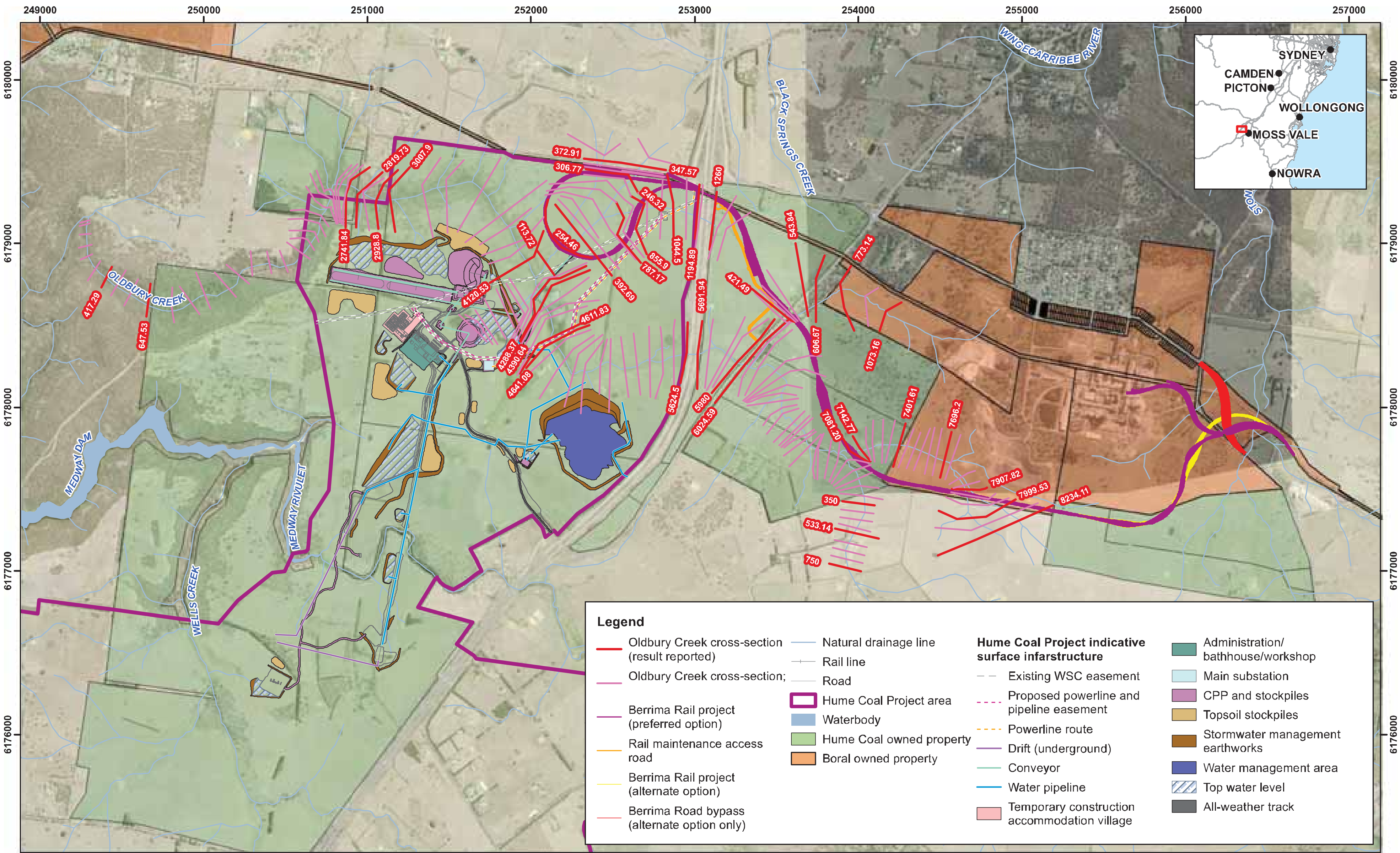

Map: 2200569A_GIS_026_A5	Author: MG
Date: 14/11/2016	Approved by: - LR

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Figure 13.11

Cumulative Oldbury Creek model cross-sections

i Cumulative flood extent

Figure 13.12 presents a comparison of the cumulative 100 year ARI flood extent for the existing and operation scenarios. Figures comparing the cumulative 5 and 20 year ARI and PMF flood extents for the existing and operation scenarios are presented in the Surface Water Assessment Report (2200569A-WAT-REP-001).

Figure 13.13 presents a comparison of the cumulative 100 year ARI flood extent for the existing and rehabilitation scenarios. Figures comparing the cumulative 5 and 20 year ARI and PMF flood extents for the existing and rehabilitation scenarios are presented in the Surface Water Assessment Report (2200569A-WAT-REP-001).

Comparison of the 100 year ARI flood extents shows that changes in flood extent during operation of the rail infrastructure will occur:

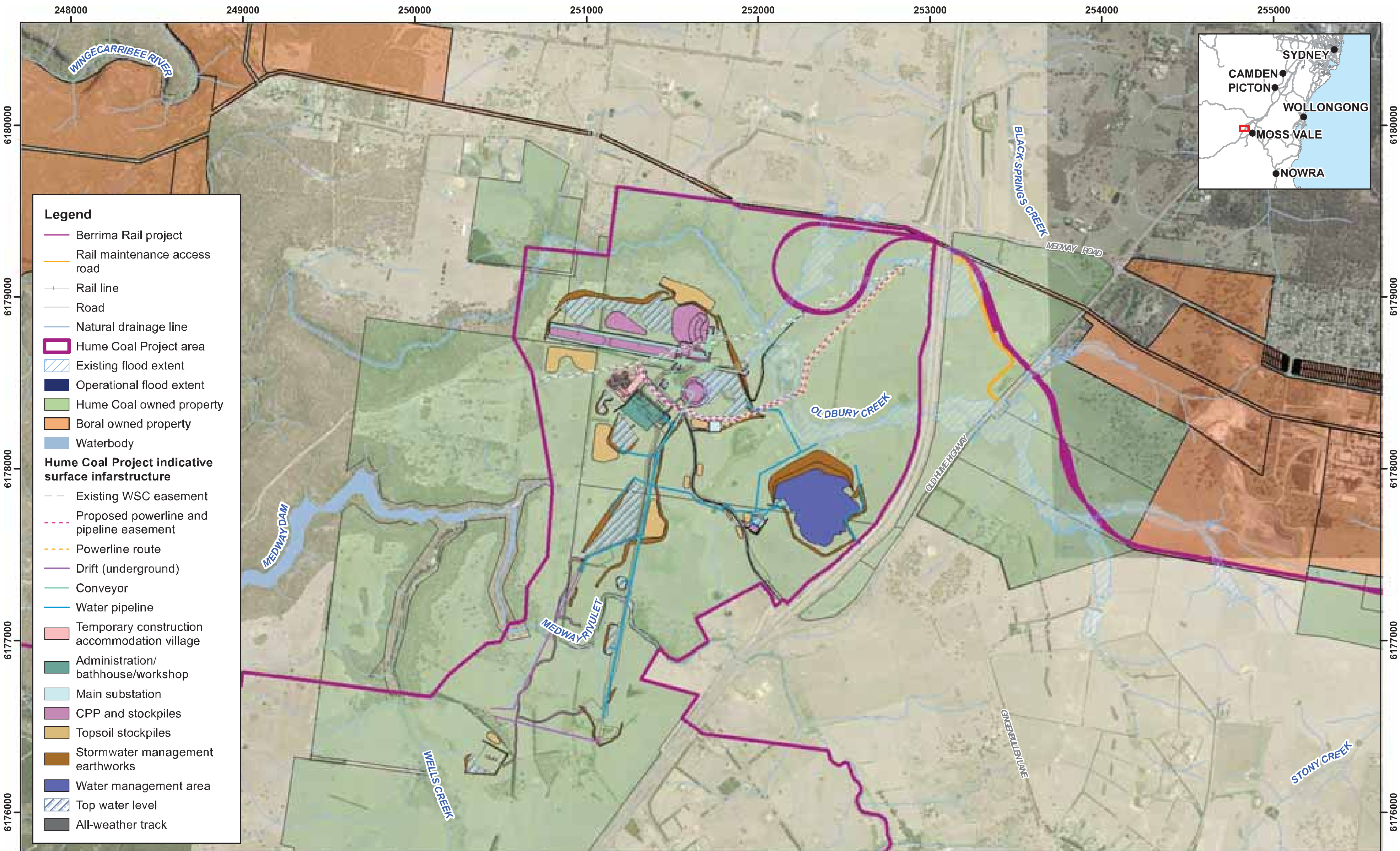
- upstream of where the rail line crosses Oldbury Creek south west of Berrima Cement works;
- just upstream of the Hume Highway on a tributary of Oldbury Creek; and
- in the vicinity of the rail loop.

The changes in flood extent all occur on land owned by Hume Coal or Boral. The increased flood extent upstream of the Hume Highway is minor.

The increase in flood levels up to the PMF to the south west of Berrima Cement works has no impact on the works or the pit.

As for the previous cases, the high order flood event behaviour will change within the rail loop in the area containing the colony of Paddy's River Box trees; however, the dominant flow regime in the area of the trees will not change.

As shown in Figure 13.13, once the rail infrastructure is removed during rehabilitation, the flood extent in these areas will return to existing conditions, apart from just upstream of the Hume Highway where the minor increase in flood extent will remain.



Map: 2200569A_GIS_027_A6	Author: MG
Date: 14/11/2016	Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal

0 250 500 m
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Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

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Figure 13.12
Cumulative 100 Year ARI flood extent - Operation

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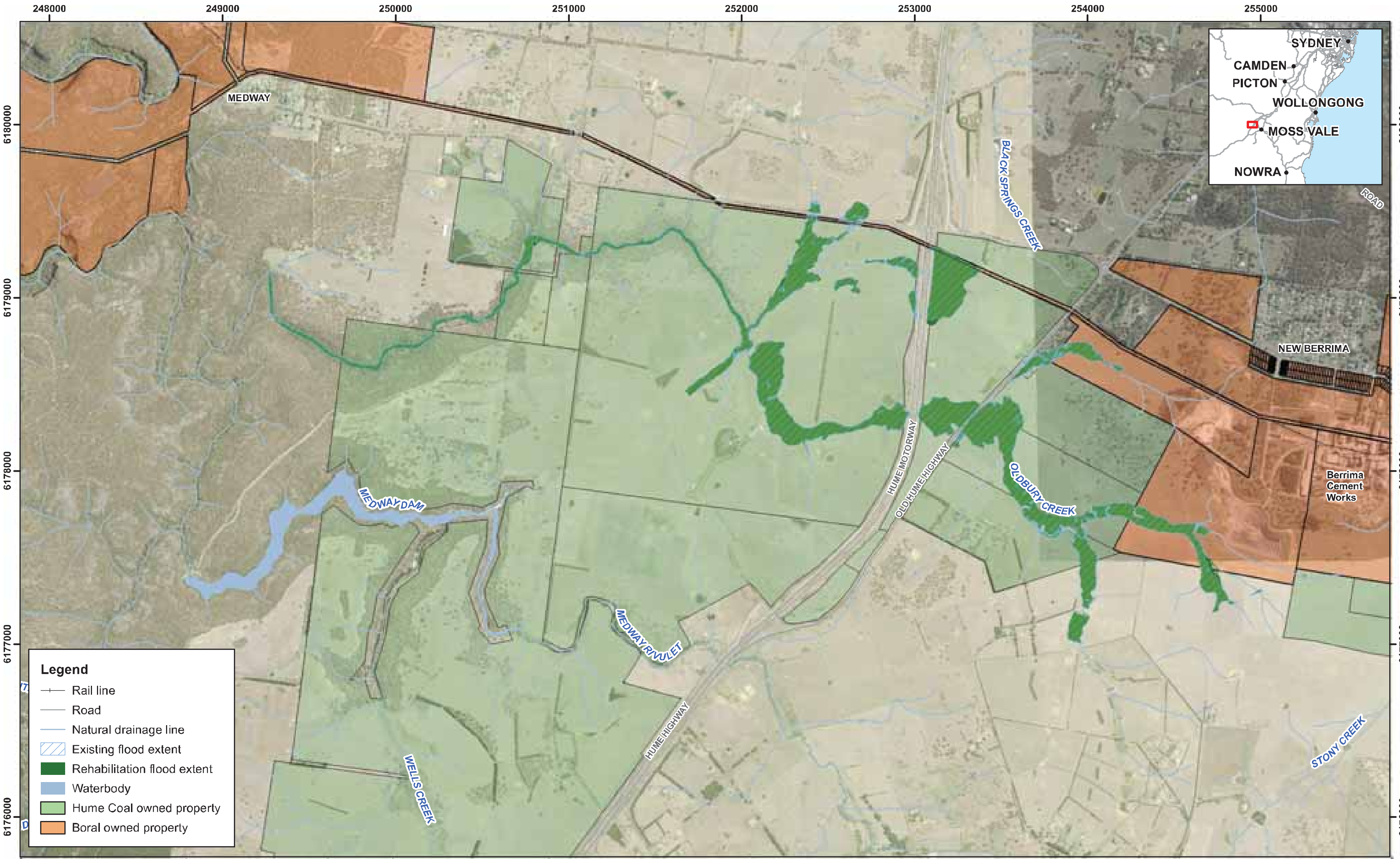

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Data source: © Land and Property Information 2015, Hume Coal		

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Coordinate system: GDA 1994 MGA Zone 56

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Figure 13.13

Cumulative 100 Year ARI flood extent - Rehabilitation

ii Cumulative flood levels

Cumulative afflux results for Oldbury Creek are presented in Table 13.16. Results are presented for the cross-sections shown in red on Figure 13.11. The cross-sections target key areas of interest including privately owned land, locations where existing roads cross streams and locations where new infrastructure is proposed to cross streams.

Cumulative afflux results are presented for the operation and rehabilitation cases. The results are the difference between the flood levels under the operational or rehabilitation and existing cases.

Comparison to the acceptability criteria for flooding events up to 100 year ARI for the operation and rehabilitation scenarios indicates the following:

- Buildings – there are no buildings located within the flood extents.
- Public roads/rail – predicted afflux will generally be less than 100 mm. The afflux at Oldbury Creek cross-section 421.49, which is just downstream of the bridge, exceeds the proposed acceptable limit, however this impact is localised and the water level is lower than the Old Hume Highway road level in any event.
- Private properties – most land located along the Berrima Rail alignment is owned by Hume Coal or Boral. Predicted afflux at private properties downstream is within the acceptability criteria (less than 250 mm).

Table 13.16 Cumulative afflux results

Cross-section number	Stream	Location	Operation				Rehabilitation			
			5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)	5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)
246.32	Tributary 2b	DS Medway Road	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.05
306.77	Catchment tributary 2	DS Medway Road	0.01	0.02	0.03	0.53	0.00	0.00	0.00	0.00
347.57	Tributary 2b	US Medway Road	-0.02	-0.01	0.00	-0.01	0.01	0.00	0.00	0.01
350	Branch	Private land	-0.13	-0.16	-0.20	-0.62	0.00	0.00	0.00	0.00
372.91	Catchment tributary 2	US Medway Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
417.29	Oldbury Creek	Private land	-0.16	-0.25	-0.33	-1.95	0.00	0.00	0.00	0.00
533.19	Branch	Private land	-0.17	-0.19	-0.21	-0.62	0.00	0.00	0.00	0.00
543.84	Tributary T1	Old Hume Hwy	-0.05	-0.06	-0.07	0.8	0.04	0.06	0.06	0.00
606.67	Tributary T1	Private land and Old Hume Hwy	0.03	0.05	0.06	1.05	0.00	0.00	0.00	0.00
647.53	Oldbury Creek	Private land	-0.05	-0.09	-0.18	0.00	0.00	0.00	0.00	0.00
750	Branch	Private land	-0.18	-0.22	-0.25	-0.67	0.00	0.00	0.00	0.00
773.14	Tributary T1	Private land	-0.04	-0.04	-0.04	-0.10	0.01	0.01	0.01	0.03
1073.16	Tributary T1	Private land	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
1194.89	Tributary 2	DS Hume Hwy	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00
1260	Tributary 2	US Hume Hwy	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
2741.84	Oldbury Creek	Private land	0.00	-0.13	-0.2	-0.04	0.00	0.00	0.00	0.00
2819.73	Oldbury Creek	Private land	0.009	0.01	-0.04	-0.31	0.00	0.00	0.00	0.00
2928.8	Oldbury Creek	Private land	-0.06	0.01	-0.05	-0.31	0.00	0.00	0.00	0.00
3007.9	Oldbury Creek	Hume Coal land	0.00	0.02	0.03	-0.16	0.00	0.00	0.00	0.00
4120.53	Oldbury Creek	Hume Coal land	-0.03	-0.03	-0.04	-0.04	0.04	0.07	0.09	0.06
4288.37	Oldbury Creek	Embankment DS inline storage	0.34	0.30	0.27	0.00	0.39	0.37	0.34	0.10
4390.64	Oldbury Creek	Embankment US inline storage	0.22	0.22	0.19	0.16	0.00	0.00	0.00	0.00
4611.83	Oldbury Creek	US inline storage	0.22	0.22	0.19	0.15	0.00	0.00	0.00	0.00

Table 13.16 Cumulative afflux results

Cross-section number	Stream	Location	Operation				Rehabilitation			
			5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)	5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)
4641.08	Oldbury Creek	US inline storage	0.20	0.20	0.16	0.02	0.00	0.00	0.00	0.00
5624.5	Oldbury Creek	DS Hume Hwy	0.01	0.01	0.01	0.08	0.00	0.00	0.00	0.00
5691.94	Oldbury Creek	US Hume Hwy	0.02	0.03	0.04	-0.01	0.00	0.00	0.00	0.00
5980	Oldbury Creek	DS Old Hume Hwy	0.01	0.02	0.04	-0.01	0.00	0.00	0.00	0.00
6024.59	Oldbury Creek	US Old Hume Hwy	0.02	0.02	0.02	-0.01	0.01	0.01	0.10	0.00
7081.2	Oldbury Creek	DS 5 x 2000 mm x 2000 mm RCBC on Oldbury Creek	0.03	0.02	0.01	0.06	0.05	0.04	0.02	0.00
7142.77	Oldbury Creek	Hume Coal Land	0.02	0.01	0.01	2.86	0.00	0.00	0.00	0.00
7401.61	Oldbury Creek	Hume Coal Land	0.01	0.00	0.01	1.32	0.00	0.00	0.00	0.01
7696.2	Oldbury Creek	Private land (Boral)	0.01	0.02	0.01	0.05	0.00	0.00	0.00	0.01
7907.82	Oldbury Creek	Private land (Boral)	0.01	0.02	0.02	0.03	0.07	0.10	0.14	0.26
7999.53	Oldbury Creek	US 5 x 2000 mm x 1200 mm RCBC on Oldbury Creek Private Land	0.00	0.00	0.00	2.04	0.15	0.18	0.23	0.47
8234.11	Oldbury Creek	Private land	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
421.49	Oldbury Creek	DS drainage depression alongside Hume Highway with 4 x 1800 mm x 900 mm RCBC	0.10	0.11	0.12	0.28	0.00	0.00	0.01	0.19
392.69	Tributary 2	US 2 x 1400 mm diameter pipe under rail loop	0.00	0.62	1.78	4.09	0.03	0.04	0.05	0.15

Table 13.16 Cumulative afflux results

Cross-section number	Stream	Location	Operation				Rehabilitation			
			5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)	5-year afflux (m)	20-year afflux (m)	100-year afflux (m)	PMF afflux (m)
855.9	Tributary 2	US 1400 mm diameter pipe under rail loop	3.42	3.88	4.74	5.89	0.00	0.00	0.00	0.00
787.17	Tributary 2	DS 1400 mm diameter pipe under rail loop	0.01	0.03	0.04	0.30	0.03	0.03	0.02	0.30
254.46	Tributary 2	US 2 x 1400 mm diameter pipe on tributary of Oldbury Creek	1.32	1.90	3.02	4.81	0.14	0.16	0.17	0.02
113.72	Tributary 2	DS 2 x 1400 mm diameter pipe on tributary of Oldbury Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: US – upstream; DS – downstream; Hwy - Highway

iii Cumulative peak velocities

Peak velocities downstream of new infrastructure crossing streams in the project area (see Table 13.9) are presented in Table 13.17. Note that in some cases the PMF velocity is reduced downstream of the structures due to backing up of flow behind the rail embankment.

Changes in peak velocity downstream of the new infrastructure are generally within the range +/- 0.8 m/s. Higher velocity changes are predicted at culvert outlets on Oldbury Creek at cross section 7081.2 and on the Oldbury Creek Tributary at cross section 113.72; however, the table shows that these velocity changes reduce downstream of the culvert outlets and the velocity changes can therefore be managed locally at the outlets. The velocity increases at these locations exceed the acceptability criterion, but these exceedances are local to the culvert outlets and can be managed through appropriate energy dissipating structures. At detailed design opportunities to reduce pipe and/or channel grades at the inlet and outlet of the structures should be investigated to reduce the high velocities at these locations.

