

APPENDIX

O

Matters of National Environmental Significance Report

Part 3 of 6

BORDER TO GOWRIE REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX

O

Matters of National Environmental Significance Report

Appendix A Additional ecological investigations post submission of the draft EIS

CONTINUED

BORDER TO GOWRIE REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT

APPENDIX

L

WEED ABUNDANCES

Weed 1km Summary Points - *Opuntia tomentosa*

B2G ECOLOGICAL ASSESSMENT

Legend

-  Flora Study Area
-  Major Watercourse (DNRME)
-  Major Road (QSpatial, 2019)

Abundance

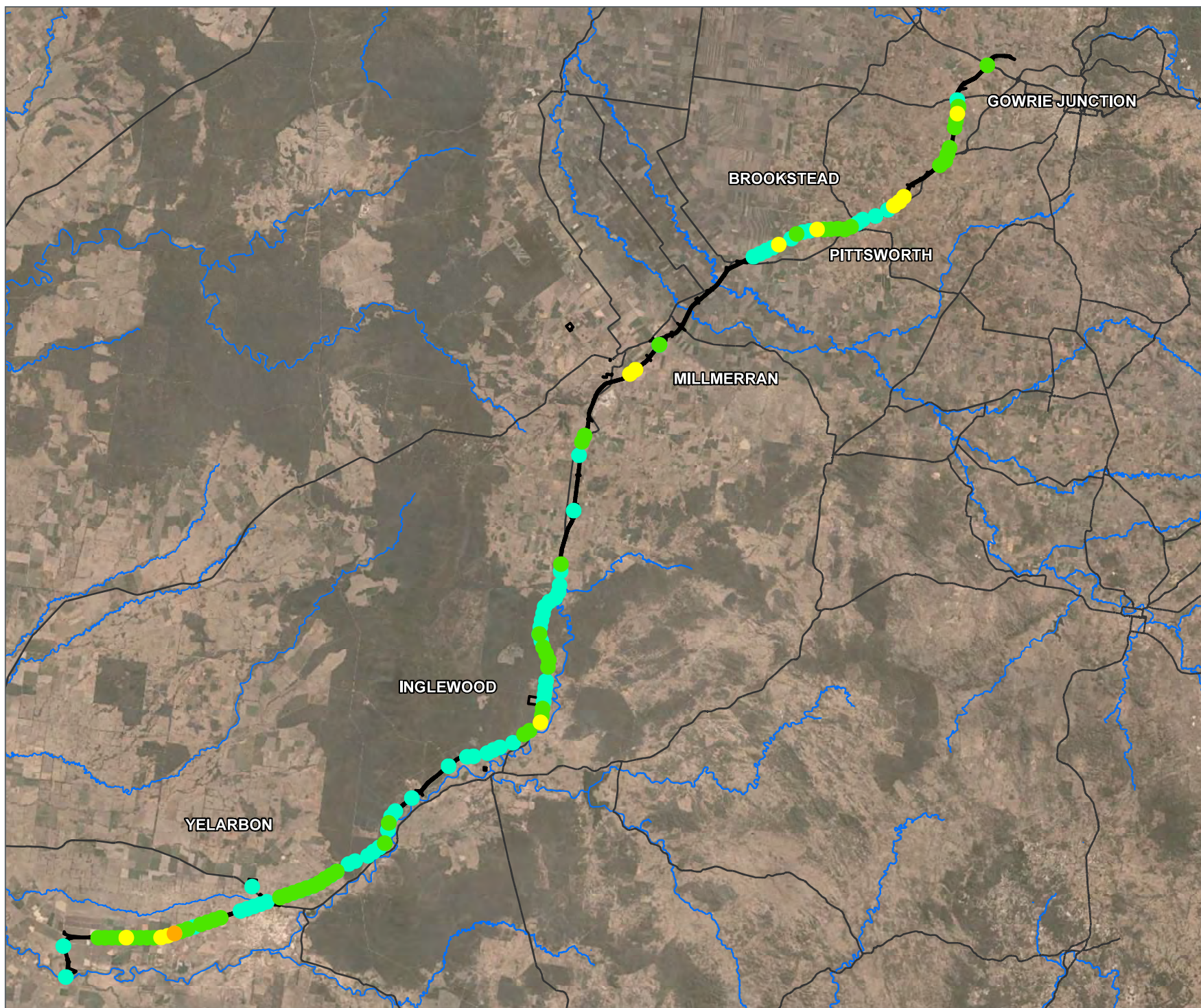
-  Present
-  Scattered
-  Low
-  Moderate

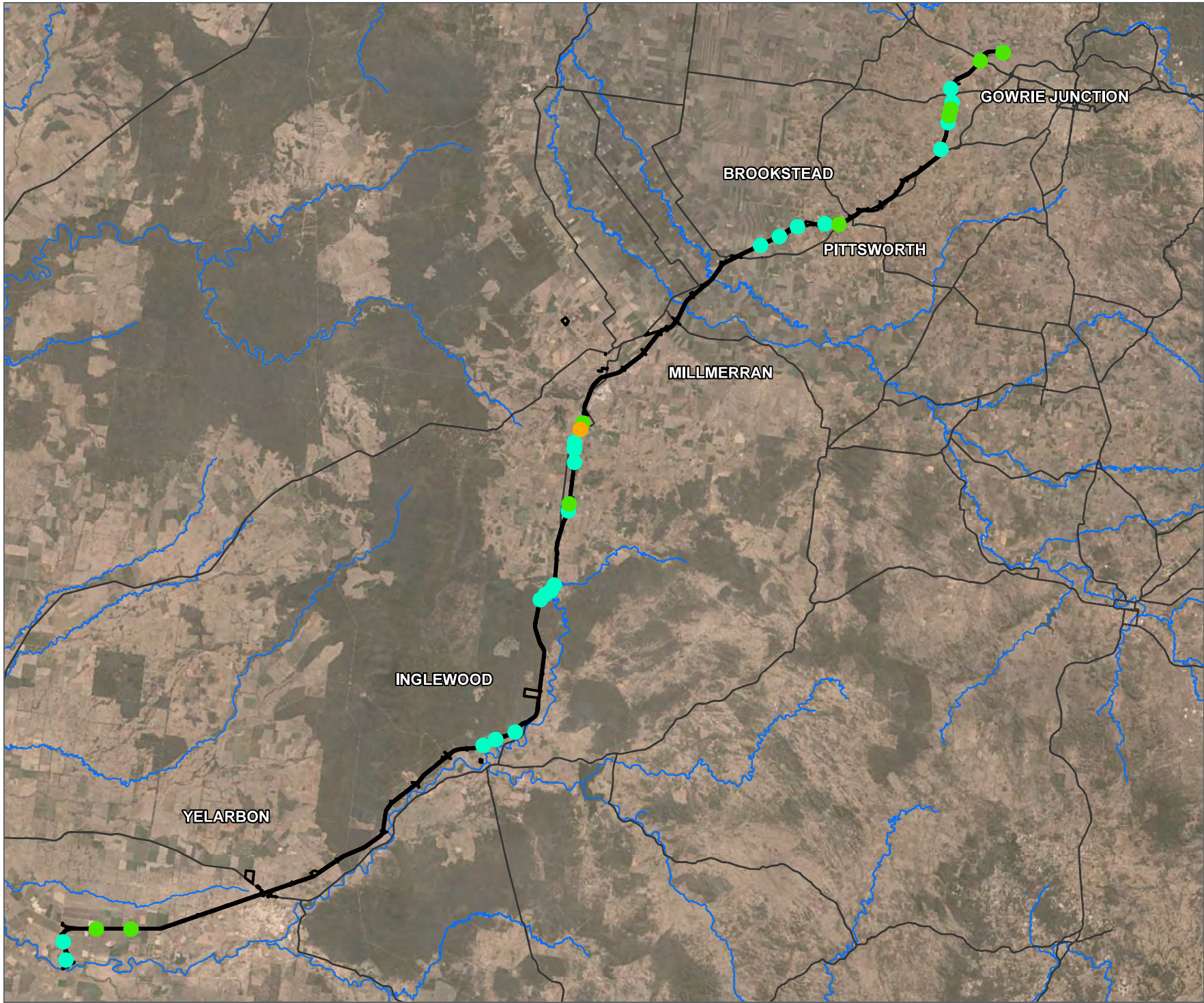
Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)





ARTC

Weed 1km Summary Points - *Lycium ferocissimum*

B2G ECOLOGICAL ASSESSMENT

Legend

- Flora Study Area
- Major Watercourse (DNRME)
- Major Road (QSpatial, 2019)

Abundance

- Present
- Scattered
- Moderate

Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_L_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)

Weed 1km Summary Points - *Bryophyllum delagoense*

B2G ECOLOGICAL ASSESSMENT

Legend

-  Flora Study Area
-  Major Watercourse (DNRME)
-  Major Road (QSpatial, 2019)

Abundance

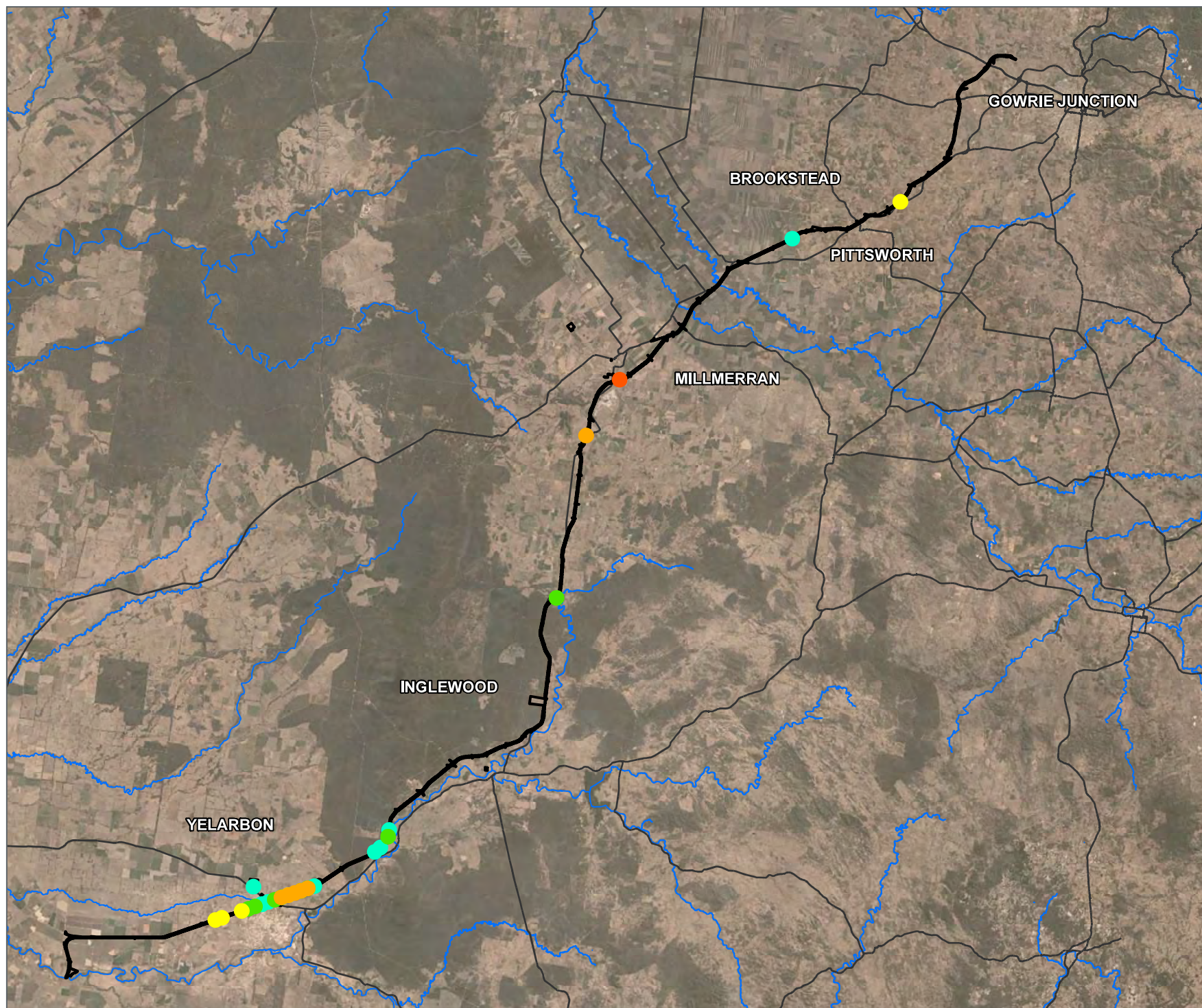
-  Present
-  Scattered
-  Low
-  Moderate
-  High

Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_L_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)



Weed 1km Summary Points - *Harrisia martinii*

B2G ECOLOGICAL ASSESSMENT

Legend

-  Flora Study Area
-  Major Watercourse (DNRME)
-  Major Road (QSpatial, 2019)

Abundance

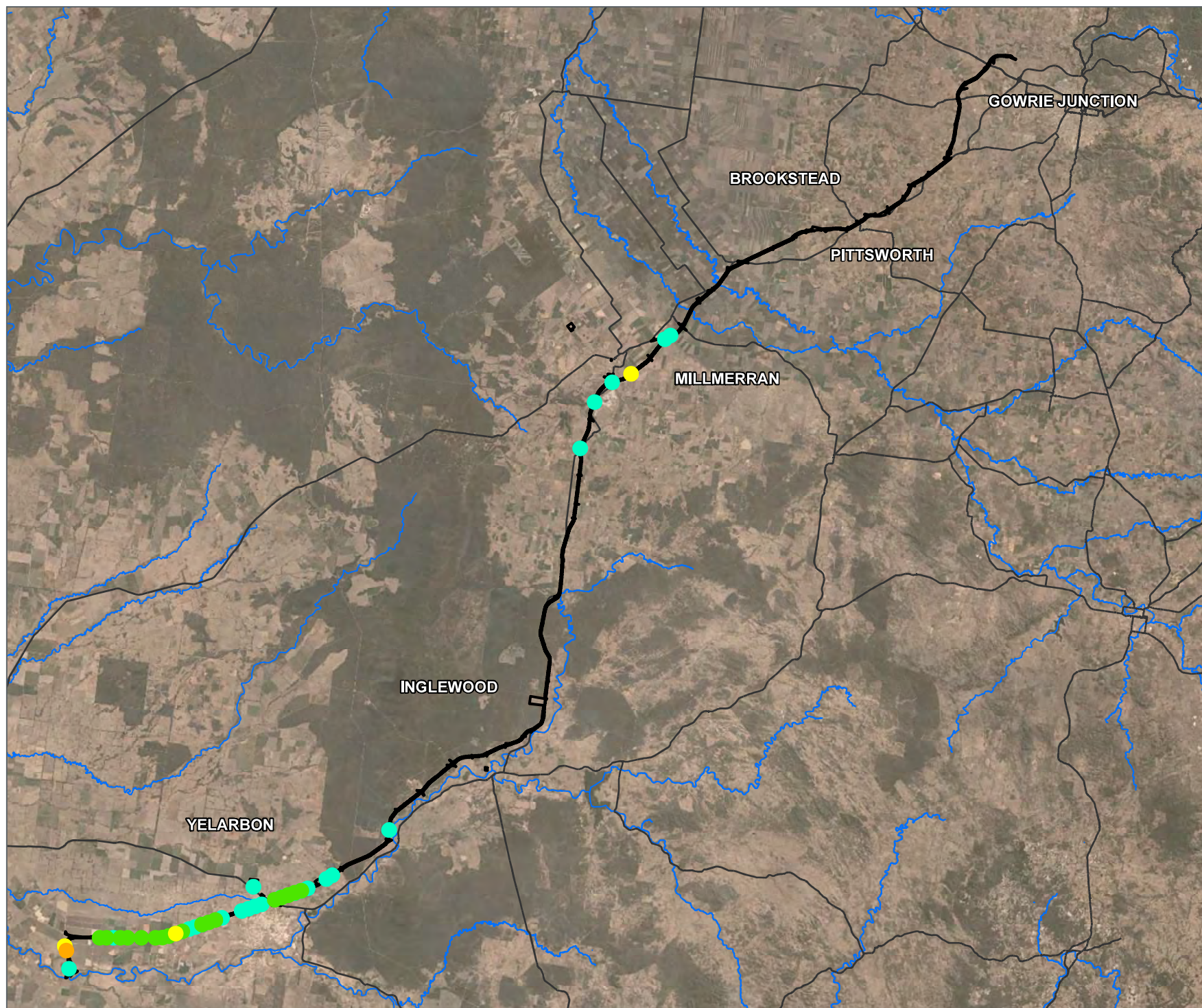
-  Present
-  Scattered
-  Low
-  Moderate

Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_L_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)



Weed 1km Summary Points - *Opuntia aurantiaca*

B2G ECOLOGICAL ASSESSMENT

Legend

-  Flora Study Area
-  Major Watercourse (DNRME)
-  Major Road (QSpatial, 2019)

Abundance

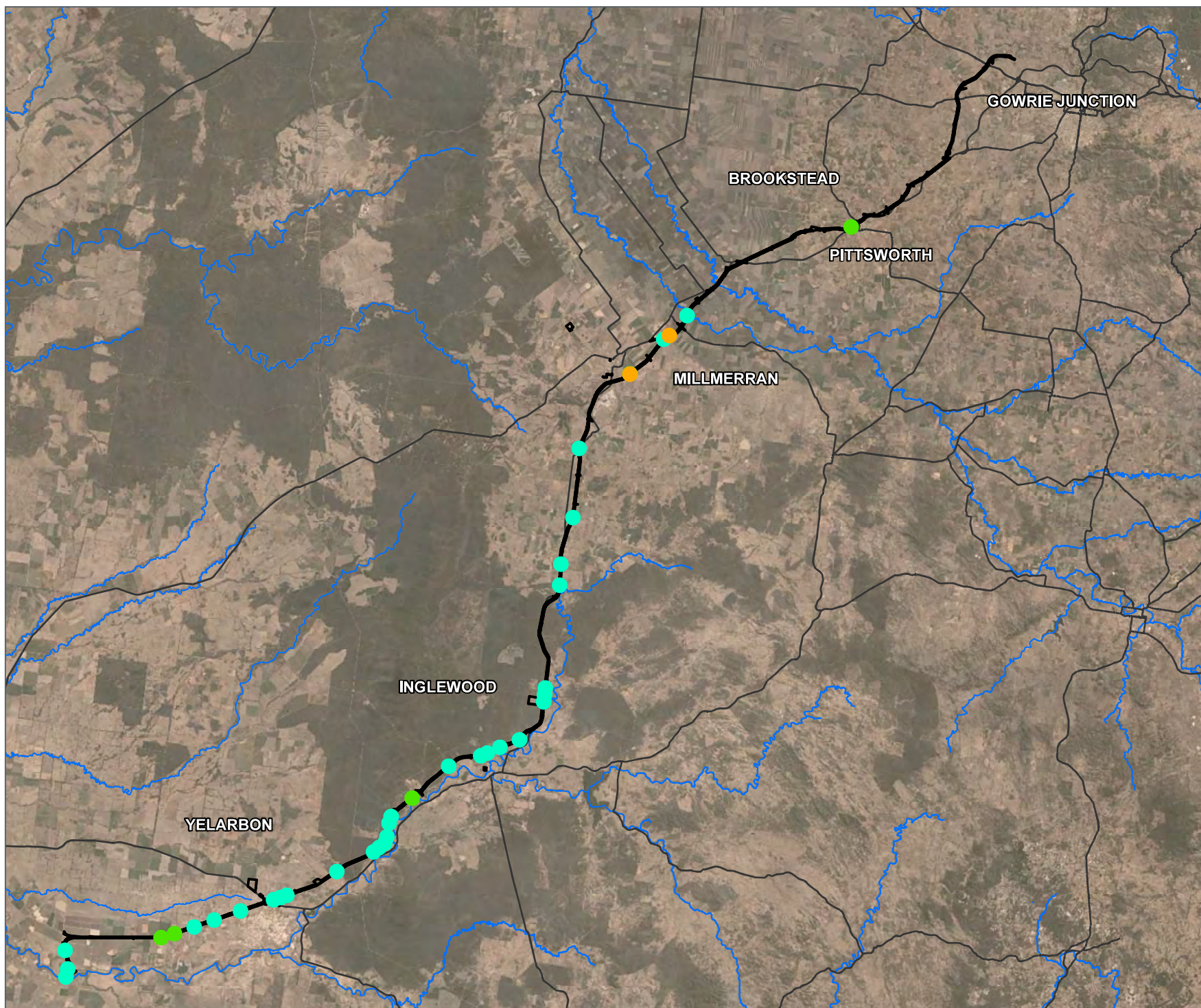
-  Present
-  Scattered
-  Moderate

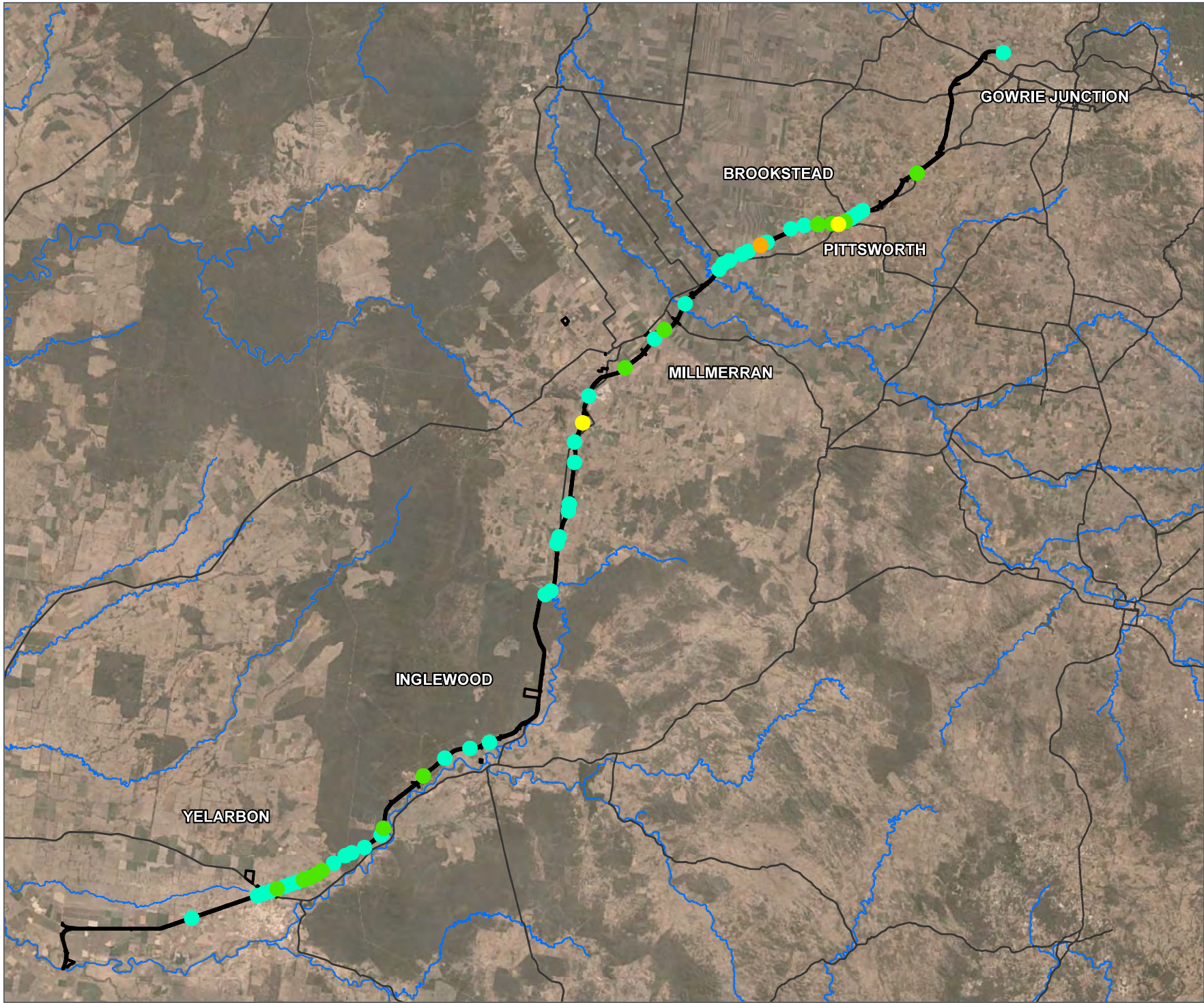
Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)





ARTC

Weed 1km Summary Points - *Opuntia stricta*

B2G ECOLOGICAL ASSESSMENT

Legend

- Flora Study Area
- Major Watercourse (DNRME)
- Major Road (QSpatial, 2019)

Abundance

- Present
- Scattered
- Low
- Moderate

Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)

Weed 1km Summary Points - Other weeds

B2G ECOLOGICAL ASSESSMENT

Legend

-  Flora Study Area
-  Major Watercourse (DNRME)
-  Major Road (QSpatial, 2019)

Abundance

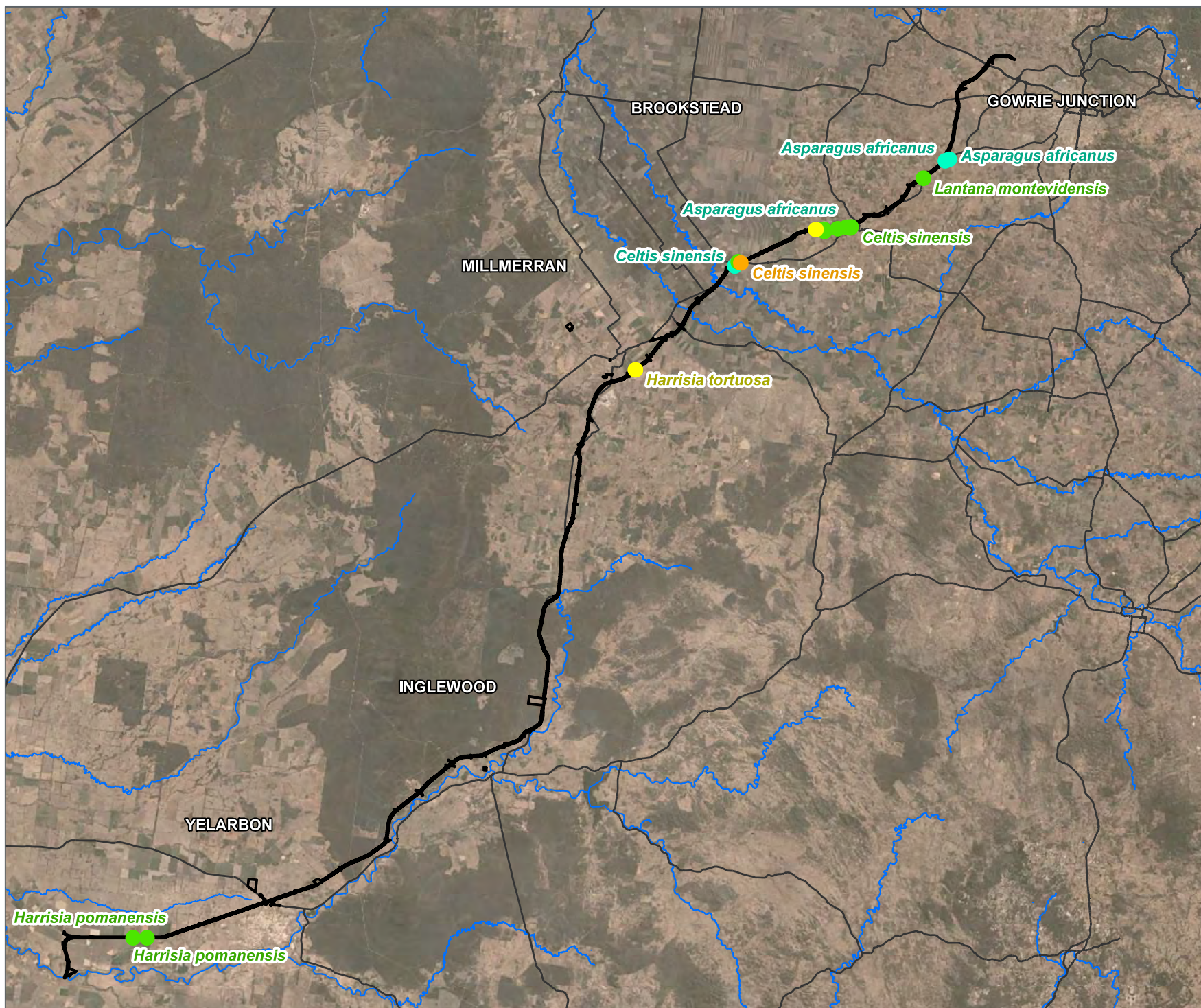
-  Present
-  Scattered
-  Low
-  Moderate

Suburb labels as per
Australian Bureau of Statistics (2011)

1:525,000 Scale at A3



Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2021-04-16 | Project: NE30044
Coordinate System: GDA 1994 MGA Zone 56
Map: NE30044-GS-068-Report_Weeds.mxd 01
Aerial Imagery supplied by the State of Queensland (2017)



Appendix D – BioCondition assessment photos

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	1	0	0	5	12	0	67	0	100%
	35	0	6	1	0	22	28	0	8	0	100%
	18	0	2	0	0	6	7	2	65	0	100%
	82	0	1	0	1	9	4	1	2	0	100%
	10	0	1	0	0	6	43	0	40	0	100%
Mean	32.00	0.00	2.20	0.20	0.20	9.60	18.80	0.60	36.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	5	80	15	0	0	0	100%
	2	0	10	0	0	73	15	0	0	0	100%
	5	0	10	0	0	65	20	0	0	0	100%
	5	0	5	0	0	75	15	0	0	0	100%
	10	0	10	0	10	40	30	0	0	0	100%
Mean	4.40	0.00	7.00	0.00	3.00	66.60	19.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	20	0	5	0	0	30	40	0	5	0	100%
	5	0	0	8	11	50	25	0	1	0	100%
	0	0	2	0	30	33	35	0	0	0	100%
	20	0	1	0	25	25	24	0	5	0	100%
	15	0	0	0	36	45	3	0	1	0	100%
Mean	12.00	0.00	1.60	1.60	20.40	36.60	25.40	0.00	2.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	52	0	0	0	35	0	3	0	100%
	68	0	10	0	0	2	15	0	5	0	100%
	65	0	10	0	0	0	15	0	10	0	100%
	71	0	20	0	0	0	3	0	6	0	100%
	64	0	4	1	0	1	10	0	20	0	100%
Mean	55.60	0.00	19.20	0.20	0.00	0.60	15.60	0.00	8.80	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	1	0	3	0	0	93	2	0	1	0	100%
	5	0	15	0	0	78	2	0	0	0	100%
	1	0	5	0	0	91	2	0	1	0	100%
	3	0	10	0	0	85	2	0	0	0	100%
	3	0	35	0	0	59	3	0	0	0	100%
Mean	2.60	0.00	13.60	0.00	0.00	81.20	2.20	0.00	0.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	20	0	0	0	55	0	15	0	100%
	0	0	1	0	0	0	94	0	5	0	100%
	3	0	1	0	0	0	94	0	2	0	100%
	2	0	5	0	0	0	78	0	15	0	100%
	1	0	20	0	0	0	74	0	5	0	100%
Mean	3.20	0.00	9.40	0.00	0.00	0.00	79.00	0.00	8.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	75	0	10	0	0	0	15	0	0	0	100%
	48	0	0	30	0	0	17	0	5	0	100%
	82	0	5	1	0	0	10	0	2	0	100%
	62	0	2	1	0	0	30	0	5	0	100%
	15	0	5	0	0	0	80	0	0	0	100%
Mean	56.40	0.00	4.40	6.40	0.00	0.00	30.40	0.00	2.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

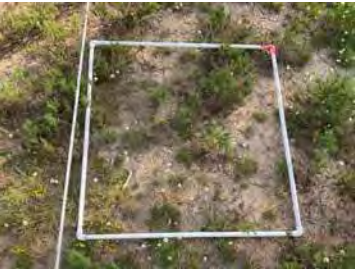
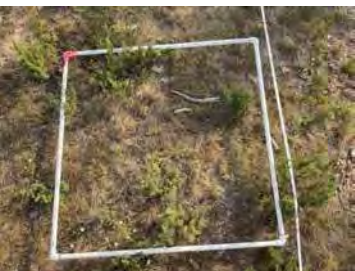


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	55	0	35	3	0	1	5	0	1	0	100%
	3	0	40	30	0	0	0	0	27	0	100%
	3	0	67	10	0	0	10	0	10	0	100%
	2	0	65	30	0	0	0	0	3	0	100%
	3	0	72	20	0	0	0	0	5	0	100%
Mean	13.20	0.00	55.80	18.60	0.00	0.20	3.00	0.00	9.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	30	0	10	0	0	0	55	0	5	0	100%
	2	0	2	0	0	1	80	0	15	0	100%
	20	0	2	0	0	0	58	0	20	0	100%
	10	0	10	0	0	1	30	0	49	0	100%
	5	0	20	0	0	2	68	0	5	0	100%
Mean	13.40	0.00	8.80	0.00	0.00	0.80	58.20	0.00	18.80	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	5	1	0	0	0	0	79	0	100%
	2	0	1	52	0	40	0	0	5	0	100%
	3	0	1	61	0	0	5	0	30	0	100%
	80	0	3	2	0	0	0	0	15	0	100%
	8	0	30	25	0	0	1	0	36	0	100%
Mean	21.60	0.00	8.00	28.20	0.00	8.00	1.20	0.00	33.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	1	0	1	65	0	33	0	100%
	1	0	3	1	0	0	66	1	28	0	100%
	0	0	1	0	0	0	40	1	55	3	100%
	2	0	3	0	0	0	70	0	25	0	100%
	0	0	4	0	0	0	15	0	66	15	100%
Mean	0.60	0.00	2.20	0.40	0.00	0.20	51.20	0.40	41.40	3.60	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	75	0	15	0	0	0	3	0	7	0	100%
	96	0	0	1	0	0	3	0	0	0	100%
	65	0	25	5	0	0	5	0	0	0	100%
	47	0	10	15	0	0	3	0	25	0	100%
	93	0	5	2	0	0	0	0	0	0	100%
Mean	75.20	0.00	11.00	4.60	0.00	0.00	2.80	0.00	6.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	63	0	25	2	0	0	10	0	0	0	100%
	72	0	15	2	0	0	8	0	3	0	100%
	80	0	15	0	0	0	5	0	0	0	100%
	80	0	0	5	0	10	5	0	0	0	100%
	60	0	35	0	0	0	5	0	0	0	100%
Mean	71.00	0.00	18.00	1.80	0.00	2.00	6.60	0.00	0.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.

	
Transect Start	Transect End

	
North	East

	
South	West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	30	0	7	0	0	2	56	0	5	0	100%
	5	0	5	25	0	0	63	0	2	0	100%
	1	0	1	0	0	0	93	0	5	0	100%
	1	0	1	0	0	0	83	0	15	0	100%
	1	0	1	0	0	0	83	0	15	0	100%
Mean	7.60	0.00	3.00	5.00	0.00	0.40	75.60	0.00	8.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	6	0	1	0	0	45	45	1	2	0	100%
	2	0	1	0	0	70	25	0	2	0	100%
	8	0	1	0	0	86	3	2	0	0	100%
	2	0	3	0	0	60	35	0	0	0	100%
	0	0	0	0	0	87	10	1	2	0	100%
Mean	3.60	0.00	1.20	0.00	0.00	69.60	23.60	0.80	1.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	86	0	1	0	2	3	8	0	0	0	100%
	10	0	2	0	0	86	2	0	0	0	100%
	50	0	25	0	0	21	3	0	1	0	100%
	66	0	2	0	0	30	2	0	0	0	100%
	25	0	0	0	0	70	5	0	0	0	100%
Mean	47.40	0.00	6.00	0.00	0.40	42.00	4.00	0.00	0.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	63	0	10	5	0	0	20	2	0	0	100%
	3	0	35	0	0	0	41	1	20	0	100%
	20	0	14	45	0	1	20	0	0	0	100%
	32	0	30	0	0	1	25	2	10	0	100%
	5	0	10	40	0	0	35	5	5	0	100%
Mean	24.60	0.00	19.80	18.00	0.00	0.40	28.20	2.00	7.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	30	0	0	0	0	65	5	0	0	0	100%
	99	0	0	0	0	1	0	0	0	0	100%
	94	0	0	0	0	1	5	0	0	0	100%
	95	0	0	0	0	0	5	0	0	0	100%
	45	0	10	0	30	15	0	0	0	0	100%
Mean	72.60	0.00	2.00	0.00	6.00	16.40	3.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	27	0	3	70	0	0	100%
	0	0	0	0	0	25	30	40	5	0	100%
	0	0	0	0	3	3	25	67	2	0	100%
	0	0	0	10	90	0	0	0	0	0	100%
	0	0	0	0	100	0	0	0	0	0	100%
Mean	0.00	0.00	0.00	2.00	44.00	5.60	11.60	35.40	1.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	5	0	0	1	79	0	5	0	100%
	5	0	0	0	0	0	5	0	10	80	100%
	15	0	3	0	0	0	20	0	5	57	100%
	3	0	3	0	0	0	20	0	7	67	100%
	2	0	10	0	0	0	30	0	25	33	100%
Mean	7.00	0.00	4.20	0.00	0.00	0.20	30.80	0.00	10.40	47.40	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	61	0	3	0	0	2	2	0	2	30	100%
	10	0	1	0	0	0	0	0	0	89	100%
	15	0	58	0	10	0	2	0	0	15	100%
	0	0	0	0	0	0	0	0	0	0	100%
	71	0	6	0	0	0	3	0	0	20	100%
Mean	31.40	0.00	13.60	0.00	2.00	0.40	1.40	0.00	0.40	30.80	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	86	0	1	0	0	0	3	0	10	0	100%
	88	0	2	0	0	0	5	0	5	0	100%
	92	0	0	0	0	0	3	0	5	0	100%
	90	0	0	0	0	0	5	0	5	0	100%
	90	0	0	0	0	0	5	0	5	0	100%
Mean	89.20	0.00	0.60	0.00	0.00	0.00	4.20	0.00	6.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	53	0	6	0	0	8	30	0	3	0	100%
	42	0	0	0	0	27	30	0	1	0	100%
	25	0	0	0	0	30	45	0	0	0	100%
	15	0	0	0	0	81	3	0	1	0	100%
	71	0	1	0	0	3	25	0	0	0	100%
Mean	41.20	0.00	1.40	0.00	0.00	29.80	26.60	0.00	1.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	1	0	0	44	10	0	35	0	100%
	20	0	1	0	0	41	3	0	35	0	100%
	5	0	3	0	0	36	50	0	6	0	100%
	15	0	5	0	0	30	10	0	40	0	100%
	5	0	2	8	0	35	20	0	30	0	100%
Mean	11.00	0.00	2.40	1.60	0.00	37.20	18.60	0.00	29.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	70	0	25	3	0	0	1	0	1	0	100%
	62	0	35	0	0	0	2	0	1	0	100%
	89	0	5	0	0	0	0	0	1	5	100%
	84	0	10	0	0	0	1	0	5	0	100%
	73	0	25	0	0	0	1	0	1	0	100%
Mean	75.60	0.00	20.00	0.60	0.00	0.00	1.00	0.00	1.80	1.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	85	0	3	0	0	10	2	0	0	0	100%
	73	0	2	0	0	16	8	0	1	0	100%
	54	0	2	0	0	40	4	0	0	0	100%
	56	0	1	0	0	25	12	0	5	1	100%
	40	0	0	0	0	8	36	0	15	1	100%
Mean	61.60	0.00	1.60	0.00	0.00	19.80	12.40	0.00	4.20	0.40	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

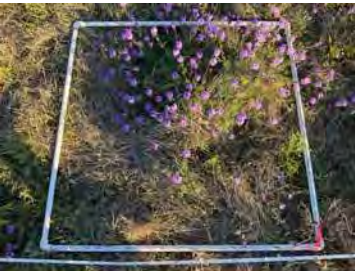


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	48	0	7	0	0	30	15	0	0	0	100%
	70	0	25	1	0	4	0	0	0	0	100%
	27	0	3	0	0	45	25	0	0	0	100%
	60	0	20	0	0	5	15	0	0	0	100%
	42	0	25	15	0	3	15	0	0	0	100%
Mean	49.40	0.00	16.00	3.20	0.00	17.40	14.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

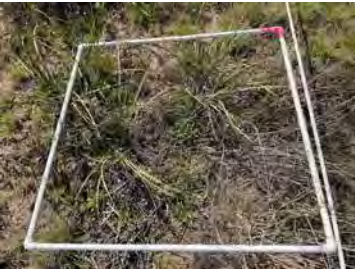


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	5	0	79	0	0	1	5	0	10	0	100%
	25	0	63	0	0	2	5	0	5	0	100%
	81	0	8	0	0	1	5	0	5	0	100%
	0	0	8	0	4	48	15	0	25	0	100%
	20	0	32	0	0	0	3	0	45	0	100%
Mean	26.20	0.00	38.00	0.00	0.80	10.40	6.60	0.00	18.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	5	20	0	0	5	0	15	40	100%
	20	0	10	10	0	0	2	0	5	53	100%
	10	0	55	5	0	0	0	0	10	20	100%
	35	0	40	0	0	0	5	0	10	10	100%
	15	0	35	20	5	0	10	0	5	10	100%
Mean	19.00	0.00	29.00	11.00	1.00	0.00	4.40	0.00	9.00	26.60	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

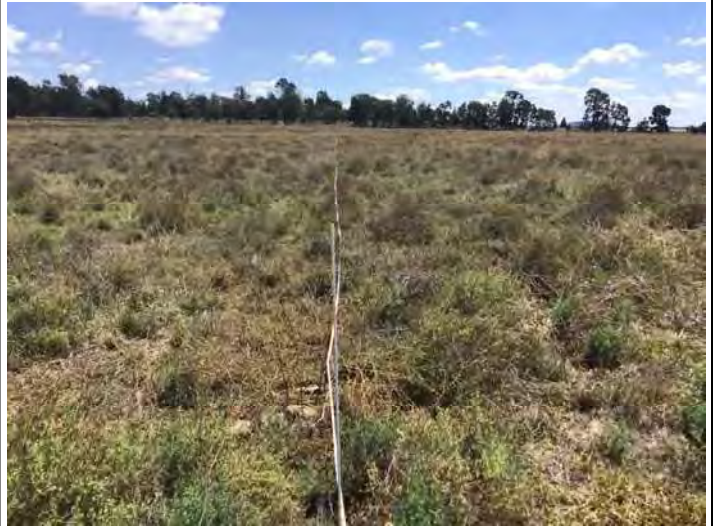
Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	0	25	0	45	15	0	0	0	100%
	53	0	0	5	0	10	25	1	6	0	100%
	40	0	0	52	0	5	2	1	0	0	100%
	63	0	3	2	0	8	20	3	1	0	100%
	49	0	0	35	0	10	5	1	0	0	100%
Mean	44.00	0.00	0.60	23.80	0.00	15.60	13.40	1.20	1.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	0	96	3	0	1	0	100%
	0	0	0	0	0	98	2	0	0	0	100%
	0	0	1	0	0	88	10	0	1	0	100%
	0	0	0	0	0	89	10	0	1	0	100%
	0	0	0	0	5	90	5	0	0	0	100%
Mean	0.00	0.00	0.20	0.00	1.00	92.20	6.00	0.00	0.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	62	3	0	20	15	0	100%
	0	0	0	0	65	5	0	5	25	0	100%
	0	0	0	5	0	5	50	0	40	0	100%
	0	0	0	0	5	55	35	0	5	0	100%
	5	0	0	0	17	15	50	8	5	0	100%
Mean	1.00	0.00	0.00	1.00	29.80	16.60	27.00	6.60	18.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	0	90	10	0	0	0	100%
	0	0	1	0	0	91	0	0	8	0	100%
	0	0	0	0	5	80	15	0	0	0	100%
	0	0	0	0	0	75	15	0	10	0	100%
	0	0	1	0	0	8	0	0	91	0	100%
Mean	0.00	0.00	0.40	0.00	1.00	68.80	8.00	0.00	21.80	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	40	0	40	0	0	10	10	0	0	0	100%
	43	0	5	2	0	40	10	0	0	0	100%
	20	0	60	0	0	20	0	0	0	0	100%
	10	0	30	0	0	25	35	0	0	0	100%
	55	0	10	0	0	15	20	0	0	0	100%
Mean	33.60	0.00	29.00	0.40	0.00	22.00	15.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	20	0	0	0	0	60	20	0	0	0	100%
	0	0	0	0	0	60	40	0	0	0	100%
	20	0	25	10	0	5	40	0	0	0	100%
	10	0	15	0	0	55	20	0	0	0	100%
	0	0	20	0	0	15	65	0	0	0	100%
Mean	10.00	0.00	12.00	2.00	0.00	39.00	37.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	20	0	0	0	0	60	20	0	0	0	100%
	0	0	0	0	0	60	40	0	0	0	100%
	20	0	25	10	0	5	40	0	0	0	100%
	10	0	15	0	0	55	20	0	0	0	100%
	0	0	20	0	0	15	65	0	0	0	100%
Mean	10.00	0.00	12.00	2.00	0.00	39.00	37.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	35	40	25	0	0	0	0	100%
	0	0	0	30	40	30	0	0	0	0	100%
	0	0	5	5	70	20	0	0	0	0	100%
	0	0	10	15	60	15	0	0	0	0	100%
	0	0	0	15	55	30	0	0	0	0	100%
Mean	0.00	0.00	3.00	20.00	53.00	24.00	0.00	0.00	0.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	80	0	8	0	0	0	5	0	7	0	100%
	20	0	10	0	0	5	2	0	63	0	100%
	67	0	10	0	0	20	0	0	3	0	100%
	30	0	10	0	0	25	5	0	30	0	100%
	48	0	7	0	0	35	5	0	5	0	100%
Mean	49.00	0.00	9.00	0.00	0.00	17.00	3.40	0.00	21.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	72	0	3	20	0	0	5	0	0	0	100%
	25	0	10	0	1	2	0	0	62	0	100%
	40	0	2	52	0	1	5	0	0	0	100%
	82	0	5	3	0	2	5	0	3	0	100%
	3	0	5	0	0	1	2	0	89	0	100%
Mean	44.40	0.00	5.00	15.00	0.20	1.20	3.40	0.00	30.80	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	39	0	15	10	0	1	0	0	30	5	100%
	40	0	18	1	0	1	15	0	10	15	100%
	20	0	20	25	0	5	15	0	15	0	100%
	30	0	15	20	0	0	5	0	15	15	100%
	5	0	39	32	0	2	2	0	10	10	100%
Mean	26.80	0.00	21.40	17.60	0.00	1.80	7.40	0.00	16.00	9.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	3	0	20	15	5	0	57	0	100%
	0	0	2	5	25	5	5	0	58	0	100%
	0	0	15	7	1	6	10	0	61	0	100%
	19	0	60	10	0	10	1	0	0	0	100%
	45	0	15	25	0	0	5	0	10	0	100%
Mean	12.80	0.00	19.00	9.40	9.20	7.20	5.20	0.00	37.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	5	0	0	52	3	0	25	0	100%
	65	0	2	5	0	20	5	0	3	0	100%
	15	0	5	0	0	40	15	0	25	0	100%
	8	0	2	0	0	75	5	0	10	0	100%
	25	0	8	0	0	56	5	0	6	0	100%
Mean	25.60	0.00	4.40	1.00	0.00	48.60	6.60	0.00	13.80	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	35	0	32	0	0	0	30	0	3	0	100%
	65	0	10	0	0	0	20	0	5	0	100%
	36	0	15	20	0	0	25	0	0	4	100%
	74	0	20	0	0	0	5	0	0	1	100%
	64	0	18	1	0	0	15	0	0	2	100%
Mean	54.80	0.00	19.00	4.20	0.00	0.00	19.00	0.00	1.60	1.40	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	2	0	0	0	68	25	5	0	0	0	100%
	1	0	0	0	7	1	3	3	85	0	100%
	0	0	1	0	28	1	2	3	65	0	100%
	1	0	1	0	63	3	0	2	30	0	100%
	0	0	2	0	10	0	0	3	85	0	100%
Mean	0.80	0.00	0.80	0.00	35.20	6.00	2.00	2.20	53.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	44	2	0	0	35	1	3	0	100%
	7	0	28	0	0	0	5	25	35	0	100%
	4	0	31	0	0	0	12	8	45	0	100%
	25	0	0	0	0	39	30	6	0	0	100%
	10	0	28	0	0	0	2	25	35	0	100%
Mean	12.20	0.00	26.20	0.40	0.00	7.80	16.80	13.00	23.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

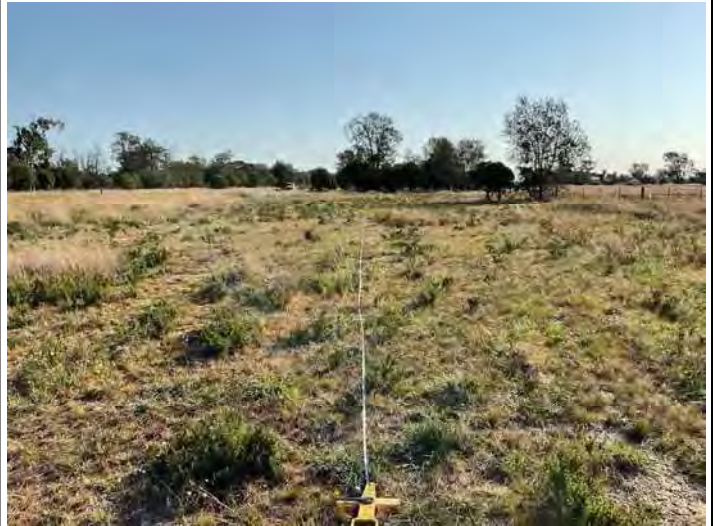
Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	74	0	15	5	0	0	3	0	3	0	100%
	51	0	2	7	0	0	20	0	20	0	100%
	72	0	1	2	0	0	0	0	25	0	100%
	62	0	10	25	0	0	0	0	3	0	100%
	68	0	30	0	0	0	0	0	1	1	100%
Mean	65.40	0.00	11.60	7.80	0.00	0.00	4.60	0.00	10.40	0.20	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

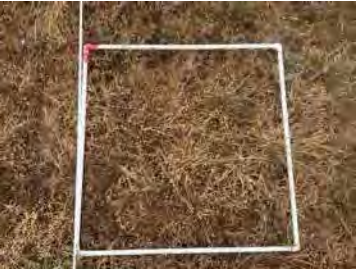


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	2	0	86	1	0	1	10	0	0	0	100%
	2	0	67	1	0	0	5	0	20	5	100%
	5	0	67	0	0	0	3	0	15	10	100%
	25	0	50	0	0	0	10	0	15	0	100%
	48	0	20	0	0	2	20	0	10	0	100%
Mean	16.40	0.00	58.00	0.40	0.00	0.60	9.60	0.00	12.00	3.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	68	0	5	10	0	0	3	0	4	10	100%
	54	0	10	20	0	0	3	0	3	10	100%
	51	0	10	15	0	1	3	0	10	10	100%
	7	0	10	25	0	0	2	0	15	41	100%
	63	0	17	0	0	0	10	0	10	0	100%
Mean	48.60	0.00	10.40	14.00	0.00	0.20	4.20	0.00	8.40	14.20	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	62	0	5	0	5	3	10	0	15	0	100%
	61	0	10	1	0	0	3	0	25	0	100%
	35	0	30	0	0	0	5	30	0	0	100%
	35	0	6	1	0	0	2	0	56	0	100%
	40	0	37	0	0	0	3	0	20	0	100%
Mean	46.60	0.00	17.60	0.40	1.00	0.60	4.60	6.00	23.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



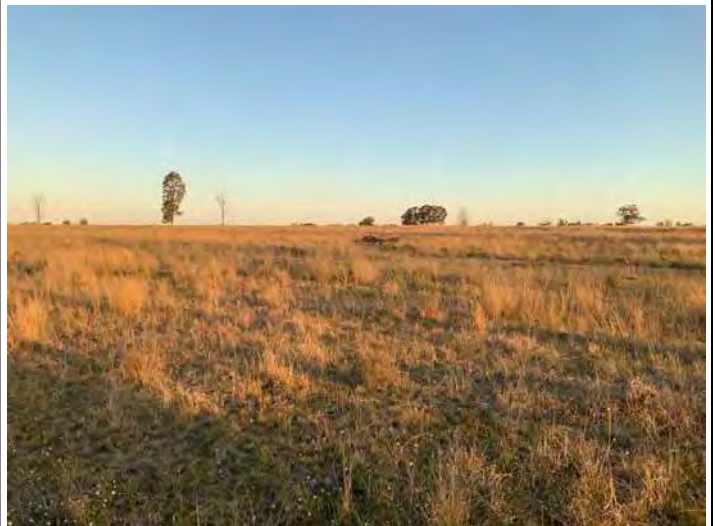
Transect Start



Transect End



North



East



South



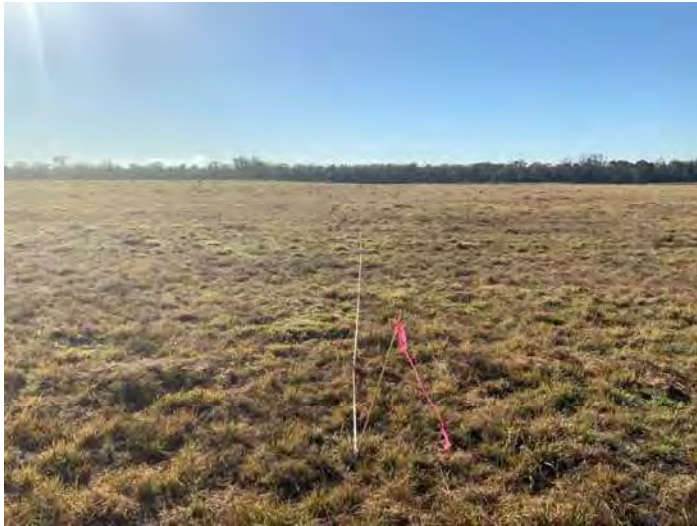
West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	77	0	0	2	0	1	15	0	5	0	100%
	30	0	1	3	0	0	46	0	20	0	100%
	15	0	2	20	0	0	33	0	30	0	100%
	70	0	10	0	0	0	15	0	5	0	100%
	43	0	2	5	0	0	30	0	20	0	100%
Mean	47.00	0.00	3.00	6.00	0.00	0.20	27.80	0.00	16.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	3	0	60	0	0	0	0	0	37	0	100%
	2	0	30	0	0	0	1	0	67	0	100%
	2	0	55	0	0	0	0	0	43	0	100%
	30	0	30	0	0	4	2	0	34	0	100%
	8	0	40	0	0	2	2	0	48	0	100%
Mean	9.00	0.00	43.00	0.00	0.00	1.20	1.00	0.00	45.80	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

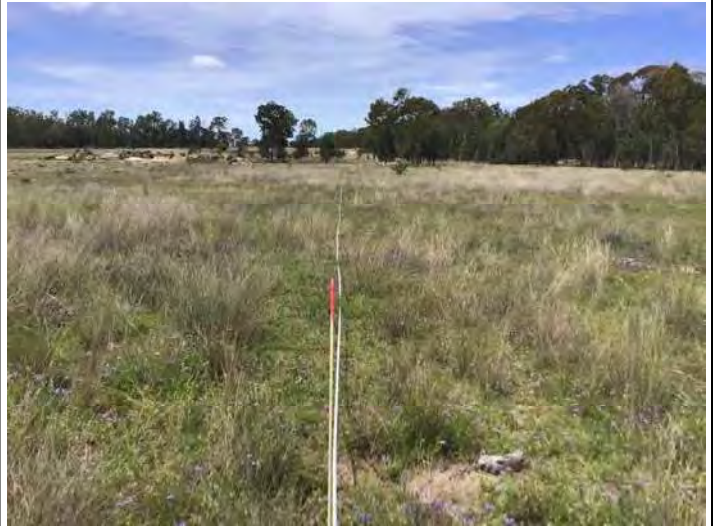
Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	5	0	35	0	10	0	50	0	100%
	0	0	8	0	45	0	35	0	12	0	100%
	20	0	2	0	25	40	8	0	5	0	100%
	10	0	10	0	15	58	5	0	2	0	100%
	61	0	25	0	0	10	3	0	1	0	100%
Mean	18.20	0.00	10.00	0.00	24.00	21.60	12.20	0.00	14.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	5	0	53	7	10	0	15	0	100%
	10	0	3	0	75	1	10	0	1	0	100%
	0	0	10	0	50	0	10	0	30	0	100%
	5	0	20	0	25	0	15	0	35	0	100%
	0	0	1	0	53	1	5	0	40	0	100%
Mean	5.00	0.00	7.80	0.00	51.20	1.80	10.00	0.00	24.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	15	0	5	0	0	50	5	0	25	0	100%
	10	0	6	0	0	63	5	1	15	0	100%
	0	4	35	0	0	49	2	0	10	0	100%
	3	0	15	0	0	45	7	0	30	0	100%
	10	0	20	0	0	45	10	0	15	0	100%
Mean	7.60	0.80	16.20	0.00	0.00	50.40	5.80	0.20	19.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

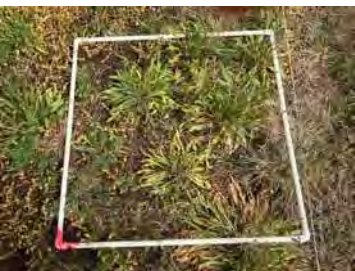


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	3	0	10	30	50	5	2	0	100%
	0	0	2	0	5	73	20	0	0	0	100%
	10	0	1	0	0	44	45	0	0	0	100%
	2	0	2	0	0	46	50	0	0	0	100%
	3	0	3	0	0	69	10	0	15	0	100%
Mean	3.00	0.00	2.20	0.00	3.00	52.40	35.00	1.00	3.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	35	0	1	0	0	49	10	0	5	0	100%
	77	0	0	0	5	15	0	0	3	0	100%
	0	0	6	0	25	35	4	0	30	0	100%
	0	0	0	0	35	63	2	0	0	0	100%
	0	0	1	0	20	29	10	0	40	0	100%
Mean	22.40	0.00	1.60	0.00	17.00	38.20	5.20	0.00	15.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	30	0	0	0	25	25	20	0	0	0	100%
	10	0	10	0	20	0	55	0	5	0	100%
	0	0	0	0	15	15	70	0	0	0	100%
	60	0	0	0	0	20	20	0	0	0	100%
	30	0	0	0	0	10	60	0	0	0	100%
Mean	26.00	0.00	2.00	0.00	12.00	14.00	45.00	0.00	1.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	79	0	0	0	0	10	8	0	3	0	100%
	61	0	0	0	0	35	3	0	1	0	100%
	72	0	0	0	0	0	3	0	25	0	100%
	81	0	1	0	0	3	15	0	0	0	100%
	63	0	0	0	0	5	30	0	2	0	100%
Mean	71.20	0.00	0.20	0.00	0.00	10.60	11.80	0.00	6.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	25	0	20	20	25	0	0	0	100%
	30	0	15	0	0	10	25	10	10	0	100%
	0	0	0	0	40	51	5	1	3	0	100%
	50	0	10	0	0	15	10	15	0	0	100%
	50	0	5	0	0	15	28	2	0	0	100%
Mean	28.00	0.00	11.00	0.00	12.00	22.20	18.60	5.60	2.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	65	0	1	0	5	5	3	1	20	0	100%
	64	0	1	0	0	10	5	0	20	0	100%
	50	0	0	0	0	10	0	0	40	0	100%
	30	0	0	0	0	3	0	0	67	0	100%
	20	0	1	0	0	10	0	0	69	0	100%
Mean	45.80	0.00	0.60	0.00	1.00	7.60	1.60	0.20	43.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	10	0	20	0	0	55	10	0	5	0	100%
	30	0	30	0	0	20	20	0	0	0	100%
	20	0	15	0	0	40	10	0	15	0	100%
	33	0	40	2	5	10	10	0	0	0	100%
	10	0	10	0	0	35	20	0	25	0	100%
Mean	20.60	0.00	23.00	0.40	1.00	32.00	14.00	0.00	9.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	95	5	0	0	0	0	100%
	0	0	0	0	75	25	0	0	0	0	100%
	0	0	0	0	87	8	2	0	3	0	100%
	0	0	0	0	64	18	3	0	15	0	100%
	0	0	0	4	77	0	12	0	7	0	100%
Mean	0.00	0.00	0.00	0.80	79.60	11.20	3.40	0.00	5.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	3	0	74	15	0	8	0	100%
	0	0	8	0	0	30	58	0	4	0	100%
	3	0	1	0	0	20	66	0	10	0	100%
	2	0	6	0	0	25	46	1	20	0	100%
	0	0	2	0	0	53	20	0	25	0	100%
Mean	1.00	0.00	3.40	0.60	0.00	40.40	41.00	0.20	13.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	60	34	5	0	1	0	100%
	0	0	0	0	65	30	5	0	0	0	100%
	0	0	0	7	53	35	5	0	0	0	100%
	40	0	1	0	0	56	3	0	0	0	100%
	35	0	8	0	0	55	2	0	0	0	100%
Mean	15.00	0.00	1.80	1.40	35.60	42.00	4.00	0.00	0.20	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	20	0	10	5	15	0	30	0	20	0	100%
	20	0	5	25	15	0	20	0	15	0	100%
	40	0	5	0	1	0	30	0	24	0	100%
	10	0	15	0	2	5	64	0	4	0	100%
	30	0	5	0	0	0	45	0	20	0	100%
Mean	24.00	0.00	8.00	6.00	6.60	1.00	37.80	0.00	16.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	20	0	2	75	0	1	1	0	1	0	100%
	65	0	5	20	0	0	5	0	5	0	100%
	0	0	2	81	0	5	2	0	10	0	100%
	82	0	0	2	0	0	15	0	1	0	100%
	35	0	1	54	0	0	0	0	10	0	100%
Mean	40.40	0.00	2.00	46.40	0.00	1.20	4.60	0.00	5.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	44	0	50	0	0	0	1	0	5	0	100%
	25	0	65	0	0	0	0	0	10	0	100%
	50	0	50	0	0	0	0	0	0	0	100%
	35	0	55	0	0	0	0	0	10	0	100%
	35	0	35	0	0	0	0	0	30	0	100%
Mean	37.80	0.00	51.00	0.00	0.00	0.00	0.20	0.00	11.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

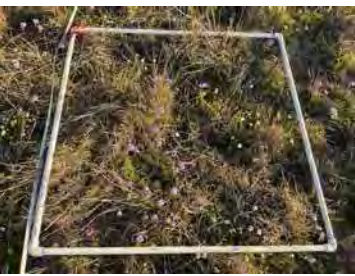


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	88	0	7	0	0	3	0	0	2	0	100%
	84	0	8	0	0	3	3	0	2	0	100%
	84	0	5	0	0	3	3	0	5	0	100%
	93	0	2	0	0	2	3	0	0	0	100%
	76	0	10	0	0	3	10	0	1	0	100%
Mean	85.00	0.00	6.40	0.00	0.00	2.80	3.80	0.00	2.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	20	0	0	5	75	0	0	0	100%
	6	0	30	0	0	15	47	0	2	0	100%
	70	0	2	0	0	20	8	0	0	0	100%
	12	0	25	0	0	35	28	0	0	0	100%
	10	0	2	0	0	85	3	0	0	0	100%
Mean	19.60	0.00	15.80	0.00	0.00	32.00	32.20	0.00	0.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	66	0	25	0	0	3	6	0	0	0	100%
	84	0	3	0	0	4	7	0	2	0	100%
	63	0	3	0	0	7	25	2	0	0	100%
	51	0	6	0	0	35	8	0	0	0	100%
	47	0	6	1	0	10	35	0	1	0	100%
Mean	62.20	0.00	8.60	0.20	0.00	11.80	16.20	0.40	0.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	77	0	12	0	0	3	8	0	0	0	100%
	27	0	10	60	0	0	3	0	0	0	100%
	73	0	2	3	0	7	15	0	0	0	100%
	54	0	6	0	0	30	5	0	5	0	100%
	70	0	2	0	0	25	3	0	0	0	100%
Mean	60.20	0.00	6.40	12.60	0.00	13.00	6.80	0.00	1.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	7	31	30	5	0	27	0	100%
	0	0	2	3	80	10	5	0	0	0	100%
	0	0	0	15	30	53	2	0	0	0	100%
	0	0	10	0	83	4	3	0	0	0	100%
	0	0	0	0	46	4	35	0	15	0	100%
Mean	0.00	0.00	2.40	5.00	54.00	20.20	10.00	0.00	8.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	3	0	17	23	0	0	55	2	100%
	0	0	20	8	5	57	10	0	0	0	100%
	40	0	0	25	0	35	0	0	0	0	100%
	0	0	15	47	0	3	0	0	30	5	100%
	1	0	5	3	0	2	0	0	84	5	100%
Mean	8.20	0.00	8.60	16.60	4.40	24.00	2.00	0.00	33.80	2.40	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	5	0	35	0	0	0	30	0	30	0	100%
	57	0	8	0	0	0	25	0	10	0	100%
	73	0	6	0	0	0	20	0	1	0	100%
	64	0	3	27	0	0	5	0	1	0	100%
	0	0	0	100	0	0	0	0	0	0	100%
Mean	39.80	0.00	10.40	25.40	0.00	0.00	16.00	0.00	8.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	1	0	4	0	0	0	65	0	25	5	100%
	42	0	25	0	0	0	30	0	3	0	100%
	1	0	5	0	0	0	92	0	1	1	100%
	3	0	70	0	0	0	27	0	0	0	100%
	49	0	20	0	0	0	30	0	1	0	100%
Mean	19.20	0.00	24.80	0.00	0.00	0.00	48.80	0.00	6.00	1.20	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	40	59	1	0	0	0	100%
	0	0	0	0	5	88	5	2	0	0	100%
	0	0	5	0	1	74	5	15	0	0	100%
	0	0	15	0	3	43	3	35	1	0	100%
	0	0	60	0	5	15	8	10	2	0	100%
Mean	0.00	0.00	16.00	0.00	10.80	55.80	4.40	12.40	0.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	65	0	25	0	0	5	3	0	2	0	100%
	43	0	2	0	0	15	35	0	5	0	100%
	79	0	1	0	5	3	10	0	2	0	100%
	33	0	8	0	25	2	5	2	25	0	100%
	81	0	2	0	0	1	10	3	3	0	100%
Mean	60.20	0.00	7.60	0.00	6.00	5.20	12.60	1.00	7.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	85	0	6	0	0	2	5	1	0	1	100%
	86	0	1	1	0	3	6	2	0	1	100%
	57	0	25	0	0	8	8	2	0	0	100%
	88	0	1	0	0	1	5	1	3	1	100%
	23	0	0	0	0	25	50	2	0	0	100%
Mean	67.80	0.00	6.60	0.20	0.00	7.80	14.80	1.60	0.60	0.60	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	2	0	20	0	0	46	25	2	5	0	100%
	10	0	3	4	0	78	5	0	0	0	100%
	5	0	40	0	0	3	10	0	42	0	100%
	15	0	25	0	10	41	7	1	1	0	100%
	45	0	2	0	0	50	3	0	0	0	100%
Mean	15.40	0.00	18.00	0.80	2.00	43.60	10.00	0.60	9.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	0	0	0	0	30	25	15	0	30	0	100%
	0	0	8	5	70	0	10	0	7	0	100%
	0	0	5	0	20	0	5	0	70	0	100%
	0	0	8	0	77	7	3	0	5	0	100%
	0	0	4	6	59	0	30	0	0	1	100%
Mean	0.00	0.00	5.00	2.20	51.20	6.40	12.60	0.00	22.40	0.20	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start

Transect End



North

East



South

West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	35	0	0	7	0	2	30	0	26	0	100%
	1	0	4	0	0	0	95	0	0	0	100%
	43	0	0	1	0	1	30	0	25	0	100%
	61	0	3	25	0	1	10	0	0	0	100%
	3	0	2	27	0	0	6	0	62	0	100%
Mean	28.60	0.00	1.80	12.00	0.00	0.80	34.20	0.00	22.60	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	5	0	0	3	38	2	2	0	50	0	100%
	5	0	0	3	62	0	10	0	20	0	100%
	1	0	0	25	30	0	3	0	41	0	100%
	0	0	7	2	0	0	0	0	91	0	100%
	30	0	0	25	10	0	5	0	30	0	100%
Mean	8.20	0.00	1.40	11.60	28.00	0.40	4.00	0.00	46.40	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East

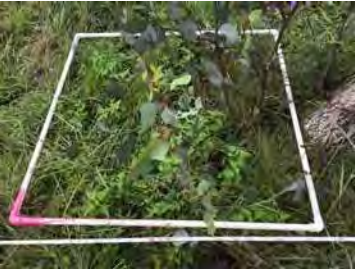


South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	29	0	5	30	0	35	1	0	0	0	100%
	96	0	2	0	0	1	1	0	0	0	100%
	84	0	15	0	0	0	0	0	0	1	100%
	71	0	25	0	0	0	3	0	1	0	100%
	90	0	6	0	0	2	0	0	1	1	100%
Mean	74.00	0.00	10.60	6.00	0.00	7.60	1.00	0.00	0.40	0.40	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

1 m x 1 m Quadrats:

Quadrats	NG	OG	NF	NS	NNG	NNF	L	R	BG	C	TOTAL
	20	0	0	74	0	2	2	0	2	0	100%
	49	0	30	3	0	5	3	0	10	0	100%
	60	0	24	10	0	1	5	0	0	0	100%
	65	0	30	0	0	0	5	0	0	0	100%
	25	0	60	0	0	2	10	0	3	0	100%
Mean	43.80	0.00	28.80	17.40	0.00	2.00	5.00	0.00	3.00	0.00	

Codes Used

NG - Native Perennial Grasses, OG - Other Native Grasses, NF - Native Forbs, NS - Native Shrubs, NNG - Non-Native Grasses, NNF - Non-Native Forbs, L - Litter, R - Rock, BG - Bare Ground, FL - Fallen Log, C - Cryptogams.



Transect Start



Transect End



North



East



South



West

APPENDIX

B

Ecology assessment

BORDER TO GOWRIE REVISED DRAFT ENVIRONMENTAL IMPACT STATEMENT

Acknowledgement of Country

Umwelt would like to acknowledge the traditional custodians of the country on which we work and pay respect to their cultural heritage, beliefs, and continuing relationship with the land. We pay our respect to the Elders – past, present, and future.

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1.0 Introduction

Umwelt (Australia) Pty Ltd has been engaged by Australian Rail Track Corporation (ARTC) to provide an approvals and environmental due diligence assessment for Stage 1 of the Temporary Material Distribution Centre (MDC) in Whetstone, Queensland (the Project). Once operational, the Project will be used to store materials and service the construction of four of the Queensland projects of Inland Rail, which are currently subject to an Environmental Impact Statement (EIS) assessment process.

To support the overarching due diligence assessment, a supplementary terrestrial ecological assessment was deemed necessary to provide additional detail regarding the flora and fauna values of the Study Area, with a particular focus on those considered Matters of State Environmental Significance (MSES) and Matters of National Environmental Significance (MNES). This report documents the terrestrial ecological assessment which has been informed by both desktop and field-based assessments.

1.1 Study Area and Development Footprint

The Project is proposed to occur within the rural locality of Whetstone, approximately 18 kilometres (km) to the south-west of Inglewood and 59 km east of Goondiwindi in Queensland. The Project will be constructed within part of Lot and plan 2/MH784, as well as parts of the South Western System Railway Line and the Cunningham Highway (the 'Study Area'). Other mapped roads connect to the Study Area including Loupals Road and Bosnjaks Road to the south and the Whetstone Access Road to the north-east. Lot 2 MH784 is freehold land located within the Goondiwindi Regional local government area.

The Study Area covers approximately 336 hectares (ha) and comprises largely flat, rural agricultural land currently used for cropping with historical evidence of use for cattle grazing. Although land use in the surrounding area is also predominantly agricultural, large intact areas of woody vegetation also occur. These areas include Whetstone State Forest to the immediate north-west of the Study Area, and Yelarbon State Forest approximately 2.5 km to the south-east.

The Study Area will be accessed from Whetstone Access Road, an existing local road that intersects with the Cunningham Highway. The Development Footprint exists along the northern boundary of the Study Area and extends south along Whetstone Access Road, covering approximately 69.3 ha.

The Study Area and the Development Footprint along with notable local landscape features are shown in **Figure 1.1**.

1.2 Objective and Scope

The objective of this assessment is to identify the presence and extent of terrestrial ecological values protected under State or Commonwealth legislation within the Study Area, discuss the potential impacts on such values and any approval implications. To achieve this, the assessment included the following tasks:

- Conduct a desktop review of available literature and previous studies in the vicinity of the Study Area and run database searches to determine known or potentially occurring threatened species or communities and migratory species.
- Undertake a field survey within the Study Area to:

- o document condition, extent and value of vegetation communities, habitat types and other ecological values within the Study Area
- o identify habitat resources for known and potentially occurring threatened species and migratory species.
- Undertake a likelihood of occurrence assessment to determine the potential or known presence of threatened species and communities as well as migratory species within the Development Footprint.
- Complete an impact assessment for known or potentially occurring MSES and MNES values, inclusive of recommended mitigation and management measures (as necessary)
 - o Determine the significance of identified impacts on MSES in consideration of the *Significant Residual Impact Guideline* (Department of State Development Infrastructure and Planning 2014).
 - o Determine the significance of identified impacts on MNES in consideration of the Commonwealth *Significant Impact Guidelines Policy Statement 1.1* (Department of the Environment 2013).



2.0 Legislative Context

The legislation relevant to the assessment is summarised in **Table 2.1** below.

Table 2.1 Relevant Legislation Summary

Relevant Legislation	Governing Agency	Summary	Project Relevance
Commonwealth			
<i>Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)</i>	Department of Climate Change, Energy, the Environment and Water (DCCEEW)	The EPBC Act is Australia's key piece of environmental legislation. It outlines nine MNES. Actions that adversely affect MNES may be deemed to be a controlled action requiring assessment under the EPBC Act.	The presence of MNES values within the Development Footprint is discussed in Section 7.0 . One MNES is relevant to the Project: threatened species and ecological communities.
State Legislation			
<i>Nature Conservation Act 1992 (NC Act)</i>	Department of Environment and Science (DES)	The purpose of the NC Act is to conserve biodiversity by creating and managing protected areas, managing and protecting native plants and animals, and managing the spread of non-native plants and animals.	Where a proposed development will result in such impacts to flora and/or fauna protected under the NC Act, authorisation from the Director General of the DES is required. The presence of species listed threatened or Special Least Concern under the NC Act within the Development Footprint is discussed in Section 4.5 .
<i>Vegetation Management Act 1999 (VM Act)</i>	Department of Resources (DoR)	The VM Act establishes the vegetation management framework for Queensland that applies to all vegetation with the exception of State forests, National parks, forest reserves, and certain other tenures defined under the NC Act and the <i>Forestry Act 1959</i> .	The presence of regulated vegetation including Regional Ecosystems (REs) within the Development Footprint and broader Study Area is detailed in Section 4.2.2 .
<i>Biosecurity Act 2014 (Biosecurity Act)</i>	Department of Agriculture and Fisheries (DAF)	The Biosecurity Act lists fauna and flora pest species as either a prohibited or restricted biosecurity matter.	The Biosecurity Act defines specific requirements for notification and management actions for all listed biosecurity matters, including specific requirements for the disposal of restricted matters. The potential presence of flora and fauna species listed as restricted matters within the Development Footprint and broader Study Area is discussed in Section 4.2.4.1 and Section 4.3.2.1 respectively.

Relevant Legislation	Governing Agency	Summary	Project Relevance
<i>Environmental Offsets Act 2014 (EO Act)</i>	DES	An environmental offset condition may be imposed for prescribed activities under the EO Act. Activities which have an impact on MSES may require offsetting under the EO Act.	The presence of MSES within the Development Footprint is detailed in Section 6.0 . MSES relevant to the Project include: protected wildlife habitat.

3.0 Methodology

3.1 Desktop Assessment

A desktop assessment was undertaken to characterise and identify the ecological values that may be supported by the Study Area. The desktop assessment included a review of existing literature and online mapping, as well as searches of publicly available databases. The following information sources were reviewed:

- EPBC Act Protected Matters Search Tool (PMST) for MNES (10 km buffer applied from the Study Area boundary) (**Appendix A**).
- Species Profile and Threats (SPRAT) database for MNES information (Department of Climate Change, Energy, the Environment and Water 2022).
- DES BioMaps/WildNet databases for species records (10 km buffer applied from the Study Area boundary) (**Appendix A**).
- DES (2021c) Protected Plants Flora Survey Trigger map to identify the locations of previously recorded threatened flora species.
- DES certified Biodiversity Planning Assessment (BPA) (2018) mapping to identify significant wildlife corridors and areas of state, regional and local biodiversity significance.
- DES (2019) Queensland Wetland areas mapping.
- DoR (2021) Vegetation Management Regional Ecosystem map (Version 12).
- DoR (2021a) Vegetation Management Watercourse and Drainage Feature map (Version 5.0).
- DoR (2021b) Vegetation Management Supporting Map, including Essential Habitat mapping.
- DAF (2016) Queensland waterways for waterway barrier works mapping.
- Qld Herbarium (2021) Regional Ecosystem Description Database (REDD) (Version 12.1).
- Atlas of Living Australia (ALA) (2022) spatial records database.
- published and unpublished ecology reports relevant to the Project, including:
 - o Supplementary Ecological Assessments: Leeson's Road, Whetstone, Yelarbon (Ausecology 2022).
 - o Inland Rail – Border to Gowrie Project: Geotechnical Investigations – Matters of National Environmental Significance Report (Australian Rail Track Corporation 2021).

Information collected as part of the desktop assessment was collated and used in the preparation of the field survey to determine target areas and appropriate survey techniques to employ.

3.2 Field Assessment

3.2.1 Other Ecological Assessments

Previously completed ecological assessments were reviewed where available. Two assessments were considered particularly relevant to the Project, both being undertaken within or in proximity to the Study Area. These studies were reviewed to gain an understanding of the ecological values across the area as well as the methods utilised to determine possible presence of the MNES or MSES values. The methods adopted by each study are summarised below.

Ausecology (2022). Supplementary Ecological Assessments: Leeson's Road, Whetstone, Yelarbon

In early 2022, Ausecology Pty Ltd (Ausecology) was engaged by ARTC to complete additional ecological assessments relevant to the Border to Gowrie (B2G) Project footprint. One of the three areas assessed ('Whetstone') primarily occurs over the Whetstone State Forest but also overlaps a section of the northern extent of the Study Area discussed in this report. The scope of the assessment included both a desktop and field assessment. The field assessment was completed in March 2022 and the primary focus was to verify RE occurrence and extent via quaternary assessments and identify the presence and extent of threatened ecological communities (TECs). Targeted searches for threatened flora and opportunistic searches for threatened fauna were also undertaken.

ARTC (2021). Inland Rail – Border to Gowrie Project: Geotechnical Investigations – Matters of National Environmental Significance Report

As described in **Section 1.0**, ARTC are continuing to progress the EIS assessment of the B2G section of the Inland Rail. To inform design and siting of the B2G project, geotechnical investigations were required to gain an understanding of the landform conditions. An MNES report was produced and published in April 2021 as supporting information to the referral of the geotechnical works. This report details the ecological surveys that have been completed as part of the overarching EIS assessment which includes:

- Initial constraints assessments in April, September and October of 2016, conducted by EcoLogical.
- Baseline seasonal sampling in Autumn and Spring 2018 totalling 14 days, conducted by Aurecon.
- Aquatic surveys over three survey periods: June 2018, November/December 2018 and May 2019 conducted by EcoLogical.
- Supplementary targeted surveys conducted by Cardno (2019–2020).

Across the entirety of the field program, a suite of methodologies has been employed including habitat assessments, verification of vegetation communities, protected plant surveys, aquatic surveys and an array of terrestrial fauna sampling and trapping techniques.

3.2.2 Umwelt Survey

Field assessments within the Study Area were undertaken by a suitably qualified Umwelt ecologist on 20 September 2022. The methods employed and the respective survey effort is detailed in **Table 3.1**. Field assessment sites are shown on **Figure 3.1**.

Table 3.1 Field Assessment Methods and Effort

Method	Description	Total Effort
Quaternary Assessments	Quaternary plots constitute rapid vegetation surveys which include marking the GPS location and recording the dominant species in the characteristic layers, along with soil/landform and structural data, as per Neldner <i>et al.</i> (2020).	14 sites
Opportunistic Threatened Flora	Opportunistic searches for flora species listed under the NC Act or EPBC Act were completed throughout the survey in areas of potential habitat. If threatened flora species were found during these searches, their location and spatial extent were recorded and notes regarding population size and photographs were collected.	NA
Fauna Habitat Assessments	Each habitat assessment occurred within a one hectare (100 m x 100 m, or 200 m x 50 m) site, and had the following characteristics recorded: • Vegetation structure and dominant species, including a description of canopy, shrub and ground layer structure and composition. • Soil composition and landform. • Presence and abundance of tree hollows and stags. • Presence and abundance of woody debris such as habitat logs and ground timber. • Rocky habitat such as surface rocks, boulders, crevices etc. • Proximity to water (both permanent and ephemeral). • Disturbance from invasive weeds/pests. • Other disturbances such as grazing pressure, clearing, thinning or fire. Any other significant habitat features, or values present, such as leaf litter, gilgai, decorticated bark, dense grass/shrub shelter, seeding grass cover, fruiting plants, nectar and pollen producing plants (i.e. mistletoe), and koala food trees.	13 sites
Active Searches	Active searching was completed at habitat assessment sites across the Study Area. Searches included scanning the trees and ground, searching beneath microhabitat such as rocks, fallen timber and peeling bark, digging through leaf litter and soil at tree bases and flushing birds from areas with a dense or grassy ground cover. Physical disturbance to habitat features and reptiles was kept to a minimum.	
Diurnal Bird Surveys	Diurnal birds were sampled using an area census method, supplemented by broad observational surveys throughout the Study Area.	8 person-hours
Opportunistic Fauna Sightings	All fauna observed directly or indirectly (scats and tracks) during the survey were recorded.	NA

3.2.3 Assumptions and Limitations

A flora assessment has inherent limitations associated with the variability of vegetation communities across a survey location, and changes to the detectability and presence of species over time. It is recognised that field studies undertaken over just one season cannot always account for all potential floral diversity present across a survey location. However, the seasonal condition during which the survey was undertaken (spring) is generally conducive to a high degree of detectable floral diversity.

The detection of fauna species during habitat assessments is limited, given the cryptic and nocturnal nature of many fauna. The species directly observed during the survey are opportunistic sightings only and not considered exhaustive. However, habitat assessment is an accepted method to identify the potentially occurring threatened and migratory species within the Study Area.

It should be noted that the objective of the survey was not to provide an exhaustive list of flora and fauna species relevant to a baseline survey effort. The survey did however record common and dominant flora species as well as all fauna species observed.

Field survey data collection to inform mapping was conducted using a hand-held iPad unit with aerial imagery. The accuracy of the iPad is generally <5 metres and is not intended to be relied upon for design purposes.

As the Study Area intersected a rail corridor and the survey team do not hold Rail Industry Workers Cards, no survey was conducted in these areas. Ausecology (2022) have previously surveyed this area and for the purpose of this assessment, the findings of this report have been used and considered to be correct.

3.2.4 Nomenclature

Taxonomic nomenclature used for the description of flora species is according to Census of the Queensland Flora 2021 (Bostock & Holland, 2021). Exotic flora species are signified in the text by an asterisk (*).

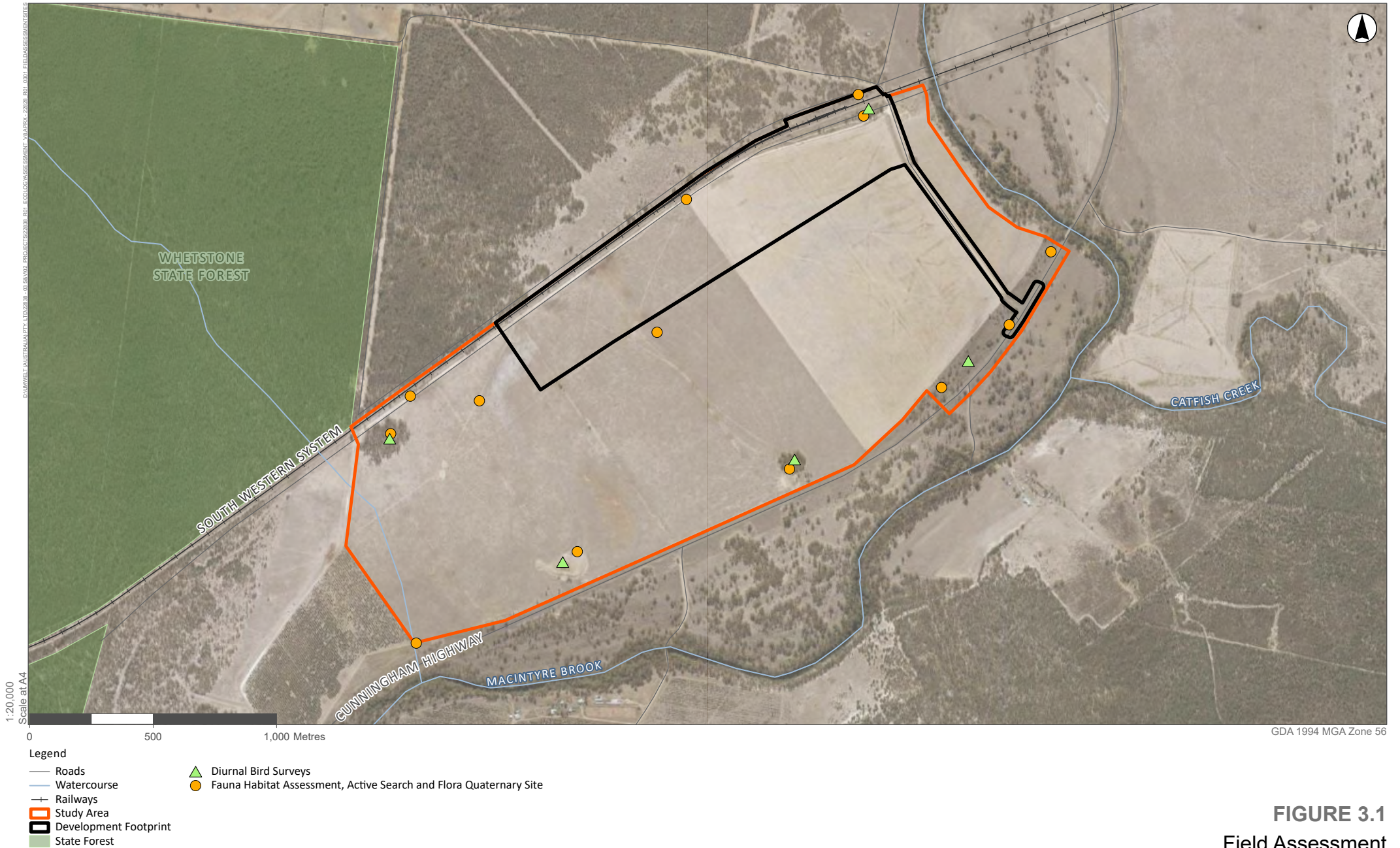


FIGURE 3.1
Field Assessment Sites

3.3 Likelihood of Occurrence Assessment

A likelihood of occurrence assessment was undertaken for threatened communities, flora and fauna species and migratory species identified as potentially occurring within the Development Footprint during the desktop assessment. The likelihood of occurrence assessment was based on a review of known records, habitat preferences and the broad habitat types and microhabitat features observed within the Development Footprint.

Listed species and communities were assigned to one of the categories described in **Table 3.2**.

Table 3.2 Likelihood of Occurrence Categories

Category	Description
Known	Listed Species: The listed species has been recently (within the last 10 years) recorded within the Development Footprint. Listed Communities: The listed community has been recently (within the last 10 years) recorded within the Development Footprint.
High	Listed Species: The listed species has been historically (not within the last 10 years) recorded within the Development Footprint or in the immediate vicinity, and the area contains preferred habitat resources which may support a population of the listed species. Listed Communities: The listed community has one or more corresponding Regional Ecosystems (REs) mapped within the Development Footprint, and key species have been recorded from the broader area (desktop search extent).
Moderate	Listed Species: This category includes species that have been recorded from the broader area (desktop search extent for all species except those considered highly mobile) and where some of the preferred habitat is present within the Development Footprint. Listed Communities: The listed community has one or more corresponding Regional Ecosystems (REs) mapped within the Development Footprint; however, key species have not been recorded from the broader area (desktop search extent).
Low	Listed Species: The Development Footprint supports some suitable habitat for the listed species, though often marginal. The listed species may disperse through the Development Footprint infrequently though is unlikely to depend on the habitat for survival. Aerial foragers and other migratory birds that may overfly the Development Footprint but will not depend on the values within this area are also included in this category. Listed Communities: The listed community has no corresponding REs mapped within the Development Footprint.
Unlikely	Listed Species: The Development Footprint offers limited to no potential habitat for the listed species, is outside its known range and/or is lacking broader habitat requirements. Listed Communities: The listed community has corresponding REs which are associated with a different bioregion or land zone than REs mapped within the Development Footprint.

3.4 Impact Assessment

MNES and MSES known or deemed to have a likely or moderate potential of occurrence within the Development Footprint were subjected to assessment under the Commonwealth *Significant Impact Guidelines 1.1* (DoE, 2013) or the Queensland *Significant Residual Impact Guideline* (DSDIP, 2014).

4.0 Ecological Values

4.1 Study Area Characteristics

The Study Area comprises historically cleared land dominated by exotic grasslands and wheat cropping with occasional patches of remnant or regrowth vegetation and scattered canopy trees, generally located close to the boundary or along existing tracks. Exotic grass cover in the ground layer is dense across the entire Study Area, and weeds such as velvety tree pear (*Opuntia tomentosa**) are common. North of the rail corridor and near the southern Study Area boundary, small and narrow, fragmented patches of eucalypt woodland in regrowth and remnant condition also occur. The highest quality vegetation within the Study Area occurs in the north-western extent: a single patch of grey-box (*Eucalyptus moluccana*) woodland on flat plains analogous to RE 11.5.20 (detailed further in **Section 4.2.2.2** below).

Aerial imagery indicates that vegetation communities and fauna habitats within the Study Area and portions of the local area are generally disturbed and fragmented as a result of ongoing agricultural land use practices. However, the local area also contains large intact areas of remnant vegetation associated with the State Forests and the Macintyre Brook watercourse and riparian vegetation. In the north-west and north-east, these occur directly adjacent to the Study Area.

Land within the Study Area is largely flat and level, occurring at elevations between 260 m and 270 m Australian Height Datum (AHD). Shallow depressions occur in select locations, largely associated with the overflow of the two farm dams present. A single, first order, drainage line is mapped within the south-western extent of the Study Area. Wetlands and watercourses are discussed further in **Section 4.3.5**.

4.2 Flora

4.2.1 Bioregion and Subregion

The Study Area occurs within the Brigalow Belt Bioregion, which covers the 500-759 mm rainfall area between the Queensland – New South Wales border in the south, to Townsville in the north. The Bioregion is characterised by the tree species brigalow (*Acacia harpophylla*) that forms forest and woodland on clay soils. Brigalow does not predominate across the entire region, with the bioregion including a range of ecosystems including eucalypt forest and woodland, grassland, dry rainforest, cypress pine woodland and riparian communities (Sattler & Williams 1999).

Within the Brigalow Belt Bioregion, the Study Area occurs within the Inglewood Sandstones subregion (Sattler & Williams 1999).

4.2.2 Vegetation Communities

4.2.2.1 Regulated Vegetation

As per the DoR Regulated Vegetation Management map, the Study Area almost entirely contains Category X non-remnant vegetation. One small area (0.15 ha) of Category B remnant vegetation is mapped along the north-western boundary of the Study Area, north of the rail corridor. No other regulated vegetation categories are mapped.

The field assessment found that extent of regulated vegetation within the Study Area was similar to that shown in the Regulated Vegetation Management map, with the Study Area dominated by Category X non-remnant vegetation. The primary difference noted was the presence of one patch of remnant Category B vegetation in the north-western extent of the Study Area, south of the rail corridor.

4.2.2.2 Regional Ecosystems

Review of the Vegetation Management Regional Ecosystem map (Version 12) (Department of Resources 2022) identified the potential presence of three REs within the Study Area. One RE (11.3.2) is listed as Of Concern while the other two are listed Least Concern under the VM Act. These REs along with their relevant VM Act Class is provided in **Table 4.1** while **Figure 4.1** displays their occurrence spatially.

Table 4.1 State Mapped Regional Ecosystems within the Study Area

RE	REDD Description	VM Act Class	Extent within the Study Area (ha)	Extent within the Development Footprint (ha)
11.5.1	<i>Eucalyptus crebra</i> and/or <i>E. populnea</i> , <i>Callitris glaucophylla</i> , <i>Angophora leiocarpa</i> , <i>Allocasuarina luehmannii</i> woodland on Cainozoic sand plains and/or remnant surfaces	Least Concern	Not present	Not present
11.3.2	<i>Eucalyptus populnea</i> woodland on alluvial plains	Of Concern	0.22 ha (confirmed by Ausecology)	0.22 ha (confirmed by Ausecology)
11.5.20	<i>Eucalyptus moluccana</i> and/or <i>E. microcarpa</i> and/or <i>E. woollsiana</i> +/- <i>E. crebra</i> woodland on Cainozoic sand plains	Least Concern	2.45 ha	Not present

Field assessments within the Study Area confirmed the presence of one State-mapped RE while the remaining two were not recorded. A single patch of RE 11.5.20 approximately 2.45 ha in size was recorded in the north-western corner of the Study Area, however will not be impacted by the Project. This area is likely too small to have been captured in the State Regional Ecosystem map which is generally developed using a scale of 1:100,000.

A small area of RE 11.3.2 (0.22 ha) was confirmed by Ausecology (2022) to occur in the far northern Study Area (see **Figure 4.2**¹), which formed the edges of several larger patches. These patches were unable to be assessed during the Umwelt survey due to their location within the rail corridor but are considered present as per the findings of Ausecology (2022).

Three non-remnant vegetation communities were also confirmed by Umwelt to occur within the Study Area and Development Footprint, as described below:

- Regrowth eucalypt woodland with scattered mature canopy trees occurs as small linear patches near the north and south of the Study Area boundary and are intersected by the Development Footprint. Dominant species vary between patches but include silver-leaved ironbark (*Eucalyptus melanophloia*),

¹ The extent of Poplar Box TEC and RE 11.3.2 shown in Figure 4.2 is not accurate. Please see mapping shown in Ausecology (2022).

Queensland blue gum (*Eucalyptus tereticornis*), poplar box (*Eucalyptus populnea*), Moreton Bay ash (*Corymbia tessellaris*) up to 12 m tall. A very sparse shrub layer is present containing wilga (*Geijera parviflora*) and velvet tree pear (*Opuntia tomentosa**). The ground layer cover is variable, but dense throughout and dominated by a mixture of exotic and native grasses including slender chloris (*Chloris divaricata*), *Austrostipa* sp., barbed-wire grass (*Cymbopogon refractus*), *Sporobolus* sp., buffel grass (*Cenchrus ciliaris**) and grader grass (*Themeda quadrivalvis**).

- The majority of the Study Area and Development Footprint is open paddock with 95 to 100 % cover of exotic and native grasses, herbs and forbs. Very rare paddock trees occur along a small strip in the centre of the site, however elsewhere no canopy or subcanopy is present. These trees have been avoided in the Project design. The shrub layer is also very low in cover (<5 %) and height (<1 m) and consists of small-leaf bluebrush (*Maireana microphylla*) and velvety tree pear (*Opuntia tomentosa**). Other common species in the ground layer included buffel grass (*Cenchrus ciliaris**), black speargrass (*Heteropogon contortus*), *Vittadinia* sp., *Einadia nutans subsp. nutans*, South American vervains (*Verbena bonariensis**), Mayne's pest (*Glandularia aristigera**), and lippia (*Phyla canescens**).
- Recently sown monoculture crops also occur within the north-eastern extent of the Study Area and Development Footprint, likely comprising wheat.

Non-remnant communities within the Study Area and Development Footprint are also shown on **Figure 4.2**.

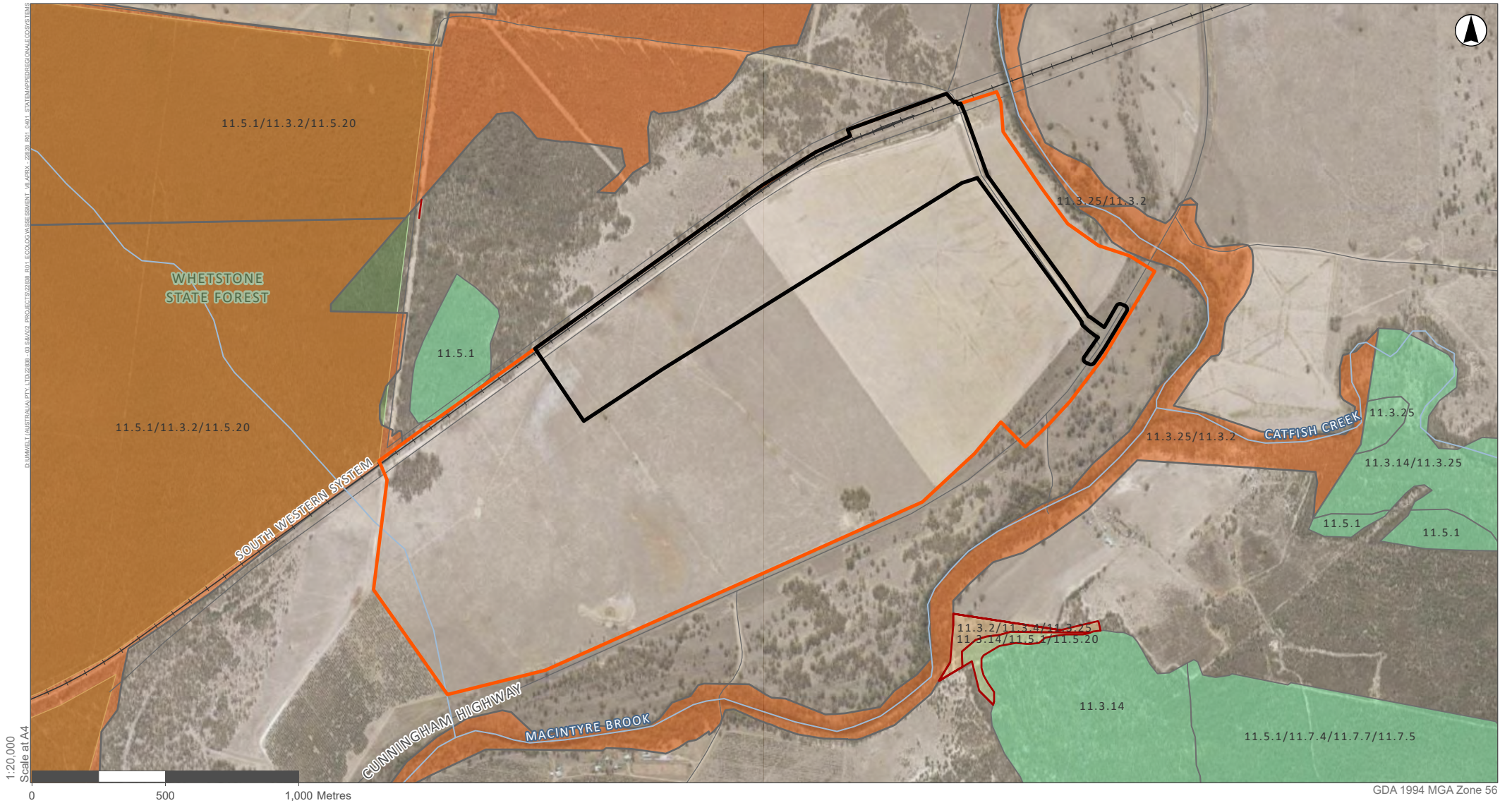
4.2.2.3 Threatened Ecological Communities (TECs)

No TECs or analogous REs were identified within the Study Area or Development Footprint during the Umwelt survey.

The Poplar Box Grassy Woodland on Alluvial Plains TEC (Poplar Box TEC) was recorded within and directly adjacent to the Study Area and the Development Footprint, associated with remnant patches of RE 11.3.2 by Ausecology (2022), located north of the South Western System Railway Line (see **Figure 4.2**²). As per Ausecology (2022), four patches of RE 11.3.2 were assessed and all were found to meet the criteria of the highest condition class of the Poplar Box TEC.

As described above, areas assessed and mapped by Ausecology were unable to be assessed during the Umwelt survey due to their location within the rail corridor. Given the Ausecology assessment was completed within the last six months, it is unlikely the vegetation community condition has changed. Therefore, the Poplar Box TEC is considered present as per the findings of Ausecology (2022).

² The extent of Poplar Box TEC and RE 11.3.2 shown in Figure 4.2 is not accurate. Please see mapping shown in Ausecology (2022).



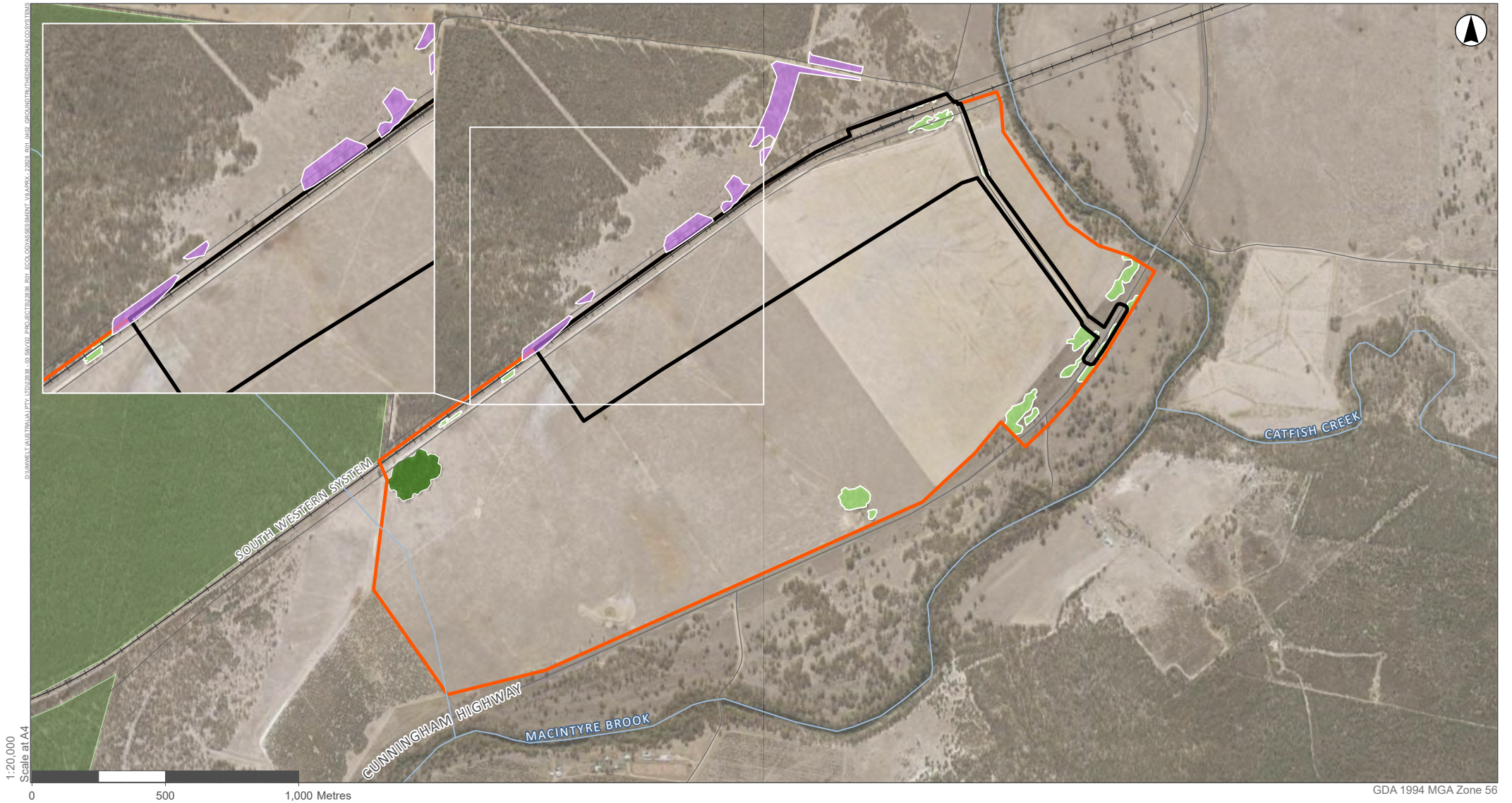
Legend

- Roads
- Watercourse
- + Railways
- Study Area
- Development Footprint
- State Forest

Vegetation Management Regional Ecosystems

- Remnant Of Concern
- Remnant Least Concern
- High Value Regrowth Of Concern
- High Value Regrowth Least Concern

FIGURE 4.1
State Mapped
Regional Ecosystems



- Legend**
- Roads
 - Watercourse
 - + Railways
 - Study Area
 - Development Footprint
 - State Forest
- Ground-truthed Regional Ecosystem (Umwelt 2022)**
- 11.5.20
 - Regrowth
- Threatened Ecological Community (RE 11.3.2) (Ausecology 2022)**
- Poplar Box Grassy Woodlands on Alluvial Plains TEC

FIGURE 4.2
Ground-truthed
Regional Ecosystems

4.2.3 Protected Plants

No high-risk areas for protected plants on the flora survey trigger map were identified within the Study Area. The closest mapped high-risk area for protected plants is approximately 1 km to the south-east of the Study Area, connected to Yelarbon State Forest.

4.2.4 Flora Diversity

The objective of the flora scope was to characterise vegetation communities and conduct searches for threatened species. Nonetheless, a total of 25 flora species were recorded within the Study Area during the Umwelt survey. These species represented the dominant species in each strata and common species in the ground layer. The dominant plant families recorded were Myrtaceae (5 taxa) and Poaceae (9 taxa). The field survey identified six introduced flora species which are discussed further in **Section 4.2.4.1** below. No flora species listed as threatened under the NC Act or EPBC Act were recorded during the field survey. The full list of flora recorded during the field survey is provided as **Appendix B**.

4.2.4.1 Introduced Flora

Six introduced flora species were recorded within the Study Area representing three families. One species, velvety tree pear (*Opuntia tomentosa**), is listed under the National Weeds Strategy as a Weed of National Significance and a Category 3 Restricted Invasive species under the Biosecurity Act.

4.3 Fauna

4.3.1 Fauna Habitat Types

The Study Area supports a total of four fauna habitat types (**Table 4.2**). Two of these fauna habitat types are also intersected by the Development Footprint. Habitat type 1 (*Eucalyptus moluccana* woodland on flat plains) and Habitat type 3 (farm dams) will not be disturbed by the Project, with the boundary of the Development Footprint a distance of approximately 500 m and 700 m from these habitat types, respectively. A description of these communities and the key fauna habitat opportunities is provided in the subsequent sections below.

It is noted that an additional RE (11.3.2) occurs within the Study Area as described in **Section 4.2.2.2**. While this RE may provide fauna habitat it was not assessed during the Umwelt survey, and as such has not been described further in this section.

Fauna habitat within the Development Footprint and broader Study Area has been subject to disturbance from clearing, agricultural practices, weeds and pests, and as a result is considered to be of reduced quality. Ongoing disturbance has led to a general lack of native understorey growth, structural complexity and microhabitat features such as fallen woody debris and leaf litter.

Table 4.2 Fauna Habitat Types

Habitat Number	Habitat Type	Extent within Study Area (ha)	Extent within Development Footprint (ha)
1	<i>Eucalyptus moluccana</i> woodland on flat plains	2.45	0
2	Regrowth eucalypt woodland with scattered mature trees	5.32	1.1
3	Farm dams	2.52	0
4A	Cleared areas – exotic pasture and tracks	222.0	42.9
4B	Cleared areas – wheat cropping	104.17	25.3

4.3.1.1 Habitat 1 – *Eucalyptus moluccana* Woodland on Flat Plains

This habitat occurs as a single patch in the north-western Study Area, flanked by barbed wire fencing to the north and west. Further north is the existing South Western System Railway Line and the Whetstone State Forest. The Development Footprint is approximately 500 m away at the closest point and no impacts area expected as a result of the Project.

Characterised as a woodland dominated by grey-box (*Eucalyptus moluccana*) with an open grassy understorey, this habitat is primarily expected to support woodland birds, small reptiles and some mammals. Mature koala food trees (grey-box (*Eucalyptus moluccana*)) are common, providing potential foraging opportunities for the koala. However, a number of existing barriers to movement (mesh fencing excluding large tracts of remnant vegetation in the adjacent Whetstone State Forest; the rail line; the Cunningham Highway) occur in close proximity and may restrict access to this habitat. Hollows in canopy trees are rare and exclusively small in size indicating suitability is limited to microbats, arboreal reptiles and some small parrot species.

When in flower, the myrtaceous canopy is likely to provide foraging opportunities for a range of common bird and flying-fox species. A single, large bull oak (*Allocasuarina luehamni*) also occurs within the canopy. This species is known to be a key foraging resource for the threatened glossy black cockatoo (south-eastern) (*Calyptorhynchus lathami lathami*); however, no evidence of foraging was recorded. Although several recruiting individuals were observed, the rarity of this species indicates the habitat provides negligible habitat opportunities for the species. No mistletoe or fruiting shrub species were recorded.

The grassy ground layer also contains occasional ground-timber, which may be used by small ground-dwelling mammals and reptiles. Occasional decorticated bark on trees may also provide opportunities for common geckos and skinks. Macropods are also likely to utilise the habitat for foraging and shelter as evident by the presence of scats in the ground layer.



Photo 4.1 *Eucalyptus moluccana* woodland on flat plains

4.3.1.2 Habitat 2 – Regrowth Eucalypt Woodland with Scattered Mature Trees

This habitat occurs as disconnected, scattered patches close to the Study Area and Development Footprint boundary, generally in proximity to the Cunningham Highway and South Western System Railway Line. In the south-eastern corner of the Study Area, this habitat is connected to the riparian vegetation of the Macintyre Brook to the east of Whetstone Access Road. Habitat exhibits a high level of disturbance, with weeds common and evidence of selective thinning.

Variable in composition and structure, this habitat is broadly characterised as regrowth woodland dominated by *Eucalyptus spp.* with an open grassy understorey. Young and mature koala food trees including Queensland blue gum (*Eucalyptus tereticornis*), poplar box (*Eucalyptus populnea*), narrow-leaved ironbark (*Eucalyptus crebra*) and Morten Bay ash (*Corymbia tessellaris*) are generally common, providing potential foraging opportunities for the koala. Hollows in canopy trees are rare; and all but one medium sized hollow recorded were small. Based on the small size and low density of hollows and the existing fragmentation impacts, habitat is not suitable for the greater glider (central and southern) (*Petauroides volans*).

As per habitat type 1, the myrtaceous canopy is likely to provide foraging opportunities for a range of common bird and flying-fox species when in flower. Rare white cypress pine (*Callitris glaucophylla*) trees were recorded in the south-eastern corner of the Study Area where the patch connects to the Macintyre Brook. However, no other key foraging resources such as mistletoe or fruiting species were recorded. Habitat opportunities for reptiles and small mammals are limited to the grassy ground layer and occasional ground-timber which consisted of occasional fallen logs.



Photo 4.2 Regrowth eucalypt woodland with scattered mature trees

4.3.1.3 Habitat 3 – Farm Dams

Two farm dams were identified within the southern Study Area approximately 700m from the Development Footprint at its closest point during the field survey. The farm dams differed in quality, however both had modified banks which had been raised primarily along the southern boundary and were dominated by common weed species.

The southern-most farm dam is the largest (approximately 2.2 ha) and highest quality (**Photo 4.3, left**). Relative to the extent observable on aerial imagery, this dam was found to be considerably larger during the field survey likely as a result of recent rainfall and the extended wet season in 2022. Margins up to 6 m wide of wetland vegetation including *Juncus sp.* and macrophytes occur on the low-lying fringes in the northern, shallow overflow areas. These areas may provide refuge and foraging opportunities for a diversity of waterbirds including some migratory shorebirds. The second farm dam located to the east is smaller in size (approximately 0.3 ha) and has more defined banks (**Photo 4.3, right**). Fringing wetland vegetation is largely absent. However, a small area of regrowth eucalypt woodland occurs directly adjacent and may provide shade to aquatic species in the dam such as turtles, as well as perching opportunities for foraging predatory birds.

Species observed utilising the farm dams during the field survey include the Australasian grebe (*Tachybaptus novaehollandiae*), Australian wood duck (*Chenonetta jubata*), sulphur crested cockatoo (*Cacatua galerita*), pied cormorant (*Phalacrocorax varius*), white-necked heron (*Ardea pacifica*), black-fronted dotterel (*Elseya melanops*), straw-necked ibis (*Threskionris spinicollis*) and intermediate egret (*Ardea intermedia*). The larger farm dam within the Study Area is conservatively considered to provide some foraging and dispersal opportunities for wetland birds while on passage to higher quality habitat, however the depth and lack of fringing vegetation at the smaller farm dam were not suitable for the ecological requirements for these species.



Photo 4.3 Two farm dams within the Study Area. Larger and higher quality dam in the west (pictured left), smaller dam in the east (pictured right)

4.3.1.4 Habitat 4A – Cleared Areas – Exotic Pasture and Tracks

Cleared areas comprising exotic pasture and tracks occur over the majority of the Study Area and the Development Footprint. Habitat is highly disturbed, and values are limited but include rare individual paddock trees (generally adjacent to tracks, on fence lines or near farm dams) and an abundance of exotic grass in the ground layer where grazing had been restricted. Rare areas of bare ground are also present as a result of recent clearing works (**Photo 4.4**). Where grass cover is high, dispersal opportunities for small reptiles and mammals occur. Common raptors, granivorous birds and common mammal species such as the eastern grey kangaroo may forage in this habitat and emu (*Dromaius novaehollandiae*) and red-backed fairy wren (*Malurus melanocephalus*) were regularly recorded. Given the species' very broad habitat requirements, habitat may also be suitable for the short-beaked echidna (*Tachyglossus aculeatus*). Habitat is not considered to provide dispersal opportunities for koala given the large expanses of area devoid of suitable trees. No potential shelter trees were recorded within this habitat.



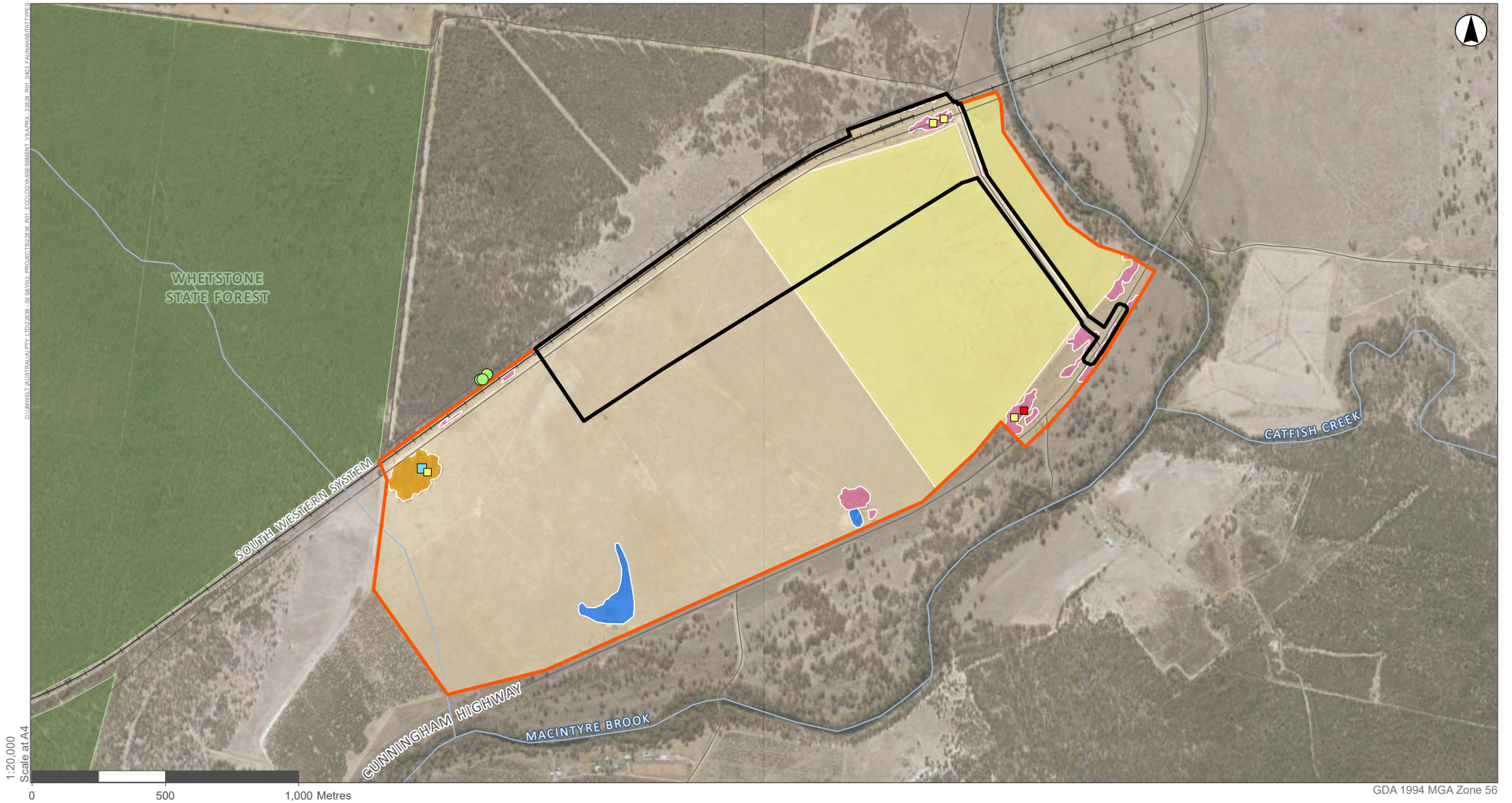
Photo 4.4 Exotic pasture

4.3.1.5 Habitat 4B – Cleared Areas – Wheat Cropping

Cleared areas comprising cropping occur in the eastern extent of the Study Area and the Development Footprint. Similar to the exotic pasture, habitat is highly disturbed and provides very limited habitat opportunities. The crop observed during the field survey was very short, likely only recently planted, however did provide ground-cover for dispersing small-bodied ground-dwelling fauna (**Photo 4.5**). Birds are the fauna group most likely to utilise this habitat for foraging and dispersal purposes. Habitat is not considered suitable for any species listed under the NC Act or EPBC Act.



Photo 4.5 **Wheat cropping**



GDA 1994 MGA Zone 56

Legend

- Roads
- Watercourse
- Railways
- Study Area
- Development Footprint
- State Forest

Potential Animal Breeding Places

- Small Hollows (Umwelt 2022)
- Medium Hollows (Umwelt 2022)
- Active Animal Breeding Place (Noisy Miner Nest) (Umwelt 2022)
- Potential Animal Breeding Place (Cardno 2021)

Fauna Habitats

- Cleared areas - exotic pasture and tracks
- Cleared areas - wheat cropping
- Eucalyptus moluccana woodland on flat plains
- Regrowth eucalypt woodland with scattered mature trees
- Farm dams

FIGURE 4.3
Fauna Habitat Types

4.3.2 Fauna Diversity

Fauna species were recorded opportunistically throughout the duration of the field survey as ecologists traversed the Study Area on foot. A total of 40 fauna species were recorded including one reptile, one amphibian, one mammal and 37 birds.

The full fauna species list is provided in Appendix B.

4.3.2.1 Introduced Fauna

A number of introduced fauna species are recognised as threats to native flora and fauna under the EPBC Act. No introduced fauna species were recorded during the field assessment; however, introduced species likely to occur (and listed as restricted matters under the Biosecurity Act) include cane toad (*Rhinella marina**), black rat (*Rattus rattus**), house mouse (*Mus musculus**), red fox (*Vulpes vulpes**) and feral cat (*Felis catus**).

4.3.3 Animal Breeding Places

Findings of the Umwelt survey confirmed the presence of one active animal breeding place within the *Eucalyptus moluccana* woodland on flat plains habitat type (habitat 1), in the western Study Area outside of the Development Footprint. A noisy miner (*Manorina melanocephala*) nest with two chicks was recorded in a low branch of the single mature bull oak (*Allocasuarina leuhamanii*) present. The noisy miner is not listed threatened or migratory under the NC Act or EPBC Act, however, the 'Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*)' is a Key Threatened Process under the EPBC Act. Additionally, small hollows which may be utilised by microchiropteran bats or small parrot species were present in regrowth eucalypt woodlands. One medium hollow was also present in this habitat type.

Ecology surveys completed by Cardno to support the B2G EIS also identified three potential animal breeding places immediately north of the Study Area, as described below:

- Large stag with 5 large hollows and 5 medium hollows
- Stag with 2 medium hollows
- Large hollow log.

4.3.4 Connectivity and Fauna Movement

Although occurring in an area used largely for agriculture, a number of protected areas including State Forests occur in the immediate vicinity of the Study Area. The Macintyre Brook also occurs directly east and south-east which has a well-developed, remnant riparian zone and was flowing heavily at the time of the Umwelt survey.

As discussed in **Section 4.3.1**, the Study Area is dominated by non-remnant cleared areas with only relatively small, scattered areas of remnant and regrowth woodland habitat. While these woodland habitats may provide increased habitat resources relative to the surrounding grasslands, a number of barriers to movement exist that may limit access to these areas. Movement within the Study Area is restricted by the large areas of cleared land and tracks. Although areas outside of the Study Area are

functionally connected for more mobile species, the South Western System Railway Line in the north and the Cunningham Highway in the south may be a barrier to movement for smaller species and also present a risk of vehicle strike for dispersing fauna.

Nonetheless, woodland patches within the Study Area are expected to provide some 'stepping-stone' opportunities and potentially facilitate the movement of threatened fauna such as the koala by limiting the distance required to travel in cleared exposed landscapes. In the south-eastern Study Area especially, regrowth woodland connects to the riparian vegetation of the Macintyre Brook. In the far northern and north-western corner of the Study Area, regrowth and remnant vegetation occurs in close proximity to the rail corridor and existing vegetation, potentially allowing the crossing of this barrier to be simplified.

The Study Area is not located within a Biodiversity Planning Assessment (BPA) Statewide Biodiversity Corridor; however, adjacent areas to the north and south are considered to be of State significance.

4.3.5 Wetlands and Watercourses

The DES Queensland Wetland mapping, MSES High Ecological Significance (HES) wetland mapping and Vegetation management wetland mapping were reviewed as part of the desktop assessment. State mapped watercourse values such as VM Act watercourses and DAF waterways for waterway barrier works were also reviewed.

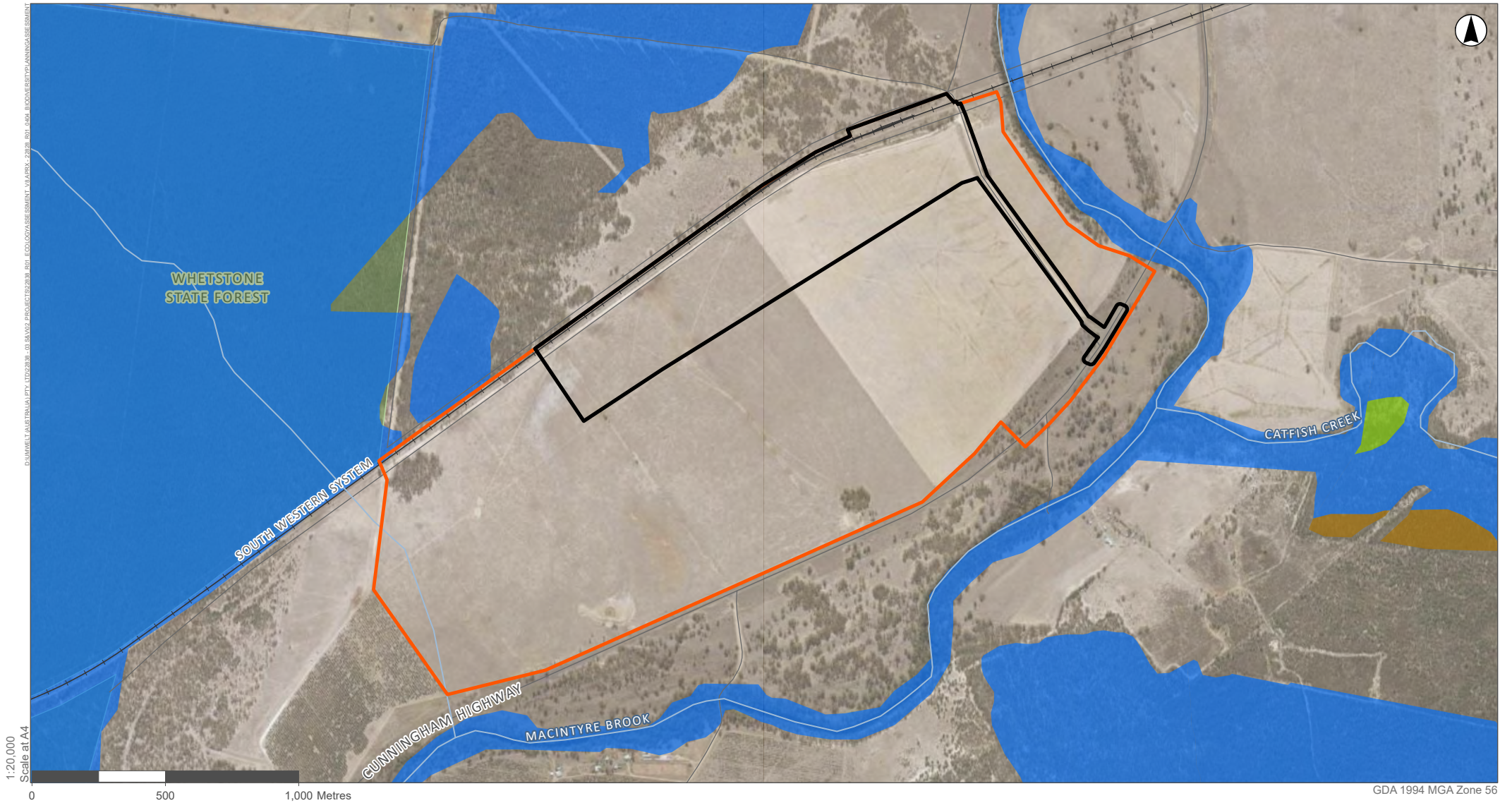
The Study Area is located within the Macintyre Brook sub-basin of the Murry Darling Basin. Macintyre Brook, a stream order 8 watercourse, flows north to south around the eastern and southern boundary of the Study Area. Feeding into Macintyre Brook, Catfish Creek, a stream order 5 watercourse, flows east to west to the south-east of the Study Area. Both Macintyre Brook and Catfish Creek occur on the VM Act Watercourses map. One unnamed, stream order 1 drainage feature, flows north to south through the western portion of the Study Area and into Macintyre Brook. However, this watercourse could not be identified during the field survey possibly due to severe exotic grass incursion. This drainage feature does not fall within the Development Footprint. Macintyre Brook and Catfish Creek are classified as Major waterways for waterway barrier works. Both of these systems are located outside of the Study Area.

The Study Area contains two mapped artificial waterbodies represented as agricultural dams. No HES wetlands occur within the Study Area.

Field surveys confirmed the presence of the two agricultural dams on the southern boundary of the Study Area (**Section 4.3.1.3**) which support aquatic flora species and may provide habitat for fauna species such as turtles, reptiles, frogs, freshwater fish and birds. Migratory birds such as EPBC Act listed snipes may utilise these habitats for foraging and roosting during migration. Although within the Study Area, farm dams are approximately 700m from the Development Footprint at the closest point. Outside of the Study Area, the Macintyre Brook is likely to support a greater diversity of aquatic fauna including the Murray cod (*Maccullochella peelii*), which was confirmed during field surveys completed for the B2G EIS (ARTC, 2021).

4.4 Essential Habitat

No areas of Essential Habitat for threatened flora or fauna species occur within the Development Footprint as per the DES Essential Habitat mapping. The nearest area of mapped Essential Habitat occurs >10 km to the south-east, within Yelarbon State Forest.



- Legend**
- Roads
 - Watercourse
 - Railways
 - Study Area
 - Development Footprint
 - State Forest
- Biodiversity Significance**
- State
 - Regional
 - Local or Other Values

FIGURE 4.4
Biodiversity Planning
Assessment Mapping

4.5 Likelihood of Occurrence

The desktop assessment identified the potential occurrence of 30 fauna and 10 flora species listed under the NC Act or EPBC Act, as well as five TECs listed under the EPBC Act within the Development Footprint (**Appendix A**). As described in **Section 3.3**, the potential presence of these values was interrogated further through the likelihood of occurrence assessment, which is detailed in full in **Appendix C**.

Findings of the assessment determined three fauna species listed under the NC Act or EPBC Act have a Moderate or High likelihood of occurrence within the Development Footprint. One TEC is Known to occur within the Development Footprint as per Ausecology (2022), however the remaining four TECs and all threatened flora species were determined to have a likelihood of Unlikely or Low.

A summary of the likelihood of occurrence results is provided in **Table 4.3** below.

Table 4.3 Likelihood of Occurrence – Summary of Results

Common Name	Scientific Name	EPBC Act Status	NC Act Status
Known			
Poplar Box Grassy Woodland on Alluvial Plains TEC		Endangered	-
Moderate			
koala	<i>Phascolarctos cinereus</i>	Endangered	Endangered
grey-headed flying-fox	<i>Pteropus poliocephalus</i>	Vulnerable	-
short-beaked echidna	<i>Tachyglossus aculeatus</i>	-	Special Least Concern

4.6 Fauna Habitat Criteria

Fauna habitat criteria have been developed for listed fauna species which have a high or moderate likelihood of occurring. This criterion is based on mapped fauna habitat types presented in this report (**Section 4.3.1**) to determine the extent of suitable habitat for each species. Fauna habitat for each species is provided in **Table 4.4**.

Table 4.4 Fauna Habitat Criteria

Common Name	Scientific Name	Associated Fauna Habitat	Extent within Development Footprint (ha)
Threatened and Species Least Concern Species			
koala	<i>Phascolarctos cinereus</i>	Regrowth eucalypt woodland with scattered mature trees.	1.1
grey-headed flying-fox	<i>Pteropus poliocephalus</i>		
short-beaked echidna	<i>Tachyglossus aculeatus</i>	All fauna habitat types.	69.3

5.0 Potential Impacts

The primary impacts on ecological values as a result of the Project will occur during disturbance of vegetation and microhabitat features during construction. Further information on the potential direct and indirect impacts associated with the Project is outlined below. The impacts discussed below are based on the Development Footprint which covers a total of 69.3 ha.

5.1 Direct Impacts

5.1.1 Vegetation Clearance and Habitat Loss

The Project has been designed and sited within the Study Area to avoid and minimise vegetation clearing wherever feasible; however, removal of native vegetation cannot be completely avoided. Predicted direct impacts (i.e. vegetation removal and associated habitat loss) based on the Development Footprint are quantified in **Table 5.1** below. Further reduction in direct impacts to regrowth eucalypt woodland with scattered mature trees, which provides habitat for koala (*Phascolarctos cinereus*) and grey-headed flying-fox (*Pteropus poliocephalus*) may be avoided during the detailed design phase.

Table 5.1 Predicted Direct Impacts to Habitat Types and Vegetation Communities

Habitat Type / Vegetation Community	RE	VM Act Status	Extent (ha) within Study Area	Extent (ha) within Development Footprint
<i>Eucalyptus moluccana</i> woodland on flat plains	11.5.20	Least Concern	2.4	0
Regrowth eucalypt woodland with scattered mature trees	-	-	5.3	1.1
Farm dams	-	-	2.5	0
Cleared areas – exotic pasture and tracks	-	-	221.9	42.9
Cleared areas – wheat cropping	-	-	104.2	25.3
Total			336.4	69.3

5.1.2 Loss or Alteration of MSES or MNES Community or Habitat

The maximum required clearing will impact on approximately 1.1 ha of habitat for species and communities considered MSES or MNES. How this loss of habitat may impact each individual species through the direct loss of foraging and breeding resources varies depending on the current utilisation of the area by the species and the species-specific habitat requirements. Predicted direct impacts for species and communities with a Moderate likelihood or higher are provided in **Table 5.2** below.

Table 5.2 Predicted Direct Impacts to MSES and MNES Values

Species / Community	EPBC Act Status ¹	NC Act Status ¹	Habitat Utilisation	Extent (ha) within Development Footprint
Poplar Box TEC	E	-	-	0.22
Koala (<i>Phascolarctos cinereus</i>)	E	E	Foraging and dispersal	1.1
grey-headed flying-fox (<i>Pteropus poliocephalus</i>)	V	-	Marginal foraging and dispersal	1.1
short-beaked echidna (<i>Tachyglossus aculeatus</i>)	-	SLC	Breeding, foraging and dispersal	69.3
Total Impact to MNES/MSES Fauna Habitat				69.3

¹ V = Vulnerable; E = Endangered; SLC = Special Least Concern

5.1.3 Disturbance, Injury and Mortality of Fauna

Clearing of vegetation can result in injury or mortality of fauna, particularly ground dwelling fauna, that may be crushed by machinery or struck by vehicles. Arboreal mammals and reptiles may be trapped in trees as they are felled. Additionally, nesting birds may be disturbed and displaced. Whilst a local impact on fauna may occur, the impact on fauna populations within the broader landscape is considered minimal.

5.2 Indirect Impacts

5.2.1 Impacts to Waterways

A single first order drainage feature exists in the western portion of the Study Area and flows north to south, connecting with the Macintyre Brook outside of the Study Area. This watercourse represents a small runoff drainage feature, heavily impacted by exotic grass that was indiscernible during the Umwelt survey. During periods of flood, it may flow into Macintyre Brook but under normal circumstances, it is unlikely to flow or hold water. This drainage feature is approximately 850 m from the Development Footprint at its closest point. No direct impacts are anticipated as a result of the Project.

Downstream impacts to Macintyre Brook from watercourses and drainage features within the Study Area are considered unlikely given the minor holding capacity and intermittent flow associated with these systems. Although the MNES species Murray cod (*Maccullochella peelii*) is known to occur in Macintyre Brook, any potential impacts to this species would be negligible as no direct works will be conducted in the waterway, no barriers to movement will be constructed and habitat complexity and flow regime would not be impacted to any material extent.

In consideration to the above, potential indirect impacts to waterways during high-rainfall periods and construction may include:

- Erosion and sedimentation.
- Reduced water quality from point and non-point sources.

- Material stockpiles may cause a direct influx of sediment in the surface water runoff from the work sites, particularly from areas of cleared vegetation.
- Increased nutrient input which may have flow on effects to vegetation and algal growth.
- Contamination of hydrocarbons and other chemicals due to spills.
- Sediment and suspended solids as a run-off from tracks and other exposed areas.
- Changes to soil chemistry due to:
 - Importation of foreign soils
 - Exposure of subsoils.
- Facilitation of the establishment of terrestrial and aquatic weed species, which may further degrade habitat value in fringing vegetation.

5.2.2 Exacerbation of Pest Fauna and Weeds

As described in **Section 4.3.2.1**, although no introduced fauna were recorded within the Study Area during the survey, some species are anticipated to occur given the area's highly disturbed nature. Introduced fauna populations, left unchecked, may flourish in newly disturbed areas, disperse into higher quality habitat areas and further contribute toward the degradation of fauna habitat within the Study Area. Newly cleared linear areas may also act as conduits for pest fauna movement.

Given the extent of historical clearing within the Study Area and the likely prevalence of these species within the existing landscape, it is unlikely that the proposed works will result in further introductions of feral vertebrate species. However, further habitat modification may facilitate larger populations of certain introduced species such as European rabbit (*Oryctolagus cuniculus**) and house mouse (*Mus musculus**) where some native species will not be able to persist. Some potential impacts of these pest fauna to native species include that they may:

- Prey on native species and compete for food.
- Carry diseases that may affect native animals.
- Act as the primary prey for other exotic predators such as feral cats or foxes which then threaten native species.

The introduction and/or spread of weeds is an indirect impact that can impact the integrity of remaining vegetation, increase the intensity and/or frequency of fires, as well as threaten the long-term survival of threatened fauna species. The weed species that pose the biggest threat to fauna and associated habitat values are the Category 3 'restricted' species listed under the *Biosecurity Act 2014*, Weeds of National Significance, as well as high-biomass grass species. High-biomass grass species can out-compete native vegetation as well as reduce the germination of native species. The high biomass of these species also increases the intensity and/or frequency of fires posing a further risk to fauna habitat.

Project activities that may increase the risk of establishment of new infestations and exacerbation of existing infestations include the following:

- Soil disturbance through vegetation clearance and construction activities.
- Areas of ground remaining bare for extended periods will establish weed species where there is little competition from other species.
- Increased vehicular traffic through the area.
- Importation of construction materials to the site which may harbour introduced species.

However, as described in **Section 4.2.2.2** weed species are common within the Development Footprint and the broader Study Area, including a high biomass of exotic grasses and ground cover species. Given the prevalence of these species, it is considered unlikely Project works will further exacerbate weed populations.

5.2.3 Activity and Noise

During the construction and operation phase, there will be an increase in noise and activity in the Study Area as machinery undertakes clearing and other activities. When activity and noise is occurring in areas adjoining retained habitat, potential impacts may include:

- Reduced foraging ability by auditory predators due to increased background noise.
- Increased risk of predation by visual predators due to increased background noise.
- Increased potential for collisions with vehicles and plant.
- Human visitation causing disturbance to foraging or breeding behaviours.

Current research indicates that there are no government policies or other widely-accepted guidelines in respect to the noise levels which may be acceptable to wildlife. The levels or character of noise that may “startle” or otherwise affect the feeding or breeding pattern of birds or other wild animals are also not firmly established in the technical literature.

Sudden loud, impulsive or impact noises are capable of causing birds and other fauna to become startled, which if occurring over the longer term, may affect feeding and breeding behaviour in some species. These impacts are expected to occur to the fauna using the habitats both within and immediately adjacent to the Study Area.

It is expected that excavation, construction and earthmoving associated with the Project will potentially cause disturbance to all groups of fauna, especially birds and hollow-dwelling fauna. This may result in the temporary avoidance of the area for the duration of these activities. The construction works will be conducted during daylight hours only and no temporary or permanent lighting will be instated as part of the Project. Impacts from noise will be limited to temporary construction noise, most of which will be of similar noise level to passing heavy vehicles.

Existing noise and lighting conditions in the Study Area are typical of land adjacent to a high-speed motorway environment and are restricted to that created by passing vehicles. The operation phase of the Project is not expected to result in increased traffic or light, therefore the impacts during the operational phases of the Project will reflect current levels.

5.2.4 Increased Dust

Deposition of dust, sand and soil resulting from construction may have potential impacts on vegetation if excessive levels are sustained over extended periods. When dust settles on plant foliage it can reduce the amount of light penetration on the leaf surface, block and damage stomata, and slow rates of gas exchange and water loss (Farmer 1993). Reduction in the ability to photosynthesise due to physical effects may result in reduced growth rates of vegetation and decreases in floral vigour and overall community health.

6.0 Matters of State Environmental Significance

MSES include certain environmental values that are protected under Queensland legislation including:

- NC Act
- *Marine Parks Act 2004*
- *Fisheries Act 1994*
- EP Act
- *Regional Interests Planning Act 2014*
- VM Act
- EO Act.

MSES that could be relevant to the Project include those listed in Schedule 2 of the Queensland Environmental Offset Regulations. Most of these MSES include flora and fauna values that have been previously discussed in **Section 4.0** and **Section 4.5**. These values within the Development Footprint, along with others that are considered MSES have been summarised in **Table 6.1** below.

Table 6.1 MSES Values

Prescribed MSES	Definition	Present in the Development Footprint
Regulated vegetation	Prescribed regional ecosystems that are 'endangered' or 'of concern' regional ecosystems, as defined under the VM Act.	No Although an Of Concern regional ecosystem is present within the Development Footprint, it does not occur within a category B area on the Regulated Vegetation Management map, as such it does not constitute a 'prescribed matter'.
	Prescribed regional ecosystem that intersects with an area shown on the vegetation management wetlands map.	
	Prescribed regional ecosystem that is located within the defined distance from the defining banks of a watercourse identified on the vegetation management watercourse map Act.	
	Prescribed regional ecosystem that is an area of essential habitat on the essential habitat map for an animal that is critically endangered wildlife, endangered wildlife or vulnerable wildlife or a plant that is critically endangered wildlife, endangered wildlife or vulnerable wildlife.	

Prescribed MSES	Definition	Present in the Development Footprint
Marine plants	Marine plants are part of the mosaic of fish habitats and are an integral and usually highly visible feature of the coastline. Fish habitat is defined under the <i>Fisheries Act 1994</i> and includes land, waters and plants associated with the life cycle of fish, and includes land and waters not presently occupied by fisheries resources. Marine plants are defined under the Fisheries Act and include the following: a. a plant (a tidal plant) that usually grows on, or adjacent to, tidal land, whether it is living, dead, standing or fallen; b. material of a tidal plant, or other plant material on tidal land; c. a plant, or material of a plant, prescribed under regulation or management plan to be a marine plant.	No The Development Footprint does not contain a tidal watercourse.
Connectivity	Prescribed regional ecosystem that: • is of sufficient size or configured in a way that maintains ecosystem functioning; and • will remain despite a threatening process within the meaning of the NC Act.	No The Development Footprint does not contain a prescribed regional ecosystem that meets the definition.
Wetlands and watercourses	Wetland in a wetland protection area as shown on the map of referable wetlands.	No No mapped wetlands or watercourses occur within the Development Footprint.
	Wetlands of high ecological significance as shown on the map of referable wetlands.	
	Wetland or watercourse in a high ecological value waters as identified under the Environmental Protection (Water) Policy 2019.	
Protected areas	Protected areas are declared under the NC Act for the conservation of Queensland's natural and cultural resources. They include: • national parks • national parks (Aboriginal land / Torres Strait Islander land / Cape York Peninsula Aboriginal land) • regional parks • nature refuges.	No The Development Footprint does not contain protected areas.
Fish habitat areas and highly protected zones of State Marine Parks	Fish Habitat Areas are declared under the <i>Fisheries Act 1994</i>. Marine parks are declared under the <i>Marine Parks Act 2004</i>.	No The Development Footprint does not contain a watercourse or marine environment.

Prescribed MSES	Definition	Present in the Development Footprint
Waterways providing for fish passage	Any part of a waterway that provides for passage of fish regulated under the <i>Fisheries Act 1994</i> for the natural movement patterns of fish species required to maintain the biological integrity of the species.	No No waterways that may provide for fish passage are found within the Development Footprint.
Legally secured offset areas	Legally secured offset areas are any areas declared as an environmental offset protection area, high nature conservation value under the VM Act or another area prescribed under a regulation.	No The Development Footprint does not contain legally secured offset areas.
Protected wildlife habitat	- an area that is shown as a high risk area on the flora survey trigger map that contains plants that are endangered wildlife or vulnerable wildlife - an area that is not shown as a high risk area on the flora survey trigger map, to the extent the area contains plants that are endangered wildlife or vulnerable wildlife - a koala habitat area as defined by the Nature Conservation (Koala) Conservation Plan 2017 - an area of habitat (e.g. foraging, roosting, nesting or breeding habitat) for an animal that is Endangered, Vulnerable or a Special Least Concern animal.	Yes Ground-truthed potential habitat for threatened and special least concern fauna species occurs within the Development Footprint.
Designated precinct in a strategic environmental area	An area identified on the Strategic Environmental Area map. Designated precincts include the Channel Country, Fraser Island, Gulf Rivers and Hinchinbrook Island.	No There are no Strategic Environmental Areas mapped within or adjacent to the Development Footprint.

6.1 Significant Residual Impact Assessment for MSES

As described in **Section 4.5**, findings of the likelihood of occurrence assessment determined that two species listed under the NC Act have a Moderate or higher likelihood of occurring within the Development Footprint. These species and their associated potential habitat are considered to comprise the Protected wildlife habitat MSES based on the definitions in **Table 6.1**. These are:

- koala (*Phascolarctos cinereus*)
- short-beaked echidna (*Tachyglossus aculeatus*).

Of the above species, one (the short-beaked echidna (*Tachyglossus aculeatus*)) is not also listed under the EPBC Act and therefore not an MNES. Protection under the EPBC Act is the highest level of protection within Australia and the impact assessment under such is therefore considered to be the most stringent. Further, the questions to be addressed in determining a significant impact to MNES and MSES are substantially the same and therefore a similar conclusion is most likely. As such, potential impacts on the remaining species (koala) has been assessed under the EPBC Act guidelines (as detailed in **Section 7.1**) and further assessment against the MSES significant residual impact guidelines has not been conducted. No other MSES values are considered relevant to the Project.

An assessment of the significance of potential Project impacts in accordance with *Significant Residual Impact Guideline* (Department of State Development Infrastructure and Planning 2014) was conducted for the short-beaked echidna (*Tachyglossus aculeatus*) (see **Appendix D**). The findings of the assessment determined that a significant residual impact on the species was unlikely given small area of proposed disturbance, the generally degraded nature of this habitat, the species' ability to disperse between habitat patches and the large areas of higher value habitat available directly adjacent the Disturbance Footprint.

7.0 Matters of National Environmental Significance

The MNES values relevant to the Development Footprint and Project are outlined below in **Table 7.1**.

Table 7.1 MNES Values

MNES Value	Location Relative to the Study Area
World heritage properties	No – There are no World heritage places within proximity to the Development Footprint.
National heritage places	No – There are no National heritage places within proximity to the Development Footprint.
Wetlands of international importance (listed under the Ramsar convention)	No – There are no Wetlands of International Importance within proximity to the Development Footprint.
Listed threatened species and ecological communities	Yes – No threatened species or communities were recorded during the Umwelt survey. However, one TEC is considered known to occur within the Development Footprint as per Ausecology (2022), and two fauna species are potential occurrences based on the available habitat and the presence of records. No listed flora species have the potential to occur within the Study Area.
Migratory species	No – No listed migratory species were recorded during the Umwelt survey and none are considered to occur within or above the Development Footprint, given the absence of farm dams and wetland habitat.
Commonwealth marine areas	No – The Development Footprint is located >250 km inland.
Great Barrier Reef Marine Park	No – The Development Footprint is located >250 km inland, and considerably south of the Great Barrier Reef Marine Park.
Nuclear actions (including uranium mines)	No – The Project is not and does not involve a nuclear action.
A water resource, in relation to coal seam gas development and large coal mining development	No – The Project is not a coal seam gas development or a large coal mining development.

7.1 Significant Impact Assessment for MNES

As described in **Section 4.5**, findings of the likelihood of occurrence assessment determined that one TEC and two species listed under the EPBC Act have a Moderate or higher likelihood of occurring within the Development Footprint.

The precautionary principle has been applied when deciding whether or not the Project is likely to have a significant impact on a value. Despite the small scale of direct impacts, significant impact assessments in accordance *Significant Impact Guidelines Policy Statement 1.1* (Department of the Environment 2013) were completed for the following values:

- Koala (*Phascolarctos cinereus*)
- Grey-headed flying-fox (*Pteropus poliocephalus*)
- Poplar Box TEC.

Poplar Box TEC is shown on **Figure 4.2**, and potential koala and grey-headed flying-fox habitat within the Development Footprint (and Study Area) is shown on **Figure 7.1**.

The full assessments are detailed in **Appendix E**. The findings of these assessments determined that the Project is unlikely to result in a significant impact on the koala, grey-headed flying-fox or Poplar Box TEC.

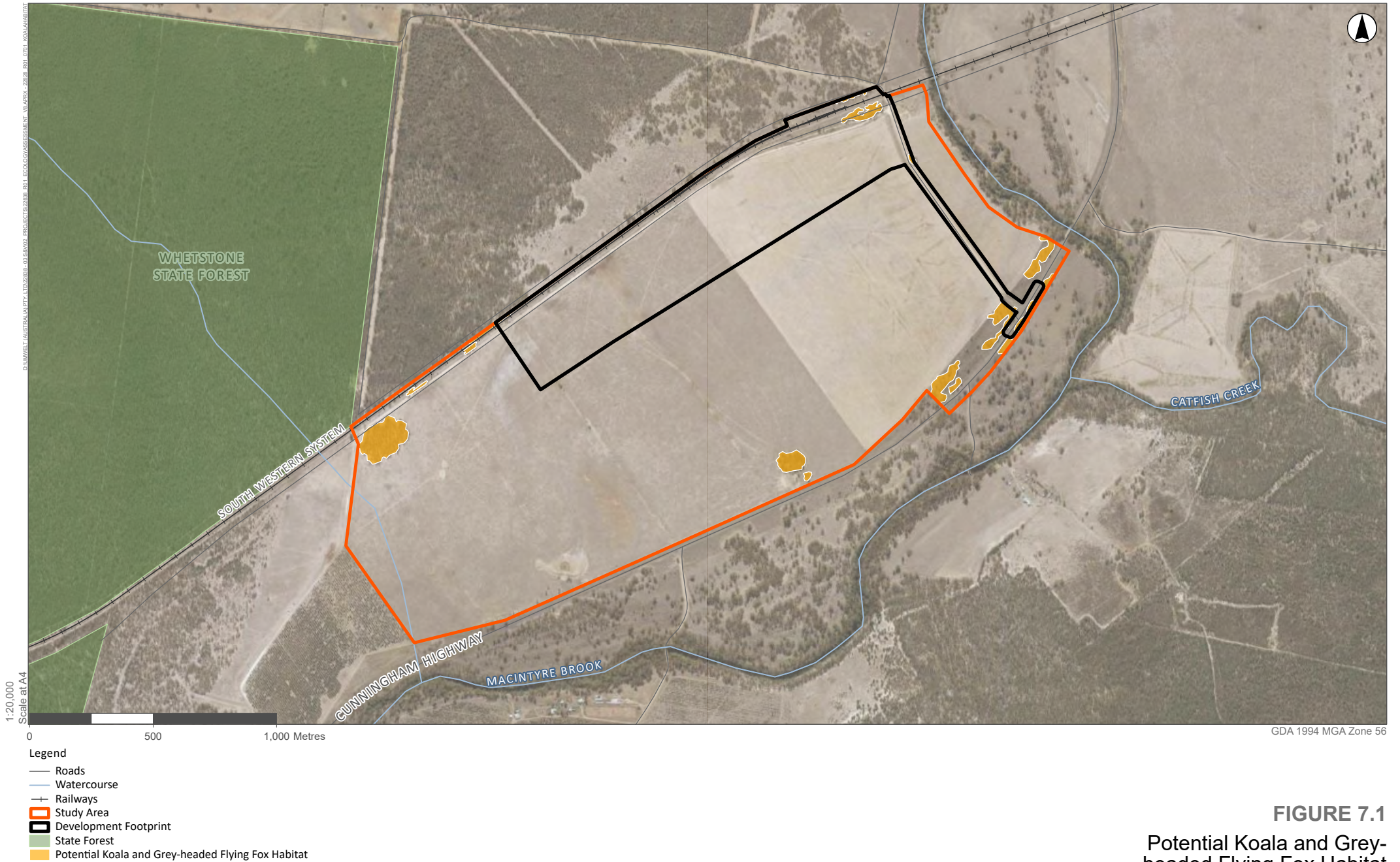


FIGURE 7.1
Potential Koala and Grey-headed Flying Fox Habitat

8.0 Mitigation Measures

Mitigation measures relevant to the planning and design, construction and construction and operation phases of the Project are summarised below.

Planning and Design

- During detailed design, areas of suitable habitat for koala and grey-headed flying-fox should be avoided wherever feasible (**Figure 7.1**).
- Vehicle washdown facilities should be utilised during construction activities to minimise biosecurity risk.
- Habitat trees and mature vegetation within the Development Footprint are to be maintained to the greatest extent possible (**Figure 4.3**).
- As potential animal breeding places have been identified within the Development Footprint, it is recommended that a Low-Risk Species Management Program (SMP) be developed and implemented for the Project. The pre-emptive preparation of a Low-Risk SMP will mitigate time risks associated with preparing a SMP for impacts to breeding places (e.g. nests and hollow bearing trees) that are present or that may be established prior to construction.
- Breeding places for colonial breeding species exists within the north-eastern section of the Development Footprint (see small hollows and vegetation identified on **Figure 4.3**). Impacts to these areas should be avoided through planning and design activities and a no-go zone should be established around this vegetation. Where impacts are necessary to this portion of the Development Footprint a High Risk SMP will be required prior to the commencement of works.

Construction

- Where clearing is required, it should be limited to the approved 'Development Footprint'. Any unauthorised clearing beyond the Development Footprint should be reported to the site manager and ARTC immediately.
- Remnant vegetation adjoining areas subject to disturbance should be clearly identified as no-go zones.
- A qualified fauna spotter catcher is to be engaged to undertake pre-clearance surveys for fauna and fauna breeding places.
- Clearing and construction activities are to be undertaken in daylight hours where possible to reduce impacts from lighting and construction noise on nocturnal species, including the koala.
- All staff and contractors should receive environmental awareness and mitigation training to ensure they are aware of their environmental responsibilities.
- If a koala is located during pre-clearance surveys or during clearing activities:
 - the individual must not be forcibly relocated
 - any tree which houses a koala as well as any tree with a crown that overlaps that tree will not be cleared until the koala vacates the tree on its own volition

- o allow a clearing buffer surrounding the tree, equal to the height of the tree or deemed suitable by the spotter catcher
- o any injured koala (and fauna in general) should be transported to a vet or recognised wildlife carer as soon as practicable.
- The Study Area should not be used for cattle grazing during construction activities to disturbance from noise. It is noted that no cattle are currently utilising the Study Area, however there is historical evidence of cattle grazing.

Construction and Operation

- All site personnel should be educated about ecological values within and adjoining the Development Footprint. Personnel should be educated about the risk of fauna injury and death and be made aware of on-site speed limits.
- Weed control and pest management measures are to be developed in accordance with the Biosecurity Queensland guidelines for invasive plants and animals and incorporated into a Construction Environment Management Plant (CEMP) and Operational and Environment Management Plant (OEMP).
- Reducing speed limits on Project roads and access tracks and limiting traffic movements during dawn and dusk.
- The presence of pest and weed species should be monitored by ARTC environmental officers and where necessary, control measures should be implemented to limit abundance and distribution on the site.

9.0 Conclusion and Recommendations

Ecological values validated within the Development Footprint include regrowth and non-remnant vegetation in degraded condition. Nonetheless, these communities support some habitat values and resources for a diversity of flora and fauna species, conservatively including listed threatened and migratory species. This includes potential animal breeding places for least concern, threatened and colonial breeding fauna. One first order drainage line is mapped along the western extent of the Development Footprint, however will not be directly impacted by the Project.

The field survey did not confirm the presence of any conservation significant fauna or flora species. However, field surveys were observational only and were not intended to provide an exhaustive list of species diversity. In the absence of baseline fauna and flora surveys, desktop assessment in combination with habitat assessment was conducted to determine the potential for listed threatened and migratory species to occur. The result of this assessment was that two threatened fauna and one special least concern fauna species listed under the NC Act or EPBC Act were considered as having the potential to occur in the Development Footprint. Additionally, one TEC was confirmed to be present within the Development Footprint by Ausecology (2021). This could not be confirmed during the field surveys as work was not permitted in the rail corridor, however the overstorey vegetation was present and it is assumed that the Ausecology assessment and mapping is correct.

These species and the TEC were subject to a significant impact assessment against the State or Commonwealth significant impact assessment criteria:

- Koala
- Grey-headed flying-fox
- Short-beaked echidna
- Poplar box TEC.

Further detailed assessment determined that significant impacts to all four values were unlikely to occur. This is primarily based on the small amount of clearing required in suitable habitat as well as the low connectivity value, degraded nature of the vegetation and the wide availability of higher quality habitat in adjacent areas.

However, to minimise any potential impacts to these species or communities it is recommended that disturbance to the following areas be minimised or avoided wherever possible:

- All areas of Poplar Box TEC as mapped by Ausecology (**Figure 4.2**).
- Areas of potential koala and grey-headed flying-fox habitat (**Figure 7.1**).

The Project has the potential to impact on a range of biodiversity values including least concern flora and fauna and habitat for these species. The proposed mitigation measures should be implemented throughout construction and operation to ensure impacts to ecological values are limited to the greatest extent possible.

As potential animal breeding places have been identified within the Development Footprint, it is recommended that a Low-Risk Species Management Program (SMP) be obtained for the Project to protect against any breeding places (e.g. nests and hollow bearing trees) that are present or that may be established prior to construction. As potential breeding places for colonial breeding species (i.e. microchiropteran bat species which may utilise hollows) were identified during the field survey, a High Risk SMP will also be required. The SMPs must effectively demonstrate the management intent of the species within the site and evidence regarding how avoidance of adverse impacts to the species will be implemented.

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APPENDIX

B

Ecology assessment

Appendix A Protected Matters Search Tool and Wildnet Database results



EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 25-Sep-2022

[Summary](#)

[Details](#)

[Matters of NES](#)

[Other Matters Protected by the EPBC Act](#)

[Extra Information](#)

[Caveat](#)

[Acknowledgements](#)

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the [Administrative Guidelines on Significance](#).

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	3
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	5
Listed Threatened Species:	31
Listed Migratory Species:	9

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at <http://www.environment.gov.au/heritage>

A [permit](#) may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	15
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	5
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	1
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar Wetlands)		[Resource Information]
Ramsar Site Name	Proximity	Buffer Status
Banrock station wetland complex	1100 - 1200km upstream from Ramsar site	In feature area
Riverland	1100 - 1200km upstream from Ramsar site	In feature area
The coorong, and lakes alexandrina and albert wetland	1300 - 1400km upstream from Ramsar site	In feature area

Listed Threatened Ecological Communities	[Resource Information]
For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps. Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.	

Community Name	Threatened Category	Presence Text	Buffer Status
Brigalow (Acacia harpophylla dominant and co-dominant)	Endangered	Community known to occur within area	In buffer area only
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area	In feature area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community likely to occur within area	In feature area
Weeping Myall Woodlands	Endangered	Community likely to occur within area	In feature area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community may occur within area	In feature area

Listed Threatened Species			[<u>Resource Information</u>]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.			
Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Calyptorhynchus lathami lathami South-eastern Glossy Black-Cockatoo [67036]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Erythroriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat may occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species habitat known to occur within area	In feature area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area	In feature area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area	In feature area
FISH			
Maccullochella peelii Murray Cod [66633]	Vulnerable	Species or species habitat may occur within area	In feature area
MAMMAL			
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Dasyurus maculatus maculatus (SE mainland population)			
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area	In feature area
Nyctophilus corbeni			
Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Petauroides volans			
Greater Glider (southern and central) [254]	Endangered	Species or species habitat likely to occur within area	In feature area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)			
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Endangered	Species or species habitat likely to occur within area	In feature area
Pteropus poliocephalus			
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area	In feature area
PLANT			
Acacia lauta			
Tara Wattle [4165]	Vulnerable	Species or species habitat may occur within area	In feature area
Androcalva procumbens			
[87153]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Cadellia pentastylis			
Ooline [9828]	Vulnerable	Species or species habitat may occur within area	In feature area
Dichanthium setosum			
bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Homopholis belsonii			
Belson's Panic [2406]	Vulnerable	Species or species habitat may occur within area	In feature area
Lepidium monoplacoides			
Winged Pepper-cress [9190]	Endangered	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat may occur within area	In feature area
Vincetoxicum forsteri listed as Tylophora linearis [92384]	Endangered	Species or species habitat may occur within area	In feature area
Westringia parvifolia [4822]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Xerothamnella herbacea [4146]	Endangered	Species or species habitat likely to occur within area	In buffer area only

REPTILE			
Anomalopus mackayi Five-clawed Worm-skink, Long-legged Worm-skink [25934]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat may occur within area	In feature area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area	In buffer area only
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area	In feature area
Uvidicolus sphyrurus Border Thick-tailed Gecko, Granite Belt Thick-tailed Gecko [84578]	Vulnerable	Species or species habitat may occur within area	In buffer area only

Listed Migratory Species		[Resource Information]	
Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Migratory Terrestrial Species			

Scientific Name	Threatened Category	Presence Text	Buffer Status
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area	In feature area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area	In feature area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat likely to occur within area	In feature area

Migratory Wetlands Species			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area	In feature area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]	
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area	In feature area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area overfly marine area	In feature area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area	In feature area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area overfly marine area	In feature area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area	In feature area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat likely to occur within area overfly marine area	In feature area
Neophema chrysostoma Blue-winged Parrot [726]		Species or species habitat may occur within area overfly marine area	In feature area
Rostratula australis as Rostratula benghalensis (sensu lato) Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area	In feature area

Extra Information

EPBC Act Referrals [Resource Information]				
Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
ARG Border Rail Project Moree to Toowoomba QLD	2013/7061	Controlled Action	Further Information Request	In feature area
Inland Rail Border to Gowrie Project, QLD	2018/8165	Controlled Action	Assessment Approach	In feature area
Not controlled action				
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In feature area
Inland Rail Border to Gowrie Geotechnical Investigations	2021/8911	Not Controlled Action	Completed	In feature area
Not controlled action (particular manner)				
132kV transmission line	2003/1024	Not Controlled Action (Particular Manner)	Post-Approval	In feature area

Bioregional Assessments			
SubRegion	BioRegion	Website	Buffer Status
Maranoa-Balonne-Condamine	Northern Inland Catchments	BA website	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

- [-Office of Environment and Heritage, New South Wales](#)
- [-Department of Environment and Primary Industries, Victoria](#)
- [-Department of Primary Industries, Parks, Water and Environment, Tasmania](#)
- [-Department of Environment, Water and Natural Resources, South Australia](#)
- [-Department of Land and Resource Management, Northern Territory](#)
- [-Department of Environmental and Heritage Protection, Queensland](#)
- [-Department of Parks and Wildlife, Western Australia](#)
- [-Environment and Planning Directorate, ACT](#)
- [-Birdlife Australia](#)
- [-Australian Bird and Bat Banding Scheme](#)
- [-Australian National Wildlife Collection](#)
- [-Natural history museums of Australia](#)
- [-Museum Victoria](#)
- [-Australian Museum](#)
- [-South Australian Museum](#)
- [-Queensland Museum](#)
- [-Online Zoological Collections of Australian Museums](#)
- [-Queensland Herbarium](#)
- [-National Herbarium of NSW](#)
- [-Royal Botanic Gardens and National Herbarium of Victoria](#)
- [-Tasmanian Herbarium](#)
- [-State Herbarium of South Australia](#)
- [-Northern Territory Herbarium](#)
- [-Western Australian Herbarium](#)
- [-Australian National Herbarium, Canberra](#)
- [-University of New England](#)
- [-Ocean Biogeographic Information System](#)
- [-Australian Government, Department of Defence](#)
- [Forestry Corporation, NSW](#)
- [-Geoscience Australia](#)
- [-CSIRO](#)
- [-Australian Tropical Herbarium, Cairns](#)
- [-eBird Australia](#)
- [-Australian Government – Australian Antarctic Data Centre](#)
- [-Museum and Art Gallery of the Northern Territory](#)
- [-Australian Government National Environmental Science Program](#)
- [-Australian Institute of Marine Science](#)
- [-Reef Life Survey Australia](#)
- [-American Museum of Natural History](#)
- [-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania](#)
- [-Tasmanian Museum and Art Gallery, Hobart, Tasmania](#)
- [-Other groups and individuals](#)

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the [Contact Us](#) page.

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WildNet Records Species List

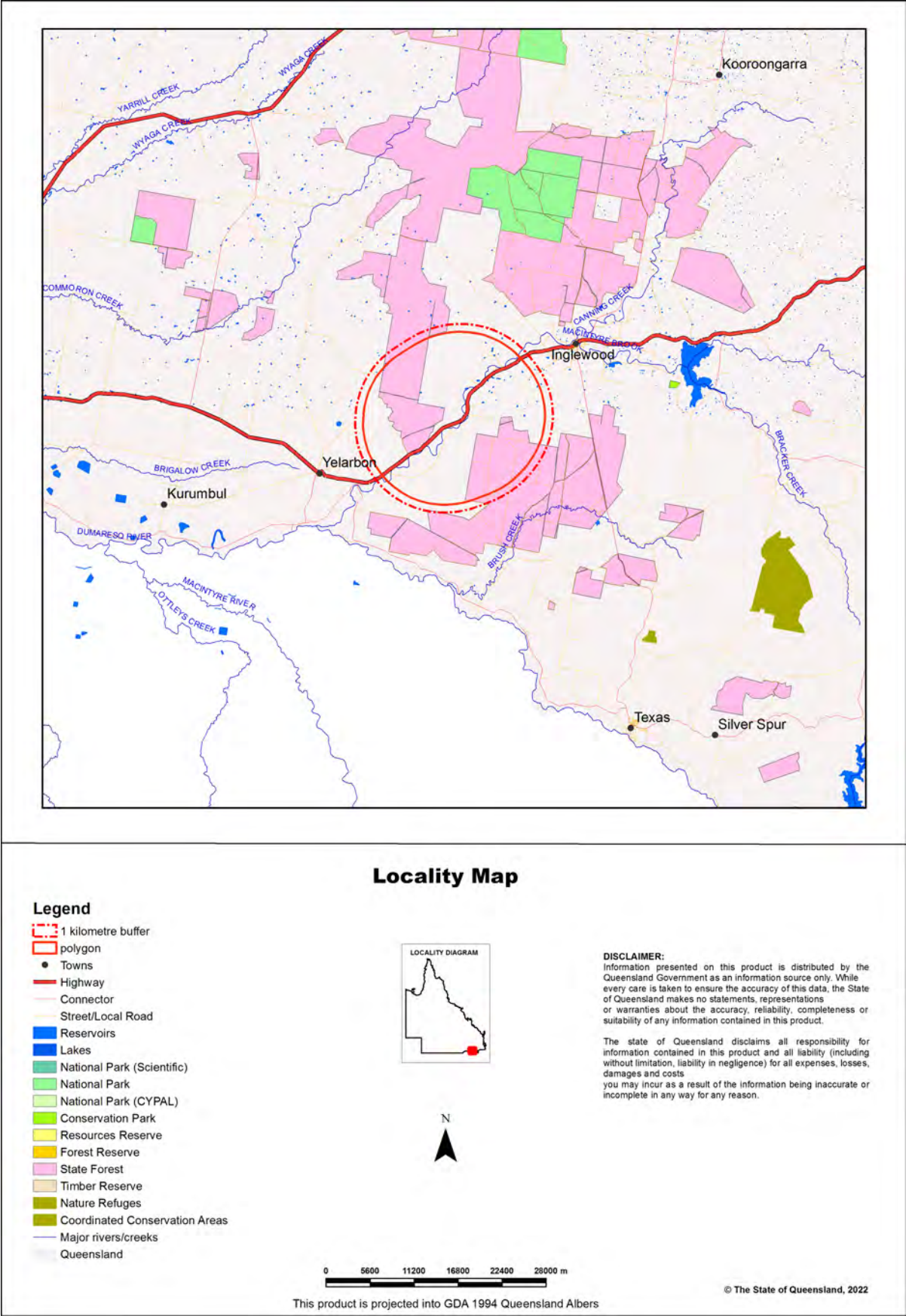


For the selected area of interest 39512.95ha Custom Geometry

Current as at 25/09/2022

Whetstone-AllSpecies10kmBuffer

Map 1. Locality Map



Summary Information

The following table provides an overview of the area of interest Custom Geometry.

Table 1. Area of interest details

Size (ha)	39,512.95
Local Government(s)	Goondiwindi Regional
Bioregion(s)	Brigalow Belt
Subregion(s)	Inglewood Sandstones, Moonie R. - Commoroon Creek Floodout
Catchment(s)	Border Rivers

Protected Area(s)

The following estates and/or reserves are located in the area of interest:

Whetstone State
Forest
Yelarbon State Forest

World Heritage Area(s)

No World Heritage Areas are located within the area of interest.

Ramsar Area(s)

No Ramsar Areas are located within the area of interest.

Species List

Introduction

This report is derived from a spatial layer generated from the [WildNet database](#) managed by the Department of Environment and Science. The layer which is generated weekly contains the WildNet wildlife records that are not classed as erroneous or duplicate, that have a location precision equal to or less than 10000 metres and do not have a count of zero.

The WildNet dataset is constantly being enhanced and the taxonomic and status information revised. If a species is not listed in this report, it does not mean it doesn't occur there and listed species may also no longer inhabit the area. It is recommended that you also access other internal and external data sources for species information in your area of interest (Refer Links and Support).

Table 2 lists the animals recorded within the area of interest and its one kilometre buffer.

Table 3 lists the plants recorded within the area of interest and its one kilometre buffer.

Table 4 lists the fungi recorded within the area of interest and its one kilometre buffer.

Table 5 lists the other species recorded within the area of interest and its one kilometre buffer.

Table 2. Animals recorded within the area of interest and its one kilometre buffer

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
624	Amphibia	Hylidae	<i>Cyclorana alboguttata</i>	greenstripe frog	C	None	0	1	07/01/2005
614	Amphibia	Hylidae	<i>Litoria latopalmata</i>	broad palmed rocketfrog	C	None	2	6	07/01/2005
596	Amphibia	Hylidae	<i>Litoria peronii</i>	emerald spotted treefrog	C	None	1	4	03/09/1996
600	Amphibia	Hylidae	<i>Litoria rubella</i>	ruddy treefrog	C	None	1	3	07/01/2005
679	Amphibia	Limnodynastidae	<i>Limnodynastes fletcheri</i>	barking frog	C	None	0	1	07/01/2005

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
684	Amphibia	Limnodynastidae	<i>Limnodynastes tasmaniensis</i>	spotted grassfrog	C	None	0	1	07/01/2005
680	Amphibia	Limnodynastidae	<i>Platyplectrum ornatum</i>	ornate burrowing frog	C	None	0	2	07/01/2005
696	Amphibia	Myobatrachidae	<i>Crinia parinsignifera</i>	beeping froglet	C	None	0	1	03/09/1996
1419	Aves	Acanthizidae	<i>Acanthiza chrysorrhoa</i>	yellow-rumped thornbill	C	None	0	5	28/09/2001
1422	Aves	Acanthizidae	<i>Acanthiza nana</i>	yellow thornbill	C	None	0	5	09/08/2009
1423	Aves	Acanthizidae	<i>Acanthiza pusilla</i>	brown thornbill	C	None	0	1	04/07/1999
1425	Aves	Acanthizidae	<i>Acanthiza reguloides</i>	buff-rumped thornbill	C	None	0	1	20/12/1994
1396	Aves	Acanthizidae	<i>Gerygone olivacea</i>	white-throated gerygone	C	None	0	5	28/09/2001
1403	Aves	Acanthizidae	<i>Pyrrholaemus sagittatus</i>	speckled warbler	C	None	0	3	09/08/2009
1371	Aves	Acanthizidae	<i>Smicromis brevirostris</i>	weebill	C	None	0	9	09/08/2009
1742	Aves	Accipitridae	<i>Accipiter cirrocephalus</i>	collared sparrowhawk	C	None	0	3	22/06/1999
1729	Aves	Accipitridae	<i>Accipiter fasciatus</i>	brown goshawk	C	None	0	2	29/09/1999
1732	Aves	Accipitridae	<i>Aquila audax</i>	wedge-tailed eagle	C	None	0	1	24/08/1999
1721	Aves	Accipitridae	<i>Aviceda subcristata</i>	Pacific baza	C	None	0	2	27/01/2001
1707	Aves	Accipitridae	<i>Haliastur sphenurus</i>	whistling kite	C	None	0	2	29/09/1999
1712	Aves	Accipitridae	<i>Lophoictinia isura</i>	square-tailed kite	C	None	0	1	18/08/2017
1714	Aves	Accipitridae	<i>Milvus migrans</i>	black kite	C	None	0	5	24/08/1999
1776	Aves	Alcedinidae	<i>Ceyx azureus</i>	azure kingfisher	C	None	0	19	27/01/2001
1993	Aves	Anatidae	<i>Anas gracilis</i>	grey teal	C	None	0	1	27/06/2000
1998	Aves	Anatidae	<i>Anas superciliosa</i>	Pacific black duck	C	None	0	18	09/08/2009
2003	Aves	Anatidae	<i>Chenonetta jubata</i>	Australian wood duck	C	None	0	15	07/01/2001
1977	Aves	Anatidae	<i>Dendrocygna arcuata</i>	wandering whistling-duck	C	None	0	1	27/06/2000
1279	Aves	Anhingidae	<i>Anhinga novaehollandiae</i>	Australasian darter	C	None	0	8	01/06/2000
1829	Aves	Ardeidae	<i>Ardea alba modesta</i>	eastern great egret	C	None	0	2	30/05/1999
1832	Aves	Ardeidae	<i>Ardea pacifica</i>	white-necked heron	C	None	0	13	24/01/2000
1830	Aves	Ardeidae	<i>Bubulcus ibis</i>	cattle egret	C	None	0	11	01/11/2000
1826	Aves	Ardeidae	<i>Egretta novaehollandiae</i>	white-faced heron	C	None	0	7	26/09/2000
1659	Aves	Artamidae	<i>Artamus cyanopterus</i>	dusky woodswallow	C	None	0	2	09/08/2009

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
1660	Aves	Artamidae	<i>Artamus leucorhynchus</i>	white-breasted woodswallow	C	None	0	2	24/01/2000
1654	Aves	Artamidae	<i>Cracticus nigrogularis</i>	pied butcherbird	C	None	0	5	28/09/2001
1656	Aves	Artamidae	<i>Cracticus torquatus</i>	grey butcherbird	C	None	0	12	05/07/2020
1644	Aves	Artamidae	<i>Gymnorhina tibicen</i>	Australian magpie	C	None	0	22	28/09/2001
1645	Aves	Artamidae	<i>Strepera graculina</i>	pied currawong	C	None	0	21	05/07/2020
1191	Aves	Cacatuidae	<i>Cacatua galerita</i>	sulphur-crested cockatoo	C	None	0	31	09/08/2009
1194	Aves	Cacatuidae	<i>Cacatua sanguinea</i>	little corella	C	None	0	13	14/11/2017
1185	Aves	Cacatuidae	<i>Calyptrorhynchus funereus</i>	yellow-tailed black-cockatoo	C	None	0	1	17/02/1993
22494	Aves	Cacatuidae	<i>Calyptrorhynchus lathami lathami</i>	glossy black-cockatoo (eastern)	V	V	0	1	17/02/1993
1193	Aves	Cacatuidae	<i>Eolophus roseicapilla</i>	galah	C	None	0	33	09/08/2009
1173	Aves	Cacatuidae	<i>Nymphicus hollandicus</i>	cockatiel	C	None	0	16	02/08/2001
1636	Aves	Campephagidae	<i>Coracina novae hollandiae</i>	black-faced cuckoo-shrike	C	None	0	7	27/06/2000
1637	Aves	Campephagidae	<i>Coracina papuensis</i>	white-bellied cuckoo-shrike	C	None	0	3	09/08/2009
1639	Aves	Campephagidae	<i>Edolisoma tenuirostre</i>	common cicadabird	C	None	0	1	20/12/1994
1089	Aves	Casuariidae	<i>Dromaius novaehollandiae</i>	emu	C	None	0	6	08/09/2021
1933	Aves	Charadriidae	<i>Vanellus miles novaehollandiae</i>	masked lapwing (southern subspecies)	C	None	0	1	24/01/2000
1628	Aves	Climacteridae	<i>Climacteris picumnus</i>	brown treecreeper	C	None	0	23	02/08/2001
18293	Aves	Climacteridae	<i>Cormobates leucophaea metastasis</i>	white-throated treecreeper (southern)	C	None	0	4	12/01/1998
1809	Aves	Columbidae	<i>Geopelia cuneata</i>	diamond dove	C	None	0	1	31/07/2000
1810	Aves	Columbidae	<i>Geopelia humeralis</i>	bar-shouldered dove	C	None	0	21	09/08/2009
18323	Aves	Columbidae	<i>Geopelia placida</i>	peaceful dove	C	None	0	27	28/09/2001
1793	Aves	Columbidae	<i>Ocyphaps lophotes</i>	crested pigeon	C	None	0	30	23/11/2001
1795	Aves	Columbidae	<i>Phaps chalcoptera</i>	common bronzewing	C	None	0	3	12/01/1998
1774	Aves	Columbidae	<i>Streptopelia chinensis</i>	spotted dove	None	None	0	1	30/04/1999
1779	Aves	Coraciidae	<i>Eurystomus orientalis</i>	dollarbird	C	None	0	21	28/03/2001

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
1603	Aves	Corcoracidae	<i>Corcorax melanorhamphos</i>	white-winged cough	C	None	0	5	05/07/2020
1605	Aves	Corcoracidae	<i>Struthidea cinerea</i>	apostlebird	C	None	0	15	23/11/2001
1607	Aves	Corvidae	<i>Corvus bennetti</i>	little crow	C	None	0	1	22/12/1998
1608	Aves	Corvidae	<i>Corvus coronoides</i>	Australian raven	C	None	0	4	27/06/2000
1609	Aves	Corvidae	<i>Corvus orru</i>	Torresian crow	C	None	0	7	09/08/2009
1610	Aves	Corvidae	<i>Corvus sp.</i>	None	C	None	0	1	28/03/2001
1754	Aves	Cuculidae	<i>Cacomantis flabelliformis</i>	fan-tailed cuckoo	C	None	0	1	03/09/1996
1751	Aves	Cuculidae	<i>Centropus phasianinus</i>	pheasant coucal	C	None	0	1	07/01/2001
1738	Aves	Cuculidae	<i>Eudynamis orientalis</i>	eastern koel	C	None	0	2	24/01/2000
1369	Aves	Estrildidae	<i>Neochmia modesta</i>	plum-headed finch	C	None	0	17	02/08/2001
1342	Aves	Estrildidae	<i>Taeniopygia bichenovii</i>	double-barred finch	C	None	0	29	28/09/2001
1343	Aves	Estrildidae	<i>Taeniopygia guttata</i>	zebra finch	C	None	0	10	02/08/2001
1704	Aves	Falconidae	<i>Falco cenchroides</i>	nankeen kestrel	C	None	0	3	28/09/2001
1691	Aves	Falconidae	<i>Falco longipennis</i>	Australian hobby	C	None	0	1	12/05/2000
1692	Aves	Falconidae	<i>Falco peregrinus</i>	peregrine falcon	C	None	0	4	28/03/2000
1767	Aves	Halcyonidae	<i>Dacelo novaeguineae</i>	laughing kookaburra	C	None	0	30	05/07/2020
1760	Aves	Halcyonidae	<i>Todiramphus macleayii</i>	forest kingfisher	C	None	0	1	22/12/1998
1762	Aves	Halcyonidae	<i>Todiramphus sanctus</i>	sacred kingfisher	C	None	0	3	23/11/2001
1572	Aves	Hirundinidae	<i>Hirundo neoxena</i>	welcome swallow	C	None	0	27	05/07/2006
1570	Aves	Maluridae	<i>Malurus cyaneus</i>	superb fairy-wren	C	None	0	35	05/07/2020
1556	Aves	Maluridae	<i>Malurus lamberti sensu lato</i>	variegated fairy-wren	C	None	0	3	05/07/2006
1291	Aves	Megaluridae	<i>Cincloramphus cruralis</i>	brown songlark	C	None	0	1	08/09/2021
1292	Aves	Megaluridae	<i>Cincloramphus mathewsi</i>	rufous songlark	C	None	0	1	28/09/2001
1552	Aves	Meliphagidae	<i>Acanthagenys rufogularis</i>	spiny-cheeked honeyeater	C	None	0	3	27/01/2001
1542	Aves	Meliphagidae	<i>Anthochaera chrysoptera</i>	little wattlebird	C	None	0	1	30/05/1999
1523	Aves	Meliphagidae	<i>Caligavis chrysops</i>	yellow-faced honeyeater	C	None	0	4	09/08/2009

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
1539	Aves	Meliphagidae	<i>Entomyzon cyanotis</i>	blue-faced honeyeater	C	None	0	9	07/01/2001
1497	Aves	Meliphagidae	<i>Lichmera indistincta</i>	brown honeyeater	C	None	0	1	12/01/1998
1499	Aves	Meliphagidae	<i>Manorina flavigula</i>	yellow-throated miner	C	None	0	2	05/07/2006
1500	Aves	Meliphagidae	<i>Manorina melanocephala</i>	noisy miner	C	None	0	6	09/08/2009
1504	Aves	Meliphagidae	<i>Meliphaga lewinii</i>	Lewin's honeyeater	C	None	0	1	04/07/1999
1507	Aves	Meliphagidae	<i>Melithreptus albogularis</i>	white-throated honeyeater	C	None	0	1	03/09/1996
1508	Aves	Meliphagidae	<i>Melithreptus brevirostris</i>	brown-headed honeyeater	C	None	0	4	03/09/1996
1489	Aves	Meliphagidae	<i>Myzomela sanguinolenta</i>	scarlet honeyeater	C	None	0	1	17/02/1993
1516	Aves	Meliphagidae	<i>Nesoptilotis leucotis</i>	white-eared honeyeater	C	None	0	17	05/07/2020
1493	Aves	Meliphagidae	<i>Philemon citreogularis</i>	little friarbird	C	None	0	4	11/11/2000
1494	Aves	Meliphagidae	<i>Philemon corniculatus</i>	noisy friarbird	C	None	0	16	09/08/2009
1471	Aves	Meliphagidae	<i>Plectorhyncha lanceolata</i>	striped honeyeater	C	None	0	6	14/11/2017
1513	Aves	Meliphagidae	<i>Ptilotula fusca</i>	fuscous honeyeater	C	None	0	2	20/12/1994
1518	Aves	Meliphagidae	<i>Ptilotula penicillata</i>	white-plumed honeyeater	C	None	0	16	09/08/2009
1589	Aves	Monarchidae	<i>Grallina cyanoleuca</i>	magpie-lark	C	None	0	34	09/08/2009
1600	Aves	Monarchidae	<i>Myiagra inquieta</i>	restless flycatcher	C	None	0	8	14/11/2017
1586	Aves	Monarchidae	<i>Myiagra rubecula</i>	leaden flycatcher	C	None	0	2	14/11/2017
1611	Aves	Nectariniidae	<i>Dicaeum hirundinaceum</i>	mistletoebird	C	None	0	6	12/05/2000
1453	Aves	Neosittidae	<i>Daphoenositta chrysoptera</i>	varied sittella	C	None	0	4	12/01/1998
1442	Aves	Oriolidae	<i>Oriolus sagittatus</i>	olive-backed oriole	C	None	0	4	24/02/2000
1444	Aves	Oriolidae	<i>Sphecotheres vieilloti</i>	Australasian figbird	C	None	0	4	27/01/2001
1449	Aves	Pachycephalidae	<i>Colluricincla harmonica</i>	grey shrike-thrush	C	None	0	30	23/11/2001
1436	Aves	Pachycephalidae	<i>Pachycephala pectoralis</i>	golden whistler	C	None	0	2	04/07/1999
1437	Aves	Pachycephalidae	<i>Pachycephala rufiventris</i>	rufous whistler	C	None	0	10	09/08/2009
1389	Aves	Pardalotidae	<i>Pardalotus punctatus</i>	spotted pardalote	C	None	0	4	03/09/1996
1392	Aves	Pardalotidae	<i>Pardalotus striatus</i>	striated pardalote	C	None	0	19	09/08/2009

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
1284	Aves	Pelecanidae	<i>Pelecanus conspicillatus</i>	Australian pelican	C	None	0	14	02/08/2001
1347	Aves	Petroicidae	<i>Eopsaltria australis</i>	eastern yellow robin	C	None	0	9	05/07/2020
1337	Aves	Petroicidae	<i>Melanodryas cucullata</i>	hooded robin	C	None	0	1	20/12/1994
1339	Aves	Petroicidae	<i>Microeca fascians</i>	jacky winter	C	None	0	3	28/09/2001
1261	Aves	Phalacrocoraciidae	<i>Microcarbo melanoleucos</i>	little pied cormorant	C	None	0	2	29/09/1999
1263	Aves	Phalacrocoraciidae	<i>Phalacrocorax sulcirostris</i>	little black cormorant	C	None	0	5	04/01/2000
1687	Aves	Phasianidae	<i>Synoicus ypsilophorus</i>	brown quail	C	None	0	1	28/03/2000
1955	Aves	Podargidae	<i>Podargus strigoides</i>	tawny frogmouth	C	None	0	7	29/09/1999
1249	Aves	Podicipedidae	<i>Tachybaptus novaehollandiae</i>	Australasian grebe	C	None	0	1	09/08/2009
1317	Aves	Pomatostomidae	<i>Pomatostomus superciliosus</i>	white-browed babbler	C	None	0	2	14/01/1998
1318	Aves	Pomatostomidae	<i>Pomatostomus temporalis</i>	grey-crowned babbler	C	None	0	5	09/08/2009
1180	Aves	Psittacidae	<i>Alisterus scapularis</i>	Australian king-parrot	C	None	0	4	04/12/2000
1182	Aves	Psittacidae	<i>Aprosmictus erythropterus</i>	red-winged parrot	C	None	0	26	02/08/2001
1154	Aves	Psittacidae	<i>Neophema pulchella</i>	turquoise parrot	C	None	0	1	09/09/2021
1147	Aves	Psittacidae	<i>Parvipsitta pusilla</i>	little lorikeet	C	None	0	8	23/11/1999
1136	Aves	Psittacidae	<i>Platycercus adscitus</i>	pale-headed rosella	C	None	0	17	09/08/2009
1139	Aves	Psittacidae	<i>Platycercus eximius</i>	eastern rosella	C	None	0	1	27/06/2000
1118	Aves	Psittacidae	<i>Psephotus haematonotus</i>	red-rumped parrot	C	None	0	10	28/09/2001
1124	Aves	Psittacidae	<i>Trichoglossus chlorolepidotus</i>	scaly-breasted lorikeet	C	None	0	1	28/09/2001
1125	Aves	Psittacidae	<i>Trichoglossus moluccanus</i>	rainbow lorikeet	C	None	0	3	03/09/1996
1160	Aves	Ptilonorhynchidae	<i>Chlamydera maculata</i>	spotted bowerbird	C	None	0	6	07/01/2001
1662	Aves	Rallidae	<i>Porphyrio melanotus</i>	purple swamphen	C	None	0	1	24/02/2000
1575	Aves	Rhipiduridae	<i>Rhipidura albiscapa</i>	grey fantail	C	None	0	8	05/07/2020
1576	Aves	Rhipiduridae	<i>Rhipidura leucophrys</i>	willie wagtail	C	None	0	32	05/07/2020
1853	Aves	Scolopacidae	<i>Tringa nebularia</i>	common greenshank	SL	None	0	1	22/12/1998
1102	Aves	Strigidae	<i>Ninox boobook</i>	southern boobook	C	None	0	1	24/01/2000

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
1314	Aves	Sturnidae	<i>Acridotheres tristis</i>	common myna	None	None	0	1	21/08/2011
1303	Aves	Sturnidae	<i>Sturnus vulgaris</i>	common starling	None	None	0	3	28/09/2001
1822	Aves	Threskiornithidae	<i>Platalea flavipes</i>	yellow-billed spoonbill	C	None	0	5	23/11/1999
1823	Aves	Threskiornithidae	<i>Platalea regia</i>	royal spoonbill	C	None	0	1	14/01/1998
1812	Aves	Threskiornithidae	<i>Threskiornis molucca</i>	Australian white ibis	C	None	0	3	24/01/2000
1800	Aves	Threskiornithidae	<i>Threskiornis spinicollis</i>	straw-necked ibis	C	None	0	18	28/09/2001
1276	Aves	Timaliidae	<i>Zosterops lateralis</i>	silveryeye	C	None	0	7	04/12/2000
1081	Aves	Turnicidae	<i>Turnix varius</i>	painted button-quail	C	None	0	1	03/09/1996
1108	Aves	Tytonidae	<i>Tyto javanica</i>	eastern barn owl	C	None	0	5	29/09/1999
35081	Insecta	Aeshnidae	<i>Anax papuensis</i>	Australian Emperor	None	None	0	1	08/09/2021
35176	Insecta	Lestidae	<i>Austrolestes aridus</i>	inland ringtail	None	None	0	1	08/09/2021
35199	Insecta	Libellulidae	<i>Diplacodes bipunctata</i>	wandering percher	None	None	0	1	08/09/2021
1071	Mammalia	Canidae	<i>Vulpes vulpes</i>	red fox	None	None	0	5	05/07/2020
22485	Mammalia	Dasyuridae	<i>Antechinus flavipes flavipes</i>	yellow-footed antechinus (south-east Queensland)	C	None	0	1	31/12/1997
793	Mammalia	Dasyuridae	<i>Sminthopsis murina</i>	common dunnart	C	None	0	1	31/12/1997
1056	Mammalia	Felidae	<i>Felis catus</i>	cat	None	None	0	4	05/07/2020
901	Mammalia	Macropodidae	<i>Macropus giganteus</i>	eastern grey kangaroo	C	None	0	3	05/07/2020
885	Mammalia	Macropodidae	<i>Wallabia bicolor</i>	swamp wallaby	C	None	0	1	03/09/1996
764	Mammalia	Muridae	<i>Mus musculus</i>	house mouse	None	None	0	1	31/12/1997
747	Mammalia	Muridae	<i>Pseudomys delicatulus</i>	delicate mouse	C	None	1	1	31/12/1997
1080	Mammalia	Suidae	<i>Sus scrofa</i>	pig	None	None	0	3	05/07/2020
838	Mammalia	Tachyglossidae	<i>Tachyglossus aculeatus</i>	short-beaked echidna	SL	None	0	4	05/07/2020
561	Reptilia	Agamidae	<i>Diporiphora nobbi</i>	nobbi	C	None	0	1	16/02/1993
512	Reptilia	Colubridae	<i>Dendrelaphis punctulatus</i>	green tree snake	C	None	0	1	10/03/2006
482	Reptilia	Elapidae	<i>Denisonia devisi</i>	De Vis' banded snake	C	None	1	1	31/12/1996
420	Reptilia	Gekkonidae	<i>Gehyra dubia</i>	dubious dtella	C	None	0	2	03/09/1996
413	Reptilia	Gekkonidae	<i>Heteronotia binoei</i>	Bynoe's gecko	C	None	0	1	03/09/1996
304	Reptilia	Scincidae	<i>Anomalopus leuckartii</i>	two-clawed worm-skink	C	None	0	2	03/09/1996
226	Reptilia	Scincidae	<i>Liopholis modesta</i>	eastern ranges rock-skink	C	None	5	5	01/12/1948
127	Reptilia	Scincidae	<i>Menetia greyii</i>	common dwarf skink	C	None	0	1	03/09/1996

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
134	Reptilia	Scincidae	<i>Morethia boulengeri</i>	south-eastern morethia skink	C	None	0	3	03/09/1996
103	Reptilia	Scincidae	<i>Tiliqua rugosa</i>	shingle-back	C	None	0	1	09/09/2021
78	Reptilia	Varanidae	<i>Varanus gouldii</i>	sand monitor	C	None	0	1	03/09/1996
61	Reptilia	Varanidae	<i>Varanus varius</i>	lace monitor	C	None	0	1	31/01/1999

Table 3. Plants recorded within the area of interest and its one kilometre buffer

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
9086	Equisetopsida	Aizoaceae	<i>Zaleya galericulata</i> subsp. <i>galericulata</i>	None	C	None	1	1	24/03/1969
35564	Equisetopsida	Asteraceae	<i>Brachyscome casstiana</i>	None	C	None	1	1	07/10/1993
35554	Equisetopsida	Asteraceae	<i>Brachyscome whitei</i> subsp. <i>whitei</i>	None	C	None	2	2	10/05/1994
10061	Equisetopsida	Asteraceae	<i>Calocephalus sonderi</i>	palebeauty heads	C	None	1	1	07/10/2007
14738	Equisetopsida	Asteraceae	<i>Cassinia laevis</i>	None	C	None	0	1	14/09/2000
26775	Equisetopsida	Asteraceae	<i>Leiocarpa panaetioides</i>	None	C	None	1	1	11/10/2020
10465	Equisetopsida	Asteraceae	<i>Olearia ramosissima</i>	None	C	None	1	1	08/07/1997
36235	Equisetopsida	Asteraceae	<i>Verbesina encelioides</i> var. <i>encelioides</i>	None	None	None	1	1	28/03/2010
11201	Equisetopsida	Boraginaceae	<i>Heliotropium europaeum</i>	common heliotrope	None	None	1	1	31/01/1999
18389	Equisetopsida	Cactaceae	<i>Cereus uruguayanus</i>	None	None	None	0	1	14/11/2017
26344	Equisetopsida	Cactaceae	<i>Harrisia martinii</i>	None	None	None	0	3	07/10/2015
16549	Equisetopsida	Cactaceae	<i>Opuntia aurantiaca</i>	tiger pear	None	None	0	5	07/10/2015
9011	Equisetopsida	Cactaceae	<i>Opuntia ficus-indica</i>	Indian fig	None	None	1	2	14/11/2017
9535	Equisetopsida	Cactaceae	<i>Opuntia tomentosa</i>	velvety tree pear	None	None	0	1	22/02/2016
18011	Equisetopsida	Casuarinaceae	<i>Allocasuarina inophloia</i>	None	C	None	1	2	14/09/2000
18013	Equisetopsida	Casuarinaceae	<i>Allocasuarina luehmannii</i>	bull oak	C	None	0	3	31/01/2002
17707	Equisetopsida	Casuarinaceae	<i>Casuarina cristata</i>	belah	C	None	0	1	01/04/1990
14431	Equisetopsida	Chenopodiaceae	<i>Maireana microphylla</i>	None	C	None	1	1	29/09/1986
10937	Equisetopsida	Chenopodiaceae	<i>Sclerolaena tetracuspis</i>	brigalow burr	C	None	1	1	24/10/1994
7047	Equisetopsida	Convolvulaceae	<i>Dichondra</i> sp. (Inglewood J.M.Dalby 86/93)	None	C	None	1	1	20/09/1986
17757	Equisetopsida	Cupressaceae	<i>Callitris endlicheri</i>	black cypress pine	C	None	1	1	22/06/1994
8221	Equisetopsida	Cupressaceae	<i>Callitris glaucophylla</i>	white cypress pine	C	None	1	4	31/01/2002
13965	Equisetopsida	Cyperaceae	<i>Cyperus bowmannii</i>	None	C	None	1	1	28/03/2010

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
17078	Equisetopsida	Cyperaceae	<i>Gahnia aspera</i>	None	C	None	0	1	14/09/2000
13593	Equisetopsida	Ericaceae	<i>Melichrus adpressus</i>	None	C	None	1	1	08/07/1997
16844	Equisetopsida	Juncaceae	<i>Juncus continuus</i>	None	C	None	1	1	06/10/1994
16776	Equisetopsida	Laxmanniaceae	<i>Lomandra longifolia</i>	None	C	None	1	1	06/10/1994
15827	Equisetopsida	Leguminosae	<i>Acacia aulacocarpa</i>	None	C	None	0	1	31/01/2002
15780	Equisetopsida	Leguminosae	<i>Acacia burrowii</i>	None	C	None	1	1	22/06/1994
14932	Equisetopsida	Leguminosae	<i>Acacia conferta</i>	None	C	None	1	2	14/09/2000
15792	Equisetopsida	Leguminosae	<i>Acacia crassa</i> <i>subsp. crassa</i>	None	C	None	1	1	21/09/1993
11842	Equisetopsida	Leguminosae	<i>Acacia cultriformis</i>	None	C	None	1	1	30/11/1984
15752	Equisetopsida	Leguminosae	<i>Acacia harpophylla</i>	brigalow	C	None	0	1	01/04/1990
14864	Equisetopsida	Leguminosae	<i>Acacia lineata</i>	streaked wattle	C	None	1	1	09/07/1975
15727	Equisetopsida	Leguminosae	<i>Acacia neriifolia</i>	pechey wattle	C	None	0	1	14/09/2000
14872	Equisetopsida	Leguminosae	<i>Acacia polybotrya</i>	western silver wattle	C	None	2	2	06/10/1994
14891	Equisetopsida	Leguminosae	<i>Acacia spectabilis</i>	pilliga wattle	C	None	1	1	30/11/1984
14085	Equisetopsida	Leguminosae	<i>Acacia striatifolia</i>	None	C	None	0	1	14/09/2000
13705	Equisetopsida	Leguminosae	<i>Aotus subglauca</i> var. <i>filiformis</i>	None	C	None	1	1	06/10/1994
15260	Equisetopsida	Leguminosae	<i>Jacksonia scoparia</i>	None	C	None	0	1	31/01/2002
15014	Equisetopsida	Leguminosae	<i>Swainsona galegifolia</i>	smooth Darling pea	C	None	1	1	02/10/1964
8254	Equisetopsida	Leguminosae	<i>Swainsona queenslandica</i>	None	C	None	1	1	02/10/1964
34114	Equisetopsida	Leguminosae	<i>Vachellia farnesiana</i>	None	None	None	0	2	07/10/2015
14847	Equisetopsida	Loranthaceae	<i>Amyema cambagei</i>	None	C	None	1	1	24/10/1994
16727	Equisetopsida	Macarthuriaceae	<i>Macarthuria neocambrica</i>	None	C	None	1	1	07/10/1993
13307	Equisetopsida	Menyanthaceae	<i>Nymphoides crenata</i>	wavy marshwort	SL	None	1	1	17/09/1968
17999	Equisetopsida	Myrtaceae	<i>Angophora leiocarpa</i>	rusty gum	C	None	0	2	31/01/2002
17766	Equisetopsida	Myrtaceae	<i>Calytrix tetragona</i>	fringe myrtle	C	None	2	2	06/10/1994
6443	Equisetopsida	Myrtaceae	<i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i>	None	C	None	0	2	31/01/2002
13610	Equisetopsida	Myrtaceae	<i>Eucalyptus bakeri</i>	Baker's mallee	C	None	1	1	16/02/1969
17249	Equisetopsida	Myrtaceae	<i>Eucalyptus chloroclada</i>	Baradine red gum	C	None	1	3	31/01/2002
17252	Equisetopsida	Myrtaceae	<i>Eucalyptus crebra</i>	narrow-leaved red ironbark	C	None	0	2	13/07/1999
30502	Equisetopsida	Myrtaceae	<i>Eucalyptus elegans</i>	None	C	None	1	1	22/06/1994
17188	Equisetopsida	Myrtaceae	<i>Eucalyptus populnea</i>	poplar box	C	None	1	1	06/10/1994
26471	Equisetopsida	Myrtaceae	<i>Eucalyptus tereticornis</i> subsp. <i>tereticornis</i>	None	C	None	1	1	06/10/1994
13609	Equisetopsida	Myrtaceae	<i>Eucalyptus viridis</i>	None	C	None	2	2	22/06/1994

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
31943	Equisetopsida	Myrtaceae	<i>Eucalyptus woollsiana</i>	None	C	None	1	2	06/10/1994
18863	Equisetopsida	Myrtaceae	<i>Kunzea opposita</i> var. <i>opposita</i>	None	C	None	2	2	06/10/1994
13465	Equisetopsida	Myrtaceae	<i>Leptospermum brevipes</i>	None	C	None	1	1	22/06/1994
16685	Equisetopsida	Myrtaceae	<i>Melaleuca densispicata</i>	None	C	None	1	1	11/07/1994
29765	Equisetopsida	Nymphaeaceae	<i>Nymphaea gigantea</i>	None	SL	None	2	2	01/04/2005
26012	Equisetopsida	Pittosporaceae	<i>Pittosporum angustifolium</i>	None	C	None	1	1	29/09/1986
5965	Equisetopsida	Poaceae	<i>Austrostipa verticillata</i>	slender bamboo grass	C	None	1	1	02/05/1976
33785	Equisetopsida	Poaceae	<i>Cenchrus spinifex</i>	None	None	None	1	1	28/03/2010
15490	Equisetopsida	Poaceae	<i>Dactyloctenium radulans</i>	button grass	C	None	1	1	28/03/2010
18913	Equisetopsida	Poaceae	<i>Digitaria eriantha</i>	None	None	None	1	1	28/03/2010
15391	Equisetopsida	Poaceae	<i>Eragrostis cilianensis</i>	None	None	None	1	1	21/03/2006
32007	Equisetopsida	Poaceae	<i>Eragrostis trichophora</i>	None	None	None	1	1	21/03/2006
18061	Equisetopsida	Poaceae	<i>Poaceae</i>	None	None	None	0	1	14/09/2000
14978	Equisetopsida	Poaceae	<i>Thyridolepis xerophila</i>	None	C	None	1	1	14/11/1994
17012	Equisetopsida	Proteaceae	<i>Hakea purpurea</i>	None	C	None	3	3	10/05/1994
9070	Equisetopsida	Proteaceae	<i>Persoonia terminalis</i> subsp. <i>recurva</i>	None	C	None	1	1	13/12/1990
18819	Equisetopsida	Rutaceae	<i>Citrus glauca</i>	None	C	None	0	1	01/04/1990
17085	Equisetopsida	Rutaceae	<i>Geijera parviflora</i>	wilga	C	None	0	1	01/04/1990
11943	Equisetopsida	Rutaceae	<i>Philotheca ciliata</i>	None	C	None	1	1	22/06/1994
17640	Equisetopsida	Santalaceae	<i>Choretrum candollei</i>	white sour bush	C	None	1	2	14/09/2003
16237	Equisetopsida	Santalaceae	<i>Santalum lanceolatum</i>	None	SL	None	0	1	01/04/1990
18054	Equisetopsida	Sapindaceae	<i>Alectryon diversifolius</i>	scrub boonaree	C	None	0	1	01/04/1990
13655	Equisetopsida	Sapindaceae	<i>Dodonaea macrossanii</i>	None	C	None	2	2	11/07/1994
17391	Equisetopsida	Sapindaceae	<i>Dodonaea viscosa</i>	None	C	None	0	1	01/04/1990
17278	Equisetopsida	Scrophulariaceae	<i>Eremophila mitchellii</i>	None	C	None	2	3	23/07/2007
16736	Equisetopsida	Solanaceae	<i>Lycium ferocissimum</i>	African boxthorn	None	None	0	7	07/10/2015
12654	Equisetopsida	Ulmaceae	<i>Celtis sinensis</i>	Chinese elm	None	None	0	5	07/10/2015
34284	Equisetopsida	Verbenaceae	<i>Glandularia aristigera</i>	None	None	None	1	2	14/09/2003

Table 4. Fungi recorded within the area of interest and its one kilometre buffer

Taxon Id	Class	Family	Scientific Name	Common Name	NCA	EPBC	Specimens	Records	Last record
29414	Eurotiomycetes	Verrucariaceae	<i>Endocarpon simplicatum</i>	None	C	None	1	1	23/09/2004
34915	Lecanoromycetes	Caliciaceae	<i>Buellia epigaeella</i>	None	C	None	1	1	23/09/2004
23239	Lecanoromycetes	Lecideaceae	<i>Lecidea ochroleuca</i>	None	C	None	1	1	23/09/2004

Table 5. Other species recorded within the area of interest and its one kilometre buffer

No species found within the area of interest and its one kilometre buffer.

