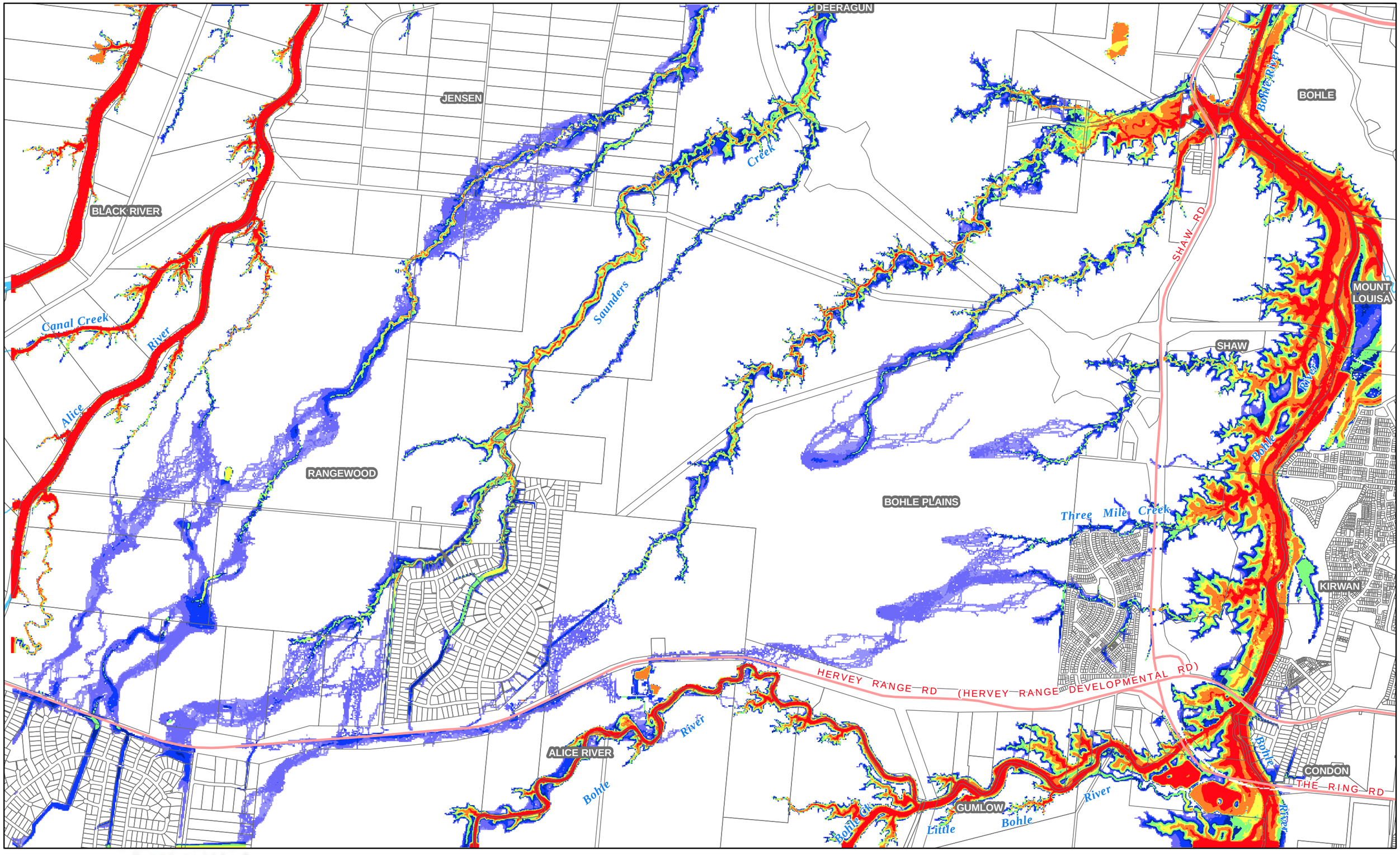

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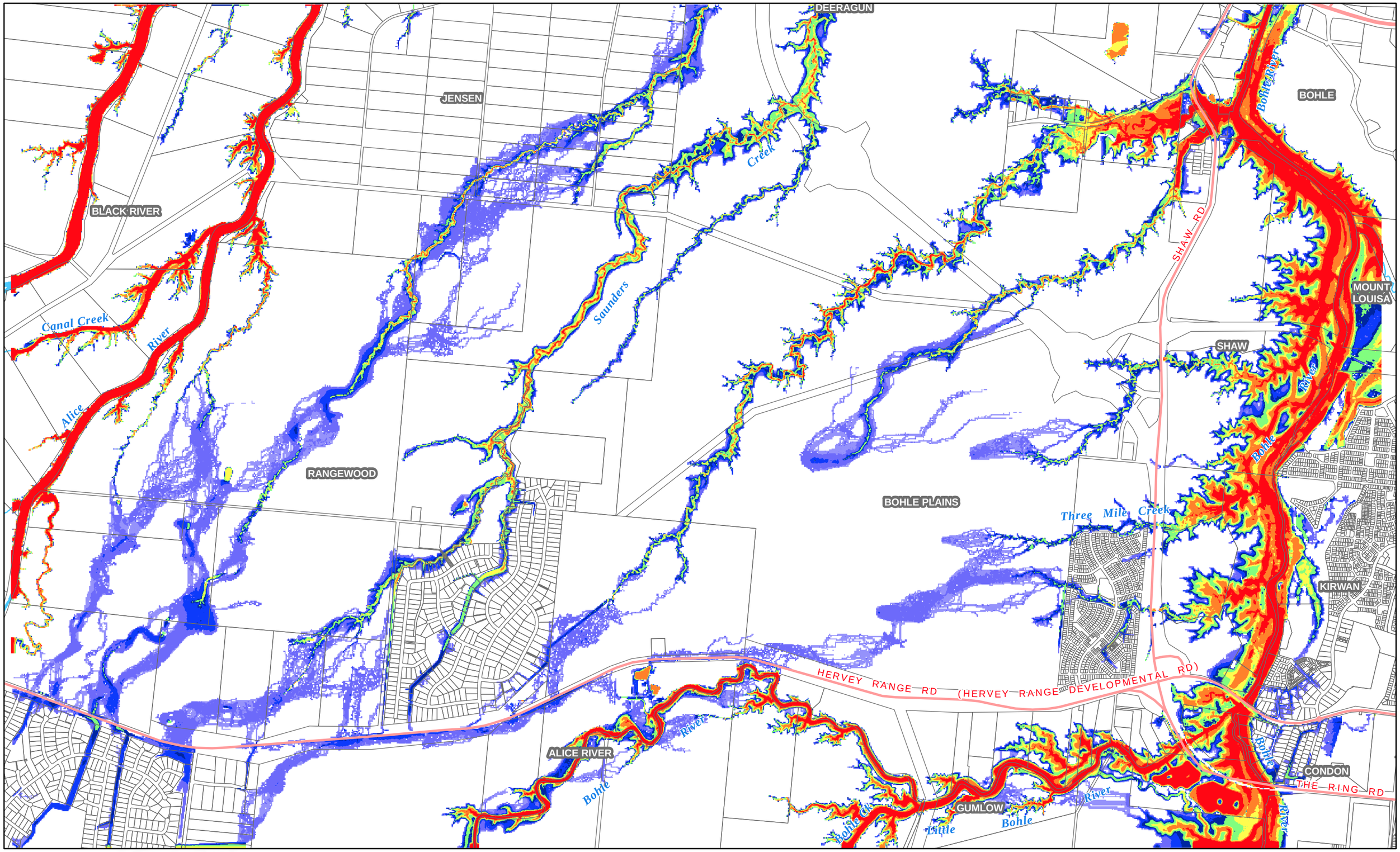
Water Depth (m)

0 - 0.3	0.3 - 0.5	0.5 - 0.75	0.75 - 1	1 - 1.5	1.5 - 2	2 - 3	> 3

UPPER BOHLE PLAINS FLOOD STUDY

50 yr ARI Base Case
Critical Duration Maximum
Flood Envelope

Figure 4-12



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Water Depth (m)

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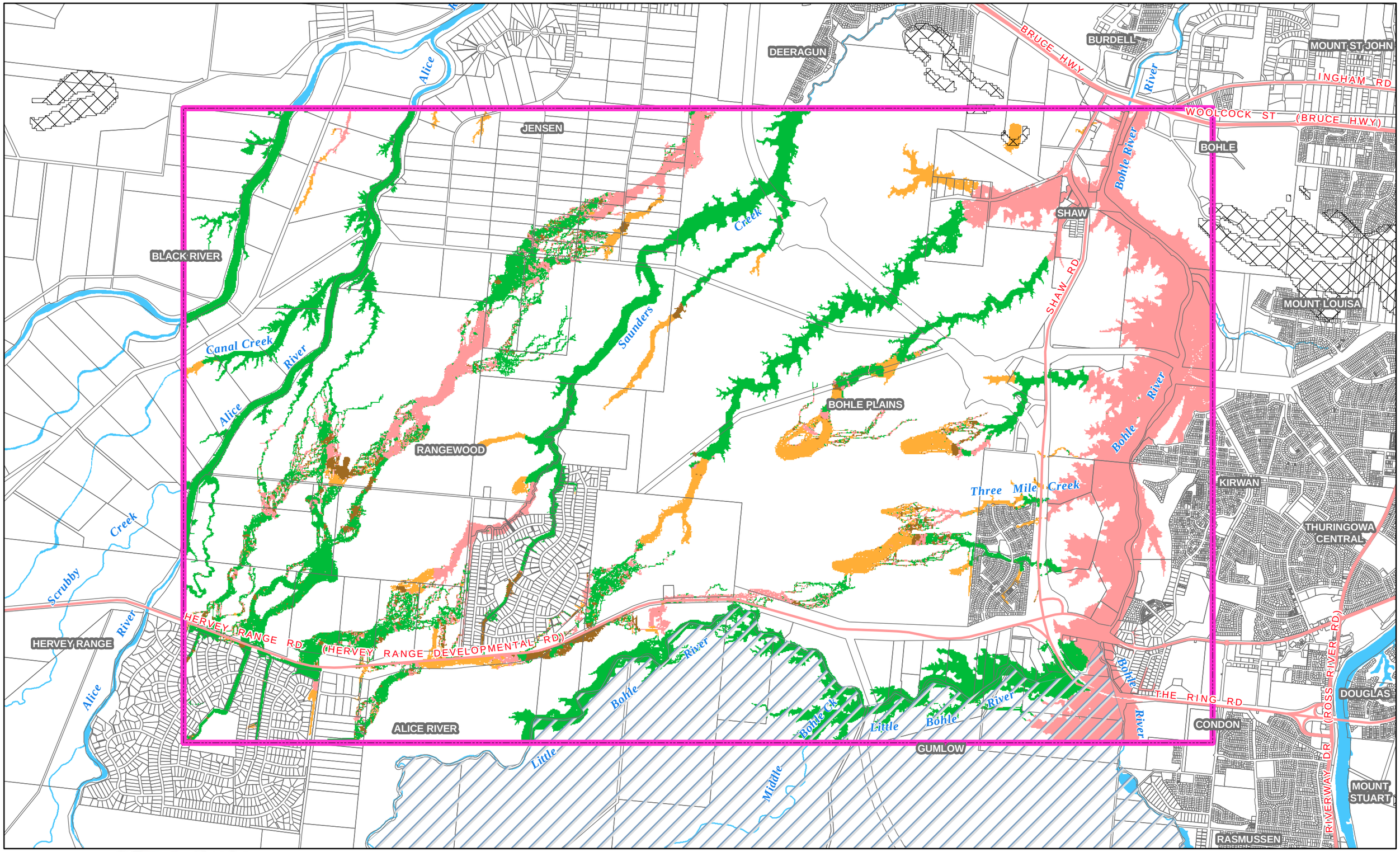
UPPER BOHLE PLAINS FLOOD STUDY
100yr ARI Base Case
Critical Duration Maximum Flood Envelope

Figure 4-13



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(when printed at A3)

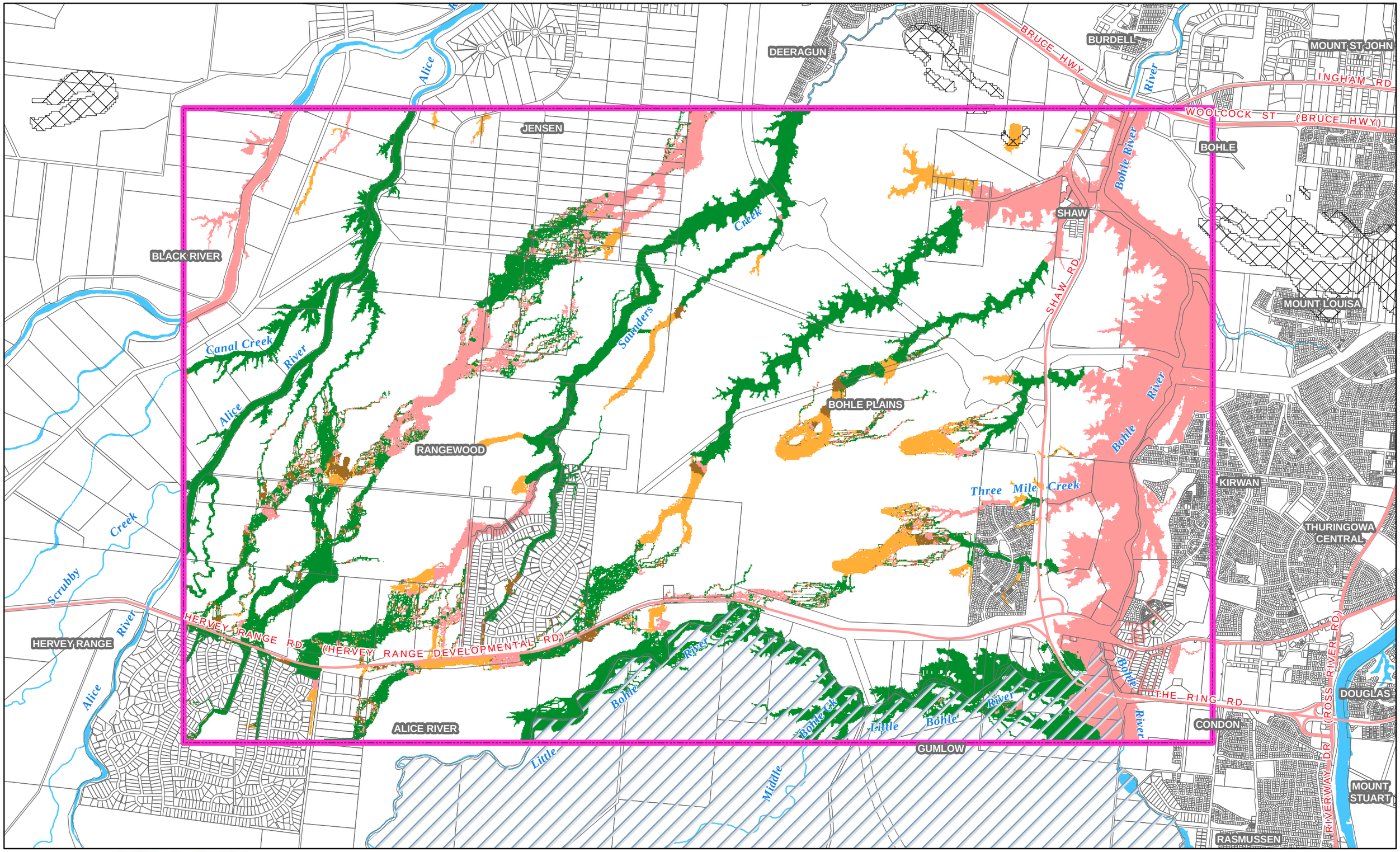
0 500 1,000 2,000 Metres

Legend
- Gumlow
- Slope > 15%
- Model Extent

Event Durations
- 1hr
- 3hr
- 12hr
- 24hr

UPPER BOHLE PLAINS FLOOD STUDY
50 year ARI Future Urbanisation Critical Duration Events