Table 13.17 Cumulative peak velocities at new infrastructure

Cross-section	Stream	Infrastructure	Cross-section distance downstream from infrastructure (m)	5 year ARI velocities (m/s)			20 year ARI velocities (m/s)			100 year ARI velocities (m/s)			PMF velocities (m/s)		
				Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff
	Oldbury Creek	Embankment inline storage	12	1.05	0.74	-0.31	1.09	0.86	-0.23	1.12	0.96	-0.16	1.35	1.55	0.20
4611.83	Oldbury Creek	Embankment inline storage	0.5	0.21	0.18	-0.30	0.28	0.24	-0.40	0.35	0.31	-0.40	1.65	1.56	-0.09
421.49	Oldbury Creek	Drainage depression alongside Hume Highway with 4 x 1800 mm x 900 mm RCBC	3	1.05	1.74	0.69	1.13	1.89	0.76	1.21	2.03	0.82	3.44	2.76	-0.68
			38	1.29	1.33	0.04	1.38	1.37	-0.01	1.45	1.51	0.06	2.93	2.82	-0.11
787.13	Oldbury Creek	1400 mm diameter pipe under rail loop	22	0.57	0.52	-0.05	0.72	0.59	-0.13	0.78	0.66	-0.12	1.33	0.72	-0.61
113.72	Oldbury Creek	2 x 1400 mm diameter pipe under rail loop	0	0.71	3.08	2.37	0.78	3.77	2.99	0.86	5.49	4.63	1.52	7.29	5.77
			2	0.71	1.71	1.00	0.78	1.86	1.08	0.86	2.04	1.18	1.52	3.56	2.04
7907.82	Tributary of Oldbury Creek	5 x 2000mm x 1200mm RCBC	0	0.88	1.93	1.13	1.00	2.19	1.19	1.1	2.41	1.31	1.94	5.36	3.42
			2	0.88	0.95	0.07	1.00	1.06	0.06	1.1	1.11	0.01	1.94	2.16	0.22
			14	1.06	1.05	-0.01	1.21	1.18	-0.03	1.35	1.29	-0.06	2.63	2.29	-0.34
7081.2	Oldbury Creek	5 x 2000mm x 2000mm RCBC	0	1.86	1.2	-0.66	1.88	1.33	-0.55	1.91	1.48	-0.43	1.32	5.79	4.47
			82	0.87	0.87	0.00	0.96	0.95	-0.01	1.06	1.05	-0.01	1.55	1.86	0.31

Note: Ex – Existing; Op – Operation; Diff – Difference; OC – Oldbury Creek; RCBC – Reinforced concrete box culvert

13.2.6 Analysis of results including summary of design impact differences

The impacts of the project on flood level are generally within the proposed impact criteria given in Section 13.2.1 iv for events up to and including the 100 year ARI event. Exceptions occur in the following areas for the operation phase:

- upstream of where the rail line crosses Oldbury Creek south west of Berrima Cement works;
- upstream of where the rail line crosses a tributary of Stony Creek to the east of the Berrima Cement works (preferred option);
- just upstream of the Hume Highway on a tributary of Oldbury Creek;
- in the vicinity of the rail loop; and
- downstream of some culverts where high velocities occur due to constriction of flow.

In all cases the impacts are confined to land owned by either Hume Coal or Boral and generally are removed for the rehabilitation phase, with the exception of the impact east of the Berrima Cement works where the rail infrastructure is to be retained under the preferred option.

The cumulative impacts of the Hume Coal and Berrima Rail projects on flood level are also generally within the proposed impact criteria, with the same exceptions noted above.

The key difference between the preferred and alternative options is the rail crossing at Stony Creek. Under the preferred option, a 4 m high rail embankment with box culverts is proposed to the north of Berrima Road. Under the alternative option, the existing rail bridge over Stony Creek will be duplicated. These design differences mean that, for the preferred option, an additional impact occurs along the tributary of Stony Creek east of Berrima Cement works for both operation and rehabilitation phases (refer to Figure 13.9).

Downstream of some structures energy dissipating measures will be required to prevent high outlet velocities causing scour of the channel. Opportunities should be investigated at detailed design to reduce culvert and/or channel grades to reduce velocities and avoid or minimise the requirement for energy dissipating structures.

13.2.7 Management and mitigation measures

Peak velocities are expected to increase immediately upstream and downstream of culverts. Erosion and scour protection measures will be required around piers and culvert inlets and outlets, which will typically take the form of rock rip-rap protection. For crossings where waterways are ill-defined, a flow spreader should be provided to transition concentrated flow back to more a natural overland flow pattern. The erosion and scour protection should be nominated as part of detailed civil design.

13.2.8 Conclusion

The flooding assessment has been based on flood models developed from recent LiDAR and ground survey data and calibrated against a recently observed flood event. The Oldbury Creek model achieved a good fit to the calibration event and can be considered to provide reliable predictions of flood behaviour in Oldbury Creek and Stony Creek. A check against the PRM confirmed model parameters for use in hydrologic modelling.

Culverts will be constructed in a number of locations to allow water to pass the proposed infrastructure and reduce flooding impacts on nearby land. The modelling results indicate that with these culverts in place, for flooding events up to 100 year ARI for the operation and rehabilitation scenarios, the flood impacts will generally remain within the proposed acceptable limits, with some exceptions on land owned by Hume Coal or Boral. These impacts are generally removed following rehabilitation, with the exception of the impact east of Berrima Cement works which is due to the retained rail infrastructure on a tributary of Stony Creek at this location (refer to Figure 13.8). The same impact findings apply to the cumulative scenario also.

Peak velocities are expected to increase immediately upstream and downstream of culverts. Erosion and scour protection measures will be required around culvert inlets and outlets so that any localised increases in stream velocity do not cause erosion of the channel lining downstream of the culvert.

i Mitigation measures

The following recommendations were made by PB based on the findings of the flood study, and will be implemented as follows:

- Further calibration of the XP-RAFTS model for the Oldbury Creek catchment model to more than one rainfall event will be considered once data from a longer baseline monitoring period becomes available, and if this data indicates further calibration is required.
- Typical scour protection measures will be required at crossing structures such as access road culverts. The model will be used and refined as necessary at the detailed design stage to inform the scour analysis and design of scour protection measures.

13.3 Erosion, sedimentation and scour assessment

This section provides an assessment of:

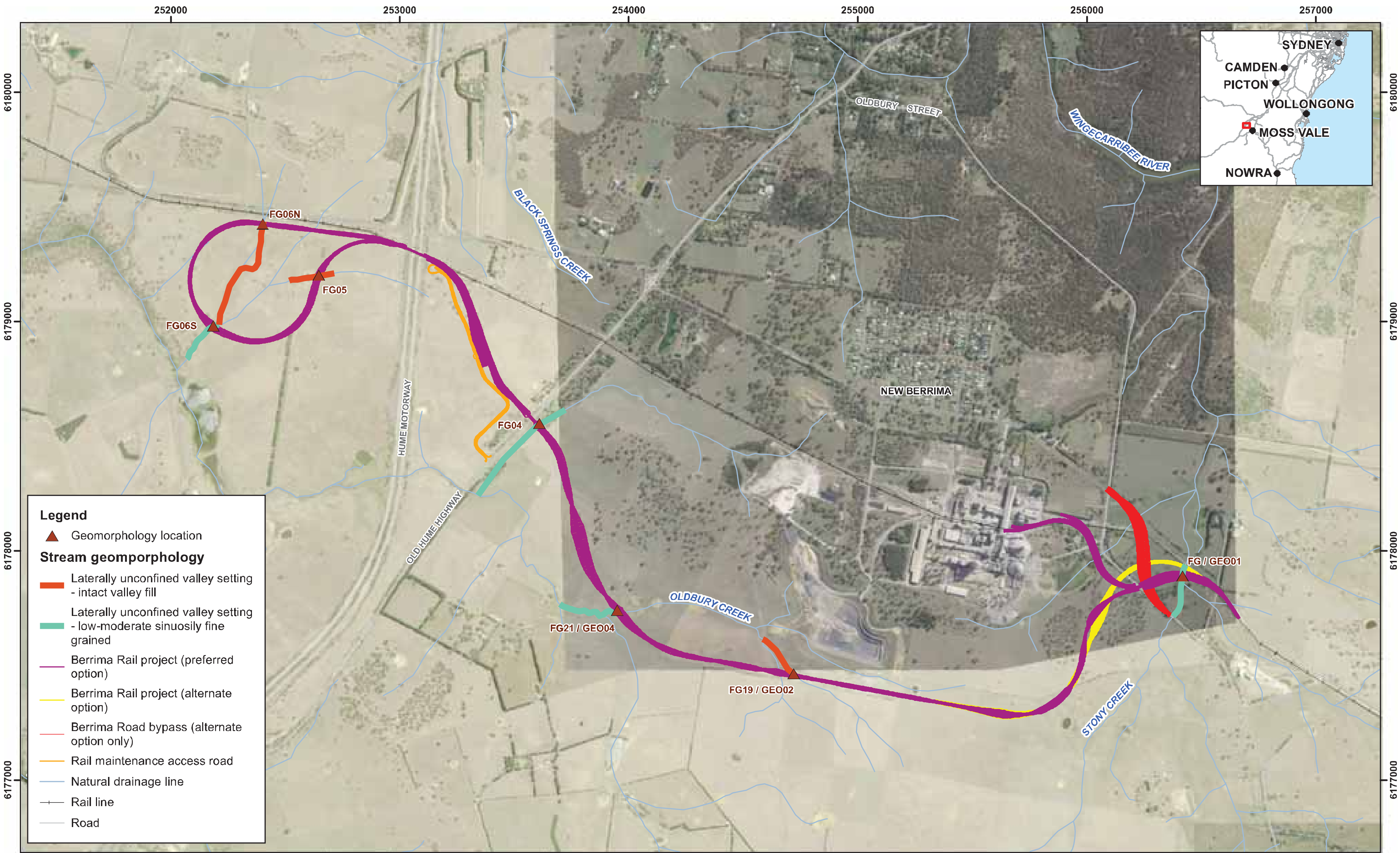
- Existing geomorphic conditions of creeks and drainage lines intersected by the rail corridor;
- Scour risk of the main structures crossing waterways and appropriate concepts for mitigating the risk;
- Scour and erosion risk around drainage outlets and typical treatment measures to protect adjacent land and receiving watercourses; and
- Erosion and sediment control measures required during construction.

13.3.1 Assessment methodology

A geomorphology assessment was undertaken to establish the baseline stability and characteristics of the creeks and drainage lines that will be intersected by the rail corridor. The assessment involved a site inspection to determine bed and bank condition and follow up desktop assessments of the hydraulic characteristics based on the available flood models and topographic data. The assessment was used to inform the erosion and sediment control and scour assessment.

The site inspection was conducted on 31 May 2016 and 1 June 2016 to assess the existing geomorphic conditions of the waterways the proposed railway will cross. The inspection sites are shown on Figure 13.14.

Potential erosion and scour risk at the new rail infrastructure crossing streams in the project area has been assessed considering the baseline geomorphic characteristics of the streams and the predicted change in peak velocity of flow at the new infrastructure. The results of the hydraulic modelling undertaken for the flooding assessment (Section 13.2) have been used to assess peak velocities downstream of the new infrastructure. Assessment of erosion and scour risk has been undertaken for the new infrastructure proposed for the preferred and alternative options.



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Date: 4/11/2016	Approved by: LR		Coordinate system: GDA 1994 MGA Zone 56
Data source: © Land and Property Information 2015, Hume Coal			Scale ratio correct when printed at A3

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Figure 13.14
Inspection sites for geomorphology assessment

13.3.2 Existing environment

A detailed description of the geomorphology and flow conditions at each site is provided in Table 13.18. Photographs of each site are provided in Photos 13.1 to 13.8.

The creeks and drainage lines that will be intersected by the rail corridor can be grouped into two categories: well defined (which includes FG/GEO01, FG04, FG21/GEO04 and FG06 (South)) and ill-defined (which includes FG19/GEO02, FG05 and FG06 (North)).

No flow was observed in the waterways visited during the site inspection. Stagnant pools were observed at FG/GEO01 on Stony Creek. Flow is expected in the well-defined waterways during rainfall events. Of the well-defined waterways, FG/GEO01 on Stony Creek is the largest waterway. FG21/GEO04 is an artificial channel draining stormwater intercepted by the Old Hume Highway to Oldbury Creek. The waterway at FG04 on Oldbury Creek is intercepted by multiple farm dams and flow is only likely to occur if the rainfall event is large enough to fill the storage of the farm dams. FG06 (South) is a small waterway locally formed possibly due to the presence of tree stumps and an existing culvert crossing. There is minimal evidence of erosion in the well-defined waterways under existing conditions.

The ill-defined waterways are basically depressions in farmland that convey overland flow during rain events, which would be expected to produce relatively shallow flow over a relatively large flood extent. The ill-defined waterways in the project area are well vegetated.

Table 13.18 Description of locations visited for geomorphology assessment

Location	Water course	Valley setting	River style	Sinuosity	Bed composition	Description	Geomorphic units	River behaviour - Low	River behaviour - Med	River behaviour - Overbank
FG / GEO01	Stony Creek	Laterally unconfined valley setting	Low-moderate sinuosity fine grained	Low	Silty clay	Channelised with major road and rail crossings and broken by local assess road	Ridge and swale topography	Disconnected pools	Free flowing with backwater created by culvert	Backwater due to rail embankment. Erosion downstream of the rail embankment due to spilling
FG19 / GEO02	Tributary of Oldbury Creek	Laterally unconfined valley setting	Intact valley fill		Silty clay	Low point of vegetated pasture	Valley fill	No flow observed but anticipated to be free flowing	No flow observed but anticipated to be free flowing	Free flowing and possibly flood storage
FG21 / GEO04	Oldbury Creek	Laterally unconfined valley setting	Low-moderate sinuosity fine grained	Low	Silty clay	Dry, disconnected channel. Broken up by multiple farm dams	Bench	Disconnected pools	Free flowing with backwater created by farm dams and road crossings	Free flowing with backwater created by farm dams and road crossings possible flood storage. Some scouring could occur at outlet of farm dams or crossways
FG04	Drainage channel alongside Old Hume Highway (tributary of Oldbury Creek)	Laterally unconfined valley setting	Low-moderate sinuosity fine grained	Low	Silty clay	Defined drainage line. Dense vegetation upstream of Old Hume highway crossing. Otherwise, moderate vegetation at bank and close to stage flow.	Bench	No flow observed but anticipated to be free flowing	Backwater created by culvert	Backwater created by culvert. Scour occurs at downstream end

Table 13.18 Description of locations visited for geomorphology assessment

Location	Water course	Valley setting	River style	Sinuosity	Bed composition	Description	Geomorphic units	River behaviour - Low	River behaviour - Med	River behaviour - Overbank
FG05	Overland flow path (flowing to tributary of Oldbury Creek)	Laterally unconfined valley setting	Intact valley fill		Silty clay	Low point of vegetated pasture	Valley fill	No flow observed but anticipated to be free flowing	No flow observed but anticipated to be free flowing	Free flowing and possibly flood storage
FG06 North	Overland flow path (flowing to tributary of Oldbury Creek)	Laterally unconfined valley setting	Intact valley fill		Silty clay	Low point of vegetated pasture	Valley fill	No flow observed but anticipated to be free flowing	No flow observed but anticipated to be free flowing	Free flowing and possibly flood storage
FG06 South	Tributary of Oldbury Creek	Laterally unconfined valley setting	Low-moderate sinuosity fine grained	Low	Silty clay	Start of channelisation with small culvert. The channel is ill defined	Forced pool due to tree stamp and culvert	Dry but anticipated to be riffled due to effect of tree stump and culvert	Dry but anticipated to be riffled due to effect of tree stump and culvert	Free flowing and possibly flood storage. The small gully will be submerged

Photo 13.1 Overland flow path to Oldbury Creek (FG06N)

Photo 13.2 Tributary of Oldbury Creek (FG06S)

Photo 13.3 Overland flow path to Oldbury Creek (FG05)

Photo 13.4 Drainage depression alongside Old Hume Hwy (FG04)

Photo 13.5 Oldbury Creek with instream storage (FG21)

Photo 13.6 Tributary of Oldbury Creek (FG19 / GEO02)

Photo 13.7 Stony Creek (FG / GEO01)

Photo 13.8 Stony Creek under existing rail line (FG / GEO01)

13.3.3 Preferred option impact assessment

The new rail infrastructure crossing streams for the preferred option is summarised in Table 13.9. The new infrastructure comprises drainage structures, including pipes, culverts and diversion drains.

Peak velocities downstream of the new infrastructure are presented in Table 13.12. Changes in peak velocity are generally within the range +/- 0.8 m/s. Higher velocity changes are predicted at culvert outlets on Oldbury Creek at cross section 7081.2 and on the Oldbury Creek Tributary at cross section 113.72; however, Table 13.12 shows that these velocity changes reduce downstream of the culvert outlets and the velocity changes can therefore be managed locally at the outlets.

13.3.4 Alternative option impact assessment

The new rail infrastructure crossing streams for the alternative option is summarised in Table 13.9. The new infrastructure includes crossing structures (bridges) and drainage outlets (pipes, culverts and diversion drains).

Peak velocities downstream of the new infrastructure are presented in Table 13.15. Changes in peak velocity are generally within the range +/- 0.8 m/s. Higher velocity changes are predicted at culvert outlets on Oldbury Creek at cross section 7081.2 and on the Oldbury Creek Tributary at cross section 113.72; however, Table 13.15 shows that these velocity changes reduce downstream of the culvert outlets and the velocity changes can therefore be managed locally at the outlets.

13.3.5 Analysis of results including summary of design impact differences

Construction of the rail embankment will intercept overland flow and will concentrate the flow at culvert locations. This will likely cause increased ponding upstream of the culvert locations and increased flow velocity downstream of the culvert locations which could increase the risk of erosion and scouring. Erosion and scour protection measures, which are part of the standard culvert crossing design features, will be required to protect the creek and culvert against localised scouring immediately downstream of the crossings (refer to Section 13.3.6).

The key difference between the preferred and alternative options is the rail crossing at Stony Creek. Under the preferred option, a 4 m high rail embankment with box culverts is proposed to the north of Berrima Road. Under the alternative option, the existing rail bridge over Stony Creek will be duplicated. These design differences are not expected to result in any difference to erosion and scour requirements in the project area (to be confirmed during detailed civil design).

13.3.6 Management and mitigation measures

i Operation phase

Erosion and scour protection measures will be required around bridges and culvert inlets and outlets, which will typically take the form of concrete aprons and rock rip-rap protection (to be confirmed during detailed civil design). The proposed erosion and scour control measures for the stream crossing infrastructure are summarised in Table 13.19.

For crossings where waterways are well-defined, scour protection should be provided at the downstream end of the culvert so that localised increases in flow velocity do not cause erosion of the channel lining downstream of the culvert.

For crossings where waterways are ill-defined, a flow spreader would be used to transition concentrated flow back to more a natural overland flow pattern.

Table 13.19 Scour and erosion protection measures

Crossing location	Design option	Waterway rail will cross	Proposed structures	Proposed erosion and scour control measures
FG / GEO01	Preferred option	Stony Creek	9 x 3600 mm x 3000 mm RCBC	Rip rap apron or basin
FG / GEO01	Alternative option	Stony Creek	Duplication of existing bridge structure	Standard abutment and pier rock protection measures as required
FG19 / GEO02	Preferred and alternative option	Tributary of Oldbury Creek	2 x 1400 mm diameter pipe	Rip rap apron and flow spreader
FG21 / GEO04	Preferred and alternative option	Oldbury Creek	5 x 2000 mm x1200mm RCBC	Rip rap apron or basin
FG04	Preferred and alternative option	Drainage depression alongside Hume Highway	4 x 1800 mm x 900 mm RCBC	Rip rap apron or basin
FG05	Preferred and alternative option	Overland flow path (flowing to tributary of Oldbury Creek)	1400 mm diameter pipe	Rip rap apron and flow spreader
FG06 South	Preferred and alternative option	Tributary of Oldbury Creek	5 x 2000 mm x1200mm RCBC	Rip rap apron and flow spreader

Note: RCBC – Reinforced concrete box culvert.

ii Construction phase

An erosion and sedimentation control plan, developed in accordance with Landcom (2004) and DECC (2008) guidelines, will be prepared to ensure the erosion and sedimentation induced by construction activities will not adversely affect the surrounding environment. With the implementation of this plan, erosion and sedimentation impacts during the construction phase are expected to be minimal.

Temporary erosion and sedimentation controls applicable to the construction phase of the project include sedimentation basins, sediment fences, diversions banks (for on and off-site water), check dams, batter chutes, temporary culverts and scour protection. Depending on the construction staging and the extent of disturbance at each stage, the temporary works may involve local controls, such as sediment fences and diversion berms that are expected to be utilised by the civil works contractor in day to day management, or more extensive measures such as temporary sedimentation basins.

The intent of the erosion and sediment control practices used on site will be to:

- Minimise the extent of disturbance, by clearing only as required, by clearing and grubbing to leave the surface rough and by minimising the time in which watercourses are disturbed.

- Control stormwater flows onto, through and from the site by separating runoff from disturbed and undisturbed areas, by constructing drainage structures early including sediment basins, cut-off drains and cross drainage culverts and by minimising runoff down batters by using batter drains.

- Minimise scour in waterways by using linings as appropriate.

- Have surfaces revegetated as soon as possible to minimise the duration of disturbance.

- Have the civil works contractor utilise local controls such as diversion banks and sediment fences to minimise erosion and sediment transport and have them progressively update these measures as required during construction.

- Have the civil works contractor maintain and inspect the erosion and sediment control measures to ensure their effectiveness remains intact.

13.3.7 Conclusion

Construction of the rail embankment will intercept overland flow and concentrate the flow through culverts, resulting in an increase in flow velocity at the culvert outlets and an increase in the risk of erosion and scouring.

For crossings where waterways are well-defined (FG/GEO01, FG04, FG21/GEO04 and FG06 (South)), scour protection should be provided at the upstream and downstream ends of the culvert so that localised increases in velocity at the outlet do not cause erosion of the channel lining downstream of the culvert.

For crossings where waterways are ill-defined (FG19/GEO02, FG05 and FG06 (North)), a flow spreader should be provided to transition concentrated flow back to more a natural overland flow pattern.

For the construction phase, an erosion and sediment control plan should be prepared to ensure that erosion and sedimentation induced by construction activities will not adversely affect the surrounding environment.

13.4 Fish passage assessment

The new rail infrastructure crossing streams in the project area has the potential to restrict fish passage. The free passage of fish within rivers and streams is a critical aspect of aquatic ecology. Obstructions to fish passage due to the construction of waterway crossings can negatively impact on native fish by restricting the migration and spawning of fish, limiting the passage of fish between feeding grounds and fragmenting fish communities and resulting in reduced gene flow within fish populations. Maintenance of connectivity between upstream and downstream habitats (longitudinal connectivity) and adjacent riparian and floodplain habitats (lateral connectivity) is an essential part of fish habitat management (DPI 2013).

The NSW Department of Primary Industries (DPI) have published guidelines (DPI 2013) which nominate the preferred waterway crossing type depending on waterway class. Using these guidelines all waterways in the project area are classified as unlikely key fish habitat (Class 4). A Class 4 waterway is a “waterway (generally unnamed) with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or free standing water or pools post rain events (eg dry gullies or shallow floodplain depressions with no aquatic flora present)” (DPI 2013, p.19).