Species table headings and codes

Taxon Id: Unique identifier of the taxon from the WildNet database.

NCA: Queensland conservation status of the taxon under the *Nature Conservation Act 1992* (Least Concern (C), Critically Endangered (CR), Endangered (E), Extinct (EX), Near Threatened (NT), Extinct in the Wild (PE), Special Least Concern (SL), and Vulnerable (V)).

EPBC: Australian conservation status of the taxon under the *Environment Protection and Biodiversity Conservation Act 1999* (Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Vulnerable (V), and Extinct in the Wild (XW)).

Specimens: The number of specimen-backed records of the taxon.

Records: The total number of records of the taxon.

Last record: Date of latest record of the taxon.

Links and Support

Other sites that deliver species information from the [WildNet database](#) include:

- [Species profile search](#) - access species information approved for publication including species names, statuses, notes, images, distribution maps and records
- [Species lists](#) - generate species lists for Queensland protected areas, forestry areas, local governments and areas defined using coordinates
- [Biomaps](#) - view biodiversity information, including WildNet records approved for publication, and generate reports
- [Queensland Globe](#) - view spatial information, including WildNet records approved for publication
- [Old wildlife data API](#) - access WildNet species information approved for publication such as notes, images and records etc.
- [WetlandMaps](#) - view species records, survey locations etc. approved for publication
- [WetlandSummary](#) - view wildlife statistics, species lists for a range of area types, and access WildNet species profiles
- [WildNet wildlife records - published - Queensland](#) - spatial layer of WildNet records approved for publication generated weekly
- [Generalised distribution and densities of Queensland wildlife](#) - Queensland species distributions and densities generalised to a 10 km grid resolution
- [Conservation status of Queensland wildlife](#) - access current lists of priority species for Queensland including nomenclature and status information
- [Queensland Confidential Species](#) - the list of species flagged as confidential in the WildNet database.

Please direct queries about this report to the [WildNet Team](#).

Other useful sites for accessing Queensland biodiversity data include:

- [Useful wildlife resources](#)
- [Queensland Government Data](#)
- [Atlas of Living Australia \(ALA\)](#)
- [Online Zoological Collections of Australian Museums \(OZCAM\)](#)
- [Australia's Virtual Herbarium \(AVH\)](#)
- [Protected Matters Search Tool](#)

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APPENDIX

B

Ecology assessment

Appendix B Flora and fauna species list

B.1 Flora Species List

Scientific Name	Family	NC Act Status	EPBC Act Status	Biosecurity Act Status
<i>Tetragonia tetragonoides</i>	Aizoaceae	Least Concern	Not Listed	-
<i>Vittadinia sp.</i>	Asteraceae	Least Concern	Not Listed	-
<i>Opuntia tomentosa</i> *	Cactaceae	-	Not Listed	Category 3 Restricted Matter
<i>Allocasuarina leuhmanii</i>	Casuarinaceae	Least Concern	Not Listed	-
<i>Einadia nutans ssp. nutans</i>	Chenopodiaceae	Least Concern	Not Listed	-
<i>Maireana microphylla</i>	Chenopodiaceae	Least Concern	Not Listed	-
<i>Cyperus sp.</i>	Cyperaceae	Least Concern	Not Listed	-
<i>Juncus continuus</i>	Juncaceae	Least Concern	Not Listed	-
<i>Corymbia tessellaris</i>	Myrtaceae	Least Concern	Not Listed	-
<i>Eucalyptus melanophloia</i>	Myrtaceae	Least Concern	Not Listed	-
<i>Eucalyptus moluccana</i>	Myrtaceae	Least Concern	Not Listed	-
<i>Eucalyptus populnea</i>	Myrtaceae	Least Concern	Not Listed	-
<i>Eucalyptus tereticornis</i>	Myrtaceae	Least Concern	Not Listed	-
<i>Austrostipa sp.</i>	Poaceae	Least concern	Not Listed	-
<i>Cenchrus ciliaris</i> *	Poaceae	-	Not Listed	-
<i>Chloris divaricata</i>	Poaceae	Least concern	Not Listed	-
<i>Cynodon dactylon</i>	Poaceae	Least Concern	Not Listed	-
<i>Cympogon refractus</i>	Poaceae	Least Concern	Not Listed	-
<i>Heteropogon contortus</i>	Poaceae	Least Concern	Not Listed	-
<i>Sporobolus sp.</i>	Poaceae	Least Concern	Not Listed	-
<i>Themeda quadrivalvis</i> *	Poaceae	-	Not Listed	-
<i>Geijera parviflora</i>	Rutaceae	Least Concern	Not Listed	-
<i>Glandularia aristigera</i> *	Verbenaceae	-	Not Listed	-
<i>Phyla canescens</i> *	Verbenaceae	-	Not Listed	-
<i>Verbena bonariensis</i> *	Verbenaceae	-	Not Listed	-

B.2 Fauna Species List

Common Name	Scientific Name	Type	NC Act Status	EPBC Act Status
northern laughing treefrog	<i>Litoria rothii</i>	Amphibian	Least Concern	Not Listed
red-necked wallaby	<i>Macropus rufogriseus</i>	Mammal	Least Concern	Not Listed
spotted black snake	<i>Pseudechis guttatus</i>	Reptile	Least Concern	Not Listed
black-fronted dotterel	<i>Elseynoris melanops</i>	Bird	Least Concern	Not Listed
straw-necked ibis	<i>Threskiornis spinicollis</i>	Bird	Least Concern	Not Listed
grey teal	<i>Anas gracilis</i>	Bird	Least Concern	Not Listed
Pacific black duck	<i>Anas superciliosa</i>	Bird	Least Concern	Not Listed
white-faced heron	<i>Egretta novaehollandiae</i>	Bird	Least Concern	Not Listed
willie wagtail	<i>Rhipidura leucophrys</i>	Bird	Least Concern	Not Listed

Common Name	Scientific Name	Type	NC Act Status	EPBC Act Status
welcome swallow	<i>Hirundo neoxena</i>	Bird	Least Concern	Not Listed
masked lapwing	<i>Vanellus miles</i>	Bird	Least Concern	Not Listed
pied cormorant	<i>Phalacrocorax varius</i>	Bird	Least Concern	Not Listed
dollarbird	<i>Eurystomus orientalis</i>	Bird	Least Concern	Not Listed
crested pigeon	<i>Ocyphaps lophotes</i>	Bird	Least Concern	Not Listed
noisy miner	<i>Manorina melanocephala</i>	Bird	Least Concern	Not Listed
sulphur-crested cockatoo	<i>Cacatua galerita</i>	Bird	Least Concern	Not Listed
emu	<i>Dromaius novaehollandiae</i>	Bird	Least Concern	Not Listed
intermediate egret	<i>Ardea intermedia</i>	Bird	Least Concern	Not Listed
magpie-lark	<i>Grallina cyanoleuca</i>	Bird	Least Concern	Not Listed
Australasian grebe	<i>Tachybaptus novaehollandiae</i>	Bird	Least Concern	Not Listed
Australian wood duck	<i>Chenonetta jubata</i>	Bird	Least Concern	Not Listed
mistletoebird	<i>Dicaeum hirundinaceum</i>	Bird	Least Concern	Not Listed
eastern koel	<i>Eudynamis orientalis</i>	Bird	Least Concern	Not Listed
black-faced cuckoo-shrike	<i>Coracina novaehollandiae</i>	Bird	Least Concern	Not Listed
black-shouldered kite	<i>Elanus axillaris</i>	Bird	Least Concern	Not Listed
superb fairy-wren	<i>Malurus cyaneus</i>	Bird	Least Concern	Not Listed
little corella	<i>Cacatua sanguinea</i>	Bird	Least Concern	Not Listed
white-breasted woodswallow	<i>Artamus leucorhynchus</i>	Bird	Least Concern	Not Listed
red-winged parrot	<i>Aprosmictus erythropterus</i>	Bird	Least Concern	Not Listed
Australian magpie	<i>Gymnorhina tibicen</i>	Bird	Least Concern	Not Listed
galah	<i>Eolophus roseicapilla</i>	Bird	Least Concern	Not Listed
red-backed fairy-wren	<i>Malurus melanocephalus</i>	Bird	Least Concern	Not Listed
nankeen kestrel	<i>Falco cenchroides</i>	Bird	Least Concern	Not Listed
apostlebird	<i>Struthidea cinerea</i>	Bird	Least Concern	Not Listed
noisy friarbird	<i>Philemon corniculatus</i>	Bird	Least Concern	Not Listed
white-throated gerygone	<i>Gerygone olivacea</i>	Bird	Least Concern	Not Listed
pied currawong	<i>Strepera graculina</i>	Bird	Least Concern	Not Listed
Torresian crow	<i>Corvus orru</i>	Bird	Least Concern	Not Listed
red-rumped parrot	<i>Psephotus haematonotus</i>	Bird	Least Concern	Not Listed
pied butcherbird	<i>Cracticus nigrogularis</i>	Bird	Least Concern	Not Listed

APPENDIX

B

Ecology assessment

Appendix C Likelihood of occurrence assessment

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
Threatened Species					
Birds					
regent honeyeater	<i>Anthochaera phrygia</i>	CE	CE	The regent honeyeater is endemic to mainland south-eastern Australia. It has a patchy distribution which extends from south-east Queensland, through New South Wales (NSW) and the Australian Capital Territory (ACT), to central Victoria. Records are widely distributed across its range, but it is only found regularly at a few localities in NSW and Victoria. The species' movement patterns are thought to be governed by the flowering of select eucalypt species. It is nomadic and partly migratory, with some predictable seasonal movements observed. The species is most commonly associated with box-ironbark eucalypt woodland and dry sclerophyll forest, but also inhabits riparian vegetation such as sheoak (<i>Casuarina</i> spp.) where it feeds on needle-leaved mistletoe and sometimes breeds. It sometimes utilises lowland coastal forest, which may act as a refuge when its usual habitat is affected by drought. It also uses a range of other habitats including remnant patches in farmland and urban areas, roadside reserves and travelling stock routes. Key tree and mistletoe species are outlined in the species' National Recovery Plan. Mature, large individual trees tend to be more important as they are more productive, particularly on highly fertile sites and in riparian areas	Low – Mistletoe is not present in the Study Area of the Development Footprint. Although eucalypt woodlands in regrowth condition were present within the Development Footprint however, these scattered trees are unlikely to support the ecological requirements of the species. Further, the abundance of noisy miners observed may exclude this species from utilising these trees. The species has not been recorded from the desktop search extent (ALA 2022). The nearest record occurs approximately 45 km north in Whetstone State Forest and is dated 2020. Due to the rarity of the species, a 10 km spatial uncertainty has been applied to the record.

Common Name	Scientific Name	EPBC Act Status [^]	NC Act Status [^]	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
curlew sandpiper	<i>Calidris ferruginea</i>	CE, M	CE	In Australia, curlew sandpipers occur around the coasts and are also widespread inland, though erratic in their appearance. In Queensland, scattered records occur in the Gulf of Carpentaria, with widespread records along the coast south of Cairns. There are sparsely scattered records inland. The species mainly occurs on intertidal mudflats in sheltered coastal areas such as estuaries, bays, inlets and lagoons, and around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded less often inland, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand, occurring in both fresh and brackish waters.	Low – Farm dams within the Study Area, although dominated by exotic grass on the fringes, may provide temporary marginal foraging and roosting opportunities during periods of high water availability. However, the Development Footprint is approximately 700m from the nearest farm dam and will not be impacted by the Project. The species has not been recorded from the desktop search extent (ALA 2022). The closest records occur at Lake Coolmunda approximately 30 km to the north-east.
glossy-black cockatoo (south-eastern)	<i>Calyptorhynchus lathami lathami</i>	V	V	South-eastern glossy black cockatoos are uncommon but widespread. They can be found from Mitchell, Queensland, through eastern New South Wales to East Gippsland, Victoria. The sub-species prefers she-oak (<i>Allocasuarina</i> spp.) dominated woodlands, or open sclerophyll forests where <i>Allocasuarina</i> is present amongst Eucalyptus, Corymbia or Angophora. The species is also known to inhabit brigalow woodlands with vegetation assemblages including <i>Allocasuarina</i>, <i>Casuarina</i>, cypress (<i>Callitris</i> spp.) and <i>Acacia harpophylla</i>. This sub-species feed almost exclusively on the seeds of nine <i>Allocasuarina</i> and <i>Casuarina</i> species and has strong site fidelity for feeding trees.	Low – Only one individual suitable foraging tree was recorded and no large hollows suitable for nest sties were present. As such, no suitable habitat is considered to occur within the Study Area or Development Footprint. Records from the 1990s from Yelarbon and Whetstone State Forests occur within the desktop search extent (ALA 2022). Several additional ALA records including from 2018 and 2020 occur in the wider local area, although have not been identified to a sub-species level. The WildNet report also identifies a 1993 record within 10 km.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
red goshawk	<i>Erythroriorchis radiatus</i>	V	E	The red goshawk is endemic to Australia. It is very sparsely dispersed across approximately 15% of coastal and sub-coastal Australia, from western Kimberley Division (north of 19°S) to northeastern NSW (north of 33°). There appears to have been a recent coastal contraction of the range in parts of eastern Australia, and a northward contraction of about 500km in NSW where it is now virtually extinct. The species occurs in coastal and sub-coastal tall open forests and woodlands, preferring areas with a mosaic of vegetation types, permanent water, and abundant small birds. Associated with gorge and escarpment country in partially cleared country in eastern Queensland. In eastern Australia, populations seem to move from inland nest sites to coastal plains in winter, thus occupying home ranges of 50–220 km².	Unlikely – The Development Footprint does not contain a suitable mosaic of vegetation types, or tall vegetation in proximity to permanent water. The species has not been recorded from the desktop search extent (ALA 2022), and the nearest record occurs approximately 65 km south near Kwiambal State Forest. Due to the rarity of this species, the record location has been generalised by 10 km.
grey falcon	<i>Falco hypoleucos</i>	V	V	The species occurs in arid and semi-arid Australia, including the Murray-Darling Basin, Eyre Basin, central Australia and Western Australia. It is mainly found where annual rainfall is less than 500 mm. The species frequents timbered lowland plains, particularly Acacia shrublands that are crossed by tree-lined water courses. It has been observed hunting in treeless areas and frequents tussock grassland and open woodland, especially in winter.	Low – The climate of the local area is considered to have a temperate climate as per BoM and the areas of regrowth woodland do not meet the preferred habitat type for the species. The species has not been recorded from the desktop search extent or wider region (i.e. within 100 km) (ALA 2022).

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
squatter pigeon (southern)	<i>Geophaps scripta scripta</i>	V	V	The known distribution of the squatter pigeon (southern) extends south from the Burdekin-Lynd divide in the southern region of Cape York Peninsula to the Border Rivers region of northern NSW, and from the east coast to Hughenden, Longreach and Charleville, Queensland. Overall, the subspecies' known distribution is estimated to occur within the latitudes, 17° to 30° S, and the longitudes, 141° to 153° 30' E. The sub-species occurs in open, dry woodland with a grassy understorey in proximity to permanent water. It prefers areas of sandy soil with sparser cover of low grasses; and is less common on heavier soils with dense grass cover. Habitat is generally defined as open-forests to sparse, open-woodlands and scrub that are: (1) mostly dominated in the overstorey by Eucalyptus, Corymbia, Acacia or Callitris species (2) remnant, regrowth or partly modified vegetation communities, and (3) within 3 km of water bodies or courses. In Queensland, squatter pigeon (southern) foraging and breeding habitat is known to occur on well-draining, sandy or loamy soils on low, gently sloping, flat to undulating plains and foothills (i.e. Queensland Regional Ecosystem Land Zone 5), and lateritic (duplex) soils on low 'jump-ups' and escarpments (i.e. Queensland Regional Ecosystem Land Zone 7).	Low – Although the Development Footprint contain eucalypt woodlands in regrowth condition, these areas had a very dense ground layer dominated by exotic grasses. Furthermore, habitats within the Development Footprint are highly modified and are less likely to be utilised over adjacent higher-quality areas. Farm dams have the potential to be used as watering points, however these will not be impacted by the Project, with the nearest point to the Development Footprint being approximately 700m away. The species has been historically (1995, 1996) recorded from Yelarbon State Forest within the desktop search extent (ALA 2022).

Common Name	Scientific Name	EPBC Act Status [^]	NC Act Status [^]	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
painted honeyeater	<i>Grantiella picta</i>	V	V	The painted honeyeater is sparsely distributed from south-eastern Australia to north-western Queensland and eastern Northern Territory. The greatest concentrations and almost all records of breeding come from south of 26°S, on inland slopes of the Great Dividing Range between the Grampians, Victoria and Roma, Queensland The species inhabits mistletoes in eucalypt forests/woodlands, riparian woodlands of <i>Eucalyptus largiflorens</i> and <i>E. camaldulensis</i>, box-ironbark-yellow gum woodlands, <i>Acacia</i>-dominated woodlands, <i>Melaleuca</i>, <i>Casuarina</i> or <i>Callitris</i> woodlands, and trees on farmland or in gardens. The species prefers woodlands which contain a higher number of mature trees, as these host more mistletoes.	Low – The species has been historically (1996) recorded from Whetstone State Forest within the desktop search extent (ALA 2022) and was also confirmed approximately 5 km to the south-west during field surveys for B2G EIS in 2021. However, habitat within the Development Footprint is not suitable due to the absence of mistletoe resources.
white-throated needletail	<i>Hirundapus caudacutus</i>	V, M	V	The white-throated needletail is widespread in eastern and south-eastern Australia. In eastern Australia, it is recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains. The species is found across a range of habitats, more often over wooded areas, where it is almost exclusively aerial, though it roosts in tree hollows and the foliage canopy. It forages for insects aerially, flying anywhere between “cloud level” and “ground level”, often forming mixed feeding flocks with other species. The species roosts in tall trees at night, mainly in forests.	Low – Three recent records occur within the desktop search extent, including one at the edge of the Development Footprint (ALA 2022). Due to its aerial nature, the species may forage over the entire Development Footprint, however no suitable roosting habitat was observed and the species is unlikely to rely on the resources within the Development Footprint for its ecological requirements.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
Australian painted snipe	<i>Rostratula australis</i>	E	E	The Australian painted snipe has been recorded at wetlands in all states of Australia. It is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, NSW, Victoria and south-eastern South Australia. The species occurs in shallow freshwater (occasionally brackish) wetlands, both ephemeral and permanent, such as lakes, swamps, claypans, inundated or waterlogged grassland/saltmarsh, dams, rice crops, sewage farms and bore drains, generally with a good cover of grasses, rushes and reeds, low scrub, lignum (<i>Muehlenbeckia</i> spp.), open timber or samphire.	Low – Under ideal conditions, the farm dams within the Study Area may provide marginal foraging and roosting habitat for migrating individuals. However, farm dams will not be impacted by the Project, with the closest point approximately 700m away. Further, the species has not been recorded from the desktop search extent (ALA 2022), and the closest record is located 80 km east near Sundown Resources Reserve (32 km spatial uncertainty).
Fish					
Murray cod	<i>Maccullochella peelii</i>	V	-	The species is known to live in a wide range of warm water habitats that range from clear, rocky streams to slow flowing turbid rivers and billabongs. The upper reaches of the Murray and Murrumbidgee Rivers are considered too cold to sustain the species. Murray Cod have a presence of micro habitat features including rocks, in-stream snags and other timbered structures, stream bank vegetation and structures that generally provide cover from fast-flowing currents.	Unlikely – No watercourses suitable for this species occur within the Development Footprint. The Macintyre Brook occurs immediately adjacent and is known to contain Murray Cod as per ARTC (2021).

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
Mammals					
large-eared pied bat	<i>Chalinolobus dwyeri</i>	V	V	Both the former and current distribution of the large-eared pied bat is poorly known. In Queensland, records are known from sandstone escarpments in the Carnarvon, Expedition Ranges and Blackdown Tablelands. It is likely that these areas support a high proportion of the Queensland populations of the species, although local population estimates have not been established. Additional records exist in the Scenic Rim near the NSW/Queensland border. The populations in this area appear to be reliant on the presence of roosts in volcanic rock types. The species requires a combination of sandstone cliff/escarpment to provide roosting habitat that is adjacent to higher fertility sites, particularly box gum woodlands or river/rainforest corridors which are used for foraging. No maternity roost sites are known in Queensland. The species has been recorded foraging in a range of vegetation types, including dry and wet sclerophyll forest, grassy woodland, Callitris dominated forest, tall open eucalypt forest with a rainforest sub-canopy, subtropical rainforest and small clearings adjacent to rainforest, sub-alpine woodland and sandstone outcrop country.	Low – Contour mapping indicates that the wider area does not contain cliffs or escarpments. Given the species only forages within proximity to roosting habitat, no areas of foraging and dispersal habitat are considered present within the Development Footprint. The species has not been recorded from the desktop search extent, with the nearest record occurring approximately 80 km north near Western Creek State Forest.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
spot-tailed quoll (SE mainland population)	<i>Dasyurus maculatus maculatus</i>	E	LC	The spot-tailed quoll was previously widely distributed from south-east Queensland, eastern NSW, Victoria, south-east South Australia and Tasmania, but it's range is estimated to have reduced significantly. The species occurs in south-east Queensland: coastally from Bundaberg to the border and inland to Monto and Stanthorpe. The subspecies has a preference for mature wet forest habitat, especially in areas with rainfall 600 mm/year. It has been recorded from a wide range of habitats, including: temperate and subtropical rainforests in mountain areas; wet sclerophyll forest; lowland forests; open and closed eucalypt woodlands; inland riparian and river red gum (<i>Eucalyptus camaldulensis</i>) forests; dry 'rainshadow' woodland; sub-alpine woodlands; coastal heathlands; occasional sightings from open country, grazing lands, rocky outcrops and other treeless areas.	Low – The species was recorded from near Inglewood in 2019 within the desktop search extent (ALA 2022). However, habitat within the Development Footprint is considered unsuitable due to the high levels of disturbance and fragmentation, lack of suitable microhabitat and only small wooded vegetation communities present.
south-eastern long-eared bat	<i>Nyctophilus corbeni</i>	V	V	The south-eastern long-eared bat has a scattered distribution mostly within the Murray-Darling Basin, but with some records outside of this area. The species inhabits a range of inland dry forest habitats including <i>Eucalyptus camaldulensis</i>, mallee, brigalow (<i>Acacia harpophylla</i>) and other arid and semi-arid habitats; in southern Queensland it is more common in box/ironbark and Callitris forests on sandy soils. The species is most abundant in vegetation with a distinct canopy and a dense, cluttered shrub layer, and in large, continuous remnants. It roosts solitarily in tree hollows, crevices, and under loose bark (particularly on dead <i>Allocasuarina luehmannii</i> or <i>Casuarina cristata</i>).	Low – Regrowth woodland habitat within the Development Footprint is highly fragmented and does not provide the cluttered understorey utilised by this species. The species has been historically (1990s) recorded from Yelarbon and Whetstone State Forests within the desktop search extent (ALA 2022). Field surveys completed for the B2G EIA recorded the species approximately 20 km north of Inglewood.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
koala (combined populations of Qld, NSW and the ACT)	<i>Phascolarctos cinereus</i>	E	E	The listed population of the koala has a wide but patchy distribution that spans the coastal and inland areas of Queensland north to the Herberton area, extending westwards into hotter and dryer semi-arid climates of central Queensland, NSW and the ACT. The species inhabits a range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities dominated by eucalypt species. Biophysical habitat attributes for the koala include places that contain the resources necessary for individual foraging, survival (including predator avoidance), growth, reproduction and movement. This includes forests or woodlands, road-side and rail vegetation and paddock trees, safe intervening ground matrix for travelling between trees and patches to forage and shelter and reproduce and access to vegetated corridors or paddock trees to facilitate movement between patches.	Moderate – Regrowth eucalypt woodland habitat within the Development Footprint is considered suitable for the species. The species has been historically (1965, 1987) recorded from the desktop search extent (ALA 2022) and was also recorded approximately 5 km east of the Study Area during field surveys completed for the B2G EIS (ARTC, 2021).
grey-headed flying-fox	<i>Pteropus poliocephalus</i>	V	LC	The grey-headed flying-fox is Australia's only endemic flying-fox and occurs in the coastal belt from Rockhampton in central Queensland to Melbourne in Victoria. The species is widespread throughout their range in summer, whilst in autumn it occupies coastal lowlands and is uncommon inland. The species is a canopy-feeding frugivore and nectarivore, which utilises vegetation communities including rainforests, open forests, closed and open woodlands, Melaleuca swamps and Banksia woodlands. It also feeds on commercial fruit crops and on introduced tree species in urban areas. The primary food source is blossom from Eucalyptus and related genera but in some areas it also utilises a wide range of rainforest fruits.	Moderate – Regrowth eucalypt woodland habitat within the Development Footprint may provide foraging and dispersal opportunities. The species has been historically (1960) recorded from the desktop search extent (ALA 2022) and was also recorded at a camp located near Inglewood approximately 16 km to the north-east as per ARTC (2021).

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
short-beaked echidna	<i>Tachyglossus aculeatus</i>	-	SLC	The short-beaked echidna is found throughout Australia, including Tasmania. It inhabits a variety of habitats including forests and woodlands, heath, grasslands and arid environments. When resting, find shelter in burrows, in tree hollows at the base of trees, in clumps of grasses, in piles of leaves and bark, under rocks, or in caves.	Moderate – All habitat within the Development Footprint is considered suitable given the broad requirements of the species. As per the WildNet report, four records occur within 10 km of the Development Footprint including one from 2020. One 1996 record occurs within the desktop search extent (ALA, 2022) to the south east in Yelarbon State Forest.
Plants					
Tara wattle	<i>Acacia lauta</i>	V	V	This species is restricted to a small region of the Darling Downs in south-eastern Qld, from Tara to Inglewood with a distributional range of approx. 140 km. The species grows in a subhumid subtropical climate, at localities characterised by a gently undulating to flat landforms. Soils are moderately deep and hardsetting with a weakly acidic to neutral sandy loam surface grading into neutral to alkaline sandy clay subsoil. Vegetation varies from open forest to low woodland with a dense or moderately dense shrub layer. Tree species present at all sites include white cypress pine (<i>Callitris glaucophylla</i>) and buloke (<i>Allocasuarina luehmannii</i>), while the understorey is diverse.	Low – As the Development Footprint is located at the limit of the species' potential distribution. Habitat within the Development Footprint is not considered suitable due to the high levels of modification and lack of shrub layer. The species was not recorded during field surveys has not been recorded from the desktop search extent (ALA 2022) and the closest record (1989) occurs 25 km to the east near Lake Coolmunda.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
-	<i>Androcalva procumbens</i>	V	LC	This species occurs primarily in NSW and limited parts of southern Queensland. Biodiversity surveys of Brigalow Belt South in 2002 recorded <i>A. procumbens</i> at only one of 32 previously known locations. The species is often found in communities of <i>Eucalyptus dealbata</i> – <i>E. sideroxylon</i> woodland, <i>Melaleuca uncinata</i> shrubland, and mallee eucalypt with <i>Calytrix tetragona</i> understorey. Associated species include <i>Acacia triptera</i>, <i>Callitris endlicheri</i>, <i>Eucalyptus melliodora</i>, <i>Allocasuarina diminuta</i>, <i>Philotheca salsolifolia</i>, <i>Xanthorrhoea</i> spp., <i>Exocarpos cupressiformis</i>, <i>Leptospermum parvifolium</i>, and <i>Kunzea parvifolia</i>. It occurs in sandy soils, often in disturbed habitats such as road verges, quarry boundaries, gravel stockpiles, and power line easements.	Unlikely – Although the Development Footprint occurs within the mapped distribution of the species, more recent data suggests the species occurs almost exclusively in NSW. Although regrowth eucalypt woodlands may be marginally suitable, the species has not been recorded from the region (within 100 km from the Study Area) (ALA 2022). The communities observed within the Development Footprint are not typical habitat for the species.
ooline	<i>Cadellia pentastylis</i>	V	V	Ooline occurs on the north-west slopes of NSW and in central and southern Queensland. In Queensland, ooline occurs from Balcomba (west of Rockhampton) south to the NSW border and west to near Blackall. Ooline grows in semi-evergreen vine thickets and sclerophyll vegetation on undulating terrain of various geology, including sandstone, conglomerate and claystone. Soils generally have low to medium nutrient content and are normally associated with upper and mid-slopes in the landscape. The altitude is generally 300-460 m above sea level, with some stands known to occur at 600 m above sea level.	Low – Habitat within the Development Footprint is considered marginal due to its low elevation (less than 300 m) and flat topography. Further, the species has not been recorded from the desktop search extent (ALA 2022) and the nearest record occurs approximately 45 km to the north west near Bendidee State Forest. Ooline is easily detectable and was not observed during field surveys.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
bluegrass	<i>Dichanthium setosum</i>	V	LC	<i>Dichanthium setosum</i> has been reported from inland NSW and Queensland. In Queensland the species has been reported from the Leichhardt, Morton, North Kennedy and Port Curtis regions. The species occurs on heavy soils (predominantly heavy basaltic black soils and red-brown loams with clay subsoil) in woodland or open woodland usually dominated by Acacia and/or Eucalyptus species. Associated climate is tropical to subtropical and seasonal, with the habitat drying out for part of the year. <i>Dichanthium setosum</i> is often found in moderately disturbed areas such as cleared woodland, grassy roadside remnants and highly disturbed pasture.	Low – As the species is known to occur in highly disturbed pasture, habitat within the Development Footprint may be suitable. However, the species has not been recorded from the desktop search extent (ALA 2022), with the closest record occurring approximately 55 km south-west in NSW.
Belson's panic	<i>Homopholis belsonii</i>	V	E	The distributional range of Belson's Panic lies within the southern Brigalow Belt Queensland, namely the Darling Downs area west of Toowoomba, near Oakey, Jondaryan, Bowenville, Dalby, Acland, Sabine, Quinalow, Goombungee, Gurulmundi and Millmerran, and further west between Miles and Roma. The species occurs at elevations ranging from 200 m to 520 m asl. It is known to occur in dry woodland habitats on poor soils, such as those derived from basalt. It occurs on rocky hills supporting white box (<i>Eucalyptus albens</i>) and in wilga (<i>Geijera parviflora</i>) woodland; flat to gently undulating alluvial areas supporting belah (<i>Casuarina cristata</i>) forest; and soils and plant communities of poplar box (<i>Eucalyptus populnea</i>) woodlands. It may also be associated with shadier areas of brigalow (<i>Acacia harpophylla</i>), myall (<i>A. melvillei</i>), and weeping myall (<i>A. pendula</i>) communities; in mountain coolibah (<i>Eucalyptus orgadophila</i>) communities; and on roadsides.	Low – Development Footprint may contain marginal habitat associated with the eucalypt woodlands in regrowth condition. However, the species has not been recorded from the desktop search extent (ALA 2022) and the closest record occurs approximately 45 km north-west near Bendidee National Park.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
winged pepper- cress	<i>Lepidium monoplocoides</i>	E	LC	As per the species' SPRAT profile and National recovery plan (2010), this species occurs primarily in NSW and Victoria. The winged pepper-cress occurs in open, sparsely vegetated sites in a range of habitats on heavy clay or clay-loam soils, usually on sites that are seasonally flooded or prone to waterlogging, in arid to semi-arid areas with an average rainfall range of 200–450mm per year. Vegetation communities in which the species occurs include grasslands, wetlands and floodplain woodlands dominated by <i>Eucalyptus coolabah</i> and <i>Eucalyptus largiflorens</i>, and chenopod shrublands dominated by <i>Atriplex</i>, <i>Maireana</i> and/or <i>Nitraria</i> species. The winged pepper-cress has apparently suffered a widespread decline in both range and abundance since European settlement. The species is subject to a number of major threats including altered hydrology, increasing salinity, weed invasion, grazing, physical damage, drought and climate change.	Low – The species occurrence within Queensland is not well known. Two ALA records occur within the desktop search extent (ALA 2022) near the township of Yelarbon to the south-west of the Development Footprint: one from 2005 with 100 m spatial uncertainty, described as occurring in “gilgaed areas on clay soils, salt scalded”, and the other from 2011 with a 10 km spatial uncertainty. Habitat within the Development Footprint is considered unsuitable as it is highly disturbed and not ‘sparsely vegetated’. Exotic grass and forbs present are also likely to out-compete this species for resources.

Common Name	Scientific Name	EPBC Act Status [^]	NC Act Status [^]	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
Austral toadflax	<i>Thesium australe</i>	V	V	Austral toadflax occurs in New South Wales, the Australian Capital Territory, Queensland and Victoria. The species was considered extinct in Queensland prior to the mid-1980s. Collections since the 1990s have been made from Kumbia, Glen Rock Regional Park, Carnarvon National Park, Crows Nest, Clifton, Warwick, Greenmount, Cambooya, Dalby, the Bunya Mountains, Blackbutt and Imbil. The species occurs in shrubland, grassland or woodland, often on damp sites. Vegetation types include open grassy heath dominated by swamp myrtle (<i>Leptospermum myrtifolium</i>), small-fruit hakea (<i>Hakea microcarpa</i>), alpine bottlebrush (<i>Callistemon sieberi</i>), woolly grevillea (<i>Grevillea lanigera</i>), coral heath (<i>Epacris microphylla</i>) and <i>Poa</i> spp., kangaroo grass (<i>Themeda triandra</i>) grassland surrounded by Eucalyptus woodland; and grassland dominated by barbed-wire grass (<i>Cymbopogon refractus</i>). It occurs on soils derived from sedimentary, igneous and metamorphic geology on a range of soils including black clay loams to yellow podzolics and peaty loams.	Unlikely – Woodland and grassland habitat within the Development Footprint is considered unsuitable due to the low abundance of native grass species and significant disturbance. The species has not been recorded from the desktop search extent (ALA 2022), and the closest record is approximately 45 km south-west near Yetman (10 km spatial uncertainty).
-	<i>Vincetoxicum forsteri</i>	E	E	The species has rarely been collected and is known from eight localities in the Dubbo area and Mt Crow near Barraba in NSW, and “Myall Park” near Glenmorgan in Queensland. This species is conserved within Goobang National Park, Eura State Forest, Goonoo SF, Pilliga West SF and Coolbaggie Nature Reserve. It grows in dry scrub, open forest and woodlands associated with <i>Melaleuca uncinata</i>, <i>Eucalyptus fibrosa</i>, <i>E. sideroxylon</i>, <i>E. albens</i>, <i>Callitris endlicheri</i>, <i>C. glaucophylla</i>, <i>Allocasuarina luehmannii</i>, <i>Acacia hakeoides</i>, <i>A. lineata</i>, <i>Myoporum</i> spp., and <i>Casuarina</i> spp.	Unlikely – The species occurrence within Queensland is not well known, and the Development Footprint does not occur near a known location. The species has not been recorded from the desktop search extent (ALA 2022), and habitat within the Development Footprint is unlikely to be suitable due to the lack of associated species and the overall high level of disturbance.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
-	<i>Westringia parvifolia</i>	V	V	<i>Westringia parvifolia</i> is known from four collections near Yelarbon, Inglewood and Goondiwindi in south-east Queensland and from near Yetman in northern New South Wales. The species grows with Baker's mallee (<i>Eucalyptus bakeri</i>) and green mallee (<i>E. viridis</i>) and between clumps of spinifex (<i>Triodia</i> sp.) on sandy and stony soils.	Unlikely – The species has been historically (1974 or earlier) recorded from the desktop search extent (ALA 2022); however, habitat within the Development Footprint is unsuitable due to the soil type and lack of associated species.
-	<i>Xerothamnella herbacea</i>	E	E	<i>Xerothamnella herbacea</i> is known from two sites north-east of Chinchilla, a single record from near Theodore and a record near Yelarbon east of Goondiwindi, Queensland. The species occurs in brigalow dominated communities in shade situations, often growing in leaf litter and associated with gilgai on heavy clay soil. Three of the four known populations occur in cleared areas of non-remnant vegetation.	Unlikely – No suitable habitat occurs within the Development Footprint as brigalow is not present nor are gilgai formations and leaf litter is largely absent. The species has been (2006) recorded from the desktop search extent (ALA 2022).
Reptiles					
common death adder	<i>Acanthophis antarcticus</i>	-	V	Found in eastern Australia (excluding far north and south) and southern Southern Australia and Western Australia. The species is found in a wide variety of well-drained habitats, including rainforests and wet sclerophyll forests, woodland, shrublands, grasslands and coastal heathlands, preferring sites with deep fixed leaf litter. Individuals burrow into sand or leaf litter, or hide under overhanging foliage.	Unlikely – The species has been (1990s) recorded from Yelarbon and Whetstone State Forests within the desktop search extent (ALA 2022), however habitat within the Development Footprint is not considered suitable due to the dense ground-layer cover and lack of leaf litter.
five-clawed worm-skink	<i>Anomalopus mackayi</i>	V	E	The long-legged worm-skink is found on the western slopes of the Great Dividing Range in south-eastern Queensland and north-eastern New South Wales. Its range has contracted eastward. In the past 20 years it has only been recorded from the Oakey and Dalby region of Queensland and the Wallangra, Mungindi and Wee Waa regions of New South Wales.	Low – The species has been recorded from the desktop search extent (WildNet 2022) however suitable habitat is unlikely to occur in the Development Footprint given the absence of black cracking clay soils, and the limited fallen timber. Further, the Development Footprint

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
				The species occurs on the lower slopes of slight rises in grassy White Box (<i>Eucalyptus albens</i>) woodland, open woodland and River Red Gum – Coolibah – poplar box (<i>Eucalyptus populnea</i>) woodland. This type of woodland is generally supported by red – black to black clay-loam soils. The species lives in permanent deep tunnel-like burrows and deep soil cracks, using fallen logs and timber as sheltering sites on the surface.	falls outside of the mapped distribution for this species (SPRAT).
collared delma	<i>Delma torquata</i>	V	V	The collared delma is endemic to Queensland, and known from the Bunya Mountains, Blackdown tablelands National Park, Expedition National Park, Western Creek, near Millmerran and the Toowoomba Range. The species normally inhabits eucalypt-dominated woodlands and open-forests in Queensland RE Land Zones 3, 9, and 10. The presence of rocks, logs, bark and other coarse woody debris, and mats of leaf litter (typically 30–100 mm thick) appears to be an essential characteristic of microhabitat and is always present where the species occurs.	Low – Essential microhabitat features were in low abundance or absent within the Development Footprint. The microhabitat available is considered unlikely to be sufficient to support this species. The species has not been recorded from the desktop search extent (ALA 2022) and the closest record occurs approximately 47 km north near Bulli State Forest.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
yakka skink	<i>Egernia rugosa</i>	V	V	The known distribution of the yakka skink extends from the coast to the hinterland of sub-humid to semi-arid eastern Queensland. This vast area covers portions of the Brigalow Belt (North and South), Mulga Lands, South-east Queensland, Einasleigh Uplands, Wet Tropics and Cape York Peninsula Biogeographical Regions. As per SPRAT, there is at least 26 known locations of the species in Queensland. The species occurs in a variety of drier forests and woodlands, usually on well-drained, gritty soils, including <i>Eucalyptus populnea</i> on alluvial soils, <i>Callitris glaucophylla</i> on sands, <i>Allocasuarina luehmannii</i>, <i>Acacia harpophylla</i>, <i>A. catenulata</i> and <i>A. aneura</i>. The species inhabits burrows, abandoned rabbit warrens, and hollow logs or in deep rock crevices.	Low – Microhabitat within the Development Footprint was largely unsuitable for this species with dense ground cover, limited fallen timber, no deep crevices or hollow logs and compact clay/loam soil which is not amenable to excavating burrows. The species has not been recorded from the region (within 100 km from the Development Footprint) (ALA 2022) and the Development Footprint does not occur near a known location as per SPRAT.
Dunmall's snake	<i>Furina dunmalli</i>	V	V	The distribution of Dunmall's snake extends from near the Queensland border throughout the Brigalow Belt South and Nandewar bioregions, as far south as Ashford in New South Wales. The species has been found in a broad range of habitats, including forests and woodlands on black alluvial cracking clay/ clay loams dominated by <i>Acacia harpophylla</i> and other <i>Acacia</i> spp., <i>Callitris</i> spp. or <i>Allocasuarina luehmannii</i>, and various <i>Corymbia citriodora</i>, <i>Eucalyptus crebra</i>, <i>E. melanophloia</i> and <i>Callitris glaucophylla</i> open forest and woodland associations on sandstone derived soils.	Low – Due to the lack of associated species and high levels of disturbance and lack of complex microhabitat, regrowth woodlands within the Development Footprint do not provide suitable habitat for the species. The species has not been recorded from the desktop search extent (ALA 2022) and the closest record (undated) is approximately 21 km to the south-east near Yelarbon State Forest.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
border thick-tailed gecko	<i>Uvidicolus sphyrurus</i>	V	LC	The border thick-tailed gecko occurs in the New England Tableland, Nandewar and Brigalow Belt South Bioregions in northern New South Wales (NSW) and in south-east Queensland in an area bounded by Durikai State Forest (SF) (Queensland) to the north, the Great Dividing Range (NSW) to the east, the Liverpool Range (NSW) to the south and Moree/Mt Kaputar National Park (NP) to the west. The species is most commonly found in undisturbed habitat remnants on rocky outcrops and stony hills within eucalypt and cypress-pine open forest or woodland between 500-1100 m elevation. It is nocturnal and shelters by day. Sheltering occurs in well-shaded micro-sites amongst boulders, rock slabs, fallen timber (logs or debris), bark on standing trees and deep leaf litter.	Unlikely – The Development Footprint occurs at elevations <300 m, lacks rocky features and contains low-levels of woody microhabitat. As such, no suitable habitat is present. The species has not been recorded from the desktop search extent (ALA 2022) and the closest record occurs approximately 55 km south-east near Arcot State Forest.
Migratory Species					
Marine Birds					
fork-tailed swift	<i>Apus pacificus</i>	M	SLC	The species is almost exclusively aerial, flying from less than 1 m to at least 300 m above ground and probably much higher. This species mostly occurs over dry or open habitats, including riparian woodland and tea-tree swamps, low scrub, heathland or saltmarsh. They are also found at treeless grassland and sandplains covered with spinifex, open farmland and inland and coastal sand-dunes.	Low –. Due to its aerial nature, the species may forage over the entire Development Footprint, however no suitable roosting habitat was observed and the species is unlikely to rely on the resources within the Development Footprint for its ecological requirements. Two records (one from 2018, the other undated) occur approximately 16 km to the south west near Yelarbon.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
Terrestrial Species					
yellow wagtail	<i>Motacilla flava</i>	M	SLC	The yellow wagtail is a regular wet season visitor to northern Australia. Increasing records in NSW suggest this species is an occasional but regular summer visitor to the Hunter River region. Habitat requirements for the species are highly variable, but typically include open grassy flats near water. Habitats include open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy edges of wetlands, rivers, irrigated farmland, dams, waterholes; sewage farms, sometimes utilise tidal mudflats and edges of mangroves.	Unlikely – Suitable habitat may occur in the Development Footprint; however, the species has not been recorded from the region (within 100 km from the Study Area) (ALA 2022). As per the SPRAT distribution map, the Development Footprint occurs within the ‘potential’ extent, and not close to a known location.
satin flycatcher	<i>Myiagra cyano-leuca</i>	M	SLC	Satin flycatchers are found extensively along the Great Dividing Range along the eastern and south-east seaboard of Australia – from Cape York to eastern South Australia. The species is also widespread within Tasmania. The species inhabits heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests.	Low – Regrowth and remnant woodland habitats within the Development Footprint may provide marginal habitat for the species while on migration, however no preferred habitat is available. However, the species has not been recorded from the desktop search extent (ALA 2022) and the closest record occurs approximately 29 km south near Dhinna Dhinawan National Park.
Wetlands Species					
common sandpiper	<i>Actitis hypoleucos</i>	M	SLC	The species utilises a wide range of coastal wetlands and some inland wetlands with varying levels of salinity. The species is mostly found around muddy margins or rocky shores and rarely on mudflats. It has been recorded in estuaries and deltas of streams, as well as on banks further upstream; around	Low – This species is known to utilise ‘dams’ and therefore farm dams within the Study Area may provide marginal habitat for vagrant individuals while on migration. However, farm dams will not be impacted by the Project, with the closest point to the Development

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
				lakes, pools, billabongs, reservoirs, dams and claypans, and occasionally piers and jetties.	Footprint being approximately 700m. The species has not been recorded from the region (within 100 km from the Development Footprint) (ALA 2022).
sharp-tailed sandpiper	<i>Calidris acuminata</i>	M	SLC	The sharp-tailed sandpiper spends the non-breeding season in Australia with small numbers occurring regularly in New Zealand. In Queensland, they are recorded in most regions, being widespread along much of the coast and are very sparsely scattered inland, particularly in central and south-western regions. The species prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh, or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, salt pans, and hypersaline salt lakes inland. They also occur in salt works and sewage farms.	Low – This species is known to utilise ‘dams’ and therefore farm dams within the Study Area may provide marginal habitat for vagrant individuals while on migration. However, farm dams were will not be impacted by the Project, with the closest point to the Development Footprint being approximately 700m. ALA records occur within 30 km at three locations in the region including Yelarbon, Yelarbon State Forest and Lake Coolmunda.
pectoral sandpiper	<i>Calidris melanotos</i>	M	SLC	The pectoral sandpiper has been recorded in all states and territories of Australia. In Queensland, most records for the Pectoral Sandpiper occur around Cairns. There are scattered records elsewhere, mainly from east of the Great Divide between Townsville and Yeppoon. Records also exist in the south-east of the state as well as a few inland records at Mount Isa, Longreach and Oakley. The species prefers shallow fresh to saline wetlands. It is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains, and artificial wetlands.	Unlikely – The species has not been recorded from the region (within 100 km from the Development Footprint) (ALA 2022), and as this species does not utilise dams no suitable habitat is considered present within the Study Area. Regardless, farm dams will not be impacted by the Project.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
common greenshank	<i>Tringa nebularia</i>	M	SLC	The common greenshank is a non-breeding migrant to Australia. The species is widespread in the Gulf country and eastern Gulf of Carpentaria. It has been recorded in most coastal regions, possibly with a gap between north Cape York Peninsula and Cooktown. Inland, there have been a few records south of a line from near Dalby to Mt Guide, and sparsely scattered records elsewhere. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats. It will also use artificial wetlands, including sewage farms and saltworks dams, inundated rice crops and bores. The edges of the wetlands used are generally of mud or clay, occasionally of sand, and may be bare or with emergent or fringing vegetation, including short sedges and saltmarsh, mangroves, thickets of rushes, and dead or live trees.	Low – This species is known to utilise ‘dams’ and therefore farm dams within the Study Area may provide marginal habitat for vagrant individuals while on migration. However, farm dams will not be impacted by the Project, with the closest point to the Development Footprint being approximately 700m. As per the WildNet report, one record from 1998 occurs within 10 km of the Development Footprint. An ALA record also dated 1998 (and likely the same WildNet record) occurs approximately 5 km to the south-west. Other records occur approximately 30 km to the north-east at Lake Coolmunda.
Latham's snipe	<i>Gallinago hardwickii</i>	M	SLC	Latham's snipe is a non-breeding visitor to south-eastern Australia, and is a passage migrant through northern Australia. The range extends inland over the eastern tablelands in south-eastern Queensland (and occasionally from Rockhampton in the north), and to west of the Great Dividing Range in New South Wales. The species is occasionally recorded at sites located to the west of the core range (e.g. in north-western and south-western Queensland, north-western New South Wales, mid-northern South Australia, the Northern Territory and Western Australia).	Low – The species has been recently (2015, 2017) recorded from Yelarbon within the desktop search extent (ALA 2022). As this species is known to inhabit modified habitats, farm dams within the Study Area are considered potentially suitable. However, farm dams will not be impacted by the Project, with the closest point to the Development Footprint being approximately 700m.

Common Name	Scientific Name	EPBC Act Status^	NC Act Status^	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
				In Australia, the species occurs in permanent and ephemeral wetlands up to 2,000 m asl. They usually inhabit open, freshwater wetlands with low, dense vegetation such as swamps, flooded grasslands or heathlands, around bogs and other water bodies. However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity.	
Threatened Ecological Communities					
Brigalow (<i>Acacia harpophylla</i> dominant and co-dominant)		E	-	The TEC is characterised by the presence of <i>Acacia harpophylla</i> either dominant in the tree layer, or co-dominant with other species – notably <i>Casuarina cristata</i> , other <i>Acacia</i> spp. or <i>Eucalyptus</i> spp. Occasionally these other species may be more common than <i>A. harpophylla</i> . The TEC has a considerable range of vegetation structure and composition united by a suite of species that tend to occur on acidic and salty clay soils. Corresponding REs in the Brigalow Belt Bioregion: 11.3.1, 11.4.3, 11.4.7, 11.4.8, 11.4.9, 11.4.10, 11.5.16, 11.9.1, 11.9.5, 11.9.6, 11.11.14, 11.12.21.	Unlikely – The majority of the Study Area is non-remnant. A small patch of vegetation mapped as non-remnant has been ground-truthed as remnant RE 11.5.20, which does not correspond to the TEC.
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions		E	-	The TEC occurs as a semi-arid to humid subtropical woodland where <i>Eucalyptus coolabah</i> subsp. <i>coolabah</i> and/or <i>E. largiflorens</i> are the dominant canopy species and where the understorey tends to be grassy. It is found on the grey, self-mulching clays of periodically waterlogged floodplains, swamp margins, ephemeral wetlands, and stream levees. Corresponding REs in the Brigalow Belt Bioregion: 11.3.3, 11.3.15, 11.3.16, 11.3.28, 11.3.37.	Unlikely – No remnant vegetation is present within the Development Footprint and vegetation communities in regrowth condition do not correspond to any analogous REs.

Common Name	Scientific Name	EPBC Act Status [^]	NC Act Status [^]	Distribution and Habitat (SPRAT 2022, DES 2022)	Likelihood of Occurrence
Poplar Box Grassy Woodland on Alluvial Plains		E	-	The TEC is typically a grassy woodland with a canopy dominated by <i>Eucalyptus populnea</i> and understorey mostly of grasses and other herbs. It mostly occurs in gently undulating to flat landscapes and occasionally on gentle slopes on a wide range of soil types of alluvial and depositional origin. Corresponding REs in the Brigalow Belt Bioregion: 11.3.2, 11.3.17, 11.4.7, 11.4.12.	Known – The majority of the Development Footprint is non-remnant. However, as per Ausecology (2022) areas of this TEC and analogous RE 11.3.2 occur in the Development Footprint north of the South Western System Railway Line (0.22 ha).
Weeping Myall Woodlands		E	-	The TEC occurs as open woodlands to woodlands, generally 4-12 m high, in which <i>Acacia pendula</i> is the sole or dominant overstorey species. Other species including <i>Alectryon oleifolius</i> subsp. <i>elongatus</i> , <i>Eucalyptus populnea</i> or <i>E. largiflorens</i> may also occur, though not as dominant species. Corresponding REs: 11.3.2, 11.3.28.	Unlikely – No remnant vegetation is present within the Development Footprint and vegetation communities in regrowth condition do not correspond to any analogous REs
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland		CE	-	The TEC is characterised by a species-rich understorey of native tussock grasses, herbs and scattered shrubs, and the dominance, or prior dominance, of white box (<i>Eucalyptus albens</i>), yellow box (<i>E. melliodora</i>) or Blakely's red gum (<i>Eucalyptus blakelyi</i>) trees. It occurs in areas where rainfall is 400 - 1200 mm per annum, on moderate to highly fertile soils at altitudes of 170 - 1200 metres. Corresponding REs in the Brigalow Belt Bioregion: 11.8.2a, 11.8.8, 11.9.9a. It can also be a smaller component of the RE 11.3.23.	Unlikely – No remnant vegetation is present within the Development Footprint and vegetation communities in regrowth condition do not correspond to any analogous REs

[^] LC = Least Concern, SLC = Special Least Concern, V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory.

APPENDIX B

Ecology assessment

Appendix D Significant residual impact assessment for matters of state environmental significance

D.1 Short-beaked Echidna (*Tachyglossus aculeatus*)

The short-beaked echidna is found in almost all terrestrial habitats in Australia. This species relies on a substrate of leaf litter and coarse woody debris for foraging. It shelters in fallen logs, rock crevices, dense leaf litter and abandoned burrows.

This species was not recorded within the Study Area during field surveys, however, given its occurrence within the desktop search extent and broad habitat requirements, it has been assessed as having a Moderate likelihood of occurrence.

As this species is a known habitat generalist, modelled habitat includes all fauna habitat types mapped within the Development Footprint and the broader Study Area. The extent of modelled habitat within the Study Area and the Development Footprint is provided below.

Fauna Habitat Type	Extent within Study Area (ha)	Development Footprint (ha)
<i>Eucalyptus moluccana</i> woodland on flat plains	2.5	0
Regrowth eucalypt woodland with scattered mature trees	5.3	1.1
Farm dams	2.5	0
Cleared areas - exotic pasture and tracks	221.9	42.9
Cleared areas - wheat cropping	104.2	25.4
Total	336.4	69.3

The SRI assessment for the species is presented below. In summary, a significant residual impact was not triggered for this species.

Evaluation Criteria	Response
Lead to a long-term decrease in the size of a local population	No. This species has not been recorded within the Development Footprint. Due to the broad habitat requirements of the species, there are large areas of potential habitat for the species in the Development Footprint and the wider region.
Reduce the extent of occurrence of the species	No. Given the small area of proposed disturbance to this species habitat, the generally degraded nature of this habitat, the ability of the species to disperse between habitat patches and the area of habitat disturbance comparative to habitat in the broader region, a long-term decrease in the size of a local population of this species is unlikely to result from the Project. Further, spotter-catchers will be present during all clearing works to relocate any individuals found during earthworks.
Fragment an existing population	No. Due to the broad habitat requirements of the species, the unimpacted portions of the Study Area and the adjacent State Forests provide substantial habitat for this species. The small area of impact relative to the surrounding region and the ability for the species to disperse between habitat patches means the Project is unlikely to reduce the species' extent of occurrence.

Evaluation Criteria	Response
Reduce gene flow among populations	No. Given the small area of proposed disturbance and the ability for the species to disperse between vegetated patches, the potential habitat loss associated with the Project is unlikely to present significant barriers to any existing population to the extent where it would become fragmented.
Disrupt ecologically significant locations (breeding, feeding or nesting sites)	No. Given the small area of proposed disturbance and the ability for the species to disperse between habitat patches, the potential habitat loss associated with the Project is unlikely to isolate habitat to the extent where genetically distinct populations would form.

APPENDIX

B

Ecology assessment

Appendix E Significant impact assessment for matters of national environmental significance

Poplar Box Grassy Woodland on Alluvial Plains Threatened Ecological Community

The Poplar Box TEC is listed Endangered under the EPBC Act. It is described as typically comprising a grassy woodland with a canopy dominated by poplar box (*Eucalyptus populnea*) and understorey mostly of grasses and other herbs. The Poplar Box TEC occurs west of the Great Dividing Range from Charters Towers, south to Leeton in New South Wales (Department of the Environment and Energy, 2019a). In Queensland, it is found in a number of bioregions including Brigalow Belt North, Brigalow Belt South, Southeast Queensland and the Darling Riverine Plains. It mostly occurs in gently undulating to flat landscapes and occasionally on gentle slopes on a wide range of soil types of alluvial and depositional origin (Webb et al. 1980).

In Queensland, the Poplar Box TEC is defined using the RE framework, where a number of REs are considered analogous with the TEC, provided that other key diagnostic criteria and condition thresholds are met.

A total of 0.22 ha of Poplar Box TEC was identified as occurring within the Development Footprint (see **Figure 4.2**). As per Ausecology (2022), the community was analogous to RE 11.3.2 in both high-value regrowth (HVR) and remnant condition. The TEC was identified to meet the Class A1 – High Quality condition thresholds. As described by Ausecology (2022), *“although several discrete patches of poplar box TEC were recorded at the site, in accordance with the poplar box TEC criteria, a patch may include small-scale (<30 m) variations, gaps, and disturbances, such as tracks, paths or breaks, or localised variations in vegetation that do not significantly alter the overall functionality of the ecological community. These breaks were included in the patch size calculations of the site. Small discrete patches of 11.3.2 (i.e. <1 ha) that were located >30m from a known compliant poplar box TEC patch were excluded.”*

Threats

A number of key threats are identified for the Poplar Box TEC, which may lead to further reduction in the extent or cause a decline in condition:

- clearance and fragmentation;
- weed invasion;
- inappropriate fire and grazing;
- dieback due to herbivory, water stress, salinity and pathogens;
- chemical impact and spray drift;
- hydrological changes;
- salinisation;
- nutrient enrichment;
- invasive fauna;
- climate change.

Habitat Critical to the Survival of the Ecological Community

As per this community's Conservation Advice (Department of the Environment and Energy 2019), the areas most critical to the survival of the ecological community are the best quality, most intact patches of the ecological community (i.e. Class A). Additional areas such as buffer zones around patches, adjoining native vegetation, and areas that meet the description of the ecological community but not the condition thresholds are also important to the survival of the ecological community. They should still be taken into consideration as part of the surrounding environment and landscape context.

The small area of Poplar Box TEC within the Development Footprint meets the definition of habitat critical to the survival of the ecological community.

Significance Assessment

An assessment of the significance of impacts to this TEC under the (Department of the Environment, 2013b) is provided in Table 9.1. The assessment identified that it is unlikely that the Project will have a significant impact on Poplar Box TEC.

Table 9.1 Significant impact assessment – Poplar Box TEC

EPBC Act criteria – is there a real chance or possibility that the Project will:	Assessment of significance
Reduce the extent of an ecological community?	No. The Poplar Box TEC is estimated to occupy a total area of approximately 1.27 million ha across a distribution from Central Queensland to southern New South Wales. The Project involves the proposed clearing of a narrow linear strip of 0.22 ha of TEC, limited to the southern edge of a patch 2.3 ha in size. Approximately 2.1 ha of the TEC will remain and is very likely to still meet the condition thresholds for the TEC. Indirect impacts including edge effects, weed incursion, erosion and sedimentation and dust are expected to remain similar to current conditions on site given the successful implementation of mitigation measures. A large portion of this patch will be retained, with the patch occurring in the middle of the community's regional distribution. Therefore, it is unlikely that the Project will reduce the extent of the ecological community.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines?	No. The Project involves the proposed clearing of a narrow linear strip of 0.22 ha of the TEC on the southern edge of the 2.3 ha patch. A large portion of this patch will be retained following construction of the Project. The patch is located in close proximity to the South Western Railway Line, and part of a large contiguous area of vegetation close to the Whetstone State Forest. Clearing will be restricted to the edge of the patch, which is already subject to edge effects and disturbance. Direct impacts as a result of the Project will not impact connectivity to the north. Therefore, the Project will not further fragment the ecological community.

EPBC Act criteria – is there a real chance or possibility that the Project will:	Assessment of significance
Adversely affect habitat critical to the survival of an ecological community?	No. All Poplar Box TEC within the Development Footprint is considered habitat critical to the survival of the community. The Project will result in direct impacts to 0.22 ha of TEC of a patch 2.3 ha in total size. This amount of clearing is considered minor and unlikely to adversely affect habitat critical to the survival of the community given the amount that will be retained. Indirect impacts are expected to remain similar to current conditions on site. This will continue to support the Poplar Box TEC in the area following the development of the Project. Where possible, micro-siting of Project infrastructure should be employed to avoid TEC areas and poplar box (<i>Eucalyptus populnea</i>) canopy trees.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns?	No. During the construction and operation of the Project, the extent of exposed ground within the Development Footprint may be increased. However, given the very flat terrain, no changes to the surface flows are anticipated. The Development Footprint does not impact on any mapped water features including farm dams or mapped drainage features. Furthermore, areas that are likely to contain potential contaminants will be banded as appropriate. Based on this, it is considered unlikely that the Project will result in a notable change to the availability of resources such as water, nutrients or soil within areas of Poplar Box TEC. Other ways in which the Project could modify or destroy abiotic factors relevant to the Poplar Box TEC include potential erosion and sedimentation, which could impact on the soil and nutrients, as well as dust deposition, which could impact on the ability of the plants to photosynthesise. Standard mitigation and management measures will be implemented to effectively reduce the risk of these potential indirect impacts.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting?	No. The proliferation of buffel grass in Queensland has contributed to the endangered status of the Poplar Box TEC as this species invades the understorey, outcompetes native flora species, leading to a decline in diversity and regenerative capacity of native vegetation. The presence and/or dominance of buffel grass in areas of mapped Poplar Box TEC are not known as the Umwelt survey was unable to assess these areas given their occurrence within the rail corridor. However, it is considered likely that buffel grass as well as other exotic grasses already occur within the community given the prevalence of these species across the Study Area. A total of 0.22 ha of the TEC along the southern edge of the patch will be directly impacted as a result of the Project. During the construction of the Project there is a chance of increased weed incursion and introduction of new weed species, however this risk will be actively managed through the implementation of standard environmental management protocols. During operation, the risk of weed incursion into the TEC is anticipated to remain similar to existing levels. This is based on the proximity of the South Western System Railway Line. As the Development Footprint is primarily occurring within areas historically cleared, no alteration of fire regimes is expected as a result of the Project. As such, it is considered unlikely to cause a substantial change in the species composition of the Poplar Box TEC.

EPBC Act criteria – is there a real chance or possibility that the Project will:	Assessment of significance
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: assisting invasive species, that are harmful to the listed ecological community, to become established; or causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community?	No. As above, the main risk to causing a substantial reduction in the quality or integrity of the ecological community is weed incursion. Due to the configuration and extent of the proposed clearing, it is expected there will be a similar risk of weed incursion into the TEC, as currently exists during the operational phase of the Project. As described above, this risk is considered low. Construction may cause an increased risk of invasive species becoming established in the TEC, however this will be effectively managed through the provisions of the site's standard environmental protocols The Project will not cause regular mobilisation of fertilisers, herbicides, chemicals or other pollutants into the ecological community and it is expected that the current risk at the site will remain following Project development. Therefore, the Project is considered unlikely to cause a substantial reduction in the quality or integrity of the ecological community.
Interfere with the recovery of an ecological community?	No. Minor direct impacts involve the proposed clearing of a narrow linear strip of 0.22 ha of TEC on the southern edge of a patch 2.3 ha in total size. Indirect impacts are expected to remain similar to current conditions on site. The Project has avoided two of the three Poplar Box TEC patches mapped in the local area. Areas to be impacted are likely to be already impacted by edge effects and occur adjacent to the rail corridor. Opportunities to further minimise the clearing of Poplar Box TEC will be explored where possible. Therefore, the Project will not interfere with priority recovery and threat abatement actions as stipulated in the conservation advice (Department of the Environment, 2013a). Habitat critical to the survival of Poplar Box TEC will remain and will continue to support the Poplar Box TEC in the area following the development of the Project.

Koala (*Phascolarctos cinereus*)

The koala is an arboreal mammal that occurs within Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia. Koalas are reported to be widespread across Queensland, occurring in patchy and often low-density populations across the different bioregions (DoE 2021).

The koala inhabits a range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities supporting *Eucalyptus* species. Koalas in Queensland inhabit the moist coastal forests, southern and central western subhumid woodlands, and a number of eucalypt woodlands adjacent to waterbodies in the semi-arid western parts of the state (Melzer et al. 2000). They are also known to occur in modified or regenerating native vegetation communities.

Field surveys undertaken within the Study Area targeted eucalypt woodlands to assess habitat suitability for koala and actively search for signs of their presence. No koalas were recorded in the Study Area, however, habitat suitable to support foraging and dispersal was recorded. Mapped within the Study Area based on ground-truthed regional ecosystem mapping, a total of 7.7 ha of koala foraging and dispersal habitat is present. Of this habitat a total of 1.1 ha of this habitat will be impacted by the Project.

Potential habitat for the koala within the Development Footprint comprises regrowth eucalypt woodland with scattered mature trees. All potential habitat is considered suitable for foraging and dispersal.

Although the extent of koala habitat within the Study Area is minimal, large patches of suitable habitat is present to the north in the Whetstone State Forest and south in association to Macintyre Brook and Yelarbon State Forest. The proximity of these large patches of koala habitat may increase the likelihood of this species utilising the Study Area for dispersal.

Based on the availability of suitable habitat within the Study Area and the occurrence of historical records within the desktop search extent, the likelihood that this species occurs within the Study Area is Moderate.

The extent of koala habitat within the Study Area and Development Footprint is provided below.

Fauna Habitat Type	Extent within Study Area (ha)	Development Footprint (ha)
<i>Eucalyptus moluccana</i> woodland on flat plains	2.4	0
Regrowth eucalypt woodland with scattered mature trees	5.3	1.1
Total	7.7	1.1

Important Populations

While not generally applicable to species listed Endangered under the EPBC Act, the Conservation Advice for *Phascolarctos cinereus* (Koala) (Department of Agriculture Water and the Environment, 2022), defines important populations of the species. These have been identified as those which are valuable for cultural, social and economic reasons as well as for the species conservation. Important populations for the conservation of the species are those that:

- have the potential to act as source populations to adjacent areas of suitable, or potentially suitable, habitat
- exist in areas of climatically suitable refugia during periods of environmental stress including droughts, heatwaves, and long-term climate change
- are genetically diverse
- are disease free and/or exhibit low rates of infection with important pathogens
- contain genes which may confer adaptation to current and future environmental stressors
- are geographical or environmental outliers within the species range.

Populations which are considered to be important for social, cultural or economic reasons include:

- cultural and spiritual importance to Indigenous people
- the social value and enjoyment of having koalas close to residential areas
- the economic value brought to local business and tourism
- the iconic species value at the national and international political and community level.

Habitat Critical to the Survival of the Species

On 22 February 2022, the koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) status of Vulnerable was upgraded to Endangered under the EPBC Act.

Potential significant impacts on koala may occur if habitat that is considered to be critical to the survival of the species is adversely impacted. The Conservation Advice for *Phascolarctos cinereus* (Koala) (Department of Agriculture Water and the Environment, 2022) defines habitat critical to the survival of the species as “the areas that the species relies on to avoid or halt decline and promote the recovery of the species”.

While the Study Area is not known to support a population of the species, the Conservation Advice includes currently ‘unoccupied’ areas in the definition of habitat critical to the survival of the species. Furthermore, the Conservation Advice also regards foraging habitat as a factor in determining habitat critical to the survival of the species. Given that foraging habitat is mapped within the Study Area, habitat critical to the survival of the species is present.

Significance Assessment

The significant impact assessment for this species is presented below. This assessment considers the information presented in the updated Conservation Advice for *Phascolarctos cinereus* (Koala) (Department of Agriculture Water and the Environment 2022), SPRAT, as well as the Referral Guidelines for the Vulnerable Koala (Department of the Environment 2014). Whilst the EPBC Act Referral Guidelines for the Vulnerable Koala have been redacted, the current Conservation Advice still references these guidelines as the source on how to “navigate the complexity of koala habitat to identify significant impacts”.

The SIA for this species is presented below. In summary, a significant impact was not triggered for this species.

Evaluation Criteria	Response
Lead to a long-term decrease in the size of a population of the species	No. The Disturbance Footprint may be used occasionally for foraging or dispersal, however this habitat is not sufficient to support a population of koala. Based on the criteria identified in the species Conservation Advice, any individuals which may utilise this habitat would not constitute an 'important population'. A maximum of 1.1 ha of potential koala habitat will be directly impacted as a result of the Project. This habitat is characterised as regrowth eucalypt woodland with scattered mature trees. As this habitat exists in a regrowth state, it is not considered highly unique or important for refuge and habitat with much greater resource potential, quality and condition occurs directly north and south of the Study Area in State forests. Given the potential absence or infrequent use of the Development Footprint and the availability of more suitable habitat adjacent to the Study Area, a long-term decrease in the size of a population is unlikely to result from the Project.
Reduce the area of occupancy the species	No. As stated in the species Conservation Advice, the estimated extent of occurrence for koala is 1,665,850 km². Koala is also widespread across Queensland, and the Development Footprint is not located near the limit of the species distribution. The Project will result in the removal of up to 1.1 ha of potential habitat, this habitat is not known to support a local population and habitat of much higher quality is widely available directly north, and south of the Study Area. Based on this, Project works are considered unlikely to materially reduce the availability or quality of habitat for the species to the point where the species' extent of occupancy would be reduced.
Fragment an existing population into two or more populations	No. The species is considered highly mobile and known to disperse large distances. Patches of potential habitat occurring within the Development Footprint are already highly fragmented as a result of historical clearing and agricultural practices. Given the minor extent of proposed impact to proposed koala habitat and the ability for this species to readily disperse across non-remnant areas, vegetation clearance associated with the Project is unlikely to present a barrier to this species local movement, to the extent that it fragments any population of this species within the area.
Adversely affect habitat critical to the survival of a species	No. The Project proposes to remove 1.1 ha of potential koala habitat which is characterised as regrowth eucalypt woodland with scattered mature trees. The remaining area of impact exists within non-remnant agricultural land used primarily for wheat cropping. While the Development Footprint is not known to support a population of the species, the Conservation Advice includes currently 'unoccupied' areas in the definition of habitat critical to the survival of the species. The quality of this habitat is such that its removal is unlikely to result in an adverse impact to habitat critical to the survival of this species given the small scale of the disturbance and the presence of existing pressure from threatening processes such as weed incursion, agricultural impacts and previous clearing events.
Disrupt the breeding cycle of a population	No. No population of this species are known to occur within the Development Footprint, and if present individuals are expected to occur in low densities. Male koala's are known to disperse large distances during the breeding season in search of a mate, and dispersal will not be hindered by the Project. As the species does not have specific breeding requirements, all potential habitat may be suitable for breeding. Given the potential absence or infrequent use of the Development

Evaluation Criteria	Response
	Footprint by this species, the Project is unlikely to disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No. Koala has very broad habitat requirements and can inhabit vegetation in varying condition, including non-remnant. Although the small area of 1.1 ha of potential habitat will be removed via vegetation clearing, areas of suitable habitat will remain within the Study Area. Given potential absence or infrequent use of the Development Footprint by this species as well as the minimal proposed clearing of potential habitat, large tracts of higher value habitat directly adjacent and the mobility of the species, it is unlikely that the Project will alter habitat to the extent where the species is likely to decline.
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	No. A number of exotic fauna species were identified within the Study Area during the field survey program. Although wild dog/dingo was not recorded during field surveys, the species is expected to occur surrounding region. The Project will employ best practice control methods for weeds and pests and is unlikely to introduce or exacerbate weeds or pests beyond existing levels.
Introduce disease that may cause the species to decline	No. Chlamydia and Koala Retrovirus (KoRV) are known threats to the species. The Project follows best practice construction and operational methods; therefore, introduction of a disease is unlikely.
Interfere with the recovery of the species	No. A National Recovery Plan for the Koala was published in 2022. Four main objectives are detailed: • Stabilise and then increase the area of occupancy and size of populations that are declining. • Maintain or increase the area of occupancy and size of populations that are stable. • Metapopulation processes are maintained or improved. • Partners, communities and individuals have a greater role and capability in Koala monitoring, conservation and management. As specified by the Conservation Advice, populations of koala in Queensland are generally of low density, widespread and fragmented. Although total population numbers of the species are known to have been significantly impacted following the 2020 bushfires, it is unclear how or if the local population/s within the region were affected and if they are declining. Given only a small subset of a local population may utilise the Development Footprint, the Project is unlikely to alter overall population numbers, dynamics or occupancy areas. Recognised threats to the species are also unlikely to be increased or exacerbated by the Project. Based on this, the Project is unlikely to interfere with the recovery of the species.

Grey-headed Flying Fox (*Pteropus melanocephalus*) - Vulnerable

The grey-headed flying-fox is highly mobile and considered 'highly adaptable' given its proclivity to occupy urbanised environments. Only a small proportion of its' wide range is used at any one time as the species selectively forages where food is available. Patterns of occurrence and relative abundance within its range vary widely between seasons and between years. At a local scale, the species is generally present intermittently and irregularly.

Important Population

An 'important population' of this species is not defined in the National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus* (DAWE 2021), however, Nationally Important Camps have been identified on the DCCEEW interactive flying fox web viewer. Nationally Important Camps are flying fox camps that have contained $\geq 10,000$ grey-headed flying-foxes in more than one year in the last 10 years or have been occupied by more than 2,500 grey-headed flying-foxes permanently or seasonally every year for the last 10 years (DAWE 2021).

As per ARTC (2021), the species was recorded at a camp located near the township of Inglewood, approximately 18 km north-east of the Study Area, however this camp does not meet the definition of a Nationally Important Camp. No Nationally Important Camps have been identified within 100 km of the Study Area.

Habitat Critical to the Survival of the Species

Habitat critical to the survival of this species, as described in the National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus* (DAWE 2021) includes:

- Important winter and spring vegetation communities that contain the following species:
 - *Eucalyptus tereticornis*, *E. albens*, *E. crebra*, *E. fibrosa*, *E. melliodora*, *E. paniculata*, *E. pilularis*, *E. robusta*, *E. seeana*, *E. sideroxylon*, *E. siderophloia*, *Banksia integrifolia*, *Castanospermum australe*, *Corymbia citriodora citriodora*, *C. eximia*, *C. maculata*, *Grevillea robusta*, *Melaleuca quinquenervia* or *Syncarpia glomulifera*
- Vegetation communities that contain native species that are known to be productive as foraging habitat during the final weeks of gestation, and during the weeks of birth, lactation and conception (August to May)
- contain native species used for foraging and occur within 20 km of a nationally important camp as identified on the Department's interactive flying-fox web viewer
- contain native and or exotic species used for roosting at the site of a nationally important Grey-Headed Flying-Fox camp as identified on the Department's interactive flying-fox web viewer.

Given the persistence of several Queensland blue gum (*Eucalyptus tereticornis*) trees, an important flowering species, the habitat to be removed broadly represents this definition.

Modelled habitat for this species within the Study Area includes vegetation communities containing suitable food resources such as fruits and blossoms. The extent of grey-headed flying fox habitat within the Study Area and Development Footprint is provided below.

Fauna Habitat Type	Extent within Study Area (ha)	Development Footprint (ha)
<i>Eucalyptus moluccana</i> woodland on flat plains	2.4	0
Regrowth eucalypt woodland with scattered mature trees	5.3	1.1
Total	7.7	1.1

Significance Assessment

The significant impact assessment for this species is presented below. This assessment considers the information presented in the updated National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus* (DAWE 2021) and the relevant SPRAT profile for this species.

The SIA for this species is presented below. In summary, a significant impact is considered unlikely to occur as a result of the Project for this species.

Evaluation Criteria	Response
lead to a long-term decrease in the size of an important population of a species	No, This species was not recorded within the Study Area. As per ARTC (2021), the species was recorded at a camp located near the township of Inglewood, approximately 18 km northeast of the Study Area, however this camp does not meet the definition of a Nationally Important Camp. An important population that is necessary for the long-term survival and recovery of this species is not known from the Study Area based on the absence of a known population (as camps or individual) of this species. A total of 1.1 ha of potential habitat occurs within the Development Footprint, associated with regrowth and remnant eucalypt woodlands. Potential habitat is likely to only be utilised occasionally by a small number of individuals, under ideal conditions when canopy trees are in flower. However, it is noted that adjacent woodlands associated with the state forests and Macintyre Brook are likely to be preferred given the significantly greater availability of resources. This species is highly mobile, travelling large distances at night in search of suitable foraging habitat. Foraging habitat for this species is highly seasonal and generally occurs in sparse distribution throughout the landscape. Given this species mobility, it is likely to avoid the area while works occur. Given that no important population is known from the Study Area and this species is not expected to rely on the Development Footprint as a foraging resource, it is unlikely that the Project will lead to a long-term decrease in the size of an important population of this species as a result of habitat clearing.
Reduce the area of occupancy of an important population	No. Habitat within the Development Footprint is marginally suitable foraging habitat and is not expected to be depended upon by this species. If this species uses the habitat within the Development Footprint, it is likely to be irregular given the large tracts of remnant, continuous habitat to the north and south of the Study Area contained in State Forests. Further, despite the species being recorded at a camp located near the township of Inglewood, approximately 18 km northeast of the Study Area, this camp does not meet the definition of a Nationally Important Camp. An important population that is necessary for the long-term survival and recovery of this species is not known from the Study Area given an absence of a known population (as camps or individual) of this species. Given the above, the Project is unlikely to reduce the area of occupancy of an important population.

Evaluation Criteria	Response
Fragment an existing important population into two or more populations	No. This species is highly mobile, travelling large distances, across cleared and developed landscapes at night in search of suitable foraging habitat. The removal of habitat within the Development Footprint would not limit this species capacity to travel between foraging habitat as this removal would not present significant barriers to the species movements. Given this, the proposed impact is unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	No. The occurrence of key tree species including Queensland blue gum (<i>Eucalyptus tereticornis</i>) broadly defines habitat within the Development Footprint as habitat critical to the survival of the species. As only several individuals in regrowth condition would be removed, the impact to this habitat is considered to be negligible. Overall, the loss of 1.1 ha of already highly fragmented, low-quality habitat is considered to have a negligible effect on the species, should it be present. Further, the region offers large tracts of remnant, continuous habitat suitable for this species to the north and south of the Study Area. Given this, the proposed impact is unlikely to adversely affect habitat critical to the survival of a species
Disrupt the breeding cycle of an important population	No. This species breeds annually in camps with births occurring from October to December. As per ARTC (2021), the species was recorded at a camp located near the township of Inglewood, approximately 18 km northeast of the Study Area.. Despite the occurrence of a camp within 18 km of the Study Area, the Project is highly unlikely to impact it especially given the small scale of disturbance proposed within the Development Footprint. Further, as the species has not been recorded at the Inglewood roost historically, it is considered likely to only be used on a temporary basis by a small subset of the population. The Project is therefore unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No. The proposed impact to marginal grey-headed flying fox habitat is negligible given the landscape context which offers large, continuous patches of remnant vegetation to the north and south of the Study Area. This species is unlikely to rely on the habitat contained within the Development Footprint for foraging given its small area and poor quality. Further, this species is highly mobile, travelling large distances at night in search of suitable foraging habitat. Foraging habitat for this species is highly seasonal and generally occurs in sparse distribution throughout the landscape. The removal of habitat contained within the Development footprint is therefore unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	No. Invasive species, particularly weeds, were recorded throughout the Study Area. However, there are no particular weed or pest species identified as relevant to grey-headed flying-fox. The Project employs best practice control methods for weeds and pests and is unlikely to introduce or exacerbate weeds or pests beyond existing levels.
Introduce disease that may cause the species to decline	No. There are no known diseases affecting the species. The Project follows best practice construction and operational methods; therefore, introduction of a disease is unlikely.
Interfere substantially with the recovery of the species	No. As defined in the National Recovery Plan for Grey-headed Flying Fox <i>Pteropus poliocephalus</i> (DAWE 2021), recovery objectives for this species include: development of robust estimate of an increasing population trend

Evaluation Criteria	Response
	• an improved understanding of habitat critical to the survival of the species • an increase in protection of habitat critical to the survival of the species and • nationally important camp sites • implementation of effective habitat restoration projects • a reduction of conflict between people and flying-foxes in residential areas through • investment in household mitigation measures • greater uptake of crop netting under subsidy schemes • decrease in the number of licences issued to harm the species • an improved understanding of threats with as yet unquantified impacts on flying foxes, such as electrocution, entanglements and climate change. The greatest threat to this species, being habitat loss and degradation is likely to occur resultant of Project impacts. However, the scale of impact, being 1.1 ha of marginally suitable habitat is unlikely to be substantial given the scale of undisturbed foraging habitat within region comparative to that proposed to be removed significant. This species is unlikely to rely on habitat within the Development Footprint and as such, it's removal will have a negligible impact on the recovery of the species.



B2G Borrow Pit Ecological Surveys

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Glossary of Terms

Acronym	Description
ARTC	Australian Rail and Track Corporation
B2G	Border to Gowrie
cm	Centimetres
EDL	Ecologically Dominant Layer
Ha	Hectare
m	Metres
MNES	Matters of National Environmental Significance
MSES	Matters of State National Environmental Significance
NC Act	<i>Nature Conservation Act 1992 (Qld)</i>
RE	Regional Ecosystem
sp.	Species (singular)
spp.	Species (plural)
sub sp.	Sub species

1 Introduction

1.1 Background

The Inland Rail Program (Inland Rail) involves the design and construction of a new inland rail connection between Melbourne and Brisbane approximately 1,700 kilometres (km) in length. The Australian Rail Track Corporation (ARTC) is the proponent for Inland Rail. The Inland Rail has been divided into 13 separate projects, five of which are located in Queensland (QLD):

- Border to Gowrie (B2G)
- Gowrie to Helidon (G2H)
- Helidon to Calvert (H2C)
- Calvert to Kagaru (C2K)
- Kagaru to Acacia Ridge and Bromelton (K2ARB)

The Border to Gowrie (B2G) section comprises approximately 176 km of new dual gauge track and 78 km of upgraded track from the New South Wales/Queensland border to Gowrie - northwest of Toowoomba.

Formation of the track requires construction materials, which will be extracted from areas outside of the proposed rail corridor, referred to as borrow pits.

1.2 Project Scope

Ausecology was engaged by ARTC to conduct ecological surveys of the proposed borrow pits associated with the B2G alignment to assess potential ecological impacts to Matters of National Environmental Significance (MNES) and Matters of State National Environmental Significance (MSES).

2 Methodology

2.1 Survey Methodology

Field surveys were conducted at ten proposed borrow pit sites between the 5th and 6th of September 2023. Appendix A provides a mapped overview of the sites. Following initial surveys, three of the sites were removed by ARTC to avoid potential impacts and are therefore not included in this report, leaving seven pits in consideration. At each proposed borrow pit site, a general vegetation assessment was conducted, along with brief searches for threatened flora and fauna.

2.2 Review of databases, literature and previous studies

Desktop searches and a review of existing information was undertaken as part of the initial ecological assessment. These searches were undertaken to help inform and identify the presence of potential threatened species, habitat and vegetation communities prescribed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act).

2.3 Ground-truthing Regional Ecosystems

For select sites where general observation was not sufficient to inform on the potential impacts of the proposed pit, quaternary surveys using the methodology outlined within *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner et al., 2022) were undertaken. The location of the quaternary sites is indicated in the individual site maps presented in the results.

2.4 BioCondition assessments

BioCondition assessments were only conducted if additional REs were identified that had not been previously assessed as part of Ausecology B2G survey efforts (Ausecology, 2022). No additional REs were identified and therefore no BioCondition assessments were undertaken as part of this supplementary assessment.

2.5 Targeted flora surveys

Formal protected plant surveys in accordance with the *Qld Protected Plants – Flora Survey Guidelines* (DES, 2020) were not undertaken for the present report. However, random meander transects were undertaken across the site targeting likely threatened flora species habitat.

2.6 Incidental fauna surveys

Targeted threatened fauna surveys were outside the scope of this supplementary assessment. However, incidental sightings of threatened fauna were logged, and opportunistic habitat searches were conducted at locations deemed to have an increased likelihood of occurrence for particular threatened species.

3 Results

The results of the borrow pit ecological surveys are presented for each site by Lot Plan in the section below.

3.1 Site ID 1 - 2SP229051 – Moorroobie Lane

Table 3-1 Monitoring results for 2SP229051

SITE SUMMARY 2SP229051	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site comprises a cropped field. Scattered mature trees are present along the access track but can easily pick a path without clearing. No MNES or MSES were recorded. See Appendix 1B for mapping of this site.	
RECOMMENDATIONS	
▪ Use existing gate and track to enter access pit site. ▪ Suitable borrow pit with no impact to MSES or MNES.	

3.2 Site ID 2 - 53MH233 – Tait's Red Ridge

Table 3-2 Monitoring results for 53MH233

SITE SUMMARY 53MH233	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site is a cleared non-remnant (Category X) paddock dominated by exotic grass such as <i>Eragrostis curvulua</i> (African lovegrass) and forbs including <i>Sclerolaena</i> spp., <i>Calotis</i> spp. along with scattered <i>Eucalyptus populnea</i>. Restricted invasive species <i>Opuntia tomentosa</i> (velvety tree pear) and <i>Harissia martinii</i> (harissia cactus) were also recorded at the site. No MNES or MSES were recorded. See Appendix 1C for mapping of this site.	
RECOMMENDATIONS	
No impacts to MSES or MSES noting that scattered mature paddock trees that may provide dispersal function for Koala will be avoided.	

3.3 Site ID 3 - 116BNT467 – Mosquito Creek Road

Table 3-3 Monitoring results for 116BNT467

SITE SUMMARY 116BNT467	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site contains shrubby non-remnant RE 11.9.13 (Category X), dominated by <i>Allocasuarina leuhmanii</i>, <i>Acacia polybotrya</i>, <i>Daviesia ulicifolia</i>, and <i>Leptospermum</i> sp. The ground layer consists predominantly of the native grass <i>Aristida caput-medusae</i>, with some cover of exotic forb species <i>Gladularia aristigera</i>. The section between the road and the proposed borrow pit contains RE 11.9.9a dominated by mature <i>Eucalyptus tereticornis</i>, <i>Eucalyptus crebra</i>, <i>Angophora leiocarpa</i>, and <i>Eucalyptus woollsiana</i>. This may also qualify as White Box TEC under the EPBC Act. Avoiding this area should be a priority. This has been avoided by using the existing access track from the entrance gate to access the borrow pit and avoid all impacts to potential MSES and MNES. This track is sufficiently wide the no additional clearing will be required. See Appendix 1D for mapping of this site.	
RECOMMENDATIONS	
Nil – suitable borrow pit using existing access and no impact to MSES or MNES	

3.4 Site ID 4 - Road Parcel Against Millmerran-Inglewood Rd

Table 3-4 Monitoring results for Road Parcel

SITE SUMMARY Road Parcel	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site is mostly cleared, with scattered mature <i>Eucalyptus crebra</i> and <i>Eucalyptus woollsiana</i>, and sparse shrubs including <i>Acacia shirleyi</i>, and <i>Acacia decora</i>. The track to the proposed pit site (bottom right image) contains non-remnant RE 11.5.20 (Category X) dominated by <i>Callitris glaucophylla</i>, <i>Eucalyptus microcarpa</i>, and <i>Eucalyptus crebra</i>. The track is ~4m wide and likely requires widening to access the proposed borrow pit. See Appendix 1E for mapping of this site.	
RECOMMENDATIONS	
- Clear and widen track along a 15m section to enable access to the proposed pit site. - No impacts to MSES or MSES noting that scattered mature paddock trees that may provide dispersal function for Koala will be avoided.	

3.5 Site ID 5 - 33MA3499 – Kooroongarra-Andersons Road

Table 3-5 Monitoring results for 33MA3499

SITE SUMMARY 33MA3499	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site is a cleared paddock filled mainly with <i>Chloris gayana</i> . A mix of native forbs such as <i>Sclerolaena muricata</i> and <i>Wahlenbergia gracilis</i> were also recorded. No MNES or MSES were recorded. See Appendix 1F for mapping of this site.	
RECOMMENDATIONS	
N/A	

3.6 Site ID 6A - 98DY182 – Heckendorfs Road

Table 3-6 Monitoring results for 98DY182

SITE SUMMARY 98DY182	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site is a grazed non-remnant (Category X) cleared paddock comprising of mainly exotic pasture grasses including <i>Chloris gayana</i> with a mix of native forbs such as <i>Sclerolaena muricata</i> and <i>Wahlenbergia gracilis</i>. No MNES or MSES were recorded. One specimen of <i>Santalum lanceolatum</i>, listed as Special Least Concern under the <i>Nature Conservation Act 1992</i> (NC Act) was recorded at the site. See Appendix 1G for mapping of this site.	
RECOMMENDATIONS	
Nil – suitable borrow pit with existing access and no impacts to MSES or MNES	

3.7 Site ID 6B - 111DY182 – Heckendorfs Road

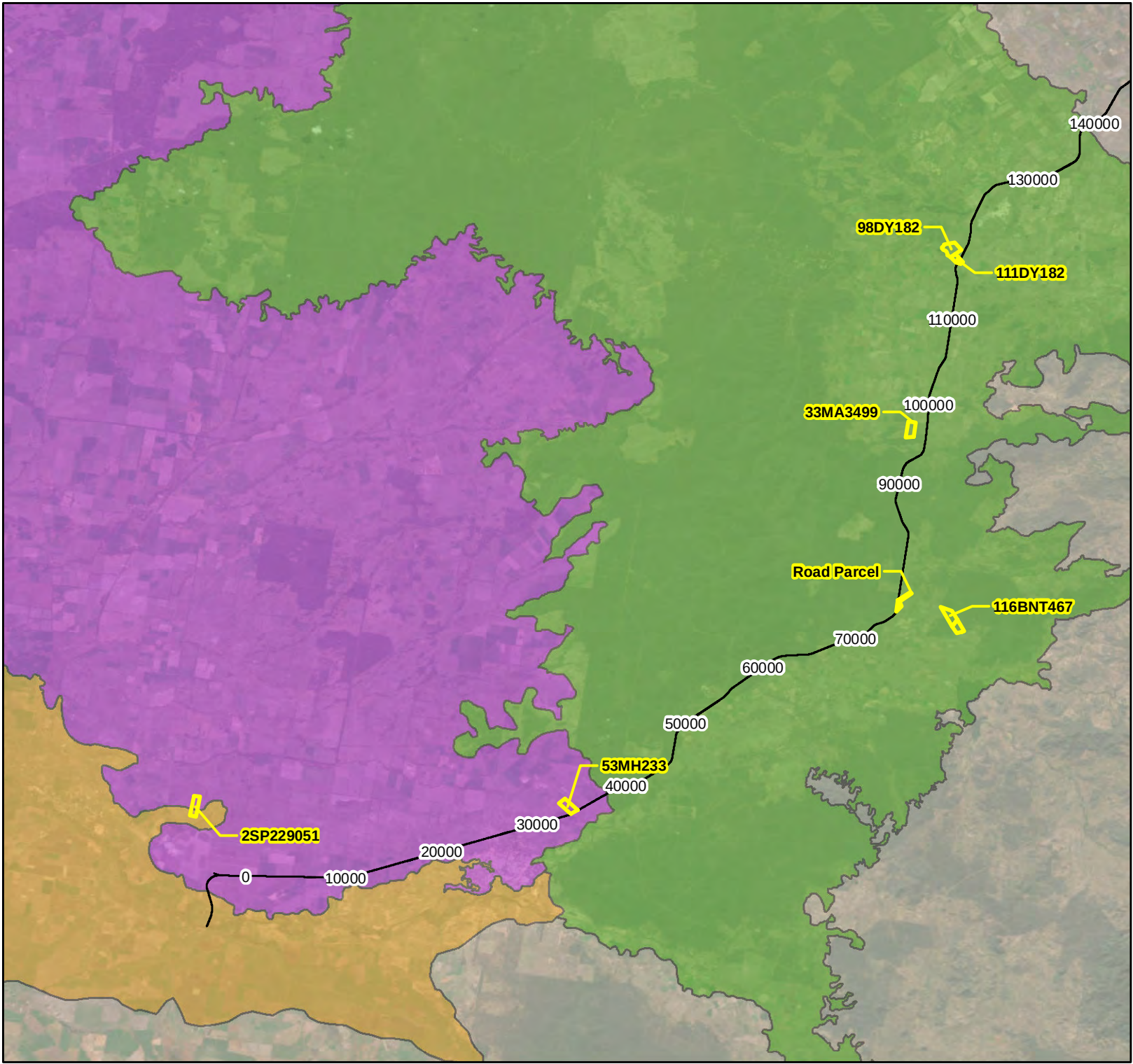
Table 3-7 Monitoring results for 111DY182

SITE SUMMARY 111DY182	
	
	
KEY OBSERVATIONS AND FIELD NOTES	
The site is a heavily grazed non-remnant (Category X) paddock of <i>Chloris gayana</i>. Scattered exotic shrubs include the restricted invasive species <i>Lycium ferocissimum</i> (African boxthorn) and <i>Gomphocarpus physocarpus</i> (balloon cotton bush). The site is located on the property adjacent to the previous site 98DY192. No MNES or MSES were recorded. See Appendix 1H for mapping of this site.	
RECOMMENDATIONS	
Nil – suitable borrow pit with existing access and no impacts to MSES or MNES	

4 References

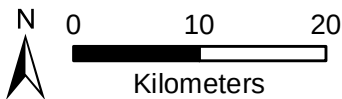
Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S., Butler, D.W., McDonald, W.J.F, Richter, D., Addicott, E.P. and Appelman, C.N. (2022) Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland. Version 6.0. Updated April 2022. Queensland Herbarium, Queensland Department of Environment and Science, Brisbane.

Appendix A – Mapping



Appendix 1A:

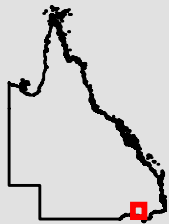
Overview Map B2G
Borrow Pits



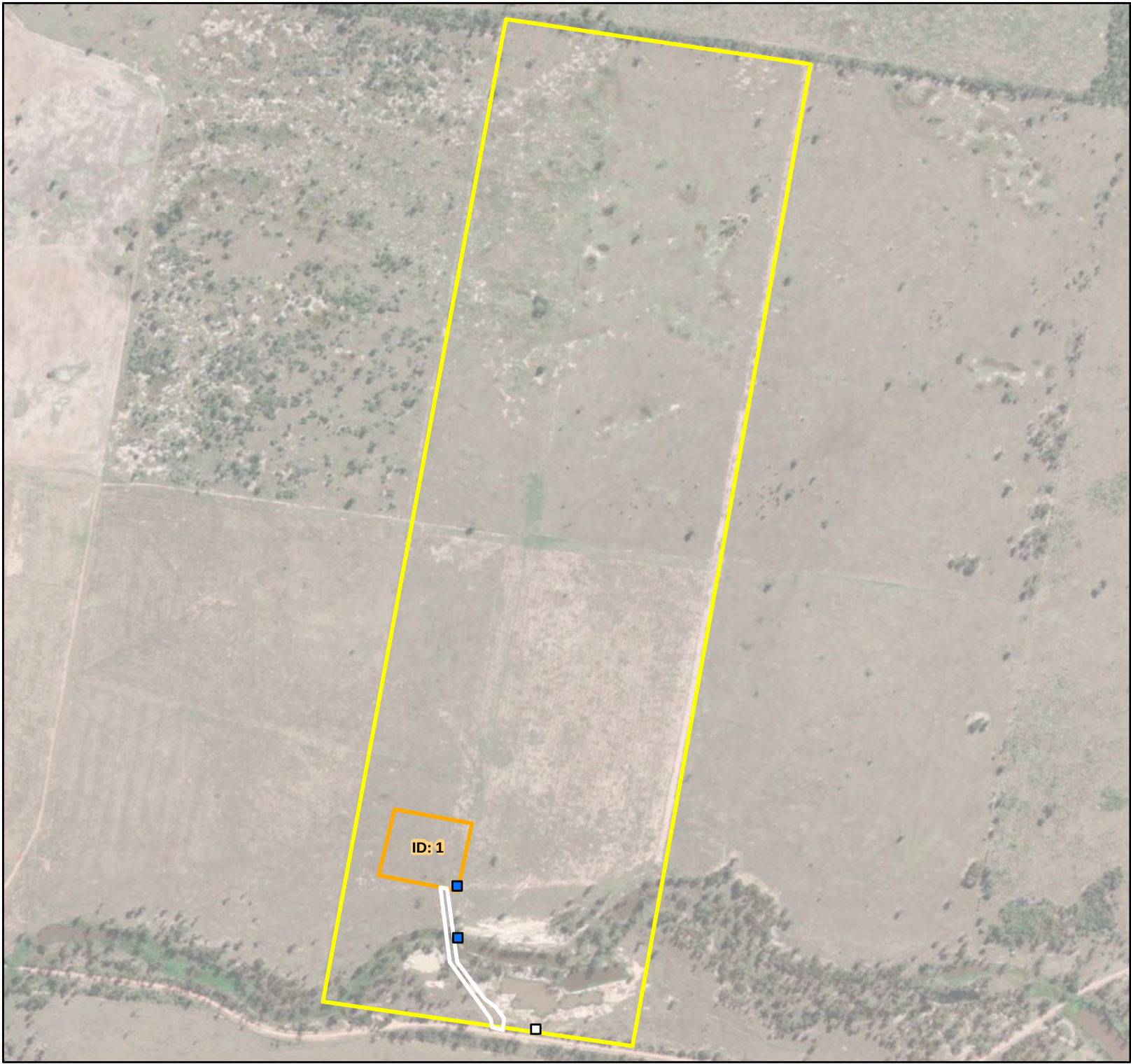
Scale: 1:600,000
Coordinate System: GCS GDA 1994
Datum: GDA 1994

Legend

- B2G
- Property
- IBRA -**
 - Castlereagh-
 - Inglewood
 - Moonie-Commonon



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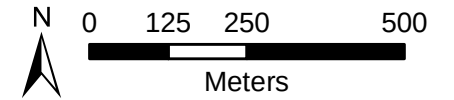


Appendix 1B:

SITE ID 1 - 2SP229051

Moorroobie Lane

B2G Proposed Borrow Pits



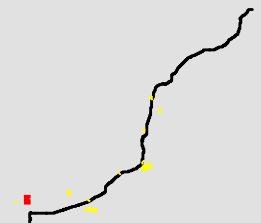
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Coordinate System: GCS GDA 1994

Datum: GDA 1994

Legend

- Photo point
- Existing gate
- Access Tracks
- Borrow Pit Extent
- Property boundary



Document History:

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1	Issued for Information	JS	LG	01/02/2024
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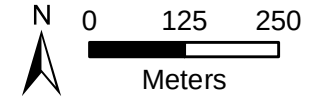


Appendix 1C:

Site ID 2 - 53MH233

Taits Red Ridge

B2G Proposed Borrow Pits



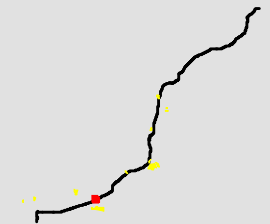
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Datum: GDA 1994

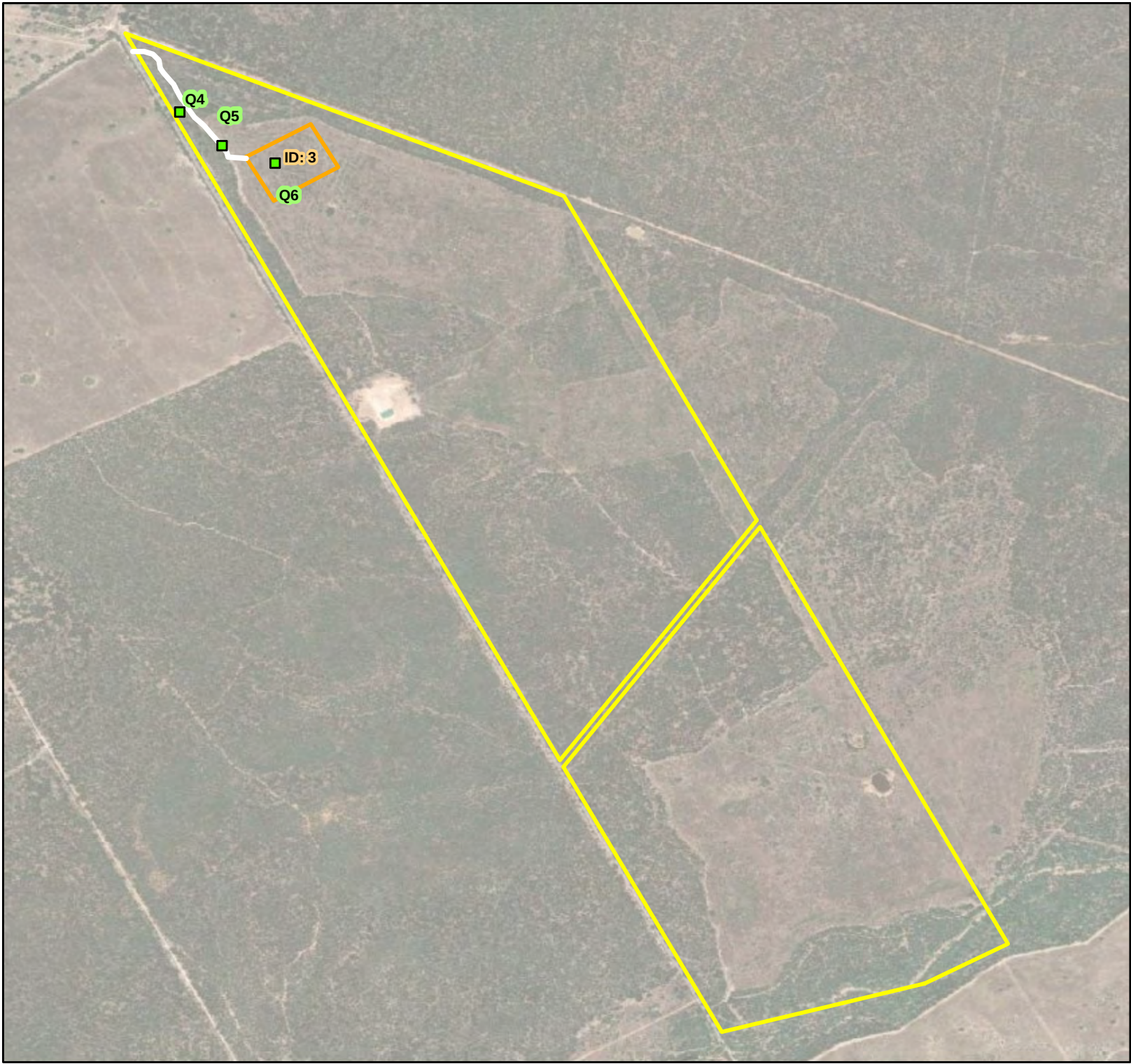
Legend

-  Photo point
-  Quaternary point
-  Access Tracks
-  Borrow Pit Extent
-  Property boundary



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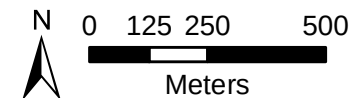


Appendix 1D:

Site ID 3 - 116BNT467

Mosquito Creek Road

B2G Proposed Borrow Pits



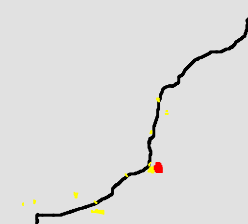
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Datum: GDA 1994

Legend

- Quaternary point
- Existing Track (Current Track)
- Borrow Pit Extent
- Property boundary



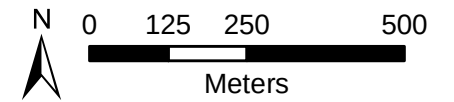
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Appendix 1E:

Site ID 4 - Road Parcel
Against Millmerran-
Inglewood Road B2G
Proposed Borrow Pits

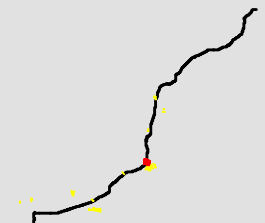


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Coordinate System: GCS GDA 1994
Datum: GDA 1994

Legend

- Quaternary point
- Photo point
- Quaternary point
- Access Tracks
- Borrow Pit Extent
- Property boundary



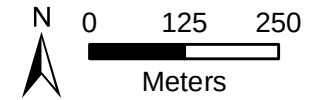
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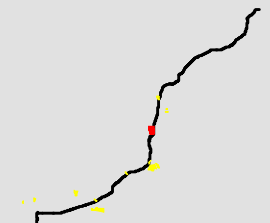
Site ID 5 - 33MA3499
Kooroongarra Road
B2G Proposed Borrow Pits



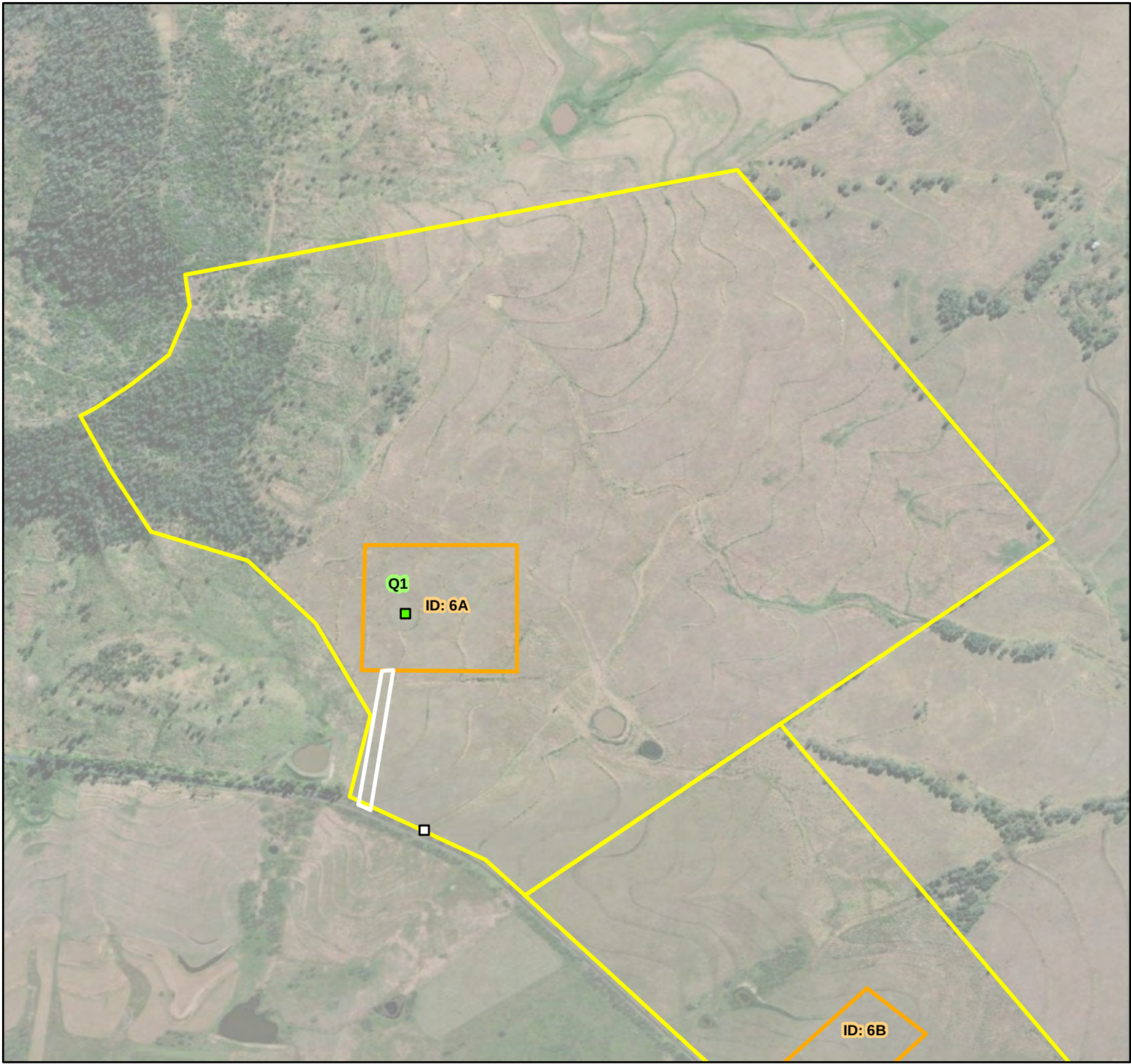
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Datum: GDA 1994

Legend

-  Photo point
-  Access Tracks
-  Borrow Pit Extent
-  Property boundary

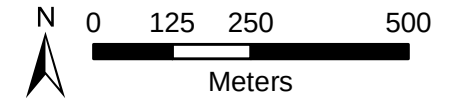


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Appendix 1G:

Site ID 6A - 98DY182
Heckendorfs Road
B2G Proposed Borrow Pits



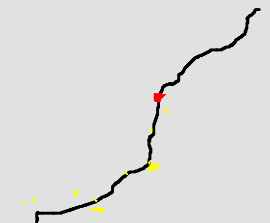
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Datum: GDA 1994

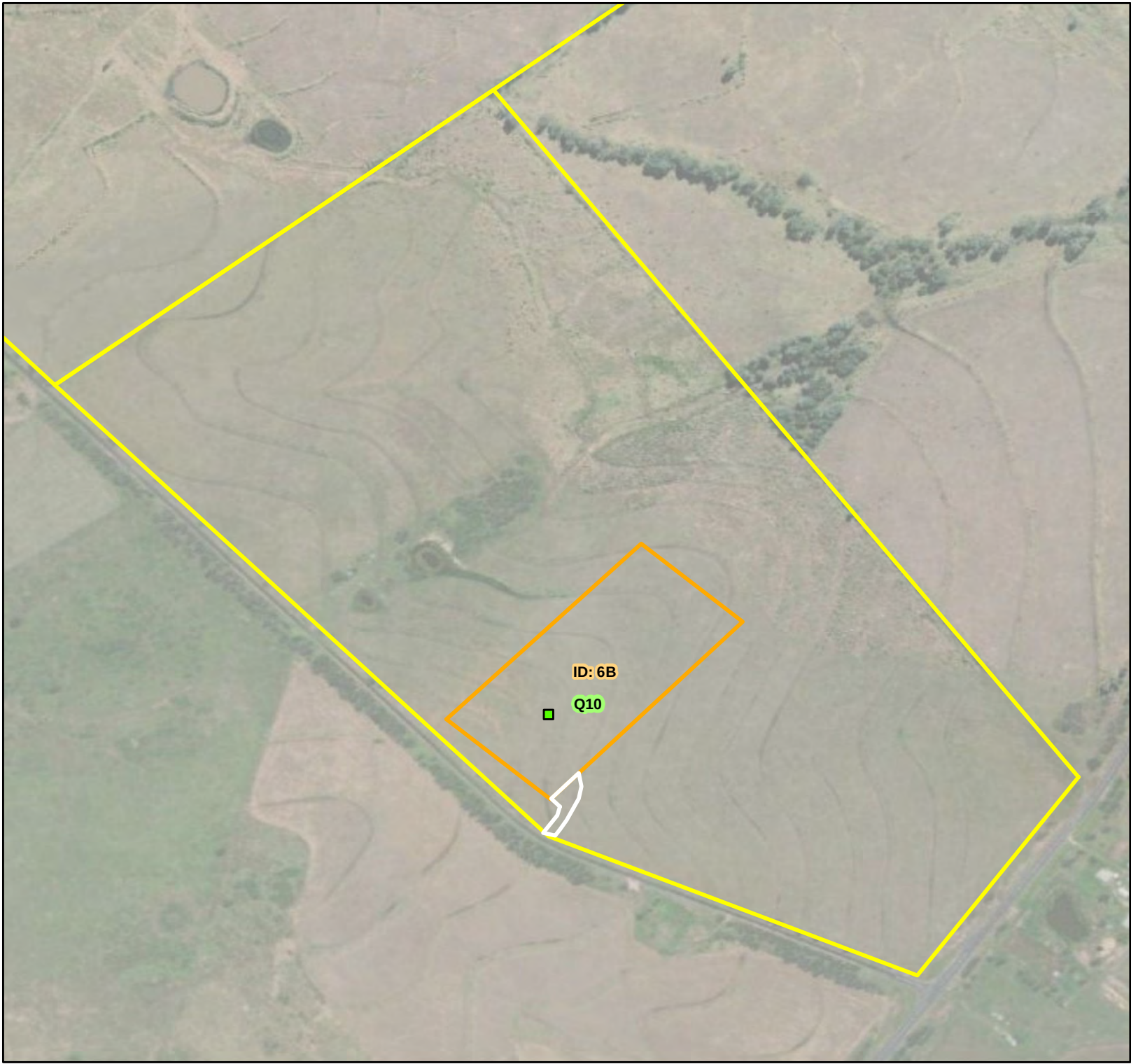
Legend

- Quaternary point
- Existing gate
- Access Tracks
- Borrow Pit Extent
- Property boundary



Document History:

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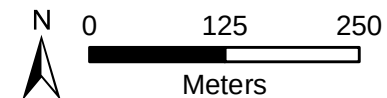


Appendix 1H:

Site ID 6B - 111DY182

Heckendorfs Road

B2G Proposed Borrow Pits



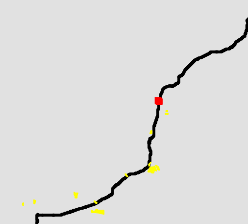
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Coordinate System: GCS GDA 1994

Datum: GDA 1994

Legend

- Quaternary point
- Access Tracks
- Borrow Pit Extent
- Property boundary



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Inland Rail (Border to Gowrie Project)

Aquatic Ecology Technical Report

Prepared for
Future Freight Joint Venture

2-0001-310-EAP-10-RP-0209

23 June 2020



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Abbreviations

Abbreviation	Description
ACA	Aquatic Conservation Assessment
ANZECC	Australian and New Zealand Environment and Conservation Council
ARTC	Australian Rail Track Corporation
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
AusRivAS	Australian River Assessment System
CEMP	Construction Environmental Management Plan
DAF	Department of Agriculture and Fisheries
DEHP	Department of Environment and Heritage Protection
DES	Department of Environment and Science
DO	Dissolved Oxygen
EC	Electrical Conductivity
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EMP	Environmental Management Plan
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
EPP	<i>Environmental Protection (Water and Wetland Biodiversity) Policy 2019</i>
EVNT	Endangered, Vulnerable or Near Threatened species
FFJV	Future Freight Joint Venture
GDE	Groundwater Dependent Ecosystem
MNES	Matter of National Environmental Significance
MSES	Matter of State Environmental Significance
NC Act	<i>Nature Conservation Act 1992</i> (Queensland)
PAH	Polycyclic Aromatic Hydrocarbons
PMST	EPBC Act Protected Matters Search Tool
SLC	Special Least Concern
TOR	Terms of Reference
TSS	Total Suspended Solids
WoNS	Weeds of National Significance

Definitions

Term	Description
Construction footprint	The area that would be directly affected by construction. It includes the location of proposal infrastructure, the area that would be directly disturbed by the movement of construction plant and machinery, and the location of the storage areas/compounds sites etc, that would be used to construct that infrastructure.
Impact assessment area	A 2 km wide corridor around the preliminary alignment, which encloses project infrastructure and the construction footprint. The Impact assessment area is the focus of the impact assessment for the aquatic ecology and surface water disciplines. This comprises the areas where the rail corridor intersects with waterways or other locations with aquatic ecology or surface water values, and adjacent areas which may be affected by the Project, including those located downstream of the rail alignment.
Rail alignment	The exact positioning of the track, accurately defined both horizontally and vertically, along which the rail vehicles operate.
Rail corridor	The corridor within which the rail tracks and associated infrastructure are located.
Watercourse	A watercourse is defined in the <i>Water Act 2000</i> as a river, creek or other stream which includes a stream in the form of an anabranch or a tributary where water flows either permanently or intermittently, regardless of flow frequency. In this report, reference to a 'watercourse' is generally made in relation to the management of water resources, consistent with the purpose of the <i>Water Act 2000</i> .
Waterway	A waterway is defined in the <i>Fisheries Act 1994</i> as a river, creek, stream, watercourse or inlet of the sea, including both permanent and ephemeral waterways, and drainage features. Waterways providing for fish passage are a Matter of State Environmental Significance, and works within a waterway may require a development application or must achieve compliance with accepted development requirements. Waterways are generally more widespread than defined watercourses, and are more relevant to the assessment of aquatic ecology values. Therefore, in addition to its statutory meaning under the <i>Fisheries Act 1994</i> , 'waterway' has been adopted in this report as the primary term when referring to aquatic ecology habitats (e.g. rivers, creeks and streams) of the impact assessment area.

Executive Summary

This technical report has been prepared to document aquatic ecology and surface water quality investigations for the Border to Gowrie section of Inland Rail (the Project).

The assessment involved a desktop review of existing information, three aquatic ecology field surveys in June 2018, November 2018 and May 2019, and four surface water field surveys in June 2018, November 2018, February 2019 and April 2019. Additional water quality data were collected at five sites in May 2019, to assist with the interpretation of macroinvertebrate data.

Between 31 and 35 sampling sites were assessed on each field trip, depending on land access arrangements. Many of the ephemeral waterways in the region were dry at the time of sampling, including at times following recent rainfall. In such instances, a habitat assessment was completed, and sampling of water quality and aquatic values occurred at larger waterways nearby. Between 14 and 18 sites had sufficient water during each field trip to collect samples for the analysis of water quality.

Field studies involved the assessment of surface water quality (physico-chemical, nutrients, chlorophyll *a* and dissolved metals), a physical habitat assessment, macroinvertebrate sampling per Queensland AusRivAS protocols and targeted fish surveys. Potential impacts of the Project were assessed by implementing a qualitative significance assessment, based on the sensitivity of environmental receptors to Project impacts and the expected magnitude of environmental impacts.

A number of protected species are known or have the potential to occur in the impact assessment area. This includes the sedge *Fimbristylis vagans* (potential to occur), and the Platypus (known to occur), which are listed as Vulnerable and Special Least Concern respectively under the *Nature Conservation Act 1992* (Qld). The Murray Cod, which is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), was confirmed to be present during the field assessments within both the Macintyre River and Macintyre Brook. The Agassiz's Glassfish was also confirmed to be present in the Macintyre River, with the western (i.e. Murray-Darling Basin) populations of this species listed as endangered under the *NSW Fisheries Management Act 1994*. Other listed flora and fauna species have been determined as unlikely to occur in the impact assessment area, including Silver Perch and Bell's Turtle for which there is no suitable habitat present within the impact assessment area.

Some mapped wetlands and groundwater dependent ecosystems occur throughout the impact assessment area, adjacent to the proposed rail alignment. Waterways to be intersected by the rail alignment are mostly ephemeral and were assessed to be in fair condition overall. Other land uses in the region, particularly agriculture, are likely to have resulted in some degradation of surface water quality and aquatic ecology values in local waterways.

The impact assessment identified that the sensitivity of aquatic ecology and surface water quality values to impacts from the Project ranged from negligible to moderate in scale, following the application of mitigation measures. The highest sensitivities (moderate) were associated with:

- Invasion of aquatic habitats by weed and pest species during the construction phase
- Declines in water and sediment quality from bank erosion, and the runoff of sediments and contaminants into waterways during the construction phase.

However, these risks can be effectively managed through a range of design features (e.g. bridges spanning waterways in preference to culverts) and through the development and implementation of

detailed environmental management plans during detail design, pre-construction, construction and operation phases of the Project.

There is limited potential for cumulative impacts from other projects in the region that either currently exist or are planned in the future. Cumulative impacts were assessed to be limited to construction and operation phase activities that may influence water quality and aquatic ecology values downstream of the Project.

1 Introduction

1.1 Background

The Australian Rail Track Corporation (ARTC) proposes to transform the way freight is moved around the country through construction of the Inland Rail project. The Inland Rail project will augment the existing national freight network between Melbourne and Brisbane via regional Victoria, New South Wales (NSW) and Queensland (QLD). The new rail line will be the largest freight rail infrastructure project in Australia, with a proposed corridor length of 1,700 km.

The Project is 216.2 km in length and extends from the NSW/QLD border at Kurumbul, approximately 18 km south east of Goondiwindi, to Gowrie, west of Toowoomba, in Queensland.

For a full project description, reference should be made to Chapter 5: Project description in the Border to Gowrie Project draft Environmental Impact Statement (EIS).

1.2 Objectives and scope of works

The objectives of the aquatic ecology and surface water study were to contribute to the draft EIS by:

- Conducting an assessment of the existing environmental values of the impact assessment area in relation to aquatic ecology and surface water quality values
- Assessing the potential impacts of the Project on these values
- Detailing mitigation measures to avoid or reduce impacts
- Outlining monitoring requirements that are relevant to the management of aquatic ecology and surface water quality values.

Eco Logical Australia (ELA) was engaged by Future Freight Joint Venture (FFJV) to conduct the following scope of works to achieve the objectives of the study:

- Conduct three surveys of aquatic ecology values at selected sites along the rail corridor. Surveys were to include physical habitat assessment for the first field trip, with subsequent aquatic ecology surveys to include assessment of macroinvertebrates and fish
- Conduct four surveys of surface water values at selected sites along the rail corridor, with two surveys occurring at the same time as aquatic ecology surveys. Water quality assessments were to include assessment of a dissolved metals suite (eight metals), pH, total suspended solids, turbidity, speciated nitrogens (ammonia, nitrate, nitrite, organic nitrogen, oxidised nitrogen, total kjeldahl nitrogen, total nitrogen), total phosphorus, chlorophyll *a*, reactive phosphorus, polycyclic aromatic hydrocarbons (PAHs), electrical conductivity and salinity.
- Conduct an impact assessment to address the Terms of reference for an environmental impact statement: Inland Rail – Border to Gowrie project (ToR, November 2018; DSDMIP 2018).

Environmental studies of aquatic ecology and surface water and the associated impact assessments were conducted in accordance with the following:

- The ToR for the Project
- The AusRivAS Physical Assessment Protocol for the Assessment of Freshwater Streams (Parsons *et al.* 2002)
- ANZECC (2000) Water Quality Guidelines, which were updated during the assessment (ANZECC 2018)

- Queensland Water Quality Guidelines (DEHP 2013)
- Water Quality Monitoring and Sampling Manual (DES 2018a)
- Survey Guidelines for Australia's threatened fish (SEWPAC 2011).

1.3 Terms of reference

Sections of the ToR relevant to the assessment of aquatic ecology and surface water values are summarised in **Table 1**, along with notes on where these requirements are addressed in this report.

Table 1 Summary of ToR relevant to aquatic ecology and surface water (Coordinator General, 2018)

ToR Section	Summary of requirement	Where addressed in this report
11.26	Addresses listed threatened species and communities	Section 2.1, 2.2 and 4.4
11.29	List of potential listed threatened species and their status	Section 4.4, Appendix B
11.45	Describes potential impacts of in stream works on hydrology and water quality	Section 5.1
11.47	Addresses how water quality would be monitored and how impacts on water quality are to be avoided/minimised	Section 5.2
11.48	Describes appropriate management and mitigation strategies which include discharge of contaminants and sediments during construction	Section 5.2
11.50	Propose suitable measures to avoid or mitigate impacts of stream works on water quality and the stabilisation/rehabilitation of any works.	Section 5.2
11.54	Addresses local impacts to alterations of riparian vegetation, bank and channel morphology and groundwater dependent ecosystems	Section 5.1 and 5.2
11.94	Identifies and describes matters of state environmental significance, state, ecological areas, regionally significant biodiversity and natural environmental values or terrestrial and aquatic ecology likely to be impacted	Section 4.2, 4.3, 4.4 and 4.5
11.95	Describes likely impacts on biodiversity and natural environmental values of affected areas arising from construction and operation of project	Section 5.1
11.96	Describes any proposed measures to avoid, minimise or mitigate potential impacts on natural values, and enhance these values	Section 5.2
11.97	Addresses requirement for construction of fauna movement corridors with regard particularly to waterway barriers to fish movement	Section 5.2 and 5.3
11.100	Addresses the need and suitability to provide fauna passage between habitat fragmented by rail.	Section 5.2 and 5.3
11.102	Identifies current distribution of animal pests and weeds on the proposed alignment.	Section 4.4
11.103	Surveys of animal pests and weeds should be undertaken in those areas identified during the desktop assessment as containing listed flora, fauna or ecological communities of national or state environmental significance	Section 4.2

ToR Section	Summary of requirement	Where addressed in this report
11.104	Addresses the impact that the Project's construction and operation will have on the spread of pest animals, weed species and disease along the proposed alignment and surrounding lands	Section 4.2; 5.1
11.105	Addresses proposed measures to control and limit spread to pests, weeds and disease	Section 5.2 and 5.3
11.117	Describe the existing noise and vibration environment that may be affected by the Project in the context of the environmental values.	Section 5.1
11.120	Describes noise and vibration emissions (including fugitive sources) that may occur during construction, commissioning and operation.	Section 5.1
11.122	Discusses the Project components likely to present an impact on noise and vibration for the construction and operation phases of the Project	Section 5.1
11.124.	Describe how the proposed project would be managed to be consistent with best practice environmental management for the activity	Section 5.2 and 5.3
11.153	Describe strategies and methods to be used to prevent, manage or remediate any land contamination resulting from the Project, including but not limited to the management of any acid generation or management of chemicals and fuels to prevent spills or leaks.	Section 5.2

1.4 Overview of the Project

The Project includes the establishment of 216.2 km of new single track railway, consisting of 7.0 km of standard gauge rail (1,435 mm) and 209.2 km of dual gauge rail (standard (1,435 mm) and narrow (1,067 mm) gauge).

The 7.0 km of standard gauge rail is a continuation of track from the North Star to NSW/QLD Border project and extends from the NSW/QLD border to the tie-in point with the South Western Line at Kurumbul. The remainder of railway for the Project will be dual standard/narrow gauge to enable interoperability with the existing Queensland Rail network.

The Project is located in the local government areas of Goondiwindi and Toowoomba regional councils. The Project will ultimately accommodate trains up to 3,600 m long, but initially will be constructed for 1,800 m long train sets.

The Project commences at the NSW/QLD border, the median line of the Macintyre River, approximately 18 km to the south east of Goondiwindi near Kurumbul. From this crossing point the alignment heads in a northerly direction for approximately 6 km before joining the Queensland Rail South Western Line to the east of Kildonan. The South Western Line is followed through Yelarbon towards Inglewood before turning off and becoming a greenfield alignment near Whetstone. The alignment skirts the hills to the west of Inglewood and then follows a new corridor that is approximately parallel with Inglewood-Millmerran Road, until joining the Millmerran Branch Line between Millmerran and Yandilla.

The Millmerran Branch Line is disused in parts due to the 2011 flood impacts, however the line is regarded as operational. The Millmerran Branch Line crosses the Condamine River floodplain and associated watercourses and waterways. The alignment continues via Pampas and Brookstead and deviates to the north and around Pittsworth, following the northern side of the Gore Highway. The alignment follows the intent of this existing rail corridor through to Southbrook, although geometric constraints prevent it from remaining within the corridor.

From Southbrook the alignment is greenfield once again and traverses to the west of Toowoomba Wellcamp Airport. The alignment passes to the west of Gowrie Mountain and crosses the Warrego Highway before termination between Leeson Road and Draper Road, on the southern outskirts of Kingsthorpe.

A broad 2 km wide impact assessment area was identified, within which lies the rail corridor including rail tracks and associated infrastructure (**Figure 1**). The focus of the assessment for aquatic ecology and surface water is those parts of the rail corridor that intersect with watercourses, waterways or other aquatic ecology or surface water values, hereafter referred to as the impact assessment area. The impact assessment area comprises those aspects of the aquatic environment that may be directly impacted by the Project, and adjacent areas that may be subject to indirect impacts. While the distance over which indirect impacts may occur is variable, the impact assessment area is defined as the area located within a 2 km buffer from the proposed rail alignment.

Fig 1. Border to Gowrie rail corridor and impact assessment area



Legend

- Border to Gowrie Rail Alignment
- Impact Assessment Area

0 15 30
Kilometres
Datum/Projection:
GDA 1994 MGA Zone 56

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2 Legislation and guidelines

This section provides an overview of legislation and guidelines that are relevant to the assessment of aquatic ecology and surface water.

2.1 Commonwealth legislation

2.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (Cth; EPBC Act) is the key piece of Commonwealth environmental protection legislation. The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the EPBC Act as Matters of National Environmental Significance (MNES).

The EPBC Act requires that proposals, or actions, that have the potential to significantly impact on MNES or the environment of Commonwealth land be referred to the Australian Minister for the Environment.

The Project was referred to the Minister for the Environment on 16 February 2018 and was subsequently deemed to be a controlled action due to potentially significant impacts on listed threatened species and communities (Section 18 and 18A of the EPBC Act).

2.1.2 Water Act 2007

The *Water Act 2007* (Cth) provides the legislative framework for ensuring that Murray Darling Basin (Australia's largest water resource) is managed in accordance with Australia's national interests. Watercourses of the impact assessment area are located within the Murray Darling Basin and are subject to the Murray Darling Basin Plan – a strategic plan for the integrated and sustainable management of water resources in the Murray Darling Basin. The Queensland Government has prepared Healthy Waters Management Plans to meet accreditation requirements under the Commonwealth *Water Act 2007* – Basin Plan 2012 (Commonwealth of Australia 2012).

The Act recognises that Australian states in which the Murray Darling Basin is located continue to manage water resources within their jurisdictions. The Act:

- Establishes the Murray Darling Basin Authority with the functions and powers, including enforcement powers, needed to ensure that Basin water resources are managed in an integrated and sustainable way
- Establishes a Commonwealth Environmental Water Holder to manage the Commonwealth's environmental water to protect and restore the environmental assets of the Murray Darling Basin, and outside the Basin where the Commonwealth owns water
- Provides the Australian Competition and Consumer Commission with a key role in developing and enforcing water charge and water market rules along the lines agreed in the National Water Initiative
- Gives the Bureau of Meteorology water information functions that are in addition to its existing functions under the *Meteorology Act 1955*
- Gives the Productivity Commission a role in reporting on the effectiveness of the implementation of the Murray-Darling Basin Plan and water resource plans and the progress towards achieving the objectives and outcomes of the National Water Initiative.

The Project spans three catchments (**Figure 2**). Between the NSW/QLD border and Gowrie, the Project is located within the Macintyre River catchment and from Yelarbon to Millwood the Project is located in the Macintyre Brook catchment of the Queensland Border Rivers drainage basin. North of Millwood the Project is located within the Condamine River catchment of the Balonne-Condamine drainage basin. Both the Queensland Border Rivers and Balonne-Condamine drainage basins are situated within the Murray Darling Basin.

2.2 Queensland legislation

2.2.1 Planning Act 2016

The purpose of the *Planning Act 2016* (Qld) is to provide an efficient, effective, transparent, integrated, coordinated and accountable system of land use planning, development assessment and dispute resolution to facilitate the achievement of ecological sustainability. The Project will be likely to trigger approval requirements for some aspects of development under the *Planning Act 2016*, following completion of the EIS.

2.2.2 Environmental Protection Act 1994

The objective of the *Environmental Protection Act 1994* (Qld; EP Act) is to protect Queensland's environment by promoting ecologically sustainable development. The EP Act has been designed to achieve its objective by setting out a program for the identification and protection of environmental values and through a range of regulatory tools. The EP Act outlines a 'general environmental duty', which specifies that persons must not carry out an activity that causes, or is likely to cause, environmental harm, unless the person takes all reasonable and practical measures to prevent or minimise the harm.

The quality of Queensland waters is protected under the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity), which is a subordinate instrument to the EP Act. Environmental values and water quality objectives are being progressively determined for areas of Queensland under the EPP Water and Wetland Biodiversity. Healthy Waters Management Plans were published for the impact assessment area in 2019, specifying environmental values and water quality objectives for several water quality zones (see **Section 4.1**).

Post-EIS approvals may involve Environmentally Relevant Activities and will be regulated under the EP Act.

2.2.3 Water Act 2000

The *Water Act 2000* (Qld) (Water Act) provides the framework to deliver sustainable water planning, allocation management and supply processes to ensure security of water resources in Queensland. Water suppliers are the primary focus of the Water Act through the administration of the *Water Regulation 2016*. The Project involves works within watercourses that are defined under the Water Act, and may require a Riverine Protection Permit to excavate, place fill or disturb native vegetation in a watercourse.

2.2.4 Vegetation Management Act 1999

The *Vegetation Management Act 1999* (Qld) (VM Act) regulates and manages the process and impacts of native vegetation clearance, including riparian vegetation fringing watercourses. The objectives of the VM Act include conservation of remnant regional ecosystems, prevention of the loss of biodiversity, maintenance of ecological processes, and conservation of vegetation in areas of high nature conservation value or lands vulnerable to land degradation.

Generally, clearing of relevant remnant or regulated regrowth vegetation requires a development approval under the *Planning Act 2016*, subject to a number of exemptions, including for Government supported transport infrastructure.

2.2.5 Nature Conservation Act 1992

The object of the *Nature Conservation Act 1992* (Qld) (NC Act) is to conserve nature through an integrated and comprehensive conservation strategy for the whole of Queensland involving (but not limited to) the following:

- Gathering of information and community education
- Dedication and declaration of protected areas
- Management of protected areas
- Protection of native wildlife and its habitat
- Use of protected wildlife and areas to be ecologically sustainable
- Recognition of interest of Aboriginal people and Torres Strait Islanders in nature and their cooperative involvement in its conservation
- Cooperative involvement of landholders.

The NC Act requires permits for activities that include the taking of protected plants and the moving of protected animals, or activities in protected areas, which are likely to be required for the Project.

2.2.6 Biosecurity Act 2014

The *Biosecurity Act 2014* (Qld) ensures a consistent, modern, risk-based approach to biosecurity in Queensland. The *Biosecurity Act 2014* provides comprehensive biosecurity measures to safeguard Queensland's economy, agricultural and tourism industries and the environment from:

- Pests (e.g. Wild dogs and weeds)
- Diseases; and
- Contaminants

The *Biosecurity Regulation 2016* describes matters that are declared to be 'prohibited' or 'restricted' matters. There is a 'general biosecurity obligation' described under the *Biosecurity Act 2014*, which states that everyone is responsible for managing biosecurity risks that are under their control, or that they know about, or should reasonably be expected to know about. This Act is likely to apply to project activities such as the use of machinery for earthworks, and the dewatering of farm dams, which may result in the spread of weeds and pests, if practical precautions are not taken.

2.2.7 Fisheries Act 1994

Waterway barrier works are regulated under the *Fisheries Act 1994* and the *Planning Act 2016* when barriers to fish movement, including partial barriers, are installed across waterways. Barrier works include construction, raising of structures such as culvert crossings, bed level and low level crossings, weirs and dams, both permanent and temporary. The legislation allows for self-assessment for low impact, minor, temporary and some regularly rebuilt waterway barriers. Works that adhere to the standards and requirements of the Department of Agriculture and Fisheries (DAF) *Accepted development requirements for operational work that is constructing or raising waterway barrier works (1 October 2018; Department of Agriculture and Fisheries 2018)* are able to proceed without development approval. Also, some instream works and types of structures that comply with Fisheries Queensland's factsheet, "What is not a waterway barrier work? (DAF 2017a)" are not considered to be waterway barriers.

The Queensland Waterways for Waterway Barrier Works (WWBW) data set shows the extent of the *Fisheries Act 1994* interest in barrier works on waterways, including within the impact assessment area. This data layer also indicates whether waterway barrier works are likely to proceed under the relevant DAF self-assessable code or require a development approval.

2.3 Relevant guidelines, strategies and plans

2.3.1 ANZECC Guidelines (2000, 2018)

The *ANZECC Water Quality Guidelines* provide water managers with tools and guidance to assess, manage and monitor water quality. They include default guideline values, which if exceeded indicate that further analysis may be required to ensure aquatic ecosystems are adequately protected. These guidelines provide a starting point for assessing water quality, in conjunction with local guidelines.

2.3.2 Queensland Water Quality Guidelines

The *Queensland Water Quality Guidelines* (DEHP 2013) provide water quality guidelines values that are tailored to Queensland regions and water types, as well as outlining a framework for deriving and applying more locally-specific guidelines for waters in Queensland. However, there are no guidelines specified for the Murray Darling Basin of Queensland.

2.3.3 DES Water Monitoring and Sampling Manual

The *Monitoring and Sampling Manual* (DES 2018a) provides an overview of the common techniques, methods and standards for the collection, handling, quality assurance and control, custodianship and data management in relation to water quality samples. The manual helps to ensure that monitoring data are collected in a consistent and scientifically-accurate manner.

2.3.4 Queensland AusRivAS Sampling and Processing Manual

The *Queensland AusRivAS Sampling and Processing Manual* (DNRM 2001) describes a bioassessment methodology adopted by the Department of Natural Resources and Mines, with a focus on the assessment of macroinvertebrates in freshwater streams. It is the protocol used by the Queensland AusRivAS models and is adapted from the River Bioassessment Manual (Davies 1994).

2.3.5 AusRivAS habitat assessment protocol

The AusRivAS habitat assessment protocol (Parsons *et al.* 2002) describes a protocol for the physical assessment of stream and river condition. The protocol is a stand-alone method of physical and geomorphological assessment. However, it also provides for the biological assessment of stream condition using AusRivAS methods.

2.3.6 Local water quality guidelines

The *ANZECC Guidelines* (2000, 2018) recognise the importance of developing local water quality guidelines from regional data. In February 2019, the Department of Environment and Science (DES) published *Healthy Waters Management Plans for the Condamine River Basin and Queensland Border Rivers and Moonie River Basins* (DES 2019a, b) after a period of public consultation in 2018.

The Healthy Waters Management Plans have been prepared to meet accreditation requirements under the 'Commonwealth *Water Act 2007* – Basin Plan 2012'. The plans confirm the environmental values in terms of desired levels of aquatic ecosystem protection, water quality objectives and management responses under the EPP Water and Wetland Biodiversity. The plans therefore provide locally-relevant water quality guidelines for the assessment of surface water quality results obtained during field surveys for the Project.

2.3.7 Other guidelines

Several other guidelines were also consulted in relation to the assessment of fish passage at waterways at the NSW/QLD border, and the assessment of aquatic ecology values in Queensland:

- *Policy and guideline for fish habitat conservation and management* (NSW Government 2013)

- *Why do fish need to cross the road – fish passage requirements for waterway crossings* (Fairfull and Witheridge 2003)
- *What is a waterway?* (Queensland Government 2017)
- *Guidelines for groundwater dependent ecosystems* (Queensland Government 2018a)
- *Aquatic ecology – Assessment of aquatic ecological values* (Queensland Government 2018b)
- *What is a waterway barrier work?* (DAF 2017b) and *What is not a waterway barrier work?* (DAF 2017a)
- *Draft Biosecurity Plan for Invasive Plants and Animals* (TRC 2020)

3 Methods

3.1 Overview of the impact assessment area

The proposed rail alignment is shown in **Figure 2** and incorporates two major basins of the Murray Darling river system; the Condamine and the Queensland Border Rivers. Major watercourses within the impact assessment area include the Macintyre River, Pariagara Creek, Condamine River and Bringalily Creek. However, the majority of watercourses and waterways in the impact assessment area are ephemeral, holding water only during the wet season or following periods of heavy rainfall.

3.2 Desktop assessment

A desktop assessment was undertaken to identify potential aquatic ecological features and constraints that may occur within the impact assessment area. The following databases and maps were reviewed:

- EPBC Act Protected Matters Search Tool (PMST), undertaken with a 10 km buffer around the rail alignment (approximately digitised into the online tool)
- Wildlife Online Database Search, a rectangular area that encompassed the entire rail alignment for all aquatic fauna and flora species listed and individual records of listed species
- Atlas of Living Australia database using a 10 km buffer around the rail alignment for all aquatic flora and aquatic fauna species listed and for all aquatic fauna records
- Queensland Matters of State Environmental Significance (MSES) mapping (DILGP 2015) which includes wetlands, and waterways mapped as per the spatial data layer Queensland waterways for waterway barrier works.
- DES Protected Plants Flora Survey Trigger Area mapping (DEHP 2014b), as it applies to aquatic plants
- DES wetland mapping (DES 2018b)
- VMA stream order mapping (DNRM 2015)
- Aquatic Conservation Assessments (ACA) and Aquatic Biodiversity Assessment Mapping Method (AquaBAMM) of DES (Queensland Globe 2019)
- Aerial imagery.

Reference was also made to previous information of relevance to the selection of a route for the Project, as described in EIS Chapter 2: Project Rationale.

Environmental values and water quality objectives for the Condamine River Basin and the Queensland Border Rivers Basin were determined by reviewing the guideline documents listed in **Section 2.3**.

3.3 Likelihood of occurrence assessment

The likelihood of occurrence of each aquatic species identified in the desktop assessment that is listed as threatened under the EPBC Act or listed as Endangered, Vulnerable or Near Threatened (EVNT) or Special Least Concern (SLC) under the NC Act was assessed, based on the species' known distribution, habitat quality within the impact assessment area, species occurrence within the region and species occurrence within the impact assessment area. Each species was assessed as known, likely, possible or unlikely to occur within the impact assessment area based on the following criteria:

- **Known** – the species has been recorded within the impact assessment area

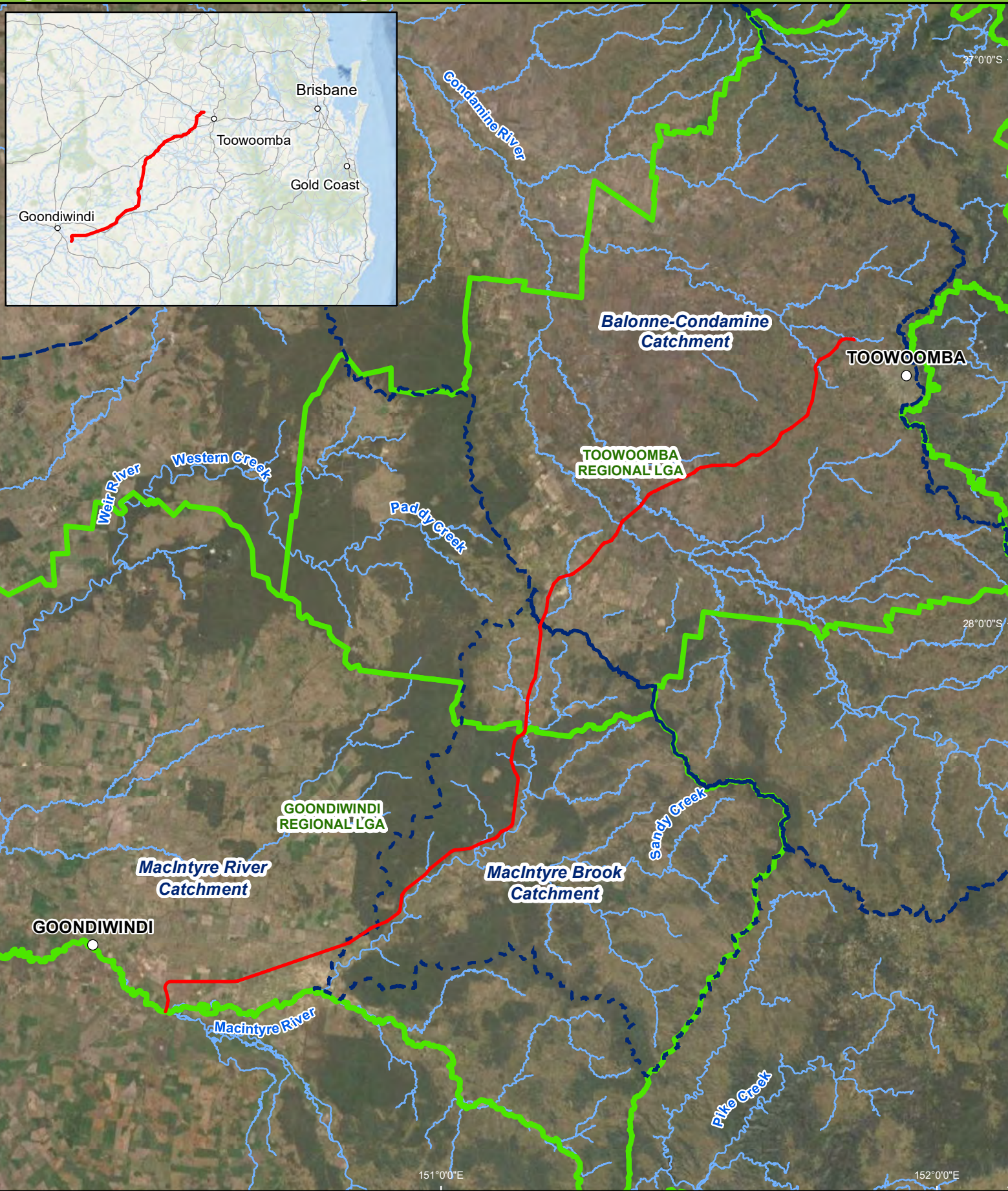
- **Likely** – the impact assessment area is within the species' known distribution; suitable good quality habitat occurs within the area and the species is known to occur within the region
- **Possible** - the impact assessment area is within the species' known distribution; marginal habitat occurs within the area and the species is known to occur within the region
- **Unlikely** – there is a low probability that the species will occur within the impact assessment area as it is outside the species known distribution, low quality habitat occurs within the area or the species is not known to occur within the region.

Likelihood assessments were initially conducted prior to undertaking field surveys, and then updated to include results post-field survey. Such updates were associated with:

- Changing the assessment of likelihood to 'known' in the event that a species was found to be present during the field surveys, or
- Reducing the likelihood of occurrence, based on an absence of habitat within the impact assessment area

The likelihood score was not downgraded in response to a failure to detect a species during field surveys, when habitat suitable for the species was identified within the impact assessment area. This approach accommodates natural changes in the distribution and abundance of some aquatic species over time, and was developed in acknowledgement of the limitations of field sampling methods, which may not capture all target species present at the time of sampling, particularly during dry periods.

Fig 2. Border to Gowrie Rail Alignment



Legend

- Border to Gowrie Rail Alignment
- Watercourse
- Catchment
- Local Government Area

0 15 30

Kilometres

Datum/Projection:
GDA 1994 MGA Zone 56

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3.4 Field surveys

3.4.1 General approach and timing of survey

A schedule of field activities was developed to determine the aquatic and surface water values of the impact assessment area. The focus of aquatic ecology assessments was to assess a representative number of sites along the rail alignment, with emphasis on habitat values at risk of disturbance.

In order to capture seasonal variation in the abundance of fish and macroinvertebrates, two aquatic ecology surveys were scheduled – one in June 2018 and one in November 2018. This timing was selected to be consistent with the *Queensland AusRivAS Sampling and Processing Manual* (DNRM 2001), which specifies that the preferred timing of surveys is May to July (referred to as the 'late wet') and October to December (referred to as the 'early wet'). Rainfall patterns across the Darling Downs are aligned with this survey timing, with highest rainfall generally occurring in the region between the months of October and March (BOM 2019). A delay between sampling and large rainfall events of at least four weeks is desirable, to allow macroinvertebrate communities to develop sufficiently following the disturbance associated with flood events (DNRM 2001).

Surface water quality values are likely to be more variable than those of aquatic ecology habitats, as they are influenced by runoff events from periods of rainfall and adjacent land use. Hence, four surface water field surveys were planned (as recommended in the AusRivAS manual) approximately three months apart, with two surveys undertaken at the same time as the aquatic ecology surveys and the remaining two surveys scheduled for September 2018 and February 2019.

However, the September 2018 water quality survey did not take place, due to dry conditions across the impact assessment area. Instead, two follow up water quality field assessments were scheduled for February and March 2019, when water was more likely to be present in local waterways. A final aquatic ecology survey was also scheduled for May 2019, to undertake further assessment of aquatic ecology values during the AusRivAS 'late wet' period. This approach resulted in the following five field surveys being completed:

- 11 to 20 June 2018 (aquatic ecology and surface water)
- 26 November to 3 December 2018 (aquatic ecology and surface water)
- 11 to 19 February 2019 (surface water only)
- 29 April to 2 May 2019 (surface water only)
- 15 to 19 May 2019 (aquatic ecology comprising macroinvertebrate and fish sampling). Water samples were also collected at the five aquatic ecology sites containing water during this survey, to assist with the interpretation of macroinvertebrate data

Field personnel undertaking the surveys were experienced in the assessment of aquatic ecology values and the collection and analysis of water quality samples. A principal level aquatic ecologist accredited in Queensland under the AusRivAS assessment method led and implemented all five field surveys.

3.4.2 Selection of sampling sites

Forty three sites adjacent to the rail alignment were initially selected as potentially suitable sampling sites. This number was significantly more than what was intended to be surveyed, but allowed for sites to be removed from the selection if land access proved to be problematic or if sites were found to be unsuitable when accessed in the field. The inclusion of a large number of potential sampling sites also provided greater certainty that sufficient water would be present at a representative selection of sites in the event that dry conditions were experienced.

Sites were positioned as close as possible to locations where the proposed rail alignment traversed watercourses, waterways or drainage features. Sites were nominally assigned into one of the following categories:

- Aquatic ecology site – where an assessment of aquatic ecology habitat values and surface water quality was to be undertaken
- Surface water quality site – where assessment of surface water quality only was to be undertaken

The distribution of aquatic ecology and surface water quality sites along the rail alignment was determined from a range of factors, including:

- Mapping and aerial photography products which provide information on aquatic habitat features, including DAF waterway barriers and DES aquatic habitat mapping
- Inclusion of waterways with a variety of stream orders along the rail corridor, ensuring waterways of varying size and complexity were sampled
- Representation of a variety of aquatic habitat types and surrounding land uses (e.g. areas where remnant riparian vegetation was intact, and areas that had been subject to disturbance from existing infrastructure or agricultural land uses)
- A relatively even spread of survey sites along the rail alignment, to determine spatial variability in aquatic and water quality values
- Practicality of access to the site and the safety of field teams

Where practical, aquatic ecology sites were located at the intersection of the rail alignment and the waterway. A surface water quality site was also generally located upstream and downstream of the aquatic ecology site, if access was possible and the waterway would provide information useful to the impact assessment. This design in the layout of sites in clusters facilitated assessment of surface water and aquatic ecology values in areas where direct disturbance is proposed, as well as adjacent upstream and downstream areas. This approach also provided additional data on the waterway in the instance that the location of the rail corridor changed within the 2 km wide impact assessment area, during the design process.

Consistent and reliable access was obtained for 34 sites that were suitable for the aquatic ecology and surface water assessments. These 34 sites consisted of 12 sites where aquatic ecology and surface water quality assessments were conducted and 22 sites where surface water quality assessments were conducted. A summary of all sites identified for potential sampling is provided in **Table 2** with their location along the rail alignment shown in **Figure 3**. More detailed maps showing the location of sites in clusters relevant to sub-catchments are provided in **Figure 4a-g**.

Sites were assigned a number in approximate numerical order from west to east. On some occasions when a site could not be accessed, an alternative site was identified on public land nearby and labelled with the site number and the letter 'R' (e.g. Site 20R). This allowed the assessment of water quality information from areas adjacent to the original site.

Table 2 Sampling sites targeted during the field surveys and associated water quality zone as specified in relevant basin plan (see Section 4.1 for a description of water quality zones)

Site	Assessment type	Waterway	Tenure
Macintyre Barwon Floodplain Water Quality Zone			
1#	Aquatic ecology and surface water	Macintyre River	Private land
2	Aquatic ecology and surface water	Macintyre River	Private land
Lower Macintyre Brook Water Quality Zone			

Site	Assessment type	Waterway	Tenure
3	Surface water	Macintyre Brook	Public land
4	Aquatic ecology and surface water	Unnamed	Public land
5	Aquatic ecology and surface water	Unnamed	Private land
6	Surface water	Macintyre Brook	Private land
7	Surface water	Macintyre Brook	Public land
8	Aquatic ecology and surface water	Unnamed	Private land
Canning Creek Water Quality Zone			
9	Aquatic ecology and surface water	Pariagara Creek	Private land
10	Surface water	Pariagara Creek	Private land
11	Surface water	Canning Creek	Private land
12	Aquatic ecology and surface water	Unnamed	Public land
13	Aquatic ecology and surface water	Cattle Creek	Public land
14	Surface water	Unnamed	Private land
15	Aquatic ecology and surface water	Unnamed	Private land
16	Aquatic ecology and surface water	Unnamed	Private land
17	Aquatic ecology and surface water	Unnamed	Private land
18	Surface water	Unnamed	Public land
19	Aquatic ecology and surface water	Nicol Creek	Public land
20	Surface water	Nicol Creek	Private land
Southern Condamine Water Quality Zone			
21#	Aquatic ecology and surface water	Unnamed	Private land
22#	Surface water	Unnamed	Public land
23	Surface water	Unnamed	Public land
24	Surface water	Grasstree Creek	Public land
25#	Aquatic ecology and surface water	Grasstree Creek	Private land
26#	Surface water	Grasstree Creek	Private land
Central Condamine Water Quality Zone			
27	Surface water	Condamine River	Public land
28	Aquatic ecology and surface water	Condamine River	Private land
29	Surface water	Unnamed	Public land
30	Surface water	Condamine River	Public land
31	Surface water	Condamine River (North Branch)	Public land
32	Aquatic ecology and surface water	Condamine River (North Branch)	Public land
33	Surface water	Condamine River (North Branch)	Public land
Oakey Creek Water Quality Zone			
34#	Aquatic ecology and surface water	Unnamed	Private land
35	Surface water	Unnamed	Public land
36	Surface water	Unnamed	Public land
37#	Surface water	Westbrook Creek	Private land
38#	Aquatic ecology and surface water	Westbrook Creek	Private land
39	Surface water	Westbrook Creek	Public land
40	Surface water	Dry Creek	Public land
41#	Aquatic ecology and surface water	Dry Creek	Private land
42	Surface water	Dry Creek	Public land
43	Aquatic ecology and surface water	Unnamed	Public land

indicates that access to the site was not reliable for all field surveys or the site was found not to be suitable for assessment

Fig 3. Border to Gowrie Rail Alignment - Aquatic Sampling Sites



Legend

- Border to Gowrie Rail Alignment
- Major Watercourse
- Minor Watercourse

B2G Sample Sites

- Aquatic Site
- Surface Water Site

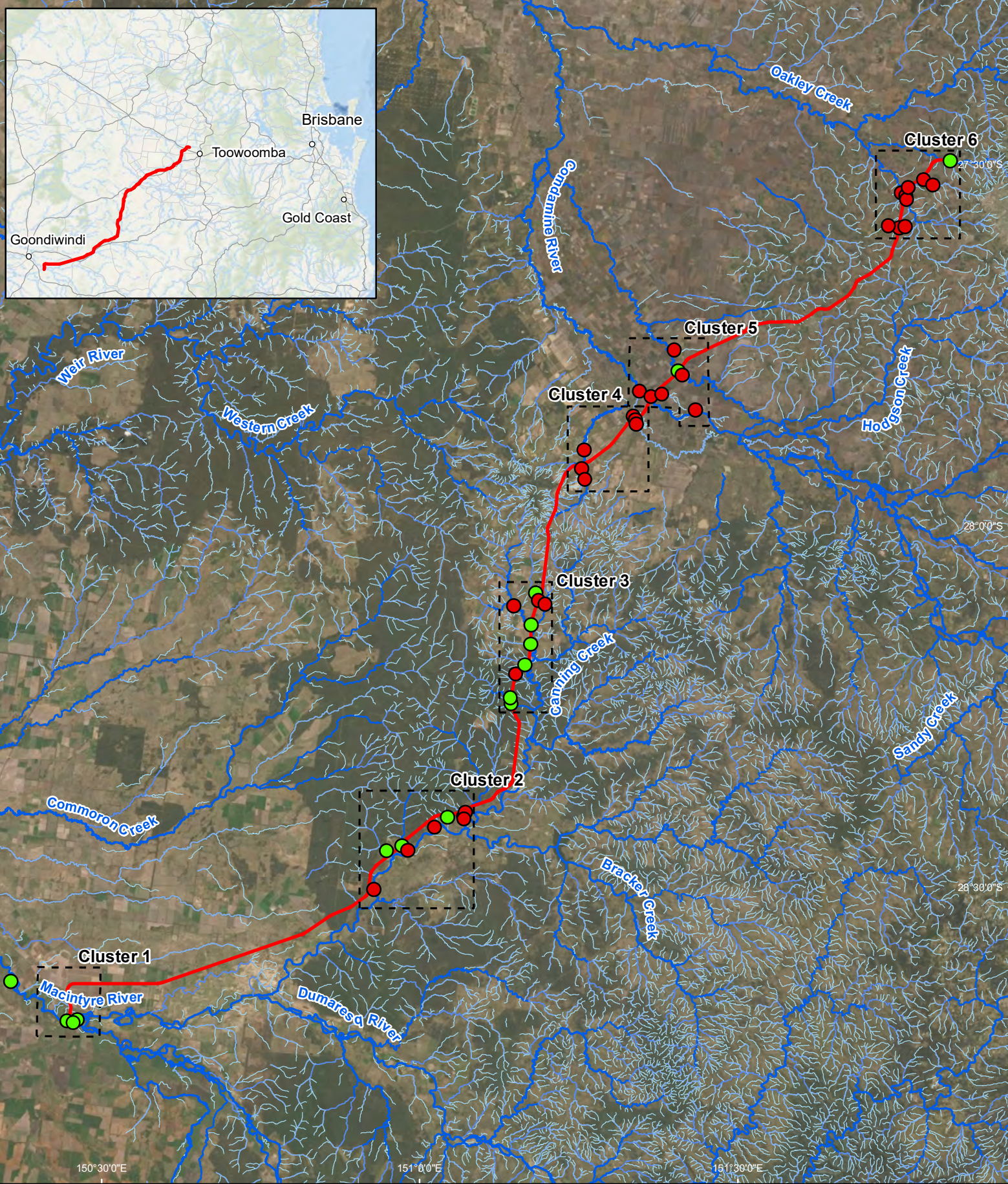
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Fig 4a. Border to Gowrie Rail Alignment - Aquatic Sampling Sites



Legend

- Border to Gowrie Rail Alignment
- Major Watercourse
- Minor Watercourse

B2G Sample Sites

- Aquatic Site
- Surface Water Site
- Border to Gowrie Aquatic Site Clusters

0 10 20
Kilometres
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Fig 4b. Macintyre Barwon Floodplain Water Quality Zone (Cluster 1 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

● Aquatic Site

● Surface Water Site

Watercourse

Stream Order

— 1

— 2

— 6

— 7

— 8

— 9

0 1 2

Kilometers

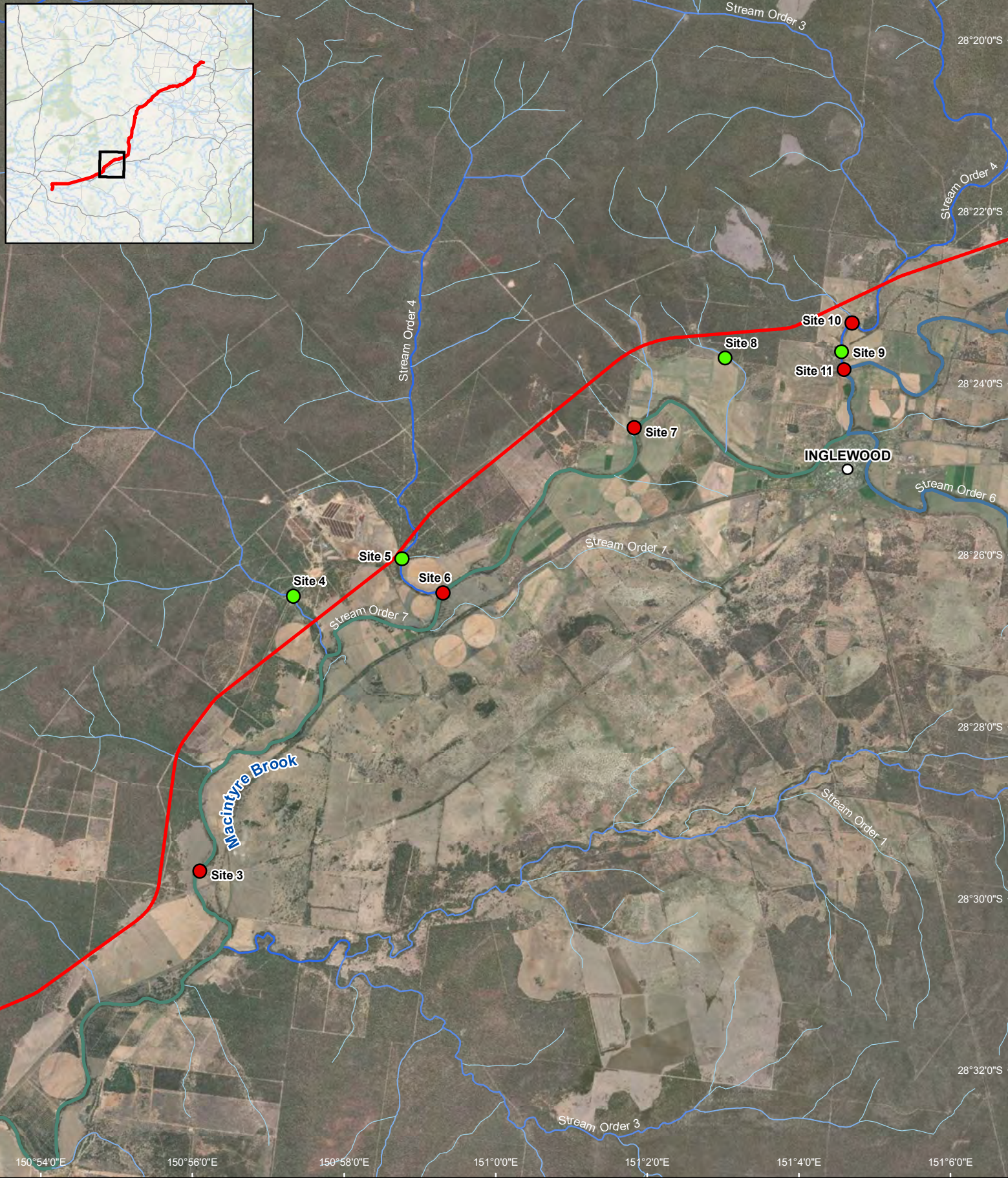
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Fig 4c. Lower Macintyre Brook Water Quality Zone (Cluster 2 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Watercourse

Stream Order

- 1
- 2
- 3
- 4
- 6
- 7

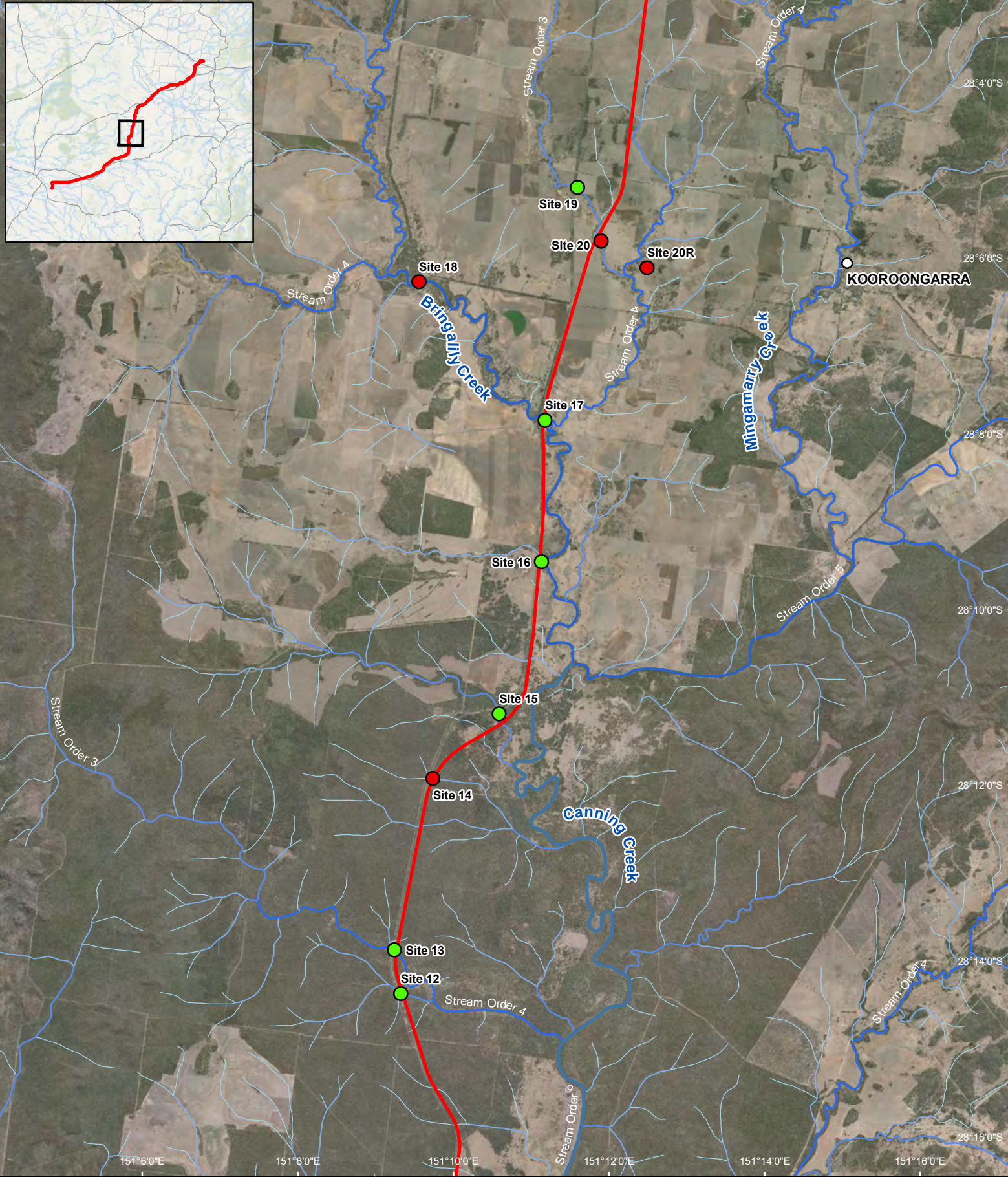
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Fig 4d. Canning Creek Water Quality Zone (Cluster 3 of 6)



Legend

Border to Gowrie Rail Alignment

B2G Sample Sites

Aquatic Site

Surface Water Site

Watercourse

Stream Order

1

2

3

4

5

6

0 1 2
Kilometers

Datum/Projection:
GDA 1994 MGA Zone 56

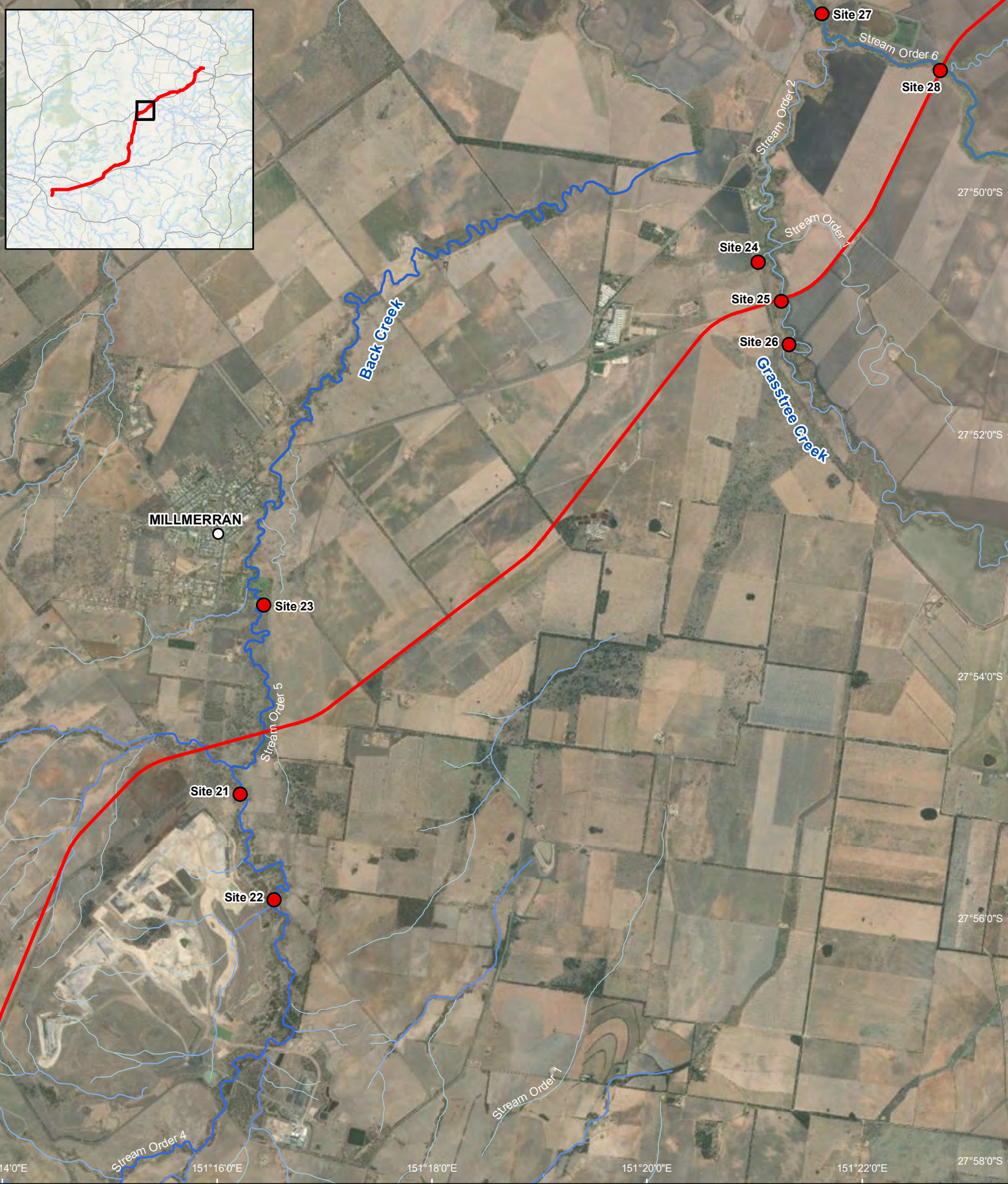
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Prepared by: PH Date: 18/06/2020

Fig 4e. Southern Condamine Water Quality Zone (Cluster 4 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Watercourse

Stream Order

- 1
- 2
- 3
- 4
- 5
- 6

0 1 2
Kilometers
Datum/Projection:
GDA 1994 MGA Zone 56

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Fig 4f. Central Condamine Water Quality Zone (Cluster 5 of 6)



Legend

Border to Gowrie Rail Alignment

B2G Sample Sites

Aquatic Site

Surface Water Site

Watercourse

Stream Order

1

2

3

4

5

6

0 1 2

Kilometers

Datum/Projection:
GDA 1994 MGA Zone 56

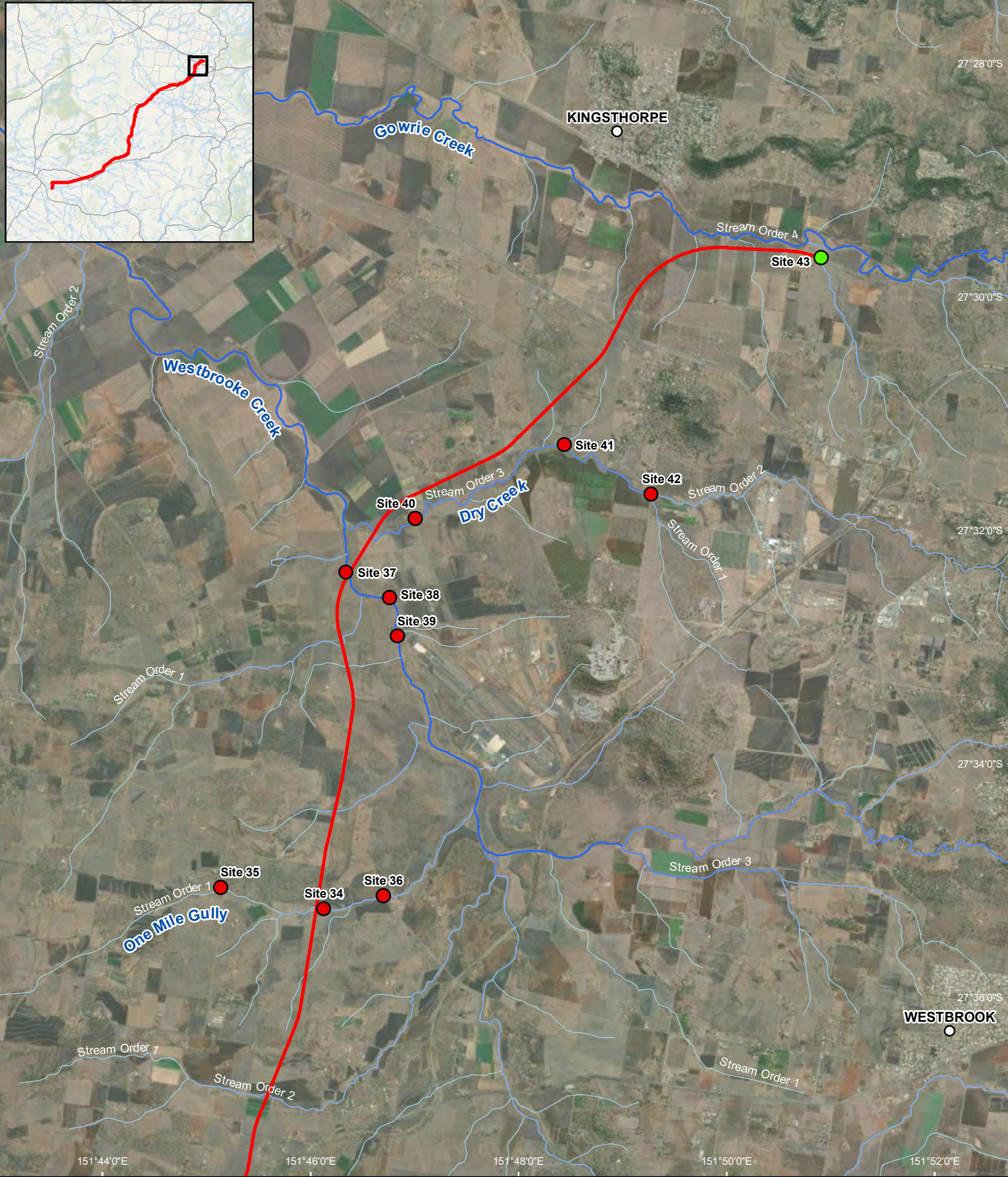
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Fig 4g. Oakey Creek Water Quality Zone (Cluster 6 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Watercourse

Stream Order

- 1
- 2
- 3
- 4
- 5

0 1 2
Kilometers

Datum/Projection:
GDA 1994 MGA Zone 56

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3.4.3 Aquatic ecology habitat assessment and sampling

Aquatic habitats were assessed at each aquatic ecology site in accordance with the AusRivAS physical habitat assessment protocol (Parsons *et al.* 2002). The following information was collected at each site:

- Site ID and name
- Date and time
- Location (latitude, longitude)
- Photographs in four directions aligned with the flow of water
- Planform sketch of the site
- Bank width and length of sampling site (100 m)
- Valley shape (steep, shallow, broad, gorge, symmetrical floodplain, asymmetrical floodplain)
- Local activities impacting on streams
- Floodplain features and local land uses
- Riparian zone composition including description of vegetation (trees >10 m in height, trees <10 m in height, shrubs and grasses/ferns/sedges)
- Shading of channel (<5 per cent, 6-25 per cent, 26-50 per cent, 51-75 per cent, >76 per cent)
- Extent of trailing bank vegetation (nil, slight, moderate, extensive)
- Native and exotic riparian vegetation (per cent composition)
- Regeneration of native woody vegetation
- Overall vegetation disturbance rating (extreme, very high, high, moderate, low or very low)
- Physical barriers to local fish passage (no passage, very restricted, moderately restricted, partly restricted, good passage, unrestricted passage)
- Type and extent of bars and dominant sediment particle size on bars
- Channel modifications, slope and shape
- Bank shape and slope
- Sediment and water oils
- Sediment and water odours
- Turbidity (visual assessment)
- Water level at time of sampling
- Artificial features of the sampling site
- Large woody debris
- Factors affecting bank stability
- Bedrock outcrops
- Artificial bank protection measures
- Extent of bedform features
- Macrophyte cover and composition
- Bed compaction
- Sediment matrix and angularity
- Bed stability
- Epifaunal substrate/available cover
- Pool substrate characterisation and variability
- Sediment deposition
- Channel alteration and sinuosity
- Bank stability
- Vegetative protection
- Riparian zone
- Filamentous algae, periphyton, moss and detritus cover

- Substrate composition
- Bank material
- Cross section sketch

The information collected was used to inform an assessment of the suitability of aquatic habitats for key species of interest, such as the Murray Cod, Silver Perch and Bell's Turtle. General site observations and photographs of aquatic habitats were also recorded.

3.4.4 Macroinvertebrate surveys

Macroinvertebrate sampling was undertaken in November 2018 and May 2019. Macroinvertebrate samples were collected in accordance with the Queensland AusRivAS assessment manual (DNRM 2001).

Freshwater macroinvertebrate sampling was undertaken to gain an improved understanding of the aquatic values, waterway health and trophic interactions occurring at each site. Samples were collected from aquatic ecology survey sites that exhibited wetted habitat at the time of assessment. Due to dry conditions, this was limited to Site 2 (Macintyre River) and Site 16 (Bringalily Creek) in November 2018, and Site 2 (Macintyre River), Sites 6R and 7 (Macintyre Brook), Site 18 Bringalily Creek and Site 42 (Dry Creek) in May 2019.

Sampling was overseen by an AusRivAS accredited ecologist following AusRivAS protocols for Queensland streams (DNRM 2001). AusRivAS specifies a standardised, qualitative, rapid bioassessment method that aims to consistently sample a wide diversity of macroinvertebrates within a defined timeframe.

The bed and edge habitats were sampled separately at each site. A standard sized dip net with 250 µm mesh was used to sample macroinvertebrates. Following collection, the samples were transferred to plastic sorting trays, where the contents were sorted and live-picked for 30 minutes. Picked specimens were placed into specimen jars with 70per cent ethanol.

Samples were identified to AusRivAS taxonomic level in the laboratory under stereomicroscope. AusRivAS taxonomic identification was primarily to Family level, with the exception of lower Phyla such as Porifera, Nematoda and Nemertea, Oligochaetes (freshwater worms), Acarina (mites), and microcrustacea such as Ostracoda, Copepoda and Cladocera. Chironomids (midges) were identified to sub-family taxonomic level.

3.4.5 Fish surveys

For the June 2018 field trip, a limited fish survey was implemented involving the deployment of baited box traps and dip-netting, targeting small fish at sites containing water. At each site, up to seven baited box traps were deployed for approximately one hour, followed by dip-netting waterway edge habitats for a period of approximately 10 minutes with an Environet®.

For subsequent field trips in December 2018 and May 2019, the scope of works was expanded and a range of additional survey techniques were applied to assess fish assemblages at aquatic ecology sites that were suitable. Targeted fish survey methods were selected from the Survey Guidelines for Australia's Threatened Fish (SEWPAC 2011), and included backpack electrofishing (where water depth was <0.5 m), seine netting (2 – 5 mm mesh) and use of fyke nets. Where fyke nets were used, two nets were deployed overnight (one 3 mm stretched mesh and one 4 mm stretched mesh). Nets were dual wing in design, with each wing 4 m in length with a 0.6 m drop. The survey methods were adapted to suit the local conditions

of the waterway, with the primary considerations being the depth of water and presence of woody debris which may foul nets.

Fish were identified to species level, with the number of each species captured, and size range for each species recorded. After processing, native fish were returned to the water, and pest species were euthanised by lethal dose of AQUI-S solution, followed by pithing or exsanguination to confirm death, in accordance with Animal Ethics Committee approval.

All sampling activities were undertaken in accordance with relevant conditions of General Fisheries and Animal Ethics permits held by Eco Logical Australia (General Fisheries Permit 196796 and Animal Ethics CA2018/07/1214) and DPM Envirosiences (General Fisheries Permit 192554 and Animal Ethics CA2017/03/1043).

3.4.6 Macro-crustaceans

Macro-crustaceans (those that can be seen with the naked eye) were collected as by-catch using fish sampling techniques (**Section 3.4.5**). Additionally, macro-crustacean specimens collected during macroinvertebrate sampling were retained for identification. All macro-crustaceans collected using fishing apparatus were returned to the water following identification. Identifications were undertaken to species level.

3.4.7 Freshwater turtles

Information on freshwater turtles was collected during field surveys through observations of habitat suitability (**Section 3.4.3**) and from incidental observations of turtles during field surveys while targeting fish and invertebrates. Freshwater turtles listed as Least Concern are likely to be abundant throughout waterways and wetlands of the impact assessment area. Relevant species include the Eastern snake-necked turtle (*Chelodina longicollis*), Broad-shelled river turtle (*Chelodina expansa*) and Murray turtle (*Emydura macquarii macquarii*).

3.4.8 Surface water quality sampling

Surface water quality data was collected at accessible aquatic ecology and surface water sampling sites in accordance with the DES Monitoring and Sampling Manual (DES 2018a). Information about site characteristics was recorded using the 'Water Quality Sampling Field Sheet' (DNRM 2002).

The following values were recorded at each site:

- Site ID and name
- Date and time
- Sampling location (latitude, longitude and reach orientation looking downstream)
- Weather (rain in the past week, cloud cover, wind)
- Observations at water sampling site (within 2 m of sampling point or on closest bank) including:
 - Shading (per cent)
 - Water odour
 - Water surface condition
 - Algae (per cent) (on substrate, in water column)
 - Macrophytes (per cent) (emergent, submerged, floating, fringing)
 - Impact (per cent) (human, pastoral animals, non-pastoral animals)
- Percent of habitat types in 100 m reach
- Reach observations (of 100 m stream length). Reach observations include:
 - Upstream land use
 - Adjacent land use of left and right banks
 - Local catchment erosion

- Water colour
- Sediment deposits
- Algae cover
- Water odour
- Substrate colour
- Water surface
- Variety of habitat
- Bars
- Flow level
- Riparian zone characteristics and values (to a maximum 100 m width) which include:
 - Width of riparian zone (left and right bank)
 - Bare ground (per cent)
 - Grass (per cent)
 - Shrubs (per cent)
 - Trees <10 m high (per cent)
 - Trees >10m high (per cent)
 - Presence of exotic riparian species
 - Width of continuous tree zone from bank
 - Description of dominant riparian species
- Macrophytes (per cent) (native and exotic)

A multi-probed, battery operated water quality meter (YSI Professional Plus) was used to measure physio-chemical parameters. The device was calibrated in the field prior to the collection of data (**Appendix C**) and used to take measurements of the following parameters:

- Dissolved oxygen (DO) (mg/L) and saturation (per cent)
- pH
- Electrical conductivity (EC) (µs/cm)
- Temperature (°C)
- Turbidity (NTU)
- Total dissolved solids (TDS) (ppm)
- Oxidation reduction potential (ORP) (mV).

Water quality samples were collected using sampling containers prepared and provided by the National Association of Testing Authorities accredited laboratory Australian Laboratory Services (ALS). Nitrile gloves were worn during sampling and field teams maintained best practice protocols to assist in prevention of on-site contamination.

Water samples collected for the purpose of analysis for dissolved metals were filtered in the field through a 0.45 µm filter using a sterile syringe. Once collected, samples were immediately placed in a refrigerator or on ice in an esky and delivered with Chain of Custody forms to ALS for analysis of the following analytes:

- Conductivity and salinity
- Total suspended solids
- Total hardness as CaCO₃ (Alkalinity)
- Nutrient suite (ammonia, nitrite, nitrate, total nitrogen, total kjeldahl nitrogen (TKN), nitrogen oxides (NO_x), reactive phosphorus (P) and total P)
- Organic nitrogen

- Dissolved metals (eight metals suite: arsenic, cadmium, chromium, copper, nickel, lead, zinc and mercury)
- PAHs
- Chlorophyll *a*

Field surveys involving both aquatic ecology and surface water quality investigations were planned for a period of nine consecutive days, with those surveys involving only surface water quality investigations planned for six consecutive days. The impact assessment area is located approximately four hours' drive from the laboratory. In order to avoid a breach of holding times for some analytes, the following approach was taken to the delivery of samples to the laboratory:

- A mid-field trip consignment of all samples collected to date was dropped at the laboratory by the field team for analysis
- Water samples for chlorophyll *a* were filtered through a glass fibre filter in the field, with the filter paper double wrapped in aluminium foil and stored in a freezer, as described in DES (2018c). Application of this method extended the laboratory holding time for Chlorophyll *a* from two days to 28 days.

A range of quality assurance processes were implemented during sampling. These included the following:

- At one monitoring site for each field trip, a second suite of water samples (duplicates) were taken and labelled DUP. This sample was a 'blind duplicate' of another site (unknown to the laboratory) and provided an opportunity to determine within-laboratory variation in the results between samples collected from the same location. The relative percent difference was calculated for duplicate samples, with a criterion of <35% applied for further investigation.
- For each field trip, a container of distilled water was transported into the field, and alongside collection of relevant site water samples, laboratory sampling containers were filled with this water (including filtration of dissolved metals samples). The samples were labelled 'Blank' and maintained and assessed alongside relevant site water quality samples, providing an opportunity to identify if the sample collection and/or storage procedures resulted in contamination of the samples.

3.5 Weather conditions and site access

Conditions were generally dry in the months prior to the aquatic ecology and surface water field surveys in June and November 2018. More frequent rainfall preceded the surface water surveys of February and April 2019 and aquatic ecology survey of May 2019, resulting in a higher proportion of sampling sites containing water.

The BoM weather station at Leyburn, Queensland, is located approximately mid-way along the alignment, and provides an indication of rainfall patterns in the region during the survey. It recorded 348 mm of rain in the twelve month period from 1 April 2018 to 1 April 2019, a majority of which fell between July and December (**Figure 5**). In comparison with historical data available for the Leyburn local area (2000 to 2018), average annual rainfall is 535.9 mm ranging from 273 to 1,022 mm. During the twelve-month period in which the study took place, Leyburn received approximately 35% less rainfall than is generally expected in an average year.

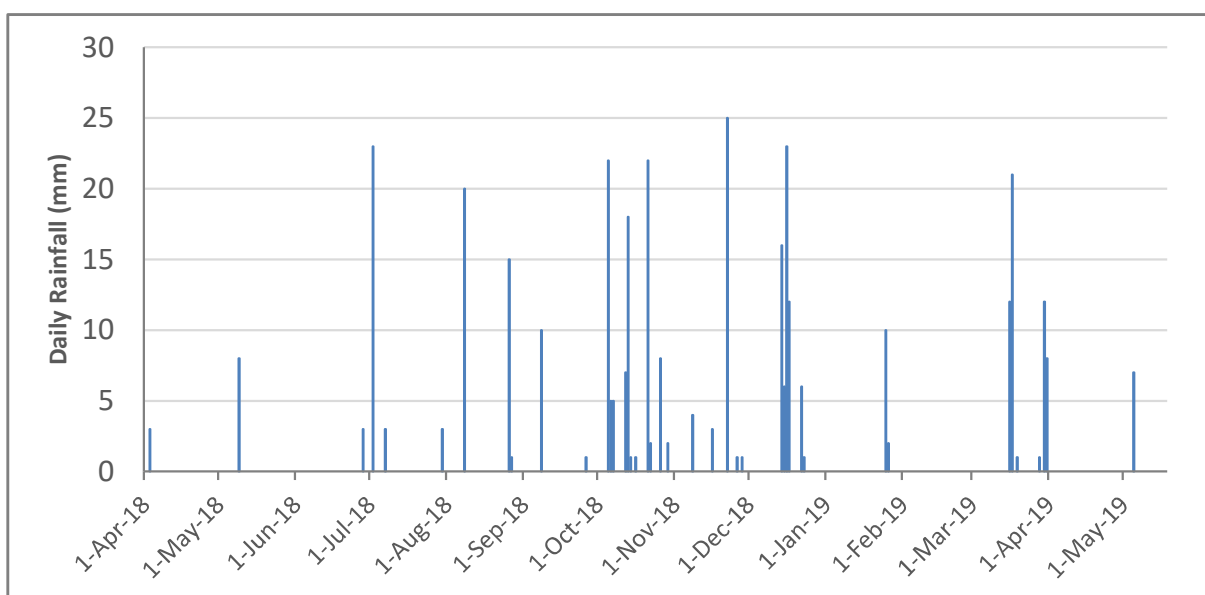


Figure 5 Rainfall data from Leyburn weather station from 1 April 2018 to 1 April 2019

The sampling sites assessed during the June 2018, November 2018, February 2019 and April 2019 field surveys are summarised in **Table 3**. In summary, the total number of sites assessed on each trip ranged from 31 to 35. Differences in sites visited among field trips related to difficulties in obtaining access to private land.

A majority of the sites were dry at the time of sampling in June and November 2018. In February 2019 approximately 50% of sites assessed contained water, increasing to 60% in April 2019. If dry sites were encountered, physical site characteristics were recorded.

Table 3 Sampling sites assessed during the four primary rounds of field surveys (- indicates not assessed)

Site	Assessment type	Waterway	June 2018 Survey date	Water Present?	November 2018 Survey date	Water Present?	February 2019 Survey date	Water Present?	April 2019 Survey date	Water Present?
1R	Surface water	Macintyre River	16/06/2018	Yes	-	-	-	-	-	-
2	Aquatic ecology	Macintyre River	-	-	29/11/2018	Yes	11/02/2019	Yes	29/04/2019	Yes
2R	Surface water	Macintyre River	16/06/2018	Yes	27/11/2018	Yes	11/02/2019	Yes	29/04/2019	Yes
3	Surface water	Macintyre Brook	17/06/2018	Yes	27/11/2018	Yes	12/02/2019	Yes	30/04/2019	Yes
4	Aquatic ecology and surface water	Unnamed	16/06/2018	No	27/11/2018	No	12/02/2019	No	30/04/2019	No
5	Aquatic ecology and surface water	Unnamed	16/06/2018	No	27/11/2018	No	12/02/2019	No	30/04/2019	No
6	Surface water	Macintyre Brook	16/06/2018	Yes	27/11/2018	Yes	12/02/2019	Yes	30/04/2019	Yes
7	Surface water	Macintyre Brook	17/06/2018	Yes	27/11/2018	Yes	12/02/2019	Yes	30/04/2019	Yes
8	Aquatic ecology and surface water	Unnamed	17/06/2018	No	28/11/2018	No	12/02/2019	No	30/04/2019	No
9	Aquatic ecology and surface water	Pariagara Creek	15/06/2018	No	28/11/2018	No	13/02/2019	No	30/04/2019	No
10	Surface water	Pariagara Creek	15/06/2018	No	28/11/2018	No	13/02/2019	No	30/04/2019	No
11	Surface water	Canning Creek	15/06/2018	Yes	28/11/2018	Yes	13/02/2019	Yes	30/04/2019	Yes
12	Aquatic ecology and surface water	Unnamed	17/06/2018	No	28/11/2018	No	12/02/2019	No	30/04/2019	No
13	Aquatic ecology and surface water	Cattle Creek	14/06/2018	No	28/11/2018	No	12/02/2019	No	30/04/2019	No
14	Surface water	Unnamed	14/06/2018	Yes	28/11/2018	Yes	13/02/2019	Yes	01/05/2019	Yes
15	Aquatic ecology and surface water	Unnamed	14/06/2018	No	29/11/2018	No	13/02/2019	No	01/05/2019	No
16	Aquatic ecology and surface water	Unnamed	13/06/2018	Yes	28/11/2018	Yes	13/02/2019	Yes	01/05/2019	Yes
17	Aquatic ecology and surface water	Unnamed	17/06/2018	No	28/11/18	No	13/02/2019	No	01/05/2019	No
18	Surface water	Unnamed	14/06/2018	No	30/11/2018	No	12/02/2019	Yes	01/05/2019	Yes

Site	Assessment type	Waterway	June 2018 Survey date	Water Present?	November 2018 Survey date	Water Present?	February 2019 Survey date	Water Present?	April 2019 Survey date	Water Present?
19	Aquatic ecology and surface water	Nicol Creek	13/06/2018	No	30/11/2018	No	12/02/2019	No	01/05/2019	No
20	Surface water	Nicol Creek	14/06/2018	No	-	-	-	-	-	-
20R	Surface water	Nicol Creek	-	-	30/11/2018	No	12/02/2019	No	01/05/2019	Yes
23	Surface water	Unnamed	13/06/2018	No	26/11/2018	No	12/02/2019	Yes	01/05/2019	Yes
24	Surface water	Grasstree Creek	18/06/2018	Yes	30/11/2018	Yes	13/02/2019	Yes	-	-
27	Surface water	Condamine River	15/06/2018	Yes	26/11/2018	No	13/02/2019	Yes	02/05/2019	Yes
28	Surface water	Unnamed	-	--	-	-	13/02/2019	Yes	01/05/2019	Yes
29	Surface water	Unnamed	15/06/2018	No	26/11/2018	No	13/02/2019	No	01/05/2019	Yes
30	Surface water	Condamine River	14/06/2018	Yes	01/12/2018	Yes	14/02/2019	Yes	02/05/2019	Yes
31	Surface water	Condamine River (North Branch)	14/06/2018	No	30/11/2018	No	14/02/2019	No	02/05/2019	No
32	Aquatic ecology and surface water	Condamine River (North Branch)	14/06/2018	No	01/12/2018	No	14/02/2019	Yes	-	-
33	Surface water	Condamine River (North Branch)	14/06/2018	No	26/11/2018	Yes	14/02/2019	No	-	-
35	Surface water	Unnamed	12/06/2018	No	01/12/2018	No	14/02/2019	No	02/05/2019	No
36	Surface water	Unnamed	12/06/2018	No	01/12/2018	No	14/02/2019	No	02/05/2019	No
39	Surface water	Westbrook Creek	15/06/2018	Yes	01/12/2018	Yes	14/02/2019	Yes	02/05/2019	Yes
40	Surface water	Dry Creek	12/06/2018	Yes	01/12/2018	Yes	14/02/2019	No	02/05/2019	Yes
42	Surface water	Dry Creek	15/06/2018	Yes	01/12/2018	Yes	14/02/2019	Yes	02/05/2019	Yes
43	Aquatic ecology and surface water	Unnamed	12/06/2018	No	01/12/2018	No	14/02/2019	No	02/05/2019	No

3.6 Survey limitations

Field surveys were undertaken during a period of long-term, below average rainfall across the impact assessment area. The local government areas of Toowoomba and Goondiwindi regional councils were subject to a drought declaration by DAF during the period of field surveys and associated impact assessment (DAF 2019), reflecting the dry conditions throughout the region. Results of the field surveys may therefore not be representative of environmental conditions during periods of average or above average rainfall. Surveys during dry conditions have the potential to yield different water quality results than those during wet periods. For example, water runoff containing sediments, nutrients and metals can be low or absent during dry conditions, resulting in good water quality. However, poor water quality can also arise in dry conditions due to high water temperatures reducing dissolved oxygen concentrations, and high evaporation rates causing the concentration of salts and other parameters in water. The quality of aquatic habitats also has the potential to be underestimated when assessed during dry conditions. These limitations have been considered in the interpretation of results.

A total of 21 of the proposed sampling sites were located on or required access through privately owned land. ARTC and FFJV coordinated access to private properties with the agreement of landholders. However, in some cases, access to private properties could not be negotiated or facilitated in the timeframes of the survey. In three cases, alternative sampling sites located on public land nearby were selected, where such areas provided suitable aquatic habitat and/or surface water values.

The laboratory holding times for some water quality analytes (e.g. reactive phosphorus, nitrite and nitrate: two days) were shorter than was practical for the transport of samples to the laboratory. The number of parameters affected was minimised by transporting samples to the laboratory every three to four days during field trips and using alternative methods for the preservation of samples where possible (e.g. chlorophyll a filter paper method; DES 2018c). Consequently, results for some parameters were obtained outside of the recommended holding times, and this has been considered when interpreting the results.

3.7 Data collation and analysis

3.7.1 Aquatic ecology physical habitat

The AusRivAS Physical Assessment Protocol is a standardised approach to assess various aquatic habitat parameters. A rating of either poor, fair, good or excellent was assigned to each habitat parameter from data recorded in the field, with an overall habitat rating calculated for low gradient streams (Parsons *et al.* 2002). The suitability of aquatic habitat for EVNT species was also determined, based on the results of the desktop assessment and field surveys.

3.7.2 Aquatic ecology macroinvertebrate communities

Macroinvertebrate data was used to calculate multiple community descriptors as described in the following sections.

Taxonomic richness

Taxonomic richness was calculated from the number of taxa present in each sample, providing an indication of community diversity at the site, with richness typically increasing with ecological condition.

PET

The Plecoptera, Ephemeroptera and Trichoptera (PET) richness was calculated from the number of taxa belonging to the three PET orders, in accordance with the method described in DNRM (2001). These three orders are widely accepted as being most sensitive to environmental change, such as habitat

degradation and pollution. A low PET richness score suggests that a site may be impacted by degradation or pollution, due to the absence of these pollution-sensitive taxa. Conversely, a high PET richness suggests a system free from degradation or pollution.

SIGNAL2

SIGNAL2 (Stream Invertebrate Grade Number – Average Level Version 2) indices were calculated, with each taxon allocated a score from 1 to 10 based on the method prescribed by Chessman (2003). Taxa with a low score are most tolerant of a range of environmental conditions, and those with a high score are more sensitive to pollution. The presence/absence data of each taxon were used to calculate the SIGNAL2 average for the site, in accordance with the protocols described by Chessman (2003).

Tolerant taxa

The percentage of tolerant taxa was calculated using the SIGNAL2 sensitivity grades derived from aquatic macroinvertebrate taxa at the Family level. Tolerant taxa are those with a SIGNAL2 score of 3 or less. Macroinvertebrate families in this group are expected to be able to tolerate changes to their environment, including habitat degradation and some pollution. An absence of the more sensitive taxa suggests environmental conditions may be too harsh for more sensitive taxa (those with SIGNAL2 score above 3) to tolerate.

AusRivAS

The macroinvertebrate and predictor variables (habitat) data was entered into the AusRivAS macroinvertebrate predictive modelling program – Version 3.2.2 (eWater 2017). The Queensland Regional Western spring and autumn models for bed and edge habitats were used (Table 4 and Table 5 respectively).

Table 4 AusRivAS habitat predictor model variables for QLD Regional Western November 2018 sampling

Code	Description	Input value for site	
		Site 2	Site 16
QLD Regional – Western – Spring – Edge habitat			
ALKALINITY	Total carbonates, Hardness as CaCO ₃ (mg/L)	70	100
DISTANCE FROM SOURCE	Distance from source (km)	180	30
LATITUDE	Latitude of site (decimal degrees)	-28.6642	-28.1563
LONGITUDE	Longitude of site (decimal degrees)	150.4678	151.1875
PROCESS ZONE	Process zone category (2 = erosional; 1 = transport; 0 = depositional)	1	1
QLD Regional – Western – Spring – Pool/Bed habitat			
BOULDER	Percent boulder (>256 mm) in habitat (%)	0	0
COBBLE	Percent cobble (64-256 mm) in habitat (%)	0	0
WETR	Range in wet season monthly rainfall means (mm)	33.8	35.1

Notes: Meteorology data for Site 2 derived from the 'New Kildonan TM' BoM monitoring station 41507 (approximately 2.5 km west). Meteorology data for Site 16 derived from the 'Duddawarra' BoM monitoring station 41543 (approximately 9 km north).

Table 5 AusRivAS habitat predictor model variables for QLD Regional Western May 2019 sampling

Code	Description	Input value for site				
		2	6R	7	18	42
QLD Regional – Western – Autumn – Edge habitat						
DRYRANGE	Range in dry season monthly rainfall means (mm)	7.5	7.5	7.5	7.5	11.0
LATITUDE	Latitude of site (decimal degrees)	-28.6631	-28.4459	-28.4075	-28.1032	-27.5277
MINTEMP	Mean daily minimum temperature (°C)	11.5	11.5	11.5	11.5	11.9
MWMR	Mean wet season monthly rainfall (mm)	71.5	71.5	71.5	71.5	87.4
STORDER	Stream order	9	7	7	5	3
WETPERCENT	Percentage rainfall in wet season (%)	65.2	65.2	65.2	65.2	72.9
QLD Regional – Western – Autumn – Pool/Bed habitat						
PROCESS ZONE	Process zone category (2 = erosional; 1 = transport; 0 = depositional)	1	1	1	1	2
STORDER	Stream order	9	7	7	5	3
WETR	Range in wet season monthly rainfall means (mm)	32.2	32.2	32.2	32.2	38.9

Notes: Meteorology data for Sites 2, 6R, 7 and 18 derived from the 'Texas Post Office' BoM monitoring station 41100 (being the nearest station that records both rainfall and daily minimum temperature). Meteorology data for Site 42 derived from the 'Toowoomba Airport' BoM station 41529 (approx. 9 km east) for the period 1996-2019.

3.7.3 Surface water quality

This section describes the approach to the collation and analysis of surface water quality data, with particular emphasis on the potential influence of surface water quality on aquatic ecology values. A separate Surface Water Quality Technical Report (Appendix P of the draft EIS) has also been prepared and provides additional consideration of surface water quality information relevant to the Project.

Water quality results were compared with relevant environmental values and water quality objectives. Environmental values and water quality objectives (target values; annual medians) for the Condamine River Basin and the Queensland Border Rivers Basin have been developed by the DES, in collaboration with the Queensland Murray Darling Committee and other stakeholders (DES 2019a, b).

Where a specific parameter/trigger value was not available for the Condamine River Basin and the Queensland Border Rivers Basin, the ANZECC Guidelines (2000, 2018) were used (95 per cent level of protection for slightly to moderately disturbed ecosystems). The Queensland Water Quality Guidelines (DEHP 2013) were also used to guide the assessment, but do not include any guidelines for sections of the Murray Darling Basin within Queensland. Hence, assessment of water quality was generally based on the ANZECC Guidelines (2000, 2018) and local Guidelines (DES 2019a, b).

It is well established that there are several abiotic factors that can modify the toxicity and bioavailability of some metals to aquatic organisms (ANZECC 2018). The ANZECC Guidelines (2000) provide a formula

to adjust water quality trigger levels to account for the reduced toxicity of these metals to biota with increasing water hardness. However, the more recent ANZECC Guidelines (2018) identify limitations to this approach, particularly for copper. Therefore, hardness and dissolved metals results from the impact assessment area have been presented for comparison with relevant guideline values, without the calculation of hardness corrected trigger levels. Discussion of the potential for high hardness concentrations at some sites to reduce the toxicity of metals is provided in **Section 4.3**.

3.8 Approach to impact assessment

A qualitative assessment is the most appropriate method for aquatic ecology and surface water quality impacts, through application of a significance assessment, as described in EIS Chapter 4: Assessment methodology of the draft EIS. This method is preferred where an impact will occur, and the sensitivity or vulnerability of the environmental values and the magnitude of the impact are important. Sensitivity criteria, magnitude criteria and a significance matrix were established to facilitate the assessment (**Tables 6-9**), and facilitate the assessment of Project impacts before and after the implementation of mitigation measures, to minimise the duration, intensity or extent of impacts.

