COFFS HARBOUR BYPASS

Blast Management Strategy

CHBPW-FGJV-NWW-EN-STG-000001- Revision B - Coffs Harbour Bypass

FERROVIAL GAMUDA JOINT VENTURE

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A	March 2023	Draft for suitably qualified and experienced person review	
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1		
2		
3		
4		
5		

CONTENTS

TABLES

GLOSSARY/ABBREVIATIONS

Abbreviation	Expanded Text
AA	The Acoustics Advisor for the CSSI approved by the Planning Secretary
AS	Australian Standard
BMS	Blast Management Strategy
BS	British Standard
CCS	Community Communications Strategy
CEMP	Construction Environmental Management Plan
CNVMP	Construction Noise and Vibration Management Plan
Council	Coffs Harbour City Council
CSSI	Critical State Significant Infrastructure
dB(A)	Decibels using the A-weighted scale which is accepted as being representative of the frequency response of the human ear.
DPE	Department of Planning and Environment, NSW (previously DPIE)
DPE, EESG	Department of Planning, Industry and Environment, Environment, Energy and Science Group
DPIE	Department of Planning, Industry and Environment, NSW (now DPE)
EIS	Environmental Impact Statement
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW)
EPA	NSW Environment Protection Authority
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999
EPL	Environment Protection Licence
ER	Environmental Representative
EWMS	Environmental work method statement
FGJV	Ferrovial Gamuda Joint Venture
Hz	Hertz - unit of frequency. The number of hertz equals the number of cycles per second.
ICNG	Interim Construction Noise Guideline (DECC, 2009)
MCoA	NSW Minister's Conditions of Approval
MIC	Maximum Instantaneous Charge (maximum explosive weight per delay)
NATA	National Association of Testing Authorities
NCA	Noise Catchment Area
NML	Noise Management Level
NSW	New South Wales
NVMP	Noise and Vibration Management Plan
OOHW	Out of Hours works
PPV	Peak Particle Velocity - is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure root mean squared (RMS) values; it is common to approximate the PPV based on an RMS measurement. PPV is commonly used as a vibration criterion, and is often interpreted as a PPV based on the Lmax or Lmax,spec index.
Project Area	The area required to facilitate the construction of the Project (i.e. construction footprint)
The Project	Coffs Harbour Bypass
REMMs	Revised Environmental Management Measures
Sensitive receiver	Includes residences, educational institutions (including preschools, schools, universities, TAFE colleges), health care facilities (including nursing homes, hospitals), religious facilities (including churches), childcare centres, passive recreation areas (including outdoor grounds used for teaching), commercial premises (including film and television studios, research facilities, entertainment spaces, temporary accommodation such as caravan parks and camping grounds, restaurants, office premises, and retail spaces), and others as identified by the Planning Secretary.
Shotfirer	a statutorily appointed Shotfirer who will hold a NSW Blasting Explosives User License, as per Part 3 of the Explosives Act 2003
TfNSW	Transport for NSW
VDV	Vibration Dose Value

1 INTRODUCTION

1.1 BACKGROUND

This Blast Management Strategy (BMS) forms part of the Construction Environmental Management Plan (CEMP) for the Coffs Harbour Bypass (the Project).

This BMS has been prepared to address the requirements of the Minister's Conditions of Approval (MCoA), the mitigation and management measures listed in the Coffs Harbour Bypass Environmental Impact Statement (EIS), the Submissions Report, Amendment Report and all applicable legislation.

The project includes a 14-kilometre bypass of Coffs Harbour, including a 12-kilometre new build from south of England's Road to Korora Hill in the north and a two-kilometre upgrade of the existing highway between Korora Hill and Sapphire. The project would provide a four-lane divided highway that bypasses Coffs Harbour, passing through the North Boambee Valley, Roberts Hill and then traversing the foothills of the Coffs Harbour basin to the west and north to Korora Hill.

1.2 PURPOSE

Condition E61 of the MCoAs stipulates that a *"Blast Management Strategy must be prepared in accordance with relevant guidelines and in consultation with the EPA, in order to ensure that all blasting and associated activities are carried out so as not to generate unacceptable noise and vibration impacts or pose a significant risk to sensitive receivers land user(s)*".

This Blast Management Strategy (BMS) is an appendix (Appendix D4) to the Noise and Vibration Management Plan (NVMP). The purpose of the BMS is to satisfy the MCoAs and provide a high-level overview of the approach to be adopted for the safe and efficient execution of controlled blasting on the Project.

1.3 OBJECTIVES

The key objective of the BMS is to minimise potential controlled blasting impacts to the local community and the built environment.

This BMS includes:

a) sequencing and review of trial controlled blasting to inform controlled blasting design;
b) regularity of controlled blasting;
c) intensity of controlled blasting;
d) periods of relief; and
e) controlled blasting program.

2 ENVIRONMENTAL REQUIREMENTS

2.1 MINISTERS CONDITIONS OF APPROVAL

The MCoA relevant to the requirements of this BMS are listed in Table 1 below. A cross reference is also included to indicate where the condition is addressed in this BMS or other project management documents.

TABLE 1 MINISTER'S CONDITION OF APPROVAL RELEVANT TO THIS BMS

<table>
<tr><th>MCoA No.</th><th>Condition Requirements</th><th>Document Reference</th></tr>
<tr><td>E54</td><td>Blasting
Blasting associated with the CSSI must only be undertaken during the following hours:
(a) 9:00am to 5:00pm, Monday to Friday, inclusive;
(b) 9:00am to 1:00pm on Saturday;
(c) at no time on Sunday or public holidays; and
(d) 7:00am to 6:00pm, Mondays to Fridays, inclusive, for work required for the Roberts Hill, Shephards Lane and Gatelys Road tunnels.
Blasting may be undertaken outside the above hours where:
(a) no sensitive receivers would be impacted by blasting; or
(b) an agreement has been made with potentially affected receivers.
This condition does not apply in the event of a direction from the NSW Police Force or other relevant authority for safety or emergency reasons to avoid loss of life, property loss and/or to prevent environmental harm.</td><td>Section 3.3</td></tr>
<tr><td>E55</td><td>Airblast overpressure generated by the blasting associated with the CSSI must not exceed the criteria specified in Table 10 when measured at the most affected residence.
<table>
<tr><th>Receiver</th><th>Type of Blasting Operations</th><th>Airblast Overpressure Limit</th></tr>
<tr><td rowspan="2">Sensitive site</td><td rowspan="2">Blasting operations lasting more than 12 months or more than 20 blasts</td><td>115 dBL for 95% of blasts per year</td></tr>
<tr><td>120 dBL maximum limit</td></tr>
<tr><td rowspan="2">Sensitive Site</td><td rowspan="2">Blasting operations lasting less than 12 months or less than 20 blasts in total</td><td>120 dBL for 95% of blasts per year</td></tr>
<tr><td>125 dBL maximum limit</td></tr>
<tr><td>Occupied non-sensitive sites, such as factories and commercial premises</td><td>All blasting</td><td>125 dBL maximum limit. For sites containing equipment sensitive to vibration, the vibration level should be kept below manufacturer's specifications or levels that can be shown to adversely affect thee equipment operation</td></tr>
</table>
Source – Table J5.4 – AS 2187.2 – 2006
Note: A sensitive site includes houses and low-rise residential buildings, theatres, schools and other similar buildings occupied by people.</td><td>Section 3.5</td></tr>
</table>

E56

Ground vibration generated by blasting associated with the CSSI must not exceed the criteria specified in Table 11 and Table 12 when measured at the most affected residence or other sensitive receiver.