The preferred waterway crossing type for Class 4 waterways under the DPI guidelines (2013) is relatively broad; however, culverts and fords are preferred to causeways. The waterway crossing types proposed for the project are provided in Table 13.20. The proposed crossings are consistent with the DPI guidelines (2013) for Class 4 waterways with the exception of the two crossings near FG06 North on Oldbury Creek. The proposed rail line is in cut at this location and flow will need to be diverted around the rail line. The detailed civil design of the diversions will need to take the DPI requirements for fish passage into account. Table 13.20 summarises the fish passage assessment.

Table 13.20 Fish passage assessment

Crossing location	Waterway where rail will cross	Fish habitat classification	Proposed crossing type	Design option
FG / GEO01	Stony Creek	Class 4 Unlikely key fish habitat	9 x 3600 mm x 3000 mm RCBC	Preferred
FG / GEO01	Stony Creek	Class 4 Unlikely key fish habitat	Duplication of bridge over Stony Creek	Alternative
FG19 / GEO02	Tributary of Oldbury Creek	Class 4 Unlikely key fish habitat	2 x 1400 mm diameter pipe	Preferred and alternative
FG21 / GEO04	Oldbury Creek	Class 4 Unlikely key fish habitat	5 x 2000 mm x1200mm RCBC	Preferred and alternative
FG04	Drainage depression alongside Hume Highway	Class 4 Unlikely key fish habitat	4 x 1800 mm x 900 mm RCBC	Preferred and alternative
FG05	Overland flow path (flowing to tributary of Oldbury Creek)	Class 4 Unlikely key fish habitat	1400 mm diameter pipe	Preferred and alternative
East of FG06 North	Overland flow path (flowing to tributary of Oldbury Creek)	Class 4 Unlikely key fish habitat	3 x 750mm diameter pipe	Preferred and alternative
FG06 North	Overland flow path (flowing to tributary of Oldbury Creek)	Class 4 Unlikely key fish habitat	This section of rail is in cut. A diversion drain will be installed to intercept overland flow from the north.	Preferred and alternative
FG06 South	Tributary of Oldbury Creek	Class 4 Unlikely key fish habitat	5 x 2000 mm x1200mm RCBC	Preferred and alternative

Note: RCBC – Reinforced concrete box culvert.

13.5 Surface water quality

The project is located in the Hawkesbury-Nepean River catchment which is part of the Sydney drinking water catchment. This section provides an assessment of the impacts of the project on surface water quality in the Sydney drinking water catchment during construction, operation and rehabilitation stages, as well as detail of proposed mitigation measures to minimise potential impacts. It should be noted that the project will not involve the discharge of mine water and, therefore, this assessment is only concerned with the management of stormwater runoff from the project to the receiving catchments.

13.5.1 Assessment methodology

i Relevant policy and guidelines

This section lists the relevant policies and guidelines that used in the surface water quality assessment. The contents of the policy / guideline documents and their relevance to this assessment are discussed in the Surface Water Assessment Report (2200569A-WAT-REP-001).

- State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011;
- Neutral or Beneficial Effect on Water Quality Assessment Guideline (WaterNSW 2015);
- Using MUSIC in Sydney's Drinking Water Catchment (WaterNSW 2012);
- National Water Quality Management Strategy;
- NSW Water Quality Objectives (OEH 2006);and
- Healthy Rivers Commission (HRC) Inquiry into the Hawkesbury-Nepean River.

The Hawkesbury-Nepean catchment specific Water Quality Objectives (WQOs) for nutrients and chlorophyll-a are provided in Table 13.21. These WQOs, together with the WQOs for other parameters in the ANZECC guidelines, have been adopted as the WQOs for the receiving environment of the project (refer Section 13.5.7 iii d).

Table 13.21 HRC recommended WQOs for nutrients (µg/L)

Water quality indicator	Forested areas and drinking water catchment	Mixed use rural areas and sandstone plateau	Urban areas – main stream	Urban areas – tributary stream	Estuarine areas
Total nitrogen	700	700	500	~1000	400
Total phosphorous	50	35	30	~50	30
Chlorophyll-a	7	7	10 - 15	~20	7

Source: Adopted from HRC (1998).

- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000); and
- Australian Drinking Water Guidelines (National Health and Medical Research Council 2011).

The Australian Drinking Water Guidelines (ADWG) values are provided in Table 13.22. The water quality guidelines in Table 13.22 have been used to establish the WQOs for the Berrima Rail Project.

Table 13.22 ANZECC and ADWG water quality guidelines

Parameter	unit	ADWG (2011) Health	ADWG (2011) Aesthetic	ANZECC Irrigation	ANZECC Livestock drinking	ANZECC Aquatic ecosystem	ANZECC Recreation
Physical parameters							
Conductivity	µS/cm	-	-	-	-	**30 - 350**	-
Temperature	°C	-	-	-	-	**-**	-
Turbidity	NTU	-	5	-	-	**2 - 25**	-
pH	pH units	-	6.8 – 8.5	6.0 - 9.0	-	**6.5 - 8.0**	6.5 - 8.5
Total dissolved solids (TDS)	mg/L	-	**600**		2,000	**-**	-
Total suspended solids (TSS)	mg/L	-	-	-	-	**-**	-
Nutrients							
Ammonia as N	mg/L	-	**0.5**	-	-	0.9	-
Nitrate (as N)	mg/L	-	-	-	400	**0.7**	10
Nitrite (as N)	mg/L	-	-	-	30	-	**1**
Total nitrogen as N	mg/L	-	-	5	-	**0.25**	-
Phosphorus	mg/L	-	-	0.05	-	**0.02**	-
Major ions							
Calcium	mg/L	-	-	-	**1,000**	-	-
Chloride	mg/L	-	250	**175**	-	-	400
Magnesium	mg/L	-	-	-	**2,000**	-	-
Sodium	mg/L	-	180	**115**	-	-	300
Sulfate as SO_4	mg/L	-	**250**	-	1,000	-	400
Heavy metals							
Aluminium	mg/L	-	0.2	5	5	**0.055**	-
Antimony	mg/L	**0.003**	-	-	-	-	-
Arsenic	mg/L	**0.01**	-	0.1	0.5	0.013	0.05
Barium	mg/L	2	-	-	-	-	**1**
Beryllium	mg/L	**0.06**	-	0.1	-	-	-
Boron	mg/L	4	-	0.5	5	**0.37**	-
Cadmium	mg/L	0.002	-	0.01	0.01	**0.0002**	0.005
Chromium	mg/L	0.05	-	0.1	1	**0.001**	0.05
Cobalt	mg/L	-	-	**0.05**	1	-	-
Copper	mg/L	2	1	0.2	0.4	**0.0014**	1
Iron	mg/L	-	0.3	**0.2**	-	-	0.3

Table 13.22 ANZECC and ADWG water quality guidelines

Parameter	unit	ADWG (2011) Health	ADWG (2011) Aesthetic	ANZECC Irrigation	ANZECC Livestock drinking	ANZECC Aquatic ecosystem	ANZECC Recreation
Lead	mg/L	0.01	-	2	0.1	**0.0034**	0.05
Manganese	mg/L	0.5	0.1	0.2	-	1.9	**0.1**
Mercury	mg/L	0.001	-	0.002	0.002	**0.0006**	0.001
Molybdenum	mg/L	0.05	-	**0.01**	0.15	-	-
Nickel	mg/L	0.02	-	0.2	1	**0.011**	0.1
Selenium	mg/L	**0.01**	-	0.02	0.02	-	-
Silver	mg/L	0.1	-	-	-	**0.00005**	-
Zinc	mg/L	-	3	2	20	**0.008**	5
Hydrocarbons							
Benzene	μg/L	**1**	-	-	-	950	-
Toluene	μg/L	800	**25**	-	-	-	-
Ethylbenzene	μg/L	300	**3**	-	-	-	-
Xylene	μg/L	600	**20**	-	-	-	-
Naphthalene	μg/L	-	-	-	-	**16**	-

Source: Adopted from ANZECC (2000) and ADWG (2011).

***Bold** guideline values denote the lowest guideline value.*

ii Project activities with potential to impact on surface water quality

Project activities with potential to impact on surface water quality during construction, operation and rehabilitation stages of the project and provided in Table 13.23.

Table 13.23 Project activities with potential to impact on surface water quality

Project activity or component	Catchment	Potential contaminants	Potential contamination pathway	Likelihood of impact
Construction				
Earthworks/ grading, construction of rail and road infrastructure and rail maintenance facility	Oldbury Creek and Stony Creek	TSS, hydrocarbons	Runoff from working areas to local waterways	Unlikely - short term potential impact that can be suitably managed.

Table 13.23 Project activities with potential to impact on surface water quality

Project activity or component	Catchment	Potential contaminants	Potential contamination pathway	Likelihood of impact
Rail temporary construction facility	Oldbury Creek	TSS	Runoff from construction facility to local waterways	Unlikely - short term potential impact that can be suitably managed.
		Hydrocarbons	Runoff from areas where spills or leaks have occurred	Unlikely - a hazardous materials plan will be developed which details the management of hazardous materials, including fuels and lubricants. A contingency plan for environmental incidents will be developed which details the response actions during an environmental incident such as an oil spill.
		TN, TP	Runoff and discharge of sewage from facilities	Unlikely - general waste will be managed to prevent contamination of waterways; grey water (eg from sinks and showers) will be subject to primary treatment and reused for drip irrigation of landscaped areas and black water (raw sewage will be subject to tertiary treatment and reused in site operations.
Operation				
Coal trains on rail line	Oldbury Creek and Stony Creek	TSS, metals	Runoff from rail line to local waterways	Potential impact during period of operation.
Rail embankments	Oldbury Creek and Stony Creek	None	Runoff from rail line to local waterways	No impact - clean fill will be used to construct rail embankments. The embankments will be compacted and vegetated to avoid impacts to waterways.
Topsoil stockpiles	Oldbury Creek and Stony Creek	None	Runoff from topsoil stockpiles to local waterways	No impact - the topsoil stockpiles will comprise clean fill. The stockpiles will be stabilised with vegetation to avoid impacts to waterways.

Table 13.23 Project activities with potential to impact on surface water quality

Project activity or component	Catchment	Potential contaminants	Potential contamination pathway	Likelihood of impact
Rail maintenance facility	Oldbury Creek	TSS, metals	Runoff from rail line to local waterways	Potential impact during period of operation.
		Hydrocarbons	Runoff from working areas to local waterways	Unlikely - drainage from working areas of the rail maintenance facility will be fully contained and oil water separators will be used.
		TN, TP	Runoff and discharge of sewage from facilities	Unlikely - general waste will be managed to prevent contamination of waterways; grey water (eg from sinks and showers) will be subject to primary treatment and reused for drip irrigation of landscaped areas and black water (raw sewage will be subject to tertiary treatment and reused in site operations.
Rail maintenance access road	Oldbury Creek	TSS, metals	Runoff from road to local waterways	Potential impact during period of operation.
Rehabilitation				
Decommissioning of mine infrastructure and rehabilitation	Medway Rivulet and Oldbury Creek	TSS	Runoff from working areas to local waterways	Short term potential impact that can be suitably managed.
		Hydrocarbons	Runoff from areas where spills or leaks have occurred	Unlikely - a hazardous materials plan will be developed which details the management of hazardous materials, including fuels and lubricants. A contingency plan for environmental incidents will be developed which details the response actions during an environmental incident such as an oil spill.

iii MUSIC modelling methodology

Stormwater quality modelling using Model for Urban Stormwater Improvement Conceptualisation (MUSIC) has been undertaken to assess the potential impacts of the following activities during the operation phase on the receiving creek systems:

- coal trains on the rail line;
- coal trains at the rail maintenance facility; and

- vehicles using the rail maintenance access road.

Three scenarios were modelled using MUSIC: existing conditions and the preferred and alternative Berrima Rail Project options. The operational phase scenarios included simulation of stormwater quality treatment measures to achieve the NorBE criteria. Details of these measures are provided in Section 13.5.7. Modelling has been undertaken in accordance with the WaterNSW standards (2012).

Water quality modelling has not been undertaken to assess potential short-term impacts during construction and rehabilitation as the potential impacts and associated mitigation controls and measures are dependent on the construction methods and staging, which would be determined at the detailed design phase of the project. Typical stormwater quality management measures to be considered during construction and rehabilitation of the project are provided in Section 13.5.7.

a. MUSIC model set up

Model nodes were established for each section of the rail corridor that is located within an external surface water catchment. The rail corridor spans four sub-catchments of Oldbury Creek and one sub-catchment of Stony Creek (see Figure 13.15). Within each catchment the rail corridor runoff is assumed to discharge to the creek line or overland flow path at the lowest point within the sub-catchment, and it is assumed that the treatment measures will be located at these discharge points.

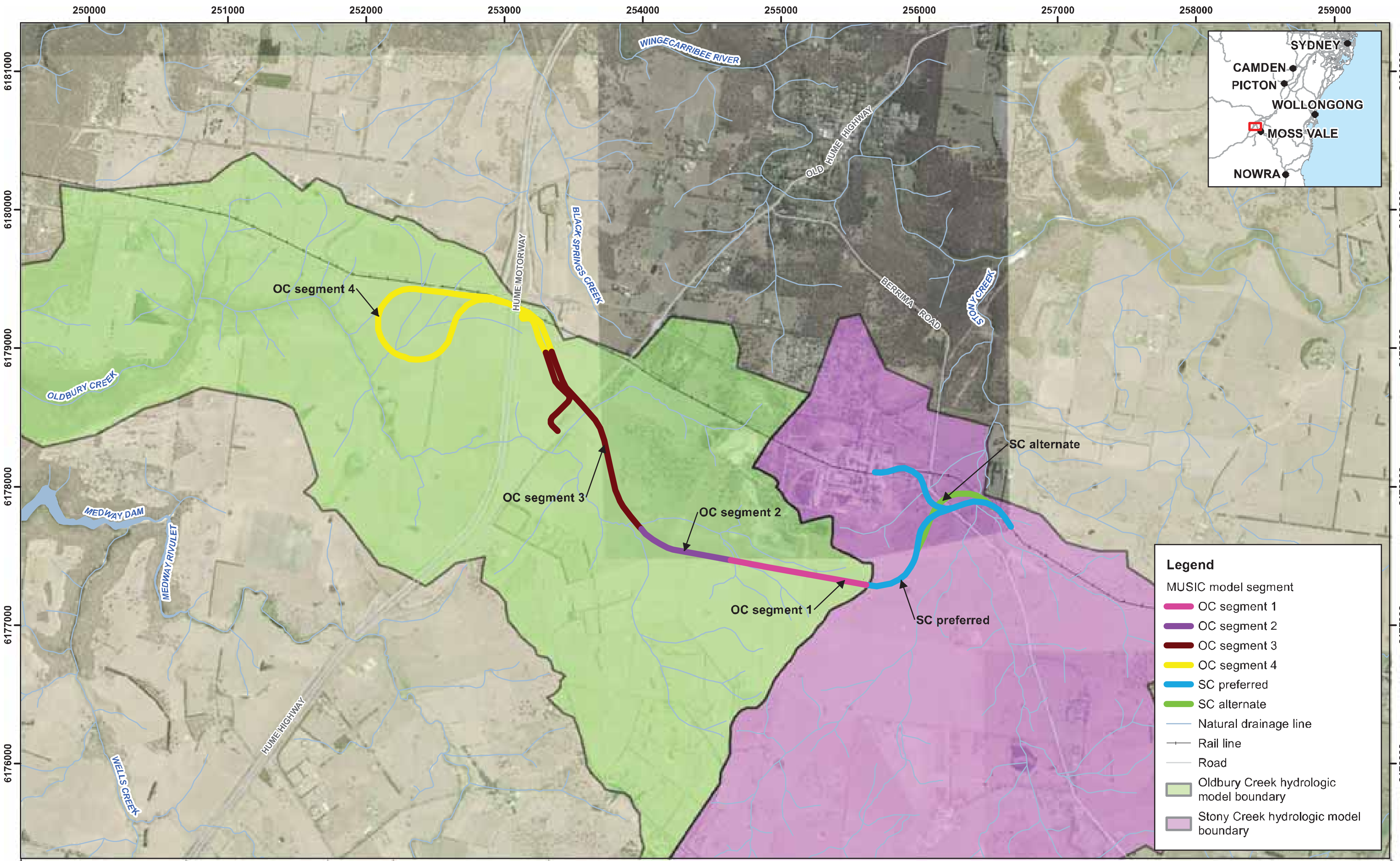
Each model node was set up to represent the following:

- The part of the catchment taken up by the proposed rail and access road corridors in its current undeveloped state, ie under existing conditions. The land use under existing conditions is assumed to be ‘agricultural’ or ‘rural residential’ (see Section 13.5.1 iii c for further definition of land use).

- The part of the catchment taken up by the proposed rail and access road corridors in its proposed developed state, for the preferred and alternate rail options. The land use under these proposed conditions is an operational rail and access road corridor (see Section 13.5.1 iii c for further definition of land use).

- The part of the catchment taken up by the proposed rail and access road corridors in its proposed developed state, ie as either the preferred or alternative rail option. The land use under these proposed conditions is an operational rail and access road corridor (see Section 13.5.1 iii c for further definition of land use).

Model nodes were separated out into sub-nodes for the proposed rail corridor, sealed access roads and revegetated cut/fill embankments. The catchment area of the proposed rail corridor or road was taken as the top width of the rail or road embankment, which includes the rail ballast and road surface and rail/road formation. The embankment areas were taken as the top width of the rail or road embankment to the toe of the embankment. The embankments will be constructed of vegetated clean fill.



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Date: 4/11/2016	Approved by: LR

Data source: , Hume Coal

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

WSP | PARSONS BRINCKERHOFF

Berrima Rail Project

Figure 13.15

MUSIC model layout

b. Climate data

The WaterNSW standard (2012) provides meteorological templates that include the rainfall and potential evapotranspiration data for various catchment areas and which form the basis for the hydrologic calculations in MUSIC. The appropriate climate zone for the meteorological template file was identified as Zone 3 using the WaterNSW website (http://www.waternsw.com.au/water-quality/catchment/development/). The template files were downloaded from WaterNSW website and directly input into MUSIC. The rainfall files were at a 6 minute time step over a period of 5 years from 1997 to 2001. They include a range of wet and dry years to ensure conditions simulated are realistic and representative of a range of rainfall patterns.

c. Modelled scenarios

The pre-development (or existing conditions) scenario was set up for each of the sub-catchments using the 'agricultural' MUSIC source node and assumed to be 100% pervious based on the land use identified from aerial photography. As a sensitivity test 'rural residential' was also considered as the pre-development land use. The stormwater pollutant parameters used for agricultural and rural residential source nodes are given in Table 13.24 and are in accordance with the WaterNSW standards (2012).

Post-development scenarios were set up for each of the sub-catchments for the preferred and alternative project options. The rail corridor sub-catchments were assumed to have the MUSIC pollutant parameters of 'unsealed roads', assuming that the sub-catchment is 50% pervious and 50% impervious. The sealed road and hardstand areas were assumed to have the MUSIC pollutant parameters of 'sealed roads', assuming that the sub-catchment is 100% impervious. The cut/fill embankments were assumed to have the MUSIC pollutant parameters of 'revegetated land'. The stormwater pollutant parameters used for unsealed roads, sealed roads and revegetated land source nodes are given in Table 13.24 and are in accordance with the WaterNSW standards (2012).

Table 13.24 Source node mean pollutant inputs into MUSIC

Base flow	**TSS**		**TP**		**TN**	
	Mean log(mg/L)	**S.D. log(mg/L)**	**Mean log(mg/L)**	**S.D. log(mg/L)**	**Mean log(mg/L)**	**S.D. log(mg/L)**
Unsealed roads (rail formation)	1.2	0.17	-0.85	0.19	0.11	0.12
Sealed roads	1.2	0.17	-0.85	0.19	0.11	0.12
Agricultural	1.3	0.13	-1.05	0.13	0.04	0.13
Revegetated land	1.15	0.17	-1.22	0.19	-0.05	0.12
Storm flow						
Unsealed roads (rail formation)	3	0.32	-0.3	0.25	0.34	0.19
Sealed roads	2.43	0.32	-0.30	0.25	0.34	0.19
Agricultural	2.15	0.31	-0.22	0.3	0.48	0.26
Revegetated land	1.95	0.32	-0.66	0.25	0.30	0.19

Note: S.D. – Standard Deviation.

For the post-development scenarios treatment measures were included in the MUSIC model to address the changes in pollutant loads and concentrations caused by the development of the rail corridor. Vegetated swales were adopted as the site specific treatment measures, which are a secondary measure mainly to treat fine materials. Primary treatment measures may be required to remove gross pollutants at some locations (eg the rail maintenance facility) but such measures were not included in the MUSIC model.

iv Assessment criteria

To assess whether the project and its associated treatment measures will have a NorBE on water quality, pre-development and post-development pollutant loads and concentrations from MUSIC have been assessed against the following criteria outlined in the WaterNSW standards (2012):

- The mean annual pollutant loads for the post-development case (including mitigation measures) must be 10% less than the pre-development case for TSSTP and TN. For gross pollutants, the post-development load only needs to be equal to or less than pre-development load.

- Pollutant concentrations for TP and TN for the post-development case (including mitigation measures) must be equal to or better compared to the pre-development case for between the 50th and 98th percentiles over the five-year modelling period when runoff occurs. Periods of zero flow are not accounted for in the statistical analysis as there is no downstream water quality impact. To demonstrate this, comparative cumulative frequency graphs, which use the Flow-Based Sub-Sample Threshold for both the pre- and post-development cases, must be provided. As meeting the pollutant percentile concentrations for TP generally also meets the requirements for TSS, cumulative frequency analysis is not required for TSS. Cumulative frequency is also not applied to gross pollutants.