The impact assessment method follows the mitigation hierarchy, which has the following sequential steps:

1. Avoidance (measures taken to avoid creating impacts, for example through the placement of infrastructure outside areas of key habitat)
2. Minimisation (measures taken to reduce the duration, intensity or extent of impacts that cannot be avoided, i.e., mitigation measures)
3. Rehabilitation (measures taken to improve the environment following exposure to impacts that cannot be completely avoided or minimised)
4. Offset (measures taken to compensate for any residual adverse impacts after implementation of the previous three steps in the mitigation hierarchy).

For each potential impact, a pre-mitigation and post-mitigation scenario was assessed and a significance ranking determined. The initial assessment of potential impact (pre-mitigation) was undertaken assuming mitigation methods associated with Concept Assessment and reference design phases of the Project had been implemented (Phases 1 and 2). Following this assessment of impact significance, additional mitigation measures associated with future project phases (Project Assessment, Project Approval, Project Implementation and Project Close-out; Phases 3-6) were then considered. These additional mitigation measures align with the detail design, pre-construction, construction and operation phases of the Project. The need to offset or compensate for residual impacts that could not be avoided through adoption of reasonable mitigation measures was also considered.

Consideration was also given to the benefits of monitoring water quality and aquatic ecology values during various stages of the Project, with recommendations provided in **Section 5.2**.

Table 6 Sensitivity criteria

Sensitivity	Description
Major	- The environmental value is listed on a recognised or statutory state, national or international register as being of conservation significance and/ or - The environmental value is entirely intact and wholly retains its intrinsic value and/ or - The environmental value is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region, state, country or the world and/ or - It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. - Project activities would have an adverse effect on the value.
High	- The environmental value is listed on a recognised or statutory state, national or international register as being of conservation significance and/ or - The environmental value is intact and retains its intrinsic value and/ or - The environmental value is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region and/ or - It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. - Project activities would have an adverse effect on the value.
Moderate	- The environmental value is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers and/ or - The environmental value is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements and/ or - It is relatively well represented in the systems/areas in which it occurs, but its abundance and distribution are exposed to threatening processes and/ or - Threatening processes have reduced its resilience to change. Consequently, changes resulting from project activities may lead to degradation of the prescribed value and/ or - Replacement of unavoidable losses is possible due to its abundance and distribution.
Low	- The environmental value is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations e.g. historical societies and/ or - The environmental value is in a poor to moderate condition as a result of threatening processes, which have degraded its intrinsic value and/ or - It is not unique or rare and numerous representative examples exist throughout the system / area and/ or - It is abundant and widely distributed throughout the host systems / areas and/ or - There is no detectable response to change or change does not result in further degradation of the environmental value and/ or - The abundance and wide distribution of the environmental value ensures replacement of unavoidable losses is achievable.
Negligible	- The environmental value is not listed on any recognised or statutory register and is not recognised locally by relevant suitably qualified experts or organisations and/ or - It is not unique or rare and numerous representative examples exist throughout the system / area and/ or - There is no detectable response to change or change does not result in further degradation of the environmental value.

Table 7 Magnitude criteria

Magnitude	Description
Major	An impact that is widespread, permanent and results in substantial irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of environmental management controls are required to address the impact.
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact.
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the Project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls.
Low	A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls.
Negligible	An extremely localised impact that is barely discernible and is effectively mitigated through standard environmental management controls.

Table 8 Significance matrix

Magnitude	Sensitivity				
	Major	High	Moderate	Low	Negligible
Major	Major	Major	High	Moderate	Low
High	Major	Major	High	Moderate	Low
Moderate	High	High	Moderate	Low	Low
Low	Moderate	Moderate	Low	Negligible	Negligible
Negligible	Moderate	Low	Low	Negligible	Negligible

Table 9 Significance classifications

Significance	Description
Major	Arises when an impact will potentially cause irreversible or widespread harm to an environmental value that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
High	Occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the environmental value. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
Moderate	Results in degradation of the environmental value due to the scale of the impact or its susceptibility to further change even though it may be reasonably resilient to change. The abundance of the environmental value ensures it is adequately represented in the region, and that replacement, if required, is achievable.
Low	Occurs where an environmental value is of local importance and temporary or transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
Negligible	Does not result in any noticeable change and hence the proposed activities will have negligible effect on environmental values. This typically occurs where the activities are located in already disturbed areas.

3.9 Assessment of cumulative impacts

Projects with spatial and/or temporal overlap can result in cumulative impacts. Cumulative impacts may:

- Differ from those of an individual project when considered in isolation
- Be positive or negative
- Differ in severity and duration depending on the spatial and temporal overlap of projects occurring in an area.

It is a requirement of the ToR for this Project that the potential for cumulative impacts be considered. This section provides details of the methods for the assessment of cumulative impacts in relation to aquatic ecology values.

Cumulative impacts of the Project were qualitatively assessed. A list of applicable projects and operations for consideration in the cumulative impact assessment was developed for assessment by all EIS disciplines (**Table 10**). The potential for spatial and temporal overlap between the Project and other projects was considered, in relation to potential impacts on aquatic ecology and surface water quality values.

The approach used to identify and assess potential cumulative impacts of the Project was as follows:

- A review of the potential impacts identified within the draft EIS assessments. The environment at the time of the ToR is the baseline, prior impacts from past land use has not be considered
- A register of assessable projects was collated with timelines to demonstrate the temporal relationship between projects. This included:

- Only 'state significant' or 'strategic' projects (i.e. coordinated projects under the SDPWO Act) that are in the public domain as being planned, constructed or operated at the time of the ToR were considered
- Additional projects were considered where they were deemed to be of local significance, as occurring through consultation with community groups and stakeholders. These included:
 - Projects listed in Goondiwindi Regional Council and Toowoomba Regional Council Development Application databases
 - Development within Priority Development Areas and State Development Areas
 - Economic Development Queensland development projects
 - Community Infrastructure Designation projects
 - Projects within the public register of environmental authorities
 - Department of Transport and Main Roads infrastructure projects
 - Private infrastructure facilities
 - Development in accordance with Regional Planning Interests
 - The Inland Rail projects immediately adjacent to the Project, being the North Star to NSW/QLD Border and Gowrie to Helidon projects
- Identification and mapping of the assessable projects and the areas of influence. Current operational projects and commercial or agricultural operations that are in the area of influence around the Project are accounted for in the baseline assessment
- Where there is a potential overlap in impacts (either spatially or temporally), a cumulative impact assessment was undertaken to determine the nature of the cumulative impact. This includes:
 - Where possible the assessment method has been quantitative in nature however qualitative assessment has also been undertaken for certain environmental values
 - Where quantitative assessment has been possible, the significance of impact has been assessed in comparison to the same criteria or guidelines as adopted by the relevant technical impact assessments
 - Where impacts are expressed qualitatively, the probability, duration, and magnitude/intensity of the impacts have been considered as well as the sensitivity and value of the receiving environmental conditions

Some of the other projects in **Table 10** were in an operational phase at the time that the Border to Gowrie Project ToR were issued. Therefore, these other projects were influencing the existing environment at the time that the desktop and field assessments were carried out for the Border to Gowrie Project. The potential for the impacts of these operational projects to act cumulatively with those of the Project is therefore inherent within the impact assessment, which predicts the additional effects of the Project on the environmental baseline. Operational projects were therefore not carried forward to the assessment of cumulative impacts (refer **Section 5.4**).

Table 10 Projects identified for consideration in the cumulative impact assessment for aquatic ecology

Projects	Status[#]	Description
Wetalla Water Pipeline (north of the Project)	Completed	This is part of the New Acland Coal Mine – Stage 3 expansion. A 45 km underground water pipeline to supply up to 5,500 ML of treated wastewater to the New Acland coal mine, which is earmarked for expansion.
New Acland (approximately 25 km northwest of the Project)	Approved with conditions	Expansion of the existing New Acland open-cut coal mine to up to 7.5 Mtpa.
Australia Pacific LNG Project (Walloons gas fields is approximately 20 km west of Millmerran)	Approved with conditions	Integrated liquefied natural gas (LNG) project. The Walloons gas fields area is the component closest to the Project.
Toowoomba Bypass (previously the Toowoomba Second Range Crossing)	Construction at time of ToR being issued Became operational in September 2019	DTMR has delivered a second range crossing that takes heavy vehicle highway traffic around north of Toowoomba rather than through it. The 41 km long bypass route runs from the Warrego Highway at Helidon Spa in the east to the Gore Highway at Athol in the west, via Charlton.
InterLink SQ – Global Logistics Centre and Industrial Park (located 8 km from Wellcamp International Airport)	Construction	InterLink SQ has two components, The InterLink Industrial Park, and the InterLink Global Logistics Centre (rail/road terminal). The Industrial Park is a master-planned logistics, warehousing and industrial estate that will provide opportunities for companies to co-locate in a logistics hub. The 140-hectare industrial park is approved, and construction has started. The InterLink Global Logistics Centre is an open access, intermodal terminal linking rail, road, sea and air. The 60 hectare site will include a three kilometre frontage along the Inland Rail route and will incorporate grain and commodities storage, processing and loading facilities, rail maintenance and provisioning, and a large container handling and storage area. The precinct will move 250,000 Import Export TEU's per year.
Toowoomba Wellcamp Airport (located 17 km west of Toowoomba CBD, and immediately south of Inland Rail corridor)	Operational – subject to expansion	The airport operates as an international cargo hub connecting Australia's leading primary producers and processors with growing consumer markets across the globe. The airport was constructed over 19 months from 2012 to 2014 and is the first major greenfield public airport development in Australia in over 50 years.

Projects	Status [#]	Description
Wellcamp Business Park	Operational – subject to continuing construction and expansion	Part of the Toowoomba Enterprise Hub. 500 hectare industrial and commercial estate surrounds Brisbane West Wellcamp Airport and is fast becoming the commerce and industry hub of Toowoomba and regional south east Queensland.
Witmack Industry Park and Charlton Logistics Park	Operational – subject to continuing construction and expansion	Part of the Toowoomba Enterprise Hub. Witmack Industry Park and Charlton Logistics Park – Witmack Industry Park is one of Toowoomba's largest industrial land developments and offers large size industrial land parcels from 2 to 5 hectares. Charlton Logistics Park is the most recent addition to the Toowoomba Enterprise Hub and provides level and fully serviced 2 hectare sites. Due to its Warrego Highway location combined with easy access to the Second Range Crossing, Charlton Logistics Park is well suited for transport and logistics operators.
Commodore Mine and Millmerran Power Station (south of Millmerran)	Operational	The Commodore Mine is an open pit coal mine, located in the Surat Basin and began supplying coal to the 850 MW Millmerran Power Station in February 2003. Millmerran Power Station is a coal-fired power station that supplies base-load power and came on line early in 2003. It supplies enough electricity to power approximately 1.1 million homes.
Pittsworth Industrial Precinct and PIP Enabling Project (Pittsworth)	Construction	New road and sewerage infrastructure at Pittsworth Industrial Precinct will open up industrial land for industries servicing agriculture and the wider region.
Doug Hall Poultry (Millmerran)	Operational	Poultry farm with approximately 200 employees producing caged, cage free, free range and organic eggs. Operations include egg grading, a feed mill with output of 1,500 tonnes per week, piggery, cropping and solar farm.
Yarranbrook Feedlot (Inglewood)	Operational	Feedlot currently licensed for 25,000 head. Operations include pivot farms.
Sapphire Feedlot (Kildonan)	Operational	Cattle feedlot and grain production. The 6,000 head Sapphire Feedlot has capacity to grow to 8,700 head with the development to be rolled out in future.
Wyemo Piggery (Texas-Yelarbon Rd, Glenarbon)	Planned	Intensive animal industries – 55,000 standard pig units Environmentally relevant activities – 8,000 standard pig units
Yarranlea Solar	Approved with conditions	100 MW solar farm located at Yarranlea.
Goondiwindi Abattoir	Approved with conditions	Proposed beef processing of 72,000 tonnes per year.
Asterion Medicinal Cannabis Facility, Wellcamp	Planned	A medicinal cannabis cultivation, research and manufacturing facility, involving construction of a 40 ha glasshouse to produce 20,000 plants per day at full capacity. Medicinal grade cannabis grown at the facility will be manufactured into a range of medicinal products. Projected capital expenditure is \$450 million.

Projects	Status [#]	Description
North Star to Border (Inland Rail)	Reference design and EIS	The North Star to NSW/QLD Border section of the Inland Rail is a new freight rail corridor approximately 30 km in length. The new rail corridor will connect North Star (NSW) to the Queensland Rail South Western Line near Yelarbon just north the NSW/QLD border.
Gowrie to Helidon (Inland Rail)	Draft EIS being prepared	This project comprises 26 km of new dual gauge track between Gowrie (north-west of Toowoomba) and Helidon (east of Toowoomba). It crosses the two Local Government Areas of Toowoomba and Lockyer Valley. The Gowrie to Helidon section of Inland Rail will include a new 6.38 km tunnel to create an efficient route through the steep terrain of the Toowoomba Range.
Helidon to Calvert (Inland Rail)	Reference design and EIS	New 47 km dual gauge rail line connecting Helidon (east of Toowoomba) with Calvert (near Ipswich), via Placid Hills, Gatton, Forest Hill, Laidley and Grandchester, extending through the LGAs of Lockyer Valley and Ipswich City. The project includes a 1.1 km tunnel to create an efficient route through the steep terrain of the Little Liverpool Range.
Calvert to Kagaru (Inland Rail)	Reference design and EIS	New 53 km dual gauge track from Calvert to Kagaru to provide convenient access for freight to major proposed industrial developments at Ebenezer in the City of Ipswich, and at Bromelton near Beaudesert in the Scenic Rim Region. The project includes a 1.1 km tunnel through the Teviot Range.
Kagaru to Acacia Ridge (Inland Rail)	Reference design and EIS	Enhancements to, as well as commissioning of, dual gauge operations along the existing interstate track between Kagaru and Acacia Ridge. The project involves 49 km of existing track to be enhanced enabling double-stacking capability along the existing interstate route both south from Kagaru to Bromelton and north from Kagaru to Brisbane's major intermodal terminal at Acacia Ridge. It extends across three LGAs of Scenic Rim, Logan and Brisbane.
Cross River Rail	Construction	New 10.2 km passenger rail line from Dutton Park to Bowen Hills, which includes 5.9 km of tunnel under the Brisbane River and the CBD. The Project will include four new underground stations at Boggo Road, Woolloongabba, Albert Street and Roma Street, and upgrades to Dutton Park and Exhibition stations.

[#] Operational projects were not carried forward to the assessment of cumulative impacts

For those future projects with potential for cumulative impacts, further assessment was made by considering the probability and duration of impact, and the sensitivity of the receiving environment, which were all ranked on a scale of Low, Medium or High. An assessment matrix method (further detailed within **Table 11** and **Table 12**) was used to determine the significance of cumulative impacts with respect to beneficial or detrimental effects.

Following the identification of each potential cumulative impact, a relevance factor score of Low, Medium and High was determined in consideration of the impacts, in accordance with the assessment matrix given in **Table 11**. The significance of the impact was determined by using professional judgement to select the most appropriate relevance factor for each aspect in **Table 11**.

The sum of the relevance factors determined the impact significance and consequence which are summarised in **Table 12**. For example if an environmental value was considered to have a probability of impact of 2, duration of impact of 3, magnitude/intensity of impact of 1 and a sensitivity of receiving environment of 1, the significance of impact would be Medium ($2+3+1+1 = 7$).

If cumulative impacts were deemed to be of 'medium' or 'high' significance, additional mitigation measures were proposed, beyond those already proposed by the relevant technical impact assessments.

Table 11 Assessment matrix for assessment of cumulative impacts

Aspect	Relevance factor		
	Low	Medium	High
Probability of impact	1	2	3
Duration of impact	1	2	3
Magnitude/Intensity of impact	1	2	3
Sensitivity of receiving environment	1	2	3

Table 12 Impact significance criteria for cumulative impacts

Impact significance	Sum of relevance factors	Consequence
Low	1-6	Negative impacts need to be managed by standard environmental management practices. Monitoring to be part of general project monitoring program.
Medium	7-9	Mitigation measures likely to be necessary and specific management practices to be applied. Targeted monitoring program required, where appropriate.
High	10-12	Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Targeted monitoring program necessary, where appropriate.

4 Existing aquatic and surface water values

4.1 Environmental values and water quality objectives

A common approach to describing the existing condition of aquatic environments is to describe their environmental values and compare the results of water quality monitoring with relevant water quality guidelines. The *ANZECC Guidelines* (2000, 2018) provide water quality guidelines for some parameters, with a particular focus on biologically available (dissolved) metals. The slightly to moderately disturbed classification (95 per cent level of protection) is most appropriate to the waterways of the impact assessment area, due to their existing level of disturbance from adjacent land uses. However, the guidelines also encourage the development and application of local guidelines, based on water quality data collected from the region.

DES has published two reports relevant to the Project and the application of local water quality guidelines:

- *Healthy Waters Management Plan: Queensland Border Rivers and Moonie River Basins* (DES 2019a) and
- *Healthy Waters Management Plan: Condamine River Basin* (DES 2019b).

The Healthy Waters Management Plans have been prepared to meet accreditation requirements under the Commonwealth *Water Act 2007* – Basin Plan 2012 (Commonwealth of Australia 2012). Each plan has been adopted following a period of public consultation in 2018, and confirms the environmental values, desired levels of aquatic ecosystem protection, water quality objectives and management responses under the EPP Water and Wetland Biodiversity.

The Project intersects six sub-catchments recognised in the local guidelines for the development of environmental values, comprising:

- Macintyre Barwon Floodplain (Queensland Border Rivers Basin; sites 1 to 2);
- Lower Macintyre Brook (Queensland Border Rivers Basin; sites 3 to 8);
- Canning Creek (Queensland Border Rivers Basin; sites 9 to 20);
- Condamine River (Condamine River Basin; sites 21 to 30);
- Condamine River North Branch (Condamine River Basin; sites 31 to 33); and
- Upper Oakey (Condamine River Basin; sites 34 to 43).

The environmental values (DES 2019a, b) attributed to each of these sub-catchments are identified in **Table 13**. 'Aquatic ecosystems' is an environmental value common across all six sub-catchments.

The water quality objectives (DES 2019a and 2019b) most relevant to the Project relate to moderately disturbed surface water ecosystems described in the local guidelines; and the default ANZECC Guidelines (2000, 2018) for pesticides, heavy metals and other contaminants for slightly to moderately disturbed ecosystems (95% level of protection). The Project intersects six *Basin Plan* water quality zones comprising:

- Macintyre Barwon Floodplain (Queensland Border Rivers Basin; Sites 1 to 2);
- Lower Macintyre Brook (Queensland Border Rivers Basin; Sites 3 to 8);
- Canning Creek (Queensland Border Rivers Basin; Sites 9 to 20);
- Southern Condamine (Condamine River Basin; Sites 21 to 26);

- Central Condamine (Condamine River Basin; Sites 27 to 33); and
- Oakey Creek (Condamine River Basin; Sites 34 to 43).

The water quality objectives differ for each of the six *Basin Plan* water quality zones and are summarised in **Table 14**.

Table 13 Environmental values for surface waters intersected by the Project (DES 2019a, b)

Environmental Values	Aquatic Ecosystems	Irrigation	Farm Supply	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural, spiritual and ceremonial values
Condamine River Basin Sub-Catchment												
Upper Oakey (sites 34 to 43)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Condamine River North Branch (sites 31 to 33)	✓	✓	✓						✓	✓	✓	✓
Condamine River South Branch (sites 21 to 30)	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Queensland Border Rivers Basin Sub-Catchment												
Canning Creek (sites 9 to 20)	✓	✓		✓					✓			✓
Lower Macintyre Brook (sites 3 to 8)	✓	✓	✓	✓		✓	✓		✓	✓		✓
Macintyre Barwon Floodplain (sites 1 to 2)	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓

Location		Water Quality Parameters														
		NTU	phosphorus µg/L	phosphorus µg/L-P/L	ammonia µg/L	nitrogen µg/L	nitrogen µg/L-N/L	nitrogen µg/L-N/L	oxygen			µS/cm	mg/L	mg/L	°C	mg/L
Station 43)	Low flow	13	110	45	5	1,000	5	10	ID	60 to 110	7.7 to 8.3	510	NA	7	20:80 percentiles of natural monthly water temperature	14
	High flow	55	340	90	ID	1,280	ID	ID			7.4 to 8.1	380		7		6
Stations 27 to 30	Low flow	25	170	20	9	860	4	4			7.4 to 8.3	890		5		2
	High flow	220	950	500	4	2,200	480	ID			7.0 to 7.6	290		4		13
Stations 21 and 22	Low flow	9	45	15	5	590	3	6			7.2 to 7.9	170		3		8
	High flow	25	60	20	ID	830	ID	ID			7.0 to 7.6	160		2		1
Floodplain Basin																
Station 20)	Low flow	35	30	8	ID	520	6	10	ID	60 to 110	7.2 to 7.8	200	NA	2	20:80 percentiles of natural monthly water temperature	2
	High flow	50	40	ID	ID	600	ID	ID			6.9 to 7.9	165		3		6
Stations 3 and 4	Low flow	11	55	11	ID	710	18	8			7.4 to 8.0	370		10		1
	High flow	25	70	ID	ID	910	ID	ID			7.2 to 8.0	250		10		2
Floodplain	Low flow	30	70	20	3	575	10	20			7.4 to 8.0	240		7		2
	High flow	110	150	ID	ID	900	195	ID			7.0 to 7.5	180		6		7

4.2 Results of desktop assessment

The desktop study identified one EVNT aquatic flora, four ENVT aquatic fauna and nineteen introduced aquatic flora which potentially could occur within the impact assessment area. In addition, important waterways and wetlands were also identified as meeting criteria for listing as MSES. These results are summarised in the following sections, and **Appendix B** provides a detailed table describing the likelihood of occurrence for EVNT listed aquatic flora and fauna.

4.2.1 EVNT aquatic flora

The Wetland/Info database identifies 136 wetland indicator plant species as having previously been recorded from the Queensland Border Rivers drainage basin and 180 wetland indicator plant species as having previously been recorded from the Condamine River drainage sub-basin (DES 2018b). Of these, one is an EVNT species, being the Endangered (NC Act) fringing rush (*Fimbristylis vagans*), recorded from the Condamine River drainage sub-basin (DES 2018b), which has potential to occur in the impact assessment area (**Appendix B**).

4.2.2 Introduced aquatic flora

The Commonwealth Government recognises 32 weeds of national significance (WoNS) across Australia, based on their:

- invasiveness and impact characteristics;
- current distribution and potential area of spread; and
- current primary industry, environmental and socio-economic impact.

The *Biosecurity Act 2014* (Qld) lists Prohibited and Restricted biosecurity matters (including weed species) for Queensland.

There are 22 introduced wetland indicator plant species known from the Balonne-Condamine drainage basin (EHP 2016). Those invasive species, including WoNS and other introduced plants, considered to pose a particular threat to aquatic biodiversity, and that could potentially occur within the impact assessment area, are listed in **Table 15**.

Table 15 Introduced wetland indicator plants known to occur in the Balonne-Condamine drainage basin, and potential to occur in the impact assessment area

Scientific name	Common name	National status [^]	BA status*	Basin / sub-basin	
				Condamine	Border Rivers
<i>Arundo donax</i>	-			✓	✓
<i>Berula erecta</i>	Water parsnip			✓	
<i>Cyperus eragrostis</i>	-			✓	✓
<i>Cyperus esculentus</i>	Yellow nutgrass			✓	
<i>Cyperus involucratus</i>	-			✓	
<i>Cyperus papyrus</i>	Papyrus			✓	
<i>Diplachne fusca var. uninervia</i>	-			✓	
<i>Echinochloa colona</i>	Awnless barnyard grass			✓	✓
<i>Echinochloa crus-galli</i>	Barnyard grass			✓	✓
<i>Eclipta prostrata</i>	White eclipta			✓	✓
<i>Egeria densa</i>	Dense waterweed			✓	
<i>Eichhornia crassipes</i>	Water hyacinth	WoNS	R3		✓
<i>Juncus articulatus</i>	Jointed rush			✓	✓
<i>Juncus bufonius</i>	Toad rush			✓	✓

Scientific name	Common name	National status [^]	BA status*	Basin / sub-basin	
				Condamine	Border Rivers
<i>Pistia stratiotes</i>	Water lettuce		R3	✓	
<i>Polypogon monspeliensis</i>	Annual beardgrass			✓	✓
<i>Salix babylonica</i>	Weeping willow			✓	✓
<i>Salvinia molesta</i>	Salvinia	WoNS	R3		✓
<i>Rorippa nasturtium-aquaticum</i>	Watercress			✓	

Notes:

[^] Species listed as WoNS; * species listed under the Queensland *Biosecurity Act 2014* (R3 = Category 3 Restricted Matter).

4.2.3 EVNT aquatic fauna

The Wetland/*Info* database identifies 17 native fish species that have previously been recorded from the Queensland Border Rivers drainage basin and 27 native fish species from the Condamine drainage sub-basin (DES 2018b). Of these, two species are listed as EVNT (see **Appendix B** for further details) and have historically been recorded from both catchments:

- Murray Cod (*Maccullochella peelii*) – Vulnerable (EPBC Act); and
- Silver Perch (*Bidyanus bidyanus*) – Critically Endangered (EPBC Act).

The Murray Cod occurs naturally within the Condamine and Queensland Border Rivers drainage basins and is found within Queensland and other Australian states. This species prefers deep water with in-stream habitat such as boulders, logs, and overhanging vegetation, and are sensitive to habitat alterations, such as altered flow regimes and overfishing (Allen *et al.* 2002). Suitable habitat for the Murray Cod occurs within the impact assessment area, including sites on the Macintyre River, Macintyre Brook, Canning Creek and the Condamine River. Bringalily Creek represents marginal habitat for the Murray Cod. The Murray Cod is known to occur within the impact assessment area (**Appendix B**), including the Macintyre River and Macintyre Brook (**Section 4.4.5**). The species also has potential to occur in the impact assessment area within large river systems such as the Condamine River. Draft referral guidelines for the Murray Cod identify that important populations of the species are present in the Macintyre River and Macintyre Brook (DotE 2016).

The Silver Perch prefers faster-flowing water, including rapids and races, and more open sections of river throughout the Murray Darling Basin (TSSC 2013). The Silver Perch was assessed as unlikely to occur in the impact assessment area, due to a lack of recent records from the region, and the presence of only small areas of habitat that may be suitable for the species (**Appendix B**).

The Wetland/*Info* database identifies five turtle species that have previously been recorded from the Queensland Border Rivers drainage basin and six turtle species from the Condamine drainage sub-basin (DES 2018b). Of these, two are listed as EVNT:

- Bell's turtle (*Wollumbinia bellii*) – Vulnerable (EPBC Act and NC Act) – Queensland Border Rivers drainage basin; and
- Southern snapping turtle (*Elseya albagula*) – Critically Endangered (EPBC Act); Endangered (NC Act) – Condamine drainage sub-basin.

The Bell's turtle inhabits narrow sections of rivers in granite country in northern NSW on the New England Tablelands, and in south-east Queensland near Stanthorpe, at the headwaters of the Queensland Border

Rivers catchment (DES 2018d). It is considered unlikely to occur in the impact assessment area (refer to **Appendix B**).

Southern snapping turtles are not typically found in the Condamine drainage sub-basin, but are generally found throughout the Fitzroy, Burnett, and Mary Rivers to the north. This species prefers flowing waters (Cogger 2014) but has been captured by the study team in a variety of habitats including deep, isolated, yet permanent, pools in both the Fitzroy and Burnett River catchments. The southern snapping turtle's appearance is superficially very similar to that of the Least Concern saw-shelled turtle (*Wollumbinia latisternum*), being differentiated by the intergular scutes on their plastron (underside of shell). It is suspected that multiple database records may be misidentifications by less experienced observers who have not handled and carefully inspected the plastron of suspected southern snapping turtles. It is unlikely that the southern snapping turtle occurs within the Condamine drainage sub-basin, and even less likely that it occurs within the impact assessment area.

The Wetland/Info database (DES 2018b) identifies the Platypus (*Ornithorhynchus anatinus*) as having previously been recorded from both the Queensland Border Rivers drainage basin and the Condamine drainage sub-basin. This species is listed as SLC, for cultural reasons, under the NC Act, and is known to occur in the impact assessment area (**Appendix B**).

A detailed description of EVNT species including information on their distribution, life history and habitat requirements is provided in Appendix L of the draft EIS (Matters of National Environmental Significance Technical Report).

4.2.4 Introduced fishes

The Wetland/Info database identified four introduced fish species that have previously been recorded from the catchments intersected by the Project. The mosquitofish (*Gambusia holbrooki*), goldfish (*Carassius auratus*) and European carp (*Cyprinus carpio*) have been recorded from both the Queensland Border Rivers drainage basin and the Condamine drainage sub-basin (DES 2018b). The guppy (*Poecilia reticulata*) has been recorded from the Condamine drainage sub-basin only (DES 2018b).

Introduced fishes can cause a variety of issues within the aquatic environment, such as competing with native fish for food and habitat, preying on native species, habitat disturbance and introduction of disease. Typically, established introduced species have a wide range of environmental tolerances, habitat requirements and food requirements. In addition, they tend to have high reproductive rates and be early maturing, allowing populations to become readily established. These attributes often allow introduced fishes to be more adaptable to changes in the environment, whether natural or manmade, than some native fish species.

4.2.5 MSES wetlands, watercourses and groundwater dependent ecosystems

The Queensland Mapping and Classification project is a system which provides maps displaying Queensland's wetland data. Within this classification system there are five wetland types identified:

- Marine: Consists of an open ocean overlying the continental shelf and associated high energy coastline
- Estuarine: Are wetlands with oceanic water that is occasionally diluted with freshwater run off from the land
- Riverine: Are systems which include all wetlands and deep water habitats contained within a channel
- Lacustrine: Are systems which are typically extensive areas of deep water habitat and wetlands (excluding those dominated by trees)

- Palustrine: Consists of all non-tidal wetlands which are dominated by trees, shrubs and persistent emergent, emergent mosses or lichens.

The Queensland Wetland Classification Mapping identifies several wetland types and values along and within 10 km of the rail alignment (**Figure 6** and **Figure 7**). These include riverine, palustrine and lacustrine wetland systems as well as mapped Regional Ecosystems (REs) that potentially contain wetland values. Riverine wetlands and REs which potentially contain riverine wetland values are common throughout the alignment as are palustrine wetlands and their RE counterparts. Lacustrine wetlands are also mapped within proximity to the alignment however these water bodies are relatively small. For the majority, areas consisting of a mosaic of REs containing a small proportion of potential wetland values (1 to 50 per cent) frequently intersect the alignment.

Multiple palustrine wetlands and some REs (11.3.4 and 11.3.5) with potential riverine wetland values along the alignment have been identified in the Queensland Referable Wetland Mapping as of High Ecological Significance (HES) as recognised under the *Environmental Protection Regulation 2008*. However, none of these mapped wetlands occur within mapped High Ecological Value waters as outlined in the EPP (Water and Wetland Biodiversity). The closest HES wetland mapped within High Ecological Value waters is approximately 25 km east of the Gowrie end of alignment.

Similarly, many of the wetlands (palustrine, lacustrine and mosaic) mapped along the alignment are also mapped as wetlands under the *Vegetation Management Act 1999* (VM Act). These wetlands predominantly occur in the eastern and western extents of the alignment.

There are mapped VM Act watercourses that intersect the alignment, with stream orders ranging from 1 to 9 as follows:

- Stream order 9: one watercourse
- Stream order 6: one watercourse
- Stream order 5: two watercourses
- Stream order 4: six watercourses
- Stream order 3: seven watercourses
- Stream order 2: 22 watercourses
- Stream order 1: 49 watercourses

The mapped VM Act watercourses that are also recognised under the *Water Act 2000* and intersect the alignment include:

- Westbrook Creek
- Condamine River
- Grasstree Creek
- Macintyre River
- Pariagara Creek
- Back Creek
- Bringalily Creek
- Nicol Creek
- Dry Creek

A watercourse determination may be required for works affecting watercourses that are not mapped under the *Water Act 2000*. ARTC is an approved entity for the purpose of the DNRME Riverine Protection Permit exemption requirements, and works can be undertaken providing that they meet the guidelines of the exemption.

Fish waterways relevant to waterway barrier works have been identified along the alignment, with maps provided in **Appendix F**. These waterways reflect areas that provide fish passage, and are defined under the *Fisheries Act 1994*. The number of waterway intersections with the centre of the rail alignment by risk classification are as follows:

- Low risk (green) – 43 waterways
- Moderate risk (amber) – 28 waterways
- High risk (red) – 7 waterways
- Major risk (purple) – 10 waterways

The level of risk relating to each waterway will be considered by the design team responsible for the design of infrastructure such as culverts, bridges and other potential barriers to fish movement. This will occur during the detail design stage of the Project.

Groundwater-dependent ecosystems (GDEs) are ecosystems that rely upon groundwater for their continued persistence. Some GDEs are entirely dependent on groundwater resources while others may utilise this intermittently. There are three types of GDEs:

- Aquatic GDEs: surface ecosystems dependent on the surface expression of groundwater
- Terrestrial GDEs: surface ecosystems dependent on the subsurface presence of groundwater
- Subterranean GDEs: include caves and aquifers

Both aquatic and terrestrial GDEs have been mapped by DES along the alignment from approximately halfway along the section to the NSW/QLD border. The mapping is suitable for use at a regional scale, and is produced from an assessment of vegetation mapping, wetland mapping, expert knowledge and the results of existing research.

Terrestrial GDEs are most dominant and concentrated in the mid-section, while aquatic GDEs are scattered towards the NSW/QLD border end of alignment. The terrestrial GDEs are associated with Canning Creek and Macintyre Brook, both of which intercept the rail alignment.

Several ephemeral springs (sourced from bedrock aquifer systems) have been mapped by DES adjacent to the Gowrie end of the alignment, and include:

- Leigh Spring
- Stone Spring
- Springside Spring
- Jimna Springs
- Wellcamp Spring
- Eustondale Spring
- Merigandan Creek.

4.2.6 AquaBAMM / Aquatic Conservation Assessments

The Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) is a methodology developed by the Department of Environment and Science to assess conservation values of aquatic ecosystems in Queensland (DEHP 2015). The method combines a multitude of different criterion scores related to biodiversity and species richness, presence of threatened species or community, presence of priority species or ecosystem, ecosystem complexity (e.g. uniqueness of geomorphology) and landscape connectivity (Clayton et.al 2006). A summary score (AquaScore) is produced and classified into one of five rankings;

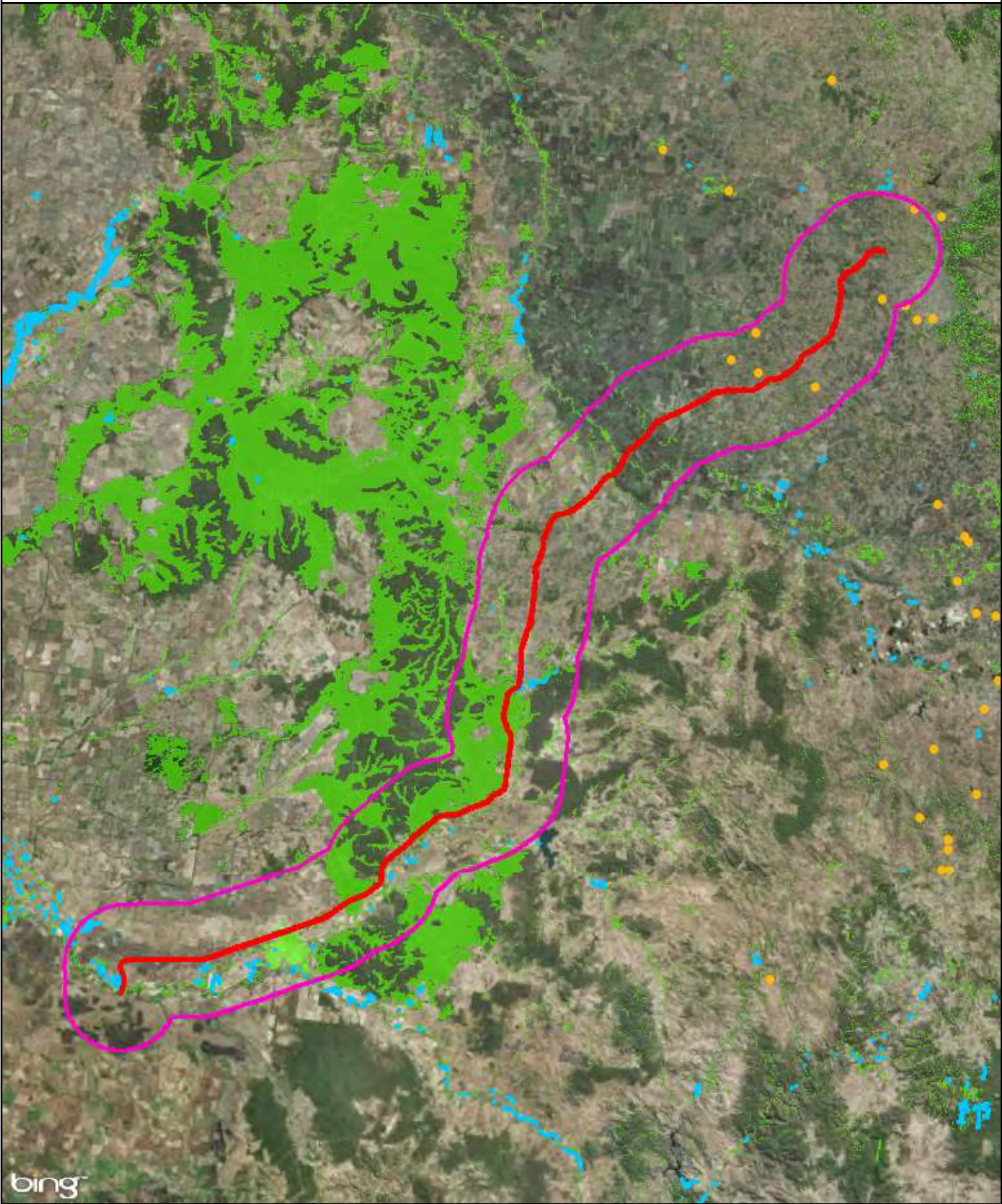
- Very High
- High
- Medium
- Low
- Very Low

The rail alignment passes through a diversity of aquatic systems which have been assessed and mapped according to available AquaBAMM spatial data and reporting (Queensland Globe 2019). The results of assessment are presented in **Table 16**. The vast majority of sites have an AquaScore of Medium or higher, indicating that aquatic ecosystems of the impact assessment area are in relatively good condition.

Table 16 AquaBAMM / ACA score for survey sites

AquaScore for Conservation Value	Survey Site Number
Very High	1R, 2, 2R, 3, 4, 5, 6, 7, 8, 9, 10, 11, 29, 30
High	12, 13, 14, 15
Medium	18,19, 20, 20R, 21, 22, 23, 24, 25, 26, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43
Low	16, 17, 27
Very Low	-

Figure 6. Groundwater Dependent Ecosystem (GDE) values along alignment



Legend

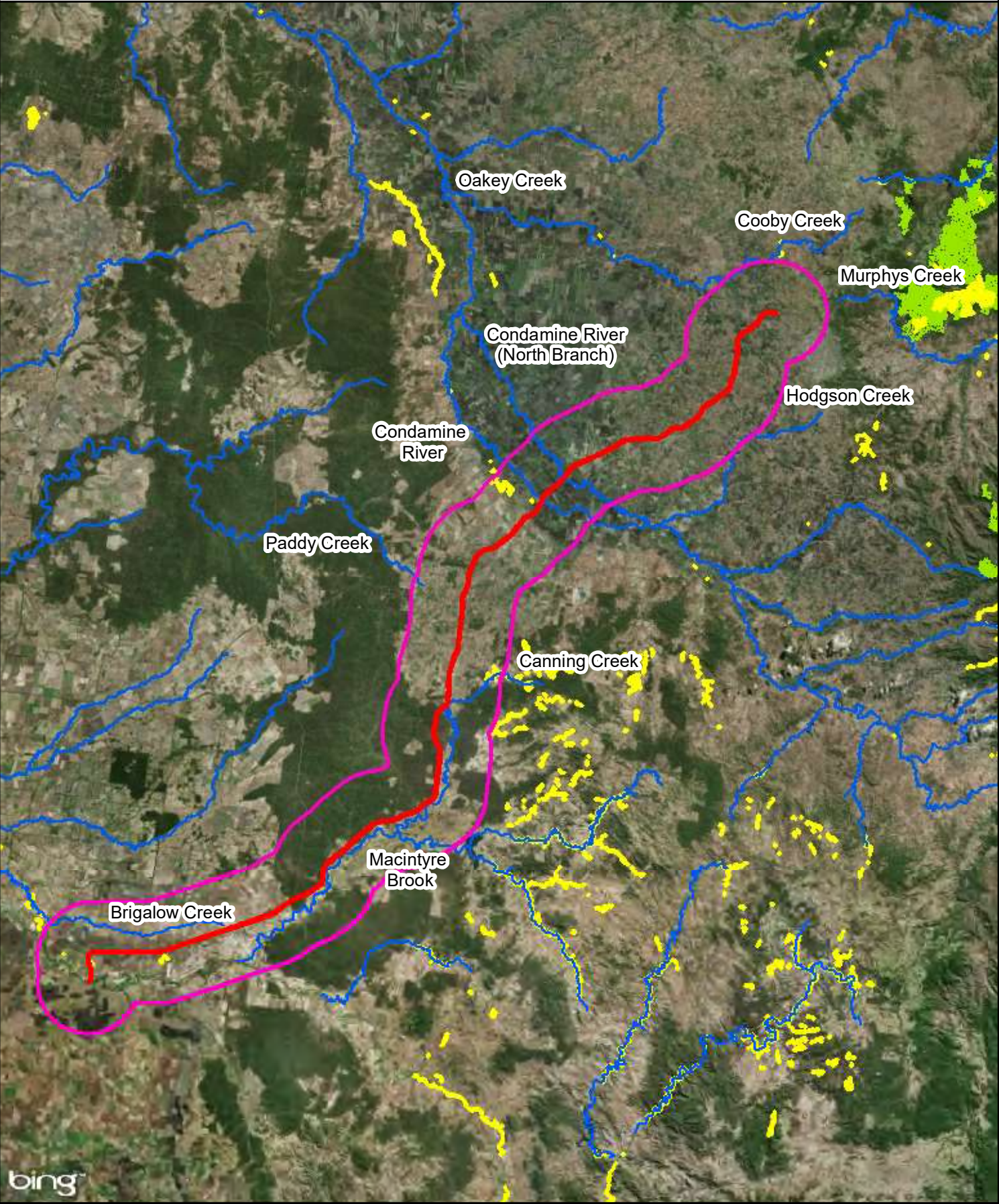
- Rail alignment
- Rail Alignment with 10 Km buffer
- Springs associated with GDE
- Terrestrial GDE
- Aquatic GDE
- Subterranean GDE

0 12.5 25 50
Kilometers

Datum/Projection:
GDA 1994 MGA Zone 56



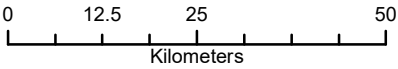
Figure 7. Wetland and watercourse values along alignment



Legend

- Rail alignment
- Rail alignment with 10km buffer
- Major watercourse

- High ecological significance wetlands
- High ecological value waters



Datum/Projection:
GDA 1994 MGA Zone 56



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4.2.7 Endangered ecological community (NSW)

The aquatic ecological community in the natural drainage system of the lowland catchment of the Darling River is listed as an endangered ecological community (EEC) under the New South Wales *Fisheries Management Act 1994*. The lowland catchment of the Darling River has been greatly modified since European settlement, with many aquatic habitats degraded, and native species in decline (NSW DPI 2007).

The listed ecological community includes the Border Rivers, including the Macintyre River, which is traversed by the rail alignment at the southern extent of the impact assessment area. The Macintyre River provides habitat typical of the listed ecological community, which includes meandering channels, deep channels, pools, wetlands, gravel beds and flood plains. A Priority Actions Statement has been developed for the EEC (NSW DPI 2019), involving a range of recovery actions including habitat protection, rehabilitation of disturbed areas and pest control.

4.3 Results of surface water field surveys

Water quality results are presented in the following sections and are grouped to facilitate assessment of sites consistent with the six sub-catchments in the local water quality guidelines (DES 2019a, b). Water quality results outside (i.e. exceeding a maximum guideline or below a minimum guideline) both the local guideline (which is an annual median) and the ANZECC (2000, 2018) guideline (for slightly to moderately disturbed ecosystems; 95 per cent level of protection) were highlighted as being 'outside the guideline'. A median value has been calculated for each site. The median should be interpreted cautiously at sites where there is a small number of data points.

Laboratory certificates of analysis are provided in **Appendix D**.

4.3.1 Macintyre Barwon Floodplain (Queensland Border Rivers Basin; sites 1 to 2)

Water quality at sites within the Macintyre Barwon Floodplain was relatively good, with a slightly alkaline pH and low EC (**Table 17**). Local guidelines for turbidity and total suspended solids during low flow conditions were exceeded in November 2018. Nutrient levels were below local water quality guidelines, with the exception of reactive phosphorus. Chlorophyll *a* concentrations were also slightly elevated across most sampling surveys, including during November 2018 despite the turbid water conditions (**Table 18**).

Dissolved metal concentrations were generally low, with only one exceedance of the *ANZECC Guideline* (2018) for copper at Site 2 in November 2018 (**Table 19**). Hardness concentrations were consistently at or above 60 mg/L and may provide some protection to biota from the toxic effects of some metals, which reduce with increased hardness (see Table 3.4.4 of the ANZECC Guidelines 2000).

The concentration of PAHs was below the laboratory level of detection at all sites for all surveys.

Table 17 Water quality results for Sites 1R, 2 and 2R in the Macintyre Barwon Floodplain – physico-chemical

Physico-chemical		pH units	Temp (°C)	DO (% Sat)	EC (µS/cm)	Salinity (g/kg)	Turbidity (NTU)	TSS (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Hardness (mg/L)
Limit of Reporting		0.01	0.1	0.1	1	0.01	0.1	5	1	1	1
ANZECC		6.5 to 7.5		90 to 110	30 to 350		2 to 25				
Basin Plan											
Low flow		7.4 to 8.0		60 to 110	240		30	25			
High flow		7.0 to 7.5		60 to 110	180		110	70			
Site	Field Trip										
1R	Jun 2018	7.45	13.5	52.5	283	0.14	25.9	28	13	11	78
2	Jun 2018	Not sampled									
	Nov 2018	7.74	25.5	83.8	224	0.10	53.2	27	12	10	71
	Feb 2019	6.77	28.7	101.6	211	0.11	22.9	23	13	11	78
	Apr 2019	7.23	21.6	76.2	216	0.10	11.2	10	16	13	93
	May 2019	7.76	16.8	84.6	299	0.14	13.0	12	15	8	70
	Median	7.49	23.55	84.2	220	0.11	18.0	17.5	14	10.5	74.5
2R	Jun 2018	7.61	14.0	57.5	239	0.12	13.4	<5	10	8	58
	Nov 2018	7.27	25.0	90.2	223	0.1	96.0	43	12	9	67
	Feb 2019	7.31	28.9	89.5	211	0.11	25.7	24	13	11	78
	Apr 2019	7.68	22.3	71.6	215	0.10	12.2	7	16	13	93
	Median	7.46	23.65	80.55	219	0.11	19.6	24	12.5	10	72.5

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 18 Water quality results for Sites 1R, 2 and 2R in the Macintyre Barwon Floodplain – nutrients

Nutrients (mg/L)		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	Total N	Total P	Reactive P	Chlorophyll a (µg/l)
Limit of Reporting		0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.01	1
ANZECC		0.013			0.015				0.03	0.015	-
Basin Plan											
Low flow		0.02			0.010			0.575	0.07	0.02	3
High flow		ID			0.195			0.9	0.15	ID	ID
Site	Trip										
1R	Jun 2018	0.02	<0.01	<0.01	<0.01	0.6	0.6	0.6	0.1	<0.01	<2
	Nov 2018	Not sampled									
	Feb 2019	Not sampled									
	Apr 2019	Not sampled									
	Median	0.02	<0.01	<0.01	<0.01	0.60	0.60	0.60	0.10	<0.01	<2
2	Jun 2018	Not sampled									
	Nov 2018	<0.01	<0.01	<0.01	<0.01	0.5	0.5	0.5	0.12	0.04	9
	Feb 2019	0.07	<0.01	0.17	0.17	0.5	0.6	0.8	0.16	0.13	2
	Apr 2019	0.03	<0.01	<0.01	<0.01	0.5	0.5	0.5	0.08	0.04	5
	May 2019	0.02	<0.01	<0.01	0.02	0.7	0.7	0.7	0.03	<0.01	7
	Median	0.03	<0.01	<0.01	0.01	0.50	0.55	0.6	0.1	0.04	6
2R	Jun 2018	0.02	<0.01	<0.01	<0.01	0.5	0.5	0.5	0.05	0.01	<1
	Nov 2018	<0.01	<0.01	0.02	0.02	0.5	0.5	0.5	0.015	0.04	5
	Feb 2019	0.03	<0.01	0.16	0.16	0.6	0.6	0.8	0.16	0.13	2
	Apr 2019	0.02	<0.01	<0.01	<0.01	0.4	0.4	0.4	0.06	0.03	4
	Median	0.02	<0.01	0.09	0.09	0.50	0.50	0.50	0.06	0.04	4

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 19 Water quality results for Sites 1R, 2 and 2R in the Macintyre Barwon Floodplain – dissolved metals

Dissolved metals (mg/L)		Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Limit of Reporting		0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.0001
ANZECC		0.024	0.0002	0.0033 [#]	0.0014	0.0034	0.011	0.008	0.00006
Basin Plan									
Site	Trip								
1R	Jun 2018	0.002	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Nov 2018	Not sampled							
	Feb 2019	Not sampled							
	Apr 2019	Not sampled							
	Median	0.002	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
2	Jun 2018	Not sampled							
	Nov 2018	0.003	<0.0001	<0.001	0.002	<0.001	0.002	<0.005	<0.0001
	Feb 2019	0.004	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.003	<0.0001	<0.001	0.001	<0.001	0.003	<0.005	<0.0001
	May 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Median	0.003	<0.0001	<0.001	0.0008	<0.001	0.001	<0.005	<0.0001
2R	Jun 2018	0.002	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Nov 2018	0.003	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Feb 2019	0.004	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.003	<0.0001	<0.001	0.001	<0.001	0.002	<0.005	<0.0001
	Median	0.003	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001

[#] Low reliability guideline (ANZECC 2018). Values outside of all guidelines are shaded orange

4.3.2 Lower Macintyre Brook (Queensland Border Rivers Basin; sites 3 to 8)

Water quality at sites in the Lower Macintyre Brook was characterised by high EC and elevated concentrations of suspended sediment and nutrients, with low dissolved oxygen (**Table 20** and **Table 21**). Such results are typical of dry season conditions, when streams form a series of isolated pools that are subject to evaporation. Dissolved metal concentrations were low, with no exceedances of the *ANZECC Guideline* (2018) and with the concentration of most metals below the laboratory level of detection (**Table 22**).

The concentration of PAHs was below the level of detection at all sites. Sites 4, 5 and 8 were dry at the time of field surveys (**Table 3**).

4.3.3 Canning Creek (Queensland Border Rivers Basin; sites 9 to 20)

Water quality at sites in the Canning Creek sub catchment was generally poor, characterised by alkaline pH and elevated concentrations of nutrients (**Table 23** and **Table 24**). EC results exceeded relevant guidelines at Site 16 but were otherwise good. Dissolved metal concentrations were generally low, with exceedances of the *ANZECC Guideline* (2018) for copper at Site 16 in November 2018, February 2019 and April 2019 (**Table 25**). Hardness concentrations at Site 16 of 100 mg/L may provide some protection to biota from the toxic effects of some metals, which reduce with increased hardness (see Table 3.4.4 of the *ANZECC Guidelines* 2000).

The concentration of PAHs was below the level of detection at all sites. Sites 9, 10, 12, 13, 15, 17 and 19 were dry at the time of field surveys (**Table 3**).

4.3.4 Southern Condamine (Condamine River Basin; sites 21 to 26)

Water quality at sites in the Southern Condamine (Sites 23 and 24) was characterised by alkaline pH, high EC and elevated concentrations of suspended sediment and nutrients (**Table 26** and **Table 27**). Chlorophyll *a* results also exceeded relevant guidelines. Such results are typical of dry season conditions, when streams form a series of isolated pools that are subject to evaporation.

Dissolved metal concentrations were generally low, with only two exceedances of the *ANZECC Guideline* (2018) for copper and lead at Site 24 (**Table 28**). Hardness concentrations at Site 24 may provide some protection to biota from the toxic effects of some metals, which reduce with increased hardness (see Table 3.4.4 of the *ANZECC Guidelines* 2000).

The concentration of PAHs was below the level of detection at all sites. Sites 21, 22, 25 and 26 were found not to be suitable for assessment (**Table 2**).

Table 20 Water quality results for Sites 3, 6 and 7 in the Lower Macintyre Brook – physico-chemical

Guideline		pH units	Temp °C	DO %Sat	EC µS/cm	Salinity g/kg	Turbidity NTU	TSS	Calcium	Magnesium	Hardness as CaCO ₃
Limit of Reporting		0.01	0.1	0.1	1	0.01	1	5	1	1	1
ANZECC		6.5 to 7.5		90 to 110	30 to 350		2 to 25		-	-	-
Basin Plan Low Flow High Flow		7.4 to 8.0 7.2 to 8.0		60 to 110 60 to 110	370 250		11 25	10 25			
Site	Trip										
3	Jun 2018	5.58	10.7	46.1	383	0.2	9.7	<5	11	10	69
	Nov 2018	7.33	23.8	89.1	406	0.19	6.5	<5	14	10	76
	Feb 2019	6.65	25.1	50.1	357	0.19	6.9	8	15	10	79
	Apr 2019	7.77	19.6	63.4	423	0.20	14.7	12	20	12	99
	Median	6.99	21.7	56.8	395	0.20	8.3	10	14.5	10	77.5
6	Jun 2018	7.97	10.2	52.7	334	0.17	17.2	20 [@]	9	8	55
	Nov 2018	7.08	21.0	51.4	427	0.2	20.8	14	15	10	79
	Feb 2019	7.20	25.1	49.7	389	0.20	15.1	12	16	10	81
	Apr 2019	7.45	18.4	53.1	433	0.21	13.7	10	20	12	99
	Median	7.33	19.7	52.1	408	0.2	16.2	13	15.5	10	80
7	Jun 2018	7.80	10.3	48.7	337	0.17	18.0	18	9	9	60
	Nov 2018	7.46	25.2	76.3	434	0.2	15.0	9	15	10	79
	Feb 2019	7.29	26.6	55.3	409	0.21	12.2	12	17	11	88
	Apr 2019	7.64	19.2	51.2	430	0.21	8.2	6	21	12	102
	May 2019	7.55	16.8	79.3	449	0.21	7.3	6	19	11	93
	Median	7.55	19.2	55.3	430	0.21	12.2	9	17	11	88

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise. @ Result was outside the relative percent difference criterion of 35% (see Section 4.3.7)

Table 21 Water quality results for Sites 3, 6 and 7 in the Lower Macintyre Brook – nutrients

Guideline (mg/L)		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	Total N	Total P	Reactive P	Chlorophyll <i>a</i> (µg/L)
Limit of Reporting		0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.01	1
ANZECC		0.013			0.015				0.03	0.015	-
Basin Plan											
Low Flow		0.008			0.018			0.71	0.055	0.011	ID
High Flow		ID			ID			0.91	0.07	ID	ID
Site	Trip										
3	Jun 2018	0.04	<0.01	<0.01	<0.01	0.8	0.8	0.8	0.04	<0.01	<2
	Nov 2018	<0.01	<0.01	<0.01	<0.01	0.6	0.6	0.6	0.04	<0.01	7
	Feb 2019	0.04	<0.01	<0.01	<0.01	1	1	1	0.06	<0.01	12
	Apr 2019	0.02	<0.01	<0.01	<0.01	1.6	1.6	1.6	0.08	<0.01	65
	Median	0.03	<0.01	<0.01	<0.01	0.9	0.9	0.9	0.05	<0.01	9.5
6	Jun 2018	0.03	<0.01	0.05	0.05	0.8	0.8	0.8	0.04	<0.01	<2.0
	Nov 2018	<0.01	<0.01	<0.01	<0.01	0.7	0.7	0.7	0.05	<0.01	4
	Feb 2019	0.05	<0.01	<0.01	<0.01	1.2	1.2	1.2	0.06	<0.01	5
	Apr 2019	0.03	<0.01	<0.01	<0.01	1.1	1.1	1.1	0.04	<0.01	10
	Median	0.03	<0.01	<0.01	<0.01	0.95	0.95	0.95	0.05	<0.01	4.5
7	Jun 2018	0.04	<0.01	0.15	0.15	0.9	0.9	1	0.04	<0.01	<2
	Nov 2018	<0.01	<0.01	0.02	0.02	0.7	0.7	0.7	0.06	<0.01	5
	Feb 2019	0.05	<0.01	0.03	0.03	1	1	1	0.04	<0.01	6
	Apr 2019	0.03	<0.01	0.09	0.09	1.1	1.1	1.2	0.04	<0.01	14
	May 2019	0.05	<0.01	0.24	0.24	1	1	1.2	0.02	<0.01	7
	Median	0.045	<0.01	0.09	0.09	1	1	1	0.04	<0.01	6.5

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 22 Water quality results for Sites 3, 6 and 7 in the Lower Macintyre Brook – dissolved metals

Guideline (mg/L)		Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Limit of Reporting		0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.0001
ANZECC		0.024	0.0002	0.0033 [#]	0.0014	0.0034	0.011	0.008	0.00006
Basin Plan									
Site	Trip								
3	Jun 2018	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Nov 2018	0.002	<0.0001	<0.001	0.001	<0.001	<0.001	<0.005	<0.0001
	Feb 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Median	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
6	Jun 2018	0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Nov 2018	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Feb 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Median	0.0015	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
7	Jun 2018	0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Nov 2018	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Feb 2019	0.002	<0.0001	<0.001	0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	May 2019	0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Median	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001

[#] Low reliability guideline (ANZECC 2018). Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 23 Water quality results for Sites 11, 14, 16 and 18 in Canning Creek and Site 20R in Nicol Creek – physico-chemical

Guideline		pH units	Temp °C	DO %Sat	EC µS/cm	Salinity (g/kg)	Turbidity (NTU)	TSS	Calcium	Magnesium	Hardness as CaCO ₃
Limit of Reporting		0.01	0.1	0.1	1	0.01	0.1	5	1	1	1
ANZECC		6.5 to 7.5		90 to 110	30 to 350		2 to 25		-	-	-
Basin Plan											
Low Flow		7.2 to 7.8		60 to 110	200		35	25			
High Flow		6.9 to 7.9		60 to 110	165		50	60			
Site	Trip										
11	Jun 2018	8.18	10.4	67.6	213	0.15	17	15	11	7	56
	Nov 2018	8.21	23.7	103.1	286	0.13	21	14	13	6	57
	Feb 2019	7.00	25.7	65.0	236	0.12	25	23	12	6	55
	Apr 2019	7.27	16.6	66.0	297	0.14	64	104	16	8	73
	Median	7.725	20.2	66.8	261	0.14	23	19	12.5	6.5	56.5
14	Jun 2018	7.70	14.7	64.30	160	0.10	44	20	4	7	39
	Nov 2018	8.09	22.5	86.60	248	0.11	37	<5	5	9	50
	Feb 2019	8.19	28.0	101.40	307	0.16	74	39	6	12	64
	Apr 2019	7.46	19.2	61.70	353	0.17	104	44	7	16	83
	Median	7.90	20.9	75.45	278	0.14	59	39	5.5	10.5	57
16	Jun 2018	7.66	12.6	56.30	184	0.11	147	32	14	4	51
	Nov 2018	7.82	18.8	82.30	382	0.17	161	56	27	8	100
	Feb 2019	8.39	29.4	120.00	636	0.33	259	170	25	12	112
	Apr 2019	7.62	19.5	32.00	1255	0.62	>1000	2170	42	18	179
	Median	7.74	19.2	69.30	509	0.25	161	113	26	10	106
18	Jun 2018	Not Sampled									
	Nov 2018	Not Sampled									
	Feb 2019	7.22	28.4	57.9	311	0.16	60.6	18	28	7	99
	Apr 2019	7.52	19.4	53.7	320	0.15	23.8	8	34	8	118
	May 2019	7.84	16.0	39.7	332	0.15	36.3	14	29	7	101
	Median	7.52	19.4	53.7	320	0.15	36.3	14	29	7	101
20R	Jun 2018	Not Sampled									
	Nov 2018	Not Sampled									
	Feb 2019	Not Sampled									
	Apr 2019	7.31	19.9	32.8	154	0.08	8.63	10	19	6	72
	Median	7.31	19.9	32.8	154	0.08	8.63	10	19	6	72

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 24 Water quality results for Sites 11, 14, 16 and 18 in Canning Creek and Site 20R in Nicol Creek – nutrients

Guideline (mg/L)		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	Total N	Total P	Reactive P	Chlorophyll ^a (µg/L)
Limit of Reporting		0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.01	1
ANZECC		0.013			0.015				0.03	0.015	-
Basin Plan Low Flow High Flow		0.001 ID			0.006 ID			0.52 0.60	0.03 0.04	0.008 ID	ID ID
Site	Trip										
11	Jun 2018	0.02	<0.01	0.02	0.02	0.9	0.9	0.9	0.06	<0.01	<2
	Nov 2018	<0.01	<0.01	<0.01	<0.01	1.2	1.2	1.2	0.11	<0.01	40
	Feb 2019	0.04	<0.01	<0.01	<0.01	2.2	2.2	2.2	0.15	<0.01	23
	Apr 2019	0.02	<0.01	<0.01	<0.01	5.7	5.7	5.7	0.33	<0.01	460
	Median	0.03	<0.01	<0.01	<0.01	1.7	1.7	1.7	0.13	<0.01	31.5
14	Jun 2018	0.25	<0.01	<0.01	<0.01	1.0	1.2	1.2	0.03	<0.01	<1
	Nov 2018	<0.01	<0.01	<0.01	<0.01	0.7	0.7	0.7	0.03	<0.01	3
	Feb 2019	0.05	<0.01	<0.01	<0.01	1.6	1.6	1.6	0.07	<0.01	6
	Apr 2019	0.03	<0.01	<0.01	<0.01	2.3	2.3	2.3	0.10	<0.01	16
	Median	0.04	<0.01	<0.01	<0.01	1.3	1.4	1.4	0.05	<0.01	4.5
16	Jun 2018	0.02	<0.01	<0.01	<0.01	1.0	1.0	1.0	0.11	<0.01	<4
	Nov 2018	0.06	<0.01	0.01	0.01	1.3	1.4	1.4	0.17	<0.01	8
	Feb 2019	0.06	<0.01	0.02	0.02	4.1	4.2	4.2	0.31	<0.01	54
	Apr 2019	1.50	0.05	0.02	0.07	29.6	31.1	31.2	3.93	<0.01	545
	Median	0.06	<0.01	0.015	0.015	2.7	2.8	2.8	0.24	<0.01	31
18	Jun 2018	Not Sampled									
	Nov 2018	Not Sampled									
	Feb 2019	0.03	<0.01	<0.01	<0.01	1.2	1.2	1.2	0.10	<0.01	7
	Apr 2019	0.02	<0.01	<0.01	<0.01	0.8	0.8	0.8	0.04	<0.01	4
	May 2019	0.02	<0.01	<0.01	<0.01	0.8	0.8	0.8	0.04	<0.01	5
	Median	0.02	<0.01	<0.01	<0.01	0.8	0.8	0.8	0.04	<0.01	5
20R	Jun 2018	Not Sampled									
	Nov 2018	Not Sampled									
	Feb 2019	Not Sampled									
	Apr 2019	0.02	<0.01	<0.01	<0.010	1.6	1.6	1.6	0.32	0.10	21
	Median	0.02	<0.01	<0.01	<0.010	1.6	1.6	1.6	0.32	0.10	21

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise

Table 25 Water quality results for Sites 11, 14, 16 and 18 in Canning Creek and Site 20R in Nicol Creek – dissolved metals

Guideline (mg/L)		Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Limit of Reporting		0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.0001
ANZECC		0.024	0.0002	0.0033 [#]	0.0014	0.0034	0.011	0.008	0.00006
Basin Plan									
Site	Trip								
11	Jun 2018	0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
	Nov 2018	0.001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Feb 2019	0.003	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Median	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
14	Jun 2018	<0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
	Nov 2018	0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
	Feb 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Median	0.001	<0.0001	<0.001	<0.001	<0.001		<0.005	<0.0001
16	Jun 2018	<0.001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
	Nov 2018	0.001	<0.0001	<0.001	0.002	<0.001	0.002	<0.005	<0.0001
	Feb 2019	0.003	<0.0001	<0.001	0.002	<0.001	0.002	<0.005	<0.0001
	Apr 2019	0.004	<0.0001	<0.001	0.002	<0.001	0.009	<0.005	<0.0001
	Median		<0.0001	<0.001	0.002	<0.001	0.002	<0.005	<0.0001
18	Jun 2018	Not Sampled							
	Nov 2018	Not Sampled							
	Feb 2019	0.002	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.0001
	Apr 2019	0.001	<0.0001	<0.001	0.001	<0.001	0.002	<0.005	<0.0001
	May 2019	<0.001	<0.0001	<0.001	0.001	<0.001	0.002	<0.005	<0.0001
	Median	0.001	<0.0001	<0.001	0.001	<0.001	0.002	<0.005	<0.0001
20R	Jun 2018	Not Sampled							
	Nov 2018	Not Sampled							
	Feb 2019	Not Sampled							
	Apr 2019	0.003	<0.0001	<0.001	<0.001	<0.001	0.004	0.008	<0.0001
	Median	0.003	<0.0001	<0.001	<0.001	<0.001	0.004	0.008	<0.0001

[#] Low reliability guideline (ANZECC 2018). Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 26 Water quality results for Site 23 and 24 in the Southern Condamine – physico-chemical

Guideline		pH units	Temp °C	DO %Sat	EC µS/cm	Salinity (g/kg)	Turbidity (NTU)	TSS	Calcium	Magnesium	Hardness as CaCO ₃
Limit of Reporting		0.01	0.1	0.1	1	0.01	0.1	5	1	1	1
ANZECC		6.5 to 7.5		90 to 110	30 to 350		2 to 25		-	-	-
Basin Plan											
Low Flow		7.2 to 7.9		60 to 110	170		9	8			
High Flow		7.0 to 7.6		60 to 110	160		25	17			
Site	Trip										
23	Jun 2018	Not Sampled									
	Nov 2018	Not Sampled									
	Feb 2019	7.18	32.0	84.70	267	0.14	8.0	8	23	8	90
	Apr 2019	7.38	19.3	68.60	290	0.14	31.1	18	30	10	116
	Median	7.28	25.65	76.65	278	0.14	19.6	13	26.5	9	103
24	Jun 2018	7.77	7.9	45.90	345	0.16	239	98	14	11	80
	Nov 2018	8.18	30.9	89.50	580	0.27	251	194	27	18	142
	Feb 2019	7.42	27.2	47.80	281	0.14	135	60	13	8	65
	Apr 2019	Not Sampled									
	Median	7.77	27.2	47.80	345	0.16	239	98	14	11	80

Values outside of guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 27 Water quality results for Site 23 and 24 in the Southern Condamine – nutrients

Guideline (mg/L)		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	Total N	Total P	Reactive P	Chlorophyll a (µg/L)
Limit of Reporting		0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.01	1
ANZECC		0.013			0.015				0.03	0.015	-
Basin Plan											
Low Flow		0.006			0.003			0.595	0.045	0.015	5
High Flow		ID			ID			0.830	0.060	0.020	ID
Site	Trip										
23	Jun 2018	Not Sampled									
	Nov 2018	Not Sampled									
	Feb 2019	0.03	<0.01	<0.01	<0.01	1.4	1.4	1.4	0.10	0.02	2
	Apr 2019	0.02	<0.01	<0.01	<0.01	0.9	0.9	0.9	0.06	<0.01	7
	Median	0.025	<0.01	<0.01	<0.01	1.15	1.15	1.15	0.08	<0.01	4.5
24	Jun 2018	0.04	<0.01	<0.01	<0.01	0.5	0.5	0.5	0.07	<0.01	<4
	Nov 2018	0.08	<0.01	0.01	0.01	4.1	4.2	4.2	0.51	0.03	28
	Feb 2019	0.04	<0.01	<0.01	<0.01	1.8	1.8	1.8	0.35	0.07	9
	Apr 2019	Not Sampled									
	Median	0.04	<0.01	0.01	<0.01	1.8	1.8	1.8	0.35	0.03	9

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

Table 28 Water quality results for Site 23 and 24 in the Southern Condamine – dissolved metals

Guideline (mg/L)		Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Limit of Reporting		0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.0001
ANZECC		0.024	0.0002	0.0033 [#]	0.0014	0.0034	0.011	0.008	0.00006
Basin Plan									
Site	Trip								
23	Jun 2018	Not Sampled							
	Nov 2018	Not Sampled							
	Feb 2019	0.003	<0.0001	<0.001	<0.001	<0.001	0.001	<0.005	<0.0001
	Apr 2019	0.002	<0.0001	<0.001	<0.001	<0.001	0.003	<0.005	<0.0001
	Median	0.0025	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
24	Jun 2018	<0.001	<0.0001	<0.001	0.001	<0.001	0.005	<0.005	<0.0001
	Nov 2018	0.002	<0.0001	<0.001	0.004	<0.001	0.006	<0.005	<0.0001
	Feb 2019	0.003	<0.0001	<0.001	0.001	0.006	<0.001	<0.005	<0.0001
	Apr 2019	Not Sampled							
	Median	0.0020	<0.0001	<0.001	0.001	<0.001	0.005	<0.005	<0.0001

[#] Low reliability guideline (ANZECC 2018). Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise.

4.3.5 Central Condamine (Condamine River Basin; sites 27 to 33)

Water quality at sites in the Central Condamine was characterised by alkaline pH and elevated concentrations of suspended sediment and nutrients (**Table 29** and **Table 30**). The high dissolved oxygen results indicate that algal growth occurs at some sites, producing high percent saturation of oxygen during the day from photosynthesis, and more than likely, consuming oxygen at night. The high chlorophyll *a* concentrations at most sites are consistent with this interpretation.

Results are typical of dry season conditions, when streams form a series of isolated pools that are subject to evaporation. Dissolved copper concentrations were consistently high, with dissolved Nickel concentrations also above the *ANZECC Guidelines* (2018) at some sites (**Table 31**). High hardness concentrations (>59 mg/L) may provide some protection to biota from the toxic effects of some metals, which reduce with increased hardness (see Table 3.4.4 of the *ANZECC Guidelines* 2000).

The concentration of PAHs was below the level of detection at all sites. Site 31 was dry at the time of field surveys (**Table 3**).

4.3.6 Oakey Creek (Condamine River Basin; sites 34 to 43)

Water quality at sites in the Oakey Creek sub catchment was characterised by alkaline pH and high EC (**Table 32**). Nutrient and chlorophyll *a* concentrations were also elevated across most sites (**Table 33**). Such results are typical of dry season conditions, when streams form a series of isolated pools that are subject to evaporation.

Dissolved copper concentrations were slightly elevated, with no other exceedances of the *ANZECC Guidelines* (2018; **Table 34**). Very high hardness concentrations (>200 mg/L) may provide some protection to biota from the toxic effects of some metals, which reduce with increased hardness (see Table 3.4.4 of the *ANZECC Guidelines* 2000).

The concentration of PAHs was below the level of detection at all sites. Sites 35, 36 and 43 were dry at the time of field surveys (**Table 3**) and Sites 34, 37, 38 and 41 were found not to be suitable for assessment (**Table 2**).

Table 29 Water quality results for Sites 27, 28, 30, 32 and 33 in the Central Condamine – physico-chemical

Guideline		pH units	Temp °C	DO %Sat	EC µS/cm	Salinity (g/kg)	Turbidity (NTU)	TSS	Calcium	Magnesium	Hardness CaCO ₃ as
Limit of Reporting		0.01	0.1	0.1	1	0.01	0.1	5	1	1	1
ANZECC		6.5 to 7.5		90 to 110	30 to 350		2 to 25		-	-	-
Basin Plan Low Flow High Flow		7.4 to 8.3 7.0 to 7.6		60 to 110 60 to 110	890 290		25 220	25 130			
Site	Trip										
27	Jun 2018	8.50	10.0	85.0	352	0.28	51.8	28	40	24	199
	Nov 2018	Not sampled									
	Feb 2019	8.34	30.3	134.1	503	0.26	87.5	74	37	25	195
	Apr 2019	7.72	17.2	50.6	233	0.11	671	214	21	12	102
	Median	8.34	17.2	85.0	352	0.26	87.5	74	37	24	195
28	Jun 2018	Not sampled									
	Nov 2018	Not sampled									
	Feb 2019	9.13	35.2	233.6	519	0.27	75.6	73	26	22	156
	Apr 2019	7.93	23.1	21.1	315	0.15	477	175	30	18	149
	Median	8.53	29.15	127.35	417	0.21	276.3	124	28	20	152.5
29	Jun 2018	Not sampled									
	Nov 2018	Not sampled									
	Feb 2019	Not sampled									
	Apr 2019	8.04	22.0	35.0	307	0.14	77.8	48	33	23	177
	Median	8.04	22.0	35.0	307	0.14	77.8	48	33	23	177
30	Jun 2018	-	14.3	65.5	356	0.22	30.0	11	29	18	146
	Nov 2018	8.83	28.8	104.6	507	0.24	98.1	63	22	19	133
	Feb 2019	8.45	25.1	59.6	365	0.19	43.0	35	25	16	128
	Apr 2019	7.71	18.7	70.4	449	0.21	95.6	70	34	26	192
	Median	8.45	21.9	67.95	407	0.215	69.3	49	27	18.5	139.5
32	Jun 2018	Not sampled									
	Nov 2018	Not sampled									
	Feb 2019	7.8	23.4	82.2	588	0.30	11.5	95	37	27	204
	Apr 2019	Not sampled									
	Median	7.8	23.4	82.2	588	0.30	11.5	95	37	27	204
33	Jun 2018	Not sampled									
	Nov 2018	7.7	25.2	106.8	212	0.10	42.9	15	12	7	59
	Feb 2019	Not sampled									
	Apr 2019	Not sampled									
	Median	7.7	25.2	106.8	212	0.10	42.9	15	12	7	59

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise

Table 30 Water quality results for Sites 27, 28, 30, 32 and 33 in the Central Condamine – nutrients

Guideline (mg/L)		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	Total N	Total P	Reactive P	Chlorophyll <i>a</i> (µg/L)
Limit of Reporting		0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.01	1
ANZECC		0.013			0.015				0.03	0.015	-
Basin Plan											
Low Flow		0.004			0.004			0.86	0.17	0.02	9
High Flow		ID			0.480			2.2	0.95	0.50	4
Site	Trip										
27	Jun 2018	0.03	<0.01	<0.01	<0.01	0.90	0.9	0.9	0.11	<0.01	5
	Nov 2018	Not sampled									
	Feb 2019	0.05	<0.01	0.01	0.01	2.20	2.2	2.2	0.23	<0.01	53
	Apr 2019	0.08	<0.01	<0.01	<0.01	1.40	1.5	1.5	0.51	0.04	24
	Median	0.05	<0.01	<0.01	<0.01	1.40	1.5	1.5	0.51	0.04	24
28	Jun 2018	Not sampled									
	Nov 2018	Not sampled									
	Feb 2019	0.07	<0.01	<0.01	<0.01	5.10	5.2	5.2	0.43	0.02	56
	Apr 2019	0.04	<0.01	<0.01	<0.01	1.50	1.5	1.5	0.31	0.01	26
	Median	0.055	<0.01	<0.01	<0.01	3.30	3.35	3.35	0.37	0.015	41
29	Jun 2018	Not sampled									
	Nov 2018	Not sampled									
	Feb 2019	Not sampled									
	Apr 2019	0.03	<0.01	<0.01	<0.01	1.80	1.8	1.8	0.66	0.37	18
	Median	0.03	<0.01	<0.01	<0.01	1.80	1.8	1.8	0.66	0.37	18
30	Jun 2018	0.02	<0.01	<0.01	<0.01	0.50	0.5	0.5	0.07	<0.01	<2
	Nov 2018	0.10	0.01	0.03	0.04	4.50	4.6	4.6	0.39	0.05	57
	Feb 2019	0.06	<0.01	<0.01	<0.01	5.10	5.2	5.2	0.43	0.02	50
	Apr 2019	0.03	<0.01	<0.01	<0.01	3.30	3.3	3.3	0.38	<0.01	72
	Median	0.045	<0.01	<0.01	<0.01	3.9	3.95	3.95	0.385	<0.01	54
32	Jun 2018	Not sampled									
	Nov 2018	Not sampled									
	Feb 2019	0.09	<0.01	<0.01	<0.01	3.70	3.8	3.8	0.43	0.03	90
	Apr 2019	Not sampled									
	Median	0.09	<0.01	<0.01	<0.01	3.70	3.8	3.8	0.43	0.03	90
33	Jun 2018	Not sampled									
	Nov 2018	0.03	<0.01	<0.01	<0.01	1.00	1.0	1.0	0.23	0.05	3
	Feb 2019	Not sampled									
	Apr 2019	Not sampled									
	Median	0.03	<0.01	<0.01	<0.01	1.00	1.0	1.0	0.23	0.05	3

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise

Table 31 Water quality results for Sites 27, 28, 30, 32 and 33 in the Central Condamine –dissolved metals

Guideline (mg/L)		Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Limit of Reporting		0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.0001
ANZECC		0.024	0.0002	0.0033 [#]	0.0014	0.0034	0.011	0.008	0.00006
Basin Plan									
Site	Trip								
27	Jun 2018	<0.001	<0.0001	<0.001	0.002	<0.001	0.006	<0.005	<0.0001
	Nov 2018	Not sampled							
	Feb 2019	0.002	<0.0001	<0.001	<0.001	<0.001	0.007	<0.005	<0.0001
	Apr 2019	0.001	<0.0001	<0.001	0.002	<0.001	0.008	<0.005	<0.0001
	Median	0.001	<0.0001	<0.001	0.002	<0.001	0.007	<0.005	<0.0001
28	Jun 2018	Not sampled							
	Nov 2018	Not sampled							
	Feb 2019	0.005	<0.0001	<0.001	0.002	<0.001	0.012	<0.005	<0.0001
	Apr 2019	0.001	<0.0001	<0.001	0.005	<0.001	0.011	<0.005	<0.0001
	Median	0.003	<0.0001	<0.001	0.0035	<0.001	0.0115	<0.005	<0.0001
29	Jun 2018	Not sampled							
	Nov 2018	Not sampled							
	Feb 2019	Not sampled							
	Apr 2019	0.003	<0.0001	<0.001	0.005	<0.001	0.015	<0.005	<0.0001
	Median	0.003	<0.0001	<0.001	0.005	<0.001	0.015	<0.005	<0.0001
30	Jun 2018	<0.001	<0.0001	<0.001	0.001	<0.001	0.003	<0.005	<0.0001
	Nov 2018	0.002	<0.0001	<0.001	0.003	<0.001	0.004	<0.005	<0.0001
	Feb 2019	0.001	<0.0001	<0.001	<0.001	<0.001	0.003	<0.005	<0.0001
	Apr 2019	<0.001	<0.0001	<0.001	0.001	<0.001	0.006	<0.005	<0.0001
	Median	<0.001	<0.0001	<0.001	0.001	<0.001	0.0035	<0.005	<0.0001
32	Jun 2018	Not sampled							
	Nov 2018	Not sampled							
	Feb 2019	0.003	<0.0001	<0.001	<0.001	<0.001	0.011	<0.005	<0.0001
	Apr 2019	Not sampled							
	Median	0.003	<0.0001	<0.001	<0.001	<0.001	0.011	<0.005	<0.0001
33	Jun 2018	Not sampled							
	Nov 2018	<0.001	<0.0001	<0.001	0.004	<0.001	0.008	<0.005	<0.0001
	Feb 2019	Not sampled							
	Apr 2019	Not sampled							
	Median	<0.001	<0.0001	<0.001	0.004	<0.001	0.008	<0.005	<0.0001

[#] Low reliability guideline (ANZECC 2018). Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise

Table 32 Water quality results for Sites 39, 40 and 42 in the Oakey Creek – physico-chemical

Guideline		pH units	Temp °C	DO %Sat	EC µS/cm	Salinity (g/kg)	Turbidity (NTU)	TSS	Calcium	Magnesium	Hardness as CaCO ₃
Limit of Reporting		0.01	0.1	0.1	1	0.01	0.1	5	1	1	1
ANZECC		6.5 to 7.5		90 to 110	30 to 350		2 to 25		-	-	-
Basin Plan											
Low flow		7.7 to 8.3		60 to 110	510		13	14			
High flow		7.4 to 8.1		60 to 110	375		55	65			
Site	Trip										
39	Jun 2018	8.12	14.0	75.5	2318	1.25	11.3	8	73	137	746
	Nov 2018	8.36	28.2	121.6	1731	0.86	20.5	14	65	94	549
	Feb 2019	8.54	29.4	148.2	2632	1.48	35.2	30	42	169	801
	Apr 2019	8.24	20.3	106.2	1843	0.92	21.9	20	87	122	720
	Median	8.30	24.3	113.9	2080	1.09	21.2	17	69	130	733
40	Jun 2018	8.42	10.4	74.6	1320	0.69	8.1	10	51	82	465
	Nov 2018	8.25	24.8	92.0	692	0.33	12.5	9	32	38	236
	Feb 2019	Not Sampled									
	Apr 2019	8.13	20.4	88.6	680	0.33	40.6	26	37	48	290
	Median	8.25	20.4	88.6	692	0.33	12.5	10	37	48	290
42	Jun 2018	8.52	9.80	72.8	1287	0.69	4.6	6	55	81	471
	Nov 2018	8.30	32.5	116.7	1157	0.56	6.1	10	49	67	398
	Feb 2019	8.44	30.8	146.6	1339	0.73	10.3	8	43	91	482
	Apr 2019	8.15	22.9	85.0	850	0.41	14.6	12	48	60	367
	May 2019	8.25	16.2	105.4	1339	0.64	5.5	<5	62	86	509
	Median	8.3	22.9	105.4	1287	0.64	6.1	9	49	81	471

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise

Table 33 Water quality results for Sites 39, 40 and 42 in the Oakey Creek – nutrients

Guideline (mg/L)		Ammonia	Nitrite	Nitrate	NOx	Organic N	TKN	Total N	Total P	Reactive P	Chlorophyll ^a (µg/L)
Limit of Reporting		0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.01	1
ANZECC		0.013			0.015				0.03	0.015	-
Basin Plan											
Low flow		0.010			0.005			1.000	0.110	0.045	5
High flow		ID			ID			1.280	0.340	0.09	ID
Site	Trip										
39	Jun 2018	0.04	0.01	0.51	0.52	0.3	0.3	0.8	0.02	<0.01	<1
	Nov 2018	0.05	<0.01	<0.01	<0.01	0.4	0.5	0.5	0.11	<0.01	13
	Feb 2019	0.06	<0.01	<0.01	<0.01	0.9	1.0	1.0	0.08	<0.01	12
	Apr 2019	0.04	<0.01	0.07	0.07	0.6	0.6	0.7	0.06	<0.01	31
	Median	0.045	<0.01	<0.01	<0.01	0.5	0.55	0.75	0.07	<0.01	12.5
40	Jun 2018	0.02	<0.01	<0.01	<0.01	0.3	0.3	0.3	0.02	<0.01	<1
	Nov 2018	0.06	0.02	0.72	0.74	0.3	0.4	1.1	0.20	0.02	7
	Feb 2019	Not Sampled									
	Apr 2019	0.02	0.02	0.90	0.92	0.3	0.3	1.2	0.06	0.02	4
	Median	0.02	0.02	0.72	0.74	0.3	0.3	1.1	0.06	0.02	4
42	Jun 2018	0.02	<0.01	1.25	1.25	0.2	0.2	1.4	0.01	<0.01	<1
	Nov 2018	0.05	<0.01	0.82	0.82	0.2	0.2	1.0	0.17	0.01	<1
	Feb 2019	0.06	0.02	0.69	0.71	0.3	0.4	1.1	0.02	<0.01	3
	Apr 2019	0.05	0.02	1.25	1.27	0.2	0.2	1.5	0.04	0.02	2
	May 2019	0.03	0.02	1.38	1.4	0.2	0.2	1.6	<0.01	<0.01	1
	Median	0.05	0.02	1.25	1.25	0.2	0.2	1.4	0.03	<0.01	1

Values outside of all guidelines are shaded orange. All units mg/L unless stated otherwise

Table 34 Water quality results for Sites 39, 40 and 42 in the Oakey Creek – dissolved metals

Guideline (mg/L)		Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Limit of Reporting		0.001	0.0001	0.001	0.001	0.001	0.001	0.005	0.0001
ANZECC		0.024	0.0002	0.0033#	0.0014	0.0034	0.011	0.008	0.00006
Basin Plan									
Site	Trip								
39	Jun 2018	<0.001	<0.0001	<0.001	<0.001	<0.001	0.004	<0.005	<0.0001
	Nov 2018	<0.001	<0.0001	<0.001	0.002	<0.001	0.007	<0.005	<0.0001
	Feb 2019	<0.001	<0.0001	<0.001	0.001	<0.001	0.006	<0.005	<0.0001
	Apr 2019	<0.001	<0.0001	<0.001	0.002	<0.001	0.010	<0.005	<0.0001
	Median	<0.001	<0.0001	<0.001	0.002	<0.001	0.005	<0.005	<0.0001
40	Jun 2018	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Nov 2018	<0.001	<0.0001	<0.001	0.003	<0.001	0.004	<0.005	<0.0001
	Feb 2019	Not Sampled							
	Apr 2019	<0.001	<0.0001	<0.001	0.002	<0.001	0.003	<0.005	<0.0001
	Median	<0.001	<0.0001	<0.001	0.002	<0.001	0.002	<0.005	<0.0001
42	Jun 2018	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Nov 2018	<0.001	<0.0001	<0.001	0.002	<0.001	0.002	<0.005	<0.0001
	Feb 2019	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Apr 2019	<0.001	<0.0001	<0.001	0.001	<0.001	0.003	<0.005	<0.0001
	May 2019	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001
	Median	<0.001	<0.0001	<0.001	<0.001	<0.001	0.002	<0.005	<0.0001

Low reliability guideline (ANZECC 2018). Values outside of guidelines are shaded orange. All results mg/L unless stated otherwise.

4.3.7 Quality assurance results

Relative percent differences for duplicate samples in June 2018 (Site 6), November 2018 (Site 3), February 2019 (Site 6), April 2019 (Site 6) and May 2019 (Site 7) were below the acceptance criterion of 35 per cent for all parameters except Total Suspended Solids (TSS) in June 2018, which was 58 per cent (raw TSS values of 11 and 20 mg/L).

When sampling pools of water that are not well mixed, there is potential for one sample to have quantities of detritus or sediment that differs slightly from the duplicate sample. With other assessed duplicate parameters showing a high degree of uniformity, the lack of mixing appears to be the principal driver of error. Also, the results of these samples are close to the laboratory limit of reporting for TSS of 5 mg/L. The relative percent difference variable is sensitive to small differences between values at low concentrations, close to the limit of reporting.

Results for field blank samples were at or below the laboratory level of detection for all samples on all field trips, except ammonia in November 2018 (0.03 mg/L) and April (0.02 mg/L), when the results were slightly above the laboratory limit of detection of 0.01 mg/L. These results indicate that the process of collecting the field blank may have resulted in some very minor contamination of the distilled water. However, several other samples in the November 2018 batch had concentrations of ammonia below the laboratory limit of detection, so any contamination was localised in this batch of samples.

Overall, the quality assurance results indicate a high level of reliability in the data collected.

4.4 Results of aquatic ecology surveys

4.4.1 Aquatic flora

Fourteen species of aquatic plants were detected from the aquatic survey in June and November 2018 (Table 35). No EVNT aquatic flora species were detected.

Table 35 Aquatic flora detected within the Project aquatic survey sites June and November 2018

Scientific name	Common name	Survey period	Site (and approximate % cover in reach)													
			2	4	5	8	9	12	13	15	16	17	19	32	43	
<i>Arundinella nepalensis</i>	Reed grass	June 2018	-	1			4		1	1		2				
		November 2018		1			4		1	1						
<i>Carex appressa</i>	Tall sedge	June 2018	-		14					3						
		November 2018			14		1		1	3						
<i>Cyperus exaltatus</i>	Tall flat sedge	June 2018	-						1	1			2	1		
		November 2018	1						1				1	1		
<i>Cyperus gracilis</i>	Slender flat-sedge	June 2018	-			1										
		November 2018	1			1										
<i>Cyperus pygmaeus</i>	Dwarf flat-sedge	June 2018	-								5			1		
		November 2018									5			1		
<i>Eleocharis acuta</i>	Spikerush	June 2018	-						1				2			
		November 2018							1				2			
<i>Eleocharis plana</i>	Ribbed spikerush	June 2018	-											5		
		November 2018			1	20								5		
<i>Juncus usitatus</i>	Common rush	June 2018	-		1		3	5	5	5	5	3	2	60		
		November 2018	3		1	1	3	3	5	5	5	3	2	60		
<i>Leptochloa digitata</i>	Umbrella cane grass	June 2018	-								5		20			
		November 2018									5		20			
<i>Ludwigia peploides</i> subsp. <i>montevidensis</i>	Water primrose	June 2018	-									30				
		November 2018														

Scientific name	Common name	Survey period	Site (and approximate % cover in reach)												
			2	4	5	8	9	12	13	15	16	17	19	32	43
<i>Marsilea drummondii</i>	Common nardoo	June 2018	-												
		November 2018	1										1		
<i>Persicaria attenuata</i>	Hairy knotweed	June 2018	-											5	
		November 2018	1											5	
<i>Persicaria decipiens</i>	Slender knotweed	June 2018	-											1	
		November 2018	3											1	
<i>Persicaria orientalis</i>	Lady's Thumb	June 2018													
		November 2018	1									1			
<i>Phragmites australis</i>	Common reed	June 2018	-								15				
		November 2018	2								20				
<i>Scirpus sp.</i>	Club rush	June 2018	-												
		November 2018											1		

- Access was not available to Site 2 during the June 2018 survey

The majority of aquatic flora species encountered during the June and November 2018 field surveys were common emergent species such as aquatic (or semi-aquatic) grasses, sedges and rushes.

The lack of both diversity and abundance of aquatic plants at some sites is likely to be indicative of dry physical conditions. More diverse aquatic communities may occur through recruitment during sustained flows or water pooling over the wetter months of the year.

4.4.2 Physical habitat

The overall physical habitat assessment scores were Fair to Good for each aquatic site surveyed in June and November 2018, with no difference between the two surveys. Channel flow status rated poor at most sites due to the dry conditions encountered at the times of assessment. Epifaunal substrate/available cover also rated poor at most sites, owing to the dominance of silt/clay substrates and general lack of substrate complexity. This is generally a reflection of the natural clay-rich bed substrates, as opposed to siltation. Bed and bank stability rated high at most sites, owing largely to good vegetative bank protection and reasonably intact riparian zones across the impact assessment area (**Table 36**). Site descriptions for Aquatic Ecology sites are provided in **Appendix A**.

Table 36 AusRivAS physical habitat assessment scores for the Project aquatic survey sites, June and November 2018

Habitat parameter		Site (and score)												
		2	4	5	8	9	12	13	15	16	17	19	32	43
Epifaunal substrate/available cover		G14	P5	P5	P4	P4	P3	F9	P5	G15	F7	F9	F7	P4
Pool substrate characterisation		G12	F7	F10	P3	F6	F7	F9	F6	F9	P3	G13	F7	P4
Pool variability		G14	P0	P0	P0	P0	P0	G13	F6	G13	G11	F6	F8	P0
Sediment deposition		G12	E16	E18	E16	P4	G13	E16	E16	G15	E16	F8	E16	E18
Channel flow status		E18	P0	P0	P0	P0	P0	P0	P0	E18	P0	P0	P0	P0
Channel alteration		G13	E16	G15	G15	G13	G13	E18	E18	E18	E16	G13	G11	F9
Channel sinuosity		F10	F7	P5	P5	F6	F6	G11	F7	G12	G13	F9	G13	F7
Bank stability	Left bank	G7	E9	E10	E9	G8	E9	G6	E9	F4	P2	F4	G7	F5
	Right bank	G7	E9	E10	E9	G8	E9	G7	E9	F4	P2	F4	G6	F5
Vegetation protection	Left bank	G7	G8	G7	G6	G6	G6	G6	G6	F4	F5	G6	F5	F5
	Right bank	G7	G8	G7	G6	G6	G6	G6	G6	F4	F5	G6	F5	F5
Riparian zone score	Left bank	G6	G8	E9	G8	G8	G6	E9	G7	F4	F5	G7	G7	P2

Habitat parameter		Site (and score)												
		2	4	5	8	9	12	13	15	16	17	19	32	43
	Right bank	G6	G8	E9	G6	G6	G6	E9	G7	F4	F5	G7	G8	P2
Total (low gradient) habitat score		G	G	G	F	F	F	G	G	G	F	F	F	F
		129	101	105	87	74	84	119	102	124	90	92	100	66

Notes:

Ratings as per AusRivAS Physical Assessment Protocol (Parsons *et al.* 2002).

Categories for each habitat parameter: E = Excellent (green shading); G = Good (yellow shading); F = Fair (orange shading); P = Poor (pink shading).

Categories for total (low gradient stream) habitat score: E = 154-200; G = 101-153; F = 48-100; P = 0-47.

4.4.3 Macroinvertebrates and stream health

Taxonomic composition

A total of 26 taxa were identified from 523 aquatic macroinvertebrates collected from two sites in November 2018. Taxa richness was slightly more diverse in the samples collected from Bringalily Creek (Site 16; 19 taxa) than in the samples collected from the Macintyre River (Site 2; 18 taxa). Taxa richness was greater in the edge habitat at each site than in the bed habitat, likely owing to the greater habitat complexity and food sources.

A total of 54 taxa were identified from 1,785 aquatic macroinvertebrates collected from five sites in May 2019. Taxa richness was most diverse in the Macintyre River (Site 2; 34 taxa), with slightly lower diversity at sites 18 (30 taxa), 42 (29 taxa), 6R (28 taxa) and 7 (27 taxa). This is likely a reflection of the lower (yet sustained) flow producing greater habitat complexity at site 2, including varying depths, velocities and substrate sizes.

The most taxa-rich orders were Hemiptera (aquatic bugs), Coleoptera (beetles) and Diptera (true flies) in both the November 2018 and May 2019 sampling rounds. Other orders included Acarina (mites), Ephemeroptera (mayflies), Trichoptera (caddis flies), Zygoptera (damselflies), Epiprocta (dragonflies), Gastropoda (aquatic snails) and Veneroida (basket clams), Decapoda (in this case prawns, shrimp and yabbies), Collembola (spring tails), Lepidoptera (aquatic caterpillars), Ostracoda (seed shrimp), Copepoda (copepods), Cladocera (water fleas), Isopoda (isopods), Rhynchobdellida (jawless leeches) and Oligochaeta (segmented worms).

PET taxa

Five PET taxa were detected in samples collected from across the impact assessment area in November 2018, and seven PET taxa were detected in May 2019. Sites 2 (Macintyre River), 6R (Macintyre Brook) and 7 (Macintyre Brook) recorded the greatest number of PET taxa, with six PET taxa recorded from each site in May 2019. PET taxa consisted of three Ephemeroptera (mayfly) taxa: Baetidae, Caenidae and Leptophlebiidae; and four Trichoptera (caddis fly) taxa: Calamoceratidae (sleeping bag caddis), Ecnomidae (caseless caddis), Hydropsychidae (net spinning caddis) and Leptoceridae (stick caddis). No Plecoptera (stoneflies) were detected, nor were they expected to occur within the sites sampled, due to the absence of riffles and suitable substrates.

SIGNAL2 scores

SIGNAL2 scores were greater for the edge habitat samples than for the bed habitat samples at each of the two sites sampled in November 2018 and ranged from 2.88 in the bed habitat of Site 16 (Bringalily Creek) to 3.92 in the edge habitat of Site 2 (Macintyre River). The SIGNAL2 value of 3.36 for the edge

habitat sample collected from Site 16 in November 2018 falls within the 20:80 percentile range of 3.13 to 3.75 for slightly to moderately disturbed waters of the Dumaresq catchment within the Queensland Border Rivers basin (Negus *et al.* 2013, cited in DES 2019a).

SIGNAL2 scores were greater for the bed habitat samples than for the edge habitat samples at each of the five sites sampled in May 2019. This is likely a reflection of the retracting water level associated with lower flow, and greater habitat complexity at Site 2, including varying depths, velocities and substrate sizes. SIGNAL2 scores in May 2019 ranged from 3.25 in the edge habitat of Site 6R to 4.33 in the bed habitat of Site 18. The SIGNAL2 values for the edge habitat samples collected from sites 6R, 7 and 18 fall within or favourably above the 20:80 percentile range of 3.13 to 3.75 for slightly to moderately disturbed waters of the Dumaresq catchment within the Queensland Border Rivers basin (Negus *et al.* 2013, cited in DES 2019a).

No SIGNAL2 guidelines are yet available for the broader Macintyre River catchment, or the Condamine River catchment. However, the SIGNAL2 scores for Site 2 fall within or just outside the 20:80 percentile guideline range of 3.33 to 3.85 for bed habitats and 3.31 to 4.20 for edge habitats of slightly to moderately disturbed waters of the Queensland Central Region, as a guide for comparison (DEHP 2013). The SIGNAL2 scores for Site 42 fall within or just outside the 20:80 percentile guideline range of these guidelines.

Tolerant taxa

The percentage of tolerant macroinvertebrate taxa (i.e. those with SIGNAL2 score of three or less) in the edge habitats ranged from 40 to 63 per cent in the samples collected in November 2018 and from 52 to 55 per cent in the samples collected in May 2019. The percentage of tolerant macroinvertebrate taxa in the bed habitats ranged from 40 to 63 per cent in the samples collected in November 2018 and from 22 to 40 per cent in the samples collected in May 2019. The percentage of tolerant taxa in the edge habitat samples collected from Sites 6R, 7, 16 and 18 fall within the 20:80 percentile range of 37.93 to 65.00 per cent for slightly to moderately disturbed waters of the Dumaresq catchment within the Queensland Border Rivers basin (Negus *et al.* 2013, cited in DES 2019a).

No tolerant taxa guidelines are yet available for the broader Macintyre River catchment, or the Condamine River catchment. However, the tolerant taxa scores for Site 2 fall within or just outside the 20:80 percentile guideline range of 25 to 50 per cent for the bed habitat and 44 to 56 per cent for the edge habitat of slightly to moderately disturbed waters of the Queensland Central Region (as a guide for comparison; DEHP 2013). The tolerant taxa scores for Site 42 fall within the 20:80 percentile guideline range of these guidelines.

AusRivAS OE50

The AusRivAS OE50 assessment method describes the biological diversity of macroinvertebrates when compared with reference sites used to create the AusRivAS model. There are five categories of diversity, called bands: X, A, B, C and D. Band A (similar to reference) is assigned when results are similar to reference sites (the expected number of families within the range found at 80% of the reference sites). Band B (significantly impaired) is assigned when there are fewer families than expected, with a potential impact either on water or habitat quality. Band X (more biologically diverse than reference) is assigned when taxonomic richness is higher than reference because of naturally high biodiversity, an impact such as mild nutrient enrichment, or artificially sustained flow in a normally intermittent stream.

Overall, AusRivAS band ratings ranged from Band A (reference condition) to Band B (significantly impaired). Aquatic macroinvertebrate assemblages in the bed and edge habitats of Site 16 (Bringalily

Creek) were in reference condition (Band A; **Table 37**) in November 2018. This was also the case for bed and edge habitats samples collected from Site 18 (also Bringalily Creek) in May 2019, each in reference condition (Band A; **Table 37**). This suggests that most/all of the expected taxa were found and that existing upstream impacts on water quality and/or habitat condition have not resulted in a loss of macroinvertebrate diversity. Both the bed and edge habitat samples collected from Site 2 (Macintyre River) were slightly impaired (Band B).

Table 37 AusRivAS model outputs for sites sampled within the impact assessment area, November 2018

Site	Bed habitat		Edge habitat		Overall Band
	OE50	Band	OE50	Band	
November 2018					
2 (Macintyre River)	0.56	B	0.73	B	B
16 (Bringalily Creek)	0.85	A	0.99	A	A
May 2019					
2 (Macintyre River)	1.22	X	1.02	A	A
6R (Macintyre Brook)	0.61	B	0.92	A	B
7 (Macintyre Brook)	1.22	X	0.83	A	A
18 (Bringalily Creek)	0.91	A	1.10	A	A
42 (Dry Creek)	0.88	A	0.75	B	B

4.4.4 Macro-crustaceans

Three macro-crustacean families: Palaemonidae (freshwater prawns), Atyidae (freshwater shrimp) and Parastacidae (yabbies), were encountered within the impact assessment area. Individuals from the family Palaemonidae were identified as *Macrobrachium australiense*. Individuals from the family Atyidae were identified as *Paratya australiense*. Individuals from the family Parastacidae were identified as *Cherax destructor*.

4.4.5 Fish

There were no fish caught in bait traps during the June 2018 survey, predominantly due to dry conditions and limitations of the sampling method. A total of 202 fish were caught across the two sites in November 2018 with sufficient water for investigation (**Table 38**). These included common native and introduced species. No Murray Cod or Silver Perch were captured. However, both sites had habitat potentially suitable for the Murray Cod. The Agassiz's Glassfish (*Ambassis agassizii*) was captured at Site 2 in the Macintyre River, on the Queensland side of the state border. The western population of this species is listed as an endangered population in NSW (NSW DPI 2013).

A total of 1,865 fish were caught across the five sites in May 2019 with sufficient water for investigation (**Table 38**). These included native species and introduced species. Six Murray Cod were caught at Site 2 on the Macintyre River, with one Murray Cod captured at Site 7 on Macintyre Brook. Other species encountered included the Murray River Rainbowfish, Unspecked Hardyhead, Australian Smelt and Southern Purple Spotted Gudgeon.

Surveys confirmed the presence of several native and pest fish species across the impact assessment area. However, the presence and abundance of fish species at many sites is likely to have been limited by the dry conditions during the approximate 12 month survey period. A greater diversity and abundance of fish across waterways of the impact assessment area is therefore assumed for the purposes of impact

assessment. The Murray Cod was confirmed to be present in the Macintyre River and Macintyre Brook, and is assumed to be present in other large waterways of the impact assessment area, including the Condamine River and larger tributaries. Many of the fish species found or assumed to be present in waterways of the impact assessment area undertake migrations, including Bony Bream, Murray River Rainbowfish, Australian Smelt and Murray Cod (Lintermans 2007).

Table 38 Summary of fish caught during November 2018 field surveys

Location	Date	Scientific name	Common name	No. captured	Size range (mm)^
Macintyre River (Site 2)	29 November 2018	<i>Ambassis agassizii</i>	Agassiz's glassfish [#]	1	35
		<i>Carassius auratus</i> *	Common goldfish*	7	45 to 50
		<i>Gambusia holbrooki</i> *	Eastern gambusia*	4	25 to 35
		<i>Hypseleotris</i> sp.	Carp Gudgeon	57	20 to 40
		<i>Leiopotherapon unicolor</i>	Spangled perch	2	30 to 45
		<i>Melanotaenia fluviatilis</i>	Murray river rainbowfish	2	35 to 45
		<i>Nematalosa erebi</i>	Bony bream	1	40
	15 -16 May 2019	<i>Craterocephalus fulvus</i>	Unspecked hardyhead	7	40 to 55
		<i>Gambusia holbrooki</i> *	Eastern gambusia*	75	25 to 40
		<i>Hypseleotris</i> sp.	Carp Gudgeon	98	25 to 45
		<i>Leiopotherapon unicolor</i>	Spangled perch	17	60 to 80
		<i>Melanotaenia fluviatilis</i>	Murray river rainbowfish	75	35 to 75
		<i>Maccullochella peelii</i>	Murray cod [#]	6	310 to 450
		<i>Retropinna semoni</i>	Australian smelt	51	40 to 70
Macintyre Brook (Site 6R)	16 – 17 May 2019	<i>Hypseleotris</i> sp.	Carp gudgeon	685	25 to 45
		<i>Craterocephalus fulvus</i>	Unspecked hardyhead	19	35 to 55
		<i>Tandanus tandanus</i>	Freshwater catfish	18	90 to 420
		<i>Gambusia holbrooki</i> *	Eastern gambusia*	147	25 to 40
		<i>Melanotaenia fluviatilis</i>	Murray river rainbowfish	27	35 to 50
		<i>Retropinna semoni</i>	Australian smelt	1	50
Macintyre Brook (Site 7)	16 – 17 May 2019	<i>Maccullochella peelii</i>	Murray cod [#]	1	490
		<i>Hypseleotris</i> sp.	Carp gudgeon	283	25 to 45
		<i>Melanotaenia fluviatilis</i>	Murray river rainbowfish	238	30 to 55
		<i>Craterocephalus fulvus</i>	Unspecked hardyhead	28	35 to 60
		<i>Carassius auratus</i> *	Common goldfish*	1	150
		<i>Cyprinus carpio</i> *	Common carp*	1	160
		<i>Gambusia holbrooki</i> *	Eastern gambusia*	3	30
		<i>Retropinna semoni</i>	Australian smelt	5	40 to 45
Bringalily Creek (Site 16)	28 November 2018	<i>Carassius auratus</i> *	Common goldfish*	3	80 to 250
		<i>Cyprinus carpio</i> *	Common carp*	6	300 to 430
		<i>Hypseleotris</i> sp.	Carp Gudgeon	101	20 to 45
		<i>Macquaria ambigua</i>	Golden perch	3	23 to 29
		<i>Melanotaenia fluviatilis</i>	Murray river rainbowfish	15	35 to 55

Location	Date	Scientific name	Common name	No. captured	Size range (mm) [^]
Bringalily Creek (Site 18)	17 – 18 May 2019	<i>Leiopotherapon unicolor</i>	Spangled perch	52	45 to 70
		<i>Hypseleotris</i> sp.	Carp gudgeon	13	30 to 35
Dry Creek (Site 42)	18 May 2019	<i>Mogurnda adspersa</i>	Southern purple spotted gudgeon	14	50 to 80

[^]Estimated length from snout to tail fork, *Pest species euthanised, # Threatened species in QLD or NSW at location of capture.

4.4.6 Freshwater turtles

Habitat suitable for freshwater turtles was observed throughout the impact assessment area. This included major systems such as the Macintyre and Condamine Rivers, as well as smaller creeks and tributaries, many of which were dry at the time of the field surveys. Turtle nesting habitat was noted to be abundant along the Macintyre River and Macintyre Brook, with the Eastern snake-necked turtle recorded at Bringalily Creek. Due to ongoing dry conditions, many turtles are likely to have moved temporarily to constructed farm dams and other more permanent sources of water during the survey period. No habitat suitable for the Bell's turtle or Southern snapping turtle was identified during the field surveys.

4.5 Synthesis of existing aquatic ecology and surface water values

A summary of key aquatic ecology and surface water values is provided in the following sections, relative to the water quality zones identified by DES (2019a, b) for the implementation of local water quality guidelines. The water quality zones generally align with sub-catchments of the impact assessment area.

In general, aquatic ecology values can be summarised as:

- Biodiversity and nature conservation
- Riparian vegetation
- Habitat connectivity
- Bank stability
- Water quality
- Sediment quality
- Water resources

Macintyre Barwon Floodplain (Sites 1 and 2)

Sites within the Macintyre Barwon Floodplain were located on the largest watercourse in the region (the Macintyre River) and had a significant amount of water present in large pools and channels. Stream banks were generally well defined. However, some areas had been subject to tunnel and gully erosion. Disturbance to the aquatic habitats was noted as a result of both adjacent land use from agricultural grazing and construction of a bridge access.

Riparian vegetation cover was high although aquatic flora comprised only a small proportion of the vegetation present (approximately 2 per cent). Aquatic fauna was recorded at Site 2, with eight native species of fish that inhabit pools and streams of the floodplain, including the Murray Cod and Agassiz's Glassfish. Habitat value in general was assessed as good, with limited barriers to fish passage. Nesting habitat for freshwater turtles was also abundant along the Macintyre River.

Water quality was generally good, with elevated turbidity, EC and suspended sediment concentrations. Macroinvertebrate assemblages were consistent with those expected for slightly to moderately disturbed

aquatic ecosystems, indicating the presence of good water quality and habitat features in the period prior to assessment. Representative site photos are provided in **Figure 8**.



Figure 8 Macintyre Barwon Floodplain representative sites November 2018 (left: Site 1, right: Site 2)

Lower Macintyre Brook (sites 3 to 8)

Lower Macintyre Brook consists of several ephemeral drainage features, some of which were dry at the time of field surveys. When water was present, small standing pools were common along with larger deeper stream sections. The poorly defined low sloped banks were consistent with a low potential for erosion. Riparian vegetation was intact at most sites.

Adjacent land consisted of native forest as well as cropping (grain fed cattle and irrigation). Therefore, a moderate to high level of disturbance exists, particularly in areas where irrigation and agricultural runoff occurs. A Eucalypt woodland vegetation community was observed along the drainage, though some clearing has occurred on the floodplains. Aquatic flora persistence and biodiversity was variable, with up to 15 per cent cover in some parts and as low as 1 per cent cover in others.

Six species of native fish were identified at Sites 6R and 7 during field surveys in May 2019, including the Murray Cod. The Lower Macintyre Brook also has suitable habitat for the Platypus, which was observed in the June 2018 survey. Macroinvertebrate scores were variable between sites and generally indicative of good water quality and habitat features. Banks also provide suitable nesting habitat for freshwater turtles. Water flow obstructions were present, including at Site 4, where a dog proof fence intersected the waterway. Overall habitat value was rated from fair to good, with some parts of the brook providing effective fish passage, even at times of low flow. Water quality at sites in the Lower Macintyre Brook was characterised by high EC and elevated TSS and nutrients, with low dissolved oxygen. Representative site photos are provided in **Figure 9**.



Figure 9 Lower Macintyre Brook representative sites, November 2018 (top left: Site 3, top right: Site 4, middle left: Site 5, middle right: Site 6, bottom left: Site 7, bottom right: Site 8)

Canning Creek (sites 9 to 20)

The Canning Creek water quality zone comprises a combination of ephemeral (some of which were dry at the time of assessment) and semi-permanent waterways (e.g. Sites 11, 14 and 16). Stream banks were variable across the impact assessment area, with some well-defined stream banks of varying slope as well as others that were flatter and less distinct waterway pathways.

Adjacent land use included native forest, road reserve and cattle grazing. Areas which have been fenced off to grazing (e.g. Site 9) have experienced less vegetation disturbance than other areas which are subject to stock access. Erosion was observed to range from moderate to severe, with the invasion of exotic pastoral weed *Lippia* detected, which is known to outcompete native riparian flora and negatively affect bank stability (reported at Sites 9 and 17). Further disturbance has also occurred through the installation of box culverts and bridge access.

Vegetation communities consisted of scattered and clumped Eucalypt woodlands, while aquatic flora cover ranged from 5 per cent (Site 9) to more than 30 per cent (Sites 16 and 17). Aquatic fauna were confirmed at semi-permanent waterways of Sites 16 and 18 where five native species of fish were recorded. These sites also provided potential habitat for EVNT species Murray Cod and SLC Platypus. In general, habit value ranged from fair to good with effective fish passage existing at the majority of sites along Canning Creek.

Water quality within the Canning Creek water quality zone was generally poor, characterised by alkaline pH and elevated concentrations of nutrients. However, macroinvertebrate assemblages in Bringalily Creek were generally consistent with those expected for sites in reference condition (Band A). Representative site photos are provided in **Figure 10**.



Figure 10 Canning Creek representative sites, November 2018 (top left: Site 10, top right: Site 12, middle left: Site 16, middle right: Site 18, bottom left: Site 19, bottom right: Site 11)

Southern Condamine (sites 21 to 26)

Southern Condamine comprised multiple ephemeral drainage features, most of which were dry at the times of assessment, with the exception of Site 24, which generally had water present. The majority of streams exhibited poorly defined, low sloped banks which were assessed as moderately stable. Adjacent land was utilised for agricultural practices such as cattle grazing, which had resulted in some bank erosion.

The riparian zone was particularly wide in some sections with a mix of native and exotic vegetation cover. Large trees such as eucalypts were often scattered, and the abundance of aquatic flora was variable. Areas which contained deeper channels and larger water bodies have the potential to support some

aquatic flora and fauna species. This may include the Murray Cod during extended wet periods, when there are larger volumes of water in the Condamine River system. However, aquatic environments are considered unlikely to provide suitable habitat for any EVNT or SLC species during average to dry periods, due to their ephemeral nature. Water quality was characterised by alkaline pH, high EC and elevated concentrations of suspended sediment and nutrients. Representative site photos are provided in **Figure 11**.



Figure 11 Southern Condamine representative sites, November 2018 (top left: Site 24, top right: Site 24, bottom left: Site 23, bottom right: Site 24)

Central Condamine (sites 27 to 33)

Central Condamine consisted of several ephemeral drainage features, some of which were commonly dry at the time of field surveys (Sites 29, 31 and 32). Some small pools of water were sustained throughout the dry periods (Site 30), while others varied with season (Site 27 and 33). There was very little water in the channel, with water generally present in small pools with infrequent deeper stands. Generally, poorly defined low sloped banks existed, which were assessed as moderately stable. However, small areas of severe erosion were noted, particularly adjacent to agricultural cropping activities. Further disturbance as a result of the existing road bridge, culvert and evidence of litter/pollution were recorded at Site 32.

Riparian zones consisted of Eucalypt woodlands, which were scattered and were sparse along some sections of the Condamine River. Native vegetation was dominant (with exotics also readily found), and aquatic flora was particularly abundant and diverse. Habitat values for aquatic fauna was found to be variable, depending on the nature of water presence.

Overall habitat value was limited, and the area is highly unlikely to provide suitable habitat for any EVNT or SLC aquatic flora or fauna species, nor were these detected. However, the Condamine River is recognised as known habitat of the Murray Cod, and the species may utilise waters of the river system during prolonged wetter periods. Water quality at sites in the Central Condamine was characterised by alkaline pH, high EC and elevated concentrations of suspended sediment and nutrients. Representative site photos are provided in **Figure 12**.



Figure 12 Central Condamine representative sites, taken November 2018 (top: Site 33, bottom left: Site 29, bottom right: Site 29)

Oakey Creek (sites 34 to 43)

Oakey Creek comprised multiple ephemeral drainage features, many of which were dry at the times of survey. Some small pools were sustained throughout drier periods. During wet periods, large deep stream channels would be common (these were not observed due to dry conditions). Stream bank slopes ranged from low to moderate, with a high potential for erosion during flood events. Prominent eroded banks and deepening of channels were particularly evident as a result of local land uses.

Adjacent areas consisted of agricultural land used for grazing, with riparian vegetation highly disturbed. This generally consisted of scattered non-remnant vegetation with sparse cover and often dominant exotic species. The riparian zone has been severely reduced in some parts of Oakey Creek (ranging from 0 – 6 m in width). Aquatic flora persistence and biodiversity were severely limited in most locations. One native fish species, the Southern Purple Spotted Gudgeon, was captured at Site 42 (Dry Creek). This site had a macroinvertebrate community typical of slightly to moderately disturbed ecosystems.

Although minimal potential fish habitat exists upstream, there is very restricted movement through waterways, as existing road culverts (such as at Site 43) have not allowed for fish passage. Overall habitat value was assessed as fair, although the area was highly unlikely to provide suitable habitat for any EVNT or SLC aquatic flora or fauna species, nor were these detected. Water quality at Oakey Creek was characterised by alkaline pH, high EC and high dissolved copper concentrations. Representative site photos are provided in **Figure 13**.



Figure 13 Oakey Creek representative survey sites, taken November 2018 (top: looking west from Site 43, middle left: Site 43, middle right: Site 43, bottom left: Site 42, bottom right: Site 42)

5 Impact assessment

5.1 Potential impacts of the Project

Potential impacts of the Project on aquatic ecology values are outlined in **Table 39**, with discussion provided in the following sections.

Clearing of riparian vegetation

Construction of rail infrastructure and associated access tracks, equipment laydown areas and crossings in proximity to waterways will be required during construction phases of the Project. This will result in the removal of habitat for some aquatic species including woody debris, and may result in minor changes in physical attributes of waterways (e.g. reduced shading and increased light penetration). The degree of riparian vegetation clearing and thus, the scale of impact, will vary across the alignment, depending on the size and scale of waterways and the extent of existing disturbance (e.g. existing rail infrastructure).

Clearing of vegetation for construction has the potential to alter temperature and light regimes of aquatic habitats. Increased light penetration into creeks which originally had dense canopy cover may potentially affect the flora composition of aquatic habitats, resulting in a reduction in the abundance and distribution of light-sensitive aquatic plants. Increased light can also be expected to promote the growth of algae and invasive aquatic plants, which may outcompete other plant species and reduce the complexity of aquatic habitats and species diversity. Increased light can also be expected to result in an increase in daytime water temperatures, affecting biological processes such as respiration rates of aquatic organisms, and displacing native species that are not tolerant of high temperatures.

Disturbance of aquatic habitat

The installation of artificial structures such as culverts and bridge pylons within waterways will result in some impacts on aquatic flora and fauna habitat values. Such works may involve the disturbance and removal of stream bed sediments, and changes in habitat structure from a soft bottom to a hard bottom. Some types of infrastructure may increase habitat availability for native and exotic fauna species that are able to utilise a broad range of habitats types, which are lacking in structural complexity. For example, naturally-occurring woody debris habitat generated by riparian vegetation may be replaced with bridge pylons or culverts, resulting in a change in the abundance and diversity of fish species in that location and adjacent areas.

Culverts have the potential to interrupt or become a barrier to aquatic fauna movement, which may affect species life stages and the ability to persist in the local area. Similarly, the installation of bridge support structures may impact on aquatic fauna habitat at a local scale, particularly that of benthos-dwelling species. Temperature and light regimes may also be altered by bridge structures at a local scale through shading of the central part of large waterways, which are not generally shaded by riparian vegetation.

Sediment runoff into waterways

Works adjacent to waterways will result in the exposure of soils which may be mobilised by rainfall and runoff into adjacent aquatic habitats, and also affect areas downstream. Stockpiling of soils close to waterways is also a potential source of sediment inputs into aquatic habitats. Increased runoff to waterways is likely to result in a decline in water quality, through an increase in turbidity and TSS concentrations, and potentially, an increase in the concentration of sediment-bound contaminants such as metals.

Suspended sediments have the potential to impact on fish, freshwater turtles and some invertebrates by disrupting the function of gills (fish and some invertebrates), reducing underwater visibility for predatory species and displacing species that are not tolerant of variable and turbid water quality conditions. This may result in localised fish kills or the displacement of aquatic species to adjacent areas. Metals and other contaminants bound to sediments that wash into waterways may have toxic effects on aquatic organisms or reduce the quality of drinking water for stock. Such effects are likely to be relatively localised (over a scale of hundreds of metres), and will reduce with distance downstream from the source.

Altered hydrology

The installation of artificial structures such as culverts has the potential to alter natural stream flows and volumes in some locations (see EIS Chapter 12: Surface Water and Hydrology). Hydrologic and hydraulic modelling predicted minimal impacts from Project infrastructure on flood flows, floodplain coverage and flow velocities under a range of flow scenarios, including extreme events. Predicted changes in flow velocities were limited in scale to immediately upstream and downstream of culverts. At these locations, such changes may cause minor changes to the location, abundance and structure of aquatic habitats, such as pools, channels, riffles and dry creek beds. This can be expected to result in minor changes to the composition and diversity of aquatic organisms in affected locations.

Changes to the timing and quantity of water flow downstream during major rainfall events are expected to be minor. These changes, have some potential to affect fauna migration and breeding activities such as spawning in fish, which are often linked to water levels and flow rates. Connectivity for aquatic fauna across the flood plains of the impact assessment area is not expected to be affected, due to the design of railway infrastructure. For example, within the Condamine River flood plain, six bridge structures will be constructed, with the largest extending a length of 1,941 m. An extensive network of culverts has also been incorporated into the reference design, with a majority of culverts within the Condamine River flood plain having a width or diameter of >2 m. These design features will minimise changes to hydrology, and are adequate to facilitate continued connectivity among habitats of the flood plain by aquatic fauna, including fish and freshwater turtles. Further details on the predicted changes to hydrology are provided in the Hydrology and Flooding Technical Report (Appendix Q1 and Q2 of the draft EIS).

Changes to groundwater resources, affecting groundwater dependent ecosystems

Project activities have the potential to impact on groundwater resources through effects such as groundwater level reduction, alteration of aquifer flow patterns, the settlement of compressible substrates and reductions in groundwater quality. GDEs are susceptible to indirect impacts from changes to groundwater resources. For example, a reduction in groundwater level may cause spring wetlands to reduce in size or dry up, resulting in a contraction of wetland extent, loss of aquatic habitat and reduction in species diversity. A decline in groundwater quality may also affect aquatic organisms living underground (e.g. stygofauna) or present within surface waters that are sourced from impacted aquifers.

An evaluation of the potential impacts of the Project on groundwater resources (see EIS Chapter 13: Groundwater) concluded that the majority of potential impacts are temporary in nature and related to the construction phase of the Project. While a small number of locations were identified where construction activities have the potential to intersect shallow groundwater resources, engineering controls were assessed to be sufficient to mitigate the extent of impacts. Controls to reduce the risk of contamination of groundwater quality from Project activities (e.g. spills) are also in place and are similar to those related to surface water quality. Further details on the predicted changes to groundwater resources are provided in the Groundwater Technical Report (Appendix R of the draft EIS).

Invasion of aquatic habitats by exotic pest species

Construction of new rail infrastructure has the potential to increase the abundance of weeds and pests and introduce new weed and pest species. The disturbance of existing weeds along the riparian corridor may result in the spread of propagules downstream, or the transport of propagules to other areas either on machinery or through natural dispersal once disturbed. Weed seeds and some pests may also be present on machinery brought in from other areas and be introduced to the local environment. Some farm dams likely to contain exotic species will need to be dewatered to facilitate construction of the Project. This may result in the spread of pest (e.g. exotic fish species) and weed species to adjacent waterways, if not managed appropriately, resulting in a reduction in aquatic habitat quality and species diversity. There are some species of weed that are present in one local government area of the impact assessment area, but are not known to be present in adjoining local government areas (GRC 2019; TRC 2020). The movement of machinery and vehicles across the impact assessment area during the pre-construction and construction phase of the Project has the potential to spread weeds into new localities.

Disturbance of fauna from noise, vibration and lighting

A range of construction activities are likely to result in an increase in noise and vibrations in the vicinity of waterways, reducing habitat quality and increasing disturbance to sensitive fauna. Noise may be created by earthworks, use of heavy machinery or piling in or adjacent to aquatic habitats. Species that are easily disturbed, such as Platypus, may move to adjacent areas to avoid being disturbed, if suitable habitat exists. Such noise and vibration may persist into the operation phase, at a reduced magnitude, and occur at frequent periods each time that a train traverses the alignment. Night works will involve the installation of temporary lighting for safety and operational purposes which may also result in disturbance to sensitive aquatic fauna. Such effects are likely to result in a reduction in aquatic habitat quality and species diversity at the locations affected, and adjacent areas.

Introduction of contaminants into waterways

Construction activities have the potential to result in the introduction of contaminants into waterways, resulting in declines in water quality (e.g. from fuel spills). Similarly, the use of herbicides during future track maintenance has the potential to impact on vegetation living in and adjacent to waterways. An increase in access to aquatic habitat by people during construction (i.e. construction workforce) has the potential to result in litter being deposited within or adjacent to waterways. Such contaminants can be expected to reduce water quality and the quality of aquatic habitats in areas affected, and adjacent areas downstream.

Impacts on EVNT species

The Project is unlikely to have a significant impact on any EVNT species. While the Murray Cod has been confirmed to occur within parts of the impact assessment area, and is assumed to be present in the larger rivers with suitable habitat, potential impacts of the Project on the species are of a low magnitude and localised in scale. Clearing of riparian vegetation and disturbance of aquatic habitats will be minimised to discrete locations where crossings occur. The design of crossings will generally include bridges in areas suitable for Murray Cod (e.g. large rivers such as the Macintyre River). An assessment of impacts on the Murray Cod in relation to significant impact criteria in the MNES Significant Impact Guidelines 1.1 (DoE 2013) is provided in **Appendix E**.

The Project is also unlikely to have a significant impact on the Silver Perch, Bell's turtle or the Southern snapping turtle, as these species are unlikely to be present in the impact assessment area. Measures in place to reduce impacts on the Murray Cod will also benefit the Silver Perch, in the event that a small

number of individuals utilise habitat within the impact assessment area from time to time. The western population of Agassiz's Glassfish is listed as endangered under NSW legislation and was confirmed to be present in the Macintyre River. The Project is unlikely to influence threatening processes for this species, which primarily relate to predation from introduced fish species, habitat degradation and rapid fluctuations in water level from regulated flows (NSW DPI 2013).

Table 39 Summary of potential impacts to aquatic ecology values

Aquatic Ecology Value	Delivery Phase	Description of potential impacts
Biodiversity and nature conservation	Pre-construction and construction	<u>Clearing of riparian vegetation</u> Removal of riparian and aquatic habitats including hollow-bearing trees, logs and burrows which will reduce the persistence of native species that utilise these habitats <u>Disturbance of aquatic habitat</u> Loss of submerged aquatic vegetation and woody debris, resulting in a reduction in aquatic habitat complexity and aquatic plant diversity River substrate disturbance (i.e. due to bridge or culvert construction) which may affect bottom dwelling aquatic flora and fauna and their associated habitats Loss of sensitive ecological processes through geomorphological alteration, including a change in photosynthesis and respiration rates from increases in sunlight and water temperature Mortality or displacement of EVNT species <u>Invasion of aquatic habitats by exotic pest species</u> Transmission and invasion of aquatic and terrestrial weeds (e.g. through vehicle and machinery movement) altering riparian and aquatic vegetation community composition <u>Disturbance of fauna from noise, vibration and lighting</u> Disturbance of aquatic fauna from noise, vibration and lighting <u>Changes to groundwater resources, affecting groundwater dependent ecosystems</u> Reduction in groundwater level, resulting in the loss of wetland habitat and an alteration of species composition within GDEs
	Operation	<u>Disturbance of aquatic habitat</u> Mortality or displacement of EVNT species <u>Invasion of aquatic habitats by exotic pest species</u> Transmission of aquatic and terrestrial weeds (through railway) may alter riparian vegetation community composition <u>Disturbance of fauna from noise, vibration and lighting</u>

Aquatic Ecology Value	Delivery Phase	Description of potential impacts
		Disturbance of aquatic fauna from noise, vibration and lighting
Riparian vegetation	Pre-construction and construction	<u>Clearing of riparian vegetation</u> Changes in community structure and composition due to clearing Reduction in shading and increase in light penetration into aquatic habitats, resulting in higher stream temperatures and conditions suitable for the proliferation of algae <u>Invasion of aquatic habitats by exotic pest species</u> Vegetation clearing allowing the colonisation of exotic species
	Operation	<u>Invasion of aquatic habitats by exotic pest species</u> Transmission of aquatic and terrestrial weeds (through railway) may alter riparian vegetation
Habitat connectivity	Pre-construction and construction	<u>Altered hydrology</u> Introduction of physical barriers to aquatic fauna movement through the construction of culverts, bridges, fencing and other infrastructure that affects the existing hydrological conditions Construction of temporary bunding to achieve a dry work area at creek crossings.
	Operation	<u>Altered hydrology</u> Introduction of physical barriers to aquatic fauna movement through the construction of culverts, bridges, fencing and other infrastructure that affects the existing hydrological conditions
Bank stability	Pre-construction and construction	<u>Clearing of riparian vegetation</u> Construction works involving disturbance to the riparian corridor may result in erosion and scouring of streambanks, which are an important component of aquatic habitats. This may result in unstable stream banks unable to support vegetation or tolerate extreme rainfall or flooding events. <u>Disturbance of aquatic habitat</u> Smothering of benthic aquatic habitat due to erosion, sediment transport and sediment deposition. Physical disturbance of stream beds and banks during construction of creek crossings

Aquatic Ecology Value	Delivery Phase	Description of potential impacts
		<u>Invasion of aquatic habitats by exotic pest species</u> Establishment of weeds such as Lippia (recorded in region) in new areas which out compete native species and affect the integrity of stream banks
	Operation	<u>Invasion of aquatic habitats by exotic pest species</u> Establishment of weeds such as Lippia (recorded in region) in new areas which out compete native species and affect the integrity of stream banks
Water quality	Pre-construction and construction	<u>Sediment runoff into waterways</u> Declines in water quality due to runoff from disturbed areas or discharge of water generated from construction activities (e.g. dewatering of a dry work area). This may include increased concentrations of suspended sediments, nutrients, metals and hydrocarbons, which may reduce the suitability of water to support environmental values (e.g. aquatic ecosystems and stock watering). <u>Introduction of contaminants into waterways</u> Spills of contaminants to waterways and in adjacent areas during works, resulting in pollution of local waterways and areas downstream and toxic effects on aquatic organisms. Spills of contaminants to groundwater, resulting in pollution of GDEs and toxic effects on aquatic organisms.
	Operation	<u>Introduction of contaminants into waterways</u> Spills of contaminants to waterways from train and associated infrastructure, resulting in pollution of local waterways and areas downstream and toxic effects on aquatic organisms.
Sediment quality	Pre-construction and construction	<u>Introduction of contaminants into waterways</u> Spills of contaminants to waterways and in adjacent areas during works, resulting in pollution of local waterways and areas downstream and toxic effects on aquatic ecosystems. <u>Sediment runoff into waterways</u> Physical disturbance of soils and mobilisation of contaminants (e.g. metals) to waterways from rainfall runoff, decreasing water quality. Increase in salinity from interplay between works, runoff and sodic or dispersive soils.

Aquatic Ecology Value	Delivery Phase	Description of potential impacts
	Operation	<u>Introduction of contaminants into waterways</u> Spills of contaminants to waterways and in adjacent areas during works, resulting in pollution of local waterways and areas downstream and toxic effects on aquatic ecosystems.
Water resources	Pre-construction and construction	<u>Altered hydrology</u> Changes in watercourse pathway and flow characteristics, including the alteration of habitat composition (ponding, channels and dry creek beds) and flow regime. Changes in water availability: riparian community structure and species composition. Temporary changes in hydrology through bunding to create a dry work area.
	Operation	<u>Altered hydrology</u> Changes in watercourse pathway and flow characteristics, including the alteration of habitat composition (ponding, channels and dry creek beds) and flow regime. Changes in water availability: riparian community structure and species composition. Altered flow regimes which result in changes to aquatic ecology and surface water.

5.2 Mitigation measures

5.2.1 Mitigation through the reference design phase

Development of the reference design has progressed in parallel with the impact assessment process. As a consequence, design solutions for avoiding, minimising or mitigating impacts have been incorporated into the reference design as appropriate and where possible.

Mitigation measures and controls that are relevant to aquatic ecology and have been factored into the reference design, or otherwise implemented by the Project, are summarised in **Table 40**.

Table 40 Initial mitigations of relevance to aquatic ecology

Aquatic ecology value	Initial mitigation measures
Biodiversity and nature conservation Riparian vegetation	• The Project has been positioned to maximise the use of existing rail corridors and to be co-located with existing road infrastructure, where possible. Co-location with existing linear infrastructure minimises the need to develop natural and rural landscapes that have not previously been subject to disturbance for a similar purpose • Greenfield components of the Project have been aligned to minimise: - the extent of impact to remnant vegetation and - the extent of impact to areas of known habitat potential - the number of watercourses and waterways traversed by the Project • The Project footprint has been restricted to what is anticipated to be required to construct, operate and maintain the works in a safe and efficient manner. Restricting the footprint minimises the extent of disturbance required to vegetation and habitats • Greenfield components of the Project have been aligned to minimise the extent of impact to remnant vegetation, and the number of watercourses and waterways traversed by the Project. Clearing of remnant vegetation will be restricted to the minimum required to enable the safe construction, operation and maintenance of the rail corridor, including minimising the disturbance of sensitive areas such as: - Habitat for critically endangered, endangered and vulnerable flora and fauna species - Critically endangered and endangered Threatened Ecological Communities - Riparian vegetation - Steep slopes - Along river banks • The Project has been developed to minimise impacts to watercourses, waterways, riparian vegetation and in-stream flora and habitats by adopting a crossing structure hierarchy where bridges are preferred to culverts, where practical • Bridge structures are provided in the reference design over the following watercourses and waterways, to minimise disturbance of aquatic habitats:

Aquatic ecology value	Initial mitigation measures
	Macintyre River, Macintyre Brook, Pariagara Creek, Cattle Creek, Native Dog Creek, Bringalily Creek, Nicol Creek, Back Creek, Grasstree Creek, Condamine River, Condamine River North Branch, Westbrook Creek and Dry Creek. Further details on the location and length of bridge structures is provided in the Hydrology and Flooding Technical Report (Appendix Q1 and Q2 of the draft EIS) and reference design drawings (Volume III of the draft EIS)
Bank stability Water quality	• The Project footprint has been established to accommodate temporary (i.e. sediment control basins) and permanent (i.e. scour protection, vegetated swales) erosion and sediment control devices during construction and operation of the Project • Bridges have been designed to minimise impacts to the bed, banks and environmental flows of waterways in accordance with requirements of the <i>Fisheries Act 1994</i> • Scour and erosion protection measures have been incorporated into the design in areas determined to be at risk, such as around culvert headwalls, drainage discharge pathways and bridge abutments
Habitat connectivity	• Waterway crossing structures (including culverts and bridges) have been designed to maintain aquatic fauna (e.g. for Silver Perch and Murray Cod) passage and minimise the risk of blockages in reference to the Accepted development requirements for operational work that is constructing or raising waterway barrier works (1 October 2018; DAF 2018) • The Project incorporates bridge and culvert structures to maintain existing flow paths and flood flow distributions, such as across the Condamine River floodplain where six bridges have been incorporated into the design with a combined length of 6 km
Water resources	• Bridge and culvert structures have been located and sized to avoid increases in peak water levels, velocities and duration of inundation • No watercourses, as defined and mapped under the <i>Water Act 2000</i>, are required to be diverted by the Project. A watercourse determination may be required for works affecting watercourses that are not mapped under the <i>Water Act 2000</i>. ARTC is an approved entity for the purpose of the Department of Natural Resources, Mines and Energy Riverine Protection Permit exemption requirements, and works can be undertaken providing that they meet the guidelines of the exemption.

5.2.2 Proposed mitigation measures

In order to manage and mitigate Project risks, additional mitigation measures have been proposed for implementation in future phases of Project delivery. These proposed mitigation measures have been identified to address Project-specific issues and opportunities including legislative requirements and accepted government plans, policy and practices.

Mitigation measures been proposed for implementation in future phases of Project delivery have been grouped and presented, as follows:

- **Table 41** identifies overarching mitigation and management measures for all ecological values
- **Table 42** provides mitigation measures specific to MNES and MSES aquatic ecological receptors that occur within the Project footprint.

The mitigation measures presented in **Table 41** and **Table 42** have been considered in the assessment of residual risk, as documented in **Section 5.3**.

Table 41 Aquatic ecology and surface water quality mitigation measures

Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
<i>Detail design</i>	<u>Value</u> Biodiversity and nature conservation <u>Potential impacts</u> Clearing of riparian vegetation Disturbance of aquatic habitat Invasion of aquatic habitats by exotic pest species	■ The Project will be refined during detail design to minimise the footprint to the extent required for the construction works and safe operation and maintenance of the Project. Confirmation of the construction approach will be achieved through the engagement of a construction contractor. ■ A Biodiversity Management Sub-plan will be developed as part of the CEMP. This plan should include appropriate criteria, directives and procedures in relation to: – Requirements for pre-clearing surveys, including aquatic and riparian habitats – Staging works so that they avoid breeding periods of the Murray Cod (September and October) as much as possible within areas of habitat (large waterways) – Staged and sequential clearing protocols – Animal handling protocols (e.g. for freshwater turtle species), including relocation and emergency care – Relocation of plants and habitats, including instream woody debris (where applicable) – Requirements for inspections and corrective actions during construction and rehabilitation activities – Biodiversity/fauna and flora management actions to be undertaken by suitably qualified persons – Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction. – Corrective actions should the outcomes not achieve to the objectives adopted ■ Construction areas including compounds, stockpiles, fuel storage areas, laydown areas and staff parking will be located and established outside the tree protection zone as defined in AS4970-2009 Protection of trees on development sites. ■ Develop a Soil Management Sub-plan which includes the following procedures and protocols relevant to potential impacts on land resources: – Soil/land conservation objectives for the Project – Management of problem soils, such as: ■ Acid sulfate soils, which may occur in proximity to wetland features and water storages, and have a low potential to occur within the impact assessment area.

		■ Erosive or dispersive soils, such as sodosols that are expected to be encountered between the Macintyre River and Yelarbon as well as along the fertile lands north of Inglewood to the west of Kooroongarra ■ Cracking clays (vertosols) that are expected to be encountered between Kooroongarra and Millmerran and from Yandilla to Gowrie ■ Saline soils, particularly in high salinity hazard areas such as between Kurumbul and Yelarbon. – Specification of the type and location of erosion and sediment controls (see below) – Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material – Vehicle, machinery and imported fill hygiene protocols and documentation, in accordance with the requirements of the <i>Biosecurity Act 2014</i> – Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction. ■ A Rehabilitation and Landscaping Management Sub-plan will be developed for the Project, as a component of the CEMP. This Sub-plan will establish the following: – Location-specific objectives for rehabilitation, reinstatement and/or stabilisation. Objectives will differ for within the rail corridor and outside of the rail corridor. Rehabilitation requirements for watercourses and waterways will be in accordance with the intent of: ■ Riverine protection permit exemption requirements (WSS/2013/726) ■ Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018), including requirements for the duration of works and the dimensions and design of culverts and other instream structures. – Timeframes for rehabilitation and/or reinstatement/stabilisation works to be achieved – Details of the actions and responsibilities to progressively rehabilitate, regenerate, and/or revegetate areas, consistent with the agreed objectives – Consideration for maintenance or performance issues of rehabilitation e.g. vegetation that does not grow and obscure signals or impact the longevity of rail infrastructure – Procedures, timeframes, measurable performance objectives and responsibilities for monitoring the success of rehabilitation and/or reinstatement/stabilization areas – Corrective actions should the outcomes not achieve to the objectives adopted
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Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
		– Where temporary construction facilities/borrow pits are required, land shall be returned to stable condition that complies with the conditions of applicable landowner agreements and regulatory approvals, e.g. Development Approval and/or Environmental Authority (EP Act) – Constructed landscape treatments shall be classified by type and documented to enable ongoing data management for life of the Project (i.e. beyond design). ■ A Biosecurity Management Sub-plan will be developed as a component of the CEMP. This Sub-plan will include: – Requirements for pre-clearing and operational surveys to determine the risk of weeds (e.g. Lippia) or pest animals (e.g. <i>Gambusia holbrooki</i>, Cane Toad) being present – Maps of the existing extent, confirmed through surveys, and severity of weed infestation and weed management requirements – Site hygiene and waste management procedures to deter pest animals – Weed surveillance and treatment during construction and rehabilitation activities – Requirements in relation to pesticide and herbicide use, including any limitations on use. Restrictions may apply in proximity to waterways, known areas of MNES or MSES habitat or land uses sensitive to spray-drift from the application of pesticides and herbicides – Vehicle, machinery and imported fill hygiene protocols and documentation – Erosion and sediment control risks associated with broad scale weed removal or treatment. – Corrective actions should the measures not achieve the adopted objectives.
	<u>Value</u> Water resources <u>Potential impacts</u> Altered hydrology	■ Design modifications during detail design will be subject to re-runs of the existing flood models to demonstrate continued compliance with the design objectives of the Project, including for extent and time of inundation, afflux and flow velocities.
	<u>Value</u> Habitat connectivity Bank stability <u>Potential impacts</u> Disturbance of aquatic habitat	■ Where the Project is unable to comply with the Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018), a development approval for operational work that is constructing or raising waterway barrier works will be required ■ ARTC is an approved entity for the purpose of the Department of Natural Resources, Mines and Energy Riverine Protection Permit exemption requirements (DNRME 2019). Where the Project is

Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
	Altered hydrology Sediment runoff into waterways	unable to comply with the exemption requirements, a riverine protection permit will be required for works within a watercourse. ■ The detail design will be developed so that no watercourses, as defined and mapped under the <i>Water Act 2000</i>, are required to be diverted for the Project. ■ The detail design will be developed to ensure that the potential for diversion of waterways as defined under the <i>Fisheries Act 1994</i> and mapped according to the spatial data layer, Queensland waterways for waterway barrier works, is minimised ■ Design modifications during the detail design will be subject to re-runs of the existing flood models to demonstrate continued compliance with the design objectives of the Project, including for extent and time of inundation, afflux and flow velocities. ■ A Soil Management Sub-plan, inclusive of erosion and sediment controls, and Surface Water Management Sub-plan will be developed as components of the CEMP.
	<u>Value</u> Water quality <u>Potential impacts</u> Sediment runoff into waterways Introduction of contaminants into waterways Invasion of aquatic habitats by exotic pest species	■ A Surface Water Management Sub-plan will be developed as a component of the CEMP. The Sub-plan will provide a surface water monitoring framework for the Project that establishes: – Additional monitoring and sampling required to establish baseline water quality conditions, as a continuation of data collected during existing environment within the draft EIS. Baseline water quality conditions will preferentially utilise water quality monitoring sites used within the draft EIS, with consideration of construction activities, seasonality and waterway sensitivity. These will be monitored, at a minimum monthly, for a period of 12-24 months prior to construction to determine baseline conditions as a reference for monitoring of impact (as per <i>Queensland Water Quality Guidelines</i> 2009). – Waterway-specific water quality criteria, based on baseline data, ANZECC/ARMCANZ, QWQG and relevant WQOs – Frequency and location of surface water sampling during construction of the Project, with consideration for: ■ Construction activities with potential to impact water quality ■ Seasonality ■ Sensitivity of receiving waterway – Further details of the surface water monitoring framework are provided in the Surface Water Quality Technical Report (Appendix P of the draft EIS)

Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
		– A risk management framework for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of instances (including accidental discharge of contaminants and sediments) that trigger contingency and ameliorative measures – <i>In situ</i> water quality parameters and laboratory analysis required for samples collected at each sampling location – QA/QC requirements for surface water sampling and analysis – Location specific impact thresholds – Responses to impact threshold exceedances (to be determined after the establishment of baseline water quality conditions) – Data management and reporting requirements ■ Dewatering of surface water storages, including private dams, will be required to comply with the <i>Biosecurity Act 2014</i> to take reasonable measure to avoid the spread of pest species (with capacity to affect water quality). A strategy for managing dewatering in order to meet water quality objectives will be required. ■ Dewatering/extraction of water from artificial impoundments will be undertaken after consultation with relevant stakeholders (e.g. impoundment owners) with relevant approvals (water plans under <i>Water Regulation 2016</i>) and agreements obtained.
Pre-construction	<u>Value</u> Biodiversity and nature conservation Riparian vegetation <u>Potential impacts</u> Clearing of riparian vegetation Disturbance of aquatic habitat Invasion of aquatic habitats by exotic pest species	■ The Biodiversity Management Sub-plan, as a component of the CEMP, will be implemented (refer above). ■ Protected plant surveys, in accordance with the requirements of the NC Act, will be undertaken as required in support of pre-construction enabling works. Such works may include additional geotechnical investigations to confirm the viability of borrow pit locations, re-fencing works or the establishment of accommodation camps. ■ Prior to any pre-construction clearing works being undertaken, the clearing extents/site boundary/limit of works will be clearly defined with flagging or marking tape. 'No go' areas will also be marked. ■ A qualified Fauna Spotter Catcher will undertake pre-clearance surveys of vegetation. ■ The Fauna Spotter Catcher will supervise the subsequent clearing of vegetation. ■ The significant adverse residual impact to habitat for MNES and MSES will be confirmed for the Project at the conclusion of the detail design process and once the Project footprint is confirmed. ■ Re-calculated impacts will be used to confirm the Project's offset obligations under Commonwealth and State requirements

<i>Delivery phase</i>	Aquatic ecology value and potential impacts	Mitigation and management measures
		■ A Draft Environmental Offsets Delivery Strategy - Queensland has been prepared for the Project (refer Appendix N: Draft offset strategy of the draft EIS). The Draft Environmental Offsets Delivery Strategy - Queensland will be revised and finalised to reflect significant residual impacts calculated at the conclusion of the detail design phase. The finalised Environmental Offsets Delivery Strategy will provide for the staged delivery of offsets where appropriate, ahead of relevant clearing works being undertaken. The Environmental Offsets Delivery Strategy will be finalised in consultation with relevant Commonwealth and State regulatory agencies, including the Department of Agriculture, Water and the Environment (Commonwealth) and DES (Queensland). ■ The Rehabilitation and Landscape Management Sub-plan, as a component of the CEMP, will be implemented (refer above) ■ Undertake pre-construction survey and mapping of weeds within the Project footprint, in accordance with the Biosecurity Management Sub-plan (refer above)

Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
<i>Construction</i>	<u>Value</u> Biodiversity and nature conservation Riparian vegetation <u>Potential impacts</u> Clearing of riparian vegetation Disturbance of aquatic habitat	■ Prior to any construction clearing works being undertaken, the clearing extents/site boundary/limit of works will be clearly defined with flagging or marking tape. 'No go' areas will also be marked. ■ A qualified Fauna Spotter Catcher will undertake pre-clearance surveys of vegetation. ■ The Fauna Spotter Catcher will supervise the subsequent clearing of vegetation. ■ Clearing extents will be limited to that required to undertake and operate the works, avoiding impacts to native vegetation and habitats as far as practicable. ■ The Rehabilitation and Landscape Management Sub-plan, as a component of the CEMP, will be implemented (refer above). Rehabilitation and landscaping will occur sequentially as work fronts are completed. ■ The salvage and relocation of fish will be managed in accordance with DAF Guidelines for Fish Salvage. ■ An appropriately qualified person will be consulted to make an assessment on the method of recovery, transport and release of fish and other aquatic fauna, as required. As a minimum, the following will be implemented: – Relocation will be undertaken by a suitably qualified person – Dewatering pumps will have an intake screen – Records of all fish recovered and the location of their release will be maintained. ■ In the event of a spill incident during construction, any impacted aquatic environments will be assessed for the presence of fauna. If necessary, salvage and recovery efforts will be undertaken.
	<u>Value</u> Biodiversity and nature conservation Riparian vegetation <u>Potential impacts</u> Introduction of contaminants to waterways Altered hydrology	■ Plant maintenance activities and refuelling must be carried out a minimum of 50 m from riparian vegetation and waterways, where practical, with appropriate interception measures in place to avoid impacts to waterways, aquatic habitats, and groundwater. ■ Works within or adjacent to watercourses will be conducted in accordance with: – Riverine protection permit exemption requirements (WSS/2013/726) or conditions of a riverine protection permit issued for the Project – Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works.
	<u>Value</u>	■ Construction tasks will be scheduled to avoid, where possible, bulk earthwork activities within the 1% AEP during periods of elevated flood risk. Where works cannot be scheduled outside of this

Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
	Water quality Sediment quality <u>Potential impacts</u> Sediment runoff into waterways Introduction of contaminants into waterways	time period, activity-specific flood readiness and response planning will be required. This planning will be developed in consultation with the relevant local government and QFES during the construction phase, to reduce the potential for sediment discharge into waterways. ■ Laydown areas and other construction facilities that are located within the 1% AEP will be temporary. Their planning and function in supporting construction will reflect the local flood risk. For example, hazardous goods will not be bulk stored in these locations. ■ Mobile plant will not be stored in the 1% AEP when not scheduled for, or in use for construction purposes. ■ Surface water monitoring will be undertaken in accordance with the monitoring procedure established in the Surface Water Management Sub-plan, as a component of the CEMP. ■ In the event that water quality objectives cannot be achieved for waters to be released, alternate treatment/disposal options are to be implemented to achieve the water criteria relevant for the waterway in question (refer to Section 2.3). ■ The Soil Management Sub-plan, including erosion and sediment control plans, will be implemented as a component of the CEMP (refer above). ■ ARTC's Enviroline will be advertised for the Project to enable members of the public to notify ARTC of issues, including concerns regarding erosion and sediment control.
	<u>Value</u> Biodiversity and nature conservation Riparian vegetation <u>Potential impacts</u> Invasion of aquatic habitats by aquatic species	■ The Biosecurity Management Sub-plan, as a component of the CEMP, will be implemented (refer above). ■ The effectiveness of weed hygiene measures will be monitored as a component of the environmental monitoring procedure for the Project. ■ Any vegetated material containing, or with the potential to contain, weed seed material will not be used for on-site mulching or erosion protection. ■ ARTC's Enviroline will be advertised for the Project to enable members of the public to notify ARTC of issues, including concerns regarding weeds and pests.
Operation	<u>Value</u> Biodiversity and nature conservation Riparian vegetation: <u>Potential impacts</u>	■ Maintenance activities and refuelling must be carried out a minimum of 20 m from riparian vegetation and waterways, with appropriate interception measures in place to avoid impacts to waterways, aquatic habitats, and groundwater. ■ Works within or adjacent to watercourses and waterways will be conducted in accordance with the intent of:

Delivery phase	Aquatic ecology value and potential impacts	Mitigation and management measures
	Introduction of contaminants into waterways Disturbance of aquatic habitat Altered hydrology Invasion of aquatic habitats by exotic pest species	– Riverine protection permit exemption requirements (WSS/2013/726) or conditions of a riverine protection permit issued for the Project – Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works. ■ Weed management protocols for the operational rail corridor and other ARTC facilities will be in accordance with the requirements of the <i>Biosecurity Act 2014</i> and incorporated into the Operation Environmental Management Plan. These protocols will include: – Site hygiene and waste management procedures to deter pest animals – Weed surveillance and treatment during operation and maintenance activities – Requirements in relation to pesticide and herbicide use, including any limitations on use. Restrictions may apply in proximity to waterways, known areas of MNES or MSES habitat or land uses sensitive to spray-drift from the application of pesticides and herbicides – Vehicle, machinery and imported fill hygiene protocols and documentation – Erosion and sediment control risks associated with broad scale weed removal or treatment. – Corrective actions should the outcomes not achieve the adopted objectives ■ ARTC's Enviroline will be advertised for the Project to enable members of the public to notify ARTC of issues, including concerns regarding weeds and pests.

Table 42 Impact mitigation measures specific to aquatic MNES and MSES that occur in the Project footprint

Sensitive environmental receptor	Project phase	Receptor-specific mitigation and management measures (in addition to those specified in Table 41)
Murray cod	Construction	■ Construction activities scheduled to avoid/minimise instream works and associated riparian habitat in identified habitat, where possible. ■ Construction works will, where possible, take place outside of the wet season when flows in floodplain systems are more likely ■ Pre-construction surveys of watercourse crossings that are identified as potential habitat if suitable waterholes are present (i.e. Condamine River floodplain channels and Macintyre River) to identify whether the species occurs. Surveys will follow the Survey guidelines for Australia's threatened fish (DSEWPaC 2011b). ■ Where a temporary impoundment or diversion is required for construction purposes and the species is found to be present, an appropriately qualified person will be consulted to make an assessment on the method of recovery, transport and release of fish and will follow relevant State (DAF) fish salvage guidelines during construction activities. ■ Where possible, instream habitat will be reinstated to pre-construction state (e.g. replacement of large woody debris and ensure no or limited change to instream flows and allow fish passage). ■ Implementation of the Biosecurity Management Sub-plan, Soil Management Sub-plan and the Surface Water Management Sub-plan.
	Operation	■ Maintenance of erosion and sediment controls within the rail corridor with specific reference to maintaining the pre-construction condition watercourses and drainage features that adjoin the rail corridor. ■ Maintenance of the effectiveness of cross drainage structure (e.g. culverts) to ensure continued connectivity of watercourses and drainage features that are aligned across the rail corridor.
Platypus	Construction	■ Construction activities scheduled to avoid/minimise instream works and associated riparian habitat in identified habitat, where possible. ■ Construction works will, where possible, take place outside of the wet season when flows in floodplain systems are more likely ■ Pre-construction surveys of watercourse crossings that are identified as potential habitat if suitable waterholes are present (i.e. Condamine River floodplain channels and Macintyre River) to identify whether the species occurs. ■ Where a temporary impoundment or diversion are required for construction purposes and the species is found to be present, an appropriately qualified person will be consulted to make an assessment on the requirement for a species management program should breeding places (i.e. burrows) be present.

Sensitive environmental receptor	Project phase	Receptor-specific mitigation and management measures (in addition to those specified in Table 41)
		- Where possible, instream habitat will be reinstated to pre-construction state (e.g. replacement of large woody debris and ensure no or limited change to instream flows and passage). - Implementation of the Biosecurity Management Sub-plan, Soil Management Sub-plan and the Surface Water Management Sub-plan.
	Operation	- Maintenance of erosion and sediment controls within the rail corridor with specific reference to maintaining the pre-construction condition watercourses and drainage features that adjoin the rail corridor. - Maintenance of the effectiveness of cross drainage structure (e.g. culverts) to ensure continued connectivity of watercourses and drainage features that are aligned across the rail corridor.

5.3 Impact assessment

Potential impacts to aquatic ecology values associated with the Project in the pre-construction, construction and operation phases are outlined in **Table 43**. These impacts have been subjected to a significance assessment as per the methodology detailed in **Section 3.8**, based on the sensitivity of aquatic ecology values to the potential impact, and the likely magnitude of the impact. Each of the potential impacts to aquatic ecology values in **Table 39** has been carried forward into the significance assessment presented in **Table 43**.

Results of the significance assessment are also summarised in **Table 44** for the pre-construction and construction phases of the Project, from the perspective of the key aquatic ecology values identified in **Table 39**. Significance ratings are derived from the highest residual significance as assessed in **Table 43**, and provide a summary of how environmental significance varies across aquatic ecology values and the various modes of potential impact from Project construction activities. Residual significance associated with the pre-construction and construction phase was higher than the operation phase for all aquatic ecology values, with the exception of habitat connectivity and bank stability.

The initial significance assessment was undertaken on the assumption that the design considerations (or initial mitigation measures) factored into the reference design phase (**Table 40**) have been implemented. Additional mitigation and management measures, including those listed in relevant management plans, were then applied as appropriate to the phase of the Project to reduce the level of potential impacts. These are documented in **Section 5.2.2 (Table 41 and Table 42)**.

The residual risk level of the potential impacts was then reassessed after mitigation and management measures in **Table 41** and **Table 42** were applied. The pre-mitigated risk levels were compared with the residual risk levels in order to assess the effectiveness of the mitigation and management measures.

The assessment has identified that the significance of impacts to aquatic ecology and associated surface water quality values range from Negligible to Moderate (**Table 44**). The following impacts were assessed to be the highest risk (moderate):

- Invasion of aquatic habitats by weed and pest species during the construction phase
- Declines in water and sediment quality from bank erosion, and the runoff of sediments and contaminants into waterways during the construction phase.

These impacts were considered to be the highest risk to aquatic ecology values, due to the relatively disturbed nature of the impact assessment area, and the potential for Project-related activities to result in further deterioration of aquatic ecology values.

The residual significance of other potential impacts on aquatic ecology values (i.e., potential impacts other than those related to biosecurity and the quality of water and sediment) was assessed to be Negligible or Low.

The residual significance of changes to groundwater levels on GDEs was assessed to be Low, due to the temporary nature of potential impacts during the construction phase, and availability of engineering design controls to reduce the extent of impacts. Existing hydrogeological and processes sustaining GDEs and wetlands are unlikely to be affected by the Project.

There will be some impacts on riparian vegetation, and on the interaction between terrestrial and aquatic ecosystems (e.g. through a reduction in shading of waterways by riparian vegetation). However, the localised scale of such impacts resulted in a residual significance rating of Low.

The residual significance of changes in hydrology and flood plain inundation were assessed to be Negligible during construction and Low during operations. This is primarily a result of the large number of bridges and culverts included in the reference design for the project, which will minimise changes to existing hydrological conditions which facilitate migration of aquatic fauna and connectivity across the flood plains of the impact assessment area.

With the implementation of appropriate environmental management and design practices (**Table 40, Table 41 and Table 42**), impacts will be minimised or confined to the localised area. Key mitigation measures to reduce impacts on aquatic ecology values include:

- Designing waterway crossings to avoid disturbance of aquatic habitats, avoid obstructions to fauna passage and minimise alterations to the natural hydrological regime. This will be achieved through use of bridge designs in preference to culverts or through application of the *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018)
- Erosion and sediment control measures, such as the storage of soil stockpiles away from waterways and the use of silt fences, will reduce the potential for construction activities to add to existing high concentrations of TSS in local aquatic habitats. The cumulative effect of the Project with existing agricultural practices will be important to take into consideration when designing and implementing management plans
- Spills and the discharge of contaminants to waterways will be avoided, and rapidly cleaned up when they occur. This will maintain existing water quality values, which are characterised by low concentrations of dissolved metals and organic contaminants, which may be toxic to biota.

Table 43 Results of significance assessment for impacts on aquatic ecology

Potential Impact (and associated aquatic ecology value)	Phase	Initial significance ¹			Residual Significance ²	
		Sensitivity	Magnitude	Significance	Magnitude	Significance
<u>Biodiversity and nature conservation</u> Removal of riparian and aquatic habitats including hollow-bearing trees, logs and burrows which will reduce the persistence of native species that utilise these habitats Loss of submerged aquatic vegetation and woody debris, resulting in a reduction in aquatic habitat complexity and aquatic plant diversity River substrate disturbance (i.e. due to bridge or culvert construction) which may affect bottom dwelling aquatic flora and fauna and their associated habitats Loss of sensitive ecological processes through geomorphological alteration, including a change in photosynthesis and respiration rates from increases in sunlight and water temperature Reduction in groundwater level, resulting in the loss of wetland habitat and an alteration of species composition within GDEs	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low
	Operation		Negligible	Low	Negligible	Low
<u>Biodiversity and nature conservation</u> Transmission and invasion of aquatic and terrestrial weeds (e.g. through vehicle and machinery movement) altering riparian and aquatic vegetation community composition	Pre-construction and construction	Moderate	High	High	Moderate	Moderate
	Operation		Low	Low	Low	Low
<u>Biodiversity and nature conservation</u> Disturbance of aquatic fauna from noise, vibration and lighting	Pre-construction and construction	Low	Moderate	Low	Low	Negligible
	Operation		Low	Negligible	Negligible	Negligible
<u>Biodiversity and nature conservation</u> Mortality or displacement of EVNT species.	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low
	Operation		Low	Low	Low	Low
<u>Riparian vegetation</u> Changes in community structure and composition due to clearing	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low

Potential Impact (and associated aquatic ecology value)	Phase	Initial significance ¹			Residual Significance ²	
		Sensitivity	Magnitude	Significance	Magnitude	Significance
Vegetation clearing allowing the colonisation of exotic species Reduction in shading and increase in light penetration into aquatic habitats, resulting in higher stream temperatures and conditions suitable for the proliferation of algae Transmission of aquatic and terrestrial weeds (through railway) may alter riparian vegetation	Operation		Negligible	Low	Negligible	Low
<u>Habitat connectivity</u> Introduction of physical barriers to aquatic fauna movement through the construction of culverts, bridges, fencing and other infrastructure that affects the existing hydrological conditions	Pre-construction and construction	Low	Moderate	Low	Low	Negligible
Construction of temporary bunding to achieve a dry work area at creek crossings.	Operation	Moderate	Moderate	Moderate	Low	Low
<u>Bank stability</u> Construction works involving disturbance to the riparian corridor may result in erosion and scouring of streambanks, which are an important component of aquatic habitats. This may result in unstable stream banks unable to support vegetation or tolerate extreme rainfall or flooding events. Smothering of benthic aquatic habitat due to erosion, sediment transport and sediment deposition.	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low
Physical disturbance of stream beds and banks during construction of creek crossings Establishment of weeds such as Lippia (recorded in region) in new areas which out compete native species and affect the integrity of stream banks	Operation	Low	Moderate	Low	Low	Negligible

Potential Impact (and associated aquatic ecology value)	Phase	Initial significance ¹			Residual Significance ²	
		Sensitivity	Magnitude	Significance	Magnitude	Significance
<u>Water quality and sediment quality</u> Declines in water quality due to runoff from disturbed areas or discharge of water generated from construction activities (e.g. dewatering of a dry work area). This may include increased concentrations of suspended sediments, nutrients, metals and hydrocarbons, which may reduce the suitability of water to support environmental values (e.g. aquatic ecosystems and stock watering). Spills of contaminants to waterways and in adjacent areas during works, resulting in pollution of local waterways and areas downstream and toxic effects on aquatic organisms. Spills of contaminants to groundwater, resulting in pollution of GDEs and toxic effects on aquatic organisms. Spills of contaminants to waterways from train and associated infrastructure, resulting in pollution of local waterways and areas downstream and toxic effects on aquatic organisms. Physical disturbance of soils and mobilisation of contaminants (e.g. metals) to waterways from rainfall runoff, decreasing water quality. Increase in salinity from interplay between works, runoff and sodic or dispersive soils.	Pre-construction and construction	Moderate	Moderate	Moderate	Moderate	Moderate
	Operation		Negligible	Low	Negligible	Low
<u>Water resources</u> Changes in watercourse pathway and flow characteristics, including the alteration of habitat composition (ponding, channels and dry creek beds) and flow regime. Changes in water availability: riparian community structure and species composition. Temporary changes in hydrology through bunding to create a dry work area. Altered flow regimes which result in changes to aquatic ecology and surface water.	Pre-construction and construction	Low	Medium	Low	Low	Negligible
	Operation	Moderate	Moderate	Moderate	Low	Low

1. Includes implementation of initial mitigation measures specified in **Table 40**

2. Assessment of residual risk once the mitigation measures identified in **Table 41** and **Table 42**

Table 44 Residual significance assessment

Aquatic Ecology Value	Potential Impact	Residual significance (Pre-construction and construction phases)
Biodiversity and nature conservation	Disturbance of aquatic habitat	Low
	Changes to groundwater resources, affecting groundwater dependent ecosystems	
	Invasion of aquatic habitats by exotic pest species	Moderate
	Disturbance of fauna from noise, vibration and lighting	Negligible
	Impacts on EVNT species	Low
Riparian vegetation	Clearing of riparian vegetation	Low
Habitat connectivity	Disturbance of aquatic habitat	Negligible
	Altered hydrology	
Bank stability	Sediment runoff into waterways	Low
	Altered hydrology	
Water quality	Sediment runoff into water courses	Moderate
Sediment quality	Introduction of contaminants into waterways	
Water resources	Altered hydrology	Negligible

5.4 Cumulative impacts on aquatic and surface water values

Twenty three projects were initially identified as having potential to contribute to cumulative impacts in combination with the Border to Gowrie project (**Table 10**). These projects are either currently operational, expected to undergo future expansion or are currently going through an approval process. Of these, five projects were considered to be relevant to the assessment of impacts on aquatic ecology values (**Table 45**).

Projects relevant to the assessment of cumulative impacts are those that will be constructed or expanded in the future, and may cause impacts to existing aquatic ecology values that are additive to impacts from the Project. Examples of aquatic ecology values that may be affected include water quality (increases in turbidity and the concentration of nutrients and metals) and additional disturbance to the habitats of aquatic fauna over a broad geographic area within the Murray Darling Basin. Only five of the initial 23 projects identified meet these criteria, as listed in **Table 45**.

Table 45 Projects considered for the cumulative impact assessment

Projects	Location	Description	Construction dates ¹
New Acland Coal Mine Stage 3	35 km northwest of Toowoomba 18 km north of the Project footprint	Expansion of the existing New Acland open-cut coal mine to up to 7.5 Mtpa.	2019-TBC
Goondiwindi Abattoir	Goondiwindi, QLD 13 km north of the Project footprint	A new beef abattoir located on the outskirts of Goondiwindi with beef processing of up to 72,000 tonnes per year.	TBC Approved with conditions by Goondiwindi Regional Council
Wyemo Piggery	Texas-Yelarbon Road, Glenarbron 8 km south of the Project footprint	A new intensive piggery, with approval for 55,000 pig units	TBC Approved with conditions by Goondiwindi Regional Council
North Star to NSW/QLD Border (Inland Rail)	Rail alignment from North Star, NSW to the NSW/QLD border Adjoins the Project at its southern limit	New 37 km rail corridor to connect North Star (NSW) to the Queensland Rail South West Rail Line just over the NSW/QLD border.	2021 – 2024
Gowrie to Helidon (Inland Rail)	Rail alignment from Gowrie to Helidon, QLD Adjoins the Project at its northern limit	New 26km dual gauge track between Gowrie (north-west of Toowoomba) and Helidon (east of Toowoomba), extending through the Local Government Areas of Toowoomba and Lockyer Valley. The Project includes a 6.38 km tunnel to create an efficient route through the steep terrain of the Toowoomba Range.	2021 – 2025

¹ TBC – To be confirmed

The projects listed in **Table 45** were identified for their potential to have cumulative impacts on aquatic ecology values for the following reasons:

- Expansion of the existing New Acland Coal Mine has the potential to impact aquatic ecology and surface water quality values in sections of the Murray Darling Basin located downstream from the Project. The proposed mine expansion is located approximately 25 km to the north of Gowrie, at the eastern extent of the Project.
- The approved Goondiwindi Abattoir which will process 72,000 tonnes of beef per year is located on the Cunningham Highway approximately 30 km west of Yelarbon near the southern extent of the Project. The abattoir project has the potential to influence water quality in sections of the Murray Darling Basin located downstream from the Project.
- The Wyemo Piggery involves the intensive production of pork and is located on Texas-Yelarbon Road, Glenarbron, approximately 8 km south of the Project. The piggery project has the potential to influence water quality in sections of the Murray Darling Basin located upstream of the Project (Dumaresq River).
- The North Star to NSW/QLD Border and Gowrie to Helidon sections of the Inland Rail Program are located immediately adjacent to the Project and are likely to influence waterways immediately adjacent to and downstream of the Project in the Murray Darling Basin. These projects occur over smaller areas than the Border to Gowrie project, with large parts of the Gowrie to Helidon project located in coastal catchments east of the Great Dividing Range, and therefore of limited relevance to the assessment of cumulative impacts.

Following consideration of the probability of impact, duration of impact, magnitude of impact and sensitivity of the receiving environment, the significance of cumulative impacts from other projects was assessed to be low (**Table 46**). The basis of the assessment is summarised as follows:

- The probability of impact was assessed as Low for all five other projects. The New Acland Coal Mine Stage 3, the Goondiwindi Abattoir and the Wyemo Piggery are located more than 8 km from the Project, and will be subject to conditions of an Environmental Authority (EP Act) that regulate the nature of water discharges to the environment, which may affect aquatic ecology values. The North Star to NSW/QLD Border and Gowrie to Helidon sections of the Inland Rail project have a similar level of environmental risk as the Project, and will be subject to a similar range of environmental management procedures to maintain impacts to the localised area. This will minimise the potential for cumulative impacts.
- The duration of impact was assessed to be Medium. While all other projects are likely to be operating for a period of more than 10 years, the construction phase of the Inland Rail projects, when impacts will be greatest, will be limited to a much shorter period of approximately 5 years.
- The magnitude/intensity of impact was assessed to be Low, due to the highly regulated nature of the other projects, which will be subject to a range of environmental management plans. Also, in the case of the mining, piggery and abattoir projects, conditions of an Environmental Authority (EP Act) will also apply and limit the nature of water discharges to the receiving environment. While there is a risk of spills or other types of environmental incidents occurring at the sites of the other projects, the impacts of these are likely to be localised, with minimal potential to act cumulatively with those of the Project.
- The sensitivity of the receiving environment was assessed to be Medium. The Murray-Darling Basin is highly modified from a range of existing land uses, including agriculture, infrastructure and mining. Existing aquatic ecology values are unlikely to be sensitive to the localised impacts from the Project acting cumulatively with the other projects. Some threatened species such as the Murray Cod are known to occur in the impact assessment area and waters downstream.

Table 46 Summary of the results of a cumulative impact significance assessment for other relevant projects

Project	Potential cumulative impact	Factor affecting impact	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
New Acland Coal Mine Stage 3 – New Acland Coal Pty Ltd	Degradation of aquatic values	Probability of the impact	Low (1)	6	Low	Will be managed through: ■ Development and implementation of the sub-plans specified in Table 41 and Table 42
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Medium (2)			
Goondiwindi Abattoir	Degradation of aquatic values	Probability of the impact	Low (1)	6	Low	Will be managed through: ■ Development and implementation of the sub-plans specified in Table 41 and Table 42
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Medium (2)			
Wyemo Piggery	Degradation of aquatic values	Probability of the impact	Low (1)	6	Low	Will be managed through: ■ Development and implementation of the sub-plans specified in Table 41 and Table 42
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Medium (2)			
North Star to NSW/QLD Border (Inland Rail)	Degradation of aquatic values	Probability of the impact	Low (1)	6	Low	Will be managed through: ■ Development and implementation of the sub-plans specified in Table 41 and Table 42 ■ ARTC to ensure the compatibility of mitigation measures and controls across projects in the Inland Rail Program
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			
		Sensitivity of the receiving environment	Medium (2)			
Gowrie to Helidon (Inland Rail)	Degradation of aquatic values	Probability of the impact	Low (1)	6	Low	Will be managed through:
		Duration of the impact	Medium (2)			
		Magnitude/intensity of the impact	Low (1)			

Project	Potential cumulative impact	Factor affecting impact	Relevance factor	Sum of relevance factors	Impact significance	Comments and management measures
		Sensitivity of the receiving environment	Medium (2)			■ Development and implementation of the sub-plans specified in Table 41 and Table 42 ■ ARTC to ensure the compatibility of mitigation measures and controls across projects in the Inland Rail Program

6 Conclusions and Recommendations

Aquatic ecology and surface water values of the impact assessment area are variable across the rail alignment. Ephemeral waterways, which have been subject to previous disturbance from agricultural development and public infrastructure such as road crossings, are dominant. However, areas of less disturbed aquatic habitat are present, and on larger waterways, these provide good quality habitat for a variety of aquatic fauna. Water quality is variable across the impact assessment area, with the absence of flow during dry conditions a key driver in small waterways.

The sedge *Fimbristylis vagans* has potential to occur in the impact assessment area and is listed as Endangered under the *Nature Conservation Act 1992* (Qld). Larger waterways of the impact assessment area including of the Macintyre and Condamine catchments also provide habitat for the Murray Cod, which is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), and the Platypus, which is listed as Special Least Concern under the *Nature Conservation Act 1992* (Qld). The Agassiz's Glassfish (listed as an endangered population in NSW) was also confirmed to be present in the Macintyre River. Other listed flora and fauna species have been determined as unlikely to occur in the impact assessment area.

The sensitivity of aquatic ecology and surface water quality values to impacts from the Project range from negligible to moderate in scale. The highest sensitivities (moderate) are associated with:

- Invasion of aquatic habitats by weed and pest species during the construction phase
- Declines in water and sediment quality from bank erosion, and the runoff of sediments and contaminants into waterways during the construction phase.

However, these risks can be effectively managed through a range of design features (e.g. bridges spanning waterways in preference to culverts) and through the development and implementation of detailed environmental management plans during detail design, pre-construction, construction and operation phases of the Project.

In implementing the Project, it is recommended that actions are taken to minimise disturbance to aquatic habitats and riparian vegetation of major waterways within the impact assessment area as much as possible. In particular, the Macintyre River and Macintyre Brook have been confirmed to provide aquatic habitats utilised by threatened species, and disturbance of these values should be minimised through a range of design, engineering and on site controls, as outlined in **Section 5.2**.

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Appendix A: Site Descriptions for Aquatic Ecology Sites

Site descriptions for Aquatic Ecology Sites are provided on the following pages.

Site descriptions for Surface Water Sites are provided in the Surface Water Quality Technical Report (Appendix P of the Project EIS)

Site Code: 2 **Location:** Macintyre River **Latitude:** 28° 39' 52" **Longitude:** 150° 28' 01" **Season:** Spring
Date: 29/11/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Permanent watercourse; Baseflow at the time of assessment; symmetrical floodplain valley shape; two stage shaped channel; defined bed and banks; bank slope vertical; bank shape concave; no distinct floodplain; no obvious channel modifications; Moderate deposition regarding bank stability; upstream and adjacent land use is predominantly native and non-native pasture for cattle grazing; bankfull width approximately 56 m; bankfull height approximately 5 m (from stream bed); substrate composition 40% sand (0.06-2 mm) and 60% silt / clay (<0.06 mm); bank material 5% gravel (2-16 mm), 55% sand (0.06-2 mm) and 40% silt / clay (<0.06 mm); 10% large woody debris; < 10% filamentous algae cover, < 10% periphyton, < 10% moss detected and < 10% detritus cover.

Riparian vegetation

Riparian zone approximately 25 m left bank and 25 m right bank; longitudinal vegetation extent semi-continuous; vegetation community *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines, vegetation characterised by sparse cover (35% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*E. tereticornis*) with occasional river she-oak (*Casuarina cunninghamiana*) and white sally wattle (*Acacia floribunda*); sparse cover (40%) of trees <10 m, dominated by snow-in-summer (*Melaleuca linariifolia*) with occasional *E. camaldulensis*, sally wattle (*A. salicina*); very sparse (10%) shrub layer, dominated by spiny-headed mat-rush (*Lomandra longifolia*) with occasional *Acacia* sp. and common reed (*Phragmites Australis*) and mid-dense (60%) groundcover, dominated by dayflower (*Commelina* sp.) and green panic (*Megathyrsus maximus*) regeneration of native woody vegetation present.

Vegetation disturbance: Moderate.

Aquatic flora

Macrophyte cover approximately 2% cover; emergent macrophytes included slender flat sedge (*Cyperus gracilis*) (1%), common rush (*Juncus usitatus*) (1%); common reed (*Phragmites australis*) (2%), tall flat sedge (*Cyperus exaltatus*) (1%) and slender knotweed (*Persicaria decipiens*) (1%).

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Good passage expected during times of flow. Located in Purple zone (Major risk of impact on fish movement)

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

The Murray cod (*Maccullochella peelii*) Vulnerable EPBC Act was confirmed to be present at this site, with six individual caught in the May 2019 field trip. Additionally, the Critically Endangered (EPBC Act) silver perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) platypus are recorded from the Border Rivers catchment (DES 2018b). The study reach provides habitat for the Murray cod and potential habitat for the platypus but is unlikely to provide habitat for the silver perch or Bell's turtle. Agassiz's Glassfish (listed as Endangered in NSW) was also found in the June 2018 field trip (on the Queensland side of the river).

Physico-chemical water quality

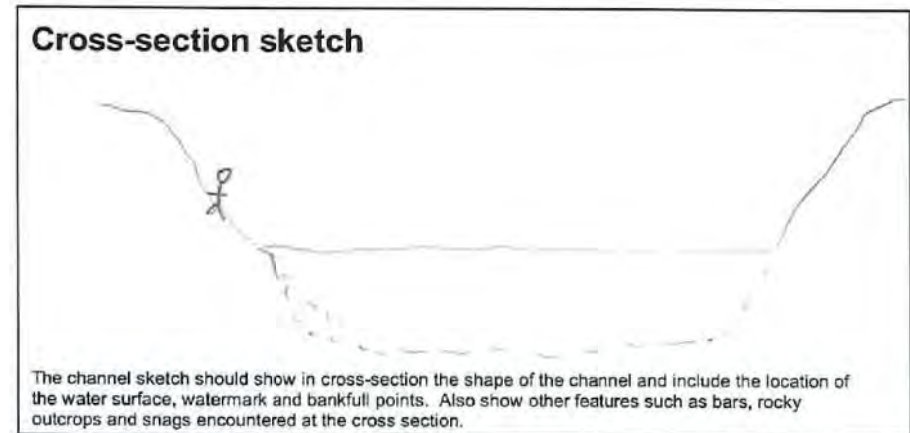
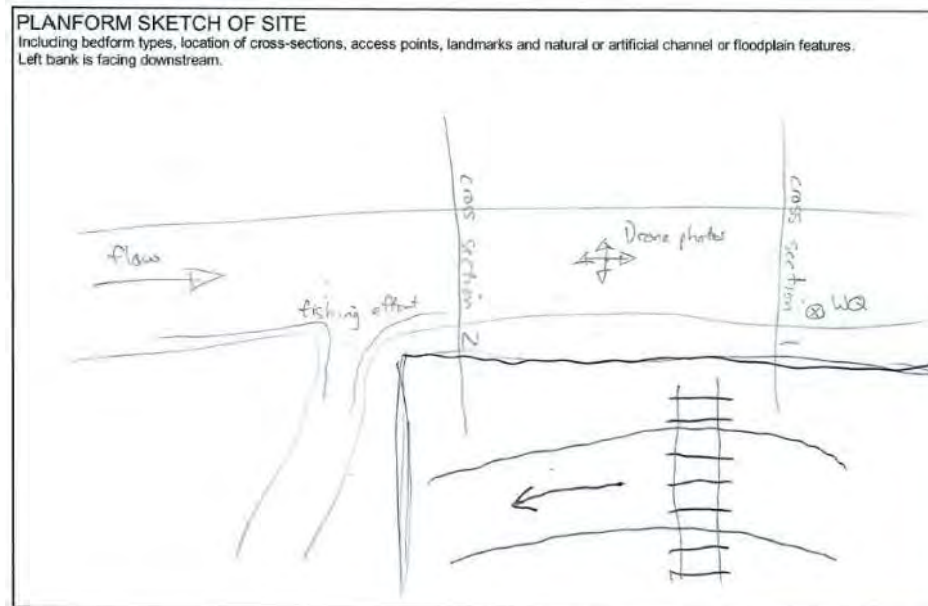
Collection time: 16:15; water temp.: 28.7°C; specific conductivity: 211.0 $\mu\text{S}/\text{cm}$ (fresh); turbidity: 22.9; dissolved oxygen: 101.6%, 7.86 mg/L; pH: 6.77; Redox: 104.6 mV.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Good (14); Pool substrate characterisation: Good (12); Pool variability: Good (14); Sediment deposition: Good (12); Channel flow status: Excellent (18); Channel alteration: Good (13); Channel sinuosity: Fair (10); Bank Stability: Good (left bank 7; right bank 7); Vegetative protection: Good (left bank 7; right bank 7); Riparian zone score: Good (left bank 6, right bank 6).

Overall habitat score: Good (129 out of 200).



Site Code: 4 **Location:** Unnamed tributary of Macintyre Brook **Latitude:** 28° 26' 21" **Longitude:** 150° 57' 28" **Season:** Autumn
Date: 16/06/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Ephemeral drainage feature; dry at the time of assessment; study reach positioned within undeveloped road reserve; broad valley setting; flat U shaped channel; poorly defined bed and banks; bank slope low; bank shape concave; no distinct floodplain; no obvious channel modifications; bed stable; upstream and adjacent land use is predominantly native forest; little local catchment erosion; bankfull width approximately 30 m; bankfull height approximately 1 m (from stream bed); substrate composition 95% sand (0.06-2 mm) and 5% silt / clay (<0.06 mm); bank material 40% gravel (2-16 mm), 50% sand (0.06-2 mm) and 10% silt / clay (<0.06 mm); 10% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 35-65%.

Riparian vegetation

Riparian zone approximately 20 m left bank and 20 m right bank; longitudinal vegetation extent continuous; vegetation community appears to be RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with sparse cover (40% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*E. tereticornis*) and rough-barked apple (*Angophora floribunda*), with occasional Baradine red gum (*E. chloroclada*); sparse cover (30%) of trees <10 m, dominated by Queensland blue gum and white cypress pine (*Callitris glaucophylla*); very sparse (15%) shrub layer, including *Acacia* sp., velvet tree pear (*Opuntia tomentosa*) and spiny-headed mat-rush (*Lomandra longifolia*); mid-dense (50%) groundcover, dominated by lovegrass (*Eragrostis* sp.), with frequent wiregrass (*Aristida* sp.); regeneration of native woody vegetation present.

Vegetation disturbance: Low to Moderate.

Aquatic flora

Macrophyte cover approximately 1% cover; fringing macrophytes included reed grass (*Arundinella nepalensis*) (1%); study reach dominated by terrestrial flora.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Very restricted passage expected during low flow, base flow and high flow, including dog-proof fence (chicken wire) on upstream side of road reserve. Located in Red zone (High risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

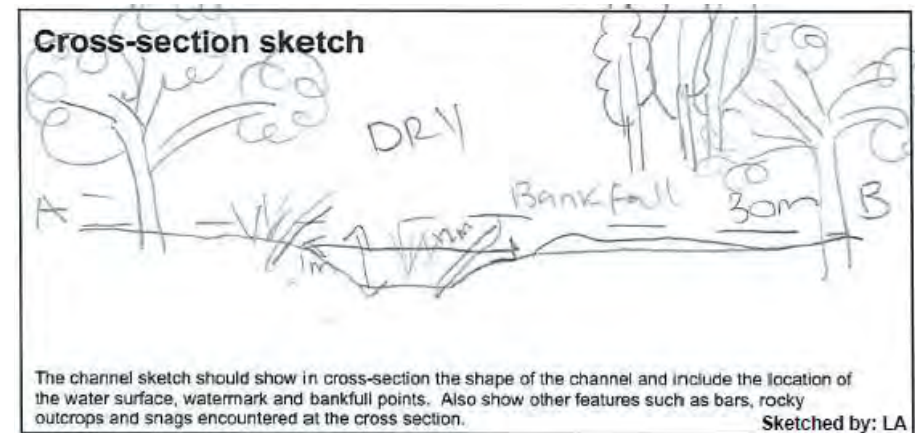
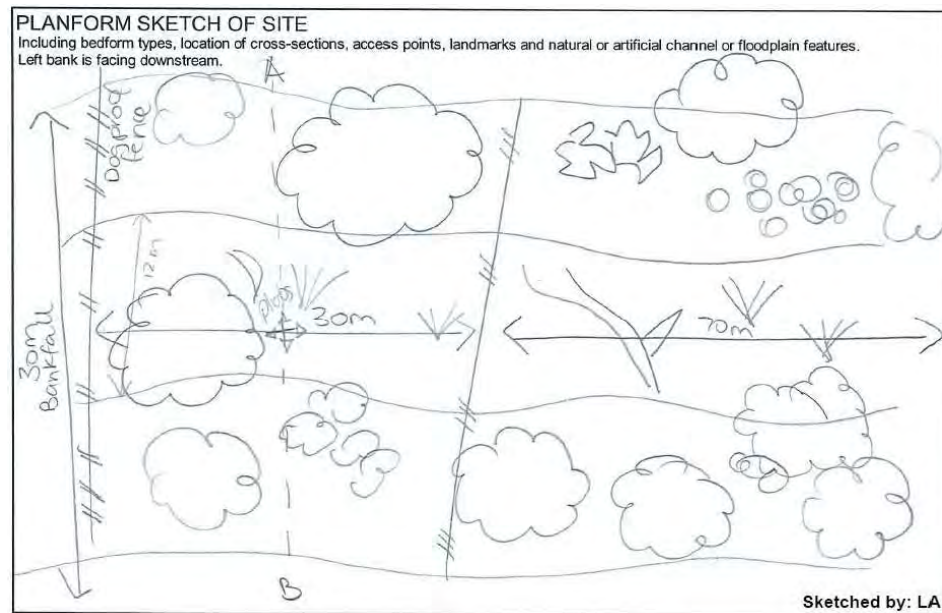
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (5); Pool substrate characterisation: Fair (7); Pool variability: Poor (0); Sediment deposition: Excellent (16); Channel flow status: Poor (0); Channel alteration: Excellent (16); Channel sinuosity: Fair (7); Bank Stability: Excellent (left bank 9; right bank 9); Vegetative protection: Good (left bank 8; right bank 8); Riparian zone score: Good (left bank 8, right bank 8).

Overall habitat score: Good (101 out of 200).



Site Code: 5 **Location:** Unnamed tributary of Macintyre Brook **Latitude:** 28° 25' 58" **Longitude:** 150° 58' 54" **Season:** Autumn
Date: 16/06/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Ephemeral drainage feature; dry at the time of assessment; symmetrical floodplain valley setting; widened channel; poorly defined bed and banks; bank slope flat ($<10^\circ$); bank shape concave; no floodplain features present; no obvious channel modifications; potential for runoff from nearby pivot irrigation; bed stable; upstream land use predominantly native forest; adjacent land use beyond left bank is irrigated cropping, with grazing on the right bank; little local catchment erosion; bankfull width approximately 65 m; bankfull height approximately 0.5 m (from stream bed); substrate composition 100% silt / clay (<0.06 mm); bank material 100% silt / clay (<0.06 mm); 5% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 65-90%.

Riparian vegetation

Riparian zone approximately 25 m left bank and 25 m right bank; longitudinal vegetation extent continuous; vegetation community appears to be RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with mid-dense cover (70% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*E. tereticornis*), with occasional coolibah (*E. coolabah*); very sparse cover (5%) of trees <10 m, dominated by Queensland blue gum; very sparse (1%) shrub layer, including velvet tree pear (*Opuntia tomentosa*); mid-dense (50%) groundcover, dominated by tall sedge (*Carex appressa*), with frequent gilgai grass (*Walwhallea subxerophila*) and occasional *Sida* spp.; regeneration of native woody vegetation very limited ($<1\%$ cover).

Vegetation disturbance: Low to Moderate.

Aquatic flora

Macrophyte cover approximately 15% cover; fringing macrophytes included common rush (*Juncus usitatus*) (1%) and tall sedge (*Carex appressa*) (14%); study reach dominated by terrestrial flora.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Good fish passage expected during low and base flow; unrestricted passage during high flow. Located in Purple zone (Major risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

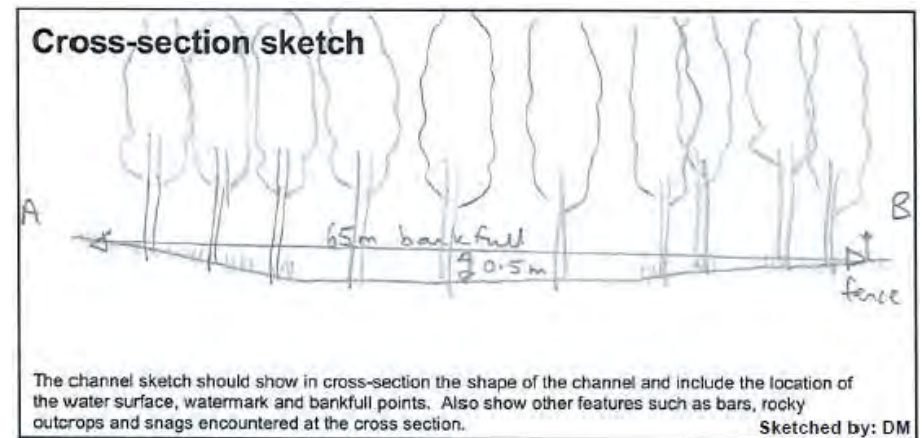
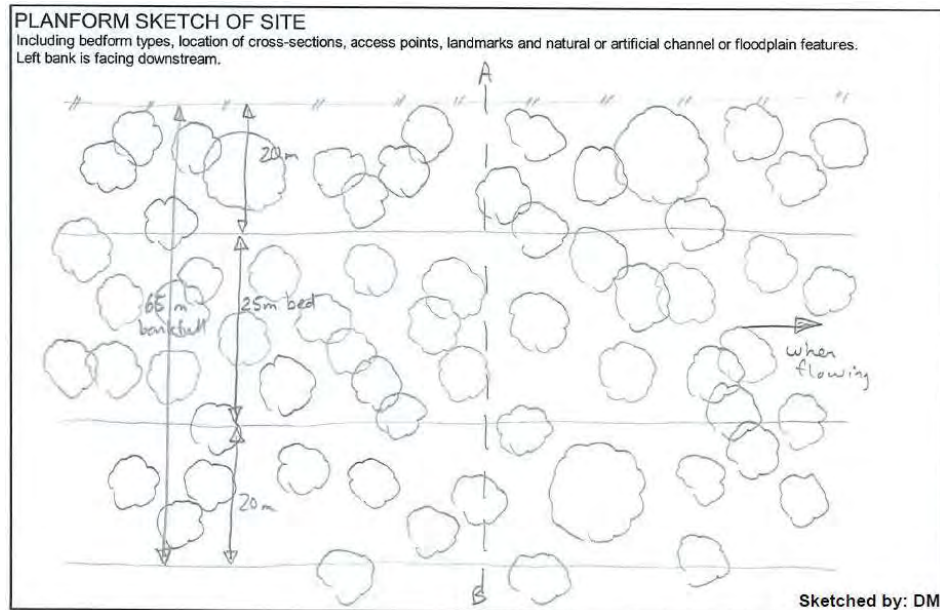
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (5); Pool substrate characterisation: Fair (10); Pool variability: Poor (0); Sediment deposition: Excellent (18); Channel flow status: Poor (0); Channel alteration: Good (15); Channel sinuosity: Poor (5); Bank Stability: Excellent (left bank 10; right bank 10); Vegetative protection: Good (left bank 7; right bank 7); Riparian zone score: Excellent (left bank 9, right bank 9).

Overall habitat score: Good (105 out of 200).



Site Code: 8	Location: Unnamed tributary of Macintyre Brook	Latitude: 28° 23' 39"	Longitude: 151° 03' 12"	Season: Autumn Date: 17/06/2018
				
Upstream	Left Bank	Downstream	Right Bank	

General Site Description

Site attributes

Ephemeral drainage feature; dry at the time of assessment; symmetrical floodplain valley setting; widened channel; poorly defined bed and banks; bank slope flat ($<10^\circ$); bank shape concave; no floodplain features present; no obvious channel modifications; potential for runoff from nearby dryland cropping; bed stable; upstream land use predominantly native forest; adjacent land use is native forest on the left bank, with dryland cropping on the right bank; little local catchment erosion; bankfull width approximately 60 m; bankfull height approximately 0.5 m (from stream bed); substrate composition 100% silt / clay (<0.06 mm); bank material 100% silt / clay (<0.06 mm); 15% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover $<10\%$.

Riparian vegetation

Riparian zone approximately 20 m on the left bank and 20 m on the right bank; longitudinal vegetation extent semi-continuous; vegetation community appears to be RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with sparse cover (20% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*E. tereticornis*); very sparse cover (10%) of trees <10 m, dominated by Queensland blue gum; sparse (20%) shrub layer, including Queensland blue gum regeneration and wattles (*Acacia* spp.); mid-dense (60%) groundcover, including heavily grazed grasses (unidentifiable), slender flat-sedge (*Cyperus gracilis*) and Mayne's pest (*Verbena aristigera*)*; regeneration of native woody vegetation abundant ($>5\%$ cover) and healthy.

Vegetation disturbance: Moderate to high (heavily grazed; intrusion of exotic species).

Aquatic flora

Macrophyte cover approximately 1% cover; fringing macrophytes included slender flat-sedge (*Cyperus gracilis*) (1%); study reach dominated by terrestrial flora.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Unrestricted fish passage in times of low, base and high flow. Located in Amber zone (Moderate risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

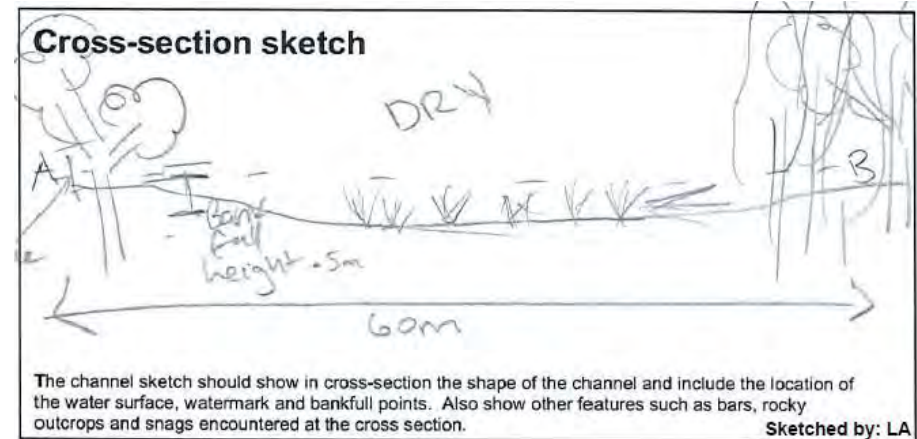
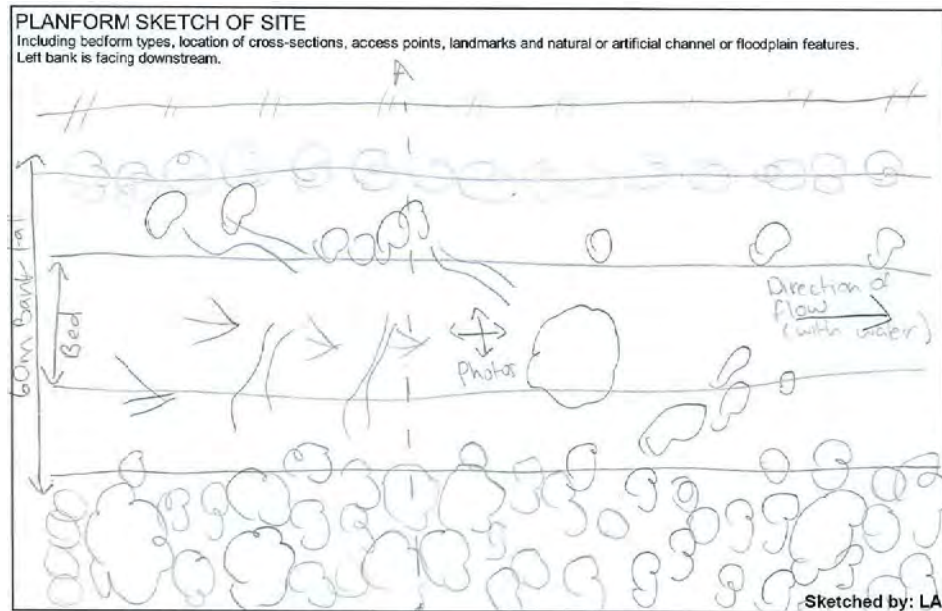
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (4); Pool substrate characterisation: Poor (3); Pool variability: Poor (0); Sediment deposition: Excellent (16); Channel flow status: Poor (0); Channel alteration: Good (15); Channel sinuosity: Poor (5); Bank Stability: Excellent (left bank 9; right bank 9); Vegetative protection: Good (left bank 6; right bank 6); Riparian zone score: Good (left bank 8, right bank 6).

Overall habitat score: Fair (87 out of 200).



Site Code: 9	Location: Pariagara Creek	Latitude: 28° 23' 35"	Longitude: 151° 04' 45"	Season: Autumn Date: 15/06/2018
				
Upstream	Left Bank	Downstream	Right Bank	

General Site Description

Site attributes

Ephemeral watercourse; dry at the time of assessment; symmetrical floodplain valley shape; flat U shaped channel; well defined bed and banks; bank slope low (10-30°); bank shape concave; no floodplain features present; no obvious channel modifications; bed moderately unstable – moderate sand deposition; upstream land use predominantly native forest; adjacent land use includes cattle grazing on crop stubble beyond the left bank, with native forest on the right bank; little local catchment erosion; bankfull width approximately 8 m; bankfull height approximately 1.8 m (from stream bed); substrate composition 100% sand (0.06-2 mm); bank material 95% sand (0.06-2 mm), 5% silt / clay (<0.06 mm); 5% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 10-35%.

Riparian vegetation

Riparian zone approximately 20 m on the left bank and 20 m on the right bank; longitudinal vegetation extent continuous; fenced off from grazing; vegetation community appears to be RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with mid-dense cover (75% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*E. tereticornis*), with abundant carbeen (*Corymbia tessellaris*), occasional rough-barked apple (*Angophora floribunda*) and white cypress pine (*Callitris glaucophylla*); sparse cover (30%) of trees <10 m, dominated by white cypress pine; very sparse (5%) shrub layer, including snow-in-summer (*Melaleuca linariifolia*) and spiny-headed mat-rush (*Lomandra longifolia*); mid-dense (70%) groundcover, dominated by common couch (*Cynodon dactylon*) and other native grasses; occasional weeds, including mother-of-millions (*Bryophyllum delagoense*); regeneration of native woody vegetation present.

Vegetation disturbance: Low (fenced off from grazing).

Aquatic flora

Macrophyte cover approximately 7%; fringing macrophytes included common rush (*Juncus usitatus*) (3% cover) and reed grass (*Arundinella nepalensis*) (4%); study reach dominated by terrestrial flora.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Unrestricted fish passage in times of low, base and high flow. Located in Purple zone (Major risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

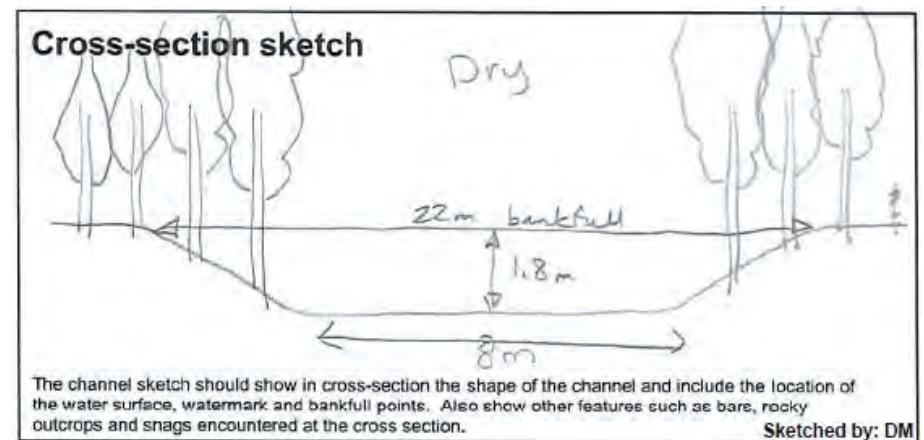
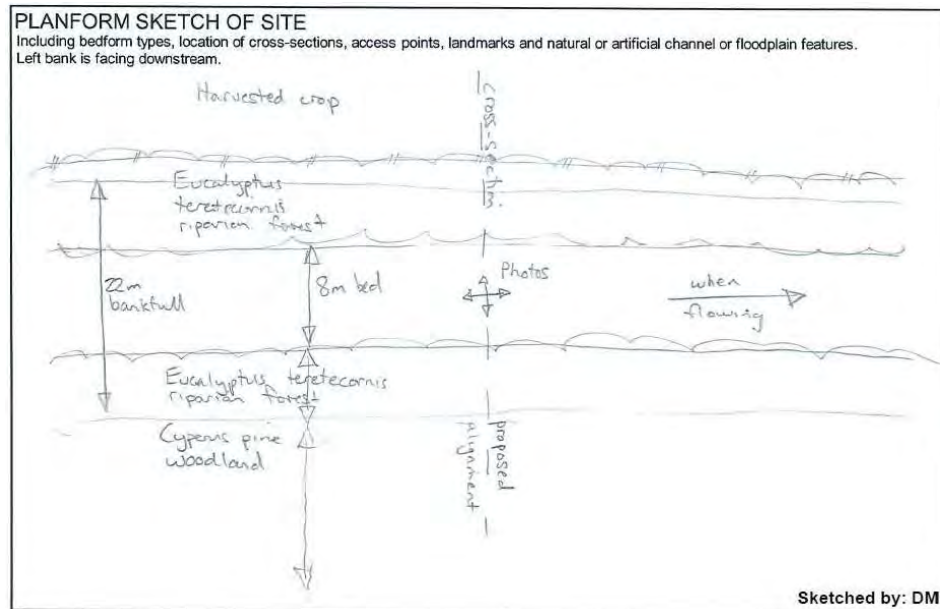
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (4); Pool substrate characterisation: Fair (6); Pool variability: Poor (0); Sediment deposition: Poor (4); Channel flow status: Poor (0); Channel alteration: Good (13); Channel sinuosity: Fair (6); Bank Stability: Good (left bank 8; right bank 8); Vegetative protection: Good (left bank 6; right bank 6); Riparian zone score: Good (left bank 8, right bank 6).

Overall habitat score: Fair (74 out of 200).



Site Code: 12 **Location:** Unnamed tributary of Canning Creek **Latitude:** 28° 14' 17" **Longitude:** 151° 09' 21" **Season:** Autumn
Date: 17/06/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Ephemeral drainage feature; dry at the time of assessment; broad valley setting; flat U shaped channel; poorly defined bed and banks; bank slope flat (<10°); bank shape concave; no floodplain features present; no obvious channel modifications; bed appears to be stable; upstream land use predominantly native forest; study reach within road corridor; adjacent land use dominated by native forest on left and right banks; little local catchment erosion; bankfull width approximately 40 m; bankfull height approximately 1 m (from stream bed); substrate composition 100% sand (0.06-2 mm); bank material 70% sand (0.06-2 mm), 30% silt / clay (<0.06 mm); 2% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 35-65%.

Riparian vegetation

Riparian zone approximately 10 m on the left bank and 10 m on the right bank; longitudinal vegetation extent semi-continuous; non-remnant vegetation in road corridor comprising study reach; adjoining vegetation community appears to be RE 11.5.4 ('*Eucalyptus chloroclada*, *Callitris glaucophylla*, *C. endlicheri*, *Angophora leiocarpa* woodland on Cainozoic sand plains and/or remnant surfaces'), with sparse cover (25% estimated crown cover) of trees >10 m, including Baradine red gum (*Eucalyptus chloroclada*), white cypress pine (*Callitris glaucophylla*) and rusty gum (*Angophora leiocarpa*); sparse cover (20%) of trees <10 m, dominated by buloke (*Allocasuarina luehmannii*) and dirty gum; sparse (45%) shrub layer, including teatree (*Leptospermum* sp.) and wattles (*Acacia* spp.); mid-dense (65%) groundcover, dominated by lovegrass (*Eragrostis* sp.), with frequent native oatgrass (*Themeda avenacea*); regeneration of native woody vegetation abundant (>5% cover) and healthy.

Vegetation disturbance: Low (expected on rail alignment) to high (in road corridor).

