6. Hydraulic modelling results and impact assessment

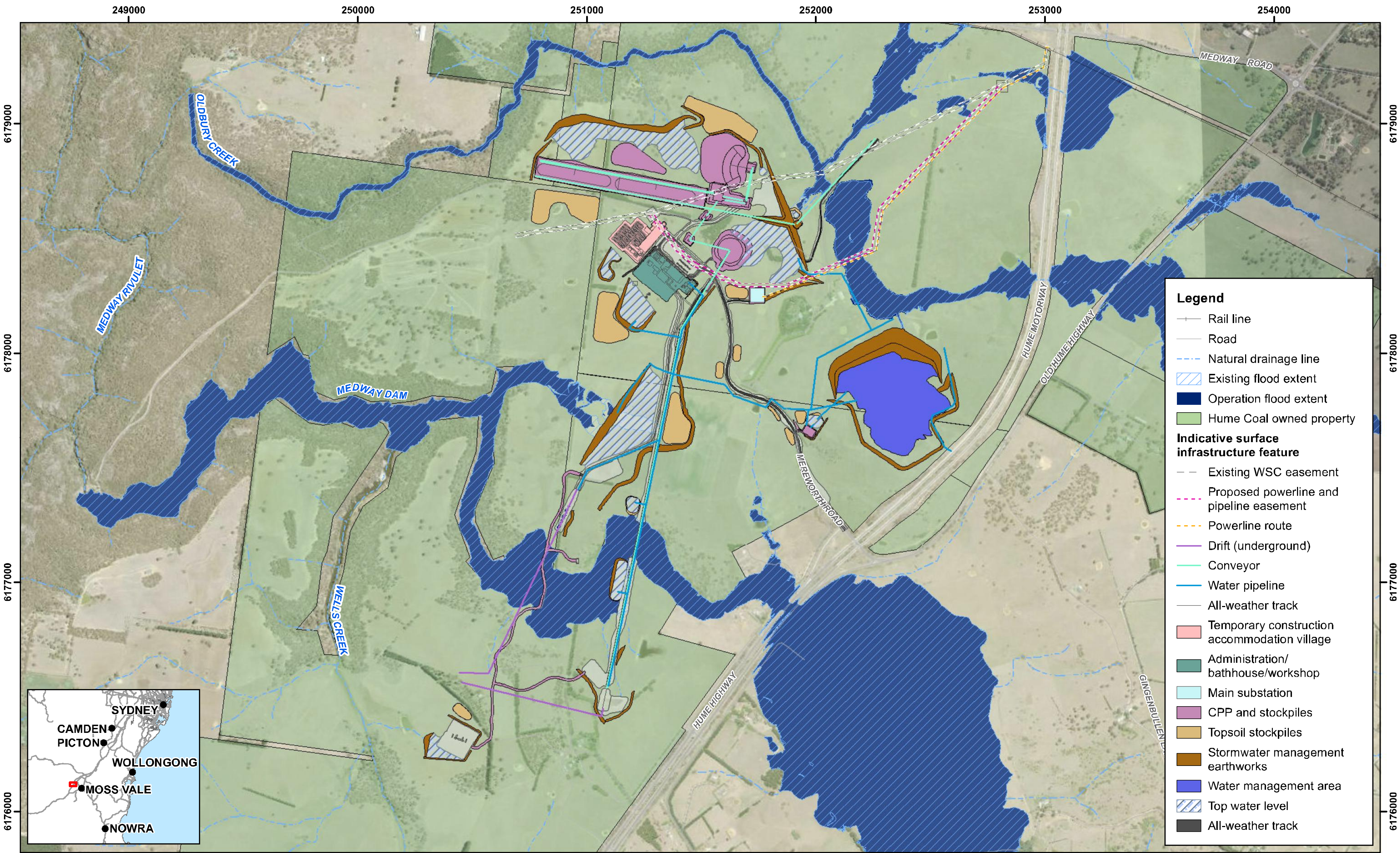
6.1 Hume Coal Project results and impact assessment

6.1.1 Flood extent

Figure 6.1 presents a comparison of the 100 year ARI flood extent for the existing and operation scenarios. Figures comparing the 5 year and 20 year ARI and PMF extents for the existing and operation scenarios are presented in Appendix D.

Figure 6.2 presents a comparison of the 100 year ARI flood extent for the existing and rehabilitation scenarios. Figures comparing the 5 year and 20 year ARI and PMF extents for the existing and rehabilitation scenarios are presented in Appendix E.

Comparison of the 100 year ARI flood extents shows that changes in flood extent during operation of the mine will be minor. Changes in flood extent following rehabilitation of the mine are only predicted in the area where SB02 was located.



Map: 2200540A_GIS_019_B4	Author: RP
Date: 14/11/2016	Approved by: LR

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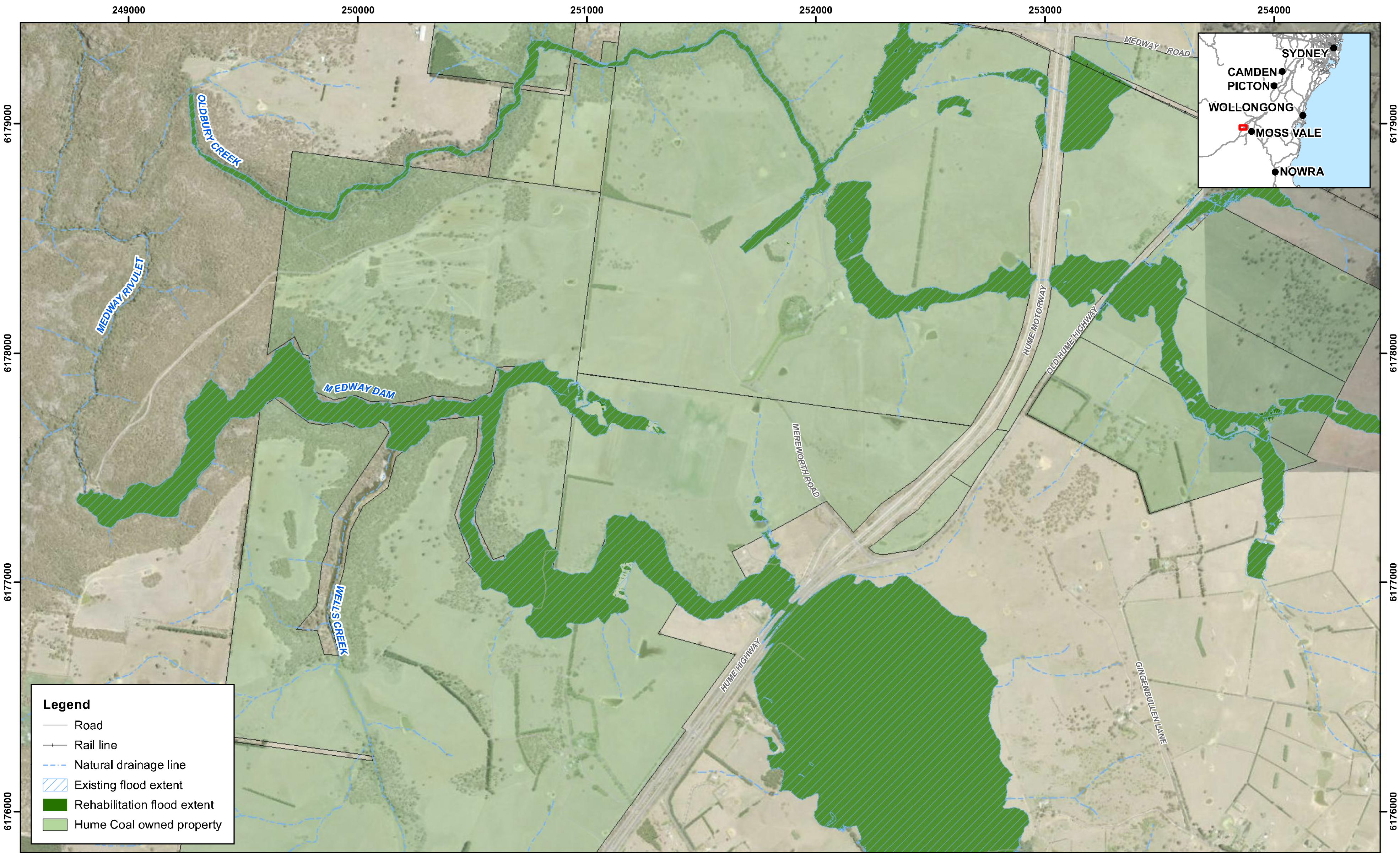
Hume Coal Flooding Assessment
Figure 6.1
100 year ARI flood extent - Operation