Table 11: Ground vibration limits for human comfort and structures

Receiver	Type of Blasting Operations	Peak component particle velocity (mm/s)
Sensitive site	Blasting operations lasting more than 12 months or more than 20 blasts	5 mm/s for 95% of blasts per year
		10 mm/s maximum limit
Sensitive Site	Blasting operations lasting less than 12 months or less than 20 blasts in total	10 mm/s maximum limit
Occupied non-sensitive sites, such as factories and commercial premises	All Blasting	25 mm/s maximum limit. For sites containing equipment sensitive to vibration, the vibration level should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Source – Table J4.5(A) – AS 2187.2 – 2006

Note: *A sensitive site includes houses and low-rise residential buildings, theatres, schools and other similar buildings occupied by people.*

Table 12: Ground vibration limits for control of damage to structures

Receiver	Type of Blasting Operations	Peak component particle velocity (mm/s)	
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction 1	All Blasting	15 mm/s 4 Hz to 15 Hz, except for heritage structures where a frequency dependent vibration criteria would be determined in accordance with AS 2187.2 – 2006.	20 mm/s 15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings 2	All Blasting	50 mm/s at 4 Hz and above	
Unreinforced or light framed structure. Residential or light commercial type building 2	All Blasting	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Unoccupied structures of reinforced concrete or steel construction	All Blasting	100 mm/s maximum, where agreed with the structure owner.	

Section 3.5

MCoA No.	Condition Requirements	Document Reference
	Infrastructure service structures, such as pipelines, powerlines, cables and reservoirs. | All Blasting | Limits to be determined by structural design methodology in consultation with the infrastructure service provider. **Table 12: Ground vibration limits for control of damage to structures (cont.) Source: Table J4.5(B) – AS 2187.2 – 2006 and Table J4.4.2.1 – AS 2187.2 – 2006 (BS 7385-2)**	
E57	The blasting criteria specified in the Tables in Conditions E55 and E56 may be exceeded where the Proponent has obtained the written agreement of the landowner and occupier to increase the relevant criteria. In obtaining the agreement, the Proponent must make available to the landowner and occupier: (a) details of the proposed blasting program and justification for the proposed increase in blasting criteria including alternatives considered (where relevant); (b) an assessment of the environmental impacts of the increased blasting criteria on the surrounding environment and most affected residences or other sensitive receivers including, but not limited to noise, vibration and air quality and any risk to surrounding utilities, services or other structures; and (c) details of the blast management, mitigation and monitoring procedures to be implemented.	Section 5.3
E58	The Proponent must provide a copy of the landowner and occupier written agreement to the Planning Secretary and the EPA, including details of the consultation undertaken (with clear identification of proposed blast limits and potential property impacts), before commencing blasting at the higher limits. Unless otherwise agreed by the Planning Secretary, the following exclusions apply: (a) the landowner and occupier may terminate at any time an agreement made with the Proponent to increase the blasting criteria, should concerns made by the landowner and occupier about the blasting criteria be unresolved. Where an agreement is terminated, the Proponent must not exceed the criteria specified in the tables in **Conditions E55 and E56** for future blasting that affects the property; and (b) the blasting limit agreed to under any agreement must not exceed a maximum Peak Particle Velocity vibration level of 25 mm/s or maximum Airblast Overpressure level of 125 dBL.	Section 5.3
E59	**Blast Management Strategy** A Blast Management Strategy must be prepared and must include: (a) sequencing and review of trial blasting to inform blasting; (b) regularity of blasting; (c) intensity of blasting; (d) periods of relief; and (e) blasting program.	Whole document
E60	The **Blast Management Strategy** must be endorsed by a suitably qualified and experienced person.	Section 6.2 & Appendix 2
E61	The **Blast Management Strategy** must be prepared in accordance with relevant guidelines and in consultation with the EPA, in order to ensure that all blasting and associated activities are carried out so as not to generate unacceptable noise and vibration impacts or pose a significant risk to sensitive receivers.	Section 6.1
E62	The **Blast Management Strategy** must be submitted to the Planning Secretary for information no later than one month before the commencement of blasting. The Strategy as submitted to the Planning Secretary, must be implemented for all blasting activities.	Section 6.1

2.2 REVISED ENVIRONMENTAL MANAGEMENT MEASURES

Relevant Revised Environmental Management Measures (REMMs) derived from Chapter 6 of the CHB Submissions Report are listed in Table 2 below. This includes reference to required outcomes, the timing of when the commitment applies, relevant documents or sections of the environmental assessment influencing the outcome and implementation.

TABLE 2 REVISED ENVIRONMENTAL MANAGEMENT MEASURES RELEVANT TO THIS BMS

REMM Ref #	Outcome	Commitment	Timing	Document Reference
NV10	Blasting	A Blast Management Strategy will be prepared as part of the Noise and Vibration Management Plan. The strategy will aim to demonstrate that all blasting and associated activities will be carried out in a manner that will not generate unacceptable noise and vibration impacts or pose a significant risk impact to residences and sensitive receivers. The Blast Management Strategy will address: • Details of blasting to be performed, including location, method and justification of the need to blast • Identification of any potentially affected noise and vibration sensitive sites and structures • Establishment of appropriate criteria for blast overpressure and ground vibration levels at each category of noise sensitive site • Details of the storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction site • Identification of hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives Determination of potential noise and vibration and risk impacts from blasting and appropriate best management practices • Community consultation procedures.	During construction	Whole document

2.3 LICENSING REQUIREMENTS

At the time of writing, no Environmental Protection Licence (EPL) has been issued relating to controlled blasting. If an EPL is issued, controlled blasting shall be undertaken in accordance with any relevant requirements listed therein.

2.4 BLASTING EXPLOSIVES USER LICENCE

Each controlled blast will be executed by a statutorily appointed Shotfirer who will hold a NSW Blasting Explosives User License, as per Part 3 of the *Explosives Act 2003*.

2.5 SAFEWORK NSW

Controlled blasting will be undertaken in accordance with the relevant legislation, guidelines, codes and standards including:

- *NSW Explosives Act, 2003;*
- *NSW Explosives Regulation, 2013;*
- the General explosive licence and security clearance conditions under the NSW explosives act and regulation;

- Australian Explosives Code; and
- AS2187: Explosives – storage transport and use.

A Notification of Blasting Activity will be lodged no less than seven working days before the intended blast date with SafeWork NSW by the holder of a blasting explosives user licence. The notification will be valid for a single event, or for a maximum of three months where there are multiple blasts at the same work location. Any subsequent changes to the notified details shall be provided to SafeWork NSW by email prior to the controlled blasting activity (note: the licence holder must retain evidence of the date/time the notification or variation was submitted via e-mail date stamp).

2.6 SECURITY CLEARANCE

Any persons, who will perform any work with explosives without being under the direct supervision of a Shotfirer, will require a security clearance under the NSW Explosives Regulation, previously named Unsupervised Handling of Explosives License.

2.7 RELEVANT DOCUMENTS

The following guidelines and industry documents are relevant to this document:

- *Explosives Act 2003*
- *Explosives Regulations 2013*
- Code of Practice – WorkCover - Tunnels Under Construction - 2006
- Code of Practice – AEISG - Mobile Processing Units - 4th Edition, September 2018
- Code of Practice – Control of Major Hazard Facilities - October 2002
- Australian Code for The Transport of Explosives by Road and Rail - 3rd Edition
- Australian Standard 2187.1-1998 Explosives — Storage, transport and use, Part 1: Storage
- Australian Standard 2187.2-2006 Explosives — Storage and use, Part 2: Use of explosives
- RMS Specification R44 – Earthworks (Cl. 4.5; Cl. 4.7 Blasting and ANNEXURE R44/A6 Blasting)
- RMS Specification G36 – Environmental Protection
- WorkCover Licensing Requirements
- German DIN 4150: Part 3 – 2016 Effects of Vibration on Structure (DIN, 2016).

FGJV are currently undertaking a review of other specifications and industry research related to controlled blasting in close proximity to elements of the Project asset such a tunnel support structures (i.e. shotcrete and bolts) and bridge abutments. This review will be used to inform element-specific vibration limits should the criteria contained in Section 3.5 be considered unsuitable.

3 SCOPE OF CONTROLLED BLASTING

3.1 LOCATION AND SCOPE OF BLASTING

Ferrovial Gamuda Joint Venture (FGJV) propose to undertake controlled blasting in areas of high strength moderately weathered to fresh rock material where conventional excavations methods would not be efficient. Controlled blasting is proposed for the heading, bench or cross passages in Gatelys Road Tunnel, Shepherds Lane Tunnel and Roberts Hill Tunnel, and in various open cuttings along the CHB alignment.

