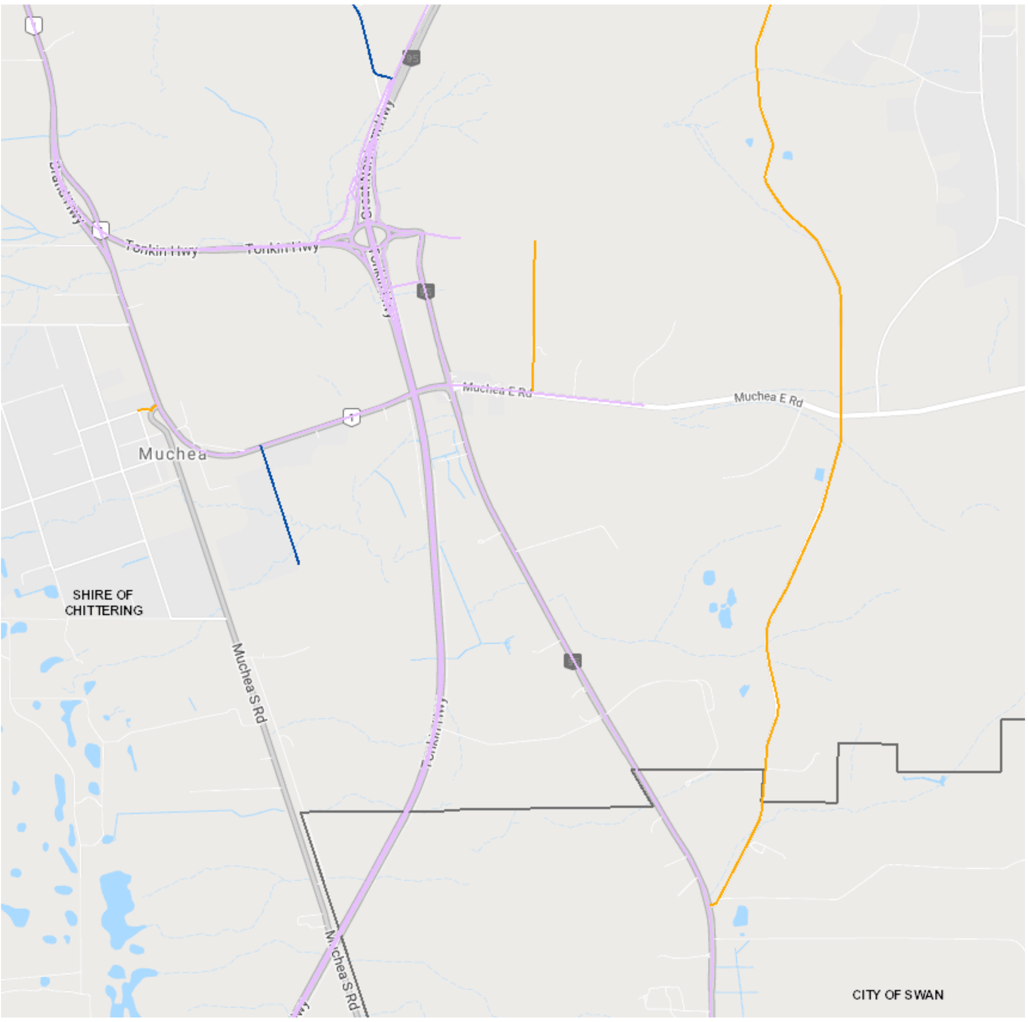


Figure 3.3. RAV Network (MRWA)

3.6 Public Transport

The MENSP indicates that public transport facilities have not been included within the overall structure plan due to the large scale industrial land uses proposed, that are likely to make the provision of feasible public transport difficult to achieve. It is noted however that the proposed road network designed to cater for trucks could readily accommodate bus routes if they were to be introduced in the future should the demand warrant services feasible.

3.7 Pedestrian and Cyclist Network

Due to the largely rural nature of the existing Site there are limited pedestrian and cyclist facilities. The MENSP indicates that no formal cycle or pedestrian facilities are provided in the overall structure plan as the large scale industrial land use would largely cause the provision of a pedestrian network futile. Where sealed shoulders are proposed cyclists could readily use this facility. At this stage there are no clear pedestrian desire lines within the Industrial Park.

4.0 ASSESSMENT OF VEHICULAR TRANSPORT NETWORK

4.1 Internal Road Network

The Site does not currently have any existing roads located within it. The Site only abuts Great Northern Highway to the west and Wandena Road to the east.

Road Hierarchy

The Site will include the southern portion of the District Loop Road as outlined in the MENSP/MIPSP. **Figure 4.1** shows this District Loop Road that would act as the main RAV 10 route through the eastern side of the Muchea Industrial Park servicing Precincts 1, 2 and 4. The draft MIPSP states that the District Loop Road is not to provide direct vehicle access to lots. For this reason if RAV 10 lots are to be provided internal roads should be designed for RAV 10 access. For example, Road 6 and/or Road 8 could be designed for RAV 10 vehicles thus providing RAV10 access to lots fronting these roads. The remaining roads within the Site are considered to be access roads and could be designed for smaller design vehicles such as a b –double as the development and lot demand requires. This is yet to be confirmed.

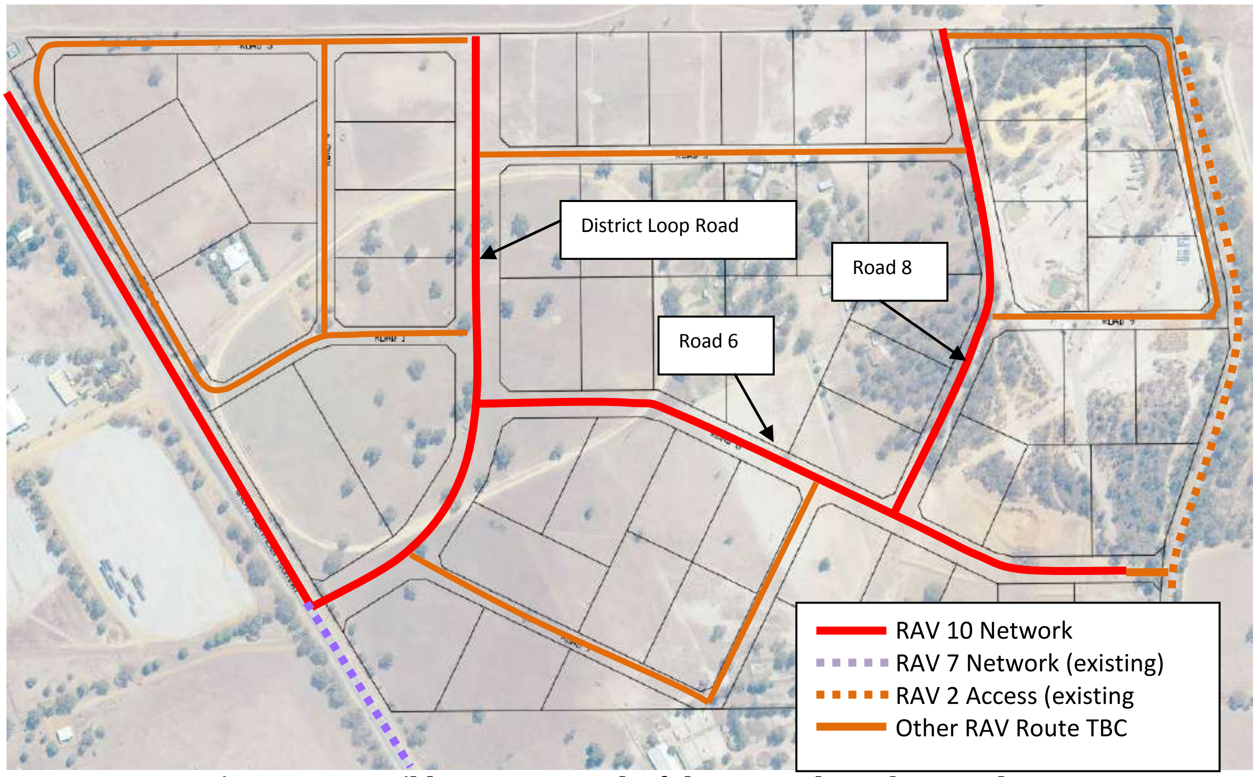


Figure 4.1: Possible RAV Network of the Internal Road Network

On district distributor roads, the priority is given to vehicle movement function over access. For this reason spacing of intersections is reduced compared to lower order road, to ensure that traffic flow is maintained with minimal disruptions. This also reduces the potential points of conflicts thereby improving safety. The layout proposes 5 internal intersections with the District Loop Road over a length of 700m. To prioritise vehicle movement function consideration should be given to restricting the turning vehicular movements at a number of intersections providing one intersection with full turning movements to service the area to the west of the District Loop Road and one intersection to service the area to the east. **(Figure 4.2)** This will result in the spacing of the two key intersections being approximately 400m. The permeability of the proposed internal road network layout will accommodate these vehicular movement restrictions.

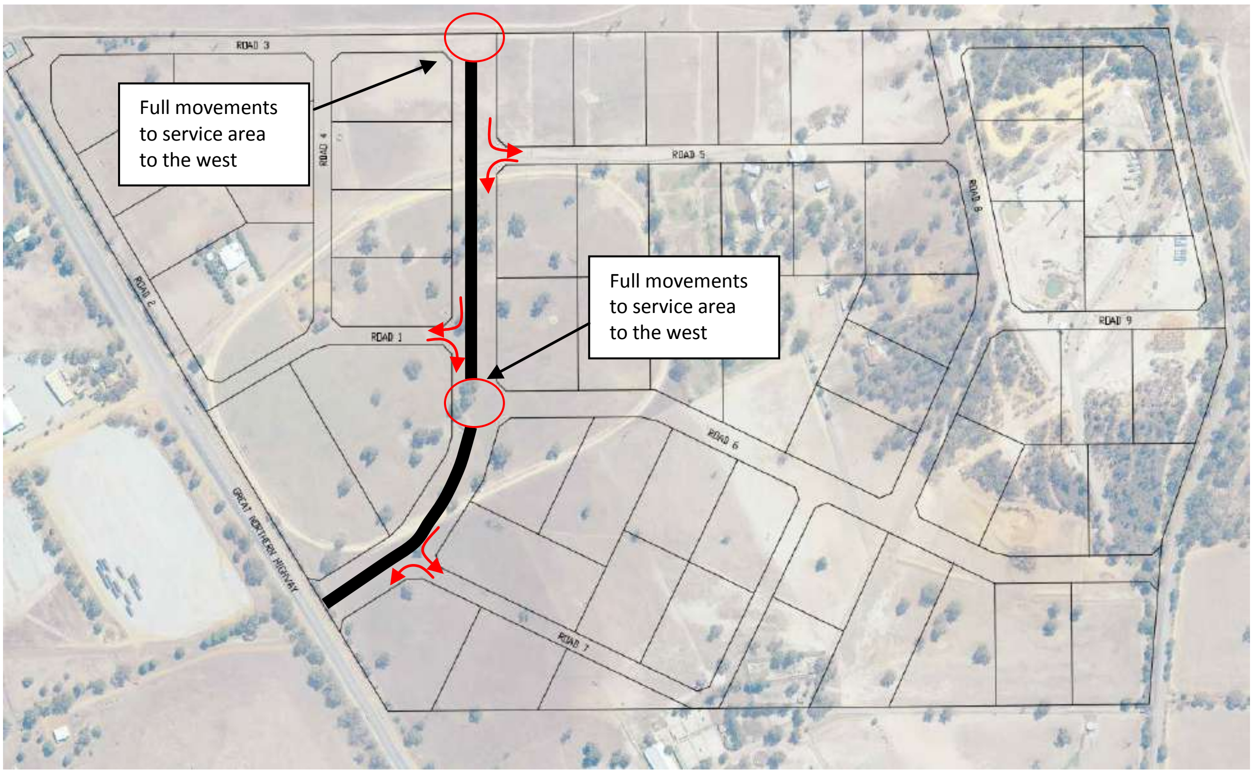


Figure 4.2 Indicative Intersection Configuration along District Distributor Loop Road

Road Reserve and Road Cross Section

The draft MIPSP outlines a 50m road reserve for the District Loop Road. The road reserve widths for the remaining roads within the local structure plan range from 20-30m. **(Figure 4.3)** The ultimate design will need to demonstrate that the road reserve is adequate to accommodate swept paths of the design vehicle (RAV 10 or smaller as proposed) at intersections, earthwork batters, public utilities as well as road drainage and swale requirements.

