TECHNICAL REPORT

3

Flooding and hydrology assessment

PART 2 OF 12

Appendix A to D

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT

INLAND RAIL

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

TECHNICAL REPORT 3

Flooding and hydrology assessment

Appendix A Proposed structure details

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT

Table A-1 Structure Details

Rail chainage (km)	Waterway	Catchment Area (km²)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
547.301			238.6	C			6	600	2400				
547.422			238.4	C			6	600	2400				
547.684			238.3	C			6	900	2400				
547.870			238.5	C			8	1200	2400				
548.050			238.6	C			10	1200	2400				
548.211			238.7	C			10	1200	2400				
548.364			239.1	C			6	600	2400				
548.388			239.1	C			8	900	2400				
548.719			239.9	C			2	900	2400				
549.023			240.8	C			4	900	2400				
550.089			244.5	C			12	600	2400				
550.220			244.8	C			8	900	2400				
550.630			245.8	C			4	1200	2400				
551.032			246.8	C			2	600	2400				
551.451			247.9	C			1	600	2400				
552.384			250.0	C			3	600	2400				
553.200			250.6	C			12	900	2400				
553.391			251.2	C			20	600	2400				
553.530			251.1	C			14	900	2400				
553.713			251.6	C			28	600	2400				
553.992	Wallaby Creek	35	251.3	C			18	1500	2400				
554.104			252.7	C			22	600	2400				
554.207			252.3	C			26	900	2400				
554.317			252.4	C			26	600	2400				
554.561			252.8	C			12	600	2400				
554.810			252.4	C			16	600	2400				
555.124			252.2	C			12	600	2400				
555.910			250.9	C			10	600	2400				
556.250			250.1	C			26	600	2400				
556.597			249.3	C			12	600	2400				
556.733			249.0	C			26	600	2400				
557.013			248.2	C			16	900	2400				
557.230			248.0	C			26	600	2400				
557.404			247.6	C			26	900	2400				
557.629			247.9	C			16	600	2400				
557.804			247.7	C			10	600	2400				
558.007			247.7	C			10	600	2400				
558.219			247.5	C			2	600	2400				
558.602			245.9	C			4	1200	2400				
558.770			245.3	C			8	1200	2400				
558.895			244.9	C			5	1500	2400				
559.167			244.2	C			10	1200	2400				
559.428			243.7	C			10	900	2400				
560.113			241.9	C			6	1200	2400				
560.293			241.7	C			4	1200	2400				
560.872				B						17	14000		
561.238				B						3	14000		
561.467				B						3	14000		
561.665				B						3	14000		
561.839				B						6	23000		
562.345	Macquarie River	25900		B						50	23000		
564.000			244.1	C			2	2	2				
565.593				B						2	14000		
566.869			254.2	C			3	1800	2400				
568.919			258.3	C			16	600	2400				
568.941			258.3	C	1	900							
570.020			252.3	C			4	3000	2400				
571.032			263.4	C			1	900	2400				
571.982			265.4	C			1	1800	2400				
572.827			262.0	C			4	2400	2400				
573.498			264.3	C			2	600	2400				
574.240			265.9	C			5	1200	2400				
575.448			264.5	C			3	1500	2400				
575.947			263.6	C			14	1800	2400				
577.329			270.8	C			4	900	2400				
577.975			274.0	C			4	1200	2400				
578.073			275.0	C			2	1200	2400				
579.232			275.1	C			6	1200	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
580.354			271.0	C			8	900	2400				
580.570			271.2	C			16	600	2400				
580.742			271.6	C			4	600	2400				
582.891			268.4	C			12	600	2400				
583.336			267.0	C			4	600	2400				
583.395			266.7	C			4	900	2400				
583.649			265.8	C			4	600	2400				
583.849			264.9	C			6	900	2400				
584.030			264.6	C			12	1200	2400				
586.236			258.6	C			12	600	2400				
586.402			258.2	C			10	1200	2400				
586.568			258.3	C			14	1200	2400				
586.732			258.3	C			16	1200	2400				
586.985			258.8	C			10	900	2400				
587.895			261.5	C			6	600	2400				
588.210			262.0	C			12	600	2400				
590.040			262.8	C			12	600	2400				
590.673			260.9	C			4	900	2400				
595.239	Ewenmar Creek	130		B						14	23000		
599.021			251.4	C			20	600	2400				
599.149			251.2	C			30	900	2400				
599.267	Goulburn Creek	24	251.9	C			30	600	2400				
599.406			252.1	C			30	900	2400				
599.601			252.8	C			20	1200	2400				
602.664	Emogandry Creek	38		B						14	23000		
604.899			274.7	C			28	1200	2400				
605.040			275.1	C			28	900	2400				
607.146	Native Dog Creek	15		B						6	14000		
607.324				B						2	14000		
608.930	Pint Pot Gully	5		B						8	14000		
609.716	Kickabil Creek	60		B						11	2300		
612.110				B						3	23000		
616.680	Milpulling Creek	39		B						7	23000		
618.446				B						5	14000		
620.301				B						3	14000		
623.147				B						13	14000		
626.141			286.1	C			2	600	2400				
627.330			276.5	C			6	1500	2400				
628.052			273.3	C			6	600	2400				
628.300			272.2	C			12	600	2400				
629.540			267.3	C			4	1200	2400				
630.401			266.3	C			8	900	2400				
630.615			266.2	C			4	900	2400				
630.740			266.0	C			8	900	2400				
631.403			265.1	C			4	1800	2400				
631.780			265.1	C			8	2400	2400				
633.678	Marthaguy Creek	413		B						50	23000		
635.127			258.2	C			6	1500	2400				
635.237			258.0	C			8	1800	2400				
635.388			258.4	C			4	1500	2400				
635.881			258.8	C			3	1500	2400				
636.519			259.7	C			1	900	2400				
636.815			259.9	C			1	900	2400				
637.420			259.9	C			12	1500	2400				
638.185			260.7	C			1	1200	2400				
638.355			260.5	C			4	1500	2400				
639.850			260.4	C			14	1200	2400				
640.130			260.3	C			10	1200	2400				
640.410			260.2	C			10	1200	2400				
640.581			260.3	C			8	1200	2400				
640.930			260.1	C			10	900	2400				
641.098			260.0	C			10	900	2400				
641.248			260.0	C			10	1200	2400				
641.381			259.4	C			8	1500	2400				
641.490			258.9	C			4	2100	2400				
641.590			259.1	C			4	1800	2400				
641.760			259.6	C			4	1500	2400				
641.980			259.5	C			2	1500	2400				
643.001				B						3	14000		

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
643.104			259.4	C			3	1200	2400				
643.173			259.3	C			1	1200	2400				
643.860			258.4	C			6	1500	2400				
644.160			258.8	C			1	600	2400				
644.745			258.1	C			3	600	2400				
645.110			257.9	C			4	600	2400				
645.363			257.8	C			8	600	2400				
645.520			257.9	C			6	900	2400				
645.940			257.9	C			10	600	2400				
646.130			257.8	C			12	900	2400				
646.284			257.6	C			12	900	2400				
646.420			257.9	C			14	900	2400				
646.538			257.5	C			18	1200	2400				
646.642			257.4	C			14	1200	2400				
646.769			257.6	C			8	1200	2400				
646.858			257.6	C			8	900	2400				
646.894			257.7	C			10	900	2400				
647.034			258.0	C			4	600	2400				
647.535			258.1	C			10	600	2400				
647.629			258.2	C			10	600	2400				
647.967			259.4	C			8	600	2400				
648.065			259.7	C			8	600	2400				
648.104			258.9	C			8	600	2400				
648.150			259.3	C			8	600	2400				
648.202			259.3	C			8	600	2400				
648.243			259.4	C			8	600	2400				
648.362			259.5	C			8	600	2400				
648.711			257.5	C			6	600	2400				
649.349			258.4	C			6	1800	2400				
649.470			258.4	C			6	1500	2400				
649.623			258.4	C			6	1500	2400				
649.751			258.5	C			6	1200	2400				
649.856			258.5	C			6	1200	2400				
650.003			258.6	C			6	600	2400				
651.728	Castlereagh River	6629		B						26	23000		
652.520				B						9	23000		
655.550			266.9	C			12	2100	2400				
656.561			265.7	C			8	900	2400				
656.669			265.5	C			18	1200	2400				
658.862			271.8	C			12	1500	2400				
658.971			271.8	C			12	1500	2400				
659.075	Judes Creek	20	271.8	C			12	1800	2400				
660.424			276.0	C			4	1200	2400				
660.849			276.1	C			14	2100	2400				
660.922			276.1	C			14	2400	2400				
661.000			276.2	C			14	2400	2400				
661.275				B						6	14000		
664.933			278.7	C			20	900	2400				
665.016			279.0	C			10	600	2400				
665.632			278.3	C			8	600	2400				
665.702			278.1	C			6	600	2400				
665.912			277.9	C			4	600	2400				
665.982			277.8	C			4	600	2400				
666.607			276.5	C			10	900	2400				
666.754			276.6	C			12	600	2400				
666.928			276.6	C			12	600	2400				
667.192			276.2	C			12	600	2400				
667.452			275.9	C			6	600	2400				
667.592			275.7	C			8	600	2400				
667.772			275.4	C			8	600	2400				
667.872			275.4	C			8	600	2400				
667.985			275.3	C			8	600	2400				
668.182			275.3	C			6	600	2400				
668.509			274.8	C			10	600	2400				
668.657			274.6	C			6	600	2400				
669.502			273.9	C			16	900	2400				
669.668			273.8	C			28	900	2400				
669.902			274.4	C			6	600	2400				
670.317			274.2	C			8	600	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
671.902			269.8	C			18	600	2400				
672.725			269.5	C			4	900	2400				
673.083	Gulargambone Creek	333		B						18	23000		
673.862			269.4	C			12	900	2400				
674.027			268.1	C			12	2400	2400				
674.431			270.4	C			8	600	2400				
674.578			270.6	C			14	600	2400				
674.782			270.8	C			14	600	2400				
674.904			270.9	C			14	600	2400				
675.032			271.0	C			14	600	2400				
675.232			271.3	C			14	600	2400				
675.432			271.3	C			18	600	2400				
675.642			271.2	C			16	900	2400				
675.961			270.9	C			12	1500	2400				
676.092			270.7	C			8	1800	2400				
676.192			270.8	C			10	1800	2400				
676.332			270.9	C			12	1800	2400				
676.461			270.7	C			8	2400	2400				
677.423			272.0	C			2	1500	2400				
677.782			271.8	C			8	1800	2400				
678.002			271.7	C			12	1800	2400				
678.828			273.1	C			2	600	2400				
679.015			273.1	C			8	600	2400				
679.133			273.1	C			6	600	2400				
679.292			273.4	C			14	600	2400				
679.310			273.5	C			4	600	2400				
679.442			273.3	C			6	600	2400				
679.450			273.3	C			6	600	2400				
679.735			273.9	C			1	600	2400				
680.139			273.1	C			14	1500	2400				
680.150			273.1	C			30	1200	2400				
680.281			273.3	C			14	1500	2400				
680.290			273.4	C			24	1200	2400				
680.402			273.4	C			10	1200	2400				
680.415			273.4	C			20	1200	2400				
680.842			272.6	C			8	2100	2400				
680.850			272.6	C			16	2100	2400				
681.122			272.8	C			6	1800	2400				
681.302			272.8	C			6	1800	2400				
681.404				B						10	14000		
681.772			271.9	C			24	2700	2400				
681.982			272.0	C			28	2700	2400				
682.094			272.3	C			24	2400	2400				
682.242				B						8	14000		
682.492			271.9	C			24	2700	2400				
682.602	Baronne Creek	433		B						6	23000		
682.920			274.8	C			12	600	2400				
683.568			276.9	C			3	900	2400				
683.709			277.1	C			8	1500	2400				
684.274			278.7	C			14	900	2400				
684.506			279.1	C			16	600	2400				
684.712			279.0	C			36	900	2400				
684.915			279.3	C			20	600	2400				
685.156			279.6	C			20	600	2400				
685.362			279.8	C			20	600	2400				
685.546			280.0	C			18	1200	2400				
686.039			282.3	C			14	1200	2400				
686.240			282.9	C			3	1200	2400				
687.139			286.5	C			4	1800	2400				
691.365			284.0	C			14	2700	2400				
693.993			282.4	C			20	600	2400				
694.038			282.5	C			4	600	2400				
694.198	Tenandra Creek	41	280.7	C			10	1800	2400				
694.575			281.0	C			5	1500	2400				
694.632			281.6	C			5	1500	2400				
695.565			287.8	C			5	1200	2400				
695.648			287.9	C			5	1500	2400				
697.470			298.4	C			3	600	2400				
697.742			298.1	C			2	900	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
697.851			297.8	C			4	1500	2400				
697.902			297.7	C			10	1500	2400				
697.983			297.2	C			8	2100	2400				
700.018	Mungery Creek	26	289.2	B						1	14000		
700.088			289.1	B						1	14000		
700.118				B						3	14000		
700.193				B						2	14000		
701.890				B						4	14000		
701.982				B						3	14000		
702.275			293.5	C			5	1200	2400				
702.306			293.5	C			12	900	2400				
702.342	Caleriwi Creek	36		B						2	14000		
702.384			293.3	C			13	1200	2400				
702.423			293.7	C			10	600	2400				
702.475			293.8	C			10	600	2400				
702.520			293.8	C			5	600	2400				
702.573			293.8	C			3	600	2400				
703.500			290.7	C			2	600	2400				
703.770			289.0	C			2	600	2400				
703.992			286.3	C			10	1500	2400				
703.992			286.3	C			10	1800	2400				
704.193			285.9	C			10	900	2400				
704.260			286.1	C			3	600	2400				
704.497			284.3	C			4	900	2400				
704.547			283.7	C			5	1200	2400				
704.589	Quanda Quanda Creek	47		B						4	14000		
704.76			283.6	C			10	900	2400				
704.680			283.6	C			12	1200	2400				
704.727			283.5	C			14	1200	2400				
704.940			283.5	C			10	900	2400				
704.940			283.5	C			7	900	2400				
705.192			283.2	C			6	2100	2400				
705.232			283.3	C			6	2400	2400				
705.359			283.4	B						1	14000		
705.408			283.3	B						1	14000		
705.460				B						4	14000		
705.735				B						6	14000		
706.891			296.8	C			2	600	2400				
707.014			293.7	C			2	2100	2400				
707.183			290.8	B						1	14000		
707.627			289.0	C			2	900	2400				
707.757			288.7	C			2	600	2400				
707.977			288.0	C			2	600	2400				
708.475	Black Gutter	3	285.3	C			18	900	2400				
708.566			285.3	C			6	600	2400				
708.648			285.2	C			3	600	2400				
708.728			285.4	C			15	600	2400				
708.897			285.9	C			7	600	2400				
708.976			285.9	C			8	600	2400				
709.113			286.3	C			4	600	2400				
709.185			286.3	C			9	600	2400				
709.235			286.3	C			3	600	2400				
709.267	Salty Springs Creek	29		B						2	14000		
709.320			286.2	C			5	900	2400				
709.355			286.2	C			4	1200	2400				
709.355			286.2	C			13	900	2400				
709.460			285.9	C			9	1500	2400				
709.565			285.5	C			6	1800	2400				
709.664			285.2	C			8	1800	2400				
709.743			284.5	C			8	2400	2400				
709.809			284.4	C			6	2400	2400				
709.873			284.4	C			8	2100	2400				
709.952			284.2	C			6	2100	2400				
710.179			285.1	C			1	900	2400				
710.604			286.0	C			7	900	2400				
710.748			285.9	C			9	1500	2400				
710.830			286.0	C			11	1500	2400				
713.533			271.6	C			8	900	2400				
713.626			271.0	C			3	900	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
713.711			270.6	C			2	900	2400				
714.162			268.1	C			2	1200	2400				
714.388			266.7	C			17	1500	2400				
714.485			266.1	C			9	1800	2400				
714.546			266.1	C			8	2100	2400				
714.593	Calga Creek	52		B						2	14000		
714.632			266.0	C			14	2700	2400				
714.695				B						4	14000		
715.376			273.8	C			3	900	2400				
716.030			276.8	B						1	14000		
717.873			280.3	C			2	900	2400				
718.044			279.2	C			2	2100	2400				
718.067			278.7	C			5	1800	2400				
718.165	Noonbar Creek	5	277.1	C			7	3000	2400				
719.410			269.1	C			15	600	2400				
719.535			268.8	C			12	600	2400				
720.094			265.2	C			5	600	2400				
720.138			265.2	C			3	600	2400				
720.360			264.6	C			5	600	2400				
720.790			262.6	C			6	600	2400				
720.990			260.6	C			10	1200	2400				
721.030			259.8	C			20	1800	2400				
721.092			260.4	C			12	900	2400				
721.178			260.4	C			20	600	2400				
721.267			260.3	C			8	600	2400				
721.322			260.1	C			20	600	2400				
721.416			259.9	C			10	600	2400				
721.490			259.6	C			8	600	2400				
721.540			259.6	C			3	600	2400				
721.590			259.4	C			5	600	2400				
721.686			259.0	C			6	600	2400				
721.810			258.3	C			5	900	2400				
722.026			257.6	C			10	1800	2400				
722.084			257.6	C			20	2100	2400				
722.164			257.2	C			6	2400	2400				
722.212			257.6	C			12	2100	2400				
722.288	Bucklanbah Creek	155		B						6	23000		
722.454			257.4	C			5	2700	2400				
722.498			257.5	C			8	2400	2400				
722.558			257.8	C			5	2400	2400				
722.620			258.0	C			4	2100	2400				
722.620			258.0	C			3	600	2400				
722.703			258.2	C			12	2100	2400				
722.831			258.4	C			9	3000	2400				
725.489			265.7	C			2	2100	2400				
728.111	Small Creek	6	253.8	C			9	1500	2400				
728.236			253.5	C			9	1200	2400				
728.280			253.5	C			15	900	2400				
728.834			252.2	C			15	900	2400				
729.879			251.6	C			7	1200	2400				
730.463			249.7	C			10	3000	2400				
730.500	Teridgerie Creek	398		B						5	23000		
730.633			250.6	C			5	2100	2400				
730.830			250.4	C			16	2100	2400				
731.159			251.6	C			3	1200	2400				
731.953			253.1	C			3	1500	2400				
732.258			253.1	C			12	2400	2400				
732.329			253.8	C			3	1800	2400				
732.876			255.3	C			3	1800	2400				
733.380			256.7	C			3	1800	2400				
734.091			258.8	C			3	600	2400				
734.612			258.9	C			3	600	2400				
734.642			258.6	C			12	600	2400				
734.704			258.4	C			12	600	2400				
734.792			259.3	C			8	600	2400				
735.300			261.4	C			2	600	2400				
735.425			261.7	C			2	900	2400				
735.425			261.7	C			3	600	2400				
735.690			261.8	C			3	1200	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
736.292			263.3	C			3	600	2400				
737.006			263.3	C			9	1200	2400				
737.140			263.6	C			4	1200	2400				
737.894	Ironbark Creek	32	264.1	C			10	1500	2400				
737.978			264.4	C			8	1500	2400				
738.148			265.0	C			2	1200	2400				
738.903			266.9	C			3	600	2400				
738.963			266.9	C			3	600	2400				
739.530			267.7	C			5	600	2400				
739.650			267.8	C			3	600	2400				
739.943			267.4	C			2	600	2400				
740.421			266.6	C			8	1200	2400				
740.465			266.6	C			5	1200	2400				
740.514			266.6	C			8	1200	2400				
740.634			266.9	C			9	900	2400				
740.699			267.0	C			7	900	2400				
741.125			268.5	C			2	600	2400				
741.260			268.9	C			3	600	2400				
741.336			269.0	C			3	600	2400				
741.457			269.3	C			1	600	2400				
741.918			268.9	C			8	1200	2400				
741.965			268.9	C			10	1500	2400				
742.024			269.0	C			9	1200	2400				
742.309			270.0	C			3	600	2400				
742.438			270.4	C			3	600	2400				
742.615			270.8	C			2	600	2400				
742.615			270.8	C			2	600	2400				
742.913			271.2	C			3	600	2400				
744.438			275.3	C			3	600	2400				
744.685			275.6	C			3	600	2400				
744.745			275.5	C			10	600	2400				
744.840			275.6	C			6	600	2400				
744.902			275.6	C			8	600	2400				
744.996			275.5	C			8	1200	2400				
745.476			277.1	C			3	600	2400				
745.585			277.4	C			3	600	2400				
745.796			277.8	C			3	600	2400				
746.855			280.4	C			3	600	2400				
747.380			281.5	C			1	600	2400				
747.768	Baradine Creek	978		B						2	23000	6	33000
749.279				B						3	14000		
752.193			280.3	C			2	2100	2400				
752.480			277.8	C			3	3000	2400				
752.713	Coolangla Creek	42		B						3	23000		
753.163			281.7	C			3	600	2400				
753.329			282.3	C			4	600	2400				
753.384			282.5	C			3	600	2400				
753.482			282.6	C			4	600	2400				
753.643			283.9	C			7	600	2400				
756.787				B						2	23000		
757.451			276.3	C			3	1200	2400				
757.542			275.5	C			4	1800	2400				
758.969	Cumbil Forest Creek	8	273.9	C			4	3000	2400				
759.458			270.5	C			12	2400	2400				
761.188			268.5	C			6	600	2400				
761.241			268.3	C			12	600	2400				
761.788			266.1	C			4	600	2400				
762.889			260.8	C			4	600	2400				
763.461	Etoo Creek	319		B						15	23000		
764.018			258.7	C			3	1200	2400				
764.068			258.7	C			2	900	2400				
764.872			257.8	C			5	900	2400				
765.008			257.7	C			2	1200	2400				
765.045			257.8	C			3	1200	2400				
765.129			257.8	C			2	1200	2400				
765.170			257.8	C			2	1200	2400				
765.608			258.5	C			4	600	2400				
765.696			258.5	C			4	600	2400				
766.411			257.7	C			2	1800	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
767.593			252.1	C			7	2400	2400				
767.915			251.7	C			4	1200	2400				
767.942	Stockyard Creek	17		B						4	14000		
768.007			251.7	C			4	900	2400				
769.144	Rocky Creek	181		B						5	23000		
769.412			253.5	C			3	1500	2400				
770.809			258.3	C			1	900	2400				
771.101			258.7	C			3	900	2400				
771.235			259.4	C			3	600	2400				
772.048			259.7	C			2	600	2400				
772.159			260.1	C			6	600	2400				
773.373	Tinegie Creek	2		B						4	14000		
773.452			263.8	C			6	2100	2400				
773.536			263.9	C			6	2400	2400				
773.615			264.3	C			4	2400	2400				
777.560			267.3	C			8	2400	2400				
778.024			266.2	C			8	3000	2400				
778.552			267.4	C			5	1200	2400				
778.974			266.8	C			1	600	2400				
779.018			266.7	C			1	600	2400				
779.635	Talluba Creek	47		B						4	14000		
779.736			261.6	C			6	2100	2400				
779.768			260.8	C			3	2700	2400				
779.799			261.0	C			3	2700	2400				
779.829				B						5	14000		
781.523				B						6	14000		
782.941			278.6	C			3	600	2400				
783.069			278.9	C			3	600	2400				
783.653	Cubbo Creek	67		B						5	23000		
785.056			279.8	C			3	2100	2400				
786.809				B						2	14000		
786.841				B						3	14000		
787.360			273.2	C			3	3000	2400				
787.383			273.2	C			3	3000	2400				
787.408			273.2	C			3	3000	2400				
787.522			274.3	C			3	2700	2400				
789.381	Rocky Creek	181		B						3	23000		
789.456				B						3	14000		
789.505				B						4	14000		
790.131			270.8	C			6	1200	2400				
790.239			271.1	C			6	600	2400				
790.328			271.0	C			6	600	2400				
792.573			285.6	C			3	600	2400				
793.834			278.3	C			2	600	2400				
794.252			276.0	C			3	600	2400				
796.110			264.3	C			9	2100	2400				
796.160			263.9	C			15	1800	2400				
796.268			263.5	C			18	1500	2400				
796.414	Coghill Creek	81		B						13	14000		
796.634			263.0	C			3	1800	2400				
796.658			262.4	C			9	2700	2400				
796.900			263.1	C			3	1800	2400				
796.926			263.1	C			2	1800	2400				
800.332			252.7	C			21	3000	2400				
800.401			252.8	C			4	3000	2400				
800.445	Mollieroi Creek	105		B						4	23000		
800.572			253.2	C			3	2700	2400				
800.592			253.1	C			3	2700	2400				
800.619			253.3	C			3	2400	2400				
800.664			253.3	C			10	2400	2400				
800.770			253.2	C			3	2100	2400				
800.861			252.7	C			15	2100	2400				
800.945			252.8	C			3	1800	2400				
800.983			252.9	C			7	1500	2400				
801.028			252.9	C			3	1500	2400				
801.730			251.2	C			10	600	2400				
801.835			250.8	C			3	600	2400				
801.890			250.8	C			12	600	2400				
802.047			250.6	C			3	600	2400				

Rail chainage (km)	Waterway	Catchment Area (km²)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
802.135			250.6	C			3	600	2400				
802.201			250.6	C			12	600	2400				
802.297			250.6	C			3	600	2400				
802.432			250.9	C			3	600	2400				
802.535			251.0	C			20	600	2400				
803.256			252.2	C			14	600	2400				
803.653	Black Creek	19	251.3	C			10	2100	2400				
803.775			251.5	C			6	2100	2400				
804.319			253.1	C			6	600	2400				
804.852			250.9	C			5	1500	2400				
804.965			250.5	C			4	1500	2400				
805.743				B						3	14000		
805.807			248.7	C			4	2100	2400				
806.364			249.5	C			4	1500	2400				
806.618			249.8	C			3	1200	2400				
806.700			249.5	C			12	1500	2400				
807.025			249.9	C			3	900	2400				
807.083			249.8	C			8	900	2400				
807.151			249.9	C			3	900	2400				
807.667			250.1	C			12	900	2400				
808.219			250.5	C			12	600	2400				
808.365			250.5	C			16	600	2400				
808.504			250.7	C			3	600	2400				
808.807			250.2	C			10	900	2400				
808.907			250.3	C			3	1200	2400				
808.953			250.3	C			6	1200	2400				
808.997			250.2	C			3	1500	2400				
809.054			249.5	C			12	2400	2400				
809.115	Goona Creek	49		B						4	14000		
810.038			253.6	C			3	600	2400				
810.666			253.2	C			6	1200	2400				
810.754			253.4	C			7	900	2400				
811.090			253.0	C			3	1200	2400				
811.136			252.9	C			3	1500	2400				
811.182			252.9	C			6	1500	2400				
811.278			253.0	C			3	1200	2400				
811.692			253.2	C			3	1200	2400				
811.732			253.3	C			3	900	2400				
812.216			253.2	C			3	1200	2400				
812.265			253.5	C			1	900	2400				
812.601			253.4	C			3	900	2400				
812.646			253.3	C			3	900	2400				
812.691			253.3	C			3	900	2400				
814.039			251.9	C			3	1500	2400				
814.130			251.7	C			6	1800	2400				
814.167			251.7	C			3	1500	2400				
814.202			251.8	C			3	1500	2400				
814.241			251.9	C			8	1500	2400				
814.901			252.1	C			3	600	2400				
815.548			251.2	C			3	900	2400				
817.059				B						2	14000		
817.116			246.0	C			32	3000	2400				
817.259				B						2	14000		
817.325				B						3	14000		
817.387				B						2	14000		
817.433				B						2	14000		
817.480				B						3	14000		
817.573				B						2	14000		
817.651	Bundock Creek	82		B						6	23000		
818.177			247.4	C			6	1800	2400				
819.649			247.2	C			4	1200	2400				
819.913			246.9	C			3	900	2400				
820.891			245.6	C			4	900	2400				
820.933			245.7	C			3	900	2400				
822.065			244.6	C			8	2100	2400				
822.200			245.0	C			4	1800	2400				
824.802			245.3	C			3	900	2400				
825.120			243.8	C			3	1200	2400				
825.399			244.0	C			3	600	2400				

Rail chainage (km)	Waterway	Catchment Area (km^2)	Upstream Invert Level (mAHD)	Structure Type	Pipe Culvert		Box Culvert			Bridge			
				Bridge or Culvert (B / C)	No.	Diameter (mm)	No.	Height (mm)	Width (mm)	No.	Span (mm)	No.	Span (mm)
825.973			243.9	C			1	600	2400				
826.688			242.0	C			1	600	2400				
826.897			241.8	C			1	600	2400				
827.847			237.6	C			2	600	2400				
827.872			237.5	C			2	600	2400				
828.223	Bohena Creek	2041		B						14	23000		
828.225			235.8	C			72	2100	2400				
828.413				B						9	14000		
828.545			235.2	C			84	2700	2400				
828.765				B						12	14000		
828.958				B						17	14000		
829.902			233.3	C			6	3000	2400				
829.932			233.2	C			6	3000	2400				
829.972			233.0	C			18	2700	2400				
830.106			232.2	C			9	2400	2400				
830.244			230.4	C			6	3000	2400				
830.286			230.4	C			6	2700	2400				
830.333			230.0	C			11	3000	2400				
830.414			230.6	C			6	2400	2400				
830.478			231.3	C			24	1800	2400				
830.739			230.6	C			12	2100	2400				
830.892			232.0	C			12	600	2400				
831.671			229.7	C			3	2700	2400				
832.136			229.4	C			2	2100	2400				
833.130			227.9	C			10	1500	2400				
833.755			226.6	C			3	2100	2400				
833.817			226.5	C			3	2400	2400				
833.889			226.5	C			3	2400	2400				
834.450				B						3	14000		
834.541				B						3	14000		
834.764				B						33	23000		
835.641				B						4	14000		
839.535			220.0	C			2	1800	2400				
839.874			219.9	C			1	1500	2400				
842.325			215.3	C			3	900	2400				
842.648			214.6	C			6	1200	2400				
842.924			214.7	C			3	1500	2400				
843.613				B						4	23000		
845.246	Namoi River/Narrabri Creek	25400		B						157	23000	10	33000
848.407				B						3	14000		
848.525			211.7	C			1	3000	2400				
848.579			211.7	C			1	2700	2400				
848.625			211.8	C			1	3000	2400				
848.646			211.8	C			1	3000	2400				
848.697			211.8	C			1	2400	2400				
848.737			211.9	C			1	2400	2400				
848.776			211.9	C			2	2100	2400				
848.864			212.2	C			1	1800	2400				
848.892			212.1	C			3	1500	2400				
848.923			212.2	C			3	1200	2400				
848.964			212.2	C			3	900	2400				
849.004			212.3	C			4	900	2400				
849.037			212.3	C			3	900	2400				
849.092			212.3	C			3	900	2400				
849.185			212.6	C			3	900	2400				
849.261			212.7	C			3	900	2400				
849.424			213.1	C			2	900	2400				
849.486			213.3	C			3	900	2400				
849.568			213.4	C			2	900	2400				
849.614			213.6	C			3	900	2400				
849.833			214.1	C			3	900	2400				
849.867			214.1	C			3	1200	2400				
850.130			214.7	C			1	1200	2400				
850.392			215.4	C			3	1200	2400				
852.454			217.6	C			1	600	2400				
852.566	Breakout of Mulgate Creek	84	217.9	C			3	600	2400				
852.583			218.0	C			3	600	2400				
852.599			218.1	C			3	600	2400				
852.641			218.2	C			3	600	2400				

TECHNICAL REPORT 3

Flooding and hydrology assessment

Appendix B Independent peer review

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT

Narromine to Narrabri (N2N) Inland Rail - Hydrologic Review

Reference: R.N21291.001.04.Hydrology_Review.docx
Date: November 2020

Document Control Sheet

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Document:	R.N21291.001.04.Hydrology_Review.docx
Title:	Narromine to Narrabri (N2N) Inland Rail - Hydrologic Review
Project Manager:	Barry Rodgers
Author:	Jack Haywood
Client:	JacobsGHD IR Joint Venture
Client Contact:	Max Towns
Client Reference:	

Synopsis: **Hydrologic Model Review for the Inland Rail Project Narromine to Narrabri (N2N) 100% feasibility design package**

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
0	02/09/20	BR		JH	
1	09/09/20				
2	10/09/20				
3	17/11/20				
4	20/11/20				

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
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BMT File	PDF	PDF	PDF	PDF	PDF						
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1 Introduction

JacobsGHD IR Joint Venture (JacobsGHD) is undertaking civil design of the Narromine to Narrabri (N2N) section of Inland Rail for the Australian Rail Track Corporation Ltd (ARTC).

It is understood that JacobsGHD completed a flood study as part of the Environmental Impact Statement (EIS) in support of the proposed project. BMT Commercial Australia (BMT) was initially engaged by JacobsGHD to conduct a review of their hydrology models used as the basis for the flood study at the 70% feasibility design stage of the project. The review was undertaken of calibrated hydrologic models and a subset of 10 smaller hydrologic models. Following the 70% feasibility design review, BMT were again engaged to review the hydrologic models developed for the 100% feasibility design, noting that models within only two catchments have changed between the two designs.

This report provides the methodology and outcomes of the review conducted by BMT. It should be noted as per BMT's proposal (agreed by JacobsGHD), that a subset of models has been selected for the review allowing the general project approach to model setup and parameterisation to be reviewed. As such, the review must not be taken as a comprehensive review of all the models supplied nor the total flood study or assessment.

2 Review Methodology

For the 70% feasibility design stage, JacobsGHD supplied eighty-four (84) hydrologic RORB models and one (1) hydrologic XP-RAFTS model for the purpose of this peer review. Supporting data for four flood frequency analyses and a subset of hydrological result files were also supplied. For the 100% feasibility design stage BMT understands the hydrology for two catchment models (Macquarie and Narromine) was updated. Hydrologic models for these two catchments were resupplied and reviewed. It is understood from JacobsGHD that no changes were made to the remaining hydrologic models between the 70% and 100% feasibility designs.

2.1 Review Elements

The hydrologic models supplied are all located within the Narromine to Narrabri study area.

The different components of the BMT review are set out in Table 2-1 along with a brief description of what the review has focussed on.

Table 2-1 Hydrologic Review Elements

<table>
<tr><th>Review Catchment/Item</th><th>Review Description</th></tr>
<tr><td>Castlereagh River</td><td>• RORB GIS layers only (catchments rely on FFA for peak flows)</td></tr>
<tr><td>Baradine Creek</td><td rowspan="3">• RORB GIS Layers
• RORB catchment files
• RORB Parameter files
• RORB Storm and Out files (Calibration and Design)
• Calibration Results</td></tr>
<tr><td>Coolbaggie Creek</td></tr>
<tr><td>Bohena Creek</td></tr>
<tr><td>Narromine (Backwater Cowal) comprising five (5) RORB models.</td><td rowspan="2">• RORB GIS Layers
• RORB catchment files
• RORB Parameter files
• RORB Storm and Out files (Calibration and Design)</td></tr>
<tr><td>Macquarie River</td></tr>
<tr><td>Ten (10) smaller RORB models</td><td>• Catchment sizes and Loss values used</td></tr>
<tr><td>Flood Frequency Analysis (FFA)</td><td>• FLIKE Inputs and Output files
• Macquarie, Castlereagh, Baradine and Coolbaggie FFA files supplied</td></tr>
<tr><td>TUFLOW Inflows</td><td>• Comparison of TUFLOW inflows and RORB outputs</td></tr>
</table>

3 Review Outcomes

3.1 General RORB Comments

- For all of the calibrated RORB models, there are more than the recommended five subareas upstream of the key gauges used in the assessments. This allows for appropriate routing in the derivation of flow hydrographs at required locations.
- For all of the calibrated RORB models, the appropriate reach type (Type 1 – Natural Waterway) was used for all reaches. This represents how water will convey through the catchments appropriately. This is appropriate given the predominantly rural nature of all catchments.
- Nodes have been placed at the downstream end of subareas, and at all confluences of watercourses. The reporting nodes have also been positioned in the appropriate places for the study.