Proposed locations of controlled blasting are provided in Table 3 and shown in Appendix 3. These locations will be subject to detailed design and further geotechnical investigations

Controlled blasting shall be undertaken with bulk emulsion and/or packaged explosive types, depending on factors such as, but not limited to, blast size, blasting frequency and logistical implications.

It is envisaged that controlled blasting may occur up to four times per day in tunnels and two times per day in cuttings. This will be subject to final construction methodology and schedule requirements.

TABLE 3 PROPOSED CONTROLLED BLAST LOCATIONS

Cut / Tunnel	From Chainage	To Chainage	Estimated Blast Volume (m3)
2	10,289	10,596	59,495
3	11,460	11,567	5,496
4	12,900	13,417	184,220
5A	13,570	13,631	28,538
Roberts Hill	13,620	13,860	32,127
5B	13,795	14,171	243,289
6	14,215	14,423	82,610
8	15,366	15,487	27,667
9	15,565	15,816	89,595
10	15,995	16,154	37,175
11	16,345	16,462	36,532
12	16,776	16,871	41,691
13A	16,937	16,995	38,513
Shepherds Lane	17,010	17,340	62,980
13B	17,310	17,344	7,599
14	17,484	17,524	2,050
15A	18,825	18,891	3,976
Gatleys	18,920	19,360	69,914
15B	19,285	19,353	24,574
16	20,232	20,632	476,442
18	21,225	21,350	35,882
19	21440	21,573	5,937
20	23,227	23,378	4,741
TOTAL			**1,601,043**

Notes:

(1) Blast locations may change following finalisation of detailed design and further geotechnical investigations. Some cuttings with a smaller quantity of high strength rock will be excavated using conventional methods if possible. They have been included in this BMS for completeness and to ensure proper planning is undertaken should blasting be required.

(2) Quantities above may change subject to ground conditions encountered on site.

3.2 POTENTIALLY-AFFECTED SENSITIVE RECEIVERS

Sections 5.4.1 and 5.4.2 of the Updated Noise and Vibration Impact Assessment (Arup, 2020) (Amendment Report) identify sensitive receivers along the alignment and groups them into 'Noise Catchment Areas' (NCAs). In the context of controlled blasting, potentially affected sensitive receivers are those located above or immediately adjacent to the alignment. This includes receivers in the following NCAs:

- NCA 2-NCA 7, NCA 10-NCA 21, NCA23 and NCA 28.

Pursuant to Sections 5.4.1 and 5.4.2 of the Amendment Report, potential overpressure and ground vibration impacts from controlled blasting shall be managed through site and blast-specific assessments. These assessments will be based on the closest receivers to the location of each blast. Further detail on the assessment process is outlined in Section 3.6 and Section 0.

3.3 BLASTING TIMING & REGULARITY

Pursuant to CoA E54, it is envisaged that controlled blasting may be undertaken daily during the permitted hours of:

(a) 9:00am to 5:00pm, Monday to Friday, inclusive;

(b) 9:00am to 1:00pm, Saturday; and

(c) at no time on Sunday or on a public holiday; or

(d) 7:00am to 6:00pm, Mondays to Fridays, inclusive, for work required for the Roberts Hill, Shephards Lane and Gatelys Road tunnels.

Controlled blasting may be undertaken outside the above hours where:

(a) no sensitive receivers would be impacted by controlled blasting; or

(b) an agreement has been made with potentially affected receivers.

Tunnels

In tunnels, it is envisaged that controlled blasting may occur up to four times per day, in the eventual case of blasting headings and bench concurrently. This will be very unlikely to happen in the same tunnel, however may occur in two tunnel locations. This will be subject to final construction methodology and schedule requirements

Open Cuttings

In open cuttings, it is envisaged that blasting may occur up to two times per week in any single location.

Controlled blasting is anticipated to start about September 2023 and will continue for approximately 24 months.

3.4 BLAST DESIGN

Tunnels

In general, the scale of controlled blasts within the tunnel will be led by the requirement to comply with vibration criteria at the adjacent infrastructure around the tunnel. The blast design is therefore based upon:

- A small blasthole diameter, most likely less than 64mm, drilled using mechanical equipment;
- A blasthole length of up to 5 metres although shorter blastholes will be required where control over the explosive weight is required;
- A nominal blasthole pattern with a spacing between blastholes of around 1 metre depending upon rock strengths, blasthole diameter and allowable explosive quantity; and
- Single or multiple explosive charges may be utilised per blasthole, which may be independently sequenced if required to achieve vibration compliance.

Blast patterns for the tunnelling works will be based on the allowable explosive charge weight per delay identified from modelling results to ensure compliance with vibration criteria at the nearest sensitive receivers. As blasting approaches closer to sensitive receivers, charge weights may need to be reduced and may require shortening of blastholes, effectively reducing the length of the advance (or depth) that each blast achieves. Conversely, where blasting occurs further from a sensitive receiver as a result of the depth of the tunnel or a greater horizontal separation distance, and larger explosive weights per blasthole can be used, the blast pattern may be expanded, and/or blasthole length increased.

Open Cuttings

Controlled blast management and mitigation practices for open cuttings have been developed by CHB to minimise the impact of blast fumes, dust, odour, fly rock, ground vibration and airblast overpressure. The procedures aim to minimise the impacts to human safety, property and public infrastructure.

A number of blast management controls are incorporated into the open cutting blast design process. These include:

- Limiting blast Maximum Instantaneous Charge (MIC) via bench height control or application of deck charges;
- Implementing a delay detonation system to minimise hole interaction;
- Use of appropriate stemming length and stemming quality to ensure maximum confinement of the explosives.

3.5 INTENSITY OF BLASTING

The intensity of blasting may be described in terms of the environmental impacts of blast vibration and air overpressure.

Pursuant to CoA E55, airblast overpressure generated by the controlled blasting associated with the CSSI must not exceed the following criteria (unless written agreement is obtained in accordance with MCoA E57 and E58):

Receiver	Type of Blasting Operations	Airblast Overpressure Limit
Sensitive site	Blasting operations lasting more than 12 months or more than 20 blasts	115 dBL for 95% of blasts per year 120 dBL maximum limit
Sensitive Site	Blasting operations lasting less than 12 months or less than 20 blasts in total	120 dBL for 95% of blasts per year 125 dBL maximum limit
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	125 dBL maximum limit. For sites containing equipment sensitive to vibration, the vibration level should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Source – Table J5.4 – AS 2187.2 – 2006

Pursuant to CoA E56, ground vibration generated by controlled blasting associated with the CSSI must not exceed the following criteria for human comfort and structures (unless written agreement is obtained in accordance with MCoA E57 and E58):

Receiver	Type of Blasting Operations	Peak component particle velocity (mm/s)
Sensitive site	Blasting operations lasting more than 12 months or more than 20 blasts	5 mm/s for 95% of blasts per year 10 mm/s maximum limit
Sensitive Site	Blasting operations lasting less than 12 months or less than 20 blasts in total	10 mm/s maximum limit

Occupied non-sensitive sites, such as factories and commercial premises	All Blasting	25 mm/s maximum limit. For sites containing equipment sensitive to vibration, the vibration level should be kept below manufacturer's specifications or levels that can be shown to adversely affect the equipment operation

Source – Table J4.5(A) – AS 2187.2 – 2006

Pursuant to CoA E56, ground vibration generated by controlled blasting associated with the CSSI must not exceed the following criteria for control of damage to structures:

Receiver	Type of Blasting Operations	Peak component particle velocity (mm/s)	
Other structures or architectural elements that include masonry, plaster and plasterboard in their construction 1	All Blasting	15 mm/s 4 Hz to 15 Hz, except for heritage structures where a frequency dependent vibration criteria would be determined in accordance with AS 2187.2 – 2006.	20 mm/s 15 Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings 2	All Blasting	50 mm/s at 4 Hz and above	
Unreinforced or light framed structure. Residential or light commercial type building 2	All Blasting	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Unoccupied structures of reinforced concrete or steel construction	All Blasting	100 mm/s maximum, where agreed with the structure owner.	
Infrastructure service structures, such as pipelines, powerlines, cables and reservoirs.	All Blasting	Limits to be determined by structural design methodology in consultation with the infrastructure service provider.	