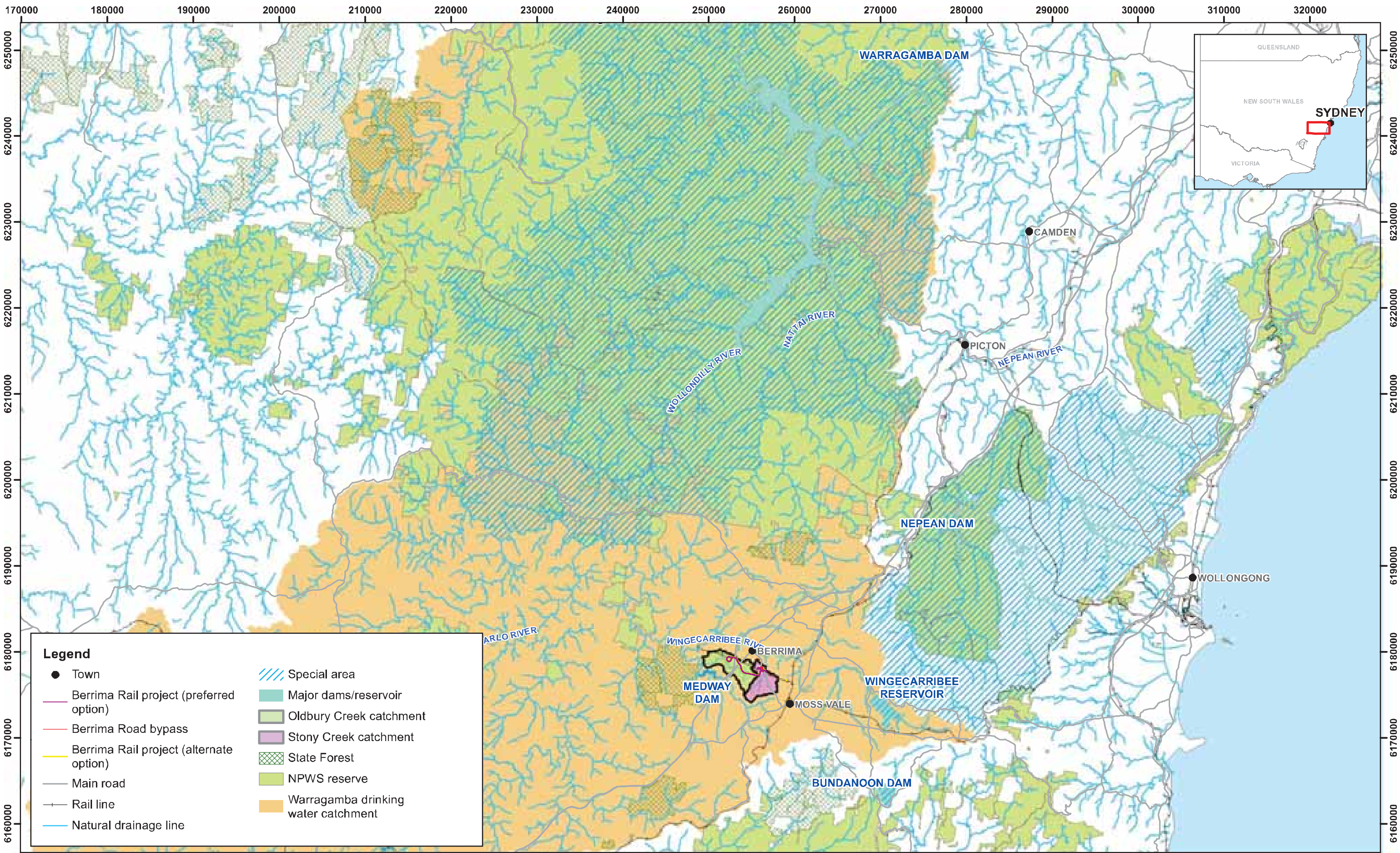
13.5.2 Existing environment

i Catchments

The project area crosses Oldbury Creek, Stony Creek and several of their tributaries. Oldbury Creek flows in a westerly direction from its headwaters in New Berrima to its discharge into Medway Rivulet, downstream of Medway Dam. Stony Creek flows in a northerly direction. The natural flow in both streams is impeded by several instream farm dams used for agricultural water supply. Oldbury Creek and Stony Creek ultimately discharge to Wingecarribee River, located to the north of the project area.

The Wingecarribee River catchment is a sub-catchment of the Hawkesbury Nepean River catchment which is located within the upper reaches of the Warragamba drinking water catchment (Figure 13.16). The Warragamba drinking water catchment covers an area of 9,051 km^2 and is part of the Sydney drinking water catchment. Warragamba Dam and its reservoir Lake Burragorang are located at the downstream end of the Warragamba drinking water catchment. This is WaterNSW's largest reservoir with a total capacity of more than two million megalitres (SCA 2015) and the capacity to supply up to 80% of Sydney's water. One quarter of the catchment is a declared Special Area, where the land is mostly pristine bushland and public access is restricted to protect water quality. The rest of the catchment is divided between eight local council areas, including the Wingecarribee Shire Council (WSC) area where the project is located.

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, hobby farms, natural areas, forestry, scattered rural residences, villages and towns, industrial activities such as the Berrima Cement works and Berrima Feed Mill, and some extractive industry and major transport infrastructure such as the Hume Highway.



Map: 2200569A_GIS_035_A2	Author: RP
Date: 15/09/2016	Approved by: LR

Data source: , Hume Coal, Google Earth

1:400,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

Berrima Rail Project

Figure 13.16

Regional setting of the Berrima rail project

ii Environmental values

Environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. Environmental values are sometimes referred to as beneficial uses.

The report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998) provides regional environmental values based on land use regions within the Hawkesbury-Nepean catchment. The land use region within the project area and applicable environmental values are provided in Table 13.25. These environmental values have been adopted for the project.

Table 13.25 Environmental values in the Berrima Rail Project area

Land use regions	Regional environmental values
Mixed-use rural and drinking water with clarification and disinfection	Aquatic ecosystems Primary contact recreation Secondary contact recreation Visual amenity Drinking water – clarification and disinfection Irrigation water supply Homestead water supply Aquatic foods (cooked)

Source: Independent Inquiry into the Hawkesbury-Nepean River System (HRC 1998).

Downstream of the confluence of the Wollondilly and Wingecarribee Rivers, the land use is predominantly drinking water catchment where environmental values include aquatic ecosystems, visual amenity, drinking water – disinfection only, and drinking water - groundwater.

iii Surface water users

Surface waters in the project area are managed under the *Greater Metropolitan Region Unregulated Water Sources Water Sharing Plan 2011*. The project area is located within the Upper Nepean and Upstream Warragamba Water Source, within the Medway Rivulet and Lower Wingecarribee River management zones.

Surface water users (other than for basic water rights) must hold a Water Access Licence (WAL) to take water from streams in the project area. The WAL specifies the annual volume that may be taken and the conditions under which water may be taken. In the Medway Rivulet Management Zone, WALs have an Environmental Flow Protection Rule that prevents pumping when there is no visible flow at the pump site. In the Lower Wingecarribee River Management Zone, WALs are divided into classes (A, B and C) and have flow conditions that indicate when pumping may commence and/or must cease. A class WAL holders are subject to daily flow sharing within a total daily extraction limit to protect instream values from risks associated with over extraction.

Figure 13.17 shows the location of surface water diversion works (pumps) and storages (dams) associated WALs in the Medway Rivulet and Lower Wingecarribee River management zones. A breakdown of the WAL volumes by water source and management zone is presented in Table 13.26.

Table 13.26 Water access licence volumes

Water source	Water management zone	Number of diversion works	Number of storages	Water access licence volume (ML/a)
Upper Nepean and Warragamba water source	Medway Rivulet management zone	13	7	1,027
	Lower Wingecarribee River management zone	29	12	1,072

a. Town water supply

There is one WAL in the Medway Rivulet Management Zone used by WSC for town water supply. The WAL is to take 900 ML per year from the reservoir behind Medway Dam. The Berrima Rail Project is not within the upstream catchment of Medway Dam (as Oldbury Creek discharges into Medway Rivulet downstream of Medway Dam) and therefore the project will have no impacts on this water user.

Lake Burragorang, the reservoir behind Warragamba Dam, is located approximately 30 km downstream of the project area in the Lower Wollondilly River Management Zone.

b. Local water users

There are 83 pumps and 48 dams in the study area. Of these, 7 pumps and 5 dams are located in the project area. An additional 2 pumps and 1 dam are located on properties owned by Hume Coal or subsidiaries of Hume Coal and have not been considered in this assessment.

Most pumps and dams in the study area are used for irrigation purposes or a combination of irrigation, stock and domestic purposes.

c. Basic water rights

Within the Berrima Rail Project area, water may be taken for stock or domestic purposes without a licence under basic water rights. Basic water rights in the study area include:

- Domestic and stock rights - Owners or occupiers of land which has stream frontage can take water without a licence. Water taken under a domestic and stock right may be used for normal household purposes around the house and garden and/or for drinking water for stock.
- Native title rights - Anyone who holds native title with respect to water, as determined under the Commonwealth Native Title Act 1993, can take and use water for a range of personal, domestic and non-commercial purposes.
- Harvestable rights – Landholders are allowed to build dams on minor streams that capture 10% of the average regional rainfall-runoff on their property without a licence to take water. The maximum harvestable right dam capacity (MHRDC) is the total dam capacity allowed under the harvestable right for a property and takes into account rainfall and variations in rainfall pattern.

The *Greater Metropolitan Region Unregulated Water Sources Water Sharing Plan 2011* estimates the water requirements of persons entitled to domestic and stock rights to be 21 ML/day in the Upper Nepean and Warragamba Water Source.

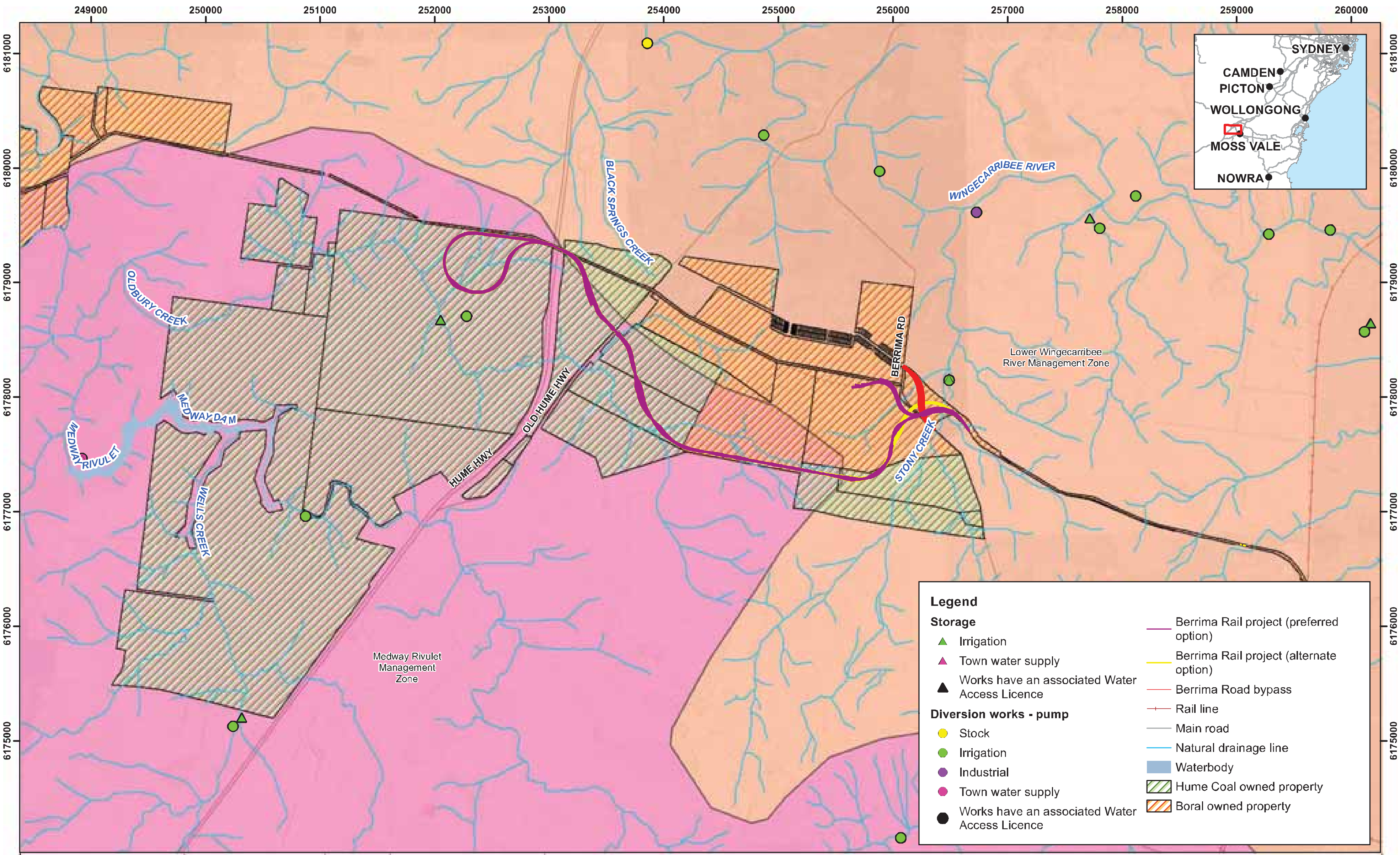
There are no native title rights in the study area. Harvestable rights are not estimated in the water sharing plan.

iv Ecosystems reliant on surface water

Ecosystems reliant on surface water in the study area include:

- Instream ecosystems; and
- Riparian ecosystems that access overbank flows and flooding.

Details of these ecosystems are provided in the ecology section of this report.



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Data source: NSW Property and Information 2015, Hume Coal, Google Earth

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

Berrima Rail Project

Figure 13.17

Surface water users

v Baseline surface water quality

Surface water quality monitoring has been undertaken in the project area since July 2014 and is ongoing to establish baseline (pre-development) surface water quality conditions. Monitoring is undertaken monthly at the locations shown on Figure 13.18.

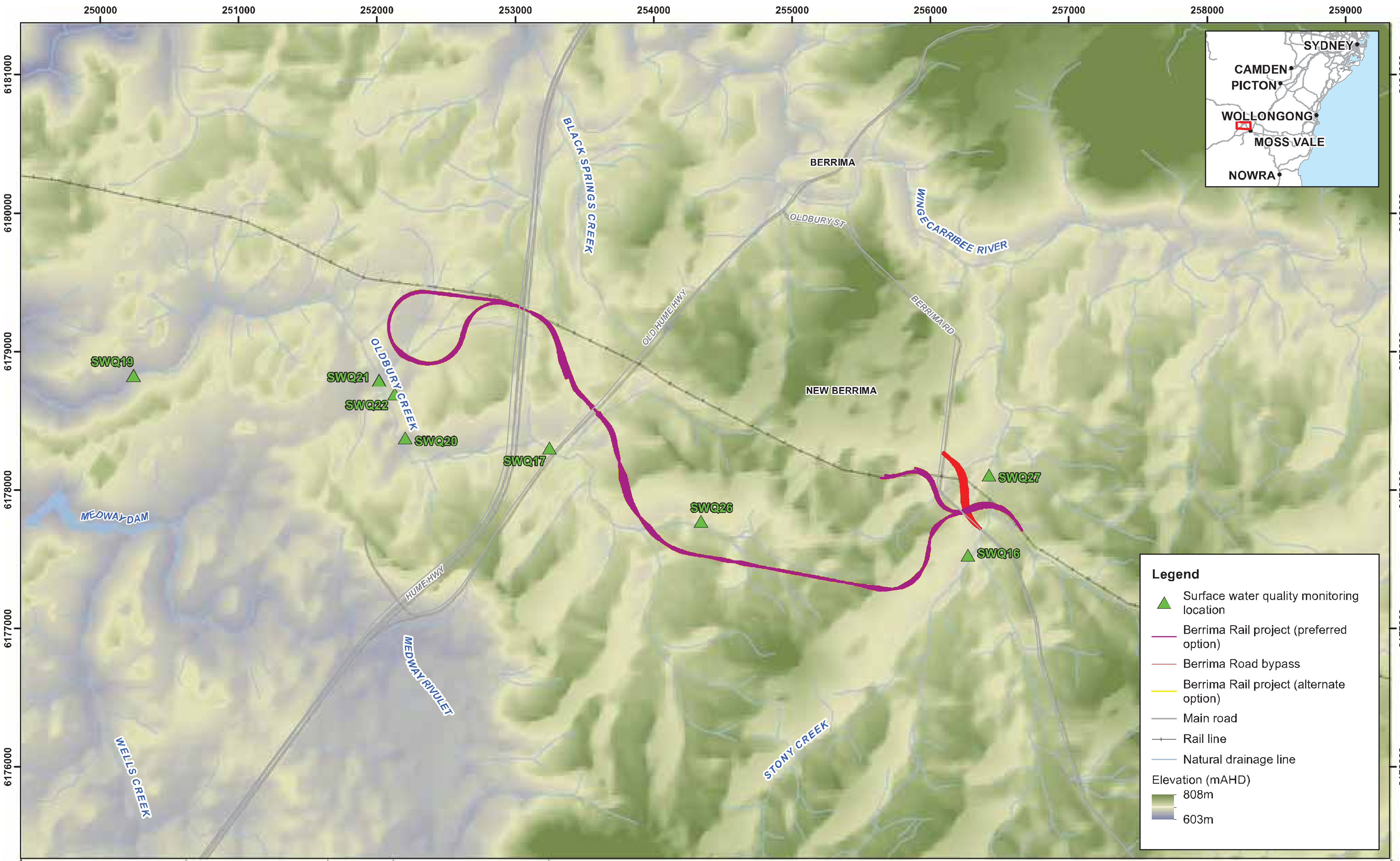
A summary of baseline surface water quality conditions in Oldbury Creek and Stony Creek for the period July 2014 to September 2015 is provided in Table 13.27. Results have been presented as a statistical analysis for monitoring locations SWQ17and SWQ19 on Oldbury Creek, SWQ20, SWQ21 and SWQ22 on farm dams on Oldbury Creek and SWQ16 on Stony Creek. There are more samples on Oldbury Creek due to their being five monitoring locations.

The results have been compared to the most conservative water quality guideline values for the environmental values in the project area, with the exception of nutrients which have been compared to the recommended WQOs in the report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998). Median and 80th percentile concentrations that exceed guideline values are shaded in grey in Table 13.30.

Baseline concentrations of key water quality parameters in Oldbury Creek and Stony Creek comply with guideline values with the exception of the following:

- Median and 80th percentile conductivity values for Oldbury Creek and Stony Creek exceed the ANZECC (2000) guideline for aquatic ecosystems;
- Median and 80th percentile concentrations of nitrogen and phosphorous in Oldbury Creek and Stony Creek exceed the WQOs recommended by the Healthy Rivers Commission (HRC 1998);
- Median and 80th percentile concentrations of aluminium and copper in Stony Creek exceed the ANZECC (2000) guideline for aquatic ecosystems and 80th percentile concentrations of aluminium in Oldbury Creek exceed the ANZECC (2000) guideline for aquatic ecosystems;
- Median and 80th percentile concentrations of iron in Oldbury Creek and Stony Creek exceed the ANZECC (2000) guideline for irrigation;
- 80th percentile concentrations of manganese in Oldbury Creek and Stony Creek exceed the ANZECC (2000) guideline for recreation;
- Median and 80th percentile concentrations of silver in Oldbury Creek and Stony Creek exceed the ANZECC (2000) guideline for aquatic ecosystems; and
- 80th percentile concentrations of zinc in Oldbury Creek exceed the ANZECC (2000) guideline for aquatic ecosystems.

Site specific WQOs will need to be developed for these parameters. This is discussed in Section 13.5.7.



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Date: 4/11/2016	Approved by: LR

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Coordinate system: GDA 1994 MGA Zone 56
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Figure 13.18
Baseline surface water quality monitoring locations

Table 13.27 Baseline surface water quality conditions in the project area

Parameter	unit	Guideline	Oldbury Creek					Stony Creek				
			No. of samples	Min	Median	80th percentile	Max	No. of samples	Min	Median	80th percentile	Max
Physical parameters												
Conductivity	µS/cm	35 – 350	39	178	456	571	1060	13	348	640	732	764
Temperature	°C	-	37	8.8	12	19	26	12	8.5	16	20	23
Turbidity	NTU	2 - 25	39	1.7	6.5	12	57	13	5.8	13	23	25
pH	pH units	6.5 - 8.0	39	5.0	7.4	7.8	9.2	13	6.4	7.3	7.6	7.9
TDS	mg/L	600	39	116	287	366	480	13	226	416	465	496
TSS	mg/L	-	39	2.0	5.0	9.0	34	13	<5	12	17	23
Nutrients												
Ammonia as N	mg/L	0.5	39	<0.01	0.04	0.12	0.42	13	<0.01	0.01	0.04	0.07
Nitrate (as N)	mg/L	0.7	39	<0.01	0.09	0.66	2.6	13	<0.01	<0.01	0.04	0.17
Nitrite (as N)	mg/L	1	39	<0.01	<0.01	0.03	0.11	13	<0.01	<0.01	<0.01	0.06
Total nitrogen as N	mg/L	0.5*	39	0.6	1.2	2.1	4.4	13	1.2	1.8	2.4	3.4
Phosphorus	mg/L	0.03*	39	<0.01	0.07	0.12	0.18	13	0.08	0.30	0.47	1.8
Major ions												
Calcium	mg/L	1,000	39	14	23	40	48	13	17	38	48	56
Chloride	mg/L	175	39	35	55	66	112	13	62	106	133	147
Magnesium	mg/L	2,000	39	7.0	9.0	13	21	13	8	18	20	20
Sodium	mg/L	115	39	20	37	50	75	13	31	53	63	72
Sulfate as SO_4	mg/L	250	39	5.0	27	73	138	13	<1	5.0	10	29
Heavy metals												
Aluminium	mg/L	0.055	39	<0.01	0.04	0.12	0.32	13	<0.01	0.06	0.16	0.30
Antimony	mg/L	0.003	39	<0.001	<0.001	<0.001	<0.001	13	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	39	<0.001	<0.001	<0.001	0.001	13	<0.001	0.002	0.002	0.003
Barium	mg/L	1	39	0.01	0.04	0.04	0.07	13	0.004	0.04	0.06	0.08
Beryllium	mg/L	0.06	39	<0.001	<0.001	<0.001	<0.001	12	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	39	<0.05	<0.05	<0.05	0.05	13	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.0002	39	<0.0001	<0.0001	<0.0001	<0.0001	13	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	39	<0.001	<0.001	<0.001	<0.001	13	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.05	39	<0.001	<0.001	<0.001	0.003	13	<0.001	<0.001	0.002	0.006
Copper	mg/L	0.0014	39	<0.001	0.001	0.001	0.002	13	<0.001	0.002	0.003	0.008
Iron	mg/L	0.2	39	0.06	0.22	0.35	0.57	13	0.10	0.35	0.54	2.4
Lead	mg/L	0.0034	39	<0.001	<0.001	<0.001	<0.001	13	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.1	39	0.007	0.06	0.13	2.2	13	0.006	0.08	0.84	3.4
Mercury	mg/L	0.0006	1	<0.0001	N/A	N/A	<0.0001	13	<0.0001	<0.0001	<0.0001	<0.0001

Table 13.27 Baseline surface water quality conditions in the project area

Parameter	unit	Guideline	Oldbury Creek No. of samples	Oldbury Creek Min	Oldbury Creek Median	Oldbury Creek 80th percentile	Oldbury Creek Max	Stony Creek No. of samples	Stony Creek Min	Stony Creek Median	Stony Creek 80th percentile	Stony Creek Max
Molybdenum	mg/L	0.01	39	<0.001	<0.001	<0.001	0.001	13	<0.001	<0.001	0.002	0.002
Nickel	mg/L	0.011	39	<0.001	<0.001	0.002	0.002	13	<0.001	0.002	0.003	0.004
Selenium	mg/L	0.01	39	<0.01	<0.01	<0.01	0.01	13	<0.01	<0.01	0.01	0.01
Silver	mg/L	0.00005	7	<0.001^	0.02	0.02	0.02	3	<0.001^	<0.01	0.01	0.01
Zinc	mg/L	0.008	39	<0.005	0.005	0.01	0.03	13	<0.005	<0.005	<0.005	0.01
Hydrocarbons												
Benzene	µg/L	1	39	<1	<1	<1	<1	13	<1	<1	<1	<1
Toluene	µg/L	25	39	<2	<2	<2	<2	13	<2	<2	<2	<2
Ethylbenzene	µg/L	3	39	<2	<2	<2	<2	13	<2	<2	<2	<2
Total xylene	µg/L	20	39	<2	<2	<2	<2	13	<2	<2	<2	<2
Naphthalene	µg/L	16	39	<5	<5	<5	<5	13	<5	<5	<5	<5

*Notes: *WQO recommended by Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River (HRC 1998).*
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.
N/A indicates low number of samples statistical value not possible to determine until more data is collected.