3.2 Individual Study Area Commentary

Table 3-1 to Table 3-5 present a summary of hydrologic model review findings for the five larger models. All five catchments were modelled using RORB software. For some catchments eg Castlereagh River, the RORB models were not supplied as the peak flows were derived using FFA techniques. Supporting files such as node and area locations were supplied and have been used to inform the reviews.

Table 3-1 Macquarie River RORB Model (MAC)

Review Item	Commentary
Subareas	• 31 subareas, this is considered sufficient to calibrate a RORB model • The range of subarea sizes is appropriate, with the largest subarea being approximately 6x the smallest
Reaches	• All reaches Type 1. Consistent with land use.
Storages	• There are no storages within the model. Lake Burrendong is a significant storage in the catchment with a significant portion of the catchment being upstream of this storage. • The inclusion of this will likely slow the flow down significantly, changing the shape of the hydrograph. However, it is understood that the storage effects have been modelled using a high kc value.
k_c	• Value of 262.71 seems very high and will have the effect of attenuating (reducing) the peak flow. It is understood from JacobsGHD that the high kc value was used to match the rising limb and peak flow rates to historic flood events and FFA respectively.
IL	• Varying losses, generally decreasing in rarer events
CL	• Consistent loss of 1.84 mm/h. This is acceptable.
Design Flows	• Match closely to FFA (within 5% for all events) and is acceptable for the study,

Table 3-2 Castlereagh River RORB Model (CAS)

Review Item	Commentary
Subareas	• 39 subareas, this is considered sufficient for RORB calibration • The range of subarea sizes is appropriate, with the largest subarea being approximately 6x the smallest
RORB Parameters	• Not applicable as the RORB model flows are scaled to match results from an FFA.

Table 3-3 Baradine Creek RORB Model (N2N7_1)

Review Item	Commentary
Subareas	• 25 subareas. 24 subareas used for calibration model, with Subarea 'Y' being added for design events. The range of subarea sizes is appropriate, with the largest subarea being approximately 5x the smallest
d_{av}	• Minor differences in value noted between design and calibration models. This is due to the additional subarea 'Y' for additional design reporting output.
k_c	• Value from calibration is 20 (x3 models), 25 and 31. The values appear reasonable and a good calibration is demonstrated. • Value adopted for design events is 20 which is reasonable based on values determined through calibration
IL	• Initial loss value adopted for design runs is 72.7mm. This comes from the November 1998 calibration event. It approximates the median of the three calibration events which is appropriate
CL	• Value of 2.9mm/h consistent between calibration and design events. • Consistent with ARR Losses from Datahub
ARF	• ARF value applied based on area (974.81km^2) is less than the total catchment size (1002.08km^2). However the catchment area to the key location of interest (C20 (node O1)) is 933.18km^2. This may have a slight effect on rainfall depths into the model in the design events but will most likely be minor
Calibration	• Only 3 of 5 calibration runs have results plotted (1997 and July 1998 events not available). It is understood from JacobsGHD that only the larger floods have been presented. • Calibration generally shows good match to the peak flows, as well as good rising and falling limbs. • Sept 1998 – Failure to match smaller peaks before and after the main peak suggests CL could be too high but as main peak matches well this is considered a minor issue and calibration is acceptable.

Table 3-4 Coolbaggie Creek RORB Model

Review Item	Commentary
Subareas	• 14 subareas. This is considered sufficient for RORB calibration • The range of subarea sizes is appropriate, with the largest subarea being approximately 4x the smallest
d_{av}	• The adopted design value of 40 matches 39.87 in calibration event outputs • No design runs provided to cross check against calibration. Discussions with JacobsGHD confirmed that this model was intended as a donor catchment model only for RORB parameter generation and ended up not being used at all. Therefore, no design runs are required.
k_c	• Value from calibration is 22 (x3 models) and 28 (x2 models). Seems reasonable and offer good matches in calibration figures. • No design kc (as model not used for design modelling) • It is understood a median value of 25 was adopted, no k_c value of 25 was used in the supplied calibration events. This should be investigated if the model is used to inform design flood modelling at any future stage of assessment.
IL	• Calibration ILs range from 20mm to 78.4mm • These differ slightly from adopted design values of 20mm to 73mm but are unlikely to result in any material change in model outcomes.
CL	• Calibration CLs range from 1.2mm/h to 1.6mm/h are consistent with adopted design values and with ARR 2019 estimated values
ARF	• Design runs not required and so no ARF values to assess
Calibration	• 4 out of 5 calibration runs have plotted results with the November 2010 event not shown. It is understood from JacobsGHD that only the larger floods have been presented. • Calibration demonstrates the model matches well to peak flows • Modelled hydrographs for the November 2000 and March 2012 events rise far later that observed, suggesting adopted IL for these events are possibly too high but the match to peak flows is considered satisfactory.

Table 3-5 Bohena Creek RORB Model

Review Item	Commentary
Subareas	• 25 subareas. This is considered sufficient for RORB calibration • The range of subarea sizes is appropriate, with the largest subarea being approximately 5x the smallest • Areas in RORB Shapefiles differ to those specified in the RORB 'catg' model file by a small margin. Likely to not affect results
d_{av}	• Adopted design value of 66 matches 66.06 in calibration event outputs and design outputs
k_c	• Value from calibration is 21 (x3 models), 22 and 25. Values seem reasonable and demonstrate a good calibration can be achieved • Design k_c is 21
IL	• Calibration ILs range from 27mm to 102mm • Design loss used is 39.7mm. The median value was 59mm so a loss of 39.7mm is conservative in this regard.
CL	• Calibration CLs range from 2.5mm/h to 3.5mm/h compared to the adopted design value of 2.5mm/h which is reasonable. • Consistent with ARR 2019 estimated values
ARF	• ARF value consistent with total area of the RORB model, and location of gauge at downstream end
Calibration	• 3 out of 5 calibration runs are plotted (2000 and 2004 events not included). It is understood from JacobsGHD that only the larger floods have been presented. • Calibrations demonstrate good matching to the peak flows, as well as a good match on rising and falling limbs.

3.3 Narromine (Backwater Cowal) RORB Models

BMT understands that following community feedback on the 70% feasibility design, more definition was required within the Narromine RORB model to map overland flow paths. The Narromine model was therefore broken up into five (5) RORB models for the 100% feasibility design. These models provide inflow hydrographs into the associated TUFLOW model that includes the Narromine catchments in the vicinity of the railway alignment.

3.3.1 Review Commentary

- Routed print locations are at the appropriate location for introduction of inflows into the TUFLOW model for each of the five RORB models which extend upstream of the model boundary.
- The range of the subarea sizes in each respective model is appropriate. The larger RORB models have proportionately larger subareas, with all models also having an acceptable minimum number of subareas required for routing.
- Reach types are consistently "Type 1 – Natural" throughout all RORB models. This is consistent with the land use and appropriate for the RORB models.
- Reach delineation is appropriate for all models, leading to appropriate values of the d_{av} parameter used in all RORB models.

- Multiple catchment areas have been used for calculations of the areal reduction factor (ARF) in RORB runs. These have been applied for each point upstream inflow into the TUFLOW model. This is an appropriate application of the ARF.
- The Initial Loss, Continuing Loss and k_c parameters for the five Narromine RORB models are shown in Table 3-6 below. This shows:
  - The Initial Loss values are consistent with using the Pre-Burst losses from Data Hub
  - The Continuing Loss values are consistent with the Data Hub losses for RORB models 3 to5.
  - The Continuing Loss values for RORB models 1 and 2 have been multiplied by a factor of 0.4 in accordance with NSW specific guidance on the Data Hub.
  - The k_c values seem appropriate for the catchment sizes.

Table 3-6 Narromine RORB Parameters

RORB Model	IL	CL	k_c	d_{av}
1	Varying IL based on Pre-burst losses	0.20	7.15	9.65
2		0.20	8.52	9.62
3		0.01	12.11	27.48
4		0.01	9.72	14.59
5		0.01	5.28	4.44

3.4 Smaller Catchment Reviews

In addition to the larger models reviewed in Section 3.2, a subset of smaller RORB models were also selected for a review. Ten models were selected for review from the approximate 80 models available. These reviews focused on ensuring the appropriate ARR 2019 data was used, and that rainfall loss values were appropriate. These reviewed models are listed below using the model identifier:

- D128980
- D17313
- D29411
- D32008
- D46230
- D57277
- D68620
- D79020
- D86480
- D98220.

3.4.1 Review commentary

- The way in which loss values were selected was initially unclear but later clarified by JacobsGHD who stated that for uncalibrated models a conservative approach was adopted by selecting the lower of the losses from neighbouring calibrated catchments or from the ARR2019 Data Hub. This appears to be a conservative approach and one which BMT deems to be appropriate. It is noted by BMT that the rainfall loss values in the smaller catchments seem to be significantly lower than those losses chosen for the design events in the calibrated catchments and those obtained from the DataHub. This will likely lead to conservative flow estimates.

- Where k_c values have been specified in models that route hydrographs to provide a point input to the hydraulic model i.e. not excess rainfall outputs, how the K_c value has been determined is not specified. Given that initial loss values are conservative then the model outputs are still likely to be conservative but future reporting should include a statement on how k_c values have been derived in these models.
- The application of the IFD and ARF data is consistent throughout all of the assessed RORB models and have been applied correctly.

3.5 Flood Frequency Analysis

A Flood Frequency Analysis (FFA) was provided for four catchments: Baradine Creek, Coolbaggie Creek, Macquarie River and Castlereagh River. The FFAs were undertaken using FLIKE software.

BMT has reviewed the supplied FLIKE software input and output files for the four catchments.

3.5.1 General Comments

The rating curves which underpin the FFA analyses appear to rely on the flow to level gaugings undertaken by Water NSW. Further clarification was sought by BMT from JacobsGHD as to how the accuracy of each rating curve used was considered noting that, in general, rating curves from government agencies tend to be less accurate for larger flows once discharge engages the floodplain. JacobsGHD confirmed that flow gauging data and cross sections at the gauges were reviewed. In the case of the Namoi River/Narrabri Creek and Bohena Creek (N2N1 TUFLOW model), the adopted rating curves were compared against TUFLOW model results to verify rating curves which is a best practice approach. JacobsGHD stated that this was not possible for Baradine Creek as the gauge had not been surveyed to Australian Height Datum and was discontinued.

Quality checks of the data only appear to be undertaken for large data gaps. It is not clear the degree to which any sanity checks may have been performed to ensure the maximum flow for each year is the actual maximum flow and not an artificial spike (as water level gauges can fail during large events). Commentary should also be made if the ‘water year’ has been used to calculate the annual maximum flow series, although this is not likely to have any notable bearing on outcomes.

The Grubbs Beck test for outliers has been performed for the FFA, however no further sensitivities appear to be undertaken.

The FFA derived peak flows for Baradine Creek and Coolbaggie Creek are notably lower than the corresponding flows from the RORB models for events rarer than the 1 in 10 AEP. It would be of value to understand some of the reasons behind these large differences. However, based on discussions with JacobsGHD, the larger RORB flows have been adopted for use on these catchments which is a conservative approach and therefore acceptable.

3.5.2 Baradine Creek FFA

It is understood from discussions from JacobsGHD that the peak flows from the Baradine Creek FFA were not adopted for design purposes, with higher peak flows from RORB modelling used instead. The gauge on Baradine Creek was also discontinued. The comments summarised below regarding the Baradine Creek FFA are included for completeness but will not affect design flood modelling and no further action is required unless the FFA is used for future purposes.

- There are 28 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.
- The peak flows from 2002 and 2006 were not included in the analysis. The reasons for the exclusion are not stated. If it is simply that the flows are very low, it is recommended that these years are still included but as censored data so that they do not unduly influence the fit of the distribution for floods at the rare tail end.
- The peak flow from 1981 was included in the analysis, however recorded flows commenced in this year and as such 1981 only has a partial record of flows in that year. Given the full year is not available, this should be removed to maintain consistency with the rest of the FFAs but it is not likely to have a notable effect on outcomes.

3.5.3 Coolbaggie Creek FFA

It is understood from discussions from JacobsGHD that the peak flows from the Coolbaggie Creek FFA were not adopted for design purposes, with higher peak flows from RORB modelling used instead. The comments below regarding the Coolbaggie Creek FFA are included for completeness but will not affect design flood modelling and no further action is required unless the FFA is used for future purposes.

- There are 38 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.
- The peak flow from 1980 has been removed from the analysis. It is assumed that this was due to the record beginning in November 1980, therefore a full year of data was not available. This is appropriate.
- 19 of the 38 years have been censored in the censored assessment. This is a significant proportion and the reasons behind this should be further explored if the FFA is to be used for future purposes.

3.5.4 Castlereagh River FFA

It is understood that the Castlereagh River FFA is relied upon to obtain peak design flow estimates which the RORB model flows are then scaled to. The FFA “without” censoring was provided for review. The findings from the review are as follows:

- There are 33 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.

- The peak flows from 1968 and 2004 were removed due to the records not being full years of recorded data. This is appropriate.
- Peak flows in 2001 and 2002 were removed. Very small flows were recorded in these two years, all less than 2m^3/s, with some missing data from the record in both years. It is assumed that the years were excluded on the basis of the missing data and are therefore 'incomplete years' which is recommended practice.
- Clarification was sought regarding by how much the RORB flows differed from the FFA derived peak flows. The response from JacobsGHD was that a scaling factor of approximately 1 was used, suggesting that the peak flow estimates from both approaches were in agreement. A comparison was also provided between the peak FFA flows derived in this assessment verses peak FFA flows derived from a previous flood study prepared by Lyall and Associates in 1996. Generally, the peak flows were in agreement with those from the 1996 study and are slightly higher.

3.5.5 Macquarie River FFA

It is understood that the Macquarie River FFA is relied upon to obtain peak design flow estimates which the RORB model flows are then scaled to. The FFA "with" censoring was provided for review. The findings from the review are as follows:

- There are 32 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.
- The peak flow from 2018 was removed from the analysis. It is assumed that this was due to the records not being complete at the time of the data collection.
- The peak flow from 1986 was included in the analysis, even though records started in June 1986. Given the full year is not available, this should be removed from the analysis to maintain consistency with the rest of the FFAs but is unlikely to result in any change in outcomes.
- Clarification was sought regarding by how much the RORB flows differed from the FFA derived peak flows. The response from JacobsGHD was that a scaling factor of approximately 1 was used, suggesting that the peak flow estimates from both approaches were in agreement. A comparison was also provided between the peak FFA flows derived in this assessment verses peak FFA flows derived from a previous flood study prepared by Lyall and Associates in 2013. Generally, the peak flows were in agreement with those from the 2013 study and are slightly higher.

3.5.6 Regional Flood Frequency Estimate (RFFE)

Regional Flood Frequency Estimates have been undertaken for the larger catchments at the gauges. From discussions with JacobsGHD, an RFFE has also been undertaken for smaller catchments and compared against RORB flows for validation.

The RFFE is a high level tool that can provide a sense check on peak flow estimates. It often contains large uncertainty bounds but these can be refined through assessing and refining the gauges used within a ‘region of influence’ to inform the RFFE.

It is not clear whether the gauges within the respective regions of influence for each assessed subject site have been further analysed. From discussions with JacobsGHD the sparsity of gauges in the assessed catchments results large regions of influence which are difficult to refine.

It is understood the RFFE peak flow estimates have not been relied upon to factor RORB flows and as such the use of this technique as a sense check on peak flows is considered appropriate.

3.5.7 Other methods flow estimation methods

For smaller catchments, it is understood that conservative parameters such as the lower bound on initial losses have typically been adopted. This is considered acceptable given the overall uncertainty of peak flow estimation in areas where there is a lack of gauged data.

Other techniques that could potentially be applied when validating the smaller catchments include the probabilistic rational method (where applicable), quartile regression technique, or reconcile results with another hydrologic model package such as WBNM. Such techniques would also include a significant degree of uncertainty but may provide an additional validation of peak flows.

3.6 Baseflow

Due to their geographic location, baseflow is not expected to have any influence on peak flood modelling results in the catchments under consideration. It is noted however that during model calibration, baseflow has been separated from the recorded hydrographs for calibration of the RORB model. From discussions with JacobsGHD it is understood that the baseflow was found to be almost negligible. It was confirmed with JacobsGHD that baseflow was not then added back into the hydraulic model for water level calibration. Given that the baseflow was assessed by JacobsGHD as being negligible this is not considered to be an issue.

3.7 TUFLOW Input Hydrographs

The hydrographs from the review subset of 10 hydrologic models were reviewed and compared to the inflow hydrographs in the TUFLOW models (as these should be the same). BMT has the following comments:

- In all cases the hydrographs used for inputs into the TUFLOW models match the outputs from the hydrology models.
- For each of the ten catchments respective TUFLOW models, a single inflow is applied which is the routed total flow from the respective catchment hydrologic model.
- The inflow location for the Bohena Creek model (“C-2” in N2N1) is 12km upstream of the printout location for the routed hydrograph. This effectively double routes the flow along this 12km length but is unlikely to result in any significant impact on results.
- Inflows into the TUFLOW models for catchments D29411, D32008, D68620, D79020 and D86480 are effectively rain on grid inputs as they utilise TUFLOW’s ‘2d_sa ALL’ command. This distributes the inflow hydrograph across all grid cells within the defined boundary (which covers the whole

catchment area). These input hydrographs have already been routed within the RORB models. It is BMT's understanding that this would lead to routing having occurred twice for these catchments, likely leading to a reduction in peak flows at the downstream end of these catchments. This issue was raised with JacobsGHD who confirmed that it affected a limited number of subcatchments. It was noted by JacobsGHD that the issue affects both calculations for the existing scenario, before Inland Rail, and the operational scenario, after Inland Rail. It was also confirmed that the catchments in question are predominantly rural with a low risk of changes significantly affecting the number of buildings impacted from the existing case to the operational scenario. JacobsGHD has stated that this will be investigated and addressed further as part of the detailed design.

4 Conclusions

BMT has undertaken a review of hydrologic models and the modelling approach for the Narromine to Narrabri (N2N) study. The review identified minor issues that are not anticipated to have a significant impact on the overall model outcomes. The overall approach is a conservative one which is best practice, particularly in those catchments with little or no gauged data.

Overall the models are deemed have been appropriately set up except for one identified issue which affects a limited number of subcatchments where routed flows are being distributed evenly across catchments. JacobsGHD were made aware of this issue and have identified a low risk of changes significantly affecting the number of buildings impacted. It is understood that this will be investigated and addressed as part of the detailed design.

BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.

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N2N Responses to BMT-WBM Independent Hydrology Review

Review Item	BMT Review Comments	JGHD Response
	Summary of General Comments on RORB Models	
	For all of the calibrated RORB models, there are more than the recommended five subareas upstream of the key gauges used in the assessments. This allows for appropriate routing in the derivation of flow hydrographs at required locations.	Noted
	For all of the calibrated RORB models, the appropriate reach type (Type 1 – Natural Waterway) was used for all reaches. This represents how water will convey through the catchments appropriately. This is appropriate given the predominantly rural nature of all catchments.	Noted
	Nodes have been placed at the downstream end of subareas, and at all confluences of watercourses. The reporting nodes have also been positioned in the appropriate places for the study.	Noted
	Commentary for Macquarie River RORB Model (MAC)	
Subareas:	• 31 subareas, this is considered sufficient to calibrate a RORB model • The range of subarea sizes is appropriate, with the largest subarea being approximately 6x the smallest	Noted
Reaches:	All reaches Type 1. Consistent with land use.	Noted
Storages	• There are no storages within the model. Lake Burrendong is a significant storage in the catchment with a significant portion of the catchment being upstream of this storage. • The inclusion of this will likely slow the flow down significantly, changing the shape of the hydrograph. However, it is understood that the storage effects have been modelled using a high kc value.	Noted Noted
Kc:	• Value of 262.71 seems very high and will have the effect of attenuating (reducing) the peak flow. It is understood from JacobsGHD that the high kc value was used to match the rising limb and peak flow rates to historic flood events and FFA respectively.	Noted
IL	• Varying losses, generally decreasing in rarer events	Noted
CL	• Consistent loss of 1.84 mm/h. This is acceptable.	Noted
Design Flows	Match closely to FFA (within 5% for all events) and is acceptable for the study,	Noted

Review Item	BMT Review Comments	JGHD Response
	Commentary for Castlereagh River RORB Model (CAS)	
Subareas:	• 39 subareas, this is considered sufficient for RORB calibration • The range of subarea sizes is appropriate, with the largest subarea being approximately 6x the smallest	Noted
RORB Parameters:	Not applicable as the RORB model flows are scaled to match results from an FFA.	Noted. A RORB model for the Castlereagh River will be developed during detailed design to follow the same approach adopted both for the Macquarie River and the Namoi River.
	Commentary for Baradine Creek RORB Model (N2N7_1)	
Subareas:	• 25 subareas. 24 subareas used for calibration model, with Subarea 'Y' being added for design events. The range of subarea sizes is appropriate, with the largest subarea being approximately 5x the smallest	Noted
d_{av}:	• Minor differences in value noted between design and calibration models. This is due to the additional subarea 'Y' for additional design reporting output.	Noted
Kc:	• Value from calibration is 20 (x3 models), 25 and 31. The values appear reasonable and a good calibration is demonstrated. • Value adopted for design events is 20 which is reasonable based on values determined through calibration	Noted
IL	• Initial loss value adopted for design runs is 72.7mm. This comes from the November 1998 calibration event. It approximates the median of the three calibration events which is appropriate	Noted
CL:	• Value of 2.9mm/h consistent between calibration and design events. • Consistent with ARR Losses from Datahub	Noted
ARF:	• value applied based on area (974.81km^2) is less than the total catchment size (1002.08km^2). However the catchment area to the key location of interest (C20 (node O1)) is 933.18 km^2. This may have a slight effect on rainfall depths into the model in the design events but will most likely be minor	The adopted ARF is based on the catchment area, 974.81km^2 , at the rail formation.
Calibration:	• Only 3 of 5 calibration runs have results plotted (1997 and July 1998 events not available). It is understood from JacobsGHD that only the larger floods have been presented. • Calibration generally shows good match to the peak flows, as well as good rising and falling limbs. • Sept 1998 – Failure to match smaller peaks before and after the main peak suggests CL could be too high but as main peak	Noted. Noted The available sub-daily rain gauge (064046) used to define the temporal distribution of rainfall is located outside the modelled catchment. This is considered one of the key reasons for failure to match smaller peaks before and after the main peak.

Review Item	BMT Review Comments	JGHD Response
	matches well this is considered a minor issue and calibration is acceptable.	
	Commentary for Coolbaggie Creek RORB Model	
Subareas:	• 14 subareas. This is considered sufficient for RORB calibration • The range of subarea sizes is appropriate, with the largest subarea being approximately 4x the smallest	Noted
d_{av}:	• The adopted design value of 40 matches 39.87 in calibration event outputs • No design runs provided to cross check against calibration. Discussions with JacobsGHD confirmed that this model was intended as a donor catchment model only for RORB parameter generation and ended up not being used at all. Therefore, no design runs are required.	Noted
Kc:	• Value from calibration is 22 (x3 models) and 28 (x2 models). Seems reasonable and offer good matches in calibration figures. • No design kc (as model not used for design modelling). • It is understood a median value of 25 was adopted, no kc value of 25 was used in the supplied calibration events. This should be investigated if the model is used to inform design flood modelling at any future stage of assessment.	Noted Noted. The proposal does not cross the catchment areas of Coolbaggie Creek and as such, flood modelling for design flood events was not undertaken.
IL	• Calibration ILs range from 20 mm to 78.4 mm • These differ slightly from reported values of 20 mm to 73 mm but are unlikely to result in any material change in model outcomes.	Noted
CL	• Calibration CLs range from 1.2 mm/h to 1.6 mm/h are consistent with reported values and with ARR 2019 estimated values	Noted
ARF	• Design runs not required and so no ARF values to assess	Noted
Calibration	• 4 out of 5 calibration runs have plotted results with the November 2010 event not shown. It is understood from JacobsGHD that only the larger floods have been presented. • Calibration demonstrates the model matches well to peak flows • Modelled hydrographs for the November 2000 and March 2012 events rise far later that observed, suggesting adopted IL for these events are possibly too high but the match to peak flows is considered satisfactory.	Noted
	Commentary for Bohena Creek RORB Model	
Subareas	• 25 subareas. This is considered sufficient for RORB calibration	Noted

Review Item	BMT Review Comments	JGHD Response
	• The range of subarea sizes is appropriate, with the largest subarea being approximately 5x the smallest • Areas in RORB Shapefiles differ to those specified in the RORB 'catg' model file by a small margin. Likely to not affect results	
d_{av}	• Adopted design value of 66 matches 66.06 in calibration event outputs and design outputs	Noted
Kc	• Value from calibration is 21 (x3 models), 22 and 25. Values seem reasonable and demonstrate a good calibration can be achieved • Design kc is 21	Noted
IL	• Calibration ILs range from 27mm to 102mm • Design loss used is 39.7mm. The median value was 59mm so a loss of 39.7mm is conservative in this regard.	Noted The adopted rainfall loss (39.7 mm) is the median rainfall loss based on calibration results for three major flood events
CL	• Calibration CLs range from 2.5mm/h to 3.5mm/h compared to the adopted design value of 2.5mm/h which is reasonable. • Consistent with ARR 2019 estimated values	Noted
ARF	• ARF value consistent with total area of the RORB model, and location of gauge at downstream end	Noted
Calibration	• 3 out of 5 calibration runs are plotted (2000 and 2004 events not included). It is understood from JacobsGHD that only the larger floods have been presented. • Calibrations demonstrate good matching to the peak flows, as well as a good match on rising and falling limbs.	Noted. Adopted median rainfall losses and RORB model parameter values were selected for design flood events based on calibration results for three major flood events.
	Commentary on Narromine (Backwater Cowal) RORB Models	
	• BMT understands that following community feedback on the 70% feasibility design, more definition was required within the Narromine RORB model to map overland flow paths. The Narromine model was therefore broken up into five (5) RORB models for the 100% feasibility design. These models provide inflow hydrographs into the associated TUFLOW model that includes the Narromine catchments in the vicinity of the railway alignment.	Noted
	• Routed print locations are at the appropriate location for introduction of inflows into the TUFLOW model for each of the five RORB models which extend upstream of the model boundary.	Noted
	• The range of the subarea sizes in each respective model is appropriate. The larger RORB models have proportionately larger	Noted

Review Item	BMT Review Comments	JGHD Response
	subareas, with all models also having an acceptable minimum number of subareas required for routing.	
	• Reach types are consistently “Type 1 – Natural” throughout all RORB models. This is consistent with the land use and appropriate for the RORB models	Noted
	• Reach delineation is appropriate for all models, leading to appropriate values of the dav parameter used in all RORB models.	Noted
	• Multiple catchment areas have been used for calculations of the areal reduction factor (ARF) in RORB runs. These have been applied for each point upstream inflow into the TUFLOW model. This is an appropriate application of the ARF.	Noted
	• The Initial Loss, Continuing Loss and kc parameters for the five Narromine RORB models are shown in Table 3-6 below. This shows: • ○ The Initial Loss values are consistent with using the Pre-Burst losses from Data Hub • ○ The Continuing Loss values are consistent with the Data Hub losses for RORB models 3 to5 • ○ The Continuing Loss values for RORB models 1 and 2 have been multiplied by a factor of 0.4 in accordance with NSW specific guidance on the Data Hub. • ○ The kc values seem appropriate for the catchment sizes.	Noted. Noted Noted Noted Noted
	• The low loss values may result in peak flow values that are conservative (high) but this is considered a precautionary approach.	Agreed. The adopted rainfall losses for design flood events are conservative. In the absence of recorded stream gauge data and feedback provided by local landowners, a precautionary approach is justified.
	Smaller catchment reviews – 3.4.1 Review commentary	
	• The way in which loss values were selected was initially unclear but later clarified by JacobsGHD who stated that for uncalibrated models a conservative approach was adopted by selecting the lower of the losses from neighbouring calibrated catchments or from the ARR2019 Data Hub.	Noted.
	• This appears to be a conservative approach and one which BMT deems to be appropriate. It is noted by BMT that the rainfall loss values in the smaller catchments seem to be significantly lower than those losses chosen for the design events in the calibrated catchments and those obtained from the DataHub. This will likely	Noted

Review Item	BMT Review Comments	JGHD Response
	lead to conservative flow estimates.	
	• Where kc values have been specified in models that route hydrographs to provide a point input to the hydraulic model i.e. not excess rainfall outputs, how the Kc value has been determined is not specified. Given that initial loss values are conservative then the model outputs are still likely to be conservative but future reporting should include a statement on how kc values have been derived in these models.	Based on calibration and verification results, and in consideration of recommendations in ARR 2019, the RORB hydrology models were parameterised as follows: • Calibrated models –median values of Kc from calibration results • Uncalibrated models – RORB model parameter values were based on ARR 2019 (ie. $\mathbf{K_c = 1.18\ A^{0.46}}$, where, A is the catchment area in square kilometres)
	• The application of the IFD and ARF data is consistent throughout all of the assessed RORB models and have been applied correctly.	Noted
	3.4 Flood Frequency Analysis	
	The rating curves which underpin the FFA analyses appear to rely on the flow to level gaugings undertaken by Water NSW. Further clarification was sought by BMT from JacobsGHD as to how the accuracy of each rating curve used was considered noting that, in general, rating curves from government agencies tend to be less accurate for larger flows once discharge engages the floodplain. JacobsGHD confirmed that flow gauging data and cross sections at the gauges were reviewed. In the case of the Namoi River/Narrabri Creek and Bohena Creek (N2N1 TUFLOW model), the adopted rating curves were compared against TUFLOW model results to verify rating curves which is a best practice approach. JacobsGHD stated that this was not possible for Baradine Creek as the gauge had not been surveyed to Australian Height Datum and was discontinued.	Noted
	Quality checks of the data only appear to be undertaken for large data gaps. It is not clear the degree to which any sanity checks may have been performed to ensure the maximum flow for each year is the actual maximum flow and not an artificial spike (as water level gauges can fail during large events). Commentary should also be made if the 'water year' has been used to calculate the annual maximum flow series, although this is not likely to have any notable bearing on outcomes.	Noted. "Water year" is based on calendar year. There is a reasonable agreement between the FFA results and the other available independent FFA estimates and as such, further sensitivities were not warranted as part of the Feasibility Design.

Review Item	BMT Review Comments	JGHD Response
	The Grubbs Beck test for outliers has been performed for the FFA, however no further sensitivities appear to be undertaken. The FFA derived peak flows for Baradine Creek and Coolbaggie Creek are notably lower than the corresponding flows from the RORB models for events rarer than the 1 in 10 AEP. It would be of value to understand some of the reasons behind these large differences. However, based on discussions with JacobsGHD, the larger RORB flows have been adopted for use on these catchments which is a conservative approach and therefore acceptable.	Noted. The gauging station for Baradine Creek is a discontinued gauge and the gauge zero is not connected to the Australian Height Datum. In addition, JacobsGHD was unable to locate the gauge or the bench mark for the gauge. Hence the RORB simulated peak flows and the FFA estimates were not reconciled and the hydrographs simulated by the RORB model for Baradine Creek were adopted. The proposal does not cross the catchment areas of Coolbaggie Creek and as such, RORB estimated peak flows were not reconciled with the FFA estimates.
	Baradine Creek FFA	
	It is understood from discussions from JacobsGHD that the peak flows from the Baradine Creek FFA were not adopted for design purposes, with higher peak flows from RORB modelling used instead. The gauge on Baradine Creek was also discontinued. The comments summarised below regarding the Baradine Creek FFA are included for completeness but will not affect design flood modelling and no further action is required unless the FFA is used for future purposes.	Noted
	• There are 28 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.	Noted
	• The peak flows from 2002 and 2006 were not included in the analysis. The reasons for the exclusion are not stated. If it is simply that the flows are very low, it is recommended that these years are still included but as censored data so that they do not unduly influence the fit of the distribution for floods at the rare tail end.	Noted
	• The peak flow from 1981 was included in the analysis, however recorded flows commenced in this year and as such 1981 only has a partial record of flows in that year. Given the full year is not available, this should be removed to maintain consistency with the rest of the FFAs but it is not likely to have a notable effect on outcomes.	Noted. To be reviewed as part of detailed design.
	Coolbaggie Creek FFA	

Review Item	BMT Review Comments	JGHD Response
	It is understood from discussions from JacobsGHD that the peak flows from the Coolbaggie Creek FFA were not adopted for design purposes, with higher peak flows from RORB modelling used instead. The comments below regarding the Coolbaggie Creek FFA are included for completeness but will not affect design flood modelling and no further action is required unless the FFA is used for future purposes.	Noted
	• There are 38 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.	Noted
	• The peak flow from 1980 has been removed from the analysis. It is assumed that this was due to the record beginning in November 1980, therefore a full year of data was not available. This is appropriate.	Noted
	• 19 of the 38 years have been censored in the censored assessment. This is a significant proportion and the reasons behind this should be further explored if the FFA is to be used for future purposes.	Noted
	Castlereagh River FFA	
	It is understood that the Castlereagh River FFA is relied upon to obtain peak design flow estimates which the RORB model flows are then scaled to. The FFA “without” censoring was provided for review. The findings from the review are as follows:	Noted
	• There are 33 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.	Noted
	• The peak flows from 1968 and 2004 were removed due to the records not being full years of recorded data. This is appropriate.	Noted
	• Peak flows in 2001 and 2002 were removed. Very small flows were recorded in these two years, all less than 2m3/s, with some missing data from the record in both years. It is assumed that the years were excluded on the basis of the missing data and are therefore ‘incomplete years’ which is recommended practice.	Noted

Review Item	BMT Review Comments	JGHD Response
	• Clarification was sought regarding by how much the RORB flows differed from the FFA derived peak flows. The response from JacobsGHD was that a scaling factor of approximately 1 was used, suggesting that the peak flow estimates from both approaches were in agreement. A comparison was also provided between the peak FFA flows derived in this assessment verses peak FFA flows derived from a previous flood study prepared by Lyall and Associates in 1996. Generally, the peak flows were in agreement with those from the 1996 study and are slightly higher.	Peak FFA flows adopted by Lyall & Associates (Gilgandra Floodplain Management Study (1996)) were derived on the basis of recorded peak stages at the discontinued Gilgandra gauge for the periods 1909-1924, 1944-1978 and 1985-1992, and details on peak gauge heights associated with a number of historic floods, including 1874 and 1890.
	Macquarie River FFA	
	It is understood that the Macquarie River FFA is relied upon to obtain peak design flow estimates which the RORB model flows are then scaled to. The FFA "with" censoring was provided for review. The findings from the review are as follows:	Noted
	• There are 32 years of data in the analysis, more than the minimum recommendation of 10 years to utilise an annual maximum series approach but there will be a large degree of uncertainty when results are extrapolated out to larger flood events such as the 1 in 100 AEP. Due to this uncertainty, other techniques (RORB and RFFE) have also been applied for comparative purposes which is in accordance with best practice.	Noted
	• The peak flow from 2018 was removed from the analysis. It is assumed that this was due to the records not being complete at the time of the data collection.	Noted. The data for the full calendar year was not available at the time of undertaking the analysis.
	• The peak flow from 1986 was included in the analysis, even though records started in June 1986. Given the full year is not available, this should be removed from the analysis to maintain consistency with the rest of the FFAs but is unlikely to result in any change in outcomes.	The upstream gauge, Macquarie River at Dubbo, shows that peak flows occurred during August and September 1986 and hence the peak flow for 1986 was included in the FFA.
	• Clarification was sought regarding by how much the RORB flows differed from the FFA derived peak flows. The response from JacobsGHD was that a scaling factor of approximately 1 was used, suggesting that the peak flow estimates from both approaches were in agreement. A comparison was also provided between the peak FFA flows derived in this assessment verses peak FFA flows derived from a previous flood study prepared by Lyall and Associates in 2013. Generally, the peak flows were in agreement with those from the 2013 study and are slightly higher.	Noted.
	Regional Flood Frequency Estimate (RFFE)	

Review Item	BMT Review Comments	JGHD Response
17	Regional Flood Frequency Estimates have been undertaken for the larger catchments at the gauges. The RFFE is a high level tool that can provide a sense check on peak flow estimates. It often contains large uncertainty bounds but these can be refined through assessing and refining the gauges used within a 'region of influence' to inform the RFFE. It is not clear whether the gauges within the respective regions of influence for each assessed subject site have been further analysed. From discussions with JacobsGHD the sparsity of gauges in the assessed catchments results large regions of influence which are difficult to refine. It is understood the RFFE peak flow estimates have not been relied upon to factor RORB flows and as such the use of this technique as a sense check on peak flows is considered appropriate.	Noted
	Other methods flow estimation methods	
18	For smaller catchments, it is understood that conservative parameters such as the lower bound on initial losses have typically been adopted. This is considered acceptable given the overall uncertainty of peak flow estimation in areas where there is a lack of gauged data. Other techniques that could potentially be applied when validating the smaller catchments include the probabilistic rational method (where applicable), quartile regression technique, or reconcile results with another hydrologic model package such as WBNM. Such techniques would also include a significant degree of uncertainty but may provide an additional validation of peak flows.	Noted RFFE was used to validate the RORB estimated peak flows in this study. If necessary, other methods would be considered during detailed design for further validation of the RORB estimated peak flows for smaller catchments.
	Baseflow	
	Due to their geographic location, baseflow is not expected to have any influence on peak flood modelling results in the catchments under consideration. It is noted however that during model calibration, baseflow has been separated from the recorded hydrographs for calibration of the RORB model. From discussions with JacobsGHD it is understood that the baseflow was found to be almost negligible. It was confirmed with JacobsGHD that baseflow was not then added back into the hydraulic model for water level calibration. Given that the baseflow was assessed by JacobsGHD as being negligible this is not considered to be an issue.	Noted
	TUFLOW Input Hydrographs	

Review Item	BMT Review Comments	JGHD Response
	The hydrographs from the review subset of 10 hydrologic models were reviewed and compared to the inflow hydrographs in the TUFLOW models (as these should be the same). BMT have the following comments:	
	• In all cases the hydrographs used for inputs into the TUFLOW models match the outputs from the hydrology models.	Noted
	• For each of the ten catchments respective TUFLOW models, a single inflow is applied which is the routed total flow from the respective catchment hydrologic model.	Noted
	• The inflow location for the Bohena Creek model ("C-2" in N2N1) is 12km upstream of the printout location for the routed hydrograph. This effectively double routes the flow along this 12km length but is unlikely to result in any significant impact on results	Noted
	• Inflows into the TUFLOW models for catchments D29411, D32008, D68620, D79020 and D86480 are effectively rain on grid inputs as they utilise TUFLOW's '2d_sa ALL' command. This distributes the inflow hydrograph across all grid cells within the defined boundary (which covers the whole catchment area). These input hydrographs have already been routed within the RORB models. It is BMT's understanding that this would lead to routing having occurred twice for these catchments, likely leading to a reduction in peak flows at the downstream end of these catchments. This issue was raised with JacobsGHD who confirmed that it affected a limited number of subcatchments. It was noted by JacobsGHD that the issue affects both calculations for the existing scenario, before Inland Rail, and the operational scenario, after Inland Rail. It was also confirmed that the catchments in question are predominantly rural with a low risk of changes significantly affecting the number of buildings impacted from the existing case to the operational scenario. JacobsGHD has stated that this will be investigated and addressed further as part of the detailed design.	Noted. Relevant TUFLOW models will be updated during detailed design.
	Conclusions	
	BMT has undertaken a review of hydrologic models and the modelling approach for the Narromine to Narrabri (N2N) study. The review identified minor issues that are not anticipated to have a significant impact on the overall model outcomes. The overall approach is a conservative one which is best practice, particularly in those catchments with little or no gauged data.	Noted
	Overall the models are deemed have been appropriately set up except for one identified issue which affects a limited number of	Noted. To be addressed during detailed design.