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Hume Coal Flooding Assessment

Figure 6.2

100 year ARI flood extent - Rehabilitation

6.1.2 Flood levels

Afflux results for the operation and rehabilitation cases for Medway Rivulet and Oldbury Creek are presented in Table 6.1 and Table 6.2 respectively. The results are the difference between the flood levels under the operational or rehabilitation and existing conditions. A positive afflux value indicates an increase in flood level and a negative afflux value indicates a decrease in flood level. During operation, decreases in flood level occur as the project reduces flows to the creeks due to reductions in the undisturbed catchments in areas taken up by the stormwater basins and mine water dams, which are designed to contain runoff and not spill to the receiving environment. Results are presented for the cross-sections shown on Figure 5.1 and Figure 5.2. The result 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.

Table 6.1 and Table 6.2 show the afflux is within the proposed acceptability criteria set out in Section 2.2, with the exception of localised afflux values of up to 340mm in Oldbury Creek on land owned by Hume Coal between the PWD and SB02 for the operational case.

For the rehabilitation scenario the impacts on Oldbury Creek are negligible on land outside of Hume Coal's ownership. The impact noted above between the PWD and SB02 occurs over a reduced extent of the creek at the rehabilitation stage but a localised afflux impact of up to 400 mm remains at the downstream embankment of the inline storages on Oldbury Creek.

Table 6.1 Medway Rivulet catchment 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)
40.37	Tributary OF1	Private land	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
77.79	Tributary OF2	US Medway Dam	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
200.76	Wells Creek	US Medway Dam	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
204.9	Tributary OF1	Private land	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
341.85	Tributary OF1	Private land	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
390.56	Tributary OF2	US Medway Dam	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00
711.48	Medway Rivulet	Medway Dam	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
1105.5	Medway Rivulet	Medway Dam	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00
1323.85	Medway Rivulet	Medway Dam	0.00	0.00	-0.01	-0.02	0.00	0.00	0.00	0.00
1677.1	Medway Rivulet	Medway Dam	-0.01	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
1925.81	Medway Rivulet	Medway Dam	0.00	0.00	-0.01	-0.02	0.00	0.00	0.00	0.00
2589.74	Medway Rivulet	Medway Dam	0.00	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
3091.73	Medway Rivulet	Private land	0.00	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00
3189.74	Medway Rivulet	Road crossing	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
3266.68	Medway Rivulet	Private land	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00
3569.79	Medway Rivulet	Private land	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
3689.74	Medway Rivulet	Private land	-0.01	-0.01	-0.01	0.01	0.00	0.00	0.00	0.00
3789.74	Medway Rivulet	Private land	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
3893.8	Medway Rivulet	Conveyor gantry	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00

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)
3989.74	Medway Rivulet	Private land	-0.01	-0.01	-0.01	0.01	0.00	0.00	0.00	0.00
4275.32	Medway Rivulet	Private land	-0.01	-0.01	0.00	0.01	0.00	0.00	0.00	0.00
4379.21	Medway Rivulet	Private land	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
4489.74	Medway Rivulet	Private land	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
4783.88	Medway Rivulet	Private land	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
4831.3	Medway Rivulet	DS Hume Hwy	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
4901.7	Medway Rivulet	US Hume Hwy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5201.84	Medway Rivulet	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5462.31	Medway Rivulet	Private land	0.00	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
5864.6	Medway Rivulet	Private land	0.00	0.00	-0.01	0.01	0.00	0.00	0.00	0.00
7383.57	Medway Rivulet	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7962.88	Medway Rivulet	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: US = upstream; DS = downstream; Hwy = Highway

Table 6.2 Oldbury Creek catchment 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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
306.77	Catchment tributary 2	DS Medway Road	0.00	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
347.57	Tributary 2b	US Medway Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
350	Branch	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
371.34	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	0.02	0.05	0.03	0.35	0.00	0.00	0.00	0.00
533.19	Branch	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
543.84	Tributary T1	Old Hume Hwy	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
606.67	Tributary T1	Private land and Old Hume Hwy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
647.53	Oldbury Creek	Private land	0.02	0.03	0.05	0.22	0.00	0.00	0.00	0.00
750	Branch	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
773.14	Tributary T1	Private land	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1073.16	Tributary T1	Private land	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
1194.89	Tributary 2	DS Hume Hwy	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
1260	Tributary 2	US Hume Hwy	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
2741.84	Oldbury Creek	Private land	0.03	0.04	0.05	0.12	0.00	0.00	0.00	0.00
2819.73	Oldbury Creek	Private land	0.01	0.04	0.06	0.18	0.00	0.00	0.00	0.00

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)
2928.8	Oldbury Creek	Private land	-0.03	0.00	0.01	0.19	0.00	0.00	0.00	0.00
3007.9	Oldbury Creek	Private land	-0.05	-0.06	-0.08	-0.01	0.00	0.00	0.00	0.00
4288.37	Oldbury Creek	Embankment DS inline storage	0.34	0.31	0.28	0.00	0.39	0.37	0.34	0.10
4390.64	Oldbury Creek	Embankment US inline storage	0.21	0.21	0.19	0.16	0.00	0.00	0.00	0.00
4611.83	Oldbury Creek	US inline storage	0.21	0.21	0.19	0.15	0.00	0.00	0.00	0.00
4641.08	Oldbury Creek	US inline storage	0.19	0.18	0.18	0.00	0.00	0.00	0.00	0.00
5624.5	Oldbury Creek	DS Hume Hwy	0.00	0.00	-0.01	0.03	0.00	0.00	0.00	0.00
5691.94	Oldbury Creek	US Hume Hwy	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
5980	Oldbury Creek	DS Old Hume Hwy	0.00	0.00	-0.03	0.03	0.00	0.00	0.00	0.00
6024.59	Oldbury Creek	US Old Hume Hwy	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
7401.61	Oldbury Creek	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7696.2	Oldbury Creek	Private land	0.00	-0.01	0.00	-0.08	0.00	0.00	0.00	0.00
7907.82	Oldbury Creek	Private land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8234.11	Oldbury Creek	Private land	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00

Notes: US = upstream; DS = downstream; Hwy = Highway

6.1.3 Peak velocities

Infrastructure crossing streams, including bridges and culverts, have the potential to change the velocity of streamflow local to the infrastructure. An increase in the velocity of streamflow can cause erosion and scour of bed sediments and impact on surface water quality and the stability of instream structures.