13.5.3 Preferred option impact assessment

This section presents the results of the MUSIC modelling for the preferred project option. Results are presented for the pre-development (existing) and post-development (operation) with and without treatment for the four sub-catchments of Oldbury Creek and the single sub-catchment of Stony Creek (see Figure 13.15).

To assess whether the project and its associated treatment measures will have a NorBE on water quality, modelling results for the operation with treatment scenario have been compared to modelling results for the existing scenario. The results were then assessed against the criteria for mean annual pollutant loads and pollutant concentrations between the 50th and 98th percentiles as specified in the WaterNSW standards (2012) and summarised in Section 13.5.1.

a. Comparison of mean annual pollutant loads

Table 13.28 provides a summary of the existing and operation with swale treatment scenarios for the Oldbury Creek and Stony Creek sub-catchments. Varying swale lengths were modelled to identify the length of swale that provides at least a 10% reduction in the mean annual load for the most onerous parameter, which was TN in all sub-catchments apart from Oldbury Creek sub-catchment 2 where the most onerous parameter was TSS. This resulted in significantly higher reductions in mean annual load for the other parameters. The resulting lengths of swale for each sub-catchment are given in Table 13.29. As well as the rail corridor, a sealed access road and hardstand areas are also located within Oldbury Creek sub-catchments 3 and 4, and a significant component of the swale length is due to the access road and hardstand areas.

Table 13.28 Mean annual pollutant load reduction (preferred option)

Parameter	Existing* (kg/yr)	Operation* with treatment (kg/yr)	Difference to existing
Oldbury Creek Sub-Catchment 1			
TSS	346	271	-22%
TP	1.37	0.613	-55%
TN	7.73	6.94	-10%
Oldbury Creek Sub-Catchment 2			
TSS	494	444	-10%
TP	2.09	0.916	-56%
TN	11.8	10.1	-14%
Oldbury Creek Sub-Catchment 3			
TSS	1100	93.3	-92%
TP	4.77	0.626	-87%
TN	25.5	22.8	-11%
Oldbury Creek Sub-Catchment 4			
TSS	1390	915	-34%
TP	6.00	2.38	-60%
TN	31.3	27.8	-11%
Stony Creek Sub-Catchment			
TSS	1060	712	-33%
TP	4.49	1.94	-57%
TN	24.5	21.7	-11%

Note: **Existing is agricultural node which is 100% pervious; Operation is unsealed road node which is 50% pervious and 50% impervious.*

Table 13.29 Swale length (preferred option)

Sub-catchment	Rail/access road corridor length (m)	Swale length (m)
Oldbury Creek 1	1,000	90
Oldbury Creek 2	1,050	85
Oldbury Creek 3 rail corridor	1,200	400
Oldbury Creek 3 road corridor	700	180
Oldbury Creek 4 rail corridor	2,800	500
Oldbury Creek 4 road corridor	400	180
Stony Creek	2,350	450

The results show that the preferred project option meets the NorBE criteria for mean annual pollutant loads in the Oldbury Creek and Stony Creek catchments, ie more than a 10% reduction in mean annual pollutant load in each sub-catchment.

b. Comparison of pollutant concentrations

Cumulative frequency graphs of TN and TP concentrations for each modelled sub-catchment for the pre-development and post-development with treatment scenarios are provided in the Surface Water Assessment Report (2200569A-WAT-REP-001). Graphs are provided for each modelled sub-catchment.

Comparison indicates that pollutant concentrations for the post-development with treatment scenario were equal to or better than the pre-development scenario between the 50th and 98th percentiles, and therefore compliance with the NorBE assessment criteria is achieved.

13.5.4 Alternative option impact assessment

This section presents the results of the MUSIC modelling for the alternative project option. Results are presented for the pre-development (existing) and post-development (operation) with and without treatment for the single sub-catchment of Stony Creek only (see Figure 13.15), as the rail infrastructure is the same in Oldbury Creek for both the preferred and alternative options. The rail corridor is 1000 m shorter within the Stony Creek sub-catchment for the alternative option.

To assess whether the project and its associated treatment measures will have a NorBE on water quality, modelling results for the operation with treatment scenario have been compared to modelling results for the existing scenario and assessed against the criteria for mean annual pollutant loads and pollutant concentrations between the 50th and 98th percentiles as specified in the WaterNSW standards (2012) and summarised in Section 13.5.1.

a. Comparison of annual pollutant loads

Table 13.30 provides a summary of the existing and operation with treatment scenarios for the Stony Creek sub-catchment. Varying swale lengths were modelled to identify the minimum length of swale that provides at least a 10% reduction in the mean annual load for the most onerous parameter, which was TSS. This resulted in significantly higher reductions in mean annual load for TN and TP. A swale length of 120 m was adopted to treat the rail corridor length of 1350 m.

Table 13.30 Mean annual pollutant load reduction (alternative option)

Parameter	Existing* (kg/yr)	Operation* with treatment (kg/yr)	Difference to existing
Stony Creek Sub-Catchment			
TSS	571	515	-10%
TP	2.5	1.1	-56%
TN	13.7	12.1	-12%

Note: **Existing is agricultural node which is 100% pervious; Operation is unsealed road node which is 50% pervious and 50% impervious.*

The results show that the alternative project option meets the NorBE criteria for mean annual pollutant loads in the Stony Creek catchment, ie more than a 10% reduction in mean annual pollutant load in the sub-catchment.

b. Comparison of pollutant concentrations

Cumulative frequency graphs of TN and TP concentrations for the pre-development and post-development with treatment scenarios are provided in the Surface Water Assessment Report (2200569A-WAT-REP-001).

Comparison indicates that pollutant concentrations for the post-development with treatment scenario were equal to or better than the pre-development scenario between the 50^{th} and 98^{th} percentiles, and therefore compliance with the NorBE assessment criteria is achieved.

13.5.5 Cumulative impact assessment

The results of modelling undertaken to assess potential impacts to surface water quality associated with the Hume Coal Project are presented in the Hume Coal Project EIS.

13.5.6 Analysis of results including design impact differences

MUSIC modelling has shown that the preferred and alternative project options comply with the NorBE assessment criteria for pollutant loads and pollutant concentrations. The preferred option requires an extra 330m of swale within the Stony Creek sub-catchment as the rail corridor is 1000 m longer within this sub-catchment compared to the alternative option.

13.5.7 Mitigation measures and monitoring program

This section presents the mitigation and management measures to be implemented for the Berrima Rail Project to avoid impacts on surface water quality. Mitigation and management measures will be implemented during construction and rehabilitation as well as during operation of the rail line.

i Construction and rehabilitation

The construction and rehabilitation phases of the project will involve earthworks activities which have the potential to cause erosion and sedimentation of local waterways if not appropriately managed.

An erosion and sediment control plan will be prepared, as specified in Section 13.3.2 ii. The erosion and sediment control plan will also be part of the Water Cycle Management Plan for the project, as required by Developments in Sydney's Drinking Water Catchment – Water Quality Information Requirements (WaterNSW 2015). The erosion and sediment control plan will be developed to achieve the surface water management objective below, and will incorporate the soil and water management principles below.

a. Surface water management objective

According to Vol. 2 of Managing Urban Stormwater: Soils and Construction the goal for surface water management is:

> '…to ensure that there is no pollution of surface or ground waters. Current best-practice erosion and sediment control techniques are, however, unlikely to achieve this goal, due to the limited effectiveness of most of these techniques. An appropriate management objective is therefore to take all reasonable measures (ie implement best-practice) to minimise water-quality impacts from erosion and sedimentation.

> Given the limited effectiveness of techniques for retaining eroded sediment, a strong emphasis should be placed on pollution prevention through erosion control, rather than relying on treatment techniques to capture these sediments.'

Therefore, with the paramount objective of not polluting surface waters in the first place, the strategy should be to minimise the discharge of sediment-laden waters from the sites to the adjacent waterways and drainage lines.

b. Soil and water management principles

The primary principle for surface water management at the site is to minimise erosion and sediment generation at the source, and where this is not possible, to capture and treat any sediment generated before discharge into receiving waterways. The following general principles provide a framework for the development of site-specific options to achieve this:

- Minimise the volume of clean surface water running onto the site from off site.
- Minimise the extent of disturbed areas.
- Minimise surface water from running onto disturbed areas of the site by staging operations and, where necessary, utilising surface water diversion drains and bunds for disposal and processing areas.
- Implement erosion control strategies to minimise generation of sediment in the surface water.
- Implement sediment control strategies to reduce the release of sediment in surface water from the site.
- Minimising the amount of surface water runoff discharged from the site and maximising reuse onsite.
- Maintain all erosion and sediment controls properly by implementing an inspection schedule.
- Vegetate disturbed areas progressively.
- Adopt strategies for early identification of potential surface water issues.

c. Specific measures

The project would utilise standard measures to minimise water quality impacts during the construction and rehabilitation phases. The principle of minimal disturbance during construction/rehabilitation would be observed and the primary focus would be on implementing erosion controls over sediment controls. By minimising erosion, less pressure is placed on sediment controls, thus reducing the risk of the project causing water pollution.

For particularly sensitive areas, the following measures would be adopted to avoid impacts:

- Clearly delineating the construction boundary;
- Clearly fencing and delineating environmentally sensitive areas that remain within the project boundary;
- Marking out vegetation within the corridor that can be retained as a buffer;

- Providing fencing and sediment fences supported by gravel filters along the edge of the footprint to prevent access and filter run-off where required;

- Addressing the importance of environmentally sensitive areas, and buffer zones, and compliance through induction and environmental training;

- Ensuring that temporary drainage does not directly contaminate run-off into the sensitive areas; and

- Providing appropriate erosion and sediment controls to prevent erosion at the source.

Where significant areas of disturbance may be required during construction, temporary sediment basins would be provided. These would be sized using *Managing Urban Stormwater: Soils and Construction* (the 'Blue Book') (Landcom 2004, DECC 2008). The sediment basins would provide sufficient volume for settling and storage of sediments. The settling zone volume would be estimated using the appropriate design rainfall depth and disturbed catchment areas and the storage zone would be estimated using the Revised Universal Soil Loss Equation. The sediment basins would be designed as Type C (coarse-grained soils), Type F (fine-grained soils) or Type D (dispersive soils) basins, as per the Blue Book classifications and the assumed soil parameters.

ii Operation

a. Modelled treatment measures

A swale system has been modelled to convey and filter stormwater runoff through vegetated channels. The adopted parameters are described in Section 13.5.1 iii. The swales will generally be located at the downstream extent of the rail corridor within each sub-catchment to treat the runoff before discharge into the local stream channels or overland flow paths. The lengths of the rail / access road corridors and required swales within each sub-catchment are provided in Table 13.29.

The swales will be effective in achieving NorBE and preventing any water quality impacts on water users and aquatic ecosystems located downstream of the discharge points from the rail corridor.

b. Management measures

The Water Cycle Management Plan will outline all surface water management works following the relevant guidelines set out in the Blue Book, Volume 1 (Landcom, 2004) and the Blue Book, Volume 2 (DECC, 2008). As the exact location of encampments, stockpiles and machinery compounds along with the fine details of proposed works are yet to be finalised, the information is intended to provide for general stormwater management strategies. The following site-specific controls would be finalised in the Water Cycle Management Plan:

- Minimise land disturbance.

- Vegetate disturbed areas progressively.

- Stabilisation and drainage of site access roads.

- Control vehicular access to site.

- Dust control.

- Soil and stockpile management.
- Clean water diversion.
- Sediment basin systems for long-term work areas, if required.
- Vegetation establishment.
- Site induction and staff training and education.
- Inspection and monitoring.
- Maintenance of surface water management measures.
- Minimise surface water runoff discharged from the site and maximise reuse onsite.
- Properly maintain all erosion and sediment controls by implementing an inspection schedule.
- Adopt strategies for early identification of potential surface water issues.

iii Surface water quality monitoring program

A surface water quality monitoring program will be implemented for the receiving environment during construction, operation and rehabilitation of the project. The program will involve surface water quality monitoring in Oldbury Creek and Stony Creek upstream and downstream of working areas during construction and rehabilitation and upstream and downstream of rail infrastructure during operation. Results of the surface water quality monitoring will be compared to site specific WQOs developed in accordance with the National Water Quality Management Strategy to assess impacts to surface water quality in the receiving environment associated with the project and trigger the implementation of mitigation and remediation measures if required.

a. Monitoring locations

Surface water quality monitoring will be undertaken at existing monitoring locations SWQ17 and SW19 on Oldbury Creek and SWQ16 on Stony Creek. Two additional locations will also be monitored: SWQ26 on Oldbury Creek, upstream of the rail alignment, and SWQ27 on Stony Creek downstream of the rail alignment. Monitoring at locations upstream and downstream of working areas and the rail alignment will allow the impacts of the project to be assessed. The surface water quality monitoring locations for the project are shown on Figure 13.19.

b. Monitoring frequency

Surface water quality monitoring will be undertaken on a monthly basis at the locations shown on Figure 13.19. Monitoring will be undertaken throughout the construction, operation and rehabilitation phases of the project.

Monthly surface water quality monitoring will continue at the locations shown on Figure 13.19 prior to commencement of the project to continue development of the baseline dataset.

c. Key parameters

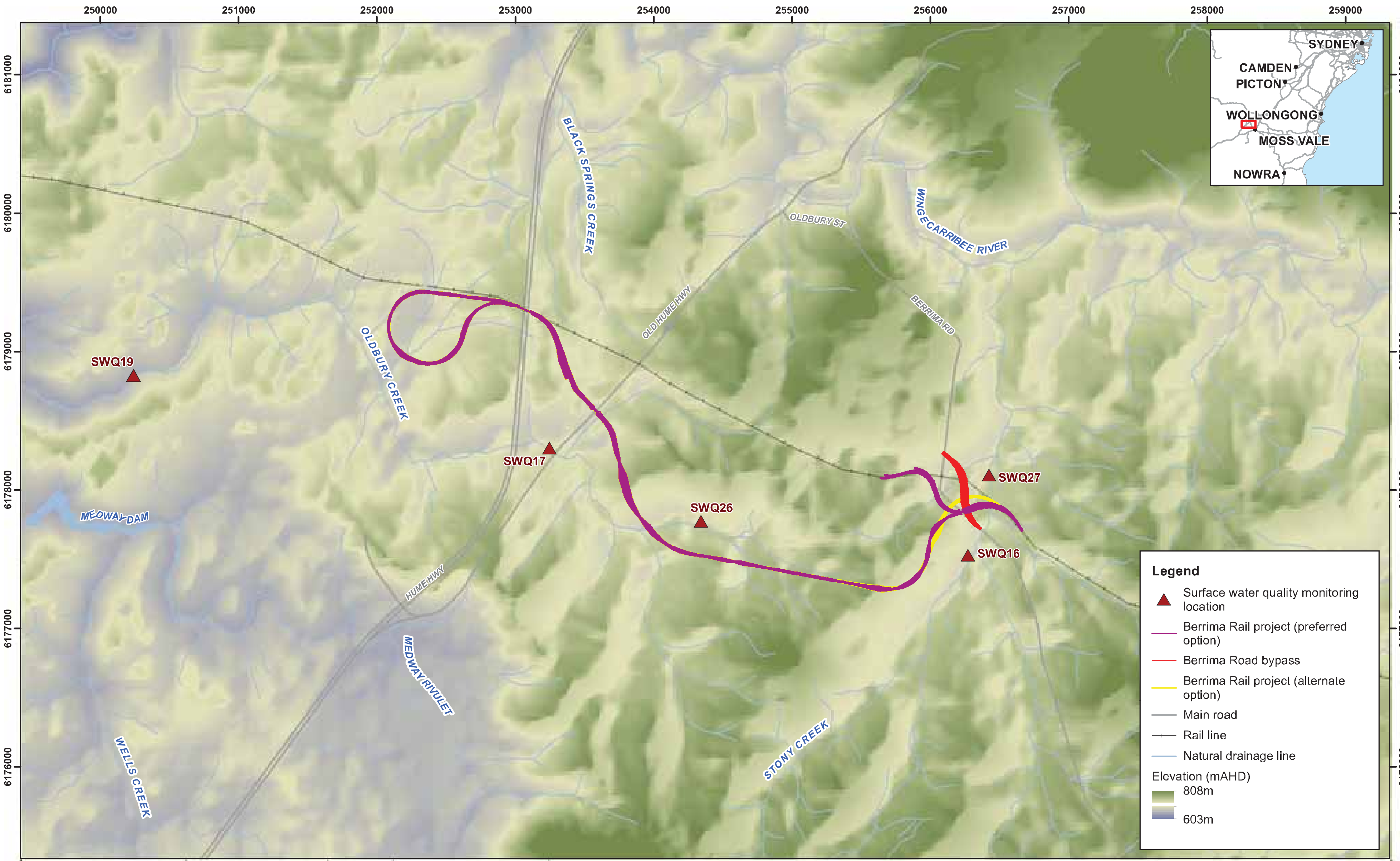
Surface water quality monitoring will be undertaken for the potential contaminants associated with project activities during construction, operation and rehabilitation of the project. Key parameters of concern in the Hawkesbury-Nepean catchment, as identified in the report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998), will also be monitored (refer Section 13.5.1).

The key parameters for the surface water quality monitoring program are summarised in Table 13.31.

Table 13.31 Parameters for surface water quality monitoring program

Category	Suite of analytes
Physical parameters	Total dissolved solids, suspended solids, turbidity
Major ions	Calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, reactive silica
Metals – dissolved	Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, zinc.
Nutrients	Ammonia, nitrate, nitrite, nitrogen (total), phosphorous (total and reactive)
Hydrocarbons	TRH/TPH, BTEX, naphthalene

Notes: TRH/TPH – Total Recoverable Hydrocarbons/Total Petroleum Hydrocarbons.
BTEX – Benzene, Toluene, Ethylbenzene, Xylene.



Map: 2200569A_GIS_038_A4	Author: RP		0 500 1,000 m 1:25,000 Coordinate system: GDA 1994 MGA Zone 56 Scale ratio correct when printed at A3
Date: 4/11/2016	Approved by: LR		
Data source: , Hume Coal, Google Earth			

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Figure 13.19

Receiving environment monitoring locations

d. Water quality objectives

WQOs are specific water quality targets that can be used as indicators of management performance.

The environmental values in the project area are provided in Section 13.5.2 and guideline values for these provided in Table 13.32.

For total nitrogen and total phosphorous, the WQOs will be adopted from the report *Healthy Rivers Commission Inquiry into the Hawkesbury Nepean River* (HRC 1998), which provides catchment specific WQOs for these nutrients.

In circumstances where the median or 80th percentile baseline concentration exceeds the guideline value in the NWQMS guidelines or the WQO in the Healthy Rivers Commission report, site specific WQOs will be developed in accordance with the referential approach in ANZECC (2000). The referential approach involves calculating WQOs on the basis of maximum acceptable departure from reference condition. The acceptable departure suggested is that the WQO be based on the 20th and/or 80th percentile (whichever is most appropriate for the indicator) of values at the reference site.

Ideally site specific WQOs should be based on 24 months of monthly baseline or reference data. The surface water quality results presented in this report are for the period July 2014 to September 2015, however monthly surface water quality monitoring is ongoing and further data will be available in future. Preliminary WQOs and the relevant source basis are provided in Table 13.32. Final WQOs will be developed using the additional surface water quality data collected prior to commencement of construction of the project.