The District Loop Road cross section is proposed to comprise of 2 x3.5m traffic lanes plus 1.5m sealed shoulders with a 5m central median. The central median will accommodate queued right turning vehicles thus minimising the delay to through traffic in line with its role as a district distributor road.

Other internal roads propose either a 20 or 30m road reserve. In accordance with WAPC Development Control Policy 4.1 a minimum road reserve of 20m is required for industrial roads typically comprising of a 10m pavement. These local access internal roads within the Site are likely to carry less than 2,000 vehicles per day hence it would be considered appropriate to adopt a 10m wide pavement. (Please note that the entire Site only generates in the order of 2,200 vehicles per day)

The draft MIPSP recommends a road reserve width of 30m for access roads, to allow for the provision of roadside swales. Where a 20m road reserve is proposed, the stormwater drainage system will need to demonstrate it meets the necessary objectives of the relevant stormwater management and drainage requirements for the region.

A preliminary review indicates that standard 10x 10m wide truncations as currently shown are not necessarily adequate at intersections in order to allow for RAV10 vehicle access. **Appendix B** contains indicative concepts showing the swept paths of RAV 10 vehicles at some intersections indicating that truncations will need to be modified during the detailed design.

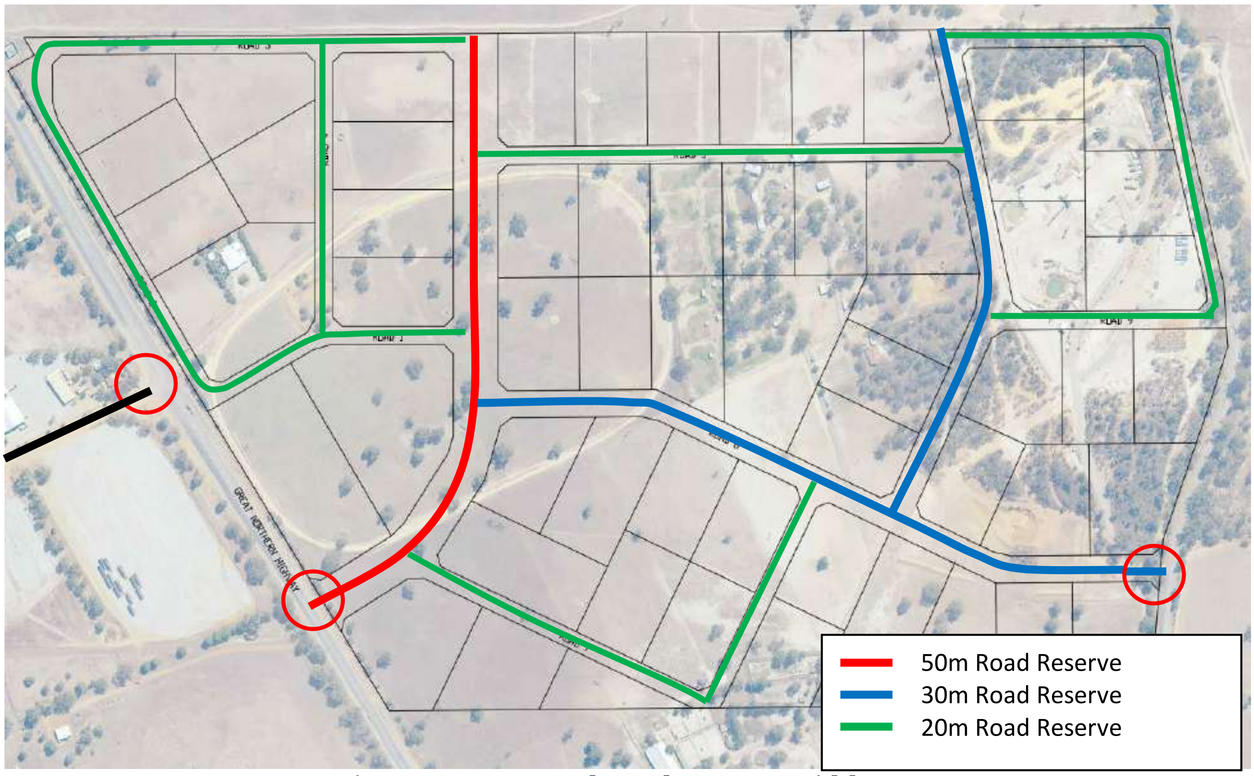


Figure 4.3: Proposed Road Reserve Widths

4.2 External Road Network

The proposed road network will result in the creation of two new intersections on the external road network; one on Great Northern Highway and the other on Wandena Road.

The draft MIPSP proposes a 4 way intersection on Great Northern Highway with the District Loop Road (this Site) and the Loop Road to Precinct 3 of the Industrial Park located on the western side of Great Northern Highway. This new 4 way intersection is proposed to be controlled via a roundabout. However, a staggered T-junction arrangement was proposed along Great Northern Highway within the MENSP for this intersection and not a roundabout.

Initial liaison with Main Roads WA has indicated that in principal there is no objection to a staggered T-junction arrangement instead of a 4 way roundabout as currently outlined in the draft MIPSP. The proposed staggered T-junction arrangement also aligns with the Local Structure Plan prepared for Precinct 3.

The proposed connection from the Site to Great Northern Highway has been positioned as close as practical to the southern end of the Site in order to maximise the staggered T separation distance. The staggered T-junction would create a right left stagger arrangement and as such the proposed intersection spacing of approximately 300m should be adequate.

Austroads *"Guide to Road Design Part 4A:Unsignalised and Signalised Intersections"* makes recommendation on the sightlines. Based on an operating speed of 110km/h the safe intersection sight distances (SISD) are 300m preferred (reaction time of 2.5 seconds) or 285m minimum (reaction time of 2.0 seconds). Whilst Great Northern Highway currently has a posted speed limit of 110km/h in the vicinity of the new intersection, it is likely that with full development of the Industrial Park the speed limit may be reduced to say 80-90km/h which will typically require reduced sight distances of 226m (preferred) and 214m (minimum). Google Streetview suggests that adequate sight lines will be available along Great Northern Highway in both directions at the proposed new intersection.

At present there is a southbound overtaking lane provided on this section of Great Northern Highway at the location of the proposed new intersection with the Site. Recent traffic counts in September 2020 indicate a considerable reduction in traffic flow since the construction of the Tonkin Highway extension – Northlink. Existing traffic volumes are in the order of 2,300 vehicles per weekday compared to 7,500 vehicles per weekday previously.

It is acknowledged however that traffic volumes are likely to increase with the full development of the Muchea Industrial Park. Based on the existing traffic volumes the overtaking lanes are not necessarily warranted. Similarly with the new Tonkin Highway extension the function of this section of Great Northern Highway has altered and on this basis the overtaking lanes may also no longer be warranted. Whilst the overtaking lanes for passing may not be warranted, however in this situation they could be used as acceleration lanes to allow heavy vehicles to accelerate and minimise the disruption of through traffic.

Subsequently two concepts with respect to the connection of the local structure plan to Great Northern Highway have been developed and are contained in **Appendix C**. These are:

Option 1: Overtaking lanes maintained through intersection
The southbound overtaking lane effectively allows for the deceleration of the left turning vehicles into the local structure plan and beyond hence a separate left turn lane has not been shown. The southbound overtaking lane has been extended so that it allows for left turning traffic from the industrial park to accelerate to speed before merging with the through traffic. A right turn acceleration lane is not provided as there is limited length between the two intersections. Ultimately, the majority of the right turning traffic is likely to use one of the two northern connections from Precinct 2 to Great Northern Highway.

Option 2: Overtaking lanes not maintained through the intersection.
The existing southbound overtaking lane used as a left turn lane. Whilst the overtaking lane to the south of the intersection is proposed to be extended and designed as an exclusive acceleration lane for left turning vehicles.

Both options propose a right turn lane on Great Northern Highway into the Site.

A new T-junction is proposed at the location of the existing Swan Recycling driveway on Wandena Road. Based on an operating speed of 110km/hr, a SISD of between 285-300m is required. Google streetview suggests that to the north of the proposed intersection the SISD is likely to be limited to 285m due to the horizontal alignment of Wandena Road whilst the SISD to the south is likely to exceed requirements.

4.3 Traffic Generation

The generation of land uses within Industrial Estates can vary depending on the industry type (low to high traffic generators) and the subsequent number of employees. It is envisaged that land uses within the MEN will likely be low traffic generators.

Guide to Traffic Generating Developments, Roads and Traffic Authority, (RTA) provides some average rates for Industrial Parks based on the number of employees. At this developmental stage of the local structure plan area, the number of employees is not known. RTA suggests a figure of 28 employees per hectare for an industrial estate where employee numbers or Gross Floor Area (GFA) are not known This employee figure has been reduced for this site to 14 employees per hectare due to the low trip generating land uses within the subject site. Additionally, it is likely that the transport orientated land uses will have a lower number of employees per site area due to the space required on site for larger transport vehicles creating a lower ratio between floor space (ultimately staff) and site area.

The MENSP (2011) suggests a trip generation rate for the MEN area of 23 trips per day per gross hectare of development. This trip rate actually corresponds to a rate of 10 employees per hectare. Adopting the higher employee density of 14 employees per hectare for the subject site will ensure a robust assessment.

The standard industrial trip generation rates per employee as outlined in RTA document can then be applied. These are 2.3 daily trips per employee with an am and pm peak hour trips rates of 0.318 and 0.365 per staff which equate to the following trip generation:

- Daily Trips = 2,216 trips per day
- Am peak hour = 306 trips per hour
- Pm peak hour = 352 trips per hour

4.4 Traffic Distribution

In the interim stage, all the Site trips will be assigned to the intersection of Great Northern Highway until such time as development to the north including the extension of the District Loop Road within Precinct 1, 2, and 4 occurs.

In terms of wider regional access to and from the Site, the majority of the traffic is expected to be via the Perth Darwin National Highway. For the purpose of trip distribution, it has been estimated that 65% of vehicle movements will be to/from the north via Great Northern Highway with 33% to/from the south via Great Northern Highway with only a small volume of traffic anticipated to use Wandena Road, say 2%. (Refer **Figure 4.4**)

Traffic volumes along Great Northern Highway are currently in the order of 2,300 vehicles per day. The MENSP indicates traffic will ultimately increase on Great Northern Highway to in the order of 5,300 vehicles per day with the additional Muchea Industrial Park traffic.