Review Item	BMT Review Comments	JGHD Response
	subcatchments where routed flows are being distributed evenly across catchments. JacobsGHD were made aware of this issue and have identified a low risk of changes significantly affecting the number of buildings impacted. It is understood that this will be investigated and addressed as part of the detailed design.	Noted. Relevant TUFLOW models will be updated during detailed design

Narromine to Narrabri (N2N) Inland Rail - Review of TUFLOW Models

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Synopsis: Review of TUFLOW models developed for the Inland Rail Project Narromine to Narrabri (N2N) 100% feasibility design package

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1 Introduction

JacobsGHD IR Joint Venture (JacobsGHD) is undertaking civil design of the Narromine to Narrabri (N2N) section of Inland Rail for the Australian Rail Track Corporation Ltd (ARTC).

It is understood that JacobsGHD completed a flood study as part of the Environmental Impact Statement (EIS) in support of the proposed project. BMT Commercial Australia (BMT) was initially engaged by JacobsGHD to conduct a review of their TUFLOW models used as the basis for the flood study at the 70% feasibility design stage of the project. Following the 70% feasibility design review, BMT were again engaged to review the TUFLOW models developed for the 100% feasibility design, noting that only two of fourteen models have changed between the two designs.

This report provides the methodology and outcomes of the review conducted by BMT. It should be noted as per BMT's proposal (agreed by JacobsGHD), the scope of the review is a verification of the basic model elements, and as such must not be taken as a comprehensive review of the models nor the flood study or assessment.

2 Methodology and Review Outcomes

2.1 General

JacobsGHD supplied several TUFLOW models that include various scenarios for the study area. These scenarios were Existing, Design (Operational), Construction and Sensitivity (Manning's 'n' and blockage).

BMT reviewed only the Design scenario for each study area as this is the primary model that contains the proposed design elements including the underlying base conditions.

2.2 Study Areas

The study area stretches from Narromine to Narrabri. Figure 2-1 identifies the study areas covered by the review. Table 2-1 lists the study areas, the design scenario and Tuflow log file(tlf) reviewed.

Table 2-1 Study Areas and Model Files Checked

Study Area	Tuflow log file and Design Scenario checked
NFMv7*	N2N_NFMv7_des21_0100yr_240hr_REV09_10m.tlf
N2N14	N2N_N2N14_DES15_0100yr_CRT_REV04.tlf
N2N13	N2N_N2N13_DES15_0100yr_CRT_REV04.tlf
N11N12	N2N_N2N11N12_des16_0100yr_CRT_REV04.tlf
N2N10	N2N_N2N10_des16_0100yr_CRT_REV04.tlf
N2N9	-N2N_N2N9_des18_0100yrCC_CRT_REV04.tlf
N2N8	N2N8_025_01PCT______D.tlf
N2N7	N2N7_014_01PCT______D__.tlf
N2N6	N2N6_023_01PCT______D.tlf
N2N5	N2N5_025_01PCT______D.tlf
N2N4	N2N4_014_01PCT______D.tlf
N2N23	N2N23_009_01PCT______D__.tlf
N2N1	N2N1_023_01PCT______D.tlf
Narrabri*	Narrabri_014_01PCT______D.tlf

*Only NFMv7 and Narrabri models were supplied for the 100% feasibility design. BMT understands from JacobsGHD that all other models incurred no changes between the 70% feasibility design and the 100% feasibility design.

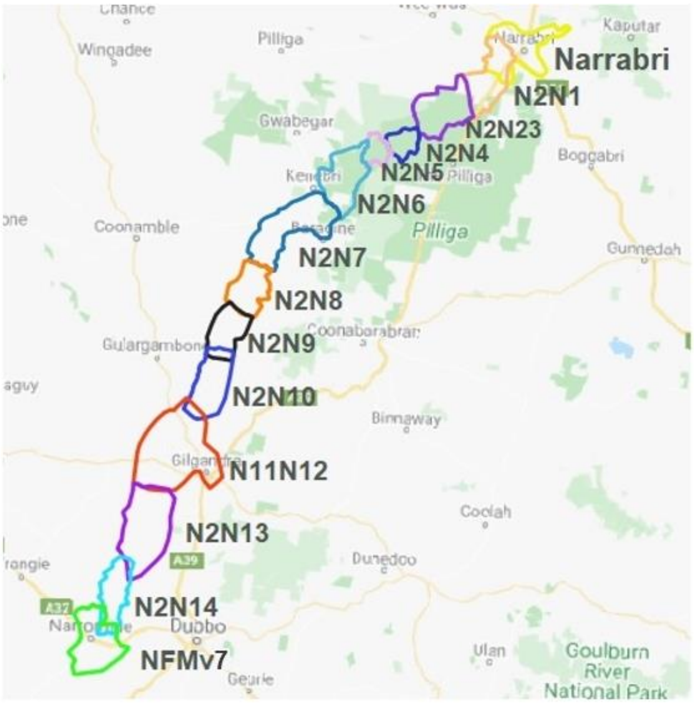

Figure 2-1 Locality Map of Study Areas

2.3 Review Elements

As per BMT's scope of works defined in the proposal, the review was conducted based on the basic elements of the TUFLOW models that are summarised in Table 2-2.

Table 2-2 Basic Elements of Model Review

Model Element	Description
1	Checking for unusual commands with tcf/ecf/tgc/tbc
2	Log file checking for warnings/errors, mass error and negative depths
3	Model extent check against flood extent
4	Material roughness (values and distribution)
5	1D-2D connections
6	Inflow application
7	Bridge losses
8	Culvert losses
9	Grid Size
10	Downstream boundary application
11	Railway design elements checks (DEM and relevant structures)
12	Visual inspection of 2D outflow hydrographs
13*	Visual comparison that modelled results agree with those presented in the Flooding and Hydrology Assessment Technical Report 3

*Review Element 13 was undertaken for the Narrabri and NFMv7 only following their supply to BMT for the 100% feasibility design stage

3 Review Outcomes

3.1 Summary of General Comments

- The proposed bridges were modelled as a Layered Flow Constriction Shape File (lfcsh). The form loss values adopted for the lfcsh are generally in accordance with typical values that are appropriate for the initial assessment. BMT understands that for the proposed Macquarie River and Narrabri viaducts a detailed assessment of form loss values was undertaken at the 100% feasibility design. For the detailed assessment of the remaining bridge structures it is suggested to calculate the final values based on pier configuration, dimension and alignment or model calibration in accordance with industry best practice. The accurate estimation of the above-stated form loss factors can have an impact on the afflux and hence flood impact for the downstream and upstream areas.
- The depth and blockage attributes of Layer 3 of the lfcsh were specified but no form loss was adopted. Whilst this is appropriate where there is no overtopping, the form loss coefficient factor is relevant where overtopping occurs. Hence, it is recommended to apply form loss coefficient for those bridge where overtopping is predicted to occur.
- Some of the bridges were modelled as a 1D structure combined with a HW type (elevation versus width) cross section table. A review of the HW table showed that no small value of width (typically 0.001) was defined at or past the top elevation. This means that if the water surface elevation overtops the top, the width would be artificially extended upwards based on the top width. A check was made at one bridge location and it was found that the PMF flood level did not reach the top of the HW table, so the cross-section definition is appropriate in this case. It is suggested to check all the bridge locations to confirm the validity of the assumption.
- In the case of “2d_SA ALL” inflow applications, the hydrologic sub-catchments were adopted as the SA polygons. The ‘SA All’ approach distributes flows to all cells equally within the SA polygon (i.e. the flows would be routed in the hydraulic model across the entire SA polygon). It was found in BMT’s concurrent review of the associated hydrology models, that these inflows are also routed hydrologically leading to routing having occurred twice for affected catchments. It is understood that JacobsGHD will investigate this issue further as part of the detailed design.
- The Manning’s n values adopted for some sections of the proposed railway line(formation) appear to be high. It appears that the underlying existing roughness were adopted. Whilst this may not have any significant impact where the railway formation is not overtopped, it is recommended to adopt representative values where there is overtopping and cross drainage structures. Note that this issue was amended for both the NFMv7 and Narrabri 100% feasibility design models.
- Whilst the 1D(culvert) entry and exit losses were appropriately specified for the Design scenario, the losses were not completely specified for the existing 1D structures. Whilst these factors are not required to be specified for 1D pipes forming a series of stormwater network (losses are built in), for culverts/pipes directly connected to the 2D domain the losses are required to be specified to derive accurate hydraulic characteristics.

3.2 Common Commentary

Table 3-1 provides commentary that are generally applicable for all the study areas.

Table 3-1 Common Commentary for All Study Areas

Element	Comments or recommendations
1	-No unusual commands were found.
2	-No unusual warnings or errors were found.
3	-Based on the 1:2000 AEP design flood inundation extent, the model extent appears to have adequate coverage.
4	- The Manning's n values are generally considered to be representative of the surface roughness of the study area
5	-The 1D-2D connections are generally in accordance with industry practice.
6	-A combination of 2d_SA, 2d_SA ALL and 2d_bc inflows were adopted that are appropriate for the study
7	-The Form loss coefficient K values adopted for Layer 1 and Layer 2 are as per typical values.
8	-The design cross-drainage structures utilised appropriate entry loss (0.4) and exit loss (1.0) that are generally in accordance with industry practice
9	-Given the extent of the model area and proposed design, a 10m grid size is considered to be appropriate.
10	-A combined HQ and HT downstream boundaries were adopted that are appropriate for the study. -The locations and extents appear to be are a reasonable distance from the area interest and adequate to allow for the transfer/exit of flow from the system
11	-The proposed design surface of the railway was found to have been incorporated into the model. -Several 1D cross-drainage structures were found to have been incorporated with the design with appropriate entry loss (0.5) and exit loss (1.0). -For the proposed bridges, whilst the blockage and form loss attributes were specified for Layer 3, no attribute (zero value) was specified for the depth of this Layer. This needs to be checked.
12	-The 2D outflow hydrographs were found to smooth
13	-For NFMv7 and Narrabri models, mapped outputs agree with model results for instances checked.

3.3 Individual Study Areas Commentary

The following tables present a summary of commentary for each study area.

Table 3-2 NFMv7 Commentary

Element	NFMv3-Comments or recommendations
4	-The main channel of Macquarie River appears to be clear of vegetation. The Manning's n value of 0.065 applied for this part of the river appears to be high. It is suggested to consider a lower n value.
5	-At some 1D structure locations, bed levels were lowered by as much as 2.7m to match the 1D node invert level. Check if these are real.
6	- It was noted that no inflows were applied within the site to the north of Mitchell Highway. This assumption needs to be confirmed to ensure the total flows have not been underestimated. -For a limited number of 2D_SA polygons (8 out of 56), the inflow applied to those polygons has been scaled (increased) using a multiplier factor in the TUFLOW boundary condition database. It appears as though this has been done to compensate for upstream catchment area that is not represented in TUFLOW. There are two issues identified with this approach (termed Type 1 and 2) with the affecting issue dependent on the model set up. These are summarised in Table 3-3 for the 8 affected SA polygons. Whilst the Type 1 issue is expected to have a larger effect on flows than the Type 2 issue, for both Type 1 and Type 2 issues the consequences are likely to have only a minor effect on model results. This is because the erroneous additional area modelled to be contributing flow is small relative to the total contributing catchment area. The affected sub catchments are also at the upstream extent of the respective TUFLOW models and so are located some distance from the railway alignment. It is recommended that the model set up is revised at the next opportunity to update the model as part of the design process.
11	-The proposed bridges and culverts were updated from the 70% feasibility design to include a 10% blockage in layer three of the flow constriction. This was checked and confirmed in this review., whilst the blockage and form loss attributes were specified for Layer 3, no attribute (zero value) was specified for the depth of this Layer. This needs to be checked. -BMT understands that form loss values for the Macquarie River viaduct were updated from the 70% feasibility design. The values have been checked and appear to be within an acceptable range for a structure of this nature. -BMT understands that culverts comprising 13 cells or more have been represented in the 2D domain for the 100% feasibility design. Whilst this is appropriate, BMT has noted two minor issues with the model set up: • A handrail layer (2d_zsh_handrail_v1_L.shp) is included at culvert locations where the culvert is now represented in 2D. This layer adds a value of 0.8m to the cell elevations. This layer is no longer required due to use of layered flow constrictions. Model results are not affected as the handrail layer is later overwritten by elevations contained in the layered flow constriction layer. However it is recommended that this layer is removed at the next opportunity to avoid confusion. • The z-shape layer (2d_zsh_NFM_Smooth_atCulvertAsBrdg_R.shp) applied at culvert locations is assumed to have the intent of lowering cell values to match the invert level of the culvert. This layer is not functioning as intended as the elevation value is ignored by TUFLOW. Instead the elevations around the perimeter used to interpolate values across the polygon. For the elevation to be applied, the 'No Merge' flag needs to be applied to the 'shape options' attribute of the layer. This flag can be included with 'min' to have the desired effect. The implications of this

Element	NFMv3-Comments or recommendations
	are likely to be minor as the layered flow constriction sets the invert level at the structure. The 2D cells within the general vicinity of the culvert which were intended to be lowered will not be lowered to the specified elevation. This may have an influence on modelled conveyance to and from the culverts but is unlikely to have any notable affect for the flood events considered in the assessment.
13	-A sample of model results for the 1% AEP event were visually cross checked against those shown in the Flooding and Hydrology Assessment Technical Report 3 (Appendix H). The checks showed the model results and mapping to be in agreement.

Table 3-3 NFMv7 SA Inflow Commentary

Type	Affected SA Polygons	Description of Issue	Consequence	Recommended Approach
1	1R, 1Z, 3N, 4O, 4X	Scaling factor increases inflow to account for missing catchment area but this is already accounted for as TUFLOW uses RORB flow with no adjustment for area	Overstates local catchment peak flow and volume	Remove scaling factor as area already accounted for using SA approach.
2	1O, 4T, 4H	Scaling factor increases inflow to account for separate upstream sub-area.	Potentially overstates peak flow due to lack of upstream routing	Remove scaling factor and apply upstream sub-area as additional inflow at upstream boundary of TUFLOW model

Table 3-4 N2N14 Commentary

Element	N2N14-Comments or recommendations
4	-The n value 0.03 used for road corridor appears to be higher than the value adopted for the paved road (0.02). It recommended to adopt 0.02 for the road corridor as well.

Table 3-5 N2N13 Commentary

Element	N2N13-Comments or recommendations
4	-Some vegetated areas of the main floodway and floodplain adopted lower Manning's n value (0.045 to 0.05) which are lower than typical values that would be appropriate for vegetated surfaces (0.08 to 0.1). -The n value 0.03 used for road corridor appears to be higher than the value adopted for the paved road (0.02). It recommended to adopt 0.02 for the road corridor as well.
6	-Inflows were applied 2d_sa layers within the floodplain and main waterway which are considered to be appropriate for the study area.
7	-No attributes were defined for Layer 3. This assumption needs be checked to ensure the highest flood level will not overtop the road.

Table 3-6 N11N12 Commentary

Element	N11N12-Comments or recommendations
4	- Manning’s n values adopted for the proposed railway (0.045 to 0.05) appear be slightly higher than typical values, but these are not expected to have a significant impact on the flooding behaviour
6	-The 2d_SA inflow at the upstream part of Castlereagh River should be checked to ensure that the runoff from the downstream catchment areas were represented in the model area.
11	-Some of the proposed bridges adopted zero blockage for Layer 1 (suggesting no piers), but a nominal form loss factor of 0.04 was applied for Layer 1 (typically if there are no piers in the waterway a form loss of zero should be adopted).

Table 3-7 N2N10 Commentary

Element	N2N10-Comments or recommendations
4	- Manning’s n values adopted for the proposed railway (0.045 to 0.05) appear be slightly higher than typical values, but these are not expected to have a significant impact on the flooding behaviour

Table 3-8 N2N9 Commentary

Element	N2N9-Comments or recommendations
4	- Manning’s n values adopted for the proposed railway (0.045 to 0.05) appear be slightly higher than typical values, but these are not expected to have a significant impact on the flooding behaviour
6	- A river inflow was applied as a 2d_bc polyline directly on the grid cells, i.e. the polyline was not snapped to the edge of the active model area(2d_Code). Whilst this does not affect the outcome, the typical practice is to snap or digitise the line along edge of the Code.

Table 3-9 N2N8 to Narrabri Commentary

Element	N2N8-Comments or recommendations
4	-The Manning’s n values adopted for some sections of railway in the 70% feasibility design (0.065 and 0.1) were deemed too high. These have now been amended in the 100% feasibility design to 0.045, which is reasonable.
11	-The following changes were made to the design going from the 70% to the 100% feasibility design: • Manning’s n roughness values for the railway updated (see #4 above) • FLC values for the Narrabri viaduct updated • A 10% blockage adopted for handrails at bridges BMT has checked and confirmed that the above stated changes were appropriately incorporated into the model.
13	-A sample of model results for the 1% AEP event were visually cross checked against those shown in the Flooding and Hydrology Assessment Technical Report 3. The checks showed the model results and mapping to be in agreement.

Table 3-10 N2N7 Commentary

Element	N2N7-Comments or recommendations
7	-A high percentage blockage (25%) was adopted for a bridge within Layer 1; this needs to be confirmed to ensure the adopted value is realistic.

4 Conclusions

BMT completed a verification of the basic elements of the TUFLOW models of the Narromine to Narrabri (N2N) study area developed by JacobsGHD. The review identified minor issues that are not anticipated to have a significant impact on the overall model outcome. Overall, the models are deemed to have been appropriately set up and the basic model outputs were found to be sensible.

It is however noted that the scope of the review is a verification of the basic model elements, and as such must not be taken as a comprehensive review of the models nor the flood study or assessment.

BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.

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N2N Responses to BMT-WBM Independent Hydraulic Model Review

Element	BMT Review Comments	JGHD Response
	Summary of General Comments	
	The proposed bridges were modelled as a Layered Flow Constriction Shape File (lfcsh). The form loss values adopted for the lfcsh are generally in accordance with typical values that are appropriate for the initial assessment. BMT understands that for the proposed Macquarie River and Narrabri viaducts a detailed assessment of form loss values was undertaken at the 100% feasibility design. For the detailed assessment of the remaining bridge structures it is suggested to calculate the final values based on pier configuration, dimension and alignment or model calibration in accordance with industry best practice. The accurate estimation of the above-stated form loss factors can have an impact on the afflux and hence flood impact for the downstream and upstream areas.	A generic approach has been adopted in combination with blockage due to piers for the majority of the new bridges excluding the proposed Macquarie River and Narrabri viaducts. Hence, generally a conservative approach has been adopted in the estimation of energy losses at the majority of new bridges for the proposal. The adopted generic approach will be updated based on the detailed information on bridge piers, skewness, scour protection etc. at the detailed design stage to minimise the potential impacts to buildings, rail lines, roads and watercourses during construction and operation of the proposal.
	The depth and blockage attributes of Layer 3 of the lfcsh were specified but no form loss was adopted. Whilst this is appropriate where there is no overtopping, the form loss coefficient factor is relevant where overtopping occurs. Hence, it is recommended to apply form loss coefficient for those bridge where overtopping is predicted to occur.	A loss coefficient of 1.56 has been adopted for bridge deck and parapet for the majority of bridges. Soffits of the bridges are located above the one per cent AEP flood event and hence modelled flood levels below bridge decks are not influenced by the adopted loss coefficient. Form loss coefficients for layer three (ie. hand rails) are expected to be negligible as hand rails are most likely to be washed away during flood events which result in overtopping of the rail formation.
	Some of the bridges were modelled as a 1D structure combined with a HW type (elevation versus width) cross section table. A review of the HW table showed that no small value of width (typically 0.001) was defined at or past the top elevation. This means that if the water surface elevation overtops the top, the width would be artificially extended upwards based on the top width. A check was made at one bridge location and it was found that the PMF flood level did not reach the top of the HW table, so the cross-section definition is appropriate in this case. It is suggested to check all the bridge locations to confirm the validity of the assumption.	The adopted maximum height of box culverts is three metres. A plank bridge has been selected to replace a culvert higher than three metres. Single span plank bridges have been represented as 1D structures and soffit levels of all plank bridges are located below the one per cent AEP flood levels. The HW table will be updated to define a small width (typically 0.001) at bridge soffit at the detailed design stage.
	In the case of “2d_SA ALL” inflow applications, the hydrologic sub-catchments were adopted as the SA polygons. The ‘SA All’ approach distributes flows to all cells equally within the SA polygon (i.e. the flows would be routed in the hydraulic model across the entire SA polygon). It was found in BMT’s concurrent review of the associated hydrology models, that these inflows are also routed hydrologically leading to routing having occurred twice for affected catchments. It is understood	This approach was adopted by JacobsGHD at the Reference Design stage. Models will be refined and updated as part of the detailed design.

Element	BMT Review Comments	JGHD Response
	that JacobsGHD will investigate this issue further as part of the detailed design.	
	The Manning's n values adopted for some sections of the proposed railway line(formation) appear to be high. It appears that the underlying existing roughness were adopted. Whilst this may not have any significant impact where the railway formation is not overtopped, it is recommended to adopt representative values where there is overtopping and cross drainage structures. Note that this issue was amended for both the NFMv7 and Narrabri 100% feasibility design models.	The rail formation is not overtopped in the one per cent AEP event with climate change and hence the adopted roughness values will not impact on adopted flooding impacts up to and including the one per cent AEP event with climate change. The adopted high Manning's n values for the rail formation in other TUFLOW models will be updated during detailed design.
	Whilst the 1D(culvert) entry and exit losses were appropriately specified for the Design scenario, the losses were not completely specified for the existing 1D structures. Whilst these factors are not required to be specified for 1D pipes forming a series of stormwater network (losses are built in), for culverts/pipes directly connected to the 2D domain the losses are required to be specified to derive accurate hydraulic characteristics.	The rail formation is generally located away from the existing transverse drainage structures and consequently, flood behaviour along the rail formation are generally not influenced by the existing drainage structures.
	Common Commentary for All Study Areas	
1	No unusual commands were found.	Noted
2	No unusual warnings or errors were found.	Noted
3	Based on the 1:2000 AEP design flood inundation extent, the model extent appears to have adequate coverage.	Noted
4	The Manning's n values are generally considered to be representative of the surface roughness of the study area	Noted
5	The 1D-2D connections are generally in accordance with industry practice.	Noted
6	A combination of 2d_SA, 2d_SA ALL and 2d_bc inflows were adopted that are appropriate for the study	Noted
7	The Form loss coefficient K values adopted for Layer 1 and Layer 2 are as per typical values.	Noted
8	The design cross-drainage structures utilised appropriate entry loss (0.4) and exit loss (1.0) that are generally in accordance with industry practice	Noted
9	Given the extent of the model area and proposed design, a 10m grid size is considered to be appropriate.	Noted
10	A combined HQ and HT downstream boundaries were adopted that are appropriate for the study.	Noted

Element	BMT Review Comments	JGHD Response
	The locations and extents appear to be are a reasonable distance from the area interest and adequate to allow for the transfer/exit of flow from the system	Noted
11	The proposed design surface of the railway was found to have been incorporated into the model.	Noted
	Several 1D cross-drainage structures were found to have been incorporated with the design with appropriate entry loss (0.5) and exit loss (1.0).	Noted
	For the proposed bridges, whilst the blockage and form loss attributes were specified for Layer 3, no attribute (zero value) was specified for the depth of this Layer. This needs to be checked.	Soffits of the proposed bridges are located above the one per cent AEP flood levels and hence modelled flood levels below bridge decks are not influenced by the adopted loss coefficient. Form loss coefficients for layer three (ie. hand rails) are expected to be negligible as hand rails are most likely to be washed away during major flood events which result in overtopping of the rail formation.
12	The 2D outflow hydrographs were found to smooth	Noted.
13	For NFMv7 and Narrabri models, mapped outputs agree with model results for instances checked.	Noted.
	NFMv7 Commentary	
4	The main channel of Macquarie River appears to be clear of vegetation. The Manning's n value of 0.065 applied for this part of the river appears to be high. It is suggested to consider a lower n value	The Macquarie River is a regulated river and landowners are not generally permitted to clear floating debris and remove snags from the river. The floating debris and snags have the potential to impede flood flow resulting in higher energy losses. The adopted Manning's n values for the main channel of the Macquarie River are in agreement with previous flood studies (Bewsher, 1998; Lyall, 2009, and Lyall, 2013) for Narromine.
5	At some 1D structure locations, bed levels were lowered by as much as 2.7m to match the 1D node invert level. Check if these are real.	The subject 1D structures are defined in the model to represent the existing pits and pipes stormwater network in the township of Narromine. These structures were included in the TUFLOW model provided by Narromine Shire Council. The subject 1D structures are located away from the proposal and the structures are unlikely to influence the flooding assessment undertaken for the proposal.
6	It was noted that no inflows were applied within the site to the north of Mitchell Highway. This assumption needs to be confirmed to ensure the total flows have not been underestimated.	The Macquarie River has a catchment area of approximately 25,900 square kilometres. The catchment area located north of Mitchell Highway is only a few square kilometres which will have negligible influence on the adopted inflows for the Macquarie River.
	For a limited number of 2D_SA polygons (8 out of 56), the inflow applied to those polygons has been scaled (increased) using a multiplier factor in the TUFLOW boundary condition database. It	Catchment areas for the identified eight 2D_SA polygons vary between 1.0 to 8.7 square kilometres and the average size of the contributing catchment area is 4.0 square kilometres. Scaling up of

Element	BMT Review Comments	JGHD Response
	appears as though this has been done to compensate for upstream catchment area that is not represented in TUFLOW. There are two issues identified with this approach (termed Type 1 and 2) with the affecting issue dependent on the model set up. These are summarised in Table 3-3 for the 8 affected SA polygons	inflows for the eight catchments provide conservative peak flows at the rail formation. Hence, no scaling factors will be used at the detailed design stage.
	Whilst the Type 1 issue is expected to have a larger effect on flows than the Type 2 issue, for both Type 1 and Type 2 issues the consequences are likely to have only a minor effect on model results. This is because the erroneous additional area modelled to be contributing flow is small relative to the total contributing catchment area. The affected sub catchments are also at the upstream extent of the respective TUFLOW models and so are located some distance from the railway alignment. It is recommended that the model set up is revised at the next opportunity to update the model as part of the design process	No scaling factors will be used at the detailed design stage for the eight 2D_SA polygons.
11	For the proposed bridges, whilst the blockage and form loss attributes were specified for Layer 3, no attribute (zero value) was specified for the depth of this Layer. This needs to be checked.	Soffits of the proposed bridges are located above the one per cent AEP flood event and hence modelled flood levels below bridge decks are not influenced by the adopted loss coefficient. Appropriate form loss coefficients for Layer three will be applied in the detailed design.
	BMT understands that form loss values for the Macquarie River viaduct were updated from the 70% design. The values have been checked and appear to be within an acceptable range for a structure of this nature.	Noted
	BMT understands that culverts comprising 13 cells or more have been represented in the 2D domain for the 100% design. Whilst this is appropriate, BMT has noted two minor issues with the model set up:	Noted
	• A handrail layer (2d_zsh_handrail_v1_L.shp) is included at culvert locations where the culvert is now represented in 2D. This layer adds a value of 0.8m to the cell elevations. This layer is no longer required due to use of layered flow constrictions. Model results are not affected as the handrail layer is later overwritten by elevations contained in the layered flow constriction layer. However it is recommended that this layer is removed at the next opportunity to avoid confusion.	The handrail layer (2d_zsh_handrail_v1_L.shp) will be excluded from the model set up at the detailed
	• The z-shape layer (2d_zsh_NFM_Smooth_atCulvertAsBrdg_R.shp) applied at culvert locations is assumed to have the intent of lowering cell values to match the invert level of the culvert. This layer is not functioning as intended as the elevation value is ignored by TUFLOW. Instead the elevations around the perimeter used to interpolate values across the polygon. For the elevation to be	Noted. The TUFLOW model will be updated at the detailed design stage to resolve the minor issue.

Element	BMT Review Comments				JGHD Response
	applied, the 'No Merge' flag needs to be applied to the 'shape options' attribute of the layer. This flag can be included with 'min' to have the desired effect. The implications of this are likely to be minor as the layered flow constriction sets the invert level at the structure. The 2D cells within the general vicinity of the culvert which were intended to be lowered will not be lowered to the specified elevation. This may have an influence on modelled conveyance to and from the culverts but is unlikely to have any notable affect for the flood events considered in the assessment.				
	NFMv7 SA Inflow Commentary				
Type	Affected SA Polygons	Description of Issue	Consequence	Recommended Approach	
1	1R, 1Z, 3N, 4O, 4X	Scaling factor increases inflow to account for missing catchment area but this is already accounted for as TUFLOW uses RORB flow with no adjustment for area	Overstates local catchment peak flow and volume	Remove scaling factor as area already accounted for using SA approach.	Agreed. No scaling factors will be used at the detailed design stage for the identified 2D_SA polygons.
2	1O, 4T, 4H	Scaling factor increases inflow to account for separate upstream sub-area.	Potentially overstates peak flow due to lack of upstream routing	Remove scaling factor and apply upstream sub-area as additional inflow at upstream boundary of TUFLOW model	Agreed. No scaling factors will be used at the detailed design stage for the identified 2D_SA polygons.
	N2N14 Commentary				

Element	BMT Review Comments	JGHD Response
4	The n value 0.03 used for road corridor appears to be higher than the value adopted for the paved road (0.02). It recommended to adopt 0.02 for the road corridor as well	The difference between the adopted Manning's n value for road and the typical Manning's n value for road is small and the small difference is unlikely to impact on flooding assessment undertaken for the proposal.
	N2N13 Commentary	
4	Some vegetated areas of the main floodway and floodplain adopted lower Manning's n value (0.045 to 0.05) which are lower than typical values that would be appropriate for vegetated surfaces (0.08 to 0.1).	Agreed. further refinement in detailed design stage is recommended. Given that the proposal is located on hillside in this area and the majority of the new cross drainage works being bridge structures with more than 5 – 8 metre clearance, the adopted lower Manning's n values would have no impact on the design.
	The n value 0.03 used for road corridor appears to be higher than the value adopted for the paved road (0.02). It recommended to adopt 0.02 for the road corridor as well	The difference between the adopted Manning's n value for road and the typical Manning's n value for road is small and the small difference is unlikely to impact on flooding assessment undertaken for the proposal.
6	Inflows were applied 2d_sa layers within the floodplain and main waterway which are considered to be appropriate for the study area.	Noted
7	No attributes were defined for Layer 3. This assumption needs be checked to ensure the highest flood level will not overtop the road.	Soffits of the proposed bridges are located above the one per cent AEP flood levels and hence modelled flood levels below bridge decks are not influenced by the adopted loss coefficient. Appropriate form loss coefficients for Layer three will be applied in the detailed design
	N11N12 Commentary	
4	Manning's n values adopted for the proposed railway (0.045 to 0.05) appear be slightly higher than typical values, but these are not expected to have a significant impact on the flooding behaviour	The rail formation is not overtopped in the one per cent AEP event with climate change and hence the adopted roughness values will not impact on flood behaviour up to and including the one per cent AEP event with climate change.
6	The 2d_SA inflow at the upstream part of Castlereagh River should be checked to ensure that the runoff from the downstream catchment areas were represented in the model area.	The Castlereagh River has a catchment area of approximately 6,630 square kilometres at the proposal. The catchment area located downstream of the proposal is very small in comparison to the catchment area of the Castlereagh River located upstream of the proposal and hence rainfall runoff generated from the smaller catchment located downstream of the proposal has been ignored.
11	Some of the proposed bridges adopted zero blockage for Layer 1 (suggesting no piers), but a nominal form loss factor of 0.04 was applied for Layer 1 (typically if there are no piers in the waterway a form loss of zero should be adopted).	A review of the model confirms that blockage factors have been adopted for all bridges included in the proposal.
	N2N10 Commentary	

Element	BMT Review Comments	JGHD Response
4	Manning's n values adopted for the proposed railway (0.045 to 0.05) appear be slightly higher than typical values, but these are not expected to have a significant impact on the flooding behaviour	The rail formation is not overtopped in the one per cent AEP event with climate change and hence the adopted roughness values will not impact on flood behaviour up to and including the one per cent AEP event with climate change.
	N2N9 Commentary	
4	Manning's n values adopted for the proposed railway (0.045 to 0.05) appear be slightly higher than typical values, but these are not expected to have a significant impact on the flooding behaviour	The rail formation is not overtopped in the one per cent AEP event with climate change and hence the adopted roughness values will not impact on flood behaviour up to and including the one per cent AEP event with climate change.
6	A river inflow was applied as a 2d_bc polyline directly on the grid cells, i.e. the polyline was not snapped to the edge of the active model area(2d_Code). Whilst this does not affect the outcome, the typical practice is to snap or digitise the line along edge of the Code.	Noted. The inflow for the river will be defined along the edge of the 2d_Code in the detailed design.
	N2N8 to Narrabri Commentary	
4	The Manning's n values adopted for some sections of railway in the 70% feasibility design (0.065 and 0.1) were deemed too high. These have now been amended in the 100% feasibility design to 0.045, which is reasonable.	The rail formation is not overtopped in the one per cent AEP event with climate change and hence the adopted roughness values will not impact on flood behaviour up to and including the one per cent AEP event with climate change. The adopted high Manning's n values for the rail formation will be updated as part of the detailed design.
11	The following changes were made to the design going from the 70% to the 100% design: • Manning's n roughness values for the railway updated (see #4 above) • FLC values for the Narrabri viaduct updated • A 10% blockage adopted for handrails at bridges BMT has checked and confirmed that the above stated changes were appropriately incorporated into the model.	Noted
13	A sample of model results for the 1% AEP event were visually cross checked against those shown in the Flooding and Hydrology Assessment Technical Report 3. The checks showed the model results and mapping to be in agreement.	Noted
	N2N7 Commentary	
7	A high percentage blockage (25%) was adopted for a bridge within Layer 1; this needs to be confirmed to ensure the adopted value is realistic.	The adopted 25 per cent blockage accounts for blockage due to piers, abutments and skew of the bridge. The adopted blockage and bridge loss coefficients will be updated at the detailed design stage.