Table 13.32 Preliminary water quality objectives for the Berrima Rail Project

Parameter	Unit	Oldbury Creek		Stony Creek	
		Preliminary WQO	Source	Preliminary WQO	Source
Physical parameters					
Conductivity	µS/cm	571	Preliminary WQO (80th percentile of baseline)	732	Preliminary WQO (80th percentile of baseline)
Turbidity	NTU	2 - 25	ANZECC aquatic ecosystems	2 – 25	ANZECC aquatic ecosystems
pH	pH units	6.5 - 8.0	ANZECC aquatic ecosystems	6.5 - 8.0	ANZECC aquatic ecosystems
Total dissolved solids (TDS)	mg/L	600	ADWG aesthetic	600	ADWG aesthetic
Total suspended solids (TSS)	mg/L	9	Preliminary WQO (80th percentile of baseline)	17	Preliminary WQO (80th percentile of baseline)
Nutrients					
Ammonia as N	mg/L	0.5	ADWG aesthetic	0.5	ADWG aesthetic
Nitrate (as N)	mg/L	0.7	ANZECC aquatic ecosystems	0.7	ANZECC aquatic ecosystems
Nitrite (as N)	mg/L	1	ANZECC recreational	1	ANZECC recreational
Total nitrogen as N	mg/L	2.1	Preliminary WQO (80th percentile of baseline)	2.4	Preliminary site specific WQO

Table 13.32 Preliminary water quality objectives for the Berrima Rail Project

Parameter	Unit	Oldbury Creek		Stony Creek	
		Preliminary WQO	Source	Preliminary WQO	Source
Phosphorus	mg/L	0.12	Preliminary WQO (80th percentile of baseline)	0.47	Preliminary WQO (80th percentile of baseline)
Major ions					
Calcium	mg/L	1,000	ANZECC livestock	1,000	ANZECC livestock
Chloride	mg/L	175	ANZECC irrigation	175	ANZECC irrigation
Magnesium	mg/L	2,000	ANZECC livestock	2,000	ANZECC livestock
Sodium	mg/L	115	ANZECC irrigation	115	ANZECC irrigation
Sulfate as SO_4	mg/L	250	ADWG aesthetic	250	ADWG aesthetic
Metals					
Aluminium	mg/L	0.12	Preliminary WQO (80th percentile of baseline)	0.16	Preliminary WQO (80th percentile of baseline)
Antimony	mg/L	0.003	ADWG health	0.003	ADWG health
Arsenic	mg/L	0.01	ADWG health	0.01	ADWG health
Barium	mg/L	1	ANZECC recreational	1	ANZECC recreational
Beryllium	mg/L	0.06	ADWG health	0.06	ADWG health
Boron	mg/L	0.37	ANZECC aquatic ecosystems	0.37	ANZECC aquatic ecosystems
Cadmium	mg/L	0.0002	ANZECC aquatic ecosystems	0.0002	ANZECC aquatic ecosystems
Chromium	mg/L	0.001	ANZECC aquatic ecosystems	0.001	ANZECC aquatic ecosystems
Cobalt	mg/L	0.05	ANZECC irrigation	0.05	ANZECC irrigation
Copper	mg/L	0.0014	ANZECC aquatic ecosystems	0.003	Preliminary WQO (80th percentile of baseline)
Iron	mg/L	0.35	Preliminary WQO (80th percentile of baseline)	0.5	Preliminary WQO (80th percentile of baseline)
Lead	mg/L	0.0034	ANZECC aquatic ecosystems	0.0034	ANZECC aquatic ecosystems
Manganese	mg/L	0.13	Preliminary WQO (80th percentile of baseline)	0.84	Preliminary WQO (80th percentile of baseline)
Mercury	mg/L	0.0006	ANZECC aquatic ecosystems	0.0006	ANZECC aquatic ecosystems
Molybdenum	mg/L	0.01	ANZECC irrigation	0.01	ANZECC irrigation
Nickel	mg/L	0.011	ANZECC aquatic ecosystems	0.011	ANZECC aquatic ecosystems
Selenium	mg/L	0.01	ADWG health	0.01	ADWG health
Silver	mg/L	0.02	Preliminary WQO (80th percentile of baseline)	0.01	Preliminary WQO (80th percentile of baseline)

Table 13.32 Preliminary water quality objectives for the Berrima Rail Project

Parameter	Unit	Oldbury Creek		Stony Creek	
		Preliminary WQO	Source	Preliminary WQO	Source
Zinc	mg/L	0.01	Preliminary WQO (80th percentile of baseline)	0.008	ANZECC aquatic ecosystems
Hydrocarbons					
Benzene	µg/L	1	ADWG health	1	ADWG health
Toluene	µg/L	25	ADWG aesthetic	800	ADWG health
Ethylbenzene	µg/L	3	ADWG aesthetic	300	ADWG health
Xylene	µg/L	20	ADWG aesthetic	600	ADWG health
Naphthalene	µg/L	16	ANZECC aquatic ecosystems	16	ANZECC aquatic ecosystems

e. WQO exceedance response

Exceedances of the WQOs at downstream monitoring locations SWQ17 and SWQ19 on Oldbury Creek and SWQ27 on Stony Creek will be investigated as follows:

- The concentration at the downstream monitoring location would be compared to the concentration at the upstream monitoring location;
- if the concentration at the upstream location exceeds or is equal to the concentration at the downstream location, no further action is required;
- if the concentration at the upstream location is lower than the concentration at the downstream location, then the monitoring locations are resampled;
- If resampling confirms the exceedance of the WQO at the downstream location and the lower concentrations at the upstream location, an investigation into the source of contamination and risks to environmental values would be undertaken; and
- If the investigation indicates potential for risks to environmental values, an action plan to mitigate potential harm would be developed.

13.5.8 Conclusion

Construction and rehabilitation phase impacts of the project on surface water quality will be subject to development of specific measures to control erosion and sedimentation, with modelling to be undertaken at the detailed design stage to demonstrate that the measures meet the NorBE criteria.

Operational phase impacts for both preferred and alternative options are simulated to meet NorBE criteria with the implementation of vegetated swales to treat runoff from the rail and access road corridors. The modelling analysis which has been undertaken in accordance with the relevant guideline demonstrates compliance with the NorBE requirements.

Surface water quality monitoring will be undertaken throughout construction, operation and rehabilitation at upstream and downstream sites on Stony Creek and Oldbury Creek to assess impacts to surface water quality in the receiving environment associated with the project and trigger the implementation of mitigation and remediation measures if required.

13.6 Conclusion

The impacts of the project on flooding in local catchments and the potential for it to contribute to scour and erosion risk around crossings and drains, impeded fish passage and impact water quality were assessed.

The flood assessment determined that with culverts in place there will only be flood impacts on Hume and Boral owned and these will cease to occur after the operations conclude and the site is rehabilitated.

An erosion and sedimentation control plan will be prepared and implemented for the construction phase. Protection measures will be implemented around the new culverts to prevent scour and erosion during operations as stream velocities will increase in these areas.

The proposed waterway crossings will be consistent with the DPI guidelines (2013) for the classes of waterways to be traversed. However, flow will be diverted at two locations on Oldbury Creek; the design of the diversions will take the DPI requirements for fish passage into account.

Erosion and sedimentation control measures will be implemented during the construction and rehabilitation phases to prevent impacts to water quality. Modelling demonstrated that the NorBE requirements will be satisfied during the operation of the rail line. The quality of surface water will be monitored at upstream and downstream sites on Stony Creek and Oldbury Creek during the construction, operation and rehabilitation phases of the project. Mitigation measures will be implemented if water quality is determined to be adversely affected by the project.

14 Land and soil resources

14.1 Introduction

This chapter summarises the soil and land assessment report (SLA) which was prepared with reference to:

- *The land and soil capability assessment scheme: second approximation* (OEH 2012);
- *Guidelines for surveying soil and land resources* (McKenzie et al 2008);
- *Australian soil and land survey handbook* (NCST 2009);
- *The Australian soil classification* (Isbell 2002);
- *Soil data entry handbook* (DLWC 2001);
- *Infrastructure proposal on rural land guideline (DPI 2013)*;
- *Agfact AC25: Agricultural Land Classification* (NSW Agriculture, 2002); and
- *Soil and Landscape Issues in Environmental Impact Assessment* (DLWC 1997).

The full technical report is included in Appendix L.

The SEARs for the project require an assessment of the likely impacts on soil and land resources. Table 14.1 lists the relevant assessment requirements and where they are addressed in this chapter.

Table 14.1 Soil and agriculture - relevant environmental assessment requirements

Relevant authority and assessment requirement	Relevant section
DP&E	
Soil Resources	
An assessment of the likely impact of the development on the environment, focusing on the specific issues identified below, including:	
- a description of the existing environment likely to be affected by the development, using sufficient baseline data;	Section 14.3
- an assessment of the likely impacts of all stages of the development, including any cumulative impacts, taking into consideration any relevant legislation, environmental planning instruments, guidelines, policies, plans and industry codes of practice;	Section 14.4
- a description of the measures that would be implemented to mitigate and/or offset the likely impacts of the development, and an assessment of: ▪ whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented; ▪ the likely effectiveness of these measures, including performance measures where relevant; and ▪ whether contingency plans would be necessary to manage any residual risks.	Section 14.5; contingency measures in 14.5.7

Table 14.1 Soil and agriculture - relevant environmental assessment requirements

Relevant authority and assessment requirement	Relevant section
- a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved.	Section 14.5.7
Agriculture NSW	
- Consideration of impacts to livestock access and movement from construction of the railway.	Section 14.5.5
- Consideration of the Infrastructure Proposals on Rural Land Guideline to assess impacts.	Impacts on farming operations and livestock see Section 14.4.2vii; Weed management will be addressed in CEMP (Section 14.5.4i); Rehabilitation see Section 14.5.6 and in Chapter 2 (Section 2.6).
DPI Water	
Soil Resources	
- An outline of the measures to be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation.	Section 14.4.2v
OEH	
- The EIS must map the following features relevant to water and soils including: ▪ a. Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map).	There are no acid sulfate soils – see Section 14.3.2v
Water NSW	
Soil Resources	
- Provide concept plans/protocols/procedures for the following: ▪ - Soil and Water Management Plan	Section 14.5.4 includes the procedures for topsoil management that will be incorporated into the Soil and Water Management Plan.

The entire project area was considered as part of the soil assessment. The impact assessment focuses on the project disturbance footprint, which is wholly contained within the project area and is shown in Figures 2.5 and 2.6.

14.2 Assessment method

The land and soil assessment comprised the following steps:

- a desktop review of existing information;
- a soil survey to characterise soil types of the project area, including field assessment and laboratory analysis. The survey points covered an area larger than the project area (Figure 14.1);
- an assessment of land and soil capability (LSC) using results from the soil survey;
- an assessment of agricultural land use; and
- an assessment of potential impacts on soil resources (Section 14.4) and proposed management and mitigation methods.

Soil sampling sites

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Figure 14.1

14.3 Existing Environment

14.3.1 Regional soil mapping

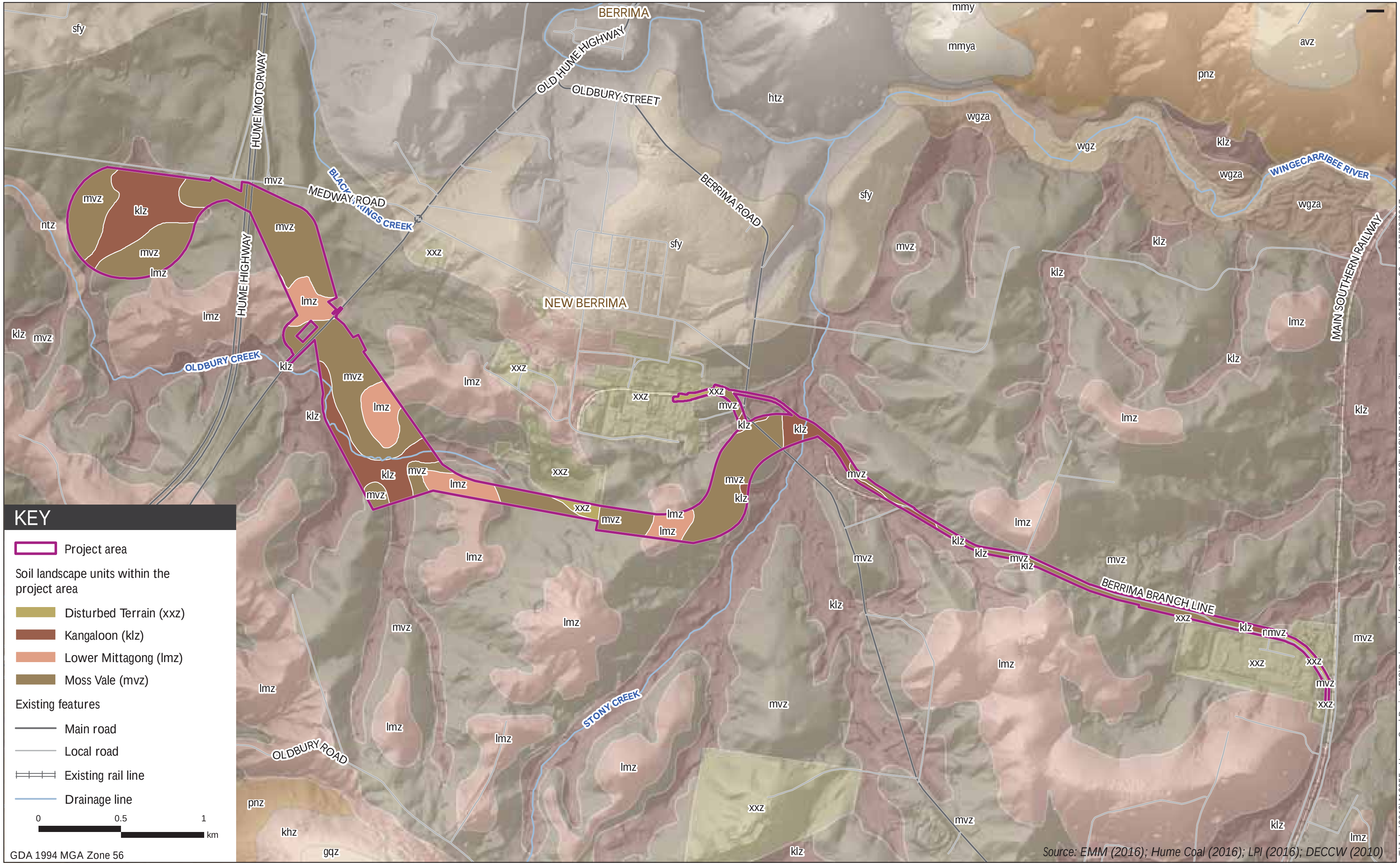
i Soil and land resources mapping

The *Soil and Land Resources of the Hawkesbury-Nepean Catchment Map* (1:100,000) identifies three soil landscapes in the project area (DECC 2008), with some of the area classified as disturbed terrain. These are described in Table 14.2 and shown on Figure 14.2.

Table 14.2 Soil landscapes in the project area

Description	General landscape	Land use	Soils and vegetation	Erosion
Kangaloon	Foot slopes within plain on Wianamatta Group Shale. Local relief 0–9m; altitude 531–745m; slopes 1–3%; rock outcrop nil	Grazing	Brown Kurosols and Hydrosols; extensively cleared open grassland	Waterlogging as a result of tree clearing
Lower Mittagong	Rises and low hills on Wianamatta Group Shale (shale). Local relief 5–90 m; altitude 534–820 m; slopes 0–25%; rock outcrop nil	Beef cattle grazing, rural residential development, olive and vineyard development, plus urban development around Mittagong and Moss Vale	Brown Kurosols, Red Kurosols, Brown Dermosols and Red and Brown Kandosols, with Yellow Natric Kurosols in drainage lines; generally Mittagong Sandstone Woodland community	Minor to moderate gully erosion occurs in cleared drainage plains; minor sheet erosion is common
Moss Vale	Rises on Wianamatta Group Shale (shale). Local relief 5–30 m; altitude 544–740 m; slopes 0–5%; rock outcrop nil	Beef cattle grazing and rural residential development	Yellow Kurosol, Red Kurosols, Brown Kurosols and Yellow Kandosols; mostly cleared pasture with isolated paddock trees	Minor to moderate gully erosion occurs in cleared drainage plains

Note: 1. The soil landscapes are mostly grouped based on geological origin and similarity in local relief and slopes and each may include a range of soil types.



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Soil landscapes of project area and surrounds

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Figure 14.2

ii Australian Soil Classification

The Australian Soil Classification (ASC) scheme (Isbell 1996) is a multi-category scheme with soil classes defined on the basis of diagnostic horizons and their arrangement in vertical sequence, as seen in an exposed soil profile. The Australian Soil Classification (ASC) scheme (Isbell 1996) orders that are mapped on a regional scale in the project area (OEH 2016a) are described in Table 14.3.

Table 14.3 Regional soil mapping – ASC soil orders distribution in the project area

Order	Description	Agricultural potential[1]	Soil Landscapes	Approximate location	ha
Kurosol	Soils with strong texture contrast between A horizons and strongly acid B horizons	Very low with high acidity (pH<5.5), low chemical fertility, low water-holding capacity and often sodic	Kangaloon	Low lying areas subject to periodic inundation	41.2
Dermosols	Lack a strong texture contrast and have a well structured B horizon. Soils have a gradual increase in clay content with depth, and a more defined structure then Kandosols.	High with good structure and moderate to high chemical fertility and water-holding capacity with few problems	Lower Mittagong, Moss Vale	Widespread over most of the project area	135.4
Other	Land associated with the Berrima Cement Works, and other industrial works.	Not assessed	Disturbed terrain	Southern end of the Berrima Branch Line, south of the Berrima Cement Works	4.7

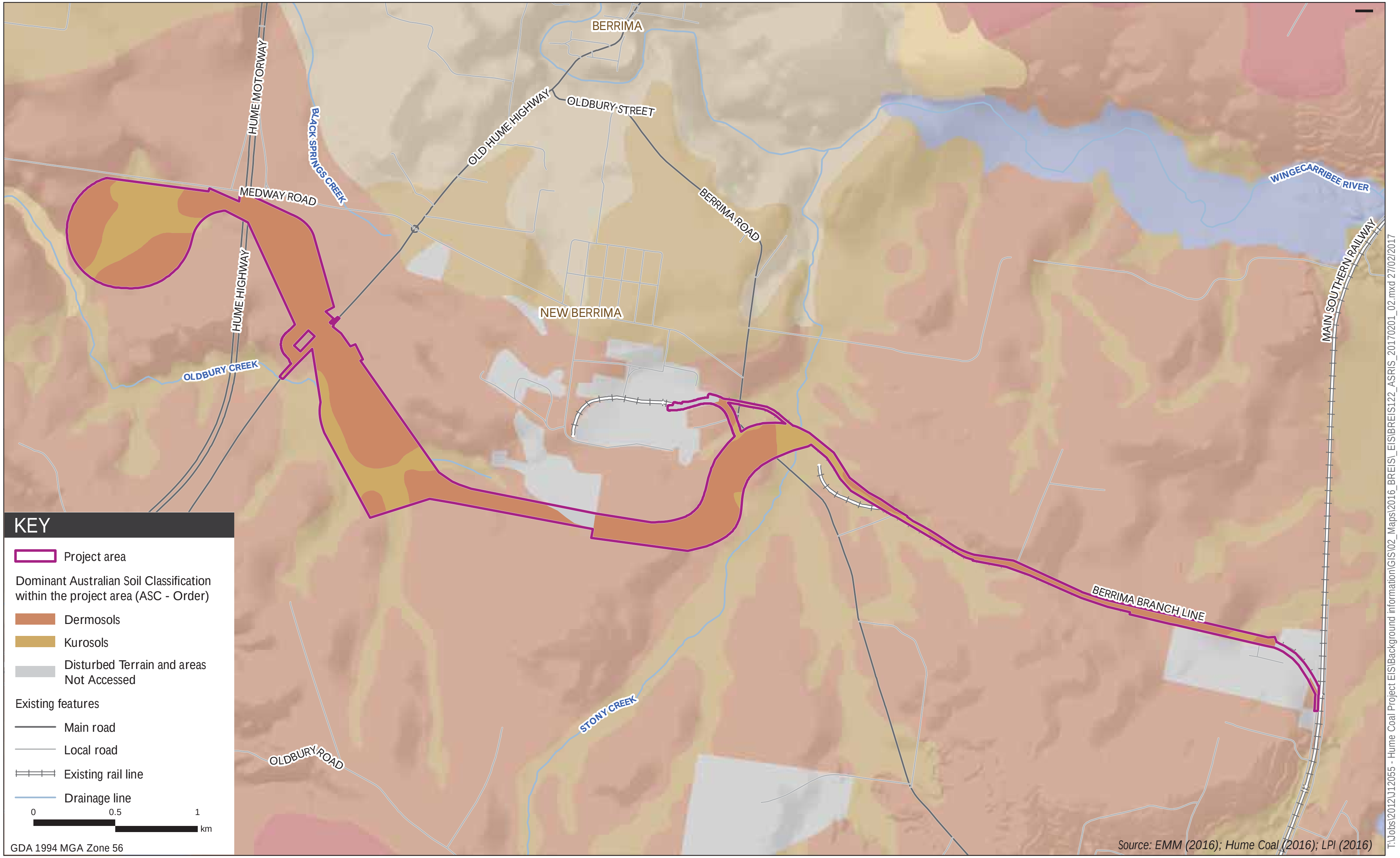
Notes: 1. Based on Gray and Murphy (2002).These descriptions are superseded by more detailed mapping by EMM.

iii Great soil group

The great soil groups (GSG) in the project area are Yellow podzolic soils – more fertile (YPm) and Yellow podzolic soils – less fertile (YPi) (OEH 2016b).

iv Inherent soil fertility

The inherent fertility based on GSG mapping of the rail project area identifies soils ranging from moderately low (2) soil fertility to moderate (3) soil fertility (Charman 1978).



Regional soil mapping - Australian Soil Classification (eSpade)

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Figure 14.3

v Hydrological soil group

Group C – slow infiltration is the predominant hydrologic soil group in the project area, which has slow water infiltration rates, impedes downwards movement of water and has a slow rate of water transmission (OEH 2016c).

vi eSPADE soil profiles

The *soil profile attribute data environment* (eSPADE) soil profile database search provides information on a number of soils profiles previously surveyed in the greater Bowral area. Table 14.4 details the six historic eSPADE soil profiles within the project area. Very few of these sites have a complete soil survey record.