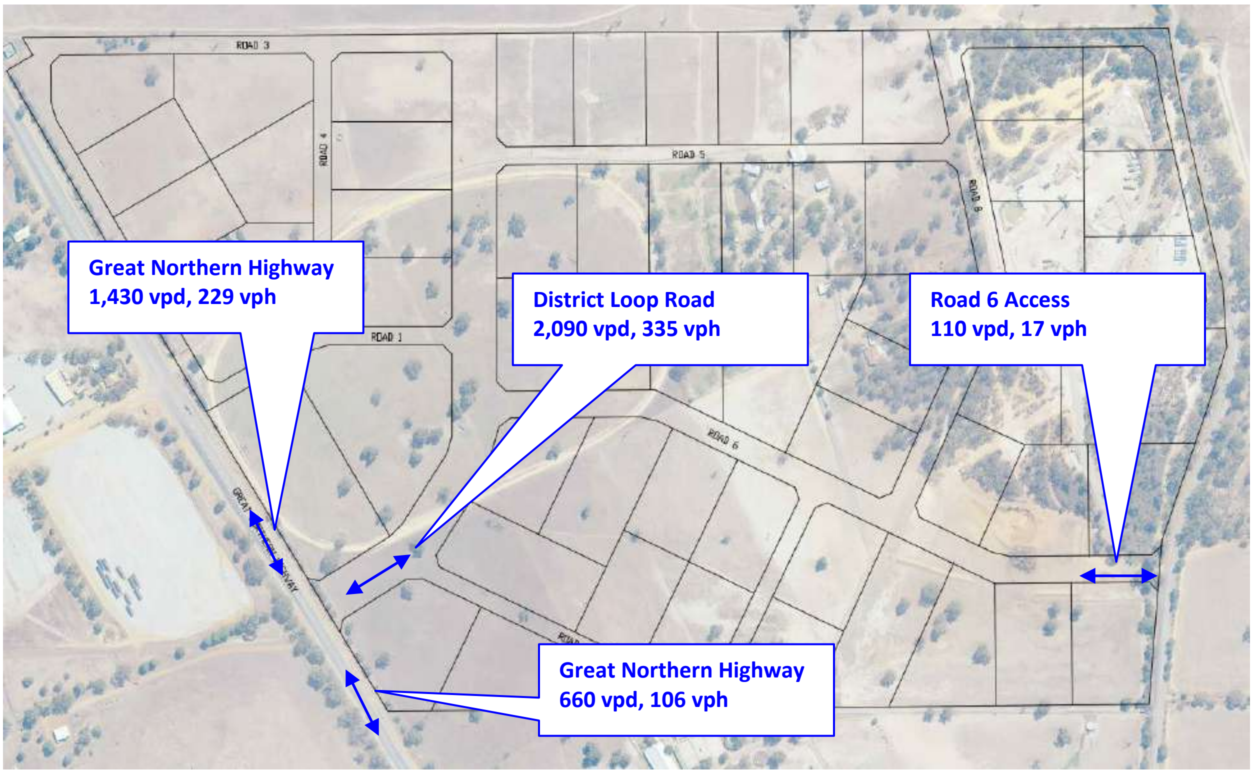


Figure 4.4: Indicative Development Daily Traffic Distribution

4.5 Impact on the Local Road Network

The Site is expected to generate approximately 2,200 vehicle trips per weekday. Indicative traffic volumes for a District Distributor Road are typically above 6,000 - 8,000 vehicles per weekday depending on the type of road. Until future development to the north of the Site occurs the District Loop road will only carry in the order of 2,100 vehicles per weekday. The MENSP estimates that this District Loop Road may ultimately carry in the order of 7,000 vehicles per weekday at full development of the entire Industrial Park. This is line with the lower volumes expected for a District Distributor Road.

The indicative maximum volume of traffic suitable for an Access Street is approximately 3,000 vehicles per day. (*Liveable Neighbourhoods, WAPC 2009 and 2015*). Distribution of the Site industrial traffic over the proposed internal road network will result in the majority of the internal roads (with the exception of the District Loop Road) carrying less than this indicative maximum.

Great Northern Highway currently carries in the order of 2,300 vehicles per weekday. It is currently constructed to a two lane undivided standard. Under the interim stage (until development to the north of the Site proceeds and new road connections to Great Northern Highway are constructed) the Site is likely to increase traffic volumes on Great Northern Highway to 3,730 vehicles per weekday and 2,960 vehicles per weekday north and south of the new connection respectively. This is less than the previous volumes on Great Northern Highway prior to the opening of the Tonkin Highway extension – Northlink, when traffic volumes where in the order of 7,500 vehicles per day. Accordingly, there is sufficient spare capacity for the additional traffic generated by the proposed Site on to Great Northern Highway.

4.6 Great Northern Highway and Southern District Loop Road Connection

The proposed intersection of Great Northern Highway and the District Loop Road, at the southern end of the Muchea Industrial Park and within this Site, has been analysed using the SIDRA computer package (*version 9*).

The assessment period analysed is for the full development of the Site without further extension of the District Loop Road, requiring the majority of Site traffic to use the Great Northern Highway intersection (with the exception of the Wandena Road connection which is likely to take negligible Site traffic). The pm peak assessment is considered to represent the worst situation with the majority of vehicles exiting the Site onto Great Northern Highway.

To ensure a robust assessment the following assumptions have been made:

- Through traffic volumes along Great Northern Highway have been generously estimated to be 5,000 vehicles per day or 500 vehicles per hour to allow for traffic increases associated with the Industrial Park along the Highway.
- The Site reaches full development prior to the extension of the District Loop Road to the north which will include further connections to Great Northern Highway.

The geometric layouts modelled are those outlined in section 4.2 and included in **Appendix B.**

The intersection under Option 1 layout would operate with a degree of saturation of 0.700 associated with the right turn from the District Loop Road onto Great Northern Highway in the pm peak hour. This movement also experiences the highest average delay of 33 seconds resulting in a level of service D and longest 95th percentile queue length of 50m.

There are minimal alterations to the intersection operation under layout Option 2 which includes a dedicated southbound acceleration lane for left turn movements onto Great

Northern Highway. The intersection would operate with a degree of saturation of 0.636 associated with the right turn from the District Loop Road onto Great Northern Highway. This movement also experiences the highest average delay of 28 seconds resulting in a level of service D and longest 95th percentile queue length of 43m.

Detailed SIDRA results are included in **Appendix D.**

The MENSP envisages that the southern connection of the District Loop Road to Great Northern Highway would be signalised. A point of difference between the two district structure plans in that the MIPSP does outline that construction staging of the development may require a third intersection with Great Northern Highway from the land to the east via the District Loop Road as shown in **Figure 4.5**. Whilst this is dependent on the stages of development it will also alter the traffic distribution patterns and potentially the ultimate intersection configurations of connections with Great Northern Highway.

As Main Roads WA is the controlling authority of Great Northern Highway, the ultimate treatment and layout of the intersections with the highway will be subject to Main Roads WA approval.

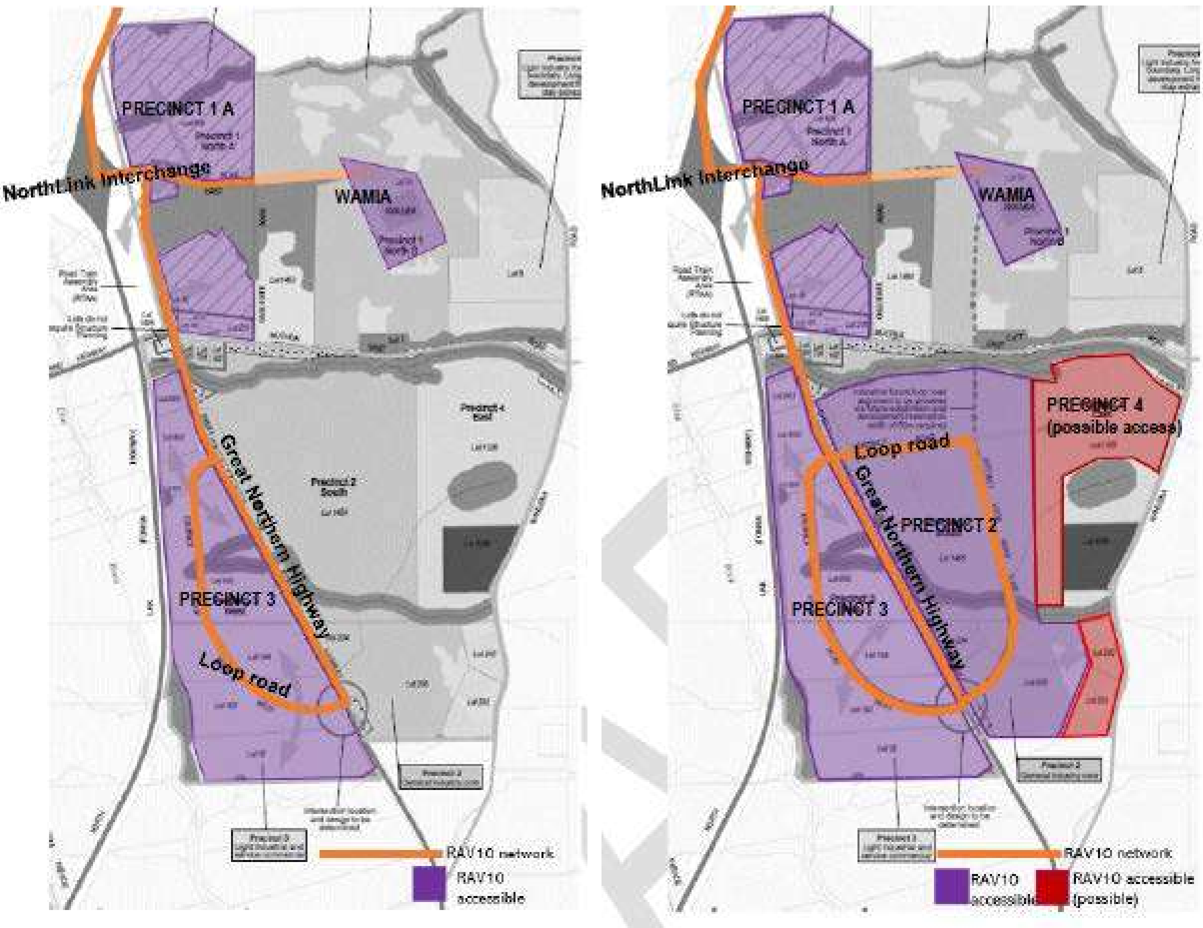


Figure 4.5: Various Road Network Connections Dependent on the Staging of Development

Further development to the north of the Site will likely see increases in generated traffic along the District Loop Road and further connections to Great Northern Highway resulting in the redistribution of traffic. As development progresses and the likely staging is known, further investigations regarding the level of intersection control will be required at the intersection of Great Northern Highway and the southern District Loop Road..

5.0 SUMMARY AND CONCLUSION

The Local Structure Plan for Lots 202-203 Wandena Road and Lots 204-205 Great Northern Highway, Muchea in the Shire of Chittering will form part of the larger area known as the Muchea Industrial Park or previously the Muchea Employment Node.

The Muchea Industrial Park has been divided into four precincts numbered 1 to 4. This Local Structure Plan forms part of both Precinct 2 (Lots 204-205 Great Northern Highway) and Precinct 4 (Lots 202-203 Wandena Road). A District Loop Road designed to accommodate RAV 10 vehicles will ultimately service precincts 1, 2 and 4 with a minimum of 2 connections to Great Northern Highway. Depending on staging of the various precincts a third road connection from the District Loop Road to the Highway is likely to be constructed. The southern District Loop Road intersection with Great Northern Highway is located within the Local Structure Plan Site of this report.