Aquatic flora

Macrophyte cover approximately 5%; fringing macrophytes included common rush (*Juncus usitatus*) (5%); study reach dominated by terrestrial flora.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Unrestricted fish passage in times of low, base and high flow. Located in Red zone (High risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

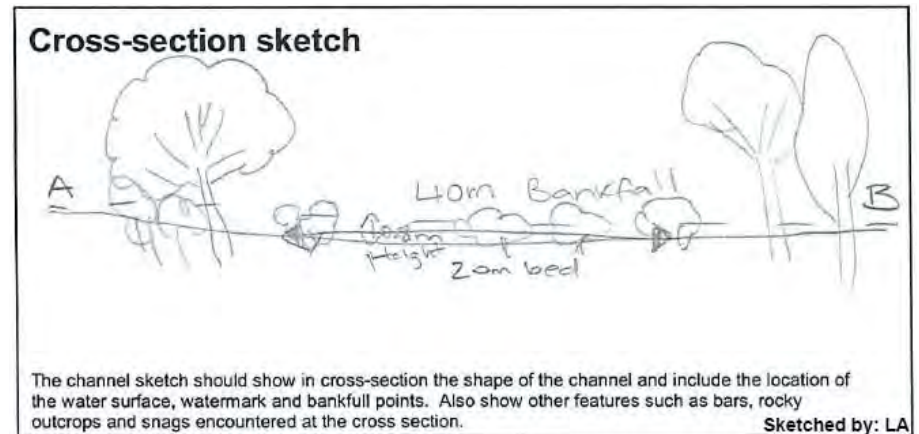
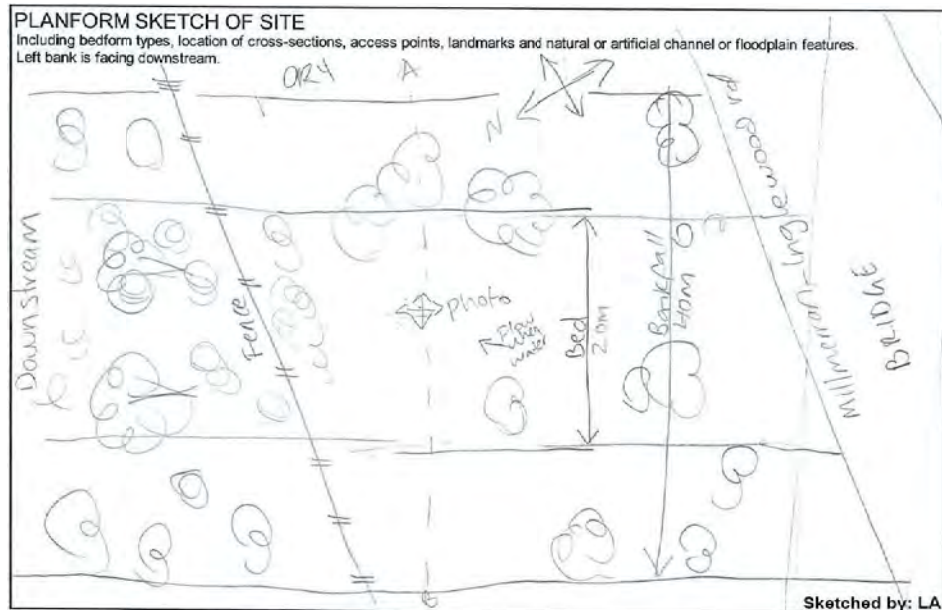
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (3); Pool substrate characterisation: Fair (7); Pool variability: Poor (0); Sediment deposition: Good (13); Channel flow status: Poor (0); Channel alteration: Good (13); Channel sinuosity: Fair (6); Bank Stability: Excellent (left bank 9; right bank 9); Vegetative protection: Good (left bank 6; right bank 6); Riparian zone score: Good (left bank 6, right bank 6).

Overall habitat score: Fair (84 out of 200).



Site Code: 13	Location: Cattle Creek	Latitude: 28° 13' 46"	Longitude: 151° 09' 15"	Season: Autumn Date: 14/06/2018
				
Upstream	Left Bank	Downstream	Right Bank	

General Site Description

Site attributes

Ephemeral watercourse; dry at the time of assessment; symmetrical floodplain valley shape; two stage channel shape; bank slope flat ($<10^\circ$); bank shape stepped; flood channels present; no obvious channel modifications; bed appears to be stable; upstream land use predominantly native forest; study reach within road corridor; adjacent land use dominated by native forest on left and right banks; little local catchment erosion; bankfull width approximately 60 m; bankfull height approximately 3 m (from stream bed); substrate composition 95% sand (0.06-2 mm) and 5% silt /clay (<0.06 mm); bank material 5% sand (0.06-2 mm) and 95% silt / clay (<0.06 mm); 1% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 35-65%.

Riparian vegetation

Riparian zone approximately 30 m on the left bank and 60 m on the right bank; longitudinal vegetation extent semi-continuous; non-remnant vegetation in road corridor; adjoining vegetation community appears to be RE 11.3.4 ('*Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains'), with sparse cover (40% estimated crown cover) of trees >10 m, dominated by Baradine red gum (*Eucalyptus chloroclada*), Queensland blue gum (*E. tereticornis*) and rough-barked apple (*Angophora floribunda*); sparse cover (30%) of trees <10 m, including white cypress pine (*Callitris glaucophylla*); very sparse (10%) shrub layer; mid-dense (60%) groundcover, dominated by blady grass (*Imperata cylindrica*); regeneration of native woody vegetation abundant ($>5\%$ cover) and healthy.

Vegetation disturbance: Low (expected on rail alignment) to high (in road corridor).

Aquatic flora

Macrophyte cover approximately 8%; fringing macrophytes included common rush (*Juncus usitatus*) (5%); spikerush (*Eleocharis acuta*) (1%), reed grass (*Arundinella nepalensis*) (1%) and tall flatsedge (*Cyperus exaltatus*) (1%); study reach dominated by terrestrial flora.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Unrestricted fish passage in times of low, base and high flow. Located in Purple zone (Major risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

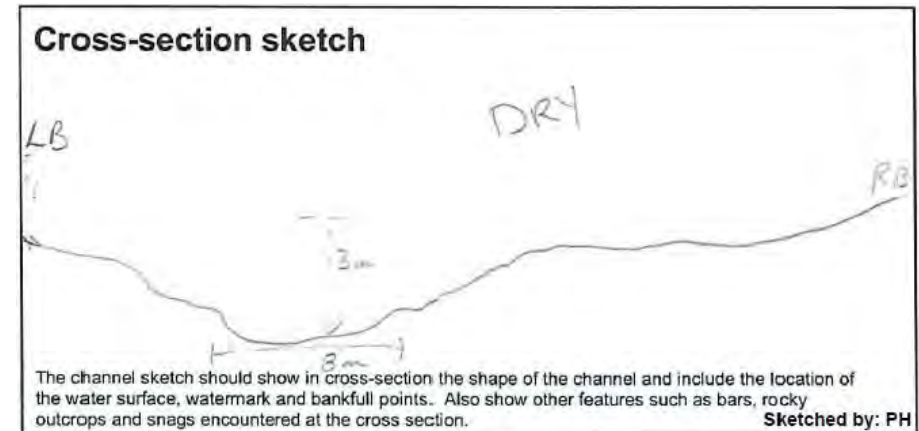
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Fair (9); Pool substrate characterisation: Fair (9); Pool variability (when wet): Good (13); Sediment deposition: Excellent (16); Channel flow status: Poor (0); Channel alteration: Excellent (18); Channel sinuosity: Good (11); Bank Stability: Good (left bank 6; right bank 7); Vegetative protection: Good (left bank 6; right bank 6); Riparian zone score: Excellent (left bank 9, right bank 9).

Overall habitat score: Good (119 out of 200).



Site Code: 15 **Location:** Native Dog Creek **Latitude:** 28° 11' 03" **Longitude:** 151° 10' 40" **Season:** Autumn
Date: 17/06/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Ephemeral drainage feature; dry at the time of assessment; bridge and agricultural fence approximately 100 m upstream; broad valley shape; widened channel shape; bank slope flat ($<10^\circ$); bank shape concave; no floodplain features present; no obvious channel modifications; bed appears to be stable; upstream land use predominantly native forest; adjacent land use dominated by native forest on left and right banks; little local catchment erosion; bankfull width approximately 30 m; bankfull height approximately 0.5 m (from stream bed); substrate composition 95% sand (0.06-2 mm) and 5% silt / clay (<0.06 mm); bank material 5% sand (0.06-2 mm) and 95% silt / clay (<0.06 mm); 5% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 10-35%.

Riparian vegetation

Riparian zone approximately 12 m on the left bank and 12 m on the right bank; longitudinal vegetation extent semi-continuous; vegetation community appears to be RE 11.3.2 ('*Eucalyptus populnea* woodland on alluvial plains'), with sparse cover (25% estimated crown cover) of trees >10 m, dominated by poplar box (*Eucalyptus populnea*), with occasional Baradine red gum (*E. chloroclada*); very sparse cover (15%) of trees <10 m, including belah (*Casuarina cristata*), poplar box and white cypress pine (*Callitris glaucophylla*); very sparse (5%) shrub layer, including wilga (*Geijera parviflora*); mid-dense (65%) groundcover, heavily grazed; occasional weeds, including lippia (*Phyla canescens*)*, mother-of-millions (*Bryophyllum delagoense*); common prickly pear (*Opuntia stricta*) and velvet tree pear (*O. tomentosa*); regeneration of native woody vegetation very limited ($<1\%$ cover).

Vegetation disturbance: Moderate.

Aquatic flora

Macrophyte cover approximately 10%; fringing macrophytes included common rush (*Juncus usitatus*) (5%); tall sedge (*Carex appressa*) (3%), tall flatsedge (*Cyperus exaltatus*) (1%) and reed grass (*Arundinella nepalensis*) (1%); groundcover mostly dead / dry (likely to be identifiable in spring).

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Unrestricted fish passage in times of low, base and high flow. Located in Red zone (High risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

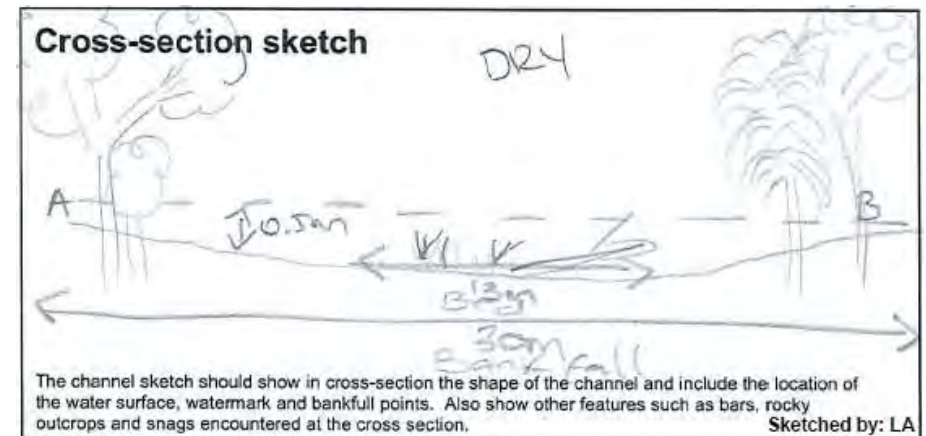
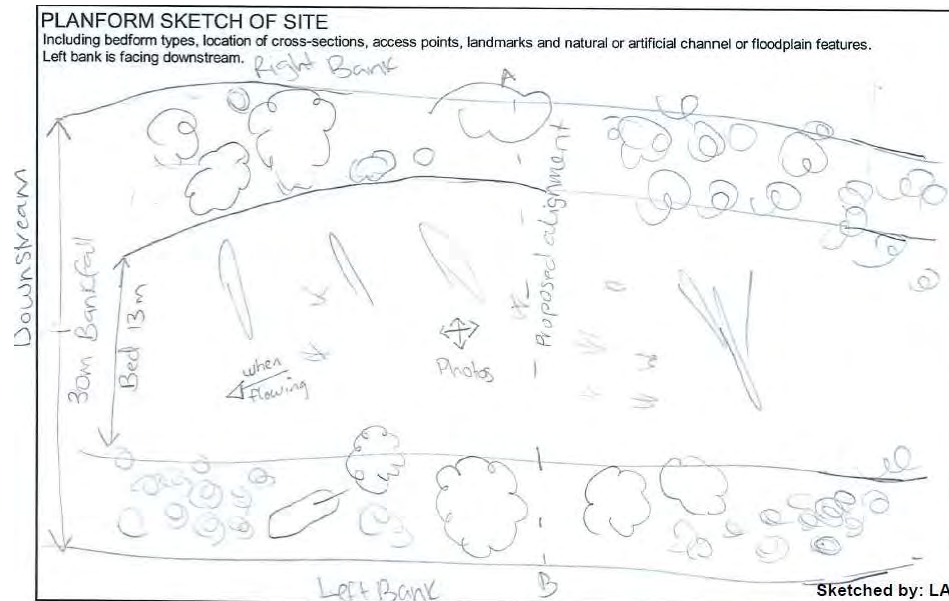
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (5); Pool substrate characterisation: Fair (6); Pool variability (when wet): Fair (6); Sediment deposition: Excellent (16); Channel flow status: Poor (0); Channel alteration: Excellent (18); Channel sinuosity: Fair (7); Bank Stability: Excellent (left bank 9; right bank 9); Vegetative protection: Good (left bank 6; right bank 6); Riparian zone score: Good (left bank 7, right bank 7).

Overall habitat score: Good (102 out of 200).



Site Code: 16 **Location:** Bringalily Creek **Latitude:** 28° 09' 21" **Longitude:** 151° 11' 14" **Season:** Autumn
Date: 13/06/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Semi-permanent watercourse; water level low at the time of assessment; symmetrical floodplain valley shape; box channel shape; bank slope vertical (80-90°); bank shape wide lower bench on left bank, undercut on right bank; floodplain features include flood channels and floodplain scours; no obvious channel modifications; bed moderately unstable – eroding; upstream land use predominantly cattle grazing; adjacent land use predominantly cattle grazing; little local catchment erosion; bankfull width approximately 31 m; bankfull height approximately 3.8 m (from stream bed); substrate composition 100 silt /clay (<0.06 mm); bank material 100% silt / clay (<0.06 mm); 10% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover 10-35%.

Riparian vegetation

Riparian zone approximately 10 m on the left bank and 10 m on the right bank; longitudinal vegetation extent scattered; vegetation community appears to be RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with very sparse cover (15% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with occasional river red gum (*E. camaldulensis*), rough-barked apple (*Angophora floribunda*) and poplar box (*E. populnea*); no trees <10 m detected; no shrubs detected; mid-dense (80%) groundcover; regeneration of native woody vegetation very limited (<1% cover).

Vegetation disturbance: High.

Aquatic flora and fauna

Macrophyte cover approximately 30%; fringing macrophytes included common reed (*Phragmites australis*) (15% estimated cover), common rush (*Juncus usitatus*) (5%), dwarf flat-sedge (*Cyperus pygmaeus*) (5%), and umbrella canegrass (*Leptochloa digitata*) (5%).

Five eastern snake-necked turtle (*Chelodina longicollis*) shells observed; no fish catch (despite seven bait traps deployed for approximately two hours, supplemented by dip-netting with Enviro-net®). Waterbody better suited to back-pack electrofishing and fyke netting.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Good passage expected during times of flow. Located in Purple zone (Major risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach provides potential habitat for the Murray Cod and Platypus, but is unlikely to provide habitat for the Silver Perch or Bell's turtle.

Physico-chemical water quality

Collection time: 9:30; water temp.: 12.6°C; specific conductivity: 209.3 $\mu\text{S}/\text{cm}$ (fresh); turbidity: 138 (poor clarity); dissolved oxygen: 62.1%, 6.64 mg/L (low, but expected for time of day); pH: 7.83 (mildly alkaline); Redox: 191.1 (moderately reducing).

Summary: Normal.

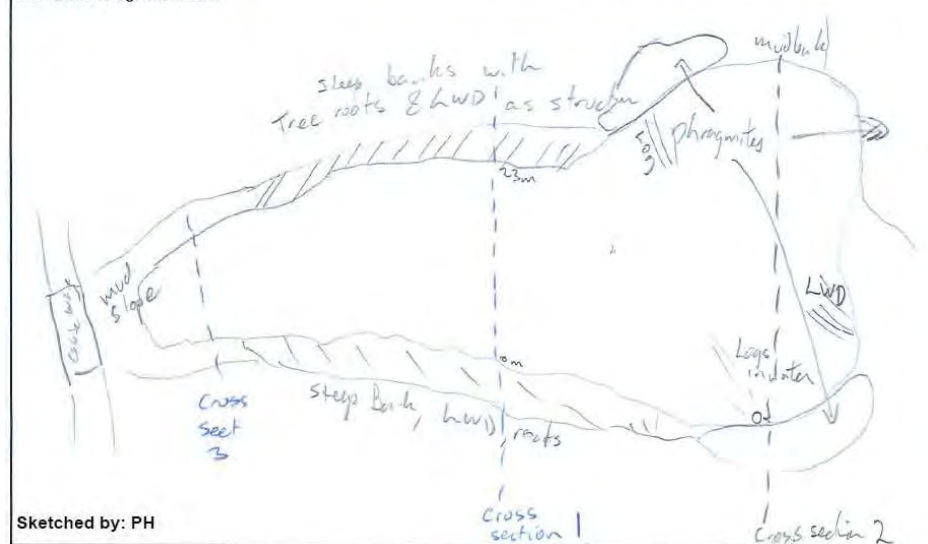
Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Good (15); Pool substrate characterisation: Fair (9); Pool variability: Good (13); Sediment deposition: Good (15); Channel flow status: Excellent (18); Channel alteration: Excellent (18); Channel sinuosity: Good (12); Bank Stability: Fair (left bank 4; right bank 4); Vegetative protection: Fair (left bank 4; right bank 4); Riparian zone score: Fair (left bank 4, right bank 4).

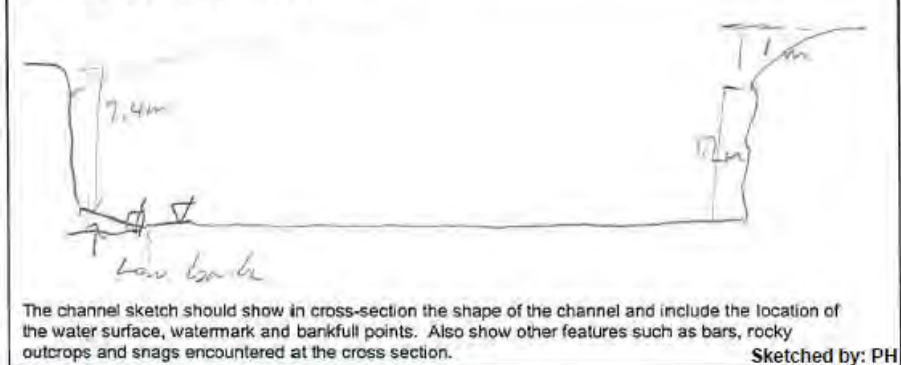
Overall habitat score: Good (124 out of 200).

PLANFORM SKETCH OF SITE

Including bedform types, location of cross-sections, access points, landmarks and natural or artificial channel or floodplain features. Left bank is facing downstream.



Cross-section sketch



Site Code: 17	Location: Bringalily Creek	Latitude: 28° 07' 44"	Longitude: 151° 11' 20"	Season: Autumn Date: 17/06/2018
				
Upstream	Left Bank	Downstream	Right Bank	

General Site Description

Site attributes

Ephemeral watercourse; dry at the time of assessment; symmetrical floodplain valley shape; two stage channel shape; bank slope moderate (30-60°); bank shape stepped; no floodplain features present; no obvious channel modifications; bed moderately unstable – eroding, affected by cleared vegetation and stock access; upstream land use predominantly cattle grazing; adjacent land use cattle grazing on left and right banks (and within stream reach); some local catchment erosion, including stream bank erosion exacerbated by lippia (*Phyla canescens*) impacts, and cattle; bankfull width approximately 30 m; bankfull height approximately 3 m (from stream bed); substrate composition 100% silt / clay (<0.06 mm); bank material 30% sand (0.06-2 mm) and 70% silt / clay (<0.06 mm); 25% large woody debris; no filamentous algae, periphyton or moss detected; detritus cover <10%.

Riparian vegetation

Riparian zone approximately 10 m on the left bank and 10 m on the right bank; longitudinal vegetation extent comprises occasional clumps; vegetation community appears to be RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with very sparse cover (15% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*Eucalyptus tereticornis*), with occasional rough-barked apple (*Angophora floribunda*); very sparse cover (5%) of trees <10 m, including Queensland blue gum; very sparse (1%) shrub layer, including *Mimosa* sp.; mid-dense (60%) groundcover, heavily grazed, dominated by common couch (*Cynodon dactylon*), with frequent lippia (*Phyla canescens*)*; no regeneration of native woody vegetation detected.

Vegetation disturbance: Very high (heavily impacted by sustained cattle grazing during drought conditions).

Aquatic flora

Macrophyte cover approximately 35%; fringing macrophytes included water primrose (*Ludwigia peploides* subsp. *montevidensis*) (30% estimated cover), common rush (*Juncus usitatus*) (3%) and reed grass (*Arundinella nepalensis*) (2%).

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Unrestricted fish passage in times of flow. Located in Purple zone (Major risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

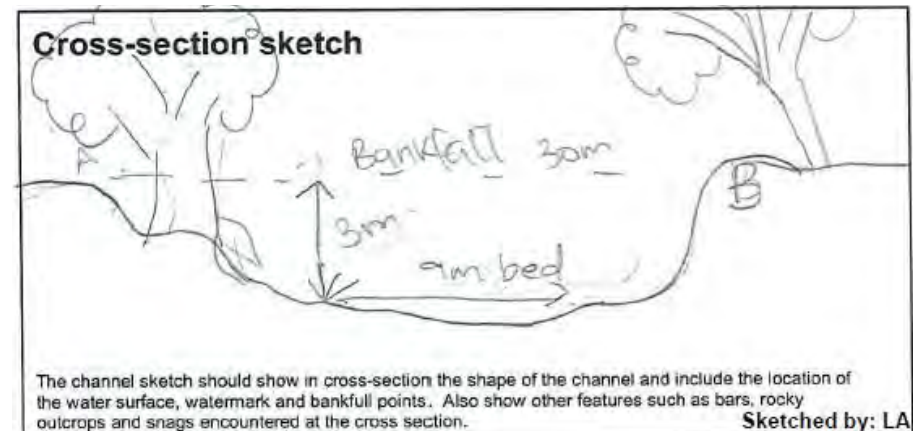
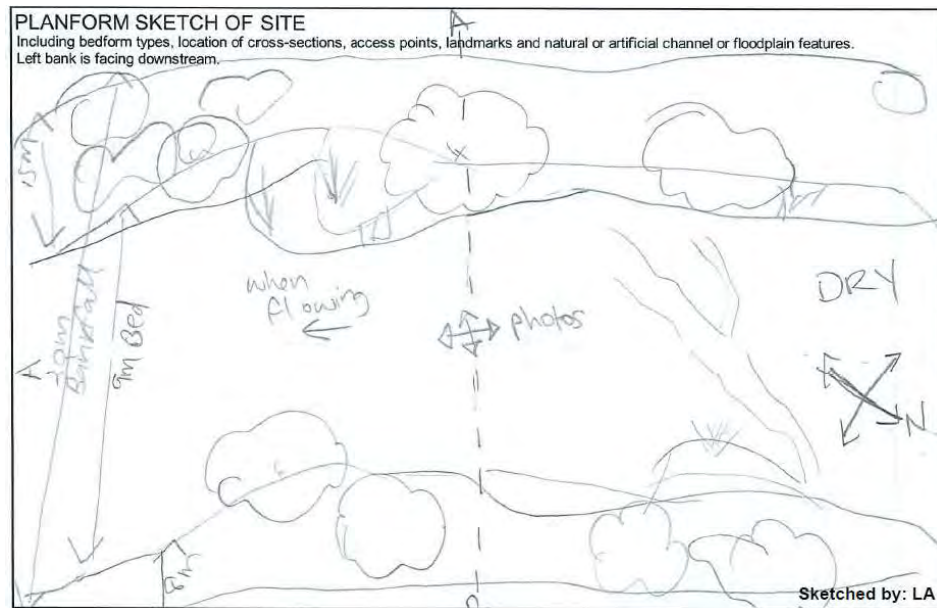
Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Fair (7); Pool substrate characterisation: Poor (3); Pool variability (when wet): Good (11); Sediment deposition: Excellent (16); Channel flow status: Poor (0); Channel alteration: Excellent (16); Channel sinuosity: Good (13); Bank Stability: Poor (left bank 2; right bank 2); Vegetative protection: Fair (left bank 5; right bank 5); Riparian zone score: Fair (left bank 5, right bank 5).

Overall habitat score: Fair (90 out of 200).



Site Code: 19	Location: Nicol Creek	Latitude: 28° 05' 07"	Longitude: 151° 11' 46"	Season: Autumn Date: 13/06/2018
				
Upstream	Left Bank	Downstream	Right Bank	

General Site Description

Site attributes

Ephemeral watercourse; dry at the time of assessment; asymmetrical floodplain valley shape; two stage channel shape; bank slope steep (60-80%) on left bank, moderate (30-60%) on right bank; bank shape stepped; floodplain features include remnant channels, flood channels and flood scours; no obvious channel modifications; bed stable, although unstable in heavily grazed paddock immediately downstream; upstream land use predominantly cattle grazing and dryland cropping; study reach within road corridor, comprising native woodland; little local catchment erosion, including stream bank erosion exacerbated by lippia (*Phyla canescens*) impacts; bankfull width approximately 150 m; bankfull height approximately 1.5 m (from stream bed); substrate composition 5% sand (0.06-2 mm) and 95% silt / clay (<0.06 mm); bank material 100% silt / clay (<0.06 mm); no large woody debris, filamentous algae, periphyton or moss detected; detritus cover <10%.

Riparian vegetation

Riparian zone approximately 100 m on the left bank and 50 m on the right bank; longitudinal vegetation extent regularly spaced; vegetation community appears to be RE 11.3.2 ('*Eucalyptus populnea* woodland on alluvial plains'), with a very sparse cover (10% estimated crown cover) of trees >10 m, dominated by poplar box (*Eucalyptus populnea*), with occasional Queensland blue gum (*E. tereticornis*); very sparse cover (10%) of trees <10 m, including poplar box and brigalow (*Acacia harpophylla*); very sparse (5%) shrub layer, including poplar box regrowth; mid-dense (80%) groundcover; regeneration of native woody vegetation present.

Vegetation disturbance: Moderate.

Aquatic flora

Macrophyte cover approximately 25%; fringing macrophytes included umbrella canegrass (*Leptochloa digitata*) (20% estimated cover), common rush (*Juncus usitatus*) (2%), spikerush (*Eleocharis acuta*) (2%) and tall flatsedge (*Cyperus exaltatus*) (1%).

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Moderately restricted passage in times of flow. Located in Red zone (High risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Vulnerable (EPBC Act and NC Act) Bell's turtle (*Wollumbinia belli*) and Special Least Concern (NC Act) Platypus are recorded from the Queensland Border Rivers catchment (DES 2018b). The study reach is highly unlikely to provide suitable habitat for these species.

Physico-chemical water quality

Dry at the time of the site visit.

Summary: Normal.

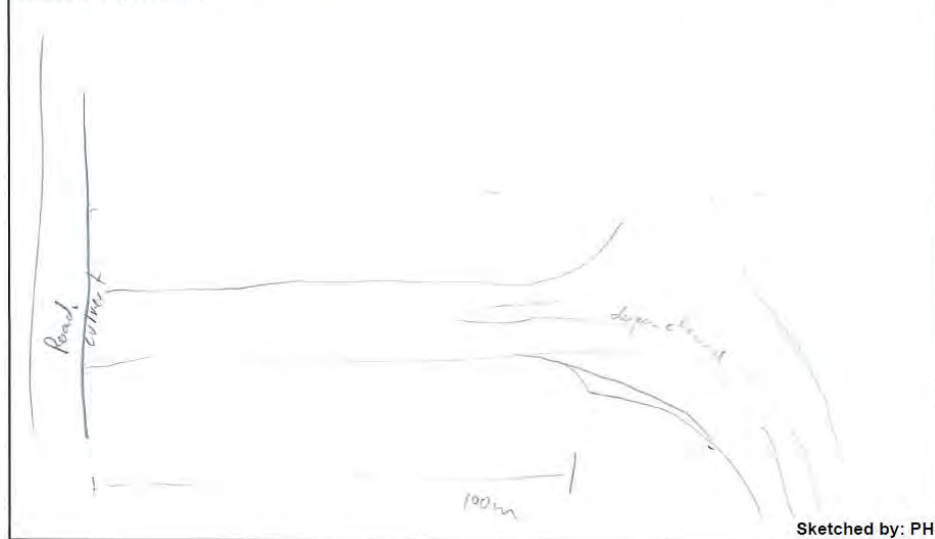
Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Fair (9); Pool substrate characterisation: Good (13); Pool variability (when wet): Fair (6); Sediment deposition: Fair (8); Channel flow status: Poor (0); Channel alteration: Good (13); Channel sinuosity: Fair (9); Bank Stability: Fair (left bank 4; right bank 4); Vegetative protection: Good (left bank 6; right bank 6); Riparian zone score: Good (left bank 7, right bank 7).

Overall habitat score: Fair (92 out of 200).

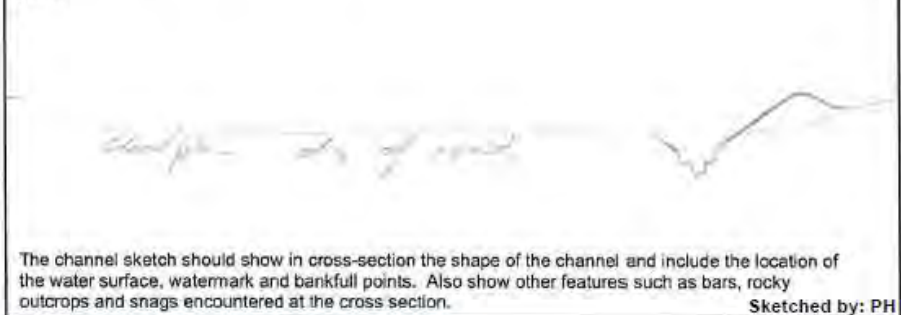
PLANFORM SKETCH OF SITE

Including bedform types, location of cross-sections, access points, landmarks and natural or artificial channel or floodplain features. Left bank is facing downstream.



Cross-section sketch

Left Bank



The channel sketch should show in cross-section the shape of the channel and include the location of the water surface, watermark and bankfull points. Also show other features such as bars, rocky outcrops and snags encountered at the cross section.

Sketched by: PH

Site Code: 32	Location: Condamine River (North)	Latitude: 27° 46' 51"	Longitude: 151° 25' 25"	Season: Autumn Date: 14/06/2018
				
Upstream	Left Bank	Downstream	Right Bank	

General Site Description

Site attributes

Ephemeral watercourse; dry at the time of assessment; symmetrical floodplain valley shape; two stage channel shape; bank slope moderate (30-60%) on left bank, steep (60-80%) on right bank; bank shape stepped; no natural floodplain features present; no obvious channel modifications; bed stable; upstream and adjacent land use dominated by irrigated cropping on Vertosol floodplains; little local catchment erosion; bankfull width approximately 65 m; bankfull height approximately 3 m (from stream bed); substrate composition 5% boulder (>256 mm) and 95% silt / clay (<0.06 mm); bank material 5% boulder (>256 mm) and 95% silt / clay (<0.06 mm); no large woody debris, filamentous algae, periphyton or moss detected; detritus cover 10-35%.

Riparian vegetation

Riparian zone approximately 10 m on the left bank and 10 m on the right bank; longitudinal vegetation extent regularly spaced; narrow riparian corridor of RE 11.3.25 ('*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines'), with a sparse cover (20% estimated crown cover) of trees >10 m, dominated by Queensland blue gum (*Eucalyptus tereticornis*); sparse cover (20%) of trees <10 m, dominated by beefwood (*Grevillea striata*); very sparse (10%) shrub layer; mid-dense (70%) groundcover; regeneration of native woody vegetation present.

Vegetation disturbance: High.

Aquatic flora

Macrophyte cover approximately 73%; fringing macrophytes included common rush (*Juncus usitatus*) (estimated cover 60%), ribbed spikerush (*Eleocharis plana*) (5%), hairy knotweed (*Persicaria attenuata*) (5%), slender knotweed (*P. decipiens*) (1%), tall flatsedge (*Cyperus exaltatus*) (1%) and dwarf flat-sedge (*Cyperus pygmaeus*) (1%).

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Partly restricted passage in times of flow. Located in Purple zone (Major risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Endangered (NC Act) fringing rush (*Fimbristylis vagans*) and Special Least Concern (NC Act) Platypus are recorded from the Condamine-Balonne Basin (DES 2018b). The study reach is unlikely to provide suitable habitat for these species, nor were any detected at the time of assessment.

Site Code: 43 **Location:** Unnamed tributary of Gowrie Creek **Latitude:** 27° 29' 38" **Longitude:** 151° 50' 59" **Season:** Autumn
Date: 12/06/2018



Upstream



Left Bank



Downstream



Right Bank

General Site Description

Site attributes

Ephemeral drainage feature; dry at the time of assessment; study reach is downstream of road and rail culvert crossings; symmetrical floodplain valley shape; flat U channel shape; bank slope moderate (30-60%) on left and right banks; bank shape concave; no natural floodplain features present; channel modifications include reinforced banks associated with road and rail crossings; bed stable; banks stable, although unstable (slumping) on adjoining land downstream; upstream and adjacent land use dominated by rainfed cropping; some local catchment erosion; bankfull width approximately 40 m; bankfull height approximately 3.5 m (from stream bed); substrate composition 100% silt / clay (<0.06 mm); bank material 100% silt / clay (<0.06 mm); no large woody debris, filamentous algae, periphyton or moss detected; detritus cover <10%.

Riparian vegetation

Riparian zone approximately 1 m on the left bank and 1 m on the right bank; longitudinal vegetation extent isolated / scattered; non-remnant vegetation, with a very sparse cover (2% estimated crown cover) of trees <10 m, including *Casuarina* sp. and *Corymbia* sp. (not accessible); no shrub layer; dense (95%) groundcover, including *Sorghum* sp., *Chloris* sp., *Setaria* sp. and *Eragrostis* sp.; no regeneration of native woody vegetation.

Vegetation disturbance: Very high.

Aquatic flora

No macrophytes detected.

Physical barriers to local fish passage and DAF waterway zoning and risk of impact

Very restricted passage (road culverts have not allowed for fish passage, although minimal potential fish habitat upstream). Located in Amber zone (Moderate risk of impact on fish movement).

Endangered, Vulnerable, Near Threatened (EVNT) or Special Least Concern (SLC) flora and fauna

No EVNT or SLC aquatic flora or fauna species were detected. The Critically Endangered (EPBC Act) Silver Perch (*Bidyanus bidyanus*), Vulnerable (EPBC Act) Murray Cod (*Maccullochella peelii*), Endangered (NC Act) fringing rush (*Fimbristylis vagans*) and Special Least Concern (NC Act) Platypus are recorded from the Condamine-Balonne Basin (DES 2018b). The study reach is unlikely to provide suitable habitat for these species, nor were any detected at the time of assessment.

Physico-chemical water quality

Dry at the time of the site visit.

Summary: Normal.

Habitat scoring – Low gradient streams (as per AusRivAS Physical Habitat Assessment Protocol)

Epifaunal substrate / available cover: Poor (4); Pool substrate characterisation: Poor (4); Pool variability (when wet): Poor (0); Sediment deposition: Excellent (18); Channel flow status: Poor (0); Channel alteration: Fair (9); Channel sinuosity: Fair (7); Bank Stability: Fair (left bank 5; right bank 5); Vegetative protection: Fair (left bank 5; right bank 5); Riparian zone score: Poor (left bank 2, right bank 2).

Overall habitat score: Fair (66 out of 200).

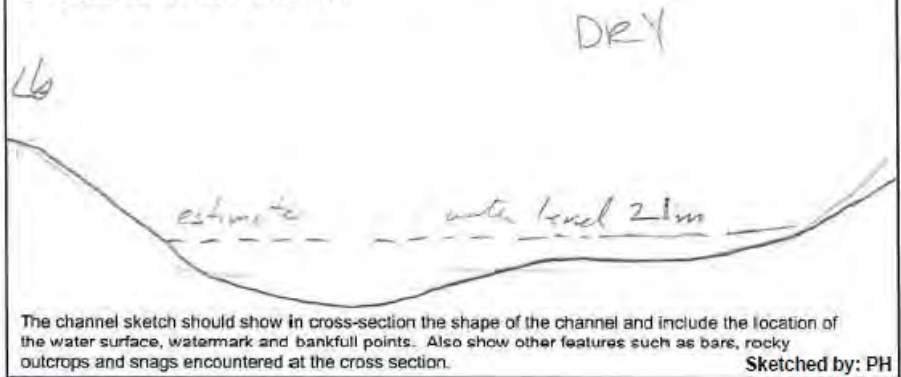
PLANFORM SKETCH OF SITE

Including bedform types, location of cross-sections, access points, landmarks and natural or artificial channel or floodplain features. Left bank is facing downstream.



Sketched by: PH

Cross-section sketch



Sketched by: PH

Appendix B: Likelihood of Occurrence

Species Name	Common Name	Status		Likelihood	Habitat Description & Justification ³
		NC Act ¹	EPBC Act ²		
FAUNA					
Fish					
<i>Maccullochella peelii</i>	Murray Cod	-	V	Known	Murray Cod are main-channel specialists and are frequently found in the main channels of rivers and larger tributaries (DoEE 2018). Preferred microhabitat consists of complex structural features in streams such as large rocks, snags (pieces of large submerged woody debris), overhanging stream banks and vegetation, tree stumps, logs, branches and other woody structures. Such structures reduce or influence stream flows and provide Murray Cod with shelter from fast-flowing water. They also serve as predatory ambush points for foraging, particularly during the day (DoEE 2019a). Where areas of deep stream occur throughout the southern portion of the impact assessment area, such as in some reaches of Brigalily Creek, potential habitat for the species occurs. Most areas in the impact assessment area are unsuitable due to the ephemeral nature of the systems. Closest known records (within 10km of the impact assessment area) occur in Dumaresq River and the southern reach of Boonal Anabranch (ALA 2018). The Murray Cod was confirmed to be present in the impact assessment area during field surveys, at the Macintyre River and Macintyre Brook.
<i>Bidyanus bidyanus</i>	Silver Perch	-	CE	Unlikely	Silver Perch are a highly migratory freshwater fish and are endemic to the Murray-Darling system (including all states and sub-basins) (Allen <i>et al.</i> 2002). Silver Perch

Species Name	Common Name	Status		Likelihood	Habitat Description & Justification ³
		NC Act ¹	EPBC Act ²		
					are consistently reported by anglers and researchers to show a general preference for faster-flowing water, including rapids and races, and more open sections of river and preference for submergent macrophytes, which may be important nursery areas for juveniles (DoEE 2018). Adult Silver Perch are omnivorous, taking a variety of small prey including zooplankton, aquatic insects, molluscs, small crustaceans and worms as well as algae (NSW DPI, 2006). A historical species record occurs in Back Creek, near Millmerran (within 10km of the impact assessment area; ALA 2018), however, due to the absence of fast-flowing water systems in the impact assessment area, the species is unlikely to occur in the impact assessment area.
Turtle					
<i>Elseya albagula</i>	Southern Snapping Turtle	E	CE	Unlikely	The southern snapping turtle is a habitat specialist (TSSC 2014). Within the river system it prefers clear, flowing, well-oxygenated waters. Water quality is an important aspect of the species ability to utilise habitat as due to its physiological adaptation to extract oxygen from water via cloacal respiration (DoEE 2017; TSSC 2014). Suitable habitat and species records are absent from the impact assessment area and surrounding region (ALA 2018). As such, the species is unlikely to occur in the impact assessment area.
<i>Wollumbinia belli</i>	Bell's Turtle	V	V	Unlikely	The species is restricted to upland streams (between 600 and 1100 m altitude) that contain permanent pools deeper than about 2 m, granite boulders and bedrock. Its habitat is often complex, with underwater caverns formed by boulders, logs and overhanging banks. In areas of lower velocity, the typical substratum is coarse granitic sand overlain by fine silt, algal growth, and dense beds of macrophytes

Species Name	Common Name	Status		Likelihood	Habitat Description & Justification ³
		NC Act ¹	EPBC Act ²		
					(DoEE 2019b). It is absent from areas away from flowing streams, such as farm ponds and natural wetlands (DoEE 2019b). The species is unlikely to occur in the impact assessment area due to the absence of suitable habitat. No species records occur within 10km of the impact assessment area (ALA 2018).
Monotreme					
<i>Ornithorhynchus anatinus</i>	Platypus	SLC	-	Known	Preferred habitat for the species includes a river or a stream with earth banks and native vegetation that provides shading of the stream and cover near the bank. The presence of logs, twigs, and roots, as well as cobbled or gravel water substrate result in increased macroinvertebrate fauna (a main food source), and the Platypus also tends to be more abundant in areas with pool-riffle sequences (Australia Museum 2018). Platypus was observed in the Macintyre Brook, near Inglewood during the dry season survey. The species is also known to inhabit the Macintyre River (ALA 2018).
FLORA					
Monocots					
<i>Fimbristylis vagans</i>	-	E	-	Potential	<i>Fimbristylis vagans</i> is a species of plant in the family Cyperaceae, a sedge family of monocotyledonous flowering plants. The species is a wetland indicator (WetlandInfo 2019). The species is associated with clay pans, open sedge land and sparse-tussock grasslands on shallow alluvial sand plains but may also occur in other ecosystems (other species of <i>Fimbristylis</i> are common in pastures of central Queensland).

Species Name	Common Name	Status		Likelihood	Habitat Description & Justification ³
		NC Act ¹	EPBC Act ²		
					The species was not detected during field surveys and no species records occur within 10km of the impact assessment area (ALA 2018).

¹E = Endangered, V = Vulnerable and SLC = Special Least Concern under the NC Act.

²CE = Critically Endangered, E = Endangered, V = Vulnerable under the EPBC Act.

³ Information should be cited as being from the Species Profile – Department of the Environment and Energy unless otherwise cited.

Appendix C: Records of Calibration for Water Quality Meter

Form: FRM-001
 Title: Water Quality Meter Calibration Certificate

Instrument make: YSI Professional Plus
 Display serial number: 14M100367
 Sonde serial number: 14M100051
 Calibrated by: D. MOORE
 Calibrated for (job no.): DPM18004 (BZA) - TRIP 1 START
 Date calibrated: 11/06/2018

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	19.4
pH 4	Dec 18	pH units	4.00	3.89	4.00	4.00
pH 7	Dec 18	pH units	7.02	6.84	7.02	7.02
pH 10	Dec 18	pH units	10.06	9.97	10.06	10.06
ORP	May 20	mV	240.2	239.2	240.2	240.2
SPC	Jan 19	µS/cm	1413	1340	1413	1413
Barometric pressure	N/A	mmHg		765.7	765.7	765.7
DO (zero)	N/A	%S	0.0	0.0	0.0	0.0
DO (sat.)	N/A	%S	100.0	94.5	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument in good condition. New batteries installed.

Signed: _____

Date: _____

Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	D. MOORE
Calibrated for (job no.):	DPM18004 (BZL) - TRIP 1 FINISH
Date calibrated:	18/6/2018

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	18.0
pH 4	Dec 18	pH units	4.00	4.03	4.00	4.00
pH 7	Dec 18	pH units	7.03	7.00	7.03	7.03
pH 10	Dec 18	pH units	10.08	9.97	10.08	10.08
ORP	May 20	mV	241.2	240.3	241.2	241.2
SPC	Jan 19	µS/cm	1413	1414	1413	1413
Barometric pressure	N/A	mmHg		765.5	765.5	765.5
DO (zero)	N/A	%S	0.0	0.4	0.0	0.0
DO (sat.)	N/A	%S	100.0	104.4	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument maintained calibration. In good condition.

Signed: D. Moore

Date: 18/6/2018

Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	P. HANCOCK
Calibrated for (job no.):	APM18004 (BZC) - TRIP 2 START
Date calibrated:	26/11/2018

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	—
pH 4	Apr 20	pH units	4.00	3.99	4.00	4.00
pH 7	Jun 20	pH units	7.01	7.29	7.01	7.01
pH 10	May 20	pH units	10.01	9.96	10.01	10.01
ORP	May 20	mV	230.7	305.6	230.7	230.7
SPC	Apr 20	µS/cm	1413	1324	1413	1413
Barometric pressure	N/A	mmHg	—	717.7	717.7	717.7
DO (zero)	N/A	%S	0.0	-0.4	0.0	0.0
DO (sat.)	N/A	%S	100.0	78.9	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument in good condition. Battery level adequate. Spare batteries inside case.

Signed: J. More

Date: 26/11/2018

Form: FRM-001
 Title: Water Quality Meter Calibration Certificate

Instrument make: YSI Professional Plus

Display serial number: 14M100367

Sonde serial number: 14M100051

Calibrated by: J. Moore

Calibrated for (job no.): DPM18004 (B2C) - TRIP 2 FINISH

Date calibrated: 2/12/2018

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	23.8
pH 4	Apr 20	pH units	4.00	4.00	4.00	4.00
pH 7	Jun 20	pH units	7.01	6.91	7.01	7.01
pH 10	May 20	pH units	10.01	10.05	10.01	10.01
ORP	May 20	mV	233.4	231.7	233.4	233.4
SPC	Apr 20	µS/cm	1413	1408	1413	1413
Barometric pressure	N/A	mmHg	716.7	716.7	716.7	716.7
DO (zero)	N/A	%S	0.0	-0.2	0.0	0.0
DO (sat.)	N/A	%S	100.0	104.7	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument has maintained calibration. Instrument in good condition.

Signed: J. Moore

Date: 2/12/2018



Form: FRM-001
Title: Water Quality Meter Calibration Certificate

Instrument make: YSI Professional Plus
Display serial number: 14M100367
Sonde serial number: 14M100051
Calibrated by: D. MOORE
Calibrated for (job no.): DPM12004 (B2A) - TRIP 3 START
Date calibrated: 10/2/2019

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	25.3
pH 4	Apr 20	pH units	4.01	3.97	4.01	4.01
pH 7	Jun 20	pH units	7.00	6.92	7.00	7.00
pH 10	May 20	pH units	9.98	9.96	9.98	9.98
ORP	May 20	mV	227.7	227.5	227.7	227.7
SPC	Apr 20	µS/cm	1413	1509	1413	1413
Barometric pressure	N/A	mmHg	745.6	745.6	745.6	745.6
DO (zero)	N/A	%S	0.0	0.0	0.0	0.0
DO (sat.)	N/A	%S	100.0	100.6	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument in good condition. Batteries replaced.

Signed:

D. Moore

Date:

10/2/2019

Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	D. MOORE
Calibrated for (job no.)	DPM18004 (B26) - Trip 3 finish
Date calibrated:	15/2/2019

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	28.0
pH 4	Apr 20	pH units	4.01	4.06	4.01	4.01
pH 7	Jun 20	pH units	6.99	7.04	6.99	6.99
pH 10	Apr 20	pH units	9.97	9.99	9.97	9.97
ORP	May 20	mV	224.6	222.3	224.6	224.6
SPC	Apr 20	µS/cm	1413	1414	1413	1413
Barometric pressure	N/A	mmHg	754.7	754.7		
DO (zero)	N/A Mar 20	%S	0.0	-0.2	0.0	0.0
DO (sat.)	N/A	%S	100.0	101.6	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument has maintained calibration.
 In good condition. Cleaned and stored for next use.

Signed: D. Moore

Date: 15/2/2019



Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	D. MOORE
Calibrated for (job no.)	DPM18004
Date calibrated:	28/4/2019 - Commencement of Trip 4

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	22.1
pH 4	10/20	pH units	4.00	4.21	4.00	4.00
pH 7	10/20	pH units	7.01	7.17	7.01	7.01
pH 10	10/20	pH units	10.03	10.21	10.03	10.03
ORP	2/21	mV	233.8	225.8	233.8	233.8
SPC	1/21	µS/cm	1413	2268	1413	1413
Barometric pressure	N/A	mmHg		—	758.84	758.84
DO (zero)	N/A	%S	0.0	-0.1	0.0	0.0
DO (sat.)	N/A 3/20	%S	100.0	109.0	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Last calibrated and used by Blue Earth Environmental. Advise BEE that their cal. solution for SPC needs replacing. Checked with two SPC cal. solution batches. Instrument in good condition.

Signed: J. Moore

Date: 28/4/2019



Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	D. Moore
Calibrated for (job no.)	DPR18004
Date calibrated:	3/5/2019 - Completion of Trip 4

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	22.3
pH 4	10/20	pH units	4.00	4.09	4.00	4.00
pH 7	10/20	pH units	7.01	7.05	7.01	7.01
pH 10	10/20	pH units	10.03	10.01	10.03	10.03
ORP	2/21	mV	233.0	239.5	235.0	235.0
SPC	1/21	µS/cm	1413	1402	1413	1413
Barometric pressure	N/A	mmHg		753.6	753.6	753.6
DO (zero)	N/A 3/20	%S	0.0	-0.3	0.0	0.0
DO (sat.)	N/A 3/20	%S	100.0	98.7	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument has maintained calibration. In good condition. Cleaned and stored for next use.

Signed: D. Moore

Date: 3/5/2019

Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	D. MOORE
Calibrated for (job no.)	DPM18004
Date calibrated:	15/5/2019 - Commencement of Trip 5

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	22.2
pH 4	10/20	pH units	4.00	4.01	4.00	4.00
pH 7	10/20	pH units	7.01	7.01	7.01	7.01
pH 10	10/20	pH units	10.03	10.02	10.03	10.03
ORP	2/21	mV	235.0	236.1	235.0	235.0
SPC	1/21	µS/cm	1413	1410	1413	1413
Barometric pressure	N/A	mmHg	769.6	769.6	769.6	769.6
DO (zero)	3/20	%S	0.0	-0.1	0.0	0.0
DO (sat.)	N/A	%S	100.0	99.7	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

In good condition. Calibrated and ready for use.

Signed: J. Moore

Date: 15/5/2019

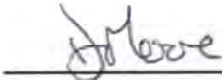
Form:	FRM-001
Title:	Water Quality Meter Calibration Certificate
Instrument make:	YSI Professional Plus
Display serial number:	14M100367
Sonde serial number:	14M100051
Calibrated by:	
Calibrated for (job no.)	
Date calibrated:	

Parameter	Calibration standard expiry date	Units	Before calibration		After calibration	
			Expected value	Measured value	Expected value	Measured value
Temperature	Factory cal.	°C	N/A	N/A	N/A	
pH 4	10/20	pH units	4.00	4.03	4.00	4.00
pH 7	10/20	pH units	7.00	7.04	7.00	7.00
pH 10	10/20	pH units	10.05	10.09	10.05	10.05
ORP	2/21	mV	1413	1438	1413	1413
SPC	1/21	µS/cm	238.0	237.4	238.0	238.0
Barometric pressure	N/A	mmHg	763.4	763.5	763.4	763.4
DO (zero)	3/20	%S	0.0	-0.8	0.0	0.0
DO (sat.)	N/A	%S	100.0	98.8	100.0	100.0

The instrument has been inspected for visible signs of wear, damage, cleanliness, and condition, and is verified to be in good working order.

Comments on the instrument:

Instrument has maintained calibration. In good condition. Cleaned and stored for next use.

Signed: 

Date: 19/5/2019

Appendix D: Laboratory Certificates of Analysis, Chain of Custody and Quality Control



CHAIN OF CUSTODY

ALS Laboratory: please tick →

ADELWAIDE 3/1 Burma Road Parafield SA 5095
Ph 08 8162 5130 E. adelaide@alsglobal.com

BRISBANE 2 Byrd Street Stafford QLD 4051
Ph 07 3242 7222 E. samples.brisbane@alsglobal.com

GLADSTONE 48 Callamondah Drive Gladstone QLD 4080
Ph 07 4976 7944 E. gladstone@alsglobal.com

MACRAE 76 Hattwood Road Mackay QLD 4740
Ph 07 4944 0177 E. mackay@alsglobal.com

MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph 03 8549 9600 E. samples.melbourne@alsglobal.com

MUDGEE 1/29 Sydney Road Mudgee NSW 2850
Ph 02 6372 6735 E. mudgee@alsglobal.com

NEWCASTLE 8/815 Marlton Road Mayfield NSW 2304
Ph 02 4014 2500 E. samples.newcastle@alsglobal.com

PERTH 4/13 Quay Place North Perth WA 6006
Ph 02 4422 2033 E. perth@alsglobal.com

PERTH 1/10 Mad Way Malaga WA 6060
Ph 08 9209 7955 E. samples.perth@alsglobal.com

SYDNEY 2/7-28 Woodpark Road Smithfield NSW 2166
Ph 02 8784 8555 E. samples.sydney@alsglobal.com

TOWNSVILLE 14-15 Deema Gaurt Baher QLD 4818
Ph 07 4735 0000 E. townsville.environmental@alsglobal.com

WOLLONGONG 1/15-21 Ralph Black Drive Nth Wollongong NSW 2500
Ph 02 4225 3125 E. wollongong@alsglobal.com

CLIENT: Eco Logical Australia		TURNAROUND REQUIREMENTS : ☒ Standard TAT (List due date):		FOR LABORATORY USE ONLY (Circle)	
OFFICE: Brisbane		(Standard TAT may be longer for some tests e.g. Ultra Trace Organics)		Custody Seal intact? Yes No N/A	
PROJECT: Inland Rail - Border to Gowrie EIS		PROJECT NO 10558		Free ice / frozen ice bricks present upon receipt? Yes No N/A	
ORDER NUMBER:		PURCHASE ORDER NO:		Random Sample Temperature on Receipt: °C	
PROJECT MANAGER: Miles Yeates		CONTACT PH: 0467 738 954		Other comment:	
SAMPLER: David Moore and Peter Hancock		SAMPLER MOBILE:		RECEIVED BY: DAME R	
COC Emailed to ALS? (YES / NO)		EDD FORMAT (or default):		DATE/TIME: 15/6/18 3pm	
Email Reports to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au		RELINQUISHED BY: [Signature]		DATE/TIME: 15/6/18 1500	
Email Invoice to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au		DATE/TIME: 15/6/18 3pm		DATE/TIME: 15/6/18 1500	

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB: Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).										Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA020-EC-P Conductivity and Salinity	EA025H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-8A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TNX, NOx, Reactive P and Total P	EK060 Organic Nitrogen	W-2 Dissolved metals - 8 metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn and Hg) - samples are field filtered	EP075B SIM PAHs (16 analytes)	ophyll a filter paper	Environmental Division Brisbane Work Order Reference EB1814632  Telephone: +61 7 3243 7222		
1	Site 14	13/6/18 noon	W		4	X	X	X	X	X	X	X				
2	Site 42	12/6/18 noon	W		4	X	X	X	X	X	X	X				
3	Site 40	12/6/18 noon	W		4	X	X	X	X	X	X	X				
4	Site 39	12/6/18 noon	W		4	X	X	X	X	X	X	X				
5	Site 30	14/6/18 noon	W		4	X	X	X	X	X	X	X				
6	Site 27	15/6/18 noon	W		4	X	X	X	X	X	X	X				
7	Site 16	13/6/18 noon	W		4	X	X	X	X	X	X	X				
TOTAL					28											

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CERTIFICATE OF ANALYSIS

Work Order	: EB1814632	Page	: 1 of 7
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Contact	: Customer Services EB
Address	: PO BOX 1422	Address	: 2 Byth Street Stafford QLD Australia 4053
	FORTITUDE VALLEY QLD 4006		
Telephone	: +61 02 8536 8667	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 15-Jun-2018 15:00
Order number	: ---	Date Analysis Commenced	: 15-Jun-2018
C-O-C number	: ---	Issue Date	: 21-Jun-2018 16:58
Sampler	: DAVID MOORE and PETER HANCOCK		
Site	: ---		
Quote number	: BN/142/18 V2		
No. of samples received	: 7		
No. of samples analysed	: 7		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Senior Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP075(SIM): Matrix spike shows poor recovery. Insufficient sample for re-extraction and re-analysis.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 14	Site 42	Site 40	Site 39	Site 30
Client sampling date / time				13-Jun-2018 00:00	12-Jun-2018 00:00	12-Jun-2018 00:00	12-Jun-2018 00:00	14-Jun-2018 00:00	
Compound	CAS Number	LOR	Unit	EB1814632-001	EB1814632-002	EB1814632-003	EB1814632-004	EB1814632-005	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	207	1380	1380	2440	449	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.10	0.69	0.69	1.25	0.22	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	20	6	10	8	11	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	39	471	465	746	146	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	4	55	51	73	29	
Magnesium	7439-95-4	1	mg/L	7	81	82	137	18	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	
Nickel	7440-02-0	0.001	mg/L	0.001	0.002	0.002	0.004	0.003	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.25	0.02	0.02	0.04	0.02	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	1.25	<0.01	0.51	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	1.25	<0.01	0.52	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	1.0	0.2	0.3	0.3	0.5	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.2	0.2	0.3	0.3	0.5	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 14	Site 42	Site 40	Site 39	Site 30
Client sampling date / time					13-Jun-2018 00:00	12-Jun-2018 00:00	12-Jun-2018 00:00	12-Jun-2018 00:00	14-Jun-2018 00:00
Compound	CAS Number	LOR	Unit		EB1814632-001	EB1814632-002	EB1814632-003	EB1814632-004	EB1814632-005
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		1.2	1.4	0.3	0.8	0.5
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.03	0.01	0.02	0.02	0.07
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		26.6	29.0	25.7	26.1	29.8
2-Chlorophenol-D4	93951-73-6	1.0	%		74.9	74.4	69.9	69.2	76.1
2,4,6-Tribromophenol	118-79-6	1.0	%		61.2	52.6	48.6	46.4	52.2
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		79.1	78.2	75.7	79.4	82.1
Anthracene-d10	1719-06-8	1.0	%		105	103	95.9	101	108
4-Terphenyl-d14	1718-51-0	1.0	%		104	105	101	107	120

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 27	Site 16	----	----	----
Client sampling date / time				15-Jun-2018 00:00	13-Jun-2018 00:00	----	----	----	
Compound	CAS Number	LOR	Unit	EB1814632-006	EB1814632-007	-----	-----	-----	
				Result	Result	----	----	----	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	582	225	----	----	----	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.28	0.11	----	----	----	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	28	32	----	----	----	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	199	51	----	----	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	40	14	----	----	----	
Magnesium	7439-95-4	1	mg/L	24	4	----	----	----	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	----	----	----	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----	
Copper	7440-50-8	0.001	mg/L	0.002	<0.001	----	----	----	
Nickel	7440-02-0	0.001	mg/L	0.006	0.001	----	----	----	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	----	----	----	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.03	0.02	----	----	----	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	----	----	----	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	----	----	----	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.9	1.0	----	----	----	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.9	1.0	----	----	----	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 27	Site 16	----	----	----
Client sampling date / time					15-Jun-2018 00:00	13-Jun-2018 00:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1814632-006	EB1814632-007	-----	-----	-----
				Result	Result		----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N				----	0.1	mg/L	0.9	1.0	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P				----	0.01	mg/L	0.11	0.11	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P				14265-44-2	0.01	mg/L	<0.01	<0.01	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	----	----	----
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons				----	0.5	µg/L	<0.5	<0.5	----
^ Benzo(a)pyrene TEQ (zero)				----	0.5	µg/L	<0.5	<0.5	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6				13127-88-3	1.0	%	28.2	26.8	----
2-Chlorophenol-D4				93951-73-6	1.0	%	73.3	74.3	----
2,4,6-Tribromophenol				118-79-6	1.0	%	46.5	53.2	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl				321-60-8	1.0	%	84.1	82.7	----
Anthracene-d10				1719-06-8	1.0	%	103	101	----
4-Terphenyl-d14				1718-51-0	1.0	%	115	113	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1814632	Page	: 1 of 10
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 15-Jun-2018
Site	: ----	Issue Date	: 21-Jun-2018
Sampler	: DAVID MOORE and PETER HANCOCK	No. of samples received	: 7
Order number	:	No. of samples analysed	: 7

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.

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 Work Order : EB1814632
 Client : ECO LOGICAL AUSTRALIA PTY LTD
 Project : 10558 Inland Rail - Border to Gowrie EIS



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK055G: Ammonia as N by Discrete Analyser	EB1814627--002	Anonymous	Ammonia as N	7664-41-7	Not Determined	----	MS recovery not determined, background level greater than or equal to 4x spike level.

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural							
Site 42, Site 39	Site 40,	----	----	----	15-Jun-2018	14-Jun-2018	1
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural							
Site 42, Site 39	Site 40,	----	----	----	15-Jun-2018	14-Jun-2018	1

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	0	11	0.00	10.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	19-Jun-2018	10-Jul-2018	✓
Clear Plastic Bottle - Natural (EA010-P) Site 14,	Site 16	13-Jun-2018	----	----	----	19-Jun-2018	11-Jul-2018	✓
Clear Plastic Bottle - Natural (EA010-P) Site 30		14-Jun-2018	----	----	----	19-Jun-2018	12-Jul-2018	✓
Clear Plastic Bottle - Natural (EA010-P) Site 27		15-Jun-2018	----	----	----	19-Jun-2018	13-Jul-2018	✓
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	19-Jun-2018	19-Jun-2018	✓
Clear Plastic Bottle - Natural (EA025H) Site 14,	Site 16	13-Jun-2018	----	----	----	19-Jun-2018	20-Jun-2018	✓
Clear Plastic Bottle - Natural (EA025H) Site 30		14-Jun-2018	----	----	----	19-Jun-2018	21-Jun-2018	✓
Clear Plastic Bottle - Natural (EA025H) Site 27		15-Jun-2018	----	----	----	19-Jun-2018	22-Jun-2018	✓
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	20-Jun-2018	10-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 14,	Site 16	13-Jun-2018	----	----	----	20-Jun-2018	11-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 30		14-Jun-2018	----	----	----	20-Jun-2018	12-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 27		15-Jun-2018	----	----	----	20-Jun-2018	13-Jul-2018	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	20-Jun-2018	10-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 14,	Site 16	13-Jun-2018	----	----	----	20-Jun-2018	11-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 30		14-Jun-2018	----	----	----	20-Jun-2018	12-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 27		15-Jun-2018	----	----	----	20-Jun-2018	13-Jul-2018	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	20-Jun-2018	09-Dec-2018	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 14,	Site 16	13-Jun-2018	----	----	----	20-Jun-2018	10-Dec-2018	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 30		14-Jun-2018	----	----	----	20-Jun-2018	11-Dec-2018	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 27		15-Jun-2018	----	----	----	20-Jun-2018	12-Dec-2018	✔
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	20-Jun-2018	10-Jul-2018	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 14,	Site 16	13-Jun-2018	----	----	----	20-Jun-2018	11-Jul-2018	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 30		14-Jun-2018	----	----	----	20-Jun-2018	12-Jul-2018	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 27		15-Jun-2018	----	----	----	20-Jun-2018	13-Jul-2018	✔
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	18-Jun-2018	10-Jul-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 14,	Site 16	13-Jun-2018	----	----	----	18-Jun-2018	11-Jul-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 30		14-Jun-2018	----	----	----	18-Jun-2018	12-Jul-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 27		15-Jun-2018	----	----	----	18-Jun-2018	13-Jul-2018	✔
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	15-Jun-2018	14-Jun-2018	✖
Clear Plastic Bottle - Natural (EK057G) Site 14,	Site 16	13-Jun-2018	----	----	----	15-Jun-2018	15-Jun-2018	✔
Clear Plastic Bottle - Natural (EK057G) Site 30		14-Jun-2018	----	----	----	15-Jun-2018	16-Jun-2018	✔
Clear Plastic Bottle - Natural (EK057G) Site 27		15-Jun-2018	----	----	----	15-Jun-2018	17-Jun-2018	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	18-Jun-2018	10-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 14,	Site 16	13-Jun-2018	----	----	----	18-Jun-2018	11-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 30		14-Jun-2018	----	----	----	18-Jun-2018	12-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 27		15-Jun-2018	----	----	----	18-Jun-2018	13-Jul-2018	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 42, Site 39	Site 40,	12-Jun-2018	19-Jun-2018	10-Jul-2018	✓	19-Jun-2018	10-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 14,	Site 16	13-Jun-2018	19-Jun-2018	11-Jul-2018	✓	19-Jun-2018	11-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 30		14-Jun-2018	19-Jun-2018	12-Jul-2018	✓	19-Jun-2018	12-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 27		15-Jun-2018	19-Jun-2018	13-Jul-2018	✓	19-Jun-2018	13-Jul-2018	✓
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 42, Site 39	Site 40,	12-Jun-2018	19-Jun-2018	10-Jul-2018	✓	19-Jun-2018	10-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 14,	Site 16	13-Jun-2018	19-Jun-2018	11-Jul-2018	✓	19-Jun-2018	11-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 30		14-Jun-2018	19-Jun-2018	12-Jul-2018	✓	19-Jun-2018	12-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 27		15-Jun-2018	19-Jun-2018	13-Jul-2018	✓	19-Jun-2018	13-Jul-2018	✓
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	15-Jun-2018	14-Jun-2018	✗
Clear Plastic Bottle - Natural (EK071G) Site 14,	Site 16	13-Jun-2018	----	----	----	15-Jun-2018	15-Jun-2018	✓
Clear Plastic Bottle - Natural (EK071G) Site 30		14-Jun-2018	----	----	----	15-Jun-2018	16-Jun-2018	✓
Clear Plastic Bottle - Natural (EK071G) Site 27		15-Jun-2018	----	----	----	15-Jun-2018	17-Jun-2018	✓

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 Work Order : EB1814632
 Client : ECO LOGICAL AUSTRALIA PTY LTD
 Project : 10558 Inland Rail - Border to Gowrie EIS



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 42, Site 39	Site 40, 12-Jun-2018	19-Jun-2018	19-Jun-2018	✔	20-Jun-2018	29-Jul-2018	✔	
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 14,	Site 16, 13-Jun-2018	19-Jun-2018	20-Jun-2018	✔	20-Jun-2018	29-Jul-2018	✔	
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 30	14-Jun-2018	19-Jun-2018	21-Jun-2018	✔	20-Jun-2018	29-Jul-2018	✔	
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 27	15-Jun-2018	19-Jun-2018	22-Jun-2018	✔	20-Jun-2018	29-Jul-2018	✔	



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	16	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	19	10.53	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	3	26	11.54	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	8	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	7	28.57	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	11	0.00	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	7	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	16	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	26	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	7	28.57	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	26	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	26	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	7	14.29	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	11	9.09	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	14.29	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH ₃) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH ₃ . This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO ₃ -. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.



CHAIN OF CUSTODY

ALS Laboratory: please tick →

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PERTH 10111 Way Malaga WA 6060
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Environmental Division
Brisbane

Work Order Reference

EB1814715

2500

N/A
N/A6.7°
5.7°

Brisbane - 81-7-3243 7222

CLIENT: Eco Logical Australia		TURNAROUND REQUIREMENTS : ☒ Standard TAT (List due date):		F C F R C
OFFICE: Brisbane		(Standard TAT may be longer for some tests e.g. Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):		
PROJECT: Inland Rail - Border to Gowrie EIS	PROJECT NO: 10558	ALS QUOTE NO.: BN/142/18 V2		
ORDER NUMBER:	PURCHASE ORDER NO.:	COUNTRY OF ORIGIN: Australia		
PROJECT MANAGER: Miles Yeates		CONTACT PH: 0487 738 954		
SAMPLER: David Moore and Loren Appleby		SAMPLER MOBILE:		
COC Emailed to ALS? (YES / NO)		EDD FORMAT (or default):		
Email Reports to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au		DATE/TIME: 18		
Email Invoice to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au		RECEIVED BY: Jess H		RELIN
		DATE/TIME: 18/6/18 1.40		DATE/

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	FA020-FC-P Conductivity and Salinity	EA026H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-8A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TN, NOx, Reactive P and Total P	EK048 Organic Nitrogen	W-2 Dissolved metals - 8 metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn and Hg) - samples are field filtered	EP075B SIM PAHs (16 analytes)	EP006 Chlorophyll a (filter paper method)	
1	Site 14	13/6/18 noon	W		1								X	Chl a: vol filtered 1,000 mL
2	Site 42	12/6/18 noon	W		1								X	Chl a: vol filtered 1,000 mL
3	Site 40	12/6/18 noon	W		1								X	Chl a: vol filtered 1,000 mL
4	Site 39	12/6/18 noon	W		1								X	Chl a: vol filtered 1,000 mL
5	Site 30	14/6/18 noon	W		1								X	Chl a: vol filtered 600 mL
6	Site 27	15/6/18 noon	W		1								X	Chl a: vol filtered 425 mL
7	Site 16	13/6/18 noon	W		1								X	Chl a: vol filtered 275 mL
8	Site 1R	16/6/18 noon	W		5	X	X	X	X	X	X	X	X	Chl a: vol filtered 500 mL
9	Site 2R	16/6/18 noon	W		5	X	X	X	X	X	X	X	X	Chl a: vol filtered 800 mL
10	Site 3	17/6/18 noon	W		5	X	X	X	X	X	X	X	X	Chl a: vol filtered 600 mL
11	Site 6	16/6/18 noon	W		5	X	X	X	X	X	X	X	X	Chl a: vol filtered 475 mL
12	Site 7	17/6/18 noon	W		5	X	X	X	X	X	X	X	X	Chl a: vol filtered 600 mL
13	Site 11	15/6/18 noon	W		5	X	X	X	X	X	X	X	X	Chl a: vol filtered 400 mL
14	DUP	16/6/18 noon	W		6	X	X	X	X	X	X	X		Duplicate of another site. 2 extra lab QA/QC amber bottles from this site.
15	FB	16/6/18 noon	W		4	X	X	X	X	X	X	X		Field blank sample
16	Site 24	18/6/18 noon	W		6	X	X	X	X	X	X	X	X	Chl a: vol filtered 250 mL
TOTAL														

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/OC Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airtight Unpreserved Plastic;

V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airtight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; Li = Lucas Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CERTIFICATE OF ANALYSIS

Work Order : **EB1814715**
Client : **ECO LOGICAL AUSTRALIA PTY LTD**
Contact : **MILES YEATES**
Address : **PO BOX 1422**
FORTITUDE VALLEY QLD 4006
Telephone : **+61 02 8536 8667**
Project : **10558 Inland Rail - Border to Gowrie EIS**
Order number :
C-O-C number :
Sampler : **David Moore and Loren Appleby**
Site :
Quote number : **BN/142/18 V2**
No. of samples received : **16**
No. of samples analysed : **16**

Page : 1 of 13
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 18-Jun-2018 13:40
Date Analysis Commenced : 19-Jun-2018
Issue Date : 22-Jun-2018 16:47



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP008 (Chlorophyll): The LOR has been raised due to the volume of filtered sample recieved
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 14	Site 42	Site 40	Site 39	Site 30
Client sampling date / time					13-Jun-2018 12:00	12-Jun-2018 12:00	12-Jun-2018 12:00	12-Jun-2018 12:00	14-Jun-2018 12:00
Compound	CAS Number	LOR	Unit		EB1814715-001	EB1814715-002	EB1814715-003	EB1814715-004	EB1814715-005
					Result	Result	Result	Result	Result
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		<1	<1	<1	<1	<2
Volume	----	0.01	L		1	1	1	1	.6

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 27	Site 16	Site 1R	Site 2R	Site 3
Client sampling date / time				15-Jun-2018 12:00	13-Jun-2018 12:00	16-Jun-2018 12:00	16-Jun-2018 12:00	17-Jun-2018 12:00	
Compound	CAS Number	LOR	Unit	EB1814715-006	EB1814715-007	EB1814715-008	EB1814715-009	EB1814715-010	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	----	----	298	251	410	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	----	----	0.14	0.12	0.20	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	----	----	28	<5	<5	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	----	----	78	58	69	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	----	----	13	10	11	
Magnesium	7439-95-4	1	mg/L	----	----	11	8	10	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	----	----	0.002	0.002	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	----	----	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	----	----	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	----	----	<0.001	<0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	----	----	0.002	0.002	<0.001	
Lead	7439-92-1	0.001	mg/L	----	----	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	----	----	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	----	----	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	----	----	0.02	0.02	0.04	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	----	----	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	----	----	<0.01	<0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	----	----	<0.01	<0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	----	----	0.6	0.5	0.8	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	----	----	0.6	0.5	0.8	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 27	Site 16	Site 1R	Site 2R	Site 3
Client sampling date / time					15-Jun-2018 12:00	13-Jun-2018 12:00	16-Jun-2018 12:00	16-Jun-2018 12:00	17-Jun-2018 12:00
Compound	CAS Number	LOR	Unit		EB1814715-006	EB1814715-007	EB1814715-008	EB1814715-009	EB1814715-010
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		----	----	0.6	0.5	0.8
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		----	----	0.10	0.05	0.04
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		----	----	<0.01	0.01	<0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		5	<4	<2	<1	<2
Volume	----	0.01	L		.425	.275	.5	.8	.6
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		----	----	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		----	----	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		----	----	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		----	----	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		----	----	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		----	----	23.5	24.4	25.2
2-Chlorophenol-D4	93951-73-6	1.0	%		----	----	66.8	67.9	69.3
2,4,6-Tribromophenol	118-79-6	1.0	%		----	----	43.0	39.7	39.2
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		----	----	76.3	80.3	80.7
Anthracene-d10	1719-06-8	1.0	%		----	----	77.6	78.4	77.2



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 27	Site 16	Site 1R	Site 2R	Site 3
Client sampling date / time					15-Jun-2018 12:00	13-Jun-2018 12:00	16-Jun-2018 12:00	16-Jun-2018 12:00	17-Jun-2018 12:00
Compound	CAS Number	LOR	Unit		EB1814715-006	EB1814715-007	EB1814715-008	EB1814715-009	EB1814715-010
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		----	----	86.2	91.6	90.0

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 6	Site 7	Site 11	DUP	FB
Client sampling date / time				16-Jun-2018 12:00	17-Jun-2018 12:00	15-Jun-2018 12:00	16-Jun-2018 12:00	16-Jun-2018 12:00	
Compound	CAS Number	LOR	Unit	EB1814715-011	EB1814715-012	EB1814715-013	EB1814715-014	EB1814715-015	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	352	356	315	352	2	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.17	0.17	0.15	0.17	0.01	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	20	18	15	11	<5	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	55	60	56	60	<1	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	9	9	11	9	<1	
Magnesium	7439-95-4	1	mg/L	8	9	7	9	<1	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	0.001	0.001	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.03	0.04	0.02	0.04	<0.01	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.05	0.15	0.02	0.05	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.05	0.15	0.02	0.05	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.8	0.9	0.9	0.8	<0.1	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.8	0.9	0.9	0.8	<0.1	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 6	Site 7	Site 11	DUP	FB
Client sampling date / time					16-Jun-2018 12:00	17-Jun-2018 12:00	15-Jun-2018 12:00	16-Jun-2018 12:00	16-Jun-2018 12:00
Compound	CAS Number	LOR	Unit		EB1814715-011	EB1814715-012	EB1814715-013	EB1814715-014	EB1814715-015
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.8	1.0	0.9	0.8	<0.1
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.04	0.04	0.06	0.03	0.01
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		<2	<2	<2	----	----
Volume	----	0.01	L		.475	.6	.4	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		23.2	20.2	21.0	22.4	21.7
2-Chlorophenol-D4	93951-73-6	1.0	%		63.0	57.2	58.6	64.5	61.7
2,4,6-Tribromophenol	118-79-6	1.0	%		36.0	32.4	32.8	36.2	36.9
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		73.6	70.4	71.2	78.6	68.2
Anthracene-d10	1719-06-8	1.0	%		72.6	68.3	69.3	78.5	69.2



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 6	Site 7	Site 11	DUP	FB
Client sampling date / time					16-Jun-2018 12:00	17-Jun-2018 12:00	15-Jun-2018 12:00	16-Jun-2018 12:00	16-Jun-2018 12:00
Compound	CAS Number	LOR	Unit		EB1814715-011	EB1814715-012	EB1814715-013	EB1814715-014	EB1814715-015
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		85.1	78.9	82.4	94.3	85.0

Sub-Matrix: WATER (Matrix: WATER)		Client sample ID		Site 24	----	----	----	----
Client sampling date / time				18-Jun-2018 12:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EB1814715-016	-----	-----	-----	-----
				Result	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	339	----	----	----	----
EA020EC: Salinity								
Salinity	----	0.01	g/kg	0.16	----	----	----	----
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	98	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	80	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	14	----	----	----	----
Magnesium	7439-95-4	1	mg/L	11	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	0.005	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	0.04	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser								
Organic Nitrogen as N	----	0.1	mg/L	0.5	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.5	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	----	----	----	----
Client sampling date / time					18-Jun-2018 12:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1814715-016	-----	-----	-----	-----
				Result	----	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.5	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.07	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	----	----	----	----
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		<4	----	----	----	----
Volume	----	0.01	L		.25	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	----	----	----	----
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	----	----	----	----
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	----	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		21.2	----	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%		60.3	----	----	----	----
2,4,6-Tribromophenol	118-79-6	1.0	%		32.3	----	----	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		72.2	----	----	----	----
Anthracene-d10	1719-06-8	1.0	%		72.1	----	----	----	----

Page : 12 of 13
 Work Order : EB1814715
 Client : ECO LOGICAL AUSTRALIA PTY LTD
 Project : 10558 Inland Rail - Border to Gowie EIS



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	---	---	---	---
				Client sampling date / time	18-Jun-2018 12:00	---	---	---	---
Compound	CAS Number	LOR	Unit		EB1814715-016	-----	-----	-----	-----
					Result	---	---	---	---
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		82.4	---	---	---	---



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1814715	Page	: 1 of 10
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 18-Jun-2018
Site	:	Issue Date	: 22-Jun-2018
Sampler	: David Moore and Loren Appleby	No. of samples received	: 16
Order number	:	No. of samples analysed	: 16

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural Site 11	----	----	----	19-Jun-2018	17-Jun-2018	2
Clear Plastic Bottle - Natural Site 1R, Site 6, FB Site 2R, DUP,	----	----	----	19-Jun-2018	18-Jun-2018	1
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural Site 11	----	----	----	19-Jun-2018	17-Jun-2018	2
Clear Plastic Bottle - Natural Site 1R, Site 6, FB Site 2R, DUP,	----	----	----	19-Jun-2018	18-Jun-2018	1

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	1	20	5.00	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
PAH/Phenols (GC/MS - SIM)	0	20	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
Container / Client Sample ID(s)							



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation				Analysis	
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Site 11		15-Jun-2018	----	----	----	21-Jun-2018	13-Jul-2018	✓
Clear Plastic Bottle - Natural (EA010-P) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	21-Jun-2018	14-Jul-2018	✓
Clear Plastic Bottle - Natural (EA010-P) Site 3,	Site 7	17-Jun-2018	----	----	----	21-Jun-2018	15-Jul-2018	✓
Clear Plastic Bottle - Natural (EA010-P) Site 24		18-Jun-2018	----	----	----	21-Jun-2018	16-Jul-2018	✓
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H) Site 11		15-Jun-2018	----	----	----	20-Jun-2018	22-Jun-2018	✓
Clear Plastic Bottle - Natural (EA025H) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	20-Jun-2018	23-Jun-2018	✓
Clear Plastic Bottle - Natural (EA025H) Site 3,	Site 7	17-Jun-2018	----	----	----	20-Jun-2018	24-Jun-2018	✓
Clear Plastic Bottle - Natural (EA025H) Site 24		18-Jun-2018	----	----	----	21-Jun-2018	25-Jun-2018	✓
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 11		15-Jun-2018	----	----	----	19-Jun-2018	13-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	19-Jun-2018	14-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	15-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	16-Jul-2018	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 11		15-Jun-2018	----	----	----	19-Jun-2018	13-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	19-Jun-2018	14-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	15-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	16-Jul-2018	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation				Analysis	
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 11		15-Jun-2018	----	----	----	19-Jun-2018	12-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	19-Jun-2018	13-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	14-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	15-Dec-2018	✓
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 11		15-Jun-2018	----	----	----	19-Jun-2018	13-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	19-Jun-2018	14-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	15-Jul-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	16-Jul-2018	✓
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 11		15-Jun-2018	----	----	----	19-Jun-2018	13-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	19-Jun-2018	14-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	15-Jul-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	16-Jul-2018	✓
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) Site 11		15-Jun-2018	----	----	----	19-Jun-2018	17-Jun-2018	✗
Clear Plastic Bottle - Natural (EK057G) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----	19-Jun-2018	18-Jun-2018	✗
Clear Plastic Bottle - Natural (EK057G) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	19-Jun-2018	✓
Clear Plastic Bottle - Natural (EK057G) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	20-Jun-2018	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Evaluation	Holding time (days)		Analysis	
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation		Date analysed	Due for analysis	Evaluation	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser										
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 11		15-Jun-2018	----	----	----		19-Jun-2018	13-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----		19-Jun-2018	14-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 3,	Site 7	17-Jun-2018	----	----	----		19-Jun-2018	15-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 24		18-Jun-2018	----	----	----		19-Jun-2018	16-Jul-2018	✓	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser										
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 11		15-Jun-2018	19-Jun-2018	13-Jul-2018	✓		19-Jun-2018	13-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	19-Jun-2018	14-Jul-2018	✓		19-Jun-2018	14-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 3,	Site 7	17-Jun-2018	19-Jun-2018	15-Jul-2018	✓		19-Jun-2018	15-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 24		18-Jun-2018	19-Jun-2018	16-Jul-2018	✓		19-Jun-2018	16-Jul-2018	✓	
EK067G: Total Phosphorus as P by Discrete Analyser										
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 11		15-Jun-2018	19-Jun-2018	13-Jul-2018	✓		19-Jun-2018	13-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	19-Jun-2018	14-Jul-2018	✓		19-Jun-2018	14-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 3,	Site 7	17-Jun-2018	19-Jun-2018	15-Jul-2018	✓		19-Jun-2018	15-Jul-2018	✓	
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 24		18-Jun-2018	19-Jun-2018	16-Jul-2018	✓		19-Jun-2018	16-Jul-2018	✓	
EK071G: Reactive Phosphorus as P by discrete analyser										
Clear Plastic Bottle - Natural (EK071G) Site 11		15-Jun-2018	----	----	----		19-Jun-2018	17-Jun-2018	✗	
Clear Plastic Bottle - Natural (EK071G) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	----	----	----		19-Jun-2018	18-Jun-2018	✗	
Clear Plastic Bottle - Natural (EK071G) Site 3,	Site 7	17-Jun-2018	----	----	----		19-Jun-2018	19-Jun-2018	✓	
Clear Plastic Bottle - Natural (EK071G) Site 24		18-Jun-2018	----	----	----		19-Jun-2018	20-Jun-2018	✓	



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EP008: Chlorophyll a & Pheophytin a								
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 42, Site 39	Site 40,	12-Jun-2018	----	----	----	19-Jun-2018	03-Jul-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 14,	Site 16	13-Jun-2018	----	----	----	19-Jun-2018	04-Jul-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 30		14-Jun-2018	----	----	----	19-Jun-2018	05-Jul-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 27,	Site 11	15-Jun-2018	----	----	----	19-Jun-2018	06-Jul-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 1R, Site 6	Site 2R,	16-Jun-2018	----	----	----	19-Jun-2018	07-Jul-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 3,	Site 7	17-Jun-2018	----	----	----	19-Jun-2018	08-Jul-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 24		18-Jun-2018	----	----	----	19-Jun-2018	09-Jul-2018	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 11		15-Jun-2018	20-Jun-2018	22-Jun-2018	✓	21-Jun-2018	30-Jul-2018	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 1R, Site 6, FB	Site 2R, DUP,	16-Jun-2018	20-Jun-2018	23-Jun-2018	✓	21-Jun-2018	30-Jul-2018	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 3,	Site 7	17-Jun-2018	20-Jun-2018	24-Jun-2018	✓	21-Jun-2018	30-Jul-2018	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 24		18-Jun-2018	20-Jun-2018	25-Jun-2018	✓	21-Jun-2018	30-Jul-2018	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	3	28	10.71	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	20	5.00	10.00	✖	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	11	18.18	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	4	35	11.43	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	11	9.09	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	4	35	11.43	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	28	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	11	9.09	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER** Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Suspended Solids (High Level)	EA025H	2	35	5.71	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	20	0.00	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	11	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH3) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH3. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Chlorophyll a and Pheophytin a	EP008	WATER	In house: Referenced to APHA 10200 H. The pigments are extracted into aqueous acetone. The optical density of the extract before and after acidification at both 664 nm and 665 nm is determined spectrometrically.
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.



CHAIN OF CUSTODY

ALS Laboratory: please tick →

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Environmental Division
Brisbane

Work Order Reference

EB1829378

N/A

N/A



Telephone : + 61-7-3243 7222

CLIENT: Eco Logical Australia		TURNAROUND REQUIREMENTS : ☐ Standard TAT (List due date):		FOR L Custody Free for receipt Random Other
OFFICE: Brisbane		(Standard TAT may be longer for some tests e.g. Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):		
PROJECT: Inland Rail - Border to Gowrie EIS	PROJECT NO: 10558	ALS QUOTE NO.: BN/142/18 V2		COC SEQUENCE NUMBER (Circle)
ORDER NUMBER:	PURCHASE ORDER NO.:	COUNTRY OF ORIGIN: Australia		COC: 1 2 3 4 5 6 7
PROJECT MANAGER: Miles Yeates	CONTACT PH: 0467 738 954		OF: 1 2 3 4 5 6 7	Other
SAMPLER: David Moore and Peter Hancock	SAMPLER MOBILE:		RELINQUISHED BY: <i>[Signature]</i>	RECEIVED BY: <i>[Signature]</i>
COC Emailed to ALS? (YES / NO)	EDD FORMAT (or default):		DATE/TIME: 11:50am 30/11/18	DATE/TIME: 30/11/18 1245
Email Reports to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au				
Email Invoice to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au				

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY		SAMPLE DETAILS MATRIX: Solid(S) Water(W)		CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered; bottle required) or Dissolved (field filtered bottle required)								Additional information	
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA000-EC-P Conductivity and Salinity	EA008H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-5A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TN, NOx, Reactive P and Total P	EK000 Organic Nitrogen	W-2 Dissolved metals - 8 metals suite (As, Cu, Cr, Ni, Pb, Zn and Hg) - samples are field filtered	EP076B SIM PAHs (16 analytes)	EP006 Chlorophyll a (filter paper method)		
1	Site 14	29/11/18	W		4	X	X	X	X	X	X	X			
2	Site 2R	27/11/18	W		4	X	X	X	X	X	X	X			
3	Site 2	29/11/18	W		4	X	X	X	X	X	X	X			
4	Site 16	28/11/18	W		4	X	X	X	X	X	X	X			
5	Site 11	28/11/18	W		4	X	X	X	X	X	X	X			
6	Site 3	27/11/18	W		4	X	X	X	X	X	X	X			
7	DUP	27/11/18	W		6	X	X	X	X	X	X	X		2 QA/QC Amber bottles	
8	FB	29/11/18	W		4	X	X	X	X	X	X	X			
9	Site 6	27/11/18	W		4	X	X	X	X	X	X	X			
10	Site 33	26/11/18	W		4	X	X	X	X	X	X	X			
11	Site 7	27/11/18	W		4	X	X	X	X	X	X	X			
TOTAL					46										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cu Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic

V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; V6 = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl Preserved Plastic; HS = Sulfuric Preserved Plastic; SP = Sulfuric Preserved Plastic; F = Fomahydroxy Preserved Glass

Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Solids; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottle; STT = Sterile Sodium Thiosulfate Preserved Bottles

CERTIFICATE OF ANALYSIS

Work Order : **EB1829378**
Client : **ECO LOGICAL AUSTRALIA PTY LTD**
Contact : **MILES YEATES**
Address : **PO BOX 1422**
FORTITUDE VALLEY QLD 4006
Telephone : **+61 02 8536 8667**
Project : **Inland Rail - Border to Gowrie EIS**
Order number : **10558**
C-O-C number : **---**
Sampler : **DAVID MOORE, PETER HANCOCK**
Site :
Quote number : **BN/142/18 V2**
No. of samples received : **11**
No. of samples analysed : **11**

Page : 1 of 9
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 30-Nov-2018 12:45
Date Analysis Commenced : 01-Dec-2018
Issue Date : 07-Dec-2018 08:35



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP075(SIM): Matrix spike shows poor recovery. Insufficient sample for re-extraction and re-analysis.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	14	2R	2	16	11
Client sampling date / time				29-Nov-2018 00:00	27-Nov-2018 00:00	29-Nov-2018 00:00	28-Nov-2018 00:00	28-Nov-2018 00:00	
Compound	CAS Number	LOR	Unit	EB1829378-001	EB1829378-002	EB1829378-003	EB1829378-004	EB1829378-005	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	232	214	213	359	274	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.11	0.10	0.10	0.17	0.13	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	<5	43	27	56	14	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	50	67	71	100	57	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	5	12	12	27	13	
Magnesium	7439-95-4	1	mg/L	9	9	10	8	6	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.001	0.003	0.003	0.001	0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.002	0.002	<0.001	
Nickel	7440-02-0	0.001	mg/L	0.001	0.002	0.002	0.002	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	<0.01	0.06	<0.01	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.02	<0.01	0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.02	<0.01	0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.7	0.5	0.5	1.3	1.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.7	0.5	0.5	1.4	1.2	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	14	2R	2	16	11
Client sampling date / time					29-Nov-2018 00:00	27-Nov-2018 00:00	29-Nov-2018 00:00	28-Nov-2018 00:00	28-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1829378-001	EB1829378-002	EB1829378-003	EB1829378-004	EB1829378-005
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.7	0.5	0.5	1.4	1.2
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.03	0.15	0.12	0.17	0.11
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	0.04	0.04	<0.01	<0.01
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		28.7	26.6	21.4	22.9	20.0
2-Chlorophenol-D4	93951-73-6	1.0	%		76.6	69.6	62.1	61.7	55.8
2,4,6-Tribromophenol	118-79-6	1.0	%		58.3	52.3	47.0	44.7	42.0
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		97.9	73.9	85.2	82.1	75.9
Anthracene-d10	1719-06-8	1.0	%		95.9	90.7	80.6	79.9	74.3
4-Terphenyl-d14	1718-51-0	1.0	%		115	93.3	97.0	93.7	89.0

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	3	DUP	FB	6	33
Client sampling date / time				27-Nov-2018 00:00	27-Nov-2018 00:00	29-Nov-2018 00:00	27-Nov-2018 00:00	26-Nov-2018 00:00	
Compound	CAS Number	LOR	Unit	EB1829378-006	EB1829378-007	EB1829378-008	EB1829378-009	EB1829378-010	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	386	388	<1	411	198	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.19	0.19	<0.01	0.20	0.10	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	<5	<5	<5	14	15	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	76	76	<1	79	59	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	14	14	<1	15	12	
Magnesium	7439-95-4	1	mg/L	10	10	<1	10	7	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	<0.001	0.002	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.001	<0.001	<0.001	<0.001	0.004	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.008	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	0.03	<0.01	0.03	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.01	<0.01	<0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.6	0.7	<0.1	0.7	1.0	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.6	0.7	<0.1	0.7	1.0	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	3	DUP	FB	6	33
Client sampling date / time					27-Nov-2018 00:00	27-Nov-2018 00:00	29-Nov-2018 00:00	27-Nov-2018 00:00	26-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1829378-006	EB1829378-007	EB1829378-008	EB1829378-009	EB1829378-010
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.6	0.7	<0.1	0.7	1.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.04	0.04	<0.01	0.05	0.23
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	0.05
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		23.5	29.6	24.3	26.0	26.8
2-Chlorophenol-D4	93951-73-6	1.0	%		63.3	73.6	67.7	70.0	65.3
2,4,6-Tribromophenol	118-79-6	1.0	%		48.8	55.2	54.2	53.8	57.6
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		68.3	71.5	81.2	73.9	76.1
Anthracene-d10	1719-06-8	1.0	%		88.1	89.0	76.0	107	84.0
4-Terphenyl-d14	1718-51-0	1.0	%		91.0	92.2	92.2	110	88.1

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	7	---	---	---	---
Client sampling date / time				27-Nov-2018 00:00	---	---	---	---	
Compound	CAS Number	LOR	Unit	EB1829378-011	-----	-----	-----	-----	
				Result	---	---	---	---	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	416	---	---	---	---	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.20	---	---	---	---	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	9	---	---	---	---	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	79	---	---	---	---	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	15	---	---	---	---	
Magnesium	7439-95-4	1	mg/L	10	---	---	---	---	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	---	---	---	---	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	---	---	---	---	
Chromium	7440-47-3	0.001	mg/L	<0.001	---	---	---	---	
Copper	7440-50-8	0.001	mg/L	<0.001	---	---	---	---	
Nickel	7440-02-0	0.001	mg/L	<0.001	---	---	---	---	
Lead	7439-92-1	0.001	mg/L	<0.001	---	---	---	---	
Zinc	7440-66-6	0.005	mg/L	<0.005	---	---	---	---	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	---	---	---	---	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	<0.01	---	---	---	---	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	---	---	---	---	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.02	---	---	---	---	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.02	---	---	---	---	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.7	---	---	---	---	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.7	---	---	---	---	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	7	----	----	----	----
Client sampling date / time					27-Nov-2018 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		EB1829378-011	-----	-----	-----	-----
Result					----	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.7	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.06	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	----	----	----	----
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	----	----	----	----
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	----	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		29.3	----	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%		71.8	----	----	----	----
2,4,6-Tribromophenol	118-79-6	1.0	%		54.4	----	----	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		71.9	----	----	----	----
Anthracene-d10	1719-06-8	1.0	%		90.6	----	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%		96.2	----	----	----	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1829378	Page	: 1 of 11
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: Inland Rail - Border to Gowrie EIS	Date Samples Received	: 30-Nov-2018
Site	:	Issue Date	: 07-Dec-2018
Sampler	: DAVID MOORE, PETER HANCOCK	No. of samples received	: 11
Order number	: 10558	No. of samples analysed	: 11

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.

Page : 2 of 11
 Work Order : EB1829378
 Client : ECO LOGICAL AUSTRALIA PTY LTD
 Project : Inland Rail - Border to Gowrie EIS



Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons	EB1829378--007	DUP	Acenaphthene	83-32-9	60.5 %	70-130%	Recovery less than lower data quality objective

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural 33		----	----	----	01-Dec-2018	28-Nov-2018	3
Clear Plastic Bottle - Natural 2R, DUP, 7		3, 6,	----	----	01-Dec-2018	29-Nov-2018	2
Clear Plastic Bottle - Natural 16,		11	----	----	01-Dec-2018	30-Nov-2018	1
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural 33		----	----	----	01-Dec-2018	28-Nov-2018	3
Clear Plastic Bottle - Natural 2R, DUP, 7		3, 6,	----	----	01-Dec-2018	29-Nov-2018	2
Clear Plastic Bottle - Natural 16,		11	----	----	01-Dec-2018	30-Nov-2018	1

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Method					
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	3	33	9.09	10.00	NEPM 2013 B3 & ALS QC Standard



Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P)		26-Nov-2018	----	----	----	03-Dec-2018	24-Dec-2018	✔
33								
Clear Plastic Bottle - Natural (EA010-P)		27-Nov-2018	----	----	----	03-Dec-2018	25-Dec-2018	✔
2R,	3,							
DUP,	6,							
7								
Clear Plastic Bottle - Natural (EA010-P)		28-Nov-2018	----	----	----	03-Dec-2018	26-Dec-2018	✔
16,	11							
Clear Plastic Bottle - Natural (EA010-P)		29-Nov-2018	----	----	----	03-Dec-2018	27-Dec-2018	✔
14,	2,							
FB								
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H)		26-Nov-2018	----	----	----	03-Dec-2018	03-Dec-2018	✔
33								
Clear Plastic Bottle - Natural (EA025H)		27-Nov-2018	----	----	----	03-Dec-2018	04-Dec-2018	✔
2R,	3,							
DUP,	6,							
7								
Clear Plastic Bottle - Natural (EA025H)		28-Nov-2018	----	----	----	03-Dec-2018	05-Dec-2018	✔
16,	11							
Clear Plastic Bottle - Natural (EA025H)		29-Nov-2018	----	----	----	03-Dec-2018	06-Dec-2018	✔
14,	2,							
FB								



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 33		26-Nov-2018	----	----	----	04-Dec-2018	24-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 2R, 3, DUP, 6, 7		27-Nov-2018	----	----	----	04-Dec-2018	25-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 16, 11		28-Nov-2018	----	----	----	04-Dec-2018	26-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 14, 2, FB		29-Nov-2018	----	----	----	04-Dec-2018	27-Dec-2018	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 33		26-Nov-2018	----	----	----	04-Dec-2018	24-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 2R, 3, DUP, 6, 7		27-Nov-2018	----	----	----	04-Dec-2018	25-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 16, 11		28-Nov-2018	----	----	----	04-Dec-2018	26-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) 14, 2, FB		29-Nov-2018	----	----	----	04-Dec-2018	27-Dec-2018	✓
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) 33		26-Nov-2018	----	----	----	04-Dec-2018	25-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) 2R, 3, DUP, 6, 7		27-Nov-2018	----	----	----	04-Dec-2018	26-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) 16, 11		28-Nov-2018	----	----	----	04-Dec-2018	27-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) 14, 2, FB		29-Nov-2018	----	----	----	04-Dec-2018	28-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) 33	26-Nov-2018	----	----	----	04-Dec-2018	24-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) 2R, 3, DUP, 6, 7	27-Nov-2018	----	----	----	04-Dec-2018	25-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) 16, 11	28-Nov-2018	----	----	----	04-Dec-2018	26-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) 14, 2, FB	29-Nov-2018	----	----	----	04-Dec-2018	27-Dec-2018	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK055G) 33	26-Nov-2018	----	----	----	01-Dec-2018	24-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) 2R, 3, DUP, 6, 7	27-Nov-2018	----	----	----	01-Dec-2018	25-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) 16, 11	28-Nov-2018	----	----	----	01-Dec-2018	26-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) 14, 2, FB	29-Nov-2018	----	----	----	01-Dec-2018	27-Dec-2018	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural (EK057G) 33	26-Nov-2018	----	----	----	01-Dec-2018	28-Nov-2018	✗
Clear Plastic Bottle - Natural (EK057G) 2R, 3, DUP, 6, 7	27-Nov-2018	----	----	----	01-Dec-2018	29-Nov-2018	✗
Clear Plastic Bottle - Natural (EK057G) 16, 11	28-Nov-2018	----	----	----	01-Dec-2018	30-Nov-2018	✗
Clear Plastic Bottle - Natural (EK057G) 14, 2, FB	29-Nov-2018	----	----	----	01-Dec-2018	01-Dec-2018	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) 33		26-Nov-2018	----	----	----	01-Dec-2018	24-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK059G) 2R, 3, DUP, 6, 7		27-Nov-2018	----	----	----	01-Dec-2018	25-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK059G) 16, 11		28-Nov-2018	----	----	----	01-Dec-2018	26-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK059G) 14, 2, FB		29-Nov-2018	----	----	----	01-Dec-2018	27-Dec-2018	✔
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G) 33		26-Nov-2018	04-Dec-2018	24-Dec-2018	✔	04-Dec-2018	24-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK061G) 2R, 3, DUP, 6, 7		27-Nov-2018	04-Dec-2018	25-Dec-2018	✔	04-Dec-2018	25-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK061G) 16, 11		28-Nov-2018	04-Dec-2018	26-Dec-2018	✔	04-Dec-2018	26-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK061G) 14, 2, FB		29-Nov-2018	04-Dec-2018	27-Dec-2018	✔	04-Dec-2018	27-Dec-2018	✔
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G) 33		26-Nov-2018	04-Dec-2018	24-Dec-2018	✔	04-Dec-2018	24-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK067G) 2R, 3, DUP, 6, 7		27-Nov-2018	04-Dec-2018	25-Dec-2018	✔	04-Dec-2018	25-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK067G) 16, 11		28-Nov-2018	04-Dec-2018	26-Dec-2018	✔	04-Dec-2018	26-Dec-2018	✔
Clear Plastic Bottle - Sulfuric Acid (EK067G) 14, 2, FB		29-Nov-2018	04-Dec-2018	27-Dec-2018	✔	04-Dec-2018	27-Dec-2018	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural (EK071G) 33	26-Nov-2018	----	----	----	01-Dec-2018	28-Nov-2018	✘
Clear Plastic Bottle - Natural (EK071G) 2R, 3, DUP, 6, 7	27-Nov-2018	----	----	----	01-Dec-2018	29-Nov-2018	✘
Clear Plastic Bottle - Natural (EK071G) 16, 11	28-Nov-2018	----	----	----	01-Dec-2018	30-Nov-2018	✘
Clear Plastic Bottle - Natural (EK071G) 14, 2, FB	29-Nov-2018	----	----	----	01-Dec-2018	01-Dec-2018	✔
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP075(SIM)) 33	26-Nov-2018	03-Dec-2018	03-Dec-2018	✔	03-Dec-2018	12-Jan-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) 2R, 3, DUP, 6, 7	27-Nov-2018	03-Dec-2018	04-Dec-2018	✔	03-Dec-2018	12-Jan-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) 16, 11	28-Nov-2018	05-Dec-2018	05-Dec-2018	✔	05-Dec-2018	14-Jan-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) 14, 2, FB	29-Nov-2018	05-Dec-2018	06-Dec-2018	✔	05-Dec-2018	14-Jan-2019	✔



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER** Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	13	15.38	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	14	14.29	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	3	27	11.11	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	3	33	9.09	10.00	✖	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	13	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	33	6.06	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	13	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	27	7.41	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	33	6.06	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	13	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	33	6.06	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH ₃) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH ₃ . This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO ₃ ⁻ . This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.



CHAIN OF CUSTODY

ALS Laboratory, please tick →

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Ph: 07 3543 7222 E: samples.brisbane@alsglobal.comGLADSTONE 45 Calamondilli Drive, Gladstone QLD 4850
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Ph: 02 4226 5125 E: wollongong@alsglobal.com

CLIENT: Eco Logical Australia

OFFICE: Brisbane

PROJECT: Inland Rail - Border to Gowrie EIS

PROJECT NO:

10558

ALS QUOTE NO.: BN/142/18 V2

ORDER NUMBER:

PURCHASE ORDER NO.:

COUNTRY OF ORIGIN: Australia

PROJECT MANAGER: Miles Yeates

CONTACT PH: 0467 738 954

SAMPLER: David Moore and Byron Heffernan

SAMPLER MOBILE:

COC Emailed to ALS? (YES / NO)

EDD FORMAT (or default):

Email Reports to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au

Email Invoice to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au

TURNAROUND REQUIREMENTS:

☒ Standard TAT (List due date):(Standard TAT may be longer for some tests
e.g. Ultra Trace Organics)☐ Non Standard or urgent TAT (List due date):

COC SEQUENCE NUMBER (Circle)

COC: 1 2 3 4 5 6 7

OF: 1 2 3 4 5 6 7

RECEIVED BY:

ANDREA LT

DATE/TIME:

3-12-18

14-25

RELINQUISHED BY:

DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

Environmental Division
Brisbane

Work Order Reference

EB1829489



Telephone: + 61-7-3243 7222

ALS USE ONLY		SAMPLE DETAILS MATRIX: Solid(S) Water(W)		CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle)									
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA020-EC-P Conductivity and Salinity	EA025H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-8A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TKN, NOx, Reactive P and Total P	EK060 Organic Nitrogen	W-2 Dissolved metals - 8 metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn and Hg) - samples are field filtered	EP076B SIM PAHs (16 analytes)	EP008 Chlorophyll a (filter paper method)		
1	Site 14	29/11/18	W		1								X	Chl a: volume filtered 1,000 mL	
2	Site 2R	27/11/18	W		1								X	Chl a: volume filtered 300 mL	
3	Site 2	29/11/18	W		1								X	Chl a: volume filtered 300 mL	
4	Site 16	28/11/18	W		1								X	Chl a: volume filtered 300 mL	
5	Site 11	28/11/18	W		1								X	Chl a: volume filtered 300 mL	
6	Site 3	27/11/18	W		1								X	Chl a: volume filtered 500 mL	
	DUP	27/11/18	W											No analysis this batch	
	FB	29/11/18	W											No analysis this batch	
7	Site 6	27/11/18	W		1								X	Chl a: volume filtered 450 mL	
8	Site 33	26/11/18	W		1								X	Chl a: volume filtered 650 mL	
9	Site 7	27/11/18	W		1								X	Chl a: volume filtered 600 mL	
10	Site 24	30/11/18	W		5	X	X	X	X	X	X	X	X	Chl a: volume filtered 100 mL	
11	Site 30	01/12/18	W		5	X	X	X	X	X	X	X	X	Chl a: volume filtered 150 mL	
12	Site 39	01/12/18	W		5	X	X	X	X	X	X	X	X	Chl a: volume filtered 500 mL	
13	Site 40	01/12/18	W		5	X	X	X	X	X	X	X	X	Chl a: volume filtered 1000 mL	
14	Site 42	01/12/18	W		5	X	X	X	X	X	X	X	X	Chl a: volume filtered 1000 mL	
TOTAL					34										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; S-H = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic
 V = VOA Vial HCl Preserved; V6 = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl Preserved Plastic; HS = HCl Preserved Specimen bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass
 Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottle; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulfate Solids; B = Unpreserved Bag; U = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles

CERTIFICATE OF ANALYSIS

Work Order	: EB1829489	Page	: 1 of 8
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Contact	: Customer Services EB
Address	: PO BOX 1422	Address	: 2 Byth Street Stafford QLD Australia 4053
	FORTITUDE VALLEY QLD 4006		
Telephone	: +61 02 8536 8667	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 03-Dec-2018 14:25
Order number	:	Date Analysis Commenced	: 03-Dec-2018
C-O-C number	: ---	Issue Date	: 10-Dec-2018 17:21
Sampler	: DAVID MOORE AND BYRON HEFFERNON		
Site	:		
Quote number	: BN/142/18 V2		
No. of samples received	: 14		
No. of samples analysed	: 14		



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Sarah Ashworth	Laboratory Manager - Brisbane	Brisbane Organics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Tom Maloney	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: FILTER (Matrix: WATER)				Client sample ID	Site 14	Site 2R	Site 2	Site 16	Site 11
Client sampling date / time					29-Nov-2018 00:00	27-Nov-2018 00:00	29-Nov-2018 00:00	28-Nov-2018 00:00	28-Nov-2018 00:00
Compound	CAS Number	LOR	Unit		EB1829489-001	EB1829489-002	EB1829489-003	EB1829489-004	EB1829489-005
					Result	Result	Result	Result	Result
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		3	5	9	8	40
Volume	----	0.01	L		1	0.3	0.3	0.3	0.3



Analytical Results

Sub-Matrix: **FILTER**
 (Matrix: **WATER**)

Client sample ID

				Site 3	Site 6	Site 33	Site 7	----
Client sampling date / time				27-Nov-2018 00:00	27-Nov-2018 00:00	26-Nov-2018 00:00	27-Nov-2018 00:00	----
Compound	CAS Number	LOR	Unit	EB1829489-006	EB1829489-007	EB1829489-008	EB1829489-009	-----
				Result	Result	Result	Result	----
EP008: Chlorophyll a & Pheophytin a								
Chlorophyll a	----	1	mg/m³	7	4	3	5	----
Volume	----	0.01	L	0.5	0.45	0.65	0.6	----

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	Site 30	Site 39	Site 40	Site 42
Client sampling date / time				30-Nov-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	
Compound	CAS Number	LOR	Unit	EB1829489-010	EB1829489-011	EB1829489-012	EB1829489-013	EB1829489-014	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	570	511	1710	678	1140	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.27	0.24	0.86	0.33	0.56	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	194	63	14	9	10	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	142	133	549	236	398	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	27	22	65	32	49	
Magnesium	7439-95-4	1	mg/L	18	19	94	38	67	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	<0.001	<0.001	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.004	0.003	0.002	0.003	0.002	
Nickel	7440-02-0	0.001	mg/L	0.006	0.004	0.007	0.004	0.002	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.08	0.10	0.05	0.06	0.05	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.01	<0.01	0.02	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.01	0.03	<0.01	0.72	0.82	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.01	0.04	<0.01	0.74	0.82	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	4.1	4.5	0.4	0.3	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	4.2	4.6	0.5	0.4	0.2	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	Site 30	Site 39	Site 40	Site 42
Client sampling date / time					30-Nov-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00
Compound	CAS Number	LOR	Unit		EB1829489-010	EB1829489-011	EB1829489-012	EB1829489-013	EB1829489-014
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		4.2	4.6	0.5	1.1	1.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.51	0.39	0.11	0.20	0.17
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		0.03	0.05	<0.01	0.02	0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		28	57	13	7	<1
Volume	----	0.01	L		0.1	0.15	0.5	1	1
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		21.4	21.1	23.6	22.8	19.7
2-Chlorophenol-D4	93951-73-6	1.0	%		50.6	56.7	62.5	64.2	56.1
2,4,6-Tribromophenol	118-79-6	1.0	%		39.1	48.8	52.1	58.9	43.3
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		85.2	81.5	84.3	94.4	80.5
Anthracene-d10	1719-06-8	1.0	%		91.2	87.6	90.1	95.7	90.8



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	Site 30	Site 39	Site 40	Site 42
Client sampling date / time					30-Nov-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00	01-Dec-2018 00:00
Compound	CAS Number	LOR	Unit		EB1829489-010	EB1829489-011	EB1829489-012	EB1829489-013	EB1829489-014
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		117	114	118	124	130



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1829489	Page	: 1 of 8
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 03-Dec-2018
Site	:	Issue Date	: 10-Dec-2018
Sampler	: DAVID MOORE AND BYRON HEFFERNON	No. of samples received	: 14
Order number	:	No. of samples analysed	: 14

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Analysis Holding Time Compliance

Matrix: WATER

Method	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural Site 24	----	----	----	03-Dec-2018	02-Dec-2018	1
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural Site 24	----	----	----	03-Dec-2018	02-Dec-2018	1

Outliers : Frequency of Quality Control Samples

Matrix: WATER

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	0	19	0.00	10.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: WATER

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Site 30, Site 40, Site 42	01-Dec-2018	----	----	----	03-Dec-2018	29-Dec-2018	✔	
Clear Plastic Bottle - Natural (EA010-P) Site 24	30-Nov-2018	----	----	----	03-Dec-2018	28-Dec-2018	✔	
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H) Site 30, Site 40, Site 42	01-Dec-2018	----	----	----	04-Dec-2018	08-Dec-2018	✔	
Clear Plastic Bottle - Natural (EA025H) Site 24	30-Nov-2018	----	----	----	04-Dec-2018	07-Dec-2018	✔	



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	06-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 24		30-Nov-2018	----	----	----	06-Dec-2018	28-Dec-2018	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	06-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 24		30-Nov-2018	----	----	----	06-Dec-2018	28-Dec-2018	✓
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	06-Dec-2018	30-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 24		30-Nov-2018	----	----	----	06-Dec-2018	29-May-2019	✓
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	06-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 24		30-Nov-2018	----	----	----	06-Dec-2018	28-Dec-2018	✓
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	06-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 24		30-Nov-2018	----	----	----	06-Dec-2018	28-Dec-2018	✓
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	03-Dec-2018	03-Dec-2018	✓
Clear Plastic Bottle - Natural (EK057G) Site 24		30-Nov-2018	----	----	----	03-Dec-2018	02-Dec-2018	✗
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	06-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 24		30-Nov-2018	----	----	----	06-Dec-2018	28-Dec-2018	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	05-Dec-2018	29-Dec-2018	✓	05-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 24		30-Nov-2018	05-Dec-2018	28-Dec-2018	✓	05-Dec-2018	28-Dec-2018	✓
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	05-Dec-2018	29-Dec-2018	✓	05-Dec-2018	29-Dec-2018	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 24		30-Nov-2018	05-Dec-2018	28-Dec-2018	✓	05-Dec-2018	28-Dec-2018	✓
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	03-Dec-2018	03-Dec-2018	✓
Clear Plastic Bottle - Natural (EK071G) Site 24		30-Nov-2018	----	----	----	03-Dec-2018	02-Dec-2018	✗
EP008: Chlorophyll a & Pheophytin a								
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	----	----	----	04-Dec-2018	22-Dec-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 33		26-Nov-2018	----	----	----	04-Dec-2018	17-Dec-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 2R, Site 6,	Site 3, Site 7	27-Nov-2018	----	----	----	04-Dec-2018	18-Dec-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 16,	Site 11	28-Nov-2018	----	----	----	04-Dec-2018	19-Dec-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 14,	Site 2	29-Nov-2018	----	----	----	04-Dec-2018	20-Dec-2018	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 24		30-Nov-2018	----	----	----	04-Dec-2018	21-Dec-2018	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 30, Site 40,	Site 39, Site 42	01-Dec-2018	06-Dec-2018	08-Dec-2018	✓	06-Dec-2018	15-Jan-2019	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 24		30-Nov-2018	06-Dec-2018	07-Dec-2018	✓	06-Dec-2018	15-Jan-2019	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	19	10.53	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	14	14.29	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	8	25.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	17	11.76	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	14	14.29	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	19	0.00	10.00	✖	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	20.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	19	10.53	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	19	10.53	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	16	12.50	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	20.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	8	12.50	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	17	5.88	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	14	7.14	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	16	6.25	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	19	5.26	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	20.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Suspended Solids (High Level)	EA025H	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	8	12.50	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	16	6.25	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	20.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH3) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH3. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Chlorophyll a and Pheophytin a	EP008	WATER	In house: Referenced to APHA 10200 H. The pigments are extracted into aqueous acetone. The optical density of the extract before and after acidification at both 664 nm and 665 nm is determined spectrometrically.
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.



CHAIN OF CUSTODY

ALS Laboratory: please tick →

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Ph: 07 4978 7544 E: gladstone@alsglobal.comMACKAY 78 Harbour Road Mackay QLD 4743
Ph: 07 4914 0177 E: mackay@alsglobal.comMELBOURNE 3-4 Westall Road Springvale VIC 3171
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y@alsglobal.com

CLIENT: Eco Logical Australia

OFFICE: Brisbane

PROJECT: Inland Rail - Border to Gowrie EIS

PROJECT NO: 10558

TURNAROUND REQUIREMENTS:

☒ Standard TAT (List due date):(Standard TAT may be longer for some tests
e.g. Ultra Trace Organics)☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: BN/142/18 V2

COC SEQUENCE

ORDER NUMBER:

PURCHASE ORDER NO.:

COUNTRY OF ORIGIN: Australia

COC: 1 2 3

PROJECT MANAGER: Miles Yeates

CONTACT PH: 0467 738 954

OF: 1 2 3

SAMPLER: David Moore and Emma Blacklock

SAMPLER MOBILE:

RELINQUISHED BY:

David Moore

RECEIVED BY:

Liam C

COC Emailed to ALS? (YES / NO)

EDD FORMAT (or default):

DATE/TIME:

16:50 14/2/2019

DATE/TIME:

16:50 14/2/19

Email Reports to (will default to PM if no other addresses are listed): milesy@ecolus.com.au

Email Invoice to (will default to PM if no other addresses are listed): milesy@ecolus.com.au

Telephone: +61-7-3243 7222

Y (Circle)

pon Yes No N/A
cept: Yes No N/A

RECEIVED BY:

DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY		SAMPLE DETAILS MATRIX: Solid(S) Water(W)		CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottles required) or Dissolved (field filtered bottles required)								Additional Information	
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA020-EC-P Conductivity and Salinity	EA025H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-9A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TKN, NOx, Reactive P and Total P	EK060 Organic Nitrogen	W-2 Dissolved metals - B metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn and Hg) - samples are field filtered	EP075B SIM PAHs (16 analyses)	EP008 Chlorophyll a (filter paper method)		
1	Site 2	11/2/19 - 12 noon	W	-	5	X	X	X	X	X	X	X	X	All metals samples are field filtered.	
2	Site 2R	11/2/19 - 12 noon	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 500 mL	
3	Site 23	12/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 1,000 mL	
4	Site 18	12/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 700 mL	
5	Site 7	12/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 600 mL	
6	Site 6	12/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 500 mL	
7	Site 3	12/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 500 mL	
8	Site 14	13/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 250 mL	
9	Site 27	13/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 100 mL	
10	Site 16	13/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 50 mL	
11	Site 24	13/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 250 mL	
12	Site 11	13/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 250 mL	
13	Site 28	13/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 100 mL	
14	Site 30	14/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 210 mL	
15	Site 32	14/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 150 mL	
16	Site 39	14/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 350 mL	
17	Site 42	14/02/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 1,000 mL	
18	DUP	12/02/2019 - 7 am	W		6	X	X	X	X	X	X	X	X	2 extra amber bottles QA/QC	
19	FB	12/02/2019 - 7 am	W		4	X	X	X	X	X	X	X	X		
TOTAL					95										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic

V = VOA Vial HC Preserved; VS = VOA Vial Sodium Bisulfate Preserved; AV = VOA Vial Sulfuric Preserved; SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;

Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

CERTIFICATE OF ANALYSIS

Work Order : **EB1903762**
Client : **ECO LOGICAL AUSTRALIA PTY LTD**
Contact : **MILES YEATES**
Address : **PO BOX 1422**
FORTITUDE VALLEY QLD 4006
Telephone : **+61 02 8536 8667**
Project : **10558 Inland Rail - Border to Gowrie EIS**
Order number :
C-O-C number :
Sampler : **DAVID MOORE AND EMMA BLACKLOCK**
Site :
Quote number : **BN/142/18 V2**
No. of samples received : **19**
No. of samples analysed : **19**

Page : 1 of 15
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 14-Feb-2019 16:50
Date Analysis Commenced : 14-Feb-2019
Issue Date : 21-Feb-2019 17:17



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
Minh Wills	2IC Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP075(SIM): Sample EB1903762-018 (DUP) shows poor matrix spike recovery due to matrix interference. Insufficient sample for re-extraction and re-analysis.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.



Analytical Results

Sub-Matrix: FILTER (Matrix: WATER)				Client sample ID	Site 2	Site 2R	Site 23	Site 18	Site 7
Client sampling date / time					11-Feb-2019 12:00	11-Feb-2019 12:00	12-Feb-2019 07:00	12-Feb-2019 07:00	12-Feb-2019 07:00
Compound	CAS Number	LOR	Unit		EB1903762-001	EB1903762-002	EB1903762-003	EB1903762-004	EB1903762-005
					Result	Result	Result	Result	Result
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		2	2	2	7	6
Volume	----	0.01	L		.5	.5	1	.7	.6



Analytical Results

Sub-Matrix: **FILTER**
 (Matrix: **WATER**)

Client sample ID

				Site 6	Site 3	Site 14	Site 27	Site 16
Client sampling date / time				12-Feb-2019 07:00	12-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00
Compound	CAS Number	LOR	Unit	EB1903762-006	EB1903762-007	EB1903762-008	EB1903762-009	EB1903762-010
				Result	Result	Result	Result	Result
EP008: Chlorophyll a & Pheophytin a								
Chlorophyll a	----	1	mg/m³	5	12	6	53	54
Volume	----	0.01	L	.5	.5	.25	.1	.05



Analytical Results

Sub-Matrix: FILTER (Matrix: WATER)				Client sample ID	Site 24	Site 11	Site 28	Site 30	Site 32
Client sampling date / time					13-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	14-Feb-2019 07:00	14-Feb-2019 07:00
Compound	CAS Number	LOR	Unit		EB1903762-011	EB1903762-012	EB1903762-013	EB1903762-014	EB1903762-015
					Result	Result	Result	Result	Result
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		9	23	56	50	90
Volume	----	0.01	L		.25	.25	.1	.21	.15



Analytical Results

Sub-Matrix: FILTER (Matrix: WATER)				Client sample ID	Site 39	Site 42	----	----	----
Client sampling date / time					14-Feb-2019 07:00	14-Feb-2019 07:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1903762-016	EB1903762-017	-----	-----	-----
				Result	Result		----	----	----
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m³		12	3	----	----	----
Volume	----	0.01	L		.35	1	----	----	----

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 2R	Site 23	Site 18	Site 7
Client sampling date / time				11-Feb-2019 12:00	11-Feb-2019 12:00	12-Feb-2019 07:00	12-Feb-2019 07:00	12-Feb-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1903762-001	EB1903762-002	EB1903762-003	EB1903762-004	EB1903762-005	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	228	230	289	339	450	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.11	0.11	0.14	0.16	0.21	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	23	24	8	18	12	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	78	78	90	99	88	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	13	13	23	28	17	
Magnesium	7439-95-4	1	mg/L	11	11	8	7	11	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.004	0.004	0.003	0.002	0.002	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.07	0.03	0.03	0.03	0.05	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.17	0.16	<0.01	<0.01	0.03	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.17	0.16	<0.01	<0.01	0.03	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.5	0.6	1.4	1.2	1.0	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.6	0.6	1.4	1.2	1.0	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 2R	Site 23	Site 18	Site 7
Client sampling date / time					11-Feb-2019 12:00	11-Feb-2019 12:00	12-Feb-2019 07:00	12-Feb-2019 07:00	12-Feb-2019 07:00
Compound	CAS Number	LOR	Unit		EB1903762-001	EB1903762-002	EB1903762-003	EB1903762-004	EB1903762-005
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.8	0.8	1.4	1.2	1.0
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.16	0.16	0.10	0.10	0.04
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		0.13	0.13	0.02	<0.01	<0.01
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		24.8	27.3	19.7	32.5	23.4
2-Chlorophenol-D4	93951-73-6	1.0	%		63.4	69.0	55.3	80.1	61.0
2,4,6-Tribromophenol	118-79-6	1.0	%		45.4	48.7	43.8	58.7	43.4
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		72.5	79.8	74.9	96.5	77.0
Anthracene-d10	1719-06-8	1.0	%		77.0	85.3	53.5	66.5	53.8
4-Terphenyl-d14	1718-51-0	1.0	%		78.0	85.3	53.7	66.4	54.8

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 6	Site 3	Site 14	Site 27	Site 16
Client sampling date / time				12-Feb-2019 07:00	12-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1903762-006	EB1903762-007	EB1903762-008	EB1903762-009	EB1903762-010	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	428	392	335	546	688	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.20	0.19	0.16	0.26	0.33	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	12	8	39	74	170	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	81	79	64	195	112	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	16	15	6	37	25	
Magnesium	7439-95-4	1	mg/L	10	10	12	25	12	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.002	0.002	0.003	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.002	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.007	0.002	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.05	0.04	0.05	0.05	0.06	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	<0.01	0.01	0.02	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	0.01	0.02	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	1.2	1.0	1.6	2.2	4.1	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.2	1.0	1.6	2.2	4.2	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 6	Site 3	Site 14	Site 27	Site 16
Client sampling date / time					12-Feb-2019 07:00	12-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00
Compound	CAS Number	LOR	Unit		EB1903762-006	EB1903762-007	EB1903762-008	EB1903762-009	EB1903762-010
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		1.2	1.0	1.6	2.2	4.2
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.06	0.06	0.07	0.23	0.31
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		24.5	25.5	27.4	23.7	25.1
2-Chlorophenol-D4	93951-73-6	1.0	%		62.8	60.7	61.4	56.5	58.9
2,4,6-Tribromophenol	118-79-6	1.0	%		39.6	35.3	33.0	31.5	42.6
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		77.4	74.0	81.7	75.7	76.5
Anthracene-d10	1719-06-8	1.0	%		55.1	50.8	57.9	53.3	54.4
4-Terphenyl-d14	1718-51-0	1.0	%		56.2	52.2	59.0	53.5	54.3

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	Site 11	Site 28	Site 30	Site 32
Client sampling date / time				13-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	14-Feb-2019 07:00	14-Feb-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1903762-011	EB1903762-012	EB1903762-013	EB1903762-014	EB1903762-015	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	306	259	557	406	614	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.14	0.12	0.27	0.19	0.30	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	60	23	73	35	95	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	65	55	156	128	204	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	13	12	26	25	37	
Magnesium	7439-95-4	1	mg/L	8	6	22	16	27	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.003	0.003	0.005	0.001	0.003	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.001	<0.001	0.002	<0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	0.006	<0.001	0.012	0.003	0.011	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.04	0.04	0.07	0.06	0.09	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	1.8	2.2	5.1	1.4	3.7	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.8	2.2	5.2	1.5	3.8	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 24	Site 11	Site 28	Site 30	Site 32
Client sampling date / time					13-Feb-2019 07:00	13-Feb-2019 07:00	13-Feb-2019 07:00	14-Feb-2019 07:00	14-Feb-2019 07:00
Compound	CAS Number	LOR	Unit		EB1903762-011	EB1903762-012	EB1903762-013	EB1903762-014	EB1903762-015
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		1.8	2.2	5.2	1.5	3.8
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.35	0.15	0.43	0.18	0.43
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		0.07	<0.01	0.02	<0.01	0.03
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		25.9	25.7	21.6	19.8	25.4
2-Chlorophenol-D4	93951-73-6	1.0	%		65.7	66.7	38.5	49.0	63.0
2,4,6-Tribromophenol	118-79-6	1.0	%		43.0	50.6	19.8	23.5	49.2
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		79.3	79.1	68.8	69.7	75.2
Anthracene-d10	1719-06-8	1.0	%		56.6	54.1	45.6	49.1	52.7
4-Terphenyl-d14	1718-51-0	1.0	%		55.0	54.1	45.8	49.0	52.2

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 39	Site 42	DUP	FB	----
Client sampling date / time				14-Feb-2019 07:00	14-Feb-2019 07:00	12-Feb-2019 07:00	12-Feb-2019 07:00	----	
Compound	CAS Number	LOR	Unit	EB1903762-016	EB1903762-017	EB1903762-018	EB1903762-019	-----	
				Result	Result	Result	Result	----	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	2850	1450	424	1	----	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	1.48	0.73	0.20	<0.01	----	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	30	8	14	<5	----	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	801	482	81	<1	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	42	43	16	<1	----	
Magnesium	7439-95-4	1	mg/L	169	91	10	<1	----	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.002	<0.001	----	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----	
Copper	7440-50-8	0.001	mg/L	0.001	<0.001	<0.001	<0.001	----	
Nickel	7440-02-0	0.001	mg/L	0.006	0.002	<0.001	<0.001	----	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	----	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	----	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	----	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.06	0.06	0.06	0.01	----	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.02	<0.01	<0.01	----	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	0.69	<0.01	<0.01	----	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.71	<0.01	<0.01	----	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.9	0.3	0.9	<0.1	----	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.0	0.4	1.0	<0.1	----	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 39	Site 42	DUP	FB	----
Client sampling date / time					14-Feb-2019 07:00	14-Feb-2019 07:00	12-Feb-2019 07:00	12-Feb-2019 07:00	----
Compound	CAS Number	LOR	Unit		EB1903762-016	EB1903762-017	EB1903762-018	EB1903762-019	-----
					Result	Result	Result	Result	---
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		1.0	1.1	1.0	<0.1	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.08	0.02	0.06	<0.01	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		21.8	25.4	25.8	28.6	----
2-Chlorophenol-D4	93951-73-6	1.0	%		47.1	57.4	62.8	68.1	----
2,4,6-Tribromophenol	118-79-6	1.0	%		31.7	40.5	55.4	77.7	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		64.9	75.5	74.3	74.8	----
Anthracene-d10	1719-06-8	1.0	%		44.9	52.1	50.4	84.6	----
4-Terphenyl-d14	1718-51-0	1.0	%		46.5	54.7	52.7	103	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1903762	Page	: 1 of 13
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 14-Feb-2019
Site	:	Issue Date	: 21-Feb-2019
Sampler	: DAVID MOORE AND EMMA BLACKLOCK	No. of samples received	: 19
Order number	:	No. of samples analysed	: 19

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- Matrix Spike outliers exist - please see following pages for full details.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons	EB1903762--018	DUP	Pyrene	129-00-0	61.8 %	70-130%	Recovery less than lower data quality objective

Method	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural Site 2, Site 2R	---	---	---	14-Feb-2019	13-Feb-2019	1
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural Site 2, Site 2R	---	---	---	14-Feb-2019	13-Feb-2019	1

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	1	35	2.86	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
PAH/Phenols (GC/MS - SIM)	1	35	2.86	5.00	NEPM 2013 B3 & ALS QC Standard

Method	Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Site 2,	Site 2R	11-Feb-2019	----	----	----	19-Feb-2019	11-Mar-2019	✓
Clear Plastic Bottle - Natural (EA010-P) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	19-Feb-2019	12-Mar-2019	✓
Clear Plastic Bottle - Natural (EA010-P) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	19-Feb-2019	13-Mar-2019	✓
Clear Plastic Bottle - Natural (EA010-P) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	19-Feb-2019	14-Mar-2019	✓
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H) Site 2,	Site 2R	11-Feb-2019	----	----	----	15-Feb-2019	18-Feb-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	15-Feb-2019	19-Feb-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	15-Feb-2019	20-Feb-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	15-Feb-2019	21-Feb-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 2,	Site 2R	11-Feb-2019	----	----	----	19-Feb-2019	11-Mar-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	19-Feb-2019	12-Mar-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	19-Feb-2019	13-Mar-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	19-Feb-2019	14-Mar-2019	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 2,	Site 2R	11-Feb-2019	----	----	----	19-Feb-2019	11-Mar-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	19-Feb-2019	12-Mar-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	19-Feb-2019	13-Mar-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	19-Feb-2019	14-Mar-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 2, Site 2R	11-Feb-2019	----	----	----	19-Feb-2019	10-Aug-2019	✓	
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 23, Site 7, Site 3, FB Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	19-Feb-2019	11-Aug-2019	✓	
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 14, Site 16, Site 11, Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	19-Feb-2019	12-Aug-2019	✓	
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 30, Site 39, Site 32, Site 42	14-Feb-2019	----	----	----	19-Feb-2019	13-Aug-2019	✓	
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 2, Site 2R	11-Feb-2019	----	----	----	19-Feb-2019	11-Mar-2019	✓	
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 23, Site 7, Site 3, FB Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	19-Feb-2019	12-Mar-2019	✓	
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 14, Site 16, Site 11, Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	19-Feb-2019	13-Mar-2019	✓	
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 30, Site 39, Site 32, Site 42	14-Feb-2019	----	----	----	19-Feb-2019	14-Mar-2019	✓	



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 2,	Site 2R	11-Feb-2019	----	----	----	15-Feb-2019	11-Mar-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	15-Feb-2019	12-Mar-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	15-Feb-2019	13-Mar-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	15-Feb-2019	14-Mar-2019	✓
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) Site 2,	Site 2R	11-Feb-2019	----	----	----	14-Feb-2019	13-Feb-2019	✗
Clear Plastic Bottle - Natural (EK057G) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	14-Feb-2019	14-Feb-2019	✓
Clear Plastic Bottle - Natural (EK057G) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	14-Feb-2019	15-Feb-2019	✓
Clear Plastic Bottle - Natural (EK057G) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	14-Feb-2019	16-Feb-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 2, Site 2R	11-Feb-2019	----	----	----	15-Feb-2019	11-Mar-2019	✓	
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 23, Site 7, Site 3, FB Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	15-Feb-2019	12-Mar-2019	✓	
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 14, Site 16, Site 11, Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	15-Feb-2019	13-Mar-2019	✓	
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 30, Site 39, Site 32, Site 42	14-Feb-2019	----	----	----	15-Feb-2019	14-Mar-2019	✓	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 2, Site 2R	11-Feb-2019	20-Feb-2019	11-Mar-2019	✓	20-Feb-2019	11-Mar-2019	✓	
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 23, Site 7, Site 3, FB Site 18, Site 6, DUP,	12-Feb-2019	20-Feb-2019	12-Mar-2019	✓	20-Feb-2019	12-Mar-2019	✓	
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 14, Site 16, Site 11, Site 27, Site 24, Site 28	13-Feb-2019	20-Feb-2019	13-Mar-2019	✓	20-Feb-2019	13-Mar-2019	✓	
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 30, Site 39, Site 32, Site 42	14-Feb-2019	20-Feb-2019	14-Mar-2019	✓	20-Feb-2019	14-Mar-2019	✓	



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 2,	Site 2R	11-Feb-2019	20-Feb-2019	11-Mar-2019	✓	20-Feb-2019	11-Mar-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	20-Feb-2019	12-Mar-2019	✓	20-Feb-2019	12-Mar-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	20-Feb-2019	13-Mar-2019	✓	20-Feb-2019	13-Mar-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	20-Feb-2019	14-Mar-2019	✓	20-Feb-2019	14-Mar-2019	✓
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G) Site 2,	Site 2R	11-Feb-2019	----	----	----	14-Feb-2019	13-Feb-2019	✗
Clear Plastic Bottle - Natural (EK071G) Site 23, Site 7, Site 3, FB	Site 18, Site 6, DUP,	12-Feb-2019	----	----	----	14-Feb-2019	14-Feb-2019	✓
Clear Plastic Bottle - Natural (EK071G) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	14-Feb-2019	15-Feb-2019	✓
Clear Plastic Bottle - Natural (EK071G) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	14-Feb-2019	16-Feb-2019	✓
EP008: Chlorophyll a & Pheophytin a								
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 2,	Site 2R	11-Feb-2019	----	----	----	14-Feb-2019	04-Mar-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 23, Site 7, Site 3	Site 18, Site 6,	12-Feb-2019	----	----	----	14-Feb-2019	05-Mar-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 14, Site 16, Site 11,	Site 27, Site 24, Site 28	13-Feb-2019	----	----	----	14-Feb-2019	06-Mar-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 30, Site 39,	Site 32, Site 42	14-Feb-2019	----	----	----	14-Feb-2019	07-Mar-2019	✓



Matrix: **WATER** Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 2, Site 2R		11-Feb-2019	15-Feb-2019	18-Feb-2019	✔	19-Feb-2019	27-Mar-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 23, Site 7, Site 3, FB Site 18, Site 6, DUP,		12-Feb-2019	18-Feb-2019	19-Feb-2019	✔	19-Feb-2019	30-Mar-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 14, Site 16, Site 11, Site 27, Site 24, Site 28		13-Feb-2019	18-Feb-2019	20-Feb-2019	✔	19-Feb-2019	30-Mar-2019	✔
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 30, Site 39, Site 32, Site 42		14-Feb-2019	18-Feb-2019	21-Feb-2019	✔	19-Feb-2019	30-Mar-2019	✔



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	4	34	11.76	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	3	29	10.34	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	4	37	10.81	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	4	30	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	4	31	12.90	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	3	24	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	35	2.86	10.00	✗	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	3	22	13.64	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	4	31	12.90	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	19	10.53	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	19	10.53	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	2	34	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	2	24	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	29	6.90	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	37	5.41	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	24	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	35	5.71	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	22	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	4	31	12.90	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	2	34	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	2	24	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	29	6.90	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	37	5.41	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	24	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	2	35	5.71	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	22	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Suspended Solids (High Level)	EA025H	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	2	34	5.88	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	29	6.90	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	37	5.41	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	31	6.45	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	24	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	35	2.86	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	22	9.09	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH3) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH3. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Chlorophyll a and Pheophytin a	EP008	WATER	In house: Referenced to APHA 10200 H. The pigments are extracted into aqueous acetone. The optical density of the extract before and after acidification at both 664 nm and 665 nm is determined spectrometrically.
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.



CHAIN OF CUSTODY

ALS Laboratory, please tick →

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Environmental Division
Brisbane
Work Order Reference
EB1911202



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CLIENT: Eco Logical Australia		TURNAROUND REQUIREMENTS : ☒ Standard TAT (List due date):		FOR LABORATORY	
OFFICE: Brisbane		(Standard TAT may be longer for some tests e.g., Ultra Trace Organics)		Custody Seal intact	
PROJECT: Inland Rail - Border to Gowrie EIS		PROJECT NO: 10553	ALS QUOTE NO.: BN142/18 V2	Free ice / frozen receipt?	
ORDER NUMBER:		PURCHASE ORDER NO.:		Random Sample T	
PROJECT MANAGER: Miles Yeates		CONTACT PH: 0467 738 954		Other comment:	
SAMPLER: David Moore and Emma Blacklock		SAMPLER MOBILE:		RECEIVED BY: DAN	
COC Emailed to ALS? (YES)		EDD FORMAT (or default):		DATE/TIME: 2/5/19 16:35	
Email Reports to (will default to PM if no other addresses are listed): milesy@ecolus.com.au		RELINQUISHED BY: <i>DM</i>		DATE/TIME:	
Email Invoice to (will default to PM if no other addresses are listed): milesy@ecolus.com.au		DATE/TIME: 2/5/19		RELINQUISHED BY:	

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

-18°C & 4°C

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB, Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information	
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA020-EC-P Conductivity and Salinity	EA025H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-8A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TKN, NOx, Reactive P and Total P	EK060 Organic Nitrogen	W-2 Dissolved metals - B metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn and Hg) - samples are field filtered	EP075B SIM PAHs (16 analytes)	EP008 Chlorophyll a (filter paper method)	All metals samples are field filtered. Frozen Chlorophyll a filter paper samples are included in this work order. Filter paper is 47mm GFF ~0.7 micron. Filtered volume is noted below and on jar. Filter paper was foil wrapped and kept frozen at minus 17°C up to delivery.	
1	Site 2	29/04/19 - 12 noon	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 850 mL	
2	Site 2R	29/04/19 - 12 noon	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 850 mL	
3	Site 3	30/04/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 250 mL	
4	Site 6	30/04/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 800 mL	
5	Site 7	30/04/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 750 mL	
6	Site 11	30/04/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 250 mL	
7	Site 14	1/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 250 mL	
8	Site 16	1/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 12 mL	
9	Site 18	1/05/2019 - 7 am	W	HT	5	X	X	X	X	X	X	X	X	Chl a volume filtered: 1,000 mL	
10	Site 20R	1/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 500 mL	
11	Site 23	1/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 600 mL	
12	Site 27	2/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 125 mL	
13	Site 28	1/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 75 mL	
14	Site 29	1/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 300 mL	
15	Site 30	2/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 150 mL	
16	Site 39	2/05/2019 - 7 am	W		7	X	X	X	X	X	X	X	X	X	Chl a volume filtered: 700 mL Two additional QA/QC bottles
17	Site 40	2/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	X	Chl a volume filtered: 550 mL
18	Site 42	2/05/2019 - 7 am	W		5	X	X	X	X	X	X	X	X	X	Chl a volume filtered: 1,000 mL
19	DUP	30/04/2019 - 7 am	W		4	X	X	X	X	X	X	X			
20	FB	30/04/2019 - 7 am	W		4	X	X	X	X	X	X	X			
TOTAL					100										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airfreight Unpreserved Plastic

V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfate Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl Preserved Plastic; HS = HCl Preserved Plastic bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass; Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; L = Lugols Iodine Preserved Bottle; STT = Sterile Sodium Thiosulfate Preserved Bottles

Approved Date: 20/02/2017

CERTIFICATE OF ANALYSIS

Work Order : **EB1911202**
Client : **ECO LOGICAL AUSTRALIA PTY LTD**
Contact : **MILES YEATES**
Address : **PO BOX 1422**
FORTITUDE VALLEY QLD 4006
Telephone : **+61 02 8536 8667**
Project : **10558 Inland Rail - Border to Gowrie EIS**
Order number :
C-O-C number :
Sampler : **DAVID MOORE, EMMA BLACKLOCK**
Site :
Quote number : **BN/142/18 V2**
No. of samples received : **20**
No. of samples analysed : **20**

Page : 1 of 15
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 02-May-2019 16:35
Date Analysis Commenced : 02-May-2019
Issue Date : 10-May-2019 14:11



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenzo(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 2R	Site 3	Site 6	Site 7
Client sampling date / time				29-Apr-2019 12:00	29-Apr-2019 12:00	30-Apr-2019 07:00	30-Apr-2019 07:00	30-Apr-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1911202-001	EB1911202-002	EB1911202-003	EB1911202-004	EB1911202-005	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	210	211	419	428	425	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.10	0.10	0.20	0.21	0.21	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	10	7	12	10	6	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	93	93	99	99	102	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	16	16	20	20	21	
Magnesium	7439-95-4	1	mg/L	13	13	12	12	12	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.003	0.003	0.002	0.001	0.002	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.001	0.001	<0.001	<0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	0.003	0.002	<0.001	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.03	0.02	0.02	0.03	0.03	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.09	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.09	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.5	0.4	1.6	1.1	1.1	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.5	0.4	1.6	1.1	1.1	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 2R	Site 3	Site 6	Site 7
Client sampling date / time					29-Apr-2019 12:00	29-Apr-2019 12:00	30-Apr-2019 07:00	30-Apr-2019 07:00	30-Apr-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-001	EB1911202-002	EB1911202-003	EB1911202-004	EB1911202-005
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.5	0.4	1.6	1.1	1.2
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.08	0.06	0.08	0.04	0.04
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		0.04	0.03	<0.01	<0.01	<0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		5	4	65	10	14
Volume	----	0.01	L		0.85	0.85	0.25	0.8	0.75
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		33.3	36.2	31.4	29.2	30.8
2-Chlorophenol-D4	93951-73-6	1.0	%		74.4	82.3	71.4	67.9	70.6
2,4,6-Tribromophenol	118-79-6	1.0	%		62.5	69.1	61.5	60.0	59.0
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		83.6	91.6	78.5	75.6	77.7
Anthracene-d10	1719-06-8	1.0	%		73.4	76.6	71.3	67.2	68.0



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 2R	Site 3	Site 6	Site 7
Client sampling date / time					29-Apr-2019 12:00	29-Apr-2019 12:00	30-Apr-2019 07:00	30-Apr-2019 07:00	30-Apr-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-001	EB1911202-002	EB1911202-003	EB1911202-004	EB1911202-005
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		81.8	88.2	78.5	73.6	73.6

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 11	Site 14	Site 16	Site 18	Site 20R
Client sampling date / time				30-Apr-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1911202-006	EB1911202-007	EB1911202-008	EB1911202-009	EB1911202-010	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	293	349	1240	314	152	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.14	0.17	0.62	0.15	0.08	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	104	44	2170	8	10	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	73	83	179	118	72	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	16	7	42	34	19	
Magnesium	7439-95-4	1	mg/L	8	16	18	8	6	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.001	0.001	0.004	0.001	0.003	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.002	0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.009	0.002	0.004	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	0.008	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.02	0.03	1.50	0.02	0.02	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.05	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	0.02	<0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.07	<0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	5.7	2.3	29.6	0.8	1.6	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	5.7	2.3	31.1	0.8	1.6	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 11	Site 14	Site 16	Site 18	Site 20R
Client sampling date / time					30-Apr-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-006	EB1911202-007	EB1911202-008	EB1911202-009	EB1911202-010
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		5.7	2.3	31.2	0.8	1.6
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.33	0.10	3.93	0.04	0.32
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	0.10
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		460	16	545	4	21
Volume	----	0.01	L		0.25	0.25	0.012	1	0.5
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		28.3	25.5	28.2	30.9	25.8
2-Chlorophenol-D4	93951-73-6	1.0	%		67.4	60.4	67.3	71.6	64.6
2,4,6-Tribromophenol	118-79-6	1.0	%		64.9	39.8	60.8	48.6	49.8
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		71.6	59.4	57.6	69.3	61.4
Anthracene-d10	1719-06-8	1.0	%		67.0	66.1	59.8	52.9	68.9



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 11	Site 14	Site 16	Site 18	Site 20R
Client sampling date / time					30-Apr-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-006	EB1911202-007	EB1911202-008	EB1911202-009	EB1911202-010
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		74.0	75.4	67.6	85.6	77.7

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 23	Site 27	Site 28	Site 29	Site 30
Client sampling date / time				01-May-2019 07:00	02-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	02-May-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1911202-011	EB1911202-012	EB1911202-013	EB1911202-014	EB1911202-015	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	286	230	307	300	445	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.14	0.11	0.15	0.14	0.21	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	18	214	175	48	70	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	116	102	149	177	192	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	30	21	30	33	34	
Magnesium	7439-95-4	1	mg/L	10	12	18	23	26	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	0.001	0.001	0.003	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	0.002	0.005	0.005	0.001	
Nickel	7440-02-0	0.001	mg/L	0.003	0.008	0.011	0.015	0.006	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.02	0.08	0.04	0.03	0.03	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.9	1.4	1.5	1.8	3.3	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.9	1.5	1.5	1.8	3.3	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 23	Site 27	Site 28	Site 29	Site 30
Client sampling date / time					01-May-2019 07:00	02-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	02-May-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-011	EB1911202-012	EB1911202-013	EB1911202-014	EB1911202-015
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.9	1.5	1.5	1.8	3.3
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.06	0.51	0.31	0.66	0.38
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	0.04	0.01	0.37	<0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		7	24	26	18	72
Volume	----	0.01	L		0.6	0.125	0.075	0.3	0.15
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		29.5	26.4	26.2	23.7	24.3
2-Chlorophenol-D4	93951-73-6	1.0	%		70.6	62.8	58.8	59.2	60.8
2,4,6-Tribromophenol	118-79-6	1.0	%		51.0	41.5	30.4	41.7	41.2
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		66.4	59.6	66.8	61.6	60.9
Anthracene-d10	1719-06-8	1.0	%		78.9	69.0	74.8	68.9	69.8



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 23	Site 27	Site 28	Site 29	Site 30
Client sampling date / time					01-May-2019 07:00	02-May-2019 07:00	01-May-2019 07:00	01-May-2019 07:00	02-May-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-011	EB1911202-012	EB1911202-013	EB1911202-014	EB1911202-015
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		92.2	81.3	87.4	81.2	83.7

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 39	Site 40	Site 42	DUP	FB
Client sampling date / time				02-May-2019 07:00	02-May-2019 07:00	02-May-2019 07:00	30-Apr-2019 07:00	30-Apr-2019 07:00	
Compound	CAS Number	LOR	Unit	EB1911202-016	EB1911202-017	EB1911202-018	EB1911202-019	EB1911202-020	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	1810	673	835	433	<1	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.92	0.33	0.41	0.21	<0.01	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	20	26	12	9	<5	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	720	290	367	99	<1	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	87	37	48	20	<1	
Magnesium	7439-95-4	1	mg/L	122	48	60	12	<1	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.001	<0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	0.010	0.003	0.003	<0.001	<0.001	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.04	0.02	0.05	0.03	0.02	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.02	0.02	<0.01	<0.01	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.07	0.90	1.25	<0.01	<0.01	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.07	0.92	1.27	<0.01	<0.01	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.6	0.3	0.2	1.0	<0.1	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.6	0.3	0.2	1.0	<0.1	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 39	Site 40	Site 42	DUP	FB
Client sampling date / time					02-May-2019 07:00	02-May-2019 07:00	02-May-2019 07:00	30-Apr-2019 07:00	30-Apr-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-016	EB1911202-017	EB1911202-018	EB1911202-019	EB1911202-020
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.7	1.2	1.5	1.0	<0.1
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.06	0.06	0.04	0.04	<0.01
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	0.02	0.02	<0.01	<0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		31	4	2	----	----
Volume	----	0.01	L		0.7	0.55	1	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		28.2	23.5	28.8	30.9	32.6
2-Chlorophenol-D4	93951-73-6	1.0	%		65.5	58.5	66.4	70.2	79.1
2,4,6-Tribromophenol	118-79-6	1.0	%		36.8	32.8	49.2	57.8	64.5
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		72.8	60.7	69.6	76.4	86.3
Anthracene-d10	1719-06-8	1.0	%		84.2	70.3	66.0	71.8	81.4



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 39	Site 40	Site 42	DUP	FB
Client sampling date / time					02-May-2019 07:00	02-May-2019 07:00	02-May-2019 07:00	30-Apr-2019 07:00	30-Apr-2019 07:00
Compound	CAS Number	LOR	Unit		EB1911202-016	EB1911202-017	EB1911202-018	EB1911202-019	EB1911202-020
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		100	87.3	75.1	75.8	93.3



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1911202	Page	: 1 of 13
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 02-May-2019
Site	:	Issue Date	: 10-May-2019
Sampler	: DAVID MOORE, EMMA BLACKLOCK	No. of samples received	: 20
Order number	:	No. of samples analysed	: 20

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers exist - please see following pages for full details.



Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural Site 2, Site 2R	----	----	----	02-May-2019	01-May-2019	1
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural Site 2, Site 2R	----	----	----	02-May-2019	01-May-2019	1

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	1	39	2.56	10.00	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)					
Suspended Solids (High Level)	4	30	13.33	15.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
PAH/Phenols (GC/MS - SIM)	1	39	2.56	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
Container / Client Sample ID(s)							

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	03-May-2019	29-May-2019	✓
Clear Plastic Bottle - Natural (EA010-P) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	03-May-2019	30-May-2019	✓
Clear Plastic Bottle - Natural (EA010-P) Site 2,	Site 2R	29-Apr-2019	----	----	----	03-May-2019	27-May-2019	✓
Clear Plastic Bottle - Natural (EA010-P) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	03-May-2019	28-May-2019	✓
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	03-May-2019	08-May-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	03-May-2019	09-May-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 2,	Site 2R	29-Apr-2019	----	----	----	03-May-2019	06-May-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	03-May-2019	07-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	08-May-2019	29-May-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	08-May-2019	30-May-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 2,	Site 2R	29-Apr-2019	----	----	----	08-May-2019	27-May-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	08-May-2019	28-May-2019	✔
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	08-May-2019	29-May-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	08-May-2019	30-May-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 2,	Site 2R	29-Apr-2019	----	----	----	08-May-2019	27-May-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	08-May-2019	28-May-2019	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	08-May-2019	28-Oct-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	08-May-2019	29-Oct-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 2,	Site 2R	29-Apr-2019	----	----	----	08-May-2019	26-Oct-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	08-May-2019	27-Oct-2019	✓
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	08-May-2019	29-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	08-May-2019	30-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 2,	Site 2R	29-Apr-2019	----	----	----	08-May-2019	27-May-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	08-May-2019	28-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	02-May-2019	29-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	02-May-2019	30-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 2,	Site 2R	29-Apr-2019	----	----	----	02-May-2019	27-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	02-May-2019	28-May-2019	✓
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	02-May-2019	03-May-2019	✓
Clear Plastic Bottle - Natural (EK057G) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	02-May-2019	04-May-2019	✓
Clear Plastic Bottle - Natural (EK057G) Site 2,	Site 2R	29-Apr-2019	----	----	----	02-May-2019	01-May-2019	✗
Clear Plastic Bottle - Natural (EK057G) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	02-May-2019	02-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	02-May-2019	29-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	02-May-2019	30-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 2,	Site 2R	29-Apr-2019	----	----	----	02-May-2019	27-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	02-May-2019	28-May-2019	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	07-May-2019	29-May-2019	✓	07-May-2019	29-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	07-May-2019	30-May-2019	✓	07-May-2019	30-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 2,	Site 2R	29-Apr-2019	07-May-2019	27-May-2019	✓	07-May-2019	27-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	07-May-2019	28-May-2019	✓	07-May-2019	28-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	07-May-2019	29-May-2019	✓	07-May-2019	29-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	07-May-2019	30-May-2019	✓	07-May-2019	30-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 2,	Site 2R	29-Apr-2019	07-May-2019	27-May-2019	✓	07-May-2019	27-May-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	07-May-2019	28-May-2019	✓	07-May-2019	28-May-2019	✓
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	02-May-2019	03-May-2019	✓
Clear Plastic Bottle - Natural (EK071G) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	02-May-2019	04-May-2019	✓
Clear Plastic Bottle - Natural (EK071G) Site 2,	Site 2R	29-Apr-2019	----	----	----	02-May-2019	01-May-2019	✗
Clear Plastic Bottle - Natural (EK071G) Site 3, Site 7, DUP,	Site 6, Site 11, FB	30-Apr-2019	----	----	----	02-May-2019	02-May-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EP008: Chlorophyll a & Pheophytin a								
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	----	----	----	02-May-2019	22-May-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	----	----	----	02-May-2019	23-May-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 2,	Site 2R	29-Apr-2019	----	----	----	02-May-2019	20-May-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 3, Site 7,	Site 6, Site 11	30-Apr-2019	----	----	----	02-May-2019	21-May-2019	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 14, Site 18, Site 23, Site 29	Site 16, Site 20R, Site 28,	01-May-2019	07-May-2019	08-May-2019	✓	07-May-2019	16-Jun-2019	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 27, Site 39, Site 42	Site 30, Site 40,	02-May-2019	07-May-2019	09-May-2019	✓	07-May-2019	16-Jun-2019	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 2,	Site 2R	29-Apr-2019	03-May-2019	06-May-2019	✓	07-May-2019	12-Jun-2019	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 3, Site 7, DUP.	Site 6, Site 11, FB	30-Apr-2019	03-May-2019	07-May-2019	✓	07-May-2019	12-Jun-2019	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification	
Analytical Methods	Method	QC	Regular	Actual	Expected		Evaluation
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	3	26	11.54	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	4	35	11.43	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	4	39	10.26	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	3	26	11.54	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	39	2.56	10.00	✖	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	3	30	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	2	26	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	18	5.56	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	35	5.71	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	26	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	3	39	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	4	30	13.33	15.00	✖	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	2	26	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	18	5.56	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	35	5.71	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	39	5.13	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	26	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	3	39	7.69	5.00	✔	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	20	5.00	5.00	✔	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Suspended Solids (High Level)	EA025H	2	30	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	2	26	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	35	5.71	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	26	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	39	2.56	5.00	✗	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH ₃) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH ₃ . This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO ₃ -. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Chlorophyll a and Pheophytin a	EP008	WATER	In house: Referenced to APHA 10200 H. The pigments are extracted into aqueous acetone. The optical density of the extract before and after acidification at both 664 nm and 665 nm is determined spectrometrically.
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.



CHAIN OF CUSTODY

ALS Laboratory, please tick →

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BRISBANE 2 Byth Street Sturtford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

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SYDNEY 277-280
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TOWNSVILLE 14
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WOLLONGONG 1
Ph: 02 4225 3125 E:

Environmental Division
Brisbane
Work Order Reference
EB1912777



Telephone: +61-7-3243 7222

CLIENT: Eco Logical Australia		TURNAROUND REQUIREMENTS: ☒ Standard TAT (List due date):		FOR LABORATOR:	
OFFICE: Brisbane		(Standard TAT may be longer for some tests e.g., Ultra Trace Organics)		Custody Seal intact?	
PROJECT: Inland Rail - Border to Gowrie EIS		PROJECT NO: 10558	ALS QUOTE NO.: BN/142/18 V2	Free ice / frozen ice bri:	
ORDER NUMBER:		PURCHASE ORDER NO.:		Random Sample Temperature on Receipt: °C	
PROJECT MANAGER: Miles Yeates		CONTACT PH: 0467 738 954		Other comment:	
SAMPLER: David Moore and Emily Messer		SAMPLER MOBILE:		RELINQUISHED BY:	
COC Emailed to ALS? (NO)		EDD FORMAT (or default):		RECEIVED BY:	
Email Reports to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au		DATE/TIME:		DATE/TIME:	
Email Invoice to (will default to PM if no other addresses are listed): milesy@ecoaus.com.au		20/5/14 7:50am		20/5/14 7:50	

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required)									Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	EA020-EC-P Conductivity and Salinity	EA025H Total Suspended Solids (TSS)	NT-1C Total Hardness as CaCO3	NT-8A Nutrients suite - Ammonia as N, Nitrite, Nitrate, Total N, TKN, NOx, Reactive P and Total P	EK060 Organic Nitrogen	W-2 Dissolved metals - 8 metals suite (As, Cd, Cr, Cu, Ni, Pb, Zn and Hg) - samples are field filtered	EP075B SIM PAHs (16 analytes)	EP008 Chlorophyll a (filter paper method)		
1	Site 2	16/5/19 12:00	W		5	X	X	X	X	X	X	X	X	All metals samples are field filtered.	
2	Site 6R	16/5/19 12:00	W		5	X	X	X	X	X	X	X	X	Frozen Chlorophyll a filter paper samples are included in this work order. Filter paper is 47mm GFF ~0.7 micron. Filtered volume is noted below and on jar. Filter paper was foil wrapped and kept frozen at minus 17°C up to delivery.	
3	Site 7	16/5/19 12:00	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 650ml	
4	Site 18	17/5/19 12:00	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 500 ml	
5	Site 42	18/5/19 12:00	W		5	X	X	X	X	X	X	X	X	Chl a volume filtered: 1,000ml	
6	DUP	16/5/19 12:00	W		6	X	X	X	X	X	X	X		Chl a volume filtered: 1,000 ml	
7	FB	16/5/19 12:00	W		4	X	X	X	X	X	X	X		+ 2 Q/A/GC bottles	
TOTAL					35										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP = Airtight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airtight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; N = Nalidamide Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugio's Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.



CERTIFICATE OF ANALYSIS

Work Order : **EB1912777**
Client : **ECO LOGICAL AUSTRALIA PTY LTD**
Contact : **MILES YEATES**
Address : **PO BOX 1422**
FORTITUDE VALLEY QLD 4006
Telephone : **+61 02 8536 8667**
Project : **10558 Inland Rail - Border to Gowrie EIS**
Order number :
C-O-C number :
Sampler : **DAVID MOORE, EMILY MESSER**
Site :
Quote number : **BN/142/18 V2**
No. of samples received : **7**
No. of samples analysed : **7**

Page : 1 of 8
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 20-May-2019 07:50
Date Analysis Commenced : 20-May-2019
Issue Date : 28-May-2019 09:01



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

<i>Signatories</i>	<i>Position</i>	<i>Accreditation Category</i>
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
Santusha Pandra	Organic Chemist	Brisbane Organics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a,h)anthracene (1.0), Benzo(g,h,i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 6R	Site 7	Site 18	Site 42
Client sampling date / time				16-May-2019 12:00	16-May-2019 12:00	16-May-2019 12:00	17-May-2019 12:00	18-May-2019 12:00	
Compound	CAS Number	LOR	Unit	EB1912777-001	EB1912777-002	EB1912777-003	EB1912777-004	EB1912777-005	
				Result	Result	Result	Result	Result	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	290	437	440	320	1290	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.14	0.21	0.21	0.15	0.64	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	12	11	6	14	<5	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	70	86	93	101	509	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	15	18	19	29	62	
Magnesium	7439-95-4	1	mg/L	8	10	11	7	86	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.002	0.001	0.001	<0.001	<0.001	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	0.002	0.002	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.02	0.03	0.05	0.02	0.03	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.02	<0.01	0.24	<0.01	1.38	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.02	<0.01	0.24	<0.01	1.40	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	0.7	1.1	1.0	0.8	0.2	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.7	1.1	1.0	0.8	0.2	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 6R	Site 7	Site 18	Site 42
Client sampling date / time					16-May-2019 12:00	16-May-2019 12:00	16-May-2019 12:00	17-May-2019 12:00	18-May-2019 12:00
Compound	CAS Number	LOR	Unit		EB1912777-001	EB1912777-002	EB1912777-003	EB1912777-004	EB1912777-005
					Result	Result	Result	Result	Result
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		0.7	1.1	1.2	0.8	1.6
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.03	0.03	0.02	0.04	<0.01
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	<0.01	<0.01	<0.01
EP008: Chlorophyll a & Pheophytin a									
Chlorophyll a	----	1	mg/m ³		7	11	7	5	1
Volume	----	0.01	L		0.65	0.5	1	1	1
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	<0.5	<0.5	<0.5
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		30.4	28.9	25.5	34.0	27.9
2-Chlorophenol-D4	93951-73-6	1.0	%		84.6	80.4	68.5	93.3	69.9
2,4,6-Tribromophenol	118-79-6	1.0	%		60.0	54.1	40.3	51.4	25.2
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		82.5	80.7	79.6	95.6	84.0
Anthracene-d10	1719-06-8	1.0	%		57.3	57.4	77.9	104	83.3



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	Site 2	Site 6R	Site 7	Site 18	Site 42
Client sampling date / time					16-May-2019 12:00	16-May-2019 12:00	16-May-2019 12:00	17-May-2019 12:00	18-May-2019 12:00
Compound	CAS Number	LOR	Unit		EB1912777-001	EB1912777-002	EB1912777-003	EB1912777-004	EB1912777-005
					Result	Result	Result	Result	Result
EP075(SIM)T: PAH Surrogates - Continued									
4-Terphenyl-d14	1718-51-0	1.0	%		60.8	61.4	82.5	112	89.7

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DUP	FB	----	----	----
Client sampling date / time				16-May-2019 12:00	16-May-2019 12:00	----	----	----	
Compound	CAS Number	LOR	Unit	EB1912777-006	EB1912777-007	-----	-----	-----	
				Result	Result	----	----	----	
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm	435	<1	----	----	----	
EA020EC: Salinity									
Salinity	----	0.01	g/kg	0.21	<0.01	----	----	----	
EA025: Total Suspended Solids dried at 104 ± 2°C									
Suspended Solids (SS)	----	5	mg/L	7	<5	----	----	----	
EA065: Total Hardness as CaCO3									
Total Hardness as CaCO3	----	1	mg/L	93	<1	----	----	----	
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L	19	<1	----	----	----	
Magnesium	7439-95-4	1	mg/L	11	<1	----	----	----	
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	----	----	----	
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----	
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----	
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	----	----	----	
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----	
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----	
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	----	----	----	
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----	
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L	0.05	<0.01	----	----	----	
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----	
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L	0.24	<0.01	----	----	----	
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L	0.24	<0.01	----	----	----	
EK060G:Organic Nitrogen as N (TKN-NH3) By Discrete Analyser									
Organic Nitrogen as N	----	0.1	mg/L	1.0	<0.1	----	----	----	
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	1.0	<0.1	----	----	----	
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser									



Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	DUP	FB	----	----	----
Client sampling date / time					16-May-2019 12:00	16-May-2019 12:00	----	----	----
Compound	CAS Number	LOR	Unit		EB1912777-006	EB1912777-007	-----	-----	-----
					Result	Result	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser - Continued									
^ Total Nitrogen as N	----	0.1	mg/L		1.2	<0.1	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		0.02	<0.01	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		<0.01	<0.01	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	----	----	----
Dibenz(a,h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(g,h,i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	<0.5	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	<0.5	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	1.0	%		25.6	29.6	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%		70.1	78.5	----	----	----
2,4,6-Tribromophenol	118-79-6	1.0	%		39.0	34.8	----	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	1.0	%		72.4	82.0	----	----	----
Anthracene-d10	1719-06-8	1.0	%		57.3	89.2	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%		63.3	95.6	----	----	----



Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2,4,6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: EB1912777	Page	: 1 of 9
Client	: ECO LOGICAL AUSTRALIA PTY LTD	Laboratory	: Environmental Division Brisbane
Contact	: MILES YEATES	Telephone	: +61-7-3243 7222
Project	: 10558 Inland Rail - Border to Gowrie EIS	Date Samples Received	: 20-May-2019
Site	:	Issue Date	: 28-May-2019
Sampler	: DAVID MOORE, EMILY MESSER	No. of samples received	: 7
Order number	:	No. of samples analysed	: 7

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO** Method Blank value outliers occur.
- **NO** Duplicate outliers occur.
- **NO** Laboratory Control outliers occur.
- **NO** Matrix Spike outliers occur.
- For all regular sample matrices, **NO** surrogate recovery outliers occur.

Outliers : Analysis Holding Time Compliance

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- **NO** Quality Control Sample Frequency Outliers exist.



Outliers : Analysis Holding Time Compliance

Matrix: WATER

Method Container / Client Sample ID(s)	Extraction / Preparation			Analysis		
	Date extracted	Due for extraction	Days overdue	Date analysed	Due for analysis	Days overdue
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural Site 2, Site 7, FB Site 6R, DUP,	----	----	----	20-May-2019	18-May-2019	2
Clear Plastic Bottle - Natural Site 18	----	----	----	20-May-2019	19-May-2019	1
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural Site 2, Site 7, FB Site 6R, DUP,	----	----	----	20-May-2019	18-May-2019	2
Clear Plastic Bottle - Natural Site 18	----	----	----	20-May-2019	19-May-2019	1

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for VOC in soils vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: WATER

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method	Sample Date	Extraction / Preparation			Analysis			
Container / Client Sample ID(s)		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation	
EA010P: Conductivity by PC Titrator								
Clear Plastic Bottle - Natural (EA010-P) Site 2, Site 7, FB Site 6R, DUP,	16-May-2019	----	----	----	22-May-2019	13-Jun-2019	✔	
Clear Plastic Bottle - Natural (EA010-P) Site 18	17-May-2019	----	----	----	22-May-2019	14-Jun-2019	✔	
Clear Plastic Bottle - Natural (EA010-P) Site 42	18-May-2019	----	----	----	22-May-2019	15-Jun-2019	✔	



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EA025: Total Suspended Solids dried at 104 ± 2°C								
Clear Plastic Bottle - Natural (EA025H) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	21-May-2019	23-May-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 18		17-May-2019	----	----	----	21-May-2019	24-May-2019	✓
Clear Plastic Bottle - Natural (EA025H) Site 42		18-May-2019	----	----	----	21-May-2019	25-May-2019	✓
EA065: Total Hardness as CaCO3								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	25-May-2019	13-Jun-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 18		17-May-2019	----	----	----	25-May-2019	14-Jun-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 42		18-May-2019	----	----	----	25-May-2019	15-Jun-2019	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	25-May-2019	13-Jun-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 18		17-May-2019	----	----	----	25-May-2019	14-Jun-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) Site 42		18-May-2019	----	----	----	25-May-2019	15-Jun-2019	✓
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	25-May-2019	12-Nov-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 18		17-May-2019	----	----	----	25-May-2019	13-Nov-2019	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) Site 42		18-May-2019	----	----	----	25-May-2019	14-Nov-2019	✓



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	27-May-2019	13-Jun-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 18		17-May-2019	----	----	----	27-May-2019	14-Jun-2019	✔
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) Site 42		18-May-2019	----	----	----	27-May-2019	15-Jun-2019	✔
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	20-May-2019	13-Jun-2019	✔
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 18		17-May-2019	----	----	----	20-May-2019	14-Jun-2019	✔
Clear Plastic Bottle - Sulfuric Acid (EK055G) Site 42		18-May-2019	----	----	----	20-May-2019	15-Jun-2019	✔
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	20-May-2019	18-May-2019	✖
Clear Plastic Bottle - Natural (EK057G) Site 18		17-May-2019	----	----	----	20-May-2019	19-May-2019	✖
Clear Plastic Bottle - Natural (EK057G) Site 42		18-May-2019	----	----	----	20-May-2019	20-May-2019	✔
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	20-May-2019	13-Jun-2019	✔
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 18		17-May-2019	----	----	----	20-May-2019	14-Jun-2019	✔
Clear Plastic Bottle - Sulfuric Acid (EK059G) Site 42		18-May-2019	----	----	----	20-May-2019	15-Jun-2019	✔



Matrix: **WATER**

Evaluation: ✖ = Holding time breach ; ✔ = Within holding time.

Method		Sample Date	Extraction / Preparation			Analysis		
Container / Client Sample ID(s)			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	22-May-2019	13-Jun-2019	✓	22-May-2019	13-Jun-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 18		17-May-2019	22-May-2019	14-Jun-2019	✓	22-May-2019	14-Jun-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) Site 42		18-May-2019	22-May-2019	15-Jun-2019	✓	22-May-2019	15-Jun-2019	✓
EK067G: Total Phosphorus as P by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	22-May-2019	13-Jun-2019	✓	22-May-2019	13-Jun-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 18		17-May-2019	22-May-2019	14-Jun-2019	✓	22-May-2019	14-Jun-2019	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) Site 42		18-May-2019	22-May-2019	15-Jun-2019	✓	22-May-2019	15-Jun-2019	✓
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	----	----	----	20-May-2019	18-May-2019	✗
Clear Plastic Bottle - Natural (EK071G) Site 18		17-May-2019	----	----	----	20-May-2019	19-May-2019	✗
Clear Plastic Bottle - Natural (EK071G) Site 42		18-May-2019	----	----	----	20-May-2019	20-May-2019	✓
EP008: Chlorophyll a & Pheophytin a								
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 2, Site 7	Site 6R,	16-May-2019	----	----	----	21-May-2019	06-Jun-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 18		17-May-2019	----	----	----	21-May-2019	07-Jun-2019	✓
Glass Fibre Filter Paper (Chlorophyll) (EP008) Site 42		18-May-2019	----	----	----	21-May-2019	08-Jun-2019	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 2, Site 7, FB	Site 6R, DUP,	16-May-2019	21-May-2019	23-May-2019	✓	23-May-2019	30-Jun-2019	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 18		17-May-2019	21-May-2019	24-May-2019	✓	23-May-2019	30-Jun-2019	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) Site 42		18-May-2019	21-May-2019	25-May-2019	✓	23-May-2019	30-Jun-2019	✓



Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Ammonia as N by Discrete analyser	EK055G	2	13	15.38	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	14	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	13	15.38	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	19	10.53	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	7	14.29	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	19	10.53	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	3	29	10.34	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Ammonia as N by Discrete analyser	EK055G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	6	29	20.69	15.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chlorophyll a and Pheophytin a	EP008	1	12	8.33	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Matrix: **WATER**

Evaluation: ✖ = Quality Control frequency not within specification ; ✔ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Method Blanks (MB) - Continued							
Suspended Solids (High Level)	EA025H	2	29	6.90	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	14	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	13	7.69	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	7	14.29	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	19	5.26	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard



Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM (2013) Schedule B(3)
Salinity	EA020-EC-P	WATER	In house: Referenced to APHA 2520B. Calculation from Electrical conductivity. This method is compliant with NEPM (2013) Schedule B(3)
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of 'non-filterable' residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C. This method is compliant with NEPM (2013) Schedule B(3)
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl ₂)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl ₂ which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH ₃ G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO ₂ - B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined separately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NO _x) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO ₃ - F. Combined oxidised Nitrogen (NO ₂ +NO ₃) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)



Analytical Methods	Method	Matrix	Method Descriptions
Organic Nitrogen as N (TKN - NH3) (discrete analyser)	EK060G	WATER	In house: Referenced to APHA 4500-Norg/4500-NH3. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with orthophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Chlorophyll a and Pheophytin a	EP008	WATER	In house: Referenced to APHA 10200 H. The pigments are extracted into aqueous acetone. The optical density of the extract before and after acidification at both 664 nm and 665 nm is determined spectrometrically.
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.

Appendix E: Significant Impact Assessment – Murray Cod

A significant impact assessment is completed in the following tables in relation to the Significant Impact Guidelines of the EPBC Act (DotE 2013) and the draft referral guidelines for the Murray Cod (DotE 2016).

Significant Impact Guidelines of the EPBC Act for Vulnerable species (DotE 2013)

Significant impact criteria	Significant impact	Response to criteria
Lead to a long-term decrease in the size of an important population of a species	No	The recovery plan for Murray Cod identifies two important populations in the impact assessment area – the Queensland Border Rivers and upland reaches of the Condamine River. These are recognised for their representation as upland populations, evidence of natural recruitment and largely intact fish community. The Project will result in only localised disturbance to habitat for Murray Cod in a small number of locations. Impacts are not expected to affect the species at a population level.
Reduce the area of occupancy of an important population	No	The recovery plan for Murray Cod identifies two important populations in the impact assessment area – the Queensland Border Rivers and upland reaches of the Condamine River. These are recognised for their representation as upland populations, evidence of natural recruitment and largely intact fish community.
Fragment an existing important population into two or more populations	No	The area of occupancy is unlikely to be affected by the Project. Bridges will be constructed over waterways in preference to culverts and fish passage will be accommodated in accordance with requirements of the <i>Fisheries Act 1994</i>. This will avoid reducing occupancy of a population or fragmenting a population.
Adversely affect habitat critical to the survival of the species	No	Habitat critical to the survival of the species is defined in the draft referral guidelines (DotE 2016) as follows: “Any section of a waterway that comprises a connected system of habitats suitable for sustained use by a Murray cod population for sheltering, foraging, breeding and upstream and downstream movement is considered by the Department to be habitat critical to the survival of the species.” Habitat critical to survival of the species is present within the impact assessment area, including in the Macintyre River and Macintyre Brook. However, impacts on these areas will be small in scale and localised. With the implementation of mitigation

Significant impact criteria	Significant impact	Response to criteria
		measures, habitat critical to the survival of the species will not be adversely affected.
Disrupt the breeding cycle of an important population	No	The recovery plan for Murray Cod identifies two important populations in the impact assessment area – the Queensland Border Rivers and upland reaches of the Condamine River. These are recognised for their representation as upland populations, evidence of natural recruitment and largely intact fish community. Impacts on hydrology of the watercourses and waterways (important for breeding) will be minimised through design and fish passage will be maintained. This is an important mitigation measure to avoid impacts to important populations in upland areas.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No	Impacts to habitat will be localised and very small in scale, confined to a small number of crossings of large river systems in the impact assessment area. Bridges will be constructed at crossings in preference to culverts, minimising the disturbance of habitat features on stream banks and beds.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	No	A range of invasive weed species are known to occur within the impact assessment area and the surrounding landscape. The clearing for infrastructure may facilitate the spread of invasive weed species in to species habitat. Hygiene procedures and a weed management plan is to be implemented to minimise the risk of introduction of weed species. The proposed Project is unlikely to heighten the risk of harm from existing pest species. The project is unlikely to introduce any non-native fish species, which is a key threat to the Murray Cod.
Introduce disease that may cause the species to decline	No	Currently, there is little known about diseases harmful to Murray Cod. Most relate to the introduction of noxious species from overseas. There is no evidence to suggest that the presence of Project infrastructure would introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	No	The Project is unlikely to interfere substantially with the recovery of the species, given the small scale of impacts on habitat and localised nature of disturbance.

Draft Referral Guidelines for the Murray Cod (DotE 2016)

The draft referral guidelines for Murray Cod provide species specific guidance on what factors may be high, medium and low risk of having significant impacts on the Murray Cod. An analysis of the potential impacts from the Project against the high and medium risk factors has been undertaken below.

Referral Guidelines risk factors for significant impacts	Significant impact	Response to Guidelines
Adverse affects on habitat critical to survival of the species		
Removing, modifying or degrading the structural elements of a significant proportion of the habitat	No	Where disturbance occurs to habitat critical to survival of the Murray Cod, this will be limited to small and localised areas and will not affect a significant proportion of habitat.
Causing the sedimentation of a significant proportion of the habitat causing a divergence of greater than 1.5 °C from the monthly median water temperature of a waterway in which the habitat occurs	No	The Project will have only localised impacts to water temperature and will not influence the overall temperature of waterways in which Murray Cod has been found. Localised changes to water temperature arising from shading from bridge structures or clearing of riparian vegetation are unlikely to influence the monthly median water temperature by more than 1.5 °C.
Reducing the water quality (especially relating to temperature, dissolved oxygen, acidity, salinity, chemical pollutants) of a significant proportion of the habitat outside the applicable minimum or maximum thresholds presented in the Australian and New Zealand guidelines for fresh and marine water quality: Volume 1 (2000) (ANZECC guidelines)	No	Water quality studies for the Project have demonstrated that water quality is impaired throughout the waterways of the impact assessment area due to current and ongoing land uses. Impacts on water quality from the Project are expected to be short-term during construction and localised to the immediate area surrounding works.
Creating a barrier which fragments habitat or alters the existing flow regime or hydrology of the habitat, for example eliminating flood pulse flows, creating weir pool effects or degrading spawning sites with low-flow accumulations of algal/periphytic growth or silt	No	Impacts of the Project on hydrology are likely to be minor and localised. Fish passage will be retained.
Adverse affects on an important population of the species		
Removing, modifying or degrading the structural elements of a significant proportion of habitat which the population may rely on for sheltering, foraging or breeding	No	Alterations to structural elements of habitat will be localised in scale and will not affect a significant proportion of habitat.

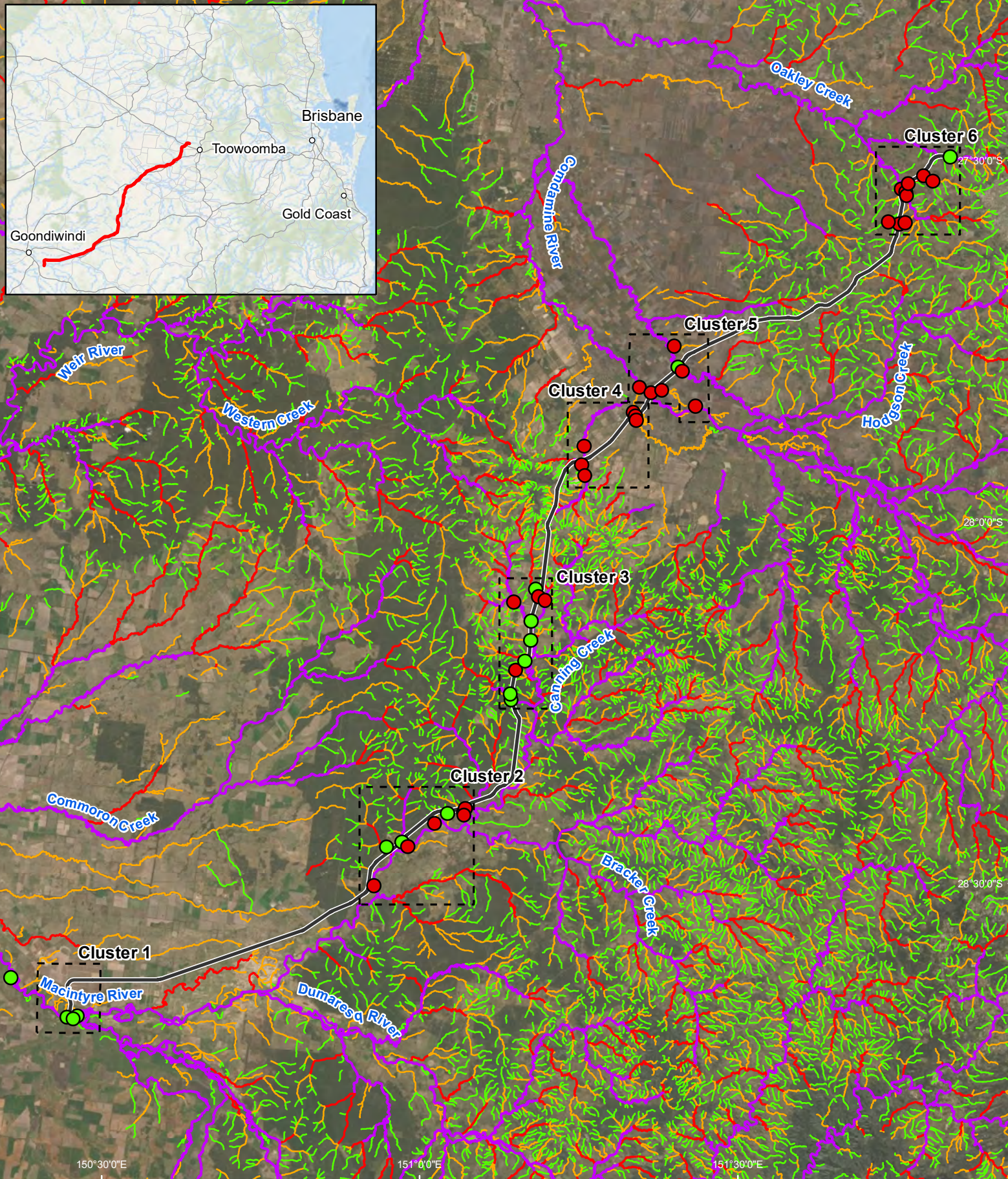
Referral Guidelines risk factors for significant impacts	Significant impact	Response to Guidelines
Fragmenting the population or substantially inhibiting the population's breeding cycle, larval recruitment or the exchange of genetic material by restricting the upstream or downstream movement of the population, including freely drifting larvae	No	The Project will not cause fragmentation of the population of Murray Cod. Fish passage will be retained.
Disrupting the activity of a breeding population in a manner which is likely to substantially diminish recruitment of larvae into the local population during a single breeding season	No	The activity of a breeding population will not be disrupted. Where possible, works in locations occupied by important populations (e.g. Macintyre River and Macintyre Brook) will be avoided during the Murray Cod breeding season.
Reducing its genetic diversity	No	The Project will not impact on the genetic diversity of the species.
Decreasing the size of the population or of any given life-history cohort of that population over the long-term	No	The Project is highly unlikely to decrease the size of the Murray Cod population or of a particular cohort of the species in the long term. Any impacts on individuals within the population will be short term, during construction, and are likely to result in the displacement of individuals for short distances.
Substantially decreasing the size of the population, or of any given life-history cohort of that population, to the extent that its reproductive capacity is likely to be substantially diminished in the succeeding one or more breeding seasons	No	
introducing a predatory or competitive native or alien fish species or pathogen that is likely to be detrimental to the population	No	The Project is unlikely to result in the introduction of a predatory or competitive fish species. Biosecurity procedures will be in place to avoid introducing exotic fish species from farm dams that are dewatered during Project activities.
Other criteria for assessment		
An action that is likely to adversely affect a large area of habitat, which does not meet the description in these guidelines of habitat critical to the survival of the species, by: substantially reducing the water quality (especially relating to temperature, dissolved oxygen, acidity, salinity, chemical pollutants) outside the applicable minimum or maximum thresholds presented in the ANZECC guidelines	No	Water quality studies for the Project have demonstrated that water quality is impaired throughout the waterways of the impact assessment area due to current and ongoing land uses. Impacts on water quality and hydrology will be minor and localised to the immediate area surrounding works. Impacts will not be substantial in scale.

Referral Guidelines risk factors for significant impacts	Significant impact	Response to Guidelines
substantially altering the existing flow regime or hydrology of the aquatic system		
An action that is likely to adversely affect a population, which is not considered an important population as indicated in these guidelines, by: - causing a long-term or substantial short-term decrease in the size of the population or of any given life-history cohort of that population, for example through an organised recreational fishing operation or event involving multiple anglers taking multiple Murray cod from an important population over a relatively short time period - causing a large reduction in the area of occupancy of the population - fragmenting the population or preventing the upstream or downstream movement of the population and the flow of genetic material - disrupting the activity of the breeding population in a manner which is likely to substantially diminish recruitment of larvae into the local population during a single breeding season - reducing the genetic diversity of the population - introducing a predatory or competitive native or alien fish species or pathogen that is likely to be detrimental to the population (such an impact could result from the action of an individual angler)	No	The Project does not involve angling or the take of Murray Cod. Any impacts on the species will be short term, localised and will not affect the area of occupancy of the species. Fish passage will be retained, allowing for continued movement of individuals and prey of the species. This will allow breeding migrations to continue. Larval recruitment of the species is unlikely to be affected by the project, with minimal, short term and localised impacts on hydrology and water quality. Biosecurity procedures will mitigate the risk of introducing pest species to habitat of the Murray Cod.

Appendix F: Maps showing the location of waterways that provide fish passage

The following map series shows the location of waterways that provide fish passage, as defined in the *Fisheries Act 1994*. Waterways are zoned according to the risk of impact on fish movement: Low risk (green), Moderate risk (amber), High risk (red) and Major risk (purple).

Queensland Waterways for Waterway Barrier Works



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site
- B2G Aquatic Site Clusters

Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

0 10 20
Kilometres
Datum/Projection:
GDA 1994 MGA Zone 56

N

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Macintyre Barwon Floodplain Water Quality Zone (Cluster 1 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 4 - Major

0 1 2

Kilometers

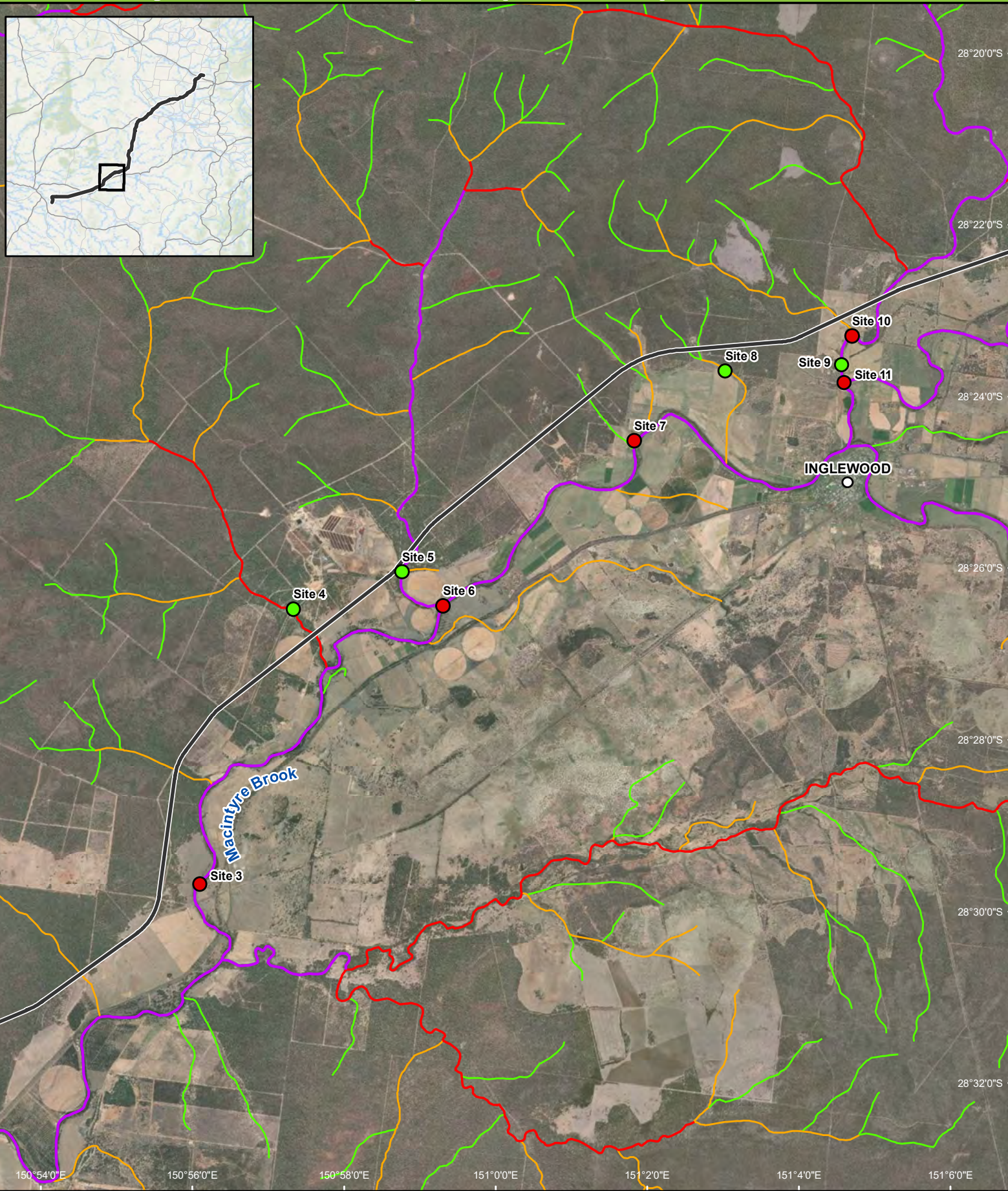
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Lower Macintyre Brook Water Quality Zone (Cluster 2 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

0 1 2
Kilometers

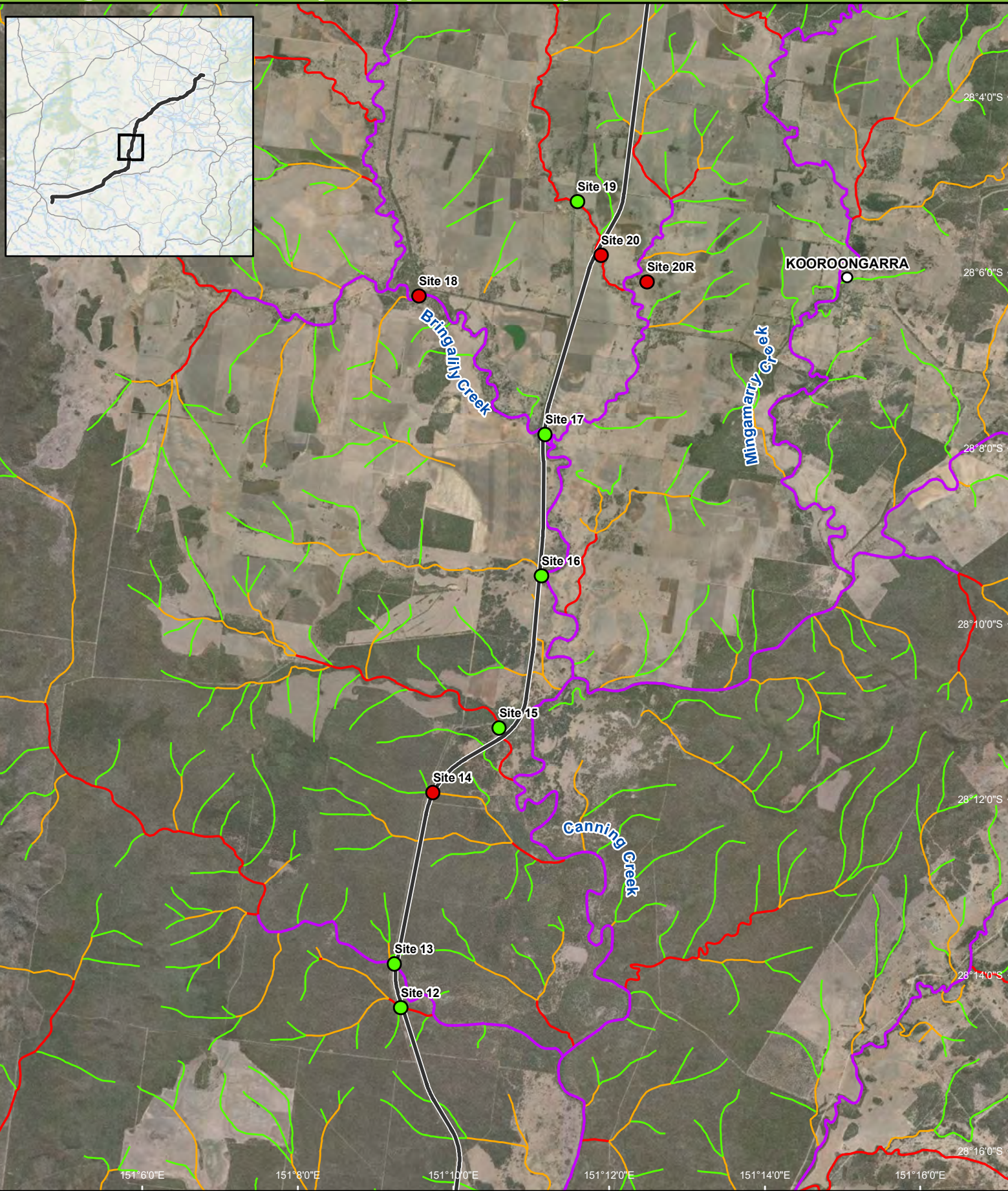
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Canning Creek Water Quality Zone (Cluster 3 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

0 1 2
Kilometers

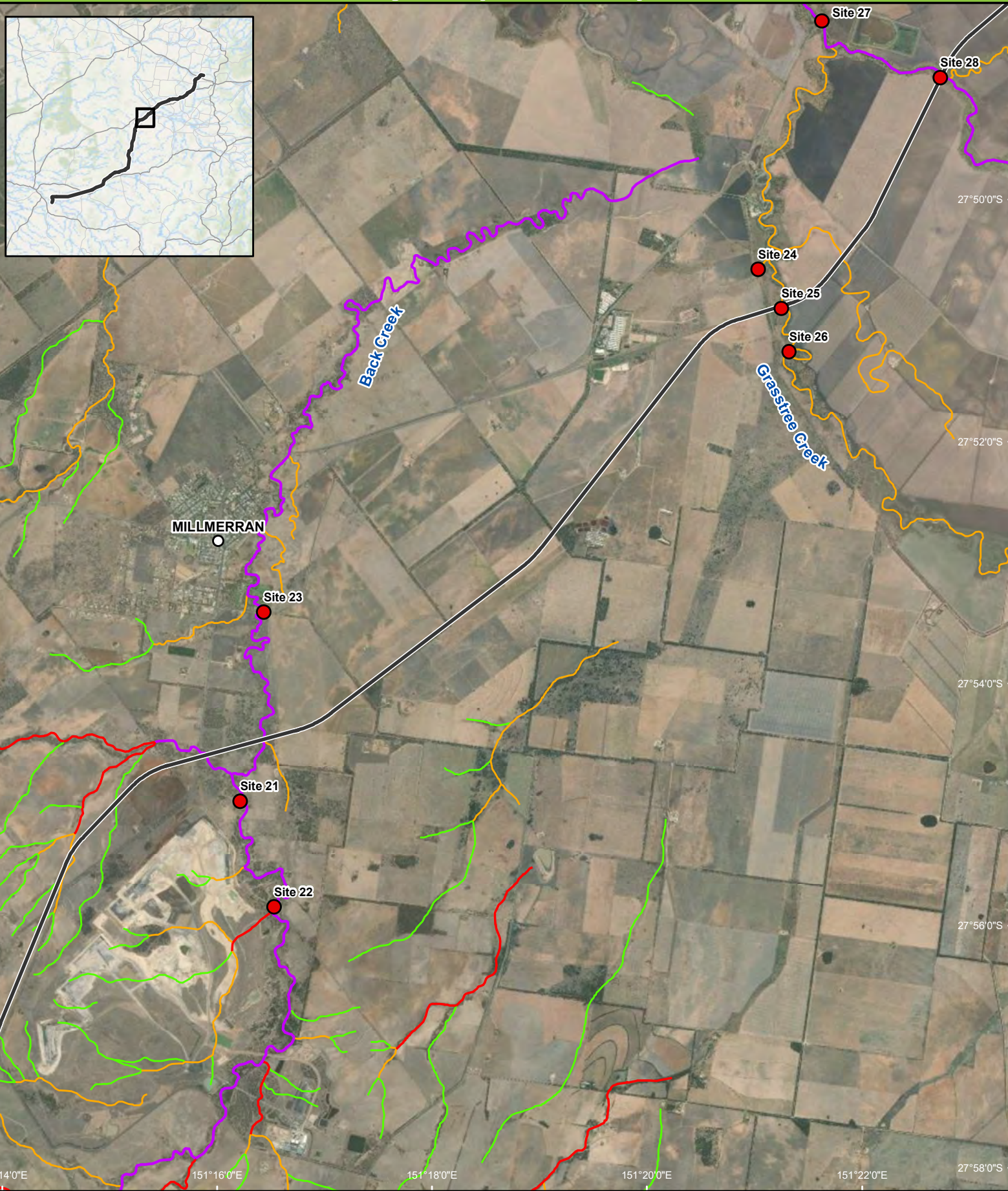
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Southern Condamine Water Quality Zone (Cluster 4 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

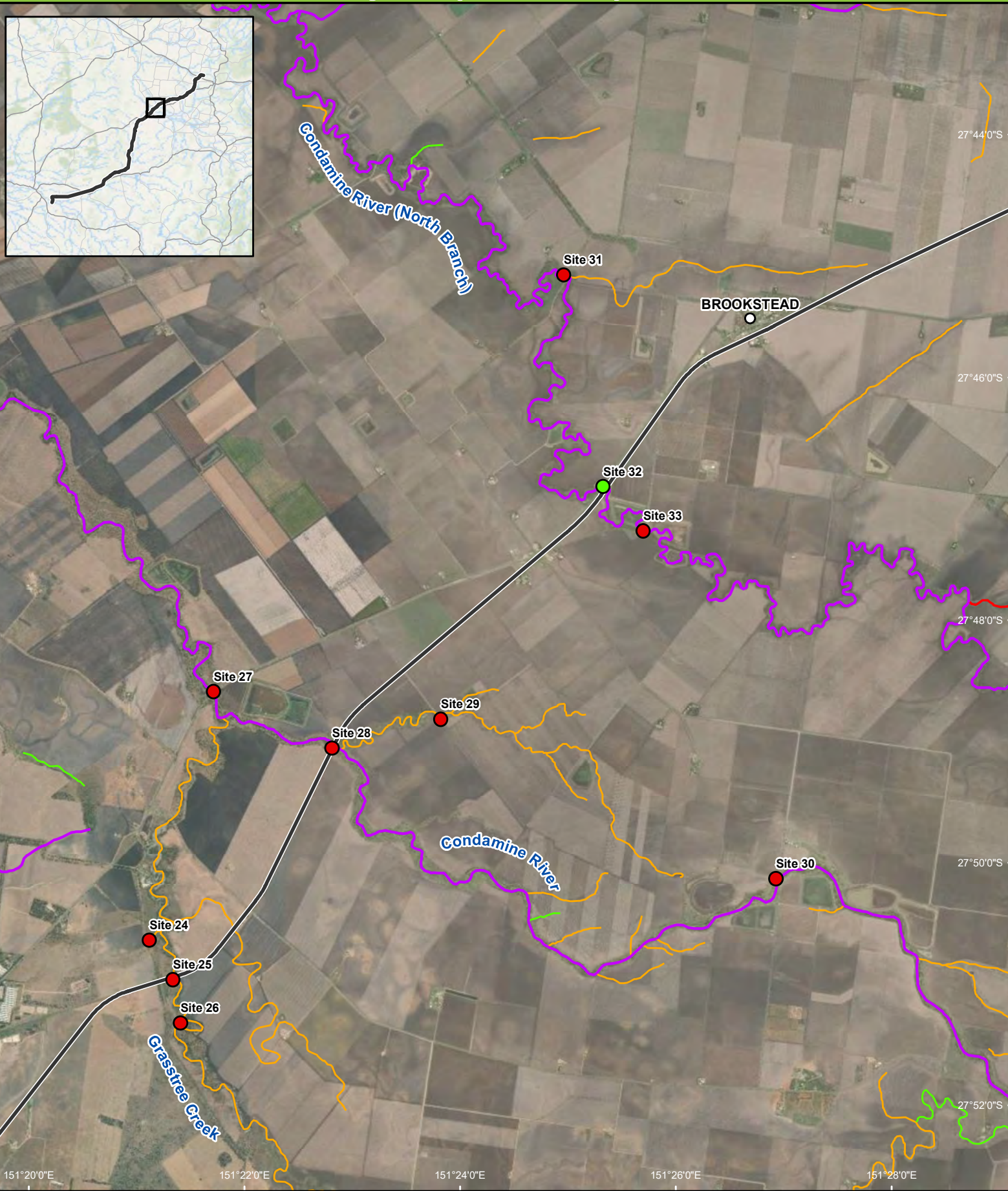
Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

0 1 2
Kilometers
Datum/Projection:
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Central Condamine Water Quality Zone (Cluster 5 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

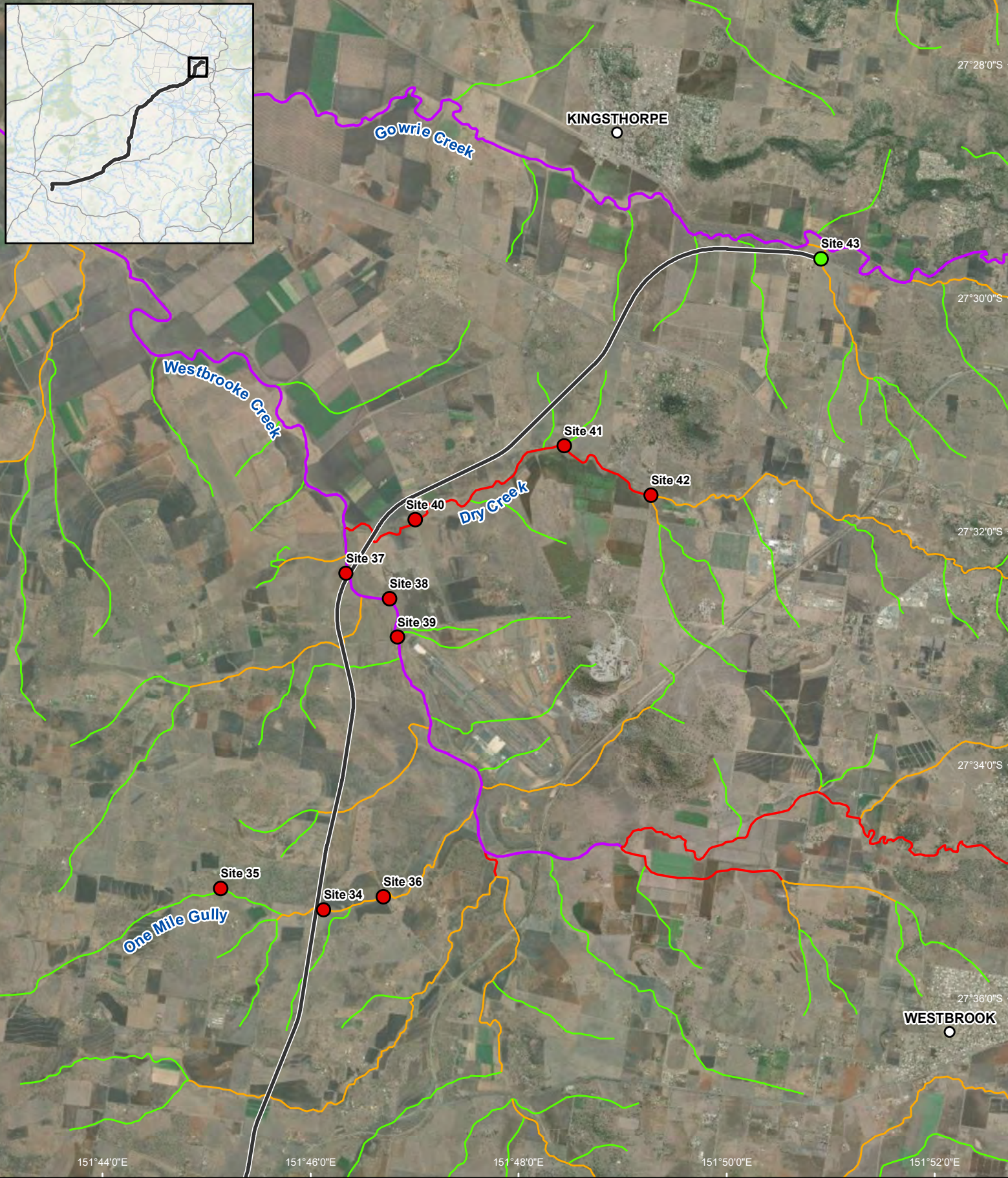
Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

0 1 2
Kilometers
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Oakey Creek Water Quality Zone (Cluster 6 of 6)



Legend

— Border to Gowrie Rail Alignment

B2G Sample Sites

- Aquatic Site
- Surface Water Site

Queensland Waterways for Waterway Barrier Works

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

0 1 2
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eDNA SURVEY

BRISBANE | PERTH | SINGAPORE | PAPUA NEW GUINEA

ARTC INLAND RAIL



B22066

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MARCH 2023

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EXECUTIVE SUMMARY

Inland Rail is a 1,700 km rail freight project connecting Melbourne to Brisbane, divided into 13 sections. ARTC commissioned Hydrobiology to conduct eDNA surveys across the North Star to NSW/QLD Border, NSW/QLD Border to Gowrie, Helidon to Calvert, and Calvert to Kagaru sections, covering approximately 307 km of the Inland Rail. This survey was conducted to build on the existing investigations and reporting undertaken for a number of listed aquatic species. The eDNA survey targeted matters of national environmental significance (MNES) aquatic species, including Murray River cod (*Maccullochella peelii*), Mary River cod (*Maccullochella mariensis*), Australian lungfish (*Neoceratodus forsteri*) and silver perch (*Bidyanus bidyanus*). The eDNA survey also assessed the absence/presence of southern purple spotted gudgeon (*Mogurnda adspersa*) and olive perchlet (*Ambassis agassizii*), which are listed as endangered in NSW, and the platypus (*Ornithorhynchus anatinus*) which is listed as special least concern in Queensland. Habitat likelihood assessments were also conducted for the MNES species and the platypus.