TECHNICAL REPORT

3

Flooding and hydrology assessment

Appendix C Modelled catchment peak flows

Table C-1 Peak discharges and critical storm duartion estimated by hydrology models

Watercourse	Name of Hydrology model	Catchment Area (km^2)	TUFLOW model Name	Name of Inflow in TUFLOW Model	20% AEP		5% AEP		2% AEP		1% AEP		0.5% AEP		1% AEP+CC		0.2% AEP		0.05% AEP		PMF	
					Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)
Macquarie River	MAC	25,900	NFM	MAC	484	36.0	1,553	24.0	2,684	24.0	4,124	24.0	5,968	24.0	6,679	24.0	8,339	24.0	12,003	24.0	40,000	-
Unnamed tributary of Blackwater Cowal	NFM_RORB1	34	NFM	Inflow_1, Inflow_2	68	9.0	106	6.0	130	5.0	154	5.0	191	3.0	199	3.0	235	3.0	314	3.0	1,497	2.5
Unnamed tributary of Blackwater Cowal	NFM_RORB2	28	NFM	Inflow_3	44	9.0	70	6.0	83	6.0	100	6.0	124	6.0	128	6.0	152	6.0	200	6.0	901	3.0
Unnamed tributary of Blackwater Cowal	NFM_RORB2	26	NFM	Inflow_4, Inflow_5	47	9.0	77	6.0	92	6.0	110	6.0	136	5.0	141	4.5	166	4.5	219	4.5	1,005	3.0
Unnamed tributary of Blackwater Cowal	NFM_RORB2	11	NFM	Inflow_6	21	9.0	32	6.0	40	4.5	48	4.5	60	4.5	62	4.5	74	3.0	99	3.0	383	2.5
Wallaby Creek	NFM_RORB3	133	NFM	Inflow_7	224	12.0	348	12.0	420	12.0	480	12.0	610	12.0	640	12.0	772	12.0	1,024	12.0	5,123	2.5
Yellow Creek	NFM_RORB4	60	NFM	Inflow_8	124	9.0	204	6.0	245	3.0	298	3.0	366	3.0	385	3.0	447	3.0	599	2.0	2,507	2.0
Unnamed tributary of Ewenmar Creek	D37717	5	N2N14	G1A_D_22	12	12.0	19	6.0	25	4.5	31	4.5	44	2.0	43	3.0	56	2.0	89	1.5	471	2.0
Unnamed tributary of Ewenmar Creek	D40467	13	N2N14	G1A_D_21	26	12.0	43	6.0	56	4.5	68	4.5	95	3.0	92	3.0	124	3.0	202	2.0	1,008	2.0
Unnamed tributary of Ewenmar Creek	D43307	6	N2N14	G1A_D_20	12	12.0	20	6.0	27	4.5	32	4.5	46	2.0	43	2.0	60	2.0	95	1.5	467	2.0
Unnamed tributary of Kookaburra Creek	D26082	2	N2N14	G1A_D_3,G1A_D_4, G1A_D_5,G1A_D_6, G1A_D_7,G1A_D_8	6	12.0	10	6.0	12	4.5	15	3.0	22	2.0	21	2.0	28	2.0	45	1.5	216	1.5
Unnamed tributary of Macquarie River	D17992	12	N2N14	G1A_D_17	23	12.0	35	6.0	46	4.5	56	4.5	75	4.5	74	4.5	96	2.0	153	2.0	755	2.0
Unnamed tributary of Macquarie River	D20251	8	N2N14	G1A_D_16	16	12.0	26	6.0	34	4.5	42	4.5	57	2.0	54	4.5	73	2.0	117	2.0	590	2.0
Unnamed tributary of Macquarie River	D28436	2	N2N14	G1A_D_15	4	12.0	7	6.0	9	4.5	11	2.0	16	2.0	15	2.0	20	2.0	33	1.5	158	1.5
Unnamed tributary of Macquarie River	D24681	4	N2N14	G1A_D_14	10	12.0	16	6.0	21	4.5	25	4.5	36	2.0	33	2.0	46	2.0	72	2.0	359	2.0
Unnamed tributary of Macquarie River	D23044	6	N2N14	G1A_D_13	13	12.0	21	6.0	28	4.5	34	4.5	49	2.0	46	2.0	63	2.0	101	1.5	480	2.0
Unnamed tributary of Kookaburra Creek	D32008	3	N2N14	G1A_D_12	8	12.0	12	6.0	16	4.5	19	4.5	27	2.0	25	2.0	36	2.0	57	1.5	283	2.0
Unnamed tributary of Kookaburra Creek	D29973	2	N2N14	G1A_D_11	4	12.0	6	6.0	8	2.0	10	2.0	16	2.0	15	2.0	20	2.0	32	0.8	151	1.5
Unnamed tributary of Kookaburra Creek	D29411	2	N2N14	G1A_D_10	6	12.0	9	4.5	12	4.5	15	2.0	22	2.0	21	2.0	29	2.0	47	1.5	219	1.5
Unnamed tributary of Kookaburra Creek	D26082	2	N2N14	G1A_D_9	6	12.0	10	6.0	12	4.5	15	3.0	22	2.0	21	2.0	28	2.0	45	1.5	216	1.5
Unnamed tributary of Macquarie River	D29660	3	N2N14	G1A_D_2	6	9.0	11	4.5	14	4.5	17	3.0	25	2.0	24	2.0	32	2.0	51	1.5	258	1.5
Unnamed tributary of Macquarie River	D31000	2	N2N14	G1A_D_1	5	12.0	9	6.0	12	4.5	14	4.5	21	2.0	19	2.0	27	1.5	45	1.5	214	1.5
Unnamed tributary of Macquarie River	D33020	3	N2N14	G1A_D_0	7	12.0	11	6.0	15	4.5	18	4.5	27	2.0	25	2.0	35	2.0	56	1.5	278	1.5
Ewenmar Creek	D46320	151	N2N13/N2N14	G2D_0	132	12.0	242	9.0	335	9.0	401	12.0	518	6.0	523	12.0	655	6.0	976	4.5	4,580	4.0
Unnamed tributary of Milpulling Creek	D57277	2	N2N13	G2_D_16	5	12.0	8	6.0	11	4.5	13	4.5	19	2.0	17	2.0	25	2.0	41	1.5	177	1.0
Unnamed tributary of Milpulling Creek	D58602	2	N2N13	G2_D_15	4	12.0	6	6.0	8	4.5	10	4.5	15	2.0	14	2.0	19	2.0	32	1.5	140	1.0
Kickabil Creek	D55490	109	N2N13	G2D_3,G3D_4, G3D_8,G3D_9	80	24.0	169	12.0	238	9.0	295	9.0	398	9.0	399	9.0	499	6.0	784	4.5	3,369	4.0
Emogandry Creek	D51940	79	N2N13	G2D_1,G2D_2	79	12.0	152	12.0	207	9.0	249	9.0	319	6.0	326	9.0	401	6.0	618	4.5	2,621	4.0
Milpulling Creek	D62900	71	N2N13	G2D_5,G2D_6, G2D_12,G2D_13	82	12.0	151	9.0	201	9.0	237	9.0	309	4.5	308	9.0	399	4.5	605	3.0	2,526	4.0
Unnamed tributary of Bundijoe Creek	D65600	1	N2N13	G2_D_18	3	12.0	5	6.0	7	4.5	8	2.0	13	2.0	12	2.0	17	2.0	29	0.8	120	1.0
Bundijoe Creek	D68620	33	N2N13	G2_D_11	38	12.0	74	9.0	101	9.0	121	9.0	157	4.5	154	9.0	199	4.5	313	3.0	1,354	3.0
Bundijoe Creek	D71660	29	N2N13	G2D_7, G2D_10	40	12.0	75	9.0	98	9.0	114	9.0	155	4.5	148	4.5	196	4.5	313	3.0	1,360	2.0
Unnamed tributary of Bootha Guy Creek	D74787	10	N2N11N12	G3D_19	18	12.0	28	9.0	36	9.0	42	4.5	63	4.5	59	4.5	79	4.5	131	2.0	555	2.0
Bootha Guy Creek	D76000	17	N2N11N12	G3D_18	29	12.0	51	9.0	63	4.5	79	4.5	110	3.0	107	4.5	144	3.0	229	2.0	1,005	2.0
Unnamed tributary of Bootha Guy Creek	D79020	26	N2N11N12	G3D_17	35	12.0	65	9.0	83	9.0	98	9.0	139	4.5	134	4.5	176	4.5	279	3.0	1,165	2.0
Castlereagh River	CAS	6,722	N2N11N12	G4D_0,G4D_1	804	-	2,139	-	3,299	-	4,283	-	5,260	-	5,402	-	6,982	-	9,589	-	27,321	-
Marthaguy Creek	D83970	416	N2N11N12	G3D_5, G3D_6	265	36.0	499	48.0	738	18.0	876	18.0	1,112	9.0	1,143	18.0	1,389	9.0	1,982	9.0	8,722	6.0
Unnamed tributary of Merrigal Creek	D86480	16	N2N11N12	G3D_16	18	12.0	36	12.0	52	9.0	63	9.0	83	4.5	80	9.0	106	4.5	170	3.0	752	2.0
Unnamed tributary of Merrigal Creek	D90180	23	N2N11N12	G3D_0, G3D_1, G3D_3,G3, D_24	36	12.0	62	9.0	77	4.5	95	4.5	130	4.5	129	4.5	163	3.0	260	3.0	1,174	2.0
Unnamed tributary of Merrigal Creek	D91440	1	N2N11N12	G3D_15	3	12.0	6	6.0	7	4.5	9	4.5	13	1.0	12	2.0	17	0.8	28	0.8	115	1.0
Unnamed tributary of Merrigal Creek	D93020	2	N2N11N12	G3D_14	4	12.0	6	6.0	8	4.5	9	4.5	14	1.5	14	2.0	19	1.5	31	1.5	138	1.0
Unnamed tributary of Bullagreen Creek	D94260	9	N2N11N12	G3D_13	15	12.0	27	9.0	35	4.5	42	4.5	58	3.0	55	4.5	74	3.0	116	2.0	534	2.0
Unnamed tributary of Bullagreen Creek	D96540	26	N2N11N12	G3D_2, G3D_4, G3D_21, G3D_22	38	12.0	66	9.0	82	9.0	98	4.5	135	4.5	135	4.5	168	4.5	266	3.0	1,193	2.0
Unnamed tributary of Bullagreen Creek	D98220	2	N2N11N12	G3D_23	5	12.0	8	6.0	10	4.5	12	4.5	18	2.0	17	2.0	23	2.0	38	1.5	174	1.0
Unnamed tributary of Castlereagh River	D99840	6	N2N11N12	G3D_20	13	12.0	20	6.0	25	4.5	31	4.5	43	2.0	42	4.5	55	2.0	88	1.5	389	1.5
Unnamed tributary of Bullagreen Creek	D93020	0	N2N11N12	G3D_12	1	12.0	2	6.0	2	4.5	3	4.5	4	1.5	4	2.0	5	1.5	9	1.5	40	1.0
Unnamed tributary of Bullagreen Creek	D93020	0	N2N11N12	G3D_11	1	12.0	1	6.0	1	4.5	2	4.5	3	1.5	2	2.0	3	1.5	6	1.5	25	1.0
Unnamed tributary of Bullagreen Creek	D93020	1	N2N11N12	G3D_10	3	12.0	4	6.0	5	4.5	6	4.5	9	1.5	9	2.0	12	1.5	20	1.5	91	1.0
Unnamed tributary of Marrigal Creek	D93020	1	N2N11N12	G3D_9	1	12.0	2	6.0	3	4.5	3	4.5	5	1.5	5	2.0	6	1.5	10	1.5	47	1.0
Unnamed tributary of Merrigal	D88825	2	N2N11N12	G3D_8	4	12.0	6	6.0	8	4.5	10	4.5	14	2.0	12	2.0	19	2.0	32	0.8	144	1.0
Unnamed in tributary of Marthaguy	D81546	5	N2N11N12	G3D_7	11	12.0	16	6.0	22	4.5	26	4.5	36	2.0	34	4.5	47	0.8	80	0.8	313	1.0
Unnamed tributary of Gulargambone Creek	D117640	25	N2N10	G5D_1,G5D_16	40	12.0	65	9.0	85	9.0	97	9.0	129	3.0	130	4.5	163	3.0	249	2.0	1,461	3.0

Watercourse	Name of Hydrology model	Catchment Area (km^2)	TUFLOW model Name	Name of Inflow in TUFLOW Model	20% AEP		5% AEP		2% AEP		1% AEP		0.5% AEP		1% AEP+CC		0.2% AEP		0.05% AEP		PMF	
					Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)	Qp (m^3/s)	Duration (h)
Unnamed tributary of Gulargambone Creek	D118420	3	N2N10	G5D_2	7	12.0	10	6.0	13	4.5	15	4.5	22	2.0	21	2.0	28	2.0	45	0.8	237	2.0
Unnamed tributary of Mariemon Creek	D115630	3	N2N10	G5D_20	8	12.0	11	6.0	15	4.5	17	4.5	25	0.8	23	2.0	31	0.8	50	0.8	255	2.0
Unnamed tributary of Gulargambone Creek	D119660	7	N2N10	G5D_3	15	12.0	24	6.0	29	4.5	36	4.5	49	4.5	50	4.5	62	2.0	98	1.5	545	2.0
Unnamed tributary of Gulargambone Creek	D121860	4	N2N10	G5D_31	8	12.0	13	6.0	17	4.5	20	4.5	28	2.0	27	2.0	36	2.0	56	1.5	304	2.0
Gulargambone Creek including Paddys CK	D123150	243	N2N10	G5D_4,G5D_5, G5D_6,G5D_18	184	36.0	354	48.0	490	18.0	567	18.0	719	9.0	737	9.0	868	9.0	1,224	4.5	7,165	5.0
Unnamed tributary of Gulargambone Creek	D125500	29	N2N10	G5D_7,G5D_8	44	12.0	74	9.0	97	9.0	111	9.0	145	4.5	148	4.5	176	3.0	272	3.0	1,636	3.0
Unnamed tributary of Gulargambone Creek	D126300	10	N2N10	G5D_9,G5D_10	21	12.0	32	6.0	40	4.5	48	4.5	68	4.5	68	4.5	81	4.5	127	2.0	703	2.0
Unnamed tributary of Baronne Creek	D127880	9	N2N10	G5D_19	18	12.0	28	6.0	35	4.5	43	4.5	60	3.0	59	4.5	74	2.0	116	2.0	669	2.0
Unnamed tributary of Mariemon Creek	D111020	23	N2N10	G5D_14	36	12.0	55	9.0	74	9.0	85	9.0	114	4.5	110	4.5	143	4.5	213	2.0	1,183	3.0
Judes Creek	D106690	30	N2N10	G5D_0,G5D_12, G5D_13	39	12.0	71	9.0	89	9.0	105	9.0	143	4.5	142	4.5	174	4.5	268	3.0	1,260	3.0
Unnamed tributary of Mariemon Creek	D114780	12	N2N10	G5D_15	22	12.0	35	9.0	44	4.5	53	4.5	73	3.0	72	4.5	90	3.0	144	2.0	771	2.0
Unnamed tributary of Judes Creek	D111020	23	N2N10	G5D_21	1	12.0	1	9.0	1	9.0	1	9.0	2	4.5	2	4.5	2	4.5	4	2.0	20	3.0
Unnamed tributary of Baronne Creek	D128980	5	N2N9	G5D_11	11	12.0	17	6.0	21	4.5	25	4.5	36	2.0	35	2.0	45	2.0	70	1.5	375	2.0
Unnamed tributary of Baronne Creek	D130040	15	N2N9	G6D_7,G6D_8	26	12.0	46	9.0	57	4.5	67	4.5	94	3.0	91	3.0	116	3.0	177	2.0	1,020	2.0
Unnamed tributary of Baronne Creek	D130840	22	N2N9	G6D_3	38	12.0	62	9.0	78	9.0	91	4.5	123	3.0	124	4.5	154	3.0	237	2.0	1,359	3.0
Unnamed tributary of Baronne Creek	D135300	12	N2N9	G6D_6	22	12.0	35	9.0	45	9.0	54	4.5	74	4.5	72	4.5	90	4.5	137	2.0	788	2.0
Baronne Creek	D132700	389	N2N9	G6D_9,Baronne_US	365	36.0	688	48.0	909	18.0	1,037	18.0	1,305	12.0	1,368	12.0	1,550	12.0	2,103	6.0	10,882	4.0
Unnamed tributary of Worinjerong	D138980	3	N2N9	G6D_14	8	4.5	14	4.5	18	3.0	22	3.0	31	2.0	30	2.0	39	2.0	57	1.5	314	2.0
Unnamed tributary of Tenandra Creek	D140980	17	N2N9	G6D_13	32	12.0	54	9.0	69	4.5	82	4.5	111	3.0	111	3.0	136	3.0	202	2.0	1,166	2.0
Tenandra Creek	D142830	1	N2N9	G6D_11	4	4.5	7	2.0	9	2.0	11	2.0	15	1.5	15	1.5	19	1.5	28	1.5	144	1.5
Tenandra Creek	D143390	42	N2N9	G6D_0,G6D_1, G6D_2	58	12.0	106	9.0	133	4.5	160	4.5	213	4.5	221	4.5	260	3.0	395	3.0	2,319	3.0
Unnamed tributary of Mungery Creek	D144860	5	N2N9	G6D_10	12	4.5	21	4.5	27	3.0	32	3.0	45	2.0	45	2.0	56	2.0	82	1.5	438	2.0
Tenandra Creek	D142830	1	N2N9	G6D_12	3	4.5	5	2.0	7	2.0	8	2.0	11	1.5	11	1.5	14	1.5	21	1.5	106	1.5
Unnamed tributary of Worinjerong	D136972	1	N2N9	G6D_15	3	12.0	5	6.0	6	4.5	8	2.0	11	1.5	11	2.0	14	1.5	22	1.5	112	1.5
Unnamed tributary of Baronne Creek	D136972	1	N2N9	G6D_16	3	12.0	4	6.0	6	4.5	7	2.0	10	1.5	10	2.0	13	1.5	20	1.5	101	1.5
Caleriwi Creek	N2N8_RORB_1_2	28	N2N8	C-29	62	9.0	144	6.0	135	4.5	158	4.5	215	2.0	213	4.5	304	1.5	401	1.5	1,560	2.0
Quanda Quanda Creek	N2N8_RORB_1_2	28	N2N8	C-28	44	9.0	84	6.0	90	6.0	105	12.0	164	4.5	160	4.5	188	3.0	277	2.0	1,328	2.0
Salty Spring Creek	N2N8_RORB_1_2	17	N2N8	C-27	27	12.0	39	9.0	45	12.0	65	12.0	76	12.0	83	12.0	89	6.0	116	6.0	650	4.0
Calga Creek	N2N8_RORB_1_2	34	N2N8	C-26	67	12.0	121	6.0	122	6.0	134	9.0	203	4.5	213	4.5	253	4.5	334	2.0	1,438	2.5
Bucklanbah Creek	N2N7_RORB_3A	114	N2N7	C-24	156	12.0	265	12.0	346	12.0	482	12.0	550	12.0	608	12.0	644	12.0	803	12.0	4,395	2.0
Unnamed tributary of Teridgerie Creek	N2N7_RORB_2	132	N2N7	C-23_3	103	12.0	192	12.0	263	12.0	306	12.0	366	12.0	404	12.0	533	12.0	676	12.0	2,440	3.0
Unnamed tributary of Teridgerie Creek	N2N7_RORB_2	50	N2N7	C-23_2	56	12.0	97	12.0	124	12.0	136	12.0	160	12.0	176	12.0	227	12.0	285	12.0	1,197	3.0
Teridgerie Creek	N2N7_RORB_2	160	N2N7	C-23_1	157	12.0	285	12.0	368	12.0	411	12.0	488	12.0	535	12.0	700	12.0	890	12.0	3,065	3.0
Baradine Creek	N2N7_RORB_1	933	N2N7	C-20	106	24.0	740	24.0	1,204	18.0	1,657	12.0	2,693	12.0	2,632	12.0	3,622	12.0	4,898	12.0	20,846	4.0
Coolangla Creek	N2N7_RORB_4	15	N2N7	C-19	38	12.0	58	6.0	72	6.0	94	4.5	109	4.5	123	4.5	161	2.0	221	2.0	932	2.0
Etoo Creek	N2N6_RORB_1	122	N2N6	C-17	144	18.0	217	18.0	273	18.0	353	12.0	416	12.0	460	12.0	481	12.0	600	12.0	2,848	4.0
Coomore Creek	N2N6_RORB_1	114	N2N6	C-16	145	18.0	197	18.0	246	18.0	321	12.0	376	12.0	417	12.0	450	12.0	559	12.0	3,081	4.0
Rocky Creek	N2N6_RORB_1	127	N2N6	C-15	156	18.0	253	18.0	292	12.0	344	12.0	404	12.0	447	12.0	480	12.0	595	12.0	3,537	4.0
Talluba Creek	N2N5_RORB_1	29	N2N5	C-13	49	12.0	93	12.0	118	12.0	132	12.0	167	12.0	185	12.0	198	12.0	248	12.0	1,395	2.0
Cubbo Creek	N2N5_RORB_1	59	N2N5	C-12	75	12.0	146	12.0	199	12.0	236	12.0	283	12.0	316	12.0	346	12.0	436	12.0	2,094	2.5
Coghill Creek	N2N4_RORB_1	48	N2N4	C-9	71	12.0	122	12.0	154	12.0	178	12.0	209	12.0	231	12.0	250	12.0	359	18.0	1,987	3.0
Mollieroi Creek	N2N3_RORB_1	92	N2N3	C-8	103	12.0	200	12.0	277	12.0	351	12.0	411	12.0	454	12.0	498	12.0	652	12.0	3,001	4.0
Goona Creek	N2N3_RORB_1	45	N2N3	C-5	44	12.0	86	12.0	122	12.0	154	12.0	193	12.0	207	12.0	236	12.0	301	12.0	1,333	2.5
Unnamed tributary of Bundock Creek	N2N2_RORB_1	30	N2N2	C-3_2	58	12.0	107	12.0	155	12.0	182	12.0	188	12.0	210	12.0	222	12.0	279	12.0	1,543	2.0
Bundock Creek	N2N2_RORB_1	34	N2N2	C-3_1	61	12.0	112	12.0	161	12.0	189	12.0	203	12.0	227	12.0	240	12.0	303	12.0	1,700	2.0
Bohena Creek	N2N1_RORB_1	2,038	N2N1	C-2	1,392	36.0	3,096	18.0	4,377	18.0	4,870	36.0	5,985	36.0	6,416	36.0	7,436	36.0	9,559	18.0	32,537	4.0
Unnamed tributary of Bohena Creek	N2N1_RORB_2	24	N2N1	C-1	47	12.0	70	12.0	90	12.0	100	12.0	118	4.5	128	12.0	152	4.5	197	3.0	1,040	2.0
Namoi River	Namoi	25,073	Narrabri	Inflow_Namoi	483	-	1,854	-	3,584	-	4,976	-	6,360	-	7,660	-	8,539	-	11,177	-	40,000	-
Horsearm Creek	Narrabri	27	Narrabri	Tnode4	32	18.0	61	12.0	80	12.0	96	12.0	115	12.0	124	12.0	138	12.0	175	12.0	795	5.0
Mulgate Creek	Narrabri	26	Narrabri	Tnode12	24	18.0	49	12.0	70	12.0	82	12.0	104	12.0	112	12.0	125	12.0	163	12.0	763	5.0
Flood runner of Horsearm Creek	Narrabri	19	Narrabri	Tnode20	24	18.0	47	12.0	69	12.0	76	12.0	103	12.0	112	12.0	124	12.0	160	12.0	555	5.0
Stony Creek	Narrabri	19	Narrabri	Tnode26	18	18.0	39	12.0	53	12.0	63	12.0	77	12.0	83	12.0	93	12.0	120	12.0	692	5.0
Unnamed tributary of Narrabri Creek	Narrabri	10	Narrabri	Tnode35	6	18.0	12	12.0	19	12.0	24	12.0	32	12.0	34	12.0	41	12.0	54	12.0	242	5.0

Table C-2 Peak discharges estimated by RFFE

Waterway	Catchment Area (km^2)	Peak Discharge (m^3/s)			
		20% AEP	5% AEP	2% AEP	1% AEP
Macquarie River	25,900	-	-	-	-
Unnamed tributary of Blackwater Cowal	34	49	113	175	234
Unnamed tributary of Blackwater Cowal	28	40	92	142	189
Unnamed tributary of Blackwater Cowal	26	40	92	141	189
Unnamed tributary of Blackwater Cowal	11	27	62	95	127
Wallaby Creek	133	87	200	308	413
Yellow Creek	60	61	140	216	289
Unnamed tributary of Ewenmar Creek	5	30	69	106	142
Unnamed tributary of Ewenmar Creek	13	46	105	163	217
Unnamed tributary of Ewenmar Creek	6	38	89	137	183
Unnamed tributary of Kookaburra Creek	2	20	47	73	97
Unnamed tributary of Macquarie River	12	35	82	127	169
Unnamed tributary of Macquarie River	8	30	69	106	142
Unnamed tributary of Macquarie River	2	20	46	71	95
Unnamed tributary of Macquarie River	4	25	58	89	119
Unnamed tributary of Macquarie River	6	26	60	93	124
Unnamed tributary of Kookaburra Creek	3	25	57	88	118
Unnamed tributary of Kookaburra Creek	2	17	40	62	83
Unnamed tributary of Kookaburra Creek	2	18	42	65	87
Unnamed tributary of Kookaburra Creek	2	20	47	73	97
Unnamed tributary of Macquarie River	3	22	52	80	107
Unnamed tributary of Macquarie River	2	22	52	80	107
Unnamed tributary of Macquarie River	3	24	56	87	116
Ewenmar Creek	151	126	292	451	603
Unnamed tributary of Milpulling Creek	2	42	97	149	200
Unnamed tributary of Milpulling Creek	2	42	97	149	200
Kickabil Creek	109	95	218	336	449
Emogandry Creek	79	83	191	295	395
Milpulling Creek	71	81	186	287	383
Unnamed tributary of Bundijoe Creek	1	45	103	159	213
Bundijoe Creek	33	68	157	243	325
Bundijoe Creek	29	66	153	235	315
Unnamed tributary of Bootha Guy Creek	10	57	130	201	269
Bootha Guy Creek	17	59	135	208	279
Unnamed tributary of Bootha Guy Creek	26	64	147	226	302
Castlereagh River	6,722	-	-	-	-
Marthaguy Creek	416	105	243	375	501
Unnamed tributary of Merrigal Creek	16	58	133	205	274
Unnamed tributary of Merrigal Creek	23	58	134	206	276
Unnamed tributary of Merrigal Creek	1	45	103	158	212
Unnamed tributary of Merrigal Creek	2	45	103	159	212
Unnamed tributary of Bullagreen Creek	9	52	119	184	246
Unnamed tributary of Bullagreen Creek	26	58	134	206	276
Unnamed tributary of Bullagreen Creek	2	44	102	158	211
Unnamed tributary of Castlereagh River	6	49	114	175	234
Unnamed tributary of Bullagreen Creek	0	45	103	159	212
Unnamed tributary of Bullagreen Creek	0	45	103	159	212
Unnamed tributary of Bullagreen Creek	1	45	103	159	212
Unnamed tributary of Marrigal Creek	1	45	103	159	212
Unnamed tributary of Merrigal	2	46	106	163	218
Unnamed in tributary of Marthaguy	5	53	122	188	252
Unnamed tributary of Gulargambone Creek	25	54	126	194	259
Unnamed tributary of Gulargambone Creek	3	44	103	158	212
Unnamed tributary of Mariemon Creek	3	44	102	157	210
Unnamed tributary of Gulargambone Creek	7	47	109	168	225
Unnamed tributary of Gulargambone Creek	4	47	108	166	222
Gulargambone Creek including Paddys CK	243	82	189	292	391
Unnamed tributary of Gulargambone Creek	29	56	130	201	269
Unnamed tributary of Gulargambone Creek	10	49	112	173	232
Unnamed tributary of Baronne Creek	9	47	110	169	226
Unnamed tributary of Mariemon Creek	23	52	120	185	248
Judes Creek	30	57	131	202	270
Unnamed tributary of Mariemon Creek	12	50	116	179	240
Unnamed tributary of Judes Creek	23	52	120	185	248
Unnamed tributary of Baronne Creek	5	46	107	164	220
Unnamed tributary of Baronne Creek	15	50	115	177	237
Unnamed tributary of Baronne Creek	22	53	123	190	255
Unnamed tributary of Baronne Creek	12	47	108	166	222
Baronne Creek	389	124	288	446	599
Unnamed tributary of Worinjerong	3	40	92	142	190

Waterway	Catchment Area (km^2)	Peak Discharge (m^3/s)			
		20% AEP	5% AEP	2% AEP	1% AEP
Unnamed tributary of Tenandra Creek	17	50	116	178	239
Tenandra Creek	1	37	85	131	175
Tenandra Creek	42	58	134	206	276
Unnamed tributary of Mungery Creek	5	41	95	147	196
Tenandra Creek	1	37	85	131	175
Unnamed tributary of Worinjerong	1	37	85	131	176
Unnamed tributary of Baronne Creek	1	37	85	131	176
Caleriwi Creek	28	50	116	180	241
Quanda Quanda Creek	28	50	116	179	239
Salty Spring Creek	17	42	96	149	199
Calga Creek	34	49	114	176	236
Bucklanbah Creek	114	75	174	271	364
Unnamed tributary of Teridgerie Creek	132	74	173	269	362
Unnamed tributary of Teridgerie Creek	50	48	111	173	232
Teridgerie Creek	160	96	227	354	477
Baradine Creek	933	514	1220	1910	2590
Coolangla Creek	15	29	68	105	141
Etoo Creek	122	96	227	356	481
Coomore Creek	114	87	205	321	434
Rocky Creek	127	94	222	349	472
Talluba Creek	29	32	76	118	160
Cubbo Creek	59	52	124	194	262
Coghill Creek	48	45	106	166	224
Mollieroi Creek	92	72	173	272	369
Goona Creek	45	34	81	128	173
Unnamed tributary of Bundock Creek	30	26	63	99	134
Bundock Creek	34	28	67	105	142
Bohena Creek	2,038	816	1960	3090	4200
Unnamed tributary of Bohena Creek	24	17	40	63	86
Namoi River	25,073	-	-	-	-
Horsearm Creek	27	24	59	94	129
Mulgate Creek	26	21	50	80	109
Flood runner of Horsearm Creek	19	14	34	53	73
Stony Creek	19	13	32	50	68
Unnamed tributary of Narrabri Creek	10	8	21	32	44