Based on an indicative lot layout, it is estimated the Site will provide 58 industrial lots typically with a lot size of 1 hectare. These lot sizes may be considered too small for RAV 10 access based on the general recommendations for a RAV 10 lot within the MIPSP. The demand for RAV 10 lots will likely be better understood as the design progresses. Under the current layout, adjacent lots may need to be purchased if RAV 10 access is required based on the current lot sizes. A preliminary review indicates that standard 10x 10m wide truncations as currently shown are not necessarily adequate at intersections in order to allow for RAV10 vehicle access.

The layout proposes 5 internal intersections with the District Loop Road over a length of 700m. To prioritise vehicle movement function along the District Loop Road consideration should be given to restricting the turning vehicular movements at a number of intersections providing one intersection with full turning movements to service the area to the west of the District Loop Road and one intersection to service the area to the east. This will result in the spacing of the two main intersections being approximately 400m. The permeability of the proposed internal road network layout will accommodate these vehicular movement restrictions.

The Site is expected to generate in the order of 2,200 vehicles per weekday with approximately 304 and 349 vehicles within the am and pm peak hours.

The additional Site traffic of 2,200 vehicles per day on the District Loop Road is lower than that ultimately expected to be carried on this category of road with the full development of the Muchea Industrial Park. The internal traffic flows within the development site are in line with those expected on local access roads.

There is sufficient spare capacity for the additional traffic generated by the Site on to Great Northern Highway with traffic volumes estimated to be in the order of 2,960-3,730 vehicles per day which is still less than the historic volumes of 7,500 vehicles per day that occurred prior to the Tonkin Highway – Northlink extension.

This Local Structure Plan proposes the creation of a staggered T-junction arrangement on Great Northern Highway with the District Loop Road (this Site) and the Loop Road to Precinct 3 of the Industrial Park located on the western side of Great Northern Highway. The draft MIPSP has alternatively proposed a 4 way roundabout. Initial liaison with Main Roads WA has indicated that in principal there is no objection to a staggered T-junction arrangement instead of a 4 way roundabout as currently outlined in the draft MIPSP.

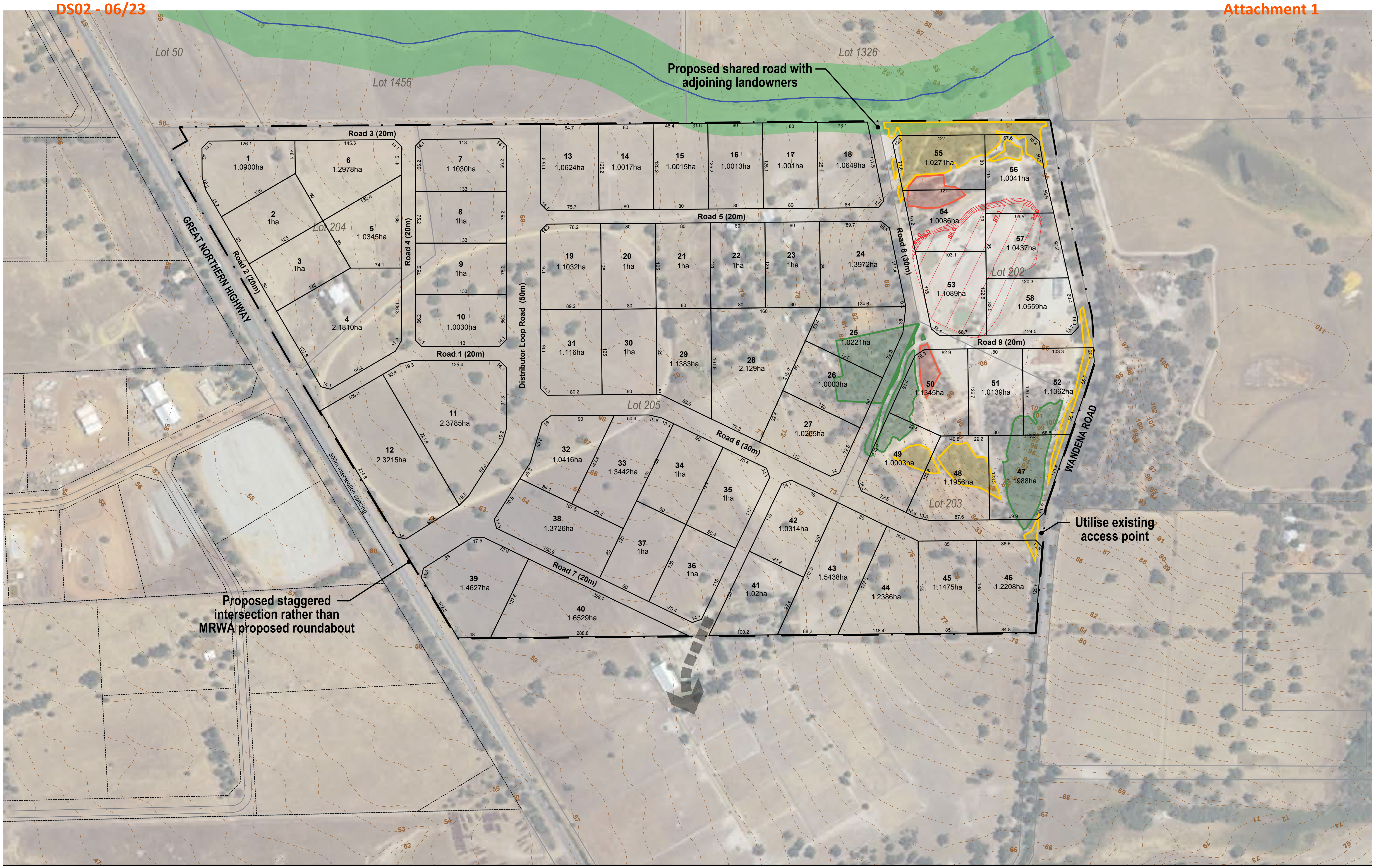
The intersection of Great Northern Highway and the southern District Loop Road which is included within the Site has been assessed. To ensure a robust assessment the analysis was based on full development of the Site without the further extension of the District Loop Road to the north of the Site, requiring the majority of Site traffic to use the Great Northern Highway intersection. Furthermore, traffic volumes along Great Northern Highway were increased generously to 5,000 vehicles per day which would allow for development within the Industrial Park. Two intersection layout options were modelled that utilised the existing overtaking lanes on Great Northern Highway in the form of acceleration lanes and/or auxiliary turning lanes. The analyses indicated that both intersections would operate satisfactorily.

Further development to the north of the Site will likely see increases in generated traffic along the District Loop Road and further connections to Great Northern Highway resulting in the redistribution of traffic. As development progresses and the likely staging is known, further investigations to confirm the level of intersection control will be required at the intersection of Great Northern Highway and the southern District Loop Road..

As Main Roads WA is the controlling authority of Great Northern Highway, the ultimate and staged treatments and layout of all intersections with the highway will be subject to Main Roads WA approval.

APPENDIX A

Structure Plan Layout



Concept Plan

Lots 202-203 Wandena Road & Lots 204-205 Great Northern Highway, Muchea

Date: 9 February 2021 | 1:5000@ A3 | 1:2500 @ A1 | 19-545 | A | Staff: MR LC | Checked: MR

0 50 100m

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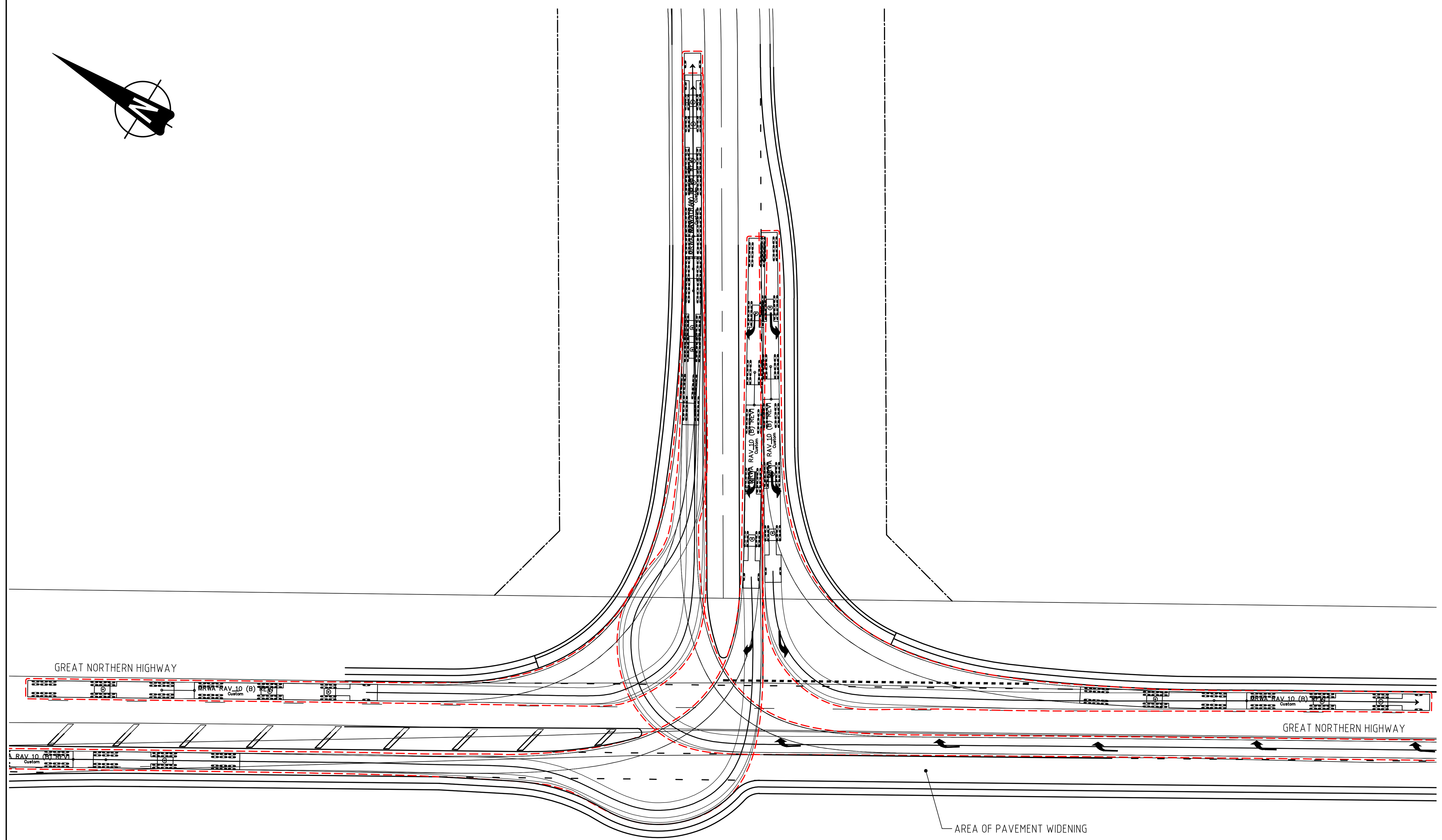
APPENDIX B