MNES species the Murray River cod was detected at a total of four sites across two sections of the Inland Rail, detailed in Table 1-1. No eDNA for silver perch, Mary River cod or Australian lungfish were detected at any site within the study area. Platypus were detected at a total of five sites, all within the QLD/NSW border to Gowrie section. Olive perchlet and southern purple-spotted gudgeon were found at a total of six and four sites respectively, all of which were located within Queensland, where they are not listed as threatened. The lack of silver perch, Mary River cod and Australian lungfish is likely to be due to the absence of key habitat features (high flow rapids and races; macrophytes, respectively) and/or the distance from species endemic range. Most sites contained low to no-flow run and pool habitat within channels that were typically eroded, with signs of flood damage, had cleared riparian vegetation and contained a variety of microhabitat in the form of woody debris and detritus.

Habitat likelihood assessments were conducted for the MNES species and the platypus. The lack of high flow rapids and races and the absence of macrophyte beds throughout the surveyed area meant no sites were deemed as potential locations for the silver perch or Australian lungfish. However, for platypus and Murray River cod, a total of 11 and six sites, respectively were deemed as possible or likely locations for each species. A total of 10 sites contained suitable habitat for Mary River cod; however given the sites were outside their natural ranges and that fact that there were no eDNA detection or historical records for this species, they are considered unlikely to occur in the study area. Despite stocking efforts for a number of these species, it has been shown that such efforts do not result in improvements in natural populations.

Species specific habitat improvements were made for sites where target species were detected. Most suggestions focussed on increasing habitat complexity through the addition of natural and artificial structures, exclusion of livestock and through the regeneration or re-establishment of riparian vegetation.

Table 1-1 Sites where eDNA of MNES and MSES species were detected and Inland Rail sections.

Target species	Sites eDNA Positive	Inland Rail Section
platypus	B2G17, B2G23, B2G21, B2G22 and B2G28	QLD/NSW border to Gowrie
Murray River cod	NS2QB12, NS2QB21, and NS2QB11	North Star to QLD/NSW border
	B2G11	QLD/NSW border to Gowrie
Mary River cod	No detections	-
silver perch	No detections	-
Australian lungfish	No detections	-
olive perchlet	H2C4A and H2C18A	Helidon to Calvert
	C2K1, C2K6, C2K7 and C2K5	Calvert to Kagaru
southern purple-spotted gudgeon	B2G37	QLD/NSW border to Gowrie
	H2C12A, H2C4A and H2C3	Helidon to Calvert

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1. INTRODUCTION

1.1 BACKGROUND

The Inland Rail project is a 1,700 km rail freight project connecting Melbourne to Brisbane via regional Victoria, New South Wales and Queensland (Figure 1-1). The project is being delivered by the Australian Government through the Australian Rail Track Corporation (ARTC) in partnership with the private sector.

The Inland Rail project is divided into 13 sections. Construction began in 2018 however the alignment of some sections are yet to be finalised. Currently, the Parkes to Narromine section has been completed and the Narrabri to North Star section is under construction in NSW while the remaining 11 sections are awaiting construction commencement. Approximately 1,100 km of the Inland Rail will utilise existing rail and infrastructure which will be updated, while approximately 600 km of new track and corresponding infrastructure is to be constructed.

1.2 OBJECTIVES AND SCOPE

Of the 13 sections of Inland Rail, Hydrobiology was commissioned to conduct eDNA sampling across four of these sections – the North Star to NSW/QLD Border, NSW/QLD Border to Gowrie, Helidon to Calvert, and Calvert to Kagaru, covering approximately 307 km of the Inland Rail.

The primary scope of this work involves the use of eDNA survey techniques to build on the existing investigations and reporting undertaken for the following matters of national environmental significance (MNES) and state significance (MSES) aquatic species, including:

- MNES:

- Murray River cod (*Maccullochella peelii*).
- Australian lungfish (*Neoceratodus forsteri*).
- Mary River cod (*Maccullochella mariensis*). We note that Mary River cod is unlikely to occur in the noted Project sections; however they have been included in the defined eDNA survey at the request of ARTC to investigate potential presence as a result of stocking outside their natural distribution.
- Silver perch (*Bidyanus bidyanus*). Again, we note that silver perch is unlikely to occur in the noted Project sections; however they have been included in the defined eDNA survey at the request of ARTC to investigate potential presence as a result of stocking outside their natural distribution.
- MSES:
 - Threatened southern purple-spotted gudgeon (*Mogurnda adspersa*) in NSW.
 - Threatened olive perchlet (*Ambassis agassizii*) in NSW.
 - Platypus (*Ornithorhynchus anatinus*), special least concern in Queensland.

Threatened turtles were not included in the eDNA surveys as turtle detection via eDNA methods is considered limited (i.e. turtles do not shed DNA as efficiently as fish, therefore detection is typically low and could result in many false negatives), while the use of eDNA as a survey tool for invertebrates such as the Darling River snail is still in its infancy and was therefore excluded.

Based on the eDNA and habitat surveys, recommendations regarding habitat improvements were also provided.

1.3 LOCATION

The eDNA survey and site assessments were conducted from the Macintyre River near Goondiwindi to Ipswich and Toowoomba. Sites were surveyed across four sections of Inland rail, with sites sampled within the Border Rivers, Balonne-Condamine, Brisbane and Logan-Albert catchments.

1.3.1 INLAND RAIL SECTIONS

This included the North Star to NSW/QLD Border, NSW/QLD Border to Gowrie, Helidon to Calvert, and Calvert to Kagaru sections. Path details of each rail section are detailed below:

- The North Star to NSW/QLD border section of Inland Rail involves upgrading old and constructing new tracks across the Macintyre River, allowing for future connections to Goondiwindi and the broader region. It follows the existing track north from North Star before crossing Bruxner Way and the border to join the existing Queensland Rail line. Final alignment for this section is yet to be identified;
- The NSW/QLD border to Gowrie sections span from the NSW/Queensland border, near Yelarbon, to Gowrie Junction, north west of Toowoomba;
- The Helidon to Calvert section will involve the construction of new track connecting Helidon (east of Toowoomba) with Calvert (west of Ipswich). This section uses the existing rail corridor and the Department of Transport and Main Roads' Gowrie to Grandchester protected rail corridor, with possible refinements being considered within a defined study area; and
- Calvert to Kagaru section follows the protected Southern Freight Rail Corridor which links the West Moreton line near Calvert to the interstate rail line near Kagaru, north of Beaudesert.

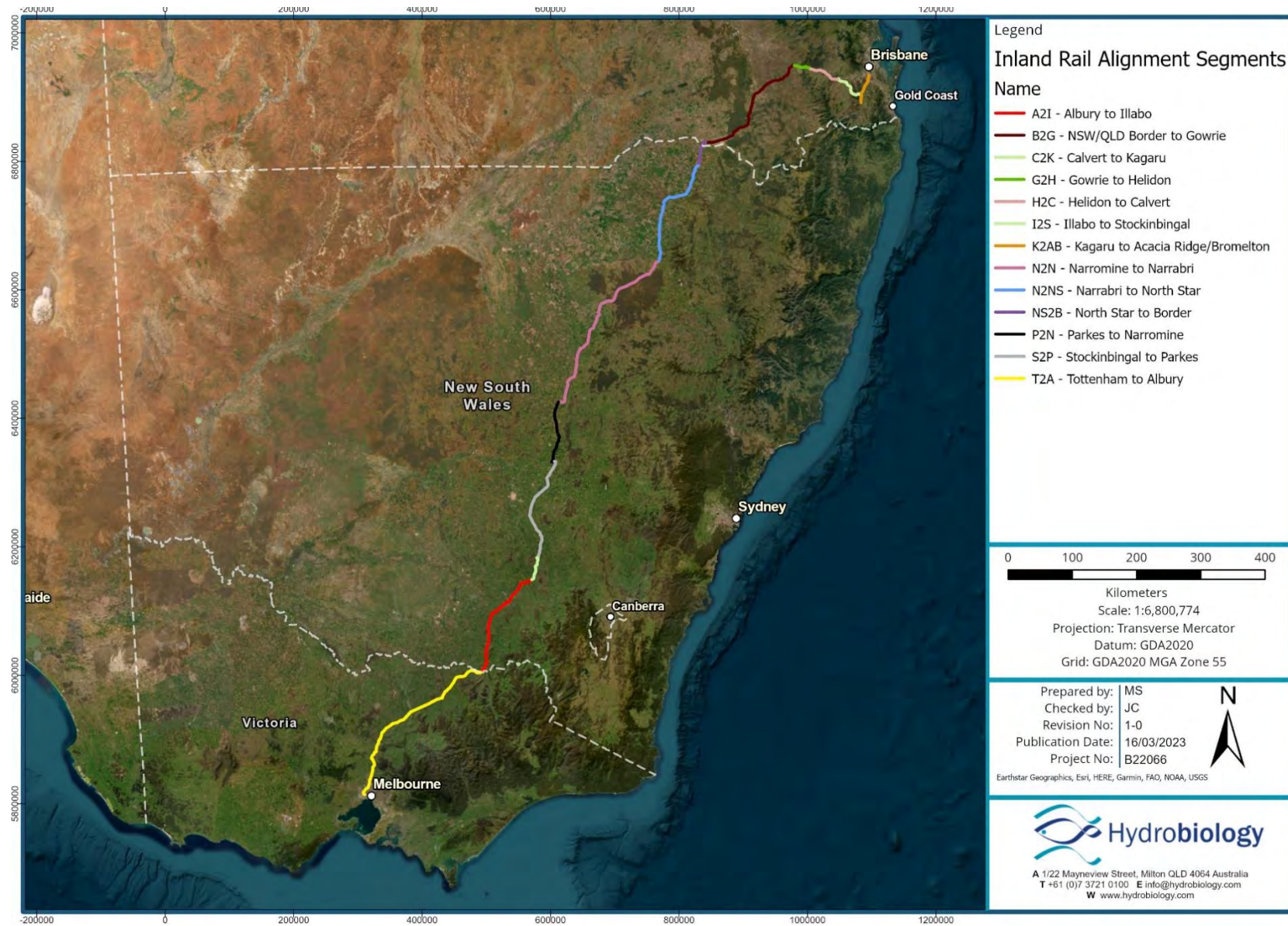


Figure 1-1 Map of inland rail project with sections distinguished

1.3.2 LOCAL BASINS AND CATCHMENTS

The 28 sampled sites were spread across 4 catchments, located within the Murray-Darling and Northeast Coast basins. Within the Border Rivers, Balonne-Condamine, Brisbane and Logan-Albert catchments, a total of eleven, five, nine and three sites were sampled, respectively.

BORDER RIVERS CATCHMENT

The Border River catchment contains the Dumaresq, Macintyre and the Barwon Rivers, which straddle approximately 450 km of the NSW and QLD border (MDBA, 2022). These rivers rise on the western slopes of the Great Dividing Range and run westward, eventually merging to form the Barwon River on the floodplains upstream of the town of Mungindi. Upstream of Mungindi, water flows are heavily regulated (MDBA, 2022). Glenlyon Dam on Pike Creek, in the upper Dumaresq catchment, regulates 88% of inflows, and Pindari Dam on the Severn River (NSW) regulates 70% of inflows. On-farm ring tanks account for 40% of constructed storage capacity in the region.

The rivers and wetlands of the region provide refugia for many native fish species, whose range has contracted across the basin (MDBA, 2022). The nationally significant Morella watercourse, Boobera lagoon and Pungboughal lagoon are located on the Macintyre River floodplain and represent one of few permanent waterbodies within the Murray Darling Basin.

CONDAMINE-BALONNE CATCHMENT

The Condamine- Balonne Rivers catchment is one of the northmost and one of the largest catchments within the Murray-Darling basin (MDBA, 2021). Most of the catchment is contained within QLD, with only a small area (16%) present within NSW. The Maranoa and Condamine are the main rivers that flow through the catchment and rise in elevated country in Queensland. Approximately two thirds of the catchment is flat, floodplain country in a complex series of rivers and creeks joining and breaking away from the Balonne River throughout the floodplains. The floodplains and rivers provides habitat for a diverse range of animals and plant communities (MDBA, 2021).

LOGAN-ALBERT CATCHMENT

The Logan-Albert Rivers catchment represents approximately 3,800 km² of the North East Coast basin. The headwaters lie in the McPherson and Main Ranges on the NSW border (Resilient Rivers Initiative, 2017). The Logan River is approximately 180 km long and flows northward before discharging into the Ramsar wetlands in southern Moreton Bay. The Albert River joins the Logan River near Eagleby, approximately 10 km upstream of the Logan River mouth. The Albert River is approximately 163 km long and is tidal for 35 km.

The major land uses for the catchment include grazing native vegetation, residential and farm infrastructure and nature conservation. Large areas of remanent vegetation are found within the mid and upper catchment in the World Heritage Areas of the Border Ranges (Resilient Rivers Initiative, 2017). Waterways within the area were designated as High Ecological Value waterways under the Environmental Protection (Water) Policy 2009. The upper catchment includes Mount Barney, Lamington, Main Range and Mount Chinghee national parks and is Heritage Listed as the Gondwana Rainforests of Australia. There are relatively large areas of mangrove forest lining the lower reaches and eucalypt vegetation across the mid and lower catchment (Resilient Rivers Initiative, 2017).

BRISBANE CATCHMENT

Like the Logan-Albert rivers basin, the Brisbane River basin is part of the North East Coast Drainage basin and covers an area of approximately 13,540 km² (CGQ, 2018). The main tributaries to the basin are the Lockyer, Bremer and Stanley rivers which all flow into the Brisbane River that discharges into Moreton Bay (I. Tibbetts et al., 2019). The headwaters of the Brisbane River are located in the Brisbane

Range about 25 km north-east of Nanango and 140 km from central Brisbane. The headwaters for the main tributaries, the Stanley, Lockyer and Bremmer rivers, are located along the Blackbutt range, the Great Dividing Range near Toowoomba and east of Cunningham's gap near Kalbar along the QLD/NSW border, respectively (CGQ, 2018).

1.4 FLOW AND RAINFALL

The eDNA and habitat assessments surveys conducted covered 28 sites that spanned 307 km along the Great Dividing Range. The climate of the western side of the range typically consists of high daytime summer temperatures and moderate winters and a wet season that typically falls during the summer months. Within the weeks prior to the survey, little rainfall (<15 mL) was recorded at Gatton, Inglewood, Millmerran, Laidley, Calvert and Kagaru (BOM, 2022). Pampas and Wellcamp received approximately 40 mL in the weeks leading up to the survey, while Goondiwindi recorded approximately 100 mL of rain in the weeks leading up to and during the survey, with 45 mL falling on the first day of the survey (BOM, 2022).

The inland rail route crosses a numerous major watercourses, including the Logan, Condamine, Macintyre and Bremer Rivers. Numerous stream flow gauges are in place throughout the study area and offer an indication on flow conditions during the survey. Table 1-1 displays the stream flow gauges from which data was extracted for the relevant survey sites. The data extracted from the gauges listed in Table 1-1 are shown in Figure 1-2. Across all areas, eDNA sampling occurred post high flow conditions, within multiple peak flows in the successive weeks and months prior to the survey.

Many of the fish species, including threatened species known to occur in the Study Area are potamodromous, meaning that they complete their lives wholly in freshwater but do undertake migrations. A number of species are diadromous or anadromous, meaning that they migrate between freshwater and saltwater to reproduce and vice versa, respectively. The spawning activity of fish species is usually highly related to flow regime. Meaning most species migrate from September to February during months of higher temperatures and rainfall with wet season conditions initiating migration and spawning. These periods are the peak movement times of fish and therefore their distributions are likely to be extended across the relative catchments. DSEWPC (2011), acknowledges the importance of timing surveys to coincide with migratory periods, as is the case for this survey.

Table 1-1 Stream flow gauges located within the study area and the sites to which the flow data is relevant.

Stream gauge	Relevant sites
416201A - Macintyre River at Goondiwindi	NS2QB12, NS2QB11, NS2QB21
416402C - Macintyre Brook at Inglewood	B2G11, B2G5, B2G10
143121A - Western Creek at Kuss Road	H2C18A, C2K4, C2K5, C2K3, C2K1
422347B - North Condamine River at Pampas	B2G28, B2G21, B2G22, B2G23
422332B - Gowrie Creek at Oakey	B2G37
145014A - Logan River at Yarrahappini	C2K7, C2K6, C2K2
No current running gauge stations nearby	NS2QB19, NS2QB5, NS2QB20 B2G16, B2G17 H2C12A, H2C3A, H2C4A, H2C17A

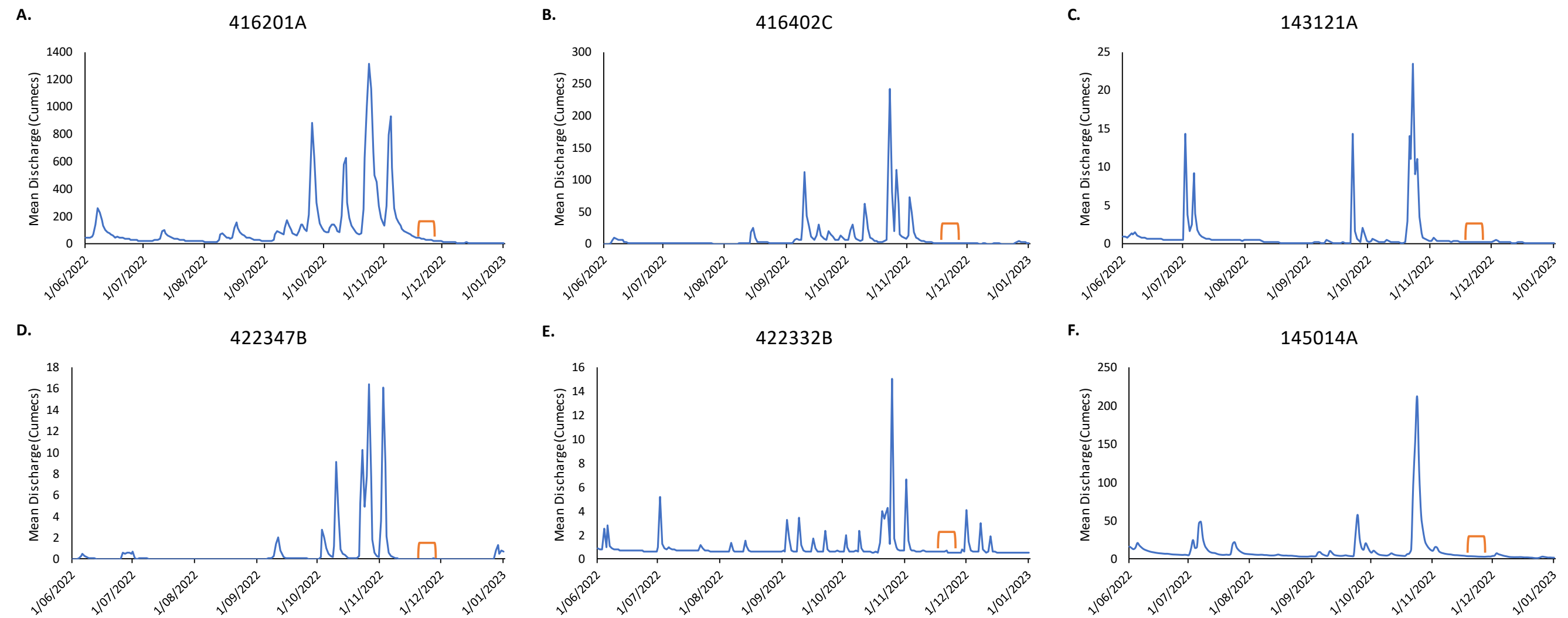


Figure 1-2 Stream flow (average cumecs/day) from gauges throughout the study area from June-December 2022. Survey dates are indicated by orange bracket. A. Macintyre River, B. Macintyre Brook, C. Western Creek at Kuss Road, D. North Condamine River at Pampas. E. Gowrie Creek at Oakey, F. Logan River at Yarrahappini

1.5 LEGISLATION RELEVANT TO LISTED SPECIES

Each of the seven target species is listed at a state and/or national level. The relevant listings and legislation for each species are detailed below.

Murray River cod:

- Vulnerable under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*;
- Endangered under *Flora and Fauna Guarantee Act 1988* (VIC); and
- Endangered in Action Plan for South Australian Freshwater Fishes (SA – non statutory listing).

Mary River cod:

- Endangered under the EPBC; and
- Not listed under *Nature Conservation Act 1992* but a no take species under *Fisheries Act 1994* (QLD)

Australian lungfish:

- Vulnerable under EPBC.

Silver perch:

- Critically endangered under EPBC;
- Endangered under *Nature Conservation Act 2014* (ACT);
- Vulnerable under *Fisheries Management Act 1994* (NSW);
- Endangered under *Flora and Fauna Guarantee Act 1988* (VIC); and
- Endangered in Action Plan for South Australian Freshwater Fishes (SA – non statutory listing)

Olive perchlet:

- Not listed under EPBC; and
- Western NSW population listed as an endangered population under the *Fisheries Management Act 1994* (NSW).

Southern purple-spotted gudgeon:

- Not listed under EPBC;
- Endangered under *Fisheries Management Act 1994* (NSW);
- Threatened under *Flora and Fauna Guarantee Act 1988* (VIC); and
- Endangered under *National Parks and Wildlife Act 1972* (SA).

Platypus:

- Not listed under EPBC;
- Special Least Concern under Nature Conservation (Wildlife) Regulation 2006 (QLD);
- Vulnerable under *Flora and Fauna Guarantee Act 1988* (VIC); and
- Endangered under *National Parks and Wildlife Act 1972* (SA).

2. METHODS

2.1 EDNA SURVEY

The use of eDNA for species detection has been found to be far more efficient than typical traditional methods for the detection of platypus (Lugg et al., 2018), threatened species of fish (Piggott, 2016) and is also a complimentary approach to traditional survey techniques (Golpour et al., 2022; Rourke et al., 2022). Regarding lungfish, in Hydrobiology's experience there are instances where eDNA detection has been less effective than traditional survey methods, though in other surveys lungfish have also been detected via eDNA and not captured via traditional survey techniques. At this stage the use of eDNA for understanding lungfish surveys is

2.1.1 SITE SELECTION

Sites were selected for sampling based on the previous works undertaken, which included:

- Habitat utilisation mapping defined in Future Freight (2020c, 2020f, 2020a, 2020d, 2020e, 2020b) – Areas noted where threatened species were likely or could possibly occur were selected for investigation; and
- Aquatic ecological survey undertaken by Ecological (2020) for the Border to Gowrie Project – Areas noted where threatened species were likely or could possibly occur were selected for investigation.

In addition to the above, Hydrobiology also selected sites for sampling based on internal expert knowledge regarding the discussed target species and habitat features identified from available aerial imagery relevant to these species.

Most sample points were along the alignment path; however some were moved due to lack of access and/or suitable habitat. Where sites could not be sampled directly along the Inland Rail alignment,

sites were moved nearby to accessible areas with suitable habitat within the same watercourse as the proposed point. Moved sites were either very close to the alignment path (approx. 100m) or were located further but were connected to the alignment path via permanent and non-impoundment watercourses. All sites selected were sampled and contained microhabitat relevant to at least one threatened species. During the field survey, two sites were moved from the proposed point due to lack of access and upstream closer to the alignment path and one was moved upstream due to a lack of free standing water at the original proposed point. The location of each test sites within the basin, catchment, watercourse and inland rail section are listed in Table 2-1 and displayed in Figure 2-1.

Table 2-1 Basin, catchment, watercourse and inland rail section of each sample site

Basin	Drainage Catchment	ARTC Section	Waterway	Site
Murray Darling	Border Rivers	NS2B North Star to Border	Unnamed Creek	NS2QB19
			Back Creek	NS2QB5
			Forest Creek	NS2QB20
			Macintyre River	NS2QB12
			Macintyre River	NS2QB21
			Macintyre River	NS2QB11
	Balonne-Condamine	B2G NSW/QLD Border to Gowrie	Macintyre Brook	B2G5
			Canning Creek	B2G11
			Pariagara Creek	B2G10
			Bringalily Creek	B2G16
			Bringalily Creek	BSG17
			Back Creek	B2G23
			Back Creek	B2G21
			Back Creek	B2G22
			Condamine River	B2G28
			Westbrook Creek	B2G37
North east coast	Brisbane	H2C Helidon to Calvert	Lockyer Creek	H2C12A
			Lockyer Creek	H2C4A
			Lockyer Creek	H2C3A
			Laidley Creek	H2C17A
			Western Creek	H2C18A
		C2K Calvert to Kagaru	Western Creek	C2K4

Basin	Drainage Catchment	ARTC Section	Waterway	Site
			Bremer River	C2K5
			Bremer River	C2K3
			Warrill Creek	C2K1
	Logan-Albert		Dugandan Creek	C2K6
	Woollaman Creek		C2K7	
	Teviot Brook		C2K2	

2.1.2 SAMPLE COLLECTION

eDNA samples were collected from the 20th-25th of November 2022, using a Smith-Root eDNA sampler with 5 µm Smith-Root self-preserving filters following Smith-Root protocol (Smith-Root, 2022). Three filters were processed at each site. The amount of water filtered averaged approximately 930 mL per site however varied between sites due to local factors such as present suspended solid concentrations which clogged the used filters. Overall the amount of material processed at each site ranged from 383-2533 mL. Samples were collected from areas of likely fish and platypus habitat (amongst snags, large woody debris (LWD), macrophytes, downstream of riffles and boulders, undercut banks, etc.). Filtration was undertaken on-site to reduce DNA degradation during transport of whole water samples (Yamanaka et al., 2016).

Clean sampling protocols were employed to minimise contamination between samples/ sites including new sampling equipment at each site, and taking care not to transfer soil, water or vegetation between sites. Filters were stored out of sunlight and at ambient temperature before being transported to the laboratory for processing. Quality control sampling was also undertaken in the form of blank samples. Three blank samples were processed with 1000 mL of clean water sampled per filter. Details regarding QA/QC measures implemented at each site including the result of blank samples are provided in Appendix B.

While eDNA samples were taken area of likely fish and platypus habitat, there are factors that must be taken into consideration when reviewing eDNA results, namely the rate of shedding and degradation and dispersal of eDNA. The rate of shedding can be influenced by an individual's species, size, age and maturity and by external factors such as temperature, pH and the presence of predators (Andruszkiewicz Allan et al., 2021). eDNA has successfully been used to determine distribution and/or presence of southern purple-spotted gudgeon, Murray River cod, Mary River cod, olive perchlet and platypus previously (Rourke et al., 2023; Stoessel et al., 2022; Wilkes Walburn et al., 2022; Yao et al., 2022). Studies on the effectiveness of eDNA to detect silver perch and Australian lungfish are not formerly published. Hydrobiology has previously conducted surveys within the Mary River basin and noted that the effectiveness of eDNA to detect lungfish varied, with some sites where lungfish were captured, eDNA results were negative; however eDNA also detected lungfish at sites where they were not captured via traditional survey techniques (Confidential client).

Once in the environment, DNA is broken down through processes such as UV exposure and microbial grazing, and is transported through advection, diffusion, mixing, settling and biological mechanisms (Andruszkiewicz Allan et al., 2021; Shogren et al., 2017). Overall fish DNA in the water column degrades rather quickly after the source species is removed, with variations between hours to weeks (Meng et al. 2022), though no formal investigations have been undertaken for the nominated target

species. It is expected that the species detected in this survey are likely recent occurrences for at least less than a month.

The amount of eDNA able to be transported and retained that can be recovered downstream of a source is highly variable and unpredictable (Shogren et al., 2017). No specific information relevant to the target species in terms of drift eDNA is available.

Fish DNA extraction, purification and quantification are detailed below. Laboratory analysis was undertaken at eDNA frontiers laboratory.

2.1.3 EXTRACTION AND SEQUENCING

DNA was extracted from each filter paper using a Qiagen DNeasy blood and tissue kit, following the eDNA frontiers lab's SOPs and detailed in Koziol et al., (2019), Stat et al., (2017), and Stat et al., (2019). Each sample was assigned an individual combination of index tags and amplified by PCR using 12S vertebrate metabarcoding primers and a species-specific qPCR assay targeting platypus. A metabarcoding library was generated and sequenced using the Illumina MiSeq. For qPCR analysis, samples were amplified using a specifically designed *Ornithorhynchus anatinus* assay (Lugg et al., 2018). Laboratory extraction and PCR controls were included to test for contamination for all tests.

Bioinformatic tools were used to analyse raw metabarcoding sequence data (Mousavi-Derazmahalleh et al., 2021) generated from the metabarcoding. The sequencing results were demultiplexed and trimmed using Obitools and quality filtered with Usearch v11 for sequencing errors (maxee=1) with a minimum length of 90 used. Sequences were then dereplicated and unique sequences were transformed into zero radius operational taxonomic units (ZOTUs) to provide sensitive taxonomic resolution (Usearch v11) (Edgar, 2018). ZOTUs, in contrast to OTUs, are a more exact sequence variant, clustering at 99% to improve taxonomic resolution. Generated ZOTUs were queried against the nucleotide database NCBI (GenBank) and assigned to the species level where possible. Taxonomic assignments were based on an in-house Python script which further filters the Blast results (evalue $\leq 1e-5$, %identity ≥ 95 , qCov =100, LULU minMatch =97%), combines them with the ZOTU table results and produces a table containing the taxonomic information available from Blast taxonomy database (accessed January 2023).

It is important to note that while sequences recovered are converted to the lowest possible taxon based on similarities and differences to a DNA database (NCBI's GenBank), this database, and the taxonomic framework that underpins it, may contain errors. Accordingly, the DNA taxon identifications should be interpreted as the best available assignment based on currently available information.

QA/QC details regarding extraction and sequencing are provided in Appendix B.

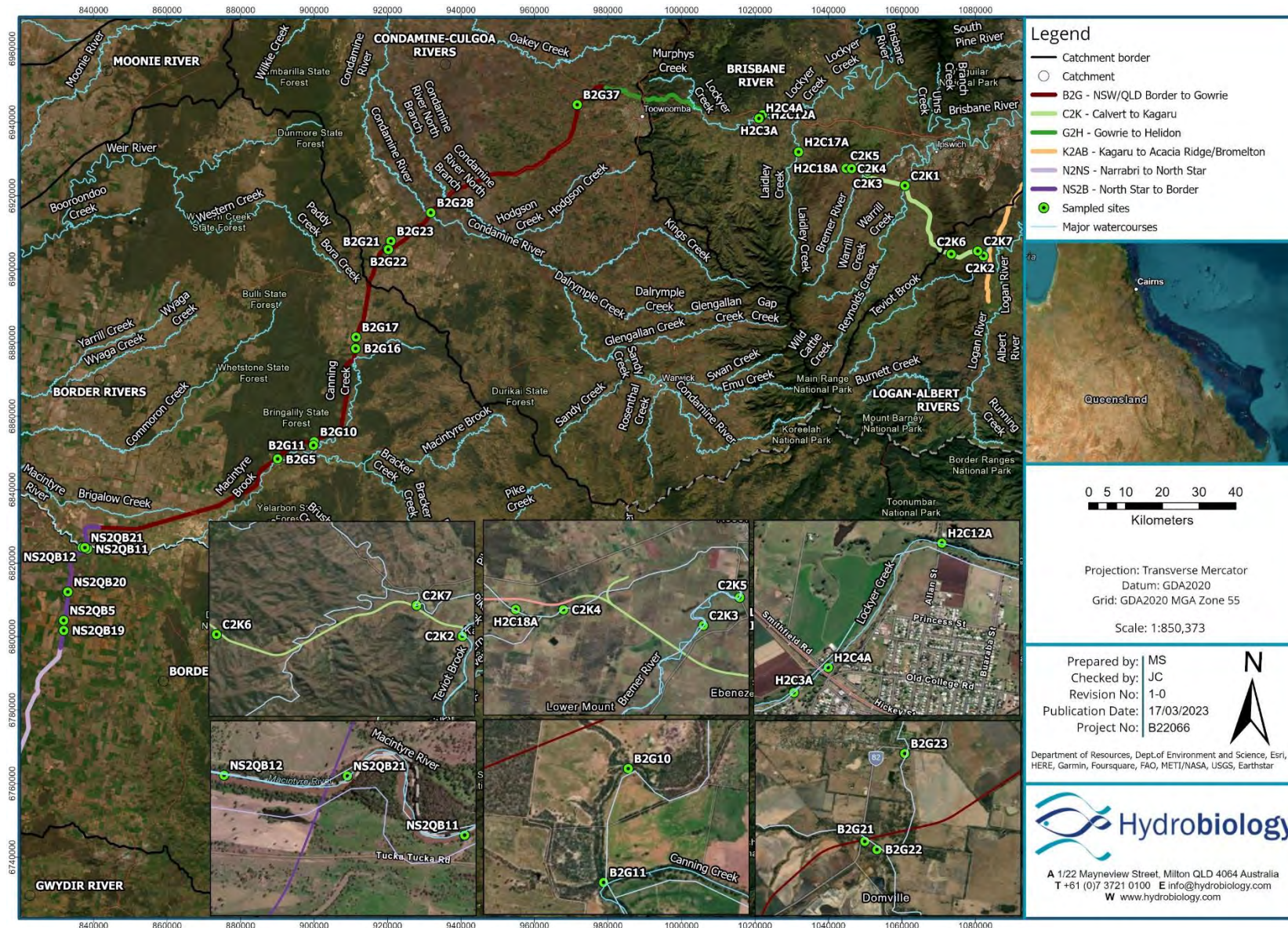


Figure 2-1 Map of study area with surveyed sites, inland rail sections, major watercourses and catchment areas indicated.

2.2 CONSERVATION SIGNIFICANT SPECIES LIKELIHOOD

At each site, habitat assessments were undertaken for each of the target species to classify the likelihood of any one species occurring at each site. The likelihood of species occurring was considered under three categories; (i) unlikely; (ii) possible; and (iii) likely. The criterion used to define each category is provided in Table 2-2. Occurrence records were taken from the Atlas of Living Australian (ALA) (2022).

Table 2-2 Criteria used for assigning likelihood of occurrences relevant to threatened and special least concern species

Likelihood of occurrence category	Criteria
Unlikely	No or very little suitable habitat present, or key habitat features absent.
Possible	Suitable species habitat present.
Likely	Suitable species habitat present and; A record occurs within 15 km in similar habitat.
Suspected	Positive eDNA results for the species were observed within 5 km at a different site.
Confirmed	Positive eDNA results returned for the species at the site.

3.

TARGET SPECIES

MURRAY RIVER COD

Murray River cod are historically distributed throughout the Murray Darling Basin. Though their range remains the same, overfishing and habitat alteration has led to a drastic reduction of their numbers which has made them scarce throughout the range, particularly within headwaters (J. D. Koehn & Clunie, 2010). It is worth noting that the species remains an important fisheries species has been extensively stocked within the Border rivers and Condamine-Balonne River catchment (DAF, 2022).

Murray River cod of upland reaches reside in small, clear rocky streams and are usually associated with complex structures such as large snags, large rocks, woody debris, undercut banks and overhanging vegetation (J. D. Koehn & Clunie, 2010). This species spawns in early spring and eggs are laid on hard substrates such as wood, rock and clay surfaces. Although this species does not require migration for spawning, individuals have been known to undertake long-distance movements prior to spawning. Murray cod populations has declined throughout in the Murray-Darling basin since European settlement due to habitat loss and degradation, pollution, barriers to movement, flow regulation and fishing (J. D. Koehn & Clunie, 2010).

Murray River cod have been recorded along the Macintyre River, approximately 15 km downstream of site NS2QB11, within the Condamine River and Bora Creek near Millmerran, and within Macintyre Brook (ALA, 2022; Ecological, 2020). As mentioned above, Murray River cod have also been stocked throughout the Border and Condamine-Balonne rivers' catchments. Relevant stocking locations included the Inglewood town weir, located 4km upstream of B2G11 and 11km downstream of B2G5, and the Goondiwindi weir, approximately 25km upstream of NS2QB21 (DAF, 2022).

MARY RIVER COD

The historical range of the Mary River cod included the Mary, Brisbane-Stanley, Albert-Logan, and Coomera River systems, however the species has sharply declined and is now found naturally only within the Mary River and is listed as vulnerable under the EPBC (Australian Government, 2016; Simpson & Jackson, 1996). Current populations found outside of the Mary River catchment are either captive bred populations or are descendants of captive individuals (Australian Government, 2016). The Mary River is one of the fastest urban growth areas in Australia, and flow alteration, habitat degradation, introduced fishes and overfishing have contributed to the species decline through fragmenting populations and reducing the availability of spawning habitat and reproductive opportunities (Espinoza et al., 2020).

Critical habitat features for Mary River cod include deep pools within permanent water holes with access to shallower water and natural base flows to inundate riffles and facilitate movement between deep pools. Mary River cod movement is typically associated with the location of mates and spawning habitats, with the fish typically moving downstream during winter and upstream during spring (Australian Government, 2016). Knowledge on Mary River cod breeding habitat is limited as breeding has not been observed, however in captivity they are known to favour hollow pipes and large woody debris and have been shown to have close association with logs and log jams in shallow littoral water and along banks with overhanging riparian vegetation during the breeding season (Espinoza et al., 2020; Simpson & Jackson, 1996). Outside of breeding season, Mary River cod still prefer complex habitats with undercut banks, LWD, deep pools and overhanging vegetation (Espinoza et al., 2020).

Natural Mary River cod populations are restricted to the Mary River catchment (ALA, 2022; Australian Government, 2016; Simpson & Jackson, 1996). Stocking has occurred within impoundments within the Brisbane river and Logan-Albert rivers catchments; however no stocking of Mary River cod had occurred within the study area (DAF, 2022).

SILVER PERCH

Silver perch are endemic to the Murray-Darling catchment and listed as critically endangered under the EPBC Act. This species occurs mainly in fast-flowing waters, particularly where there are rapids or races (McDowall, 1996). Silver perch undertake large migrations to spawning sites upstream during spring and summer, where spawning has been observed to occur over gravel or rock rubble substrate (McDowall, 1996). Populations of silver perch have declined sharply, and the species is now sparsely distributed across its former range. This decline is thought to be due to habitat loss and degradation, barriers to migration, egg mortality, spawning failures and pressures from non-native species (Bray & Thompson, 2021).

Silver perch are the second-most stocked species in Australia and hatchery-reared fingerlings have been stocked in the Murray-Darling basin, in impoundments east of the Great Dividing Range and north to the Fitzroy-Dawson catchment (Queensland Government, 2020). However, they have not been stocked within or near the study area (DAF, 2022). Silver perch have been recorded within the Macintyre River, approximately 60 km upstream of NS2QB12, in Back Creek in Millmerran approximately 5 km from B2G23, and within Spring Creek in Toowoomba (ALA, 2022).

AUSTRALIAN LUNGFISH

The Australian lungfish (*Neoceratodus forsteri*) is listed under the EPBC Act as vulnerable and a recovery plan has been drafted (DCCEEW, 2017). It is also a no-take species under the *Fisheries Act 1994*. The species was eligible for listing as vulnerable (DotE, 2014) as a result of past changes to its core habitat, limited geographic range and suspected poor recruitment. The recruitment of adult breeding population is suspected to be unsustainably low, and the populations is expected to

undergo a substantial decline over the next three generations. Its area of occupancy is estimated to be less than 2,000 km². Its natural distribution is assumed to be the Mary and Burnett systems with claims of being native to the Brisbane River with Pine River systems being subject to debate (Kemp, 2013; Wager, 1993). The species has also been translocated to several systems with populations persisting in the Condamine, Logan, Albert, and Coomera Rivers (Kemp, 2013).

The Australian lungfish requires clear or turbid, low-flow or still, vegetated, shallow pools to support spawning and feeding (Allen et al., 1989; Merrick & Schmida, 1984). Macrophytes are essential for reproduction with submerged or emergent variants providing nesting surfaces for egg laying and refuges for juveniles (Kemp, 2013). Adult lungfish favour submerged logs, dense banks of aquatic vegetation, or underwater caves formed by bed scouring under submerged logs. While lungfish can be found in both pools and riffles, their preferred habitats are pools of 3-10 m depth. In habitats such as these, they can often live in large groups (Kemp, 1986). All lungfish under 500 mm in length collected by Brooks and Kind (2002) were caught in dense macrophyte growth favoured for spawning, suggesting that juveniles prefer the same habitat and are probably slow to disperse after hatching. Juvenile lungfish are almost always found in dense macrophyte bed cover or similar in water of 500 mm depth or less.

Australian lungfish have been recorded within the Macintyre River, over 60 km from nearest site of NS2QB11, within the Condamine River near Millmerran, in Lockyer Creek within 500 m of H2C12A (record from 2003), in Mount Walker Creek approximately 4 km from C2K1, within the Logan River approximately 12 km downstream of C2K2 and along the Bremer River between C2K3 and C2K5, approximately 1.5 km from each site (ALA, 2022). Records from the Bremer River are from captures in 1992.

It is worth noting that the Bremer River was noted in Appendix K of the Calvert to Kagaru section of the EIS as “habitat critical for the survival of the species”. This is largely due to known records within proximity of the project. The lungfish was classified as being possible to occur within the study area however were not identified during targeted searches in 2016. Suitable habitat was identified within Purga Creek and Teviot Brook, however these areas are outside of the known distribution for Australian lungfish. Where the project intersects the Bremer River, habitat was not considered breeding or foraging habitat due to the lack of macrophytes and deep pools and the ephemeral nature of the section of river. The area was included within habitat mapping to ensure a conservative approach during the impact assessment, however the habitat should not be considered “habitat critical to the survival of the species”.

PLATYPUS

Platypus are listed as special least concern by the NCA (1992). Within Queensland, platypus are found along rivers east of the Great Dividing Range and in some western-flowing streams.

Platypuses inhabit a range of freshwater habitats including permanent freshwater streams and stream banks, shallow lakes, ephemeral streams and isolated pools, wetlands, and artificial water storages. Substrate composition is an important driver of platypus habitat quality with a substrate composition of pebbles, cobbles, gravel and other coarser rocks forming preferred habitats (T. R. Grant, 2004). Platypuses construct burrows above the water surface into the side of streambanks, generally preferring vegetation-consolidated banks of greater than 0.95 m in height (Brunt et al., 2018). Due to this, riparian vegetation is also known as a key platypus habitat driver with vegetation providing bank stability which is essential for platypus burrows (Serena et al., 2001a).

Platypus mating and nest building taking place in late winter to early spring, with egg laying occurring between July and November with young leaving their burrows in December to April (Grant, 2015).

Platyfish have been observed within the Macintyre River approximately 18 km downstream of NS2QB11, the Macintyre Brook 3 km upstream of B2G11, Pine Creek at Millmerran, Lockyer Creek within 1 km of H2C3A and H2C4A, Lagoon Creek in Laidley and within the Bremner River approximately 6km downstream of site C2K5 (ALA, 2022).

OLIVE PERCHLET

The olive perchlet is gazetted as endangered under the NSW *Fisheries Management Act 1994* (FMA). Historically, the olive perchlet range extends from north Queensland into NSW, Victoria and South Australia (SA) but has drastically reduced. It is now naturally extinct in SA, where it is present only as a single translocated population (DPI, 2013; MDBC, 2007). It was thought to be extinct in Victoria for 93 years, however a lone population was rediscovered in Mullaroo Creek in Victoria during 2022 (ALA, 2022; MDBC, 2023). Excluding the lone Victorian population, the current distribution range of the olive perchlet extends from north Queensland to northern NSW where they occur in coastal streams (eastern) and within Murray-Darling drainages (western). Eastern and western populations are treated as genetically distinct and the western population is listed as endangered within NSW (DPI, 2013). The western population of olive perchlet were once widespread throughout the Murray-Darling system but have suffered serious decline. The population is now found in limited sites in the Darling River drainage and an isolated population in the central Lachlan catchment (DPI, 2013; MDBC, 2007).

Olive perchlet typically inhabit slow flowing or still environments with diverse microhabitat. They are known to inhabit rivers, creeks, ponds and swamps. During the day they are typically found in areas with overhanging vegetation, aquatic macrophyte beds, logs, dead branches and boulders, and will disperse to feed during the night (DPI, 2013; MDBC, 2007).

Threats for the western population of the olive perchlet include habitat loss and degradation, predation by invasive species, poor water management and spawning failures from cold water pollution (DPI, 2013).

SOUTHERN PURPLE-SPOTTED GUDGEON

The southern purple-spotted gudgeon is gazetted as endangered under the FMA. Historically, the southern purple-spotted gudgeon was known to persist within Queensland, NSW, Victoria and SA. The species is now threatened (regionally extinct) within Victoria, critically endangered within SA, endangered within NSW and is not listed within Queensland (DPI, 2017; Gomon & Bray, 2018).

The southern purple-spotted gudgeon inhabits coastal drainages from as far north as the Pascoe River in Queensland to the Clarence River in Northern NSW, which forms the Eastern NSW population, and throughout the Murray Darling Basin in NSW through to SA, which in NSW is referred to as the western population. The species was close to being extinct in SA prior to a captive breeding population and has been dwindling in NSW. As of 2017, the NSW Murray-Darling Basin population is confined to small remnant populations with limited gene flow between populations (DPI, 2017; Gomon & Bray, 2018). Few recent records exist in NSW of the Eastern population despite targeted surveys (ALA, 2022; DPI, 2017). Although the species is threatened in parts of its overall range, the southern purple-spotted gudgeon is common in coastal streams of central and southern Queensland (ALA, 2022; Gomon & Bray, 2018).

Southern purple-spotted gudgeon are a benthic species, typically found in a variety of habitats that include freshwater rivers, creeks and billabongs, preferring still or slow-flowing deeper waters with low turbidity. The fish often utilises aquatic and overhanging vegetation, leaf litter, rocks, snags and other woody debris (DPI, 2017; Gomon & Bray, 2018).

Threats to the species include predation by non-native fishes, habitat degradation and loss from anthropogenic activities and other fish species, water levels fluctuation due to drought and river regulation, thermal pollution and degraded water quality (DPI, 2017; Gomon & Bray, 2018).

4.

RESULTS AND DISCUSSION

4.1 HABITAT

Site imagery and notes are displayed in Table 4-1. Across most sites, the available water was typically turbid, shallow in tributaries, deep in riverine sites and overall slow flowing. Macrohabitat was largely limited to pools and contained a mixture of microhabitat relative to small and large woody debris. Evidence of flood water was prevalent at most sites, evident in recently eroded banks and debris around structures and vegetation.

Table 4-1 Habitat notes and imagery of each site throughout study area.

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
Murray	NS2B North star to border	Unnamed Creek	NS2QB19	Isolated pools present under road and rail bridges and connected by a small channel. There is limited habitat available and present water was turbid. Signs of macropods and cattle activity.		
		Back Creek	NS2QB5	Limited habitat available, waterway likely an ephemeral creek with a small area of emergent macrophytes. Waterway sampled at road crossing/culvert. Riparian vegetation is heavily cleared around site, with signs of cattle activity. Limited water available is turbid.		
		Forest Creek	NS2QB20	Waterbody under road crossing with box culverts, flows through cattle paddocks. Casuarina trees present around the pool which is turbid with limited habitat. Tadpoles (suspected striped marsh frogs) and fish sites within pools.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
		Macintyre River	NS2QB12	Turbid pool within large channel impacted by cattle. Large tree trunk snags, marginal grasses and overhanging vegetation provide some habitat. Riparian vegetation is largely intact.		
		Macintyre River	NS2QB21	Run and pool habitat present, with visible movement of turbid water along surface. Pebble bar, backwater, large snags and overhanging vegetation are present, providing some habitat. Riparian vegetation is intact.		
		Macintyre River	NS2QB11	Riparian vegetation is continuous along left bank while semi-cleared and scattered along right bank. Eroded areas present along both banks. pebbled bars present on bends. Shed and pump infrastructure present on right bank, small accommodation setup present on left bank. Fisherman present during sampling, samples taken upstream.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
	B2G NSW/QLD border to Gowrie	Macintyre Brook	B2G5	Packed earth road crossing running through wetland site, water rich in tannins but not turbid. High coverage of duckweed along water surface, little open water remains. High coverage of emergent macrophytes along banks. Crop farming along right bank and livestock paddock on left banks with signs of cattle activity within the site.		
		Canning Creek	B2G11	Turbid series of large, sandy pools. heavy riparian clearing only on one bank, other largely intact. LWD and overhanging vegetation providing habitat. tributary inflow present.		
		Pariagara Creek	B2G10	River reduced to a series of large, turbid pools with a road crossing through site. Banks are largely undefined; however erosion is evident with sand deposition in stream. Banks and surrounding area are largely open as riparian vegetation has been heavily cleared. Large woody debris and emergent macrophytes providing some in stream habitat. LWD coverage limited instream, some along banks but unable to be sampled due to access. Mosquito fish observed at site.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
		Bringalily Creek	B2G16	Main channel contains limited SWD and LWD in form of fallen trees and associated debris. Backwater lined with emergent macrophytes, including <i>Ludwigia</i> sp., contains small woody debris (SWD) and LWD in the form of stags and fallen branches. Riparian vegetation heavily cleared with small pockets remaining. Water is very turbid. Site popular with water birds, with large amounts of droppings along banks. Cockatiels and Scaley-breasted lorikeets currently breeding in hollows of stags with backwater and there are large volumes of waterbird droppings along water's edge.		
		Bringalily Creek	BSG17	Turbid pools upstream of road crossing. Riparian vegetation heavily cleared along both banks, however no LWD within sample reach. Emergent sedges along banks.		
		Back Creek	B2G23	Riparian vegetation heavily cleared along both banks, which are shear and clearly eroded. Pools are deep, turbid and without any visible flow. Limited SWD present while LWD is in the form of fallen trees. site upstream of road crossing where LWD have been deposited during high flow events.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
		Back Creek	B2G21	Series of shallow, turbid pools present within degraded incised drainage channel with heavily eroded banks that have collapsed in some areas. SWD and LWD in the form of fallen trees and exposed roots. surrounding land heavily cleared, road access to coal mine adjacent to water way and sign of cattle activity throughout area. Site moved from original proposed point due to lack of access.		
		Back Creek	B2G22	Series of shallow pool within heavily incised and degraded drainage channel with collapsed banks. Vegetation heavily cleared throughout area. mine access road near site and signs of recent cattle activity. SWD and LWD in form of fallen trees and tree roots. upstream fence has large number of woody debris ensnared. fish bubbles visible. Site moved from original proposed point due to lack of access.		
		Condamine River	B2G28	Rail crossing over fast flowing river with large amount of LWD trapped along middle pylons. LWD forming barricade, redirecting high flow along ends of the rail crossing and to banks which have become heavily eroded and collapsed along most of the reach, exposing artificial stone placed around bridge abutments. Surrounding land heavily cleared for crops on both sides of the river. Site and rail crossing downstream of a stream confluence.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
		Westbrook Creek	B2G37	Shallow, flowing stream in small channel located within a broader channel. No woody debris present, however pebbled line stream bed. Surrounding area heavily cleared no exposed ground as dense groundcover throughout area, and no noticeable livestock activity - dog print noted along water's edge.		
North East Coast	H2C Helidon to Calvert	Lockyer Creek	H2C12A	Large channel with deep pool and low flowing run habitat passing under bridge. Riparian vegetation is isolated along the right bank, but nearly entirely cleared on the left bank. Woody debris is present within channel but downstream. Artificial boulders placed around bridge pylons for armouring provide good habitat. Fish bubbles seen within channel.		
		Lockyer Creek	H2C4A	Wide flowing channel passing under rail (upstream) and road bridges. Woody debris trapped around pillars of both bridges and geofabric (erosion sheet?) material wrapped around rail bridge pylons during floods. Some fish bubbles observed around road bridge pylons. Around bridges, bedrock along the banks is exposed. Mix of concrete, bedrock and artificially placed rocks within the stream. Buttresses from road gutters shoot into waterway however impact is limited as water hits exposed rock and concrete. Further downstream, natural cobbles (<25cm) form small bar around which is a natural riffle. Riparian zone is completely cleared for infrastructure and, along right bank downstream of road crossing, for agriculture. Cattle observed along banks and within waterway.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
		Lockyer Creek	H2C3A	Wide channel with broad banks. Left bank largely exposed sandstone bedrock. Somewhat eroded banks with grass cover vegetation. Left side cleared for road, housing and park, right bank for livestock. Upstream of rail and road bridges. SWD and LWD in form of fallen saplings and debris. Fish bubbles seen around debris. Several pairs of rainbow bee-eaters using hollows in right bank.		
		Laidley Creek	H2C17A	Well-formed channel below road bridge, artificial rocks armouring pylons form riffle zone across waterway. upstream banks heavily vegetated and surrounding land cleared for agriculture. Downstream, large section of bank has collapsed on bend. LWD and SWD from fallen trees and flood debris above and below water line. Downstream banks heavily vegetated with some LWD.		
		Western Creek	H2C18A	Large, deep pool in bend of creek bed. Banks well vegetated with mature trees, shrubs and grasses, however surrounding land completely cleared. Banks are somewhat eroded and steep, comprised of clay along right bank but exposed stone is visible along left banks. Macrophytes (Potamogeton sp.) and complex algae (charophytes) around water edge and some woody debris present in pool and streams. Fish, including mosquito fish, and turtle observed within pool.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
	C2K Calvert to Kagaru	Western Creek	C2K4	Creek running within larger, steeper channel which is enclosed by riparian overstory. Good riparian vegetation coverage along banks, most of the dominant vegetation are water associated plants eg Casuarina, Lomandra, Callistemon. Surrounding land largely cleared. Shrubs including lantana, climbers such as cat claw and grasses dominant. Undercut banks present within the stream, LWD and SWD provide habitat within the channel. No macrophytes present. Banks are very steep, channel is heavily incised and there are signs of erosion.		
		Bremer River	C2K5	Channel flows below road bridge, with abutments concreted and lined with blue stone. Banks are steep but shallow, and have isolated and scattered coverage of mature trees, and a largely bare understory as there is little groundcover. Upstream has high coverage from overhanging veg. Surrounding land is completely cleared for farming. Longnecked turtle and water dragons observed and potentially an eel observed at site.		
		Bremer River	C2K3	Macrophytic algae in stream, fish and fish bubbles sites. Large fish (possibly carp) sighted. Relatively enclosed waterway with established riparian vegetation on both banks. Riparian vegetation largely dominated by callistemon which provide microhabitat in the form of LWD. Surrounding land entirely cleared for grazing livestock. Banks are steep along sections of reach. Property pumping water from river and bank has been lined in areas without riparian cover.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images	
		Warrill Creek	C2K1	Banks, particularly along bends, highly eroded with numerous collapses observed as well as undercut banks. some riparian cover remains along banks. LWD and SWD washed down during floods. Overhanging vegetation provided by callistemon trees, which are the dominant form of riparian vegetation. Feet of banks eroded, virtually no ground cover remining. Cattle and fresh pig scats along waterway. Turtles, water dragons, mullet and mosquito fish observed.		
		Dugandan Creek	C2K6	Series of isolated pools within much larger channel. Site upstream of spring confluence with another major (dry) channel. Sediment is very coarse sand, with banks showing signs of erosion with several section collapsed. Isolated pools remain but adjoining streambed is like quicksand and wet below the surface. Riparian vegetation is mainly intact, with Casuarina dominant in the canopy however some rainforest species also present. Lantana is dominant within the understory with some grasses and tobacco bush present. Persicaria present within pool. Little woody debris available, channel largely contains leaf litter debris from Casuarina. The channel would be susceptible to erosion during high flow events but currently dry through most of its reach. Cattle and pig tracks observed.		
		Woollaman Creek	C2K7	Well formed, relatively wide channel with the site downstream of a stream confluence. Right and left bank are predominantly sand, with large boulders an exposed bedrock along left bank. Riparian vegetation is comprised of casuarina, eucalyptus and bloodwoods with grassed understory and is largely intact, though cleared in surrounding farmland. Banks are eroded in some areas, and channel contains sand banks along the bends. LWD and Casuarina needles along stream bed. Fish (potentially young bass) and water dragons observed.		

Catchment	ARTC section	Waterway	Site	Habitat notes	Images
		Teviot Brook	C2K2	Site within an existing channel that has formed within a larger channel. Banks are comprised of sand and show signs of erosion, with remnants of silt fencing trapped within some eroded banks. Lower reaches have intact riparian vegetation which is largely comprised of Callistemon. in cleared area, patches of Persicaria and Schoenoplectus provide cover. left bank at site and upstream largely cleared. Site is upstream of two road crossings and downstream of cattle property. Cattle tracks and scats by water way upstream and flood debris caught on cattle fences and trees. Water very turbid.	

4.2 SPECIES LIKELIHOOD OF OCCURENCES

Habitat assessments were conducted at each site to determine the likelihood of platypus and MNES aquatic species Murray River cod, Australian lungfish and silver perch being present at each site based on preferred/required habitat features. Species specific habitat attributes present within each study region are detailed in the sections below (Table 4-2).

The below commentary discusses those sites where occurrences are likely based on available habitat, relevant to the platypus, Murray River cod, Mary River cod, Australian lungfish and silver perch. eDNA results are explored fully in Section 4.3.

Platypus

Platypus are likely to occur at one site – H2C4A. However favourable habitat for platypus exists at all sites within the H2C Helidon to Calvert except H2C3 and half the sites within the NS2B North star to border sections. Favourable habitat attributes present at most favourable sites include:

- Consolidated banks with vegetation;
- Large woody debris;
- Convex banks;
- Debris at water level;
- Permanent waterbody;
- Coarse rocky substrate;
- Deep pool/run habitat; and
- No impoundment of the stream.

Australian lungfish

Australian Lungfish is native to the North East Coast basin, therefore appearances of the species in the Murray Darling Basin is low. Though some sites contained favourable micro and macrohabitat for Australian lungfish, such as still or low flowing permanent water bodies, woody debris and undercut banks, there was a notable absence of submerged macrophyte beds at all the 28 surveyed sites. Macrophyte beds are key for Australian lungfish because they are used by the species for foraging and spawning, providing suitable habitat for the successful deposition of eggs and refuge for juveniles (Allen et al., 1989; Kemp, 2013; Merrick & Schmida, 1984). While a records exist near Rosewood within 15 km of sites C2K3 and C2K5, the lack of suitable habitat means that these sites were still classified as unlikely.

Along the study area, Lockyer Creek and Bremer River were listed as habitat critical for the survival of the species in Appendix K of the EIS report for the Calvert to Kagaru section due to historical records. Australian lungfish have been recorded in Lockyer Creek within 500 m of H2C12A, and along the Bremer River between C2K3 and C2K5, approximately 1.5 km from each site (ALA, 2022). During a targeted survey however no lungfish were found at the Bremer River and the habitat of the river where the project intersects it was described as representing no foraging or breeding habitat due to the lack of macrophytes, lack of deep pools and the ephemeral nature of the river at this section. The previous survey however did find favourable habitat within Purga Creek and Teviot Brook, however the sites were outside of the species known distribution.

During the eDNA survey, Bremer River, Lockyer River and Teviot Brook sites were all classified as unlikely due to the lack of macrophytes and other key features. No sites were located along Purga Creek.

Silver perch

Silver perch are endemic to the Murray-Darling basin however they are heavily stocked outside of this basin. All sites were assessed for suitable habitat; however sites within the Murray Darling Basin were inherently more likely to contain natural populations of silver perch.

Silver perch presence is known to be strongly correlated with high flowing streams, typically with rapid and races present. While favourable micro and macrohabitat attributes such as woody debris, rock substrate, deep pool/run habitat were present, particularly at sites within the H2C Helidon to Calvert and NS2B North star to border sections, high flow habitats were absent. As no rapids or races were evident at any surveyed site, all sites were classified as unlikely locations for this species. Furthermore, there are no records with 15 km of the surveyed sites.

Murray River cod

The Murray River cod is only found within the Murray Darling Basin, therefore likelihoods displayed in Table 4-3 was for sites within their respective basin only. Favourable habitat suggests that Murray River cod are likely to be found at one site, N2QB4, though suitable habitat was found at six sites. Most, of the sites with favourable habitat include habitat attributes such as:

- Overhanging vegetation;
- Large snags;
- Other LWD;
- Large rocks;
- Deep pools; and
- No impoundment of the stream.

Mary River cod

The Mary River cod is naturally found only within the Mary River in the North East Coast basin and is stocked little elsewhere. Therefore all sites were assessed for suitable habitat however sites within the Murray Darling Basin were inherently unlikely to contain Mary River cod, regardless of habitat available. As no records exist near the sites, no site was classified as likely. Sites with possible habitat largely contained:

- Overhanging vegetation;
- Large snags or other LWD;
- Still/low flowing waters;
- Variety of shallow and deep pools; and;
- Lack of stream impoundment.

Intact riparian corridors were restricted to sites along the Macintyre River.

Table 4-2 Number of sites with favourable and unfavourable habitat features for each target species for the study area for each species.

Species	Found microhabitat	
	Favourable features	Unfavourable features
Australian lungfish	• Still/low flowing water with deep pool – 9/12 • Submerged macrophytes – 0/12 • LWD - 11/12 • Undercut banks - 2/12	• Impoundment of stream - 0/12 • Riparian clearing – 11/12
Silver perch	• Fast flowing water - 3/28 • Rapids and races present – 11/28 • Small woody debris – 24/28 • Gravel or rock rubble present - 15/28 • LWD – 24/28 • Deep pool/run habitat – 17/28	• Impoundment of stream – 2/28 • Riparian clearing – 24/28
Platypus	• Consolidated banks w. vegetation - 18/28 • LWD - 24/28 • Coarse rocky substrate (e.g. pebbles, cobbles and gravel) - 15/28 • Convex bank profile at water level – 28/28 • Debris at water level at bank - 24/28 • Permanent waterbody - 18/28 • Deep pool/run habitat – 17/28	• Impoundment of stream – 2/28 • Riparian clearing - 24/28
Murray River cod	• Overhanging vegetation - 7/16 • Large snags - 12/16 • Other LWD - 11/16 • Large rocks – 1/16 • Undercut banks – 0/16 • Deep pools - 8/16	• Impoundment of stream – 2/16 • Riparian clearing - 13/16
Mary River cod	• Overhanging vegetation – 17/28 • LWD - 24/28 • Undercut banks – 3/28 • Slow flowing pools - 24/28	• Impoundment of stream – 2/28 • Riparian clearing - 24/28

Table 4-3 Likelihood of target species being present at sites based on habitat features present/absent at each site typically observed with target species. Likelihood classification defined in Table 2-2. Grey indicates sites within basins that are outside of the natural distribution of the species – the Mary River cod is found in the Mary River in the North East Coast Basin while the Murray River cod and silver perch are endemic to the Murray Darling River basin. Bold text indicates where species were confirmed or are suspected to occur and the habitat likelihood assessment result of the site.

Catchment	ARTC section	Waterway	Site	Australian lungfish	Silver perch	Platypus	Murray River cod	Mary River cod
MURRAY DARLING	NS2B North star to border	Unnamed Creek	NS2QB19	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Back Creek	NS2QB5	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Forest Creek	NS2QB20	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Macintyre River	NS2QB12	Unlikely	Unlikely	Possible	Possible & Confirmed	Possible
		Macintyre River	NS2QB21	Unlikely	Unlikely	Possible	Possible & Confirmed	Possible
		Macintyre River	NS2QB11	Unlikely	Unlikely	Possible	Likely & Confirmed	Possible
	B2G NSW/QLD border to Gowrie	Macintyre Brook	B2G5	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Canning Creek	B2G11	Unlikely	Unlikely	Unlikely	Possible & Confirmed	Possible
		Pariagara Creek	B2G10	Unlikely	Unlikely	Unlikely	Unlikely but Suspected	Unlikely
		Bringalily Creek	B2G16	Unlikely	Unlikely	Unlikely but Suspected	Unlikely	Unlikely
		Bringalily Creek	BSG17	Unlikely	Unlikely	Unlikely but Confirmed	Unlikely	Unlikely
		Back Creek	B2G23	Unlikely	Unlikely	Possible & Confirmed	Possible	Possible
		Back Creek	B2G21	Unlikely	Unlikely	Unlikely but Confirmed	Unlikely	Unlikely
		Back Creek	B2G22	Unlikely	Unlikely	Unlikely but Confirmed	Unlikely	Unlikely
		Condamine River	B2G28	Unlikely	Unlikely	Possible & Confirmed	Possible	Unlikely
		Westbrook Creek	B2G37	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
NORTH EAST COAST	H2C Helidon to Calvert	Lockyer Creek	H2C12A	Unlikely	Unlikely	Possible	Unlikely	Unlikely
		Lockyer Creek	H2C4A	Unlikely	Unlikely	Likely	Unlikely	Unlikely
		Lockyer Creek	H2C3A	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Laidley Creek	H2C17A	Unlikely	Unlikely	Possible	Possible	Unlikely
		Western Creek	H2C18A	Unlikely	Unlikely	Possible	Unlikely	Possible

Catchment	ARTC section	Waterway	Site	Australian lungfish	Silver perch	Platypus	Murray River cod	Mary River cod
	C2K Calvert to Kagaru	Western Creek	C2K4	Unlikely	Unlikely	Possible	Possible	Possible
		Bremer River	C2K5	Unlikely	Unlikely	Unlikely	Unlikely	Possible
		Bremer River	C2K3	Unlikely	Unlikely	Unlikely	Possible	Possible
		Warrill Creek	C2K1	Unlikely	Unlikely	Possible	Possible	Possible
		Dugandan Creek	C2K6	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Woollaman Creek	C2K7	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely
		Teviot Brook	C2K2	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely

4.3 SPECIES DETECTIONS

Species specific detection using metabarcoding and quantitative PCR analysis (platypus only) returned a range of species throughout the study area. It is important to note that the natural range of some species does not occur within some of the assessed catchments. For example, the natural distribution of Murray River cod is within the Murray River basin but not easterly flowing catchments. Despite this, metabarcoding and eDNA for all species was conducted at every site regardless of individual species range. Presence/absence data of threatened species are displayed in Table 4-4. Results are explored below.

4.3.1 TARGET SPECIES DETECTIONS

Analysis of the eDNA found evidence of platypus, Murray River cod, olive perchlet and southern purple-spotted gudgeon across the surveyed area (Figure 4-1 to Figure 4-4 and Table 4-4), however Australian lungfish, Mary River cod and silver perch were notably absent.

MURRAY RIVER COD

Murray River cod were detected at a total of four sites across two sections of the inland rail. The species was detected at three sites within the North star to NSQ/QLD border section:

- NS2QB12;
- NS2QB21; and;
- NS2QB11.

Murray River cod were also detected at one site within the NSW/QLD border to Gowrie section - B2G11.

Murray River cod are known to persist within the Murray Darling River basin and not the Northeast coast basin, therefore the absence of detections from sites within the Helidon to Calvert and Calvert to Kagaru sections is not unexpected. Sites NS2QB12, NS2QB21 and NS2QB11 were all located within an uninterrupted section of the Macintyre River prior to the junction of the Dumaresq and Macintyre Rivers. Site B2G11 sits along Canning Creek which, via the Macintyre Brook, is connected to the Dumaresq and Macintyre Rivers. B2G11 is also approximately 100 km upstream of other sites with positive Murray River cod detections.

While Murray River cod spend the majority of their life within a small area, often around a particular snag in favourable habitat, they will migrate up to 120 km (typically upstream) to spawn, typically when water levels are high. Following migration, adults will return to the area they occupied prior, often to the same snag. It is therefore possible that the Murray River cod DNA from the sites along the Macintyre River belong to the same population as the source of the DNA within site B2G11.

PLATYPUS

Platypus were detected at a total of five sites, all of which are within the B2G NSW/QLD border to Gowrie section. Platypus were detected at sites:

- B2G17;
- B2G23;
- B2G21;
- B2G22; and
- B2G28.

Site B2G28 is located within the Condamine River itself while B2G21, B2G22 and B2G23 are located in Back Creek, which is a tributary of the Condamine River. Individual home ranges of platypus are

typically <15 km, with male home ranges typically encapsulating numerous females' (Bino et al., 2019). However, young dispersing males have been known to travel more than 50 km in the Yarra River system and nearly 45 km in the Wimmera River system (Serena & Williams, 2013). Therefore it is suspected that the detection from Back Creek sites and those from the Condamine River are from individuals within the same population.

Platypus detection at site B2G17 was from Bringalily Creek which is a tributary of the Dumaresq River, where sightings have been recorded (ALA, 2022). The Bringalily Creek population is not expected to be from the same platypus population as that in the Condamine River and Back Creek. It is worth noting that platypus appear capable of migrating between adjacent river basins (Furlan et al., 2013). Genetic connectivity has been found between platypus in adjacent disconnected river systems within NSW, suggesting overland dispersal (Kolomyjec et al., 2009). However, it is unclear how often and over what distance platypus are able to successfully move between water bodies (Furlan et al., 2013). Platypus have been recorded travelling overland distances of 7-8 km (Furlan et al., 2013), however as B2G17 is at least 25 km (linear distance overland) from any other site tested that contained platypus DNA, overland dispersal between the two systems is unlikely.

OLIVE PERCHLET

Olive perchlet were detected at six sites through the Helidon to Calvert and the Calvert to Kagaru sections. Within the Helidon to Calvert section, olive perchlet were detected at sites:

- H2C4A; and
- H2C18A

Within the Calvert to Kagaru section detections occurred at sites:

- C2K1;
- C2K6;
- C2K7; and
- C2K5.

All detections were within Queensland in the vicinity of Undullah, Rosewood, Calvert or Gatton. The western population of olive perchlet is listed as endangered within NSW; however this species is not considered threatened in Queensland.

SOUTHERN PURPLE-SPOTTED GUDGEON

Detections of Southern-purple spotted gudgeon occurred at a total of four sites. Three detections occurred within the Helidon to Calvert section:

- H2C12A;
- H2C4A; and
- H2C3.

One detection occurred within the NSW/QLD border to Gowrie section at B2G37.

These sites encompass Toowoomba and Gatton, Queensland, and there were no detections for any sites within NSW where the species is listed as endangered.

It is worth noting the detections returned do not separate an individual species of *Mogurnda* (genera of Southern-purple spotted gudgeon). *Mogurnda* DNA detected during the survey is expected to be that of *Mogurnda adspersa* (Southern-purple spotted gudgeon) due to distribution ranges of *Mogurnda* species (Atlas of Living Australia (ALA), 2022). Other Australian *Mogurnda* species are largely restricted to central northern Australia.

MARY RIVER COD

Mary River cod was not detected at any of the 28 visited sites. This is not unsurprising as all sites were outside of the Mary River basin (natural distribution) and there were no nearby records or known stocking of the species.

SILVER PERCH

There were no detections of eDNA for silver perch at any of the 28 visited sites. The lack of detections was unsurprising considering the endemic range of the species and the scarcity of historical records of natural or stocked populations. The absence of silver perch was largely attributed to the ephemeral nature of some sites and limited availability of high flow environments and absence of rapids and races.

Silver perch have been well studied under cultured conditions, however knowledge on their biology, environmental tolerances and habitat requirement in the wild are scarce (DPI, 2006). The species is known to have inhabited environments characterised by extremes in environmental flows, with periods of drought punctuated by major floods (Koster et al., 2021; NSW Department of Primary Industries (DPI), 2006). They have been known to occupy slow flowing and turbid water sources including lowland rivers of the west and north of the Murray-Darling Basin, floodplains, lakes and reservoirs. However, they have been noted by anglers and researchers to show a more general preference for high flow environments where rapids and races are present and within open sections of the river (Clunie & Koehn, 2001; DoE, 2013; DPI, 2006).

AUSTRALIAN LUNGFISH

As with the silver perch and Mary River cod, there were no detections of Australian lungfish at any of the 28 visited sites. Australian lungfish are known to occur within the Northeast coast catchments, but not the Murray Darling River basin, therefore the absence of lungfish in the North star to QLD/NSW border and QLD/NSW border to Gowrie sections is not unexpected.

The absence of Australian lungfish within the Northeast coast basin sites was also unsurprising due to a lack of key habitat feature. For the Australian Lungfish, the complete absence of submerged macrophyte beds (i.e. largely shallow pool habitat present), which limits breeding and foraging habitat.

As mentioned earlier, previous surveys conducted by Hydrobiology targeting Australian lungfish have noted that the effectiveness of eDNA to detect lungfish varied – at some sites where lungfish were electrofished eDNA results were negative however eDNA also detected lungfish at sites where electrofishing was unsuccessful.

4.3.2 COMMUNITY FISH ASSEMBLAGES

FISH

A total of 15 families comprising 28 species of fish were detected throughout the surveyed area (Appendix A). Most were species native to Australia, although eastern mosquito fish and Eurasian carp were present at all but 10 and five sites, respectively. Western carp gudgeon and Eurasian carp were the most widely distributed species, absent from four and five sites, respectively.

The Brisbane River catchment was the most diverse, containing 24 species across the nine sites, three of which were found in no other catchment. The most diverse site within the Brisbane River catchment, Bremer River site C2K5, recorded 15 species of fish. The Logan-Albert Rivers catchment was the next most diverse, with 17 fish species detected across three sites, one of which was unique to the catchment. The most diverse site was C2K2, located within Teviot Brook, with 16 individual fish species, making this site the most diverse for fish across the study area. Border Rivers and the

Balonne-Condamine Rivers catchments were comparatively less diverse, with 13 species across 11 sites and 11 species across 5 sites recorded, respectively, and no unique species in either catchment.

4.3.3 OTHER VERTEBRATES

While not the target of this investigation, metabarcoding of vertebrate DNA detected a number of other vertebrate species. These results provide a preliminary analysis of other species at each site; however this is not comprehensive as their habitats were not targeted nor were other vertebrate species targeted beyond fish and platypus. Therefore, these detections are considered incidental.

FROGS

Four families of amphibian were represented encompassing five species throughout the surveyed area, including the Wallum rocketfrog (*Litoria freycineti*) (Appendix A).

The wallum rocketfrog is of particular note as it is listed as vulnerable in Queensland under the NCA and, was detected within Queensland at site B2G10. Wallum rocket frogs are largely confined to the coastal lowlands and sand islands of southeast Queensland and NSW. They typically inhabit coastal wet heath where it can be found around sedge swamps, freshwater lakes and drainage lines on low nutrient soils. The wallum rocketfrog has also been recorded a considerable distance from water in eucalypt forest near wet heath habitat (Hines et al., 2004; Meyer, 2012; Meyer et al., 2006). Their detection during this survey is out of their typically distribution range, however it is worth noting that historical records (from 1978-2004) exist in other similarly unlikely locations that are outside of their usual distribution. Unusual records includes towns such as Armidale, Tenterfield, Bonalbo, Kyogle and Bundarra in NSW and Fernvale in Queensland. While the record should not be discounted, further investigation is required.

REPTILES

The Macquarie River turtle, saw-shelled turtle and *Chelodina* sp., all from the Chelidae family, were detected at a total of two, five and 10 sites across the study area, respectively (Appendix A). None of these species are listed as threatened in NSW and Queensland.

BIRDS

A total of 27 bird species along the project extent were detected, representing 18 families (Appendix A). Most birds throughout the area were common, though there were a few species of interest or note:

- Sacred kingfisher (New Zealand subspecies) are found throughout most of Australia except central Western Australia (WA) and suitable habitat was observed throughout much of the study area for this species. However, the New Zealand subspecies, *vagans*, was detected at B2G16. This subspecies has not been historically recorded in Australia. This subspecies detection is likely an error allocation in the Global database likely due to missing or unsuitable reference sequences for local taxa.
- Red junglefowl is native to South East Asia but are kept for poultry in Australia. Detection during this survey is expected to be from farmed or escaped animals. Detections for this species were returned at sites B2G28, H2C17, C2K5 and C2K2.
- Princess parrots (*Polytelis alexandrae*) are listed as vulnerable federally, and in the Northern Territory, SA and WA. Extent occurrences vary greatly between years, with the species not being recorded for considerable amounts of time followed by years with abundant records (DCCEEW, 2023). This nomadic species are typically found within interior Australia, but large numbers estimated to 25,000 birds are held within private aviaries in Australia alone (DCCEEW, 2023). Records exist within Queensland (ALA, 2022). It is possible that these are wild princess parrots that have traversed

outside of their normal range, however it is more likely that they are birds that have escaped aviaries. Princess parrot eDNA was detected at site B2G10 only.

- Western corellas (*Cacatua pastinator*) are typically known to occur within the Wheat Belt and formerly around Perth, WA. Isolated records exist within NSW and Queensland; however most records are either not recent or based on human observation (ALA, 2022). Western corella detections occurred at site B2G10. B2G10 also contained princess parrot DNA, another species which, as detailed above, is typically found within western and central Australia. As with princess parrots, western corella are sometimes kept as aviary pets and are able to interbreed with other corella species found along the eastern coast of Australia. As with princess parrots, it is possible that the eDNA was from wild birds that have traversed outside of their normal range, however given that two typically Western Australian species were both identified at the same site, it is more likely that the eDNA is from captive individuals.

MAMMALS

A total of 16 mammal species, representing nine families were detected throughout the surveyed area (Appendix A). Of these 16 species, six were livestock species (i.e. cattle, sheep, deer, pigs). This data may prove useful to understand causes of habitat degradation and determine appropriate management measures regarding their access where threatened species have been detected.

The remaining mammals were comprised of three bats, four marsupials and three rodents, which included the Lakeland Downs mouse. This species is of note because genetically distinct populations are typically found within the dry savanna of northern Australia (ALA, 2022), therefore their detection represents a potential range expansion.

Of the three bat species eDNA was assigned to, one species is not known to occur within Australia. The monando fruit bat (*Boneia bidens*) is native to Indonesia and no known records exist within Australia. The assignment of eDNA to species not known to occur within the study area is most likely due to missing or unsuitable reference sequences for local taxa. No other bat species from this genus are known in Australia, however the family to which the genus belongs, Pteropodidae, is represented by other genera in Australia, such as the *Pteropus* genus, to which one of the other detected species, the little red flying-fox (*Pteropus scapulatus*), belongs.

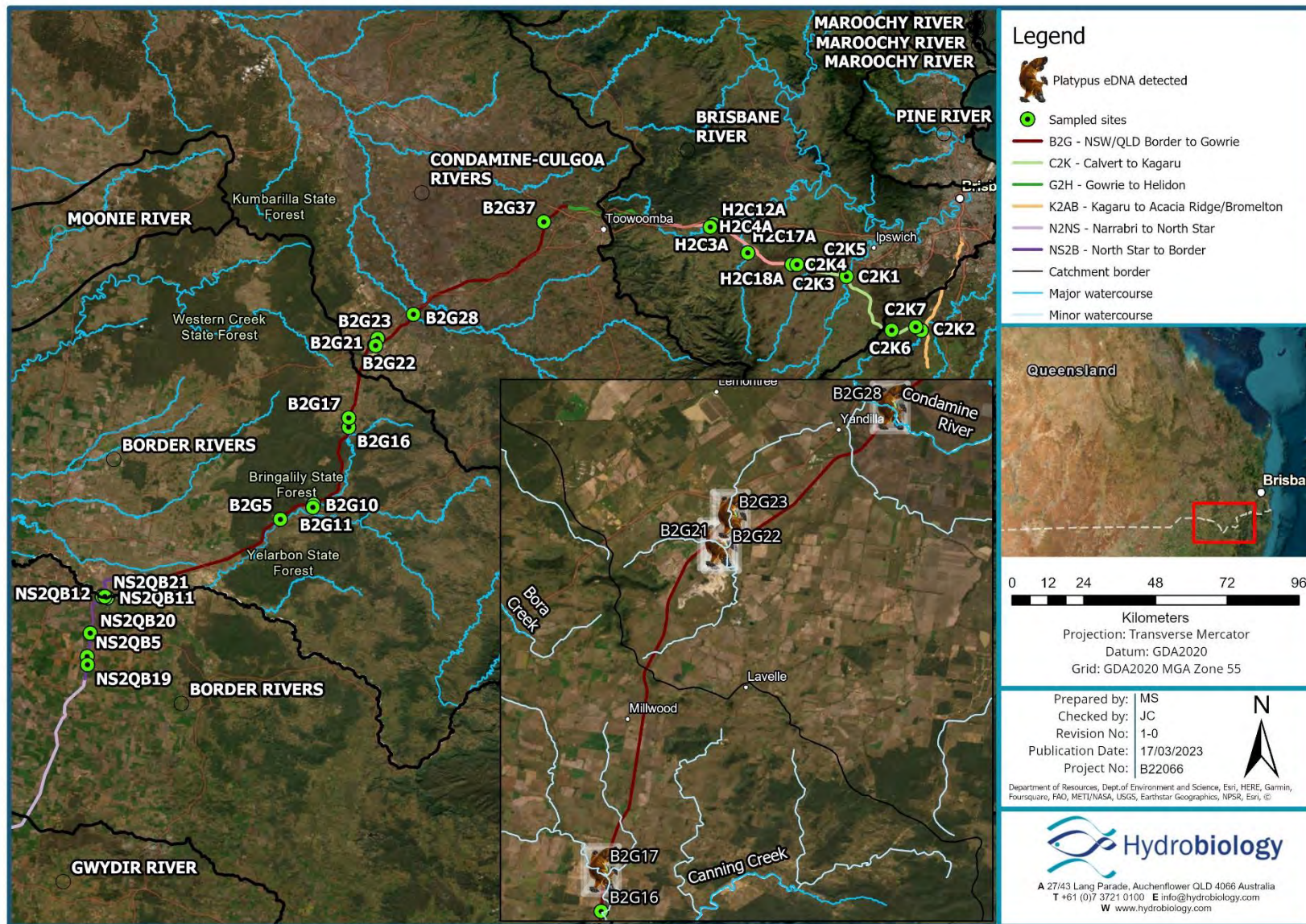


Figure 4-1 Platypus positive eDNA locations across the study area.

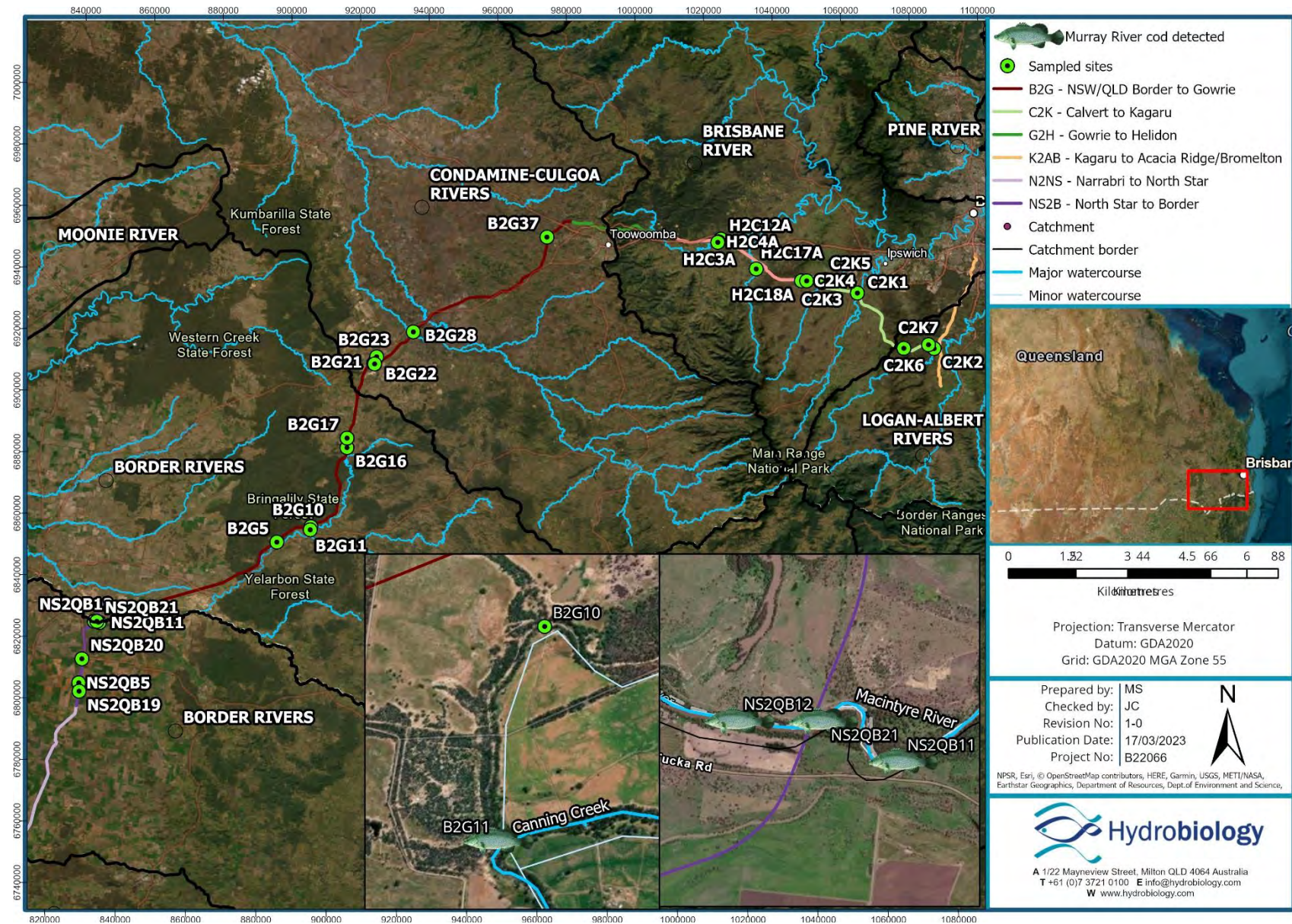


Figure 4-2 Murray River cod positive eDNA locations across the study area.

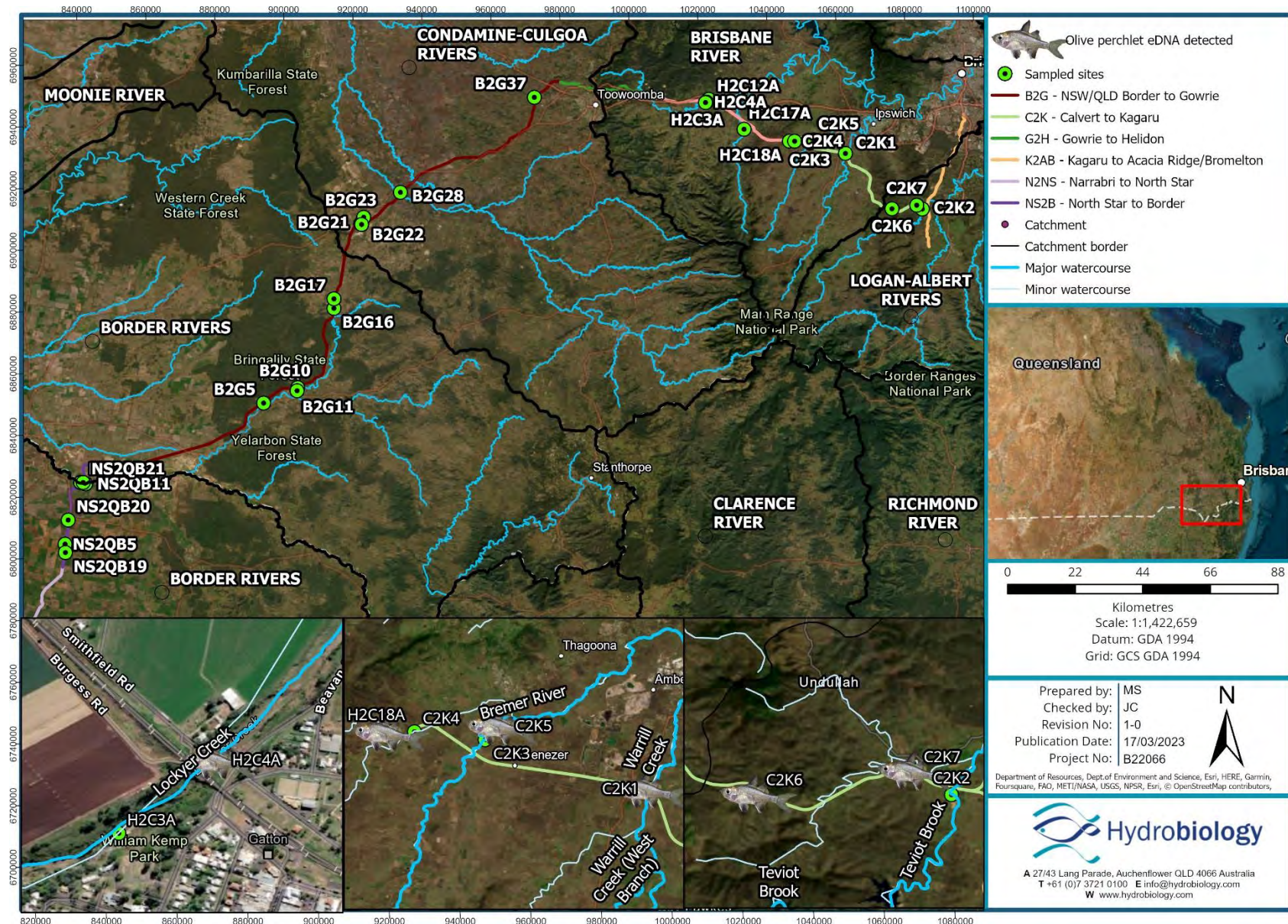


Figure 4-3 Olive perchlet positive eDNA locations across the study area.

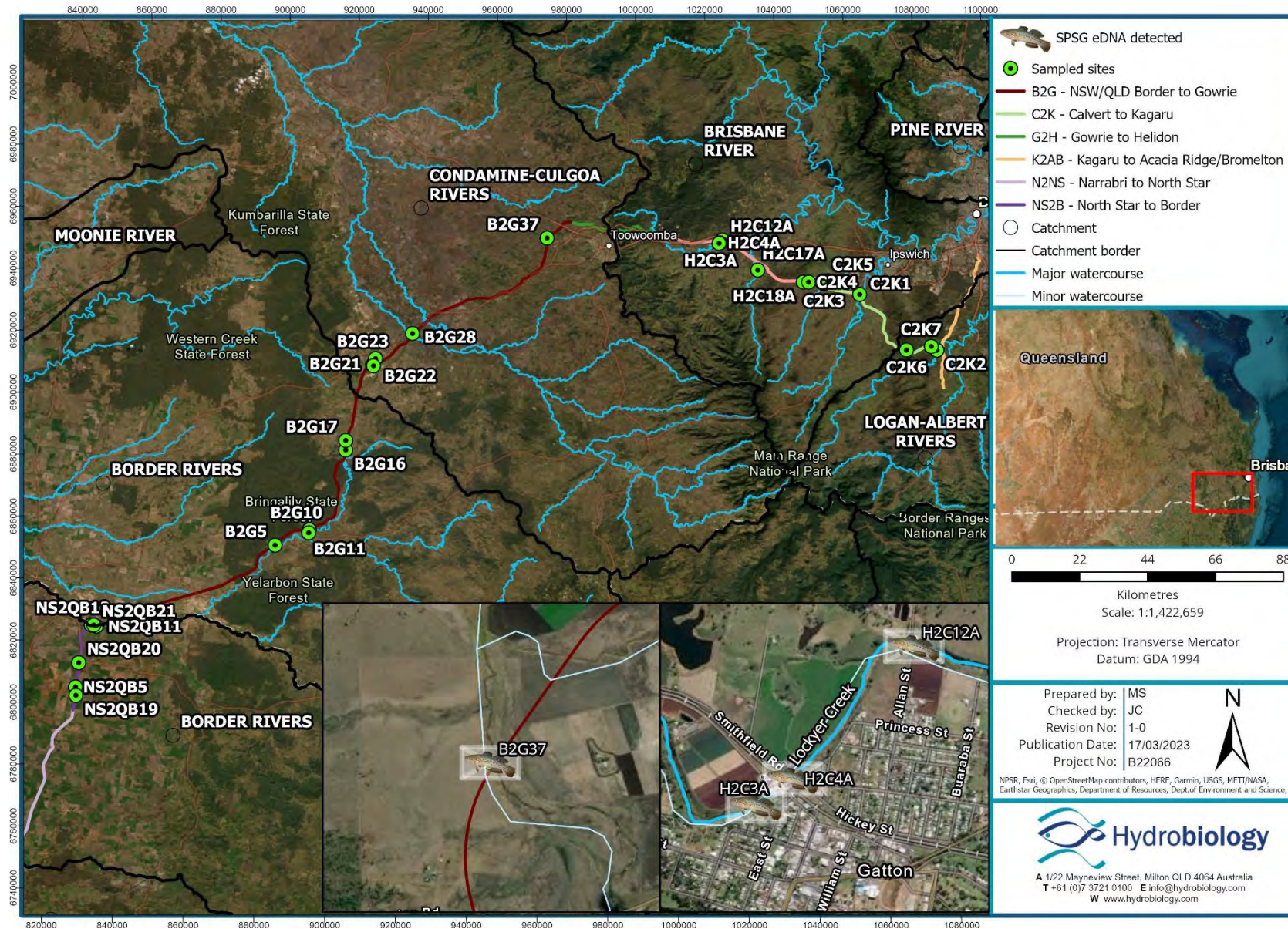


Figure 4-4 Southern purple-spotted gudgeon positive eDNA locations across the study area.

Table 4-4 eDNA detection results for targeted threatened fish and platypus across all sites.

Catchment	ARTC section	Waterway	Site	Australian lungfish	Silver perch	Platypus	Murray River cod	Mary River cod	Olive perchlet	Southern purple-spotted gudgeon
Murray Darling	NS2B North star to border	Unnamed Creek	NS2QB19	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Back Creek	NS2QB5	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Forest Creek	NS2QB20	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Macintyre River	NS2QB12	Negative	Negative	Negative	Positive	Negative	Negative	Negative
		Macintyre River	NS2QB21	Negative	Negative	Negative	Positive	Negative	Negative	Negative
		Macintyre River	NS2QB11	Negative	Negative	Negative	Positive	Negative	Negative	Negative
	B2G NSW/QLD border to Gowrie	Macintyre Brook	B2G5	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Canning Creek	B2G11	Negative	Negative	Negative	Positive	Negative	Negative	Negative
		Pariagara Creek	B2G10	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Bringalily Creek	B2G16	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Bringalily Creek	BSG17	Negative	Negative	Positive	Negative	Negative	Negative	Negative
		Back Creek	B2G23	Negative	Negative	Positive	Negative	Negative	Negative	Negative

Catchment	ARTC section	Waterway	Site	Australian lungfish	Silver perch	Platypus	Murray River cod	Mary River cod	Olive perchlet	Southern purple-spotted gudgeon
		Back Creek	B2G21	Negative	Negative	Positive	Negative	Negative	Negative	Negative
		Back Creek	B2G22	Negative	Negative	Positive	Negative	Negative	Negative	Negative
		Condamine River	B2G28	Negative	Negative	Positive	Negative	Negative	Negative	Negative
		Westbrook Creek	B2G37	Negative	Negative	Negative	Negative	Negative	Negative	Positive
North east coast	H2C Helidon to Calvert	Lockyer Creek	H2C12A	Negative	Negative	Negative	Negative	Negative	Negative	Positive
		Lockyer Creek	H2C4A	Negative	Negative	Negative	Negative	Negative	Positive	Positive
		Lockyer Creek	H2C3A	Negative	Negative	Negative	Negative	Negative	Negative	Positive
		Laidley Creek	H2C17A	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Western Creek	H2C18A	Negative	Negative	Negative	Negative	Negative	Positive	Negative
	C2K Calvert to Kagaru	Western Creek	C2K4	Negative	Negative	Negative	Negative	Negative	Negative	Negative
		Bremer River	C2K5	Negative	Negative	Negative	Negative	Negative	Positive	Negative
		Bremer River	C2K3	Negative	Negative	Negative	Negative	Negative	Negative	Negative

Catchment	ARTC section	Waterway	Site	Australian lungfish	Silver perch	Platypus	Murray River cod	Mary River cod	Olive perchlet	Southern purple-spotted gudgeon
		Warrill Creek	C2K1	Negative	Negative	Negative	Negative	Negative	Positive	Negative
		Dugandan Creek	C2K6	Negative	Negative	Negative	Negative	Negative	Positive	Negative
		Woollaman Creek	C2K7	Negative	Negative	Negative	Negative	Negative	Positive	Negative
		Teviot Brook	C2K2	Negative	Negative	Negative	Negative	Negative	Negative	Negative

4.4 HABITAT IMPROVEMENTS

Sites varied greatly across the study area and improvements could be made to increase habitat suitability for target species. Habitat improvements for each site where target species were detected, suspected or likely to occur are detailed in Table 4-5 and explored below. Suggestion for habitat improvements were made for Murray River cod and platypus. All other target species were not detected or, as is the case of olive perchlet and southern purple-spotted gudgeon, were not listed as threatened in the state in which they were detected. Overall, there was a focus on the re-establishment and/or regeneration of riparian and stream vegetation, which in-time will improve habitat complexity (i.e. regulation of water quality, input of debris, etc.) and erosion control.

MURRAY RIVER COD

Murray River cod are known to favour deep, slow flowing turbid waterbodies, preferably with boulders, undercut banks, overhanging vegetation and large woody debris. During the breeding season, eggs are deposited on clay beds, rocks, logs and other hard substrates in shallow and warm water (Allen et al., 1989; DCCEEW, 2022; J. Koehn & Clunie, 2010b). During the habitat likelihood assessments, habitat was largely limited at most sites. Habitat degradation has been listed alongside poor management of waterways, overfishing and regulation of water flows as major causes for the species decline (DCCEEW, 2022; J. Koehn & Clunie, 2010).

HABITAT COMPLEXITY

Throughout the study area, habitat complexity was typically low, due to absence of large boulders or rocky habitat, undercut banks and, within the Border to Gowrie section sites, the somewhat limited amount of LWD. Loss of habitat complexity has been a problem for many freshwater species in Australia, including Murray River cod, and various strategies have been adopted to increase habitat complexity, including the addition LWD and structures that mimic its properties.

The removal of LWD through de-snagging of rivers and clearing of riparian vegetation has reduced habitat complexity throughout the Murray River cod's distribution (Kalatzis & Baker, 2010; J. Koehn & Clunie, 2010a; J. D. Koehn, 2004). LWD naturally forms from complex root structures along the banks and from riparian vegetation and flood debris. It provides surfaces for egg deposition, predator protection for small-bodied individuals, areas of reduced flow and foraging/hunting grounds (J. Koehn & Clunie, 2010a, 2010b). One of the first programs to highlight the connection between LWD and the fish found that fish occupancy increased with the density of LWD in the Murray River (Nicol et al., 2004). Since then, numerous projects have incorporated natural 'snag stacks' and manmade 'fish hotels'. One of the largest restoration and monitoring projects began in 2006 and restored 4,450 snags to the Murray River between Lake Mulwala and Lake Hume (J. P. Lyon et al., 2019; J. Lyon & Tonkin, 2014). After seven years of monitoring, a three-fold increase in the local Murray River cod population was observed within the re-snagged area, largely due to immigration of fish to the restored stretch of the river (J. P. Lyon et al., 2019; J. Lyon & Tonkin, 2014). The project demonstrated the benefits of large-scale river rehabilitation, however smaller localised programs can also deliver benefits to fish populations. Re-snagging, the addition of 'fish hotels' and pipes within the Dewfish Demonstration Reach (DDR) in the Condamine catchment saw Murray River cod return to and/or increase in numbers in Oaky and Myall Creek (Hydrobiology, 2016). Part of the DDRs success is a result of the diversity in microhabitats offered (Hutchison et al., 2013).

In addition to LWD, undercut banks, rocky habitat and/or large boulders have been seen to further improve habitat complexity for Murray River Cod, however were notably scarce across the study area. Undercut banks are important for Murray River cod and other species as they provide instream cover and breeding habitat. "Lunkers" are artificial habitat constructed from wood and rock placed against

the edge of stream to replicate undercut banks while improving stream bed stability (NRCS, 2007). Their introduction to some streams in the USA where they were designed showed considerable improvement to trout numbers (Brown, 2001). Within Australia, they have been used in projects such as the DDR in the Condamine catchment, in the rehabilitation of Mullinmur Billabong, and as part of habitat enhancement works along the Goulburn, Delatite, Rubicon and Acheron Rivers (DCEEW, 2021; Douglas & Abery, 2009; Hydrobiology, 2016). Within these projects, they have been associated with increases in the recruitment and overall population of several species, including large bodied fish (DCEEW, 2021; Douglas & Abery, 2009; Hydrobiology, 2016). Their effectiveness for Murray River cod is expected to be improved if used in conjunction with rocky habitat such as rock boulder piles or rocky reefs, as this would reduce the distance between spawning and nursery habitat for the species (Hutchison et al., 2013). Rocky structures are used as refugia, nurse areas and staging posts for fish and Murray River cod have been shown to favour complex rocky habitat over macrophytes, bare substrate and SWD near the streambank (Hutchison et al., 2013). While habitat complexity can be improved through re-snagging, boulder seeding and the addition of structures such as cod pipes, fish hotels and lunkers, these techniques are immediate and/or short-term strategies. For the best results, these strategies should be used while long-term actions, namely restoration of the riparian corridors with indigenous species, come to fruition (Hutchison et al., 2013).

RIPARIAN VEGETATION AND BANK STABILITY

Intact riparian corridors and vegetation needs to be established along Murray River cod habitat for a range of reasons, including bank stability and erosion control. Riparian vegetation provides temperature control and shade, complex habitat through root structures and a continual supply of snags, transfer of energy from the terrestrial environment into aquatic food webs, bank stability and erosion control (Arthington, 2009; Pusey & Arthington, 2003). Increased fine sediment loads can impair Murray River cod through filling of undulations and holes the fish frequent as well as the smothering of spawning habitats (J. D. Koehn, 2004), oxygen depletion of the stream bed and a loss of food items as smothering of interstitial particles removes macroinvertebrate habitat (Leitner et al., 2021). Riparian vegetation is highly effective at binding stream banks and controlling erosion, however can be hindered by ungulates and in areas where banks are steep, eroded and/or tall.

Along the Macintyre River, in which Murray River cod were detected at sites N2SQB12, N2SQB21 and N2SQB11, stream banks at bends were steep, tall and showed signs rotational failure (bank collapse or slumping). These sites also contained eDNA from goats, pigs and cattle. Short term improvements would involve the removal or exclusion of ungulates from the area. Larger scale works and appropriate management actions to address bank stability and erosion within heavily eroded sections of the river would require hydraulic and geomorphological assessments. Stabilising of these banks and consequent erosion control would rely on processes such as reprofiling of the banks (may require removing and/or adding sediment) and the installation of rock groynes into the river while the bank itself and the top of the bank was being revegetated. Lunkers could also be incorporated into this work to stabilise the banks while providing valuable undercut bank habitat for Murray River cod. This approach would allow riparian vegetation to establish and feasibly stabilise the bank while rock groynes attract sediment and eventually disintegrate naturally into the river. For the best results, riparian vegetation should be dominated by native, if not indigenous, species with an effort to eradicate and prevent weed species.

Re-establishing or regeneration of riparian vegetation should focus on the inclusion of native, if not indigenous, species and removal of noxious or invasive weeds. Non-native and/or invasive species can rapidly invade disturbed sites. Once established, non-native species compete with native plants for space, nutrients and sunlight and rarely provide the food or habitat required by native fauna (Department of the Environment and Heritage (DEH), 2004). For example, native species, such as species of Eucalyptus, Acacia, and Melaleuca, have sclerophyllous leaves, which may persist for

months or years before completely breaking down, therefore ensures a continuous food resource for stream organisms (DES, 2013).

PLATYPUS

Platypus tend to occur in areas that have stable banks for burrowing, intact streamside vegetation, aquatic invertebrates for food, complex aquatic habitats (including woody structures), and reliable water flows. However, platypus are known to persist in areas where some of these aforementioned features are absent, often in degraded agricultural settings (Bino et al., 2019; Bryant, 1993; Rohweder, 1992; Serena et al., 2001b), such as that seen at sites B2G21 and B2G22. During the habitat likelihood assessment, there was an absence of coarse rocky substrate or intact riparian vegetation at virtually all sites. At some sites, permanency of the waterbody was questionable and deep pool/run habitat was absent, while at others features such as consolidated banks with vegetation, LWD or debris at water level on the bank were not present.

HABITAT COMPLEXITY

Platypus density in an area is thought to be constrained by food availability, assuming that there is sufficient surface water (Serena & Williams, 2010). The presence of suitable foraging habitat is a key indicator for platypus presence, particularly when combined with suitable nesting and breeding habitat (Rohweder, 1992; Serena & Williams, 2010). Key foraging habitat for platypus is typically comprised of coarse bed substrate, undercut banks and LWD (T. Grant, 2004; Rohweder, 1992; Serena et al., 2001b). Within the study area, undercut banks and coarse bed substrate were notably absent from virtually all sites, including those where platypus were detected, however LWD was more prevalent.

Platypus have shown preference for complex habitats, with undercut banks, LWD and coarse substrates for foraging. Favourable substrates include gravel, pebbles, cobbles, large rocks and coarse particulate organic matter, while consolidated clay, willow tree roots and fine silt are negatively correlated with foraging activity (T. Grant, 2004; Rohweder, 1992; Serena et al., 2001b). As mentioned earlier, siltation can impair waterways through clogging of interparticle spaces which, subsequently, reduces the diversity and abundances of platypus' main food source – macroinvertebrates (Duan et al., 2008; Leitner et al., 2021). Similarly, macroinvertebrates are also common amongst woody debris, where some fauna will graze on the wood itself, while other graze on the biofilm or other macroinvertebrate species (J. Koehn et al., 2000). As a result, woody debris is often used as foraging habitat by platypus and LWD coverage is positively correlated with platypus activity. Even in habitats where LWD is limited, addition of woody debris has been seen to rapidly increase macroinvertebrate densities and consequently increase platypus foraging activity at sites where wood was deposited (Coleman, 2022). In addition to complex substrate and LWD, Serena et al (2001b) found that foraging activity by platypus was also positively correlated the coverage provided by undercut banks. As with LWD and coarse substrate, increased macroinvertebrate densities have been observed in undercut bank habitats, ergo represent a foraging environment for platypus (Rhodes & Hubert, 1991; Serena et al., 2001b). However, undercut banks are also used by platypus for burrows (Serena et al., 1998a).

STABLE EARTH BANKS

Stable earthen river and creek beds are essential for platypus for the construction of nesting and resting burrows (Serena et al., 2001b). Burrows can be very long reaching up to 55 m, however most platypus burrows typically reach 10 m in length, and are typically found along undercut or convex banks often associated with overhanging vegetation and established riparian vegetation. Burrow use and construction is positively correlated with the coverage of overhanging and riparian vegetation, through largely to be a result of the bank stabilisation the plants offer.

RIPARIAN VEGETATION

For reasons mentioned detailed above, riparian vegetation is important for waterways and the fauna that inhabit them. For platypus, riparian vegetation is particularly important as it provides woody debris, prevents erosion that would foul foraging habitat and stabilises the banks that their burrows are constructed in. The amount of overhanging vegetation has also been found to be positively linked to burrow usage (Serena & Williams, 2010). Overhanging vegetation provides protection for their burrows and provide in-stream organic material (Bryant, 1993; Rohweder, 1992; Serena et al., 2001b). Overhanging vegetation is expected to protect platypus burrows by obscuring their burrows from predators, reducing damage caused to the burrows by erosion and act as screen for light and noise from the surrounding environment (Bethge, 2002; Serena et al., 1998b). Overhanging vegetation and the detritus it deposits also provides an additional foraging habitat for platypus (Serena and Williams 2010).

Species present within riparian vegetation has been shown to correlate to platypus activity. Platypus activity is positively correlated with the number of medium and large Eucalyptus, Acacia and Populus trees growing along the bank and negatively correlated with the number of medium and large exotic trees (Serena et al., 2001b).

POLLUTION

Pollution, from debris or changes in water quality, can have indirect and direct impact platypus populations, particularly around populated, agricultural and industrial areas (Munday et al., 2002). Indirect impacts of pollution would include changes to macroinvertebrate communities through: sedimentation and clogging of interstitial spaces; elevated concentrations of organic compounds such as nitrogen and phosphorus leading to algal blooms; and; elevated concentrations of metals from industry and vehicles including cadmium, zinc and lead which are toxic to many macroinvertebrates (Kownacki & Szarek-Gwiazda, 2022; Leitner et al., 2021; Richmond et al., 2018). Given the surrounding land uses where platypus were detected metal contamination is not expected to be an impacting process in the study area.

Litter and debris can represent significant problem for platypus. Platypus can become trapped by instream structures such as pipes and culverts and become ensnared in other forms of debris (Bino et al., 2019; Serena & Williams, 2010). Their specialised feet are unable to remove litter trapped against their bodies, with repercussions of wounds and lesions to drowning (DoELWP, 2016). They can become hooked by and tangled within discarded fishing hooks and lines, and become ensnared by plastic and rubber loops, such as those found in tamper proof seals, hair bands, bracelets, cable ties, caning jar rings etc. (Bino et al., 2019; Serena et al., 1998b; Serena & Williams, 2010). In a study on platypus populations around Melbourne, 40% of captured individuals had plastic or rubber loops around the animals head and/or body (Serena et al., 1998b; Serena & Williams, 2010).

Table 4-5 Favourable micro and macrohabitat features observed at each site where species were detected and suggestions for long and short term improvements of habitat.

Site and Likelihood	Favourable micro and macrohabitat characteristics	Improvements
Platypus		
B2G16 (Suspected)	• Large woody debris • Convex banks • Debris at water level • Permanent water body • Deep pool/run habitat • No impoundment of stream	Short term • Introduction of coarse substrate using gravel beds • Removal and/or exclusion of cattle • Increase amount of LWD • Artificial undercut bank habitat created through the installation of lunkers Long term • Consolidated banks with vegetation • Re-establish riparian vegetation • Removal of exotics and replaced with native eucalyptus, acacia or populus tree species
B2G17 (Confirmed)	• Consolidated banks with vegetation • Convex bank profiles at water level • Deep pool/run habitat • No impoundment of the stream.	Short term • Removal and/or exclusion of cattle • Introduction of gravel beds and other coarse substrate • Artificial undercut bank habitat created through the installation of lunkers • Install LWD within the mainstream • Addition of SWD/LWD along stream banks • Establish overhanging plants on stream bed • Artificial undercut bank habitat created through the installation of lunkers Long term • Re-establish riparian vegetation • Removal of exotics and replaced with native eucalyptus, acacia or populus tree species
B2G23 (Confirmed)	• Consolidated banks with vegetation • Large woody debris • Convex bank profiles at water level • Debris at water level • Permanent water bodies • Deep pool/run habitat • No impoundment of the stream.	Short term • Introduce coarse rocky substrate • Removal and/or exclusion of cattle and goats • Increase amount of LWD • Artificial undercut bank habitat created through the installation of lunkers Long term • Re-establish riparian vegetation • Removal of any willow trees and replaced with native eucalyptus, acacia or populus tree species

Site and Likelihood	Favourable micro and macrohabitat characteristics	Improvements
B2G21 and B2G22 (Confirmed)	- Consolidated banks with vegetation - Large woody debris - Sections of convex bank profiles at water level - Debris at water level - No impoundment of the stream.	Short term - Temporary sedimentation protection - Coarse substrate through instruction of gravel beds - Removal and/or exclusion of cattle - Increase amount of LWD - Vegetate along the river bank and between pools with shrubs and other plants that will overhang the water and provide cover for platypus during movement between isolated pools - Artificial undercut bank habitat created through the installation of lunkers - Identify nearby permanent water holes nearby that will serve as drought refugia. Improve habitat characteristics in these areas - Removal of barbed wire fencing through stream Long term - Establish suitable habitat between creeks and permanent waterbodies with riparian vegetation, stable banks and microhabitat - Re-establish riparian vegetation to provide cover and bank stability - Consider reprofiling and vegetation banks to reduce chance of collapse - Establish connection to permanent waterbody with suitable habitat - Establish water monitoring program at these sites due to proximity to Millmerran township and Commodore coal mine and power station - Removal of any willow trees and replaced with native eucalyptus, acacia or populus tree species
B2G28 (Confirmed)	- Consolidated banks with vegetation - Large woody debris - Coarse rocky substrate - Convex bank profiles at water level - Debris at water level - Permanent water bodies - Deep pool/run habitat - No impoundment of the stream.	Short term - Increase volume of coarse rocky substrate - Removal and/or exclusion of cattle and pigs - A large mass of LWD was deposited against rail bridge pilons during eDNA survey. LWD should not be removed from the system but instead redistributed downstream of the rail crossing - Vegetate along the river bank with shrubs and other plants that will overhang the water - Artificial undercut bank habitat created through the installation of lunkers Long term - Re-establish riparian vegetation - Removal of any willow trees and replaced with native eucalyptus, acacia or populus tree species - Reprofiling of eroded banks and establishing erosion control for high flow (flood) events
Murray River cod		

Site and Likelihood	Favourable micro and macrohabitat characteristics	Improvements
NS2QB12 (Confirmed)	- Overhanging vegetation - Large snags - Other LWD - Deep pools - No impoundment of stream - Intact riparian corridor	Short term - Artificial undercut bank habitat created through the installation of lunkers - Increase habitat complexity through fish hotel installation, cod pipes and boulder seeding - Removal and exclusion of cattle from the streambed Long term - Establish intact riparian veg in areas in cleared areas along the top of the bank and on the bank itself - Reprofiling and stabilisation of bends within the Macintyre River prone to erosion
NS2QB21 (Confirmed)	- Overhanging vegetation - Large snags - Other LWD - Deep pools - No impoundment of stream - Intact riparian corridor	Short term - Artificial undercut bank habitat created through the installation of lunkers - Increase habitat complexity through fish hotel installation, cod pipes and boulder seeding - Removal and exclusion of goats and cattle from the riparian zone and main channel Long term - Establish intact riparian veg in areas where it is clear along the top of the bank and on the bank itself - Reprofiling and stabilisation of bends within the Macintyre River prone to erosion
NS2QB11 (Confirmed)	- Overhanging vegetation - Large snags - Other LWD - Deep pools - No impoundment of stream	Short term - Artificial undercut bank habitat created through the installation of lunkers - Increase habitat complexity through fish hotel installation, cod pipes and boulder placement - Removal and exclusion of pigs and cattle from the riparian zone and main channel Long term - Establish intact riparian veg in areas where it is clear along the top of the bank and on the bank itself - Reprofiling and stabilisation of bends within the Macintyre River prone to erosion
B2G11 (Confirmed)	- Overhanging vegetation - Large snags - Other LWD - Deep pools - No impoundment of stream	Short term - Artificial undercut bank habitat created through the installation of lunkers - Increase habitat complexity through additional LWD, fish hotel installation, cod pipes and boulder placement - Removal and exclusion of cattle from the riparian zone and main channel Long term - Re-establish riparian corridors comprised of native, if not indigenous plant species

Site and Likelihood	Favourable micro and macrohabitat characteristics	Improvements
B2G10 (Suspected)	• Overhanging vegetation • Large snags • Other LWD • Deep pools	Short term • Artificial undercut bank habitat created through the installation of lunkers • Increase habitat complexity through additional LWD, fish hotel installation, cod pipes and boulder placement • Removal and exclusion of cattle from the riparian zone and main channel Long term • Re-establish riparian corridors comprised of native, if not indigenous plant species • Removal of waterway barrier at road crossing to improve connectivity

5.

CONCLUSION

Overall most sites within the study area consisted of pool and run habitat within heavily eroded channels which showed signs of flood damage and partial, if not total, riparian clearing. Microhabitat within the sites typically consisted of small and large woody debris and detritus.

Positive eDNA results were returned for the following species:

- Olive perchlet - found at a total of six sites through the Helidon to Calvert and the Calvert to Kagaru sections of Inland Rail. The species was found within Lockyer, Western and Warrill creeks and the Bremer River within the Brisbane River catchment and within Dugandan and Woollaman creeks in the Logan-Albert catchment within Queensland. No detections occurred in NSW where the species is threatened;
- Southern purple-spotted gudgeon – found at a total of four sites across the Helidon to Calvert and NSW/QLD Border to Gowrie sections. eDNA was found at three sites within Lockyer Creek in the Brisbane Rivers catchment and once within Westbrook Creek in the Balonne-Condamine Rivers catchment. No detections occurred in NSW, where the species is threatened;
- Platypus - found at five sites within the QLD/NSW border to Gowrie section in the Condamine River, Bringalily Creek and Back Creek. eDNA suspected to be from at least two populations; and
- Murray River cod – detected three times within the Macintyre River in the North Star to Border section and once in Canning Creek within the NSW/QLD border to Gowrie section.

eDNA for silver perch, Mary River cod and Australian lungfish were not detected at any sites. This was largely attributed to the distance of sites from their endemic ranges of (Mary River for Mary River cod and Murray Darling basin for silver perch) and/or lack of suitable habitat (rapids and races for silver

perch, lack of macrophytes for lungfish). We note that eDNA detection of lungfish can be problematic. In our experience surveys targeting Australian lungfish have noted that the effectiveness of eDNA to detect lungfish varied. At some sites where lungfish were electrofished, eDNA results were negative however eDNA also detected lungfish at sites where electrofishing was unsuccessful. The noted historical records 500 m from H2C12A (record from 2003) and 1.5 km from C2K3 and C2K5 (record from 1992), could be investigated further via traditional fish sampling techniques such as electrofishing, etc; however we note that these records are outdated and habitat characteristics including critical macrophyte habitat were absent at these sites.

Habitat likelihood assessments were conducted for the MNES species and the platypus. The lack of high flow rapids and races (silver perch preferred habitat) and the absence of macrophyte beds (foraging and spawning habitat for lungfish) throughout the surveyed area meant no sites were deemed as potential locations for the silver perch or Australian lungfish. However, for platypus and Murray River cod, a total of 11 and six sites, respectively were deemed as possible or likely locations for each species. A total of 10 sites contained suitable habitat for Mary River cod; however given the sites were outside their natural ranges and that fact that there were no eDNA detection or historical records for this species, they are considered unlikely to occur in the study area. Despite stocking efforts for a number of these species, it has been shown that such efforts do not result in improvements in natural populations.

In addition to identifying Murray River cod and platypus eDNA at multiple sites, the eDNA survey also identified DNA belonging to a range of mammals, birds, reptiles and other fish. Of these, several species were of note – particularly the wallum rocket frog and the Lakeland's plains mouse. While eDNA can be prone to misidentifying hybrid species, these eDNA results could represent a range expansion of these species.

A range of site specific long and short term habitat improvements have been suggested for platypus and Murray River cod – the only target species detected in areas where they are protected under legislation. Generally, habitat suitability improvements rely upon the increase of habitat complexity for breeding and foraging sites through the addition of natural and artificial structures, improvement of bank stability, exclusion of livestock and the regeneration and/or re-establishment of riparian vegetation.

6.

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APPENDIX A. EDNA RESULTS

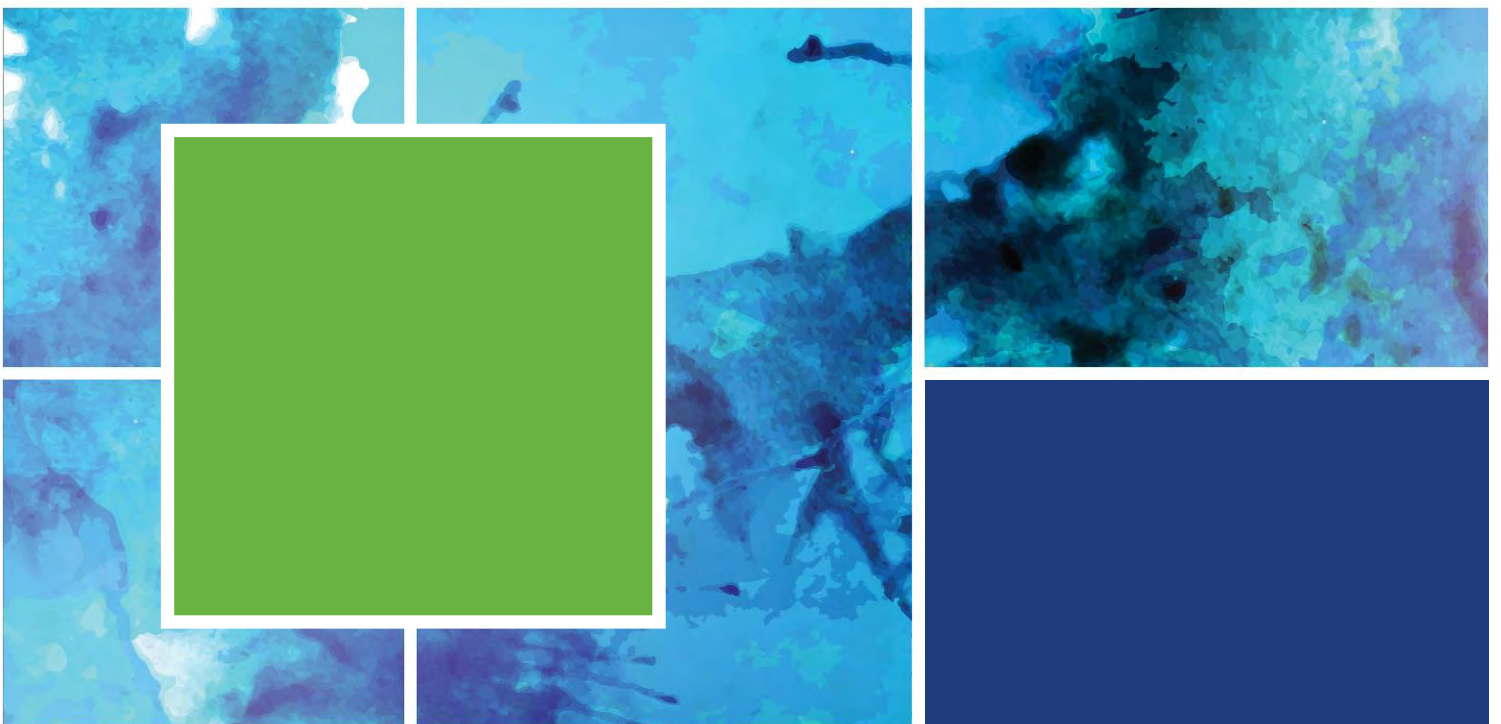


Table 6-1 Taxonomic diversity in water samples detected using 12S assay targeting vertebrates. Presence of the species at each site is indicated by the symbol *. Bolded species name indicates target species. Taxonomy was assigned as per NCBI and classifications were standardised according to the Global Biodiversity Information Facility (accessed January 2023). A dash is used where a classification category does not exist for that taxa, and blank cells indicate where taxa could not be resolved to a lower taxonomic level. Blue text indicates taxa that are not recorded from the study area according to GBIF.

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2	
Actinopterygii	Anguillidae	Anguilla		Freshwater eels																				*	*	*	*	*	*	*	*	*	
	Atherinidae	Craterocephalus	<i>Craterocephalus marjoriae</i>	Marjorie's hardyhead																*	*	*	*										
			<i>Craterocephalus stercusmuscarum</i>	Fly-specked hardyhead																		*	*										
	Clupeidae	Nematalosa	<i>Nematalosa erebi</i>	Bony bream	*	*		*	*			*	*	*	*	*				*	*						*						
	Cyprinidae			Carp	*	*	*					*	*	*	*	*				*	*	*	*	*		*		*	*	*			
		Cyprinus	<i>Cyprinus carpio</i>	Eurasian carp	*	*	*	*	*	*		*	*	*	*	*	*		*	*	*	*				*	*	*	*	*	*	*	*
	Poeciliidae	Gambusia		Mosquito fish	*	*	*	*			*	*	*			*	*	*	*	*	*	*	*			*	*	*		*			*
		Xiphophorus			Tooth-carps																						*						
			<i>Xiphophorus maculatus</i>	Southern platyfish																							*		*				
																											*		*				
	Mugilidae	Mugil	<i>Mugil cephalus</i>	Flathead grey mullet																									*	*		*	*
	Retropinnidae	Retropinna	<i>Retropinna semoni</i>	Australian smelt				*	*			*				*				*	*							*		*		*	*
	Ambassidae	Ambassis	<i>Ambassis agassizii</i>	Olive perchlet																			*			*		*		*	*		
	Cichlidae			Cichlid																													*
	Eleotridae	Gobiomorphus	<i>Gobiomorphus australis</i>	Striped gudgeon																							*	*	*	*	*	*	*
		Hypseleotris		Carp gudgeon				*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			<i>Hypseleotris klunzingeri</i>	Western carp gudgeon				*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
<i>Hypseleotris</i> sp. 'Lake's carp gudgeon'			Lake's carp gudgeon				*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
<i>Hypseleotris</i> sp. 'Midgley's carp gudgeon'			Midgley's carp gudgeon				*	*	*		*	*	*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2
		Mogurnda		Purple spotted gudgeon																*	*	*	*									
		Philypnodon	Philypnodon grandiceps	Flathead gudgeon																							*	*		*	*	*
			Philypnodon macrostomus	dwarf flathead gudgeon																							*	*				
	Percichthyidae	Maccullochella	Maccullochella peelii	Murray River cod				*	*	*		*																				
		Macquaria	Macquaria ambigua	Golden perch				*	*	*		*			*	*			*	*												
			Macquaria novemaculeata	Australian bass																									*			*
	Terapontidae			Grunters								*	*	*	*	*	*	*	*	*	*	*	*	*	*						*	*
	Tetrarogidae	Notesthes	Notesthes robusta	Bullrout																									*			*
	Plotosidae	Tandanus	Tandanus tandanus	Eel-tailed catfish					*	*		*			*					*		*	*	*	*	*	*	*	*			*
Amphibia	Bufonidae	Rhinella	Rhinella marina	Cane toad																		*	*		*					*		
	Limnodynastidae	Limnodynastes	Limnodynastes salmini	Salmon-striped frog	*																											
	Myobatrachidae	Mixophyes	Mixophyes fasciolatus	Great barred frog																										*		
	Pelodryadidae	Litoria	Litoria freycineti	Wallum rocket frog									*																			
			Litoria peronii	Peron's tree frog							*		*																			

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2
Aves	Anatidae	Anas		Dabbling ducks				*		*	*							*	*			*	*	*		*						
			<i>Anas platyrhynchos</i>	Mallard				*			*		*			*		*	*	*		*	*	*	*	*		*	*		*	
		Chenonetta	<i>Chenonetta jubata</i>	Australian wood duck										*	*	*		*	*						*	*	*	*				
		Dendrocygna	<i>Dendrocygna eytoni</i>	Plumed whistling duck																		*										
	Dromaiidae	Dromaius	<i>Dromaius novaehollandiae</i>	Emu															*													
	Columbidae	Geopelia	<i>Geopelia cuneata</i>	Diamond dove																					*							
			<i>Ocyphaps lophotes</i>	Crested pigeon															*													
	Alcedinidae	Dacelo	<i>Dacelo novaeguineae</i>	Laughing kookaburra																				*			*		*			
		Todiramphus	<i>Todiramphus sanctus vagans</i>	Sacred Kingfisher										*																		

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2
	Coraciidae	Eurystomus	<i>Eurystomus orientalis</i>	Oriental dollarbird														*														
	Phasianidae	Gallus	<i>Gallus gallus</i>	Red junglefowl															*					*		*						*
	Rallidae	Gallinula	<i>Gallinula chloropus</i>	Common moorhen												*				*	*											
				Passerine														*														
	Artamidae	Gymnorhina	<i>Gymnorhina tibicen</i>	Australian magpie														*														
	Corcoracidae	Struthidea	<i>Struthidea cinerea</i>	Apostlebird														*														
	Corvidae	Corvus		Crows											*		*															
	Meliphagidae	Philemon		Friarbird									*																			
	Monarchidae	Grallina	<i>Grallina cyanoleuca</i>	Magpie-lark							*		*																			

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2
	Ardeidae	Bubulcus	<i>Bubulcus ibis</i>	Cattle egret																*												
		Egretta		Egret			*									*																
	Phalacrocoracidae	Phalacrocorax	<i>Phalacrocorax sulcirostris</i>	Little black cormorant									*						*													
			<i>Phalacrocorax varius</i>	Australian pied cormorant															*													
	Threskiornithidae	Threskiornis	<i>Threskiornis aethiopicus</i>	African sacred ibis												*						*	*									
	Cacatuidae	Cacatua		Cockatoo												*	*		*												*	
			<i>Cacatua galerita</i>	Sulphur-crested cockatoo															*													
			<i>Cacatua pastinator</i>	Western corella									*																			
	Psittacidae	Polytelis	<i>Polytelis alexandrae</i>	Princess parrot									*																			

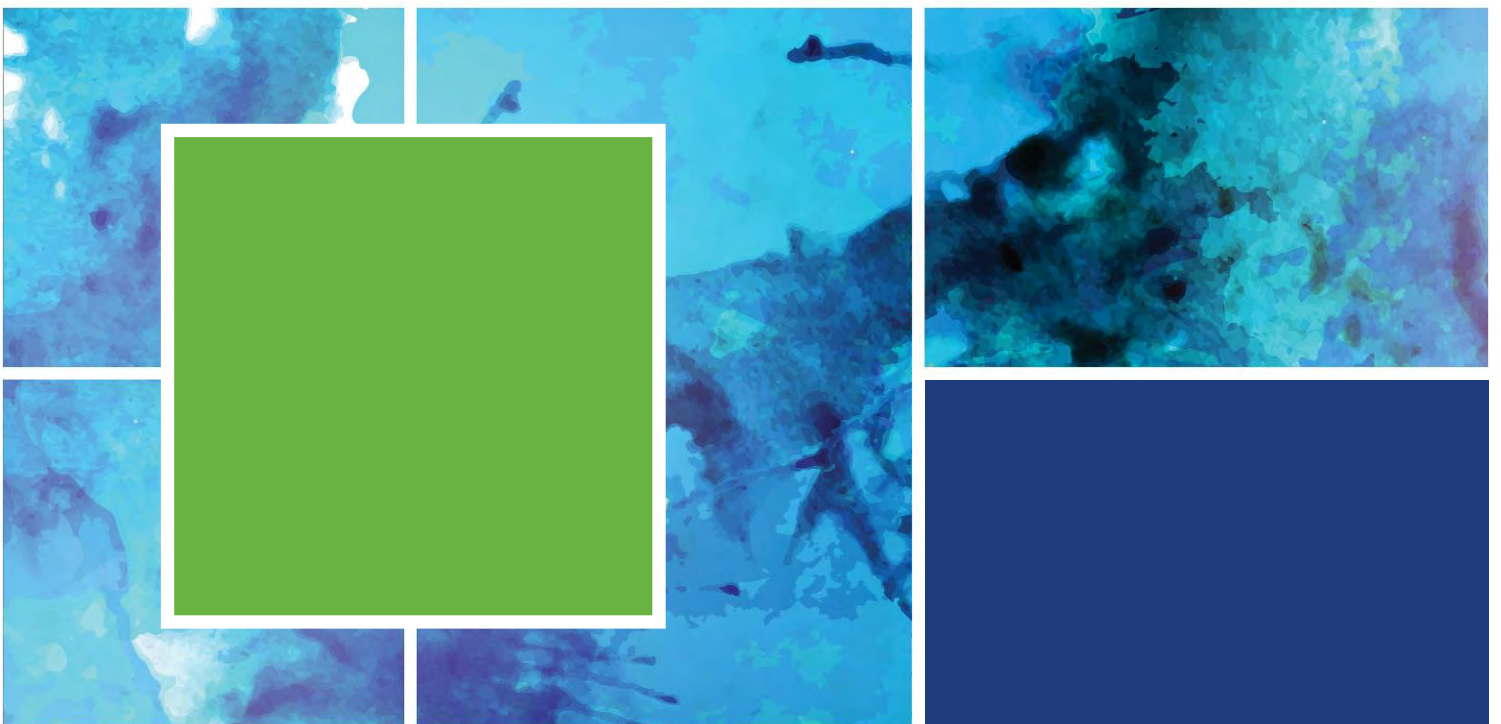
Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2
Mammalia	Bovidae	Bos		Cow	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			Bos taurus	Domesticated cattle				*																			*					
		Capra	Capra hircus	Goat	*	*		*								*						*					*					
		Ovis		Sheep	*	*																*					*					
	Cervidae	Cervus	Cervus elaphus	Red deer																												*
	Suidae	Sus	Sus scrofa	Wild boar						*									*	*	*								*			
	Molossidae	Mormopterus	Mormopterus planiceps	South-eastern freetail bat				*																								
	Pteropodidae	Boneia	Boneia bidens	Manado fruit bat	*					*																						
Pteropus		Pteropus scapulatus	Little red flying fox																				*									

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	BSG10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2
	Macropodidae	Macropus	<i>Macropus giganteus</i>	Eastern grey kangaroo																											*	
	Petauridae	Petaurus	<i>Petaurus breviceps</i>	Sugar glider								*																				
	Phalangeridae	Trichosurus	<i>Trichosurus caninus</i>	Short-eared possum																				*		*						
			<i>Trichosurus vulpecula</i>	Common brushtail possum	*	*		*	*	*	*	*	*	*	*	*	*	*	*							*	*	*	*	*	*	*
	Muridae	Leggadina	<i>Leggadina lakedownensis</i>	Lakeland Downs mouse										*																		
		Mus	<i>Mus musculus</i>	House mouse					*																							
		Rattus	<i>Rattus rattus</i>	Black rat							*																					
Reptilia	Chelidae	Chelodina		Snake-necked turtles		*							*			*	*	*		*	*				*		*	*				
		Emydura	<i>Emydura macquarii</i>	Macquarie River Turtle																									*		*	

Class	Family	Genus	Species	Common name	NS2QB19	NS2QB5	NS2QB20	NS2QB12	NS2QB21	NS2QB11	B2G5	B2G11	B2G10	B2G16	B2G17	B2G23	B2G21	B2G22	B2G28	B2G37	H2C12A	H2C4A	H2C3	H2C17	H2C18A	C2K4	C2K5	C2K3	C2K1	C2K6	C2K7	C2K2	
																												*	*	*			
		Myuchelys	Myuchelys latisternum	Saw-shelled turtle																					*	*	*				*		*

APPENDIX B.

QA/QC



EDNA FIELD SURVEY

Specific QA/QC procedures implemented during eDNA sampling included:

- Prior to sampling taking place, the equipment that would be in contact with the eDNA filter (tubing) was disinfected within a 10% bleach solution.
- The 'clean-hands' – 'dirty-hands' sampling techniques was used for all water sampling. This involved one person to take the sample (primary sampler – 'clean hands') only handling the eDNA filters after the seal on the sterile zip-locked foil bag that contained the filter had been opened by the other person (secondary sampler – 'dirty hands').
- Powder-less nitrile gloves (double gloved) were used when collecting eDNA samples. Care was taken not to touch the inside surfaces of the filter bag or expose the filter to the atmosphere for extended periods of time.
- Samples were taken in areas of free-standing water and sediment was avoided to prevent clogging of eDNA filter with fine sediment.
- At sites where canoes were necessary to access the sampling location, downstream location were sampled first to prevent contamination by the canoe itself. Similarly, samples were taken upstream of any observed fishing or water discharge.
- A total of 3 samples were taken at each site in areas of suitable microhabitat to ensure best detection of eDNA present at the site. Macrohabitats samples and potential factors affected eDNA sampling are detailed in Table 6-3.
- For QA/QC purposes the QC field blank sample was collected to quantify potential contamination during sampling using clean water. All blank samples returned no fish DNA (Table 6-2).

EDNA LAB ANALYSIS

SAMPLE STORAGE

Filter membranes were transported ambiently to eDNA frontiers laboratories where they were stored at -20°C until scheduled for DNA extraction.

PCR ANALYSIS

Result criteria for PCR analysis:

- Positive: Indication of exponential amplification with a C_T average of <40;
- Possible: Indication of exponential amplification with a C_T average of <40, but fewer than two replicates within a single dilution amplified; and
- Negative: Lack of amplification, C_T average 40 and above.

eDNA Frontiers noted that because this assay is designed to be species-specific, positive amplification should be indicative of a positive detection of the target species, *Ornithorhynchus anatinus*.

METABARCODING

A wide range of taxa were detected in the water samples using a vertebrate metabarcoding assay. Contamination attributable to *Homo sapiens* and *Canis lupus familiaris* were removed from the dataset. Although detections of cow, sheep, goat, pig, deer, and chicken are possibly due to environmental contamination, these were left in the dataset as they could potentially be true detections from nearby locations. Laboratory extraction controls were all negative, and the positive control amplified successfully.

Table 6-2 Taxonomic diversity in blank field samples detected using 12S assay targeting vertebrates. Presence of a species eDNA is indicated by the symbol *. Bolded species name indicates target species. Taxonomy was assigned as per NCBI and classifications were standardised according to the Global Biodiversity Information Facility (accessed January 2023). A dash is used where a classification category does not exist for that taxa, and blank cells indicate where taxa could not be resolved to a lower taxonomic level. Blue text indicates taxa that are not recorded from the surveyed area according to GBIF.

Class	Order	Family	Genus	Species	Common name	Blank 1	Blank 2	Blank 3
Actinopterygii	Anguilliformes	Anguillidae	Anguilla		Freshwater eels			
	Atheriniformes	Atherinidae	Craterocephalus	<i>Craterocephalus marjoriae</i>	Marjorie's hardyhead			
				<i>Craterocephalus stercusmuscarum</i>	Fly-specked hardyhead			
	Clupeiformes	Clupeidae	Nematalosa	<i>Nematalosa erebi</i>	Bony bream			
	Cypriniformes	Cyprinidae			Carp			
			Cyprinus	<i>Cyprinus carpio</i>	Eurasian carp			
	Cyprinodontiformes	Poeciliidae	Gambusia		Mosquito fish			
			Xiphophorus		Tooth-carps			
				<i>Xiphophorus maculatus</i>	Southern platyfish			
	Mugiliformes	Mugilidae	Mugil	<i>Mugil cephalus</i>	Flathead grey mullet			
	Osmeriformes	Retropinnidae	Retropinna	<i>Retropinna semoni</i>	Australian smelt			
	Perciformes	Ambassidae	Ambassis	<i>Ambassis agassizii</i>	Olive perchlet			
		Cichlidae			Cichlid			
		Eleotridae	Gobiomorphus	<i>Gobiomorphus australis</i>	Striped gudgeon			

Class	Order	Family	Genus	Species	Common name	Blank 1	Blank 2	Blank 3
			Hypseleotris		Carp gudgeon			
				<i>Hypseleotris klunzingeri</i>	Western carp gudgeon			
				<i>Hypseleotris</i> sp. 'Lake's carp gudgeon'	Lake's carp gudgeon			
				<i>Hypseleotris</i> sp. 'Midgley's carp gudgeon'	Midgley's carp gudgeon			
			Mogurnda		Purple spotted gudgeon			
			Philypnodon	<i>Philypnodon grandiceps</i>	Flathead gudgeon			
				<i>Philypnodon macrostomus</i>	Dwarf flathead gudgeon			
		Percichthyidae	Maccullochella	<i>Maccullochella peelii</i>	Murray River cod			
			Macquaria	<i>Macquaria ambigua</i>	Golden perch			
				<i>Macquaria novemaculeata</i>	Australian bass			
		Terapontidae			Grunters			
	Salmoniformes	Salmonidae	Salmo	<i>Salmo salar</i>	Atlantic salmon			
	Scorpaeniformes	Tetrarogidae	Notesthes	<i>Notesthes robusta</i>	Bullrout			
	Siluriformes	Plotosidae	Tandanus	<i>Tandanus tandanus</i>	Eel-tailed catfish			
Amp hibi	Anura	Bufonidae	Rhinella	<i>Rhinella marina</i>	Cane toad			

Class	Order	Family	Genus	Species	Common name	Blank 1	Blank 2	Blank 3
		Limnodynastidae	Limnodynastes	<i>Limnodynastes salmini</i>	Salmon-striped frog			
		Myobatrachidae	Mixophyes	<i>Mixophyes fasciolatus</i>	Great barred frog			
		Pelodyadidae	Litoria	<i>Litoria freycineti</i>	Wallum rocket frog			
				<i>Litoria peronii</i>	Peron's tree frog			
Aves	Anseriformes	Anatidae	Anas		Dabbling ducks			
				<i>Anas platyrhynchos</i>	Mallard			
			Chenonetta	<i>Chenonetta jubata</i>	Australian wood duck			
			Dendrocygna	<i>Dendrocygna eytoni</i>	Plumed whistling duck			
	Casuariiformes	Dromaiidae	Dromaius	<i>Dromaius novaehollandiae</i>	Emu			
	Columbiformes	Columbidae	Geopelia	<i>Geopelia cuneata</i>	Diamond dove			
			Ocyphaps	<i>Ocyphaps lophotes</i>	Crested pigeon			
	Coraciiformes	Alcedinidae	Dacelo	<i>Dacelo novaeguineae</i>	Laughing kookaburra			
			Todiramphus	<i>Todiramphus sanctus vagans</i>	Sacred Kingfisher			

Class	Order	Family	Genus	Species	Common name	Blank 1	Blank 2	Blank 3
		Coraciidae	Eurystomus	<i>Eurystomus orientalis</i>	Oriental dollarbird			
	Galliformes	Phasianidae	Gallus	<i>Gallus gallus</i>	Red junglefowl			
	Gruiformes	Rallidae	Gallinula	<i>Gallinula chloropus</i>	Common moorhen			
	Passeriformes				Passerine			
		Artamidae	Gymnorhina	<i>Gymnorhina tibicen</i>	Australian magpie			
		Corcoracidae	Struthidea	<i>Struthidea cinerea</i>	Apostlebird			
		Corvidae	Corvus		Crows			
		Meliphagidae	Philemon		Friarbird			
		Monarchidae	Grallina	<i>Grallina cyanoleuca</i>	Magpie-lark			
	Pelecaniformes	Ardeidae	Bubulcus	<i>Bubulcus ibis</i>	Cattle egret			
			Egretta		Egret			
		Phalacrocoracidae	Phalacrocorax	<i>Phalacrocorax sulcirostris</i>	Little black cormorant			
				<i>Phalacrocorax varius</i>	Australian pied cormorant			

Class	Order	Family	Genus	Species	Common name	Blank 1	Blank 2	Blank 3
	Psittaciformes	Threskiornithidae	Threskiornis	<i>Threskiornis aethiopicus</i>	African sacred ibis			
		Cacatuidae	Cacatua		Cockatoo			
				<i>Cacatua galerita</i>	Sulphur-crested cockatoo			
				<i>Cacatua pastinator</i>	Western corella			
		Psittacidae	Polytelis	<i>Polytelis alexandrae</i>	Princess parrot			
Mammalia	Artiodactyla	Bovidae	Bos		Cow			
				<i>Bos taurus</i>	Domesticated cattle			
			Capra	<i>Capra hircus</i>	Goat			
			Ovis		Sheep			
		Cervidae	Cervus	<i>Cervus elaphus</i>	Red deer			
		Suidae	Sus	<i>Sus scrofa</i>	Wild boar			
	Chiroptera	Molossidae	Mormopterus	<i>Mormopterus planiceps</i>	South-eastern freetail bat			
		Pteropodidae	Boneia	<i>Boneia bidens</i>	Manado fruit bat			
			Pteropus	<i>Pteropus scapulatus</i>	Little red flying fox			

Class	Order	Family	Genus	Species	Common name	Blank 1	Blank 2	Blank 3
	Diprotodontia	Macropodidae	Macropus	<i>Macropus giganteus</i>	Eastern grey kangaroo			
		Petauridae	Petaurus	<i>Petaurus breviceps</i>	Sugar glider			
		Phalangeridae	Trichosurus	<i>Trichosurus caninus</i>	Short-eared possum			
				<i>Trichosurus vulpecula</i>	Common brushtail possum			
	Rodentia	Muridae	Leggadina	<i>Leggadina lakedownensis</i>	Lakeland Downs mouse			
			Mus	<i>Mus musculus</i>	House mouse			
			Rattus	<i>Rattus rattus</i>	Black rat			
Reptilia	Testudines	Chelidae	Chelodina		Snake-necked turtles			
			Emydura	<i>Emydura macquarii</i>	Macquarie River Turtle			
			Myuchelys	<i>Myuchelys latisternum</i>	Saw-shelled turtle			

Table 6-3 Macrohabitat and microhabitat sampled for eDNA at each site and factors that affected eDNA sampling.

Catchment	ARTC section	Waterway	Site	Macrohabitat sampled					Microhabitat sampled					Factors affecting eDNA sampling			
				Riffle	Run	Deep pool	Shallow pool	Cascade	Undercut banks	LWD	SWD	Backwaters	Macrophytes	Depth (m)	Slipperiness/bogginess	Suspended material	Flow
Murray Darling	NS2B North star to border	Unnamed Creek	NS2QB19	✖	✖	✖	✓	✖	✖	✓	✖	✖	✓	1	û	Turbid	û
		Back Creek	NS2QB5	✖	✖	✖	✓	✖	✖	✓	✓	✖	✖	0.5	û	û	û
		Forest Creek	NS2QB20	✖	✖	✖	✓	✖	✖	✖	✖	✖	✖	0.2	û	Turbid	û
		Macintyre River	NS2QB12	✖	✖	✓	✖	✖	✖	✓	✓	✖	✖	>2	û	Turbid	Low flow
		Macintyre River	NS2QB21	✖	✓	✓	✖	✖	✖	✓	✓	✖	✖	>2	û	Turbid	Low flow
		Macintyre River	NS2QB11	✖	✓	✓	✖	✖	✖	✓	✓	✖	✖	>2	û	Turbid	Low flow
	B2G NSW/QLD border to Gowrie	Macintyre Brook	B2G5	✖	✖	✖	✓	✖	✖	✓	✓	✖	✓	<0.5	û	û	û
		Canning Creek	B2G11	✖	✖	✓	✖	✖	✖	✓	✓	✖	✖	1.5	û	Turbid	û
		Pariagara Creek	B2G10	✖	✖	✖	✓	✖	✖	✖	✓	✖	✖	0.3	✓	Turbid and tannin rich	û
		Bringalily Creek	B2G16	✖	✖	✖	✓	✖	✖	✓	✖	✓	✓	-	û	Very turbid	û
		Bringalily Creek	BSG17	✖	✖	✓	✖	✖	✖	✖	✖	✖	✓	2	û	Turbid	û
		Back Creek	B2G23	✖	✖	✓	✖	✖	✖	✓	✖	✖	✖	-	û	Very turbid	No flow
		Back Creek	B2G21	✖	✖	✖	✓	✖	✖	✖	✖	✖	✖	0.5	û	Very turbid	No flow
		Back Creek	B2G22	✖	✖	✖	✓	✖	✖	✓	✓	✖	✖	0.5	û	Very turbid	No flow
		Condamine River	B2G28	✓	✓	✖	✓	✖	✖	✓	✖	✖	✖	-	û	û	No flow
		Westbrook Creek	B2G37	✖	✓	✖	✖	✖	✖	✖	✖	✖	✓	1	Boggy soft sand and clay	Turbid	Moderate flow
North East Coast	H2C Helidon to Calvert	Lockyer Creek	H2C12A	✖	✓	✓	✖	✖	✖	✖	✓	✖	✖	>2	û	û	Low, visible flow
		Lockyer Creek	H2C4A	✖	✓	✓	✖	✖	✖	✓	✓	✖	✖	>1.5m	û	û	Low, visible flow

Catchment	ARTC section	Waterway	Site	Macrohabitat sampled					Microhabitat sampled					Factors affecting eDNA sampling			
				Riffle	Run	Deep pool	Shallow pool	Cascade	Undercut banks	LWD	SWD	Backwaters	Macrophytes	Depth (m)	Slipperiness/bogginess	Suspended material	Flow
		Lockyer Creek	H2C3A	✖	✓	✓	✖	✖	✖	✖	✖	✖	✖	>3m	û	û	Low flow
		Laidley Creek	H2C17A	✓	✓	✖	✖	✖	✖	✖	✓	✖	✖	>2	û	û	Moderate flow below bridge
		Western Creek	H2C18A	✖	✖	✓	✖	✖	✖	✖	✖	✖	✓	>2	Slippery clay and sand edges	Turbid	Low flow
	C2K Calvert to Kagaru	Western Creek	C2K4	✖	✓	✖	✖	✖	✖	✓	✓	✖	✖	>1m, bed highly variable	Steep clay banks slippery when wet	Turbid	Low flow
		Bremer River	C2K5	✖	✖	✓	✖	✖	✖	✓	✓	✖	✖	3m	Clay banks slippery when wet	Very turbid	No flow
		Bremer River	C2K3	✖	✖	✓	✖	✖	✖	✓	✖	✖	✖	1.5m, bed highly variable	Clay banks slippery when wet	Very turbid	No flow
		Warrill Creek	C2K1	✖	✖	✓	✖	✖	✖	✓	✖	✖	✖	>1m	Banks black clay, slippery and boggy when wet	Very turbid	Low flow
		Dugandan Creek	C2K6	✖	✖	✖	✓	✖	✖	✓	✖	✖	✓	0.5	Very boggy sand banks	✖	No flow
		Woollaman Creek	C2K7	✖	✖	✓	✖	✖	✖	✓	✖	✖	✖	<1.5m	Soft sand	Turbid	Low flow
		Teviot Brook	C2K2	✖	✓	✖	✖	✖	✖	✓	✓	✖	✓	0.5m	Soft sand	Very turbid	Low flow



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Fauna Survey Report

Targeted survey for Brigalow Woodland Snail *Adclarkia cameroni* within selected parts of the Inland Rail Project area, Queensland.

Compiled by BOOBOOK for ARTC

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Abbreviations

ARTC	Australian Rail Track Corporation
B2G	Border to Gowrie
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DES	Department of Environment and Science (State)
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
GIS	Geographic Information System
GPS	Global Positioning System
GTRE	Ground-truthed Regional Ecosystem
km	kilometre (s)
L	Litre (s)
m	metre (s)
mm	millimetres
MNES	Matters of National Environmental Significance (EPBC Act)
MSES	Matters of State Environmental Significance (State legislation)
NC Act	<i>Nature Conservation Act 1992</i>
Qld	Queensland
RE	Regional Ecosystem (s)
REDD	Regional Ecosystem Description Database
SF	State Forest
TSSC	Threatened Species Scientific Committee

Conclusions drawn in this report are based on available information at the time of writing. Any additional information may alter such conclusions and the author reserves the right to do so if such information becomes available. This report has been made as at the date of the report and is not to be used after six (6) months and not if there are any material changes meanwhile. In either event it should be referred back for review. To the extent permitted by law BOOBOOK does not accept liability for any loss or damage which any person may suffer arising from any negligence or breach of contract on its part. This report was prepared for the benefit of the party to whom it is directed only and for the purpose identified within. BOOBOOK does not accept responsibility to any other person for the contents of the report.

Executive Summary

BOOBOOK Ecological Consulting (BOOBOOK) was commissioned by Australian Rail Track Corporation (ARTC) (the Client) to undertake a targeted survey for Brigalow Woodland Snail (*Adclarkia cameroni*) for the proposed Inland Rail Project (the Project). The survey focussed on a 100 km long Area of Interest (AOI) within the Border to Gowrie (B2G) section of the Project.

The Brigalow Woodland Snail is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act* (EPBC Act) and is so classed as a Matter of National Environmental Significance (MNES). It is also listed as vulnerable under the *State Nature Conservation Act 1992* and is therefore also a Matter of State Environmental Significance (MSES).

Brigalow Woodland Snail was predicted to occur within the Survey Area based on the EPBC Act Protected Matters Search Tool (PMST). No targeted surveys for Brigalow Woodland Snail are known to have previously been undertaken within the Survey Area by suitably qualified personnel.

The field survey had the following objectives:

- ✎ To confirm presence/absence of the Brigalow Woodland Snail within the Survey Area; and
- ✎ If detected, to obtain information relating to habitat use by Brigalow Woodland Snail within the Survey Area.

A field survey was conducted over a five-day period in August 2022 by BOOBOOK personnel. The survey was conducted at 20 sites between Wellcamp (near Toowoomba) and Canning Creek (between Millmerran and Inglewood).

Key findings of the survey are summarised as follows:

- ✎ Sixteen (16) species of land snail were recorded within the Survey Area.
- ✎ Brigalow Woodland Snail was detected at 11 of the 20 survey sites.
- ✎ The survey detected 22 live individuals and at least 39 dead shells of Brigalow Woodland Snail.
- ✎ Brigalow Woodland Snail was found within a 60 km stretch of the AOI between Brookstead and Canning Creek.
- ✎ Brigalow Woodland Snail was detected in the following remnant and/or regrowth regional ecosystem (RE) types in the Survey Area:
 - RE 11.3.2: *Eucalyptus populnea* woodland on alluvial plains.
 - RE 11.3.25: *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.
 - RE 11.3.17: *Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains.
 - RE 11.9.5: *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks.

Survey results confirmed the known general habitat preferences of Brigalow Woodland Snail outlined in TSSC (2016). Within the Survey Area, these can be summarised as follows:

- ✎ Fringing/riparian woodlands dominated by River Red Gum (*Eucalyptus camaldulensis*) on clay soils along watercourses and other streams.
- ✎ Woodlands dominated by Poplar Box (*E. populnea*) and/or Belah (*Casuarina cristata*) and/or Brigalow (*Acacia harpophylla*) on alluvial plains with clay soils.
- ✎ Woodlands dominated by Belah (*Casuarina cristata*) and/or Brigalow (*Acacia harpophylla*) on undulating low hills with clay soils.

Brigalow Woodland Snail was found in remnant and regrowth vegetation (irrespective of vegetation width and patch size) providing suitable shelter sites such as logs, dense leaf litter, low shrubs, flood debris piles and loose bark accumulations were present.

Brigalow Woodland Snail was not detected in woodlands dominated by Mountain Coolibah (*E. orgadophila*), Silver-leaved Ironbark (*E. melanophloia*) and/or Narrow-leaved Ironbark (*E. crebra*) on low basalt hills. These are represented by the following RE types within the Survey Area:

- ✎ RE 11.8.4: *Eucalyptus melanophloia* woodland to open woodland on Cainozoic igneous rocks - note that this RE may be dominated by *E. crebra* (DES 2021) which was the case at two of the sampled survey sites.
- ✎ RE 11.8.5: *Eucalyptus orgadophila* open woodland on Cainozoic igneous rocks.

No estimates of the total population size of Brigalow Woodland Snail can be made within the Survey Area based on the current survey results as diurnal searches were undertaken only. Population studies would require further field work at night after rain when the species is most active and live individuals are readily detectable. Regardless, it is clear from the results of this survey that Brigalow Woodland Snail is distributed throughout a significant portion of the Survey Area (wherever potentially suitable RE and microhabitat is present), and that the Survey Area likely supports a significant population of the species.

1. Introduction

1.1 Purpose & Scope

BOOBOOK Ecological Consulting (BOOBOOK) was commissioned by Australian Rail Track Corporation (ARTC) (the Client) to undertake a targeted survey for Brigalow Woodland Snail (*Adclarkia cameroni*) for the proposed Inland Rail Project (the Project). The survey focussed on a 100 km Area of Interest (AOI) within the Border to Gowrie (B2G) section of the Project.

The Brigalow Woodland Snail is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) and as Vulnerable under the State (Qld) *Nature Conservation Act 1992* (NC Act). Brigalow Woodland Snail has not previously been detected within the AOI, however no previous targeted searches by land snail specialists are known to have been undertaken. Potential presence of the species within B2G was predicted by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) Protected Matters Search Tool (PMST) (DCCEEW 2022a). ARTC requested information on presence/absence of Brigalow Woodland Snail within the B2G portion of the AOI.

1.2 Survey Area Description

The Survey Area extended for approximately 100 km between Wellcamp (west of Toowoomba) in the north and Canning Creek in the south (between Millmerran and Inglewood). The location of the Survey Area is shown within Appendix A.

The Survey Area is almost entirely located within the Toowoomba Regional Council apart from the southern extremity which is within Goondiwindi Regional Council. Land uses throughout the Survey Area include livestock grazing, cropping, mining and forestry. Major roads include the Toowoomba Cecil Plains Road, Gore Highway and Millmerran Inglewood Road.

North of the Condamine River the Survey Area lies within Subregion 31 (Eastern Darling Downs) of the Brigalow Belt South bioregion (Sattler and Williams 1999). South of the Condamine River the Survey Area is within Subregion 32 (Inglewood Sandstones). The majority of the Survey Area has been cleared of native vegetation. On the flat to gently undulating clay plains that were formerly dominated by native grassland, Poplar Box (*Eucalyptus populnea*) and/or Brigalow (*Acacia harpophylla*) communities the few vegetated areas that remain consist of shade lines, strips and clumps of remnant or regrowth vegetation. The main area of relatively intact vegetation is in the extreme southern end of the Survey Area (north of Inglewood) adjoining Bringalily State Forest (SF).

Elevation within the Survey Area ranges from about 330 m to 610 m. Between Wellcamp and Millmerran the geology is primarily Tertiary basalt and Quaternary alluvium. South of Millmerran are primarily Cretaceous sediments.

The northern two thirds of the Survey Area is drained by the Condamine River and its tributaries, forming part of the Balonne-Condamine catchment. South of Millmerran the remainder of the Survey Area drains into the Macintyre Brook via Canning Creek and its tributaries, part of the Border Rivers catchment. Both catchments are within the Murray Darling Basin.

1.3 Survey Team and Timing

The field survey was led by Craig Eddie (BOOBOOK, Principal Ecologist) over a five-day period from 22nd to 26th August 2022. Craig Eddie is an ecologist and land snail specialist with over 35 years of land snail survey experience.

1.4 Limitations

The field survey was conducted within or as close as possible to the AOI. Where land access limited access to sites within the AOI, the nearest accessible area with similar soils and vegetation was selected for survey (e.g. Condamine River). The survey focussed on areas with remnant vegetation and/or regrowth rather than cleared areas as highly modified sites do not provide suitable habitat for the target species.

Conditions during the survey were highly favourable for detection of Brigalow Woodland Snail. Available rainfall records for the central part of the Survey Area at Pittsworth (weather station 41082) showed that the region had received significant rainfall (total 635 mm) over multiple rain events between January and July 2022 (BOM 2022). A further 35 mm had fallen in the two weeks immediately prior to the survey hence ground conditions were very moist.

2. Species Profile

2.1 Taxonomy

The Brigalow Woodland Snail (*Adclarkia cameroni*) belongs to the family Camaenidae. It is one of three species within the genus *Adclarkia*. Although first collected in the mid-1980's (OZCAM 2022), Brigalow Woodland Snail was formally described in 2010 (Stanisic *et al.* 2010).

2.2 Legislative Status

The Brigalow Woodland Snail is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act) and as Vulnerable under the Queensland *Nature Conservation Act 1992* (NC Act).

2.3 Description

The shell of Brigalow Woodland Snail is pale brown, thin and approximately 20mm in diameter when adult. The shells are depressedly globose with a low, domed spire (Stanisic *et al.* 2010). The reddish subsutural band on the shell described by Stanisic *et al.* (2010) is a variable feature and may be lacking in some specimens (C. Eddie pers. obs.). Like all species of *Adclarkia*, the teleoconch sculpture on the upper half of the shell is of fine, scaly pustules (Stanisic *et al.* 2010). The protoconch (i.e. the first whorl) sculpture is pustulose (Stanisic *et al.* 2010). The lower half of the shell is smooth and glossy with a narrowly open umbilicus. The lip is thin and barely reflected (Stanisic *et al.* 2010). The shell of the Dulacca Woodland Snail, which also occurs within the broader range of the Brigalow Woodland Snail, is thicker (including the lip), slightly smaller in diameter and much flatter. The Boggomoss Snail (*A. dawsonensis*) does not occur within the range of the Brigalow Woodland Snail (Stanisic 1996). It is slightly larger than the Brigalow Woodland Snail.

The living animal of Brigalow Woodland Snail is described as being “grey” (Stanisic *et al.* 2010). The mantle is pale orange and the black mottling on the lung roof of the animal is visible through the shell (C. Eddie pers. obs.).

2.4 Distribution

Publicly accessible records of Brigalow Woodland Snail (ALA 2022) show that it is found in a small area of southern inland Queensland between Bowenville in the east and Miles in the west. Most records are broadly associated with the Condamine River floodplain (ALA 2022).

The known distribution of the species is entirely within the Brigalow Belt bioregion. The majority of records lie within Subregion 31 (Eastern Darling Downs) with other occurrences in Subregion 26 (Southern Downs) and Subregion 32 (Inglewood Sandstones). Subregions 26 and 31 have extensive areas of fertile clay plains (Sattler and Williams 1999) that are substantially cleared of native vegetation. Consequently, the current distribution of Brigalow Woodland Snail is highly fragmented (ALA 2022) and largely restricted to retained patches and strips of habitat along riparian corridors (TSSC 2016).

2.5 Ecology

There are no studies of the ecology of Brigalow Woodland Snail. The species is known to live in a variety of woodland types where it shelters under logs, rocks, and other ground debris (Stanisic *et al.* 2010, TSSC 2016). Like other camaenid land snails the species is presumed to be active at night after rain. During periods of inactivity the Brigalow Woodland Snail will aestivate (i.e. enter a period of dormancy) at its chosen shelter site. In order to conserve moisture, live snails attach to the underside of logs, rocks, leaves or the ground surface and seal any gaps in the shell opening with mucus. Burrowing into shallow soil has been observed in captivity (C. Eddie pers. obs.).

2.6 Habitat

2.6.1 Vegetation Associations

At the time of the species description Stanisc *et al.* (2010) described the habitat of the Brigalow Woodland Snail as “Brigalow/eucalypt woodland”. Stanisc (in TSSC 2016) describes the Brigalow Woodland Snail as occurring in “remnant and scattered *Acacia harpophylla* (Brigalow) and woodland patches (such as road verges and riparian corridors) on the Condamine River floodplain, especially in the area around Dalby and Chinchilla”. Virtually no other habitat information has been published since the species description and subsequent Commonwealth listing (TSSC 2016). There are currently no documented RE associations or vegetation structural/floristic data available for known sites.

2.6.2 Microhabitat

The Brigalow Woodland Snail shelters beneath logs, under rocks, among leaf litter and in loose bark piles at the base of trees (Stanisc *et al.* 2010, C. Eddie pers. obs.). The species can occur in non-remnant habitats (e.g. regrowth and grassland) providing there are suitable shelter sites (TSSC 2016).

In summary, microhabitat features critical to the survival of the species include:

- ✦ logs;
- ✦ rocks;
- ✦ timber/vegetation piles;
- ✦ loose bark piles;
- ✦ loose bark at the base of trees; and
- ✦ dense leaf litter.

One or more of the above microhabitat features needs to be present for the species to be present at any given site. However, there is no data available concerning the abundance/density of microhabitat features required to support the species.

2.7 Movement Patterns

Nothing is known of the movements of Brigalow Woodland Snail; however, the species is considered to be of very limited mobility (Stanisc in TSSC 2016). Movement between suitable microhabitat sites (e.g. log piles) may be possible (Stanisc in TSSC 2016). Movement patterns of Australian land snails are poorly studied. Ridgeway *et al.* (2014) studied the behavioural ecology, including movement patterns, of several species of camaenid land snails in the Sydney region of New South Wales (NSW). These species were *Pommerhelix duralensis*, *Meridolum corneovirens* and *M. middense* which are comparable in size or a little larger (15-30mm in diameter) than Brigalow Woodland Snail. The study of Ridgeway *et al.* (2014) found that these snails moved only short distances during any one observation (often <1m) and that the longest recorded movement was 3.5 m out of 50 survey-animal nights. Ridgeway *et al.* (2014) also concluded that the very low dispersal rates recorded for two of the species suggested that they are highly susceptible to habitat fragmentation. Although not confirmed by field studies, it is probable that Brigalow Woodland Snails also move short distances and that they are equally as susceptible to habitat fragmentation through the creation of isolated populations.

2.8 Breeding Biology

Nothing is known of the breeding biology of Brigalow Woodland Snail (TSSC 2016). It is assumed, like other camaenid land snails, that it lays its eggs in depressions in soil under logs and other ground debris; multiple egg laying events per season are possible depending on the frequency and timing of weather events (Stanisc in TSSC 2016). Although not confirmed, the species is expected to reach sexual maturity during its second wet season (Stanisc in TSSC 2016).

Land snail eggs are prone to desiccation therefore an overstorey of trees and shrubs, in addition to ground shelter sites (e.g. logs and other debris), is considered critical to maintaining high levels of humidity at potential egg-laying sites (Stanisc in TSSC 2016).

2.9 Feeding Ecology

Nothing is known of the food or feeding ecology of Brigalow Woodland Snail. Like other camaenid land snails it is presumed to feed at night after rain upon hyphae and fruiting bodies of native fungi, lichen, algae and other detritus/biofilm among ground debris (Stanisic in TSSC 2016).

3. Methodology

3.1 Desktop & Literature Review

The following data and information sources were reviewed to inform this survey:

- ✎ PMST (DCCEEW 2022a);
- ✎ Species Profile and Threats Database (SPRAT) (DCCEEW 2022b);
- ✎ Atlas of Living Australia database (ALA 2022);
- ✎ Queensland Museum fauna specimen database (OZCAM 2022);
- ✎ State government pre-clear and remnant regional ecosystem (RE) mapping (DES 2022a);
- ✎ State government Wildlife Online database (DES 2022b);
- ✎ Client-supplied ground-truthed regional ecosystem (GTRE) mapping;
- ✎ Relevant published and other publicly available literature; and
- ✎ Satellite imagery for the Survey Area (Google Earth, Queensland Globe).

A series of potential field survey sites were selected during examination of relevant imagery for the Survey Area. Potential sites were chosen to in areas that were representative of all vegetation types/REs within the Survey Area, as well as all of the major watercourses. Suitability of potential field sites was assessed during the field survey.

3.2 Field Survey

3.2.1 Targeted Snail Searches

In the absence of species-specific survey guidelines for Brigalow Woodland Snail standard terrestrial land snail survey techniques (e.g. Stanisic *et al.* 2010, Cameron and Pokryszko 2005) and recommendations for survey of Brigalow Woodland Snail within the Conservation Advice (TSSC 2016) were followed. The Conservation Advice provides the following survey guidelines:

- ✎ The species “lives under forest debris and is best detected by turning logs and raking accumulated leaves”.
- ✎ “The best times for survey are during the months of summer storms and rain (generally October to March)”.
- ✎ “The snail is nocturnal, suggesting that night surveys would be preferable; however, given the difficulty with night observation of snails in their habitat, daylight searching can be equally effective”.
- ✎ “Survey effort for recording presence/absence should be at least two person hours targeting areas of preferred snail microhabitat”.

Surveys for the target species conformed to the survey guidelines in the following ways:

- ✎ The field survey was conducted outside of the preferred survey period of October – March, however survey conditions were highly favourable for detection of the species due to preceding wet conditions.
- ✎ Active searching of potential shelter sites within a range of vegetation types was the primary search method.
- ✎ Each site was searched for a minimum of two person hours (which included as much of each habitat in which the survey site was located) unless all microhabitat at the survey site was searched in less time.

Active searching included rolling logs and other ground debris, checking the inside of hollow logs, overturning rocks/rock piles, lifting fallen bark piles and raking through leaf litter and piles of fallen bark and flood debris. The undersides and hollows of logs were checked for aestivating live snails, while the top few centimetres of soil beneath logs was raked to detect whole shells or fragments of dead snails. Note that active searching was carefully undertaken to minimise microhabitat disturbance at all survey sites. The location (and number of shells) of Brigalow Woodland Snail (where detected) was captured by Global Positioning System (GPS) and recorded electronically for incorporation into relevant Geographic Information System (GIS) layers.

A sample of surface soil and leaf litter was collected from under logs/rocks or around the bases of trees from each survey site for post-field laboratory sorting. The amount of leaf litter/soil collected from each survey site varied from 0.1 to 3.5 L due to the amount available per site. For example, at sites adjoining the major watercourses most of the leaf litter had been washed away following recent floods. Leaf litter samples were dried and then sieved.

Shells of dead land snails were extracted from leaf litter using a stereo microscope under laboratory conditions. This additional search technique (e.g. Stanisic *et al.* 2010) was useful to detect juvenile snails and shell fragments where shells of the target species were not otherwise detected during active searches. Any land snails extracted from leaf litter samples were identified to species level using relevant field guides (e.g. Stanisic *et al.* 2010) and the BOOBOOK land snail reference collection.

Nocturnal searches were not undertaken as live snails were not necessary to confirm presence of the species within the Survey Area i.e. the species was readily detected by the presence of dead shells. As per the Conservation Advice (TSSC 2016), the presence of dead shells was assumed to be an indicator of living specimens.

Voucher specimens of land snails from each survey site were retained for identification confirmation. Shells of dead Brigalow Woodland Snails were collected under Scientific Purposes Permit WA0026174.

Land snail taxonomy within this report follows the MolluscaBase database (MolluscaBase 2022).

Brigalow Woodland Snail was readily distinguished from most other species of land snail present in the Survey Area by the shape and size of the shell. However, shape and size of the shell is variable and the Brigalow Woodland Snail is superficially similar to several undescribed species in the family Camaenidae which overlap with the broader range of the Brigalow Woodland Snail in the Brigalow Belt. As such size, colour and shape of the shell are not reliable identification characters on their own (C. Eddie pers. obs.). All specimens of *Adclarkia* were distinguished from other undescribed (and potentially confusing) species of Camaenidae by examining differences in microsculpture on the shell surface. This was undertaken by examining voucher specimens under a stereo microscope in the laboratory. All *Adclarkia* are sculptured with fine, elongate pustules each with a raised periostracal scale on the teleoconch (Stanisic *et al.* 2010). This feature is absent from shells of the undescribed Brigalow Belt camaenids, hence examination of shell microsculpture was the primary method of identification.

3.2.2 Microhabitat Assessments

As the focus of this survey was detecting the species (i.e. to determine presence/absence) detailed microhabitat assessments were not performed. However, a simplified microhabitat assessment was undertaken at each survey site. A range of microhabitat characteristics of potential importance to the species were assessed within a 50 m x 10 m plot including:

- ✦ abundance of small (<30cm diameter) and large logs (>30cm diameter);
- ✦ abundance of loose rocks/stones;
- ✦ abundance of trees with loose basal bark/basal bark piles;
- ✦ presence/absence of other bark piles (e.g. disassociated fallen bark);
- ✦ presence/absence of log piles (e.g. stick-raked piles resulting from previous clearing);
- ✦ density of leaf litter;
- ✦ density of ground layer;
- ✦ presence/absence of flood debris piles; and
- ✦ presence/absence of gilgais.

Notes about disturbances were recorded at each survey site such as clearing (including historical), thinning/selective logging, grazing, feral animal diggings/wallows, and fire, flood and storm damage.

4. Results

4.1 Desktop Searches

Previous land snail searches have been undertaken in or near the Survey Area as part of bioregion-wide surveys (e.g. Stanisic 1998) or as incidental activities during ecological assessments (BOOBOOK unpubl. data). These are not

considered to have been comprehensive. More importantly, no targeted surveys for Brigalow Woodland Snail are known to have been previously undertaken in the Survey Area.

Publicly accessible database records for Brigalow Woodland Snail within the Survey Area are shown within Appendix A. Specimen-backed records of Brigalow Woodland Snail were derived from searches of the Atlas of Living Australia (ALA 2022) and Queensland Museum (OZCAM 2022) databases. Records of Brigalow Woodland Snail from the Wildlife Online database (DES 2022b) were not used as several are not specimen-backed and the remainder are duplicates of ALA or OZCAM records.

The desktop search results (Appendix A) show that the Brigalow Woodland Snail has not previously been recorded from the Survey Area (ALA 2022, OZCAM 2022). The nearest publicly available records to the Survey Area are approximately 45-55 km to the northwest.

4.2 Targeted Searches

Existing desktop data was not adequate to address matters relating to Brigalow Woodland Snail within the Survey Area hence a targeted survey was performed as part of this study. Twenty (20) survey sites were sampled for Brigalow Woodland Snail. The location of each survey site is shown within Appendix A and descriptive notes for each are shown in Appendix B.

The field survey had the following objectives:

- ✎ To confirm presence/absence of the Brigalow Woodland Snail within the Survey Area; and
- ✎ If detected, to obtain information relating to habitat use by Brigalow Woodland Snail within the Survey Area.

The field survey was undertaken over a five-day period with weather conditions being mild and with nil precipitation.

At least sixteen (16) species of native land snail and two species of introduced slug were recorded within the Survey Area (Table 1). The total number of land snail species recorded may increase pending further examination of undescribed species within the families Camaenidae, Rhytididae and Charopidae.

Table 1: Terrestrial molluscs detected within the Survey Area.

Family	Scientific Name	Common Name	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Camaenidae	<i>Adclarkia cameroni</i>	Brigalow Woodland Snail	-	-	-	-	-	-	-	X	X	X	X	X	X	X	-	X	X	X	-	X
Camaenidae	Camaenidae sp. (undescribed – likely at least 2 spp.)	A Woodland Snail	-	-	X	-		X	X	-	-	-	-	-	X	-	-	-	-	-	-	X
Camaenidae	<i>Neveritis aridorum</i>	Nomadic Velvet Snail	-	X	X	X	X	X	-	-	X	-	X	-	X	-	-	-	-	-	-	-
Camaenidae	<i>Neveritis misella</i>	Mid-eastern Velvet Snail	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-
Charopidae	Charopidae sp. (undescribed)	A Pinwheel Snail	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Charopidae	<i>Cineropa / Elsothera</i> sp. (undescribed)	A Pinwheel Snail	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Charopidae	<i>Discocharopa aperta</i>	Minuscule White Pinwheel Snail	-	-	X	-	-	X	-	-	X	-	-	-	-	-	X	-	-	-	-	-
Punctidae	<i>Paralaoma servilis</i>	Mort's Pinhead Snail	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pupillidae	<i>Cylindrovertilla hedleyi</i>	Hedley's Amber Pupasnail	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Pupillidae	<i>Gastrocopta hedleyi</i>	Brigalow Pupasnail	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pupillidae	<i>Gastrocopta pediculus</i>	Weakly Toothed Pupasnail	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pupillidae	<i>Gastrocopta strangei</i>	Strange's Pupasnail	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Pupillidae	<i>Pumilicopta bifurcata</i>	Many-toothed Pupasnail	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Pupillidae	<i>Pupoides pacificus</i>	Single-toothed Pupasnail	-	X	X	-	-	X	-	-	X	-	-	-	-	-	X	-	-	-	-	-
Rhytididae	Rhytididae sp.	a Carnivorous Snail	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	X	-	-	-	-

Family	Scientific Name	Common Name	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Subulinidae	<i>Erelopeas tuckeri</i>	Tucker's Awlsnail	-	-	-	X	-	X	-	X	X	-	-	-	X	-	X	-	-	-	-	X
INTRODUCED SLUGS																						
Agriolimacidae	<i>Deroceras panormitanum</i>	Brown Field Slug	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Limacidae	<i>Letourneuxia nyctelia</i> (formerly <i>Lehmannia nyctelia</i>)	Striped Field Slug	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Brigalow Woodland Snail was detected at 11 of the 20 survey sites (Appendix C). Numbers of individuals recorded at each site and relevant microhabitat notes are summarised in Table 2.

Table 2: Summary of sites where Brigalow Woodland Snail was detected with RE and microhabitat notes.

Site No.	Brigalow Woodland Snail Detected	No. of live individuals	No of dead shells	RE	Microhabitat Notes
S01	No	-	-	Non-remnant	Microhabitat included dense grass and piles of flood debris.
S02	No	-	-	11.8.5	Microhabitat included logs, leaf litter accumulations and small rocks.
S03	No	-	-	Non-remnant	Microhabitat included small logs/log piles and fallen bark.
S04	No	-	-	11.8.4	Microhabitat included logs and small rocks.
S05	No	-	-	11.8.4	Microhabitat included logs, leaf litter accumulations and small rocks.
S06	No	-	-	11.8.5	Microhabitat included logs, small rocks, leaf litter accumulations and a boulder pile.
S07	No	-	-	11.9.5	Microhabitat included small logs and leaf litter accumulations.
S08	Yes	2	10	11.3.25	Brigalow Woodland Snail found under small logs, rubbish (discarded blanket) and piles of flood debris.
S09	Yes	2	4	11.3.25	Brigalow Woodland Snail found under logs, loose bark piles at base of trees, under ground plants (e.g. chenopods) and piles of flood debris.
S10	Yes	0	1	11.3.25	Brigalow Woodland Snail found under logs and piles of flood debris.
S11	Yes	2	2	11.3.2	Brigalow Woodland Snail found under small logs and leaf litter accumulations.
S12	Yes	1	1	11.3.2	Brigalow Woodland Snail found under small logs.
S13	Yes	2	4	11.3.17	Brigalow Woodland Snail found under logs.
S14	Yes	5	5	11.3.25 / 11.3.2	Brigalow Woodland Snail found under logs and piles of flood debris.
S15	No	-	-	11.9.5	Microhabitat included small logs and leaf litter accumulations.
S16	Yes	0	1	11.9.5	Brigalow Woodland Snail found under small logs and leaf litter accumulations.
S17	Yes	4	4	11.9.5	Brigalow Woodland Snail found under logs and leaf litter accumulations.
S18	Yes	1	1	11.3.17	Brigalow Woodland Snail found under small logs and leaf litter accumulations.
S19	No	-	-	11.3.18	Microhabitat included small logs and leaf litter accumulations.
S20	Yes	2	6	11.9.5	Brigalow Woodland Snail found under small logs and leaf litter accumulations.

Both live and dead Brigalow Woodland Snails were detected during the survey.

Although it was not the intention of the survey to detect live individuals, living Brigalow Woodland Snails were incidentally encountered during diurnal hand searches at nine sites. Approximately 39 dead Brigalow Woodland Snail shells were also found. The survey methodology was consistent with the TSSC (2016) guidelines.

Brigalow Woodland Snail was detected within the Survey Area between Brookstead and Canning Creek. The survey results extend the known distribution of the species eastwards and south-eastwards by up to 55-60 km.

4.3 Regional Ecosystem and Microhabitat Associations

4.3.1 Regional Ecosystem Associations

Brigalow Woodland Snail was detected within four of the seven sampled RE types these being:

- ✱ RE 11.3.2: *Eucalyptus populnea* woodland on alluvial plains.
- ✱ RE 11.3.25: *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.
- ✱ RE 11.3.17: *Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains.
- ✱ RE 11.9.5: *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks.

Survey results confirmed the known general habitat preferences outlined in TSSC (2016). Within the Survey Area, these can be summarised as follows:

- ✱ Fringing/riparian woodlands dominated by River Red Gum (*Eucalyptus camaldulensis*) on clay soils along watercourses and other streams.
- ✱ Woodlands dominated by Poplar Box (*E. populnea*) and/or Belah (*Casuarina cristata*) and/or Brigalow (*Acacia harpophylla*) on alluvial plains with clay soils.
- ✱ Woodlands dominated by Belah (*Casuarina cristata*) and/or Brigalow (*Acacia harpophylla*) on undulating low hills with clay soils.

Brigalow Woodland Snail was not detected in woodlands dominated by Mountain Coolibah (*E. orgadophila*), Silver-leaved Ironbark (*E. melanophloia*) and/or Narrow-leaved Ironbark (*E. crebra*) on low basalt hills. These are represented in the Survey Area by the following RE types:

- ✱ RE 11.8.4: *Eucalyptus melanophloia* woodland to open woodland on Cainozoic igneous rocks - note that this RE may be dominated by *E. crebra* (DES 2021) which was the case at two of the sampled survey sites.
- ✱ RE 11.8.5: *Eucalyptus orgadophila* open woodland on Cainozoic igneous rocks.

Brigalow Woodland Snail was not detected at survey site S019 (Bringalily Creek). The site searched had loamy soils and the RE was attributed to 11.3.18: *Eucalyptus populnea*, *Callitris glaucophylla*, *Allocasuarina luehmannii* shrubby woodland on alluvium. This site had a limited amount of searchable microhabitat. It is likely that Brigalow Woodland Snail occurs in at least some of the riparian/alluvial vegetation communities on heavier soils associated with this stream, however further surveys would be required.

Pre-clearing regional ecosystem mapping (DES 2022a) indicates that three grassland REs are potentially present in the Survey Area these being:

- ✱ 11.3.21: *Dichanthium sericeum* and/or *Astrebla* spp. grassland on alluvial plains. Cracking clay soils.
- ✱ 11.3.24: *Themeda avenacea* grassland on alluvial plains. Basalt derived soils.
- ✱ 11.8.11: *Dichanthium sericeum* grassland on Cainozoic igneous rocks.

Survey Site S01 was located in an area pre-clear mapped as 11.3.21/11.3.24. This area was heavily infested by weeds and therefore was difficult to search. Although the substrate and landform was generally suitable for Brigalow Woodland Snail, the species was not recorded from the northern extremity of the Survey Area. The only terrestrial mollusc detected at this site was the introduced Brown Field Slug (*Deroceras panormitanum*).

Survey Site S03 was located in an area pre-clear mapped as RE 11.8.11. Searchable microhabitat at this site was similarly limited, however six species of terrestrial mollusc were detected. This included a medium-sized undescribed camaenid similar in general appearance to Brigalow Woodland Snail. The potential occurrence of Brigalow Woodland Snail in these grassland REs cannot be ruled out and may need further investigation. Brigalow Woodland Snail is known to occur within clearings (derived grassland) outside the Survey Area but only where there is suitable microhabitat (i.e. shelter sites) present (BOOBOOK unpubl. data). Grasslands are notoriously difficult to search for land snails as they typically have little microhabitat to search and are frequently overgrown with weeds.

Brigalow Woodland Snail was found in both remnant and mature regrowth RE types. It was also found in both patches and strips of vegetation (including roadside strips) of a variety of sizes and widths.

4.3.2 Microhabitat Associations

Although it was beyond the scope of this survey to undertake detailed assessments of microhabitat at each survey site, Table 3 summarises the results of the simplified microhabitat assessment undertaken.

Table 3: Summary of microhabitat features recorded at each survey site within 50m x 10m plot.

Site No.	Small Logs (<30cm dia.)	Large Logs (>30cm dia.)	Log Piles	Trees With Loose Basal Bark Piles	Other Bark Piles	Loose Rocks / Stones	Leaf Litter	Ground Layer (%)	Flood Debris Piles	Gilgais	BWS Detected?
S01	0	0	Absent	0	Absent	0	0	75-100	Present	Absent	No
S02	1-5	0	Present	0	Absent	1-5	<25	75-100	Absent	Absent	No
S03	0	0	Present	0	Absent	0	0	50-75	Present	Absent	No
S04	1-5	1-5	Absent	0	Absent	1-5	<25	75-100	Absent	Absent	No
S05	1-5	1-5	Absent	0	Absent	1-5	<25	75-100	Absent	Absent	No
S06	1-5	0	Absent	0	Absent	11-15	<25	50-75	Absent	Absent	No
S07	1-5	0	Absent	0	Absent	0	<25	75-100	Absent	Absent	No
S08	1-5	0	Absent	0	Absent	0	<25	50-75	Present	Absent	Yes
S09	1-5	0	Absent	1-5	Absent	0	<25	50-75	Present	Absent	Yes
S10	1-5	0	Absent	0	Absent	0	<25	50-75	Present	Absent	Yes
S11	1-5	0	Absent	0	Absent	0	<25	75-100	Absent	Absent	Yes
S12	1-5	0	Absent	0	Absent	0	<25	75-100	Absent	Absent	Yes
S13	1-5	1-5	Absent	0	Absent	0	<25	50-75	Absent	Absent	Yes
S14	1-5	0	Absent	1	Absent	0	<25	50-75	Present	Absent	Yes
S15	0	0	Absent	0	Absent	0	<25	50-75	Absent	Absent	No
S16	1-5	0	Absent	0	Absent	0	<25	75-100	Absent	Absent	Yes
S17	1-5	0	Absent	0	Absent	0	<25	50-75	Absent	Absent	Yes
S18	1-5	0	Absent	0	Absent	0	<25	75-100	Absent	Absent	Yes
S19	0	0	Absent	0	Absent	0	<25	75-100	Absent	Absent	No
S20	1-5	1-5	Absent	0	Absent	0	<25	50-75	Absent	Absent	Yes

Brigalow Woodland Snail was detected alive under logs, among moist flood debris piles, under rubbish (e.g. a discarded blanket) and under bark piles at the base of trees. These findings are consistent with known microhabitat preferences. Dead shells were also detected among leaf litter accumulations and under low shrubs (e.g. chenopods).

4.4 Other Comments

No estimates of the total population size of Brigalow Woodland Snail can be made within the AOI based on the current survey results as diurnal searches were undertaken only. Population studies would require further field work at night after rain when the species is most active and live individuals are readily detectable. Regardless, it is clear from the results of this survey that Brigalow Woodland Snail is distributed throughout a significant portion of the AOI (wherever potentially suitable RE and microhabitat is present), and that the AOI likely supports a significant population of the species.

Most of the habitat available for Brigalow Woodland Snail is highly fragmented due to past clearing and there are limited opportunities for dispersal by the species between patches due to its low mobility and presence of potential barriers such as roads. Likewise, many small patches are susceptible to edge effects and other threats such as clearing, microhabitat loss, weed invasion and wildfire. Regardless, Brigalow Woodland Snail was found to persist in narrow strips of vegetation (<30 m wide). Note that such strips may not necessarily meet remnant vegetation mapping criteria (Neldner *et al.* 2022), however for the purposes of the snail they represent known or potential habitat.

5. Conclusions

Key findings of the survey are summarised as follows:

- ✎ At least sixteen (16) species of land snail were recorded within the AOI.
- ✎ Brigalow Woodland Snail was detected at 11 of the 20 survey sites.
- ✎ The survey detected 22 live individuals and at least 39 dead shells of Brigalow Woodland Snail.
- ✎ Brigalow Woodland Snail was found within a 60 km stretch of the AOI between Brookstead and Canning Creek.
- ✎ Brigalow Woodland Snail was detected in the following remnant and/or regrowth habitat types in the AOI:
 - RE 11.3.2: *Eucalyptus populnea* woodland on alluvial plains.
 - RE 11.3.25: *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.
 - RE 11.3.17: *Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains.
 - RE 11.9.5: *Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks.
- ✎ Live Brigalow Woodland Snails were detected in the following microhabitat situations: under logs, among moist flood debris piles, under rubbish (e.g. a discarded blanket) and under bark piles at the base of trees.
- ✎ Although much of the habitat within the AOI has been cleared and fragmented the survey has demonstrated that a significant population of Brigalow Woodland snail occurs within the AOI.

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7. Figures



Figures 1a-b: Representative images of Brigalow Woodland Snail (*Adclarkia cameroni*) at survey site S08 - Condamine River North: bleached shell of a dead adult in flood debris (left) and live subadult on the underside of a discarded blanket within the river channel (right).



Figures 1c-d: Habitat at survey site S08 – Condamine River North: narrow fringe of River Red Gum (*Eucalyptus camaldulensis*), River Cooba (*Acacia stenophylla*) woodland RE 11.3.25 (left, right).



Figures 2a-b: Representative images of Brigalow Woodland Snail at survey site S09 - Condamine River: bleached shell of a dead adult under a saltbush (left) and live subadult found on the underside of loose bark at the base of a River Red Gum (right).



Figures 2c-d: Habitat at survey site S09 – Condamine River: River Red Gum open woodland RE 11.3.25 (left, right).



Figures 3a-b: Habitat at survey site S10 – Grass Tree Creek: fringe of River Red Gum, River Cooba woodland RE 11.3.25 (left, right).



Figures 4a-b: Habitat at survey site S11 – Lindenmayer Road: narrow roadside strip of alluvial Poplar Box (*E. populnea*) woodland RE 11.3.2 (left, right).



Figures 5a-b: Habitat at survey site S12 – Lovell Road: narrow strip of alluvial Poplar Box woodland RE 11.3.2 (left, right).



Figures 6a-b: Habitat at survey site S13 – Owens Scrub Road reserve: alluvial Poplar Box, Belah (*Casuarina cristata*) woodland RE 11.3.17 (left, right).



Figures 7a-b: Habitat at survey site S14 – water reserve: narrow fringe of River Red Gum open woodland along the bank of Back Creek RE 11.3.25 (left); alluvial Poplar Box woodland RE 11.3.2 on the adjoining floodplain (left, right).



Figures 8a-b: Habitat at survey site S16 – Millmerran Inglewood Road: narrow strip of Brigalow (*Acacia harpophylla*) woodland RE 11.9.5 (left, right).



Figures 9a-b: Habitat at survey site S17 – east of Millmerran Inglewood Road: retained shade line of Brigalow, Belah woodland RE 11.9.5 (left, right).



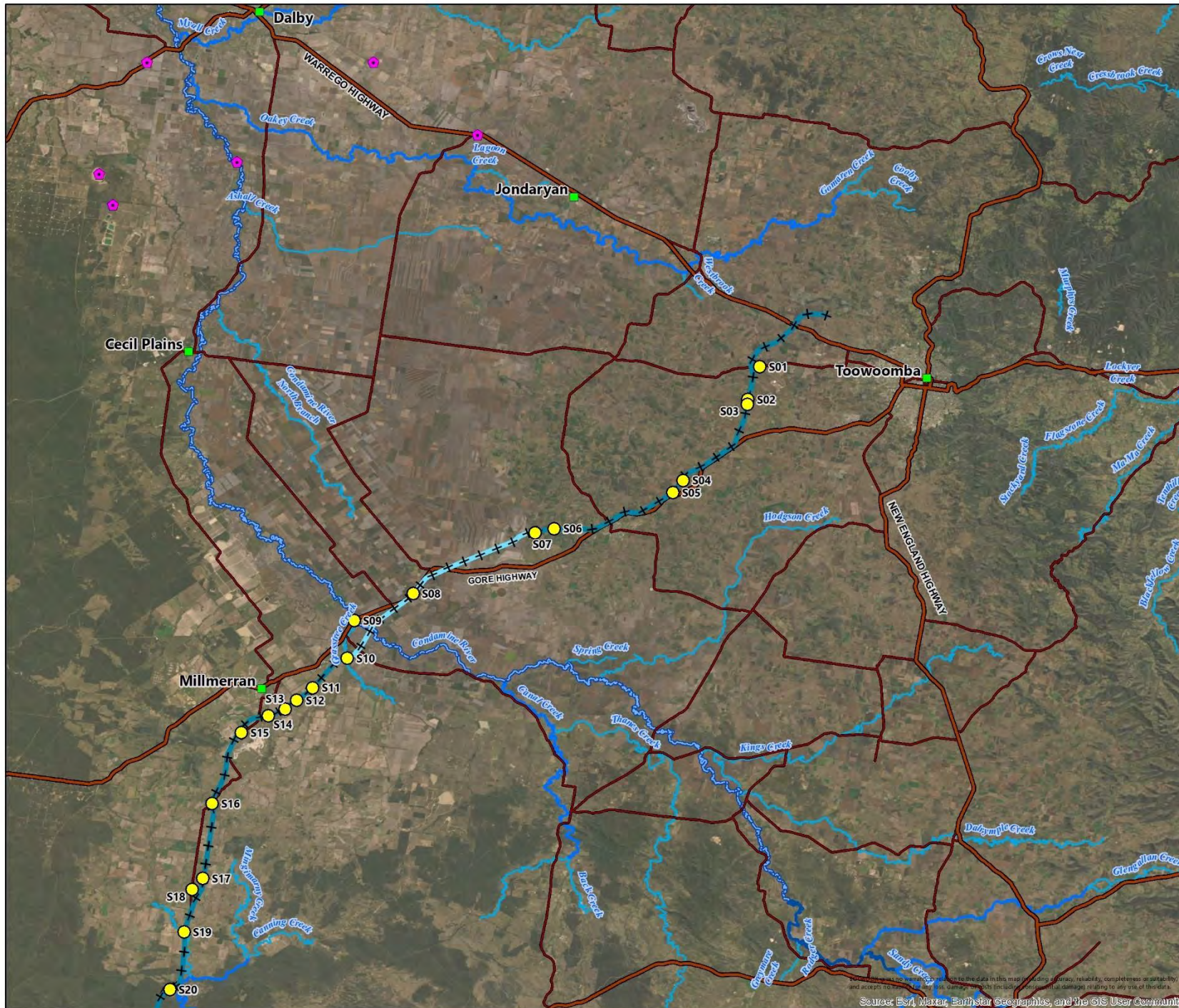
Figures 10a-b: Habitat at survey site S18 – Millmerran Inglewood Road: disturbed Poplar Box, Brigalow woodland RE 11.3.17 on the floodplain of Nicol Creek (left, right).



Figures 11a-b: Habitat at survey site S20 – southeast of Millmerran Inglewood Road: regrowth Brigalow, Belah woodland RE 11.9.5 (left, right).

Appendix A. Location of the Survey Area and field survey sites.

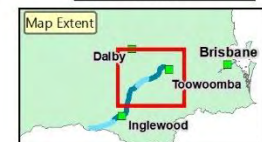
Appendix A: Location of the Study Area and Survey Sites



- Settlement
- Snail Survey Site
- ALA - Previous records
- ARTC Network**
- +— 0
- +— 1
- Major Roads**
- Highway
- Secondary Roads
- Ordered Streams**
- 5
- 6
- 7
- 8



Project: AIC
DWS Survey
Map No: PC892_AppA
Date: 30/08/2022
Drawn: L. Hardwick
Approved: C. Eddie
Scale: 1: 400,000 @ A3
Datum: GDA94



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Appendix B. Characteristics of Survey sites.

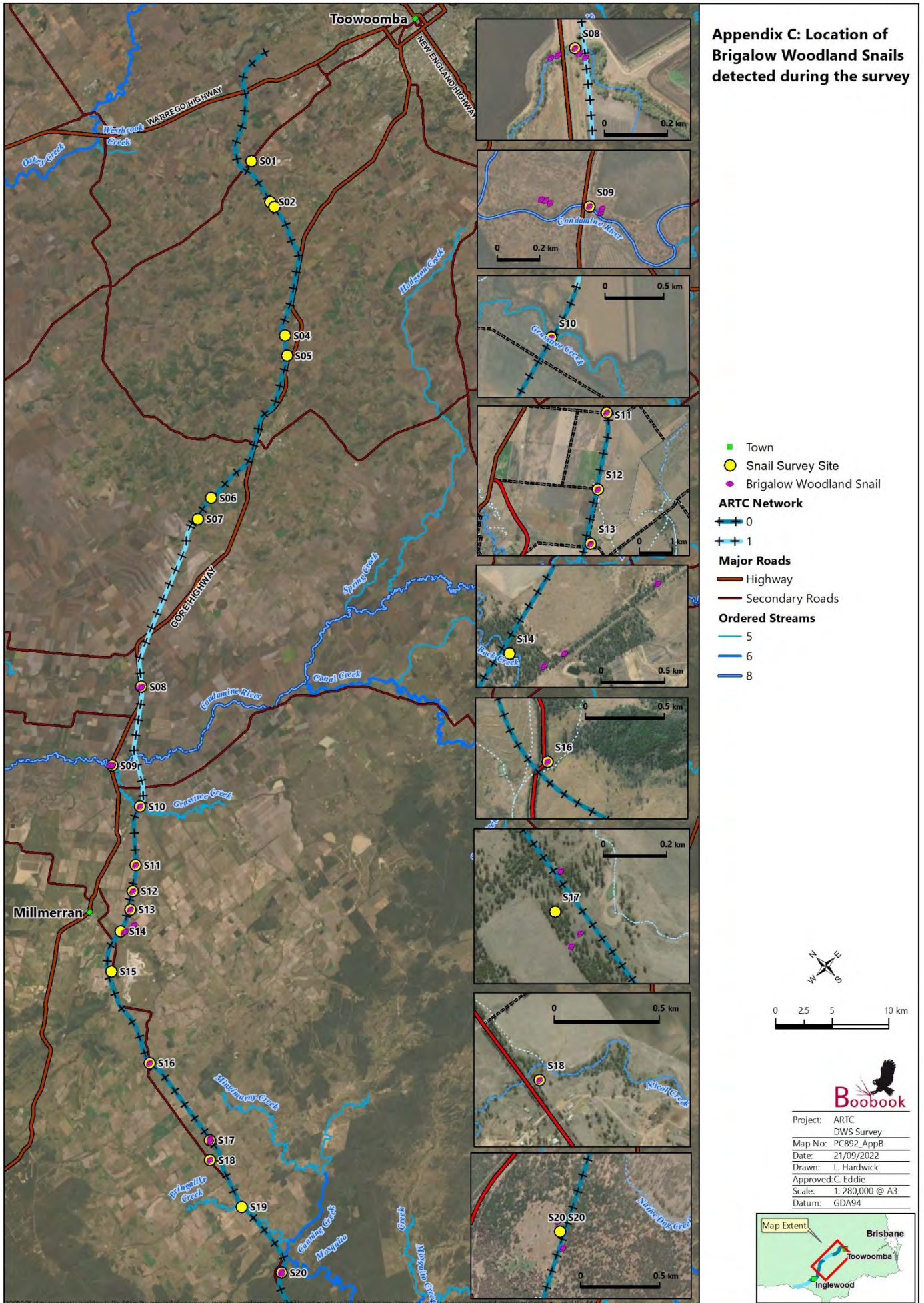
Site Code	Lot / Plan	General Location	Date Surveyed	Search Effort (mins)	RE Code	RE Condition	Landform	Substrate	Elevation (m)	Vegetation
S01	Road parcel	Toowoomba Cecil Plains Road: Westbrook Creek crossing	26/8/2022	60	N/A	Non-remnant	Floodplain beside watercourse	Brown clay.	444	Derived grassland dominated by introduced grasses and forbs. Occasional <i>Salix babylonica</i> along creek bank.
S02	12SP228312	East of Berghofer Road	26/8/2022	60	11.8.5	Remnant	Hill slope.	Brown clay.	576	<i>Eucalyptus orgadophila</i> open woodland with scattered <i>E. melanophloia</i> ; midlayer sparse <i>Acacia decora</i> ; ground layer composed of native and introduced grasses and forbs.
S03	12SP228312	East of Berghofer Road: One Mile Gully	26/8/2022	60	N/A	Non-remnant	Floodplain beside watercourse.	Brown clay.	520	Derived grassland dominated by introduced grasses and forbs; widely scattered <i>Angophora floribunda</i> .
S04	2RP110779	West of Linthorpe Valley Road	22/8/2022	120	11.8.4	Remnant	Hill slope (basalt).	Brown clay with scattered small rocks.	550	<i>Eucalyptus crebra</i> woodland; midlayer of canopy recruits & <i>Notelaea microcarpa</i> ; ground layer composed of native and introduced grasses and forbs.
S05	5RP841180	Corner of Geitz Road and Gore Highway	22/8/2022	60	11.8.4	Remnant	Hill slope (basalt).	Brown clay.	609	<i>Eucalyptus crebra</i> woodland; midlayer of canopy recruits, <i>Acacia</i> spp. & <i>Lycium ferocissimum</i> ; ground layer composed of native and introduced grasses and forbs.
S06	3RP7480	South of Glen Devon Road	22/8/2022	120	11.8.5	Remnant	Hill crest.	Brown clay with rock/boulder outcrop (basalt).	515	<i>Eucalyptus orgadophila</i> , <i>Callitris glaucophylla</i> woodland; midlayer of <i>Geijera salicifolia</i> , <i>Notelaea macrocarpa</i> , <i>Alphitonia excelsa</i> & <i>Carissa ovata</i> ; ground layer mix of native & introduced grasses & forbs.
S07	Road parcel	Roche Road	22/8/2022	30	11.9.5	Regrowth	Undulating plain.	Brown clay.	453	Narrow roadside strip of <i>Acacia harpophylla</i> woodland with scattered <i>Casuarina cristata</i> ; midlayer dominated by canopy recruits & <i>Geijera salicifolia</i> & <i>Eremophila mitchellii</i> ; ground layer dominated by <i>Megathyrsus maximus</i> & some forbs (chenopods).

Site Code	Lot / Plan	General Location	Date Surveyed	Search Effort (mins)	RE Code	RE Condition	Landform	Substrate	Elevation (m)	Vegetation
S08	Road parcel	Gore Highway: Condamine River North	23/8/2022	60	11.3.25	Regrowth	Watercourse.	Brown clay.	391	Narrow fringe of <i>Eucalyptus camaldulensis</i> with midlayer of <i>Acacia stenophylla</i> ; ground layer mix of native and introduced grasses and forbs.
S09	Road parcel	Gore Highway: Condamine River	23/8/2022	60	11.3.25	Remnant	Watercourse.	Brown clay.	407	<i>Eucalyptus camaldulensis</i> fringing woodland with midlayer of <i>Acacia stenophylla</i> ; ground layer mix of native and introduced grasses and forbs (particularly <i>Phyla canescens</i> and chenopods on floodplain).
S10	4RP16058	Millmerran Branch Railway: Grass Tree Creek	23/8/2022	60	11.3.25	Remnant	Watercourse.	Brown clay.	393	Narrow fringe of <i>Eucalyptus camaldulensis</i> with midlayer of <i>Acacia stenophylla</i> ; ground layer mix of native and introduced grasses and forbs.
S11	Road parcel	Lindenmayer Road	23/8/2022	60	11.3.2	Remnant (roadside strip)	Plain.	Brown clay.	406	<i>Eucalyptus populnea</i> woodland; sparse midlayer of <i>Notelaea microcarpa</i> ; ground layer dominated by <i>Megathyrsus maximus</i> & <i>Chloris gayana</i> .
S12	Road parcel	Lovells Road	23/8/2022	60	11.3.2	Remnant (roadside strip)	Plain.	Brown clay.	413	<i>Eucalyptus populnea</i> woodland; midlayer absent; ground layer dominated by <i>Cenchrus ciliaris</i> .
S13	2SP136970	Owens Scrub Road/Lovells Road junction	23/8/2022	120	11.3.17	Remnant	Plain.	Brown clay loam.	426	<i>Eucalyptus populnea</i> , <i>Casuarina cristata</i> woodland; midlayer dominated by <i>C. cristata</i> saplings ground layer mix of native and introduced grasses and forbs.
S14	140DER34129	Reserve via Foxwood Road	25/8/2022	60	11.3.25/1 1.3.2	Remnant	Watercourse (Back Creek) and adjoining plain	Brown clay.	378	<i>Eucalyptus camaldulensis</i> fringing open woodland with scattered <i>Angophora floribunda</i> along Back Creek. Adjoined by <i>Eucalyptus populnea</i> woodland on adjoining plain. Dense grassy ground layer + <i>Lomandra longifolia</i> & <i>Bryophyllum</i> spp.
S15	Road parcel	Millmerran Inglewood Road	24/8/2022	60	N/A (ex 11.9.5)	Regrowth (roadside strip)	Undulating low hills.	Brown clay.	436	Narrow roadside strip of <i>Acacia harpophylla</i> , <i>Casuarina cristata</i> woodland; midlayer dominated by canopy recruits & <i>Geijera parviflora</i> ; ground layer composed of introduced & native grasses & forbs including chenopods.