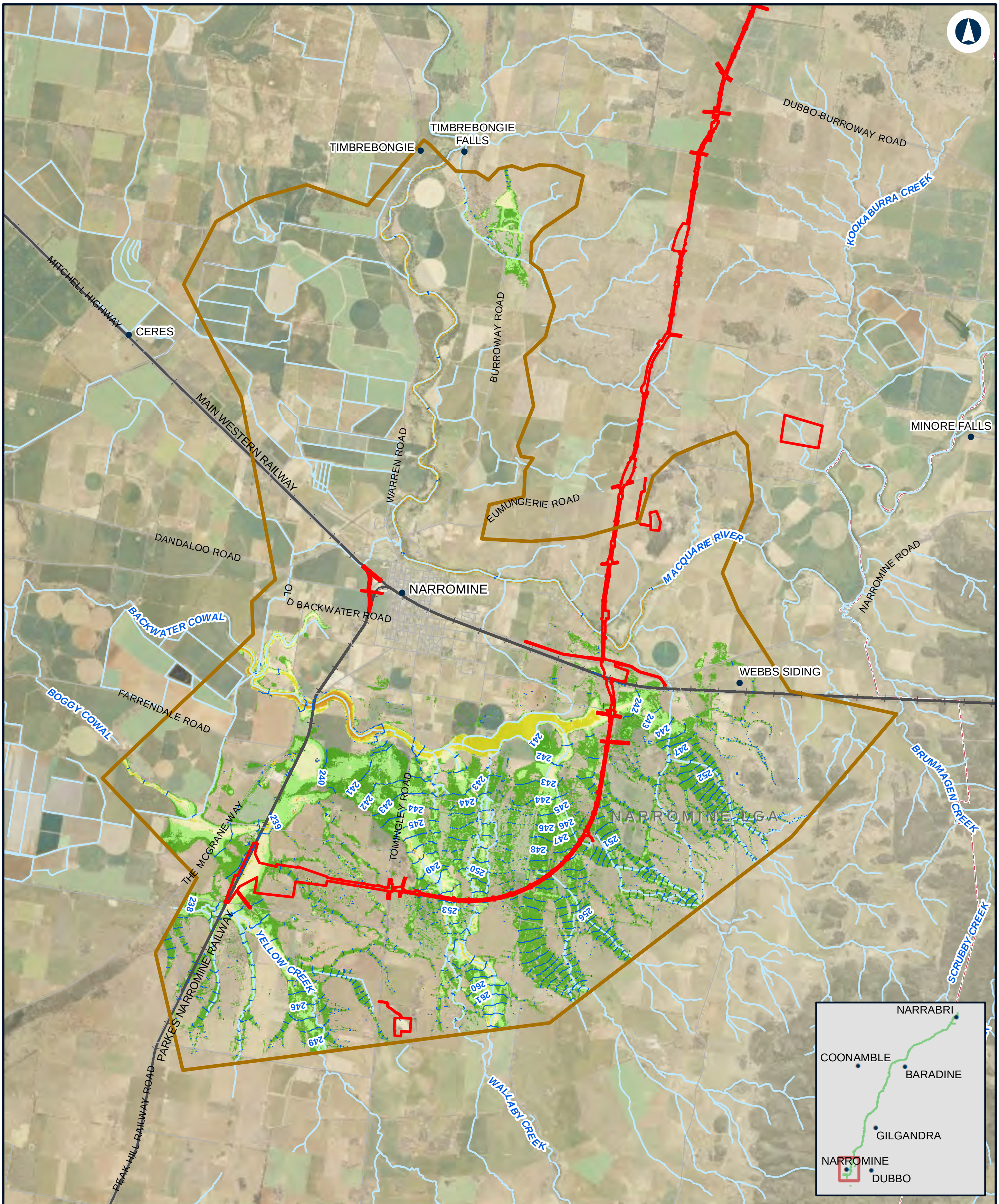
TECHNICAL REPORT

3

Flooding and hydrology assessment

Appendix D Existing flood mapping

NARROMINE TO NARRABRI ENVIRONMENTAL IMPACT STATEMENT



NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 20% AEP -NFM

Appendix D - Figure 1.1a

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:140,120
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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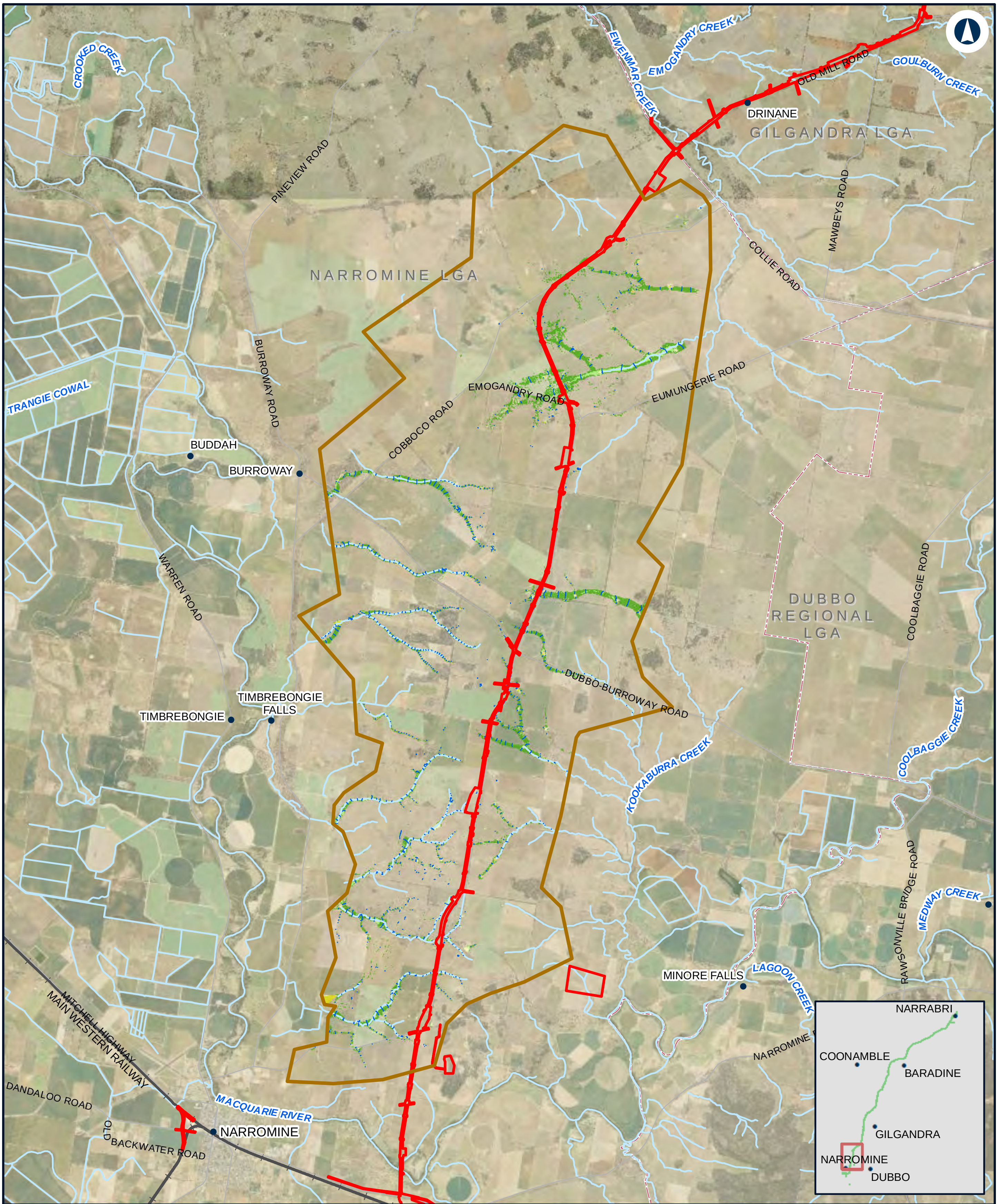

NARROMINE TO NARRABRI | Existing peak depth / level (contour) - 20% AEP -N2N14 | Appendix D - Figure 1.1b

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:150,260
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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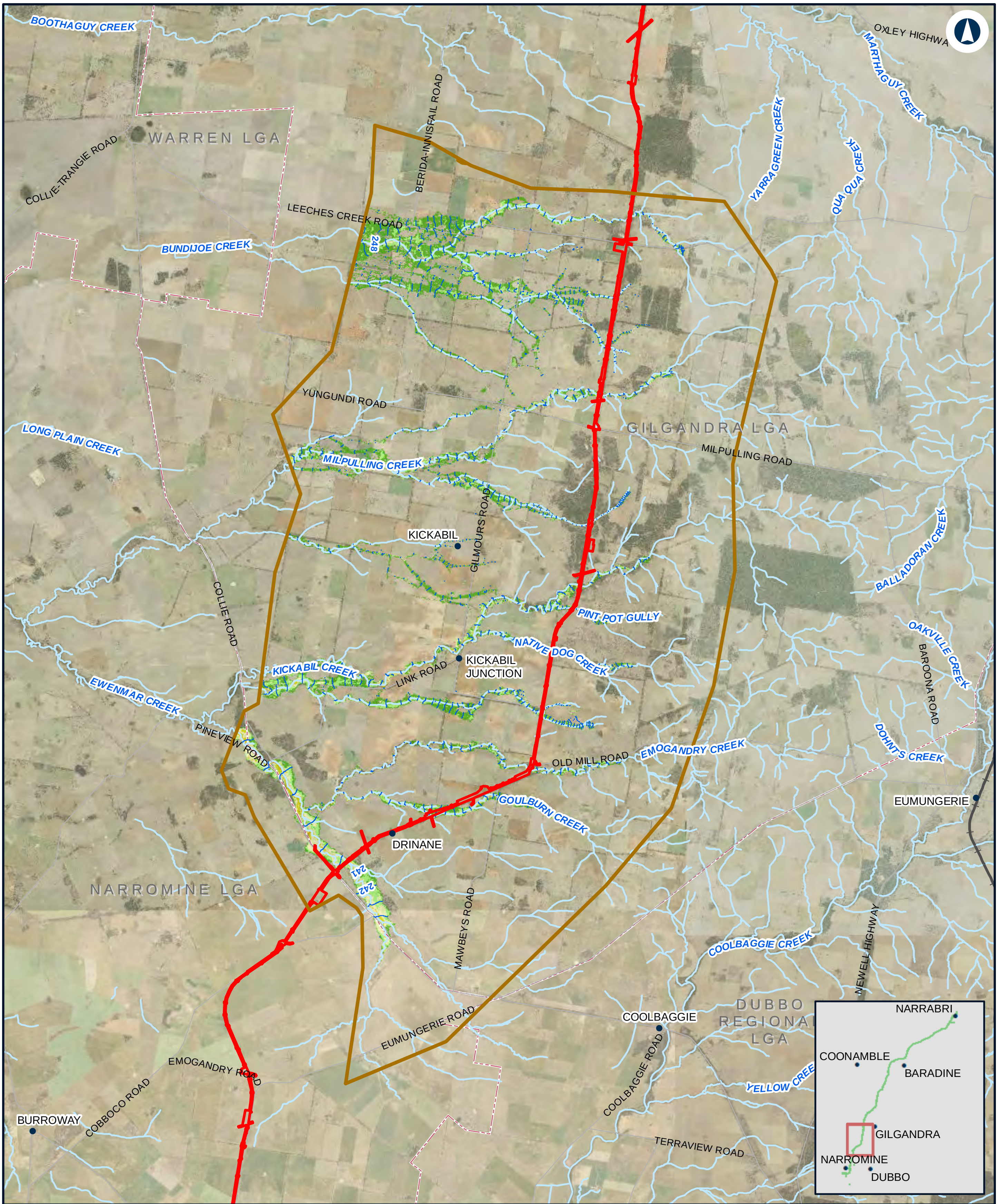

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -N2N13 Appendix D - Figure 1.1c

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:187,070
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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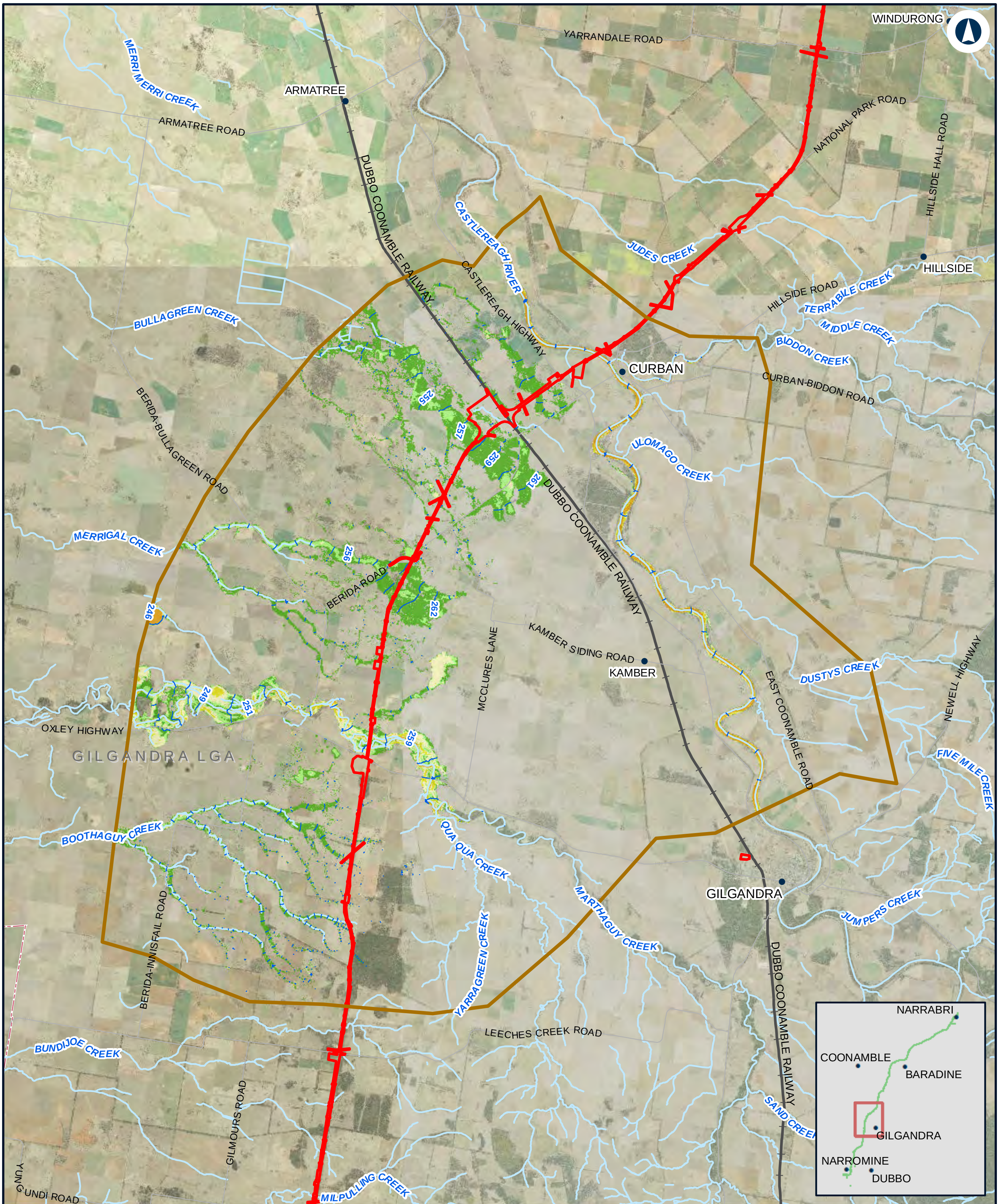

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -N2N11N12 Appendix D - Figure 1.1d

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:198,370
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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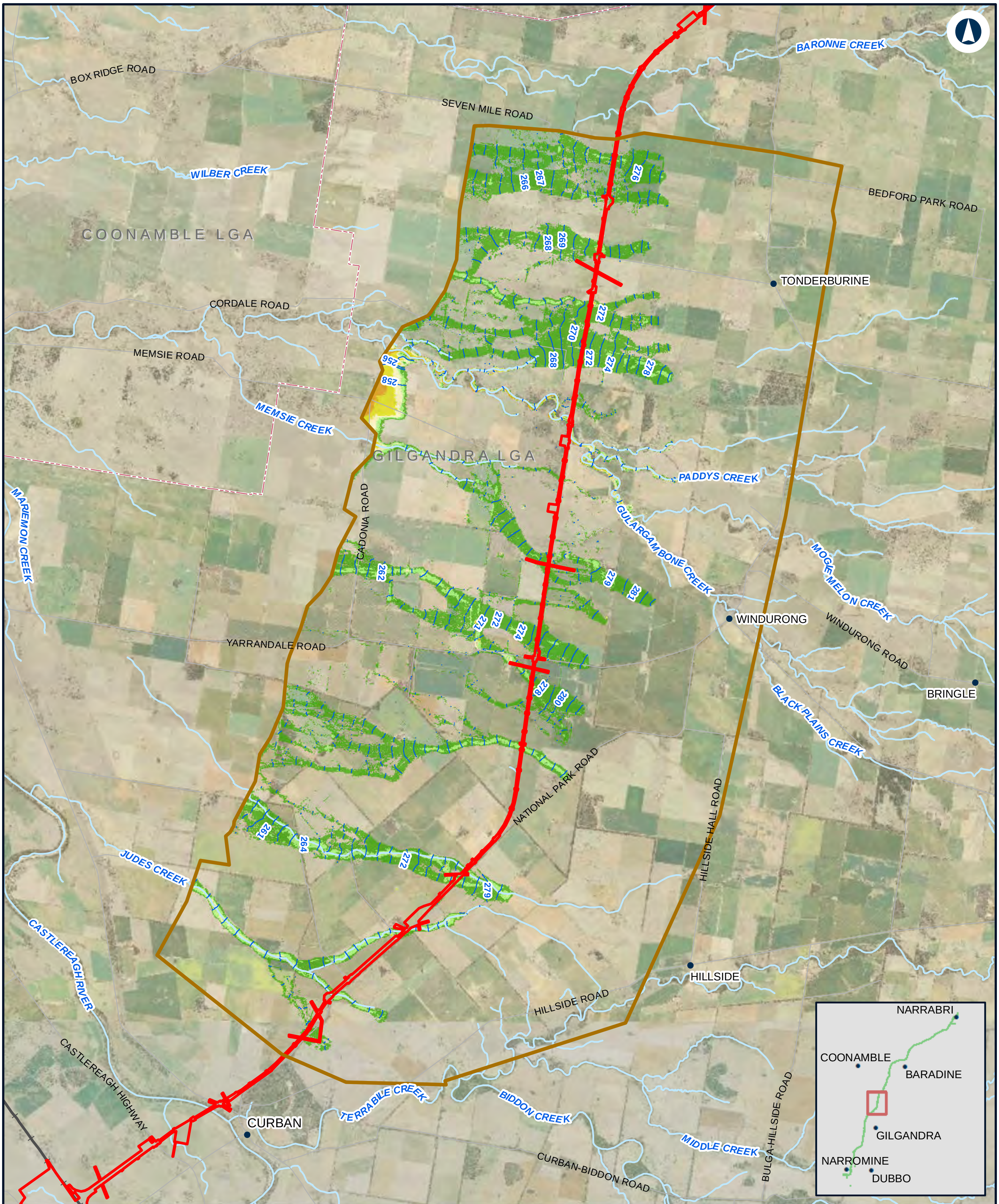

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -N2N10 Appendix D - Figure 1.1e

0 1.5 3 Km

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:134,750
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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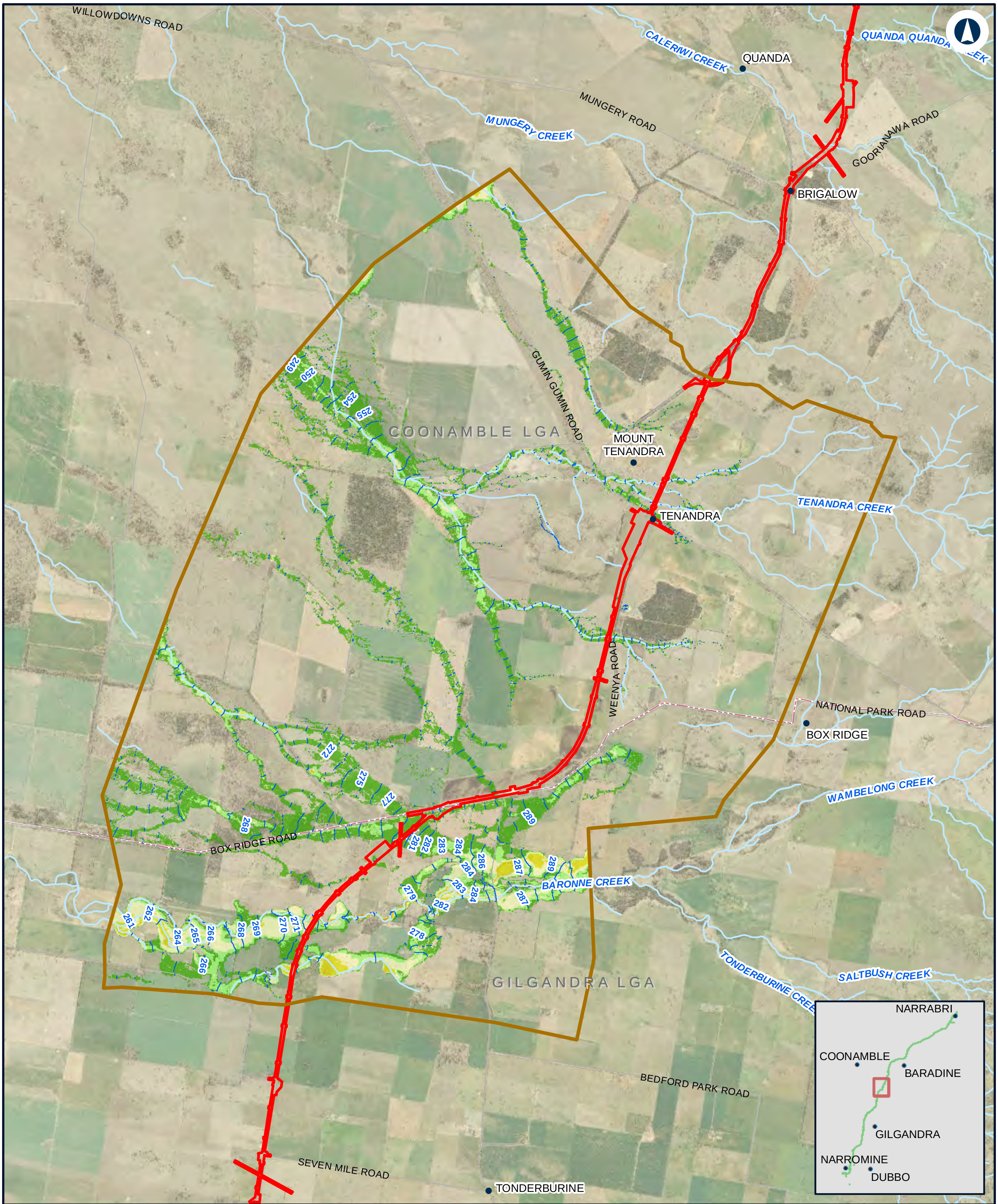

NARROMINE TO NARRABRI | Existing peak depth / level (contour) - 20% AEP -N2N9 | Appendix D - Figure 1.1f

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:104,540
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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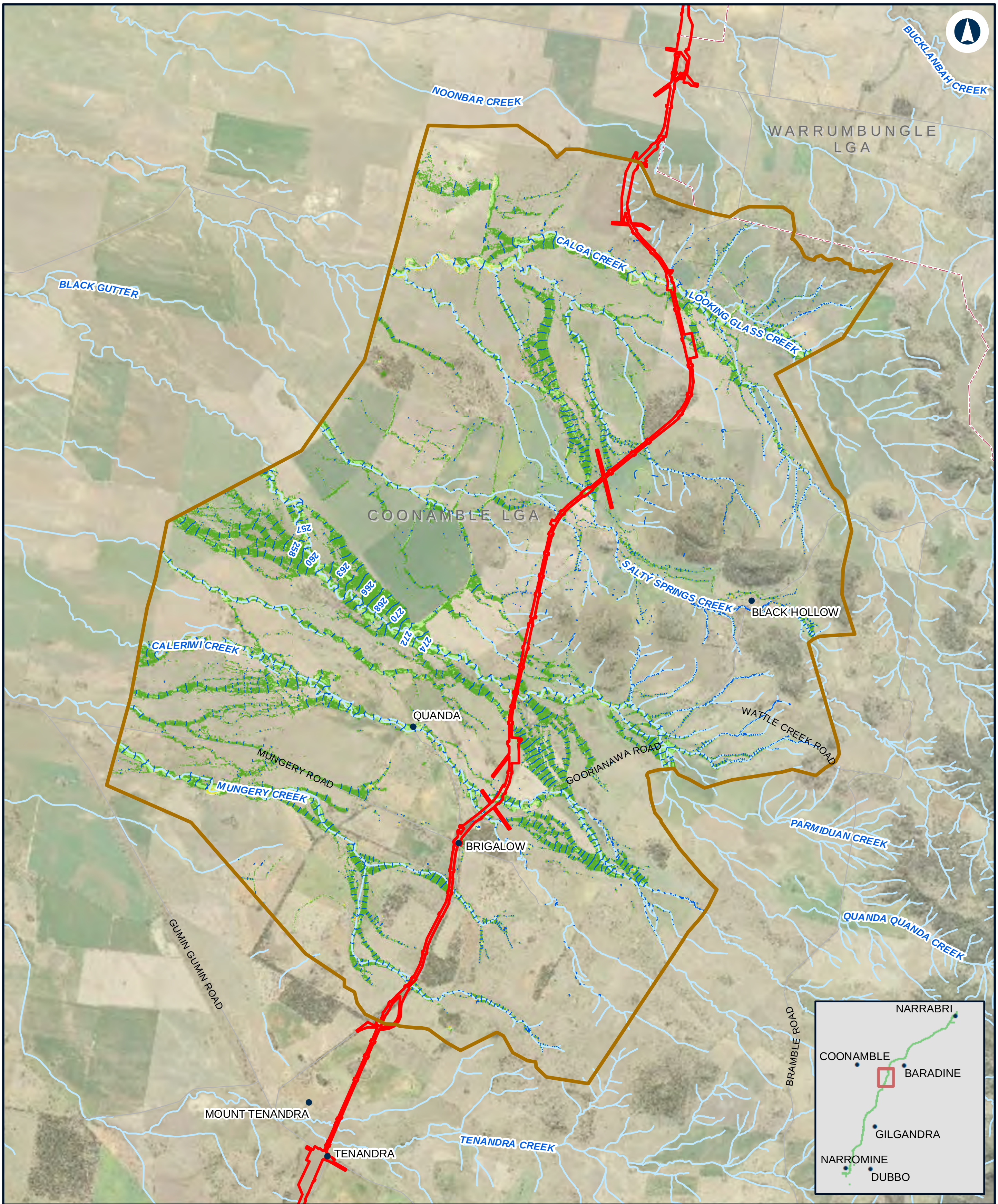

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 20% AEP -N2N8

Appendix D - Figure 1.1g

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:109,460
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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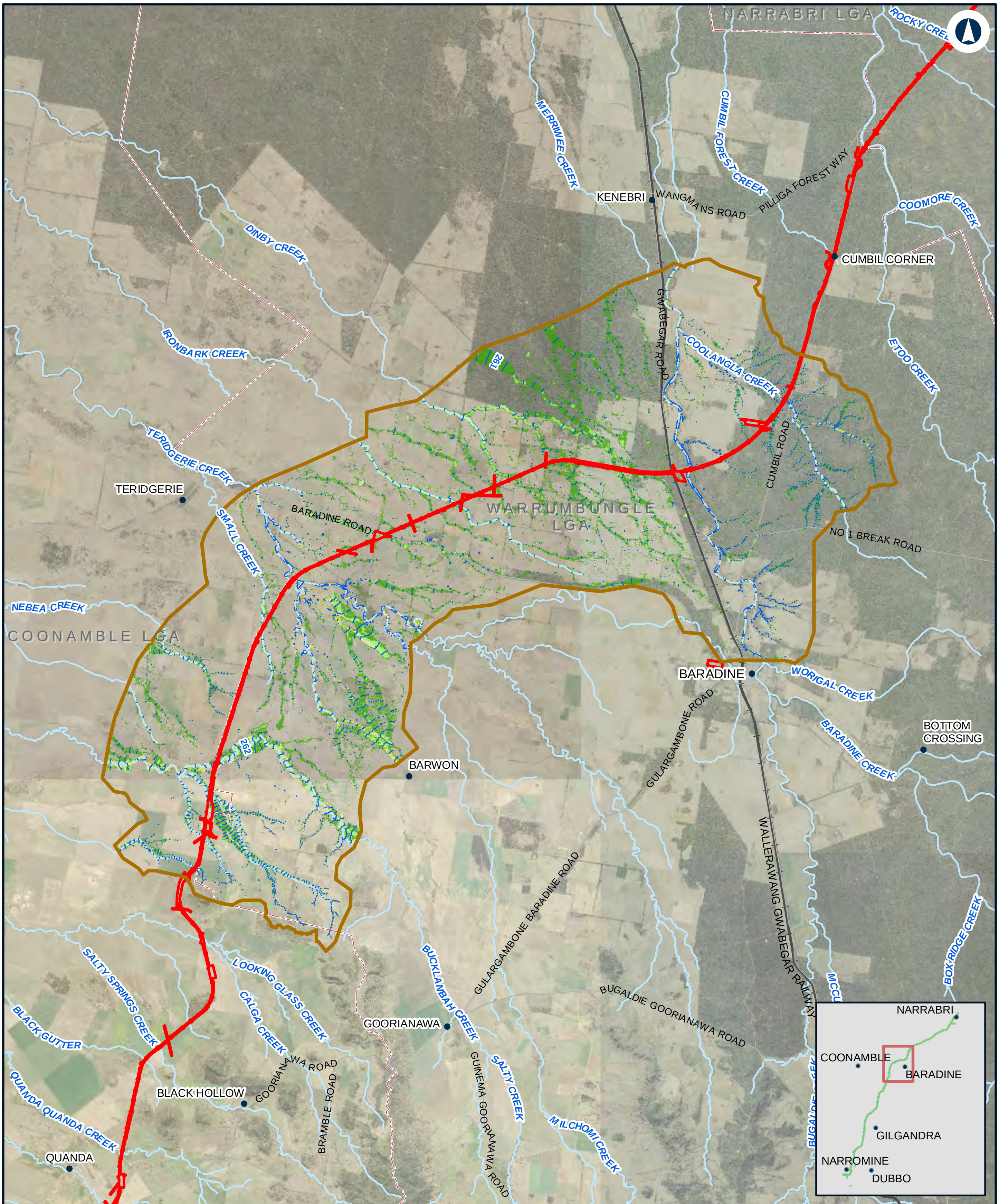
G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP005_FloodBehaviourDepth_20pcExist.mxd



NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 20% AEP -N2N7

Appendix D - Figure 1.1h

0 3 6 Km

Coordinate System: GDA 1994 MGA Zone 55

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ARTC will not be responsible for any loss or damage suffered as a result of any person whatsoever placing reliance upon the information contained within this GIS map.

Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:212,360
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

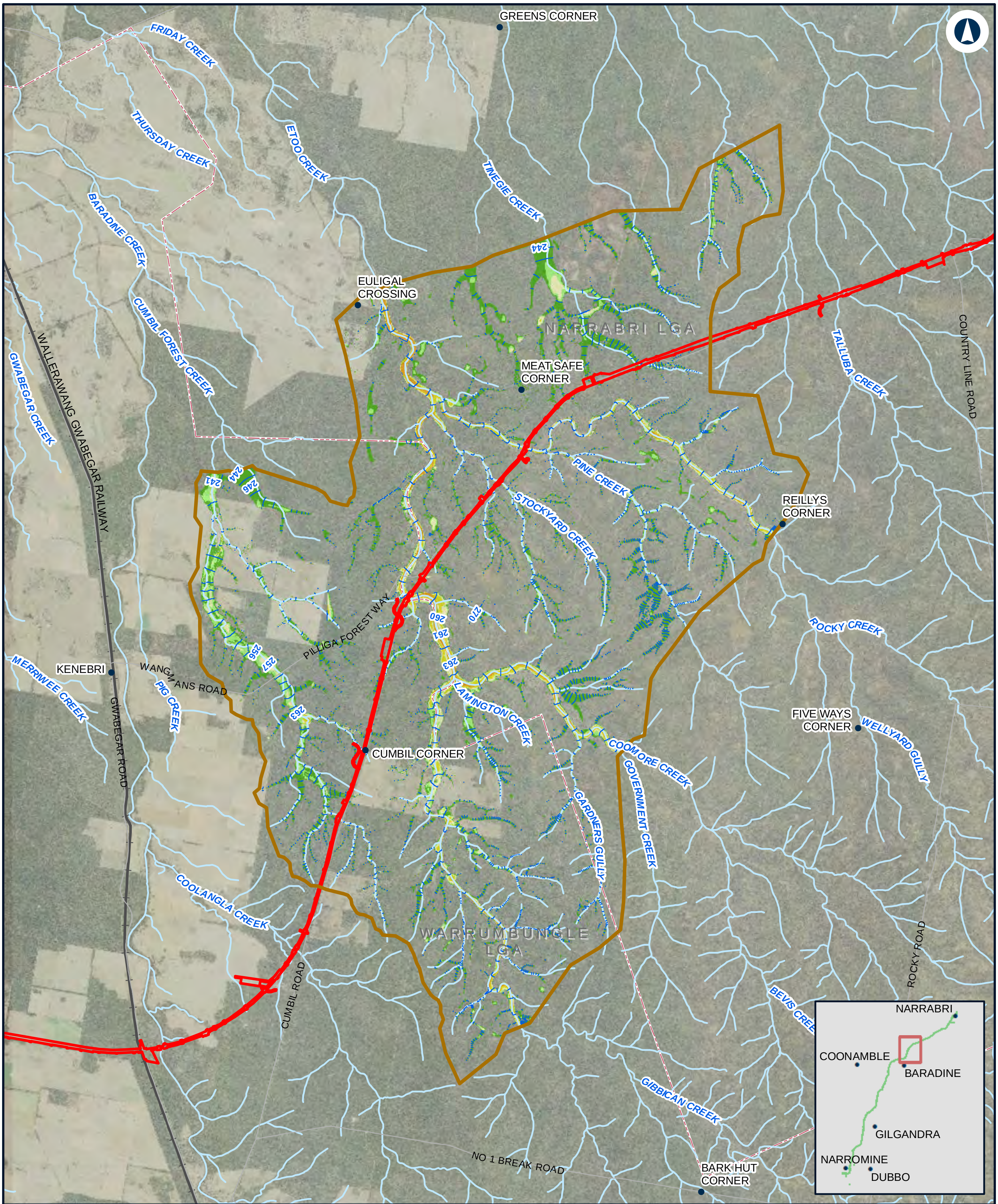
Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP005_FloodBehaviourDepth_20pcExist.mxd



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -N2N6 Appendix D - Figure 1.1i

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:152,780
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

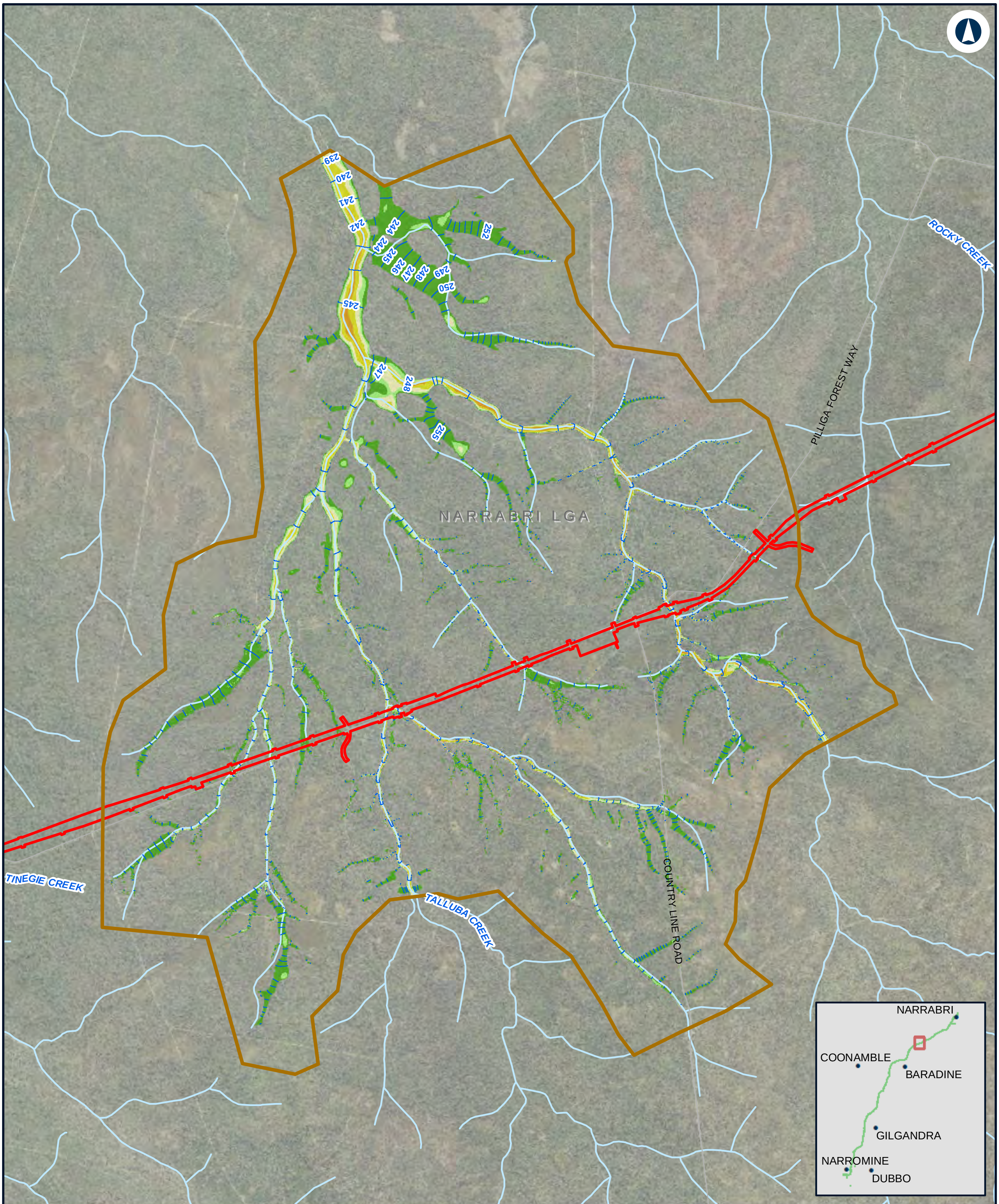
LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -N2N5 Appendix D - Figure 1.1j