Source: Table J4.5(B) – AS 2187.2 – 2006 and Table J4.4.2.1 – AS 2187.2 – 2006 (BS 7385-2)

As detailed in Section 2.7, FGJV is currently reviewing specifications and research available within the industry to determine whether vibration criteria that differs from the tables above are required for controlled blasting in the vicinity of Project asset elements such as tunnel support structures (i.e. shotcrete and bolts) and bridge abutments.

3.6 BLAST MODELLING OF EXPLOSIVE QUANTITIES

Using the data obtained from a Site Law Assessment, initial blast designs will adopt a conservative approach to build confidence in the vibration model and embed safe and efficient blast practices. The data from the trial blasts as well as each subsequent controlled blast shall be fed back into the vibration model to ensure ongoing refinement. Controlled blast design is therefore an iterative process whereby vibration contour drawings will be updated where necessary and used by the team to ensure that the correct notifications and property condition surveys have been put in place.

Blast patterns will also be modified and designed according to the MIC and the criteria that must be achieved. The measured vibration results after each blast will be analysed and adjustments to subsequent designs will be determined accordingly.

3.7 CONTINGENCIES AND TRIAL BLASTING

The implementation of controlled blasting will adopt a conservative approach. An initial, small-scale trial blast will be designed using conservative estimates of vibration prediction constants and be undertaken within a representative geological area along the alignment. The trial blast will not provide any detail on fragmentation or diggability, but rather information on the vibration attenuation over distance. These relationships are integral in determining the scale of blasting (i.e. advance rate per day) that can be used.

If the trial blast indicates that the modelling has underestimated the level of vibration, several mitigation measures may be adopted, including:

- limiting the quantity of explosive by further reducing the length of the blasthole or the length of the explosive column;
- reducing the blasthole diameter; and
- use of alternative explosive types.

Open Cuttings

A trial blast will be completed at the first cutting to be blasted on the Project. The trial blast will be a smaller scale production blast designed to ensure peak ground vibration at the nearest receiver is <5mm/s using a conservative 95th percentile k value of 1840m/s to ensure that the vibration limits are complied with (the average k value is 1140). The vibration monitoring results from the trial blast will then be used to back-calculate the Project-specific k value to be used for the baseline design of subsequent production blasts across the whole alignment. The Project-specific k value will also be continually validated with vibration monitoring results throughout blasting operations to ensure it remains appropriate in the numerous blast locations along the alignment.

Should significantly different geology be encountered in new location, FGJV will assess the need for another trial blast and undertake one if required.

Tunnels

The blasting trials are anticipated to consist of three trial blasts at each portal, consisting of approx. 1kg, 3kg and 7kg of MIC, respectively. These MIC volumes are estimates only and are anticipated to change during the trials depending on the result of preceding trial blasts. Should there be sufficient baseline data available from the open cutting blasting to determine a robust and appropriate k-value, tunnel-specific trial blasts may not be required.

3.7.1 TRIAL BLAST MONITORING

Vibration monitoring will be undertaken during the trial blast to assess the quantity of MIC against attenuation of vibration over distance within the subject geology. External geophones (transducers) will monitor ground vibration (Peak Particle Velocities - PPV) in three directions (transverse, vertical and longitudinal particle velocities) and report the level in mm/s. The recording duration will be set to exceed the duration of the blast to ensure that the entire event is captured.

Monitoring locations will be identified prior to the trial blast as being fit for use (AS 2187) by the blasting consultant, and approval received from the property owners as required. At least five monitoring locations will be selected and will generally include:

- The nearest five residential properties generally a property towards the north, south, east and west of each blast zone, or as otherwise determined by the expert blasting consultant;
- Any heritage item at risk of damage, that is within 50 metres of each blast zone (this refers to heritage listed buildings/infrastructure or other items, and not Heritage Conservation Areas);
- Commercial properties that contain potentially sensitive equipment, such as electronic or scientific apparatus or other equipment with tight tolerances for vibration impacts;
- As otherwise required under the Project EPL

Where property owner approval is not obtained, alternative locations may need to be utilised in appropriate public areas.

Trial blast data will be reviewed by the expert blast consultant for analysis, to identify a relationship between MIC and vibration impacts.

Further detail on controlled blast monitoring is provided in Section 5.5.

4 CONTROLLED BLAST MANAGEMENT

4.1 PRE-BLAST ACTIVITIES

Prior to undertaking drilling and blasting, the following actions will be completed:

- Provide reasonable notice of intended blasting and the anticipated impacts on the nearby properties, occupants of these premises, authorities and any affected public utilities owners;
- Submit blasting notification to NSW WorkCover detailing the proposed blasting activities for the intended period of blasting;
- A condition survey report of adjacent infrastructure, including an assessment of any increased susceptibility of the infrastructure to vibration related effects;
- A broad scale visual assessment of surrounding areas of interest/concern to ensure no external hazards are present and/or precluding blasting from occurring; and
- Preliminary review assessing the expected maximum explosive quantities for control of vibration.

4.1.1 BLAST NOTIFICATION

A blast notification form will be completed prior to undertaking blasting activities and submitted to the New South Wales WorkCover.

4.1.2 PREPARATION OF DRILLING AREA

The area where blasting will be undertaken will be prepared to a condition to enable accurate drilling to achieve both the alignment and grade requirements.

4.1.3 DESIGN AND LAYOUT OF BLASTHOLES

Drilling of blastholes will be completed using well maintained, hydraulic drill equipment. Key considerations include:

- The Shotfirer and/or blasting engineer will establish a drilling pattern, including blasthole lengths, and record the information on a blast pattern design worksheet;
- The type and quantity of explosive which will be loaded into the blastholes will be identified and clearly marked on the plan;
- The total quantity of explosive for each blast will be calculated and reconciled against the designed quantity; and
- The nearest distance to the closest property, or other sensitive receiver or infrastructure, will be used to calculate the expected level of vibration.

4.1.4 TUNNEL WALL CONTROL

Protection of the walls of the tunnels may be improved by adjusting the explosive loading practices around the perimeter of the excavation, including the use of a reduced hole spacing and/or adjusted explosive loading. The perimeter drill holes will be accurately set up in terms of their alignment to minimise drilling error over depth.

4.1.5 BLASTHOLE DRILLING

Blasthole drilling will only be completed once the area has been cleared to establish a reasonable platform to ensure that blastholes can be accurately drilled, both in terms of their inclination as well as the depth. Careful placement of drill holes to ensure the tunnel and cut batter presplit profile is achieved is critical to the design.

4.1.6 TRANSPORT AND STORAGE OF EXPLOSIVES

Transport and storage requirements for blasting activities will be managed by the drill and blast contractor in accordance with the NSW Explosives Act 2003 and the NSW Explosives Regulation 2013.

It is anticipated that explosives for controlled blasting of open cuttings will be stored off site under the appropriate authority license and delivered to site as required with no explosive will be stored on site. The quantity of explosive and detonators required for each blast will be transported daily from the magazines in approved/licenced vehicles. Any unused explosive will be returned to the offsite magazine at the completion of loading.

For controlled blasting for the tunnels, FGJV are investigating opportunities to establish an on-site magazine to store explosives in accordance with the relevant legislation and guidelines.

4.1.7 PRIMING AND LOADING OF THE BLASTHOLE

The following key issues will be included as part of the blasthole priming and loading methods:

- Prior to loading a blasthole, the Shotfirer will confirm the depth of the blasthole is consistent with the depth indicated on the blasting plan;
- Where blastholes are loaded with packaged product, the diameter, length and number of cartridges will be recorded;
- Where the blastholes are loaded with bulk emulsion, the quantity of explosive will be carefully controlled and monitored to be consistent with the designed quantities;
- Any overloaded blastholes shall be remediated as directed by the Shotfirer and may include removal of the excess explosive, or implementation of additional burden/cover;
- The maximum quantity of explosive loaded into any blasthole will be reported on the blast loading plan; and
- The total quantity of explosive loaded into the blast will be reconciled against the quantity indicated on the submitted blast plan. Where the quantities differ, a comment for the variation will be included on the blast loading plan and confirmed as acceptable prior to initiating the blast.