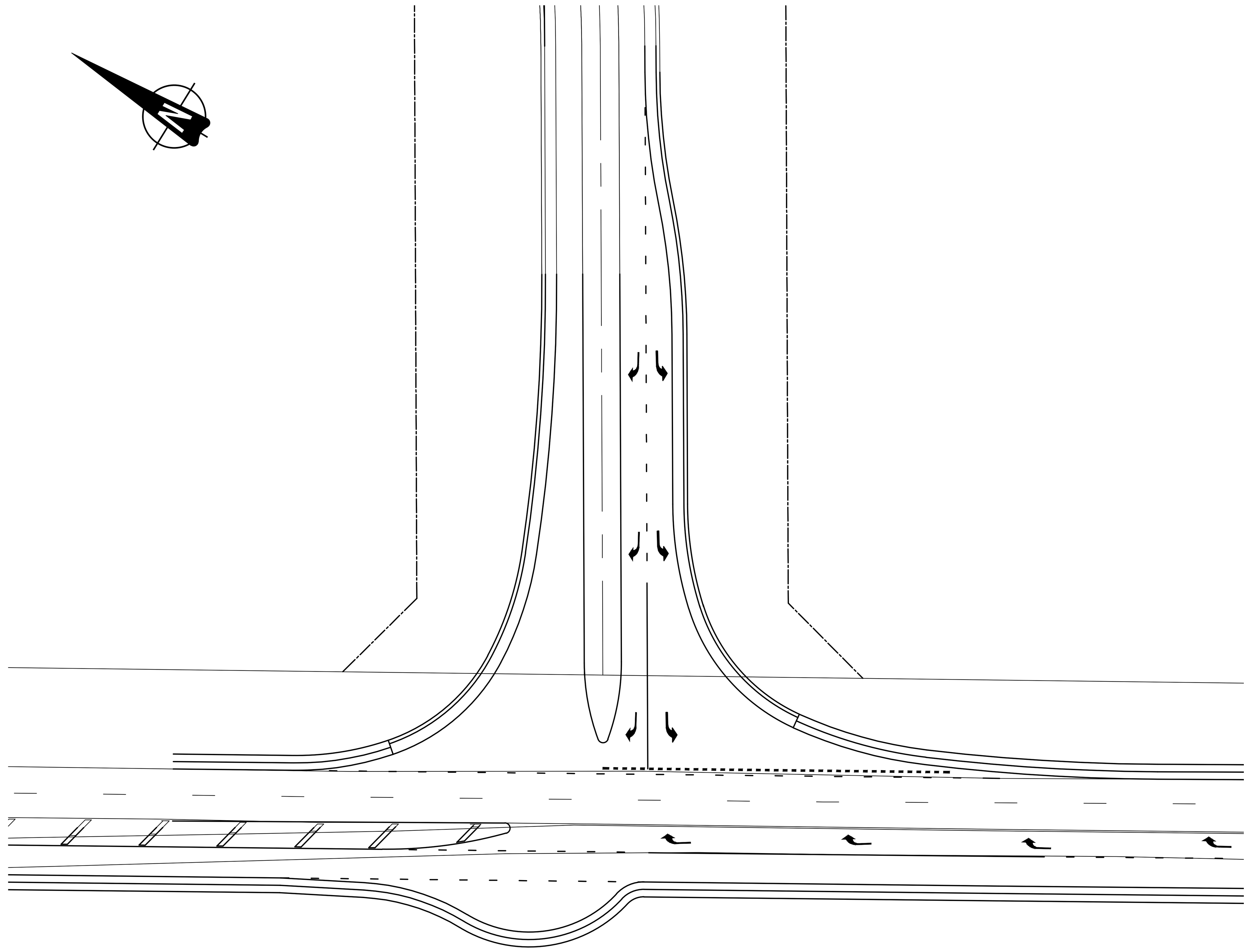
Concept Layouts for
Great Northern Highway and District Loop Road Intersection

INTERSECTION LAYOUT PLAN - OPTION 1

1:2000

1:2000 0 20 40 80 120 Half Size 1:4000 - SCALE (m)





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MRWA RAV 10 SWEPT PATHS

1:500

1:500 0 5 10 20 30 Half Size 1:1000 - SCALE (m)

T-INTERSECTION TREATMENT - OPTION 1

1:500

1:500 0 5 10 20 30 Half Size 1:1000 - SCALE (m)

PROJECT:	No.	DATE	REVISION	BY
GREAT NORTHERN HIGHWAY MUCHEA	A	29-9-2020	ISSUED FOR COMMENT	MJV

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TUSNO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT: **ELEMENT**

DRAWING: **OPTION 1 INTERSECTION TREATMENT**

STATUS: **FOR COMMENT**

SCALE	1:2000	DRAWING No.	20-3-35/800
DATE	SEPT 2020	REV No.	A
DESIGN	JH	ORIGINAL DRAWING SIZE	A1
DRAWN	MJV	FILE NAME	S:\ACTIVE PROJECTS\20-03-035\ACAD\20335-800.dwg
CHECK		APP'D	

CONSULT AUSTRALIA

INTERSECTION LAYOUT - OPTION 2

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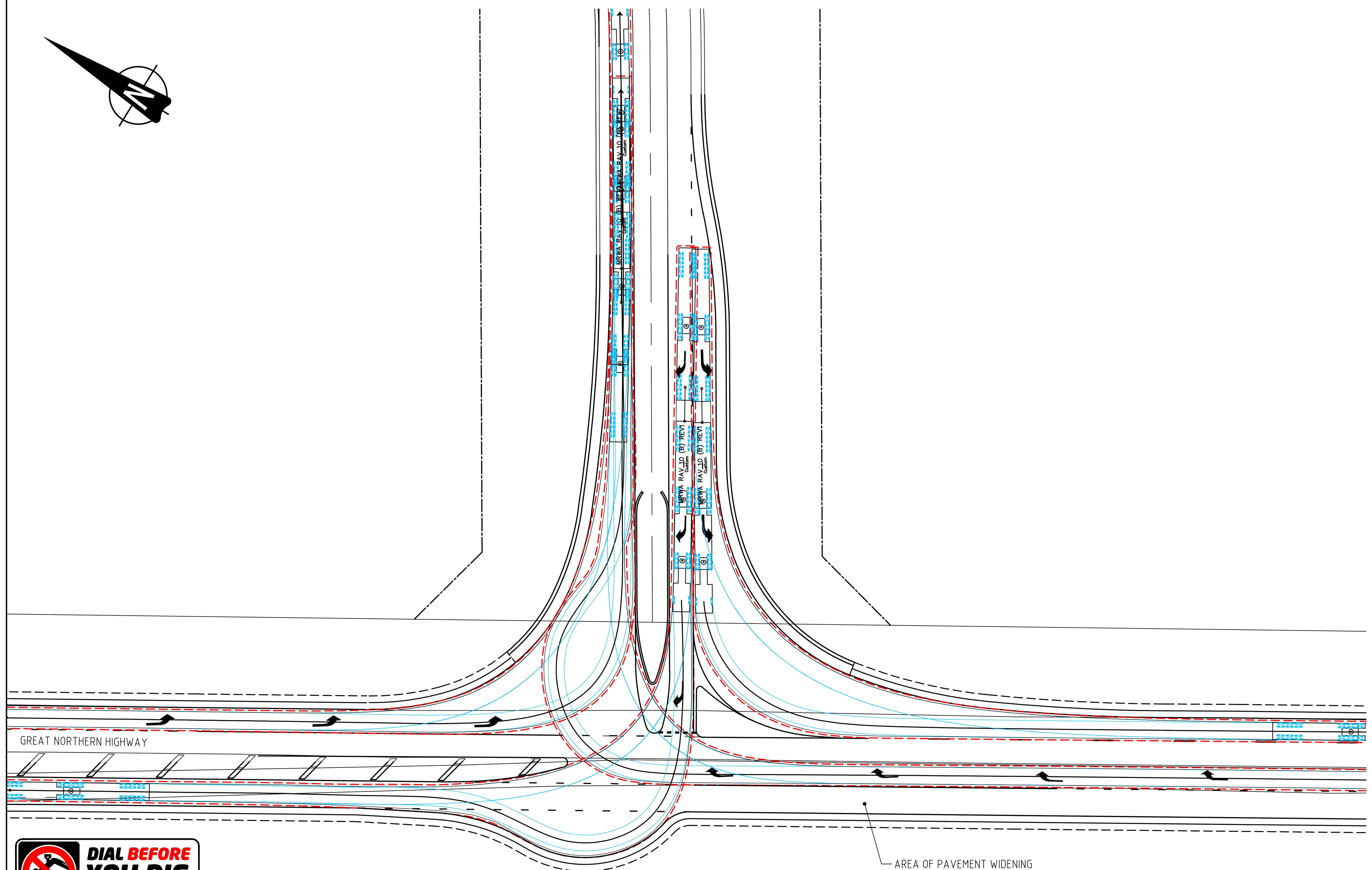
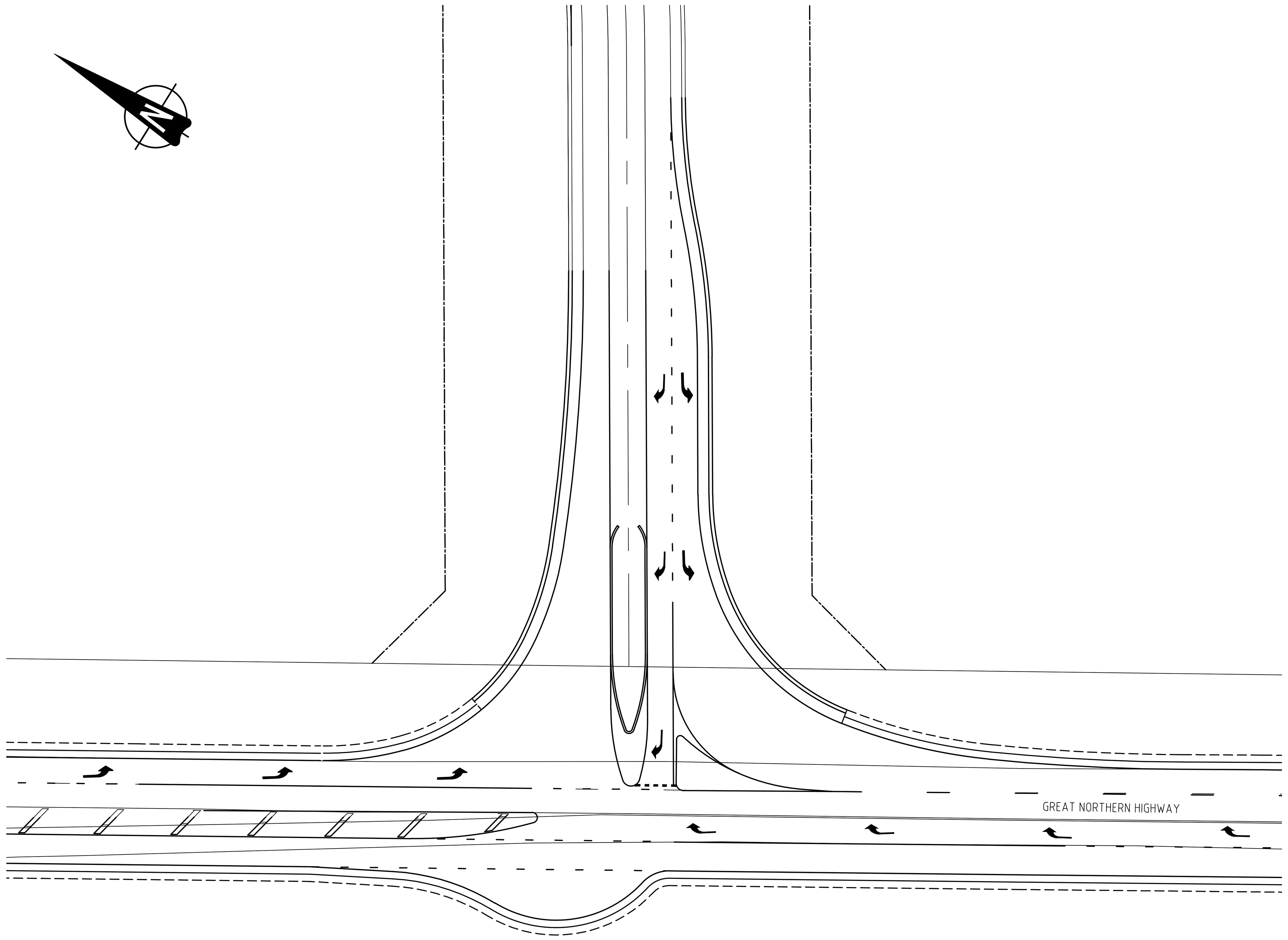
1:2000
Half Size 1:4000 - SCALE (m)