Figure 4-14



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LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663G_WR_24

AECOM

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Scale: 1:40,000
(when printed at A3)

0 500 1,000 2,000 Metres

Legend

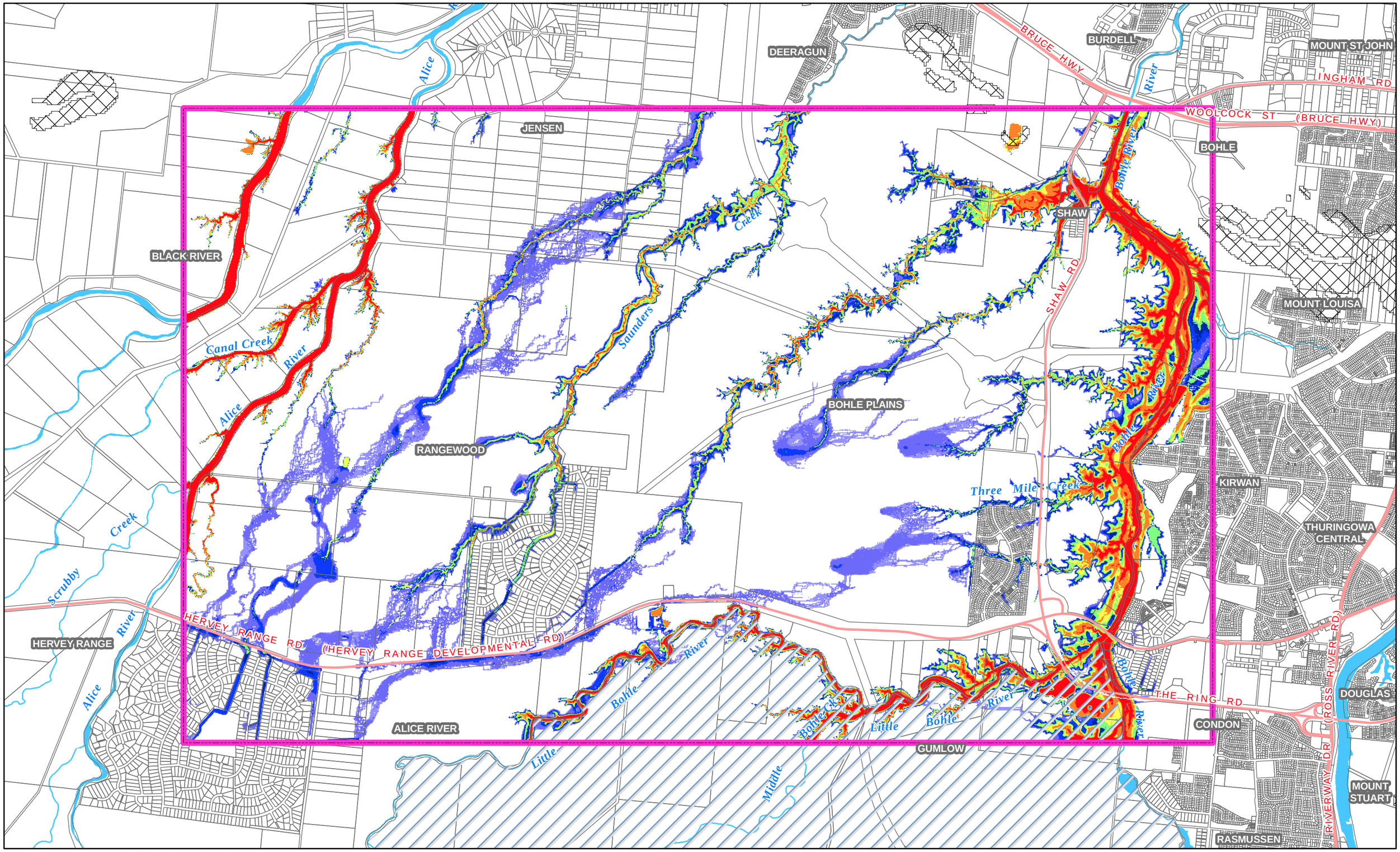
- Gumlow
- Slope > 15%
- Model Extent

Event Durations

- 1hr
- 3hr
- 12hr
- 24hr

UPPER BOHLE PLAINS FLOOD STUDY
100 year ARI Future Urbanisation Critical Duration Events

Figure 4-15



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FILE NAME 60212663G_WR_25

AECOM

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Scale: 1:40,000
(when printed at A3)

0 500 1,000 2,000 Metres

Legend

- Model Extent
- Slope > 15%
- Gumlow

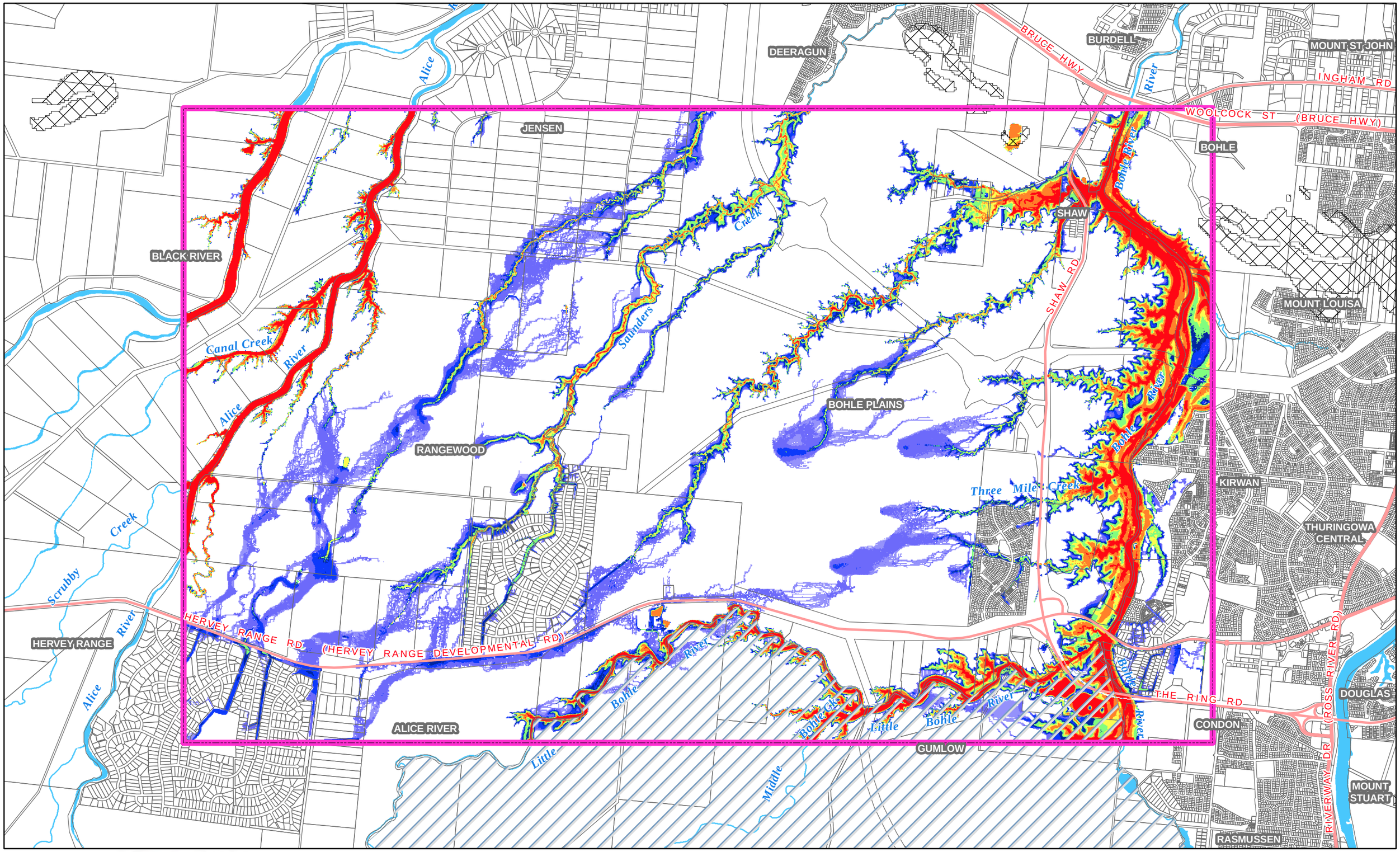
Water Depth (m)

0 - 0.3 | 0.3 - 0.5 | 0.5 - 0.75 | 0.75 - 1 | 1 - 1.5 | 1.5 - 2 | 2 - 3 | > 3

UPPER BOHLE PLAINS FLOOD STUDY

50 yr ARI Future Urbanisation Critical Duration Maximum Flood Envelope

Figure 4-16



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Scale: 1:40,000
(when printed at A3)

0 500 1,000 2,000 Metres

Legend

- Model Extent
- Slope > 15%
- Gumlow

Water Depth (m)

0 - 0.3 | 0.3 - 0.5 | 0.5 - 0.75 | 0.75 - 1 | 1 - 1.5 | 1.5 - 2 | 2 - 3 | > 3

UPPER BOHLE PLAINS FLOOD STUDY

100 yr ARI Future Urbanisation Critical Duration Maximum Flood Envelope

Figure 4-17

5.0 Flooding Assessment

This section details the flooding due to the ARI design storm events for rural developments, residential developments and major arterial roads. Note that analysis of flooding to the south of Hervey Range Road at the Rupertswood development has been previously reported in the *LBRFS* report and is not repeated in this report.

5.1 Base-case

Base-case flood maps for design ARI storm events are provided in **Appendix B**. The maps show water depths, flood levels and flow velocities for the following ARI storm events:

- 2 Year ARI
- 5 Year ARI
- 10 Year ARI
- 20 Year ARI
- 50 Year ARI
- 100 Year ARI
- Probable Maximum Flood

Descriptions of the flooding for the various design events are provided in **Table 5-1**. Note that flood impacts for the 2 and 5-year ARI storm events will be less than presented in Table 5-1 due to local drainage storage not taken into account in the large scale flood model.

Table 5-1 Upper Bohle Plains Area Flooding

Event	Description
2 Year ARI	- No residential property inundation in Kalynda Chase Development - Inundation of backyard at lots adjacent to the Saunders Creek and table drain for Rangewood development - Overland flow on 15 lots at the southeast corner of the Rangewood development - Approximately 20 rural lots in the northern part of the study area are inundated - Flooding on Tompkins Road of up to 0.3m near the culvert - Overland flow on industrial lots along Tompkins Road
5 Year ARI	- No residential property inundation in Kalynda Chase Development - Increased inundation of backyard at lots adjacent to the Saunders Creek and table drain for Rangewood development - Increased overland flow on 15 lots at the southeast corner of the Rangewood development. - Approximately 21 rural lots in the northern part of the study area are inundated - Flooding on Tompkins Road of up to 0.5m near the culvert - Increased overland flow on industrial lots along Tompkins Road
10 Year ARI	- No residential property inundation in Kalynda Chase Development - Flooding of approximately 0.4m on Fulford Annex in Kalynda Chase Development - Inundation of approximately 0.6m along Chowchilla Lane in Kalynda Chase development - Increased inundation of backyards at lots adjacent to the Saunders Creek and table drain for Rangewood development - Increased overland flow on 17 lots at the southeast corner of the Rangewood development. - Approximately 21 rural lots in the northern part of the study area are inundated - Flooding on Tompkins Road of up to 0.8m near the culvert - Flooding of up to 0.4m on Shaw Road Bohle River tributary crossing - Increased overland flow on industrial lots along Tompkins Road
20 Year ARI	- No residential property inundation in Kalynda Chase Development - Flooding of approximately 0.5m on Fulford Annex in Kalynda Chase Development

Event	Description
	- Inundation of approximately 0.6m along Chowchilla Lane in Kalynda Chase development - Inundation of approximately 0.4m along Greygone Court in Kalynda Chase development - Inundation of up to 0.5 m at Bloomfield Way in Kalynda Chase development - Increased inundation of backyard at lots adjacent to the Saunders Creek and open channel drain for Rangewood development - Increased overland flow on 17 lots at the southeast corner of the Rangewood development. - Approximately 21 rural lots in the northern part of the study area are inundated - Flooding on Tompkins Road of up to 1.2m near the culvert - Flooding of up to 0.8m on Shaw Road at Bohle River tributary crossing - Increased overland flow on industrial lots along Tompkins Road
50 Year ARI	- No residential property inundation in Kalynda Chase development - Flooding of approximately 0.5m on Fulford Annex in Kalynda Chase development - Inundation of approximately 0.7m along Chowchilla Lane in Kalynda Chase development - Inundation of approximately 0.4m along Greygone Court in Kalynda Chase development - Inundation of approximately 0.5m at Bloomfield Way in Kalynda Chase development - Inundation of up to 1m in backyards at most lots adjacent to the Saunders Creek and open channel drain for Rangewood development - Overland flow on 17 lots of up to 0.9m at the southeast corner of the Rangewood development. - Approximately 22 rural lots in the northern part of the study area are inundated - Flooding on Tompkins Road of up to 1.4m near the culvert - Flooding of up to 1.1m on Shaw Road at Bohle River tributary crossing - Increased overland flow on industrial lots along Tompkins Road
100 Year ARI	- 4 residential properties inundated in the western side of the Kalynda Chase development near the open channel drain - Overland Flow on Mannikin Way of up to 0.4m in the Kalynda Chase development - Flooding of approximately 0.5m on Fulford Annex in Kalynda Chase development - Inundation of approximately 0.7m along Chowchilla Lane in Kalynda Chase development - Inundation of approximately 0.5m along Greygone Court in Kalynda Chase development - Inundation of approximately 0.5m at Bloomfield Way in Kalynda Chase development - Increased inundation in backyards at most lots adjacent to the Saunders Creek and open channel drain for Rangewood development - Overland flow on 17 lots at the southeast corner of the Rangewood development - Approximately 22 rural lots in the northern part of the study area are inundated - Flooding on Tompkins Road of up to 1.7m near the culvert - Flooding of up to 1.4m on Shaw Road and Bohle River Tributary crossing - Increased overland flow on industrial lots along Tompkins Road
PMF	- Widespread inundation affecting residential properties within Rangewood and Kalynda Chase developments in area near or next to open channel drains or creeks - Most rural lots in the northern part of the study area are inundated - Shaw industrial area is completely inundated

5.1.1 Rural Flooding Summary

Approximately 22 rural lots in the northern part of the study area are inundated for events ranging from the 2-year ARI storm event along Saunders and Stony Creeks. Note that flood impacts for the 2 and 5-year ARI storm events will be less due to local drainage storage not taken into account in the large scale flood model.