Peak velocities downstream of new infrastructure crossing streams in the study area are presented in Table 6.3. Peak velocities are presented for the following new infrastructure:

- The conveyor crossing Medway Rivulet to transport coal from the conveyor drift to the AWA precinct.
- The road crossing Medway Rivulet to provide access between the conveyor drift and ventilation shaft and the AWA precinct, which includes 17 box culverts.
- The embankment at the downstream end of the inline storages on Oldbury Creek which will be raised and used to provide access between the CPP precinct and the train load out facility. The embankment will have an access road, a conveyor to transport coal and poles for electricity lines.

The project will not include any structures that pose significant obstruction to or constriction of flood flows. Peak velocities are expected to increase immediately downstream of the conveyor piers and box culverts and scour protection measures will need to be designed as part of the detailed civil works design.

The peak velocities reported in Table 6.3 are for cross-sections located immediately downstream of the new infrastructure. The results show that the impact on velocity at these downstream locations during operation is minor, with changes in velocity in the range +/- 0.3 m/s.

In the rehabilitation case the infrastructure will be removed and the ground levels around crossing structures will be restored to existing levels which will restore the existing conditions velocity regimes.

Table 6.3 Peak velocities at new infrastructure

Cross-section	Stream	Infrastructure	Cross-section distance downstream from infrastructure (m)	5-year			20-year			100-year			PMF		
				Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff
3789.74	MR	Conveyor gantry	0	0.48	0.44	-0.04	0.52	0.48	-0.02	0.58	0.54	-0.04	0.58	0.54	-0.04
3189.74	MR	Road crossing with 17 x 1800 mm x 1200 mm RCBC	0	0.37	0.48	0.11	0.40	0.50	0.10	0.43	0.52	0.09	0.64	0.75	0.11
4288.37	OC	Embankment inline storage	12	1.05	0.73	-0.32	1.09	0.84	-0.25	1.12	0.94	-0.18	1.35	1.51	0.16
4611.83	OC	Embankment inline storage	0.5	0.21	0.18	-0.03	0.28	0.24	-0.04	0.35	0.31	-0.04	1.65	1.56	-0.09

Notes: Ex = existing; Op = operation; Diff = difference; MR = Medway Rivulet; OC = Oldbury Creek

6.2 Cumulative results and impact assessment

The cumulative impacts of the Hume Coal Project and Berrima Rail Project were assessed in the Oldbury Creek catchment where infrastructure from both projects is located. The Berrima Rail Project has preferred and alternate options; however, there is no difference between these options in the Oldbury Creek catchment – refer to the Berrima Rail EIS (EMM 2016b) Chapter 14 for further details.

The Oldbury Creek hydrologic model (refer Section 4) was used to generate peak flows for the cumulative Oldbury Creek HEC-RAS model.

The Oldbury Creek HEC-RAS model, as described in Section 5, was revised to include cross-sections targeting key infrastructure for both the project and Berrima Rail Project during operation and rehabilitation. The cumulative Oldbury Creek HEC-RAS model cross-sections are shown on Figure 6.3.

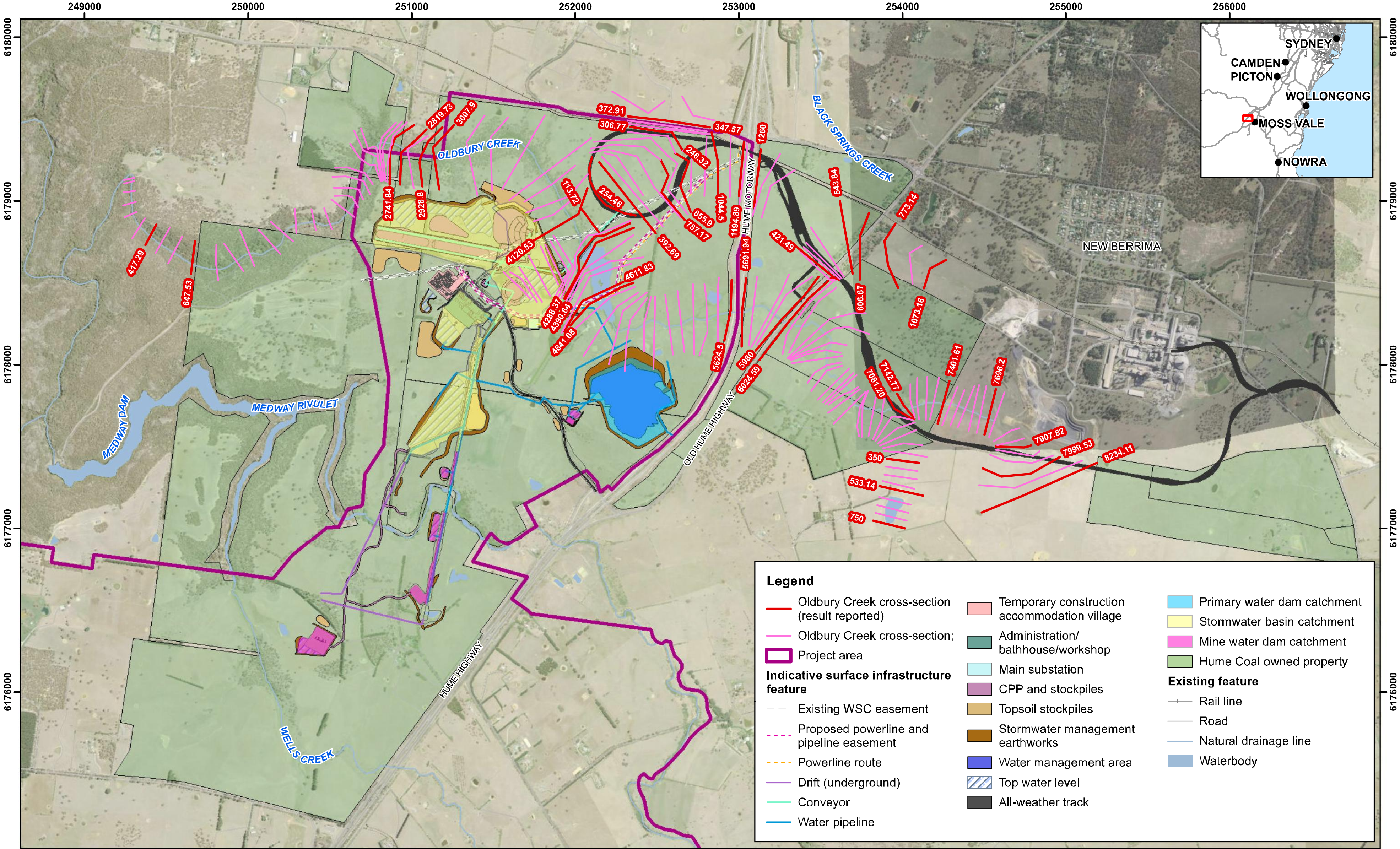
The cumulative Oldbury Creek HEC-RAS model was run for the 5 year, 20 year, 100 year ARI and PMF events for the following scenarios:

- The cumulative operation scenario, which incorporates the proposed surface infrastructure for the Hume Coal Project and the proposed infrastructure for the Berrima Rail Project.
- The cumulative rehabilitation scenario, which incorporates the proposed final landform at completion of the Hume Coal Project and the Berrima Rail Project.