4.1.8 CLEARANCE PROCEDURES

Safety of personnel within work areas will be achieved through documented clearance procedures. Procedures will be completed for any controlled blasting that may be required.

Prior to blasting, all personnel will be evacuated to a safe working area. Blast safety procedures will be developed and implemented. Safe working areas will be determined by the Shotfirer in consultation with other relevant site personnel in accordance with risk management procedures. These areas will contain a permanent source of fresh air and maintain positive means of egress in the event of an emergency. These locations are to be risk assessed individually and comply with WorkCover NSW Work Health and Safety requirements.

Personnel evacuation and clearance will be controlled by FGJV under the direction of the Shotfirer. An electronic monitoring system which can be monitored from a safe working area will be the primary means of personnel accountability. All FGJV personnel, sub-contractors and visitors will use an electronic system as part of the site-specific induction for personnel entering the relevant area of works.

Blast sentries/guards will be positioned at strategic locations as determined by the Shotfirer in consultation with other relevant site personnel. A final clearance shall be conducted prior to initiation. Upon confirmation to the Shotfirer and senior supervisors that all personnel are evacuated from the clearance area, the direction to commence firing procedures will be given. Initiation of the blast will be conducted by the Shotfirer only when they are satisfied that it is safe to do so. The Shotfirer will have full discretion to terminate the blast sequence at any time if they determine it is unsafe to proceed.

Following the blast, blast fumes will be given appropriate time to clear. This complies with the NSW “Tunnels Under Construction Code of Practice 2006” air quality and ventilation systems guidelines. When it is determined safe, the Shotfirer will inspect the blast location and confirm complete detonation. Upon confirmation that the area is safe to enter the ‘All Clear’ will be given by the Shotfirer and personnel allowed to re-enter.

In accordance with the blast safety procedures, the Shotfirer will ensure relevant controls are implemented to neutralise and make safe the blast area and ensure geotechnical risks are managed before allowing personnel entry.

4.2 INITIATION

Blasting, including the loading and sequencing of blastholes will be completed in accordance with all applicable NSW legislation. Key issues include:

- The Shotfirer/Blasting Engineer will determine the initiation sequence;
- Preference shall be given to the use of electronic detonators to ensure maximum control over vibration levels; and
- A blast initiation plan shall be documented for each blast and assessed for likely compliance with imposed vibration criteria.

4.3 FIRING

Firing of the blast will be under the control of the Shotfirer. The following key issues will be confirmed:

- The community team have informed the potentially affected persons of the intent to blast;
- The area will be inspected to ensure all personnel are a safe distance from the blasting activities; and
- Put in place all control points to block access to the tunnel or cuttings, including internal access other than ramps, at a safe distance from the blast area. The safe distance will be determined through standard risk assessment procedures.

4.4 MISFIRES

Should a misfire (failure of an explosive to detonate) occur, an investigation into the root cause will be conducted including a review of the loading and firing process, review of the blast design and initiation sequence, and analysis of the performance of the initiation system. Following a blast, the re-entry process is as follows:

- After the blast is fired and the tunnel area has been adequately ventilated, the Shotfirer will visually inspect the entire shot for evidence of misfires.
- If found, the Shotfirer will notify FGJV immediately along with the blast guards; and
- The Shotfirer will decide the safe and appropriate method of action.

If a misfire (unexploded explosive) is detected during excavation:

- Stay well clear;
- Warn all personnel in the area;
- The Project Area supervisor will notify the Shotfirer immediately; and
- A detailed and safe excavation plan will be formulated and implemented.

4.5 FLYROCK

All blasts shall be designed with due consideration for the likelihood of, and tolerance for, flyrock.

Blasting in the underground environment is often highly energetic and may generate significant flyrock. The need to control this flyrock will vary on the location of blasting within the tunnel and whether there are sensitive services or equipment in the vicinity that may be damaged. Flyrock control in the tunnel environment may be achieved through the use of stemming and/or blast mats or other barricades.

Conversely, blasting portals or ramps that are open to the surface require complete control over flyrock. Surface blasts shall be designed to minimise flyrock using a number of methodologies including, but not limited to:

- Increased stem heights based on Scaled Depth of Burial Calculations; and
- Importation of 'false burden' where required to provide additional blast cover.

4.6 FUMES

Blast fumes may result from non-ideal detonation of explosives due to a number of factors, including presence of ground water and lack of confinement. Prevention of fume due to groundwater is a function of using the appropriate explosive type for the ground conditions and this shall be assessed collaboratively by the blasting contractor and/or a specialist blasting consultant.

Fumes due to lack of confinement are generally a result of soft ground conditions which is not expected to be the case on this Project. Other controls relating to fume such as quality assurance of manufactured products and correct priming and loading practices will be addressed in the Blast Management Plan.

4.7 DUST

Dust in the underground environment will be managed through adequate ventilation in conjunction with re-entry procedures that are predicated on effective air monitoring.

Dust from potential blasting in a surface environment will be managed through ensuring adequate stemming length is provided.

4.8 RECORD KEEPING

Accurate records of each blast shall be kept and include the following details as a minimum:

a) Date, identification number and time of blast;
b) Location, number and diameter of blast holes loaded;
c) Depth of each drill hole loaded;
d) Inclination of drill holes;
e) Types and amounts of explosives used;
f) Maximum instantaneous charge;
g) Initiation Plan; and
h) Ground vibration at monitoring locations.

The Shotfirer shall maintain responsibility for ensuring that all information is recorded as the blast is loaded.

4.9 RECONCILIATIONS AND REPORTING

Prior to firing each blast, the following documents will be compiled:

- A pre-blast sheet confirming that the expected level of vibration at each of the nearest sensitive receivers complies with the vibration limits;
- A completed drilling sheet prepared by the Shotfirer showing the measured depth of each blasthole. The sheet will identify and clearly mark any “anomalous” blastholes;
- A blast loading plan showing the depth of each blasthole, quantity of explosive in each blasthole and the stemming length.
- A blast initiation plan showing the firing sequence.
- Reconciled explosive quantities used versus the designed quantity will also be shown and any variations accounted for;
- A signed blast summary sheet showing that each of these forms been received and no variations between the intended and implemented design exist.

These actions are in accordance with the specifications listed in the Australian Standards AS2187.2 document.

Procedures will be developed and implemented to address accounting and reporting issues associated with the loss or theft of explosives.

5 ENVIRONMENTAL MANAGEMENT & COMMUNITY NOTIFICATION

5.1 PROPERTY CONDITION SURVEYS

The objective of a condition survey report is to document the pre-existing condition of the infrastructure prior to the commencement of any construction. The condition surveys therefore establish the benchmark of the condition of the property for later reference should any claim of damage be made. All condition surveys shall be prepared to meet these objectives.

Pursuant to MCoA E71, before the commencement of any work that may cause damage to buildings, structures, utilities and the like that are identified in the documents listed in Condition A1 as being at risk of damage, a condition survey of those buildings, structures, utilities must be undertaken by an appropriately qualified independent professional. The results of the surveys must be documented in a Condition Survey Report for each item surveyed. Copies of Condition Survey Reports must be provided to the owners of the items surveyed prior to the work commencing.

5.2 COMMUNITY CONSULTATION AND NOTIFICATION

A Community Communications Strategy (CCS) has been prepared in accordance with MCoA B3 to provide an approach to stakeholder, community communications and engagement. The CCS has been approved by DPE prior to the commencement of works, for implementation in accordance with MCoA B4. All community consultation, notification and complaints management associated with blasting will be undertaken in accordance with the CCS.

In line with the process outlined in the CCS, residents and businesses within the relevant offset zones for tunnelling/blasting activities shall be notified before tunnelling/blasting is to occur near that property. Notification will include the likely times, dates and duration of blasting activity near the property.

Nearby residents and businesses will be consulted/informed about controlled blasting by:

- meeting with nearby residents and businesses to provide information about blasting and process for each blast;
- meetings to occur before blasting starts and then ongoing during construction, as required and requested by residents and businesses;
- obtain written agreement from residents and business (based on vibration limit predications) for increased blasting limits in accordance with the EPL/MCoA; and
- notify residents, businesses and motorists of each controlled blasting.