5.1.2 Developments Summary

Rangewood Development

Figure 5-1 shows the flooding water depth for the Rangewood development for the 50-year 24-hour ARI storm event. Flooding issues which may occur within the development include:

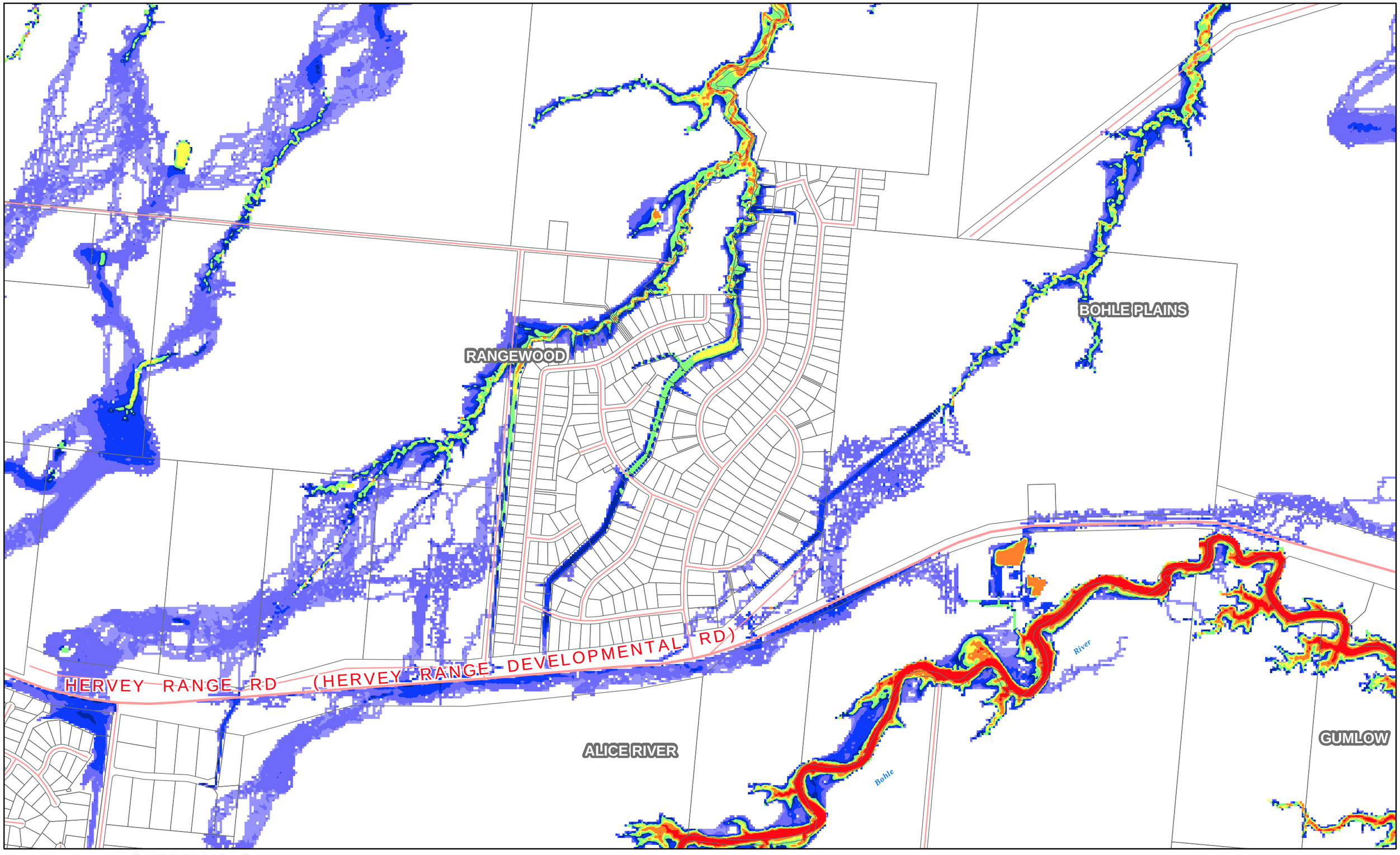
- up to 1 metre inundation in most backyards downstream of the open channel drain that flows through the middle of the development;
- up to 1 metre inundation in the backyards of 12 lots adjacent to Saunders Creek;
- overland flow at approximately 17 lots of up to 0.9 metres at the southeast corner of the development.

Kalynda Chase Development

Figure 5-2 shows the water depth for the Kalynda development area for the 50 year 24 hour ARI storm event. Flooding issues which may occur within the development include:

- inundation of up to 0.7 metre along Chowchilla Lane;
- Inundation of up to 0.5 metre at Bloomfield Way
- inundation of up to 0.5 metre along Fulford Annex;
- inundation of up to 0.4 metre along Greygone Court.

The results should be used with caution as the 10 metre grid does not act as a full drainage model and does not account for local drainage and storage along the roads. Urban drainage elements can be incorporated into the model that will account for local storage as a refinement at a later date.



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LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663G_WR_27

AECOM

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Scale: 1:15,000
(when printed at A3)

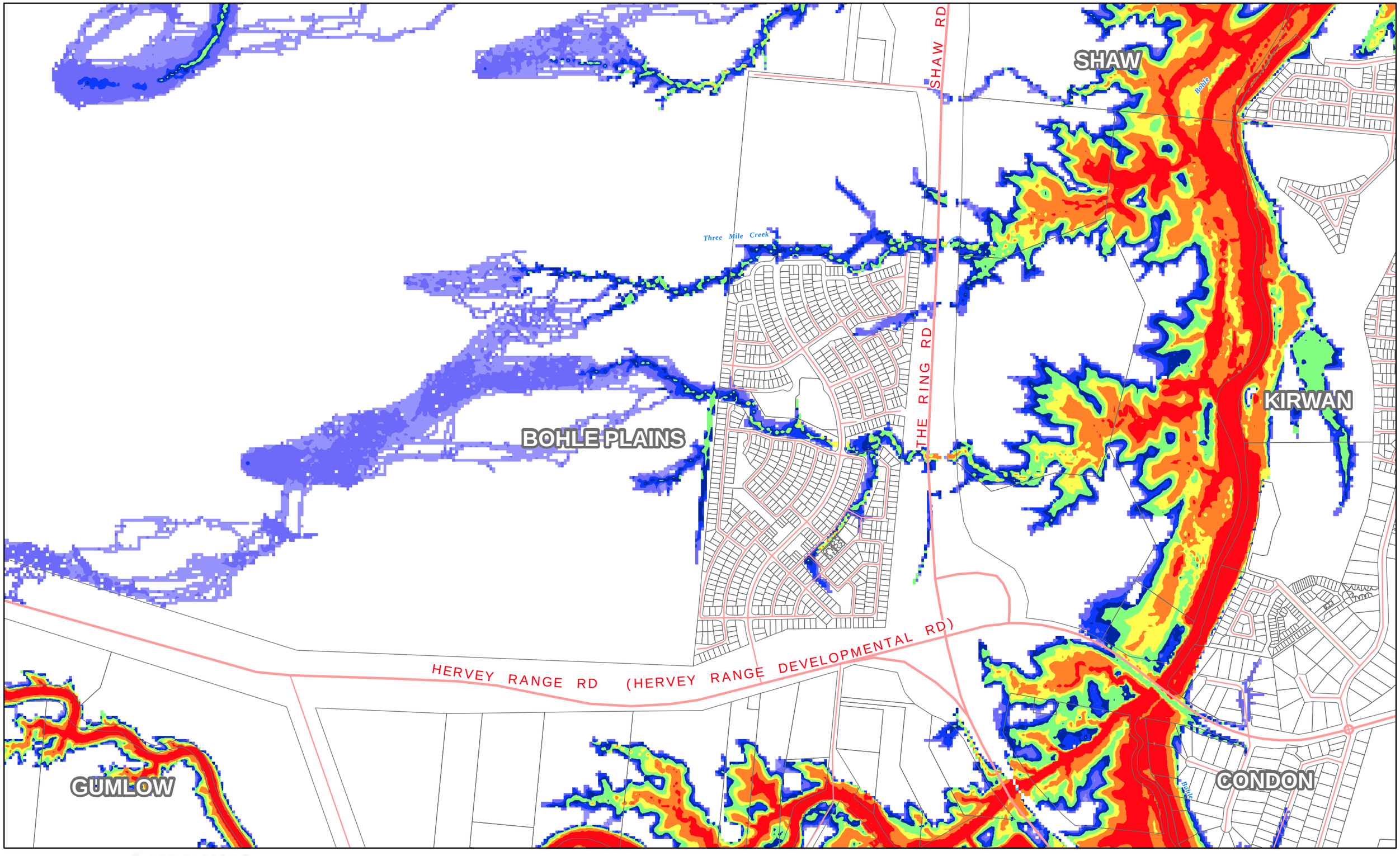
0 250 500 1,000 Metres

Water Depth (m)

0 - 0.3 | 0.3 - 0.5 | 0.5 - 0.75 | 0.75 - 1 | 1 - 1.5 | 1.5 - 2 | 2 - 3 | > 3

UPPER BOHLE PLAINS FLOOD STUDY
50yr 24hr Water Depths for the Rangewood Development Area

Figure 5-1



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(when printed at A3)

0 250 500 1,000 Metres

Water Depth (m)

0 - 0.3	0.3 - 0.5	0.5 - 0.75	0.75 - 1	1 - 1.5	1.5 - 2	2 - 3	> 3

UPPER BOHLE PLAINS FLOOD STUDY

50yr 24hr Water Depths for the Kalynda Development Area

Figure 5-2

5.1.3 Main Arterial Roads Summary

Shaw Road

The Bohle River tributaries in the northeast portion of the model extents that cross Shaw road cause flooding along the roadway for events equal to and greater than the 10 year ARI storm event (Figure 5-3). Approximate water depths at the crossing for different ARI storm events are summarised in Table 5-2. According to Volume 1 of Queensland Urban Drainage Manual (2007), the maximum flow depth at a roadway kerb is 0.25 metres. Shaw Road will need to be closed in the area for any ARI storm event equal to or exceeding the 10-year event to ensure travel safety.

Table 5-2 Approximate water depth on Shaw Road

ARI [yr]	Water depth on Shaw Road [m]
2	-
5	-
10	0.4
20	0.8
50	1.1
100	1.4
PMP	3.6

Options to mitigate flooding of Shaw Road include:

- upstream detention basins on the west side of the proposed Ring Road alignment that detain flows from the tributaries of the Bohle River and Saunders Creek may relieve flooding at Shaw Road and reduce the required culvert size along the proposed Ring Road alignment;
- raising the road with larger culverts;
- realignment to higher ground.

Tompkins Road

Tompkins Road at Shaw Road and the surrounding industrial lots are subject to inundation for all ARI events modelled. Table 5-3 below shows the approximate water level near the culvert at Tompkins Road (located approximately in the middle of the road alignment). Tompkins Road and access to nearby proposed industrial lots will be limited during any significant storm event.

Table 5-3 Approximate water depth on Tompkins Road

ARI [yr]	Water depth on Tompkins Road [m]
2	0.3
5	0.5
10	0.8
20	1.2
50	1.4
100	1.7
PMP	3.8

Options to mitigate flooding of Tomkins Road include:

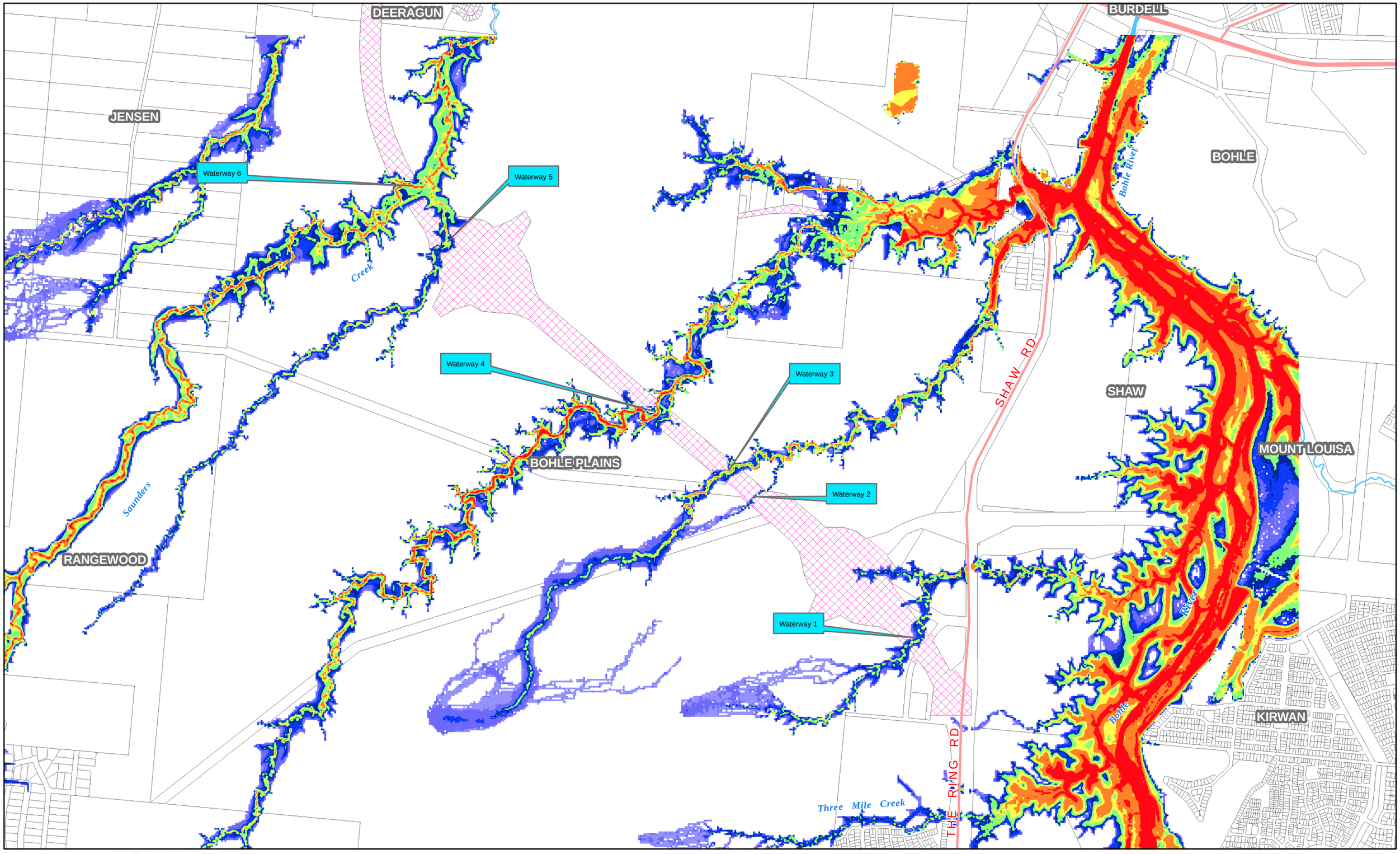
- upstream detention basins on the west side of the proposed Ring Road alignment that detain flows from the tributaries of the Bohle River and Saunders Creek may relieve flooding at Shaw Road and reduce the required culvert size along the proposed Ring Road alignment;
- raising the road with larger culverts
- realignment to higher ground.

Proposed Ring Road Corridor

The Department of Transport and Main Roads (DTMR) plans to construct Stage 4 of the Ring Road in the area between the Bruce Highway and Dalrymple Road. Figure 5-3 shows the 6 waterways going through the proposed alignment and Table 5-4 provides maximum water surface elevations and flows at the intersections.