Site Code	Lot / Plan	General Location	Date Surveyed	Search Effort (mins)	RE Code	RE Condition	Landform	Substrate	Elevation (m)	Vegetation
S16	Road parcel	Millmerran Inglewood Road	24/8/2022	60	11.9.5	Regrowth (roadside strip)	Undulating low hills.	Brown clay.	466	Narrow roadside strip of <i>Acacia harpophylla</i> woodland; midlayer dominated by canopy recruits with some <i>Lycium ferocissimum</i> ; ground layer dominated by <i>Megathyrsus maximus</i> , <i>Cenchrus ciliaris</i> & forbs including chenopods.
S17	2RP145435	East of Millmerran Inglewood Road	25/8/2022	60	11.9.5	Regrowth	Undulating low hills.	Brown clay.	481	<i>Acacia harpophylla</i> , <i>Casuarina cristata</i> woodland (shade line); midlayer composed of <i>Geijera parviflora</i> & <i>Lycium ferocissimum</i> ; ground layer dominated by native grasses & chenopods.
S18	Road parcel	Millmerran Inglewood Road: Nicol Creek	24/8/2022	30	11.3.17	Remnant (disturbed)	Plain beside watercourse.	Brown clay.	363	<i>Eucalyptus populnea</i> , <i>Acacia harpophylla</i> woodland (disturbed); midlayer of <i>Geijera parviflora</i> ; ground layer dominated by introduced grasses & forbs.
S19	Road parcel	Millmerran Inglewood Road: Bringalily Creek	24/8/2022	60	11.3.18	Remnant	Plain beside watercourse.	Pale brown loam.	404	<i>Eucalyptus populnea</i> , <i>Callitris glaucophylla</i> woodland; midlayer of <i>Geijera parviflora</i> ; ground layer dominated by introduced grasses & forbs.
S20	10MH737	Southeast of Millmerran Inglewood Road	25/8/2022	60	11.9.5	Regrowth	Plain.	Brown clay.	330	<i>Acacia harpophylla</i> , <i>Casuarina cristata</i> woodland (with scattered <i>Melaleuca lanceolata</i>); midlayer composed of <i>Geijera parviflora</i> & <i>Lycium ferocissimum</i> ; ground layer dominated by native grasses & chenopods.

Appendix C. Location of Brigalow Woodland Snails detected during the
survey.

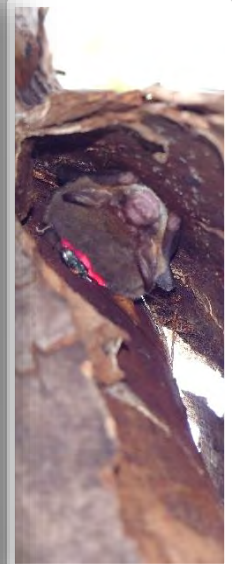
Appendix C: Location of Brigalow Woodland Snails detected during the survey



MICROBAT SURVEYS AND RESEARCH

INLAND RAIL: N2N AND B2G

Prepared for
ARTC



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Project Title: Microbat surveys and research – N2N, B2G

Project Author/s: Dr Elizabeth Williams

Project Summary: Targeted microbat surveys and tracking research were undertaken in the Inland Rail N2N and B2G project segments, to extend on previous surveys and determine foraging and roosting habitat requirements for threatened species management and mitigation.

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Date:

Director

EXECUTIVE SUMMARY

BACKGROUND

Targeted microbat surveys and tracking research was undertaken for two threatened microbat species in large, forested areas of the B2G and N2N segments of the Inland Rail project. The target species included South-eastern Long-eared Bat *Nyctophilus corbeni* and Large-eared Pied Bat *Chalinolobus dwyeri*, both of which are listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Queensland *Nature Conservation Act 1992* and New South Wales *Biodiversity Conservation Act 2016*.

Whilst general microbat surveys have been undertaken in both study areas, these targeted surveys were conducted to extend on previous data to examine distribution of the target species. Tracking research was also undertaken to reveal local foraging and roosting requirements of the species, particularly in relation to the management and mitigation of impacts from the Inland Rail project.

METHODOLOGY

Field surveys were undertaken in the non-breeding season for both of the target species (February-March 2023 in the N2N study area and March-April 2023 in the B2G study area), and included harp trapping, bat call identification, GPS- and radio-tracking, and habitat assessments.

At the N2N study area, 24 *N. corbeni* were captured in harp traps, with four tagged with GPS tags (for foraging and roosting information) and a further nine tagged with radio tags (roosting only). Six unique roost trees were detected through tracking, including one in the N2N alignment. Further roosting and foraging areas were identified from GPS data both within and outside the impact footprint.

In the B2G study area, including the Canning Creek offset property, 10 *N. corbeni* were captured in harp traps. Three of these were used for GPS-tracking, with a further six individuals tagged with radio tags only. Tracking located eleven unique roost trees, with further roosting and foraging areas recorded through GPS data.

FINDINGS

Nyctophilus corbeni - Roosts

Nyctophilus corbeni were recorded roosting in a range of tree species, of various sizes (including saplings), although almost entirely in dead or dying trees. During the non-breeding season that this study was undertaken (February-April), roosts were primarily under bark. In contrast, studies undertaken during the breeding season (October-December) have found that tree trunk hollows and fissures are important roosting habitat, likely due to temperature stability. Hollows are also likely to be preferred during hibernation months (May-August). As such, standing trees with loose bark and/or trunk hollows are important roosting structures for *N. corbeni* to provide year-round roost habitat.

Several tracked individuals returned to the same areas, if not the same trees, on consecutive days to roost. This indicates that *N. corbeni* may have preferred roosting areas and likely has a memory for numerous roost trees within these preferred areas.

Nyctophilus corbeni – Foraging

GPS tracking revealed that *N. corbeni* foraged in areas up to 3,805 hectares per night per individual, within a linear span (nightly foraging diameter) up to 13 km. However, other studies have found this nightly foraging distance can be as great as 25 km.

Foraging was often targeted to areas with diverse vegetation structure (e.g., containing dense midstorey and/or understorey cover) and with diverse flora species, likely due to increased prey invertebrates in such areas.

Tracked bats were recorded foraging and/or moving in the landscape in the same areas frequented on preceding nights, including the Canning Creek offset property. Whilst this suggests that *N. corbeni* return to known foraging areas repeatedly, tracking was undertaken only for a short duration at each study area, whereas this pattern may change seasonally as food resources vary within the landscape.

N2N Study Area

Considering the vegetation composition of the impact alignment, the diversity of roost trees (species and size) used by *N. corbeni* during this study, the widespread distribution of *N. corbeni* in the Pilliga forests, and the large nightly foraging range of the species, it is likely that the majority of the N2N impact footprint is suitable roosting and/or foraging habitat for *N. corbeni*.

No *C. dwyeri* were trapped in the N2N study area, although calls of the species were detected at one location on one night in the west of the Pilliga forests, near where there are historical records of the species. As there is no suitable roosting habitat in the vicinity of the N2N study area, it is unlikely the disturbance footprint in the Pilliga forests impacts important foraging habitat of the species.

B2G Study Area, including Canning Creek Offset Property

The vegetation along the alignment in the B2G study area is comprised of various tree species that were found to be suitable for roosting or foraging of *N. corbeni*. Additionally, tracking data revealed the species crossed cleared land to forage in small or large patches of regrowth and remnant vegetation. This indicates the majority of the B2G impact footprint is suitable roosting, foraging or dispersal habitat for *N. corbeni*, taking into account the foraging range of the species, and the movement within the landscape revealed by tracking data.

No tracked individuals were found to be roosting on the Canning Creek offset property, although multiple tagged *N. corbeni* foraged there on several nights.

The forested areas on the two property lots in the west of the Canning Creek property were frequented by GPS tracked *N. corbeni* on multiple nights, indicating suitable foraging habitat for this species. While the forested areas were not surveyed specifically during this study, it is considered that these property lots are currently likely unsuitable for roosting due to the tendency for the species to avoid roosting near forest edges. However, revegetation of the adjacent cleared areas could result in parts of these remnant areas being suitable for roosting, particularly as the ground-truthed vegetation confirmed that tree species are present that *N. corbeni* was found to roost in within the adjacent Bringalily State Forest.

The central area of the Canning Creek offset property (adjacent on both sides to Millmerran-Inglewood Road and the B2G alignment) was the focus for survey effort. Three *N. corbeni* were trapped in this area and GPS tracking data revealed that several individuals were found to use the area over multiple nights. While the advanced and young regrowth in this part of the offset property is suitable foraging habitat, at the time of surveys, there was a general absence of dead or dying trees with the bark or trunk hollow features preferred for roosting. However, the maturing trees in the advanced regrowth areas have the potential to become suitable roosting habitat if surrounding areas continue to regenerate (reducing the proximity to forest edge) and natural or artificial senescence occurs (to provide suitable microhabitat of hollows or peeling bark).

Several individuals were also found to cross Millmerran-Inglewood Road (between blocks of Bringalily State Forest and/or Canning Creek), indicating this single major road is not a barrier to their movement in the landscape. The cumulative effect of multiple linear clearings is unknown for *N. corbeni*, however such infrastructure can pose other impacts than as a movement barrier.

The eastern portion of the offset property was visited only once due to unmaintained roads and/or wet weather, with no tagged microbats located. The absence of tagged bats in this area is not unexpected, considering tracking was focused closer to the alignment. However, the more mature vegetation, including senescing trees with buckling/peeling bark and trunk hollows, indicated suitable roosting habitat was widespread in the area.

No *C. dwyeri* were detected by trapping or acoustic calls within the B2G study area, with their key requirement of proximal roosting habitat absent in the general area.

MANAGEMENT AND MITIGATION RECOMMENDATIONS

Disturbance Footprint

The major threats and potential impacts from the Inland Rail project in the study areas relate to roost tree loss for *N. corbeni* through clearing activities, and the loss of roost microhabitat features (i.e., bark) from unsuitable fire management. Other potential impacts include foraging habitat loss, as well as habitat fragmentation, vegetation composition modification, vehicle strike and loss of usable habitat or behavioural disruptions due to noise, vibration and/or light.

Measures to minimise or manage these impacts for the various construction and operational phases are provided. Due to the particularly significant potential impact relating to *N. corbeni* roost loss, and the species' usage of a wide range of tree species and sizes, the removal of any native tree species should be reduced. Particular avoidance and/or care with dead or dying trees is also recommended, as these are preferred roosting habitat.

Mitigation of Residual Impacts

Direct loss of maternity and non-breeding tree roosts for *N. corbeni* is an impact with limited mitigation measures. Specifically, successful mitigation methods for *N. corbeni* roosts are unknown.

Standard artificial microbat roost boxes have been found to be unsuitable for *Nyctophilus* species. However, specially constructed roost boxes with increased chambers and ventilation have been found to be used more by non-threatened *Nyctophilus* species, and may be suitable for *N. corbeni*. Chainsaw cavities have also been found to mimic natural trunk cavities more than standard microbat roost boxes, and are currently being trialled for *N. corbeni* in NSW.

Artificial bark mimics have been successfully used overseas for threatened microbats that naturally roost under bark.

To mitigate the loss of both non-breeding (bark) roosts and breeding/hibernating (tree trunk hollow) roosts, it is recommended that a trial be undertaken using specially designed microbat boxes and artificial bark mimics. This could be conducted on the Canning Creek offset property, particularly since it is known to be used for foraging and dispersal of *N. corbeni* and currently has a lack of roosting microhabitat in certain parts of the property.

Offset Property Management

The primary recommendations for offset property management relate to the provision and/or retention of roosts for *N. corbeni*. In particular, this includes limiting the removal of standing dead or dying trees, suitable fire management to retain roost features (e.g. peeling/buckling

bark), and establishing suitable artificial roost structure (both breeding and non-breeding roosts) in areas with limited natural roosts.

Secondary land management activities are recommended that will further provide or retain foraging and/or roosting habitat for *N. corbeni* and *C. dwyeri*, as well as reducing risk of injury through entanglement on fences.

Microbat Surveys and Research

Inland Rail: N2N and B2G

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Table of Terms and Abbreviations

ALA	Atlas of Living Australia
ARTC	Australian Rail Track Corporation
B2G	Border to Gowrie project
BoM	Bureau of Meteorology (Commonwealth)
Cd	<i>Chalinolobus dwyeri</i> Large-eared Pied Bat
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DEWHA	Department of the Environment, Heritage, Water and the Arts (Commonwealth; superseded)
N2N	Narromine to Narrabri project
Nc	<i>Nyctophilus corbeni</i> South-eastern Long-eared Bat
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW Government)
PCT	Plant Community Type
Qld	Queensland
RE	Regional Ecosystem
TSSC	Threatened Species Scientific Committee

1.0 INTRODUCTION

1.1 OBJECTIVES

ARTC required specialist surveys and research to be undertaken for two threatened microbat species that occur in large, forested areas of the Border to Gowrie (B2G) and Narramine to Narrabri (N2N) segments of the Inland Rail project. The target species included South-eastern Long-eared Bat *Nyctophilus corbeni* and Large-eared Pied Bat *Chalinolobus dwyeri*, both of which are listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Queensland *Nature Conservation Act 1992* and New South Wales *Biodiversity Conservation Act 2016*.

The objectives of the surveys and research were to:

- Increase survey effort in suitable habitat of the B2G study area (including Canning Creek offset property) and N2N study area, to provide information on the species' presence and distribution within the study areas;
- Undertake tracking of the target species (if present/captured) to identify day roosting and foraging preferences in these localities;
- Evaluate the habitat along the Inland Rail alignment, based on the knowledge collected on distribution and habitat preferences; and
- Provide information on potential mitigation and management measures, for various ARTC documents, including the Species Management Plan and Construction Management Plan.

Whilst general microbat surveys have previously been undertaken in both study areas, this targeted survey will extend on previous data, include more concentrated effort of microbat surveys along the alignment and disturbance footprint, and include specialised tracking of captured target microbats to uncover new knowledge for threatened species management.

1.2 STUDY AREAS

1.2.1 N2N Study Area

The N2N study area (in New South Wales) includes the forested areas from south of Narrabri to north of Baradine, including Pilliga East, Euligal, Cumbil and Baradine State Forests (**Figure 1.1**). These forests are known to be a strong-hold for *N. corbeni*, with captures in the area higher than elsewhere in Australia (e.g., Turbill and Ellis, 2006). Additionally, records of *C. dwyeri* suggest a strong population of the species in Pilliga forests and surrounding National Parks, although typically away from the Inland Rail alignment.

1.2.2 B2G Study Area

The B2G study area (in Queensland) includes the forested areas north of Inglewood, primarily Bringalilly State Forest, but also encompassing Wondul Range National Park and Whetstone State Forest (**Figure 1.2**). *Nyctophilus corbeni* is known to occur throughout the study area and surrounding protected areas, whilst *C. dwyeri* is known to occur in the connected Western Creek State Forest to the north.

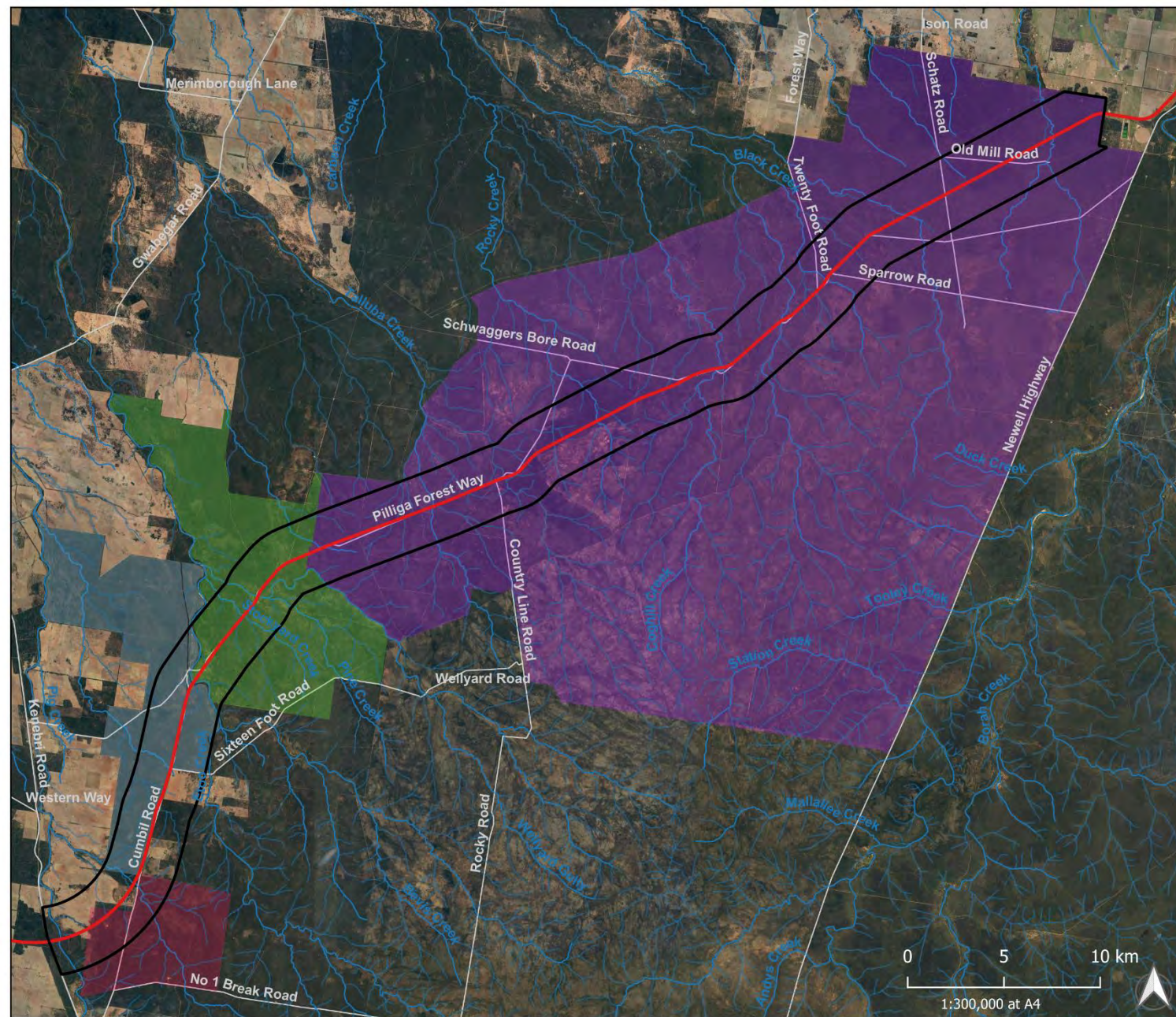


Figure: 1.1

Title: N2N study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 13/05/2023

LEGEND

— Watercourses

— Key roads

□ Target area

ARTC Data

■ N2N alignment

Protected Areas

■ Baradine State Forest

■ Cumbil State Forest

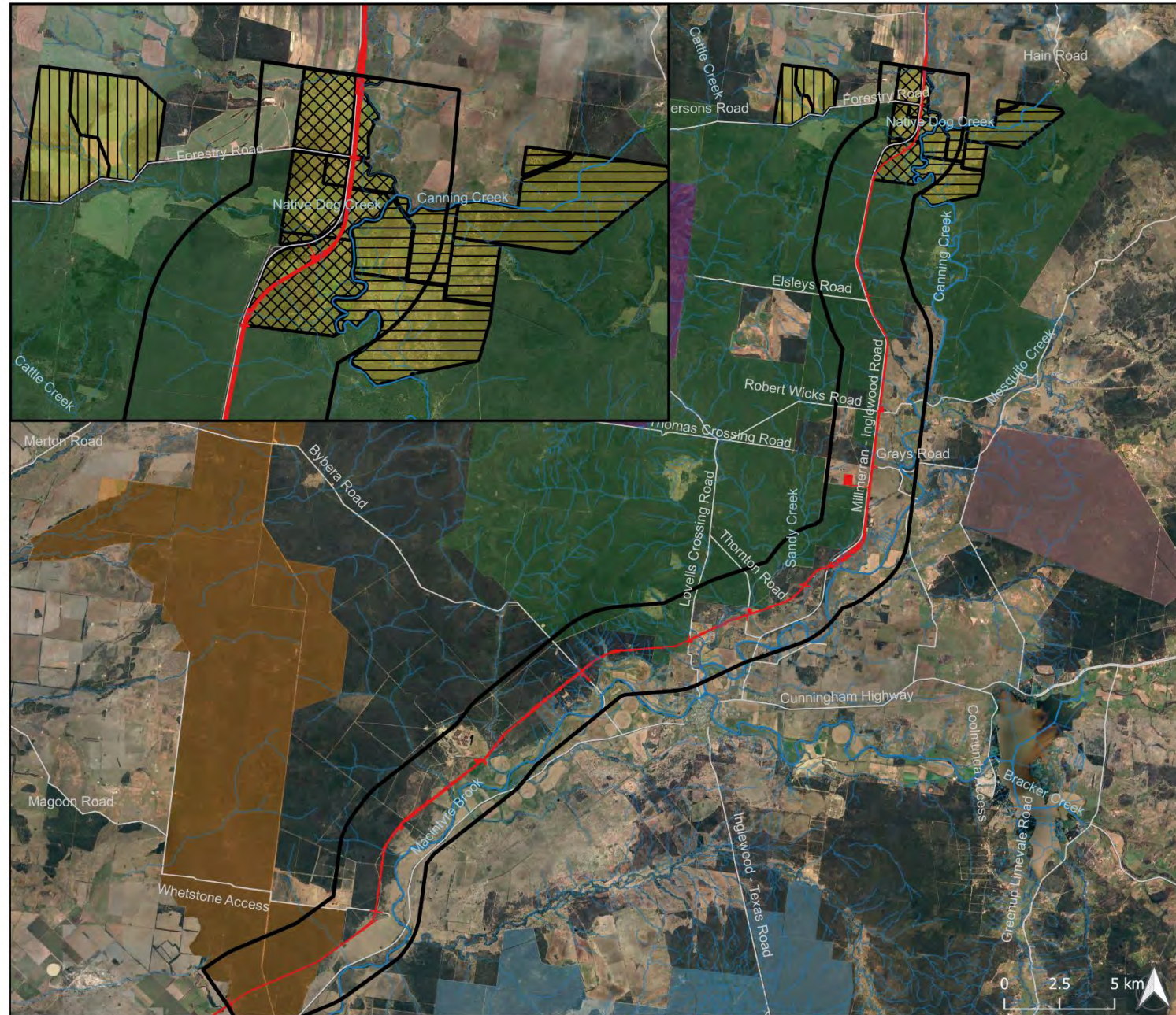
■ Euligal State Forest

■ Pilliga East State Forest

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Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56



Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: 1.2

Title: B2G study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 13/06/2023

LEGEND

— Watercourses

— Key roads

□ Target area

ARTC Data

■ Inland Rail footprint

■ Canning Creek property

▨ Canning Creek - central lots

▨ Canning Creek - eastern lots

▨ Canning Creek - western lots

Protected Areas

■ Bringalilly State Forest

■ Devine State Forest

■ Whetstone State Forest

■ Wondul Range National Park

■ Yelarbon State Forest

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2.0 ECOLOGY OF THREATENED SPECIES

2.1 LARGE-EARED PIED BAT *CHALINOLOBUS DWYERI*

2.1.1 *Distribution*

Chalinolobus dwyeri is patchily distributed from central Queensland to southern New South Wales, typically within 500 km of the coast (e.g., see DCCEEW, 2023a; DCCEEW, 2023b). Occurrence within this area is highly dependent on the habitat requirements of the species, particularly relating to suitable roosting structure.

N2N study area

The species is known to occur in the Pilliga IBRA sub-region, associated with the following vegetation formations and Plant Community Types (PCTs) in the N2N study area (as per NSW OEH, 2023a and state mapping NSW DPE, 2023):

- Pilliga Outwash Dry sclerophyll forests
 - PCT 88: Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion
- Western Slopes Dry Sclerophyll Forests
 - PCT 398: Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion
 - PCT 399: Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion
 - PCT 404: Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests
 - PCT 405: White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions

There are two ALA records of this species along the south-western part of the alignment in the N2N study area; one in Baradine State Forest in 2019 and the other in Cumbil State Forest in 2018.

B2G study area

State government species distribution mapping (Laidlaw and Butler, 2021) indicates potential *C. dwyeri* habitat exists in much of the State Forests that border the alignment in the Inglewood area, with high suitability habitat ~10 km to the north-west of the Canning Creek Offset Property.

There is one record of the species in ALA in Western Creek State Forest from 1997, which is within ~40 km of the B2G study area.

2.1.2 *Habitat*

Chalinolobus dwyeri requires a combination of suitable roosting and foraging habitat for continued occupancy (DCCEEW, 2023b).

Maternity roosts are typically in caves with a dome-shaped roof, with enough space for juveniles to learn to fly (DCCEEW, 2023b). Non-maternity roosts include cliffs, escarpments or rocky outcrops (typically sandstone or rhyolite; DCCEEW, 2023b), comprising not only caves, but also fissures and crevices in exposed rock (Williams and Thomson, 2018). The species has also been found roosting in abandoned Fairy Martin nests and abandoned mines (Schultz, 1998; Williams and Thomson, 2018).

Foraging habitat often includes fertile valleys and plains, along watercourses, upper slopes, crests and ridges (Williams and Thomson, 2018; DCCEEW, 2023b). Vegetation types in these areas include eucalypt woodland, dry and wet sclerophyll forest, grassy woodland, *Callitris* forest, subtropical rainforest, as well as small clearings and sandstone outcrop country adjacent to such areas (DCCEEW, 2023b). The species has also been observed foraging in open and fragmented pastoral landscapes near these vegetation types (Williams and Thomson, 2018).

2.1.3 Threats

Threats to *C. dwyeri* primarily relate to loss of suitable foraging and/or roosting habitat (DCCEEW, 2023b; NSW OEH, 2023a). In particular, this includes:

- Clearing and isolation of forest and woodland near cliffs, caves and abandoned mines;
- Unsuitable fire regimes (intensity, frequency, season and type), either from anthropogenic sources or wildfire;
- Loss of roosting habitat due to the construction of dams and other waterway management;
- Damage or disturbance to roosting and maternity sites from land operations (e.g., mining), recreational caving or pest animals such as goats; and
- Climate change and pesticide use impacts on invertebrate food sources (i.e., reduction in insects during drought conditions or in areas of high pesticide use).

2.1.4 Survey Guidelines

As per the *Survey Guidelines for Australia's Threatened Bats* (DEWHA, 2010), surveys for *C. dwyeri* are best undertaken between October and March. A combination of the following methods is recommended:

- Use of passive acoustic call recorders to identify the unique calls of *C. dwyeri*; these should be positioned in the vicinity of caves, mines, rocky outcrops and in foraging areas such as vegetation corridors, flyways, sandstone gorges, watercourses and water bodies. Active call recorders along transects can also be undertaken from dusk. The survey effort recommendation for acoustic recorders is a total of 16 passive detector nights for a minimum of 4 nights, and/or a total of 6 active detector hours over a minimum of 3 nights.
- Roost searches in suitable habitat, including in culverts, mines, caves, rock overhangs and crevices.
- Use of harp traps and/or mist nets to capture the species in forest flyways, near roosts, scarps, cliffs and riparian zones. The survey effort for harp traps and/or mist nets is 16 trap/net nights for a minimum of 4 nights.

2.2 SOUTH-EASTERN LONG-EARED BAT *NYCTOPHILUS CORBENI*

2.2.1 Distribution

Nyctophilus corbeni has a patchy distribution through southern central Queensland, central western New South Wales, north-western Victoria and eastern South Australia, typically inland of the Great Dividing Range (TSSC, 2015).

N2N study area

The species is known to occur in the Pilliga IBRA sub-region, associated with the following vegetation formations and PCTs in the study area (as per NSW OEH, 2023b and state mapping NSW DPE, 2023):

- Pilliga Outwash Dry Sclerophyll Forests
 - PCT 88: Pilliga Box - White Cypress Pine - Buloke shrubby woodland in the Brigalow Belt South Bioregion
- Inland Rocky Hill Semi-arid Woodlands
 - PCT 256: Green Mallee tall mallee woodland on rises in the Pilliga - Goonoo regions, southern Brigalow Belt South Bioregion
- Western Slopes Dry Sclerophyll Forests
 - PCT 398: Narrow-leaved Ironbark - White Cypress Pine - Buloke tall open forest on lower slopes and flats in the Pilliga Scrub and surrounding forests in the central north Brigalow Belt South Bioregion
 - PCT 399: Red gum - Rough-barked Apple +/- tea tree sandy creek woodland (wetland) in the Pilliga - Goonoo sandstone forests, Brigalow Belt South Bioregion
 - PCT 404: Red Ironbark - White Bloodwood +/- Burrows Wattle heathy woodland on sandy soil in the Pilliga forests
 - PCT 405: White Bloodwood - Red Ironbark - Black Cypress Pine shrubby sandstone woodland of the Pilliga Scrub and surrounding regions

There are numerous ALA records of this species along the alignment in the N2N study area, particularly in Cumbil State Forest, Euligal State Forest and Pilliga East State Forest. The forests in the Pilliga area are known as a stronghold for the species.

B2G study area

State government species distribution mapping (Laidlaw and Butler, 2021) indicates the entire B2G study area is potential habitat for the species, with the majority of the area having high potential for suitable habitat.

There are four records in ALA within 10 km of the alignment in Bringalily State Forest, and two records from previous ARTC surveys in the area.

2.2.2 Habitat

Nyctophilus corbeni is found in a wide variety of woodland and forest types, including those dominated by box, ironbark, native cypress pine, Buloke (*Allocasuarina luehmannii*), Brigalow (*Acacia harpophylla*), Belah (*Casuarina cristata*), smooth-barked apple (*Angophora costata*), river red gum (*Eucalyptus camaldulensis*) and various types of tree mallee (TSSC, 2015). It is typically found in large areas of forest (TSSC, 2015) that includes high tree stem density, especially those containing dead trees, as these provide key roosting habitat (Law et al., 2016). Specifically, the species roosts in tree hollows, crevices and under loose bark.

The species feeds on invertebrates by taking prey in flight, by gleaning them off foliage or foraging on the ground (TSSC, 2015).

2.2.3 Threats

Habitat loss and fragmentation are the predominant threats facing *N. corbeni*, particularly in relation to the reduction or fragmentation of the large, forested areas it requires (TSSC, 2015). The loss of suitable roosting habitat (tree hollows, loose bark) from clearing and fire is another major threat (SPRAT; NSW OEH, 2023b). Considering the variable height that the species forages, vehicle/train strike is another potential threat.

The loss of invertebrate food sources through pesticide use in or adjacent to foraging habitat, climate change (e.g. drought) and inappropriate fire regimes are further threats to the species. (NSW OEH, 2023b)

2.2.4 Survey Guidelines

As per the *Survey Guidelines for Australia's Threatened Bats* (DEWHA, 2010), surveys for *N. corbeni* are best conducted between October to April on warmer nights.

Passive acoustic call recorders can be used to identify areas where long-eared bats occur; however, *N. corbeni* cannot be distinguished from other long-eared bats by call alone. Hence, there are no survey recommendations of survey effort relating to call recorders for *N. corbeni*.

Mist nets and/or harp traps should be placed in flyways, dense vegetation and/or near water bodies and water courses for a total effort of 20 harp trap nights per project area <50 ha, for a minimum of 5 nights.

3.0 METHODOLOGY

3.1 FIELD SURVEY TIMING

Field surveys and research were undertaken between the following dates:

- N2N study area: 24 February – 10 March, 2023; and
- B2G study area: 16 March – 6 April, 2023.

During the N2N field survey, days were generally warm-hot (32.1-38.3°C daily maximum; Narrabri Airport AWS, BoM, 2023) with overnight temperatures variable (13.5-23.5°C daily minimum). Less than 2 mm of rain fell in the area on 27 and 28 February, which caused an increase in humidity in the following days.

Weather was more variable during the B2G field survey, with daily maximum between 22.9-37.0°C (Texas Post Office, BoM, 2023) and overnight temperatures dropping to 9.8-20.4°C. Storms and rain occurred in the area on 24-26 March (29.2 mm; Woodspring, BoM, 2023) and 29-30 March (60 mm), although it was highly patchy in the general area. This wet weather caused vehicle access issues to the Canning Creek offset property, which is only accessible through areas of Brigalow black soil.

3.2 HARP TRAPPING

Harp trapping was primarily undertaken to capture the target species; thus, traps were located in areas and habitats suitable for either *C. dwyeri* or *N. corbeni*. However, the species and number of all microbats collected during trapping were recorded, to provide further knowledge on the species that occur in the study areas.

Following capture overnight, microbats were either released prior to dawn or kept in canvas bags until release early the following evening.

N2N Study Area

Harp traps were located in eight locations in Pilliga East State Forest, Euligal State Forest and in Coolangla Creek between Cumbil and Baradine State Forests (**Figure 3.1**). Trapping was undertaken between 25 February – 5 March, 2023. A total of 56 trapping nights were undertaken, with harp traps in the same location for a maximum of 4 nights as per animal ethics requirements. This is greater than the minimum recommendation of 16 trapping nights per standard study area for both target microbat species, and greater than the N2N EIS surveys of 16 trapping nights total.

B2G Study Area

Harp traps were positioned in 15 locations in Bringalily State Forest and 10 locations in the south-west of the Canning Creek offset property between 17 March – 3 April, 2023 (**Figure 3.2**). A total of 95 traps nights were undertaken; in particular, this included 5 nights on the Canning Creek offset property and 9 nights in Bringalily State Forest. While further trapping was planned for the Canning Creek offset property, wet weather from the middle of the field survey period made access difficult and unsafe. These access issues also meant that some traps on the Canning Creek offset property were not opened on one night (see **Appendix 1** for details).

This trapping effort is greater than the minimum recommendation of 16 trapping nights per standard study area for both target microbat species.

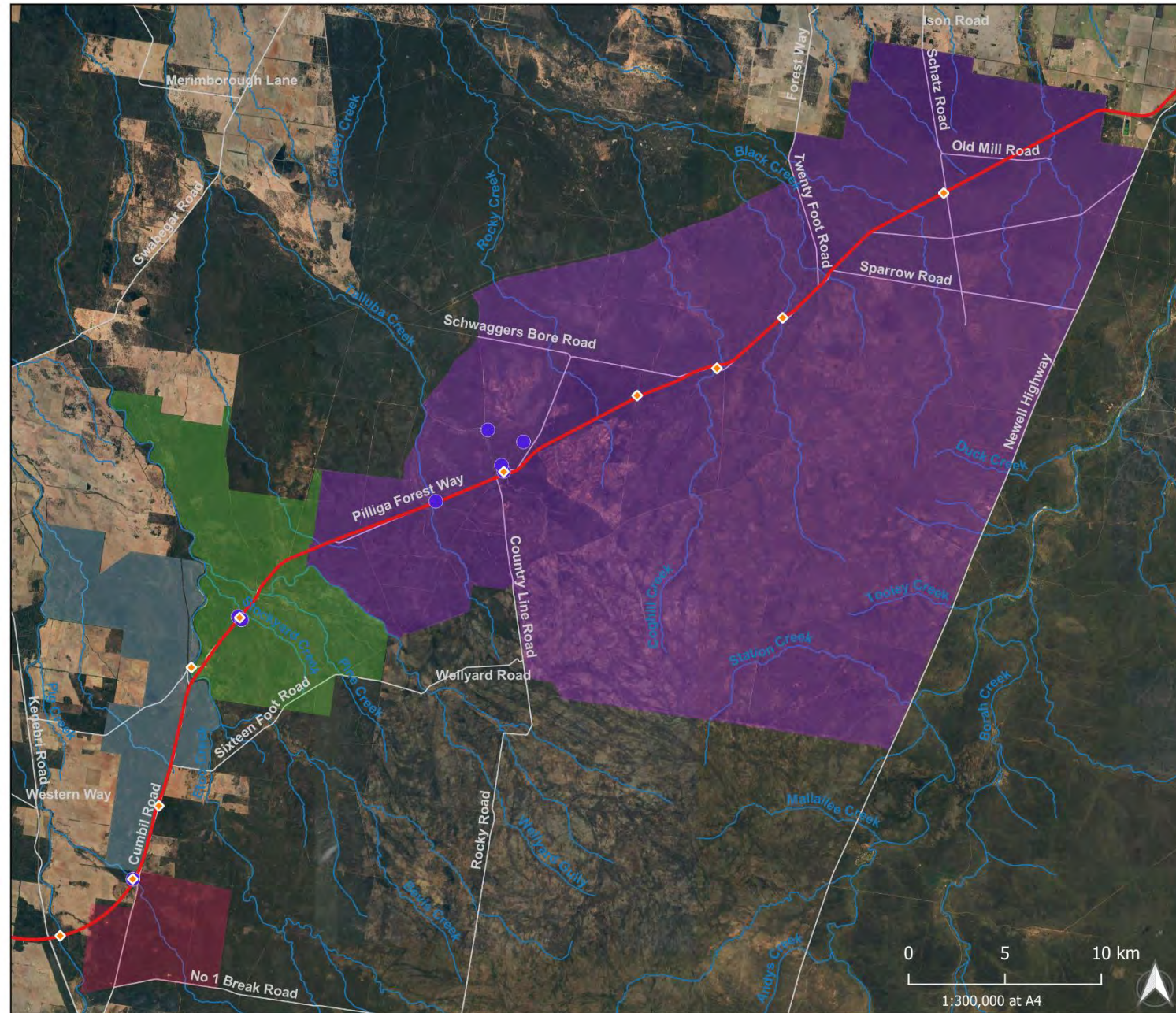


Figure: 3.1

Title: Harp trap and acoustic recorder locations in the N2N study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 10/05/2023

LEGEND

- Watercourses
- Key roads

Survey Methods

- ◆ Acoustic recorder
- Harp trap

ARTC Data

- N2N alignment

Protected Areas

- Baradine State Forest
- Cumbil State Forest
- Euligal State Forest
- Pilliga East State Forest

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Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

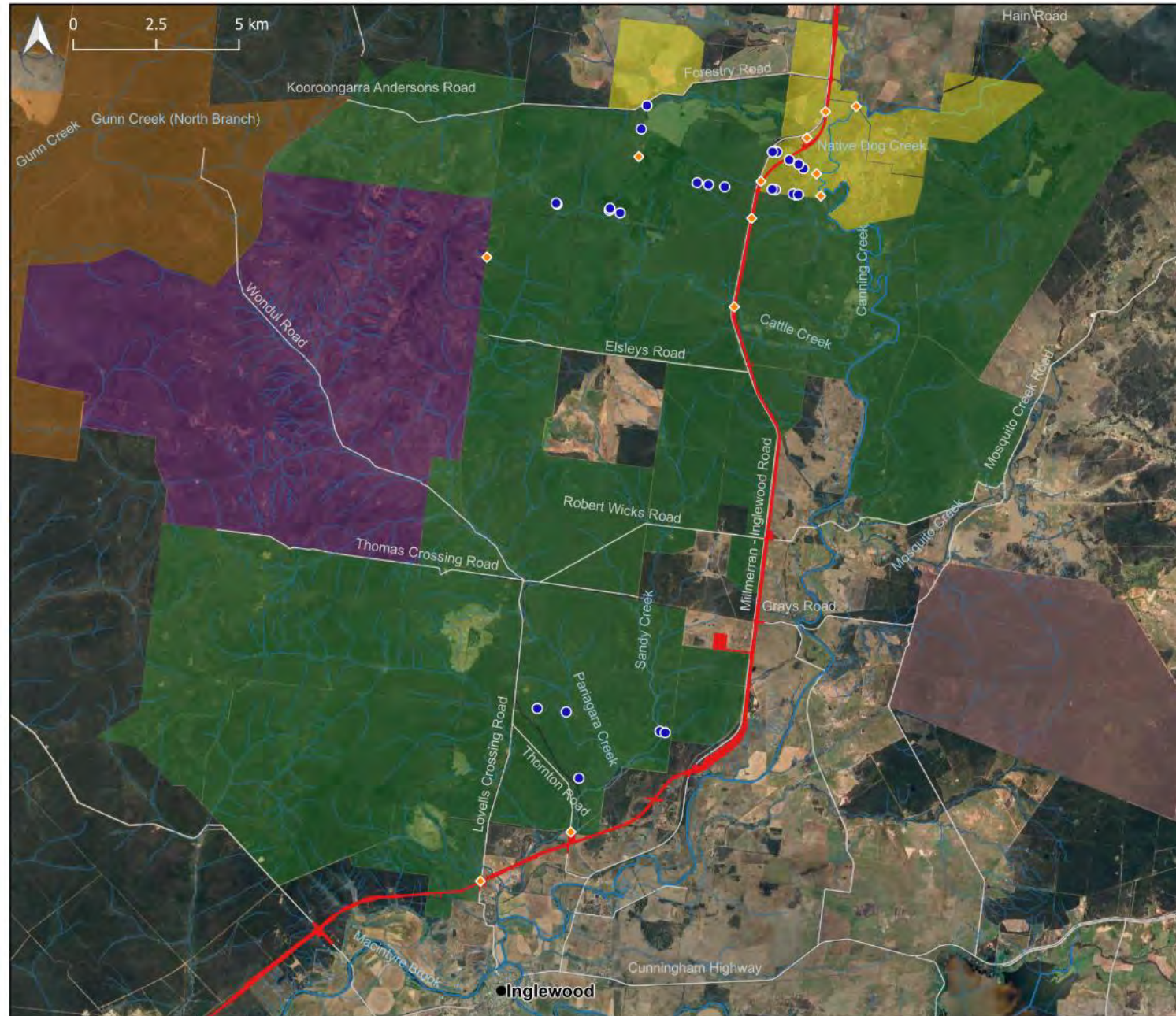


Figure: 3.2

Title: Harp trap and acoustic recorder locations in the B2G study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 18/04/2023

LEGEND

- Watercourses
- Key roads

Survey Methods

- ◆ Acoustic recorder
- Harp trap

ARTC Data

- Inland Rail footprint
- Canning Creek property

Protected Areas

- Bringally State Forest
- Devine State Forest
- Whetstone State Forest
- Wondul Range National Park
- Yelarbon State Forest

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Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

3.3 ACOUSTIC CALL ANALYSIS

Microbat calls were collected with AudioMoth recorders positioned for between 2-6 nights per location, depending on weather and other logistical constraints.

Data was analysed with Wildlife Acoustics Kaleidoscope software, with calls requiring a minimum of 3 pulses for identification. Due to the diversity of microbat calls for each species (i.e., social, search, feeding calls, etc.), only search phase calls were used for identification, as these are the most reliable.

As mentioned previously, *N. corbeni* cannot be identified by call analysis alone, and is therefore grouped with the other *Nyctophilus* species (long-eared bats) in call analysis. Several other microbat species have also been grouped together due similarity in call structure.

N2N Study Area

Acoustic recorders were located at 10 positions within 500 m of the alignment in locations anticipated to capture frequent microbat calls (see **Figure 3.1** above). All recorders were positioned for between 3-4 full nights at each location, with a total of 31 nights in total. This is greater than the minimum recommendation of 16 nights of passive call recording per standard study area for *C. dwyeri*.

B2G Study Area

Seven acoustic recorders were positioned on the Canning Creek offset property, with a further six acoustic recorders either located on the B2G alignment in the study area, or in Bringalily State Forest in areas where *C. dwyeri* may frequent, should it be present (see **Figure 3.2**). All recorders were positioned for between 2-6 full nights at each location, with a total of 50 nights in total (24 of which were on Canning Creek). This is greater than the minimum recommendation of 16 nights of passive call recording per standard study area for *C. dwyeri*.

3.4 RADIO- AND GPS-TRACKING

Radio- and GPS-tracking involves attaching small devices ('tags') to the back of captured individual microbats (**Photos 3.1** and **3.2**). Tagged microbats are then released, with follow-up involvement and the data collected depending on the type of tag used. Attached tags are either removed by the microbat (either tag type), left attached for natural detachment as the fur grows (radio tags), or require recapture to remove tags manually (GPS tags).

To ensure microbats are not encumbered by attached tags, our animal ethics permits stipulate that tags must not be more than 8% of the individual microbat's bodyweight. Due to the small weight of radio tags (Holohil LB-2X, 0.31 g), these were able to be used on any target microbat species. However, the larger GPS tags (Lotex Pinpoint 10 + Holohil LB-2X; 1.31 g) could only be used on female *N. corbeni* above 16.5 g bodyweight (note: *N. corbeni* show sexual dimorphism with females typically larger than males).

Tracking was primarily undertaken to collect information on:

- Roosting habitat (radio and GPS tags); and
- Foraging range and habitat (GPS tags only).

Tagged microbats (both radio and GPS tags) were attempted to be located during the day with tracking antennae and receivers to determine their diurnal roosting habitat. When a tagged microbat was located, variables recorded included:

1. Roost parameters

- Tree species, height, DBH, alive/dead/health status
- Roost height, cardinal direction, roost type and description (hollow, peeling bark, fissure)
- Photos of tree and roost (if visible)
- GPS coordinates taken.

2. Habitat parameters (25 x 25 m plot)

- Dominant vegetation species and density in upper, mid and ground layers
- Alive/dead status of all tree species
- Photos of each cardinal direction of the general habitat in the area
- Photo of tree cover directly above the roost tree.

GPS tags were programmed to collect a GPS point during night hours either every 30 minutes (fine-scale foraging; battery life 2-4 days) or every 2 hours (longer-term foraging data; 8-10 days). GPS tags were required to be retrieved to download the GPS data that is stored onboard. Note, there are no GPS tags currently small enough to allow for remote data download. GPS tags were therefore prioritised for retrieval following the estimated battery expiration, with GPS tags either removed from microbats or found on the ground having been shed/removed by the individual microbat.



Photo 3.1 South-eastern Long-eared Bat *Nyctophilus corbeni* with a radio tag attached



Photo 3.2 South-eastern Long-eared Bat *Nyctophilus corbeni* with GPS tag attached

3.5 HABITAT ASSESSMENT

Habitat assessments of the disturbance footprint within the N2N and B2G study areas were undertaken at the end of each field survey. This timing was to ensure that the knowledge on roosting and/or foraging habitat acquired during the field trip could be used to accurately evaluate the habitat values present.

The areas evaluated were inspected for potential roosting habitats similar to what was observed during tracking studies, as well as what has been published in scientific literature for the species. The diversity of vegetation, as well as vegetation structure, was also considered during assessment as a measure of foraging habitat quality.

Landscape attributes (specifically, distance to watercourses and forest edges) were also incorporated in habitat assessment following tracking data collection.

Consequently, assessment points (incorporating a 50 x 50 m representative plot) of the roosting and/or foraging habitat suitability for both threatened microbat species was undertaken:

- primarily:
 - along each alignment within the respective study area and the Canning Creek property, where access was possible,
 - at areas determined from satellite imagery, topographical/geological analysis or local knowledge, as potential habitat for cave-roosting *C. dwyeri*.
- secondarily:
 - where roosts were detected within the study areas,
 - at deployment locations of harp traps or acoustic recorders, or
 - during roost searches and meanders within the study area.

In areas where access was not possible (due to land access, vegetation density, weather/soil conditions), habitat assessment was undertaken by evaluating available mapping. Specifically, State mapping of regional ecosystems ('RE', Queensland) or plant community types ('PCT', NSW), or ground-truthed mapping (Canning Creek), were used to identify which areas had tree species considered to be suitable for roosting and/or foraging based on the findings from this study.

4.0 FINDINGS

4.1 MICROBAT COMMUNITY

4.1.1 Harp Trapping

N2N Study Area

Overall, 1,927 microbats from 12 species were captured over 56 harp trap nights (7 traps over 8 nights total). Of these trapped microbats, 24 *N. corbeni* were captured and no *C. dwyeri* were captured. Capture locations are depicted in **Figure 4.1**.

Of note, over 1,500 microbats were captured over a 3-night period following showers on preceding days; it is assumed the high humidity and temperature increased food resources and, consequently, microbat foraging activity, over these nights.

A full list of species and numbers captured at each location is provided in **Appendix 1**, with a summary of the species provided in **Table 4.1**.

B2G Study Area

In total, 347 microbats from 11 species were captured over 14 nights of trapping (total of 95 trap nights). Three *N. corbeni* were captured during the 5 days of trapping on the Canning Creek offset property, and a further 7 *N. corbeni* were trapped in Bringalily State Forest immediately adjacent to Canning Creek (**Figure 4.2**). No *C. dwyeri* were trapped in the B2G study area.

4.1.2 Acoustic survey

Acoustic surveys detected five additional microbat species that were not captured in harp traps (**Table 4.1**), including three likely calls of *C. dwyeri*. This species was recorded in a creek on one night in the western N2N study area, in the vicinity of previous ALA records. No other calls of *C. dwyeri* were found elsewhere in the N2N study area or on subsequent nights, or from the B2G study area and Canning Creek offset property.

Table 4.1 Microbat species recorded during harp trapping (H) and acoustic surveys (A) at the N2N and B2G study areas. Threatened (target) species are highlighted in pale green; species in blue text are unconfirmed detections from acoustic calls that could be multiple species.

Family	Species	Common Name	N2N	B2G	
				Bringalily SF	Canning Creek
Emballonuridae (Sheath-tailed Bats)	<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tailed Bat	H, A	A	A
Molossidae (Free-tailed Bats)	<i>Austronomus australis</i>	White-striped Free-tailed Bat	A	A	A
	<i>Ozimops lumsdenae</i>	Northern Free-tailed Bat	A	A	A
	<i>Ozimops planiceps</i>	Southern Free-tailed Bat	H, A ¹	-	-
	<i>Ozimops ridei</i>	Eastern Free-tailed Bat	A ¹	H, A ¹	-
	<i>Ozimops petersi</i>	Inland Free-tailed Bat	A ¹	A ¹	-
Vespertilionidae (Vesper Bats)	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	A	-	-
	<i>Chalinolobus gouldi</i>	Gould's Wattled Bat	H, A	H, A	H, A
	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	H, A	H, A	A
	<i>Chalinolobus nigrogriseus</i>	Hoary Wattled Bat	-	A	A
	<i>Chalinolobus picatus</i>	Little Pied Bat	H, A	H, A	H, A
	<i>Nyctophilus corbeni</i>	South-eastern Long-eared Bat	H(24), A ²	H(7), A ²	H(3), A ²
	<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	H, A ²	H, A ²	H, A ²
	<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat	H, A ²	H, A ²	A ²
	<i>Scotorepens balstoni</i>	Inland Broad-nosed Bat	H, A	H, A	H, A
	<i>Scotorepens greyii</i>	Little Broad-nosed Bat	H, A ³	H, A ³	H, A
	<i>Scotorepens</i> sp. (Parnaby)	Central-eastern Broad-nosed Bat	H, A ³	H, A ³	H, A
	<i>Vespadelus regulus</i>	Southern Forest Bat	-	A ⁴	A ⁴
	<i>Vespadelus troughtoni</i>	Eastern Cave Bat	A	A	A
	<i>Vespadelus vulturnus</i>	Little Forest Bat	H, A	H, A ⁴	H, A ⁴

A¹ = species that have similar call spectrograms and cannot be distinguished from acoustic calls alone. Species with the same superscript number are grouped together.

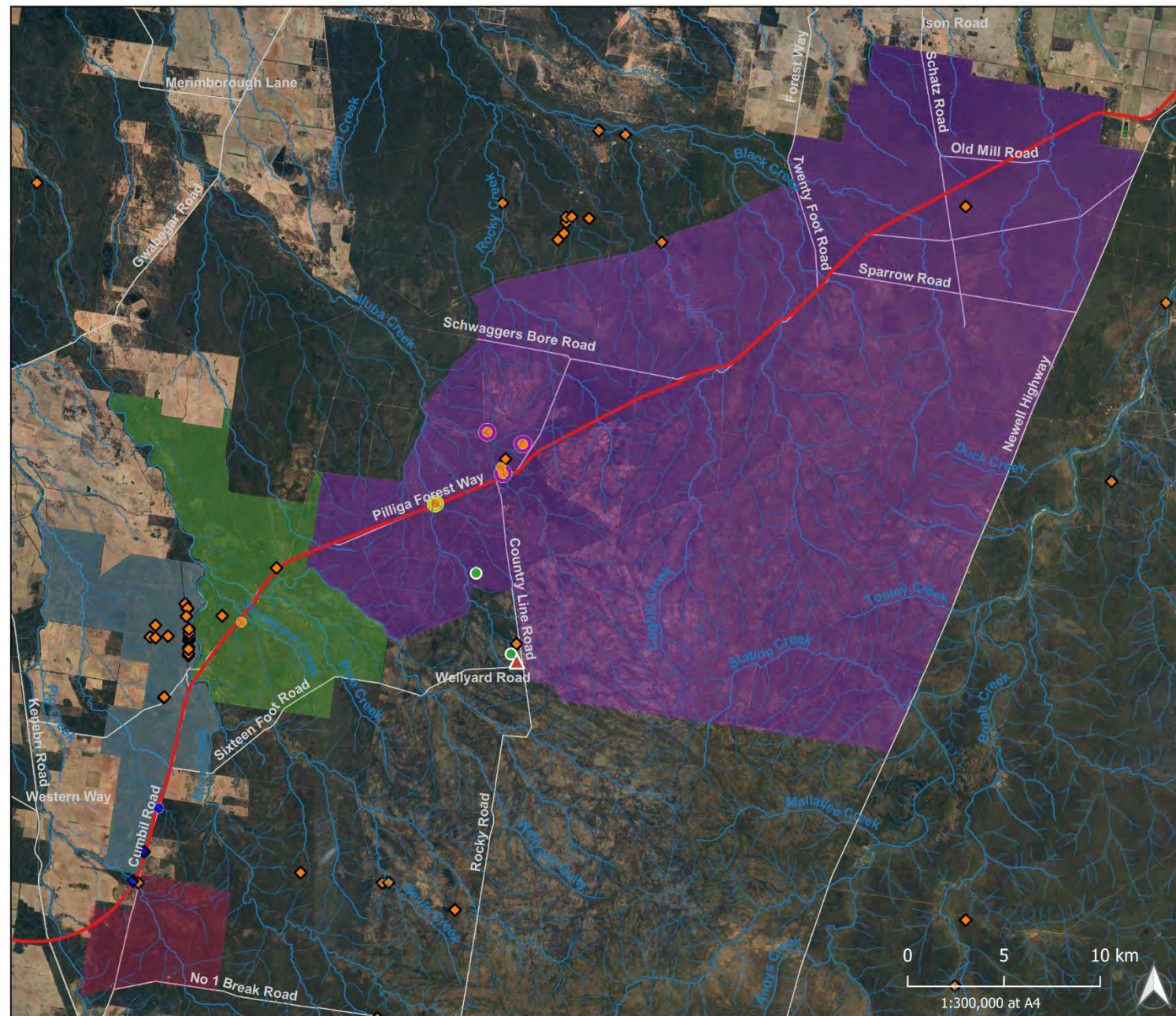


Figure: 4.1

Title: Threatened species in N2N study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 06/06/2023

LEGEND

- Nyctophilus corbeni captures
- ◆ ALA Nyctophilus corbeni
- Chalinolobus dwyeri call
- ◆ ALA Chalinolobus dwyeri
- ▲ Caves
- Watercourses
- Key roads
- Other MNES threatened species**
- White-throated Needletail
- Other MSES threatened species**
- Little Pied Bat
- Yellow-bellied Sheath-tailed Bat

ARTC Data

■ N2N alignment

Protected Areas

■ Baradine State Forest

■ Cumby State Forest

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Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

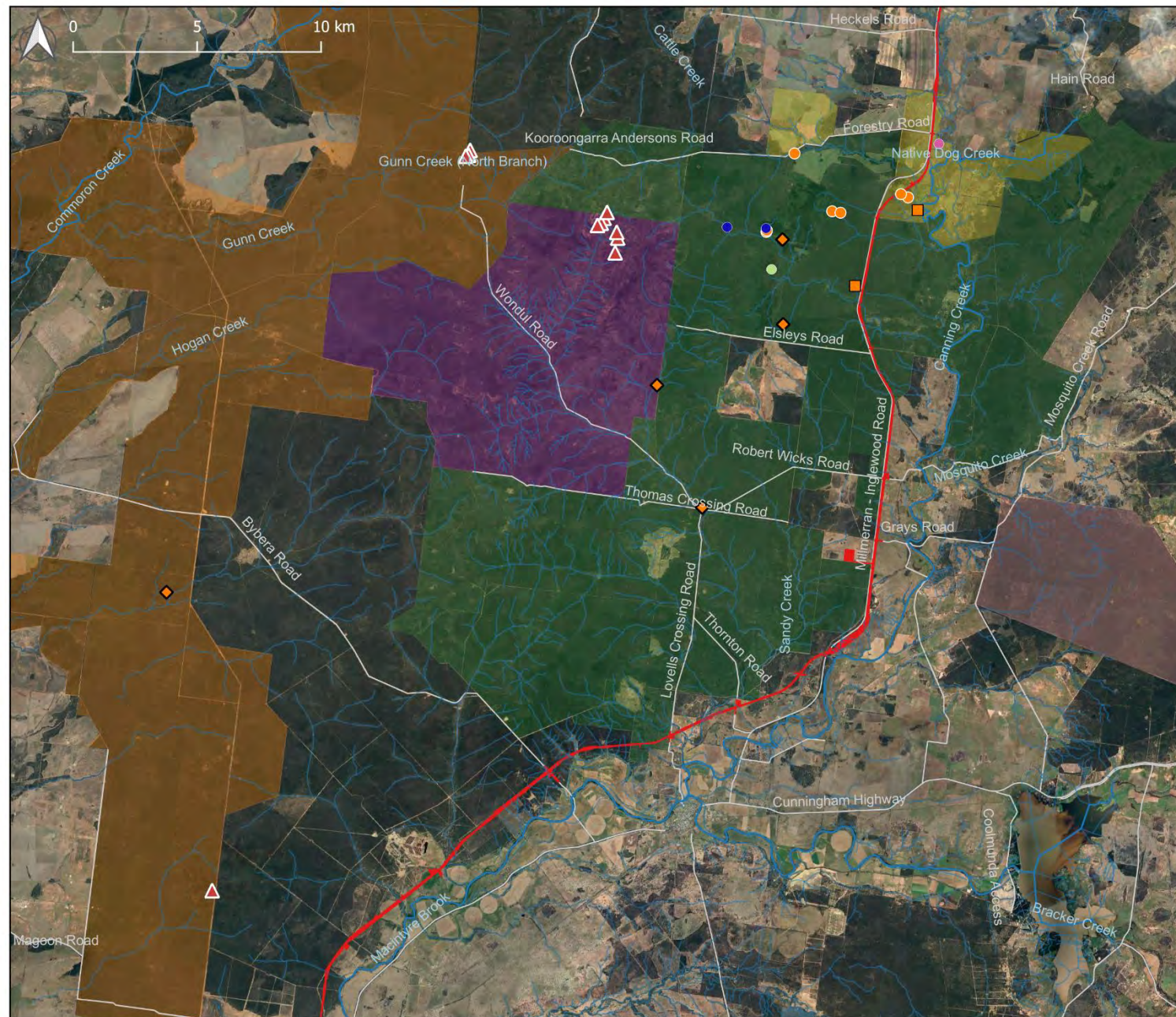


Figure: 4.2

Title: Threatened species in B2G study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 14/06/2023

LEGEND

● Nyctophilus corbeni captures

◆ ALA Nyctophilus corbeni

▲ Caves

— Watercourses

— Key roads

Other MNES threatened species

● Glossy Black-cockatoo

● Squatter Pigeon

Other MSES threatened species

● Powerful Owl

ARTC Data

■ ARTC Nyctophilus corbeni

■ Inland Rail footprint

■ Canning Creek property

Protected Areas

■ Bringallily State Forest

■ Whetstone State Forest

■ Wondul Range National Park

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Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

4.2 LARGE-EARED PIED BAT *CHALINOLOBUS DWYERI*

4.2.1 Roosting habitat

No suitable roosting habitat for *C. dwyeri* was found within 5 km of either the N2N or B2G study area alignments. Whilst there is no precise information on the distance that this species will fly from roosting habitat, its morphology (i.e., short, broad wings) and the limited information available on home ranges suggests the species is likely to predominantly exist within a few kilometres of roosting habitat (DCCEEW, 2023b). However, this estimate should not be relied upon for management purposes (DCCEEW, 2023b).

No suitable breeding roost locations (larger caves with dome rooves or indentations) were located at either study area.

N2N Study Area

The closest located rock overhangs or caverns to the N2N alignment were the Salt Caves, approximately 9.2 km south of the alignment on Country Line Road (see **Figure 4.1** above). This rocky area and shallow caverns were likely suitable for occasional, non-breeding roosting only, and are unlikely to contribute to significant roosting habitat for the species.

B2G Study Area

Small rocky escarps, rock overhangs and caverns up to 12 m deep were found in Wondul Range National Park, approximately 9.9 km west of the alignment and 10.2 km west of the Canning Creek offset property (**Photos 4.1 and 4.2; Figure 4.2**). Inspection of a number of these caverns found occasional microbat faeces (**Photo 4.3**) and moth wings (food remnants), with an unidentified grey microbat also disrupted from one cavern.

In general, the rocky areas that were visited were of marginal *C. dwyeri* roosting habitat, due to the low escarpments (typically 2-3 m high) and shallow nature of most of the caverns. Additionally, these roosts were generally infrequently clustered and isolated in the landscape. The evidence of occasional microbat habitation in these caverns is more likely to be of another, non-threatened, cave-dwelling species.

Additionally, Queensland National Parks and Wildlife Service and Queensland Forestry staff commented that caves and rock overhangs also exist in Whetstone State Forest, approximately 5.9 km north-west of the alignment (**Figure 4.2**); however, these were not visited due to time constraints.



Photo 4.1 Example of the caverns inspected in Wondul Range National Park



Photo 4.2 Example of the inside of caverns inspected in Wondul Range National Park



Photo 4.3 Microbat faeces were detected in several of the caverns examined

4.2.2 Foraging habitat

The vegetation and general landscape (containing riparian and fertile valleys/plains) of both the N2N and B2G study areas would be suitable foraging habitat for *C. dwyeri*. However, a key requirement for this species is proximity to roost habitat, which, as described above, is lacking to both study areas. The detection of infrequent *C. dwyeri* calls in the west of the N2N study area indicates very occasional use of the area, while there is very limited evidence that the species exists in the vicinity of the B2G study area.

While occasional foraging of *C. dwyeri* may occur at the N2N study area, when individuals travel from the surrounding area where caves/escarpments and records of the species have been confirmed, it is unlikely that the disturbance footprint is an important foraging area.

4.3 SOUTH-EASTERN LONG-EARED BAT *NYCTOPHILUS CORBENI*

At N2N, of the 24 captured *N. corbeni*, four were tagged with GPS tags (three of which were retrieved), and a further nine with radio tags only. Of the ten *N. corbeni* trapped at B2G, three were tagged with GPS tags (all retrieved; one damaged without data) and a further six with radio tags. GPS data tracks are provided in Appendix 3. Note, GPS tags require retrieval from the tagged microbat to download the data.

In terms of landscape attributes, foraging points were generally within 1.1 km of moderate waterways (those with permanent water pools, e.g., Canning Creek) and 300 m of minor watercourses and drains (**Table 4.2**). Similar distances were observed with roosts. While concentrated foraging areas were recorded up to the edge of forested areas, roosts were only observed in remnant forest interiors. Dispersal data and potential individual foraging points were recorded throughout the landscape, including in cleared areas, up to 5.1 km from contiguous forest (see Appendix 3).

Table 4.2 Distance to landscape attributes for foraging and roosting data. Note, for N2N, there were five foraging clusters and ten roost points; for B2G, there was three foraging clusters and nine roost points.

Data type	N2N			B2G		
	Mean	Min	Max	Mean	Min	Max
Foraging cluster						
Distance to watercourse	1,047 m	85 m	1,805 m	1,115 m	701 m	1,495 m
Distance to minor watercourse	245 m	30 m	760 m	296 m	0 m	652 m
Distance to forest edge	>10 km	-	-	781 m	98 m	1,675 m
Roosts						
Distance to watercourse	1,340 m	131 m	1,910 m	957 m	536 m	1,888 m
Distance to minor watercourse	280 m	24 m	1,331 m	362 m	5 m	833 m
Distance to forest edge	>10 km	-	-	3,275 m	598 m	4,484 m

4.3.1 Roosting

Radio-tracking undertaken in this study indicates that, during the non-breeding season, *N. corbeni* roosted in a range of tree species, including:

- Brigalow (*Acacia harpophylla*) – five unique roost trees in the B2G study area (four of these were by the same tagged microbat)
- Narrow-leaved ironbark (*Eucalyptus crebra*) – three roosts (N2N)
- Native cypress (*Callitris* sp.) – two roosts (N2N)
- Acacia sp. (likely *Acacia burrowii*) – two roosts (B2G)
- Rusty gum (*Angophora leiocarpa*) – two roosts (B2G)
- Buloke (*Allocasuarina luehmannii*) – one roost (N2N)
- Baradine gum (*Eucalyptus chloroclada*) – one roost (B2G)
- Red Ash (*Alphitonia excelsa*) – one roost (B2G)

Tree age/size was highly variable, from DBH 3.5 cm (small sapling Acacia) to 32 cm (mature Brigalow/ironbarks). Roosts were typically in dead trees, or live trees with dead stems/large branches. Fourteen of the recorded roosts were beneath bark; specifically, either bark that had detached from the hardwood and 'buckled' outwards (see **Photos 4.4** and **4.5**), beneath a 'plate' of outer bark that remained on an otherwise smooth hardwood core (**Photo 4.6**), or that was peeling from the hardwood (**Photo 4.7**). Two hollows were also used (**Photos 4.7** and **4.8**). Photos and details of all roost features and roost trees are provided in **Appendix 2**.



Photos 4.4 and 4.5 Examples of known roosts under the 'buckled' bark of dead trees



Photos 4.6 and 4.7 Examples of known roosts under a bark 'plate' (left) and peeling bark (right)



Photos 4.8 and 4.9 Examples of known roosts in tree trunk fissures and trunk hollows

The tracking undertaken in this study found some differences in roost preferences to other published studies (e.g., Law et al., 2016, 2018 and Gonsalves, 2022). Specifically, the roosts located during this study in non-breeding season were predominantly under bark, whereas the previous studies, mainly undertaken during the breeding season (October to December), found that roosts were often in the hollows and fissures of dead tree trunks, particularly *Allocasuarina luehmannii*. One potential explanation is that, during the breeding season, tree trunk hollows provide a more stable temperature for growing young or conserving energy for lactation; whereas, during the non-breeding season, roost temperature is less imperative. This has been found in other Australian bat species (Lumsden et al., 2002; Goldingay and Stevens, 2009) and is the reason this report recommends the retainment of trees with hollows for breeding and/or hibernation.

Roost fidelity (returning to the same roost) was variable at both study locations; that is, roosts were either changed daily or revisited in consecutive days. For example, one female tagged bat used the same tree on four out of five consecutive nights that she was tracked at B2G. In contrast, other tagged individuals were not located in the same roosts on subsequent days. However, in general, for several of the microbats tracked, roosts were in different trees, but in the same area/s throughout the study period. This indicates that *N. corbeni* may have preferred roosting areas and likely has a memory for numerous roost trees within these preferred areas. This latter point is supported by the direct flight of one tagged *N. corbeni* from one roost to another during GPS retrieval. This information indicates the retainment of known or possible tree roosts is important for the longevity of individuals. However, if an occupied roost does need to be removed, delaying disturbance to the roost for one day is likely to result in the natural dispersal of the individual to another roost in the landscape.

N2N

Six unique roost trees were identified through radiotracking, one of which was within the alignment footprint (**Figure 4.3**). Tagged microbats were found to both change roosts daily, or return to the same roost as previous night/s.

GPS tracking data detected a further nine roost locations, although the individual trees cannot be determined with the GPS tag accuracy (<30 m). Two of these roosts were in an area not visited during field survey; however, satellite imagery and State fire and vegetation mapping indicate it is a scorched eucalypt forest, similar to other located roosts.

Considering the diversity of roost tree species and size, and their widespread distribution in the Pilliga forests, it is likely that the majority of the N2N impact footprint is suitable roosting habitat for *N. corbeni*.

B2G

Eleven unique roost trees were identified through radiotracking, with none of these in the alignment or on the Canning Creek offset property (**Figure 4.4**). However, both harp trapping and GPS tracking data confirms the use of the Canning Creek offset property by *N. corbeni*.

Treed areas on the two western property lots of the Canning Creek offset property were visited by one GPS tracked *N. corbeni* on two nights (see Appendix 3), including a significant foraging effort in one area for over four hours. These western property lots were not surveyed specifically during this study, although previous ground-truthed vegetation surveys indicate that tree species are present that *N. corbeni* is known to roost in within Bringalily State Forest. In the current condition, the treed areas of the western lots are likely suitable foraging habitat only, due to the propensity of *N. corbeni* to avoid roosting in forest edges. However, revegetation of the surrounding cleared areas may mean these remnant forest patches become more suitable for roosting.

The central area of the Canning Creek offset property (adjacent to Millmerran-Inglewood Road and the B2G alignment) was the focus for survey effort. Three *N. corbeni* were trapped in the area and GPS tracking indicated that a fourth individual captured in Bringalily State Forest moved through the central part of the property over two nights (Appendix 3). Searches over eight consecutive days for tagged microbats found no roosts at the Canning Creek offset property. This may be due to a general lack of suitable roosting structures in this area; in particular, the mature regrowth vegetation had limited dead or dying standing trees with suitable bark or hollows at the time of the study. However, the maturing trees in the advanced regrowth areas have the potential to become suitable roosting habitat if surrounding areas continue to regenerate (thus reduce the proximity to forest edges) and natural or artificial senescence occurs (to provide suitable microhabitat of hollows or peeling bark).

The eastern portion of the offset property was visited only once due to wet weather and/or unmaintained road access issues, with no tagged microbats located. However, the more mature vegetation, including senescing trees, indicated suitable roosting habitat was available in the area.

4.3.2 Foraging

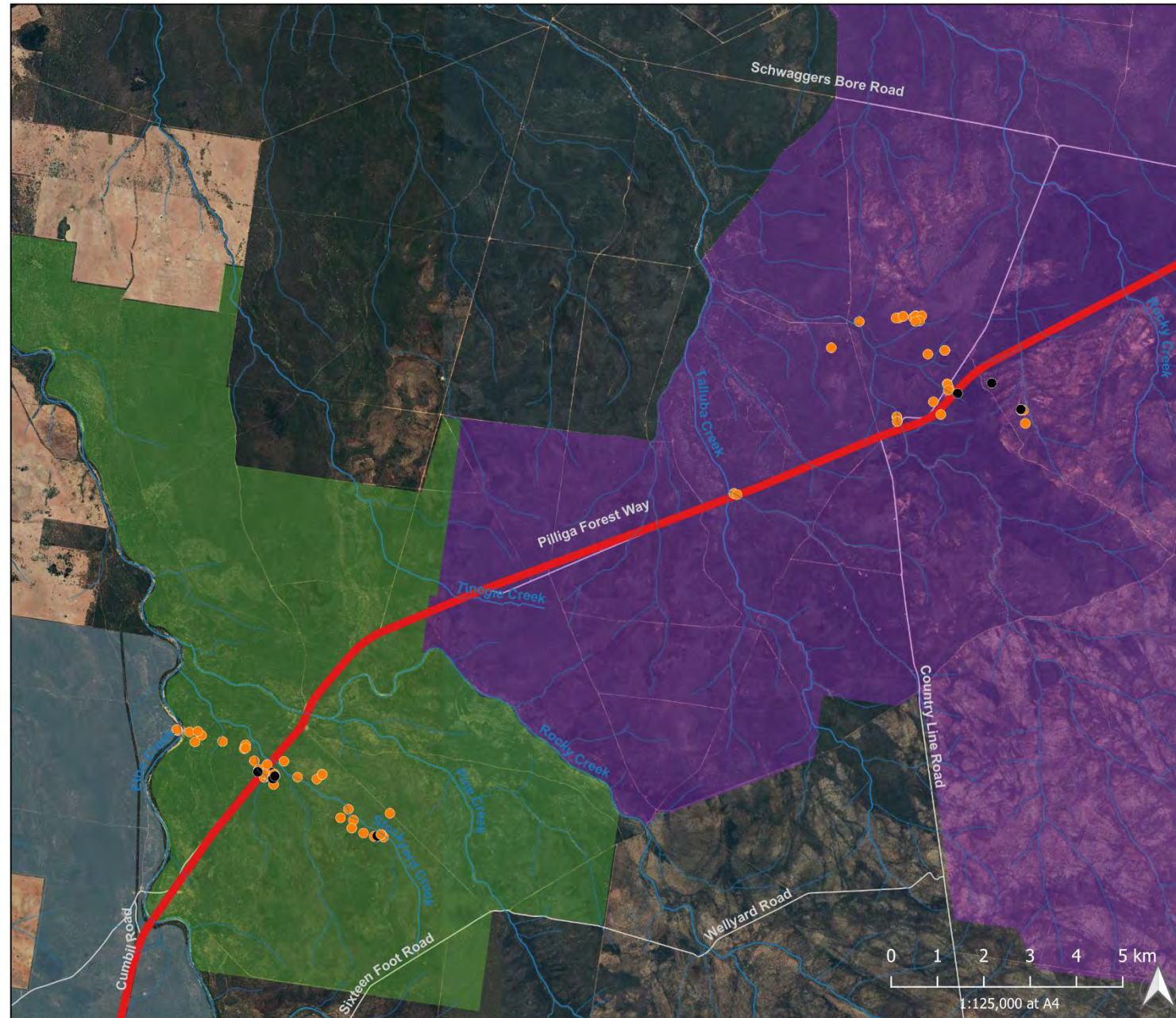
The GPS tracking data revealed that *N. corbeni* foraged in areas up to 3,805 ha per night, with up to 13 km between the most distant foraging points per night (i.e., nightly foraging diameter). Other tracking studies on *N. corbeni* in the Pilliga have found this nightly foraging diameter to be as large as 25 km (personal comm., NSW DPI). Foraging range and distance were greater at B2G than N2N, likely due to inherent differences in resources between the two study areas at the time of tracking.

Several areas were visited for habitat assessment where GPS tagged microbats showed concentrated foraging efforts (i.e., ≥ 3 consecutive GPS foraging points), with vegetation typically more diverse in structure (e.g., distinct ground and midstorey layers) and flora species than surrounding areas. Areas within the vicinity of riparian vegetation or ephemeral creeks and drains were also highly visited. Riparian and other diverse vegetation are likely to contain a higher abundance of invertebrate prey for microbat species.

Tracked bats were recorded foraging and/or moving in the landscape in the same areas frequented on preceding nights, including the Canning Creek offset property. Whilst this suggests that *N. corbeni* return to known foraging areas repeatedly, it is also likely that this pattern may change seasonally as food resources vary within the landscape.

The Canning Creek offset property was used by at least four of the ten captured *N. corbeni* during the study, three of which were trapped on the property. The fourth individual was captured in Bringalily State Forest to the west; however, GPS data showed her flying to/on Canning Creek on both nights that data was recorded. In total, four of the ten tagged *N. corbeni* moved across Millmerran-Inglewood Road (between blocks of Bringalily State Forest or to the Canning Creek offset property; see Appendix 3), indicating this single major road is not a barrier to their movement in the landscape. The cumulative effect of multiple linear transport corridors for *N. corbeni* is unknown due to the paucity of knowledge for the species. However, considering the species avoids roosting in areas of considerable disturbance (e.g., commercial thinning; Law et al., 2016), it is possible that the species may display avoidance and/or barrier effects with multiple cleared transport lines. Additionally, linear transport infrastructure is typically considered to cause reduced activity of microbats in Australia (e.g., Bhardwaj, 2017) likely due to habitat loss, fragmentation and degradation, as well as adverse impacts from vehicle strike, light and pollution, with cumulative impacts likely (Altringham and Kerth, 2015).

GPS data from the B2G study area, and information from other research on *N. corbeni* (personal comm., NSW DPI), indicates that the species will travel across cleared land to forage in remnant or regrowth woodland and forest patches.



Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: 4.3

Title: Nyctophilus corbeni roosting and foraging points at N2N study area

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 10/05/2023

LEGEND

- Detected roosts
- Foraging/dispersal points
- Watercourses
- Key roads

ARTC Data

■ N2N alignment

Protected Areas

- Cumbil State Forest
- Euligal State Forest
- Pilliga East State Forest

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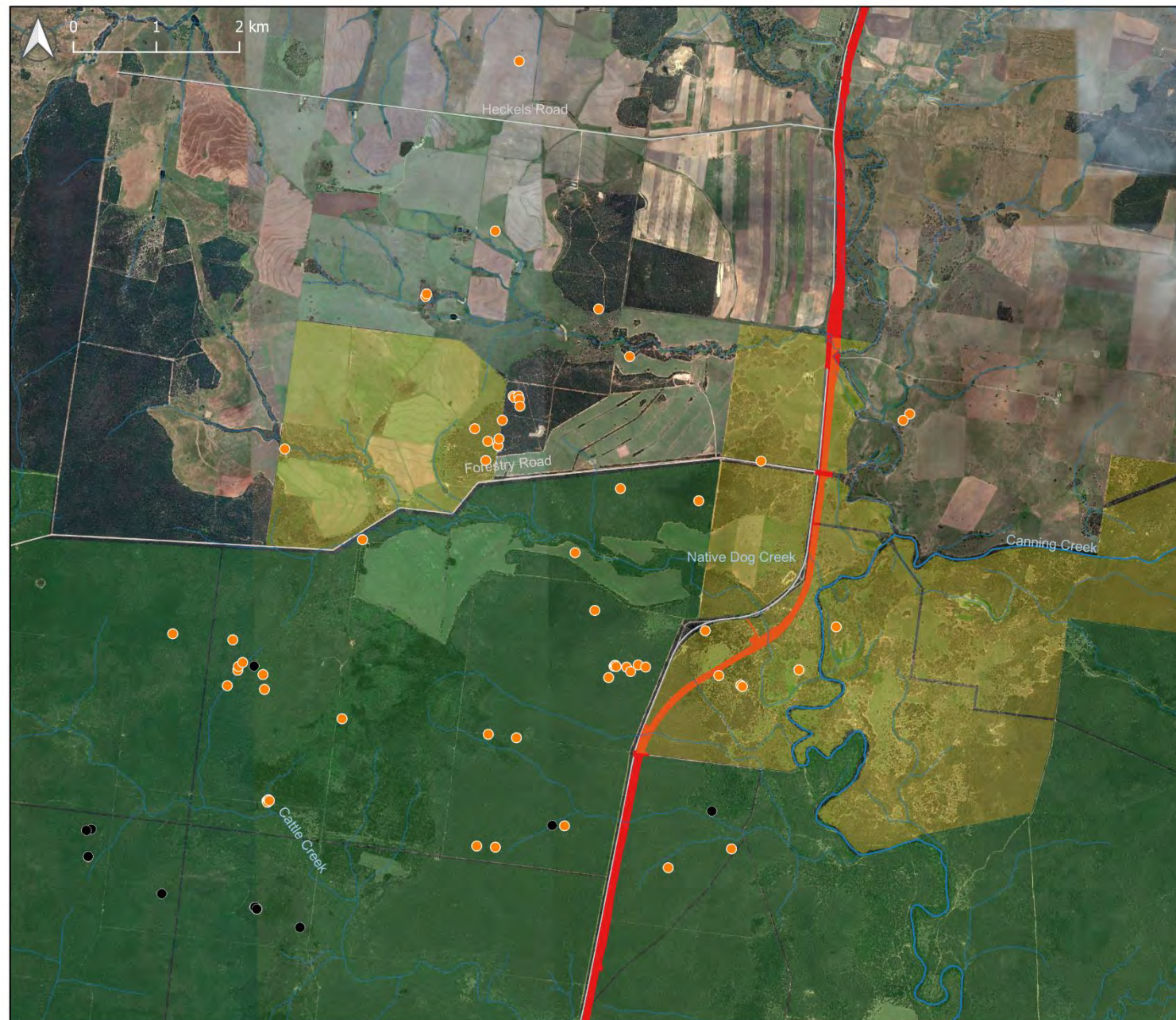


Figure: 4.4

Title: Nyctophilus corbeni
roosting and foraging
points at B2G study
area

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

Drawn: EW 10/05/2023

LEGEND

- Detected roosts
- Foraging/dispersal points
- Watercourses
- Key roads

ARTC Data

- Inland Rail footprint
- Canning Creek property

Protected Areas

- Bringalily State Forest

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Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

4.4 OTHER THREATENED TAXA

Three other nationally threatened fauna species were detected during the microbat surveys and research in the study areas (see locations on **Figures 4.1** and **4.2**), including:

- Squatter Pigeon (southern) *Geophaps scripta scripta*
 - two individuals sighted together on the Canning Creek offset property on 18 March, 2023;
- White-throated Needletail *Hirundapus caudacutus*
 - five individuals observed on multiple days between 4-8 March, 2023, foraging around the fire tower and surrounding forests near the Salt Caves in Pilliga East State Forest, and towards the N2N alignment; and
- Glossy Black-cockatoo (south-eastern) *Calyptorhynchus lathami lathami*
 - three young male birds recorded on multiple days in Bringalily State Forest between 20 March – 5 April, either feeding in *Allocasuarina* species or coming to a waterbody to drink.

For the N2N study area, NSW listed threatened species recorded during the field survey included:

- Little Pied Bat *Chalinolobus picatus* (Vulnerable)
 - captured in harp traps on numerous occasions (see Appendix 1 for dates and locations, also Figure 4.1),
 - calls for this species were also recorded in the N2N alignment;
- Northern Free-tailed Bat *Ozimops lumsdenae* (Vulnerable)
 - calls for this species were recorded in the N2N alignment;
- Yellow-bellied Sheath-tailed Bat *Saccolaimus flaviventris* (Vulnerable)
 - captured in a harp trap on 27 February, 2023 (see Figure 4.1),
 - calls for this species were also recorded in the N2N alignment;
- Eastern Cave Bat *Vespadelus troughtoni* (Vulnerable)
 - calls for this species were also recorded in the N2N alignment;

For the B2G study area, one Qld listed threatened species included one probable sighting of Powerful Owl *Ninox strenua* in Bringalily State Forest west of the B2G alignment (Figure 4.2) on 25 March, 2023.

5.0 HABITAT ASSESSMENTS

A summary of the approximate habitat for both threatened species is provided in **Table 5.1**. These estimates were calculated following habitat assessment based on either known information on *C. dwyeri* biology, or after *N. corbeni* tracking data collection. Specifically, habitat was assessed based on this biological knowledge and the landscape context (either point visits along the alignment and/or examination of ground-truthed REs, where available) for *N. corbeni*. The criteria developed to assess *N. corbeni* habitat is provided in **Table 5.2**, which is based on four main parameters derived from the findings from **Section 4.3** and other published information on the species.

Note, the hectares provided should be used as a guide only, as precise boundaries were not mapped during the field survey, and roads/tracks have not been omitted when these are within the disturbance footprint.

Table 5.1 Estimated hectares of habitat impacted in the study areas. Note, the study areas are not the full length of the Inland Rail project segment (e.g., not the full length of B2G segment).

Microbat species	Habitat type	N2N study area (ha)	B2G alignment in study area (ha)	Canning Creek property
<i>Nyctophilus corbeni</i>	Likely roosting	962	56	241
	Suitable roosting	61	109	205
	Potential roosting	215	162	737
	Suitable foraging	218	348	746
	Marginal foraging/ dispersal only	95	238	805
<i>Chalinolobus dwyeri</i>	Marginal foraging	340	0	0

Table 5.2 Criteria used to assess habitat suitability for *Nyctophilus corbeni*

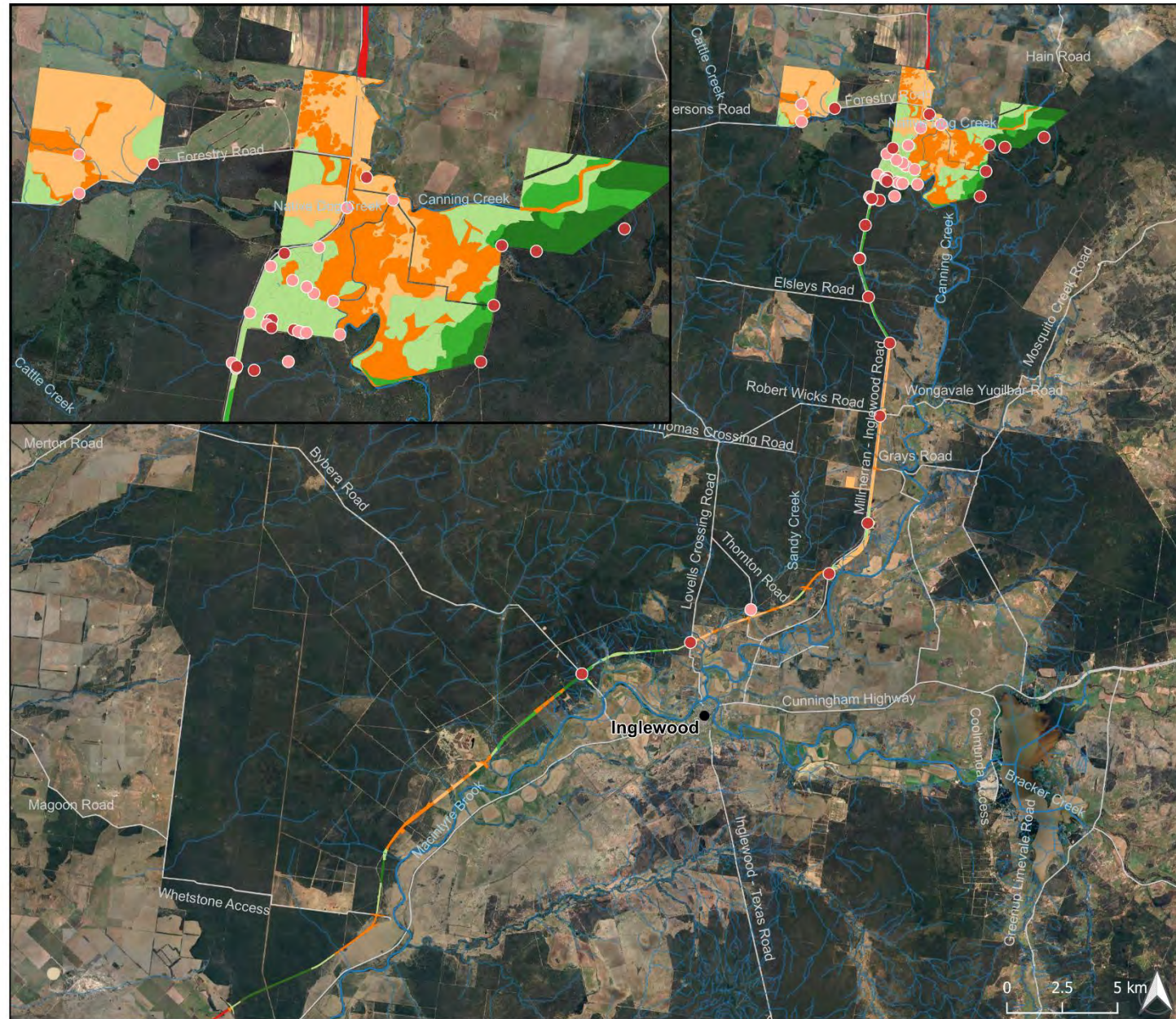
Parameters:	Roost trees	Vegetation diversity	Water proximity	Forest proximity
Description, summary of knowledge	For roosting habitat; Certain tree species are known to contain roosts, or shed bark and form trunk hollows suitable for roosting	Foraging habitat; Vegetation present/ RE/PCT with structural (i.e. upper, mid, ground storey) and/or species diversity	Roosting and foraging Typically roost and/or forage within 1 km of water	Roosting and foraging Typically roost/forage within 1 km of large forest areas
Likely roosting habitat	>500 m to forest edge; AND Onsite habitat assessment recorded many suitable roosting microhabitat and trees OR Remnant RE/PCT predominantly comprised of suitable roost tree species (3)	Present (1)	Distance to minor watercourse is <1 km (1)	1 = Distance to large areas of woodland or forest is <1 km (1)
Suitable roosting habitat	>500 m from forest edge; AND Onsite habitat assessment recorded many suitable roosting microhabitat and trees OR RE/PCT contains suitable roost tree species as co-dominant (2)	Present (1)		
Potential roosting habitat	RE/PCT contains suitable roost tree species, but has some disturbance (e.g., selective logging) or is maturing regrowth, or is within 500 m of forest edge (1)	Present (1)		
Suitable foraging	Limited trees for roosting present (either standing trees or roost-forming species) (0)	Present (1)		
Marginal foraging	Limited trees for roosting present (either standing trees or roost-forming species) (0)	Absent/limited (0); E.g., cleared pastoral areas with isolated trees and other vegetation	>1 km to minor watercourse	>1 km from large areas of woodland or forest (0)
Non habitat	Limited trees for roosting present (either standing trees or roost-forming species) (0)	Absent/limited (0)		



Title: Nyctophilus corbeni habitat assessment along N2N study area alignment

Drawn: EW 10/05/2023

■ Marginal foraging



Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: 5.2

Title: Nyctophilus corbeni
habitat assessment at
B2G study area

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

Drawn: EW 05/05/2023

LEGEND

Habitat Assessment Points

- Primary
- Secondary

Habitat Assessment

- Likely roosting
- Suitable roosting
- Potential roosting
- Suitable foraging
- Marginal foraging/dispersal only

Protected Areas

- Bringalily State Forest
- Whetstone State Forest
- Wondul Range National Park

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6.0 MANAGEMENT AND MITIGATION OF IMPACTS

6.1 NATURE OF IMPACT

Key points on the ecology for the two threatened microbat species relevant to impact identification and management are described below. These key points were elucidated from the current study, as well as relevant published scientific articles (notably Law et al., 2016; Law et al., 2018; Williams and Thomson, 2018; Gonsalves et al., 2022; see **Section 4.0** for further details).

- *Nyctophilus corbeni*
 - roosts in trees of varying species and sizes (from as little as 3.5 cm DBH), typically under peeling or buckling bark, in small hollows or fissures in trunks;
 - roosts are most commonly in dead or dying trees, but do occur in live trees;
 - typically changes roosts daily (both maternity and non-breeding roosts), although can occupy a roost on consecutive days;
 - maternity roosts are more likely to be tree trunk hollows, whereas non-breeding roosts can be highly variable, including under thin, peeling bark;
 - considered a clutter-specialist species, preferring to forage and/or roost in areas of dense trees, and in or adjacent to large areas of forest;
 - often in close proximity to ephemeral drains and watercourses.
- *Chalinolobus dwyeri*
 - roosts in rocky escarps, overhangs and caves or caverns in a variety of rock types;
 - requires large caverns/caves with a domed roof for breeding;
 - forages around and above the canopy of forests and (less frequently) individual trees, often in or near riparian or highly fertile areas;
- Both species:
 - feed on a variety of insects and invertebrates, with the highest abundance of these prey often in areas of diverse vegetation (species and/or structure) and waterways;
 - moves in the landscape along typical microbat flyways (e.g., along watercourses, tracks and roads);
 - forages several kilometres from roosts, including traveling many kilometres per night.

Considering these key ecological parameters, the key threats to *C. dwyeri* and *N. corbeni* associated with the Inland Rail project at the two study areas are described in **Table 6.1**. Estimated areas of foraging and roosting habitat loss are provided in **Table 5.1** in **Section 5.0**.

Table 6.1 Threats and potential impacts in the study areas associated with the Inland Rail project

Threat	Potential impact associated with Inland Rail project	Project phase
Direct roost loss (<i>N. corbeni</i>)	Tree removal (clearing, fire) and unsuitable fire management will reduce roost trees and roost microhabitats (e.g., peeling/buckling bark, hollows, fissures) for breeding and non-breeding microbats	• Construction • Operation
Vegetation clearing	Direct loss of foraging habitat	• Construction • Operation
Habitat fragmentation	Forest-dwelling microbats, particularly <i>N. corbeni</i> , are sensitive to forest fragmentation; fragmentation can be due to clearing and/or disturbance from noise, light or vibration causing avoidance of otherwise suitable habitat	• Construction • Operation
Introduction of weeds	Weed proliferation may modify the current/preferred habitat for microbats, particularly tree-roosting species like <i>N. corbeni</i>	• Construction • Operation
Inappropriate fire regimes or fire management/controls	Low intensity, patchy and infrequent fire is required to maintain <i>N. corbeni</i> roosts, as well as maintain suitable habitat composition for both threatened microbat species	• Construction • Operation
Vehicle strike	Injury or mortality of individuals through interaction with vehicles, machinery or trains	• Construction • Operation
Noise, vibration and light	Loss of useable habitat and behavioural disruptions due to noise, vibration and/or light	• Construction • Operation

6.2 MEASURES TO AVOID, MINIMISE AND MANAGE IMPACTS

Considering the threats and species ecology outlined in **Section 6.1**, measures to minimise and manage impacts are provided in **Table 6.2** below. Note, this is not an exhaustive list of mitigation measures for the target species, which should be developed with close consultation with engineers and planners.

Table 6.2 Mitigation measures suitable for *Chalinolobus dwyeri* (Cd) and *Nyctophilus corbeni* (Nc) in relation to the Inland Rail project at the N2N and B2G study areas.

Activity	Mitigation Measure	Cd	Nc
Pre-construction Phase			
Site Preparation	Works that could cause disturbance to roosts (e.g., tree clearing, ground vibration) should be scheduled to primarily avoid breeding season (October-December) and, where possible, the hibernation period (June-August)	✓	✓
	The extent of disturbance of suitable habitat should be delineated and clearly marked to avoid unnecessary habitat loss	✓	✓
	Dead trees, or those with peeling/buckling bark, hollows or fissures, should be avoided to minimise loss of suitable roosts		✓
	The removal of standing dead and live trees should be minimised to minimise the loss of suitable roosts		✓
	The width of clearing/disturbance areas should be kept as narrow as possible to minimise habitat fragmentation	✓	✓
	Disturbance at and near cave structures should be avoided to minimise habitat disturbance	✓	
	A spotter-catcher or other suitably qualified specialist should identify all potential maternity roosts in the disturbance area	✓	✓
	Exclusion zones should be established around active breeding places and monitored until the site has been vacated	✓	✓
	Along the length of the alignment, suitable undisturbed 'recipient' sites should be identified to release microbats captured during clearing activities	✓	✓
Site Work Instruction	All site personnel, including contractors, should be made aware of the extent of any unauthorised access areas, as well as specific limitations related to construction works being conducted in or within proximity to microbat roosts	✓	✓
Construction Phase			
Access	Access to and from the project footprint should occur along designated access tracks only, to avoid unnecessary habitat disturbance and fragmentation	✓	✓
	To avoid entanglement, the use of barbed wire should be avoided, particularly on the top strand of required fencing	✓	✓
	Exclusion or restricted zones should be established around breeding roosts that have been located/initiated after the commencement of construction	✓	✓

Activity	Mitigation Measure	Cd	Nc
Clearing	Areas to be cleared will remain clearly demarcated for the duration of clearing activities	✓	✓
	Clearing will occur, and be monitored to comply, only within the approved areas	✓	✓
	Clearing activities should be supervised by a suitable qualified and experience Environmental Officer, with a spotter-catcher on hand at all times to relocate and/or manage disturbed microbats	✓	✓
	All vegetation clearing within identified threatened microbat habitat should comply with clearing related approvals	✓	✓
	Clearing should be undertaken in a sequential manner to allow microbats to escape clearing activities into nearby, undisturbed areas	✓	✓
	Dead or dying standing trees should be thoroughly inspected for potential or occupied <i>N. corbeni</i> roosts, with particular attention to features similar to the known roosts provided in photos in Appendix 2		✓
	Identified roosts that are currently occupied by microbats, plus a 20 m radius buffer, should be marked and left uncleared until the roost is re-checked the following day. Ground disturbance, or other spreading disturbances (light, noise, vibration) should be avoided for up to 100 m, depending on the nature of the disturbance. As <i>Nyctophilus corbeni</i> typically change roosts daily, even during the breeding season, it is possible that clearing activities only need to be suspended for one day to allow for self relocation.		✓
	Where potential roost trees (with peeling/buckling bark, hollows or fissures) need to be removed: • trees should be inspected by a spotter-catcher to determine occupancy and, where microbats are present, these should be captured (rather than flushed from the roost) to prevent predation from birds such as currawongs, kookaburras, butcherbirds, corvids, etc.; • trees should be felled gently/lowered to the ground and inspected immediately by a spotter-catcher, before being left for a short period (approximately 10 minutes) to allow microbats to escape that were not identified previously, prior to the tree being processed; • during the hibernation period (June-August), microbats may be less inclined or slower to depart from disturbed roost trees, and spotter-catchers should be more vigilant for potential roosts and occupancy; • displaced, uninjured microbats should be relocated to the recipient site during night hours and within 24 hours of capture; and • injured microbats should receive veterinary attention immediately and, when recovered, should be released into the recipient site.		✓
Weed Management	Weed management strategies should be implemented to minimise the introduction and/or proliferation of weed species	✓	✓
	Vehicle, equipment and personnel access should be restricted in areas known or suspected to contain weed infestations, with weed control measures undertaken early where required	✓	✓
	All vehicles/equipment should possess current weed hygiene declarations	✓	✓

Activity	Mitigation Measure	Cd	Nc
	Vehicles/equipment should have current and updated risk assessments to determine the level of inspection, washdown and certification when travelling to, within and between project areas	✓	✓
Light, Noise and Vibration Management	Equipment, vehicles and activities that emit light, noise and/or vibration should be regularly maintained to optimal working order to minimise these emissions	✓	✓
	Equipment types, as well as activity methods and sequence, should be considered to reduce all light, noise and vibration disturbance to microbat habitat during construction, during both daylight and night hours	✓	✓
	Equipment parts and add-ons that reduce light, noise and vibration should be implemented and maintained (e.g., light shields/hoods to prevent light spill into adjacent areas, quietening guards, etc.)	✓	✓
Progressive Rehabilitation	Excluding ongoing operational or maintenance tracks and areas, rehabilitation of areas should be planned, commenced, monitored and managed as soon as possible to initiate habitat restoration	✓	✓
Operational Phase			
Clearing	As per Construction Phase	✓	✓
Light, Noise and Vibration management	Equipment, vehicles and activities that emit light, noise and/or vibration should be regularly maintained to optimal working order to minimise these emissions	✓	✓
	Modelling should be undertaken to determine the lowest possible levels of ongoing light, noise and vibration disturbances near any potential roost or foraging habitat	✓	✓
Fire Management	Measures to minimise the risk of wildfire in surrounding areas is required, particularly those methods that do not include further habitat disturbance (i.e., local prevention around hot work, rather than the construction of fire breaks)	✓	✓
	At offset properties: - planned burns should be undertaken at a frequency suitable to the vegetation community type and level of resilience, to maintain diversity of age and structure; - planned burns should be undertaken in a manner to ensure a patchy mosaic of low intensity fire and unburnt areas results; - already cleared fire breaks should be maintained to reduce the risk of wildfire from neighbouring areas; and - current access tracks should be maintained where possible to allow fire control and management.		✓
Entanglement	All temporary or permanent fencing should avoid the use of barbed wire wherever possible, particularly as the top strand, to minimise microbat entanglement	✓	✓
Weed Management	As per Construction Phase	✓	✓
Progressive Rehabilitation	As per Construction Phase	✓	✓

Activity	Mitigation Measure	Cd	Nc
Rehabilitation Phase			
Revegetation	Revegetation should include flora species and densities as per the relevant RE or PCT that existed prior to disturbance, with areas close to the train line omitting common roost tree species such as ironbarks, Brigalow, native cypress and Buloke.		✓
Weed Management	As per Construction Phase	✓	✓
Fire Management	As per Construction Phase		

6.3 MITIGATION OF RESIDUAL IMPACTS

6.3.1 Artificial roosts for *Nyctophilus corbeni* roost loss

Apart from measures to minimise tree loss (from clearing or fire) described in **Table 6.2**, direct loss of maternity and non-breeding tree roosts for *N. corbeni* is an impact with limited mitigation options. In particular, roosts of this species are typically under peeling/buckling bark, in trunk hollows or fissures in dead trees, which can be difficult to replicate.

Microbat roost boxes

Artificial microbat roost boxes are often suggested as a mitigation method for tree-roosting species; however, there is limited evidence that they provide valuable roosting structures for many Australian species of microbats. Several research studies have found that uptake of microbat roost boxes is species-specific, with *Nyctophilus* species rarely occupying them. For example, a study spanning 22 years, with four sites and over 100 microbat roost boxes of various designs, found only one least concern microbat species used the artificial roosts with any degree of regularity (Griffiths et al., 2017). Whilst the study was conducted outside the distribution of *N. corbeni*, one comparable species (e.g., *Nyctophilus geoffroyi*) was a common inhabitant of the study area, but did not use the artificial roost boxes.

In another study, where *N. geoffroyi* and *N. gouldi* (both with similar roosting preferences to *N. corbeni*) were common in the landscape, less than 5% occupancy rate of any microbat species were found to occupy artificial roost boxes, with no *Nyctophilus* maternity roosts detected (Rueegger et al., 2019). Of interest, artificial roost boxes that were designed and implemented during the study with increased chambers and ventilation were found to contain more *Nyctophilus* species than standard roost boxes. Considering the non-breeding roosts recorded at both the N2N and B2G study areas were often in exposed locations under bark and with high levels of ventilation, it is possible this design could be more suitable to *N. corbeni*; however, further examination and monitoring is required to confirm this.

Chainsaw cavities

Nyctophilus species (other than *N. corbeni*) have been found to occupy cavities carved into live trees with a chainsaw (which does not kill the tree if undertaken correctly), with a front plate subsequently attached with an entrance hole (Rueegger, 2017). One artificial cavity was also considered to be a *Nyctophilus* maternity roost. Chainsaw cavities have also been found to have more comparable microclimate (e.g., stable roost temperatures) to microbat tree hollows, compared to artificial bat boxes, which have highly fluctuating temperatures (Griffiths et al., 2018). As the maternity roosts of *N. corbeni* are typically located in tree trunk hollows (e.g., see Law et al., 2016, 2018 and Gonsalves et al., 2022), likely due to a greater stability in microclimate providing energy efficiency whilst microbats are at rest, chainsaw cavities may provide suitable maternity roosting opportunities for *N. corbeni*.

The NSW DPI has recently started examining whether chainsaw cavities, as well as ring-barking trees to create suitable bark roosts, are used by *N. corbeni*; however, no details are yet available.

Bark mimics

Overseas, several types of bark mimics have been successfully developed for microbat species that roost under bark. 'Bat Bark' is made from a synthetic mould (typically polyurethane, fibreglass or polyresin) to replicate typical roosts of target species (see Noteman, 1998; Taylor et al., 2020). 'BrandenBark' is another example of a bark mimic that has been successfully occupied by various

microbat species in several areas of the United States, including as maternity roosts (e.g., Gumbert et al., 2013; Adams et al., 2015).

While bark mimics require consideration of the target species roost preferences (shape, attachment location, microclimate, etc.), their increased development, research and successful implementation provides an opportunity for extension in Australia.

6.3.2 Offset Property

Considering the Inland Rail project will result in residual impacts to threatened microbat species through loss of maternity and non-breeding roosting sites (for *N. corbeni*), as well as reduced foraging habitat for both *N. corbeni* and *C. dwyeri*, adequate offset property management will be important to mitigate such impacts. Offset property management recommendations relevant to the two threatened microbat species are provided in **Section 7.0**.

6.4 MONITORING OF IMPACTS

A monitoring plan, including detailed measurable targets and thresholds, for each of the mitigation methods detailed in **Table 6.2**, should be developed to ensure compliance and allow adaptive management actions.

As train strike for microbat species is a specific threat in these forested areas, with limited information on practical mitigation measures in Australia or overseas. Specifically, as *N. corbeni* (and various other microbat species) fly and forage at a range of heights, including picking invertebrates from the ground, to above the canopy foliage (TSSC, 2015), it is recommended that adequate monitoring is undertaken to determine the extent of this ongoing threat. Specifically, this could involve regular surveys for microbat carcasses along high biodiversity areas of the alignment/s.

7.0 OFFSET PROPERTY MANAGEMENT RECOMMENDATIONS

The primary recommendations for offset property management relate to the provision and/or retention of roosts for *N. corbeni*. In particular, this includes limiting the removal of standing dead or dying trees, suitable fire management to retain roost features (e.g., peeling/buckling bark), and establishing suitable artificial roost structure in areas with limited natural roosts.

Secondary land management activities are also recommended that will further provide foraging and/or roosting habitat for *N. corbeni* and *C. dwyeri*, as well as reducing risk of injury through entanglement on fences.

7.1 LIMIT REMOVAL OF STANDING DEAD OR DYING TREES

The removal or disturbance of any standing, native, dead trees, or trees with dead branches or sections, should be minimised, regardless of species or size. In particular, *N. corbeni* is known to roost in a range of native tree species of various ages, including small (dead) saplings that may have been outcompeted during natural thinning processes.

Furthermore, all dead or dying native tree species should be retained as *N. corbeni* roost preferences vary throughout the year. Specifically, hollows are likely to be favoured during breeding season and hibernation, whilst under ventilated bark is more commonly used as a roost during warmer, non-breeding months. Additionally, *N. corbeni* is known to prefer dense stands of trees, thus clearing, thinning or disturbance of any trees may restrict roosting in the area.

If any clearing work does need to be undertaken, it is important to avoid the months during hibernation (June-August) to minimise mortality from energetic stress, as well as the breeding season (October-December), to minimise risk of young abortion or displacement.

7.2 FIRE MANAGEMENT

Suitable fire management is required to protect current roost features of trees for *N. corbeni*. In particular, peeling or loose bark and the edges/internal structure of trunk hollows can be consumed by moderate to high intensity fire, and these should be avoided.

Research has indicated that, in the Pilliga, *N. corbeni* preferred either unburnt or areas of patchy, lightly burnt forest due to the creation of suitable roosts (i.e., dead trees, curling thick bark; Gonsalves et al., 2022). However, areas with moderate to high intensity fires were avoided for both roosting and foraging (see also Law et al., 2016).

Fire can also alter the vegetation composition, especially in recovering habitats such as the young Brigalow, cypress and Buloke regrowth in the south-western property lots of the Canning Creek offset property. In addition to the patchy, low intensity burn recommendation above, consultation with an appropriate expert on fire frequency suitability for such vegetation and habitats, should fuel management require control burns.

7.3 ARTIFICIAL ROOSTS

Offset properties, with agreements to offset *N. corbeni* residual impacts, should be surveyed to determine the current existence of natural roosts. It is likely that, in areas of regrowth or young forest, limited natural roosting opportunities may exist. As such, artificial roosts are required to encourage usage of the offset properties.

Artificial roosts for *N. corbeni* have not been investigated in Australia, although similar-roosting congeneric microbats (i.e., other *Nyctophilus* species) rarely occupy standard microbat roost boxes. Therefore, it is recommended that a study be undertaken following determination of suitable roosting habitat areas, on whether microbat roost boxes adapted for *N. corbeni* roost preferences (i.e., increased ventilation for non-breeding season and suitably insulated for breeding season) or chainsaw cavities (for breeding roosts), and an artificial bark prototype (for non-breeding roosts) may be suitable roost substitutes.

7.4 HABITAT MANAGEMENT

7.4.1 Grazing

While grazing should pose limited disturbance to roosts of *N. corbeni*, monitoring of the effects of cattle grazing should be implemented to ensure no distinct change in composition or density of vegetation, or direct impacts to roost trees and their features (i.e., pushing over dead trees).

7.4.2 Weed Management

As for grazing, weed incursion and/or proliferation can result in a change to the composition or density of suitable vegetation and microbat habitat. As such, suitable methods should be undertaken to control existing weeds, as well as prevent the introduction of new weed species.

Weed control measures need to minimise indirect impacts on microbats, such as the reduction of insect food resources (chemical application) or damage to potential roost trees (mechanical removal).

7.4.3 Erosion Management

The monitoring and stabilisation of current or additional erosion is also important. In particular, erosion can result in the direct loss of roost trees or the modification of suitable foraging and roosting habitat.

7.5 ENTANGLEMENT

To reduce the risk of entanglement on barbed-wire, the top strand of fences should be plain steel wire. As microbats primarily use echolocation to navigate the landscape, fencing wire is difficult to 'see' and is a common cause of injury and death.

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APPENDIX 1

Microbat species and numbers captured in harp traps

APPENDIX 1 – MICROBAT SPECIES AND NUMBERS CAPTURED IN HARP TRAPS

Species initialisms included in harp trap capture tables. Conservation status is as per Commonwealth (EPBC Act) or State legislation, and includes V = Vulnerable or LC = Least Concern.

Initialism	Species Name	Common Name	Conservation Status	
			EPBC	State
Cg	<i>Chalinolobus gouldi</i>	Gould's Wattled Bat	LC	LC
Cm	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	LC	LC
Cp	<i>Chalinolobus picatus</i>	Little Pied Bat	LC	V (NSW)
Nc	<i>Nyctophilus corbeni</i>	South-eastern Long-eared Bat	V	V (NSW, Qld)
Nge	<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	LC	LC
Ngo	<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat	LC	LC
Op	<i>Ozimops planiceps</i>	Inland Free-tailed Bat	LC	LC
Or	<i>Ozimops ridei</i>	Eastern Free-tailed Bat	LC	LC
Sf	<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tailed Bat	LC	V (NSW)
Ss	<i>Scotorepens</i> species*	Broad-nosed Bat	LC	LC
Vv	<i>Vespadelus vulturnus</i>	Little Forest Bat	LC	LC

*Broad-nosed Bats (*Scotorepens* spp.) were not always identified to species in the field before release due to the need to undertake various measurements (e.g. finger bones) for accurate identification.

Site coordinates for harp trapping in the N2N study area

Site Name	Latitude	Longitude
Coolangla Creek (dbl)	-30.84792	149.08037
Nr Stockyard Creek #1	-30.72604	149.13833
Nr Stockyard Creek #2	-30.72615	149.13880
Ned's Creek Rd (dbl)	-30.67177	149.24479
Cubbo Creek #1	-30.65800	149.28167
Cubbo Creek #2	-30.65777	149.28160
Cubbo Creek Rd East	-30.64399	149.29234
Cubbo Creek Rd West	-30.63840	149.27303

(dbl = double, where two traps are set up side-by-side)

Harp trap captures in the N2N study area

Date	Site	Cg	Cm	Cp	Nc	Nge	Ngo	Op	Sf	Ss	Vv
25/02/2023	Coolangla Creek (dbl)					3				1	
	Nr Stockyard Creek #1					1					2
	Ned's Creek Rd (dbl)	1			1	9	2	1		2	5
	Cubbo Creek #1	13	1		1	28	2			15	5
	Cubbo Creek #2					0					
26/02/2023	Coolangla Creek (dbl)	1									
	Nr Stockyard Creek #1				1						2
	Ned's Creek Rd (dbl)					7					2
	Cubbo Creek #1	5				7	2	2		9	5
	Cubbo Creek #2					0					
27/02/2023	Coolangla Creek (dbl)	2				2				4	
	Nr Stockyard Creek #1					1					
	Ned's Creek Rd (dbl)	7				9		7	1	27	9
	Cubbo Creek #1	17				19		3		78	14
	Cubbo Creek #2										
28/02/2023	Coolangla Creek (dbl)									1	2
	Nr Stockyard Creek #1										1
	Ned's Creek Rd (dbl)	60	1		3	15	3			78	16
	Cubbo Creek #1	89	2	1	3	9	2			255	77
	Cubbo Creek #2	18			2	8	4			67	14
2/03/2023	Nr Stockyard Creek #2					4				1	1
	Ned's Creek Rd (dbl)	4				3	1	1		18	6
	Cubbo Creek #1	52			4	10	2	1		148	15
	Cubbo Creek #2					10				3	3
	Cubbo Creek Rd East	34			2	5	1	4		36	25
	Cubbo Creek Rd West	62		1	1	4		8		91	39
3/03/2023	Nr Stockyard Creek #2									5	
	Ned's Creek Rd (dbl)					1				12	2
	Cubbo Creek #1 and #2	1				2				6	4
	Cubbo Creek Rd East	6			2			4		15	5
	Cubbo Creek Rd West	1				2				8	12
4/03/2023	Nr Stockyard Creek #2										3
	Ned's Creek Rd (dbl)	3				3				26	15
	Cubbo Creek #1	1				2				8	2
	Cubbo Creek #2					0					
	Cubbo Creek Rd East	5		3	1	5		1		5	17
	Cubbo Creek Rd West					1		1			3
5/03/2023	Nr Stockyard Creek #2										1
	Ned's Creek Rd (dbl)					1				2	5
	Cubbo Creek #1	7			1	1				7	1
	Cubbo Creek #2					0					
	Cubbo Creek Rd East	7		1	2					14	13
	Cubbo Creek Rd West				1	1					2

Site coordinates for harp trapping in the B2G study area

Site Name	Latitude	Longitude
Scorched habitat track	-28.33906	151.09245
Pariagara Creek (dbl)	-28.34011	151.10133
Sandy Creek (dbl)	-28.34582	151.13012
Corner creek	-28.34617	151.13170
Southern dam	-28.35824	151.10492
Northern dam (dbl)	-28.17518	151.12907
Northern fire tower track	-28.18155	151.12723
Southern fire tower track (dbl)	-28.20431	151.12031
Fire tower dam #1	-28.20357	151.11689
Fire tower dam #2	-28.20432	151.11723
Offset property Trap #1 (east)	-28.19298	151.17691
Offset property Trap #2 (mid)	-28.19179	151.17543
Offset property Trap #3 (west)	-28.19056	151.17255
Offset property south #1 (dbl)	-28.20013	151.17438
Offset property regrowth #1	-28.19861	151.16809
Offset property regrowth #2	-28.19850	151.16718
Offset property south #2	-28.20006	151.17464
Offset property south #3	-28.20000	151.17416
Bringalily SF Trap Rd #1 (east)	-28.19764	151.15261
Bringalily SF Trap Rd #2 (central)	-28.19699	151.14760
Bringalily SF Trap Rd #3 (west)	-28.19642	151.14415
Cattle Creek #1	-28.20164	151.10097
Cattle Creek #2	-28.20159	151.10094

(dbl = double, where two traps are set up side by side)

Harp trap captures in the B2G study area

Date	Site	Cg	Cm	Cp	Nc	Nge	Ngo	Or	Ss	Vv
17/03/2023	Scorched habitat track	0	0	0	0	0	0	0	0	0
17/03/2023	Pariagara Creek (dbl)	3	0	0	0	3	0	0	2	2
17/03/2023	Sandy Creek (dbl)	0	0	0	0	4	0	0	2	2
17/03/2023	Corner creek	0	0	0	0	3	1	0	2	0
17/03/2023	Southern dam	4	1	0	0	4	0	0	8	3
18/03/2023	Scorched habitat track	0	0	0	0	0	0	0	0	0
18/03/2023	Pariagara Creek (dbl)	0	0	0	0	0	0	0	0	0
18/03/2023	Sandy Creek (dbl)	0	0	0	0	1	0	0	1	0
18/03/2023	Corner creek	0	0	0	0	0	0	0	1	0
18/03/2023	Southern dam	0	0	0	0	1	0	0	1	0
19/03/2023	Northern dam (dbl)	0	0	0	0	0	0	0	1	1
19/03/2023	Northern fire tower track	0	0	0	0	0	0	0	0	0
19/03/2023	Southern fire tower track (dbl)	0	0	1	0	1	0	0	3	0
19/03/2023	Fire tower dam #1 and #2	11	1	2	2	9	0	2	10	3
20/03/2023	Northern dam (dbl)	0	0	0	1	5	0	1	7	2
20/03/2023	Northern fire tower track	0	0	0	0	0	0	0	0	0
20/03/2023	Southern fire tower track (dbl)	0	0	0	0	2	0	0	14	0
20/03/2023	Fire tower dam #1	3	1	1	1	11	0	2	26	1
20/03/2023	Fire tower dam #2	0	0	0	0	28	0	0	2	0
21/03/2023	Northern dam (dbl)	0	0	0	0	1	0	0	5	1
21/03/2023	Northern fire tower track	0	0	0	0	0	0	0	1	0
21/03/2023	Southern fire tower track (dbl)	0	0	0	0	2	0	0	2	1
21/03/2023	Fire tower dam #1 and #2	0	0	0	1	10	0	0	2	1
22/03/2023	Northern dam (dbl)	0	0	0	0	2	0	0	0	0
22/03/2023	Northern fire tower track	0	0	0	0	1	0	0	1	1
22/03/2023	Southern fire tower track (dbl)	0	0	1	0	0	0	0	1	0
22/03/2023	Fire tower dam #1	0	0	0	0	3	0	0	2	0
22/03/2023	Fire tower dam #2	0	0	0	0	7	0	0	0	0
No trapping – no spare tyre plus storms										
26/03/2023	Offset property Trap #1 (east)	0	0	0	0	0	0	0	0	0
26/03/2023	Offset property Trap #2 (mid)	0	0	0	0	1	0	0	2	2
26/03/2023	Offset property Trap #3 (west)	0	0	0	1	0	0	0	0	1
26/03/2023	Offset property south #1 (dbl)	1	0	0	0	0	0	0	1	0
26/03/2023	Offset property regrowth #1 and #2	0	0	0	0	1	0	0	1	0
27/03/2023	Offset property Trap #1 (east)	0	0	0	0	0	0	0	0	0
27/03/2023	Offset property Trap #2 (mid)	0	0	0	1	0	0	0	0	5
27/03/2023	Offset property Trap #3 (west)	0	0	0	0	2	0	0	1	0
27/03/2023	Offset property south #1 (dbl)	0	0	0	0	0	0	0	0	1
27/03/2023	Offset property regrowth #1	0	0	0	0	3	0	0	0	0
27/03/2023	Offset property regrowth #2	0	0	0	0	1	0	0	0	1
28/03/2023	Offset property Trap #1 (east)	0	0	0	0	1	0	0	1	0
28/03/2023	Offset property Trap #2 (mid)	0	0	0	1	1	0	0	1	1
28/03/2023	Offset property Trap #3 (west)	0	0	0	0	1	0	0	0	0

Date	Site	Cg	Cm	Cp	Nc	Nge	Ngo	Or	Ss	Vv
28/03/2023	Offset property south #1 (dbl)	0	0	0	0	1	0	0	0	0
28/03/2023	Offset property regrowth #1	0	0	1	0	3	0	0	0	0
28/03/2023	Offset property regrowth #2	0	0	0	0	4	0	0	0	0
29/03/2023	No trapping – storms and poor access									
30/03/2023	Offset property Trap #1 (east)	Not opened due to access issues from rain								
30/03/2023	Offset property Trap #2 (mid)	Not opened due to access issues from rain								
30/03/2023	Offset property Trap #3 (west)	Not opened due to access issues from rain								
30/03/2023	Offset property dam west	0	0	0	0	0	0	0	0	0
30/03/2023	Offset property dam east	1	0	1	0	3	0	0	1	4
30/03/2023	Offset property south #2 and #3	0	0	0	0	0	0	0	0	2
31/03/2023	Offset property Trap #1 (east)	0	0	0	0	0	0	0	0	0
31/03/2023	Offset property Trap #2 (mid)	0	0	1	0	0	0	0	1	1
31/03/2023	Offset property Trap #3 (west)	0	0	0	0	0	0	0	0	1
31/03/2023	Offset property dam west	0	0	0	0	3	0	0	0	1
31/03/2023	Offset property dam east	0	0	0	0	0	0	0	0	0
31/03/2023	Offset property south #2	0	0	0	0	0	0	0	0	0
31/03/2023	Offset property south #3	0	0	0	0	2	0	0	0	1
1/04/2023	Bringalily SF Trap Rd #1 (east)	0	0	0	0	0	0	0	0	2
1/04/2023	Bringalily SF Trap Rd #2 (central)	0	0	0	0	0	0	0	0	2
1/04/2023	Bringalily SF Trap Rd #3 (west)	0	0	0	0	0	0	0	0	0
1/04/2023	Fire tower dam #1 (dbl)	0	0	0	0	0	0	0	0	0
1/04/2023	Cattle Creek #1	0	0	1	0	0	0	0	0	0
1/04/2023	Cattle Creek #2	0	0	0	0	2	0	0	0	0
2/04/2023	Bringalily SF Trap Rd #1 (east)	0	1	0	0	0	0	0	0	1
2/04/2023	Bringalily SF Trap Rd #2 (central)	0	0	0	1	1	0	0	0	1
2/04/2023	Bringalily SF Trap Rd #3 (west)	0	0	0	1	0	0	0	1	0
2/04/2023	Fire tower dam #1 (dbl)	0	0	1	0	2	0	0	0	0
2/04/2023	Cattle Creek #1 and #2	0	0	1	0	1	0	0	0	0
3/04/2023	Bringalily SF Trap Rd #1 (east)	0	0	0	0	1	0	0	0	1
3/04/2023	Bringalily SF Trap Rd #2 (central)	0	0	1	0	0	0	0	1	0
3/04/2023	Bringalily SF Trap Rd #3 (west)	0	0	0	0	0	0	0	1	4
3/04/2023	Fire tower dam #1 (dbl)	0	0	1	0	2	0	0	0	0
3/04/2023	Cattle Creek #1 and #2	0	0	0	0	0	0	0	0	1

APPENDIX 2

Roost details and photos of tracked bats

APPENDIX 2 – ROOST DETAILS AND PHOTOS OF TRACKED BATS

Study Area	Vegetation Summary	Roost Tree Species				Height (m)	Roost Location	Microbat (tag)	Notes
		Species	Health	DBH (cm)	Height* (m)				
N2N	Callitris, Allocasuarina and eucalypt woodland; Fire evidence	<i>Callitris</i> spp.	Dead	19	7	4	Under buckled bark	Female (230-28)	Watched emerge at dusk to confirm tree
	Callitris, Allocasuarina and eucalypt woodland; Fire evidence	<i>Eucalyptus crebra</i>	Dead	26	8	3.5	Under buckled bark; visible	Female (230-09a)	
	Callitris, Allocasuarina and eucalypt woodland; Fire evidence	<i>Allocasuarina luehmannii</i>	Live	18	6	2.5	Hollow; visible	Female (230-09b)	Not natural diurnal roost; escaped to here from <i>E. crebra</i> roost on GPS retrieval, but likely a known roost
	Callitris, Allocasuarina and eucalypt woodland; Fire evidence	<i>Callitris</i> sp. (suspected)	Dead	22	16	Unknown	Unknown	Female (791-05)	Signal not clear on precise roost location but likely large dead Callitris
	Scorched <i>Eucalyptus crebra</i> woodland	<i>Eucalyptus crebra</i>	Dead	32	11	6	Under buckled bark	Female (445-06)	Detached GPS tag located under bark
	Scorched <i>Eucalyptus crebra</i> woodland	<i>Eucalyptus crebra</i>	Live	30	13	8	Under buckled bark	Male (437-06)	Location based on strongest signal
B2G	Callitris, Allocasuarina and Eucalyptus/Angophora woodland	<i>Eucalyptus chloroclada</i>	Partially dead	17 (roost in dead trunk)	8	3.75	Hollow	Male (165-04)	Detached tag found in hollow; initial tree stem was ringbarked, but mature resprouted stems also present
	Acacia dominated patch in Callitris, Allocasuarina and eucalypt woodland	<i>Acacia</i> sp. (likely <i>A. burrowii</i>)	Dead	3.5	6	2	Under buckled bark; visible	Male (472-22)	
	Angophora, Callitris and Acacia woodland	<i>Acacia</i> sp. (likely <i>A. burrowii</i>)	Dead	13	5	1.7	Under buckled bark; visible	Male (472-24)	

Study Area	Vegetation Summary	Roost Tree Species				Height (m)	Roost Location	Microbat (tag)	Notes
		Species	Health	DBH (cm)	Height* (m)				
	Brigalow/Wilga woodland; unburnt	<i>Acacia harpophylla</i>	Dead	16	11	6	Under buckled bark	Male (633a-22)	Location based on strongest signal
	Brigalow/Wilga woodland; unburnt	<i>Acacia harpophylla</i>	Dead	18	11	5	Under buckled bark	Male (633a-23)	Location based on strongest signal
	Brigalow/Wilga woodland; unburnt	<i>Acacia harpophylla</i>	Live, dead limbs	26	13	4	Under buckled bark	Male (633a-24)	Location based on strongest signal;
	Brigalow/Wilga woodland; unburnt	<i>Acacia harpophylla</i>	Dead	32	11	3.5	Under buckled bark	Male (633a-25)	Location based on strongest signal
	Allocasuarina, Callitris and eucalypt woodland	<i>Angophora leiocarpa</i>	Dead	9	9	4.75	Under bark plate; visible	Male (633b-04)	
	Eucalypt, Allocasuarina, Callitris and Acacia woodland	<i>Angophora leiocarpa</i>	Dead	12 (roost), 15	8	3	Under bark plate; visible	Female (847-22)	Observed roosting in this tree on 4 occasions
	Ironbark, Callitris woodland; unburnt	<i>Alphitonia excelsa</i>	Dead	18	5.5	3	Under bark; visible	Female (847-23)	
	Brigalow/Wilga woodland; unburnt	<i>Acacia harpophylla</i>	Dead	25	11	6	Under buckled bark	Male (913b-04)	Location based on strongest signal

*Dead trees were often snapped off/burnt and likely were taller when alive

N2N – Female, 230-28 (under bark, dead *Callitris* sp.)



N2N – Female, 230-09a (under bark, dead *Eucalyptus crebra*)



N2N – Female, 230-09b (trunk fissure, live *Allocasuarina luehmannii*)



N2N – Male, 437-06 (under bark, live *Eucalyptus crebra*)



N2N – Female, 445-06 (under bark, dead *Eucalyptus crebra*)



N2N – Female, 791-05 (precise location unknown, likely dead *Callitris* sp.)



B2G – Male, 165-04 (tag in trunk hollow, dead stem of live *Eucalyptus chloroclada*)



B2G – Male, 472-22 (under bark, *Acacia* sp. likely *burrowii*)



B2G – Male, 472-24 (under bark, *Acacia* sp. likely *burrowii*)



B2G – Male, 633a-22 (under bark, dead *Acacia harpophylla*)



B2G – Male, 633a-23 (suspected under bark, dead *Acacia harpophylla*)



B2G – Male, 633a-24 (suspected under bark, live *Acacia harpophylla*)



B2G – Male, 633a-25 (suspected under bark, dead *Acacia harpophylla*)



B2G – Male, 633b-04 (under bark, dead *Angophora leiocarpa*)



B2G – Female, 847-22 (under bark, dead *Angophora leiocarpa*)



B2G – Female, 847-23 (under bark, dead *Alphitonia excelsa*)



B2G – Male, 913b-04 (suspected under bark, dead *Acacia harpophylla*)



APPENDIX 3

Routes of GPS tracked bats

APPENDIX 3 – ROUTES OF TRACKED BATS

N2N (Figures 3.1)

- Fig. A3.1a - GPS tagged bat 230, with 10 nights of data at 2 hr GPS point intervals
- Fig. A3.1b - GPS tagged bat 445, with 1.5 nights of data at 2 hr GPS point intervals
- Fig. A3.1c - GPS tagged bat 791, with one night of data at 30-minute GPS point intervals

B2G (Figures 3.2)

- Fig. A3.2a - GPS tagged bat 071, with one night of data at 30-minute GPS point intervals
- Fig. A3.2b - GPS tagged bat 284, with two nights of data at 30-minute GPS point intervals
- Fig. A3.2c – Radiotagged bats data points

Note, foraging routes with a solid line depict consecutive GPS data points, while dashed lines are the route between two points where an intermediate point or points are missing due to invalid geometry (i.e., not enough satellites were picked up at the time programmed to take a GPS point).

Numbers are provided to assist in understanding the chronological order of tracking, with each bat's route beginning at a 'Start', then 1, 2, etc., until the bat finds a roost at daybreak. Bats with more than one night of data, will have numbers 11, then 12, etc., for the second night, and the third night with 21, 22, etc. When a GPS tag was found on the ground or removed from the bat, the coordinate is labelled with 'End'.

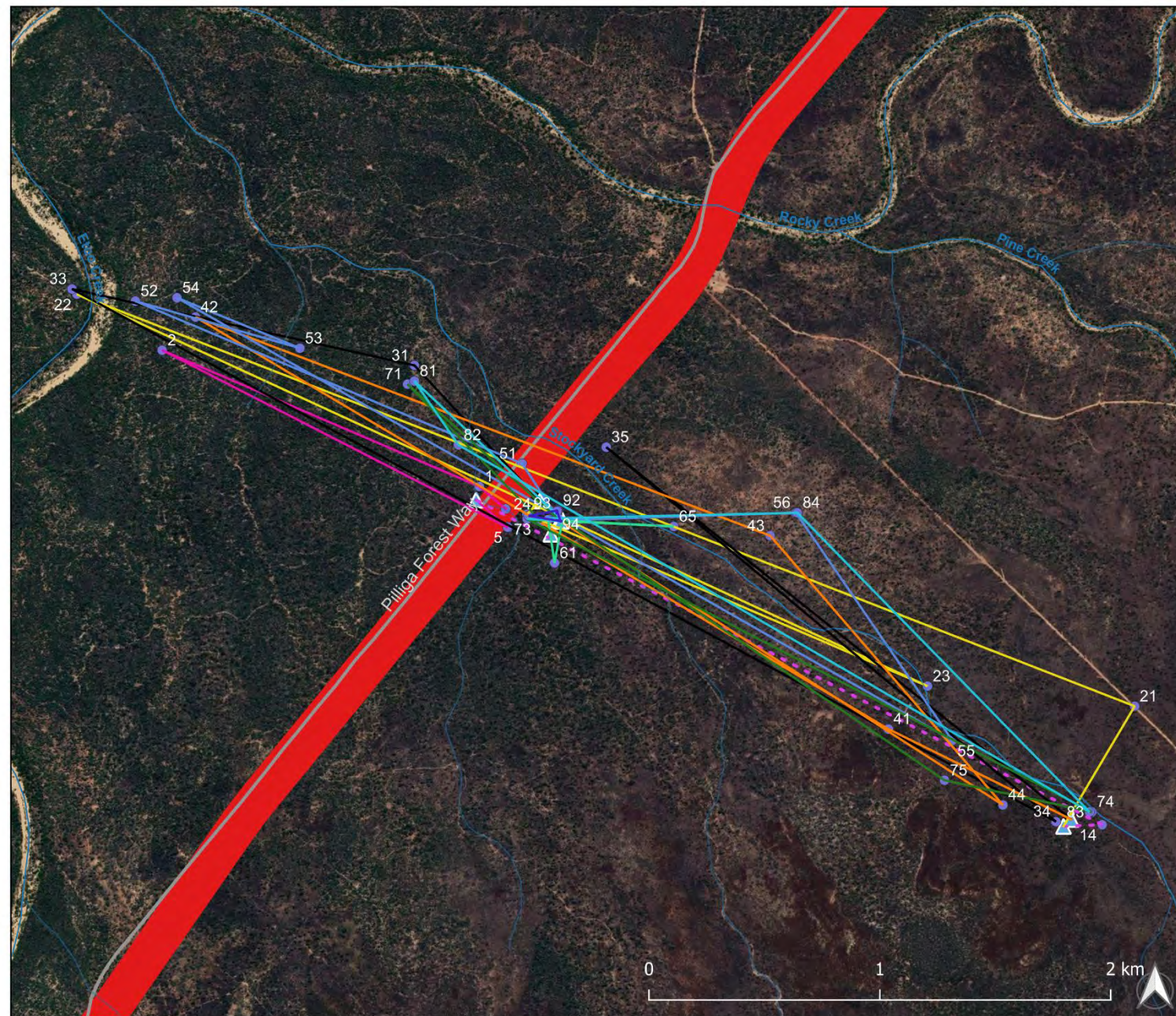


Figure: A3.1a

Title: GPS tagged bat 230 -
10 nights 2 hr data

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

Drawn: EW 13/06/2023

LEGEND

— Watercourses

— Key roads

▲ Roost

● GPS point

Foraging Routes

— Night 1

— Night 2

— Night 3

— Night 4

— Night 5

— Night 6

— Night 7

— Night 8

— Night 9

— Night 10

ARTC Data

■ N2N alignment

(c) BAAM Ecology
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Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: A3.1b

Title: GPS tagged bat 445 -
2 nights patchy 2 hr data

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

Drawn: EW 13/06/2023

LEGEND

— Watercourses

— Key roads

▲ Roost

● GPS points

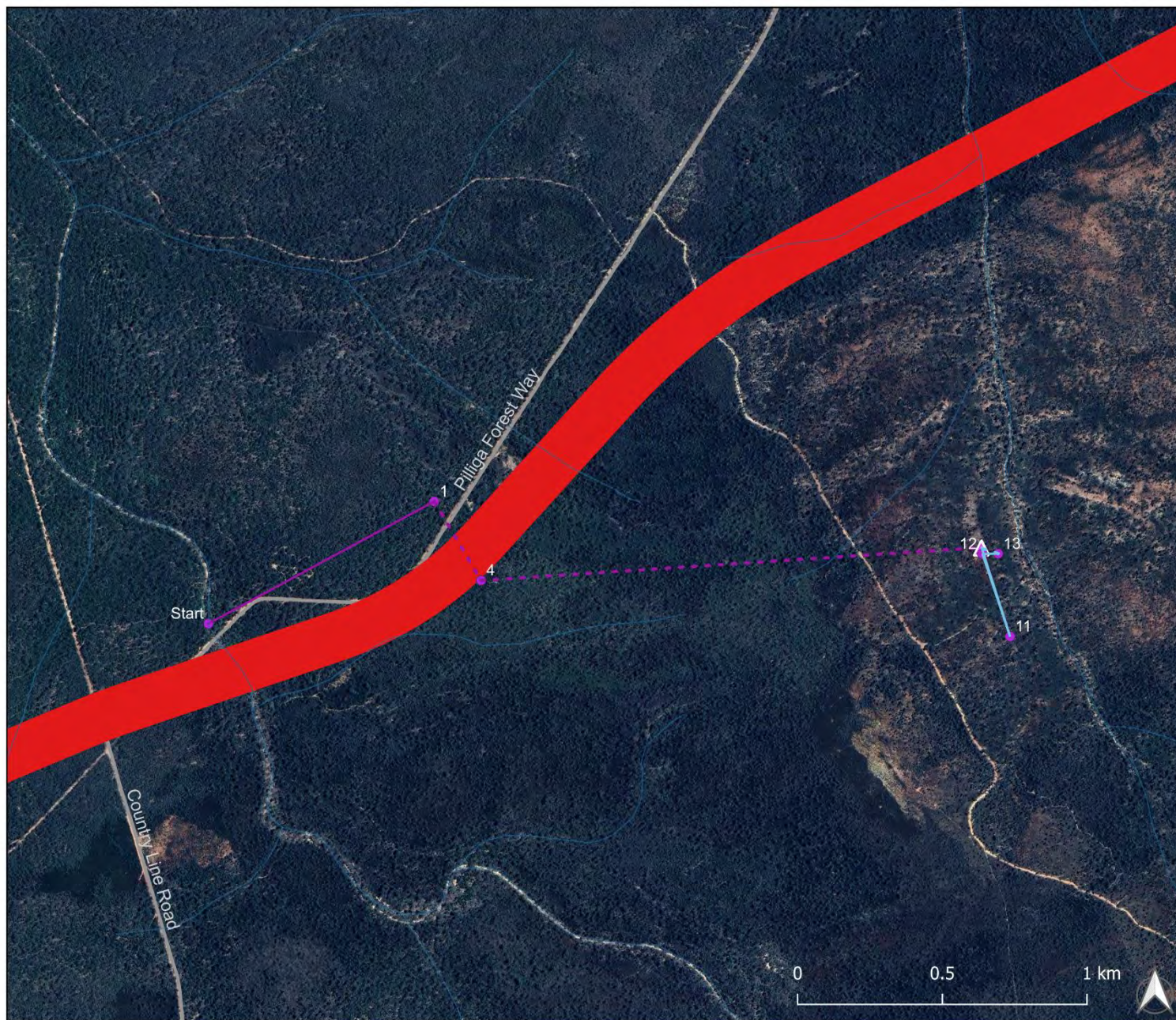
Foraging Routes

— Night 1

— Night 2

ARTC Data

■ N2N alignment



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Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: A3.1c

Title: GPS tagged bat 791 -
1 night 30 min data

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

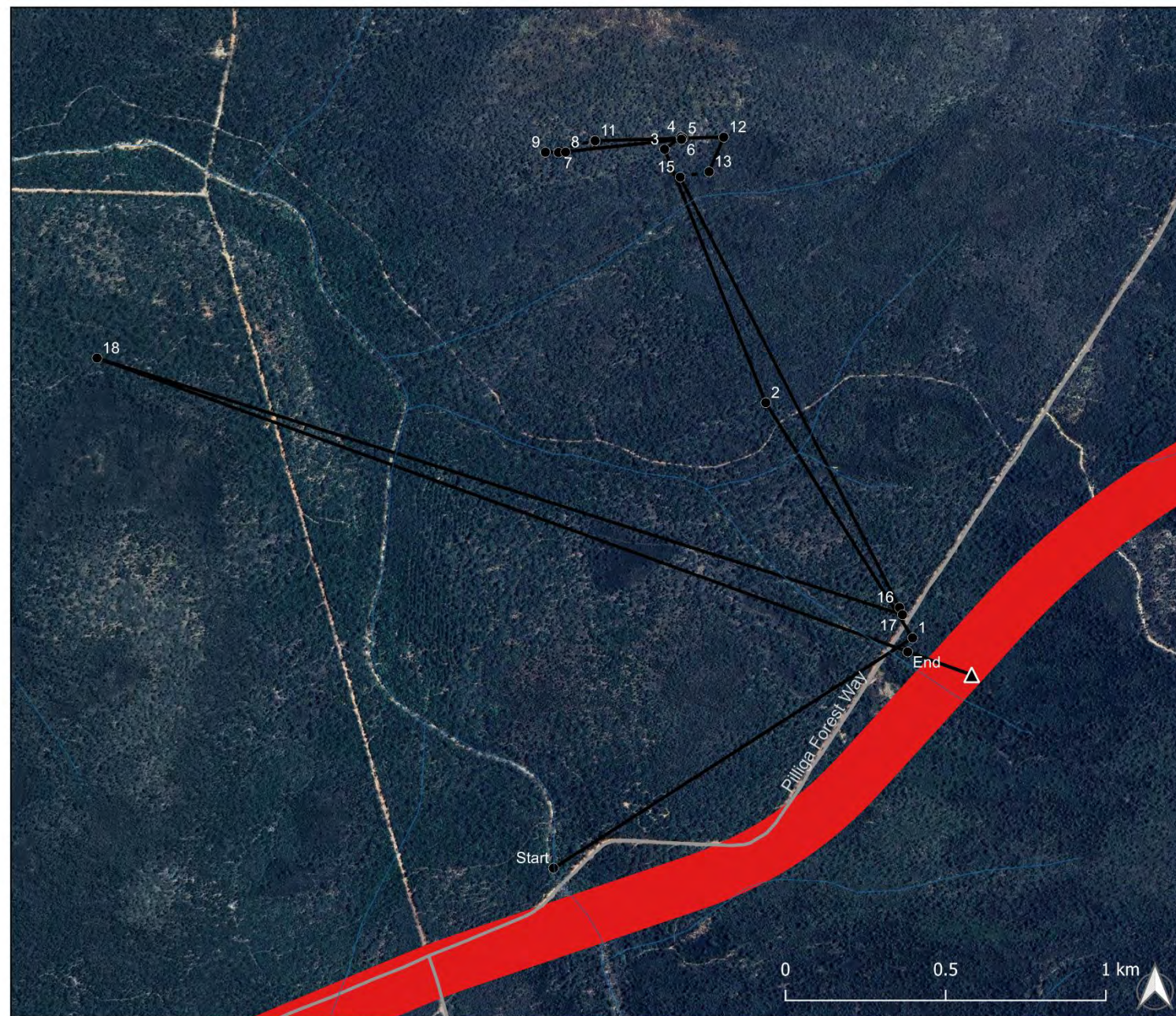
Drawn: EW 13/06/2023

LEGEND

- Key roads
- Watercourses
- ▲ Roost
- GPS point
- Foraging route

ARTC Data

- N2N alignment



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Data sources: ARTC Inland Rail alignment April 2023; NSW Gov DCS Road Segment Data; NSW Gov DFS Named Watercourses; NSW Gov Dedicated State Forests / Forestry Corp NSW; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: A3.2a

Title: GPS tagged bat 071 -
1 night GPS data only

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

Drawn: EW 120/06/2023

LEGEND

Watercourses

Key roads

GPS data points

071

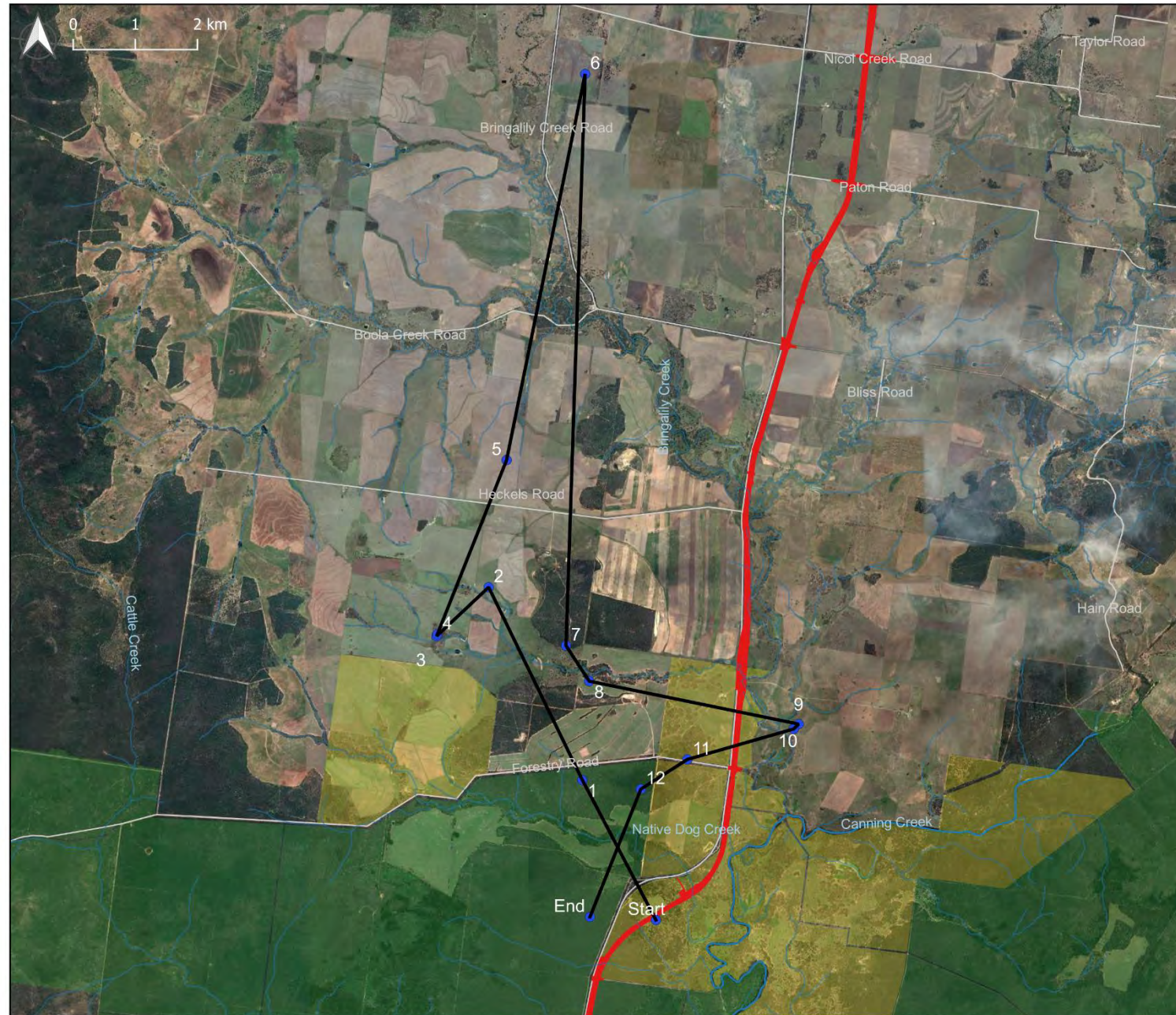
ARTC Data

Inland Rail footprint

Canning Creek property

Protected Areas

Bringalily State Forest



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Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

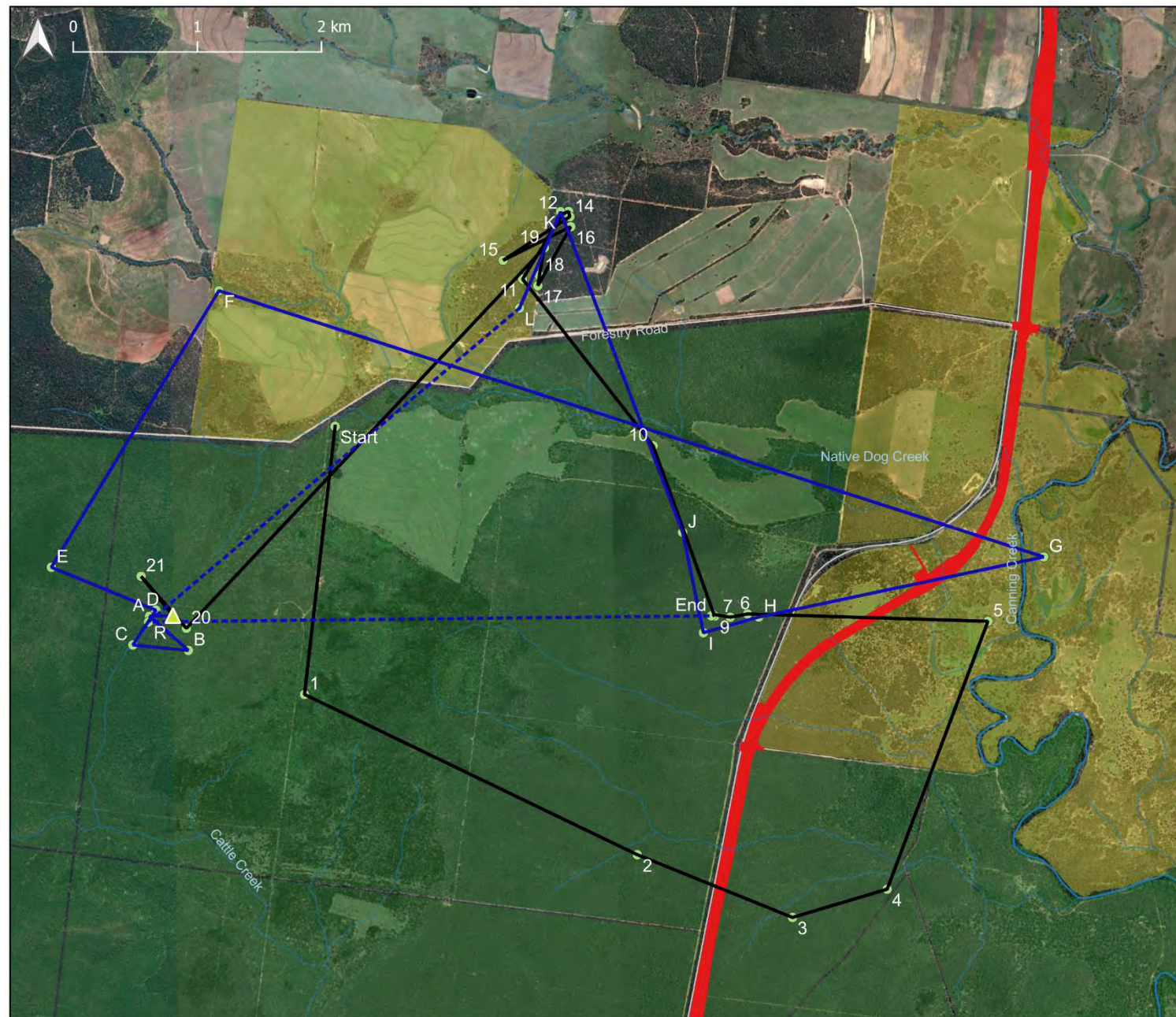


Figure: A3.2b

Title: GPS tagged bat 284 -
2 nights GPS data

Project: Microbat Surveys and
Research, Inland Rail

Client: ARTC

Drawn: EW 12/06/2023

LEGEND

Watercourses

Key roads

284 GPS foraging points

284 Roosts

Foraging routes

Night 1 foraging

Night 2 foraging

Night 2 foraging - incomplete

ARTC Data

Inland Rail footprint

Canning Creek property

Protected Areas

Bringalily State Forest

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Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56

Figure: A3.2c

Title: B2G Radiotagged bat data points

Project: Microbat Surveys and Research, Inland Rail

Client: ARTC

Drawn: EW 12/06/2023

LEGEND

Watercourses	
Key roads	
Release point	
Roosts	
Tags removed	
Incomplete route	

Tagged bats

165	
427	
633a	
633b	
845	
913a	
913b	

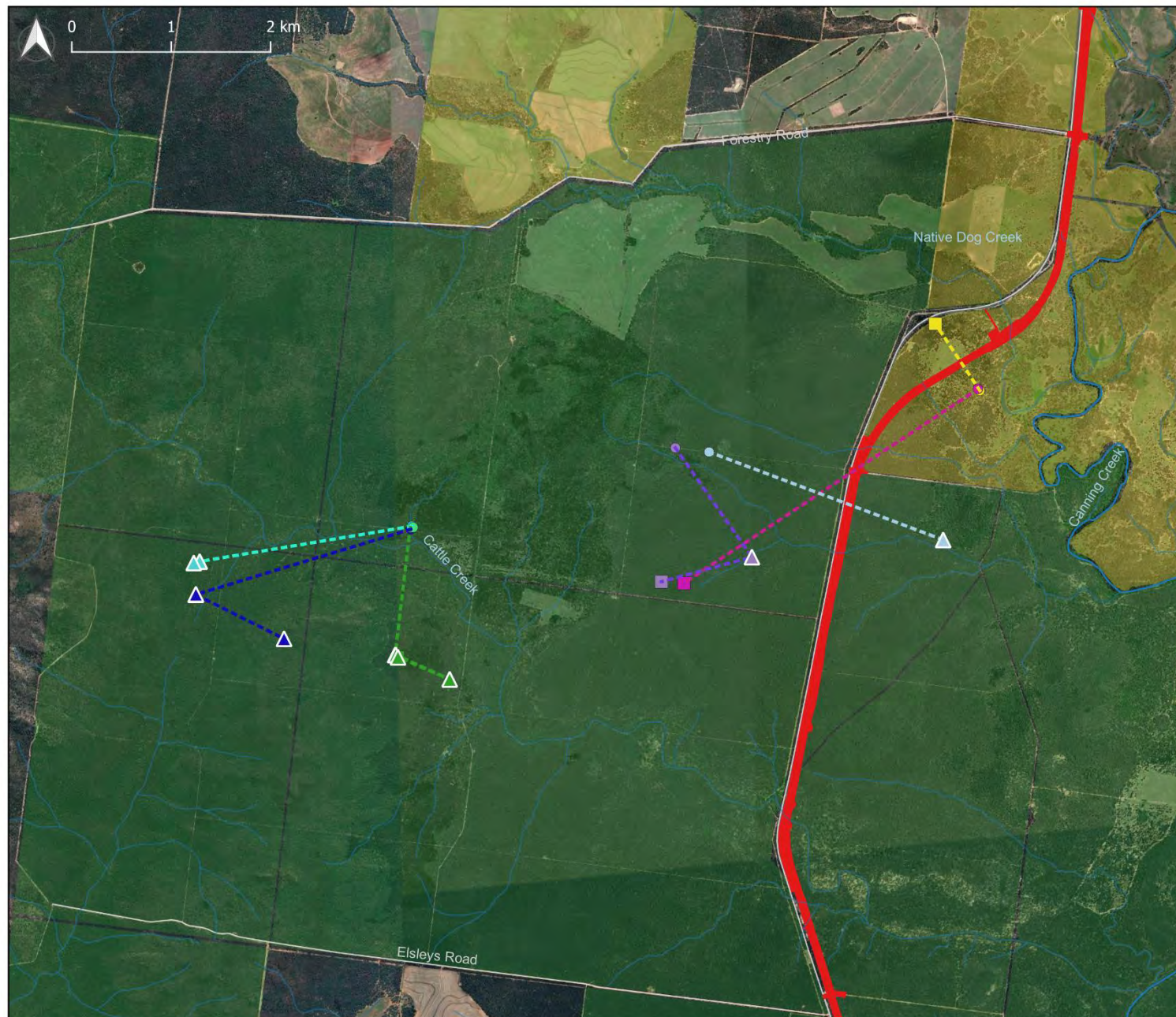
ARTC Data

Inland Rail footprint	
Canning Creek property	

Protected Areas

Bringalily State Forest	
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Data sources: ARTC Inland Rail alignment and offset property April 2023; Qld Gov Populated Places; Qld Gov Watercourse Lines; Qld Gov Protected Areas; Qld Gov Roads and Tracks; ; WMS Ausmaps / Google; Coordinate System: GDA2020 Zone 56



Koala Genetics Study Project

Inland Rail Program

12 March 2024

Project No.: 0628339

Signature Page

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Inland Rail Program

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Acronyms and Abbreviations

Name	Description
AEP	Annual Exceedance Probability
ALA	Atlas of Living Australia
ARTC	Australian Rail Track Corporation
N2N	Narromine to Narrabri
N2NS	Narrabri to North Star
NS2B	North Star to Border
B2G	Border to Gowrie
ELA	Eco Logical Australia
G2H	Gowrie to Helidon
H2C	Helidon to Calvert
C2K	Calvert to Kagaru
K2AB	Kagaru to Acacia Ridge/Bromelton
DAWE	Department of Agriculture, Water and Environment
DCCEEW	Department of Climate Change, Energy, the Environment and Water (formerly Department of Agriculture, Water and Environment)
DES	Department of Environment and Science
DOEMP	Draft Outline Environmental Management Plan
DTMR	Department of Transport and Main Roads
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
FFJV	Future Freight Joint Venture
GHD	GHD Group Pty Ltd
IRP	Inland Rail Program
KMP	Koala Management Plan
MNES	Matters of National Significance
OCG	Office of the Coordinator-General
RFI	Request for Information
SAT	Spot Assessment Technique
SEQ	Southeast Queensland
ul	micro litre
UniSC	University of Sunshine Coast
WSP	Williams Sale Partnership

EXECUTIVE SUMMARY

Environmental Resources Management Australia Pty Ltd (ERM) was commissioned by Australian Rail Track Corporation (ARTC) to conduct studies into koala genetics, habitat, occurrence, and utilisation across sections of the Inland Rail Program (IRP) from Narromine to Acacia Ridge/Bromelton (note: Kagaru to Acacia Ridge/Bromelton section (K2ARB) is no longer a part of the IRP) (the project area). The study was conducted along these sections of the IRP as per the scope outlined by ARTC. A collaboration has been undertaken with the University of the Sunshine Coast (UniSC) Detection Dogs for Conservation (DDC) Team to obtain genetic information from koalas across the project area. This report presents the findings and recommendations of this collaborative study project to support koala management throughout the design, construction, and operation of the IRP.

The project area for this study included properties with existing land access agreements (LAA) in place with ARTC and other publicly accessible land (road reserves, state forests and travelling stock reserves) within the IRP alignment and is situated across central-north New South Wales (NSW), from the township of Narromine north to the border, and south-east Queensland, from the border north to Toowoomba and then east to the Brisbane suburbs of Acacia Ridge and Bromelton. The final section of the rail from Kagaru to Acacia Ridge and Bromelton (K2ARB) has since been removed from the IRP, however, remains included in this study in order to provide a more robust analysis of koala genetics. The IRP involves the construction of 500km of new tracks in northern New South Wales and south-east Queensland and the upgrade of existing tracks along an additional 1600km throughout the existing inter-state line.

The IRP was separated into 13 sections at the time of the study (now reduced to 12 in response to IR review), being delivered through the planning and approvals stages as distinct projects. The genetics study focuses on eight (8) sections between the town of Narromine and Brisbane and here after these eight sections will be referred to as the IRP for the purpose of this report. Land use histories vary considerably across the eight sections of the IRP with extensive clearing for agriculture present, particularly west of the Great Dividing Range, while large areas of state forests also remain. The IRP also extends through heavily urbanised areas including the regional cities and townships of Toowoomba, Narrabri, Moree and Narromine. ARTC has identified the need to provide appropriate identification, assessment, and management of key environmental issues associated with the IRP. One such environmental issue is the presence of koalas and key areas of habitat and connectivity within the IRP and the need for innovative approaches for baseline assessment and ongoing monitoring. This forms the rationale for undertaking this koala genetic study, focusing on understanding koala occurrence and habitats, and important connectivity across the landscape, to assist in identifying key opportunities for koala management at the local and landscape scale.

Using desktop reviews and learnings from previous surveys throughout the IRP, key threats have been identified to koala populations within the IRP. These include:

- Habitat loss and degradation (including habitat fragmentation, edge effects and barrier effects);
- Injury or mortality from vehicle strike;
- Injury or mortality from train strike;
- Injury or mortality from predators, including domestic dogs, foxes and dingoes;
- Prevalence of disease (as well as increased susceptibility); and
- Extreme weather events (drought, flood, heat stress).

To more effectively identify important areas of koala habitat within the IRP, hotspots of potential koala activity were established using a combination of existing koala presence data, sourced from the Atlas of Living Australia, community groups and previous IRP surveys, and mapped areas of known koala habitat. Field verification of koala hotspots was undertaken by a range of specialists for ARTC.

Koala detection dogs provide reliable, efficient, and accurate methods for surveying large areas of the alignment. Survey locations for this study were informed by pre-fieldwork 'hotspots' of known koala activity to maximise detection of fresh koala scats.

A total of 120 detection dog surveys were undertaken throughout the IRP at 118 locations. Of these, fresh scats and individual koalas were found at forty-one (41) sites with detections made in northern NSW and southeast Queensland. Across these sites, seventy-three (73) fresh koala scats were detected and thirty-six (36) unique individuals identified. Samples were separated into two distinct groups: coastal (those samples located east of the Great Dividing Range - Toowoomba) and inland (those samples located west of the Great Dividing Range). Twenty samples were categorised as coastal while the remaining 13 as inland.

The most common habitat type that was sampled in the study area consisted of poor to moderate quality eucalypt open forest and woodland dominated by *Eucalyptus camaldulensis* and/or *E. tereticornis* with a mixture of other notable canopy species were identified but with less consistency across sites. Other prominent habitat types were dominated by *Allocasuarina luehmanni*, *Casuarina cunninghami*, *Casuarina cristata* and *Callitris glaucophylla*. Based on a review of koala habitat assessment criteria and methods undertaken by the Australian National University (2021), many of the dominant species identified throughout the IRP are also identified as locally important koala trees within the koala management bioregions relevant to the various stages of the IRP. Important ancillary habitat trees were also present. The type of habitats that surveys were completed in were consistent with DCCEEW (previously known as DAWE) classifications of koala habitat (forests or woodlands, higher proportion of feed trees, remnant or non-remnant vegetation, and roadside or railway vegetation) (DAWE, 2022). In low koala density areas, obtaining adequate samples for analysis can be challenging. For this study, noting the limited access to land parcels for sampling, comparisons have been made with other genetic data from other studies across Queensland and New South Wales, using data held in UniSC databases. Some samples were pooled with IRP samples to form three groups along the Inland Rail alignment, while other groups were included to help contextualise the population status along the IRP alignment.

Overall, the three groups from which samples were collected in this study, compared to other groups in the larger landscape had:

- High levels of heterozygosity: Higher levels of heterozygosity equate to larger genetic diversity within a population(s), which is positive as genetic diversity is linked to both individual health and at population level, evolutionary potential; with Group 3 (B2G + G2H) higher than the other groups;
- Low levels of inbreeding and of relatedness between individuals: this suggests gene flow is currently occurring within the groups and the potential for negative impacts due to excessive inbreeding is minimal;
- Relatively small population size, with Group 3 (B2G + G2H) having a larger population size relative to other groups. This results in overall lower densities of koalas across the landscape;
- No concerns regarding sex ratio, but high chlamydia prevalence, except Group 3 which is medium prevalence (however the sample size remain very low). The ratio of males to females is not of concern for genetic health although chlamydia prevalence is high. Caution should be taken when interpreting these findings as the sample size is small; and
- Diet analysis results indicate that the diet of koalas varies between individuals and varies alongside geographic location. With a key consistency being that tree species with a higher relative abundance within a geographic location was reflected in the results of scat collected within that geographic location.

There appears to be reasonable connectedness of koala populations within the landscape, and so it is imperative that ongoing design and management measures support the ability for koalas to traverse the landscape through the maintenance of habitat connectivity. Although scat detections throughout the IRP were made across broad geographic areas with notable gaps in sample locations, further investigation of koala genetics at a broader landscape scale will be beneficial for overcoming these limitations. This approach will also enable a greater understanding of koala genetics at a broader scale and inform effective koala management and impact mitigation measures within the IRP.

1. INTRODUCTION AND PURPOSE

1.1 Background

Environmental Resources Management Australia Pty Ltd (ERM) has been engaged by Australian Rail Track Corporation (ARTC) to conduct a study into koala occurrence and genetics for the Inland Rail Program (IRP) to better manage this species during delivery of the IRP. In doing so, a collaboration has been undertaken with the University of the Sunshine Coast (UniSC) Detection Dogs for Conservation (DDC) Team to obtain genetic information from these koala populations across the IRP.

This Report provides a description of survey effort and discussion of results from the field survey effort, including the results of the genetic analysis of sampled scats and a summary of habitats sampled. The results of the field surveys have been assessed to identify areas of koala hotspots and locations where the IRP traverses landscapes where connectivity for koala should be focused to maintained connectivity for the species.

1.2 Objectives

This study aims to provide an understanding of, and contribute new knowledge to, the current status of inland koala populations. Doing so will provide valuable contributions to scientific knowledge while also aligning with the objectives of state and federal koala recovery plans to identify priority areas for threat reduction, opportunities for collaborative studying and identifying priority areas of koala habitat for protection and restoration. Following previous field assessments throughout the IRP, this study aims to extend what is currently known about koalas in the project area and results will contribute to the design and application of koala management strategies that are tailored to the local regions of the IRP. To achieve this, two primary objectives have been identified to guide study efforts:

- Provide an assessment of koala genetics for populations present along the IRP alignment, identifying genetic diversity, gene flow and population structure along the alignment; and
- Identify health characteristics such as the presence of disease, particularly Chlamydia (*Chlamydia pecorum*), in populations of koala along the IRP alignment. Although the prevalence of koala retrovirus is also an important population characteristic that informs conservation management, sampling for koala retrovirus was deemed to be beyond the scope of this genetics research as sampling fresh scat material for koala retrovirus was not thought to have provided robust and meaningful results that could positively inform koala management within the IRP.

1.3 Ecology and Existing Knowledge of the Koala

The koala, *Phascolarctos cinereus*, is a tree dwelling marsupial and is known as one of Australia's most iconic and recognisable animals. Identifiable by their stocky bodies, residual tails, and muscular limbs with sharp climbing claw, koalas will typically weigh between 4 and 15 kilograms, with males weighing up to 50% more than females (Nowak, 2005). Body weight is known to fluctuate throughout their range, with individuals in more southern extents typically weighing up to twice that of those in the north (DCCEEW 2022).

Populations are distributed across eastern and southern mainland Australia, particularly in forests on more fertile soils or with easily accessible water sources. Predominantly solitary, koalas will maintain home ranges of highly variable sizes depending on the quality of habitat available. Known estimates range from 135 ha (Ellis et al. 2002), to as little as 1 ha (Davies, et al., 2013). In the agricultural landscapes of SEQ, home ranges are known to vary between 5.3 ha and 91.4 ha (Davies, et al., 2013). Although generally considered sedentary, males are known to disperse over longer distances than females (DES 2022).

Koalas occupy a range of forest and woodland habitats however their presence is dependent on the availability of appropriate food trees. Koalas possess a highly specialised diet with only a small number of species proving appropriate food resources. These trees belong almost exclusively to the genus *Eucalyptus*, however some *Corymbia*, *Angophora* and *Lophostemon* species are also known (Youngentob, Marsh, & Skewes, 2021). While not important as food resources, ancillary tree species provide important structural habitat features that are used for thermoregulation, resting, movement and protection (Youngentob, Marsh, & Skewes, 2021). Due to the low caloric content of their diet, koalas will typically rest up to 22 hours a day (Johnson 2018), with the majority of activity being crepuscular or nocturnal. The toxicity found in eucalypt leaves is not palatable to most herbivores and so koalas maintain little to no competition for food resources (Johnson 2018).

Koalas are capable of breeding annually when conditions are favourable but is heavily influenced by seasonality, population density, food quality and availability, and climate. Reproduction will fail or not occur when conditions are unsuitable or when individuals exhibit poor physical condition (DCCEEW 2022). Like most marsupials, gestation is relatively short in koalas at approximately 30 – 36 days. Joeys are dependent on their mothers for the first 12 months of life and will remain with them until sexual maturity at 2 years old. The life expectancy for a koala is between 13 and 18 years although males may have a slightly lower survival rate than females (DCCEEW 2022).

1.3.1 Key Threatening Processes

The Southeast Queensland bioregion supports some of the largest populations of koalas in the state and habitat identified as important koala habitat extends over 6 million hectares (ha) (Fowler, Houlden, Hoebe, & Timms, 2001). On a similar note, the Northern Tablelands Koala Management Area (KMA 4) and NSW North-Coast Koala Management Area (KMA 1) are additionally important areas for koala populations. These areas contain small koala populations that are fragmented throughout, however still provide important habitat for the species. The importance of habitat is acknowledged by the Southeast Queensland Koala Conservation Strategy 2020-2025 (DES 2020), which outlined the top two actions as Habitat Protection and Habitat Restoration, followed by threat management, improved mapping, monitoring, studying and reporting, community engagement, and partnerships and strategic co-ordination. The Conservation Advice for the koala combined populations of Queensland, New South Wales and the Australian Capital Territory (12 February 2022), references a study by Adams-Hosking et al. in 2016 reflecting that the population in the Southeast Queensland region to be 15,821. This study provides an estimation of a 53% decline over three preceding generations (15-21 years).

A number of key threats to koala populations within the proposed IRP are present and have the potential to be exacerbated by its development and operation. These are:

- Habitat loss and degradation (including habitat fragmentation, edge effects and barrier effects);
- Injury or mortality from vehicle strike;
- Injury or mortality from train strike;
- Injury or mortality from predators, including domestic dogs, foxes, and dingoes;
- Prevalence of disease (as well as increased susceptibility); and
- Extreme weather events (drought, flood, heat stress).

Stressors to the environment, including heatwaves, droughts, bushfires, and floods are known to cause high mortality in koalas, as well as this, post extreme event recovery can be impaired by other threatening processes (DCCEEW 2022). The 2019-2020 “Black Summer” bushfires effected koala populations from south-east Queensland down to eastern Victoria. Literature estimates that the catastrophic event had immense impacts to koala populations along the east coast of Australia (Dunstan et al., 2021, Cristescu et al., 2021, Phillips et al., 2021).

Although the black summer fires had devastating effects to koala populations, recent studies have shown in some areas within three months of the fire event koalas are able to live wholly within a burnt habitat, being able to disperse through a previously burnt area that was severely impacted from fire (Matthews et al., 2007, M. Lane and K. Marsh). This information was recorded from GPS trackers and observations of fresh scat in burnt habitat. Overall, scientific literature suggest that scale and severity of fire has a large influence of the effects to both koala individuals / populations and their respective habitat, however, even high severity fire does not necessarily render a landscape as unusable habitat to a koala (Law et al., 2022b).

Koala populations have experienced significant declines in recent decades following wide scale deforestation and habitat fragmentation. (Seabrook, McAlpine, Phinn, Callaghan, & Mitchell, 2003). Agriculture, mining and urbanisation are significant drivers of this change in land use and in the Southeast Queensland bioregion large areas of remnant forests have been removed since 2000 (de Oliveira, Murray, de Villiers, & Baxter, 2014). Within the area covered by the IRP, historic land clearing, largely for agricultural purposes has been undertaken. Within the IRP, the vegetation quality varies considerably between remnant forests to low-lying cleared flood plains.

Vehicle related mortality and domestic and wild dog attacks pose significant impact to koala populations (de Oliveira, Murray, de Villiers, & Baxter, 2014). Mortality from these occurrences typically remove healthy breeding individuals, posing a threat to juvenile koala dispersal post-weaning (occurring in both males and females). Mature males are at higher risk due to larger home ranges and increased activity during the breeding season, with males typically dispersing more frequently and over larger distances than females. Although males have a higher risk of mortality and will disperse more frequently, losses of any individual to this trauma have the potential to negatively affect or even disrupt gene flow (DCCEE 2022).

Disease can be a major contributor to population decline and population viability, with wild populations carrying disease pathogens (DCCEE 2022). Quigley and Timms (2020) identifies the two major pathogens affecting koalas as *Chlamydia pecorum*, leading to chlamydial disease and koala retrovirus (KoRV). The significant impact of disease, particularly from Chlamydia and KoRV, is routinely highlighted in koala literature (Grogan, et al., 2017; McCallum, Kerlin, Ellis, & Carrick, 2017; Polkinghorne, Hanger, & Timms, 2013) therefore presenting a need to include it as a threat that needs to be mitigated for the IRP. Narayan (2019) reflects on the presence of population instability in the face of human-induced environmental changes, which may lead to reduced genetic variability of wild koalas and increases in population vulnerability to diseases. While it is not known to what extent these diseases currently impact the koala population within the IRP, it can be assumed that the risks associated with disease transmission remain high for the population.

1.4 Assessing Koala Genetics to Inform Management

Current understanding of koala abundance at local scales is limited across their distribution and the differentiation of distinct populations of koalas is difficult due to limited genetic data. A lack of consistent monitoring methodologies has also led to a high level of uncertainty at a bioregional scale that limits opportunities to implement effective management strategies (Adams-Hoskins, et al., 2016). Understanding population genetics at the local scale provides valuable insight into population health, patterns of dispersal and gene flow, and population stability in the face of current and future threatening processes. While it is beyond the scope of this study to identify distinct populations of koalas along the IRP alignment, this study will provide a locally specific investigation of genetic diversity that is important for informing future management for koalas along the IRP.

2. PROJECT AREA DESCRIPTION

The IRP will provide a service for the interstate freight market that is reliable and competitive in price and availability relative to road transport. The Australian Government has engaged ARTC to deliver the 1600 km long IRP through enhancements and upgrades of the existing inter-state line, and 500 km of new track in northern New South Wales and south-east Queensland.

The focus of this Report is on the sections of IRP from Narromine, New South Wales to Acacia Ridge/Bromelton, Queensland. This portion of the IRP is broken up into eight sections: Narromine to Narrabri, Narrabri to North Star, North Star to Border, Border to Gowrie, Gowrie to Helidon, Helidon to Calvert, Calvert to Kagaru, Kagaru to Acacia Ridge and Bromelton. Each of these sections of the IRP crosses varying landscape and as such can be elaborated on below and shown in Figure 2-1.

2.1 QLD Inland Rail Project Sections

Kagaru to Acacia Ridge and Bromelton (K2ARB)

The K2ARB was the last section of the IRP, however the planned 49 kilometres of existing track upgrades through Kagaru to Acacia Ridge and Bromelton is no longer a part of the IRP. The former K2ARB section of the IRP is still able to provide meaningful insights into koala genetics and critical habitat and so data collected from this section has been included in this koala genetics study. It is the section of the previous IRP most urbanised with pockets of vegetation consisting of nature/wildlife refuges, and road parcels having wildlife crossings or bridges to uphold connectivity for koala activity. To note it is in proximity to the Greenbank Military Reserve.

Calvert to Kagaru (C2K)

Calvert to Kagaru covers 53-kilometres of the IRP and it possesses more koala hotspots across the Teviot Range, Peak Crossing and Ebenezer localities. Outside of these biodiversity corridors the IRP passes through more highly fragmented agricultural land, dominated by pasture grasses with isolated trees or woody regrowth.

Calvert to Kagaru (C2K)

Calvert to Kagaru covers 53-kilometres of the IRP and it possesses more koala hotspots across the Teviot Range, Peak Crossing and Ebenezer localities. Outside of these biodiversity corridors the IRP passes through more highly fragmented agricultural land, dominated by pasture grasses with isolated trees or woody regrowth.

Gowrie to Helidon (G2H)

Gowrie to Helidon is the shortest section of the IRP being of 28 kilometres long yet holds significance to the IRP, being intersected by the Toowoomba Range, a known koala hotspot and biodiversity corridor. Outside of this mountain range native viable habitat is highly fragmented and compromised by grazing lands.

Border to Gowrie (B2G)

Border to Gowrie, a 217-kilometre section (including 9 km of North Star to Border (NS2B)) of the IRP moving through South-East Queensland and reflecting a continuation of the detriment of agricultural practises and urbanised land, with extensive grazing areas intersected by State Forests. Riparian zones, notably the Condamine River, are of high value for koala activity.

2.2 NSW Inland Rail Project Sections

North Star to Border (NS2B)

North Star to Border, a 39-kilometre stretch (30 km in NSW and 9 km in QLD) reaching the border of NSW and Queensland. This section of the IRP also is suffering the harsh effects from land modified for agricultural practises with large tracts of remnant vegetation rare and most native vegetation in isolated woodland re-growth pockets and in a degraded state. Koala activity is linked to riparian habitat of drainage lines and on the banks of the Macintyre River.

Narrabri to North Star (N2NS) (Phase 2)

Narrabri to North Star section is 187 kilometre long, however, this study is only concerned with Phase 2 upgrading 13-kilometres of existing railway between Moree and Camurra, then building upon 2-kilometres of new track across the Mehi-Gwydir floodplain. The rail corridor and surrounding area has been heavily affected by agricultural activities with 'patches' of native woodland vegetation existing sporadically. Koala sightings have especially been associated with riparian corridors including the Mehi River and Gwydir River, Traveling Stock Reserves (TSRs) and isolated road parcel trees.

Narromine to Narrabri (N2N)

Narromine to Narrabri is a 306 km stretch of the IRP in Northern NSW. Much of this portion of the IRP is fragmented woodland habitat altered for agricultural purposes like running livestock or growing crops. The most northern section is dominated with state forests of The Pilliga, with historic records indicating koala presence by Etoo Creek.



Legend

Inland Rail Alignment

B2G - NSW/QLD Border to Gowrie

C2K - Calvert to Kagaru

G2H - Gowrie to Helidon

H2C - Helidon to Calvert

K2AB - Kagaru to Acacia Ridge/Bromelton

N2N - Narramine to Narrabri

N2NS - Narrabri to North Star

NS2B - North Star to Border

LGA Boundary

Data Source:

ESRI World Topographic Map

ARTC Koala Genetics Study IRP Area

Drawing No: 0628339_N2AB_TM_G001_R2.mxd

Date: 14/02/2024

Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

Drawing Size: A4

Reviewed By: MD

0 10 20 30Km

N

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Koala Genetics Study Project – Inland Rail Program (NSW and QLD)

Client: ARTC

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F2-1

3. SURVEY LOCATIONS

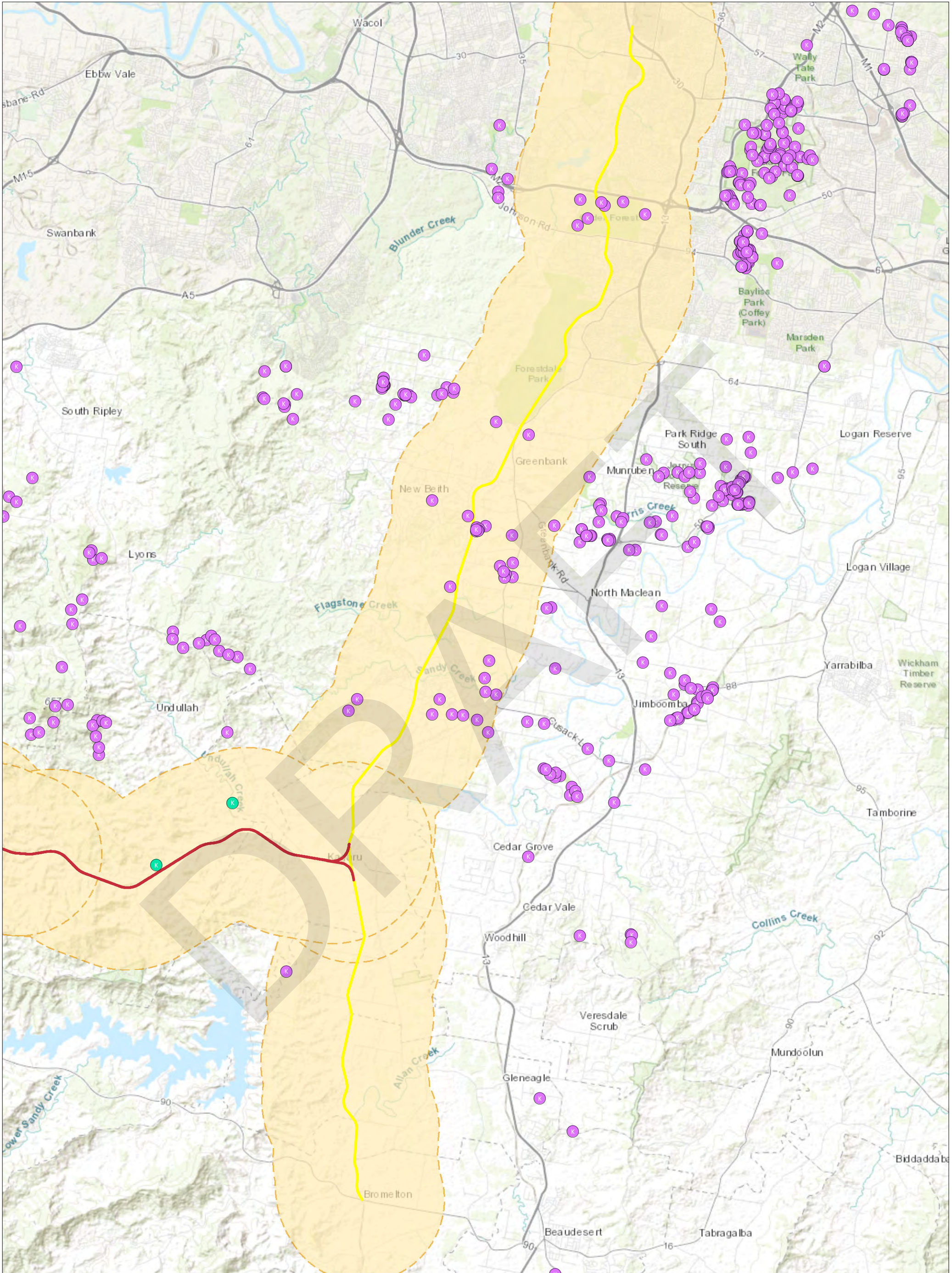
As the ARTC IRP operates across a wide geographic area, koala 'hotspots' were selected throughout the alignment and searching for scat was undertaken at each location. This provides suitable coverage across the entire IRP, while maximising the time spent in the field to collect samples.

Using Queensland and NSW state koala habitat mapping and historic koala presence data from ALA, BioNet and WildNet and previous surveys for the IRP (Figure 3-1), potential koala hotspots were identified. Hotspots were defined as those areas containing both a high abundance of historic presence records and potentially suitable habitat for either koala foraging or dispersal. These hotspots were used to identify potentially important locations to be ground-truthed through this genetics study. Only areas within the IRP where land access agreements could be obtained were included in desktop and field-based surveys.

Identifying these pre-fieldwork 'hotspots' of activity, based on koala observations, rather than only sampling habitat types, was chosen to maximise detectability while also providing adequate coverage of IRP. The delineation of koala hotspots is based on triangulating; known areas of high koala activity, previous data acquired from Environmental Impact Statements across the IRP and quality of habitat at each site. The table below outlines pre-fieldwork 'hotspot' locations for each section of the IRP and thus survey effort required. The location of these survey points is shown across the entire IRP in Figure 3-1.

Table 3-1 Pre-fieldwork koala hotspot locations and number per project

Project and length	Number of Pre-fieldwork hotspot locations per Inland Rail Project
Narromine to Narrabri (306km)	7
Narrabri to North Star (187km)	9
North Star to Border (39km)	4
Border to Gowrie (207km)	10
Gowrie to Helidon (28km)	3
Helidon to Calvert (47km)	2
Calvert to Kagaru (53km)	4
Kagaru to Acacia Ridge and Bromelton (49km)	3
Program-wide combined Narromine to ARB	42



- Legend**
- 3km Buffer Along The IRP Alignment
 - Inland Rail Alignment**
 - Koala Records (Australian Living Atlas)
 - C2K - Calvert to Kagaru
 - C2K Koala Observations (FFJV)
 - K2AB - Kagaru to Acacia Ridge/Bromelton

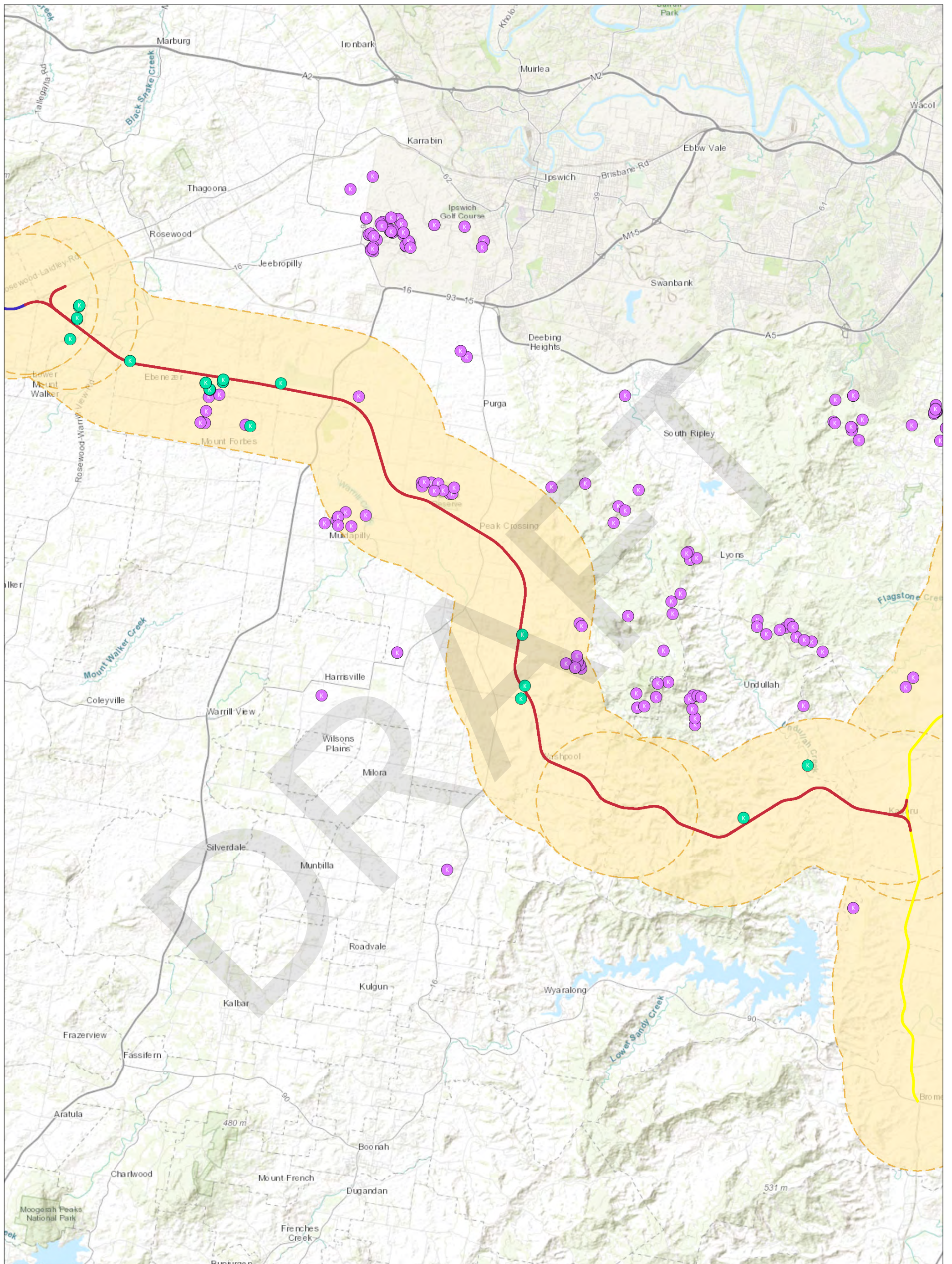
Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		Client: ARTC
0 2 4Km 		
N 		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F3-1a





Legend

-  3km Buffer Along The IRP Alignment
-  Koala Records (Australian Living Atlas)
-  C2K Koala Observations (FFJV)
- Inland Rail Alignment**
- C2K - Calvert to Kagaru
-  H2C - Helidon to Calvert
-  K2AB - Kagaru to Acacia Ridge/Bromelton

Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd

Date:	14/02/2024
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Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

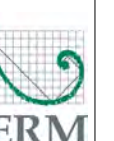
A horizontal scale bar with three segments. The first segment is labeled '0', the second '2', and the third '4Km'.