MRWA RAV 10 SWEPT PATHS

1:500



T-INTERSECTION TREATMENT - OPTION 2

1:500

0 5 10 20 30
1:500
Half Size 1:1000 - SCALE (m)

DIAL BEFORE YOU DIG
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PROJECT:

GREAT NORTHERN HIGHWAY
MUCHEA

No.	DATE	REVISION	BY
A	29-9-2020	ISSUED FOR COMMENT	MJV

Porter Consulting Engineers

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CLIENT:

ELEMENT

DRAWING:

OPTION 2
INTERSECTION TREATMENT

STATUS: **FOR COMMENT**

SCALE	1:2000
DATE	SEPT 2020
DESIGN	JH
DRAWN	MJV
CHECK	

DRAWING No.	REV No.	ORIGINAL DRAWING SIZE
20-3-35/801	A	A1

FILE NAME S:\ACTIVE PROJECTS\20-03-035\ACAD\20335-801.dwg

APP'D

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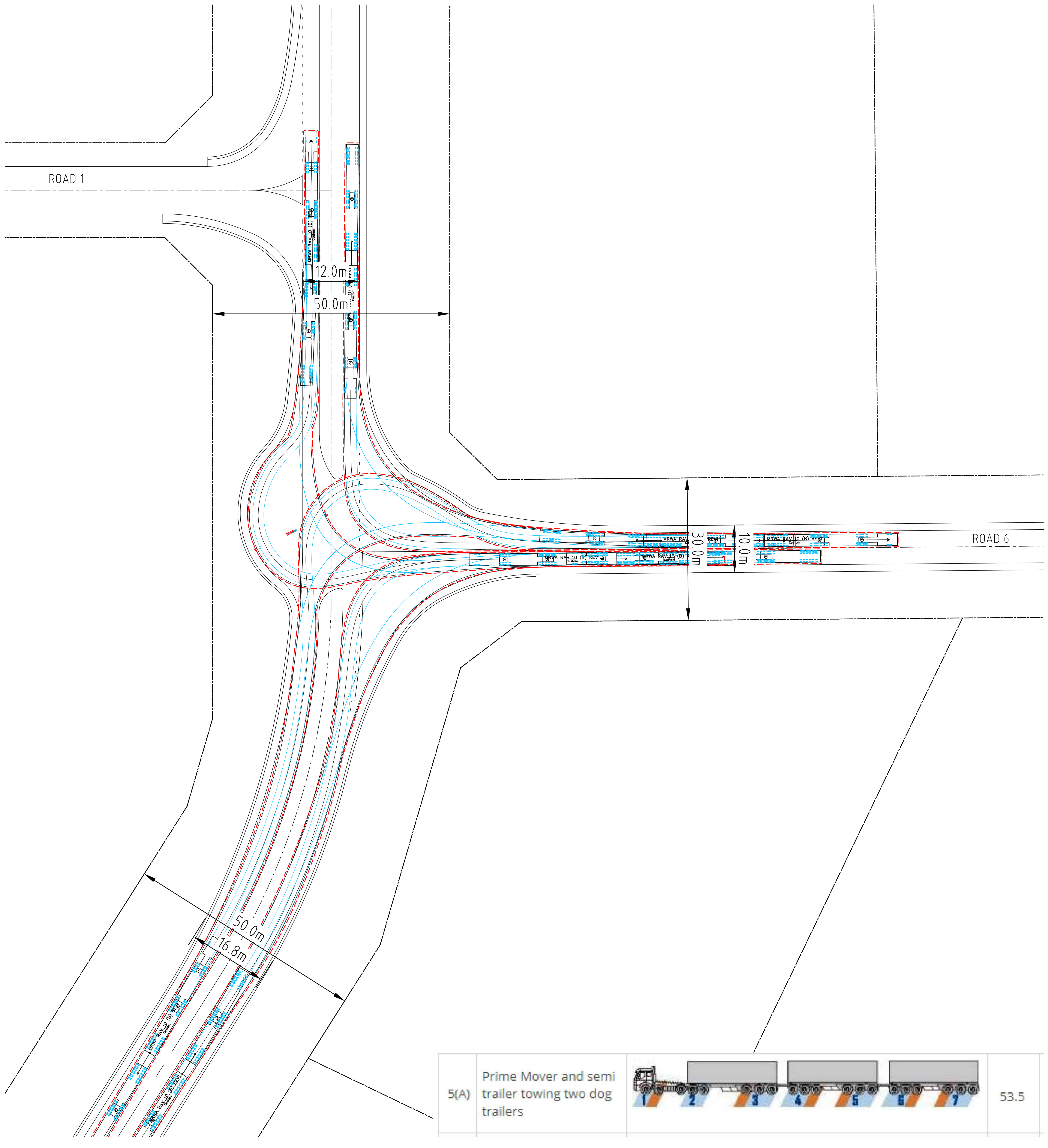
APPENDIX C

Sample Internal Road Network Swept Paths



MRWA RAV 10 SWEPT PATHS

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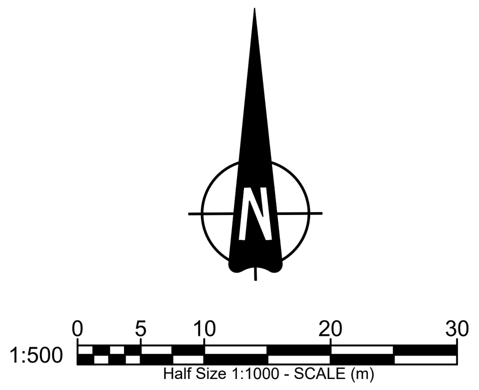

PROJECT:

GREAT NORTHERN HIGHWAY MUCHEA

No.	DATE	REVISION	BY
A	29-9-2020	ISSUED FOR COMMENT	MJV

Porter Consulting Engineers

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TUSNO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:

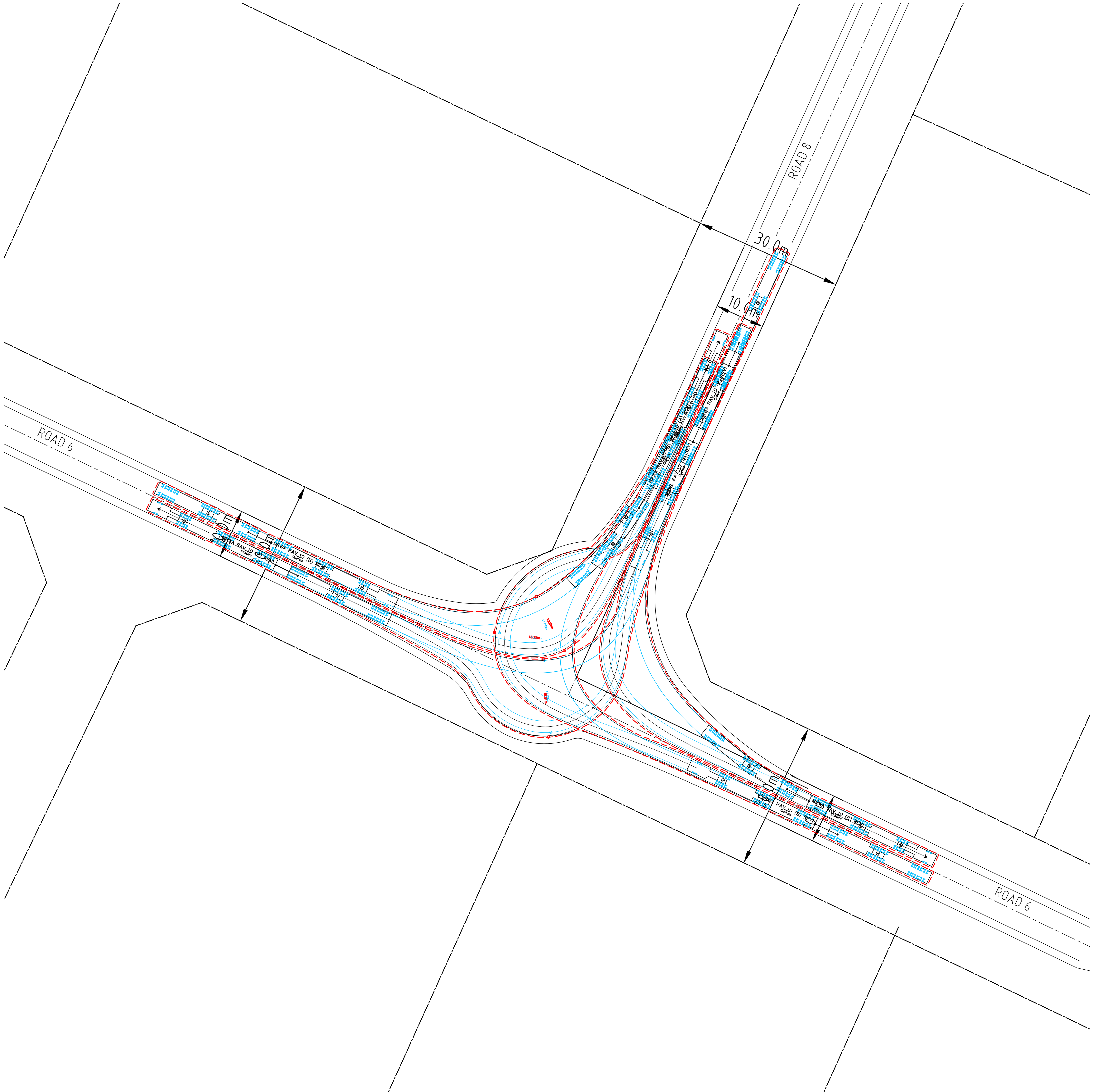
ELEMENT

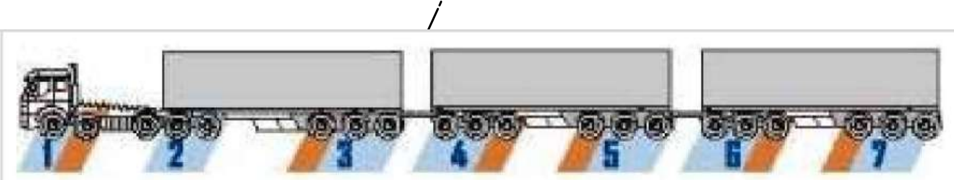
DRAWING:

RAV 10 SWEPT PATH
ROAD 6 AND MAIN ENTRANCE ROAD

STATUS: **FOR COMMENT**

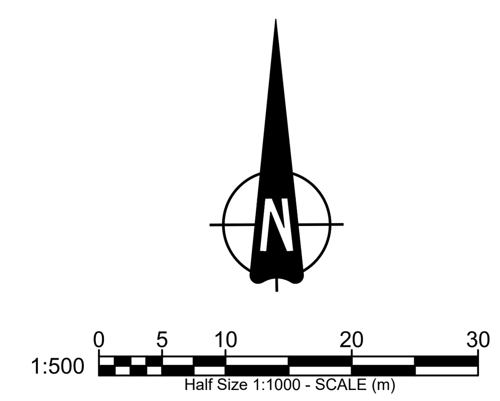
SCALE	1:2000	DRAWING No. 20-3-35/802	REV No. A
DATE	SEPT 2020		ORIGINAL DRAWING SIZE A1
DESIGN	JH		
DRAWN	MJV	FILE NAME S:\ACTIVE PROJECTS\20-03-035\ACAD\20335-802.dwg	
CHECK		APP'D	



5(A)	Prime Mover and semi trailer towing two dog trailers		53.5

MRWA RAV 10 SWEPT PATHS

1:500



PROJECT:

GREAT NORTHERN HIGHWAY MUCHEA

No.	DATE	REVISION	BY
A	19-10-2020	ISSUED FOR COMMENT	MJV

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CLIENT: **ELEMENT**

DRAWING: **RAV 10 SWEPT PATH ROAD 6 AND ROAD 8 ENTRANCE ROAD**

STATUS: **FOR COMMENT**

SCALE	1:2000
DATE	OCT 2020
DESIGN	JH
DRAWN	MJV
CHECK	

DRAWING No.	REV No.	ORIGINAL DRAWING SIZE
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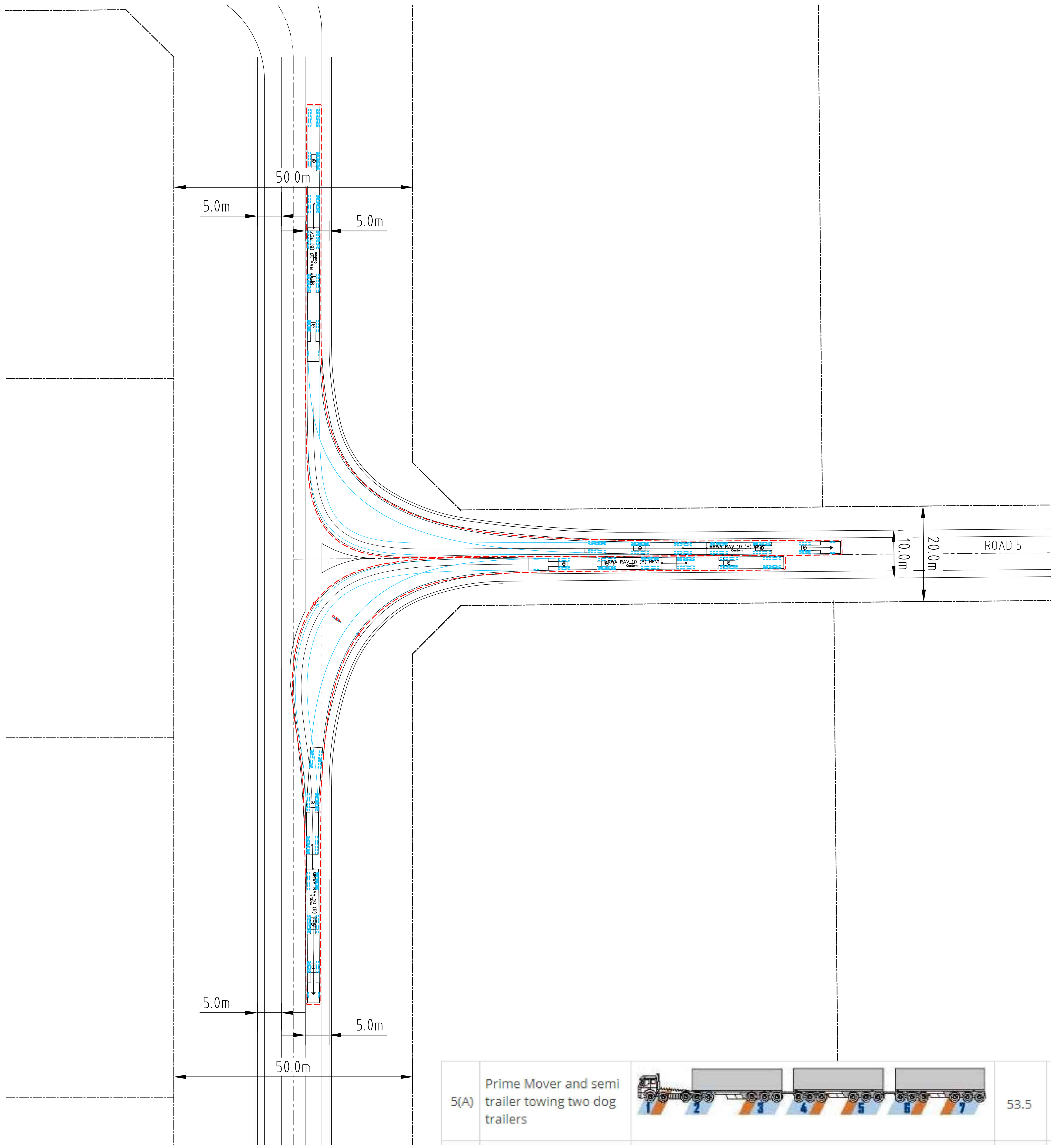
FILE NAME S:\ACTIVE PROJECTS\20-03-035\ACAD\20335-803.dwg

APP'D



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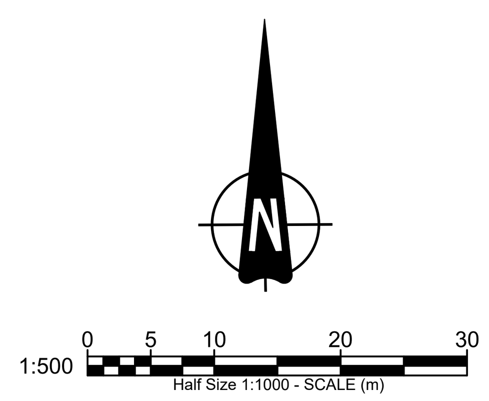

PROJECT: **GREAT NORTHERN HIGHWAY MUCHEA**

No.	DATE	REVISION	BY
A	29-9-2020	ISSUED FOR COMMENT	MJV

Porter Consulting Engineers

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CLIENT: **ELEMENT**

DRAWING: **RAV 10 SWEPT PATH ROAD 5 AND MAIN ENTRANCE ROAD**

STATUS: **FOR COMMENT**

SCALE	1:2000
DATE	SEPT 2020
DESIGN	JH
DRAWN	MJV
CHECK	
DRAWING No.	20-3-35/804
REV No.	A
ORIGINAL DRAWING SIZE	A1
FILE NAME	S:\ACTIVE PROJECTS\20-03-035\ACAD\20335-804.dwg
APP'D	

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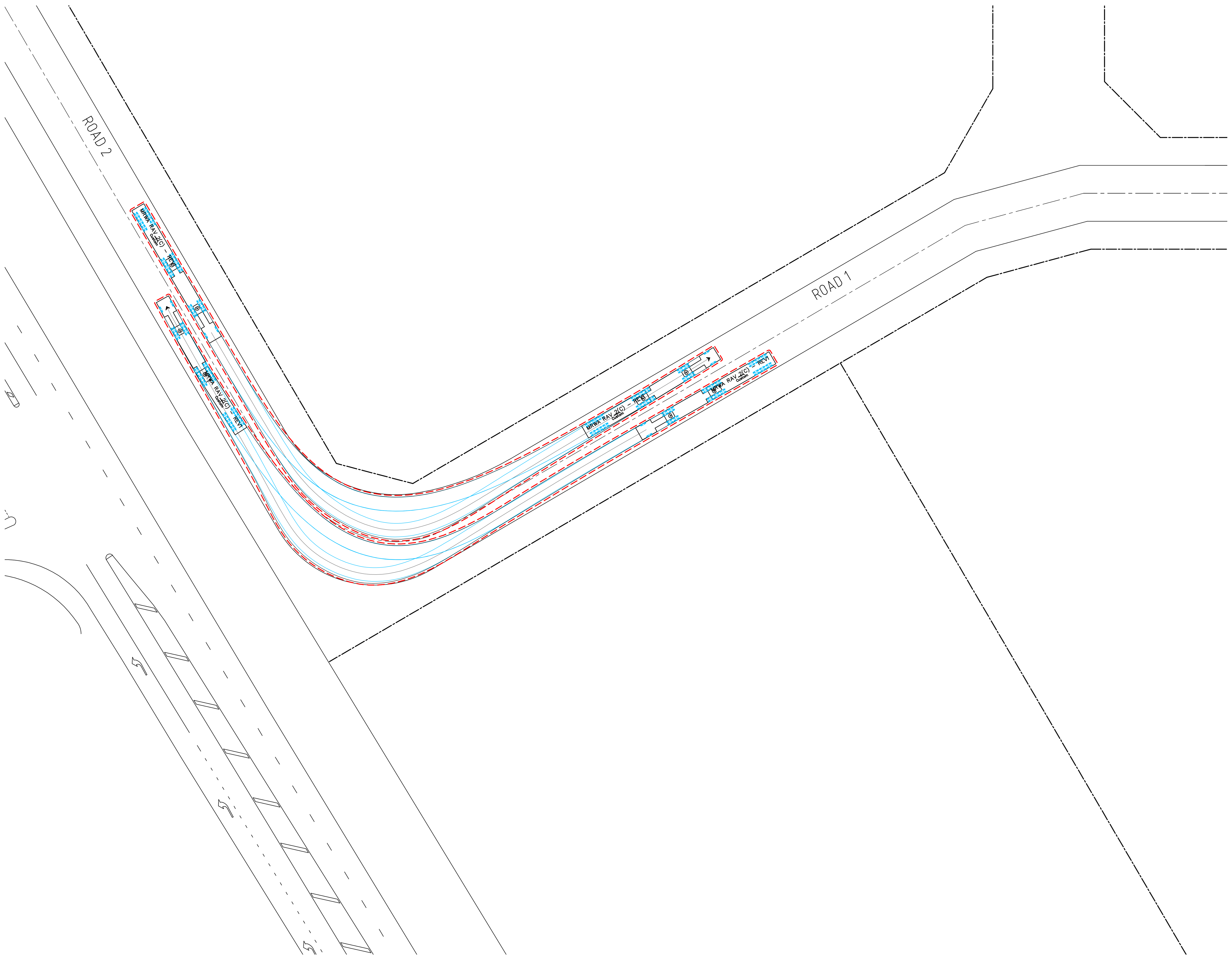

MRWA RAV 2 27.5m B-DOUBLE SWEPT PATHS

1:500

1:500

0 5 10 20 30

Half Size 1:1000 - SCALE (m)

PROJECT:

GREAT NORTHERN HIGHWAY MUCHEA

No.	DATE	REVISION	BY
A	29-9-2020	ISSUED FOR COMMENT	MJV

Porter Consulting Engineers

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TUSNO Pty Ltd ACN 070 097 148 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 636 396 385

CLIENT:

ELEMENT

DRAWING:

RAV 2 SWEPT PATH ROAD 1 AND ROAD 2

STATUS: **FOR COMMENT**

SCALE	1:2000
DATE	SEPT 2020
DESIGN	JH
DRAWN	MJV
CHECK	

DRAWING No.	REV No.	ORIGINAL DRAWING SIZE
20-3-35/805	A	A1

FILE NAME S:\ACTIVE PROJECTS\20-03-035\ACAD\20335-805.dwg

APP'D

APPENDIX D

SIDRA Detailed Results

Site: 101 [Great Northern Highway and Loop Road PM Peak Proposed - Option 1 (Site Folder: General)]

New Site
Site Category: (None)
Stop (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Great Northern Highway														
2	T1	250	30.0	263	30.0	0.162	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	109.9
3	R2	24	30.0	25	30.0	0.034	11.6	LOS B	0.1	1.4	0.46	0.70	0.46	65.8
Approach		274	30.0	288	30.0	0.162	1.0	NA	0.1	1.4	0.04	0.06	0.04	104.8
East: Loop Road														
4	L2	98	30.0	103	30.0	0.111	8.7	LOS A	0.4	4.5	0.27	0.62	0.27	64.1
6	R2	181	30.0	191	30.0	0.700	32.8	LOS D	4.6	49.9	0.88	1.21	1.80	48.1
Approach		279	30.0	294	30.0	0.700	24.3	LOS C	4.6	49.9	0.67	1.00	1.26	52.7
North: Great Northern Highway														
7	L2	46	30.0	48	30.0	0.096	9.1	LOS A	0.0	0.0	0.00	0.23	0.00	54.6
8	T1	250	30.0	263	30.0	0.096	0.1	LOS A	0.0	0.0	0.00	0.08	0.00	107.6
Approach		296	30.0	312	30.0	0.096	1.5	NA	0.0	0.0	0.00	0.11	0.00	95.5
All Vehicles		849	30.0	894	30.0	0.700	8.9	NA	4.6	49.9	0.23	0.39	0.43	79.3

Site: 101 [Great Northern Highway and Loop Road PM Peak Proposed -Option 2 (Site Folder: General)]

New Site
Site Category: (None)
Stop (Two-Way)

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Great Northern Highway														
2	T1	250	30.0	263	30.0	0.162	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	109.9
3	R2	24	30.0	25	30.0	0.032	11.1	LOS B	0.1	1.3	0.43	0.68	0.43	66.2
Approach		274	30.0	288	30.0	0.162	1.0	NA	0.1	1.3	0.04	0.06	0.04	104.9
East: Loop Road														
4	L2	98	30.0	103	30.0	0.067	8.5	LOS A	0.0	0.0	0.00	0.59	0.00	65.6
6	R2	181	30.0	191	30.0	0.636	27.7	LOS D	4.0	43.0	0.84	1.14	1.56	50.7
Approach		279	30.0	294	30.0	0.636	21.0	LOS C	4.0	43.0	0.55	0.95	1.01	55.2
North: Great Northern Highway														
7	L2	46	30.0	48	30.0	0.032	9.1	LOS A	0.0	0.0	0.00	0.67	0.00	72.2
8	T1	225	22.2	237	22.2	0.139	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	110.0
Approach		271	23.5	285	23.5	0.139	1.5	NA	0.0	0.0	0.00	0.11	0.00	102.3
All Vehicles		824	27.9	867	27.9	0.636	7.9	NA	4.0	43.0	0.20	0.38	0.35	82.0

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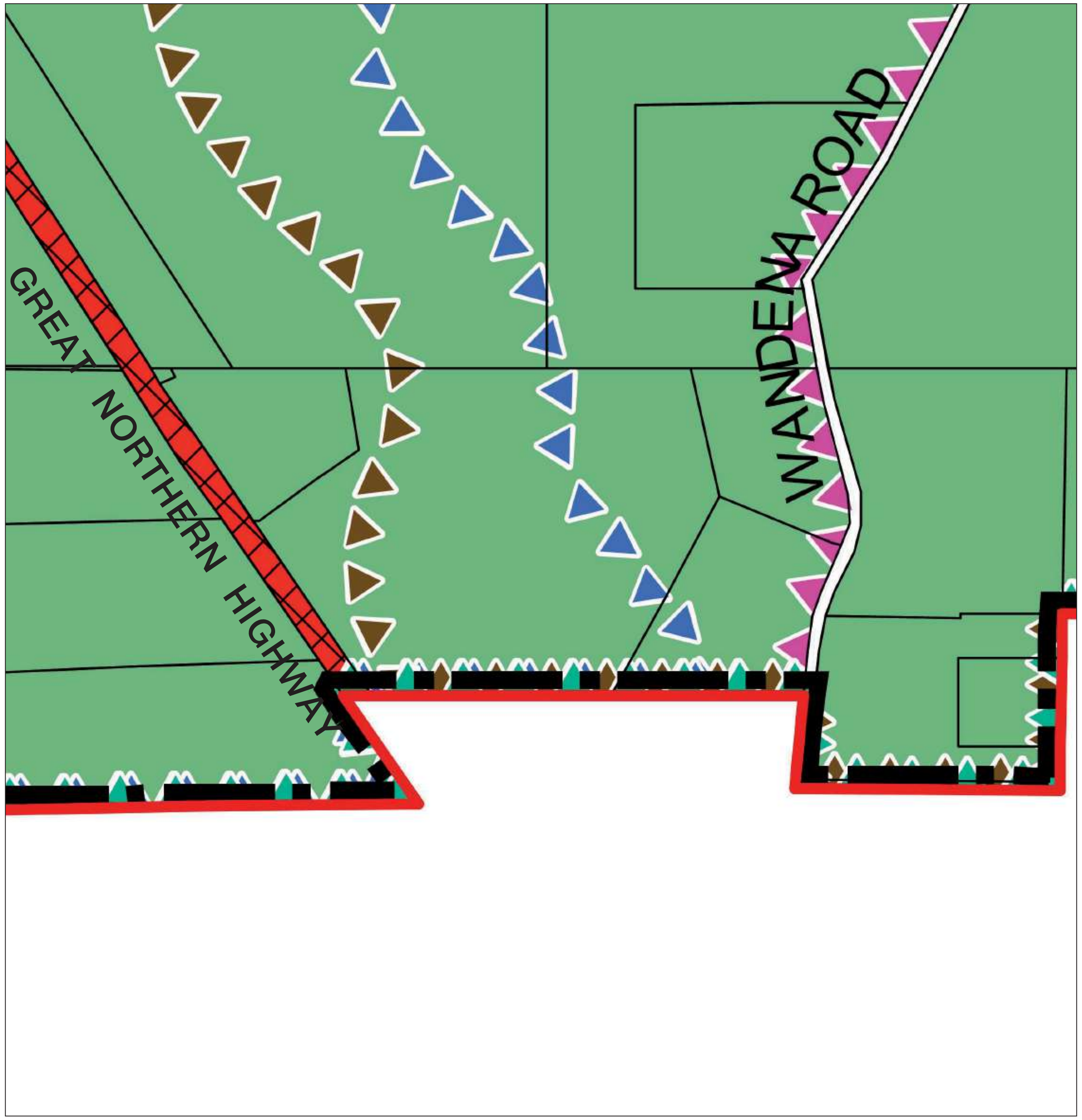
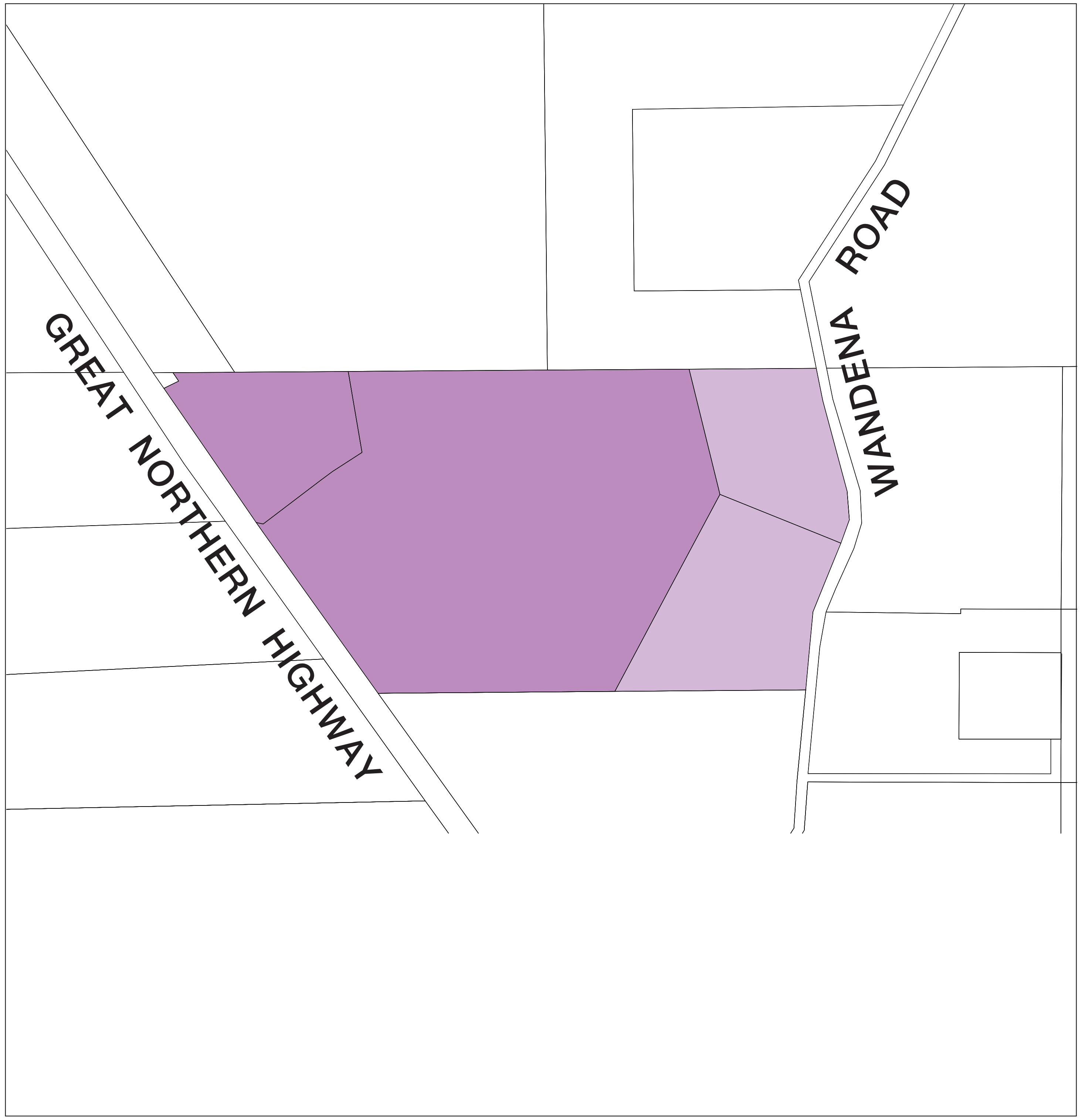


Existing Zoning



Proposed Zoning

Local Scheme Reserves	Zones	Other		
Highway	Agricultural Resource	Scheme Area Boundary	Muchea Employment Node	Military Considerations
	Light Industrial	Local Government Boundary	Basic Raw Materials	Waste and Waste Water Treatment
	General Industry		Land Refuse	Water Prone

Scheme Amendment

Lots 202 and 203 (109) Wandena Drive and Lots 204 (3362) and 205 Great Northern Highway, Muchea

Date: 20 February 2023 Scale: NTS@ A3 File: 19-545 PL1B Amendment Staff: MR/LC Checked: MR

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
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