Additional proposed structures were included in the cumulative Oldbury Creek HEC-RAS model. The proposed structures are described in Table 6.4.

Table 6.4 Proposed structures for the cumulative operation scenario

Waterway	Crossing type and location	Design option	Mitigation measure
Tributary of Oldbury Creek	Culverts on south eastern side of rail loop	Berrima Rail Project	2 x 1400 mm diameter pipe
Oldbury Creek	Culverts to the east of Old Hume Highway	Berrima Rail Project	5 x 2000 mm x 2000 mm RCBC
Drainage depression alongside Hume Highway	Culverts immediately east of Old Hume Highway	Berrima Rail Project	4 x 1800 mm x 900 mm RCBC
Overland flow path (flowing to tributary of Oldbury Creek)	Culvert on eastern side of rail loop	Berrima Rail Project	1400 mm diameter pipe
Oldbury Creek	Culverts to the south east of Berrima Cement Works	Berrima Rail Project	5 x 2000 mm x 1200 mm RCBC



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Date: 14/11/2016	Approved by: LR

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

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Hume Coal Flooding Assessment
Figure 6.3
Cumulative Oldbury Creek model cross-sections

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6.2.1 Cumulative flood extent

Figure 6.4 presents a comparison of the cumulative 100 year ARI flood extent for the existing and operation scenarios. Figures comparing the cumulative 5 year and 20 year ARI and PMF extents for the existing and operation scenarios are presented in Appendix F.

Figure 6.5 presents a comparison of the cumulative 100 year ARI flood extent for the existing and rehabilitation scenarios. Figures comparing the cumulative 5 year and 20 year ARI and PMF extents for the existing and rehabilitation scenarios are presented in Appendix G.

Comparison of the 100 year ARI flood extents shows that changes in flood extent during operation 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.

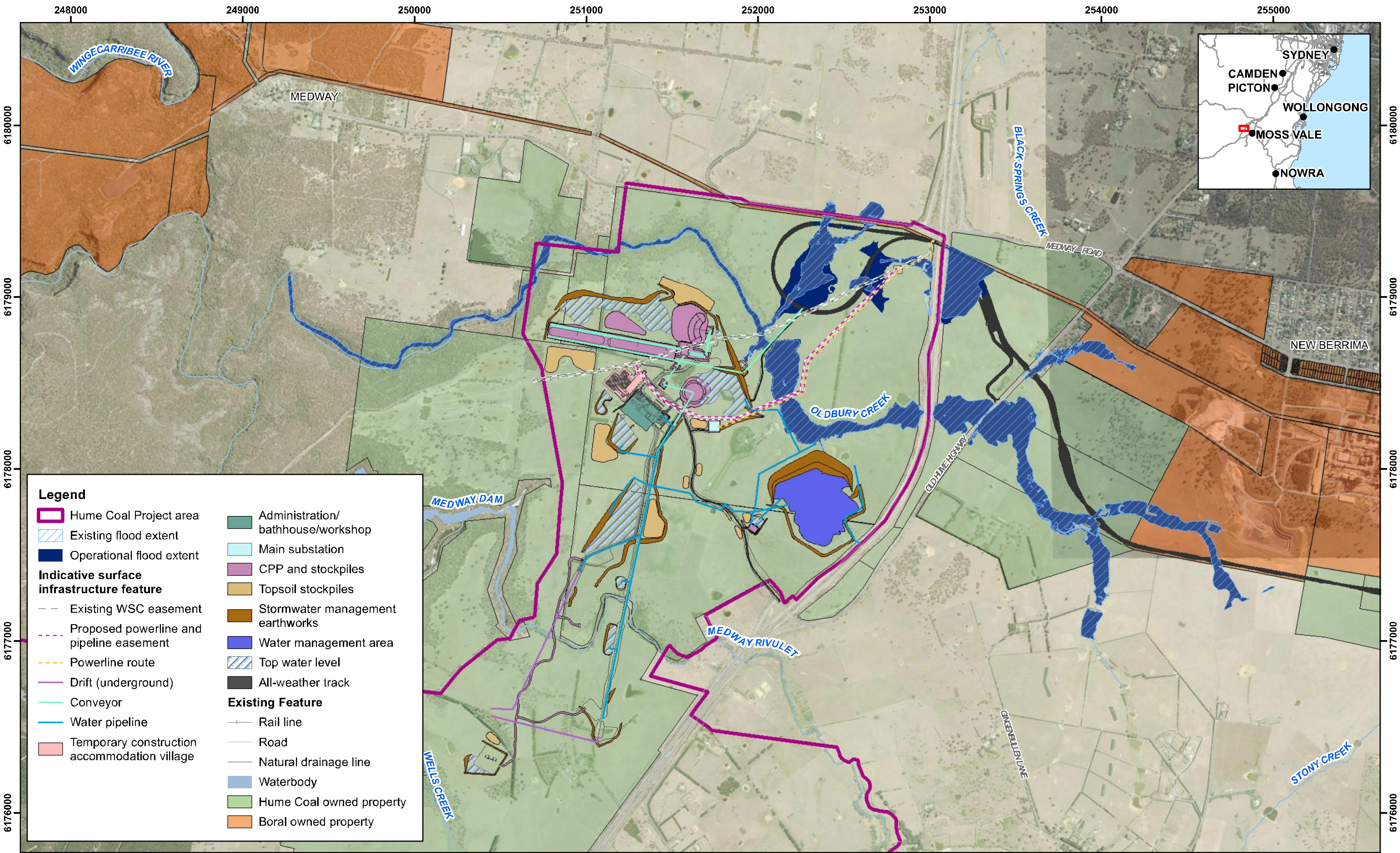
The changes in flood extent all occur on land owned by Hume Coal or Boral. The increased flood extent upstream of the Hume Highway is minor.

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.

The high order flood event behaviour will change within the rail loop in the area containing the colony of Paddy’s River Box trees. Refer to the Hume Coal EIS Ecology Report (EMM 2016c) for discussion on the impact of flow / flood regime changes on these trees.

As shown in Figure 6.5, once the 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.

The impacts around the rail loop, the Hume Highway and around Berrima Cement Works are all impacts related to the rail infrastructure only. Impacts downstream in the vicinity of the Hume Coal Project do not contribute to these. Similarly, localised impacts on flooding caused by the Hume Coal Project do not contribute to these areas upstream that are affected by the rail infrastructure. Therefore, there is no cumulative impact of both projects on flooding in Oldbury Creek. Further details of the flooding impacts of the Berrima Rail Project are addressed in the Berrima Rail Project EIS.