Table 14.4 eSPADE historic soil profiles within the project area

Site ID	Soil type (GSG)	Surface texture	Surface pH	Easting[1]	Northing[1]
Survey name and date					
Sydney Catchment Authority reconnaissance soil survey – Moss Vale (1004229) 13/2/2001					
Profile 28	Red Podzolic	Light medium silty clay loam	6	259382	6175341
Profile 29	Red Podzolic	Light silty clay loam	6.5	256776	6177340
Profile 31	Red Podzolic	Sandy clay loam	6	253594	6178608
Soil Landscapes of the Burragorang 1:100 000 Sheet (1001013) 6/11/1998					
Profile 20	Red Earth	Loam	7	251504	6179690
Profile 22	Yellow Earth	Sandy Loam	7.5	251704	6179590
Bowral/Mittagong Effluent (1000635) 10/09/1994					
Profile 10	-	Clay loam	7	256904	6177400

Notes: 1.MGA Zone 56.

14.3.2 Regional land use and capability

i Land use

As described in Chapter 6, the existing land use in and surrounding the project area comprises a mixture of agricultural, industrial, rural residential and residential land uses. The land use in the project area where the rail loop and new rail line will be constructed is mostly improved pasture for grazing. There is also some land which already has rail and road infrastructure.

ii Land and soil capability classes

OEH's land and soil capability class definitions are in Table 14.5. Most of the project area is mapped as Class 4 – moderate capability land and Class 3 – high capability (mapping data sourced from OEH 2015b) (Table 14.6 and Figure 14.4).

Land and soil capability has been assessed at a local scale using the field survey results, and is described in detail in Section 14.3.4.

Table 14.5 Land and soil capability class definitions (OEH 2012)

LSC Class	Description
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)	
1	**Extremely high capability land:** Land has no limitations. No special land management practices required. Capable of all rural land uses and land management practices.
2	**Very high capability land:** Land has slight limitations. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	**High capability land:** Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)	
4	**Moderate capability land:** Moderate to high limitations for high-impact land uses. It will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture; and the limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	**Moderate-low capability land:** High limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
Land capable for a limited set of land uses (grazing, forestry and nature conservation)	
6	**Low capability land:** Very high limitations for high-impact land uses, and is generally suitable for limited land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation.
Land generally incapable of agricultural land use (selective forestry and nature conservation)	
7	**Very low capability land:** Severe limitations that restrict most land uses and generally cannot be overcome. Generally suitable only for selective forestry and nature conservation.
8	**Extremely low capability land:** Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation.

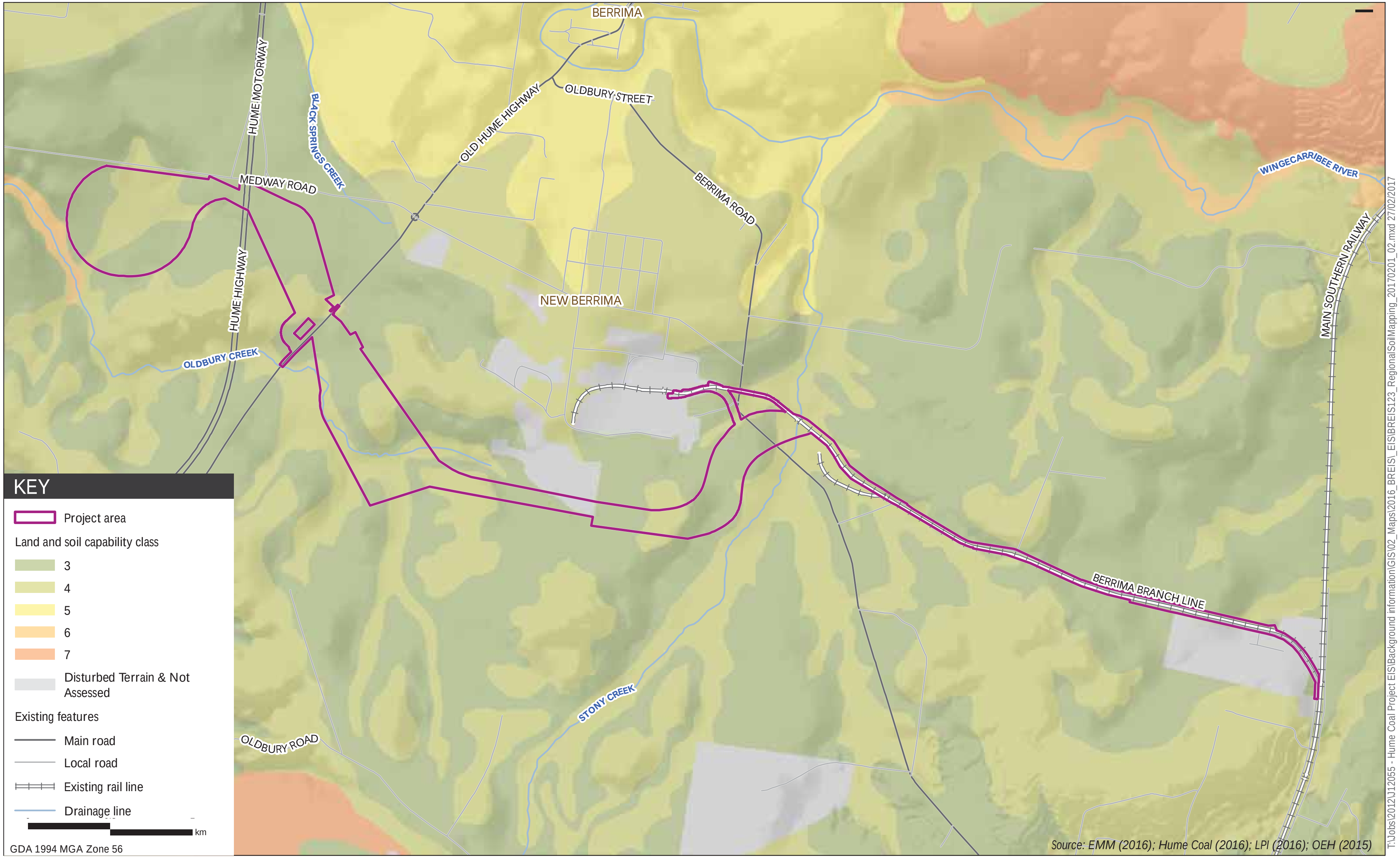
Table 14.6 Regional land and soil capability classes in the project area

LSC Class	Soil landscapes	Area
3	Moss Vale	113.9
4	Kangaloon, Lower Mittagong	62.7
8	Disturbed Terrain (existing infrastructure)	4.7

iii Agricultural suitability assessment

The majority of the project area comprises agricultural suitability Class 3 land (Figure 14.4), which is grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with sown pasture. The overall production level is moderate because of edaphic or environmental constraints. Erosion hazard, soil structural breakdown or other factors, including climate, may limit the capacity for cultivation and soil conservation or drainage works may be required (NSW Agriculture 2002).

There is a minor amount of Class 5 land also comprising rail infrastructure, which is unsuitable for agriculture or at best suited only to light grazing (NSW Agriculture 2002).



Land and soil capability in the project area (regional soil mapping)

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Figure 14.4

EMM HUMECOAL

iv Biophysical Strategic Agricultural Land

The NSW Government has mapped Biophysical Strategic Agricultural Land (BSAL) across the whole of NSW, based on a desktop study, and the resultant maps accompany the Mining SEPP. BSAL is land with high quality soil and water resources capable of sustaining high levels of productivity. As of October 2015, the *Strategic Agricultural Land Map* prepared by OEH and presented in the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (DP&E 2013) indicates there is no BSAL in the project area. The closest mapped BSAL area is about 2 km south of the project area, on Mount Gingenbullen. The project is linear infrastructure that is not subject to the Gateway process.

v Acid sulphate soil planning map

There are no acid sulphate soils in the project area, as per the *Guidelines for the Use of Acid Sulfate Soil Risk Maps* (DLWC 1998).

14.3.3 Surveyed soils of the project area

i Summary of soil units

The soil types in the project area as identified by the field survey are summarised in Table 14.7 and shown on Figure 14.5. Visual assessment of cut batters along the existing rail corridor in the eastern part of the project area identified a possible texture contrast soil, most likely a Kurosol.

Table 14.7 Soil types in the project area

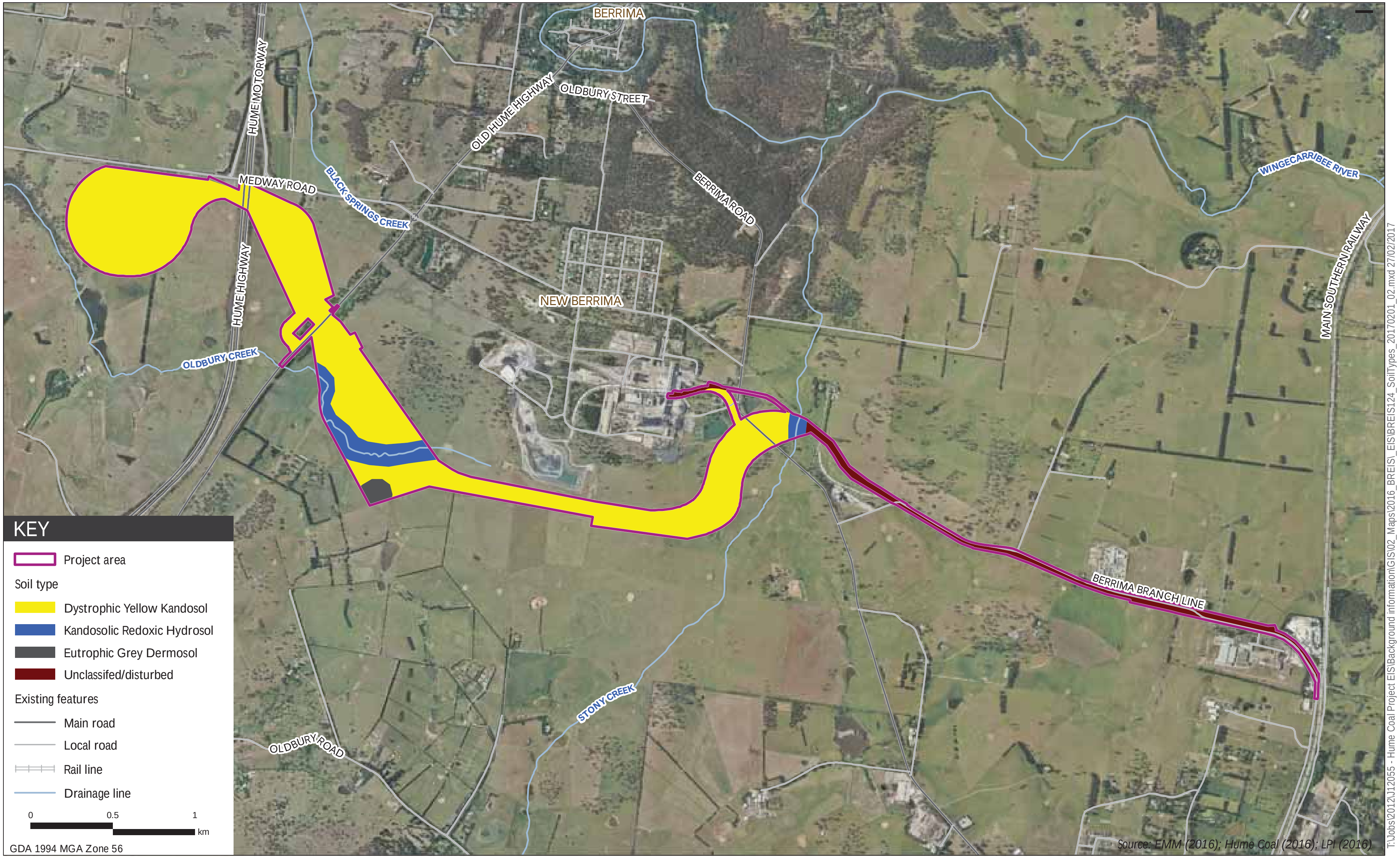
ASC order (Soil type)	Total area mapped within project area	
	ha	**%**
Kandosol	147.5	81.4
Hydrosol	13.3	7.3
Dermosol	2.2	1.2
Unclassified (probably Kurosol)	18.4	10.0

ii Dystrophic Yellow Kandosol

This soil unit occurs on all slopes and crests of low rolling hills on sandstone and shale surface geology (see Photograph 14.1). Soils are lacking strong texture contrast with silty clay loams over light clays, making a transition to medium clays at depth. The soil surface is mostly firm when dry and without surface coarse fragments. Topsoils have few coarse fragments and are without mottling. Subsoils have few coarse fragments, massive structure and are imperfectly drained. Mottling is common to many, with colouring typically being orange or red. The Dystrophic Yellow Kandosol can be strongly acidic and is most commonly non-saline and non-sodic.

Two variations were noted, a shallow phase variation (10% of total occurrences) and a variation with a redder hue in the upper B2 horizon (10%). The shallow phase variation typically exists on steep slopes or hillcrests. Another variation exists on spurs and ridge lines with a redder hue in the upper B2 horizon.

Land within the project area that is characterised by this soil type is extensively cleared and used mainly for grazing improved pastures and existing infrastructure.



Soil type distribution across the project area

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Figure 14.5

EMM HUMECOAL

Photograph 14.1 Dystrophic Yellow Kandosol (Site 754)

iii Kandosolic Redoxic Hydrosol

The Kandosolic Redoxic Hydrosol occurs on raised or lower drainage depressions and valley flats (Photograph 14.2). Soils are weakly to moderately developed with variable textures and colour grades depending on the localised site morphology.

A horizons are silty clay loam to light clay grading with depth towards medium to heavy clay B horizons. Surface condition is cracked and without coarse fragments. They have no coarse fragments throughout the profile. Orange mottles may be present at depth. Subsoils typically have no segregations.

Kandosolic Redoxic Hydrosol have moderately low fertility, are strongly acidic, slowly permeable, poorly drained, sodic in the B horizon and are moderately saline in the A horizon.

Land use on this soil type in the project area is generally for improved and native pastures. Coverage of the Kandosolic Redoxic Hydrosol is limited to drainage depressions and associated floodplains that experience regular inundation.

Photograph 14.2 Kandosolic Redoxic Hydrosol (site 645)

iv Eutrophic Grey Dermosol

Eutrophic Grey Dermosols occur on gently to moderately inclined rolling low hills to rolling hills on small, randomly distributed, isolated basalt intrusions (Photograph 14.4). Soils are moderately to well developed (depending on landform element). The soil lacks strong texture contrast and has increasing clay content with depth.

A horizons are typically greyish brown silty loam over grey medium to heavy clay B horizons. The soil surface is mostly without coarse fragments and of firm to cracked condition. Eutrophic Grey Dermosols generally have few or no coarse fragments in the lower A and upper B horizons with coarse fragments more common in the lower B horizon. Subsoils commonly have red and orange mottling with no segregations.

Eutrophic Grey Dermosols are of moderately high fertility, moderately permeable, poorly drained and have moderate to low salinity. They have sodic B horizons and very strongly acidic A horizons.

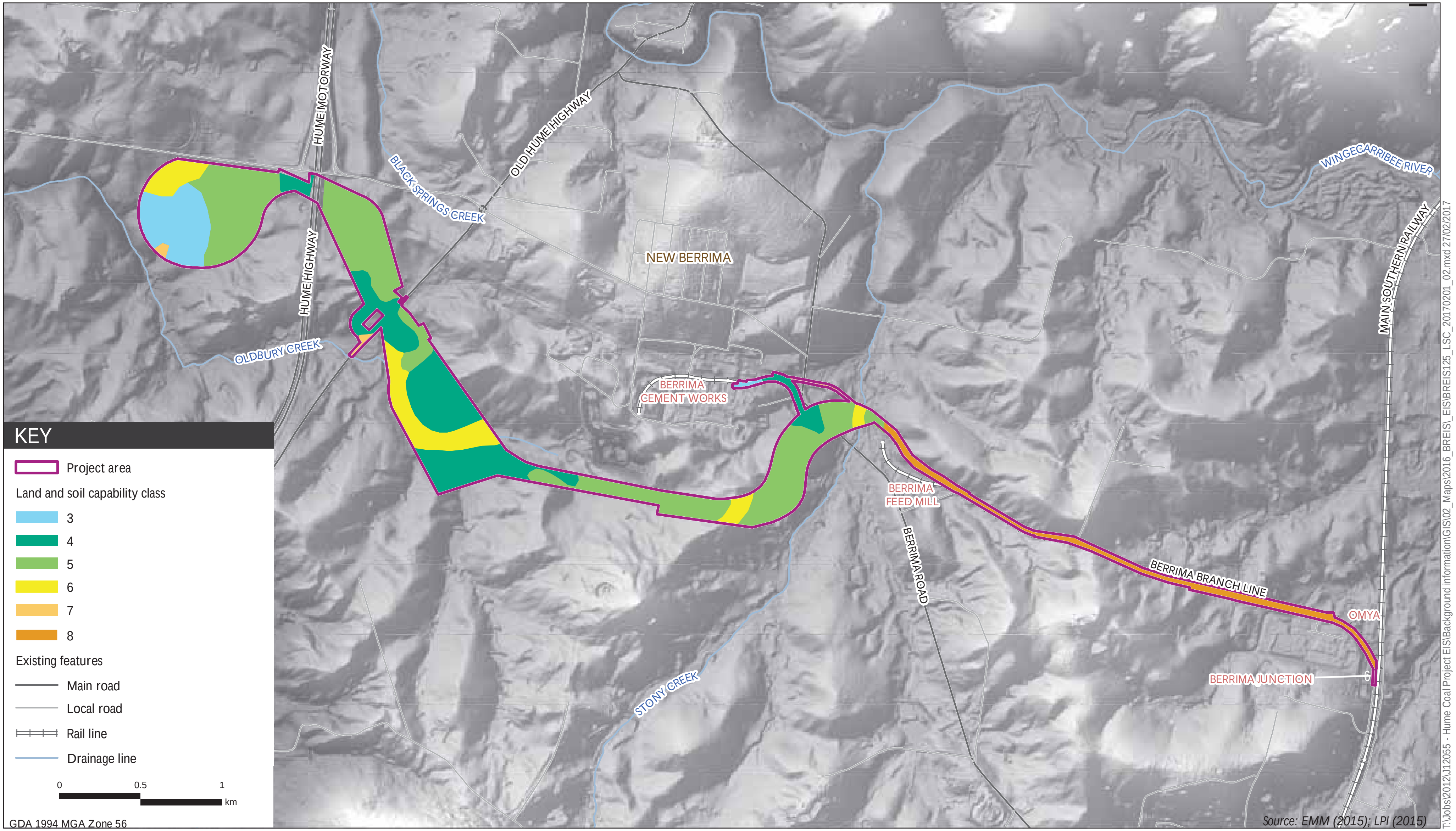
Land use on this soil type within the project area is grazing native and improved pastures. Eutrophic Grey Dermosols appear to be limited to the small, randomly distributed, isolated basalt intrusions. They were not recorded away from these surface geology expressions. Only one small portion of the project area was mapped as this soil type.

Photograph 14.3 Eutrophic Grey Dermosol (site 648)

14.3.4 Land and soil capability assessment

Initially the region and project area were classed as Class 3 and Class 4 in terms of land and soil capability classes (Section 14.3.2ii) (OEH mapping). The survey (ie field testing) concludes that the project area mainly consists of Class 4 (25% of land area) and Class 5 (44% of land area) capability land (Figure 14.6) and, therefore, its agricultural productivity ranges from moderate to moderate-low capability.

These soils are most suited for grazing. Occasional cultivation may be possible land with the implementation of suitable soil conservation measures. Almost half of the sites were poorly drained or waterlogged (13 of the 29 sites). This is consistent with the geological mapping (see Figure 6.3), which maps most of the project area as floodplain deposits of silt and clay.



Land and soil capability of the project area

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Figure 14.6

14.3.5 Agricultural land use – project area

The majority of the project area is currently used for grazing cattle or railway operations.

i Hume Coal owned properties

Mereworth: The Mereworth property comprises approximately 500 ha and is split by the Hume Highway. The majority of the property lies on the western side of the Hume Highway and is the location of the proposed surface infrastructure area. The property comprises pasture for cattle, with some paddocks cultivated for fodder crops.

Stonington: The Stonington property is approximately 122 ha with the entire property currently used as permanent pasture except for the Remembrance Driveway plantings which are excluded from grazing. All grazing paddocks will be converted to improved pasture (ryegrass) in the coming year.

Eastern properties: The Eastern properties are an amalgamation of properties, namely Leets Vale and 325 Berrima Road which is currently used as permanent improved pasture.

ii Other properties

There is some freehold land comprising paddocks of pasture grass surrounding the Berrima Cement Works. Cattle grazing is currently undertaken in some areas (predominantly to the east of the cement works) by agistment.

14.4 Impact assessment

14.4.1 Potential risks to soil resources

i Soil degradation

The soil resources in the project area could be degraded by a number of processes and such degradation could reduce the agricultural potential of the affected land:

- Nutrient decline: a decline in nutrient content could occur while the soil is stored in stockpiles. This could be amended by adding fertilisers to the returned soil (Keipert 2005).
- Structural decline: breakdown of the aggregates (or peds) by compaction from heavy vehicles and machinery.
- Acidification: A gradual increase in acidity of the soil could lead to a decline in pasture growth from long-term application of nitrogenous fertilisers and the increased leaching processes following the loss of deep-rooted vegetation.

ii Loss of soil resource

Up to 84,330 m^3 of topsoil and subsoil will be stripped from the direct disturbance footprint of the project, and stored in stockpiles for later use in rehabilitation. There is a risk that not enough soil will be stripped for effective rehabilitation. Some soil is always lost during handling (ie stripping, stockpiling and spreading), and poor site selection for stockpiles may further decrease the available soil, particularly if the stockpile has to be relocated.

The types and areas of soils to be disturbed are summarised in Table 14.8.

Table 14.8 Area and type of soils disturbed

Soil type	Preferred option		Alternative option	
	Operational footprint (Ha)	Construction footprint (Ha)	Operational footprint (Ha)	Construction footprint (Ha)
Dystrophic Yellow Kandosol	25.45	84.17	24.38	82.18
Kandosolic Redoxic Hydrosol	0.94	3.22	0.68	3.22
Unclassified (assumed Kurosol)	1.72	1.95	0.86	1.69
TOTAL	**28.11**	**89.34**	**25.92**	**87.09**

iii Soil erosion and sediment transport

Erosion results in loss of soil from the landscape leading to deterioration of the land's productive capacity and its capacity to perform ecosystem functions. The potential for soils to erode determines which management measures should be used and whether the soils are appropriate to use for rehabilitation.