Table5-4 Maximum flow rate and water surface elevations across the proposed road corridor

Waterway	Model Location		Water Surface Elevation		Maximum Flow Rates [m^3/s]	
	X	Y	50yr24hr	100yr24hr	50yr24hr	100yr24hr
1	975	385	15.0	15.1	23.5	27.9
2	881	470	15.7	15.9	1.8	3.8
3	866	483	15.9	15.9	32.8	36.0
4	825	516	14.8	14.9	79.0	92.6
5	699	622	17.2	17.3	23.0	27.4
6	680	646	17.2	17.4	104.5	122.5



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FILE NAME 60212663G_WR_11

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(when printed at A3)

0 500 1,000 Metres

Legend

- Main Road
- Property Boundary
- Proposed Ring Road Corridor

Water Depth (m)

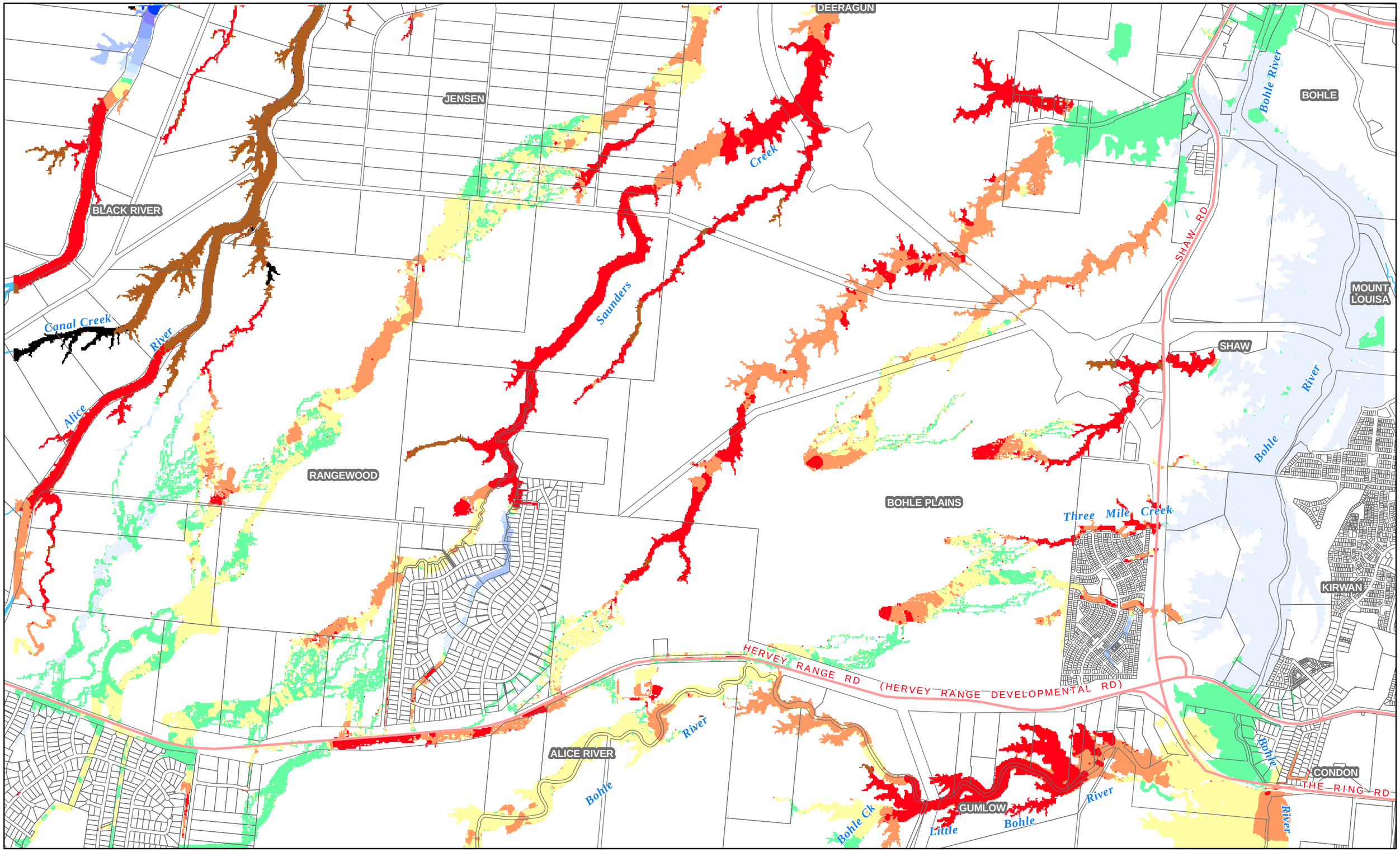
0 - 0.3 | 0.3 - 0.5 | 0.5 - 0.75 | 0.75 - 1 | 1 - 1.5 | 1.5 - 2 | 2 - 3 | > 3

UPPER BOHLE PLAINS FLOOD STUDY
Waterways Flowing Across the Proposed Ring Road Corridor

Figure 5-3

5.2 Future Urbanisation Scenario

Figure 5-4 and Figure 5-5 show that the future urbanisation scenario generally increases the flood levels for the 50 and 100-year ARI storm events from the base-case. As exceptions, water levels decrease from the base-case at the Bohle River downstream of Hervey Range Road and downstream of Rangewood table drain. The reduced water level in these areas may be due to differences in the timing and magnitude of the peak flows between base-case and the future urbanisation scenario.



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Scale: 1:30,000
(when printed at A3)

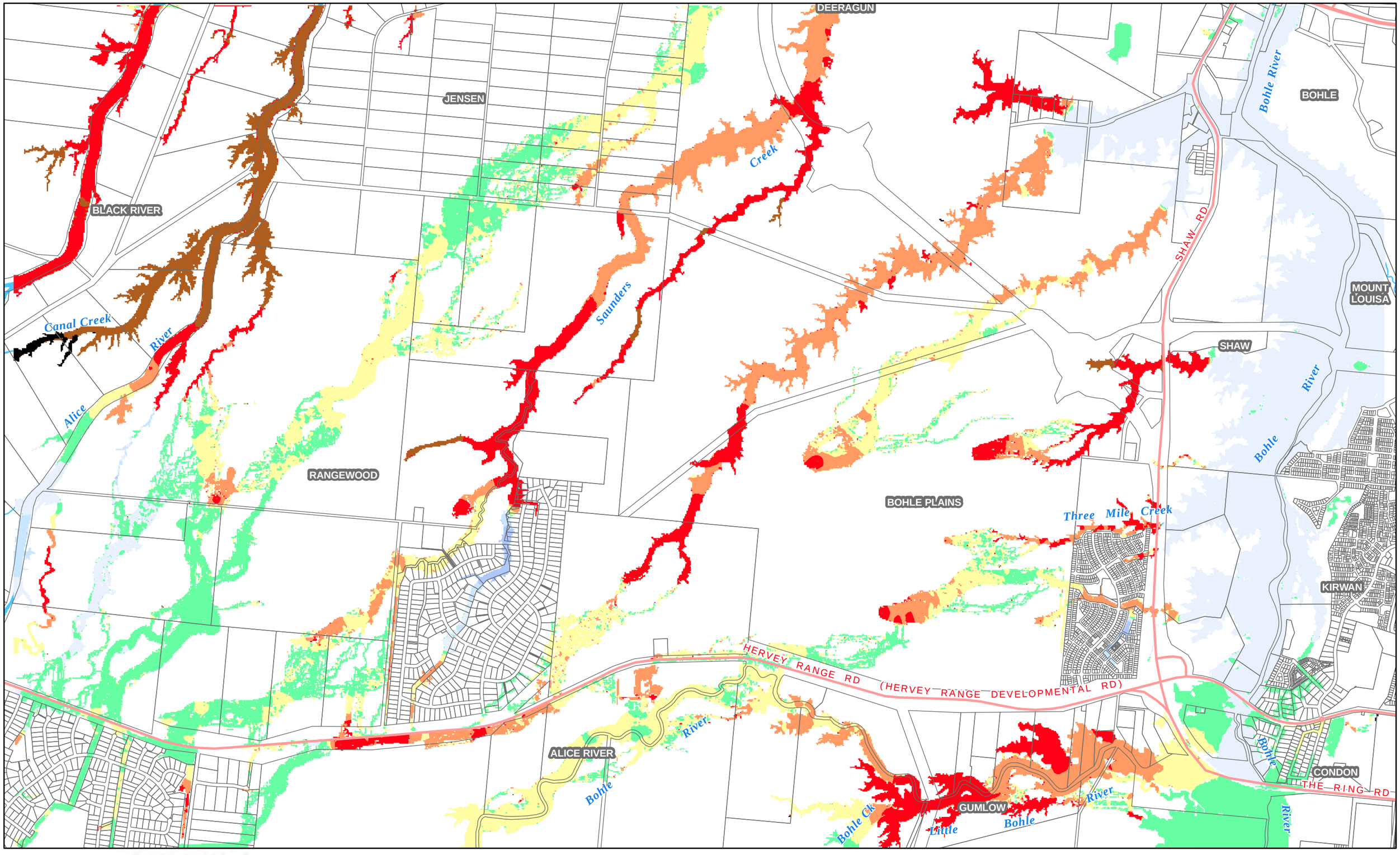
0 500 1,000 2,000 Metres

Afflux (m)

Below -1	-1.00 - -0.50	-0.50 - -0.25	-0.25 - -0.1	-0.10 - -0.05	-0.05 - -0.01	-0.01 - 0.01	0.01 - 0.05	0.05 - 0.1	0.1 - 0.25	0.25 - 0.5	Above 0.5

UPPER BOHLE PLAINS FLOOD STUDY
Future Urbanisation Afflux for 50 yr ARI

Figure 5-4



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FILE NAME 60212663G_WR_30

AECOM

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Scale: 1:30,000
(when printed at A3)

0 500 1,000 2,000 Metres

Afflux (m)

Below -1	-1.00 - -0.50	-0.50 - -0.25	-0.25 - -0.1	-0.10 - -0.05	-0.05 - -0.01	-0.01 - 0.01	0.01 - 0.05	0.05 - 0.1	0.1 - 0.25	0.25 - 0.5	Above 0.5

UPPER BOHLE PLAINS FLOOD STUDY
Future Urbanisation Afflux for 100 yr ARI

Figure 5-5

6.0 Summary, Conclusions & Recommendations

Existing calibrated hydrologic and hydraulic models of the Upper Bohle Plains area have been updated with LiDAR topography as well as infrastructure built after the original models were developed. The hydrologic models included portions of the Black River, Saunders Creek, Stony Creek and the Bohle River catchments and the hydraulic model is bounded by the Alice River to the west, the Bohle River to the east and the Little Bohle River hydraulic model to the south. Model results include the 2, 5, 10, 20, 50, 100 year and PMP critical duration events, water surface elevations, depth of flow and velocity for base-case and future urbanisation scenarios. Maximum flood envelopes have been developed for the 50 and 100 year ARI events for the same range parameters and scenarios.

The base-case and urbanised case scenario results indicate that rural areas, existing and proposed development and existing and proposed arterial roads may be impacted due to the 50-year Annual Recurrence Interval (ARI) or lesser storm event including:

- approximately 22 rural lots may be impacted by flooding along Saunders and Stony Creeks;
- approximately 29 lots may be impacted along the Rangewood development open channel drains;
- approximately 4 local roadways may be impacted along the Kalynda Chase development open channel drains (further refinement of the model with respect to local drainage may provide different results);
- Shaw Road may need to be closed at the intersection with a Bohle River tributary in the northeast corner of the model during a 10-year or greater ARI storm event;
- Tomkins Road may need to be closed along most of its entirety during a 2-year or greater ARI storm event.
- Proposed industrial areas around Tompkins Road may be inundated during a 2-year or great ARI storm event and access to facilities may be limited due to flooding on Tompkins Road

In all cases, mitigations options would include:

- upstream detention basins on the west side of the proposed Ring Road alignment that detain flows from Saunders Creek and tributaries of the Bohle River may relieve flooding of Shaw Road, Tomkins Road and reduce the required culvert size along the proposed Ring Road alignment;
- raising roads and adding larger culverts;
- realignment of roads to higher ground.

The primary recommendations for model and analysis refinements include:

- alternative analysis for the placement of detention facilities to reduce downstream flooding impacts;
- evaluation of raising or realigning roadways;
- analysis of regional diversions to reduce impacts to developed areas.

7.0 References

Australian Rainfall and Runoff (1987) Institution of Engineers, Australia

Australian Rainfall and Runoff (1998) Institution of Engineers, Australia

Bohle Plains Flood Planning Report (2010) AECOM Australia Pty Ltd

Bohle River Floodplain Management Study (2001) Maunsell McIntyre Pty Ltd

Kern Drain Trunk Drainage Assessment (2008) Maunsell AECOM

Liberty Rise Development Flooding Assessment (2008) Maunsell AECOM

MIKE FLOOD 1D-2D Modelling User Manual (2009) DHI Software

Preparation of Flood Studies and Reports – Guidelines (2010) Townsville City Council

RAFTS-XP User's Manual (1994) WP Software

Ring Road Stages 2 & 3 – Bohle River Flooding (2006) Maunsell AECOM

The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method (2003) Bureau of Meteorology - Hydrometeorological Advisory Service

Willowbank Estate Stages 19 to 24 Operational Works Flood Assessment (2008) Maunsell AECOM

Appendix A

Base-case and Future Urbanised Case Hydrology Input Parameters

Appendix A

A1 Base Case Input Parameters

Table A-1 Updated Existing Black River sub-catchment parameters

Sub-catchment	Total Area [ha]	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
A1	2620	0.05	0	6.0
SC1	980	0.05	0	7.1
CC1	930	0.05	0	6.6
CC2	740	0.05	0	0.45
LC1	3390	0.05	0	5.2
HR1	1500	0.05	0	6.4
B3	3110	0.05	0	8.0
B1	1220	0.07	0	9.3
B2	1830	0.06	0	8.6
B4	730	0.05	0	9.8
LC2	830	0.05	0	0.40
B5	230	0.05	0	0.30
LC3	230	0.05	0	0.30
CC3-1	150	0.05	0	0.30
SC3	160	0.05	0	0.40
A4-1	100	.05	0	0.30
AC2	370	.038	0	1.6
B6-a-1	370	0.05	0	0.30
B6-a-2	120	0.05	0	0.30
B6-b-2	110	0.05	0	0.30
A5-1	210	0.045	0	0.40
AC3-b	610	0.05	0	0.30
AC3-a	340	0.035	0	0.40
B7-a	410	.05	0	0.40
LOWC1	270	0.05	0	4.6
B7-b	320	.05	0	0.40
MLP1	190	0.05	0	0.30
AC4-b	520	0.05	0	0.30
AC4-a	230	0.05	0	0.40
B8	180	0.03	0	0.30
B9	300	0.04	0	0.30
LOWC2	210	0.05	0	0.40
LOWC3	320	0.05	0	0.30
MLP2	290	0.05	0	0.60
LOWC4	180	0.05	0	0.30
BB1	200	.05	0	3.1
AC5	560	0.05	0	0.3
BB2	100	0.05	0	0.3
A2-1	950	0.05	0	10.0
A2-2	960	.05	0	7.0
A2-3	60	.05	0	10.0
A2-4	20	.04	0	12.0
A2-5	30	.06	2	1.0
A2-6	110	.06	1	1.50
A2-7	40	.05	1	11.0
A2-8	20	.05	6	1.70
A2-9	25	.05	7	1.40
A3-1	11	.05	2	8.0

Sub-catchment	Total Area [ha]	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
A3-2	11	.05	5	3.78
A3-3	38	.06	0	1.00
A3-4	43	.05	0	6.7
A3-5	7	.06	3	4.7
A3-6	2	.04	4	4.9
A3-7	13	.06	0	6.1
A3-8	35	.06	0	6.3
A3-9	68	0.035	0	4.1
SC-2	760	.05	0	4.8
SC3-1	38	.06	0	6.1
B10	0	0.025	0	1.0
B11	0	0.025	0	1.0
Dummy OUT	0	.025	0	1.0
AR2-f-e	15	.05	6	1.0
AR2-h-i	23	.05	5	1.0
AR-2-g	11	0.05	5	1.0
AR-2-d-c	22	.05	5	1.0
AR2-b-a	39	0.06	0	0.8
AS1-9C	71	.05	18	.70
A5-2	77	0.045	0	0.4
B6-b-1	110	0.05	0	0.3
B6-b-3	95	.05	0	0.3
B6-b-4	130	0.05	0	0.3
CC3-2	320	0.05	0	0.3
A4-3	120	0.05	0	0.3
A4-2	140	0.05	0	0.3