Map: 2200540A_GIS_039_A5	Author: RP
Date: 14/11/2016	Approved by: LR

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

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Coordinate system: GDA 1994 MGA Zone 56

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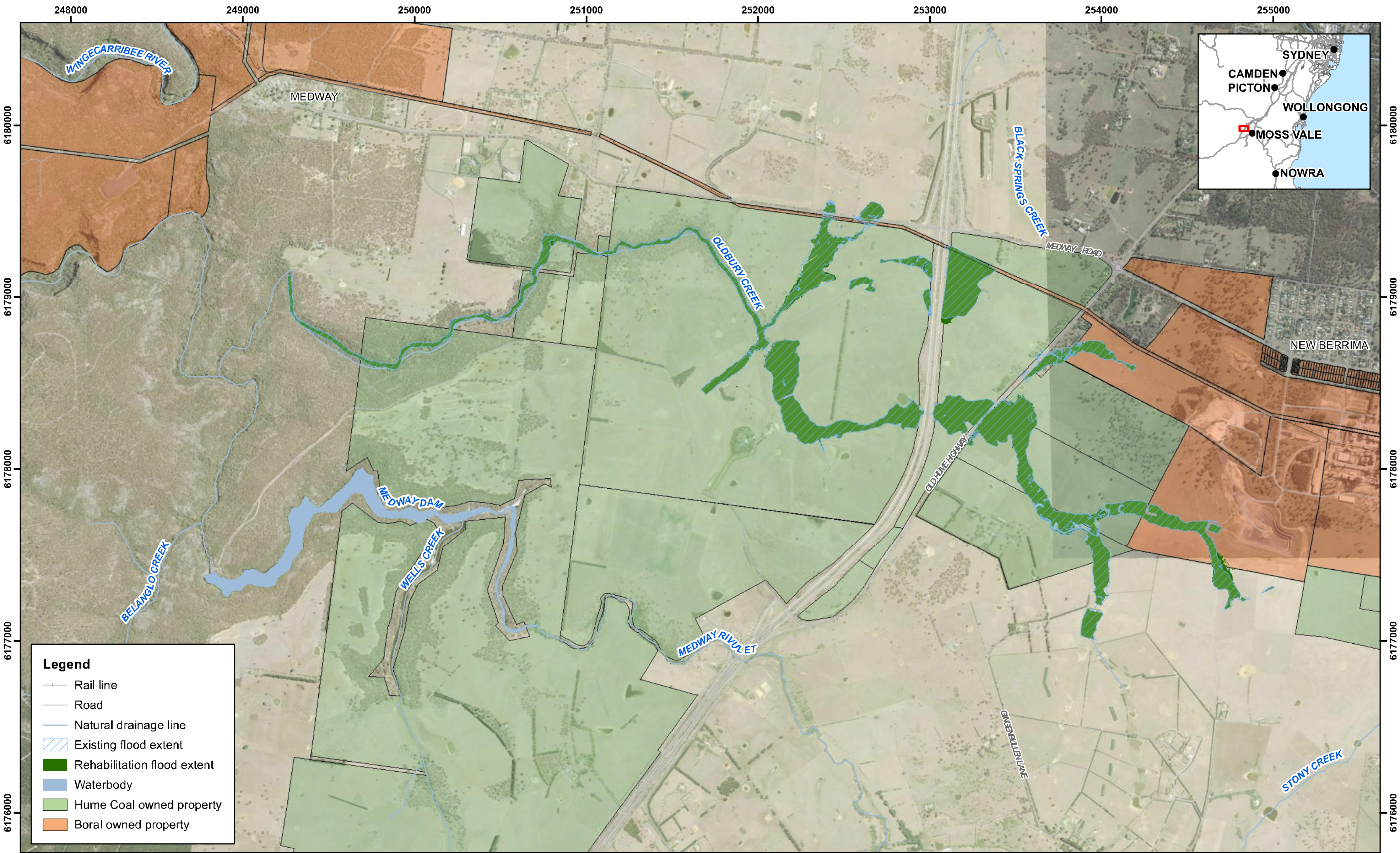
Hume Coal Flooding Assessment

Figure 6.4

Cumulative 100 Year ARI flood extent - Operation



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Hume Coal Flooding Assessment

Figure 6.5

Cumulative 100 Year ARI flood extent - Rehabilitation

6.2.2 Cumulative flood levels

Cumulative afflux results for the operation and rehabilitation cases for Oldbury Creek are presented in Table 6.5 for the cross-sections shown in Figure 6.3. 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. The results are the difference between the flood levels under the operational or rehabilitation and existing cases.

As discussed in the previous section, the impacts of both projects are not hydraulically linked and there is therefore no cumulative impact. Details of the impacts associated with the rail infrastructure are presented in the Berrima Rail EIS. Impacts on flood level related to the Hume Coal Project under the cumulative scenario are similar to those reported in Section 6.1.2.

Table 6.5 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

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)
3007.9	Oldbury Creek	Hume Coal land	0.00	0.02	0.03	-0.16	0.00	0.00	0.00	0.00
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
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

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)
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
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	1.9	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										

6.2.3 Cumulative peak velocities

Cumulative peak velocities downstream of new infrastructure crossing streams in the study area are presented in Table 6.6.

High velocity changes are predicted at culvert outlets on Oldbury Creek at cross sections 7907.82 and 7081.2 and at the rail loop culvert outlets on a tributary of Oldbury Creek at cross sections 787.17 and 113.72. However, the table shows that these velocity changes reduce further 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 6.6 Cumulative peak velocities at new infrastructure

Cross-section	Infrastructure	Cross-section distance downstream from infrastructure (m)	5-year			20-year			100-year			PMF		
			Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff	Ex	Op	Diff
4288.37	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	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	Drainage depression alongside Hume Highway with 4 x 1800 mm x 900 mm RCBC	3	1.05	1.74	0.69	1.13	1.90	0.77	1.21	2.03	0.82	2.85	5.68	2.83
		19	1.33	1.27	-0.06	1.59	1.53	-0.06	1.84	1.68	-0.16	2.68	3.49	0.81
787.17	1400 mm diameter pipe under rail loop	2	0.00	0.97	0.97	0.01	1.06	1.05	0.01	1.13	1.12	0.03	1.84	1.81
		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	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	0.10	0.78	1.86	1.08	0.86	2.04	1.18	1.52	3.56	2.04
7907.82	5 x 2000 mm x 1200 mm RCBC on Oldbury Creek	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	5 x 2000 mm x 2000 mm RCBC on Oldbury Creek	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

Notes: Ex = Existing; Op = Operation; Diff = Difference

6.3 Potential impacts on mine assets outside the modelled areas

The ventilation shaft pad is located outside the modelled area within the catchment of Wells Creek (see Figure 1.2). The pad is located on high ground at a level of approximately 645 to 650 mAHD, which is approximately 20 m above the adjacent channel of Wells Creek. This infrastructure is therefore well above the PMF level of this watercourse and not at risk of flooding, and will not have an impact on flooding in the Wells Creek catchment.

6.4 Potential impacts on other drainage features

In addition to impacts on main stream flooding, a review of potential impacts on other localised drainage features was also undertaken. A key feature relating to local drainage processes is an existing easement in place that appears to drain a small catchment from east of the Hume Motorway across the road and into a farm dam on land owned by Hume Coal (see Figure 1.2). This easement contains a buried pipe and passes through the site of the proposed PWD. The PWD will incorporate a diversion drain to intercept clean water from the catchment external to the dam and divert it around the dam and into Oldbury Creek.