0 0.95 1.9 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:69,470
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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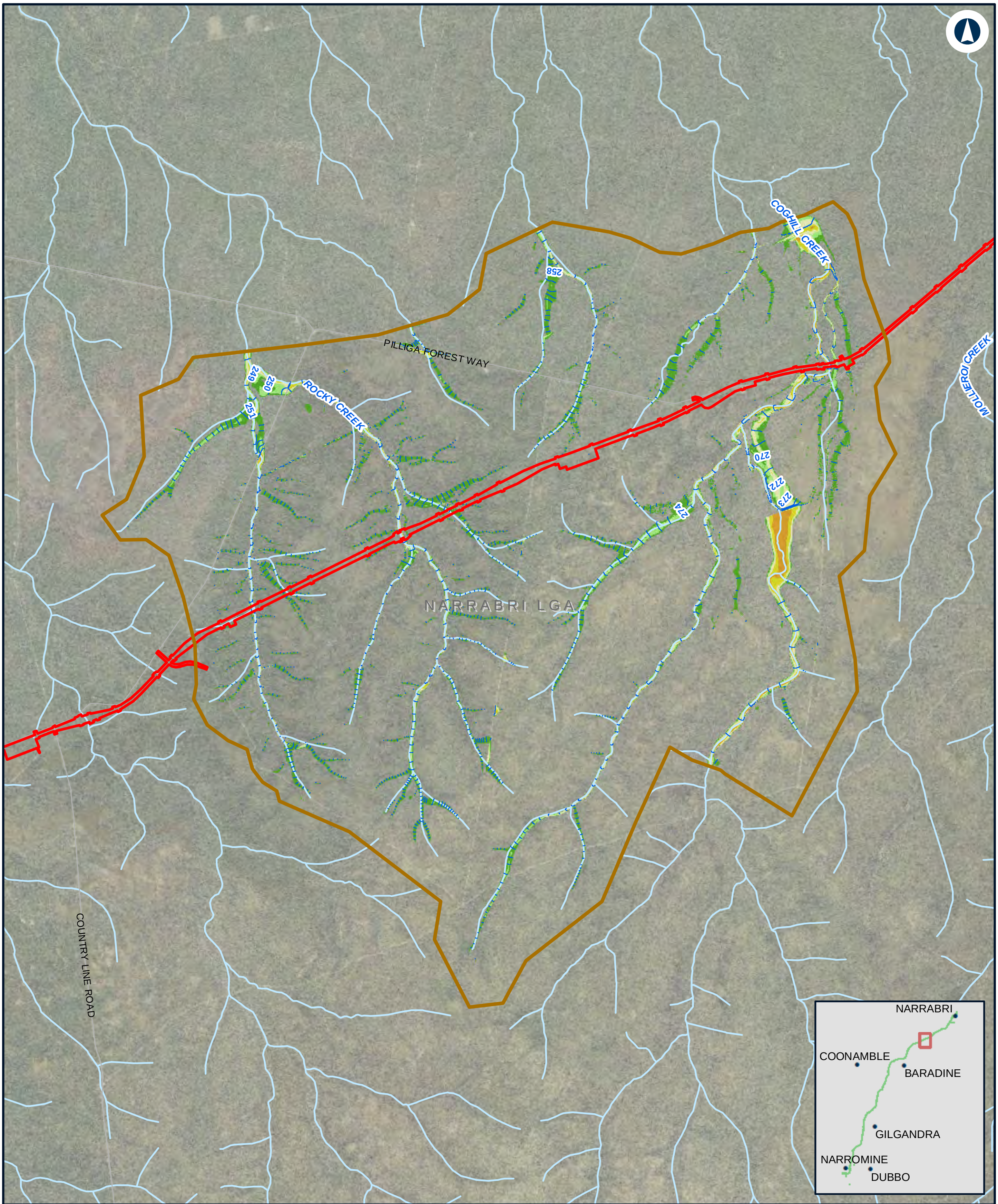

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -N2N4

Appendix D - Figure 1.1k

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:80,540
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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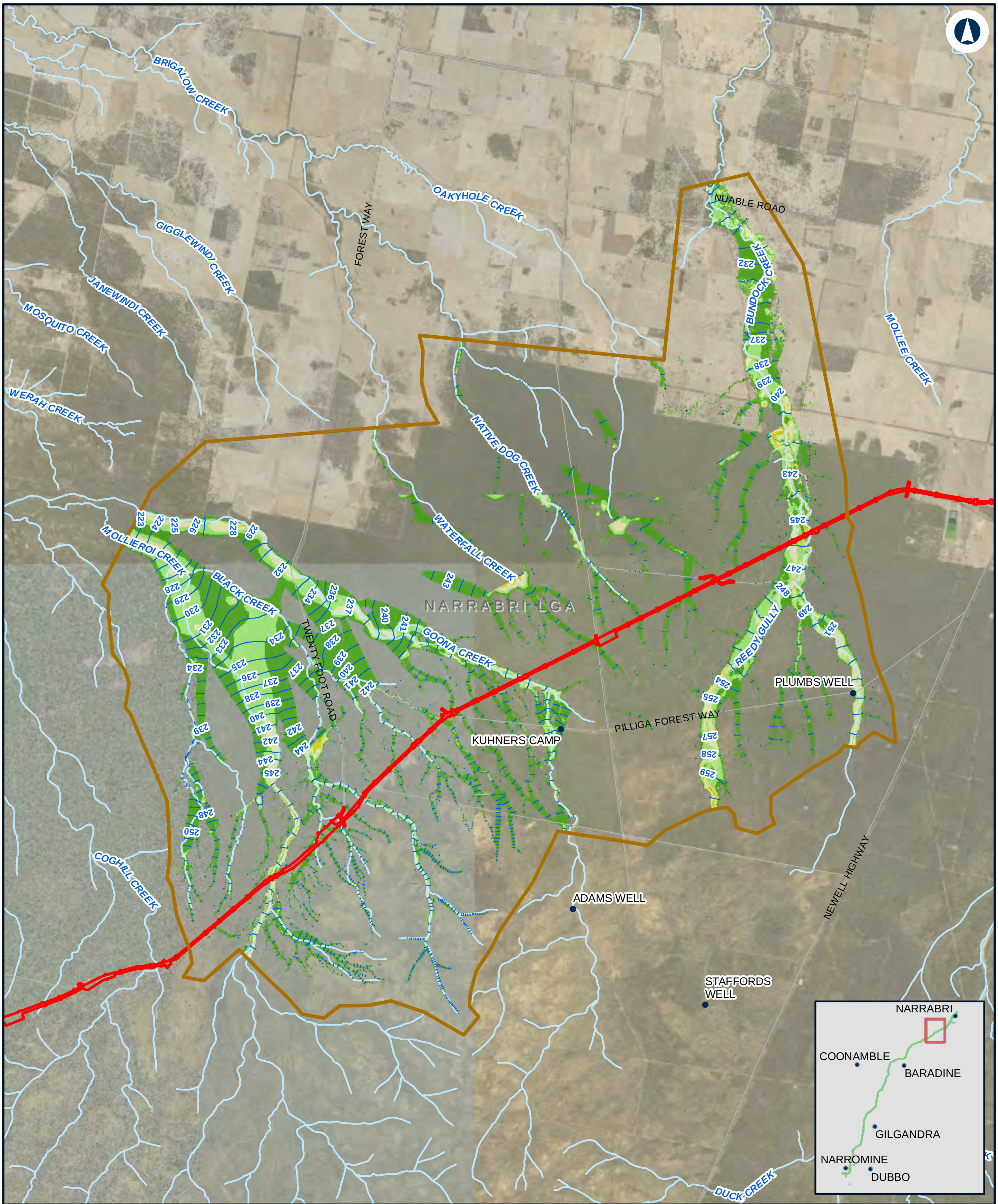

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 20% AEP -N2N23

Appendix D - Figure 1.1l

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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ARTC will not be responsible for any loss or damage suffered as a result of any person whatsoever placing reliance upon the information contained within this GIS map.

Date: 27/10/2020
Paper: A4
Author: JacobsGHD
Scale: 1:139,650
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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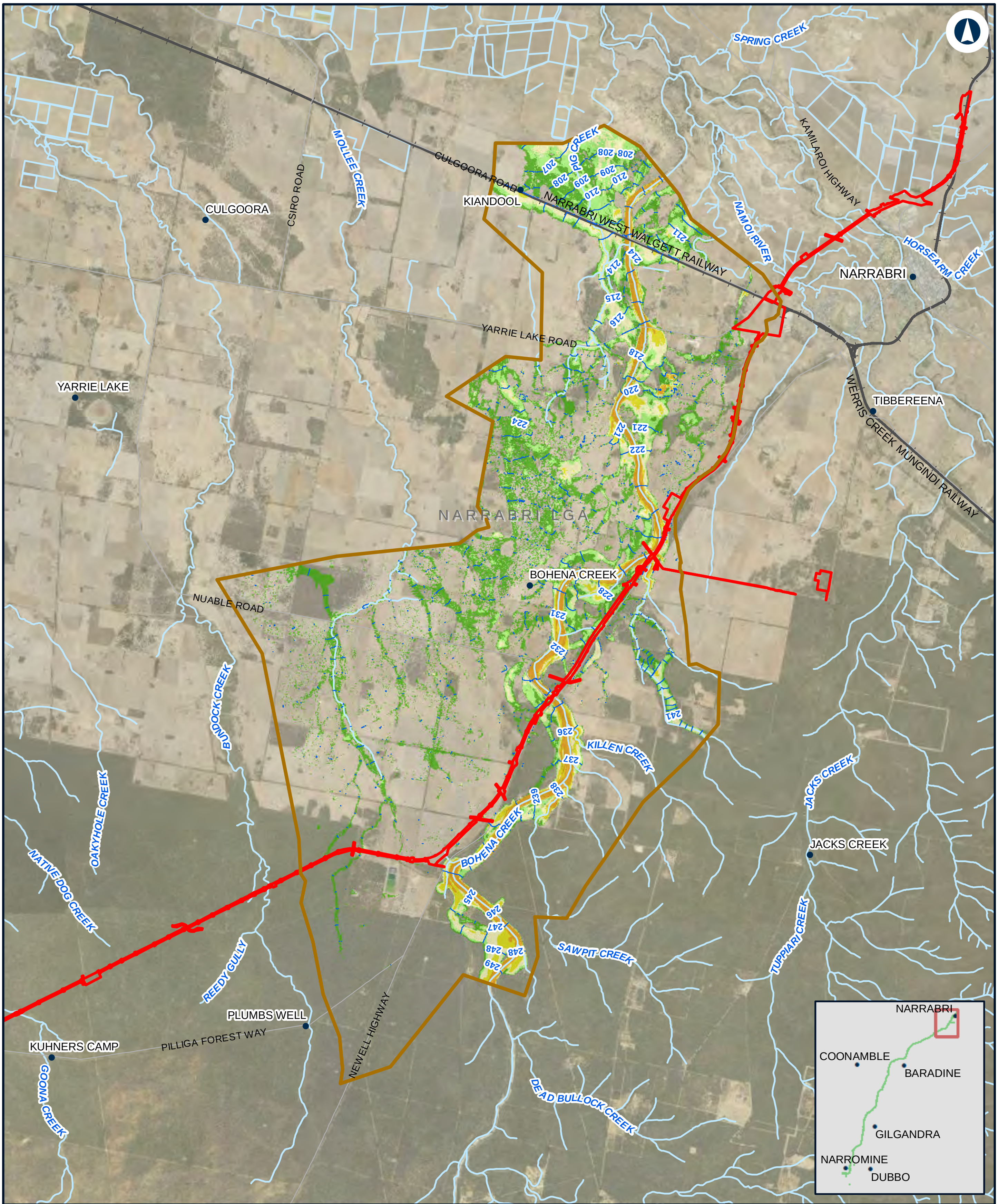

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 20% AEP -N2N1

Appendix D - Figure 1.1m

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020
Paper: A4
Author: JacobsGHD
Scale: 1:160,830
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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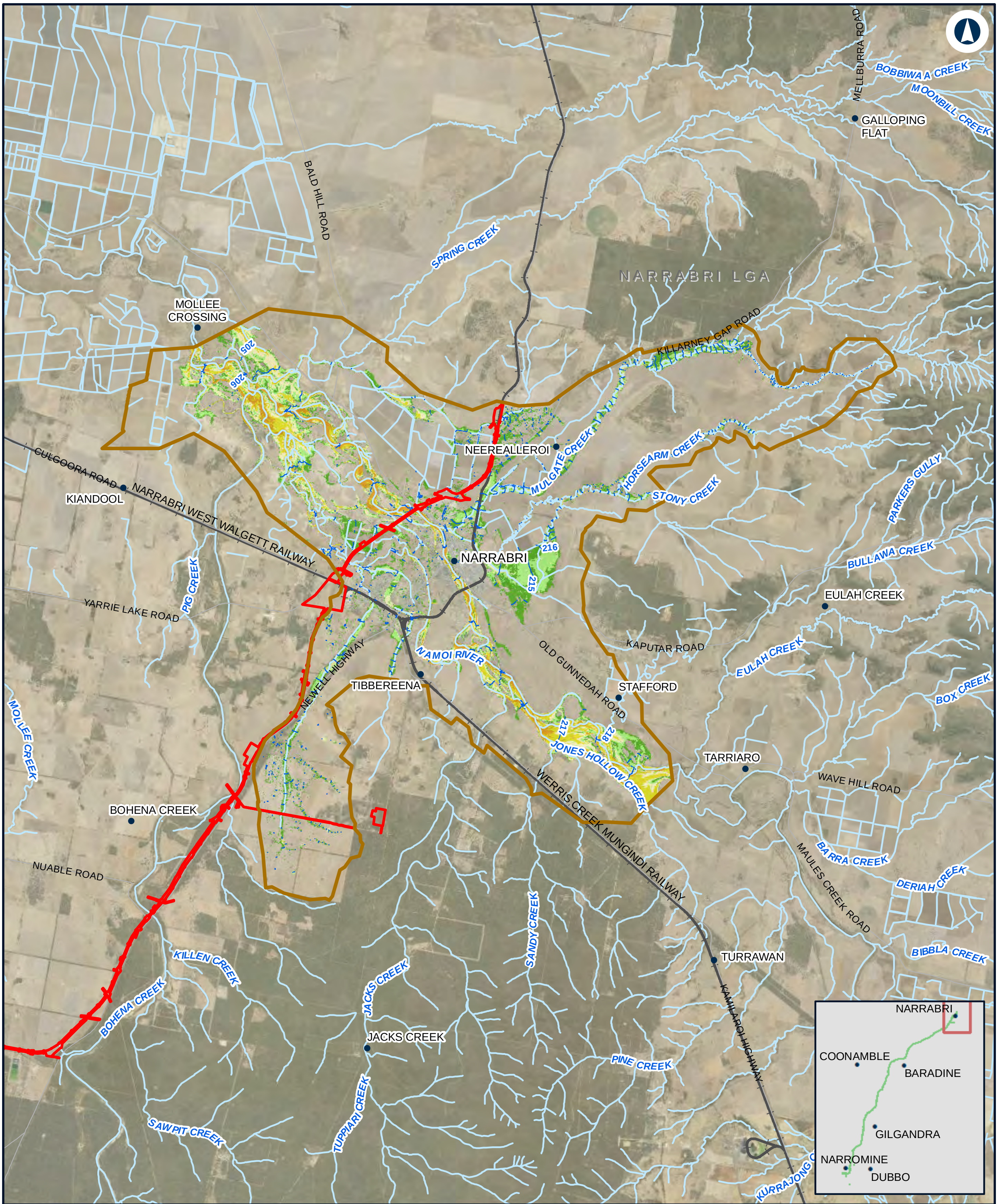

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 20% AEP -Narrabri Appendix D - Figure 1.1n

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:190,920
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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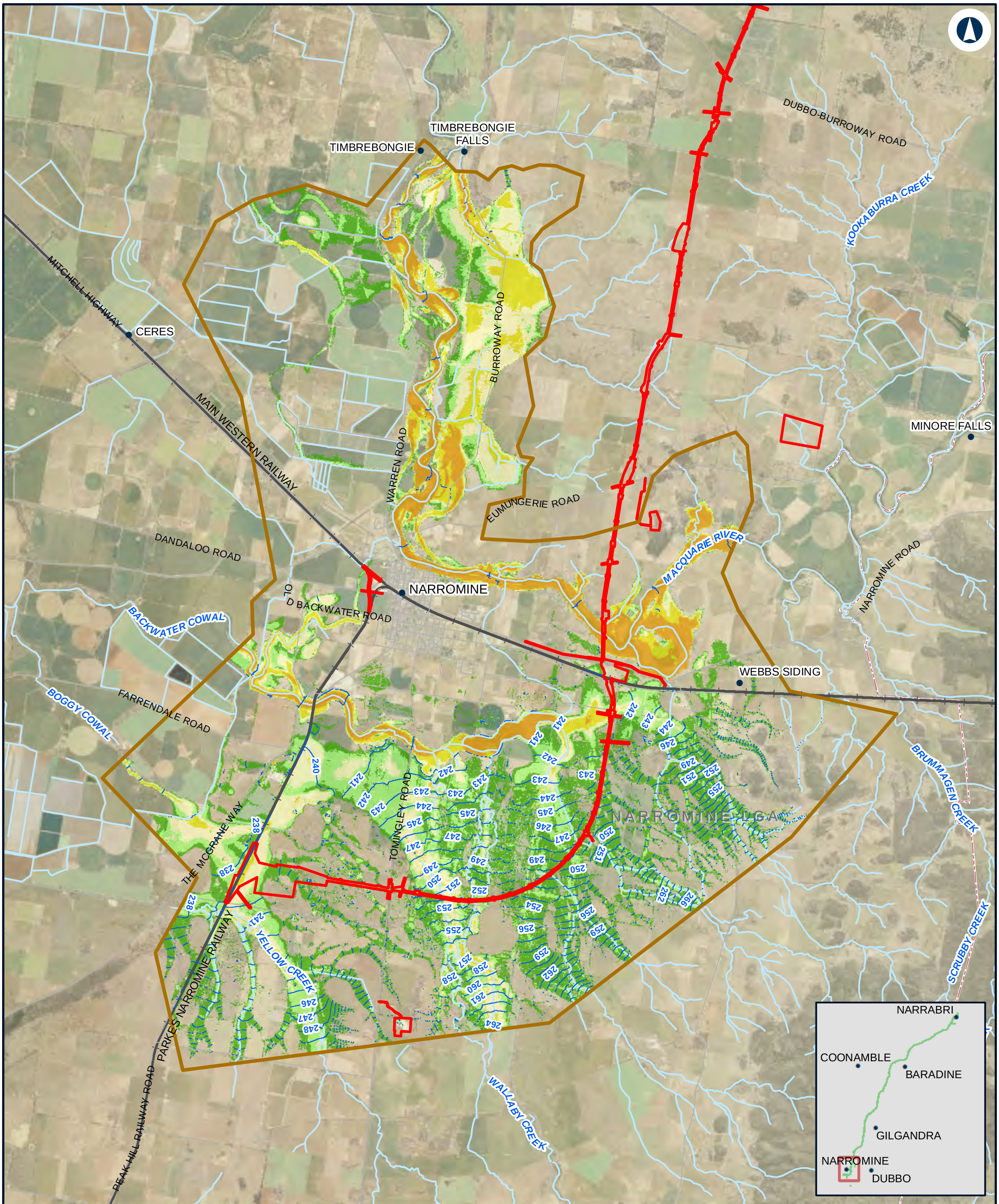
G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP005_FloodBehaviourDepth_20pcExist.mxd



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -NFM

Appendix D - Figure 1.2a

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:140,120
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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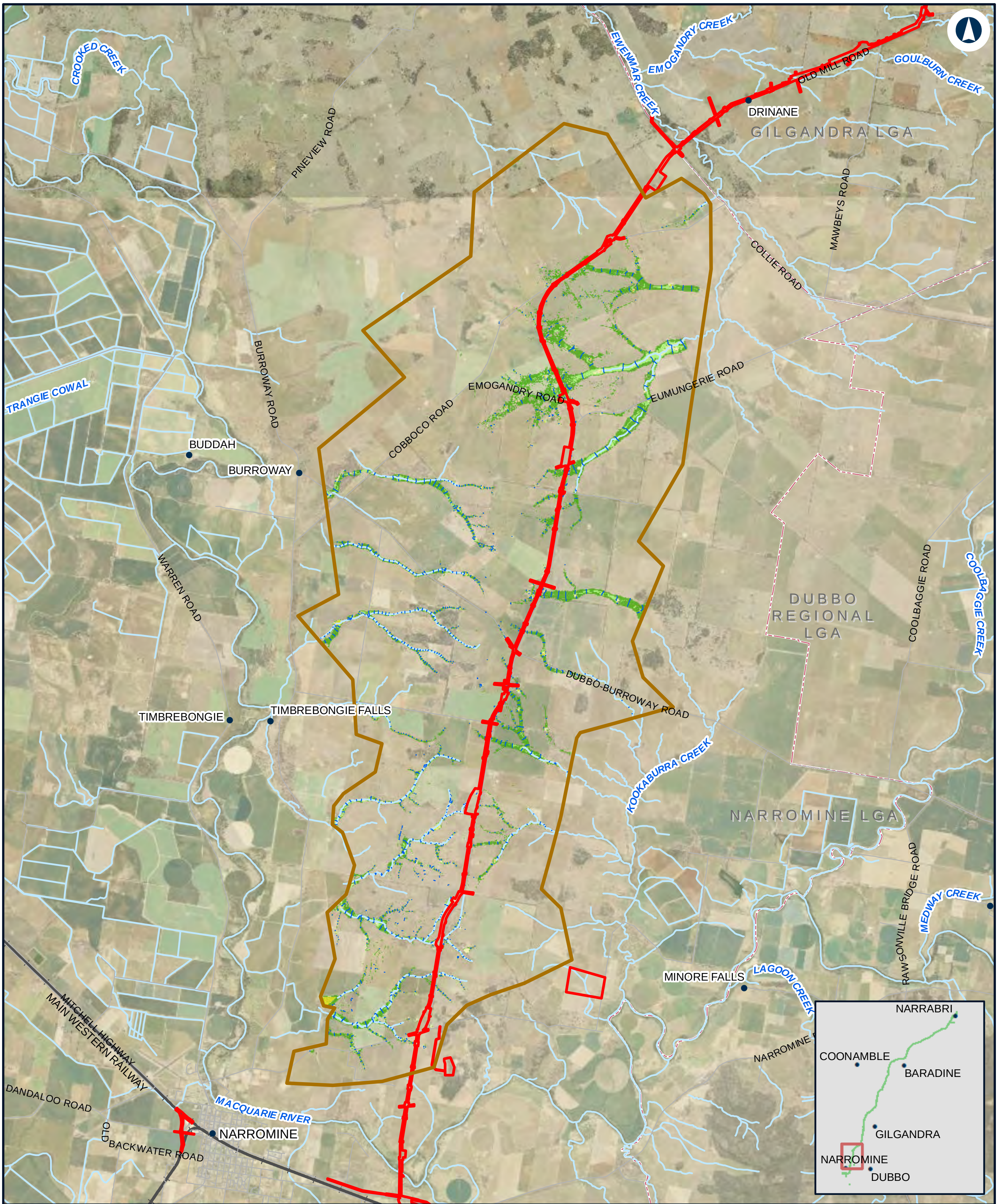

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N14 Appendix D - Figure 1.2b

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:149,670
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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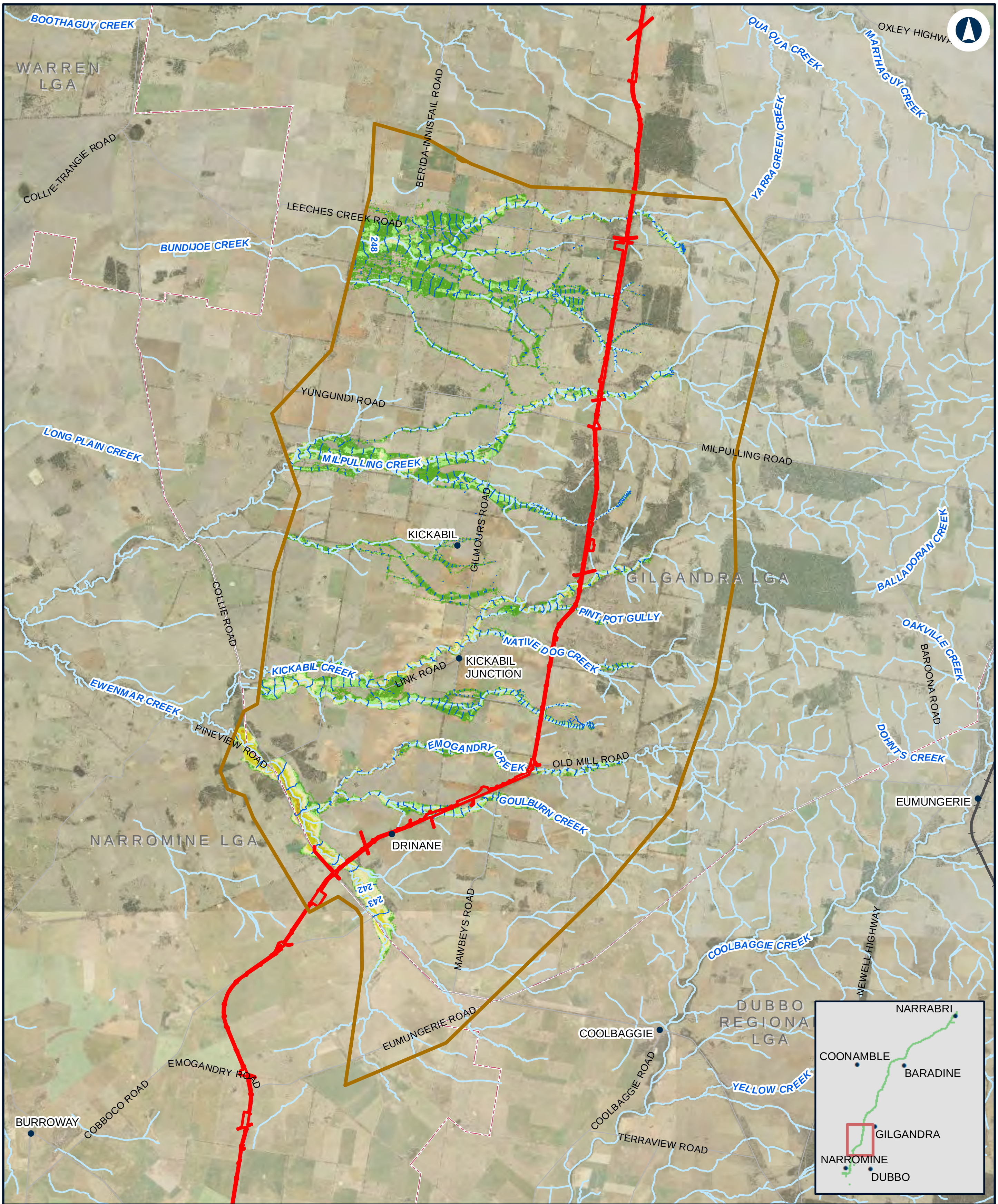

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N13

Appendix D - Figure 1.2c

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:186,350
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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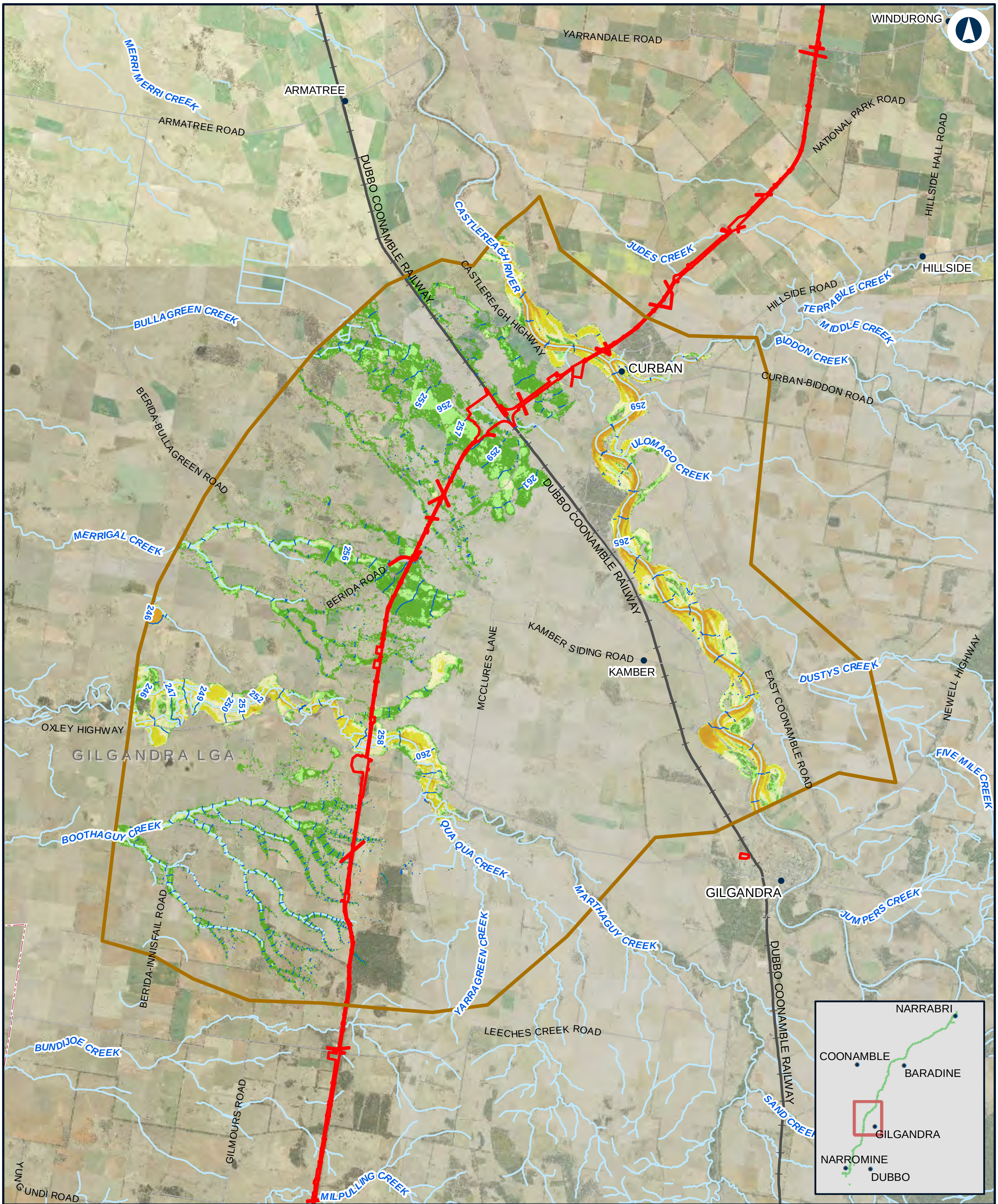

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N11N12 Appendix D - Figure 1.2d

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:198,370
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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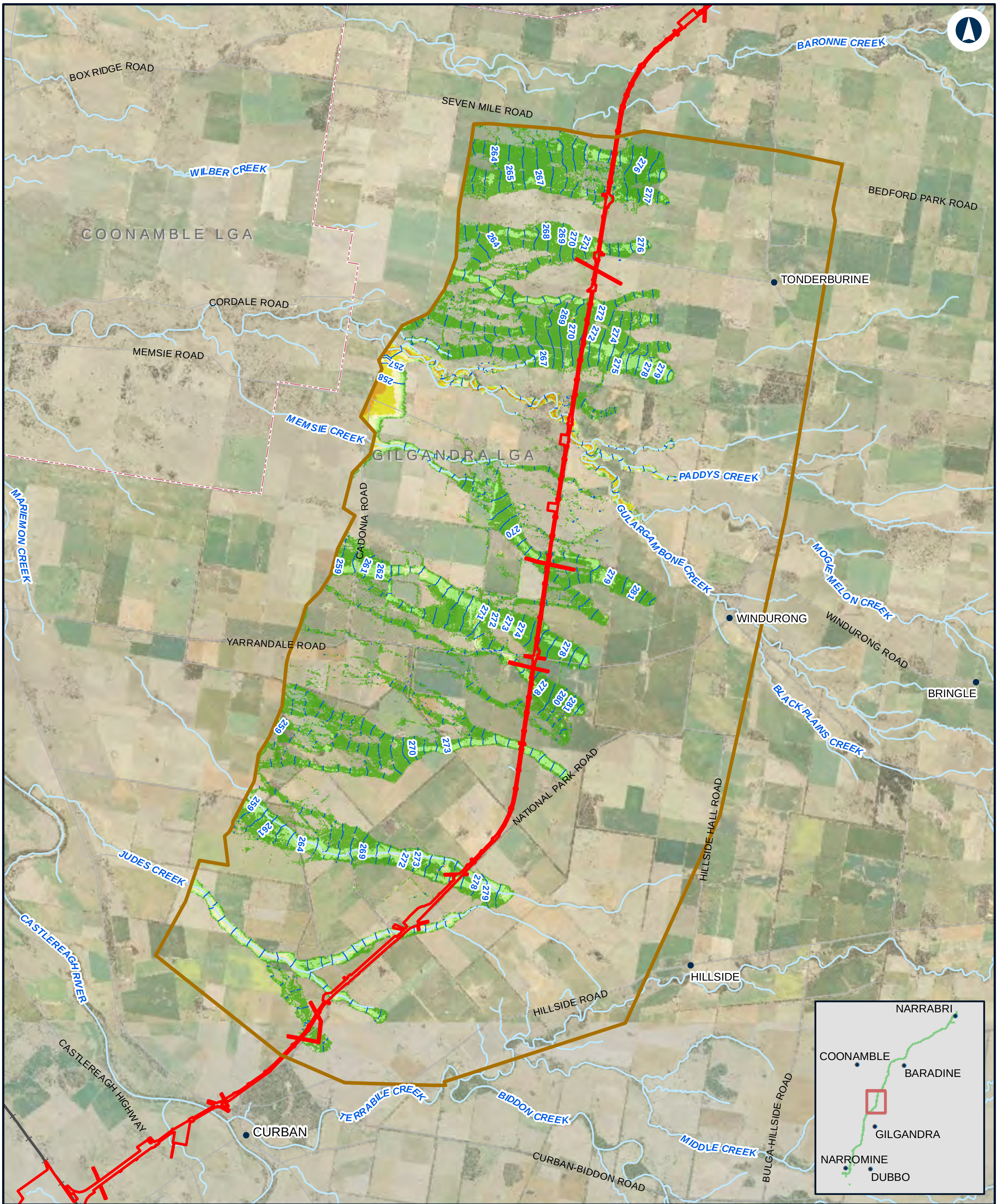
G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP008_FloodBehaviourDepth_5pcExist.mxd



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N10 Appendix D - Figure 1.2e

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:134,230
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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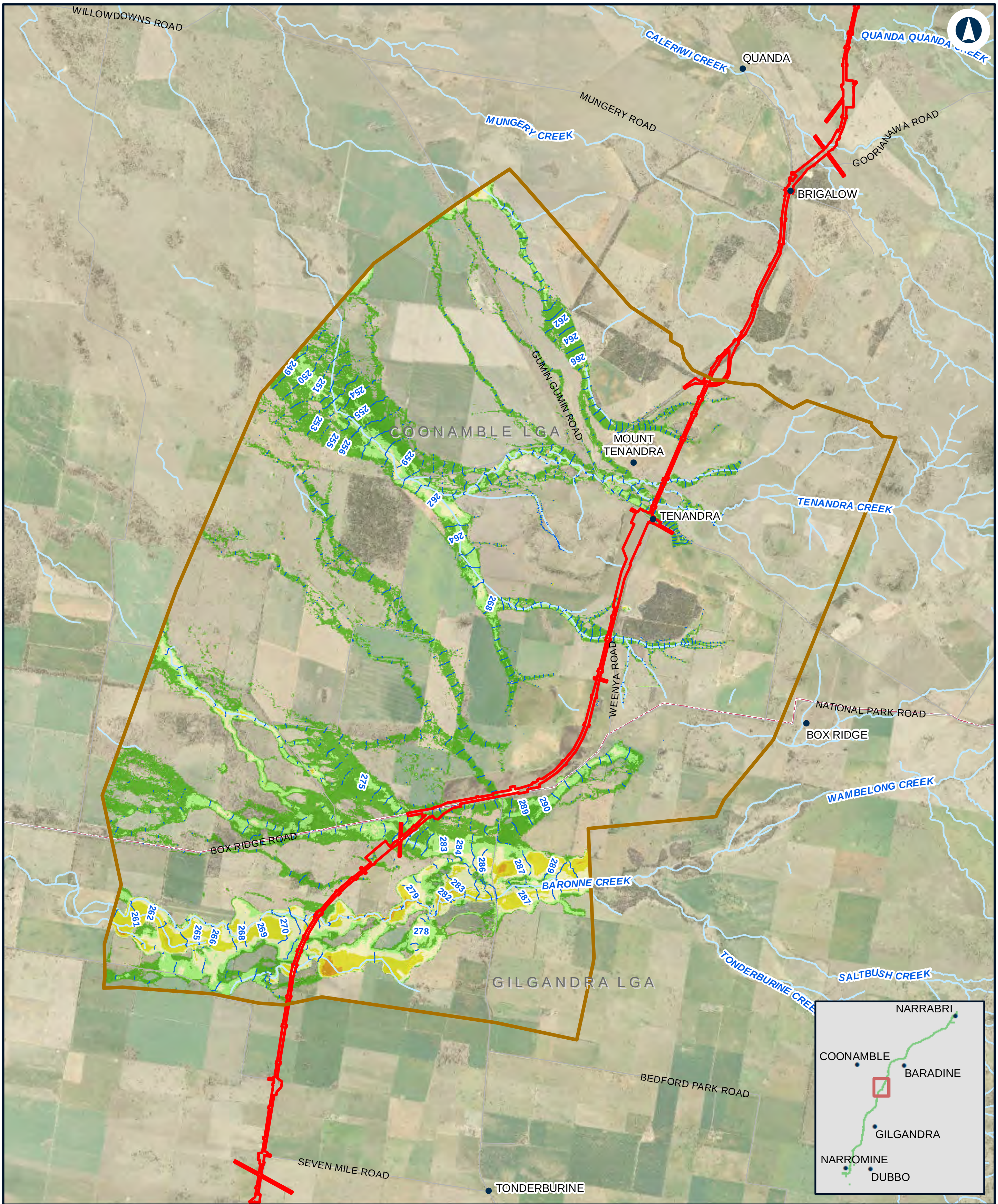