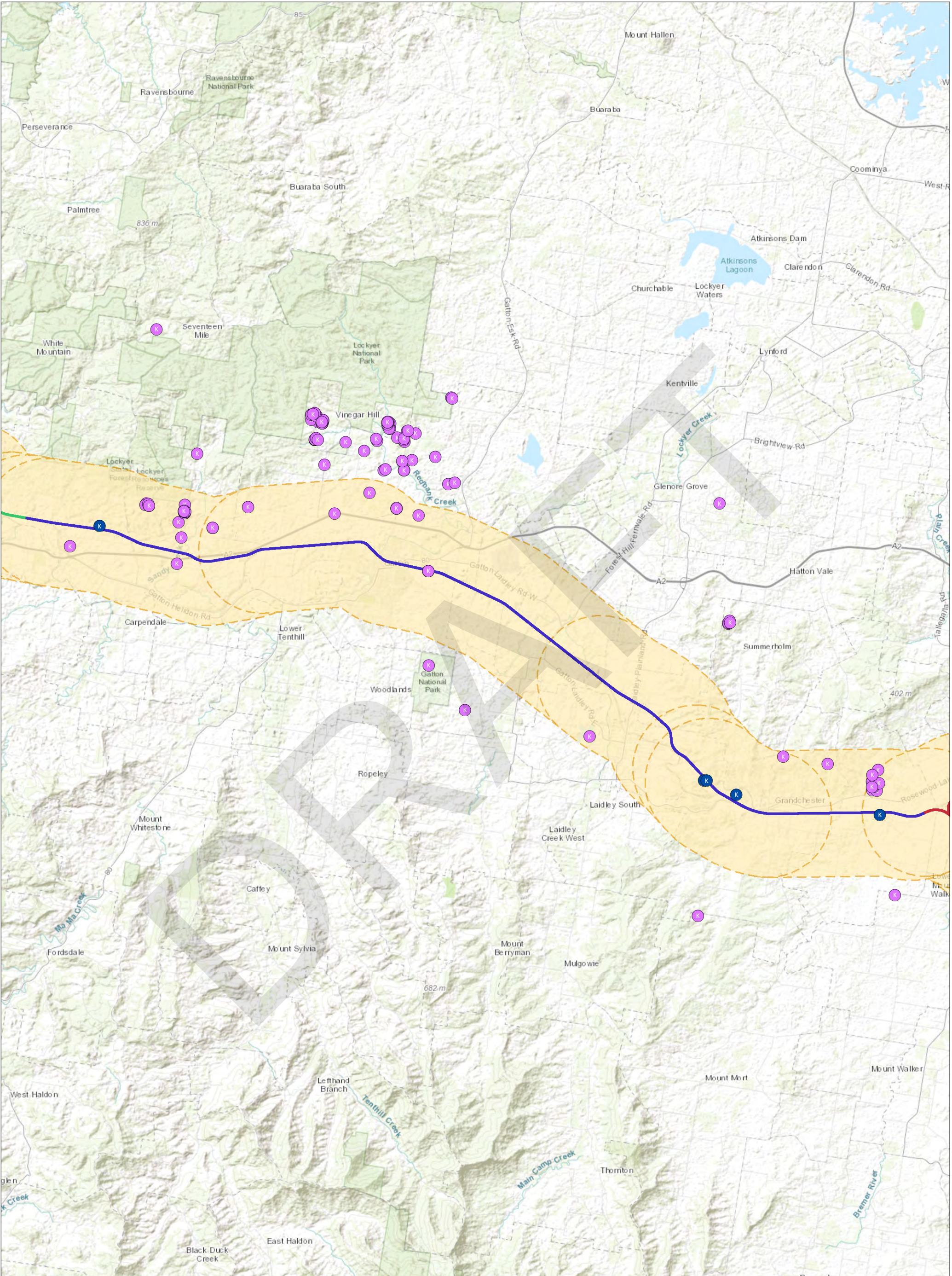
Koala Genetics Study Project – Inland Rail Program
(NSW and QLD)

Client: ARTC

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F3-1b





Legend

3km Buffer Along The IRP Alignment

Koala Records (Australian Living Atlas)

H2C Koala Observations (FFJV)

Inland Rail Alignment

C2K - Calvert to Kagaru

G2H - Gowrie to Helidon

H2C - Helidon to Calvert

Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd

Date: 14/02/2024

Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

Drawing Size: A4

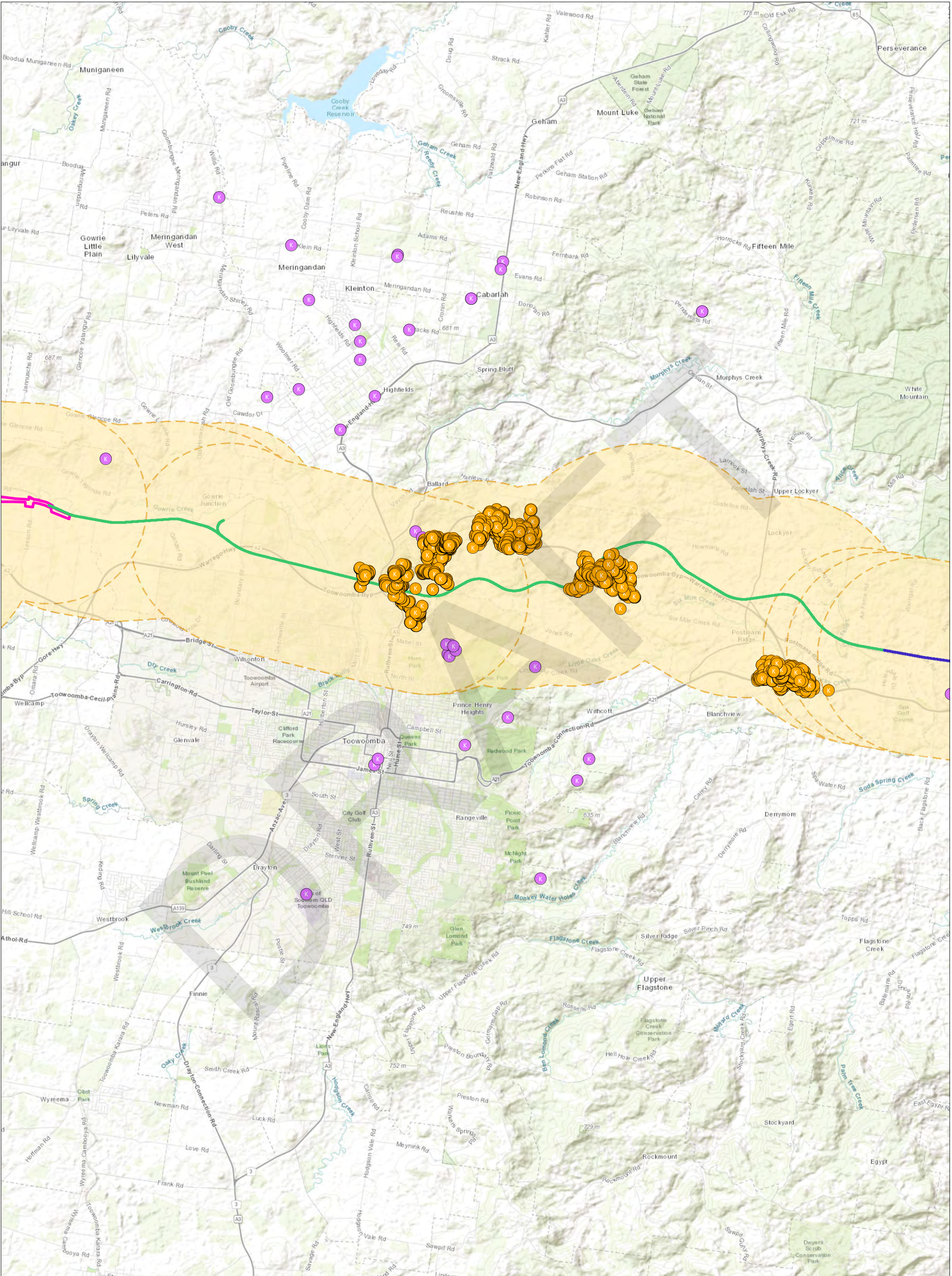
Reviewed By: MD

Koala Genetics Study Project – Inland Rail Program (NSW and QLD)

Client: ARTC

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F3-1c



Legend

3km Buffer Along The IRP Alignment

Koala Records (Australian Living Atlas)

G2H TSRC Koala Tracking (DTMR)

Inland Rail Alignment

B2G - NSW/QLD Border to Gowrie

G2H - Gowrie to Helidon

H2C - Helidon to Calvert

Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd

Date: 14/02/2024

Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

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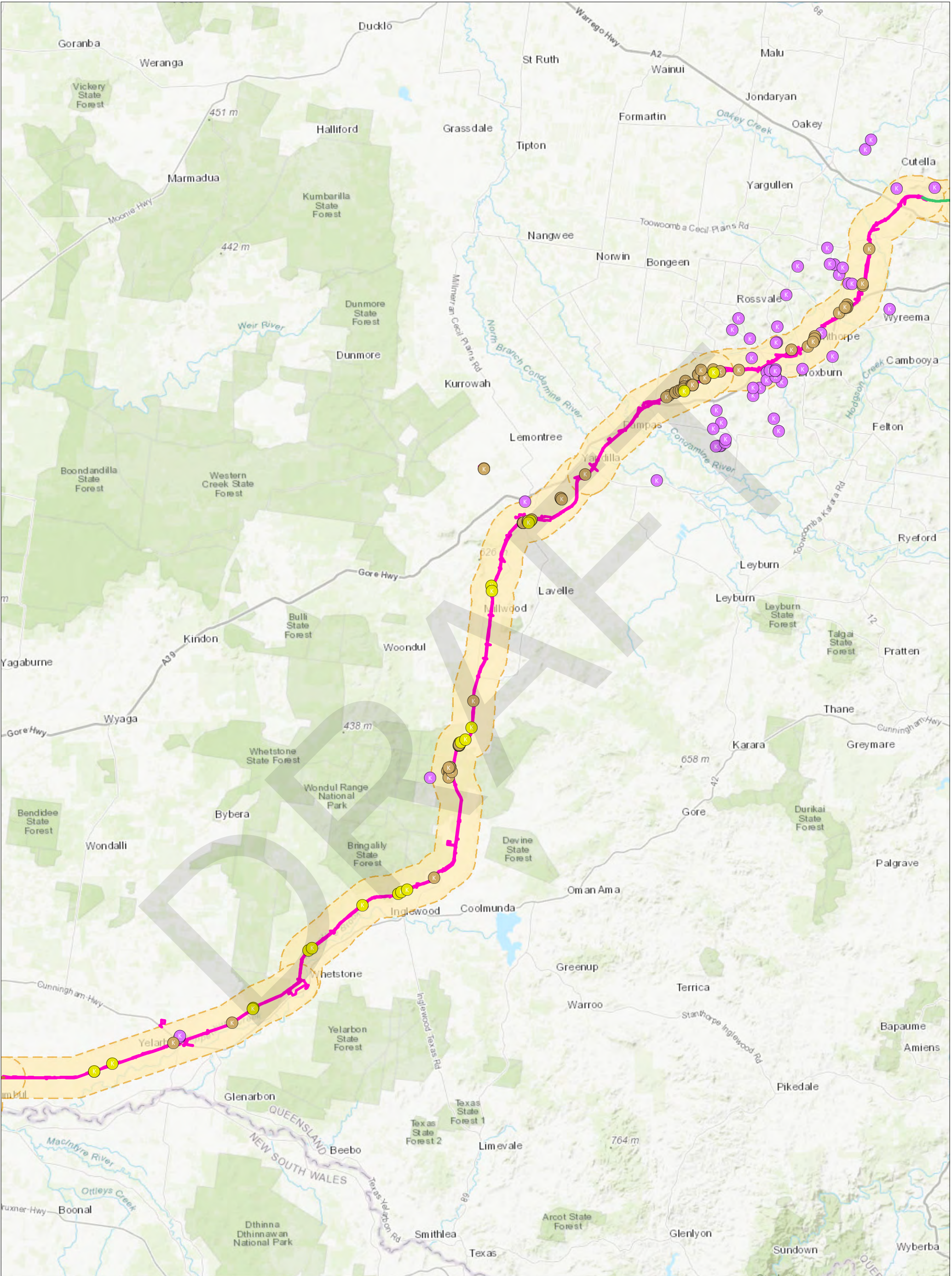
Reviewed By: MD

Client: ARTC

024km

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F3-1d



Legend

3km Buffer Along The IRP Alignment

Koala Records (Australian Living Atlas)

B2G Koala Observations (Ausecology)

B2G Koala Observations (Cardno)

Inland Rail Alignment

B2G - NSW/QLD Border to Gowrie

G2H - Gowrie to Helidon

NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd

Date: 14/02/2024

Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

Drawing Size: A4

Reviewed By: MD

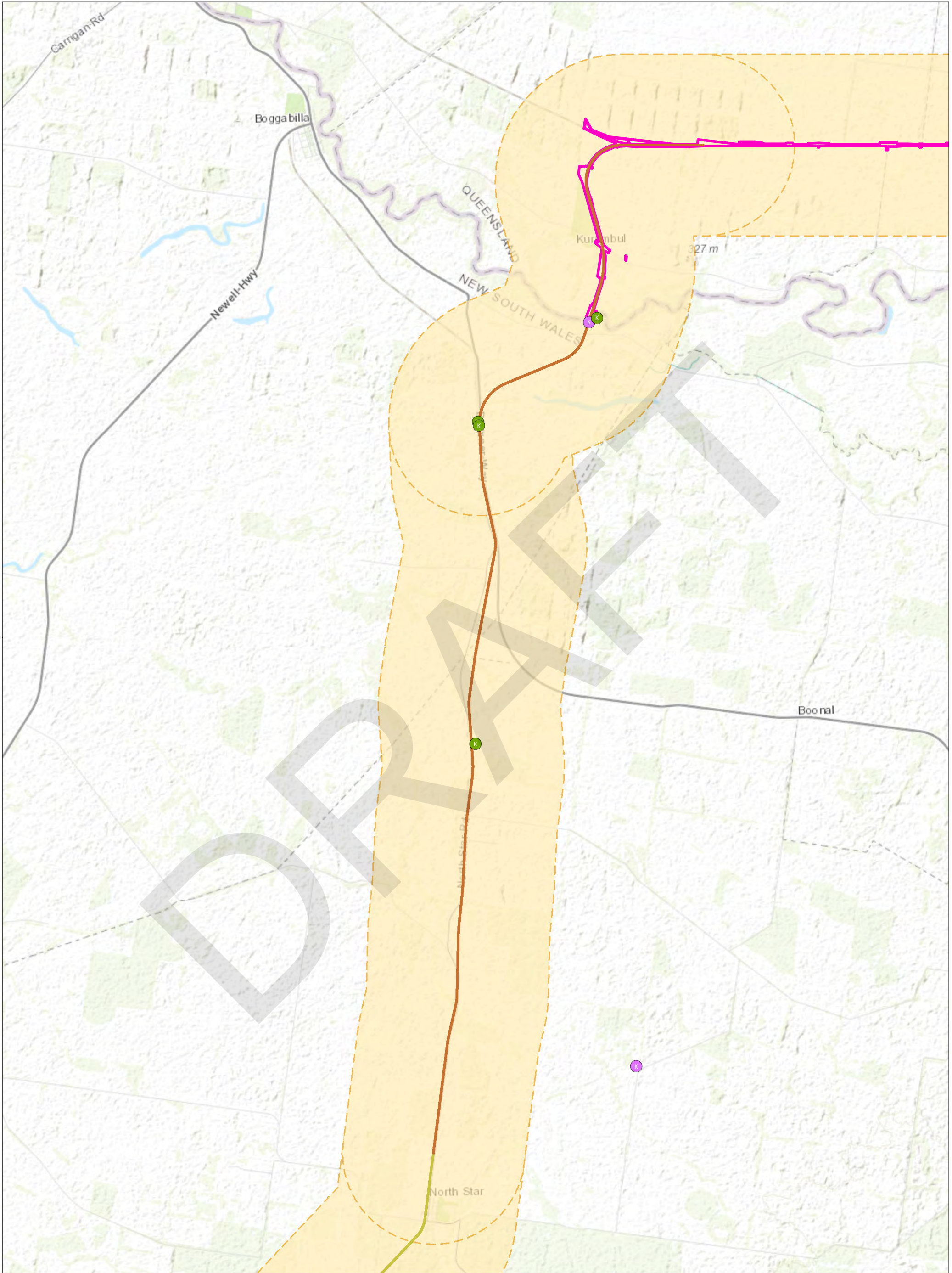
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ERM

F3-1e



Legend

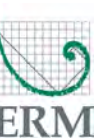
- 3km Buffer Along The IRP Alignment
- Koala Records (Australian Living Atlas)
- NS2B Koala Observations (FFJV)
- Inland Rail Alignment
- B2G - NSW/QLD Border to Gowrie
- N2NS - Narrabri to North Star
- NS2B - North Star to Border

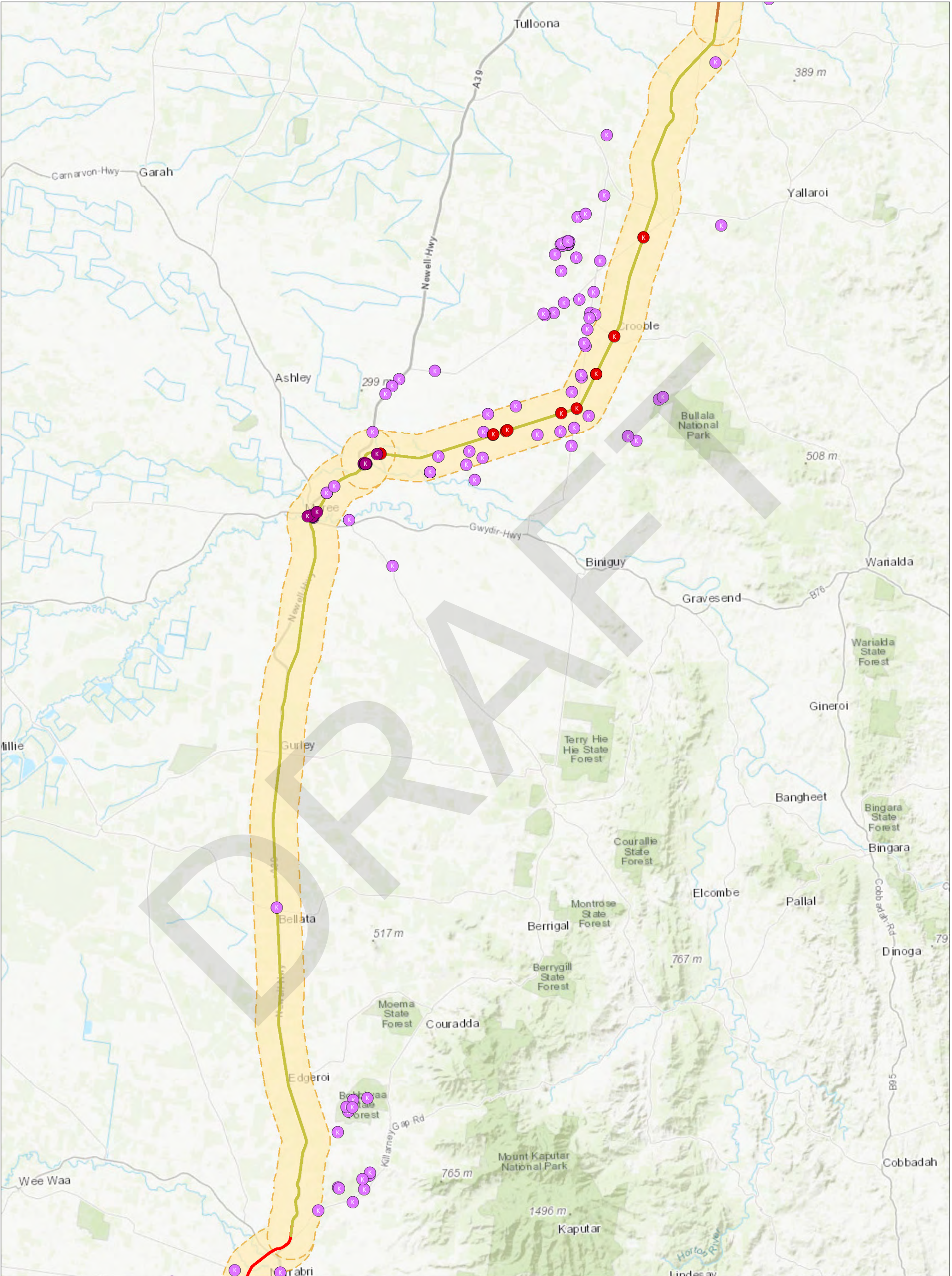
Data Source:
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Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		Client: ARTC
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F3-1f





Legend

3km Buffer Along The IRP Alignment

Koala Records (Australian Living Atlas)

N2NS SP2 Observed Koala Sightings (BDAR)

N2NS Koala Records (Umwelt/GHD)

Inland Rail Alignment

N2N - Narramine to Narrabri

N2NS - Narrabri to North Star

NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd

Date: 14/02/2024

Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

Drawing Size: A4

Reviewed By: MD

0

2

4

Km

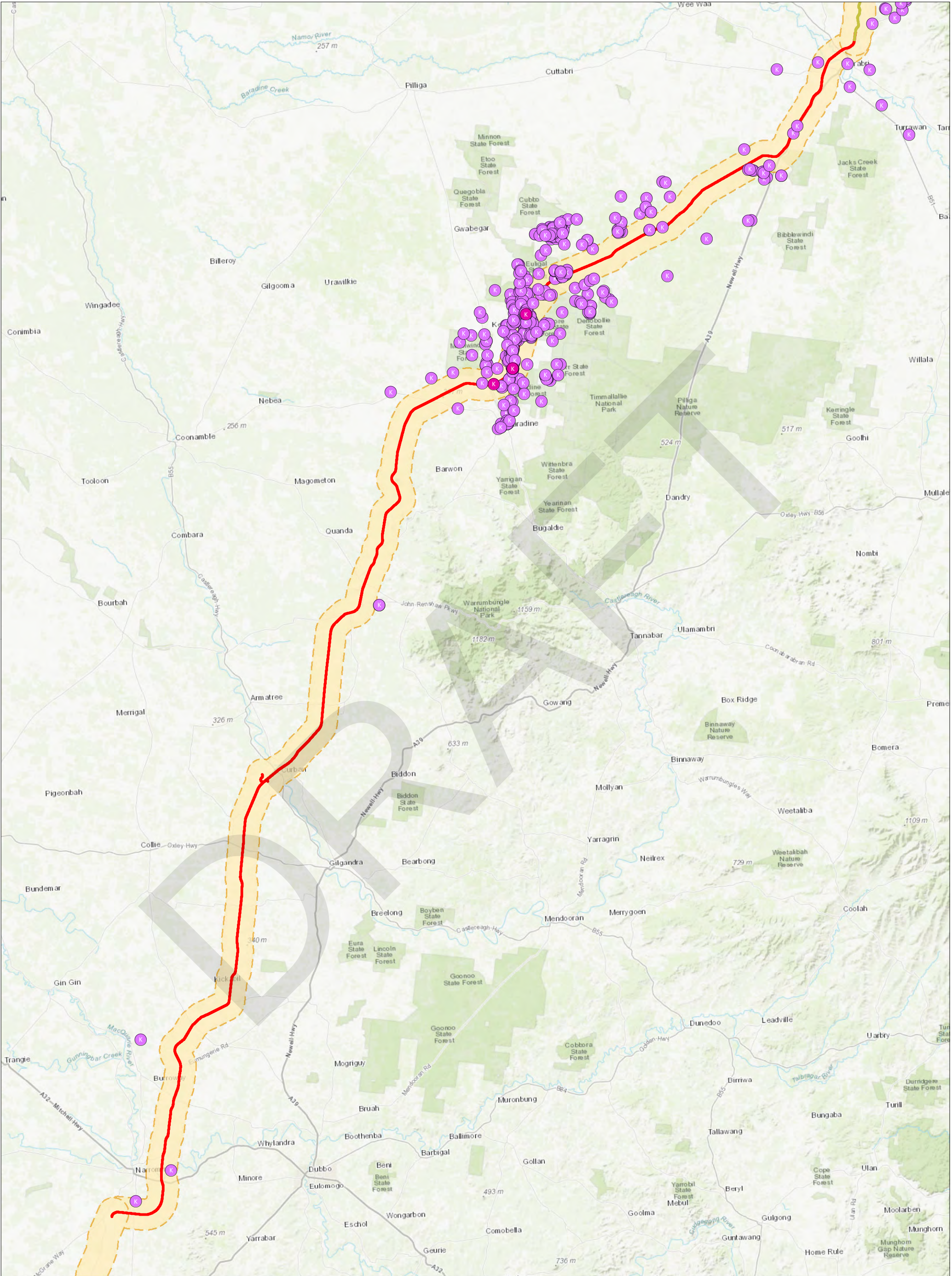
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ERM

F3-1g



Legend

3km Buffer Along The IRP Alignment

Koala Records (Australian Living Atlas)

N2N Koala Observations (GHD)

Inland Rail Alignment

N2N - Narramine to Narrabri

N2NS - Narrabri to North Star

Data Source:
ESRI World Topographic Map

Location of Koala Records across IRP Area

Drawing No: 0628339_N2AB_TM_G002_R3.mxd

Date: 14/02/2024

Drawn By: VN/CB

Coordinate System: GDA2020 MGA Zone 56

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Koala Genetics Study Project – Inland Rail Program (NSW and QLD)

Reviewed By: MD

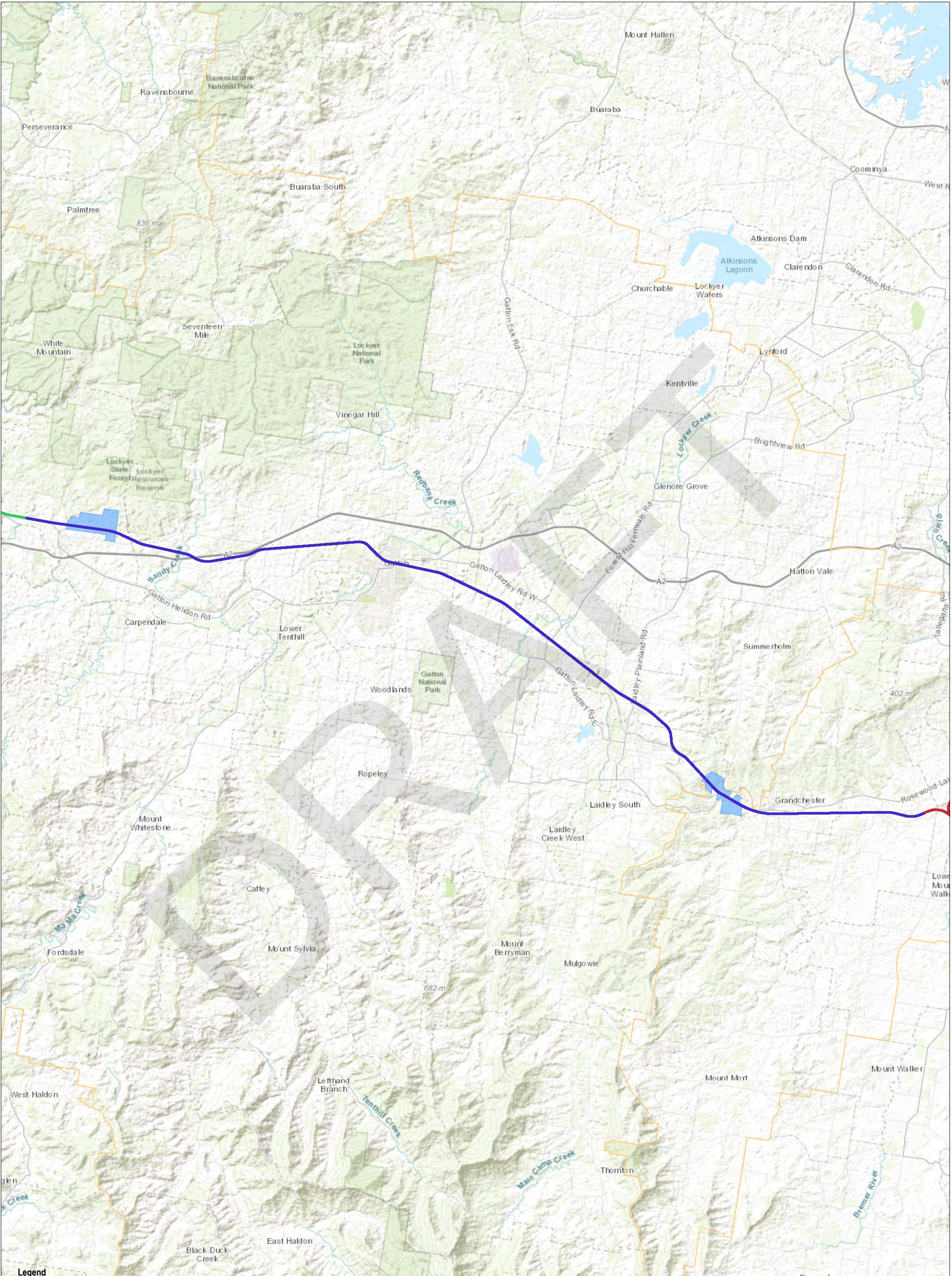
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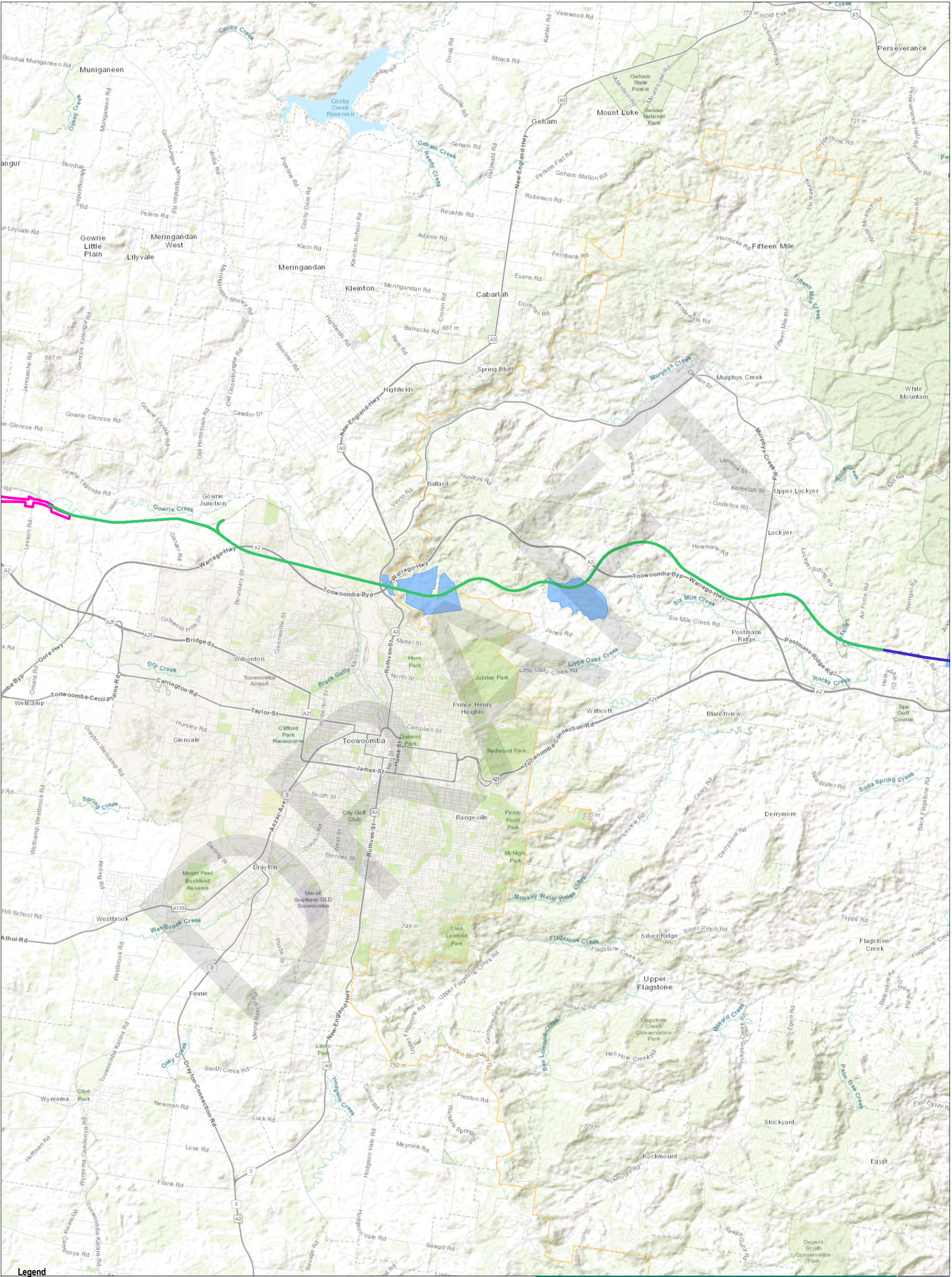
F3-1h



- Legend**
- Pre-fieldwork Hotspots
 - Inland Rail Alignment**
 - C2K - Calvert to Kagaru
 - G2H - Gowrie to Helidon
 - H2C - Helidon to Calvert
 - LGA Boundary

Data Source:
ESRI World Topographic Map

Location of Pre-Fieldwork Koala Hotspots across IRP Area			F3-2c
Drawing No: 0628339_N2AB_TM_G003_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC	
Drawn By: VN/CB	Reviewed By: MD		
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy. 	
0 2 4Km 			



Legend

- Pre-fieldwork Hotspots
- Inland Rail Alignment**
- B2G - NSW/QLD Border to Gowrie
- G2H - Gowrie to Helidon
- H2C - Helidon to Calvert
- LGA Boundary

Data Source:
ESRI World Topographic Map

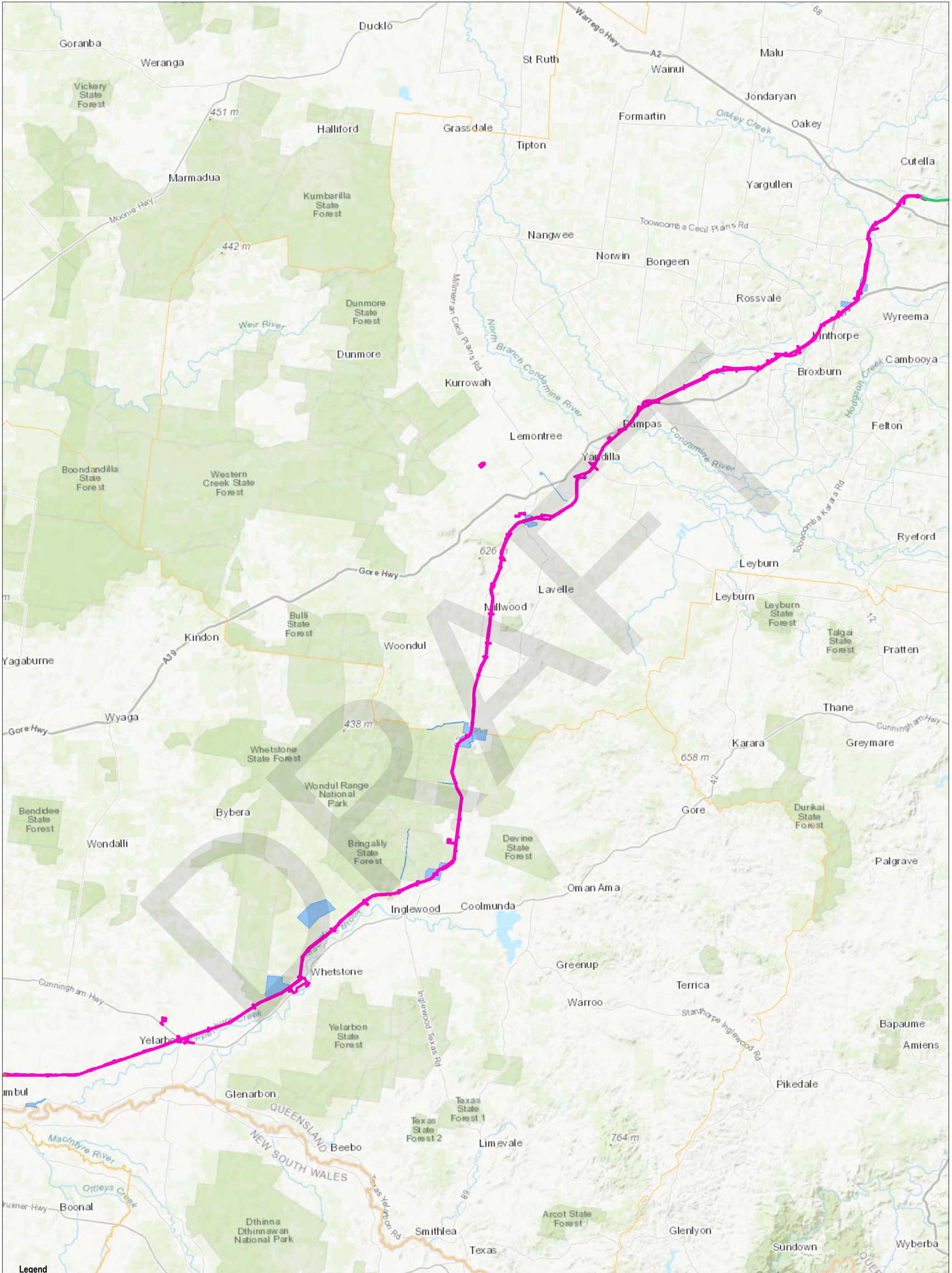
Location of Pre-Fieldwork Koala Hotspots across IRP Area

Drawing No: 0628339_N2AB_TM_G003_R3.mxd	Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
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Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		
024km N ↑		

F3-2d



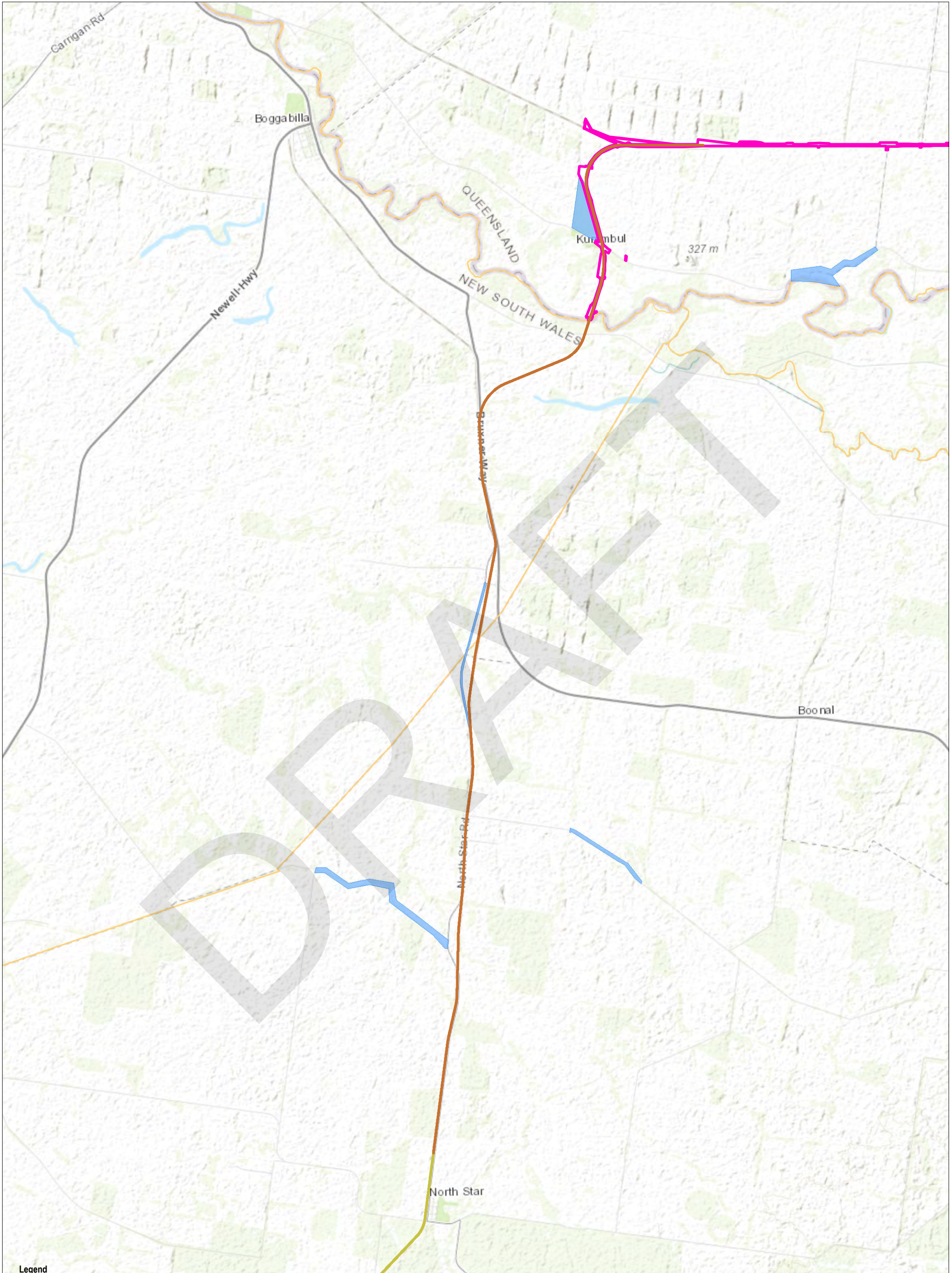
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- Legend**
- Pre-fieldwork Hotspots
 - Inland Rail Alignment**
 - B2G - NSW/QLD Border to Gowrie
 - G2H - Gowrie to Helidon
 - NS2B - North Star to Border
 - LGA Boundary

Data Source:
ESRI World Topographic Map

Location of Pre-Fieldwork Koala Hotspots across IRP Area		F3-2e
Drawing No: 0628339_N2AB_TM_G003_R3.mxd		
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
0 2 4km		



- Legend**
- Pre-fieldwork Hotspots
 - Inland Rail Alignment**
 - B2G - NSW/QLD Border to Gowrie
 - N2NS - Narrabri to North Star
 - NS2B - North Star to Border
 - LGA Boundary

Data Source:
ESRI World Topographic Map

Location of Pre-Fieldwork Koala Hotspots across IRP Area

Drawing No: 0628339_N2AB_TM_G003_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		
024Km 		N 
		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F3-2f





- Legend**
- Pre-fieldwork Hotspots
 - Inland Rail Alignment**
 - N2N - Narramine to Narrabri
 - N2NS - Narrabri to North Star
 - NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

Location of Pre-Fieldwork Koala Hotspots across IRP Area

F3-2g

Drawing No: 0628339_N2AB_TM_G003_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)		
Date: 14/02/2024	Drawing Size: A4	Client: ARTC		
Drawn By: VN/CB	Reviewed By: MD			
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.		
024Km				



4. METHODOLOGY

4.1 Previous Survey Effort

Prior to the field surveys conducted by ERM, several field surveys have been completed to inform various stages of the IRP development process. A summary of these additional surveys can be seen in Table 4-1 below. Koalas and koala scats and tracks were confirmed throughout the IRP. Critical habitat has also been verified with ground-truthed vegetation surveys undertaken for the developmental process.

Table 4-1 Summary of previous survey effort

Inland Rail Section	Consultant	Timing of Surveys	Survey types	Scat Detection	Koala detection
N2N	GHD	- September and November 2018; - March, August, September, October 2019; - February 2022	- Active searches; - Spotlighting; - Call Playback; - Thermal Drone imaging	Yes	Yes
N2NS (Phase 2)	NGH	- December 2015; - December 2019; - February 2020	- Koala SAT searches; - Spotlighting	Yes	Yes
NS2B	FFJV	Between October 2018 and October 2019.	- Call Playback; - Spotlight searches; - Active searches	No	Yes
B2G	ELA	April -October 2016	- Koala habitat assessments; - Koala SAT searches; - Incidental fauna observations	Yes	No
		June 2018- May 2019	- Koala habitat assessments; - Koala SAT searches; - Incidental fauna observations	Yes	No
G2H	Arup	March 2017	- Spotlighting; - Active Searches; - Koala SAT searches	Yes	No
	EMM	September 2018- May 2019	- Spotlighting; - Active Searches; - Koala SAT searches	Yes	No
	Eco logical Australia	December 2018- April 2019	- Spotlighting; - Active Searches; - Koala SAT searches	Yes	Yes
H2C	Arup/SMEC	March-June 2016	- Active Searches; - Koala SAT searches	Yes	No

Inland Rail Section	Consultant	Timing of Surveys	Survey types	Scat Detection	Koala detection
	EMM	■ September-November 2018	■ Koala habitat assessments; ■ Incidental fauna observations	Yes	No
	ELA	■ December 2018-April 2019	■ Koala habitat assessments; ■ Koala SAT searches; ■ Incidental fauna observations	Yes	No
C2K	Jacobs-GHD	■ March-May 2016	■ Koala habitat assessments; ■ Koala SAT surveys; ■ Incidental fauna observations	Yes	Yes
	GHD	■ December 2016 – February 2017	■ Active Searches	Yes	No
	EMM	■ September-November 2018	■ Incidental fauna observations	No	Yes
	FFJV	■ December – April 2019; ■ May 2019; ■ June – July 2019	■ Koala habitat assessments; ■ Koala SAT surveys; ■ Incidental fauna observations	Yes	No
K2ARB	WSP	■ May-June 2016	■ Koala habitat assessments; ■ Koala SAT surveys; ■ Incidental fauna observations	Yes	No
	ERM	■ February-May 2018 ■ January 2020	■ Koala habitat assessments; ■ Koala SAT surveys; ■ Incidental fauna observations		

4.2 Current Field Survey Effort

A total of forty (40) field days have been undertaken throughout the IRP across five (5) separate field surveys between April and December of 2022. It is important to note that conditions across the survey periods were unseasonably wet. High rainfall and moisture is known to speed up the decomposition of scat material and may have had impacts on the detectability of scat when fieldwork was undertaken directly after significant rainfall.

Table 4-2 Survey Effort for Genetics Study

Inland Rail Section	Survey effort
K2ARB	4 days
C2K	5 days
H2C G2H	6 days
B2G	8 days
NS2B	5 days
N2NS	5 days
N2N	7 days
TOTAL DAYS	40

4.3 Koala Detection Dog Surveys

The application of trained detection dogs in threatened species conservation has been identified as a highly efficient, non-invasive survey technique that consistently outperforms alternative methods while also minimising risk of additional disturbance and issues surrounding detectability. Previous studies have proven the methods capacity to accurately detect scats with dogs able to distinguish between individuals within a species, as well as closely related non-target species (Bennett, et al., 2022; Cristescu, Miller, & Frère, 2020).

The field surveys for detecting and collecting koala scats for genetic analysis were completed by a UniSC dog handler and ERM ecologist with experience in fauna surveys.

Each hotspot site was distinguished using field collected data including location name, survey unique identifying number including for each sample, GPS coordinates. A purpose-built koala database developed for the Study was used field data collection. The detection dog was fitted with a GPS collar to ensure that the survey effort for each sampling location was quantifiable. Any ecological characteristics that may have influenced the detectability and decay of scats was also recorded (example: wet areas will increase decay rates; therefore scats will be detectable for a shorter amount of time, fire also decrease scat survival time).

Surveys were performed using a fresh scat detection dog, an accurate and fast way to collect genetic material in areas where koala presence has been confirmed. This method is designed to maximise the chance of detecting fresh scat for genetic analyses in the minimum amount of time and allows for coverage of large areas. Surveys were undertaken within predefined koala hotspots where land access agreements could be established by the client. Koalas/scats detected were photographed, and fresh scat material was collected and refrigerated for genetic analysis. Any opportunistic observations of koala scats, scratches or individual koalas made on foot or from the vehicle while traveling between survey locations were also recorded. Anecdotal and historic observations made by the members of the public and property owners were collected by the DDC team.

Upon detection of a koala, three characteristics were observed using binoculars. (1) The sex of the koala, (2) any external signs of Chlamydia infection (ocular infection/conjunctivitis known as pink eyes, or urinary tract infections known as wet bottom), and (3) The presence of an ear tag showing evidence of previous veterinary care.

4.4 Diet Preference and Vegetation Assessment

Variations in nutritional value and palatability is common in koala food trees, even those species considered to be important for populations in other areas. The development of DNA profiles of local food tree species was undertaken using single nucleotide polymorphism panels for comparison with DNA extracted from koala scats – informing food tree preference to guide targeted future rehabilitation efforts.

Leaf samples were taken from established trees throughout the IRP to ensure adequate spatial coverage. Only species identified as locally important koala trees were included in the study. Two samples were collected from each tree and included mature and immature leaves, provided that adequate confidence in species identification was possible. Samples were collected from all trees where a koala or koala scat was detected as well as additional samples from areas where no detections were made.

To ensure geographic coverage throughout the range, each species was sampled from a minimum of three sites. Samples were collected from four individuals of each species present at each site. Where abundant and widespread species were present, samples were only taken to ensure accurate coverage of geographic range. This approach allowed for the prioritisation of rare or restricted species, where present, without impacting on landscape level genetic diversity.

4.5 Data Analysis

The UniSC team has developed innovative and koala specific genetic analysis techniques. The use of microsatellites for analysis is now surpassed by next generation genotyping, providing thousands of markers, increasing the definition of genetic analyses for more accurate results. Our method targets both coding and non-coding regions of the DNA and enables more reliable assessments of genetic diversity.

The development of molecular tools was built on Dr Romane Cristescu's (our nominated Genetic Study Lead) proven track record in conservation genetics, especially in developing markers for koalas, as published in the peer reviewed literature:

- *Cristescu RH, Sherwin WB, Handasyde K, Cahill V & DW Cooper (2010). Detecting bottlenecks using BOTTLENECK 1.2.02 in wild populations: the importance of the microsatellite structure. Conservation Genetics, 11:1043-1049 (IF : 2.0); and*
- *Cristescu RH, Cahill V, Sherwin WB, Handasyde K, Carlyon K, Whisson D, Herbert CA, Carlsson BJ, Wilton AN & DW Cooper (2009). Inbreeding and testicular abnormalities in a bottlenecked population of koalas (Phascolarctos cinereus). Wildlife Research, 36: 299-308 (IF: 0.7).*

Genetic information was obtained from non-invasively collected koala scats detected using a detection dog trained to detect fresh koala scat. These non-invasive survey methods are valuable for detecting low density species, avoiding unnecessary disturbance to individuals, and for efficiently and cost effectively surveying large areas (Bennett, et al., 2022).

Landscape genetic analysis provides information on the health of koala populations in terms of inbreeding, genetic diversity and landscape genetic connectivity. High levels of inbreeding puts individuals at risk of decreased fitness and may lead to increased disease susceptibility. Landscape genetic analysis can also provide unique insights into how populations are connected or isolated. Gene flow reflects not just the ability of animals to move through the landscape (i.e. landscape permeability), but also survival that contributes to the next generation. Our experienced team has demonstrated experience in the collection and analysis of genetic data, and importantly interpretation of data that will provide important insights to the IRP.

The following sections provide detailed descriptions of the data analysis methodology conducted by the UniSC team.

4.5.1 Genetic Analysis

The best DNA quality is found in very fresh koala scats (Schultz, Cristescu et al. 2018). Therefore, scats were only collected if they were estimated to be less than one week old (categories 1 and 2, Table 4-3), still presenting a shiny mucus layer and a strong smell. Scats were collected in a sterile 50 ml falcon tube without direct skin contact to avoid contamination and further degradation or loss of DNA. Samples were transferred to a -20°C freezer at the end of each survey. A total of 73 samples were collected for genetic and disease analyses from dog surveys and opportunistic koala sightings.

Table 4-3 Guide used to age koala scats in the field

Scat age categories	Age	Characteristics
1	One day old or less	Very fresh (wet mucus and smell)
2	Couple of days old	Fresh (dry shine and smell)
3	Couple of weeks	Medium fresh (dry shine or smell when broken)
4	Months old	Old (no shine, no smell)
5	More than a few months	Very old and discoloured

4.5.1.1 DNA Extraction

All samples were processed for extraction of both koala and *Chlamydia* DNA. The protocol of Schultz et al. (2018) was followed to isolate DNA from koala scats. The QIAamp PowerFecal Pro DNA Kit (Qiagen) was used following the manufacturer's instructions. An additional one-hour incubation step (65° C) after adding the buffer to the faecal sample was added and samples were vortexed for seven minutes at maximum speed using Genie 2 Vortex Mixer (Scientific Industries). Final DNA isolates were eluted in 200 ul of elution buffer and concentrated down to a volume of ~ 30 ul. The amount of DNA present in extracted samples (both koala and foreign) was determined using the Thermo Scientific NanoDrop 2000 Spectrometer (Thermo Fisher Scientific, Victoria). Extracted DNA was stored at -80°C until being shipped to Diversity Arrays Technology (DART, Canberra).

4.5.1.2 Genotyping

DNA aliquots were genotyped using a next-generation sequencing protocol for detecting single nucleotide polymorphisms (SNPs) by DART (Kilian, Wenzl et al. 2012). For samples collected during this study, DARTag was used as a targeted approach involving a specifically designed molecular probe panel (koala specific capture probes) to select small target regions containing sequence variants. A total of 4,393 koala SNPs were genotyped. Sex and *Chlamydia* specific markers were also genotyped as an extra step.

To increase sample size and improve our ability to conduct more broad-scale genetic analyses, we increased our dataset by including data from samples genotyped in previous studies using the DARTcap method. DARTcap is a selective step after complexity reduction to genotype specific markers from DARTseq representations with the help of capture probes, which is a cost-efficient method that combines DARTseq and sequence capture techniques. The DARTcap method differs from DARTag in that genotyping is selective and restricted to specific markers selected from the DARTseq representation, but only producing approximately 2,000 SNPs for koalas. In comparison, DARTag also targets many markers, but is not restricted to markers identified by the DARTseq platform. Because SNPs generated by DARTcap and DARTag are from corresponding regions, we were able to co-analyse DARTag data generated during this study with DARTcap data generated in previous studies. The improved dataset allowed for more robust genetic analyses.

4.5.1.3 Filtering of genetic data

When working with non-invasive scat samples, genotyped data is filtered to improve the quality of the dataset by removing samples with too little data (low *individual call rate*) as well as SNP loci that were not called across most samples (low *locus call rate*). The thresholds for these filters can be adjusted depending on the type of analysis, e.g., only few loci are needed for identifying unique individuals, however many high-quality loci are needed for measuring genetic diversity. Therefore, different filtering regimes are applied for different analyses. Constant thresholds are also applied to remove potentially erroneous loci. This includes filtering for allele read depth (minimum threshold of 5) and minor allele frequency (MAF, minimum threshold of 0.01) and loci appearing on the same contig as another (*secondary loci*). Given that filtering can result in previously polymorphic loci becoming monomorphic, a filter to remove all monomorphic loci is also applied. All filtering was done using the R package *dartR* (Gruber, Unmack et al. 2018). Further details of specific filtering are presented in the respective results sections (Section 6).

4.5.1.4 Genetic fingerprinting and sexing

Genetic fingerprinting allows for each scat sample to be allocated to an individual. This adds value by avoiding double-counting of the same individual sampled in different locations or at different times. Duplicate samples were removed by using filtered data to estimate pairwise relatedness values which range from 0 (no kinship relationship) to 1 (a duplicate individual, 100% relatedness – i.e., to be removed).

Seven different relatedness estimators currently exist and several were used to investigate and remove duplicates. Results were primarily reported from the *dyadml* estimator which performed best in estimating pairwise relatedness (Milligan 2003). All relatedness analyses were conducted in R using the *related* package (Pew, Muir et al. 2014).

Koala sex can be determined through sex-linked genetic markers. When using non-invasive sampling techniques such as scat, low quality DNA can impact sex identification confidence. With this limitation in mind, this Report provides the sex call from SNP genetic markers i.e., male versus female (M /F). Sex ratio is the relationship between the number of males to the number of females. Typically, the sex ratio in natural, healthy populations is expected to be 1:1. Risks of extinction are increased if population sex ratios significantly deviate from 1:1. However, a small bias of sex ratio towards females can sometimes be desirable, especially in very small or rapidly declining populations. Sex ratio can only be calculated for a site if a sufficient proportion of random individuals are sampled, or for landscape surveys where sampling has achieved high coverage of the area.

4.5.1.5 Measuring genetic diversity

Genetic diversity was calculated using GenAIEx v. 6.5 (Peakall and Smouse 2012). We calculated three values:

- Observed Heterozygosity, H_o - the calculated level of heterozygosity from the allele frequencies of the population under study;
- Expected Heterozygosity, H_E (adjusted for small sample size) - the level of heterozygosity that could be expected based on observed allele frequencies if the population was at the Hardy-Weinberg equilibrium (panmictic population with constant genetic variation across generations). This is relevant as it allows the calculation of the inbreeding coefficient below; and
- Inbreeding coefficient, F_{IS} - the proportion of the variance in the subpopulation contained in an individual, it can range from -1 to 1 (the closer to 1, the higher the degree of inbreeding). Note that inbreeding can not only result from non-random mating but also from small, isolated populations, where all individuals are more closely related than large populations.

4.5.1.6 *Chlamydia* detection

The prevalence of *Chlamydia* (percentage of koalas with the pathogen) is an important population characteristic for informing conservation management. It has been shown that the *Chlamydia* pathogen can be detected in koala scats using SNP genotyping (Cristescu, Miller et al. 2019). However, pathogen prevalence does not equal disease, as the presence and severity of the disease varies greatly between individual koalas, as well as between populations (Ellis, Girjes et al. 1993, Waugh, Hanger et al. 2016). Notably, individual koalas can shed large numbers of *Chlamydia* organisms without clinical signs of disease (Wan, Loader et al. 2011) and populations can have high *Chlamydia* prevalence (infection) with low noticeable health impact (disease). For example, 90% of koalas in the Mt Lofty ranges were *Chlamydia* positive but had a low prevalence of clinical disease (Weigler, Girjes et al. 1988, Polkinghorne, Hanger et al. 2013). Therefore, quantifying *Chlamydia* prevalence is only the first part of understanding the threat that this pathogen presents to an individual and a population.

4.5.1.7 Koala Retrovirus Detection

Much like the prevalence of *Chlamydia*, the prevalence of koala retrovirus is an important population characteristic that informs conservation management. Unlike *Chlamydia* detection, the methodology for sampling koala retrovirus from fresh scat material is noted to retain issues regarding the specificity and sensitivity of testing. While remaining an active area of research, the reliability of results was not thought to have provided robust and meaningful results that could positively inform koala management within the IRP. As such, sampling for koala retrovirus was deemed to be beyond the scope of this genetics research.

4.5.2 Genetic co-analyses for DArTcap and DArTag data

To increase the number of samples used to calculate genetic measures, and therefore increase the robustness of comparisons, samples previously genotyped for other projects were co-analysed. As genetic technology is progressing rapidly, some of the data was created using a previous method (DArTcap), while some samples used the current method (DArTag). Only markers that are common for both methods were used for these analyses.

Genotype data developed through DArTcap and DArTag procedures were merged together for the samples collected from sites in NSW and QLD. A total of 594 koala samples and a total of 1162 koala SNPs were available for the analyses. Genotyped data were filtered following the methods described in Section 1.2.3 (Filtering of genetic data) to improve the quality of the data set. A total of 327 koala samples and 902 koala SNPs were retained after filtering for quality. Relatedness among the koala samples was estimated following the methods described in Section 4.5.1.4 (Genetic fingerprinting and sexing) to identify duplicate samples.

4.5.2.1 Genetic structure

The number of ancestral genetic clusters (K) was assessed using fastStructure (Raj, Stephens et al. 2014) and STRUCTURE software V 2.3 (Pritchard, Stephens et al. 2000). fastStructure utilises an algorithm for approximate inference of the population structure from large SNP genotype data sets using a variational Bayesian framework, hierarchical priors and heuristic scores to identify the number of populations and weak population structures within data. STRUCTURE analyses differences in the distribution of genetic variants amongst samples with a Bayesian iterative algorithm by placing samples into groups whose members share similar patterns of variation. STRUCTURE is powerful but comparatively slow for large datasets. Although fastStructure is less powerful it is much faster and provides a reasonable alternative for large datasets (Stift, Kolář et al. 2019). Hence, herein we report the results from both fastStructure and STRUCTURE analyses.

The results generated by the STRUCTURE program were collated using STRUCTURE HARVESTER web-based program to detect the most likely number of genetic clusters that best fit the data using the ΔK method (Earl and VonHoldt 2012).

The number of genetic clusters (K) was set to vary between 1 to 10 and the STRUCTURE program was set to run five independent iterations with the length of burn-in period of 10,000, and 100,000 MCMC (Markov Chain Monte Carlo) repetitions after burn-in, using admixture ancestry model with correlated allele frequencies among populations without prior sample location information. In addition, principal component analysis (PCA) was conducted for the 255 samples from 24 locations (locations were assigned to each sample in ArcGIS based on Councils) using the *dartR* package (Gruber, Unmack et al. 2018). The first two principal components that explained the majority of the variation were used to plot the data.

4.5.2.2 Genetic diversity and population differentiation

To estimate the genetic diversity among koala populations, the 255 unique koala samples from 24 different locations were grouped into ten different groups based on their geographical proximity (Figure 4-1), noting that the number of samples available at some locations was very small (Appendix Table A2). Six samples were removed from the population genetic diversity indices estimates; three from Redland City Council (sample names: DR220116KM1A, DR220115KM1E and 221015MB1A) because they were located on North Stradbroke Island, and another three from Goondiwindi (sample names: 220623Bi1C, 220623Bi1B and 220623Bi2B) due to a very small sample size for the location and no other close sample locations that these could be grouped with. To quantify the population genetic diversity, observed heterozygosity H_o , expected heterozygosity H_e and inbreeding coefficient F_{IS} were calculated using GenAlEx software V6.5 (Peakall and Smouse 2012), as described in Section 4.5.1.4 (Measuring genetic diversity). In addition, the average internal relatedness (IR), a measure that reflects the parental relatedness (Amos, Worthington Wilmer et al. 2001) was measured across the individuals in each group using GENHET function (Coulon 2009) in R. Further, contemporary effective population size (N_e) and associated parametric 95% confidence intervals were estimated using NeEstimator v2 (Do, Waples et al. 2014), implementing linkage disequilibrium method with random mating model and 0.05 as the lowest allele frequency. To estimate the genetic differentiation between populations (i.e., 10 groups here), pairwise F_{ST} values were calculated using GenAlEx software V6.5 (Peakall and Smouse, 2012). Geneflow, a measure of movement of alleles between populations via migration or gametes, was estimated as effective number of migrants (N_m) per generation using the F_{ST} values calculated in GenAlEx software V6.5 (Peakall and Smouse, 2012). Note that these numbers reflect historical rates of gene flow and may not represent current gene flow.

4.5.2.3 Genomic relationship

Genomic relationship among individual koalas was estimated as an additive relationship matrix using the R package *dartR* (Gruber et al. 2018) for all 255 samples, and categorised by group (assigned in section 1.3.2, Genetic diversity and population differentiation). The additive relationship matrix is a theoretical framework for estimating a relationship matrix that is consistent with an approach to estimate the probability that the alleles at a random locus are identical in state (Endelman and Jannink 2012). Additive relationships carry information on genetic resemblance from common inheritance and are based on probabilities that gene pairs are identical by descent (Wright 1922).

4.5.2.4 Sexing

Sex of unique individual koalas was determined using sex-linked genetic markers for koalas used in co-analyses. Of the 255 samples available for co-analyses, 115 samples passed the genotyping quality control for sex determination. Of the 36 ARTC samples available for co-analyses, 31 samples passed the genotyping quality control for sex determination.

4.5.2.5 *Chlamydia* detection

The prevalence of *Chlamydia* (percent of koalas with the pathogen) was estimated in koala scats using SNP genotyping for the samples used in DArTcap and DArTtag co-analyses. Of the 255 samples available for co-analyses, 105 samples passed the genotyping quality control for *Chlamydia* detection. Of the 36 ARTC samples available for co-analyses, 30 samples passed the genotyping quality control for *Chlamydia* detection.

4.5.2.6 Tree genetic analysis

To cross reference the diet preference of koala from scat collected during the genetics study, a DNA library of potential feed tree species was undertaken alongside the koala scat analysis by researchers from the University of Queensland.

Referring to literature a list of candidate koala food trees species for Queensland was collated (utilising species from genera Eucalyptus, Corymbia and Angophora). With this list, leaf samples were taken from four individual trees per species per sampling site along the eastern edge of QLD and NSW with the specimens being prepared (air drying, freezing etc.) for DNA extraction. Existing tree DNA sequences were supplemented into the study from other projects as well.

After specimen collection and preparation the samples underwent DNA extraction via automated plate-based extraction protocol, by Diversity Arrays Technology P/L, Canberra, Australia (DArT) to compile (DNA fragments) and single nucleotide polymorphisms (SNPs). Following this, the now created panel underwent validation to remove unusable datasets, final product being able to discriminate most eucalypt species (exceptions being closely related species or subspecies).

Further detailed information for this research can be found in Appendix C.

**Figure 4-1 Map provided by UniSC of sample groups included in co-analyses;
(A) North and (B) South**

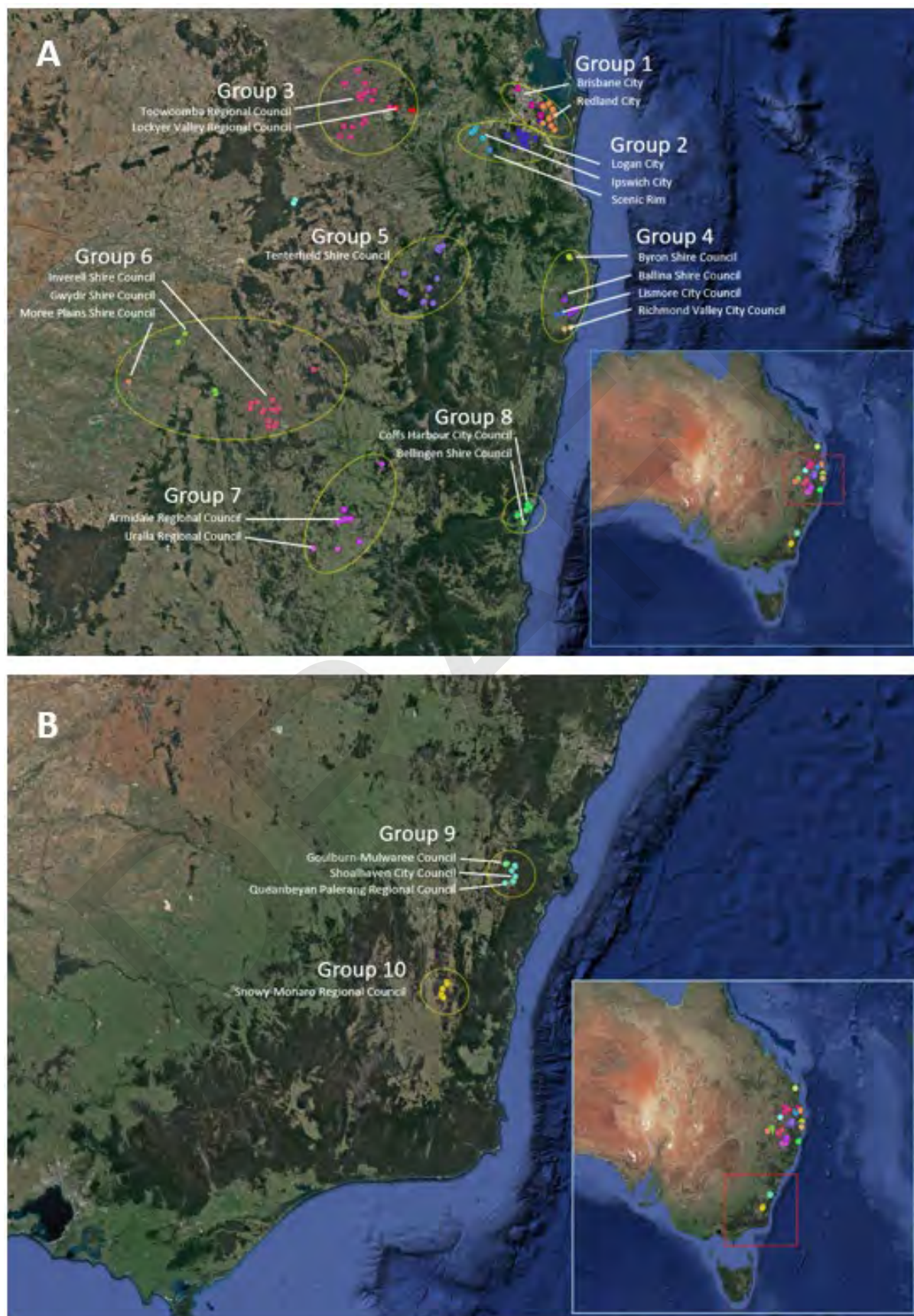


Table 4-4 Groupings of koala samples used for genetic diversity estimates

Group	Sample locations in the group (sample size)	Sample size per group	Number of ARTC Samples
Group 1	Brisbane City (05)	43	
	Redland City (37) (= Koala Coast)		
Group 2	Logan City (17)	24	4
	Ipswich City (06)		6
	Scenic Rim Regional (02)		2
Group 3	Lockyer Valley Regional (10)	34	10
	Toowoomba Regional Council (24)		6
Group 4	Byron Shire Council (02)	25	
	Ballina Shire Council (19)		
	Lismore City Council (02)		
	Richmond Valley Council (02)		
Group 5	Tenterfield Shire Council (31)	31	
Group 6	Inverell Shire Council (29)	36	
	Gwydir Shire Council (04)		2
	Moree Plains Shire Council (03)		3
Group 7	Armidale Regional Council (18)	21	
	Uralla Shire Council (03)		
Group 8	Coffs Harbour City Council (06)	08	
	Bellingen Shire Council (02)		
Group 9	Goulburn Mulwaree Council (07)	17	
	Shoalhaven City Council (09)		
	Queanbeyan–Palerang Regional Council (01)		
Group 10	Snowy Monaro Regional Council (10)	10	

4.5.3 Diet Analysis

4.5.3.1 Sequencing of potential food tree species

DNA was extracted from leaf samples using an automated plate-based extraction protocol, by Diversity Arrays Technology P/L, Canberra, Australia (DArT). The remaining reference leaves were extracted using CTAB extraction buffer with chloroform clean-up and ethanol precipitation. This protocol has been optimised for Eucalyptus by DArT in association with prior clients for Eucalyptus genotyping. Read counts for targets (DNA fragments) and single nucleotide polymorphisms (SNPs) within those targets were determined by DArT using their standard proprietary pipelines (Grewe et al. 2015, Kilian et al. 2012). Species belonging to the different genera and Eucalyptus subgenera were run through the DArT pipelines separately, to maximise the number of potentially useful loci identified. Read proportions for the reference and alternative SNP alleles at each locus were determined using custom code in R studio 1.2.5033.

4.5.3.2 Identification of species-specific SNPs and panel validation

Prior to identification of species-specific SNPs, a Principal Components Analysis was performed on the Hamming genetic distance matrix generated from the SNP data in GenAlEx 6.1 to confirm the species designations of the samples. Samples that did not cluster with their designated species or samples with one or more heterozygous loci were removed from the dataset. Additionally, for a small number of species that were taxonomically distinct from all other species in the datasets (i.e. *Araucaria cunninghamii* and *Acacia melanoxylon*), in silico DArTs that were present only in the target species were also identified as potential species-specific genetic markers.

The list of species-specific SNPs identified from the DArTseq data was filtered to retain only a single SNP per unique DArT sequencing fragment to minimise the impact of linkage disequilibrium among potential markers. Up to 30 SNPs/in silico DArTs were then selected per species for oligo design, using species-specific SNPs that were identified in the middle of the DArT target. Oligos were designed by identifying probe regions flanking the selected SNPs using primer design software in Genious (Drummond et al. 2009). The selected tags (SNPs and flanking regions) were run through a DArTag assay and were hybridised to denatured eucalyptus DNA before final amplification.

The products of DArTag assay were then sequenced on the HiSeq 2500 (Illumina), demultiplexed and targeted SNPs detected using DArT P/L's proprietary analytical pipeline (DARToolbox). There were four species (*E. prava*, *E. laevopinea*, *E. andrewsii* and *Araucaria cunninghamii*) that were not included in the validation panel due to a lack of available samples. It was confirmed that these markers did not amplify in any non-target species, however, amplification in the target species could not be confirmed.

After validation 1122 markers were retained and the marker panel was able to discriminate most eucalypt species. There were some exceptions where closely related species or subspecies could not be distinguished, although DNA from one or more of the species in question was confirmed to be present. This was particularly notable for the ironbarks from the series *Siderophloiae* (*E. crebra*, *drepanophylla*, *fibrosa*, *rhombica*, *dura*, *cullenii*, *whitei*, *melanophloia*).

4.5.3.3 Diet determination from scats

DNA was extracted from the koala scats using CTAB extraction buffer with chloroform clean-up and ethanol precipitation (Healey et al. 2014). Those SNPs that were confirmed to be species-specific on the DArTag platform were amplified and sequenced from the faecal DNA extracts (as described above) to determine the composition of the koalas' diets. The sequencing read counts were filtered and removed if the average number of reads per detected marker was less than 3 or if fewer than two SNPs were detected in target species that had 3 or more validated markers to remove likely sequencing errors and low frequency contamination. The remaining filtered readers for each marker were normalised to account for differences among markers in amplification efficiency. The number of scaled reads for each target species was then averaged across those markers that were found in the highest proportion of target tree species individuals. The averaged scaled reads per target species were then converted to relative abundance by dividing by the total number of averaged scaled reads across all target species.

4.6 Limitations to Study

While this study helps address current knowledge gaps, the restriction of access to study sites to within the boundary of the IRP and where landowner agreements could be established limited the ability to accurately sample across koala populations. Furthermore, the geographic distance between detected samples establishes challenges for movement and dispersal distance in koalas is closely associated with habitat connectivity (Rus, McArthur, Mella, & Crowther, 2021). In highly disturbed landscapes, such as those typical throughout the agricultural land of the IRP, koala home ranges are likely to be larger than in contiguous forest environments (Ellis, Melzer et al. 2002). Considering repeat surveys were not undertaken, this does potentially increase the risk of recording false absences.

Additionally, surveys were unable to be extended to areas surrounding the ARTC footprint, which would have allowed for greater geographic coverage and increased sample sizes, enabling more population-level comparisons. These factors constrained the number of samples that could be collected, limiting our ability to capture the broader landscape and seasonal context of koalas using the project footprint. Co-analysing the samples collected along the ARTC footprint with samples from previous surveys was completed to address this limitation. The results of this study should not be considered a thorough indication of koala population levels however can be used as a proxy for koala health and population genetics at the local scale.

DRAFT

5. FIELD SURVEY RESULTS SUMMARY

A total of one hundred and twenty (120) detection dog surveys were undertaken throughout the IRP. Of these, fresh scats and individual koalas were found at forty-one (41) sites with detections made in northern NSW and Southeast Queensland (Figure 5-1). These detections were made within the N2NS, B2G, G2H, H2C, C2K, and K2AB sections of the IRP.

5.1 Scat Detections

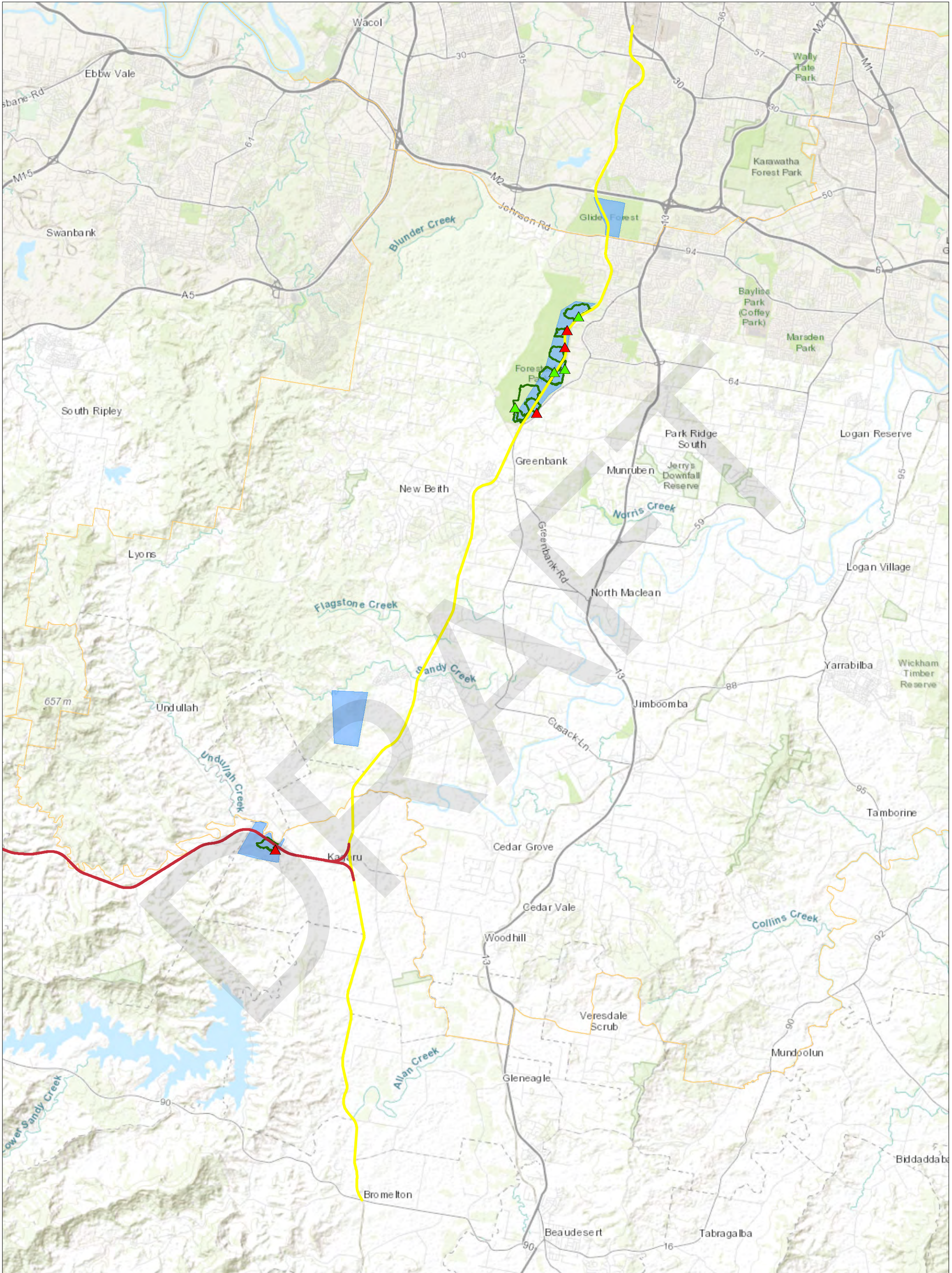
Koala detection dog surveys returned seventy-three (73) fresh scat detections throughout the IRP. The majority of these scat detections were found within QLD sections of the IRP. These were spread throughout the city council municipalities of Toowoomba, Logan City, Lockyer Valley Regional Council, City of Ipswich, Goondiwindi Region and Scenic Rim.

The remaining scats were identified in the two NSW council municipalities of Gwydir Shire and Moree Plains Shire in the townships of Croppa Creek and Moree.

5.2 Koala Detections

A total of eight (8) koala detections were made throughout the QLD sections of the IRP, within the city council municipalities of Toowoomba, Lockyer Valley Regional Council, City of Ipswich and Logan City. Five (5) individuals were identified as healthy with no signs of Chlamydia infection. Three (3) dead individuals were found, two (2) of which were identified only through bones. Cause of death could not be determined, however on one (1) dead female no obvious signs of chlamydia infection could be detected. Only one individual in the Lockyer Valley was found with 'Wet Bum', an indicator of chlamydia infection.

Koala detection dog surveys throughout the NSW sections of the IRP returned a single detection of an individual made in Moree on 22 July 2022. The individual was of unknown sex and no signs of Chlamydia infection could be observed. The individual was located in riparian vegetation along the edge of a river. No scat was found for collection within the vicinity.



Legend

Dog Surveys

- No Detection
- Detection
- Dog Track
- Pre-fieldwork Hotspots
- LGA Boundary

Inland Rail Alignment

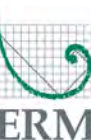
- C2K - Calvert to Kagaru
- K2AB - Kagaru to Acacia Ridge/Bromelton

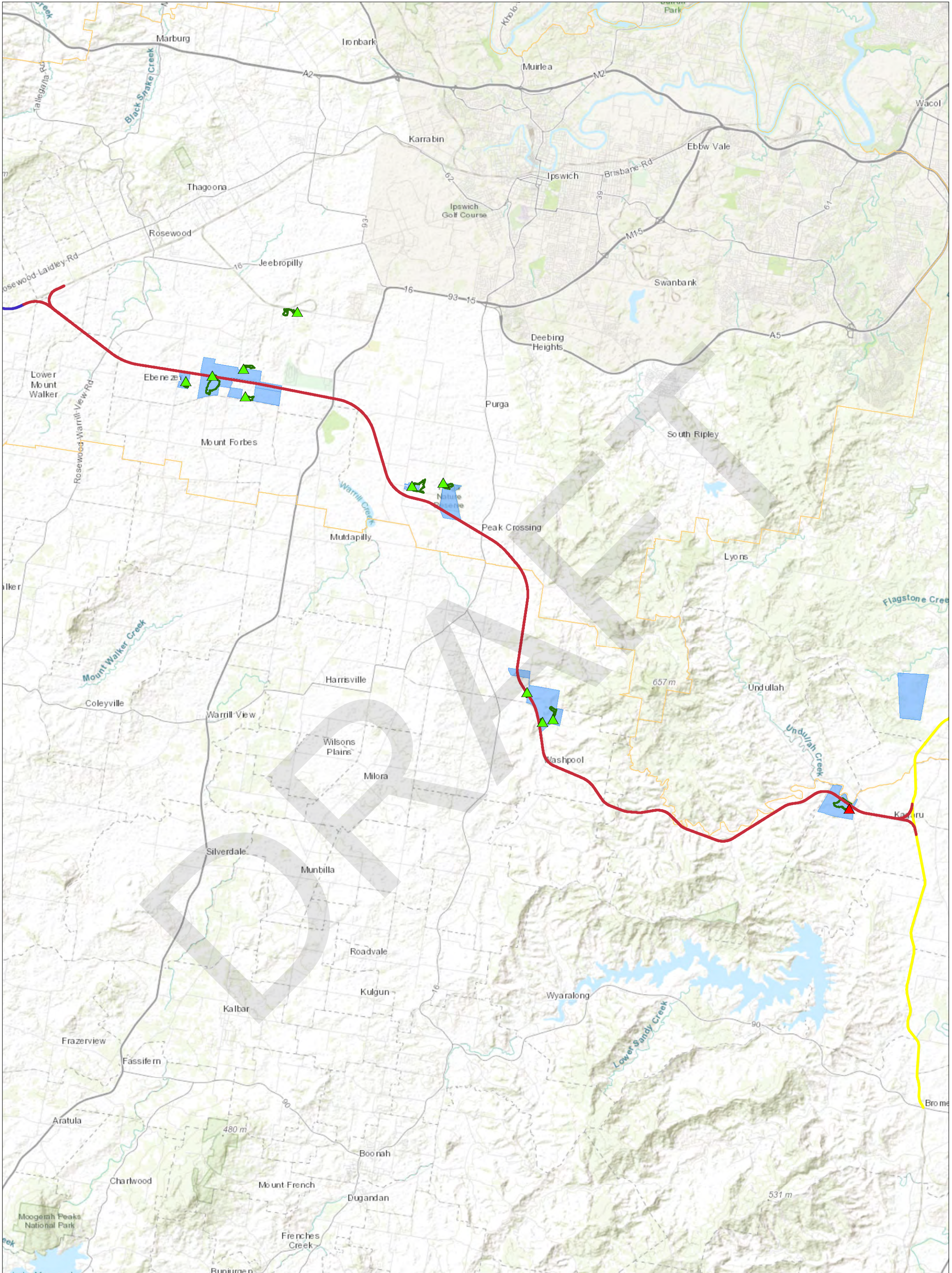
Data Source:
ESRI World Topographic Map

Locations of Detection Dog Surveys

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Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		
		 This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-1a





Legend

Dog Surveys

- No Detection
- Detection
- Dog Track
- Pre-fieldwork Hotspots
- LGA Boundary

Inland Rail Alignment

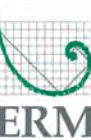
- C2K - Calvert to Kagaru
- H2C - Helidon to Calvert
- K2AB - Kagaru to Acacia Ridge/Bromelton

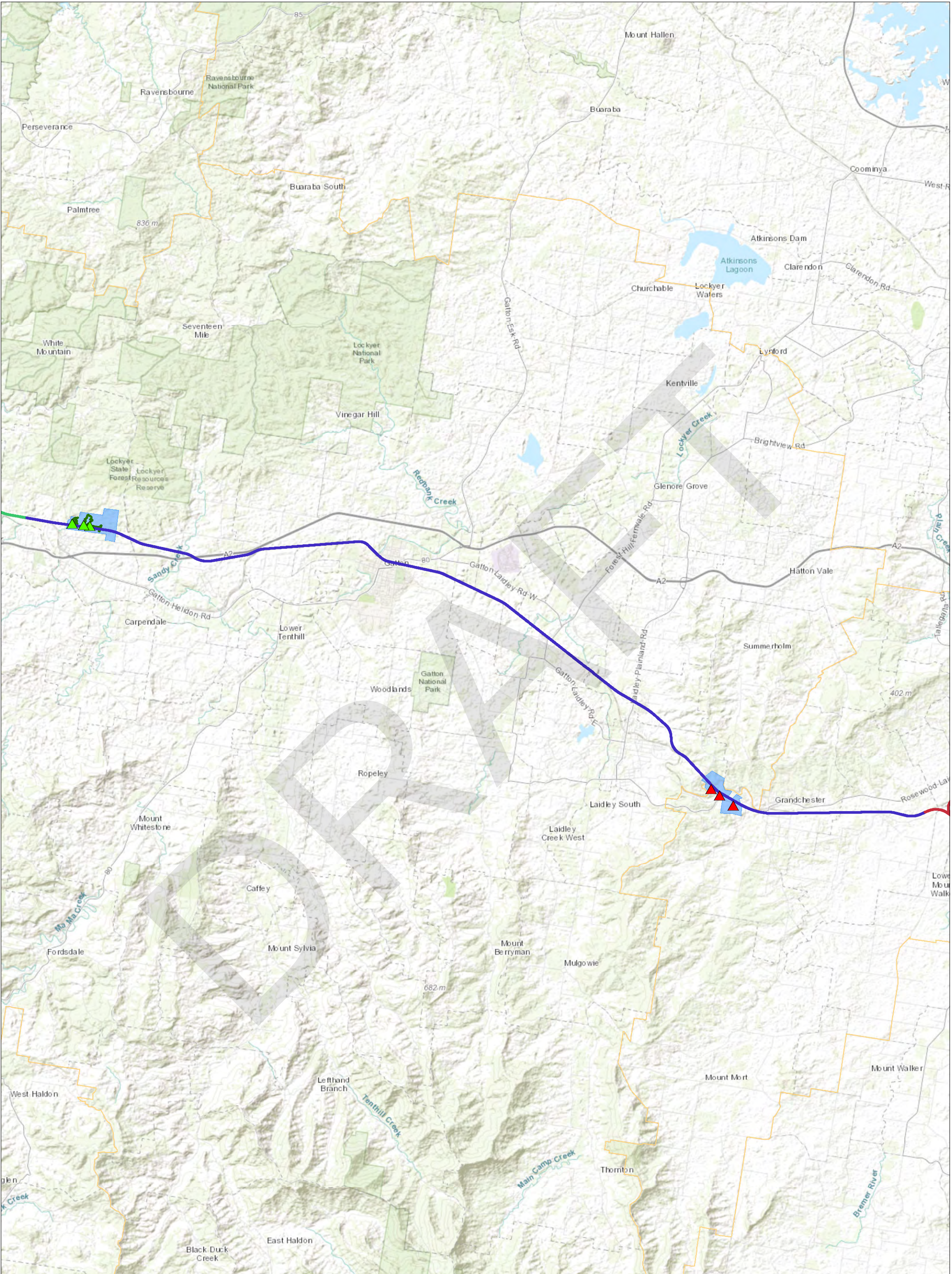
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Locations of Detection Dog Surveys

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Coordinate System: GDA2020 MGA Zone 56			
			This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-1b





Legend

Dog Surveys

No Detection

Detection

Dog Track

Pre-fieldwork Hotspots

LGA Boundary

Inland Rail Alignment

C2K - Calvert to Kagaru

G2H - Gowrie to Helidon

H2C - Helidon to Calvert

Data Source:

ESRI World Topographic Map

Locations of Detection Dog Surveys

Drawing No: 0628339_N2AB_TM_G004_R3.mxd

Date: 14/02/2024

Drawn By: VN

Coordinate System: GDA2020 MGA Zone 56

0

2

4Km

N

Koala Genetics Study Project – Inland Rail Program (NSW and QLD)

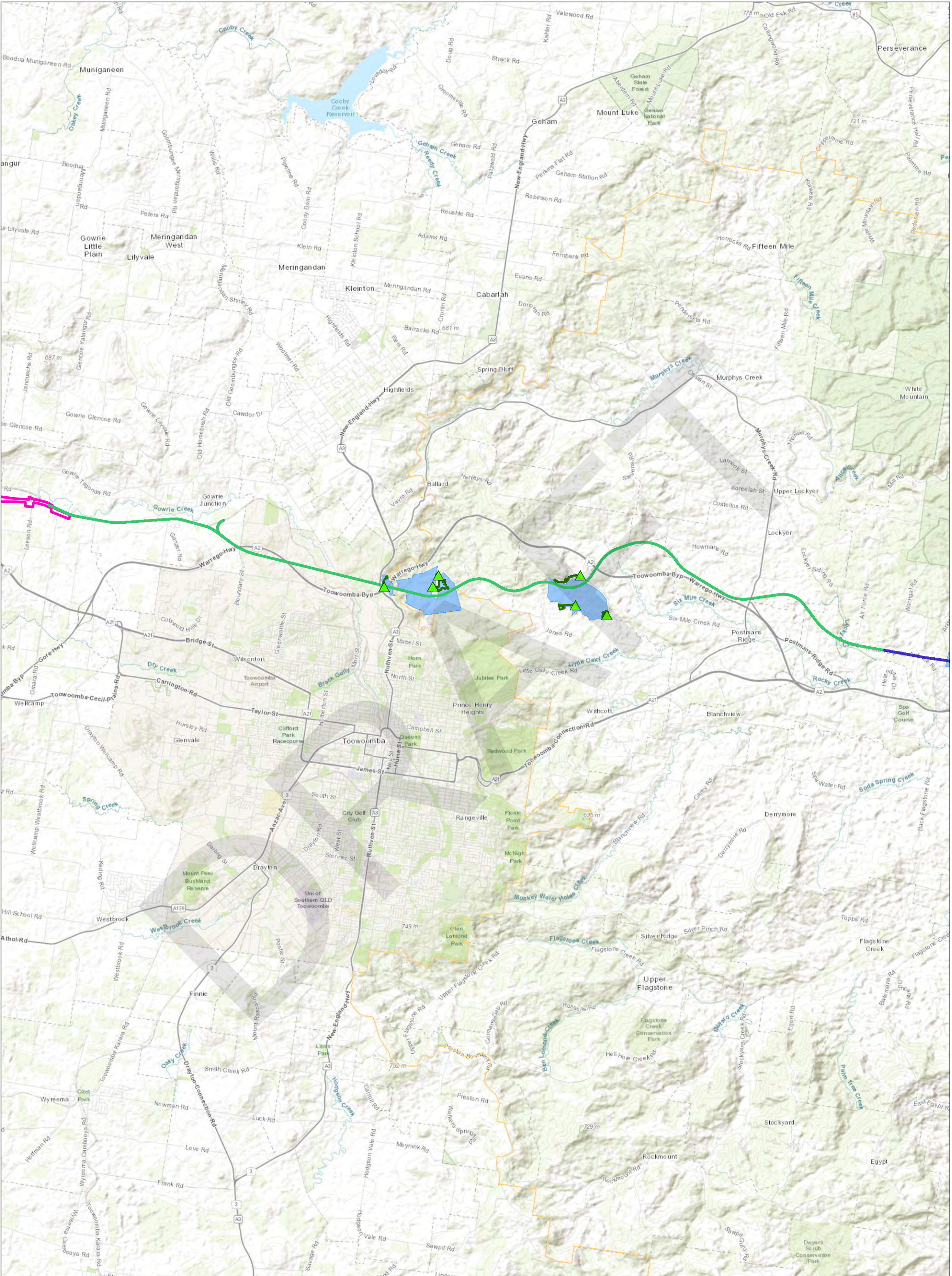
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Reviewed By: MD

Client: ARTC

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F5-1c



Legend

Dog Surveys
Detection
Dog Track
Pre-fieldwork Hotspots
LGA Boundary

Inland Rail Alignment
B2G - NSW/QLD Border to Gowrie
G2H - Gowrie to Helidon
H2C - Helidon to Calvert

Data Source:
ESRI World Topographic Map

Locations of Detection Dog Surveys

Drawing No: 0628339_N2AB_TM_G004_R3.mxd
Date: 14/02/2024
Drawn By: VN

Drawing Size: A4
Reviewed By: MD

Coordinate System: GDA2020 MGA Zone 56

024km

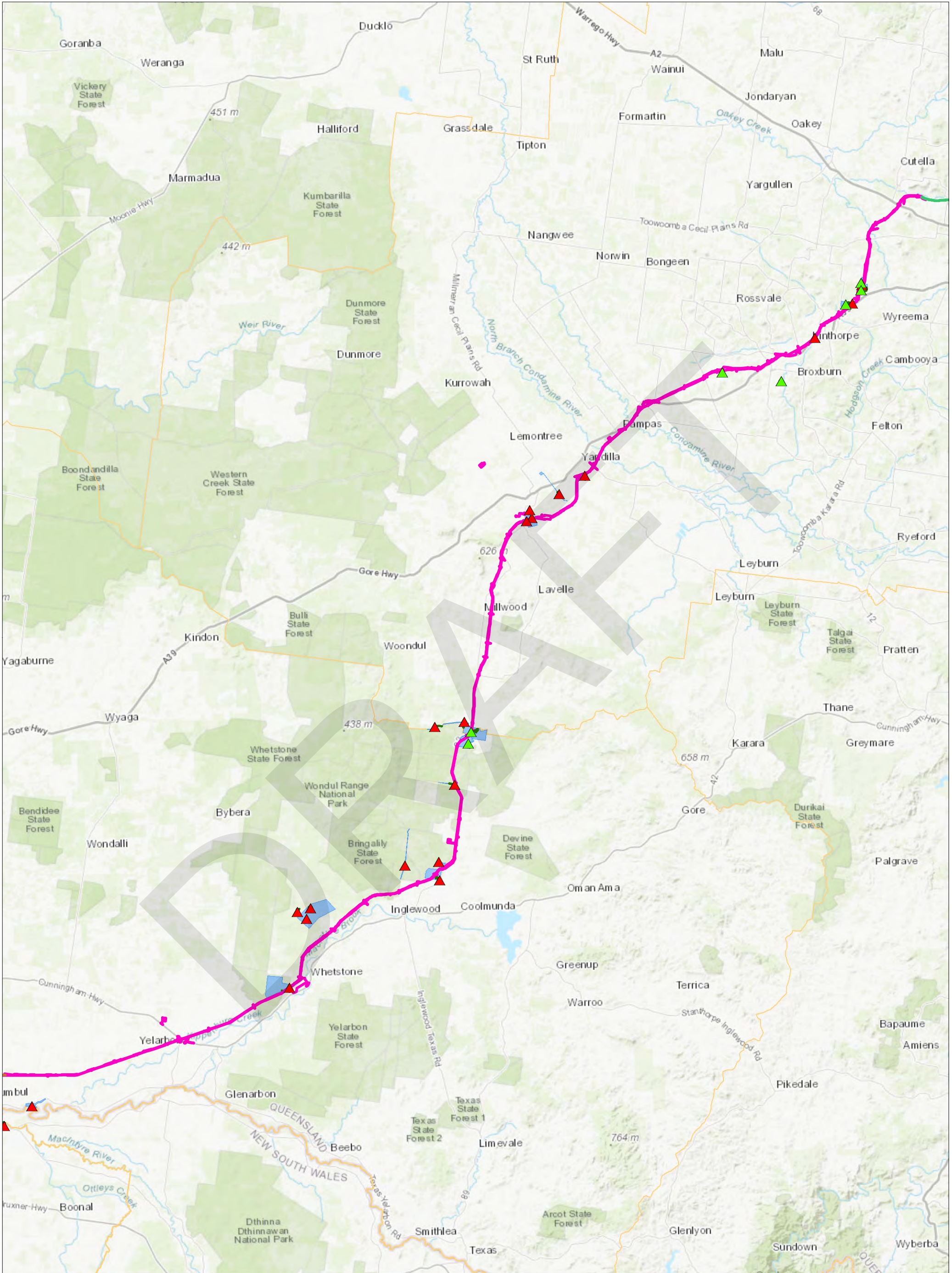
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Koala Genetics Study Project – Inland Rail Program (NSW and QLD)

Client: ARTC

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-1d



Legend

Dog Surveys

- No Detection
- Detection
- Dog Track
- Pre-fieldwork Hotspots
- LGA Boundary

Inland Rail Alignment

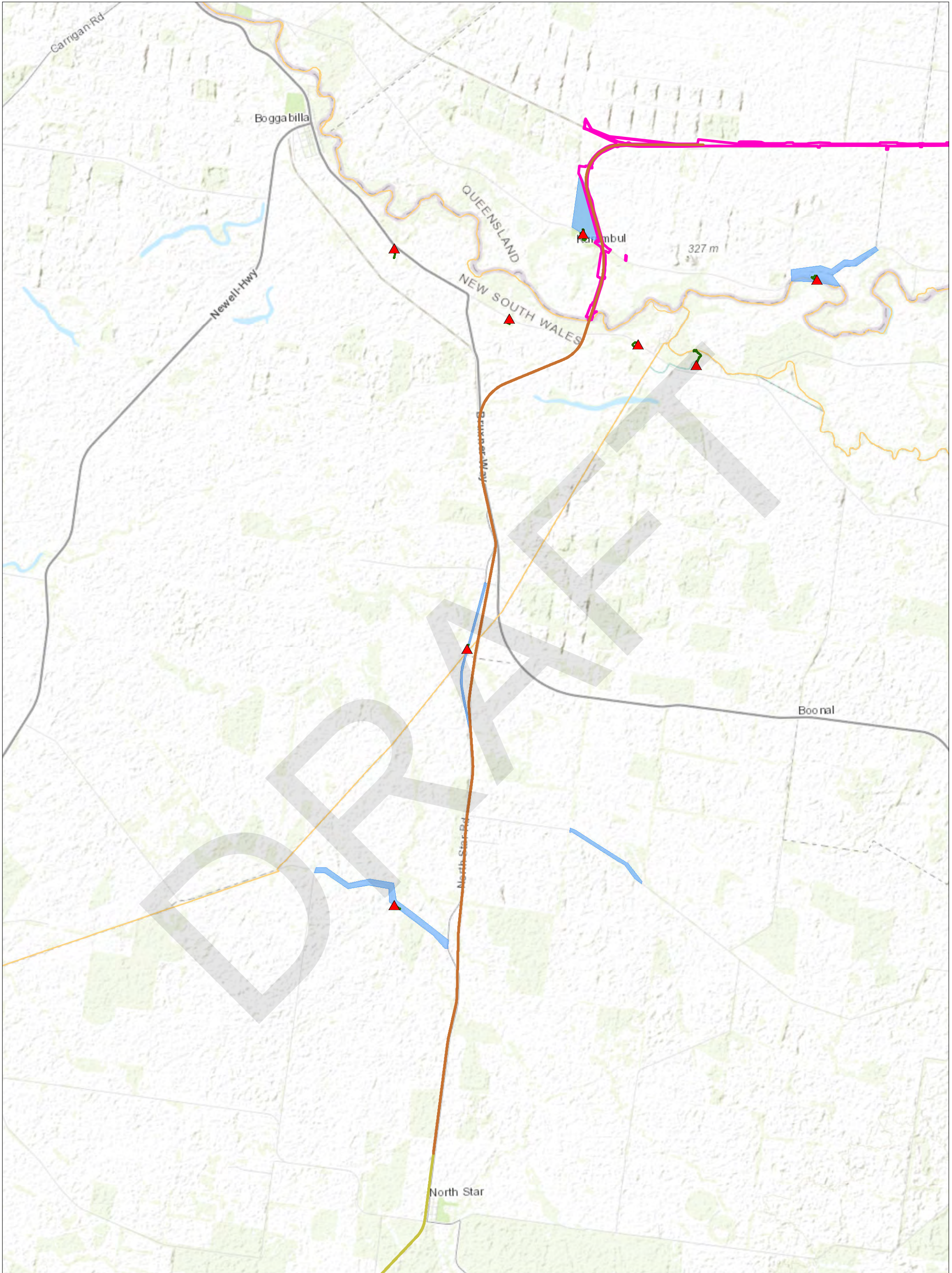
- B2G - NSW/QLD Border to Gowrie
- G2H - Gowrie to Helidon
- NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

Locations of Detection Dog Surveys

Drawing No: 0628339_N2AB_TM_G004_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4		
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Coordinate System: GDA2020 MGA Zone 56			
0 2 4Km			This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-1e



- Legend**

Dog Surveys

 - No Detection
 - Dog Track
 - Pre-fieldwork Hotspots
 - LGA Boundary
- Inland Rail Alignment**

 - B2G - NSW/QLD Border to Gowrie
 - N2NS - Narrabri to North Star
 - NS2B - North Star to Border

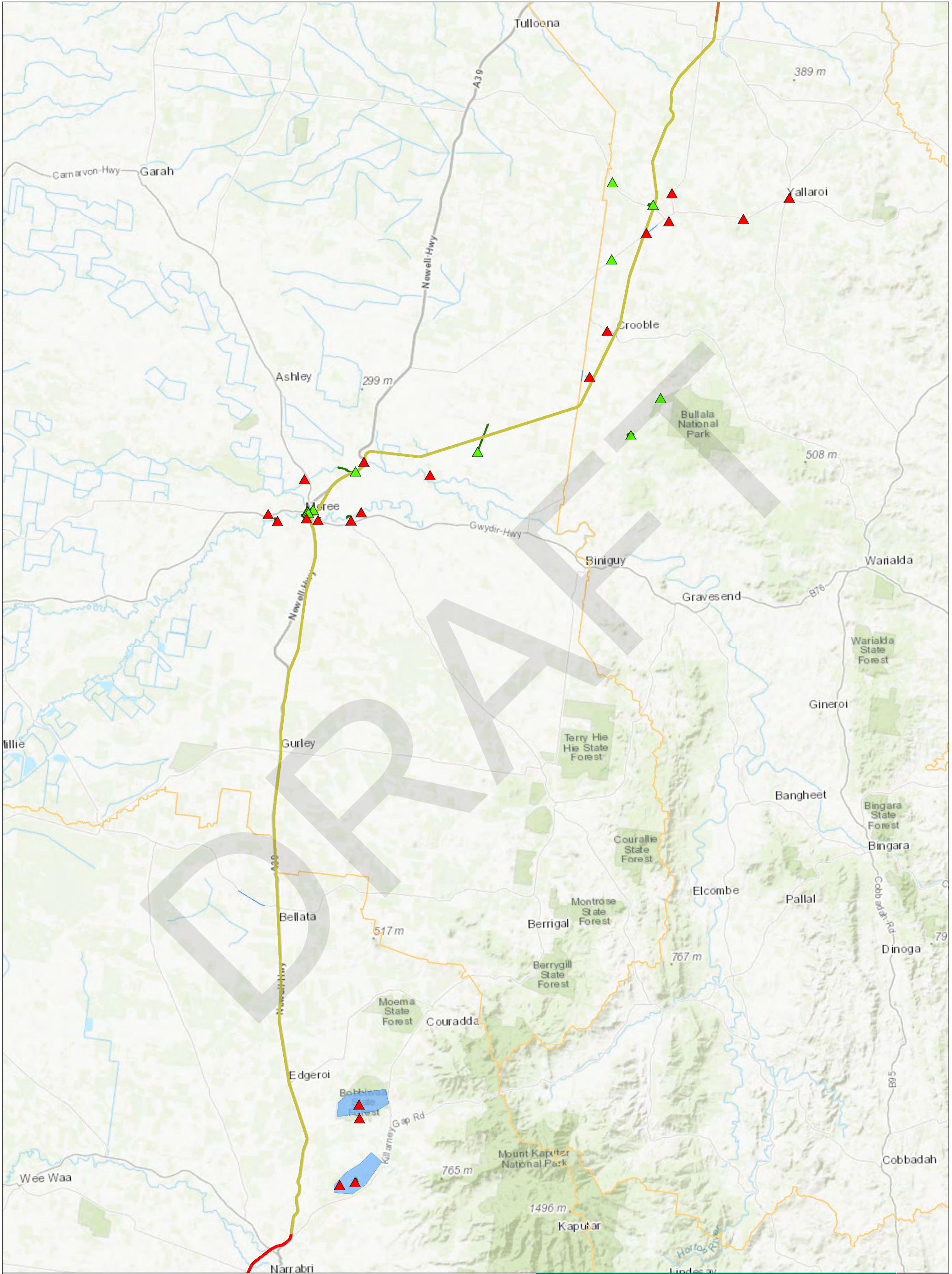
Data Source:
ESRI World Topographic Map

Locations of Detection Dog Surveys

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Date: 14/02/2024	Drawing Size: A4	Client: ARTC	
Drawn By: VN	Reviewed By: MD		
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	
0 2 4Km			

F5-1f





Legend

Dog Surveys

- No Detection
- Detection
- Dog Track
- Pre-fieldwork Hotspots

Inland Rail Alignment

- N2N - Narramine to Narrabri
- N2NS - Narrabri to North Star
- NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

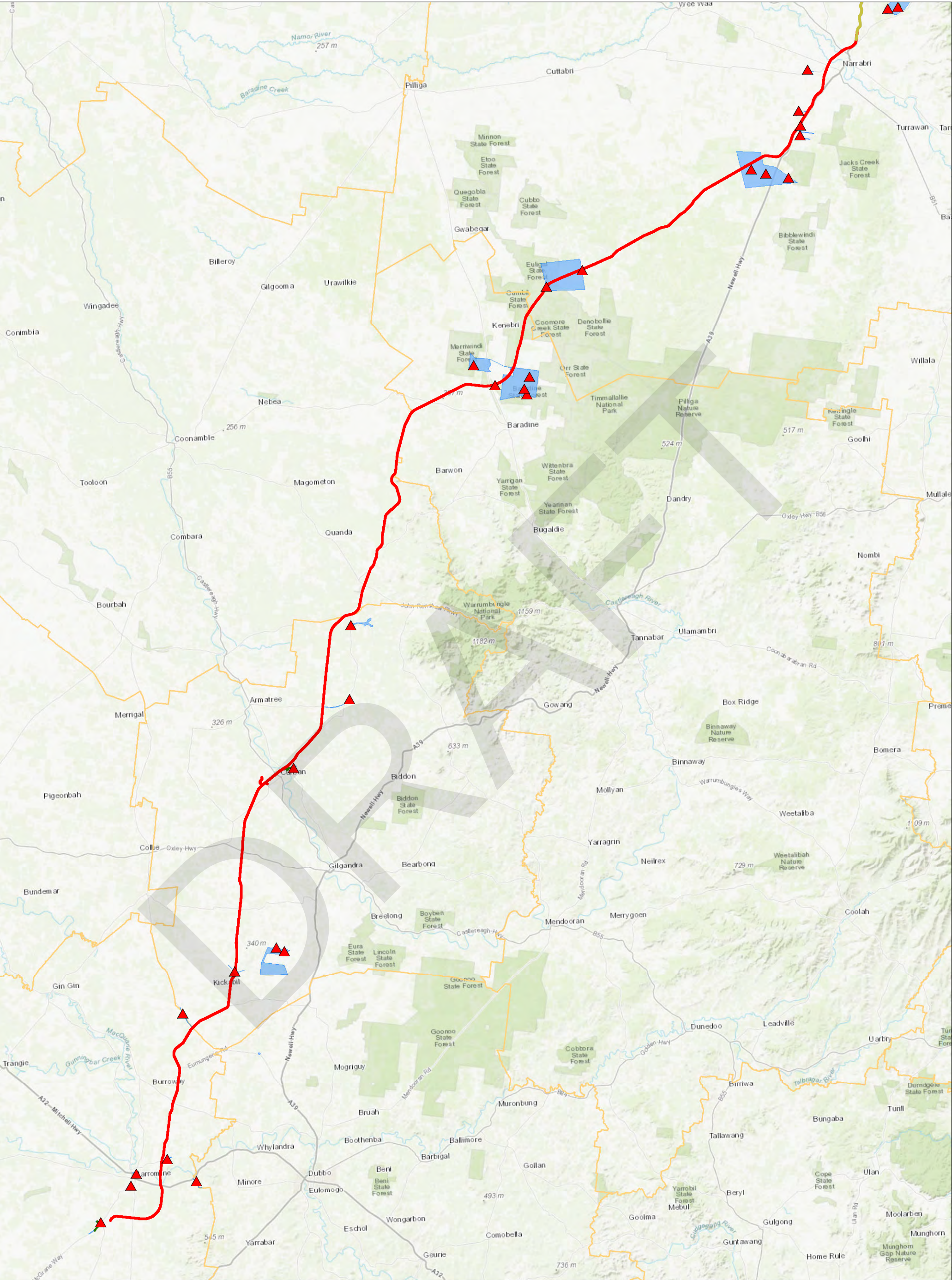
Locations of Detection Dog Surveys

Drawing No: 0628339_N2AB_TM_G004_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4		
Drawn By: VN	Reviewed By: MD	Client: ARTC	
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	
0 2 4Km			



F5-1g





Legend

Dog Surveys

- No Detection
- Dog Track
- Pre-fieldwork Hotspots

Inland Rail Alignment

- N2N - Narramine to Narrabri
- N2NS - Narrabri to North Star

Data Source:
ESRI World Topographic Map

Locations of Detection Dog Surveys

Drawing No: 0628339_N2AB_TM_G004_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC	
Drawn By: VN	Reviewed By: MD		
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	
0 2 4Km			
			

F5-1h

5.3 Vegetation assessments

To gain a broad understanding of the available koala habitat within the IRP a total of ninety-one (91) vegetation assessments were completed alongside the detection dog surveys. See figure 5-2 for a representation of vegetation assessment survey effort.

The landscape throughout the survey sites was dominated by fragmented and disturbed remnant or advanced regrowth vegetation found along roadsides, ephemeral creek lines and publicly accessible areas (i.e., state forest, council parklands).

Overall, three Eucalypts presented as the main dominant canopy species: *Eucalyptus populnea*, *E. crebra* and *E. camaldulensis*. Each of the regions in the study area displayed varying quality and abundance of koala habitat. Accordingly, the habitat can be broken up into three different sections of the IRP:

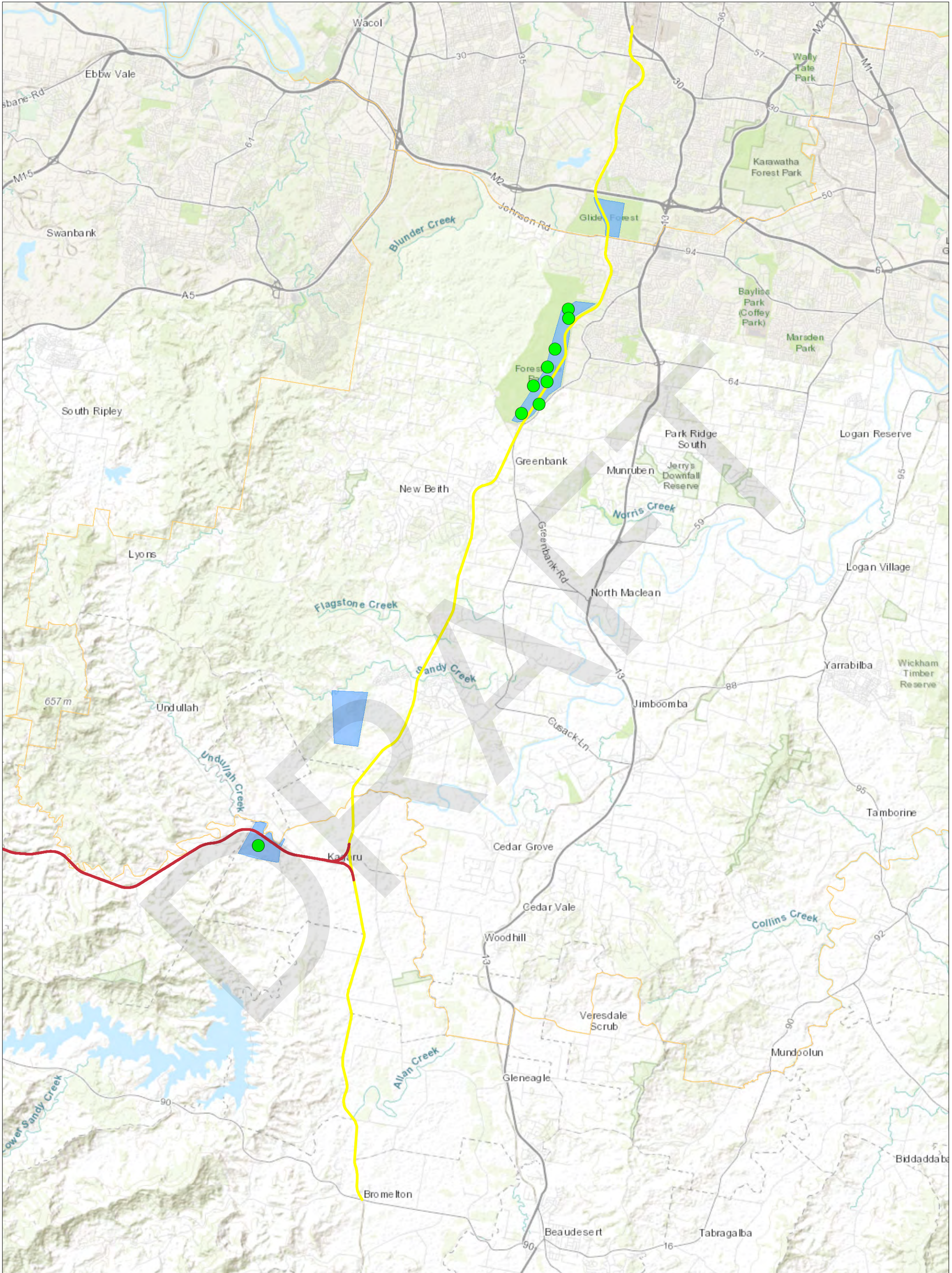
- East of the Toowoomba range (K2ARB, C2K, H2C and G2H);
- West of the Toowoomba range to the Queensland-NSW border (B2G); and
- New South Wales (NS2B, N2NS and N2N).

East of the Toowoomba Range vegetation surveys showed canopy species being dominated by *Eucalyptus crebra*, *E. citriodora* and *Corymbia intermedia*.

West of the Toowoomba region found canopy species being dominated by *E. populnea*, *E. camaldulensis*, *E. chloroclada*.

The NSW regions found canopy species being dominated by *E. camaldulensis*, *E. populnea* and *E. crebra*.

A further breakdown of koala food-tree availability across the projects of the IRP is found in Section 9 Koala Habitats in the Study Area.



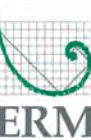
- Legend**
- Quaternary Assessment
 - Pre-fieldwork Hotspots
 - LGA Boundary
 - Inland Rail Alignment

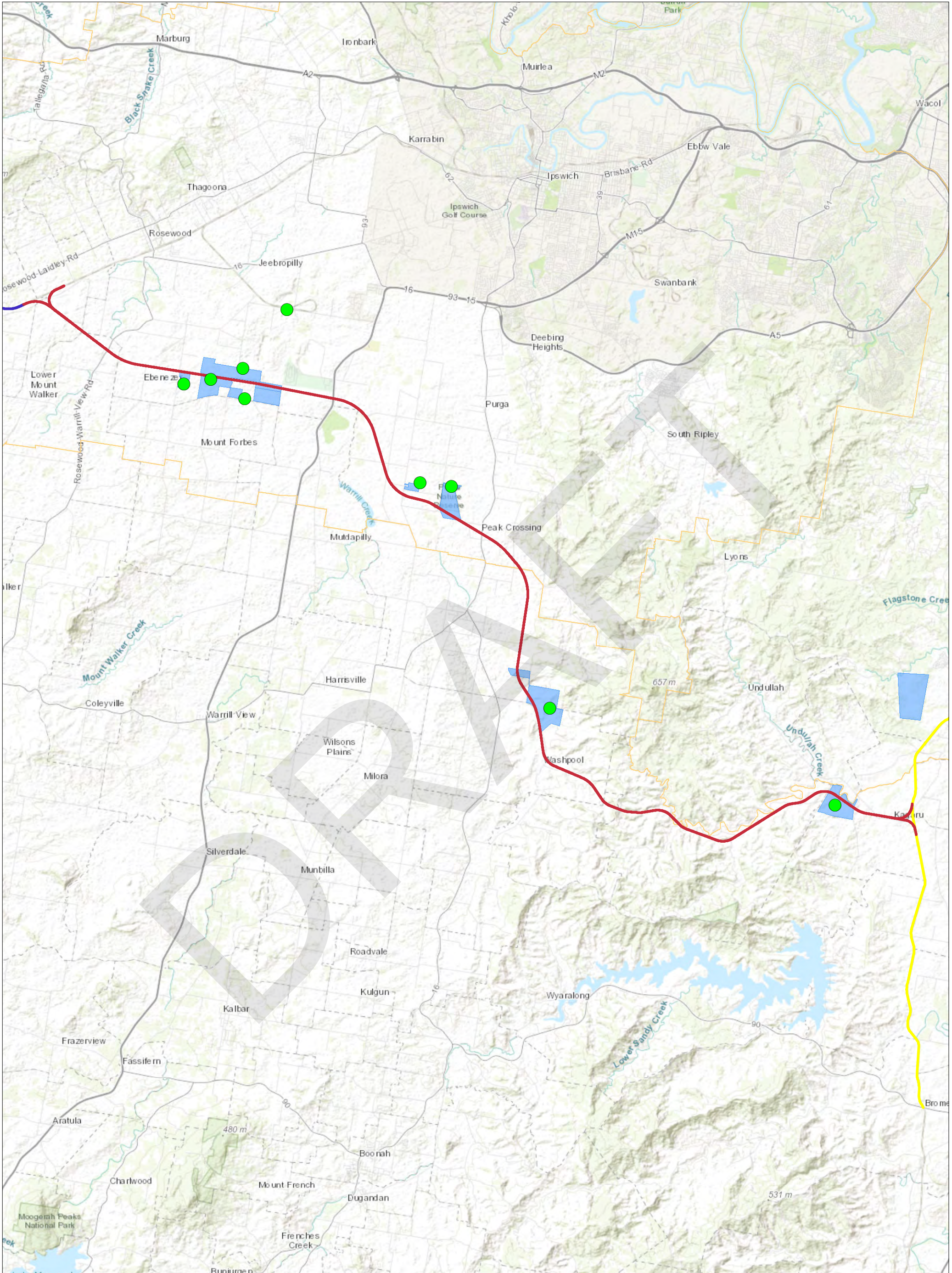
Data Source:
ESRI World Topographic Map

Vegetation Assessments Across the IRP

Drawing No: 0628339_N2AB_TM_G005_R3.mxd	Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC
Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		
0 2 4km		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-2a





- Legend**
- Quaternary Assessment
 - Pre-fieldwork Hotspots
 - LGA Boundary
 - Inland Rail Alignment

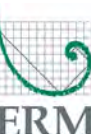
Data Source:
ESRI World Topographic Map

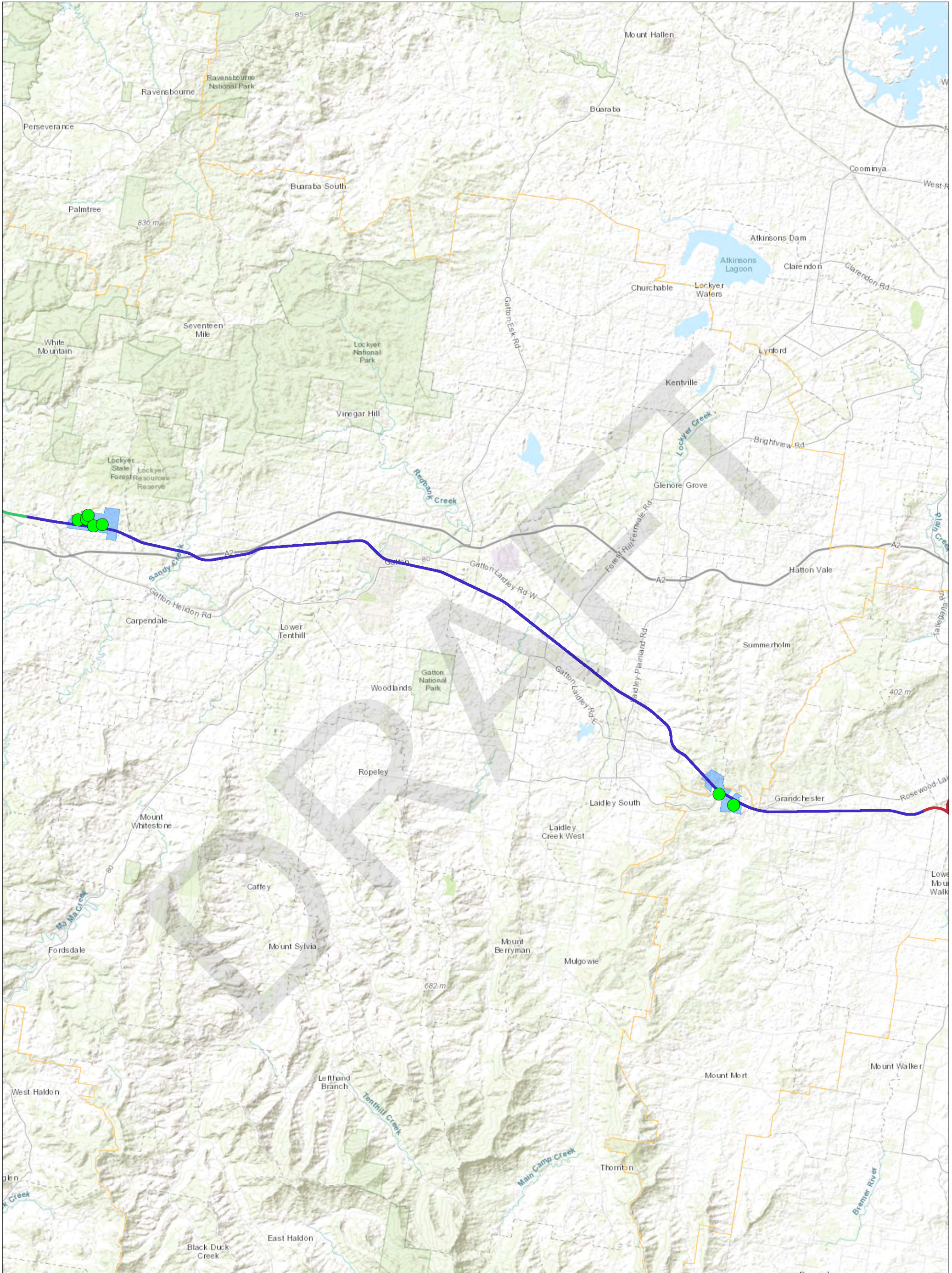
Vegetation Assessments Across the IRP

Drawing No: 0628339_N2AB_TM_G005_R3.mxd	Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC
Drawn By: VN/CB	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		
0 2 4km		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.



F5-2b





- Legend**
- Quaternary Assessment
 - Pre-fieldwork Hotspots
 - LGA Boundary
 - Inland Rail Alignment

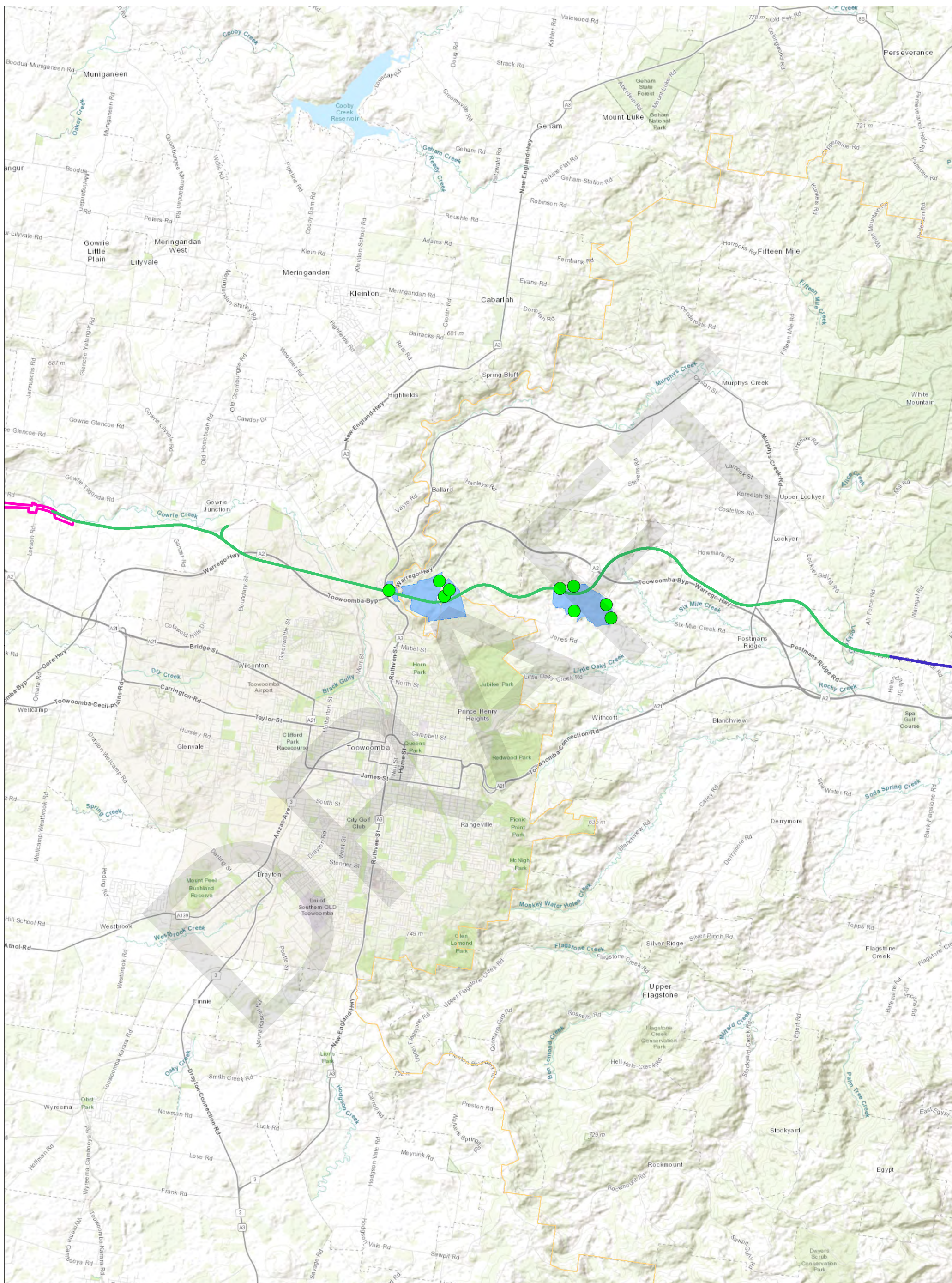
Data Source:
ESRI World Topographic Map

Vegetation Assessments Across the IRP

Drawing No: 0628339_N2AB_TM_G005_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4		
Drawn By: VN/CB	Reviewed By: MD	Client: ARTC	
Coordinate System: GDA2020 MGA Zone 56			
024Km		N This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	

F5-2c





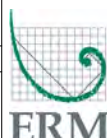
Legend

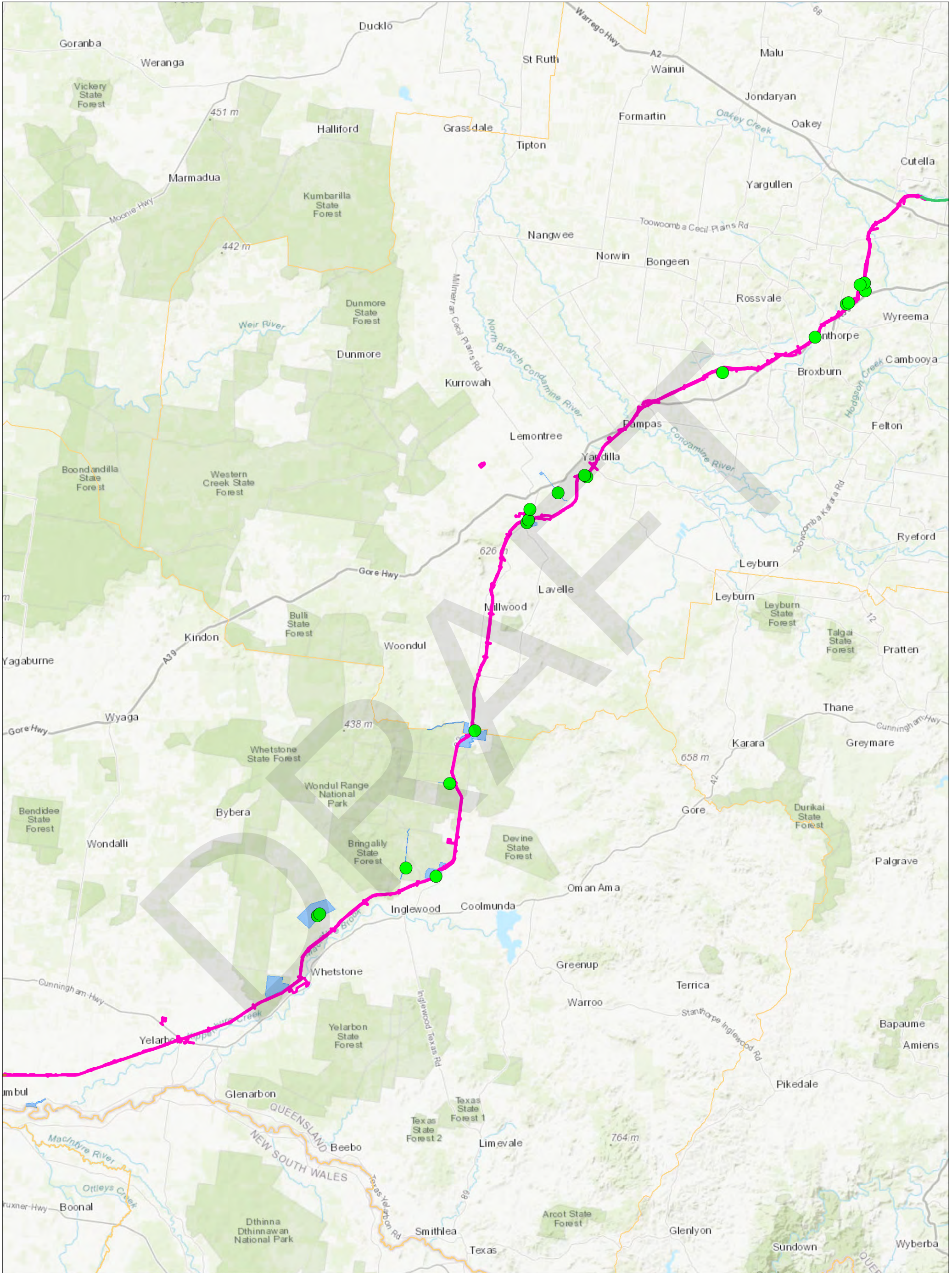
-  Quaternary Assessment
 Pre-fieldwork Hotspots
 LGA Boundary

Data Source:
ESRI World Topographic Map

Vegetation Assessments Across the IRP

F5-2d

Koala Genetics Study Project – Inland Rail Program
(NSW and QLD)



- Legend**
- Quaternary Assessment
 - Pre-fieldwork Hotspots
 - LGA Boundary
 - Inland Rail Alignment

Data Source:
ESRI World Topographic Map

Vegetation Assessments Across the IRP

Drawing No: 0628339_N2AB_TM_G005_R3.mxd	Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN/CB	Reviewed By: MD	Client: ARTC

Coordinate System: GDA2020 MGA Zone 56

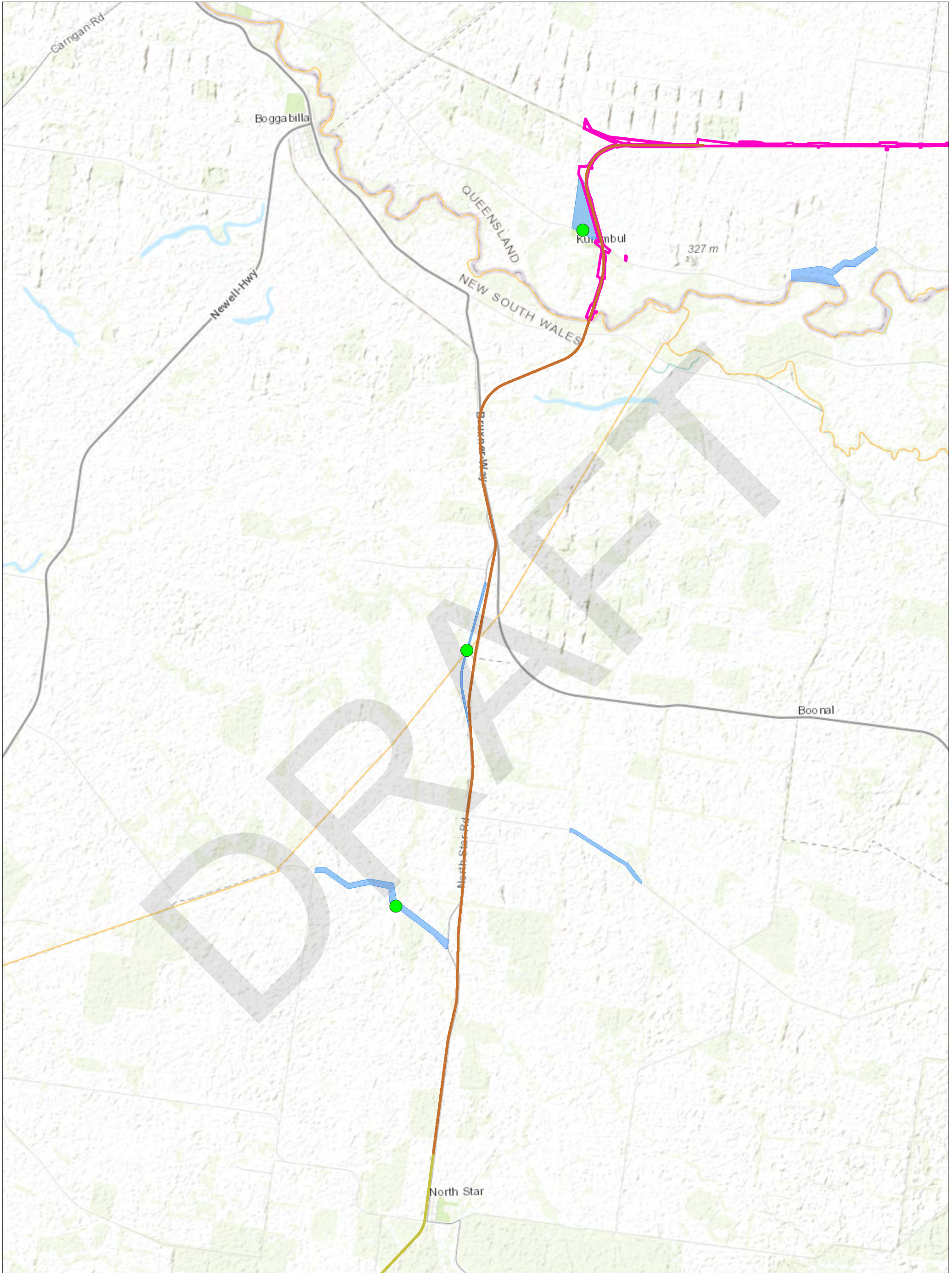
0 2 4km



This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-2e





- Legend**
- Quaternary Assessment
 - Pre-fieldwork Hotspots
 - LGA Boundary
 - Inland Rail Alignment

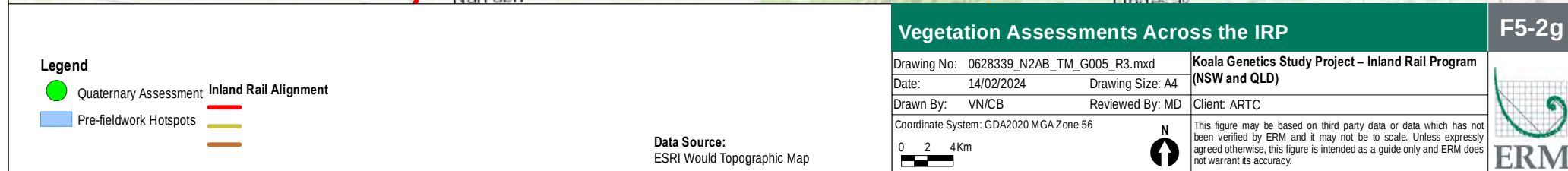
Data Source:
ESRI World Topographic Map

Vegetation Assessments Across the IRP

Drawing No: 0628339_N2AB_TM_G005_R3.mxd	Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN/CB	Reviewed By: MD	Client: ARTC
Coordinate System: GDA2020 MGA Zone 56		
0 2 4Km		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F5-2f





6. GENETIC ANALYSIS RESULTS AND DISCUSSION

Genetic analysis of koala scats detected using detection dog surveys was completed by the Detection Dogs for Conservation research group at the University of the Sunshine Coast. This section provides a compilation of the analysis and findings written by the team from UniSC, with the draft technical outputs from UniSC included in Appendix A.

6.1 Extraction, quality control unique individuals

A total of 73 fresh koala scat samples were collected for genetic analyses. All samples were genotyped using DArTag, however, as is typical in genotyping, particularly with non-invasive samples, genotypes differed in DNA quality. Therefore, some samples were excluded from subsequent analyses due to insufficient data. Figure 2-3 in Appendix A shows the location of all genetic samples and also which samples were used in subsequent analyses (successful genotyping), samples that were duplicates of the same individual koala (successful genotyping but removed due to duplication) and samples with poor DNA quality (insufficient genotype data). For further details see Appendix A Table A3.

Only approximately 200 SNPs are required for identifying unique individuals (Schultz et al. 2018); therefore, the focus was on maximising the number of individuals that could be used while retaining sufficient high-quality SNPs. In addition to the constant filters described in the methods, we applied a stepwise increasing locus call rate filtering, from 0.2 to 0.9, resulting in only retaining SNPs with at least 90% data. Samples were also filtered for individual call rate using an increasing call rate filtering from 0.1 to 0.2, resulting in only retaining individuals with at least 20% data. This resulted in the removal of 22 samples due to insufficient data, with 51 genotyped samples left for this analysis. A total of 230 loci were retained with 8.4% missing data.

Further genetic analyses revealed that there were 25 samples had at least one duplicate sample (scats collected from the same individual; see Appendix A Table A4). Sixteen of the duplicates were removed from the data set, as they did not represent unique individuals. This resulted in a total of 36 unique individual koalas successfully sampled. We have therefore genetically identified the minimum number of unique individuals present at the time of survey, but not the maximum, due to samples that did not meet our data quality thresholds being excluded.

6.1.1 Measures of Genetic Diversity

For detailed genetic analyses, such as determining genetic diversity, a different filtering process is required. For these analyses, the focus was on maximising the quality of the data while trying to maintain as many individuals as possible. In addition to the constant filters, we applied a stepwise increasing locus call rate filtering, from 0.2 to 0.8, resulting in retaining only SNPs with at least 80% data. Samples were also filtered for individual call rate through another stepwise increasing individual call rate filter, from 0.2 to 0.5, resulting in retaining only SNPs from individuals with at least 50% data. This resulted in the removal of 31 samples due to insufficient data, with 42 genotyped samples remaining for this analysis. A total of 2,805 loci were retained with 6.94% missing data. Thirteen duplicate samples (from 10 individuals) were identified in this dataset and subsequently removed from further analyses, leaving 32 individual koalas for examination of genetic diversity.

From these 32 individual koalas, we calculated three values of genetic diversity: observed Heterozygosity H_O , expected Heterozygosity H_E (adjusted for small sample size), and inbreeding coefficient F_{IS} . The 32 individual koalas from the footprint were spread across a large geographical area, therefore we grouped the samples between Coastal and Inland, splitting the samples between east (Coastal: $N = 20$) and west (Inland: $N = 12$) of Toowoomba (Table 6-1).

Table 6-1 Heterozygosity and inbreeding for Inland versus Coastal samples collected as part of the IRP project.

	H_O <i>(Higher is better)</i>	H_E <i>(Higher is better)</i>	F_{IS} <i>(Lower is better)</i>
Coastal (N = 20)	0.275	0.319	0.138
Inland (N = 12)	0.295	0.349	0.157

Caution should be taken when interpreting this geographically split data, as the sample sizes were low (≤ 20), which decreased the robustness of these estimates.

These results are best interpreted by comparing them with other populations where diversity measures were calculated using similar methods. For example, using similar methods, the UniSC team estimated diversity measures for NSW koalas in the Northern Tablelands (N = 76) to be $H_O = 0.225$, $H_E = 0.279$ and $F_{IS} = 0.190$; and for Redland City Council (mainland), Southeast Queensland koalas (N = 227) to be $H_O = 0.237$, $H_E = 0.320$ and $F_{IS} = 0.259$. Additional examples are provided in Table 6-2 and; all used the same method as in this report and indicate that the Inland and Coastal groups have high heterozygosity compared to other populations and average inbreeding. It is important to note, however, that samples grouped as Inland and Coastal are widely spread and geographically distant koalas were artificially pooled together. The comparison would have been improved by having a larger sample size over smaller geographic areas.

Table 6-2 Observed heterozygosity for Inland versus Coastal samples collected as part of this study compared to other populations (note that for heterozygosity, higher values are better).

Population	H_O
*ARTC Inland (N = 13)	0.295
*ARTC Coastal (N = 20)	0.275
Coastal NSW (Port Macquarie Hospital group 1) (35)	0.265
Northern Tablelands (20)	0.258
Coastal NSW (Port Macquarie Hospital group 2) (25)	0.247
Coffs Harbour (8)	0.235
Redlands mainland (44)	0.215

** Caution should be exercised when interpreting these results, as samples were obtained across a wide geographic range and may not be comparable with restricted geographic areas.*

Table 6-3 Inbreeding for Inland versus Coastal samples collected as part of the project compared to other populations (note that for inbreeding, lower values are better).

Population	F _{IS}
Northern Tablelands (20)	0.083
Northern Rivers (18)	0.096
Coffs Harbour (8)	0.099
Coastal NSW (Port Macquarie Hospital group 1) (35)	0.113
Redlands mainland (44)	0.117
*ARTC Coastal (N = 20)	0.138
Redlands Minjerribah urban areas (52)	0.154
*ARTC Inland (N = 13)	0.157
Coastal NSW (Port Macquarie Hospital group 2) (25)	0.178
Redlands Minjerribah (73)	0.196
Snowy Mountains (41)	0.235

** Caution should be exercised when interpreting these results, as samples were obtained across a wide geographic range and may not be comparable with results obtained from more restricted geographic areas.*

Further comparisons can be made by consulting from Kjeldsen et al. (2016). Here, measures are presented from other wild koala populations across Queensland, New South Wales and Victoria, using SNPs obtained through double digest restriction-associated (DARTseq), which differed from our koala specific DARTag panel (a panel we developed to increase non-invasive data recovery and consistency).

Here again, comparison with the Inland and Coastal groups suggest that these groups may have healthy observed heterozygosity and inbreeding averages; however, as noted above, the ARTC samples are spread over a vast geographical range and are compared to populations that are likely more geographically restricted (the difference in geographic spread could not be ascertained from Kjeldsen's paper).

Table 6-4 Genetic diversity established through double digest restriction-associated SNP sequencing (DArTseq)

State	Location	n	H _o	H _E	F _{IS}
QLD	St Bees Island	19	0.29	0.35	0.23
QLD	St Lawrence	19	0.26	0.30	0.20
QLD	Koala Coast	24	0.22	0.30	0.32
QLD	Ipswich	23	0.27	0.31	0.19
NSW	Port Macquarie	45	0.23	0.28	0.21
NSW	Campbelltown	9	0.27	0.33	0.27
VIC	South Gippsland	19	0.24	0.30	0.27
VIC	Cape Otway	13	0.24	0.25	0.11

Note: Wild koala populations across QLD, NSW and Victoria (note that the geographic spread of the samples for this study is unknown). n = sample size, H_O = observed heterozygosity, H_E = expected heterozygosity, F_{IS} = inbreeding coefficient. Table taken from Kjeldsen et al. (2016).

6.1.2 Sexing

Applying quality control for genotype data, locus call rate of 0.9 and individual call rate of 0.8, retained 31 unique individuals for sexing from the 36 ARTC samples. Of the 31 samples tested for sexing, 15 were female, and 16 were male (Appendix Table A3).

6.1.3 Chlamydia detection

Quality control of genotype data for locus call rate and individual call rate of 0.8 retained 30 unique individuals for *Chlamydia* pathogen detection, of which 19 (63.3%) had *Chlamydia* pathogen present. Samples that tested positive for the *Chlamydia* pathogen were evenly distributed across the ARTC footprint. It is important to note, however, that presence of the *Chlamydia* pathogen does not always equate to clinical disease.

6.2 Genetic co-analyses for DArTcap and DArTag data

From the 327 samples retained after the basic filtrations, 72 samples were identified as duplicates. After removing the 72 duplicates, a total of 255 unique koala samples were retained for further genetic analyses (Appendix Table A1). Of the 255 samples used in DArTcap and DArTag co-analyses, 101 samples were genotyped using DArTcap methodology and 154 samples were genotyped using DArTag methodology. The samples were collected across multiple projects; of the 255 samples used in this report, 36 were collected for the ARTC project.

6.2.1 Genetic structure

To identify possible genetic clusters, all 255 samples were analysed together without prior population information using fastStructure and STRUCTURE software. fastStructure predicted the presence of two to six (i.e., $K = 2 - 6$) genetic clusters (Figure 6-1), while STRUCTURE results indicated the presence of three genetic clusters (i.e. $K = 3$, Figure 6-2), as inferred by the ΔK which peaked at $K = 3$ (Figure 6-3).

Samples from Brisbane and Redland City had membership proportions different to other QLD and Northern NSW samples (Figure 6-2). Similarly, samples from Inverell were different from the other samples, although marginally similar to samples from Armidale, Uralla, Coffs Harbour and Bellingen (Figure 6-2). The samples from the most Southern NSW locations, such as Goulburn-Mulwaree, Shoalhaven City, Queanbeyan–Palerang and Snowy Monaro were genetically distinct from all other sample locations (Figure 6-2).

A similar pattern of membership proportions was evident in fastStructure plots (K3 plot in Figure 6-3). Further increasing the number of predicted genetic clusters to $K = 4-6$ showed similar genetic structure of the samples from neighbouring locations (K4 to K6 plots in Figure 6-1). Overall, samples from closer geographic proximities showed similar genetic structure, which supported grouping samples for further genetic analyses.

DRAFT



Figure 6-1 The number of genetic clusters as predicted from fastStructure form K = 2 to K = 6. Each bar represents an individual koala and its membership proportions to defined clusters.

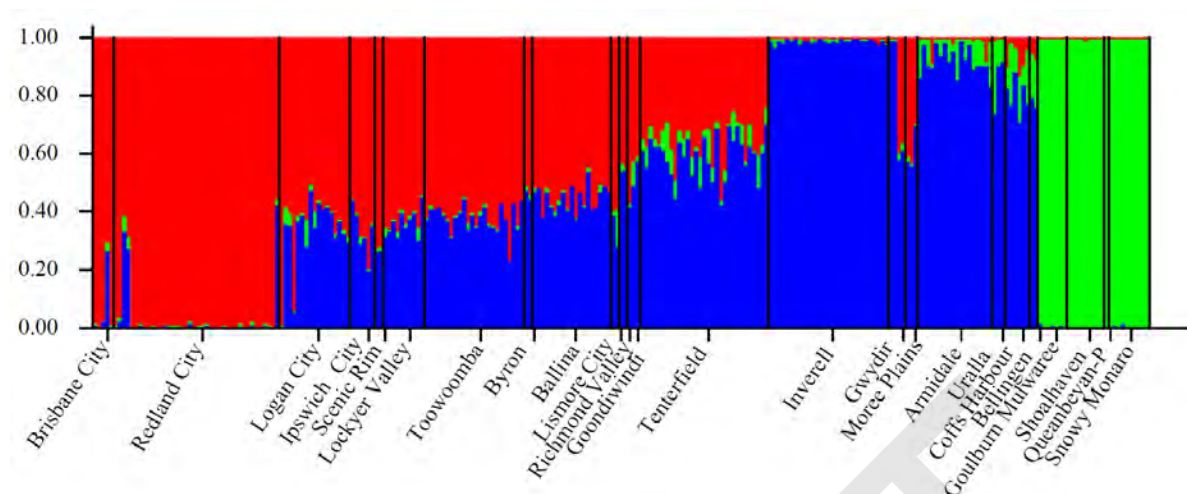


Figure 6-2 STRUCTURE plot showing the ancestral membership proportions defined by STRUCTURE results at K = 3 for 255 koala samples from 24 locations.

Each bar represents individual koala and its membership proportions to defined clusters. The details of individual koala and location information are given in Appendix A Table A1 in the order as it appears in Figure 3.

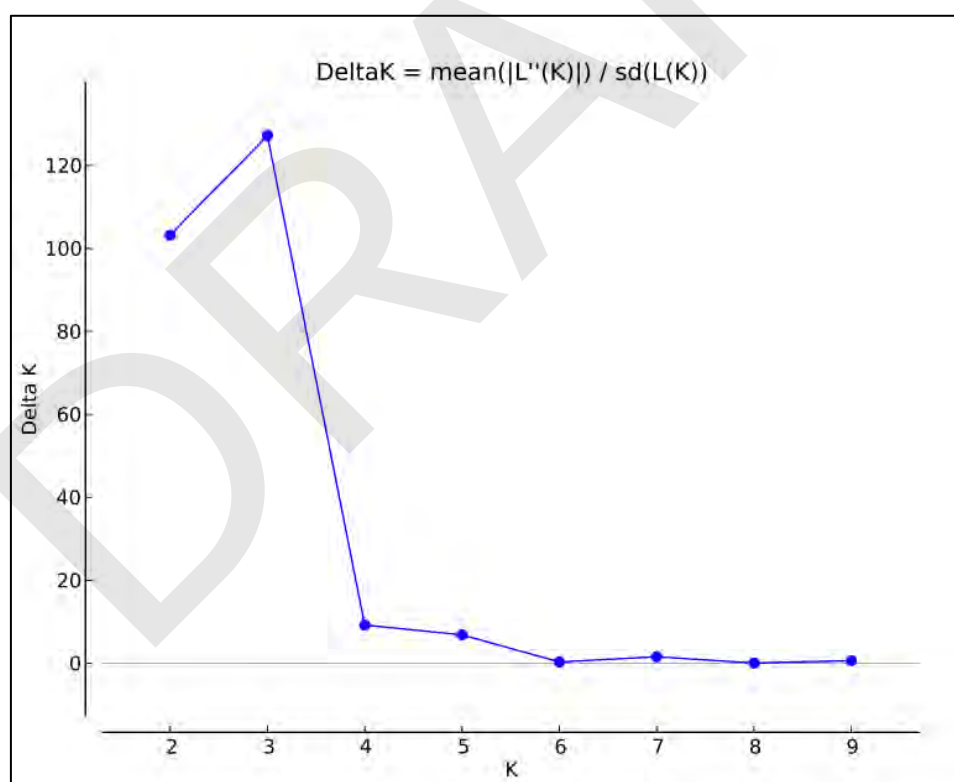


Figure 6-3 Delta K value generated for the STRUCTURE result at different K, which indicates the optimal number of ancestral clusters (K = 3).

PCA analysis of the 255 samples indicated that the samples from Goulburn-Mulware, Shoalhaven City, Queanbeyan–Palerang and Snowy Monaro formed a single cluster that was distinct from all other locations (Figure 6-4 and Appendix A Figure A2). Samples from Brisbane City and Redland City also formed a cluster that was somewhat separated from all other samples. Apart from the two clusters, the remaining samples from all other locations did not form easily separated clusters.

6.2.2 Genetic diversity between koala groups

Observed heterozygosity was broadly similar between koala groups (Table 6-5), with the exception of the two most Southern NSW groups, which had lower values for observed heterozygosity than other groups (i.e., Group 9 and Group 10). Observed heterozygosity was less than the expected heterozygosity in all koala groups. The lowest level of inbreeding was observed for Group 10 (samples from Snowy Monaro Regional Council), followed by Group 7 (samples from Armidale and Uralla).

Internal relatedness, which describes inbreeding at an individual level, was averaged across individuals and compared at population level and showed the highest averages in Groups 9 and 10 (Table 6-5). IR values can vary between 1 and -1, where maximum value of 1 indicates when all loci are homozygotes regardless allelic frequencies and the minimum value -1 is only reachable when all loci present only two alleles and the individual is heterozygote for all loci (Aparicio, Ortego et al. 2006). Overall, the average IR of populations observed in the present report is comparable to past studies (e.g., Kjeldsen et al., 2016; presented here in Table 6-6 for ease of comparison).

The estimated effective population size (N_E) varied between different koala groups and was lowest for Group 6 (samples from Inverell, Gwydir and Moree Plains). Groups 7, 8, 9 and 10 had N_E over 100 (Table 6-5).

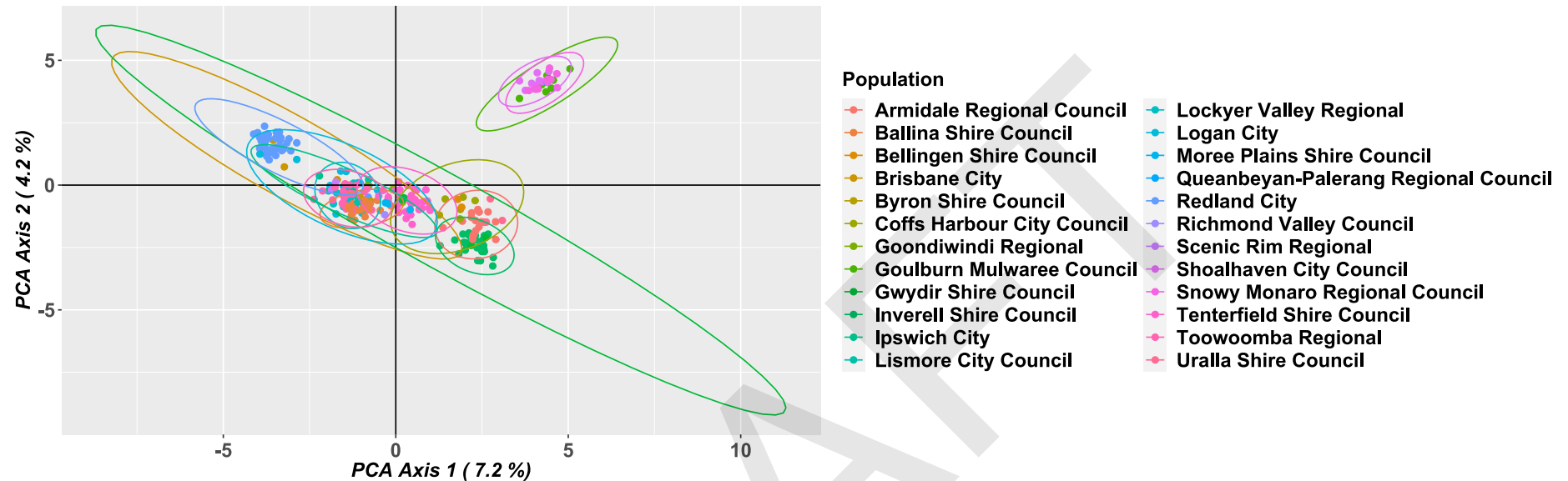


Figure 6-4 Principal component analysis (PCA) plot for 255 unique koalas from 24 sample locations.

Each location has its own 95% CI ellipse and each dot represents an individual koala. A duplicate figure with location name next to the ellipse is given in Appendix A Figure A2 and the details of individual koala and location information are given in Appendix A Table A1.

Table 6-5 Genetic diversity indices for ten groupings of koalas from 24 separate locations, divided into 10 geographic groupings.

Details of grouping by location are given in Appendix Table A2. ARTC samples fall into groups 2, 3 and 6 (Group 2: Logan City + Ipswich City + Scenic Rim Regional; Group 3: Lockyer Valley Regional + Toowoomba Regional Council; and Group 6: Inverell Shire Council + Gwydir Shire Council + Moree Plains Shire Council).

Group	Sample size	$H_O \pm SE$	$H_E \pm SE$	$F_{IS} \pm SE$	$IR \pm SD$	N_E (CI)
Group_1	42	0.219 $\pm$ 0.005	0.256 $\pm$ 0.006	0.144 $\pm$ 0.008	0.276 $\pm$ 0.146	79.9 (76.6 – 84.1)
Group_2	25	0.245 $\pm$ 0.005	0.298 $\pm$ 0.005	0.178 $\pm$ 0.008	0.215 $\pm$ 0.159	69.1 (64.1 – 72.5)
Group_3	34	0.261 $\pm$ 0.005	0.299 $\pm$ 0.005	0.125 $\pm$ 0.007	0.170 $\pm$ 0.129	170.1 (155.6 – 187.9)
Group_4	25	0.215 $\pm$ 0.006	0.251 $\pm$ 0.006	0.144 $\pm$ 0.009	0.288 $\pm$ 0.134	48.7 (46.0 – 51.5)
Group_5	31	0.253 $\pm$ 0.005	0.283 $\pm$ 0.005	0.106 $\pm$ 0.008	0.153 $\pm$ 0.114	156.0 (137.2 – 165.9)
Group_6	36	0.228 $\pm$ 0.006	0.260 $\pm$ 0.006	0.124 $\pm$ 0.007	0.230 $\pm$ 0.102	43.8 (42.5 – 45.4)
Group_7	21	0.224 $\pm$ 0.006	0.245 $\pm$ 0.006	0.084 $\pm$ 0.013	0.242 $\pm$ 0.107	108.7 (97.3 – 129.8)
Group_8	08	0.202 $\pm$ 0.007	0.233 $\pm$ 0.006	0.132 $\pm$ 0.009	0.312 $\pm$ 0.124	151.5 (94.4 – 499.5)
Group_9	17	0.160 $\pm$ 0.006	0.191 $\pm$ 0.006	0.162 $\pm$ 0.013	0.451 $\pm$ 0.095	120.8 (97.2 – 167.4)
Group_10	10	0.171 $\pm$ 0.007	0.177 $\pm$ 0.006	0.037 $\pm$ 0.009	0.412 $\pm$ 0.078	210.4 (116.5 – 1481.9)

Note - H_O = observed heterozygosity, H_E = expected heterozygosity, F_{IS} = inbreeding coefficient, IR = internal relatedness and N_E = effective population size. SE: standard error, SD: standard deviation, CI: 95% confidence interval.

Table 6-6 Genetic diversity of wild koala populations across QLD, NSW and Victoria (from Kjeldsen et al., 2016).

State	Location	n	H_O	H_E	F_{IS} ($P < 0.01$)	IR ($\pm SD$)	$N_{E_{LD}}$ (95 %CI)
QLD	St Bees Island	19	0.29	0.35	0.23	0.29 (± 0.15)	Infinite (∞)
QLD	St Lawrence	19	0.26	0.30	0.20	0.21 (± 0.11)	Infinite (∞)
QLD	Koala Coast	24	0.22	0.30	0.32	0.42 (± 0.29)	Infinite (921.20- ∞)
QLD	Ipswich	23	0.27	0.31	0.19	0.26 (± 0.16)	Infinite (∞)
NSW	Port Macquarie	45	0.23	0.28	0.21	0.25 (± 0.15)	116.8 (109.8-124.6)
NSW	Campbelltown	9	0.27	0.33	0.27	0.34 (± 0.27)	2.7 (2.4-3.2)
VIC	South Gippsland	19	0.24	0.30	0.27	0.31 (± 0.34)	Infinite (∞)
VIC	Cape Otway	13	0.24	0.25	0.11	0.20 (± 0.11)	46.7 (40.8-54.4)

6.2.3 Genetic differentiation among groups

Significant genetic differentiation was observed among the 10 koala groups ($F_{ST} = 0.117$, $P < 0.001$, $F'_{ST} = 0.166$). Pairwise comparison of F_{ST} values indicated significant differences between all koala groups (Table 6-7), where Group 9 and 10 (samples from most Southern NSW) indicated high level of genetic differentiation to all other groups, although the pairwise F_{ST} value is very small for between group 9 and 10 (Table 6-7).

Table 6-7 Pairwise FST values for ten groupings.

All values are statistically significant ($P < 0.001$) for each comparison. Details of grouping by location are given in Appendix A Table A2. Lower values indicate higher level of genetic similarity.

	Group_1	Group_2	Group_3	Group_4	Group_5	Group_6	Group_7	Group_8	Group_9
Group_2	0.059								
Group_3	0.086	0.035							
Group_4	0.132	0.075	0.099						
Group_5	0.092	0.035	0.047	0.08					
Group_6	0.153	0.092	0.098	0.134	0.055				
Group_7	0.166	0.105	0.119	0.151	0.072	0.072			
Group_8	0.142	0.086	0.107	0.130	0.058	0.088	0.066		
Group_9	0.222	0.170	0.183	0.214	0.147	0.18	0.179	0.164	
Group_10	0.23	0.181	0.188	0.226	0.154	0.188	0.192	0.185	0.066

Gene flow between koala groups was tested as the number of effective migrants (N_m) between groups. A high number of effective migrations was observed between Group 2 and Group 3 (i.e. between Logan City + Ipswich City + Scenic Rim Regional Council populations and Lockyer Valley + Toowoomba Regional Council populations), as well as between Group 2 and Group 5 (i.e. between Logan City + Ipswich City + Scenic Rim Regional Council populations and Tenterfield population, Table 10). Overall, $N_m > 1$ was observed for all comparisons, except those involving Group 1 (Brisbane + Redland City) vs Group 9, as well as Group 10 (samples from two groups in most Southern NSW) and Group 4 (samples from Byron, Ballina, Lismore and Richmond Valley) vs Group 9 and Group 10 (samples from two groups in most Southern NSW, Table 10).

Table 6-8 Number of migrants (N_m) between koala groups as estimated using FST values.

	Group_1	Group_2	Group_3	Group_4	Group_5	Group_6	Group_7	Group_8	Group_9
Group_2	3.985								
Group_3	2.649	6.766							
Group_4	1.651	3.076	2.257						
Group_5	2.458	6.966	5.007	2.864					
Group_6	1.381	2.470	2.301	1.618	4.293				
Group_7	1.255	2.132	1.849	1.410	3.241	3.208			
Group_8	1.506	2.672	2.053	1.671	4.093	2.584	3.513		
Group_9	0.875	1.226	1.109	0.919	1.454	1.140	1.151	1.281	
Group_10	0.839	1.131	1.073	0.860	1.372	1.080	1.051	1.105	3.522

6.2.4 Genomic relationship

The genomic relationship heatmap indicates higher relatedness of koalas within the same location or to neighbouring locations in comparison to the distal locations (Figure 6-5). Overall, the genomic relationship heatmap indicated a relatedness pattern that supported the observed genetic structure analyses (Section 6.2.1).

6.2.5 Sexing

The 115 samples that passed quality control for sex determination belonged to the following groups: Group 1 (n = 27), Group 2 (n = 10), Group 3 (n = 14), Group 4 (n = 23), Group 5 (n = 20), Group 6 (n = 5), Group 9 (n = 11) and Group 10 (n = 2). Two samples from Goondiwindi and another sample from North Stradbroke Island are not presented here, due to being geographically separated from the koala location groups. Koala sex by group is indicated in Table 6-9.

Table 6-9 Koala sex by group as estimated using genotyping of sex markers.

ARTC samples fall into Group 2, 3 and 6 (Group 2: Logan City + Ipswich City + Scenic Rim Regional Council; Group 3: Lockyer Valley Regional Council + Toowoomba Regional Council; and Group 6: Inverell Shire Council + Gwydir Shire Council + Moree Plains Shire Council).

Group	Male	Female	Sex ratio
1	8	19	1:2.4
2	6	4	1:0.7
3	7	7	1:1
4	11	12	1:1.1
5	13	7	1:0.5
6	2	3	1:1.5
9	5	6	1:1.2
10	1	1	1:1

6.2.6 Chlamydia detection

From the 105 samples that passed quality control for *Chlamydia* analysis, 57 samples (54.3%) were positive for *Chlamydia*. *Chlamydia* prevalence in each group is indicated in Table 6-10. Two samples from Goondiwindi and another sample from North Stradbroke Island were removed from the analyses.

Table 6-10 Chlamydia prevalence for each group as indicated by the genotyping of Chlamydia markers for 105 samples.

ARTC samples fall into Groups 2, 3 and 6 (Group 2: Logan City + Ipswich City + Scenic Rim Regional Council; Group 3: Lockyer Valley Regional Council + Toowoomba Regional Council; and Group 6: Inverell Shire Council + Gwydir Shire Council + Moree Plains Shire Council).

Group	Positive	Negative	Prevalence
1	16	8	67%
2	8	2	80%
3	7	7	50%
4	9	11	45%
5	6	12	33%
6	3	1	75%
9	6	4	60%
10	1	1	50%

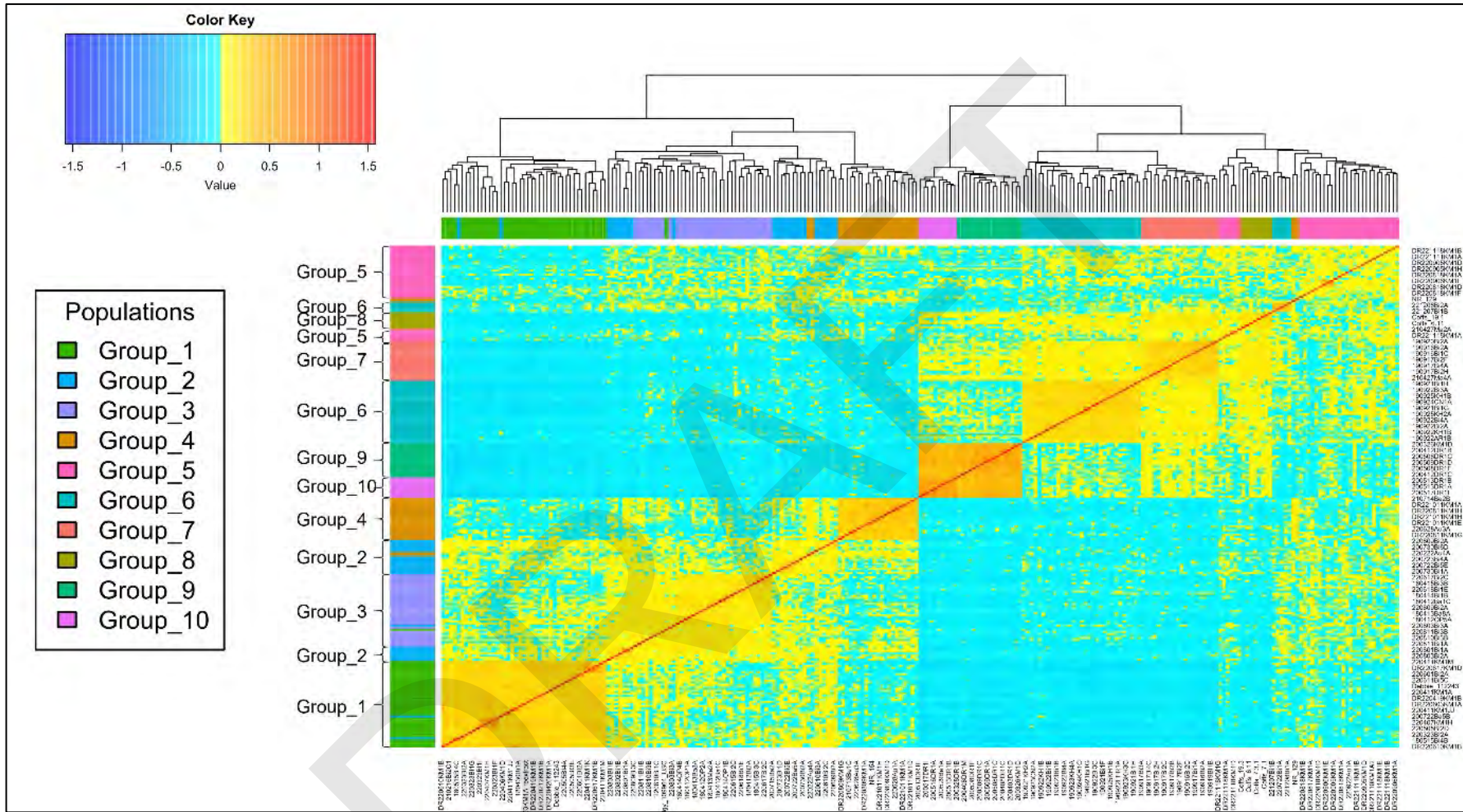


Figure 6-5 Genomic relationship matrix heat map for 10 geographic groupings as indicated in Table 2. Relatedness varies from high (red) to low (blue) as indicated by the colour key.

6.3 Diet Analysis

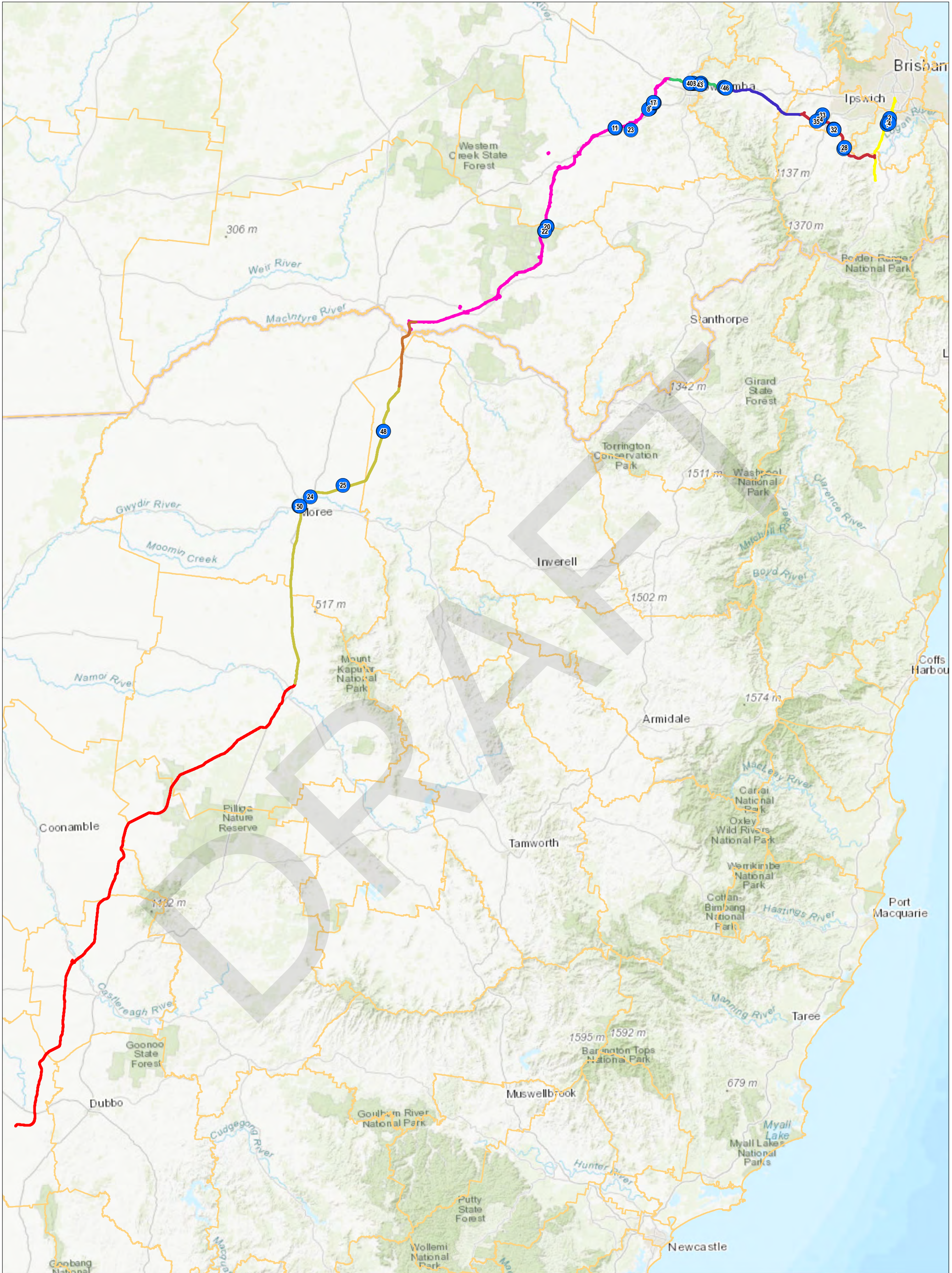
Of the 55 scat samples sequenced in this study, 49 returned reads for the validated diet markers after quality control filtering. Across all samples, between 1 and 7 tree species were detected per sample (average = 3.35). Thirty-seven individual species were detected across the 49 validated samples with several other species potentially present as indicated by the presence of markers for groups of target species. The most frequently detected species were *Eucalyptus chloroclada* (detected in 18 samples), *E. tereticornis* (17 samples), *E. amplifolia* (16 samples) and *E. camaldulensis* (16 samples). These species were also often found at high relative abundance within samples (range of average relative abundances: 24% to 44%). *E. prava* was detected in a single sample (IR21: 220623BI1B), however, as the markers for this species have not been validated it could not be included in the relative abundance calculations. The diet species detected differed between geographic regions and between individuals (Figure 6-6). See Appendix B for a breakdown of sample number identification and location.

In the Brisbane region *Eucalyptus seeana* was detected in three out of four samples collected in the south at an average relative abundance of 48.35%. *E. tereticornis* was detected in seven out of nine samples collected west of Brisbane at an average relative abundance of 62.6% (Figure 6-7, Table 6-11).

In the Toowoomba region, the tree species detected varied considerably between samples. *E. amplifolia*, *E. tereticornis*, *E. chloroclada* and *E. melliodora* were all detected in four or more samples (from 11) at relative abundances between 10.3% and 34.6% (Figure 6-8, Table 6-12).

In the region to the north-east of Goondiwindi *E. camaldulensis* was found in all six samples at an average relative abundance of 39.7%, while *E. amplifolia* and *E. tereticornis* were also found at high relative abundance in two individuals each (Figure 6-9, Table 6-13).

In the Moree Region, five out of seven samples contained *E. camaldulensis* with an average relative abundance of 35.2%, however the abundances ranged from 1% to 100%. While *E. populnea* and *E. chloroclada* were also found at high relative abundance (64.6% and 58.7%, respectively) in 3 and 2 samples, respectively (Figure 6-10, Table 6-14).



- Legend**

Diet Samples

Inland Rail Alignment

B2G - NSW/QLD Border to Gowrie

C2K - Calvert to Kagaru

G2H - Gowrie to Helidon

H2C - Helidon to Calvert

K2AB - Kagaru to Acacia Ridge/Bromelton

N2N - Narramine to Narrabri

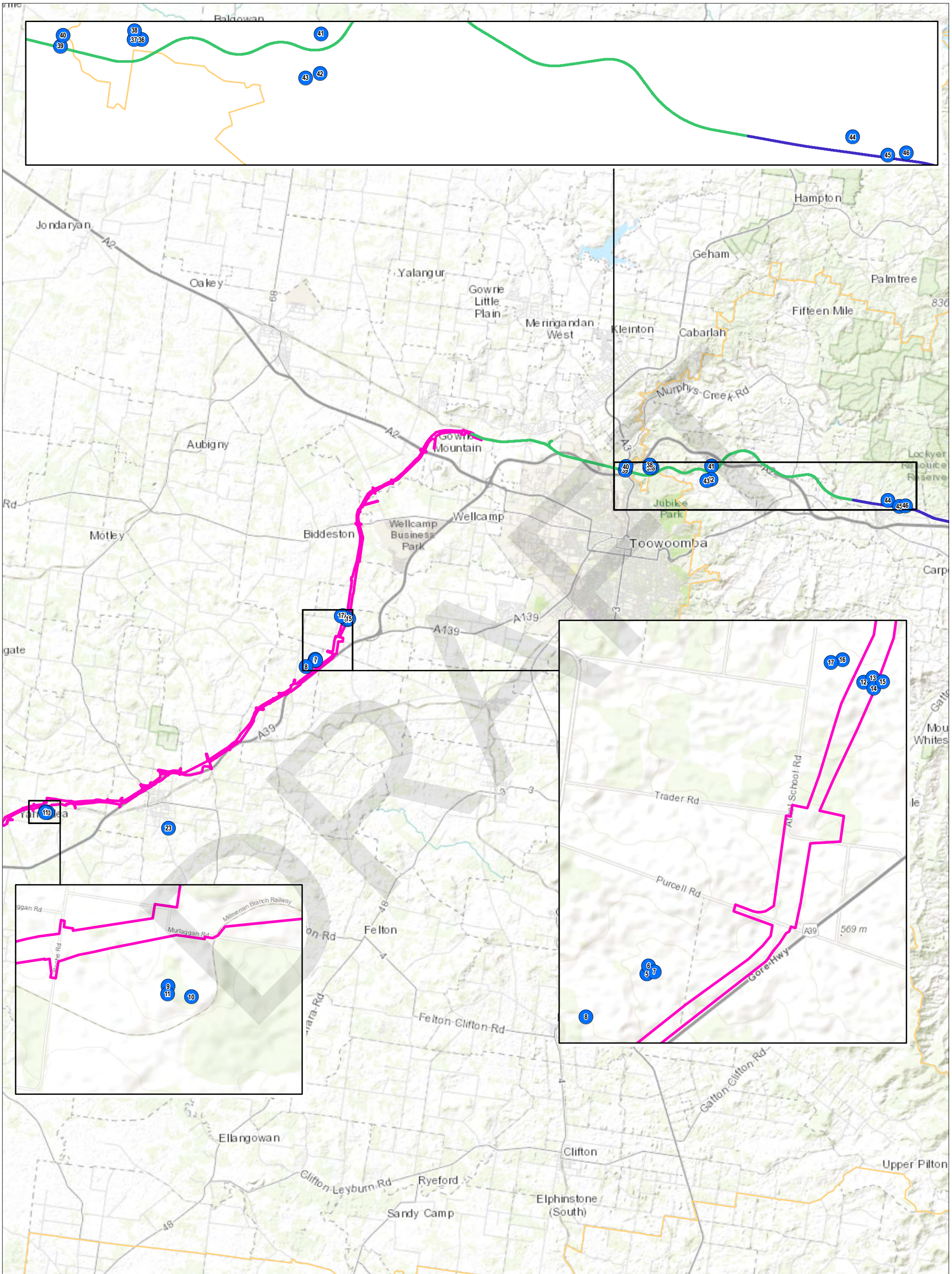
N2NS - Narrabri to North Star

NS2B - North Star to Border

LGA Boundary
- Data Source:**
ESRI World Topographic Map
- Map Of Diet Sample Locations Across The Entire Study Area**
- F6-6**
- | | | | |
|---|------------------|--|---|
| Drawing No: 0628339_N2AB_TM_G011_R0.mxd | | Koala Genetics Study Project – Inland Rail Program (NSW and QLD) | |
| Date: 14/02/2024 | Drawing Size: A4 | | |
| Drawn By: VN | Reviewed By: MD | Client: ARTC | |
| Coordinate System: GDA2020 MGA Zone 56 | | | |
| 0 10 20 30km | | <div><div>N</div><div></div></div> | This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy. |
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Table 6-11 relative abundances of the different dietary tree species detected in each sample in the Brisbane region, each abundance is given in a percentage of the sample

	Sample Number												
Species	1	2	3	4	27	28	29	30	31	32	33	34	35
<i>Angophora leiocarpa</i>			56.1										
<i>Corymbia citriodora</i>					6.7							8.3	
<i>Corymbia variegata</i>					15.6								
<i>Eucalyptus amplifolia</i>			4.6	4.7				58.2	43.4		0.2		
<i>Eucalyptus camaldulensis</i>								21.0	3.5				
<i>Eucalyptus cambageana</i>				1.2									
<i>Eucalyptus chloroclada</i>				1.6	2.1		100		2.1		2.9	4.7	
<i>Eucalyptus crebra and/or elegans</i>												4.8	
<i>Eucalyptus crebra, elegans and/or fibrosa</i>					5.6								
<i>Eucalyptus exserta</i>								0.2				0.2	
<i>Eucalyptus platyphylla</i>									1.2				
<i>Eucalyptus populnea</i>											1.3		
<i>Eucalyptus punctata</i>			10.2										
<i>Eucalyptus melanophloia</i>											22.6		
<i>Eucalyptus melanophloia and/or whiteii</i>													4.2
<i>Eucalyptus resinifera</i>											14.3		
<i>Eucalyptus rhombica</i>					13.0								
<i>Eucalyptus seeana</i>	66.5	100	26.9										
<i>Eucalyptus tereticornis</i>	33.5		2.3		57.2	100		20.5	49.8	100	58.7	82.0	95.8
<i>Eucalyptus tereticornis and/or robusta</i>				92.4									



Legend
● Diet Samples

Inland Rail Alignment
— B2G - NSW/QLD Border to Gowrie
— G2H - Gowrie to Helidon
— H2C - Helidon to Calvert
— LGA Boundary

Data Source:
ESRI World Topographic Map

Map of sample locations in the Toowoomba Region, relative abundances of the different dietary tree species detected in each sample as indicated in Table 6-12

Drawing No: 0628339_N2AB_TM_G013_R0.mxd
Date: 14/02/2024
Drawn By: CB
Reviewed By: MD

Koala Genetics Study Project – Inland Rail Program (NSW and QLD)
Client: ARTC

Coordinate System: GDA2020 MGA Zone 56

0 1 2 3km



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F6-8

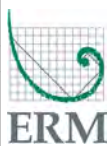
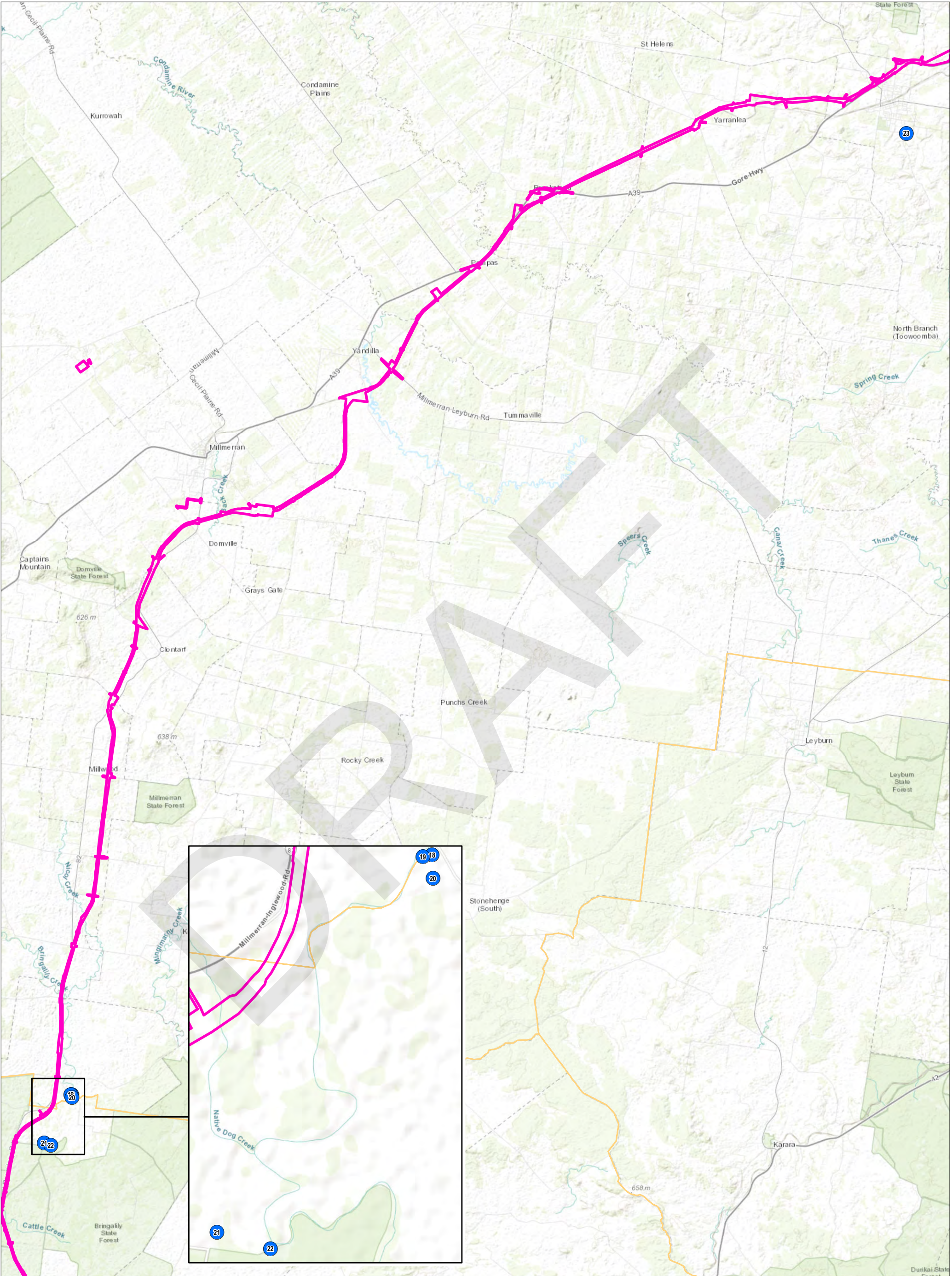


Table 6-12 relative abundances of the different dietary tree species detected in each sample in the Toowoomba region, each abundance is given in a percentage of the sample

	Sample Number																							
Species	5	6	7	8	9	10	11	12	13	14	15	16	17	36	37	38	39	40	41	42	43	44	45	46
<i>Corymbia maculata</i>																							48.3	21.7
<i>Eucalyptus albens</i>								5.2	0.2										37.7					
<i>Eucalyptus amplifolia</i>			68.6	58.6												11.1			0.9		55.4	100	18.4	22.2
<i>Eucalyptus blakelyi</i>			6.0											59.7										
<i>Eucalyptus brownii</i>					84.2		2.1																	
<i>Eucalyptus camaldulensis</i>		24.4		41.4																8.9				
<i>Eucalyptus carnea</i>														38.2										
<i>Eucalyptus chloroclada</i>	26.5	61.3	7.2						4.5					2.1			49.0		1.3	17.6				
<i>Eucalyptus conica</i>								6.1																
<i>Eucalyptus coolabah</i>							0.1																	
<i>Eucalyptus crebra, elegans and/or fibrosa</i>	33.0								8.1		11.9													40.1
<i>Eucalyptus cullenii and/or whitteii</i>							8.0																	
<i>Eucalyptus dura</i>					15.8	21.1																		
<i>Eucalyptus dura and/or siderophloia</i>															100									

	Sample Number																							
Species	5	6	7	8	9	10	11	12	13	14	15	16	17	36	37	38	39	40	41	42	43	44	45	46
<i>Eucalyptus dura, fibrosa and/or rhombica</i>												7.8												
<i>Eucalyptus eugenoides</i>																	0.4							
<i>Eucalyptus exserta</i>		3.1																		12.1				
<i>Eucalyptus fibrosa</i>													5.7											
<i>Eucalyptus granitica and/or whitteii</i>									19.1	38.6	68.9													
<i>Eucalyptus longirostrata</i>																73.5	2.4	18.0						
<i>Eucalyptus macta</i>	40.5		10.5																					
<i>Eucalyptus melanophloia</i>												85.8	74.2							50.1				
<i>Eucalyptus melanophloia and/or whiteii</i>								70.7																
<i>Eucalyptus melliodora</i>									2.4	1.0						15.4	15.7	2.3	7.7					
<i>Eucalyptus microcarpa</i>						5.0																		
<i>Eucalyptus orgadophila</i>						53.7	4.7	14.9	64.8	60.5	18.1		10.4											
<i>Eucalyptus platyphylla</i>							0.0	0.3																
<i>Eucalyptus populnea</i>						20.2	85.0	2.9																
<i>Eucalyptus punctata</i>																		79.3						

	Sample Number																							
Species	5	6	7	8	9	10	11	12	13	14	15	16	17	36	37	38	39	40	41	42	43	44	45	46
<i>Eucalyptus rhombica</i>									0.9		1.1													
<i>Eucalyptus siderophloia</i>													4.9											
<i>Eucalyptus tereticornis</i>		11.2															9.9			23.4	32.4		33.3	16.0
<i>Eucalyptus tereticornis and/or robusta</i>																			52.4					
<i>Eucalyptus tindaliae</i>			7.7																					
<i>Eucalyptus whiteii</i>												6.4	4.8											



Map of sample locations in the Region north-east of Goondiwindi, relative abundances of the different dietary tree species detected in each sample as indicated in Table 6-13

Drawing No: 0628339_N2AB_TM_G014_R0.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC	
Drawn By: VN	Reviewed By: MD		
Coordinate System: GDA2020 MGA Zone 56		N 0 1 2 3Km This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	

This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

Legend

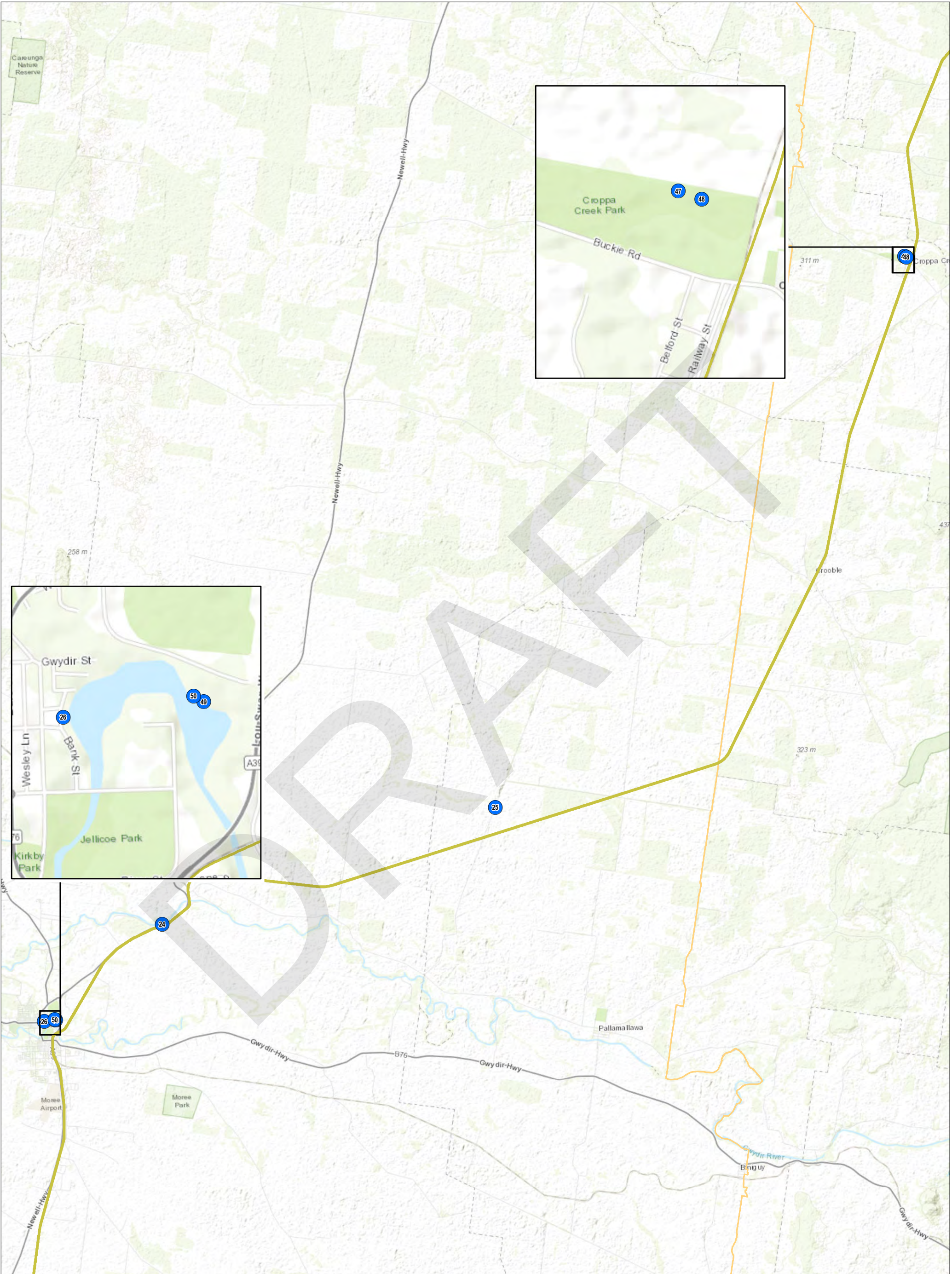
-  Diet Samples
-  B2G - NSW/QLD Border to Gowrie
-  LGA Boundary
-  Inland Rail Alignment

Data Source:
ESRI World Topographic Map



Table 6-13 relative abundances of the different dietary tree species detected in each sample in the region north-east of Goondiwindi, each abundance is given in a percentage of the sample

	Sample number					
Species	18	19	20	21	22	23
<i>Eucalyptus amplifolia</i>		13.4	63.3			
<i>Eucalyptus blakelyi</i>					29.5	
<i>Eucalyptus camaldulensis</i>	39.0	21.9	28.1	17.6	57.2	74.7
<i>Eucalyptus chloroclada</i>		15.7	8.7		12.2	
<i>Eucalyptus conica</i>	61.0	6.3				
<i>Eucalyptus drepanophylla</i>				21.3		
<i>Eucalyptus major</i>		14.7				
<i>Eucalyptus platyphylla</i>						25.3
<i>Eucalyptus tereticornis</i>		28.1		61.1		
<i>Eucalyptus woollsiana</i>					1.2	



Map of scat sample locations in the Moree Region, relative abundances of the different dietary tree species detected in each sample as indicated in Table 6-14

Drawing No: 0628339_N2AB_TM_G015_R0.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4		
Drawn By: VN	Reviewed By: MD	Client: ARTC	
Coordinate System: GDA2020 MGA Zone 56			This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.
			

- Legend**
- Diet Samples
 - Inland Rail Alignment**
 - N2NS - Narrabri to North Star
 - LGA Boundary

Data Source:
ESRI World Topographic Map

F6-10



Table 6-14 relative abundances of the different dietary tree species detected in each sample in the Moree region, each abundance is given in a percentage of the sample

Species	Sample Number						
	24	25	26	47	48	49	50
<i>Eucalyptus amplifolia</i>						51.5	
<i>Eucalyptus blakelyi</i>	47.4						
<i>Eucalyptus camaldulensis</i>	4.7		1.0	22.5		48.0	100
<i>Eucalyptus chloroclada</i>	18.3		99.0				
<i>Eucalyptus melliodora</i>					6.9		
<i>Eucalyptus platyphylla</i>						0.4	
<i>Eucalyptus populnea</i>		23.2		77.5	93.1		
<i>Eucalyptus tereticornis</i> and/or <i>robusta</i>	29.6						
<i>Eucalyptus rhombica</i>		35.4					
<i>Eucalyptus woollsiana</i>		41.5					

7. KOALA GENETIC ANALYSIS AND CONCLUSIONS

The IRP transects the Queensland and New South Wales landscape, and as part of the genetics study, data collected by UniSC from the broader landscape has been utilised for further analysis and therefore a deeper understanding of how the koalas in close proximity to the IRP play compare to other koala populations in the broader New South Wales and Queensland regions.

A key priority for IRP is to preserve current landscape connectivity for movement of koalas, despite creating a potential linear barrier. Unfortunately, along the footprint, and within the accessible area for sampling, the number of individual koalas sampled presents a challenge for connectivity analyses across the IRP. Indeed, for genetic samples to be collected, a koala needs to have been present at the survey site in the few days prior to a site visit. In low koala density or large home range areas, a koala might only be present at a specific site for a very narrow window throughout the year.

On this basis, some samples were pooled from other studies with IRP samples to form groups along the IRP, while other groups were included to help contextualise the population status associated with the IRP and include.

- Narrabri to North Star (Group 6);
- Border to Gowrie and Gowrie to Helidon (Group 3); and
- Calvert to Kagaru and Kagaru to Acacia Ridge and Bromelton (Group 2).

We further calculated genetic differentiation between these groups, and to other groups added for context. How similar or dissimilar the groups are to one another reveals the extent of gene flow. Group 2 and 3 values showed low differentiation between Border to Helidon and Calvert to Acacia Ridge.

Overall the three groups which included IRP samples, compared to other groups in the larger landscape had:

- High levels of heterozygosity: Higher levels of heterozygosity equate to larger genetic diversity within a population(s), which is positive as genetic diversity is linked to both individual health and at population level, evolutionary potential; with Group 3 (B2G + G2H) higher than the other groups;
- Low levels of inbreeding and of relatedness between individuals: this suggests gene flow is currently occurring within the groups and the potential of negative impacts due to excessive inbreeding is minimal;
- Relatively small population size, with Group 3 (B2G + G2H) having a larger population size relative to other groups. This results in overall lower densities of koalas across the landscape; and
- No concerns regarding sex ratio, but high chlamydia prevalence, except Group 3 which is medium prevalence (however the sample size remain very low). The ratio of males to females is not of concern for genetic health although chlamydia prevalence is high. Caution should be taken when interpreting these findings as the sample size is small.

To overcome current limitations, future studies should attempt to sample across a broader geographic range than just the IRP. This may assist in overcoming the geographic gaps in detected samples while also enabling more robust assessments of koala genetics and current threats at a landscape level. Repeat surveys may also assist in increasing the rate of detection of individuals across the IRP.

8. KOALA DIET ANALYSIS AND CONCLUSIONS

A key priority for IRP is to preserve the foraging variability and options for koalas, while also removing the necessary trees used for foraging by koalas in the vicinity of the rail alignment. The relative abundances of the tree species detected in each scat sample analysed by UniSC were provided to offer insight into the dominant and minor components of the diet to identify preferred foraging trees.

Overall, four species should be considered to be the main preferred foraging trees: *Eucalyptus chloroclada*, *E. tereticornis*, *E. amplifolia*, and *E. camaldulensis*. This may be a result of local availability of species, that is, some individuals may only have access to woodlands dominated by *E. tereticornis* and as a result their diet is also dominated by this species. Each of the regions in the study area showed significant differences in the diet preferences of koalas. Accordingly, we will examine the preferred foraging trees in three different sections of the IRP:

- East of the Toowoomba range;
- West of the Toowoomba range to the Queensland-NSW border; and
- New South Wales.

The Brisbane region had the lowest variety of tree species identified, with the southern samples dominated by *E. seeana*, and the western samples dominated by *E. tereticornis*. However, a total of 20 species or species groups were recorded in the 13 samples, although at lower abundances.

The Toowoomba region had the greatest number of samples and also the largest variety of tree species identified (total 35 species or species groups), featuring 4 main species at relatively equal abundances: *E. amplifolia*, *E. tereticornis*, *E. chloroclada* and *E. melliodora*. The region north-east of Goondiwindi added an additional three species to the large variety of species identified in Toowoomba: *E. drepanophylla*, *E. major*, and *E. woollsiana*. However, these were found in lower abundances as *E. camaldulensis* was the dominant species in all samples. This makes this region the most diverse for the foraging preferences of the individuals.

The diet analysis in the NSW region near Moree was also dominated by *E. camaldulensis*, however, *E. populnea* and *E. chloroclada* were also identified as important foraging species. There were 10 total species identified in the diet analysis.

Section 5.3 reveals the results from the in-field vegetation analysis supports the diet preference further with vegetation samples in the Brisbane region being dominated by *E. crebra*, *E. citriodora* and *Corymbia intermedia*, the Toowoomba region being dominated by *E. populnea*, *E. camaldulensis* and *E. chloroclada*, and the NSW regions being dominated by *E. camaldulensis*, *E. populnea* and *E. crebra*. Noting there was a difference in field observed canopy dominance versus the scat analysis of the same regions.

For example, the Toowoomba region scat analysis indicated feed tree preferences due to results lacking the three dominant tree species that were observed for that region. The most common species detected in scat samples for this region were *E. amplifolia*, *E. tereticornis*, *E. chloroclada* and *E. melliodora*. This supports the idea that while a eucalypt species is dominating a region, the individual koala will seek out its desired food tree. Appendix C also agrees stating '*The diet species detected differed between geographic regions and between individuals*'.

The spatial variability in the preferred diet trees of koalas indicates that any replacement planting should be done in accordance with the bioregion. Preferred food trees should be planted, however care should be taken to not develop a monoculture that would result in individual diets becoming dominated by one or two species, therefore reducing the nutritional value to be gained.

As with the genetic analysis, future studies should attempt to cover a broader range across the IRP to provide a more robust analysis. Repeat surveys may also assist in increasing the rate of detection of individuals across the IRP.

9. KOALA HABITATS IN THE STUDY AREA

The IRP comprising of eight sections, being of eight distinct projects, reflects considerably varying histories across the IRP. Land use varies from agricultural areas (largely cleared and utilised for intensive cultivation through to livestock grazing), to large areas of state forests and protected areas as well as extending through heavily urbanised areas particularly the suburbs of southern Brisbane and regional cities and townships of Toowoomba, Narrabri, Moree and Narromine.

To overcome the limitations of a small sample size from this study, a landscape approach was taken that incorporated historic koala observation data and ground-truthed koala habitat assessments to evaluate the potential suitability of habitat and opportunities to maintain connectivity of key areas within the IRP and surrounding landscape. This section (Sections 8.1.1-8.1.8) therefore presents a discussion based on the findings of this study including:

- areas of high density of koala records, identified as koala hotspot region;
- areas where maintenance of connectivity are important (post-identification of survey hotspots);
- key areas to undertake ongoing koala monitoring to assess the performance of proposed mitigation measures determined to maintain or improve genetic diversity in identified koala populations;
- a project-specific habitat connectivity strategy to maintain and improve habitat connectivity to avoid and minimise impacts to koala; and
- how knowledge from this study can inform impact assessment and offsetting of significant impacts resulting from the IRP.

Using a combination of approaches including results from this study and desk-top assessments of historic koala records and habitat availability, koala hotspot regions within each project were defined. as:

- A high density of historic koala records is known;
- Suitable koala habitat is present; and
- Detection dog surveys returned positive detections of koala occupancy.

9.1 Kagaru to Acacia Ridge and Bromelton

The K2ARB is no longer apart of the IRP, however data from the study associated in the areas within the K2ARB section will still provide beneficial data on important koala populations, habitat areas and identification of genetic diversity.

9.1.1.1 Historic Koala Records

The 2016, 2018 and 2020 field investigations did not record any sightings of koalas. There are records for this species within 10 km of Beaudesert Road, Bromelton Loop, Middle Road/Greenbank Loop and Kagaru Loop Enhancement Work Areas. As a part of the environmental investigations for K2ARB a search of the Queensland Government Wildlife database returned koala records within the Glider Forest (in 2018), as well as near the southern part of the Greenbank Military Training Area (in 2015), closest to the Middle Road/Greenbank Loop Enhancement Work Area. Since 2011, there have been 10 records of koalas within 5 km of the EIS Disturbance Footprint. The infrequent and low number of records indicate that koalas occur within the Study Area, and at very low densities. As a part of the environmental investigations for K2ARB potential koala scratch marks were found on *Eucalyptus propinqua* trees and likely koala scats were observed within the Glider Forest, close to the Project Area.

ALA records of koala presence show a high density of recent records throughout the K2ARB, particularly within Karawatha Forest, Glider Forest and throughout patches of retained vegetation and creeks adjacent to and surrounded by heavily urbanised areas. It should be noted that the proximity to urban areas may influence the number of sightings that have historically been made of individuals in relation to the size and quality of habitat.

From 2014-2018, OWAD Environment undertook surveys with detection dogs to determine koala distribution, genetics and infection status across selected areas (protected areas, forests, and reserves) in the Brisbane City Council (BCC) and Logan City Council (LCC) Local Government Areas (LGAs). The results of the BCC Koala Detection Dog Study showed a decline in koala genetic diversity from 2016 to 2018 (most noticeable in the Larapinta, Karawatha and Larapinta locations which make up part of the broader Flinders Karawatha Bioregional Corridor) and was concluded to be a result of habitat fragmentation due to industrial and residential developments in the area (OWAD Environment, 2018a). The LCC LGA Detection Dog Studies found koala scats at 63% of the 50 parks sampled in the initial work across the LCC LGA (OWAD Environment, 2014), koala scats at 11 of the 21 properties surveyed in the following survey (OWAD Environment, 2015), and KoRV-A detected in 28% of the individuals identified during 2018 surveys across 84 locations (OWAD Environment, 2018b). The results of these surveys identified three main genetic populations across LCC LGA and BCC LGA including:

- Northern cluster within the BCC LGA;
- Central cluster within predominately the BCC LGA; and
- South-western cluster which is within the LCC LGA.

When comparing these populations, the results of these surveys indicated that the northern and central clusters of koala populations in the BCC LGA were less genetically diverse than those in the south-western cluster found in LCC LGA, demonstrating a greater level of permeability across the landscape in LCC LGA (OWAD Environment, 2018b). It also noted that koala movement and dispersal in the LCC LGA was largely constrained by geographical areas, showing four main populations within this LGA (OWAD Environment, 2018b).

9.1.1.2 Findings from the Study

A single hotspot was identified in K2ARB and was located inside the Greenbank Military Reserve. Four koala scat detections were made following detection dog surveys and numerous historic koala records are present. The hotspot is defined as extending from the Logan Motorway south to the edge of contiguous forest and Teviot Brook. A few key forests and reserve provide. These include The Glider Forest, Parkinson Bushland Reserve and Karrawatha Forest which both contain historic records of koalas, provide important corridors within the hotspot connecting the surrounding landscape. Retained vegetation in riparian zones is likely to be of high importance for maintaining connectivity.

Table 9-1 Koala Hotspot Region within K2ARB

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	Inclusive of New Beith to Glider Forest (Hilcrest)	Remnant vegetation and high-value regrowth vegetation patches, and remnant vegetation lining creeks, both dominated by Koala food trees.	The Glider Forest Parkinson Bushland Reserve Greenbank Military Training Area	Koala records within intact remnant vegetation with linkage to other vegetated area.

9.1.1.3 Available Koala Habitat

In line with the environmental investigations for the K2ARB, extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the K2ARB. Survey effort was conducted in-line with state and federal guidelines undertaken by WSP in May-June 2016, and ERM in February-May 2018 and January 2020. This consisted of active searches and Spot Assessment Technique (SAT) searches.

The environmental investigations for K2ARB identified that this Project Area is characterised by urbanisation, notably adjacent to the Greenbank Military Training Area, with patches of vegetation within the Project Area being frequently managed (cleared) for existing general rail operations. Koala habitat is available in the form of regrowth woodlands and some wildlife corridors of remnant-to-advanced-regrowth vegetation dominated by eucalypt species common across the Project Area.

Typical koala food tree species found in this region include *Corymbia intermedia*, *E. seena* and *E. tereticornis*, see Table 8-2 for a breakdown of canopy species identified on the Koala Detection Dog Surveys.

Table 9-2 Available Koala Habitat within K2ARB

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
84	■ <i>Melaleuca quinquinervia</i> ■ <i>Corymbia intermedia</i> ■ <i>Lophostemon suaveolens</i> ■ <i>Eucalyptus seeana</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads
85	■ <i>Eucalyptus tereticornis</i> ■ <i>Eucalyptus crebra</i> ■ <i>Corymbia intermedia</i> ■ <i>Lophostemon suaveolens</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads
86	■ <i>Eucalyptus tereticornis</i> ■ <i>Corymbia intermedia</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads
87	■ <i>Lophostemon suaveolens</i> ■ <i>Eucalyptus seeana</i> ■ <i>Melaleuca quinquinervia</i> ■ <i>Corymbia intermedia</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads
88	■ <i>Eucalyptus tereticornis</i> ■ <i>Lophostemon suaveolens</i> ■ <i>Melaleuca quinquinervia</i> ■ <i>Corymbia intermedia</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads

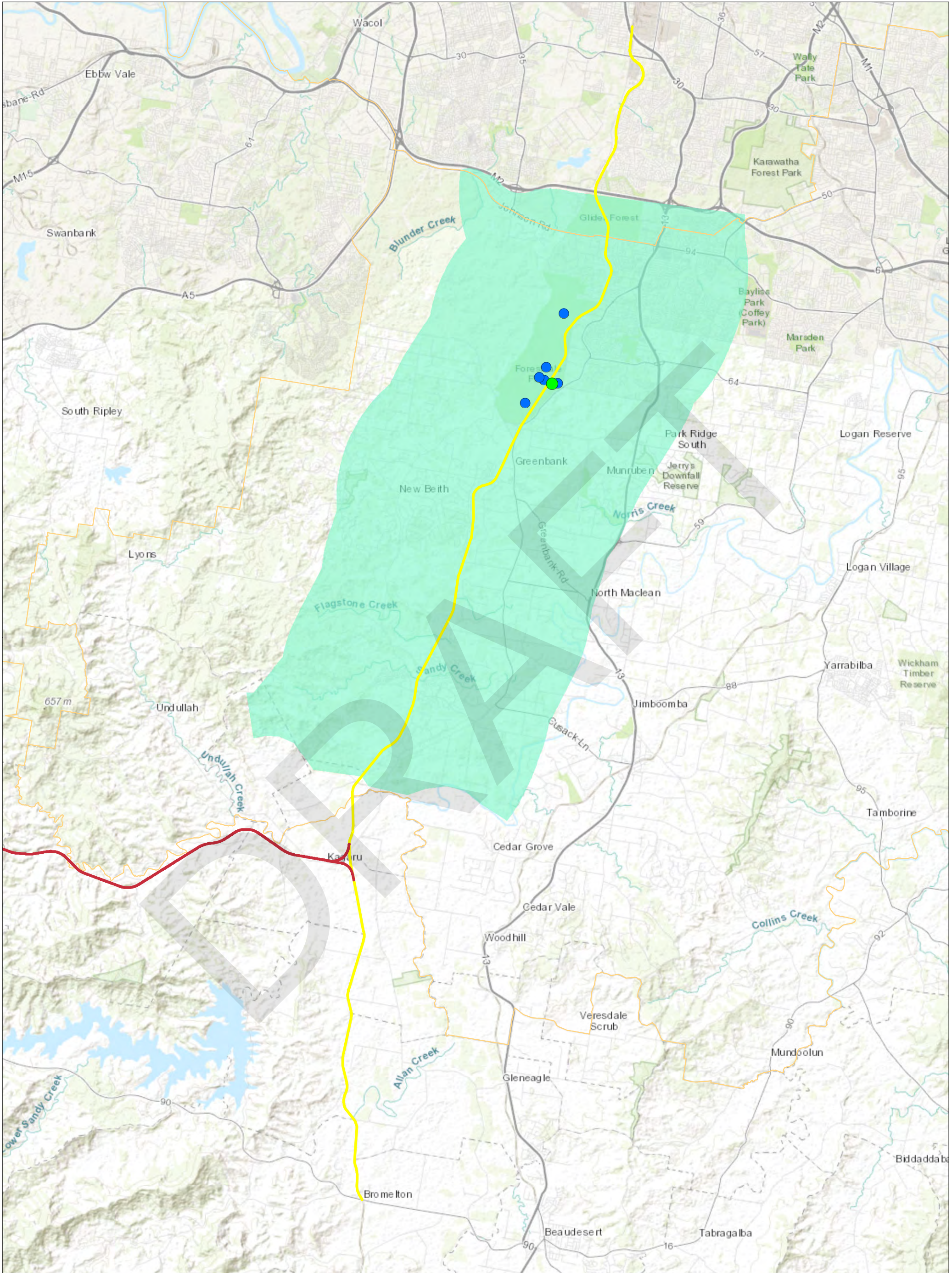
Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
89	■ <i>Eucalyptus seeana</i> ■ <i>Melaleuca quinquinervia</i> ■ <i>Corymbia intermedia</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads
90	■ <i>Corymbia citriodora</i> ■ <i>Lophostemon suaveolens</i> ■ <i>Melaleuca quinquinervia</i> ■ <i>Corymbia intermedia</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads
91	■ <i>Corymbia citriodora</i> ■ <i>Lophostemon suaveolens</i> ■ <i>Melaleuca quinquinervia</i>	Intact remnant vegetation	Located in Greenbank Military Reserve, adjacent to heavily urbanised landscape and major roads

9.1.1.4 Opportunity for Connectivity

Locations considered important for maintaining connectivity include the eucalypt dominated woodland of the Glider Forest as well as the vegetation of the Greenbank Military Training Area, existing as a fauna corridor in contrast to the surrounding predominately urban landscape. Both forested areas are important components of the broader Flinders-Karawatha Biodiversity Corridor which is notable as one of the largest and last remaining stretches of continuous forest within SEQ (McGregor & Jones, 2016). The full extent of this corridor extends from Karawatha Forest to Flinders Peak to Brisbane's south and west to the southern side of Ipswich (McGregor & Jones, 2016). The continued connectivity of suitable habitat provided by the corridor will be critical for koalas within the SEQ extent and the surrounding landscape. Maintenance of connectivity through utilising existing crossing structures should be prioritised. Crossing structures should be in line with the koala Sensitive Design Guidelines (2022) and consider the best practice design of structures recommended in the WSP Preliminary Fauna Connectivity Strategy for the B2G Project, however within this section of the IRP the proponent was able to demonstrate that no additional fauna connectivity structures were required for KARB for the EPBC referral application.

Where offsetting is required for significant residual impacts to the koala, priority should be given to potential offset sites within 5km of the alignment, and with vegetation connected to, or in close proximity to, the hotspot region and containing koala food trees important for the K2ARB such as *E. tereticornis*, *E. crebra* and *Lophostemon* and *Corymbia* spp.

See Figure 9-1 for hotspot region associated within K2ARB.



- Legend**
- Koala sightings
 - Scat detections - East
 - Active Koala Hotspots
 - LGA Boundary
 - Inland Rail Alignment**
 - C2K - Calvert to Kagaru
 - K2AB - Kagaru to Acacia Ridge/Bromelton

Data Source:
ESRI World Topographic Map

Active Koala Hotspots with K2AB

Drawing No: 0628339_N2AB_TM_G006_R3.mxd
Date: 14/02/2024
Drawn By: VN

Koala Genetics Study Project – Inland Rail Program (NSW and QLD)
Drawing Size: A4
Reviewed By: MD
Client: ARTC

Coordinate System: GDA2020 MGA Zone 56



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9.2 Calvert to Kagaru

9.2.1.1 Historic Koala Records

Studies undertaken for the C2K EIS confirmed koala presence throughout the Project Area. Observations of nine individuals and scat/scratch marks were found in Ebenezer, Peak Crossing and Washpool localities. ALA database showed several records throughout Project Area and even more in the greater surroundings. These records were largely concentrated in patches of protected forest, particularly across the ranges. The majority of these records are recent and were made post 2010.

9.2.1.2 Findings from the Study

Two hotspots have been identified within C2K and have been ranked in terms of priority for mitigation and management actions. Hotspot one is inclusive of the towns of Ebenezer to Peak Crossing and incorporates a mosaic of cleared agricultural land, advanced regrowth, and remnant vegetation. Riparian zones and protected nature reserves offer important corridors to koala dispersal within this hotspot, with prominence of Warrill Creek and the eucalypt dominated woodland of Purga Nature Reserve. Six scat detections were made following detection dog surveys and were noticeably within proximity to clusters of historic koala records.

Hotspot two is within proximity to hotspot one and is separated by a narrow section of cleared agricultural land. Due to the absence of historic records in between these hotspots, and the inability to survey in these areas, these hotspots have been delineated for the purpose of this study. It is possible that dispersal between hotspots occurs through the use of paddock trees and riparian vegetation, however this cannot be confirmed through this study. Hotspot two is inclusive of sandy creek south of Peak Crossing to the town of Washpool. Sandy Creek, Purga Creek and the eucalypt dominated woodlands across the Tevoit Range that extends beyond the IRP offer the primary corridors for koala movement within this hotspot and likely enables connectivity to suitable habitat in the surrounding area. Three koala scat detections were made just north of Washpool following detection dog surveys.

Table 9-3 Koala Hotspot Regions within C2K

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	Inclusive of Ebenezer to Peak Crossing	Remnant vegetation and high-value regrowth vegetation patches, and remnant vegetation lining creeks, both dominated by Koala food trees.	Warrill Creek Purga Nature Reserve	Koala records within intact remnant vegetation with linkage to other larger vegetated area.
2	Inclusive of Sandy Creek (Peak Crossing) to Washpool.	Remnant vegetation of the Mountain Range, and remnant vegetation lining creeks, both dominated by Koala food trees.	Sandy Creek Purga Creek Teviot Range	Koala records within intact remnant vegetation with linkage to other larger vegetated area.

9.2.1.3 Available Koala Habitat

In line with the C2K EIS extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for C2K. Survey effort was conducted in-line with state and federal guidelines undertaken by Jacobs-GHD in March-May 2016, GHD in December-February 2017, EMM September-November 2018 and FFJV December-April, May-July 2019. This consisted of habitat assessments, active searches, SAT searches and incidental observations.

The C2K EIS studies undertaken identified that this Project Area has remnant vegetation associated with sloping and steep topography or is highly fragmented with majority of the IRP dominated by pasture grassland, isolated trees and areas of advanced regrowth; by-products of historic land clearing. Remnant eucalypt vegetation is associated with the Peak Crossing, Teviot Range and Ebenezer areas (To the North and South of the Project Area). Most koala records are associated with riparian habitat near Western Creek, Warrill Creek and Purga Creek including its associated floodplains.

Typical koala food tree species found in this region include *E. crebra*, *C. citriodora* and *C. tessellaris*, see Table 9-4 for a breakdown of canopy species identified on the koala detection dog surveys.