To allow this existing drainage pipe to continue to function unimpeded it is proposed to modify the section of pipe within land owned by Hume Coal to relocate and extend it around the PWD and either discharge into the clean water diversion drain around the PWD or further downstream towards Oldbury Creek. A new outlet headwall and scour resistant connection will be required at the new pipe outlet. Scour protection will be provided in the form of a rock apron downstream of the headwall, and extending across the floor and walls of the diversion drain if required to discharge to the drain. The pipe hydraulics and associated scour protection at the outlet would be determined at the detailed design stage of the Project, with a hydraulic analysis of the changed tailwater condition for the drainage line. The pipe extension will be design to ensure no impact on the cross drainage system upstream.

6.5 Potential impacts on ecology

There are no significant changes to flood hydrology caused by the Hume Coal Project. The flood regime is essentially unchanged by the project, with only minor changes in flood levels for high order events. The potential impacts of the minor changes are addressed in the Hume Coal Project Biodiversity Assessment Report (EMM 2016c).

6.6 Mitigation measures

The impacts of the project on flood extent, level and velocity are minor and no specific flood mitigation measures are required.

Peak velocities are expected to increase immediately upstream and downstream of the conveyor piers and culverts hence erosion and scour protection measures will be required at these locations, 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.

6.7 Sensitivity analyses

Sensitivity analyses were undertaken for key hydrologic and hydraulic parameters in order to understand the sensitivity of the model predictions of the flood behaviour to variations in these parameters. This section provides an understanding of the range of results possible due to model uncertainty. This has focussed on the Oldbury Creek catchment as this catchment will experience most change in flood hydraulics due to the impact of the surface infrastructure.

6.7.1 Rainfall continuing losses

Sensitivity testing was undertaken for the continuing loss rate for the Oldbury Creek catchment. A continuing loss of 2.5 mm/hr was simulated and the results were compared to those for the simulated value of 3.7 mm/hr that was adopted from the model calibration (refer Table 4.2). The results were compared in both the hydrologic and hydraulic models for the existing and operation scenarios and are given in Table 6.7.

Table 6.7 Sensitivity of continuing loss values

ARI	RAFTS node DN2		HEC-RAS cross-section 3007.9 on Oldbury Creek					
	Existing peak flow (m^3/s)	Operation peak flow (m^3/s)	Existing water level (mAHD)	Operation water level (mAHD)	Afflux (m)	Existing velocity (m/s)	Operation velocity (m/s)	Difference (m/s)
Continuing loss 3.7mm/hr								
5	29.3	27.4	631.10	631.05	-0.05	1.83	1.82	-0.01
20	50.5	47.9	631.55	631.49	-0.06	2.08	2.08	0.00
100	*73.9*	70.1	631.98	631.90	-0.08	2.24	2.23	-0.01
Continuing loss 2.5mm/hr								
5	33.8	31.7	631.19	631.15	-0.04	1.92	1.89	-0.03
20	54.4	51.7	631.61	631.57	-0.04	2.14	2.11	-0.03
100	77.6	73.6	632.03	631.96	-0.07	2.27	2.25	-0.02

The results show that while peak flows differ by up to 15% and water levels differ by up to 100 mm, the afflux result only differs by up to 20 mm, with higher afflux predicted for the adopted continuing loss value of 3.7 mm/hr. Velocity differences are very minor at 0.01 to 0.03 m/s. A difference in 100mm in water level does not produce a perceptible difference in flood extent across the catchment. The results show that flood levels and extents are not sensitive to variation in continuing loss and the afflux predictions are higher for the adopted value, indicating that the impact prediction is conservative with respect to the continuing loss parameter.

6.7.2 Hydraulic roughness

Sensitivity testing was undertaken on the hydraulic roughness by varying the adopted Manning's *n* values in Table 5.1 by +/-20%. The results are provided below at a sample of cross sections in Tables 6.8 and 6.9.

Table 6.8 Results of sensitivity tests on hydraulic roughness (cross section 4120.53 on Oldbury Creek)

ARI	Cross-section 4120.53 on Oldbury Creek					
	Existing water level (mAHD)	Operation water level (mAHD)	Afflux (m)	Existing velocity (m/s)	Operation velocity (m/s)	Difference (m/s)
Mannings values unchanged						
5	640.10	640.14	0.04	1.34	1.30	-0.04
20	640.45	640.52	0.07	1.65	1.54	-0.09
100	640.77	640.85	0.08	1.88	1.72	-0.16
PMF	644.47	644.45	-0.02	3.41	3.00	-0.41
Mannings values increased by 20%						
5	640.19	640.23	0.04	1.22	1.18	-0.04
20	640.57	640.63	0.06	1.50	1.40	-0.10
100	640.90	640.98	0.08	1.72	1.57	-0.15
PMF	644.63	644.60	-0.03	3.26	2.88	-0.38
Mannings values decreased by 20%						
5	640.02	640.04	0.02	1.48	1.46	-0.02
20	640.35	640.39	0.04	1.80	1.72	-0.08
100	640.65	640.72	0.07	2.06	1.90	-0.16
PMF	644.25	644.22	-0.03	3.64	3.20	-0.44

Table 6.9 Results of sensitivity tests on hydraulic roughness (cross section 1044.5 on Oldbury Creek Tributary)

ARI	Cross-section 1044.5 on Oldbury Creek tributary					
	Existing water level (mAHD)	Operation water level (mAHD)	Afflux (m)	Existing velocity (m/s)	Operation velocity (m/s)	Difference (m/s)
Mannings values unchanged						
5	657.84	657.84	0.00	0.61	0.60	-0.01
20	657.88	657.88	0.00	0.68	0.67	-0.01
100	657.91	657.91	0.00	0.75	0.75	0.00
PMF	658.38	658.44	0.06	1.30	1.19	-0.11
Mannings values increased by 20%						
5	657.86	657.87	0.01	0.54	0.50	-0.04
20	657.90	657.91	0.01	0.60	0.57	-0.03
100	657.94	657.94	0.00	0.64	0.63	-0.01
PMF	658.45	658.49	0.04	1.13	1.08	-0.05
Mannings values decreased by 20%						
5	657.81	657.82	0.01	0.77	0.74	-0.03
20	657.84	657.84	0.00	0.85	0.85	0.00
100	657.87	657.87	0.00	0.95	0.95	0.00
PMF	658.28	658.39	0.11	1.61	1.30	-0.31

The sensitivity test demonstrated that water levels and afflux levels are not particularly sensitive to significant variations in the Mannings *n* values, with differences of less than 100mm predicted for water level and less than 50mm predicted for afflux. A difference in 100mm in water level does not produce a perceptible difference in flood extent across the catchment. Velocities are also not sensitive to the change in roughness, with maximum differences of 0.3m/s between the varied roughness scenarios observed.

7. Conclusions

7.1 Conclusions

The flooding assessment has been based on flood models developed from recent LiDAR and ground survey data and calibrated against a single recently observed flood event. The models achieved a good fit to the calibration event and can be considered to provide reliable predictions of flood behaviour for the given event in Medway Rivulet and Oldbury Creek. A check against the PRM confirmed model parameters for use in hydrologic modelling. Sensitivity analyses on the key parameters of continuing loss and hydraulic roughness have been carried out with only minor changes to model results of water level, afflux and velocity.