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N9 Appendix D - Figure 1.2f

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:104,540
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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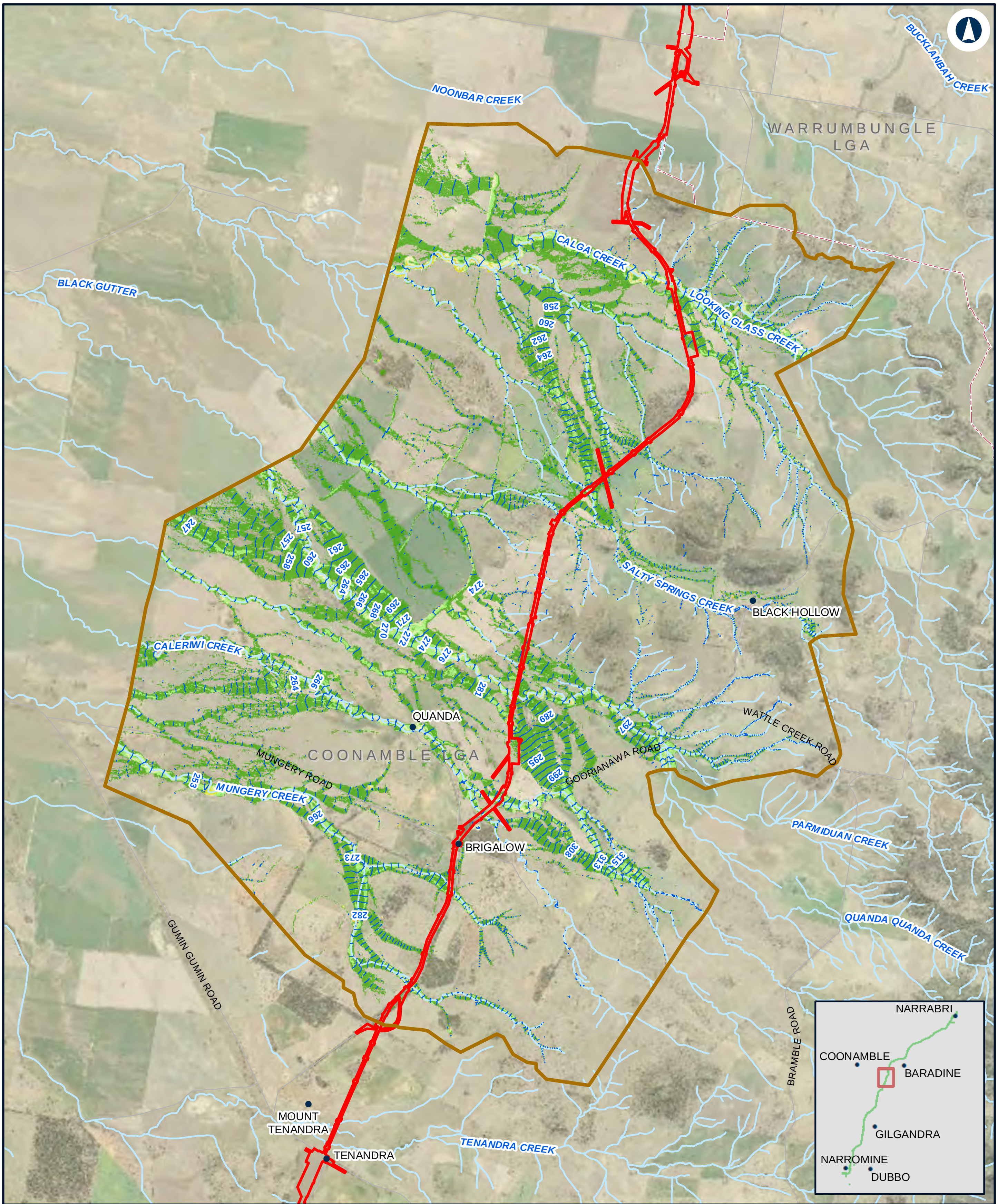

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 5% AEP -N2N8

Appendix D - Figure 1.2g

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:109,040
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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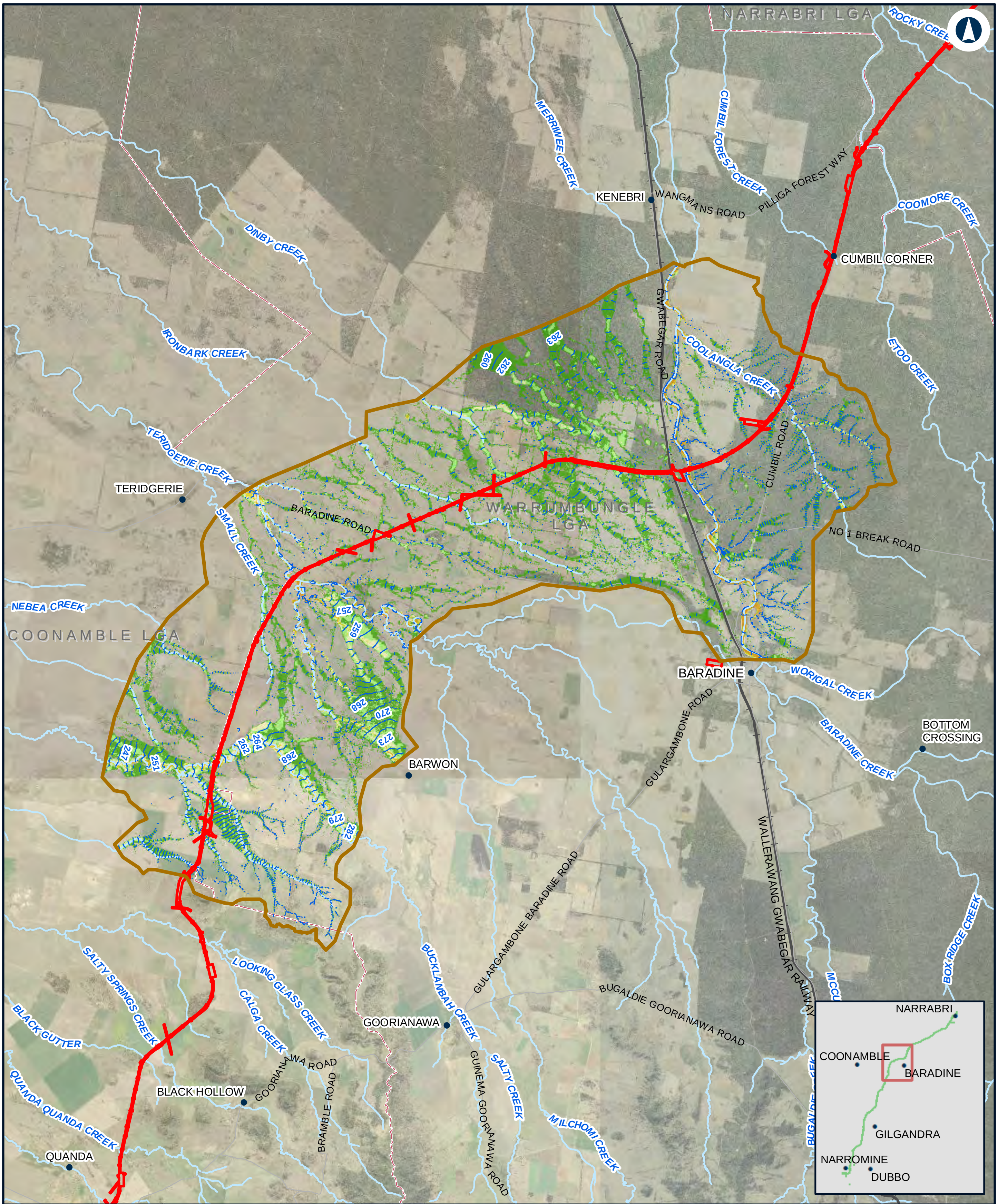

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 5% AEP -N2N7

Appendix D - Figure 1.2h

0 3 6 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:212,360
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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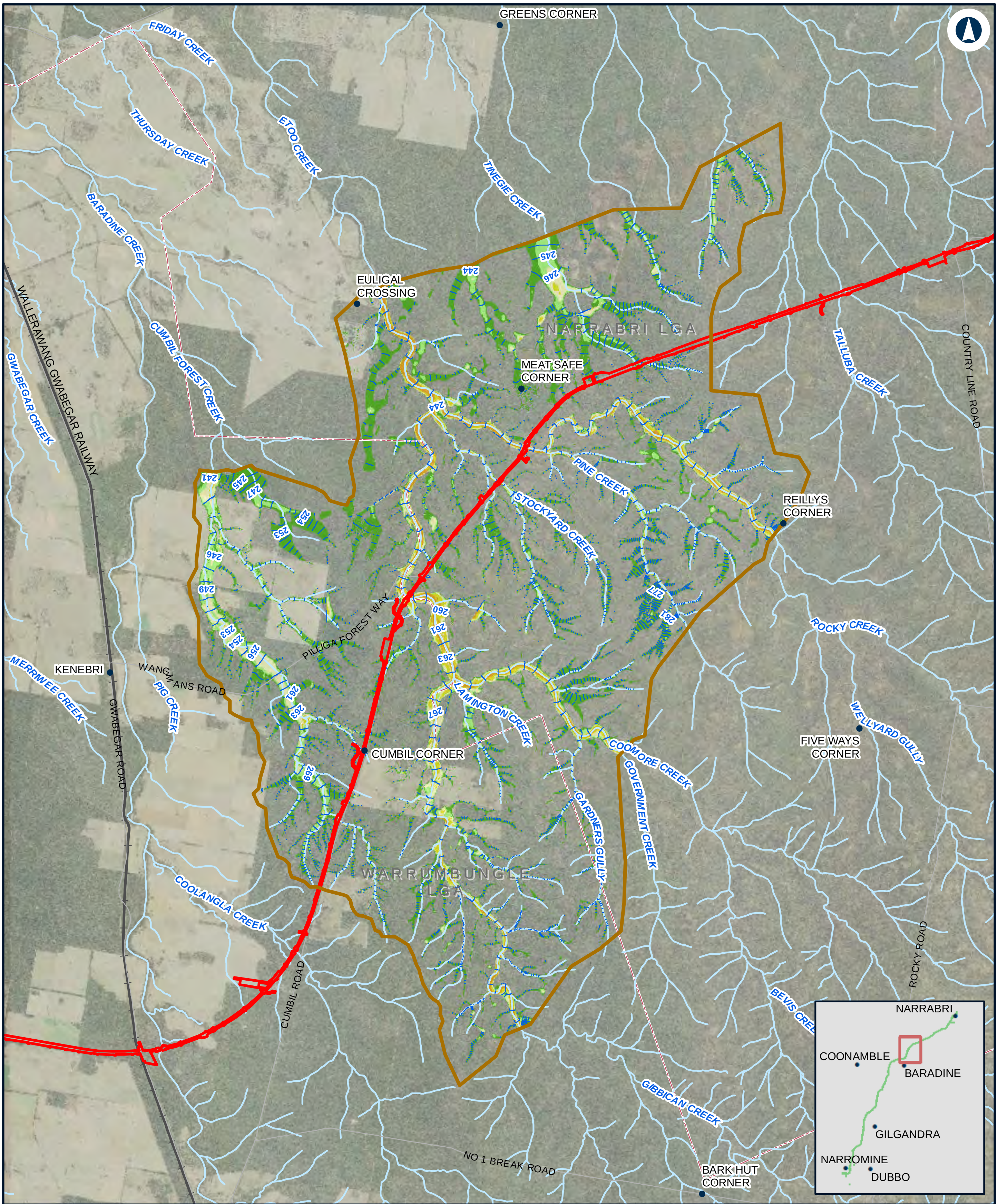

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 5% AEP -N2N6

Appendix D - Figure 1.2i

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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ARTC will not be responsible for any loss or damage suffered as a result of any person whatsoever placing reliance upon the information contained within this GIS map.

Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:152,190
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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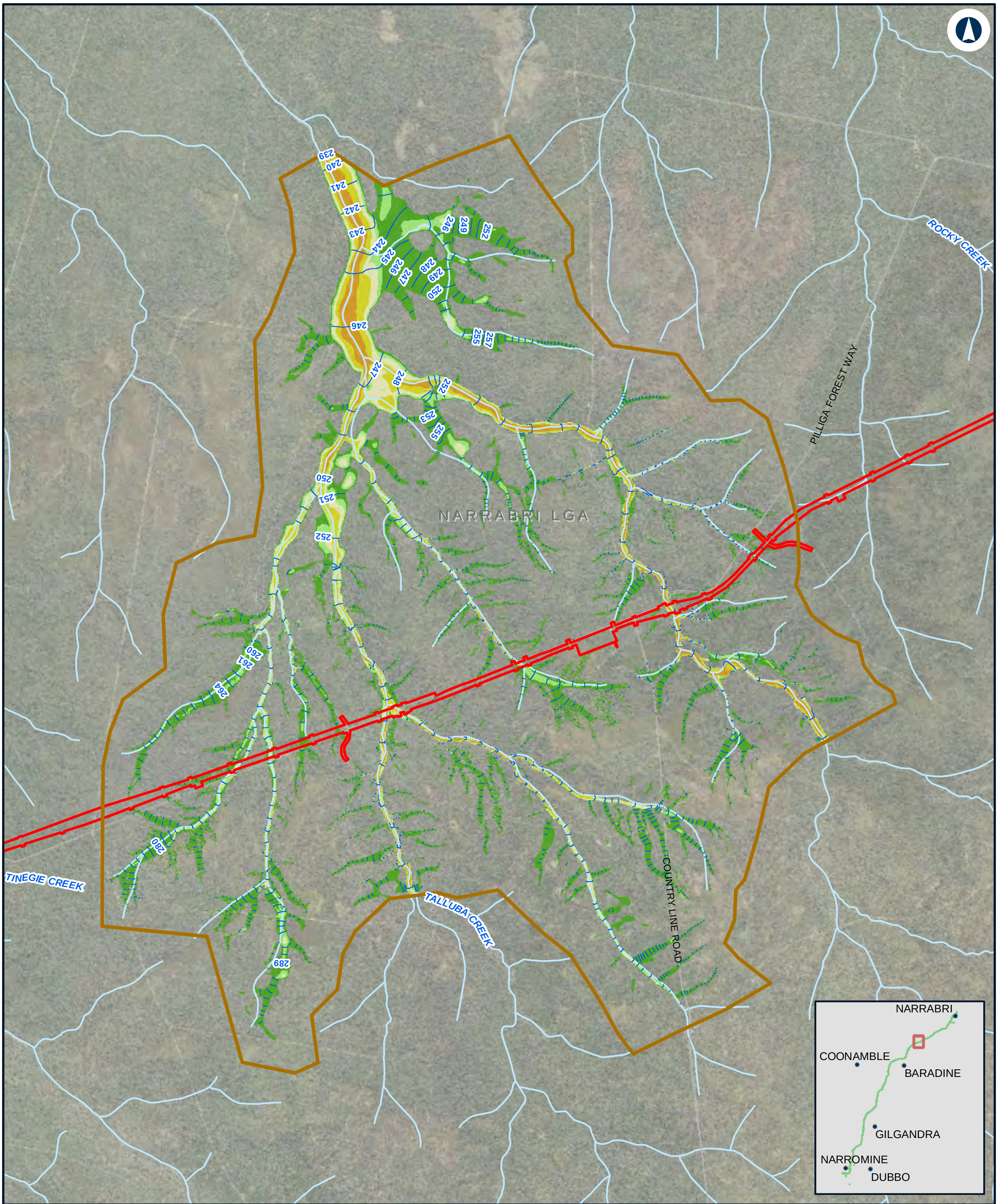

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N5 Appendix D - Figure 1.2j

0 0.95 1.9
Km

Coordinate System: GDA 1994 MGA Zone 55

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ARTC will not be responsible for any loss or damage suffered as a result of any person whatsoever placing reliance upon the information contained within this GIS map.

Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:69,470
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

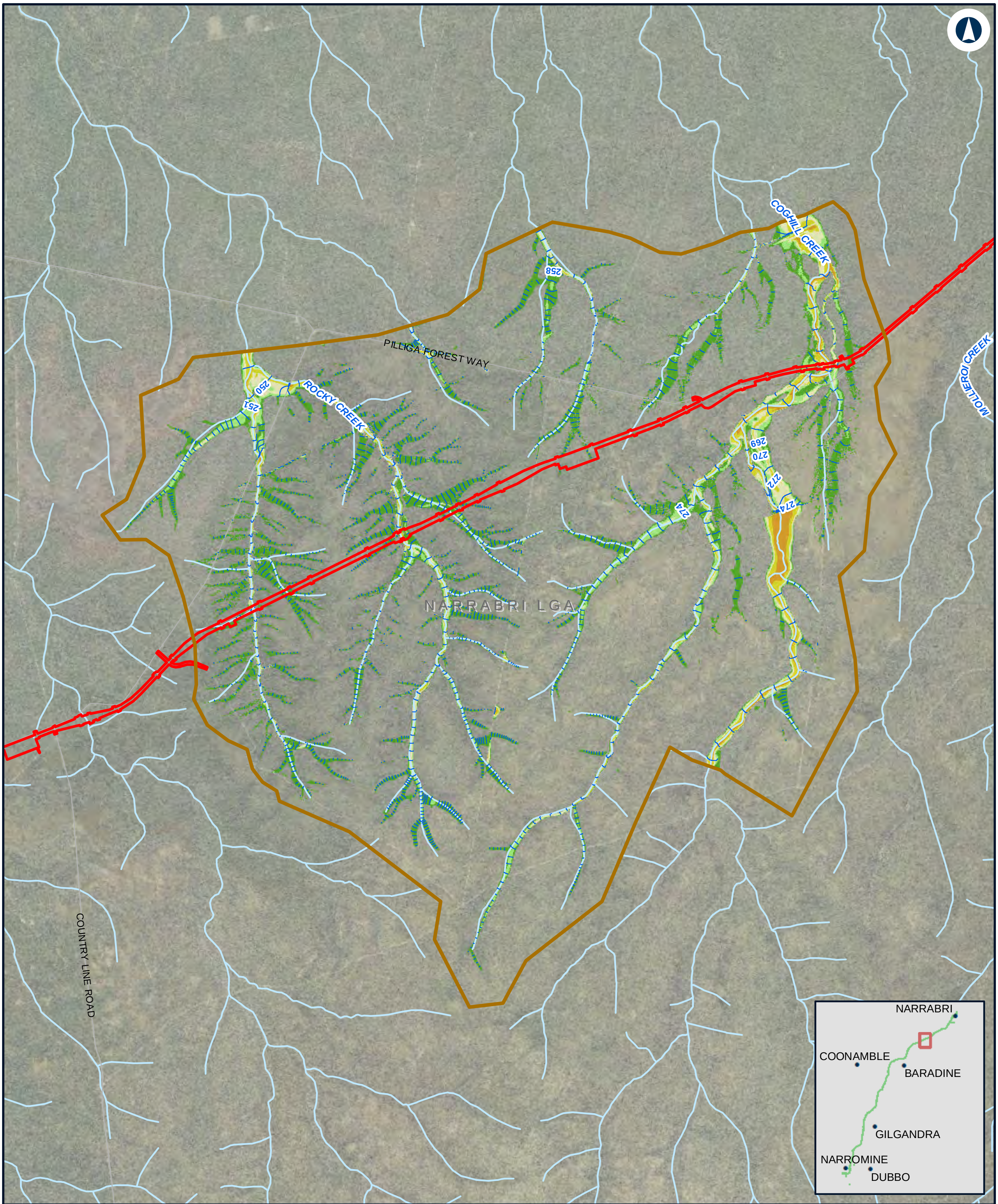
- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.



NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 5% AEP -N2N4

Appendix D - Figure 1.2k

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:80,540
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

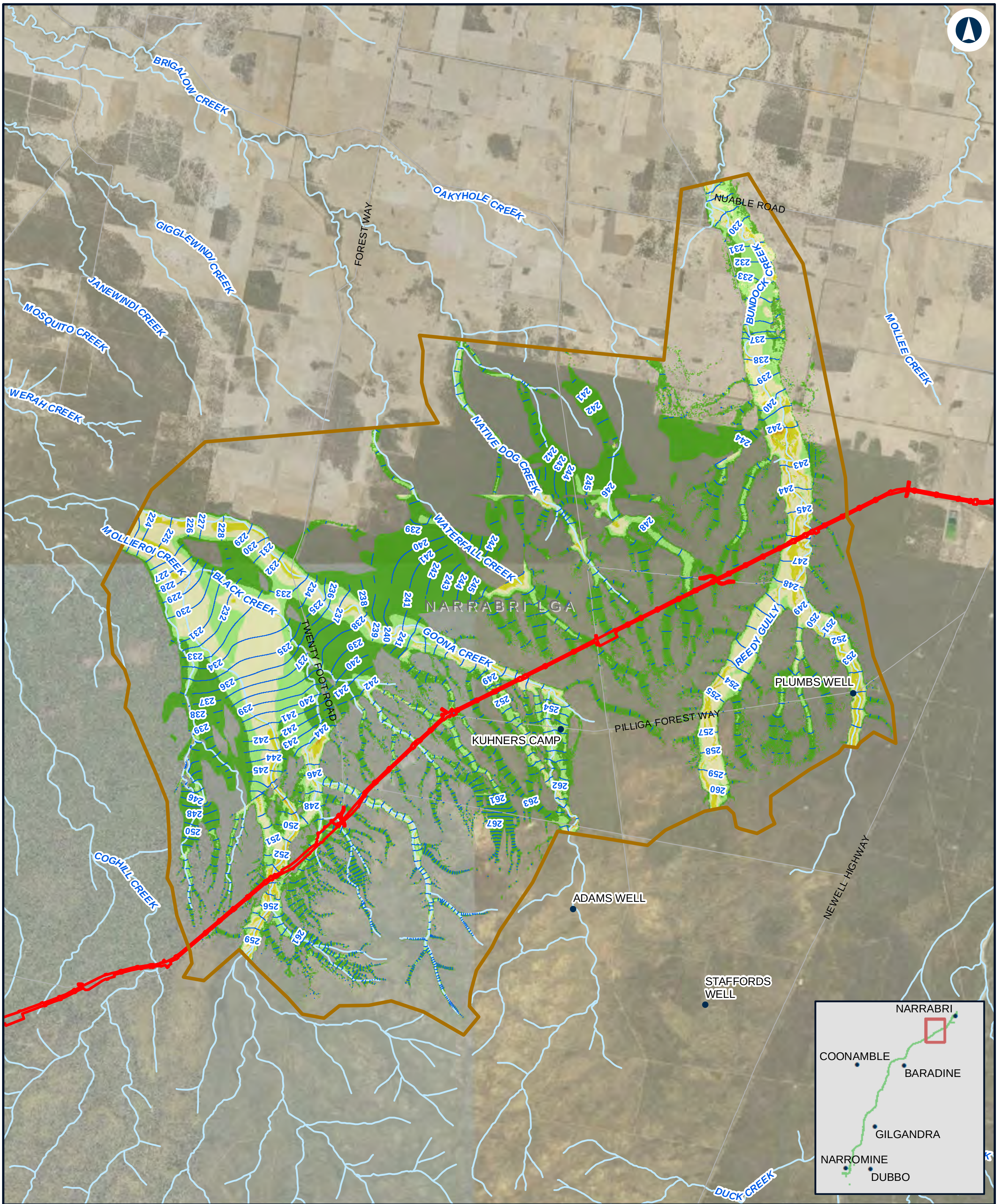
- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.



NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 5% AEP -N2N23

Appendix D - Figure 1.2l

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:139,650
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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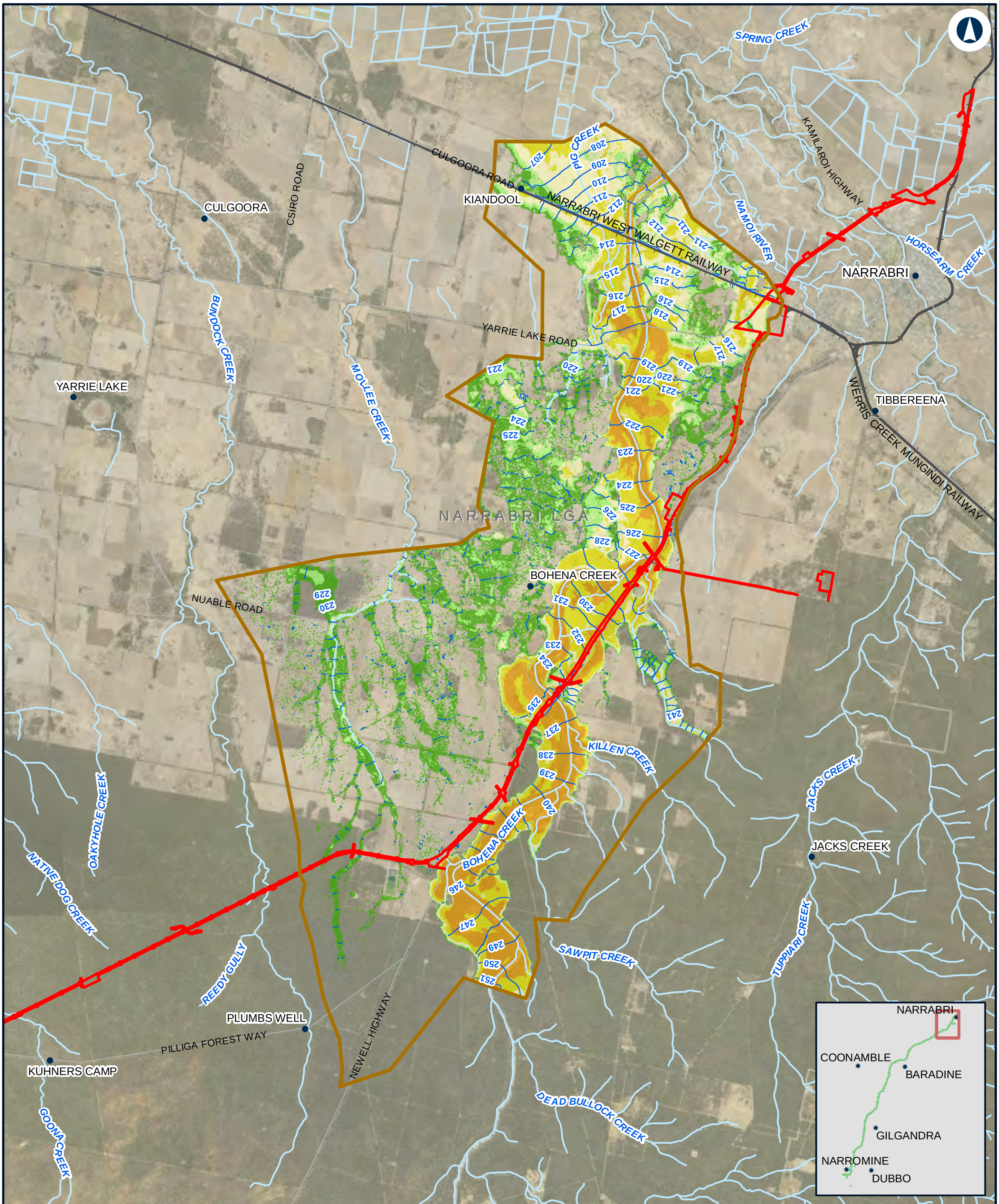

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -N2N1 Appendix D - Figure 1.2m

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:160,210
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

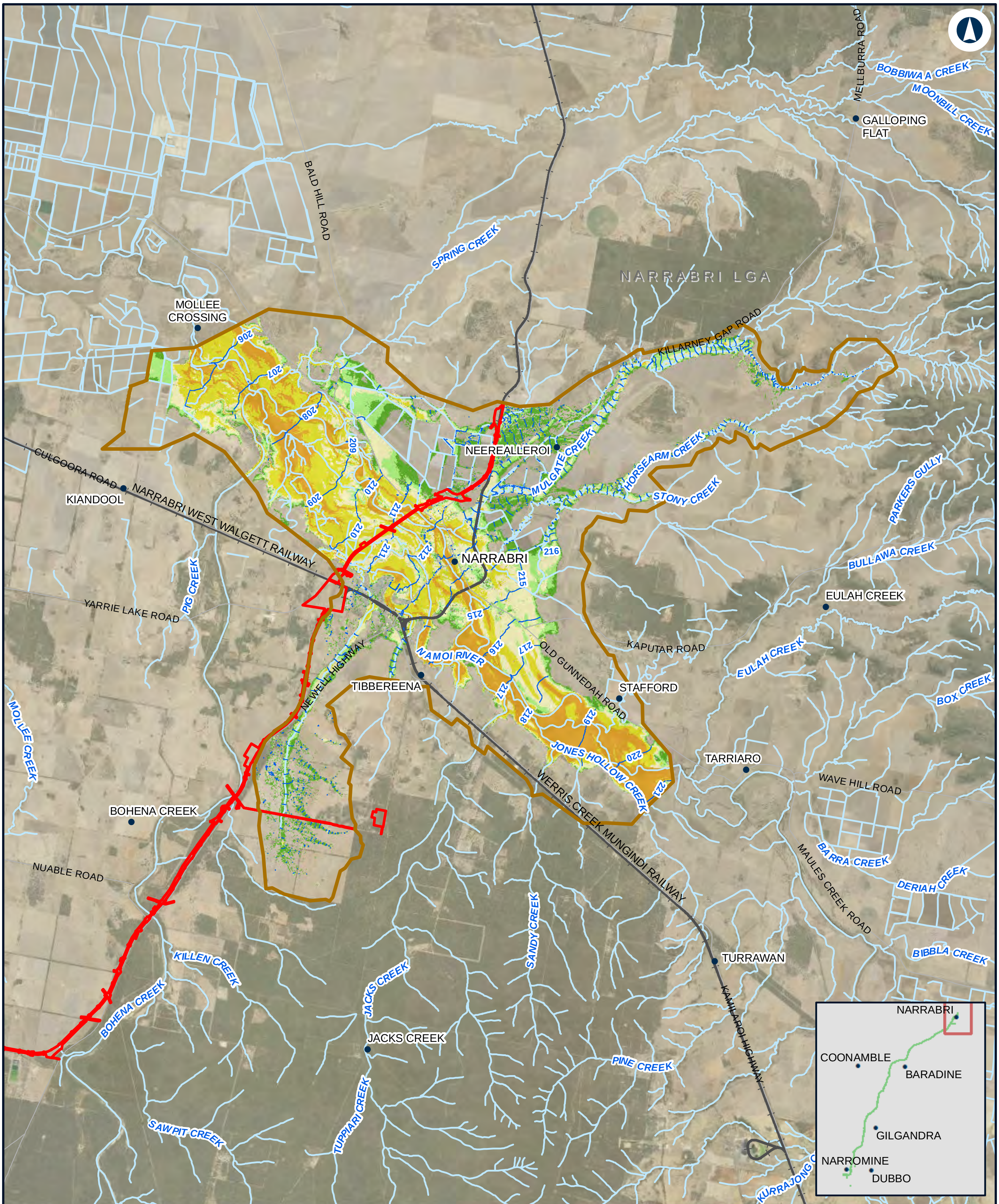
- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 5% AEP -Narrabri Appendix D - Figure 1.2n

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:190,920
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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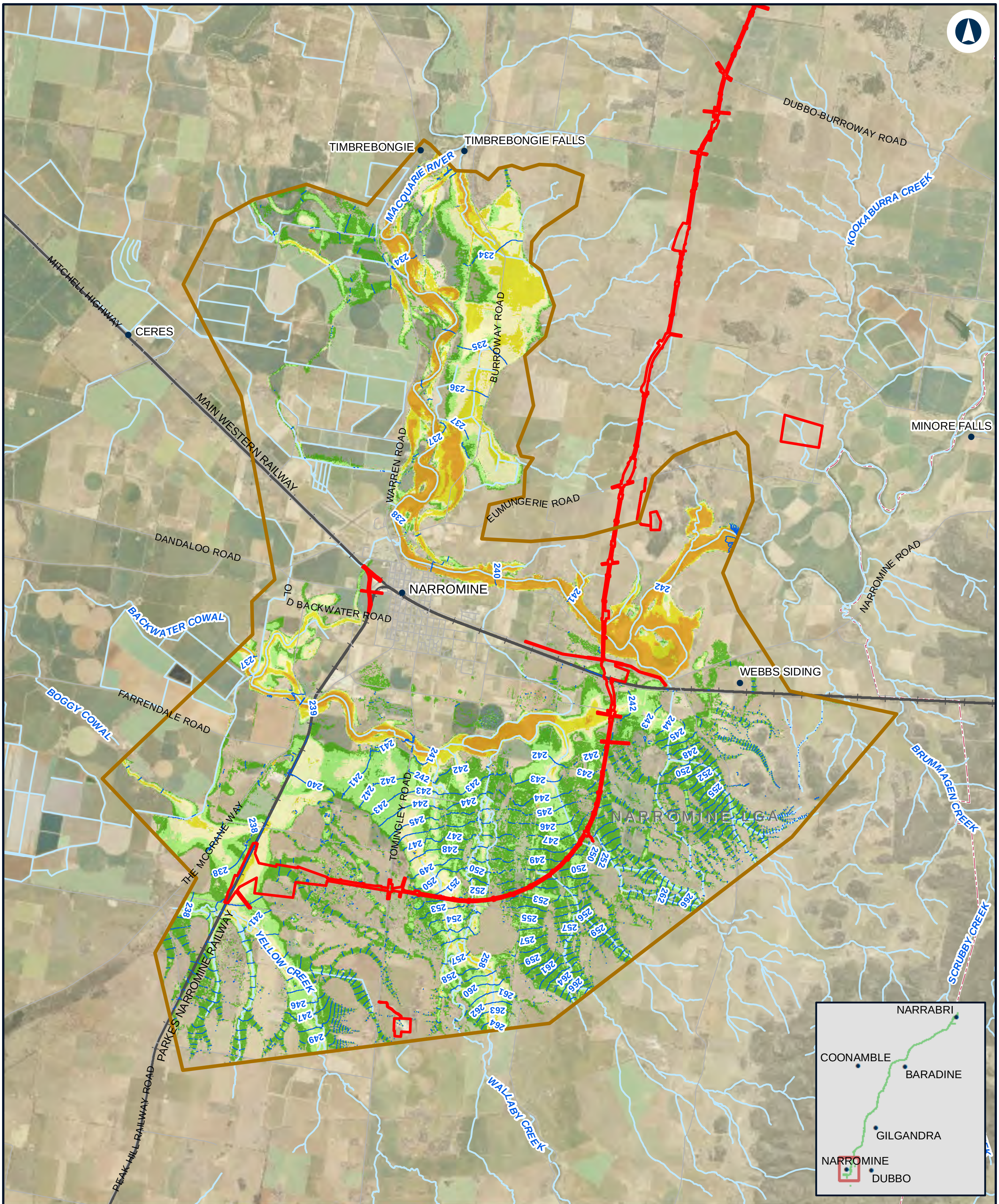