A Community and Stakeholder Engagement (CSE) Action Plan will also be implemented, with a focus on the inception period of the controlled blasting program.

5.3 WRITTEN AGREEMENTS

Pursuant to MCoA E57, the blasting criteria specified in the Tables in Conditions E55 and E56 may be exceeded where the Proponent has obtained the written agreement of the landowner and occupier to increase the relevant criteria. In obtaining the agreement, the Proponent must make available to the landowner and occupier:

a) details of the proposed blasting program and justification for the proposed increase in blasting criteria including alternatives considered (where relevant);

b) an assessment of the environmental impacts of the increased blasting criteria on the surrounding environment and most affected residences or other sensitive receivers including, but not limited to noise, vibration and air quality and any risk to surrounding utilities, services or other structures; and

c) details of the blast management, mitigation and monitoring procedures to be implemented.

Pursuant to MCoA E58, the Proponent must provide a copy of the landowner and occupier written agreement to the Planning Secretary and the EPA, including details of the consultation undertaken (with clear identification of proposed blast limits and potential property impacts), before commencing blasting at the higher limits. Unless otherwise agreed by the Planning Secretary, the following exclusions apply:

a) the landowner and occupier may terminate at any time an agreement made with the Proponent to increase the blasting criteria, should concerns made by the landowner and occupier about the blasting criteria be unresolved. Where an agreement is terminated, the Proponent must not exceed the criteria specified in the tables in Conditions E55 and E56 for future blasting that affects the property; and

b) the blasting limit agreed to under any agreement must not exceed a maximum Peak Particle Velocity vibration level of 25 mm/s or maximum Airblast Overpressure level of 125 dBL.

5.4 RESPITE

MCoA E54 provides limitations on times of the day and days of the week that blasting events may take place. It is envisaged that the limited blasting windows will provide sufficient mitigation of the impacts of blasting without the need to provide further respite periods. This however will be assessed on an ongoing basis as construction works proceed in light of any complaints received from the local community.

5.5 MONITORING

Vibration and airblast monitoring shall be carried out in accordance with the guidelines provided in Australian Standard AS 2187.2-2006 (Appendix J). Section J3 of the standard provides guidelines for how to measure vibration and airblast overpressure caused by blasting, with Section J3.2 and J3.3 providing more specific guidance on standard equipment and techniques used for monitoring respectively.

Vibration from blasting is measured as Peak Particle Velocity (PPV), expressed in millimetres per second (mm/s), and monitoring is to be carried out in all 3 axes. This arrangement enables a rapid assessment of vibrations in a coordinate system applicable to most man-made structures. The frequency range of the measurement equipment will be between 2 Hz and 250 Hz, as this will contain the expected frequency of vibration. Monitoring shall be carried out on the property foundations near the point of concern as the preferred choice.

Airblast overpressure monitoring is monitored using a microphone, with the results expressed in decibels Linear (dBL). The absolute maximum pressure level will be recorded for the full duration of the blast event. Where required, the microphones will be located adjacent to the vibration monitors, orientated towards the blasting location.

It is anticipated that in some instances for controlled blasting within the tunnels, airblast overpressure will no longer be a key impact given blasting will be underground away from the tunnel portal. In these instances, only vibration from blasting would be measured.

All monitoring will be undertaken by competent personnel, suitability trained and experienced in undertaking blast monitoring and in accordance with AS AS2187 recommendations.

Monitoring instruments will be calibrated in accordance with manufacturers specifications or relevant Australian Standards. Monitoring and monitoring equipment calibration records will be maintained by blast consultant and provided to FGJV throughout the delivery of the Project.

Monitoring records will be completed to record details like:

- Date and time of measurements
- Name of person undertaking the measurements
- Type and model number of instrumentation
- Time of day, length of measurement and measurement time intervals
- Monitoring location (including a sketched map of area)
- Measurement location details and number of measurements at each location

6 DOCUMENT REVIEW AND APPROVAL

6.1 CONSULTATION

This BMS has been developed in consultation with FGJV Environmental Managers, Construction Managers, the Environment and Sustainability Manager and finally the Project Director.

External consultation for this BMS was undertaken with EPA as required under MCoA E61. Pursuant to MCoA A5, evidence of this consultation is provided in Appendix 1.

Pursuant to MCoA E62, this BMS shall be submitted to the Planning Secretary for information no later than one month before the commencement of blasting. The Strategy as submitted to the Planning Secretary, must be implemented for all blasting activities.

The FGJV Environment and Sustainability Manager will be the authorised contact person for communications with the relevant stakeholders i.e. TfNSW, DPE and the EPA on environmental matters. Liaison will include reporting on the ongoing environmental performance and key environmental matters on the Project to these stakeholders.

6.2 REVIEW AND ENDORSEMENT

In accordance with MCoA E60, this BMS has been endorsed by a suitably qualified and experienced person. This endorsement is provided in Appendix 2.

In accordance with MCoA A30(d) the Project Acoustic Advisor (AA) shall review all noise and vibration documents required to be prepared under the terms of this approval and, should they be consistent with the terms of this approval, endorse them before submission to the Planning Secretary (if required to be submitted to the Planning Secretary) or before implementation (if not required to be submitted to the Planning Secretary).

APPENDICES

APPENDIX 1 STAKEHOLDER CONSULTATION AND COMMENTS TRACKING REGISTER

APPENDIX 2 ENDORSEMENT OF BMS BY QUALIFIED PERSON

HEILIG & PARTNERS
Engineered Excellence

- Tunnelling
- Construction
- Open Pit Mining
- Quarrying
- Underground Mining
- Blast Design
- Blast Permitting
- Vibration Monitoring
- Vibration Analysis
- Expert Witness

91 Burdekin Drive
Sinnamon Park. QLD. 4073. Australia
P.O. Box 1176
Mt.Ommaney QLD. 4074. Australia

Telephone +61 7 3715 7599
Facsimile +61 7 3715 7588

Email group@heiligandpartners.com.au
www.heiligandpartners.com.au

datatrap
vibration management software

Thursday, March 23, 2023

Ref:jhh:BMS Coffs Harbour Endorsement

Ms. Anna Burke
Coffs Harbour Bypass Team
28 Isles Drive
Boambee Valley, NSW 2450

RE: Endorsement of Coffs Harbour Blast Management Strategy (BMS)

Dear Anna,

Further to the Blast Management Strategy (BMS) that has been prepared for the Coffs Harbour Bypass project, I have reviewed this document with respect to its accuracy, appropriateness for the project and its ability to act as a working document to inform and guide management to deliver a safe solution with respect to blast outcomes. In preparing this assessment, I have reviewed the document based upon my 39 years of experience within the construction industry together with my knowledge gained from holding a shotfirer's license for 37 of these years.

It is my professional view that the BMS has met the key requirements of a document that illustrates the potential impacts associated with blasting, how these will be assessed, the controls that might be necessary to mitigate the effects to acceptable levels as specified in the Conditions of Approval and a monitoring approach to quantify confirm compliance with the above.

The BMS addresses the requirements of the Conditions of Approval and Coffs Harbour Bypass blast management framework appropriately.

As always, you are most welcome to contact me at your convenience to discuss in further detail any of the issues raised in this letter.