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:

- the project will have negligible impacts on flood levels in the Medway Rivulet catchment for both operational and rehabilitation scenarios up to the 100 year ARI event.
- the impacts of the project on flood levels in the Oldbury Creek catchment will be within proposed acceptable limits for public roads and private land for the operational scenario, apart from a localised impact on Oldbury Creek between the PWD and SB02 downstream of the inline storage on Hume Coal land.
- the project will have negligible impacts on flood levels in the Oldbury Creek catchment for the rehabilitation scenario, apart from a localised impact downstream of the inline storage on Hume Coal land.

The cumulative modelling results for the Hume Coal Project and Berrima Rail Project indicate that the impacts of the two projects are hydraulically independent. The main impacts on flood behaviour due to the rail project are located around the rail loop and upstream crossings on Oldbury Creek. The localised impacts on flood behaviour caused by the mine surface infrastructure do not contribute to the impacts caused by the rail infrastructure.

Peak velocities are expected to increase immediately downstream of the conveyor piers and culverts. Erosion and scour protection measures will be required around piers and culvert inlets and outlets so that the locally increased velocities do not cause erosion of the channel lining downstream of the infrastructure.

A drainage easement with buried pipe exists that appears to drain a small catchment from east to west across the Hume Motorway into a farm dam on land owned by Hume Coal. The downstream section of this pipe will be intercepted by the proposed PWD. It is proposed to modify the existing drainage arrangement to allow the pipe to discharge around the PWD and allow this drainage line to continue to function unimpeded and ultimately discharge to Oldbury Creek as it does currently.

The project does not significantly alter flooding regimes. Potential impacts of the minor changes on ecology are addressed in the Hume Coal Project Biodiversity Assessment Report (EMM 2016c).

7.2 Limitations

The limitations of this flooding assessment are as follows:

- The XP-RAFTS models for the Medway Rivulet and Oldbury Creek catchments rely on the stream gauge rating curves in Section 3.5.

- The XP-RAFTS models for the Medway Rivulet and Oldbury Creek catchments were only calibrated to one rainfall event.
- The HEC-RAS models for the Medway Rivulet and Oldbury Creek catchments are steady state models which assume that peak flow will occur simultaneously in all locations and storage effect is ignored. The models will over predict water levels and are therefore conservative.
- HEC-RAS provides a one dimensional representation of open channel flow which results in estimates of cross-section averaged velocity. In reality flows downstream of culverts and other constrictions will vary locally and with depth and will have complex turbulent flow distributions. This needs to be considered during detailed civil design of scour protection works.
- The existing landform modelled relies on the accuracy of the LiDAR, which is in the order of +/-150mm.

8. References

AustRoads 2013 Guide to Road Design Part 5B: Drainage – Open Channels, Culverts and Floodways.

Bureau of Meteorology 2006 The Estimation of Probable Maximum Precipitation in Australia: Generalised Southeast Australia Method. Hydrometeorological Advisory Service, Bureau of Meteorology, October 2006.

Bureau of Meteorology 2003 The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method. Hydrometeorological Advisory Service, Bureau of Meteorology, June 2013.

Department of Environment and Climate Change 2007 Practical Consideration of Climate Change, Floodplain Risk Management Guideline. Version 1.0, 25 October 2007.

EMM 2016a Hume Coal Project Environmental Impact Statement.

EMM 2016b Berrima Rail Project Environmental Impact Statement.

EMM 2016c Hume Coal Project Biodiversity Assessment Report.

Engineers Australia 1987 Australian Rainfall and Runoff, 3rd Edition - A Guide to Flood Estimation

Engineers Australia 2006 Australian Runoff Quality – a guide to water sensitive urban design, Wong, T. H. F. (Editor-in-Chief), Engineers Media, Crows Nest, New South Wales.

Hume Coal 2013 Light detection and ranging (LiDAR) data obtained from aerial laser survey on 25 October 2013

Manly Hydraulics Laboratory (MHL) Public Works (2015) Hume Coal Hydrometric Monitoring Interim Report November 2015, Report MHL2411, November 2015.

Mine Advice Hume Coal Project Environmental Impact Statement Subsidence Assessment, June 2016.

NSW Government 2005 Floodplain Development Manual, The Management of Flood Liable Land. Department of Infrastructure, Planning and Natural Resources, April 2005.

Parsons Brinckerhoff 2016. Hume Coal Project Surface Water Flow and Geomorphology Assessment Report. Document reference 2172599B-SFW-REP-000 RevD. 16 September 2016.

Parsons Brinckerhoff 2016. Hume Coal Project Water Fieldwork and Monitoring Report. Document reference 2200539A-RES-REP-7812 RevC. 7 July 2016.

Snowy Mountains Engineering Corporation (SMEC) 2014 Wingecarribee River Flood Study, prepared for Wingecarribee Shire Council, February 2014.

Thompson, P. L. and Kilgore, R. T. 2006. HEC 14 – Hydraulic design of Energy dissipators for Culverts and Channels. Hydraulic Engineering Circular Number 14, Third Edition. July 2006.

URS Austraila (URS) 2008 Whites Creek Flood Study, prepared for Wingecarribee Shire Council, 2008.