Table 9-4 Available Koala Habitat within C2K

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
75	■ <i>Corymbia citriodora</i> ■ <i>Eucalyptus crebra</i>	Likely remnant	Edge of cleared pastoral land
76	■ <i>Corymbia citriodora</i> ■ <i>Eucalyptus crebra</i>	Advanced regrowth/remnant	Edge of cleared pastoral land
77	■ <i>Eucalyptus tereticornis</i> ■ <i>Callitris glaucophylla</i>	Advanced regrowth/remnant	Purga Nature Reserve
78	■ <i>Eucalyptus crebra</i> ■ <i>Eucalyptus tereticornis</i> ■ <i>Corymbia tessellaris</i>	Advanced regrowth/remnant	Purga Nature Reserve
79	■ <i>Corymbia tessellaris</i> ■ <i>Eucalyptus crebra</i> ■ <i>Corymbia citriodora</i>	Advanced regrowth/remnant	Connectivity with local nature reserved edging pastoral land
80	■ <i>Eucalyptus woollsiana</i>	Advanced regrowth/remnant	Connectivity with local nature reserved edging pastoral land
81	■ <i>Corymbia tessellaris</i> ■ <i>Eucalyptus crebra</i> ■ <i>Eucalyptus tereticornis</i> ■ <i>Lophostemon suaveolens</i>	Advanced regrowth/remnant	Connectivity with local nature reserved edging pastoral land
82	■ <i>Corymbia citriodora</i> ■ <i>Eucalyptus crebra</i>	Advanced regrowth/remnant	Connectivity with local nature reserved edging pastoral land
83	■ <i>Eucalyptus crebra</i> ■ <i>Corymbia tessellaris</i>	Advanced regrowth/remnant	Connectivity with local nature reserved edging pastoral land

9.2.1.4 Opportunity for Connectivity

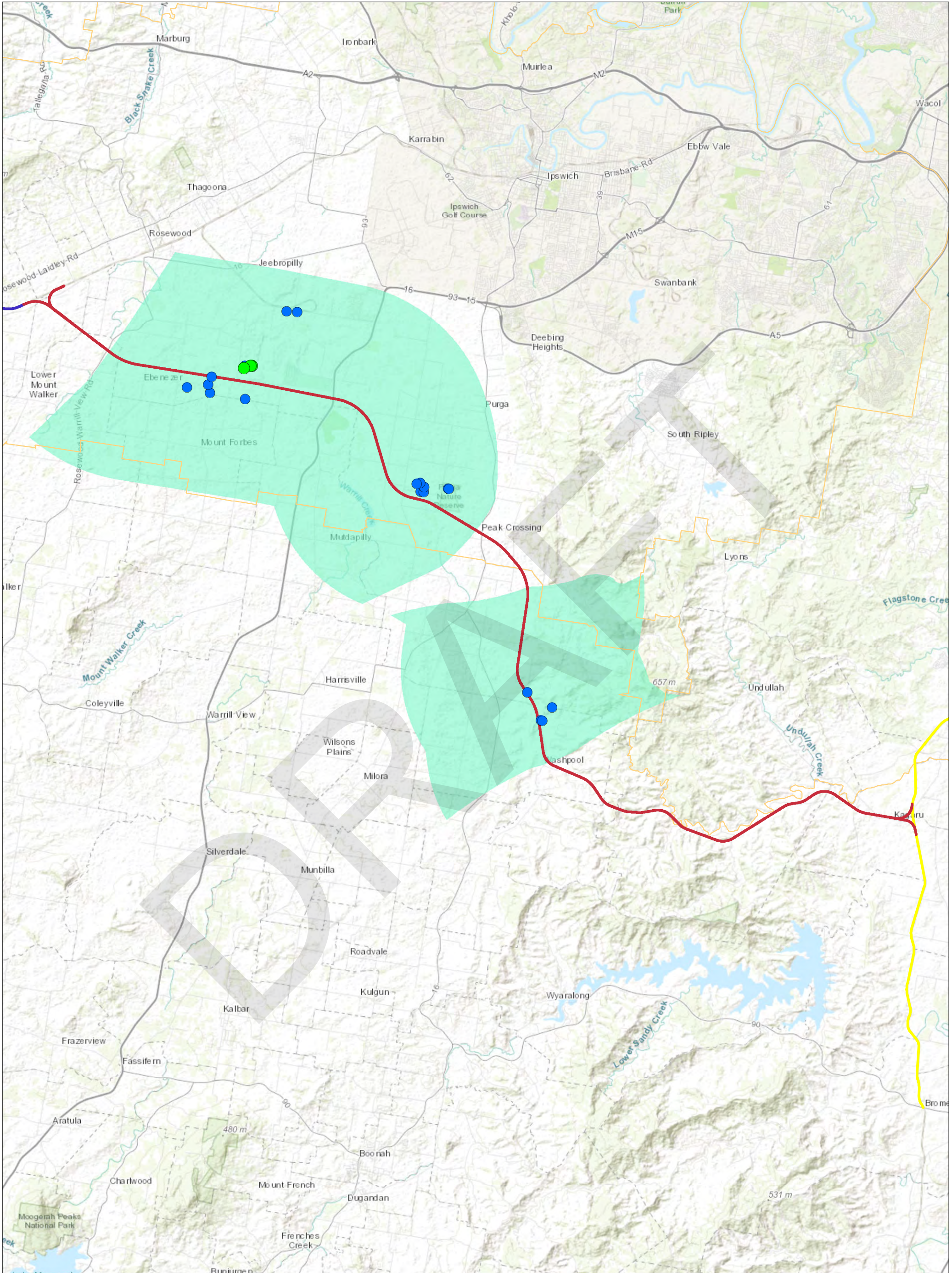
Locations considered important for maintaining connectivity include the eucalypt dominated woodland of the Purga Nature Reserve as well as the riparian vegetation along Purga, Sandy and Warrill creeks. These provide important fauna corridors throughout otherwise heavily cleared agricultural land. Connecting fragmented eucalypt vegetation to the contiguous forest of the Teviot Ranges will also be important for improving connectivity. Maintenance of connectivity through utilising existing crossing structures should be prioritised. Crossing structures should be in line with the Koala Sensitive Design Guidelines (2022) and consider the WSP Preliminary Fauna Connectivity Strategy for the B2G Project.

The eastern edge of C2K overlaps with the Flinders-Karawatha Biodiversity Corridor. In addition to providing important continuous koala habitat, this corridor is critical for facilitating extensive connectivity across the broader landscape. In particular, this corridor is likely to provide connectivity between the second hotspot of C2K and the active hotspot identified within K2ARB. As such, any efforts to maintain or improve connectivity will be beneficial to local koalas across the landscape, beyond the extent of the IRP.

Where offsetting is required for significant residual impacts to the koala, priority should be given to potential offset sites within 5km of the alignment, and with vegetation connected to, or in close proximity to, the hotspot region and containing koala food trees important for the C2K such as *E. tereticornis*, *E. crebra*, and *Lophostemon* and *Corymbia spp.*

See Figure 9-2 for hotspot locations associated within the Project Area.

DRAFT



- Legend**

 - Koala sightings
 - Scat detections - East
 - Active Koala Hotspots
 - LGA Boundary
- Inland Rail Alignment**

 - C2K - Calvert to Kagaru
 - H2C - Helidon to Calvert
 - K2AB - Kagaru to Acacia Ridge/Bromelton

Data Source:
ESRI World Topographic Map

Active Koala Hotspots with C2K

Drawing No: 0628339_N2AB_TM_G006_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN	Reviewed By: MD	
Coordinate System: GDA2020 MGA Zone 56		Client: ARTC
024Km		N This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.

F9-2



9.3 Helidon to Calvert

Studies undertaken for the H2C EIS confirmed koala presence throughout the IRP. Observations of five individuals and scat/scratch marks localised to between Helidon and Gatton as well as between Laidley to Calvert. One was recorded near Helidon, three between Laidley and Grandchester and one near Calvert. ALA database showed several records throughout Project Area and even more in the greater surroundings.

9.3.1.1 Findings from the Study

Two hotspots have been identified within H2C following desk top assessments and detection dog surveys and have been ranked in terms of priority for intervention and mitigation measures. Hotspot one is inclusive of Helidon, Lockyer State Forest and Ringwood and is likely to connect to the Adjacent hotspot in G2H. Remnant eucalypt vegetation is still dominant, particularly across the range and in riparian creek vegetation. Historic koala records are numerous surrounding the town of Helidon and three scat detections were made following detection dog surveys.

A considerable gap between hotspot one and hotspot two is present in H2C with the landscape dominated primarily by cleared agricultural land and urban areas with minimal records of koala presence. Hotspot two is bordered by the town of Laidley and is inclusive of the remnant forest surrounding the town of Grandchester and Western Creek on the outskirts of Calvert. Historic koala records are present within the area defined as the hotspot but no detections were made following detection dog surveys. Consultation with community members and local organisations have confirmed that anecdotal observations of koalas within the hotspot is known with sightings and known instances of koala fatalities presented in community consultation workshops for the IRP.

Table 9-5 Koala Hotspot Regions within H2C

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	Inclusive of Helidon, Lockyer State Forest to Ringwood.	Remnant vegetation of the Mountain Range and lining creeks, dominated by Koala food trees.	Lockyer State Forest Helidon Hills	Koala records within intact remnant vegetation with linkage to other larger vegetated area.
2	Inclusive of Laidley to Western Creek (Calvert).	Remnant vegetation of the Mountain Range and lining creeks, dominated by Koala food trees.	Little Liverpool Range	Koala records within intact remnant vegetation with linkage to other larger vegetated area.

9.3.1.2 Available Koala Habitat

In line with the H2C EIS, extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the Helidon to Calvert Project. Survey effort was conducted in-line with state and federal guidelines undertaken by Arup/SMEC in March-June 2016, EMM in September-November 2018 and ELA December-April 2019. This consisted of habitat assessments, active searches, SAT searches and incidental observations. Studies undertaken to support the H2C EIS identified that remnant vegetation was fragmented and typically occurred in areas characterised by rocky ranges and sloping topography such as the Lockyer Valley, Helidon Hills and the Little Liverpool Range. Regrowth of varying quality is also present along roadsides and in isolated patches adjoining pastoral land and urban areas.

Typical koala food tree species found in this region include *E. crebra* and *C. citriodora*, see Table 8-6 for a breakdown of canopy species identified on the koala detection dog surveys.

Table 9-6 Available Koala Habitat within H2C

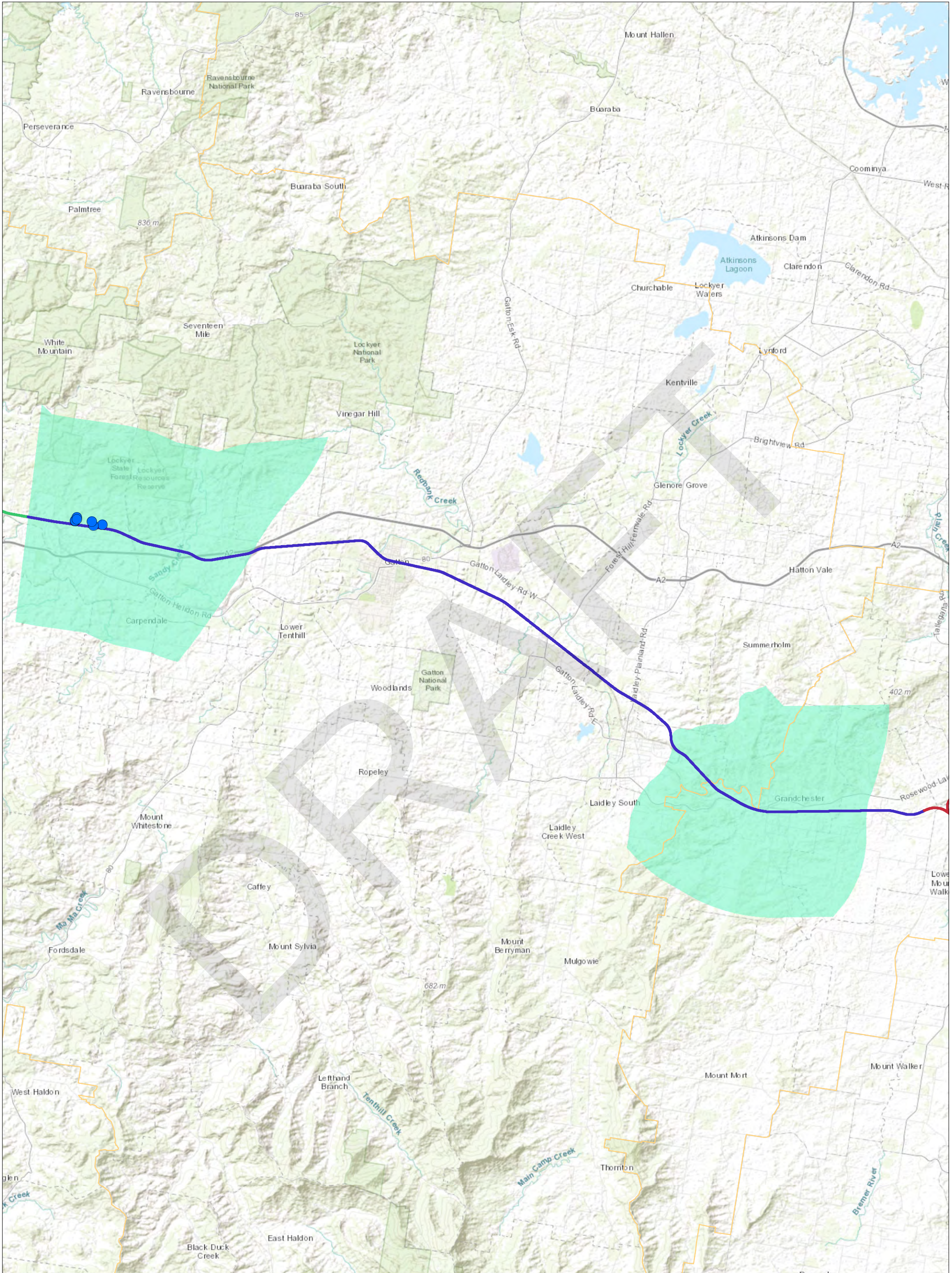
Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
68	■ <i>Eucalyptus crebra</i> ■ <i>Corymbia citriodora</i>	Advanced Regrowth	Riparian zone adjacent to cleared agricultural land
69	■ <i>Eucalyptus crebra</i> ■ <i>Corymbia citriodora</i>	Advanced regrowth	Cleared pastoral land
70	■ <i>Corymbia citriodora</i> ■ <i>Corymbia gummifera</i> ■ <i>Lophostemon suaveolens</i>	Remnant	Riparian zone in continuous forest
71	■ <i>Corymbia citriodora</i>	Remnant	Continuous forest
72	■ <i>Lophostemon suaveolens</i> ■ <i>Corymbia citriodora</i>	Remnant	Continuous forest
73	■ <i>Corymbia citriodora</i>	Remnant	Continuous forest
74	■ <i>Corymbia citriodora</i>	Remnant	Continuous forest

9.3.1.3 Opportunity for Connectivity

Locations considered important for maintaining connectivity include the eucalypt dominated woodland of the Lockyer State Forest as well as the Little Liverpool Range and Helidon Hills. These provide important fauna corridors throughout otherwise heavily cleared agricultural land. Also of note for potential connectivity are the riparian vegetation along the Lockyer Creek and Gatton National Park. Maintenance of connectivity through utilising existing crossing structures should be prioritised. Crossing structures should be in line with the Koala Sensitive Design Guidelines (2022) and consider the WSP Preliminary Fauna Connectivity Strategy for the B2G Project.

Where offsetting is required for significant residual impacts to the koala, priority should be given to potential offset sites within 5km of the alignment, and with vegetation connected to, or in close proximity to, the hotspot region and containing koala food trees important for the H2C such as, *E. crebra* and *Lophostemon* and *Corymbia spp.*

See Figure 9-3 for hotspot locations associated with the Project Area.



- Legend**
- Scat detections - East
 - Active Koala Hotspots
 - LGA Boundary
 - Inland Rail Alignment
 - C2K - Calvert to Kagaru
 - G2H - Gowrie to Helidon
 - H2C - Helidon to Calvert

Data Source:
ESRI World Topographic Map

Active Koala Hotspots with H2C

Drawing No: 0628339_N2AB_TM_G006_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4		
Drawn By: VN	Reviewed By: MD	Client: ARTC	
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy. ERM	
024Km			

F9-3

9.4 Gowrie to Helidon

9.4.1.1 Historic Koala Records

High densities of koala records are present within G2H with the vast majority recorded between 2010 and 2021. These records occur within the eucalypt woodland between Postmans Ridge and Toowoomba, particularly adjacent to the Toowoomba bypass. Records are present within the more heavily urbanised Toowoomba however these are less frequent. Rocky creek and the adjacent vegetation contain many records between Helidon Spa and Postmans ridge all of which are recent. Many of these records are likely to be in association with the recent infrastructure upgrades, namely the development of the Toowoomba bypass.

9.4.1.2 Findings from the Study

A single hotspot of koala activity was identified within G2H and is inclusive of Mt Kynoch on the outskirts of Toowoomba to Helidon. Extensive historic records are present and numerous detections were made following detection dog surveys. The hotspot also possesses key koala habitat corridors across the Toowoomba range, which is heavily dominated by remnant forest, and the Lockyer Creek. The hotspot is also likely to overlap with adjoining hotspots within H2C.

Table 9-7 Koala Hotspot Region within G2H

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	Inclusive of Mt Kynoch to Helidon.	Remnant vegetation of the Mountain Range and lining creeks, dominated by Koala food trees.	Lockyer Creek Toowoomba Range	Koala records within intact remnant vegetation with linkage to other larger vegetated area.

9.4.1.3 Available Koala Habitat

In line with the G2H EIS, extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the Gowrie to Helidon Project. Survey effort was conducted in-line with state and federal guidelines undertaken by Arup in March 2017, EMM in September-May 2019 and ELA December-April 2019. This consisted of habitat assessments, active searches, SAT searches and incidental observations.

The majority of G2H is dominated by cleared pasture and cropping land with considerable barriers to koala movement. Of the available eucalypt vegetation, the majority is highly fragmented regrowth of mixed quality with remnant mature eucalypt open forest isolated to the central portion of G2H. Notably the Toowoomba Bypass is a major existing barrier to koalas in the region. Suitable koala habitat is found in the Helidon Hills and Toowoomba Ranges areas as well as being characterised by riparian habitat, notably Gowrie Creek.

Typical koala food tree species found in this region include Narrow-leaved ironbark *E. crebra* and *C. citriodora*, see Table 8-8 for a breakdown of canopy species identified on the Koala Detection Dog Surveys.

Table 9-8 Available Koala Habitat within G2H

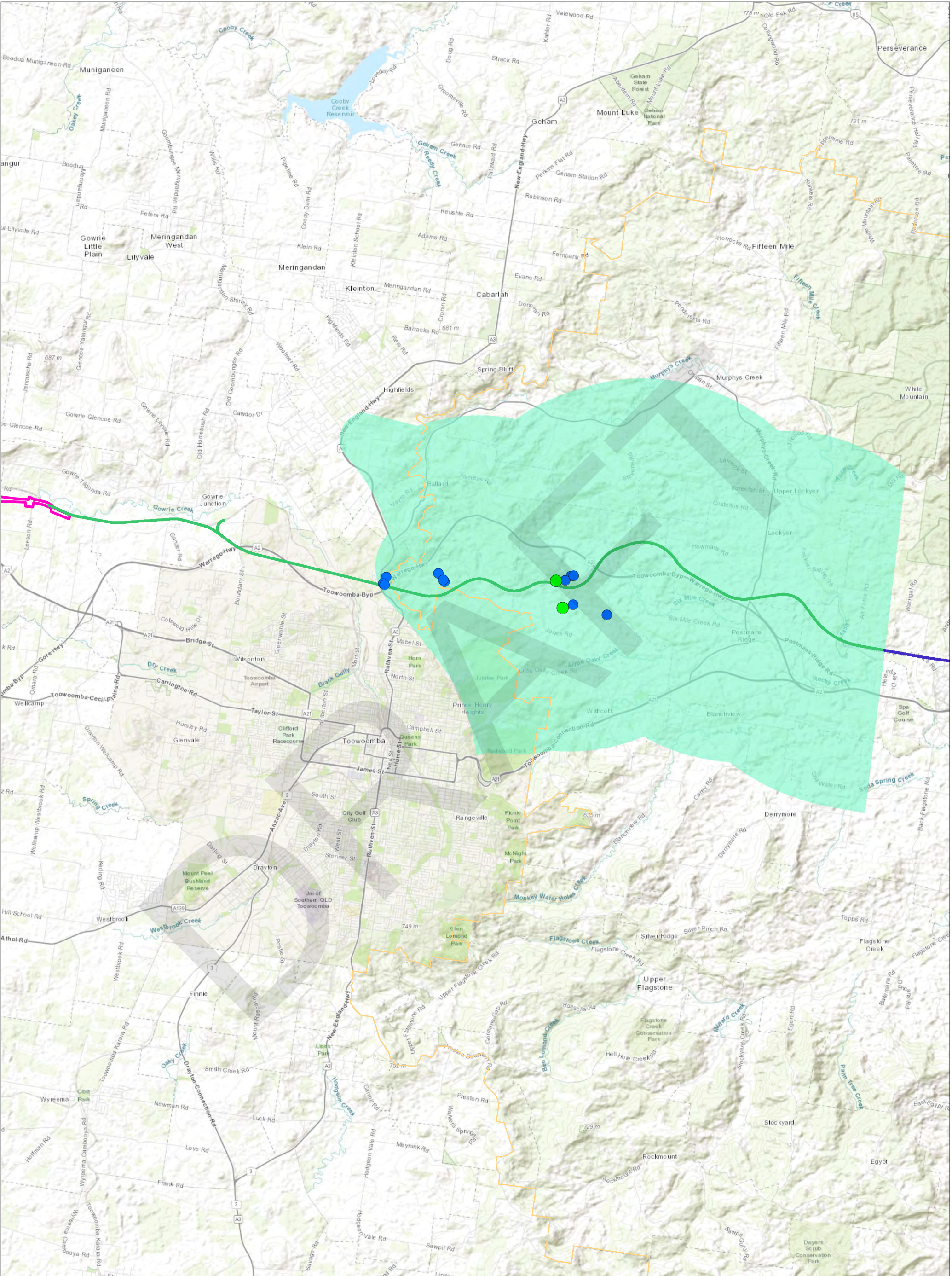
Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
59	■ <i>Eucalyptus crebra</i> ■ <i>Corymbia citriodora</i>	Remnant	Continuous forest
60	■ <i>Eucalyptus crebra</i> ■ <i>Corymbia</i>	Remnant	Continuous forest
61	■ <i>Eucalyptus crebra</i>	Remnant	Continuous forest with powerline track
62	■ <i>Eucalyptus citriodora</i>	Remnant	Continuous forest with access tracks
63	■ <i>Eucalyptus moluccana</i> ■ <i>Corymbia citriodora</i>	Remnant/Advanced regrowth	Continuous forest
64	■ <i>Corymbia citriodora</i> ■ <i>Eucalyptus crebra</i>	Remnant	Continuous forest
65	■ <i>Eucalyptus tereticornis</i> ■ <i>Corymbia citriodora</i>	Remnant	Continuous forest
66	■ <i>Eucalyptus tereticornis</i> ■ <i>Corymbia sp</i>	Remnant	Road corridor
67	■ <i>Lophostemon confertus</i>	Remnant	Continuous forest adjacent to urban infrastructure

9.4.1.4 Opportunity for Connectivity

Locations considered important for maintaining connectivity include the eucalypt dominated woodland of the Toowoomba range and the remnant riparian vegetation of the Lockyer Creek. These areas provide important fauna corridors across a landscape that has been heavily modified for both agriculture and urban development. Smaller creeks such as Rocky Creek also provide valuable corridors between remnant woodland and retained advanced regrowth. Major roads, such as the Toowoomba bypass, offer significant barriers to koala movement within G2H. Crossing structures should be in line with the Koala Sensitive Design Guidelines (2022) and consider the WSP Preliminary Fauna Connectivity Strategy for the B2G Project.

Where offsetting is required for significant residual impacts to the koala, priority should be given to potential offset sites within 5km of the alignment, and with vegetation connected to, or in close proximity to, the hotspot region and containing koala food trees important for the G2H such as, *E. crebra*, *E. moluccana*, *E. tereticornis* and *Lophostemon* and *Corymbia spp.*

See Figure 9-4 for hotspot locations associated with the Project Area.



- Legend**

 - Koala sightings
 - Scat detections - East
 - Active Koala Hotspots
 - LGA Boundary
- Inland Rail Alignment**

 - B2G - NSW/QLD Border to Gowrie
 - G2H - Gowrie to Helidon
 - H2C - Helidon to Calvert

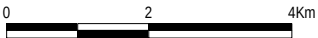
Data Source:
ESRI World Topographic Map

Active Koala Hotspots with G2H

Drawing No: 0628339_N2AB_TM_G006_R3.mxd
Date: 14/02/2024
Drawing Size: A4

Drawn By: VN
Reviewed By: MD

Coordinate System: GDA2020 MGA Zone 56

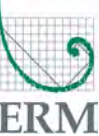


Koala Genetics Study Project – Inland Rail Program
(NSW and QLD)

Client: ARTC

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F9-4



9.5 Border to Gowrie

9.5.1.1 Historic Koala Records

Historic koala records accessed from ALA are present in high densities throughout the B2G project with a particularly dense cluster of records surrounding Toowoomba. Noticeably, a high proportion of these records are recent (between 2010 and 2021). Large areas of intact forest are present adjacent to B2G, yet records are also common throughout more heavily cleared agricultural land. These are largely located in linear stretches of roadside vegetation however riparian zones and fragmented patches of regrowth and remnant vegetation throughout the landscape also appear to provide a degree of habitat.

Previous active searches and SAT searches undertaken in 2016 returned detections of koala scat within the B2G IRP however no individuals were detected.

9.5.1.2 Findings from the Study

Three hotspots were identified in B2G and have been provided with an initial ranking of priority for management and mitigation measures. Hotspot one is inclusive of Pittsworth to Athol and it largely dominated by isolated regrowth vegetation surrounded by cleared or semi-cleared pastoral land. Patches of isolated roadside vegetation also are present. No major corridors for koala movement have been identified, however connectivity may be provided by the paddock trees and small isolated remnant vegetation and regrowth that is present. Koala records are known from both historic presence data and detection dog surveys within the IRP. Extensive anecdotal evidence of koala activity has also been provided by local organisations and community members following community consultations.

Hotspot two is inclusive of Bringalily, Whetstone State Forests within the IRP and is noted to provide extensive corridors of suitable koala habitat. While slightly adjacent to the IRP, the Yelarbon State Forest and Devine State Forest also offer important areas of protected koala habitat. Corridors are maintained between these state forests through remnant roadside vegetation, paddock trees and riparian vegetation along key creeks and waterways. Historic koala records and detection dog surveys both confirm the presence of koalas within the IRP and is likely to be an important area for koala persistence and dispersal in the landscape.

The third hotspot is inclusive of Domville State Forest, Millmerran and the Condomine River. While relatively few records are known from historic data records or from detection dog surveys, numerous anecdotal evidence was provided by local organisations and community members. Of note within this hotspot is the presence of mining outside Domville. Existing riparian vegetation is likely to still provide corridors for connectivity and critical koala habitat, however existing land use practices may establish barriers to connectivity.

Table 9-9 Koala Hotspot Regions within B2G

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	Inclusive of Pittsworth to Athol.	Isolated regrowth vegetation dominated by koala food trees surrounded by pastoral land.		Patches of isolated and roadside vegetation with Koala records.
2	Inclusive of Bringalily State Forest, Whetstone State Forest, and Yelarbon State Forest	Intact remnant vegetation in the State Forests is dominated by koala food trees.	Bringalily State Forest, Whetstone State Forest, and Canning Creek	Being of continuous remnant vegetation forming part of a larger protected vegetation area. Riparian habitat with Koala records.
3	Inclusive of Domville State Forest, Millmerran, to the Condamine River.	Isolated regrowth vegetation dominated by koala food trees surrounded by pastoral land. Remnant vegetation in both the State Forest and lining creeks, dominated by koala food trees. Surrounded by pastoral land.	Condamine River and floodplain Domville State Forest	Isolated riparian habitat and roadside vegetation with Koala records, and intact remnant vegetation with linkage to other larger vegetated area.

9.5.1.3 Available Koala Habitat

In line with the B2G EIS extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the Border to Gowrie Project. Survey effort was conducted in-line with state and federal guidelines undertaken by ELA from April to October 2016 and June 2018 to May 2019. This consisted of active searches, SAT searches, call playback and spotlighting.

The B2G EIS studies found the Project Area has been significantly modified by the clearing of native vegetation, overall being heavily fragmented by agriculture and urbanised land use. Suitable koala habitat was revealed to be within the riparian corridor of the Condamine River and associated floodplain and in regrowth and isolated vegetation around Pittsworth and surrounding regions in the north of the Project Area. Notably this Project is characterised by its proximity to Durakai and Bringalily State Forests.

Typical koala food tree species found in this region include *Eucalyptus camaldulensis*, *Eucalyptus populnea* and *Eucalyptus chloroclada*, see Table 9-10 for a breakdown of canopy species identified on the koala detection dog surveys.

Table 9-10 Available Koala Habitat within B2G

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
41	■ <i>E. populnea</i> ■ <i>E. camaldulensis</i>	Historically cleared pastoral land with advanced regrowth	Isolated vegetation amongst pastoral land
42	■ <i>E. populnea</i> ■ <i>E. camaldulensis</i>	High dieback Historically cleared pastoral land with advanced regrowth	Isolated vegetation amongst pastoral land
43	■ <i>Eucalyptus camaldulensis</i> ■ <i>Corymbia erythrophloia</i>	Historically cleared pastoral land with advanced regrowth	Riparian zone
44	■ <i>E. populnea</i> ■ <i>E. camaldulensis</i> ■ <i>E. tereticornis</i> ■ <i>Casuarina cristata</i>	Historically cleared pastoral land with advanced regrowth	Isolated vegetation amongst pastoral land
45	■ <i>E. tereticornis</i> ■ <i>E. populnea</i> ■ <i>Acacia salicina</i>	Historically cleared pastoral land with advanced regrowth Significant dieback	Isolated vegetation amongst pastoral land
46	■ <i>E. tereticornis</i> ■ <i>Casuarina cunninghamiana</i> ■ <i>Acacia salicina</i>	Remnant/advanced regrowth Some dieback	Isolated patch of trees surrounded by cleared agricultural land
47	■ <i>E. chloroclada</i> ■ <i>E. melanophloia</i> ■ <i>Callistris glaucophylla</i>	Historically cleared agricultural land with some remnant/advanced regrowth	Adjacent to ephemeral creek
48	■ <i>E. crebra</i>	Historically cleared with moderate dieback along agricultural land	Adjacent to Creekline surrounded by cleared pastoral land
49	■ <i>E. melanophloia</i> ■ <i>E. crebra</i>	Narrow linear strip of remnant vegetation	Isolated roadside vegetation surrounded by cleared pastoral land
50	■ <i>E. crebra</i> ■ <i>E. chloroclada</i>	Historically cleared Creekline on pastoral land	Isolated vegetation surrounded by cleared pastoral land
51	■ <i>E. melanophloia</i> ■ <i>E. chloroclada</i>	Advanced regrowth along potential Creekline	Isolated vegetation surrounded by cleared pastoral land
52	■ <i>E. melanophloia</i> ■ <i>E. chloroclada</i>	Mature paddock trees along Creekline with cleared understory	Adjacent to mine site and surrounded by cleared pastoral land
53	■ <i>E. chloroclada</i> ■ <i>Corymbia erythrophloia</i> ■ <i>E. melanophloia</i>	Advanced regrowth with occasional mature trees	Along ephemeral creek Pastoral land connected to Devine State Forest and Bringalily State Forest
54	■ <i>E. populnea</i> ■ <i>Eucalyptus camaldulensis</i>	Remnant	Road corridor through state forest

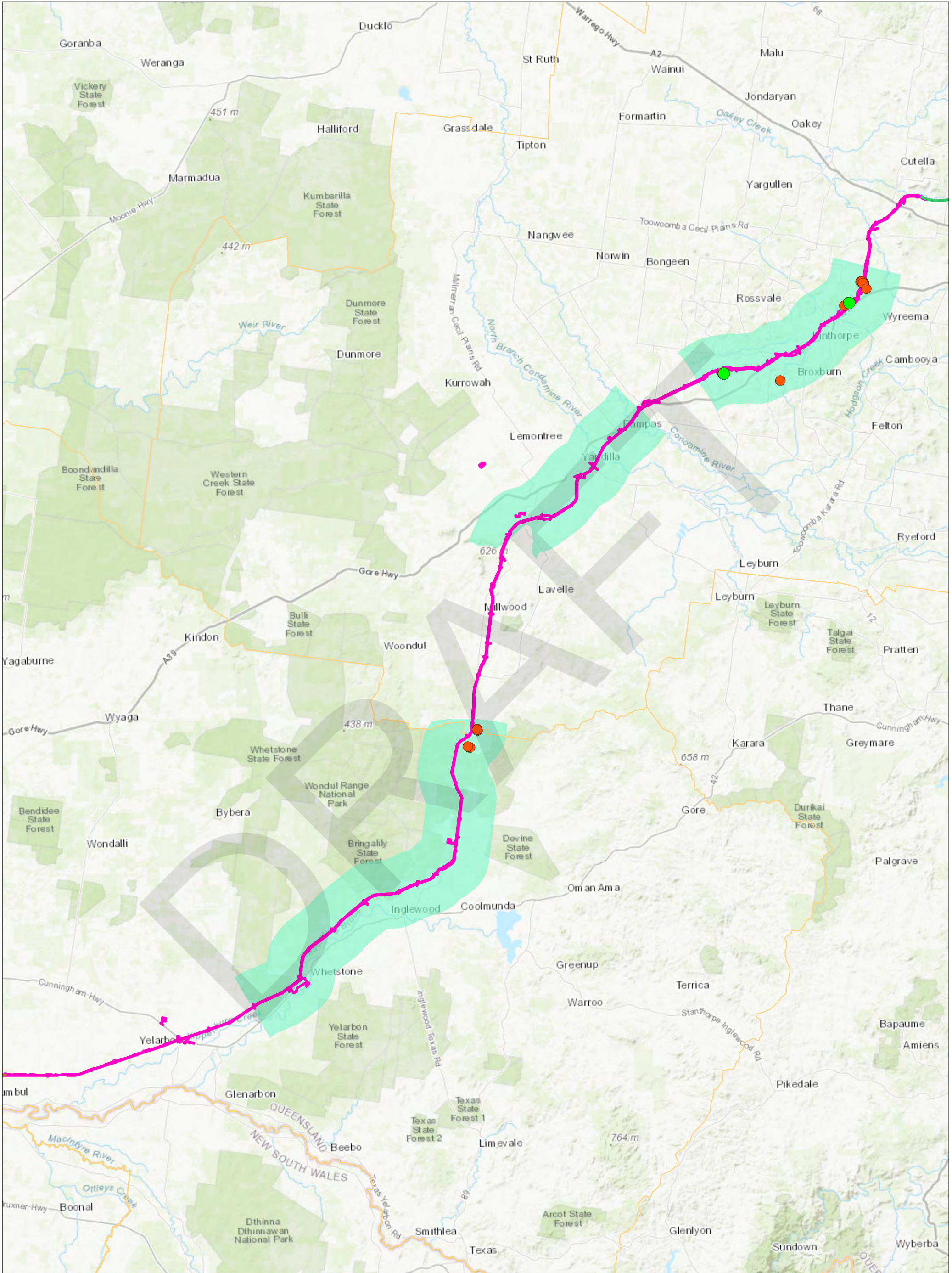
Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
55	■ <i>E. populnea</i> ■ <i>Eucalyptus camaldulensis</i>	Remnant	Road corridor through state forest
56	■ <i>Eucalyptus camaldulensis</i> ■ <i>Corymbia erythrophloia</i>	Advanced regrowth with occasional mature trees	Cleared pastoral land within close proximity to state forest
57	■ <i>E. populnea</i> ■ <i>Eucalyptus camaldulensis</i> ■ <i>E. tereticornis</i> ■ <i>Casuarina cristata</i>	Advanced regrowth and evidence of historic fires	Adjacent to quarry and connected to state forest
58	■ <i>E. tereticornis</i> ■ <i>E. populnea</i> ■ <i>Acacia salicina</i>	Advanced regrowth and evidence of historic fires	Adjacent to quarry and connected to state forest

9.5.1.4 Opportunity for Connectivity

Locations considered important for maintaining connectivity include the eucalypt dominated woodland of the Bringalily, Whetstone and Domville State Forests, which provide important corridors to more contiguous forests outside of the IRP, including Devine and Yelabon State Forests and Wondul Range National Park. Riparian zones are also important corridors for fauna connectivity with the Canning Creek and the Condamine River and associated floodplains providing critical connectivity across otherwise cleared agricultural land. Crossing structures should be in line with the Koala Sensitive Design Guidelines (2022) and the WSP Preliminary Fauna Connectivity Strategy for the B2G Project.

Where offsetting is required for significant residual impacts to the koala, priority should be given to potential offset sites within 5km of the alignment, and with vegetation connected to, or in proximity to, the hotspot region and containing koala food trees important for the B2G such as, *E. crebra*, *E. tereticornis*, *E. Camaldulensis*, *E. populnaea*, *E. melanophloia*, and *Lophostemon*, *Angophora*, and *Corymbia spp.*

See Figure 9-5 for hotspot locations associated within the Project Area.



- Legend**
- Koala sightings
 - Scat detections - West
 - Active Koala Hotspots
 - LGA Boundary
 - Inland Rail Alignment**
 - B2G - NSW/QLD Border to Gowrie
 - G2H - Gowrie to Helidon
 - NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

Active Koala Hotspots with B2G

Drawing No: 0628339_N2AB_TM_G006_R3.mxd	Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	
Drawn By: VN	Reviewed By: MD	Client: ARTC

Coordinate System: GDA2020 MGA Zone 56

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9.6 North Star to Border

9.6.1.1 Historic Koala Records

Historic koala records accessed from ALA are present in the Project Area, with records seen near heavily cleared agricultural land. These are largely located in linear stretches of roadside vegetation in the North Star locality. Riparian zones and fragmented patches of regrowth and remnant vegetation throughout the landscape also appear to provide a degree of habitat with records from the Macintyre River. It should be noted that the proximity to urban areas may influence the number of sightings that have historically been made of individuals in relation to the size and quality of habitat.

Previous active searches and SAT searches undertaken in 2018 returned detections of one individual along the Macintyre River as well as scat and scratch marks found in 2021 across the Project Area.

9.6.1.2 Findings from the Study

No historic koala presence records are known across NS2B and field surveys did not return detections. NS2B is mostly comprised of highly modified agricultural land with very little available habitat that could support koalas or aid in dispersal. No hotspots have been identified within NS2B. Further field surveys have been proposed for July 2023.

9.6.1.3 Available Koala Habitat

In line with the NS2B EIS extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the North Star to Border Project. Survey effort was conducted in-line with state and federal guidelines undertaken by FFJV in October 2018 to October 2019 and in 2021. This consisted of active searches, SAT searches, call playback and spotlighting.

The NS2B EIS studies found the Project Area has been significantly modified by agricultural land use, where the clearing of native vegetation has been extensive. Large tracts of remnant vegetation are rare within the Project Area, with most of the remaining native vegetation occurring in small fragments, often in a highly degraded state. Koala habitat is available in the form of riparian vegetation along waterways or drainage lines, with an individual identified within the riparian vegetation of the Macintyre River. Typical koala food tree species found in this region include Poplar box (*Eucalyptus populnea*), see Table 9-11 for a breakdown of canopy species identified on the Koala Detection Dog Surveys.

Table 9-11 Available Koala Habitat within NS2B

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
38	■ <i>Eucalyptus populnea</i> ■ <i>Casuarina cristata</i>	Some mature trees and advanced regrowth with cleared understory and limited recruitment	Isolated patch of vegetation surrounded by cleared pastoral and cropping land
39	■ <i>Eucalyptus populnea</i>	Narrow linear roadside vegetation with some mature trees and advanced regrowth	Isolated patch of vegetation surrounded by cleared pastoral and cropping land
40	■ <i>Eucalyptus populnea</i>	Narrow linear roadside vegetation with some mature trees and advanced regrowth	Isolated patch of vegetation surrounded by cleared pastoral and cropping land

9.6.1.4 Opportunity for Connectivity

No hotspots of koala activity have been identified within the NS2B owing to its relatively small size and a lack of koala detections. However, the Macintyre River offers important opportunities for maintaining connectivity and improving available habitat and, across the broader landscape, can provide some connection to Yelarbon State Forest, albeit over large geographic distances. Smaller creeks and drainage lines throughout the cleared agricultural land may also provide opportunities for improving connectivity across the landscape. Crossing structures should be in line with the best practice designs and aim to support the objectives of the Koala Habitat Protection Guidelines (2019) and State Environmental Planning Policy (SEPP) (Biodiversity and Conservation) (Chapter 4 Koala habitat protection) 2021. The design and best practice recommendations provided by the WSP Preliminary Fauna Connectivity Strategy and NSW Koala Strategy (Environment and Heritage Department of Planning and Environment, 2022) for the B2G Project will also provide valuable learnings for the implementation of suitable koala crossing structure.

9.7 Narrabri to North Star (Phase 2)

9.7.1.1 Historic Koala Records

Numerous historic records sourced from ALA exist within N2NS. These records are largely more recent than those of N2N being made between 2010 and 2021. These records are noticeable concentrated around the town of Moree with records present within the riparian vegetation of the Mehi river as well as roadside vegetation across the broader landscape. Spotlighting and SAT searches undertaken in 2015 returned positive detections of both koala individuals and scats.

Another cluster of historic records is present surrounding the town of Crooble. Records made before 2010 exist in the nearby Bullala National Park. More recent records are present but appear to be restricted to linear strips of riparian vegetation and roadsides with minimal connectivity.

As presented in the N2NS EIS (2017), an additional fourteen individuals have been sighted across the project. These detections were made at fauna survey sites 15 and 16, with an additional four being made opportunistically along the project. Two additional scats were found along the project.

9.7.1.2 Findings from the Study

Desk-top assessments of historic presence data and field surveys have identified one koala hotspot within N2NS. This hotspot extends from the Mehi River in Moree to the town of Croppa Creek. Riparian vegetation along the Mehi River and Gwydir River, as well as along roadside vegetation in the surrounding landscape are likely to be important corridors for koala movement and surveys returned detections of scats and individual koalas.

Table 9-12 Koala Hotspot Region within N2NS

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	Inclusive of Moree to Croppa Creek.	Isolated regrowth vegetation dominated by koala food trees surrounded by pastoral land. Remnant vegetation lining a creek dominated by koala food trees. Surrounded by pastoral land.	Mehi River Gwydir River	Isolated riparian habitat and roadside vegetation with Koala records.

9.7.1.3 Available Koala Habitat

In line with the N2NS EIS extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the Narrabri to North Star Project. Survey effort was conducted in-line with state and federal guidelines undertaken by NGH in December of 2015 and 2019, and February 2020 within Phase 2. This consisted of active searches, SAT searches and spotlighting.

The N2NS EIS studies revealed majority of the Project Area has been heavily modified by past and ongoing disturbances associated with the rail corridor and surrounding agricultural activities. Patches of koala habitat were determined to exist sporadically within the Project Area and are typically associated with riparian corridors, Travelling Stock Reserves (TSRs), road reserves or remnant to regrowth vegetation skirting farmland. Typical koala food tree species found in this region include *Eucalyptus tereticornis*, *Eucalyptus camaldulensis* and *Eucalyptus populnea*, see Table 9-13 for a breakdown of canopy species identified on the Koala Detection Dog Surveys.

The southern end of the IRP is located immediately north of Narrabri on an embankment above the Namoi River. Of significance, the alignment traverses the Gwydir River floodplain. The northern end of the Project Area at North Star is located south of the Macintyre River.

The implementation of dedicated wildlife culverts is considered best practice for koala sensitive design however other options are also available to ensure connectivity is maintained. These include refuge poles and koala rails within culverts are also proven to still be useful.

Table 9-13 Available Koala Habitat within N2NS

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
26	■ <i>Eucalyptus camaldulensis</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Creek line
27	■ <i>Eucalyptus camaldulensis</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Creek line
28	■ <i>Eucalyptus camaldulensis</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Creek line
29	■ <i>Eucalyptus populnea</i> ■ <i>Casuarina cristata</i>	Isolated regrowth patch of vegetation surrounded by pastoral land	Road corridor
30	■ <i>Eucalyptus populnea</i> ■ <i>Casuarina cristata</i>	Isolated regrowth patch of vegetation surrounded by pastoral land	Road corridor
31	■ <i>Eucalyptus crebra</i> , ■ <i>Eucalyptus tereticornis</i> ■ <i>Eucalyptus amplifolia</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
32	■ <i>Eucalyptus tereticornis</i> ■ <i>Allocasuarina costata</i> ■ <i>Eucalyptus melanophloia</i> ■ <i>Eucalyptus amplifolia</i> ■ <i>Casuarina glaucophylla</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
33	■ <i>Eucalyptus tereticornis</i> ■ <i>Corymbia tessellaris</i> ■ <i>Allocasuarina luehmannii</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
34	■ <i>Eucalyptus moluccana</i> ■ <i>Allocasuarina luehmannii</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Creek line
35	■ <i>Angophora floribunda</i> ■ <i>Eucalyptus. sp</i> ■ <i>Casuarina glaucophylla</i> ■ <i>Allocasuarina luehmannii</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
36	■ <i>Casuarina cristata</i>	Isolated regrowth patch of vegetation surrounded by pastoral land	Road corridor
37	■ <i>Eucalyptus populnea</i> ■ <i>Casuarina cristata</i>	Isolated regrowth patch of vegetation surrounded by pastoral land	Road corridor

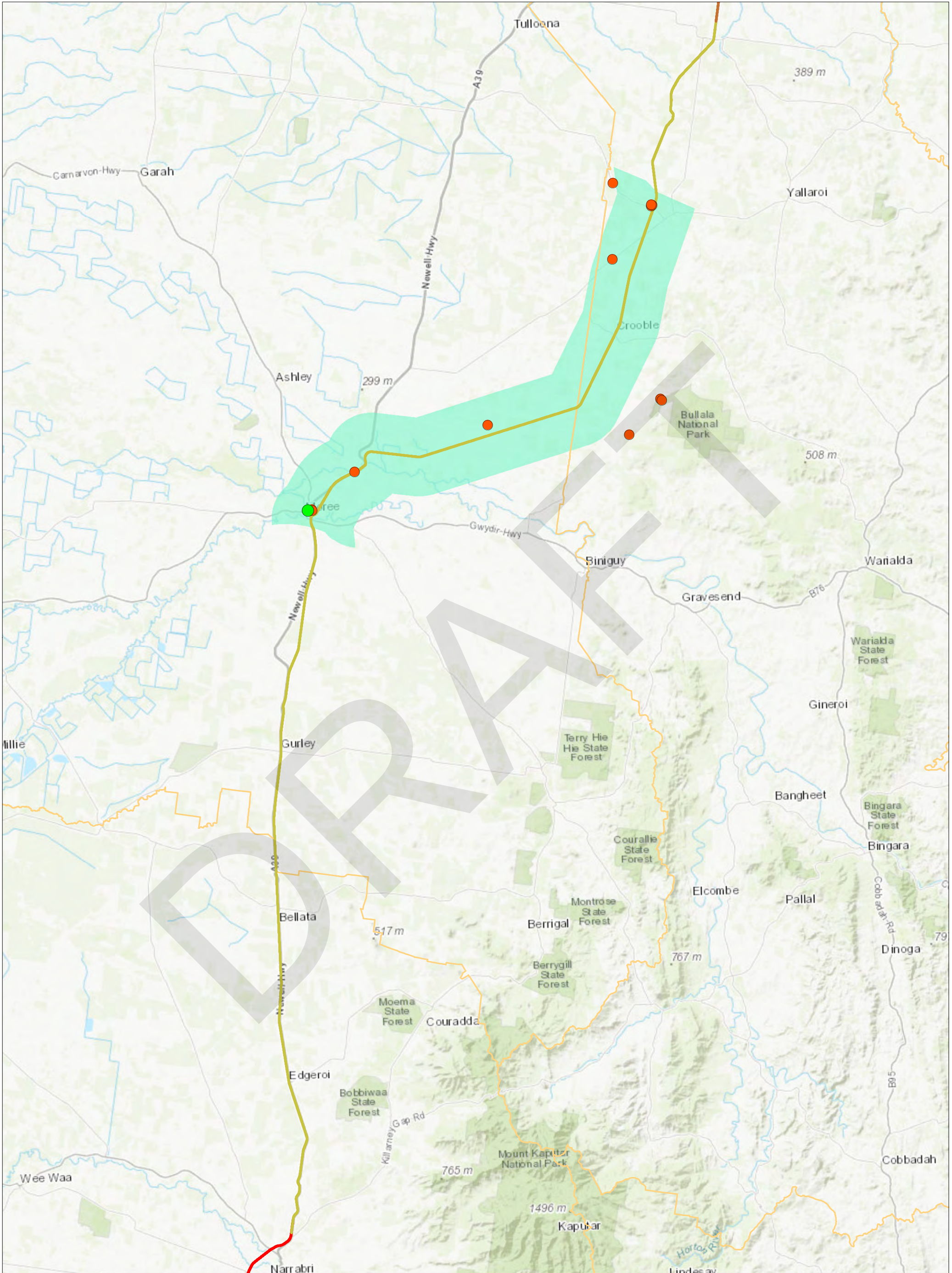
9.7.1.4 Opportunity for Connectivity

Focus should be placed on sections of the Project Area which cross riparian habitat and therefore could have the potential to form a barrier. Locations of importance would include Mehi River and Gwydir River. Refuge poles will likely be beneficial where canopy and mature trees are limited.

Culverts and koala

The landscape of N2NS (Phase 2) is largely heavily cleared agricultural land with little in the way of contiguous remnant forest. Riparian zones are considered important for maintaining fauna corridors within N2NS and of particular importance is Mehi and Gwydir Rivers. Riparian vegetation does provide opportunities to maintain connections with remnant forest outside of the IRP, such as Bullala CCA Zone 1 National Park, and other smaller retained vegetation. Maintenance of connectivity through utilising existing crossing structures should be prioritised. Crossing structures within N2NS (phase 2) should be in line with the best practice designs and aim to support the objectives of the Koala Habitat Protection Guidelines (2019) and State Environmental Planning Policy (SEPP) (Biodiversity and Conservation) (Chapter 4 Koala habitat protection) 2021. Design will also be in line with The Koala Sensitive Design Guidelines (2022) and consider the WSP Preliminary Fauna Connectivity Strategy for the B2G Project.

See Figure 9-6 for hotspot locations associated within the Project Area.



- Legend**
- Koala sightings
 - Scat detections - West
 - Active Koala Hotspots
 - Inland Rail Alignment**
 - N2N - Narramine to Narrabri
 - N2NS - Narrabri to North Star
 - NS2B - North Star to Border

Data Source:
ESRI World Topographic Map

Active Koala Hotspots with N2NS

Drawing No: 0628339_N2AB_TM_G006_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC	
Drawn By: VN	Reviewed By: MD	This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	
Coordinate System: GDA2020 MGA Zone 56			
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F9-6



9.8 Narromine to Narrabri

9.8.1.1 Historic Koala Records

Historic koala records sourced from ALA throughout the N2N alignment of the IRP are heavily concentrated around the Pilliga Nature Reserve with additional records located sporadically towards the south. Presence records are noticeably absent between the town of Kickabil and Tenandra State Forest, an approximately 54km stretch of the IRP. While pockets of vegetation do exist in the form of roadside vegetation and small reserves, suitable habitat is largely absent from the landscape, with the bulk of surrounding land cleared pastoral and/or cropping land. The bulk of these records were recorded before 2010. Some records made between 2012 and now exist however are themselves not recent with the most recent record made in 2016. Post 2010 records within N2N are isolated to the Pilliga Nature Reserve with no recent records made anywhere else along the project.

During previous survey work along the IRP, koala scats were detected at Coolangala Creek and Etoo Creek following surveys in 2018 and 2019. The age of these scats was not known, and no individuals were observed. While this is an indication that some individuals were at least present at the time, it is unknown if these areas provided permanent habitat or were merely used for dispersal.

Findings from the Study

With a combination of desktop reviews of historic presence data and ground-truthing field surveys, a single hotspot has been identified within N2N. This hotspot is located south of Narrabri and is inclusive of the Pilliga Nature Reserve. While koala detections were not made within this hotspot following the field surveys for the IRP, the high density of historic records and the presence of potentially suitable habitat were identified as being suitable for inclusion as an area of priority for the IRP.

Table 9-14 Koala Hotspot Region within N2N

Hotspot Number	Hotspot Extent	Local Habitat Values	Corridors	Reason for Hotspot
1	South of Narrabri inclusive of The Pilliga Nature Reserve.	Remnant vegetation dominated by koala food trees.	The Pilliga Nature Reserve	Being of continuous remnant vegetation forming part of a larger protected vegetation area.

9.8.1.2 Available Koala Habitat

In line with the N2N EIS extensive ground-truthing and field surveys were undertaken to determine the extent of koala habitat for the Narrabri to Narromine Project. Survey effort was conducted in-line with state and federal guidelines undertaken by GHD in September and November of 2018 as well as March, August, September, October of 2019. This consisted of active searches, drone surveys, spotlighting and call playback.

Results revealed much of the southern and central portion of the Project Area is located in land cleared for agriculture. In the northern end of the Project Area, large sections are in areas dominated by vegetation associated with state forests of the Pilliga National Park (state forest sections). Typical koala food tree species found in this region include *Eucalyptus camaldulensis*, *Eucalyptus crebra* and *Eucalyptus microcarpa*. A detailed assessment of canopy species identified along the IRP is presented in Table 9-15.

It was determined that for the N2N Project riparian vegetation is likely to provide habitat and dispersal corridors for this species, with Etoo Creek (near the Aloes picnic area in the Pilliga), identified as a key site for observing koalas from both anecdotal and the GHD survey data. There is a record from 2019 associated with roadside vegetation south of Narromine.

The N2N EIS stated that evidence provided to the recent inquiry in koala populations in NSW noted that the Pilliga koala population was ‘completely unviable’ or already extinct (Legislative Council Portfolio Committee 7 2020) and this is supported by *Lunney et. al.* in 2017, which found decline of over 80 per cent in both the distribution and activity of koalas. These findings support those of this study that suggests that any koalas still present within the Pilliga are in extremely low densities and population viability is likely to be in decline.

Table 9-15 Available Koala Habitat within N2N

Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
1	■ <i>Eucalyptus tereticornis</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest creek line
2	■ <i>Eucalyptus microcarpa</i> ■ <i>Eucalyptus dwyerii</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
3	■ <i>Eucalyptus crebra</i> ■ <i>Callitris glaucophylla</i> ■ <i>Allocasuarina luehmannii</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
4	■ <i>Eucalyptus camaldulensis</i> ■ <i>Eucalyptus crebra</i> ■ <i>Angophora floribunda</i> ■ <i>Allocasuarina luehmannii</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest creek line
5	■ <i>Eucalyptus camaldulensis</i> ■ <i>Callitris glaucophylla</i> ■ <i>Brachychiton</i> sp. ■ <i>Eucalyptus populnea</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
6	■ <i>Eucalyptus camaldulensis</i> ■ <i>Callitris glaucophylla</i> ■ <i>Allocasuarina luehmannii</i> ■ <i>Angophora floribunda</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest creek line
7	■ <i>Eucalyptus chloroclada</i> ■ <i>Eucalyptus crebra</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
8	■ <i>Eucalyptus crebra</i> ■ <i>Allocasuarina luehmannii</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
9	■ <i>Eucalyptus camaldulensis</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Ephemeral creek line
10	■ <i>Eucalyptus camaldulensis</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Ephemeral creek line
11	■ <i>Eucalyptus populneus</i> ■ <i>Eucalyptus microcarpa</i>	Advanced regrowth, historically cleared	Road corridor
12	■ <i>Eucalyptus microcarpa</i> ■ <i>Callitris glaucophylla</i>	Advanced regrowth, historically cleared	Road corridor

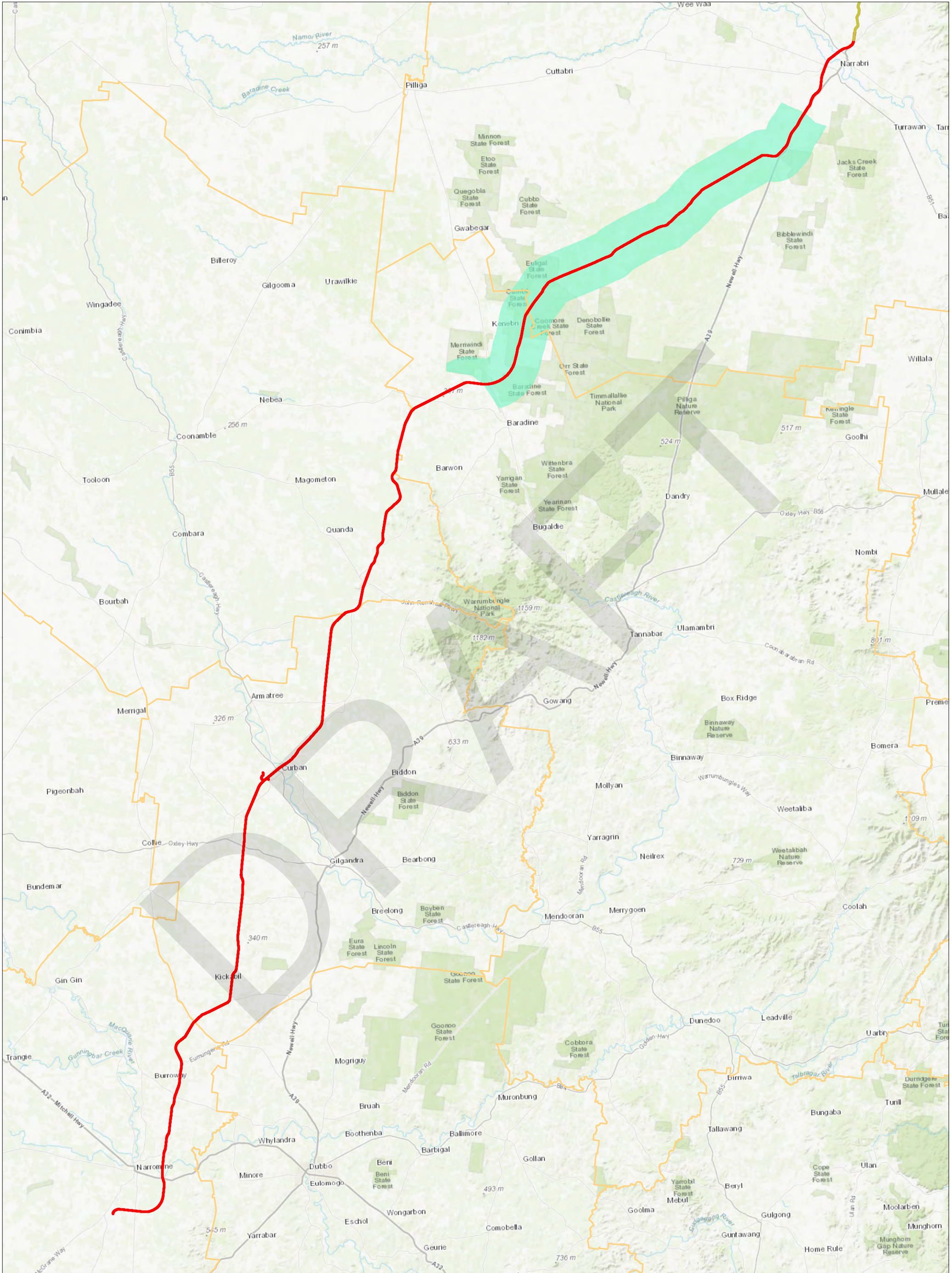
Quaternary Number	Dominant Canopy Species	Vegetation Quality	Landscape Context
13	■ <i>Eucalyptus tereticornis</i> ■ <i>Eucalyptus populnea</i> ■ <i>Casuarina glauca</i>	Advanced regrowth, planted canopy species	Managed Parkland
14	■ <i>Eucalyptus camaldulensis</i>	Remnant canopy, understory cleared	Riparian habitat edging urbanised area
15	■ <i>Eucalyptus populneus</i>	Remnant canopy, understory cleared	Road corridor
16	■ <i>Eucalyptus dealbata</i> ■ <i>Callitris glaucophylla</i>	Isolated remnant patch of vegetation surrounded by pastoral land	Road corridor
17	■ <i>Eucalyptus dealbata</i> ■ <i>Eucalyptus microcarpa</i> ■ <i>Callitris glaucophylla</i> ■ <i>Allocasuarina luehmannii</i>	Isolated remnant patch of vegetation surrounded by pastoral land	Road corridor
18	■ <i>Eucalyptus woollsiana</i> ■ <i>Eucalyptus dealbata</i> ■ <i>Callitris glaucophylla</i> ■ <i>Allocasuarina luehmannii</i>	Isolated advanced regrowth patch of vegetation surrounded by pastoral land	Road corridor
19	■ <i>Eucalyptus woollsiana</i> ■ <i>Eucalyptus crebra</i> ■ <i>Allocasuarina luehmannii</i> ■ <i>Callitris glaucophylla</i>	Isolated remnant patch of vegetation surrounded by pastoral land	Managed land/State Forest
20	■ <i>Eucalyptus crebra</i> ■ <i>Callitris glaucophylla</i> ■ <i>Allocasuarina luehmannii</i>	Isolated remnant patch of vegetation surrounded by pastoral land	Managed land/State Forest
21	■ <i>Eucalyptus camaldulensis</i> ■ <i>Casuarina Cunninghamiana</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Ephemeral creek line
22	■ <i>Eucalyptus moluccana</i> ■ <i>Allocasuarina luehmannii</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation as a part of a larger protected vegetation area.	Managed land/State Forest
23	■ <i>Eucalyptus tereticornis</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Ephemeral creek line
24	■ <i>Eucalyptus blakelyi</i> ■ <i>Callitris glaucophylla</i>	Remnant vegetation lining a creek. Surrounded by pastoral land.	Ephemeral creek line
25	■ <i>Eucalyptus microcarpa</i> ■ <i>Eucalyptus dwyeri</i> ■ <i>Callitris glaucophylla</i>	Isolated advanced regrowth patch of vegetation surrounded by pastoral land and managed land/state forest	Road corridor

9.8.1.3 Opportunity for Connectivity

Despite the lack of recent koala records in this section, focus should be placed on sections of the Project Area which cross riparian habitat and therefore could have the potential to form a barrier. Locations of importance would include Coolangala Creek and Etoo Creek.

The Pillaga Nature reserve is considered important for maintaining connectivity. While no koala detections were made in N2N and historic records are largely from before 2010, the Pillaga and surrounding state forests still offers an extensive network of suitable eucalypt woodland that extends across the broader landscape beyond the IRP. Riparian vegetation is noted to be of particular importance for connecting smaller state forests and retained vegetation towards the south of the IRP. Crossing structures should be in line with the Koala Sensitive Design Guidelines (2022) and consider the WSP Preliminary Fauna Connectivity Strategy for the N2N Project.

See Figure 9-7 for hotspot locations associated within the Project Area.



Legend

Active Koala Hotspots Inland Rail Alignment

N2N - Narromine to Narrabri

N2NS - Narrabri to North Star

Data Source:
ESRI World Topographic Map

Active Koala Hotspots with N2N

Drawing No: 0628339_N2AB_TM_G006_R3.mxd		Koala Genetics Study Project – Inland Rail Program (NSW and QLD)	
Date: 14/02/2024	Drawing Size: A4	Client: ARTC	
Drawn By: VN	Reviewed By: MD		
Coordinate System: GDA2020 MGA Zone 56		This figure may be based on third party data or data which has not been verified by ERM and it may not be to scale. Unless expressly agreed otherwise, this figure is intended as a guide only and ERM does not warrant its accuracy.	
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F9-7



10. CONCLUSION AND RECOMMENDATIONS

This study aimed to help support already existing knowledge of the koala in the IRP regions, and to dive deeper into the movement of the species across the vast landscape. The new information gathered from this study can further support decisions made to maintain and/or improve habitat connectivity and help acknowledge key areas for ongoing koala monitoring to ensure measures put in place are effective.

A key priority for IRP is to preserve current landscape connectivity for movement of koalas, despite creating a potential linear barrier. Due to low koala density and a low number of koala's sampled across the IRP, previous samples were pooled from other studies to form groups along the IRP in order to perform connectivity analysis across the IRP. Other groups outside the IRP were also formed for comparison and to help contextualise the population status associated with the IRP.

The genetic diversity results from this study indicated 10 geographical groupings of koalas, three of which Included IRP ARTC samples:

- Calvert to Kagaru and Kagaru to Acacia Ridge and Bromelton (Group 2);
- Border to Gowrie and Gowrie to Helidon (Group 3); and
- Narrabri to North Star (Group 6).

Overall, these three groups compared to the other groups in the larger landscape had:

- High levels of heterozygosity: Higher levels of heterozygosity equate to larger genetic diversity within a population(s), which is a positive indicator as genetic diversity is linked to both individual health and, at population level, evolutionary potential (with Group 3 (B2G + G2H) showing higher heterozygosity than the other groups);
- Low levels of inbreeding and of relatedness between individuals: This suggests gene flow is currently occurring within the groups along the IRP and the potential of negative impacts due to excessive inbreeding is minimal;
- Relatively small population size, with Group 3 (B2G + G2H) having a larger population size relative to other groups. This results in overall lower densities of koalas across the landscape; and
- No concerns regarding sex ratio, but high chlamydia prevalence, except Group 3 which is medium prevalence (however the sample size remain very low). The ratio of males to females is not of concern for genetic health although chlamydia prevalence is high. Caution should be taken when interpreting these findings as the sample size is small.

When compared with the results of the vegetation assessments, the analysis of eucalypt forage species from the sampled scats indicates some variability between the dominant eucalypt species measured and the eucalypts detected in the scats (Table 10-1). The spatial variability in the preferred diet trees of koalas indicates that any replacement planting should be done in accordance with the bioregion. Preferred food trees as detected in the scat analysis should be planted, however care should be taken to not develop a monoculture that would result in individual diets becoming dominated by one or two species, therefore reducing the nutritional value to be gained.

Table 10-1 Summary of dominant eucalypt detected in samples and vegetation assessments

Locality	Dominant eucalypt detected in scat samples	Dominant canopy trees from vegetation assessments
Brisbane region (east of the divide)	<i>E. seeana</i> , <i>E. tereticornis</i>	<i>E. tereticornis</i> <i>C. citriodora</i> , <i>C. intermedia</i> , <i>E. crebra</i>
Toowoomba region (west of the divide)	<i>E. amplifolia</i> , <i>E. tereticornis</i> , <i>E. chloroclada</i> and <i>E. melliodora</i>	<i>E. crebra</i> , <i>E. citriodora</i> and <i>C. intermedia</i>
Moree region	<i>E. camaldulensis</i> , <i>E. populnea</i> , <i>E. chloroclada</i>	<i>E. camaldulensis</i> , <i>E. populnea</i> and <i>E. crebra</i> .

Based on these findings, the following recommendations should be prioritised throughout the IRP:

1. This genetics study provides a baseline assessment of koala genetics within the IRP; however it is recommended that additional surveys be completed beyond the IRP in order to increase the robustness of genetic analysis and allow for further analysis to identify distinct population groups of koalas within the IRP.
2. It is evident that there is considerable movement/dispersal of koalas along the Study Area, therefore it is imperative to adhere to the objectives and recommendations of the KMP to ensure adequate corridors and or ways for koalas to be able to move through the IRP respectively.
3. To further the effectiveness of this study in identifying distinct koala population groups within the IRP and beyond, an effort to enable surveys to be conducted in all landholder properties along the IRP and beyond should be prioritized as this would enable true representation of the movements and dispersal ranges of koala groups within each area.
4. Forage tree preference indicates that koalas may seek out preferred forage trees that are not part of the dominant tree species within a landscape. Although the current study represents a small sample size, the eucalypt species detected in the sampled scats did not always contain the dominant species as measured from vegetation assessments.

This genetics study revealed that mitigation measures are necessary to maintain and/or improve current koala genetic diversity by allowing gene flow along and across the Inland Rail alignment, supporting the objectives of the Draft Koala Management Plans (KMPs) developed for the IRP. The KMPs will ensure that these mitigation measures are successful by monitoring measurable outcomes and adopting an adaptive management approach.

This study provides data to support assessments of koalas along the IRP alignment and forms part of the baseline for ongoing monitoring as a part of the KMPs. To overcome the current limitations of the study, additional surveys across areas unable to be sampled and beyond the IRP will likely provide more accurate assessments of priority areas for koala mitigation and management measures within the IRP.

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APPENDIX A UNISC GENETICS METHODS AND RESULTS

DRAFT

Note – Results presented here are preliminary as the genetic analyses were somewhat limited by the small sample size; caution should be exercised when interpreting these results. Additional work will be conducted to increase the data set, including re-extraction of samples that failed quality control and further detection dog surveys to locate and collect additional koala scat samples. Once this is complete, the combined genetic data set will be re-analysed, which may alter the results.

Acronyms and glossary

Allele: a variant of a gene. The size of an allele can vary in size (e.g., between one nucleotide to hundreds of nucleotides). At the population level, variation in alleles is used to estimate patterns of genetic diversity.

Coverage: also called read depth, describes the number of times that a given nucleotide in the genome has been read. In Next Generation sequencing methods such as used here, the genome is fragmented into short sections of base pairs. These are read individually and then assembled through bioinformatics. For this assemblage to work with minimal error, multiple individual reads are required per fragment and nucleotide to achieve a certain level of confidence for a SNP call.

DDC: Detection Dogs for Conservation at the University of the Sunshine Coast.

DNA: Deoxyribonucleic acid, a molecule carrying genetic information.

Effective population size (N_e): Broadly, this refers to the number individuals in a population who are able to contribute to the next generation's genetic material and is usually a subset of the census population. More specifically, N_e is the size of an idealised population that would lose genetic diversity at the same rate as the actual population. This is one of the most important parameters in population genetics and conservation biology because the genetic 'health' of a population is directly dependent on the effective population size, and indirectly linked to the census size of a population. The likelihood that a gene will be sampled as the next generation is produced is affected by the breeding structure of the population. In an 'ideal population':

- The number of breeding males is equal to the number of breeding females.
- Mating is random and all of the organisms will produce offspring.
- One organism doesn't produce more offspring than another.
- The population of breeding organisms remains constant from one generation to the next.

In an ideal population, all individuals have an equal opportunity to pass on their genes and the effective population size should be equal to the census population. In reality, this does not occur because not all members within a population mate, the ratio of males to females is rarely equal, mating isn't random, and generations overlap. Due to these factors, the effective population size is never as large as the census population. It is important to note that N_e is particularly sensitive to an unequal number of males and females in the population.

In short, the effective population size translates the census size of a real population into the size of an idealised population showing the same rate of loss of genetic diversity, inbreeding, or genetic drift for a population under study. In a natural population, the ratio of effective population size to census population size (N_e/N) is typically 0.1 (Frankham 1995, Palstra and Ruzzante 2008). The relationship between these two measures is complex and it is important to refrain from making inferences about census population size based on effective population size (Palstra and Fraser 2012).

Current recommendations for the genetic conservation of species in the wild are that:

- to avoid inbreeding depression, effective population size needs to be ≥ 100 , and
- to maintain evolutionary potential of a species, effective population size needs to be ≥ 1000 .

Effective population size recommendations are based on Extinction Theory, as summarised in Mace et al. (2008). The explanations below are extensively drawn from Mace et al. (2008), for specific references see the original paper.

All things being equal, the probability of extinction is greater when a population size is small or its decline rate is high. Small populations are more susceptible to demographic stochasticity, whereby random variations in birth and death rates can lead to extinction even when the average population growth rate is positive. In addition, small populations can suffer disproportionately from genetic effects, such as accumulation of recessive deleterious alleles under inbreeding, loss of quantitative characters that allow adaptation, accumulation of mildly deleterious mutations, and various other behavioural, social, and demographic factors. To safeguard genetic variability over hundreds of years, it was previously recommended that minimum effective population sizes of at least 50 be maintained, however has been revised to 100 (Frankham, Bradshaw et al. 2014).

Evolutionary potential: the capacity of a population to evolve to cope with environmental changes. Often simplistically equated with genetic diversity (especially for quantitative characters, such as fitness), but it is also influenced by N_e .

F-statistics (fixation index) is the basic method used to measure the amount of subdivision in populations, and consists of three measures, F_{IS} , F_{ST} , and the less commonly used F_{IT} . These measures relate to the amounts of heterozygosity at various levels of a population structure: individual (I), subpopulation (S) and total (T).

F_{ST} estimates the amount of structuring of a population into subpopulations, and can range from 0 to 1 (where 0 means complete sharing of genetic material and 1 means no sharing). In this report, F'_{ST} , the standardised F_{ST} (produced by dividing F_{ST} by the maximum value it can obtain, given the observed within-population diversity) was also calculated to enable comparisons of our results to other studies.

F_{IS} , also called inbreeding coefficient, is the proportion of the variance in the subpopulation contained in an individual and can range from -1 to 1 (the closer to 1, the higher the degree of inbreeding). Note that inbreeding can not only result from non-random matings (matings between cousins for example), but also from small isolated populations, where all individuals are more closely related than large populations.

Gene flow: movement of alleles between populations via migrants or gametes. Gene flow maintains genetic diversity and promotes evolution by spreading new genes and combinations of genes throughout a species' range, however it may also constrain evolution by preventing adaptation to local conditions (and therefore, animal translocations need to be carefully thought out).

Genetic diversity: The extent of genetic variation in a population (or species, or across a group of species), for example heterozygosity or allelic diversity.

Genetic drift: changes in the genetic composition of a population due to random sampling in finite populations.

Genetic stochasticity: genetic consequences of small populations, including inbreeding, loss of genetic diversity due to genetic drift and chance fixation of deleterious mutations that reduce

fitness and can drive a population or species towards extinction (often in combination with other factors).

Genotype: in diploid species (species with two sets of chromosomes - paternal and maternal copies), genotype is often used to refer to the particular pair of alleles that are carried by an individual. A genotype is described as homozygous if it features two identical alleles and as heterozygous if the two alleles differ. The process of determining a genotype is called genotyping.

Hardy-Weinberg Equilibrium: is a principle that is used to examine, based on observed genotype frequencies (see observed / expected heterozygosity), whether a population is experiencing forces such as natural selection, non-random mating, genetic drift, and gene flow. The Hardy-Weinberg Equilibrium states that in the absence of these forces, the genetic variation in a population will remain constant from one generation to the next. Therefore, if a population of interest is found not to be at the Hardy-Weinberg Equilibrium, underlying causes can be explored.

Heterozygosity: refers to the presence of two different alleles within a diploid individual, here it refers to the presence of two different nucleotides at a specific SNP locus. Commonly, at the population level, two measures of average heterozygosity (calculated for all SNP loci and all individuals) are reported:

H_O = observed heterozygosity, the calculated level of heterozygosity from the allele frequencies of the population under study,

H_E = expected heterozygosity, the level of heterozygosity that could be expected based on observed allele frequencies if the population was at the Hardy-Weinberg* equilibrium.

The comparison between observed and expected level of heterozygosity is a measure of interest:

- A lower observed heterozygosity compared to the expected heterozygosity can be a sign of inbreeding.
- A higher observed heterozygosity compared to the expected heterozygosity can be due to the mixing of two previously isolated populations.

IR: Internal Relatedness is a measure of inbreeding at the individual level (as opposed to population level, such as F_{IS}). It is calculated from heterozygosity data and does not require a pedigree, which is difficult to obtain in wild populations. Internal relatedness is currently the most widespread used index for inbreeding and its main strength is that allele frequencies are incorporated into the measure.

Inbreeding occurs when individuals are more likely to mate with relatives than with randomly chosen individuals in the population. Inbreeding increases the probability that offspring are homozygous, which can lead to lower fitness, a phenomenon commonly referred to as inbreeding depression.

Inbreeding depression: reduction in fitness due to inbreeding.

Koala Coast: The Koala Coast is a region in southeast Queensland that extends from Brisbane (south of the Brisbane River) through to Logan (east of the M1 Motorway) and Redland Coast Local Government Areas. The Koala Coast has been identified as one of the most important natural koala populations in Australia.

Locus (plural **loci**): refers to a specific position in the genetic material (such as in a chromosome), for example where a SNP is detected.

Nucleotide: A nucleotide is the basic structural unit and building block for DNA. These building blocks are hooked together to form a chain of DNA. There are four types of bases in DNA. They are called: Adenine (A), Cytosine (C), Guanine (G) and Thymine (T).

PCA (Principal Component Analysis): a method that attempts to represent the dissimilarities between samples in a low dimensional space (2-3 dimensions).

Polymorphism: any difference in the nucleotide sequence between individuals. Here, we refer to polymorphic loci when, across the population, differences occur between individuals (the opposite situation is a monomorphic locus where all individuals in the population have the same DNA sequence).

SD: Standard Deviation

SE: Standard Error

Sex ratio: the relationship between the number of males to the number of females. Typically, the sex ratio in natural populations is expected to be 1:1. Risks of extinction are increased if population sex ratios deviate from 1:1. However, a small bias of sex ratio towards females can sometimes be desirable, especially in very small or rapidly declining populations.

SEQ: South East Queensland

Small populations: the fact that small, isolated, populations are more prone to extinction (or extirpation) is well established, and therefore a goal in conservation is to avoid species being fragmented into small populations. In general, there are four sources of stochasticity that can cause small population to go extinct (from Shaffer 1981):

- demographic stochasticity: chance events in the survival and reproductive success of a finite number of individuals,
- environmental stochasticity: due to temporal variation of habitat parameters and the populations of competitors, predators, parasites, and diseases,
- natural catastrophes: such as floods, fires, droughts,
- genetic stochasticity: resulting from changes in gene frequencies due to founder effect, random fixation, or inbreeding – all influencing survival.

SNP: Single Nucleotide Polymorphism is the most common type of genetic variation. Each SNP represents a difference in a single DNA building block, called a nucleotide (there are four nucleotides: A, C, T and G).

Structure: within a species, genetic structure exists because not all individuals are able to breed with all other individuals of the same species, due to geographic proximity (even if a species distribution is continuous). Simplistically, this reflects that individuals that live close to each other have a higher chance of breeding than individuals further apart. Population structure (i.e., the genetic differentiation of local populations) is increased by mutation, genetic drift (due to finite population size) and natural selection favouring adaptations to local environmental conditions; but is decreased by gene flow (the movement of gametes, or individuals). Population structure is higher when gene flow between populations is lower, and so population structure is increased by habitat fragmentation and isolation.

Population structure can be studied through allele frequencies and can only be inferred with a sample size large enough to calculate robust allele frequencies. Therefore, sample size dictates the unit of comparison and the scale at which genetic structure can be examined.

Genetic structure can be hierarchically described:

- **Broad-scale structure** (often studied through a Bayesian statistic programs) usually defines ‘populations’ as independent breeding units, with each population descending from a different lineage and with very little to no gene flow. The software usually tests whether distinct populations can be inferred **without any *a priori* geographic information** and identifies migrants (individuals belonging genetically to one population, but geographically to another one), and admixed individuals, that are offspring of migrants between populations.
- **Fine-scale structure** (often calculated through F_{ST} , see F-statistics) usually describes sub-populations (also called local populations or demes) where gene flow exists but is restricted. Genetic structure at this level is studied by comparing allele frequencies between artificially constructed populations (e.g. between countries, between states, between councils) and then testing whether the populations should be considered one or multiple, and how similar the populations are to one another (pairwise F_{ST}).
- Finally, the distribution of related individuals in space, an even finer structure that can be referred to as “cryptic”, can be described through autocorrelation measures, where distances between all individuals and their genetic relatedness are compared.

Table A1. The list of 255 unique samples available from 24 sample locations for genetic data analysis with DArTcap and DArTag genotype data.

Sample Name	Sample Location	Latitude	Longitude	ARTC sample
180430Bi1A	Brisbane City	-27.5023	153.1839	No
210216Bi2B1	Brisbane City	-27.5738	153.1815	No
210216Bi2C1	Brisbane City	-27.5729	153.1803	No
Kidgy_109964_USC	Brisbane City	-27.382	152.993	No
Debbie_112243	Brisbane City	-27.5006	153.1067	No
180515Bi4B	Redland City	-27.6511	153.249	No
201127Bi1B1	Redland City	-27.6153	153.1799	No
DR220115KM1E	Redland City	-27.4139	153.4706	No
DR220116KM1A	Redland City	-27.4297	153.4988	No
220411KM1P	Redland City	-27.5944	153.2478	No
220411KM1JJ	Redland City	-27.5982	153.2424	No
220323BI2A	Redland City	-27.5683	153.2966	No
220323BI1F	Redland City	-27.4899	153.246	No
220406KM1D	Redland City	-27.5083	153.1974	No
220411KM1A	Redland City	-27.6024	153.2472	No
220323BI1G	Redland City	-27.4887	153.2458	No
220411KM1N	Redland City	-27.596	153.2463	No
DR220212KM1B	Redland City	-27.6788	153.2893	No
220323BI1I	Redland City	-27.4897	153.2448	No
220406KM1G	Redland City	-27.5108	153.1986	No
220411KM1M	Redland City	-27.5974	153.2444	No
220407KM1H	Redland City	-27.4903	153.2481	No
DR220420KM1A	Redland City	-27.4909	153.2449	No
DR220623KM1A	Redland City	-27.6302	153.1963	No
DR220603KM1A	Redland City	-27.6037	153.2448	No
220411KM1K	Redland City	-27.5985	153.2405	No
220505BI3E	Redland City	-27.5353	153.2785	No
DR220419KM1B	Redland City	-27.5916	153.2487	No
DR220617KM1D	Redland City	-27.595	153.2443	No
DR220603KM1A-reextract	Redland City	-27.6037	153.2448	No
DR220610KM1C	Redland City	-27.6504	153.264	No
220505BI2A	Redland City	-27.5315	153.2815	No
DR220610KM1D	Redland City	-27.6488	153.2611	No
DR220617KM1B	Redland City	-27.6003	153.2433	No
DR220420KM1D	Redland City	-27.4899	153.2458	No
DR220610KM1B	Redland City	-27.6491	153.2644	No
DR220622KM1H	Redland City	-27.489	153.2448	No
220505BI2D	Redland City	-27.5331	153.2821	No
220505BI4A	Redland City	-27.5251	153.2777	No

DR220610KM1A	Redland City	-27.6464	153.2667	No
220601Bi5F	Redland City	-27.5289	153.2728	No
220611Bi5C	Redland City	-27.5299	153.2742	No
220601Bi2A	Redland City	-27.5318	153.2815	No
220601Bi5C	Redland City	-27.5347	153.2737	No
221015MB1A	Redland City	-27.401	153.4382	No
180515Bi4C	Redland City	-27.6513	153.2488	No
200722Bi5E	Logan City	-27.7406	153.0629	No
200723Bi4A	Logan City	-27.8013	152.9727	No
200722Ba5B	Logan City	-27.7388	153.063	No
200730Bi2A	Logan City	-27.7858	153.0442	No
200723Bi1D	Logan City	-27.7236	153.0661	No
200722Ba5A	Logan City	-27.7416	153.0625	No
200730Bi1A	Logan City	-27.79	153.0616	No
200730Bi6D	Logan City	-27.7381	153.133	No
200714Bi5D	Logan City	-27.7544	153.029	No
200722Ba3A	Logan City	-27.7124	153.0506	No
200715Ba2A	Logan City	-27.7491	153.022	No
200730Bi8B	Logan City	-27.7162	152.9054	No
220610Bi2C	Logan City	-27.7047	152.9959	Yes
220610Bi3A	Logan City	-27.7058	152.9989	Yes
220610Bi2A	Logan City	-27.7004	152.9966	Yes
220609Bi2A	Logan City	-27.6827	153.0032	Yes
220803Bi3A	Ipswich City	-27.6984	152.6182	Yes
220803Bi2A	Ipswich City	-27.6878	152.6358	Yes
220803Bi1A	Ipswich City	-27.6672	152.6562	Yes
220803Bi1B	Ipswich City	-27.667	152.6517	Yes
220802Bi1B	Ipswich City	-27.7334	152.7094	Yes
220802Bi1E	Ipswich City	-27.7368	152.7097	Yes
220801Bi1A	Scenic Rim Regional	-27.8256	152.7624	Yes
220801Bi2A	Scenic Rim Regional	-27.8204	152.7666	Yes
220811Bi1B	Lockyer Valley Regional	-27.5365	152.1315	Yes
220810Bi1B	Lockyer Valley Regional	-27.5163	152.0096	Yes
220811Bi3B	Lockyer Valley Regional	-27.5398	152.1436	Yes
220809Bi1B	Lockyer Valley Regional	-27.5163	151.9722	Yes
220809Bi2A	Lockyer Valley Regional	-27.5141	151.9703	Yes
220810Bi1D	Lockyer Valley Regional	-27.5151	152.0113	Yes
220811Bi1A	Lockyer Valley Regional	-27.5374	152.1315	Yes
220810Bi1C	Lockyer Valley Regional	-27.5164	152.0067	Yes
220811Bi1D	Lockyer Valley Regional	-27.5380	152.1306	Yes
220810Bi3B	Lockyer Valley Regional	-27.5238	152.0087	Yes
180415Bi3B	Toowoomba Regional	-27.6558	151.6588	No
180412Bi2A	Toowoomba Regional	-27.4432	151.7337	No
180413Ba6A	Toowoomba Regional	-27.5165	151.9525	No

180415Bi3C	Toowoomba Regional	-27.6562	151.6586	No
180412Ba1A	Toowoomba Regional	-27.4246	151.737	No
180413Ba8A	Toowoomba Regional	-27.3973	151.8326	No
180410Ma5A	Toowoomba Regional	-27.4585	151.7289	No
180412Ba1C	Toowoomba Regional	-27.4247	151.7387	No
180414OP1B	Toowoomba Regional	-27.3427	151.6049	No
180415Ba3A	Toowoomba Regional	-27.6506	151.5874	No
180412OP1A	Toowoomba Regional	-27.4242	151.7428	No
180414OP4B	Toowoomba Regional	-27.2503	151.6978	No
180412OP2A	Toowoomba Regional	-27.4217	151.7436	No
180414Bi1B	Toowoomba Regional	-27.347	151.59	No
180413Ma1A	Toowoomba Regional	-27.4364	151.7059	No
180415OP2B	Toowoomba Regional	-27.4032	151.7768	No
180412OP5A	Toowoomba Regional	-27.3463	151.7582	No
180413Ma2A	Toowoomba Regional	-27.4665	151.8157	No
220624Bi1A	Toowoomba Regional	-27.7306	151.6415	Yes
220617Bi2C	Toowoomba Regional	-27.7205	151.5597	Yes
220809Bi3C	Toowoomba Regional	-27.5149	151.9543	Yes
220615Bi2C	Toowoomba Regional	-27.6296	151.7422	Yes
220618Bi1E	Toowoomba Regional	-27.6033	151.7614	Yes
220615Bi2E	Toowoomba Regional	-27.634	151.736	Yes
220222Au4A	Byron Shire Council	-28.5877	153.415	No
220222Au5A	Byron Shire Council	-28.5794	153.4059	No
210713Be1C	Ballina Shire Council	-28.8837	153.3723	No
210714Be2B	Ballina Shire Council	-28.9826	153.4146	No
220628Au1A	Ballina Shire Council	-28.9609	153.4544	No
DR221011KM1E	Ballina Shire Council	-28.9468	153.4462	No
DR220811KM1H	Ballina Shire Council	-28.9676	153.4453	No
DR220809KM1E	Ballina Shire Council	-28.959	153.4544	No
DR221011KM1G	Ballina Shire Council	-28.9544	153.4574	No
DR220809KM1D	Ballina Shire Council	-28.9585	153.454	No
DR221011KM1A	Ballina Shire Council	-28.9494	153.4349	No
DR220811KM1G	Ballina Shire Council	-28.9646	153.4473	No
DR220809KM1G	Ballina Shire Council	-28.9604	153.4539	No
220627Au3B	Ballina Shire Council	-28.954	153.4565	No
DR221011KM1D	Ballina Shire Council	-28.9482	153.4431	No
DR220811KM1C	Ballina Shire Council	-28.9703	153.4334	No
DR220809KM1F	Ballina Shire Council	-28.965	153.432	No
DR220809KM1A	Ballina Shire Council	-28.9608	153.4334	No
220628Au3A	Ballina Shire Council	-28.9667	153.4336	No
DR220809KM1B	Ballina Shire Council	-28.955	153.4547	No
DR221011KM1H	Ballina Shire Council	-28.9524	153.4589	No
NR_154	Lismore City Council	-28.9895	153.3078	No
NR_39	Lismore City Council	-28.9747	153.3596	No

NR_129	Richmond Valley Council	-29.0794	153.42	No
NR_A_14	Richmond Valley Council	-29.0913	153.3699	No
220623Bi1C	Goondiwindi Regional	-28.1784	151.1934	Yes
220623Bi1B	Goondiwindi Regional	-28.1771	151.1927	Yes
220623Bi2B	Goondiwindi Regional	-28.2007	151.1819	Yes
DR220905KM1A	Tenterfield Shire Council	-28.6983	152.0688	No
DR220906KM1H	Tenterfield Shire Council	-28.8251	152.0438	No
DR220818KM1E	Tenterfield Shire Council	-28.5297	152.3489	No
DR220906KM1D	Tenterfield Shire Council	-28.8292	152.0557	No
DR221111KM1B	Tenterfield Shire Council	-28.9091	152.3083	No
DR221118KM1B	Tenterfield Shire Council	-28.8098	152.2742	No
DR220905KM1H	Tenterfield Shire Council	-28.6974	152.0775	No
DR220906KM1A	Tenterfield Shire Council	-28.834	152.0568	No
DR220818KM1A	Tenterfield Shire Council	-28.5282	152.3476	No
DR220906KM1E	Tenterfield Shire Council	-28.8244	152.0448	No
DR221111KM1A	Tenterfield Shire Council	-28.9046	152.3108	No
DR221118KM1E	Tenterfield Shire Council	-28.8045	152.2778	No
DR220905KM1B	Tenterfield Shire Council	-28.7008	152.0724	No
220922Au1A	Tenterfield Shire Council	-28.8442	152.0843	No
DR220818KM1D	Tenterfield Shire Council	-28.5263	152.3457	No
DR221110KM1B	Tenterfield Shire Council	-28.897	152.2338	No
DR221118KM1A	Tenterfield Shire Council	-28.8115	152.2722	No
DR220818KM1F	Tenterfield Shire Council	-28.5265	152.3441	No
DR221118KM1D	Tenterfield Shire Council	-28.8026	152.2715	No
DR220817KM1A	Tenterfield Shire Council	-28.5379	152.356	No
DR220819AS1A	Tenterfield Shire Council	-28.5121	152.3574	No
DR221110KM1A2	Tenterfield Shire Council	-28.9013	152.225	No
DR221118KM1C	Tenterfield Shire Council	-28.8026	152.2715	No
DR221110KM1C	Tenterfield Shire Council	-28.8968	152.2332	No
DR221119KM1A	Tenterfield Shire Council	-28.7362	152.3421	No
DR220818KM1B	Tenterfield Shire Council	-28.5278	152.3476	No
DR220906KM1I	Tenterfield Shire Council	-28.8267	152.0451	No
DR221116KM1A	Tenterfield Shire Council	-28.5031	152.3896	No
DR221118KM1G	Tenterfield Shire Council	-28.8005	152.2794	No
DR220905KM1D	Tenterfield Shire Council	-28.7021	152.0767	No
DR220906KM1B	Tenterfield Shire Council	-28.8351	152.0573	No
190921Bi1N	Inverell Shire Council	-29.6137	150.8406	No
190923KH4A	Inverell Shire Council	-29.779	151.0259	No
190925KH2A	Inverell Shire Council	-29.655	150.9435	No
190922KH1B	Inverell Shire Council	-29.6584	151.0015	No
190921Bi1B	Inverell Shire Council	-29.617	150.8299	No
190923KH3C	Inverell Shire Council	-29.779	150.9793	No
190922Bi3C	Inverell Shire Council	-29.606	150.8912	No
190923Bi1B	Inverell Shire Council	-29.7376	150.9701	No

190921Bi1A	Inverell Shire Council	-29.6181	150.8296	No
190921Bi1H	Inverell Shire Council	-29.6161	150.8273	No
190923CN2A	Inverell Shire Council	-29.7796	150.9835	No
190922KH2A	Inverell Shire Council	-29.6594	151.0253	No
190922AR1A	Inverell Shire Council	-29.6469	151.0615	No
190922Bi1B	Inverell Shire Council	-29.661	151.0434	No
190922AR1B	Inverell Shire Council	-29.6469	151.0615	No
190922FFR1A	Inverell Shire Council	-29.6467	151.0623	No
190923Bi1F	Inverell Shire Council	-29.7344	150.9826	No
190925KH1A	Inverell Shire Council	-29.6762	150.9315	No
190921KH2A	Inverell Shire Council	-29.7517	151.0413	No
190921Bi3A	Inverell Shire Council	-29.6512	150.8315	No
190925KH1B	Inverell Shire Council	-29.6762	150.9315	No
190922Bi2A	Inverell Shire Council	-29.666	151.0463	No
190922Bi4C	Inverell Shire Council	-29.5895	151.0128	No
190922Bi4A	Inverell Shire Council	-29.5896	151.0133	No
190921Bi1F	Inverell Shire Council	-29.6167	150.8281	No
190921Bi1G	Inverell Shire Council	-29.6162	150.8276	No
190923KH3A	Inverell Shire Council	-29.779	150.9793	No
190922Bi3A	Inverell Shire Council	-29.6062	150.8913	No
210310Ba6A1	Inverell Shire Council	-29.3755	151.3444	No
190924KH1C	Gwydir Shire Council	-29.5238	150.5468	No
190924CN1A	Gwydir Shire Council	-29.5462	150.554	No
221207Bi1B	Gwydir Shire Council	-29.1218	150.3052	Yes
221207Bi7A	Gwydir Shire Council	-29.183	150.2515	Yes
220722Bi1A	Moree Plains Shire Council	-29.4626	149.844	Yes
221208Bi2A	Moree Plains Shire Council	-29.4621	149.85	Yes
221208Bi1A	Moree Plains Shire Council	-29.4619	149.8443	Yes
190916Bi4A	Armidale Regional Council	-30.4223	151.6029	No
190917Bi1B	Armidale Regional Council	-30.4455	151.543	No
190917Bi2B	Armidale Regional Council	-30.3613	151.5843	No
190916Bi1B	Armidale Regional Council	-30.4177	151.6346	No
190920Bi2A	Armidale Regional Council	-30.5776	151.714	No
190916Bi1C	Armidale Regional Council	-30.4172	151.6337	No
190917Bi2J	Armidale Regional Council	-30.3578	151.5898	No
190919Bi1A	Armidale Regional Council	-30.4327	151.5658	No
190916Bi2A	Armidale Regional Council	-30.4193	151.645	No
190917Bi2C	Armidale Regional Council	-30.3608	151.5833	No
190917Bi2H	Armidale Regional Council	-30.3524	151.5855	No
190916Bi2C	Armidale Regional Council	-30.4212	151.6466	No
190919Bi1B	Armidale Regional Council	-30.4322	151.5659	No
190916Bi3B	Armidale Regional Council	-30.4276	151.598	No
190917Bi1A	Armidale Regional Council	-30.4455	151.543	No
190917Bi2F	Armidale Regional Council	-30.3576	151.5825	No

210427Ma2A	Armidale Regional Council	-30.0395	151.8967	No
210427Ma4A	Armidale Regional Council	-30.5796	151.7139	No
190917Bi3A	Uralla Shire Council	-30.6313	151.5375	No
190917Bi4C	Uralla Shire Council	-30.626	151.3416	No
190917Bi4A	Uralla Shire Council	-30.6259	151.3393	No
Coffs_1.7	Coffs Harbour City Council	-30.3371	153.0927	No
Coffs_6.11	Coffs Harbour City Council	-30.3193	153.0727	No
Coffs_19.3	Coffs Harbour City Council	-30.3972	152.9917	No
Coffs_2.1	Coffs Harbour City Council	-30.3393	153.0935	No
Coffs_7.3.1	Coffs Harbour City Council	-30.3602	153.061	No
Coffs_7.1	Coffs Harbour City Council	-30.3638	153.0617	No
Coffs_19.1	Bellingen Shire Council	-30.4028	152.9869	No
Coffs_22.1	Bellingen Shire Council	-30.4482	153.0416	No
200508DR1C	Goulburn Mulwaree Council	-34.8999	150.0571	No
200509DR1D	Goulburn Mulwaree Council	-34.9078	150.0369	No
200509DR1C	Goulburn Mulwaree Council	-34.9112	150.0392	No
200509DR1A	Goulburn Mulwaree Council	-34.9049	150.0494	No
200508DR1F	Goulburn Mulwaree Council	-34.9028	150.0569	No
200508DR1A	Goulburn Mulwaree Council	-34.8958	150.0528	No
200507DR1B	Goulburn Mulwaree Council	-34.9081	150.0517	No
200412DR1A	Shoalhaven City Council	-34.9711	150.1017	No
200403DR1D	Shoalhaven City Council	-35.0656	150.1231	No
200412DR1E	Shoalhaven City Council	-35.0214	150.1472	No
200408DR1M	Shoalhaven City Council	-34.9204	150.142	No
200328DR1B	Shoalhaven City Council	-35.07	150.1299	No
200326KM1D	Shoalhaven City Council	-35.0645	150.1256	No
200412DR1B	Shoalhaven City Council	-34.9716	150.1039	No
200408DR1C	Shoalhaven City Council	-34.9326	150.1458	No
200412DR1C	Shoalhaven City Council	-34.9702	150.1058	No
200511DR1A	Queanbeyan-Palerang Regional Council	-35.0853	150.0286	No
200516DR1D	Snowy Monaro Regional Council	-36.1089	149.3072	No
200517DR1M	Snowy Monaro Regional Council	-36.0637	149.3187	No
200516DR1B	Snowy Monaro Regional Council	-36.1278	149.3076	No
200517DR1I	Snowy Monaro Regional Council	-36.066	149.3144	No
200516DR1A	Snowy Monaro Regional Council	-36.1317	149.3037	No
200529Be1A	Snowy Monaro Regional Council	-36.1445	149.3298	No
200513DR1B	Snowy Monaro Regional Council	-36.0099	149.3721	No

200513DR1F	Snowy Monaro Regional Council	-36.002	149.3663	No
200527DR1B	Snowy Monaro Regional Council	-36.0217	149.3727	No
200513DR1A	Snowy Monaro Regional Council	-36.0088	149.3719	No

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Table A2. Groupings of koala samples used for genetic diversity estimates.

Group	Sample locations in the group (sample size)	Sample size per group	Number of ARTC Samples
Group 1	Brisbane City (05)	43	
	Redland City (37) (= Koala Coast)		
Group 2	Logan City (17)	24	04
	Ipswich City (06)		06
	Scenic Rim Regional (02)		02
Group 3	Lockyer Valley Regional (10)	34	10
	Toowoomba Regional (24)		06
Group 4	Byron Shire Council (02)	25	
	Ballina Shire Council (19)		
	Lismore City Council (02)		
	Richmond Valley Council (02)		
Group 5	Tenterfield Shire Council (31)	31	
Group 6	Inverell Shire Council (29)	36	
	Gwydir Shire Council (04)		02
	Moree Plains Shire Council (03)		03
Group 7	Armidale Regional Council (18)	21	
	Uralla Shire Council (03)		
Group 8	Coffs Harbour City Council (06)	08	
	Bellingen Shire Council (02)		
Group 9	Goulburn Mulwaree Council (07)	17	
	Shoalhaven City Council (09)		
	Queanbeyan–Palerang Regional Council (01)		
Group 10	Snowy Monaro Regional Council (10)	10	

Note. Three samples from Goondiwindi were collected for the ARTC project but do not appear in this table, as they were not included in the analyses.

Table A3. Overview of all ARTC samples, including sample name, whether samples were duplicates, data quality control (QC) for subsequent analyses, whether data was used to estimate number of unique individuals, whether data was used for genetic diversity analyses, Sex, Chlamydia detection, and geographical coordinates (DARtag analyses).

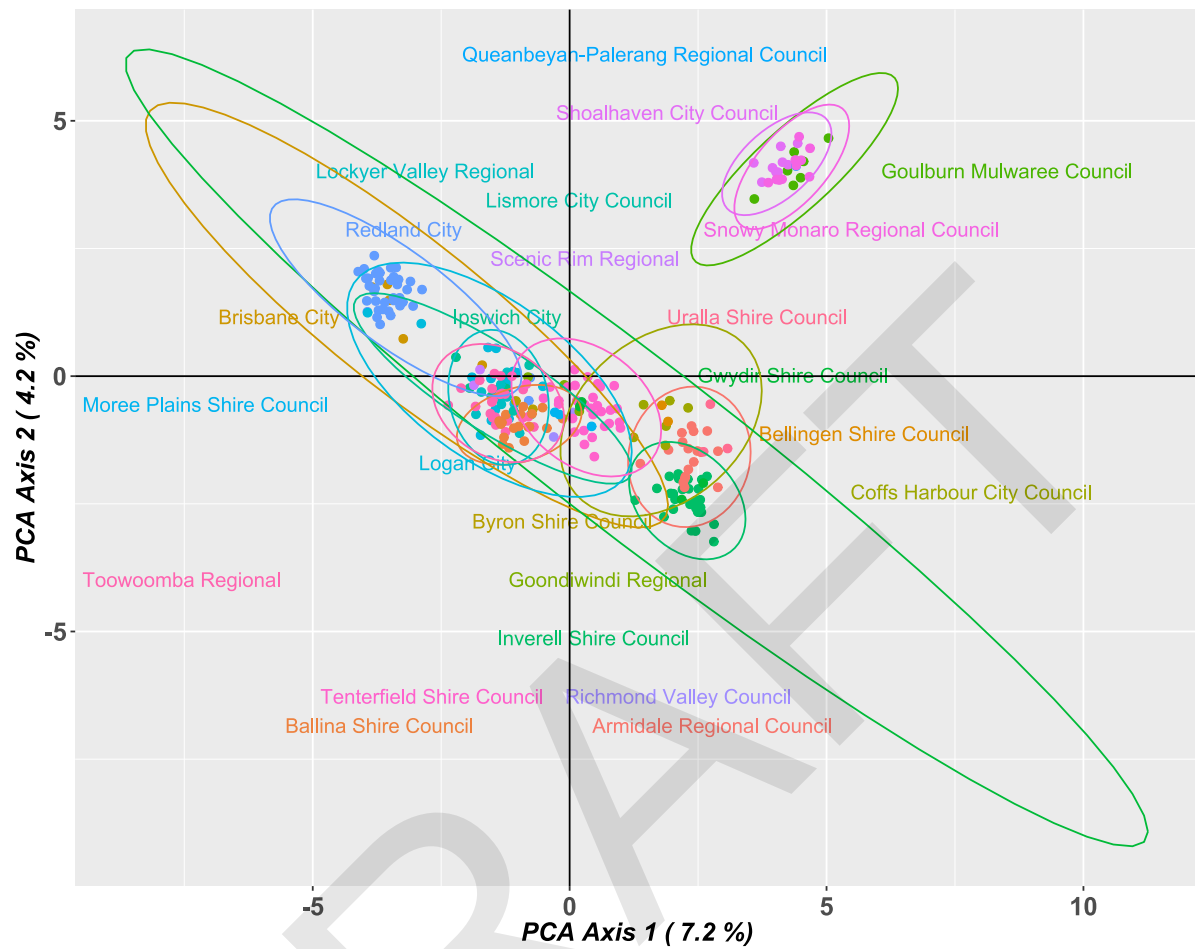
Sample ID	Duplicate	QC for Unique individual (Pass/Fail)	Unique individuals	Genetic diversity	QC for Sex (Pass/Fail)	Sex	QC for Chlamydia (Pass/Fail)	Chlamydia detection	Lat	Long
220609Bi1A	-	Failed	-	No	Failed	-	Failed	-	-27.7122	152.9889
220609Bi2A	No	Pass	Yes	Yes	Pass	F	Pass	Yes	-27.6827	153.0032
220610Bi2A	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.7004	152.9966
220610Bi2B	-	Failed	-	No	Failed	-	Failed	-	-27.7036	152.9941
220610Bi2C	No	Pass	Yes	Yes	Pass	F	Pass	Yes	-27.7047	152.9959
220610Bi3A	No	Pass	Yes	Yes	Pass	F	Pass	Yes	-27.7058	152.9989
220610Bi3B	-	Failed	-	No	Failed	-	Failed	-	-27.7058	153.001
220615Bi2A	-	Failed	-	No	Failed	-	Failed	-	-27.6307	151.7425
220615Bi2B	-	Failed	-	No	Failed	-	Failed	-	-27.6301	151.7423
220615Bi2C	No	Pass	Yes	Yes	Pass	F	Pass	No	-27.6296	151.7422
220615Bi2D	Yes	Pass	No	No	Failed	-	Failed	-	-27.6301	151.7427
220615Bi2E	Yes	Pass	No	No	Failed	-	Failed	-	-27.634	151.736
220617Bi2A	-	Failed	-	No	Failed	-	Failed	-	-27.7193	151.5579
220617Bi2B	Yes	Pass	No	No	Failed	-	Failed	-	-27.7198	151.5579
220617Bi2C	Yes	Pass	Yes	Yes	Pass	F	Pass	No	-27.7205	151.5597
220617Bi2D	Yes	Pass	No	No	Failed	-	Failed	-	-27.7203	151.5579
220618Bi1A	-	Failed	No	No	Failed	-	Failed	-	-27.6052	151.7634
220618Bi1B	-	Failed	No	No	Failed	-	Failed	-	-27.6058	151.7643
220618Bi1C	Yes	Pass	No	No	Failed	-	Failed	-	-27.6058	151.7644
220618Bi1D	-	Failed	-	No	Failed	-	Failed	-	-27.6052	151.7652
220618Bi1E	Yes	Pass	Yes	No	Pass	M	Pass	No	-27.6033	151.7614
220618Bi1F	Yes	Pass	Yes	Yes	Failed	-	Failed	-	-27.6035	151.7603
220623Bi1A	-	Failed	Yes	No	Failed	-	Failed	-	-28.1773	151.1926
220623Bi1B	No	Pass	Yes	Yes	Pass	F	Pass	No	-28.1771	151.1927
220623Bi1C	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-28.1784	151.1934
220623Bi2A	-	Failed	-	No	Failed	-	Failed	-	-28.1997	151.1782
220623Bi2B	Yes	Pass	No	No	Failed	-	Failed	-	-28.2007	151.1819
220624Bi1A	No	Pass	Yes	Yes	Pass	F	Pass	Yes	-27.7306	151.6415
220713Bi2A	-	Failed	-	No	Failed	-	Failed	-	-29.4195	149.9071
220713Bi4A	-	Failed	-	No	Failed	-	Failed	-	-29.3697	150.0833
220721Bi3A	Yes	Pass	No	No	Failed	-	Failed	-	-29.4632	149.8442
220722Bi1A	Yes	Pass	Yes	Yes	Pass	M	Pass	Yes	-29.4626	149.844

220801Bi1A	Yes	Pass	Yes	Yes	Pass	F	Pass	No	-27.8256	152.7624
220801Bi1B	Yes	Pass	No	No	Failed	-	Failed	-	-27.8252	152.7619
220801Bi2A	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.8204	152.7666
220802Bi1A	-	Failed	-	No	Failed	-	Failed	-	-27.7337	152.7079
220802Bi1B	-	Failed	-	No	Failed	-	Failed	-	-27.7334	152.7094
220802Bi1C	-	Failed	-	No	Failed	-	Failed	-	-27.735	152.7112
220802Bi1D	-	Failed	-	No	Failed	-	Failed	-	-27.737	152.711
220802Bi1E	Yes	Pass	No	No	Failed	-	Failed	-	-27.7368	152.7097
220802Bi3A	No	Pass	Yes	No	Failed	-	Failed	-	-27.6961	152.6082
220803Bi1A	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.6672	152.6562
220803Bi1B	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.667	152.6517
220803Bi2A	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.6878	152.6358
220803Bi3A	No	Pass	Yes	Yes	Pass	M	Pass	No	-27.6984	152.6182
220809Bi1A	-	Failed	-	No	Failed	-	Failed	-	-27.5159	151.9719
220809Bi1B	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.5163	151.9722
220809Bi2A	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.5141	151.9703
220809Bi3A	-	Failed	-	No	Failed	-	Failed	-	-27.5171	151.9536
220809Bi3B	No	Pass	Yes	No	Failed	-	Failed	-	-27.5167	151.9533
220809Bi3C	No	Pass	Yes	Yes	Pass	M	Pass	No	-27.5149	151.9543
220810Bi1A	-	Failed	-	No	Failed	-	Failed	-	-27.515	152.0122
220810Bi1B	No	Pass	Yes	Yes	Pass	M	Pass	No	-27.5163	152.0096
220810Bi1C	No	Pass	Yes	Yes	Pass	F	Failed	-	-27.5164	152.0067
220810Bi1D	No	Pass	Yes	Yes	Pass	F	Pass	No	-27.5151	152.0113
220810Bi3A	-	Failed	-	No	Failed	-	Failed	-	-27.523	152.0119
220810Bi3B	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.5238	152.0087
220811Bi1A	Yes	Pass	Yes	Yes	Pass	F	Pass	Yes	-27.5374	152.1315
220811Bi1B	No	Pass	Yes	No	Failed	-	Failed	-	-27.5365	152.1315
220811Bi1C	Yes	Pass	No	No	Failed	-	Failed	-	-27.5379	152.1305
220811Bi1D	Yes	Pass	Yes	Yes	Pass	F	Pass	No	-27.538	152.1306
220811Bi3A	Yes	Pass	No	No	Failed	-	Failed	-	-27.5402	152.1394
220811Bi3B	No	Pass	Yes	Yes	Pass	M	Pass	Yes	-27.5398	152.1436
221207Bi1A	Yes	Pass	No	No	Failed	-	Failed	-	-29.1214	150.3042
221207Bi1B	Yes	Pass	Yes	Yes	Pass	M	Pass	Yes	-29.1218	150.3052
221207Bi1C	Yes	Pass	No	No	Failed	-	Failed	-	-29.1228	150.3042
221207Bi5A	No	Pass	Yes	Yes	Failed	-	Failed	-	-29.0955	150.2545
221207Bi7A	No	Pass	Yes	Yes	Pass	F	Pass	No	-29.183	150.2515
221208Bi1A	No	Pass	Yes	Yes	Pass	F	Pass	Yes	-29.4619	149.8443
221208Bi1B	-	Failed	-	No	Failed	-	Failed	-	-29.4621	149.8443
221208Bi2A	Yes	Pass	Yes	No	Pass	F	Pass	Yes	-29.4621	149.85
221208Bi2B	Yes	Pass	No	No	Failed	-	Failed	-	-29.4619	149.8496
221208Bi2C	Yes	Pass	Yes	Yes	Failed	-	Failed	-	-29.4614	149.8493

Table A4. Pairwise table showing relatedness values between samples that are very likely from the same individual koala. Note that, on five instances, individuals were identified as the same individual with more than one other sample, whilst the other samples are duplicates. The asterisk indicates which sample was removed based on insufficient data.

Sample 1	Sample 2	Wang (2002)	Lynch and Ritland (1999)	Milligan (2003)
220615Bi2D	220615Bi2E	0.934	0.906	0.944
220615Bi2E	220623Bi1A	0.839	0.527	0.796
220623Bi1A	220623Bi2B	0.887	0.735	0.854
220623Bi2B	220802Bi1E	0.982	0.962	1
220802Bi1E	220615Bi2D	0.980	0.963	0.971
220615Bi2D	220623Bi1A	0.877	0.642	0.804
220615Bi2D	220623Bi2B	0.939	0.897	0.948
220615Bi2E	220623Bi2B	1	1	1
220615Bi2E	220802Bi1E	0.929	0.827	0.937
220623Bi1A	220802Bi1E	0.913	0.829	0.866
220617Bi2B*	220617Bi2C	0.687	0.798	1
220617Bi2C	220617Bi2D*	0.687	0.790	1
220617Bi2D*	220617Bi2B*	0.391	0.560	0.947
220618Bi1C*	220618Bi1E	0.908	0.898	0.966
220618Bi1E	220618Bi1F*	0.962	0.964	1
220618Bi1F*	220618Bi1C*	0.903	0.889	1
220721Bi3A	220722Bi1A	1	1	1.098
220801Bi1A	220801Bi1B	0.604	0.717	1.041
220811Bi1A	220811Bi3A*	0.995	0.994	1
220811Bi1C*	220811Bi1D	0.958	0.953	1
221207Bi1A*	221207Bi1B	0.905	0.913	1.036
221207Bi1B	221207Bi1C*	0.728	0.800	1.055
221207Bi1C*	221207Bi1A*	0.758	0.819	1.088
221208Bi2A*	221208Bi2B*	1	1	1
221208Bi2B*	221208Bi2C	1	1	1
221208Bi2C	221208Bi2A*	1	1	1.119

Figure A2. Principal component analysis (PCA) plot for 255 unique koalas from 24 locations. Each location has its 95% CI ellipse.



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APPENDIX B

UNISC DIET STUDY SAMPLE ID

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Table 11-1 Sample Id And Locations Taken From Unisc Koala Diet Analysis Data, Sample Number Was Assigned For The Purposes Of Mapping And Identification In This Report

Sample ID	Latitude	Longitude	Sample number	Sample ID	Latitude	Longitude	Sample number
220609Bi1A	-27.7122361	152.9889027	1	220722Bi1A	-29.4625715	149.8439588	26
220609Bi2A	-27.6826527	153.0032046	2	220801Bi1B	-27.8252010	152.7619230	27
220610Bi2B	-27.7036150	152.9941374	3	220801Bi2A	-27.8203614	152.7665640	28
220610Bi3B	-27.7057817	153.0009636	4	220802Bi1A	-27.7336759	152.7079343	29
220615Bi2B	-27.6300514	151.7423274	5	220802Bi1B	-27.7333631	152.7094265	30
220615Bi2C	-27.6296256	151.7421600	6	220802Bi1D	-27.7370225	152.7109793	31
220615Bi2D	-27.6301272	151.7427218	7	220802Bi1E	-27.7368031	152.7096508	32
220615Bi2E	-27.6339930	151.7360492	8	220803Bi1B	-27.6669582	152.6516855	33
220617Bi2B	-27.7198355	151.5579458	9	220803Bi2A	-27.6877892	152.6357785	34
220617Bi2C	-27.7205485	151.5596708	10	220803Bi3A	-27.6983854	152.6182173	35
220617Bi2D	-27.7203316	151.5579190	11	220809Bi1A	-27.5159188	151.9718864	36
220618Bi1A	-27.6052280	151.7633827	12	220809Bi1B	-27.5163362	151.9721761	37
220618Bi1B	-27.6058229	151.7642981	13	220809Bi2A	-27.5141105	151.9702833	38
220618Bi1C	-27.6057513	151.7643698	14	220809Bi3A	-27.5170733	151.9536104	39
220618Bi1D	-27.6051905	151.7652475	15	220809Bi3C	-27.5148848	151.9542791	40
220618Bi1E	-27.6032513	151.7613683	16	220810Bi1A	-27.5150194	152.0122013	41
220618Bi1F	-27.6034761	151.7602613	17	220810Bi3A	-27.5230155	152.0119375	42
220623Bi1A	-28.1773021	151.1926390	18	220810Bi3B	-27.5238411	152.0087000	43
220623Bi1B	-28.1771044	151.1927035	19	220811Bi1B	-27.5365243	152.1315362	44
220623Bi1C	-28.1784397	151.1933634	20	220811Bi3A	-27.5402114	152.1394267	45
220623Bi2A	-28.1996994	151.1782250	21	220811Bi3B	-27.5397950	152.1436227	46
220623Bi2B	-28.2007315	151.1818646	22	221207Bi1A	-29.1214000	150.3041700	47
220624Bi1A	-27.7306276	151.6414796	23	221207Bi1B	-29.1217500	150.3052200	48
220713Bi2A	-29.4194731	149.9071345	24	221208Bi2A	-29.4621400	149.8500100	49
220713Bi4A	-29.3697201	150.0832739	25	221208Bi2B	-29.4619100	149.8495700	50

APPENDIX C

KOALA DIET ANALYSIS BY UQ

DRAFT

Koala Diet Analysis

Australian Inland Rail



December 2023

By Michaela Blyton



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

Scope and Limitations

This report details the tree species identified in koala scat samples through the detection of species-specific genetic markers (SNPs: single nucleotide polymorphisms) on the DarTag platform (Diversity Arrays Technologies) using a panel of 1029 validated and 93 unvalidated oligos covering 89 potential food tree species found in the state of Queensland. Only species included in the oligo panel can be detected using this method. As such, if other species not in the panel were eaten by the koalas sampled, then those species would not be identified.

Failure to detect a species in a sample does not guarantee that the species was not eaten, particularly where the total number of diet associated reads returned for that sample is low (< 50). As such, it is recommended that the total number of diet associated reads returned be taken into account when considering the results for a particular sample.

The relative abundances of the tree species detected in a sample are provided to offer insight into the dominant and minor components of the diet. However, it should be noted that at this time the method for assigning the relative abundance values has not been validated against data from koalas with known diets. Validation of the method is currently in process but until it is completed the relative abundance values should be treated with caution.

Methods

Queensland Diet DarTag Oligo Panel

Potential food tree species sampling: A list of candidate koala food trees species for Queensland was assembled with reference to numerous published lists of koala food and shelter trees for Queensland and New South Wales. The list included not only eucalypts (the genera *Eucalyptus*, *Corymbia* and *Angophora*), but also a number of non-eucalypts, including species from the genera *Melaleuca*, *Acacia*, *Allocasuarina*, *Casuarina* and *Lophostemon*.

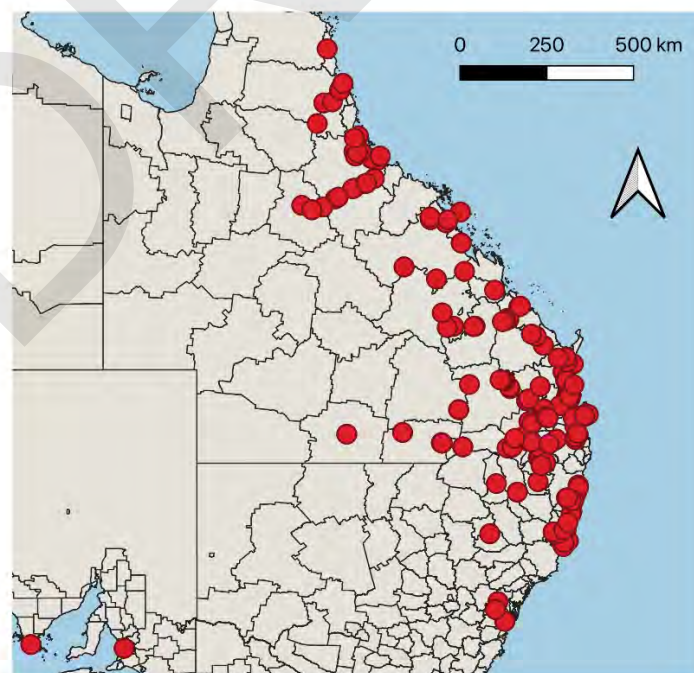


Figure 1. Map illustrating the geographic distribution of sites where leaf samples were collected from candidate koala food tree species.

The locations of all trees from which genetic material was included in the development of the Queensland panel can be seen in *Figure 1*. A more detailed, interactive, map can also be viewed on the “Our Methods” page of our website www.whatdokoalaseat.org and we encourage the reader to view this map to better understand our collections. The viewer can click on individual points to learn more about the samples included and to access links to websites providing information about each species. A complete list of tree taxa and number of replicates included in the development of the Queensland panel is listed in *Table 1*. Most leaf samples were collected specifically for this project by Dean Nicolle, of Currency Creek Arboretum, in June 2021. Dr Nicolle is Australia’s pre-eminent eucalypt expert. During these collections, 4 individual trees were sampled per species/site combination, for 73 taxa from 135 locations, for a total of 144 unique site-species combinations and 576 leaf samples. Sequencing was performed on combined DNA extracts from two individual trees from each site/species combination, so that these collections contributed 288 sequence representations.

Existing tree sequence data from other projects was also included. This included the red gum species *E. tereticornis* and *E. blakelyi*, which were collected by John Whale at locations throughout NSW and Queensland as part of his PhD research into the genetics of this group. It also included numerous ironbark species from the series *Siderophloiae*, collected by Ben Moore during a previous research project in Queensland, and some species that had been included in a previous study of koala diet composition in the forests of northeast NSW. These were included to increase the range of geographic and thereby genetic variation included in our collection, and in some instances trees from beyond Queensland were also included.

After collection in the field, leaf samples were either air-dried immediately, dried on silica immediately, or returned frozen to a university and subsequently freeze-dried prior to extraction of DNA.

Table 1: List of candidate koala food tree taxa for which gene sequences were included in the development of the Queensland panel. Note that most sequencing wells included DNA from two individuals.

Taxon	Number of Sequencing Wells
<i>Acacia melanoxylon</i>	2
<i>Allocasuarina littoralis</i>	10
<i>Allocasuarina</i> sp.	5
<i>Allocasuarina torulosa</i>	9
<i>Angophora costata</i>	3
<i>Angophora floribunda</i>	4
<i>Angophora leiocarpa</i>	2
<i>Araucaria cunninghamii</i>	2
<i>Casuarina glauca</i>	4
<i>Casuarina</i> sp.	2
<i>Corymbia citriodora</i>	6
<i>Corymbia clarksoniana</i>	2
<i>Corymbia dallachiana</i>	2
<i>Corymbia erythrophloia</i>	4
<i>Corymbia gummifera</i>	5
<i>Corymbia intermedia</i>	10
<i>Corymbia maculata</i>	6
<i>Corymbia tessellaris</i>	8
<i>Corymbia trachyphloia</i> subsp. <i>trachyphloia</i>	8
<i>Corymbia variegata</i>	4
<i>Eucalyptus acmenoides</i>	8
<i>Eucalyptus albens</i>	6
<i>Eucalyptus amplifolia</i> subsp. <i>sessiliflora</i>	2

<i>Eucalyptus andrewsii</i>	2
<i>Eucalyptus bancroftii</i>	4
<i>Eucalyptus blakelyi</i>	8
<i>Eucalyptus brownii</i>	2
<i>Eucalyptus brunnea</i>	2
<i>Eucalyptus camaldulensis</i>	5
<i>Eucalyptus camaldulensis</i> subsp. <i>acuta</i>	4
<i>Eucalyptus camaldulensis</i> subsp. <i>camaldulensis</i>	2
<i>Eucalyptus cambageana</i>	4
<i>Eucalyptus campanulata</i>	2
<i>Eucalyptus carnea</i>	6
<i>Eucalyptus chloroclada</i>	2
<i>Eucalyptus citrodora</i>	2
<i>Eucalyptus conica</i>	4
<i>Eucalyptus coolabah</i>	8
<i>Eucalyptus crebra</i>	10
<i>Eucalyptus cullenii</i>	4
<i>Eucalyptus drepanophylla</i>	8
<i>Eucalyptus dunnii</i>	2
<i>Eucalyptus dura</i>	4
<i>Eucalyptus elegans</i>	4
<i>Eucalyptus eugenioides</i>	6
<i>Eucalyptus exserta</i>	7
<i>Eucalyptus fibrosa</i>	4
<i>Eucalyptus fibrosa</i> <i>nubilla</i>	4
<i>Eucalyptus grandis</i>	7
<i>Eucalyptus granitica</i>	4
<i>Eucalyptus haemostoma</i>	2
<i>Eucalyptus intertexta</i>	2
<i>Eucalyptus laevopinea</i>	4
<i>Eucalyptus largiflorens</i>	2
<i>Eucalyptus latisinensis</i>	2
<i>Eucalyptus longirostrata</i>	4
<i>Eucalyptus macta</i>	2
<i>Eucalyptus major</i>	4
<i>Eucalyptus melanophloia</i>	2
<i>Eucalyptus melanophloia</i> subsp. <i>melanophloia</i>	6
<i>Eucalyptus melliodora</i>	4
<i>Eucalyptus microcarpa</i>	4
<i>Eucalyptus microcorys</i>	8
<i>Eucalyptus moluccana</i>	6
<i>Eucalyptus nobilis</i>	2
<i>Eucalyptus ochrophloia</i>	2
<i>Eucalyptus orgadophila</i>	6
<i>Eucalyptus pellita</i>	4
<i>Eucalyptus pilularis</i>	8
<i>Eucalyptus platyphylla</i>	8
<i>Eucalyptus populnea</i>	8
<i>Eucalyptus portuensis</i>	2
<i>Eucalyptus prava</i>	3
<i>Eucalyptus propinqua</i>	8
<i>Eucalyptus punctata</i>	6

<i>Eucalyptus racemosa</i>	7
<i>Eucalyptus resinifera</i>	3
<i>Eucalyptus resinifera</i> subsp. <i>hemilampra</i>	4
<i>Eucalyptus rhombica</i>	2
<i>Eucalyptus robusta</i>	8
<i>Eucalyptus saligna</i>	8
<i>Eucalyptus scoparia</i>	2
<i>Eucalyptus seeana</i>	4
<i>Eucalyptus siderophloia</i>	8
<i>Eucalyptus sideroxylon</i>	2
<i>Eucalyptus signata</i>	2
<i>Eucalyptus taurina</i>	4
<i>Eucalyptus tereticornis</i>	18
<i>Eucalyptus tindaliae</i>	5
<i>Eucalyptus whitei</i>	5
<i>Eucalyptus woollsiana</i>	2
<i>Lophostemon confertus</i>	6
<i>Lophostemon suaveolens</i>	2
<i>Melaleuca quinquenervia</i>	2
<i>Syncarpia glomulifera</i>	2
<i>Syncarpia glomulifera</i> subsp. <i>glomulifera</i>	4
Grand Total	447

Sequencing of potential food tree species: DNA was extracted from leaf samples collected by Dean Nicolle using an automated plate-based extraction protocol, by Diversity Arrays Technology P/L, Canberra, Australia (DART). The remaining reference leaves were extracted using CTAB extraction buffer with chloroform clean-up and ethanol precipitation. DNA extracts were sequenced at high density (returning approximately 2.5 million reads per sample) on the DARTseq platform by Diversity Arrays Technology P/L, Canberra, Australia (DART). The *Eucalyptus* Dartseq (1.0) product was selected that uses the PstI/HpaII restriction enzyme combination, which returns approximately 50 000, 64 bp loci with an average read depth for the reference allele of > 20. This protocol has been optimised for *Eucalyptus* by Diversity Arrays Technologies in association with prior clients for *Eucalyptus* genotyping. Read counts for targets (DNA fragments) and single nucleotide polymorphisms (SNPs) within those targets were determined by DART using their standard proprietary pipelines [1, 2]. As DART's pipelines are optimised to identify loci that are present and variable across the majority of the samples in the dataset, loci with private alleles may not be retained if the species in the dataset are too taxonomically distinct. As such, species belonging to the different genera and *Eucalyptus* subgenera were run through the pipelines separately, to maximise the number of potentially useful loci identified. Read proportions for the reference and alternative SNP alleles at each locus were determined using custom code in R studio 1.2.5033 [3].

Identification of species-specific SNPs and panel validation: Prior to identification of species-specific SNPs, a Principal Components Analysis was performed on the Hamming genetic distance matrix generated from the SNP data in GenAlEx 6.1 to confirm the species designations of the samples. Samples that did not cluster with their designated species were then removed from the dataset. Loci for which one or more individuals were heterozygous were also removed from the dataset as these loci could not contain fixed private alleles. Species-specific SNPs were identified in the remaining loci using custom written code in R studio 1.2.5033 [3]. Additionally, for a small number of species that were taxonomically distinct from all other species in the datasets (i.e. *Araucaria cunninghamii* and *Acacia melanoxylon*), in silico darts that were present only in the target species were also identified as potential species-specific genetic markers.

The list of species-specific SNPs identified from the DArTseq data was filtered to retain only a single SNP per unique DArT sequencing fragment to minimise the impact of linkage disequilibrium among potential markers. Up to 30 SNPs/in silico darts were then selected per species for oligo design. Of the suitable SNPs, those that were fixed, had higher DArTseq read counts and higher reproducibility were preferentially selected. Where SNPs from DArT targets that were only present in some individual trees had to be included, those that were present in a higher proportion of the individuals were given preference. Oligos were designed for the selected SNPs in house by DArT by identifying probe regions flanking the selected SNPs using primer design software in Genious [4]. Of the candidate species-specific SNPs only those that were found in the middle of the DArT target were suitable for oligo design.

The selected tags (SNPs and flanking regions) were then amplified and sequenced using the designed oligos from generally four individual trees of each species using the DArTag platform to establish that they remained species specific on the different platform. Briefly, the pooled species-specific oligos were hybridized to denatured eucalyptus DNA, then the targeted SNPs were copied and amplified with simultaneous addition of demultiplexing primers. The products of DArTag assay were then sequenced on the HiSeq 2500 (Illumina), demultiplexed and targeted SNPs detected using DArT P/L's proprietary analytical pipeline (DarToolbox). There were four species (*E. prava*, *E. laevopinea*, *E. andrewsii* and *Araucaria cunninghamii*) that were not included in the validation panel due to a lack of available samples. As such, the SNPs/in silico darts for these species could not be fully validated. We confirmed that these markers did not amplify in any non-target species, however, we could not confirm amplification in the target species.

After validation we retained 1122 markers with the number of markers identified per taxon/species shown in Table 2. The marker panel demonstrated the ability to discriminate most eucalypt species, with some exceptions where closely related species or subspecies could not be distinguished, even though we could be confident that DNA from one or more of the species in question was present. This was particularly notable for the ironbarks from the series *Siderophloiae* (*E. crebra*, *drepanophylla*, *fibrosa*, *rhombica*, *dura*, *cullenii*, *whitei*, *melanophloia*).

Table 2: List of DarTag markers in the Queensland panel for candidate koala food tree taxa

Taxon	Number of DarTag Markers	
<i>Acasia melanoxylon</i>	28	
<i>Allocasuarina</i>	10	
<i>Allocasuarina littoralis</i>	19	
<i>Allocasuarina torulosa</i>	0	
<i>Angophora</i>	24	
<i>Angophora costata</i>	7	
<i>Angophora floribunda</i>	6	
<i>Angophora leiocarpa</i>	17	
<i>Araucaria cunninghamii</i>	60	unvalidated
<i>Casuarina glauca</i>	15	
<i>Casuarina sp1</i>	9	
<i>Casuarina sp2</i>	18	
<i>Corymbia citriodora</i>	8	
<i>Corymbia clarkoniana</i>	17	
<i>Corymbia dallachiana</i>	16	
<i>Corymbia erythrophloia</i>	14	
<i>Corymbia gummifera</i>	8	
<i>Corymbia gummifera</i> and/or <i>intermedia</i>	1	
<i>Corymbia intermedia</i>	5	
<i>Corymbia maculata</i>	10	
<i>Corymbia tessellaris</i>	5	

<i>Corymbia trachyphloia</i>	11	
<i>Corymbia variegata</i>	15	
<i>Eucalyptus acmenoides</i>	9	
<i>Eucalyptus albens</i>	14	
<i>Eucalyptus amplifolia</i>	14	
<i>Eucalyptus andrewsii</i>	13	unvalidated
<i>Eucalyptus bancroftii</i>	19	
<i>Eucalyptus bancroftii</i> and/or <i>seeana</i>	8	
<i>Eucalyptus blakelyi</i>	7	
<i>Eucalyptus brownii</i>	13	
<i>Eucalyptus brunnea</i>	12	
<i>Eucalyptus camaldulensis</i>	35	
<i>Eucalyptus cambageana</i>	15	
<i>Eucalyptus campanulata</i>	12	
<i>Eucalyptus carnea</i>	9	
<i>Eucalyptus chloroclada</i>	17	
<i>Eucalyptus conica</i>	11	
<i>Eucalyptus coolabah</i>	16	
<i>Eucalyptus crebra</i>	3	
<i>Eucalyptus crebra</i> and/or <i>elegans</i>	1	
<i>Eucalyptus crebra</i> and/or <i>drepanophylla</i>	1	
<i>Eucalyptus crebra</i> , <i>elegans</i> and/or <i>fibrosa</i>	1	
<i>Eucalyptus cullenii</i>	5	
<i>Eucalyptus cullenii</i> and/or <i>crebra</i>	1	
<i>Eucalyptus cullenii</i> and/or <i>melanophloia</i>	1	
<i>Eucalyptus cullenii</i> and/or <i>whitteii</i>	1	
<i>Eucalyptus drepanophylla</i>	2	
<i>Eucalyptus drepanophylla</i> and/or <i>dura</i>	1	
<i>Eucalyptus dunnii</i>	13	
<i>Eucalyptus dura</i>	7	
<i>Eucalyptus elegans</i>	3	
<i>Eucalyptus eugenioides</i>	13	
<i>Eucalyptus exserta</i>	11	
<i>Eucalyptus fibrosa</i>	4	
<i>Eucalyptus fibrosa</i> and/or <i>taurina</i>	1	
<i>Eucalyptus fibrosa</i> and/or <i>whiteii</i>	1	
<i>Eucalyptus grandis</i>	13	
<i>Eucalyptus granitica</i>	12	
<i>Eucalyptus granitica</i> and/or <i>whitteii</i>	1	
<i>Eucalyptus haemastoma</i>	5	
<i>Eucalyptus intertexta</i>	10	
<i>Eucalyptus laevopinea</i>	9	unvalidated
<i>Eucalyptus largiflorens</i>	11	
<i>Eucalyptus latisinensis</i>	9	
<i>Eucalyptus longirostrata</i>	19	
<i>Eucalyptus macta</i>	13	
<i>Eucalyptus macta</i> and/or <i>resinifera</i>	1	
<i>Eucalyptus major</i>	20	
<i>Eucalyptus melanophloia</i>	6	
<i>Eucalyptus melliodora</i>	12	
<i>Eucalyptus microcarpa</i>	10	
<i>Eucalyptus microcorys</i>	14	

<i>Eucalyptus moluccana</i>	5	
<i>Eucalyptus nobilis</i>	12	
<i>Eucalyptus ochrophloia</i>	11	
<i>Eucalyptus orgadophila</i>	9	
<i>Eucalyptus pellita</i>	17	
<i>Eucalyptus pilularis</i>	6	
<i>Eucalyptus platyphylla</i>	15	
<i>Eucalyptus populnea</i>	13	
<i>Eucalyptus portuensis</i>	6	
<i>Eucalyptus prava</i>	11	unvalidated
<i>Eucalyptus propinqua</i>	15	
<i>Eucalyptus punctata</i>	11	
<i>Eucalyptus racemosa</i>	7	
<i>Eucalyptus resinifera</i>	12	
<i>Eucalyptus rhombica</i>	18	
<i>Eucalyptus robusta</i>	6	
<i>Eucalyptus saligna</i>	13	
<i>Eucalyptus scoparia</i>	17	
<i>Eucalyptus seeana</i>	13	
<i>Eucalyptus siderophloia</i>	4	
<i>Eucalyptus sideroxylon</i>	17	
<i>Eucalyptus signata</i>	8	
<i>Eucalyptus taurina</i>	2	
<i>Eucalyptus tereticornis</i>	8	
<i>Eucalyptus tindaliae</i>	15	
<i>Eucalyptus whiteii</i>	4	
<i>Eucalyptus woollsiana</i>	9	
<i>Eucalyptus dura</i> and/or <i>siderophloia</i>	1	
<i>Eucalyptus dura</i> , <i>fibrosa</i> and/or <i>rhombica</i>	1	
<i>Eucalyptus dura</i> , <i>fibrosa</i> and/or <i>taurina</i>	1	
<i>Eucalyptus fibrosa</i> and/or <i>rhombica</i>	1	
<i>Eucalyptus melanophloia</i> and/or <i>whiteii</i>	1	
<i>Eucalyptus tereticornis</i> and/or <i>robusta</i>	2	
<i>Lophostemon confertus</i>	6	
<i>Lophostemon suaveolens</i>	12	
<i>Melaleuca glutaraldehyde</i>	17	
<i>Syncarpia glomulifera</i>	14	
Grand Total	1122	

Diet Determination from Scats

DNA was extracted from the koala scats using CTAB extraction buffer with chloroform clean-up and ethanol precipitation [5]. 100 mg of material taken from the centre of each scat sample was ground into a fine powder using the TissueLyser II (Qiagen). Each sample was bead beaten three times at 30 Hz for 1 minute after snap freezing in liquid nitrogen. The samples were then digested in 1000 µl (scats) of extraction buffer (0.1 M Tris-HCL, 1.4 M NaCl, 0.02M EDTA, 20 g.l⁻¹ of cetyltrimethyl ammonium bromide and 0.3 % β-mercaptoethanol) in a ThermoMixer (Eppendoff) at 65 °C for 1 hour with mixing at 1000 rpm. The digested samples were centrifuged for 10 minutes at 16 000 g. The supernatant was then washed twice in one volume of chloroform:isoamyl alcohol (24:1). The DNA was then precipitated by addition of a half volume of 5M NaCl to the separated aqueous phase, followed by 3 volumes of cold 95% ethanol and incubation at -20 °C for 1 hour. The samples were then centrifuged for 10 minutes at 16 000 g. The DNA pellet was washed with 700 µl of 70% ethanol followed by 700 µl of 95% ethanol. The DNA was dried for

30 minutes at 65 °C and resuspended in 40 µl of TE buffer. Inhibitors were removed from the DNA extracts using the OneStep PCR Inhibitor Removal Kit (Zymo) according to the manufacturer's instructions.

Those SNPs that were confirmed to be species-specific on the DArTag platform were amplified and sequenced from the faecal DNA extracts (as described above) to determine the composition of the koalas' diets. The resulting sequencing read counts by sample table was then filtered to remove likely sequencing errors and low frequency contamination. For each target species, sequencing reads were pruned from the dataset if the average number of reads per detected marker was less than 3 or if fewer than two SNPs were detected in target species that had 3 or more validated markers. The remaining filtered readers for each marker were then divided by the average number of reads returned for that marker in the target tree species to account for differences among markers in amplification efficiency. The number of scaled reads for each target species was then averaged across those markers that were found in the highest proportion of target tree species individuals (e.g if three markers were detected for a target species in a sample with two of those found in all trees sequenced for that species while the last marker was only found in half the target trees, then the scaled reads would be averaged across to two fixed markers while the reads from the last marker were not considered). The averaged scaled reads per target species were then converted to relative abundance by dividing by the total number of averaged scaled reads across all target species.

Results

Of the 55 scat samples sequenced on the DArTag platform using the Queensland diet oligo panel, 49 returned reads for the validated diet markers after quality control filtering. An average of 333.59 filtered diet reads were returned per sample (range: 3 to 1591) with less than 50 filtered reads returned for three samples.

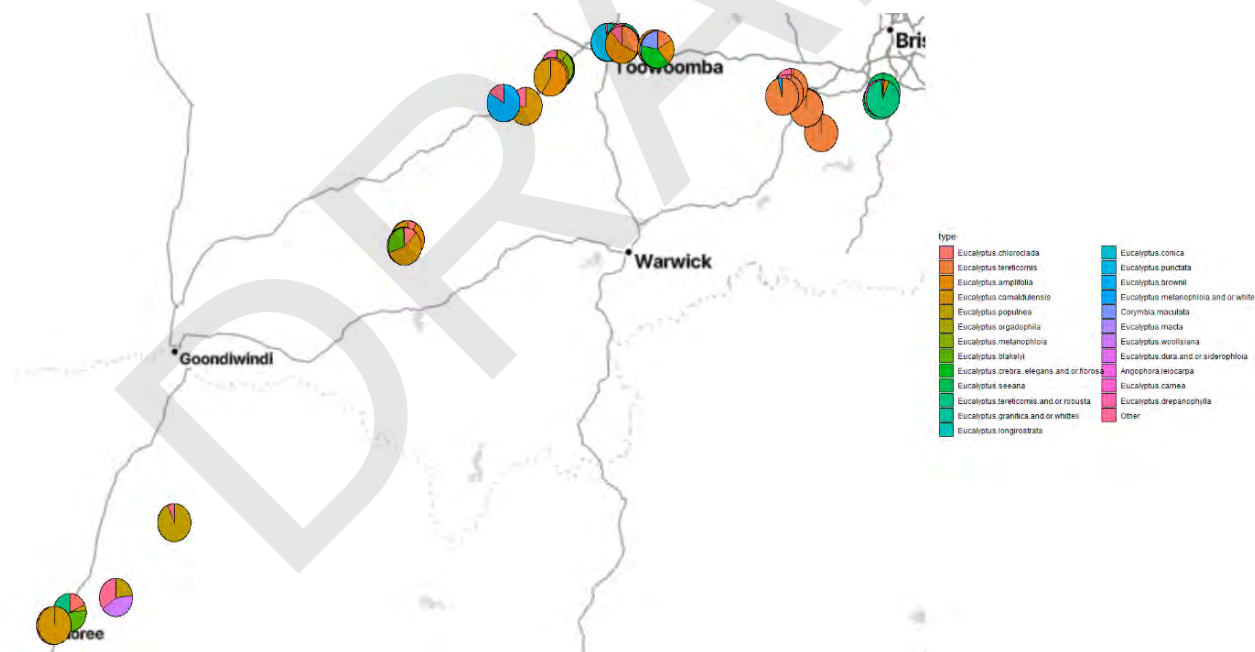


Figure 2. Map of scat sample locations with pie charts illustrating the relative abundance of the different dietary tree species detected in each sample.

Across all samples, between 1 and 7 tree species were detected per sample (average = 3.35). Thirty-seven individual species were detected across the 49 samples with several other species potentially present as indicated by the presence of markers for groups of target species. The most frequently detected species were *Eucalyptus chloroclada* (detected in 18 samples), *E. tereticornis* (17 samples), *E. amplifolia* (16 samples) and *E. camaldulensis* (16 samples). These species were also often found at high relative abundance within samples (range of average relative abundances: 24% to 44%). *E. prava* was detected in a single sample (IR21: 220623BI1B), however, as the markers for this species have not been validated it

could not be included in the relative abundance calculations. Please see a breakdown of the results by sample in the excel workbook “ARTC diet analysis results”. The diet species detected differed between geographic regions and between individuals (*Figure 2*).



*Figure 3. Map of scat sample locations in the **Brisbane Region** with pie charts illustrating the relative abundance of the different dietary tree species detected in each sample.*

In the Brisbane region *Eucalyptus seeana* was detected in 3/4 samples collected in the south at an average relative abundance of 64.5%, while *Eucalyptus tereticornis* was detected in 7/8 samples collected west of Brisbane at an average relative abundance of 72.4% (*Figure 3*).



*Figure 4. Map of scat sample locations in the **Toowoomba Region** with pie charts illustrating the relative abundance of the different dietary tree species detected in each sample.*

In the Toowoomba region, the tree species detected varied considerably between samples. *E. amplifolia*, *E. tereticornis*, *E. chloroclada* and *E. melliodora* were all detected in four or more samples (from 11) at relative abundances between 10.3% and 34.6% (*Figure 4*).

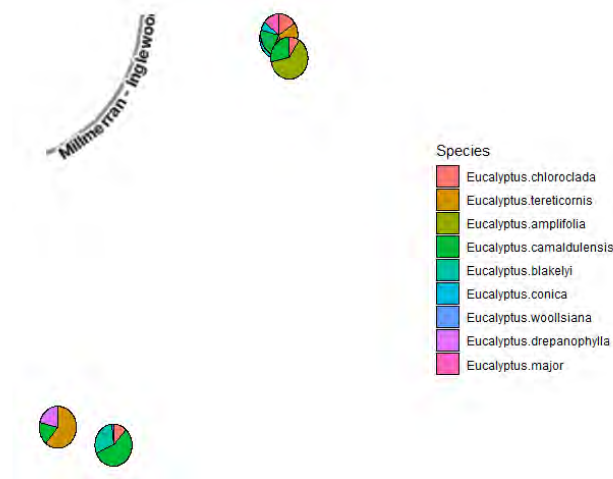


Figure 5. Map of scat sample locations in the **Region to the north-east of Goondiwindi** with pie charts illustrating the relative abundance of the different dietary tree species detected in each sample.

In the region to the north-east of Goondiwindi *E. camaldulensis* was found in all five samples at an average relative abundance of 32.7%, while *E. amplifolia* and *E. tereticornis* were also found at high relative abundance in two individuals each (*Figure 5*).

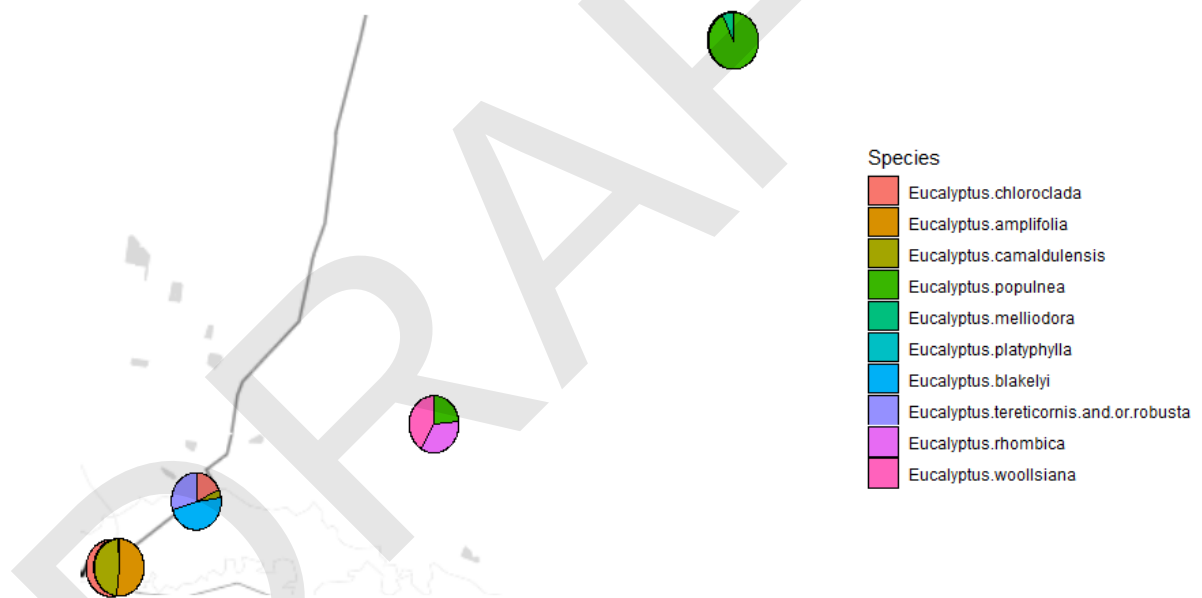


Figure 6. Map of scat sample locations in the **Moree Region** with pie charts illustrating the relative abundance of the different dietary tree species detected in each sample.

In the Moree Region, 5/7 samples contained *E. camaldulensis* with an average relative abundance of 35.2%, while *E. populnea* and *E. chloroclada* were also found at high relative abundance (64.6% and 58.7%, respectively) in 3 and 2 samples, respectively (*Figure 6*).

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DRAFT

B2G SUPPLEMENTARY ECOLOGY SURVEY REPORT MEMO

TO	Phoebe Moore
FROM	David Dique
DATE	9 February 2024
REFERENCE	0618472
SUBJECT	Supplementary Ecology Surveys – greater glider (southern and central) and TEC surveys

Dear Phoebe Moore:

Environmental Resources Management Australia Pty Ltd (ERM) has been engaged by Australian Rail Track Corporation (ARTC) to assist with the ecological studies associated with the proposed Border to Gowrie Project (B2G) (the Study Area) of the Inland Rail Program within the Darling Downs Region, Queensland.

Areas within the Study Area have been previously surveyed and classified as potential greater glider (*Petauroides* spp.) habitat by Ausecology (see Attachment A). ERM was engaged to re-examine these areas using spotlighting surveys and new habitat assessment methodology published in Eyre et al. (2022), the key guidance on describing greater glider habitat in relation to assessments under the EPBC Act.

Additionally, in a previous survey conducted by Cardno, the threatened ecological community (TEC) White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (WB TEC) was identified as potentially occurring in an isolated patch within the Study Area (Cardno, 2021). Surveys undertaken by Ausecology (Ausecology, 2023) identified between 3.19 and 3.43 ha of potential TEC within that patch, however the report supplied from Ausecology does not detail the effort undertaken and surveys were only able to be conducted on a portion of the potential WB TEC within the Project footprint due to limited access to the site in wet weather.

As Cardno conducted this survey from outside the property boundaries and via GIS analysis, ERM was engaged to undertake a field survey to define the extent of the TEC patch more accurately within the property boundaries.

Information and data collected during these surveys undertaken by ERM will be documented in the technical report and will also be summarized in the B2G EIS Flora and Fauna Chapter. The results of both surveys are detailed in upcoming sections.



David Dique
Partner

1. BACKGROUND INFORMATION

1.1 GREATER GLIDER

The greater glider (southern and central) (*Petauroides volans*) is mostly restricted to eucalypt forest and woodlands of eastern Australia, inhabiting areas from approximately Townsville in Queensland through to southern Victoria. Areas of tall and moist montane eucalypt forests on fertile soils with abundant old hollow bearing trees typically provide habitat for high abundances of greater gliders, however they also inhabit drier habitats in south-eastern Queensland. In such areas of potential habitat, the distribution of gliders may be patchy due to variability in forage quality (DCCEEW, 2022). The majority of greater glider habitat are forests or woodlands where *Corymbia citriodora*, *Eucalyptus moluccana*, *E. tereticornis*, *E. crebra*, *C. intermedia* and/or *E. portuensis* are dominant or co-dominant (Eyre et al., 2022).

Modelled distribution mapping in the species SPRAT Profile (DCCEEW, 2023a) shows that most of the Study Area overlaps habitat where the species may occur and is likely to occur, with only small portions of the Study Area located outside of the modelled species distribution:

- at the southern end of the railway alignment from the border to the Gore Highway;
- between Canning Creek and south Millmerran; and
- between Millmerran and Pittsworth, excluding drainage lines and creeks with suitable vegetation and regional ecosystems.

Greater gliders den in tree hollows, with a preference for large hollows (>10 cm in diameter) in large, old trees. Multiple dens are used by individuals, with a preference for live hollow-bearing trees over standing dead trees. Regrowth forest where sufficient hollows are present can support the species. In southern Queensland, greater gliders appear to require a minimum of 2-4 live den trees for every 2 ha of suitable habitat (DCCEEW, 2022). Due to the difficulty in identifying hollow-bearing trees, the density of 'large' trees can be used as a surrogate for hollow-bearing trees (Eyre et al., 2022). Individuals use multiple dens, with those in south-eastern Queensland recorded using between four and 20 different den trees (DCCEEW, 2022). Of the den trees recorded in the Brigalow Belt bioregion, 84% were live trees, and 16% were stags, indicating that while dead trees cannot be used for foraging, they hold value for denning (Smith et al., 2007).

Greater gliders have been found to occupy hollows with entrances <10 m high, and as high as 40 m from the ground in Victoria (Goldingay, 2011). This indicates that trees should be tall for both denning and dispersal reasons, as it is unlikely that a hollow would form close to the base of a tree.

Greater gliders are sensitive to disturbance and fragmentation and prefer large remnant patches of habitat that are highly connected, however, will reside in small remnant habitat patches (<20 ha) in some areas, particularly if they are connected to other patches (DCCEEW, 2022; Eyre et al., 2022). Average density for patches with large trees in the Brigalow Belt bioregion has been recorded as 14.9 ($\pm$ 5.1) per ha. This appears to be sufficient for greater gliders to persist, and where connected with appropriate vegetated corridors, to disperse through the environment (Eyre et al., 2022).

Greater glider preference for tree species varies regionally. In the Brigalow Belt bioregion, the species shows a primary preference for *Eucalyptus fibrosa*, and secondary preferences for *E. moluccana* and *C. citriodora* for both foraging and denning (Eyre et al., 2022; Smith et al., 2007). As systematic assessments of species preferences have not been undertaken, this does not exclude other tree species from use by greater gliders in the bioregion.

1.2 WHITE BOX-YELLOW BOX-BLAKELY'S RED GUM GRASSY WOODLAND AND DERIVED NATIVE GRASSLAND

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland is a threatened ecological community (TEC) listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*. This TEC can occur either as woodland or derived grassland (i.e. a grassy woodland where the tree overstorey has been removed) (DECCW NSW, 2010) and provides important habitat for a suite of woodland animals including marsupials, reptiles, amphibians, birds and invertebrates. The ecological community occurs in the following bioregions: Brigalow Belt South, Murray Darling Depression, Nandewar, New England Tableland, NSW North Coast, NSW South Western Slopes, Riverina, South Eastern Queensland, South East Corner, South East Coastal Plain, South Eastern Highlands, Southern Volcanic Plain, Sydney Basin and Victorian Midlands (TSSC, 2006; DECCW NSW, 2010; DCCEEW, 2023b).

The ecological community must be, or have previously been, dominated or co-dominated by one or more of the following overstorey species (or hybrids of these species with any other *Eucalyptus* species): white box (*Eucalyptus albens*), yellow box (*E. melliodora*) or Blakely's red gum (*E. blakelyi*). It must have a predominately native understorey (i.e. more than 50% of the perennial vegetative ground layer must comprise native species). The area covered by the ecological community (i.e. the patch size) must be greater than 0.1 hectares (ha) and contain 12 or more native understorey species (excluding grasses), including one or more important species.

If the ground layer does not meet this last criterion (i.e. does not contain 12 or more native forb species and one or more important species) then the patch size must be 2 ha or greater in area and have an average of 20 or more mature trees per ha, or natural regeneration of the identified dominant overstorey eucalypts (DECCW NSW, 2010).

Areas which do not meet the above criteria are not considered to be part of the listed ecological community. In addition, communities with a continuous shrub layer of more than 30% cover are excluded from the listed ecological community, as they are considered to be shrubby woodland and do not constitute Box-Gum Grassy Woodland. Areas which are degraded to the extent they are excluded from the community definition may still retain important components of the ecological community (e.g. seed bank, soil biota) and/or provide important habitat for fauna (fallen logs, tree hollows, native grasses, paddock trees, bush rocks, rocky outcrops). Consequently, the restoration and management of these degraded areas is important for the successful recovery of the ecological community (DECCW NSW, 2010).

2. METHODOLOGY

2.1 SURVEY TIMING AND TEAM

Surveys were conducted in the Study Area by two experienced fauna ecologists over a four-day period between 18 and 21 December 2023. Weather conditions during the day were warm, cloudy, and dry. While spotlighting at night, cloud cover and light showers were experienced. During the survey period, a total of 4.2 mm of rain was recorded at the Gray's Gate Exchange TM Station, Millmerran on Tuesday 19 December (BoM, 2024). In the six weeks prior to the surveys, a total of 104 mm of rainfall was recorded in the region (BoM, 2024).

No preferred survey period for greater gliders was stated in the guidelines defined by Eyre et al. (2022). Surveys to assess TEC condition and extent are to be conducted after significant rain or in autumn (TSSC, 2006), this is further discussed in upcoming sections. Leading the field planning and design was Dr David Dique, a 30-year experienced Principal Ecologist. Leading the TEC assessments was Tim Callaghan, a Senior Ecologist and Botanist with 9 years' experience.

2.2 GREATER GLIDER SURVEYS

2.2.1 VEGETATION AND HABITAT ASSESSMENTS

Vegetation and habitat assessments were undertaken to describe important habitat features within the Study Area. These assessments were required to determine the vegetation present on site and the suitability of habitat for greater gliders and were undertaken to collect data in accordance with appropriate guidelines (Eyre et al., 2022).

Thirteen sites that had been previously mapped by Ausecology in the Study Area (refer to Attachment A) were surveyed by ERM using the updated habitat definitions and guideline methodology (refer to below and Table 1) with approximately one habitat assessment conducted per 100 m of previously mapped habitat (30 in total).

Habitat attributes that were considered are outlined below:

- Presence of *C. citriodora*, *E. fibrosa*, and/or *E. moluccana* as the dominant or co-dominant species, as these have been reported as the preferred species used for both denning and foraging in the Brigalow Belt;
- Presence of other potential denning or foraging tree species;
- Trees >30 cm diameter at breast height (DBH) that can be selected for foraging;
- Trees >50 cm DBH that can be selected for denning as these trees are more likely to contain suitable hollows for sheltering by greater gliders. These can be live or dead;
- Patch size >20 ha if habitat connectivity is low and large tree density is suitable; and
- Small patches <20 ha and as small as 3 ha are potentially suitable if trees are sufficiently close together to facilitate gliding between patches (Eyre et al., 2022).

In accordance with the new methodology guidelines (Eyre et al., 2022), the number of hollows was not used as a defining habitat attribute. This decision was made following a review of studies of ground-based tree hollow estimates which found that utilising estimates of hollows in trees results in inconsistent reporting due to high variability and low reliability among observers. Additionally, tree DBH and the presence of hollows is a demonstrated correlation throughout Australia and can be used as a surrogate measure for tree habitat value (Eyre et al., 2022).

TABLE 1. HABITAT, POTENTIAL HABITAT AND NOT HABITAT AS DEFINED BY EYRE ET AL. (2022)

Habitat	Potential habitat	Not habitat
Regional ecosystems with confirmed greater glider records	Regional ecosystems that do not have confirmed greater glider records but are identified by experts as potential greater glider habitat	Regional ecosystems with no confirmed records of greater gliders, and identified by experts as non-habitat
Contains habitat attributes (but not necessarily all attributes)	Contains habitat attributes (but not necessarily all attributes)	Does not contain habitat attributes

The vegetation and habitat assessments were conducted in accordance with the Survey guidelines for Australia's threatened mammals (DSEWPC, 2011), were non-invasive and involved visual techniques along a transect to record:

- Habitat connectivity and proximity to water sources;
- Condition of vegetation types;
- Signs of threatened species, such as scats, tracks and/or scratches; and
- Breeding or denning habitat features – tree species, tree height, and DBH.

Additionally, general observations were made at each of the vegetation and habitat assessment sites for the potential presence of listed threatened species.

2.2.2 SPOTLIGHTING

In accordance with the Survey guidelines for Australia's threatened mammals (DSEWPC, 2011) nocturnal spotlighting surveys searching for greater glider (*Petauroides volans*) were undertaken at important habitats across the Study Area, generally between 7:00pm and 9:00pm. Thirteen patches were surveyed for greater gliders (refer to Figures 1 and 2), with one spotlighting survey conducted per patch using handheld spotlights (50 watt) and two observers.

2.2.3 THREATENED ECOLOGICAL COMMUNITY SURVEY

The TEC survey location was on the corner of two cattle properties on Blackwell Road, Clontarf (Figure 3). The vegetation outside of the Project footprint was unable to be surveyed adequately due to the heavily disturbed nature of the ground layer. The relevant areas of the properties within the alignment were surveyed as one continuous 2.1 ha patch of potential White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC. Surveys were conducted using the key diagnostic criteria and the condition thresholds (refer to Attachment B) established in *Approved Conservation Advice for the White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland* (DCCEEW, 2023b):

- It has, or previously had, an overstorey dominated or co-dominated by: *Eucalyptus albens* (white box) and/or *E. melliodora* (yellow box) and/or *E. blakelyi* (Blakely's red gum).
- It has a predominantly native ground layer.
- Tussock grasses are conspicuous in the ground layer (except in some situations, such as under dense groves of shrubs or regenerating trees), usually with several native species from some the following genera: *Austrostipa*, *Bothriochloa*, *Chloris*, *Cymbopogon*, *Dichanthium*, *Microlaena*, *Poa*, *Themeda*, *Rytidosperma* or *Sorghum*.
- Amongst the grass tussocks and sometimes in swathes, a range of broad-leaved forbs and petaloid monocots (e.g. lilies *sens. Lat.*) may be a major component of the plant diversity.

- While shrubs may be dominant locally within areas of the ecological community, areas of native vegetation with a continuous shrub layer, in which the average shrub cover of the whole patch is greater than 30%, is considered to be a shrubby woodland and is not part of the listed ecological community. In assessing this, the effects of disturbance need to be considered, for example where heavy grazing may result in high densities of shrubs during a recovery phase.

This was conducted using a meandering quaternary survey method throughout the 2.1 ha patch, where flora species are recorded, samples are taken for identification, and community assemblage and landform observations are made.

Three person hours were spent characterising the patch of TEC in the field. A further one and half person hours were spent reviewing field results, verifying species and classifications with Tim Callaghan (SME). The team had adequate experience to perform this assessment.

2.3 SURVEY LIMITATIONS

Three patches of potential greater glider habitat were unable to be accessed due to the unavailability of a land access agreement prior to commencement of the surveys. Two of these patches were located around Yandilla, and the third patch was located near Potters Road outside of Inglewood (refer to Attachment A – circled areas). The area outside of the Project footprint was unable to be surveyed adequately for potential TEC as the ground layer was heavily grazed, and no identification of groundcover species could be made.

3. RESULTS

3.1 GREATER GLIDER HABITAT ASSESSMENTS

While conducting habitat assessments no signs of greater gliders were observed – scats, tracks, or scratches on trees – in any of the thirteen sites surveyed.

Ten of the sites assessed (total of 13) were identified as not greater glider habitat (refer to Table 1; Eyre et al., 2023) due to the presence of one or more of the following attributes:

- were dominated by *Callitris* spp. or *Angophora* spp.;
- did not feature preferred food trees in the bioregion *C. citriodora*, *E. fibrosa*, or *E. moluccana*, or other eucalypt species;
- did not meet the minimum patch size to support greater gliders as the large tree density was unsuitable for a small patch (average 14.9 trees per ha);
- did not feature large trees (>30 cm DBH); or
- the large trees that were present were in too low a density to allow greater glider dispersal/movement in the Brigalow Belt, that is, they did not meet the minimum density of 9.8 large trees per hectare (refer to Plate 1).

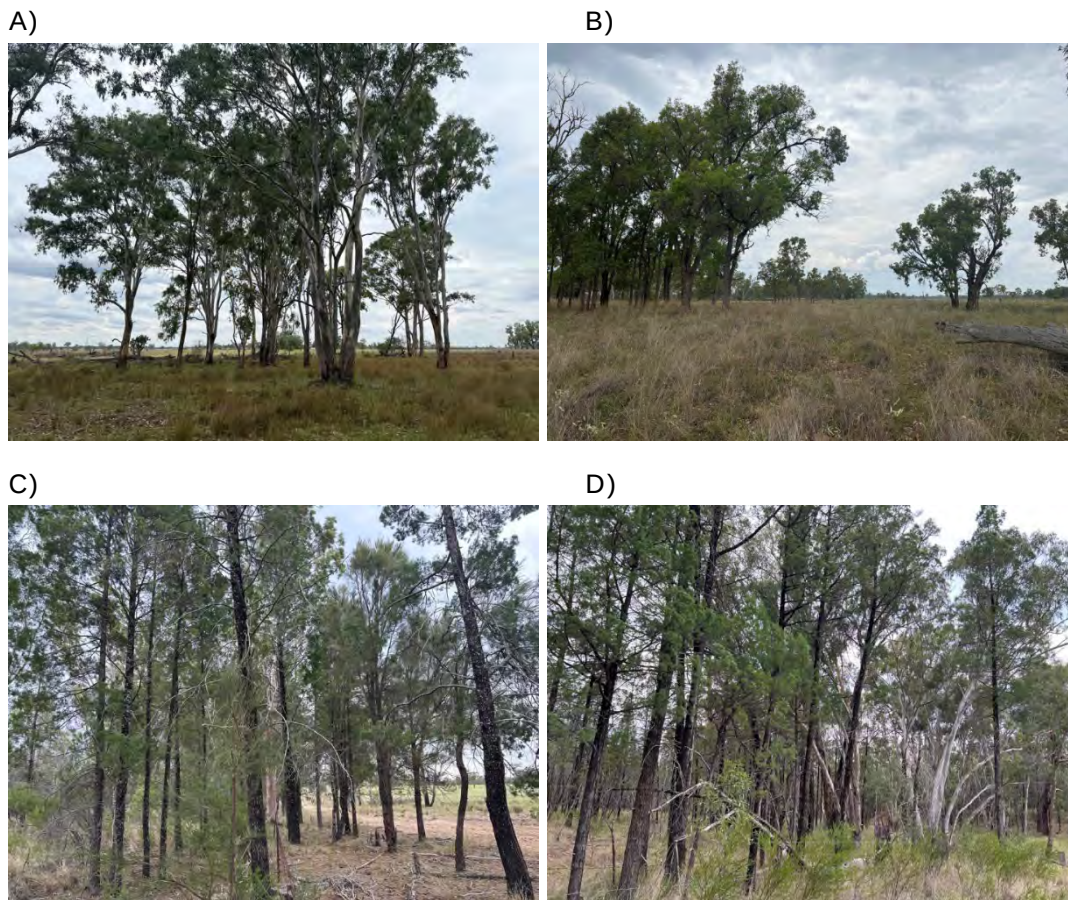


PLATE 1. REPRESENTATIVE PHOTOS FROM UNSUITABLE GREATER GLIDER HABITAT – A) FIGURE 1, INSET 2, NORTHERN PATCH; B) FIGURE 1, INSET 3, CENTRAL PATCHES; C) FIGURE 2, INSET 5; AND D) FIGURE 2, INSET 7.

Three patches were identified as potential greater glider habitat (refer to Table 1) as they had some habitat attributes, but did not have records nearby, and there were no records located within 10 km of the Study Area. One patch, of which 2.44 ha was located within the railway alignment, was located on Back Creek (refer to Figure 1, inset 1, eastern patch). The remaining two patches were located along Bringalily Creek, 1.46 ha of the northern patch and 1.55 ha of the southern patch was located within the railway alignment (refer to Figure 1, inset 3, northern and southern patches). These two patches are 0.88 km apart, with poor connectivity along the creek between them. All three patches were classed as regional ecosystem (RE) 11.3.25: *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines. Additionally, they met the following habitat attribute requirements, as defined by Eyre et al. (2022):

- Presence of other potential denning or foraging species;
- Trees > 30 cm DBH that can be selected for foraging;
- Trees > 50 cm DBH that can be selected for denning as these trees are more likely to contain suitable hollows for sheltering by greater gliders. These can be live or dead; and

- Small patches <20 ha and as small as 3 ha are potentially suitable if trees are sufficiently close together to facilitate gliding between patches.

While Eyre et al. (2022) did not mention tree height as a key habitat attribute, the greater glider has been documented to prefer tall trees with hollows >10 m high (Goldingay, 2011). The trees observed in these patches were comparatively short, averaging approximately 15 m, with a maximum height of 20 m. Hollows that were observed were between 6 and 10 m high.

A)



B)



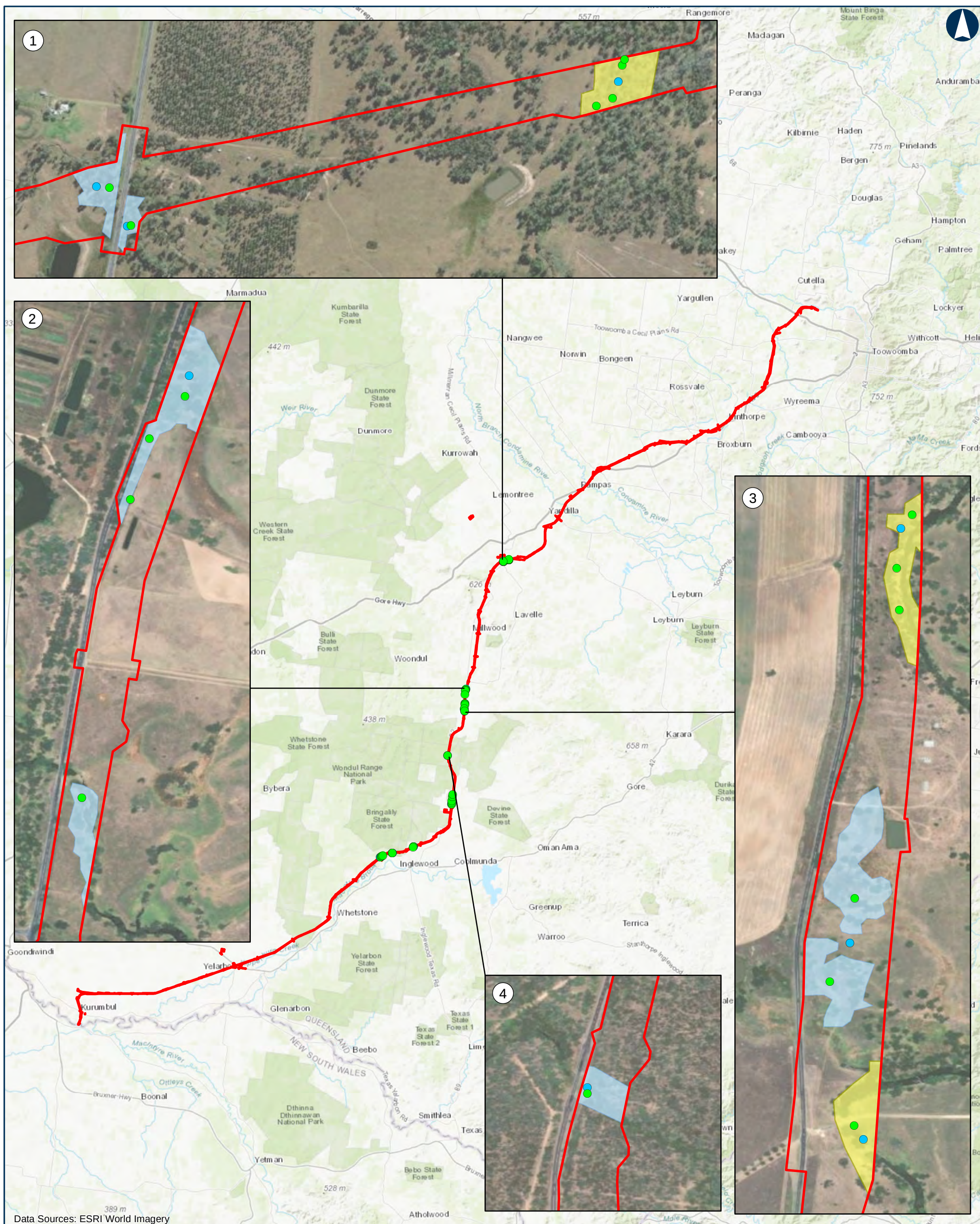
C)



D)



PLATE 2. REPRESENTATIVE PHOTOS FROM POTENTIAL SUITABLE HABITAT – A) FIGURE 1, INSET 1, EASTERN PATCH; B) FIGURE 1, INSET 3, NORTHERN PATCH; C) FIGURE 1, INSET 3, NORTHERN PATCH; AND D) FIGURE 1, INSET 3, SOUTHERN PATCH.



Border to Gowrie



Coordinate System: GDA 1994 MGA Zone 56

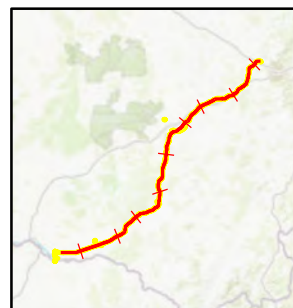
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Author: ERM - VN Scale: 1:8,000
Data Sources: OLD DNRM 2017, ESRI

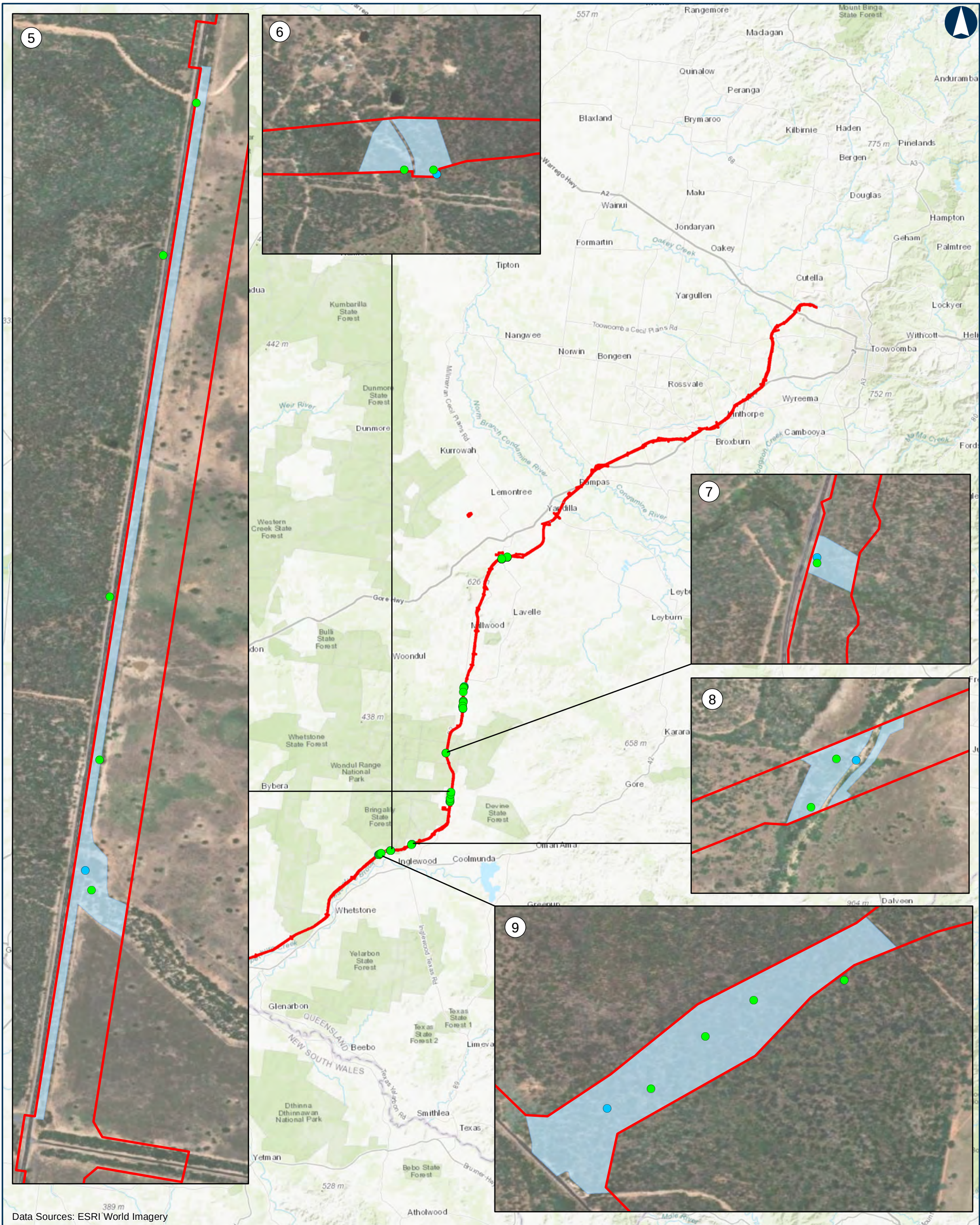
LEGEND

- Habitat Assessment
● Spotlighting
 Construction Impact Zone
 Potential Greater Glider Habitat
 Greater Glider Habitat Previously Mapped by Ausecology



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Data Sources: ESRI World Imagery

Border to Gowrie

Figure 2 - Sites ground verified as suitable *Petauroides volans sensu lato* - Greater Glider habitat in the Southern portion of the Study Area

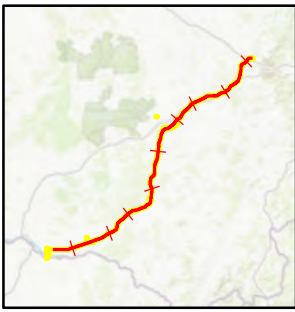
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km

Coordinate System: GDA 1994 MGA Zone 56

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- LEGEND**
- Habitat Assessment
 - Spotlighting
 - Construction Impact Zone
 - Potential Greater Glider Habitat
 - Greater Glider Habitat Previously Mapped by Ausecology



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3.2 GREATER GLIDER SPOTLIGHTING

No greater gliders were observed while spotlighting. Additionally, no other threatened species were observed. Of the hollows identified during the habitat mapping surveys, spotlighting confirmed some were occupied by brushtail possums (*Trichosurus vulpecula*) (refer to Plate 3). This indicates that the hollows that are present are large enough for greater gliders to reside in, however, they would need to be able to disperse to these sites via connected patches of habitat.



PLATE 3. SPOTLIGHTING PHOTOS OF *T. VULPECULA*

3.3 WHITE-BOX TEC EXTENT AND CONDITION OF PATCHES

The following observations relate to the site surveyed for the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC (refer to Plate 4):

- The site is located in the Brigalow Belt South IBRA bioregion, and the regional ecosystem was identified and ground verified as 11.9.9a - *Eucalyptus crebra* woodland on fine-grained sedimentary rocks by the state-wide mapping. This regional ecosystem correlates to the TEC;
- The total area confirmed to be TEC within the Project footprint was 2.1 ha;
- The dominant overstorey species was *Eucalyptus albens* (white box);
- The ground layer that was conspicuous was predominantly native. There were two tussock grasses that were present and conspicuous – *Dichanthium sericeum* and *Chloris ventricose*. No other native or non-native grasses were identifiable due to high grazing pressure;
- Broad leaved forbs and petaloid monocots were not observed due to high grazing pressure, despite recent rain;

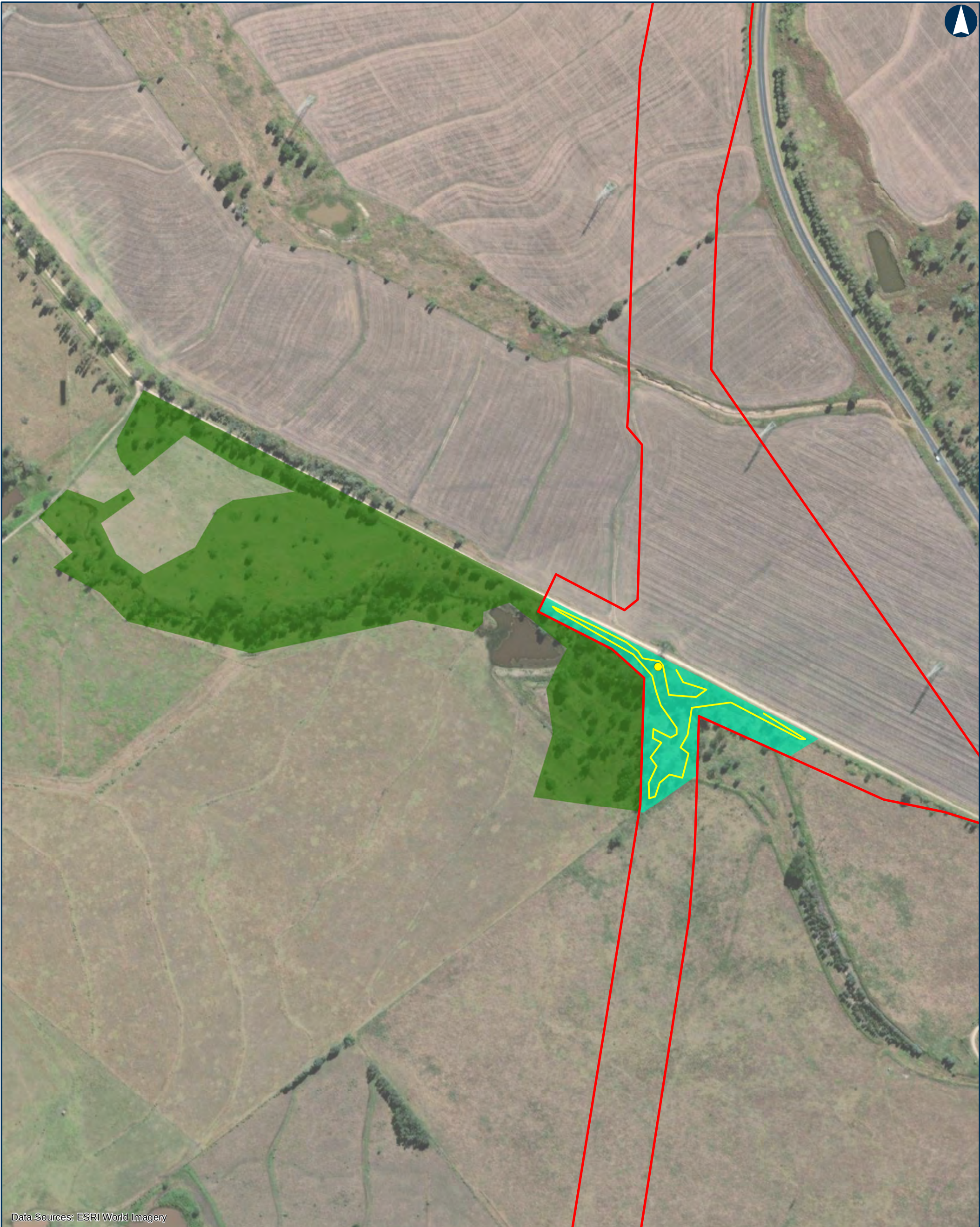
- At the time of assessment, the woodland had an average shrub cover of less than 30%; and
- The patch contained natural regeneration of *E. albens*.

Following this, the site surveyed is considered to be a continuous patch (refer to Figure 3) as the gap between the trees was not greater than 75 m. The patch was assessed to be in Class C according to the condition thresholds (refer to Attachment B), as it meets each of the criteria. According to the state and transition model, this patch has been classed as a fertilised pasture, largely due to the high grazing pressure and low diversity of grasses and herbs. It is likely that a reduction in grazing pressure would raise the condition to Class B, as additional ground layer species would become conspicuous and identifiable. This would also likely change the patch to be classified as a native pasture under the state and transition model.

The TEC may extend outside of the Project footprint; however, it was unable to be surveyed adequately due to the disturbed and heavily grazed nature of the ground layer species. It was determined that the TEC extends beyond the Project footprint to the tree line based on general observations in the field, desktop assessment and expert analysis (refer to Figure 3). The patch likely extends beyond the properties within the scope of this survey, and therefore the entire patch size would not be able to be determined definitively without surveying these areas as well. This area would also be classed as a Class C according to the condition thresholds (refer to Attachment B). As the ground layer species present could not be determined, the classification under the state and transition model is also unable to be determined.



PLATE 4. PHOTOS TAKEN DURING THE TEC SURVEY



Data Sources: ESRI World Imagery

Border to Gowrie

Figure 3 - Site mapped for White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC

0 50 100
m

Coordinate System: GDA 1994 MGA Zone 56

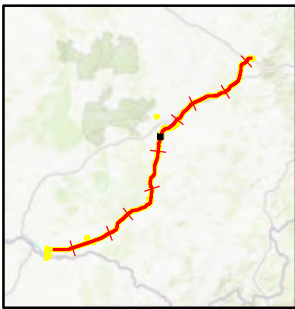
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Date: 2/02/2024
Author: ERM - VN
Data Sources: QLD DNRM 2017, ESRI

Paper: A3
Scale: 1:5,000

LEGEND

- Quaternary Assessment
- Timed Meander
- Construction Impact Zone
- Extent of potential TEC
- Likely TEC outside of alignment



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4. CONCLUSIONS

Three sites within the Study Area have potential to be suitable foraging or breeding habitat for the greater glider, however it is likely that these sites are not accessible by individuals due to low connectivity. Two of the sites are tenuously connected to one another on Bringalily Creek in a narrow habitat corridor. While the third is more isolated, it still has the potential to be connected to other suitable habitat along Back Creek. This is reflected by the spotlighting surveys, where no greater gliders were observed. In accordance with guidelines established in Eyre et al. (2022), the remaining 10 sites surveyed are considered not suitable as greater glider habitat due to lack of connectivity, lack of large trees, low tree density, and/or dominance by tree species unable to be used for foraging or denning.

Based on this field survey, the site assessed for the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC within the Study Area is a Class C patch of the ecological community. While the TEC survey requirements state that surveys in northern regions of the TEC distribution with summer dominant rainfall should be conducted in autumn to obtain the best measure of species richness, we believe that the November and December rainfall was sufficient to provide opportunities for vegetation growth. Given the survey timing and the recent rainfall a reasonably representative sample of species richness was taken, particularly given the heavy grazing pressure. Outside of the Project footprint, the TEC was determined to extend to the tree line based on general observations in the field, desktop assessment and expert analysis. This area was unable to be sampled adequately due to the highly grazed nature of the ground layer. Therefore, using a precautionary approach we assume this site, both inside and outside the Project footprint, meets the requirements of the threatened ecological community.

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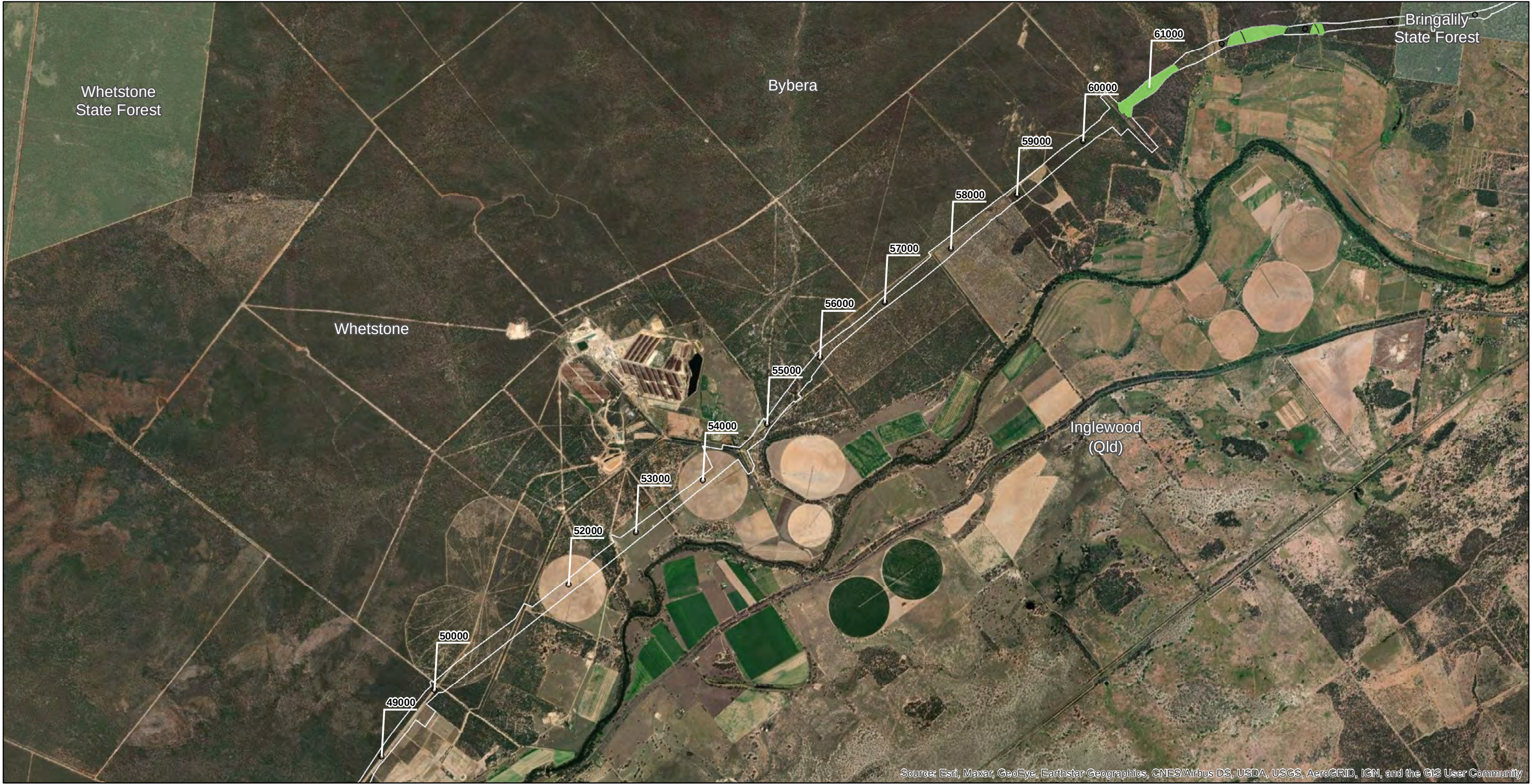
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ATTACHMENT A AUSECOLOGY HABITAT MAPPING SURVEYS



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Appendix E - 15 Fauna Matters Habitat
Petauroides volans sensu lato - Greater Glider

N



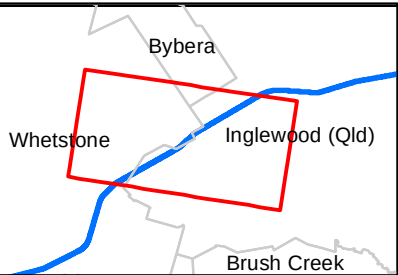
0 1 2 Kilometers

Scale 1:43,680 at A3
Coordinate System: GDA2020 MGA Zone 56
Datum: GDA2020

Legend

- Habitat
- Chainage Points
- Bringallily state forest
- Whetstone state forest
- B2G Alignment

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI



Document History:					
Rev	Reason for Issue	Author	Reviewer	Approver	Date
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2	Issue for Information	JS	LG	LG	01/04/2022
2	Issue for Information	JS	LG	LG	12/04/2022



Appendix E - 15 Fauna Matters Habitat
Petauroides volans sensu lato - Greater Glider

N

012

Kilometers

Scale 1:43,550 at A3
Coordinate System: GDA2020 MGA Zone 56
Datum: GDA2020

Legend

	Habitat		Chainage Points
	Bringalily state forest		B2G Alignment

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI

Document History:

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Appendix E - 15 Fauna Matters Habitat
Petauroides volans sensu lato - Greater Glider

N

012

Kilometers

Scale 1:43,480 at A3
Coordinate System: GDA2020 MGA Zone 56
Datum: GDA2020

Habitat

Bringalily state forest

B2G Alignment

o

Chainage Points

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI

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Appendix E - 15 Fauna Matters Habitat

Petauroides volans sensu lato - Greater Glider

N

012

Kilometers

Scale 1:43,680 at A3
Coordinate System: GDA2020 MGA Zone 56
Datum: GDA2020

Legend

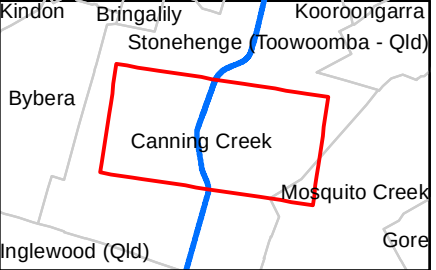
Habitat

Chainage Points

Bringalily state forest

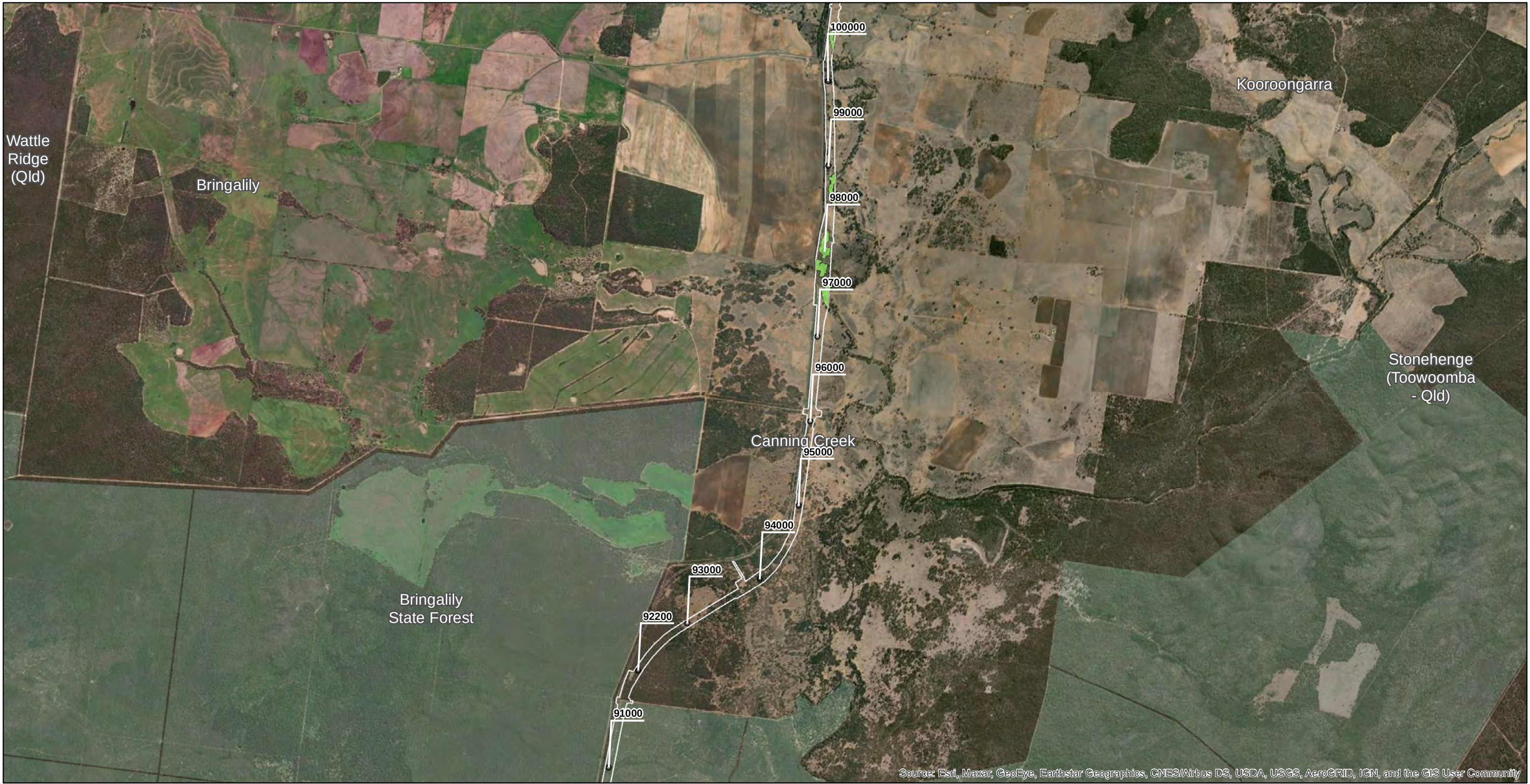
B2G Alignment

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI



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Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Appendix E - 15 Fauna Matters Habitat

Petauroides volans sensu lato - Greater Glider

N



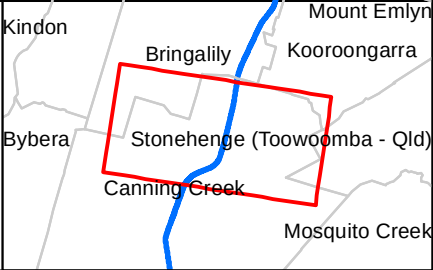
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Datum: GDA2020

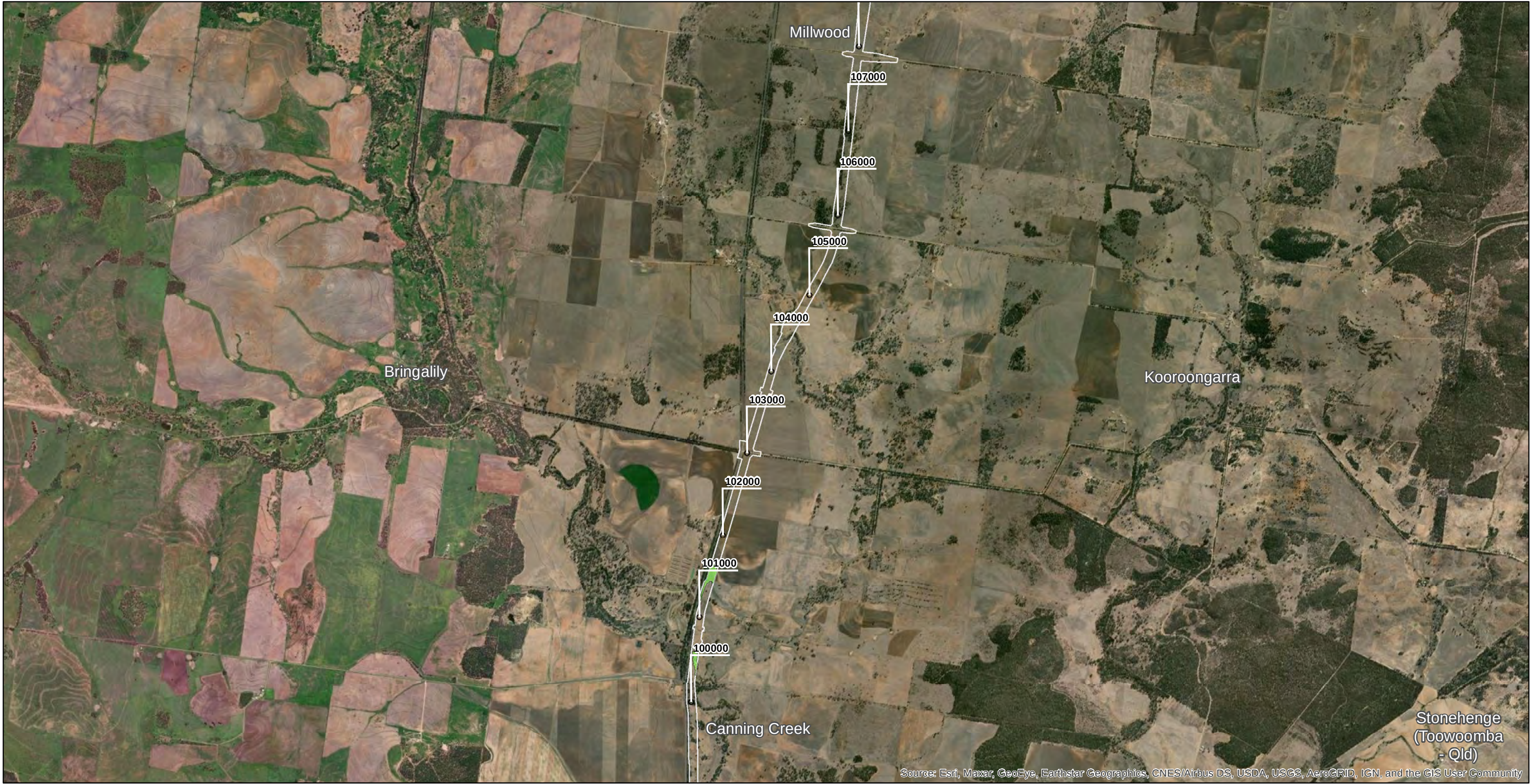
Legend

	Habitat		Chainage Points
	Bringalily state forest		
	B2G Alignment		

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI



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2	Issue for Information	JS	LG	LG	12/04/2022





Appendix E - 15 Fauna Matters Habitat

Petauroides volans sensu lato - Greater Glider

N

012

Kilometers

Scale 1:43,550 at A3

Coordinate System: GDA2020 MGA Zone 56

Datum: GDA2020

Legend

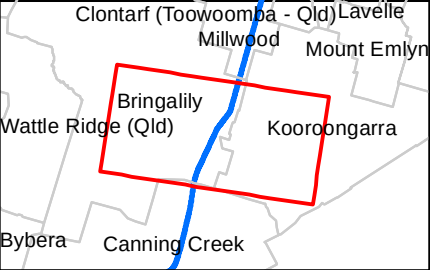
Habitat

Chainage Points

B2G Alignment

Data Sources:

- Ausecology
- Survey Layers
- State of Queensland Department of Environment
- Major watercourse lines
- MSES Protected areas
- ARTC
- Footprint
- Chainage
- Basemap ESRI



Document History:

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Appendix E - 15 Fauna Matters Habitat

Petauroides volans sensu lato - Greater Glider

N



012



Kilometers

Scale 1:43,420 at A3

Coordinate System: GDA2020 MGA Zone 56

Datum: GDA2020

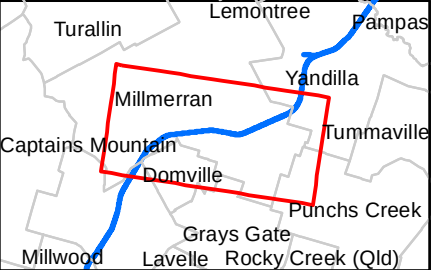
Legend

Habitat

Chainage Points

B2G Alignment

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI



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2	Issue for Information	JS	LG	LG	12/04/2022





Appendix E - 15 Fauna Matters Habitat
Petauroides volans sensu lato - Greater Glider

N



0 1 2 Kilometers

Scale 1:43,620 at A3
Coordinate System: GDA2020 MGA Zone 56
Datum: GDA2020

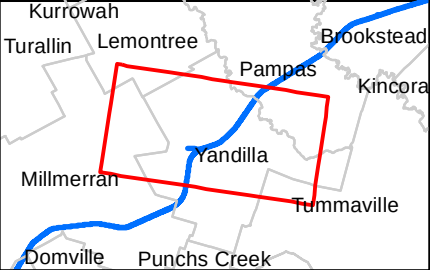
Legend

 Habitat

 Chainage Points

 B2G Alignment

Data Sources:
Ausecology
Survey Layers
State of Queensland Department of Environment
Major watercourse lines
MSES Protected areas
ARTC
Footprint
Chainage
Basemap ESRI



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2	Issue for Information	JS	LG	LG	12/04/2022

ATTACHMENT B TEC CONDITION THRESHOLDS AND STATE TRANSITION MODEL

TEC Condition Classes and Thresholds:

Table 1 in Conservation Advice (DCCEEW, 2023b)

Condition Class	Patch Size*	Features present
Class A Good quality understorey and mature overstorey both present.	0.1 ha (1,000 m ²) or larger	- The ground layer is predominantly native* and - the understorey contains at least 12 native, non-grass species (such as forbs, shrubs, ferns and sedges) and - at least one of the understorey species should be a species recognised as 'important' (e.g. grazing-sensitive, regionally significant, listed threatened or uncommon species) (see 'Important' column in plant species list at Appendix A – Species lists) and - the patch contains 10 or more mature trees* per hectare consistent with the key diagnostics for the ecological community
Class B Good quality understorey present. Characteristic trees may be absent.	0.1 ha (1,000 m ²) or larger	- The ground layer is predominantly native* and - the understorey contains at least 12 native, non-grass species (such as forbs, shrubs, ferns and sedges) and - at least one of the understorey species should be a species recognised as 'important' (e.g. grazing-sensitive, regionally significant, listed threatened or

Threatened Species Scientific Committee
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White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland Conservation Advice

		uncommon species) (see 'Important' column in plant species list at Appendix A – Species lists)
Class C Allows for a lower diversity in the understorey in areas where there is regeneration and/or tree density may be relatively dense.	2 ha (20,000 m ²) or larger	- The ground layer is predominantly native* and - The patch contains 20 or more mature trees* per hectare and/or - The patch contains natural regeneration of dominant overstorey eucalypts*

State Transition Model:

Appendix 3 in National Recovery Plan (DECCW NSW, 2010)