Yours truly,

John Heilig

Dr. John Heilig
Principal - Heilig & Partners Pty Ltd
RPEQ#6304

APPENDIX 3 PROPOSED CONTROLLED BLASTING LOCATIONS

LEGEND

- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,000

0 250 500 1,000 ft

0 75 150 300 m

Esri Community Maps Contributors, Geoscape, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS

LEGEND

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1:4,000

0 250 500 1,000 ft

0 75 150 300 m

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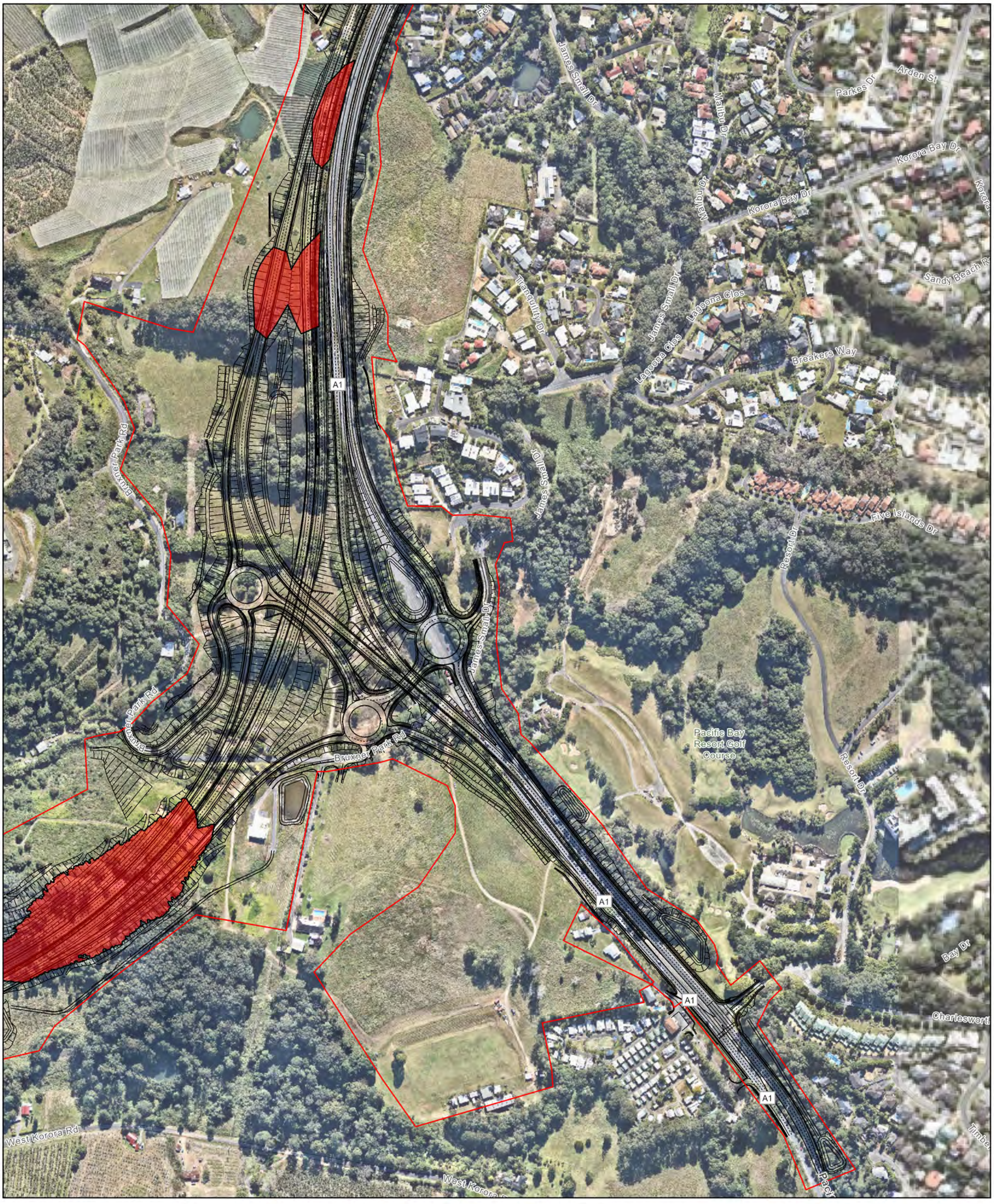


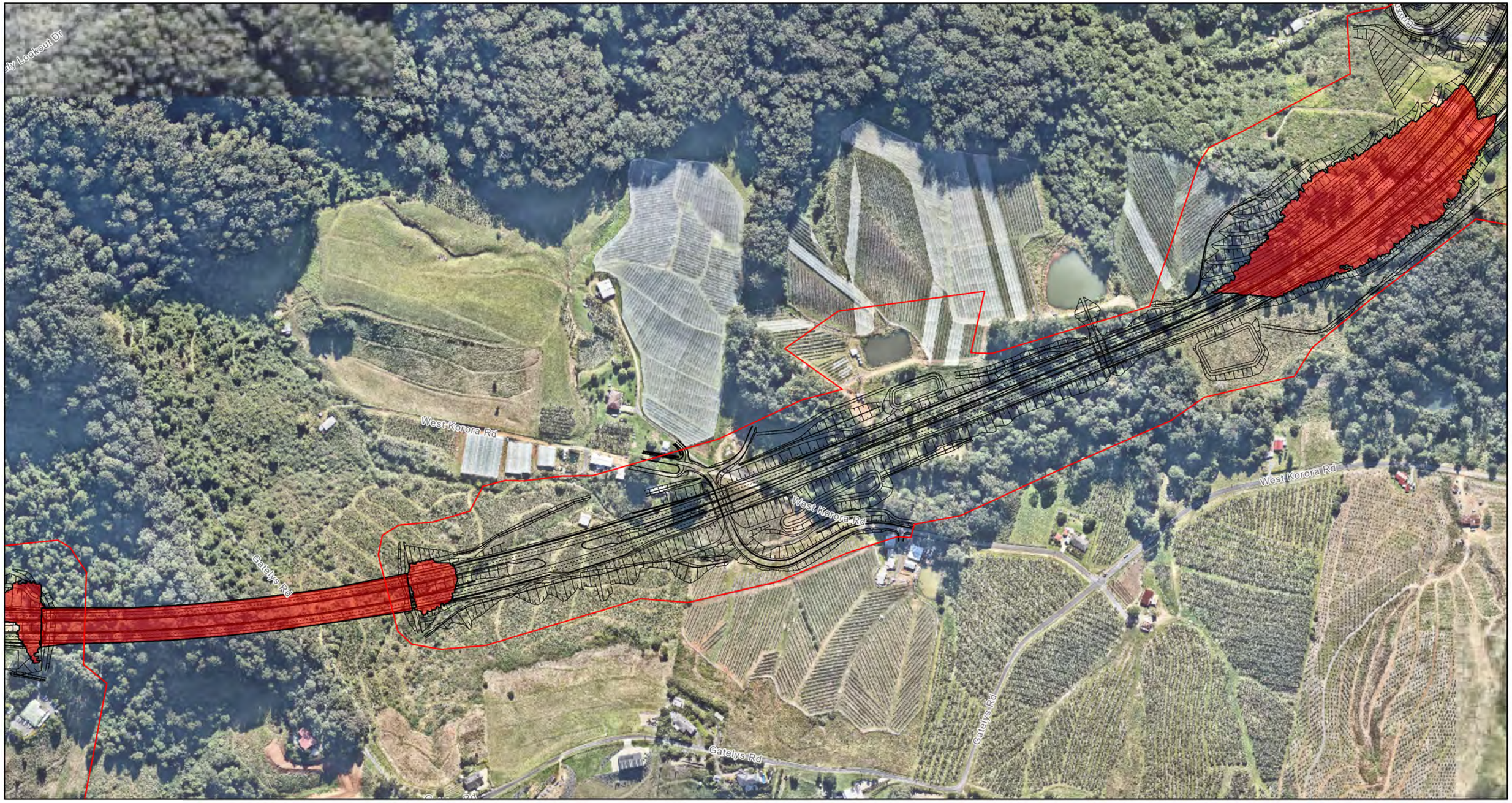
LEGEND

- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,500

0 280 560 1,120 ft

0 85 170 340 m



LEGEND

- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,100

0 275 550 1,100 ft

0 80 160 320 m

Esri Community Maps Contributors, Geoscape, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS

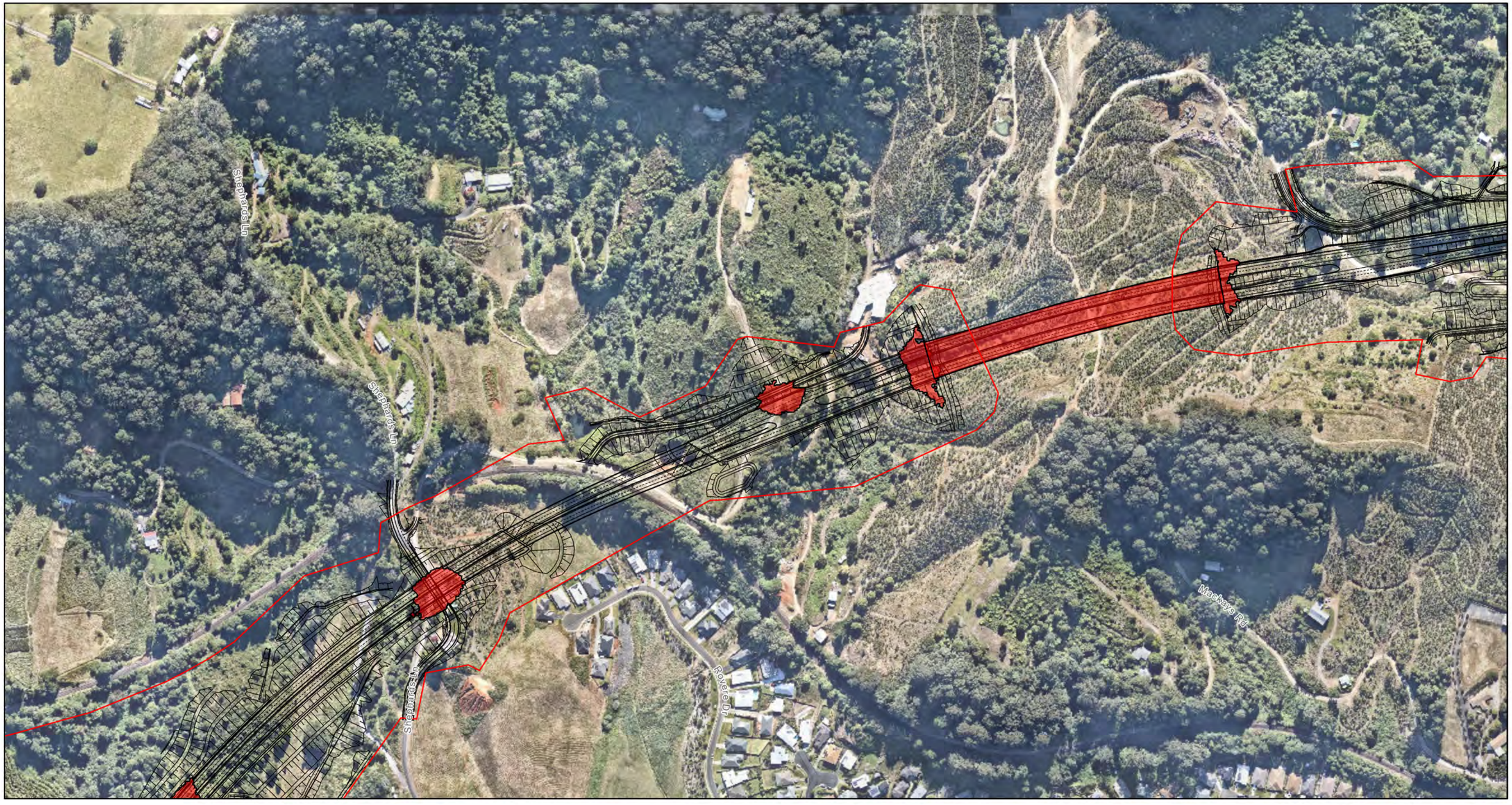
LEGEND

- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,000

0 270 540 1,080 ft

0 80 160 320 m



LEGEND

- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,000

0 270 540 1,080 ft

0 80 160 320 m

Esri Community Maps Contributors, Geoscape, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS

LEGEND

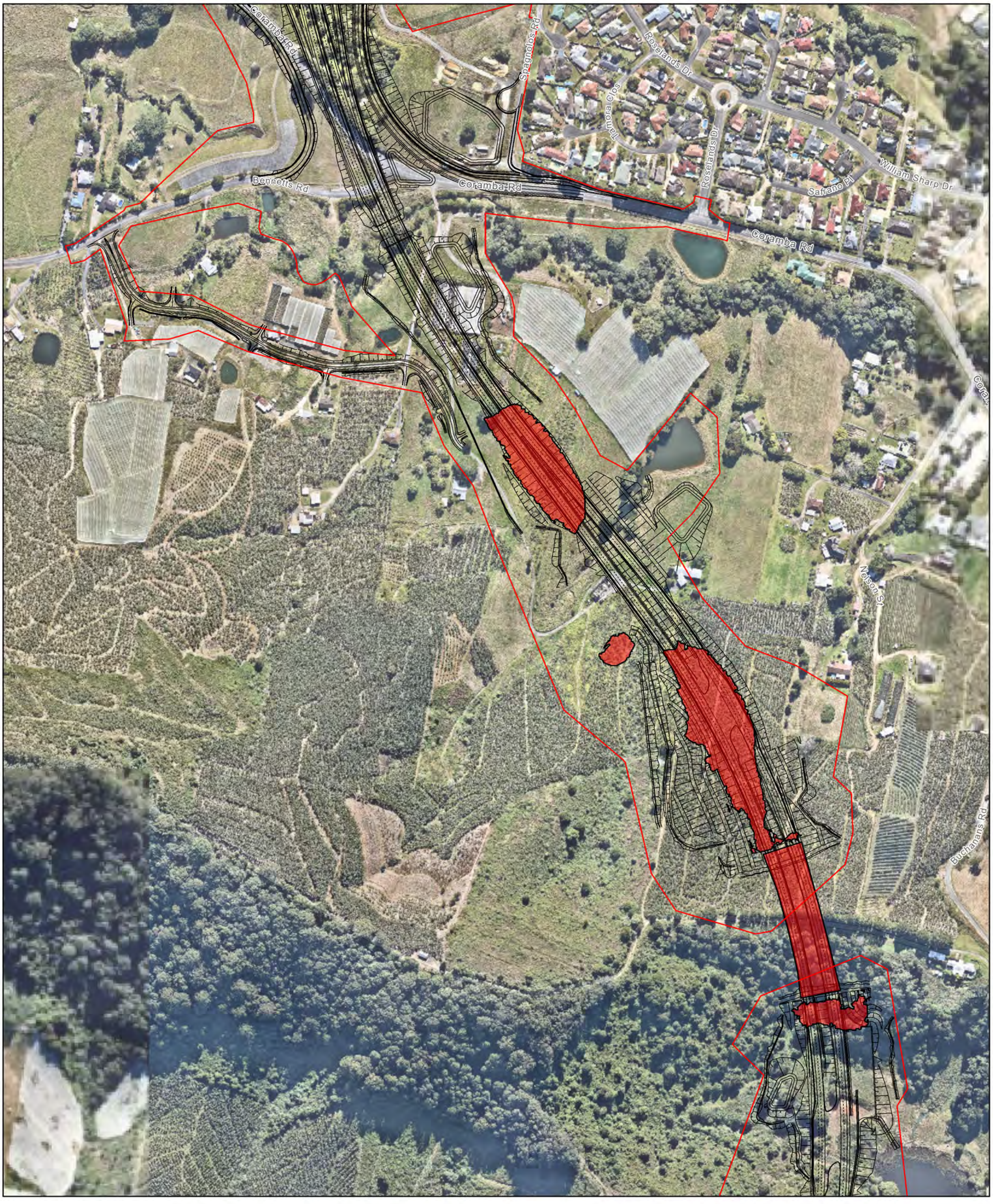
- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,000

0 250 500 1,000 ft

0 75 150 300 m

Esri Community Maps Contributors, Geoscape, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS



LEGEND

- Proposed Controlled Blasting Locations
- Approved Construction Boundary – EIS
- Project Design

1:4,000

0 250 500 1,000 ft

0 75 150 300 m

Esri Community Maps Contributors, Geoscape, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS

LEGEND

Proposed Controlled Blasting Locations

Approved Construction Boundary – EIS

Project Design

1:4,000

0 250 500 1,000 ft

0 75 150 300 m

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0 250 500 1,000 ft

0 75 150 300 m

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0 250 500 1,000 ft

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