Appendix A

WLEP Flood Planning Area Maps

Wingecarribee Local Environmental Plan 2010

Flood Planning Area Map -

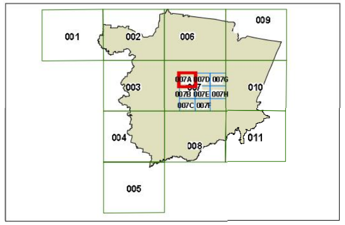
Sheet FLD_007A

Flood Planning Area

100yr +0.5m Flood Extent

Cadastre

Cadastre 04/05/10 © Land and Property Management Authority



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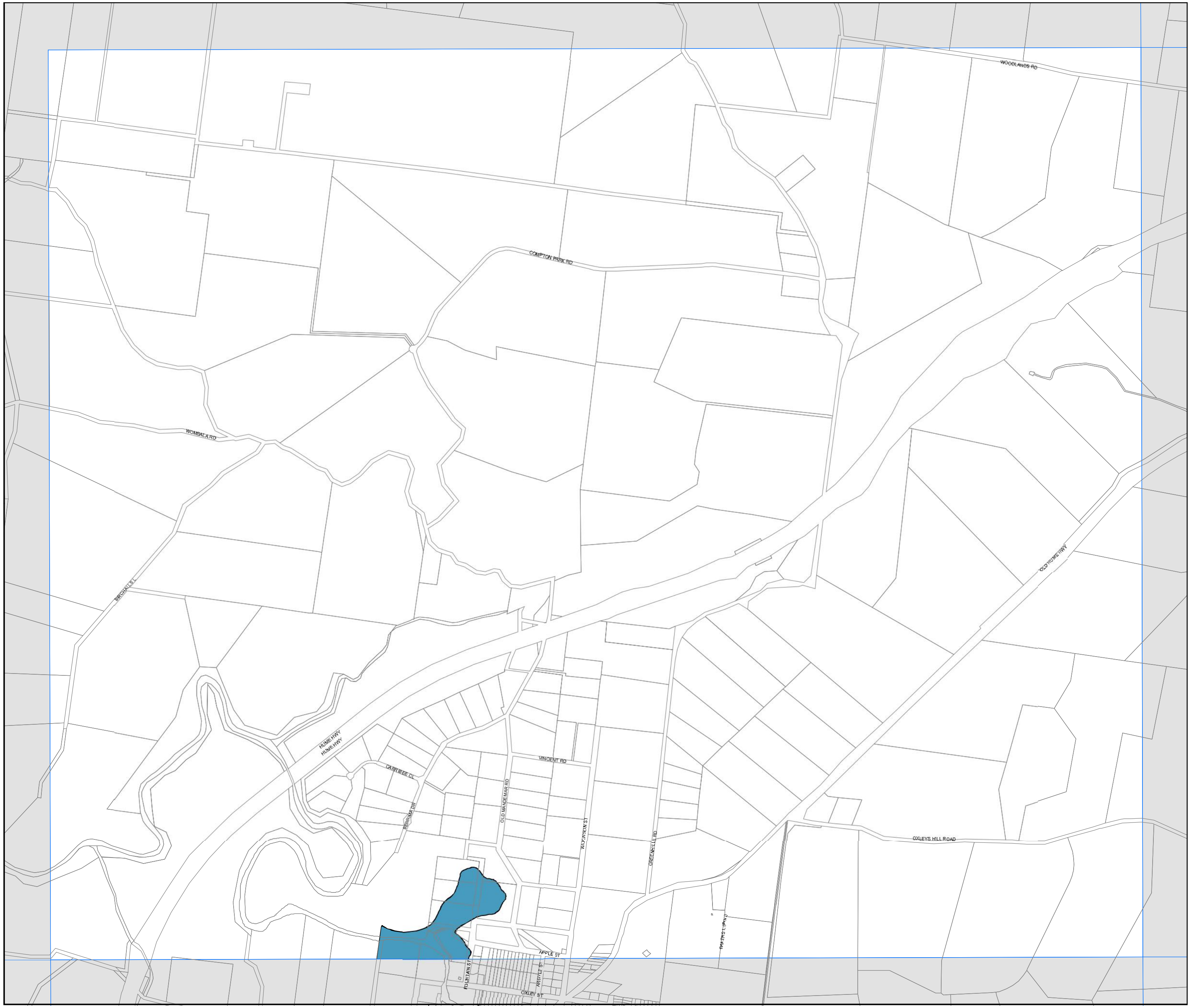

Wingecarribee Local Environmental Plan 2010

Flood Planning Area Map -

Sheet FLD_007B

Flood Planning Area

100yr +0.5m Flood Extent

Cadastre

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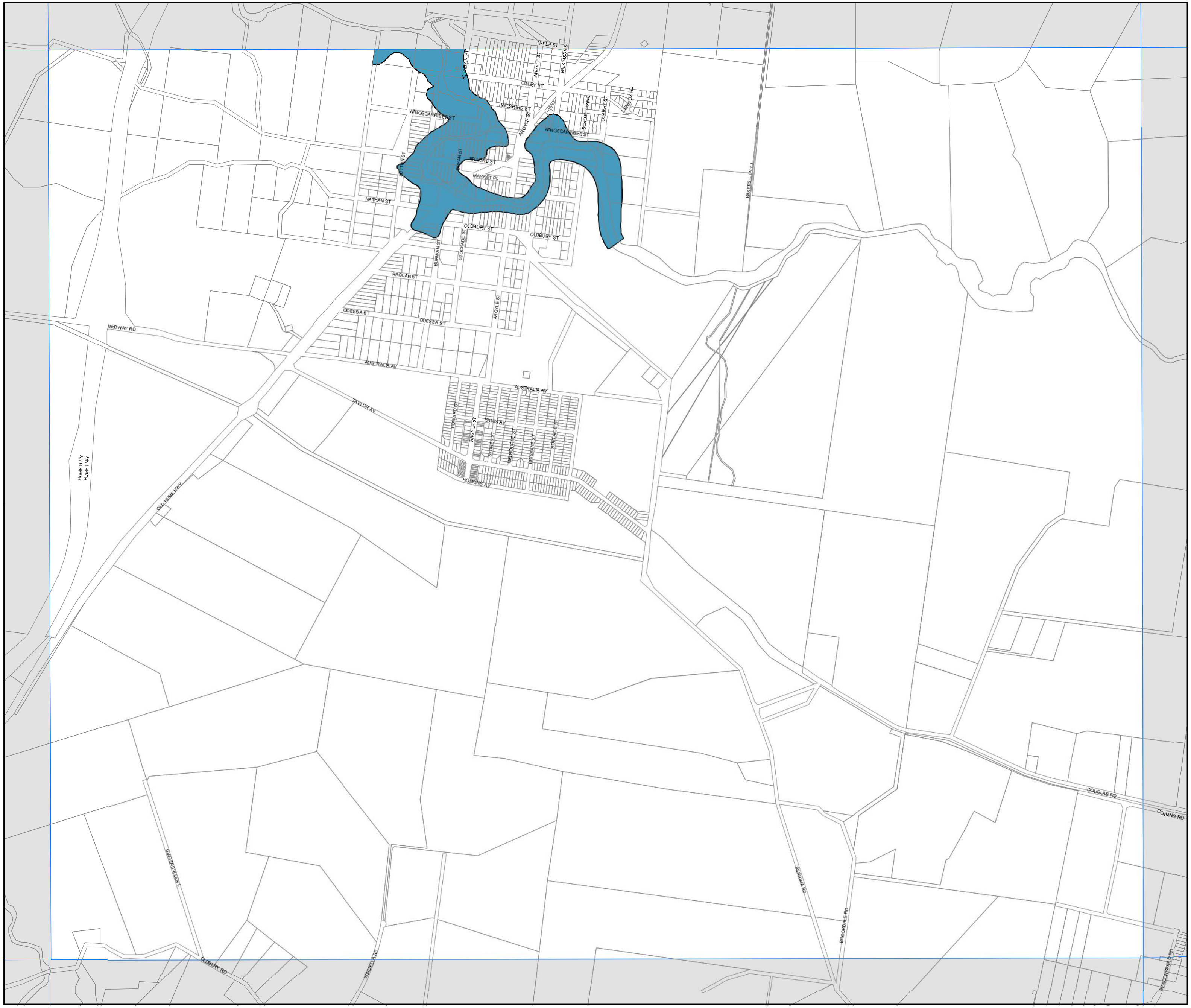

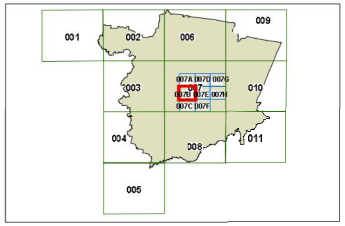

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Wingecarribee Local Environmental Plan 2010

Flood Planning Area Map -

Sheet FLD_007C

Flood Planning Area

100yr +0.5m Flood Extent

Cadastre

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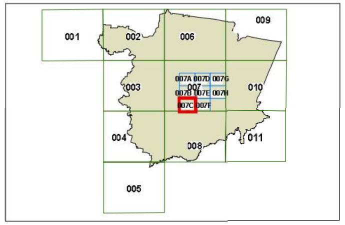

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