The Kandosolic Redoxic Hydrosol soils are sodic and will be highly erosive, and are therefore not recommended to be used in rehabilitation. The Dystrophic Yellow Kandosol soils are slightly sodic and have the potential to be subject to erosion, particularly on a slope.

iv Soil contamination

Small areas of soil contamination could occur from hydrocarbon spills during soil stripping and construction activities; although the likelihood of occurrence is considered to be low in consideration of measures that will be implemented in accordance with the project CEMP.

14.4.2 Post disturbance land use and land capability

Most of the land will be returned to grazing, however the post disturbance LSC (once rehabilitation has been completed) will be reduced across 14% of the project area. This will result in an increase of land classified as Class 7 (14%).

The post-disturbance land capability of the areas of land to be disturbed around the railway line (ie maintenance roads, construction areas, topsoil stockpile areas) should be able to be returned to their original land capability with careful management and improvement of the soil structure and fertility. The area of the railway line itself will be returned to Class 7, based on the projected depth of re-spread topsoil being no deeper than 25cm. Exposed wall cuttings will be Class 8. The Berrima Branch Line will remain in use, and has been calculated as Class 8. Table 14.9 shows the pre-and post-disturbance areas of each LSC class for the preferred and alternative options.

Table 14.9 Land and soil capability classes – post disturbance

Class	Capability	Current area (ha)	Post disturbance (ha)	
			Preferred option	Alternative option
Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)				
1	Extremely high	0	0	0
2	Very high	0	0	0
3	High	17.5	15.3	15.3
Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)				
4	Moderate	44.5	34.4	34.4
5	Moderate–low	79.0	59.9	59.6
Land capable for a limited set of land uses (grazing, forestry and nature conservation)				
6	Low	21.5	19.0	19.0
Land generally incapable of agricultural land use (selective forestry and nature conservation)				
7	Very low	1.2	25.2	25.4
8	Extremely low	17.7	27.6*	27.7*

*Note: *the railway will be on this land and it will not be available for agricultural use.*

14.4.3 Impacts to agricultural land use

The impact to agricultural land use of the proposed railway corridor is limited to the proposed construction footprint. Cattle will be able to cross the railway line at specified access locations. After construction, the area of land impacted will only comprise area of the infrastructure itself (the operational disturbance footprint). The railway corridor does bisect some paddocks; however, the paddocks will still be able to support the current grazing land use, albeit with a slightly reduced number of stock as shown in Table 14.10 and Table 14.11. Most of the site will revert to grazing land after rehabilitation.

Table 14.10 Agricultural impact of proposed works (preferred option)

Property Name	Property Size (ha)	Stocking rate/ha	Operational disturbance footprint (ha)	Impact (No. Stock)	Construction footprint (ha)	Impact (No. Stock)
Mereworth	500	3	10.87	33	43	129
Stonington	122	3.3	6.08	20	12.8	42
Leets Vale	40	3.1	1.08	3	3.9	12
325 Berrima Rd	40	3.1	0.45	1	3.5	11
Other freehold		1	9.62	10	26.14	26
TOTAL			**28.1**	**67**	**89.34**	**220**

Table 14.11 Agricultural impact of proposed works (alternative option)

Property Name	Property Size (ha)	Stocking rate/ha	Operational disturbance footprint (ha)	Impact (No. Stock)	Construction footprint (ha)	Impact (No. Stock)
Mereworth	500	3	10.9	33	43	129
Stonington	122	3.3	6	20	12.8	42
Leets Vale	40	3.1	1	3	3.9	12
325 Berrima Rd	40	3.1	0.55	2	3.5	11
Other freehold		1	7.47	7	24.2	24
TOTAL			**25.92**	**65**	**87.09**	**218**

14.4.4 Difference between the impacts of the two options

There is very little difference between the two options in the impacts to soil resources. The alternative option will result in approximately 2.2 ha less of overall soil disturbance. This equates to 2.2 ha of less land available to agriculture during operations and also during construction for the preferred option, which is a calculated stock number reduction of 1 stock during operation; and about 2 less stock during construction.

14.5 Management and mitigation measures

14.5.1 Measures to prevent loss of soil resource

To mitigate the risk of not enough soil being available for rehabilitation, soil requirements must be accurately determined before construction works begin. The volume of soil required for rehabilitation (84,330 m^3) was calculated using the area estimated for rehabilitation multiplied by the depth of soil required (Table 14.12).

Table 14.12 Depths of topsoil in each section of the project area

Surface disturbance	Topsoil (m)	Subsoil (m)
Section 1 - Railway line (Eastern properties)	0.15	0.15
Section 2 - Railway line (Stonington)	0.2	0.1
Section 3 - Railway line (btw Hume Hwy and Old Hume Hwy)	0.3	0.0
Section 4 - Rail loop area	0.15	0.15

14.5.2 Measures to manage soil erosion and sediment transport

Soil erosion management will be implemented during construction activities, particularly at embankments. Drainage structures have been designed for the railway line and associated infrastructure to manage water runoff for the life of the operations (see Chapter 13). Sediment control measures, including but not limited to silt fences, will also be used during construction (also described in Chapter 13).

To minimise the risk of loss from wind and water erosion to stockpiled topsoil, a vegetative cover will be established. Stockpiles will also be located where they are not exposed to overland or flood flow.

Soil may erode after the topsoil has been spread on the rehabilitated areas. Soil erosion and sediment control will be considered where there could be impacts to waterways, as well as impacts to the rehabilitation itself.

14.5.3 Measures to prevent soil contamination

Hydrocarbon management practices will be implemented to prevent hydrocarbon spills during construction activities (eg. re-fuelling, maintenance, hydrocarbon storage) and spill containment materials will be available to clean-up any spills if they occur. If hydrocarbons are spilled during soil stripping, the impact will be isolated and clean-up procedures will mitigate any impacts from the spill.

Construction materials, such as ballast aggregate materials and sub-ballast capping material will generally be sourced off-site. Any material brought onto site will need to be clean and contaminant-free.

14.5.4 Measures to minimise soil degradation

The Soil and Water Management component of the CEMP will contain the following management measures to minimise structural decline of disturbed soils.

i Topsoil stripping procedure

The area to be stripped will be clearly defined on the ground, avoiding any waterlogged or similarly constrained areas. The target depths of topsoil and subsoil to be stripped for each location will be clearly communicated to machinery operators and supervisors.

- Machinery haulage circuits will be located to minimise the compaction of the stockpiled soil.
- Soil stockpile locations will be identified during planning and will be stripped of topsoil before they are stockpiled.
- Topsoil and subsoil will be stripped to the required depths as nominated in this assessment and then stockpiled. Subsoil will be stripped and stockpiled separately where identified as suitable. Depending on compaction and recovery rates, deep ripping may be required to maximise topsoil recovery. Where soils are shallower, topsoil and subsoils will be stripped and stockpiled together.
- Handling and rehandling of stripped topsoil will be minimised as far as practicable by progressively stripping vegetation and soil only as needed for development activities.
- Soil stripping in very wet conditions will be avoided if practicable. Soils will be stripped when they are slightly moisture conditioned.
- To avoid dust hazards, stripping of soil during particularly dry conditions will be avoided where possible.

ii Topsoil stockpile management

- Stockpiles will be located at appropriate distances from water courses and dams.
- Topsoil stockpiles will generally not be higher than 3 m.
- Subsoil stockpiles can be designed to be over 3 m high; however, will have an embankment slope grade suitable to limit erosion potential.

- The surface of the soil stockpiles should be left in a 'rough' condition. If required, sediment controls will be installed downstream of stockpile areas to collect any runoff.

- Overland water flow onto or across stockpile sites will be prevented.

- Stockpiles will be seeded with an appropriate grass mixture to stabilise the surface, restrict dust generation, minimise erosion and weed growth.

- After the stockpiles are established, machinery and vehicles will be excluded for general access (stockpile maintenance works excepted). The location will be marked on site maps to protect the stockpiles from future disturbance.

- The stockpile locations will be surveyed and data recorded about the soil types and volumes present.

- The establishment of weeds on the stockpiles will be monitored and control programs implemented as required.

iii Topsoil application procedure

The topsoil application procedure will essentially be the reverse of the stripping procedure. It will be designed to minimise any degradation of soil characteristics, consistent with industry leading practice.

Generally, all soils will be applied 0.2–0.3 m thick so they are deep enough for ripping and plant growth.

The rehabilitation strategy will include the following measures:

1. A soil balance plan will be prepared before the topsoil is spread, which shows the depths and volume of soils to be reapplied in particular areas. The plan will take account of the relative erodibility of the soils, with more erodible material being placed on flatter areas to minimise the potential for erosion.

2. When the area to be rehabilitated has been re-profiled and/or deep ripped, the subsoil will be spread onto the site, followed by the topsoil (or all at once if not stripped and stored separately).

3. Soil will be respread in even layers at a thickness appropriate for the land capability of the area to be rehabilitated.

4. Soils will be contour ripped to encourage rainfall infiltration and minimise run-off.

5. As soon as practicable after respreading, pasture grasses will be seeded.

6. Erosion and sediment controls will be implemented where deemed necessary prior to vegetation establishment.

14.5.5 Measures to mitigate impacts to agricultural land use

The alignment of the rail infrastructure has considered the impacts of segmenting paddocks and excluding access to land parcels. Where possible, the alignment has minimised the potential impact of reducing the viability of agricultural production in those areas. Livestock access areas will be created to cross the line.

14.5.6 Rehabilitation

The rail infrastructure will remain for the duration of the project. Therefore there is limited opportunity for direct-return of topsoil to rehabilitation. During rehabilitation the rail infrastructure will be dismantled and removed. Some re-profiling of steep slopes formed by embankments along the railway line may be required, and the surface material will be deep ripped and covered with topsoil and seeded with pasture species and returned to grazing pasture. See Chapter 2, Section 2.6 for additional rehabilitation management details, including completion criteria.

14.5.7 Operational monitoring and maintenance

During the life of the project the following parameters will be monitored, and will be included in the CEMP:

- erosion and sediment control;
- vegetation cover on topsoil piles; and
- weed species alongside the railway lines.

14.5.8 Contingency measures

If the topsoil stripping procedure is carried out as currently proposed, no contingency measures should be needed. However, if there is not enough topsoil available at the time of rehabilitation, or if the topsoil material has been degraded, the following contingency measures will be implemented:

- Topsoil will be spread at a shallower thickness and/or only on selected parts of the site.
- Fertilisers and other soil additives will be added to the topsoil and subsoil to improve fertility and structure.

14.6 Conclusion

The project could result in degradation of soils, a degrading of the LSCs in the project area and a reduction in paddock size and stocking capacity. Soil stripping, soil stockpiling and erosion and sediment control procedures will be implemented to prevent soil degradation. The rehabilitation strategy is designed to return much of the project area to the pre-disturbance LSCs. However, the LSCs will be degraded across 14% of the project area which will result in an increase of Class 7 land. The reduction in paddock size and stocking capacity as a result of the project will be minimal; during construction it will be reduced by 9-10% for each property, which reduces to 5% or less during operations. The impacts of segmenting paddocks and excluding access to land parcels will be minimised by creating access areas to move from one side of the track to the other in areas where livestock cannot roam freely (steep cuttings or embankments).

15 Visual amenity

15.1 Introduction

This chapter investigates the potential impacts on visual amenity as a result of the project. The assessment describes the:

- visual impact methodology used in the visual assessment;
- existing landscape within which the project will be sited;
- character of the visual components of the project and the staging of project development;
- impacts of the project from representative viewpoints in and around the project area; and
- measures to mitigate visual impacts of the project.

This visual impact assessment (VIA) has been prepared following the appropriate guidelines, policies and industry requirements. The VIA was prepared with regard to industry standards included within the *Guidelines for Landscape and Visual Impact Assessment* (GLVIA) Third Edition (2013) prepared by the Landscape Institute and Institute of Environmental Management and Assessment as there are no Federal, NSW Government or Local Government Authority planning policies, guidelines or standards policies applicable to this assessment.

15.2 Assessment method

15.2.1 Overview

The assessment involved the following stages:

Stage 1: View type and context – the existing landscape baseline is described noting its character and complexity;

Stage 2: Visibility baseline assessment – the zone of visual influence of the project is established, where appropriate, the use of computer generated zones of theoretical visibility, based on topographical data, or through fieldwork analysis. This establishes the locations where views of the project may be possible. Fieldwork to establish the types and locations of receptors within this theoretical zone;

Stage 3: Viewpoint and photomontage selection – key public and private viewpoints of the project area are selected and the project's level of exposure to them is determined;

Stage 4: Magnitude of change - the magnitude of visual change and the changes arising from the project are assessed and the need for project modifications or other mitigation measures evaluated;

Stage 5: Visual sensitivity – the capacity of the landscape to absorb change without a loss of quality (its visual sensitivity) is determined;

Stage 6: Evaluation of significance – the significance of change in the landscape is a function of the magnitude of change when considered against the view type/context and the sensitivity of a receptor (see below for further detail); and

Stage 7: Mitigation – the modified and mitigated project (if applicable) is assessed and final visual impacts are described and illustrated and their significance documented.

The significance of a change in the landscape is a function of the magnitude of that change when considered against the view type/context and the sensitivity of a receptor. Typically, a noticeable change in the landscape in an unmodified rural or natural setting would be considered to be significant, whereas a change in an already heavily modified landscape could be considered slight or moderate.

Table 15.1 illustrates how the magnitude of a change in the landscape is assessed, and its significance rated against the sensitivity of a receptor.

Table 15.1 Evaluation of significance matrix

Magnitude of change	Visual sensitivity		
	High	**Moderate**	**Low**
High	Substantial	Moderate/ Substantial	Moderate
Medium	Moderate/ Substantial	Moderate	Slight/ Moderate
Low	Moderate	Slight/ Moderate	Slight
Negligible	Slight	Slight	Negligible
Key:	Significant (red)	Not significant (green)	

The primary assessment tools for determining the significance of impact were the site inspections, and photographs of the views from the selected viewpoints to determine the level of change to assess visual impacts, taking into consideration the nature of the landscape, topography, the distance between the viewpoint and the proposed installation, as well as the type of view experienced.

15.3 Existing environment

The land use within the project area where the rail loop and new rail line will be constructed is improved pasture for grazing, with a number of roads traversing the area. The wider region has a mixed character, consisting of grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns, and some extractive, as well as other industries and major infrastructure. Photographs 15.1 to 15.3 illustrate the project area and surrounds.

Photograph 15.1 View from Medway Road looking south-east across the northern portion of the proposed rail loop location

Photograph 15.2 **View from the embankment on the western side of the Hume Highway looking south-west across the location of the northern half of the rail loop**

Photograph 15.3 View on the eastern side of the Hume Highway from Medway Road looking south-west towards the location of the new rail line and maintenance facility

With the exception of the Berrima Branch Line, the main land uses adjacent to the project corridor are currently agricultural, industrial, and rural residential.The proposed rail line will be alongside the operational Berrima Cement Works, which includes a quarry. Other industrial businesses (such as the feedmill, pipe manufacturer and hot water heater manufacturer) are also adjacent to the rail line.

The road network in and around the project area consists of a range of roadways. The Hume Highway runs north-south through the project area.

On the western side of the Hume Highway, the project area has frontage to Medway Road along its northern boundary. On the eastern side of the Hume Highway the new rail line crosses the Old Hume Highway and finishes at Berrima Road.

15.4 Visible project components

The project is described in detail in Chapter 2. The project elements that could be visible to external viewers are:

- 8.2 km of new railway track, or 7.6 km if the alternative option is constructed;
- a number of road and creek crossings, including:
  - a grade separated crossing over Berrima Road and a new rail siding into the Berrima Cement Works, with the rail line passing over the road (the preferred option) or;
  - if Berrima Road is relocated by WSC, the road will be constructed so that the rail line passes under the road (alternative option),
  - the existing rail bridge over Stony Creek will be decommissioned and a new bridge and culvert will be constructed to accommodate the new rail line; and
  - a bridge will be constructed over the Old Hume Highway to allow crossing of the rail line over the highway.
- Rail Maintenance Facility adjacent to the new rail line comprisinga 6-8 m high shed, as well as a shed at the northern provisioning point;
- an approximately 950 m long and 4 m high noise wall (relative to the height of the railway track); and
- topsoil stockpiles adjoining the railway line approximately 3 m in height.

15.4.1 Train movements

When undertaking a VIA of the project, it is important to consider the number of train movements per day. The visual impact of trains is a temporary change to a view, with trains not generally being stationary in one location along the track, except during coal loading activities.

The transport of product coal from Hume Coal will require approximately 50 train movements per week along the new rail spur. There will be approximately 120 weekly train movements (60 trains each way) associated with the existing users of the Berrima Branch Line, therefore, with the Berrima Rail Project in operation the total weekly movements along the Berrima Branch Line will be approximately 170.

15.5 Viewpoint assessment

15.5.1 Viewpoint selection

Representative viewing locations or 'viewpoints' were selected as part of the field assessment (26 May 2016). These viewpoints were selected through a detailed analysis of aerial photography and topographic plans.

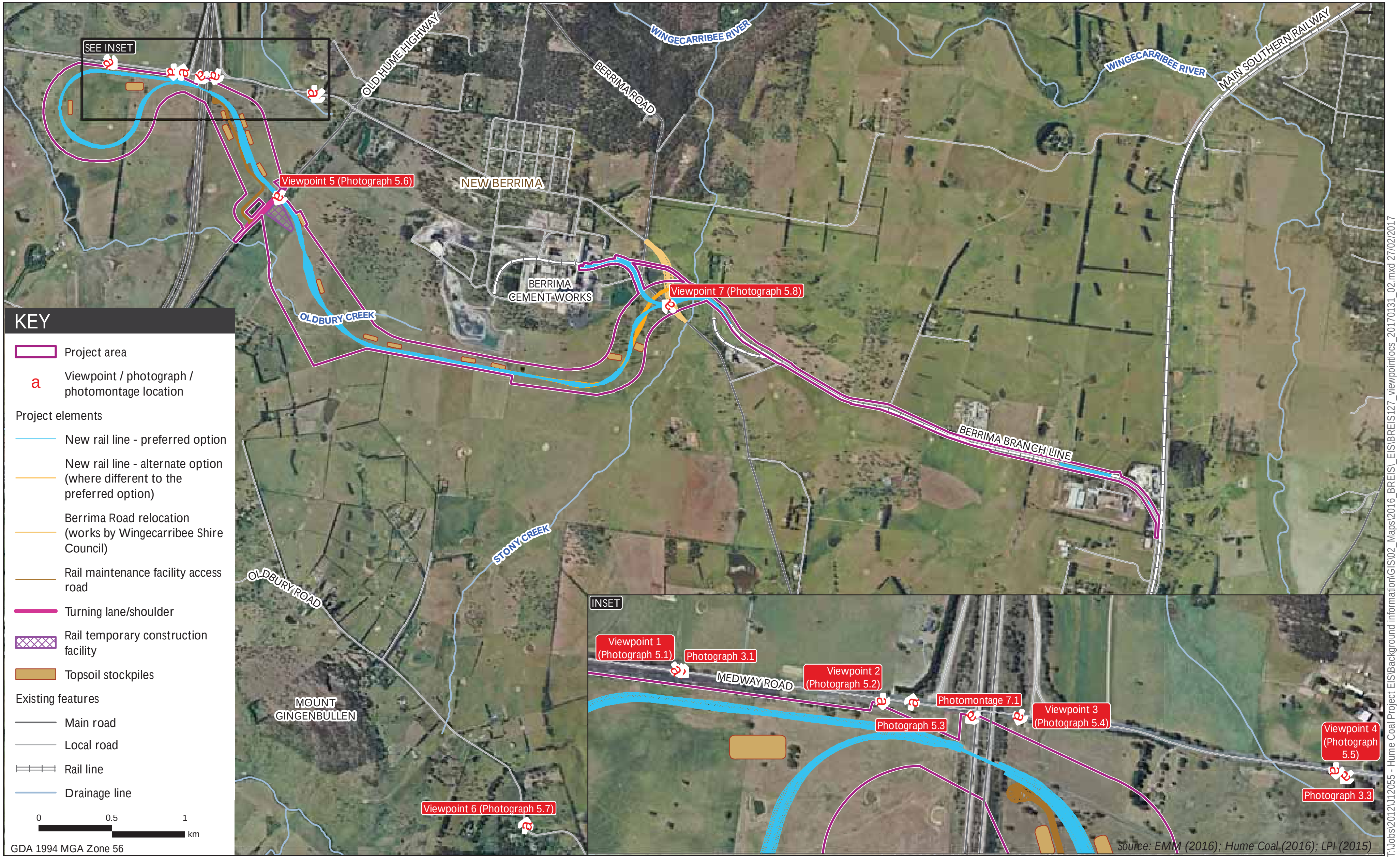
The viewpoints assessed are as follows:

- viewpoint 1 – from Medway road, looking south-east towards the location of the rail loop;
- viewpoint 2 – from Medway road (further east than viewpoint 1, closer to the Hume Highway), looking south towards the location of the rail loop;
- viewpoint 3 – northern side of Medway Road (east of Hume Highway) looking south west towards the Hume Highway underpass;
- viewpoint 4 – view from Medway Road (east of Highway) looking south-west towards rail maintenance facility and railway line;
- viewpoint 5 – view looking south-west along the Old Hume Highway towards proposed rail crossing location;
- viewpoint 6 – view looking north from Oldbury Road; and
- viewpoint 7 – view looking along Berrima Road north-west towards the Berrima Road bridge crossing associated with the preferred option.

Each of the seven viewpoints is illustrated in Figure 15.1.

15.5.2 Viewpoint analysis

Photographs 15.4-15.11 and Tables 15.2-15.7 provide an overview of each viewpoint and includes an assessment of these viewpoints in accordance with the method outlined in Section 2.2 of the VIA (see Appendix M).



Viewpoint, photograph and photomontage locations

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Figure 15.1