Table A-2 Updated Existing Stony creek sub-catchment parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
R3-a	40	0.06	0	0.70
R3-b	30	0.06	0	1.0
R3-c-d	20	0.04	7	1.0
R3-e-f	30	0.05	5	0.90
R3-g	20	0.05	3	1.4
R3-h-i-j	20	0.05	6	1.2
R3-k	20	0.05	7	1.2
R3-l	10	0.05	3	1.2
S1-1CL	480	0.048	54	1.3
S1-2-1-1CL	100	0.05	70	0.7
S1-2-1CL	40	0.05	51	3.7
S1-2-2CL	50	0.05	57	5.0
S1-2-3CL	130	0.048	64	0.7
S1-3CL	130	0.05	62	0.7
S1-4CL	90	0.05	70	0.7
S1-5CL	280	0.0373	50	0.7
S1-6aCL	130	0.0373	23	0.7
S1-6b-Cl	20	0.0373	50	0.7
S1-6c-Cl	10	0.0373	50	0.7
S1-7aCL	170	0.05	4	2.7
S1-7b1Cl	170	0.05	16	0.7
S1-7b2Cl	190	0.05	10	0.7
S1-8CL	170	0.05	3.2	2.94

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
S1-8CL-1	150	.05	0	2.94
S1-8CL-2	180	.05	5	2.94
S1-8-bCL	150	.05	0	2.94
S1-9CL-1	250	0.05	18	0.7
S1-9CL-2	100	0.05	3.2	2.94

Table A-3 Updated Existing Case Saunders Creek Sub-catchment Parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
R7-e-c	80	0.07	0.3	0.7
R7-d-b	70	0.06	0	0.8
R4-a	10	0.04	4.7	1.5
R4-b	10	0.05	19.4	1.1
R4-d	10	0.05	5.8	1.3
R4-f-e	20	0.05	5.2	0.7
R4-g-h	30	0.05	6.1	1.2
R4-6-c	20	0.05	3.1	1.2
R6-a	20	0.06	0.2	1
R6-d	10	0.05	4.2	1.3
R6-e	10	0.05	3.2	1
R6-f	10	0.05	6.2	1
R6-g	20	0.05	3.8	0.9
R6-h-i-j	30	0.05	4.9	0.9
R6-b	20	0.06	4.7	1.1
R6-k	20	0.06	1.5	0.7
LBR-N1-rev	60	0.06	1	0.7
LBR-1h-rev	80	0.06	0	0.4
LBR-1i-rev	40	0.06	0	0.3
LBR-1j-rev	40	0.06	0	0.5
SA-8-a	90	0.065	0	0.5
SA-7-a	70	0.065	0	0.5
SA-7-b-1	60	0.065	0	0.5
SA-6-a	80	0.065	0	0.5
SA-6-b	100	0.065	0	0.6
SA-5	100	0.065	0	0.5
SA-4-a	160	0.065	0	0.5
SA-3-a	80	0.065	0	3.5
SA-2-a	120	0.05	0	0.5
SA-1-d	110	0.05	0	0.5
SA-1-e	50	0.05	0	0.5
Dummy-Out	40	0.05	0	0.1
SA-1-c	20	0.05	0	0.7
SA-2-c	50	0.05	0	0.6
SA-2-b	30	0.05	0	0.5
SA-3-c	60	0.05	0	4.3
SA3-b	40	0.05	0	5.9
SA-9-a2-2	80	0.065	0	0.5
dummy	170	0.065	1	1.0
SA-8-b	110	0.065	0	0.5
SA-4-b	80	0.065	0	5.3
SA-1-g	30	0.05	0	0.5
SA-1-h	30	0.05	0	0.5
SA-1-f	20	0.05	0	0.7

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
SA-1-a	110	0.05	0	0.5
SA-1-b	30	0.05	0	0.6
Dummy Node	80	0.025	0	0.0
SA9-A2-1	105	0.065	0	0.5
SA-7-b-2	20	0.065	0	0.5
SA-8-b-1	50	0.065	0	0.2
SA-8-b-2	50	0.065	0	0.2
RW1	10	0.06	0	0.7
RW2	20	0.06	0	0.7
RW3	25	0.06	0	0.5
RW5	7	0.06	0	0.5
RW4	47	0.06	0	0.5
RW7	20	0.06	0	0.5

Table A-4 Updated Existing Case Bohle River 1 Sub-catchment Parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
F	80	0.04	5	0.63
I	70	0.04	5	0.58
D	20	0.04	0	0.58
K	10	0.04	5	4.1
E1a2	20	0.04	5	0.50
E1a3	30	0.04	5	0.50
E3	20	0.04	5	0.81
J	20	0.04	5	0.58
H	10	0.04	5	0.61
G1	10	0.04	5	0.50
G2	10	0.04	5	0.50
C	20	0.04	5	0.53
E1b	30	0.04	5	0.51
ER2a	20	0.04	5	2.6
ER1b	20	0.04	5	1.1
ER1a	60	0.04	5	0.55
EK2c	80	0.04	5	1.6
EK2a	40	0.04	5	1.7
B1	40	0.04	5	0.50
A3	90	0.04	5	0.50
AK2	70	0.04	5	1.1
AK1	140	0.04	0	1.0
AK4	100	0.04	5	0.74
AK3	260	0.04	0	1.4
AK5	200	0.04	0	0.57
AR2	110	0.04	5	0.85
AR1	50	0.04	5	0.5
AR3	40	0.04	5	1.7
EK2d	20	0.04	5	1.5
EK2b	50	0.04	5	0.46
EK4	30	0.04	5	0.71
ER3	60	0.04	5	0.99
EK1a	40	0.04	5	1.03
EK1b	190	0.04	5	1.5

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
EK1c	170	0.04	5	1.1
EK3	110	0.04	5	0.73
ER2b	80	0.04	5	2.2
EK5	30	0.04	5	0.61
G2A	30	0.04	0	0.50
G3	20	0.04	0	0.50

Table A-5 Updated Existing Case Bohle River 2 Sub-catchment Parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
B17	70	0.025	5	1.27
B16b-1	90	0.025	5	0.49
B14C	90	0.025	8	3.2
B13a	110	0.025	5	1.56
B17a1	30	0.025	5	4.33
B17b	140	0.025	5	1.54
B10-a	130	0.025		0.4
B11b	150	0.025	5	0.38
B12	130	0.025	5	0.56
B15-b	160	0.025	5	0.46
B16-a	120	0.025	5	5
B16-b-2	120	0.025	5	0.49
Bushervey	70	0.025	5	0.22
B17a2	20	0.025	5	4.33
B14A	60	0.025	5	0.3
B14B	100	0.025	8	0.4
B13-b	120	0.025	1	1.56
B13-c	110	0.025	1	1.56
B10-a1	30	0.025	0	0.04
B10-b	90	0.025	1	0.4
B11-a	120	0.025	5	0.3

A2 Urbanised Case Input Parameters

Table A-6 Urbanised Black River sub-catchment parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
A1	2620	0.025	0	6.0
SC1	980	0.025	13	7.1
CC1	930	0.025	39	6.6
CC2	740	0.025	63	0.4
LC1	3390	0.025	24	5.2
HR1	1490	0.025	15	6.4
B3	3110	0.025	26	8.0
B2	1830	0.025	0	8.6
B4	730	0.025	31	9.8
LC2	830	0.025	70	0.40
B5	230	0.025	42	0.30
LC3	230	0.025	50	0.30
CC3-1	150	0.025	60	0.30
SC3	160	0.025	49	0.40

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
A4-1	100	0.025	27	0.30
AC2	370	0.025	40	1.60
B6-a-1	370	0.025	45	0.30
B6-b-2	110	0.025	45	0.30
A5-1	210	0.025	35	0.40
AC3-b	610	0.025	70	0.30
AC3-a	340	0.025	70	0.40
B7-a	410	0.025	63	0.40
LOWC1	270	0.025	70	4.60
B7-b	320	0.025	35	0.40
MLP1	190	0.025	70	0.30
AC4-b	520	0.025	70	0.30
AC4-a	230	0.025	67	0.40
B8	170	0.025	56	0.30
B9	290	0.025	40	0.30
LOWC2	210	0.025	70	0.40
LOWC3	320	0.025	70	0.30
MLP2	290	0.025	70	0.60
LOWC4	180	0.025	10	0.30
BB1	200	0.025	50	3.10
AC5	560	0.025	35	0.30
BB2	90	0.025	15	0.30
A2-1	950	0.025	34	9.2
A2-2	960	0.025	34	6.5
A2-3	60	0.025	34	10.0
A2-4	20	0.025	34	12.2
A2-5	30	0.025	34	1.0
A2-6	110	0.025	34	1.5
A2-7	40	0.025	34	11.3
A2-8	20	0.025	34	1.7
A2-9	30	0.025	34	1.4
A3-1	40	0.025	45	8.0
A3-2	10	0.025	45	3.8
A3-3	40	0.025	45	1.0
A3-4	40	0.025	45	6.8
A3-5	10	0.025	45	4.8
A3-6	0	0.025	45	5.0
A3-7	10	0.025	45	6.1
A3-8	40	0.025	45	6.4
A3-9	70	0.025	45	4.2
SC-2	760	0.025	50	4.8
SC3-1	40	0.025	50	6.1
B10	0	0.025	49	1.0
B11	0	0.025	0	1.0
Dummy OUT	0	0.025	0	1.0
AR2-f-e	20	0.025	70	1.0
AR2-h-i	20	0.025	70	1.0
AR-2-g	10	0.025	70	0.9
AR-2-d-c	20	0.025	70	1.0
AR2-b-a	40	0.025	70	0.80
AS1-9C	70	0.025	70	0.70
A5-2	80	0.025	35	0.40
B6-b-1	110	0.025	70	0.50
B6-b-3	90	0.025	70	0.50

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
B6-b-4	130	0.025	70	0.50
CC3-2	320	0.025	70	0.50
B6-a-2	120	0.025	70	0.50
A4-3	140	0.025	70	0.50
A4-2	80	0.025	70	0.50

Table A-7 Urbanised Stony creek sub-catchment parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
R3-a	40	0.025	70	0.7
R3-b	30	0.025	70	1.0
R3-c-d	20	0.025	70	1.0
R3-e-f	30	0.025	70	0.9
R3-g	20	0.025	70	1.4
R3-h-i-j	20	0.025	70	1.2
R3-k	20	0.025	70	1.2
R3-l	10	0.025	70	1.2
S1-1CL	480	0.025	54	1.3
S1-2-1-1CL	100	0.025	70	0.7
S1-2-1CL	40	0.025	51	3.7
S1-2-2CL	50	0.025	57	5.0
S1-2-3CL	130	0.025	64	0.7
S1-3CL	130	0.025	62	0.7
S1-4CL	90	0.025	70	0.7
S1-5CL	280	0.025	50	0.7
S1-6aCL	130	0.025	70	0.7
S1-6b-Cl	20	0.025	50	0.7
S1-6c-Cl	10	0.025	50	0.7
S1-7aCL	170	0.025	70	2.7
S1-7b1Cl	170	0.025	70	0.7
S1-7b2Cl	190	0.025	70	0.7
S1-8CL	170	0.025	3.2	2.94
S1-8CL-1	150	0.025	0	2.94
S1-8CL-2	180	0.025	5	2.94
S1-8-bCL	150	0.025	0	2.94
S1-9CL-1	250	0.025	18	0.7
S1-9CL-2	100	0.025	3.2	2.94

Table A-8 Urbanised Saunders Creek Sub-catchment Parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
R7-e-c	80	0.025	70	0.70
R7-d-b	70	0.025	70	0.80
R4-a	10	0.025	70	1.5
R4-b	10	0.025	70	1.1
R4-d	10	0.025	70	1.3
R4-f-e	20	0.025	70	0.70
R4-g-h	30	0.025	70	1.2
R4-6-c	20	0.025	70	1.2
R6-a	20	0.025	70	1.0

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
R6-d	10	0.025	70	1.3
R6-e	10	0.025	70	1.0
R6-f	10	0.025	70	1.0
R6-g	20	0.025	70	0.9
R6-h-i-j	30	0.025	70	0.9
R6-b	20	0.025	70	1.1
R6-k	20	0.025	70	0.70
LBR-N1-rev	60	0.025	70	0.70
LBR-1h-rev	80	0.025	70	0.70
LBR-1i-rev	40	0.025	70	0.40
LBR-1j-rev	40	0.025	70	0.30
SA-8-a	90	0.025	70	0.50
SA-7-a	70	0.025	70	0.50
SA-7-b-1	60	0.025	70	0.50
SA-6-a	80	0.025	70	0.50
SA-6-b	100	0.025	70	0.50
SA-5	100	0.025	70	0.60
SA-4-a	160	0.025	70	0.50
SA-3-a	80	0.025	70	0.50
SA-2-a	120	0.025	70	3.50
SA-1-d	110	0.025	70	0.50
SA-1-e	50	0.025	70	0.50
Dummy-Out	40	0.025	70	0.50
SA-1-c	20	0.025	70	0.70
SA-2-c	50	0.025	70	0.60
SA-2-b	30	0.025	70	0.50
SA-3-c	60	0.025	70	4.3
SA3-b	40	0.025	70	5.9
SA-9-a2-2	190	0.025	70	0.5
dummy	170	0.025	70	1.0
SA-8-b	110	0.025	70	0.50
SA-4-b	80	0.025	70	5.3
SA-1-g	30	0.025	70	0.50
SA-1-h	30	0.025	70	0.50
SA-1-f	20	0.025	70	0.70
SA-1-a	110	0.025	70	0.50
SA-1-b	30	0.025	70	0.70
Dummy Node	80	0.025	70	0.70
SA9-A2-1	80	0.025	70	0.50
SA-7-b-2	20	0.025	70	0.50
SA-8-b-1	50	0.025	70	0.50
SA-8-b-2	50	0.025	70	0.2
RW1	9.06	0.025	70	0.06
RW2	10	0.025	70	0.065
RW5	20	0.025	70	0.065
RW7	25	0.025	70	0.065
RW4	7	0.025	70	0.065
RW3	47	0.025	70	0.065

Table A-9 Urbanised Case Bohle River 1 Sub-catchment Parameters

Sub-catchment	Total Area [ha]	Catchment Manning's 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
F	80	0.025	70	0.60
I	70	0.025	70	0.60
D	20	0.025	70	0.60
k	10	0.025	70	4.1
E1a2	20	0.025	70	0.50
E1a3	30	0.025	70	0.50
E3	20	0.025	70	0.80
J	20	0.025	70	0.60
H	10	0.025	70	0.60
G1	10	0.025	70	0.50
G2	10	0.025	70	0.50
C	20	0.025	70	0.50
E1b	30	0.025	70	0.50
ER2a	20	0.025	70	2.6
ER1b	20	0.025	70	1.1
ER1a	60	0.025	70	0.60
EK2c	80	0.025	70	1.6
EK2a	40	0.025	70	1.7
B1	40	0.025	70	0.50
A3	90	0.025	70	0.50
AK2	70	0.025	70	1.1
AK1	140	0.025	70	1.0
AK4	100	0.025	70	0.70
AK3	260	0.025	70	1.4
AK5	200	0.025	70	0.60
AR2	110	0.025	70	0.90
AR1	50	0.025	70	0.50
AR3	40	0.025	70	1.7
EK2d	20	0.025	70	1.5
EK2b	50	0.025	70	0.50
EK4	30	0.025	70	0.70
ER3	60	0.025	70	1.0
EK1a	40	0.025	70	1.0
EK1b	190	0.025	70	1.5
EK1c	170	0.025	70	1.1
EK3	110	0.025	70	0.7
ER2b	80	0.025	70	2.2
EK5	30	0.025	70	0.60
G2A	30	0.025	70	0.50
G3	20	0.025	70	0.50