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -NFM Appendix D Figure 1.3a

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:140,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

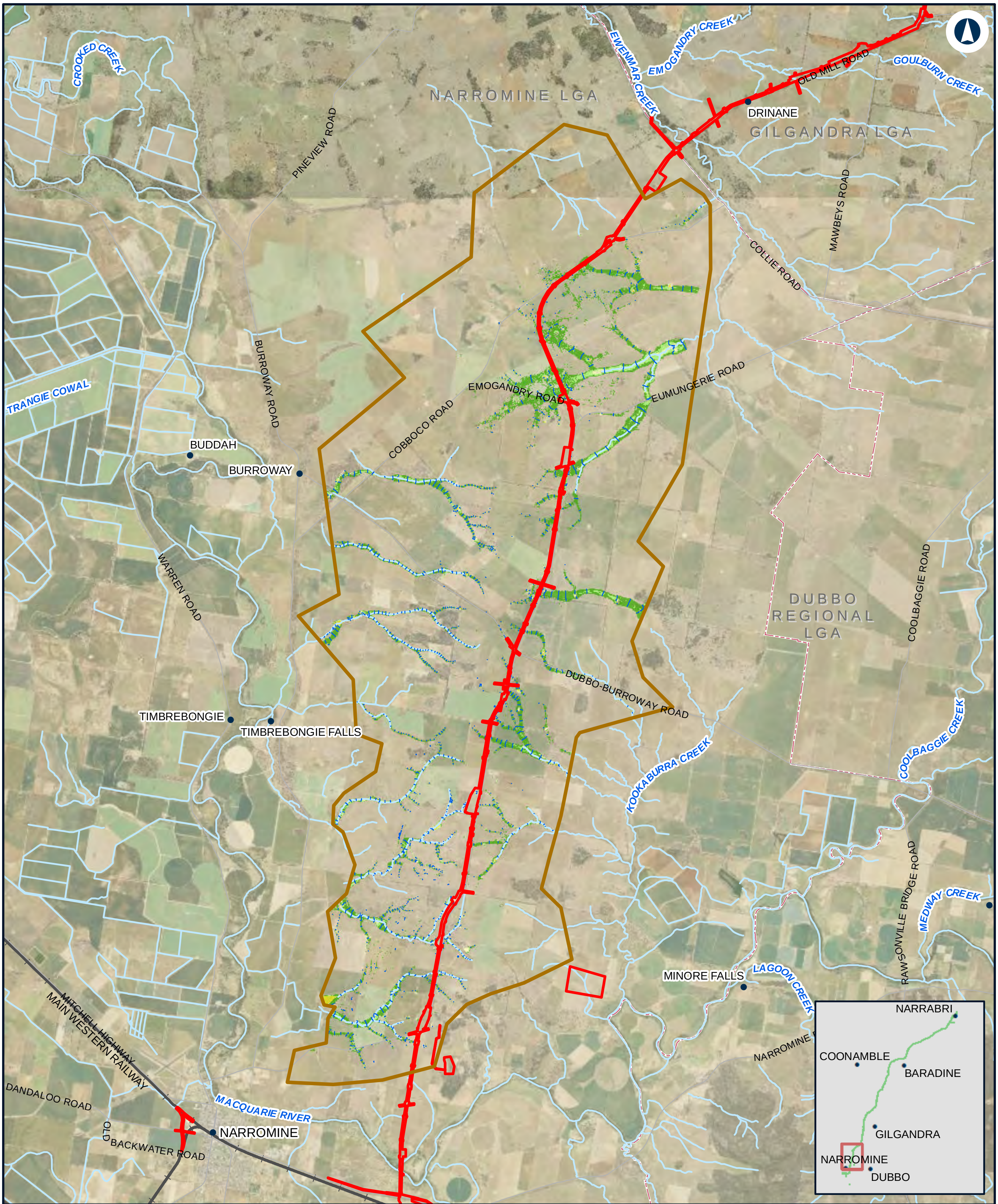
Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP006_FloodBehaviourDepth_2pcExist.mxd



NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 2% AEP -N2N14

Appendix D Figure 1.3b

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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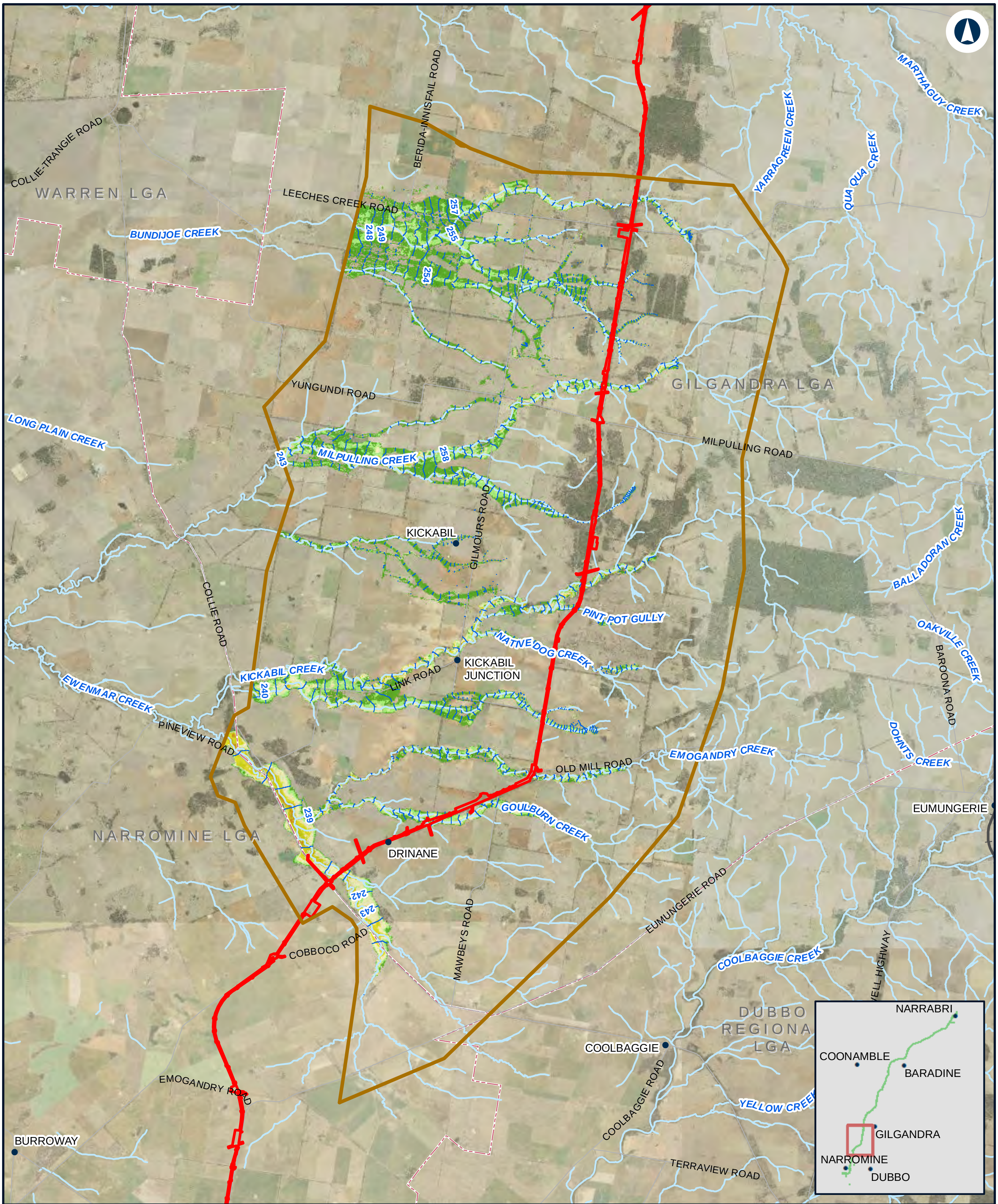
G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP006_FloodBehaviourDepth_2pcExist.mxd



NARROMINE TO NARRABRI — Existing peak depth / level (contour) - 2% AEP -N2N13 — Appendix D Figure 1.3c

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:180,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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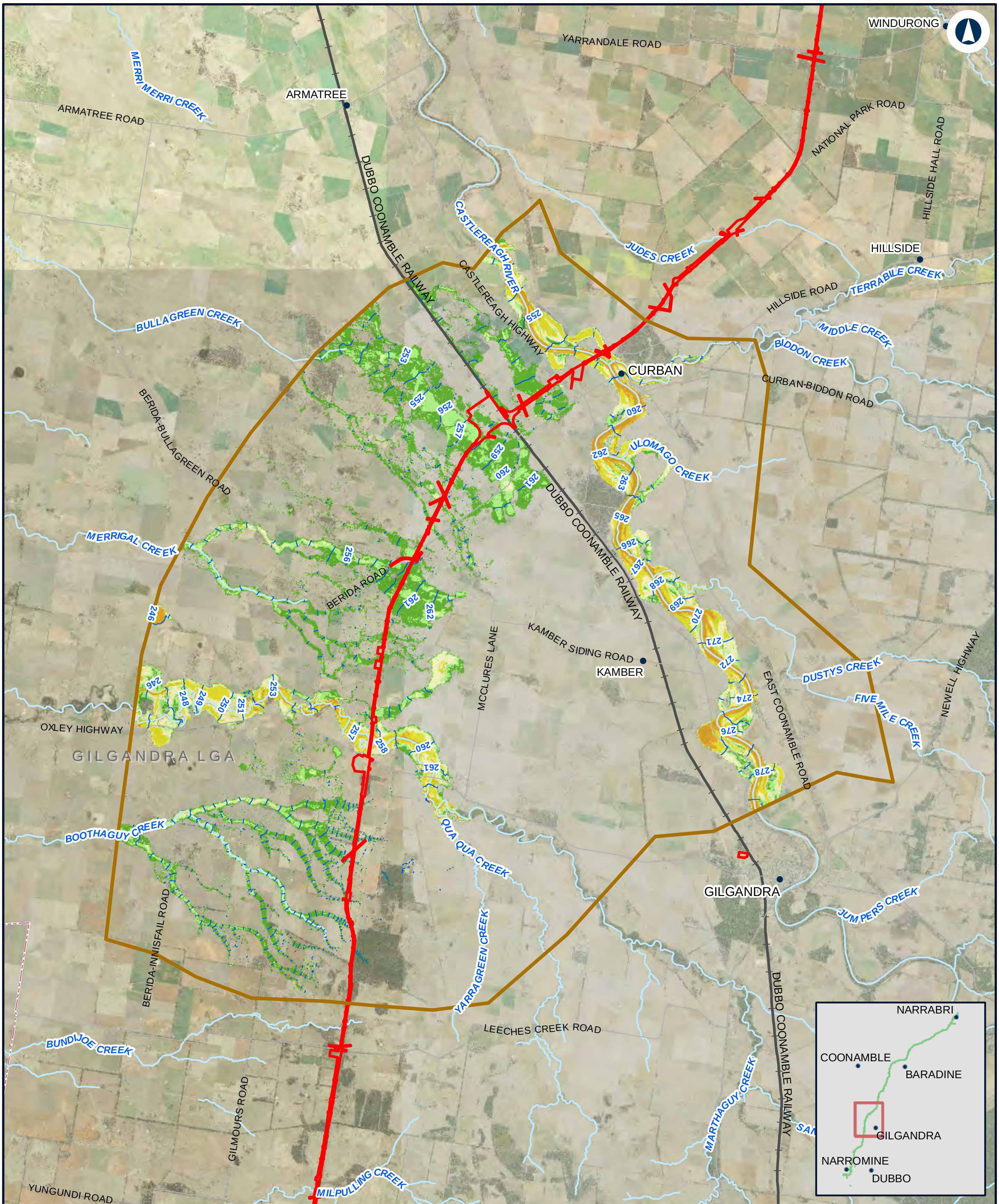
G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP006_FloodBehaviourDepth_2pcExist.mxd



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -N2N11N12 Appendix D Figure 1.3d

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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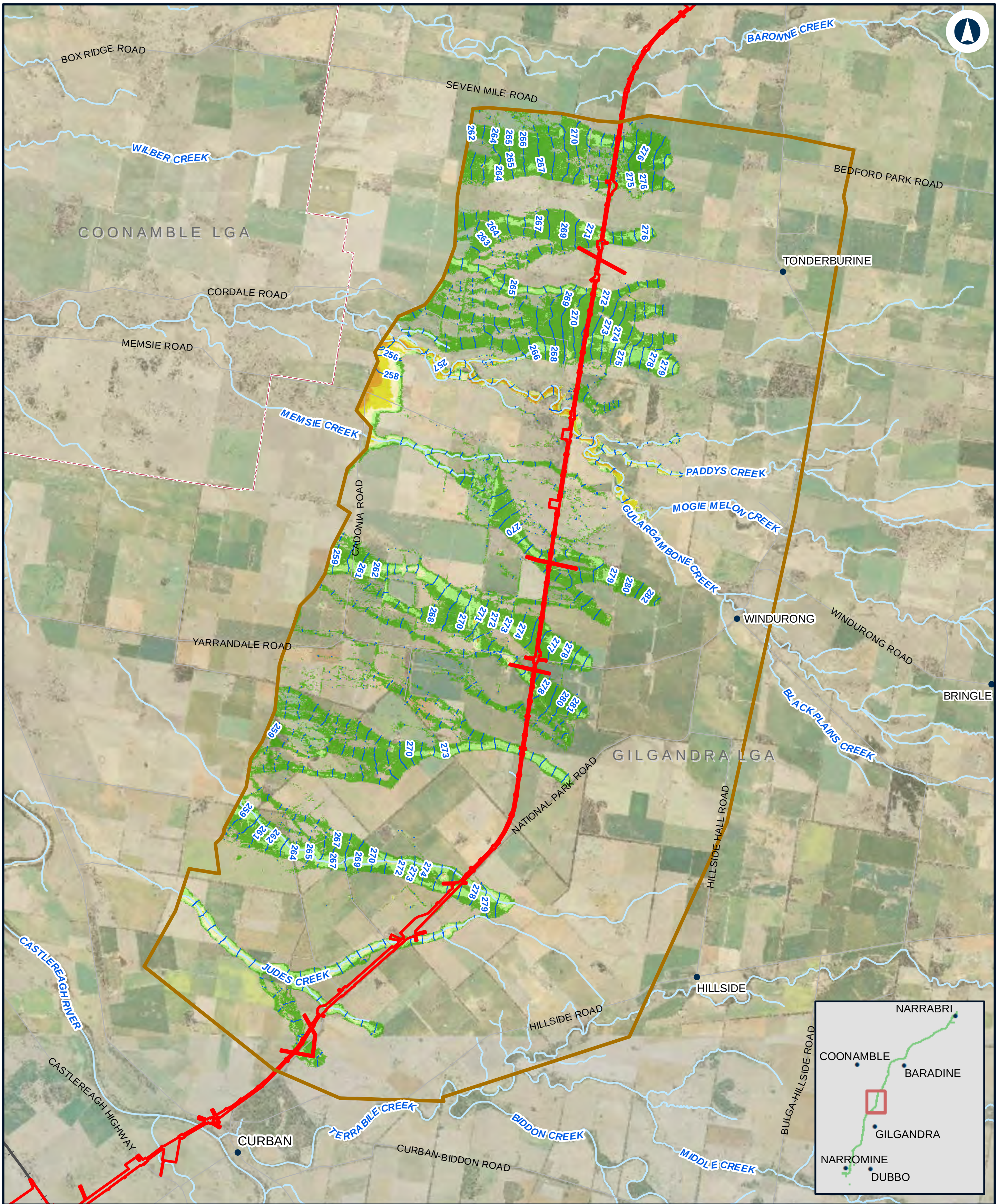

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -N2N10 Appendix D Figure 1.3e

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:130,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)
- 1.0m - 2.0m
- > 2.0m

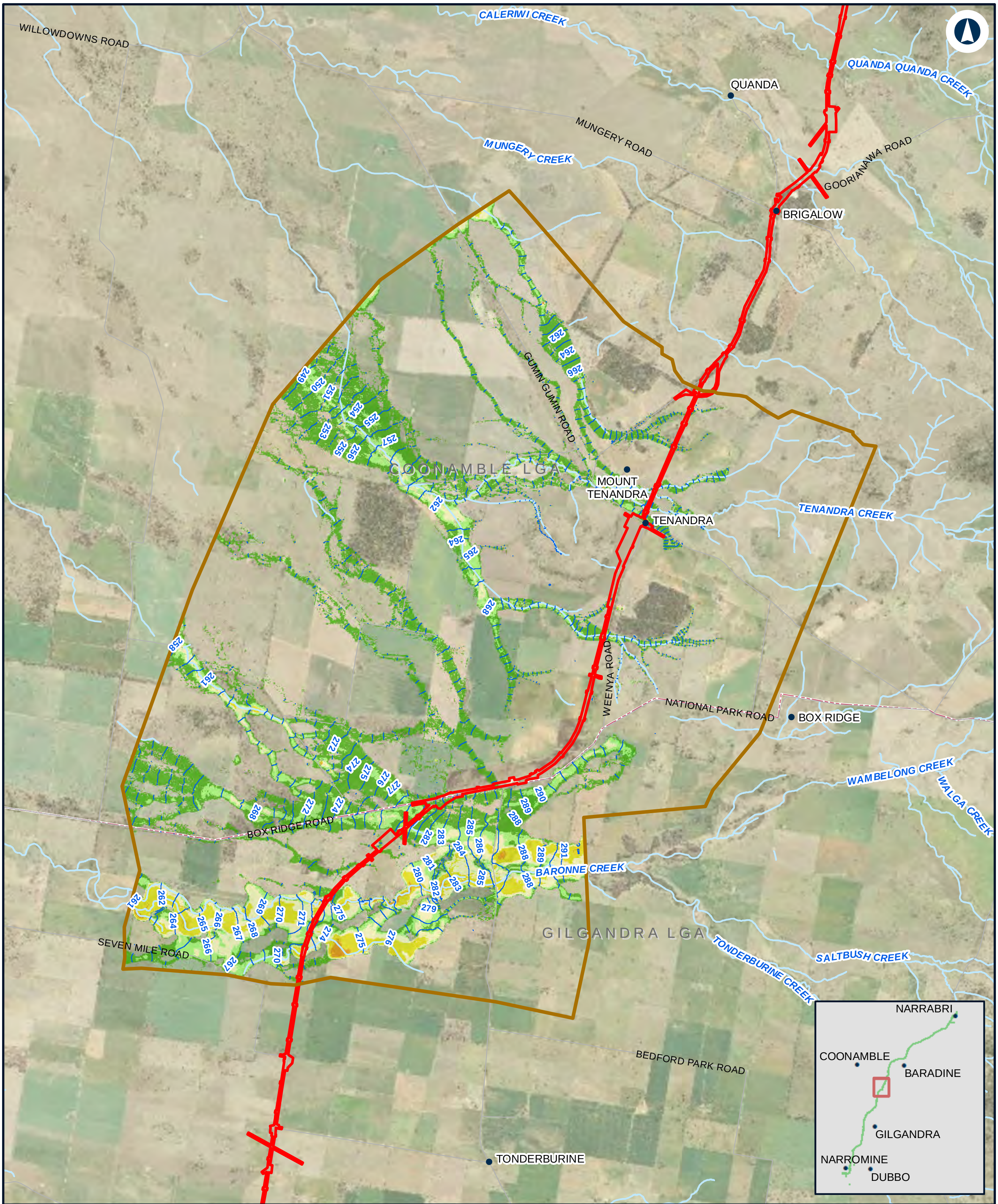
Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m

INLAND RAIL ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

G:\22\19593\GIS\GIS_2500_N2N_v2\Maps\Deliverables_EISFinal\EIS\FloodingHydrologyAssessment\Apendix\2500_EISFSRAPP006_FloodBehaviourDepth_2pcExist.mxd



NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -N2N9 Appendix D Figure 1.3f

0 1.5 3 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:110,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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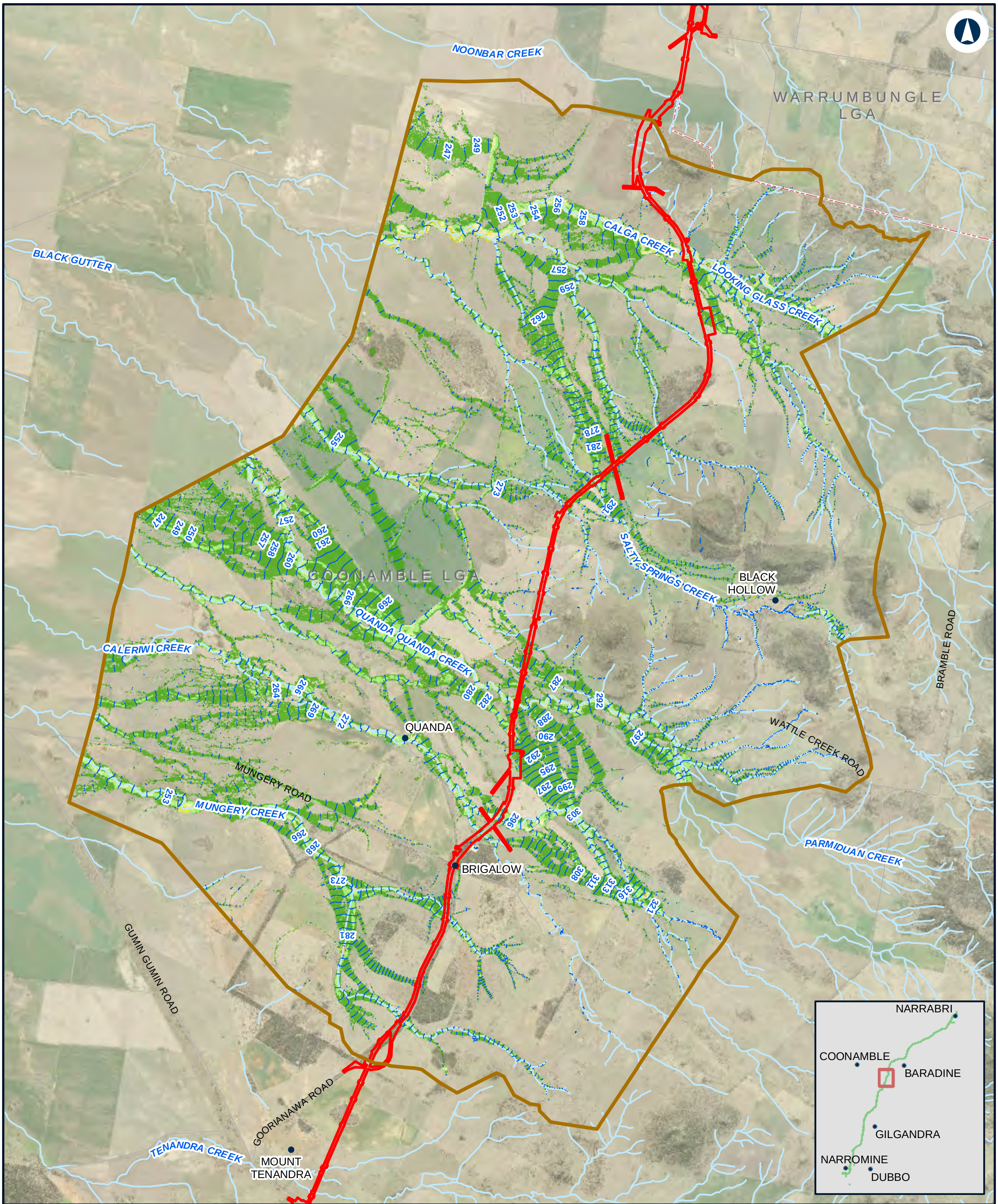

NARROMINE TO NARRABRI

Existing peak depth / level (contour) - 2% AEP -N2N8

Appendix D Figure 1.3g

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:100,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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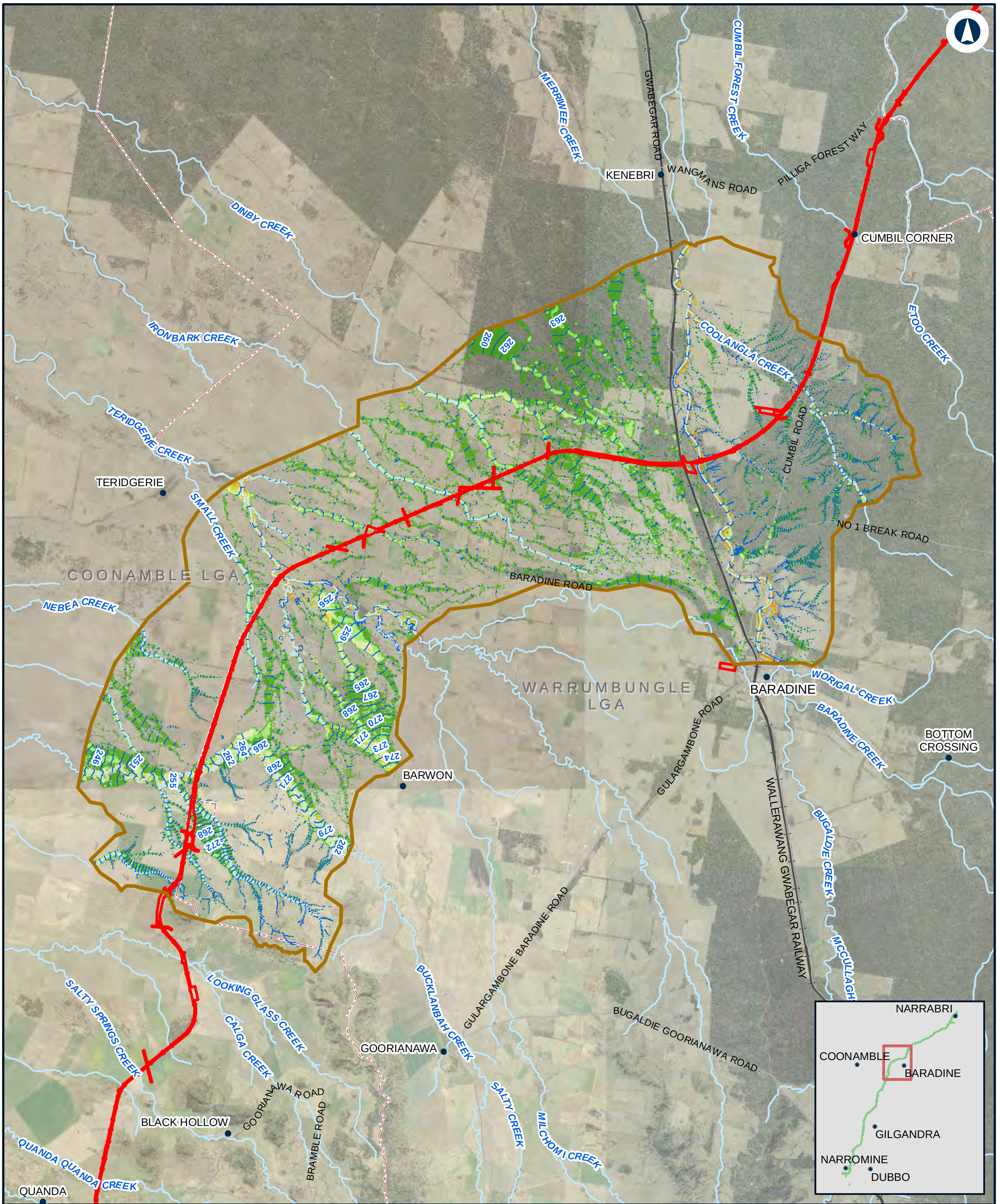

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -N2N7 Appendix D Figure 1.3h

0 2.5 5 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:200,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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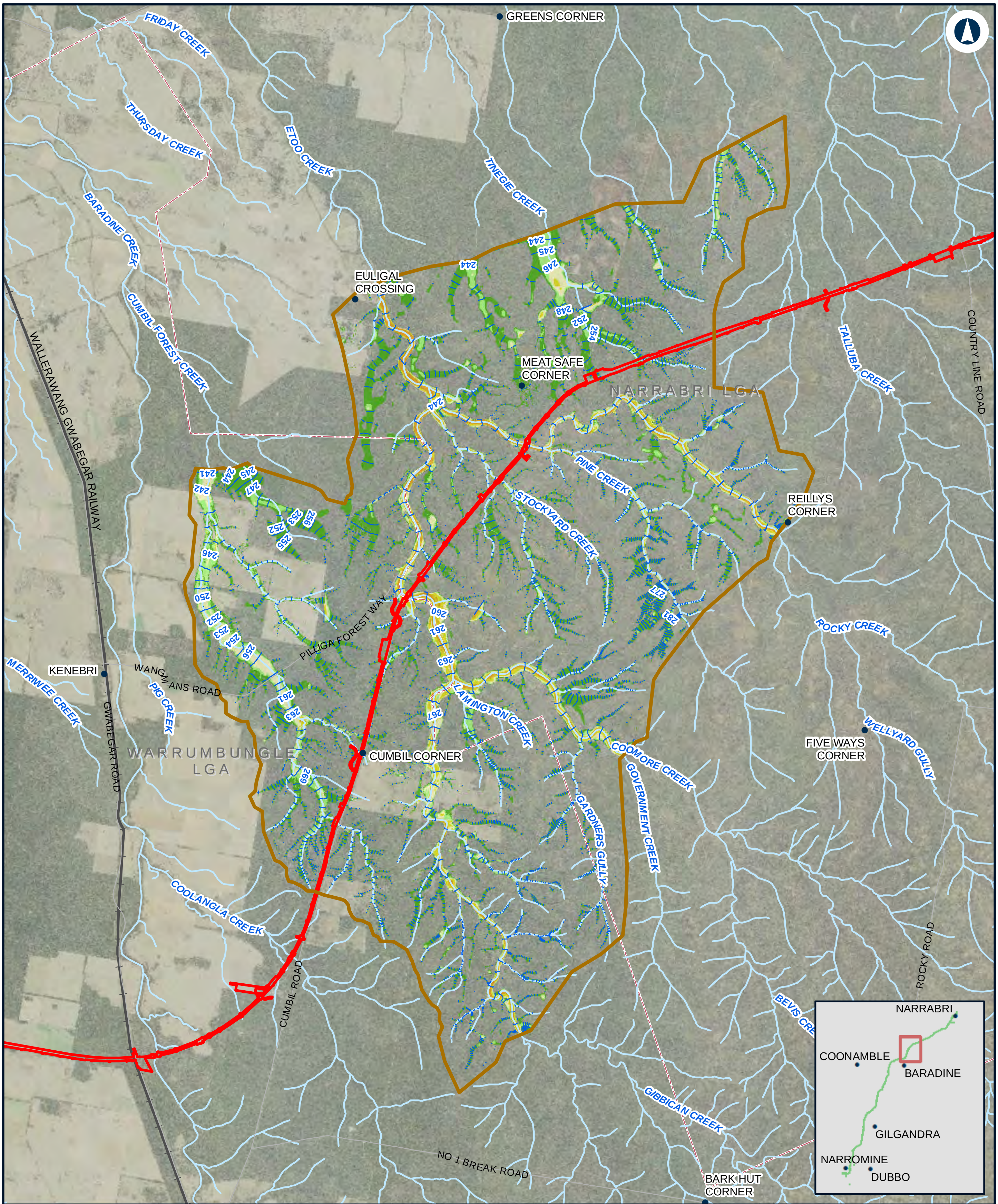

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -N2N6 Appendix D Figure 1.3i

0 2 4 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:150,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

INLAND RAIL ARTC

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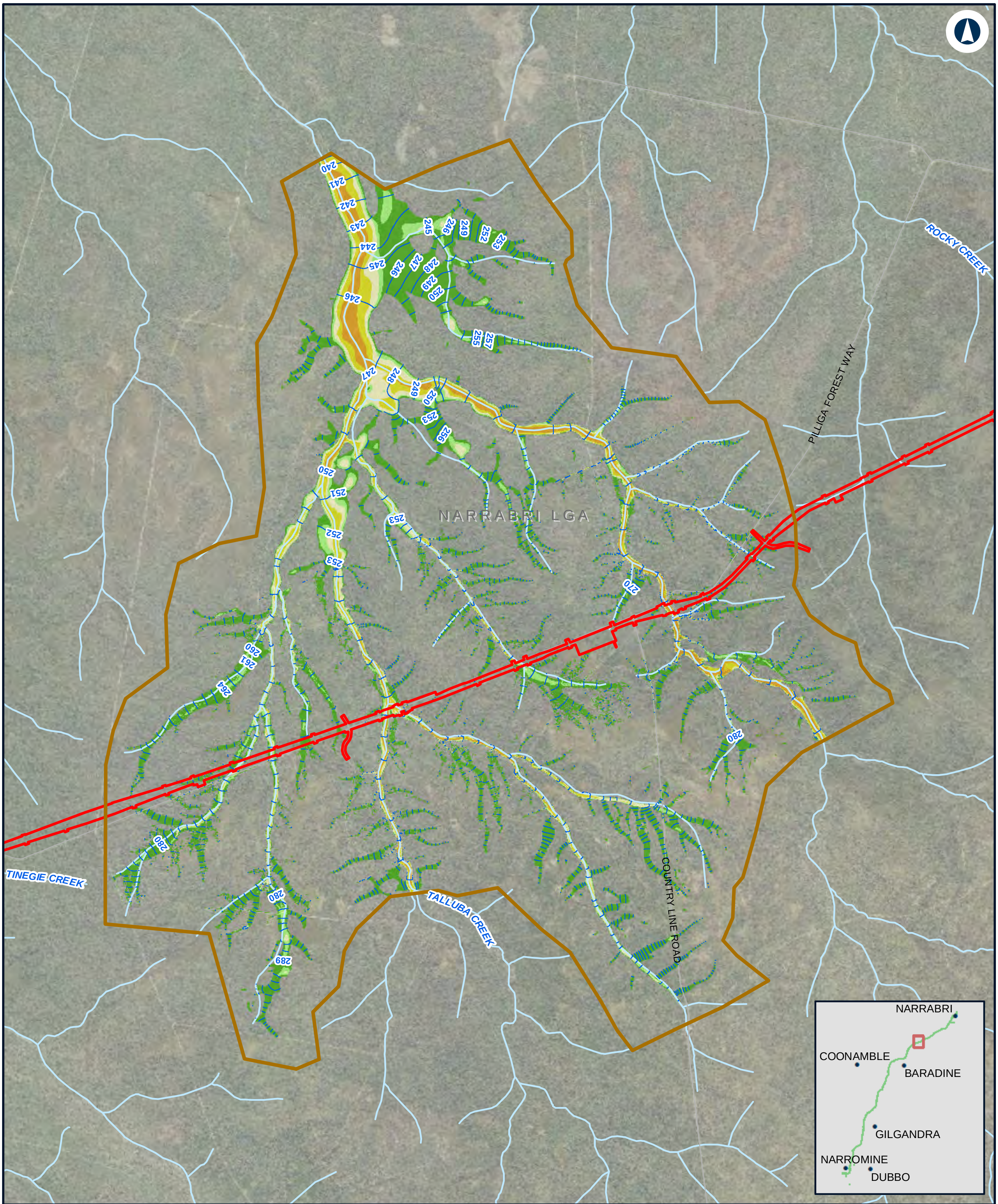

NARROMINE TO NARRABRI Existing peak depth / level (contour) - 2% AEP -N2N5

Appendix D Figure 1.3j

0 1 2 Km

Coordinate System: GDA 1994 MGA Zone 55

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Date: 27/10/2020 Paper: A4
Author: JacobsGHD Scale: 1:70,000
Data Sources: Basemap layers: NSWSS; all other layers: JacobsGHD

LEGEND

- The proposal site
- Model boundary
- Flood level (mAHD)

Flood depth

- 0.0m - 0.25m
- 0.25m - 0.5m
- 0.5m - 1.0m
- 1.0m - 2.0m
- > 2.0m

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