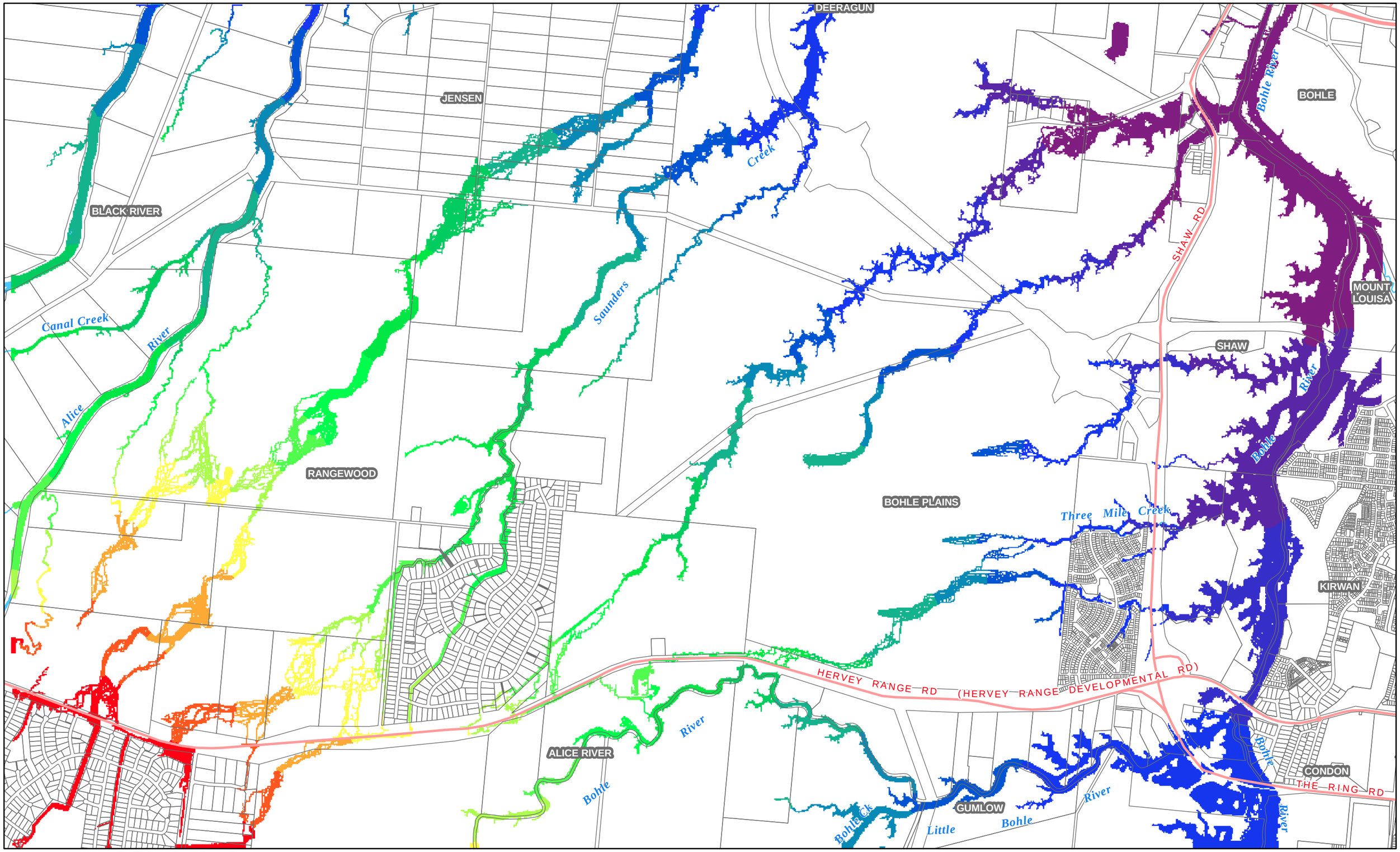
Table A-10 Urbanised Case Bohle River 2 Sub-catchment Parameters

Sub-catchment	Total Area [ha]	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
B17	80	0.018	70	0.60
B16-b-1	70	0.018	70	0.60
B14C	20	0.018	70	0.60
B13a	10	0.018	70	4.1
B17-a1	20	0.018	70	0.50
B17-b	30	0.018	70	0.50
JuncDummy	20	0.018	70	0.80

Sub-catchment	Total Area [ha]	Catchment Mannings 'n' [n value]	Percentage Impervious [%]	Catchment Slope [%]
B10-a	20	0.018	70	0.60
B11b	10	0.018	70	0.60
B12	10	0.018	70	0.50
B15-b	10	0.018	70	0.50
B16-a	20	0.018	70	0.50
B16b-2	30	0.018	70	0.50
Bushervey	20	0.018	70	2.6
B17-a2	20	0.018	70	1.1
B14b	60	0.018	70	0.60
B10-b	80	0.018	70	1.6
B11-a	40	0.018	70	1.7
B13-b	40	0.018	70	0.50
B13-c	90	0.018	70	0.50
B14-a	70	0.018	70	1.1

Appendix B

Hydraulic Modelling Results



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_01

AECOM

N

Scale: 1:30,000
(when printed at A3)

0 500 1,000 2,000 Metres

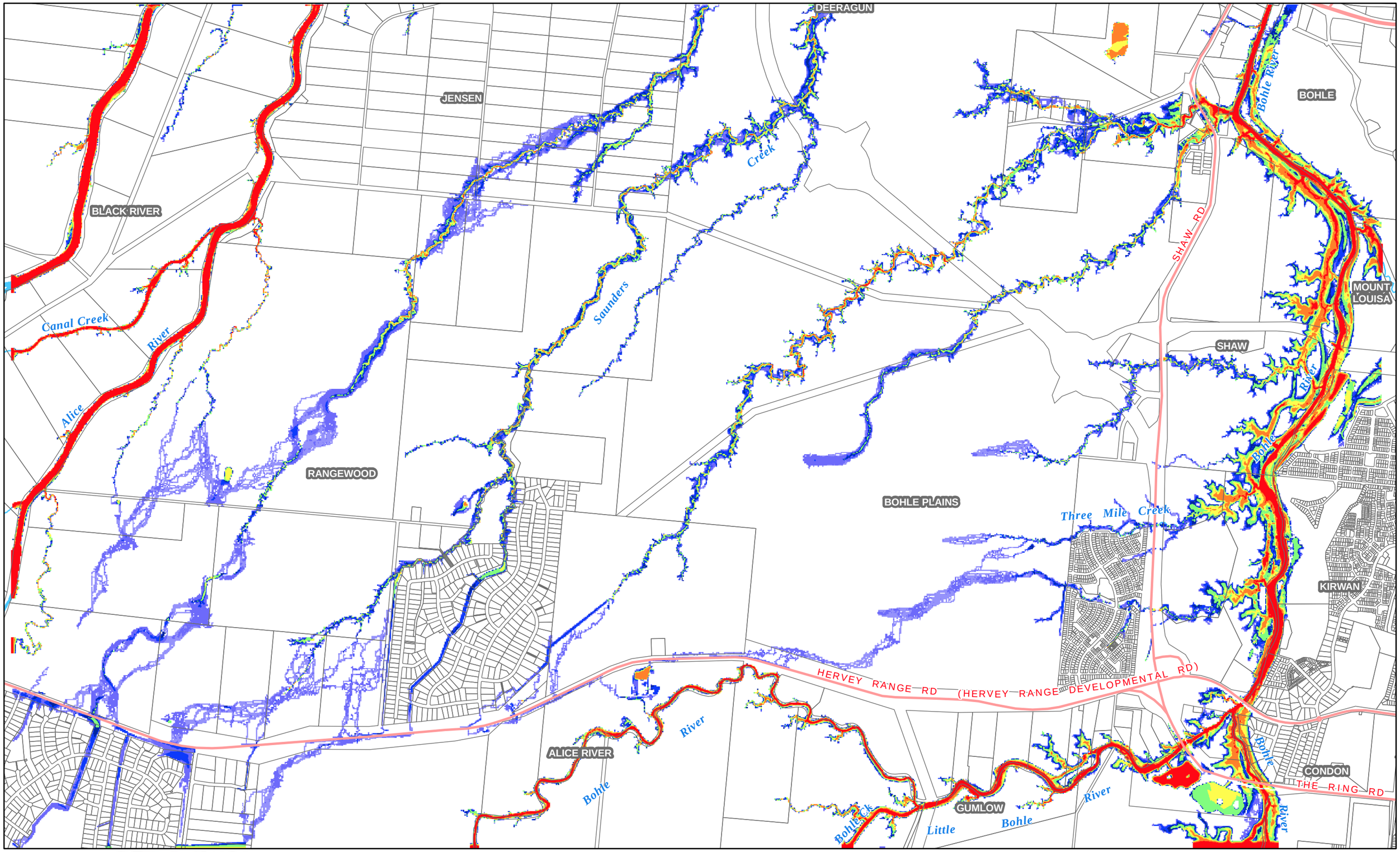
Water Levels (m AHD)

< 10 | 10 - 12 | 12 - 14 | 14 - 16 | 16 - 18 | 18 - 20 | 20 - 22 | 22 - 24 | 24 - 26 | 26 - 28 | 28 - 30 | 30 - 32 | 32 - 34 | 34 - 36 | 36 - 38 | 38 - 40 | > 40

UPPER BOHLE PLAINS FLOOD STUDY

2 year 24 hr ARI Flood Levels Base Case

Figure B1



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_02

AECOM

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Scale: 1:30,000
(when printed at A3)

0 500 1,000 2,000 Metres

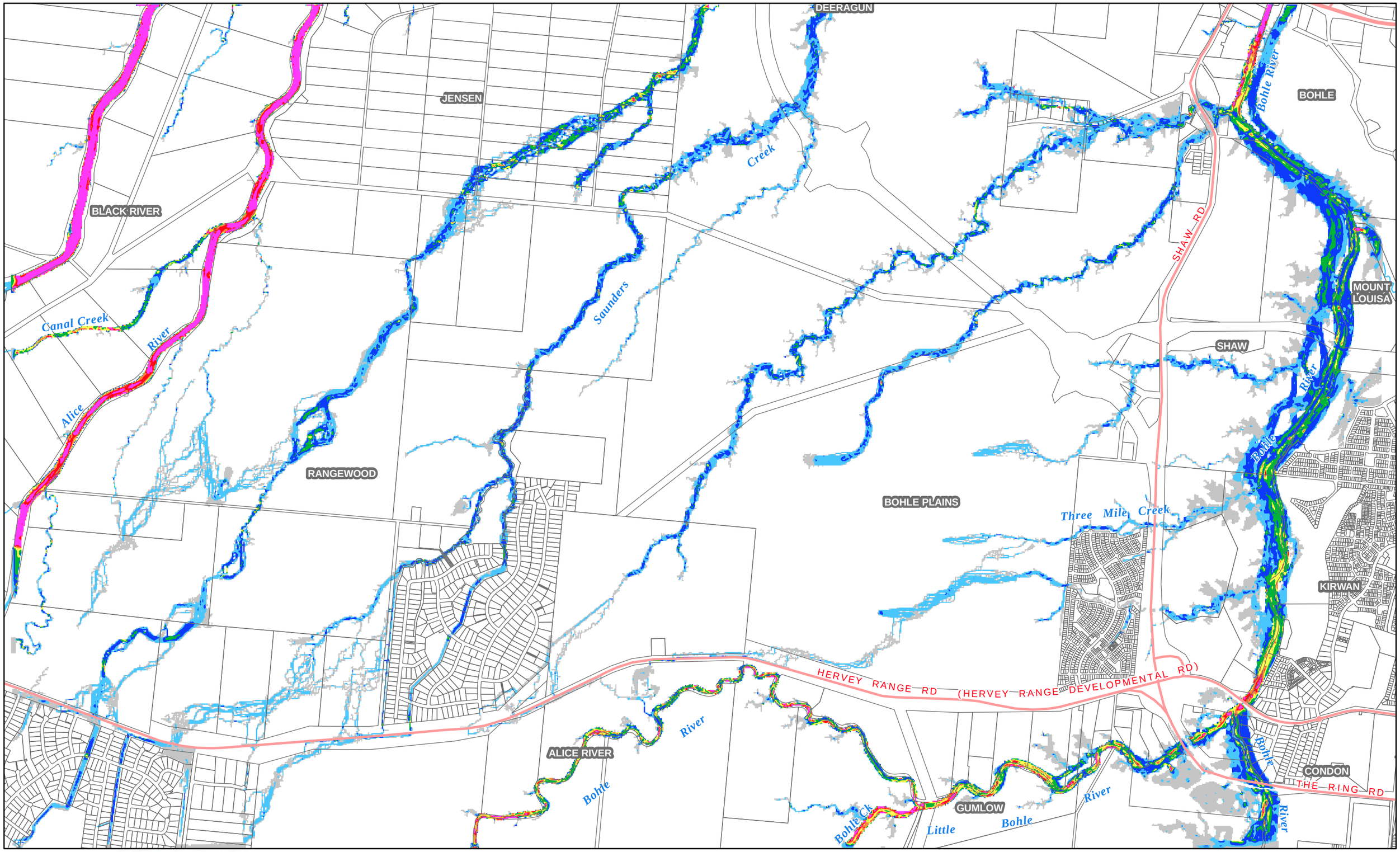
Water Depth (m)

0 - 0.3	0.3 - 0.5	0.5 - 0.75	0.75 - 1	1 - 1.5	1.5 - 2	2 - 3	> 3

UPPER BOHLE PLAINS FLOOD STUDY

2 year 24 hr ARI Water Depths Base Case

Figure B2



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_03

AECOM

N

Scale: 1:30,000
(when printed at A3)

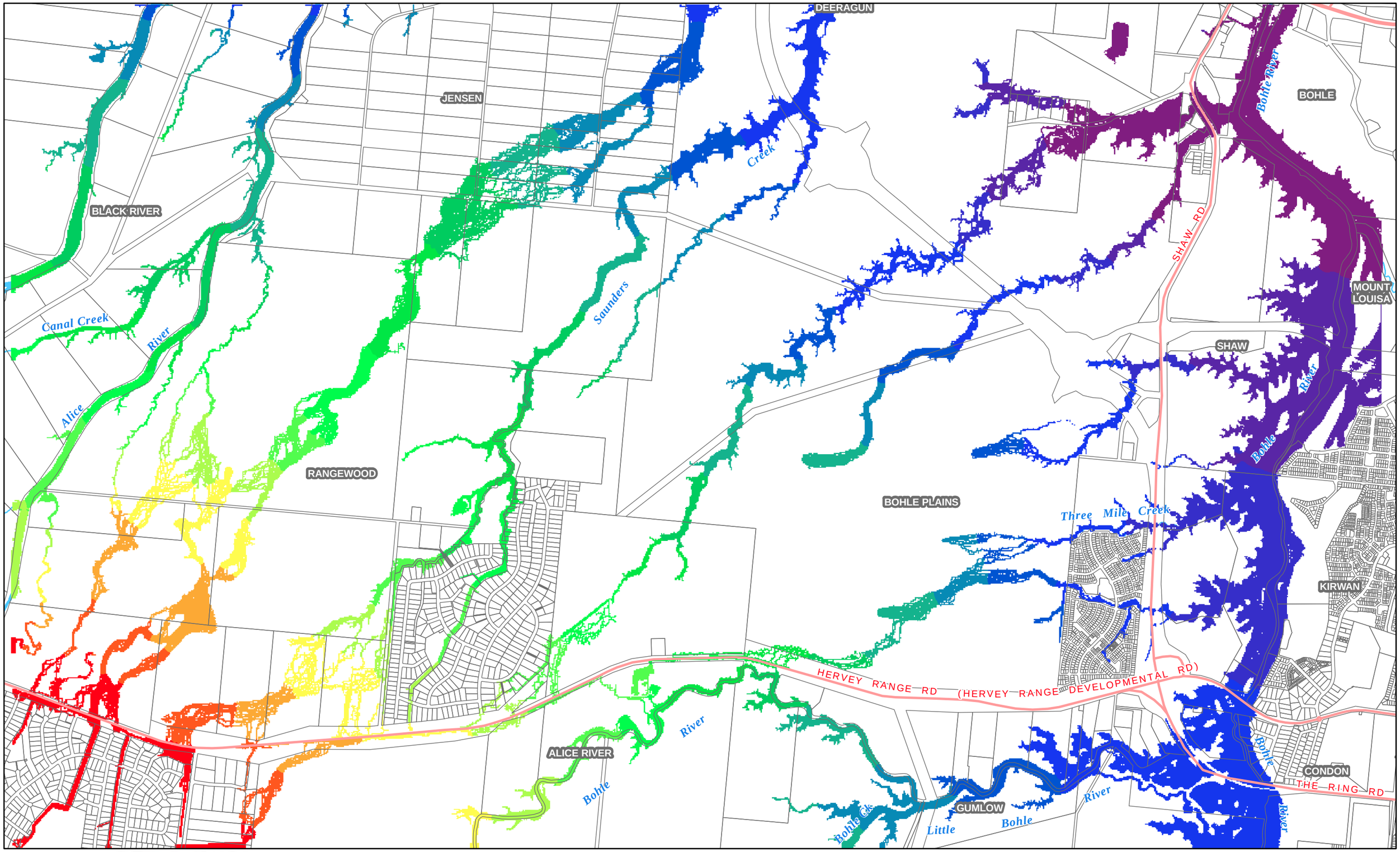
0 500 1,000 2,000 Metres

Velocity (m/s)

0 - 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.00	1.00 - 1.25	1.25 - 1.50	1.50 - 1.75	1.75 - 2.00	Above 2

UPPER BOHLE PLAINS FLOOD STUDY
2 year 24 hr ARI Velocity Base Case

Figure B3



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_04

AECOM

Scale: 1:30,000
(when printed at A3)

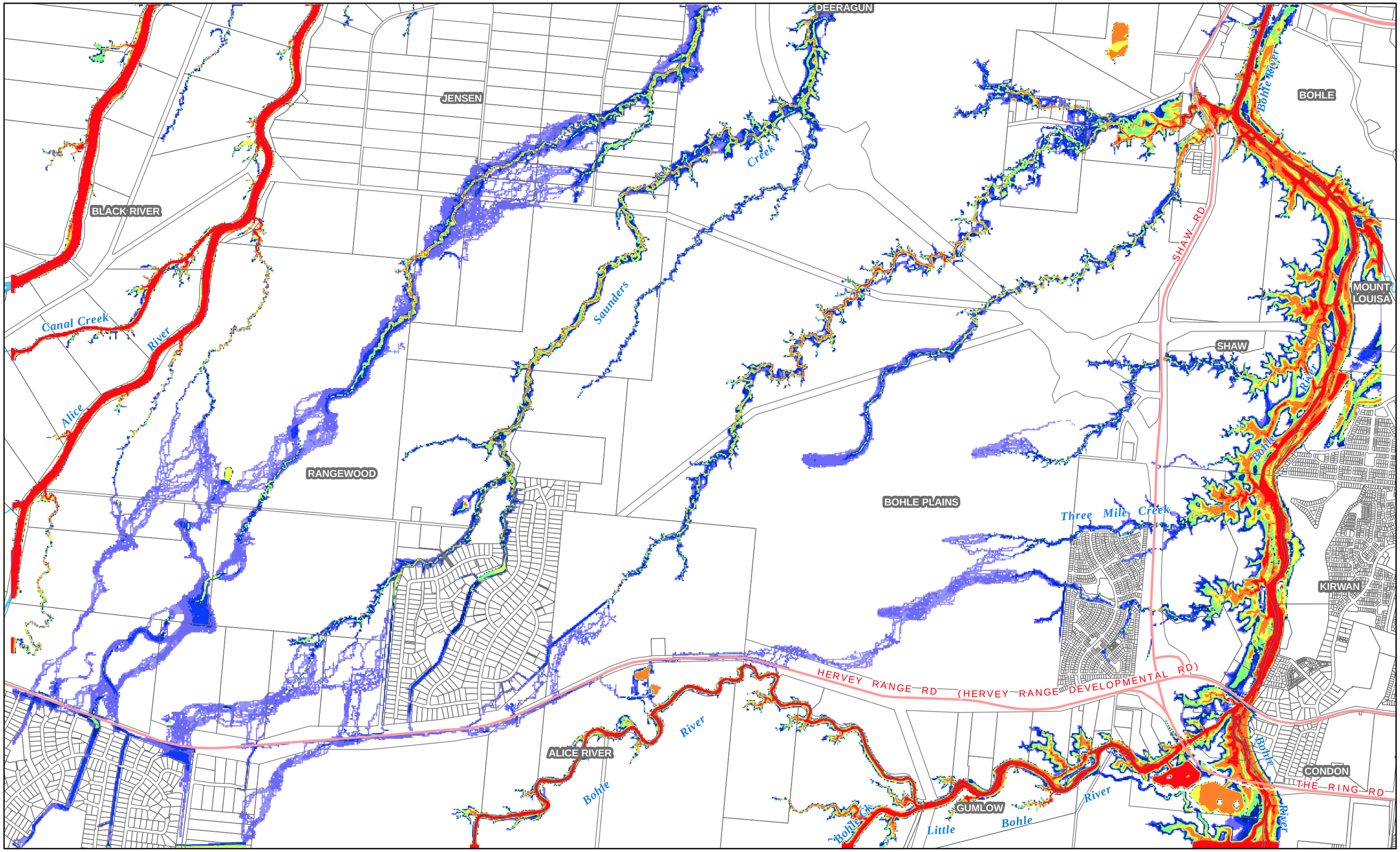
0 500 1,000 2,000 Metres

Water Levels (m AHD)

< 10 | 10 - 12 | 12 - 14 | 14 - 16 | 16 - 18 | 18 - 20 | 20 - 22 | 22 - 24 | 24 - 26 | 26 - 28 | 28 - 30 | 30 - 32 | 32 - 34 | 34 - 36 | 36 - 38 | 38 - 40 | > 40

UPPER BOHLE PLAINS FLOOD STUDY
5 year 24 hr ARI Flood Levels
Base Case

Figure B4



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_05

AECOM

N

Scale: 1:30,000
(when printed at A3)

0 500 1,000 2,000 Metres

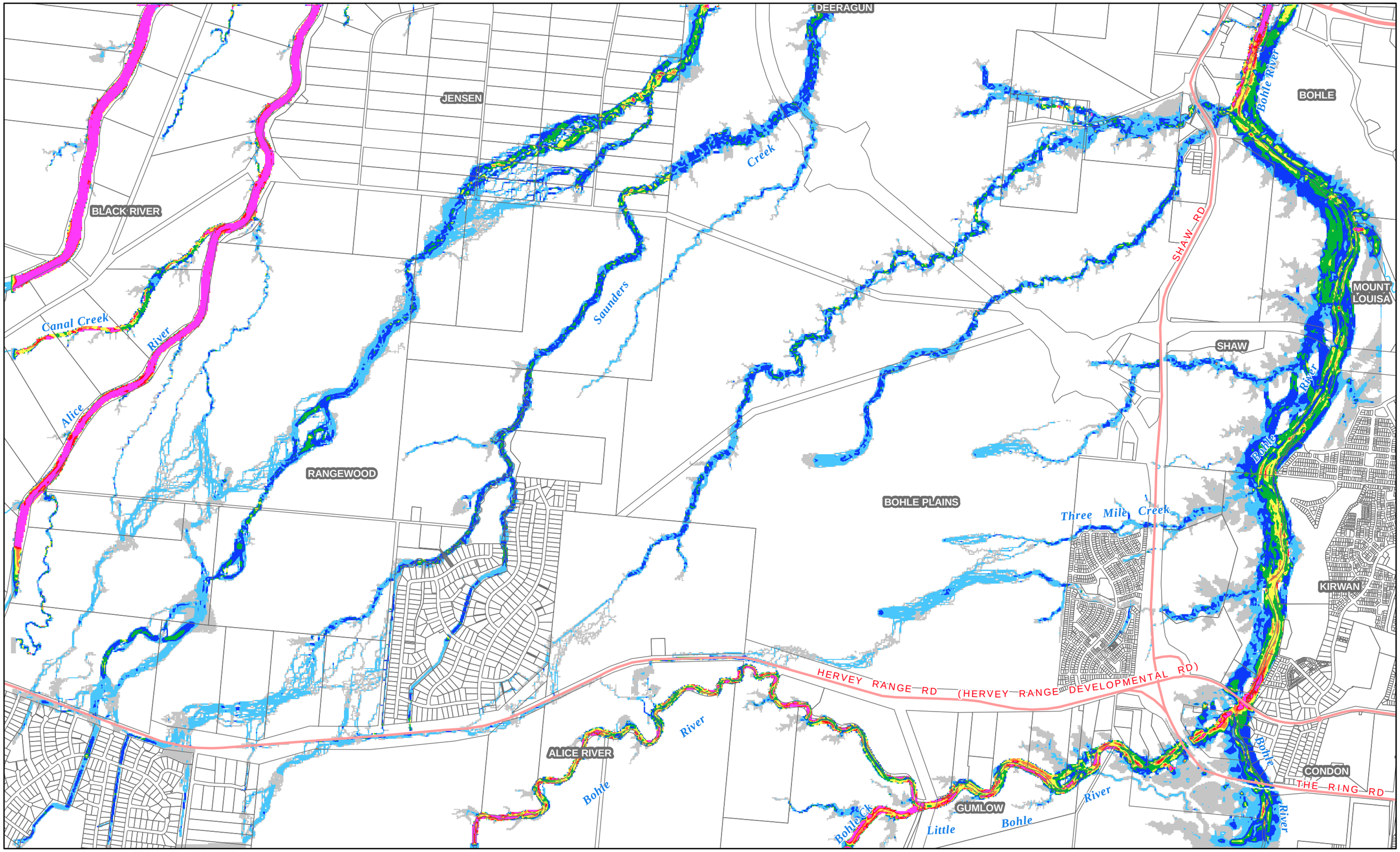
Water Depth (m)

0 - 0.3	0.3 - 0.5	0.5 - 0.75	0.75 - 1	1 - 1.5	1.5 - 2	2 - 3	> 3

UPPER BOHLE PLAINS FLOOD STUDY

5 year 24 hr ARI Water Depths Base Case

Figure B5



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_06

AECOM

N

Scale: 1:30,000
(when printed at A3)

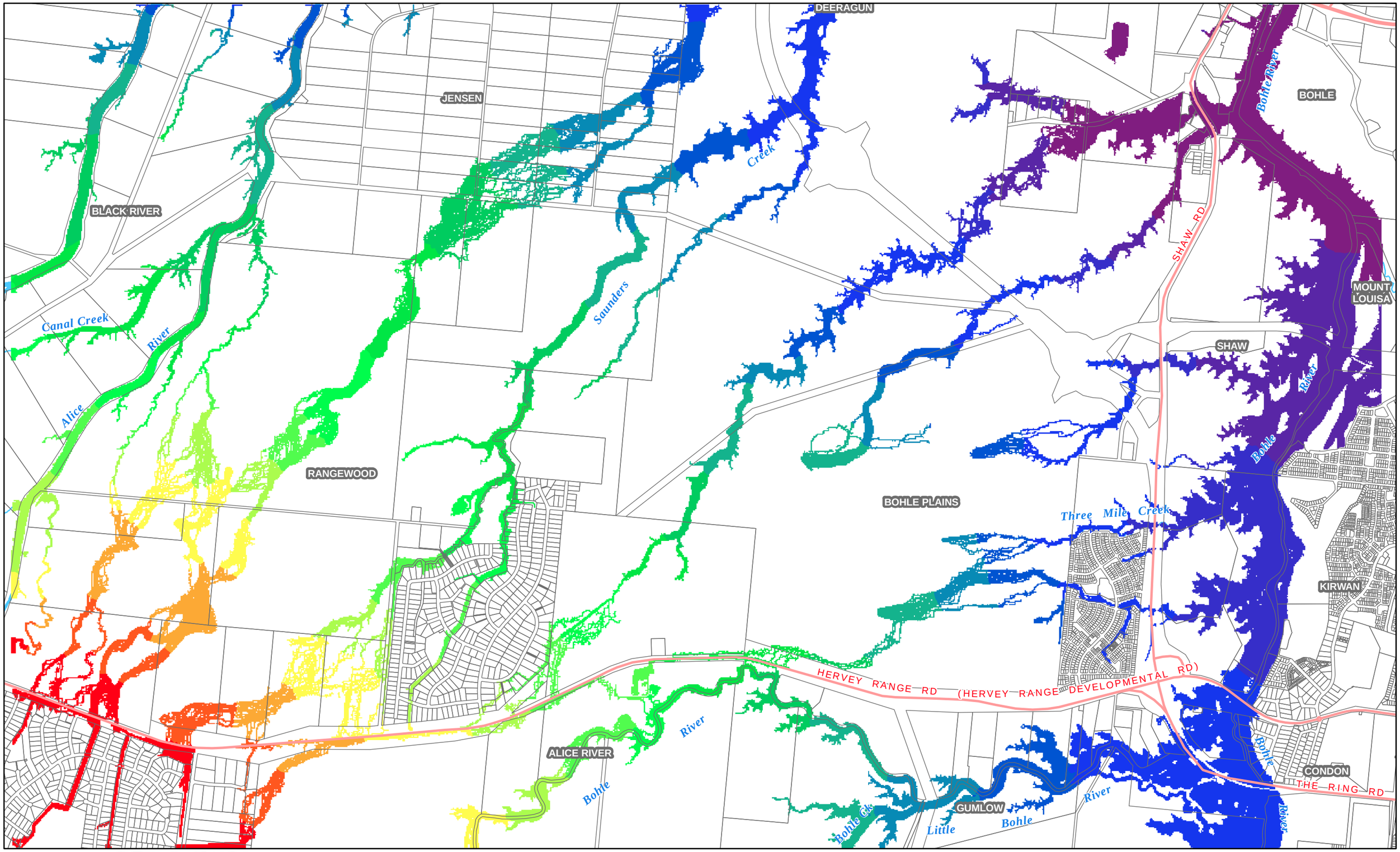
0 500 1,000 2,000 Metres

Velocity (m/s)

0 - 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.00	1.00 - 1.25	1.25 - 1.50	1.50 - 1.75	1.75 - 2.00	Above 2

UPPER BOHLE PLAINS FLOOD STUDY
5 year 24 hr ARI Velocity Base Case

Figure B6



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_07

AECOM

N

Scale: 1:30,000
(when printed at A3)

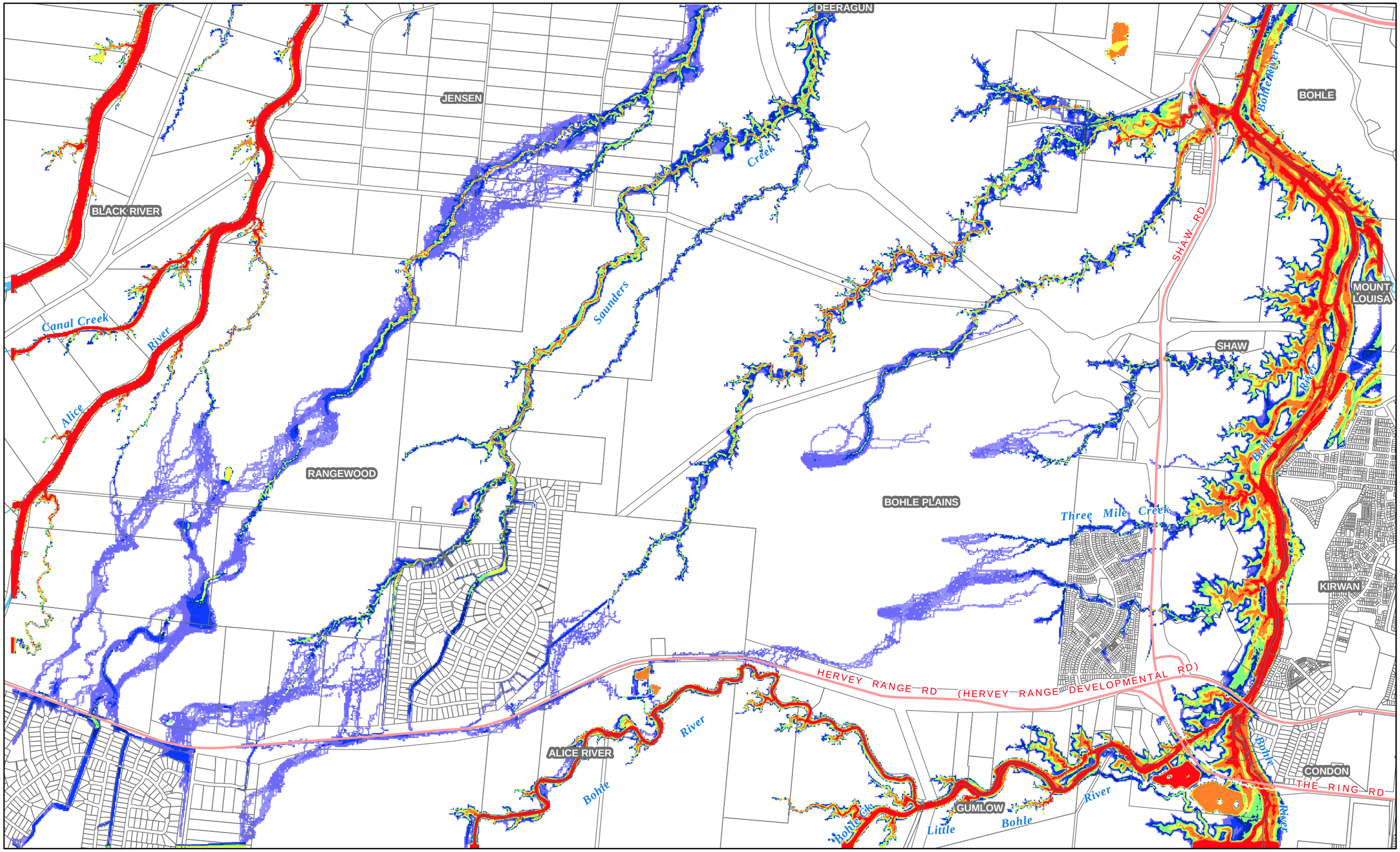
0 500 1,000 2,000 Metres

Water Levels (m AHD)

< 10 | 10 - 12 | 12 - 14 | 14 - 16 | 16 - 18 | 18 - 20 | 20 - 22 | 22 - 24 | 24 - 26 | 26 - 28 | 28 - 30 | 30 - 32 | 32 - 34 | 34 - 36 | 36 - 38 | 38 - 40 | > 40

UPPER BOHLE PLAINS FLOOD STUDY
10 year 24 hr ARI Flood Levels
Base Case

Figure B7



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_08

AECOM

N

Scale: 1:30,000
(when printed at A3)

0 500 1,000 2,000 Metres

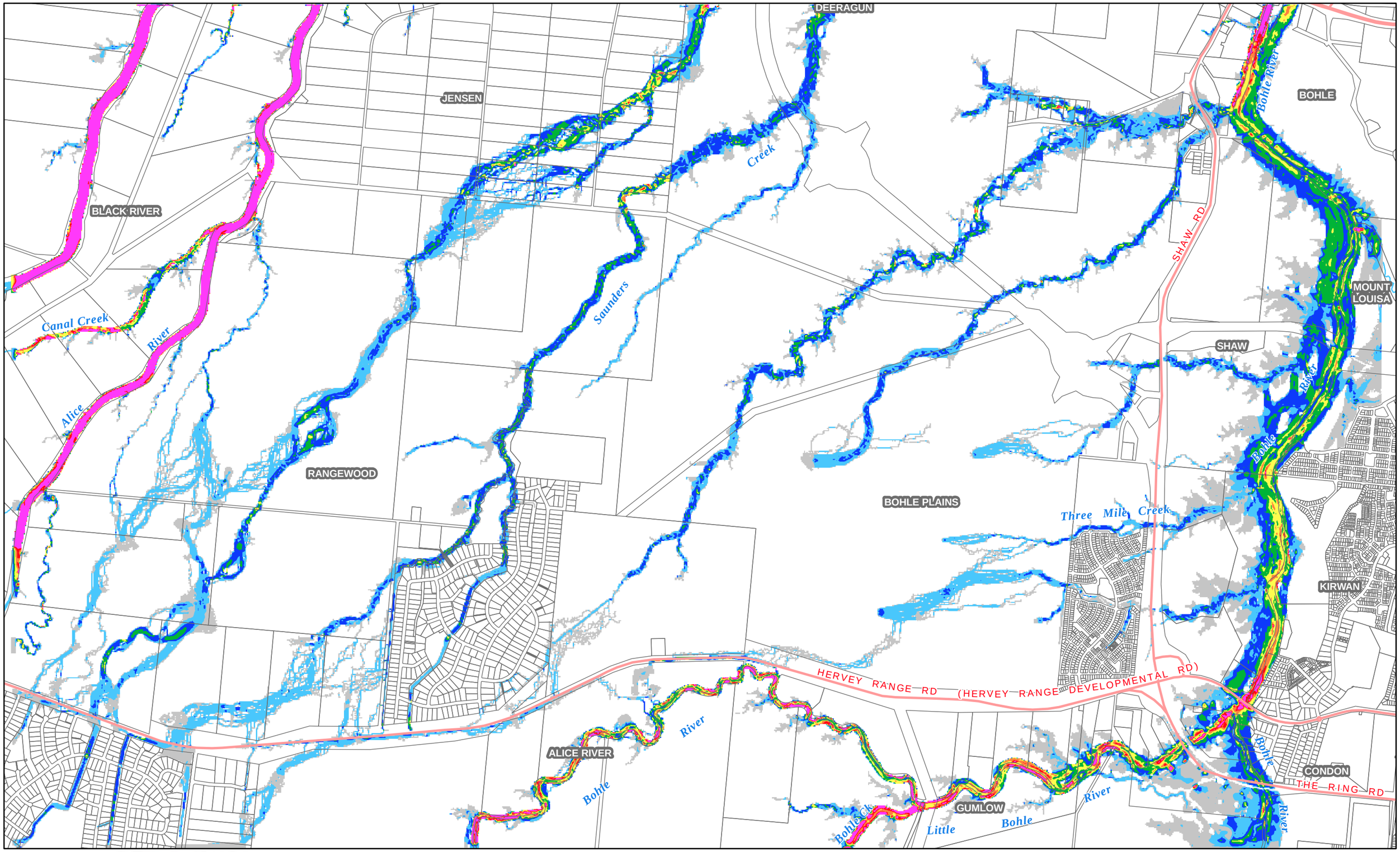
Water Depth (m)

0 - 0.3	0.3 - 0.5	0.5 - 0.75	0.75 - 1	1 - 1.5	1.5 - 2	2 - 3	> 3

UPPER BOHLE PLAINS FLOOD STUDY

10 year 24 hr ARI Water Depths Base Case

Figure B8



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_09

AECOM

N

Scale: 1:30,000
(when printed at A3)

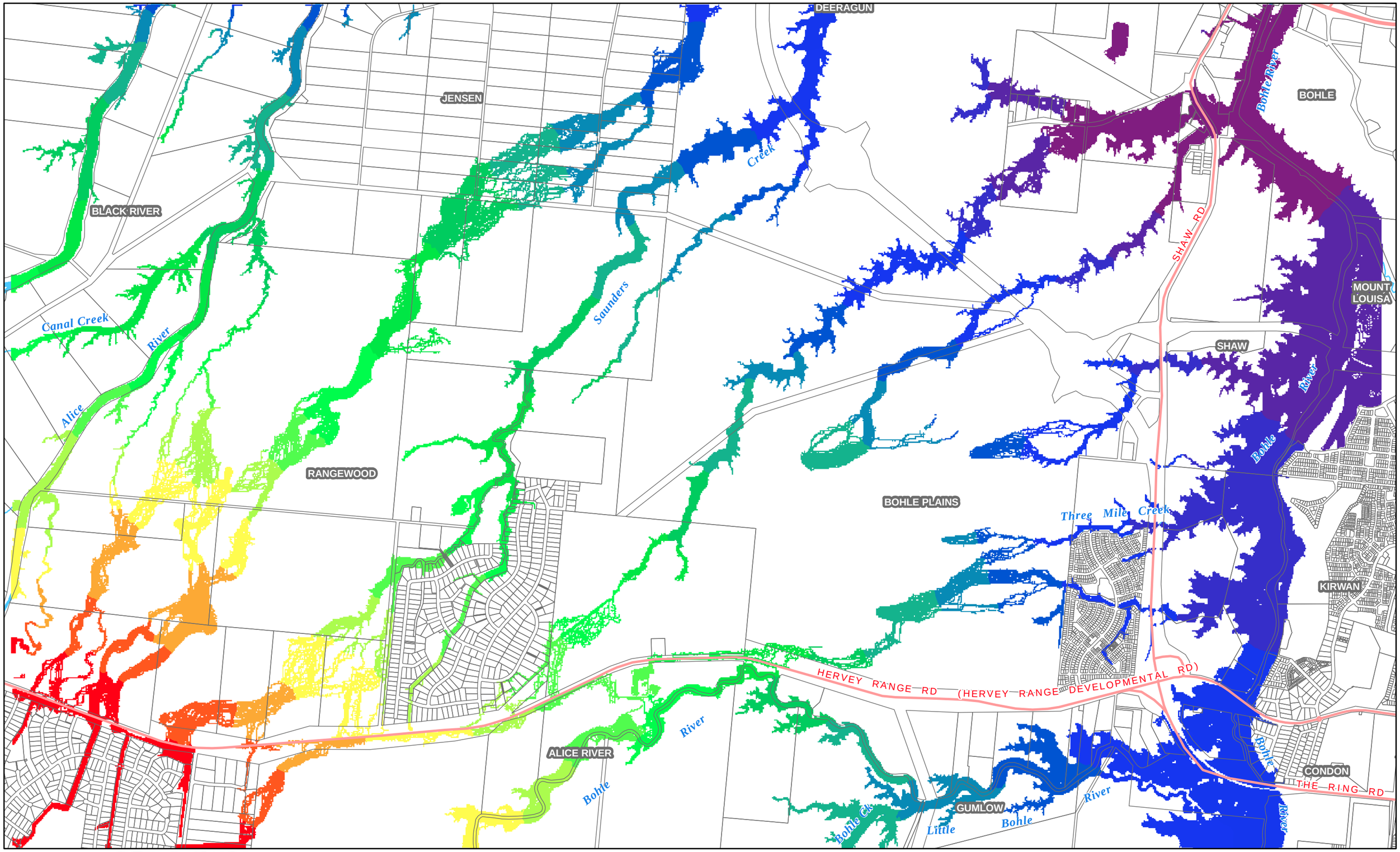
0 500 1,000 2,000 Metres

Velocity (m/s)

0 - 0.25	0.25 - 0.50	0.50 - 0.75	0.75 - 1.00	1.00 - 1.25	1.25 - 1.50	1.50 - 1.75	1.75 - 2.00	Above 2

UPPER BOHLE PLAINS FLOOD STUDY
10 year 24 hr ARI Velocity Base Case

Figure B9



PROJECT ID 60212663

LAST MODIFIED dxe 14-June-2011

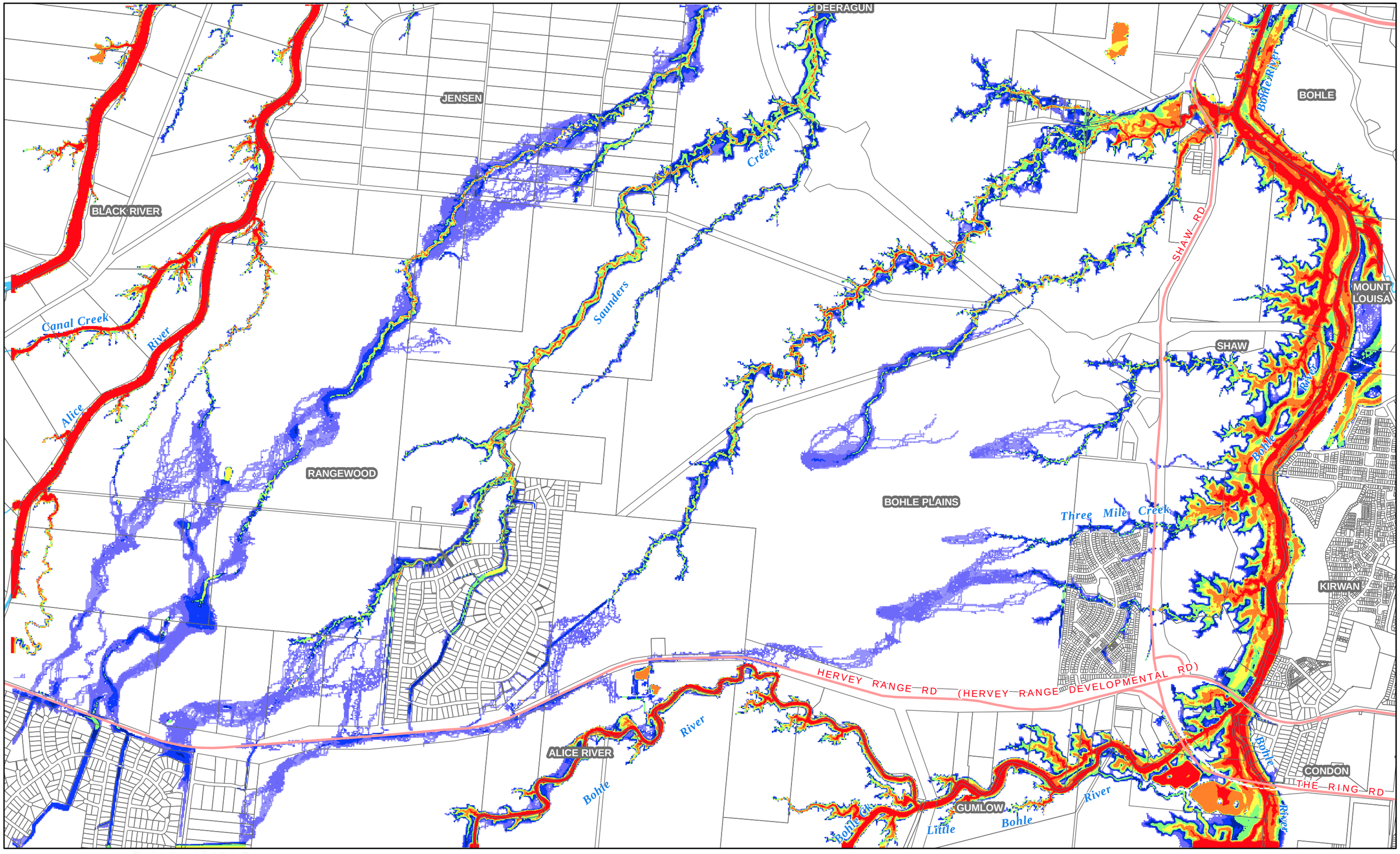
FILE NAME 60212663_WR_AP_10

AECOM

Scale: 1:30,000
(when printed at A3)

UPPER BOHLE PLAINS FLOOD STUDY
20 year 24 hr ARI Flood Levels
Base Case

Figure B10



PROJECT ID 60212663
LAST MODIFIED dxe 14-June-2011
FILE NAME 60212663_WR_AP_11

AECOM

N

Scale: 1:30,000
(when printed at A3)

0 500 1,000 2,000 Metres

Water Depth (m)

0 - 0.3	0.3 - 0.5	0.5 - 0.75	0.75 - 1	1 - 1.5	1.5 - 2	2 - 3	> 3

UPPER BOHLE PLAINS FLOOD STUDY

20 year 24 hr ARI Water Depths

Base Case

Figure B11